*Smart system of renewable energy storage based on **IN**tegrated E**V**s and b**A**tteries to empower mobile, **D**istributed and centralised **E**nergy storage in the distribution grid*

Deliverable nº:	**D10.2**
Deliverable name:	**Pilot Methodology**
Version:	**2.0**
Release date:	**31/10/2018**
Dissemination level:	**Public**
Status:	**Submitted** (Draft, Peer-reviewed, Submitted, Approved)
Author:	**Schneider Electric**

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 731148.

Document history:

Version	Date of issue	Content and changes	Edited by
0.1	27/02/2018	First draft version	Schneider Electric
0.2	27/02/2018	Second draft version	Per Gjerløw
1.0	28/02/2018	Submitted version	Per Gjerløw
1.1	30/10/2018	Addition of chapter "3.6 Specifics for the German pilot"	Fabian Burkard Paul Spies Malte Thoma
1.2	31/10/2018	Peer-reviewed UPC	Pau Lloret
1.3	01/11/2018	Peer-reviewed SIN	Joseph Negreira
2.0	08/11/2018	Final version	Per Gjerløw

Peer reviewed by:

Partner	Reviewer
SIN	Joseph Negreira
CITCEA UPC	Pau Lloret

Deliverable beneficiaries:

WP / Task
All

Table of contents

Executive summary **5**

1 Introduction **6**

2 PUC description **8**

2.1 PUC overview for all pilots 9

3 Key Performance indicators **10**

3.1 General KPIs 10

3.2 Specifics for the Dutch pilot 12

3.2.1 Objectives 12

3.2.2 Implementation Process 14

3.3 Specifics for the Norwegian pilot 18

3.3.1 Objectives 18

3.3.2 Implementation Process 22

3.4 Specifics for the Spanish pilot 25

3.4.1 Objectives 25

3.4.2 Implementation Process 28

3.5 Specifics for the Bulgarian pilot 29

3.5.1 Objectives 29

3.5.2 Implementation Process 31

3.6 Specifics for the German pilot 32

3.6.1 Objectives 32

3.6.2 Implementation process 35

Abbreviations and Acronyms (standard INVADE list)

Acronym	Description
AI	Artificial intelligence
API	Application programming interface
BRP	Balance responsible party
CES	Centralised energy storage
DES	Distributed energy storage
DSO	Distribution System Operator
EV	Electric vehicle
FCR	Frequency containment reserve
FO	Flexibility operator
GUI	Graphic user interface
HA	High Availability
MV/LV	Medium voltage/Low voltage
KPI	Key Performance Indicator
PUC	Pilot Use Case
PV	Photo voltaic
SMA cloud	Security Monitoring and Analytics cloud (Oracle)
SoRE	Share of renewable energy
TSO	Transmission System Operator
V2B	Vehicle to building
V2G	Vehicle to grid
V2H	Vehicle to home

Executive summary

This document presents the KPIs, pilot implementation process and objectives from a business point of view for each pilot in the project.

There have been defined a list of KPIs, presented in section 4, common for all the pilots and others that are specifically to the pilots themselves.

The document is structured in 3 main parts:

- PUC description
- PUC overview for all pilots
- KPIs

These KPIs and processes are in a preliminary state that will be changed/optimised during the execution of the project in these 2 years remaining, so the final Pilot Methodology will be exposed in D10.5 Final Pilot Methodology.

1 Introduction

This document shows the methodology for the pilots that make up the project.

Note that this document is a first version that will have its continuation in the deliverable *D10.5: "Final Pilot Methodology*" in which all the KPIs finally used by the different pilots will be shown, as well as the corrections to the first design of this document.

We are at an early stage in the design and implementation of the pilots so this document will be very active throughout the project execution-period, as some of the components might be discarded or the facilities updated.

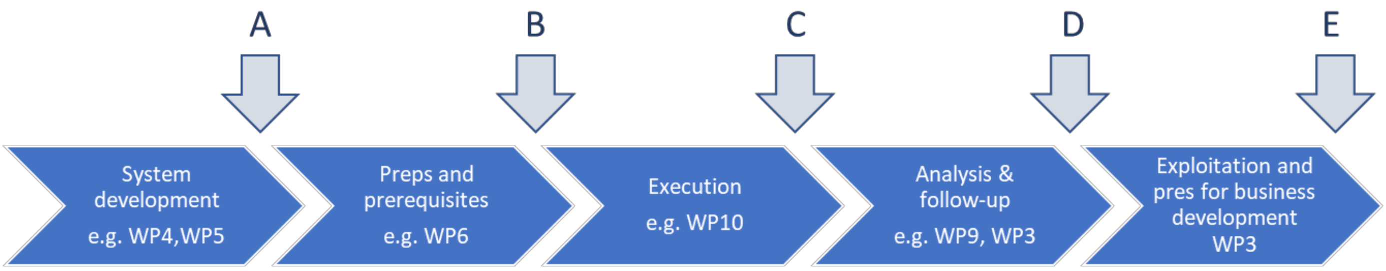

Figure 1 Basic process showing the different main steps. The arrows mark the transitions whereby performance tests will be performed according to KPIs specified.

Figure 1 shows the main steps of the process that will enable reaching the objectives of each pilot and answering the research questions that were specified in D10.1. Each step will be associated with a set of Key Performance Indicators (KPI). Each KPI represents a target that should be met to secure timeliness and quality of work. Some of the KPIs are composed of multiple elements that can be addressed separately (Reve & Stokke, 1996). However, it is the interplay between these performance indicators that are considered important. Consequently, an overarching KPI has been defined. In some instances this has also been done to reduce the number of indicators and thus simplify the process of monitoring the quality of the process. This follows practices that are well-established in multiple industries.

Each step in Figure 1 is separated by an annotated arrow market by a letters A, B, C, D and E. These points in the process define specific test points where results should be validated according to predefined KPIs. The KPIs defined for each step can thus be considered the acceptance key for the entrance to the next step in the process. A few

KPIs are introduced to monitor the quality and rate of execution the steps as they unfold. They become the navigators for managing the internal process.

Some of the KPIs have required a new set of parameters that, to our knowledge, have not been applied previously. This relates especially to the execution and analysis phases (transition C and D). In such cases the parametric construction has been defined and justified. The general idea is to produce pertinent answers to the research questions specified for each pilot and define salient measures of performance that qualifies the answers.

The KPIs specified for points A and B address the provisions and prerequisites required to launch the pilots. These are related to system development and acquisition of the infrastructure elements such as batteries. WP4, WP5 and WP6 are typically work packages that will cater for this or support those steps in the process.

The execution step will basically explore the technical potential of INVADE and trim performance of each pilot accordingly. Consequently, this step will essentially answer the technical questions asked by each pilot owner and the project overall. The business and user-related questions will mainly be answered in the associated analytic step that follows the pilot demonstrations. By evaluating the technical performance and tests performed it will be possible to determine the possibilities and likely impact offered by the INVADE platform; the idea is to determine its best use and what it can do for each pilot owners and others. This will constitute a very important input to the final exploitation phase where the idea is to enthuse recruited stakeholders that can pick-up the results and inject this into their own business development.

2 PUC description

- **PUC.1: Mobile energy storage using EVs for V2G, V2B and V2H operations**

The use case involves mobile energy storage using EVs with focus on V2G, V2B and V2H operations along with higher renewable integration. This use case will demonstrate a link to the transport sector using renewable energy sources in each pilot site. Emphasis in PUC-1 has been placed on smart charging by means of schedules with the possibility of reverse flow. The use of more novel or more experimental entities that have not yet reached the industry will be limited.

- **PUC 2: Centralised energy storage using an array of batteries at the sub-station or street level**

The use case involves a centralised energy storage unit comprised of an array of smaller batteries at the substation and/or community level. This use case will demonstrate the applicability of large-scale centralised storage units at the substation/street level to demand side management, power quality improvement, power peak-shaving and emergency back-up operations.

- **PUC 3: Distributed energy storage using individual batteries at the household level**

The use case focusses on distributed energy storage units spread across multiple households showcasing the benefits of such distributed storage across households.

There is another special case included inside PUC-3 which is one of the cases in Norway where households and smart devices will be treated. INVADE Integration platform will connect remotely with these smart devices and will establish a bidirectional communication link in order to collect all the electrical information and send control signals back to them.

- **PUC 4: Hybrid level energy storage solutions addressing a combination of use cases 2 and 3**

The use case implements a hybrid/combination of centralised and distributed energy storage units at both substation/street and household levels, a combination of use cases 2 and 3.

2.1 PUC overview for all pilots

This table gives an overview of which PUCs to be valid in the different pilots.

Table 1 Use Cases related to Pilots

Pilot	PUC-1	PUC-2	PUC-3	PUC-4
Norway - Lyse	X		X	
The Netherlands – Greenflux/ElaadNL	X			
Bulgaria - Albena	X	X		
Spain - EYPESA		X		
Germany - badenova				X

3 Key Performance indicators

The different KPIs are listed in the tables below. They are organised according to each defined use case and will be explored within the different pilots. All KPIs are listed as general to apply for all pilots. Then the overview for each specific pilot with dedicated KPIs are listed, and commented with "local customization". All KPIs are related to the research questions listed in deliverable D10.1.

3.1 General KPIs

General KPIs common for all pilots have been listed in Table 1 and explained below.

Table 1 General KPIs

KPI no	Key Performance Indicator	Description	PUC
1	Standard defined methodology used to reduce time of adaptation in Scaling up the pilots. This KPI should prove that "timeframe" for adapting new customers is "0".	To prove the benefits of using open standard protocols and reducing the possibilities of brand specific customizations. It's important to avoid local "tailor-made" solutions that will influence on the scalability, both in time and in re-structuring of register/database.	All
2	KPIs proving the reduction of the vulnerability in latency by using batteries in households. KPI= actual response / theoretical response with no latency	To demonstrate the improvement of using batteries due to better % of usage, and at the same time reduce the probability of black-outs. Lower safety margin and maximum utilization in the installation to reduce power-peaks.	All
3	KPI for sizing of the battery in new, efficient households vs. old households, to improve efficiency and reduce power-peaks / costs. This KPI reflects the size in kWh vs. peaks. (lengths & heights) KPI = peak reduction / battery cost [kW/NOK]	This recommendation will reflect the sizing of the battery due to different kinds of connected basic loads, and fast-acting loads with limited duration. This will prove how households with "modern heating" and "0" base-loads will have very quick ROI when power-tariffs will be introduced.	1 and 3

KPI no	Key Performance Indicator	Description	PUC
		Battery cost = energy capacity * unit cost	
4	Same as the KPI no. 4, but including also the possibility to curtail basic loads, and move usage in time. KPI = base reduction / battery cost [kWh/NOK] = unit battery cost	This recommendation will prove the necessity of curtailing basic loads in combination with batteries in “old” households to achieve the efficiency, and to meet new tariff-structure.	1 and 3
5	KPI will prove the % of improvement in charging with a dynamic smart charging “system” vs. charging systems not reflecting the “valley-filling” possibilities within the smart charging. KPI 30% improvement. Volume of valley without smart charging = V1 Volume of valley with smart charging = V2 KPI >= 1-V2/V1 = 0,3	To compare the models of charging with a fixed setting of the maximum capacity reflecting the limitation in the installation in worst case vs. the Smart Charging model. Smart Charging using dynamic set points and predictions due to input form big data analytics.	1 and 3
6	Same KPI as no. 5, but introducing DC-charging with OCPP 2.0, with reverse energy-flow.	Proving the new possibilities within the OCPP 2.0, giving the possibilities to balance the grid when including the reverse energy-flow. Again, reduce the risk of exploit the Grid / “living on the edge” without increasing the risk of black-outs, and to avoid “comfort-curtailing” when EV is connected.	1 (Elaad, Lyse)
7	KPI will prove the quality-improvement of including the battery in the installation. Reflecting the standards of quality measuring e.g. TDH = Total Harmonic Distortion < 5%	This KPI will measure the improvement in voltage stability / noise (odd harmonics) cancelling of including the battery in an installation. Both on households / building level and on the substation level.	All

3.2 Specifics for the Dutch pilot

3.2.1 Objectives

GreenFlux is aiming to use the developed Smart Charging features and tools in commercial offerings. It is also possible that a role like Flexibility Operator, for the EVs or in a wider approach, will be adopted by GreenFlux.

Elaad has been founded as a cooperation between the Dutch DSOs. The primary focus for Elaad within this project is study the impact on the grid from a DSO perspective. What are the best ways for a DSO to make use of EV flexibility without overstepping the non-commercial nature of a DSO. Elaad will use these learnings to become a better knowledge institute for Smart Charging, and that way be a valued knowledge source for its DSOs, but also for government bodies, from local to (inter)national level. One of the essential ingredients for future large-scale adaptation of the solutions INVADE is trialing in this project will be interoperability. This requires open standards. Therefore, the INVADE consortium goes beyond the scope of DSOs and supports government with knowledge, being also very active bringing its experience to standardisation bodies.

<u>Business rationale</u>

From the Dutch pilot, the main reason for this project is to explore and show the impact and benefit of smart charging and managing the flexibility in the grid. We expect that this pilot will provide insight and proof of “tomorrows” EV-charging solutions.

<u>Expected result</u>

The results INVADE wants to achieve derives from two perspectives: From the DSO perspective the project wants to protect the grid and quality of service by influencing charging behaviour of EVs. From the commercial perspective this pilot will investigate how to manage flexibility for homes and businesses, and how this can be monetised. The results of all sub-pilots should give insight in the aimed effects for managing energy flexibility.

KPIs for PUC-1 are, where this is possible, compared between smart charging equipment (with the Smart Charging algorithm) and normal charging equipment (without algorithm). This will contain measurements on:

- The share of renewable energy

SoRE = 100* Volume of RE/Total Volume of Energy [%]

- The kW-max for the grid connection

  kW-Max < Threshold [kW]

- APX price effects. (APX is an energy exchange operating the spot markets for electricity in the Netherlands, the United Kingdom, and Belgium).
- Session duration.

List of KPIs to be Measured

Table 2 KPIs specifically for the Dutch pilot

KPI no	Key Performance Indicator	Definition	PUC
1	The share of renewable energy	To show the improvement in share of renewable energy	1
2	The kW-max for the grid connection.	To demonstrate the optimization of the available grid-capacity vs EV-charging control.	1
3	APX price effects	To demonstrate the APX price-effects	1
4	Session duration	To demonstrate effects in session duration	1

3.2.2 Implementation Process

For the different types of sub-pilots/locations, there will be a different time frame for the implementation process.

Sub-pilot 1 – Home locations

1) **February 2018**
   Establish and confirm protocols, data exchange agreements with third parties (especially eSmart) coherent with pilot design.
2) **February - March 2018**
   Develop user recruitment plan
   a) Describe the necessary hardware facilities
   b) Develop pilot user agreements
   c) Develop communication materials: webpages, newsletters, press releases
3) **March – June 2018**
   User recruitment
   a) Facility / hardware checks

   b) Platform onboarding

4) **May – June 2018**
   Platform and API integration tests

5) **July 2018 – June 2019**
   Deployment / roll-out

   a) **July** Initial roll-out (approximately 10-20% of the pilot users)

   b) **September** Full roll-out

   c) **December** Flexibility adjustments based on preliminary results

Sub-pilot 1 will have passive user recruitment initially, where webpages, newsletters and press releases will be used to attract willing pilot users. This way, more willing users, with an intrinsic interest in innovative projects and new technology will be attracted - in contrast to customers that are only interested in monetary rewards for their involvement. Secondly, it will help in selecting those pilot users based on their situation, i.e. charge point type, PV installation, number of sockets per charge point (preferably this is a mix of single and double sockets) or vehicle type (full electric vehicles preferred over hybrid EVs).

If the passive user recruitment cannot provide enough pilot users, there will be active recruitment among known customers.

Deployment will be done in steps, where new functionality (such as more flexibility or increased price dependence) will be added for small groups of pilot users first. Gradually more users will then be added to receive the same updates. Smooth but stepwise development will allow for increased robustness against flaws and failures, while aiding in getting a clear view on possible and expected performance improvements of the updates.

Since there will be a variety of software (resulting from the variety of hardware) it is important to keep an eye on different effects of algorithms on different firmware in order to minimise these deviations.

Sub pilot 2 – Office locations on large scale

1) **February 2018**
   Establish and confirm protocols, data exchange agreements with third parties (especially eSmart) coherent with pilot design.

2) **February - March 2018**
   Develop user recruitment plan
   a) Describe the necessary hardware facilities
   b) Develop pilot user agreements
   c) Develop communication materials: webpages, newsletters, press releases
3) **February – June 2018**
   Active user recruitment
   a) Facility / hardware checks
   b) Platform onboarding
4) **May – June 2018**
   Platform and API integration tests
5) **July 2018 – June 2019**
   Deployment / roll-out
   a) **July** Initial roll-out (approximately 10-20% of the pilot users, 20-50% of local hardware)
   b) **September - October** Full roll-out (first to all customers, then to all charge points on the customer's sites).
   c) **December** Flexibility adjustments based on preliminary results

Sub-pilot 2 will start with active user recruitment, where existing buildings with EV charging infrastructure will be targeted for involvement in the pilot. Deployment will again be done in steps, where an extra careful consideration is taking in the steps from initial roll-out to roll-out on all charge points on a pilot site. The advantage of this slowed deployment is that it allows for an extra comparison between smart charged EVs and normally charged EVs, which may contain information on customers (EV drivers) preferences.

Sub-pilot 3 – Office locations on small scale

1) **February 2018**
   Establish and confirm protocols, data exchange agreements with third parties (especially eSmart) coherent with pilot design.

2) **April - June 2018**
   Software development: We use agile/scrum. In bi-weekly iterations we will plan, build and demonstrate the internal functionality and external interfaces.

3) **June 2018**
   Platform and API integration tests

4) **July 2018 – June 2019**
   Deployment / roll-out

   a) **July** Initial roll-out

   b) **September - November**

      Development and deployment of backlog issues and bugfixes

   c) **December** Flexibility adjustments based on preliminary results

Sub-pilot 3 starts with the physical setup of the site. Charge points have already been installed and are being connected. The local controller will be installed and the software for it created. On-site renewables, cable limits and equipment will be added and managed through a local optimization algorithm. For the local EV drivers it should be easy to participate in testing. The development process is agile/scrum, which means that the work is done in bi-weekly increments. Each increment starts with setting a scope for that increment, and ends with a small demonstration.

Sub-pilot 4 – Large scale public

1) **February 2018**
   Establish and confirm protocols, data exchange agreements with third parties (especially eSmart) coherent with pilot design.

2) **March - May 2018**
   Software development: Using agile/scrum. In bi-weekly iterations the internal functionality and external interfaces will be planned, built and demonstrated. In order:

   a) Public interfaces

   b) Congestion management

   c) Congestion management with BRP

   d) Congestion management with FCR

3) **June 2018**
   Platform and API integration tests
4) **July 2018 – June 2019**
   Deployment / roll-out
   a) **July** Initial roll-out
   b) **September - November**

      Development and deployment of backlog issues and bugfixes
   c) **December** Flexibility adjustments based on preliminary results

Sub-pilot 4 involves a system that is already in a production environment. This means that the incremental development needs to be carefully planned and introduced, to make sure it doesn't disturb normal operation. First the focus will be on the primary scenario: congestion management through static variable capacity. After that it will include a simulated BRP. Efforts to collaborate with a real BRP is foreseen. Final increment will be the frequency control on top of the congestion management.

3.3 Specifics for the Norwegian pilot

3.3.1 Objectives

The focus of the Norwegian pilot is to demonstrate the ability of the integrated INVADE platform to co-operate with an existing home energy management system. The technological shift in management systems, especially in the private end-user market, can be considered as a shift from centralised solutions where one actor controls every technical aspect of an installation, to an ecosystem where multiple independent or competing actors operate in the same space (e.g. a residential home). In order to ensure the commercial viability of the integrated INVADE platform, it is crucial to implement and demonstrate the ability of the platform to operate in such an ecosystem.

As part of the pilot, there will be several installations of energy-centric equipment in residential homes. The equipment will be purchased by existing service providers on the general principle that the physical installations should be as close to commercial products as possible. To account for the technological advancements in the years to come as well as shifts in regulations and incentives, some of the products (e.g. batteries) are not available or are immature as a service today. Through collaboration with the service provider it is expected to find solutions that resemble what will be offered as a standalone commercial product in the future. The pilot equipment will, to the greatest extent, be purchased through Smartly AS and Lyse Energisalg AS, both fully owned by and part of the Lyse Group.

The pilot area will be in the Stavanger region where Lyse is located, and where most of the end customers live. The Pilot participants will be families in households, Housing cooperatives and employees at Lyse.

The pilot is split into different categories in order to get as close as possible to the variety of technical energy-centric equipment at households and businesses. The following categories will be tested with the INVADE platform:

- Heating control 3 zones + water heater control. 10 installations in private households with existing PV systems.
    - Goal: Better utilization of self-produced energy. -
    - Using optimised energy management, floor and hot water warm up when the solar system produces the maximum. This in order to better utilise self-produced energy, as well as minimise energy delivered to the electricity grid.
- Smart EV charger. 20 installations in private households.
    - Goal: EV-chargers are controlled so that the car is charged during periods of high capacity in the mains and low energy prices.
    - When using smart EV charging, the charger will be switched off when the price level is at its highest or the grid capacity are low.
- 10 kWh battery energy storage. 10 installations in private households.
    - Goal: Control energy consumption
    - The energy consumption is taken from the battery when the grid capacity is low or the energy price is high by doing peak reduction.
- 3 kWp solar plant + 10 kWh battery for energy storage. 5 installations in private households.
    - Goal: Better utilization of self-produced energy.

    - When using a battery in combination with solar production, the consumer gets better use of self-produced energy and less energy is delivered to the electricity grid.

- 3 kWp solar plant + 10 kWh battery for energy storage + Smart EV charger. 6 installations in private households.
    - Goal: Load management.
    - When using EV-charging in combination with solar power and battery, the system ensures that the electric car is charged in periods when the mains is not overloaded.
- 3 kWp solar plant + Smart EV charger + water heater control. 9 installations in private households.
    - Goal: Better utilization of self-produced energy.
    - When using EV-charging in combination with solar power and water heater control, the consumer gets better use of self-produced energy and less energy is delivered to the electricity grid.
- 7 kWp solar plant + 10 kWh battery for energy storage + 11 Smart EV charger (200 end users). Lyse Head office
    - Goal: Better utilization of self-produced energy and load management.
    - When using a EV- charging system in combination with solar power and battery, the system contributes to charging the electric cars during periods when the power grid is not overloaded. Consumers will also spend more of their own energy, and less energy will be delivered to the electricity grid.
- 50 EV chargers in Housing cooperatives. (500 end users)
    - Goal: Control energy consumption
    - The electric cars are charging during periods when the mains is not overloaded.

The total residential installations in the Norwegian pilot are as follows:

- 30 PV installations

- 70 Smart EV-charger installations
- 30 Battery installations
- 10 smart heating/boiler installations.
- Housing cooperatives, where the focus is on charging points (500 users)

In addition, a combined PV, EV-charging and battery solution that consists of 7 kWp PV, 10 kWh Battery and 11 smart EV-chargers will be included in the pilot. There are 200 active users of the system, which is located at the Lyse Headquarters.

The following input will be combined in the Norwegian pilot.

- Energy consumption from the main meter in each household.
- Energy production from PV-systems.
- Energy consumption/storage from Batteries
- Energy consumption from EV-chargers
- Energy prices: production, consumption and grid fee.
- External input, Weather data from yr.no

Outputs and results from the pilot:

- Optimise energy consumption based on hourly rate.
- Optimise energy consumption based on effect/power.
- Optimise utilization of self-produced energy.

<u>Business rationale</u>

In the short-term the pilot objectives are related to early adapt of new technology to be tested and validated, and be implemented into the Smartly ecosystem to ensure the long-term ambitions of our company.

<u>Expected result</u>

Through the pilot it is desired to show the effect and benefit of smart management of energy-efficient components in the home in order to better utilise their own energy consumption. It is expected that the pilot will provide the necessary answers to how energy efficient a home can be by using new technology.

The desired achievements are related to optimal consumption of self-produced solar power and power management throughout the day to get the lowest possible power bill for the end customer. The commercial side of the pilot will be to look at how one can make money selling flexible services to end customers and how this should be handled. The result of the pilot will also be decisive for the choice of business model.

List of KPIs to be Measured

Table 3 KPIs specifically for the Norwegian pilot

KPI	Key Performance Indicator	Definition	PUC
1	Optimise energy consumption based on hourly rate.	To test different set-ups of battery / flexible loads, to adapt to different tariffs. (time of use)	1
2	Optimise energy consumption based on effect/power	To test different set-ups of battery / flexible loads, to adapt to different tariffs. (peak-power)	1
3	Optimise utilization of self-produced energy.	To test different set-ups of battery / flexible loads, for self-consumption vs feed-in to the grid.	1

1. PUE = Turnover/kWh where turnover is one of the following: Service degree/comfort level/production rate/convenience level. This is better measured in relative terms. = (PUE after – PUE before)/PUE before [%] KPI > ??%
2. KPI = peak reduction/battery cost [kW/NOK]
3. Gross production per period = P/t, Gross consumption per period = C/t, KPI = 100* (P/t)/(C/t) = 100P/C [% ratio of self-consumption] <= 1.

3.3.2 Implementation Process

The pilot will have 3 types of sub pilots:

1) Private home with different technical equipment to get as close as possible to the actual situation in households
2) Existing system with chargers, battery and solar systems.
3) EV chargers in Housing cooperatives.

All 3 pilots will have the same level of implementation at the technical level, but different implementation processes on installation and configuration.

Recruitment of all the pilots for private homes will be done through existing sales channels, and Pilot equipment will as far as possible be purchased through Smartly AS and Lyse Energisalg AS, both of which are full and part of the Lyse Group. There will be an INVADE discount to participate in the project through campaigns on our website and social media. The batteries in project will be free rental to pilots, but will be recruited in the same campaign. Campaigns for participation in INVADE start January 2018 and expire until mid-March 2018. After this, all households will be recruited and installation will follow the established processes with completion targets in May.

Existing system with chargers, battery and solar system. The existing battery solution provided by Fronius will be upgraded to meet the pilot needs. In this sub-pilot the battery will be upgraded with 4 additional battery units that gives a 10 kwh 2- way storage capacity. Implementation of this pilot as an exciting installation will be a technical implementation only. Integration of EV-chargers, battery and PV – API, will provide data from the end of May and implementation of INVADE AI execution will be done in January 2019.

EV-chargers in Housing cooperatives will be the last pilot installations. This is because the sale process in this area is complex and difficult. All decisions of procurement are decided at the annual board meeting in the Housing cooperatives. These meetings will be held in April 2018 and the installations will start after procurement is decided. The Project have 27 offers in different housing cooperatives.

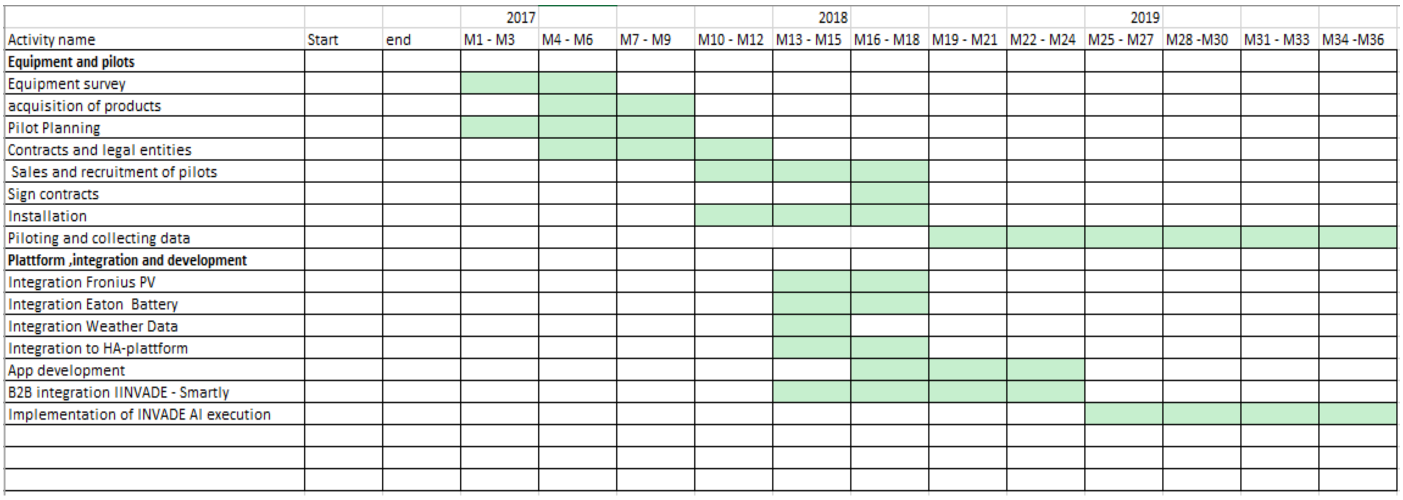

Figure 2: Norwegian pilot implementation Gantt

Contracts and legal entities: December 2017 – February 2018

Clarify legal relationships between customer and supplier related to contractual requirements and obligations

Sales and recruitment of pilots /sign contracts: January 2018 – March 2019 (Households), April 2018 – May 2018 (Housing cooperatives)

Campaign management, customer contact, customer meetings and customer agreements

Installation: January 2018 – March 2019 (Households), April 2018 – May 2018 (Housing cooperatives)

Coordinate device vendors and field engineers to minimise customer impact. Install customer equipment

Piloting and collecting data: June 2018 – end of the project

Poll relevant data sources on agreed intervals and deliver relevant data on defined format to eSmart

Integration Fronius PV: January 2018 – June 2018

Develop and integrate a polling API towards Fronius and reformat the data to event based forwarding DataStream to eSmart

Testing and validation of implementation

Integration Eaton Battery: January 2018 – June 2018

Develop and integrate a polling API towards Eaton and reformat the data to event based forwarding data-stream to eSmart

Testing and validation of implementation

Integration to HA-platform: January 2018 – June 2018

Implement event based integration to HA-platform

Testing and validation of implementation.

Integration Weather Data: January 2018 – March 2018

Prepare Smartly weather data source for INVADE GUI

Testing and validation of implementation

App development: April 2018 – October 2018

Implement INVADE GUI functions in the Smartly customer app

Testing and validation of implementation, release of new functionality, step by step.

B2B integration INVADE – Smartly: January 2018 – December 2018

Clarify requirements of data entities, define API-standard, develop, implement and test agreed API

Testing and validation of implementation

Implementation of INVADE AI execution: December 2018

Implement control on/off execution based on AI responses from eSmart

3.4 Specifics for the Spanish pilot

3.4.1 Objectives

The storage system, combined with the Integrated INVADE platform and power electronics will provide a network with a reliable and efficient energy backup, as well as a new business model for daily use by households sharing storage capacity.

The Spanish pilot aims to develop a business case for a Flexibility Operator supplying services to a:

- DSO: flexibility services are required to improve its operation, through congestion management, voltage control and controlled islanding to offer redundancy (for a specific time) to critical consumers such as hospitals, police stations, and DSO control centre rooms, connected to DSO secondary substations.
- BRP: flexibility services will allow performing a day-ahead, an intra-day optimization and self-balancing.

Business rationale

The flexibility will be contributing to manage efficiently the storage in the electrical network. The main objective then is to define and explore the business case from a Flexibility Operator side from a business and economic perspective.

- Relation to societal ambitions:

  In a short-term period, this will allow a higher integration of renewables in the grid and better electricity service quality through the services offered to the DSO. Referring to the long term, it will reduce the physical infrastructure necessary in the development of the electricity system and the change of behaviour and needs of the end users.

- Relation to business ambitions:

  Explore the role of the Flexibility Operator and learn about the new business opportunities it offers in a short-term period.

  In the long term (and when it is legal), be able to create a Flexibility Operator entity, thus opening a new area to the company group within the energy sector.

Expected result

In this validation pilot, the following outcomes are expected:

- Control and observability of the LV network
- Facilitate at the DSO as a part of the open market for services
- Participation of distributed generation and energy storage in network management
- Provide back-up service to head quarter
- Optimised market interactions of the BRP (cost savings for the BRP)

The main reason behind each KPI is the same, improve the controlled islanding confined to a grid area limited by one feeder of the secondary substation where the centralised battery is installed.

- % of reduction in congestion problems = a Ratio that can be defined as Max number of congestions per period after /Max number of congestions per period before. //average numbers may also be used

- % of reduction in voltage/reactive power problems as before. Reactive compensation should have an efficiency of more than 95%
- Amount of time controlled islanding can be sustained
- % of BRP cost savings in the FO scenario compared to the scenario with no FO
- % of increase in hosting capacity in the grid
- % of decrease in future grid investments necessary in the FO scenario compared to the scenario with no FO
- % of decrease in emissions from the diesel generator previously used to offer controlled islanding to the DSO control centre

List of KPIs to be Measured

Table 4 KPIs specifically for the Spanish pilot

KPI no	Key Performance Indicator	Definition	PUC
1	Congestion Reduction Issues	% of reduction in congestion problems	2
2	Energy and Power reduction	% of reduction in voltage/reactive power problems	2
3	Islanding Time	Amount of time-controlled islanding can be sustained	2
4	BRP Cost Savings	% of BRP cost savings in the FO scenario compared to the scenario with no FO	2
5	Capacity of the Grid	% of increase in hosting capacity in the grid	2
6	Grid Investments Reduction	% of decrease in future grid investments necessary in the FO scenario compared to the scenario with no FO	2
7	Optimization Diesel Generation	% of decrease in emissions from the diesel generator previously used to offer controlled islanding to the DSO control centre	2

3.4.2 Implementation Process

The pilot carried out in Spain will follow the next development and implementation process.

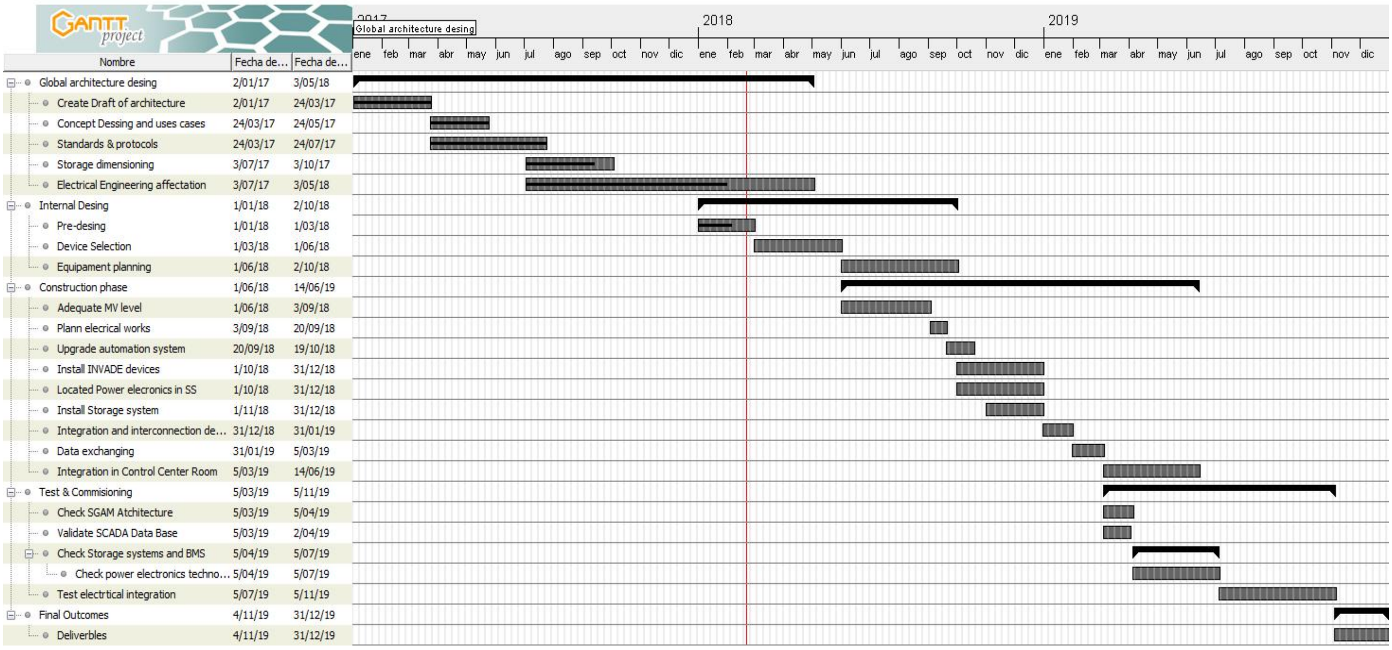

Figure 3:The Spanish implementation plan in Gantt

There are 5 main phases in the implementation process during the project:

1) Global Architecture Design – Concept Design, Architecture and business for the DSO.

2) Internal design – validation process for the prerequisites and technical requirements from EPESA

3) Construction phase – Development and construction time for devices and software required in the SS.

4) Test and commissioning – Tests and commissioning of the meters and final installation

5) Final Outcomes – Final results and report.

3.5 Specifics for the Bulgarian pilot

3.5.1 Objectives

The pilot in Albena, Bulgaria, is going to demonstrate how a centralised battery storage could contribute to the overall energy efficiency of a large number of consumers. It will also address the benefits that electric vehicles can offer on its own and in combination with a centralised and stationary battery unit.

At the site of the five-star-hotel Flamingo Grand, a PV installation and a battery with inverter will be installed to increase the share of the renewable energy that is used.

The motivation of the project is based on the fact that a large share of renewable energy sources brings volatility into the grid energy consumption. In some cases, this volatility could lead to financial penalties by the grid operators or energy suppliers, which would cause increase instead of decrease of the energy costs. By using battery storage systems and smart charging of EVs, the consumption of energy can be controlled/balanced. Energy management approaches like peak shaving, peak shifting, valley filling, etc., may change the form of the curve of used power. Using constant residual power from the grid will lead to financial benefits for the owner and thus, make the business model of the project profitable.

Business rationale

The societal ambitions and the business ambitions coincide regarding our project. It will increase the trust of investors, which turn out to be energy end customers in renewable energies. The project will especially lead to financial benefits in the short-term and the long-term. In parallel to that, there will be benefits for the society from a low carbon economy perspective.

Expected result

Within this pilot the primary objective is to display the benefits of a battery for the low voltage grid. Next, it will be demonstrated that renewable energy for self-consumption leads to financial benefits without imbalance energy penalties. The flexibility cloud of the INVADE platform will provide a pool of flexibility in which different flexibility sources will be included. This means that the pilot site also will demonstrate the synergy between centralised battery storage and the centralised mobile battery storage that consists of electric vehicles.

List of KPIs to be Measured

Table 5 KPIs specifically for the Bulgarian pilot

KPI no	Key Performance Indicator	Definition	PUC
1	Benefits from a battery at Substation level for % increase in renewable for self-consumption. SoRE = 100* Volume of RE/Total Volume of Energy [%]	A smart operating battery at LV-substation level will influence in the share of renewable used at the hotel-site	2
2	Benefits of a battery at Substation level for % decrease of imbalance energy	The battery will have effect on the amount of balancing energy a customer normally needs. The decrease of the imbalance energy leads to direct financial benefits.	2
3	Peak Shaving, kW_{max} control	The daily peak power is responsible for the dimensioning of the power infrastructure. The Percentage of lowering safety margin for black-outs is important measure of the effect of the battery.	All
4	Smart-charging + battery	How to increase the EV-charging capacity by using smart EV-charging in combination with battery. This will optimise the EV-charging due to capacity-(valley-filling) in combination with battery-storage.	1
5	Smart-charging with renewable	Same as above, but now also focusing on using maximum of renewable for EV-charging.	1

KPI no	Key Performance Indicator	Definition	PUC
6.	$P_{max}b$ = Max peak per day/week or month before action. $P_{max}a$ = after implemented action. Improvement in % = $100*(P_{max}a-P_{max}b)/P_{max}b$ Also: Number of peaks above threshold before and after = K If Peak > = K then it counts as p_{before} and p_{after}. Reduction = $100(p_{after}-p_{before})/p_{before} < 0$	Improvement in power-usage reduction in the building / hotel when involving the end-user, giving them incitements to participate in “competitions”. Introducing app`s and dashboard. This can be proved with or without other intervention in the building.	1

3.5.2 Implementation Process

The implementation process of the pilot starts with the installation and setup of the pilot infrastructure by the end of June 2018. The installation of the battery, the PV panels and the charging points will be done in parallel. Adding them to the existing SCADA system is planned also to be done without any necessary preparations.

The effects of the added infrastructure will be transparent and free to be observed at the SCADA system of Albena via a special dedicated web site www.albena.energy. A small demonstration of the energy management approaches will be done at the beginning of exploitation.

Then, the SCADA system will be connected to the INVADE flexibility platform in order to receive control signals for the operation modes and also to send feedback information back. Based on that information the INVADE platform will be able to make decisions for the next step of optimization.

At the beginning the connection with the real energy markets will be simulated. The used market data will be gathered manually to set up the initial working conditions. Afterwards, a real-time connection to the energy market will be launched and the real effect of the battery will be measured.

3.6 Specifics for the German pilot

3.6.1 Objectives

The German pilot focusses on a hybrid approach. It will use one centralised energy storage (CES) device on one hand as well as connect distributed energy storages (DES) in private households on the other hand. The examination of new business models plays a decisive role in this context to facilitate the roll out of ideas developed in the INVADE project later on in the market.

Centralised energy storage

This sub-pilot wants to develop a solution for the DSO to control and improve the power quality of the grid in a selected area with a weak end-feeder and a high penetration of PV-generation. Another main goal is to test two separate value streams within one single battery and its practical implications on the technological as well as economic side.

The CES will be fully owned by the DSO and deployed for grid usage purposes only, not offering its services to other potential customers in order to stay within the regulatory framework. Although the battery is only deployed for grid usage purposes, it generates two different value streams by offering its flexibility which is not required to solve the local issue of voltage control as a means of peak-shaving for the entire electrical grid. So an additional value for the DSO shall be generated.

Distributed energy storage

This sub-

pilot aims at connecting already existing decentralised batteries of households to offer auxiliary services to the DSO. On top to the aim of the home management system intending to maximise the self-sufficiency of the household, the use of the battery is also offered to the DSO for peak shaving. The DSO can control the energy consumption at the grid connection point of a household (or several households). In return, the customer receives lower grid usage tariffs for his energy consumption, because he is providing the DSO access to his home management system and acts therefore “grid friendly”.

Business rationale

Centralised energy storage

In the short-term, the redox-flow battery foreseen as CES should be tested to review the feasibility and illustrate the suitability of the technology for purposes of a DSO. It is of utmost importance for the DSO to use a reliable and more or less maintenance-free technology that allows to control the voltage and avoids expansive grid enhancement. By offering auxiliary services in the form of peak-shaving to the entire grid, the pilot uses multiple value streams showing the versatility of CES. This is a major step forward in the practical use of batteries with a potentially great influence on the economic performance. If this approach turns out to be economically reasonable, it is planned to use battery technology for similar purposes in other areas of the electrical grid with much more customers and PV systems connected. Further, it is planned to offer to other DSOs in the region the service of installing, operating and maintaining battery storages for similar purposes as a flexibility operator.

Distributed energy storage

Small batteries on household level currently aim at only one revenue stream for the customer which reduces the energy consumption from the grid in the household and maximises self-sufficiency. Within INVADE, the battery allows to use its remaining flexibility potential by other market partners such as the DSO who is interested to balance the grid and to reduce peaks in demand. It allows for analysing the economic potential for the customer as well as the DSO on the basis of practical examples. If both sides are benefiting, the business idea can be extended to much more households, increasing the flexibility potential to the DSO or other market parties. Today, already 1,000 systems are installed in the grid area of badenova with numbers increasing fast from year to year, so the market potential is evident.

Additionally to the economic impacts, the pilot demonstrates the technical feasibility for both, the customer and DSO, to use batteries on household level as flexibility service to the grid without financially hindering the customer.

Expected result

Centralised energy storage

The sub-pilot exemplary demonstrates the possibilities of large-scale batteries to offer services to the grid and to improve the power quality. It is expected that the battery is able to handle the situation with occasionally occurring voltage quality issues at the weak end-feeder of the local DSO. Deploying the battery for multiple grid applications uncovers additional value. The pilot gives insights for developing novel business models for grid-scale batteries based on hands-on experience.

The scalability of the solution plays a crucial issue in the commercial development of a business idea. Similar situations within the network of the local DSO could be solved with centralised batteries. Ultimately, the solution can be provided to other DSOs.

Distributed energy storage

The pilot provides insights and suggests a possibility to handle increased decentralised energy generation while both, households and the DSO, financially benefit from the flexibility potential of the DES.

In addition to the commercial purpose of the pilots, the pilot proves that households can participate as a means of flexibility without losing any comfort. The DSO achieves an additional means of flexibility and is ready to integrate and propose novel business models for both itself and the end-users.

List of KPIs to be measured

Table 6 KPIs specifically for the German pilot

KPI no	Key Performance Indicator	Definition PUC	PUC
1	DSO cost savings	Cost savings of the DSO compared to other solutions such as grid enforcement or other types of control devices	2
2	Additional DSO cost savings	Cost savings regarding the peak power fees to the upstream network operator	1 and 2
3	Additional revenues for private households	Amount of additional revenues for customers compared with common approach of optimizing self-sufficiency only	1
4	Frequency of flexibility usage	How frequently is flexibility requested by the DSO provided by DES and CES	1 and 2
5	Flexibility potential of DES	Testing and examining the flexibility potential that DES can offer in addition to the actual purpose of optimizing self-consumption	1

3.6.2 Implementation process

Centralised energy storage

The implementation process follows a strict time frame that allows a first commissioning in January 2019 and a full control by the INVADE platform starting from 1st of march 2019.

August – September 2018

Selecting battery supplier and battery technology

September – October 2018

Formal purchasing process including detailed technical specification as well as purchasing contract and placing the order

October 2018 – January 2019

Manufacturing of battery and testing in laboratory

Preparation of solid base, earthing and electrical connection for the battery container

Signing a contract with farmer allowing placing the battery on his ground

Installation of equipment

- Electric meters have to be installed that measure energy consumption of the farmer's house as well as the energy generation from the PV systems
- Delivery and installation of the battery container

November2018 – January 2019

Preparing communication between INVADE platform and battery

- Developing and integration of an API from the BMS to the INVADE platform
- Testing communication in laboratory surrounding

December 2018 – January 2019

Control algorithm

- Implementation of control algorithm in INVADE platform

- Testing execution of control request from the INVADE platform by the battery
- Testing proper function of control algorithm based on actual status data of the battery

January – February 2019

Test and commissioning in the field

- Platform control algorithm tests, bugfixes
- Communication tests, bugfixes

March 2019 – end of the project

Monitoring and collecting data

Distributed energy storage

In contrast to the pilot with the large-scale battery, the sub-pilot for DES has a different focus and timeline. The chosen approach requires to enrol real customers with proper hardware and to install additional communication and metering devices in the private households.

August 2018

Identifying potential customers with required key components that are necessary for the pilot site test setup

September 2018 - October 2018

Customer recruitment

- Sales approach to potential customers via mailing, telephone and personal visits
- Identification with following prerequisites in the grid area of badenova: Existing PV-plants, DES and home management systems further compatible to SMA standards
- Active customer recruitment
    - Hardware check
    - Signing contract with data privacy statement

November 2018 – December 2018

Installation of required additional components in participating private households

- Communication gateway
- Version update of home management system (if required)
- Smart meter (the installation of a smart meter is alternatively due to regulatory issues in Germany)

November 2018 – January 2019

Preparing communication between INVADE platform and home management systems

- Providing REST-API description of the SMA cloud the home management systems are connected with to selected project partners
- Gap analysis of REST-API and INVADE platform-API
- Adaption of INVADE platform to REST-API or programming a protocol converter
- Testing communication in laboratory surrounding

January – February 2019

Test and commissioning in the field

- Platform control algorithm tests, bugfixes
- Communication tests, bugfixes

March 2019 – December 2019

Monitoring and collecting data