*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:	**D10.4**
Deliverable name:	**First Results from Pilots**
Version:	**1.0**
Release date:	**28/02/2019**
Dissemination level:	**Public**
Status:	**Submitted**
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	18/02/2019	First version	Cristobal Cordobes
0.2	19/02/2019	Second version	Per Gjerløw
0.3	21/02/2019	Third version	Per Gjerløw
0.4	21/02/2019	Peer-review from JN	Joseph Negreira
0.5	25/02/2019	Peer-review from PL	Pau Lloret
1.0	26/02/2019	Peer Reviewed Corrections	Cristobal Cordobes / Per Gjerlow

Peer reviewed by:

Partner	Reviewer
UPC	Pau Lloret
SIN	Joseph Negreira

Deliverable beneficiaries:

WP / Task
All

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Abbreviations and Acronyms

Acronym	Description
API	Application Programming Interface
EV	Electric Vehicle
DER	Distributed Energy Resources
DoA	Description of Action (Annex I of the Grant Agreement)
DSO	Distribution System Operator
KPI	Key Performance Indicator
OCMP	Open capacity Management Protocol
OCPP	Open charge Point Protocol
PLC	Power Line Communications / Carrier
PUC	Pilot Use Case
PV	Photo voltaic
V2G	Vehicle to Grid
WP	Work Package

Executive summary

This deliverable contains the initial findings from pilots' development from tasks T10.2 to T10.7. In order to obtain the required information to determine the progress so far in the project a survey was conducted. This was supported with direct talks with the pilot owners on the achievements. The pilot owners were confronted with their original claims and goal definitions in the EC Grant agreement and asked to determine their achievements so far compared to this. Each pilot has been constructed around different use-cases and is not easily compared. The most notable achievement common to all is the successful effort in setting up an experimental rig and regime that has started to yield data and valuable experience through direct interactions with different stakeholders. The effort documented here has helped to improve the awareness of pilot owners and to continue to sharpen focus in order to meet the obligations made at the outset of the project. The remaining part of the project will be used to follow this up to ensure maximum outcome from each of the pilots now running.

1 Introduction

This document shows the first results that each pilot has achieved during the first 26 months of the project. Each pilot owner was asked to take part in a survey where they were confronted with claims and promises entered into the Grant agreement (concretely in its annex 1 - DoA). The approach was applied to reinforce awareness of the original objectives of the project and help to gauge the gap between what has been achieved so far and the ultimate goals.

The present document will be used as a foundation for optimizing and developing each pilot further until the end of the project, ending up in D.10.7.

This first period of the project has been quite important to implement hardware and to create the architecture defined in the previous deliverables, for supporting the business aspects according to the DoA for each pilot.

There has been a high demand for defining the correct main devices and integrate them in the defined architecture. Next steps will be to define and create a full “test plan” from the INVADE-cloud throughout to all local platforms and DER’s.

In the following sections there will be a status report from each of the pilots explaining their processes for bringing their pilot into the defined “test mode”, what results have been achieved during this first period and the progression in their specific pilot. Each pilot will also describe and evaluate how this first period of development/testing is matching the requirements in the DoA specifics per pilot like:

- Value capture
- Stakeholders involvement
- Policy implications in the pilot
- User acceptance
- KPI´s results involved
- Impacts in the project
- Future actions until de end of the project

2 Norway: Pilot in Stavanger

2.1 Achievements and results per M26

Achievements and results according to the DoA

The Lyse pilot investigates and demonstrates the intersection between V2H/loads/PV, effect based tariffs and energy management in private homes and buildings, and how they are combined in new business models. The pilot demonstrates this within use case 1 Mobile and use case 3 Distributed energy storage at multiple households. The working process has been divided in two. Pilot installations and the technical platform integration and development.

Pilots

The pilots have been recruited through social media and existing sale channels. The benefit by doing this is the existing delivery process for equipment which enables effective deployment of pilots. The pilot has grown in number of users and scale compared to the DoA. The background for this is input from the PO regarding scale. We added payment for pilots to participate in the project to get more pilots and more engagement into the project.

The pilots have different combinations of equipment to get as similar as possible to the variation of equipment at a household level. The pilots have therefore been divided into different categories to cover this variation. All pilots have been installed in time according to the progress plan and timeline for the task. We have met some issues regarding data from the power meter in each household. This is related to the AMR and lack of standardization on how to collect these data. On 01.01.2019 this was standardized from the DSO and authorities.

The objectives of the DoA have been met except for the V2X where lack of equipment is the main course for the delay. We are still working to achieve this objective.

Platform integration and development

To prove that the INVADE platform can be inter-operable with existing smart solutions or ecosystems, we have integrated the local ecosystem Smartly AS with the INVADE platform. This has been done through API and development to match the business models developed in WP9.

2.2 Specific pilot objectives

In the DoA it´s specified the following for the pilot:

Context, players (use case 1 Mobile and use case 3 Distributed)

The Lyse pilot will investigate and demonstrate the intersection between V2H/loads/PV, effect-based tariffs and energy management, and how they can combine in new business models. We will also demonstrate how the Integrated INVADE platform can be inter-operable with existing smart solutions. The pilot will take place in the Triangle Smart City & Communities large scale pilot area in Stavanger.

Following: It will be explained what have been achieved so far,and how.

As part of the pilot, there are several installations of energy-centric equipment in residential homes. All the energy-centric equipment at the household level has been integrated to the Smartlty ecosystem. The integration has been done at a cloud-to-cloud API level with all the different stakeholders. Battery, PV and EV charger supplier's API's have been integrated as a part of the project. Integration at this level will enable easy setup and scalability. As a part of the business model aspect of the project the Lyse pilot has developed 3 different services to provide to the Pilots/customers 1. Optimize energy consumption based on hourly rate. 2. Optimize energy consumption based on effect/power. 3. Optimize utilization of self-produced energy. All the services are related to problems to solve within electric consumption for end customers. The focus for the pilot is the downstream services within the business model developed in WP9. The Lyse pilot uses the Smartly ecosystem to demonstrate that the INVADE platform can be inter-operable with existing smart solutions. This work has been done by a cloud to cloud integration between the two platforms. The project has developed and implemented a standardized API for easy onboarding of new customers which enables easy setup of pilots. This also enables easy upscaling of new customers after the project. Dataflow from the Smartly ecosystem to the INVADE platform is implemented as an event based solution. Any new event at the customer site will generate data to the INVADE platform. The INVADE platform provides AI based on the input/data from the existing ecosystem and ads value by creating a control plan for optimization within the 3 services mentioned.

2.3 Value capture

How far has the pilot brought added value the way you originally described it:

Specificities: This pilot brings added value through the following special features:

The project DoA claims:

1. Having Europe's highest EV penetration and exploiting the pilot customer base in the Triangulum project, recruiting of EV end users is feasible.
2. Being one of Europe's first countries to introduce effect-based tariffs, this makes the V2H highly relevant with respect to economy and business models.
3. Demonstrating how the new INVADE-platform can integrate with existing

industrial smart ICT-platforms gives the project high industrial relevance, which will be demonstrated in the Stavanger-pilot.
4. Bringing in a strong end user perspective in the pilot will result in business plans applicable to market.
5. Using the same large-scale pilot area as Triangulum-project (SCC) will create synergies between projects.
6. Being one of Europe's most advanced energy companies with respect to applying new digital business models and services, these elements will be incorporated and thus further improved and differentiate this pilot.

Pilot experiences to this project claims

1. The recruitment has been easy because of the high EV penetration in Norway. As an example, we recruited 20 pilots within 30 minutes trough social media.
2. The V2H highly relevant with respect to economy and business models, but the lack of V2X equipment makes it difficult to fulfill this.
3. We have proven that the INVADE platform can be integrated to an existing platform. If the platform add value we still need to find out. If it adds value it will have high industrial value.
4. The pilot has already been important for our business and market needs for end users.
5. There is no direct connection between the two projects but they are complementary In terms of co2 emission and goals within the smart city context.
6. The existing business models and services at Lyse has improved the pilot. Especially in terms of product development and the service aspect.

2.4 Stakeholders

Stakeholders that have actually been involved:

- Lyse Elnett (DSO) responsible for the distribution network & grid, effect tariffs, large scale load shifting and customer management (via internal sub-provider).
- Lyse R&D & Innovation, responsible of Task T.10.3, + prototyping and business plan work, WP9.
- EV-vendor Schneider electric with V2H-functions
- End users
- Smartly AS, the local ecosystem
- Housing Associations
- Retail shop, Coop
- Eaton electric, Battery supplier
- Fronius, PV and battery supplier
- Installers, electricians
- Energy retailer

2.5 Policy implications

What is the current impact on policies compared to what you prognosticated?

Policy implication: This pilot will have a great impact on both national and European level, due to its strong focus on combining technology, digitalisation, end user focus, regulation and business models. It will be small in size, but comprehensive with respect to content.

No significant impact on the policies yet.

2.6 User acceptance

How have you measured end-user acceptance, approval or support? What are the results so far?

NTNU are still doing the survey's, so measurement has not been done yet. We have had meetings and have a good communication plan to inform the customers through the project period. Some pilots are very engaged and some are not.

2.7 KPIs

A set of KPIs was specified in deliverable D10.2. Explain how the pilot is meeting the performances/performance requirements that you specified at that time. You may also add new KPIs.

KPI´s will be explained/proved during testing period.

2.8 Project impacts

Underneath we have listed the anticipated project impacts listed in the DoA. Please refer to the description of each impact as specified in the DoA before you answer. Pay special attention to the part 2.2 Measures to maximise impact.

Impact specified in DoA	What pilot results contribute to this impact
Relevant, compatible with the broad EU energy policy context such as Climate-Energy packages, Energy Union	Norway need to adapt a more efficient way of using and distribute electricity to meet the future needs within electrification of the society to reduce co2 emission. The pilot shows how the customers can contribute in to this.
Ongoing policy developments in the field of the design of the internal electricity market, of the	The pilot has very high relevance to the design of EU's internal energy market and discussions on self-

retail market, ongoing discussions on self-consumption	consumption. The focus on end users and flexibility services addresses this topic. The pilot will prove the customer value of the new business models in a customer centric energy system.
Enhanced interconnections between Member States and/or between energy networks	The DSO`s in Norway do not trade in a flexibility market yet. There will most likely be a local flexibility market (upstream services) as the transformation to electricity in the transport sector goes faster than the development of the local grid and capacity. Optimization of grid capacity on a local level will most likely have an impact on the interconnections.
The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way	Better utilization of energy consumption at the household level by using batteries or other equipment with storage capabilities and controllable loads gives the end customers the possibility to use all own PV production as efficient as possible. This enables renewable production at the household level increasing in a stable and secure way without destabilizing the power network.
EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project	Some of the services developed in the project already has relevance in the energy market when it comes to the downstream part of the business model created in the pilot.
The demonstrated solutions have the potential to be scaled (if needed) and replicated	Yes! The standardized API and onboarding of new customers is already in place. This means that the Lyse pilot in Stavanger can scale up with new customers at any time.
Competitive demand response schemes for the benefit of the grid and the consumers *Validated contributions for improved, stability and flexibility in the distribution grid, avoid congestion; enabling near real-time pan European energy balancing market*	As mentioned earlier there is not a flexibility market in Norway which include the end customers at the household level to affect the distribution grid. But if the customer base was big enough they could represent a virtual powerplant to improve stability and flexibility in the distribution grid. The invade business

	models are two-sided or multisided which enables this scenario.
Emergence of new services provided by storage systems to the distribution grid and the consumers/prosumers at affordable costs, deferral of investments in grid reinforcement	The effect-based tariff that is tested in the pilot will demonstrate that even out consumption by cutting peak-power at multiple households will have an impact on the investment in grid reinforcement. The new regulation and terms for network rent in the Norwegian market will be implemented during the next two years. The whole idea behind the new network tariff is to give customers in private household's incentives to reduce the peak-power to get a lower energy bill.
Conversion of excess electricity, avoid curtailment, provide services to the grid	The Lyse pilot focus on optimize utilization of self-produced energy.
Creation of synergies with transport users (e.g. services to the grid with smart charging) / support the decarbonisation of transport	in progress, lack of available equipment and development within V2X since the project started.
Current regulations, standards and interoperability issues, regulatory environment for privacy and data protection	This is solved throug a standard templateregistration to »Data og Teletilsynet« in the beginning of the project. This is a mandatory registration in Norway.

2.9 The future

General reflections on the future and what you anticipate of further achievements before the termination of the project.

New functionalities or developments may be required according to the user requirements and integration with INVADE platform.

3 The Netherlands

3.1 Achievements and results per M26

Achievements and results according to the DoA

Goals of the project according to the DoA:

1. Design a flexibility management system that supports the distribution grid and electricity market while coping with grid limitations, uncertainty and variability with high penetration of renewable energy, electric vehicles and an increased number of diverse smart grid actors.

Our solutions and result

GreenFlux setup a smart charging system for supporting the grid via managing demand for energy of Electric Vehicles (EV). The grid capacity and limits depend on the available energy, which can vary because of renewable energy and other actors. In the NL pilot, GreenFlux defines profiles for the electric vehicle, via communication with the central INVADE cloud system. This system receives the available energy from the grid via special developed open protocol OSCP and combines that with the received need for electric vehicles. Based on that information, improved profiles are sent back to GreenFlux who is the charge point operator and uses these new profiles for the charge management. This way grid overload is prevented and availability of renewable energy or the lack of it is combined in the charge profiles.

2. Develop a model for batteries including EVs focusing on prediction of batteries lifetime and impact factors contributing to life extension, and prepare a model for optimal sizing, positioning and scheduling of batteries in the distribution grid

Our solutions and result

Elaad used the batteries at the offices for managing the load for its pilot. Information and model from VTT was used to find the right batteries based on the profiles, availability and cost of the batteries and the office needs. The results of the battery usage are used to improve the models VTT made.

<u>Domain 2 – Office Building / EV Test Site including Stationary Battery (and V2G)</u>

On april 18th, 2018 Secretary of State Van Veldhoven officially opened the test site of Elaad in Arnhem. This test site is located in business park Arnhems Buiten (former KEMA site) and contains all types of charging stations that are used in the public area in the Netherlands, a fast charger, a charging island, two charging lanterns, solar panels and urban windmills. All this equipment is made available to the INVADE project.

Figure 1. Office building

As part of the Invade project some additional hardware was installed. As part of the Invade project, the site is equipped with meters so that unique tests and research can be carried out. Also, a stationary battery was installed. Originally some V2G stations are foreseen, but due to the immaturity of this technology we experienced difficulty in obtaining these and foresaw a big delay in the project . Preventing delay was one of the reasons why it was decided to install a stationary battery, in order to be able to already test Device-to-Grid functionality. We are currently using our knowledge on vehicle behavior to simulate the arrival of V2G ready cars at the site with the stationary battery.

Figure 2. Stationary Battery

At the time of writing this deliverable, Elaad is still looking for options to purchase and install the V2G (DC) charger we ordered several months ago and which was supposed to have been delivered. All equipment together form a completely smart energy system that can all be centrally controlled via a computer system.

All this hardware is required to do the tests defined for the Invade project. But it also lays the basis for testing after INVADE. The Elaad Test Lab is a unique laboratory with a test site for research on and testing of Smart Charging, Power Quality and Interoperability.

See also:

https://www.elaad.nl/news/secretary-of-state-van-veldhoven-opens-test-lab-for-research-on-charging-of-electric-cars/

https://www.youtube.com/watch?v=vB3l6i3eQ0c

3. Deliver the Integrated INVADE Platform based on Flexibility Cloud enabling flexible management algorithms, functions and monitoring and control dashboards using Internet of Energy Things, Big data analytics and visualisation techniques to provide real-time information and control tools to stakeholders applying data protection and cyber security principles by design

Our solution and result

The NL pilot is using the Flexibility Cloud which is made by eSmart for improving the charge profiles. Elaad as grid owner and public charge point operator is sending the data this INVADE platform and gets energy profiles returned for managing their charge stations. GreenFlux is sending the charge needs via basic profiles to this INVADE platform and receives improved charge profiles from this INVADE platform that is used for managing the charging.

Tests with Smart Charging:

Instructing the electric car and infrastructure to charge faster or slower at certain times.

Testing Power Quality:

What effect does a charging electric car have on the quality of the electric current, the voltage and the stability of the electricity grid.

Interoperability:

Car manufacturers and battery manufacturers can test their products at the Elaad Test Lab on interoperability and compatibility.

4. Integrate the INVADE platform with existing infrastructure and systems in selected pilot sites in Bulgaria, Germany, Spain, Norway and the Netherlands and validate the platform through mobile, distributed, centralised and hybrid use cases in large scale demonstrations in accordance with national and European regulations and standards

Our solution and result

Hardware installed

Domain 3 - Public domain chargepoints

For the Invade project the existing charging network of EVnetNL is made available for smart charging tests. This charging network consists of 800 charge stations located across the Netherlands in about 200 municipalities. All charge stations have a 3X35A Grid connection. The charge stations are from a handful of different suppliers and all support OCPP1.6.

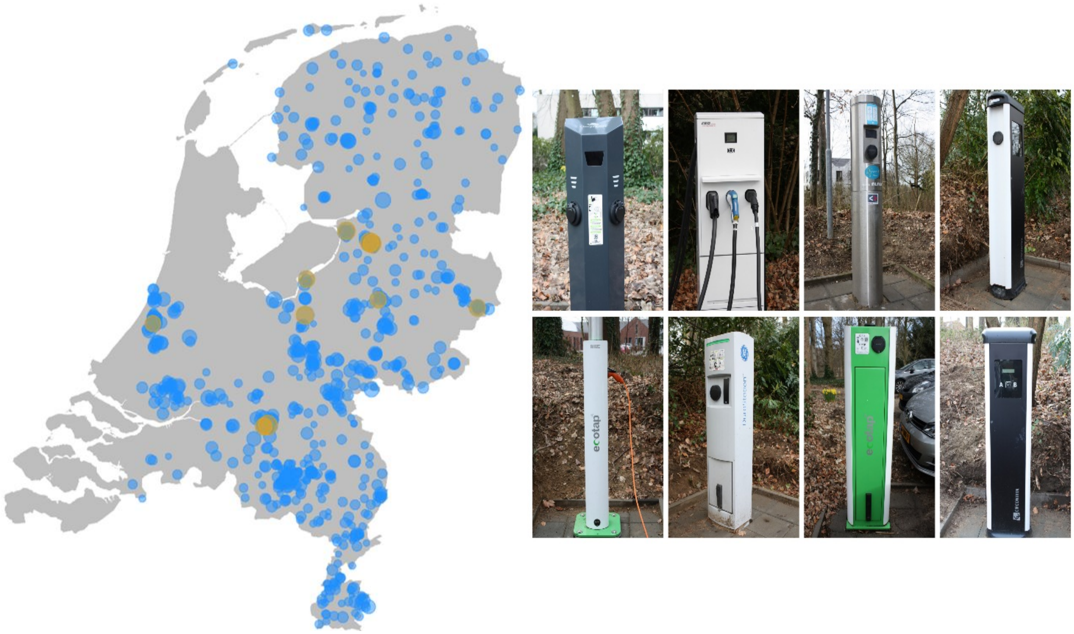

Figure 3.EV chargers

For the Dutch pilot sites, there are existing operating systems from Elaad and GreenFlux.

Pictures below show how the INVADE platform is integrated with existing platforms for the Dutch pilot and how this is working together:

High level architecture

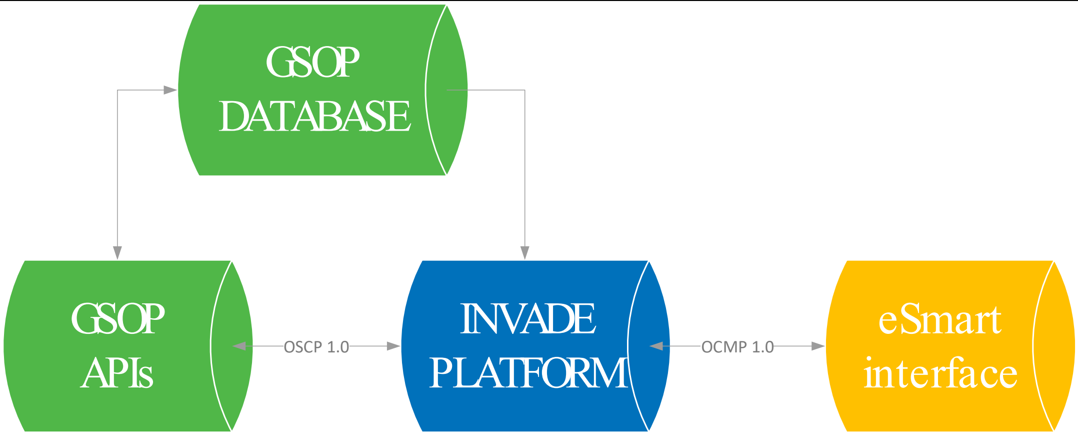

Figure 4.High level architecture

Message flows

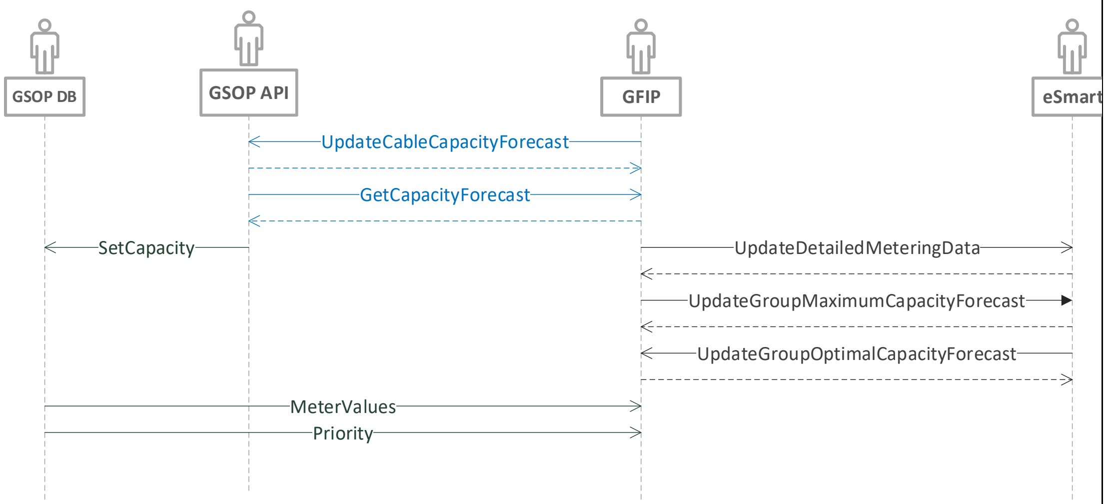

Figure 5.Message flows

The Dutch pilot takes into account all the national and international regulations, but also makes use of open standard protocols like OCPP and OSCP. The INVADE pilot also contributed to these protocols as an update of the OSCP protocol is developed under protocol name: OCMP. This should become the next OSCP version when the INVADE pilot tests prove the added value, which is currently being tested.

5. Design innovative and competitive business models and verify them through planned activities such as analysis of users practises and behaviour, deferral of grid investments, exploitation user group and dedicated workshops to enable monetary and social benefits for a full chain of stakeholders

Our solution and result

In a separate work package the business models are setup. This includes having users and other stakeholders involved. For the Dutch pilot this means that we prove that with smart charging and the same grid input, we can manage up to ten times more charge stations. Normally the charge process for EV drivers would be interrupted when there is a lack of current available on the grid because of less renewable energy. With INVADE we showed already that we can manage and balance this without disturbing the user. After the INVADE pilot this will become one of the business models used by GreenFlux and available also for other companies to use and learn from. Current experience and user interviews for INVADE show that they are very satisfied.

6. Engage with full chain stakeholders to support large scale deployment of INVADE within EEA and beyond and to build awareness of the project and its contribution to both climate change and energy efficiency targets

Our solution and result

The NL pilot involves many different stakeholders in the value chain, including DSOs, CPO's, Mobility Providers, property owners and EV drivers. Also regions (Province Brabant) is involved in the pilot. The INVADE research done by Elaad to investigate impact of batteries and V2G, together with large amount of chargers involved (800), the impact on the grid is measured and leveraged. The INVADE pilots from GreenFlux show already that we can install up to 80 charge stations in a parking lot with limited grid extension. The Dutch pilot shows that a huge amount of electric vehicles (app. 3000 vehicles use the stations that are part of the INVADE project) can be used. This will have direct impact on the climate goals set by COP21. First pilot results also show that the energy need is much more balanced than without.

Software developed

Major achievements and results for the Dutch pilot are realized in software development, incorporating all stakeholders. The following software building blocks are created:

1. DSO: Prediction of Electricity Grid Usage - on District level (System approach (2))
2. Optimizer: INVADE platform Energy management - on District level (System approach (2))
3. CPO: Controlling Charge Transactions – on Grid Connection level
4. IntegrationExchange of information between roles via standard protocol OCMP

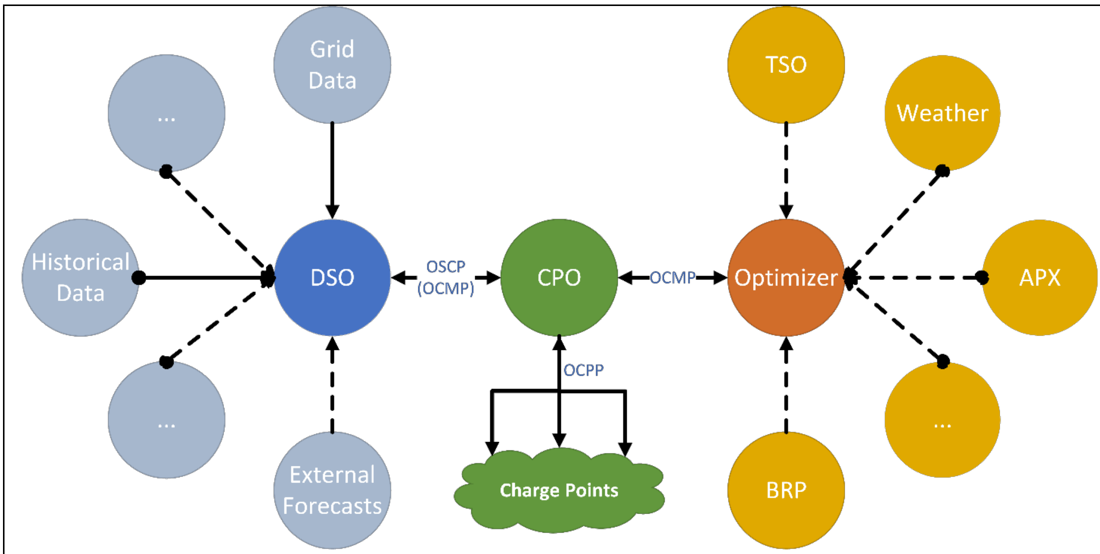

Figure 6.DSO prediction of electricity Grid usage

<u>DSO: Prediction of Electricity Grid Usage - on District level (System approach (2))</u>

Elaad is founded and funded by the Dutch DSO’s and represents them in the EV-domain. DSO’s manage the Low - and Mid Voltage Electricity Grid, also referred to as Distribution Grid. The distribution grid in the Netherlands (and Europe) is historically designed for peak demand. For the Low Voltage Grid, this has resulted in a situation where the sum of the total capacity of household connected to a substation is usually much higher than the capacity of that substation. Given the fact that households never use the available full capacity at the exact same time, this has proven itself as an effective means to restrain the costs for the Electricity Grid . However, with the coming of EVs, those household connections, and explicit EV charger connections, is expected to lead to congestion issues at a certain point in time.

It is the legal task of a DSO to maintain a stable electricity grid. The current/future situation, that is to be changed, is related to actual demand by connected users. Currently the grid connection is measured as a summarized effect of all devices behind the connection. For payment of energy consumed this is adequate, but for optimal flexibility management this is insufficient. There is an endless number of different devices that can consume energy behind a metered connection, but within the Invade project we have divided them into two simple categories:

1. Flexible load: Devices that can/could have a delayed function, like heating, cooling, washing. Theoretically these devices could be turned on a bit later or earlier without discomfort to the owner. Having control over these devices (within margins) could help in managing grid usage during peak moments.
2. Non-flexible load: devices that cannot be delayed, such as cooking, TV, light, etc. Influencing behavior of these type of devices would have immediate and unacceptable impact for the owner.

Having flexible load devices metered separately, knowing exactly how much of the total load from a connection is flexible and at what times, is a first step towards more detailed balancing capability that would have the least impact on the life of consumers.

Optimizer: INVADE platform Energy management - on District level (System approach (2))

Elaad is founded and funded by the Dutch DSO's and represents them in the EV-domain. By Dutch law, DSOs are not allowed to engage in commercial activities, such as energy management including generation, supply and balancing of electricity. For the nationwide transmission the TSO is responsible, by law.

As stated before, the legal task of a DSO to maintain a stable electricity grid which in the eMobillity industry translates to managing (peak) capacity. However, other stakeholders in the eMobility industry have other interests such as balancing demand/supply (BRP), maximizing use of renewable energy (Generator), frequency (TSO) and effective use of charging infrastructure (CPO). All these interests need to be aligned with the mobility need of the driver. In the Invade project we have defined an Optimizer role for this. Within the boundaries of the maximum available capacity in the electricity grid, the Optimizer can enhance this profile to take into account the other mentioned interests. The result of this enhancement results in a new Optimal capacity profile on a district level. The Invade Platform is the pivotal part of this value adding optimization.

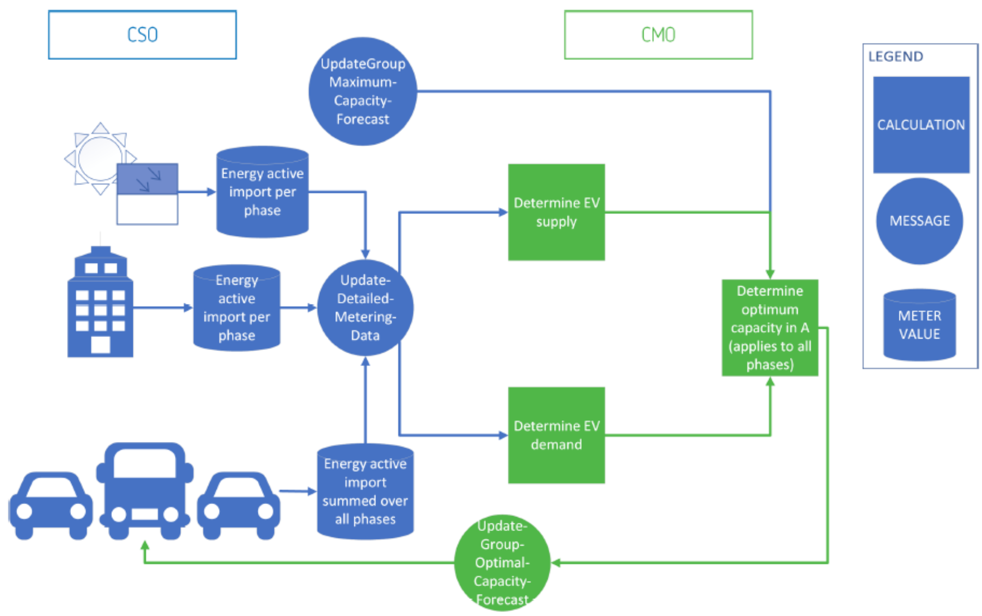

Figure 7.Invade platform Energy management

The Invade platform is the central part of the developed software and the integration with the other software building blocks is based on open protocols (see next section). The configuration and data flow of all software building blocks is operational. As the optimization algorithm is based on AI tooling, a period of machine learning is required, which is currently in progress. The actual predictions & optimization outcomes are expected in April 2019. These will translate to advanced control algorithm and is expected to start in June 2019. The demonstration itself is running since October 2018 based on the DSO optimization, to create a baseline reference. For more information on Invade Platform we refer to deliverable D8.4 (Cloud based flexibility management system) and D10.5 (Final Pilots Methodology).

CPO: Controlling Charge Transactions – on Grid Connection level

The outcome of the previous two software building blocks, is a multi-actor optimized district charging profile. This district charging profile needs to be transferred to charging profiles for individual charging sessions. This is the scope of the software building block described in this section.

For the Minimal Viable Product of this building block, we have defined an algorithm which takes the optimal capacity profile as a basis. At any point in time, the number of active charging sessions is extracted from the CPMS. If the charging speed of all active charging sessions exceeds the optimal capacity, all sessions will be limited. We use a minimum threshold of 13A, to limit the user impact. Whenever a session stops or a new session starts, the calculation is repeated.

In the remainder of the project we will enhance the algorithm, taking into account calculated user needs. As we have historic data of the anonymous RFID and the location it is used, we can make an prediction of the charging time. If the prediction is considered accurate, we will include the expected energy need and finish time, to optimize the charging transactions.

With the implementation of the MVP algorithm, we encountered that delivering charging profiles in near-time to real-world charging stations through existing systems introduces challenges beyond the correct determination of available grid capacity. One example is the increased message volume to and from the remote charging stations. Since these charging stations are connected over GPRS data connections, data transmission speed and latency is a real factor. In practice, when sending hundreds of charging profiles at once, the charge point management system (CPMS) must be able to cope with these rates, even when dealing with unreliable and variable response times from the charging stations.

Originally, the charging stations were to be given exact set points for charging speed and time intervals. These were updated whenever the number of running sessions in the pool changed, or whenever a new grid capacity limit was introduced. For example, if 99 sessions were running in pool A, and a new vehicle arrived and started charging, all 100 running sessions would get an updated charging profile that distributed the available current equally among them. During peak hours, this situation could occur many times per minute, resulting in hundreds of charging profiles being set every minute.

In our case, the existing interface on the CPMS for applying charging profile was only ever designed to handle 10 in-flight messages at a time. This required the messages to be queued before being sent to the CPMS.

This required a three-step solution:

- Reduce the charging speed resolution (rounding the ampere value to the nearest integer) to increase the odds that the previously set value would still be valid. In many cases, the one extra vehicle added to the pool did nothing to the other charging vehicles, negating the need to set new charging profiles for them;
- Introduce a queuing mechanism before sending out the profiles, ensuring that no more than 10 charging profiles are in-flight at any given time, so as not to overload the CPMS. This did result in charging profiles arriving many minutes after they are generated;
- Reserving a safe amount of current in case the charging stations could not be reached in time to reduce their charging rates.

Further measures for optimizing message delivery in rate-constrained settings could be:

- Recording the response times of the individual charging stations, and prioritizing the charging stations that respond the fastest (which would hold up the queue the least);
- Introduce an express-lane for large changes in charging current over small corrections; these messages could be pushed to the front of the queue and get priority service.
- Introducing a mechanism for replacing charging profiles that are waiting in the queue. If, for instance, a profile for charging station A is generated at 11:00:00 with a limit value of 14A, and an updated charging profile with limit value 13A is generated at 11:02:00 while the earlier profile is still queued, the new profile should replace the old profile before being sent out;

Mostly, this rate constraint was related to the original system design and updating that system to a more capable implementation was outside the scope of the INVADE project. The lessons learned from this, however, might be applicable in many real-world cases where the delivery of messages is constrained by existing systems.

3.2 Specific pilot objectives

In the DoA it´s specified the following for Dutch pilot:

Context, players (use case 1 Mobile)

GreenFlux and Elaad strive to accommodate as much renewable energy in the energy system as possible. We would like to explore the possibilities of matching demand to sustainable generation. The possibilities to explore consist of G2V possibilities and V2x possibilities (x = home or building of grid).

We also would like to explore the possibilities of G2V DC and G2V AC and make a fundamental comparison between them, proven in practical implementations. In these comparisons, we will include technical developments, market structuring and impact on EV-drivers. The Dutch pilot will cover three domains and two different approaches to charging electric vehicles on renewable energy.

Domain 1

A charge point at home in own driveway or carport. Usually there is only one charge point and the available maximum power for charging is low.

If there is renewable energy available, it is almost always from roof solar panels. The charge point is connected to the grid connection of the house

Domain 2

A group of charge points at an office building, a shopping centre, a football stadium, etc. The charge points are all connected to the same network connection and often have to divide the available capacity to prevent overloading this connection. The charge points are sometimes publicly accessible but not 24/7. Local renewable energy production can come from solar panels, but also from windmills or other sources

Domain 3

A charge point in the public domain. The charge point has its own connection to the electricity grid and its own energy contract. It is completely interoperable (everybody can charge there) and it is available 24/7. Connection to renewable energy sources is via the energy contract, this might be reflected in dynamic energy prices.

The NL pilots focus on use case 1 (PUC-1): Mobile energy storage using EVs for V2G, V2B and V2H operations.

The pilot focuses on the impact of electric vehicle charging on the electricity network and the possibility to use as much as possible renewable energy, meanwhile keeping the energy grid in balance. This will be done as much as possible with the use of standard or de-facto standard protocols between systems. The pilot is split in several categories or sub-pilots in order to do unique trials, experiments and create learnings on small scale as well as involving large amount of charge stations and users (EV drivers) to make impact on large scale.

No grid currently in existence is really prepared for immediate full-scale adoption of EVs. Grids are either not suitable for total extra capacity needed or cannot handle the peak loads of a working population coming home in the evening and starting to charge all at once. Dealing with these (peak) capacity issues in the traditional way, simply just adding more copper in the ground nation-wide, will cost our society at least tens of billions of euros. The EV is a demand side challenge, but there is also a supply side challenge for the grid that is becoming ever more apparent. Using sun and wind energy is very environmentally conscious, but this creates supply peaks at moments where there may not be demand peaks. This is a serious challenge for a grid operator (DSO). Instead of looking at these two trends as two separate problems, each could just be the solution to the problem the other presents. By exploring the possibilities of matching EV demand to sustainable generation, looking at EV not just as a car but as a storage solution as well, we can solve part of the supply-demand issues by using both G2V (grid to vehicle, charging a car) and V2G (Vehicle to grid, EV as power source to the grid). The exploration of the technical possibilities, market structures and EV driver participation all coincide in a technical & market development that is generally called Smart Charging, although Local Smart Charging might be more accurate as we try to match locally generated energy as much as possible with local demand, to reduce the impact on the grid.

There are several ways DSO can influence demand on the grid:

1. **Load shifting**, means we reduce charging speeds at one point in time to reduce the maximum peak load, and charge more off-peak. Since most EVs are parked for much longer than time actual spent charging, this can be done (mostly) without and hinderance to the EV driver.
2. **Load curtailment**, means the DSO requests contractor energy consumers to reduce their energy demands for a certain period of time.
3. **Load shedding**, when other options fail or aren't quick enough, the DSO can choose to shutdown certain grid connections to protect the rest of the grid. The is usually a last resort.

Besides these demand influencing approaches there are also three supply approaches to balance the grid:

1. **Production capacity**, if demand is greater than production, but the grid isn't used to its full capacity production can be increased. Different power plant types have different start-up times so it is important to foresee needs properly, to choose the right production source on time.
2. **Energy storage**, large batteries in local grids can store energy and solve local peak demands
3. **Device to grid (D2G / V2G)**, similar to the previous option, the energy stored in EV batteries could be used to solve local grid issues. This technology is not mature and wide spread yet, but the general consensus is that it has enormous potential.

In this document we will refer to INVADE use case 1 (PUC-1): Mobile energy storage using EVs for V2G, V2B and V2H operations as Smart Charging and is about finding the balance between above options of influencing supply and demand to protect the grid. Preferably through load shifting and local storage solutions.

Pilot HOME

Domain 1 focuses on charge points at home in the own driveway or carport. In the HOME pilot, these charge points are, at this moment, 25 charge points connected to the INVADE database.

For all these charge points, the following data is collected:

- Available grid connection per individual charge point
- Energy consumption
- Max capacity of the charge point
- Renewable energy production (40% of households have Solar PV production)

Based on this data, the optimal capacity is calculated and communicated using OCMP to charge point to optimize the overall energy consumption profile.

Practical solution

Metering of separate charge points is available for the Charge Point Operator. However, at this moment these measurements are not made available to DSOs. Reason for this is that DSOs are tied to a very strict regulatory framework that does offer room for experiments in this area but offers limited possibilities to create structural solutions. And in addition to that there are also very strict privacy laws limiting the usage and combination of data for new purposes. At the moment, DSO lack information to create a bottom-up picture of energy consumption in the grid.

Given the situation described above, within the INVADE project we have chosen to reverse-engineer a normal neighbourhood consumption from substation, available grid data, estimation of non-flexible load, EV car and driver information publicly available.

First, we have decided to use postal codes as a way of defining an area. There is a lot of information available on postal code level about population build up, types of houses, industry, etc. One postal code in itself is still too small an area to be really representative and well-balanced. So, we have chosen two districts of postal codes that we already have experience with (and have data on) in the cities of Arnhem and Ede. We have mapped these districts to the actual distribution grid.

Households – non-flexible loads

Based on the information we have on the postal codes, we extracted information on the number of households per district. We combined these households with standard profiles for energy consumption to estimate the non-flexible load for the district. The following graph shows how the energy is consumed over a year, based on hourly measurements.

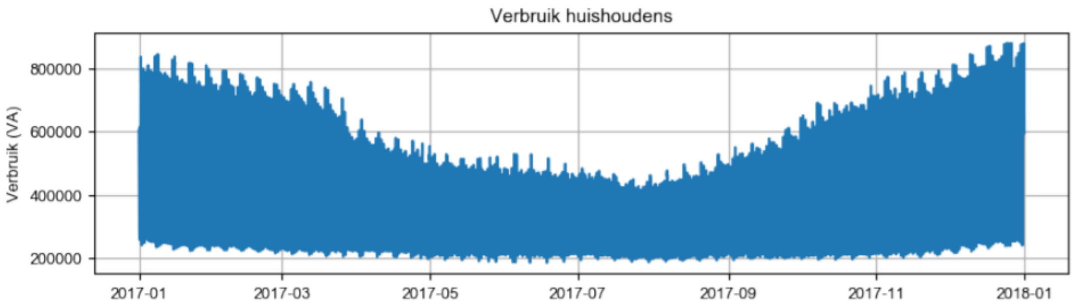

Figure 8. Households Nn flexible loads energy

If we zoom in to look at an average week, the energy consumption graph looks like this:

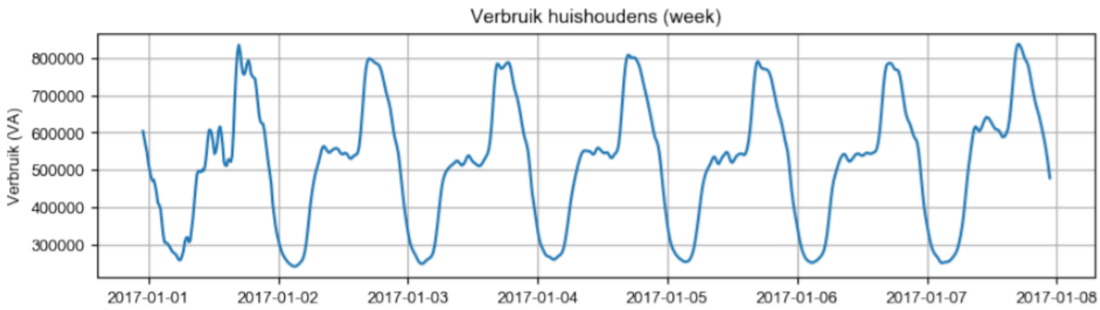

*Figure 9.*Electrification of mobility per district

According to the Central Bureau for Statistics (CBS), 71,3% of the households in our postal codes own a car. Given the fact that the sale of new non-electric vehicles will be banned in the Netherlands by 2030, and because we are investigating what the impact of large scale EV usage would be, we will assume for this pilot that all cars in our neighbourhoods have switched to EV.

Naam	verbruik	aantal	percentage	totaal
Tesla Model S	0,191	9661	0,330	0,063
Nissan Leaf	0,158	3351	0,114	0,018
Renault Zoe	0,148	2993	0,102	0,015
Tesla Model X	0,224	2706	0,092	0,021
BMW I3	0,163	2449	0,083	0,014
Volkswagen Golf	0,160	2422	0,082	0,013
Hyundai IONIQ	0,144	1765	0,060	0,009
Opel Ampera	0,168	759	0,025	0,004
Overig	0,176	3104	0,106	0,019
Totaal	| 29210	1	0,176	

We multiplied the number of cars with the average usage of cars per day. In total in the Netherlands we drive an average of 13.269 kilometres per year per car, or 36,35 kilometres per car per day. To translate range into electricity demand, we noted that, like with combustion vehicles, not every EV is equally efficient in turning electricity into mileage. We've used information from ev-database.nl to look up the most used cars and their effectiveness. Taking into account the various models and market shares, the average EV-kilometre will cost about 0,176 kWh. Finally, we made a correction for the fact that the effective energy need is higher since charging a car is not 100% efficient. In the best case, an on-board charging unit in the car has an efficiency of 0.9. That means the actual energy demand is higher.

Required Charging infrastructure

To supply the energy required, to the number of cars required, we made a mapping with the actual chargers of the EVnetNL network. To prove scalability, we matched over 680 charging stations of our nationwide public charging network for this test, equalling close to 1.000 charging points. With this mapping, in the Invade project we "virtual move" actual charging behaviour of our nationwide charging network to two districts.

Example HOME PILOT:

In order to visualize the use case, a detailed example has been worked out. For this example, one of the charge points observed in the HOME pilot has been analyzed in order to establish a baseline. This example use case is representative for the average charge point in that it has a maximum charging capacity of 11 kW (16A) and there is PV production on site. In this case, smart charging was applied, although without the use of the optimal capacity.

In Figure 10 the grid loads are shown over a day. This includes the household consumption (excluding the charge point), PV production and EV charging loads (for convenience, PV production is shown as a negative load). From this example can be seen that the moment when the EV is plugged in for charging coincides with the afternoon household consumption peaks.

When these grid loads are combined into one figure, the net grid load can be calculated. For this example, the net grid load was around 10 kW just before 19:00. From this figure, it is obvious that EV charging has a huge influence on the total energy consumption pattern. The peak load shifts from 2,5 kW without EV charging, to 10 kW with EV charging. For one charge point this is already significant, but this can potentially lead to big problems when 10 or more people in the same street plug in their EV at the same time.

This problem is avoided by charging based on optimal capacity. This optimal capacity is calculated and communicated by eSmart algorithms and takes into consideration not only the household consumption pattern, but (if available) also PV production data and current energy prices. In this example, the max charging capacity is simulated without using the actual algorithm that will be used during the pilot for exemplary purposes.

In the ‘old situation’, the EV charging session is started around 16:30 and is completed at 21:30. During this period, 20 kWh is charged into the EV battery. In the new situation, the optimal capacity is changed from the technical max capacity (11 kW) to the household consumption peak load (about 2,5 kW). In the new situation, the same amount of kWh’s is charged, but over a longer period. Figure 12shows the new (simulated) peak loads in this situation.

In this 'new’ situation, the peak load is lowered from 10 kW to 2,5 kW, but the car is still full in the morning. Of course, this example situation is a bit over simplified, because if the amount of required kWh’s had been higher than 20 kWh, lowering the charging capacity to 2,5 kW wouldn’t have been enough to fill the battery. In order to cater to these situations, we need to use the algorithm.

The situation in the office pilot is similar to this, but then using more than one charge point for the optimal capacity optimization. In the final results, both use cases will be reported in detail and using the eSmart algorithm and real EV charging data.

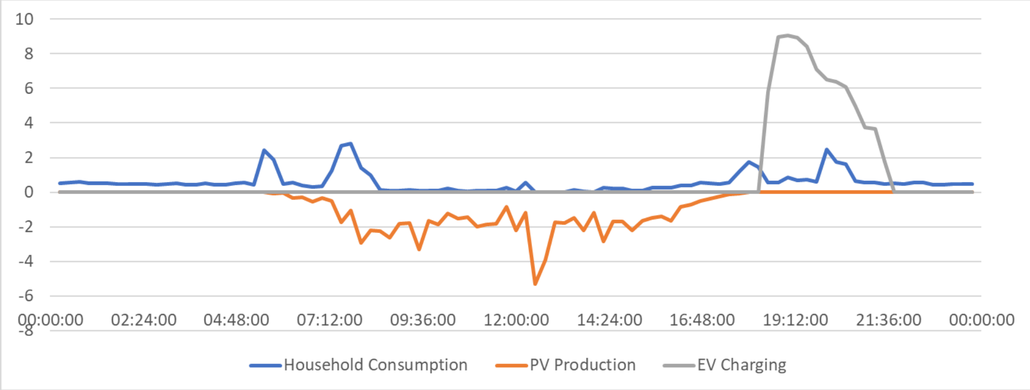

Figure 10.Example use case grid loads without optimal capacity

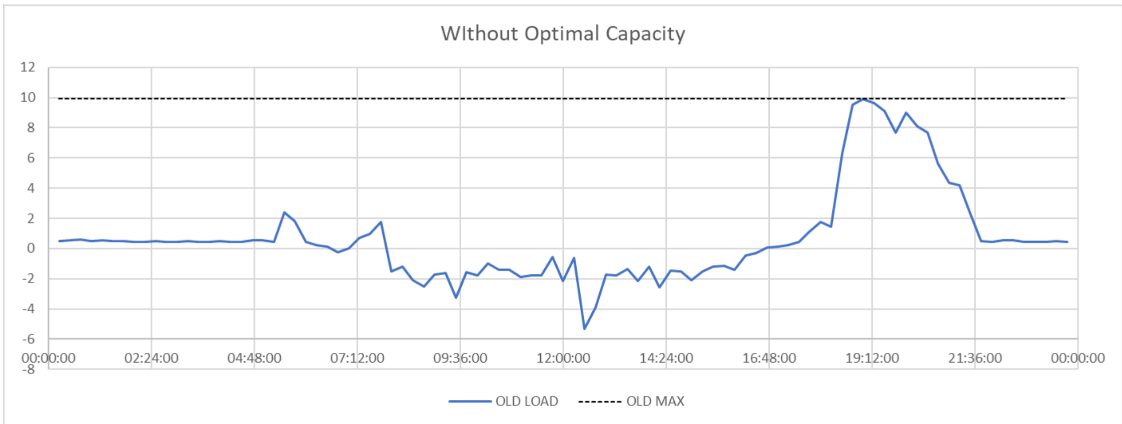

Figure 11.. Example case total grid load without optimal capacity

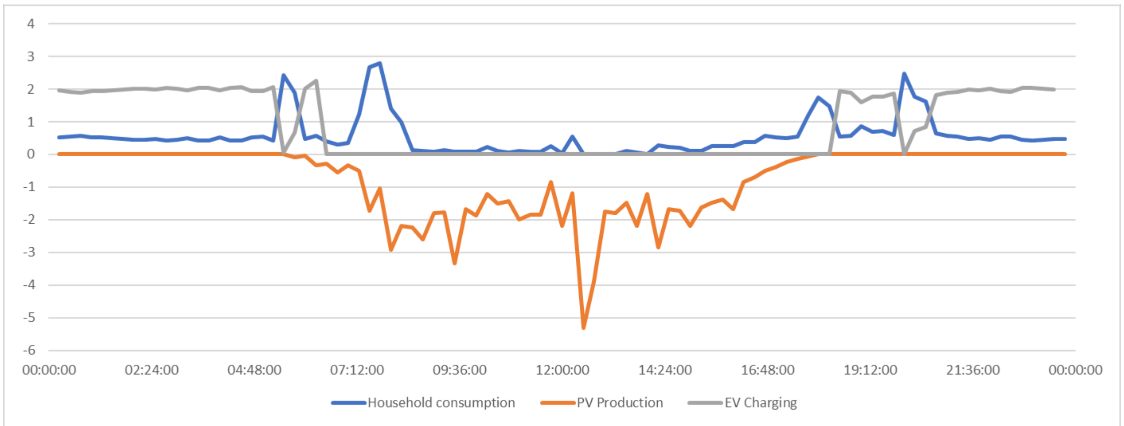

Figure 12.Example use case grid loads with optimal capacity

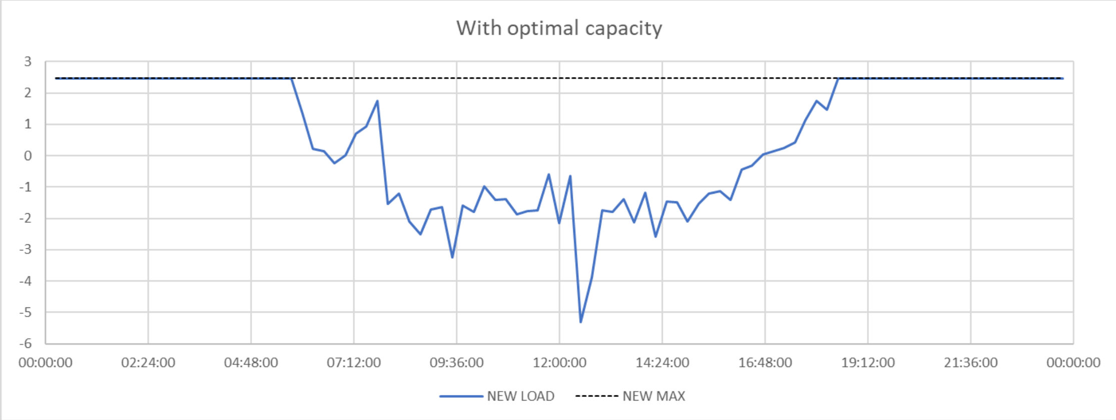

Figure 13.Example case total grid load with optimal capacity

Pilot OFFICE

Domain 2 focuses on charge points at office buildings.

Goal of pilot is to optimize sharing of capacity over charge points in the clusters

250 charge points connected over several charge clusters in different locations

- Available grid connection for all charge point clusters
- Energy consumption
- Max capacity of the charge point

Based on this data, the optimal capacity is calculated and communicated through OCMP to charge point to optimize overall energy consumption profile.

We used a similar approach as for the domestic pilot, but now plotted (different) chargers at an office neighborhood.

So far, data has been collected since the beginning of December 2018. At the moment no optimal capacity is sent to the charge points, so (smart) charging is performed based on max available capacity.

Domain 3 - Public domain charge points

As described, in the public domain we have bundled and virtual moved charging stations of the EVnetNL as if they were two future districts with many charging stations and electric cars. The actual use of electricity by the cars is adapted to the capacity on the local electricity grid. This can mean that at certain moments cars charge less quickly. This is done in such a way that EV drivers notice little or nothing of this. This is how we prepare for the future.

Location: Ede – Doesburgerbuurt

Household grid Connection: 490
Consumption: 3.14 GWh
Number of cars (1st): 349
Expected consumption EVs: 0.9 GWh
Number of (virtual) charge stations: 364

Location: Arnhem – Schuytgraaf-Noord

Household grid Connection: 305
Consumption: 1.16 GWh
Number of cars (1st): 217
Expected consumption EVs: 0.5 GWh
Number of (virtual) charge stations: 322

Figure 14.Location charge points

In order to gain experience for the future, it is very important to do experiments here now. So that at the moment when it is necessary, we know what works and what does not work. That is why this test is done as if nearly 1.000 public charging points of EVnetNL are located in two neighborhoods, one in Ede and one in Arnhem. With this we take a look into the future where many electric cars and charging stations will be located in a neighborhood.

It was decided to do this in such a way that EV drivers do not notice this to anything. We can also demonstrate that the concept works with minimal adjustments to the load. For public charging stations it is already common that when charging two cars at the same time on a charging station, the charging speed of both cars is slightly reduced. Within the INVADE project we use exactly this space.

3.3 Value capture

<u>*How far has the pilot brought added value the way it was originally described?*</u>

Specificities: This pilot will be the first comparison between Grid to Vehicle and Vehicle to Grid. It will provide the first professional and, more importantly, the first scalable solutions for driving on renewable energy and it will be the first European realisation of smart charging using only open and standardised communication protocols.

Vehicle to Grid

Although the technology behind smart charging is already widely used, the same does not hold true for the technology behind Vehicle to Grid: bi-directional charging. The bi-directional charging station is not yet available on a significant scale, either. The topic has attracted major interest, but development has been much slower than anticipated at the time of writing the INVADE proposal.

Smart Charging describes a system in which electric vehicles provide the demand response service to allow for throttling of charging rate during a charging session. With Vehicle-to-X (V2X) reverse power flow is also accounted for. The combination thus allows for smart bi-direction power transfer between an Electric Vehicle (EV) and the power grid.

Vehicle to Grid is actually a collective term for a range of applications in which the electric vehicle's battery is used to buffer electricity. Options include 'Vehicle to Home', 'Vehicle to Office', and the actual 'Vehicle to Grid'. Each application has its own value proposition.

Vehicle-to-Home or Vehicle-to-Building are in essence similar use cases. In both cases the objective is load balancing the buildings demand and charging the EV when the building has a surplus in electricity from solar or urban wind, therefore storing excess renewable energy for later use. It also has the potential to relieve the buildings connection to the power grid, allowing for smaller and thus cheaper connection.

Vehicle-to-Grid is another possible use case. Electricity networks are operated to ensure security of energy supply, to ensure that all consumers can purchase energy at affordable prices and to foster competitiveness. Vehicle-to-Grid can become an instrument for grid operation, in particular congestion management and over time maybe also restoration. As Vehicle-to-Grid will connect to the electricity grid on the Low Voltage level, the first perspective taken into account must be the local grid operation (executed by the DSO).

Traditionally, the utilization of passenger cars is very low, since parked about 95% of the time. This can potentially be increased for EVs by providing demand response services to the grid or to buildings. The type of EV used for V2G could be either a Battery Electric Vehicles (BEV) or a Plug-in Hybrids (PHEV).

Several studies have shown that EVs are suitable for V2X purposes, however there remain barriers that have to be account for such as standardization of communication protocols, the role of battery, business case. More pilot projects are therefore required to further examine the technology and bring it to the next Technological Readiness Level.

AC vs. DC

National electrical distribution grids are traditionally transporting Alternating Current (AC), while a EVs battery or fuel-cell requires Direct Current (DC). Therefore, DC to AC conversion is required when a vehicle is delivering electrical power to the grid with V2G. This conversion can take place in either the vehicle or the charging point. If the cable connecting the EV to the charging point transports electrical energy with DC, the technology is named DC V2G. The conversion then takes place at the charging point. When the connecting cable transport electrical energy through AC, it is called AC V2G, and an on-board bi-directional converter is required for the vehicle.

Both these technologies have their respective advantages and disadvantages:

- For DC V2G no additional on-board hardware is required in the vehicle, but these charging stations are currently larger and more expensive than for AC V2G. This can be explained by the fact that DC chargers are currently mainly developed for fast charging use.
- Via the ChaDeMo protocol a first building block for communication of DC V2G is available, for AC V2G no communication protocols are yet available.
- There are currently hardly any charge points available that support (controlled) DC or AC V2X charging. The number of AC chargers far exceeds the number of DC chargers (as these are mainly used for fast charging only)

Maturity of Technology

Both technologies are still in its infant phase, being developed and tested in different pilot projects. Nearly all V2X pilots that are currently running are DC based, since there are momentarily no AC V2G vehicles commercially available. And also DC V2G vehicles are only very limited available on the market. In practice, only 3 cars are actually used in demonstrations around the world: Nissan Leaf (BEV), Nissan EV200 (van) and the Mitsubishi Outlander (PHEV).

V2X can be seen as the “next generation technology”. We have included this in the project to primarily test this technology as we perceive it as very valuable for the use “the day after tomorrow”. We believe V2G technology is very promising as it makes the next step possible in storage of sustainable produced electricity (sun and wind) during the day for use later that day or week. Especially an office environment is now perceived as interesting.

As explained however, both cars and charging stations are hardly available, and if so at very high costs (which is always the case with next generation technology in the beginning). Various vehicle manufacturers are currently in the process of developing EV’s with V2X, but various boundaries still exist. At the moment DC V2G is the dominating technology over AC V2X. For both however, there still lacks standardization in the communication chain. For DC the EV can communicate with the charging point following the ChaDeMo protocol, but communication with a central back office is currently only done with proprietary solutions or adapted standards.

Protocols

There are three relevant protocols between a charge point and an electric vehicle:

- Mode 3 communication is used by 99% of all vehicles charging on AC (actually probably 100%).
- ISO 15118 is a protocol that is 'superimposed' on Mode 3 (a high frequency modulation is added) and is suitable for AC-charging. ISO 15118 is not supported by most EVs and is not supported by most charge points. The ISO 15118 standard consists of 8 parts. Part 3 describes the details of V2G, however: this part is not yet written, it's blank and will be updated in a future release.
- ChaDeMo. Is a relatively small standard meant for DC charging.

Both mode 3 communication and the current version of the ISO 15118 protocol do not support V2G. ChaDeMo does support V2G. Therefore currently the only option for V2G pilots is a ChaDeMo charging point. However, this holds some drawbacks:

- Nearly all grid connections for EVs (>99%) are powered by AC.
- ChaDeMo chargers are relatively more expensive and also larger, since it is required to hold a AC-DC convertor inside. A standard wallbox for AC charging costs about €1k (including installation), while a ChaDeMo charger costs roughly €25k.
- There are only limited number cars that support ChaDeMo including the Nissan Leaf and the Mitsubishi outlander. Again, this is will suit for a small scale pilot, but is not yet suitable for large scale.

Recommendations on further developments

At the writing of the proposal of INVADE, it was expected V2G would take-off before 2019. In practice we see that developments of V2G have been much slower than anticipated. Looking at current status, the following topics should be addressed in order to bring V2G to the next level:

1. *Standardization on communication between all interfaces.*

   The advantage of open protocols is already proven by the worldwide implementation of the Open Charge Point Protocol (OCPP). Open standards will accelerate the further development of V2G technology. In OCPP 2.0 there is not yet support for V2G use cases. There is however data structure compliance with ISO 15118 edition 1.0 (which currently also doesn't support V2X) and ChaDeMo. Future versions of OCCP will include V2X uses cases based on both ISO 15118 edition 2.0 (which will support V2X) and ChaDeMo. In order to develop this successfully support from the industry is required. In the Invade project we will detail a RfC how V2F could be included into OCPP. We will file this RfC to the organisation managing OCPP, namely OCA.

2. *Uniform requirements from the Distribution system operators (DSO) for the power grid.*

   Though there are requirements for solar invertors, no specific technical requirements for V2X exist yet. In national grid codes, distribution systems are addressed as a general topic and have to deal with under/over voltage situations and anti-islanding functionality. However, current requirements are limited and should be extended or become more specific on ‘mobile’ distribution units.

3. *Pilot projects that prove the concept of the technology and congestion and balancing processes of the distribution grid*
4. *Regulatory and tax aspects.*

   In the Invade deliverable “D9.3 Report on legal policy implications” bottlenecks and possible solutions for Smart Charging of electric vehicles it is shown that the current tax and regulatory climate for smart charging and V2G is currently unfavourable. An example is the double tax which is paid in the case where the battery is charged, discharged and charged again. For both charging cycles within the same transaction, tax has to be paid for the used energy while the battery is at the same level as without discharging. This is something that has to be solved to ensure an open market for V2X.

Static Battery

As development of V2G has been much slower than anticipated at the time of writing the Invade proposal, Greenflux and Elaad added a static battery to the testing ground, to be able to test reverse power flows as if the battery were V2G cars charging and discharging.

The Elaad testing ground has been fitted with specialized Power Quality meters, which can measure and log events in the voltage and currents on several locations in the local grid. This way the influence of different devices and the ability of the storage device to handle those can be closely monitored. This is, at least in The Netherlands, an unique feature.

For the selection of a static battery as an alternative for the delayed V2G chargers and in addition to the actual V2G charger once it arrives, we considered the following requirements:

- We want to research in what way storage can best be used to locally (behind the DSO meter) balance the power requested and use a variable grid connection (connection at which the maximum allowed power can temporarily be lowered). Focus lays both on the technical and realisation level and the commercial value.

- We want to research how storage can best be used to balance the power when there are intermittent renewable energy sources in the local grid. Investigate the possibility to use storage devices to improve power quality in local grids. For instance; phase imbalance, voltage dips and surges, harmonic distortion.
- We need (De-)charging speed: 2C. To be able to quickly react to grid events with sufficient power, like voltage dips, and to reduce the effect high capacity users like, Fast Chargers have on the local grid, it is imperative to have enough power capacity. For this reason, the decision was made to request a 2C battery storage. This xC value represents the ratio between capacity and (de-)charging speed. This means the entire power in the battery can be fed into the grid in half an hour, or the battery can be fully charged in half an hour. Because the required storage capacity is 100 kWh (more over this in the next paragraph), this means the capacity of the energy convertors in the storage device needs to be 200 kW.
- Storage capacity: 100 kWh Elaad decided on a required storage capacity of 100 kWh. This fairy high amount of storage is required to allow Elaad to perform tests with combinations of multiple goals, like combining local balancing and energy market services. This way experiments can be run to investigate how different use cases can be run alongside each other and if there are certain optimum combinations.

We approached a handful of suppliers and spoke with them about the solutions they offered. From a price perspective most systems were comparable (prices per kWh). The service guarantees and delivery data of the system however seemed to be more challenging. Some potential suppliers were start-up companies who in practice had not yet delivered any system. In the end we choose for a supplier that has a track record, strong service organisation, relative short delivery time and competitive price.

3.4 Stakeholders

What stakeholders have actually been involved?

As it was remarked In DoA,

Stakeholders are

- E-mobility Service Providers
- CPOs
- Distribution Grid Operators (via Elaad all Dutch DSO's are represented in this pilot)
- EV-drivers
- Charge Point Manufacturers

The picture below shows the different stakeholders. The green ones are all involved in the Dutch pilot. They are explained below the following picture.

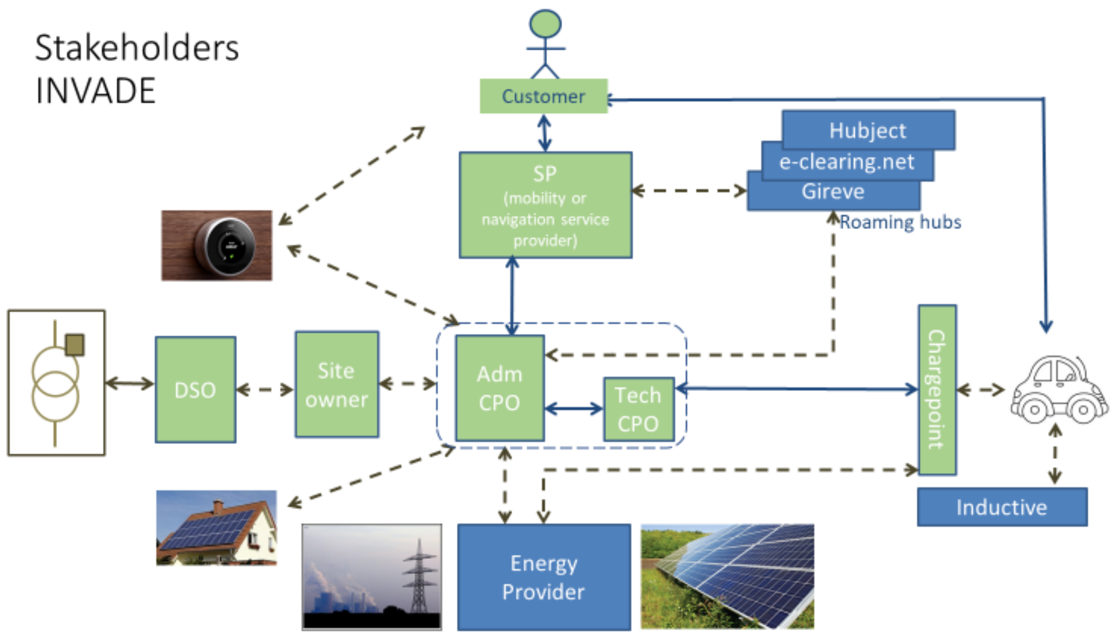

Figure 15.Involved stakeholder (green)

DSO

Elaad is a group of 11 DSO's and they are involved as main partner in the Dutch pilot. On individual bases the DSO Enexis is involved as one of the main DSO's in province Brabant where part of the pilot from GreenFlux is executed.

Site owner

Different site owners are involved: Elaad building owner where the office pilot takes place, the High-Tech Campus in Eindhoven and the Enexis as parking lot owner in Den

Bosch are involved. Not only the pilots take place on their premises, but also the energy amount they use for other purposes is taken into account for defining the charge and load profiles

CPO

GreenFlux and EVNetNl are involved as technical and administrative CPO. They manage the charge processes towards chargepoints and the transaction communication towards the Service Providers

Service Provider

GreenFlux is involved as service provider within the Dutch pilot, and via roaming several other connected service providers use the INVADE setup e.g. customers from New Motion and many other SPs.

Charge point manufacturer

The charge stations in the Duch pilot are equipped with smart charging controllers. Partially these are delivered by GreenFlux, but also Alfen is involved for delivering their smart chargers.

Customer

The EV driver is of course involved, as the Dutch pilot is all about managing the charge process of the EV drivers. Although the first results of the INVADE pilot show that without the EV driver noticing, the charge process can be influenced enough for balancing the grid and dealing with peak moments, while the impact for the driver is limited.

3.5 Policy implications

What is the current impact on policies compared to what you prognosticated?

The biggest overall barrier to energy storage in the current EU legislative landscape is that Europe does not have a common regulatory approach to energy storage. Since energy storage is not mentioned in the Electricity Directive, storage is often considered to be a generation system and therefore falls under the network codes for generation systems. From an EV perspective, it makes sense to consider storage as a fourth component of the energy system, after generation, transmission and distribution, with its characteristics, properties and services taken into account. A clear definition of energy storage should be included in the Electricity Directive, also taking into account electric mobility.

A direct consequence of the current situation is the unclear situation concerning ownership since, according to the unbundling principle, TSOs and DSOs cannot own or control generation systems. Even though grid operators have a clear interest in directly operating storage systems to balance the grid and having direct control over them would allow a safer and prompter balancing of the electricity grid.

The manufacturer of electric vehicle supplies the EV to e-driver and he determines whether EV is suitable for Smart charging. Like the approving of "conventional cars" is done by an independent organisation, the same would make sense for EVs. This because the car manufacturer has access to important data, such as the State of Charge and Time of departure. This is very important data for building a smart Charging profile. Therefore, this data should be unlocked, open and freely available for the e-driver.

It is currently unclear who determines that the battery of the electric car is used for Smart Charging, and, when the e-driver has connected his electric car to several initiatives, which initiative takes precedence. The roles and responsibilities of the various parties involved in providing flexibility by means of Smart Charging are still unclear. The CPO may be concerned with load balancing (control via the charge point) while the e-driver has given the supplier permission to use the car on TSOs reserve markets (control via the car). Furthermore, privacy/GDPR regulation limits exploitation of data in Smart Charging initiatives. This is a question of openness and communication in order to reduce distrust between customers on one side and vendors/authorities on the other.

Charge point connections can have different capacities, such as: 3 x 25, 3 x 35 or 3 x 63 amps. The higher the capacity of the connection, the faster a car can be charged, and the more flexibility is generated for the use of the car for Smart Charging. If charging is temporarily stopped, for example, the car can be charged on time by speeding up the charging (according to the e-driver’s wishes).

A high capacity connection is significantly more expensive than a lower capacity connection. One of the reasons for this is the difference in capacity that must be reserved on the grid in order to meet the peak load of the connection. The tariffs for the connection are determined by national administrative boards. Because of these higher costs, mostly low-capacity connections are installed in the (semi-)public domain.

The core task of the grid operator is the distribution of electricity to the consumer: they may not trade, generate or supply. Under current legislation (group prohibition and rules for congestion management from the Electricity Act and Grid Code), it is unclear whether they may purchase flexibility from third parties. The question is whether this is in line with the statutory duties of the grid operators. As a result, it is unclear whether they may deploy Smart Charging. Under current regulations, grid operators may only temporarily apply congestion management. They are obliged to eliminate situations of transmission scarcity as quickly as possible by investing in grid upgrades. Grid operators are not allowed to own batteries themselves, nor are they allowed to give compensation for offering flexibility in the Netherlands.

Another concern is the possibility of double grid fees being imposed on storage systems. Storage systems take electricity from the grid when they are charging and inject electricity into the grid when they discharge. However, since some member states impose taxation on both generation and consumption, storage system owners consequently have to pay double grid fees. This penalty can apply to all storage systems connected to the grid, including the batteries of electric and hybrid vehicles in vehicle-to-grid mode.

3.6 User acceptance

<u>How have you measured end-user acceptance, approval or support? What are the results so far?</u>

Consent EV driver

Given the importance of INVADE, Elaad has fully committed charging stations to participate in the pilot. This means that, in certain circumstances, the speed of charging sessions can be reduced to ensure grid stability. As Elaad is neither an e-mobility service provider, nor a charge point operator, this means that we have no direct relation with the EV driver. EVnetNL validates a user at a charging station directly with the e-mobility service providers, get a simple yes/no in return and start or refuse the charging session accordingly. Consequently, EV drivers participating do this without explicitly choosing to. Other projects work based on explicit consent, this is not the approach in this INVADE demonstration.

Impact on the EV driver

The actual impact on the EV driver experience is very limited. Most cars are connected to a charging station for much longer than just the time spent charging. Slight adjustments of the charging speed therefore go unnoticed in most cases. In cases where the effect can be noticed, because the EV driver leaves before charging is complete, the effect is always still within the boundaries the EV driver is familiar with. Dual socket charging stations are very common. They often have a grid connection that cannot support both sockets at full power so when the second charging starts, the first one is throttled a bit. Initially, the thresholds stay within the same boundaries of throttling, to minimize the actual impact on the EV driver experience. So, if a car was charging for instance at 15 Ampere, the session may be throttle to 12 Ampere (about 20 percent).

Privacy

For the regular business of exploiting charging infrastructure, there is no knowledge of the EV driver identity and no information is handled that could lead to his/her identity. Although this project may impact the charging speed, it has no other business impact. We don’t engage with the EV driver directly and do not collect additional information about any driver or car. Therefore, there are no additional privacy concerns to be addressed within this project.

3.7 KPIs

You specified a set of KPIs in D10.2. Explain how the pilot is meeting the performances/performance requirements that you specified at that time. You may also add new KPIs.

The D10.2 specified KPIs will be evaluated when enough metering data is available.

3.8 Project impacts

Underneath we have listed the anticipated project impacts listed in the DoA. Please refer to the description of each impact as specified in the DoA before you answer. Pay special attention to the part 2.2 Measures to maximize impact.

Impact specified in DoA	**What pilot results contribute to this impact**
Relevant, compatible with the broad EU energy policy context such as Climate-Energy packages, Energy Union	The first Dutch pilot results show that 'unpredictable' availability of renewable energy can perfectly be managed by smart charging electric vehicles. The vehicles us peak availability of energy by renewables by charging the vehicles at max power, while in periods of less available energy the Electric Vehicles, but also the battery storage at Elaad are used for a balance in the grid.
Ongoing policy developments in the field of the design of the internal electricity market, of the retail market, ongoing discussions on self-consumption	Elaad delivered policy analyses including proposals to improve and solve gaps. The Dutch pilot also shows that with usage of both storage and electric vehicles, on local and national level demand response of local renewable energy can be handled.
Enhanced interconnections between Member States and/or between energy networks	Result of the Dutch pilot is both an analyses of the available and to be used open protocols as well as upgrade of existing OSCP protocol. This supports both interconnection and competition on energy networks and between stakeholders.
The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way	Result of the Dutch pilot is an competitive ecosystem which can handle large amount of renewable energy by using storage and electric vehicles to manage and balance the grid. The Dutch pilot also shows that this is the best stable and secure way, as it is not dependent on a single source, but is using many (hundreds) of individual assets to deal with this – with large amount of electric

	vehicles using smart charging, you do not depend on a single vehicle.
EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project	Since the start of the Dutch pilot we prove that the setup of the architecture and systems are competitive and profitable. Although the continuation of the test must still prove the value of the INVADE cloud system, which depends on cost and usability.
The demonstrated solutions have the potential to be scaled (if needed) and replicated	The Dutch pilot is using already 800 public charge points, 250 semi public and 25 private chargers. And the components in the setup are all connected via open available protocols and interfaces. This way we prove the scalability and replicability, as the interfaces and setup is also available for other organizations outside our pilot.
Competitive demand response schemes for the benefit of the grid and the consumers *Validated contributions for improved, stability and flexibility in the distribution grid, avoid congestion; enabling near real-time pan European energy balancing market*	With the use of OCMP protocol, a competitive demand response scheme is used during the pilot for benefit both grid and EV drivers. Validation of the improved profiles and schemes are part of the current on going test of this pilot.
Emergence of new services provided by storage systems to the distribution grid and the consumers/prosumers at affordable costs, deferral of investments in grid reinforcement	The results of the Dutch pilot show that usage of storage and electric vehicles will reduce peaks and valleys on the grid. This will result in lower maintenance cost. The pilot also shows that without larger grid connections, more electric vehicles can be charged. This has a direct impact on the cost for site owners and EV drivers.
Conversion of excess electricity, avoid curtailment, provide services to the grid	The first Dutch pilot results show that excess of electricity can be stored in a battery and used for direct vehicle charging with max power. This way curtailment can be avoided, as long as there are enough electric vehicles available.
Creation of synergies with transport users (e.g. services to the grid with	The Dutch pilot result show that smart charging can contribute to manage the gird

smart charging) / support the decarbonisation of transport	in a better way. Also locally produced renewable energy can be consumed directly on the spot, which reduces load on the grid.
Current regulations, standards and interoperability issues, regulatory environment for privacy and data protection	As part of the Dutch activities, Elaad did research to current regulations and standards. Also an upgraded standard for grid management is developed to get a better connection to the INVADE cloud and for better profiles for charging and storage. Privacy is manage by making sure that no personal data is shared between stakeholders. The Dutch pilot proves that this data is also not needed for grid management.

3.9 The future

General reflections on the future and what you anticipate of further achievements before the termination of the project.

Both Elaad and GreenFlux are very excited to see if the INVADE cloud will indeed give added value for grid and charge management. A lot is already possible, but INVADE cloud should make much more detailed profiles and analysis. It will be interesting to see if this is indeed valuable.

GreenFlux and Elaad are also looking forward to the results of the V2G setup. So far the results for getting good installations where very disappointing and also the progress in the market on this topic is much slower. The Dutch pilot hopes to be able to do some good trials during before termination of the project.

4 Germany: Pilot in Freiburg

4.1 Achievements and results per M26

Achievements and results according to the DoA

Central Energy Storage

20th of February 2019 the innovative Redox-Flow-Battery was delivered on site. The days after the electrolyte was filled in slowly and under specified temperature conditions. Now the start up procedure is running, to reach full capacity and power as fast as possible. In parallel, the communication link to the grid control center of bnNETZE was established via an LTE-Modem. Operational values as well as warning messages are transmitted and displayed. A remote emergency stop function has been realized. The internal reaction procedures – depending on importance levels of different warnings – are established and the operation personal was trained.

Manufacturer of this Redox-Flow-Battery is Storion Energie GmbH, a start up company located near Freiburg, which was established in September 2018. This company is a joint venture of ITN Energy Systems (USA) and Knoll (Germany), which is a SME active in the field of special machines construction and battery solutions. badenova is the first customer of Storion Energie. The Battery is the only one of its kind in Germany. Extraordinary is the high power density of the built in stacks, which is much higher compared to other Redox-Flow-Batteries available from competitors.

The efficient cell stacks as well as the tanks came from ITN Energy Systems. All other components such as the insulated container, control cabinet, inverter and energy management system are locally produced and installed in Germany.

The redox-flow battery will be in full operation in the beginning of March. On the run, many details have been solved as e.g. grounding issues, metering, taxation issues for stored energy, regulation issues as well as design of the local voltage control algorithm including trigger values based on the analysis of measurement data dating from summer last year – a period of high temperature and solar energy production.

Distributed Energy Storage

All ten private households ("energy pioneers") are equipped with necessary communication and control hardware. Thus an important milestone is achieved. An additional energy pioneer outside the market area of badenova was contracted and connected. Two households own an electric vehicle and/or a plug-in hybrid. Charge control is enabled by installing a Mennekes Wallbox in both cases, which is compatible to the SMA system. SMA is the preferred hardware partner of badenova regarding home management systems and market leader in this field as well as in inverters. All household data is already visible on the SMA platform. The following figures shows the visualization of one energy pioneer.

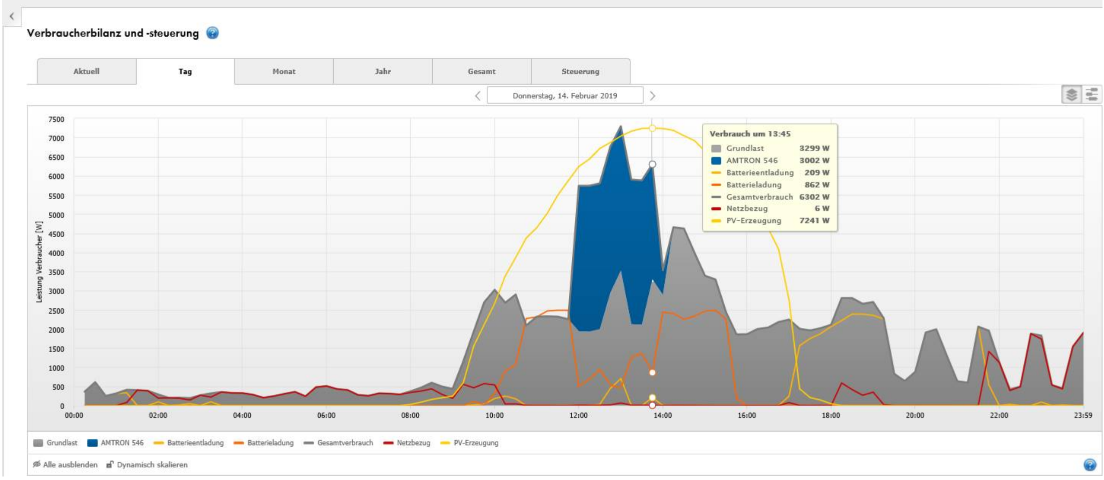

Figure 16.Energy Storage: Distributed

The communication link from the SMA API to the INVADE API has already been built and is under testing by badenova. The households are technically prepared to receive control signals. These control functions have already been tested by special test routines. Further efforts have to be done to ensure that useful control signals from INVADE are generated and translated into the SMA format.

4.2 Specific pilot objectives

In the DoA it´s specified the following:

Context, players (use case 4 Hybrid)

Overall in Germany there is a trend to intensify the utilization of energy storage technologies. In the past two years, for example, badenova has sold about 60 PV storages to private households, and there are already several hundred battery storage installations of private individuals in the entire supply area of bnNetze (the subsidiary of badenova responsible for electricity and gas networks). bnNetze itself is currently examining ways to improve the electricity network for higher utilization by renewable sources and electric vehicles and has also included battery storage in the considerations.

This is why badenova intends to examine three use cases in the INVADE project:

- UC-4.1: connection optimized control of private PV storages (less than 10 kWh)
- UC-4.2: the use of battery storages at end-feeders and weak points of the electricity network of the bnNetze (batteries with 10 kWh to 100 kWh capacity, whereby the storages can be operated by private or commercial customers or badenova itself)
- UC-4.3: the use of battery storage in a city district with a high density of PV and electromobility (batteries with 10 kWh to 500 kWh capacity).

Under the existing market conditions, these batteries could be connected and marketed as virtual power plants. However, this approach can even lead to additional network load if marketing does not take into account the capacity of the network. For this reason, algorithms should be developed and tested in INVADE that enable a balance between the interests of the market and the grids and that are at the same time economical or that could be economical due to adjustments of the regulatory/market framework. Within badenova's network area adequate facilities will be identified and connected, that are necessary for the successful pilot implementation and that allow to examine research questions of the INVADE project on the basis of the three use cases.

Explain how far you have achieved this and in what way. Specify how you have measured/gauged this.

Central Energy Storage

The redox-flow battery will be in full operation in the beginning of March. The battery is customized especially to the needs of the project INVADE and badenova. The communication interface to INVADE was programmed individually to send time series and receive control signals from INVADE platform. Further, the connection to the grid control center of bnNETZE has been established as a second path.

The CES provides 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 was achieved by successfully incorporating two separate value streams within one single battery. In addition to the autonomously working voltage control algorithm another business case is actively executed by the INVADE platform on request of the grid control center. 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 to the electrical grid of bnNETZE. The DSO can benefit from two different value streams which makes the investment of the battery more profitable.

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

Distributed Energy Storage

Eleven energy pioneers willing to actively shape the future of the energy industry were found for the project. The battery storages of these energy pioneers are controlled by the central INVADE platform as a superior management authority at certain times. The already installed home management systems take the role of a local energy management authority at the unit level and allows to be overruled by INVADE.

This sub pilot offers auxiliary services to the DSO as well. In addition to the prosumer self-balancing that already takes place, the use of the batteries is also offered to the DSO for peak shaving. A request from the DSO triggers the process to calculate an optimized schedule for the battery usage. After running the optimization algorithm a control signal is send back to the households to regulate the residual load at the grid connection point of each household (or several households). In return, the customer receives lower grid usage tariffs for acting grid-friendly, as he provides the DSO the possibility control the energy consumption of the household. The relevant energy data is visualized in dashboards and is available to the respective energy pioneer.

In general, small batteries on household level currently aim mostly only one value stream in Germany: minimizing energy consumption from the grid. INVADE enables the evaluation of the economic potential for the customer as well as the DSO on the basis of real cases. If both sides are beneficiaries, the business idea can be extended to much more households. Nowadays, already 1,000 systems are installed in the electricity grid area of bnNETZE. With numbers growing fast, the market potential is evident.

4.3 Value capture

How far has the pilot brought added value the way originally it was described

Specificities

The INVADE platform will integrate various assets such as renewable energy sources (wind energy, PV plants, biomass), batteries at both community and household levels, within the existing infrastructure and ICT tools at the pilot site.

The application of energy storages in private households creates direct experience relevant for the possibility of integrating storages in Germany. This promotes acceptance and proves the benefit of demand-response in private households. Increasing self-consumption ratios and reducing costs is an important goal for private households. There will be at least 10 private pilot households with individual battery capacity of 10 kWh engaged in the pilot site (use case UC-4.1). The number of pilot households can be increased if necessary.

Centralized energy storages in the distribution grid or big storages in neighbourhoods can have several advantages: (a) to intermediately store electricity from renewable sources, (b) to create grid stability, (c) to reduce grid maintenance costs and (d) to reduce the need for grid enhancements and investments. On the other hand, grid stabilization competes with the marketing of storage facilities in virtual power plants. Therefore, new products for grid operators and energy suppliers have to be developed. There will be 2 to 3 centralized energy storage units (10 - 500 kWh) capacity integrated in the INVADE platform (use cases UC-4.2 and UC-4.3).

Central Energy Storage

The CES does not use a common lithium-ion battery but a very innovative technology based on the so-called “redox-flow principle". Unlike lithium-ion batteries, it employs vanadium ions in different oxidation states to store chemical potential energy. This approach has many advantages:

- Vanadium is used to harden metals, e.g. in the automotive industry. So it’s a very common material with no limitations in availability
- The electrolyte contains only non-flammable containing substances, including more than 60% distilled water
- Vanadium is a byproduct in the manufactory of iron: the melting residue from titanomagnetite ores, which can further be processed to steel, contains up to 25% vanadium. The extraction of vanadium can be done without overexploitation of nature and the associated consequences for the ecosystem
- A redox-flow battery does not use any rare earths or other “conflict” materials such as manganese or cobalt
- The capacity loss over the years is negligible
- A redox-flow battery records a long cycle and calendar life and can be excellently recycled

Distributed Energy Storage

Today the costs for energy from a residual PV plant is about 20 ct/kWh lower than energy taken from the grid. The huge price difference represents one of the main reasons for the significant additions of residual PV systems in Germany partly combined with small PV storage systems to increase self-sufficiency rate. Households have a strong incentive to use as much as possible of the self-generated energy due to the significant lower price. In consequence the market for private PV storages developed rapidly over the last few years. As of today, more or less all new PV systems are sold in combination with a storage including a home management system to maximize self-sufficiency and to minimize expensive energy supply from the grid.

Yet, home management systems are lacking to keep an eye on the broader context such as the needs of the electrical grid. INVADE provides an additional value by taking over the role of the superior management authority on an upper level. This implies taking into consideration the needs of superordinate interests and creating additional revenues by implementing a new business model.

The superior business model which will be analyzed as soon as control signals are send is preventing peak loads in the bnNETZE grid from the perspective of the DSO. DSOs in Germany pay a grid usage fee to the upstream network operator for the maximum power at transfer points. Typically, load peaks in the grid occur in the morning, around noon or in the evening. When connected to the INVADE platform, DES can offer their flexibility potential to the DSO in order to avoid peaks in the grid. All test sites have established a setup where the DSO can use the flexibility potential of DES as a means of peak-shaving.

Added value for private households with DES:

- Monetary: financial surplus for the participating pilot customers
- Ecologically: relief for the electricity grid and thus more capacity for new renewable generation facilities

⇨ promote the energy revolution

4.4 Stakeholders

Stakeholders that have actually been involved:

Badenova itself is with its subsidiaries WärmePlus (largest producer of thermal energy in Freiburg), bnNetze (network operator) and badenova AG & Co. KG (vendor of energy and PV-/battery-/eMobility-installations heavily involved in the development of the future energy system in Freiburg). Currently, badenova runs projects via Klimapartner Oberrhein with Fraunhofer ISE (institute for Solar Energy Systems) and Fraunhofer IPM (institute for Physical Measurement Technology), that have a close link to INVADE (e.g. a Power-To-Gas-plant near the Freiburg trade fair).

For participation in the project the following additional stakeholders can contribute to the INVADE pilot:

- **Frey architects**, builders of the Green Tower, the largest skyscraper in Freiburg, that will be equipped with a PV façade, a greenhouse and a large-scale battery. Completion of the building is planned for 2019, and the connection of the battery to the INVADE system has already been confirmed. Further information can be found under http://www.freyarchitekten.com/projekte/smart-green-tower/
- **FWTM** ("Freiburg economy tourism and trade fair") is responsible for the marketing of the Green City and the content of Freiburg trade fairs and exhibitions. It builds a new building near the existing trade fair that is planned to be equipped with a larger battery storage. FWTM collaborates with badenova in the Green Industry Park initiative which tries to develop the Freiburg North Industrial area in a sustainable way. Additional information about FWTM-activities under http://fwtm.freiburg.de/pb/,Lde/451264.html
- Industrial companies like Pfizer (they operate in Freiburg according to their own evaluation the "most ecological location"), Micronas (micro sensors) and Trumpf/Hüttinger (DC/DC-converters, inverters, lasers), that are interested in the

INVADE platform to further improve their energy efficiency and to avoid network peaks.

As there are many operators of energy systems throughout the city, the platform provided in Freiburg should be open to a large number of users on a non-discriminatory basis. Badenova tries to implement the platform in close agreement with the city of Freiburg and its open city data platform. If successful, the INVADE platform could be used by badenova-subsidiaries Gemeindewerke Gundelfingen, Stadtwerke Kirchzarten, Stadtwerke Freudenstadt and Gemeindewerke Umkirch (each of them municipal utilities) and badenova- sister companies within the Germany-wide Thüga network (with nearly 100 municipal utilities).

The INVADE project helps to build up substantial know-how of battery storage technologies within the badenova group. This has multiple effects on sister companies in the group as well as on external partners.

The plus on know how is already used to develop several battery projects together with industrial companies as well as other municipalities:

- A battery project combined with a medium sized PV-system of about 30kW$_p$ as well as fast EV-charging points (>150 kW) is under development together with the largest BMW retailer in and around Freiburg.
- Another battery project combined with a large PV-system of 200kW$_p$ as well as with EV-charging points (11-22 kW) is under development with a b2b-wholesaler of electric parts.

Other stakeholders that are involved are as follows:

- Trumpf Hüttinger: The inverter used in the CES is supplied by the locally based company Trumpf Hüttinger
- Storion Energie GmbH: Storion is a spinoff of the R&D innovator, ITN Energy Systems. ITN's path to the creation of Storion involved:
    - More than $40 million in research and development through 20 years of innovation.
    - Fundamental power generation/storage research with various academic and government partners
    - Pioneering advances in stack design, electrolyte chemistry, and membrane technology

As soon as the Redox-Flow-Battery is fully operational guided tours will be offered using “Klimapartner Oberrhein”. This organization is a highly relevant combination of large companies, research institutes, leading executives from administration as well as politicians with an interest in climate protection.

4.5 Policy implications

Policy implication:

The INVADE badenova pilot project incorporates local and regional authorities and further stakeholders via Klimapartner Oberrhein, a network of the most important actors for climate protection in the region from science, economy and municipalities. The climate partners currently include around 110 members, including numerous cities and municipalities, in particular Freiburg. The network was initiated by badenova and promoted by badenova’s innovation funds. Further information can be found under: https://www.klimaschutz-oberrhein.de/

The project works as a sample project for the community and will be a further step to increase the ratio of locally produced energy. If successful, additional power installations (both from renewable sources and CHP) can be integrated into the INVADE platform. The project will show advantages and limits of the given regulatory framework to encourage policy in the adaption and further development of the framework of “Energy cells” or “Energy neighbourhoods” and to enable a higher amount of renewable energies in the network.

The INVADE project influences communities, regional politics and national legislation:

- In conjunction with a community near Freiburg an innovative project is under development to build up the first areal storage system in the South-western part of Germany. Several buildings consisting of a town hall, a kindergarten and an event hall shall be electrically connected and supplied with self-generated PV-energy from the roof. Together with a battery storage system the self-sufficiency rate shall be increased to at least 75%. The concept is sweetened by connecting the street lights of the main street to this system. This kind of energy usage is perfectly complementary to PV-production over day and so a perfect application for battery storage technology. An optimal utilization of the battery capacity can be guaranteed and lifecycle costs are reduced by adding many different kinds of usage. Last but not least the battery copes with the emergency energy supply of the area. Therefore the battery is dimensioned to have more energy capacity than required for optimizing self-sufficiency. It is the first project combining many different aspects and will mean a breakthrough in areal network supply based on renewable energies and battery storage technology
- The mentioned project is a blueprint for a large construction project in the city of Freiburg. At the moment a new city district (Dietenbach) is planned starting to be built in 2022/2023. The target is to build a climate neutral district for around 13.000 inhabitants. Strong contacts to the administration of the city of Freiburg have been established.
- Further strong input has been given to the German regulation authority, to prevent discrimination of battery storage usage compared to electric vehicles. The current legislation allows electric vehicles to benefit from significantly reduced grid usage fees, provided that they contribute to grid stability. Unfortunately, batteries were not explicitly mentioned in the regulatory

framework. It was possible to ensure that customers with controllable storage units can also benefit from reduced grid usage fees by directly contacting the German federal network agency (BNetzA). This can be seen as a first step in the right direction. Subsequently, the legislation must now be officially extended to battery storage systems.

4.6 User acceptance

How have you measured end-user acceptance, approval or support? What are the results so far?

User acceptance during the installation phase was ensured by personal customer service including customer visits, phone calls and e-mails. The PV battery systems are expected to receive first control signals by March. Regular operation depends on progress in other work packages within the INVADE project.

Three months after commissioning it is planned to survey all participating energy pioneers on their customer satisfaction. Questions regarding market research will be included into the survey and the results will be available until the end of the project. Alongside reporting to the EU on status quo, it is very important to inform the highly intrinsic motivated energy pioneers on the progress of the INVADE project and to understand their point of view. Beside personal updates, the energy pioneers will be invited to workshops, aiming to provide space for open discussion and knowledge exchange.

4.7 KPIs

You specified a set of KPIs in D10.2. Explain how the pilot is meeting the performances/performance requirements that you specified at that time. You may also add new KPIs.

DSO cost savings (KPI 1)

The DSO cost savings compared to other solutions have not been analysed yet. This is work to be done until the end of the project.

Additional DSO cost savings (KPI 2)

Cost savings regarding the peak power fees to the upstream network operator can only be analysed after sending control signals. So far, there is only an absolute value available for peak power fees to the upstream network operator.

Additional revenues for private households (KPI 3)

So far, only cost savings for private households have been identified.

If further incentives are given to the customer, the analysis will be extended to possible revenues that could be achieved on the customer side. If not, the KPI will be changed to "cost savings for private households" <u>Frequency of flexibility usage (KPI 4)</u> This KPI will be measured during the project's run-time. <u>Flexibility potential of DES (KPI 5)</u> The flexibility potential that distributed energy storage can offer in addition to the actual purpose of optimizing self-consumption will be examined with the available data. Testing has to be done hands-on during the operation phase.

4.8 Project impacts

<u>Underneath we have listed the anticipated project impacts listed in the DoA. Please refer to the description of each impact as specified in the DoA before you answer. Pay special attention to the part 2.2 Measures to maximize impact.</u>

Impact specified in DoA	**What pilot results contribute to this impact**
Relevant, compatible with the broad EU energy policy context such as Climate-Energy packages, Energy Union	The EU's renewable energy directive sets a binding target of 20% final energy consumption from RES by 2020. Core of some business models used by badenova is, to control centralized as well as decentralized storages in a grid friendly manner. This approach helps to integrate more renewable energies in electrical grids already operating on their maximum level. By offering more attractive PV and battery products, more customers will decide to be renewable energy prosumers.
Ongoing policy developments in the field of the design of the internal electricity market, of the retail market, ongoing discussions on self-consumption	During INVADE first contacts to the German regulation authority (BNetzA) have been established. The question was, if distributed storages operating in a grid friendly manner can be awarded with significantly lower grid usage tariffs. This regulation already exists for interruptible load and EVs but not explicitly for batteries. This problem could be solved with a positive result. The decision from the regulation authority to include batteries will help to operate distributed storages in a grid friendly way all over Germany.
Enhanced interconnections between Member States and/or between energy networks	Within the collaboration in the project badenova learned e.g. about the Norwegian electricity market. As soon as smart meters will be rolled out in Germany, many lessons learned can be transferred.

The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way	Controlling the central as well as the distributed batteries in a grid friendly way allows to integrate a higher share of renewable energies. By improving badenova's business model concerning PV battery systems, more sales will be generated. An increasing number of prosumers helps the EU to reach the 50% target.
EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project	Many efforts have been set in developing business models for selling and operating storage systems for private households as well as combined systems for commercial customers. Depending on some regulatory changes, which seem to be under way in the next 2 years, promising business models have been found.
The demonstrated solutions have the potential to be scaled (if needed) and replicated	The pilot site of the CES is testing multiple use cases within one battery on a local point in the grid. The local task is to provide ancillary services because the installed PV systems cause voltage issues. The second use case is to avoid peaks for the entire electrical grid. It is already planned to move the CES to other locations with more PV generation and more customers, only being connected over a weak line to the main grid. In such locations, the challenges of the electrical grid in the future are more evident than in the chosen location. If the pilot site turns out to be successful, the solution can be provided as a service to other DSOs. The connection of 10 households together with the market leader of inverters in Germany (SMA) is a good starting point, to develop business models and into the market in wide and effective range.
Competitive demand response schemes for the benefit of the grid and the consumers *Validated contributions for improved, stability and flexibility in the distribution grid, avoid congestion; enabling near real-time pan European energy balancing market*	Demand side response will become increasingly important for German utilities in the future. If prosumers integrate their flexibility into a superior scheme, they will receive attractive financial benefits while enhancing the stability of the energy system. Furthermore, smart meters will be tested. They are an additional prospective demand response enabler.
Emergence of new services provided by storage systems to the distribution grid and the consumers/prosumers at	Designing a new business model leads to new and affordable services to the costumer. Deferral of investments in grid reinforcement is a consequence of grid friendly components.

affordable costs, deferral of investments in grid reinforcement	
Conversion of excess electricity, avoid curtailment, provide services to the grid	Many private households are confronted with a 70% feed-in barrier of PV-systems. The inverter is restricted to feed-in only 70% of the peak power of the PV plant. A battery storage allows excess produced electricity to be stored for later use. Distributed and central batteries may be used for several services to the grid, for instance frequency regulation or voltage control.
Creation of synergies with transport users (e.g. services to the grid with smart charging) / support the decarbonisation of transport	The German pilot PV battery system is compatible to smart charging infrastructure. In fact, two energy pioneers will charge their vehicles controlled by the smart home management system. Using self-produced photovoltaic electricity is less expensive than consuming electricity directly from the grid and thus electric vehicles become more attractive for PV battery system owners which supports the decarbonisation of the transport sector.
Current regulations, standards and interoperability issues, regulatory environment for privacy and data protection	Further strong input has been given to adjust the German regulation authority. Through direct contact with the German federal network agency it was ensured that customers with controllable storage units can also benefit from controllable load regulation (paragraph 14a, EnWG).

4.9 The future

General reflections on the future and what you anticipate of further achievements before the termination of the project.

INVADE has a strong impact on developing the business case “battery” for home and commercial use within the badenova group. A large amount of know how could be built up. It is very common, that after termination of INVADE effective business cases have been developed which will be introduced creating significant revenues within only a few years.

INVADE enables the analysis of the economic potential for the customer as well as the DSO on the basis of hands on experience with at least ten distributed household batteries and one central battery. If all stakeholders are benefiting, the business idea can be scaled up and subsequently a higher number of batteries will offer an increasing flexibility potential to the DSO or other market parties. Nowadays, already 1,000 systems are installed in the electricity grid area of bnNETZE and within Germany around 100,000. A further task before

termination of the project will be to evaluate whether the business idea can be transferred to a large-scale business model, including sensitivity analysis of the relevant parameters like available storage capacity and development of electricity prices.

5 Bulgaria: Pilot in Albena

5.1 Achievements and results per M26

Achievements and results according to the DoA

Pilot site Bulgaria demonstrates Use Case 2 – benefits for the energy grid from centralized energy storage and controllable loads. In this regard Albena has acquired a battery storage system with capacity of 201 kWh and has made small upgrades to 2 hotels' boiler stations. In order to bring volatile energy production into the grid Albena has also installed a 27kWp PV system. The necessary infrastructure has been installed in M18 and M19 of the project. Immediately after the installation numbers of tests have been performed to ensure that the equipment is capable to carry out the pilot tasks. The PV system generates renewable electricity and feeds it in the hotel local grid. It is being consumed right on spot, so no energy is supplied into the middle voltage grid. The battery has performed according to various energy management approaches – local kWmax control, manual Charge and Discharge cycles, stick to a predefined load profile, act according to the day ahead market prices, etc. The control of the battery has been done in manually. In M24 Albena has started configuring the pilot in the IIP. The configuration is necessary in order to be defined the exact business models and roles: portfolio optimization on the energy markets, flexibility services for the BRP, self-balancing and optimization for the BRP, etc. After the configuration is successfully done, control signals from IIP are received, analyzed and distributed to the according controllers. For evaluation and further process improvement metering data is sent back to the IIP.

5.2 Specific pilot objectives

According to the DoA, the specifics objectives are:

Context, players (use case 2 Centralised)

Centralised electrical energy storage with capacity of 200kWh will be installed at a transformer substation 20kV/0,4kV site.

The transformer station supplies 2 hotels, restaurants, a spa centre, swimming pools, etc.

Furthermore, on the hotel rooftop a PV system of 100kWp will be installed in order to cover the daily peak electricity consumption. Full energy monitoring structure is already installed at the site. The hotel has its own 300m² solar thermal station installed.

How far have been achieved these objectives and in what way?

- Installation of the infrastructure: The necessary Infrastructure has been acquired and installed on time.
    - The battery is functioning as expected and can be controlled manually and automatically. The battery system consists of 3 modules with 67kWh storage capacity each, made by Samsung and manufactured by the German company TESVolt. There are 3 Inverters SunnyTriPowerStorage 60 STPS60 manufactured by the German company and world inverter technology leader SMA. The total storage capacity is 201 kWh.
    - The PV system has 27kWp installed power and is feeding energy in the low voltage grid of the hotel as expected.
    - 2 controllable loads – The boiler stations of a new and an old hotel are equipped with PLCs that can perform exact control of the demand.
- Set up of the local SCADA system: The SCADA system can receive control signals and distribute them to the participating infrastructure.

Set up of the communication of the controllable loads: They can receive external control signals.

5.3 Value capture

How far has the pilot brought added value:

- Increased share of renewable energy for self-consumption reducing energy costs for the owner, reducing CO2 emissions, and reducing grid costs for the local DSO
- A working model for utilizing the domestic potential of solar energy in tourist services by combining solar electrical and solar thermal power generation.
- Experience in modern energy management: fully functioning demand side management on consumer site will be available. This will lead to better exploitation of energy infrastructures and reduce power peak consumption. Better reliability of the grid as well as reduced voltage drop will decrease energy network losses.

The pilot has made significant progress since the beginning of the project. All 3 micro objectives have been accomplished:

- The share of renewable energy for self-consumption has been increased. The 27 kWp PV installation at hotel Flamingo Grand is the first step towards larger industrial PV parks in Albena. The fact that the station's connection point to the grid is far from the trade energy meters of the company presented a problem that was solved within INVADE. Now, larger PV projects are easier to achieve and thus to make further reductions of CO_2 emissions, energy costs and grid losses.
- The combination between PV power and solar thermal power is possible. The solar thermal power is stored in large buffer water tanks and the PV power is

stored in the battery for later use. Both energy types have single source – the sun but have different applications that are now easier to manage.

- Albena has achieved significant experience in the modern energy management. The possibility to make demand side management and to respond to various factors has prepared Albena to become an active partner on the local energy markets. The process was also facilitated by the vast development of the Independent Bulgarian Energy Exchange (IBEX) in November 2018 when the state decided that the electrical supply for the industry must traded on the market. Regarding the local grid, Albena is now able to manage loads in order to save from infrastructure upgrades.

5.4 Stakeholders

Stakeholders that have actually been involved:

Not only is the owner interested in the project pilot, but also other hotel owners. After the successful implementation of the project, the pilot model will be rolled-out to the other hotels in Albena. The model will also be presented to other tourist resorts as an example of energy and financial efficiency.

As part of the DoA Albena demonstrates the flexibility potential of battery and controllable loads at one of its hotels. The outcome of the project however seems to be so promising, that Albena decided to extend the scope of the project on 2 further hotels – Paradise Blue and Borjana. While the implementation in the newly built Paradise Blue Hotel was easy and comprehensible, the implementation in the in the old hotel Borjana has set a flag of efficiency because no large investments were necessary. With a controller unit and sensors Albena has managed to double the flexibility potential of the pilot. Further roll out is being prepared.

5.5 Policy implications

Policy implication: Country/European level policy actions.

The Bulgarian energy law doesn’t treat flexibility sources; thus, no impact was encountered.

5.6 User acceptance

How have you measured end-user acceptance, approval or support? What are the results so far?

In the case of Albena pilot there are two kinds of end-users: • The maintenance team of the grid accepts and approves the changes and overall the future energy grid. The benefits of flexibility are acknowledged. • The guests of Albena accept and approve the new energy management approach and show interest in the applied technologies. Our hotel managers have been trained to answer the questions that the guests ask them. Moreover, a special visualization dedicated to present the processes has been elaborated.

5.7 KPIs

You specified a set of KPIs in D10.2. Explain how the pilot is meeting the performances/performance requirements that you specified at that time. You may also add new KPIs.

The in D10.2 specified KPIs will be evaluated when enough metering data is available. Additionally, the pilot's profitability will also be analysed. Each control signal will be evaluated and its effect on the financial and technical results will be aggregated.

5.8 Project impacts

Underneath we have listed the anticipated project impacts listed in the DoA. Please refer to the description of each impact as specified in the DoA before you answer. Pay special attention to the part 2.2 Measures to maximize impact.

Impact specified in DoA	What pilot results contribute to this impact
Relevant, compatible with the broad EU energy policy context such as Climate-Energy packages, Energy Union	Minimize Co2 footprint in general, and reduced peak power impact to the grid.
Ongoing policy developments in the field of the design of the internal electricity market, of the retail market, ongoing discussions on self-consumption	This will be well explained in the final documentation of the test and validation process.
Enhanced interconnections between Member States and/or between energy networks	In Albena the ownership of the MV-grid inbetween the hotels are owned by Albena themselves. Therfore this interconnection is already a part of this pilot.
The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way	The created flexibility can contribute to the better utilization of RES. Curtailment of RES can be avoided.

EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project	The lowered energy costs contribute to the competitiveness of the touristic product.
The demonstrated solutions have the potential to be scaled (if needed) and replicated	Albena has demonstrated how easy can be the replicability of the project.
Competitive demand response schemes for the benefit of the grid and the consumers *Validated contributions for improved, stability and flexibility in the distribution grid, avoid congestion; enabling near real-time pan European energy balancing market*	Albena demonstrates those benefits by adjustment of the power flows in pre defines time intervals.
Emergence of new services provided by storage systems to the distribution grid and the consumers/prosumers at affordable costs, deferral of investments in grid reinforcement	Energy storages will be a part of the flexibility zone, as a service, and it will influence on the stability and maintaining the energy-supply of the selected 5-star hotels.
Conversion of excess electricity, avoid curtailment, provide services to the grid	Yes, all of them.
Creation of synergies with transport users (e.g. services to the grid with smart charging) / support the decarbonisation of transport	Albena is already using EV`s for transport between the airport and the hotels, and inbetween the hotels. In next step we will create a big parking-slot with PV-roofs to charge all EV`s with renewables.
Current regulations, standards and interoperability issues, regulatory environment for privacy and data protection	This issue is covered throug terms and conditions with all guests when booking/arriving Albena.

5.9 The future

General reflections on the future and what you anticipate of further achievements before the termination of the project.

Albena expects optimization of the energy costs on the energy markets before the termination of the project.

6 Spain: Pilot in Estabanell

6.1 Achievements and results per M26

Achievements and results according to the DoA

According with the DoA, "the INVADE project aims to deliver a Cloud-based flexibility management system integrated with EVs and batteries empowering energy storage at mobile, distributed and centralized levels to increase the share of renewables in the smart grid." Aligned with the overall objective of the project, the Spanish Pilot addresses use case 2, where a centralized energy storage system is installed at a secondary substation with the objective of providing flexibility to the DSO and BRP through the INVADE platform. The objectives of the INVADE project are addressed in the Spanish pilot by testing and validating the use of flexibility by the Spanish DSO (Estabanell); expecting that the findings provided by this use case will allow a better usage of the grid and therefore potentiate the increase of the share of renewables in the electric grid. At Estabanell, a 210 kWh battery was installed at a secondary substation inside the company's headquarters. This battery is connected to a power electronics device which controls the battery and allows the DSO to manage the grid at the pilot location. Estabanell has configured its pilot site at the INVADE platform and is now dealing with its integration; with the aim of communicating the flexibility needs of the DSO and BRP and receiving back the flexibility responses.

6.2 Specific pilot objectives

Specificed in DoA:

Context, players (use case 2 Centralised)

The pilot will take place in Granollers since there is a secondary substation which supplies the headquarters of the DSO and a number of private households. The DSO is an example of an entity with critical services needing electricity redundancy.

The issue here is that redundancy depends on the HV distribution and transmission network, meaning that in the event of a blackout impacting both, all services will be down. The current alternative is to have genset ready for use, which means storing fuel and an expensive investment, which are only used under extraordinary circumstances. This requires the genset to be up and running some hours a month, only for testing purposes. New back-up systems must be studied in order to be applied in the pilot area as storage batteries will change short-circuit values.

Explain how far you have achieved this and in what way. Specify how you have measured/gauged this.

In order to act as a backup service for the critical building, half of the capacity of the battery is reserved to supply the building in case of electric failure. For this scenario, a test will be carried out, where the scenario is simulated and the control centre room of the DSO is supplied by the battery for a period of 2 hours (which is, in principle, enough time for any electric failure at the HV distribution or transmission network to be resolved). To perform this test, the battery and power electronics device were installed onsite already and are being tested and connected between each other and with Estabanell's systems. Once the equipment is stable and the connections are done, the test will be carried out.

6.3 Value capture

How far has the pilot brought added value as it was originally described:

CO2 reduction, increased grid resilience without the need of further investments in networks, demand response activities and management of flexibility. The specificity of this Use case, is that one of the users of the battery system will be the head quarter of a DSO, including their control centre room, which makes this user a critical one, while using a secondary substation shared with other neighbours. While the rest of the users will be participating in demand response actions, for the critical user, the KPIs must take into consideration the endurance and resilience of the system, thanks to newly designed power electronics managed by the Integrated INVADE platform.

The value captured in the Spanish pilot can be described in several aspects. - In terms of CO2 reductions, the test addressing the controlled islanding scenario aims to validate the use of a battery as a backup system for a critical building such as the control center room of the DSO. By validating this scenario, the diesel generator can be avoided as well as all CO2 emissions associated with the test runs of the generator. - Respect to the increase on grid resilience, the two other scenarios addressed by the DSO (voltage control and congestion management) intend to demonstrate the ability of the battery and power electronics device to manage the voltage and make congestions' predictions and management. These flexibility services intend to allow a DSO to control its grid in eventualities of voltage/current fluctuations and therefore avoiding further investments. - Demand-response activities are not addressed in the Spanish pilot due to the impossibility of incorporating the municipality (stakeholder associated with this scenario) in the pilot activities. - The management of flexibility is a value captured within the Spanish pilot by using the Invade platform to manage the battery and provide flexibility services to the DSO and BRP.

6.4 Stakeholders

Stakeholders that have actually been involved:

In the Spanish pilot, the stakeholders involved are the DSO and the BRP.

6.5 Policy implications

Policy implication:

European level policy actions concerning the management of a DSO. The relevant regulation for distribution grid interaction is the EU directive 2009/28/CE on renewable energy promotion, the Royal Decree 1110/2007 on metering, ITC/3022/2007 Act remote control, ITC/3860/2007 Act on electric tariffs and Royal Decree 842/2002 LV installations.

Grid operators increasingly must collaborate with other actors in order to realize smart grid innovations. For routine maintenance, grid operators typically acquire technologies in one-off transactions, but the innovative nature of smart grid projects may require more collaborate relationships. This pilot studies how a transactional versus relational approach to governing smart grid innovation projects affects incentives for other actors to collaborate.

We would analyse two uses cases of smart grid innovation based on extensive archival data. We find that projects relying on governance are more likely to provide incentives for collaboration.

Especially non-financial incentives such as reputational benefits and shared intellectual property rights are more likely to be found in projects relying on relational governance.

Policy makers that wish to stimulate smart grid innovation projects should consider stimulating long-term relationships between grid operators and third parties, because such relationships are more likely to produce incentives for collaboration.

6.6 User acceptance

How have you measured end-user acceptance, approval or support? What are the results so far?

Within the Spanish pilot there is no interaction with end-users such as electricity customers or electric vehicle owners; therefore, this section is not applicable.

6.7 KPIs

You specified a set of KPIs in D10.2. Explain how the pilot is meeting the performances/performance requirements that you specified at that time. You may also add new KPIs.

KPI's defined in D10.2 can be analysed and quantified once the pilot is fully implemented and there is data that allows this quantification.

6.8 Project impacts

Underneath we have listed the anticipated project impacts listed in the DoA. Please refer to the description of each impact as specified in the DoA before you answer. Pay special attention to the part 2.2 Measures to maximise impact.

Impact specified in DoA	**What pilot results contribute to this impact**
Relevant, compatible with the broad EU energy policy context such as Climate-Energy packages, Energy Union	According to the WP: Modify the electricity markets by guaranteeing the participation of renewables (including critical building) and the entry of new agents, as well as allowing the storage of energy and the appearance of the figure of the aggregator of demand. Identify a capacity threshold will be created with dispatch priority. Replace the access priority of renewables by a non-discriminatory procedure of restrictions and redistribution. The application of these measures will support the development of the photovoltaic market in Europe, allow buildings to become active elements of the energy system, as well as improve the integration and enhancement of different renewable technologies in electricity markets.
Ongoing policy developments in the field of the design of the internal electricity market, of the retail market, ongoing discussions on self-consumption	The results observed from the BRP scenario can possibly contribute to understand the applicability of flexibility to potentiate self-balancing portfolio optimizations within BRPs or electric retailers.
Enhanced interconnections between Member States and/or between energy networks	Not applicable.

The EU power network will be capable of integrating large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way	The findings from testing voltage control and congestion management flexibility services in the distribution grid, potentiate a better control and predictability over the grid, contributing to its increase in share of renewables.
EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project	Testing an aggregation product such as the invade platform on a real operating environment contributes to its development and improvement, potentiating its competitiveness increase.
The demonstrated solutions have the potential to be scaled (if needed) and replicated	The functions tested at the pilot site have the potential to be replicated in further locations with similar characteristics. Once the concept is validated, it can be applied to other DSOs or BRPs with similar needs.
Competitive demand response schemes for the benefit of the grid and the consumers *Validated contributions for improved, stability and flexibility in the distribution grid, avoid congestion; enabling near real-time pan European energy balancing market*	Findings from congestion management, voltage control and self-balancing portfolio optimization expect to contribute to the improvement of these services in the electric system.
Emergence of new services provided by storage systems to the distribution grid and the consumers/prosumers at affordable costs, deferral of investments in grid reinforcement	Testing the controlled islanding scenario with a battery at a substation level of the distribution grid may contribute to the emergence of new services associated with backup services for critical buildings.
Conversion of excess electricity, avoid curtailment, provide services to the grid	Not relevant.
Creation of synergies with transport users (e.g. services to the grid with smart charging) / support the decarbonisation of transport	Not relevant.
Current regulations, standards and interoperability issues, regulatory environment for privacy and data protection	Findings from communication standards used in the pilot as well as interoperability between systems may contribute for the further development of these.

6.9 The future

General reflections on the future and what you anticipate of further achievements before the termination of the project.

Before the termination of the project we expect to have the integration with the Invade platform completed and therefore test its use within the DSO and BRP flexibility services.

7 Overall Conclusion

This document reflects the current status of the different pilots in INVADE compared to the claims and objectives specified in the contractual agreement. As each pilot is very distinct and addresses different use cases thery are not easlily compared. However, the descriptions given provides a fair overview of where the project stands with regard to its original ambitions. This document provides a good insight on what has been done and achieved in the various pilot areas, how various stakeholders have been engaged and what needs to be done during the remaining part of the project to come even closer to the ambitions defined for the project. Beyond all, this dopcument is a testimonial over different approaches and equipment needed to set up extensive test sites. The experiences documented carries signdificant value in itself for others going down similar avenues in the future. That in itself is an important achievement - bringing with it significant experience that can be capitalized on and shared in the future.