e-harbours
WP 3.5 Application of Smart Energy Networks
Technical and Economic Analysis
Summary results of showcase Zaanstad, case study REloadIT

Author: Municipality of Zaanstad

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

1.1 Introduction

The e-harbours report 3.7 focuses on the *organizational and legislative aspects* of smart energy solutions. A long list of general barriers has already been composed (deliverable 3.3).
The report 3.7 addresses the analysis on a local basis (country/city/harbour), where the smart energy solutions are hampered.

This e-harbours report 3.5 focuses on the *technical and economical aspects* of smart energy solutions. The scope of WP3.5 is the translation of the 6 universal business cases (e-harbours report WP3.4) on the level of every showcase. It gives an overview of the potential for the exploitation within the existing local (national) rules and regulations.

This document summarizes the results for the case study REloadIT at Zaanstad.

Universal business cases

The final document of WP3.4, "Strategies and Business Cases for Smart Energy Networks " [1], gives an overview of universal business cases for the exploitation of smart energy networks. Demand side flexibility is a term which is used for devices, installations and/or companies which are able to adapt the energy consumption to some extent without compromising their proper operation. Examples are installations which can shift non critical activities in the time or devices which can store energy for later use. The economical potential of the flexibility, offered by these devices, installations and/or companies is estimated in the WP3.4. WP3.4 summarizes the following cases:

1. Contract optimization: The present flexibility can be used in order to reduce the energy cost within the margins of the existing energy contract. Examples are shifting energy consumption to cheaper off-peak tariff hours or reduction of the peak power.

2. Trade on the wholesale market: Significant amounts of energy are traded on energy exchange markets. Due to the variable price on these energy markets, the presence of flexibility can be used for energy cost reduction.

3. Balancing group settlement: Balancing responsible parties (BRP's) are responsible for balancing electricity production and consumption in their portfolio. Flexible consumers can help a BRP in order to maintain the balance of his portfolio.

4. Offer reserve capacity: In case BRP's are not able to maintain the system balance, the transmission system operator (TSO) has reserve capacity in order to restore the balance. Customers can offer their flexibility directly to the TSO for balancing purposes of the total system control area.

5. Local system management: The local distribution grid has a limited capacity and some combinations of local power injection and consumption may result in congestion. Flexibility can be used to operate the local grid in an optimal way within its constraints.

6. Offer further grid stabilization services: Large scale producers and consumers can offer flexibility for reactive power balancing or preventing congestion of the transmission grid.

The scope of WP3.5 is the translation of the "theoretical" business cases of WP3.4 into realistic business cases in your context.

1.2 The strategy in showcases Zaanstad

The goal of this case study is to examine how to optimise the exploitation of renewable energy combined with electric mobility. Two strands of work have been defined:
1: The software development of the REloadIT smart grid application; a real demonstration project of a smart grid system.
2: An inventory to the different business cases the smart grid application could be based up on.

Furthermore several stakeholders were consulted: end-users and operation officers of the municipality of Zaanstad, suppliers of the charging infrastructure were involved during the development process and testing of the application. DSO and TSO's were consulted for the services they could offer for the development and exploitation of a smart grid.

The task of the development of the software and the analyses of the business cases was subcontracted to an external smart grid consultancy company EnergyGO.
This document focuses on the technical and economic issues for exploiting a smart grid system.
The software application has been described in appendix A.

1.3 Scope of the e-harbours showcases in Zaanstad

The main objectives to be addressed are:

- How to optimise the usage of renewable local energy to be consumed by the electric cars of Zaanstad.
- Develop and demonstrate the capability of the smart grid application under practical conditions: i.e. the reliability of the ICT-system and availability of electric cars, the user friendliness etc.
- Determine the available flexibility under different scenario's, and determine the economical value of the availability flexibility.
- Organise stakeholder meetings with key players.

Parallel to the development of the Smart Grid application, a "smart energy contract" was negotiated with an energy supplier.

Deliverables REloadIT:

- Software application REloadIT
- Business cases assessment report EnergyGO (Dutch)
- Minutes stakeholder meetings.

1.4 Optional: Extended/limited scope

- Parallel to the development of the Smart Grid application, a "smart energy contract" was negotiated with an energy supplier. Apart from incentives for energy reduction, the smart part of the contract was the introduction of local balancing of productions and consumption. Read more about the contract on: http://eharbours.eu/wp-content/uploads/Boekje-Energie-inkoop-congres-ENG-versie.pdf
- A local and major spin off at the Municipality of Zaanstad was the cooperation with different stakeholders on the development of a "smart and open energy system". This system aims to reuse residual industrial heat for housing, hospitals, swimming pools etc. The smart part of it is the connection of this city-heating system with 'green power to heat'. The basis idea is tot introduce balancing capacity/flexibility with the heating system. Read more about the contract on: http://eharbours.eu/uncategorized/cooperation-large-end-users-and-consumers-on-smart-grid-zaanstad
- A recently developed tool by our regional grid operator Alliander, called 'Sustainable Energy D-cision Tool', is used and tested to estimate the financial outcomes from different perspectives

(energy supplier / grid operator / prosumer). This is not further elaborated as part of the showcase.

2 Summary results

2.1 Case study REloadIT

2.1.1 Introduction

The municipality of Zaanstad aims to be climate neutral in 2020. Local renewable energy production, as well as clean mobility is stimulated. Within the REloadIT project a smart grid system has been developed tested to examine whether the benefits of renewable energy production can be matched with flexible energy consumption.
Subsequently, several business cases were analysed to see which business case is the most viable one. The parameter used to indicate the value of a smart grid application is:

Flexibility: that is the percentage of cost reduction of the energy bill, by exploiting the flexibility within a process. In the Zaanstad show case: the shift in time and intensity of the charging current of the batteries of the electrical vehicles.

2.1.2 Investigation summary.

Available information

- The power consumption profile of the car fleet being logged by the REloadIT data base.
- Load profile electric cars of the Netherlands based on European project GRID-4-Vehicles.
- Whether profiles of wind speed and solar radiation of the Netherlands.
- Report universal business cases Vito/HAW. http://eharbours.eu/wp-content/uploads/e-harbours_Strategies-and-Business-Cases-for-Smart-Energy-Networks_wp3_4.pdf

Preconditions analyses

- The electric cars are operational during all seasons, 24 hours a day.
- Base line scenario. For the determination of the amount of flexibility as defined by RGU for the benchmarking, the non-smart charging option for each scenario is used as the base line.
- Tariff structure applied for the simulations and analyses of the cases:
    - Standard tariff : 0,059 Euro/kWh
    - Peak or day tariff : 0,065 Euro/kWh
    - Off peak or night tariff : 0,049 Euro/kWh
    - Wind tariff : 0,06 Euro/kWh
    - Tax 1 : 0,11 Euro (usage <10000 kWh/year)
    - Tax 2 : 0,05 Euro (usage >10000 kWh/year)
    - Tax 3 : 0,01 Euro (usage >50000 kWh/year)
    - Fixed tariffs : 380 Euro discount on "tax 1" user, discount : 175 Euro "tax 2" user, per grid connection
    - PV - energy : "accumulating demand and supply (e.g. salderen)
    - Whole sale market : APX the Netherlands based on 2012 tariffs.
- For all scenario's we assume tax 2 as precondition.
- Battery specifications: Based on the theoretical assumptions, the total capacity of a battery is 100%. For the analyses we assume a battery charge/discharge cycle efficiency of 90%, lowest state of charge: 20%. Unlimited number of cycles allowed.

Predefined business models

For the REloadIT showcase we considered Contract optimization for the Zaanstad car fleet, as well as trading on the wholesale market. For a 1000 cars case study, we examined a BC with trading on the wholesale market. Balancing group settlement is not valid for the direct involved stakeholders of the project.
Due to the actual small scale of the REloadIT showcase the predefined options: *Offer reserve capacity* and *Offer further grid stabilization* are not suitable as business models now.

Business cases analysed

The investigated business cases are presented in table 1. Business case (4) is based on the fictitious rollout of 1000 charging stations upcoming years in the region at 35 municipalities.

Business case – name	Business case – description
0. EV (base case)	Charging 16 Electric Vehicles (EV)
1. EV + PV + salderen	Smart charging 16 EV with standard energy contract & production of solar energy with standard revenue (“*saldering*”)
2. EV + PV + demand shifting	Smart charging of 16 EV on locally produced solar energy with standard energy contract and standard revenue
3. EV + PV + demand shifting	Smart charging of 16 EV on locally produced solar energy, including smart cost management (day/night tariff, optimal contracted load capacity)
3. EV + PV + APX	Smart charging of 16 EV on locally produced solar energy, including smart cost management (APX)
4. 1000EV + PV + APX	Smart charging of 1000 EV on locally produced solar energy, including smart cost management (APX).

Table 1: Investigated scenario’s.

Results quantification of the flexibility

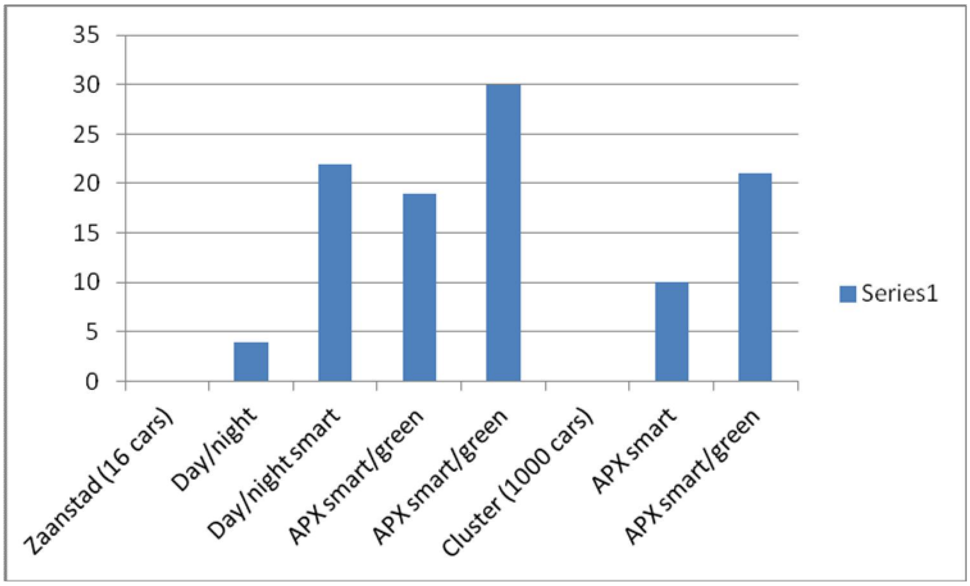

Figure 1: Percentage flexibility due to flexibility within the process of charging batteries.

3 Conclusions

- Electric cars seem to be the **ultimate source of flexibility** (15-30%). Although technical specifications of batteries may influence the economic viability caused by negative influence on the life cycle of the batteries, by charge- discharge algorithms.
- Financial gains are a main driver by **avoiding** taxes and networks costs.
- The present definition of private network avoids exploitation of renewable sources of energy other than on the local estate. Up scaling is thereby hampered.
- **Present tariff structure** hampers private customers to enter flexibility market. An only day/night tariff is available.

4 Lessons learned

4.1 Technical issues

Lessons learned

- Zaanstad specific:
  - Charge-only infrastructure is not fit for net balancing
  - Charging stations of the Zaanstad region not integrated in one ICT-entity
  - Possibilities depend highly on the generation or type of electric cars used for the show case i.e. the specification of the batteries used.
  - At the moment it is technically not possible to feed electricity into the grid. The actual charging station was not designed being able to be used for discharging batteries.
- Recommendations
  - Upscale test with more users and type of electric cars.

- Upscale test with more flexible energy consumers. For example, integration of water pumps, combined water and energy storage, and renewable energy systems (wind and solar).

4.2 Economic/organisational issues

Lessons learned

- Matching of flexible energy demand with variable (green) energy production has proven to be an economical value.
- Under present conditions a smart grid development still needs additional financial support.
- There is no way (yet) to benefit from the flexibility available in large scale e-mobility, because:
  - No clustered access to the flexibility market possible
  - The tariff structure is not supporting flexibility
  - Investments costs of a smart grid project are considerable.
- Up scaling is necessary to optimise the REloadIT application and its financial benefits.

4.3 Recommendations

- Practical : Start upscaling by exploiting the (huge) flexibility of large vehicles.
- Policy : Add an incentive on taxes and network operating costs

4.4 Ideas for further investigation

- Examine market models to have access to system balancing market.
- New innovative financial market models are needed to match energy demand with flexible renewable energy production.
- Think about mixed market option in order to benefit from different business cases.

5 References

- *Website of REloadIT: www.reloadit.nl*
- *Available presentations and brochures, refer to e-harbours website: http://eharbours.eu/showcases/showcase-zaanstad*
- *Report on business case study, EnergyGO*
- *Whether profiles of wind speed and solar radiation of the Netherlands.*
- *Report universal business cases Vito/HAW. http://eharbours.eu/wp-content/uploads/e-harbours_Strategies-and-Business-Cases-for-Smart-Energy-Networks_wp3_4.pdf*

Appendix A: Concepts REloadIT application

The REloadIT project has been launched at the 1th of March 2013. The usage of application is still under test. It comprises the test of the reservation system. The findings during these tests are fed back to the operator/administrator of the system. Final phase of the project was to evaluate whether REloadIT objectives have been met, and define recommendations to be instrumental to the sustainable mobility plan of the municipality. Major objective is to guarantee the optimum usage of the electric vehicles. The technical barriers encountered during these project phases, including the lessons learned, are described in paragraph 2.1.2.

Within the REloadIT, the following phases can be distinguished common to software development process : Specification phase, design phase, implementation, commissioning and testing phase.The specifications of the functional and the technical design of smart grid were defined by smart grid specialists from VITO in close corporation with the municipality of Zaanstad . This specification document has been used as basis for the tendering process. The REloadIT smart grid software application has been developed and deployed by a Dutch company EnergyGO.
Since March 2013 the municipality Zaanstad is testing their smart grid. This means that the energy demand to charge the batteries of the electric cars matches -as smart as possible- the variable electricity production of the solar energy systems. The smart grid algorithm is based on optimisation of the usage of the cars and weather forecasts, and the load management system (charger) of the smart grid. Based on rules that are calculated by the developed software application.

<u>The basic rules are:</u>

a. Maximize the use of the available renewable energy (three or four solar energy systems and an optional (virtual) wind turbine) to charge the electric cars. The surplus of renewable electricity is supplied to the municipality of Zaanstad through the distribution grid.
b. Guarantee that the state of charge of each electric car is sufficient for the next planned travel. By means of a car reservation system the usage of the electric cars is intelligently planned. Taken into account the calendar containing travel times, travel distance, and time the battery has to be fully charged. The aim is to prevent that at anytime, a driver is held up by an empty battery.
c. Charge the batteries as much as possible at low energy tariffs. A day ahead the data of the APX-price real time are imported. In the tests which are running during 2013 a limited set of cars is included. However for the various business cases calculations the information for all charging stations and electric vehicles is incorporated and extrapolated. The municipality has now 16 charging stations, the business cases will also encompass one scenario with a larger share of e-vehicles and charging stations (based on the aimed volumes of the Metropolitan Region Amsterdam).

To gain insight on the economical value of the match of charging electric vehicles and locally produced renewable energy, 4 business cases scenarios have been selected. Calculations have been carried out to determine the flexibility and to analyse the potential cost reduction for each scenario. The outcomes of these analyses are presented in paragraph 2.1.2.

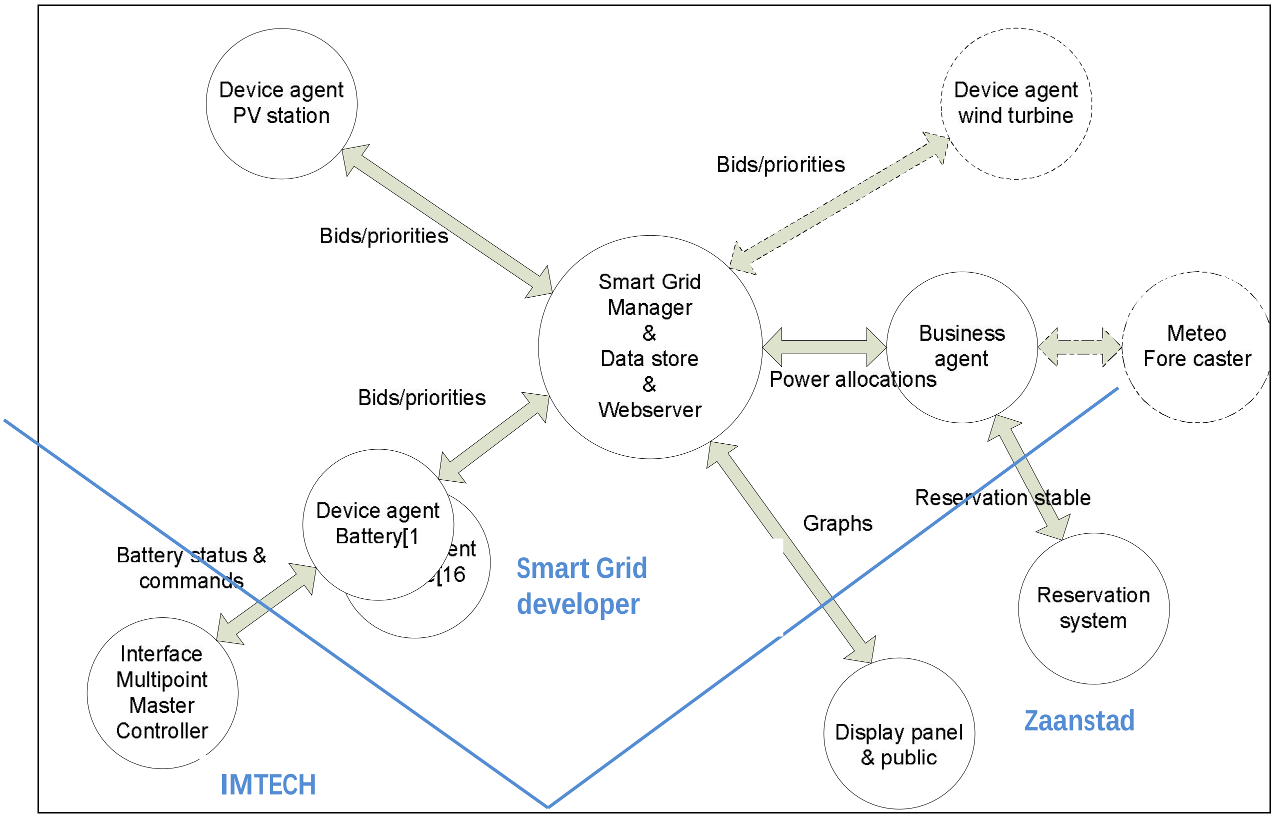

Figure 2: Software architecture proces data flow ReloadIT

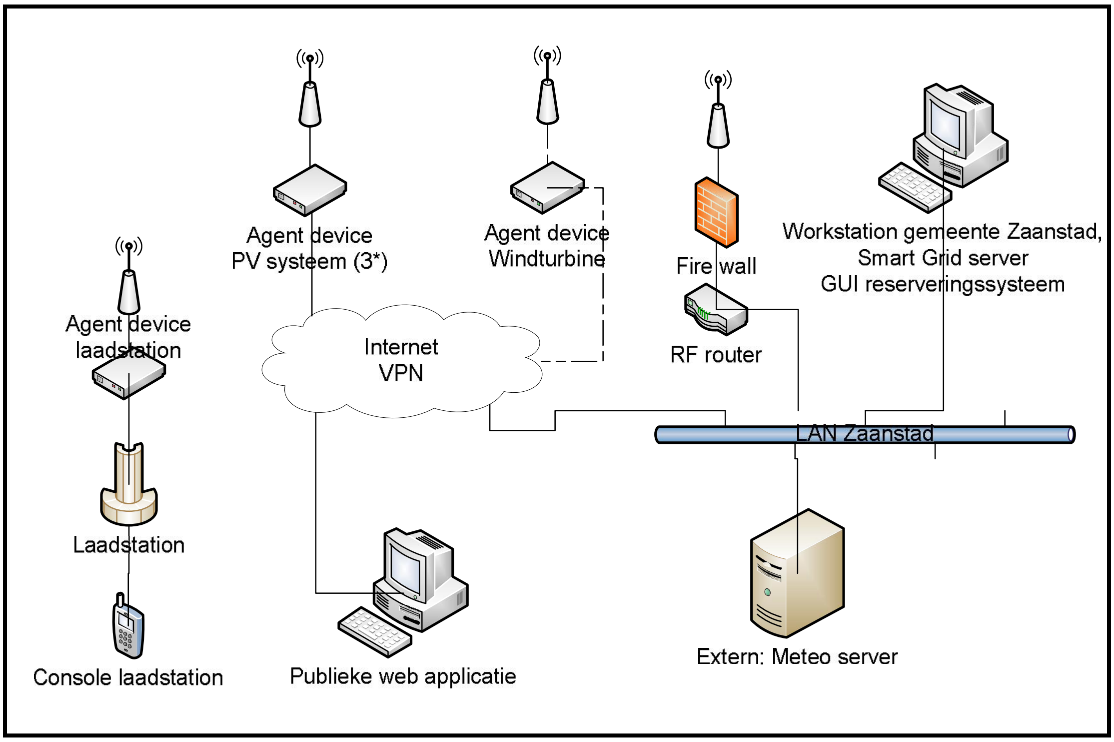

Figure 3: ICT infrastructure REloadIT

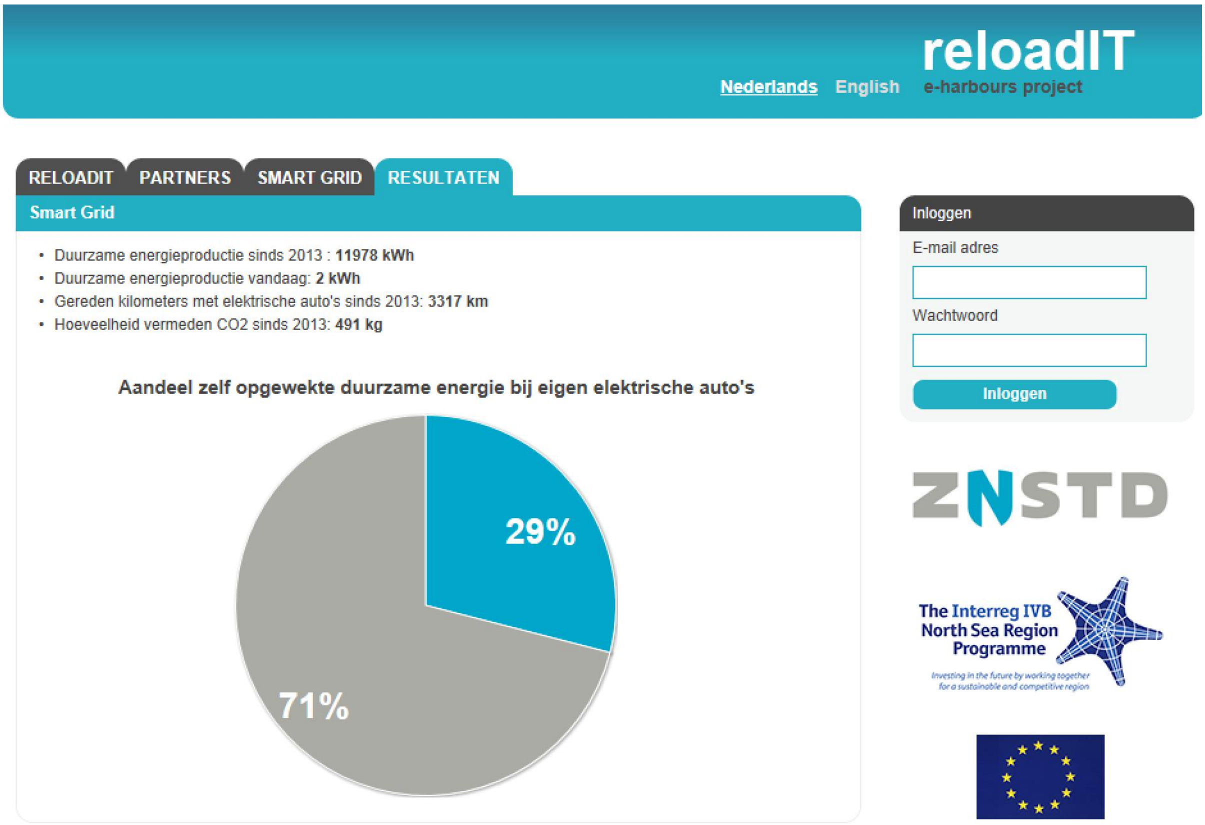

Figure 4: Web site REloadIT