e-harbours

WP 3.5 Application of Smart Energy Networks

Technical and Economic Analysis
Summary results of showcase “Search for flexibility provided by electric boats in Amsterdam”

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1.1 Introduction

Smart energy networks are intelligent and flexible solutions which combine flexible energy consumption, local generation of (renewable) energy and energy storage on different levels. In any smart energy network, the presence of both technical/economical and organisational/legislative conditions is crucial.

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 each of the showcase in Amsterdam.

Universal business cases: 6 possibilities defined

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.

1.2 The strategy in showcase "Search for flexibility provided by electric boats in Amsterdam"

The strategy was to combine theory based on reports by Waterrecreatie advies and TNO (Centre for Applied Scientific Research), with input based on interviews with a boating company, an aggregator and an association.

We interviewed a company in the field of electric boating, in order to find out whether companies are interested in the smart grid concept. We also interviewed an "aggregator", a commercial party which is authorized to trade on the wholesale market on behalf of a pool of customers.

Furthermore, we had contact with the association of electric boating "Vereniging Electrisch Varen Nederland". (http://www.ev-nl.nl/).

We also studied documents. First a policy document of the Water authority of Amsterdam ("Nota Varen in Amsterdam") in which emission- targets for boats are formulated for the coming years. This in order to estimate the coming developments in electric boating. We also got information about the current state of electric canal cruising and the consequences for business operations from two investigations (conducted by interviewing the branch), completed by Waterrecreatie Advies and TNO.

1.3 Scope of the e-harbours showcase "Search for flexibility provided by electric boats in Amsterdam"

The Amsterdam canal boats are number 1 tourist attraction in the Netherlands (over 3 million visitors a year). Given the large scale of boating, approximately 250 boats for commercial use (canal cruise boats an rental boats) and 14.000 small leisure boats (owned by citizens of Amsterdam) the transfer to electric boating could contribute to the air quality in Amsterdam and to flexibility of energy use (smart grids) on the long run. The Amsterdam canal boats could potentially be an interesting energy buffer, consuming the energy during low demand hours or when local renewables are in excess. The scope of this case study was to estimate the potential of flexibility provided by electric boats in Amsterdam if all boats become electric.

Deliverables:
- This report
- Brochure Smart Grid
- Factsheet Smart Grid
- Minutes meeting Greenjoy (26-08-2013)
- Report "Rondvaart en Recreatievaart in Amsterdam"
- Report "Elektrisch varen in de Amsterdamse Grachten"
- Presentations at the expert meeting of September 9th

1.4 Optional: Extended/limited scope

The original scope was to develop a Smart Marina Overamstel. Projectbureau Wibaut aan de Amstel - responsible for the development of the Overamstel area - and the Air quality Department worked together to develop a sustainable marina in the Overamstel area. The idea was to tender the exploitation of the sustainable marina, whereby the winner should be allowed to build and manage the marina. In line with the e-harbours project the original idea was to include sustainability as a selection criterion for the project plans. The presence of a smart grid solution, a rental company of 20-30 electric boats and a solar power installation with a smart charging infrastructure could provide significant scoring advantage in the tender. In order to inform the tenderers and help them with the smart grid development, various brochures were written by Projectbureau Wibaut aan de Amstel and the Airquality Department in collaboration with a smart grid expert (see above "deliverables": factsheet Smart Marina and Brochure Smart grid").

The flexibility for the smart grid system in the Overamstel Marina could be provided by the 20-30 electric rental boats. By linking the electric boats to locally generated energy, an optimum balance could be achieved with a smart grid. To provide the flexibility for the smart grid system, the electric rental boats were an essential part of the smart marina tender. Unfortunately, a legal problem arose for the Smart Marina business case. Waternet (the Water Authority of Amsterdam) has put a stop on licensing boats, also electric boats (so also the 20-30 electric rental boats that were part of the Smart Marina Show case). The envisioned electric rental boats in the case of the Smart Marina were needed in order to provide the flexibility in the Smart Grid. Without the electric rental boats, the number of electric boats in the marina is too insecure to create flexibility. Concluding: without the licenses for 20-30 electric rental boats it was not reasonable to give extra scoring points on smart solutions in the tender and there was no proper business model for smart grids left. In 2012 extensive research has been done to find a solution, but it appeared to be a very complicated legal matter and a hot political topic as well. In April 2013, the definite conclusion of Projectbureau Wibaut aan de Amstel was that they would eliminate "the presence of a mart grid" as a selection criterion.

Despite the fact that the Overamstel Smart Marina will not be developed anymore, the Air quality department had the opinion that it's important to learn lessons anyway. Therefore, the Air quality department hired smart grid expertise and interviewed different parties in order to estimate the potential of a smart grids based on electric boats. Given the large scale of boating in Amsterdam, the transfer to electric boating is interesting for the e-harbours project. Apart from the fact that it has a direct influence on air quality the transfer can contribute to flexibility of energy use (smart grids) on the long run.

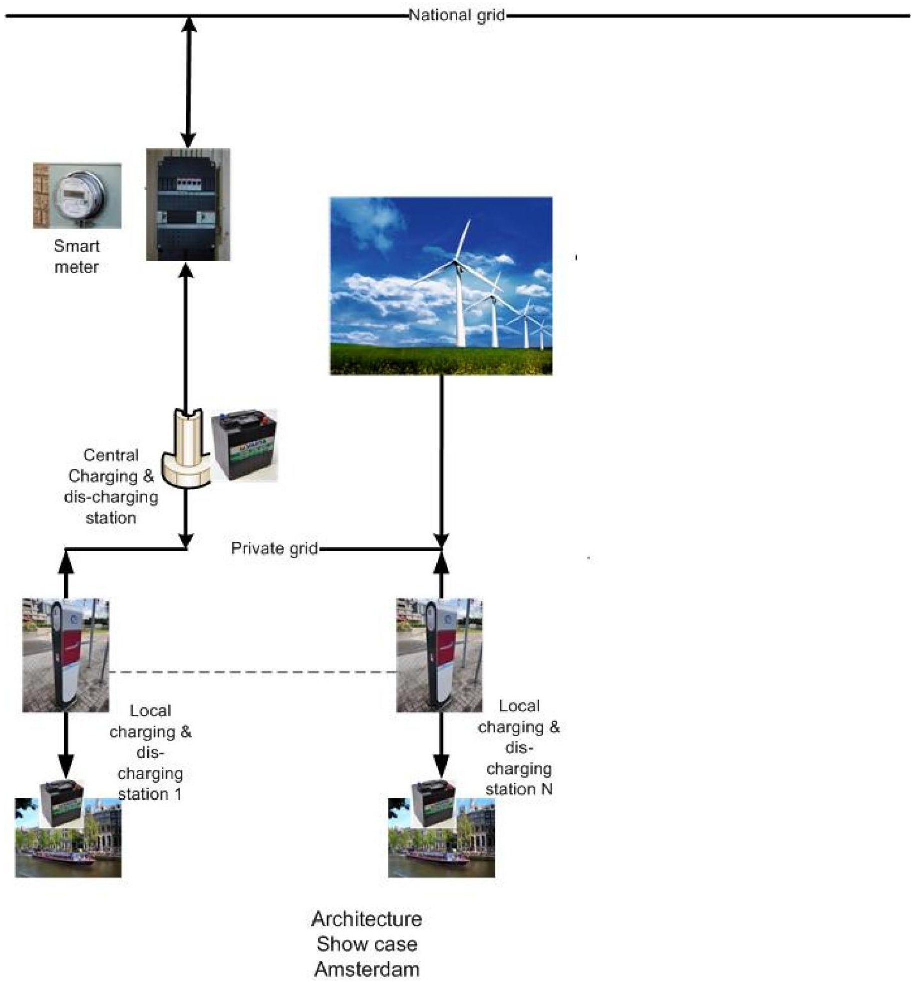
2 RESULTS

2.1 Case study electric boating

2.1.1 Introduction

The scope of this case study was to estimate the potential of flexibility provided by electric boats in Amsterdam if all boats become electric. Given the large scale of boating in Amsterdam, the transfer to electric boating is interesting for the e-harbours project. Apart from the fact that it has a direct influence on air quality the transfer can contribute to flexibility of energy use (smart grids) on the long run.
We have analysed the following 6 scenarios using standard tariff as the base line scenario.

1. Local level: Optimizing battery charging process based on
    a. day night tariff
    b. day night tariff plus wind energy
2. On cluster level: Optimizing battery charging process based on
    c. day night tariff
    d. day night tariff, plus wind energy
    e. wholesale market (APX tariffs)
    f. wholesale market (APX tariffs), plus wind energy



Configuration(s) of possible smart grid electric boating

2.1.2 Investigation summary and conclusion

Available information

- Interview with Greenjoy
- Interview with Aggregator company
- Contact with the association of electric boating “Vereniging Electrisch Varen Nederland”. (http://www.ev-nl.nl/), they gave information in order to verify the assumptions made as preconditions for the analysis.
- Reports and presentations of TNO (Centre for Applied Scientific Research) and Waterrecreatie advies

Preconditions analyses

- The electric boats are only operational during spring and summer season. The exploitation of autumn and winter period is not clear, but could become part of another virtual power plant (see ideas for further investigation).
- The batteries of the boats are only charged during evening and night time. They are not connected with a charging infrastructure during the trips.
- 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 business 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
Whole sale market	: APX the Netherlands based on 2012 tariffs.

Battery specifications

Based on the theoretical assumptions, the total capacity of a battery is 100% and it could be charged to 100% in, for instance, 1 hour. However, based on the battery type used, these parameters are lower. Also keep in mind the limited allowable amount of charge cycles of a battery. The life time of a battery is also influenced by the charging algorithm of the smart grid charger. For the analyses we assume an battery charge/discharge cycle efficiency of 90%, lowest state of charge: 20%.

In the following paragraphs the business cases on “local” and ”cluster” level are described, and some reflections on *balancing group settlement*. “Local” means: exploiting the business cases for a small fleet of boats at 1 geographical location using one grid connection but a energy usage of >10000 kWh/year. Cluster level means: a so called virtual power plant of one or more boats, on more than one geographical location. We assume that both on local and cluster level taxes are the same i.e. 175 Euro fixed discount , and 0,05 Euro tax per kWh.

Analysis 1: Local level

For estimating the potential of this business case we assume that the boats are coupled via a standard grid connection. A connection comparable with a stand house hold.

Today the company Greenjoy handles a standard tariff structure. We considered using day/night tariff optimisation. Knowing that the boats are charged only during evening and night time this seems to be an obvious scenario. A virtual “smart grid controller” takes care of the charging algorithm.

The results of the analyses show:

a. Optimizing on day night tariff the financial gain will be 10%.
b. Optimizing on wind energy, and day night tariff the financial gain will be 13%.

The exploitation of flexibility, by smart charging, contributes to a cost reduction of: 4 and 6 %.

NOTE1: The financial gain between the base and case a and b, show that only 50% of the tariff-difference between peak and off peak tariffs (which is almost 20%) can be exploited. This is caused by the fixed part of the energy price (that are the energy taxes and transport fees: more than 100% on top of the energy price) for small consumers (<10000 kWh) in the Netherlands. For large consumers the picture is quite different (see chapter conclusions). Secondary effect is that during normal charging hours a part of the off peak period will be consumed as well.

NOTE 2: In the Netherlands two off peak time slots are defined: between 9 pm and 7 am, and 23pm and 7 am. For our calculations we assumed the second time slot.

NOTE 3: Trading on the whole sale market is a hypethetical option because it is only an option when the total energy consumption is high enough to be a partner on the whole sale market.

Analysis 2: Cluster level

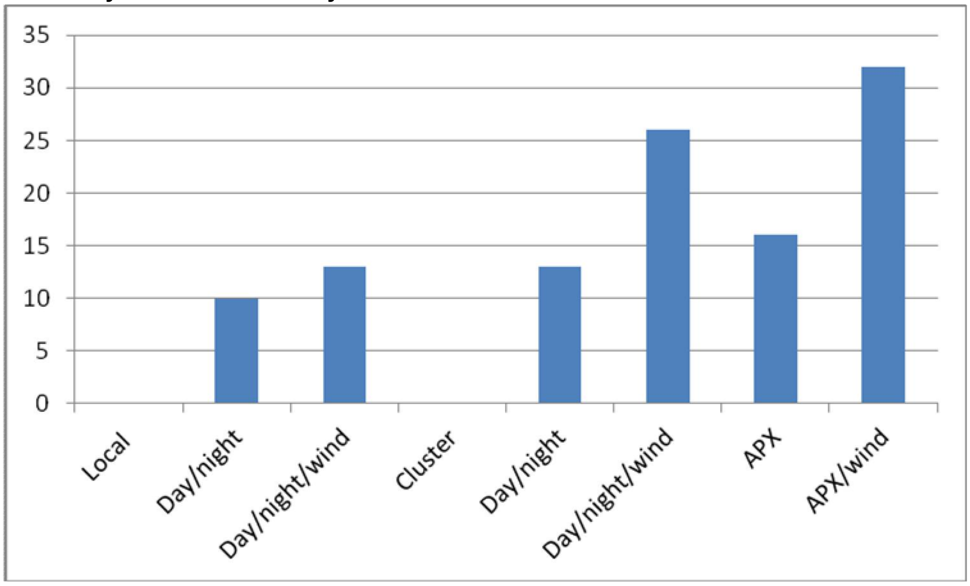
In order to become part of the wholesale market we assumed a virtual cluster of boats located on one or many different locations in the Netherlands. Second assumption is that the cluster may be considered as one legal entity which is responsible an accountable on behalf of the total fleet of boats or the participating fleet owners. This entity could be one company or an association representing the cluster. Keep in mind that the tax tariffs for users >10000 are significantly lower. We also assume that the wind turbines are regarded as part of the legal entity i.e. part of private network. Under the present circumstances in the Netherlands this is not accepted. For the calculations we implemented a smart charging scenario optimising the best financial gains.

a. Optimizing on day night tariff the financial gain will be 13%.
b. Optimizing and trading on the whole sale market the financial gain will be 26%.
c. Optimizing on day night tariff and wind energy the financial gain will be 16%.
d. Optimizing on wind energy and trading on the whole sale market the financial gain will be 32%.

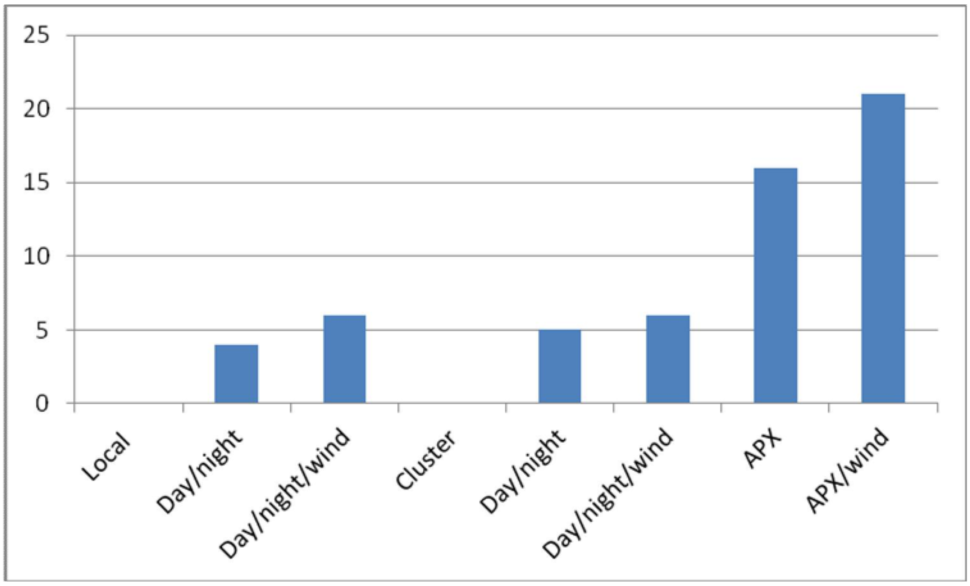
The exploitation of flexibility, by smart charging, contributes to a cost reduction of: 5, 6, 16, 21 %.

We also discussed the possibilities to exploit the potential of flexibility with a commercial party in the Netherlands. This company is a so called aggregator which is authorized to trade on the wholesale market on behalf of a pool of customers. The big question was: is there a product on the market which can act on the balancing market and offer reserve capacity to the grid. Answer: they have plans for the future but presently, acting on the reserve market is not an option.

Summary results case study electric boats



The percentage of financial cost saving on energy bill per boat per scenario.



Contribution cost saving on energy bill due to exploitation of flexibility.

Upscaling scenario's

Dutch potential reserve capacity

We had contact with the association of electric boating "Vereniging Electrisch Varen Nederland". (http://www.ev-nl.nl/). They gave information in order to verify the assumptions made as preconditions for the analysis. Based on estimations of VEVN the potential off the current number of electric boats in the Netherlands is 2000-3000. The average capacity of a boat is 20 kWh, which means that theoretically the boats represent an energy pool of more than 40 MWh. The estimated real time power is in the order of 8-12 MWatt.

Amsterdam future potential
Based on the current numbers of the Amsterdam fleet, the potential number of electric boats in Amsterdam is 200 canal cruise boats and approx. 14.000 small leisure boats. Theoretically the Amsterdam fleet represent an energy pool of more than 60 MWh (see table below).

Possible scale if all Amsterdam boats become electric				
	Needed battery	How to charge?	Number	KWh
Small private leisure boats	1-3 KWh	Charge at home	12.500	Not relevant, not in cluster
Private leisure boats	10-20 KWh (average 15 KWh)	Public charging	1.500	22.500 KWh
Bigger commercial boats	150-250 KWh (average 200 KWh)	Private charging (cluster) or public charging	200	40.000 KWh
Total (rounded)				63 MWh

This is just an estimation, based on the current number of boats in Amsterdam and given the fact that Amsterdam is tightening the rules for licences to ban fossile fuel motors from the canals in the coming 10 to 15 years.

Stakeholder meetings
We had meetings with the following parties:
- Greenjoy electric boating company (minutes available)
- Aggregator company (email correspondence)
- We had contact with the association of electric boating "Vereniging Electrisch Varen Nederland". (http://www.ev-nl.nl/), they provided figures on the numer of boats, and their battery capacity, used as preconditions for the upscaling (email correspondence with boating information).
- TNO presentation and telephone call.
- Consult Waterrecreatie (report)

3 Overall conclusions

The case study shows that the batteries of the electric boats offer a great potential for flexibility, and could be exploited as part of a smart grid application. Local optimisation can be implemented without changing Dutch laws, however integrating wind energy can only be exploited in case the turbine is located at the local estate, and regarded as part of a private grid.

The cluster application also has an even higher potential being part of a grid balancing business case, however we assumed for the sake for the analysis, that clustering consumers and producers dispersed over the region would be an option. This is not yet the case yet, this option would be very important to enable exploiting balancing group settlement.

4 Lessons learned

4.1 Technical issues
Based on the interview with our stakeholders we conclude that technical issues are not the show stopper of using electric boats as part of a smart grid. The electric boats are all equipped with an adequate ICT infrastructure that has enough functionality to support the implementation of a smart

grid application (remote monitoring and control: real time remotely charging and discharging batteries).
Chargers should be upgraded to higher charging currents, and for exploiting balancing group settlement be replaced by charge-discharg devices.

4.2 Economic issues

The analyses of the different scenario's show that there are viable business cases, using both local and cluster optimisation. However the big question remains whether the gain is high enough to cover possible extra investements.

4.3 Ideas for further investigation

1. Search for more combinations and types and mixes of business models: think about the option of being able to exploit the flexibility only during autumn and winter time.
2. Investigate legislative options for associations in order to unite companies to organise a cluster, as one authority.
3. Finding coalitions with network owners to integrate the battery capacity on the grid, by for instance integrating the batteries in or nearby a distribution station.

5 References

[1] Minutes meeting Greenjoy, 26 August 2013
[2] meeting with Power house, 3 October 2013
[3] Report Waterrecreatie Advies, "rondvaart en recreatievaart in Amsterdam", 1 November 2012
[4] Report Waterrecreatie Advies, "Elektrisch varen in de Amsterdamse Rondvaart", 4 September 2013
[5] Presentation TNO (Centre for Applied Scientific Research), "Schone aandrijving voor de Amsterdamse rondvaart", 9 September 2013
[6] Waternet (Water Authority Amsterdam), "Nota Varen in Amsterdam 2.0", September 2013
[7] e-mails "Vereniging Electrisch Varen Nederland".