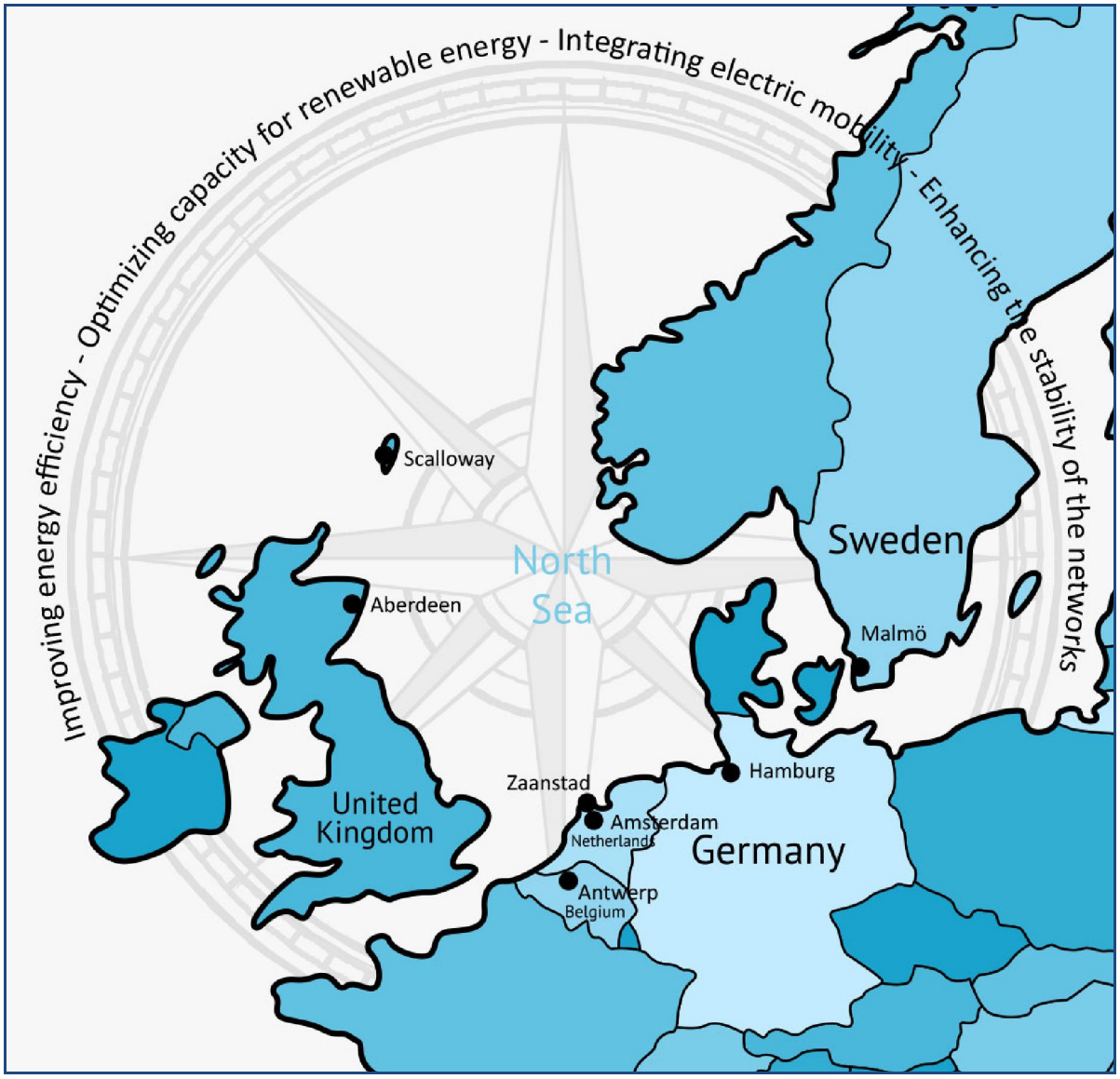
e-harbours electric

The e-harbours Journey

Point of Arrival: Smart Energy Networks in the North Sea Region



The 28 member states of the European Union have agreed upon ambitious targets that address both climate change, energy security and economic competitiveness. How to achieve the far-reaching goals of the '20-20-20 agenda'?

Can Smart Energy Networks help to speed up the energy transition?
That has been the focus of the e-harbours project, formed by eight partners from seven harbours in five countries around the North Sea. In this document, we present an overview of our journey.

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

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February 2014.

The e-harbours project is financially supported by the Interreg North Sea Region program.
Cover illustration based on Colourbox. This report is also available online at eharbours.eu

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Management Summary

Background

The European Union has agreed upon ambitious targets to address climate change, energy security and economic competitiveness. By 2020 primary energy consumption must be cut by 20% across Europe and the share of renewable energy must be increased to 20%. Without smart demand management, the grid will physically not be able to cope with a substantial increase in decentralized and intermittent renewables. In some parts of Europe, this is already a reality.

Why e-harbours?

Large industrial cities and harbour areas, with a dense variety of production and consumption processes, are a perfect testing ground for smart energy concepts. The aim of e-harbours is to explore the possibilities for large-scale implementation of smart energy networks, specifically through *four pillars* of energy optimisation:

1. Optimising **capacity** in the system for additional **renewable energy**, intermittent by nature
2. A strong improvement in **energy efficiency**, supporting savings
3. The integration of **electric mobility**, reducing fossil fuels and possibly adding a buffer to the grid
4. Enhanced **stability** for the energy network, and greater energy-security

The e-harbours consortium

The e-harbours project comprised seven 'showcase' locations in Belgium, Germany, The Netherlands, The United Kingdom (Scotland) and Sweden. These showcases had different approaches: some were searching for flexibility among industrial consumers, while others created awareness by practical application of a smart grid, the development of energy labelling or business case benchmarking.

Things that e-harbours found: our top 10

1. **Costs form a key driver**. Our case studies show that (local) uptake of renewable resources, combined with the exploitation of flexibility, can result in an energy cost reduction of around 15%. In some instances, this cost reduction can be realised with limited investments, resulting in profitable business cases. Local green energy can be profitable in both large and small harbours. For e-mobility applications electrical storage potentially can bring even higher rewards.
2. **For large harbours, finding *flexibility* is the key.** Flexibility is needed to profit from local green production. Our energy audits have demonstrated a large amount of flexible electric loads available at large industrial users. Their exploitation could reduce total electricity costs in the order of 5-15%.
3. **The potential to find flexibility and deliver smart energy varies.** We expected to find a lot of exploitable flexibility in cold stores, for example, but in fact we found more flexibility in large industrial production facilities (such as chemical plants).
4. **E-mobility is a key element of a future smart system concept.** Electric cars, boats and vessels, Heavy Goods Vehicles, cranes and reefers offer great potential as part of smart energy systems. Our showcases have shown this at a small scale. The challenge is to scale up and get these pilots into the mainstream. Vehicle technology is improving but the high cost of e-mobility and battery load cycle limitations remain barriers that have to be overcome.
5. **The theory (and technology) works but the business cases do not.** There are profitable *business cases* for smart energy, but they are not exploited yet. We encountered a lack of awareness of the economic value of flexibility, and of its potential. Also, organisations are reluctant to modify their 'core business', even when they are aware of the potential benefits of exploiting flexibility.
6. **Existing regulatory and fiscal regimes are not helpful.** Present tariff structures in the energy sector do not reward the exploitation of flexibility. In countries like The Netherlands, there is a trend towards higher taxes on energy tariffs at the expense of variable base pricing, reducing the difference between *on peak* and *off peak* energy. This dampens the potential to find costs savings and undermines the economic value of any flexibility within the system.

Concerning the exploitation of flexibility, there is no such thing as best practice that can be exchanged internationally. Markets, tariffs, fiscal and regulatory regimes vary too much between countries. What works in Sweden might not work in Germany. The present definition of private networks needs be reconsidered. Energy regulation should encourage opportunities to develop 'private energy areas'.

7. **One size does not fit all.** While a lot of flexibility can be found in large harbours, the small harbours in the region tell a different story. These ports, with only a handful of significant energy consumers in a limited range of industries, can provide little or no usable flexibility. However there are significant opportunities for raising energy efficiency and awareness. Many of these small harbours are situated in - often remote - regions where there is great potential for renewable energy, like on the Shetlands and Orkney islands.
8. **Regenerating harbour areas provides opportunities.** The City of Malmö puts smart energy at the heart of its efforts to regenerate the Western and Northern harbours. That is the way to do it. Embedding smart energy in regeneration and new development provides better opportunities than retrofitting, finding business cases in existing harbour operations.
9. **Despite the challenges, our message is getting across.** We experienced a gradual rising of awareness among e-harbours industrial partners and other stakeholders on topics like renewable energy and smart energy systems. They are interested in energy saving and – in particular - cost reduction as long as it does not impact on their core business.
10. **...And occasionally you uncover something exciting.** Who had thought reefers (refrigerated containers) can be an important source of flexibility? Another example: we carried out some work to develop an energy label for fish. In doing this work, we generated some fascinating data on the vast differences in the energy embedded in catching, processing and distributing different species of fish. This will lead to new research.

Key recommendations for policy makers

1. We strongly support the shift we perceive in European energy policy, from subsidizing renewable energy resources, towards exploiting smart energy concepts. Help find solutions which provide a clear return on investment and align with the long-term investment strategies of industry, investors and developers.
2. Encourage the development of "private network energy" concepts, enabling 'pro-sumers' to exchange energy. This will support local communities in their energy transition.
3. Reward flexibility in the system. Flexibility is not exploitable in the current energy market, partly because of an increasing unbalance between base price and levies on energy. Taxes, distribution and transport fees, subsidies, and other 'contributions' form an increasing part of the overall energy price and are no incentive for smart behaviour. Redesign the system of incentives and penalties in line with smart energy concepts.

What next?

We are ready for the next step in the development of smart energy systems; during the last years many pilot projects in this field have shown that technology is not an obstacle anymore, both residential developers and industrial companies are ready for further implementation. By implementing a few policy changes as recommended, we think the next step to a more sustainable energy supply is within reach.

Then the next generation of pilot-projects could focus on (virtual) taxing, fair pricing of network costs, balancing, and encouragement of reserve capacity. Working towards the same goal:

Green energy and energy management as a starting point, fossil resources as a backup resource.

0. The starting point

What made us start the e-harbours project? These considerations formed the basis of our project:

- Europe must increase the share of renewable sources in the energy system, at a fast pace. The power grids will have to accommodate sources like wind turbines, solar power plants, co-generation facilities, that are more diverse, more geographically dispersed, and less controllable. It becomes more complicated to keep the electricity grid stable.
- The European power grids have been devised as centralised systems, centred around a few production units that can be regulated by the grid operator. For a centralised system, it is a major change that thousands of businesses and households start delivering intermittent electricity to the grid. The old one-way system develops into a two-way system. The existing grid can cope with flexible sources only to a certain degree, and in some places the grid even now (while the share of renewables is still low) gets stretched to the limits.
- So, we must find energy efficient and flexible solutions that help to manage the grid, creating room for the uptake of 'green' sources like wind or solar power. Those solutions go under the common name of *smart energy systems* or (less precise) 'Smart Grids'.

> ***What is a Smart Energy System?***
> *We define a smart energy system as an energy network that is able to adapt to the introduction of renewable energy sources. The network maintains its balance by using innovative techniques like demand side management.*

- Harbour areas, nodal points in the international logistic and economic network, are perfect places to analyse the chances of smart energy systems. The energy use in the harbour regions is immense, but energy efficiency remains too low, and the share of renewable energy is still disappointing. Both from an economic viewpoint (the energy costs are too high) and from an environmental perspective (the emission of CO_2 and other greenhouse gases is excessive) there is urgent need for improvement.

That sums up why eight partners from five countries around the North Sea decided to develop the e-harbours project. In this report, we show how we discovered great chances for energy savings and reduction of energy costs at many facilities in our harbour regions, how we identified sources of flexibility, and investigated how they could be exploited in profitable business cases. But we will also show how difficult it proved to get smart energy solutions introduced.

1. Tackling the "big fish"- flexibility of large users

Where do we find the massive amounts of flexibility, which is needed to keep electricity grids stable, when the input of intermittent renewables is rising? First of all, we searched for large industrial consumers and producers of energy in our harbour areas, trying to identify sources of flexibility in their operations.

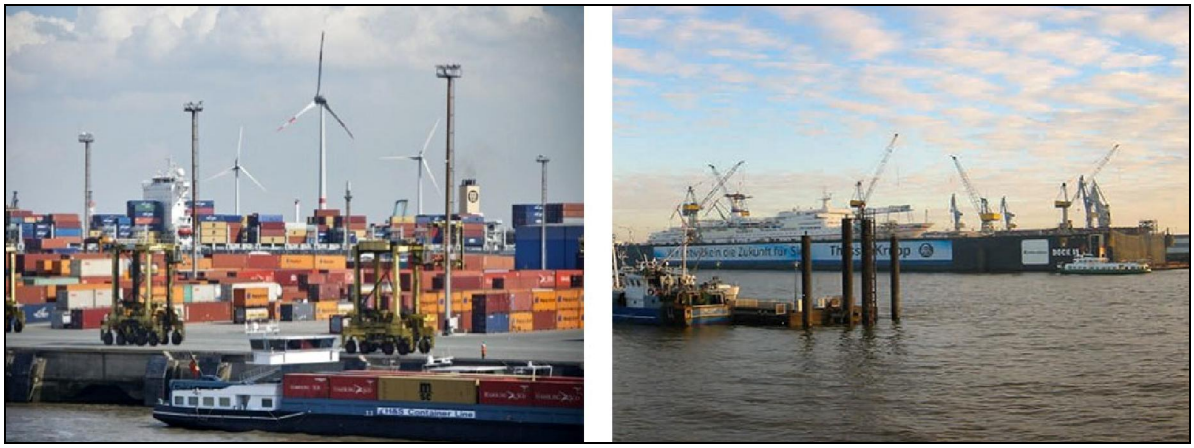
> ***Demand side flexibility.*** *Actions voluntarily taken by a consumer to adjust the amount or timing of his energy consumption. Some installations can shift non-critical activities over time, other devices can store energy for later use. This demand side flexibility can be employed by grid operators and balancing responsible parties to maintain the equilibrium in the power grid.*

1.1 Business cases for flexibility

The e-harbours report "*Strategies and Business Cases for Smart Energy Networks*" [1] identifies six different ways to make flexibility profitable. For individual households and small business, normally the only options available are shifting energy consumption to cheaper off-peak tariff hours or reduction of the peak power. Large consumers and producers of energy have more options, like buying electricity on the wholesale market or selling flexibility to parties that are responsible for keeping the power grid stable.

1.2 Examples from the Antwerp and Hamburg showcases

In both the Antwerp and the Hamburg port area, companies were interviewed in order to investigate the potential and financial value of the flexibility of the electricity consumption related to their production process.



Detailed case-studies in the Antwerp and Hamburg harbour areas identified a huge potential for reduction of energy costs and integration of renewables. We present three smart examples:

[1] Available on our website www.eharbours.eu as the WP3.4 report, [EHAR 2013],

Sludge processing plant
A new facility in the Antwerp harbour is processing sludge from the Scheldt river. The electric pumping installations of this facility have an uptake of several Megawatts. The flexibility found in the process is exceptional: several MW's of flexibility during long periods of time. The buffers can store sludge for a long period, which makes the facility well suited for local wind balancing. The installation can save up to 15% on its energy costs. And it could contribute substantially to balancing the local power grid (negative reserve capacity). Exploiting this flexibility requires organisational and personnel measures like introducing a 16 or 24 hour shift. A new contract has to be negotiated between the company and subcontractors in order to remove that barrier, and achieve a valid business case.

(*picture: the Amoras sludge facility)*

Cold stores in the Antwerp and Hamburg harbours
Cold stores for deep frozen products can deliver flexibility by varying the temperature of the warehouse. In cold stores for exotic fruits, temperature limits appeared to be very tight. Wider temperature limits introduce flexibility, but may influence the quality of the cargo, which is unacceptable. In some cases the flexibility can be used exploiting the differences between day- and night-tariff, this could yield a cost reduction of 9%. However other cold store companies showed less potential for flexibility, mainly caused by a lower insulation level and/or undersized refrigeration system. The best option seems to be to install a wind turbine on the local estate, then a cost reduction of 15% is within reach.

Chemical production plant
A large industrial company in the Hamburg harbour recently installed a large gas powered Combined Heat and Power Plant to cover the lion's share of the heat demand. From a grid point of view the company is a net power producer, since the CHP plant generally produces more electricity than is consumed. As the earlier used gas boilers are still operational, there is a large flexible potential (by regulating down the CHP temporarily and covering the heat demand using the boilers). This is a prime example of 'negative' flexibility, where the facility (at the request of the grid operator) increases its power consumption in periods of excess supply.
By turning down the CHP the production of electricity can be reduced by several MW, for periods from a few minutes to several hours. Reaction time of the CHP is rather fast, and sufficient for the provision of tertiary or even secondary reserve capacity. There is a clear business case for this provision of (negative) reserve capacity, and the company is working on that now. The amount of flexibility could be increased even more if electric heaters would be installed to temporarily cover heat demand when the CHP is turned down, instead of gas boilers. This could double the now available flexible load.

1.3 Exploiting flexibility in networks

Case-studies from Malmö and Zaanstad focused on newly developing industrial zones. Directing the emerging (energy) infrastructure towards smart solutions can bring great cost-savings and more opportunities for renewable sources in the future.

The Northern Harbour in Malmö is the energy hub of the city and the region. Several big energy-producing facilities are located there. The e-harbours team in Malmö looked for a better match between production and demand, reusing excess heat and thus making capacity available for electricity production, while increasing the share of renewables.

A comparable development is going on in Zaanstad, where plans are evolving to build a **Smart Open Energy System** around the local district-heating network. A joint project of no less than 20 businesses, housing associations, network companies and other stakeholders. Local industries can deliver excess heat to the network, renewable sources like wind turbines can also be connected. The sheer number of partners involved enhances the possibilities for profitable uses of flexibility. The system will also improve energy efficiency in the region, and enlarge the share of renewables.

1.4 Flexibility and renewables in an industrial environment – Findings

Finding flexibility is a matter of determination

Almost in every case-study of harbour companies flexibility can be found, provided that you look beyond the obvious sources. A sludge processing plant in the Antwerp harbour would not have been considered an easy candidate to deliver flexibility - it turned out to be the facility with the highest potential within the project. But: **flexibility is an unknown asset.** Quite often, companies and institutions have a limited knowledge of their own energy usage patterns and energy streams. The potential economic value of energy flexibility proved unknown for many companies at the start of e-harbours.

Can you make money with the available flexibility?

We would like to answer 'yes' to this question, but the answer is more ambiguous. Not all business cases for smart energy networks are available to all types of customers (or industries) in all countries. Small customers seldom have access to energy markets or reserve capacity markets, often their only option is to optimize their energy contract.

It's a big step to actual implementation

In different harbour zones, we found promising options, resulting in an electricity cost reduction of up to 15% within current market conditions. **In practice, however, still no company made the step to actual implementation.** Even when the company is really interested, actual profits are often not in balance with investment costs or the total costs of energy of the production process.
All showcases within e-harbours show that economics are the main driver to make energy systems flexible. So, a major breakthrough can only be expected if and when the price for flexibility increases. We also found profitable business cases in some companies, which will not be exploited because of organizational barriers. Companies remain reluctant to offer flexibility to the electricity system

because it often implies less flexibility in their daily operations, and avoid the risks of influencing their primary process.

Legal and Social aspects
Although some cases look nice from an economic point of view, quite an additional number of barriers have to be overcome, foremost practical, social and legal issues. For a more detailed analysis, see the report by the Hamburg and Antwerp teams of e-harbours on non-technical barriers.[2]

Social barriers. In the sludge processing plant in the Antwerp harbour, a limited amount of staff is needed to keep operations going. A sound business case for flexibility in this company depends on the introduction of a night shift and weekend work, a social issue that should not be underestimated.

Legal barriers. In the Hamburg study on the use of reefer containers, liability issues proved important. The terminal operator is obliged by contract to ensure power delivery to the reefers at all times. Given the high value of transported goods, the value of a single reefer may exceed the annual revenues from the business case. In several showcases of e-harbours legislative barriers prohibit local trading of energy. For example, in the Netherlands integrating wind energy is permitted only when the turbine is located at the site or in the direct vicinity of the site.

Differences between countries still have an influence
The energy markets and regulations differ from country to country. Hamburg and Antwerp are similar harbours, but business cases can be very different. For example, large consumers in Germany can receive exemptions from grid fees based on their consumption profile, which is not possible in other countries. Therefore, not all business cases are equally relevant in each country.

[2] http://eharbours.eu/wp-content/uploads/e-harbours_Hamburg_Barrier-analysis_March-2013.pdf, see also the IEEE-report by Vito on the same subject.

2. The power of many – Smart concepts for dispersed users

Many small fish combined can form a massive catch. Several showcases of e-harbours (Amsterdam, Malmö and Zaanstad) have explored the ways private consumers and small enterprises (SME's) can contribute to smart energy systems. In all these cases, electric vehicles play an important role. No wonder, since large numbers of electric vehicles combined can act as a large end consumer or a massive battery, a medium to store energy and a tool of flexibility.

2.1 Electric boating

The Amsterdam showcase of e-harbours investigated whether the huge battery packs of electric canal cruise boats and small leisure (rental) boats could potentially be used as a balancing tool for the local grid. An exploration of the business cases showed possible reductions in energy costs of 10 to 12%. When the boating companies cooperate with other companies (both users and producers of energy), the cluster can start trading on the energy market (APX). Then really staggering reductions on energy costs of 25 to 30% come within reach. Technical issues are not the show stopper. The conclusion: there are viable business cases, especially when boating companies unite, and can forge a coalition with network owners to integrate the battery capacity in the grid.

2.2 Smart homes for smart households

In the residential area Western Harbour in Malmö seven smartly designed rental apartments have been built, owned and managed by the energy company E.ON. Part of the energy is produced on the spot by solar collectors, photovoltaics and a small wind turbine on the roof. Each apartment has at least one electric vehicle included in the contract, from cars to bikes. All houses are equipped with smart grids. Price adjusting solutions are tested, that steer for example the charging of the electric cars. The grid electricity has a fully variable price (connected to the Nord pool spot intraday market). Flexibility has been found in tumble dryers, washing machines and of course charging the electric vehicles, the business case for scaling up will of course depend on the extra investment needed to connect each new apartment to a smart energy system.

2.3 Charging a fleet of electric vehicles in a smart way

In the REloadIT project, the Municipality of Zaanstad charges the batteries of her electric vehicles with energy from renewable energy sources. The software of the smart grid system maximizes the use of renewable energy. The smart system charges the batteries at the lowest possible tariffs, based on 'day ahead' prices at the APX energy market. In this case, the system generates flexibility by shifting electricity usage in time and intensity, influencing the charging current of the battery packs in the cars. The municipality has calculated business cases for a virtual configuration (of a thousand cars throughout the region).
The REloadIT project began on a small scale. Nevertheless, the project helped the municipality to develop a much deeper understanding of its own energy behavior, and of the way the energy market is organized. This resulted in a new energy contract for the Municipality, which not only reduced the energy bill by a massive amount, but also improved the prospects for the intake of locally produced renewables.

2.4 The power of many – general remarks

The e-harbours showcases make clear that households, small enterprises and local organizations, when combined, can act as a large end consumer and thus provide a massive amount of flexibility. This flexibility can be made available to the grid in a profitable way - when organisational and juridical problems can be overcome. The canal cruise companies in Amsterdam have a clear business case in hands, when they can forge a coalition with network owners to integrate the battery capacity of the ships in the local power grid.

Which barriers prevent the provision of flexibility by households and small enterprises? Two major issues: - Can small users get access to energy markets? In fact this concerns the definition of a private network (can prosumers trade energy within a predefined private grid, without paying taxes and network costs?).
- Will governments impose an energy-taxing system that supports flexibility? A flat-rate tax does not enhance the flexible use of energy.

3. Get smart, act smart – information and awareness raising

The case-studies presented above concentrated on relatively well-developed energy systems, with relatively well-informed stakeholders. Part of the e-harbours project focused on stakeholders, that are less familiar with new developments like smart energy systems. In small ports, and among consumers, the first goal therefore is to provide more information about energy matters, and raise the awareness how important this topic is for our future.

3.1 Energy monitoring in small fishing harbours

Small harbours can be intensive consumers of energy. A fishing port like Scalloway, situated on the Shetland islands in the northern part of the North Sea, consumes around 1.8 GWh per year, and produces CO2 emissions of around 1350 ton per year. There are thousands of harbours like this in the North Sea Region. The Scalloway showcase demonstrated, that even the low-hanging fruits of energy saving and improved energy efficiency have not been picked yet. A related study in the Scottish fishing port of Fraserburgh reached the same conclusions.

Even small fishing ports have got cold stores and an ice plant. These could in theory be used as providers of flexible load for intelligent demand side management. The local grid is in many cases not able to accommodate more wind turbines or other intermittent resources. It is clear that the Shetlands could profit mightily from the development of a local smart energy system, but in practice the islands still seem far removed from that goal. The showcases in Scalloway and Fraserburgh therefore have focused on raising the energy awareness among harbour stakeholders, by investigating the chances to raise energy efficiency, training and advising the end users. (*Picture: Scalloway harbour*)

3.2 Labelling hidden energy content

Clearer product labelling is one of the measures proposed by the European Commission to make 'hidden' energy consumption more transparent for end-consumers. The research team of e-harbours at Robert Gordon University in Aberdeen has been investigating the possibilities to implement an energy label for fish products. Existing labels for fish products do take ecological topics in account, but tend to bypass the energy theme. It is expected that having a clearly visible label with information on the 'energy cost' of a product helps consumers make an informed decision and encourages more sustainable behavior. With consumer spend as a driving force behavior change among businesses can also be encouraged.
It proved to be a difficult and time-consuming process to find a local retail partner that is able and willing to take the energy label for fish products to the next level. But the research into the energy consumption of fishing boats provided surprising results: the energy uptake appears to differ greatly, depending on the type of fish caught. Further research in this intriguing find will be undertaken by Robert Gordon University.

4. Comparing the showcases

The e-harbours project has explored a variety of very different showcases. But which ones are the best? And how does one define best? And can one even think about best when comparing an experimental smart home in Malmo with an electric vehicle recharging system in Zaanstad or the flexibility found in a large industrial process in Antwerp? After all, these business cases are trying to achieve slightly different things and will help optimise harbour energy in different ways. Ultimately, success or failure and 'best' are subjective terms.
Nevertheless – and taking full account of these qualifications – it is still a useful exercise to at least try to get some sense of those business cases that capture a significant amount of flexibility, which are relatively inexpensive and which are more easily transferable to harbours in other regions and other countries. Robert Gordon University were charged with developing a methodology for benchmarking and comparing the showcases.

4.1 Are apples smarter than oranges? Evaluating and benchmarking the showcases

The approach developed by RGU is a combination of the simple and the complex. The simple part was the development of a set of variables that describe concepts such as flexibility, cost and transferability and which enable partners to produce data in a standard form (from a range of very different harbours, showcases and individual business cases). This data is tabular form will allow an easy 'high' level' comparison of the business cases. But not all variables are equal. Some variables – such – as flexibility – are regarded by e-harbours partners as more important than others. Consequently, the complex bit involves weighting these variables in terms of relative importance and developing a mathematical model which allows us to compare – with some validity - the relative performance of very different business cases against a variety of quantitative and qualitative criteria.

4.2 The variables and the high level table

Data on a range of variables were captured. To allow comparability, flexibility (defined technically by VITO as a variable combination of time cost, energy availability and capacity) has been monetised as percentage of the total annual energy bill.
Hard numbers were also collected for variables such as the energy mix before and after the intervention (to establish how much renewable energy the intervention adds to the system), and economic data such as investment and running costs.
The RGU team also collected qualitative data. Partners were asked to score their business cases on how organisational, technical and legislative transferability and on other important business case factors such factors such as stakeholder interest and potential for local wealth creation.

5. The point of Arrival of e-harbours: Findings, Lessons learned and Recommendations

5.1 Things that e-harbours found: our top 10

1. For large harbours, finding *flexibility* is the key

- The e-harbours project was funded on the premise that harbour regions - with their enormous demand for energy - would have substantial amounts of untapped 'flexibility' within their energy systems; flexibility that could be captured and exploited by smart solutions. Because of the wide variety of energy consumers in harbour regions, who use energy for different purposes at different times (and perhaps have the capacity to defer when they use energy or even store energy when there is excess production), there is the opportunity to shift - enough - energy demand at certain times so that it better matches the supply of intermittent renewables.
- Some of these initial assumptions have proved to be correct. For example, flexibility *is* needed to maximise the benefits from the production of local renewable energy. Such flexibility is available in large quantities, especially at medium and large industrial plants and in the batteries of e-mobility devices. This flexibility is ready to be exploited. Our energy audits have demonstrated a large amount of flexible electricity capacity available at large industrial users, in the order of approx. 5-15% of total electricity costs.
- Smart consumption enables flexibility, thus enhancing the security of the supply chain. Most of the EU-countries have enough short term flexibility, and partly, that is already exploited by large producers and consumers. These early adopters can make money and can inspire other end-users. We need to start enabling more suppliers of capacity to meet future demand for flexibility.

2. Costs are the key driver for consumers

- Adding more renewables (without changing the energy system) will increase differences between supply and demand, putting a strain on security of supply. Smart energy systems will help stabilize the grid, and make costly investments in grid capacity superfluous.
- But consumers do not realise how precarious their power supply is. They currently have their energy demands met and there is energy available when they need it. So, there is little economic or public pressure to introduce smart energy initiatives or optimise energy supply and demand. It is 'somebody else's business'.
- Harbour businesses and stakeholders are motivated to make money or reduce costs. There must be a financial incentive to invest in smart energy systems. Our case studies show that capturing flexibility or increasing the uptake of local renewable resources can reduce energy costs by up to 20% in large harbours. For e-mobility applications electrical storage potentially can bring even higher rewards. That is the incentive to embrace smart energy (in theory).

3. The potential to find flexibility and deliver smart energy varies

- Some of our initial assumptions were wrong. 'Classic' models of energy flexibility suggest that there will be substantial amounts of energy to be captured by linking industrial plants which need to 'dump' excess energy (e.g. from refrigeration processes) to those which require large amount of energy for heating. While we found some flexibility in cold stores, for example, we found much more in large industrial production facilities such as chemical plants or sludge processing.
- Scale is also critical. We expected to find the same potential to capture flexibility and exploit smart energy solutions in harbours of *all* sizes. However, for flexibility we find that economies of scale are vital and there is likely to be little or no commercial flexibility in small harbours.

Our wish list: topics for future research in large harbours

- ü Start pilots on (virtual) taxing and fair pricing of network costs, balancing, and reserve capacity. Seek a larger scale: complete harbour areas. Think of Metropolitan areas such as Amsterdam, Hamburg, Antwerp & Malmö. Renewable sources and energy management as a starting point, fossil sources used only as a backup.
- ü Encourage exploitation of industrial residual heat, combined with 'power to heat or refrigerate'.
- ü Focus on maximizing usage from green peak-production in 'heat' or 'refrigeration', Do not neglect the niche: research possibilities of process interventions (e.g. fish label)
- ü Focus on avoiding peak demand. Do not neglect the niche: research possibilities of local fossil backup production (e.g. diesel cranes or hospitals).

4. E-mobility is a key element of a future smart system concept

- Because of the numbers of vehicles and vessels operating within a defined harbour hinterland, electric mobility is one of our four pillars of smart energy and energy optimisation. Electric cars, boats and vessels, HGV's , specialised harbour vehicles, buses, cranes and reefers offer great potential as part of smart energy systems.
- Our partners in Zaanstad and Malmo have shown how this can be done at a small scale with electric cars. Our partners in Amsterdam have demonstrated that electric boats have a role to play. Our links with other European projects have shown that there are potentials, from hybrid ferries (Scotland) to powering heavy harbour vehicles through induction or overhead power charging (e.g. Siemens).
- The challenge is to scale up and get these pilots into the mainstream. Vehicle technology is improving but the high cost of e-mobility and battery load cycle limitations remain barriers that have to be overcome. Scale is also an issue.

5. The theory (and technology) works but the business cases do not

We have identified business cases for smart energy which have yet to be exploited. There are three main issues why theory has not yet been translated into action:

- **No sense of urgency**: In many businesses, current energy costs are low compared to the total cost of production or operation, too low for most users to start implementing smart energy systems. An energy share of 20% of total running costs can be considered as a threshold for action. Also, security of energy supply is still perceived very high, since there have been very few major blackouts or power quality issues yet, despite the grids often operating at their limits. As a consequence, there is no real sense of urgency among stakeholders (business, government, consumers) to exploit smart solutions.
- **Limited business potentials**: There are currently only few options to earn money by exploiting flexibility. The value of flexibility is still quite low and the key policy drivers are currently negative. There are opportunities even now for early adopters to make money, but it has not yet become "common sense" to look at flexibility as an economic asset.
- **Internal issues**: With much of the challenge being about changing the mind set of individuals within an organisation, addressing the *organisational* pillar is one of the key challenges for exploiting flexibility. Unclear or dispersed responsibilities or scepticism against innovations can prevent a good concept from being implemented, even if technical solutions are there.

6. Existing regulatory and fiscal regimes are not helpful

- On the topic of flexibility, there is no such thing as best practice that can be exchanged internationally. Energy markets, tariffs, subsidies, fiscal and regulatory regimes vary too much from country to country. So what works in The Netherlands might not work in Germany.
- Energy markets misdirected by uncoordinated policies (taxes, levies, juridical barriers) can produce suboptimal results. We need standardisation and coordination of policy. Identifying and exploiting available flexibility also requires tailor made solutions. Local conditions require local analysis and local business cases, local expertise and local energy. Without standardisation, localism is the only approach.
- Energy regulation should encourage – not discourage - opportunities to develop 'private energy areas', so that a number of local energy consumers can combine to create a virtual power plant.
- In some countries (like The Netherlands), there is a trend towards higher taxes on energy tariffs at the expense of variable base pricing, reducing the difference between *peak* and *off peak* energy. The basic production price of energy is relatively low across Europe, but additional taxes and fees are rising sharply and now make up the larger part of the energy bill. In most countries, the consumer is best off when he can avoid taxes through local production, but present definition of local/private networks needs be reconsidered. New legislation and juridical frameworks would assist us to exploit flexibility.
- Putting more money in renewable energy can still help to realize the energy goals of the European Union, but there is more to be gained. Create added value by investing in smart and flexible integration of renewables. Stimulate the development of markets for flexibility (like the capacity market), and make public funding available for smart energy investments.

7. One size does not fit all

- While a lot of flexibility can be found in big harbours, small harbours (like Scalloway and Fraserburgh) , with only a handful of significant energy consumers and a limited range of industries at hand - can provide little or no commercial flexibility. But there are significant opportunities for promoting energy efficiency, raising awareness and promoting more local renewables. These are relatively low cost solutions for small harbours. And if every small harbour in Europe can reduce demand by a MW hour…
- Many of these small harbours are situated in - often remote - regions where there is great potential for renewable energy. In Shetland and Orkney, the local grids are already operating at or close to capacity. For these port hinterlands, a grid that cannot absorb increasing volumes of renewables is a reality rather than a theory. These areas are a microcosm of the challenges that Europe as a whole will have to face in the future.

Our wish list: topics for future research in small harbours

- ü Start an energy-awareness programme for small harbours.
- ü Incentives for cooperation to overcome split incentives, or deviating processes.
- ü Support local energy service companies in starting-up businesses on this topic. Think EU, act local.
- ü Look for ways to increase the energy efficiency of fishing boats.

8. Regenerating harbour areas provides opportunities

- Harbours expand, diminish, flourish and – occasionally – fail. Historic harbours often have lots of land to regenerate and rejuvenate. Harbour municipalities are leading the way in terms of energy management, renewables and energy flexibility.
- Embedding smart energy in regeneration and new development provides better opportunities than retrofitting, finding business cases in existing harbour operations. Smart energy based rejuvenation and regeneration can lead to a high quality of life for its inhabitants and potential inward investors, and leave municipalities in a strong economic position to compete in their 'post-harbour' eras.

9. Despite the challenges, our message is getting across

- We experienced a gradual raising of awareness among e-harbours industrial partners and other stakeholders on topics like renewable energy and smart energy systems. Harbour authorities, industrial partners, municipal colleagues and other stakeholders are genuinely interested in the issues and of the potential of smart energy optimisation in harbour regions, and of the potential to harness some of the business cases that we have identified.
- But while industrial partners are interested in energy saving and flexibility, they will not modify their 'core business' to accommodate it. The message is clear. Profitability comes first, smart energy flexibility comes second.

10. …And occasionally you uncover something exciting.

- Our partners in Hamburg and Belgium have found that reefers (refrigerated containers) can form a substantial and important source of future flexibility. Further work will be carried out with harbours stakeholders to develop smart energy solutions to capture the flexibility offered by these cold containers.
- Another example – our partners from RGU carried out some analysis to develop an energy label for fish. In doing this work, they found it takes around 1 MW hour of energy to catch, process and distribute a tonne of haddock. In contrast, a tonne of Mackerel requires around 7% of this amount. Clearly, there is a potential for improvement here.

5.2 Lessons for stakeholders

In the following table, we have summarised the findings of the e-harbours programme. We make a distinction between findings that are relevant for government bodies and policy makers, and lessons for consumers or business.

Lessons for policy makers	Lessons for business (and domestic) consumers
The grid works at the moment The security of the energy supply in the EU countries is high, blackouts and power cuts are rare. The drawback: there is little economic or public pressure to increase the security of the power grid. It is perceived as 'somebody else's business'.	**The grid works at the moment** For the average consumer and business, energy is only a minor part of total running costs and they have security of supply. The sense of urgency at consumers' level is too low.
Adding more renewables will - eventually - overwhelm the system Adding more renewables (without changing the energy system) will increase differences between supply and demand, straining the security of supply. Our showcases demonstrate what happens when an energy grid reaches capacity and renewables can't be added anymore. Smart energy systems will help stabilize the grid, and make costly investments in grid capacity superfluous.	**Consumers do not realise how precarious their power supply is** It could help to make visible on the energy bill what the additional costs are of adding more renewable capacity to the system. And then reward flexible consumers that reduce the costs for integration of renewables. Starting with end-users with relatively high energy bills, and businesses investing in new production facilities.
Green production needs smart consumption Putting more money in renewable energy does not help anymore to realize the energy goals of the European Union. The basic production price of energy is relatively low, but additional taxes and fees are rising sharply and now make up the larger part of the energy bill. In most countries, the consumer is best off when he can avoid taxes through local production. The subsidies that are directed towards enhancing renewable energies should be diminished, in favour of an approach that stimulates the development of markets for flexibility (like the capacity market),and makes public funding available for smart energy investments.	**Smart consumption and green production makes business sense** For consumers, investing in local energy production, adapted to local consumption, already is the cheapest solution. Energy is cheap to produce, but taxes and fees can make it expensive to buy. So the consumer is better off when he can avoid taxes through local production. Changing legislation and juridical frameworks could open new opportunities. Example: the definition of private nets.... Flexibility is available in large quantities, especially at medium and large industrial plants and in the batteries of e-mobility devices. Solutions have been found and can be transposed to other industrial plants/areas
Technically, flexibility is ready to be exploited Flexibility is available in large quantities, especially at medium and large industrial plants and in the batteries of e-mobility devices We need to start enabling more suppliers of capacity to meet future demand for flexibility.	**Technically, flexibility is ready to be exploited** Smart consumption enables flexibility, thus enhancing the security of the supply chain. Most of the EU-countries have enough short term flexibility, and partly, that is already exploited by large producers and consumers. These early adopters can make money and can inspire other end-users.

The energy market does not value flexibility and smart operation There are currently only few options to earn money by exploiting flexibility. This will stay the case, as long as the market for flexibility remains underdeveloped. We urgently need a new market design (like the development of a capacity market). Smart infrastructures cannot function without smart markets. The future perspective of the energy market needs to be European, thus increasing competition and enabling transnational solutions.	**Institutional colleagues do not value it either** Identifying and exploiting available flexibility requires determination. How can internal support for flexibility be created if there is no financial value? Addressing the *organisational* pillar is one of the key challenges. Even where a technical solution has been identified to exploit flexibility, internal institutional opposition or apathy can kill an idea.
There is no such thing as best practice Energy markets, regulation and legislation differ greatly from country to country. What works in The Netherlands might not work in Germany or the UK. Energy markets misdirected by uncoordinated policies (taxes, levies, juridical barriers) can produce suboptimal results. We need standardisation and coordination of policy	**Existing business cases take advantage of local conditions** Identifying and exploiting available flexibility also requires tailor made solutions. Local conditions require local analysis and local business cases, local expertise and local energy. Without standardisation, localism is the only approach
Policy makers need to think of e-mobility as mobile energy storage And tailor their policies accordingly Policy makers need to build flexibility into their procurement of vehicles. Combing electric vehicles with smart houses is a smart way forward	**e-mobility business cases - It is all about scale** Fewer large vehicles may provide more predictable flexibility than lots of smaller ones. Cars can work, so do buses. Small boats and big vessels work, but not necessarily middle sized ones.
Do not forget small harbours, a little can go a long way If every small harbour can reduce demand by a MW hour…	**Energy efficiency and awareness raising can make a big difference** Small harbours often have constrained grids. Focus on energy efficiency and awareness raising, seeking low cost solutions.
Harbours change Harbours often have lots of land to regenerate and rejuvenate, a blank canvas. Harbour municipalities are leading the way in terms of energy management, renewables and energy flexibility. There is a lot of harbour land for redevelopment across Europe. Can it be exploited?	**Harbours change** 7.000 used to work in the Malmo Western Harbour dockyards. 10.000 now work in the modern, high tech, low carbon, energy efficient Western Harbour, enjoying the benefits of low energy costs. Is there a better place to invest, work, live and do business? Smart energy rejuvenation can lead to a high quality of life.
Demand for smart energy will come from people and businesses EU's energy goals can be reached by investing in smart energy systems and demand side flexibility (options that are much more cost-efficient than building energy storage facilities or backup power plants)… ….and harbours are perfect places to invest.	**Demand from people and business will come from better awareness and information (about energy, economics and processes)** EU's energy goals can be reached by promoting greater uptake of smart energy systems and demand side flexibility (options that are much more cost-efficient than building energy storage facilities or backup power plants)… …what's more, harbours and harbour cities are perfect places to reach industrial and domestic consumers.

5.3 Key recommendations

1. We strongly support the shift we perceive in European energy policy, from simply subsidizing renewable energy resources, towards exploiting smart energy concepts. Help find solutions which provide clear returns and align with the long-term investment strategies of industry, investors and developers.

2. Encourage the development of “private network energy” concepts, that can function apart from the national power grids. They can deliver renewable energy to local communities of residential and/or industrial consumers, while reducing the amount of network taxes that have to be paid for using the grid.

3. Allow the customer that saves energy or provides flexibility to the system a clear profit: a lower energy bill. Current energy markets are not able to reward the exploitation of flexibility, partly because of an increasing unbalance between base price and levies on electricity. Taxes, distribution and transport fees, subsidies, and other ‘contributions’ form an increasing part of the overall electricity price, but do not create any incentive to stimulate better customer behaviour. Contribution fees should be redesigned in such a way that it gives an incentive to customers and suppliers which contribute to solving grid issues and imposes a penalty on those who don’t.

What next?

We are ready for the next step in the development of smart energy systems; during the last years many pilot projects in this field have shown that technology is not an obstacle anymore, both residential developers and industrial companies are ready for further implementation. By implementing a few policy changes as recommended, we think the next step to a more sustainable energy supply is within reach. Then the next generation of pilot-projects could focus on (virtual) taxing, fair pricing of network costs, balancing, and encouragement of reserve capacity. Working towards the same goal:

Green energy and energy management as a starting point, fossil resources a backup resource.

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Key recommendations for policy makers from the e-harbours project

1. We strongly support the shift we perceive in European energy policy, from subsidizing renewable energy resources, towards exploiting smart energy concepts. Help find solutions which provide a clear return on investment and align with the long-term investment strategies of industry, investors and developers.
2. Encourage the development of "private network energy" concepts, enabling 'pro-sumers' to exchange energy. This will support local communities in their energy transition.
3. Reward flexibility in the system. Flexibility is not exploitable in the current energy market, partly because of an increasing unbalance between base price and levies on energy. Taxes, distribution and transport fees, subsidies, and other 'contributions' form an increasing part of the overall energy price and are no incentive for smart behaviour. Redesign the system of incentives and penalties in line with smart energy concepts.

The e-harbours project run between September 2010 – February 2014 and was supported by EU Interreg IVB North Sea Region Programme.

More information is available online at eharbours.eu