Energy of an Integrated Future - Opportunities for the Öresund Region

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Energy for an Integrated Future

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INTRODUCTION

Strategies for the Öresund Energy System

By Tim Cycyota

The Öresund Region is a transnational region encompassing areas of southern Sweden (Skåne) and southeast Denmark (Sjælland and Hovedstaden). The Energi Öresund project seeks to offer strategic and cooperative energy planning for the region as a whole in order to meet the energy goals of Sweden, Denmark, and its constituent local municipalities. The project is funded by EU INTERREG IV, a European Union initiative dedicated to promoting cooperation and knowledge transfer between municipalities and stakeholder groups across the borders of neighbouring European countries. This report, "Towards an Integrated Future: Strategies & Opportunities for the Öresund Region," produced by students at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University in cooperation with Energi Öresund and its partners, is both an example of this cooperation as well as an extension of the project's goals for strategic energy savings into the future for Öresund.

Part of this report builds upon and expands on previous work conducted by IIIEE students in 2011 ("Energy Futures Öresund — Bridging the Gaps to a Greener Tomorrow") and 2012 ("Strategic Energy Solutions — A Case Study of the Öresund Region") on the issue of energy sustainability in the Öresund region. It explores a wide variety of related technical and social topics and offers specific recommendations for improvement. It also examines guidelines drafted by Energi Öresund, offering recommendations for improvement and suggestions for the implementation of these guidelines. These chapters are section one of the report.

As the Energi Öresund project ends in 2013, this report also seeks to explore further examples of collaboration in the region beyond the context of the energy system. In a wide variety of areas from urban farming to urban transportation to the building process, section two of the report utilises a broader and forward-looking view of innovations and improvements that could be used for an integrated and sustainable future in the Öresund region. This section may be contextualised through "distributed economies," the concept of local and regional systems working together through the sharing of knowledge and resources towards the goal of overall prosperity and improvement. Through technical explorations, conceptualisations of systems, and considerations of economic and social implications, a potential sustainable future for Öresund emerges where collaboration and innovation work together to achieve economic, social, and environmental improvements.

"Towards an Integrated Future: Strategies & Opportunities for the Öresund Region" is both an examination of the present and an exploration of the future for Öresund, and it hopes to promote collaboration and cooperation among all stakeholders for a sustainable energy future in the region.

NO CHARGE FOR CHARGING

Municipal Incentives for an Electric Vehicle Future

By Ariel Drehobl, Francesca Favorini-Csorba & Sophia Küpers

Private vehicles produce a significant portion of emissions in the Öresund region. A focus on reducing emissions from personal vehicles is therefore necessary to achieve carbon neutrality for the region. Electric vehicles (EVs) offer a promising solution to the issue of increasing carbon emissions by providing an alternative to conventional private transportation. However, the transition to EVs so far has been slow in the Öresund region. Norway, on the other hand, has become the EV capital of the world, with the highest number of EVs per capita.

Although some barriers need to be overcome in order to reach Norway's level of success, municipalities in the Öresund region can look to the example of Norway for inspiration. This article will focus on how incentives can be implemented on the municipal level in order to encourage increased private ownership of EVs. The scope of this study covers incentives to promote private EV ownership but does not address the disincentives for internal combustion engine (ICE) vehicles. In this study, EVs are defined as plug in hybrid vehicles and those running on fuel cells and batteries.

EV Incentives in Denmark

Denmark aims to be fossil fuel free by 2050, and increasing EVs will be a strategy to reach this end. In October 2012, 1 500 out of 2.1 million vehicles registered in Denmark were electric, with almost half of the electric vehicles located in Copenhagen.[1] That year only 363 EVs were sold as compared to the 5 000 the government had anticipated. Recently, the Danish government downgraded the expectation of 400 000 EVs by 2020 to 200 000 EVs.[2] Better Place, an international, venture-backed company that sold charging and battery switching stations for electric vehicles, invested heavily in the Copenhagen market for EVs by installing battery exchange stations in the city. However, Better Place went bankrupt in 2013 due to a "lack of financing and dearth of customers," leaving their Copenhagen charging stations and batteries virtually unused.[3] Currently investment in EV infrastructure has stagnated as the demand for private EVs has continued to remain low.

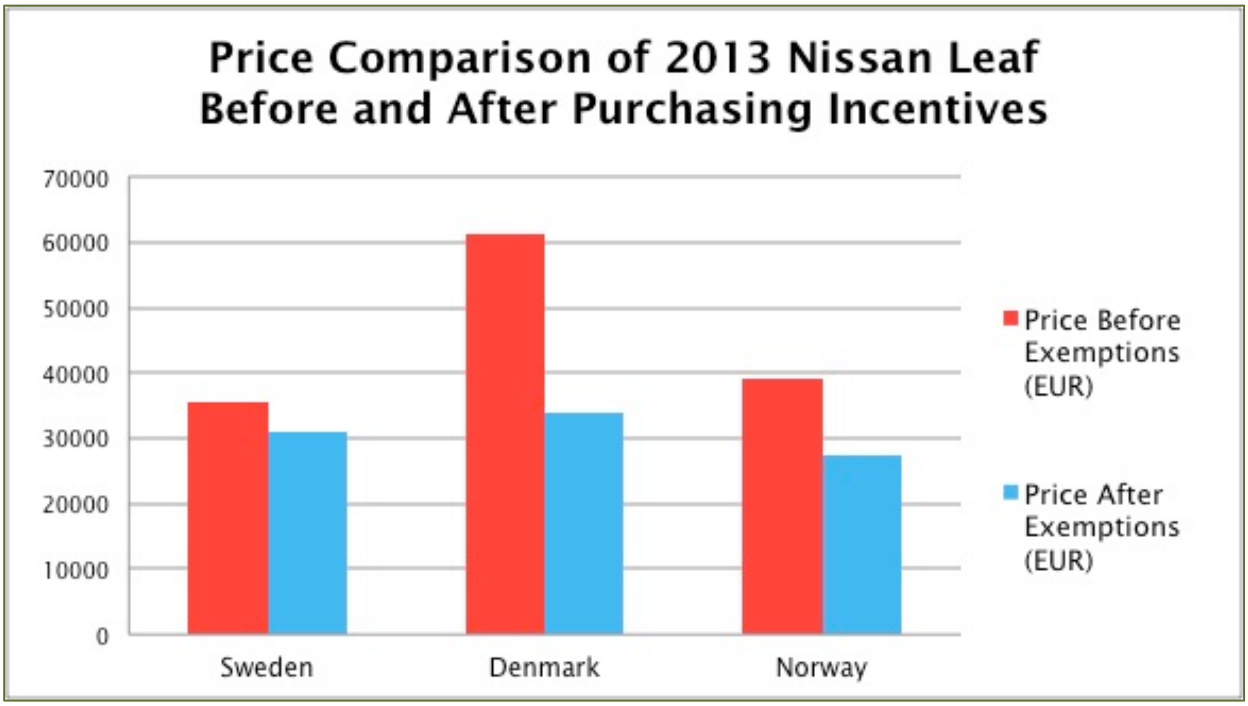
The Danish government has implemented policies to promote EVs in the national market. The parliament passed a tax reform that exempted electric cars from paying various fees. For example, the registration tax for passenger cars in Denmark is 180% based on the initial value of the car, so by removing this tax the EVs become more affordable as compared to other new cars on the market. Car purchasers also receive a deduction of DKK 4 000 (EUR 536) when purchasing a car with efficiency of 16 km/litre or more. Since cost plays a large role in consumers' decision to switch to EVs, these subsidies are important, but need to go further.

In addition, Copenhagen offers free parking for EVs in certain areas in the city. Although there is no national requirement for the government to purchase a certain percentage of green cars for its fleet, the public sector is currently the largest consumers of EVs in the country. Recently, a government proposal by the coalition party Radikale stated that a quarter of publicly operated vehicles could be made electric by 2015 in order to stimulate sales.[4] Denmark lacks the potential catalyst for encouraging EV ownership based on national pride due to a lack of domestic car production.

Currently most of the political incentives have focused on the vehicles, with less focus on the charging points and infrastructure. Hoping to increase the demand for EVs, the government endorsed a recommendation by the national road authority Vejdirektoratet, the national transport authority Trafikstyrelsen, and national energy officials Energistyrelsen to increase the number of EV charging stands in numerous locations along the Danish motorways.[4] The potential for fast charging stations that only take 15-30 minutes to charge has also been considered for Copenhagen. The Danish Electric Vehicle Alliance along with Copenhagen Economics recently developed a new model for taxing cars that focuses on incentivising less CO_2 emissions and rewarding greener technology and safety features.[5] The government also created an EV promotion programme that focuses on gathering technical, organisational, economic, and environmental data about the use, operation, and maintenance of EVs in order to help increase the demand for EVs on the public market.

EV Incentives in Sweden

The Swedish government aims for the country to become independent of fossil fuels for vehicles by 2030. The Swedish Energy Agency set a goal of 85 000 EVs on Swedish roads by 2020, but this projection was recently revised to 18 000 cars.[6] Although measures such as greening the public car fleets, and introducing and adapting a variety of incentives for private EVs have been adopted throughout the last decade, EVs are not quite successful in Sweden. In 2012, Sweden could only claim 1 285 EVs in



Prices from the wed-based Nissan Price Database for each country.

the country, and emissions from transportation currently account for one third of national emissions.[7,8]

On a national level, incentives for private individuals to purchase an EV are given through an environmental subsidy (Supermiljöbilspremie) of currently maximum of SEK 40 000 (EUR 4 432), vehicle tax exemptions (5 years exemption from annual vehicle fee), and reduced vehicle taxes for eco-cars in general. Further incentives introduced by the government are exemption from congestion charges in Stockholm and funding of research and development of EV batteries and charging points. These policy measures are good steps, even though they are not focused only on EVs. In addition, the initial investment is still perceived as a barrier for buying EVs, even with the given financial incentives.

Local initiatives have been subject to campaigns like a municipality ranking undertaken by the Swedish Association of Green Motorists that ranks cities based on their visions and success in greening private vehicle transport. Gröna Bilister conducts research on greener transportation, lobbies for environmental concerns in the area of vehicles, and informs the public about policies and best alternative choices. Strategies found in their municipality analysis include providing free parking, local and regional car-sharing businesses, and awareness programmes. Malmö, capital of the Skåne region, is already offering an attractive charging infrastructure, partly based on solar and wind power. The city ran an e-mobility project in collaboration with an energy provider, including test-driving for households and the general public. As a reward for their efforts, Malmö was awarded the title of Elbilsbästa Kommun, or best electric car municipality, in 2013.[9] Such strategies play a major role in making a transition to private EV ownership attractive and in inspiring other municipalities in the Öresund region.

Although the number of available EVs and the number of EVs on Swedish roads are increasing, the country still lacks domestic manufacturing of EVs. Since the popular Swedish manufacturer Volvo does not have EVs on its current agenda, the government may not be interested in providing further or higher incentives for imported EVs, since those incentives would do little in terms of fuelling the national economy.[10,11]

Slow charging stations are already widely accessible in Sweden, given high voltage and reliability of the existing grid. However, a need for development of fast charging stations has been identified.[6]

One idea adopted on a national level in terms of green cars already is to make public fleets run on electricity only. Increasing the visibility of EVs on Swedish roads could lead to higher awareness among private individuals—awareness apparently being one of the most difficult barriers to overcome in the case of Sweden.[8] The idea of increasing awareness is not only limited to EVs, but applies also to alternatives to car ownership, as discussed below.

Case Study: Norway

Globally, Norway has the highest number of EVs per capita, and the highest density of EVs in a capital city. As of October 2013, there were over 15 000 EVs on Norwegian roads. As such, Norway is a good case to examine, particularly from the perspective of other Scandinavian countries. At first glance, Norway's situation seems to be relatively similar to that of Denmark or Sweden. The financial incentives offered by the government are comparable to those of the other countries: no purchase taxes on EVs, exemption from the 25% VAT, no charges on toll roads, and free municipal parking. Although these are comparable, these incentives do more for removing financial barriers than those of Sweden and Denmark.

An additional incentive for purchasing an EV offered by Norway is free access granted to bus lanes. Because of the large amount of time saved, particularly for drivers during rush hour, this provision has been highlighted as an important incentive.[12] Another important distinction between Norway and the other two countries is the presence of domestic manufacturers of EVs. Although the original Norwegian manufacturer, Think Global, has since gone bankrupt, Buddy Electric is still in business. With Think Global being the first EV manufacturer in Norway, and one of the early movers in the EV sector in general, there was a certain amount of national pride associated with it and may have had a role in catalysing a consumer switch to EVs in Norway.[12] The incentives offered by the national government have helped to build off this initial push, and now a growing infrastructure that supports an easy transition to EVs has helped to sustain it.

As of the end of 2013, Norway has approximately 3 770 public charging points at roughly 110 different charging stations. Of these, 70 are quick-charging stations, at which an EV can be charged up to 80% capacity within 20-30 minutes. Ease of access to charging stations goes a long way to addressing the "range anxiety" associated with EVs—the fear that the car's battery will not last long enough to complete a journey before reaching a charging point.

Transnova, a government agency formed with the express purpose of overcoming institutional and practical barriers to climate measures in transport, funded a data collection project on the charging points in order to increase their overall user-friendliness.[13] Transnova collaborated with the Norwegian Electric Vehicle Association to create the Nobil Charging Station Database, which is publicly owned and accessible. Its accessibility allows private citizens, businesses, NGOs and other organisations to both contribute to the database and build services using the data system. These services include apps or websites showing, for example, the type of charging stations, its availability, the number of charging points and its exact location. In addition, all new cars entering the Norwegian market can access information on available charging stations from their in-car GPS system.[14] This participatory database works to solve problems of convenience, while simultaneously contributing to the normalisation of EVs: the more people participate in the data collection and service creation, the more information about EVs is disseminated and the

INCENTIVE	SWEDEN	DENMARK	NORWAY
Estimated number of EVs	1 300	1 500	15 000
EVs per 10 000 inhabitants	1	3	30
Direct subsidy	✔		
Registration fee eliminated		✔	
Annual vehicle tax exemption	✔		
Purchase tax exemption			✔
Exemption from VAT			✔
Exemption from toll charges			✔
Exemption from congestion charges	✔*		
Free/cheaper parking (in select municipalities)	✔*	✔*	✔*
Free access to bus lanes			✔
Free charging			✔*

* Only in certain municipalities

more EVs become accepted in everyday society.

Challenges

Numerous barriers to implementation exist which must be overcome by municipalities in the Öresund Region in order to successfully introduce EVs to the private market:

1. Perceptions of higher prices;
2. Lack of necessity to change technology;
3. Lack of infrastructure;
4. Lack of public acceptance;
5. Pre-existing behaviour and perceptions;
6. Range anxiety;
7. Obsolescence anxiety;
8. Cold Nordic winter; and
9. Low regional accessibility.

The price of EVs poses one of the biggest obstacles to the expansion of EVs in the region, but economic incentives may aid in overcoming this barrier. Consumers also may not feel compelled to switch to EVs, as the price is so much higher than comparable internal combustion vehicles. One of the reasons for this is that consumers tend to look mostly at initial investment and not at the operating costs for a vehicle over its lifespan.[8,11,12]

The lack of infrastructure for EVs poses a major perceived obstacle. Viable locations for electric car chargers or battery switching stations must be located close to electricity sources in order to minimise energy transport. Homes may be ideal for personal charging points, however, purchase and installation costs of charging stations may be a barrier. Public charging stations are also crucial, however, property owners would need to be convinced to allow charging stations to be installed. In this way, municipalities can help promote EVs by building up the charging infrastructure available to the public. Access to charging stations should not be seen as a major obstacle because over short distances, EVs are not more complicated than cars running on other fuel.

The lack of public acceptance of EVs also poses a barrier, as EVs are not yet common in the Öresund Region. As will be seen in the car-sharing example below, when consumers are more familiar with EVs, they are more likely to purchase one in the future. It is also difficult to change the behaviour when a social norm is already ingrained into society. Currently, ICE vehicles and their infrastructure are the societal norm, and this perception is difficult to change. Anxieties over the range that the car can physically travel may also deter new consumers from purchasing EVs. Underestimating EVs' capacities and overestimating one's own needs can be major psychological barriers that need to be overcome. Anxiety of obsolescence may also act as a barrier, as consumers may worry about the potential for EV technology to advance quickly: if they purchase an EV too early, the technology may become obsolete before they have fully utilised their investment.[15]

The cold Nordic winter may also pose a problem as batteries that operate in harsh climates require more energy and are less efficient.[16] A final barrier involves the current lack of visibility of EVs outside of cities and an overall low regional accessibility. EVs would need to spread outside of the Swedish and Danish cities in order to fully meet the demands on the countries in reaching their emission goals.

Opportunities

Although there are barriers to the implementation of electric vehicles, numerous potential solutions also exist that municipalities can enact to encourage consumers to switch to EVs. An increased emphasis on car-sharing of electric vehicles as well as various political, economic, and social strategies can aid in increasing EV ownership in the region.

Car-Sharing: Incentives

As an alternative to owning an EV, a shift towards the services that cars provide could be beneficial. In order to achieve goals of carbon neutrality, using cars more efficiently through car-sharing programmes, rather than only focusing on EV ownership, should also be considered. Regional car-sharing businesses that include EVs or focus only on EVs can make these cars more accessible to broader groups of society. Ideas can be drawn from projects already implemented (e.g. in a car-sharing business in Gothenburg) where EVs are partially rented by companies that can use them as advertising space, increasing both the visibility of the ad and the visibility of the car. Such initiatives are crucial to increase the visibility and accessibility of EVs, but they need to take place now when the share of EVs still has high potential to increase. In these circumstances, businesses can find niche markets and promote better transportation at the same time. Strategies are not limited to businesses alone; for example, municipalities that have EVs in their fleets could consider car-sharing programmes with these cars after business hours.[17]

Car-sharing offers a method of introducing society to electric vehicles. Rate of adoption theory points to five main factors that influence an innovation's adoption and diffusion into popular society. These include relative advantage, compatibility, complexity or simplicity, trialability, and observability.[18] EV car-sharing fleets address many of these aspects, and as such offer a possible direction for municipalities to take in terms of encouraging a general transition to EVs. For example, car-sharing addresses the two main concerns associated with EVs, the cost of the cars and range-anxiety. With car-sharing, the cost of the vehicle itself is no longer a major barrier for consumers, and because car-sharing organisations can ensure that consumers will always get fully- or adequately charged vehicles for their expressed needs, range anxiety diminishes as well. These points address the compatibility and simplicity factors mentioned above as the car fits easily into the consumer's life and can be suited to the consumer's exact needs.

Increasing the trialability is also an important factor when it comes to EV car-sharing fleets. According to an employee with the Swedish EV car-sharing company, Move About, consumers surveyed after three months of membership in the car-sharing programme stated that they would be more likely to buy an EV in the future, after having driven EVs as part of the car-sharing fleet.[11] Car-sharing gives consumers a low-risk way to try an EV, which is important in increasing consumer willingness to accept an innovation like an EV.

Car-sharing also increases the observability of EVs. Personal cars are generally parked for the majority of their use phase, and therefore are only visible on the roads for very limited periods of time. EVs as part of car-sharing fleets are used by multiple customers throughout the course of the day, and as such are highly visible to other potential consumers. This increase of visibility can have a large impact on the normalisation of EVs and can therefore contribute to higher rates of adoption among private consumers.

Having charging stations in easily accessible areas is important for decreasing range anxiety. Oslo, 2013.

Recommendations

Based on the findings, there are several actions that municipalities could take to increase the percentage of EVs owned or used by private consumers. The feasibility of implementation of each recommendation will vary depending on the municipality, but each municipality can identify the areas in which they will have most potential.

1. Invest in charging infrastructure (especially fast charging infrastructure);
2. Increase visibility of existing EVs;
3. Familiarise potential customers to EVs through test driving;
4. Public private partnerships;
5. Low emissions zones;
6. Off-peak pricing to allow cheaper charging at night; and
7. Mobility as part of new energy plans.

Increasing the number of charging points and services around them can have a significant impact on addressing range anxiety and thus improve the public's perception of the simplicity of owning an EV (e.g. Nobil charging station database).[14] In places where slow charging is already accessible, a transition to fast charging might be necessary in order to make charging more time efficient and attractive.

Also, if more municipalities allowed free EV parking in visible areas, promoted EV car-sharing programmes, and/or transition the government-owned vehicle fleet to EVs (like Lund), this could increase the overall visibility of EVs in public spaces. As a component of familiarisation programmes, EV awareness events such as EV rallies, car-sharing initiatives, and test driving can be effective projects (e.g. Danish EV Promotion Programme).[16]

Further, public-private partnerships such as making municipality-owned EVs accessible to private individuals after work hours can overcome accessibility barriers and increase EV use efficiency.[17] In many cities, low emission zones have already been established where only low-emitting vehicles, such as EVs or hybrids, are allowed to circulate. Examples can be found e.g. in Lund, Malmö and Copenhagen.[19]

In addition to this, off-peak pricing can have the dual benefit of encouraging consumers to choose EVs because of the opportunity for low cost charging at night, but can also serve to address potential issues with increased electricity demand that the municipality's energy system may not be able to handle.[20] Since an increase in the number of EVs could have could have an impact on the energy system of a municipality, incorporating considerations of e-mobility in new energy plans could be important to ensure adequate electrical supply at the necessary times.

Conclusion

The potential for an increase in EV ownership in the Öresund Region is relatively high given the infrastructure and programmes that are already in place. Many incentives that are perceived as significant are given by the national governments and cannot be adjusted on a municipal level. What municipalities can do is increase those incentives that make sense in the given municipalities. Options and capacities may vary, but municipalities can examine opportunities such as providing parking and car-sharing solutions, investing in charging stations, generally collaborating with local energy suppliers and businesses, and adopting EVs for municipal car fleets. Such measure can change public perception and discourse around the barriers for implementation of EVs and help the Öresund Region in its transition from fossil fuel cars.

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ROLL MODELS

Environmental Leadership with Electric Vehicles in Malmö

By Umashree Pancholy, Martin Petrushevski & Masahiro Suzuki

The transportation sector is one of the biggest consumers of fossil fuels and produces a significant proportion of greenhouse gas (GHGs) emissions. Recently a number of measures have been taken in the energy, transport and building sectors to increase the awareness of citizens in relation to the climate effects of GHGs, and of what can be done to reduce emissions. In 2009, the Swedish Government approved a target for the Swedish vehicle fleet to become fossil fuel independent by 2030.

The increase of battery electric vehicles (EVs) in the government fleet could offer a potential pathway to meeting this objective. EVs have the advantage of reducing average vehicle energy consumption and CO_2 emissions. The scope of this report, therefore, is to draw a comparison between environmental impacts of EVs and internal combustion vehicles (ICEs), by analysing criteria focused on air and noise pollution, and illustrate the health benefits of transportation emission reduction. Costs of EVs and essential city infrastructure are not considered in this research.

Policy

Malmö is perceived as a front-runner for environmental practices in Sweden. The city of Malmö has shown great strides when it comes to meeting targets, implementing environmental policies, and achieving reductions.[1] Malmö has achieved this through high public awareness, strong local political support and by utilising EU funding programmes. The political support is a crucial factor in this matter since the city not only has short-term targets, but also holds a long-term vision for the sustainable development of the city.[2]

In the year 2009, the Malmö City Council adopted the Environmental Programme for Malmö 2009-2020.[3] This set ambitious targets for reducing GHG emissions by 40% in 2020, as compared to the levels in 1990. The city's energy usage should consist of 100% renewable energy sources by 2020 in order to reduce dependence on fossil fuels. Realising that the users of clean vehicles need an encouraging push to adopt such steps and make policies successful, Malmö also implemented a number of financial, administrative and communication policies.[3]

The city set up its own environmental program for both cargo and passenger vehicles. By the end of 2015, all the city's administration vehicles should be classified as cleaner vehicles EVs, plug-in-hybrids, hybrids (HEV), vehicles driven on biogas or ethanol, and petrol and diesel vehicles that have no more than 120 g CO_2/km tailpipe emissions. In total 75% of these clean vehicles should run on biogas, hydrogen or electricity (including plug-in-hybrids).[1]

Environmental Factors

Air Quality

Malmö's environmental department is responsible for measuring and monitoring the city's environmental quality. The city has two types of measuring stations: stationary stations and mobile vehicles. Air quality data is published on a regular basis through monthly and annual reports on Malmö's website (Malmö.se). According to the organisation, one of the difficulties they are facing is to measure the efforts made towards achieving sustainable urban development, calculate the reductions in Malmö's carbon footprint, and present results in terms of the improvement of environmental quality and human health.

Emission Levels

Air pollution affects human health negatively, also contributes to vegetation degradation, and creates problems on local and global scales, such as: climate change, acidification of ecosystems, eutrophication and ozone depletion.[3,4] The effects of reduced air quality from traffic pollution can be seen strongly in urban areas. For example, the city of Malmö is where public health is most affected. Particulate matter (PM), nitrogen oxides and carbon monoxide are particles emitted into the atmosphere during fuel combustion that contribute to air pollution.[5]

Nitrogen oxides and hydrocarbons form ground level ozone, or smog, in a chemical reaction under the influence of sunlight. The traffic sector is the biggest source of ozone in urban environments. High concentrations of these gases can cause pulmonary and respiratory related health problems on human population, acidification and eutrophication on ecosystems, and contribute to further increase the rate of climate change.

Measuring air quality started in Dalaplan, a residential area of Malmö, in 2005 and since the lowest level of CO emissions has been noted in 2012. Nitrogen oxide emissions have also been decreasing annually, and 2012 had an average of 16 mg/m^3, which is approximately 60% less than the local environmental quality targets and 20% below the national environmental quality standards.

Trends in reduction have also been seen for sulphur dioxide and PM emissions. The decreasing tendency has been mainly attributed to governmental efforts for reduction of traffic congestion and aims to reach local and national environmental targets. The steady annual increase in procurement of "green cars" in the city is an effect of these aims, and has contributed in reducing air pollutant emissions.[6]

Municipal Car Park

According to data from November 2013 from the Swedish Statistics Office, the city of Malmö has registered 10 558 cars in total. From that amount, 10 011 are conventional combustion vehicles (petrol and diesel) and only eleven are EVs.[7]

As stated by Malmö's environmental department, their municipal car park has a total of 888 vehicles, from which seven are run on electricity.[6] Most commonly used conventional combustion vehicles are Ford Focus, VW Eco-UP!, VW Touran TSI, VW Caddy Skåp and Toyota Yaris.[6] All seven EVs are Mitsubishi i-MiEV's. Vehicles used to transport personnel in groups have been excluded in the table below.

FUEL TYPE	NUMBER OF CARS	TOTAL CO_2 g/km	AVG CO_2 g/km
Petrol	152	16030	105
Diesel	133	18832	142
Electric	7	0 (13.4)*	0 (1.92)*
Ethanol	141	24053	171
Gas	9	1362	151
Gas/Petrol	385	61568	160

Types of vehicles in Malmö's municipal car park and their CO_2 emissions (November 2013)

*Indirect emissions by consuming electricity in Sweden by EV (Mitsubishi i-MiEV)

Performance Comparisons

This study compares the environmental impacts of noise and emissions between fuel combustion vehicles and fully electric vehicles. The emissions analysis includes CO_2 and air pollutants from the exhaust gases such as nitrogen oxides, PM, and volatile organic compounds (VOC). Mitsubishi i-MiEV, an EV model of which seven units have been purchased by the Malmö municipality, is used in this analysis for comparing the emission level with ICEs.

Emissions and Fuels Consumption

The transportation sector is one of the biggest emitters of CO_2 in Malmö with a share of 471 474 tonnes/year/km^2 in 2011.[8] According to the Swedish Environmental Protection Agency, passenger cars alone account for approximately 70% of emissions within this sector.[8] Malmö's fleet is dominated by gasoline and diesel ICEs (approx. 95%), however, the increase in share of alternative energy production and fuels, supported with the current Swedish energy mix, can provide significant GHG reduction potential in the transportation sector.[7,9] According to IEA, in 2013 the energy mix for Sweden was dominated by hydro (44%) and nuclear (40%). A well-to-wheel based analysis, based on primary electricity production source, was utilised for this research paper to see environmental performance for vehicles which run on hydrogen, electricity, biogas and compressed natural gas.[9]

EVs do not emit GHGs in their use phase.[6] However, substantial emissions are being produced during electricity production at the power generating facilities. A study conducted in Switzerland compared the environmental performance of ICEs and EVs on a well-to-wheel basis and determined the amount of GHG emissions for their life cycle use phase. Results obtained from this research support the policy for implementation of low emission EVs over ICEs in Malmö's municipal car park. For example, the study shows that regardless of the origin of the electricity (renewable or nonrenewable), EVs outperform internal combustion, HEV and PH-ICEV gas vehicles with a significantly lower energy demand (MJ/km) and lower level of GHG emissions (g $CO_{2\text{-eq}}$/km).

The benefits of EVs in Sweden may be even greater than seen in the Swiss study due to Sweden's low carbon electricity production methods. According to the Mitsubishi Motor Corporation, a Mitsubishi i-MiEV consumes 0.09 kWh when driven for one kilometer.[11] Since CO_2 emissions per kWh from electricity generations in Sweden are calculated as 22 g in the latest research of IEA, the amount of CO_2 emitted to run a Mitsubishi i-MiEV per km can be estimated as 0.09 x 22 = 1.98 g.

Healthcare Benefits

The European Commission sets emission standards for vehicles due to their impacts on the health of citizens, crop yields and the environment. The types of emissions regulated include NOx, PM and VOCs. In particular, the transport sector is estimated as responsible for more than 40% of emissions of NOx and nearly 40% of primary $PM_{2.5}$ emissions.[5] These pollutants can cause severe impacts on health, such as respiratory disease, cardiovascular disease, and lung cancer.[5]

In 2001, the Clean Air for Europe (CAFE) Program was launched with an aim "to develop, collect and validate scientific information on the effects of air pollution".[12] One of the outcomes of the programme was a cost-benefit analysis of mitigation measures for each pollutant in the respective countries of the European Union. According to CAFE, mitigation of NOx would save EUR 5 900 per tonne and $PM_{2.5}$ up to EUR 34 000 per tonne in Sweden.[13]

The figure below shows the amount of NOx, $PM_{2.5}$ and VOCs released from cars in 2011 in Malmö, and the total damage/potential benefit of these pollutants to human health and crop yields when reduced per tonne.

The estimate suggests that there are potential benefits accounting for over EUR 4 500 000 in total when all the four pollutants are eliminated. The reduction potential and its subsequent benefits by EV introduction can be significantly influenced by the type of electricity generation. However, a country like Sweden where the air pollutants per kWh are low due to its energy production techniques would likely experience a marked return in environmental, social and economic benefits.

Life Cycle Emissions

Life Cycle Emissions (LCE) are all the GHG emissions associated with the production, use and disposal of a product. It is important to consider the emissions during production and after the use phase of a product, especially when it is not the use phase that accounts for a large part of the total emissions related to a product. As opposed to ICEs, where the use phase accounts for more than 80% of the total GHG throughout its life cycle, almost half of the emissions associated with EVs is generated during its production phase.[14] This is mainly due to the high environmental load of production of batteries, which is one of the most important components of EVs.

Ricard AEA, a London-based international consultancy specialised in energy and environment, states that the life cycle emissions of EVs are less than half of the total emissions generated by ICEs.[14] In their analysis, the average LCE of EVs emits 136 g of CO_2 per km, whereas estimates range as high as 265g per km in the case of ICEs. Ricard AEA also projects that the LCE of EVs can be reduced to 16g per

POLLUTANT	AMOUNT tonne/year	MARGINAL DAMAGE (per tonne)	POTENTIAL BENEFITS in TOTAL	POTENTIAL BENEFITS of MUNICIPALITY*
NOx	580	5 900	€ 3 422 000	€ 287 814
$PM_{2.5}$	11.5	34 000	€ 391 000	€ 32 866
VOCs	780	980	€ 764 400	€ 64 291
			Total. € 4 577 450	Total. € 384 971

Air Pollutants and Potential Benefits in Malmo and Benefits Potentially Brought by the Change in Municipality's Car Use

*Calculation is based on the assumption that all present municipal cars are replaced by EVs km, due to the expected development of car batteries in the future.

Noise

Noise is an important element when considering environmental impacts related to cars. In this case, there are two major sources of noise while driving: engines and tires. Hybrid vehicles and EVs produce less noise compared to conventional vehicles. A study conducted by the Netherlands National Institute for Public Health and the Environment (RIVM), shows that there is a significant difference in noise level up to 10 decibel between the cars, when driving at speeds less than 20 km per hour. When driven faster than 50 km per hour, the difference in noise level reduces as driving speed gets faster and becomes almost the same. This is because noise from tires becomes dominant while moving at this speed.[15]

Concerns exist that reduced engine and tire noise in EVs may increase car accidents with pedestrians. Those issues have been raised in relation to concerns for people with limited eyesight and relevant social organisations. In order to determine the appropriateness for setting a noise standard for car manufacturers, countries and regions including the United States, Japan and the European Union have been conducting studies to analyse the correlation between noise and car accidents with pedestrians.[16,17,18] The Japanese Ministry of Land, Infrastructure, Transport and Tourism imposed a guideline in 2011 for the automobile industry requiring the installation of warning sound systems which get automatically activated while driving at low speeds of less than 20 km per hour.[19]

Case Study: London

Greater understanding of domestic travel demands, relevant stakeholder engagement and careful aligning of policies can further accelerate the implementation process of EVs. The city of London provides an insightful example.

Similar to Malmö, London also has ambitious environmental targets. The city aims to reduce GHGs by 60% by 2025, as compared to the level of 1990, in order to meet the United Kingdom's national climate target. Hence, by reducing the GHG emissions, London's government aims to provide an improved living environment to its citizens. The main political instrument for achieving the target is the introduction of EVs and promotion of car-sharing among the public. A rebate of up to 25%, equivalent to GBP 5 000 (EUR 5 983), can be offered when purchasing an EV in London.[20] In addition, the Greater London Authority is planning to replace their car fleet with 1 000 EVs by 2015, as to further accelerate the deployment of EVs and develop its essential infrastructure in the city.[21]

A study conducted by Transport for London provides interesting data on travel demands of the public. Results of this study show that 40% of Londoners travel by car on a daily basis and the average travel time is 16.4 minutes per day, accounting for travel distance of 2.4 km. The research also points out that only 5% of car users travel more than 75 km per day and more than 95% of the people are within the range of what can be travelled by one full charge of today's average electric vehicle.[22] In addition, the data has been utilised by the city for communicating the feasibility and importance of car-sharing and EVs to the citizens of London.

This case study addresses the importance of having a greater understanding of the transportation demand among its citizens for EV policy introduction. A further research on travel patterns of the residents in Malmö can bring benefits in improving the public acceptance of introducing EVs, thus accelerate the transition towards greener transport in the city.

Conclusion

This research concludes that EVs have more environmental and health benefits than ICEs. EVs are also found as more energy-efficient than vehicles with internal combustion engines and hybrid vehicles. Criticisms also address that EVs are responsible for large amount of CO_2 during their production stage due to the high environmental load of its battery. However, life cycle emissions of CO_2 from EVs are estimated as less than half of the total emissions generated by ICEs. With regard to society's perspective on noise levels, there is a significant difference between noise levels generated by EVs and combustion vehicles. The difference between the two types of cars can be up to 10 decibels when driven at a speed less than 20 km per hour. As for impacts on health, EVs can help reduce emissions of pollutants including PM, NOx and VOCs, which will in turn create marked benefits for the citizens in Malmö. Even though there are barriers to implementation, the introduction of EVs for municipality personnel will not only bring benefits to the city, but also deliver encouragement for Malmö to accelerate the transition towards greener transportation.

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BUILDING DIALOGUES

Recommendations for Energy Focus in Buildings

By Tim Cycyota, Qing Miao & Emily Nilson

The Energi Öresund project, comprised of representatives from municipalities, businesses, energy companies, and universities, seeks to implement guidelines for strategic energy planning and energy savings in the region.[1] The Öresund region has set itself the goal of achieving carbon neutrality within 15-20 years.[2] Since the urban areas of Öresund are rapidly expanding, energy efficiency in new urban development has been put as a top priority by Öresund regional municipalities as a key factor to fulfilling this goal.

According to the existing development plan of the Copenhagen municipality, during the next 25 years there will be approximately 45 000 new buildings[3] (commercial and residential), while in the county of Skåne in Sweden new dwelling areas have been increasing since 2011.[2] Buildings, given their long life cycle and high use, play a crucial role in overall energy efficiency and energy saving strategies. However, it seems that the current urban planning process is still facing several barriers to reach the expected successful implementation.

The European Union has set up a series of policies supporting sustainable development in urban areas. The most important is the Directive 2010/31/EC on the energy performance of buildings. It provides a methodological framework for the calculation of integrated energy performance of buildings and standards for new buildings, as well as energy certification for buildings or building units. The Directive also set up an ambitious requirement that all new buildings are to be near-zero energy buildings from 31 December 2020.[4]

Background

The guidelines set forth by Energi Öresund put a focus on energy use and savings in all stages of the urban planning process. This includes energy consumption of buildings, energy and resource flows in urban areas, transport and

BARRIERS FOR ENERGY SAVINGS THROUGH URBAN PLANNING[2]	
Acceptance	• Risk aversion in decision making among building developers • Energy efficiency as low priority in decision making
Motivation	• Lack of consumer demand • Broken agency: benefits that result from energy efficiency investments (e.g. lower energy bills) are reaped by the end-user and not the investor • Uncertainty in planning and regulation • Lack of enforcement regulation
Practical	• End-user behaviour • Lack of learning as a result of project-based work • Skill gaps in building contractors and subcontractors

waste management.[1] This paper focuses in particular on guidelines related to reducing energy consumption in buildings, though general lessons may be drawn for all parts of the urban planning process.

The construction process for a building may be divided into several stages: planning & design, construction and operation.[1] The Energi Öresund guidelines note that the complex requirements for energy use in a particular building as well as mistaken assumptions for use or construction may have a negative effect on a building's energy use and greenhouse gas emissions overall.[1] To that end, the guidelines make recommendations for reducing complexity and mistaken assumptions. These include, broadly:

- Establishment of targets for reducing total energy consumption from the beginning of the building process;
- Optimisation of daylight and artificial lighting conditions during design;
- Separation of different energy uses in the building for monitoring, including heating and operational electricity;
- Measurement of the quality of energy-saving measures before and after the building is placed in service;
- Evaluation of lifetime building costs and inclusion into cost-benefit analyses;
- Coordination and communication between phases and operators in the building process; and
- Examination of how different construction methods can influence energy consumption during the design stage.[1]

Recommendations

Below is a number of general and technical recommendations that may add value to the existing Energi Öresund guidelines. These recommendations are divided into four categories: 1) planning, design and calculation; 2) building process; 3) building use and occupation and 4) collaboration and communication.

Plans, Designs & Calculations

Systems approach – When designing and constructing a building, it is important to look at the building and the energy-using devices within it as an entire system. Using a systems approach to building (rather than the conventional building process) is a key component of greatly reducing energy use at low costs, as energy savings at the system level are often much higher than energy savings at the device level.[5]

Building codes – Increasingly stricter building codes can greatly impact energy efficiency in buildings. Denmark is a key example of this: over the past 40 years, building codes have been gradually tightened to the point where the energy requirements are considered some of the strictest in the world. This has been a clear tool to encourage an increasingly higher energy standard in Denmark's buildings. Despite this success, this method is often better in theory than in practice as it can be rather contentious. Even in Denmark, where it worked well for the past few decades, recent developments have been lacking and there have been difficulties furthering the improvements.[6] Regardless, making building codes stricter can have a clear impact on energy efficiency in buildings, as municipalities, builders and occupants are essentially forced to adhere to the standards.

Certifications – Similarly, mandatory green building certifications (e.g. LEED or Passive House) can also greatly impact energy efficiency in buildings. As a start, certifications could be deemed mandatory for all new municipal or commercial buildings. This forces building design and construction firms to develop expertise in green building techniques in order to remain competitive.[5] Although it is important to note that this, too, is often easier in theory than it is in practice.

Measuring methodology – The development or use of a tool similar to United Nations Environment Programme's Common Carbon

Metric could be beneficial to the region both as a clear way of measuring energy use in buildings and as a basis of comparison as the global use of the metric increases. The Common Carbon Metric was launched at COP-15 in 2010. The metric aims to measure, report and verify reductions in energy use in the building sector, as well as provide a foundation for consistency and comparability in energy reporting.[7,8] Öresund's use of this metric or similar would allow for a common measuring and reporting scheme for performance comparisons within and outside of the region.

Energy modelling throughout the design process – Energy modelling can be used to evaluate a number of building characteristics, including orientation, glazing percentage, mechanical systems, and can be used throughout the design process to ensure an integrated approach.[9] This recommendation is consistent with the existing Energi Öresund guideline regarding measurement of energy-savings before and after the building is placed in service.[1]

Other technical recommendations – While a number of technical recommendations appeared in previous versions of the Energi Öresund guidelines, two additional recommendations are worth mentioning: emphasising the importance of the building envelope and the use of windbreak shrubs and trees. The building envelope is the main frame of the building – the main structures and components (e.g. insulation) that separate the interior from the exterior. Focusing on a high-performance building envelope at the beginning of the building design phase can greatly reduce the need (or even eliminate altogether) for mechanical systems while also minimising heating and cooling loads. An emphasis on designing an exemplary building envelope can completely alter the rest of the building processes and systems.[5] Additionally, in a previous version of the Energi Öresund guidelines, it was noted that wind conditions can "influence energy performance more than expected".[10] Because of this, and because many areas with the Öresund region are known for wind, it would be beneficial to recommend the use of windbreak shrubs and trees around buildings to reduce variation in energy performance.[11]

Building Process

Detailed specifications – Leading up to and during the construction phase, it is crucial to have detailed and properly documented specifications. This can eliminate the need for on-site decisions. Building specifications are drawn with the building system in mind – a change in one system will inevitably have impacts on all other systems connected to it. Eliminating the need for on-site decisions can greatly reduce the risk of altering a building's planned energy efficiency.[11]

Mandatory commissioning – Additionally, mandatory commissioning is an important element of maintaining energy efficiency throughout the building process. Commissioning is a process of systematically checking the proper installation and operation of building systems and components. Commissioning can identify problems that, if left unfixed, would increase energy use by 20% or more.[5] Mandating commissioning on all building projects in the Öresund region could be an important tool in identifying and fixing problems before they escalate.

Building Use & Occupation

Building use and occupation considerations must be included in the Energi Öresund guidelines, as the use phase accounts for approximately 80-90% of a building's energy-related emissions.[7] Building users have a tremendous impact on a building's energy use and steps must be taken to educate building occupants on what they can do to minimise their impact. This can be done through mandatory education and awareness for all building occupants, involvement of occupants in building energy issues, and implementing direct occupant payment for energy use.

Occupant education and involvement – Mr. Nielsen, Head of Technology and Service at Lundafastigheter, the municipal building management company in Lund, discussed a pilot programme that is currently being done within Lund municipality to involve and educate building occupants about energy use. This programme aims to help tenants visualise energy consumption in their building, its current state, and how it relates to the overall energy goals for the building that have been set by Lundafastigheter.[12] While this is certainly a step in the right direction for involving building occupants in energy consumption, it does not allow tenants to see their own individual impact. Having a system in which tenants can explicitly see how their own actions impact the building's energy use could be a potential next step in this concept.

Direct energy payment – Furthermore, direct occupant payment for energy use can lead to proper incentives to reduce energy consumption on an individual level. It reduces the "split incentives" that come about when energy-saving actions have no impact on energy prices paid.[13] Mr. Nielsen noted that this is a recent development within Lundafastigheter buildings.[12]

Collaboration

Beyond all technical and procedural solutions for reducing energy use in the building process, consistent collaboration and communication among all relevant actors is essential. The sharing of information, expertise, and responsibility between municipalities, planners, builders, operators, and tenants allows consideration of the full picture of a building's life cycle, as well as present potentially innovative solutions for saving energy.

Integrated Design Process – Building processes seeking to focus on energy savings can benefit from the application of an Integrated Design Process (IDP). An IDP may be differentiated broadly from conventional building design processes through active dialogue between engineers, designers, and developers early and often in the planning process, with the architect generally serving as a facilitator and team leader as opposed to a single decision maker.[14] Choosing to focus on reducing energy use in the case of the Energi Öresund guidelines already gives such a process a clear goal, a crucial component of an IDP. Establishment of a structured framework for discussion and appointment of a design facilitator are thus the components of an IDP requiring action by specific actors.[15] Facilitators should offer the mental space for team members to bring their own areas of expertise towards the goal of energy reduction while keeping all aspects of the building design in focus. Not only a clear structure but also the expectation of active engagement with a project team are crucial for an IDP, which may be encouraged through careful explanation and increased experience with using such a design model.[16] While the application of IDP to green buildings in general is still a relatively new phenomenon, a 2012 Danish study found that in two separate building cases, the application of IDP to the building design (in one case, IDP was actively required by the developer as a condition of bidding for the design) improved the overall effectiveness of applying sustainability principles to the building.[17] Incorporation of IDP practices into the guidelines could serve as a useful measure for actors seeking a system for improving their own collaboration practices in the Öresund region.

Contest models – Contest models of building construction also have potential for improving communication and collaboration in the design and operation of buildings. By giving designers and contractors a short window of time to develop a building's design with selection based on criteria promoting energy savings, constant iteration and improvement of design strategies through intense collaboration becomes the necessity for securing a contract. Such an example may be seen in Seattle, where the construction contract for a US Army Corps of Engineers was tied to specific performance goals, including an accelerated design-build competition. Participants in the bidding for the contract demonstrated "an unprecedented level of integration among the team throughout the design and construction process," resulting in a final design for the building that more than exceeded the energy performance goals for the building.[9] Municipalities and developers in the Öresund region could benefit greatly from the implementation of such a system due to the increased collaboration and communication necessary between designers and engineers in order to win contracts, spurring innovation and greater appreciation for the integration of an energy focus into all parts of the design process.

Conclusion

The current Energi Öresund guidelines for focusing on energy use in all stages of the building process have the potential to greatly impact the energy efficiency of construction projects in the region. Through a combination of technical and procedural solutions, stakeholders in the building process may come together for better planning, design, and construction. However, it is worth noting that in order for these solutions to be successful, stakeholders must demonstrate an interest and a commitment to reducing energy use, as well as understand how better collaboration and communication may lead to this reduction. Securing these commitments must be an essential strategy for Energi Öresund moving forward with the implementation of these guidelines.

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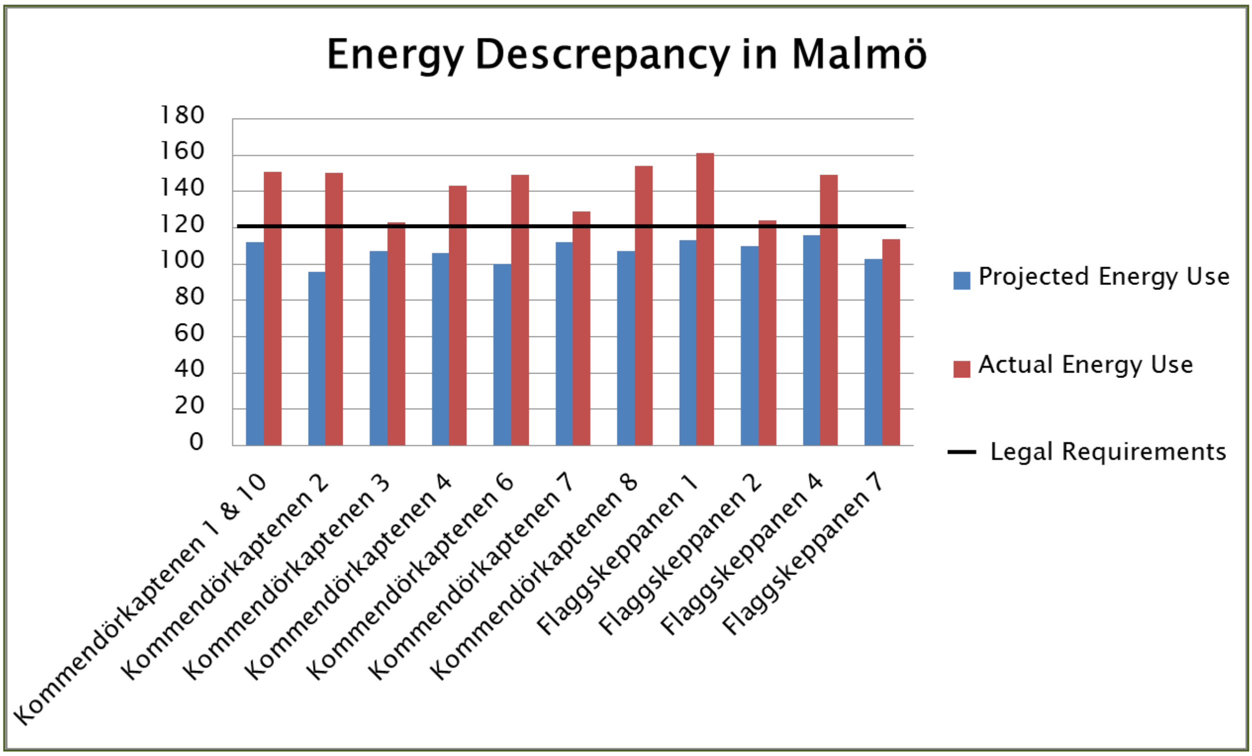
DEALING WITH THE ENERGY GAP

Reducing the discrepancy between planned and actual energy usage in buildings

By Boris Kupchik, Chih-Ching Lan & Aaron Perry

Prior to a building's construction, a detailed projection of the energy use of that building is performed. These calculations include the expected heat and hot water use in the building, but not tenant electricity use. A 2010 report has identified that there is a discrepancy between these projections and the actual performance of many new buildings built in Sweden, and it is likely there is a similar situation in Denmark.[1] While several possible reasons for this discrepancy have been identified, more information is required to establish the causes of this energy gap in specific buildings.[2] To complicate matters, different laws between Sweden and Denmark means there is different data on projected and actual energy performance available in each country, with Sweden having more accessible data that Denmark.

This gap is an area of concern for a number of stakeholders in this field, and is an area of active research.[3] We have examined some of the laws and literature surrounding these issues, and have interviewed a number of interested parties for their insights. From this we have identified three areas that warrant further atten-



While the projected energy use for all of these buildings is below the legal limit, the actual energy use is higher than the projection and in most cases higher than the legal limit. Adapted from Kjellman et al. 2010.

tion and should be considered in future guidelines or recommendations. The first deals with how projections are made prior to the construction process, and attempt to prevent the discrepancy from occurring in the first place. The last two deal with fixing the energy gap after a building has been built by clearly stating who is responsible for conducting, or paying for an energy audit, and by establishing incentives for both owners and developers to ensure both that an audit is performed, and buildings are built to the agreed upon specifications.

Background Legislation

European Union Directive

The building sector, which includes both residential and commercial buildings, accounts for 40% of energy consumption in the European Union (EU). For this reason, reducing energy use in this sector is a primary goal in achieving the EU's "20-20-20" targets to reduce greenhouse gas emissions, raise renewable energy share, and improve energy efficiency all by 20%. Directive 2010/31/EU on the energy performance of buildings, also known as the Energy Performance of Buildings Directive (EPBD), aims at promoting guiding principles for Member States regarding improvement of building energy efficiency. This Directive encompasses methodology for calculating the energy performance of buildings, setting minimum requirements, defining and setting targets for nearly zero-energy buildings, creating financial incentives and market barriers, as well as establishing a system for energy performance certificates.[4]

Specifically the Directive states that Member States shall adopt a methodology for calculation of energy use in buildings, taking into account thermal characteristics, heating insulation, hot water supply, air conditioning, built-in lighting installations, and indoor climatic conditions. Along with this methodology for calculation, minimum energy performance requirements need to be established for both new buildings and existing buildings. In addition, the Directive states that Member States shall provide instruments to promote the improvement of energy performance and set up a system for energy performance certification. Lastly, regular inspection of heating and air conditioning system needs to be put in place.[4]

Swedish Legislation

In Sweden, the implementation of the EPBD is carried out by several government agencies including the National Board of Housing, Building and Planning, the Swedish Energy Agency, and the Ministry of Enterprise, Energy and Communication. The building code in Sweden is divided into three climatic zones each with different energy performance requirements, especially for heating. The Öresund region falls in South zone. The Swedish building regulations are based on measured energy consumption value for heating, hot water, cooling, and auxiliary energy. The table below lists the current energy requirements for

Maximum allowed bought energy use per area heated to 10 °C [kWh/m²]		
	Residential buildings	**Non-residential buildings**
Other heating source	**90**	**80**
Electrical heating	**55**	**55**
Maximum installed electrical power for heating [kW]		
	Residential buildings	**Non-residential buildings**
	4.5	**4.5**

buildings in South Sweden.[5] Unlike Denmark, municipalities do not regulate the how the energy performance calculations are done, only that the projected building energy use meets the standards. The municipalities do follow the building project development process by performing two compliance checks, during and after the construction phase. The first is an asset rating, done during the construction phase. The second is verification of the building's energy performance during the second heating season of the building. Property owners or their representatives are responsible for providing the energy performance of the building to the municipality (usually the heat/energy billing statements). In addition an energy declaration must be done for all new buildings and whenever a building is sold (if the sale is after 10 years of the last declaration). This is supposed to be carried out by an independent energy expert, at the expense of the owner.[6] During the course of our interviews it was suggested that some of the information provided in the initial reporting of the building's energy performance can be improved upon, and that there is some conflict between developers and building owners over who should pay for these and more detailed energy audits.[7]

Danish Legislation

In Denmark, the implementation of the EPBD is fulfilled by the Danish Energy Agency, and the Danish National Agency of Enterprise and Construction. The energy performance requirements are in the Danish Building Regulations (BR10). Currently, the minimum energy frame requirements in the BR10 are:

- >52.5 + 1,650 / A [kWh/m^2. year] for residential buildings, and
- >71.3 + 1,650 / A [kWh/m^2. year] for non-residential buildings.

The way in which the energy performance calculations are done are tightly regulated, and can be found in the BR10 and in a publication by the Danish Research Institute.[8] These calculations need to be performed and audited by a certified energy consultant for accuracy before a building permit is issued. As this law must comply with the EU EPBD the calculation must include energy used for hot water, heating, cooling, ventilation as well as electricity for fans, pumps and lighting (lighting is only calculated in non-residential building)[9]. Other than the requirements for the energy performance projections (no requirements in Sweden versus strict requirements in Denmark), the biggest difference in laws between the two countries is that unlike Sweden, Denmark does not require a follow-up on the building's energy use after it has been constructed.

Planning Recommendations

There are very clear benefits to making changes to the planning process of building a new building, most notably to prevent the gap from occurring in the first place. The chapter "Energy Focus in Buildings" goes into more detail, listing some of the specific best practices of energy efficient planning and construction. Our focus for this section is to examine some of the existing standards that companies can follow to help ensure an accurate estimate of a building's energy performance. As explained earlier Denmark has a structured procedure that all companies must follow for calculating the energy performance of buildings. Therefore the goal here is to highlight some of Swedish methodologies for calculating and verifying energy performance that have arisen in the absence of direct government intervention, and to recommend a minor addition to these standards.

Swedish Methodologies and Standards

SVEBY - Standardisera och verifiera energiprestanda for byggnader (Standardisation and verification of the building's energy performance)

According to SVEBY documents, the goal of the framework is to avoid future conflict in energy performance verification between the contractor and the developer.[10] The actual verification analysis is done in three steps: identify the actual energy consumption of the building, identify reasons for the discrepancy, and describe how a more accurate calculation could be done. SVEBY requires different kinds of input documents: system documents (information about subsystems, functional requirements, data about standardised tenant, etc.), construction documents (results of monitoring, tests and updated energy calculations) and real operational documents (information about real tenants' behaviour, data collected after 12 or more months). Moreover, a significant part of the SVEBY framework is dedicated to measuring and verifying the energy use requirements. For example, the framework states that uncertainty of heat meters should not be higher than 3% and in case of electricity meters - not higher than 5%, and if an electrical installation's consumption is higher than 3 kWh/m^2 then a separate meter should be used.

ByggaE is a methodology for quality assurance that tries to ensure that new construction of energy efficient buildings will meet their functional requirements. This project was funded by the Swedish construction industry, a programme for construction of low-energy buildings, a zero emission interest group, and the Västra Götaland region. The ByggaE methodology is based on mapping and structuring all energy documentation and data from the buildings planning stage and construction process. The objective of the ByggaE method is to remove any information shortage from the construction process.[11] The documentation is organised in into groups: general and summary documents, planning documentation, supporting documentation of the design stage, design documentation, supporting documentation of the construction stage, construction documentation, control documentation, management documentation. ByggaE is a rather new standard, and thus some refinement is still necessary, including identifying what parts of the methodology are mandatory and what are recommended.

SCNH - Sveriges Centrum för Nollenergihus (Swedish centre for zero-energy)

The framework developed by SCNH is dedicated to passive houses, net zero buildings and buildings with a very low energy consumption. It lays a clear, mathematical, definition of all these terms. For example, the sum of a Passive house's delivered balanced energy must be less or equal to the total amount of energy delivered to that building during the year. A weighting factor is provided for different types of energy:

Energy balanced= 2.5* (Electricity delivered - Electricity produced) + (Delivered energy- - Produced energy) + 0.8 * (Delivered heat - Produced heat) + 0.4 (Delivered cooling - Produced cooling) <=0

The SCNH guideline includes concrete data for electricity and energy consumption limits, heat loss limits, noise level from the houses' heating, cooling and ventilation systems in different types of buildings, such as sport centres, schools, retail shops, etc. Measurement instructions are also provided by the SCNH guideline. As a result the SCNH guideline is a well-structured standard, which provides useful technical recommendations for the construction companies on what results in energy consumption could be reached and what specific technical parameters should be considered in order to meet all the energy requirements.[12]

Our recommendations

We believe that these frameworks are reasonable and practically guidelines and that encouraging the more widespread use of any of these guidelines will help to reduce the energy gap.

The only disadvantage of these guidelines is that they are all rather new (only 1 or 2 years old) and their actual effectiveness and the benefits they provide can only be fully known after several years of use. For Sweden we believe there is no need to establish state-level guidelines, and Denmark may want to watch some of the developments in the programs to improve their own. That being said through interviews it also became clear a national guideline on the energy use of different types of commercial and public building could be useful. Similar to SCNH, such a guideline should consider different types of building uses, because residential houses, blocks of flats, offices and industrial buildings all have different energy consumption requirements. Therefore different assumptions in energy planning should be applied. A national guideline for all various building types would give developers a good base on which to start their calculations.

Post-Construction Recommendations

Our recommendations for guidelines dealing with building energy use after construction has been completed are broken into two sections: improving measurements and data availability and creating incentives for stakeholders in this field. Given Swedish reporting requirements, there is much more data available for Sweden than for Denmark and much of our analysis is based on the Swedish example. However, we believe that these recommendations can be useful for both countries.

Improving Measurements and Energy Audits

As stated previously, there is a lack of publically available data on Danish building performance; however the quality of the Swedish data also leaves much to be desired for many stakeholders. For instance when building owners report their energy usage after two years they typically submit the information from their energy bill. While this is enough to identify if a gap between planned and actual energy use exists, it is not enough to determine the cause of the gap. In order to gain this additional insight a more extensive energy audit should be performed. However, there is a conflict over who should pay for the audit and the type of audit that should be performed. Developers would like more information on the performance of the buildings that they construct (to assess their performance and to better their processes), ideally in the form of an audit conducted according to the specifications in the standards that they followed (see planning recommendations section). Building owners are responsible for submitting a more detailed energy declaration; however they receive no personal benefit from this and have no incentive to pay for a more detailed audit than is required by law. Currently, in some cases the cost of the more extensive audits is split between the owners and the developers, however this is not ideal.

A possible solution could be a two stage process for assigning responsibility for the audit. The owner of the building should provide energy data from his energy bills to the municipality as required by law. If a significant discrepancy was identified then the owner should pay for the energy audit recommend by the municipality. If the developer would like a more detailed audit they should pay for the difference in price. Should it turn out that the primary cause of the discrepancy was the fault of the developer, the municipality should compel the developer to cover some of the owner's costs from the audit.

Establishing Proper Incentives

One of the EnergiÖresund draft guidelines (2013) for dealing with the gap between calculated and actual energy usage is to give municipalities the ability to fine developers or require them to improve underperforming buildings.

As stated previously, one of the reasons that building owners seem to be reluctant to pay for a full energy audit to determine the cause of the energy inefficiency is that they receive no direct benefits from the results. By enabling municipalities to compel these fixes, building owners now have an incentive to invest the additional money necessary required to perform an audit, in the event that a gross discrepancy is discovered from their initial reporting. The audit should be able to determine if the developer is at fault and therefore responsible for the improvements, or if the fault lies with the building owners and tenants, in which case the municipality can advise the owners on the steps they can take to reduce their energy consumption.

Once enough information about new building performance is collected, a public list of company performance should be made available as part of a campaign to raise awareness of both the discrepancy between planned and actual energy usage, but also of the benefits of energy efficiency in general. The EU's goal in the EPBD of having all new buildings be nearly "zero-energy" by 2020 should be part of this campaign. In addition, during our interviews it was recommended that a positive incentive be built into the system for developers, one that would encourage companies to do better and reward well performing companies. One suggestion would be preferential terms when bidding on public contracts for those that agree to build extremely energy efficient buildings (Skanska Interview).

Conclusions

This discrepancy between the projected energy performance of new buildings and their actual performance is a serious problem that needs to be corrected. We acknowledge that our recommendations are not detailed or ground breaking, but we have tried to identify ideas and recommendations that can be applied and used in the Öresund region now. There are other, more detailed reports that will be published in the coming years that will provide a more technical understanding of this problem, and that will allow for more detailed guidelines to be created. However, for now, raising the visibility of the issue, publicising the tools that can be used to mitigate the problem, acquiring more data, and creating the correct incentives developers and building owners will help to shift the behaviour of stakeholders to one in which this problem is conscious thought of in planning and carefully monitored throughout the process by all involved.

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TOO HOT TO HANDLE

Hot Water Connected Appliances: A Game Changer for District Heating in Low Energy Areas?

By Matteo de Besi, Benedict Omare & Saurabh Saraf

District heating (DH) is already well established in certain areas of the Öresund region. Whether an area is connected to DH or not depends primarily on the density of the population, the age of the constructions, the energy demand, and the distance from the district heating supplier.[1,2,3,4] However, in recent years the development of district heating has slowed as a result of an increase in new energy-efficient building areas which have a reduced heat load when compared to conventional building areas and reduced the need for district heating.[5] This paper seeks to study if Hot Water Connected (HWC) appliances can justify DH connection in such low energy districts. These appliances differ from conventional ones as they use heat from DH network to heat process water or air, thereby offering electricity savings and heat load increases. This study combines inputs from literature review and interviews of professionals and academics working in this sector.

Background

DH has seen a number of improvements with the technology progressing from first generation, second generation, third generation to fourth generation. The generational changes are marked by changes in material use and improvements in energy efficiency, reduced energy losses and a reduction in the amount of energy needed to produce heat.[1] DH plants have also allowed the cogeneration of heat and electricity through Combined Heat and Power (CHP) which has resulted in higher efficiency and energy recovery. More recently, HWC appliances that are connected to DH are being tested with positive results with regards to reduction in electricity consumption.

DH has played an important role in reducing greenhouse gas emissions and energy recovery from industrial waste heat and incinerated municipal waste. Mr. Zinko, a consultant with ZW Energiteknik AB, Sweden remarked that in Sweden they try to utilise maximum waste heat from the pulp and paper industry.[4] With the emergence of ultra-energy efficient housing with as much as 90% energy savings, the future of DH companies is at threat and efforts are needed to identify alternative uses that could retain DH functions so that the benefits from DH continue to be enjoyed and further savings made.

Despite an expansion of low energy buildings and introduction of energy efficient appliances, the use of electricity has increased. Sweden for example has had an increase from 9 TWh to 20 TWh between 1970 and 2010.[6] This can be explained by a growing number of households and domestic appliances.

HWC appliances provide an interesting alternative use that could potentially play a dual role of reducing electricity need and increasing the heat load so as to make DH connection to energy-efficient housing viable. A study on application of HWCs in Solbjer, Sweden showed that their application can reduce the total electricity use in Solbjer by 10% and climate impacts by 50-80%.[10]

In further sections we have identified a number of common household appliances that traditionally operate on electricity but now have the possibility of using heat from DH. An analysis will be carried out to determine whether these HWC appliances have the capacity to increase the heat load to justify connection to DH and whether HWC offer significant energy savings. The findings of this paper will hopefully feed into the energy guidelines being developed by Energi Öresund so as to provide guidance to municipalities that are considering connecting low energy districts to DH.

Our analysis has taken into consideration the different country-specific contextual factors that would affect the feasibility of connecting DH to low energy district and the use of HWC appliances. These factors are summarised in the table below.

The table captures some differences in between Sweden and Denmark. A major difference is the obligatory DH connection in Denmark, while it is not the same in Sweden. Swedish household electricity prices are lower than Danish prices, which is a reason why using individual heat pumps in Sweden can be more cost-effective.[7] The reasons for the above are electricity production from nuclear and hydro in Sweden. In Denmark on the contrary, major amount of electricity is produced from coal, which makes usage of heat from their CHP plants an important issue. Another difference was in technical characteristics of the systems in both countries. In Sweden DH is fed at temperatures of around 70 – 120 ºC and existing regulations prevent further lowering of temperature. In Denmark, it is fed at temperatures as low as 40 ºC.[1]

Alternative Uses of DH

The following section lists the different ways in which the DH infrastructure can be utilised, apart from its main function of heating houses. Although the focus of this report is on using the DH for feeding appliances in low energy areas; these alternatives are worth mentioning, especially because in our research they came as important factors in support of using the DH.

Substituting Electricity with Heat

The emergence of hot water-fed and heat-fed appliances in applications such as dish washing, drying and clothes washing have the potential of increasing the utility of DH and thus retain the demand for DH services for low energy districts. Though the total consumption of these devices is negligible when compared with energy requirements needed for space heating, the devices do reduce electricity consumption, make use of waste heat provided through DH systems, and offer other gains such as time saving.[10]

In Sweden, there is a company called ASKO that is selling HWC appliances such as dishwashers, dryers, and washing machines.[3,11]

In addition, DH can be used to provide floor

Country	DH obligation	DH Feed temperature	Average DH prices (EUR/GJ)[8]	Electricity 2011 (EUR/kWh)[9]	Electricity sources 2011	Citizens Served by DH (2011)
Sweden	No	70 – 120 ºC	20.63	0.204	Hydro: 44.8% Nuclear: 39.6% Other renewable (excluding wind): 7.6%	48%
Denmark	Yes	55 ºC	27.8	0.298	Fossil fuels: 65.8% Wind: 26.8% Other renewable: 7.2%	61%

heating which are also installed in passive houses for families that desire extra comfort.[12]

District Cooling

The use of DH for district cooling has been applied for cooling in some countries such as Finland which is made possible by the combination of DH with absorption cooling units.[13] This is important because it allows DH infrastructure to be used during summer when heating requirements are normally low and thus allows the maintenance of a stable heat load during the year for the DH infrastructure.

This approach is, however, not typical or common in Scandinavia because often, the possibility to use water sources for cooling exist.[1]

Stockholm, for example, is using deep lake water cooling instead of compressor driven cooling.[3]

In addition, due to the relatively short summers in the region, there is not much heat load to justify the economic costs for district cooling except for high density places like offices and hospitals.[4]

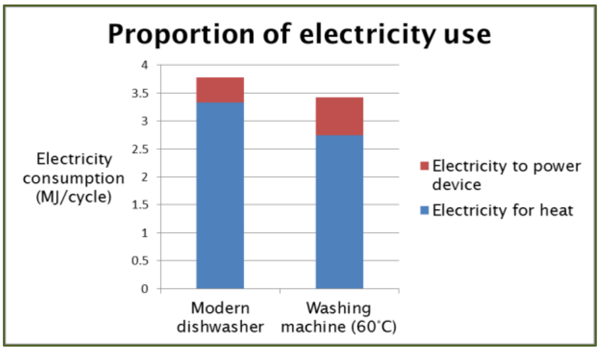
Advantages of Using HWC

Increased Heat Load

According to Swedish 2010 data, detached houses consumed about 36 TWh of which 16 TWh was for electricity for domestic heating (space heating and domestic hot water production) at a price of SEK 145 öre/kWh (EUR 16 cents/kWh) of electricity. The same houses consumed 20 TWh for domestic electricity at a price of SEK 185 öre/kWh (EUR 21 cents/kWh) of electricity.

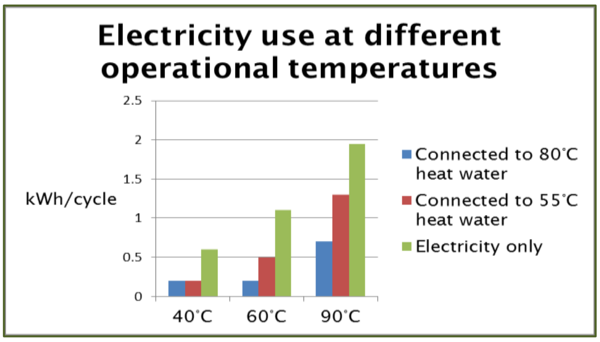
The potential for household use to increase the heat load is said to be symbolic and not very large.[14] Indeed a study, found that the combined heat load for 220 cycles of 1 300 000 dishwashers and 200 cycle of 2 100 000 washing machines corresponded to 2.5 PJ (0.7 TWh) which is approximately 3.5% of the total domestic electricity used in Sweden.[15]

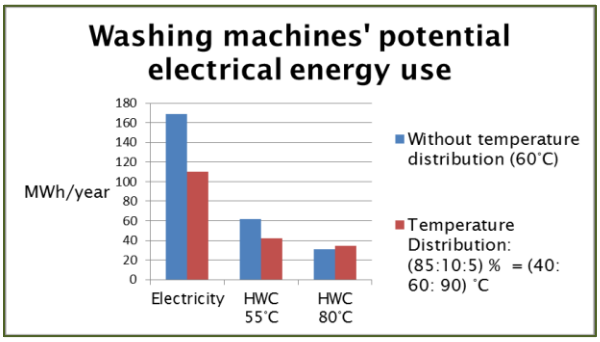
Modern machines are increasingly becoming both energy and water efficient but the major part of the energy demand is used to heat the machines, crockery and the clothes rather than on heating water as shown in the following figure.[15] Other studies have shown that significant electricity savings can be achieved by using heat.[10,16]



The price of electricity has been steadily rising in Denmark & Sweden, compared to district heating. If the trend continues in the future, then connecting to DH may offer potential savings.

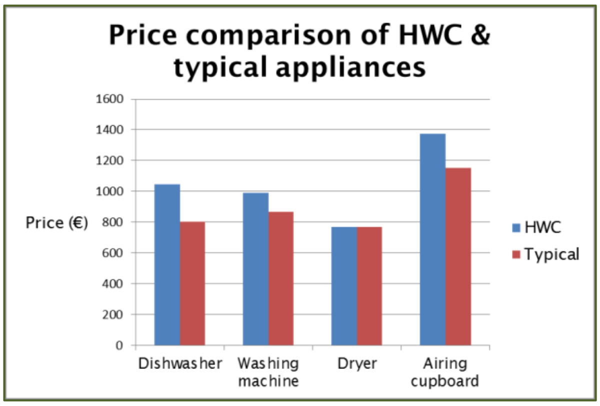
It must be noted, however, that the potential energy savings are related to the temperature of the DH incoming water with more gain from devices connected to water with higher temperature as shown in the following figures which show differences between machines that are only connected to electricity and those that are heat-fed.[15]





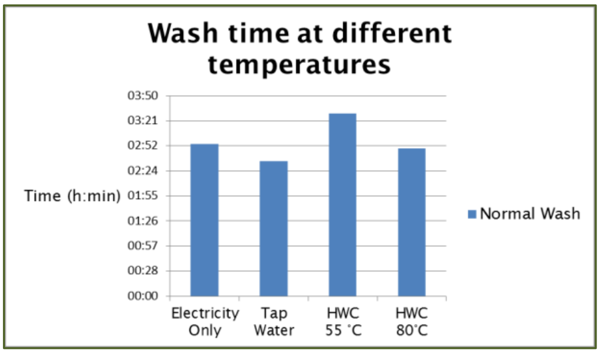
Cost Savings

Whereas the price of DH in Sweden has remained relatively constant between 1996 and 2011, the price of competing energy sources such as electricity, oil, gas oil and natural gas have been increasing.[6] Domestic electricity prices for detached houses have seen the largest increase in price over the same duration and if trends remain the same, HWC may be a viable option to cut down on costs for households when expensive electricity is substituted with less expensive DH in some household appliances.



Time Savings

It is argued that HWC appliances have the potential to save cleaning time as the time needed to heat water is reduced.[10] However, modern devices are using less amounts of water and therefore, only limited time savings are made. Using values for the Asko D5654 SOF HWC dishwasher model, when it is both heat water connected and tap water connected, we see that the time differences are not very significant.



Limitations

When it comes to using DH in low energy buildings the type of DH which is used today will not be the same as what we expect to use in the future. The delivery temperature of the heat pipes in particularly is likely to be lower.[5] The DH network in Denmark and Sweden has a mix of three pipe types classified as first, second and third generation which deliver heat at different temperatures. Currently third generation pipes are able to deliver heat at the lowest temperature; ranging from 55-100 °C.[1] In the future however, if fourth generation district heating is successfully developed, delivery temperatures could be lower than 50 °C.

This expected future decrease in the feed temperature of district heating could have an effect on whether connecting HWC appliances is advisable. The amount of electricity used by HWC appliances depends on the quality of the incoming hot water; the higher the temperature of the water, the greater the electricity savings will be.[10] However, for all Asko HWC machines a minimum input temperature of 55 °C is recommended if electricity savings are to be worthwhile. If the input temperature is lower than 55 °C, the machines will require more electricity to reach the required washing temperature which would result in negligible electricity savings.[10]

An additional limitation to HWC appliances is high installation costs. As a result of the added complexity of the HWC appliances, installation costs are higher compared to traditional appliances; this is due to the need for plumbers for installation.[15] The added costs could be problematic when installing HWC appliances in single household buildings or as a retrofit project in existing housing, however, in new buildings containing common laundry rooms, the investment costs are similar to conventional appliances.[15]

Factors for Connection

As seen from the previous sections the decision to connect or not to connect new, low energy district areas to the heating network is highly context-dependent. There are a number of key factors that can be taken into consideration by the municipalities prior to making a decision; these factors could have a significant influence on ensuring that the benefits of extending the DH network outweigh the costs. These are:

1. The proximity of the housing area to an existing DH network – The location of the new housing area is extremely important. If it is built close to an existing DH network then connection costs would be considerably lower compared to if it were to be built further away.[4]

2. The availability of an energy source that can provide heat to a DH network – The proximity of cheap heat is also important. Using waste heat from industry and municipal waste plants, or using geothermal heat can lower the costs of the DH.[17] District heating from waste heat can be cheaper than other energy sources which could help make installation of DH economically feasible.[2] The proximity of the housing area to such a source would also need to be considered as this can influence the costs.

I/S Kraftvarmeværk Thisted is testing concentrated solar power for district heating.

3. The cost of electricity – If the regional cost of electricity is high, then DH could prove to be a low cost alternative.[4] High energy prices could incentivise adaptation to cheaper DH. The source of the heat would also need to be considered as this will influence its cost.
4. The availability of alternative technologies – There is some documented evidence of using solar collectors for community heating, at the same time it has been discussed that it is more efficient to use excess wind power (combined with heat pumps) for heating rather than storing in batteries.[1,18,19] The viability of DH should also be studied based on these alternatives. Needless to say, that some low energy houses (passive) may not even benefit from a DH connection.
5. Temperature of incoming DH water – as demonstrated in previous sections, temperatures of incoming DH water must be at least 55 °C for electricity savings to be made.

It is evident that the regional conditions can be influential in determining the economic viability of connecting new housing to the district heating network. This decision depends on many interconnected factors. In the paper we have attempted to show that there are reasons to retain DH in low district areas; mainly that the potential uses as well as benefits that can be attributed to DH plants can significantly con-

tribute to fulfilment of the EU 20 20 20 goals. Additionally, the expected development of fourth generation district heating may allow 50% reduction in heat demands, whilst still retaining the viability of the district heating.[14] This could allow the continued expansion of energy efficient housing areas and district heating together.

Conclusion

It has been suggested that there is no major increase in heat load associated with HWC appliances.[3,4] However, these appliances do contribute to significant savings in electricity. It has been shown that dishwashers and washing machines alone consume 3.5% of the total domestic electricity used in Sweden. The figure will be higher if we consider other devices such as dryers, floor heating, and airing cupboards that can also be heat fed to offset electricity consumption. If a municipality wants to continue to improve the energy efficiency of new districts, then a connection to the DH network combined with the installation of HWC appliances in buildings may be beneficial. This decision to connect new building areas to the district heating network should not solely be justified by the use of the HWC appliances.

Hence, a decision to connect new housing areas to DH should be supported by a thorough context specific analysis of the area. Specific guidelines could be established in conducting such an analysis. The analysis could include gathering information regarding the aforementioned criteria. These guidelines could be incorporated into the overall Energi Öresund guidelines for municipalities.

However, with HWC appliances, significant electricity and emission savings can be realised. Therefore, if the decision of connecting DH to new housing areas has already been made then including HWCs should be seen as a positive step forward towards achieving the EU 20 20 20 goals.

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MANOEUVRE INTO THE FUTURE

The Environmental Impacts of Manure Use in Biogas Production

By Manavi Bhardwaj, Erik Hansen & Elana Hawke

Biogas is becoming a fast growing renewable energy source in Sweden for its uses in generating electricity and producing heat. In addition Sweden is leading the way in upgrading biogas for use as a vehicle fuel.[1] The benefits of biogas over fossil fuels are significant in terms of reduced greenhouse gas (GHG) emissions, which are furthered by the use of manure for biogas. Indirect environmental benefits, such as reduced eutrophication, are also worth highlighting.

The thousands of farms spread across Sweden allow manure to be sourced at the municipal or regional level. In areas where livestock production is concentrated to a relatively small area with many producers and high density of animals, it becomes possible to use manure from several farms in a single biogas system.[2] This has been the case for the Karpalund biogas plant in Kristianstad. In addition to other organic substrates, such as food and slaughterhouse wastes (sewage is excluded as it may be contaminated with pesticides, medicines and heavy metals), the agriculture sector in Kristianstad supplies manure to the plant. The resulting residue of biogas production is available for use as biofertiliser.

Currently, the Karpalund plant uses a mixture of organic substrates including food wastes, slaughterhouse wastes and manure. Around 82% of the biogas produced at the plant is used as a vehicle fuel[3] in the city buses, for municipal car sharing and by other private operators.[4] The municipality of Kristianstad aims to further increase the use of biogas in its transport sector as part of its commitment towards reducing GHG emissions from transport.[4] In addition, using manure would reduce GHG emissions from agriculture, and would further highlight Kristianstad's efforts towards reducing its total GHG emissions as a municipality.[4]

However, the use of manure as substrate for biogas comes with high economic costs for the biogas plant, which opens a discussion for the potential of subsidising the use of manure for biogas. Against the backdrop of the Karpalund biogas plant as a case study, this paper analyses

The Karpalund plant uses manure from local farms to create fuel for local vehicles.

(i) the environmental benefits of using manure, particularly with regard to climate change and its indirect impact on eutrophication in the region, (ii) the key challenges the use of manure brings for biogas production, and (iii) the role of subsidies in addressing these challenges.

Case Study: Karpalund

The Karpalund biogas plant receives a mixture of 35% manure, 30% pre-treated household food waste, 20% slaughterhouse waste, and 15% of other wastes that include feed waste, and industrial, and restaurant food waste (such as expired food, left overs and by products).[3]

A fresh steady flow of wastes enters the plant and is transferred to mixing tanks. The mixing tank allows some residence time for hydrolysis of raw materials and provides a buffer for mixing and even flow of raw materials. Materials of animal origin (e.g. slaughterhouse waste and manure) must be hygienised through heat treatment before they can be digested as per regulations administered by The Swedish Board of Agriculture within Animal By-product Ordinances.[1] This takes place in three small tanks. Decomposition of the substrates by anaerobic bacteria takes place through a two-step process. A part of the decomposition takes place in two big reactors, and the remaining volume flows into a smaller and older reactor. On average the substrates stay in the reactors for 40 days at 38 $^{\circ}$C releasing carbon dioxide and methane as biogas. The methane content of the biogas is approximately 66%. This biogas is sent through pipelines to two upgradation plants, resulting in around 97% methane content.

The by-product from the reactors is stored in a concrete structure till it is delivered by trucks to farms to use as biofertiliser. When the trucks go to deliver biofertiliser they also pick up manure from the farms. Manure is stored by the farmers in tanks that are emptied by the plant once a week. The plant depends on fresh manure (older manure may have undergone methane leakage resulting in lesser biogas). Around 43 GWh of energy is produced a year from 90 million kg/year of substrate. Out of this, around 7% is used to heat the plant, around 82% is used as compressed biogas in vehicles, and the remainder is used in a combined heat and power (CHP) plant.

Use of Manure at the Plant

Manure forms an important substrate for the plant for a number of reasons. The biofertiliser that is delivered to farmers in return for the manure they provide is used locally in Kristianstad, and thus unnecessary transportation costs and emissions can be avoided.[5] Excess biofertiliser is sold to farmers who do not provide manure.

Manure is also believed to make the process of biogas production more stable, since it contains trace elements required by the bacteria. Further, manure acts as a diluting agent, increasing the substrate mix fluidity and its ability to be pumped. The manure at the plant is mostly cow manure (two thirds cow and one third pig manure) and in fluid form. Thus no additional water is needed. Further, in comparison to pig manure, cow manure yields higher nitrogen content fertiliser and has higher biogas potential.[3]

Manure is mixed with other wastes in order to produce biogas, including food waste and slaughterhouse waste.

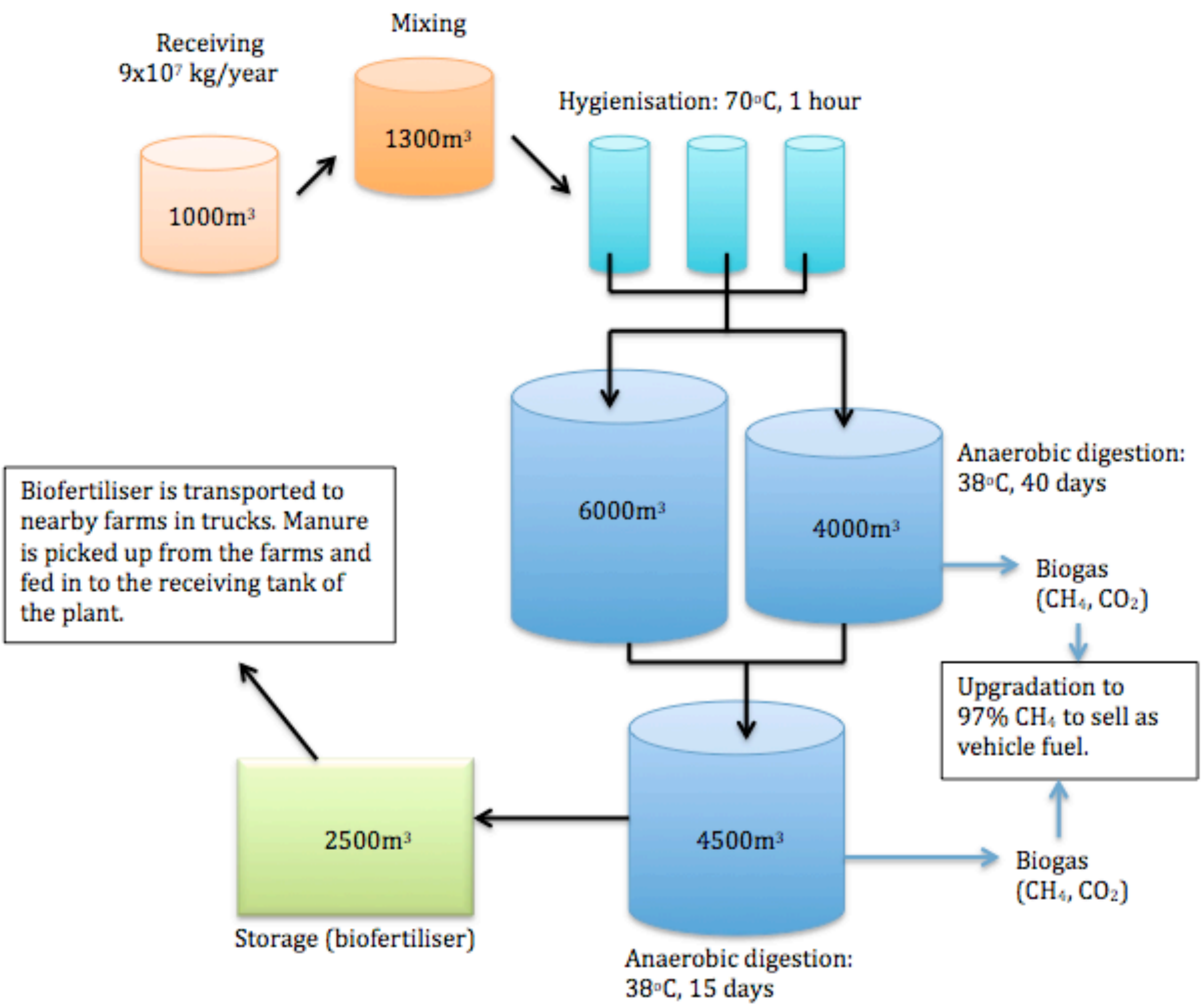
The operations of the Sysav biogas plant at Malmö that will use food waste from the region will begin in the end of 2015, and this will redirect the food waste currently being received by the Karpalund plant to the Sysav plant.[3,6] Sysav is a waste management company operating in southern Skåne. Thus the Karpalund plant will have to seek alternative sources of waste. This creates an opportunity for increasing the use of manure as a potential substrate.

Environmental Benefits

The Intergovernmental Panel for Climate Change (IPPC) outlines that the two leading causes of GHG emissions come from the combustion of fossil fuels, and enteric fermentation and manure management from agricultural livestock.[7] In Sweden the agricultural sector represents more than 10% of national GHG emissions, with the handling of manure representing more than 10% of agricultural emissions.[2]

Manure left on the field to decompose naturally releases two potent greenhouses – methane and nitrous oxide.[8,9] Methane and nitrous oxide have global warming potentials that are 21 times and 310 times, respectively greater than carbon dioxide over a 100-year period.[7] Manure also emits ammonia, volatile organic compounds, hydrogen sulphide and other particulate matter. These air pollutants can be hazardous to animal and human health.[8]

Using manure as a biogas substrate has the potential to significantly reduce the amount of



Process flows and biogas production at the Karpalund biogas plant.

methane, as well as other GHGs released from agriculture (i.e. nitrous oxide, and carbon dioxide). The methane released from manure represents wasted potential energy as well as a pollution source. When manure is used for biogas production this potential energy is captured, and the pollution is significantly reduced. A life cycle assessment (LCA) undertaken by Börjesson *et al.* determined that the use of biogas from manure instead of fossil fuel use produces a climate benefit of over 148%.[10] The reason that the climate benefit exceeds 100% is due to reduced emissions from agriculture in addition to reduced emissions from decreasing fossil fuel use for energy.

Other organic wastes also offer climate benefits exceeding 100% when used for biogas. Household waste offers climate benefit of 103%, and industrial waste produces a climate benefit of 119%.[10] Assuming that slaughterhouse waste at the Karaplund biogas plant falls under the category of industrial waste, the calculations by Börjesson *et al.* when applied to the context of the plant, reveal a net climate benefit of approximately 125% from the existing substrate mix at the plant.

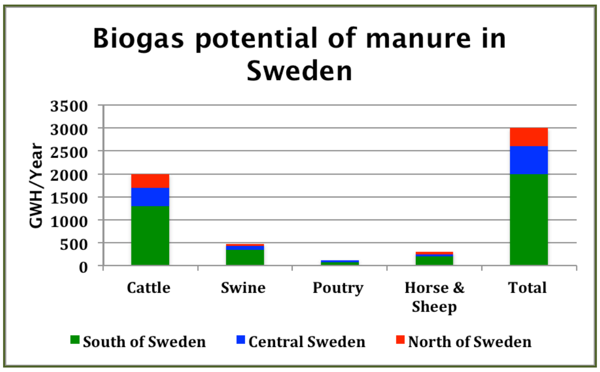
Using the by-product of biogas production as biofertiliser, instead of synthetic fertilisers, produces numerous benefits, most of which can significantly reduce climate change impacts. Biofertiliser is rich in all the essential nutrients (e.g. nitrogen, phosphorous, potassium, calcium and magnesium).[11] Unlike in conventionally handled manure these nutrients are soluble and readily available for plants to utilise. Nutrients in conventionally handled manure are less readily available to be taken up by plant roots, and can consequently leach below the root systems into groundwater systems eventually ending up into surrounding watercourses, leading to eutrophication.[12] In the south of Sweden agricultural run-off ultimately ends up in the Baltic Sea. The Baltic Sea is already highly polluted and suffers from excessive algal growth and low productivity. This is largely attributed to decades of fertiliser runoff. Biofertilisers also have a much lower biological oxygen demand (BOD) than manure. BOD is the, "Chemical procedure for determining how fast biological organisms use up oxygen in a body of water".[13] Low BOD fertilisers are beneficial to the health of the soil.[13]

Further, inorganic fertilisers have high levels of GHG involved in their production thus contributing further to climate change.[11,12] Sweden has potential within its current agricultural system to increase its biogas production from manure. Tufvesson *et al.* estimate this potential to be up to 3 TWh/year, with 85% of this production coming from cattle and swine manure.[2] The research presents that two thirds of this potential would be generated from the southern Skåne region of Sweden. Climate benefits of using manure in the south of Sweden are greater than in the north, in that spontaneous emissions are greater in warmer temperatures of the south.[14]

Challenges

There are economic and logistical challenges associated with using manure as a biogas substrate in Sweden. Arguably, the biggest barriers are economic in nature.

The use of manure comes with high economic



In Sweden manure provides the largest climate benefits in its southern part, with cattle manure offering the highest biogas potential in comparison to other manure types. Used with permission from Tufvesson et al. 2013.

costs for the biogas plant – its high water content makes it a heavy substrate to transport, and its low biogas potential leads to insufficient yield.[15] The low biogas potential of manure causes it to have thin profit margins under standard conditions. This creates a situation where a given biogas plant can only economically justify sourcing manure from sources very close to the plant itself.[4]

There is a current discussion within the Swedish government for subsidising the use of manure for biogas – this amounts to SEK 0.20 (EUR 0.02) per kWh obtained from manure.[3,15] The effectiveness of this subsidy would depend on who gets the money – the farmers or the biogas plant? There could possibly be various takers for the money, and for manure to be economically viable for the Karpalund plant it would make economic sense for the subsidy to go to the stakeholder that turns manure to methane.

In addition to the economic challenges, there are logistical challenges that come into play when using manure. The major logistical issues facing increasing biogas from manure production are the sourcing of manure, and the distribution of biofertiliser. The bacteria in a biofertiliser digester are sensitive to changes. A biogas plant must have a consistent supply of non-varying substrate if it is going to run properly.[12] This requires biogas plants to make long-term arrangements with suppliers of substrates. An alteration in the supply of manure over the short or long-term may thus prove to be problematic.

A biogas plant must also be able to distribute its biofertiliser. This includes shipping it to farmers, as well as having the farmers demand it. A drop in demand for biofertiliser thus may also create a logistical challenge for the plant.[12]

Opportunities in Challenges

Despite the above-mentioned challenges, there are opportunities with using manure for biogas. The use of manure can be advantageous for a biogas plant relying on a substrate mix as it would minimise or eliminate the need for additional water.[4] In addition, there are logistical benefits for the farmers supplying the manure. The common arrangement biogas plants have with farms is one where the farmer trades their manure for an equal amount of biofertiliser, and as has been discussed, biofertiliser is considered superior to manure as a fertiliser.

Conclusions

Agriculture is the largest emitter of methane in Sweden.[16] Using manure as a biogas substrate will significantly reduce GHG emissions. It is important to note that biogas does not contribute in the same way that fossil fuels do to the greenhouse gas effect, in that biogas does not add carbon to the ecosystem.

There are economic benefits to using manure for biogas. First, there is an international interest in implementing biogas technology. Supporting biogas domestically will create an expertise in the field, and promote the development of technologies.[12] Both of these will be marketable internationally. Second, it promotes the creation of jobs domestically in Sweden. Third, using manure for biogas does not compete with agricultural land, like growing crops for biogas does, but instead enhances it.

However, the use of manure comes with high economic costs for the biogas plant – its high water content makes it a difficult substrate to transport, and its low biogas potential leads to small profit margins. Since the benefit to use manure is based on positive externalities for the biogas plant, subsidies could prove to be an efficient solution to internalise the externalities, making the use of manure economically more viable, and subsequently lead to increased use of manure for biogas.

The Karpalund Plant at Kristianstad could potentially benefit from a subsidy for manure in biogas production. The subsidy may not only help it deal with the economic challenges it is currently experiencing with the use of manure, but also possibly increase the use of manure in its substrate mix, especially given the expected decrease in the food waste input that will be redirected to the Sysav biogas plant in Malmö.

The environmental benefits of using manure for biogas need to be communicated to decision makers so that adequate funding is available in order to realise its full potential.

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Photo of biogas fuelling a car in Kristiandstad. Used with permission from the Karpalund biogas plant.

Photo of cows feeing against the backdrop of the Karpalund biogas plant. Used with permission from the Karpalund biogas plant.

Photo of manure being delivered at the Karpalund biogas plant. Used with permission from the Karpalund biogas plant.

WASTED OPPORTUNITIES

Searching for Waste Management Strategies around the World

By Shu-Yuan Chang, Thor Morante & Haiya Zhang

The Energi Öresund project intends to deal with several aspects of a sustainable, low-impact way of living in the area. It aims to sustain itself with low-energy characteristics and has a focus on the waste management concept that qualifies as an innovative, efficient approach. The initiative defined a set of emerging issues to be addressed in an ideal Waste Management System (WMS), aiming to properly establish functionality between sorting and collection, transportation and final disposal of its waste. These issues are established within the following step-by-step hierarchy:

1. Reduction of waste produced, intended to diminish consumption among residents;
2. Reuse and recycle of the waste; and
3. Waste-to-energy transformation.

With these criteria in mind, we were asked to find applicable proposals of WMS for the region, with focus on cases addressing waste transportation activities. Thus, research led us to a diverse range of case studies from around the world. We started with cities from different continents considered to be 'sustainable' or which have at least been pioneers in several 'green' concepts while developing its infrastructure (i.e. Freiburg, Germany; Malmo, Sweden; etc.). We hoped to find appropriate, effective and innovative practices and technologies which could be of value for Energi Öresund.

Background

When looking up good practices in sustainable cities, we identified three main categories of activities: waste collect, transport and treatment/disposal. Among them, some of the positive examples are:

Sorting and Collection

- Pay-as-you-throw (PAYT) scheme in San Francisco, Taipei, etc.[1]
- Kerbside collection in Rome, Auckland, etc.[2]
- Extended producer responsibility programmes in most cities of Germany and other European countries, as well as Japan.[3,4]

Transportation

- Water Channel system in London.[5]
- ENVAC system in Wembley, UK.[6]

Disposal

- Gasification in New Bedford, Massachusetts, USA[7]
- Thermal depolymerisation in Carthage, Missouri, USA[8]
- Biogas grid injection in Oxfordshire, UK[9,10]

- Mechanical biological treatment system (MBT) in Lübeck, Germany, and Manchester, UK[11]

We realised that waste transportation seemed to be the least dealt-with step. A household-to-disposal-site via garbage trucks system seems to be the recurrent sight. We felt there were two cases qualifying as an innovative approach: Water Channel system and ENVAC.

Usage of water channels: In London's EcoPark, in order to diminish the impact of waste transportation from households to its final disposal and treatment landfill, they are exploring the usage of an adjacent canal for transportation.[5] This would imply waste collecting sites located at diverse points of the canal's route, where civilians would deposit their waste for it to be collected by a water-based transportation system.

This could imply a reduction of the amount of trucks used, their affluence, the emissions of green house gas (GHG), and the energy costs in the comparison between trucks and boats. It is, nevertheless, still a research for feasibility, for there are implications regarding how many collecting sites would be needed, and also regarding the proximity or not of the household to the canal: thus, it wouldn't necessarily be applicable for all citizens.

ENVAC automated system: At Wembley, England, there's a plan to rationalise the way waste is disposed, using the ENVAC system, which implies the use of pipes and tubes that connect the households or exteriors of them to a collection centre.[6] Thus, the sorted waste is vacuumed from the houses at an average speed of 80 km/h -rendering it a quick process-, avoiding the collection of the waste one household at a time or, even in a better case, from a defined set of collection centres. In this case, all the vacuumed waste is collected from a single point for later disposal and treatment, reducing the amount of energy used for transportation of waste regarding fuels of trucks and emissions of GHG. The main problems arising with the system have to do with the costs associated to its implementation and, regarding energy, the amount used for the vacuuming of the waste.

While these cases are positive and efficient within its aims and goals, innovation on a functional, interlinked system was absent. The three-step process of collection, transportation and final disposal was not a linear, consecutive and linked system. In other words, the different WMS may specialise in one step or another, but not in a unified system.

Findings

The overall results of our research, thus, set us with a particular hypothesis:

Waste management solutions in the various sustainable city development projects are not more advanced than what it is considered a 'good standard' in the country addressed. While we observed positive practices and examples in other cities, they are barely innovative solutions on waste prevention and collection, waste transport, and/or waste disposal. In addition, the existing WMS rarely attempt to address managing waste locally, and even less, linking the three practices to work as a linear, concordant scheme.

With help from Prof. Thomas Lindhqvist of

Sorting of recyclable waste by consumers contributes greatly to the effectiveness of a WMS.

IIIEE, this finding was then shared with more than twenty waste management experts from Nordic countries and a few western European countries. We would like to see if they agree with our hypothesis. Six of them answered within the publication deadlines: five of them agreed; the sixth one opposed, nevertheless, did not provide a counter-example.

Conclusions

The Energi Öresund initiative is looking for waste management solutions that address reduction, recycling, waste-to-energy conversion, as well as low-energy waste transport. With these criteria in mind, we started researching into world-known sustainable cities for best practices. We found very common practices implemented in these sustainable cities: source separation, PAYT, and kerbside collection. While they are good examples, they are not really beyond a normal good standard held in the country. Therefore, we extended research list to other less-known cities to look for some innovations.

In other cities, we were able to identify some exciting technologies such as ENVAC system for transferring and sorting household waste, or the MBT system that takes care of sorting and biological treatment after kerbside collection. Some cities attempted to go beyond regular practices. Biogas grid injection is such example.

However, many of these practices are either in testing phase, or require further improvement before being considered by the Öresund region.

At this stage, we formed the hypothesis. To further test, Professor Lindhqvist helped us send out the hypothesis to waste management and city planning professionals. These professionals hold various positions at Stockholm Business Region Development, Extended Producer Responsibility Alliance in Brussels etc. Many of the feedbacks agree with our hypothesis. One disagrees, but could not come up with a strong case to oppose.

Taking this result back to Energy Öresund initiative, we intend to demonstrate that there is tremendous potential for the Öresund region to develop an innovative waste management solution. To truly address the low-energy theme, the waste management system ought to take a wholesome approach, covering collection, transport and treatment aspects. The efforts need to come at the city planning stage in order to achieve a harmonised integrated system.

While taking notes from existing waste management systems from other cities, the project should also keep in mind that there is not yet an example of extraordinary standard and tackles waste management holistically. Therefore, Energi Öresund has the opportunity and potential to create a new system. We would like to provide our research as base examples to innovate. Furthermore, we strongly recommend the Initiative to look into links between collection, transport and treatment. There are much more to be done to achieve optimal waste management at low energy consumption. Lastly, we believe it is important to initiate various city planning stakeholder dialogues at an early

Collection and transportation are the biggest gap in WMSs stage: communication will help set the project objectives clear, and further move on into implementation.

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INTRODUCTION:

Distributed Economies in Öresund

By Francesca Favorini-Csorba & Erik Hansen

The concept of distributed economies is a production approach that focuses on local resources/strength and regional market demand rather than centralized mass production. It physically and culturally links production and consumption, encouraging goods and services to have the context of local populations in mind. This promotes high quality products and services that are well suited to the quality needs and lifestyles of those consuming them.

These economic systems are not meant to exist in isolation. The regions are internally complex, but benefit from connection to surrounding regions and the global system. As a result, an interconnected web is formed, in which the local resources, needs, values, and ecosystems are prioritised within regional nodes, but an active collaboration between nodes ensures that the system as a whole progresses collectively.

In this section of the report, we identify areas of opportunity for the Öresund region that would promote a distributed economic system. From integrated mobility services to a reconceptualization of building design and construction to a plan for energy from algae, this section envisions an Öresund region that is at the forefront of a sustainable future.

Wind farms in Denmark are often fully or partially owned by cooperatives of local farmers.

LAYING THE FOUNDATIONS

Conceptualising Distributed Economies in the Building Sector

By Tim Cycyota, Qing Miao & Emily Nilson

Distributed economy (DE) systems are those where "different innovative development strategies can be pursued in different regions," with "regions" in this context defined loosely as individual units in terms of geography, organisation, or resources.[1] Successful examples of distributed economies are often discussed in industrial contexts, like in Fryslân, an economic region in the North Netherlands where different industries worked in cooperation with municipalities and each other to reduce fossil fuel use and promote renewable energy through exploration of business opportunities involving resource sharing and collaboration.[2] However, building systems may also achieve benefits from the application of a distributed economy model, including increases in building efficiency and a more sustainable sharing of energy generation across communities. This article explores a conceptualisation of a distributed economy model for buildings, including that model's ramifications for energy savings and collaboration within the building system.

DE in Buildings

The building system may be divided into several phases, with each involving different stakeholders. The planning and design phase involves various stakeholders, including municipalities, developers and architects; the construction phase involves contractors and engineers; and the operation phase involves building managers and tenants.[3] Importantly in the context of distributed economies, these different stakeholders use different resources, represent different knowledge bases, and operate on different scales of activity. Thus, these stakeholders may be seen as representing the different "regions" of a distributed economy model.[1]

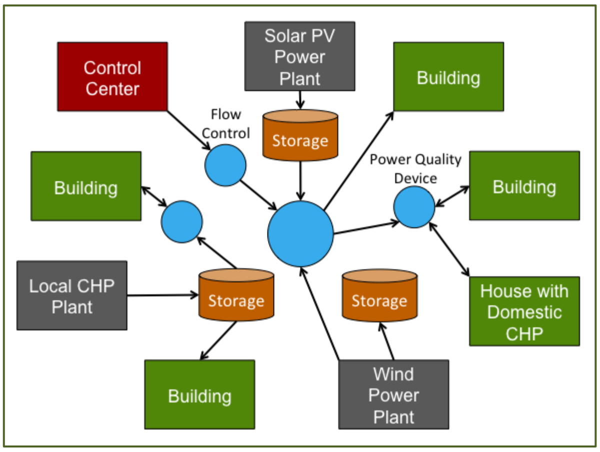
The overall goal of a distributed economy model is to create economic growth that may be experienced on the level of an individual firm or region, while at the same time having the side effect of promoting sustainability and efficiency.[1] These goals are certainly of interest in building systems; as discussed earlier in this report, the Energi Öresund project seeks to reduce energy consumption and associated carbon emissions in the Öresund region while at the same time ensuring stable and sustainable economic growth.[4] A distributed economy model has the advantage of placing an equal weight of responsibility upon all stakeholders involved. The success of a distributed system relies on every individual contributing their own resources and expertise in service to the greater whole, with the interactions between these individuals creating increased productivity and innovation.[1] In addition, distributed economy models, in theory, offer new relationships between producers and consumers, an important consideration for the building system in terms of incentivising building tenants to reduce their energy consumption, and incentivising planners and builders to design more efficient and sustainable buildings.[5] Finally, distributed economy models, in theory, create new balances in inter- and intra-regional exchanges of resources.[1] For the building sector, these resources may be physical (e.g. local sourcing and production of lumber or other building materials), but may also be infrastructural (e.g. energy systems implemented through new building communities) or informational (e.g. knowledge sharing and expertise).

Smart Grids & Buildings

In a distributed economy, the building sector must inevitably be integrated with other systems, particularly the energy system. Buildings, given their long lifecycle and high use, play a crucial role in energy planning. From a technological standpoint, the concept of a "distributed economy" could refer to a "distributed energy system" in urban energy planning, including energy production, conversion, transmission, distribution and consumption.[6] Unlike traditional centralised energy generation centres, like power plants, distributed energy generation aims at utilising local energy sources such as wind, solar and biomass and storing energy locally. Smart grid technology is the predominant factor that determines the efficient use of local energy in a distributed system.[7] It differs from conventional one-way power flow by its electricity networks that intelligently integrate generators and consumers to efficiently deliver electricity.[8] If a distributed energy system were to be introduced into urban planning, local wind and solar energy generation could both fulfil the energy demand and transfer additional energy into the smart grid. Since the smart grid is an interactive system driven by the utilities and customers, it can provide the flexibility needed to integrate variable energy generation like wind and solar.

In addition to renewable energy, cogeneration (combined cooling, power and heat) could also be included in distributed energy systems for buildings. Both local industrial and municipal waste could be used as sources for district electricity generation and heating. In the ideal case, passive house technology could be regarded as one of best examples of distributed energy generation in the building system, with a net grid system gain in terms of electricity, heat and cooling. With closer proximity to energy consumers and smaller unit sizes and more diverse use of local resources, the application of a distributed energy system and local renewable energy source incorporation in the planning and design phase of buildings would significantly improve energy efficiency and utility flexibility, safety and security.

However, building systems may present challenges to the implementation of distributed energy systems. Although distributed energy systems seem to work effectively in networks with smart grid technologies that utilise the local sources, it makes the energy consumption sectors (e.g. blocks of buildings) fragmented. This fragmentation may lead to lack of compatibility between sectors, and requires knowledge sharing and collaboration to overcome.



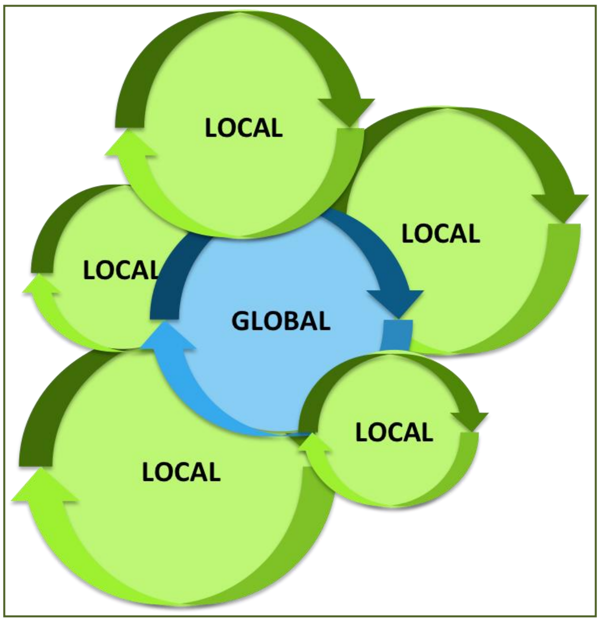
Distributed energy system using smart grid technology. Adapted from Platts 2013.

Knowledge Sharing

Distributed economy models rely on knowledge sharing and collaboration, which are the main drivers for and the power behind the proper functioning of the system.[9] Gradually improving both technological and communicative skills can lead to dramatic changes within society.[1]

Collaboration Mechanisms

Knowledge sharing and collaboration are fundamental to a functioning distributed building system. As termed in literature, knowledge would be shared "glocally," supplemented by both global and local solutions.[9] Knowledge and competence would be generated on both local and global levels and would interact with each other. In a "glocal" setting, local individuals would develop such innovations to benefit their regional situation and transfer that knowledge to other localities and to the global market, where it would be adjusted and refined for application to other regions. For the building sector, this knowledge would be in the form of new energy-saving technologies, new synergies with energy or waste management solutions, new architectural practices, or new forums for intensive collaboration. One example of a new phenomenon in the sustainable building sector is using the "Cradle to Cradle" (C2C) approach developed by William McDonough and Michael Braungart. In this approach, building materials are viewed as assets that either maintain or improve their resource quality over time (rather than being down-cycled in traditional building).[10] There are a number of innovative solutions for C2C products on the market today, including mushroom insulation and tree bark shingle siding.[11] A distributed economy model would provide for a platform in which such ideas can be developed, shared and communicated.



Within this type of system, all building-related stakeholders would be involved.[9] For the building industry, a distributed economy takes the Integrated Design Process (IDP) a step further to include all stakeholders like raw material procurers and building end-users. Additionally, various competencies would join together to form "hubs."[9] In the building industry, each hub would encompass a building-related discipline, like architects, engineers, building managers or municipalities, and would act as knowledge centres for innovative solutions and best practices. A distributed building system would promote both vertical (through the entire building process) and horizontal (through these competency-based hubs) knowledge sharing and collaboration.

Furthermore, a distributed economy system puts decision-making power where it most makes sense. Local decision-makers are allowed more influence on their region and adhering to their specific needs and desires, as they are the most knowledgeable about their specific situation.[9] In a distributed building system, building end users can also exert influence, acting as "suppliers" of ideas and market drivers for innovation.[1] Building end-users are most knowledgeable about their specific needs

"Glocal" knowledge generation and collaboration is a cyclical process. Adapted from Luoma et al. *2011.*

and desires for the buildings they will inhabit, and hence can and should be able to work collaboratively with all others in the distributed building system to achieve their desired goal.

Requirements

While exemplary knowledge sharing and collaboration in a distributed building system seem good in theory, there are a number of things that need to be in place for it to be able to work.

Improved ICTs – Improved information and communication tools underlie a distributed building system.[9] Architects, engineers, municipalities, and all other stakeholders across the world need to have access to each other's ideas and technological innovations. This can be achieved through a robust information technology platform.

Flexibility – Stakeholders in the building industry must be willing and capable of constant learning from internal and external sources and they must possess flexibility in assessing, adapting and implementing new and innovative solutions for their regions.[1]

Open sourcing – Open source innovation would provide for a collaborative platform in which stakeholders can participate in developing and sharing innovative ideas and solutions for the building industry.[9]

Conclusion

In implementing a distributed economy model in the building system, stakeholders not only have the opportunity to improve their energy savings and achieve innovations in areas like waste generation from the building process and maintenance of buildings, but also directly engage with each other, recognising that the entirety of individuals in the building system from suppliers of raw materials to building tenants have a role to play in the creation of a sustainable culture and future.

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GRIDLOCKED

The Transition to Distributed Energy Systems and its Potential Problems

By Boris Kupchik & Aaron Perry

There is a transition in many regions from a centralised power generation scheme to distributed power generation. The use of distributed power generation is not new. In the very early days of electricity production, distributed power generation, with small power plants providing power to the community, was the only option. Thanks to economies of scale much of the world now operates very large power plants which can provide power to a large area.

This relatively recent switch back to distributed generation has been driven in part by deregulation of energy markets, and has some benefits compared to centralised generation. However, the switch from centralised generation to distributed generation may create some issues if not anticipated and dealt with properly. The physical infrastructure that makes up our current power system is designed for centralised generation.

Integrating distributed generation with this system can cause unintended effects such as voltage spikes and do damage to this infrastructure as well as household appliances.[1] While these problems exist, the solutions to these problems are well known, and policy changes and upgrades to systems can help with a smooth transition to distributed generation.

The Generation Dichotomy

The current energy system is a centralised system, where electricity is produced via large scale power stations with a high voltage and distributed over a wide area. These large power stations usually use fossil fuels as an energy source; however, application of the wind and solar farms or other types of renewables is also possible in this classic approach to energy systems design. Electricity from these large scale plants is transported for the long distances at high voltage before being taken down to a lower voltage by transformers for use in customers' homes.[2]

A distributed energy system has many smaller electricity producers, which put their produced electricity into the existing grid. Such an approach creates electricity flow to both the directions (to and from the households). A distributed energy system supports the adoption of small scale renewables, and creates conditions for a more stable energy system. If a single producer goes offline, the others will be able to compensate. In addition, if a large section of the grid goes down islands or pockets of distributed generation will remain powered. In order to transition to a distributed energy system, some new infrastructure and policies are required. On the infrastructure side, energy storage will be necessary as will more advanced switching technology. On the policy side, more complicated metering and energy trading schemes are required in order to measure and adequately bill/pay for the electricity produced and used by different stakeholders.[3]

Transitional Challenges

In theory, a distributed energy system is more stable and sustainable than the classic setup. However, this system is not being constructed in isolation, but on top of the existing centralised power distribution system. Building one system on top of another can create instability in the current system, and problems with power quality. The main issue comes from the fact that the current infrastructure is designed for power flow in one direction, from the producers to the consumers. Too much power flow in the opposite direction can cause unwanted voltage spikes and other damaging reverse power flow effects.

Depending on the current system, meters may also need to be upgraded to deal with the reverse flow. Even potential benefits of a distributed energy system can be dangerous under the old centralised set up.[1] As mentioned before islanding can be useful for communities with distributed generation by providing local power in times of system outage, but it can also be very dangerous to utility working trying to repair the grid during an outage if they are unaware that power is still being generated in part of the system.

Case Study: Australia

Australia is a good case to look at to see some of the problems that can arise in the transition to distributed generation. The government-funded renewable energy programme there led to the rapid adoption of personal solar panels on houses and farms. The amount of renewable energy that was being put on the grid was so great that the reverse power flow effects began to affect power quality. During times of peak generation, voltage spikes were occurring in the system which can damage equipment and household appliances. The solution the utility companies came up with was to limit the number of new permits allowed for household renewable energy installations. While this solution mitigated the power quality issues, it also hinders Australia's renewable energy targets.[4]

Recommendations

Avoiding the issues related to transitioning to distributed generation in the Öresund region will require both policy initiatives and upgrades to physical infrastructure. The initiatives mentioned here are widely applicable. More research is necessary to determine the exact level of vulnerability of the Öresund region to risks outlined above. Clear technical standards for interconnection with the main grid combined with safety rules can prevent some of these issues from occurring, but this may not be enough.

An analysis of the electric grid may reveal that it can only safely handle a certain load from distributed generation before negative effects start to occur. A basic way of dealing with this issue is to do exactly what has been done in the Australia case, limit the number and size of plants that can be hooked up to this grid.[1] This situation is of course not ideal, and may be a step backwards if the plants being hooked up are solar or wind, since one of the goals of the region's energy policy is to increase the share of renewable sources of power on the grid.

In order to increase the capacity for distributed generation on a network, upgrades and reinforcement of weak areas of the network will need to be carried out. This can be done though central planning rather than on a case by case basis for each new installation. Who will pay for these upgrades is still a debated question. In many countries fees are collected as part of the per kWh billing rate to help maintain infrastructure. While there may be a fee to hook up a new installation to the grid, net producers of power will no longer be paying the per kWh rate, leaving the cost of the upgrades and maintenance of the entire system to other users in the system.[1] A new tariff structure may be required depending on the current billing structure of utilities in the Öresund region to deal with this issue. Investments in the network do not need to stop at what is necessary to allow for distributed generation. There are newer technologies, such as intelligent switches and control systems, which can provide greater and better information about the state of the grid, improving further improving its stability and operation.[1]

Conclusions

Distributed generation has numerous benefits including increased efficiency, reduced need for major capital investments (i.e. new major power plants), and enhanced reliability. However, the transition to this system from our current centralised generation model is a potentially rocky road, and with power quality at stake these are not issues to be taken lightly. Failure to adapt physical infrastructure to distributed generation could lead to slower adoption of renewable energies. Cost of the necessary upgrades is still a potential issue, but if done right, the transition to distributed generation may be the first steps towards a next generation smart grid.

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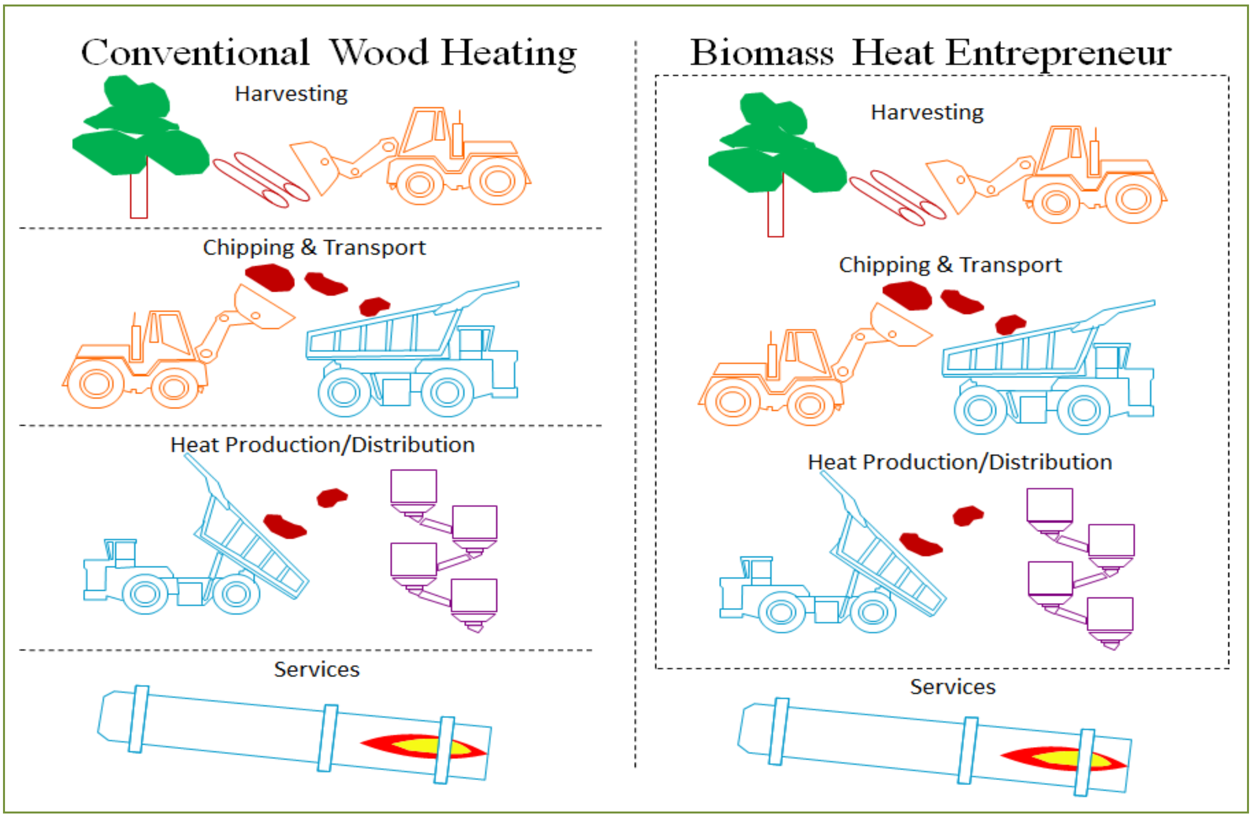
LEAVING THE FOSSIL AGE

Heat Entrepreneurship and District Heating

By Matteo de Besi, Benedict Omare & Saurabh Saraf

Too many jokes, poems, stories, and songs have been written about dinosaurs. The demise of the majestic beasts provides a good allusion to large, well-established organisations that consider themselves "too big to fail" that failure can indeed affect them. Some contemporary examples, like Nokia, show companies that were market leaders previously, but have suffered from the impact of disruptive technologies resulting in a decrease in their share value. These cases highlight the need for evolution and adaptation for the survival of industries.

In the context of District Heating (DH), this sector historically has been governed by local municipalities and has benefitted from incentives (like subsidies and support) for meeting national climate targets and enhancing the economic viability of its operations. Currently however, the challenges to sustaining DH are more visible than ever before. First, high energy efficiency levels have been met at households which have reduced heating needs, and technological progress has made individual heating systems economically viable to the extent that some technologies have made the use



A comparison between conventional heat production and small-scale heat entrepreneurship. In heat entrepreneurship each step occurs within the same community (adapted from Alakangas, 2003) of hot water unnecessary. Despite these imminent challenges, the importance of DH cannot be underestimated in supplying affordable and reliable heat to the community.

However, areas distant to the DH network may have to bear the brunt of the high costs of connecting to DH. It is evident that efforts must be made to ensure that necessary heat is provided at an affordable price to these communities. The development of smaller, self-sufficient, and local systems that are able to offer resilience in heat supply, especially for remote rural communities, can thus be explored to avoid the aforementioned risks. Heat entrepreneurship, which allows the privatisation of heat production and supply, offers the opportunity to develop these resilient heat networks. This paper will explore the concept of heat entrepreneurship, illustrating how its application, which utilises available and affordable technologies, can benefit local communities by generating heat, as well as environmental & employment benefits.

Heat Entrepreneurship

Heat entrepreneurship involves either individual entrepreneurs, or groups of entrepreneurs (cooperatives etc) that invest their resources to develop and run small scale decentralised heat plants. The heat can be generated from locally sourced biomass such as wood and agricultural residue, or from alternative technologies like solar heating or wind. The generated heat is sold to customers in the locality as a comprehensive service per MWh of heat supplied, which includes connection fees, basic fees and user charges. The entrepreneurs are exposed to the economic and technical risks in the operations, however they benefit from full control in decision making.

Heat entrepreneurship can be exercised at different levels, whereby 1) producers form individual units, where they produce and consume their own energy; 2) local economies, where different producers form synergies to provide reliable supply to consumers; and 3) distributed economies, where the different established local economies link up. Hence these systems are contrasted from the typical centralised systems. The steps of raw material sourcing, processing, transport and heat production do not occur in isolation in decentralised heat generation as shown in the figure above. Rather they happen within a community.

This decentralisation allows the formation of flexible, self-reliant systems of production and consumption, whilst contributing to the improvement of social well-being, quality of life and the provision of environmental benefits. These positive impacts are achieved by providing affordable energy services, reducing environmental harm through sustainable resource management, and preventing distributive energy losses. These issues are typically associated with centralised heating systems.[1]

Benefits

Heat entrepreneurship can provide substantial economic, environmental, and social benefits to the communities involved. Some of the advantages associated with heat entrepreneurship are the described in the following sections.

Business Opportunities

The development of local heating enterprises not only creates additional business opportunity for the entrepreneur undertaking the endeavour, but also for other farmers and businesses in the locality. These farmers will be able to sell their waste, agricultural residues or nonmarketable timber to the entrepreneur. For example in the Hameenkoski municipality in Finland, a local heat entrepreneur sources 90% of the wood required to generate the heat from local forest owners.[2] These forest owners, who otherwise supply wood to the local saw mills, are able to also sell their unmerchantable wood to the entrepreneur for heat production and thus create an additional revenue stream.[2]

Additional Incomes

Farmers and community members involved in heat entrepreneurship can benefit substantially from the creation of additional income streams. An individual heat entrepreneur in Ruovesi municipality in Finland generates one third of his farms income from his enterprise. The municipality pays the entrepreneur EUR 25.2/MWh for the heat produced, giving him an additional EUR 33 600 per year.[2]

Increased Use of Local Labour

The emergence of new heating enterprises will also bring new employment opportunities to the local community. The size of the operation will determine the level of employment.

Use of Local Resources

The use of local forest or agricultural resources for heating can help develop and promote the local economy. By bringing additional resource streams to farmers and local forest owners, instead of importing raw materials from elsewhere, revenues remain within the community. Using local resources is also beneficial for the entrepreneur, as transport costs will be low. Exploiting local knowledge and leasing or borrowing local equipment can reduce transaction costs for the entrepreneur, whilst also generating incomes for equipment owners.

Improved Waste and Natural Resource Management

The use of local resources can also enhance the sustainable management of local natural resources. This can be done by creating additional streams of raw material from multiple sources and utilising it in an effective and useful way. Another crucial aspect of such a system is the incentive it generates for the community to maintain the natural resources in a sustainable manner. As the community reaps the benefits of heat generation from locally sourced fuel, it also has incentives to use the

A pig farmer (right) in Tovsgårdvej (Thisted, Denmark) uses animal waste to make biogas, providing heat to local households.

fuel (or natural resource) in a manner that does not compromise with the sustainability of the system.

Resilience

In a centralised system whereby a significant amount of the heat is supplied by industry and municipal waste heat, various perturbations that affect the existence of industries and decrease the supply of waste material needed for incineration, as witnessed in Sweden, can have significant negative effects.[3] In a decentralised or distributed system the community is able to develop some level of flexibility by relying on locally available materials and local networks. Heat entrepreneurship can help create resilience as the communities' heat supply is independent of these large centralised industries, thereby also enhancing heat security.

Challenges

Due to the size of its operations, decentralised heat enterprises can often face a number of challenges. Competing with the economic and technical efficiency of the incumbent centralised heating systems, for example, can be difficult for such small-scale systems.[4] These challenges are described in the following sections.

Privatisation

The distributed heat generation would depend on local entrepreneurs for managing operations on the local scale. Okkonena & Suhonen (2010) mention "privatisation" as a business model for promoting decentralised heat generation.[5] However, regulatory conditions should be provided to ensure that no monopolies are created which would result in unfavourable heat prices.

Fuel Logistics

Establishing fuel logistics in decentralised heat production can be a challenging task as biomass production (the fuel) is dependent on climatic factors, thus causing it to be available only sporadically. Additionally, this limited biomass may also face competition from other farmers who want to produce heat or power. Eventually the situation may lead to an escalation in prices.

Planning Difficulties

A distributed system may also lead to increased complexity. This may make it difficult to plan at a large scale, if the demand for heat is being met appropriately.

Economies of Scale

Technical constraints and cost competitiveness may be limiting factors in distributed heat generation due to the small-scale nature of operations. Hence, small-scale operations may not be as efficient from technical and economic viewpoints as large centralised systems.

Conclusions

To ensure the success of heat entrepreneurship, it is required that an assessment of technical, social and economic factors be conducted by the entrepreneur. This calls for developing business models that are innovative in the sense that they ensure stable heat supply, reliable supply chains, affordable services to the customers, and strong business-to-business relations. The economic and technical risks can also be overcome through public-private partnerships. For example, in Thisted (Denmark) the municipality offered the farmers a subsidy to be able to install equipment and offer heat to local communities.

In the context of the Öresund region, our vision is that throughout its rural areas, heating services are provided by local, decentralised heating enterprises. Due to the prevalence of agricultural land in the region the primary fuel will likely come from agricultural residue and waste. The primary aim of these enterprises would be to provide affordable heat to areas that are not connected to the DH network. Additionally, the enterprises would assist in the rural, economic and social development of the area. New opportunities for business will be established, and the local level of employment could improve. Furthermore, heating enterprises could encourage more sustainable use of natural resources and also create closed loop waste streams throughout the region.

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SEAWEED SOLUTIONS

The Potential for Energy from Macroalgae for the Öresund Region

By Elana Hawke & Umashree Pancholy

The use of macroalgae for the generation of biogas in the Öresund region presents a potential solution to remediate the highly polluted Baltic Sea. It also presents a unique case whereby a nuisance substance (macroalgae), can be transformed into a desirable resource (an energy source).

This article investigates the use of macroalgae for remediating the polluted Baltic Sea through energy production, presents the Smyge case study, and discusses the associated benefits and challenges.

Background

The Baltic Sea is a semi-enclosed body of water surrounded by Scandinavia, northeastern Europe, and the westernmost part of Russia. It is the largest body of brackish water in the world (413 000 km^2), making it a unique marine environment, and is home to a wide diversity of biotic life.[1,2,3] Up until the 1950s, the Baltic was a healthy and thriving ecosystem. However, decades of increasing human activity from countries adjacent to the catchments feeding the Sea have resulted in serious damage to the Baltic's health, and it is now considered by scientists to be highly polluted.[4,5] The activities that have contributed the most to the deteriorating water quality are: excessive nutrient and pollutant inputs from the discharge of human and industrial waste, phosphorous and nitrogen inputs from fertiliser runoff from agricultural land, the dumping of World War II chemical agents, and shipping accidents releasing bunker fuels into the marine environment.[2, 4]

These anthropogenic inputs have resulted in eutrophication of water in the Baltic. Eutrophication processes now contribute to annual algal blooms occurring off the coast during the warmer summer months. These can be so large that they can be observed on satellite altimetry. Algal blooms exacerbate poor water quality and their toxicity poses a risk to human and animal health. Additionally, anthropogenic inputs are stimulating excess macroalgal (seaweed) growth directly off the coast of many Baltic bordering countries, most commonly the red algae *Polysiphonia fucoides*.[6]

Macroalgae is very efficient in accumulating nutrients and therefore grows rapidly in the nutrient rich waters. The rapid growth causes a shortage of growth areas for other algal species.[6] In the late summer, macroalgae detaches from its area of growth and floats to the surface. Large quantities of the seaweed are washed up on the beach by onshore winds, accumulate in piles, and begin to decompose. Some of the macroalgae sinks to the sea bottom where a large amount of oxygen is required to break down the macroalgae, thereby causing further oxygen depletion.[2,6]

The Öresund region supports a strong tourism industry with many of the population heading to Baltic beaches in the summer to spend their holidays. Decomposing seaweed gives off an offensive smell and can affect the aesthetics of the beach, which in turns impacts tourism as tourists are less likely to frequent heavily covered beaches.[6,7] On beaches in the southern Skåne region of Sweden, the dead seaweed is removed and is disposed of in landfill. This is an issue as it is an expensive process and hinders Sweden's goals to minimise waste to landfill, as it is not feasible to incinerate seaweed due to its high water content.[6]

Below we discuss a potential solution for remediating the Baltic.[8]

Energy from Macroalgae

While macroalgae is currently considered a nuisance to the Baltic, it has the potential to be turned into a valuable resource.[6,9] Our proposal is to harvest the excess coastal algal growth and as well as that deposited on the beaches, and put it through an anaerobic fermentation process for biogas production. The logic in doing this is that macroalgae are efficient at assimilating nutrients and heavy metals, therefore, removing macroalgae from the marine system could lessen the potential eutrophication threat.[9] Turning the macroalgae into a biogas, generates an energy source that can then be used for transportation, heating of houses, and for local electricity production.[10] A recent study determined that 6 000 tonnes of macroalgae per year could be harvested, which would make enough biogas to heat 6 000 homes or fuel 10 000 cars.[6] By replacing the fossil fuels traditionally used for these processes, there is a positive climate benefit by reducing the amount of climate change inducing greenhouse gases emitted.[11] Furthermore, the residues of algal biogas production could possibly be use as a fertiliser for agriculture, thereby replacing eutrophication producing synthetic fertilisers.[12]

Case Study: Smyge Plant

In 2010, a southern Baltic Sea eutrophication counteract project was initiated (Wetland, Algae, Biogas - WAB). This is a collaborative project between 11 organisations in Sweden and Poland focusing on reducing eutrophication through the collection of macroalgae for biogas production projects. Funding from the Southern Baltic Programme was provided for 3 years for feasibility studies.[13] As part of this initiative, a biogas pilot plant was constructed in Smygehamn, close to the city of Trelleborg. This pilot plant consists of two shipping containers which house the biogas fermentation equipment, and an area for the digestate to be contained before undergoing fermentation.[6] During the four summer months (June-September), macroalgae from nearby beaches are collected and taken to the plant. Macroalgae is removed using three different types of equipment: grip-claw loader, power-rake, or beach cleaner.[14] Macroalgae is stored and covered with plastic lining to reduce spontaneous emissions, before being added to the fermenter for anaerobic fermentation and biogas production.

Because the plant is a pilot plant, production is still on a very small-scale, with the main goal being to determine the most efficient methods to collect the macroalgae and produce the biogas. Other projects, such as the using municipal wastewater to grow algae and growing algae in nearby wetlands, are also occurring as part of

The Smyge Biogas Plant. The macroalgae remains covered in plastic before anaerobic fermentation using chemicals.

WAB project and on the Smyge site.[13]

Benefits and Challenges

As with any project that takes a nuisance and converts it into a resource, the benefits come with associated challenges. These are discussed in the following section.

Because macroalgae assimilates nutrients effectively, by removing macroalgae from the system water quality is enhanced and there is an immediate improvement in the health of the water body.[6] This is beneficial for marine life and the ecosystem as a whole, and particularly advantageous for commercial fisheries such as the Baltic herring fishery that has experienced significant decline due to pollution problems.[15] Conversely taking all the macroalgae off the beaches could affect marine life, which requires some algae for their habitat or as their food source.[14] Running machines over the beach could disturb fragile organisms that live in the tidal zone. Machines could also disturb sea birds.

Macroalgae provides a renewable energy source, replacing nonrenewable fossil fuels. Moreover, macroalgae biogas is a carbon neutral energy source as methane released during combustion comes from the carbon dioxide molecules extracted from the atmosphere and stored in the alga's cells during photosynthesis.[9] Furthermore smaller macroalgae biogas production units would help to decentralise overall energy production in the Öresund region. Renewable energy systems that obtain energy through many different sources are generally more stable, and thus protect against disruptions and perturbations in the system.[6]

Much of Sweden's biogas production comes from agricultural and slaughterhouse waste, with a lesser amount from food crops such as sugarbeets, maize, wheat, and barley. Producing biogas from coastal and beach derived macroalgae means that valuable growing land in the Öresund region can used for food production, rather than growing crops for biogas production. Additionally photosynthetic bacteria in macroalgae capture sunlight more efficiently than terrestrial plants meaning that macroalgae requires less time to grow to the equivalent density of land plants.[16] Terrestrial plants also need large quantities of water for their growth, if this cannot be provided from rainfall it must be provided from irrigation, which has associated implications (high power use etc.). Macroalgae can be grown without this input.

Öresund tourism industry has much to benefit from such macroalgal biogas projects. For example, tourism on the island of Öland depends on beach tourism and recreational activities. In 2005, algal blooms in the Baltic Sea heavily affected Öland, deterring tourists from visiting the Öland area, with a consequent loss of 28 million euros to the local economy.[7] Utilisation of macroalgae from sea and from beaches would help prevent an event like this occurring.

Macroalgae can be used to generate bio-diesels as well as biogas, and investigating this option is another possibility for the Öresund region. Algal biofuels are a fungible fuel that can be substituted directly for diesel or petrol.[11] Further research and trial plants are needed to determine if full-scale production is feasible. Such production could possibly this could be used to fuel the equipment used to collect the macroalgae of the beaches.

For organic material to be useful in biogas production, it has to meet a number of criteria, such as a high organic material content, high nutrient content, and low quantities of inhibiting substances.[6] The organic material content in the macroalgae is very important for the anaerobic digestion process, which is why the macroalgae needs to be free from sand and other contaminating substances. The organic content has to exceed certain levels or the process will yield very low amounts of biogas.[6]

Currently the macroalgae is collected using a tractor in the edge of the water and on the beach. For freshness and low sand content, the macroalgae should be collected directly from the water which requires a specialised aquatic plant harvester.[6] In addition, the drivers need to be skilled at picking up the algae, otherwise sand and other substances contaminate it. Currently the best methods to collect the macroalgae are being trialled, at the moment the machines being used consume approximately 60 litres of fuel (diesel or ethanol) for 5 hours of work and the daily cost is EUR 600 to rent the machines, including the drivers, on the whole this is not very cost effective.[14]

As presented above, the costs for establishing and running this type of project can be quite high.[14] Investment is needed in the equipment to harvest the macroalgae and transport to the plant, the production plant itself and the system to deliver the biogas product to end-user. Then there are the on going maintenance costs of the plant and delivery systems. Upgrading units may also be required to upgrade the lower methane content biogas for use in vehicles.

From a nutritional standpoint, the macroalgal residue could be used as a fertiliser after the biogas process is completed.[6] Macroalgae has a nitrogen:phosphorus:potassium (N:P:K) ratio which is sufficient for most crops.[6] However, one issue is that tests have shown that macroalgae bio-fertiliser can contain have high heavy metal contents, in particular cadmium, which exceeds the permitted limits in Sweden according to the Swedish environmental protection agency.[6] As heavy metals can accumulate up the food chain and present toxicity issues to people and animals, more research is required to determine how to lessen or remove the cadmium, so that the residue can be used as a fertiliser.

There are longevity issues around using macroalgae as an energy source, as macroalgae digestate is only available during the summer months. If eutrophication potential is lowered, then growth of the macroalgae is also expected to reduce. Thus in a specific area macroalgae alone cannot be relied on for energy production. However, if the biogas production units are movable instead of fixed, they can be transported to the area where there is a bloom, and this can used to address longevity around energy generation issues.

Finally, questions whether macroalgal biogas is CO_2 neutral when transportation and other factors come into play need to be addressed. A life cycle assessment would need to be conducted to fully analyse this and these are usually time consuming and can be costly.[17]

Conclusion

While the proposal to use macroalgae for biogas production has a number of potential benefits there also are a number of challenges relating to environmental consequences of the process, its sustainability and economic feasibility. Considerable research, development and economic analysis is needed to determine whether the process can be developed to be economically sustainable. However, throughout history humanity has been challenged by such issues and has managed to find interesting and innovative solutions to them. What may not be economically viable today may be in the future as circumstances change, so research and development into potential solutions must continue.

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MOVING FORWARD

Integrated Mobility in the Öresund Region

By Ariel Drehobl, Francesca Favorini-Csorba & Sophia Küpers

The notion of "distributed economies" is a development approach that stresses small scale, flexible collaboration that promotes the development of an area based on its particular strengths and opportunities.[1] One vision of a distributed economy within the Öresund region includes an integrated mobility system linking Copenhagen, Malmö, and Lund. The collaboration of these cities through an integrated mobility project would take advantage of and enhance the sense of belonging to the region. This type of project would help the region to meet carbon reduction targets by reducing private vehicle use, but also help to further develop the regional economy by facilitating easier travel between and within the cities.

Integrated Mobility System

Integrated mobility systems involve the combination and integration of numerous mobility possibilities in order to create the most efficient personal transportation system. Integrated mobility incorporates various forms of transportation – such as car- and bike-sharing, buses, trams, subways and trains – in order to meet the needs of the customers. The integration of these systems can be done simply and cheaply through the use of information and communication technologies, such as smartphones. An integrated mobility system will provide alternatives types of travel, increase ability to travel by foot or bike, improve transport options, and reduce the overall environmental impact of journeys.[2] By integrating mobility, more efficient and effective transport systems are created, which allow for more sustainable options for travellers.

Potential for Success

Many components of an integrated mobility system are already in place in the Öresund region. Currently, these are scattered and in various phases of expansion and development; however, there is a high potential to have a system of personal transportation that allows for flexible, efficient, and individualised travel within the region. Examples of this development can be found on both sides of the bridge.

Regional Policies

In the area around Copenhagen, regional and local train companies cooperate and are planning to establish an umbrella organisation for coordination and benefit sharing. Copenhagen's urban planning strategies have also incorporated a feeder system approach to public transportation, which physically integrates bus and train terminals with other transportation facilities such as bike racks, and therefore ensures a fluent transition from one mode of transportation to another. In addition, Danish national legislation requires that every workplace be connected to the public transport network, which is an important consideration for mobility services as well as new construction. Implementing similar policies in Lund and Malmö would facilitate an easier integration of transport services in the region as a whole.

Public-Private Partnerships

Additionally, public-private partnerships exist that can be expanded for further integration. A Copenhagen-based bike sharing project was launched in 2013 that offers bikes which can be used with or without electricity. These bikes are equipped with Android tablets that give access to information about public transport options, bike stations, and cultural sites in the city.[3] Furthermore, an online system allows for pre-booking of bikes as well as for convenient payment for the service used. Here, the national Danish railway system and the operating company Cykel DK collaborate to combine the already known sharing approach with up-to-date technology for both commuters and visitors.[4] Cycling, which is already part of local culture, is taken to a new level where strategic positioning of the stations and user friendly technology attract a broad target group. This example shows how public-private partnerships could fuel acceptance of alternative transportation with attractive and efficient technologies.

Information & Communication Technology

Other initiatives within the region can also serve as inspiration for an integrated Öresund mobility system. Both Sweden and Denmark have comprehensive websites with real time information on the weather, nearest transport stations, and times of arrival of transport modes. Rejseplanen, the Danish website, already includes bicycle and rneys. Both sites include information for trips between the two countries. In addition, the existing smartphone apps facilitate flexible and spontaneous transportation choices. The Danish transportation app is already prevalent: 90% of Danes are aware of the app, and 60% believe it is integral to their transportation experience.[5]

Because of the important role that information and communication technology plays in implementing successful integrated mobility systems, an additional factor in the likely success of such a system in the region is the high rate of internet usage. People in both countries of the Öresund region are well connected to the internet: as of 2012 in Sweden 92% and in Denmark 90% of the inhabitants are online. With regard to smartphone usage, in 2013, 79% of Swedes between 15 and 65 used smartphones, and in 2011, 50% of all mobile phones owned by households in Denmark were smartphones.[6,7] These numbers are likely to grow with an increased accessibility and lower prices in the coming years, making it even more possible for the region to have common apps that can be used for individualised travel planning with real time information elements.

Common Characteristics

Looking beyond the infrastructural and organisational linkages that would facilitate an integrated mobility system in the region, the Öresund region benefits from common characteristics. Similarities between the Swedish and Danish languages, combined with the prevalence of English as a second language means that language does not represent much of a barrier to integration. Additionally, the concept of sustainable transportation resonates with the overall environmental awareness of the population within the entire region. The physical connection between the coasts could foster a shared sense of belonging in which linked transportation systems could play an important role.

Recommendations

In light of the high potential for an integrated Öresund mobility system, we recommend key areas to focus on in order to create the most effective and innovative system.

- Integrated mobility card for the Öresund region;
- Attractive and user-friendly online profile and data system;
- Make app accessible in Swedish, Danish, and English;
- Incentives and rewards;
- Commuter/family/student membership plans;
- Bike-sharing to reduce abandoned bike waste;
- More diversified transport in response to weather delays; and
- Implementing public-private partnerships.

Currently, Denmark and Skåne use different transport cards; these cards can be combined to create more cohesiveness. An attractive online database and profile system can also be developed and integrated with the transport card. The system would allow commuters to collect data about their travel patterns and adjust their travel subscription accordingly. Social media and interactive aspects should also be incorporated to create a sustainable travel community. The website and smartphone-based app should be accessible in Swedish, Danish, and English in order to be inclusive to the region's commuters.

A reward system can be designed so that travellers receive benefits based on the sustainable transport choices they make (e.g. more points for taking a shared bike, rather than a shared car). For example, the Gothenburg integrated mobility system initiative, GO:SMART, is collaborating with Volvo to provide tangible rewards for subscribers based on their sustainable travel choices. In the Öresund mobility system, points amassed could be redeemable for discounts either on future transport purchases or in partnership with participating businesses or organisations, such as coffee shops, museums, or restaurants within the region. The GO:SMART initiative is currently testing their reward-based system to determine how to best incentivise sustainable transport.

Transportation plans can also be adapted to match the needs of specific social groups, such as commuters, families, and students. Commuters may want a plan that focuses on consistent transport use along similar routes. Families may be more interested in car-sharing programmes, while students may want a plan that focuses more on bike-sharing. Before the establishment of membership plans, market research should be conducted to determine the best combination of services for each stakeholder group. Once established, these plans could also be adjusted to match the actual needs of the customers

Numerous residents have commented on the abandoned bikes in university areas, especially in Lund. By implementing a bike-sharing programme, the number of abandoned scrap bikes would be reduced and the city's bikes would be more efficiently utilised.

Traffic delays also cause problems in the region, as transportation becomes inaccessible after extreme weather events or accidents. By having a wider variety of transport methods available – such as the option to rent a car or a bike – delays due to weather could be mitigated for passengers who can choose these modes of transportation over those that are delayed.

The implementation of public-private partnerships involving transport in the Öresund Region would create major opportunities for transportation integration and growth in the future. Municipality vehicles could be used in car-sharing schemes after office hours in order to increase the overall efficiency and cost effectiveness of the municipal-owned cars. Regional bike-sharing programmes, such as Copenhagen's Cykel DK, can be integrated throughout the region, so that commuters originating in Copenhagen can ride a bike to the train station, take a train over the bridge, then pick up another bike in Malmö to finish their commutes. Public-private partnerships would also be seen through private organisations offering incentives for sustainable transport by offering discounts in exchange for reward points earned. These businesses can remain static or change temporally and can be a way for businesses to market themselves and for good transport behaviour to be promoted and maintained in the region.

Conclusion

Although the Öresund region already includes aspects of integrated services into its transportation system, much more can be done to create a more effective and attractive mobility system. By offering a wider variety of modes of transportation, linking the regional transportation networks, incorporating public-private partnerships, and emphasising new technologies and incentives for sustainable transport, the region can increase its transport efficiency and sustainability.

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SHARING PEDALS

The Potential for Bike Sharing in Öresund

By Chih-Ching Lan, Martin Petrushevski & Haiya Zhang

"There are two types of mayors in the world: those who have bike-sharing and those who want bike-sharing." – President of Greater Lyon, France.

What is Bike Sharing?

Bike-sharing is a transportation scheme developed to facilitate the short distance travel needs of an urban population by providing short-term shared use of bicycles.[1] The programmes run on a use-when-needed principle, in which costs, responsibilities of ownership and maintenance are bypassed.[2] The flexibility of the scheme enables users to pick up their bicycles from unattended docking stations at any time of the day and drop them off at different stations. Recent modernization of the system informs users on the closest available bicycles via their mobile phones. Rapid global expansion led to the development of over 500 bike-sharing programmes in 49 countries, with a fleet of more than 500 000 bicycles.[3]

Bike-sharing has a profound impact on the urban environments. It incentivises growth of cycling populations, diversifies public transport, and decreases the amount of transport-related greenhouses gas emissions.[4] Although many large cities have embraced these programmes, bike-sharing has not been widely embraced in the Öresund region. In Copenhagen, the city-run programme was suspended in 2012 due to high costs of operation and improving the existing technology. While bike ownership is fairly common in this region, we still believe that establishing bike-sharing programmes will provide environmental and social benefits to the area.

Bike-sharing programmes are designed to serve as part of the integrated travel of trains and buses. These programmes are good for one-way spontaneous trips. We believe they suit the Öresund region because they will be able to connect cities and stations.

In addition, cyclers do not need to worry about locking bikes, theft and vandalism. It is a shift of responsibility and maintenance from individuals to the bike-sharing programme operators.

In a university town such as Lund, student numbers fluctuate throughout the year. High transaction costs (large amount of effort and low return on investments) often cause students to abandon their bikes. A bike-sharing programme will provide the service without imposing burden on the students.

Bike-sharing & Distributed Economies

The concept of distributed economies can be seen as a strategy for guiding industrial developments towards sustainability.[5] The overlap between the distributed economies concept and bike-sharing can be seen in the shared principles for diversification of needs and wants and creation of new producer-consumer relationships, where the aim is in improving quality of life of urban population, through implementation of innovative practices and integrated designs, and especially the link between intra and inter regional collaboration and exchange of resources. Furthermore, potential benefits from interlinking these two concepts can be seen for diversification of mobility options, like public transport and alternative modes, and increased economic resilience and coherence of the whole Öresund region.

Implementation & Obstacles

While benefit of bike-share schemes is widely desired, there are challenges to be addressed in order to achieve a well-functioning system. This section will look into a few obstacles which we think are relevant to the Öresund region. Sample cases are drawn to demonstrate how different cities and programmes solve these issues. Hopefully it will offer insights for Energi Öresund project when considering its own bike sharing programme.

Climate

The harsh winter limits the ability of bike-sharing to be used year round. Not only is it unsafe, but also it is hard on the bikes. If not appropriately addressed, bike share programme will face outstanding maintenance cost and liabilities. Cities with such climate often close down the programme during winter time. The Copenhagen city bike programme had bikes available from April to November. The Nice Ride bike-share programme in Minneapolis St. Paul, USA, has a similar schedule.[6] During these winter months, bikes are taken to storage, and maintenance is carried out to prepare for the next biking season.

Maintenance

Most of the bikes for such programme are designed to be hearty and easy to maintain. In Copenhagen and Minneapolis St. Paul, bikes are made with strong aluminium alloy frame and extra wide tires. Therefore, bikes are more resistant to outdoor weather and road conditions. In Hangzhou, China, instead of a fully automated renting system, rental stations are managed by professionals. They perform maintenance when the bikes are not in use.

Theft & Vandalism

As compared to all global bike-sharing programmes, Paris' Velib Bike programme has very high rate of theft and vandalism. During the first two years of operation, they had to replace 20 600 bikes at a cost of EUR 400 each.[7] Most programmes prevent theft by designing the bikes with distinguished looks that are easily recognisable. The Hangzhou bike share programme has experienced relatively low theft and vandalism rate. It is partially due to the fact that users who do not return the bike are put on a black list. Afterwards, their access to the bike system is denied.

Bike-sharing Evolution

1st generation: Free-bike system
Started in Amsterdam 1960s. Bikes for free. Collapse of programme within days

2nd generation: Coin-deposit system
Biggest success in Copenhagen 1995. Coin operated docking stations throughout the city. Theft issues due anonymity of users

3rd generation: IT-based system
Magnetic stripe cards, electronic racks and bike locks run by IT systems and mobile phone apps are part of this 3d generation. Frontrunners were Rennes (1998) and Munich (2000), followed by Lyon (2005), Paris (2007) and worldwide spread out after 2008

4th generation: Demand-responsive, multi-modal system
Builds upon the 3rd generation bike sharing systems by adding electric bicycles, bicycle redistribution systems, mobile and solar powered docking stations, and interlink with the public transportation smartcard systems.

Redistribution

After use, bikes are scattered around the city depending on the user traffic flows. City centre docking stations are packed with bikes after morning rush hour, while suburb docking stations are left with no bikes. Most current programmes use trucks to redistribute bikes after rush hours. This is costly and undesired. Future bike-sharing programmes are looking for new solutions for redistribution, such as user incentivize based bike redistribution system discussed in the future outlook.

Information Systems

Most North America and European bike-sharing programme have automated systems to record credit card information of users in order to deduct deposits and fees. To provide more convenience to the users, the Capital Bike-share programme in Washington DC aims to provide live information feed on bike availability at each docking station.[8] This requires update from stations to the website at all times. These systems are expensive to install and maintain.

Liability and Cost

High liability cost could potentially paralyse a bike-sharing programme. Inexperienced bikers and hectic city traffic creates high risk for accidents. Adding the purchase of insurance to the fee could be an option. However, some programmes introduced helmet either according to regulation, or to reduce risk. The Melbourne bike programme introduced a system where users could purchase a helmet for SEK 30 (EUR 3.3), and return it for SEK 18 (EUR 2). Better solutions are yet to be discovered in this area.

To conclude, these challenges are commonly faced by bike-sharing programmes around the world. Some cities produced better solutions than others. However, redistribution, information system and liability considerations are yet to be tackled more effectively. The new generation of bike shares programme design shall look for more systematic and cost-efficient solutions.

Future Outlook

Lessons learnt from existing bike-sharing systems around the world together with current research have contributed to our future outlook of the bike-sharing model in Öresund region, which will be consisted of four main special features:

1. Portable modular docking stations and innovative bike redistribution system or
2. Flex stations;
3. Smart card integration with various public transportation modes;
4. Advanced technologies such as touchscreen kiosks and embedded GPS tracking.

Mobile Docking Stations

Mobile docking stations first launched in Montreal's BIXI system in 2009. Instead of having fixed docking stations, which consist of multiple docks and a kiosk, the mobile docking stations can be deployed and relocated in line with user demands and usage patterns, or even can be erected as an extra-large docking station for particular events.[2] The stations are networked wirelessly and solar powered and are mounted onto sets of platforms. The service terminals of each bike stand are self-contained and no wiring is needed when installing. Therefore these stations can be located accordingly by just placing the modules without fixing them on the ground. The BIXI docking stations can be assembled or disassembled within 20 minutes and flexibly in response to demands.[7]

Together with the mobile docking station, we suggest a user incentivize based bike redistribution system.[2] Instead of having vehicles to relocate bikes, riders will perform the redistribution by applying demand-based pricing. For instance, a preferable pricing or credit system for docking bikes at rather empty stations.

Flex Stations

Another alternative to have mobile docking stations is to have a flex stations system, which is a station-less system. Flex stations employ advanced mobile phone technology to allow users to unlock bikes by receiving a code on the mobile phone. Riders leave and lock bicycles in the major intersections and notify the location to information programme. The flex station approach allows bicycles to be accessed throughout the city and minimizes the infrastructure for operation.[9] However, flex station also raise issues of predictability and accessibility of available bikes and their locations. Currently, flex stations are employed by several cities in Denmark, Germany and North-America, and.[10]

Smart Card Integration

A seamless integration of bike-sharing system with various public transportation of modes via smartcards can facilitate multi-modal transportation network linkages and enhance user convenience. Bike-sharing stations will be located efficiently near transit stations. The holistic integration of numerous modes public transportation alternatives are crucial for reducing private car ownerships. Nonetheless, to establish a system like this requires the involvement of multiple agencies, which can be costly and challenging in terms of coordination.[2]

Advanced Technologies

Advanced technologies, such as smart cards, mobile phone, GPS tracking and information system not only allow users to access, locate and reserve bikes (especially with flex stations) but also play important roles regarding bicycle security. For instance, installed GPS units, membership and real time information programme and enhanced locking mechanisms can deter theft and facilitate the recovery of bicycles. Nevertheless, build-in GPS units can be costly and increase the risk of financial loss.

Cities in Öresund region, such as Malmö, are already facilitated with excellent biking infrastructure in general. A well-designed bike-sharing scheme can be a potential option for phasing out private auto ownership as well as increasing mobility integration towards a carbon neutral future.

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REACHING NEW HEIGHTS

Food Production and Vertical Farming

By Manavi Bhardwaj & Erik Hansen

The food system as we know it today is globalised. Sweden and Denmark are no exception to this. Centralised food distribution systems cause most of the food we consume to travel long distances, even when that food is produced in close proximity to the place where it will be eventually consumed. Modern industrial agriculture is associated with energy intensive processes that consume large quantities of fossil fuels contributing to many problems, such as climate change. In addition to this, the growing world population requires sufficient food, which progressively increases the pressures on land, often at the cost of environmental degradation. Do we have the capacity to supply modern cities with food without severe environmental and social costs? Are there solutions that can allow for increased urbanisation, without creating a food crisis?

By 2050, around 70% of the world's population is projected to be living in urban areas.[1] The high population density of future cities is likely to create increasingly worse food supply problems in urban centre. Addressing such issues may require a revolution in terms of where and how we obtain our food. Transformative responses to these challenges may require us to redefine the concept of farming. Today food is not a central issue in municipal planning.[2] There is a growing constituency however that feel this is a mistake. According to the Symbiocity approach (a conceptual framework for sustainable urban development, developed by the Swedish Association of Local Authorities and Regions and SKL International), the challenges of a city can be turned into opportunities. Vertical farms could be one such opportunity to address the challenges associated with the current food system.[3]

Opportunities

Vertical farming has the potential to address many of the foreseeable issues facing the world in regards to food, resource scarcity, and pollution. It is a solution that would radically change many of the current predominant farming methods, and in this way, if widely implemented, vertical farming could be considered an agricultural revolution.

Urban agriculture and greenhouses have been pursued as an alternative to intensive agriculture, but at a much smaller scale. Vertical farms represent a way that greenhouse and urban agriculture technology can conjoin into a new technology that not only possesses the benefits of each of the previous practices, but also imbues synergies.

In the Swedish context, the government has recently shown initiative towards supporting urban agriculture through its 'Delegation of Sustainable Cities' that was appointed in 2008 to work with municipalities, the business sector and other parties to promote the sustainable development of cities, urban communities and housing areas.[3] Urban agriculture has the benefit that it lends itself towards a decentralised food system. Food produced through urban agriculture is generally not sold on the world market, but consumed locally. This alleviates the environmental, food quality, and economic costs of food transportation. In addition, it has the potential to change a community's relationship to what they eat allowing an individual to better understand the realities of food production.[4]

Greenhouse farms allow for the production of crops when season or climate would not normally allow. This has clear benefits in the Öresund region, where the season and climate limits agriculture. Greenhouse farms offer a prototype for the vertical farms of the future, and in that sense may be regarded as the transition required to make vertical farms widespread, as vertical farms are essentially greenhouse farms stacked one above another.

Farming Techniques

Three techniques that are used in greenhouse farms could be utilised in vertical farms.[5] These are aeroponics, hydroponics and drip irrigation. In aeroponics, a technique developed by NASA in its efforts to grow food in space, plants are suspended in such a way that their roots are exposed to air saturated with water vapour and nutrients.[5] In hydroponics, plants are suspended in such a way that their roots are dipped in water dissolved with nutrients.[5] In drip irrigation, plants grow in troughs made of inert material, and a narrow tubing on the surface of the troughs drops nutrient filled water accurately at the base of each stem.[5]

A more recently developed technique for greenhouse farms is aquaponics. Aquaponics is a symbiosis of aquaculture and hydroponics. In aquaponics, fish waste is used as the nutrient source for plants. Nitrifying bacteria convert the fish waste to nitrites and nitrates. Nitrates are taken up by plants, which in turn filter the water to allow fish survival.[6] Aquaponics UK claims that it is possible to produce 30-50 kgs of vegetables from one kg of fish.[6]

In 1999, Dickson Despommier of Columbia University, developed the modern concept of vertical farming. However, as of 2010, the discussion on vertical farms was still limited to a vision for the future, seemingly floating at the planning stage.[7] This could be largely attributed to technical barriers, such as lighting, energy, water, nutrient delivery, and vertical farm design. However, the last few years have seen a sudden mushrooming of vertical farm pilot projects, ranging from less sophisticated to highly futuristic designs. This possibly reflects the growing awareness towards the need for decentralised food systems, resulting in more attention and funding for further innovation to overcome the challenges associated with vertical farms.

The Swedish company Plantagon International offers a number of design approaches for vertical farms.[8] The parasite design approach is based on retrofitting existing buildings with cultivation facilities. In case of the stand-alone design, the entire building is exclusively committed to food production, and in the integrated approach, the building hosts a number of functions other than farming (including office spaces and restaurants). Another approach called industrial symbiosis, is aimed at finding symbiosis between urban functions and vertical

Plantagon's vertical farm in Linköping (under construction).

farms.[8]

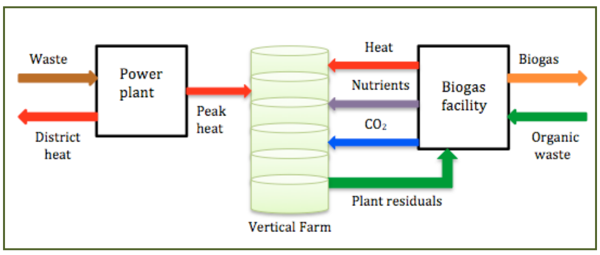
Plantagon has proposed the construction of a 17-storey tall vertical farm in the city of Linköping in Sweden. Linköping could potentially provide a unique example to the world in its advancements of vertical farm technologies. The city already boasts a sustainable waste management system that includes waste to energy for district heating, and biogas production. This has resulted with the collaboration between the Municipality of Linköping and Linköping University.[9] The vertical farm could meet its energy requirements from excess heat produced in the city's power plant, and organic waste from the farm could be used in the city's biogas plant that could in return provide CO_2 and nutrients for the growth of plants in the greenhouse. The development of the vertical farm would also benefit from research and development at Linköping University and technology provided by other stakeholders to use within the farm. Plantagon hopes to use this symbiotic system as the leverage for a sustainable investment and economic opportunity that the vertical farm will provide.[9] Using this plant as a model for other cities, Plantagon envisions to use its vertical farm technology in other parts of the world that could benefit from it. This prototype building that will be called the International Centre of Excellence for Urban Agriculture, and will be a place for scientists to test new technologies aimed at improving urban farming.[10]

Challenges

In spite of recent progress, there are significant technological and economic challenges that need to be overcome for vertical farming to seriously compete with conventional agriculture. One of the current problems with vertical farms is the lighting. Light has to be very tightly controlled, be uniformly distributed to all plants, and be available all year round.[11,12] In regions like Öresund this stands out as an obvious challenge, and using artificial light raises questions about the farm's energy efficiency. A design approach that allows uniform distribution of sunlight to all plants are helical structures – plants grow at the top of the helix and are slowly transported down as they move along a belt wrapped in the form of the helix, receiving sunlight, and are finally harvested as they reach the end of the helix at the bottom of the vertical farm.[8] In addition to light, there are other technical challenges, such as heating and cooling requirements, space, and materials used for building that are yet to be fully addressed.

We are limited in knowledge in terms of our understanding of replicating ecosystem functions. So far the operating vertical farms seem to yield positive results for the future. However, as efforts are scaled up, and the possibility of a high dependency on vertical farms for food increases, the possible failure of such a system can have disturbing impacts on food supply. Increasing dependency on vertical farms thus comes with its risks.

Today a stand-alone vertical farm is not an economically viable option. The new way of doing things will have to be integrated with the pre-existing local infrastructure.[13] Industrial symbiosis could make vertical farms economically feasible. In the Öresund region, potential vertical farms could benefit from harvesting residual heat from industry and office buildings in order to prolong the otherwise short growing season. Retrofitted designs such as rooftop farms are also likely to be a cheaper option than stand-alone designs. Weight issues for an



An industrial symbiosis design approach. Adapted from Plantagon.

existing building associated with retrofitting rooftop farms could be addressed by adopting growing techniques such as hydroponics that do not use soil. Using existing abandoned buildings such as warehouses could also be a less expensive option than building an entire new structure.

A likely challenge for vertical farms is ensuring customers. A vertical farm that produces only a few types of vegetables may find it difficult to compete with a grocery store that offers large varieties of vegetables. However, the Öresund region has experienced an increased interest in locally produced food the last couple of years. This could indicate a likely acceptance for food produced in vertical farms in the future. A web-based survey on consumption habits conducted by the Swedish cooperation 'Coop' indicated that 85% of the respondents (43 808 persons) buy locally produced food because they want to contribute towards reducing climate impacts, and shorter transportation and distribution networks.[2] In Sweden, the local food movement has been driven by Fonte's[14] 'reconnection perspective'. Import-oriented agriculture and loss of food culture has led to the movement, which relocalises food systems. This is out of environmental concerns, the desire to improve social life, and to bolster local identity within the community.[14] It remains to be seen as to whether consumer interest in local food will extend to a demand for food produced in vertical farms.

Discussion

Vertical farming offers a promising opportunity for sustainable urban agriculture. By way of a closed loop system, where waste becomes input for new processes, greenhouse gas emissions associated with transport and storage in the current food system can be avoided, and plants can be grown without using herbicides, pesticides, or fertilisers. Combined with the absence of tractors, plows, and shipping, this can significantly reduce fossil fuel use. Methane generation from composting the inedible parts of plants and animals can be used to add energy back to the grid. Waste heat generated within municipalities can be used to heat the farms. All such outcomes would support the initiatives towards climate neutrality in the region.

Given the existing financial and technical challenges, vertical farming is still a work in progress as a concept. Whether vertical farms can make cities self-sufficient is highly questionable given the sheer size and population density of existing cities. Further, it is not possible to grow all the possible varieties of plants to meet the demands for food in a city within the limitations of a vertical farm.

Instead of food sufficiency as an end goal, the vertical farm could be seen as a technological solution that encompasses human connections by providing a space for a community to gather, to learn, and to cooperate. The purpose of the vertical farm could be seen in the wider context of a sustainable city as part of a sustainable symbiotic system. Municipalities could adopt an interdependent approach involving local administrative, academic and business entities showcasing that sustainable development is best tackled with integrated innovation. This new way of thinking could make the region a leader in vertical farms, and support the development of such initiatives in other parts of the world. Sweden has made large advancements in regards to vertical farm technology. Likewise there are good examples in Denmark of urban agriculture and modern greenhouses, although Denmark does not appear to have any investments in vertical farms themselves.

A food system that involves multiple vertical farms is a good example of a functional decentralised food system. If functioning in an ideal manner, the vertical farm system provides food locally, but shares information, technology, and support throughout the whole system of vertical farms. This allows for technological advancements to progress quickly.

Vertical farms could also be seen as a way to engage the community and encourage education on sustainability and food production. Vertical farms make our food choices visible. Knowing where the food comes from, knowing how water, nutrients, and energy may be utilised in food production, may help us become aware of not only the consequences of our food choices, but also the food, water, and energy that we waste. This awareness may translate to behavioural change in the way we think about consumption - the current driver of environmental degradation.

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Photo of vertical farm integrated within a city. Used with permission from Plantagon.

Photo of Plantagon's vertical farm in Linköping. Used with permission from Plantagon.

Illustration of an industrial symbiosis approach adapted from Plantagon. Retrieved from http://plantagon.com/urban-agriculture/industrial-symbiosis/

WHAT DO THEY WANÅS BE?

A Sustainable Tourism Case Study

By Shu-Yuan Chang, Thor Morante & Masahiro Suzuki

Wanås, a rural estate, is located in the countryside of Östra Göinge, 65 miles northeast of Malmö. It started from milking business (now converted to organic practice), and then evolved to a varied set of activities. Nowadays, it includes an art foundation consisting of a Danish-style medieval castle, an art sculpture park, a café, an art shop and deli. In its concept, it offers an example of sustainable tourism that portrays a strong commitment to environment and rural development within a Distributed Economy scheme.

This unique sustainable agro-tourism destination attracted nearly 80 000 visitors last year.[1] It has been recognised by the media and other organisations, including The New York Times and OECD, as a case of successful rural development.[1,2] In this paper, we will analyse how the three key factors of Wanås (farming, arts and its cafe/deli) contribute to its success within a distributed economy. Applicability of those success factors to other farmers and cities will be discussed, and several recommendations for Wanås to further strengthen its network will be addressed.

Though kept indoor most of the year, cows are set outside for at least 2 months during summer.

Wanås Factors

Organic Farming

Wanås started producing milk in the 18th century, and converted from traditional production to organic farming in 1997.[3] Currently, the animal husbandry practice is performed through sustainable breeding and "the production is KRAV and CO_2 certified."[3] The shift of their milking practice towards organic was especially influenced by art, according to the CEO of the Wanås Estate.[4]

Besides providing milk to its cafe, they mainly supply local schools and represent one of the biggest dairy providers for Skånemejerier companies. Additionally, they offer free tours for visitors to see how cattle live and the process of organic milk production.

'Green' Art

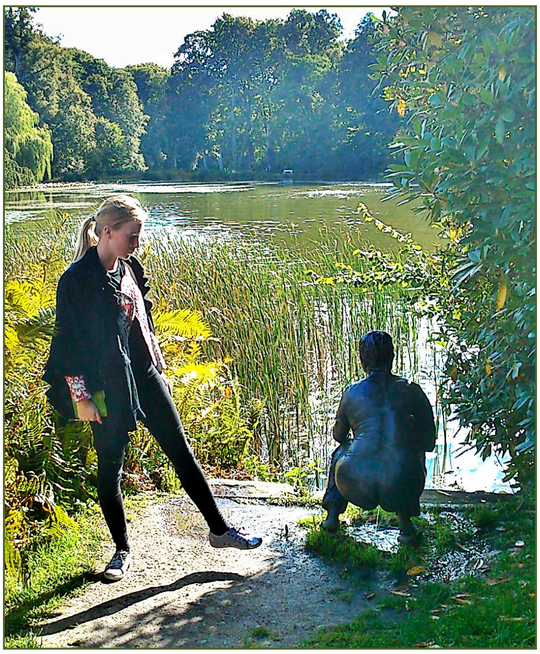
Nested by the Wanås Foundation and its stated strong environmental impact, contemporary art in the form of sculpture and painting are practised in premises of the farm, comprising a sculpture park, an art gallery, and an art shop. For this, Nordic and international artists are invited to create art in the park, drawing their inspiration from it and reproducing their experience for a purposed confluence between the social and the environmental concepts within the artistic expression.

The art program focuses on children as the main audience (though not excluding other audiences), involving them in different processes of artistic contemplation, creation and perception within socio-environmentally aimed conceptualisations. With that, the approach has ranged from seminars on art and ecology to on-going, multi-participative creation of a fictional set of adventures of an organic milk cow from the farm, among others.

Cafe and Deli

A cafe and a deli in Wanås promote the local produce with joint work and for joint benefit of the local farmers. A part of the European Network of Regional Culinary Heritage, the cafe derives its offer from most of the farm's and neighbouring farms' original products, adding the local culinary value to it. Only a few of its ingredients come from extra-regional and international locations, due to acceptance of limitations for the production of certain crops (i.e. lemons, oranges, etc.).

The deli serves as a central point for local farmers to sell their products in a more market-like scenario, where the offers vary according to seasonality and availability of the crops. The environmental criterion for this aspect has to do with local consumption of local goods, emphasising in the quality and distribution of the locally produced.



Future Vision

Wanås's success, so far, has been achieved by its effort in local business development and strong environmental commitments. The concept of a distributed economy is to strive for innovative regional development and connecting a local network together to maximise the usage of local resources, by which that could provide advantages to be more flexible and resilient to future challenges.[5] Therefore, the revision of the following ideas could prove to be fitting to further develop the distributed economy of the region and Wanås itself: the creation of travel packages, deployment of alternative transportation, and strengthening the collective regional network.

Travel Package

Considering the amount of tourists already visiting Wanås' premises, we believe that the consideration of creating a business model related to further strengthen the touristic area would provide new tools for the distributed economy to grow in favour of locals. In that sense, the possibility of addressing 'travel package' opportunities could attract new actors in the collective network, as well as opportunities for the already existing ones, and the promotion of the rural development of the region.

A travel package would cover guided tours of the art exhibition and farm, workshops of art making and farming practices, food, accommodation and transportation. It can include other activities organised by local citizens, including neighbouring farmers.

Wanås' art is inspired and created in the park, looking for reconnections with the environment.

As of today, Wanås provides internet links of closely located hotels on their website as an accommodation option for overnight stays. In other words, travellers are currently required to book guided tours and activities offered separately. For potential guests, this could mean facing various challenges, including an inability to access information due to language barriers and the lack of IT literacy. Travel packages could solve this issue by integrating the booking processes of Wanås and their accommodation partners, offering additional information on recommended travel plans in the Östra Göinge region. In this sense, a targeted audience is to be considered so to adapt travel packages and existing infrastructure according to the kind of tourist addressed.

This may help strengthen the relationships within the community of local tourism in the region, including not only Wanås, but travel service providers, local businesses, and farmers.

Transportation

Alternative transportation is another aspect to be considered in the future to strengthen the sustainability of Wanås. Currently, Wanås calls on visitors to use public transportation instead of travelling by a car. However, this is not a simple option for travellers since a bus that connects the closest train station, Hässleholm C, and Wanås runs only once every hour on weekdays, and once every two hours on weekends. Therefore, a potential solution would be a cooperative ownership approach of electric buses.

Electric buses as a next generation of cleaner transportation are becoming a reality. Under the project name of ElectriCity, the city of Gothenburg is planning to introduce a bus completely run by electricity as an alternative public transportation in 2015.[6] Stakeholders of the tourism of Östra Göinge region, including Wanås and local farmers, can cooperatively own electric buses as an alternative method to transport travellers from train stations closely located, including Hässleholm C. It can be also incorporated into the travel package, i.e. transporting international visitors from Copenhagen Airport. The travel tour may start on the bus, explaining the history and culture of Skåne region, previewing the art exhibition they are about to visit, offering recommended travel plans and even commenting on the environmental impacts of transportation itself. It is expected to gain attention from domestic and international media for its environmentally conscious transportation scheme, bringing additional benefits to improve the reputation of Wanås and Skåne region as an attractive travel destination.

A Collective Network

In order to provide the suggested service of travel packages, it is necessary to set up a collective network in the Skåne region that could provide an information platform to unite farmers, tourist operators, local residents and municipality. Moreover, it could build-up other sources of income by engaging with each other. To be more specific, different farms have different farming activities, cultivation crops and different operational styles; therefore, this common platform would enable them to share their vision to the public by organising activities such as local festivals, farming workshops, markets, education trainings, family days, and a varied set of events and their organisation. Different activities could be organised based on different targeted groups. Tourist operators and local municipalities could play a role of marketing via media to assist and promote the activities.

According to the research from University of Wisconsin, such a network mobilising collective action by farmers and their activities motivates general public to get involved.[7] More importantly, the provision for farmers and consumers with a wealth of information and support is fundamental.

Conclusions

Considering that a distributed economy's aim is to improve local economies by using local resources, we have perceived that Wanås evolution has shown to be successful for the local farmers.[5] In this scenario, the local action has met both the environmental concept and trend, rendering Wanås' status to be a solid one, with over 80,000 visitors a year, which add to the company's regular organic milk sales.

In order to address other areas of economic activity as to further develop the distributed economy, and following the line of tourism which is entangled especially to the cafe and art activities within the park, sectors such as tourist accommodation (hotel/hostel) and transportation (be it public, with tour operators or with farmers as shareholders) appear to be necessary to be considered, and doing so by following the same 'green' parameters that have been a seal of the already existent distributed economy.

Strengthening of local actors in a more participative way (if these two variables are to seriously be undertaken in a collective way) could further increase the farmers and locals in general in the validity of the distributed economy towards their own development and growth. Lastly, we believe that in order to strengthen the concept of distributed economy, it is important to take the lesson of Wanås' success elements, and, thus, develop its applicability to other farms in the Skåne region. Moreover, creating a collective network that involves stakeholders, farmers, tourist operators, local residents and municipalities is essential in order for a distributed economy scheme to perform effectively.

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THE AUTHORS

This report was compiled as part of the international Master's in Environmental Science, Policy and Management (MESPOM) programme. This degree is a two-year Erasmus Mundus program supported by the European Commission, and operated by four European and two North American universities. Students will study in at least three out of the six consortium universities: Central European University in Hungary, University of Aegean in Greece, Lund University in Sweden, and Manchester University in United Kingdom, Monterey Institute for International Studies in United States, and University of Saskatchewan in Canada.

MESPOM Batch 8 consists of 33 students from 19 countries around the world. The authors are 21 out of the 33 students who studied at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University in the fall of 2013.

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The MESPOM group exploring renewable energy in Thisted with advisors.

THE INTERNATIONAL INSTITUTE FOR INTERNATIONAL ENVIRONMENTAL ECONOMICS

Established in 1994 by the Swedish Parliament, the International Institute for Industrial Environmental Economics (IIIEE) has grown to become a leading international research and teaching centre pursuing strategic preventative solutions in sustainable development. As part of Lund University, the IIIEE offers undergraduate and postgraduate programmes in a multidisciplinary environment, focusing on pragmatic approaches to foster the transition towards an environmentally conscious society.

The IIIEE seeks to facilitate this transition by engaging in a combination of education and research activities with the aim of bridging academia and practice in this public and private sectors. The Institute's researchers and teachers have background in natural sciences, technology, law, economics, and other social sciences.

The IIIEE is proud of is multidisciplinary and multicultural approaches to sustainability, stemming from its international students, faculty, and staff.

By collaborating with other departments at Lund University and with other universities worldwide, the Institute explores and advances knowledge in the design, application, and evaluation of strategies, policies, and tools for a transition towards these sustainable solutions.

Alumni are found within consulting, industry, research, NGOs, international, and national governments, and other fields. The IIIEE has a strong alumni network consisting of over 640 members representing over 80 countries.

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Thank you!

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