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Urban Symbiosis as a Strategy for Sustainabilising Cities: An Overview of Options and their Potential, Pitfalls and Solutions

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Introduction

A century ago, about 1 in every 7 people lived in urban areas. Meanwhile, the ratio became 1 to 1 and the proportion of urban dwellers in the world is still raising sharply UN Department of Economic and Social Affairs Population Division [1]. Cities grow not only in population; they are also strengthening their function as nodes in the metabolism of our society. 80% of the energy consumption takes place in urban areas [2]. In other words, urban areas are growing and have an over-proportional, and growing ecological footprint [3].

The rapid economic and population growth not only cause climate change; also several resources are becoming scarcer. The long supply lines of energy and raw materials make cities vulnerable for international conflicts and natural disasters that interrupt supplies. A transition in the urban metabolic processes is necessary to prevent urban catastrophes, create urban resilience, and contribute to global sustainable development. In this paper, urban symbiosis is presented as a strategy for optimizing the urban metabolic system. It uses the proximity of various infrastructures for symbiotic effects, thereby reducing resource consumption and emissions. The paper briefly sketches urban systems and their impacts in terms of climate change and resource depletion. Afterwards it analyses urban symbiosis by describing various examples, their costs and benefits, and barriers for implementation. Finally it reflects upon new vulnerabilities and lock inns that might result from urban symbiosis.

Urban Symbiosis

Cities have the potential to provide various services for their citizens far more efficiently than rural areas can: The geographic proximity of activities creates various options for symbiosis between these activities as distances for transport, often a major cost factor, are relatively small. Moreover, as cities are still growing, while the population of many rural areas is in decline, cities are still constructing new urban areas [4]. This provides an opportunity for constructing new, more efficient infrastructures that utilize the symbiotic options that have been developed in recent decades.

Virtually all modern cities have sewage systems, drinking water systems, traffic systems, energy systems, public transport systems, waste collection systems. These systems are generally not the result of the implementation of a single blue print; they have in part been planned, been adapted, expansions have been planned, elements have been modernized, systems have merged and elements have been replaced or merged. Parts of these systems might have grown organically during the history of a city Cf. e.g. [5].

Urban systems generally emerged as independent entities, often established by profit driven entrepreneurs. For example, before the 20th century, drinking water supply generally emerged as a private business (Cf. e.g. 17th century London [6] and 18th and 1 century Amsterdam [7], just like electricity supply [8] and telecommunications [9,10]. As private and public interests intermingled strongly, and monopoly power could be abused, these systems were often brought under some form of public control or statutory frame works. In recent decades, some of these systems have been (partially) (re-)privatized for an overview [11].

Urban systems are of crucial importance for a well-functioning city life. Malfunctioning or break downs can be catastrophic, as for example the New York black out of 1973 [12] causing riots and massive looting, various sewer and drinking water damages due to natural catastrophes [13], a fire in a main telecommunications cable in Tokyo, 1984 laming economic life in a vital urban area for almost two months [14]. The software

defect that caused a 9 hour national phone outage in the USA in 1990 [15] is in fact not a failure of an urban infrastructure, just like the succumbing of the New Orleans levees during hurricane Katrina (devastating 300.000 homes and the urban infrastructures of New Orleans that prevented the population from returning) [16]. The severe impacts of interruptions of service of infra systems make these services vulnerable for social conflicts: strikes in public transport [17], or garbage collection [18] can be effective means to fight labor disputes.

Most urban systems are quite robust, and often they function unaltered for decades. An extreme example might be the street plan of some cities that can be traced back thousands of years. Systems can survive unaltered, but are often quite vulnerable for damage if errors occur. The city archive of Cologne collapsed on March 3rd 2009, probably due to the construction of a new underground line [19]. The novelty of the construction method of that underground line was specifically blamed. This created question marks and additional requirements regarding the construction method for Amsterdam's new underground line, which had already been contracted [20]. This pattern is rather common in infra systems development: novelty appears to create risks for the responsible decision makers: accidents/ malfunctioning might be blamed to them. Applying established methods might not cause less risk for the public, but it causes less political risks for decision makers; blame avoidance, a well-known political phenomenon [21]. Blame avoidance implies avoiding innovation in urban infrastructure.

Urban Ambitions: Climate Neutrality and a Circular Economies

Cities increasingly take responsibility for the grand challenges that humanity faces. Many cities have adopted policy declarations aiming at climate neutrality [22,23]. Especially in China, many cities are aiming at a circular economy, i.e. much more efficient metabolic systems [24]. Often national statutory action is surpassed by city initiatives.

It is a complex procedure to establish the emissions of cities. In fact, cities and their surrounding rural areas coexist by a division of tasks that cannot simply be assigned to rural area or city. This has resulted in a complex framework for calculating greenhouse gas emissions [25]. Urban symbiosis is an innovation strategy that aims at the scope 1 emissions of a city and the efficiency of urban infra systems.

Urban Symbiosis as Innovation Strategy

In the 1980s, a gradual change took place in analyzing innovation: The thus far prevalent 'techno-science' analysis of technological change, explaining technological change as being the result of the unavoidable progress of science, gradually disappeared. Instead, 'socio technical analyses of technological change emphasized that the construction of technology was not merely a linear product of scientific change. Instead, technological change was analyzed as a militia-faceted process, in which knowledge, social actors and physical elements could play a role. Various theories differed especially regarding the importance of social processes versus new knowledge and technical processes. However, the basic analysis for all these approaches was aimed at explaining the (un-) successful introduction of new ideas and new artifacts.

Urban symbiosis can be successfully analyzed using actor network theory [26,27]. However, the voluntaristic character of actor network theory points to a major problem in urban symbiosis types of innovation: As the infra systems involved are characterized by a culture of autonomy, there is hardly any space for the so called 'translator spokesman' to start building an actor network that comprises two or more infra systems. Moreover, initiatives emerging from one of the infra systems can easily be rejected by the other(s) as being motivated by self-interest.

For the success of urban symbiosis, it is not so much important to explain how a translator-spokesman translates actors in an actor network and how he keeps them aligned; it is far more important to understand how alliances across organizational divides, alliances that serve different actor worlds, could be formed. It therefore does not only take alignment of actor interests, but also alignment of institutional interests. For example, institutions might be involved in competitive processes that prohibit cooperation. Third party involvement might be a way to bridge those conflicts. [28].

In the remaining part of this paper, I will sketch a number of urban symbiosis innovations, and will briefly analyze watt these options require in terms of technological and institutional change. These will be grouped as:

a. Heat options

b. Biogas generation options

c. And non-energy related symbiosis options

Options for heat recovery

Most of our urban systems generate, or contain heat as a by- or waste-product. This heat might be recovered for heating purposes, or to generate other forms of energy. In order to use waste heat it is often necessary to have a district heating system and/or use heat pumps that are able to upgrade the heat.

Heat pumps are devices that transport heat opposed to their natural direction of flow. Their coefficient of performance (COP), being the ratio of heat energy transported and the electric energy used by the pump is in general between 3and 4, which implies that heat pumps are 3 to 4 times as efficient as electric heaters.

Industrial Waste heat

Industrial waste heat might be a huge heat source of high quality and therefore ideal for feeding a district heating system. In general, industry will not treat the heat that conventional district heating systems require (about 90oC) as waste heat.

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Often, industrial waste heat is 60-80oC. The solution for district heating might be twofold:

a. Upgrading the heat by using a heat pump, which will require additional energy

b. A district heating system with a lower working temperature, which will require quite substantial investments in the system, but will lead to a higher efficiency.

There are advantages and disadvantages for both parties involved:

A. Advantages

I. A source of cheap heat for the city, a source of additional income for industry.

II. Energy efficiency leading to less overall energy consumption and less CO2 emissions.

III. Less thermal emissions, meaning less disturbance of marine ecosystems.

B. Disadvantages

i. District heating needs heat all the time: no maintenance gaps.

ii. Interdependence: what if future conditions change, heating changes, waste heat availability changes?

iii. Costs might be high if the waste heat is not at close distance.

iv. What if industry becomes more efficient and produces less waste heat?

Especially these dynamic factors ('what if') curb the freedom of the organizations involved. In fact the symbiosis will diminish the freedom of operation of each participating organization which often turns out to be a main barrier. Heat from sewage Figure 1.



Figure 1: Design for a district heating system using waste heat from Rotterdam port area to heat the region Rotterdam-The Hague.

Heat from sewage

Much of the heat we use can be re-used. In a shower for example, heat is only used for about 3 seconds before disposal. The outflow of shower water can be used to pre-heat the water entering the heater. In this way, showers take far less energy [29].

However, also after water has been disposed in the sewers, its heat can be used. Water entering the sewer from a household is on average about 20 oC. Thereby the sewer could be a source of low quality heat that might be used for heating using heat pumps. However, sewer systems that also drain storm water might be colder during high rainfall and melting snow.

The disadvantage of using the heat from the sewage might be that the water temperature will be lower when arriving at the waste water treatment plant. As sewer pipes are dug in rather deep, their temperature will always be around 11 oC (the constant temperature of the soil deeper than 1 meter for NW Europe) and so the sewage temperature will always tend to move towards 11 oC. A lower sewage temperature might mean that more heat is required for the sewage treatment process.

Using the heat of the effluent of the wastewater treatment plant does not create such a disadvantage [30]. It might even lower thermal pollution if the effluent is discharged in open waters. Using the heat of effluent is attractive if there is a large heat consumer nearby (e.g. a swimming pool or a main line of the district heating system). For example, in Raalte, the Netherlands, the effluent of the waste water treatment plant supplies half of heat required for heating the local swimming pool which saves 57000m3 of natural gas annually. Security of heat supply might be an issue here: cities might have more than one waste water treatment plant, which they might use to switch of a complete plant for maintenance.

Heat from drinking water production

Drinking water wells pump up water at a constant temperature of about 11 oC. Although the temperature is often lower than the sewage water (except in periods of lots of winter storm- and melting water), this might serve as a more constant source of heat for heat pumps, provided that there are nearby consumers. For drinking water production, it is attractive to lower the temperature of the water as lower water temperatures lower the risk of bio films forming in the drinking water pipes. In Culemborg, the Netherlands, the local water well of the Vitens water company provides heat for a district heating system for 200 dwellings [31].

Heat from large electricity transformers

High Voltage Electricity generally enters the city at a transformer station, where it is transformed into lower voltages. This might create significant losses, i.e. heat is formed that has to be disposed of. The normal solution is to cool the transformer by cooling fins. However, especially if there is a nearby district

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heating network or other heat consumer, the heat could be used as an additional heat source [32].

Heat from roads

Roads are rather good 'black' surfaces, i.e. they reflect little light. In summertime, they can become about 15oC warmer than the ambient temperatures. Road surfaces can be used as heat collectors that can produce hot water. As this hot water is only available during warm periods, it cannot be used directly for heating purposes. However, under the right conditions, it might be stored underground in specific layers of sand for example, to be used during winter time. The capillaries that collect the heat from the road prevent that the road is damaged by the high temperatures. The same capillaries might also be used to warm the road during winter time, preventing frost damage to the road and contributing to traffic safety [33]. The heat that roads produce in Western Europe is far more than what is required for de-icing in winter. Domestic heating could use the heat but only if distances are short. In general there are no residential areas near motorways and therefore heat from road is more appropriate for urban roads [34].

Heat and Cold from open water

Many cities have a water infrastructure: canals, rivers and sea shore. This water might both be used for heat and cold supply. Especially deep water might be used for this aim. Heat pumps might use the heat from open water to obtain heat for district heating in winter and/or to get rid of heat in summer.

In Scheveningen, a part of The Hague, a 2 step system has been created: water is pumped through a district heating/cooling system. The water is heated (and cooled in summer) by sea water. In winter, an additional heat pump heats the water to 11 oC. By using this distribution temperature, the pipes do not need insulation. The inhabitants have a private heat pump to produce heat for their home system. In summer they can use the system for cooling.

By this use of open water, winter water temperatures might go down a bit, which is probably in the direction of a more natural situation. Summer water temperatures might go up somewhat, which could be a problem especially for rivers and canals.

The city of Drammen, Norway has the largest sea-water/heat pump heating system. It produces 14MW of hot water, sufficient for 85% of Drammen's hot water needs [35].

Biogas

Biogas exists of a mixture of gases. It is produced by the anaerobic decomposition of organic matter. It can be produced from almost any organic waste.

From sewage

In modern wastewater treatment facilities, anaerobic digesters produce biogas, while removing the pathogens, conserving the nutrients from the sewage and lowering the oxygen demand of the sewage. The biogas is often used in the wastewater treatment facilities themselves; often electricity is produced in a CHP and the resulting heat is used for various processes in these facilities. As the need for heat is rather limited, it is often argued that the biogas should be used where there is also a high demand for heat, i.e. a CHP facility for district heating [27].

From organic waste

Biogas might also be produced from organic waste. In the past, when waste water treatment took more energy, organic waste was collected as it could relatively easy be composted and returned to agriculture. The mineral cycle was closed in this way. In some cases, large amounts of organic wastes were converted to bio fuel by hydrogenation, pyrolysis, gasification, or bioconversion [36]. A pioneer of biogas production was the city of Linkoping that had to deal with large amounts of waste from slaughterhouses [37]. Nowadays, as wastewater treatment plants become net producers of energy, it could be advantageous to combine organic waste with sewage and treat it in the waste water treatment facilities. This will create more biogas and diminish the costs and energy consumption of domestic waste collection schemes [38].

With the change in efficiency of waste water treatment plants and their biogas production, a rule has often been reversed: It used to be forbidden to add organic waste to the sewage. In some places it is now even encouraged to use macerators (kitchen waste disposers) to grind organic waste and dispose of it in the sewers [27]. Of course, as always, chemicals that affect the anaerobic digestion process are not to be disposed of in this way.

Non energy examples of urban symbiosis

Insect protein production from food waste

Proteins are an essential ingredient of human food: meat, fish, dairy, eggs, and various vegetable sources like peas and beans. When people get richer, their animal based protein consumption rises even more. This has large environmental effects. Beef and veal produced in Western Europe takes large amounts of soy fodder that is often imported from Brazil, where rainforests are cleared to grow soy beans. Animals are 'rather inefficient' in producing meat proteins and so almost 95% of the vegetable proteins are lost in this process.

There are various better alternatives:

a. Soy fodder could be the base for attractive food products

b. More effective forms of protein production could be promoted (chicken, fish)

c. New forms of proteins could be developed.

Edible insects might be interesting to breed in urban areas. They might be fed on food waste. Especially if cities have separate food waste collection systems (either by separate collection bins

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or by carburetors/macerators/kitchen waste disposers attached to a separate sewer pipes) this might be an interesting option for smaller scale insect production. Some problems:

a. Although insects are eaten in large parts of the world, the richest part of the world seems to have developed a taboo on insect consumption. Can this taboo be broken or will this taboo act as a cultural frame for developing nations?

b. Although insects might be rather efficient producers of protein, breeding them might require higher temperatures (e.g. mealworms) that require heating energy…

c. There might be various biological risks: contamination of the food waste, contagious diseases, etc.

The disadvantages of insect breeding might easily reinforce cultural resistance.

Separate collection of Urine

Waste water can be a source of minerals: Struvite is a phosphate containing mineral that can be recovered and be used as fertilizer. Struvite might form spontaneously in waste water clearing facilities and pipes. In this way it is often a nuisance as it clogs pipes, etc. Separate urine collection might lead to less energy consumption of waste water treatment and a higher recovery of minerals.

The urine might be collected from urinals and from special toilets in which urine is kept apart from the faeces. Special toilets might have a social acceptance problem.

Other products might be obtained from wastewater e.g. alginate polymer. For an overview: [39] These changes are not so much a symbiosis between urban systems as well as a systemic change within the wastewater system that requires changes in behaviour of citizen, and perhaps changes in markets that might use these products.

Electricity grid stabilisation by smart communication

Electricity demand and supply can be better managed in order to avoid shortages in electricity that have to be filled at high costs. Peak demand can be lowered. As peak demand defines the electricity production capacity, investments can be reduced, especially investments that are only used to deal with exceptional peaks. It also leads to higher electricity prices at moments that there is plenty electricity (due to good winds/sunshine), as electricity demand will be shifted to these moments.

a. 'Smart grids' allow users to postpone electricity consumption until prices are low, while it allows producers to produce when prices are high. Various industrial and domestic electric appliances are able to postpone consumption:

b. Washing machines can be programmed to wash laundry within a larger time frame. However, washing at night creates noise. Dish washers, can be programmed to wash dishes within a larger time frame.

c. Cold Storage and Freezers, operating temperatures of storage might vary a bit to allow for avoidance of peak electricity consumption.

d. (Micro) CHP units could be equipped with small heat storage to provide them some flexibility in electricity supply.

e. Smart grids might potentially safe billions of Euros in electricity production and transport. [40]

f. In the future, electric vehicles might act as stabilizers of the electricity grid, by smart management of charging. This is the so-called Virtual Power plant. It will create enormous streams of data, to administer electricity consumption and grid stabilization efforts [41].

Roads as infrastructure corridors

Roads divide areas and create various nuisances. Shielding is often required to prevent serious health effects created by noise, particulate matter and traffic accidents involving dangerous substances. Potentially the nuisances can be minimized by combining the road trajectory with other infrastructures. Roads and railroads are frequently combined, but also various other infrastructures might use the corridor, provided that they do not have negative interaction, or their combination creates additional risks. Shielding measures (trees for reducing particulate matter and sound walls to reduce noise might also be selected to increasing biomass production and for being a carrier of PV cells. Roadside grass might be used to generate bio fuel (as it is often problematic to use it as animal feed [42].

Towards an urban metabolic system

Urban symbiosis: a physical, economic and political challenge

There are an overwhelming number of options for urban symbiosis. However, one might wonder why so few of them are actually applied. Why is it so difficult to realize urban symbiosis projects that are often quite interesting both from an economic and an environmental point of view. The main reason is that these projects are hard to define:

a. Complexity: a project does not only need to be good (profitable, environmentally sound,) in total; it also needs to be good for each separate partner.

b. More enemies: Instead of defending a project in one organization, the product champion needs to defend it in two.

c. Monopolistic relations: In free markets, unwilling partners might just be exchanged. That is in urban symbiosis often impossible. Partners know that and might start an unproductive bargaining game.

d. Urban symbiosis projects are often no core business for all the involved partners.

e. These arguments have been further elaborated [26,27,31,43-45].

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Urban Symbiosis: mere incremental change and lots of lock in?

Symbiosis as a strategy for environmental improvement has sometimes been called an incremental change strategy that does not contribute to the changes that are required. It thereby contributes to further lock in, creating actually a barrier for sustainability transitions.

Actually, the integration of technical system proves not to be limited to incremental change. The development of symbiosis between systems does not create a main barrier to transitions. On the contrary, in fact the integration of technical systems might contribute to, or even trigger transitions [46].

In conclusion, it is fair to say that there are many options for urban symbiosis. It is fair to say that these options might reduce resource consumption and emissions by tens of percent. The main barrier is in the complexity of managing all the interests involved [31].

References

1. UN Department of Economic and Social Affairs Population Division (2012). World Urbanization Prospects: The 2011 Revision.
2. The World Bank (2010) Cities and Climate Change: An Urgent Agenda. the World Bank Washington DC, USA.
3. Amend T, Eißing S (2010) A Big Foot on a Small Planet? Global Footprint Network and German Federal Ministry for Economic Cooperation and Development. Eschborn, Germany pp. 1-134.
4. UN Department of Economic and Social Affairs PD (2014) World urbanization prospects, the 2014 revision. Highlights (ST/ESA/SER.A/352) New York, USA.
5. Cronon W (2009) Nature's metropolis: Chicago and the Great West. WW Norton & Company, New York , USA .
6. Tomory L (2015) London's Water Supply before 1800 and the Roots of the Networked City. Technology and Culture 56(3): 704-737.
7. Lintsen H (1995) Geschiedenis van de techniek in Nederland: de wording van even modern samenleving, 1800-1890. Deel II, Walburg Pers, Netherlands.
8. Hughes TP (1985) Networks of Power: Electrification in Western Society, 1880-1930. Baltimore, John Hopkins University Press, USA.
9. Fischer CS (1994) America calling: A social history of the telephone to 1940, Univ of California Press, USA.
10. De Wit WO (1998) Telephony in Nederland 1877-1940: opkomst en ontwikkeling van even grootschalig technisch systeem, TU Delft, Delft University of Technology, Europe.
11. Bognetti G, Obermann G (2008) Liberalization and privatization of public utilities: origins of the debate, current issues and challenges for the future. Annals of Public and Cooperative Economics 79(3-4): 461-485.
12. Frum D (2000) How We Got Here: The 70's: The Decade that Brought You Modern Life. For Better or Worse Basic Books New York, USA.
13. Jafari N, Shahsanai A, Memarzadeh M, Loghmani A (2011) Prevention of communicable diseases after disaster: A review. J Res Med Sci 16(7): 956-962.
14. Takanashi N (1988) The Achilles 'Heel of the information society: Socioeconomic impacts of the telecommunication cable fire in the Setagaya telephone office, Tokyo. Technological Forecasting and Social Change 34(1): 27-52.
15. Burke D (1995) All circuits are busy now: The 1990 AT&T long distance network collapse. California Polytechnic State University, USA.
16. Kates RW, Colten CE, Laska S, Leatherman SP (2006) Reconstruction of New Orleans after Hurricane Katrina: a research perspective. Proceedings of the National Academy of Sciences 103(40): 14653-14660.
17. Van Exel NJA, Rietveld P (2001) Public transport strikes and traveller behaviour. Transport Policy 8(4): 237-246.
18. Civili M (2016) New Garbage strike affects Italy.
19. Linder T, Tretyakov V, Blumenthal S (2010) Rescue robots at the collapse of the municipal archive of cologne city: a field report. 2010 IEEE Safety Security and Rescue Robotics IEEE, Bremen, Germany.
20. Berkhout K, Rosenberg E (2009) Keulse metro was lichtend voorbeeld voor Noord-Zuidlijn NRC.
21. Weaver RK (1986) The politics of blame avoidance. Journal of public policy 6(4): 371-398.
22. Brugmann J (1996) Planning for sustainability at the local government level. Environmental Impact Assessment Review 16(4): 363-379.
23. Lindseth G (2004) The Cities for Climate Protection Campaign (CCPC) and the framing of local climate policy. Local environment 9(4): 325-336.
24. Zhou G (2015) Low-Carbon City Initiatives in China: Planning Approaches, Dilemmas and Opportunities. Stockholm, Sweden, p. 31.
25. WRI/WBCSD (2017) Greenhouse Gas Protocol. Retrieved 7-9-2017.
26. Vernay AL et al. (2013) Exploring the socio-technical dynamics of systems integration-the case of sewage gas for transport in Stockholm, Sweden. Journal of Cleaner Production 44(0): 190-199.
27. Vernay AL (2013) Circular Urban Systems, moving towards systems integration. Delft University of Technology, Delft, Europe.
28. Vernay AL, Mulder KF (2015) Organizing urban symbiosis projects. Proceedings of the Institution of Civil Engineers-Engineering Sustainability 169(5): 181-188.
29. Wong L et al. (2010) Shower water heat recovery in high-rise residential buildings of Hong Kong. Applied Energy 87(2): 703-709.
30. Tassou S (1988) Heat recovery from sewage effluent using heat pumps. Heat Recovery Systems and CHP 8(2): 141-148.
31. Vernay AL, Mulder KF (2015) Organising urban symbiosis projects. Engineering Sustainability, Proceedings of the Institute of Civil Engineers.
32. HAZI A, Hazi G, Gabriel SV (2013) 0pportunity study for heat recovery from large power transformers in substations. termotehnica Supliment 1(2013): 2247-1871.
33. Pan P (2015) A review on hydronic asphalt pavement for energy harvesting and snow melting. Renewable and Sustainable Energy Reviews 48: 624-634.
34. Weijers E, Groot GD (2007) Energie winning uit weginfrastructuur. Innovatie programme Rijkswaterstaat, Utrecht.
35. Anonymous (2015) Drammen Fjernvarme.
36. Demirbas MF, Balat, Mustafa, Balat, Havva (2011) Biowastes-to-biofuels. Energy Conversion and Management 52(4): 1815-1828.
37. Olsson L, Fallde M (2014) Waste d potential: a socio-technical analysis of biogas production and use in Sweden. Journal of Cleaner Production.

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38. Nowak O, Peter Enderle, Petar Varbanov (2015) Ways to optimize the energy balance of municipal wastewater systems: lessons learned from Austrian applications. Journal of Cleaner Production 88: 125-131.

39. Fooij H (2015) Wastewater as a resource: strategies to recover resources from Amsterdam's wastewater. Civil Engineering and Management MSc Enschede, University of Twente, Europe.

40. Brendel M (2015) Smart grid levert miljarden op. Technisch Weekblad.

41. Binding C, Gantenbein D, Jansen B (2010) Electric vehicle fleet integration in the danish EDISON project-A virtual power plant on the island of Bornholm. Power and Energy Society General Meeting, 2010 IEEE, Providence, USA.

42. Weijers EP, Groot GJD (2007) Energiewinning uit weginfrastructuur, Inventarisatie in opdracht van 'Wegen naar de Toekomst' (Innovatieprogramma Rijkswaterstaat).

43. Pandis IS, Brandt N (2011) The development of a sustainable urban district in Hammarby Sjöstad, Stockholm, Sweden? Environment, Development and Sustainability 13(6): 1043-1064.

44. Pandis IS (2013) The potential of the infrastructural system of Hammarby Sjöstad in Stockholm, Sweden. Energy policy 59(0): 716-726.

45. Pandis IS (2013) Implications of systems integration at the urban level: the case of Hammarby Sjöstad, Stockholm. Journal of Cleaner Production 48(0): 220-231.

46. Mulder K, Kaijser A (2014) The dynamics of technological systems integration: Water management, electricity supply, railroads and industrialization at the Göta Älv. Technology in Society 39: 88-99.

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