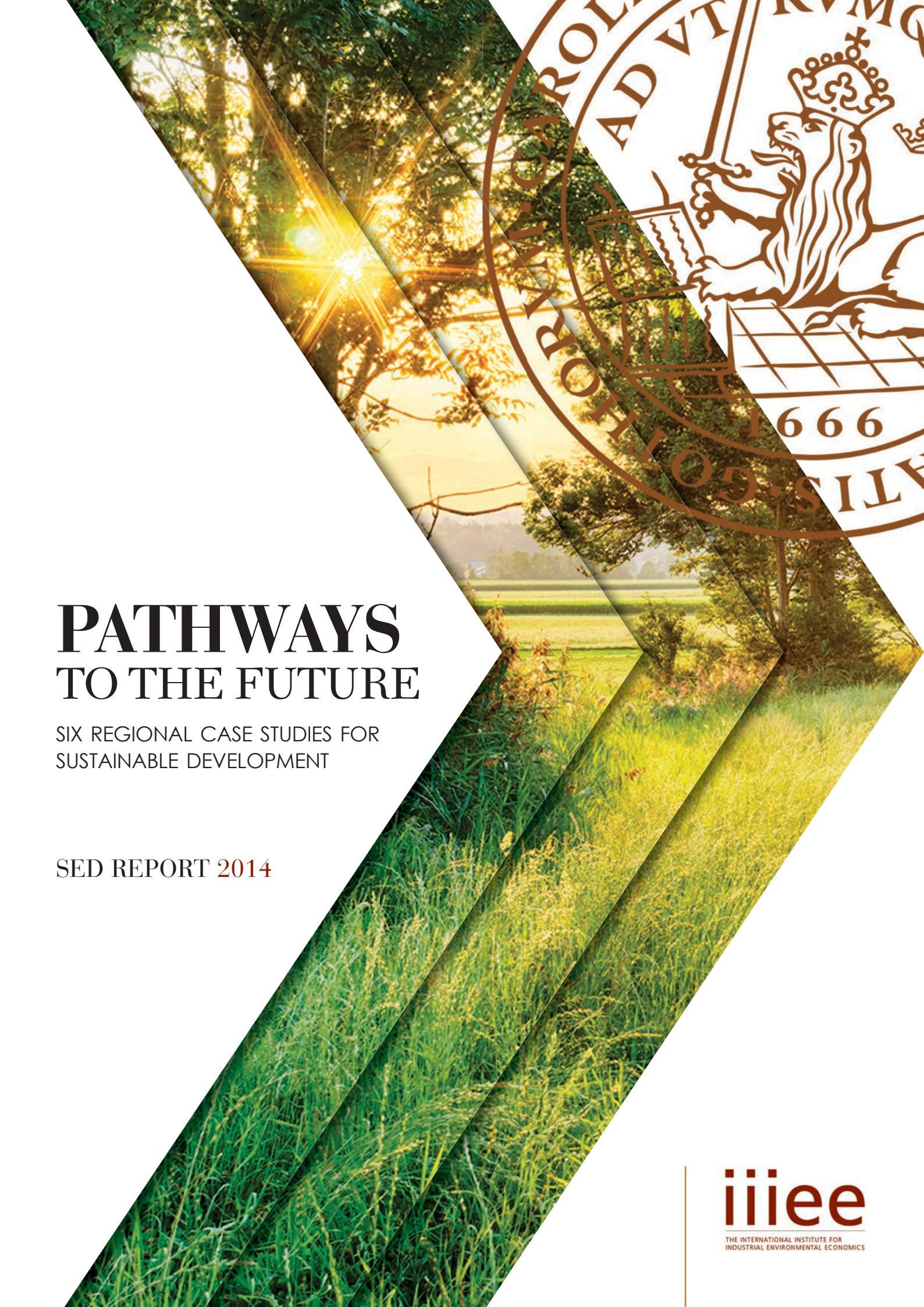

PATHWAYS
TO THE FUTURE

SIX REGIONAL CASE STUDIES FOR
SUSTAINABLE DEVELOPMENT

SED REPORT 2014

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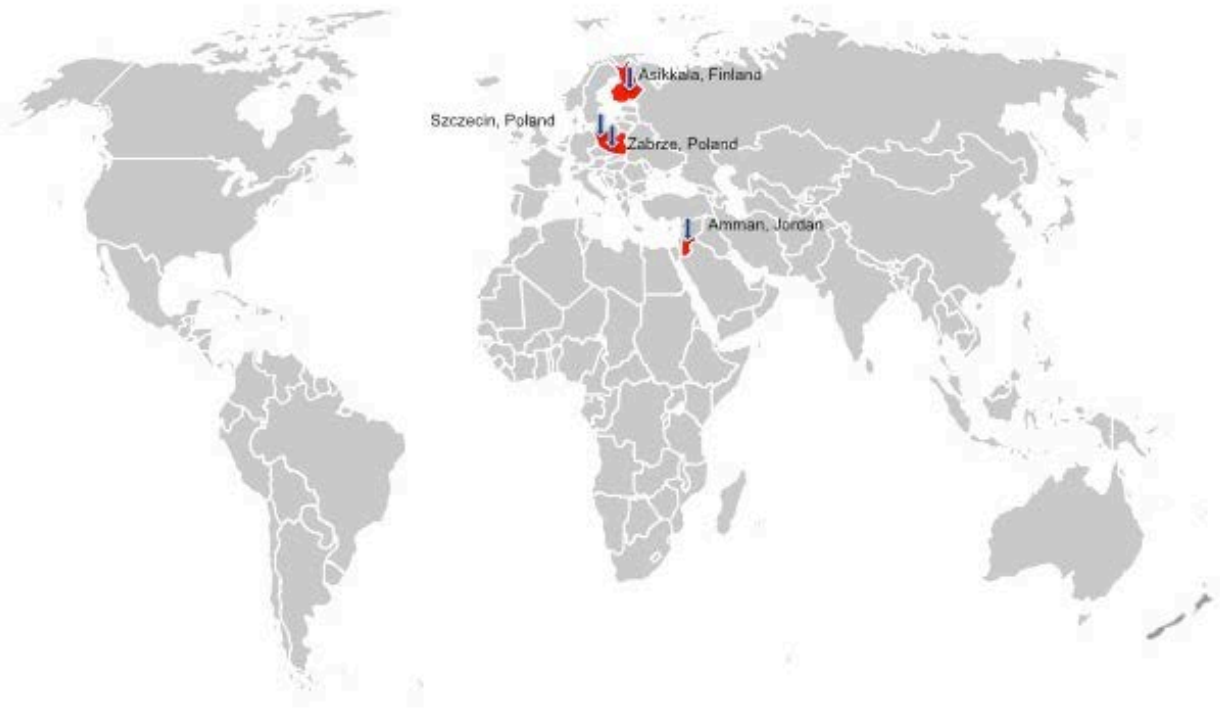


SED 2014 Project Locations

Asikkala, Finland Szczecin, Poland Zabrze, Poland Amman, Jordan

Table of Contents

Introduction

We live on a planet of finite resources, and sustainability is a necessary principle required to ensure future generations do not have to pay for the accumulated environmental pressure from society today. The term sustainable development first appeared in 1987. It is defined by the World Commission on Environment and Development (the Brundtland Commission) as *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* Since then there has been extensive discussion of the concept and there is recognition of three essential aspects of sustainable development: economic, social and environment. Sustainable systems should therefore take into account these three so-called 'pillars' of sustainability as all three are interconnected.

Today, environmental and social problems continue to grow, which undermines the key goal of sustainable development. The shift towards sustainable development requires continual learning and shared experiences across borders. As a way to contribute to this shift, master students from the International Institute for Industrial Environmental Economics (IIIEE) got involved in various projects, covering different sustainability-related areas. Under a course named Strategic Environmental Development (SED) students contribute to more sustainable practices.

SED is an opportunity for IIIEE students to apply their knowledge and experience to real-life projects with clients across Europe. Students are required to systematically approach a task and are bound by the complexity of real-life systems. The students must communicate to a non-technical and non-academic audience to ensure their messages and ideas are both understood and applied in the future. The project is limited in time with only a few weeks of preparation and a week on-site to complete interviews and gather information.

This report compiles the experiences and recommendations from the six student-groups. Each group was assigned a supervisor from the IIIEE.

Institute Summary

The International Institute for Industrial Environmental Economics was established in 1994. A distinct addition to Lund University it was founded on the principle that prevention is the best method, and to address global challenges we must address them with sustainable development in mind. IIIEE is both a research institute as well as the house of two masters programs to create an interdisciplinary environment that teaches students to solve problems from a system-approach. Projects like SED are a way for IIIEE to directly interact with the "real-world" and provide students the sort of experience they need once they have graduated, giving them both the governmental and corporate perspective of addressing environmental issues. Therefore, bridging the gap between academia and practice through collaboration with clients and a diverse set of stakeholders.

Team and Project Summaries

Szczecin, Poland

West Pomerania is one of Poland's 16 administrative regions located in the north-west of the country on the border with Germany. Three study teams visited the region in March and April 2014 to undertake projects on waste management, bio-resource management and improving the sustainability of port of Szczecin, the region's capital.

Waste Management: Szczecin, Poland

Photo: (from left) *Stephanie Wischner, Bilyana Spasova, Thomas Lindhqvist* (Supervisor), *Beau Damen and Konstantina Ouzounoglou*

The West Pomerania waste management team implemented a project to evaluate how the Polish waste management revolution is taking shape in the region. The purpose of the project was 1) to observe and learn about recent changes in the municipal solid waste system of West Pomerania; 2) to identify areas where the regional government could focus attention to improve the system further; and 3) to share relevant lessons from experience in other European countries. The project involved desk research, site visits and interviews with waste management professionals in Poland, Germany and Sweden.

Beau Damen is from Australia and has an academic background in Economics and Communication.

Konstantina Ouzounoglou is from Greece with an education in Civil Engineering.

Bilyana Spasova is from Bulgaria and holds degrees in Economics and European Studies.

Stephanie Wischner is from Germany and has an academic background in International Business.

Biogas: Szczecin, Poland

Photo: (from left) *Armando Hurtado, Andrius Plepys* (Supervisor), *Erika Olsson and Ben Fethers*

The West Pomerania bio-resources team worked closely with the West Pomeranian Marshal's Office to seek ways to improve on sustainable bio-resource management for the region as a whole. The key task of

the team was to focus on ways the region can benefit from increased biogas generating capacity, through transferring our classroom knowledge and experiences from the field in Skåne into the Polish context. Deliverables included a final presentation to the West Pomerania Marshal's Office and a detailed client report.

Ben Fethers is from Australia and has an academic background in Environmental Science.

Armando Hurtado-Sandoval is from Mexico and holds a degree in Business Economics.

Erika Olsson is from Sweden and has an educational background in Political Science.

Green Port: Szczecin, Poland

Photo: (from left) *Mikael Backman* (Supervisor), *Aline Maigret, Jekaterina Dmitrijeva, Teve Kink and Claire Lawson*

The West Pomerania port team was given the task of building a vision for the port of Szczecin to become a Green Port. To complete this task the team analyzed key aspects of the port to identify opportunities and challenges. Aspects analyzed were: the port's location, economic significance, and plans for development. The team identified how to overcome the main obstacle, which is the need to establish a common Green Port vision among stakeholders. In short, this opportunity provides the basis for our recommendations and suggested strategic framework.

Aline Maigret is from Belgium with a degree in Political Sciences.

Teve Kink is from Estonia with an academic background in Human Geography.

Jekaterina Dmitrijeva is from Estonia with an education in Town & Regional Planning.

Claire Lawson is from Canada and has an academic background in Environmental Sciences.

Biogas: Asikkala, Finland

Photo: (from left) *Åke Thidell (*Supervisor) *Raffaele Rossi, Katja Viita* (Asikkala Municpality), *Riitta Talja, Mia Pantzar and Simon Bager*

The team in Finland performed an initial feasibility study on biogas potential in the municipality of Asikkala, investigating substrates available in the region and suitable uses of output. Project activities included analysis of best practices, interviews with a wide array of relevant stakeholders, and identification of potential challenges.

Simon Bager is from Denmark and holds a degree in Geography.

Mia Pantzar is from Sweden and holds a degree in Environmental Studies.

Raffaele Rossi is from Italy and has an educational background in Business Economics.

Riitta Talja is from Finland and holds a degree in International Business.

Smart City: Zabrze, Poland

Photo: (from left) *Marcin Lesiak (City of Zabrze), Patrycja Długosz, Mallory Anderson, Tilmann Vahle, Nathalie Becker, Steinar Kaldal Sarah Kloke and Mikael Backman* (Supervisor)

The team travelled to the city of Zabrze, which is located in the Silesia region in southern Poland. Zabrze city authorities are working ambitiously to transform the city from Europe's most polluted one to a green forerunner in Poland. With plans to develop a new city district, Nowe Miasto, the team was invited by the Mayor of Zabrze to take part in the development by proposing a vision of how Nowe Miasto could be developed in a smart, sustainable way. Expanding our scope to the wider regional context, we investigated among others issues of social inclusion, integrated building, local value creation and environmental protection.

Mallory Anderson is from the United States of America and has an academic background in Environmental Studies.

Nathalie Becker is from Germany with an educational background in Life Sciences.

Patrycja Długosz is from Poland and holds a degree in politics and International Relations.

Sarah Kloke is from Germany and has an academic background in Political Sciences.

Steinar Kaldal is from Iceland with an educational background in Political Sciences.

Tilmann Vahle is from Germany and holds a degree in Environmental Studies and International Politics.

Solar PV: Amman, Jordan

Photo: (from left) *Shu Masuda, Cedric Zhao, Emma Åberg and Matthew Alison*

Not in photo: *Håkan Rodhe* (Supervisor)

The team in Jordan has worked with the Regional Centre for Renewable Energy & Energy Efficiency on three deliverables related to the up-scaling of solar PV

deployment for self-consumption in Jordan. First, a report identifying and assessing current conditions for the deployment of solar PV within the industrial and commercial sector was completed. The main output is a set of key recommendations to overcome barriers and capitalise on opportunities for up-scaling. Second, a brochure outlining the progress of solar PV installations and case studies targeted at the general public. Lastly, the team designed a financial scheme for the Jordanian Renewable Energy and Energy Efficiency Fund, with the aim to upscale the solar PV market within the residential sector.

Emma Åberg is from Sweden holds a degree in Political Science.

Matthew Alison is from Australia and has an educational background in Finance and Economics.

Shu Masuda is from Japan and holds a degree in Civil and Chemical Engineering.

Cedric Zhao is from China and has an academic background in Environmental Studies.

Changing for the Better

Changing Mindsets and Finding the Means for Improved Municipal Waste Management in West Pomerania

By Beau Damen, Bilyana Spasova, Konstantina Ouzounoglou and Stephanie Wischner

Introduction

Poland is currently experiencing a 'revolution' in its municipal solid waste management system (hereafter referred to as the MSW system). The changes have been designed to make the system better and more consistent with European Union (EU) requirements. However, while striving to better align itself with EU legislation, Poland risks developing its MSW system in a way that creates a technical and economic lock-in effects that are environmentally ineffective and, ultimately, unsustainable. To avoid such a situation, the country and its administrative regions need to take a different approach from the one they are currently engaged in. This brief will present the risks associated with the current approach and what could be done today and in the coming years to deal with this challenge. Thus, it makes recommendations for the regional government of West Pomerania in regard to the areas which need attention to further improve the overall MSW system.

Picture 1: New-Old Town of Szczecin

A 'Revolution' in Waste Management

Formerly, the MSW system in Poland was based on a user-pays approach. Households and businesses were responsible for identifying and contracting waste management companies to collect and treat their waste. As of 1 July 2013, key changes in the national Acts on *Waste* and *Maintaining cleanliness and order in municipalities* came into effect [1,2]. The biggest change embodied in these new legislative provisions is a shift in responsibilities as illustrated in Figure 1. It effectively places the whole responsibility of managing the Polish MSW system in the hands of municipal governments – the smallest administrative unit in the country [3, 4]. As part of the changes, Poland's sixteen administrative regions have been charged to support the municipalities by developing regional waste management plans and collecting aggregate information on the performance of the MSW system [3].

Shifts in responsibilities - Polish MSW system

Actor	Old Responsibilities	New Responsibilities
Households & Businesses	• Select and pay for individual contract with waste management companies	• Pays municipalities a tax or fee for waste management services
Waste collection companies	• Collect and treat waste for households and businesses that they have contracts with	• Collect waste and treat waste in municipalities where they are the contracted waste management company
Municipality	• Own/manage certain waste management facilities • Report on packaging waste collected	• Establish, maintain and pay for municipal waste system • Report on packaging waste and other waste streams that are collected
Provincial government	• Collect information on the waste management system	• Set regional objectives • Collect information on the waste management system • Collect fees for certain activities with environmental impact

Figure 1: Key recent shifts in waste management responsibilities in Poland [3]

Drivers for change

Primarily, the changes in the Polish legislation are designed to ensure that the country is complying with EU waste management requirements. As a member of the EU since 2004, Poland is bound to comply with EU principles, objectives and targets. For example, EU legislation for MSW is based upon the 'polluter pays principle' and the principle of 'extended producer responsibility' (EPR) [5]. Further, EU legislation is underpinned by the waste management hierarchy (see Figure 2), which prioritises waste management options based on their impact on the environment and human health. Preference in the hierarchy is given to waste prevention, reuse and recycling. However, according to the latest statistics, most of the waste generated in Poland is going to landfill, while only small portions are recovered or recycled (see Figure 3).

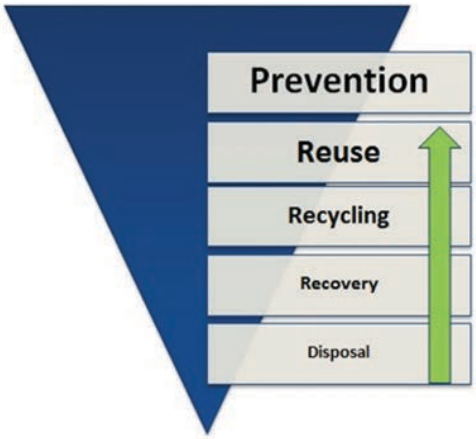


Figure 2: Waste Management Hierarchy

EU Directives such as the Waste Framework Directive (2008/98/EC), Landfill Directive (99/31/EC) and Incineration Directive (2000/76/EC), which are based on the hierarchy, outline key requirements and targets for the MSW system in EU member states. For example, by July 2016, biodegradable municipal waste going to landfills should be reduced by 35% by weight compared to the total amount of biodegradable municipal waste generated in 1995. Similarly, to meet EU requirements, by 2020 Poland is required to 1) reuse and recycle 50% by weight of paper, metal, plastic and glass from households; and 2) reuse, recycle and recover 70% by weight of non-hazardous construction and demolition waste. Meeting these requirements presents a

significant challenge for Poland [6,3].

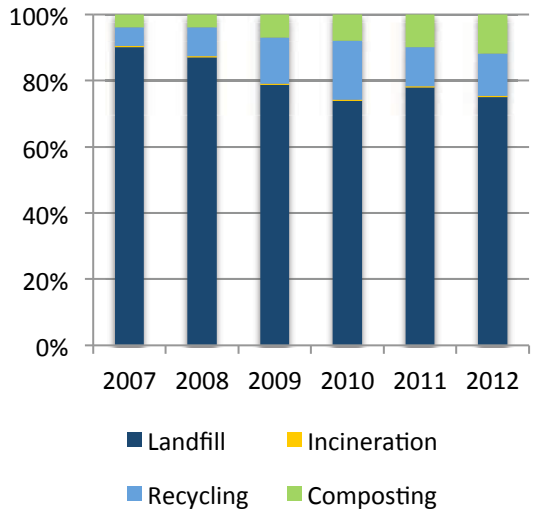


Figure 3: Treated Municipal Waste in Poland 2007-2012 [7]

If Poland is unable to meet EU requirements the country could face a number of financial penalties. The threat of such penalties also acts as a driver for the recent changes to the MSW system.

As noted above, the changes in the Polish MSW system have resulted in greater responsibility being placed on municipal and regional governments. To better understand whether the MSW system is developing as required, it is necessary to investigate how the changes at the national level are impacting at the lower levels of government. The remainder of this report is dedicated to the MSW system in the region of West Pomerania.

The Waste Management System in West Pomerania

In 2013, the region of West Pomerania generated 898,110 tonnes of waste. Over the next decade it is expected that the volume of waste generated in the region will grow by around 11% [2].

Due to the changes within the national MSW system, waste management in the region of West Pomerania has been undergoing a number of transformations. However, as the changes - flowing from national legislation - have to take full effect, waste management in West Pomerania results in similar outcomes to those at the national level with most of the waste generated in the region still going to landfill, while only small amounts of MSW are composted or recycled [8]. As a result, at this stage, any observed change in the system is largely organizational in nature and closely related to the new responsibility that municipal governments have assumed for the MSW system.

The vision for the regional MSW system is outlined in the West Pomerania waste management plan (WMP) for 2012-17. This plan divides the 114 municipal governments in the region into four waste management zones. The plan outlines objectives, strategies and requirements for a new MSW system. It also refers to the waste hierarchy as the key principle underpinning the provisions of the plan. Some of the objectives outlined in the plan reflect the particular pressures imposed by national and EU legislation. For example, the third objective of the plan, which is to reduce the weight of municipal waste landfilled to a maximum 60% of waste generated by the end of 2014, is designed to support national efforts to avoid future penalties for landfilling imposed under the EU Landfill Directive [3,8]. In the context of the changes currently under way, it is important to consider how such time pressures may have shaped the waste management strategies identified in the plan and the action currently being undertaken by municipal governments in the region to

meet the requirements of the plan. For example, in order to meet the objectives of the plan there is a risk that municipalities will opt for quick technological solutions that will prevent the future development of alternative, perhaps, more sustainable waste management options.

The vision for the MSW system

To meet the objectives envisioned for the new regional MSW system, the plan specifies minimum requirements for waste management operators and the required number and type of waste treatment facilities and landfills in each zone. Waste treatment facilities include incineration, mechanical-biological (MBT) and biological processing facilities (Table 2). Such options will generally help make the region compliant with the landfill requirements of EU directives, but could trap the MSW system at the lower levels of waste hierarchy; namely recovery and disposal.

Table 2: Existing and planned waste treatment capacity in West Pomerania (tonnes/year) [2]

Year	2013	2023
Waste Generated	898,110	994,311*
Treatment Capacity**		
• Existing (15)	869,650	869,650
• Planned (19)		1,113,800
Total	869,650	2,003,450
Treatment (Under) or Over-Capacity	(28,460)	1,009,139

* Estimate

** Includes incinerators, MBT & biological processing and assumes that all planned facilities are implemented before 2023. Due to administrative and funding restrictions this situation may not eventuate.

According to the plan, waste treatment capacity is expected to more than double in the future. Currently, the region does not have sufficient capacity for waste treatment. While the plan aims to address this deficiency and meet the requirements of the modest expected growth in waste generated over the next decade, if implemented as specified, treatment capacity will more than double and lead to significant excess capacity (Table 2). While it is important to recognize that due to administrative and funding restrictions all of this capacity may not be developed, it is equally important to consider how the provisions in the plan for treatment could impact on the evolution of the MSW system.

In contrast to the significant expansion of treatment capacity, other objectives under the plan include increasing source separation and separate collection and the creation of municipal systems for waste recycling, recovery and disposal [8]. Such objectives, imply a slightly different system, that is less focused on treatment, recovery and disposal and more in-line with the goals of the higher levels of waste management hierarchy; namely prevention, reuse and recycling.

Observing a system in transition

To better understand how the MSW system is developing in response to the plan, the authors categorized their observations of the system from site visits and interviews in West Pomerania into strengths, weaknesses, opportunities and threats (SWOT). The terms strengths and weaknesses refer to elements of the MSW system that can be influenced by the regional government and the municipalities. The terms opportunities and threats refer to forces that can impact on the operation of the system, but are outside the direct influence of the regional government and the municipalities.

The observed strengths of the system relate mostly to the stronger role that munic-

ipalities play in the new MSW system and the general level of support for the regional waste management plan. Representatives from municipal governments interviewed for this report indicated that they are receiving good support from the regional government to access the knowledge, capacity and funds to implement the plan [1,9]. A number of activities, including capacity building with residents and municipalities and expansion of waste treatment capacity, are already underway [1,2,10,9,11,12].

The weaknesses observed in the system are related to the type of MSW system being encouraged by the current plan and a lack of capacity at all levels of the system to transition away from treatment and disposal to more advanced waste management practices. As noted previously, the plan relies heavily on technological solutions such as incineration and MBT for effective waste treatment. This could lead to technology 'lock-in' and future over-capacity. This could also discourage municipalities from developing infrastructure for waste recycling and prevention. For example, during interviews it was apparent that at present municipal governments are focused on meeting requirements to reduce biological waste going to landfill by installing or upgrading MBT facilities. Meanwhile, recycling rates remain low at around 10 percent [1,9]. In general, the MSW system prioritizes landfill and recovery over prevention, re-use and recycling.

Key Finding 1

The waste management system, as designed at present, is only capable of low levels of recovery and recycling.

The current system also relies on the capacity of municipalities and residents to properly manage the MSW system and its various waste streams. For example, the tendering process to secure municipal waste management services has become a critical determinant of the effectiveness of the MSW system. The tender process needs to anticipate multiple and often complex requirements of the system such as the frequency of waste collection and the number and type of bins required for different dwellings (Picture 2).

Picture 2: Separate collection bins for paper, plastic and glass packaging waste

Based on feedback from interview respondents there is consensus that municipalities currently lack the necessary capacity to design effective tender processes for waste management services [1,10].

Key Finding 2

Municipalities face considerable challenges in organizing effective systems for separate collection of different waste streams.

A related challenge is the public's lack of awareness and understanding of improved waste management practices [1,2,9,11]. Most respondents acknowledged that the behaviours required to improve waste separation and sorting at source are new to the public and require sustained education and awareness raising efforts. Respondents al-

so acknowledged that while municipalities are using differentiated fee structures to encourage residents to separate waste at source, the incentives may not yet be enough to support changes in waste disposal behaviours [1,2,9].

Key finding 3

To improve the regional waste management system there is a strong need to improve public awareness of better waste management practices and strengthen systems for source separation and recycling.

Opportunities observed included potential new sources of funding for improved waste management; particularly from EU and the West Pomerania regional waste management fund. Additional opportunities include the potential for cooperation between municipalities in the management of waste and for the regional government to lobby for improvements in the national extended producer responsibility system. At present, the EPR system is considered ineffective and suffers from a number of loopholes, such as no penalties when producers are not paying their fees. This allows producers to avoid paying for the effective collection and recycling of waste packaging [10].

The key threats to the system are related to future changes in EU or Polish national waste management legislation. These threats could result from future, more stringent restrictions on incineration emission, enforcement of new requirements for recycling and re-use of waste or the imposition of stricter guidelines and criteria for waste prevention. The inability to accurately foresee such developments requires that any plans for the MSW system account for the possibility of such changes.

Key finding 4

It is necessary to plan for future in order to avoid technological lock-in effects that may restrict the region's ability to respond to future changes in regulation.

Lesson learned: Swedish experience with technology 'lock-in'

Maybe one of the biggest opportunities for Poland to improve the MSW system is to learn from other countries – both from their positive experiences and from their mistakes. In this sense, it is important to consider the example of Sweden. It is often seen as a role model in terms of waste management, but this reputation has a downside, which can be well illustrated by the example of two municipally-owned waste management companies, located in Southern Sweden – NSR and Sysav.

Both of them have taken different approaches to waste management: the first one has focused on biological treatment and the second one on incineration. Over the years, the two companies have made costly investments that have locked them in to those technologies and limited their possibilities to explore other options [13]. For instance, the Sysav has created huge incineration capacities, which is considered to be the second worst waste management option according to the waste hierarchy.

Today, this company and Sweden as a country want to climb up the waste management hierarchy [14]. However, the "lock-in" effect has taken place because of the large investments, heavy infrastructure and overcapacities. Thus, they face nowadays significant challenges in doing so.

Focus areas for action

While it is clear that the West Pomerania MSW system is undergoing change, based on field observations and the SWOT analysis presented above, there are areas where the regional and municipal governments could focus action to ensure the system is more consistent with the objectives specified in the regional waste management plan and the broader principles underpinning national and EU legislation related to the waste hierarchy. To identify these areas for action a gap analysis was conducted. It compares the current performance of the system with a desired target state.

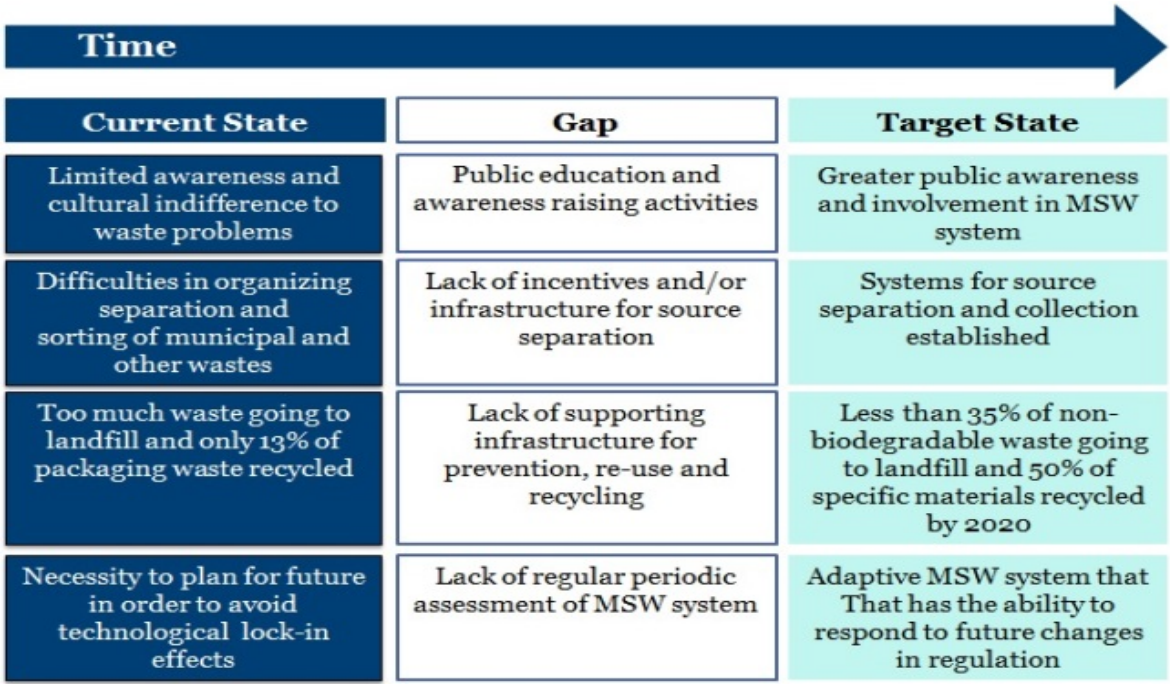
Before proceeding, it is important to note that the actions suggested in this section should be considered as part of a continuous and incremental process of change. Experience from other countries indicates that the creation of new habits and lifestyles to accompany a new MSW system is a gradual process that evolves over time and it is not possible to change the whole MSW system overnight.

Gap Analysis

The outcome of the gap analysis is illustrated in Figure 4. Here, the key findings regarding the current state of the MSW system are addressed and linked to an element of the desired state of the MSW system as described in the regional WMP.

As a result of this analysis and for the purpose of this report, suggested areas for action address 1) the lack of public awareness related to waste management; and 2) the challenges faced by municipalities in designing systems for separate collection and the low level of material re-use and recycling.

These areas for action are further defined as 'Changing the mindsets' and 'Finding the means'. 'Changing mindsets' refers to education and awareness raising activities designed to increase attractiveness of good waste management practices. 'Finding the means' includes incremental measures to improve the capacity of municipalities to collect, separate and recycle waste.



** Readily recyclable materials*

Figure 4: Gap Analysis [8]

Criteria to assess actions

Before discussing each of the action areas in more detail, it is important to acknowledge that any action to better guide change to the MSW system in West Pomerania will require varying degree of effort and funding. As a result, it is necessary to identify relevant criteria by which to assess the feasibility and attractiveness of various possible actions. For the purpose of this report three criteria have been used to guide suggestions for action. These include:

Cost – The total projected cost incurred by the regional and municipal governments for a suggested action. Cost refers not only to budget appropriations, but also to external costs or benefits such as the expected change in environmental state expected to result from an action.

Potential for change and scale-up – The magnitude or amount of change that is expected to result in the system from a particular action. A related criterion is the ease with which an action can be expanded or replicated elsewhere in the region.

Administrative ease – The feasibility of an action given existing regulation and legislation. Generally, actions that require significant changes in legislation or new regulations are considered less feasible; at least in the short-term.

For the purpose of this report no detailed assessments of each suggested action against these criteria were produced. As a result, should action be considered in the future, a more detailed assessment using these criteria or others used by the regional government will be required.

Changing mindsets

Changing mindsets is about communicating effectively with households about the importance of improved waste management and what they can do to contribute. For all such activities it is important to build on residents' attitudes and behaviour. In this regard it might be possible to work together with universities to get a better picture of the current situation through surveys at low costs. Surveys can reveal information on behaviour triggers and where households need more help.

In order to communicate effectively, it is also important to provide guidance to municipalities on clear waste management communication strategies. Sysav, the Swedish waste management company, suggests that messages should be consistent and have the following characteristics:

- Use 2-3 key message which are easy to understand;
- Focus content on why and how to prevent, re-use and recycle;
- Use positive messages ('Thanks for separating') instead of negative ones ('You have to separate')
- Repeat these messages constantly;[14]

Recommendation

Focus on few simple, consistent messages and repeat them regularly.

Further, it is important to establish a standardised regional branding for collection. This can include regulating the colours of the bins, containers and plastic bags of different waste streams and further work with symbols on the bins as illustrated in Picture 2. A standardised and simple system makes it easier for the residents to adopt the new system [15] since people are often unsure about how to handle different waste fractions [1,10].

Flyers clearly identifying the different waste streams and associated pick-up times of the bins can further assist the residents [16]. To introduce such a system is relatively easy – from an organisational and administrative point of view - and the potential for change and scale-up is high. The cost of implementation could for example be introduced into the tender requirements for waste management contractors.

Picture 3: Colour-coded bin from Region 21 [9]

Recommendation

Introduce standardised recycling system and work with colours and symbols to make it easy to understand and to use.

A related recommendation is to introduce a specific day or time period that is used to focus public awareness activities on the MSW system; for example a 'Clean-up West Pomerania day'. On this day waste management issues in the region can be highlighted and further shown what can be done about them. This again would be relatively easy to implement. Funding to support such an activity might be available from the regional fund for environmental protection.

According to Swedish experts [14, 15], initially activities aiming to change behaviours should be focused on leverage groups such as universities and public organisations where people may be more willing to change their practices. In this regard, schools are especially important as the actions of children have been shown to have a strong multiplier effect. Studies have revealed that children can successfully teach their parents about recycling and change their behaviour [17]. Introducing a systemized school program on waste management is, therefore, important and promises a high potential for change and scale-up. Some municipalities such as Region 21, Mysliborz and Koszalin are already focusing awareness activities towards children and have found different ways to make waste management interesting and fun [1, 9, 11, 12] (Picture 4).

Picture 4: Learning materials from Region 21 [9]

Such actions can be easily replicated in other parts of the region. Additionally, schools could consider introducing related activities such as a recycling competition among schools. This is a cost-effective way to generate interest in the MSW system that could be combined with other environmentally-friendly behaviour such as switching off lights to save electricity.

Recommendation

Focus on leverage groups such as school children, university students and public institution officials.

Lesson learned: German experience with information for residents

In the case of Berlin the waste management company BSR provides boxes with playful learning material which can be handed over from class to class for three different topics: recycling, littering and waste prevention. Also a pocket-sized flyer working with different colours as well as icons was found to get the best response from residents.

Another example from Sweden and Germany are feedback loops which show residents what positive environmental impact their recycling behaviour can have. For example, the use of visual materials to illustrate how much biogas can be generated from biodegradable wastes or how many trees are saved when paper is recycled. Picture 5 shows a poster from a campaign in Germany to this effect. These posters have a high potential to influence the way people think about waste and provoke changes in behaviour. Developing such professional information campaigns can be costly. However, revenues generated from a functional EPR system can be used to finance such activities, which is the solution that has been adopted in the case of Berlin [18].

Recommendation

Create posters with feedback loops to visualise the effect of positive actions.

Picture 5: Example feedback poster from BSR [16,19] (In the future over 100 waste collection vehicles will be fuelled with biogas from organic waste. This saves 2,5 million litres of diesel in a year)

Finally, Swedish experience has revealed that it is very important to match education and communication activities as well as the provision of infrastructure with the actual waste management system in place in order to create confidence and acceptance of the system [14,15]. It can have a negative effect when residents are taught that recycling is important and how it has to be done but no bins or facilities for separation are provided.

Recommendation

Match education and communication activities with existing infrastructure.

Finding the means

Finding the means is about developing capacity within the MSW system, improving source separation and creating opportunities for the re-use and recycling of waste.

Firstly, it is beneficial to investigate the value of waste streams generated through recycling. This is useful to illustrate possible revenues for the municipalities and give them more incentives to invest in waste management. Commissioning a research report on the topic is one relatively simple way of acquiring such information. The in-

formation can further be shared with various actors within the waste management system. The regional fund for environmental protection can be one possible source of funding.

Recommendation

Investigate the value of waste streams generated through recycling.

Given the importance of the waste management tender process for the operation of the system, one specific action that could promote significant positive change is training municipal waste management representatives on the design and implementation of tender processes. Better designed waste management tenders will increase the minimum requirements of the system and deliver better waste management outcomes. Currently, the tender requirements only include the number of bins for mixed waste, but they could be extended to also include provisions on bins for separate collection. Implementing such training activities would require the regional government to build on its existing capacity building efforts with municipalities.

Recommendation

Provide training for municipal waste management representatives on the design and implementation of tender processes.

Related to provisions for source separation and collection, is consideration of how to best organize infrastructure and facilities for sorting and separate collection; especially with regard to apartment blocks where space for such facilities is particularly limited. For example, measures could include tender requirements to provide residents with coloured plastic bags and 3-in-1 bins to facilitate source separation. In this regard, but also when it comes to communication, the municipalities can work together with housing associations to investigate and propose effective solutions.

In addition, the existing collection facilities (recycling stations and containers) can be rebranded and promoted since residents are often unaware of them.

Recommendation

Provide residents with coloured plastic bags and 3-in-1 bins to facilitate source separation.

Again, as noted above, experience suggests that it is particularly useful to prioritise separation projects with leverage groups and strategic institutions such as government institutions, schools and universities. These groups can serve to provide useful examples of how the waste management system can be improved and provoke further action. Picture 6 shows a pilot project in Koszalin where bins in form of animals were introduced and were successful in getting the children to separate waste.

Picture 6: Pilot project in Koszalin, where animal shaped waste bins make it fun for children to sort their waste. [11]

The regional government could also encourage municipalities to collaborate on the organization of waste management to take advantage of synergies and economies of scale [9]. Such a co-ordination on a

larger scale can be more efficient and increase eligibility for EU funding for waste management infrastructure [9,20].

Finally, the regional government could also consider influencing developments at the national level by lobbying for changes to the EPR system. A functional EPR system is important source of revenue and therefore the administrative effort would pay itself back very quickly.

Lesson learned: Germany's monetary income for activities

In Berlin a large portion of communication activities as well as the provision and collection of separate waste bins for glass and paper is financed through money from the nationwide EPR system.

Towards a better system

As noted above, the process for establishing a better waste management system is gradual in nature. The MSW system is complex relying on the combined efforts of numerous actors. As a result, when considering action to change the system at the regional level it may be useful to consider sequencing related actions as a pathway toward a better MSW system. At each stage along the pathway experiences and lessons learned can be used to inform subsequent actions. For example, Figure 5 presents a successful example pathway from Berlin for a sequence of actions in the area of 'Changing mindsets'. While the actions described here may not be directly applicable to the case of West Pomerania, they show how one municipal government successfully engaged with residents in a step-wise manner to raise awareness regarding the MSW system and reasons for adopting a specific system such as potential rewards and savings.

The journey along this pathway requires the cooperation of residents, waste management companies and government at the regional and municipal level. Therefore, it is important to maintain the credibility of the system. This means that the MSW system should always match the information made available to residents [21].

Finally, while the pathway to a better system will be gradual, it is still important to consider how decisions made today will

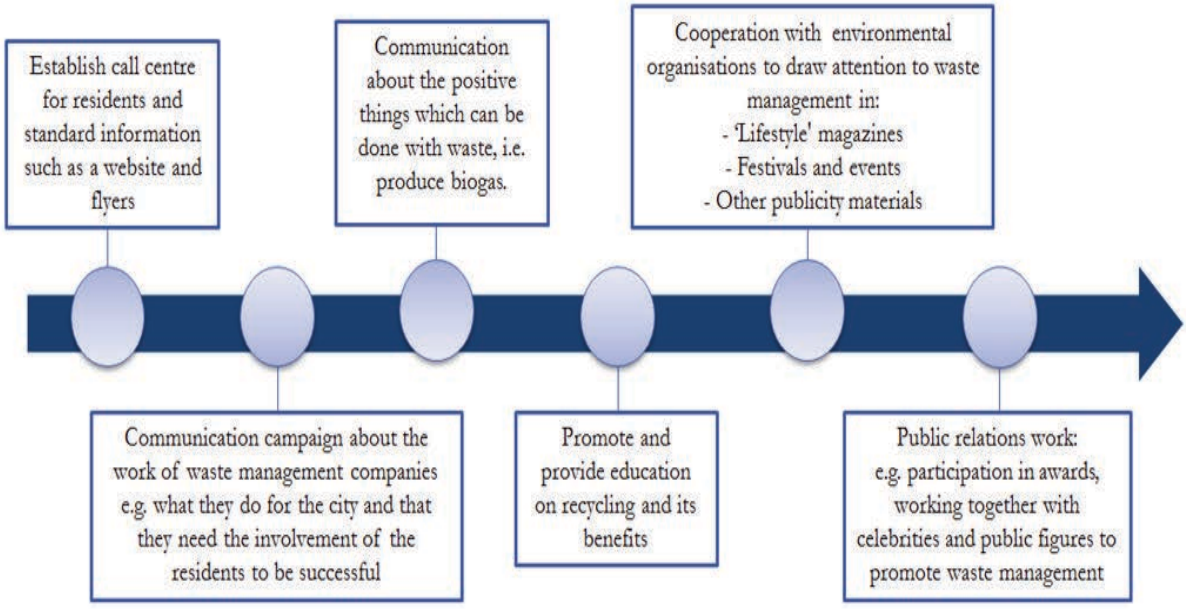


Figure 5: Example of a pathway of actions for 'Changing mindsets' from Berlin

shape the MSW system in the future and how this might conflict with changes in future requirements of the system. For example, if legislation at the EU or national level changes, large investments in technological solutions might be quickly made redundant or prove ineffective in meeting stricter targets or requirements.

Funding a better system

Funding will be crucially important in putting the region on the pathway to a better MSW system. In this regard there are different options available at European and national level.

At the European level, 'Structural Funds' and 'Cohesion Funds' are the main financial tools used by Polish authorities to support their activities on waste management [18]. The Structural Funds are based on the European Regional Development Fund (ERDF) and the European Social Fund (ESF). These funds also include the LEADER programme, which aims to contribute to regional development by enhancing the competitiveness, to create sustainable jobs, and to promote entrepreneurship [20]. Furthermore, the region can apply for EU funds for education or training programmes [20].

At the national level, funding is available from the 'The National Fund of Environmental Protection and Water Management' that was established in 1989 to supplement EU funds for regional development, by prioritising environmental protection projects and innovative solutions [19]. This fund is based on taxes and incomes from non-compliant behaviour such as exceeding landfill restrictions and emission limits from incineration.

In both cases, the funds are distributed to the regions and then to the municipalities according to the national or regional plans and the additional requests from the municipalities [18].

Conclusion

While the current revolution in waste management in Poland presents a significant challenge for the country it also represents a great chance for motivated regions like West Pomerania to establish itself as a leader in waste management. Currently, West Pomerania focuses on disposal and recovery. This is considered a 'least-best' solution when looking at the waste management hierarchy. West Pomerania should use the opportunity to review the transition currently underway in the MSW system to put in place actions to move up the waste management hierarchy and away from reliance on technological solutions such as incineration and MBT. As Swedish experience demonstrates, investments in these solutions can easily lead to costly lock-in effects. An alternative approach is look for ways to move up the waste management hierarchy in gradual and incremental steps based on an evolving understanding of the system and capacity of waste management stakeholders. The analysis outlined in this brief suggests that action in this regard should focus on the two areas of 'Changing mindsets', which includes education and awareness raising activities designed to increase attractiveness of good waste management practices, and 'Finding the means', which includes measures to improve the capacity of municipalities to collect, separate and recycle waste.

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Sustainable Bio-Resource Management in West Pomerania

Enabling regional biogas production

Armando Hurtado, Ben Fethers & Erika Olsson

Introduction

This brief outlines how the Marshal's office in West Pomerania, a region in the very northwest of Poland, can promote the effective production of biogas as one component of sustainable bio-resource management. It comprises a summary of an applied course project that was carried out in March-April 2014, commissioned by the West Pomeranian Marshal's Office.

The project was derived through identification that effective bio-resource management constitutes a regional challenge and significant opportunity, both in utilizing the relative abundance of biomass for energy and creating cleaner waste fractions to achieve compliance with numerous directives at the EU level. Better management of bio-waste streams in the region is recognized as a key component towards overcoming this challenge and formed our key focus.

Objective of brief: To outline how the Marshal's office can *support the regional biogas system,* as part of enabling Western Pomerania to become *the leading Polish region in sustainable bio-resource management.*

This brief summarizes technical literature, experiences from the Swedish national and Skåne regional context, as well as experiences and information attained during a one-week study visit in West Pomerania. Swedish experiences are explored due to the success attributed to biogas development in the area and the relevant experiences that can be drawn from the importance of local policies.

Bio-resources and Biogas

The biosphere is under increasing threat from anthropogenic stressors such as eutrophication and greenhouse gas emissions, while natural finite resources are being depleted to provide goods and services to a growing population. Improving bio-waste management can contribute towards reducing this impact, along with our dependency on finite raw materials for production of goods and energy. Managing bio-resources can thus enable production systems to be shifted towards a more socially, economically and environmentally sustainable path.

Bio-resources can be divided into two categories. *Primary bio-resources*, such as crops, meat and timber products are intended for direct use or consumption. Waste streams arising from the production and consumption of primary bio-resources constitute *secondary bio-resources,* including spent grain, sawdust, slaughterhouse and household wastes. As technology develops, opportunities to utilize bio-

resources through innovation become more widely available (e.g. bio-gas, bio-refineries), prompting decision-makers to reconsider the tangible value of bio-waste.

The term biogas refers to the gas produced as a result of the anaerobic digestion process or fermentation of organic matter. The fermented material can be derived from many sources (known as substrates), including manure, sewerage sludge, municipal solid waste or any other biodegradable feedstock or waste. The gas produced is made of mostly methane and carbon dioxide, and can be combusted for heat and electricity, or upgraded to be used as a vehicle fuel.

The biogas production system has the potential to both generate beneficial economic returns, whilst also providing direct and tangible benefits to the environment and society. It is important to consider the holistic suit of potential costs and benefits in analysing how a biogas system can be part of a broader strategy for sustainable management of bio-resources within the region.

Environmental Benefits

Producing biogas can provide direct and tangible benefits for the environment. It can *mitigate climate change* by reducing methane emissions otherwise emitted naturally; and by substituting fossil based vehicle fuels. This has been showcased in the municipality of Kristianstad, Sweden, where ambitious political goals for emission reductions has spurred biogas production intended for public transport use, resulting in the replacement of about 3,4 million litres of gasoline annually [1].

Further, separating out bio-waste fractions enables the *improved utilization of other waste fractions*, making material recycling more efficient and thus decreasing the need for raw material production. Other tangible environmental benefits of biogas production can include the promotion of nutrient recycling through bio-fertilizers and reduced use of industrial fertilizers, decreased air particulates, reduced odour regarding output material and elimination of infectious agents.

Economic Benefits

Producing biogas can serve as a source of revenues to the producer. Depending on the possibilities to sell the energy and digestate generated, this can be either a direct revenue or avoidance of alternative costs. The Szczecin wastewater treatment plant is an example of the latter. The plant uses its sewage sludge to generate biogas and is able to generate 60% of the plant's electricity needs in the process, equivalent to savings of almost 1,3 million PLN per year (EUR 0,31 million) [2]. This can be important also to small-scale farmers, where the additional income from selling energy to the grid and improved soil quality from nutrient recycling can provide important additional incomes.

As mentioned, better waste separation can also enable improved recycling of other waste fractions, and allow incinerators and mechanical biological treatment (MBT) plants to run more efficiently, thereby increasing the overall profitability of the waste management system. By treating the biological waste streams in a biogas system, environmental costs such as the clean up of landfills and water bodies can be avoided. Finally, the biogas system can support the development of new industries, such as bio-refineries, and promote a reputational value to the region. While indirect social benefits, such as improved health (e.g. due to better air quality in cities where

biogas is used to substitute fuels in city transportation), are difficult to assess, it is important to include these in the regional economic valuation of the biogas system.

Social and Legal Benefits

One of the key social benefits from increasing biogas production is job creation. Swedish region Skåne has estimated that achieving the 2020 regional objectives of biogas production could create up to 3000 new full time jobs in the region [3]. Developing the biogas system can thus strengthen local economies. Given substrate availability and distribution networks throughout the region, similar employment prospects are achievable within the West Pomeranian region. The value of improved health levels from improved air quality where biogas is used as a vehicle fuel has been previously mentioned. This was a key motive behind Lund municipality's decision to run all public transportation on biogas. After this change, air quality improved drastically in the municipality [4]. Putting a strategic focus on biogas and its benefits as a waste management strategy can also improve the overall environmental awareness among citizens in the region. Using biogas as a part of the waste management strategy can also help municipalities to achieve compliance to EU directives.

It is clear that many benefits of a biogas system overlap several policy areas. In order to understand its full value, one needs to consider all relevant policy areas.

The West Pomerania Region

West Pomerania is a provincial region in northeast Poland. The region's population is over 1 700 000 covering an area of 22 892 km^2 split up into 18 separate land counties. The capital of the Province is the city of Szczecin, with larger cities of Koszalin and Stargard Szczecinski. The region contains rich deposits of natural energy resources (gas, oil, wind) as well as large areas of arable land. There is an extensive electricity, district heating and gas grid throughout the region. There are currently eight biogas plants, four derived from sewerage sludge and four based on substrates derived from agriculture, as well as ten landfill gas capture sites located within the region.

Economy

Generally speaking, the region's economy is spatially diverse, with an employment structure typical of other Polish regions characterized by a proportionally larger services sector, to a smaller production and even smaller agricultural sector. This structure is particularly true of the Szczecin and Koszalin townships, upon which most economic activity in the region is centred.

General population trends over time show a gradually ageing population, with a proportionally large unemployment rate of 22%, compared to the national average of 18% [5]. Small and medium sized enterprises (SME's) represent a very significant proportion (over 99%) of businesses in the region, with almost three quarters of these individually operated. This sector is well developed and plays a major role in driving the economy, yet lacks innovation and effectiveness [6]. Regional investment is focused on improvement through establishing technology and information transfers between businesses, encouraging innovation clusters as well as research and development projects for learning. The region's agricultural sector is dominated by micro, small and medium sized enterprises in agricultural crop production, animal production, agro-food production, forestry and

wood production.

Agriculture

Despite the agricultural sector experiencing negative growth over the last five years, the region contains a sizable agricultural sector. The industry is dominated by micro-, small- and medium-sized enterprises in agricultural crop production (cereal, sugar beets and potatoes), animal production (pigs, cattle and hens), agrifood production, forestry and wood production. Farms are typically small (averaging 22 hectares) and most are owned privately [5].

Energy

Primary energy in the region is generated predominately through the combustion of hard or brown coal. Such methods are carbon intensive and unsustainable, and should be downscaled in order to meet the demands of several EU directives. Poland's long-term energy strategy highlights energy diversification, energy security, the development of competitive energy markets and increasing the use of renewable energy sources as key priorities.

The National Renewable Energy Action Plan (NREAP) transposes the EU Renewable Energy Directive (2009/28/EC) by announcing ambitions to double the country's share in renewable energy sources to 15% by 2020. On a regional level, West Pomerania is a key leader in Poland's renewable energy ambitions, generating 20.8% of its energy from renewable sources in 2008, mostly from wind power [7].

The Biogas Value-chain: Operational Factors

The efficient production and distribution of biogas includes actor collaboration between many different spheres of society. The system also relates to many different political sectors, including agriculture, waste management, energy and environment. To enable an economically, environmentally and socially sustainable biogas system, relevant actors and policies all need to be aligned. This also presents the greatest challenge for biogas deployment on a wider scale.

This brief applies a comprehensive value chain perspective to the biogas system, considering both *operational factors* (the availability of substrates, transportation, technological treatment, distribution, retail

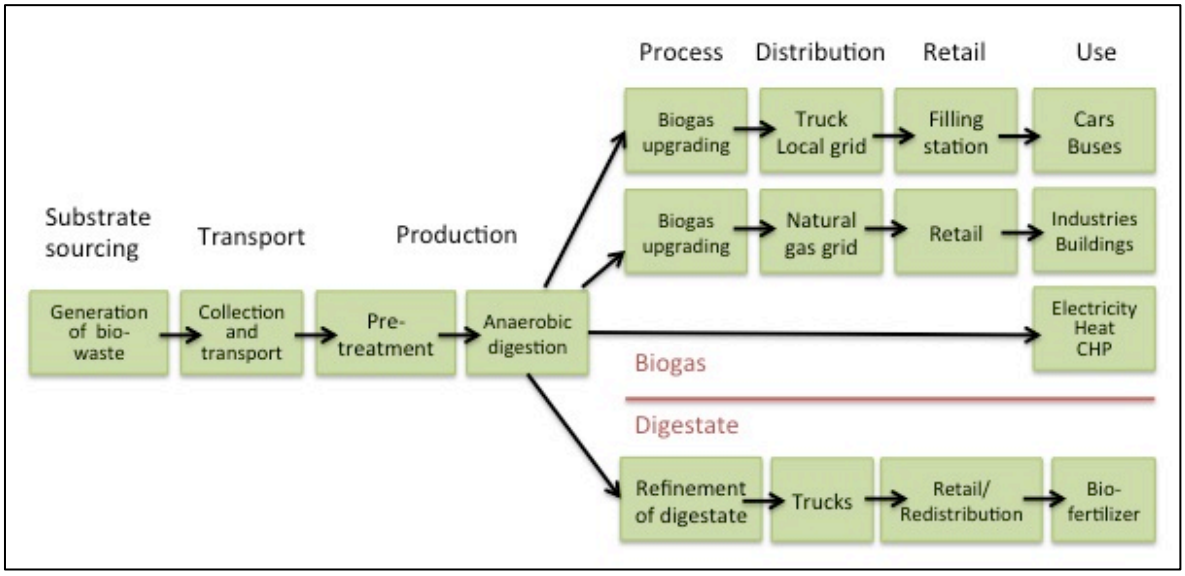

Figure 1: The Biogas value chain. Adapted from [2].

and use/consumption) and the *underlying drivers* such as policies, capacity building and market incentives. An outline of the operational drivers in a typical biogas system is provided in figure 1.

Substrates

Substrates (inputs) are defined as biological materials suitable for methane production through anaerobic digestion. Major substrates identified within the West Pomerania region are primarily the result of agricultural, industrial and household activities, and typically include plant and animal waste material, manure or sewerage. Important factors to consider regarding substrates in deciding upon biogas installation include the source, availability and type of substrates to be used.

The current Polish definition of agricultural biogas demands it to be derived from raw agricultural materials, by-products of agriculture, liquid or solid animal manure, agricultural processing by-product or residues, as well as forest biomass. Organic food waste and wastewater sludge does not form part of this definition, restricting the use of such materials as a bio-fertilizer. Food wastes could however be added to wastewater sludge to increase the production of biogas, something which is done in several Swedish municipalities.

Biogas substrate mapping for major organic waste sources within West Pomerania was conducted using regional data obtained from the Polish 2012 statistical yearbook and the West Pomeranian Marshall's office. Substrates were identified in light of aspects affecting biogas investment feasibility, including substrate cost, pretreatment complexity, degree of hazardousness, substrate moisture and biogas yield and local information to form the summary table and conclusions regarding substrates in the region.

Substrate Type	Amount within the region *(Data sourced from [8] and [5])*
Animal Manure	Over 315,000 pig, and over 100,000 cattle produced in the region in 2012.
Slaughterhouse Waste	Over 28,000 tonnes generated throughout the region in 2012.
Wastewater Sludge	Over 28 million tonnes of dry sewer sludge generated in 2012 from 493 plants.
Organic Industry Waste	Over 195,000 tonnes generated in 2012
Agricultural Crop Waste	Over 2 million tonnes of wheat, rye, barley, rape and sugar beets produced in 2012
Organic Household Waste	Over 2.8 million tonnes generated in 2012.

- Animal manure is the most freely available substrate in the region with regards to transport and biogas plant functionality. Current uses include direct application to farmland. Non-hazardous, yet contains high moisture content, making transport a potential issue.
- Slaughterhouse waste is Under-utilized in existing biogas plants. Contains very high potential energy yields, with low moisture content. Can be source of revenue for collection
- Agricultural crop waste in the form of un-utilized sugar beets, rape, turnip rape, meadow hay and potatoes may have potential to be used in combination with other substrates for biogas productivity. Further data regarding surplus yields and waste fractions are needed for a feasibility analysis.
- Select industries, such as fish processing should be considered, as they have high-energy yields with low moisture content.
- Organic household waste fractions have the potential to produce high-energy

yields and solve common issues relating to solid municipal waste management, yet are inconsistent and must be separated at source.
- Biogas production from municipal wastewater sludge can account for a significant portion of onsite plant electricity and heat usage. Combining municipal biodegradable waste as co-substrate in this process is possible but can require substantial retrofitting to the plant [2].

Transport

Depending on the type and availability of a particular substrate, economic feasibility of a biogas plant can largely be determined upon transport costs and the weight of the substrate in proportion to its energy yield – directly indicated by its moisture content. To achieve economic viability, the following general max distances are suggested in siting a biogas plant: 50 km for slaughterhouse waste; 30 km for liquid manure/sludge; 100 km for agricultural waste and 100 km for organic industry waste [9].

Karpalund plant, located near Kristianstad, Sweden provides a good example of how planning logistically around existing resources is essential in locating a larger biogas plant. It is positioned in an agricultural area, where there is a possibility to access manure from farmers, as well as to redistribute the bio-fertilizer to the farmlands (provided for free to farmers that deliver manure to the plant). There are also links to the food industry and a slaughterhouse in close proximity the local area, enabling the plant to source substrates within economically feasible distances.

Production Technology

A biogas plant requires different equipment such as pasteurization tanks, digesters, cleaning and storage tanks. Some waste substrates require additional treatment steps to reduce the risk of operational disruptions or contaminations, such as: hygienisation (to eliminate unwanted bacteria) separation of solids and liquids or adjustment of water content [10].

A process where several substrates are mixed to a slurry and treated collectively is referred to as a co-digestion process. Co-digestion usually results in increased methane content in the produced gas, yet must be carefully mixed to ensure a dry matter proportion between 2-12% [7]. After this, the slurry enters the silo where biogas is produced as a result of several chemical processes. The gas produced contains high level of methane content, at least 55%.

Distribution, Retail and Use

Figure 2: Karpalund Biogas Plant

After biogas has been produced, an effective distribution system and demand for end uses of the outputs needs to be in place. It is of course also essential to consider what type of use is possible, given the markets available for potentially substitutable resources, and desirable already in the long-term planning of a biogas system.

This needs to be done in collaboration between producers and policy-makers to allow for consideration of uses that are not already in place. From the Karpalund plant in Sweden, the gas is distributed in a local grid and serves primarily as a vehicle fuel for local public transport. An increased production has also allowed for biogas to be sold outside of the local market.

Biogas investment feasibility depends largely on demand and available distribution infrastructure for biogas. Electricity and heat usage can be advantageous as it can be easily produced with the lower grade methane gas and as such does not require upgrading technology investments. It can then be used locally for distributed energy needs or be sold back to both the electricity or heating grid given available infrastructure.

Upgrading the methane gas by removal of hydrogen sulphide and carbon dioxide particles allows injection into the gas grid or use as a vehicle fuel, which can serve to substitute natural gas and other fossil fuels sourced from resource intensive activities [11].

There is an extensive electricity, gas and district heating grids throughout the West Pomerania Region supporting gas upgrading, yet it should be noted that the network fails to cover many agricultural areas. Injection to the natural gas grid is naturally only possible in places that have access to it, but can in these places comprise a promising and efficient alternative.

A second key aspect of biogas output requiring attention is the distribution of the biogas digestate, which is produced in proportionally large volumes and can be sold or applied as a natural fertilizer. Transport efficiency, as well as general acceptance among farmers, food producers and other stakeholders is required, highlighting the role of stakeholder management and logistics. Currently, the digestate derived from biogas plants using wastewater treatment sludge as the primary substrate is typically not used as a bio-fertilizer, even though certification systems (e.g. Swedish REVAQ) have been developed. The residues are instead often used as filling materials or for land reclamation. Regional bio-resource management should look into quality measurements and improvements, but also for alternative uses for this output (e.g. recycling of phosphorus).

The Biogas Value-chain: Underlying Drivers

Public support for policies addressing environmental challenges and supporting sustainable development are essential in promoting long-term stability that is often needed for investing in new technologies. An environmentally concerned public ensures that the topic remains on the political agenda, which can guide the focus in research and development. A key experience from Sweden is that environmental political objectives, policy instruments and the ability to form collaborative networks that bring together the many different actors concerned with the biogas value chain are important elements in the promotion of biogas systems.

Legal and Political Context

The EU Waste Framework Directive (2008/98/EC) introduces basic concepts and classifications for waste management through use of the waste hierarchy. The Directive also sets provisions and a common definition of bio-waste, in addition to the requirement for member states to

transpose waste prevention programmes on the national level.

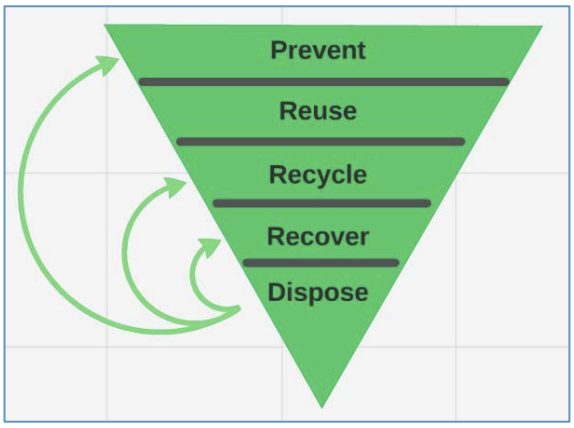

Figure 2 - Waste Hierarchy and the resulting improvements possible through biogas production.

The EU Landfill Directive (1999/31/EC) requires member states to transpose action plans into national strategies to reduce biodegradable waste going to landfill. This strategy must ensure that after 5 years of implementation, biodegradable municipal waste going to landfill must at most 75 % of 1995 levels. This target must be reduced to 50 % after 8 years, and to 35 % of 1995 levels after 15 years. [6] Short-term plans to address this directive within the region involve wide-scale implementation of mechanical and biological treatment plants and waste incinerators, in line with the National Waste Management Strategy. Under these scenarios, organic waste would be incinerated, composted for land reclamation or landfilled.

The Renewable Energy Directive (2009/28/EC) sets mandatory national targets for renewable energy consumption to achieve an EU wide goal of 20% renewable energy and 10% renewable energy for transport by 2020, revised to 15% for Poland, who failed to meet its 2010 indicative target, signalling the urgent need to create incentives for increased investment in renewable energy. Recent amendments to the Polish Renewable Energy Act designed to facilitate increased levels of renewable energy deployment confirms a plan proposed to introduce an energy auction system to promote further large scale renewable energy investment, along with small scale distributed renewable energy production.

In Poland, the National Energy Policy and the National Renewable Energy Action Plan sets the objective of 15% renewable energy in the national energy mix by 2020 and 20% by 2030. Guiding these targets are planned increases to electricity and heat sourced from biogas by 2020 to 4 TWh and 5.8 TWh respectively. This translates to up scaling biogas energy capacity from 74 MW currently, to 802 MW by 2020. The Polish energy policy also sets out a 10% target for renewable fuels in the transport sector by 2020.

Environmental Policy Instruments

Various policy instruments can be used to support the production of biogas. Environmental policy instruments can be divided into three broad categories: *informative* (e.g. campaigns, environmental management systems, eco-labels), *administrative* (e.g. permits, emission standards, liability rules) and *economic* (e.g. taxes, subsidies) [12]. The political targets set out on the EU, national, regional and local level, constitute indirect *administrative policy instruments*. In Sweden, a lack of a national objective for biogas production has been put forth as a hindering factor for an increased biogas production. The missing long-term commitment to the development of biogas has discouraged investments due to uncertainty about future profitability [13]. Other national objectives that promote the production of biogas have been described

above. Regional goals promoting biogas have been set in many Swedish regions. In Skåne, both the regional government and the regional public transportation company have set targets relating to biogas production. The region's goal is to achieve regional biogas production of 3 TWh per year and the regional public transportation aims to be fossil-free by 2018.

Informative instruments are commonly used by the regional and local actors, such as interest networks (towards a range of actors) and the municipal waste management companies (towards households). An independent regional network organization, Biogas Syd, was established in 2006 for the promotion of biogas in the region. The network met the need of a focal organization to drive the agenda, create a common perspective and develop a competence centre. The network works to spread knowledge (especially to farmers) and anchor projects politically, a crucial factor in development of a biogas system, as politics are important to all the steps of the biogas value chain [13]. A regional biogas potential study has been performed by Länsstyrelsen i Skåne. The methodology of this study, tools to perform a biogas potential study and guidance for municipal biogas mapping can be found via the Biogas Syd website.

In Skåne, it has been shown very important to enable collaboration between different actors within the municipalities and the region. Without good communication throughout the biogas value chain, it is very difficult to make the decision to build and operate a biogas production facility [14].

In Sweden, several *economic policy instruments* have been deployed to promote biogas production, including long-term development *subsidies*. Many investments in biogas were enabled by two financing programs provided by the Swedish Environmental Agency between 1998-2008; so-called Local investment programs (LIP) and Climate investment programs (KLIMP). These investment programs could provide support to projects that decreased greenhouse gas emissions, contributed to changing the energy system to renewable sources or provided energy efficiency improvements and have been very important to the development of the biogas system in Sweden [1,13,15,4,16]. Sweden has also implemented energy *taxes;* both the consumption of energy and a CO2 tax. Such taxes increase fiscal revenues while steering the energy system towards renewable energy sources. Both these taxes are imposed on fossil-based petroleum products (competing with biogas), while natural gas and biogas was exempted until 2013 and biogas is de-facto exempted also after this year. Other taxes include the *environmental premium* given to cars that run on renewable fuels and tax exemption for the private benefit of having company-owned cars run on biogas. The latter instrument has however continuously been put in place for short time periods, creating uncertainty around the longevity of the exemption [13].

In Poland, a certificate system for renewable energy has been introduced. There are four certificates issued in the polish market, three of which are applicable to biogas. Some of the challenges are limited time periods (green and yellow expire in 2018) and oversupply on the market. The brown certificates (agricultural biogas) have been used to any significant extent, due to limitations to allowed substrates and small economic incentives.

Table 1: Polish Green Certificate Scheme Eligibility

	Electricity	Heat	CHP	Upgraded gas	Upgraded vehicle fuel
Green	X				
Yellow			X		
Brown				X	
White	N/A	N/A	N/A	N/A	N/A

As the table demonstrates, there no certificate system for vehicle fuels made from upgraded biogas, something that is explained by the fact that upgraded biogas was not considered a fuel before the 2013 update of the biofuel and bio-component act. Ordinances and standards remain to be developed (Interview, Rogulska 2014).

Additional support mechanisms in Poland include parking fee exemptions for vehicles in accordance to the share of renewable they use, however these measures rest at the local governmental level, making it important for local government to take an active part in implementing the program. Public procurement policies are also in place to encourage the public purchasing of vehicles that can use both bio-fuels and petroleum products.

Previously, specific investment support to agricultural biogas investments was provided also in Sweden. However, the amount granted (max SEK 1,8 million), was not enough to drive forth large-scale implementation. A new production support will potentially be established for agricultural biogas plants, however there are already concerns about the amounts being too small to make a difference [13]. Both countries thus demonstrate how support for agricultural biogas production has to be of a fairly large scale to be successful. However, this support does not have to be provided by direct subsidies. An agricultural plant in Swedish municipality Bjuv, where manure is co-digested with industrial organic waste, provides an example of this. The plant is large scale and co-owned by the farmer, the plant entrepreneur and an energy utility company. The utility company buys the gas, which is then upgraded and distributed to the natural gas grid. The production has been profitable almost from the start, an example of how support can be provided by innovative business models rather than by financial subsidies [17].

Suggestions

Several challenges need to be faced in the production of biogas, both on a plant-, regional and national level. In addition to getting operational factors in place, the legal and political setting should provide support for the deployment of new technologies such as biogas. The research behind this paper has found that the national support mechanisms often have been determining for the successful introduction of biogas technology to the market, but also that biogas systems are dependent on local collaboration to enable long-term growth and profitability. Biogas plants are also typically dependent on demand-side objectives (resulting in purchasing of renewable energy or fuels) and limitations put on incumbent competitors in technology (such as landfills and fossil energy). Based on the experiences from the Swedish region Skåne, several suggestions can be made to the Marshal's office of Western Pomerania

Creating a Regional Bio-resource Network

Based on our research findings from the Polish and Swedish context, the im-

portance of national environmental objectives and policy instruments cannot be understated. These serve as the general context and drivers for energy, agricultural and environmental policies, within which the biogas system sits. However, the Swedish experiences showcase that even with general environmental national objectives, none relating specifically to biogas, and a few policy instruments, much can be done *on the regional level* to promote biogas production. In fact, the region presents the most appropriate administrative level to drive biogas development, as it combines two different needed functions. First, the capacity to gather actors from different spheres of society to accumulate the necessary knowledge and interest to drive the agenda. This involves a triple- or even quadruple helix perspective; public sector, industry, academia and civil society. Secondly, the ability to "stay local" - in touch with the municipalities which (in both Sweden and Poland) are responsible for waste management and the local industries and wastewater treatment plants etc. Waste management and sewage management needs are matched with substrate availability, something that should be used as a resource. To do so effectively, Swedish regions (especially those with a substantial biogas potential) have developed regional organizations to promote biogas, which has been proven effective to spur biogas development. Developing such a network organization is therefore suggested for West Pomerania. While the region has several regional organizations with bearing on the biogas system in place, none of them is actively driving the agenda. However, a biogas network could be placed within an existing organization. This should also promote a more coherent agenda and enabling actors to tap into synergies between different areas. The North-West Centre of Bioeconomy), Green Chemistry cluster and Ostoja at the West Pomeranian university of technology are some of the relevant organizations to run a biogas network. All network actors should provide funding to, and representation in the network.

Mapping of Bio-resources

The biogas network needs to provide a detailed mapping of regional bio-resources and biogas. The mapping should assemble data from agriculture, industry, waste management and other sectors where substrates can be sourced.

Creating a Roadmap for Bio-resources

Based on discussions and agreements in the network and results of the bio-resource mapping, a regional roadmap for bio-resources should be created. Having such a document in place allows for a more coherent and consistent approach and better planning and communication of bio-resource issues in the region.

Installing a bio-resource official at the Marshal's office

To promote more efficient use of bio-resources in West Pomerania, an official/administrator could be installed at the Marshal's office to work for this issue in the region. This person could also hold a key responsibility in the network organization and serve as the link between the Marshal's office and other members of the network.

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Building a Green Port

A Framework for the Port of Szczecin

By Aline Maigret, Claire Lawson, Jekaterina Dmitrijeva and Teve Kink

Introduction

Port of Szczecin

The port of Szczecin, together with the port of Swinousjcie, comprises one of the largest port complexes on the Baltic Sea. Managed by the Authority of Szczecin-Swinoujscie Seaports and owned largely by the Polish State Treasury, the port of Szczecin handles between two and ten million tonnes of cargo annually, is defined as a medium-sized port, and is located in West Pomerania [1]. The port is situated in an advantageous location 68 km inland from the Baltic Sea and directly on the Oder River thus providing the shortest transit route between the Baltic and Adriatic seas. As such, the port of Szczecin is an essential actor within the trimodal Central European Transport Corridor (CETC) which links Scandinavia with central and southern Europe; furthermore, Ukraine and other Black Sea countries are also linked via road, rail, and again, by way of the Oder River [2].

Figure 1 Location of the Port of Szczecin

Not only is the port of Szczecin significant due to its geographical location, it is also an important economic activity hub that stimulates growth within the City of Szczecin and surrounding areas. With a current unemployment rate of 18% in the Voivodeship [3], both ports are important job providers and market stimulators due to their diverse activities and plans for development.

One might wonder what does the role of the port has to do with building this concept of a *green port*. The following sections are designed to provide the answer to this question as well as provide details on:

- What a Green Port is
- Why it is important
- How Szczecin can become one

Figure 2 Port of Szczecin

Our Project

The initial task given for our project was to build a vision for the port of Szczecin to become what we identified as a *Green Port.* Based on the port's location, economic sig-

nificance and plans for development, we found there to be a beneficial opportunity for the port to develop and adopt an economic green growth strategy within its core business with the ultimate goal of branding itself as a green port; in short, this opportunity provides the basis for our recommendations. Our project provides a framework for developing a sustainable strategy as well as suggestions on why and how the port can move towards being a credible green port. The framework, which is guided by Renato Orsato's Competitive Environmental Strategies [4], was developed using the knowledge and insights acquired through both desk-top research and a one-week interview period in Szczecin.

Figure 3 Meeting the Port Authority

Background: Green Ports

Definition

Currently, there is neither a universal nor widely accepted definition of a green port; Common identified attributes include - a green port is a port that is built upon, and is proactively engaged in, the three pillars of sustainability: People, Profit, and Planet.

Figure 4 The three pillars of sustainability

For the purposes of this project, the definition presented by the World Association for Waterborne Transport Infrastructure (PIANC) together with the International Association of Ports & Harbours (IAPH) was edited as follows [5]:

A green port is one in which the port authority together with port users, proactively and responsibly develops and operates using an economic green growth strategy and stakeholder participation. By means of a long term vision, a green port assures development that anticipates and supports the needs of future generations, for their own benefit and the prosperity of the region that it serves.

Why Go Green?

There are numerous economic, environmental, and social reasons to support a shift to green business practices within ports. First of all, environmental concerns are increasing worldwide and shipping is part of the problem. NOx emissions, among others, are of major concern due to their influence on eutrophication and photochemical smog. Recent studies have found oceangoing vessels account for 15% of global NOx emissions and ports around the world play a significant role in curbing such emissions [6]. For example, the Port of Gothenburg is proactively taking responsibility for emissions from ships by implementing and enforcing the environmentally differentiating Port Tariff within its port practices which includes the Environmental Ship Index (ESI) and the Clean Shipping Index (CSI) [7]. In this way, the port rewards those ships that have made efforts to reduce their emissions as well as other impacts.

Furthermore, stricter environmental legislation is inevitably going to be enforced in both the near and far future; therefore, getting ahead of the legislation and taking leadership is always an added incentive to

support green practices. Market demands are also changing and the term ''sustainability'' is taking off within the language of leading ports worldwide such as the ports of Antwerp, Rotterdam, and Gothenburg. Incentives to invest in sustainable transportation are also increasing as funding is available from international and national sources due to the added environmental, social, and economic benefits such as increased efficiency, decreased emissions, job creations, and cost savings.

Figure 5 Techno-biosphere Boundary

How to Go Green?

A first step in going green is *integrating stakeholders*, i.e. individuals or organisations that have interest in how the Port is managed. The table below proposes an overview of the main port stakeholders. Amongst other things, integration enables better communication of green port operations and practices.

Also, *effective and efficient operational planning* is of high importance. With regard to environmental targets, the port's strategy should *embed environmental goals* within the organization's vision and mission statements. For the port of Sczcecin and Swinoujscie particularly, this would not only mean actively using the Environmental Management System (EMS), but rather utilising the EMS as a tool for embedding environmental goals in the business strategies, such as the Port of Szczecin's development strategy (see page 35 for further details).

Table 1 Identified green collaboration stakeholders

Port authority: Szczecin and Świnoujscie Seaports Authority
Port users: ship owners, terminal operators, shipping lines, waste reception, etc.
Port personnel: Port of Szczecin and Świnoujscie's employees
Maritime organization: Maritime Cluster of Western Pomerania (regional), IMO (international)
Governmental organization: Environmental protection and inspection, police, fire brigade, customs, etc.
Community stakeholders: Non-governmental organization, community groups, tourists, etc.
Knowledge providers: The Laboratory of Work Environment Research, Maritime Academy, West Pomeranian University of Technology Szczecin, etc.
Investors and funding association: Potentially, BSAP, Marco polo
Competitors: Baltic sea and German ports
National regulators: Polish government
Local authorities: Marshall office
Press/media: Regional and national polish press, e.g. Telewizja Pomerania

Going green therefore means moving from a reactive to a *proactive attitude*. A Green port should proactively manage activities within and outside the port area. Regard-

ing the latter, both regional and international cooperation are of high importance. *Regional cooperation* for the port of Szczecin and Swinoujscie means increasing cooperation within the Baltic Sea Region. For example, regional cooperation facilitates generation of efficient transport solutions and would benefit the port.

Regarding *international cooperation*, it can occur through the context of *Green Clubs*. A best known example is the "EcoPorts" organised under the European Sea Port Organisation (ESPO). This network provides ports with the opportunity to share experiences and best practices [8]. Furthermore, EcoPorts offers the Ports Environmental Review System (PERS) which is the only recognized port-sector specific standard; ports can display leadership by acquiring PERS certification.

Advantages of Going Green

Firstly, going green enables a port complex to *save energy and resources*, i.e. to be more efficient. Using less energy and resources, results in reduced production and purchasing. Accordingly, not only can green business practices help to protect the environment; they could also improve a company's 'bottom line' and image. In the long run, such money savings have the potential to improve *financial competitiveness* of the Port.

Going green can also bring opportunities in terms of financial support, i.e. *access to funding*. Within the Baltic Sea area context, the Baltic Sea Action Plan (BSAP) provides - amongst other things - green port initiative projects with possibility of funding. The BSAP is part of the HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission) initiatives, aiming at achieving a good environmental status for the Baltic Sea [9].

Within the European Union context, the Marco Polo scheme also offers potential funding for the port of Szczecin and Świnoujscie with regards to its transportation *development strategy*. Marco Polo is run by the European Commission and supports projects easing road congestion by promoting a switch to greener transport modes for European freight traffic [10].

Environmentally conscious business practices help *attract green partners*, such as investors who are following the trend of the growing interest for sustainability. Figure 6 illustrates communicating such practices.

Also, adopting green practices may pave the way for *green port networking* opportunities, allowing the exchange of both experience and knowledge amongst various stakeholders and ports. The previously mentioned "EcoPorts" network serves the principle of "ports-helping-ports" by gathering professionals from several European ports to work jointly towards the improvement of the sector's environmental performance [8].

Figure 6 Credibility of Going Green

Greening the Port of Szczecin

Current situation

Liquefied Natural Gas (LNG): The LNG Terminal plan in Swinoujscie, allowing deliveries of natural gas from around the world, is the largest Polish energy secu-

rity investment project. Furthermore, it is the first project of its kind in Central and Eastern Europe and the Baltic Sea region. The project includes the construction of: the LNG Terminal in Swinoujscie (1) that will allow receiving natural gas transported by sea, the Szczecin – Swinoujscie gas pipeline (2), necessary infrastructure to provide access to the outer harbour (3) and port infrastructure (4), including the LNG carrier unloading berth [11].

River rail transport: One of the Port of Szczecin's development strategy goals with regards to transportation is to better integrate the complex in the sea-land transport corridor North-South. This can be done by investing in the provision of the port access (from both land and sea) and infrastructure. This might ultimately facilitate the development of intermodal transport between ports [12, 13]. As illustrated in Figure 7, *Intermodal transportation* involves transporting a person or a load from its origin to its destination, by a sequence of at least two transport modes, with transfer taking place at an intermodal terminal [14]. It also implies shifting from roads to more sustainable means of transportation, e.g. maritime-based logistics.

Skolwin restoration project: Skolwin, situated on the left bank of the Oder River, is a degraded post-industrial area from the former Paper Mill industry of the region. A social restoration project has been set out in the area in order to revitalize the economic function of Skolwin. Four main projects are in place: the reconstruction of a coastline as well as its equipment near River Port Skolwin – Odroujście (1), the modernization of road access to this River Port (2), the purchase of river dredger to implement dredging works for operators (3), and a *Green Port* construction by – amongst other things- building a multifunctional waste treatment plant (4) [15].

Immediate Opportunities

SWOT Analysis

In order to evaluate the current situation in the Port of Szczecin, SWOT analysis was used as a tool to identify main Strengths, Weaknesses, Opportunities and Threats. The information was obtained during the one week on-site interviewing period. The identified strengths and weaknesses are internal and not depending on the external factors which influence the identified opportunities and challenges. The table 2 presents the main findings for each section of the SWOT analysis:

Table 2 Key findings of SWOT

Strengths	Weaknesses
-Advantageous location -Value added services -Compliance	-No common green vision -Collaboration -External communication
Opportunities	**Threats**
-Common green vision -EcoPorts certification -Green transport corridor -Funding and legislation	-Competitors -Transition costs

Strengths: The Port is located at the beginning of the potential intermodal corridor from North to South. Mainly due to the Oder River, it has a great potential to be used as an alternative for the road freight of the goods from the Baltic Sea region to the Central Europe. Apart from that, the Port has a huge capacity for further development of the area. Additionally, the Ports

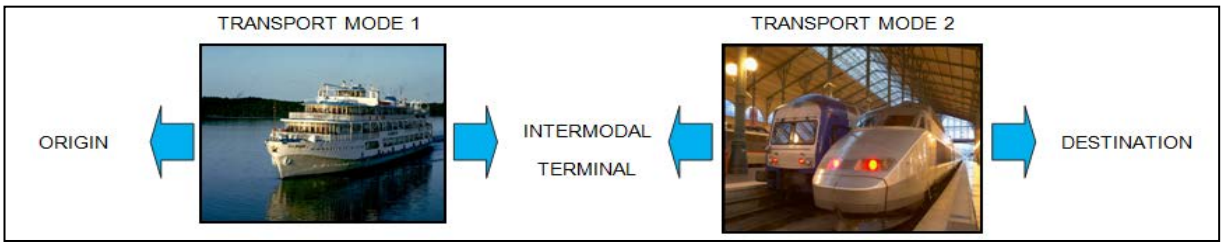

Figure 7 Intermodal transportation

of Szczecin and Swinoujscie already have established value-added services when it comes to the waste handling. The Port has an ISO14001 certificate and complies with all the required regulations, which provides a basis for becoming a Green Port as it can be used as a tool for embedding environmental goals in business strategies.

Weaknesses: The main identified weakness is the lack of a common green vision for the Port, which is mainly due to the insufficient collaboration with the relevant stakeholders such as local authorities, businesses and local residents. In addition, Szczecin Port does not have an effective external communication which could be facilitated through the use of corporate social responsibility (CSR) reporting; also lacking is the promotion of the Port's environmental improvements and targets.

Opportunities: There are several opportunities for Szczecin Port to become more competitive and at the same time greener. Linking the opportunities with the previously mentioned weaknesses, it is important to have a common green vision together with the relevant stakeholders, especially the city of Szczecin. To support the port's image for potential investors and businesses, the Port should obtain an EcoPorts certification, which adds up to the overall credibility of the Port internationally. The advantageous location of Szczecin Port offers a great opportunity for intermodal transport corridor, which would decrease the GHG emissions and allow for better connectivity between the Northern and Southern Europe. The green gateway status shall differentiate the Szczecin Port from its competitors and attract the potential investors and businesses to come to the area for further development.

Threats: The major threats or challenges are the competitor ports nearby Szczecin Port. In addition, transition costs, which include the time needed for planning, building, negotiations and the cost of new technology and infrastructure; and other related inevitable obstacles that are inherent to project planning and depend mainly on the external factors resulting in numerous uncertainties.

Benchmarks

The sustainability improvements in the Scandinavian ports have proved that it pays to be a Green Port [16]. It is important to notice that the way towards being a Green Port is gradual and has many intermediate points. There are various green activities that improve ports' environmental performance and at the same time have financial benefits.

For instance, the port of Trelleborg has saved 1 000 000 kWh per annum by changing the light bulbs and fixtures to more eco-efficient models. In addition, the Port of Trelleborg reduced 20% of CO2 and NO_x emissions by training its employees in Eco-driving [17]. Likewise, Copenhagen and Malmö Port reduced 15% fuel use with a financial benefit of ~463 000 PLN per year [18, 19]. Stockholm port has won the ESPO Award 2011 thanks to its successful

Corporate Social Responsibility communication and activities [20]. The port of Gothenburg has improved its operational efficiency by using as little road freight to and from the port as possible [21]. All those examples, summarized in the Scandinavian benchmarking table, are potential saving methods for the Port of Szczecin.

It is essential also to look into the competitor ports such as Port of Hamburg in Germany, which has the goal to become a smartPORT [22]. To achieve this goal, the Port of Hamburg concentrates on energy and logistics to reduce the emissions and energy consumption, at the same time accelerating the trade flows and efficiency of the port activities. The emission reduction is mainly gained from investments into the alternative energy sources. The logistics part is concentrating on the intermodal transport network and infrastructure software, which helps to regulate the traffic [22]. Most of the ambitious goals, which aim to reduce significant amount of CO_2 emissions of the Port of Hamburg are set for May 2015.

There is so much that ports can do directly to improve its environmental performance. Indirect tools are usually targeted incentives for the ship owners and businesses in the port area. In Sweden, for instance, there are environmentally differentiated fairway dues with an aim to reduce the NO_x and SO_2 emissions from the vessels [23]. Similarly, the Port of Rotterdam charges extra from the ships that are inefficient and emit more so the discount is given for the cleaner vessels [24].

Table 3 Scandinavian benchmarking

Ports	Green activities	Gains
Trelleborg	-Light bulbs and fixtures -Eco-driving -AdBlue	-1 000 000 kWh p.a. -20% emission reduction -NO_x reduction
Ystad	-Onshore-power supply(2012)	-emission reductions -license to operate
Copenhagen-Malmö	-Eco-driving -Oil barriers -Industrial symbiosis	-15% fuel reduction p.a.=463 000 PLN
Gothenburg	-Carbon neutrality -Environmental Ship Index	-Operational efficiency -Image
Stockholm	-Corporate Social Responsibility (CSR)	-ESPO Award 2011

Intermodal Green Corridor

Medium to long-distance intermodal transport has been strongly advocated by the European Commission as a solution for ensuring the sustainability of the freight transport sector [25]. In line with the European Union's ''motorways of the sea'' concept which suggests a modal shift towards maritime-based logistic chains [26],

The National Development Strategy for the Westpomeranian Region until 2015 and the Regional Innovation Strategy of the Westpomeranian Region for 2011-2020 support restoration of the transport function of the Oder River [27, 28]. Secured in the Port's investments strategy for 2014-2020 are the improved road and rail access to the ports of Szczecin and Swinoujscie as well as deepening of the fairway to 12.5 meters - measures aimed at modifying the existing logistical arrangements [29, 13]. Integrating the Oder River with a larger transportation corridor will facilitate transformation of the Ports of Szczecin and Swinoujscie into the green gateway in the intermodal transportation route improving overall sustainability, connectivity and accessibility. This green corridor concept is represented in the picture below.

Figure 8 Potential Green Corridor

Recommendations

Green Strategy Framework

Orsato's framework (2006) provides a basis for the Port of Szczecin to plan further steps towards Green Port branding. As represented in Table 4, the framework offers a typology of four specialized environmental strategies that corporations may adopt; Eco Efficiency, Environmental Cost Leadership, Beyond Compliance Leadership and Eco-Branding.

Table 4 Adapted Orsato Framework

Competitive Advantage		Internal Processes	Products/services
	Lower Costs	**ECO-EFFICIENCY** Short term strategy • Increase productivity + Decrease EI = COST SAVINGS • Stakeholder integration • Industrial symbiosis (closed-loop system)	**ENVIRONMENTAL COST LEADERSHIP** Long term strategy Services offered at LOW COSTS + LOW ECO-IMPACTS
	Differentiation	**BEYOND COMPLIANCE LEADERSHIP** Present strategy Publicize ISO certification-CSR framework 1. Embed goals in strategies – EMS tool 2. EcoPort Certification - PERS 3. Stakeholder integration 4. Reactive to proactive	**ECO-BRANDING** Credibility strategy Branding the Port as a Green Port
		Competitive focus	

These strategies are divided between two types of potential competitive advantages:

- Lower Costs: gain from more efficient processes (e.g. Eco-driving and LED) or by using cheaper and more environmentally friendly raw materials for products and services (e.g. LNG?).
- Differentiation: gain from differentiated process, product or service as compared to competitors (e.g. Cold Ironing). It is not necessarily the cheapest option for the clients but they are willing to pay for a price premium.

The framework also distinguishes the firm appropriate competitive focus:

- Internal Processes: processes that help to provide services or produce products.
- Products/services: contents of products and services.

Using this framework would allow the Port to reach green operations and therefore be branded as a Green Port. The Port will achieve this is by utilizing the three other

building blocks outlined in the table above: Environmental Cost Leadership, Eco-Efficiency, and Beyond Compliance Leadership. Achieving Environmental Cost Leadership (ECL) will ultimately lead to the Port being able to brand itself as a credible Green Port, but before ECL can be achieved, the Eco-Efficiency building block must be performed. We recommend that the Port focus on the most attainable building block first, which is Beyond Compliance Leadership, due to the investment in ISO 14001 certification. Eco-Efficiency and, subsequently, ECL are relatively longer-term building blocks to be achieved. All three building blocks will result in increasing the credibility of the Port to ultimately achieve Eco-branding. Below is an outline of the framework outlined in its different stages, beginning first with the ultimate goal of Eco-branding. This is further illustrated in the step-by-step framework on page 10.

Be Attractive

The suggested framework recognises that the economic growth of the Port shall be balanced with environmental protection and social progress within the region. Both short and long-term objectives of the proposed strategic development shall therefore be transparent and inclusive in their planning and implementation stages. The green port strategy holds a potential to contribute to the city's larger Szczecin Floating Garden 2050 Project, serving as a driver for the sustainable logistics development [30].

Greening of the Szczecin Port requires increased stakeholder integration and communication with actors [31] ranging

from the public and port authorities, technical experts, contractors, representatives of industries and businesses and non-governmental organisations to financiers, cargo owners, shipping companies and local communities. Better involvement, improved communication, and, as a consequence, a more comprehensive and inclusive development strategy will result in increased and diversified attractiveness of the Port to foreign investments bringing numerous added value to the local economy and improving the quality of development.

One of the key opportunities embedded within the Green Port framework is industrial symbiosis, which is the cooperation of industrial entities as a way to reach benefit that couldn't have been reached by themselves alone [4]. Within the Port of Szczecin context, this implies sharing services, utilities, resources between industries, and alliance of the Port with the emerging green chemistry cluster [32, 33]. It shall facilitate the creation of a circular economy, which is an alternative to a traditional linear economy (make, use, dispose) which aims at relying on renewable energy as well as minimising and eliminating the use of toxic chemicals; while also trying to eliminate waste through careful design [34].

Together with the move towards a circular economy, the Port of Szczecin shall also allow for innovation and diversification of activities. A Green Szczecin Port shall, therefore, increase its employment capacity and competitiveness, becoming more attractive for businesses, tourists and local residents.

Table 1 Proposed green port framework

Eco – Branding Credibility strategy Branding the port as a Green Port	Eco-Branding should be an ultimate goal for the Port of Szczecin. It is a credibility strategy, which allows the port to brand itself as a Green Port. The eco-branding stage is achievable only gradually with good planning and incremental steps.
Environmental Cost Leadership Long term strategy Services offered at low costs + low eco-impacts	Environmental Cost Leadership strategy is the long term strategy for the port where the services are offered with the low costs and low environmental impacts.
Eco-Efficiency Short term strategy • Increase productivity + decrease environmental impact = cost savings • Stakeholder Integration • Industrial symbiosis (closed-loop system)	Eco-efficiency is a short term strategy for the port. This strategy includes increased productivity and decrease in environmental impacts, which saves the costs. The strategy requires relevant stakeholder integration and creation of industrial symbiosis.
Beyond Compliance Leadership Present strategy 1. Publicise ISO Certification – CSR Framework 2. Embed Goals in strategies – EMS tool 3. Stakeholder Integration 4. EcoPorts Certification – PERS 5. Reactive to proactive	The beyond compliance leadership is a present strategy for the port. This requires the Port of Szczecin to publicize ISO certification and CSR framework. This can be done by embedding the environmental goals in strategy and using the EMS as a tool. Moreover, the EcoPorts Certification (PERS - Port Environmental Review System) should be achieved in order to gain more credibility and acknowledgement internationally. Apart from that, it is important to integrate all the stakeholders in planning and decision-making and move from reactive to proactive approach.

Green Corridor Development

Cooperation with the ports of Ystad and Trelleborg through the TEN-T ''motorways of the sea'' projects shall leverage economic benefits, reduce investment risks and allow for information and expertise exchange.

Continuing the work on the Swinoujscie - Trelleborg ''motorways of the sea'' project [29] in the post co-funding application period would assist in the creation of the intermodal transport corridor particularly suitable for trucks [35].

With the support of the West Pomerania Marshal's Office [29] and Oder Partnership, the development of intermodal transport corridor starting in Ystad, connecting the Baltic and Adriatic seas through the Port of Szczecin [36] is seen to have strategic potential to coexist and function along with the core Baltic - Adriatic Corridor where the Port is currently identified as a branch of the main corridor starting in the Ports of Gdansk and Gdynia [37].

The already established collaboration with the Ports of Ystad and Trelleborg could be reinforced with the application of the proposed green framework through increased transparency and communication of the sustainability work undertaken at the Port.

Conclusions: Roadmap for Further Development

Maritime transport and bunkering are one of the largest emission contributor's worldwide. Port activities contribute to serious environmental pollution and have significance influence on the health and safety of many workers and locals. Taking the path of a Green Port by proactively developing greener port operations and mind-set, is therefore an essential step for Ports to undertake to be a positive and influential actor in society. Aside from environmental concerns and stricter legislation, the greening of port operations is also driven by, and facilitated through, increased efficiency measures and subsequent financial savings. Through desk-top research and a one-week interview period in Szczecin, we found that a lack of a common green vision was a major weakness within the port and among port actors. We also found that this weakness provides an immediate opportunity to increase collaboration and strengthen working relationships among port actors by way of improving external communication. Therefore, our main recommendation is to follow our green strategy framework which supports the port of Szczecin to achieve and benefit from being a Green Port.

In order to do so, the Port must:

a) Strive to achieve a common working green vision among port actors through strengthened stakeholder integration,

b) Set environmental goals and targets while simultaneously embedding them within business strategies using the EMS and PERS as the facilitating tools,

c) Proactively improve external communication using CSR as the facilitating tool, and

d) Continue the current development plans for intermodal transportation and use appropriate green language to emphasize the green efforts in this area.

All of the above mentioned recommendations fall under our green strategy framework which is designed to build an image to attract funding, attract diverse port cli-

ents, operators, and investors, as well as to increase port operational efficiency, cost savings, and credibility as a branded Green Port. As this project was designed to provide a vision for the port of Szczecin to follow and develop, we also recommend that the port of Szczecin continue its collaboration with the IIIEE Lund University so that this vision, as well as an action plan, may be developed further by future IIIEE MSc. students.

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Biogas in Asikkala

An Initial Feasibility Study

By Simon Bager, Mia Pantzar, Raffaele Rossi and Riitta Talja

Introduction

In a global setting of growing environmental concerns, Finland aims to become a pioneering country in achieving climate change mitigation targets. Regional-level decisions, particularly in rural areas, will have an impact on this goal. Local solutions for renewable energy, such as biogas, will contribute to meeting the country's goals and increase competitiveness [1].

In accordance with national targets, the Municipality of Asikkala (pop. 8 500), located in the Päijät-Häme region in southern Finland, became a HINKU member in 2013 with the aim to address energy inefficiencies and the sub-optimal use of natural resources (see box) [2]. Through the deployment of biogas technology, a significant reduction in emissions could be achieved. For these reasons, a project investigating the feasibility of a biogas system in the area has been undertaken. Study activities included an examination of best practices, meeting with relevant local and regional stakeholders, and identifying and addressing potential challenges.

The findings of the study are presented in this report. This includes an analysis of biogas technology and its suitability to the local context, an outline of the proposed biogas system, and recommendations to the local authorities and stakeholders.

The HINKU initiative, administered by the Finnish Environment Institute (SYKE), aims to find ways of curbing greenhouse gas (GHG) emissions and providing strategies that can be upscaled. HINKU stands for *Carbon Neutral Municipalities* and was launched in 2007.

The 16 municipalities currently part of HINKU are committed to reducing their GHG emissions by 80% by the year 2030 from 2007 levels. SYKE measures emissions in CO_2 equivalents, and standardises the calculations to ensure comparability over time and between municipalities.

www.hinku-foorumi.fi

Biogas Production

Biogas is an energy source, most often produced by anaerobic (oxygen-free) fermentation of organic material. The naturally occurring process includes steps of microorganisms breaking down carbohydrates, proteins and fats [3,4]. Biogas is a mixture of mainly methane (CH_4) and carbon dioxide (CO_2) (table 1).

Table 1 Composition of biogas

Compound	%
Methane, CH_4	50–75
Carbon dioxide, CO_2	25–45
Water vapour, H_2O	1–2
Carbon monoxide, CO	0–0.3
Nitrogen, N_2	1–5
Hydrogen, H_2	0–3
Hydrogen sulfide, H_2S	0.1–0.5

The respective fractions depend partly on the choice of organic input materials (*substrates*) [5], but from an energy perspective, methane is the important fraction, as it can be utilised for energy production through combustion.

Biogas is a renewable energy source and particularly attractive since it does not suffer from some of the weather dependencies that other renewables do [6].

Substrates

In principle, any organic material is suitable as a biogas substrate. The higher calorific value and the higher the number of carbon-atoms the more methane the substrate will generate. Gas production may be maximised by combining different substrates [7]. A high liquid content is beneficial for the process, with a dry matter (DM) content of about 2–12% being preferable. This ensures thorough mixing and increases the dissolving of CO_2 in the water, increasing the methane content of the biogas.

Microorganisms need nitrogen (N) to form proteins, and the amount of nitrogen available to the bacteria is often stated in relation to the amount of carbon (C). Normally, the C/N-ratio has to be less than 30, as nitrogen otherwise becomes a limiting factor for growth, but should not be too high either, as this inhibits fermentation [3,8].

Liquid sludge and manure are commonly used substrates. Fermenting manure helps avoid methane emissions otherwise associated with its storage. Since manure alone does not give a high biogas yield, it is often combined with energy crops [9]. The high liquid content of manure makes local sourcing important in order to reduce transport costs.

Slaughter- and food wastes are also suitable substrates, although they must be sanitised prior to fermentation to eliminate harmful bacteria [7].

Sludge from sewage treatment plants may also be used; however, it may complicate potential applications of the fermentation residues (*digestate*). The spreading of sewage digestate on farmland, although technically and chemically feasible, is associated with ethical and regulatory concerns. The digestate can alternatively be dried and then incinerated for energy production [10,11,12].

Forestry residues could have high potential as biogas substrates, considering the size of the Finnish forestry industry. However, its low calorific value requires a different gasification technology and has therefore not been considered in this study.

When planning a biogas plant, it is important to ensure a stable and even supply of substrates in order to prevent interruptions in production. Similarly, it is essential to investigate the long-term availability of the chosen substrates, and potentially sign contracts with suppliers [13].

Biogas Technology

Anaerobic digestion is an energy efficient and environmentally beneficial biogas technology; a simple and reliable process that can be applied on a small scale [4,14].

The chosen mix of substrates (①, figure 1) is mixed, crushed, sanitised and pre-heated depending on the substrate ②. The mixture is then fed into an anaerobic digester where it is left to ferment (*retention time*) ③ [5]. Required retention time depends on type of microorganism, temperature, and the uniformity of the substrates. Two types of methanogenic microorganisms exist: mesophilics, which require lower temperatures (32–42°C), and thermophilics, requiring higher temperatures (48–55°C). In general, the energy balance is better in the mesophilic range than in the thermophilic, but the thermophilic digestion results in a 50% higher rate of degradation and thus a higher biogas yield. However, thermophilic

methanogens are more temperature sensitive than mesophilics and small variations in temperature can cause a substantial decrease in activity. In general, the longer the substrates are exposed, the better the anaerobic decomposition [3]. The gas is collected and stored in a storage tank and the resulting digestate is stored in a separate gas-tight tank for later use ④. After about 12–24 hours of storage, the digestate loses its smell and becomes essentially odourless. However, the high ammonium content together with the higher pH can lead to increased ammonia emissions [3]. It is important that the digestate is tested regularly for heavy metals and other harmful substances, depending on the applicable regulations.

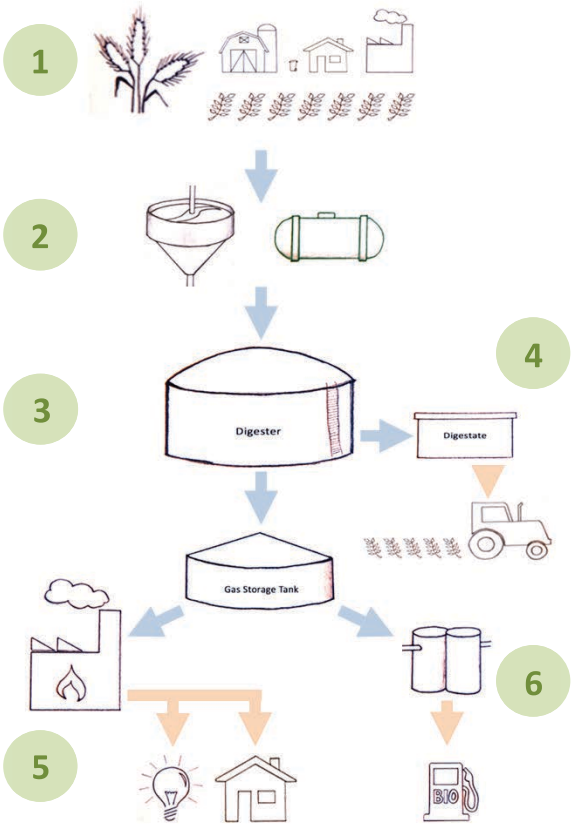

Figure 1 Schematic illustration of the various steps in the biogas production process

Utilisation of Biogas

It is commonly said that biogas production offers several benefits, e.g. reduced greenhouse gas (GHG) emissions, reduced loss of nutrients, and the transformation of waste into a high-value by-product.

The gas can be incinerated in a Combined Heat and Power (CHP) plant ⑤, producing steam to drive a turbine generating electricity and heat. A conventional CHP plant transforms roughly a third of the energy to electricity and the rest to heat. Consequently, the plant's location largely affects its profitability [7].

The biogas may also be used as vehicle fuel ⑥. However, the gas needs to be *upgraded*, in order to be suitable as combustible gas for fuel or the grid. Upgrading removes impurities and the bulk of CO_2 until the methane content is at least 96%. The fuel is then compressed and distributed to tank stations either via pipelines or by trucks [5]. If biogas-driven vehicles replace fossil fuel-driven vehicles, GHG emissions reduction benefits can be dual, as emissions from fossil fuel combustion are avoided, along with fugitive methane emissions from the substrates [15]. Upgraded biogas can alternatively be fed into a national or local natural gas grid. It may thereby help diversify and decentralise energy supply and increase energy security [16].

Biogas production can help convert problematic and expensive waste streams such as food waste and sewage sludge into a valuable bio-fertiliser (digestate), which can replace artificial fertiliser, the production of which requires energy and causes GHG emissions [8]. Depending on the substrates used in fermentation, the digestate will have different qualities. Generally, all nutrients contained in the substrates remain

in the digestate, making it a high-quality bio-fertiliser and soil conditioner [6,7]. Using the digestate as bio-fertiliser thus contributes to closing the nutrient cycle and further reducing the overall environmental impact, as it achieves energy and nutrient recovery (figure 2).

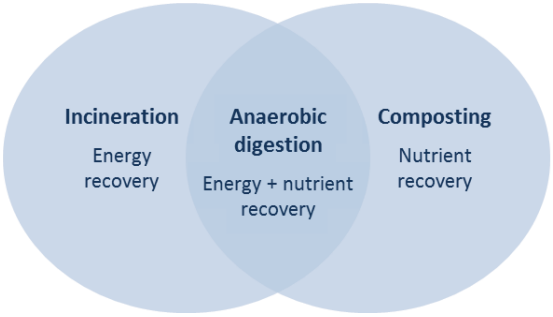

Figure 2 Dual benefits of biogas production

Manure substrates are more liquid, alkaline, and ammonium rich after fermentation – improving the digestate quality as a bio-fertiliser. It penetrates better into the soil and contains a more easily available form of nitrogen.

Finally, biogas is beneficial in waste management terms since it reduces waste volumes and the need for alternative treatment such as landfilling. Consequently, it may contribute to the protection of groundwater resources and to a more sustainable waste handling process.

A Success Story: Joutsa

In Joutsa, located approximately 100 km north of Asikkala, a biogas plant processing sewage treatment sludge, biological household waste and waste oil and fats began operating in April 2014. The plant, located on municipal land leased for 30 years, cost EUR 1.6 million to construct. The payback period is estimated to be about 7 years. Figure 3 illustrates the financing structure of the plant [17].

Figure 3 Financing structure, Joutsa biogas plant

The plant has a capacity to handle 7 000 tonnes slurry per year, which is small for an industrial plant, but currently only has a permit to handle 4 750 tonnes. The plant handles about 1 000 tonnes of household biowaste, which is transported to the facility from nearby municipalities, 2 000 tonnes of sewage sludge and 500–1 000 tonnes of septic tank waste. The plant produces about 1 500 MWh of biogas per year. The gas is upgraded to fuel and sold at a biogas station, located in connection with the plant, at a price of about EUR 80/MWh. The digestate remaining after fermentation is hygenised and analysed, and subsequently collected by local farmers to use as bio-fertiliser on their fields [17].

The plant generates revenue by selling fuel and charging gate fees for waste handling. The gate fees are EUR 70/tonne for biowaste, EUR 55/tonne for wastewater sludge, and EUR 13/tonne for septic tank waste. Gas sales provide roughly a third of the plant income, while the remaining part comes from waste management fees. The plant provides employment for 1 person on-site, but additional jobs are created through transportation of inputs and digestate, as well as other related activities [17].

Substrates and Biogas Potential

Asikkala's tough HINKU emissions reduction commitment requires investments in

the energy, transport, and agriculture sectors. A biogas facility could contribute to this [18]. The following section proposes a likely scenario where the potential for biogas depends on a number of factors, including:

- the substrates available;
- the use of the final product;
- the location of the plant;
- the financial investments; and
- the legislative context.

Therefore, the actual or realistic potential is significantly smaller than what is theoretically, technically or financially possible (figure 4) [2].

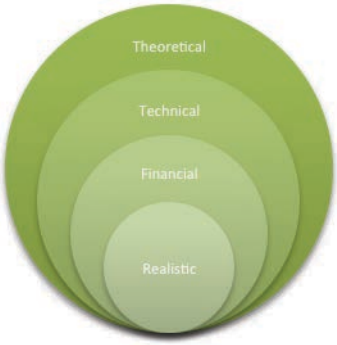

Figure 4 Levels of feasible biogas potential

A number of substrates are available in the region. From a financial point of view, an important distinction between the various substrates is whether they are revenue generating, revenue neutral or incur a cost. Revenue generating substrates allow the facility to charge a gate fee to take the material, as is the situation with sewage sludge in Joutsa, while revenue neutral substrates are available for free, as is the case with industrial waste at a biogas facility in the nearby municipality, Laukaa. Finally, substrates that incur a cost on the plant include those that the facility would have to purchase, e.g. energy crops [17,19].

Utilisation of bio-waste is expected to grow in the near future due to EU regulations. After 2016, landfilling of bio-waste will be limited; biogas could play a role in the sustainable reuse of these resources [20].

Sewage Treatment Sludge

Sewage sludge from the local wastewater treatment plant could be a potential revenue-generating substrate. The municipality, through the wastewater treatment plant, is currently spending a significant amount of money transporting and treating the sewage sludge produced (EUR 70 per tonne) [21]. Fermenting the sludge to create biogas reduces both costs and waste, creating a win-win situation for Asikkala. The quantities available currently amount to 900 m^3 per year at a 20% DM content.

Industrial Waste

A small number of industries in Asikkala generate organic by-products that are suitable for biogas production. As landfilling of organic waste will be limited after 2016, the potential to utilise this waste should be assessed in detail at a later stage [20].

Farm Residues

In Asikkala there are about 200 farmers producing substrates suitable for biogas production [12].

Most farms producing manure are spreading it onto their fields. Unless given a financial incentive, it will probably be difficult to convince these farmers to send the manure to a biogas plant and receive digestate in return. However, farmers who have excess manure and currently pay to dispose of it might be interested in delivering it to a biogas plant [22]. The amount of manure considered waste is estimated to be at least 10 000 m^3 of pig manure and at least 2 000 m^3 of cattle manure per year [23,24].

Most farms in Asikkala plough their crop residues back into the soil. Given financial

incentives, farmers indicate that these residues could instead be set aside for biogas production. However, ploughing crop residues back into the soil improves soil quality, limiting the amount that can be extracted sustainably [23]. The potential has not been assessed in this study, as other substrates are easily available.

Figure 5 Biomass can be used for biogas production

Energy Crops

There are several local farmers currently growing crops and feed grass who have expressed interest in switching to growing energy crops for biogas production, if financially attractive [23,24]. The potential for growing energy crops in the region is very high, and would be more than enough to cover the needs of a biogas facility of the proposed size.

Municipal Household Food Waste

Using municipal household food waste to generate biogas is common in both Finnish and foreign biogas facilities, and the Joutsa plant (*page 48*) handles about 1 000 tonnes per year. In Asikkala municipality, food waste from residential areas is currently collected and transported to Kujalan Komposti in Lahti for composting. One way for the municipality to meet its obligations under the new waste management law is to ensure collection of the all food waste for biogas production. The potential for household food waste to be utilised for biogas production is estimated to be in the order of 1 700 tonnes per year, including what is currently composted [25].

Potential Applications

There is evidently a range of suitable substrates available to feed into a potential biogas plant in Asikkala. For the project to be feasible, however, the end products – the biogas and the digestate – need to find suitable applications. This section presents potential uses that have been identified and suggests what could best suit Asikkala.

Energy Production

Asikkala currently receives all its electricity and natural gas from Lahti Energia. The gas, originating from Russia, is expensive and local development of heat and power production is therefore attractive [26,27]. It also resonates with municipal and national plans to move away from Russian gas dependency.

Combining the biogas plant with CHP production is only financially viable if there is sufficient local demand for the heat and the electricity. The district heating system in central Asikkala could use the heat, but Lahti Energia, who owns the heating network, will arguably choose the cheapest option [26]. There is no significant industrial heat demand, and although farmers need heat for e.g. space and water, their temperature needs peak at a maximum of 70–90 °C [22,23,24]. These farms are also sparsely located, making the location of a CHP plant problematic.

Farmers have expressed interest in using biogas to cover their electricity needs, if financially attractive [22,24]. Given its limited scale, however, Asikkala's biogas plant would not receive the national feed-in tariff and the electricity would be sold at market price. Combining the biogas plant with a central CHP facility is consequently not considered economically viable in Asikkala.

Farmers could alternatively receive biogas through a local grid to use for on-site energy production. However, this option might be unnecessary since farm-scale heat production is commonly run on wood chips from forests owned by the estate, which is a cheap and sustainable solution [23,24].

Vehicle Fuel

As CHP production is an unfeasible option, the most financially attractive use of the biogas is to upgrade and sell it as vehicle fuel, similar to what nearby Joutsa and Laukaa plants are doing. These sites, and VA Syd in Lund, demonstrate that a stable and increasing fuel demand exists and that fuel sales can generate considerable revenues. The demand in Asikkala is currently unknown, but a biogas plant should produce enough gas to fuel at least 200 cars driving 15 000 km per year. Three potential sources of demand have preliminarily been identified [10,17,19]:

- *Vehicles passing through the region, e.g. to and from vacation homes:* the Finnish Transportation and Infrastructure Directive aims to extend the gas station network by 2020. Biogas plays an important role in meeting this target, especially in areas not connected to the gas grid [11].
- *Local agricultural vehicles:* agriculture has a high use of vehicle fuel compared to other Finnish industries [7]. A pioneering group of local farmers has shown interest in biofuels, e.g. using rapeseed oil for biodiesel production. The same cluster might be interested in local fuel-grade biogas production and assist its development [12].
- *Investing in new biogas vehicles, and potential retrofitting of existing vehicles from gasoline to gas:* No local public transportation system exist, meaning that demand for gas-driven vehicles have to come from individuals and local industry. Retrofitting may prove challenging as no existing car shop in Asikkala currently performs such changes.

Distributing the upgraded gas through a grid is not considered feasible. Use of gas burners for household heating is unusual in Finland and the national gas grid is highly limited [11].

Figure 6 The ease of fuelling a biogas car

Digestate as Bio-fertiliser

In Asikkala and neighbouring Padasjoki, crop farming is more common than livestock farming, and most livestock farms also have cropland for growing their own feed. As the supply of manure cannot meet the demand for this, farmers purchase artificial fertiliser, meaning that there is a potential to meet local demand by using the digestate as bio-fertiliser [7,12,22,23].

In the 1990s, part of this demand was met by spreading sludge from Asikkala's wastewater treatment plant onto the fields. Since then, national regulations have restricted this application, leading to composting of the sludge. Demand for manure and artificial fertiliser could partly be met by spreading the digestate onto the fields. However, the EU Water Framework Di-

rective (2000) restricts the amount and types of nutrients, such as nitrogen, that can spread onto agricultural lands. As the current wastewater treatment plant in Asikkala does not remove nitrogen from the sludge, there is a risk that the resulting digestate would contain high levels of nitrogen, limiting application [21].

Suggested Facility

Based on the availability of substrates and the potential use of the gas, a mesophilic, two-step biogas facility is suggested for cost, ease-of-use and public acceptance considerations. This would require fermentation tanks of 1 300 m^3 and 800 m^3, an upgrading facility to convert the gas to fuel grade, a vending station to sell the gas, and storage capacity for 6 000 m^3 of by-products and digestate. Such a facility has a capacity to handle 7 000–12 000 m^3 of substrate per year. This would cover the substrates currently available in the region, while having capacity to increase intake as new substrates become available. The digestate could be used as bio-fertiliser on nearby farms.

Figure 7 Upgraded biogas stored in tanks

Two potential substrate scenarios are suggested. The above-mentioned substrates can be combined in numerous ways, as long as technical considerations, such as dry matter content, C/N-ratio, retention time, and fermentation processes are taken into account. The calculations of dry matter content, biogas and digestate production, storage needs, and energy consumption are based on a Finnish context. The data on the sludge was provided by the wastewater treatment plant (table 2) [28].

Table 2 Total amounts of substrates available

Input	Amount (t)	DM content (%)	Methane potential (m^3CH_4/tDM)
Sewage sludge	1 000	20	300
Pig manure	10 000	5	300
Cattle manure	2 000	7	200
Household bio-waste	1 700	27	400
Cut grass	1 000	35	350
Total	**15 700**	**10.5**	

In *Scenario 1*, the plant runs on sewage sludge, manure, and cut grass or energy crops. In *Scenario 2*, the plant runs on sewage sludge and manure. It is assumed that all of the sludge is utilised. Both scenarios have 7 000 m^3 of substrates, which is in the lower range of the capacity of the proposed plant. However, gas production is 35% higher in *Scenario 1*, due to the addition of energy crops, as this improves the fermentation process. It is therefore imperative that energy crops are added to the substrate mix, even if these must be procured at a cost. The direct GHG emission reductions from substituting fossil fuels with biogas have been estimated using an efficiency of 22 km/kgCH_4 for biogas cars and replacing emissions of 166 gCO_2/km for conventional fuel. The detailed figures are in table 3 [29].

In both scenarios, the plant retention time in the two fermentation tanks is set to 21 and 15 days, respectively. Most of the heat and electric energy to run the plant is produced in a gas burner on site, requiring about 10% of the produced gas, while the

remainder of the heat and electricity demand is bought on the spot market.

Table 3 Biogas scenarios

Input	Scenario 1	Scenario 2
Sewage sludge	900	900
Pig manure	5 000	5 000
Cattle manure	700	1 100
Grass/energy crop	400	0
Total substrate (t)	7 000	7 000
DM (%)	8.84	7.24
Total DM (t)	619	507
Total CH_4 production (m^3)	152 600	112 490
Total CH_4 production (kg)	130 473	96 179
Total range from yearly gas prod. (km)	2 899 400	2 137 300
Potential CO_2 savings (tCO_2e)	483	356

From a GHG perspective, production of biogas has a dual benefit: the reduction in CO_2 from fossil fuels used in transport and the reduction of methane from manure, caused by storing and spreading it. Methane emissions are significantly reduced if the manure is digested in a biogas plant before being spread onto the fields, and the reduction could be of the same magnitude as the reduction in CO_2 from the replaced fossil fuel. This would bring the total GHG emission reduction to around 1 000 tonnes per year in Asikkala's case, although it depends on local conditions. Biogas also has indirect environmental benefits such as a reduction in pollutants contributing to eutrophication, a reduction in waste volume, and a reduction in the leakage of nutrients into the environment. Crop residues can leak up to 30 kg nitrogen per hectare. This leaching will be dramatically reduced if crop residues are used for biogas production, although soil quality issues must be taken into consideration. Furthermore, a recycling of nutrients through digestate application will reduce the need for fossil fuel-based fertilisers, further contributing to GHG emission reductions [30].

Legally, nothing prevents the building of a biogas plant but enough time and resources should be allocated to obtaining all the permits needed. The process for getting permits can range from months to beyond a year. Once the decision to move forward has been made, the legal requirements should be considered more in-depth [18].

Location of the Plant

The location of the plant influences transportation of substrates and financial payback time, as well as public support for the facility. Based on these factors, three possible locations have been identified, each with a number of drawbacks and advantages:

1. Location at wastewater treatment plant

The advantage of this location is that dewatering the sludge will no longer be necessary. Also transportation of the sludge is avoided, saving energy and fuel. Transporting substrates and digestate could lead to increasing traffic in the area, and as the plant is located in a residential area, a biogas facility in that location could lead to complaints from neighbours [21].

2. Location at Saitta industrial ground

Saitta is set aside for industry and located roughly one kilometre west of Vääksy, the main residential area of Asikkala, on Road 24. This means that smell and noise will not cause nuisance to neighbours. Proximity to the road facilitates easy transport of substrates to and from the plant, while the area nearest the road would be a good location for the gas station. The drawback of this location is that the sludge would have to be dewatered and transported to Saitta.

3. Location at existing industrial ground

The biogas plant could alternatively be placed in proximity to a number of smaller industries located southeast of Vääksy next to Road 24. However, some of these areas are located on top of class-1 groundwater reservoirs, which could hinder development [31]. The advantages and drawbacks are similar to the Saitta location, the difference being that the area is located east of Vääksy on the road to Lahti, which could potentially increase traffic to a proposed biogas station.

Figure 8 Map of Asikkala with potential biogas locations added [32]

Financing

Subsidies

The Ministry of Employment and the Economy financially supports investments in clean and efficient energy production. Two support mechanisms are relevant for biogas production: the feed-in tariff system and the Energy Investment Aid scheme. However, the minimum capacity requirements for the feed-in tariff system make the proposed biogas plant in Asikkala ineligible for this support [11].

The Energy Investment Aid aims to support worthy projects not eligible for the feed-in tariff system. Aid levels typically range from 25% to 30% of the investment cost, decided on an individual basis. Projects involving state-of-the-art technology can receive up to 40%. Support for the programme is sensitive to political considerations and budget constraints, and might change in the future. The investment aid is based on actual costs: half of the subsidy is given when half of the costs have been borne, and the other half upon finalisation of the plant. Therefore, the aid does not support the upfront investment [11].

Ownership

In order to ensure long-term stability and jointly share the risks involved, a collaborative ownership structure composed of companies, farmers associations and the municipality is recommended. This organisational structure would represent local interests and would be eligible to receive government subsidies, as this cannot be granted to individuals [11,12,22,23,33].

To attract private and commercial investors and build support for the facility, a local biogas association (*Asikkala Biogas*) should be established. This can serve as a forum for discussion, build support for biogas locally, and distribute information to relevant stakeholders and residents.

Investment

The total project cost is estimated to be EUR 1 500 000. As subsidies cover 25-30% of the cost, EUR 1–1.2 million needs to be raised for the project to be launched.

The municipality can contribute EUR 50 000 without the consent of the city council, but can in principle invest a larger sum [26]. The contribution from individuals is estimated to be upwards of EUR 100 000 [12,22,23,24]. Gasum and Lahti Energia have been identified as potential investors and would benefit from gas grid development. Additional support might be given through foundation grants.

Assuming a financing structure similar to Joutsa, the project could also receive a loan from Finnvera, a government-owned financing company [11,17].

Highlighting the financial attractiveness of the project is paramount to gather private investments and should be central to the communication of setting up the plant. Obtaining support and commitment from local authorities is a vital factor for success, and is an important lesson learned from existing facilities of the same scale [13].

Plant Financials

The project cost for the plant is based on benchmarking and calculations for a plant with a capacity in the range of 7 000–12 000 m^3 of substrate per year. The subsidy level, interest rate, and administrative costs are assumed to be similar for the two scenarios, as is the price at which the gas is sold, and the gate fees charged to handle the sludge and manure. See table 4 [28].

Table 4 Financial details for the two scenarios

Financials	Scenario 1	Scenario 2
Plant investment cost (EUR)	1 500 000	1 500 000
Subsidy level (%)	30	30
Interest rate (%)	4	4
Gas sales (EUR/kg)	1.55	1.55
Gas sales (EUR)	202 300	149 000
Total fees (EUR)	74 000	80 000
- *Manure (EUR)*	35 000	35 000
- *Sludge (EUR)*	45 000	45 000
- *Crops (EUR)*	-6 000	N/A
Administrative costs (EUR)	41 000	41 000
Operating costs (EUR)	71 300	56 300
Gross Revenue (EUR)	282 300	229 000
Net profit (EUR)	170 000	130 700
Internal Rate of Return (%)	12.75	8.00
Payback (years)	6.2	8.0

Due to the increased gas production, *Scenario 1* is more profitable than *Scenario 2*, and thus has a shorter payback period and a higher internal rate of return. However, both scenarios have reasonable payback periods.

Competition

The availability of substrates, especially revenue-generating ones, is essential to the economy of the biogas plant. The number and proximity of biogas facilities in the region will determine how many resources are available. It is therefore imperative that long-term contracts with substrate suppliers are secured, as it is expected that the Asikkala facility will be competing for resources with other biogas facilities in the future. Currently a new biogas facility is developed near Lahti, opening in 2014, expecting to produce 50 GWh of gas for heat and electricity generation.

Additionally, securing demand for the produced biogas fuel is a vital part of making the plant financially viable. It must be expected that private fuel demand will not be enough to sell all gas produced in the start-up period. Therefore, it is imperative to secure demand otherwise, e.g. through procurement guarantees with industry, farms, and the municipality, each promising to buy a guaranteed amount of fuel until sufficient local demand exists. The proposed biogas association, in particular, plays a key role in fostering this demand.

Recommendations

When deciding upon a future course for biogas in Asikkala, a number of factors influence which scenario is the most suitable and must be taken into consideration. If a decision to construct a biogas facility in Asikkala is further advanced, these will need to be further studied. Based on the findings presented, a number of suggestions are provided.

Biogas Facility

It is suggested to construct a biogas plant and an upgrade facility to convert the gas to fuel-grade quality. The plant should have a capacity to handle larger amounts of substrates than is currently available, enabling it to meet future gas demand. Most importantly, the plant must be able to handle crop residues and energy crops, as this increases gas production considerably, which leads to increased plant profitability. The potential environmental benefits increase if manure is included and digestate replaces artificial fertiliser, as fugitive methane and production-related emissions are reduced.

Figure 9 Biogas vehicle fuelling station

Of the three alternatives, a location at the existing wastewater treatment plant would lead to the lowest environmental and financial costs. However, such a location is considered politically and socially unacceptable due to smell and nuisance. Therefore, it is suggested to locate the plant at the Saitta industrial ground, as this would still be financially and environmentally profitable, as well as politically feasible.

Financing and Ownership

The plant has a favourable payback time, and therefore, it is suggested to move forward with the process. In order to attract both private and commercial investors and build momentum, it is paramount to establish the *Asikkala Biogas* association. There is a need to raise EUR 1-1.2 million for plant development, out of which private and municipal investment is expected to cover at least EUR 0.2 million.

The profitability of the plant hinges on creating demand for biogas, as this accounts for over 70% of plant income. It is therefore imperative that *Asikkala Biogas* works towards fostering local demand. Competition for resources could become an issue, but as abundant amounts are locally available, it is not assumed to be problematic.

Achieving Political and Public Support and Engaging Stakeholders

The Municipality of Asikkala and the proposed biogas association are key actors in generating public and political support for the project. The biogas plant is financially viable, and, with a location at Saitta, it is expected that complaints can be minimised. The municipality can support the project financially through part-ownership and procurement of gas, but more importantly by informing residents and businesses in Asikkala about the benefits of the project. Support among farmers and industry should be built in collaboration with the biogas association, the agricultural expert organisation ProAgria, and the Central Union of Agricultural Producers and Forest Owners (MTK). The local farmers and other industries can provide substrates and receive digestate, which would otherwise cost money. Getting their support is vital for success.

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[Pictures] Simon Bager, Mia Pantzar & Riitta Talja

Smart City Zabrze

Building on a Mine of Opportunities

Mallory Anderson, Nathalie Becker, Patrycja Długosz, Sarah Kloke, Steinar Kaldal and Tilmann Vahle

Zabrze is in a fascinating situation: a city on the verge of a transition from a Polish mining and industrial centre to a modern and sustainable hub, offering an attractive location for both the city's residents and tourists. Mayor Małgorzata Mańka-Szulik and her dedicated administration are leading the city through the transition which combines progress and innovation while remembering the city's industrial heritage. We see that Zabrze is well on its way to become the vibrant, sustainable city it is aiming to be. Still, there are several steps necessary to become a place that draws attention across Poland and internationally.

Zabrze and Lund have established a fruitful partnership over the last years giving us as students of Lund University an opportunity to consult the city of Zabrze on the development of a new city district "Nowe Miasto" that the municipality envisions as a sustainable city district. Nowe Miasto is a ca. 250ha large plot of mostly agricultural land and wetland vegetation. It is located between Zabrze, the village Rokitnica, industrial zones as well as forests in the west and east, 7km north of the old city center. Extended forest areas are adjacent in the east and west (see figure 1). It also contains a small stream, which adds aesthetic value to the area.

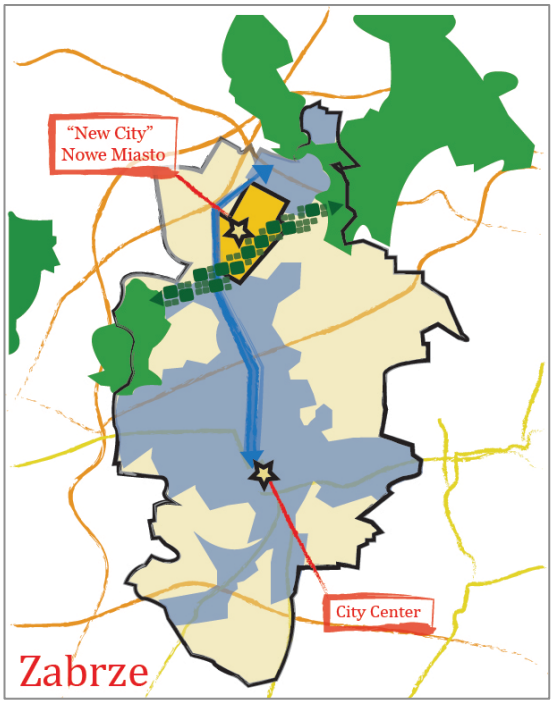

Figure 1. Zabrze, Nowe Miasto.

In this report we introduce the reader to the vision for the Smart City Zabrze that will help pave the way for sustainable development of the Nowe Miasto area. The vision constitutes of three pillars: 1) the creation of a green network along the stream, 2) building a pilot community, a showcase of sustainable urban planning and 3) a golf course which respects the local environment. As the development of Nowe Miasto will be an integral part of Zabrze's overall transition towards sustainability, we decided to expand our scope beyond the investment area itself and added further recommendations for the old city.

Approach

This report is based on the principle of value based planning, as applied successfully by the Swedish city of Malmö. This approach identifies the key values of a development area and sets a framework to help planners implement these values as they realize their vision. As important values are maintained more easily, the process remains flexible to allow for new adjustments and developments in the future. Starting from a strong vision of Zabrze as the most sustainable city in Poland, we propose six values that should be the cornerstones in the urban planning process and help to translate the vision into practice.

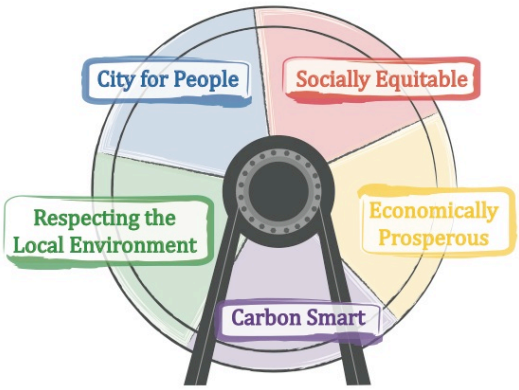

Figure 2. Values for Nowe Miasto investment area.

City for People - People go where people are. Walkable cities tend to have a vibrant city life. The key is providing access to attractive public space, where people meet, innovate, and relax. The aim is to create a magnetic city, which increases the quality of life for the old residents and attracts new.

Socially Equitable - A healthy community does not leave anyone out, but works to raise the tide of all the people. A plan that provides affordable housing as well as job opportunities is essential to a cohesive community.

Economically Prosperous - Prosperity based on smaller, interconnected but flexible entities and a focus on clean technology and innovation trigger the transition to a resilient, distributed economy.

Climate Smart - Climate change must be addressed at all levels through mitigation efforts as well as adaptation planning. Zabrze has an opportunity to leapfrog dated technologies by creating a smart community in Nowe Miasto, combining new solutions with highly energy efficient buildings and renewable energy sources.

Respecting the Local Environment - Green space is a valuable asset for both the health and wellness of people and for preserving local biodiversity. This adds to the resilience of a community and is important for education and recreation of youth and adults alike.

Green Network

The creation of a protected green area across the central part of Nowe Miasto, couched in a larger green network running from the South-West part to the North-West (see figure 1, indicated in green), will provide access to, and connect, the surrounding nature. This will enhance both the area's recreational value and local biodiversity.

The creation of a green network presents Zabrze with the opportunity to expand its already existing industrial heritage tourism concept, as successfully combined in the formerly heavily industrialized Ruhr area in Western Germany. Zabrze would thus become the green heart of the Silesian Metropolis.

This has been a widely practiced planning technique since the renowned German planner Schmidt recommended the inte-

gration of a network of green spaces to separate developments in the early 1900s [1]. Protecting green spaces has been long recognized to promote the health of the people living near nature as well as providing economic and social benefits.

Economic benefits include an increase in property values in the area. Furthermore, a network of this kind could support branding and identity creation, which increases visibility of Zabrze nationally and internationally. Socially and culturally the benefits for Zabrze could include increased tourism revenue as well as general aesthetic value of the city; it would also promote healthy lifestyle by encouraging to walk, hike, bike or simply spend time out in the fresh air. The existing horse-riding activities could be embedded in a comprehensive sports concept. Other recreational activities could be created such as promoting picnics and barbeques, and facilitating art exhibitions. It could also aid local knowledge creation and education by making school excursions possible.

The green network would have a great positive impact on the environment; it would help water retention and provide space for storm water management as well as providing air quality improvements. Importantly, it would preserve and even enhance the existing biodiversity.

Storm Water Management

The Mikulczycki creek has been straightened and flooding problems on the south end of the property have been identified. This can be eased through intelligent water management on the property including a creek restoration and constructed wetlands or retention ponds. Holding rainwater in the green network and allowing it to slowly flow downstream will ease the southern flooding problems. These renaturalised wetland areas are well known for being important places for habitat, and will be rich with songbirds and attractive during all seasons.

Figure 3. Zabrze student team along the Mikulczycki creek.

Smart Nowe Miasto

The municipality of Zabrze has decided to develop the area of Nowe Miasto into a highly attractive new part of the city to create new living space and improve the image of the city.

Creating a Vibrant Community

Green space surrounding urban areas is a highly valuable resource. From an environmental perspective, the first priority should be to preserve these green areas and even improve their quality. We understand that the city of Zabrze has a strong interest in building a sustainable pilot community on the Nowe Miasto investment area, as it is very attractive for residential development. We strive for providing a concept how this development can be carried out in a manner which preserves the unique character of open green space. Furthermore, we aim to provide guidelines to create a ground-breaking lighthouse project - a liveable, socially integrative, carbon smart city, which respects the local environment.

The basic prerequisite for a city to work is creating an attractive place to be for people. It has to be acknowledged that it is always a major challenge to develop a vibrant and sustainable community from scratch. The distant location of Nowe Miasto requires sustainable mobility solutions that decrease car dependency.

> *First we shape the cities - then they shape us* - Jan Gehl [2]

Built infrastructure shapes human behaviour in many ways. In older cities, housing was located around vital functions and public space, such as the market place. On the contrary, new cities are often characterised by long distances and the strict separation of residential, commercial and recreational zones. This new style of urban planning with a focus on car-based infrastructure has not only caused a lock-in into unsustainable, but also unhealthy and often socially isolated lifestyles.

Against this background, it is crucial from a social and an environmental sustainability perspective to design Nowe Miasto in a way which invites outdoor city life with frequent social interactions. Major components are highly attractive public space, such as parks and small squares with shops and gastronomy as well as short distances between vital city functions.

The Jan Gehl architects' tool box for a "City for People" introduces five planning principles which we suggest to the planners of Zabrze (see box 1).

1. Carefully locate the city's functions to ensure shorter distances between them and a critical mass of people and events.

2. Integrate various functions in cities to ensure versatility, wealth of experience, social sustainability and a feeling of security in individual city districts.

3. Design city space so it is inviting and safe for pedestrian and bicycling traffic.

4. Open up the edges between the city and buildings so that life inside buildings and outside in city spaces can work together.

5. Work to strengthen the invitations to invite longer stays in city space because a few people spending a lot of time in a place provides the same sense of lively space as many people spending only a short time. Of all the principles and methods available for reinforcing life in cities, inviting people to spend more time is the simplest and most effective. [2]

Box 1 Jan Gehl's Toolbox

Sustainable Transportation

Zabrze has the opportunity to leapfrog over the mistakes many cities have made when developing new city districts that are heavily dependent on car transportation. Many of those cities, for instance Copenhagen and Lund, realising the benefits of sustainable transport, have modified their streets in an effort to make them more bicycle/pedestrian friendly.

It will be of major importance to establish a convenient public transport connection between Nowe Miasto and the old city center from the beginning of the development. If the connection is designed in such a way that it makes public transport convenient, empty areas between Nowe Miasto and Zabrze´s centre might fill with retail and res-

idential development, smartening up depressed areas. Cities have seen economic benefits in improving public transportation connections between city districts. For instance, Portland's (USA) newly improved public transport line resulted in 3.5 billion US dollar new economic development around the route that connects the centre to the surrounding areas [3].

One way to run an effective city bus system is to establish a bus rapid transit system (BRT), also called "surface subway". The major advantages are the capacity and speed of light rail or metro with the flexibility, lower cost of a bus system [4]. Both for such a system and for local buses, we suggest using gas-powered buses since these have considerably lower emissions of air pollutants and CO_2 than comparable diesel buses. Zabrze is planning on building a biogas plant that could feed the city buses with locally produced biogas. This is in line with the climate smart aspirations of Zabrze.

Creating appealing sustainable transport solutions is a challenge. The aim should be to build a city which invites people to walk, use the bike or public transport. Offering the option of safe bicycle lanes along all roads can encourage citizens to switch from cars to bicycles as the main transport mode. Bicycle stands, stationary bicycle air pumps and secure bike paths and special bicycle traffic lights at street crossings therefore must be integrated into the infrastructure design from the beginning.

The strategic planning for the transportation system/infrastructure in Nowe Miasto can benefit from a framework such as the newly developed Transport Toolkit. Developed by the Low Emission Development Strategies Global Partnership (LEDS GP) Transport Working Group, together with the United Nations Environment Programme, and introduced in 2014, the toolkit is designed to give urban planners and policy makers the capacity to implement a variation of low carbon transport initiatives. The Transport Toolkit includes multiple web-based tools to help city authorities through the process, which consists of six steps (see figure 4). [5]

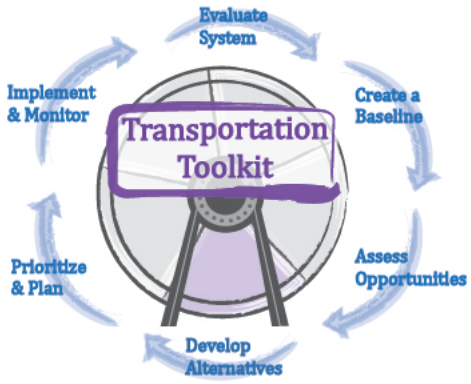

Figure 4. LEDS Transportation Toolkit adapted from LEDS Transport Working Group.

Climate Smart Energy Solutions

The community of Nowe Miasto could become a showcase of a cutting-edge smart energy system, based on a mix of renewable energy sources, highly energy efficient buildings and a smart grid, which interacts with aware consumers in households and offices. It should follow the following principles: reduce energy demand wherever feasible, increase efficiency, and use renewable energy for the remaining demand (see figure 5).

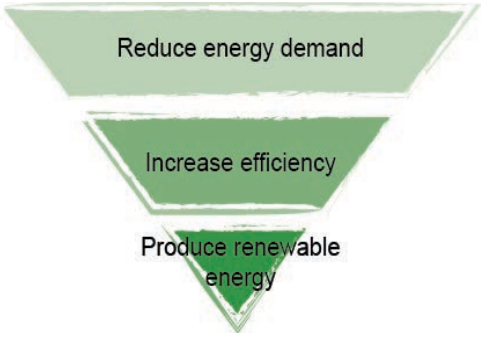

Figure 5. Energy Triangle adapted from Sweco.

Ideally, Nowe Miasto will be energy self-sufficient over most parts of the years and supplied with energy from local renewable energy sources. As renewable electricity generation highly fluctuates it is important to rely on a mix of different energy carriers as well as storage or back-up capacity. Wind and solar energy have proven to complement each other relatively well. Windy weather is often combined with less sunshine and the other way around. Small-scale photovoltaic (PV) systems, which are integrated into the building design, can reduce a four-persons-households' electricity purchase from the grid by 30%. If the PV system is connected to a battery another 30% of electricity consumption can be covered over the year [6]. This could be complemented with a wind energy project. Zabrze has a relatively good position for installing wind farms with wind conditions of 5.88 m/s at an altitude of 60m [7]. One smaller wind mill would generate approximately 3.5 million kWh of electricity per year, equalling the electricity consumption of roughly 1000 inhabitants [8, 9].

For heating, we recommend investigating the potential for heat pumps and small-scale geothermal energy. Using heat from existing mine shafts for this technique may be feasible, as has been proven in Glasgow, Scottland [10]. Another option might be to install small combined heat and power plants in multi-apartment buildings, which can be run on biomass such as wood pellets.

Integrated Building Design

The design of new buildings in Nowe Miasto will play a major role in determining the carbon footprint of the community.

A life cycle approach in evaluating performance and costs of materials should be taken since materials, which are cheap to buy and install, may cause significant costs in maintenance and disposal. In more energy efficient buildings, the energy embedded in the building materials may account for up to half of the energy footprint [11]. Other environmental impacts may also be significant, such as water and resource use and pollution during production and toxicity at the end-of-life stage.

Using natural materials has the potential to significantly reduce the environmental impacts from a life-cycle perspective. Moreover, natural materials have low toxic content and can contribute to a healthier indoor climate, improving the quality of life for the inhabitants.

Examples are wooden beam structures for walls and ceilings or natural clay bricks and shingles instead of conventional bricks [11]. As the markets for production, distribution and application of such materials is so far underdeveloped, there is great potential for creating local expertise for this market niche – thereby fostering the local economy.

Applying an integrated building design is of great importance to maximize the benefits of low-energy buildings. Integrated building design makes use of natural principles allowing for passive heating, cooling and ventilation, as well as natural lighting. To do so, buildings are constructed according to local conditions, such as wind directions and seasonal variations in light and vegetation [12].

A popular example of integrated building design is the installation of green roofs, which significantly reduce the buildings energy consumption, temporarily store rainwater, purify water and air and add to local biodiversity [13].

Figure 6. Vision of an attractive green roof neighbourhood (Source: Malmö stad)

Photovoltaic panels on rooftops will play a crucial role in covering the remaining energy requirements of the system.

While in Sweden and Germany energy neutral houses are typically only 7-9% more expensive than normal buildings, this price difference is currently 15-30% in Poland, partly due to the state of the construction market [14]. However, the economic feasibility of very low energy buildings including geothermal energy and PV has been proven locally by the Zabrzańskie Centrum Innowacji (Zabrze innovation centre, ZCI).

Figure 7. Bo01 development in Malmö, Sweden (Source: Malmö stad).

In the development of the Western Harbour project, the municipality of Malmö has made use of a dialogue-based approach between the municipality, investors and developers, which proved crucial to push beyond national regulations. Together, goals were formulated, lessons learned were examined and experiences were transferred to the next development stage. This approach has proven to be successful and could be a good strategy to ensure that Zabrze's ambitions will be implemented in practice. Likewise, intelligent business models and contracts are important to align the incentives of all parties to achieve the best results [15].

Intelligent Waste Management

Regarding waste, Nowe Miasto has the potential to build an innovative waste management system that makes use of disposed material in the most efficient way, while promoting sustainable recycling practices of the residents.

Zabrze has invested in an advanced separation system of waste in the past. Former investigations into the existing waste management system identified a potential for generating biogas from local substrates deriving from waste.

An intelligent and innovative solution for Nowe Miasto does take up the present waste management practices and builds on the locally available waste resources.

Figure 8. Waste station feeding underground waste infrastructure. (Source: Malmö stad, Western Harbour Guide)

Suggested solutions include using biodegradable wastes for the production of bio-

gas for local use, and the establishment of a suction system for waste separation (figure 8). Material recycling should have priority over energy recovery (combustion).

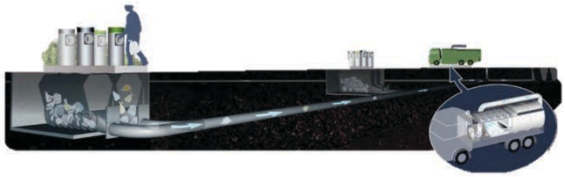

Figure 9. Underground waste suction system as applied in Malmö, Sweden. (Source: Malmö stad, Western Harbour Guide)

Employing an underground suction system reduces the need for waste collection efforts carried out by waste trucks taxying through the community. Locating the waste collection sites close to buildings and decreasing the development of odour from biodegradables increases the comfort for the residents and creates a tidy surrounding.

Waste collection rates can be successfully promoted by the introduction of volume-dependant fees for residual waste. Informing the residents about the local practices is important to support this intelligent waste management system.

Intelligent wastewater management

Similar to the waste generated in the new residential area, wastewater can be considered a resource. Extracting heat from warm wastewater that otherwise gets disposed of in the local wastewater infrastructure is a viable option to reduce the demand for energy. Two systems are envisioned: Heat extraction from high-temperature wastewater in residential buildings, and heat extraction from low-temperature wastewater in the local wastewater infrastructure.

In order to reduce the freshwater use of the residents of Nowe Miasto, collected grey water from the buildings' roofs is a solution that combines well with the installation of green roofs. Grey water suffices for sanitary appliances such as flushing toilets but also for watering gardens.

Maximizing the potential, water-efficient in-house applications for toilets and showers that decrease the use of water are cheap, easy to implement and effective [16].

Urban Gardening

Small garden plots have become embodied into Polish culture as a quiet place that provides privacy to people living in large apartment blocks. Newer architectural designs can provide the desired privacy as well as creating inviting green spaces that are integrated into housing and retail areas. Malmö has experienced *crime-free* zones around its community gardens as well as beautification of apartment buildings.

Today, every new apartment in Malmö's Western Harbour district is equipped with a garden box for urban farming.

Figure 10. Urban Villas in Malmö with garden boxes on balconies (source: Malmö stad).

Golf Course

The city of Zabrze has a high interest in building a golf course on the Nowe Miasto investment area as it increases the area's attractiveness for residents and visitors

while preserving its green character. However, building a golf course in Nowe Miasto might create challenges with regards to all three pillars of sustainability.

Internationally, many, if not most, golf courses struggle with profitability due to their capital intensive nature [17]. In fact, all seventeen 18-hole golf courses which were built in Poland since the 1990s, are in the red [18].

From a social perspective, ensuring accessibility for all inhabitants of Nowe Miasto and visitors will be crucial. One way to enhance the social value of the golf course area is to build a multifunctional golf course with designated safe areas allowing for other activities. Also, by opening the clubhouse for other sport clubs, conferences or other indoor activities, the building, which would otherwise be empty large part of the year, can be utilised better way [19]. More functional variety will therefore mean more people using the area all year round and thus there will be a better chance to create revenues.

If possible environmental impacts of golf courses are not kept in mind during the design stage, the course can have serious ecological impacts [20]. By conducting a Strategic Environmental Impact Assessment (SEA) for the golf course, golf architects can prioritise on how to design the course in the most sustainable way. Basic environmental principles should be:

- As little landscape change as possible. The bigger the change, the bigger negative environmental impact and more maintenance is required [21];
- Use native vegetation as much as possible in landscape design, like planting locally native drought resistant plants from Zabrze botanical garden;
- Use organic fertilizers and pesticides;
- Use local material for necessary landscape inputs, e.g. sand, rocks, etc;
- Use/purchase recycled/natural golf course equipment (plastic and wood), e.g. benches, bins, flags and tee signs;
- Use natural water systems as much as possible (gravity and topography) to reduce energy and construction input. Piping, culverting and canalising the water flows can degrade natural water ecosystems [22].

If the three pillars of sustainability are used as focus areas in the design of the golf course, the Nowe Miasto golf club can be the first certified eco-friendly golf club in Poland. Poland´s best-known golf course, Modry Las, is now striving for a greener image by building eco-friendly show homes at the course area [23]. Nowe Miasto can take a step further and be a showcase for how to build an entire golf resort in a sustainable and eco-friendly way.

Figure 11. Innovative building of the ZCI (Source: ZCI).

New City in Old Boundaries

If designed carefully, Nowe Miasto will be the lighthouse project in Southern Poland, showcasing a modern, sustainable community. However, the efforts put into this

new part of the city should not divert attention from the old centre. Zabrze has been constantly investing in the maintenance and modernisation of its cultural and industrial heritage. We strongly encourage the municipality to build on this potential and to further foster a transition to a vibrant and sustainable community within the old boundaries of the city.

The guiding principles should be to limit urban sprawl and instead work on densification in the old city centre, always with the aim to create a lively, walkable and healthy community, which respects the local environment.

Local value creation

In order to become a sustainability forerunner among Polish municipalities, it will be vital to attract businesses, which engage with sustainability: not only to be a consumer of technological- and knowledge-based sustainable solutions, but also a producer. The foundation of a CleanTech Centre, similar to the CleanTech City in Malmö, could be a strategic step in creating favourable conditions for this kind of businesses [24].

A first step in this direction has been taken through the establishment of the Zabrze innovation centre (see Figure 11).

It has been shown that innovations develop to a large extent in regions, or knowledge clusters. This is because even in a digital world, direct social interaction between creative individuals is crucial for the development and dissemination of innovations [25]. Therefore, the ZCI could yield even higher benefits, if integrated into a regional CleanTech development concept. With the recently founded CleanTech cluster in Krakow and the Energy Efficiency Foundation in Katowice, the region of Southern Poland has great potential to become the CleanTech forerunner nationally and internationally.

Today, Poland is the OECD country with the smallest public fund for innovations [25]. Combining forces in the region might be a good strategy to lobby for more national support.

Refurbishment of existing buildings

The existing building stock of Zabrze offers great potential for improvements in energy efficiency (retrofitting). Given the current low standard of insulation, such measures can be very cost-effective. The municipality has recently started a subsidy scheme to accelerate this refurbishment.

Particularly for the high rise buildings, socially equitable solutions have to be identified so that the current residents are not displaced. One such approach has been successfully implemented by architects Druot, Lacaton and Vassal in Paris: Structurally independent winter gardens with highly insulating glass surfaces were added to the existing buildings, adding attractive living space. Thermal efficiency was improved by 50% without increasing the price per square meter. The residents – most from low-income background – were consulted throughout the process and none had to move due to the refurbishment [26]. This example shows that cost-effective, socially equitable refurbishment is possible and can add to the quality of life in existing buildings.

The old buildings of Zabrze – predominantly brick buildings often with elaborate wall decorations – present a different challenge altogether; here, a sensitive approach should be taken, balancing energy efficiency and preserving the beauty of the buildings. Highly insulating windows, roof and

floor insulations and intra-wall insulations could be options to be explored.

Rich local culture in vacant spaces

Zabrze can make use of its vacant buildings and areas by following the model of Renew Australia: An independent body that guarantees very short-term, very cheap leases of private and public owners to entrepreneurs and artists. This can attract a young, culturally interested audience and support community spirit, thereby fostering its image for the young population. These gain an opportunity to try out creative actions with very low costs, while the owners retain the option to end the lease with short notice. Vacant spaces are used, their value increased and cultural, entrepreneurial local culture is fostered. The approach created over 70 new businesses within a year in the small town Newcastle, Australia and is now copied internationally (Project Renew Newcastle) [27].

Tools

There are many tools and methods that could support cities like Zabrze in their efforts to become more sustainable.

One that stood out in our research is the Reference Framework on European Sustainable Cities (RFSC). It is an online toolkit designed to help cities integrate sustainable development into their planning. It does this by providing the tools and support that cities need to integrate sustainable principles into their policies and programs. It is a joint initiative of the Member states of the European Union (EU), the European Commission and European organizations of local governments, and is available to Zabrze free of charge [28].

Zabrze could use RFSC as they develop new sustainable ideas and projects and to monitor progress of projects already in action.

Once signed in, the toolkit will allow Zabrze to create a profile and its own account on the web-based platform. Zabrze can then match/network with other comparable cities. The tool also allows for networking by finding other cities that use that same toolkit for similar projects. Notably, profile and network participation are complementary to the tools that are the focal point of the framework.

Importantly, the toolkit is not intended for ranking cities, but rather gives methodology in achieving a particular goal. Furthermore, it should facilitate better communication within a city, including different departments of a municipality by engaging each one in the design process, as well as between cities, associations etc. Also, better results are to be expected from a specific project by using the toolkit's integrated approach, tools for monitoring, and to build capacity.

Additionally, a city can affiliate its account with for example a university. Meaning, that if Zabrze were to create a profile and affiliate the IIIEE Team Zabrze with it, the Team would be able to help out with the process. It could also be used for future projects and long-term cooperation with the IIIEE.

Lastly, Ms Axelle Griffon [23], representing the RFSC, suggested that there would be financial means by the EU for sustainable action plans, which will be available in the near future (next year was mentioned). It has been hinted that cities using the tool might have more chances to receive the funding as they are committed to sustainable urban development.

Final remarks

Summing up, the development of Nowe Miasto presents Zabrze with great opportunities. Considering all dimensions of sustainability and applying a value-based planning approach will allow the city to make full use of the potential both of the development area and its existing resources. In this, setting bold goals for low-energy and environmentally sensitive community development will be as important as preserving and enhancing the existing nature. Also, integrating the project into the larger context of Zabrze is important. Keeping in mind our recommendations, we are confident that Zabrze will be successful in becoming a sustainable forerunner.

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Interview with Vesna Vasilijkovic, Architect, City of Lund, 2014-03-24

Interview with Jakob Economou, Project Leader, Malmö Cleatech City, 2014-03-25

Interview with Nora Smedby, PhD Candidate, IIIEE, Lund University, 2014-03-26

Interview with Anja Krechting, Senior Policy Advisor, Ecofys, 2014-03-27

Interview with Malin Norling, Malmö Environmental Department, City of Malmö, 2014-03-27

Interview with Johanna Wittenmark, Brunnshögsprojektets, City of Lund, 2014-03-31

Interview with Mayor Małgorzata Mańka-Szulik, Mayor of Zabrze, City of Zabrze, 2014-04-08

Interview with Tadeusz Dębicki, President of Zabrze Agency for Investment Development, City of Zabrze, 2014-04-07

Interview with Rafał Kobos, Mayor's Plenipotentiary for Investors' Issues, City of Zabrze, 2014-04-07

Interview with Magdalena Korzeniowska, Head of the Real Estate Transfer Department, City of Zabrze, 2014-04-07

Interview with Zenon Rodak, Head of Urban Planning Department, 2014-04-09

Interview with Kazimierz Ladziński. Head of the City Board of Roads and IT Infrastructure, 9 April 2014

Interview with Janusz Famulicki, Head of Ecology Department, 2014-04-09

Interview with Lesław Złotorowicz, President of Zabrze Enterprise of Thermal Energetics (ZPEC), 2014-04-10

Interview with Edwin Roald, Golf course architect and GEOSA specialist (Golf Environment Organization Sustainability Advisor), 2014-04-15

On the Horizon

Up-scaling Solar PV for Self-Consumption in the Jordanian Market

Emma Åberg, Matthew Alison, Shu Masuda, Cedric Zhao

Introduction & Background

Solar PV has the potential to reshape Jordan's energy future and deliver the country a huge range of economic, social and environmental benefits. There are many opportunities that can be capitalised on to reach this potential, as reflected by solid regulatory framework on renewable energy and other attractive contextual factors supporting the case for increased solar PV deployment.

The Regional Center for Renewable Energy & Energy Efficiency (RCREEE) engaged the International Institute for Industrial Environmental Economics (IIIEE) at Lund University to conduct a research project on up-scaling solar photovoltaics (PV) for self-consumption in Jordan.

The project entails 3 deliverables: 1) a report detailing barriers, challenges, and recommendations in the Jordanian solar PV market; 2) a brochure outlining the process of solar PV installation and case studies targeted at the general public; 3) a financial scheme for the Jordanian Renewable Energy and Energy Efficiency Fund (JREEEF). This report will focus on the first deliverable due to length constraints. A separate section on JREEEF is summarised at the end of this report.

The main output of this report is a set of key recommendations targeted at relevant stakeholders. These recommendations will focus on how to overcome barriers and capitalise on opportunities for up-scaling solar PV self-consumption in Jordan. Recommendations have been built on primary research through engagement with stakeholders across the public and private sector. Key stakeholders included policy makers, associations, developers, utilities, financial institutions and the end-users.

For deliverable one, our research focused on:

- commercial and industrial sectors
- on-grid solar PV
- generation of electricity for self-consumption

Current Electricity Market

The total installed capacity of electrical energy generating plants in Jordan was 3312 MW in 2012 [1]. More than 99% of this energy was generated from fossil fuel, see Figure 1 [1]. Unlike other countries in the region, Jordan does not have access to any significant fossil fuel reserves [2], and the country instead imports about 96% of its total energy consumption sources [3]. At this point in time a majority of Jordan is heavily reliant on gas imports from Egypt via the Arab Gas Pipeline. A volatile situation in Egypt as well as other major oil trading partners has resulted in more frequent power shortages and blackouts and forced Jordan to occasionally operate its power plants on highly expensive imported

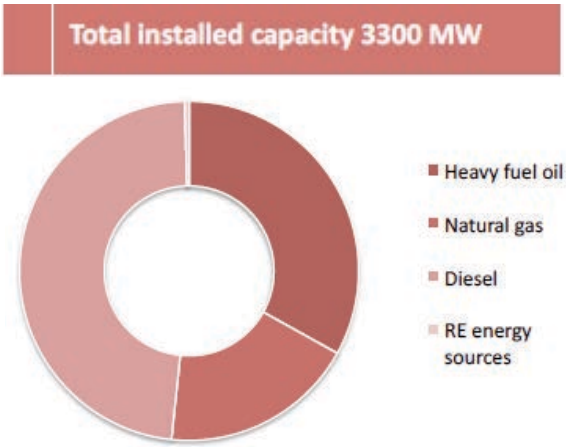

Figure 1, Electrical energy production by type of fuel in 2012. Source: Data from NEPCO

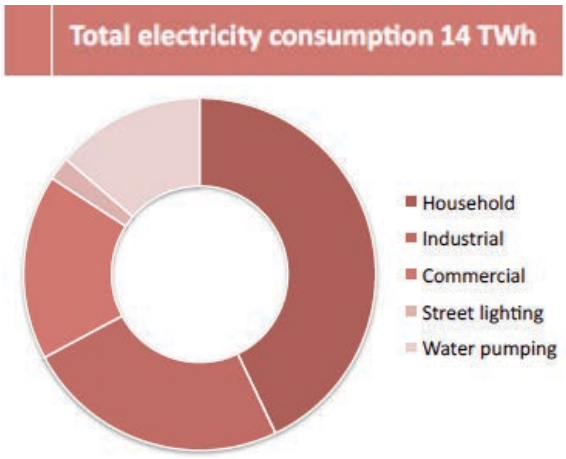

Figure 2 Electrical energy consumption by sector in 2012. Source: Data from NEPCO

diesel [2]. The total electricity consumption in Jordan reached 14274GWh in 2012 [1]. The main demand came from households followed by the industrial and commercial sectors, see Figure 2. According to the Electrical Regulatory Commission the electricity demand is set to increase by 250% in 2025 based on the 2012 demand level [1,4].

The Jordanian government decided to restructure the electricity sector in 1997, where the main objective was to increase the capacity and efficiency of Jordan's electricity sector [5]. Since the restructure, the Jordanian power sector is now regulated by the Electricity Regulatory Committee (ERC). The electricity sector is operating on a single buyer model, where there is strong competition in the entry of new power generators. The generators include the Central Electricity Generating Company and Samra Electric Power Generating Company. The electricity from generators is sent to the state-owned National Electric Power Company (NEPCO), the single buyer on the market, who operates the transmission systems. The electricity is then distributed to consumers through the Jordanian Electric Power Company (JEPCO) and two other private distribution companies.

Large electricity consumers, such as industries, are supplied through NEPCO directly [5].

Achievements for Solar PV

Although the installed capacity from solar PV is only roughly 8MW as of April 2014 [6], it should be noted that there are 320MW worth of solar PV projects that have been approved with a signed power purchasing agreement (PPA) that will be brought into operation between the second half of 2014 and the end of 2015. This tremendous increase in installed capacity that will be seen over the next few years is thanks to solid supporting schemes recently set up and introduced by the policy makers, and an enthusiastic private sector. More specifically, it has been governmental supporting schemes in the form of 'direct proposal schemes' and 'competitive tendering process' that have been the main drivers of this rapid deployment of solar PV [8,9].

The direct proposal scheme entails proposals from the private sector to the government for large-scale electricity generation projects (renewables). If successfully approved, a PPA is awarded and the generated electricity is sold to the utilities at a

preferential price for a set period of time. The competitive tendering process is similar, but it is the government who secures land for development and the PPA is awarded via a competitive bidding process.

Such large-scale projects with the objective of selling back to the utilities are well on track for greater diffusion, with applications for direct proposal schemes flooding in and the 3rd round of competitive tendering process open as of 2013. However, this report, as mentioned before, will focus on the self-consumers market, that is, those who produce electricity for the purpose of their own consumption, not for selling to utilities or third parties. Within this market, the focus will be on the non-residential segment (commercial and industrial), as requested by RCREEE. The solar-PV self-consumption market in Jordan has great potential that is currently not being met. The following chapter will outline the current opportunities present in this nascent market.

High Potential for the Solar PV Self-Consumption Market

A high level of enthusiasm regarding solar PV in general was observed throughout various stakeholder interviews, focus groups, and roundtable discussions. In particular, an increasing interest in solar PV for self-consumption purposes was evident, given the many attractive opportunities it presents. For example, several schools and hospitals have either implemented or are in the process of implementing mid-size solar PV systems ranging between 10kw and 2MW [10]. A fresh food retailer that was interviewed is in the process of installing a 2MW system to offset their high electricity bill [11]. Abu Darwish mosque has installed a 10kW system that has reduced their electricity costs by 80% [12]. The opportunities surrounding the solar PV self-consumption market are characterised by: the supporting policy schemes in place, high electricity tariffs and a high solar potential.

Supporting Policy Schemes in Place

Jordan is one of few countries in the Middle East region that has a relatively comprehensive renewable energy policy in place. The Ministry of Energy and Mineral Resources has set a renewable energy target of 7% of Jordan's energy mix by 2015 and 10% by 2020 [13]. For renewable energy self-consumption, the government introduced the Renewable Energy and Energy Efficiency Law in 2012, which forms the basis for supporting schemes and other incentives (see table 1).

Table 1, Description of main supporting schemes for Solar PV self-consumption.

Supporting schemes for PV generated electricity for self-consumption
Net metering A billing mechanism that credits customers for excess self-generated electricity they feed back into the grid. Each month the customers pay the utility the net difference between what they consumed and what they fed back into the grid. If what they produced exceeds what they consumed, the excess is rolled over to the next month on a kwh basis. The Jordanian net-metering scheme allows for project up to 5MW to make use of the scheme.
Wheeling The transfer of electricity through transmission and distribution lines from off-site generation to area of use for self-consumption. The Jordanian wheeling regulation is applicable for projects regardless of size. A wheeling charge is paid to the relevant utility.

Figure 3, Solar PV installation at Mosque Abu Darwish. Amman, Jordan. Photo: Håkan Rodhe, IIIEE.

High Electricity Tariff Rates

Jordan has relatively high electricity tariff rates, compared to other countries in the region. Even with government subsidies, Jordan's electricity prices for the residential sector are more than ten times higher than its oil-rich Gulf Coast neighbours [14]. Moreover, the electricity tariff rates are especially high for the commercial sector, including banks, telecommunications, and retailers, with tariffs reaching EUR 0.28/kWh in 2013 [15]. All sectors except residential and agricultural are expected to experience between a 5.0% and 15% annual increase in electricity tariff rates from 2013 to 2017 [15]. Such a dilemma makes it crucial for sectors with high electricity tariff rates to seek new energy solutions such as solar PV.

High Solar Potential

Jordan has tremendous potential for solar energy with a 90% desert climate and an average of 330 sunny days every year [16]. The irradiation in the country ranges from 2200 kWh/m^2 – 2550 kWh/m^2, with the southern part of Jordan getting more direct sunlight on a regular basis. In comparison, Germany only receives a maximum direct sun irradiation of 1,200 kWh/m^2 [17]. A study by German Aerospace Centre suggests that the economic potential of PV in Jordan is 4.5 TWh/year that would constitute one third of current electricity demand [18].

General Barriers & Challenges

In the following section, we will address identified general barriers that affect commercial and industrial-scale self-consumers. These barriers may appear as discouraging but could be overcome relatively easily within the next few years with commitment and initiative from policy makers and key stakeholders.

Policy & Regulation

A solid, transparent and predictable policy framework is crucial for the diffusion of solar PV. From our interviews and analysis, it became evident that there was confusion over policy interpretation and concerns over policy predictability amongst stakeholders, while the needs of some consumer segments were not adequately covered by existing policy.

Confusion over regulation interpretation

Not only was this prevalent in discussions involving various stakeholders, but also within the same organization. There is the greatest amount of confusion over the net metering policy among different stakeholders. For example, many misunderstood the fact that the monthly surplus was rolled over on a kWh hour basis, not on a monetary basis [8,19,20]. There have been multiple cases in industry where confusion over the net metering policy lead to misinformed hesitation in investment [8,20]. In addition, some stakeholders had misunderstood other aspects such as the way in

which the peak capacity charge was calculated for large industries [20].

Concerns over policy unpredictability

Various stakeholders voiced concerns over the unpredictability of the supporting schemes in place. Many brought up cases where a supporting scheme was suddenly changed – often having an adverse affect. For example, the fact that the purchasing price for the direct proposal scheme was lowered from the original promised price, and the fact that an additional impact study step was added to the net metering application process both added extra complications to the process [6,8,19,20,21,22,23]. Executives of a large industrial company turned down a solar PV proposal, because they believed the supporting schemes were too volatile [19], bringing up the examples mentioned above. Large consumers who want to make use of the newly implemented energy wheeling policy also voiced their concerns over the possibility of a sudden increase in the wheeling charge in the future [22,23].

The policy 'grey-zone' for large consumers

Despite the increased interest from large-scale consumers for solar PV, current supporting policies do not adequately cover their needs and solar projects - which tend to be larger than 5MW.

Regarding the net metering scheme, the biggest issue is that projects over 5MW cannot make use of the scheme. In addition, it is quite unclear how the current net metering scheme will account for the day/night/peak capacity tariff structure that most large consumers pay [24]. This is not clearly indicated in any of the regulatory documents, and one utility company did not know how exactly they would adapt net metering to this tariff structure, as they had not had this case before [25].

The energy wheeling regulation is crucial for most large-scale consumers and projects. Energy wheeling allows for alternative distribution and business models, but the regulation does not adequately cover each of these specific circumstances [26]. For example, a large telecommunications company wanted to install a large centralized solar PV plant and distribute the electricity to thousands of telecom towers around the nation [23]. However, it was unclear to them how and if they would be covered by the energy wheeling regulation. For example, a hotel association had everything in place: the will, the finance, permits, etc., to install a large solar PV plant and distribute electricity to the member hotels [22]. However, once again it was unclear how the energy wheeling regulation would account for this 'collective model', and was the only bottleneck. Due to large consumers and projects being a policy grey-zone, a high impact (installed capacity, investment/job opportunity) and high potential segment is being excluded.

Financial & Economic

Difficulties in accessing financing

Even though the upfront cost per kW of installed solar panels in Jordan is low (EUR 1-1.5/W) [10], compared to international price levels, the cost is still significant for Jordanian consumers. Since most upfront costs for solar PV projects for self-consumption are financed via debt, access to bank loans is crucial [19,27].

The first challenge related to bank loans for solar PV systems is the limited access to green loans. Two of the major commercial banks are offering preferential Green loans that have been made available through the

French Agency for Development's Green credit line and Central Bank of Jordan's Green lending program. These loans offer interest rates (4-5.5%) that are substantially lower than the average interest rates and return payment periods (10-13 years) that are longer than usual [27].

However, there are some limitations. The French Agency for Development require that a minimum of US$ 700,000 (EUR 0.5 million) be withdrawn each time a bank wants to make use of their Green credit line program [28]. According to interviewed financial stakeholders, this requirement forms a barrier to providing green loans to small and medium size enterprises (SME's) [27]. The lending program provided by the Central bank is also more suitable for larger investments and has up until today mainly financed solar PV projects under the direct proposal scheme [27].

The second challenge relates to the inability of customers to meet the requirements for bank loans. Banks require in general that: the payments are secured via a power purchase agreement (PPA) or inward letter of credit for large companies and collateral for SME's; a feasibility study has been conducted and that the qualification of the management of the company meet certain standards [27]. In order to get a bank loan it is also crucial that the company's balance sheets meet certain requirements. The past year's downturn followed by the Arab spring has affected much of the industrial and commercial sectors that serve in the regional market, resulting in inadequate balance sheets to meet loan requirements. According to interviewed stakeholders, the overall requirements to obtain a bank loan in Jordan today are the hardest to meet for SME's [28].

The third challenge is associated with the limited knowledge on feasibility of renewable energy projects among banks. Limited knowledge about a certain technology or industry tends to create a more conservative approach in the evaluation of loan applications [27,28].

Economic Attractiveness

For certain sectors, solar PV is still not economically feasible simply due to the fact that the cost of generating electricity through solar PV is higher or comparable to that of retail electricity. Since the cost of generation is relatively homogeneous across all sectors [15], it is the retail electricity prices that are the biggest determinant of feasibility. Certain sectors such as the metallurgical industry and agriculture still pay relatively low electricity tariffs [15], and find it more difficult to justify investing in solar PV from an economic standpoint. Even when electricity tariff rates are sufficiently high to render solar PV profitable, it can be overlooked due to relatively long payback periods [10]. From our interviews, payback periods range from 4 – 8 years for commercial and industrial projects depending on factors such as electricity tariff rates and facility size [8,10,11,19]. The upper end of this range

Figure 4, Solar PV installation Sehatty resort. Dead Sea, Jordan. Photo: Emma Åberg, IIIEE.

has proven to be too long for some potential consumers, particularly those who are vulnerable to changing contextual factors that may force them to move operations abroad [19].

Furthermore, solar PV investments are often compared to other electricity generating options, or even other general investments. In this case, the solar PV option may be overlooked due to longer payback periods or lower net-present value/returns when compared to other options. For example, a large industrial company was considering installing a large-scale solar PV plant for self-consumption, but dropped the proposal in favour of a co-generation plant that was more attractive in terms of payback period, net present value, and practical applicability (the excess steam could be used for one of the manufacturing steps) [19].

Technical & Physical

Technical and physical barriers exist in Jordan in the form of current grid capacity, building stock space issues, structural integrity of buildings and ownership structure of buildings.

Grid capacity

Grid capacity is crucial to the smooth deployment of solar PV particularly for larger scale projects such as those being proposed by commercial and industry sectors in Jordan. Stakeholders have stated that current grid capacity is insufficient for the load that is required for future self-consumption projects – particularly large wheeling projects [8,22,29]. Therefore, without grid capacity upgrades, projects will stall and investment in future projects is unlikely.

NEPCO is currently upgrading the grid capacity under the "Green Corridor" upgrade, scheduled to finish in 2017, which should adequately handle the additional load once completed. There is however scepticism from private sector stakeholders as to whether this deadline will be met. Uncertainty hinders the ability of companies to safely invest in solar PV projects [22,30].

Distribution companies such as JEPCO place the emphasis of the bottleneck on consumers. Projects connected to distribution lines may require new dedicated feeder line to be installed in order to support the larger electrical loads. Since the cost is borne by the consumer, the consumer may downgrade the project size to avoid bearing these extra costs. This often stalls projects, lessens the project size or can terminate projects completely [25].

Space and structural issues

Solar PV requires adequate space on roof or ground as well as structural integrity of buildings to be able to mount panels. Many sites lack space and structural integrity to support panel installation. Therefore, off site panel installation is often required, resulting in increased transaction costs of the projects and also installation costs, adding to already high upfront costs [10].

Quality Control

The quality of modules, bracketing, inverters and installs is a key concern for Jordan's self-consumption solar PV market. Infant solar PV industries are susceptible to new market entrants offering inferior, low quality products to unaware consumers. This has an adverse impact on the trust and reputation of the industry and can hinder the growth of the industry if not controlled adequately, as people lose confidence in the technology.

Currently Jordan lacks any standards or guidelines for quality control of solar PV products and services [8,20,21,31]. Even though the Jordanian PV market is relatively new, there are over 300 solar PV companies already registered due to the underlying potential of the market [6]. The infancy of the market makes it difficult to rate/rank current companies, and a lack of knowledge of consumers about differences in quality and efficiency makes it difficult to ascertain quality before installation is complete [8,20,21,31]. While some discussion has taken place about quality control issues, it still remains an underestimated issue within the industry. For example, some major Jordanian suppliers and manufacturers still do not see this as a potential problem [32].

Administrative

Internal administrative procedures such as bureaucracy and decision-making processes, and external administrative procedures within both regulation and financing add to the project install timeline. Within regulation, the net metering process requires an impact study to be carried out by a third party [10,11,21]. This makes up the largest proportion of the pre-install phase of a project and can take up to five months. Within the financing process, feasibility studies are generally outsourced to third parties and are therefore time-consuming. The time lag between engaging with the client and the start of the installation makes it very difficult for retailers and installers to maintain client interest [21]. This also adds extra risk to the project if modules and parts are ordered from overseas to shorten the time line prior to final approval from a client [21].

Long internal decision making processes for sectors, such as schools, hospitals, and some large industries, delays project starts and adds risk to developers who must order stock ahead of time with no guarantee of an install timeframe [21,27].

Table 2, Summary matrix of segment specific barriers

	Policy + Regulatory	Financial + Economic	Technical + Physical	Administrative
Large Private Consumers	Grey-zone - > 5MW + not covered - Structure of Tariffs - Energy Wheeling unclear	Easier access to capital - Easier to meet requirements - Targeted green loans	Uniform	Relatively long internal decision making
Small Private Consumers	Most needs covered - < 5MW covered - Energy Wheeling not needed	Difficulties accessing capital - More difficult to meet requirements - Green loans not targeted		Relatively quick internal decision making
Social Sector Consumers	Most needs covered - < 5MW covered - Energy Wheeling not needed	Easier access to capital - Access to public financing - Less stringent payback period requirement - Higher Tariffs		Internal decision making can be a bottleneck
Uniform Barriers (Across Segments)	- Confusion over interpretation - Unpredictability		- Quality Control - Grid Capacity - Structural/Space	- Time consuming initial project setup
Key Stakeholders	- Policy Makers - Associations	- Financial Sector - Policy Makers	- Utilities - Policy Makers - Installers	- Utilities - Policy Makers - Financial Institutions

Segment Specific Barriers

In parallel to the identification of barriers, an analysis was conducted to determine which segment of consumers each barrier most significantly affected. Through this analysis, three distinct segments were identified: Large Private Consumers (medium/large industry, large hotels, telecommunication), Small Private Consumers (SME's, retail, restaurants etc.), and Social Sector Consumers (Schools and Hospitals). The table above gives a general overview of how each segment is affected by different barrier groups, and of key stakeholders who can help overcome these barriers.

- Technical and Physical barriers seem to affect all three segments uniformly.
- Large private consumers face comparatively higher regulatory and administrative barriers, while facing comparatively lower financial barriers.
- Small private consumers face comparatively lower regulatory and administrative barriers but face comparatively higher financial barriers.
- Social sector consumers face comparatively low regulatory and financial barriers, with only administrative barriers being a bottleneck. This sector has seen the most activity out of the three.

Key recommendations

Clear up Confusion over Policy and Regulation

If the confusion over interpretation of the current policies and regulations continue, particularly regarding the net metering scheme, stakeholders will find it difficult to commit to solar PV investments, while misinformed investments will continue. Policy makers and utilities must make an effort to make supporting schemes as clear as possible. For example, with the most commonly misunderstood net metering scheme, the ERC and utilities could include specific examples of calculations or electricity bills on their website. Industry associations could also contribute – for example, by creating brochures that better explain policies and point out common misconceptions. They should also act as the interface for better communication between policy makers and the private consumers.

Adjust Policy to Account for Large Consumers

The policy grey-zone for large consumers and projects is leading to the exclusion of a high impact potential segment – one from which there is significant and increasing interest. Policy makers should act to update existing supporting schemes – particularly the net metering and energy wheeling regulations – in order to better meet their needs. The 5MW cap for net metering is problematic as most large industries; hotels, telecom etc. require facilities larger than 5MW to offset any significant amount of their consumption. The same limit applies for energy wheeling. Although NEPCO said that they would consider buying surplus production from facilities larger than 5MW on a case-by-case basis, this is not sufficient. There needs to be a written guarantee made in the legal documents. Furthermore, the energy wheeling regulation must be updated in order to specify how alternative distribution and business models that arise from energy wheeling will be accounted for by the regulation. Industry associations can play a crucial role by conveying the needs of the large consumers to the policy makers. For example, an industry association successfully lobbied for changing the maximum allowed

installed capacity for net metering from 25% to 100% of average demand.

Target Green Loans at SME's

Access to capital is crucial to finance the high initial cost of solar PV systems. In our interviews with financial institutions it has been confirmed that SME's have significant difficulties in accessing bank loans in general and green loans in particular.

Stakeholders, such as financial institutions and policy makers, must take the necessary steps to incentivise commercial banks to provide loans to SME's. This could, for example, be done via risk-sharing tool such as shared loans among multiple financial institutions.

In addition, both the Central Bank of Jordan's Green lending program and AFD's Green credit line, that are available for commercial banks today, could be adapted to better account for SME's by imposing less stringent requirements.

Promote Third Party Ownership

One way to address several of the barriers identified in this report would be to allow for and promote third party ownership business models. Such models have shown to be successful in overcoming many of the key barriers to deployment of solar PV in countries such as the United States and Singapore [33,34].

Stakeholders have indicated a high demand for this type of business model especially among large-scale industries and certain commercial branch associations. Many larger electricity consumers are reluctant to become power producers and want to focus on their core business instead [6,31]. Others, such as the hotel association, want to invest in centralised solar PV systems that support multiply legal identities within the same branch [22].

The barrier to these innovative business models today is that under current legal framework third party sale of electricity is not allowed [24]. Stakeholders such as policy makers, associations, solar businesses and potential consumers must come together and lobby for the legalisation or partial legalisation (only for large consumers) of third party sales. The key is to convey the benefits of these business models to policy makers.

Address Quality Concerns

Without adequate quality control the solar PV market in Jordan is at risk of becoming flooded with unreliable products and installations. This has the potential to set the growth of the industry back years if consumers lose confidence in the technology. Policy makers, industry associations, current retailers and manufacturers need to be involved in the establishment of a rating system for inverters, modules and installations to avoid a situation that many other infant solar PV markets have been through previously.

Figure 5 Team Jordan and partner, RCREEE

JREEEF Financial Scheme

One of the deliverables for this project was to design a financial scheme for JREEEF. A separate report has been produced and presented to RCREEE for this purpose and this section gives an overview of the findings and recommendation in that report.

The aim of the financial scheme is to support the deployment of solar PV among residential groups and attract multilateral and bilateral funding to JREEEF. The group was specifically asked to look into the possibilities to support deployment of Solar PV among low-income groups.

Findings

No incentives to install solar PV for low-income groups

Low-income groups face the same barriers to adoption of solar PV as other segments, however these are amplified due to higher income constraints. Key barriers among private households are usually; high up-front cost, technology risk and the complexity of the system which calls for particular knowledge [24]. In addition to these barriers low-income families in Jordan today have low or no economic incentives to install solar PV. The later is due to very low electricity consumption levels in combination with the direct cash transfer subsidies that cover most of the electricity expenses [35].

Financial schemes in other countries

Interesting models for financing residential renewable energy systems were found in India and Tunisia. In both cases external funding from multilateral sources were used to provide interest rate buy-down schemes. These schemes allows for banks to offer loans to targeted residential customers at concessional rates of interest. This enabled banks to make their normal rate of return for a perceived high-risk loan, while the customers are able to pay the lower, more affordable interest rate [36].

Other than financial support schemes, innovative business models have shown to be successful in overcoming key barriers among residential customers [33]. Leasing of solar PV systems is one example of a business model that is now well established in the US and could potentially be an option in Jordan. Leasing means that a third-party owns and operates a customer sited solar PV system and customers pay a monthly fixed price to self-generate electricity from this system. According to interviews with concerned stakeholders, leasing models for other purposes are well established and accepted in Jordan [27,28]. Particularly parts of the population are reluctant to engage in loans with interest on religious grounds [27,28].

Key design features to attract funding to JREEEF

We have looked into multilateral and bilateral funding that reaches the MENA region and Jordan in order to identify key aspects of financial schemes funded before. The following design features have been identified [37]:

- Enables the development of the domestic market and financial institutions;
- Targets institutions instead of directly targeting end-users;
- Is innovative and has the ability to combine successful mechanisms from other schemes;
- Allows for small donor contributions to be scaled up with the help of domestic institutions.

Recommendations

Target upper middle-income groups instead of low-income families

Since electricity consumption within upper middle income groups is higher compared to low-income groups, there is a greater incentive to install solar PV. According to current electricity tariff structure in Jordan electricity tariffs increase considerably for every kWh that exceeds 600 kWh/month [15]. Installing solar PV offsets the highest tariff bracket (>600kWh) therefore substantially lowering the payback period for high consumption groups. Direct cash transfer subsidies still reach about 70% of the population including parts of the middle-income group [35]. However, subsidies are inefficient and due to state budget constraints will eventually have to be removed. Most feasible would be that subsidies for the wealthiest groups are removed first which could trigger the deployment of solar PV.

Table 3 Payback period for upper middle-income family. Source: RCREEE

Payback period upper middle income family consuming 600-750 kWh per month	
Size of system	1kW
Electricity generation	1900 kWh/year
Electricity consumption	7212-9000 kWh/year
Household electricity expenditure	512-770 Euro/year
Cost of system	1400 Euro/kW
O&M cost	4-5 Euro/year (negligible)
Payback period	5-7 years

Financial scheme for JREEEF

For the design of the financial scheme for JREEEF we suggest that an interest rate subsidy, comparable to the mechanisms used in India and Tunisia, is combined with the promotion of third party leasing models. This is a new innovative approach that has not been tried before but it combines two successful ways of overcoming key barriers to the deployment of solar PV among residential customers.

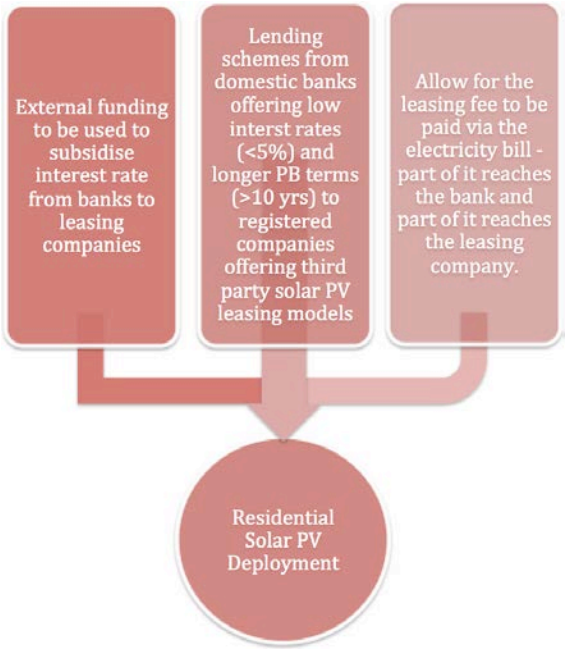

Figure 5 JREEEF Financial Scheme Design

Benefits of the scheme:

- Removes the high upfront cost and the technical responsibility from the end-customer
- Helps develop the market and a new business model for solar PV that has shown to be successful in other countries
- Allows a relatively small amount of funding to be efficiently utilised as local commercial banks provide 100% of the final loan
- Provides security for the leasing company and the bank through payment by the end-consumer via the electricity bill

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Additional list of interviews, workshops, roundtables, presentations and study visits

Interview with Mohammad Amin Abu Zarour, National Electric Power Company (NEPCO), Engineer at Power System Planning Department, 2014-04-10

Interview with Wijdan AlRabadi, Electricity Regulatory Commission, Commissioner, 2014-04-07

Interview with Walid Shahin, National Energy Research Center, Director, 2014-04-09

Study visit to a paper mill. 2014-04-08.

Presentation at the Third Jordanian Renewable Energy Dialogue. 2014-04-13.

Key Learning Outcomes

Waste Management: Szczecin, Poland

The key findings of the project are that the waste management system in West Pomerania is currently only capable of low levels of recovery and recycling. The municipalities in the region face considerable challenges in organizing effective systems for separate collection of waste. To improve the system there is a need to improve public awareness regarding waste management. Finally, future plans should avoid technology 'lock-in' the treatment of waste, and should be built to be flexible as new technologies and strategies are developed.

Biogas Team: Szczecin, Poland

During this project, we have learned about biogas technology and how a biogas system can provide benefits to the environment and society at large. Deriving energy from bio-resources reduces the demand for coal, which is the main fuel source in this region. Coal is a challenge due to the high levels of pollutants such as CO2, NOx, SOx and particulates. The project has demonstrated clearly the necessity to create collaborations between different actors along the value chain that are often disconnected from each other. The team found that there was no key organization coordinating biogas and bio-resource management in the region. An organization to oversee this could make a large difference for biogas production. The project has shown the challenges and importance of including environmental cost and benefits in economic considerations as well as allowing us to analyse pathways to system change, which has been much discussed throughout our masters program.

Green Port: Szczecin, Poland

The project provided the opportunity for acquiring comprehensive knowledge of what aGreen Port is, how ports can become one, why ports like Szczecin should become one and what the current trends are worldwide. Ports are facing major challenges moving forward into a future with stricter legislation, evolving client demands, and growing green trends. As an important part of the city, the Port of Szczecin's developments should be further aligned with the city strategy and a common vision can enable this improved alignment. There is a great potential for developing the use of the Oder River and integrating it into a larger intermodal Green Corridor connecting Northern, Central and Southern Europe in an environmentally and economically sustainable way. Such development requires relevant stakeholders to be involved at all stages of the decision making processes and planning. Environmental work should be incorporated and embedded in port projects and strategies; the environmental management system can be used as a tool to facilitate this.

Biogas: Asikkala, Finland

Conducting the SED project in collaboration with the Municipality of Asikkala and HINKU was a very rewarding experience. Dealing with the complexity of biogas technology and working on long-term planning to improve our knowledge of the field was important learning experiences.

The report illustrates that there is significant biogas potential in the region, and that the local settings favour upgrading the gas for transportation fuel. However, it was found that contextual hurdles such as building local support and raising capital exist, and that it is essential not to overlook these challenges. Interaction and collaboration with a wide variety of stakeholders proved to be a critical to project success. The importance of cooperation among stakeholders, as well as teamwork, is a valuable key learning from this experience.

Smart City: Zabrze, Poland

The project of creating a smart and sustainable profile for a new city development was a complex task, which required collecting a vast number of sustainable development strategies and selecting context-specific solutions. These solutions included the recommendation of making the new development a “lighthouse project” filled with a mixture of renewable energy and heating options, spaces designed for people rather than around the car, and water management opportunities for both household waste water and rain water. The area has a small stream in need of restoration to create a healthy ecosystem and beautiful amenity to the area, and this can be used as an additional aspect to the city’s already thriving tourism concept. Finally, the city is interested in a golf course, which is a challenge to run sustainably and economically. Therefore, the proposal of a green certification for the course will make the course more attractive to tourists and easier on the environment. The team learned the power of a strong leader and motivated people within the municipality.

Solar PV: Amman, Jordan

The report has outlined the vast opportunities for solar PV deployment in Jordan, which is one of the key learnings from the SED project. These opportunities range from its solar potential to regulatory framework.

The team has learned the different barriers and challenges that could potentially hinder the solar PV deployment in Jordan. These barriers and challenges can, however, be overcome easily with improved administrative processes and clarified policy framework and other key recommendations identified in the report.

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Swedish-Polish Sustainable Energy Platform

Amman, Jordan

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