SYMBI
Interreg Europe

17th September 2018

Input study for the 3rd study visit "Sharing practices on waste to energy systems"

HAMK Häme University of Applied Sciences

&

Regional Council of Häme

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1 Introduction

SYMBI (Industrial Symbiosis for Regional Sustainable Growth and a Resource Efficient Circular) project is an international EU project focused on improving industrial symbiosis for a resource efficient economy. The aim of the project is to contribute to improve the implementation of regional development policies and programmes related to the promotion and dissemination of industrial symbiosis and circular economy.

This document is the first deliverable of SYMBI project Activity A3.4, which is the input documentation of an interregional study visit aiming to share practices among project partners and stakeholders on waste to energy systems. The purpose of this document is to highlight the main aspects and rationale of the visit and serve as background material for the main topics to be handled during the visit.

The input paper (to be shared beforehand) will be used as the primary source of knowledge for the exchange of experience process, prescribing the practices to be exchanged, addressing the main issues tackled by the project, and securing stakeholders' interest. In particular, the input study will:

- Serve as background material for the economic and environmental aspects, and technical specifications related to practises on waste to energy systems.
- Present the main aim and locations of the study visit

The report is structured as follows: section 2 outlines the key activities and objectives of the SYMBI project; section 3 demonstrates the rationale and strategic ground of the interregional study visit. Section 4 presents the background research conducted to better define the topics based on economic, environmental and technical specifications on waste to energy practises. Finally, section 5 elaborates on the organisational issues of the study visit.

2 The SYMBI project

The “Industrial Symbiosis for Regional Sustainable Growth and a Resource Efficient Circular Economy – SYMBI” project aims to improve the provisions and support the implementation of policy instruments and measures for the diffusion of industrial symbiosis, to add value, reduce production costs, and relieve environmental pressures through increased resource efficiency and greenhouse gas emissions. The overall improvement is anticipated to positively contribute in regional sustainable development and job creation.

Circular economy is an emerging model that keeps resources in the economy as long as possible. Resources can be reused, creating further value while relieving environmental pressures. Resource efficiency, as outlined in the circular economy model, is primarily based on: a) the "cradle to cradle" principle, focusing on eco-design and regenerative modes of consumption, and b) industrial symbiosis, which involves territorial synergies to manage waste and share services, utilities, and by-product resources. The territorial aspect of industrial symbiosis brings regions to the forefront of the transition towards circular economy.

Industrial symbiosis requires policy reforms measures at different levels. EU regions show very different levels of performance on each area relevant to industrial symbiosis, and advance at a different pace towards green growth models. There is thus a need to share and exchange practices, experiences, and knowledge within this fragmented context to: a) lift barriers by following successful examples, b) foster balanced territorial development and reduce disparities, and c) reverse the backwardness of least-favoured regions.

The project is funded by the Interreg Europe program. Interreg Europe funds interregional cooperation projects in the field of research and innovation, SME competitiveness, low-carbon economy and environmental and resource efficiency, SYMBI being part of the latter. The general objective of Interreg Europe programs is to promote the exchange of experience and good practices among European Union countries.

2.1 SYMBI activities

The SYMBI project brings together 9 partners from 7 countries to diffuse industrial symbiosis and align regional policies with the circular economy package of the European Commission (EC). To support the transition towards a resource efficient economy, the project includes a wide range of activities, focusing on promoting the interregional learning process and the exchange of experience among regional authorities. Project activities include:

- Evaluation and analysis of existing regional and national policies on industrial symbiosis and circular economy.
- Mapping the investment potential of participating regions in industrial symbiosis.
- Identification of good practices and benchmarking of eco-systems of by-product and energy exchanges.
- Prescribing green public procurement as an enabler of industrial symbiosis.
- Promoting public dialogue and consultation process to build consensus and ensure the successful implementation of regional action plans, through the support and participation of key regional stakeholders.
- Fostering interregional learning and capacity building through workshops, study visits, and policy learning events.
- Joint development of action plans to promote the improvement of the policy instruments addressed by the project.
- Increasing awareness, promoting and disseminating the project results and knowledge beyond the partnership.

2.2 SYMBI expected results

SYMBI will improve 8 policy instruments, relevant to the abovementioned policy areas; 6 of the managing authorities participate in the consortium, so as to secure the impact of the project. SYMBI activities will:

- Incentivise regional waste transformation systems and cross-sectoral synergies
- Promote the use of secondary raw materials
- Prioritise green procurement
- Unlock investments by regional and local financial actors

- Explore, assess, expand, and enhance current practices in ecosystems of industrial innovation
- Build consensus between regional stakeholders

2.3 SYMBI partners

The SYMBI consortium consists of nine partners from seven EU countries: Spain, Italy Greece, Slovenia, Hungary, Poland and Finland (see table 1). The partners differ from each other in size and as organizations. Most of the partner organisations are public sector organisations operating regionally in their countries. The most vastly operating organisation comes from Slovenia, as the Slovenian partner is a nationally operating governmental body. The smallest partner organisation is the Greek partner whose operation area is regional in the city of Kozani.

Table 1 Introduction of the SYMBI partners

Partner	**Abbreviation**	**Country**	**Local/ Regional/ National**	**Role in the project**
Foundation FUNDECYT Scientific and Technological Park of Extremadura	FUNDECYT	Spain	Regional	Lead Partner
Environment and Territory Regional Ministry	Andalusia	Spain	Regional	Partner
The Malopolska Region	Malopolska	Poland	Regional	Partner
Chamber of Commerce of Molise	COC - Molise	Italy	Regional	Partner
Government Office for Development and European Cohesion Policy	SVRK	Slovenia	National	Partner
Municipality of Kozani, Development and Planning Bureau	Kozani	Greece	Local	Partner
Pannon Novum West-Transdanubian Regional Innovation Non-Profit Ltd	PA-NOV	Hungary	Regional	Partner
Regional Council of Häme	HAME	Finland	Regional	Partner
Häme University of Applied Sciences Ltd	HAMK	Finland	Regional	Advisory partner

3 Rationale of the study visit on sharing practices on waste to energy systems

The Waste Framework Directive (Directive 2008/98/EC on waste) sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery. It explains when waste ceases to be waste and becomes a secondary raw material when applying end-of-waste criteria, and how to distinguish between waste and by-products. Waste legislation and policy of the EU Member States are required to apply as a priority order waste management hierarchy shown in the figure 1 below. As the figure shows waste prevention is the first step material management when the product has not yet gained the waste status and which should be taken into consideration already in the making and usage of the product. After that the material, now already under the secondary raw material, by-product or waste status, should according to possibilities be firstly prepared to reuse, recycled or recovered in other ways, such as energy in this hierarchic order. Disposal e.g. landfilling is the least favoured option.

Figure 1. The waste management hierarchy (Directive 2008/98/EC on waste)

The previous SYMBI project events; workshops and study visits have covered the first three steps of the waste hierarchy;

- 4 interregional workshops on how to unlock investments, stimulate secondary raw materials markets, and launch industrial symbiosis demonstration project
- 2 interregional study visits to transfer experiences on waste transformation into byproducts.

The theme of the second study visit held in Häme-Region then covers the best regional practices related not only recycling various materials but using them in energy production as well. In this case energy is produced by refining biogas out of biowaste. Moreover, this biogas is used in a factory producing isolation material for building construction. Thus, an industrial symbiosis will be presented as well.

The SYMBI event themes also contribute to the same themes as the Science for Policy report by the Joint Research Centre (JRC), the European Commission's science and knowledge services publication *Towards a better exploitation of the technical potential of waste-to-energy (2016)* where stated as such: "When waste cannot be prevented or recycled, recovering its energy content is in most cases preferable to landfilling it, in both environmental and economic terms. Waste-to-energy can therefore play a role and create synergies with EU energy and climate policy, but must always be guided by the principles of the EU waste hierarchy. The Commission will examine how this role can be optimised, without compromising the achievement of higher reuse and recycling rates, and how the corresponding energy potential can best be exploited." (page 4). It should be noted, that in the context of the SYMBI study visit the term WtE has been maintained to refer to all processes that recover energy from waste and not only to dedicated waste incineration plants.

4 Focal aspects in practices on waste to energy systems

Municipal solid waste (MSW) is collective and miscellaneous trash collected from households, commerce, and organizations. MSW consist of packing, biodegradable waste such as food waste, recyclable materials such as, metal, glass, wood, paper, inert waste (e.g. construction waste), composite waste and waste plastics, domestic hazardous waste, and toxic waste. MSW compositions vary considerably based on their sources. (Beyene et al. 2018)

4.1 Economic aspects in practices on waste to energy systems

Economic development and related increase in global energy demand has created pressure on the supply of energy resources. Waste to energy conversion is an ecologically and economically attractive practice which is growingly associated with energy demand, waste disposal, and environmental monitoring. The main advantages of waste to energy solutions are: reduction of organic contaminants; reduction of mass and volume of waste (80% and 90% respectively); high potential for the saving of land; use of recyclables; reduction of emissions and environmental burdens; environmental compatible for co-generation (heat and electricity production) as a renewable resource of waste; technical and economic feasibility. (Moya et al. 2017).

4.2 Technical specifications in practices on waste to energy systems

The commonly known waste to energy (WtE) conversion technologies are thermal conversion methods (incineration, pyrolysis, and gasification), biochemical conversion in which bacteria, other microorganisms, and enzymes are applied to break down biomass (anaerobic digestion and fermentation), and landfilling. Electricity, heat, fuel gases, liquids, and solids are the primary recovery products of those technologies. (Beyene et al. 2018)

A comparison summary of WtE technologies is presented on the following figure 2. The summary outlines benefits and limitations of a specific technology and also the primary output products and the commonly used application target. Gas is the most common primary product

output from WtE technologies and electricity the most common application. The benefits and limitations vary according to the technology.

TABLE 2

Comparison summery of WtE technologies [56,58,63,81,85,89,93,94,101–111].

S. No.	WtE technologies	Benefits	Limitation	Primary product	Application
1	Incineration	Suitable for high calorific value Reduce volume and mass up to 80% and 70% respectively	The high capital, maintenance, and operation costs Produces harmful pollutants generation of solid residues	Heat	Generation, electricity and steam/heat
2	Pyrolysis	Produce high-quality fuel Reduces flue gas treatment suitable for carbonous waste Decrease MSW volume up to 50–90%	High viscosity of pyrolysis High operating, maintenance and capital cost	Char, bio-oil and syngas	Electricity, production chemicals and solvents
3	Gasification	Production of fuel gas/oil, which can be used for various purpose	Immature, inflexible, less competitive technologies High risk of failure	Syngas producer gas	Generation electricity and chemicals
4	Landfill	Low cost, natural resources are recycled to soil	Soil and groundwater pollution Large land area required	Landfill gas	Electricity
5	Anaerobic digestion (AD)	Preferred for biomass with high water content Higher composition of methane (CH_4) and lower composition of carbon dioxide (CO_2) than landfill	Unsuitable for wastes containing less organic matter Lignin can persist for very extended periods of time to degrade	Biogas and dig estate	Electricity, nitrogen rich fertilizer Agricultural, and food biorefinery
6	Ethanol fermentation	Does not contribute to the increase in CO_2 emissions	It is limited only on starch/ cellulose/rich MSW	Bioethanol	Fuel, agricultural biorefinery
7	Photobiological process	A wide spectral energy can be used by photosynthetic bacteria	Nitrogenize enzymes get inhibited in the presence of O_2. Light conversion efficiency is low	H_2 gas CO_2, organic acids	Bioelectricity
8	Dark fermentation	Utilizing wide range of biodegradable substrates More feasible for mass production of H_2, light-independent process		H_2 gas	Bioelectricity
9	Microbial fuel cell (MFC)	An effective method of electricity generation and odor removal from waste Zero contribution to GHG emission	It does not function at very low temperatures because microbial reactions are slow at low temperatures	H_2 gas	Bioelectricity, biohydrogen production, wastewater treatment
10	Microbial electrolysis cell (MEC)	High product (H_2) recovery, and substrate degradation than the photo, dark fermentation, and MFC High hydrogen translation efficiency Low energy requirement Applicability to numerous organic substrates	The yield effects by substrate composition High internal resistance Dense architecture High capital cost	H_2 gas, CH_4, acetate, hydrogen peroxide, and formic acid	Used for generation of electricity and immediate wastewater treatment

Figure 2. Comparison summary of WtE technologies, (Beyene et al. 2018)

4.3 Environmental aspects in practices on waste to energy systems

Energy recovery from waste can represent a sustainable option for the type of waste flows that cannot be reused or recycled, by diverting it from ending up to landfill, which could ultimately result in lower greenhouse gas emissions and in economic, social and environmental benefits (for example avoided methane emissions). It is also recognised that

efficient energy recovery from residual waste can enhance environmental benefits compared to landfill disposal, make an important contribution to the EU's renewable energy targets in replacing fossil fuels, and help provide energy security and independency throughout Member States. (EC JRC 2016)

A key issue for WtE is the disposal of residues that are left after gaining the energy from the material. The disposal of residues can be very costly for an operator and incorrect disposal can cause environmental harm. For waste incineration, there are two main residues which require disposal which are Incinerator Bottom Ash (IBA) and Air Pollution Control Residues (APCr). IBA exhibits similar properties to natural aggregates and its use can give significant environmental and social benefits. Such examples of these benefits are: reducing the quarrying of primary aggregates and associated processing; additional recovery of recyclable material through ferrous and non-ferrous metals extraction; IBA landfill reduction; and a lower carbon footprint compared to primary aggregates. (EC JRC 2016)

5 The study visit

5.1 Attendees

The target audience should include all those individuals, bodies, companies and organisations that can be impacted by the project outcomes and are interested in utilising project outputs to support the diffusion of industrial symbiosis towards circular economy. During the project lifecycle, partners have managed to expand their network of contacts, adding new stakeholders and interested institutions from across Europe such as regional development agencies, higher education institutes and research centres, chambers of commerce, professional associations, public authorities and private companies.

5.2 Agenda, date and locations

The interregional study visit on sharing practices on waste to energy systems will be held in Finland, Häme-Region 18th – 20th September 2018. The hosting organisations of the event are Häme University of Applied Sciences and the Regional Council of Häme. The working language of the workshop is English. The agenda of the event can be found from Annex 1. The venues of the study visit are site visits to Circular Economy Village of Fortum Ltd., Riihimäki and to the Eco Industrial Park and Forssa Symbiosis in the City of Forssa. The companies of the cite visits are presented in more detail later on in this paragraph. Other venues of the visit are three campuses of Häme University of Applied Sciences; Hämeenlinna, Forssa and Mustiala. In the Hämeenlinna campus the participants will hear about the Circular economy and waste to energy projects at HAMK from the Research Director in Bioeconomy Research Unit **Annukka Pakarinen** and Head of Cleantech Research Unit **Harri Mattila**. The participants will also have the change to visit the Construction Engineering Laboratory of HAMK Hämeenlinna and learn about the near zero energy solutions of the laboratory. In the Forssa campus as part of the agenda the participants will join the circular economy startup event FRUSH, which is presented in more detail later on the paragraph. In the Mustiala campus a steering group meeting will be held and during it a parallel session for stakeholders to network and have negotiations with Finnish companies and each other.

Table 2: Interregional study visit details

SYMBI - Interregional study visit on sharing practices on waste to energy systems	
Thematic focus	Sharing practices on waste to energy systems
Host organisation	Häme University of Applied Sciences and The Regional Council of Häme
Date	18-20 September
Venue	Circular Economy Park of Fortum Ltd., Riihimäki Häme University of Applied Sciences, HAMK, Hämeenlinna Industrial symbiosis in Forssa Region Häme University of Applied Sciences, HAMK, Forssa (FRUSH) Häme University of Applied Sciences, HAMK, Mustiala
Language	English
Number of participants	30-35 participants
Type of participants	Regional authorities' officials, stakeholders, external experts
Format	Site visits, oral presentations, event participation
Contact details	Iida Holck E-mail: iida.holck@hamk.fi Telephone: +358 50 330 6731 Arto Saarinen E-mail: arto.saarine@hame.fi Telephone: +358 50 305 2539

5.2.1 Fortum

Fortum Oyj is a Finnish energy company operating in the Nordic and Baltic Countries, Poland, Russia and India. The company's business includes electricity and heat production and sales, power plant utilization and maintenance services, and other energy-related services. The company's main products are electricity, heat and steam. In addition, Fortum provides recycling and waste services such as environmental expert services and hazardous waste

handling. 96 % of the company's electricity production across EU is carbon emission free. (Fortum 1, N.d.)

In June 2016, Fortum set up a Circular Economy Village in Riihimäki, Finland. The Village is a refinery complex developed by Ekokem, which Fortum acquired in 2016. In the village, municipal waste is processed through the Eco Refinery - an automated sorting plant, the Plastic Refinery - the first in Finland to produce recycled plastic, and the Bio Refinery, which produces biogas and is owned by the company's partner Gasum. The concept of the Circular Economy Village is unique, both nationally and internationally. (Fortum 2, N.d.)

Once fully operational, the Eco Refinery of the Circular Economy Village will annually receive around 100,000 tonnes of municipal waste, from which the refinery will separate biowaste (about 30% of the waste), plastic (4%), metal (3%) and recovered fuel suitable for industrial use (50%). The remaining amount is reject, which is not suitable for recovery. The biowaste will be turned into biogas and fertilisers, and the plastic and metal into recycled raw material for industry use. The reject will be used to generate electricity and district heat in the waste-to-energy plants in Riihimäki. (Fortum 2, N.d.)

5.2.2 Eco Industrial park: Forssa symbiosis

Eco-industrial Park in Forssa region consists of three main symbioses between ten companies showed in figure 3. Two of the symbioses are bio-based symbioses, which are based on material exchange. The symbiosis generates secondary materials such as big feed, fertilizers, biogas and biofuels from waste and by-products. The majority of the biogas is used as energy for the manufacturing process of glass wool insulation at a local construction company. The third symbiosis is based on the utilization of biogas in the area. The importance of the symbiosis is significant regionally as it reduces the need for exported materials such as soybean for big feed of fossil fuels for energy and fuel. Forssa region is one of the main regions in Häme, where the Finnish SYMBI partners are also located. (Winther 2017.)

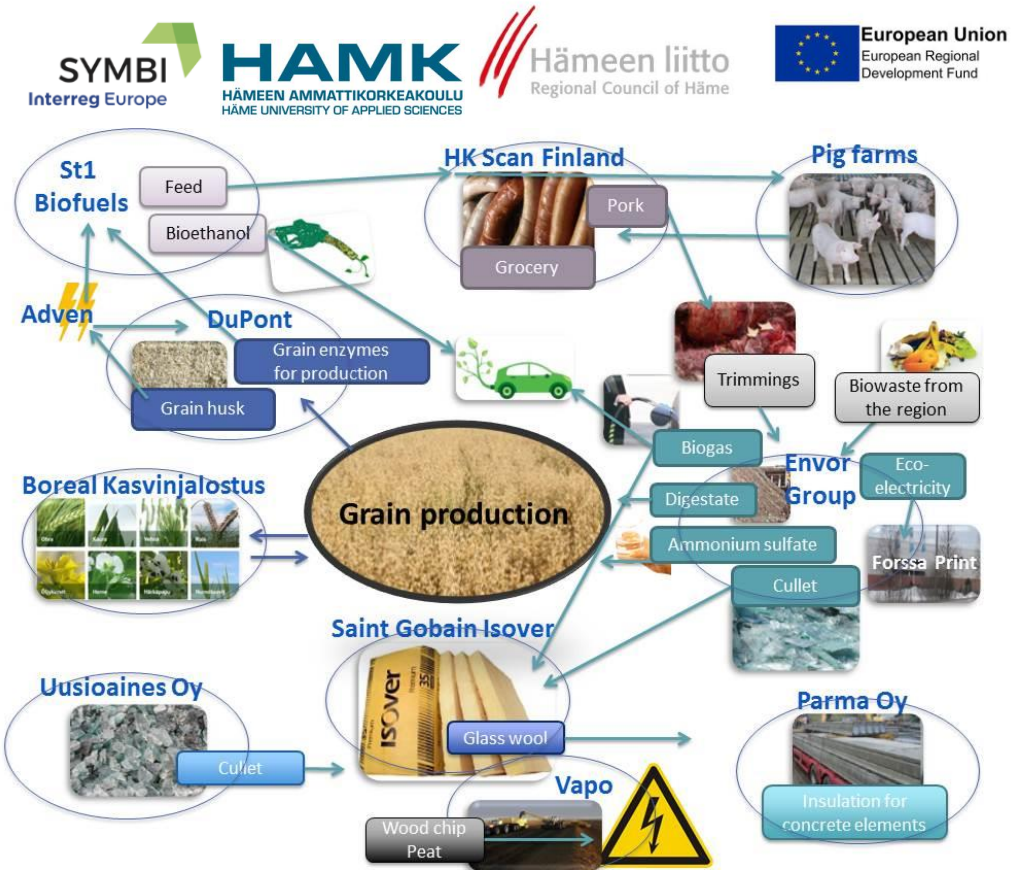

Figure 3. Industrial symbiosis in Forssa region, Finland (Caven 2015)

During the study visit the participants get a tour around three of the companies in the Forssa symbiosis. The companies are presented in the paragraphs below. A newly made video of the symbiosis has been made to better demonstrate the symbiosis around the area. The video can be found here.

5.2.2.1 Envor Group

Envor Group offers diverse and complementary environmental management services. In 2012 the Envor Group recycled approximately 95 000 tons of waste to be utilized as a raw material. The company emphasizes that any waste material contains at least some percentage of useful raw materials that can be separated and processed to be used by different industries. In the handling of flat-glass and biowaste Envor Group is the leading organization in Finland. Operationally the certified ISO 9001 quality system and the ISO 14001 environmental management system are followed. In addition to waste management services the company also produces biogas and bioethanol from waste based materials. (Envour Group N.d.)

5.2.2.2 Loimi-Hämeen Jätehuolto Oy (Loimi-Häme wastemanagement Oy)

Loimi-Hämeen Jätehuolto Oy operates with municipal solid waste (MSW) from its 16 owner municipalities in Southwest Finland. The company's office and Kiimassuo waste center locates in the city of Forssa and they also have a another waste center in Säkylä and seven smaller waste stations around the area total of 130 000 inhabitants. Loimi-Hämeen Jätehuolto Oy is the parent company to LHJ Group, which consist of four companies providing business to business services in comprehensive waste management.

5.2.2.3 Uusioaines

Uusioaines Ltd. has specialized in the recycling of glass since 1995 in the Forssa area. The company collects and recycles packaging glass and float glass. On the packaging glass side, the major suppliers are Palpa Lasi Oy, drinks' companies and waste management companies. Suppliers of float glass (windows and windscreens) include glass sellers, cutters, downstream operators and construction companies. The glass is crushed, cleaned and sorted according to colour. The collectable glass is refined for reuse as raw materials, in other words as cullet and delivered for industrial use. The capacity of the glass treatment plant is sufficient to meet the needs for the whole of Finland. (Uusioaines Oy N.d.)

5.2.3 The FRUSH Event

FRUSH is a Circular Economy Event for Startups and Growth Enterprises held for the second time ever in Forssa, Finland. The event is a combination of latest talks, dynamic workshops and pitching. The purpose of the event is to boost the development of growth and start-up enterprises as well as to create and promote new business opportunities around circular economy. The vision behind the event is to be the leading national circular economy event.

FRUSH brings together businesses and methods used in circular economy all around Finland. The event is aimed at everyone interested in the subject: growth seeking enterprises, start-ups, investors, cities, students of the field and research institutes. Networking and finding of funding and investment opportunities and learn about the latest trends in circular economy directly from the experts are in the heart of the event. The main promoters of the event are

Häme University of Applied Sciences and Forssan Yrityskehitys Oy. The first FRUSH event was also funded by Regional Council of Häme, Town of Forssa and SEUTU-program.

FRUSH was organized for the first time as a pilot in 2017 in the spinning mill area of Forssa on the premises of Häme University. The event will take place in the same location this year on the 19th and 20th of September 2018. (FRUSH 2018)'

FRUSH is one of the practices to speed up the development of circular economy in Finland; start-ups and small scale companies among circular economy and various financiers are networking and creating business relationships.

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7 Annex 1: agenda

SYMBI Project

"Industrial Symbiosis for Regional Sustainable Growth and a Resource Efficient Circular Economy"

STUDY VISIT IN FINLAND, Häme Region

AGENDA

"SHARING PRACTICES ON WASTE TO ENERGY SYSTEMS IN CIRCULAR ECONOMY"

Day 1 Tuesday 18th September

Venues: Circular Economy Park of Fortum Ltd., Riihimäki & Häme University of Applied Sciences, HAMK, Hämeenlinna

8.15-8.30	**Meeting point in Helsinki Railway station**
	• Meeting point chartered bus stop in Mikonkatu 15-19 • Bus will departure towards Riihimäki at 8.30
9.30	**Study visit to Circular Economy Park of Fortum Ltd., Riihimäki**
	• Presentation of the Fortum Riihimäki circular economy activities, especially the recycling of plastics
12.00	**Networking lunch in Fortum Riihimäki**
14.00	**Häme University of Applied Sciences HAMK, Hämeenlinna**
	Circular economy and waste to energy projects at HAMK; **Annukka Pakarinen** Research Director in Bioeconomy Research Unit at HAMK, **Harri Mattila** Researcher, Principal Lecturer
14.45	**Site visit in the Construction Engineering Laboratory of HAMK Hämeenlinna**
	• **Khoa Dang**, Project Engineer, Sheet Metal Centre HAMK
16.00	**Arriving at the hotels in Hämeenlinna**
18.30	**Dinner** restaurant the Gingerbread House (Piparkakkutalo)

	(At own cost)

Day 2 Wednesday 19th September

Venues: Envitech area, Forssa & Häme University of Applied Sciences, Forssa

9.00	**Bus will pick participants up from hotels**
10.00	**Field visit to Industrial symbiosis in Forssa Region**
	Presentation of the Forssa industrial symbiosis in Envor's premises and a bus tour around the area. Companies presented during the visit: • Envor Group Oy (Comprehensive waste management solutions, production of biogas) • Loimi-Hämeen Jätehuolto Oy (Municipal solid waste management) • Uusioaines Oy (Glass recycling)
13.00	**Networking lunch in Scandic Forssa**
14.00	**FRUSH Event - Auditorium**
14.00 15.00 15.45 16.45 17.30	• Responsible examples – Business Management and Entrepreneurship students and SYMBI project • **Dr Mariana Van der Walt,** New Zealand, Opportunities for Finnish Circular Economy companies in New Zealand • **Jukka Teräs**, Finland, Senior Research Fellow, Nordregio • **MEP Sirpa Pietikäinen,** Finland**,** How does the EU promote and finance the Circular Economy? • **Patrick Pitkänen**, Finland, Director Advanced Fuels, ST1
18.00	**Networking event hosted by Envor Group Ltd.** Announcement of the Pitching Competition winners
20.00	**Bus to Mustiala inn accommodation**

Day 3 Thursday 20th September

Venue: Häme University of Applied Sciences, Mustiala

8.30	**Breakfast at Mustiala inn**
9.30	**A visit in the 'automated cattle shelter' at HAMK, Mustiala campus**
10.30	**SYMBI steering group meeting at Mustiala campus meeting room Neuvo**
	Parallel session for stakeholders: Time for stakeholders attending the study visit to have private negotiations with Finnish companies. Meeting room Lehtevä.
13.00	**Lunch at Mustiala**
14.00	**Departure from Mustiala towards Helsinki**
15.30	**Bus arrives in Helsinki-Vantaa airport**
16.00	**Bus arrives in Helsinki city center**