Symbiotic bio-Energy Port Integration with Cities by 2020

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Deliverable D3.3: "*Evaluation report of the industrial symbiosis potential at the port sites*"

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D3.3 "Evaluation report of the industrial symbiosis potential at the port sites"

The Technical Annex of the project describes deliverable D3.3 as an Evaluation Report of the Industrial Symbiosis Potential at the Port Sites, to be submitted by Month 24, on the premise that Deliverable D3.1 would have evaluated the internal and external [symbiotic] flows for each port site by Month 12. However, Month 12 also hosted an important project milestone: a decision on the role of port partners in the project, on the basis of their assessed energy flows and bioenergy resource potential. In order for the milestone to be fulfilled and a decision to be made on port partners, it was agreed at the time that contents of deliverable D3.3, which addressed the bioenergy potential, would be included in D3.1, which addressed flows, into one report.

Thus, parts of what has been delivered as D3.1 covers contents of D3.3. The following table gives the exact said parts:

Table 1. Parts of Deliverable 3.1 which cover contents of Deliverable D3.3

D3.1 Part	Page
Executive Summary	4
Malmö	19-25
Mantova	29-32
Wismar	34-39
Astakos	40-46
Discussion	47

In the interests of project clarity, the remainder of this deliverable discusses on the knowledge previously shared. **A table of the bioenergy potential of each port is given below, corrected in accordance to the Corrigenda of Deliverable D3.1 (1/7/2014) submitted separately:**

Table 2. Bioenergy potential per port

Port	Malmö	Mantova	Wismar	Astakos
Sum. Bioen. Pot. (MW)	233	681	175	157
Internal	38,3	0	0	0
External	194	681	175	157

A. INDUSTRIAL SYMBIOSIS LIMITATIONS

In 2007, M. Chertow proposed that in the Western world "uncovering existing symbioses has led to more sustainable industrial development than attempts to design and build eco-industrial parks incorporating physical exchanges". She also proposed the "3-2" heuristic, as a way to identify symbiotic connections. According to this heuristic, three entities (or "Functional Units" as they are called within EPIC2020) need to exchange two different flows among them to be considered as an Industrial Symbiosis Network (ISN). Synergies that cannot fulfill this criterion are called "Precursors" or "Kernels".

Based on this principle, during the EPIC2020 project, the four port areas were examined and several synergies were identified. Using the 3-2 heuristic, one can tell which port areas host existing ISNs. Additionally, some limitations were also defined by Chertow, such as the non-inclusion of recycling plants in the 3-2 heuristic. By analysing the collected industrial data, the networks of all the four ports were uncovered and further extensions were proposed by the time D3.1 was written.

Malmö was found to have a very large and quite complex ISN. Although, some of the FUs of this network are recycling plants, there is no doubt that the industries form a well-established ISN. Some of the key components of this network, as shown in the graphs of D3.1, are the Sysav, the Norcarb and the E.On Flintrannan industries. The first serves as a sink of all kind of municipal and hazardous waste, while providing the city of Malmö with electrical and thermal energy. Norcarb serves as the supplier of a steam network, and last but not least, E.On Flintannan produces heat for the District Heating (DH) Network of the city, by burning timber by-products. Many activities are built around those FUs.

Wismar, on the contrary, showcases a very simple way to form industrial synergies. There are four timber processing industries which valorise their timber byproducts by exchanging them with their own energy plants for electrical and/or thermal energy. These exchanges do not form an ISN according to the 3-2 heuristic, but form significant kernels. However, some of these synergies, that take place among the dominant industries, such as sawdust and boards exchange, are in accordance to the 3-2 heuristic,. Finally, there is a significant production of biogas, using a mix of cow's manure and corn silage, producing energy for the municipality and a sewage treatment facility for municipal and dairy waste valorisation, producing fertiliser for regional agricultural farms.

Mantova has an established ISN among complementary FUs, with Polimeri being the "heart" of it. Not only are the exchanges clearly following the 3-2 heuristic, but also the D.H. Network is expanding, creating opportunities for new investments in energy, while a brand new bioethanol plant is planned to be built in the area where IES used to operate, to fight unemployment and valorise the great bioenergy potential of the area.

Astakos was found to have negligible industrial activity within the port area. However, there is some fish farm activity around it and, generally, the industrial activities of the greater area include olive oil, dairy, meat and other types of food production. Within the Astakos port area, no ISN was identified, according to the 3-2 heuristic; wider boundaries had to be used for the inclusion of industries further apart.

B. FROM INDUSTRIAL SYMBIOSIS TO BIOENERGY NETWORKS

As the data show, the internal bioenergy potential, which is the potential found within the narrow port area boundaries, is very small compared to the project goals. This has led to the inclusion of primary sector flows which are located around the port area. These flows have added a tremendous potential for each case, leading to the formation of "Bioenergy Networks" (BN). These networks differ from the typical ISN in that their first priority is to valorise biomass into bioenergy. Inclusion of the primary sector widens the scope of research towards Industrial Ecology goals.

This kind of Symbiosis is not completely new. There are several success stories around the globe, where bio-economies were built on biomass to bioenergy systems, forming BNs according to the newly proposed definition. For example the Norrköping ISN, whose "heart" is a power plant, running on waste flows, connected with a bioethanol plant and a biogas plant, running on grain and organic byproducts respectively. This network integrates farms, forests and the Municipality, with a pulp and paper industry and a chemical plant in harmony. Other BN examples include: a sugar biorefinery in People Republic of China, Mallee trees plantation in Narrogin Australia, Plantations near oil and petrochemical industries in Alberta Canada.

In EPIC2020 all types of biomass producers are included, to form complete and self-sufficient BNs. Biomass, however, needs to be transformed into bioenergy, using some kind of technology, the "Enablers", as discussed previously in D3.1. Additionally, while ports and municipalities play a significant role in gathering data, they also support building of a "trust network", making it easy to collect data that would otherwise be impossible to collect, since many industries would feel competitive to each other.

C. GOALS AND MARKET ANALYSIS

Compared to superstructures of biochemical products, IS in general, do not form a "left to right" reading. However, by incorporating the primary sector functional units as orange blocks, the secondary sector functional units as blue blocks, the enablers as green blocks and the end users as red blocks; a trend from orange to red blocks is formed. This is not only to visualise the components of the Network, but it also serves as a hint as to where the bioenergy production needs to go.

Red blocks are the ones that create the demand for bioenergy, in addition to the demand of each specific industrial unit. For example, when an Industrial unit needs Natural Gas (NG) to run, an Anaerobic Digestion enabler could be proposed to produce the amount of gas needed for its needs. Similarly, when there is need for heat, to cover the DH Network demand, it is possible that a CHP enabler is proposed. This can now be fed either with some types of biomass or with biogas produced by an Anaerobic Digestion plant.

Producing more bioenergy than needed is not sustainable, thus End Users are quite important actors in a BN. Furthermore, when the proposed enablers produce more bioenergy than the network can absorb, then the forms of bioenergy need to be exportable, or "packagable", such as bioethanol or Compressed Biogas. A big variety of End Users not only might increase the quantity of bioenergy demand, but also the types of bioenergy demand. This means that a series of diverse technologies might also be included, further to the three main ones, such as gasification, liquefaction, pyrolysis, hydrolysis, hydrogenation etc.

Apart from red and blue blocks, there is also a hidden type of information block, which is called "regional goals". According to this, Mantova's DH Network is expanding, Malmo's biogas demand is increased while more land is now available for future investments, Wismar grows interest in investments in forestry and timber processing technologies and Astakos welcomes any type of industrial activity in its industrial area within the port.

As mentioned before, there are some units which are considered to be central to the networks. These are key players, which need to remain sustainable in order to ensure the viability of the remaining FUs connected to them. For this reason, every type of competitive investment should be communicated with these FUs to ensure that the rest of the industries are not harmed as well. It might turn out that stability of a BN might be subject to new technologies and thus communications may need to be strengthened and promoted among industrial partners. This could be accomplished even by promoting exchanges of shares or adjustments through incentives changes. An example would be the production of bioethanol in Wismar instead of electrical and thermal energy, from timber byproducts. This would demand radical changes for all major industries, even their closure .

Tested or mature synergies are depicted in the BNs as axial lines. The meaning of an axial line is that a connection is already in place, but this connection is not valorised exhaustively. The existence of numerous axial lines is a good sign of a developing BN. Each of them needs to be evaluated separately from local authorities to decide if they should be promoted more or not. This is a top priority for each area, as good practises: simple and profitable investments tend to be reapplied very fast, as in the case of photovoltaics in Greece. The role of the public authorities could play a catalytic role at this stage.

According to the criteria above, the bigger the number of blue and red blocks, the more stable a BN is. The more complementary the blue blocks, the easier it is to establish long-lasting symbioses among them. Additionally, the clearer the goals, the better business orientation for new investment. Finally, the more axial lines in the BN, the more creative and active the actors of the network are, and the more work is needed by public authorities' side.

D. Evaluation per port

Malmö was found to have the most complex BN. There are some recycling companies, several power plants and food processing industries. Biomass from industries is so far valorised satisfactorily. There is a DH network for the city, which is fed by several plants. Additionally, there is a steam network, which supplies five industries, creating a strong backbone of trust and cooperation among them. Extensive studies to evaluate biomass availability in the Scania region have been completed previously, forming a fertile ground for new business opportunities. There is a big number of non-bioenergy producing industries, as well as four existing enablers, at least one under construction and one more is proposed. The blue blocks appear to be complimentary with each other, creating a highly dense and thus stable network. Finally, the regional goals are really clear, there is need for NG compatible biogas production.

Mantova is a much smaller port with a much smaller BN. The ISN follows the 3-2 rule, and while IES has closed, new opportunities arose for a Bioethanol plant. No biomass is produced by the plants in Mantova. The DH network will be extended to include more areas, growing this way the demand of thermal energy. The huge amount of Biogas potential, due to the extensive livestock activities in the greater area, could lead to the substitution of part of the Natural Gas. The abundance of lignocellulosic material could lead to greater bioethanol production, which could even feed a bioethylene (cracking) plant, for feeding Polimeri. On the other hand, biogas is already being produced, and this has reduced the social acceptance for future similar investments, as there are some concerns for the quality of air and people's health. Nevertheless, the need to face unemployment presses for new investments, and currently several business models are developed. Regional goals and incentives could be reformed based on the need for new jobs.

Wismar is connected with many ports. Within the port there are some of the biggest timber processing industries worldwide, which have invested in CHP technologies to valorise their by-products: mainly sawdust, bark and bad quality logs. Ilim, a timber factory, feeds several other factories, forming a more open synergy, while most of the industries are competitors with each other. There is also agricultural and livestock activity around the port, and a small portion of their bio-waste is already valorised. Eleven buses are running on NG, and could run in the near future on biogas. A good starting point for initiating a promising network in the area could be the investment in Hydrothermal Liquefaction, to produce bio-crude, valorising a portion of timber by-products of all the industries. This could then feed a second generation biorefinery, which could also be supplied with energy from any of the power plants that are built next to the timber processing industries. The new unit could provide extra income for all the industrial units and even create a platform for further cooperation.

Astakos has negligible industrial activity within the port area. Several companies are investigating from time to time the opportunity to invest in the port area to access world markets with reduced costs. There is neither DH network nor NG network. On the other hand, there is a growing interest in investing in bioenergy production, following great paradigms, such as the Chytas pig farms. Waste from olive mills, dairy industries, fish farms, rice mills and MSW could be valorised within the port, creating a multi-feed eco-friendly power plant, which could attract new investment within the port area, supplying low price energy: steam / heat / electricity and port benefits. The greater area of Astakos has great production of biomass due to extensive agricultural and livestock activities.