Bioeconomy Benchmarking Study:
International Experiences in Eco-industrial parks

Cássia Ayres: Pioneer into Practice – Climate Kic

STOKin julkaisusarja

STOK raportti 18/2015

Julkaisija: STOK – Sähköisen talotekniikan osaamis- ja kehittämiskeskus, Posintra Oy

Taitto: Cássia Ayres

Kannen kuva: Topi Haapanen

ISBN 978-952-7177-00-6 (PDF)

Table of Contents

Executive summary ……6

Part I: About bioeconomy ……7

1. Concept ……8

2. Potential for growth of bioeconomy ……9

3. Finnish context: transition to bioeconomy……11

3.1 The national bioeconomy strategy ……11

3.2 Potential opportunities for sectorial investments……11

3.3 Transition factors analysis……13

3.4 Limitations of the national strategy ……18

Part II: Case Studies……20

1. Experiences in Nordic countries……21

1.1 Finland……21
1.2 Denmark……25
1.3 Norway……29
1.4 Sweden ……33

2. Experiences in West-European countries……37
2.1 United Kingdom……37
2.2 The Netherlands ……39
2.3 Germany……42

3. Experiences in Developing countries……45
3.1 Brazil……45
3.2 China……50
3.3 India ……56

Part III: Enabling and Disabling factors: Assessing Pobi……59

1. Enabling and disabling factors against POBI factors ……60

2. Conclusion and recommendations ……63

Appendices ……66

References……73

List of Figures

Figure 1. Bioeconomy conception. Source: BioVale, 2015……9
Figure 2. Top ten Finnish export products……12
Figure 3. Resume of export products by sector……12
Figure 4. Phase of Finnish transition towards bioeconomy……17
Figure 5. Finnish multi-level analysis……17
Figure 6: Forssa region……21
Figure 7: Envi Grow Park……22
Figure 8. Lolland Region……26
Figure 9. Østfold region……30
Figure 10. Örnsköldsviks region……34
Figure 11: Main actors in the biorefinery cluster……35
Figure 12. BioVale system ……39
Figure 13. Biobased production pipeline from tomato by-products……41
Figure14: The sunliquid process for the production of cellulosic ethanol from agricultural residues……42
Figure 15. Position of countries sampled in Bioeconomy 2013……45
Figure 16. Flow of production Guitang of complex……53
Figure 17. Stakeholder management framework……65
Figure 18: Multi level perspective framework……65
Figure 19: International Bioeconomy Policy……71
Figure 20: Bioeconomy national strategies worldwide……72

List of tables

Table 1. Other relevant initiatives in Forssa Region……..24

Table 2. Facts about Lolland region. ……..29

Table 3. Main actors in the biorefinary cluster……..35

Table 4. Enabeling factors in Brazil……46

Table 5: Santa Cruz bio-industrial park……..47

Table 6: Enabling factors in China……51

Table 7: Enabling factors in India……56

Table 8. Pobi Assessment framework ……61

Executive summary

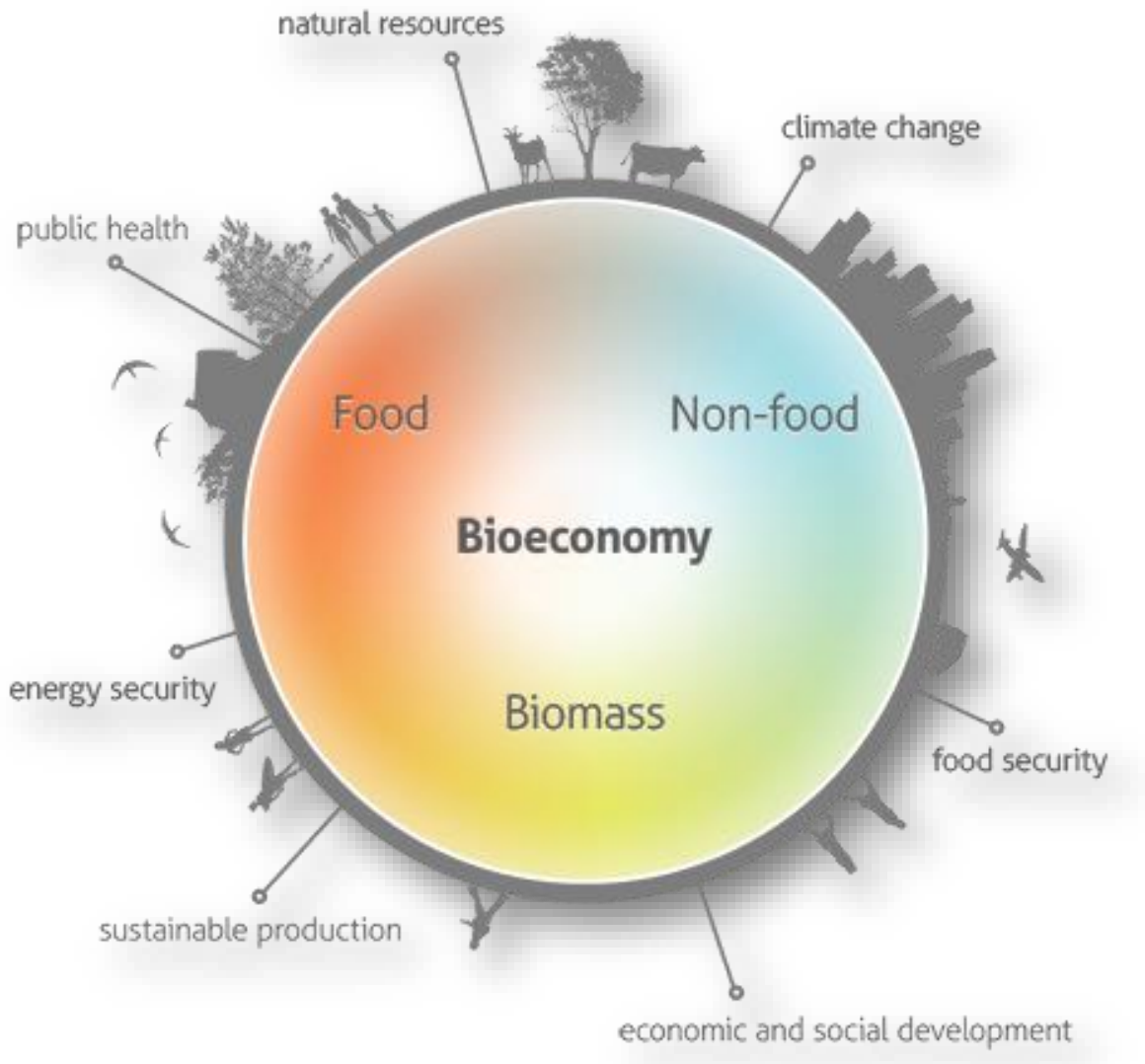
Bioeconomy has gradually becoming widespread in regional, national and international policy discourse in Europe and abroad. According to the UK policy for bioeconomy implementation, currently, at least 34 countries have policies or strategies in place in relation to this topic. Yet, these strategies vary considerably in their scope. Some, such as those in Germany and Finland, take a broad view, encompassing the whole bioeconomy within a single strategy at the national level. Others take a regional approach, such as in Flanders. An overview of European Bioeconomy can be found on the appendices.

In a local perspective, the concept has been significantly examined and integrated in policymaking in the Nordic countries. In Finland, for example bioeconomy was launched in 2014 as part of a national strategy which aims to create 100,000 new jobs and increase the economy up to € 100bn by 2025 using the best assets of the environment in a sustainable way. Specifically, the city of Porvoo has recently been involved in this broad ambition through the Pobi - Porvoo Kilpilahti evolving into a biobusiness park – a program to be partially implemented with European Unnion Developmenrt Funds. It aims at developing an advanced industrial park for bio- and recycling businesses, involving established organizations and attracting new companies with practices orientated to sustainable development for the petrochemical sector in the Kilpilahti area. Under Posintra's leadership and coordination, the methodology of this program towards a successful bio-industrial park encompasses a sustainable vision for this economic cluster in a long-term perspective and take into account a close synergy with different stakeholders: companies operating in applicable businesses, public authorities and specialized consultants in this field.

As per Posintra Oy's roles outlined above, this report aims to inform and orientate this company and its subcontractors' decisions during the implementation of Pobi program in Porvoo Kilpilahti area towards successful practices. Ultimately, this report provides relevant and up to date data about the panorama of bioeconomy in its diverse approaches and it resumes experiences worldwide focusing on enabling and disabling factors. Finally, these factors allow to assess Pobi's feasibility and to produce practical recommendations for the program to consider and use to develop in its further stages.

PART I

ABOUT BIOECONOMY



1. Concept

Bioeconomy addresses the production and use of biological resources for conversion into commercial products, ranging from food and feed to bio- based products and bio-energy. Therefore, bioeconomy incorporates agriculture, forestry, fisheries, food processing, and parts of the energy, chemicals and biotechnology sectors. As a system, the bioeconomy has existed since humans first appropriated natural resources for their own gain, such as burning firewood or cultivating crops. In recent years there has been a renewed focus on utilising biological resources more efficiently, so as to reduce pressure on natural resources, as well as starting the transition away from finite fossil resources (Building a High Value Bioeconomy. 2015). Additionally, bioeconomy works in closed loop circles reusing raw materials permanently, transforming technical materials from the waste streams into new raw nutrients for manufacturing goods and consequentially reducing waste in the natural environment.

Complementary definitions in the Nordic countries consider also bioeconomy as a result of advanced biotechnology incorporated into industrial systems, involving three elements: the use of advanced knowledge of genes and complex cell processes to develop new processes and products, the use of renewable biomass and efficient bioprocesses to support sustainable production, and the integration of biotechnology knowledge and applications across sectors (The Finnish Bioeconomy Strategy, 2014). The figure 1 below resumes both visions about bioeconomy conception.

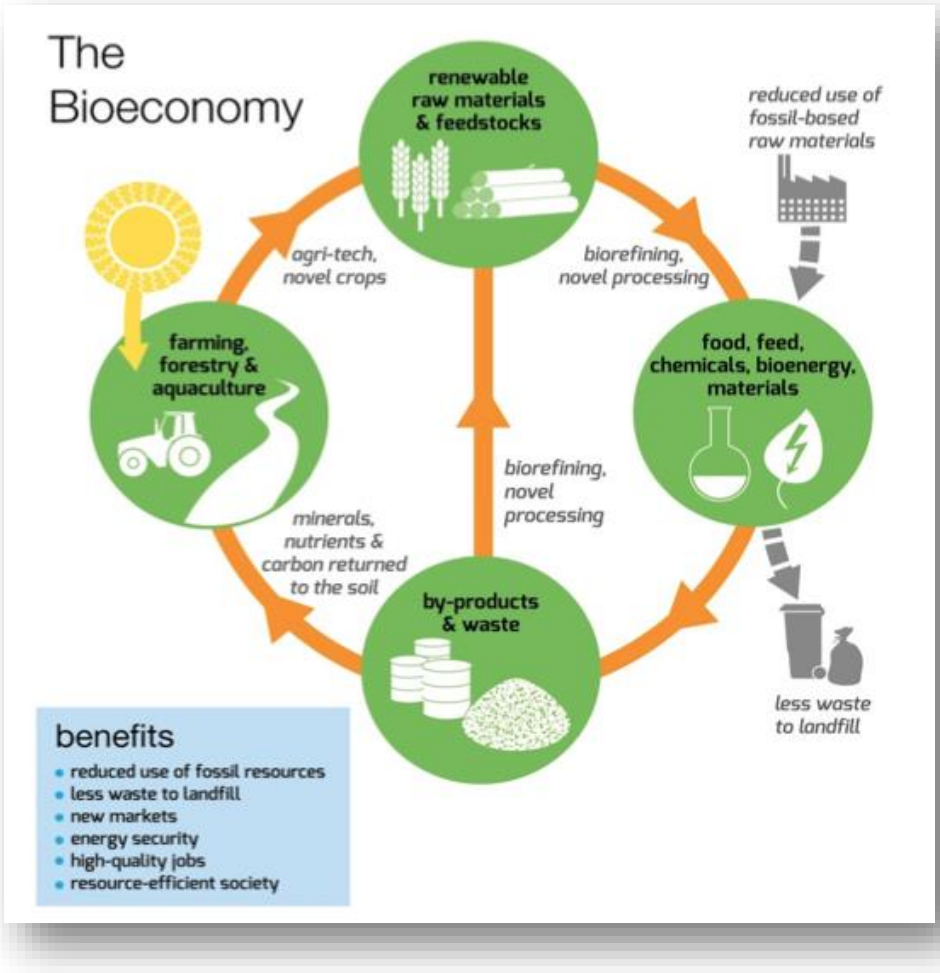


Figure 1. Bioeconomy conception. Source: BioVale, 2015

2. Potential for growth of bioeconomy

Most specialized reports in this sector consider that the outcomes of bio-economy strategies have been modest, globally. Despite of national or regional policies have been in place for a number of years, coherent bio-economy strategies are relatively recent. Therefore, bioeconomy has a significant potential for its development. The European Union is one of the main inductors of initiatives in this sector by funding programs to support the developing bio-based economy in Europe. In fact, the Bio-based Industries consortium 2014 report points out important figures about estimated streams of investments that will be available for beneficiaries in Europe to co-fund bio-based innovations and market developments as follows:

- More than €70 billion will be invested in research and innovation through the centrally managed Horizon 2020;
- Through the European Structural and Investment Funds (ESIF) between €80 – €100 billion (European Regional Development Fund / ERDF) will be invested in innovation-drivers, infrastructures, logistics and take-up;
- €70 billion (European Social Fund / ESF) investments in skills, life-long learning, social integration, employment services, capacity building entrepreneurship and social innovation;
- More than € 100 billion will go into funding for Rural Development (European Agricultural Fund for Rural Development / EAFRD), Maritime Investments and Fisheries (European Maritime and Fisheries Fund);
- Approximately €66 billion will go into Trans-European transport connections and environmental projects;

Conversely, the Nordic Innovation Report states that the European bioeconomy currently has robust results: an annual turnover of approximately €2 trillion and employs 22 million people. One of the reasons for this is because European nations have a natural potential for developing its bioeconomy, and are largely self-sufficient in many agricultural, forestry and some marine products. The same report observes that innovation and research are at the core of the transition to a bioeconomy that with its cross-cutting nature can address complex and interconnected challenges while achieving economic growth. Specifically in the Nordic countries, the Nordic Innovation report "Creating value from bioresources" states that the total turnover of the key bioeconomy sectors in the Nordic countries is approximately €184 billion (including agriculture, fisheries and aquaculture, forestry, food industry, forest industry and bioenergy and biofuels). In total, this constitutes 10% of the total Nordic economy. According to the Nordic Innovation report, the current volume of bioeconomy is as follows: 9% of the economy in Denmark, 12% in Finland, 18% in Iceland, 6% in Norway, and 10% in Sweden.

3. Finnish context: transition to bioeconomy

3.1 The National Bioeconomy Strategy

The Finnish bioeconomy position is considered very promising according to the document "Benchmarking Finnish and Dutch bioeconomy transition governance, (2014) and "The Finnish Bioeconomy Strategy: Sustainable Growth from Bioeconomy". Nowadays, Finland generates €60 billion and as mentioned before, the national strategy aims to grow the bioeconomy to €100 billion in 2025. According to the document "The Finnish Bioeconomy Strategy: Sustainable Growth from Bioeconomy", (p. 3), the objective of the Finnish Bioeconomy Strategy is "to generate new economic growth and new jobs from an increase in the bioeconomy business and from high added value products and services while securing the operating conditions for the nature's ecosystems. The leading idea of the strategy is that competitive and sustainable bioeconomy solutions for global problems will be created in Finland, and that new business will be generated both in the Finnish and international market, thus boosting the welfare of the whole of Finland".

The strategic goals of the National Bioeconomy Strategy are:

- A competitive operating environment for the bioeconomy,
- New business from the bioeconomy,
- A strong bioeconomy competence base,
- Accessibility and sustainability of biomasses.

3.2 Potential opportunities for sectorial investments

In order to support these goals, Finland has clear strengths coming from the supply of biomass since 60% of the country is covered in forests. This has led to a strong presence of forestry and related industries. Currently four out of the top ten Finnish export products are related to this industry as shown in the figure 2. Its share to total exports is 20% and total value around € 11 billion euros in 2012 in the sectors grouped in the figure 3. Overall, specialists agree that the mostly recognized actors which will catalyze this transition are: highly educated work force, strong cooperation between business and research and innovative capacity. (Bioeconomy in the Nordic region: Regional case studies)

Figure 2. Top ten Finnish export products. Source: Benchmarking Finnish and Dutch bioeconomy transition governance (2014)

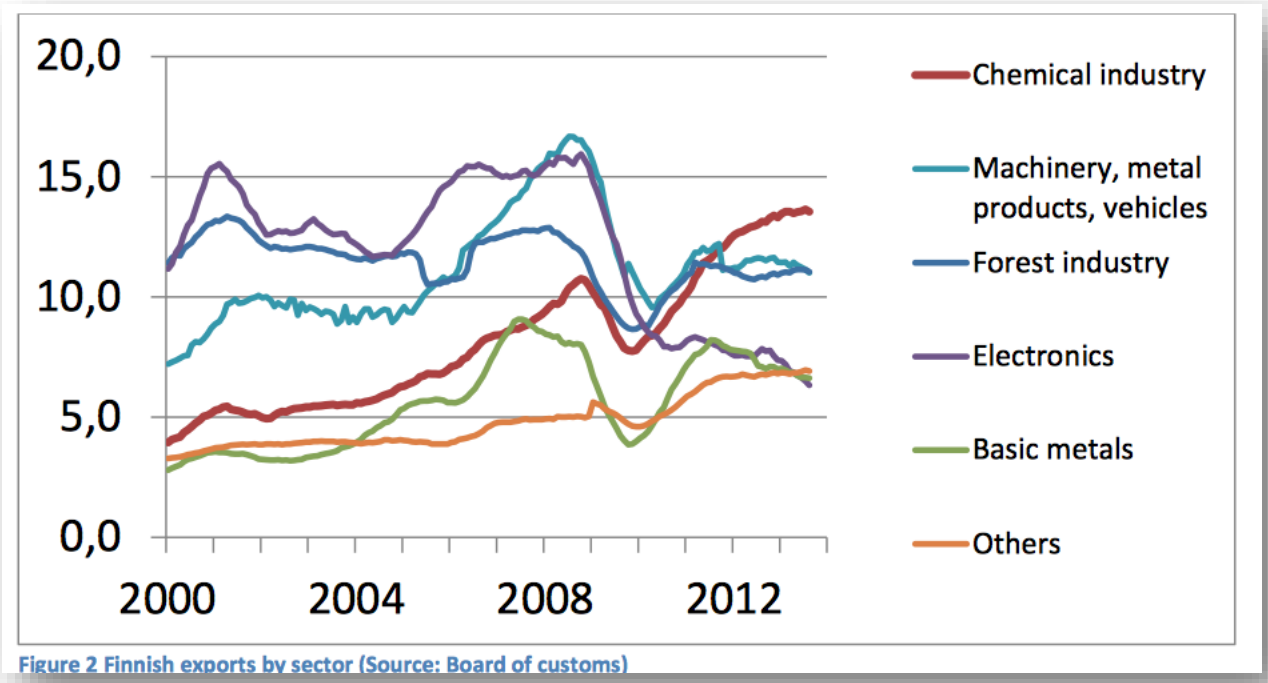


Figure 3. Resume of export products by sector.

The Benchmarking Finnish and Dutch bioeconomy transition governance, (2014) states that the efforts of the Finnish government have so far been focused too much on energy generation which has

obscured the strengths of the country in other areas of the bioeconomy such as: chemical, agricultural, ICT and pharmaceutical highlighted as follows:

Chemical is a sector that makes up 23% of Finnish exports with a value of € 13,3 billion. It has evolved out of refining side streams of the distributed pulp & paper industry, producing for example alcohol, chemicals and yeast. However, when the pulp & paper industry became more centralized in the 70's the diversified upcycling of side streams went into decline and the businesses involved often were sold off to foreign companies.

Agriculture and food sector plays a smaller role in Finland due to its geographical location, most of the agriculture is located in the South and West of the country. The region of Seinajoki is presenting itself as a leading hub in food related innovations. An interesting innovation that is the result of a crossover between the food and forestry sectors is Benecol developed by dairy company Raisio, a cholesterol lowering product made from a side stream of the pulp industry and added to margarine or other dairy products.

ICT (and gaming) are sectors of growing importance for the Finnish economy. These sectors develop based on the knowledge and competencies built up around Nokia (which interestingly used to be a paper company). Although less obvious than the chemical or forestry sector, also the ICT sector has links to the bioeconomy, e.g. GPS systems for efficient timber harvesting.

Pharmaceutical and construction industries do not seem to play an important role in the Finnish bioeconomy discourse at the moment. As the use of biomass could play an important role in these sectors, it could lead to interesting synergies when these sectors are involved in the process.

3.3 Transition factors analysis

In the transition analysis made by the Benchmarking Finnish and Dutch bioeconomy transition governance, (2014) the consultants paid specific attention to the transition dynamics and roles of different actors in the process of implementing bioeconomy. During fact-finding missions they had a series of interviews with a variety of Finnish stakeholders from public to private sectors and have read relevant documents among which are policy documents of ministries. These results of the transition analysis provide indicators for the state of the Finnish Bioeconomy transition. In particular for Pobi program, the following findings in a national level allow Posintra to proceed a preliminary

examination of critical factors that can empower and restrict further steps in Kilpilahti if they are coincident with the opinions of stakeholders in a local level.

The findings are summarized in the seven main topics:

Urgency - There seems to be a broad consensus on the need for a transition to bioeconomy. However, the urgency varies significantly among stakeholders. Some stakeholders argue that Finland is already well on its way to a bio-based economy, while others argue that there are still many barriers to overcome. The crucial part here is the focus on incremental innovation (by those who believe Finland is well on its way) versus on radical innovation (by those who believe that the bioeconomic structure needs to be radically transformed). So the overall urgency for the bioeconomy needs to be strengthened among stakeholders.

Ownership - There seems a lack of ownership of the bioeconomy transition. The Ministry of Economics and Employment seems to claim some ownership (together with the Ministries of Agriculture and Forestry and of Environment), however, that is not recognized by other private and public partners. In any case the Ministries play a central, pivotal role with little active input from the industry and societal partners. The major cause is that various parties have a different understanding of what the bioeconomy is and in what way it can or should be stimulated. The problem is that without a major role of the industry and societal partners the bioeconomy transition is doomed to fail.

The silo structure - The Finnish economy and governance structure are organized along the axis of strict silo's, which are quite powerful. This silo structure is a typical characteristic of the old, fossil economy. The new, bioeconomy cuts across this silo structure, because it deals with energy, chemistry, transport, agrifood, forestry in an integral and coherent manner. This implies that the silo structure needs to be broken down and a new, horizontal, cross-sectoral economic structure needs to be built up to further the bioeconomy transition. Collaboration at a regional level could be useful in this respect because bridging these silos is often easier at a regional than at the national level.

Industrial Regime - The industry, in particular the forestry industry, plays a pivotal role in the Finnish economy in general and in the bioeconomy in particular. The Forestry regime is characterized as quite conservative by most of the interviewees. According to one of the respondents there are basically three integrated forestry and pulp companies that dominate the market. These are the only

ones that can take the biomass out and therefore are the gatekeepers of the bioeconomy. This poses problems, whereas most stakeholders look at the forestry industry as the potential leader of the bioeconomy transition, they do not take up that leading role yet. This sector has been focusing predominantly on high-efficiency, low- cost bulk products, such as paper, or biomass (black liquor) co-firing for energy production, while the highest value added in the bioeconomy comes from high quality specialty products, which require a more diversified business ecosystem. The same holds for the agricultural sector that seems to be lagging behind in the bioeconomy transition process.

Transition pace - All parties seem to agree that the bioeconomy transition goes too slow. Even the representatives from the forestry and chemical sector admit this. One explanation for this is the focus on the short-term and on product and technological innovation. This results in a focus on quick fixes and ready-made solutions, such as 'looking for the new Nokia' as one of the interviewees put it. Instead the bioeconomy transition is a cumbersome, long-term process of searching, learning and experimenting.

Cultural drawbacks - We found a kind of Finnish modesty in judging Finnish economic and innovation achievements and averseness to risk taking in scaling up radical innovation. Scaling up from small-scale radical innovation to mainstream requires risk taking and willingness to leave the beaten track. According to one of the respondents "the good ideas are there, but nobody is prepared to take the risk." In general Finnish culture seems to be characterized by modesty. In most cases this is a laudable trait, however, it might obscure radical innovations within a transition process. If Finland wants to lead the global bioeconomy transition, it is necessary to share Finnish best practices and innovations with the rest of the world. A highly interesting area we encountered is the refining that happens to side streams of the pulp industry. An example in this area is ForChem, a company that refines tall oil into high quality specialty products, such as antibiotics, printing ink and adhesives.

Implementation gap - According to most interviewees Finland is good at developing visions and strategies (paperwork), but not so good in implementing strategies and ideas. This is referred to as the implementation gap. We also see that reflected in the Finnish bioeconomy strategy that focuses more on the 'what' (content) than on the 'how' (process), see also next section. At the same time we find a plethora of pilots and innovations taking place from the bottom-up, which are often still

small-scale, fragmented and lack an overarching vision that connects the dots. Somehow these bottom-up innovations and top-down vision development need to be connected to drive the transition forward.

The aforementioned topics lead to a provisional assessment of the stage in which the Finnish bioeconomy transition is and the dynamics at multiple scales that either reinforce or hamper the transition. The Benchmark study Finland and Dutch, 2014, report assess that the Finnish bioeconomy transition is at the end of the pre-development phase (see figure 4 below). Although there are ample bottom-up developments, the transition has not yet reached the tipping point phase, due to lack of urgency, common understanding and ownership. In the tipping point (or take-off phase) there is more turbulence, chaos and increasing conflicts between the old and new order. Analyzing the dynamics of the transition at various scales, we assess that most stimulating driving forces are at the micro-level and most debilitating forces at the meso-level, or in the regime in particular the silo structure and the dominance of the forestry regime is a major barrier. Figure 4 summarizes the findings of the multi-level analysis.

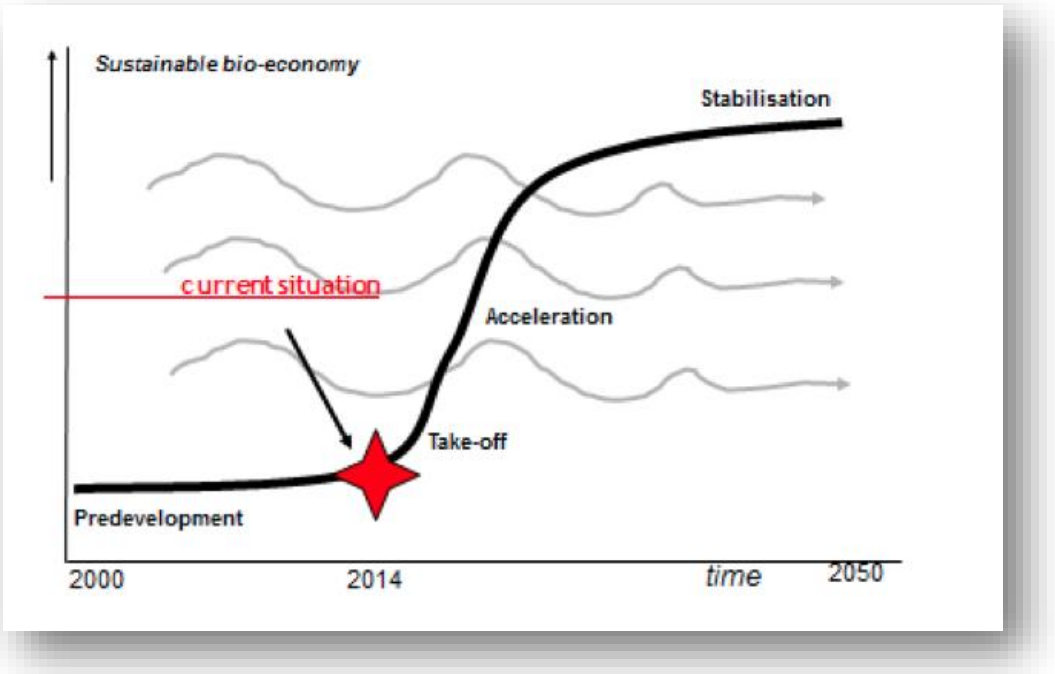


Figure 4. Phase of Finnish transition towards bioeconomy: Source Benchmark study Finland and Dutch, (2014)

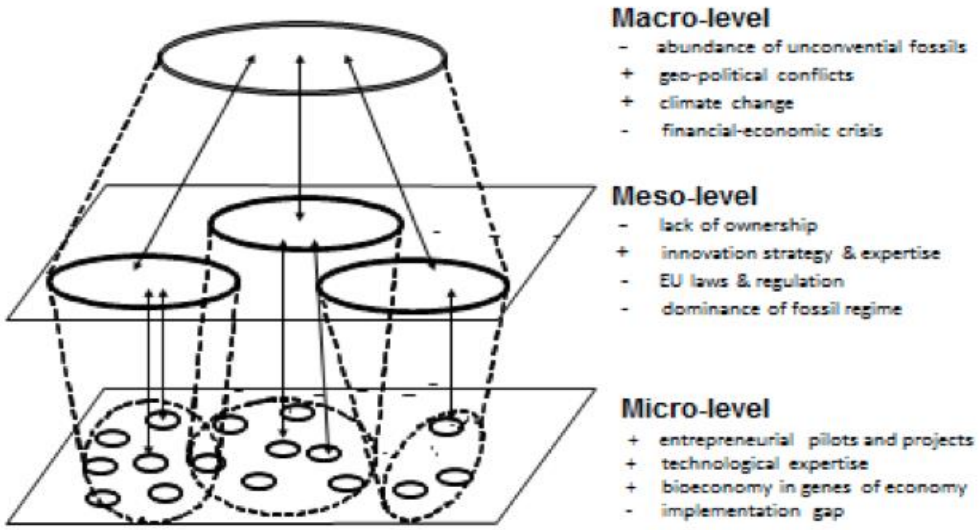


Figure 5. Finnish Multi-level analysis. Benchmark study Finland and Dutch (2014)

3.5 Limitations of the National Strategy

Despite the fact that the Finnish bioeconomy strategy provides an integral approach to the grand challenges facing Finnish society with a clear vision and objectives, the Benchmark study of Finland and Dutch, identified some weaknesses in this strategy, which are connected to topics identified in the previous section of this report. These areas observed in the national level, may have some co-incidences when compared with local stakeholders opinions when consultations and surveys will be performed in Porvoo - Kilpilahti. Therefore, knowing the disadvantages in the national scenario would permit opportunities of intervention of Posintra Oy to act accurately and promptly.

Weakness 1: Lack of sense of urgency

The first weakness of this strategy is that it does not address the business-as-usual activities by creating and strengthening a sense of urgency amongst different stakeholders.

Weakness 2: Lack of explicity in the players' roles

As observed before, the Finnish market has a strong silos and influential industry regime, consequently the market can potentially undermine this transition at several stages. This will demand the government to manage the resistance of these players which might emerge in subsequent complex stages of implementation. Also, the strategy does address the areas where new business is likely to emerge, but it could be more explicit in how the players active in this field will be mobilized to contribute to the transition strategy and build up counterweight for the vested interests.

Weakness 3: The presence of a top down leadership approach

The vision on the future bioeconomy is sharp. Yet, transition process is extremely complex, take decades and cannot be controlled and commanded in a top-down manner. An implementation strategy or transition agenda that plays into this complexity, is supported by progressive industrial players and key societal stakeholders and details the necessary next steps is largely absent. A transition governance strategy requires a subtle, consistent, long-term strategy of searching, learning and experimenting in multiple domains and at multiple scale levels. This requires a common vision, joint urgency and commitment from a diversity of stakeholders. For these specialists it would be

helpful to work on connecting the vision of the strategy to promising transition pathways and on-going pilots which provide the seeds of radical change.

Weakness 4: Lack of involvement towards ownership of private sector

The crucial issue identified in the national strategy is the ownership issue, already discussed in the previous section. One of the main results from our fact finding missions is that the players that are expected to implement the strategy do not feel involved in the process and feel little responsibility for the strategy as proposed by the government. This carries the risk that the Finnish bioeconomy strategy remains as "a dream on paper". One example of this is that the section four of the Finnish bioeconomy strategy, which addresses the implementation and monitoring, is brief and vague. It actually does state the set-up of a bioeconomy panel consisting of actors from bioeconomy sectors. This could help in involving different stakeholders and this is a laudable effort from a transition perspective. However, selection of panelists should be done with great care, making sure that the panel will not be dominated by the usual suspects representing the vested interests but includes leaders and new players from sectors that are expected to play a key role in the future bioeconomy system, e.g. clean tech, food, health, and services sectors as detailed in the strategy but also other sectors relating to the pathways which will be discussed in the next section. By including these leaders from different domains a shared vision of bioconomy can emerge of the outlines of the future system and the barriers that face new developments. This increases the potential to come to novel solutions and accelerating the transition process.

The Finnish bioeconomy strategy is overall clear and integral, but its conduction has a top-down approach that needs to be mixed with a bottom-up one, so than it can be developed into a co-creation strategy, allowing private stakeholders to ensure ownership and lead the process together with the public sector. If Posintra takes the mentioned drawbacks of the national strategy in consideration, they could be potentially converted into advantages for Pobi.

PART II

CASES STUDIES SECTION

1. Experiences in Nordic countries

1.1 Finland

Facts about the region: Forssa

Forssa is located in South-west Finland, 100 km from Helsinki as shown in the figure 6 and in a logistically favorable location at the midpoint between the three largest cities in Finland. The Forssa sub-region is one of the three sub-regions of the Häme region. It consists of the city of Forssa and four municipalities: Jokioinen, Tammela, Humppila and Ypäjä. There are approximately 37 000 inhabitants of the Forssa sub-region, of which 17 700 live in the city of Forssa. The key sectors of the local economy in Forssa are: food, construction, environmental technology, electronics, ICT, metal and printing industries. (Bioeconomy in the Nordic region: Regional case studies, 2014)

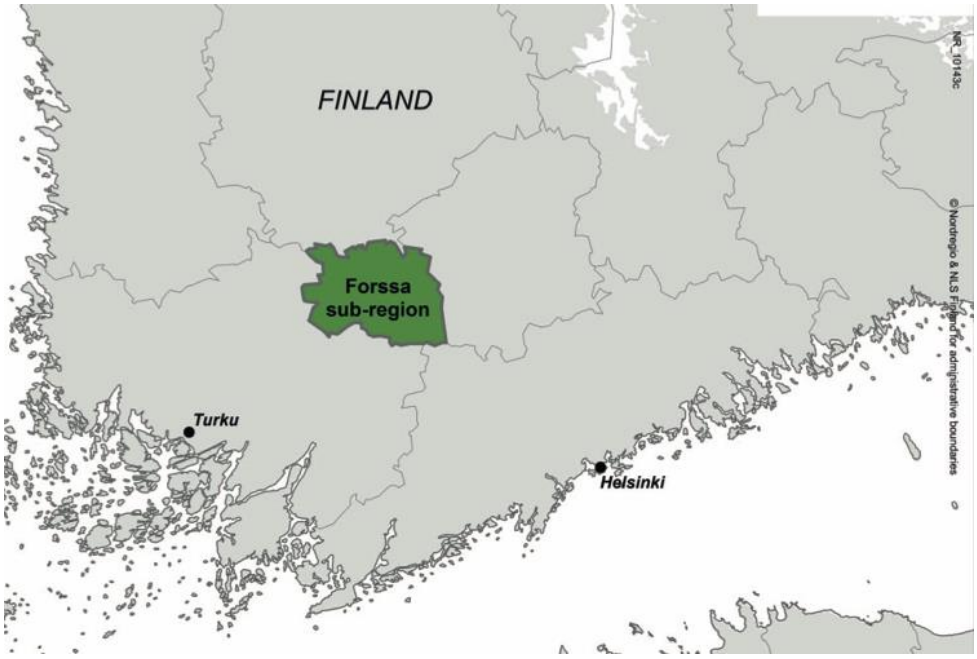


Figure 6: Forssa region. Source: Bioeconomy in the Nordic region: Regional case studies, 2014

Bioeconomy is a relatively new term in the Forssa region. According to the interviews in the region, the bioeconomy concept in Forssa was launched as part of the Forssa Brightgreen concept approximately five years ago as part of a regional strategy in the Council of Häme 2013–2014. This concept focuses strongly on the possibilities of the bioeconomy incentivizing new business development strategy of the Forssa region in the municipalities of Forssa, Humppila, Jokioinen, Tammela and Ypäjä. Brightgreen is based on business activities that are environmentally friendly and support sustainable development. The strategy, with a focus on environment and energy, wellness, green logistics, and technology is seen as an important success factor in the current development of Forssa green growth and the bioeconomy as demonstrated in the figure 7 below.

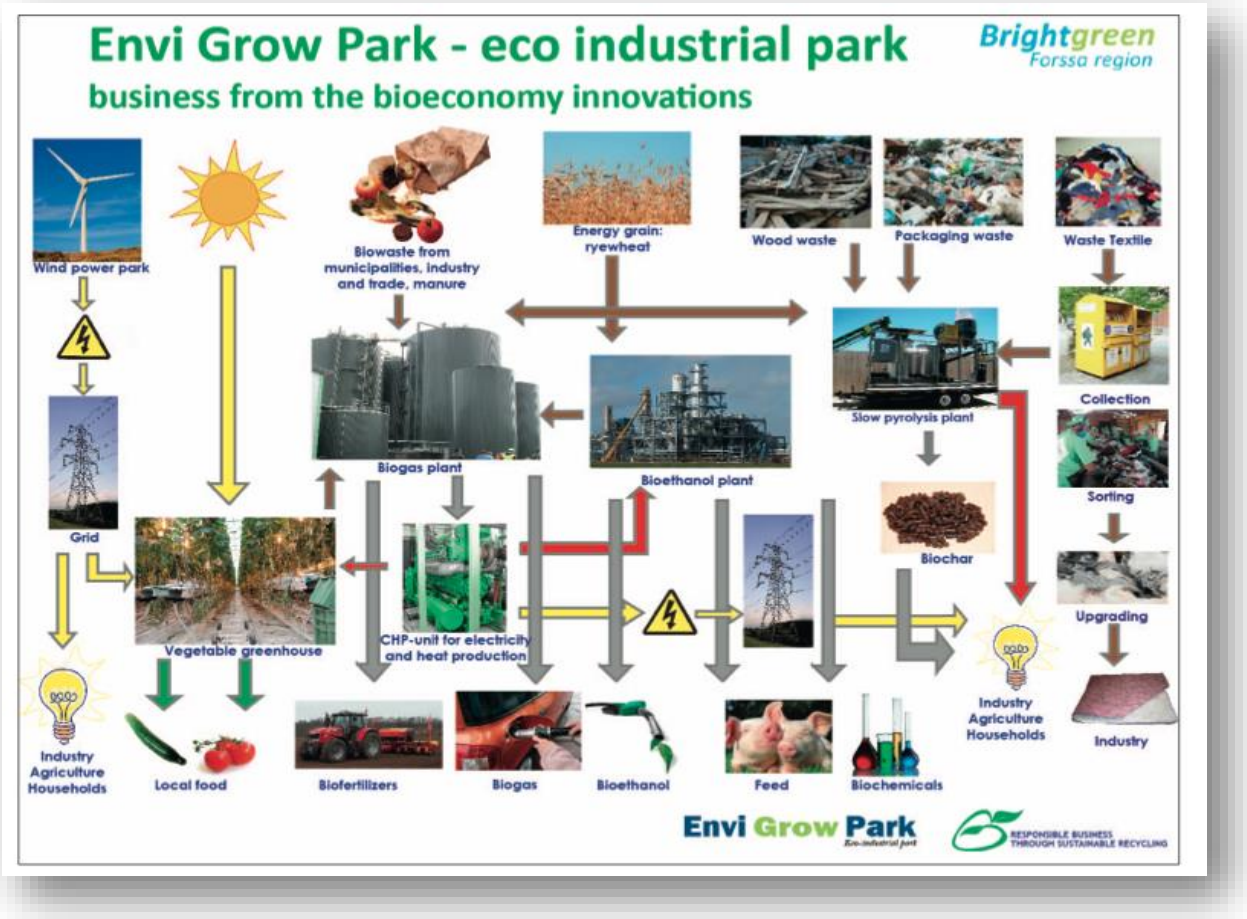


Figure 7: Envi Grow Park: Source Bioeconomy in the Nordic region: Regional case studies, 2014

Envi Grow

Envi Grow eco-industrial park is an efficient zone of green solutions and a compact industrial development model, which recycles materials, energy, expertise and information in a closed-loop system that is kind to the environment and good for local business. It has been boosting innovation and sustainable growth in southern Finland. Envi Grow Park is currently home to more than 20 companies, employing 200 experts who specialize in recycling and waste management or operate with recycled materials and renewable energy. The latest addition to the Park is a new biomethane filling station for cars and trucks. Biomethane is also used in the manufacture of glass wool-based insulation materials, and the green electricity produced from biogas by the local CHP unit is used in a printing house.

The project builds upon the achievements of the Forssa Envitech area, which over the past 20 years has emerged as a major exponent of an increasingly integrated bioeconomy. The Forssa area of southern Finland's Kanta-Häme Region is resolutely green – "Bright Green Forssa Region", they call themselves – and Envi Grow Park is evolving into a virtuous circle where one industry's recycled waste is another company's fuel.

A green hub

Acting as a green hub, Envi Grow Park's benefits from the cutting-edge research and environmental expertise produced by its cluster of leading technological innovators. In this way expertise and information are "recycled" along with materials, waste products and energy. Established and developing activities at the Park include the production of local organic food in large modern greenhouses; the production of green covers (sod turf) and bio-fertilizers; biogas, bioethanol and synthetic diesel for use as transport fuel; the use of carbon dioxide separated from biogas; industrial aquaculture using bioenergy; and innovative recovery and reuse of by-products from the food industry.

Private and public investment over the next years is estimated to top EUR 150 000 000, as plans are already in place for a wind farm and for a bio-hybrid power plant combining biogas and bioethanol production.

Significant additional investments are expected from all operators in the Park.

The Manager at the Forssa Region Development Centre argues that Envi Grow Park is a modern concentration of both municipal and private, multifaceted and competitive high-tech companies. The Park has shown and will continue to show the way to a sustainable future for the bioeconomy.

Sector/Activity	Main Actors	Description
Food industry	HK Ruokatalo Atria SME companies (e.g., Makuliha, Jokioisten Leipä)	2,000 jobs Large-scale investments in Forssa by large food companies Innovative SMEs, such as Lähiruoka
Envi Grow Park, Eco Industrial Park, Cleantech Companies	Envor Group, LHJ Group, Watrec FSKK, MTT, HAMK	Flagship project: a biorefinery with an estimated investment of €100 million, planned to open in 2015
MTT Center of Expertise	MTT Agrifood Research Agriculture, food, and circulation companies, TSKK, HAMK	Building on the long-term expertise of MTT Loimijoki Food Valley initiative by FSKK (planning stage)
Green logistics initiatives	Municipalities, HAMK, Regional Council of Häme	Green Growth & logistics-related development projects (e.g., HEA; Humppila Eco Airport and Logistics Centre)
Textile recycling	HAMK in co-operation with municipalities, VTT, LAMK, SYKE, National Consumer Research Centre, Envor	Public–private pilot projects (e.g. Tex-Vex Humppila, R&D work)
Education and training/natural resources	HAMK, HAMI (Häme Vocational Institute)	Degree programmes and training with a focus on the bioeconomy Forssa is the pilot region.

Table 1. Other relevant initiatives in Forssa Region

EU Funding

Total investment for "Envi Grow Park" was EUR 285 600, of which the EU's European Regional Development Fund contributed EUR 114 240 from the "Southern Finland ERDF Program" for the 2007 to 2013 programming period.

Summary of Bioeconomy activities in Forssa

The Forssa region is an inspiring and promising example of a Nordic bioeconomy initiative with local and regional commitment and long-term systematic effort. However, even greater courage would be welcomed to see the bioeconomy as a sustainable success element and the international extension of the Forssa region, especially in terms of jobs and euros.

Forssa has the advantage of a long tradition of bioeconomy-related know-how and expertise, especially in agriculture. The region is definitively not starting from zero but building on previous knowledge. Regarding the regional and local development bioeconomy initiatives, the key public and private actors have succeeded in preparing a common vision. Bright green Forssa provides a vision that should be relatively easy to understand and commit to. The Brightgreen regional/local vision is important for attracting new players and focusing on joint development efforts.

The Forssa region may face a relatively common risk among smaller city regions of diversifying its limited financial and human resources into too many development fields and programs. If properly executed, the Brightgreen Forssa program is an instrument for focusing on, rather than spearheading programs and key priorities of the bioeconomy. Dividing the development resources into numerous small programs to avoid causing displeasure does not usually bring long-term success.

The bioeconomy is an area where patience and long- term development pay off in the long run. However, short-term "victories" are needed in addition to rapid development steps. Gradual slow development is insufficient. The balance between a "sense of urgency" and strategic thinking is hard to find most likely, this is also true in the Forssa region.

Finally, it is important to note that the development of bioeconomy activities in the Forssa region, although systematically supported by public sector initiatives, has been and remains crucially dependent on private sector initiatives. Public sector actors can and should provide development platforms, but in the long run, they cannot act as key locomotives of regional bioeconomy initiatives.

1.2 Denmark

Facts about the region: Lolland

The case study chosen for Denmark concentrates on the municipality of Lolland (which has a smaller geographical area than the entire island of Lolland). Lolland Municipality, has an area of 892 km^2, covers approximately two-thirds of Lolland Island and has a population of approximately 46 000 inhabitants, which represents the lowest population density in Denmark. The largest towns in Lolland are Nakskov, with 12 866 residents, and Maribo, the second largest town, with 5 923 residents. Lolland is part of Zealand region and its localization can be found in the map below.

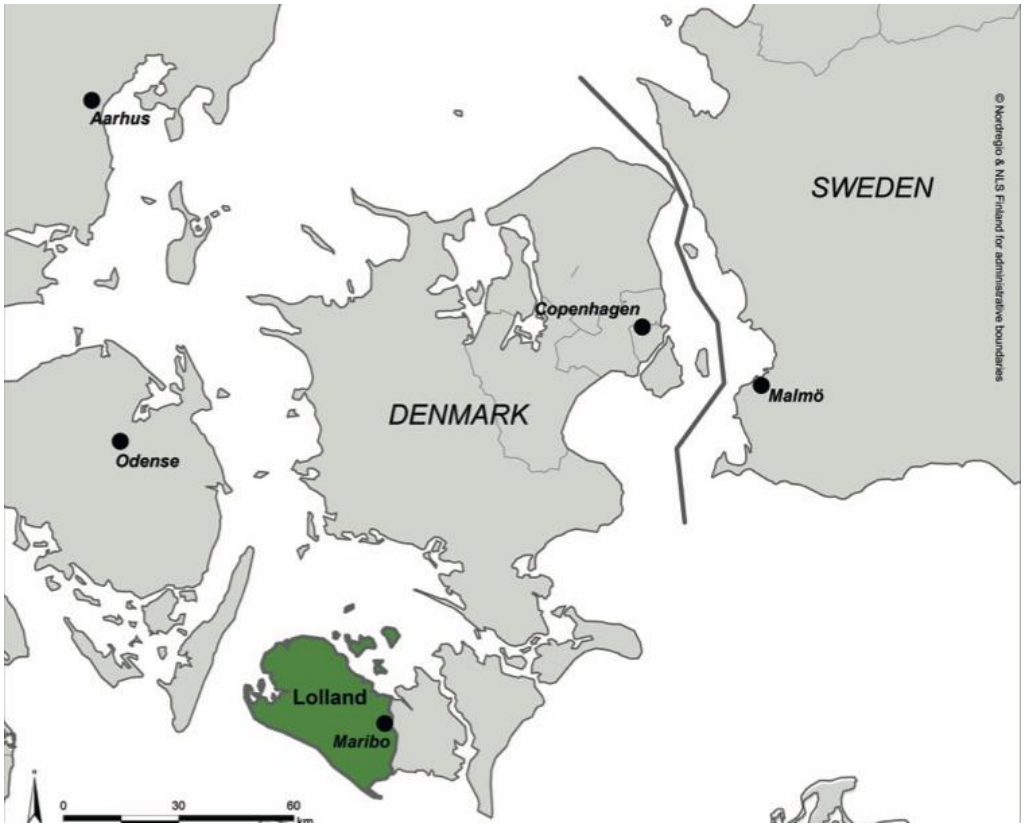


Figure 8. Lolland Region. Source: Bioeconomy in the Nordic region: Regional case studies, 2014

Region Zealand is known internationally as one of Europe's leading regions because of its work on climate issues, renewable energies (RE) and developing solutions for the future. This has called for innovative and practical solutions that promise not only alternative energy sources but also new jobs and improved quality of life. Zealand has taken the role of a model region in terms of sustainable economy and green growth, and this has influenced significantly its modes of governance, through strengthening co-operation between local communities, private companies, SMEs, cultural institutions, research institutions, municipalities and the region.

The absence of universities or major industrial clusters in Lolland makes its economy more fragile and highly dependent on fewer economic activities. In fact, Lolland Island has been immersed in a strong economic depression that has left 2 000 skilled workers unemployed, which in turn has triggered out-migration to larger metropolitan areas, and brain drain, increasing poverty, disinvestment and increased dependency on national subsidies. Nevertheless, a number of areas of Lolland and Region Zealand used to be home to important manufacturing powerhouses, which in a number of cases have been transformed to meet the expectations of today's markets. For instance, Lolland's tradition of shipbuilding fed into the production of wind turbines during the 1990's (OECD 2012). In

1999 and 2000 the Nakskov harbor underwent a number of transformations, including the demolition of old structures and a general clean up, with the intention of attracting new industries and meeting new local needs.

The bioeconomy of the Lolland Region

Today, Lolland has a growing industrial sector based mostly around green energies and agro-industry, and it is the leading region in the production of wind generator components. This is mainly because of the presence of Vestas Wind Systems, a world leading manufacturer in the wind energy sector, which settled in Lolland in 1999. Vestas is currently the largest industry of its type and is an important source of employment for the region.

The joint effort of Nakskov and Lolland together with other municipalities focusing on “green” sustainable development based on local resources and renewable energy has successfully attracted a number of firms and partnerships of various types. This in turn has resulted in a significant drop in unemployment and has played a role in bringing Lolland out of the severe economic recession in which it was immersed.

Region Zealand has specialized in the production of energy with a major focus on renewable sources. This sector benefits from proximity to Copenhagen, which has a large demand for energy, and increasingly that from renewable sources. There is a longer tradition of renewable energy in Region Zealand. However, there has been a boost in the diversification of sources and new projects since 2007, because of sustained support.

Green Center: an innovative research and development center

Green Center is a business and research unit working together with agriculture, agribusiness and eco-technology industries. Green Center is part of the Knowledge Center” Råhavegård” and is located in the Zealand Region. It has modern laboratories, which offers biological, plant technological and environmental analyses and development facilities. This also includes a separate GMP-laboratory. The center owns 250 acres of farmland, of which 70 acres are experimental fields. The Center’s main tasks are innovation within food and agroindustry, plant production and management assistance in general, combining science with the business opportunities available by assessing today's trend.

The results are achieved through research and development projects, experience groups and networks, business coaching and counseling, laboratory trials, analysis and test production.

Green Center focuses on optimizing utilization of various biomasses. It works with both naturally occurring and intensive produced biomass from agriculture. In the future, sustainably produced biomass will be their most important commodity and resource for food production and development, and non-food use such as energy. Society needs the best commercial and environmental exploitation of these resources.

The Green Center is trialing techniques to cultivate algae on a large scale. Intensive agriculture could produce CO_2 and nitrogen, which can be used in the production of algae. The potential uses of algae include purifying water by removing nitrate deposits from intensive farming, and sewage treatment. The Algae Innovation Centre, Lolland (AIC) was initiated by the Green Center in 2010 in partnership with Aalborg University and Roskilde University. “The project aims to establish a demonstration and pilot plant for algae cultivation experiments, and conduct research on how society and businesses can optimally utilize algae production technologies”.

Summary of Bioeconomy activities in Lolland

The Lolland region has focused on the green economy for a relatively long time. In addition to providing practical and innovative solutions for local and regional problems, the focus on the “green economy” represents a significant export potential for the larger region of Zealand. However, it should be stated that job creation and an economic boost from green economy renewable energies has occurred in Lolland, but the impact should not be exaggerated. The green growth is expected to offer only a limited solution to the structural challenges of Lolland. Having stated this, the actors in the region are at the forefront in thinking about new ways to structure industrial symbiosis. Today, in relation to developing the bioeconomy, integrated solutions (including symbiosis and industry–community interactions) represent one important focus area. This is closely related to projects dealing with side current management and new products and being early in this field can potentially offer first mover advantages over other regions and large firms.

Lolland Municipality	Industry	R&D	Policies
■ Sustainability ■ Branding ■ Economic Growth ■ Competitiveness ■ Population Growth ■ Job Creation New Education ■ Innovative Supply Systems	■ Branding ■ Cheaper Test & Demonstration ■ Faster Access to the Commercial Market ■ Society Tests ■ Real Situations, Real Systems, Real Population, Real Society	■ Full Scale Research ■ Technical Knowledge ■ Socio-Economic Analyses ■ Well-defined Geography, Demography, Economy and Energy Systems	■ Bottom-up Tools to Reach Macro-political Goals for Sustainability and Competitiveness ■ Growth in the Peripheral Areas of the EU

Table 2. Facts about Lolland region. Bioeconomy in the Nordic region: Regional case studies, 2014

From a governance perspective, there is a feeling of "bottom up" or "involvement" in the way in which the bioeconomy is developed or explored. Co-creation processes are seen as an important "method" for realizing the bioeconomy, and this is envisaged to include meetings, development of clusters, and utilization of the quadruple helix concept. From an outside perspective, this is probably important because it helps to build a common vision and understanding of priorities and actions. However, we also notice that this is a sort of governmental organized bottom-up approach, where the main actor working to develop the bioeconomy is the region, and it seeks other actors. The region is also active at the top, and it participates in the national bioeconomy panel to devise strategies on the national scale.

1.3 Norway

Facts about the region

This case study focuses on wood processing as part of the bioeconomy of Østfold County in Norway, and specifically on one of the world's most advanced biorefineries, Borregaard. Østfold County is situated in southeastern Norway, bordering Akershus and southwestern Sweden (Västra Götaland County and Värmland), and covers an area of 4 182 km^2. It is one of the 19 NUTS 2 regions in Norway and part of the larger NUTS 3 region of Østlandet (NO03) together with the counties of Buskerud, Vestfold and Telemark. Details of the region can be found in the figure 11 below.

The total population of Østfold County is approximately 285 000, with Sarpsborg and Fredrikstad comprising the fifth largest urban area in Norway (with a total population of approximately 130

000). Østfold is relatively densely populated, with 70 people per km2. higher population density. Furthermore, although agriculture makes up an important part of the economic activity in the region, 83% of the population live in urban areas.

Traditionally, Østfold has been dominated by manufacturing industries; however, there have been major changes in industry structure over the past 30–40 years, where the county has gone from being dominated by a large processing industry (including wood processing) and commodity production to having a more diverse employment structure. In manufacturing, the number of jobs has decreased by more than 10 000 over the past 25 years.

Figure 9. Østfold region. Source: Bioeconomy in the Nordic region: Regional case studies, 2014

Bioeconomy in Østfold region

Borregaard, headquartered in Sarpsborg, operates globally and has subsidiaries in 20 countries. It has a turnover of 500 million EUR and has 1 050 employees in plants and sales offices in 16 countries throughout Europe, the Americas, Asia and Africa. Over the years, Borregaard has changed its product base from cellulose for paper to the production of chemicals such as lignin and vanillin. In the 1980s, the company had already started to specialize its production and to create a narrower product base. By acquiring the competitors, Borregaard became sufficiently large to focus on research

and development (R&D), and the Sarpsborg headquarters became the centre of R&D. The specialization strategy allowed the company to enter markets with more stable and higher prices.

The activities conducted in the headquarters in Sarpsborg are highly knowledge intensive, with a strong focus on R&D and ways to produce new and sustainable products from wood. In line with its strategy for specialization and increased value creation, Borregaard invests considerable resources in R&D; 3–4% of its turnover is used for innovation (compared with 0.5% in the traditional wood-processing industries), and 9% of Borregaard's employees work in R&D. This extensive investment in R&D is directed towards the development of value-added products from renewable raw materials. This explains how Borregaard has managed to upgrade its product portfolio and become a world leading biorefinery.

The restructuring of the product base has been a gradual process, and the company has developed from producing paper and pulp to becoming a spruce-based biorefinery focusing on wood chemistry and other selected niches of organic chemistry, using wood (mainly Norwegian spruce but also storm-felled wood from Sweden) as the main raw material. Today, Borregaard is one of the world's most advanced and sustainable biorefineries. Its production is based on renewable energy and is completely independent of fuel oil. The concentrated residues from the production processes are used for heat and power production, and the diluted residues are converted to biogas for its own heating purposes. In the end, only 2–3% of the raw material exits as waste.

The main strategy of Borregaard has always been to exploit the raw material in the best possible way. The business model thus focuses on exploiting the whole bioresource for value-added products. The company develops and supplies specialty products for a variety of applications in the specialty cellulose, lignin, fine chemicals and food additive industries. The raw material comes mostly from within a radius of 10 km from the headquarters in Sarpsborg, avoiding expensive and environmentally harmful transport and creating jobs locally. Nevertheless, transport/logistics comprise 1/3 of the cost of raw materials.

By using natural, sustainable raw materials, Borregaard produces advanced and environmentally friendly biochemicals, biomaterials and bioethanol that can replace oil-based products. The company also holds strong positions in the market for ingredients and fine chemicals. The activities are related to many value chains in the business ecosystem, and the end products are not produced alone but in co-operation with, and tailored for, the companies producing them.

Summary of Bioeconomy activities in Østfold

The Norwegian bioeconomy case study of the Østfold County is an example of a strong locomotive company dominating the bioeconomy activities in the region without significant regional cluster formation. The company, Borregaard, could be regarded as more globally/nationally based than a regionally based company. However, Borregaard contributes to the local environment through various development projects such as the Kunnskapsfabrikken (Knowledge Factory) initiative.

There is no significant regional cluster formation around Borregaard. Rather, the Borregaard company controls the whole value chain from extracting wood/ forest residues to the end products (e.g., cellulose, lignin, fine and basic chemicals, food ingredients, and ethanol). As such, Borregaard's overall organization resembles that of a cluster, where the parts of the value chain can be seen as a form of network that occurs within a geographic location, where proximity ensures certain forms of commonality and increases the frequency and impact of interactions.

The relative low average education level in the region does not seem to be a major challenge from the viewpoint of Borregaard, because its international brand and reputation allow it to attract highly skilled engineers. There is some co-operation with the local colleges to educate technicians to work at the plants.

Despite the global approach of Borregaard, support from the state-level support system (Innovation Norway) has been important for developing bioethanol in the region. Moreover, it should be noticed that the local forest owners that provide Borregaard with raw material for their production are important regional actors in the Østfold bioeconomy.

To achieve this, there is a need for updated regulations, good interaction between research and technology communities and those who apply the knowledge, and good interaction between research and society.

3.4 Sweden

Facts about the region

This case study focuses on the bioeconomy in the Örnsköldsvik region in Sweden. The focus is on the analysis of innovation in Green Growth and the bioeconomy, and the concentration of environmental expertise in the region.

Örnsköldsvik is located in Sweden, 550 km from Stockholm. There are approximately 55 000 inhabitants of Örnsköldsviks Kommun or the Municipality of Örnsköldsvik. The Municipality has a much larger population than the central town, as the municipality is vast with very large forest areas and minor areas of agriculture. It consists of several rural communities in the countryside.

Historically, the most important economic activity of Örnsköldsvik has been trade and heavy industry. The major industrial ventures include MoDo, a pulp, paper and logging enterprise established in 1903 by Frans Kempe´s company, Mo, and Domsjö AB. Another historically important industrial company is Hägglunds, a heavy industrial company. Currently, M-Real (formerly MoDo) operates a pulp mill in Husum, 30 km north of Örnsköldsvik City, and Domsjö Fabriker (another ex-Modo mill) operates a specialty cellulose mill in Örnsköldsvik. Other notable companies based in Örnsköldsvik include Svensk Etanolkemi (ethanol products) and Fjällräven (outdoor equipment and clothing). Today, a large part of the bioeconomy related activities in the Örnsköldsvik region form a cluster built around the pulp mill in Domsjö.

Figure 10. Örnsköldsviks region

Bioeconomy in the Örnsköldsvik region

Forestry industries have been important for the Örnsköldsvik area since the late 19th century. The bioeconomy concentration in the Örnsköldsvik region has a long tradition, originating from pulp mill activities in the early 20th century (especially the pulp mill in Domsjö established by Mo and Domsjö AB). The main products have been paper and pulp, with energy production from less refined parts of the raw material as a side product. The production of chemicals, chlorine and ethanol entered the scene in the 1930s, when the region's leading pulp & paper company established what can be seen as an early version of a biorefinery.

The Örnsköldsvik region faced a serious downturn period during the 1990s, when many local businesses closed, down-sized, or relocated to more central regions of Sweden. This resulted in the loss of around 5,000 jobs in the Örnsköldsvik region. However, the regional decline created among the local actors a sense of urgency to create new industries and jobs in the Örnsköldsvik region. The idea of building a cluster and technology park based on the novel biorefinery initiative, together with the increasing popularity and awareness of clustering initiatives, paved the way to regional biorefinery cluster formation in the Örnsköldsvik region. The cluster company Processum as early as 2003 started to gather the local and regional forces behind a joint clustering initiative in the field

of biorefining. The cluster development received an additional boost in 2005 when Processum received the first VINNVÄXT funding for the development work for the “Biorefinery of the Future”. In 2013, the industrial research institute SP (a Swedish equivalent of companies such as Germany’s Fraunhofer) bought 60% of sum shares.

The following table 3 and figure 11 list the major actors of the bioeconomy in the Örnsköldsvik region, with a focus on biorefining activities.

Sector/Activity	Main Actors
Key companies	Aditya Birla Domsjö Fabriker (pulp and biorefinery) Akzo Nobel (specialty chemicals) Holmen (Printing paper, paperboard, forestry and energy production operations) SEKAB (Ethanol R&D and production)
R&D, education institutes	Umeå University Mid-Sweden University
Clustering initiatives	SP Processum

Table 3 and figure 11: Main actors in the biorefinary cluster.

The Örnsköldsvik Biorefinery of the Future Cluster: a summary

SP Processum's and VINNVÄXT's "Biorefinery of the Future" project is the flagship of the Örnsköldsvik bioeconomy. The purpose of the Biorefinery of the Future is to accelerate development in the field of biorefining woody biomass in other words, together with its member companies, academic partners and the local community, to create, promote and invent products and processes based on lignocellulose feedstock in a triple helix setup (Industry-Government-University). To do this, 80% of the project funding is devoted to research and development. The majority of this is directed towards innovation and development rather than more fundamental research. All research is done in an open innovation network setting. The remaining 20% is devoted to building the innovation system. In the past three years, substantial resources have been devoted to scaling up promising projects. The project leaders have invested in a set of pilot equipment that can take technologies from the laboratory scale to a first demonstration scale and have created a regional test bed.

The Örnsköldsvik Biorefinery of the Future Cluster has 20 member companies. Most of the Cluster companies are in some way connected to the forest industry, the chemical industry or the energy industry. They base many new ideas on existing capital investments in the mills of the pulp and paper industry. A greenfield investment in an average sized biorefinery could easily amount to 1.5 billion euros.

For this reason, a large number of endeavors in biorefining are dedicated to turning existing mills and infrastructure into biorefineries. The same reasoning applies to energy sector utilities. The cluster's main strategy in biorefining is to improve the existing mills to create more value, new chemicals, and new materials, and to turn residual streams into products and thereby to increase both the economic efficiency and that of the feedstock usage. In other words, once woody biomass has been processed into the main product (e.g. pulp and paper), the number of complementary products and complementary streams in a biorefinery set-up are maximized. This process will also decrease the generation of waste from the production sites and improve the environmental footprint of the industry even further.

According to the evaluation of Processum (2014), biorefining and the bioeconomy are a focus for many regional development actors along the coast of northern Sweden, including the business incubator Åkroken in Sundsvall, SP Processum AB, Solander Science Park, ETC, Biofuel Region, Uminova and Bio4Energy. However, the current challenges include the administrative borders and the

awkward fact that for certain initiatives, Processum needs to apply for funding in each of three counties. In any case, biorefineries and the bioeconomy are well represented in the documents; for example, in the EU structural fund programs.

Processum has taken a specialist role in the regional innovation system for biorefineries. Three years ago, Processum hired a patent engineer, a function co-financed by VINNVÄXT and five member companies. Since 2011, 77 patents have been filed. The patent service is open to external regional partners. The fact that SP bought Processum is in itself an improvement and a change in the innovation system in Västernorrland. Processum now constitutes the first RISE (Research Institutes of Sweden) institute in the region.

Co-operation between the firms and other actors (municipality and academia primarily) regarding the cluster application of VINNOVA (funded by VIN- NVÄXT) was formalized as part of the establishment of the triple helix. The municipality has a responsibility for relations with other governmental actors (such as the county board) and can work on issues such as education and relationships with citizens. It is also important for the municipality to create a business environment where the firms feel welcome and can develop in the region.

2. Experiences in Western-European countries

2.1 United Kingdom

The BioVale: an innovation cluster for the bioeconomy

Yorkshire and the Humber has all the assets to become a leader in the bioeconomy, but these assets are not yet sufficiently integrated or linked together and gaps exist between the region's agriculture, industry and knowledge base. BioVale is a new initiative to respond to this by developing and promoting Yorkshire and the Humber as an innovation cluster for the bioeconomy, building on the region's unique combination of world-class science, innovative agriculture, and bio-based industry.

City of York Council is a founding member of BioVale, and is working in partnership with the University of York (UoY), Biorenewables Development Centre (BDC), Food and Environment Research Agency (Fera), Askham Bryan College, and businesses in the region, including AB Agri, Drax, and Croda, to develop new supply chains and attract new investment in the bioeconomy. BioVale provides a 'one-stop-shop' bringing together business and academia to support the development of

innovative, high value products and processes. It brokers a range of support mechanisms that include:

- Open access R&D and demonstration facilities;
- Training and exchange of skilled staff;
- Development of business growth space;
- Inward investment, trade and export;
- Advocacy with policy makers.

BioVale will also work with the Local Enterprise Partnerships (LEPs) and central Government to deliver against the objective that universities should play a stronger role in economic development and that cluster strengths should be used to stimulate regional growth. The BDC and UoY have already helped facilitate a Memorandum of Understanding between BioVale and Industries & Agro-Resources in France, and have brought forward a collaboration agreement with similar clusters based in Holland and Germany. This has led to joint research, sharing of facilities, and cooperation on developing new markets. Investments in BioVale are expected to catalyze the creation and safeguarding of 45 000 new jobs by 2025, as well as over £2 billion per annum additional economic activity to create a bioeconomy of over £12 billion in Yorkshire and the Humber.

Project Benefits:

- Four companies have recently relocated to the region from other parts of the UK, and the US, in order to access regional facilities and expertise.
- BioVale and Askham Bryan College have started a major project to improve bioeconomy workforce skills and will deliver specialized skills support for over 200 trainees by Summer 2015.
- The Biorenewables Capital Grant Scheme has secured £1 million of funding, over half of which is from Europe, to help regional businesses invest in innovative new equipment.
- BioVale represents local companies as a member of the Bio-based Industries Consortium: the private sector partner in the EU's Bio-based Industries Public-Private Partnership.

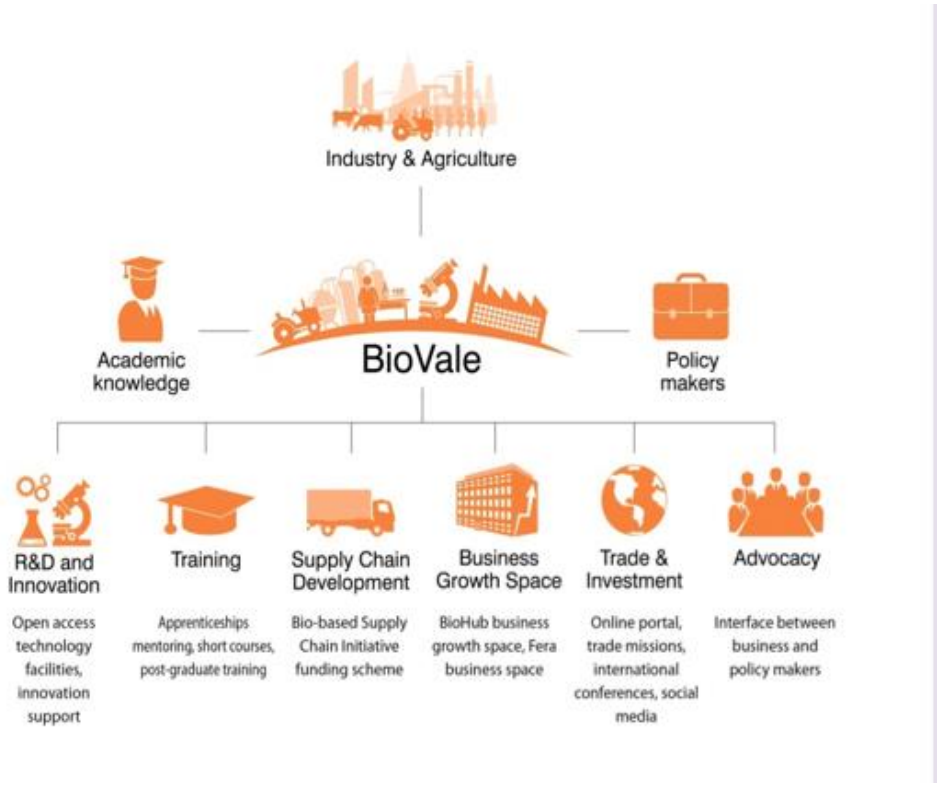


Figure 12. BioVale system

2.2 The Netherlands

Tomatoes Plant Waste Recycling

The Netherlands has a world leading horticultural sector. One of the main crops produced is tomatoes which are normally grown in greenhouses where the plants are trained vertically to grow to an average of 20m in length. Once the tomato crop is finished, in around October or November, there is a large amount of plant waste remaining in the form of tomato plants and stems. Disposing of this waste has, historically, represented a cost burden to vegetable growers who have to pay for its removal either for incineration or composting. In the case of composting, as the region has an abundance of organic waste from the horticultural industry, there is little additional value to be gained through the production of compost as a side stream. Therefore, a collective of organizations was formed to create new value chains by finding ways to use this waste stream more innovatively. This case study represents an integrated approach to isolate and/or convert the organic waste stream into products such as food, fibers, packaging and crop protection products.

Numerous sectors and companies were involved in the industrial development of the tomato-based by-products including; Smurfitt Kappa; Provalor; Koppert Biologics; TNO; Wageningen University; Biobase Westland; The Greenery; various tomato growers; the food industry; the packaging industry and recycling companies. This collective of companies, institutes and academics, worked together to develop innovative solutions in pre-processing technologies and screening methods to test for valuable bio-active compounds in the tomato plant waste. The different wastes that were considered included fibers from the plant stems, fluid, also from the plant stems which is rich in antibacterial agents and the tomatoes themselves which would otherwise be discarded if market price fell too low or if the tomatoes did not meet retailer/consumer requirements in terms of quality and appearance.

The cooperative focused on developing integrated approaches centered on development of strong value chains and creation of 'biomass hubs' to minimize the cost of transportation of biomass. To measure and evaluate progress different objectives were set. These included the development of feasibility studies to analyze technical development and economic viability; market research; business modelling of bio-based products in new supply chains; the development of communication strategies; trials of new products on the market and the co-development of strategies between growers and retailers. It was also necessary to invest in infrastructures for the collection, storage and refining of the organic waste streams.

Communication strategies employed to raise awareness of the initiative and its products included conferences, workshops and the production of newsletters. However, the difference in languages and cultures across industries did present a challenge in terms of establishing value chains. Furthermore, the concept of turning waste streams into food or feed products was a difficult to communicate to the public who are wary of the concept. At the time of publication, the project is approximately at half way point with the time frame running between 2012 and 2016. The initiative required an investment cost of approximately €15 million.

Project Benefits:

- Sustainable supply chain development
- Production and use of natural compounds for crop protection
- Conversion of costs into revenues

- Production of foods associated with health benefits (fibres)
- Contribution towards the development of a circular bioeconomy
- Additional business model for horticultural industry- increased profitability

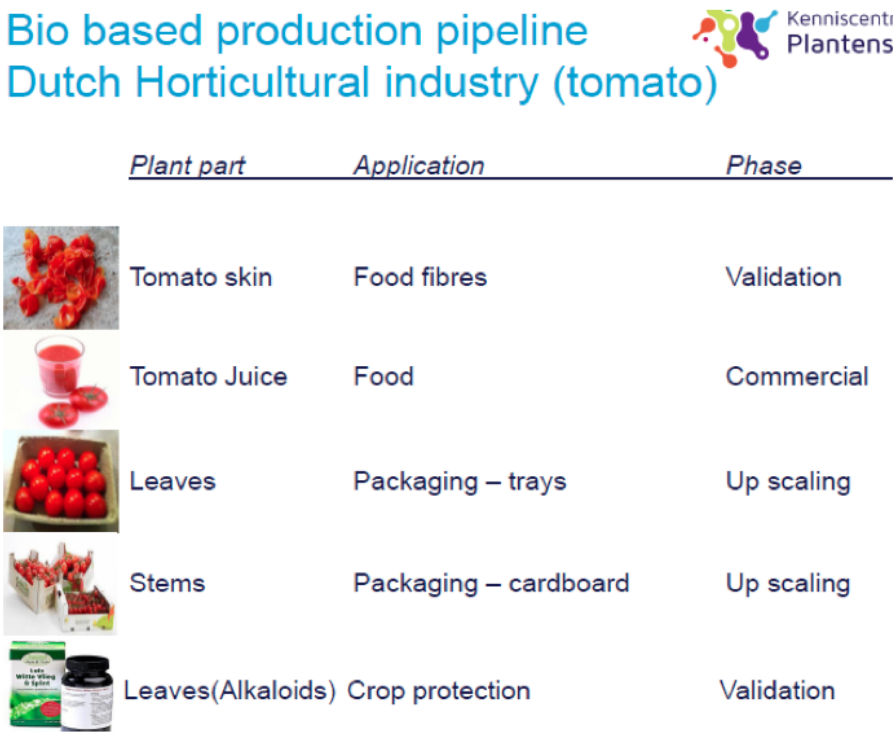


Figure 13. Biobased production pipeline from tomato by-products

2.3 Germany

Sunliquid Technology for the Production of Cellulosic Ethanol from Agricultural Residues

This case study highlights the development and commercialization of sunliquid, a cutting edge technology, which enables the conversion of lignocellulosic feedstock, such as wheat straw or corn stover, into cellulosic ethanol that can be blended with petrol and used as a transport fuel. Sunliquid was developed by Clariant, a globally operating specialty chemicals company based in Switzerland. The cellulosic ethanol produced by this process is an advanced biofuel with high greenhouse gas savings of about 95%, which, as it is produced from agricultural residues, does not compete with food or feed production.

The development of Sunliquid technology began in 2006 with first laboratory research and was soon up-scaled through the development of an initial pilot plant in Munich, which started into operation in February 2009. With the technology successfully developed at pilot scale a demonstration plant with an annual capacity of 1000 tons of cellulosic ethanol was constructed in Straubing, also in Germany, which became fully operational in July 2012. The demonstration plant has been confirming the technology on an industrial scale for about two years now. Based on the findings from this demonstration plant, a process design package delivering the technological blueprint for commercial production facilities with a capacity of 50 to 150.000 kt/a was finalized in 2013.

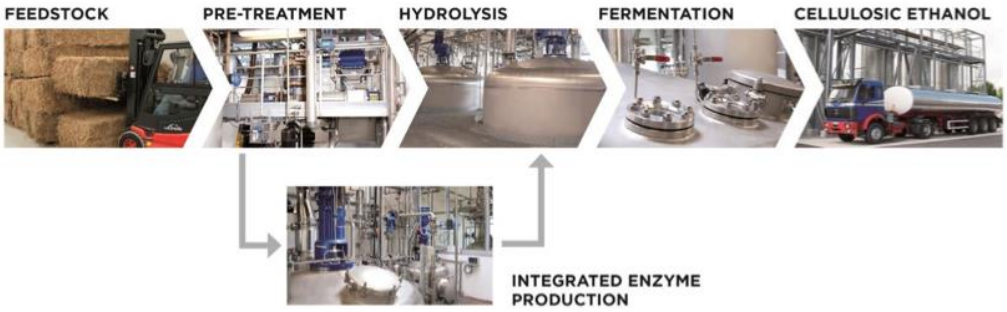


Figure 14: The Sunliquid process for the production of cellulosic ethanol from agricultural residues

Sunliquid provides the ideal technology to utilize this feedstock with a broad range of socioeconomic and environmental benefits across the EU. Several long-term studies, including a study published by WWF in 2012, have shown that depending on the region and prevailing local conditions, up to 60%

of the residual straw can be collected from the fields and made available for recycling without negative impacts on soil fertility. Furthermore, cellulosic ethanol from agricultural residues produced with the Sunliquid technology saves up to 95% GHG emissions compared to fossil fuels. Using the Sunliquid technology, 27 million tons of cellulosic ethanol could be produced per year in the EU which would be equivalent to the energy content of almost 18 million tons of fossil-based petrol. This means that around 25% of the EU´s demand for gasoline predicted for 2020 could be met by cellulosic ethanol produced in the EU.

As a result the production of lignocellulosic bioethanol is more broadly accepted. Its benefits are increasingly acknowledged in the diversification of farmer's incomes and in the potential to create jobs in rural areas whilst at the same time contributing a valuable solution to the challenge of mitigating the impacts of climate change and contributing towards EU energy security.

Investment and the Value Chain

In this case, the political objective in both Germany and the wider EU to reduce carbon emissions in transport through fostering the use of advanced biofuels has been the main market driver. As a leader in industrial biotechnology, Clariant has invested significant amounts in research and innovation. Furthermore, regional and national investments have played an important role in fostering and developing this technology. For example, the total project volume for the Sunliquid demonstration plant was €28 million: EUR 16 million in investment and just under EUR 12 million for accompanying research measures. The Bavarian state government and the German Federal Ministry of Education and Research (BMBF) have each put around EUR 5 million into this and other research initiatives relating to the project, the rest of the project volume is being covered by Clariant.

Recently, the European Commission approved funding for the project: "Sunliquid large scale demonstration plant for the production of cellulosic ethanol" under FP7 research program. The project is being realized by a consortium of 6 partners from different European countries, with Clariant being the Project Leader.

Several industries apart from the fuels sector are part of the value chain. This includes the agricultural sector where feedstock is sourced, the engineering sector that has been involved in the construction of the plants and the chemical and biochemical industry. Within the chemical industry, ethanol is also recognized as a chemical building block in the production of products such as bio-

based plastics, which provide an additional use of the cellulosic ethanol. This demonstrates the diversification of income and the creation of jobs in the logistics chain.

The novel and innovative Sunliquid process has overcome numerous technological challenges to enable the economic and sustainable production of cellulosic ethanol. Cellulosic ethanol is the first product based on agricultural residues entering the market. This is a huge step forward for the bioeconomy and provides an excellent case to demonstrate the positive benefits that the bio-based economy can have on an environmental, economical, technological and societal level. However, first investments in the production of cellulosic ethanol technology have been delayed due to ongoing regulatory uncertainty.

Benefits:

- The aim of the Fuel Quality Directive and the Renewable Energy Directive to reduce CO_2 emissions in the transport sector
- The potential to reduce CO_2 emissions by up to 95%
- Abundant, sustainably sourced feedstock (wheat straw)
- Potential to create up to 300 000 jobs and €15 billion
- Potential to supply 16% or EU fuel market by 2030
- Ongoing B2B and B2C communications efforts
- Consumer and manufacturer demand for lower CO_2 emissions from cars
- EU technological leadership in the field of lignocellulosic biofuel development
- National, regional and industry investment in demonstration biorefinery

3. Experiences in developing countries

Brazil, China and India were strategically selected into this report because they have a significant contribution for bioeconomy globally as shown in the figure 15 below. Building the Bioeconomy (2015). A part from the relevant case studies presented this document focused on the examination of evidences of success and failures in their enabling factors which to draw some final conclusions.

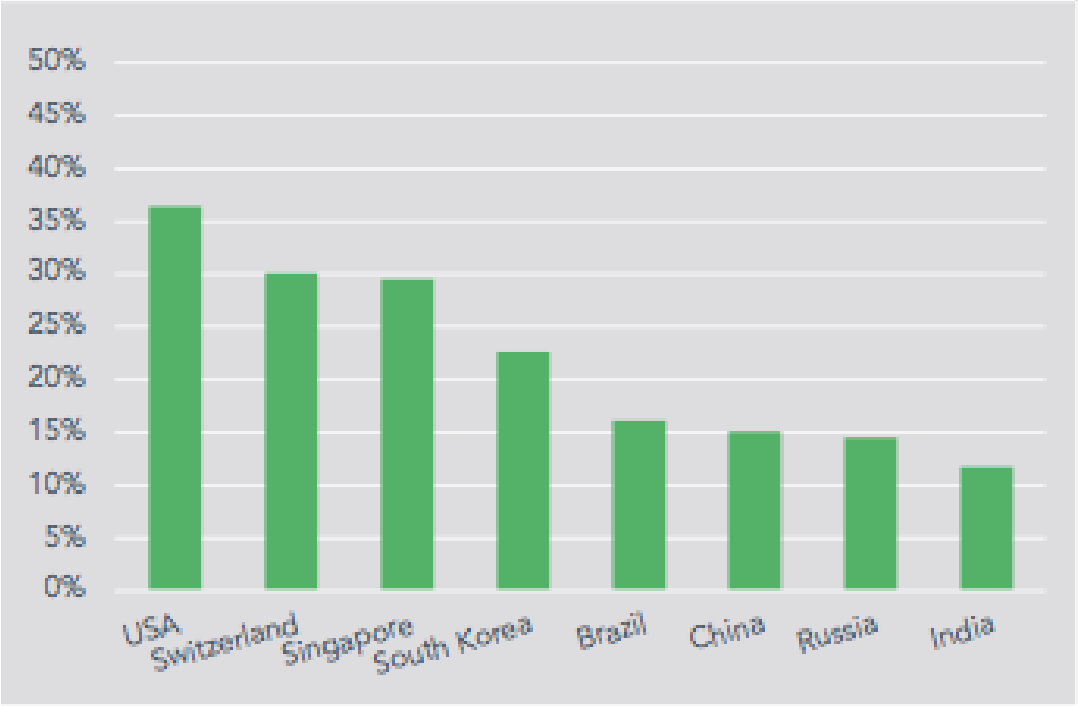


Figure 15. Position of countries sampled in Bioeconomy 2013. Building the Bioeconomy 2015

3.1 Brazil

Overall context

Brazil has a number of innovation policies in place both at the federal and state level with some form of national innovation policies and frameworks having been in place for decades. A number of important government institutions and agencies such as BNDES, FINEP and others have been supporting innovation and investment in Brazil since the 1970s. Some experiences of grouped enabling factors are detailed in the table 4 below.

Enabling factors	Success stories	Stumbling blocks
Human capital	• Growing research workforce; doubling in size since 2000 • Ciência sem Fronteiras (Science Without Borders) – promising program to build human capital	• Lack of a skilled work force • Low % of population in tertiary education
Infrastructure for R&D	• Relatively high level of R&D spending • Successful ag-biotech and biofuels partnership programs e.g. BNDES/FINAP PAISS and EMBRAPA-BASF Cultivance	• Health biotech sector capacity less mature than ag-biotech and biofuels • Funding conditions from government agencies • Challenging regulatory environment for clinical trials
Intellectual property protection	• WTO member and TRIPS signatory • 20 year patent term protection provided • 10 year minimum patent term period • RDP in place for agrochemicals	• ANVISA involvement in pharmaceutical patent examination process • RDP not available for biopharmaceuticals for human use • No patentability for isolated microorganisms, (e.g. bacteria and yeast) in industrial and environmental biotech
Regulatory environment	• Biosimilar pathway introduced • Relatively clear regulatory regime in place: ANVISA responsible for regulation of biologics and biosimilars and CTNBio responsible for biotech and GM products	• INPI long processing times and large backlog (estimated at 8-10 years)
Technology transfer frameworks	• Framework in place through 2004 Innovation Law • Patenting and licensing activities at universities and PROs increased sine 2004	• Tech transfer and commercialization still by international comparisons low • Universities have limited tech-transfer capacity • Publication requirements and registration of licensing fees
Market and commercial incentives	• R&D tax credits are in place through Law No. 11.196	• Some R&D tax credits limited through being contingent on issuing of patent – long backlogs at INPI reduce attractiveness • Strict biopharmaceutical pricing environment • Extensive use of IRP
Legal certainty (including the rule of law)	• Government anti-corruption push; new anti-corruption law introduced 2014 • Independent judiciary	• Patent disputes are resolved relatively quickly and preliminary injunctions are also granted, but overall the judiciary and many administrative bodies are over-burdened

Table 4. Enabling factors in Brazil. Source: Building the Bioeconomy 2015

Santa Cruz eco-industrial park

Santa Cruz eco-industrial park was the first EIP to be launched in the Rio de Janeiro Metropolitan Area (RJMA) and started its operations in September 2002. The fourteen Santa Cruz Industrial District industries located in Santa Cruz municipality signed an agreement with the state government and FEEMA in order to be part of the Eco-Industrial Sustainable Development Program (Rio ECOPOLO). It is expected that the conversion of this industrial district into an EIP will result in social, environmental and economic advantages to the parties involved. Details about Santa Cruz eco-industrial park, such as industries involved, byproducts, jobs and environmental achievements can be found in the table 5 below.

Industry/industrial sector	Byproducts	Jobs	Environmental achievements
Aciquimica industrial Ltda/recycling of non-metal scrap	Manganese sulfate; zinc, copper oxide; steam, wastewater	60	Air monitoring system, effluent treatment station (ETS), underground water monitoring system
Basf S.A. transnational/chemical industry	Solvents, acids, desiccants	277	Responsible care program, emergency control system, ETS, waste sorting and recycling
Casa da Moeda do Brasil/Brazilian banknote printing and coin minting	Ink sludge, galvanic sludge, plastic, paper, metal plates/dies	1975	ETS, plastic, paper, metal plate/die recycling, environmental training program
Ecolab chemical Inc/hygiene, sanitary products	Acetone, ethanol, acids, paper, cardboard, packing	125	Paper recycling, emergency control system, solid and liquid effluent treatment
Fabrica Carioca de.Catalisadores S.A/ petrochemical	Contaminated gas emission, effluents with ammonia and sodium compounds, sludge	220	Environmental, health and safety program, gas emission control system, ISO 9001, 14,001 certified, emergency control system
Gerdau – Cosigua S/A/steel mill	Iron scrap, metal slag, air particulates, oil	1700	Metal scrap recycling and reuse, 97.2% water reuse, ETS, environmental management system (EMS), air quality monitoring system
Usina Termoelétrica de Santa Cruz/electricity (natural gas power generator)	Solid waste, sludge, solid, gas and liquid effluents, ash, sulfur particulates	230	Air quality monitoring system, EMS, environmental, health and safety program, energy cascading
Latasa Ltda/aluminum – metallurgy	Aluminum slabs, other byproducts, VOCs emission, liquid effluents	136	Environmental, health and safety program, ISO 9001, 14,001, OHSAS 18,001, water reuse, aluminum slabs 100% recycled
Morganite do Brasil Ltda electronic equipment	Solvent, metal scraps	78	ISO 9001 certified, waste recycling program
Novartis Biocências S.A/pharmaceutical, baby accessories and food products	Solvents, hydraulic fluids, chemicals, plastics, paper, cardboard, glass	365	Solvent reuse; plastic, paper, cardboard, glass recycling; ETS, EMS
NUCLEP S.A/heavy nuclear-electric equipment, components	Grease, oil, sludge	530	ISO 9001, ASME, CENEN NE 1.16 certified, ETS
Pan Americana chemical S/A/chemical products	Aluminum, cardboard packing	58	Bureau Veritas QS, Responsible Care, ISO 9001/14,001 certified, ETS
SICPA chemical Brasil Ltda/paints and varnishes	VOC (volatile organic compound), effluents	240	Bureau Veritas QS, ISO 9,001 certified, EMS, VOC reduction system
Valesul Alumínio S.A./metallurgical (aluminum and aluminum alloy metallurgy)	SO particulates, dust, water with oil, spent pot lining (SPL), aluminum dregs	616	ISO 9,001, 14,001, BS 8800, OHSAS 18,001, aluminum recycling, air quality MS, SPL reuse as a energy generator

Table 5: Santa Cruz bio-industrial park: Source Building the Bioeconomy, 2015

The industrial diversity shown above and the existing organizational relationship are positive factors driving possible implementation of EIP strategies in Santa Cruz, such as: byproduct and waste exchange; energy efficiency; water reuse; and sharing of information, human resources and services such as training, canteen, recreational facilities, common warehouse facilities, transportation, marketing services and cooperation between the actors involved.

In order to make the EIP program feasible, an action plan defining the Santa Cruz EIP's main goals was developed:

- Byproduct and waste management program: implementation of a central waste and effluent treatment station serving the whole park; development of waste inventory; identification of possible synergies, reuse and recycling possibilities.
- Implementation of environmentally sound production practices, instead of end-of-pipe solutions.
- Recruitment of new industries, to achieve the right mix to facilitate industrial synergies.
- Air quality monitoring system: development of an integrative system to monitor regional air quality, which is a major problem for the industries to get their environmental licenses.
- Rainwater and surface runoff monitoring system.
- Development of an environmental management plan.

- Compensatory measures: planting native species in order to reestablish the site's ecological balance.
- Incentives to environmental initiatives in the park's surrounding area.
- Ensuring compliance to environmental regulations.
- Information, training and service sharing.
- Community socio-environmental initiatives: recycling program, social and educational programs.
- Energy efficiency, water conservation, environmental research and educational programs.
- Creation of a centralized management association, the Santa Cruz EIP Management Association (AEDIN)

Benefits

Many industries have found that environmental management practices do not increase costs and liabilities, posing a barrier to economic development. Just the opposite; they can yield positive economic, environmental and social returns. Unlike the experience in other places in the world, AEDIN did not have problems to encourage industries to make their input and output flows available. The byproduct and waste inventory database was to be the first step to enable implementation of byproduct and waste synergies]. Since 2002, some of Santa Cruz EIP's initial goals have been implemented: environmental practices; development of environmental management plan; planting native species; incentives to the local community to develop environmental initiatives in the park's surrounding area; compliance with environmental regulations; information and some service sharing, like canteens and recreational areas; community recycling program; social and educational programs; and finally the existence of a central management association, AEDIN, coordinating the whole program.

Moreover, participants related that there are competitive advantages for participating industries: improved economic efficiency, higher return on investment (ROI), increased environmental performance and reduced production costs.

With regards to main strengths, Santa Cruz was successful because of three main factors:

- Predominance of private sector in the planning and implementation of EIPs. In the RJMA, EIP pilot projects are being managed by the private sector with no public sector input or participation.

- The existing organizational relationship in the Santa Cruz EIP helped the industries to overcome initial barriers. The high group and management organization capacity, centralized in AEDIN, were positive factors.
- Industrial sector diversity would open up new paths to innovation, education and cooperation, leading to an increase in sustainable development awareness among the actors involved. The extant industrial sector diversity in the Santa Cruz EIP would allow the development of byproduct and waste synergies in the near future, besides services and process sharing. In Paracambi, the industrial mix was selected looking for possible byproduct and waste synergies.
- Human resources availability: there are plenty of unemployed and qualified workers throughout the RJMA.

Drawbacks

Despite the increasing awareness of sustainable development among the parties involved, much still needs to be done. For example, the byproduct and waste inventory has been concluded, but no waste exchanges have taken place. The lack of public and institutional commitment to promote the EIP's dissemination is making it hard for the Santa Cruz EIP to evolve the way it was initially envisioned only with the industries' support and work. The lack of knowledge and familiarity with the EIP concept and the possible benefits resulting from its implementation is also making the process slow.

Development of a specific EIP development strategy and methodology for Rio de Janeiro state, considering that it has different political, economic, environmental and natural resource constraints in comparison to developed nations.

An EIP label may be created and used as a marketing tool, leading to enhanced market image, increased market share and new market niche access.

Summary of Santa Cruz eco-industrial park

Inspired by experiences in Europe, North America and Asia, EIPs were launched in Rio de Janeiro as a potential environmental planning strategy to foster sustainable development and to improve the

degraded urban and environmental condition existing in the RJMA. From what has been accomplished to date, EIPs are at an early stage of development. Unlike what was expected, collaboration among governments, private institutions and industries, communities and academia, although a central issue to EIP development, has not evolved the way it should have. Changes in political administrations and public agency leadership caused the state government to withdraw EIP support, so the EIP idea has not become the environmental planning strategy for sustainable development that was expected.

3.2 China

Overall context

Chinese policymakers have for a number of years made innovation a central part of economic and industrial policymaking. The main policy instruments and planning tools include the "Medium and Long-term Plan for Science and Technology Development 2006- 20" launched in 2006 and the more recent Twelfth Five-Year Plan, 2011-2015". Both plans emphasize the need for China to grow its innovation capacity and have set ambitious general targets and sector specific ones, including for biotechnology. For example, the former set as a target the increase of R&D spending as a percentage of GDP to 2% by 2010 and 2.5% at a minimum by 2020. The plan also included economic growth targets linked to technological advances as well as emphasizing the need for the development of an indigenous high-tech capability through a policy of "indigenous innovation".

Enabling factors	Success stories	Stumbling blocks
Human capital	• Chinese universities becoming more competitive internationally e.g. Peking and Tsinghua • Highest number of university science and technology graduates in the world	• Relatively low level of researchers as a proportion of total workforce • Low level of tertiary education as % of population
Infrastructure for R&D	• High level of R&D spending – absolute and % of GDP • World leader in patenting activity	• Limited R&D clinical capacity: low levels of clinical trials • Low levels of basic and translational research investment
Intellectual property protection	• WTO member and TRIPS signatory • 20 year patent term protection provided • RDP in place NCEs	• Challenging enforcement environment: High rates of counterfeit medicines • No availability of RDP for biologics • Narrow patent protection for biologics
Regulatory environment	• SFDA has by comparison to other emerging markets extensive regulatory framework	• No biosimilar pathway • Regulation of non-innovative biologics outside international best practices • Regulatory requirements and procedures for clinical trials are onerous and delay product registration • Barriers for ag-biotech: i) product must be registered and approved in country of export prior to application for approval in China; and ii) import applications must include viable seeds • Indigenous innovation policies
Technology transfer frameworks	• Legal framework in place since early 2000s • University patenting increases by almost 50% per year • Increased tech transfer, licensing and spin-offs	• Quality of patent applications • Universities have limited capacity to fully commercialize innovations
Market and commercial incentives	• R&D tax credit available and reduced rates of corporation tax and VAT for qualifying high-technology enterprises	• Strict reimbursement policies have limited the number of biological drugs available
Legal certainty (including the rule of law)	• New government led anti-corruption push	• Legal redress, enforcement of contracts and administrative justice inconsistently available or applied

Table 6: Enabling factors in China. Building the Bioeconomy 2015

The Guitang Group and Guigang Eco-Industrial City

China produces 10.5 million tons of sugar annually from 539 sugar industries, the majority from sugar cane. Over the last few years, the sugar industry in China has experienced a significant economic decline. This industry has to increase its productivity to remain competitive with Brazil, Thailand, and Australia, three major sugar producing countries. Low prices for sugar on world markets in recent decades have eliminated the industry in former leading countries, including Hawaii and Puerto Rico in the US. Sugar production is becoming much less competitive in the Philippines.

The Guangxi Zhuang Autonomous Region, in the far south of China, is the largest source of sugar, producing more than 40% of the national output. The cost of producing sugar is high in Guangxi. Most farmers have small landholdings, productivity is low, and sugar content of the canes is low. Most refineries are smaller scale and fail to utilize their by-products. This gap causes them to lose secondary revenues and generate high levels of emissions to air, water, and land. The farmers burn the cane leaves every harvest season, generating air emissions. Ning Duan estimates that there are 70,000 families growing sugar in the Region and that there are 100 sugar mills. The economy of the town of Guigang is 50% dependent upon sugar related industries.

The Guitang Group is a state-owned enterprise formed in 1954 that operates China's largest sugar refinery, with over 3800 workers. The Group owns 14 700 ha 's land for growing cane. Though the sugar industry in China is generally responsible for high levels of emissions, this company has created a cluster of companies in Guigang to reuse its by-products and thereby reduce its pollution. The complex includes: an alcohol plant, pulp and paper plant, toilet paper plant, calcium carbonate plant, cement plant, power plant, and other affiliated units. The goal of the initiative is to reduce pollution and disposal costs and to seek more revenues by utilizing by-products. The following figure 16 shows the present flows of materials and water.

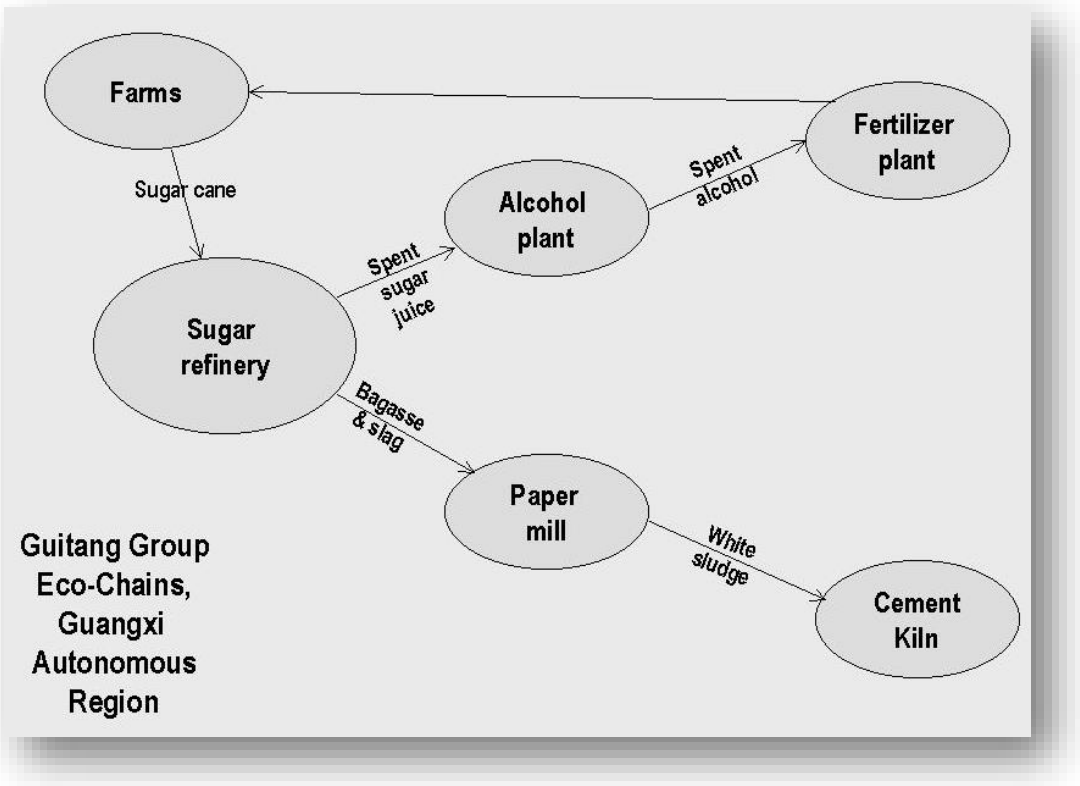


Figure 16. Flow of production of Guitang complex. Source: Building the Bioeconomy 2015

The output of the Guitang complex of companies is: 120 000 tons of sugar, 85 000 tons of paper, 10 000 tons of alcohol, 330 000 tons of cement, 25 000 tons of calcium carbonate, 30 000 tons of fertilizer, and 8 000 tons of alkali per year. In the late 1990s the secondary products accounted for 40% of company revenues and nearly as large a portion of profits and taxes paid.

The Guitang Group's plans for the future include expansions of the industrial ecosystem and changes in processes at various stages. This innovative plan includes:

- Construct a new beef and dairy farm using dried sugarcane leaves as feed.
- Construct a milk processing factory to make fresh milk, milk powder and yogurt for the local market.
- Construct a beef packing house to process beef, oxhide, and bone glue.
- Build a biochemical plant to make amino acid based nutrition products and other bio-products using the byproducts from the beef packinghouse.
- Develop a mushroom growing company using manure from the new dairy and beef farm.

- Process residue from the mushroom base to use on sugarcane fields as natural fertilizer.

China's expected entry into the World Trade Organization poses a major threat to the economy of Guangxi. With barriers to lower-priced imports lowered, the economy of this Region could be injured profoundly. So Guitang Group's eco-industrial initiative has strategic importance for this and other sugar producing regions in China.

City of Guigang Plans to Become an Eco-Industrial City

The Group's example has inspired the town of Guigang to adopt a five year plan to become an Eco-Industrial City. The heavy dependence of its economy on the sugar industry makes it important to improve the efficiency of its many processing plants. The plan calls for smaller sugar producers to send their by-products to Guitang's eco-industrial complex and sets targets for high by-product utilization. (Targets for the city: "utilization of sugarcane slag reaches more than 80%, use of spent sugar-juice reaches 100%, use of spent alcohol reaches 100%.") The plan also calls for consolidation of cane growing land into larger holdings. (It will require a transition for small farmers into other crops or into industrial employment.) It includes training of industry and government managers in eco-industrial principles and methods and broader dissemination of Cleaner Production strategies. Some of the long-term goals of this plan are:

- Develop an eco-sugar cane park to enable planting of organic cane, increases in sugar content of canes, increase in production per m^3 of land, and extend the harvest period.
- Enlarge the paper mill with a goal of increasing production to 300 000 tons per year in 3 phases.
- Switch some production from sugar to fructose, which has a strong market.
- Build a facility to produce fuel alcohol from spent sugar juice and sugar (capacity 200,000 tons per year). This product will help reduce air pollution from vehicle exhaust.
- Adopt low chlorine technology to bleach pulp. Paper made by this technology will be much whiter than the paper made by traditional technologies. (The Guitang Sugarcane Eco-Industrial Park Project website)

Guigang and the leadership of the town are supported by China's State Environmental Protection Bureau (SEPA) and the China National Cleaner Production Center (CNCPC). Ning Duan, Deputy President of the Chinese Research Academy of Environmental Sciences, has been a key advisor to the

Guitang Group. Financing is from the financial bureau of Guigang City. The local tax administration will return 50% of the agriculture tax to construction of irrigation systems for sugarcane farms.

Overall, Guitang Group approximates a relatively simple, idealized industrial complex model. Nemerow (1995) proposed just such an enterprise in his groundbreaking work outlining 15 models for by-product utilization, anchored by different primary plants. To the extent that the GG is— and continues to be—successful, it supports the validity of Nemerow's thesis. Ramaswamy and Erkman have reported a pattern parallel to the GG case in India, where Seshasayee Paper and Boards Ltd. mill faced a growing shortage of wood for pulping. There, the paper industry invested in a new subsidiary sugar refinery as a source of bagasse, which in turn contracted with an alcohol refinery and a methane generator to use the spent molasses. Seshasayee supported the conversion of regional farms to sugar cane production and supplied farms with treated water from both the paper and the sugar mills.

3.3 India

Overall context

In 2014 a new draft National Biotechnology Strategy was issued building on the 2007 draft. This Draft Strategy hopes to further develop India's biotech capacity by continuing the work commissioned and begun in the 2007 plan as well as targeting specific sub-sectors such as agricultural biotechnology which are now recognised as a priority. Overall the 2014 Strategy shifts the focus to the translational and developmental elements of biotech R&D. Out of the 10 guiding principles identified in the Strategy, four relate to translating R&D into tangible products and services and the targeting of areas of need in the Indian bioeconomy.

Enabling factors	Success stories	Stumbling blocks
Human capital	• High total number of academic papers published	• Low university rankings; outside top 200 generally and 100 for life sciences • Low rate of researchers as a percentage of population; lowest among the BRICs
Infrastructure for R&D	• Targeted biotech initiatives in place: Biotechnology Industry Partnership Programme and Small Business Innovation Research Initiative	• Low levels of R&D spending - 0.76% of GDP • Limited R&D clinical capacity: low levels of clinical trials • Low levels of basic and translational research investment • Limited R&D biopharma investment
Intellectual property protection	• WTO member and TRIPS signatory	• Section 3(d) and patentability requirements outside international best practice • No RDP • Use of compulsory licenses and patent revocations • Limited protection of plant varieties
Regulatory environment	• Biosimilar guidelines introduced in 2012	• High rates of counterfeit and substandard drugs • Regulatory authority for biopharmaceuticals and ag-bio is spread out over various layers of the Indian central and state government • Since 2011 no applications for field trials or commercialization of GM seeds approved
Technology transfer frameworks	• Incubators and tech transfer offices in place in some institutions	• Low rates of university patenting • Low rates of tech transfer • Not passed a Bayh-Dole type bill
Market and commercial incentives	• R&D tax credits and credits for special economic zones in place	• New 2013 Drug (Prices Control) Order place strict price controls on large number of biopharmaceuticals
Legal certainty (including the rule of law)	• New 2013 anti-corruption law, Lokpal Act	• Legal redress, enforcement of contracts and administrative justice inconsistently available or applied

Table 7: Enabling factors in India. Building the Bioeconomy 2015

Naroda Industrial Estate, Gujerat, India

Naroda Industrial Estate is one of the largest sites for eco-industrial development in the world. 700 companies with 35 000 employees operate on 30 km² of land. Naroda was founded in 1966 by the Gujarat Industrial Development Corporation, which also oversees 256 other estates. Industries at this estate include chemical, pharmaceutical, dyes and dye intermediates, engineering, textile, and food production. Naroda Industrial Association (NIA), including 80% of the companies, has founded a Charitable Hospital, a bank, and has constructed a common effluent treatment plant. It has also planted 30,000 trees.

The initiative at Naroda Industrial Estate is an industrial ecology networking project seeking a cooperative approach to achieve pollution prevention. Local leadership comes from the NIA and the Local Bureau of the Confederation of Indian Industry (CII). Researchers from University of Kaiserslautern are providing technical assistance and guidance in eco-industrial principles and methods. (The project is funded by the German Ministry for Education and Research.)

The effort began with a baseline survey of NIA members, focussing on material, water and energy usage. Local university graduates conducted surveys of 477 respondents and data was analysed in a geo-information system or GIS. This identified common environmental problems as a basis for designing individual projects for the participating companies. The Association convened open meetings in which the companies explored their needs, using a broad eco-industrial network framework proposed by Ed Cohen-Rosenthal (as we describe in Chapter 11 of the Handbook.) In these discussions they identified focus points for projects and created project teams with managers. Subjects of the first four projects were recycling of spent acid; recycling of chemical gypsum; recycling of chemical iron sludge, and reuse/recycling of biodegradable waste.

In the spent acid project four chemical companies planned to collect their spent acid (H_2SO_4) to produce Ferrous Sulphate ($FeSO_4$). Their combined by-product outputs would yield enough to attain the concentration necessary for the generation of Ferrous Sulphate. A fifth firm with the necessary technology and energy supply is doing the processing. The companies will pay half of usual waste disposal fees for the recycling. The recycling firm will create 10 new jobs.

The chemical gypsum project started with a company that discovered this by-product could be used in concrete production instead of incurring the costs of transportation and landfill tipping fees. Through project information channels three other companies with the same by-product joined the initial one. This group set up the logistics and a drying area for handling their common output. They are recycling 300 tons per month, instead of adding that mass to the landfill.

The iron sludge project involves producers of dyes and dye intermediates who generate large quantities of iron oxide in a form that is quite hazardous. The project team identified production process changes to reduce the volume of iron oxide and to reduce the hazardous impurities. Through the network this Cleaner Production solution has been shared with all the firms in this industry.

The food companies at Naroda, mostly small operations, collectively generate large volumes of food wastes (ca 100 tons per month). They have done a feasibility study to identify ways of utilizing this output, possibly through fermentation processes. As a group they could act to handle a problem that no one firm could deal with.

After these first four projects started 15 firms in the ceramic industry formed a fifth with a Cleaner Production (CP) approach to assuring purity of their input materials. They are jointly investing in a testing laboratory.

The Naroda stakeholders are interested in establishing an Eco-Industrial Networking Centre to disseminate and share their experiences and to help individual companies handle some of their internal CP issues. This would build upon the improved access to information, easier project management, and consideration of new recycling technologies the eco-industrial network has already achieved. This initiative at Naroda Industrial Estate has demonstrated that once isolated companies can work effectively in a collaborative approach and improve their environmental and financial performance.

PART III

SYNTHESIS OF THE CASE STUDIES:

ASSESSING POBI THROUGH ENABLING AND DISABLING FACTORS

1. Enabling and disabling factors against POBI factors

From the case studies described above, it can be concluded that they illustrate possibilities of bioeconomy by improving employment and regional growth, not only in an urban context but also in a rural environment. Yet, it is difficult to compare them in a straight-forward manner due to the diversity of sectors as well as the different geographical and socio-economical contexts they represent. Rather than comparing these experiences or simply ranking them, this report has selected and analyzed the core enabling and disabling factors that have impacted these initiatives and applied to Pobi program aiming to contribute to the first steps of it implementation through global these lessons learned.

Hence, through the selection of these factors, it has also been possible to create a framework for assessing Pobi's main features and therefore to test them against these factors that can also be seen as indicators of feasibility. These indicators reveled strenghs of this program, also weakness. These drawbacks, can be seen as an opportunity to improve this program characteristics. For this purpose, this report made useful recommendations and suggestions. It is important to highlight that this assessment is a preliminary conclusion through the author's observation together with Posintra's first impressions about Pobi.

Moroever, this assessment, which is a deliverable component of this report, can enable a second level of deliverables that can deepen broaden the understanding of Pobi with regards to its factors of feasibility such as: advanced SWOT analysis, surveys questionnaires, applications of approaches such as Multi Level Perspective and Stakeholder management.

The 10 case studies presented display 9 enabling and 6 disabling factors or indicators with respectively influences as follows.

Enabling factors	How it influences	Disabling factors	How it influences	Pobi assessment
Availability of Natural resources or raw materials	Catalyses competitiveness by creating a good cost/benefit relation	Difficult access or high cost of raw material resources	Disable competitiveness and it makes it difficult to compete on the global market.	+ Available biomass from forest and feedstock in Porvoo area
Co-operation and synergies between actors such as public-private partnerships, enabeling leadership of private sector and co-creation	Enables the learning process, exchange of innovation	Lack of co-operation or difficulty of connecting partners acting in a more "isolated environment"	Create more challenges for catalytic solutions	+ - Good history of cooperation with local actors, such as public sector and established organisations. However, a lack of private ownership as per the top-down approach from the public sector has to be revised in order to develop into a co-creation strategy
Industrial symbiosis	Allow interactions of innovative processes, values, prices and exchange of raw materials and deliveries.			+ solid experiences in Kilpilahti can add knowhow to future practices
Communication, branding with the concept of bioeconomy added to business strategies	Great communication and branding challenge today is related to the need to scale up the activities.			+ - Some private organisations already take advantage of communication to position its brands addressing sustainability challenges as the government itself through the National Strategy. However, other organisations should take advantage of this process.
Good access to economic activities and infrastructure	Create competitiveness	Location disadvantages: lack of accessibility to economic centers and infrastructure	Disable competitiveness by increasing the costs and lack of workers	+ Integrating the eco-industrial park in Kilpilahti where infrastructure are in place represent a strong advantage for Pobi

Presence of qualified workforce (preferably local) With sufficient educational level.	Enable immediate "hands on" processes with an "indigenous" and less expensive workforce	Lack of human resources Out-migration (particularly of young people)	Creates dependence of international workforce / increase costs / lack of local understanding. It has a negative influence on innovation.	+ - Presence of local work force, however it might be insufficient for future complex challenges.
Policy framework and governance in place	Creates vision, purpose, targets and engages a wide range of stakeholders within the process. In practice, it facilitates markets, infrastructure and action by consumers	Lack of a legal framework and weak governance	Disable processes and undermine the potential of skilful and creative organisations to join expertise and put them into practice and slow down transformations	+ The Bioeconomy National Strategy is one of the great incentives of Pobi to succeed
Funding	Catalyses opportunities for the market as a whole and make changes happen	Absence of funding	Disable development opportunities in the market and sector as a whole.	+ The EU Regional Fund is a main source of resources as a kick off of Bioeconomy.
Academic community / R&D	It open access to R&D and demonstration facilities And enables training and exchange of skilled staff	Absense of R&D	Lack of intelectual support to implement and succeed in initiatives.	+ - R&D from Aalto University in clean tech and Social applied sciences from Haga-Helia business school could create a pool of professionals orientated to Kilpilahti activities. Specific activities however may require more specialized knowledge.

Table 8. Pobi Assessment framework

2. Conclusion and recommendations

The analysis made against these factors or indicators suggests that Pobi has potential strengths and opportunities to succeed and a good level of feasibility. Yet, some factors have to be taken into account and developed in order to improve chances to achieve its aimed results. Among them, to empower the private leadership, and use the concept of bioeconomy into business strategies consist in more controllable measures that Pobi could support in a short-term perspective. However, from a long-term perspective, and external environment, Pobi would possibly influence and enhance the local workforce and knowledge production in specific issues in the Kilpilahti context.

As an advisory institution, Posintra plays an important role towards these improvements. Its participation can not only provide guidance for all parts involved but also helps to drive forward goals and coordinate activities in the development of the bioeconomy. This role can help to focus the needs of government, agencies and public bodies as well as of industry and other stakeholders. Ultimately, Posintra's main role is to understand and manage these stakeholders' priorities and expectations and converge them into a common vision of bioeconomy.

Based on this main role, this report produced the three recommendations and suggestion for implementation as follows:

1- To build a strong network among relevant stakeholders and therefore a conducive environment for Bioindustral park in Porvoo-Kilpilahti, by creating an effective multi-stakeholder platform. This would allow to redefine the paradigm of relationship between government, academia, industry and civil society to up scaling bioeconomy initiatives in a societal level, enabling a balanced ownership.

2- To defined and communicate properly clear objectives and guiding principles of bioeconomy in Kilpilahti to enable understanding and productive partnerships.

3- To impact on research and development and knowledge exchange from academic institutions and significantly wider understanding of emerging aspects of the bioeconomy, in particular those important for Kilpilahti activities in order to accelerate progress in this sector.

Suggestion for implementation: practical tools

Multi-level Perspective and Stakeholder Management consist in two proved effective tools largely used to address stakeholder's common understanding and participation as shown in the figures. In practice, these approaches would possibly permit:

1- To consider a wider range of factors that can contribute and undermine the implementation of Pobi, by carefully examining the three main levels in Pobi landscape, regime and niche.
2- To understand how common practices and social/cultural norms affect change promesses? and act upon it.
3- To comprehend how innovation can be developed in this given environment
4- To identify and map relevant stakeholders
5- To engage effectively with stakeholders in co-creation processes: meetings, development of clusters towards a common vision and understanding of priorities and actions.

Figure 17. Stakeholder Management framework

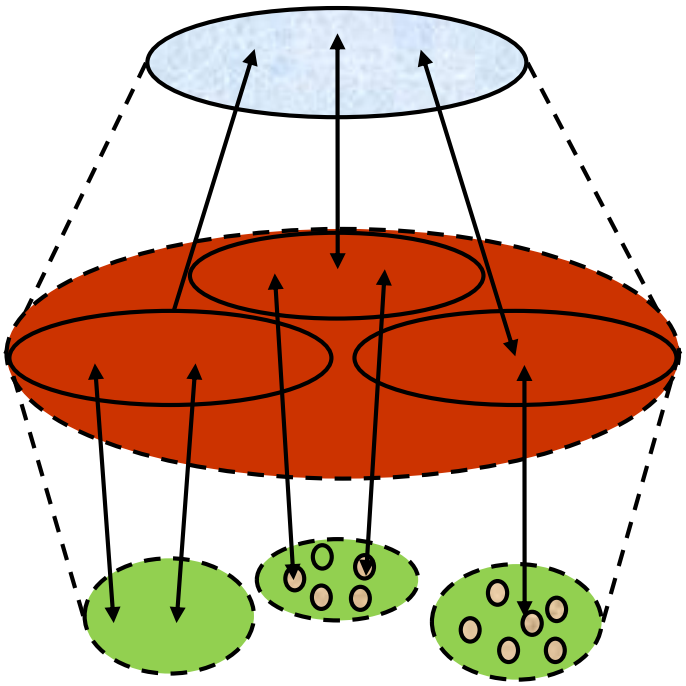


Figure 18. Multi level perspective framework

Appendices

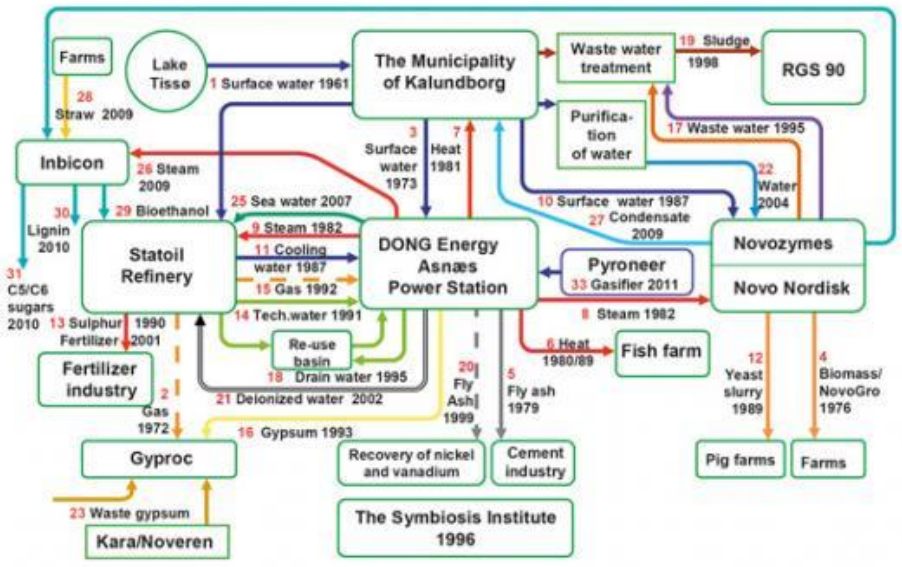
Other five experiences with bio-parks and industrial symbiosis

1- Kalundborg Symbiosis (Denmark)

The Kalundborg Symbiosis is an industrial ecosystem, where the residual product of one enterprise is used as a resource by another enterprise, in a closed cycle. An industrial symbiosis is a local collaboration where public and private enterprises buy and sell residual products, resulting in mutual economic and environmental benefits.

In the development of the Kalundborg Symbiosis, the most important element has been healthy communication and good cooperation between the participants. The symbiosis has been founded on human relationships, and fruitful collaboration between the employees that have made the development of the symbiosis-system possible. On the right, you can read about some of the most important lessons in creating and maintaining successful symbiosis that we have learned over the last four decades.

Source: http://www.symbiosis.dk/en/system



2- Kokkola – Finland

A successful experience in Finland involving most significant concentrations of inorganic chemistry. Kokkola (KIP) provides a complete, top-class operating environment for large-scale industry.

Characteristics:

- The Scandinavia largest concentration of inorganic chemistry companies
- 70 ha of inbuilt land zoned for heavy chemicals industry
- Decades of traditions, solid expertise
- Positive attitude towards chemicals industry
- Top-class logistics

Services performed:

- Rich commercial life, with emphasis on chemicals, shipbuilding industry,

ICT and laser/metal

- Areas: timber, trade, transport, the food industry
- About 150,000 persons inhabit the Kokkola regions employment area
- The area's increase in jobs has been Finland's fastest during the 2000's.
- Diversified and high-level educational opportunities.
- Approach

The area forms a powerful chemical industry cluster benefiting members through considerable synergies.

Raw materials. Being the home of diversified chemical industry, KIP's raw materials stock is outstanding.

Logistics and location. State-of-the-art transport connections to the world, the first covered All Weather terminal in the Nordic countries. The same track gauge is used all the way to China and the airport can be reached in 15 minutes. Kokkola is a safe and stable gateway to the East and the EU.

In Kokkola, operations run smoothly and briskly with seamless cooperation between the various

operators in the area. The atmosphere is pro-entrepreneurial and the chemical industry is welcomed with open arms. There is good supply of competent and committed labour. Source: http://www.kip.fi/Page.aspx?cid=1

3- Styria - Industrial Ecology – Austria

For several years no researchers identified industrial ecosystems comparable to Kalundborg. However, Erich Schwarz at Karl-Franzens-Universität Graz has discovered and studied a much larger, more diverse "industrial recycling network" in the Austrian province of Styria. The research started by tracing the by-product inputs and outputs of two major enterprises and soon found a complex network of exchanges among over 50 facilities. Industries participating include agriculture, food processing, plastics, fabrics, paper, energy, metal processing, wood working, building materials, and a variety of waste processors and dealers.

Materials traded in the Styrian network include the familiar recyclables like paper, power plant gypsum, iron scrap, used oil, and tires, as well as a wide range of other by-products. Schwarz does not report on activities relating to energy co-generation or cascading.

The plant managers in Styria were not aware of the larger pattern of exchange that had evolved spontaneously until the research team informed them of their findings. They were motivated purely by the revenues from by-products they could sell and the savings in landfill disposal costs for either sold or free outputs. In some cases the by-products are less expensive or of higher quality than primary materials would be.

The Styrian recycling network suggests that Kalundborg may be unique only in the level of awareness developed there. Dr. Schwarz and his research team are studying other spontaneously occurring industrial ecosystems (they call them industrial recycling networks) in Northern German. This research initiative is developing information system tools and business networks to extend the pattern of exchange further.

Source: http://www.eoearth.org/view/article/153824/

4- Biopark Terneuzen – The Netherlands

Sustainable growth, in the context of good stewardship of the environment and its resources, is one of the biggest ongoing challenges facing politicians and industrial leaders. Zeeland Seaports has identified a route that provides a uniquely innovative solution. Biopark Terneuzen represents a new way of thinking in the creation of agro-industrial sustainability. Under the 'Smart Link' heading, Biopark Terneuzen promotes and facilitates the exploitation of key synergies between businesses located in the same geographic area. Specifically, it helps to maximise the potential of the exchange and use of each other's by-products and waste products, which then become feedstock, energy or utility supplements for their own production processes.

Partners:

Biopark Terneuzen, BER / Holland Innovation, Cargill, DELTA NV, Dow, DSD, Econcern / Evelop, Express Energy / Bio2E, Gemeente Terneuzen, Ghent Bio Economy Valley, Goes on Green, HZ University of Apllied Science, Heros Sluiskil, ICL-IP, Impuls Zeeland, Lijnco Green Energy / Schücking, Nedalco, Provincie Zeeland, ROC Westerschelde, Sagro, Valuepark Terneuzen, Wageningen UR, WarmCO2, Yara, Zeeland Seaports

Source: http://www.bioparkterneuzen.com/en/biopark.htm

5- Brazilian Industrial Symbiosis Program - PMSI

In the constant quest for sustainable development of industries, FIEMG features of the Minas Gerais Estate Industrial Symbiosis Program - PMSI, a version of the British NISP (National Industrial Symbiosis Program), whose goal is to promote profitable interactions between companies of all industry sectors.

In practice, the program establishes business from underutilized resources that are available. Energy, water, materials and waste from industries can be recovered, reprocessed and reused. This is a great opportunity for business and all businesses, regardless of size or sector, can participate.

With the identification of opportunities in workshops, the technical team involved is working for the consolidation of major synergies. There are currently more than 280 possible synergies, which means hundreds of companies under negotiation. The opportunities are for wooden pallets, iron

scale, wood, electrical wires, food waste, laboratory tests, clay, fabric strips, metal scraps and others.

The resources that have not awakened interest in the workshops are stored in the bank data for future opportunities, if there is the emergence of demands in the next events.

The initial results, in addition to verifying the proper perspective of the project, show that industrial symbiosis has the potential to significantly reduce industrial pollution and mitigate adverse environmental impacts, while companies profit and develop new economic mechanisms.

Below, the results of PMSI until December 2012:

- 317 participating companies;

- 139 793 tonnes of waste diverted from landfills;

- 194 815 tons of reduced use of virgin raw materials;

- 87 476 tons of reducing carbon emissions;

- 13.65 million m^3 of reused water;

Source: http://www.fiemg.org.br/Default.aspx?tabid=1098

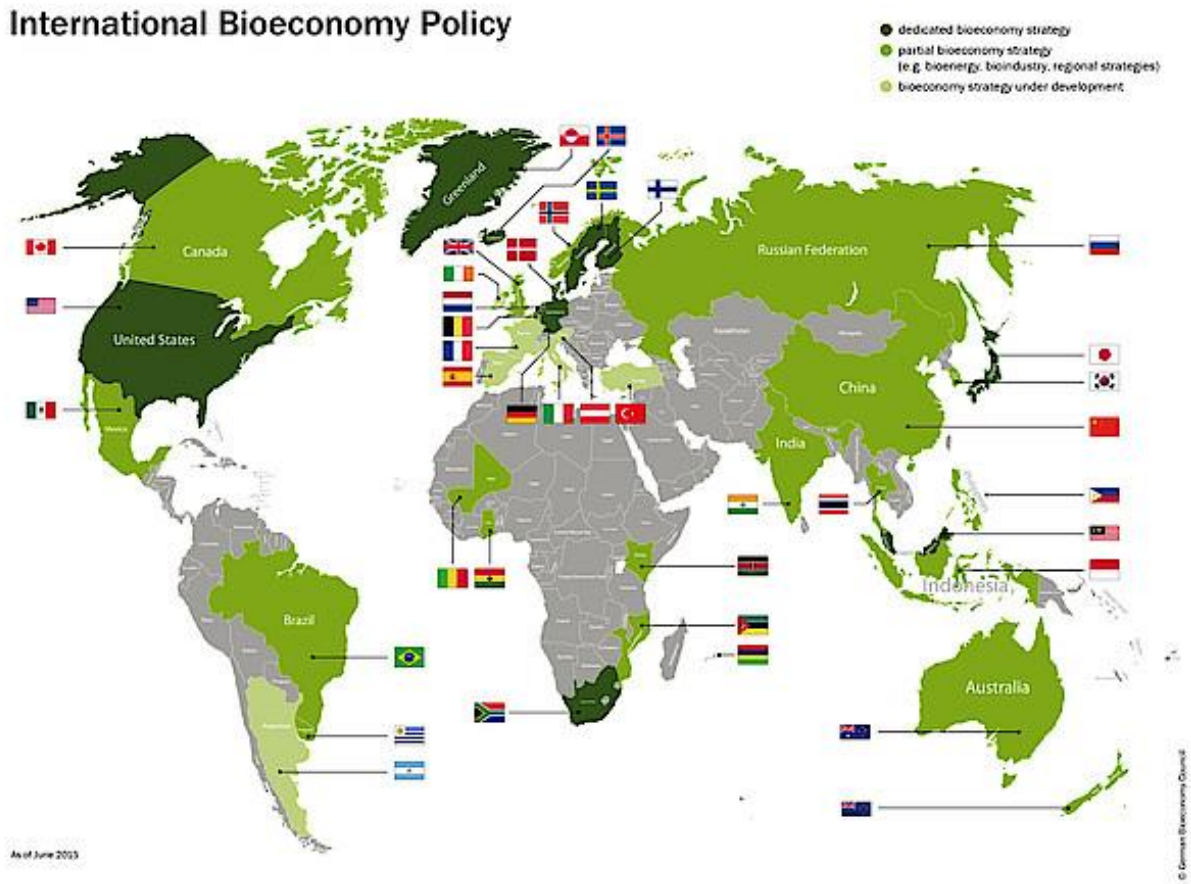


Figure 19: International Bioeconomy Policy

Country	Document	Policy aim / contents	Year
Belgium *(Flanders)*	The vision and strategy of the government of Flanders for a sustainable and competitive bio-economy in 2030	The Strategy contains 5 strategic objectives providing the framework for the (further) development of a Flemish bio-economy	2013
Canada *(British Columbia (BC))*	BC Bio-economy	The finding of the Bio-economy Committee, established in 2011, are presented along with recommendations for action by the BC government on how to accelerate the development of BC's bio-economy.	2011
Denmark	No specific strategy	Bio-based solutions encapsulated within the Government's growth plan for water, bio and environmental solutions.	2013
Finland	Finnish Bio-economy Strategy	The Strategy contains 4 strategic objectives providing the framework for the (further) development of the Finnish bio-economy	2014
France	No specific strategy	A variety of individual initiatives in the area of the bio-economy	'07-'14
Germany	National Policy Strategy on Bio-economy	To develop a coherent policy framework for a sustainable bio-economy	2013
Hungary	The future landscapes of bio-economy: Hungary	To deliver insights into the Hungarian bio-economy scene	2014
Italy	No specific strategy	A variety of individual initiatives in the area of the green economy	'08-'14
Sweden	Swedish Research and Innovation Strategy for a Bio-based Economy	To provide a national strategy for the development of a bio-based economy and to propose a Swedish definition of the term.	2012
The Netherlands	The Bio-based Economy in the Netherlands	The document presents the aims and scope of several bio-based initiatives undertaken in the Netherlands	2013
USA	National Bio-economy Blueprint	To lay out strategic objectives that will help	2012

Figure 20**:** Bioeconomy national strategies worldwide

References:

"Benchmarking Finnish and Dutch bioeconomy transition governance, (2014). Available at: http://www.drift.eur.nl/wp-content/uploads/2011/12/20141222-Benchmarking-Dutch-and-Finnish-Bioeconomy-Transitions-Final.pdf. Assessed on 15.09.15

Bioeconomy in the Nordic region: Regional case studies 2014 Available at: http://www.nordregio.se/en/Publications/Publications-2014/Bioeconomy-in-the-Nordic-region-Regional-case-studies/. Assessed on 20.09.15

Building a High Value Bioeconomy, 2015. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/408940/BIS-15-146_Bioeconomy_report_-_opportunities_from_waste.pdf.

Assessed on 20.09.15

Building the Bioeconomy, 2015: Examining National Biotechnology Industry Development Strategies Globally. Available at: http://www.pugatch-consilium.com/reports/Pugatch%20Consilium,%20Building%20the%20Bioeconomy%202015.pdf. Assessed on 26.09.15

Multilevel perspective approach towards transition. Available at: http://www.sciencedirect.com/science/article/pii/S2210422411000050. Assessed on 26.09.15

Other links for European cases on Bioeconomy:

http://ec.europa.eu/research/bioeconomy/pdf/where-next-for-european-bioeconomy-case-studies-0809102014_en.pdf

http://www.bio-economy.net/reports/reports.html

http://www.bio-economy.net/reports/files/building-a-bio-based-economy-for-Europe-in-2020.pdf

http://biooekonomierat.de/en/bioeconomy/international0/

"The Finnish Bioeconomy Strategy: Sustainable Growth from Bioeconomy".

Available at: https://www.tem.fi/files/40366/The_Finnish_Bioeconomy_Strategy.pdf. Assessed on 22.09.15

Euroopan unioni
Euroopan aluekehitysrahasto

Leverage from
the EU
2014–2020