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***Cross-clustering partnership for boosting eco-innovation
by developing a joint bio-based value-added network for the Danube Region***

Framework Conditions for Cluster Development in bio-based industry
in **Slovenia**

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Introduction

Slovenia is situated in the southern part of Central Europe and it covers approx. 20,273 km², with population of around 2 million. Slovenia's land area is mostly covered with forests (around 58 %) and is thus among the most forested countries in Europe. Due to great natural diversity, with

different climate conditions and relief structure, Slovenian forests have a diverse vegetation structure. Other basic features that determine the natural resource base, alongside forest cover, for the development of bioeconomy in Slovenia are permanent grassland cover and topography.

Table 1: Slovenia's country indicators

| | | |
|--|---|--------------|
| Size of the country | Total land area | 2,027,300 ha |
| | Utilised agricultural area | 30.5% |
| | Utilised forest area | 63.3% |
| | Nature protection area | 11.3% |
| Population indicators | Inhabitants | 2,063,768 |
| | Inhabitants per km ² | 100 |
| Economic indicators | Gross domestic product | 42,775 Mio € |
| | Gross domestic product per capita | 20,130 € |
| Energy indicators (2007) | Gross inland consumption | 307 PJ |
| | Total production of primary energy | 148 PJ |
| | Primary production of renewable energy | 31 PJ |
| | Biomass and waste | 60% |
| | Electricity from renewable energy sources | 22.1% |
| | Energy imports | 65% |
| | CO ₂ emissions per capita | 8,5 t |
| Availability of biomass resources (2007) | Theoretical potential | 1,104,794 ha |
| | Technical potential | 19,6 PJ/a |

Source: www.stat.si (2016)

Agricultural production is rendered difficult in one way or another on more than 70% of agricultural land in Slovenia, which means that Slovenia has relatively difficult conditions for agricultural production. Unfavourable conditions do not actually prevent agricultural production but do have severe negative impacts on the ability of Slovenian agriculture to compete and adopt (BERST, 2015). There are minimal efforts to introduce grass-based (e.g., *Miscanthus giganteus*) biomass for producing briquettes and pellets for heating, but production is on very small scale and not widely popular due to competition with arable land for food or animal feed production.

Biogas production in Slovenia is growing in small increments and it is currently behind national goal of 35 MW energy production (cogeneration system for heat and power) by 2020. Main sources for biogas production in the region are: agricultural waste, organic waste on municipal landfills, biodegradable waste from food processing industry, waste from public utilities and organic kitchen waste. Parallel to biogas use in the energy sector, Slovenia is yet to see increase in biogas or biofuel use in transport sector.

In light of this, the most important renewable energy source or biomass in Slovenia is wood and its by-products. Wood as biomass is mostly used in

energy sector (wood chips and pallets for heating) and pulp and paper industry. Efforts in the past have been made to exploit abundance of the raw material in the polymer industry, namely for the use of biopolymer production. Due to strong export lines of the raw wood local biomass use is still underutilised and in need of improvements. Breakthrough of competitive bio-based products (biopolymers, biochemical, phyto-pharmacies, etc.) has not yet been realised due to dominant role of research institutions, which produce scientifically important results, but don't turn those into profitable market driven products. In this regard Slovenia has good opportunities in for wood-based biomass for fuelling energy sector, paper and pulp sector and civil engineering sector (eco- or bio-base material production and construction). The use of biomass in the field of renewable energy sources has been gaining ground in the recent years. Energy utilisation of biomass constitutes one of the most important renewable sources in Slovenia. In regards to power generation from renewable resources, the highest growth rates were recorded in the use of landfill gas, which is accounted for by investments made in landfills, and in biomass use, which is increasing by yearly basis.

Table 2: Yearly installed capacities in MW

| | 2008 | 2009 | 2010 | 2015 | 2020 |
|------------------|------|------|------|-------|-------|
| Hydro | 10.1 | 21.2 | 34.3 | 211.8 | 452.3 |
| Biomass | 0.4 | 0.8 | 1.2 | 11.3 | 25.8 |
| Wind | 0.0 | 0.5 | 1.0 | 181.0 | 411.0 |
| Geothermal | 0.0 | 0.0 | 0.0 | 3.0 | 28.0 |
| PV | 1.0 | 3.5 | 7.0 | 34.0 | 119.0 |
| Biogas | 1.0 | 3.5 | 6.0 | 18.5 | 35.0 |
| Landfill, sewage | 0.5 | 0.5 | 1.0 | 4.0 | 8.0 |

Source: 4biomass project (2011)

According to an analysis, done by Slovenian Forestry Institute, potential of wood biomass in Slovenia are in scope of 450.000 tonnes of wood per year from forests. In long term we can count with 1m³ of wood biomass per ha of forest. According to the report, an important source of wood biomass for energy purposes is thin wood from thinning in early stages of forests. To develop stable and quality forest, regular thinning is necessary. Alongside primary wood biomass there are 120.000 tonnes of wood waste per year from abandoned agricultural land and 361.000 dry tonnes of wood waste per year from wood processing industry.

Slovenia is among the countries with the highest number of collected waste and management of recycling, but lacks better capabilities to treat different kinds of waste. A wide processing system is need in this regards. A new directive on waste determines an establishment of a system for separate collection in 2015 for at least paper, metal, plastic and glass. Slovenia already has such a system in place, but the results of separate collection are still far from those desired. In order to come close to those parts of Europe that are recycling resources efficiently, Slovenia needs to adopt measures designed to achieve the following goals from this directive:

- by 2020 the preparations for reuse and recycling of waste material – at least paper, metal, plastic and glass from households and where possible

from other sources, if such waste streams are similar to household waste – must rise to at least 50% of the total weight;

- by 2020 the preparations for reuse, recycling and material recovery – including infilling with waste generated by replacement materials, non-hazardous construction waste and demolition waste, with the exception of naturally present materials – must rise to at least 70% of the total weight. (Source: ARSO, 2015)

Slovenia has also made great strides to lower waste from construction related activities, which in 2011 contributed to 6 million tonnes (26%) of total produced waste. This figure was lowered to 4.6 million tonnes (18%) in 2013.

Key assets can be found in the primary biomass production (wood), chemicals & polymers (medical sector and automobile sector), and pulp and paper industries. All of the sectors thrive with different success relative to key points of cluster organization, actors, biomass supply, competitive bioeconomy products, funding and policies. With this in mind, Initial stage (IS) and Drive to maturity stage (DMS) are moderate or high according to cluster organization and actors (mainly policy and knowledge institutes). This changes, when we look at biomass supply (although this depends on the industry sector), funding, policies and bioeconomy products, with a low to moderate number of companies/clusters in the IS or DMS stage.

Table 3: Stage of development of relevant industries

| Key asset | Primary biomass sector | Food & Feed | Pulp & Paper | Chemicals | Polymers | Phyto-pharma | Textile & Clothing | Energy | Construction |
|----------------------------|------------------------|-------------|--------------|-----------|----------|--------------|--------------------|--------|--------------|
| Initial stage and take off | | | | | | | X | | |
| Drive to maturity stage | | X | | X | X | X | | | |
| Age of mature production | X | | X | | | | | X | X |

Source: DanuBioValNet (2017)

Current situation in the region

In terms of bioeconomy and bio-clusters it should be pointed out that in Slovenia, despite its potentials (solid resource base, vibrant SME sector with comparatively strong orientation towards green products, strong research and innovation activity in bioeconomy sectors and public financing thereof), bioeconomy is not yet mainstreamed as a policy priority. No bio clusters in a strict sense of the term exist in Slovenia. A number of clusters gathering R&D institutions and corporate sector were emerging in the country since late 1990s, with a strong Government support. Technology clusters in Slovenia (some of them developing potentials in bioeconomy sectors) are not operating within strict regional boundaries (BERST, Bio-Economy Regional Strategy Toolkit, 2014).

In May, 2009, Slovenia published a public tender for operational programme for strengthening regional development potentials in the 2007-2013 period. The objective was to establish and ensure the successful operation of Slovenian research centres of excellence at European and international level by using funds from the European Regional Development Fund and other funds. The main purpose of this cooperation was to acquire ideas, knowledge, experience, products, services and technologies to be used in Slovenia, and to improve the mobility of researches. Alongside mentioned masseurs, Slovenia also published a call related to Competence centres, with the main focus of connecting research and development centres with industry partners, and capacity to develop and use new technologies to develop new competitive products, services and processes in priority technological development areas.

(CoE and CC Instrument Evaluation, 2014)

Although we have yet to see emergence of bio-clusters in Slovenia other existing cluster have intertwined bio economics in their operations and strategic vision. Clusters, like Automobile Cluster of Slovenia, Wood industry cluster, Construction Cluster of Slovenia, and others, already employ research and innovative solutions to adopt their products and service towards circular economy and more sustainable production. This also reflects their willingness to place competitive bio-based products on the market. In terms of barriers for the development of the bio-based clusters we can extrapolate previous experiences, which correlate to relatively weak sense of ownership and lax internal organization, lack of funding (public funding is replaced with membership

fees), absence of long-term political commitment towards clusters, and shift of the organizational structure of clusters (shift from medium and large companies to small and medium companies).

First cluster program in Slovenia was designed with the objective to support the process of clustering in Slovenia by stimulating continues technology and manufacturing change. The program was part of the Slovenia's Entrepreneurship and Competitiveness Policy in the period 1999-2004. Public support of cluster development was seen as strategic and considered as an important tool for enhancing or reinforcing competitiveness of the Slovenian economy. Even though the program was not dedicated towards bioeconomy, program saw to rise of networks of SMEs in the area of wood, plastic, automotive, tool making, construction, energy and environment. These cluster became desired partners in international consortiums and networks, and were regarded as a good example of inter-company cooperation in Europe (Poly4Eml, Biopolymers for Emerging Industries, 2014).

During the next period (2004-2009) Slovenia slowly became disconnected from the EU cluster development path. Cluster development in terms of its capacity to facilitate development of new value chains and support industrial transformation was hampered. Entrepreneurship program saw a change from horizontal policy approach to a vertical approach, thus also changing means of funding and priorities - cluster organizations could no longer be funded. In the following period (2009-2013) focus was shifted to Centres of Excellence and Competence centres, aimed at promoting specialization and higher investment in key technology areas of crucial importance for the Slovenian economy. Even though research related to bioeconomy was on a very high level, the horizontal approach in forming clusters was however too weak, focusing too much on branches of one sector (Poly4Eml, 2014). Public support towards bioeconomy strengthened in period between 2014-2016, and adaptation of Slovenia's Strategy for Smart Specialisation (S4) helped prioritized aspects of bioeconomy in its Strategic priority 4 ("smart use of resources"). It also borrows results and key findings from the EU clustering project initiatives BERST and Poly4Eml, which addressed the challenge of Slovenia's innovation policy model.

Table 4: Key asset evaluation for Slovenia

| Key asset | Primary biomass sector | Food & Feed | Pulp & Paper | Bio Chemicals | Bio Polymers | Phyto-pharma | Textile & Clothing | Renewable Energy (biomass, biogas, biofuels) | Eco-Construction |
|--|------------------------|-------------|--------------|---------------|--------------|--------------|--------------------|--|------------------|
| Cluster organization | X | | X | | | | | | X |
| Enterprises | | | | | | X | | X | |
| Policy makers | | | | | | | | X | |
| Knowledge institutes | | | | X | X | | | | X |
| Biomass supply | X | | X | | | | | | |
| Competitive bio-based industry product on the market | | | | X | X | X | | X | X |
| Funding | | | | | | | | | |
| Policies, programs and regulations | | | | | | | | X | |

Source: DanuBioValNet (2017)

Even though the market percentage of bio-based products in Slovenia is relatively small compared to other commercially available products and mainstream alternatives, there are a few Slovenian companies/producers, who offer bio-based products alongside main product lines. In phytopharmacy sector companies like Cinkarna d.d., Karsia Dutovlje d.o.o. and Unichem d.o.o. offer bio-herbicides and bio-pesticides alongside more traditional product lines. In polymer sector Plastika Skaza d.o.o. is involved in producing bio-alternatives to their main products and is looking into further research and development options in this sector. Furthermore, most of the producers of prefabricated homes or constructions, which are

gathered under the umbrella organization Section of Slovenia's prefabricated home producers, have in their portfolio eco-friendly products/houses made from bio-based materials and building blocks (from wood-based panels to bio-insulation materials).

The potential exploitation of solid biomass is still high in Slovenia, due to abundance of land covered with forests. This can be incorporated in the field of medical devices, biopolymers and advance bio-composites, renewable sources based on biomass, agriculture, phytopharmacy, food production and packaging, and wood-based energy efficient construction.

Regional Bio-based industry Strategy

Due to lack of statistical values in the bioeconomy sector, which could provide a clearer picture, the following table contains statistical indicators taken from the BERST project (for the period 2014). It conducted thorough analysis and includes

indicators from Eurostat, RIS (Internet usage in Slovenia), National statistics and a correction of regional values compared to national values (standard deviation).

Table 5: Statistical values in the bioeconomy sector for Slovenia in period 2010 - 2014

| Criteria | Indicator | Region | |
|----------------------|--|--------|------|
| | | 2010 | 2014 |
| Land use | Forestry land (% of total land area) | | 18,6 |
| | Agricultural & horticultural land (% of total land area) | | 23,5 |
| Biomass availability | Agricultural biomass production (kg/capita) | | 2,38 |
| | Blue biomass production (kg/capita) | | 0,0 |
| | Forestry biomass production (kg/capita) | | 1,4 |
| | Waste production (kg/capita) | | 0,08 |
| Innovation | SME birth rate (% of total firms in region) | | 18,8 |
| | R&D expenditure (index (EU = 1)) | | 0,51 |
| | R&D employment (% of total employment in region) | | 05 |
| Cluster size | Firms in total bio-based industry sectors (% of total firms in region) | | 19,8 |
| | Employment in total bio-based industry sectors (% of total employment in region) | | 20,8 |
| | Firms in primary biomass sector (% of total firms in region) | | |
| | Employment in primary biomass sector (% of total employment in region) | | |
| | Firms in food & feed sector (% of total firms in region) | | |
| | Employment in food & feed sector (% of total employment in region) | | |
| | Firms in paper & pulp sector (% of total firms in region) | | 2,0 |
| | Employment in paper & pulp sector (% of total employment in region) | | 2,1 |
| | Firms in chemicals sector (% of total firms in region) | | 0,9 |
| | Employment in chemical sector (% of total employment in region) | | 3,4 |
| | Firms in polymers sector (% of total firms in region) | | |
| | Employment in polymers sector (% of total employment in region) | | |
| | Firms in phyto-pharma sector (% of total firms in region) | | |
| | Employment in phyto-pharma sector (% of total employment in region) | | |
| | Firms in textile sector (% of total firms in region) | | 0,9 |
| | Employment in textile sector (% of total employment in region) | | 1,2 |
| | Firms in energy sector (% of total firms in region) | | 0,2 |
| | Employment in energy sector (% of total employment in region) | | 0,9 |
| Quality of workforce | Secondary & Tertiary education in bio-based industry (% of total population in region) | | 85,5 |

Source: Statistical office of Slovenia, EURSTAT, RIS, BERST project (2014)

Slovenia is yet to adopt a regional Bio-based industry strategy and needs to improve public support to be in line with smart use of resources that was set in the Strategy S4 by the Government office for development and European cohesion policy. Even though there is no bioeconomy goals set out, it should be noted that the Strategy S4 promotes networks for the transition to circular economy, connecting stakeholders into value chains according to the principle "economy of closed material cycles" to development new

business models for the transition to circular economy. Focus areas and technologies are divided into:

- Technologies for sustainable biomass transformation and new bio-based materials
 - Technologies for use of secondary and raw-materials and reuse of waste
 - Production of energy based on alternative sources
- S4 summarizes the key strengths, weaknesses, opportunities and threats (SWOT analysis) of Slovenia's economic, research and development

innovation system. The relevant strengths, weaknesses, opportunities and threats, which are presented in more detail in the supporting document, served as the basis for identifying the S4 concept and the relevant policy mix.

- Diversified economic structure → potential in terms of complementarity and the provision of integrated solutions.
- High level of research and development activity (RDA) in the business sector.
- Good research and development (R&D) capacity and potential in the public sector.
- Strong involvement of Slovenian stakeholders in international value chains and networks.
- High productivity of well-managed companies, including subsidiaries of multinational companies in Slovenia, in particular those with preserved function of development.
- Areas of excellence in academic and industrial research.
- Educated labor force, language skills and willingness to learn.
- Comparatively intensive research, development and innovation (RDI) policy over the past 15 years and a stimulating tax environment for RDI.
- Well-developed infrastructure/internet accessibility.
- High-quality living and working environment, and resources for the transition to green economy:
 - security
 - clean and healthy living environment, preserved biodiversity, natural resources
 - developed tourist infrastructure and tradition and cultural heritage
- The awareness that structural changes are needed is gradually growing → this is reflected in the gradual innovation-related changes (e.g. in terms of companies being prepared to cooperate with each other). (Source: Slovenia's Smart Specialization Strategy, 2015)

Poly4Eml initiative was established in context that cluster platforms can be perceived as an effective approach for promoting entrepreneurship and

to develop emerging industries. It also covered creation of various tools and services to integrate demand and innovative solutions along selected value chains that can further serve as a policy mix to support emerging industries through clusters. Even though biopolymers were used as a base case to develop a policy model, this could be extended to different emerging bio-industries, as well to serve as a model for further regional implementation of the Slovenia's Smart Specialisation Strategy (Poly4Eml, 2014).

In the scope of Poly4Eml following value chains have been noted and in the scope of this report expanded to include:

1. Advanced Packaging
2. Advanced Packaging for Food
3. Advanced Packaging for Food (selective barrier materials)
4. Advanced Packaging for Pharmaceuticals/ Cosmetics
5. Coatings and Adhesives Applications
6. Thermal Insulation Applications
7. Automotive
8. Biopolymer-based automotive components
9. Wood-Polymer Composites
10. Wood hybrid composites for construction

Proposed value chains should be at the core of the yet to be established strategy to engage the Slovenian bioeconomy.

Cluster (Automotive Cluster of Slovenia) and Centre of excellence (PoliMaT) were partners in the Poly4Eml, and both were included in its Value chain voucher scheme, which proved to be an effective instrument to help SMEs and entrepreneurs to get access to most desirable support services. Also, the Poly4emi deliberations suggested that a voucher scheme which is managed by private SME intermediary organizations can be much more effective due to a number of factors: fewer administrative issues, better understanding of the target groups and much better alignment of the voucher objectives with the broader scope of programme (Poly4Eml, 2014).

Strategy implementation

Even though Poly4eml demonstrated that cluster management could play a critical role in emerging industries, it did not have a long-term impact on the policy support. It showed that investment in key enabling technologies with the highest multiplier effect is an important priority for Slovenian National Research and Innovation Policy and has already been expressed in the strong support of bio-cluster development in previous years. The key challenge is how to further stimulate vertical integration, create new value chains and best support the opportunities arising from cross-cutting issues. Efforts are needed to improve conditions for bioeconomy innovation and growth. Alongside this, new

policy models need to be based on a systemic approach. Lack of knowledge and effectiveness of policy support measures as well as capability to address challenges are main constraints (ESCA report, 2014).

Bioeconomy provides a huge potential for the development of bio-based products, with the potential in wood-based constructions and products, and industrially available biopolymers (these include cellulose, starch or lignin) or biopolymers produced from agricultural and forestry materials through application of new technologies or techniques.

Future challenges for cluster development in bio-based industry

Even though there is no bioeconomy policy or programme framework in place, that would address bio-industry as a whole and promote vertical alignment within bio-sector, general conditions for the development of Slovenian bioeconomy are favourable. To develop a perfect strategy for establishing bioeconomy in a region through a systematic approach a combination of following dimension should be implemented: bioeconomy as a strategic policy objective, involvement of relevant actors in the policy development process, financial support through thematic and generic programmes, innovation hubs, clusters as catalysts and cross-border collaboration (ESCA report, 2014).

Future policies should address the prevailing attitude of the cluster organizations, who see themselves as more research and innovation oriented entities, rather than part of industrial networks with common strategic objective. In the past, these types of organizations already developed good bio-based products and services, but lacked the necessary structures and to capitalize on it with breakthrough on the market. Bio-clusters and even

traditional clusters, for that matter, should approach organizational division with clear membership conditions and provide better ("enriched") services to cluster participants. They should also promote a long-term objectives and own strategies that link different projects within cluster network, and have in place a clear idea what kind of benefits (services) they can provide cluster members

Public support and bioeconomy policy framework should be aimed to boost entrepreneurship and SME growth in bio-based industry, and in broader sense linking emerging industries with research and innovation institutions (i.e. Centres of Excellence and Competitive Centres). The main role of bio-based clusters should be aimed at development new international and transnational linkages in bioeconomy sector and address new bio-based value chains. Bio-oriented framework should provide means to develop and promote bio-cluster excellence. For interconnected bio-business it should be pointed out, that meaningful support services are crucial to tackle problems raised by bioeconomy emergence and rise in the future.

Annex

Definitions/Glossary

Clusters: Clusters are generally described as groups of specialised enterprises, often SMEs, and other supporting actors in a particular location that cooperate closely together.

Cluster initiatives: A cluster initiative is an organised effort aiming at fostering the development of the cluster either by strengthening the potential of cluster actors or shaping relationships between them. They often have a character like a regional network. Cluster initiatives usually managed by a cluster organisations.

Cluster organisations: Cluster organisations are entities that support the strengthening of collaboration, networking and learning in innovation clusters and act as innovation support providers by providing or channelling specialised and customised business support services to stimulate innovation activities, especially in SMEs. They are usually the actors that facilitate strategic partnering across clusters. Cluster organisations are also called cluster managements.

Cluster participants: Cluster participants are representatives industry, academia or other intermediaries, which are commonly engaged in a cluster initiative. Given the case a cluster initiative has a certain legal form, like associations, cluster participants are often called cluster members.

Cluster policy: Cluster policy is an expression of political commitment, composed of a set of specific government policy interventions that aim to strengthen existing clusters and/or facilitate the emergence of new ones. Cluster policy is to be seen as a framework policy that opens the way for the bottom-up dynamics seen in clusters and cluster initiatives. This differs from the approach taken by traditional industrial policies which try (and most often fail) to create or back winners.

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