Distributed Bio-Based Economy

– Driving Sustainable Growth

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Preface

Bio-economy is here to stay. It is much more than just biomass-based production or biotechnology. Bio-economy is a societal strategy to combat climate change and the increasing scarcity of natural resources. Accordingly, we should not only view bio-economy as a new business sector but also consider the wider spatial and material flow aspects of increasing bio-based production.

The goal of this publication is to raise discussion on the distributed bio-economy as part of the future societal and economic system. How does bio-economy build up spatially? What is the path to a resource efficient bio-economy?

In the vision of distributed bio-based economy of year 2050, the well-being of people is based on the sustainable and versatile use of renewable natural resources and their high added value, as well as creative know-how. Much can already now be done to reach the vision but the paradigm change requires radical changes in thinking and decision-making. The world of distributed bio-based economy is a world of opportunities. Sustainable solutions will yield interest faster than we think.

Eeva Hellström
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Sitra, the Finnish Innovation Fund

Sitra, the Finnish Innovation Fund´s Landmarks Programme (2010–2014) identifies future needs and seeks new ways for the countryside to respond to challenges related to climate change and the new faster-paced, mobile way of life. The Programme accelerates profitable business based on local solutions of the green economy.

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Limited resources – infinite opportunities

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Population growth, increased competition over natural resources and climate change – many of these changes were once seen as problems. However, when looking back in time in 2050, more than troubles, they have created new business models and consumption patterns. Especially, they have contributed to the development of the distributed bio-based economy. Our town, for example, is nearly self-sufficient in terms of nutrients, food and energy. Yet, we trade actively in the global market, allowing us access to commodities that are produced more efficiently elsewhere.

1.1 The vision: Our town

It is a warm and dry day in 2050. The windows of huge greenhouses glitter in the morning sun as coaches pass silently transporting people from home to work. A network of train tracks built above streets connects the town to nearby communities and bigger cities. The town center is busy with people, and a group of school kids has gathered around the statue in the central square. The statue used to be a fountain but it was renewed when water consumption was limited in the town. Although water resources are scarce, they are still sufficient for the town's needs, thanks to the well-functioning biological treatment and recycling systems.

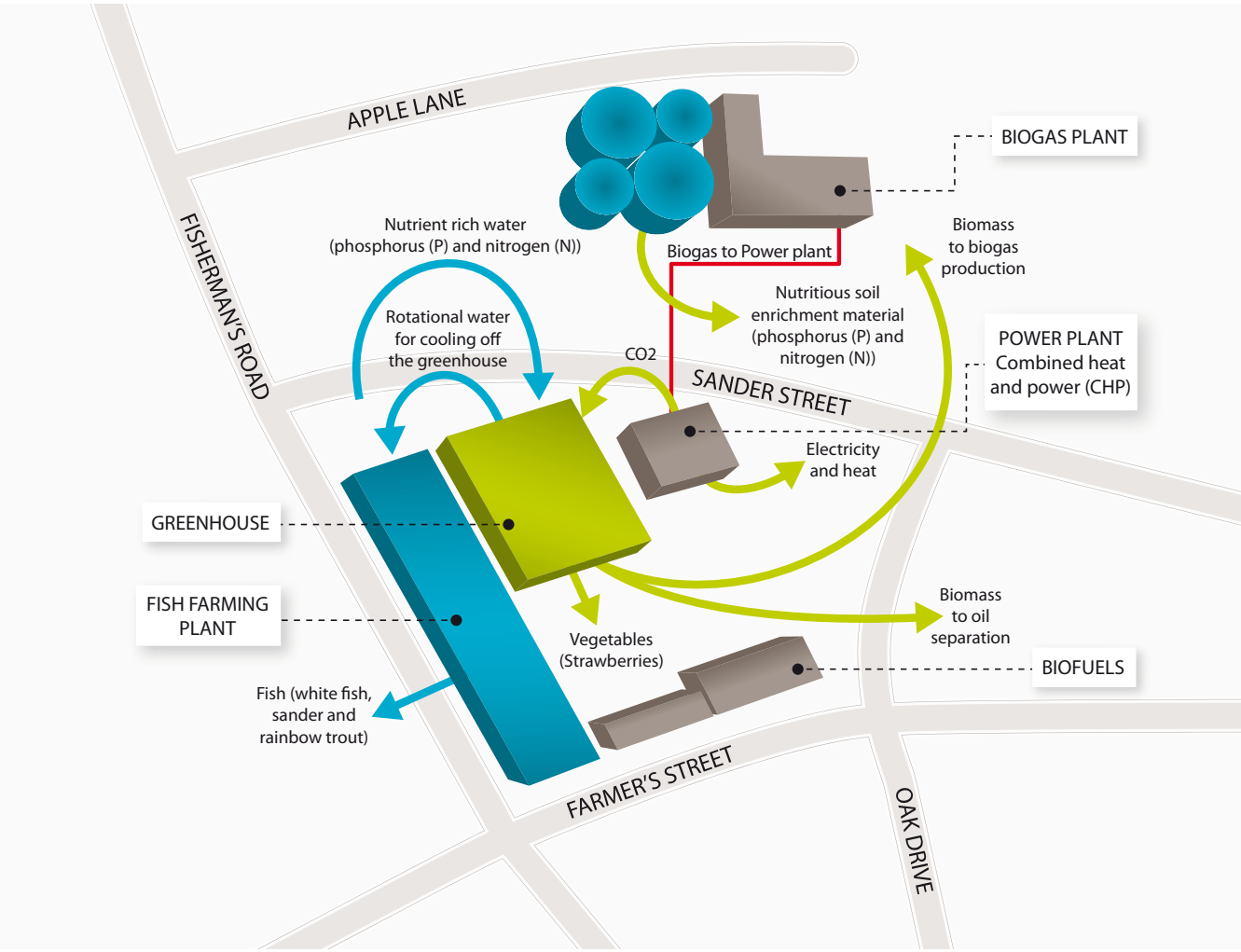
Our town is nearly self-sufficient in terms of nutrients, food and energy. Local food production creates the base for our living, as it supports both our nutrition and source of living. In addition, we are actively trading in the global market, which allows us access to commodities that are produced more efficiently elsewhere. The grains produced are different around the world, as the production is based on local breeds. This secures food production globally even if one type of grain or breed is affected by a hazard. Almost all commodities needed for food production in our town are produced locally, including fertilizers.

Our town is fully self-sufficient in energy, too, thanks to energy efficient houses, vehicles and appliances as well as local energy sources based on solar and wind energy as well as biogas. Solar energy applications are integrated in houses while wind energy is produced in the wind park close to the town. Biogas is collected from farm residues from the farms producing food for the town. All food waste is also collected and processed with anaerobic digestion before the remaining material is used as fertilizers in the farms and gardens.

Forests nearby our town are used for collecting fruits and berries as well as for recreational services. They also provide feedstock for many manufacturers who utilize fiber and bacteria from the forest plants in their production processes. We are especially proud of our chilli plantations for local medicine production. This unique business concept has been licensed to thousands of towns around the world.

In our home town, there are some 100 000 habitants, like in many communities around the world today. It seems that the town is not growing nor getting smaller in the near future. This is a good size for a more or less self-sufficient community. In our town, self-sufficiency is due to the distributed bio-based economy, which has been the backbone of our society for several years.

The whole story started over 30 years ago. The first step was a biogas plant (Picture 1) that utilized waste from the local greenhouse and fish farming as well as other wastes from the town to produce heat and electricity as well as fertilizers to local farmers. Thereafter several other towns have developed a similar kind of distributed bio-based concept based on a wide variety of local biomass sources.



Picture 1: *A biogas plant utilizes wastes of the local greenhouse and fish farming as well as other wastes to produce heat and electricity as well as fertilizers to local farmers and greenhouses.*

Living in 2050

Housing

Houses are versatile. Green roofs and urban agricultural gardens are very common. Although houses produce most of their own energy, they are usually connected to electricity and gas networks as well as waste collection systems. Energy networks are mainly used to balance production and consumption with real-time pricing. In construction, local materials with low life-cycle costs are preferred. Old building blocks are constantly renovated in order to achieve better energy and resource efficiency.

Eating

The diet is based on a wide variety of food. Local and fresh food is preferred, and the diet varies according to season. In addition to traditional meat and fish based protein sources, several other protein sources, such as bugs and algae, are widely utilized. Although local production is preferred, food is traded globally and almost every foodstuff is available. However, the price variation of various foodstuffs is huge.

Clothing

Clothes are mainly based on natural materials. New fibre sources have been taken into use in the textile industry. As clothes are produced in unmanned factories, personnel costs do not determine the location of the factory anymore. The availability of raw material is more crucial. The production of clothes is more or less tailored. Everyone can order clothes based on one's needs and fashion preferences.

1.2 The future: Our world

During the decades prior to 2050, the scarcity of water resources has caused unrest in many parts of the world, especially in the Middle East where population has multiplied from the times when water resources were just sufficient. The water crisis has also triggered full scale wars during the past twenty years. However, water scarcity is not an issue all over the world. Many regions have enough water, and some regions have to fight floods and heavy rains more than six months a year.

Water is not the only resource that has changed the world balance. Today, in 2050, natural resources are more valuable than ever before. Nearly all natural resources are scarce due to the rising consumption of the nine billion people living on the planet. Although population growth has slowed down during the past decades, the increased well-being of people has increased the need for material resources.

Fortunately, it was understood long ago that we cannot use much more non-renewable resources, so most of our consumption is based on renewable resources and recycling. For example, the use of industrial fertilisers has decreased all over the world, and they have been replaced by biological fertilisers that are mainly produced locally from farm and communal waste and fish residues. This is due to the limited phosphorus resources and energy intensive production methods of nitrogen.

The usage of non-renewable resources such as fossil fuels has also decreased remarkably after the global peak in consumption in the early 2020s. Technology breakthroughs in bio, nano and material sciences have helped us adapt to the world of limited resources. Sunlight is the only resource that cannot be used over its limits, and that's why most of the modern processes are based on it.

Today, nearly all energy is produced from renewable sources such as the sun, wind, hydro, biomass and waste. Naturally, energy sources used to depend on the region, as not all possibilities are available everywhere. It's actually a necessity to rely on renewable energy, as the price of fossil fuels is very high due to its limited availability and high transportation costs. Limited oil and gas resources are mainly utilized for more advanced applications than energy production. In addition to the cheaper price, renewable energy is used widely because it can be produced locally. Its availability is not affected by possible crises in other parts of the world. It can also be modified according to the changing climate conditions and environment.

Changes in the climate and environment have shaped the basic needs of people in different regions. In addition to the water problems described earlier, there are also changes in energy consumption patterns around the world. Shorter winter periods have decreased the need for heating in arctic and boreal regions while additional power is needed for air-conditioning in areas where summers used to be mild and in other warm areas where living standards have risen.

The changing climate has also made many regions more vulnerable to extreme weather conditions. Especially heat and heavy rains have caused problems leading to poor soils, erosion and landslides. These problems have been answered to by reforestation, which in addition to better soil management helps fight climate change.

Forests absorb carbon and are therefore effective carbon sinks. The forests and other renewable green stocks not only help control climate change but also provide valuable raw materials, food and recreational services for communities with almost infinite opportunities. In addition to these benefits, the increased forest cover provides more shelter for a variety of species which would have easily met extinction without the careful care taken of the rainforests in the tropics and other forest areas around the globe.

Sunlight is the only resource that cannot be used over its limits.

Population growth has slowed down globally but the world population is still growing, and the population hasn't spread evenly across the globe. Today nearly 22 % of the people live in Africa whereas the continent's share of the world population was only 15 % in 2010 (Population Reference Bureau 2011). Still, the population in Africa keeps growing faster than in any other region of the world. On the contrary, the population growth in Asia has already slowed down nearly to the European level.

The changing climate has increased the number of people moving from one region to another. However, people don't only move between countries and regions but also from rural to urban areas within the same region. Today 70 % of the world's nine billion people live in cities while the share reached 50 % only 42 years ago (UN-Habitat 2009). This has been a challenge not only to the cities but also the regions surrounding them, as they have to feed the urban population. Lately the urbanization trends seem to have slowed down a bit, thanks to the increased number of jobs in small and middle sized communities created by the Distributed Economy Models.

Society in 2050

Energy

The energy needs of the society are fulfilled with renewable energy sources. Individual buildings produce energy e.g. through solar panels mainly for their own use. The buildings are connected to the smart electricity and biogas grids to balance possible shortages in their own consumption as well as to feed in any extra energy for others to use. Communities also have own power plants powered by biogas, hydrogen, sun, wind and waves, depending on their location. Huge centralized energy production systems produce energy in a global scale in the most optimal locations. Energy production sites of all sizes are connected to smart grids that coordinate the production according to the current needs in real time. The grids are connected to each other and they can serve regions across the continents while they can also be used independently. The global scale gas network complements the electricity infrastructure.

Food and nutrition

While most food is produced locally from local feedstock, networks for global food trade and services exist. Emergency plans for disasters ensure delivery of sufficient amounts of food and nutrients to the affected regions. Thanks to the small scale production methods and limited service areas of basic food stuff, large regions don't usually suffer from scarcity of food at the same time. Therefore, also food aid can be directed fairly easily through pre-planned channels. Nutrition recycling is an essential part in food production.

Logistics and travelling

Although the production of food and basic goods is mainly local and communication systems are effective, efficient transportation systems exist as well. Electric trains move people and goods within and between regions while information is shared through technological solutions in real time between any locations in the world. Remote areas can be reached by cars fueled with hydrogen and biofuels or by hydrogen powered airplanes.

1.3 The key: Glocal solutions

In 2010, researchers estimated that if all the people living on Earth at the time used natural resources the same way they were consumed in industrialized countries, they would have needed 4-5 globes to fulfil the resource needs of the population (Global Footprint Network 2011). Therefore, it was clear that changes in resource utilization were truly needed, if people wished to ensure sustainable life on our planet in the future, even if we didn't have additional challenges from climate change and population growth.

At that time, the biggest challenges with natural resources were related to the availability of fresh water, food and nutrients and affordable energy. Not all of the challenges related to natural resources created problems around the world but different regions faced different problems. Therefore the feasible solutions also differed from region to region.

Today, in 2050, most of the waste and biological effluents are used for food, goods or energy production. These basic needs are mainly fulfilled locally. Still, there are many goods and services with

global markets. The global economy has transformed into a glocal economy where global and local solutions supplement each other in a sustainable way.

Three decades ago, landfills were still a typical end point for waste but today, in 2050, only few landfill sites exist. Non-renewable resources such as oil and metals are still needed in many processes but the materials are often recycled. Technological solutions have remarkably increased the efficiency of resource utilization.

Most raw materials are processed and all valuable components are separated and used for producing the goods where they provide best value. Industrial residues are used as feedstock for other products, and industries have created well-functioning networks and value chains with other industries located nearby. Factories and other industrial sites utilizing different components of the same raw materials are often located close to each other, and they usually provide services for the company network around them. In many areas closed-loop value networks have been created, where different types of industries produce and use residues and wastes from the neighbouring plants, and even the energy needed for production is produced locally.

Although local solutions are very common, many goods are still produced in specific areas for global markets (Picture 2). Those who have access to non-renewable resources usually succeed in global business as their availability is not self-evident in many regions. Many goods that need high technology or large amounts of metal are produced in a centralized way, and few producing sites can serve the whole world. Real-time trading systems ensure that the goods can be traded optimally in a global scale.

LOCAL MATERIAL CYCLE

- Basic needs, such as food and energy production
- Nutrients for bio-based production
- Biobased residues used as feedstock for other products
- Business based on closed loop value networks

GLOBAL MARKETS

- Goods produced through cenralised production systems
- Mineral based products and specialised bio-based products
- Special products only available in cartain locations
- Electricity and gas from global smart-grids
- Convertible local bio-economy concepts for global usage
- Global on-line services

Picture 2: *In 2050, real time trading systems enable a glocal world economy.*

Technological solutions have also eased the development of local energy production all over the world, and many other sources of energy in addition to biogas have been taken into use. In addition to local energy production, global super grids balance renewable energy production all over the world, allowing e.g. multi-terawatt solar parks in African and Middle-East deserts and huge off-shore wind parks in the North Sea. Fifth generation solar panels provide energy especially in the tropical and sub-tropical regions, whereas wave and wind power are widely used in coastal areas and open fields. The smart electricity grids balance the power supply at all times, and the small local production sites feed in electricity according to the needs of the grid. Most of the world's regions have been connected to each other by the grid but they can also operate independently if needed.

Both local and global markets are guided by policies. Unlike today, the status of individual countries diminishes while the general decisions, especially those related to consumption of non-renewable natural resources, are made at a global level. At the same time local decision-makers have more influence on local structures, and choices related to basic needs are often made in a local or regional context.

1.4 The concept: Distributed bio-based economy

The development path in our vision requires the simultaneous development of a global bio-based economy and the introduction of distributed production models at a local level.

In a bio-based economy the production of goods and services is based on sustained ecosystems and renewable biological resources, i.e. biomass. The bio-based economy is the key means to replace fossil fuels while ensuring a sustainable food production.

In a bio-based economy, material cycles are efficient and sustainable. Waste from one process is a raw-material for another. Many technologies operate on the side flows or waste from other processes and provide side benefits such as reduced nutrient emissions.

The Distributed Economy Model is often connected to the bio-based economy due to the locality of biomass production and low sustainability of its transportation over long distances. The distributed bio-based economy emphasizes the possibilities of local production close to the site where raw-materials are obtained from.

The success of a distributed bio-based economy is based on the economy of numbers instead of the economy of scale. Goods are often produced locally in closed-loop value networks, where different types of industries produce and use residues and wastes from the neighbouring plants, and even the energy needed for production is produced locally. The future concepts of the distributed bio-based economy are modular and multipliable. A bio-based economy is not only a bundle of new technology and bio-related economy but also a new way of thinking of how to live in a sustainable way. It is a cross-cutting issue having an effect on the whole society.

The success of a distributed bio-based economy is based on the economy of numbers instead of the economy of scale.

The Distributed Bio-Based Economy Model is glocal – both local and global. For example, global scale energy and information grids as well as open real-time trading schemes enable distributed bio-based economy hubs to operate as a part of the global market in an optimal way.

2 Drivers and development paths

The development of the distributed bio-based economy is driven by the increasing scarcity of resources and needs to combat and adapt to climate change. Local production decreases dependency on global market changes, and decreases societies' vulnerability to hazards. Information technology, which is embedded everywhere, enables diversified production portfolios, where goods are produced at both local and centralised production sites. As consumers require more information on the origin of the products, responsible local producers gain increasing appreciation.

2.1 Scarcity of resources

The scarcity of natural resources is a key driver for the development of the distributed bio-based economy. Consumption models familiar to us today become impossible when non-renewable natural resources, such as fossil fuels, are scarce and their price peaks year after year. This is especially the case with energy intensive industrial production. Rising energy prices also affect transportation costs, which leads to more careful thinking before transporting goods or material resources from one place to another.

When natural resources are scarce, efficient use, reuse and recycling of materials becomes more tempting than before. High material and energy prices encourage industries to invest in material and energy efficient technologies at the same time as they look for ways to sell their residues further. Sometimes higher transportation costs make it more profitable to have several small plants close to the material resources than to centralize all production in one place.

While material intensive industries locate themselves close to the resources, they can provide additional resources for other industries that benefit from the residues of the first industries. All these companies also need services, which create new local markets for service providers. This leads to a situation where more and more small-scale industrial plants cluster close to each other and support the livelihoods of small and medium sized communities.

In addition to industrial production, the scarcity of resources affects food production all over the world. Rising transportation costs affect food chains but also food production itself has to find new paths in the changing world. Population growth creates rising needs for food in the poorest regions of the world while climate change affects farming possibilities in many areas irrespective of the wealth of the region. Changing climate conditions also make food production more vulnerable

to environmental hazards, and especially large mono-cultural plantations and highly bred grains farmed in large areas can be threatened.

All these factors are unfavourable for large scale monoculture and international food industry multinationals. On the contrary, they can benefit small and medium scale farmers and the food industry producing food from local feedstock and local breeds for local consumption. Local production lessens the dependency on global market changes, and the large variety in production makes food stocks less vulnerable to hazards. Naturally, transportation and international trade of food will not disappear but more and more of the needs of people in both urban and rural areas will be fulfilled by local and regional production.

Recycling phosphorus becomes business.

Both industrial and food production can also support energy production. If residues cannot be utilized in further production, they can be used for energy. In some cases, such as biogas production, waste can first be used for energy production e.g. through anaerobic digestion and thereafter the remaining residues can be used in the production chain as nutrients.

Nutrients have an important role in the bio-based economy in general, too. Phosphorus resources are diminishing at the same time when more and more food should be produced. Therefore, recycling phosphorus becomes business, and bio-based feedstock for producing phosphorus can be found from all over the world.

2.2 Technological developments and competence

While limited resources, easily pitched small-scale production sites and high transportation costs make local production more profitable than ever, the globalization trend continues. Improved information technology and networks ensure that information and technological and social solutions are spread to every corner of the world. Globalization brings a wide variety of solutions to different regions, and while the options are countless, it becomes valuable to make the right choices for the local conditions. Local bio-based production concepts can be multiplied all over the world. However, the more convertible the concept is for local needs, the better chances it has to be chosen from the sea of alternative solutions.

The more convertible the concept is for local needs, the better chances it has to be chosen from the sea of alternative solutions.

The development of information technology and production technologies create new markets for virtual and distributed business models. Many services can be provided online, and especially information services can be produced anywhere irrespective of the location. While the amount of information increases, it becomes of crucial importance to be able to select the information truly important for the individual company or consumer. This in turn creates a new market for service providers.

Technological development changes the patterns also in goods production. After a huge growth in the amount of technological devices people use, the number of devices turns into descent again. This is on the one hand due to the increased costs of raw materials, and on the other hand a result of technological development.

In the future, information technology is not limited to certain devices but is embedded everywhere. One device can do the work of several devices of today, and the general ambiance support-

Natural Resource Strategy for Finland

For an industrialized nation, the Finnish economy is exceptionally strongly based on added value obtained from natural resources, particularly renewables. Well-being and wealth must, however, be created in more sustainable ways in the future. As Finland aims to stand in the international core team looking for sustainable solutions for development, building an intelligent and responsible bio-based economy has become a major strategic goal in the Finnish natural resource policies.

The policy development started in April 2009, when the first comprehensive Natural Resource Strategy for Finland was published by Sitra, the Finnish Innovation Fund. The strategy aims at leading Finland to a more sustainable path and creating a new way of thinking about natural resources. The bio-based economy is a key issue in the national strategy, followed by efficient material consumption and recycling and added value produced from local resources. The strategy was compiled by a broad group of experts from political, administrative, business, research and media organizations. The work was soon continued at the governmental level.

The work that began as a non-governmental effort was soon continued at the governmental level. Based on the Natural Resource Strategy for Finland, in December 2010, the Government of Finland submitted its strategy report on natural resources to the Finnish Parliament. The report "Building an Intelligent and Responsible Natural Resource Economy" is based on separate bio-economy and mineral strategies published earlier the same year, but it also brings together several other perspectives (including water economy, ecosystem services, material and energy efficiency) to form a coherent whole. In the report it is discussed how the objectives of sustainable natural resource utilization, national competitiveness and well-being as well as global responsibility could be combined. According to the strategy report, Finland will be a responsible forerunner in the field of intelligent natural resource based economy globally in 2050. (TEM 2011)

In the new Programme of the Finnish Government, published in 2011, it is noted that the Government will promote the sustainable use of natural resources on the basis of the National Natural Resource Strategy. The policies laid down in the strategy will be updated during this parliamentary term, including the development of the bio-economy.

ing efficiency and sustainable consumption decreases the demand for large and mono-functioning models. At the same time information technology is not limited to certain devices but it is embedded everywhere. Materials adapt to their changing environment. Smart food packages indicate if the food has become spoiled. Garments adapt to the temperature and breath or insulate according to the current needs and buildings adjust their ventilation and temperature on their own while maintenance can be done just before anything breaks apart.

Sometimes competitive edge is achieved by economy of scale, sometimes by economy of numbers.

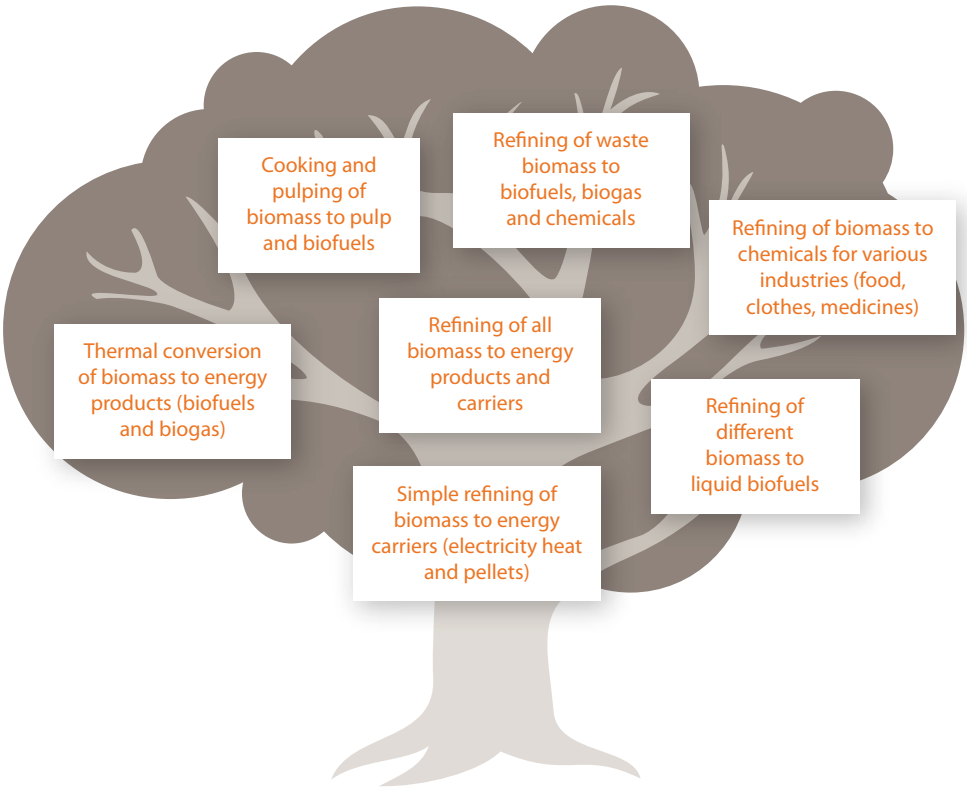
The development of technology does not only lead to easy-to-replicate models for distributed production but also to large centralized manufacturing units. Sometimes competitive edge is

achieved by economy of scale, sometimes by economy of numbers. Production processes that need large amounts of expensive technology or that are dependent on a certain type of raw material will be centralized, and these products will be shared globally. Examples of this type of industry can include pulp and bio-based plastic production.

Due to the development of renewable energy sources, such as solar, wind, hydro, wave and tidal energy, the global energy production portfolio becomes more diversified. A great share of energy is produced locally but also huge centralized systems exist in places, where optimal production conditions are, e.g. solar energy in the Middle East and Africa as well as wind in windy seas, such as the North Sea. Electricity is distributed globally. Smart electricity and gas grids cover most of the world. They can serve all the continents but they can also be used independently in isolated regions, should a need arise. Electricity grids are self-guided, and only the amount of electricity needed is produced at a time, or if needed, electricity storages can be utilized to balance intermittent electricity production.

Smart electricity and gas grids cover most of the world.

Biogas and hydrogen are the main energy carriers. They are mainly produced from algae and other fast growing biomass sources. Old natural gas networks have been modified to these dominant energy gases. Also, new gas networks have been built – almost all the towns in the world are connected into a huge global scale gas network that complements the electricity infrastructure.



Picture 3: *Technological breakthroughs will create wide variety of bio-based products in chemistry, energy technology and medicine as well as food industry.*

Technological breakthroughs in the sectors of nano, material and bio sciences will create a wide variety of bio-based products in chemistry, energy technology and medicine as well as food industry (Picture 3). New kinds of bio-based materials and other commodities can be utilized in houses, vehicles and all over the infrastructure surrounding us. The production chains will be designed to achieve closed-loop solutions. At the end of the lifecycle, these bio-based materials can be recycled or used as a raw material for the next product.

Markets are open for those who respect global needs and support sustainable solutions.

Some of the products require ultimately high technology and they are produced only in a few production plants. However, most of the basic needs, such as food, energy, common necessities and medicines, are met by local production units. As resource utilization becomes more efficient and micro refineries can utilize small fractions of different feedstock, new opportunities for local production are opened.

2.3 Awareness in consumption

One of the key drivers for the Distributed Economy Models is consumer behaviour. Sustainable resource utilization as well as energy and material efficient consumption models will be more familiar to the people all over the world as they become aware of the limited resources and the world becomes more transparent. By 2050, the level of environmental and social awareness is high in all parts of the society. Therefore, markets are open for those who respect global needs and support sustainable solutions.

Consumers will require more information on the origin of the products they use. It is an advantage for producers, if they can show that the product has been produced locally and in a sustainablemanner. Sometimes the consumers can take part in the production process so that they become familiar with the origins of the products. Participation in the production can strengthen the cohesion between local producers and consumers, which further on strengthens the consumers' commitment to the product.

Local production also has an advantage because people identify themselves to smaller regions than before. While the significance of individual countries is not so strong, people sense places at a more local level. Therefore, local products have a strong added value compared to products from other regions. Responsible local producers can be desired neighbours, and the NIMBY phenomena will turn into PIMBY, preferably in my backyard.

Picture 4: *Preferably in my backyard.*

In addition to the origin of the product, consumers want to know the effects of the product on the environment and on the globe as a whole. The length of the product's lifecycle is an important factor when making choices between options, as most products that have to be replaced more often also consume more materials and therefore have negative effects on the world around us.

Consumers require information on the sources of the goods and services they use. Easy-to-use tracking paths indicating the product's life cycle from feedstock to consumer and back to production through waste recycling are as normal as ingredient lists are today.

Distributed business models and value networks

3

The winning concepts of the distributed bio-based economy are modular, multiplied, resilient, robust, efficient and adaptable. Although the distributed bio-based economy is based on versatile local production nodes, geographical and substantial hubs connect global producer and user networks and ensure an efficient production method. The power behind these solutions lays in knowledge and competence, and new partnerships along the value chain. Accordingly, distribution is not only a geographical term but it also refers to distribution of work and responsibilities.

3.1 Competitive edge

The bio-based economy is versatile; there is a place for complementary small and large scale solutions. Generally, the quantity and quality of biomass feedstock defines the optimal size of the production unit and the end-products. Local production units are sized to meet local demand and the competitiveness is based on local synergies, robust technologies and multiplied business concepts – economy of numbers; while the competitiveness of large scale production units, targeting to global markets, is usually based on fast growing feedstock nearby, high technology and the economy of scale in production.

In a Distributed Business Model, products and services are produced close to the source of the raw-materials. At the same time the production should take place close to the end users, so that unneeded transportation is avoided and products can be recycled easily. Waste from one process is raw-material for another. Close cooperation of different actors is needed to fully take advantage of these opportunities. Unlike materials, information needed for the production and value creation can be provided anywhere.

Waste from one process is raw-material for another.

Although local bio-based economy solutions are often based on synergies and cooperation of many local stakeholders, competition between technologies, solutions and concepts will be hard. Only the fittest business concepts will survive. In the distributed bio-based economy, the winning concept is modular, multiplied, resilient, robust and efficient; and it can be adapted to the local needs of various societies. Although the local units could work on a standalone mode, it is essential that they are also part of the larger networks and also linked to the global market in order to operate optimally in real time.

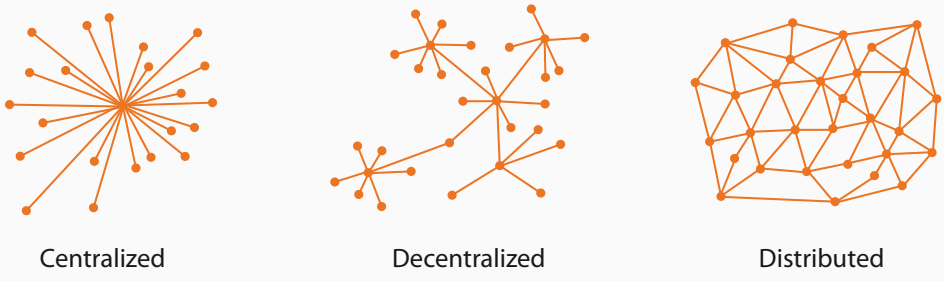
The Distributed Economy Model offers a possibility for more intensive utilization of local services. For example, energy for electricity and heating can be produced from local biomass. In case the local biomass stocks are more than sufficient, biomass or electricity and heat can be delivered also to neighbouring areas. In case of insufficient stocks, the energy needs can be fulfilled by the neighbouring areas.

3.2 Modularity and networks

The distributed bio-based economy is built on modular and multipliable concepts. The distributed units, the modular nodes, are the key components of the Distributed Business Models. Each module or production site is a node of its own, and is linked to several other nodes according to the needs and deliverables of each node. Each node is highly valuable for the other nodes.

The distributed bio-based economy is built on modular and multipliable concepts.

Information and communication technologies create new possibilities for virtual communities and virtual business processes, on which distributed modular business concepts can be built on. The information and knowledge networks can be utilized to connect single distributed units to each other in order to optimize efficient use of resources.



Picture 5: *In a Distributed Business Model each module or production site is a node of its own, and it is linked to several other nodes according to the needs and deliverables of each node (Van den Dool A. et al 2009).*

Especially in bio-based energy production, where local feedstock plays an important role, small-scale energy production units will become popular. Although the production takes place in the origin of feedstock, electricity and fuels can still be produced regionally, multi-regionally or even globally thanks to global wide super grids of electricity and gas networks.

In the energy market, distributed power units can be linked together through common administration and ownership as well as smart power grids to create virtual power plants. The same analogue can be utilized in the various concepts of the distributed bio-based economy. A number of distributed bio-based production units all over the world can be adaptively controlled taking into account local and global market needs in real time or in advance.

Although the nodes create the base of distributed business models, competences can cluster together and form geographical or substantial hubs. The hubs connect the global producer and user networks and ensure efficient production methods. Just-in-time production and flexible outsourc-

ing show way to more developed hubs, where the needs and resources of small and bigger scale players meet. In 2050 business ecosystems are being created by hubs and global value networks around them.

Logistics has an important role in the new business ecosystems. Production needs to be based on flexible systems, where components can be produced in different locations and brought together at the time of compilation of the final product.

While the Distributed Economy Models are based on nodes and hubs, the power behind these lays in knowledge and competence. The importance of human capital increases when economy is based on knowledge and this happens when technologies, processes and the market make the economy work. Highly competent knowledge workers are required to handle the new economy.

3.3 New partnerships and cooperation

New types of partnerships and collaboration are needed for effective distributed business models and processes. Collaboration networks within large corporations or single links between companies and other organisations are not enough when distributed business models are made to work. In addition, new partnerships along the value chain are required. Stakeholders from all relevant sectors including different companies, government authorities, designers, contractors and financiers are to be included in the processes to ensure smooth design, development and utilization of the business models.

Distribution is not only a geographical term but it also refers to the distribution of work and responsibilities. One company cannot and is not supposed to try to do everything on its own, and outsourcing will become a permanent part of new business models. Virtual communities are already part of societies' everyday life but virtual business processes are still to develop. Several companies have already utilized ICT technology to transact business especially in retail markets but more is expected to happen. This, together with new ways of distributing the work and responsibilities, creates opportunities for new types of actors such as integrators, intermediaries, and brokers.

The development of new business models in new partnerships does not mean that the producing stakeholder chain would keep all ideas and information to itself. Customers, suppliers, competitors, universities, research institutes and other relevant stakeholders can participate in business development and innovation procedures through open source innovation. This can enable more productive generation of new ideas, which can be brought quickly to the market. Collaborative, open and interdisciplinary space encourages innovation, because innovation feeds on collaboration, combination and confrontation of different ideas, perspectives and experiences.

Distributing work and responsibilities, creates opportunities for integrators, intermediaries, and brokers.

In order to find the fittest solution, local cooperation plays a very crucial role. By combining operators, which can utilize products, side-products and residues of other operators, an efficient ecosystem can be created. This kind of ecosystem can create closed-loop material flows and be almost self-sufficient, relying mainly on local raw materials. From the risk management point of view, self-sufficient systems tolerate global market disturbances better than systems that rely on raw materials bought from global market.

4 Pathway to sustainable economy and well-being

By offering economically, socially and ecologically viable solutions to many of the major struggles of today, the distributed bio-based economy has great potential to help in building a strong sustainable way of life. The world of the distributed bio-based economy is the world of opportunities for those who find alternative solutions and connect themselves with counterparts around the globe. In this report, a destination is visioned. Decision-makers are now encouraged to explore these opportunities and smoothen the path forward.

The distributed bio-based economy can provide a wide variety of products and services that people need for good living. Basic needs, such as food and energy, can be produced locally. Products can be used and consumed close to where the raw-materials are obtained from. This decreases the need for transportation over long distances and makes communities more self-sufficient. A number of such bio-based economy solutions already exist.

By 2030, solutions related to the distributed bio-based economy are being introduced in different parts of the world. By 2050, they form networks all over the world.

In the bio-based economy, waste from one process is raw-material for another. Many technologies operate on the side flows or waste from other processes and provide side benefits such as reduced nutrient emissions. This creates effective material loops and decreases the problems of climate change and resource depletion. A life-cycle view needs to be embedded into all design, planning, construction, use, and recycling.

The bio-based economy is the key means to replace fossil fuels. In addition, distributed models enable the efficient use of scarce resources and intelligent waste management. However, as the renewing capacity of biomass is limited, processes and consumption patterns, including energy efficiency, must be very efficient.

The distributed bio-based economy, if properly implemented and managed, has great potential to help build a strong sustainable way of life by giving the opportunity to substitute scarce resources with renewable ones. Combined with dematerialized consumption patterns it opens extensive opportunities. The Bio-based economy is not only related to economy and technology

but will also be part of our daily lives through land use planning and architecture such as urban cultivation and green roofs.

The lack of job opportunities in rural areas across the world has caused a significant and long lasting trend of urbanization, and consequent depopulation of rural areas. However, recent technological development and new business trends are creating economic opportunities even for the rural areas. Many new income opportunities are to be found in the distributed bio-based concepts, which are not only contributing to the positive environmental impacts, but are at the same time a powerful engine for economic growth in rural areas.

Educated and competent people are needed to operate distributed plants and to design higher value-added products and services. Primary production, cultivation, and harvesting will link closely to the secondary production and the use and recycling of the products. New opportunities rise not only in agriculture, forestry, and fish farming, but in food, chemical, pharmaceutical, and energy industries as well. Technologies and equipment are manufactured, and knowledge intensive services, such as consulting and legal services in planning, operation, optimization and maintenance are needed.

The Bio-based economy will also be part of our daily lives through land use planning and architecture.

The distributed bio-based economy improves the security of supply of critical commodities, such as energy, food, and nutrients. Although it is based on globally connected systems, the concepts can also operate stand alone. Distributed systems are less vulnerable to disturbances, and enable safeguarding the functioning of critical infrastructures and the population's living conditions even in emergency situations.

Biomass has characteristics that differentiate it from fossil resources, for instance regarding the availability and distribution. Distributed production of energy from renewable sources is possible almost everywhere as renewable raw materials are more or less distributed globally. More centralized systems are highly interdependent and prone to collapse in crises creating vast emergencies. Societies using local resources can easily adapt to the changing conditions by applying and modifying the global concepts to local needs.

Distributed bio-based concepts are a powerful engine for economic growth in rural areas.

It is necessary to focus the development work of the distributed bio-based economy models on some selected areas, as the possibilities are countless. At the same time it is unavoidable that all development work cannot create well functioning solutions for future needs. Distributed systems have to be built up from the needs or from the bottom up, as fulfilment of needs create the structure for the economy. The fittest solutions survive while the less successful ones can support other options or meet the dead end. The world of the distributed bio-based economy is the world of opportunities for those who find alternative solutions and connect themselves with counterparts around the globe.

Leading the path: Questions to decision-makers

In order to move towards sustainable bio-based economy within the next decades, critical decisions have to be made the soonest. The transition requires radical changes in thinking and decision making. To ensure the right decisions, the right questions have to be asked – and right answers to be given. Some fundamental questions for decision-makers are presented here as a starting point for discussion.

1. ***Is*** *bio-based economy only a new multidimensional business sector or a new societal structure?*
2. ***What*** *is the optimal combination of local and global business models?* ***How*** *can they complement each other in the most efficient way?*
3. ***How*** *can we create an enabling environment, including regulation incentives and cooperation, for distributed bio-based economy?* ***Who*** *should take the lead?*

How the report was made

This report builds up a scenario for the year 2050 that is largely based on the distributed bio-based economy. Several positive and even optimistic assumptions are made to concretize the vast potential of the distributed bio-based economy in taking advantage of the possibilities and in meeting the challenges that we face today. We never know for sure what will happen in the future. In any case, the distributed bio-based economy should be seen not only as one possibility, but also as a potential path forward.

In addition to the expert views of the authors, the report is largely based on studies on the distributed bio-based economy commissioned or conducted by Sitra, the Finnish Innovation Fund. Other relevant material on the bio-based economy and related issues has also been used to cover the current and future developments comprehensively. These include among others, International Energy Agency's Energy Technology Perspectives (2010), OECD's Green Growth Strategy (OECD 2011), and EU strategies on the bio-based economy (See for example www.bio-economy.net/).

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