Bioeconomy Transformation– summary of the bioeconomy activities at VTT

Bio4Fuels Days 2017: Scientific meeting

November 2-3, 2017

Trondheim

Research Professor Kristiina Kruus, VTT

VTT Technical Research Centre of Finland Ltd

Suomi Finland 100

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- VTT is one of the leading research and technology organisations in Europe.
- We use our scientific and technological excellence to provide innovation services for our domestic and international customers and partners.

* Loikkanen, T. et al. Roles, effectiveness, and impact of VTT. Towards broad-based impact monitoring of a research and technology organisation. 2013. VTT, Espoo. VTT Technology 113. 106 p. + app. 5 p.

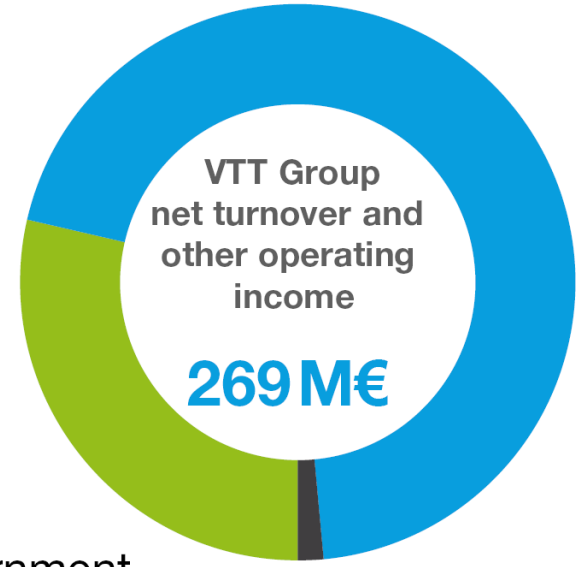
Net turnover and other operating income
269 M€ (VTT Group 2016)

Unique research and testing infrastructure

Personnel 2,414
(VTT Group 2016)

Wide national and international cooperation network

VTT Group net turnover and other operating income 2016



Net turnover 188 M€ (Parent company 163 M€)

Government grant 77 M€

Other operating income 4 M€

VTT's net turnover (Parent company, 163 M€) consisted of

- 62% public sector revenue and of 38% private sector revenue,
- The domestic revenue accounted for 64% and foreign revenue for 36% of the net turnover.

  Of the foreign revenue 83% came from Europe, 10% from North and South America, 6% from Asia and 1% from elsewhere.

VTT organisation and Leadership Team 4.9.2017

Ministry of Economic Affairs and Employment

VTT Board

Antti Vasara
President & CEO

Petri Kalliokoski
Executive Vice President, Deputy CEO

Erja Turunen
Executive Vice President

Jussi Manninen
Executive Vice President

Business area: KNOWLEDGE INTENSIVE PRODUCTS AND SERVICES

Research areas
- Sensing and integration
- Connectivity
- Data-driven solutions
- National Metrology Institute VTT MIKES
- Micronova manufacturing services

Business area: SMART INDUSTRY AND ENERGY SYSTEMS

Research areas
- Lifecycle solutions
- Nuclear safety
- Smart energy and transport solutions
- Digital engineering
- Business innovation foresight

Business area: SOLUTIONS FOR NATURAL RESOURCES AND ENVIRONMENT

Research areas
- Industrial biotechnology and food solutions
- Biomass processing and products
- Sustainable energy and chemical technologies

FINANCE & BUSINESS SUPPORT

Tanja Huoponen
Chief Financial Officer (CFO)

HUMAN RESOURCES

Kirsi Nuotto
Senior Vice President

MARKETING AND COMMUNI-CATIONS

Jussi Ollila
Senior Vice President

STRATEGY & BUSINESS INTELLIGENCE

Katri Kallio
Vice President

VTT SUBSIDIARY COMPANIES

VTT Expert Services Ltd, Laura Apilo, CEO
VTT Ventures Ltd, Antti Sinisalo, CEO
VTT International Ltd, Matias Markkanen, CEO
VTT Memsfab Ltd, Howard Rupprecht, CEO

Anu Vaari
Senior Scientist, personnel representative

VTT's R&D infrastructure – an essential part of the national

A pilot-scale research environment for fibre processes

BIORUUKKI – Bioeconomy pilot and research facility

Engine and vehicle laboratory

Centre for Nuclear Safety

Biotechnology and food research piloting environment

MICRONOVA – Clean room

ROViR – Remote Operations and Virtual Reality Centre

PrintoCent – Pilot factory for printed intelligence

VTT MIKES Metrology

Towards the Bioeconmy

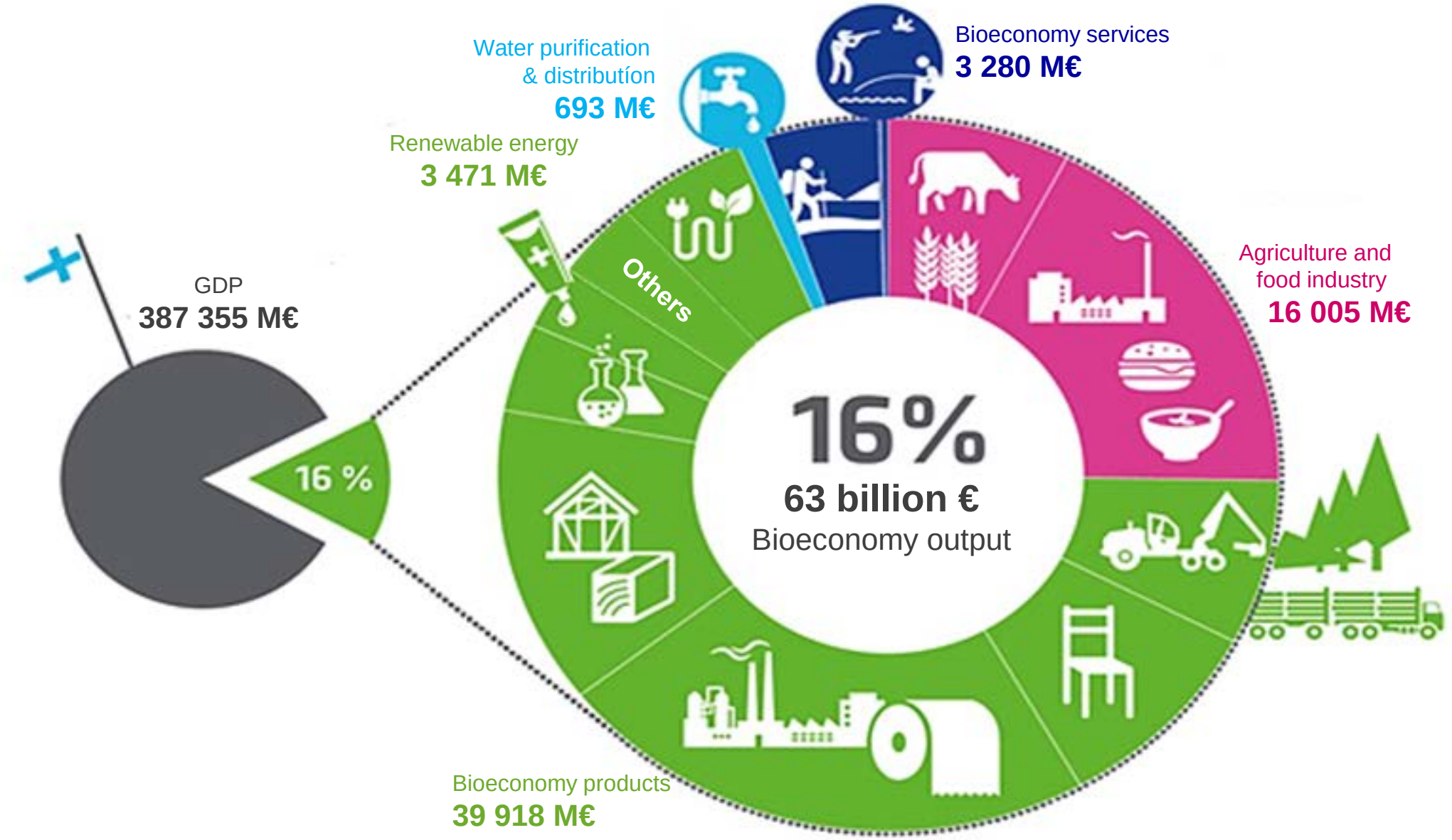
National drivers

- **Biomass resources per capita the largest in Europe (per capita)**
  - Annual growth of wood biomass 105 Mm3
  - Agricultural land area 2,3 M ha
  - Organic wastes and sidestreams 74,1 Mtn
- **Forest industry accounts for 20%**
  of Finnish export (bulk products), a need to develop novel added-value products
- **High level expertise in biotechnologies, material sciences and process technology**

Global drivers

- Climate change
- Oil dependency
- New sources of affordable and safe food
- Added-value from by-products and waste
- Bio-based products gaining consumer appreciation

Bioeconomy in Finland 2014



Source: LUKE 2014

Bioeconomy’s significance in Finland

Turnover €60bn

Share of employment 13%

Share of exports 26%

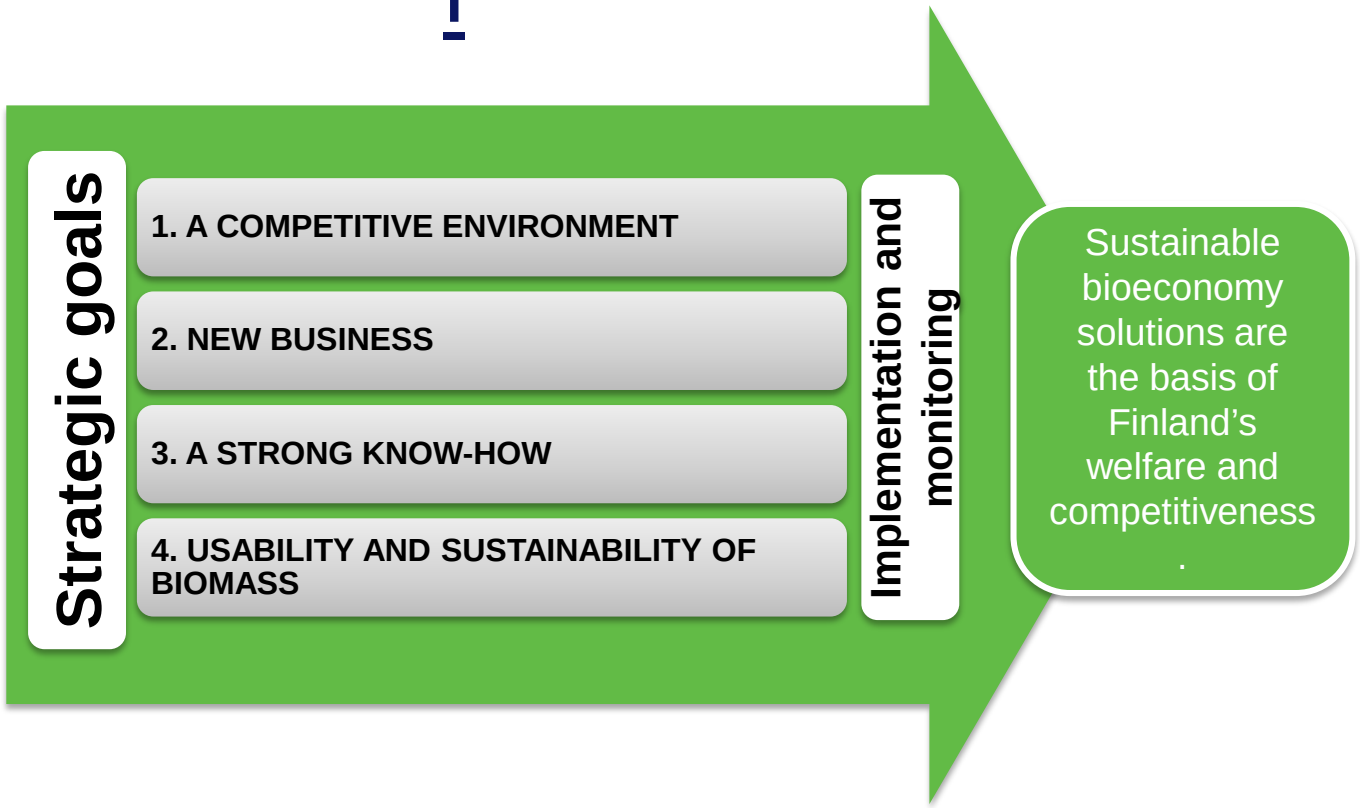
Finland seeks to increase its bioeconomy output to 100bn euros by 2025 and to create 100,000 new jobs in the process.

Bioeconomy combines wood processing, chemistry, energy, construction, technology, food and health.

About half of Finland’s bioeconomy consists of forest bioeconomy.

Finland’s bioeconomy strategy
Vision and strategic goals

www.bioeconomy.fi



Aims of the VTT Bioeconomy programme

- Develop smart technologies for biomass processing and product concepts and **support the creation of bio-based value chains and eco-systems in Finland** from raw-materials to products
- **Support industrial renewal** by developing value added product solutions and sustainable process concepts
- Promote national and international **collaboration**
- Utilize multidiciplinary research in problem solution
- **Implementation of the national bioeconomy strategy and decision making** by providing technology opportunities and concept evaluations
- Making Finland as a **forest bioeconomy technology hub**
- Developing **demonstration and piloting facilities** for bioeconomy

VTT Bioeconomy Transformation 20112-2017

PROGRAMME OUTLINE

General process technologies:
- Freedstock disassembly and fractionation: pretreatments, pulping, matrix architexture
- Process engineering, product recovery, process concepts, sustainability

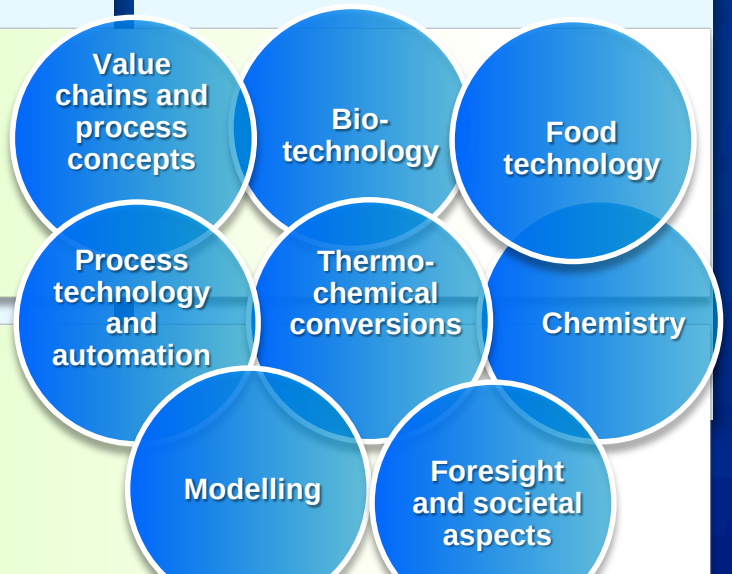
Biotechnical production platform
- Cell factories
- Enzymatic conversions
- Synthetic biology

Thermochemical production platform
- Pyrolysis
- Gasification

Chemical conversion platform
- Platform chemicals, cellulose derivatives, valorization of lignin
- Novel solvents (DES, ILs)

Products:
- Biobased products: composites, web-based products, packaging materials, textile fibres
- Food, food ingredients and feed
- Biofuels and energy

Competences throughout the programme:
- Intelligence to bioeconomy
- Industrial symbiosis and ecosystems
- Scenarios and Socioeconomics
- Digitalization



- **Volume 32 M€/a, equals 200 person years annually (jointly funded 65%, contract research 20%; self-funded 15%)**
- **200 customers, from which 15key customers**
- **240 peer review articles (2015)**
- **18 patent applications, 115 notification of inventions (2015)**

Industrial

Several spin-off companies

20 % industrial contract work, 200 industrial clients

Commersialization of the foam foming

Several BBI projects

Patents and invention closures

BIORUUKKI piloting center

Scientific

Tekes large strategic openings
Lif, DWOC, NeoCarbon

Peer reviewed scientific articles
PhD thesis

Active collaboration among the European and national RTOs and universities

Societal

National Bioeconomy strategy

Active participation in national bioeconomy events

Bioeconomy scenario work 2016

Active in preparation of H2020 reserach programmes and BBI- and ERA-NET-programmes

Various roadmaps and scenarioworks

IMPACT

Food production in the bioeconomy

Food production is an essential part of the bioeconomy. The great challenges are increasing population, urbanization, climate change, shortage of clean water in the same time a need to produce healty and nutritious food.
More from less – a need to utilize the waste and side streams. An increasing need for plant-based proteins.

EXAMPLES FROM THE RESEARCH

Image: Fazer

- **Development of fractionation technologies**
  - For different types of plant sidestreams
  - Novel solvents for fractionation
  - Oat fractionation technology licenced to Fazer (2015)
- **Plant proteins**
  - Novel sources, developing the technological properties
  - Roadmap to improve the Finnish self sufficiency in proteins (2015)
- **Novel sources for foods and food ingredients**
  - Food from wood, insects and plant cell lines (CellPod)
- **Novel technologies, e.g. 3D-printing**
- **Food economy 4.0,** VTT's vision of an era of smart consumer centric food production, a roadmap

Novel products from wood

Wood as a raw material will find novel ways. In addition to conventional paper and packaging applications, totally new applications and businesses will emerge.

EXAMPLES FROM THE PROGRAMME

- **Added-value from cellulose**
  - **Nanocellulose**
  - Developed a technology to produce nanofibrilled cellulose in high consistency
  - Promising results to use nanocellulose in **electronics applications** e.g. flexible sensors
  - **Thermoplastic cellulose**
- **Textile applications**
- **Development of the foam forming technology**
- **Biocomposites**
  - Development of technologies for recycled materials
- **Modification of lignin to added-value products**
  - LigniOx – e.g. as a surfactants in cement
  - CatLignin – reactive lignin for resins

Production of biochemicals from renewables

Production of biobased chemicals will increase. It is foreseen that in 2030 major part of the chemicals will be biobased, and especially utilizing CO_2 as a raw material will increase.*

* The DeLoitte Study, 2014

EXAMPLES FROM THE PROGRAMME

- **Development of the production hosts and enzymes,** synthetic biology
- **Development of the pretreatment technologies,** AlkOx, novel solvents
- **Conversion of pectin to aldaric acid**, which can be further modified and used for instance as a starting material for chemicals.
- **Biotechnical conversion of xylose to xylonic acid, further modification -biotechnical or chemical – to different chemicals**
- **Polymer precurcor production from CO_2 utilizing solar energy and electrolysis of water.**

Production of energy and chemicals by thermochemical conversions

Liquid biofuels are needed for reduction of emissions. Production of biofuels from biomass needs to be smart and sustainable. A balance between biofuels and –chemicals is needed.

EXAMPLES FROM THE PROGRAMME

- **Gasification and pyrolysis technologies for production of energy carriers**
  - The VTT Integrated gasification-BTL-process for liquid fuels and heat production, in the large scale in 2025 .
  - VTT's pyrolysis technology is utilized in Fortum's biooil plant in Joensuu. It utilizes forest residues and the plant started in 2013. Capacity of total 50 000 tn biooil equals heating of 10 000 single family houses.
- **Production of chemicals by thermochemical conversion**
  - Two stage pyrolysis technology produces pyrolysisoil which can be fractioned to energy and chamical products.
  - α-olefin and BTX (benzen, toluen ja xsylen) production from syngas using Fischer-Tropsch ja aromatization
  - Biotechnical route from syngas to ethanol

Current examples of industrial bioeconomy in Finland

- **Renewable energy** with combined pulp, paper, heat and power production, and in local district heating
- **Biofuels** from crude tall oil in pulp production (UPM), saw dust, wood residues for bioethanol production(ST1)
- **Bio oil** from forest residues combined with heat and power production (Fortum pyrolysis plant in Joensuu)
- **Äänekoski multi bioproduct mill** and an ecosystem (MetsäFibre)
- **Fuels and bioproducts** from lignin combined with pulp production (LignoBoost, Stora Enso)
- Investments on **dissoliving pulp** line in Uimaharju (Stora Enso)
- Plans for an industrial scale biorefinery converting wood into **bio-monoethylene glycol (bMEG), bio-monopropylene glycol (bMPG) and lignin** up to 150,000 metric tons per year (UPM)
- **Cosmetics and food additives** from wood and other forest products (Lumene)
- **Xylitol** production from xylose (DuPont)

st1

Valmet

Metsä

LIGNOBOOST

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