

The Forest based Biorefinery - Chemical and Engineering Challenges and Opportunities

Introduction

Åbo Akademi, 3 May 2010

SVP Markku Karlsson, UPM-Kymmene

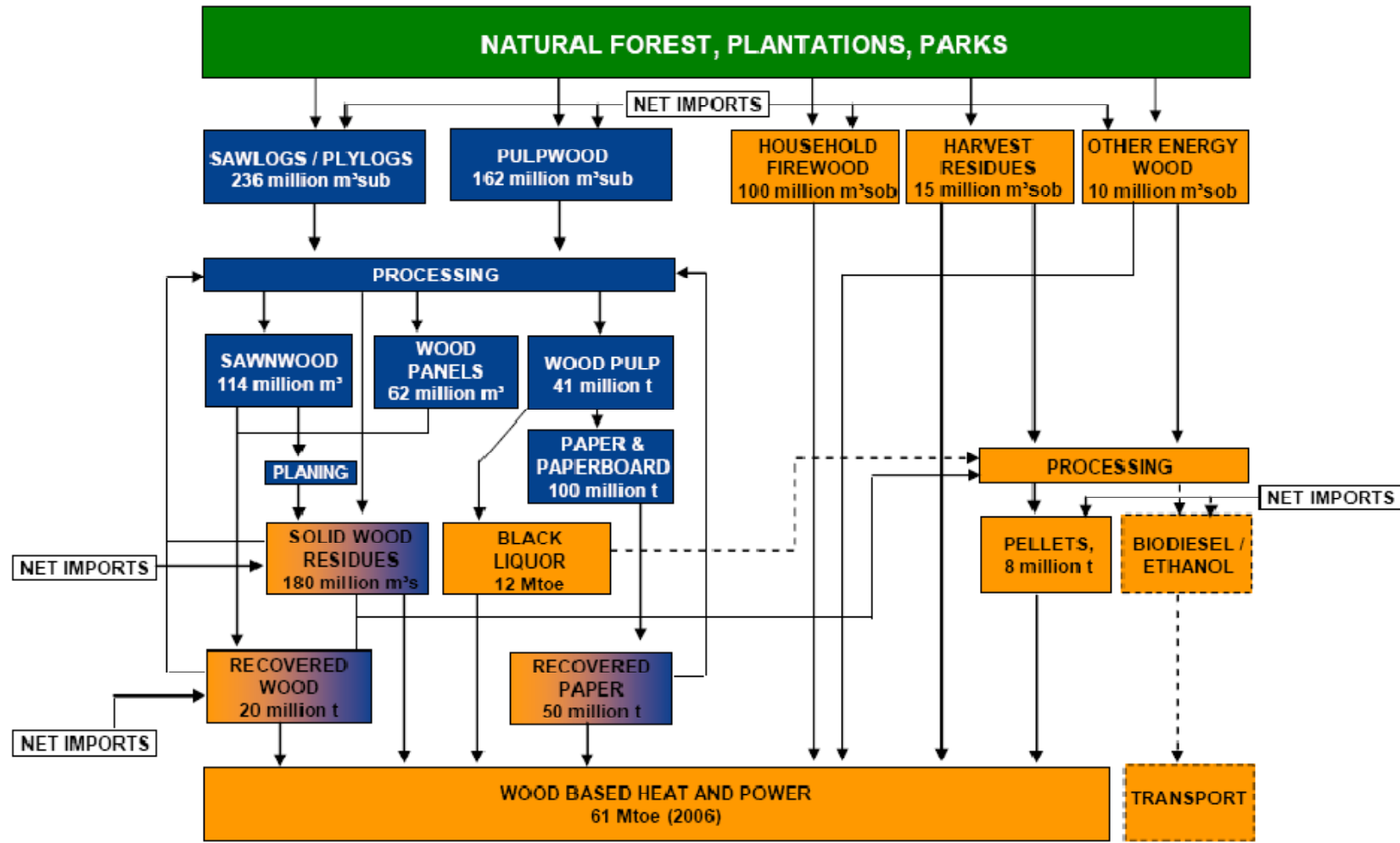


Content

- Strategic initiatives
 - Forest industry situation
 - EIBI
 - Forest industry renewal
- Biorefinery development
 - UPM's biofuels concept portfolio
 - 2nd generation biofuels – from research to demonstrations
 - Nanocellulose
 - Biochemicals
 - Biocomposites
- Summary

FOREST INDUSTRY SITUATION

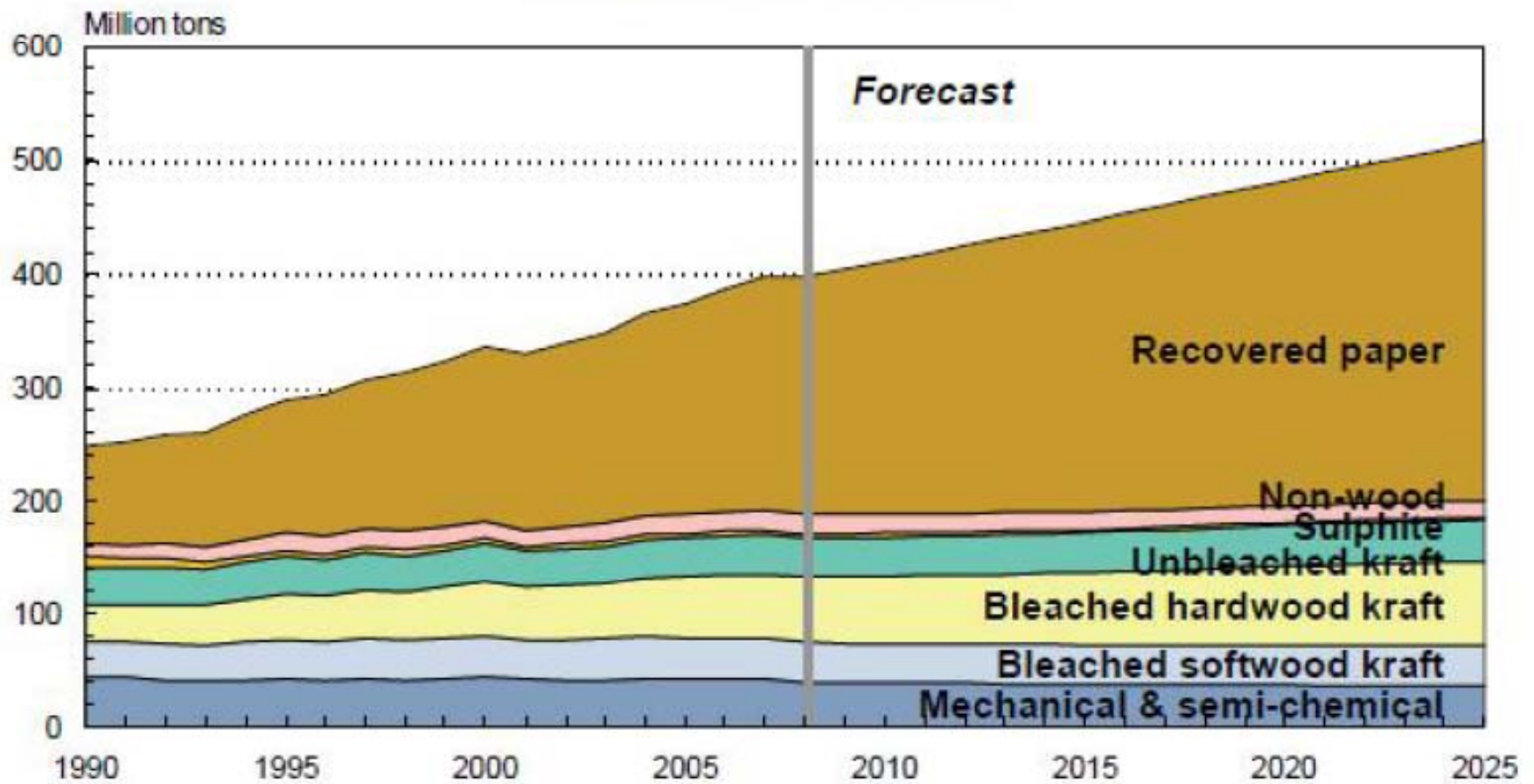
Wood flows by end uses in EU-27



Source: Pöyry

FOREST INDUSTRY SITUATION

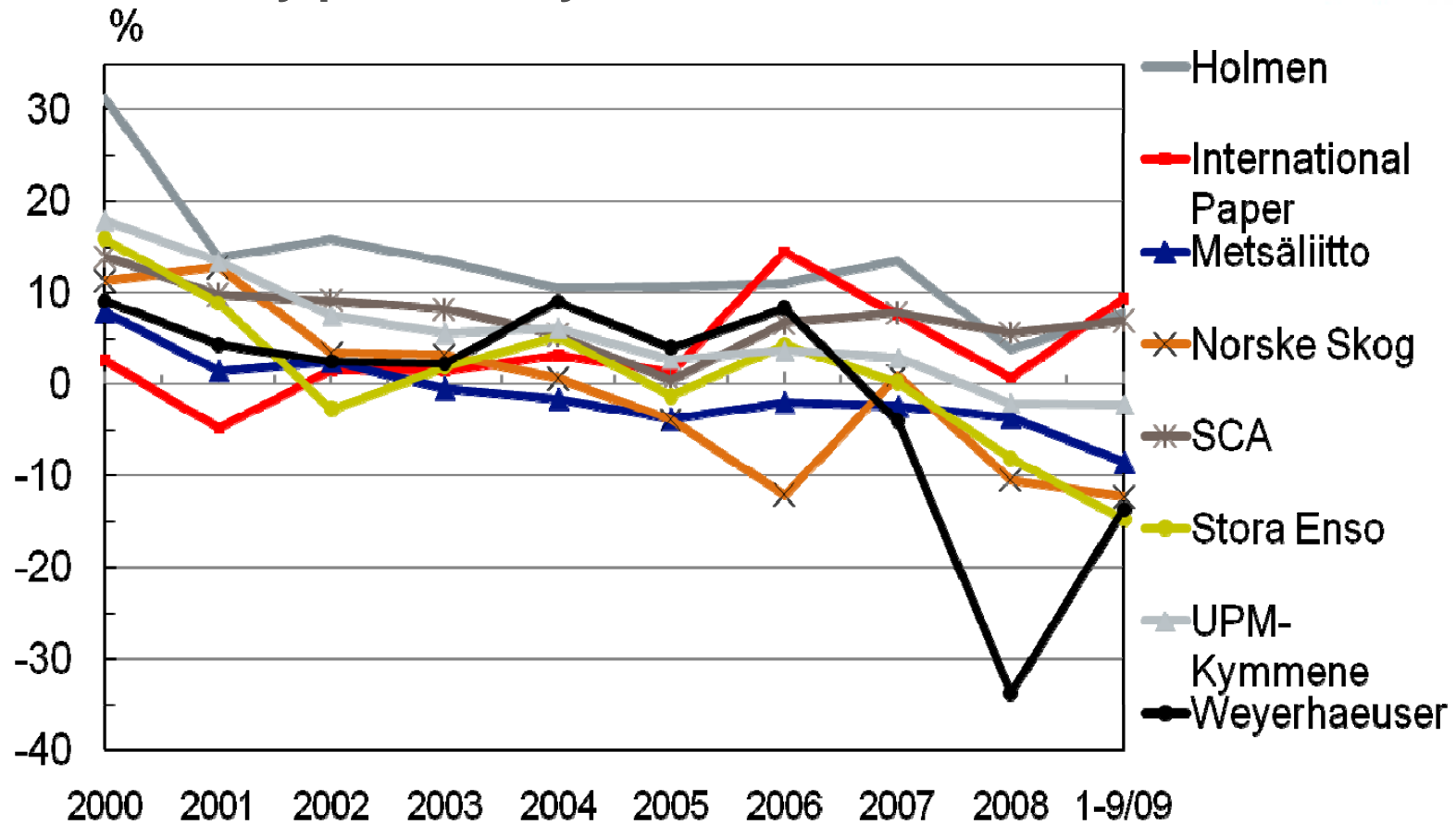
World consumption of paper-making fibre



Source: Pöyry

FOREST INDUSTRY SITUATION

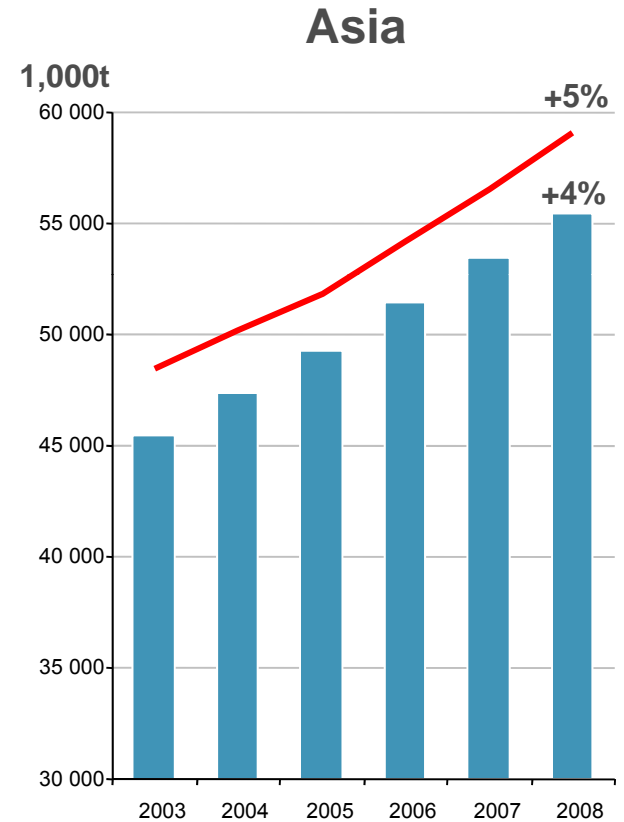
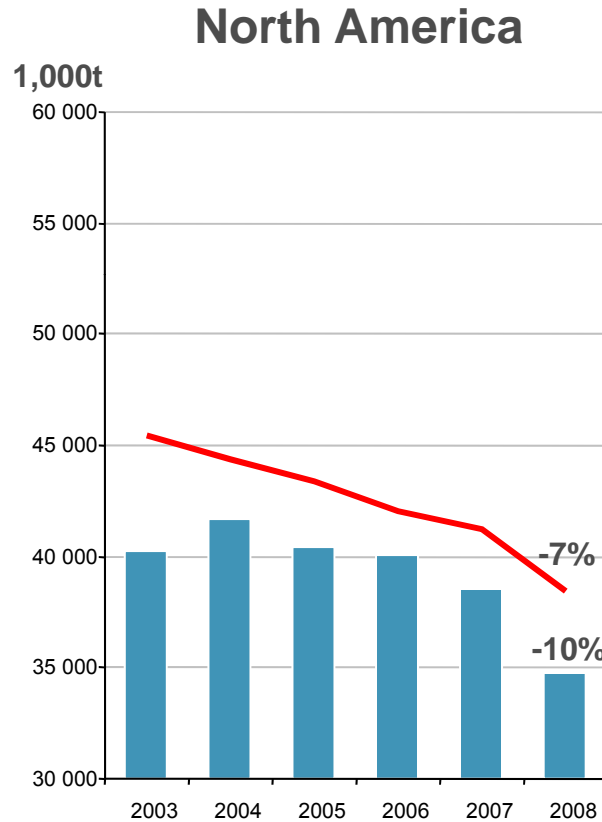
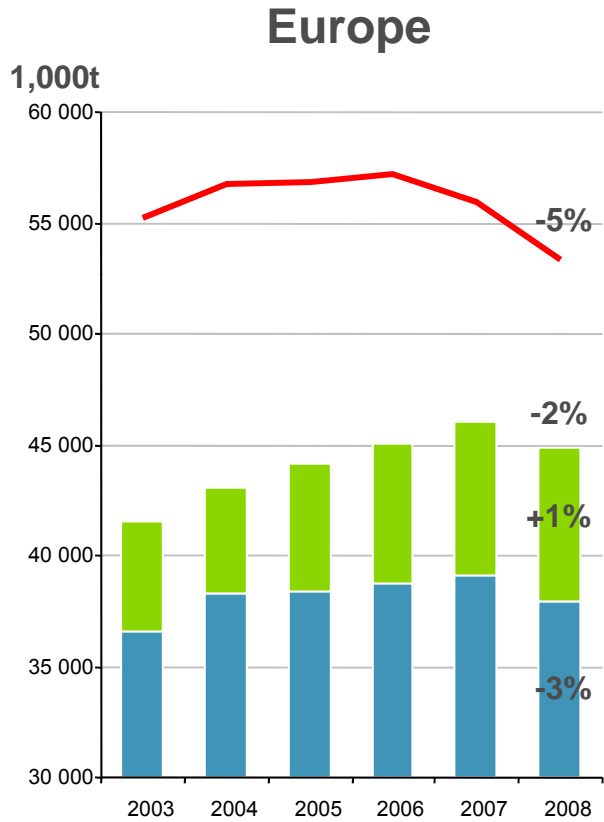
Forest Industry profitability



Profit before taxes in selected forest industry companies relative to turnover (Source: Finnish Forest Industries Federation)

FOREST INDUSTRY SITUATION

Graphic paper demand and capacity



W. Euro demand E. Euro demand Capacity

NA demand Capacity

Asia demand Capacity

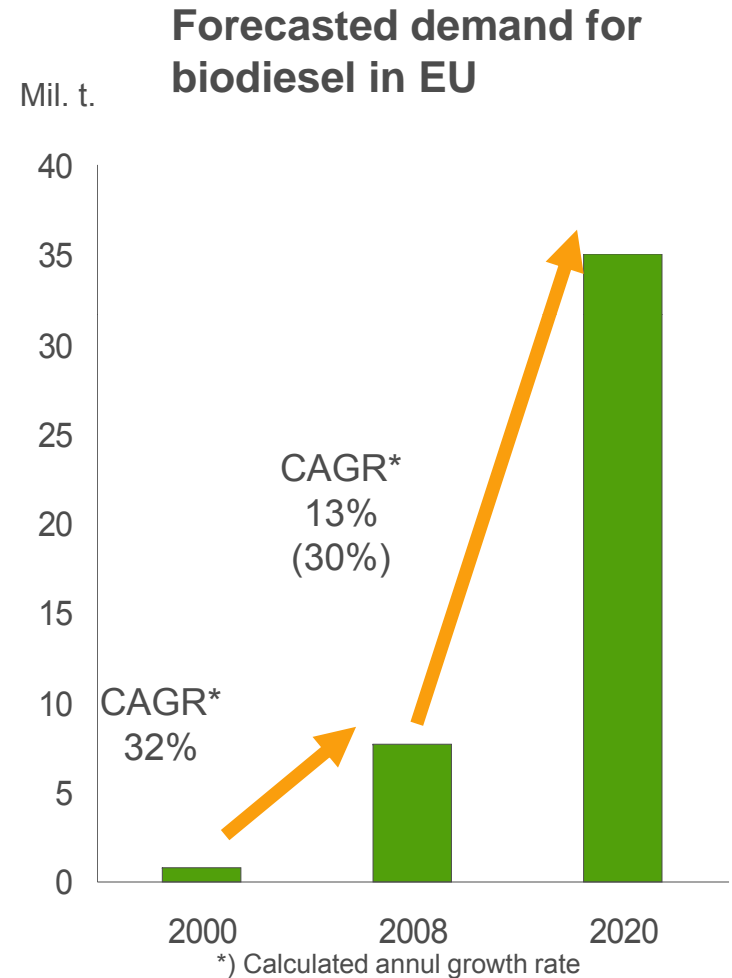
Source: Cepiprint, Cepifine, PPPC, PPI

PRODUCTION OF 2ND GENERATION BIOFUELS

Demand for biofuels will grow remarkably in EU by 2020



- EU climate and energy goals for year 2020:
 - 20 % reduction of CO₂ emissions
 - 20 % energy from renewable sources
 - 20 % improvement in energy efficiency
 - **10 % biofuels in transport**
- EU renewable energy (RES) directive favours advanced biofuels:
 - advanced biofuels which are produced from lignocelluloses, waste and residue based raw materials are **double counted** when calculating renewable target
 - 5% of these would be regarded as 10%
- National targets given for Finland:
 - 16% GHG reduction in non emission trading sector
 - +9.5%-units RES to 38% share of energy consumption
 - Implementation Plan in June 2010 to be submitted to EC



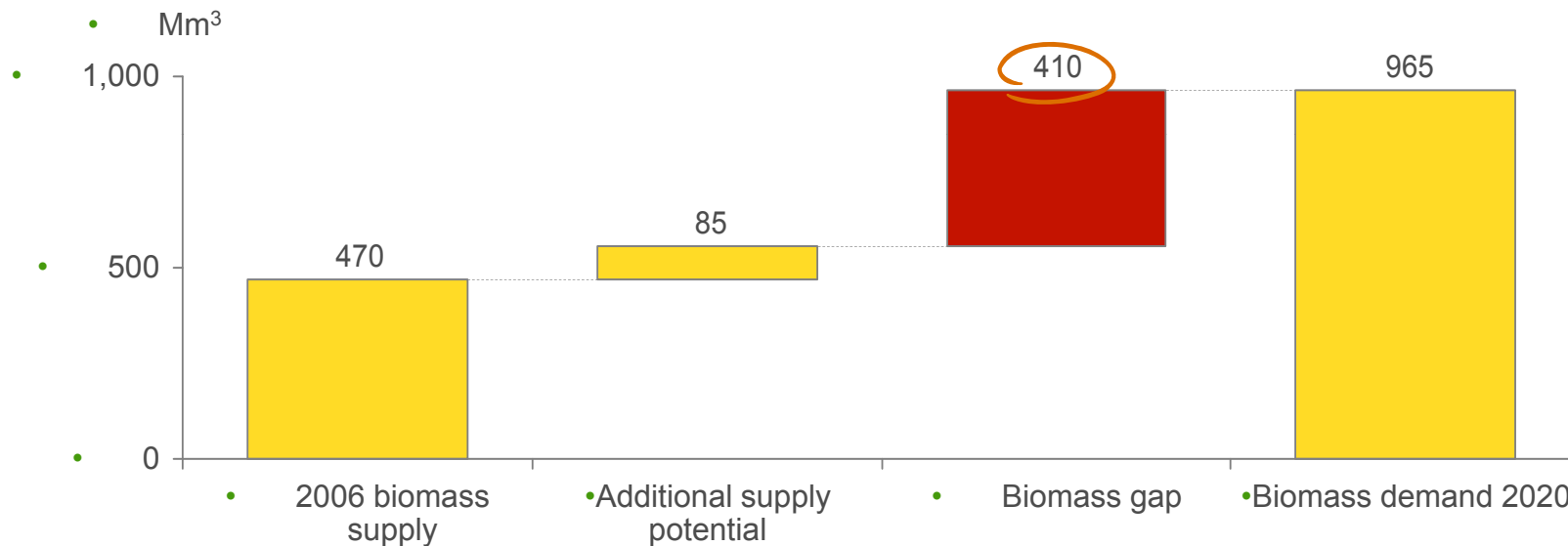
Source: Directive of the European Parliament and of the Council on The Promotion of the Use of Energy from Renewable Sources

BIOMASS FEEDSTOCKS – EXPECTATIONS FROM INDUSTRY

**Biomass supply in EU-27 will be scarce
In 2020 a gap of 350–410Mm³ biomass
predicted**



Estimation of EU-27 woody biomass gap 2020



Biomass gap in EU-27 will drive imports and global trade

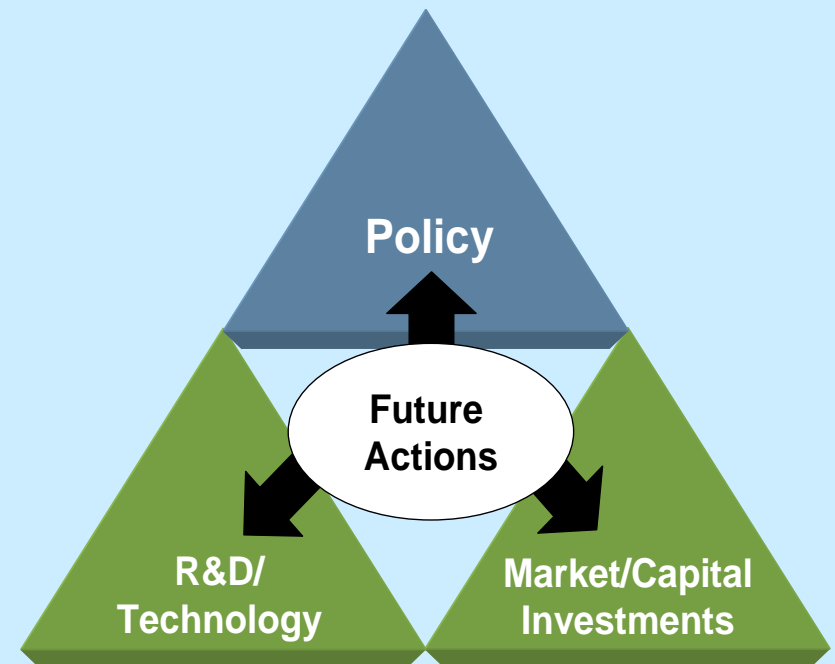
ACTIONS FOR FOREST INDUSTRY RENEWAL

Acceleration of market introduction

EU SET-Strategic Energy Technology Plan for 2020

- European industrial initiatives
 - Large demonstration actions supported by RTD
 - Indicative budget in 2010–2020 about 60 B€ for seven demonstration programmes, CCS, Bioenergy, Wind, PV, Smart grids etc.
- EERA - European Energy Research Alliance started

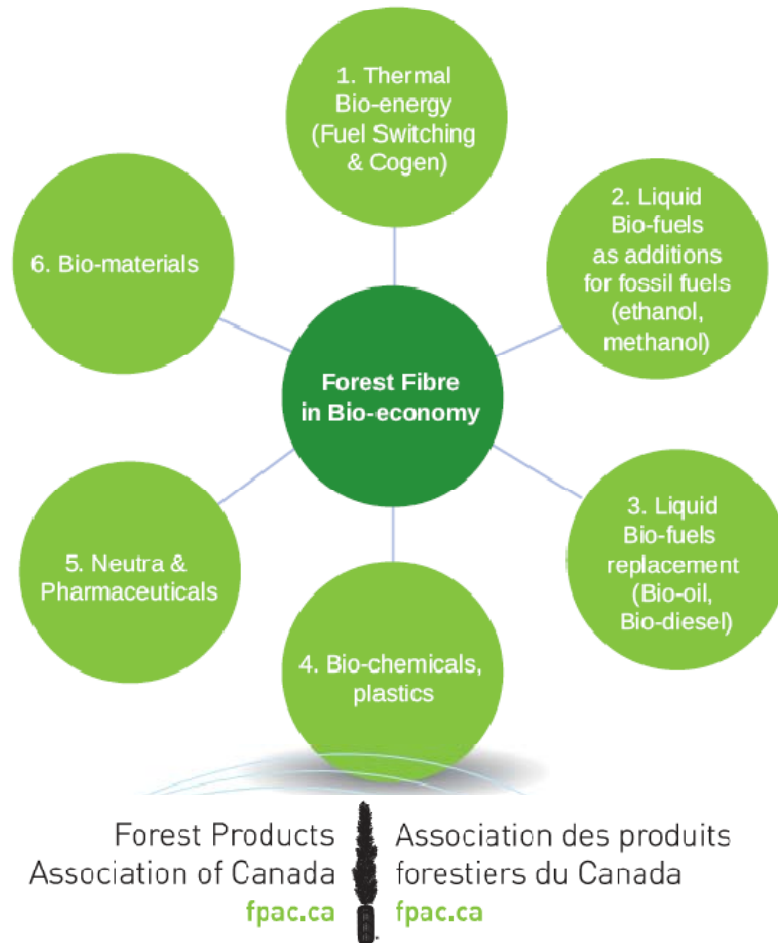
US Department of Energy



PRODUCTION OF 2ND GENERATION BIOFUELS

Bio-pathways project in Canada

FOREST BIO-PRODUCTS CONTINUUM



Main conclusions:

- Canada has both a natural and a strategic advantage to grasp the enormous potential of the bio-economy.
- Lumber sector is the cornerstone to the competitiveness of the traditional and emerging forest products industry.
- Some paper segments will show financial potential under a bio-refinery scenario.
- Bioeconomic opportunity is stronger when integrated within the traditional industry's operations rather than on a stand-alone basis.
- Government policy can play dramatic role in skewing bio-industries' performance
- Companies that make the conversion can begin to cash in on a rapidly-growing international market for clean energy and carbon-neutral products. But there is no time to lose.



European Biofuels
TECHNOLOGY PLATFORM

EUROPEAN INDUSTRIAL BIOENERGY INITIATIVE (EIBI)

Objectives and activities

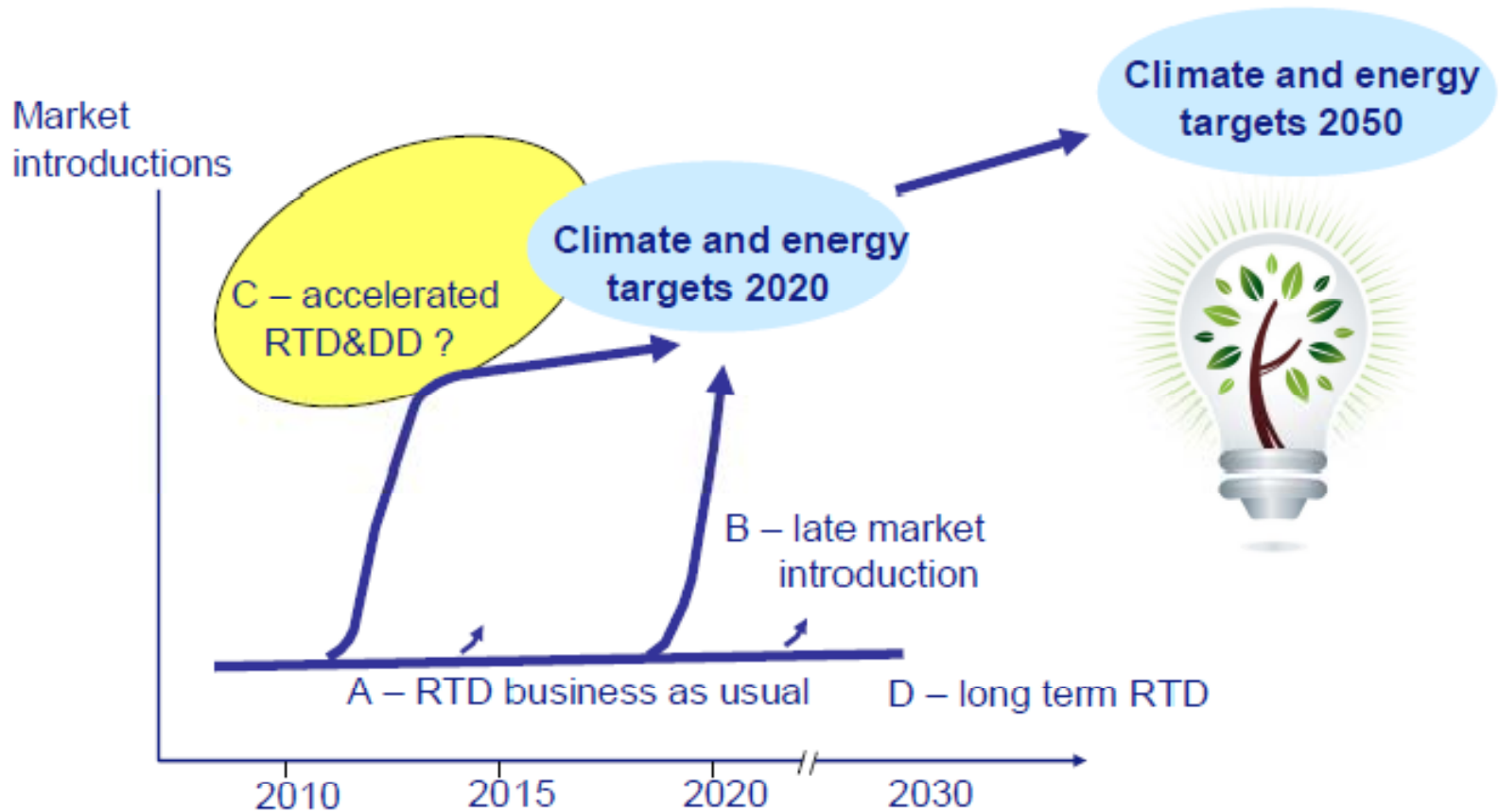
Markku Karlsson

Vice Chair of EBTP Steering Committee

Chair of Working Group 1 „Biomass Availability and Supply“ / UPM Kymmene



Routes to 2020 targets



EIBI: objective, activities, budget

Key objectives

- Enabling commercial availability of advanced bioenergy at large scale by 2020, including advanced biofuels covering up to 4 % of EU transportation energy needs by 2020.
- Strengthening EU world technology leadership for renewable transport fuels, in particular for diesel and jet engines, serving the fastest growing area of transport fuels in the world.

Core activity

- Selection and funding of demonstration and reference plants, via calls for projects
 - **Demonstration:** outcome of demo unit should allow first commercial unit to be designed and performance guaranteed.
 - **Reference plant:** first commercial scale unit

Estimated budget : 8 billion € over 10 years, to fund 15 to 20 demonstration and / or reference plants



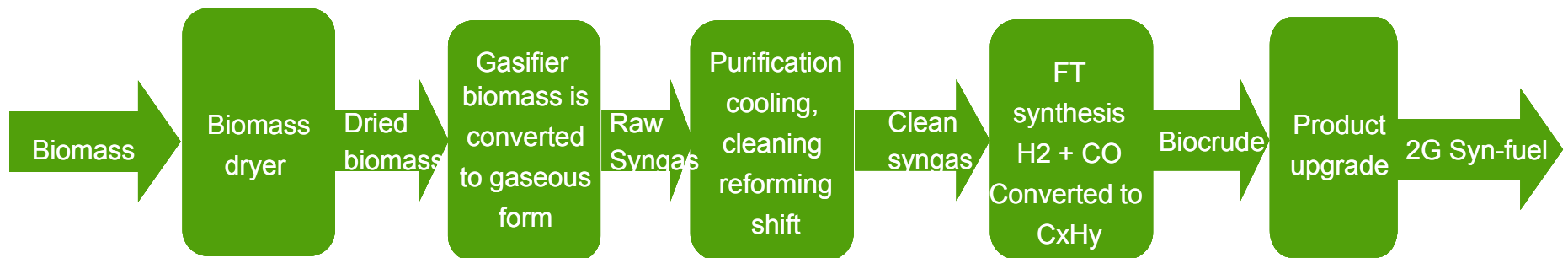
Current status:

- .Conceptual study completed
- .Out Side Battery Limit Engineering study for Kymi & Rauma completed
- .Environmental Impact Assessment in 3 locations
- .Biomass dryer test runs completed
- .Piloting of biomass gasifier on going
- .Demonstration of the whole concept planned

Next steps:

- .Final technology / concept decision Basic Engineering & Permitting

TOTAL INVESTMENT COST ABOUT 350 MEUR.
FUNDING IS EXPECTED THROUGH PUBLIC/PRIVATE PARTNERSHIP.



d) Budget, Timing & Funding

Overview on estimated Budget per value chain

*RSFF = Risk Sharing Finance Facility

7 "generic" value chains		Estimated # of demo / reference needed	Total estimate d budget M€	Public funding M€	Comments Ratio Public Grant /RSFF*
1	Synthetic fuels / hydrocarbons from biomass via gasification	1 D 2 R	1300-1700	650-850	50%/50%
2	Bio-methane and other gaseous fuels from biomass via gasification	1 D,2 R	500 - 800	250-400	50%/50%
3	High efficiency power generation via gasification of biomass	2 R	600 - 900	300-450	50%/50%
4	Bioenergy carriers from biomass via other thermochemical processes like pyrolysis, torrefaction etc.	2 R	300 - 400	150-200	50%/50%
5	Ethanol and higher alcohols from carbohydrates containing biomass ^[1]	1D 2 R	900 - 1200	450-600	50%/50%
6	Renewable hydrocarbons from carbohydrates containing biomass via biological and/or chemical process	2 D 1 R	400 - 500	200-250	50%/50%
7	Production of bioenergy carriers from CO ₂ & sunlight through micro-organism based production (algae, bacteria etc.) and further upgrading into transportation fuels and valuable bio-products	2-3 D 1 R	1200 - 1500	600-750	50%/50%
Additional activities					
B	- Contribution to production and harvesting of biomass - Reserve for still unidentified value chains		800 - 1000	400-500	50%/50%
TOTAL			6000 - 8000	3 000- 4000	

Forest industry renewal

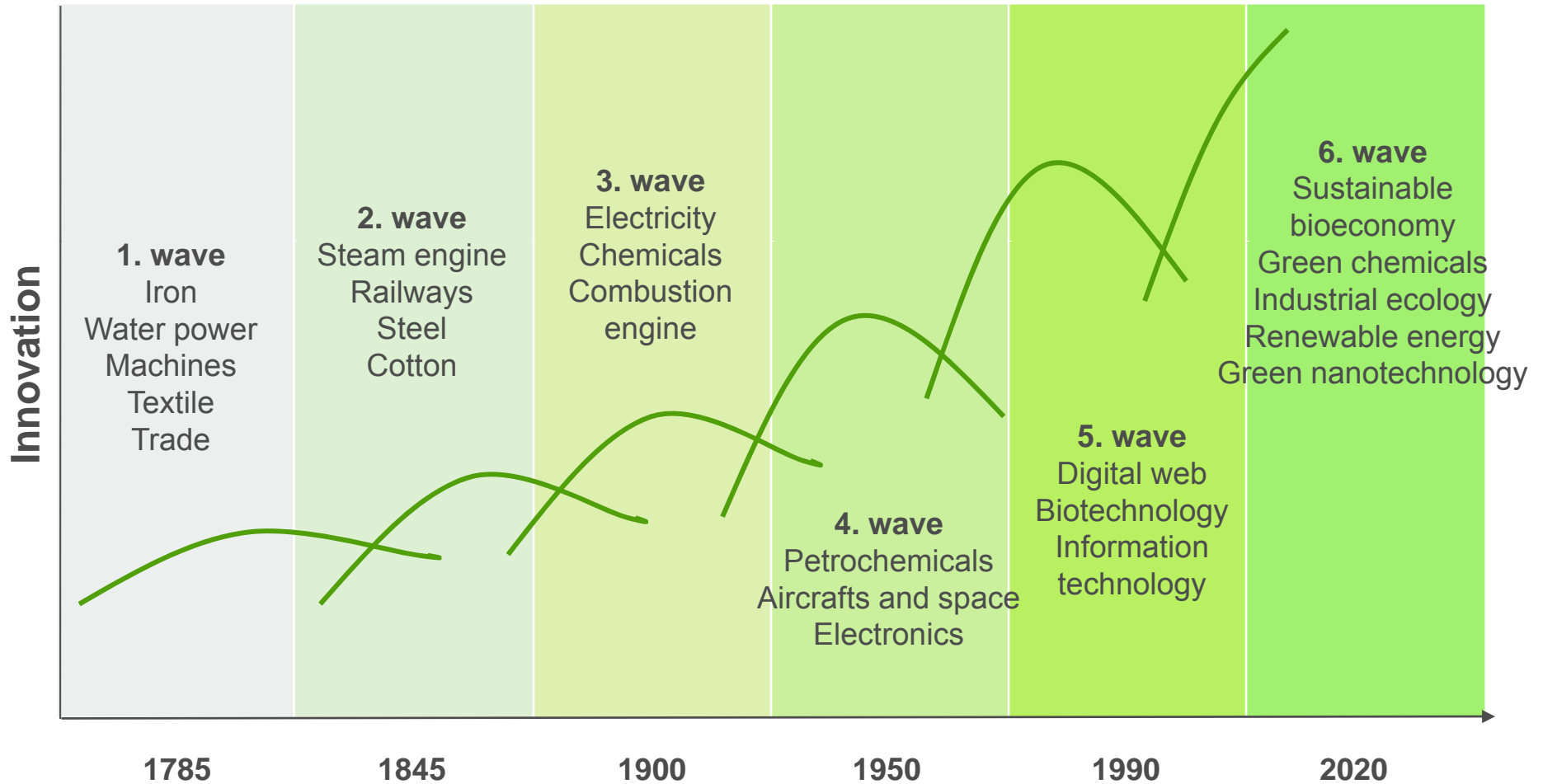


ACTIONS FOR FOREST INDUSTRY RENEWAL

The sixth industrial revolution is bio-based



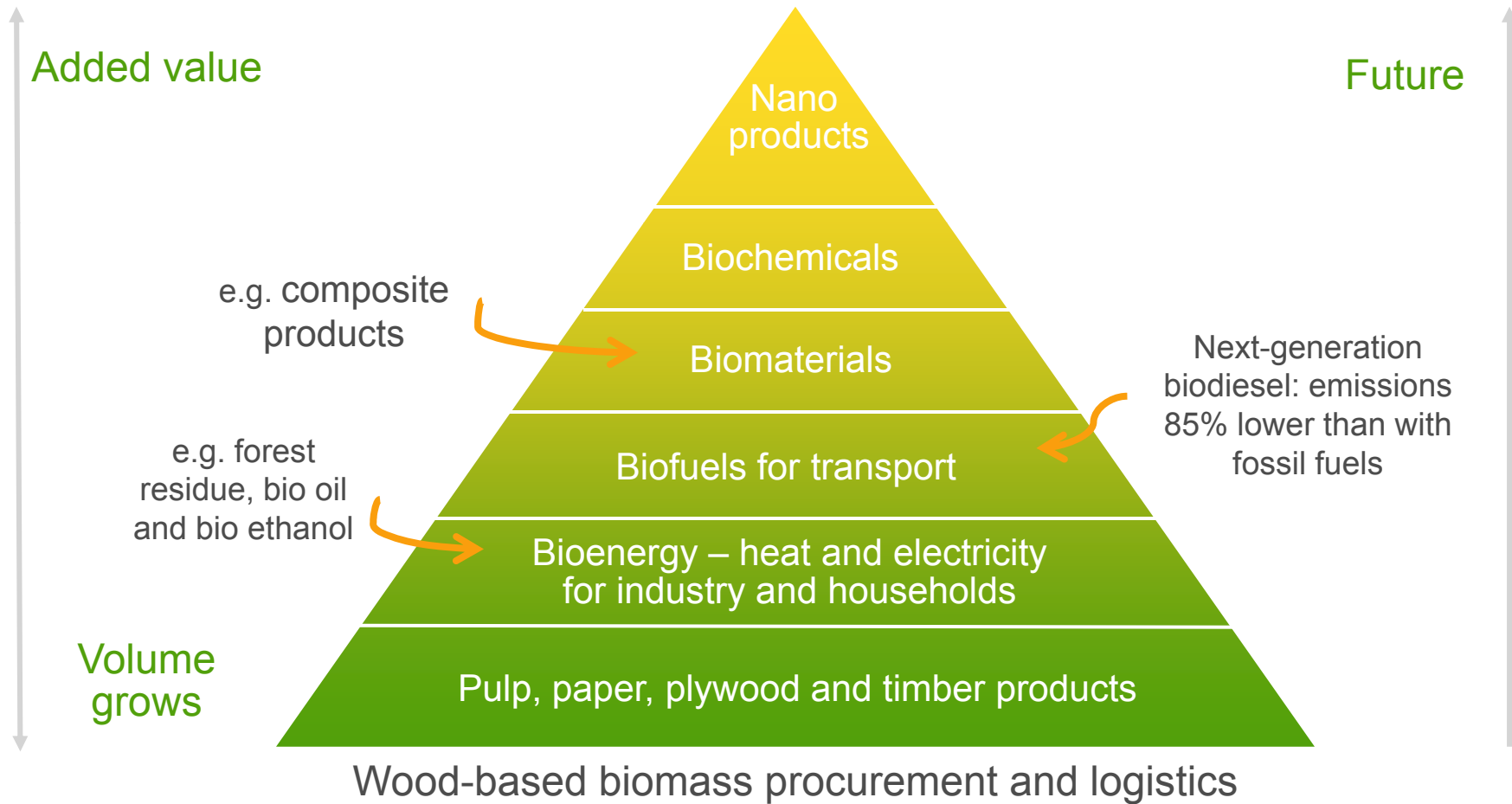
The Biofore Company UPM



Source: FFIF 2009

ACTIONS FOR FOREST INDUSTRY RENEWAL

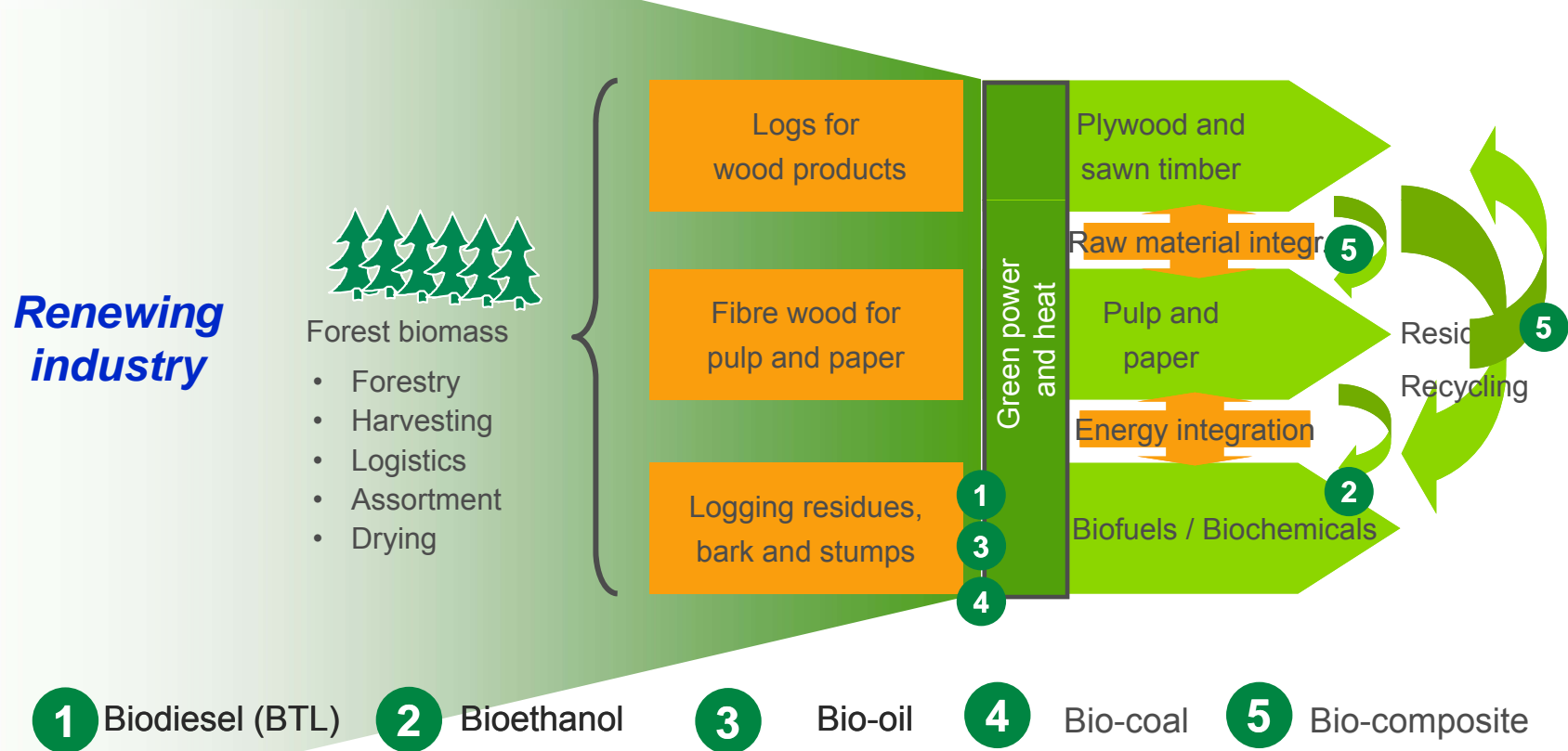
Bio-based products have substantial markets



ACTIONS FOR FOREST INDUSTRY RENEWAL

Production of 2nd generation biofuels

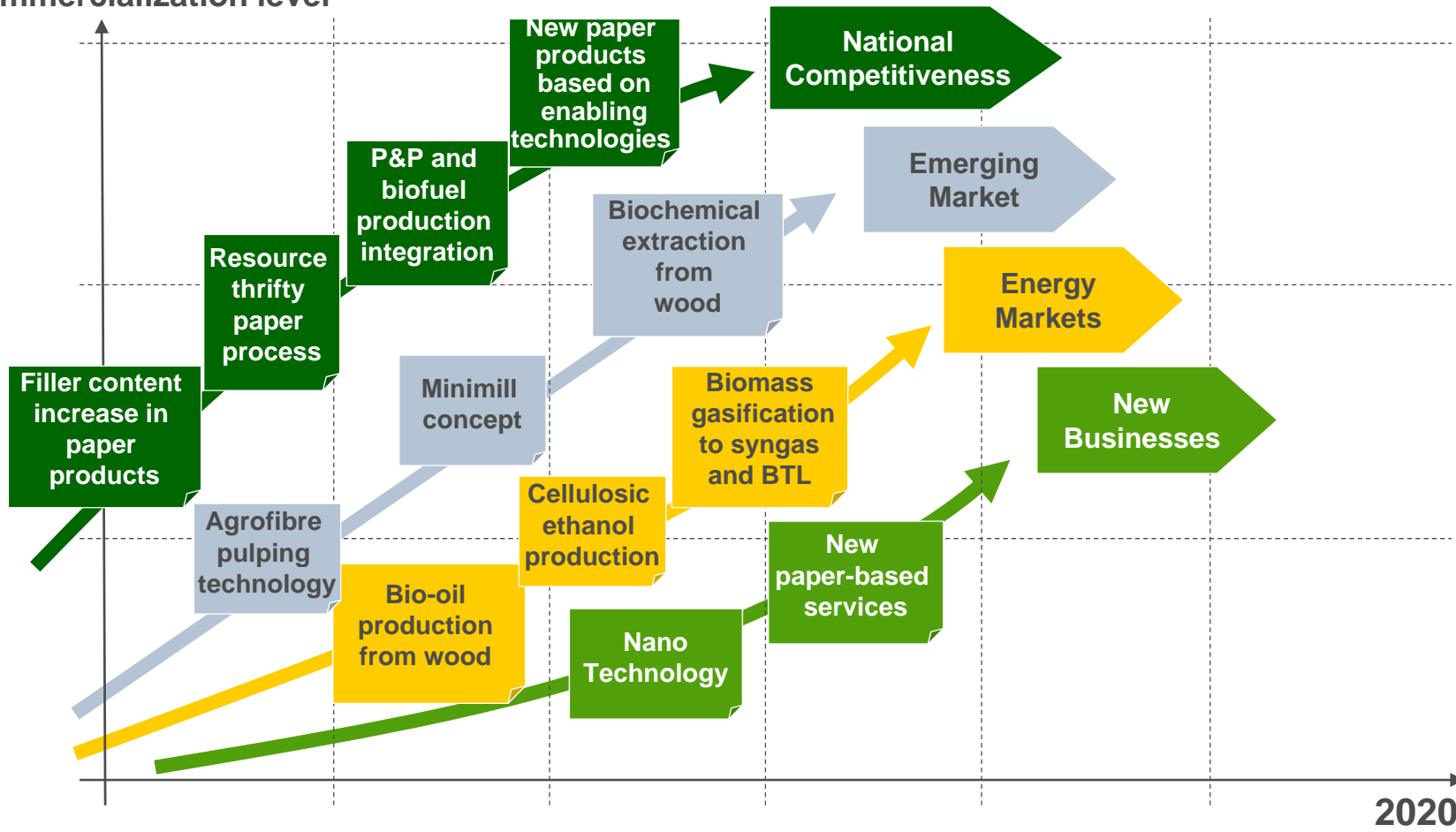
Sustainable development = radical reduction of CO₂ + Non-food + sustainable value chain



ACTIONS FOR FOREST INDUSTRY RENEWAL

Finnish Forest Industry Roadmap

Business portfolio,
commercialization level





UPM's Biofuel Concept Portfolio

PRODUCTION OF 2ND GENERATION BIOFUELS

UPM – The Biofore Company



Current activities

- 24,000 employees
- Sales 9.5 billion euros
- Production in 14 countries, worldwide sales network
- Listed in the NASDAQ OMX Helsinki Ltd.



Energy and Pulp



Paper



Engineered Materials

On-going new activities and future opportunities



RFID tags



Biocomposites



Biofuels



Biochemicals

In the next few years, UPM plans to become a significant player in the field of second generation biofuels

PRODUCTION OF 2ND GENERATION BIOFUELS

UPM's Biofuel Concept Portfolio

1	BTL Wood biodiesel	<ul style="list-style-type: none">▪ Kymi, Rauma and Stracel mill sites are evaluated for the possible commercial scale Biomass to Liquids plant.▪ In the process, energy wood is converted into high quality diesel fuel.▪ Gasification and gas cleanup are piloted at the Gas Technology Institute's pilot plant in Chicago in co-operation with Andritz
2	Bioethanol	<ul style="list-style-type: none">▪ Bioethanol concept is being developed together with a project consortium.▪ Commercial and industrial wastes are used as raw material for enzymatic ethanol production.▪ Ethanol is used as a gasoline blending component.
3	Bio-oil	<ul style="list-style-type: none">▪ Pyrolysis oil production concept is developed together with Metso and Fortum.▪ Energy wood is used as raw material and the production is integrated into a power boiler.▪ Bio-oil is mainly used as a substitute for fossil light and heavy fuel oil in heating applications.

PRODUCTION OF 2ND GENERATION BIOFUELS
Value-add from integrated biorefineries



**Integrated
Virgin
Biorefinery**

Pulp	Paper	Bio-Chemicals, Bio-oil, FT crude
Heat & Power generation	Waste water treatment	Bio-Composites

**Integrated
Urban
Biorefinery**

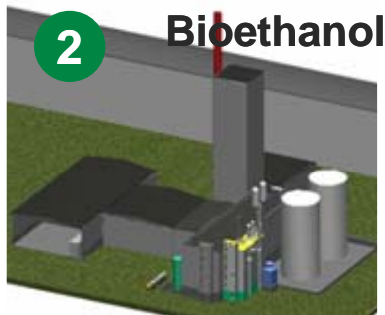
DIP	Paper	Waste	Bio-Ethanol
Heat & Power generation	Waste water treatment	Waste to Energy	Bio-Composites

Now

2010 -

PRODUCTION OF 2ND GENERATION BIOFUELS

Three concepts in piloting stage and EIAs* in 3 different locations

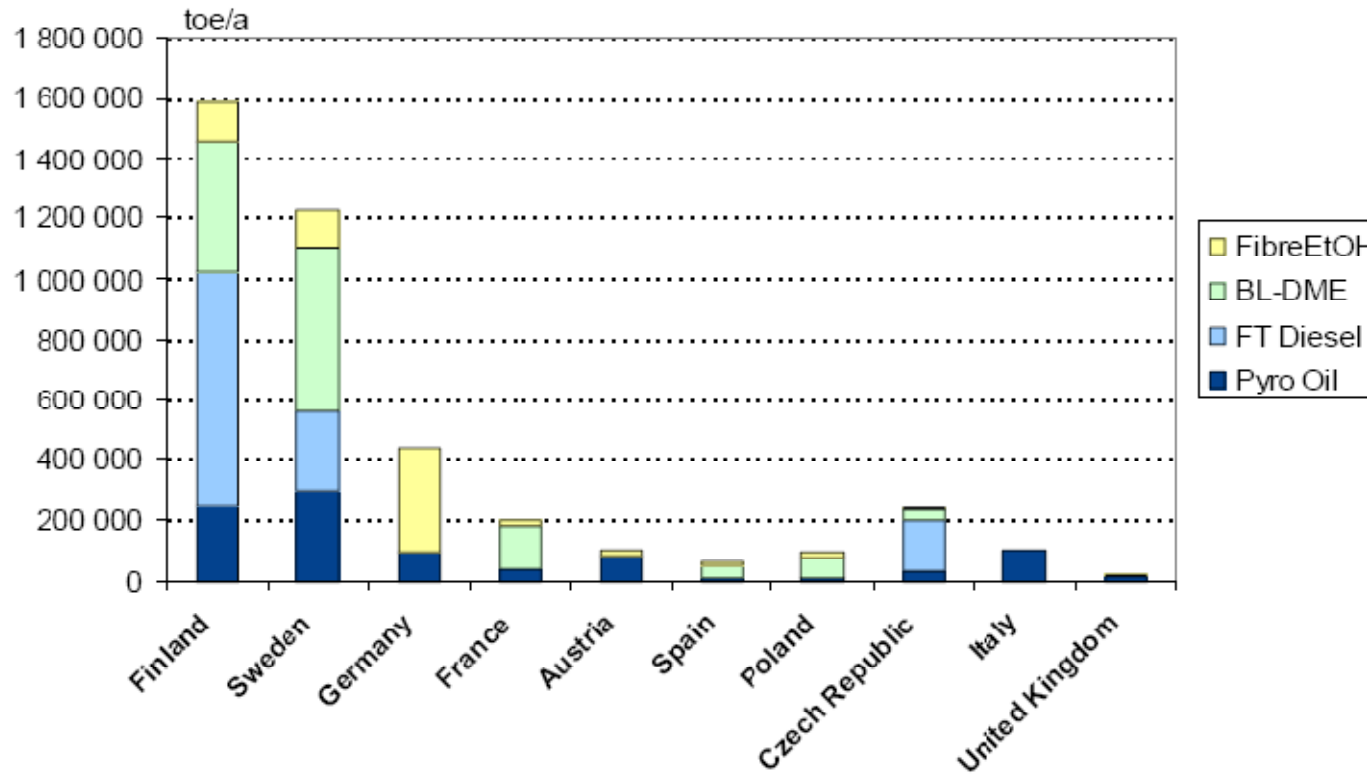


+ Biodiesel mill at Stracel

PRODUCTION OF 2ND GENERATION BIOFUELS

Scenario of the Biofuels Business Potential

Analysis – 4 Mtoe

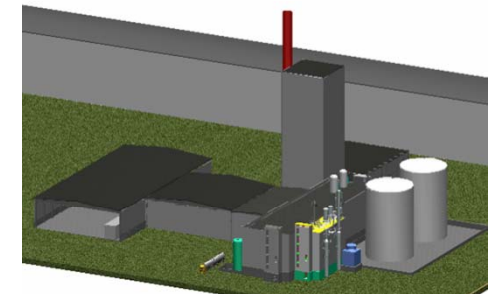
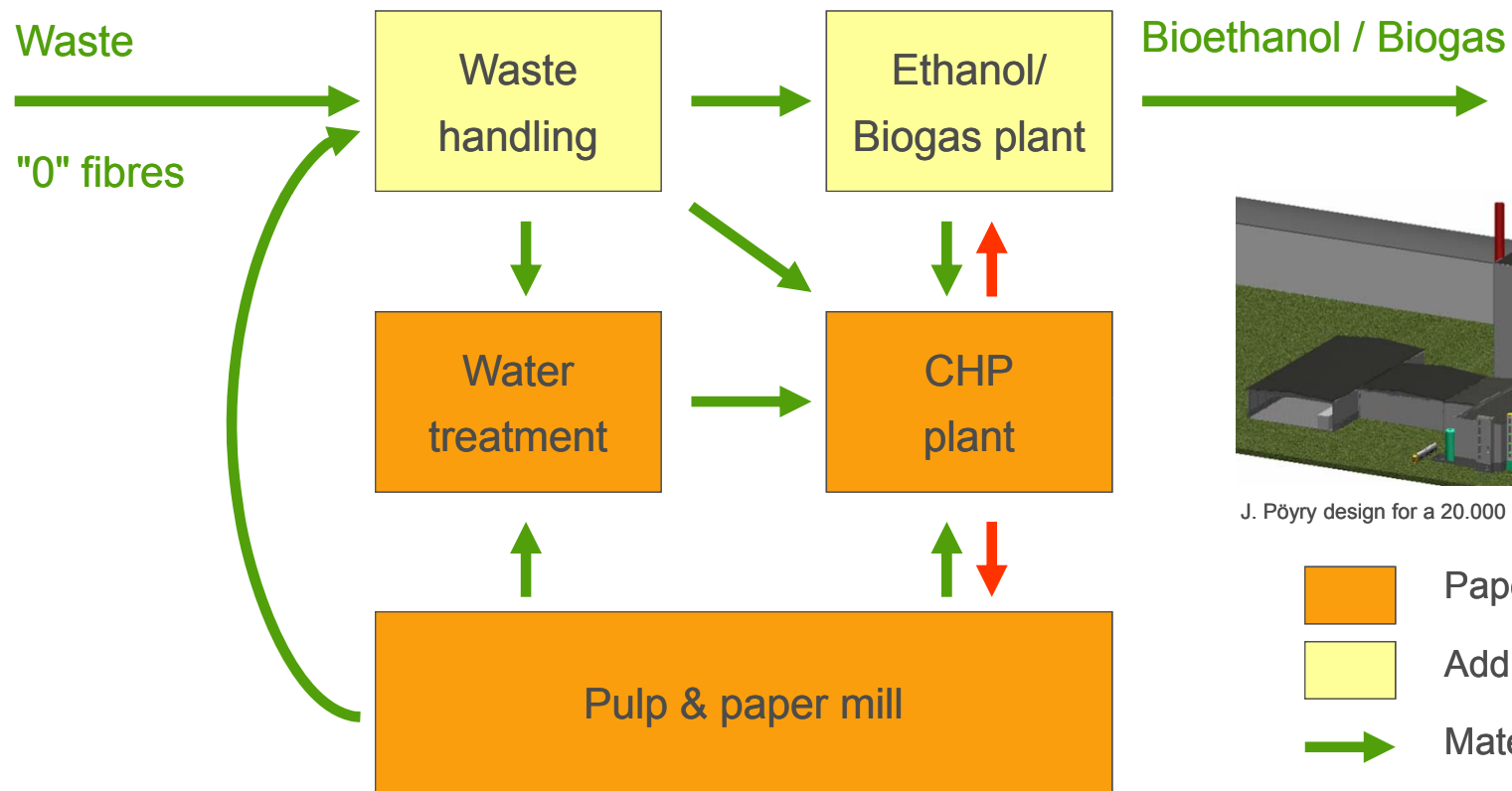


Liquid biofuels in European pulp and paper industry by year 2020.





PRODUCTION OF 2ND GENERATION BIOFUELS

2G bioethanol concept

2

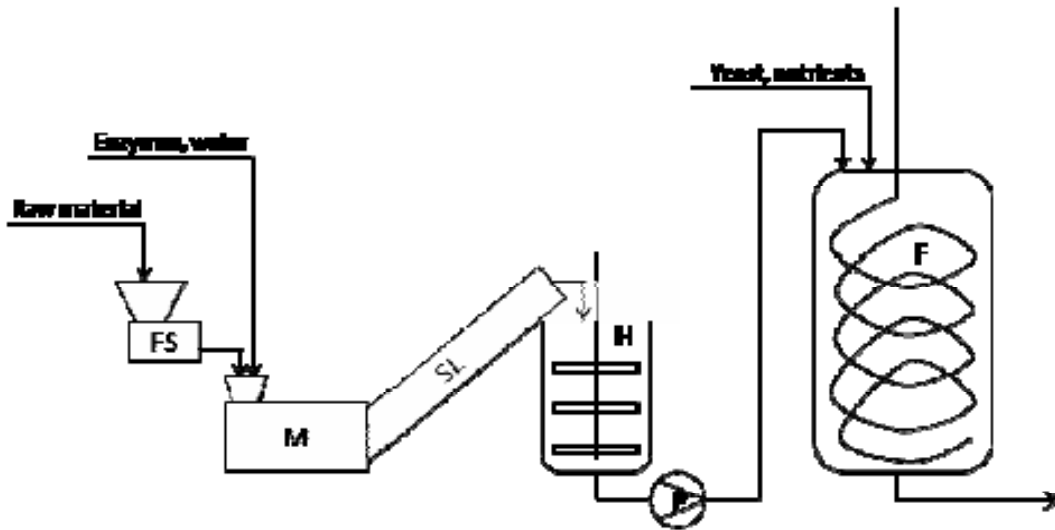


J. Pöyry design for a 20.000 m³/a bioethanol unit

-  Paper mill units
-  Additional units
-  Material flow
-  Energy flow

PRODUCTION OF 2ND GENERATION BIOFUELS

Bio-ethanol status



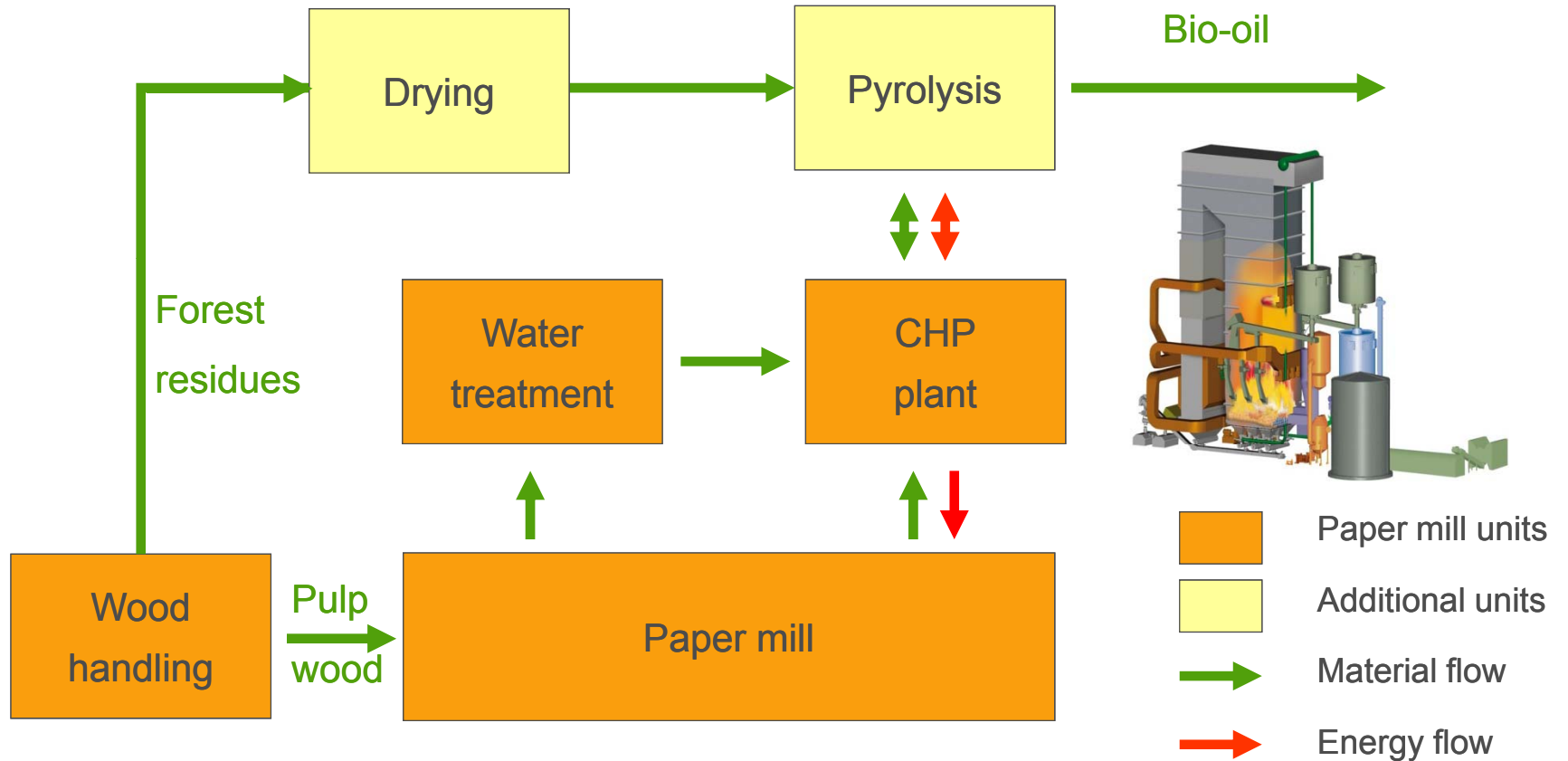
FibreEtOH – From a waste to a valuable biofuel

- The innovative focus in the FibreEtOH project is to demonstrate for the first time globally in a commercial scale a cost efficient paper fibre based ethanol production with high, > 70 % overall energy efficiency with high > 50 % green house gas reduction.
- The proposed demonstration plant with 20 000 m³/a ethanol production capacity will be build using 250 000 t/a waste
- The project is led by UPM Kymmene a leading forest products industrial player and is supported by the EC with €8.6 million.

PRODUCTION OF 2ND GENERATION BIOFUELS

2G bio-oil concept – CHPF*

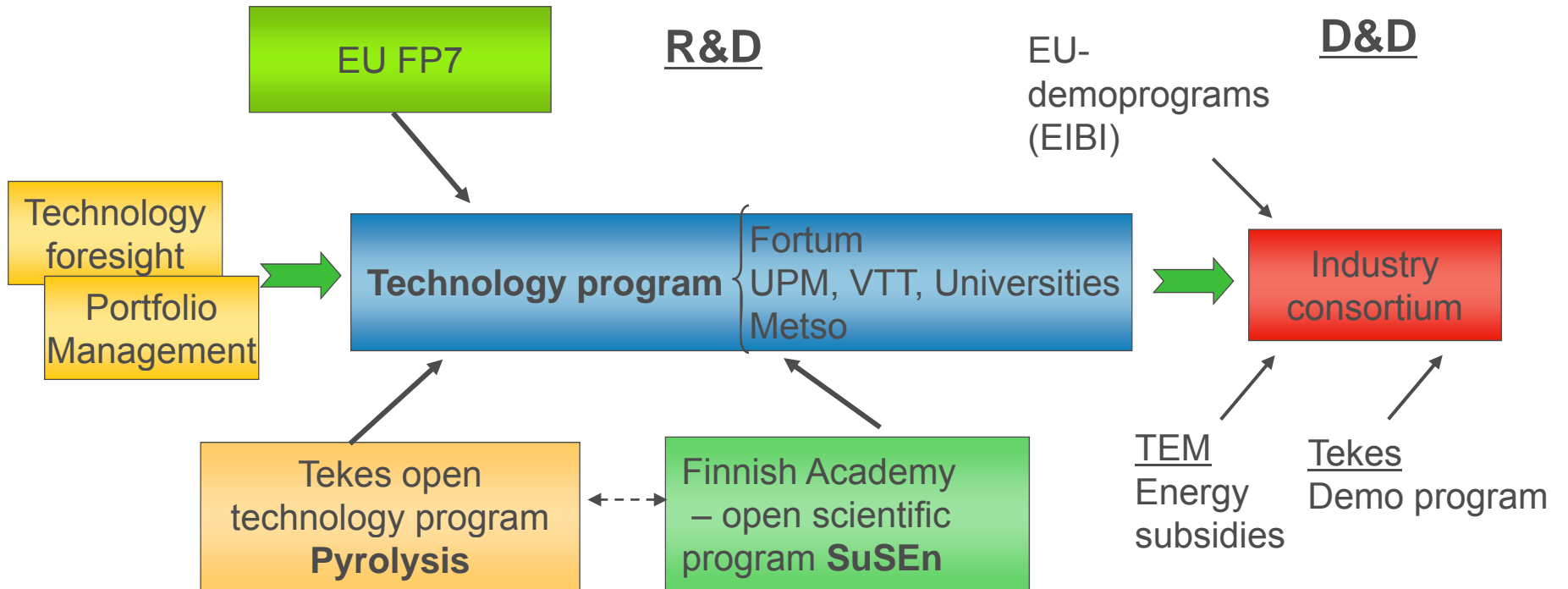
3



*Combined heat, power and fuel

PRODUCTION OF 2ND GENERATION BIOFUELS

Case Biofuels R&D and D&D value chains



PRODUCTION OF 2ND GENERATION BIOFUELS

Integrated bio-oil production



Pyrolysis piloting at Metso's R&D Center in Tampere, Finland

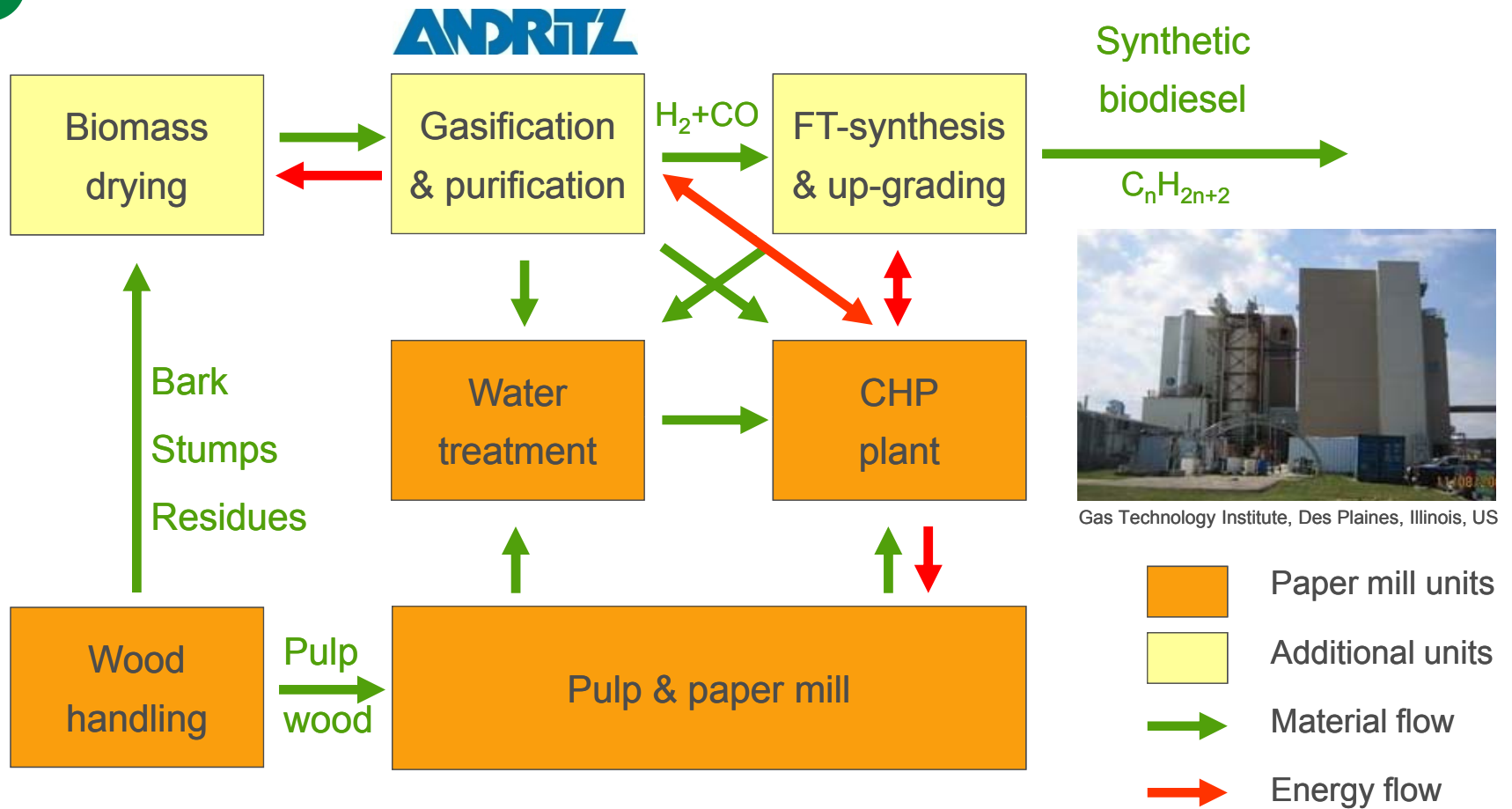
- Metso, UPM, Fortum and VTT have developed an integrated biomass-based bio-oil production concept to provide an alternative to fossil fuels
- The consortium has developed a bio-oil production process in which a pyrolysis reactor is linked to a conventional fluidized bed boiler
- Proof-of-concept has been done:
 - More than 70 tons of bio-oil have been produced from sawdust and forest residues
 - Longest continuous test run has been over 200 hours
- Bio-oil utilization has been proven
 - More than 20 tons of bio-oil has been used to replace heavy fuel oil at district heating boiler in Masala, Finland



PRODUCTION OF 2ND GENERATION BIOFUELS

2G biodiesel concept

1



Gas Technology Institute, Des Plaines, Illinois, US



The Biofore Company **UPM**

Second Generation Bio-diesel – from piloting to demonstrations



FROM PILOTING TO DEMONSTRATIONS

UPM is evaluating the suitability of mill sites for the commercial scale BTL plant



The Biofore Company UPM

- Environmental impact assessment at Kymi and Rauma mills in Finland and Stracel mill in France
 - Integration to existing pulp or paper mill will increase efficiency.
- The technical concept is being finalised
 - pilotting plant at Gas Technology Institute in Chicago together with Andritz/Carbona.
- UPM's BTL-biodiesel is well suited for the current diesel motor technology and fuel distribution infrastructure.
- The investment decision can be made after the piloting program has been finished and the final technical concept has been selected.



FROM PILOTING TO DEMONSTRATIONS

Feed stock pretreatment

- Feed stocks consists of bark, forest residue and stumps
- Thermal drying at UPM Rauma mill and pelletization before shipment
- Total amount ~ 600 t (metric)



FROM PILOTING TO DEMONSTRATIONS

The Pilot Plant facilities at the GTI are used as testing platforms for Gasification and Gas Cleanup for the BTL process

The Biofore Company



UPM

Pilot Plant sections:

- Gasification Plant (FFTF)
- Gas cleanup and processing (AGTF)

Main characteristics of the Pilot Plant:

- Oxygen blown pressurized fluidized bed gasification
- Catalytic tar reforming & gas cleanup
- Plant capacity is 7-17 MMBtu/h (2-5 MW_{th}) biomass fuel input



Source: GTI

FROM PILOTING TO DEMONSTRATIONS

Purpose of FFTF Pilot testing

- Evaluate UPM biomass and related gas yield and quality
- Verify data for scaleup and integration
- Generate data for EIA
- Determine process parameters for the full scale plant
- Generate operation data on entire gasification island process
- New installation was build
 - new gas processing, conditioning and cleaning equipment were designed by Carbona and installed by GTI



Advanced Gasification Test Facility (AGTF)

FROM PILOTING TO DEMONSTRATIONS
**Several campaigns and set points
during the test program**

- Carbona Inc. & UPM are responsible for test program
- Fuels: bark, logging residue and stumps
- Different bed materials
- Different reformer catalysts
- Different operating conditions
- Long duration testing



Catalyst Test Facility (CTF)

FROM PILOTING TO DEMONSTRATIONS

GTI plant designed for pressurized gasification



Background:

- Existing pilot, designed for pressurized fluidized bed gasification for coal
- Existing infrastructure for operation and auxiliaries
- Excellent research and laboratory facilities for analytical support

Modifications for BTL biomass testing:

- Carbona designed partly new and partly modified equipment
- Process arrangement modified to fit and connect existing and new process



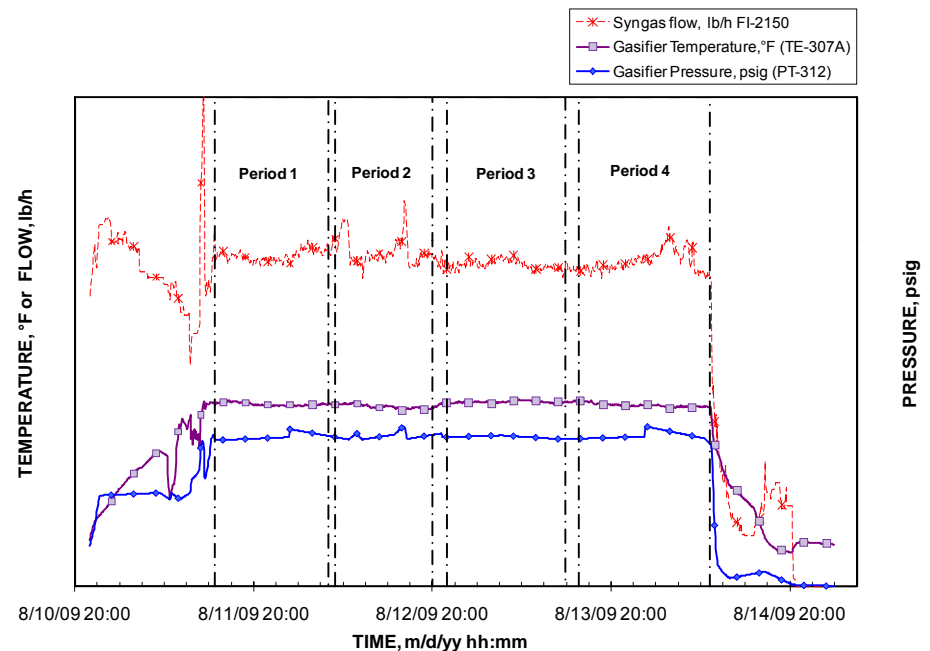
Flex-fuel test facility (FFTF)

FROM PILOTING TO DEMONSTRATIONS

Steady state process data from pilot plant



- Fuel and carbon conversion
- Gas yield and gas properties (H₂/CO ratio, etc.)
- Gas composition and gas contaminants (nitrogen, sulfur and chlorine compounds)
- Tar and methane reforming, reformer performance,
- Auxiliary material (oxygen, steam, bed material) consumption
- Solid waste amount, composition and contaminants
- Waste water contaminants
- Long duration test runs to follow



PRODUCTION OF 2ND GENERATION BIOFUELS

Summary



- The versatile utilization of biomass throughout the new value network offers many growth opportunities, which are boosting the renewal of the forest industry
- The production concepts of advanced biofuels are very capital intensive and require radical technological solutions.
- Public policy makers need to recognize – and act – to support the integration of forest operations with bio-energy operations. This approach provides positive impact on jobs, the national economy, rural communities, and the environment
- The role of forest industry can be a catalyst for future biorefineries and biofuels due to existing platform and infrastructure.



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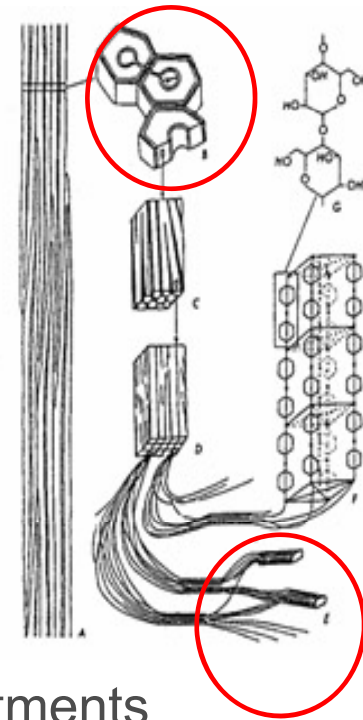
FOREST INDUSTRY RENEWAL NANOCELLULOSE

NANOCELLULOSE

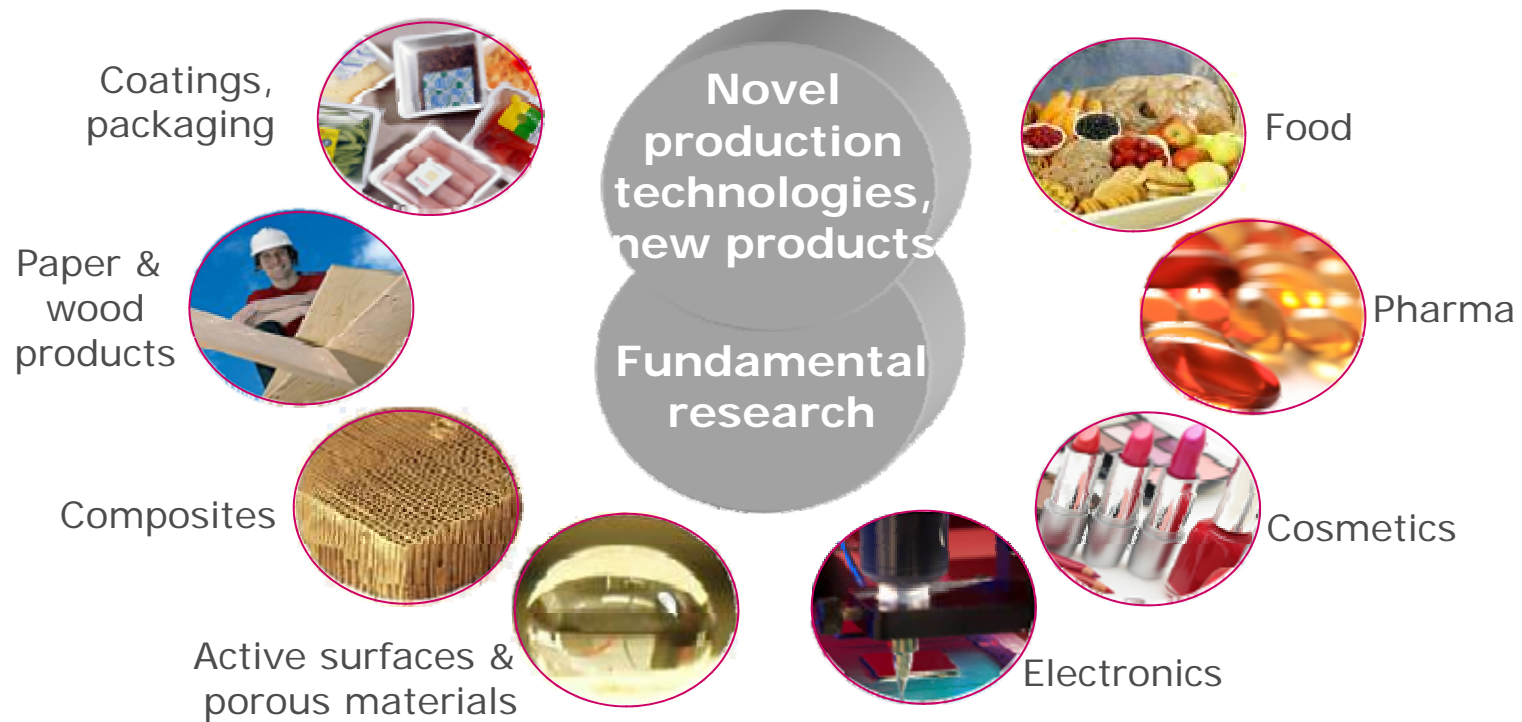
VTT, HUT and UPM as partners in Finnish Centre for Nanocellulosic Technologies



- VTT, the Helsinki University of Technology HUT and UPM as partners in an internationally unique Centre for Nanocellulosic technology
 - the aim is to create new uses for cellulose as raw material and substance
 - combines basic research, applied research, commercialization and business competence
 - >>> to speed up the launch of new profitable products on the market in the near future
 - employs around 40 researchers
- An equal consortium of three partners
- Operations are financed by public and private investments



NANOCELLULOSE Fields of action





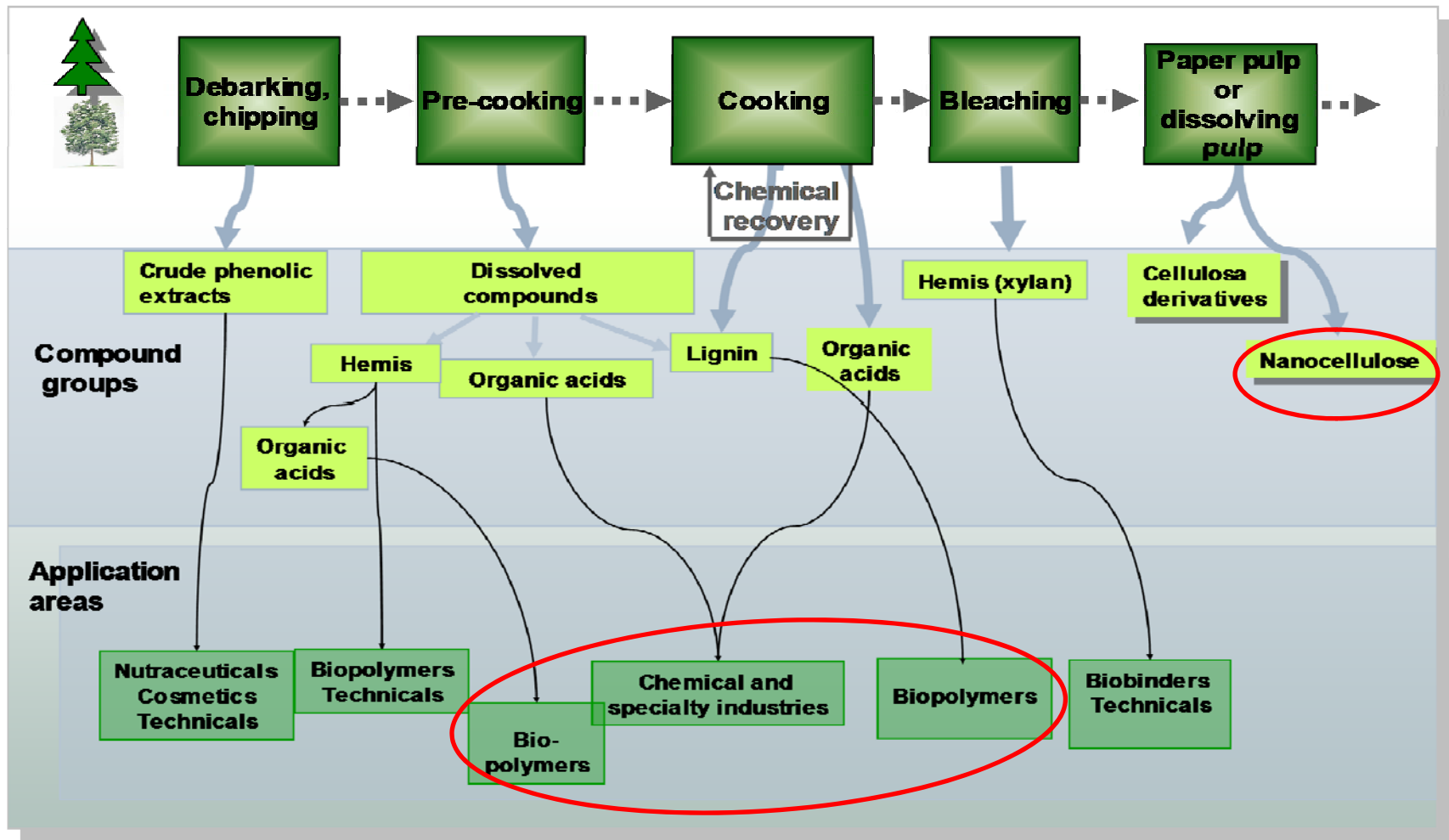
The Biofore Company **UPM**



FOREST INDUSTRY RENEWAL BIOCHEMICALS

BIOCHEMICALS

Chemical pulping process as a source for biochemicals



BIOCHEMICALS AND BIOFUELS

UPM Biorefinery Development Center



- Piloting facilities (i.e. pilots & analytical equipment) for creation of New business in
 - *Biofuels*
 - *Biochemicals*
- Located at Kaukas mill site and supported by UPM Research Center.
- In biochemicals, extensive cooperation with universities and research institutes
- Biofuels research started in October 2008 and biochemicals in the beginning of 2009
- Personnel about 20

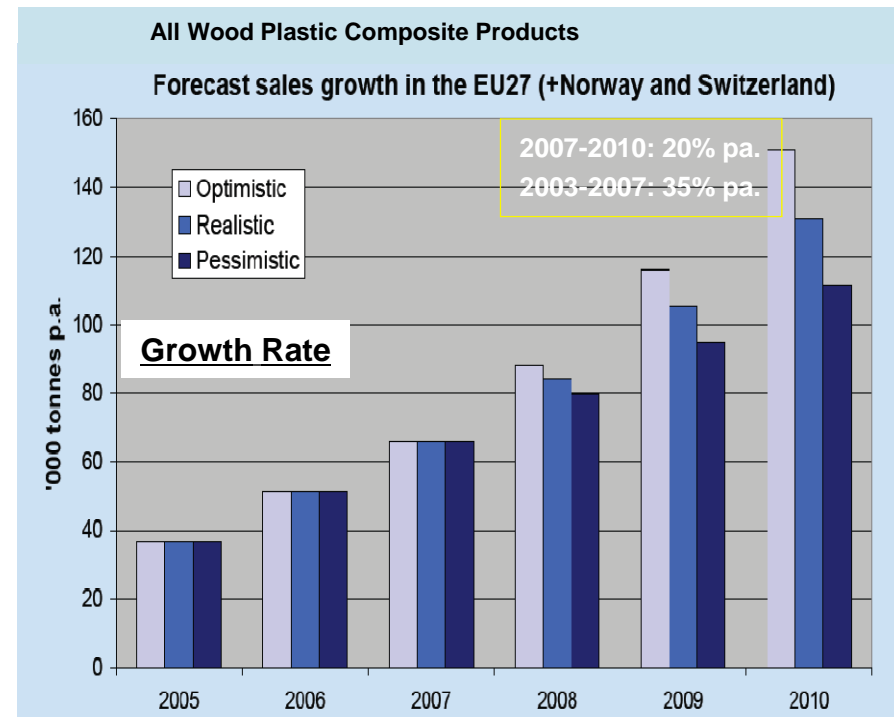


FOREST INDUSTRY RENEWAL COMPOSITES



COMPOSITES Growth market

- Wood Plastic Composite (WPC) contains polymers and wood.
- WPC is used to make for example decking boards, window frames and cladding products.
- In the US, WPC have an established market.
- Europe's composite markets are taking their first steps.



COMPOSITES

From waste to world-class green designs



*) In the past label waste containing plastic, paper, adhesive and silicone was incinerated or disposed off in a landfill

FOREST BASED BIOREFINERIES

Summary

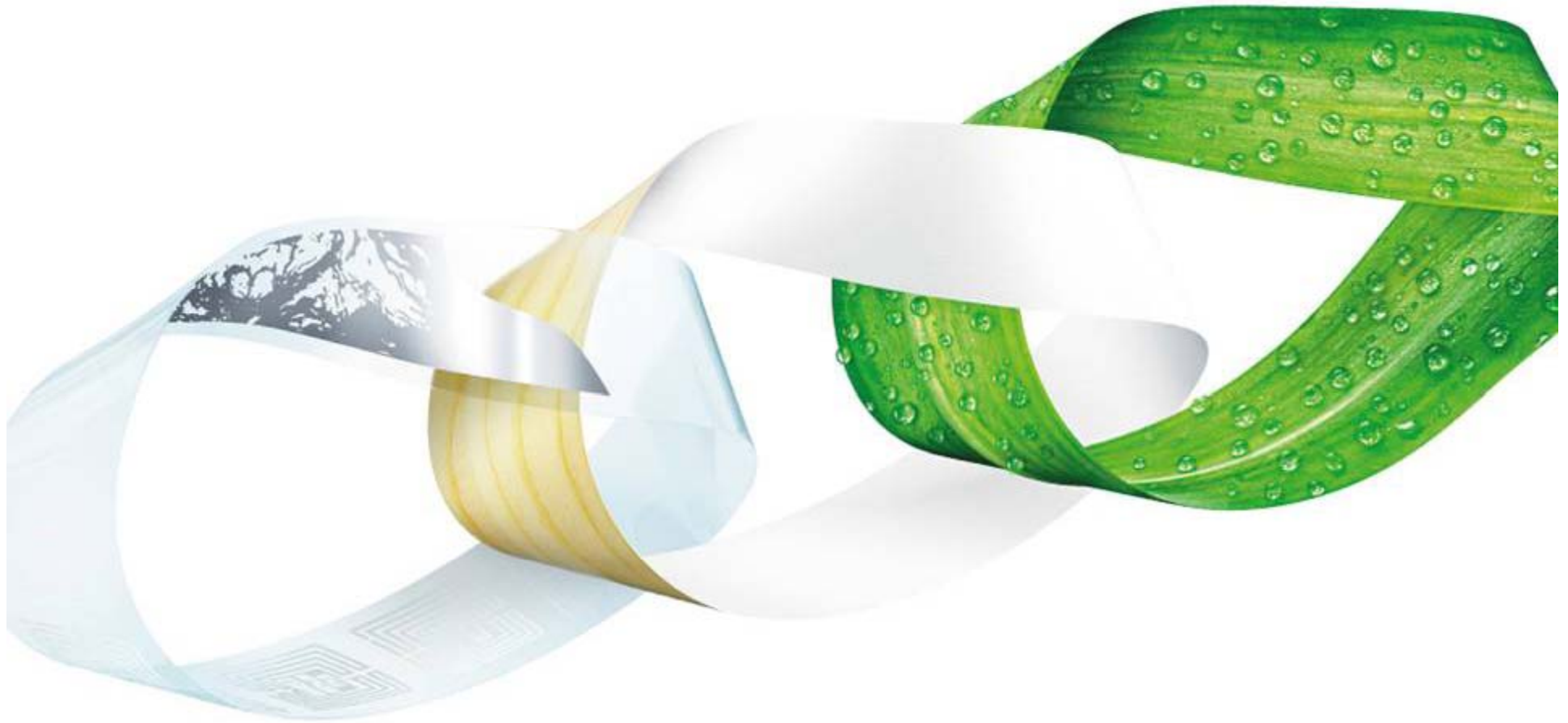


- The versatile utilization of biomass throughout the new value network offers many growth opportunities, which are boosting the renewal of the forest industry
- Understanding the technology management process together with strategic and financial criteria creates a platform for closing the gap between science and technology
- Open innovation is very good collaboration method at the beginning where we are working with basic development and moving to joint projects
- A lot of these thinking is based on trust between different partners (universities, institutes, industry). Without trust this is difficult to achieve
- The role of forest industry can be a catalyst for future biorefineries and biofuels due to existing platform and infrastructure.
- It is essential that universities and companies can work to together for common goal – renewal of the forest industry



The Biofore Company **UPM**

Thank you for your attention!





The Biofore
Company

