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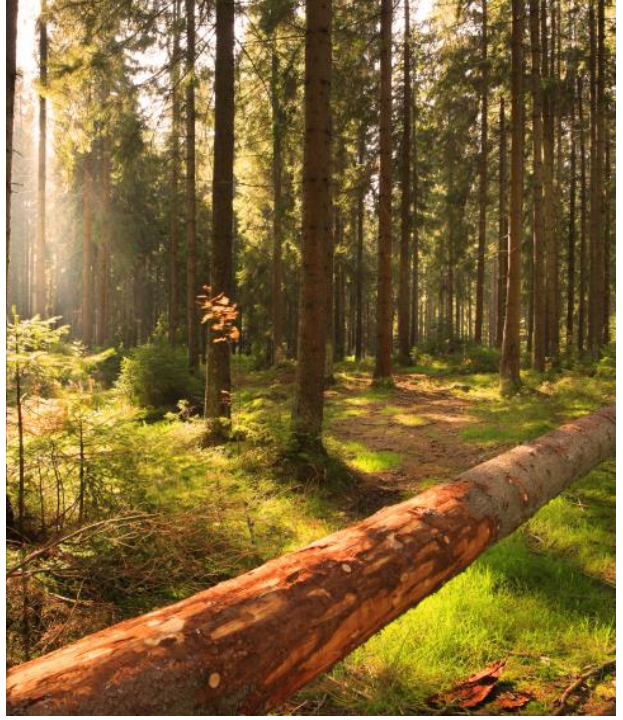
FORRETNINGSMULIGHETER BASERT PÅ PYROLYSETEKNOLOGI

Kai Toven

Skog- og trebruk bidrar til vekst og gode klimaløsninger

4. Desember 2019

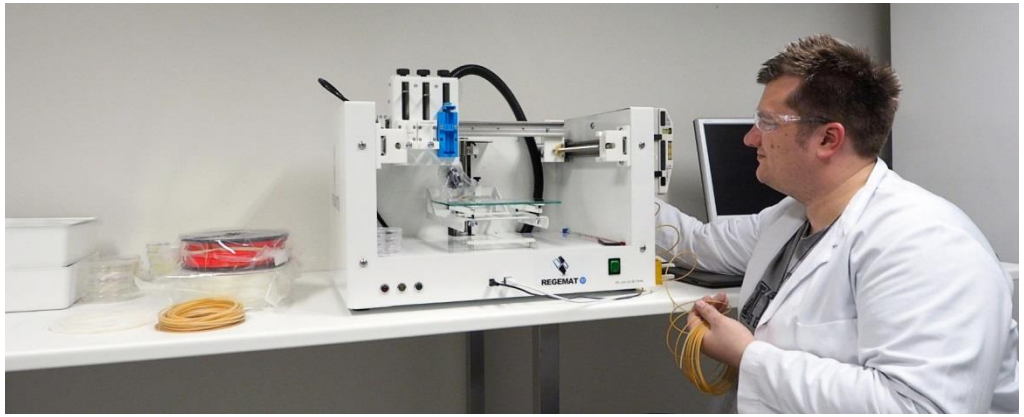
RISE PFI AS



Focus areas at RISE PFI

Biorefining and bioenergy

Fibre technology and applications



Biocomposites

Nanocellulose and carbohydrate polymers

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Outline

- Om pyrolyse teknologi
- Biokarbon applikasjoner
- Applikasjoner for pyrolyseolje
- Aktiviteter relatert til termokjemisk konvertering ved RISE PFI

Pyrolysis technologies

Mode		Conditions	Liquid	Biocarbon	Gas
Fast pyrolysis	**"Thermal Liquefaction"**	~ 500°C, short vapor residence time ~ 1-2s	**75 %**	**12 %**	**13 %**
Intermediate pyrolysis	**"Carbonisation" and " Thermal liquefaction"**	~ 400°C, long vapor residence time ~ minutes to hours	**45 %**	**30 %**	**25 %**
Slow pyrolysis	**"Carbonisation"**	~ 400°C, long vapor residence time ~ hours to days	**35 %**	**35 %**	**30 %**
Gasification		~ 800°C	**5 %**	**10 %**	**85 %**

- Pyrolysis – Thermal processing of biomass in absence of oxygen

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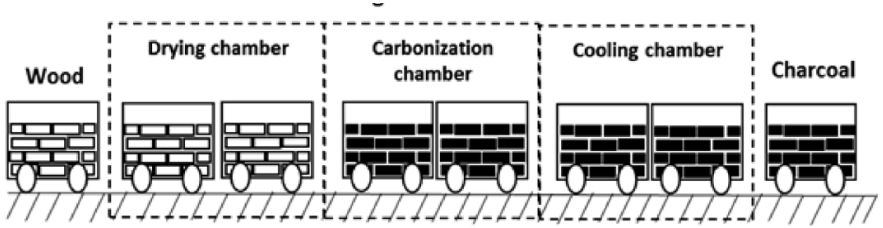
Pyrolysis technologies

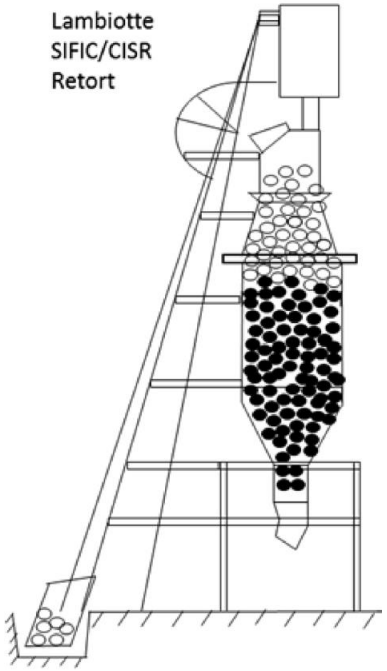
Slow pyrolysis

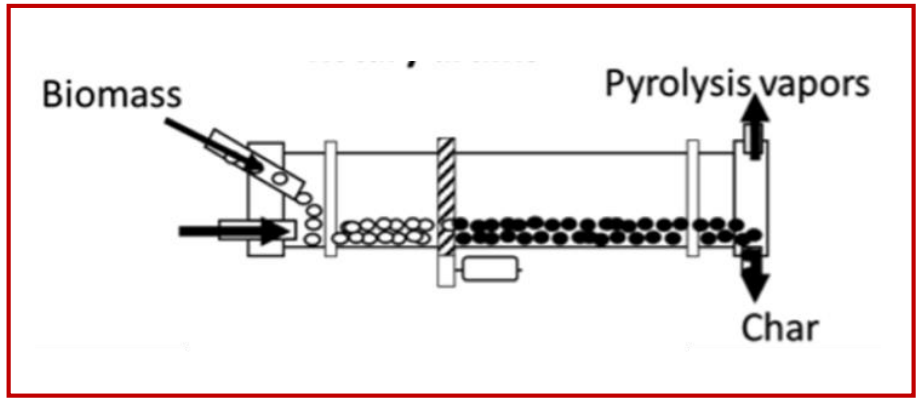
- Industrial carbonisation process
- About 30-35% charcoal yield
- No utilisation of byproducts

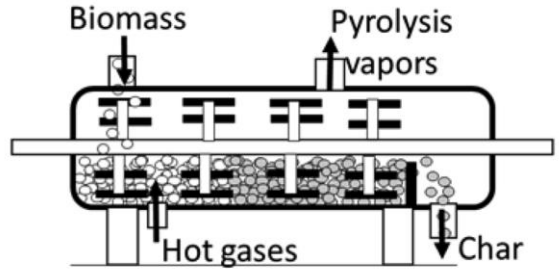
Intermediate pyrolysis

- Somewhat lower charcoal yield
- Utilize condensate byproduct









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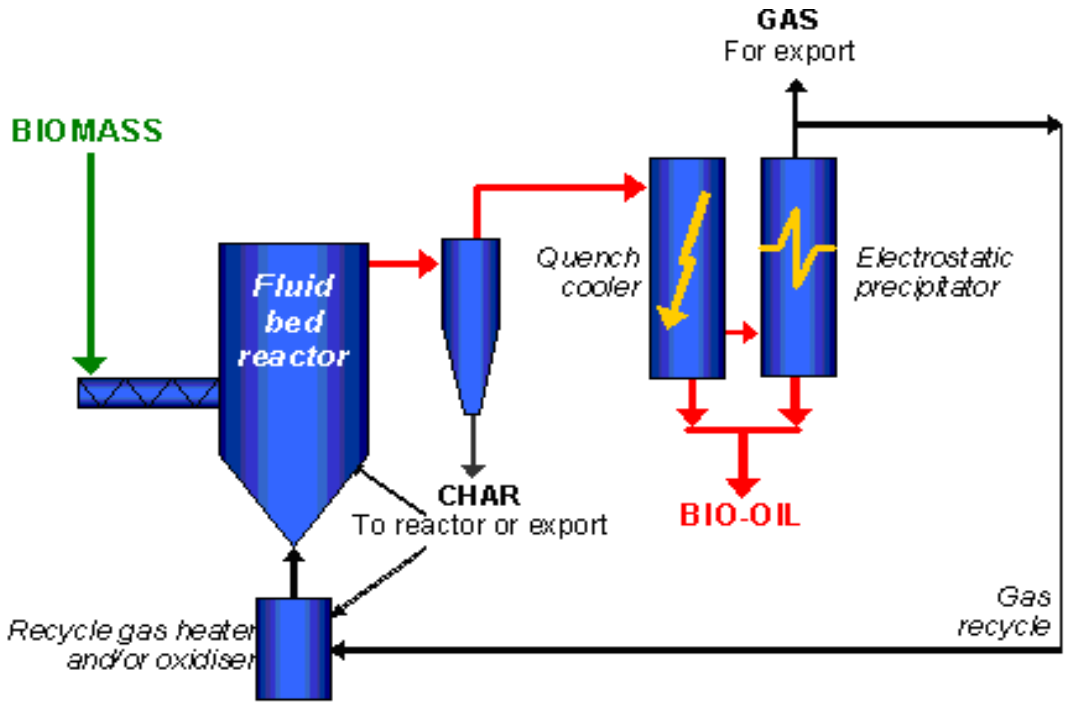
Pyrolysis technologies



Mode		Conditions	Liquid	Biocarbon	Gas
Fast pyrolysis	**"Liquefaction"**	~ 500°C, short vapor residence time ~ 1-2s	**75 %**	**12 %**	**13 %**

*National Team Leaders for **IEA Bioenergy Task 34 – Pyrolysis** at the opening of **EMPYRO** in Hengelo Netherlands 20th May 2015.*

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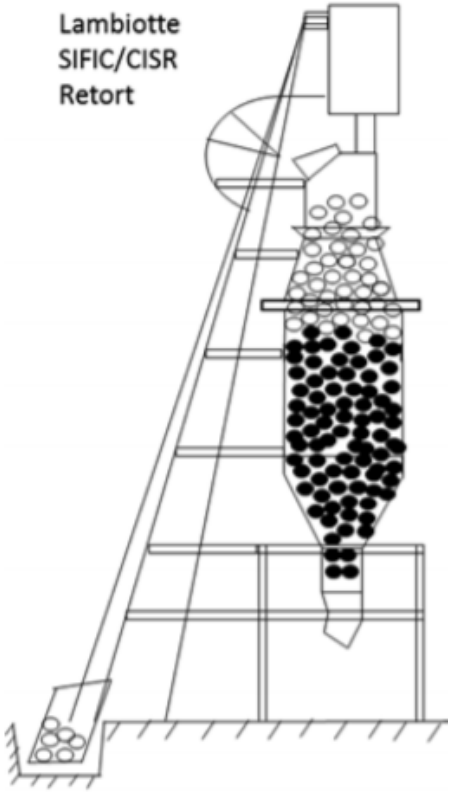
Biocarbon reductant material – Challenges and possibilities

Key challenges

- Profitability
- Product functionality

Potential in novel pyrolysis technology

- Very low carbon yields in commercial biocarbon production by slow pyrolysis
- Side product valorisation
- Integration advantages
- Logistiscs
- Speciality biocarbon products



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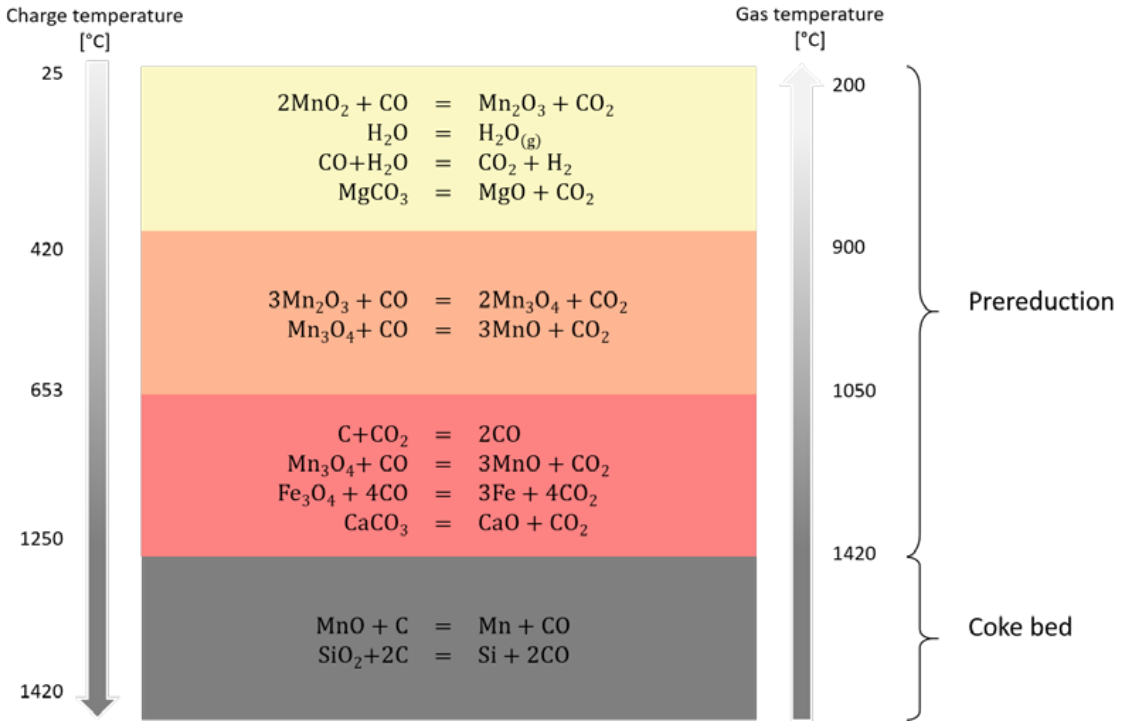
BioSinter – BioBrensel til sintring av manganmalm

- Ny teknologi for å produsere et kalkholdig karbonisert biobrensel egnet for sintring av manganmalm basert på fyllstoffholdig restråstoff fra produksjon av avispapir

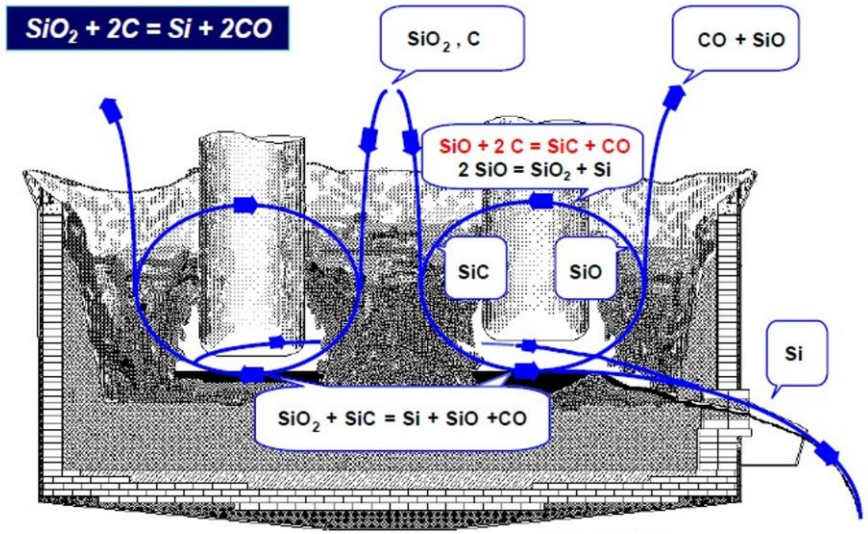
PyroGass - *Biocarbon reductant material for Mn production*

- Eramet Norge og Ferroglobe Manganese bruker idag 300.000 tonn kull årlig til produksjonen av Mn-legeringer noe som genererer årlige utslipp på 1 million tonn CO2.



PyrOpt / LiCoSi – Biocarbon for Si production

- Elkem har som mål at minst 40% av reduksjonsmaterialet skal være fornybart innen 2030 (110.000 tonn) og at alt reduksjonsmateriale skal være fornybart innen 2050
- Vil kunne gi en reduksjon på CO2 utslipp på 330.000 tonn pr år tilsvarende 4% av CO2 utslippene fra Norsk prosess industry og 0.6% of totale CO2 utslipp i Norge.



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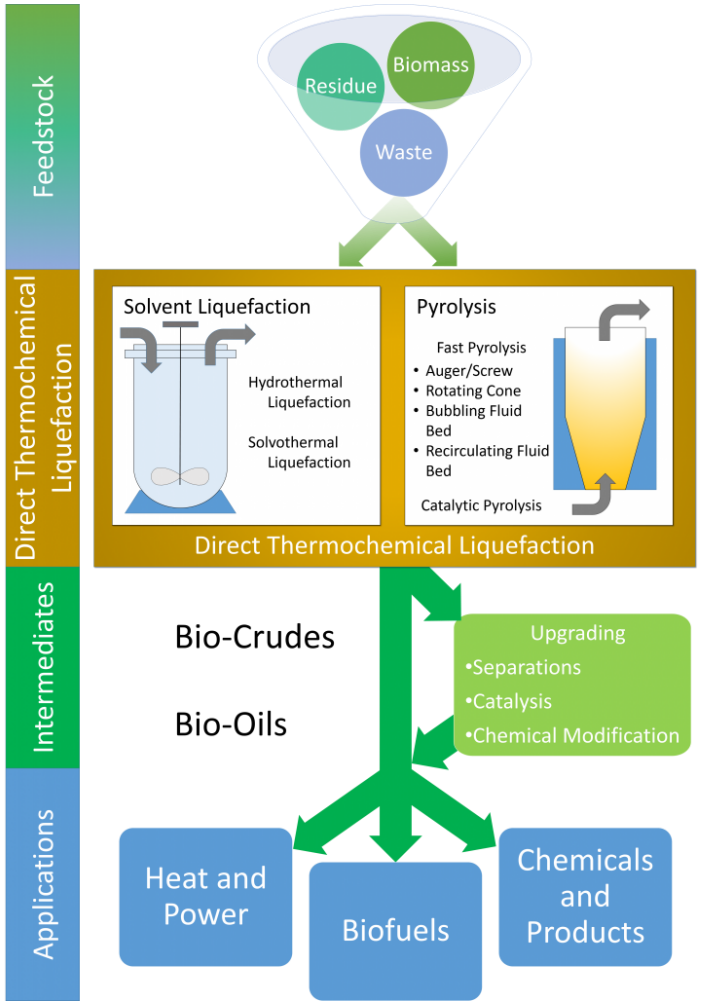
IEA Bioenergy

Task 34

Direct Thermochemical Liquefaction

Task 34 Members: 2019-2021 Triennium



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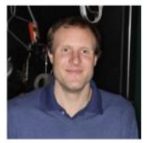

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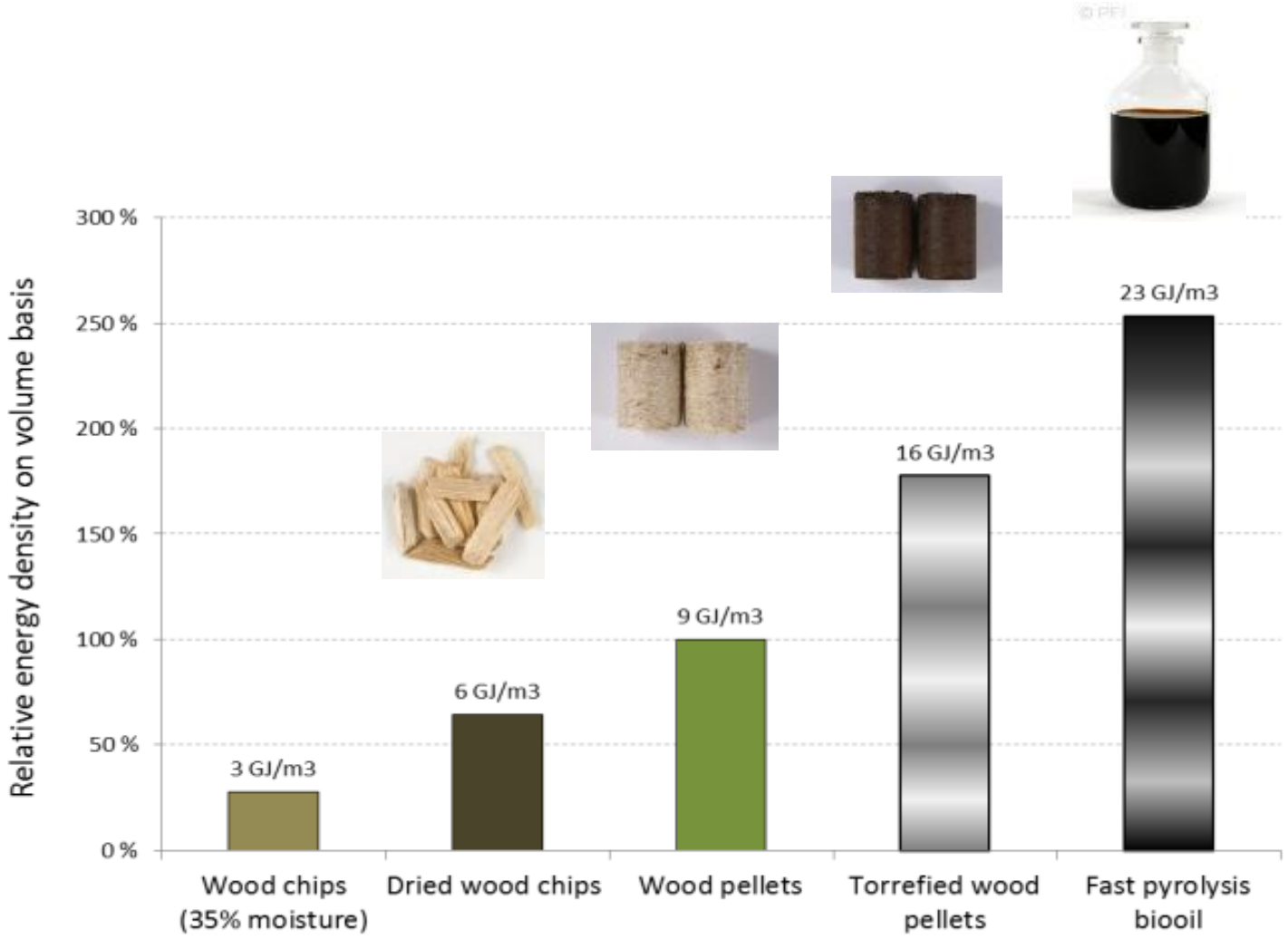
Pyrolysis technology – Logistics



Fast pyrolysis technology – Heating fuel and Transportation fuel

- Two commercial scale fast pyrolysis demonstration plants in operation in Europe: **EMPYRO** in Hengelo, Netherlands and **Fortum Joensuu** plant in Finland
- Fast pyrolysis liquid production is about to be commercialized as renewable heating fuel
- Standardisation of fast pyrolysis bio-oils.
  - Two ASTM burner fuel standards.
  - European CEN standard published (EN 16900:2017)

Property	Grade G	Grade D
Gross heat of combustion, min (MJ/kg)	15	15
Water content, max (mass %)	30	30
Pyrolysis solids content, max (mass %)	2.5	0.25
Kinematic viscosity at 40 °C, max (mm^2/s)	125	125
Density at 20 °C (kg/dm^3)	1.1 - 1.3	1.1 - 1.3
Sulfur content, max (mass %)	0.05	0.05
Ash content, max (mass %)	0.25	0.15
pH	Report	Report
Flash point, min (°C)	45	45
Pour point, max (°C)	-9	-9

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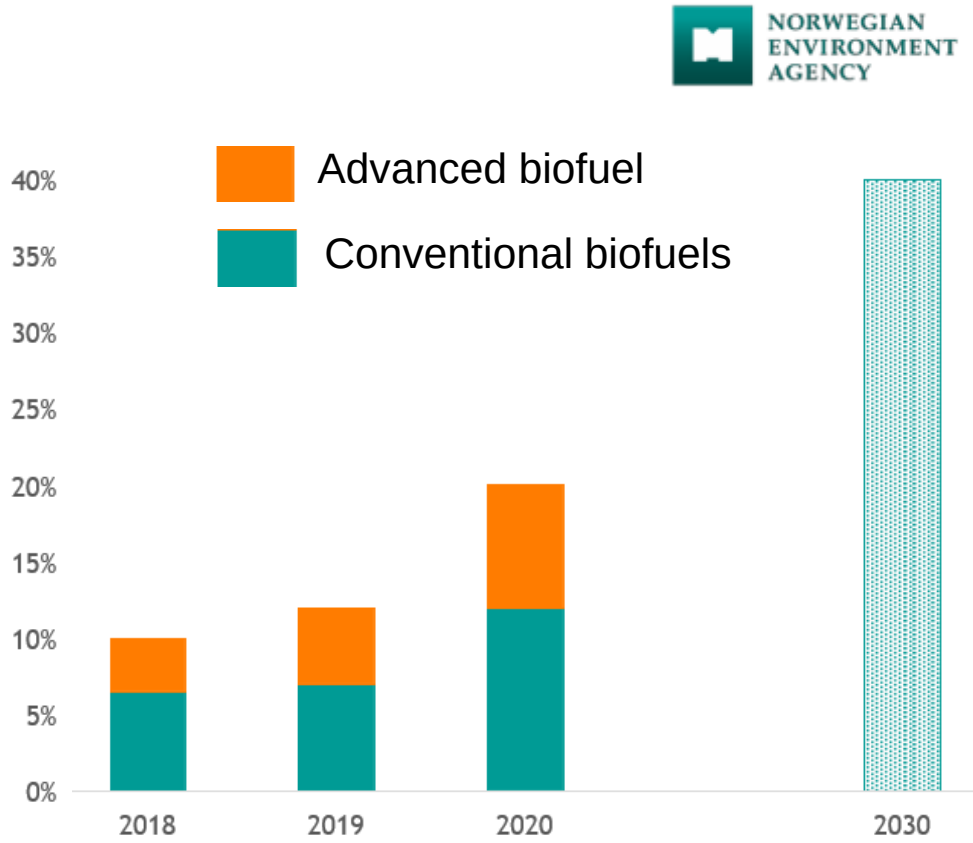
Norwegian incitements – Biofuels for transportation

Policy measures to promote biofuels

- Blending requirement for biofuel
  - Minimum 20% biofuel in road transport by 2020 out of which minimum 8% advansed biofuel.
  - Min 40% biofuels in road transport by 2030
  - Advanced biofuel «count double»
  - 0.5 per cent advanced biofuels in aviation fuel in Jan 2020 and regulatory changes will be introduced in the Product Regulation.
  - 30% biofuel share in sold aviation fuels by 2030
- Sustainability criteria
- Exception from CO2-tax
- Exception from road usage tax outside the blending requirement



Pyrolysis oil applications – Fast pyrolysis oil as transport fuel

Upgrading strategies

- **«Oil refinery compatible crude oil»**
  - Miscible with petroleum
  - Oxygen removal
  - Contaminant removal
- **«Drop in» fuel**

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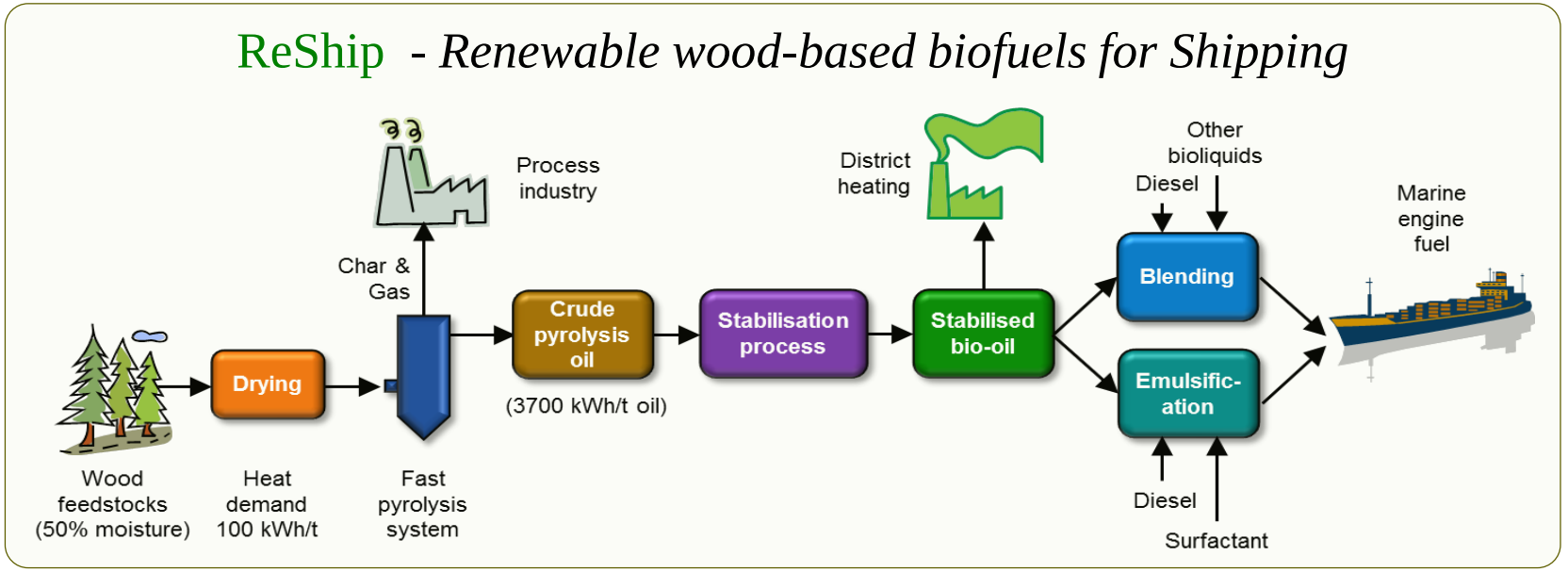
ReShip – "Drop in fuel" for marine fuel blends

Goal:

- To develop cost-competitive pyrolysis oil based multicomponent fuels which meet the performance requirements of marine engines



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NTNU

Silva Green Fuel

Rolls-Royce

Solvang ASA

Aston University

at skog

Treklyngen

Wilh. Wilhelmsen

The Research Council of Norway

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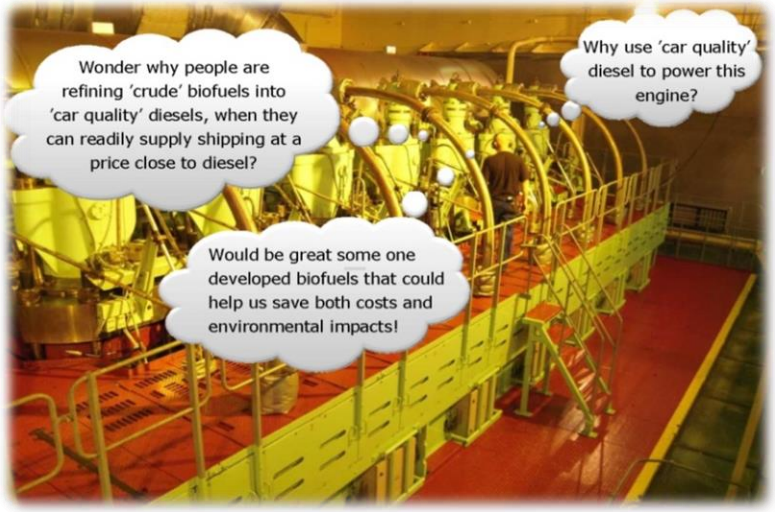
Pyrolysis oil applications – Fast pyrolysis oil as transport fuel



Pyrolysis oil and MGO

3-component fuel blend of pyrolysis oil in MGO

Fuels	Higher Heating Value (MJ/kg)	Kinematic viscosity (mm2/s at 40 °C)	Flash point (°C)	Density (kg/m3)	Acid number (mgKOH/g)	Water (%)	Pour point (°C)
MGO	45,3	2 – 6	> 60	< 890	<0,5	-	-6 - +0
3- component fuel blend	34	30	~ 50	950	10	0,5%	n.a

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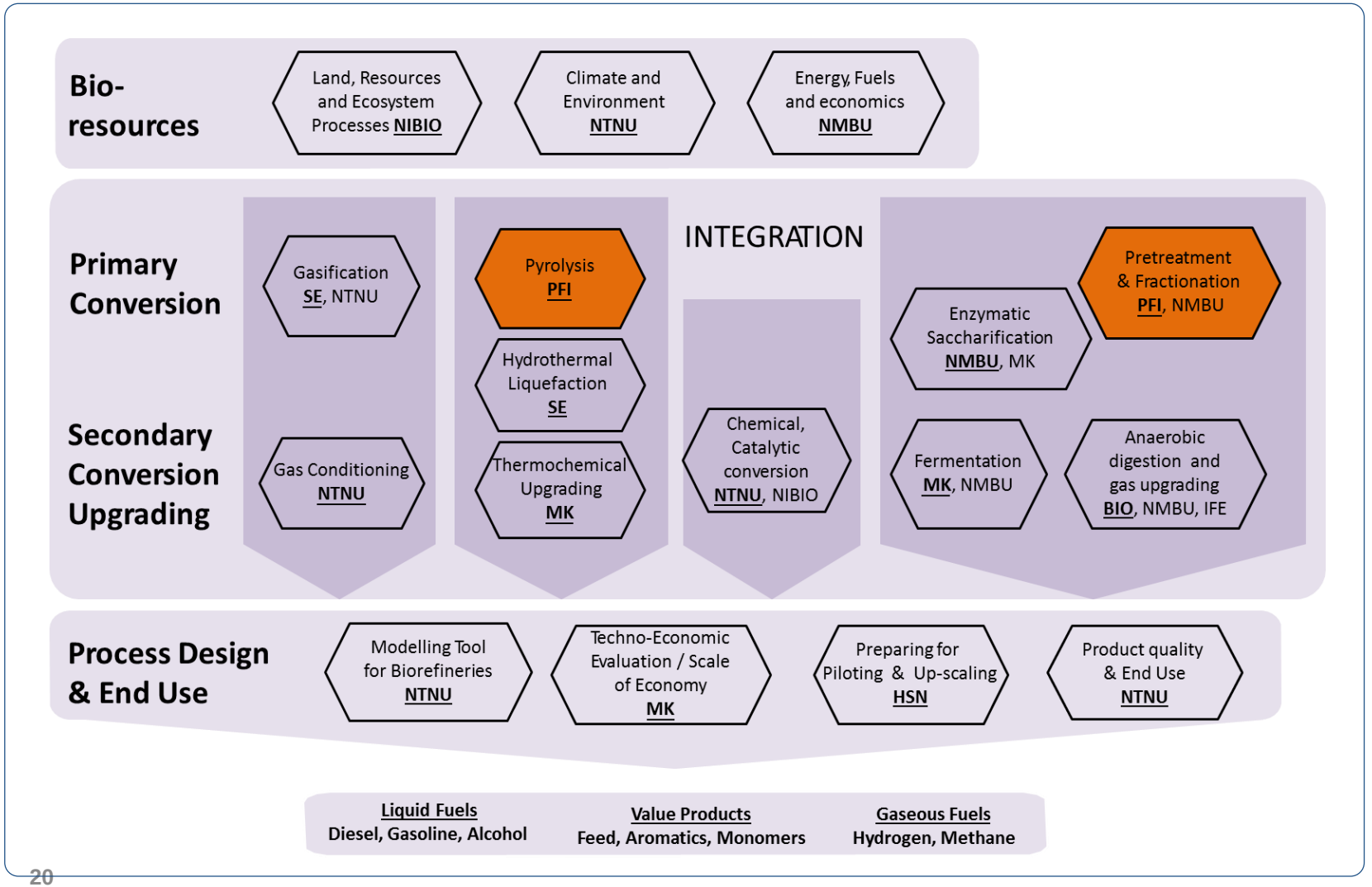
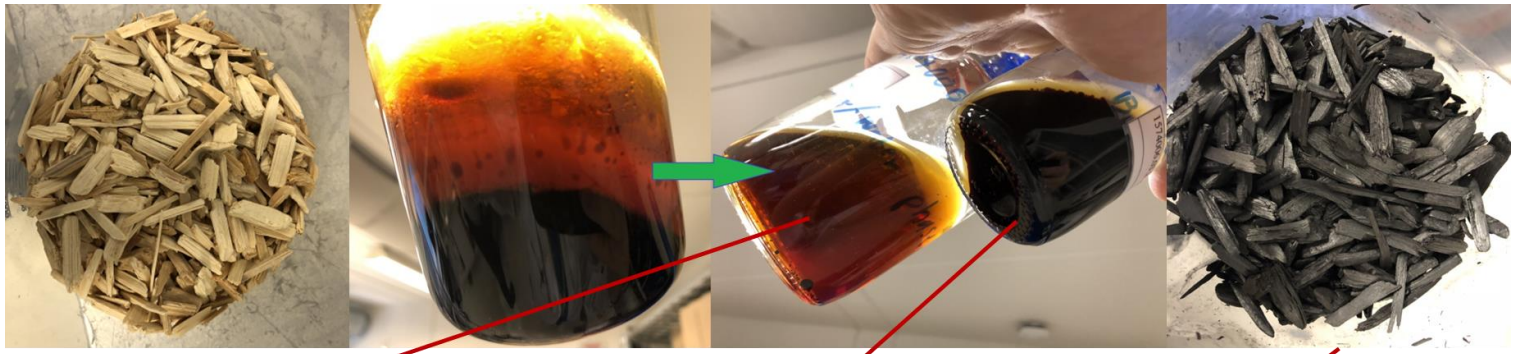
Background – Norwegian Centre for Sustainable Biobased Fuels and Energy (2017-2015)



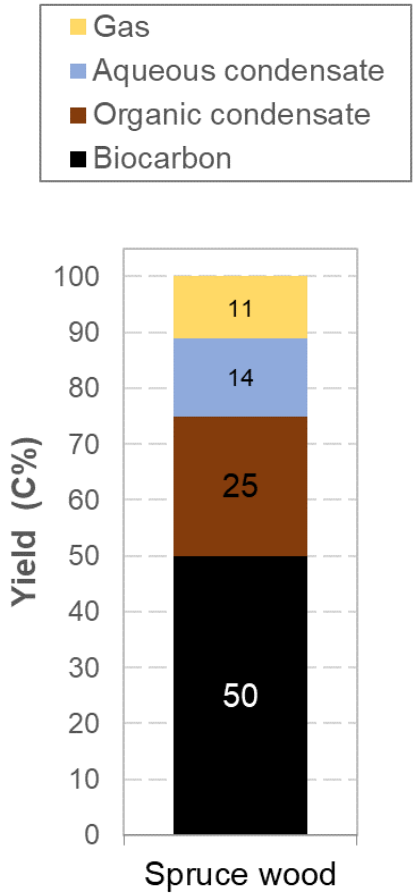
Pyrolysis technology – Bio4Fuels (2017-2025)

Combine pyrolysis and anaerobic digestion

- Coproduction of biocarbon, liquid fuel and biogas
- High carbon conversion yields



- Aqueous condensate for biogas transportation fuel
- Storage stable organic condensate for upgrading to oil refinery compatible oil
- Biocarbon



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RISE PFI – Research subjects within thermochemical conversion

- New type of energy carriers from biomass
- Direct thermal liquefaction
  - Direct liquefaction by fast pyrolysis
  - Pyrolysis liquid upgrading
  - Fast pyrolysis with catalytic vapour upgrading
  - Hydrothermal liquefaction of slurries
- Carbonisation by slow and intermediate pyrolysis
  - Reductant materials in ferroalloy industry
  - Other biocarbon applications
- Biorefining
  - Catalysed pyrolysis for building block chemicals
  - Refining pyrolysis oils into biochemicals
  - Integrated concepts

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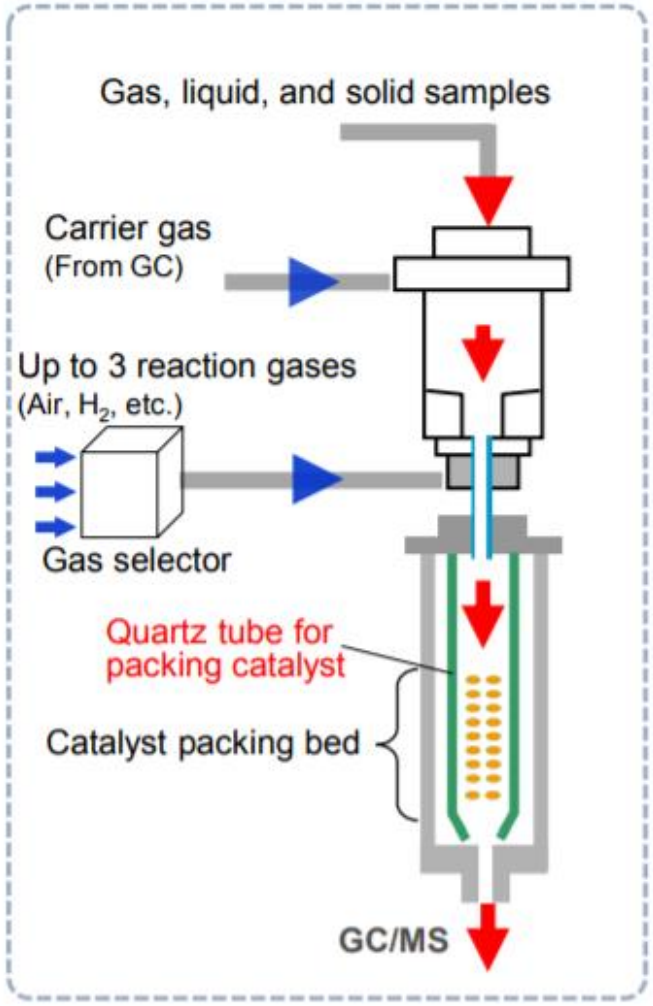
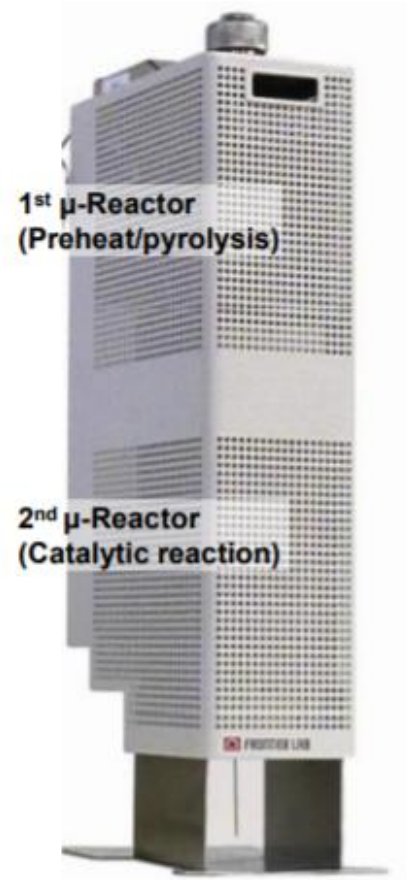
RISE PFI – Pyrolysis tandem reactor system

NorBioLab

Pyrolysis tandem reactor system with GCMS detector

- Screening pyrolysis conditions
- Screening catalysts
- Raw material flexible reactor system





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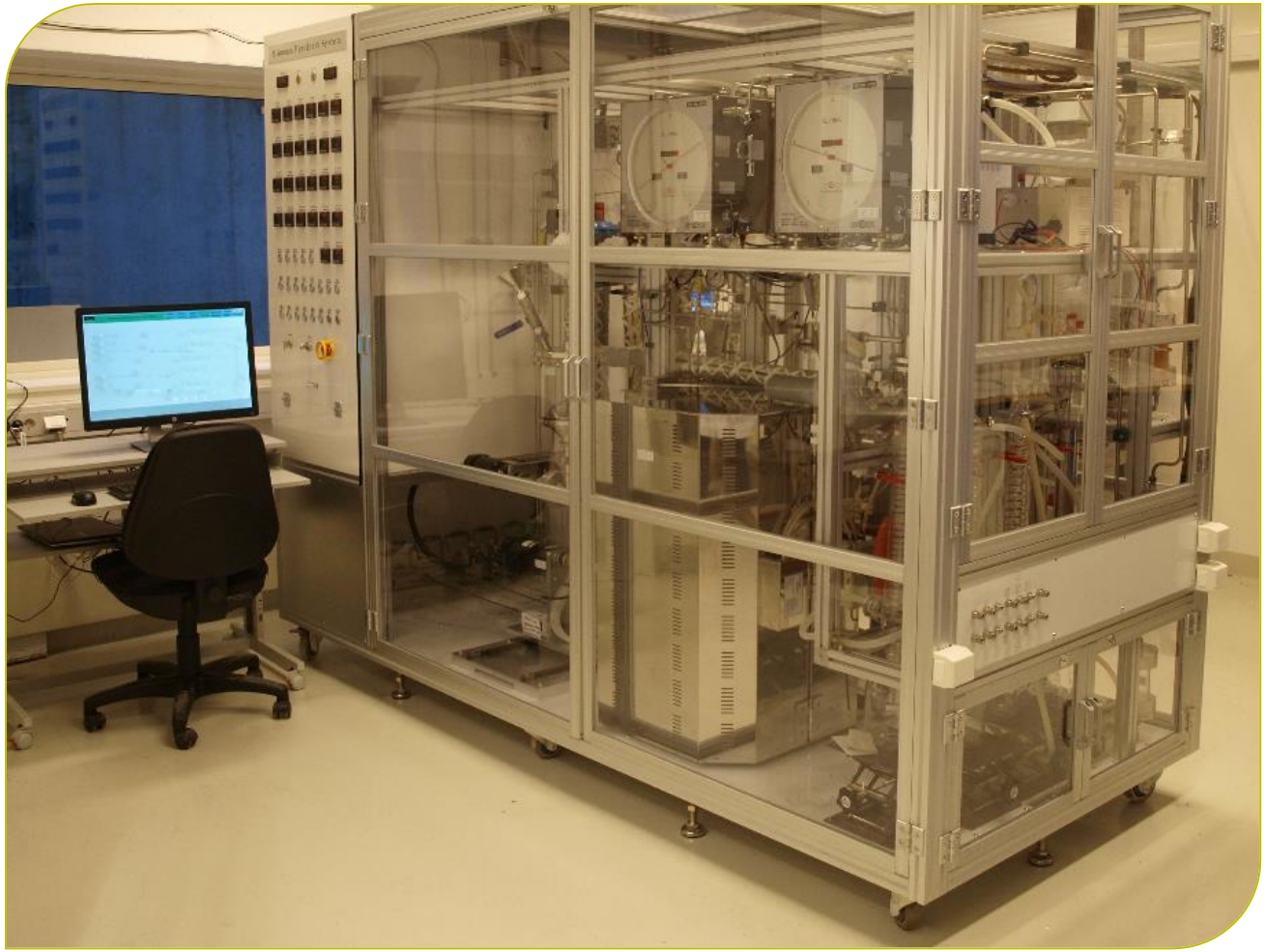
RISE PFI – Pyrolysis Process Development Unit

- An advanced **Pyrolysis Process Development Unit** is established at PFI as part of NorBioLab
- The system is capable of testing
  - Fast pyrolysis with/without fractional condensation
  - Carbonization by slow or intermediate pyrolysis with/without fractional condensation
  - Catalytic fast pyrolysis
  - Fast pyrolysis with direct catalytic vapour upgrading
- Unique tool for developing new pyrolysis processes for producing hydrocarbon fuels, bio-chemicals and biocarbon from biomass



RISE PFI – Tools

Tools for characterising carbon materials

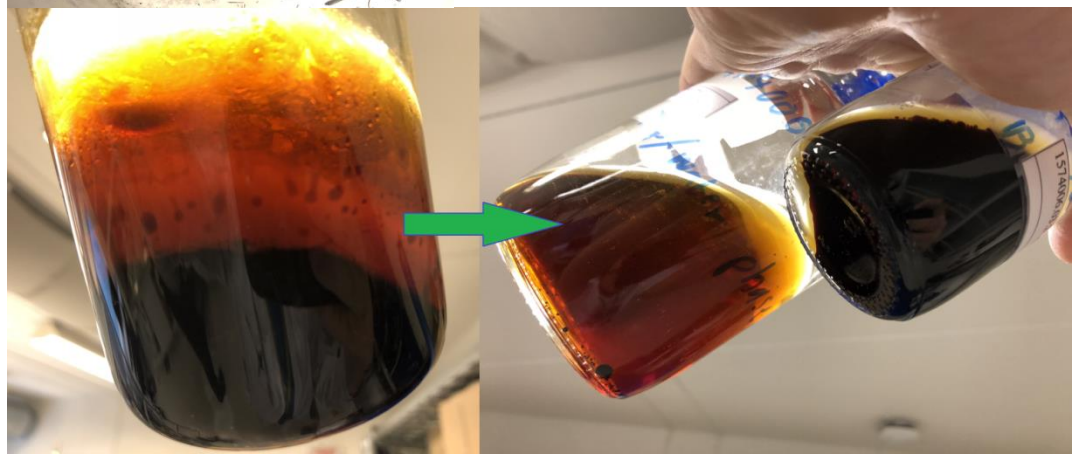
- Fuel properties
- Chemical characteristics
- Morphological characteristics
- Strength properties

Tools for characterising pyrolysis liquids

- Fuel properties
- Chemical characteristics
- Upgrading techniques

Agglomeration techniques

- Pelletizers and briquetting press
- Techniques for analysing strength properties of agglomerated materials



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RISE PFI – Projects

- **Bio4Fuels** - Norwegian Centre for Sustainable Bio-based Fuel and Energy (WP lead Pyrolysis)
- **NorBioLab II** - Norwegian biorefinery Laboratory (National research infrastructure project)
- **ReShip** – Renewable wood-based biofuels for shipping (Competence building project for industry)
- **PyrOpt** - Optimized biomass pyrolysis for production of tailor-made renewable silicon reductant materials (Innovation project)
- **Pyrogass** – Production of biogas transportation fuel and biocarbon reductant material by combining anaerob digestion and pyrolysis technology (Innovation project)
- **FuturePack** – Catalytic pyrolysis for platform chemicals (KPN project for industry)
- **BioSinter** – Biobased manganese ore sintering process (Innovation project)
- **Lignin4Si** – Coproduction of fermentable sugars and biocarbon reductant material for Si/FeSi production (Innovation project)
- **Biokarbon MidtNorge** (Regional innovation project)
- **BioVekst –** Charcoal as substitute for peat in growth media (Innovation project)
- **AIRY**– Biotumen boards (Innovation project)
- **Bioraffinaderi MittSkandinavien** – Interregional Norway Sweden project
- **Decarbonize –** Ny bærekraftig teknologi for desentralisert produksjon av biokarbon for jord og vekstmedier
- **LiCoSi** – Lignin compatibility with Si furnacces (Innovation project)
- **C-Cap** – Carbon capture from cruise and passenger ships

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THANK YOU

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