HTL technology for Black Liquor

Lessons learned

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Valmet’s R&D addresses global megatrends

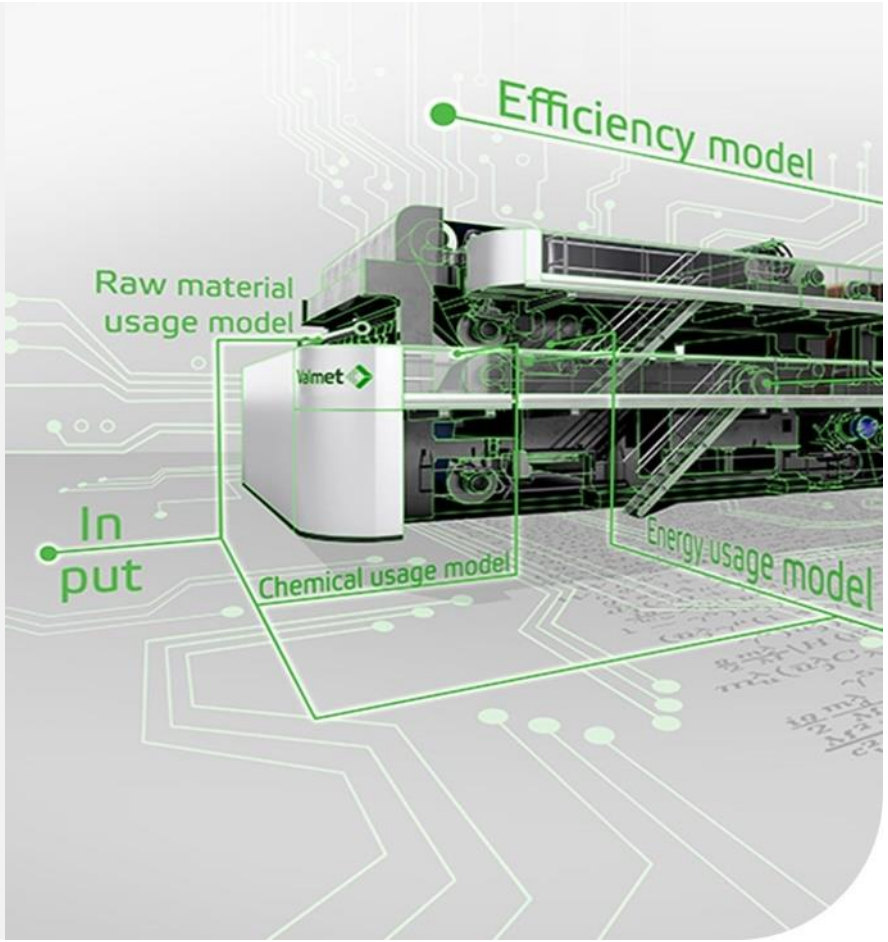
R&D focus areas

- Promotion of renewable materials
- Raw material, water and energy efficiency
- Emission reductions
- Circularity
- Productivity and environmental improvements with digitalization

24
research and development centers

EUR **98** million
R&D spending in 2021

~1,300
protected inventions



Illustrative figures of the combined company.

Strategic direction towards more valuable products

Resources

Biomass
- Forest residues
- Agro residues

Plastics
- Mixed plastic waste (Polyolefins)
- Polystyrene

Industrial residual wastes
- Pulp & Paper
- Mechanical forest industries
- Process industries

Municipal solid waste (MSW)
- Refuse derived fuels (RDF)

Commercial & Industrial wastes (C&I)
- Refuse derived fuels (RDF)

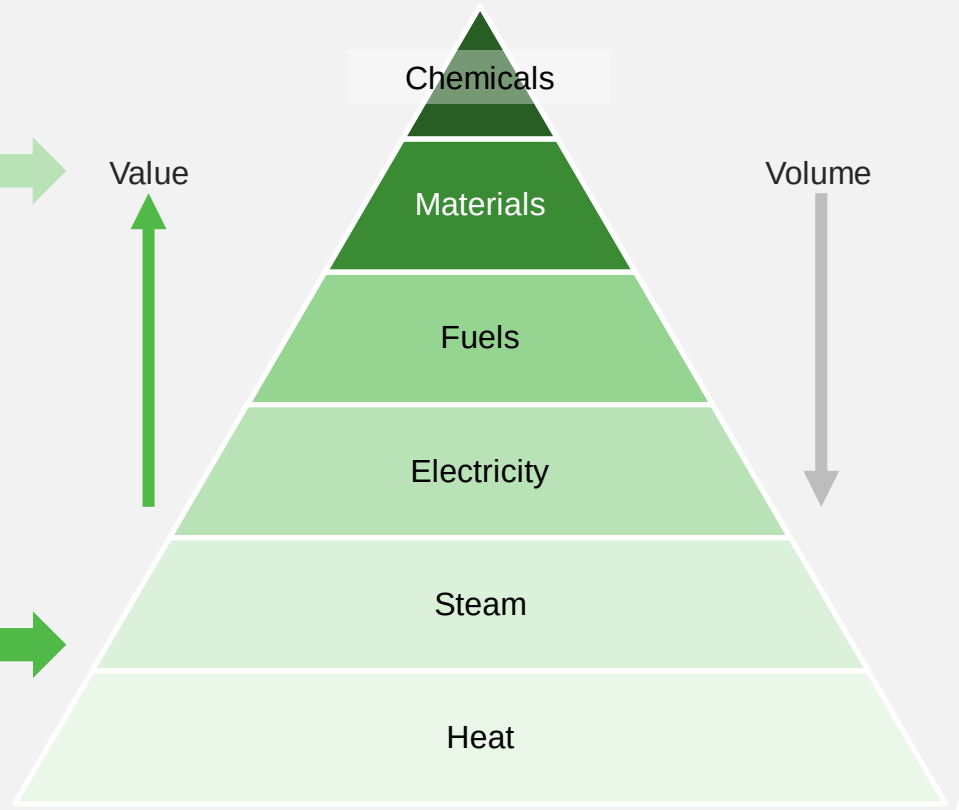
Thermo-Chemical Conversion

Pyrolysis (HTL)

Gasification

Combustion

Value



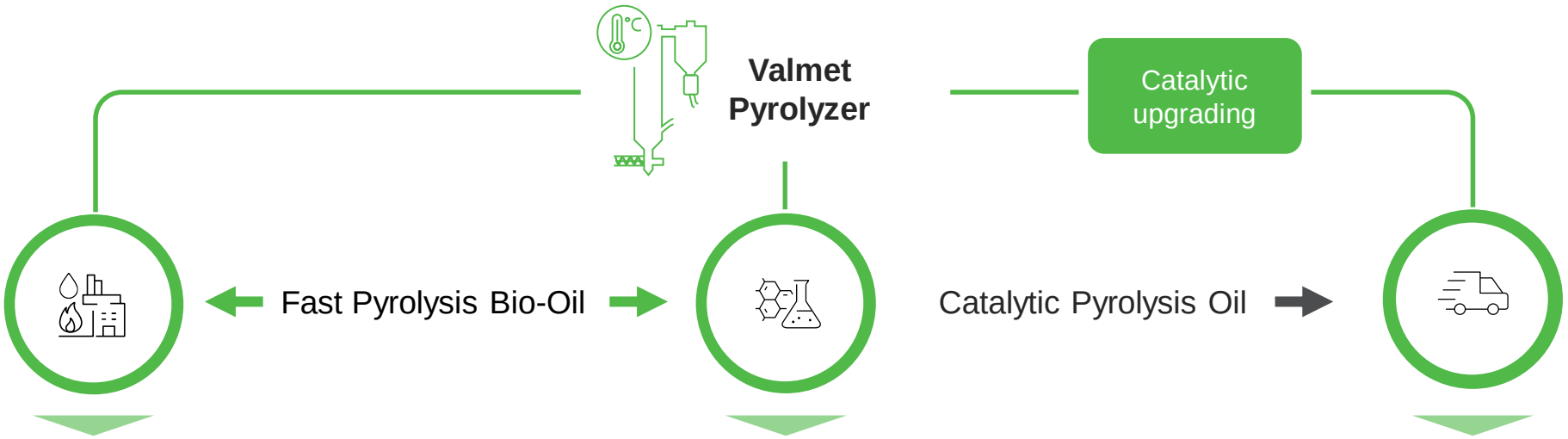
Catalytic pyrolysis pilot plant commissioned successfully

Valmet Energy R&D Center (Tampere, Finland)

- Pyrolysis pilot with continuous catalytic treatment of pyrolysis vapors
  - Design of demo/commercial unit, Feeds 10 tons/d
  - Utilizes commercially available catalyst
- Separate pyrolysis and catalytic upgrading stages
- Product yield & quality in line with targets[1]
  - Feedstocks: dried & milled biomass
  - Energy yield > 40% to liquid products
- Product liquid properties
  - Low oxygen content: 10-20 %
  - Low acidity: TAN 10-30
  - High heating value: > 35 MJ/kg
  - Distillable[2]

[1]Based on previous and current pilot scale
[2]According to batch distillation / Simdist

Fast pyrolysis at commercial scale, focus now on catalytic pyrolysis



FPBO	TRL 9

- Fast pyrolysis system proven in operational environment
- Commercial plant (50 kt/a) started 2013 (Joensuu, Finland)

Specialty chemicals	TRL 8

- Circa small industrial plant to produce commercial bio-solvent, Cyrene™
- Pyrolyzer input 2 t_{DS}/h, start-up 2025

Transport fuels	TRL 7

- Piloting ongoing on small industrial scale (400 kg/h feed)
- Target to reach readiness for 5 t/h in 2024 and 50 t/h by 2027
- Commercial target: 100 kt/a product

HTL at Valmet

Long history

- Already studied at Chalmers University of Technology in early 2010's
  - Valmet build there a bench-scale research system
- Biomass alternatives were explored in 2014 – 2017
- Participation in BL2F and an IIT Madras R&D projects
- Support for the TAU piloting equipment EHTA
- HTL has a monitoring status – participating in selected projects

HTL of Black Liquor

Lessons learned from BL2F project

- Black Liquor is abundant and interesting feedstock
  - Available in a point source, relatively constant quality
  - Cooking chemicals require salt separation, IHTL concept approach promising
- The quality of HTL-oil meets requirements
- The mechanical development need further studies
- Integration to Pulp Mill reduces the production cost of fuel intermediate
  - Potential to use other streams like bark and sludges
- Side streams of HTL have potential for further utilization
- IHTL on a simplified version remains interesting technology for further development


Valmet
FORWARD