Business from technology

Known Challenges Associated with the Production, Transportation, Storage and Usage of Pyrolysis Oil in Residential and Industrial Settings

Technical Information Exchange on Pyrolysis Oil

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Dr. Jani Lehto
VTT Technical Research Centre of Finland

Outline

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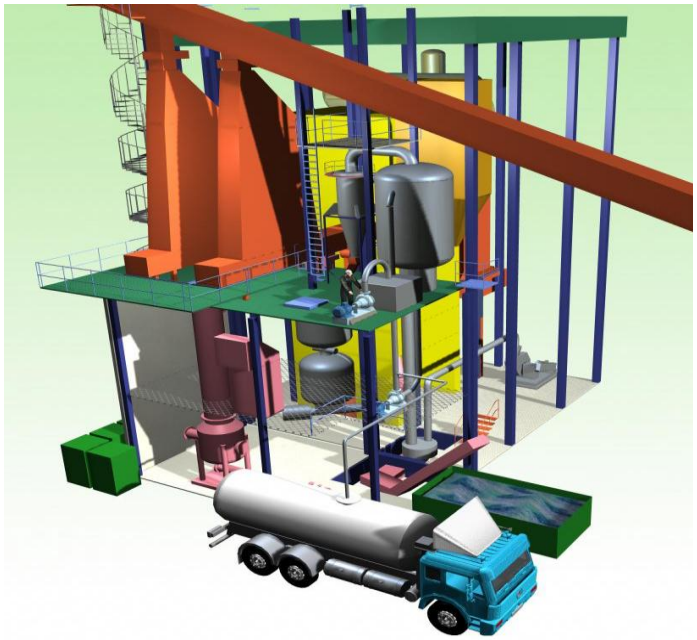
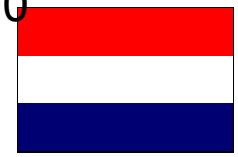
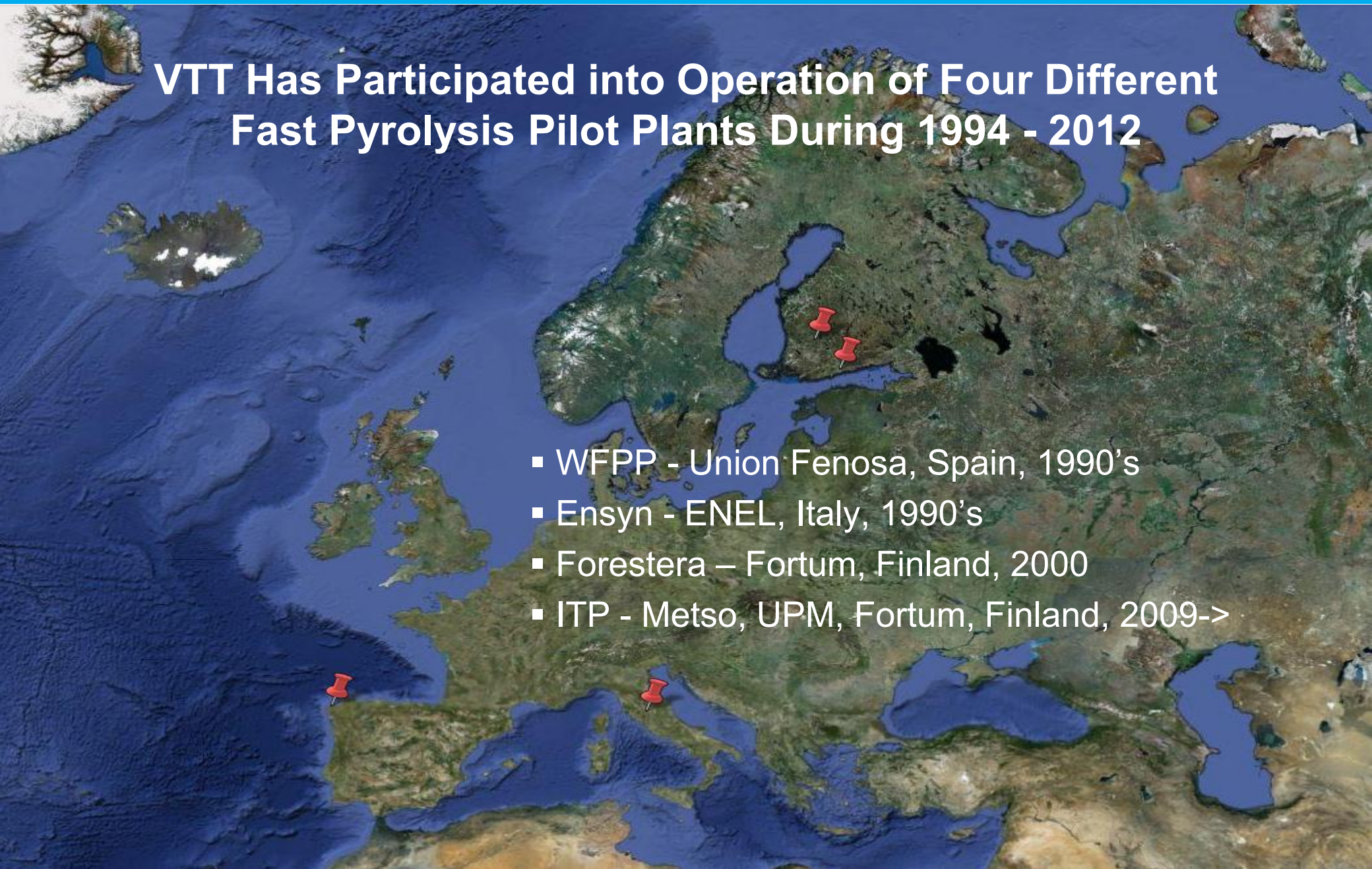


Introduction to Fast Pyrolysis Oil Production And Boiler Utilisation Technology - First 20 Years

- **Oil production** R&D - Prof Donald Scott 1981
  - First stated objective to produce alternative fuel oil
  - Scott, Piskorz et al publications cover all aspects of fast pyrolysis from conventional to hydro- and catalytic pyrolysis, and to feed material pre-treatment to increase sugars in oil
- An IEA Bioenergy development team during the early 80's
- Ensyn established 1984
- Union Fenosa/Spain (University of Waterloo), ENEL/Italy (Ensyn Tech), Fortum, BTG, etc. in Europe in the 90's
- First **industrial scale combustion tests** in Stockholm at the end of the 90's (Birka/Fortum)
- Smaller boiler Neste & Fortum during the 90's
- VTT & Oilon tests early 2000
- BTG co-firing early 2000



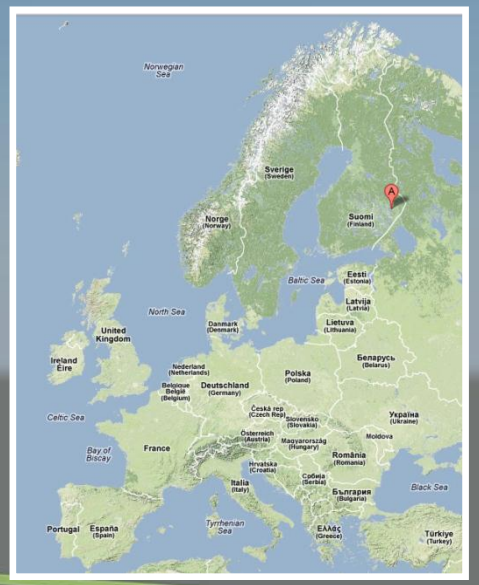
VTT Has Participated into Operation of Four Different Fast Pyrolysis Pilot Plants During 1994 - 2012



- WFPP - Union Fenosa, Spain, 1990's
- Ensyn - ENEL, Italy, 1990's
- Forestera – Fortum, Finland, 2000
- ITP - Metso, UPM, Fortum, Finland, 2009->

Fortum Joensuu: an Integrated Bio-Oil Demonstration Plant

Bio-oil capacity	30 MW
Annual production	50 000 t, 210 GWh
Start-up	2013
Feedstock	Forest residues, sawdust



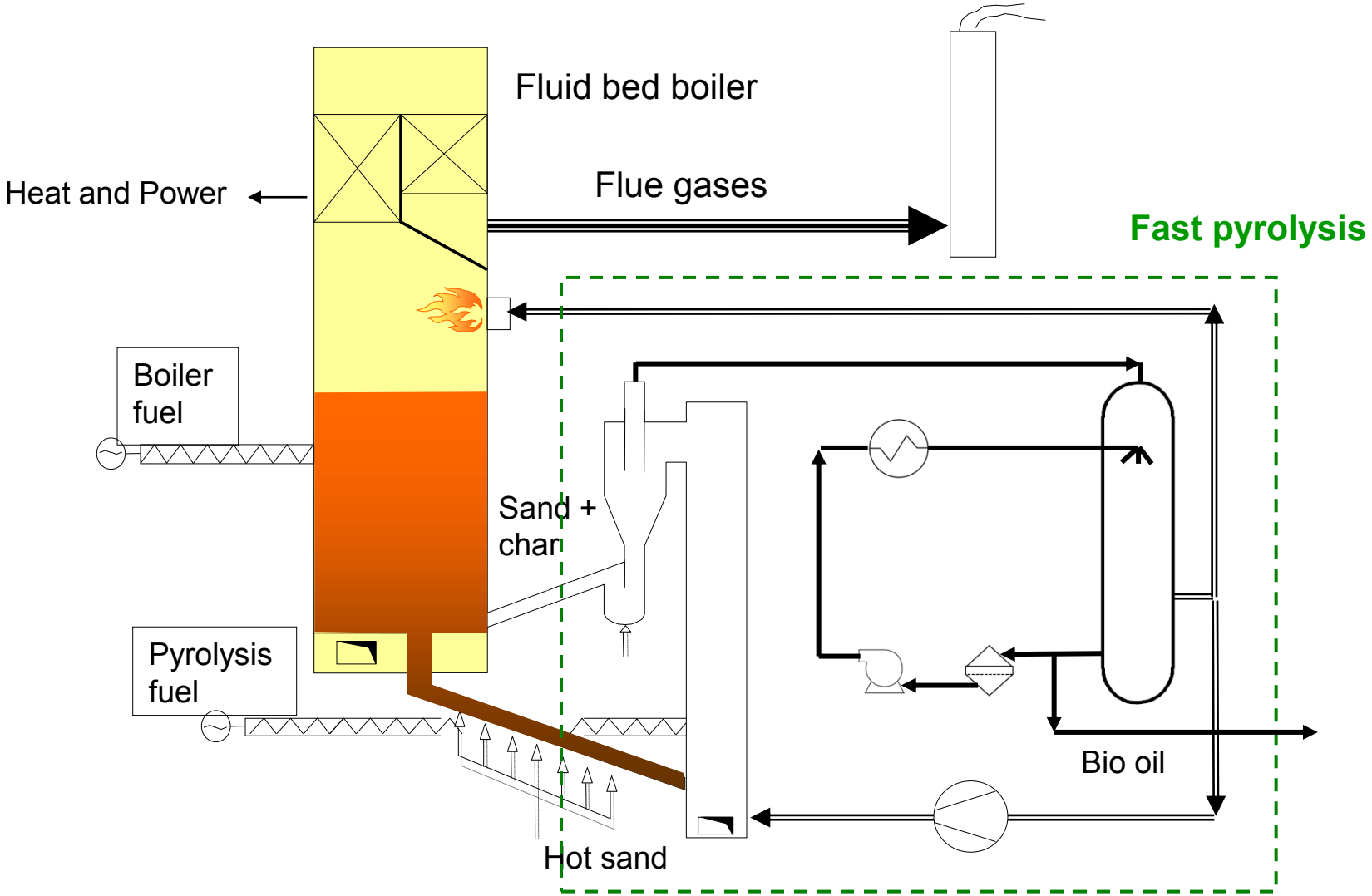
Reactor and pyrolysis oil recovery inside the boiler building

Fuel receiving, drying and crushing

Bio-oil tanks

Source:

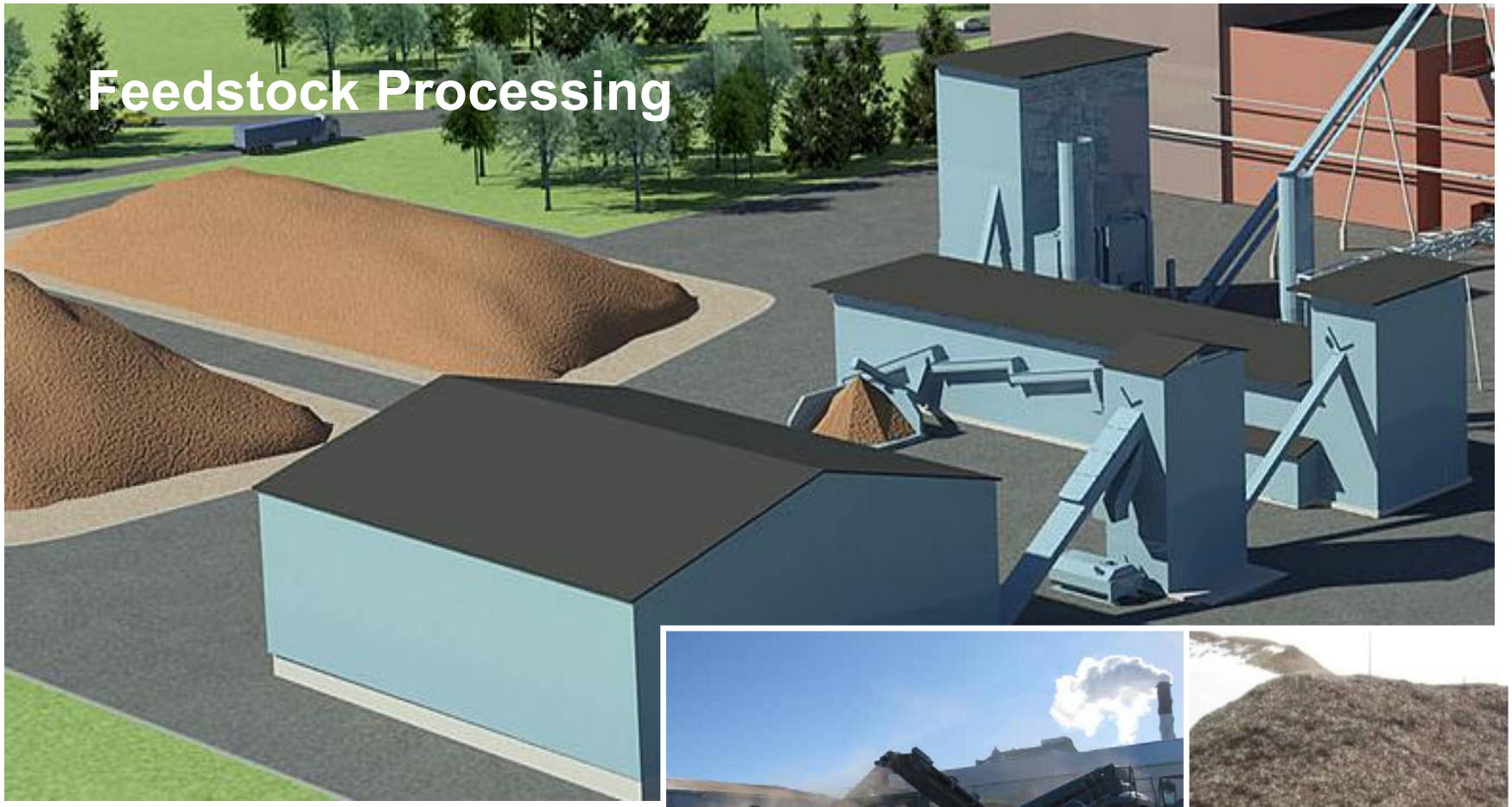
The Integrated Pyrolysis – VTT Technology



The Main Challenges in General

- The most important challenge is to make pyrolysis oil production competitive in combustion applications
  - We must be capable of operating in the margin between the price of the reference fuel and the price of the feedstock
  - Reduce both CAPEX and OPEX
    - Intelligent process integrations through the whole value-chain
  - Maximize pyrolysis oil yield
  - Maximize energy recovery
- Standards and specifications both for pyrolysis oil and combustion systems are still under development
- Primary emissions of pyrolysis oil combustion and emission control

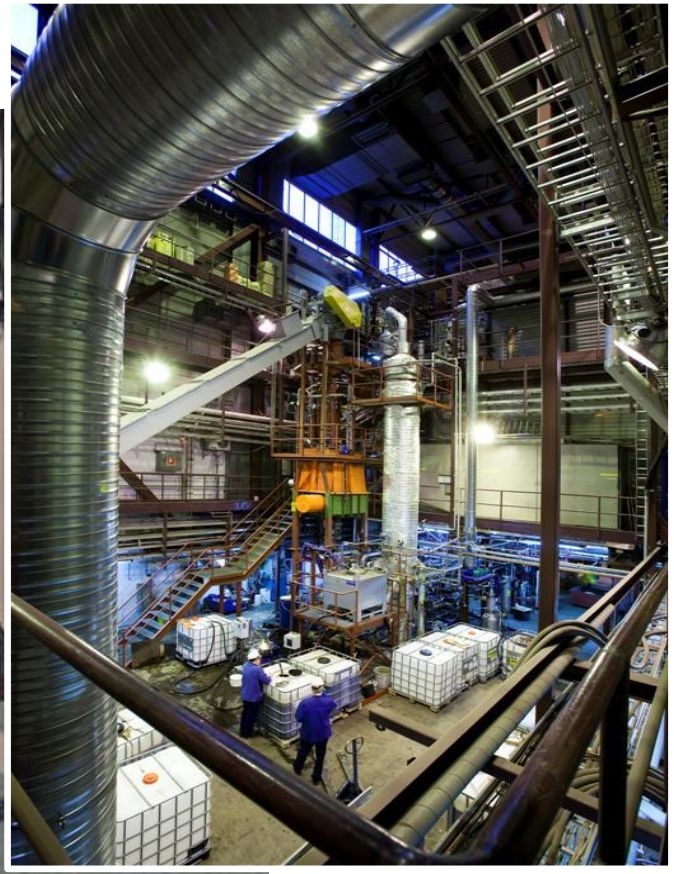
Feedstock Processing



Challenges Associated with the Feedstock Processing

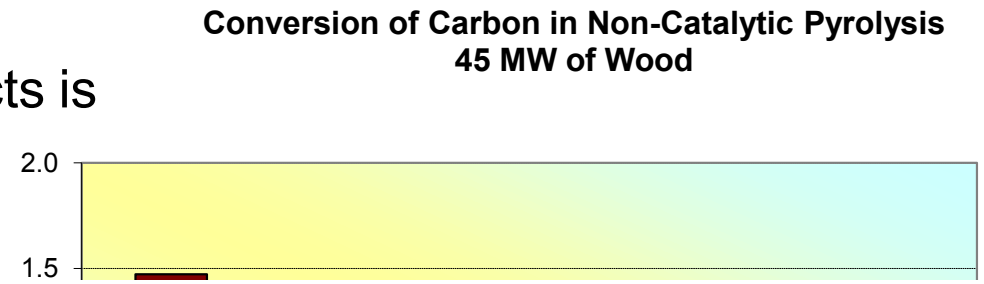
- Quality control of the feedstock procurement
  - Usually there are several different suppliers for the feedstock, which makes the feedstock quality control very challenging
  - Sustainability issues (EU) – traceability of feedstock
  - Cost of feedstock (as always)
- Demanding and energy consuming requirements for pyrolysis inputs
  - Low moisture content and very small particle size
- Cost competitive fuel processing including transportation
  - Where are the best preconditions for the processing?
  - There is no such thing as free heat in power plant environment
  - Process integrations to maximize energy efficiency (for example utilization of secondary process heats for drying in pulp mill)

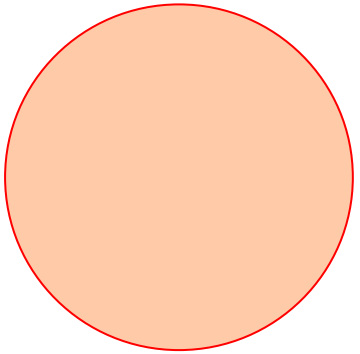
Pyrolysis Oil Production



How to Make Pyrolysis Oil Production Feasible?

- It is not all about maximizing the pyrolysis oil production, as significant amount of by-products are produced in any case
- Utilisation of these by-products is therefore also as critical





Challenges Associated with the Production of Pyrolysis Oil

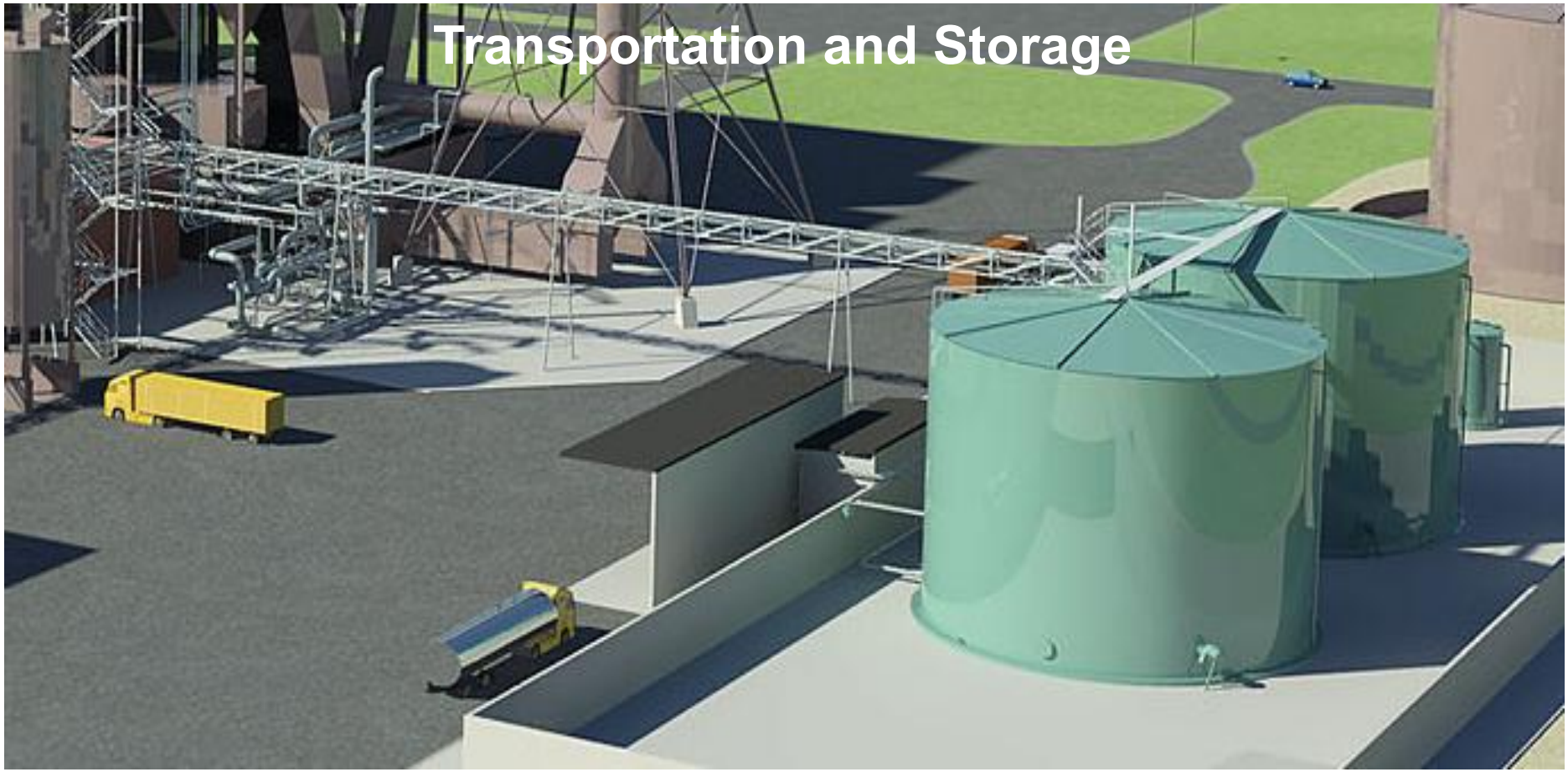
- Use of inhomogeneous solid fuels, like chips, is always challenging*
- Production of relatively homogenous (particle size, moisture) feed to pyrolysis reactor
- Plugging of certain process parts such as the inlet of the condenser during the operation
  - Online cleaning methods
- Reducing the amount of solids in the oil (especially the ash)
  - Design of systems and separation devices
- Permitting, lack of standards and specifications, HSE-issues
  - The oil classification has an effect on almost everything
  - New process and new people → extra care is needed
- Expensive materials needed for condenser, oil piping and oil tank
  - Cost effective materials, coatings

* The RAND corporation data from the 70's and the 80's

Challenges Associated with the Production of Pyrolysis Oil

- Phase separation and stability
  - Product is a two phase system for example when using forest residues as feed
  - Feedstock moisture must be low enough to avoid phase separation due to water in product (water in the oil must be below 30-35 wt.%)
  - Certain increase in viscosity can be dealt with in boiler combustion
- In an integrated concept, the functionality of the main boiler can not be compromised

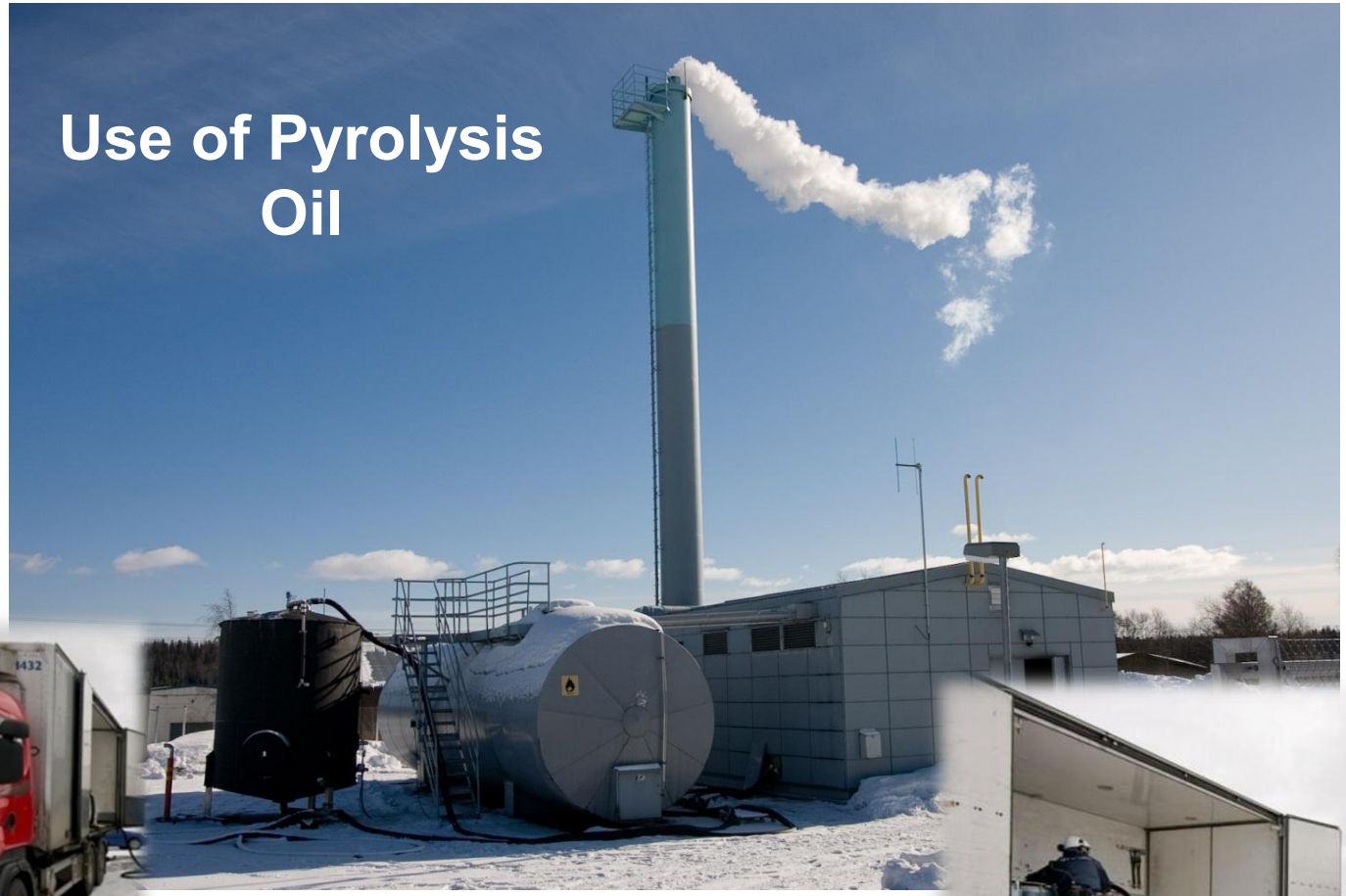
Transportation and Storage



Challenges Associated with the Transportation and Storage

- Pyrolysis oil as such is not ”infrastructure ready”
- The materials for whole utilisation chain must be compatible with the oil properties (low pH, high density, energy content etc.)
- The transportation and storage solutions as well as the distribution chain of the oil should be desinged based on the type of the end-use (peak or process)
  - Continuous process use is more preferable due to smaller need for storage capacity
  - No scale advantage yet
- Relevant guidelines for storage and transportation needs to be specified for the fast pyrolysis oil

Use of Pyrolysis Oil



Source: Fortum

Challenges Associated with Combustion

- Cost-efficient combustion concept
  - Everything from the storage and piping to the gaskets and burner needs to be designed to fit the purpose
  - Primary emissions and emission control concepts (especially for NOx and particulates)
    - Feedstock quality
    - Incombustible material such as ash and sand in the oil should naturally be minimized
  - Pre-heating of pyrolysis oil is needed (just like HFO)
- Design of burner system if many different fuels are used
  - Support fuel for pyrolysis oil firing is not necessary
  - Continuous 100 % pyrolysis oil combustion tested in Masala, Finland (even unmanned)

Challenges Associated with Combustion

- Based on our experiences, it seems that stability and aging issues are not as importat as expected earlier
  - Even very poor quality oils has been combusted
- Some boiler capacity might be lost while replacing HFO and LFO
  - In this case, the oxygen content of the pyrolysis oil actually helps due to the lower need for combustion air

    → lower amount of flue gases generated

Flame before the fine-tuning

Flame after the fine-tuning

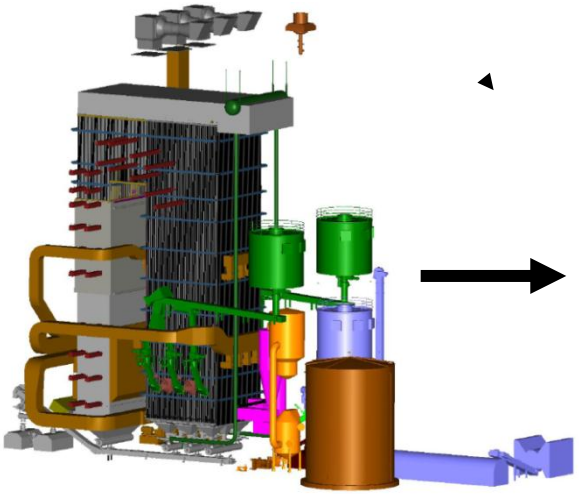
100 % Bio-Oil Combustion in Action

Quality Control Through Whole Fuel Chain

FEEDSTOCK PROCESSING

PYROLYSIS OIL PRODUCTION AND STORAGE

TRANSPORTATION AND USE



BIOMASS

Moisture content and other fuel analyses

CHAR, GAS AND LIQUID

On-line monitoring of gas, water and solids

FUEL OIL

Specifications
On-line monitoring of emissions

Quality control

- Fast pyrolysis oil is completely different than mineral oils or other bio-oils, like biodiesels
- Analytical methods including on-line methods have to be tested, developed, and validified
- Fast analyses needed to the field
- Guidelines for storage and transportation and MSDS specified for fast pyrolysis oil

http://www.vtt.fi/inf/pdf/publications/2010/P731.pdf

SolidStandards project PyNe Newsletter 30

The SolidStandards project (www.solidstandards.eu) supports implementing solid biofuel standards in practice, and addresses ongoing and recent developments related to solid biofuel quality and sustainability issues, in particular the development of related standards and certification systems. The core of the action is the organisation of 35 training events for producers, traders and end-users of solid biofuels and actors involved in standardization and certification. Training aims at increasing the target group's ability to implement quality and sustainability standardization and certification.

The consortium will work with seven selected solid biofuel companies and support them in implementing European quality standards. The process will be documented and shall serve as a guideline for standard implementation. The SolidStandards project is funded by the Intelligent Energy Programme and coordinated by WIP.

Guidelines for Transportation, Handling, and Use of Fast Pyrolysis Bio-Oil.
Part 1 – Flammability and toxicity - submitted to Energy & Fuels
Part 2 – Material resistance and MSDS - under work

Conclusions

- Fast pyrolysis bio-oil as an alternative fuel oil: a very challenging task
- Standards, specifications and guidelines are urgently needed to help to establish markets
  - ASTM/EN fuel oil standards for various use
  - Specifications for the systems using pyrolysis oil
  - Guidelines for storage and transportation needs to be specified
- In addition to oil production, use of by-products is as critical
  - Sub-optimisation must be avoided, the whole chain from the feedstock to the heat production has to be considered
  - Process integrations whenever possible
- Minimize the incombustile solids in pyrolysis oil
- Quality control through the whole fuel-chain is a must
- Combustion solutions and emission control under development
- VTT publication on pyrolysis oil combustion will be published in autumn

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VTT - 70 years of
technology for business and society