



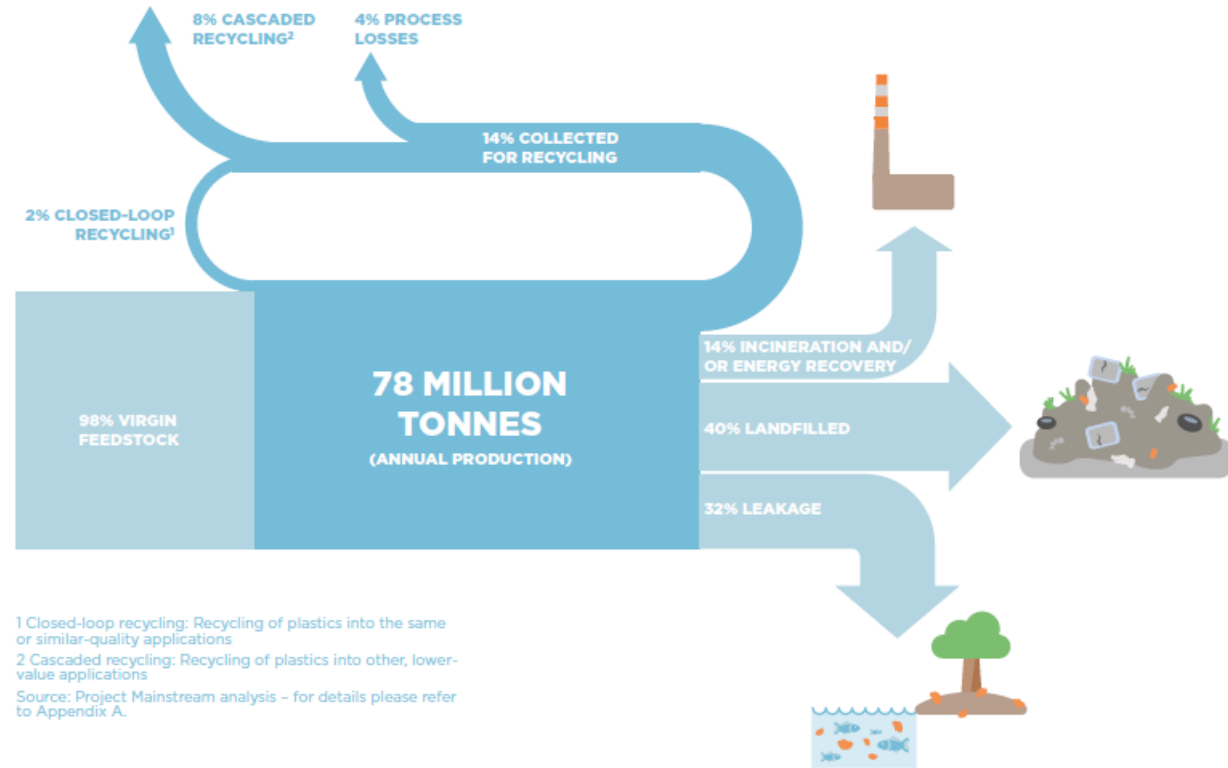
Role of thermolysis (pyrolysis) of plastics in feedstock recycling

Contact:

Muhammad.queshi@vtt.fi
anja.oasmaa@vtt.fi

Global plastic flow

FIGURE 4: GLOBAL FLOWS OF PLASTIC PACKAGING MATERIALS IN 2013



Plastic waste management has many fronts...



- At VTT we are aware of the challenges involved in this problem.
- We believe that for true circular economy, the whole plastic recycling value chain needs active research and innovative solutions



Scaling up fast pyrolysis of biomass to world first commercial-scale integrated fast pyrolysis plant producing biofuel for industrial boilers with Finnish industry



SFS-EN 16900:2017



IEA BIOENERGY COLLABORATION



FORTUM, PORVOO, FINLAND



VALMET, TAMPERE, FINLAND



FORTUM DEMONSTRATION - JOENSUU, FINLAND

1980	1985	1990	1995	2000	2005	2010	2015	2020
------	------	------	------	------	------	------	------	------

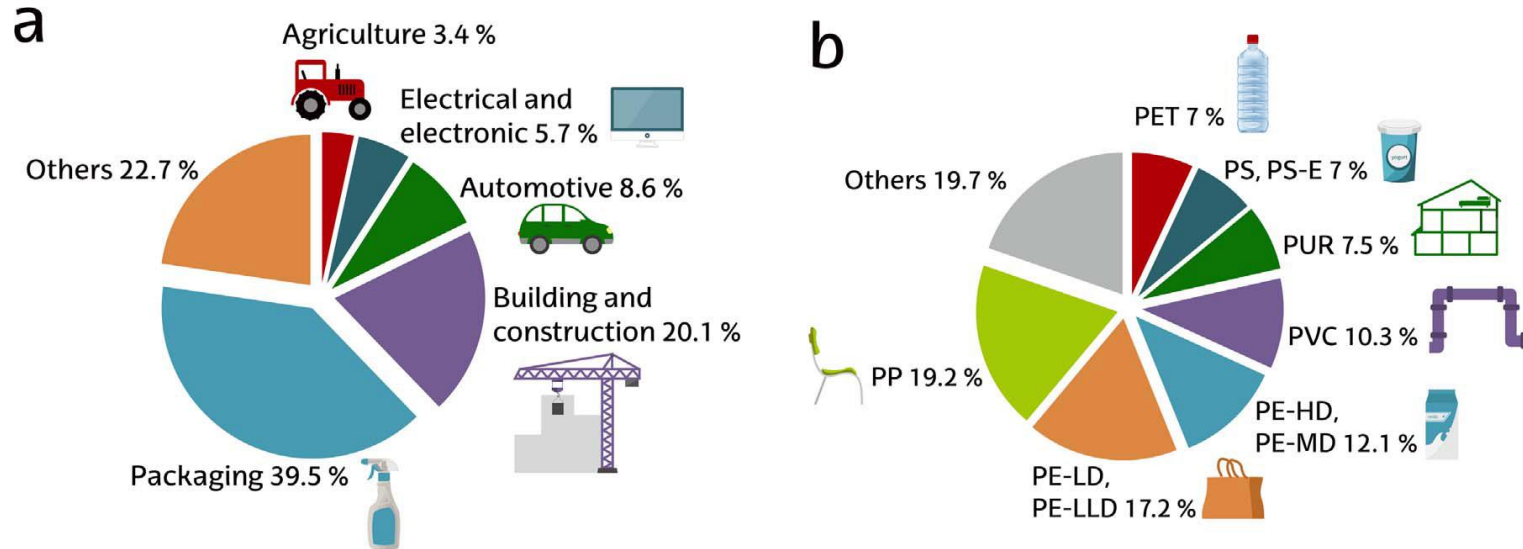
- IEA Bioenergy assessments
- Networking – Co-operation with leading research groups



- Systematic development of analytical methods
- Initiation of standardisation, REACH
- Participation in European pilots, VTT's own pilot 20 kg/h
- Industrial combustion tests
- Patents,

- Valmet pilot plant
- Fortum demonstration plant
- Standards for boiler use
- REACH registration
- TEA, modelling
- Strong US co-operation in HDO
- Strong publishing policy

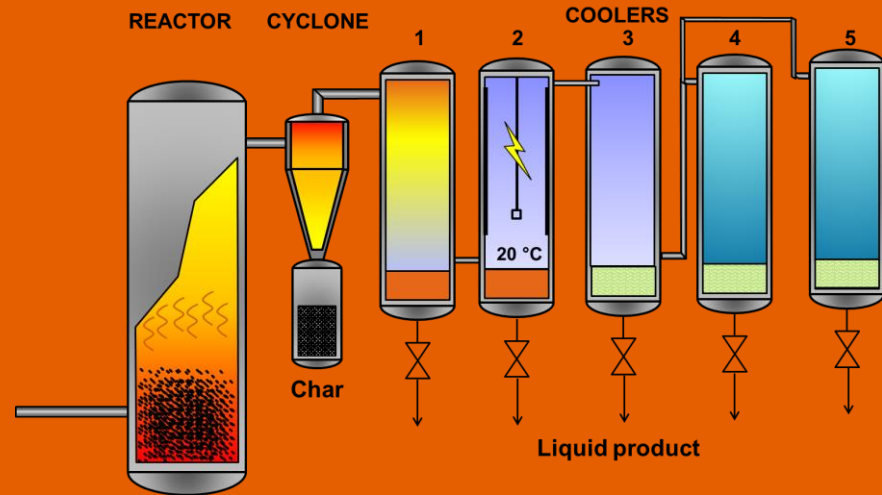
Which plastic for recycling?



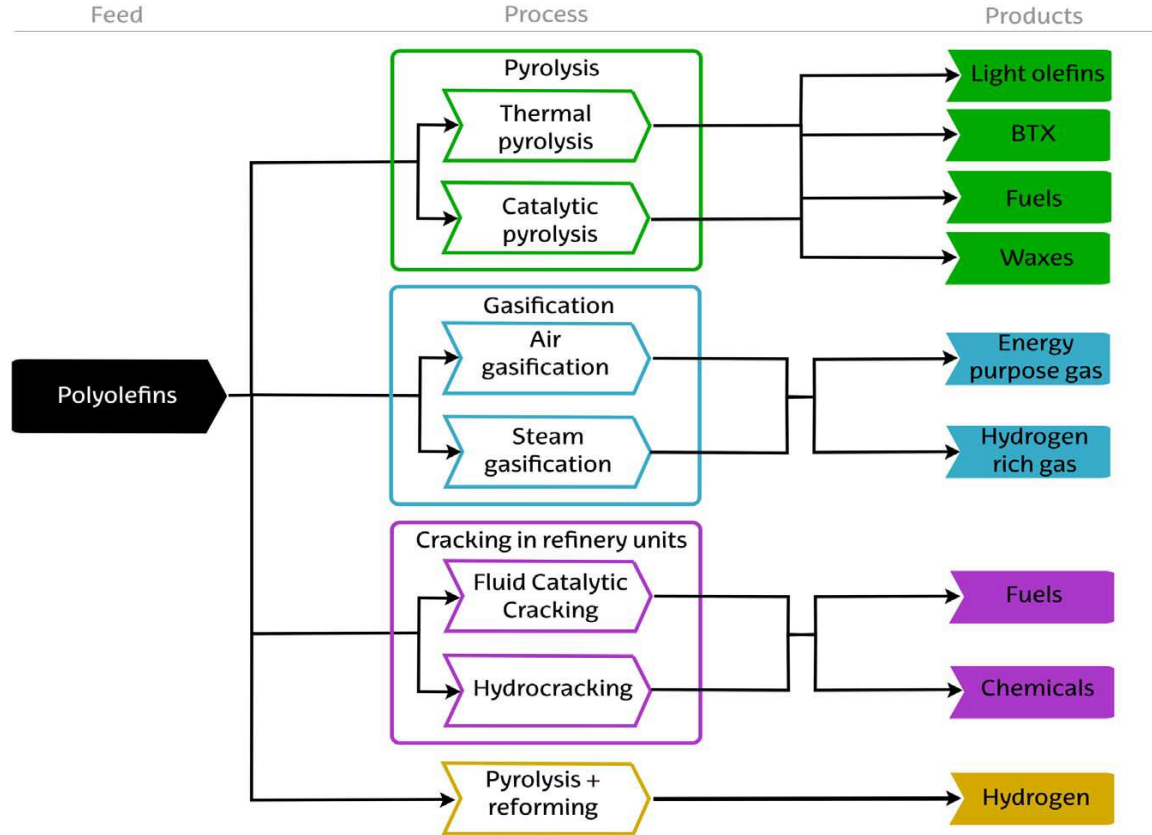
Current plastic distribution demand in Europe depending on their application (a) and type of polymer (b)

Thermolysis (pyrolysis) of plastics

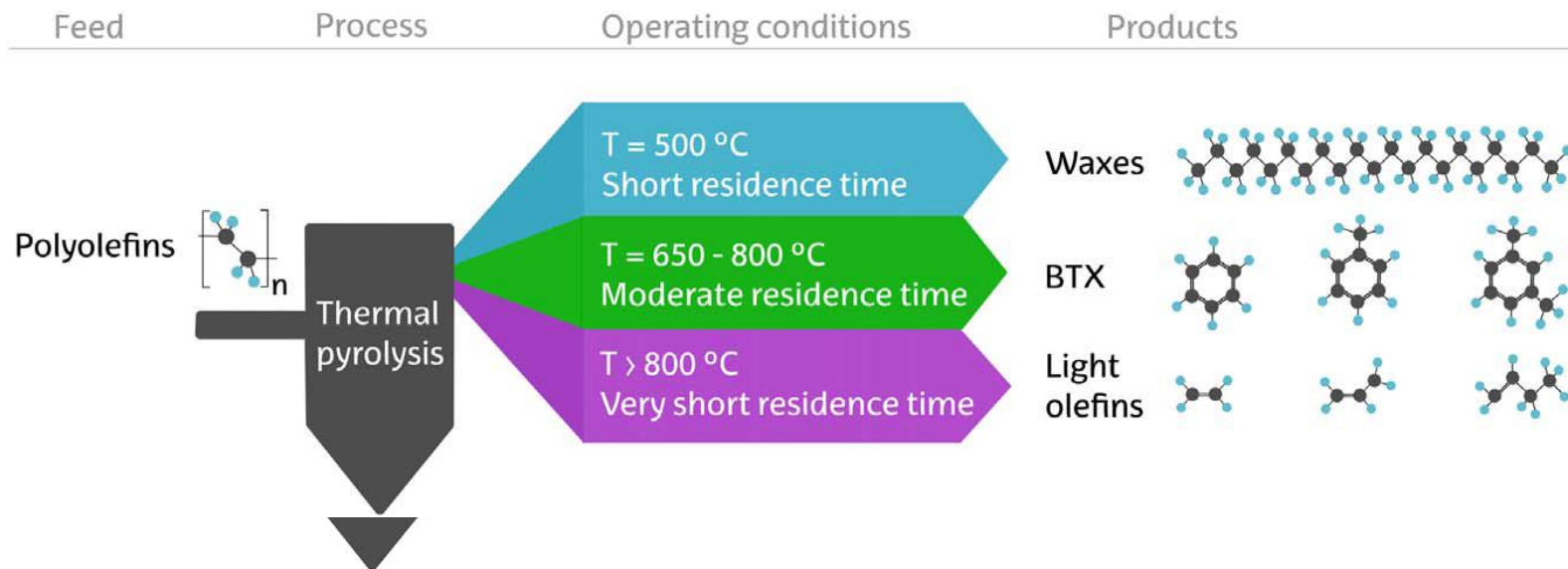
- *Thermal or catalytic decomposition of a material in an oxygen-free environment or in presence of steam into liquid product for chemicals or fuels*



Thermo/Chemical recycling pathways


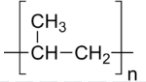
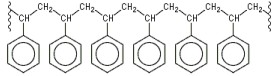
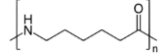
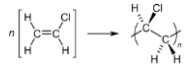
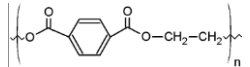
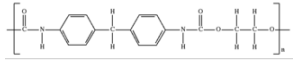



Pyrolysis products



Conditions for the selective production of waxes, BTX (Benzene, Toluene and Xylene) and light olefins from polyolefins by thermal cracking.

Plastics to liquids via thermolysis – monomers and other products

RESIN	STRUCTURE	MAJOR ORIGIN OF WASTE	THERMOLYSIS PRODUCT
PE		Household, industrial plastic packaging, agricultural plastics	Waxes, paraffins, olefins
PP		Household and industrial plastic packaging, automotive	Waxes, paraffins, olefins
PS		Household, industrial plastic packaging, construction, demolition, WEEE	Styrene, its oligomers
PA-6		Automotive waste	Caprolactam
PMMA		Automotive, construction waste	MMA (methyl methacrylate)
PET		Household plastic packaging	Benzoic acid, vinyl terephthalate
PUR		Construction, demolition, automotive	Benzene, methane, ethylene, NH3, HCN
PVC		Construction plastic waste	HCl (< 300C), benzene

**OIL REFINERY FEEDS
> CHEMICALS,
DIESEL**

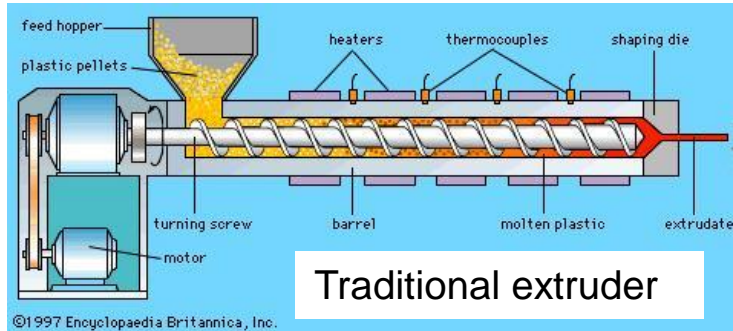
**MONOMERS
> NEW
PRODUCTS**

**UPGRADING >
CHEMICALS, FUELS**

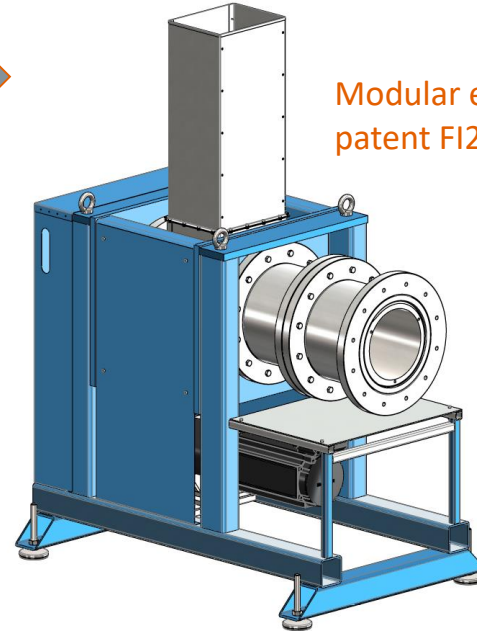
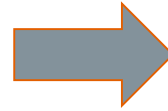
Reactor comparison for plastic thermolysis

	Temp. profile	Heat exchange and transfer	Particle size	Residence time	Process flexibility	Non-catalytic thermolysis	Catalytic thermolysis	Value of obtained products	Scale-up	Costs
Fixed Bed	Red	Red	Yellow	Green	Red	Yellow	Yellow	Green	Red	Yellow
BFB	Yellow	Green	Yellow	Yellow	Green	Green	Green	Green	Yellow	Yellow
CFB	Yellow	Green	Yellow	Yellow	Green	Green	Yellow	Green	Yellow	Red
Rotary kiln	Red	Red	Green	Green	Yellow	Green	Grey	Red	Yellow	Yellow
Melting vessel	Red	Red	Yellow	Green	Yellow	Green	Grey	Yellow	Grey	Yellow
Extruder	Yellow	Red	Yellow	Grey	Green	Grey	Yellow	Green	Green	Yellow

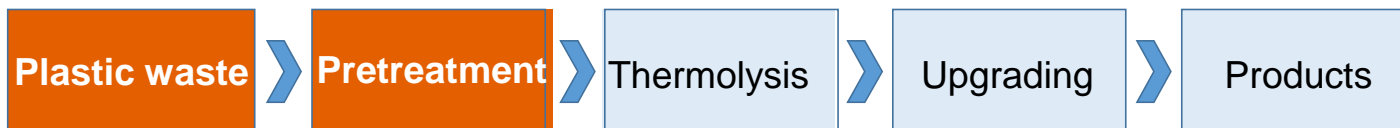
Integrated material pretreatment to thermolysis



Traditional extruder



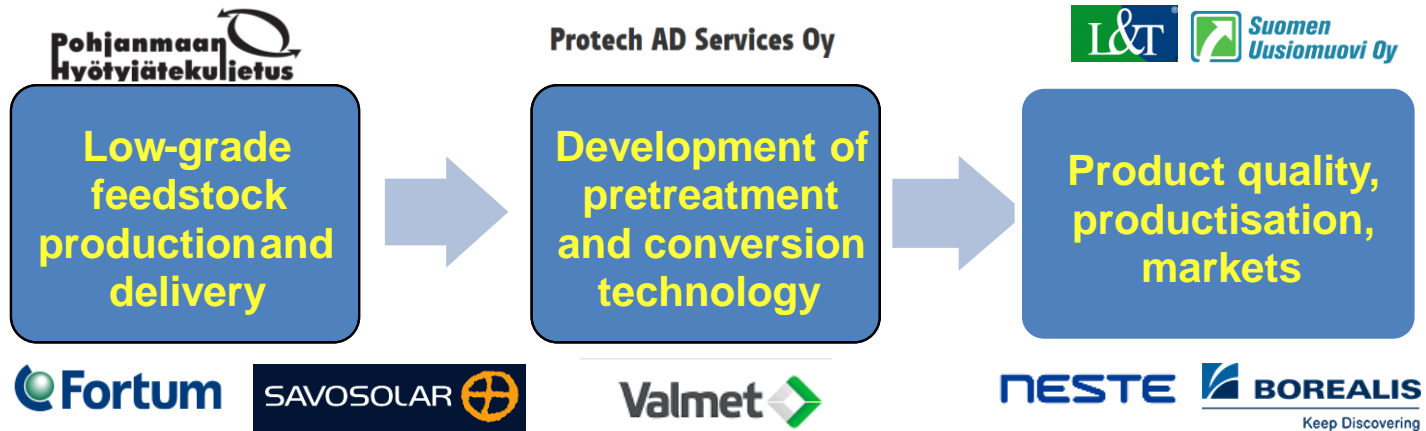
- Heterogenous feed including foils which otherwise are difficult to process
- Processing to granules or straight to thermolysis as melt compound



Contact: Juha.mannila@vtt.fi

BF WasteBusters 2017-18 – Industrial mixed plastic and wood waste to new products

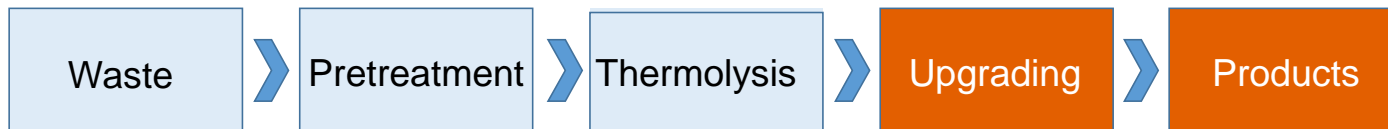
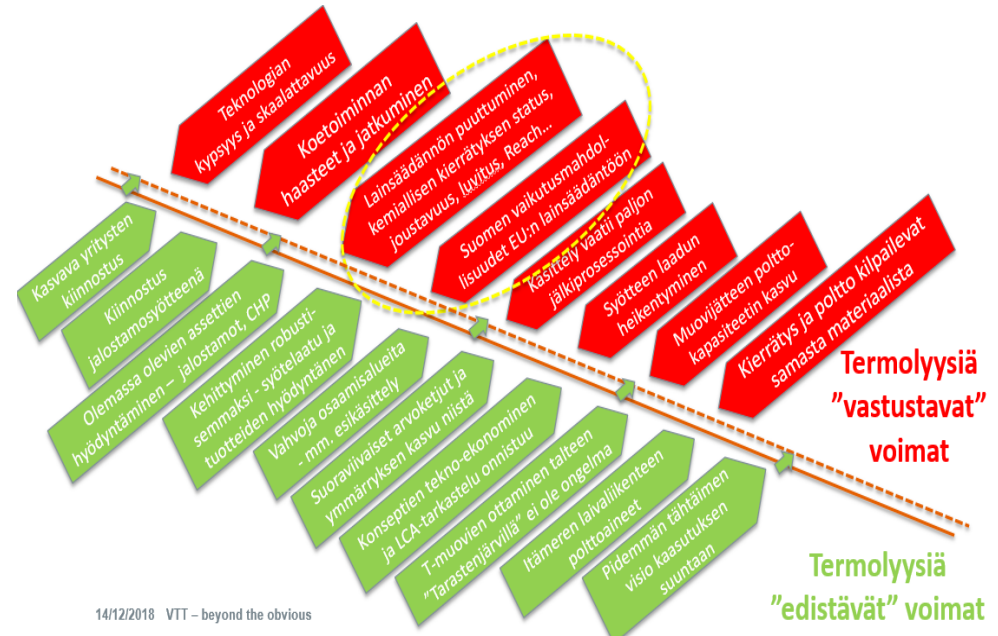
- *The emphasis was to support establishing markets for waste-derived products and related technologies in Europe*



Contact: anja.oasmaa@vtt.fi

New business opportunities

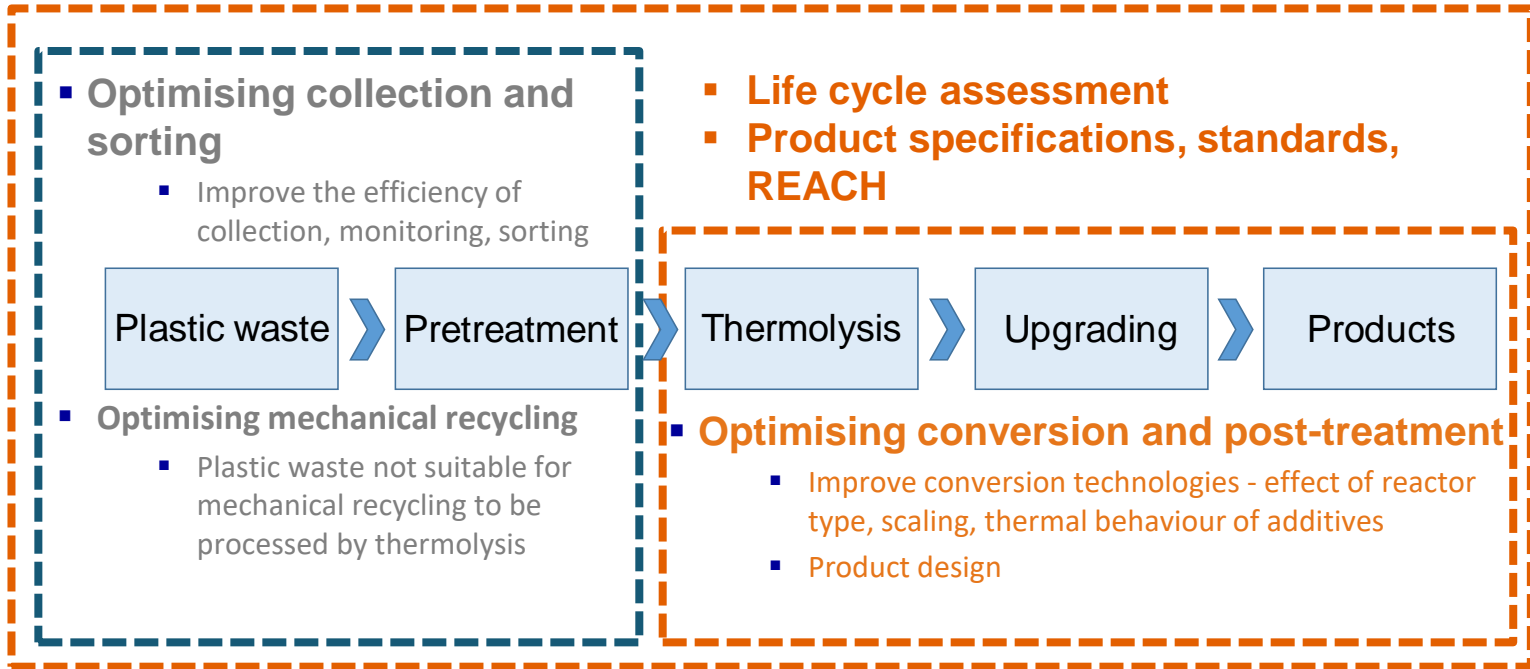
- A market review on key waste-derived products to identify e.g. bottlenecks hindering new waste-derived business beyond Europe, global key players and risks related changes in current supply-chain.



Key challenges and VTT solutions

Key challenge	VTT solutions
Discontinuous availability of waste due to lack of long-term binding agreements with feedstock suppliers	Waste supplier in the consortium
Complex sorting and conversion technologies	Cost-effective pretreatment/conversion techniques for heterogenous waste , VTT IPR <ul style="list-style-type: none"> ➤ Scalable modular extruder for heterogenous plastics ➤ New reactor technology for heterogenous plastics ➤ Biomass pyrolysis patent family to be applied for plastics
Permitting, legislative requirements Unclear legislation related to products (i.e. fuels) from chemical recycling	Waste hierarchy can be overtaken if it is justified by LCA Lobbying, dissemination REACH <ul style="list-style-type: none"> ➤ LCA positive ➤ REACH to be initiated ➤ VTT active in changing the legislation

Overall target - Integration of mechanical and chemical recycling



➤ *Optimisation of the whole value chain from plastic waste to specified products*

Exploitation



- **Arvi – Material value chains 2015-16**

- The role of thermal conversion technologies in plastic recycling
- Need of companies



10.5.2019 VTT – beyond the obvious



- **BF WasteBusters 2017-18**
Industrial mixed plastic to new products via pyrolysis

- Wax to refinery feed and new products
- Olefins to oil refinery feed
- Diesel fuel for IC-engines

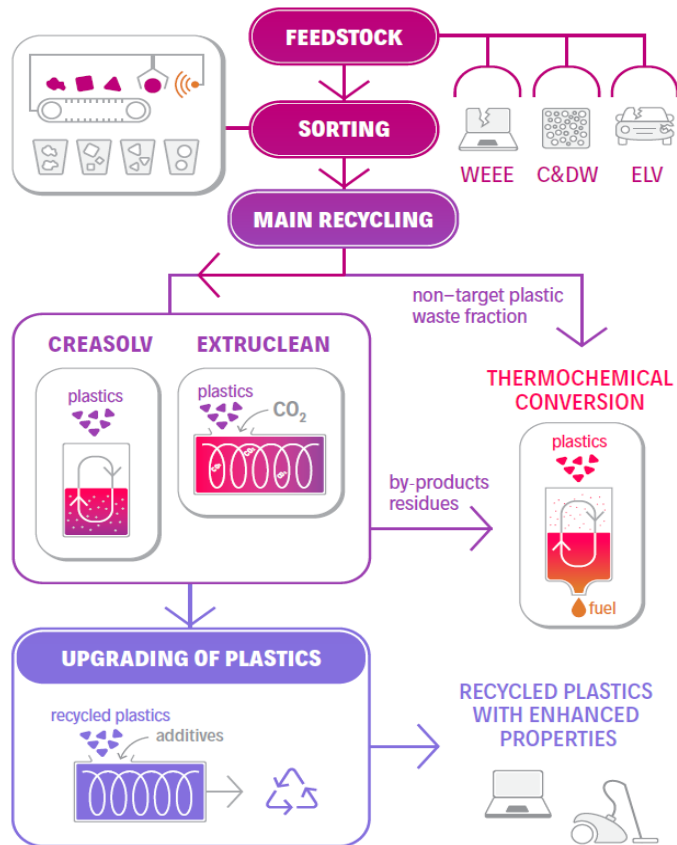


- **EU NonTox 2019-22** - Removing hazardous compounds from WEEE, ELV and C&D plastics, pyrolysis of rejects
- **BF Co-Creation PS recycling** – New ecosystem for PS by integrating mechanical and chemical recycling > Co-Innovation proposal
- **BF BioFlex** - Liquid fuels from plastics and rubber for flexible power generation and marine transport

- **Strong networks**
- **New IPR, business**
- **New top expertise**

EU NONTOX 2019-22

Removing hazardous compounds from WEEE, ELV and C&D plastics



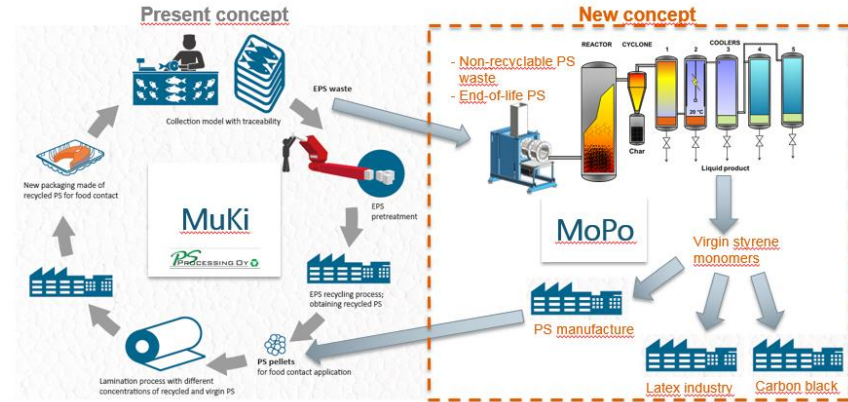
BF Co-Creation MoPo – Monomers from polymers

CHALLENGE

- Need for aromatics
- Unclear data on amounts of PS in plastic waste
- No separate collection of polystyrene
- High volume/weight ratio costly for transportation
- POPs in PS waste
- Product responsibility force companies to handle their PS waste
- Limited amount of PS can be mechanically recycled

SOLUTION

- PS waste which cannot be recycled mechanically to be thermolyzed (VTT's patents) back to monomers for Latex industry or carbon black and to PS
- High yields of monomers can be obtained by pyrolysis of PS, also from mixed waste
- Apply VTT patented Modix extruder to densify PS waste
- Apply VTT IPR (two different processes) for thermolysis of heterogenous plastic waste, possibility to remove Cl and POPs
- VTT technology can be licenced abroad



BENEFIT

- Improved PS utilization diminishes harmful waste in nature
- New overall solution for PS waste (present solution combustion) creates business for companies
- Increase production of aromatics to replace fossil sources in PS, Latex industry etc.
- Virgin monomers from end-of-life PS
- Utilisation of POP containing PS waste possible

BF BioFlex - Production of sustainable storable liquid fuels for flexible power generation and marine transport

? CHALLENGE

- Need to limit greenhouse gas emissions - fossil fuels to be replaced with low-carbon sustainable fuels
- Need for flexible bioenergy to balance variable renewable energy, emergency supply
- Need for low-S liquid fuels
- Need to demonstrate the applicability of bio oils for marine diesel engines and stationary engines for power generation

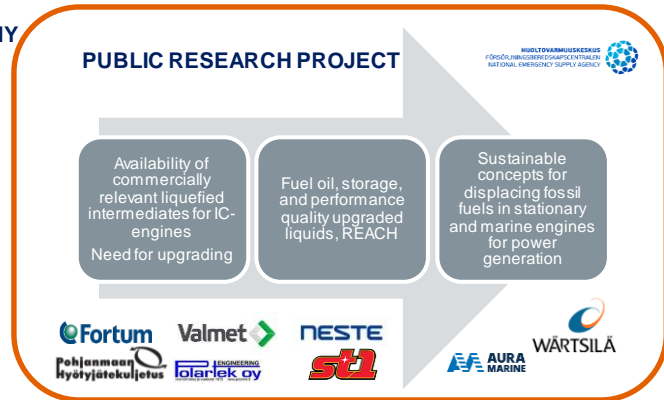
✂ SOLUTION

- Develop concept for a step-wise (decrease gradually the share of fossil fuels) approach for feasible and sustainable production of biomass and waste-derived liquid fuels for large diesel engines
- Develop liquid fuels with adequate quality and low emissions
- Prepare data for future fuel specifications, and based on earlier standardisation expertise, prepare the methodology towards standardisation, and REACH

PRIVATE COMPANY PROJECTS



PUBLIC RESEARCH PROJECT



PRIVATE COMPANY PROJECTS



👍 BENEFIT

- Flexible and feasible concept for sustainable production of adequate quality liquid fuels for large diesel engine use



Thank you!

<https://www.vttresearch.com/>