

LUUDI I PROCESI



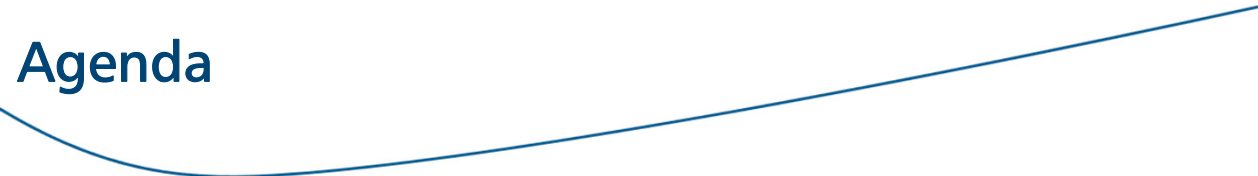
Examination of the possibility of Pyrolysis oil using in INA

Marinela Bojc Takács, Maja Fabulić
Ruszkowski, Dejan Bogojević
INA, Development

September 25th



Agenda



Pyrolysis at a glance

Market status

Pyrolysis technology, Pyro oil quality

Pyro oil co-processing routes

Pyro oil stability & aging

Co-processing of Pyro oil in HDS small-scale unit

Conclusions & outlook

Pyrolysis at a glance

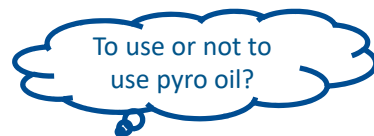
KEY QUESTIONS

Why?

Where?

In what way?

In which dosage?



TECHNICAL EVALUATION

Quality

Regulation

Stability

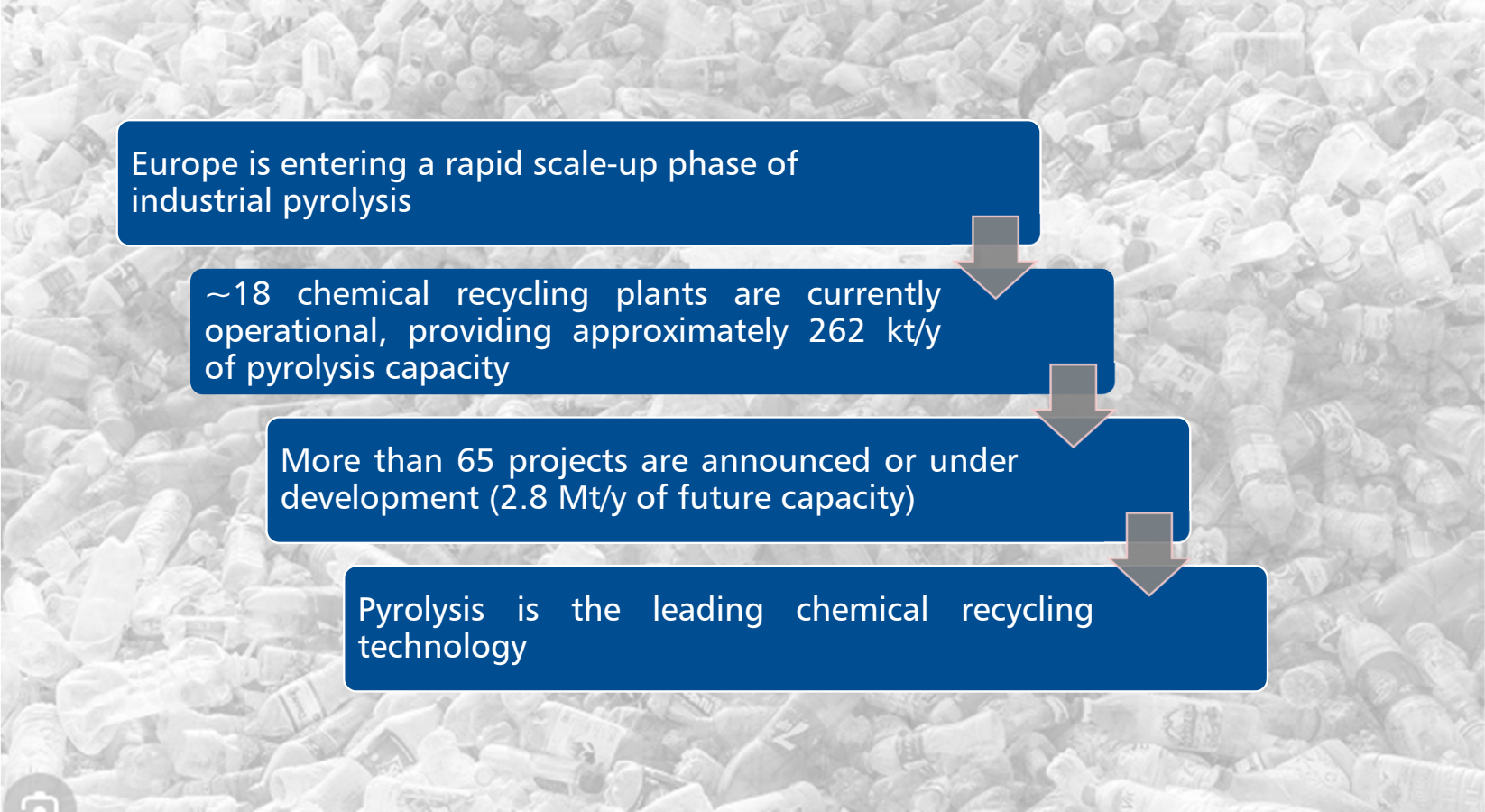
Storage

Utilization

UTILIZATION

- ✓ Co-processing of pyro oil can be considered for refinery co-processing
- ✓ Circular economy feedstock
- ✓ Commercial potential

Market status



Europe is entering a rapid scale-up phase of industrial pyrolysis

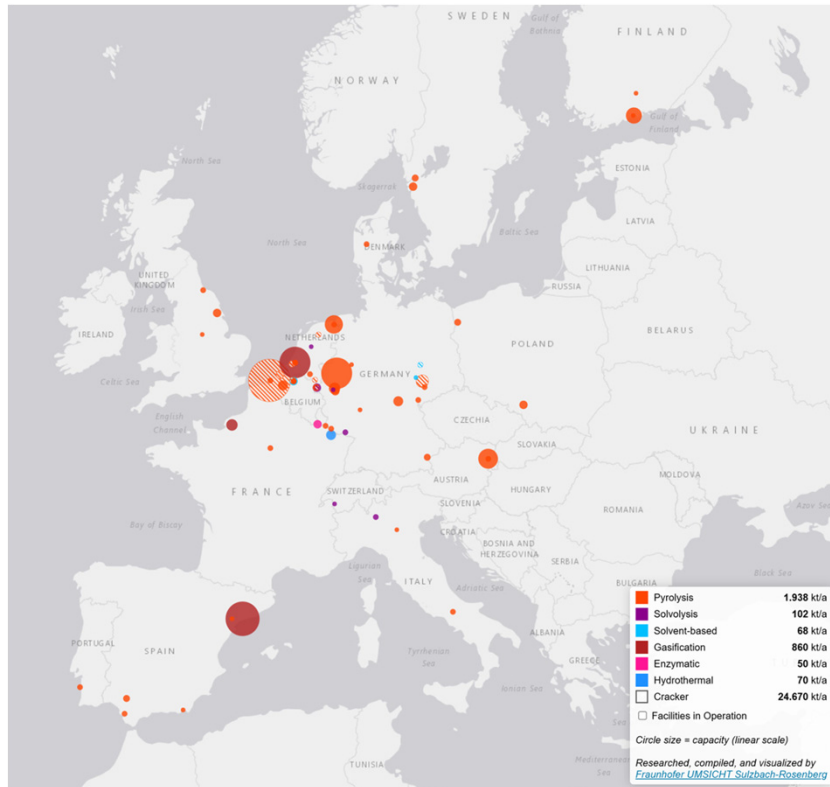
~18 chemical recycling plants are currently operational, providing approximately 262 kt/y of pyrolysis capacity

More than 65 projects are announced or under development (2.8 Mt/y of future capacity)

Pyrolysis is the leading chemical recycling technology

The European pyrolysis market is transitioning from pilot and demonstration projects to industrial-scale deployment

Market status

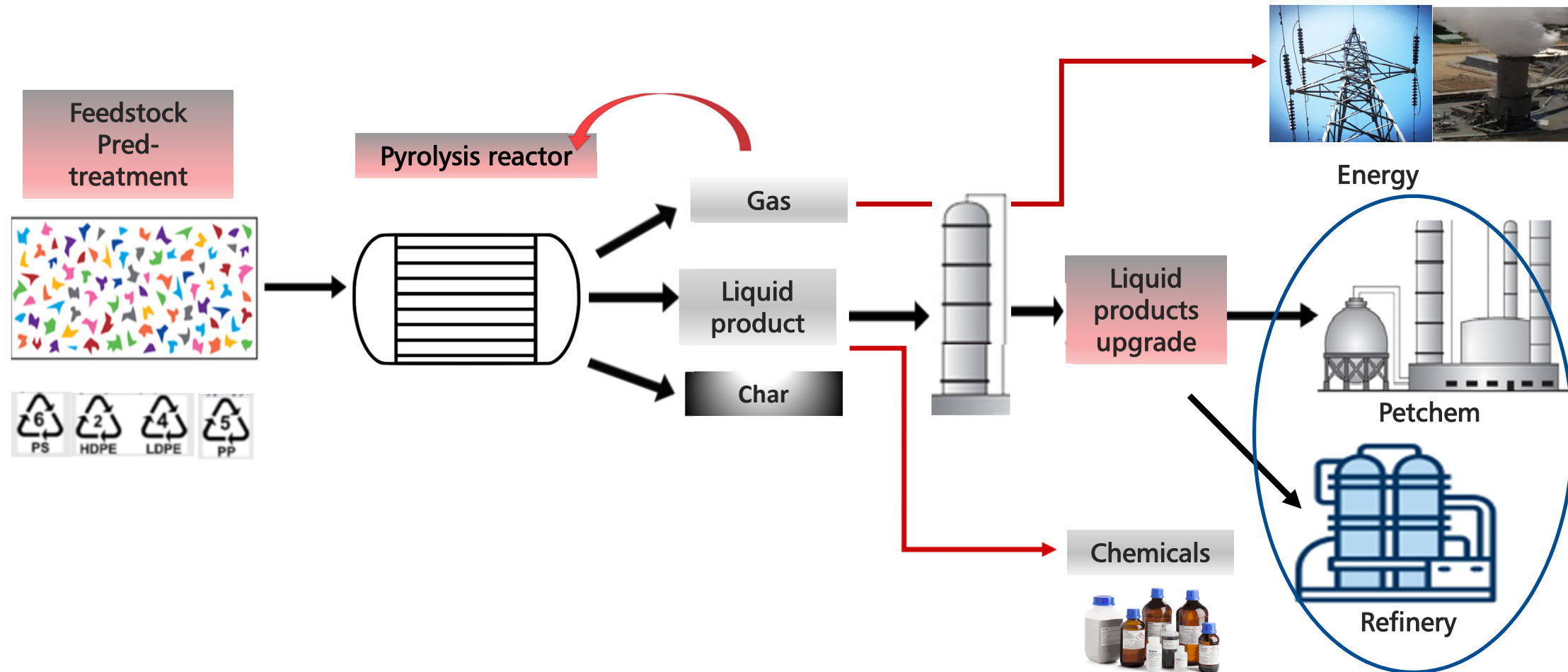


Chemical Recycling Facilities Map in Europe — Capacities & Status | Fraunhofer UMSICHT

- Plastic Energy (UK/Spain) - plastic pyrolysis
- Pyrum Innovations (Germany) - tire pyrolysis
- Circotec (UK/NL) - tire pyrolysis + upgrading
- Mura Technology (UK) - hydrothermal/plastic recycling project with Dow
- OMV ReOil (Austria) - refinery integration
- Enviro Systems (Sweden)
- Quantafuel/Viridor platform - plastic pyrolysis Norwegian/Danish
- Blue Alp (NL/BE)–plastic pyrolysis

The pyrolysis oil market is expanding quickly in Europe, driven by circular economy policies and demand for alternative fuels and petrochemical feedstocks

Pyrolysis technology

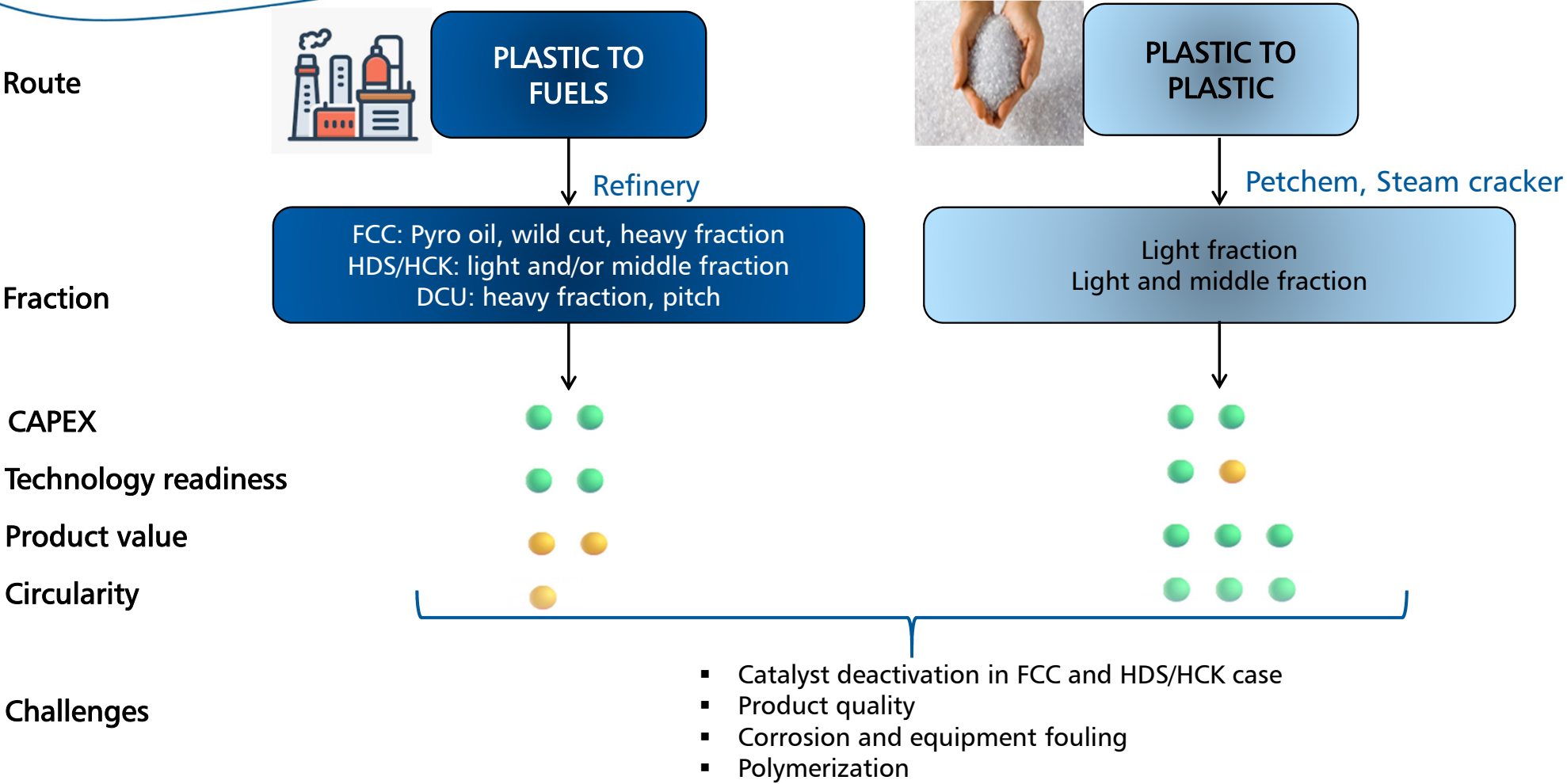


Pyro oil quality analyzed in INA, Development

Properties	Pyrolysis oil	
	Waste plastics max. value	Waste tires max. value
Type of sample	wide cut	wide cut
Density @15°C, kg/m ³	793 - 830	870 - 1060
Kinematic viscosity @40°C, mm ² /s	1,5 - 1,8	2,0 - 2,2
S content, ppm	15 - 30	700 - 1800
Nitrogen, wt. %	<0,1	0,4-0,75
Cl, ppm	50-165	32-1005
Total Acid number, mg KOH/100g	1 - 5	4 - 10
Ash content, wt. %	<0,001	max. 0,003
Carbon residue, wt. %	<0,001	<0,26
Total aromatics, wt. %	< 8	35 - 45
Polyaromatics, wt. %	1,4 - 2,2	5,0 - 13,0
Benzene, vol. %	<0,14	<2
Low heating value, MJ/kg	43 - 46	42,5 - 43,3
Metals, ppm	Typical Si, Fe, Zn, Pb, Cu, Ni, Cr, V, Si (typical <5 ppm except Si, F)	significantly higher than pyro plastics, typical high Zn, Ca, Fe, Cu, Pb, Cr, Ni



Pyro oil co-processing routes



Recommendations: Testing on small and pilot scale, plus finally in commercial scale

Pyro oil stability & aging

Stability drivers

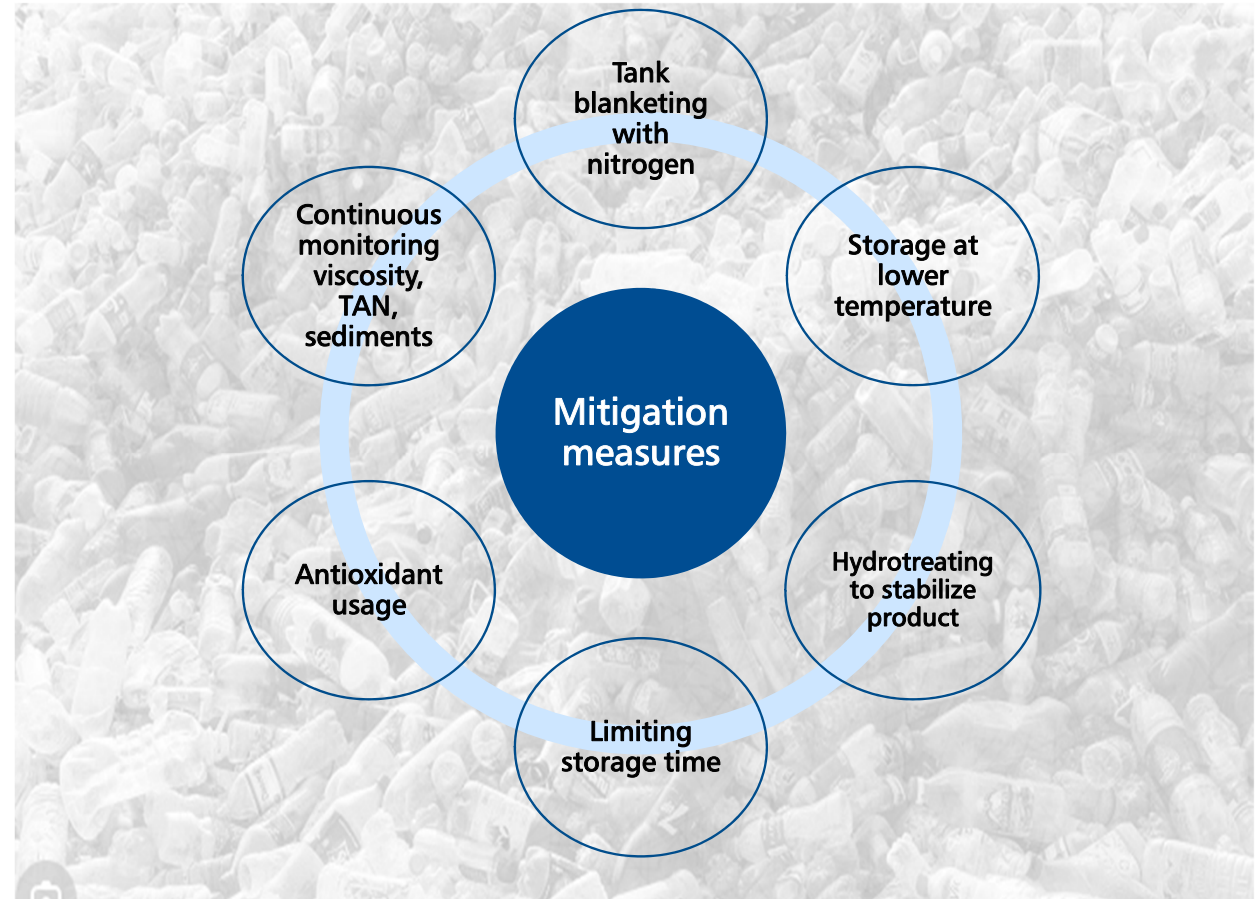
Pyro oil stability depends on:

- Chemical Composition
- Oxygen and Water Content
- Contaminants
- Storage Conditions

Aging effects

Aging causes changes in chemical and physical properties that may lead to:

- Polymerization
- Oxidation
- Phase Separation

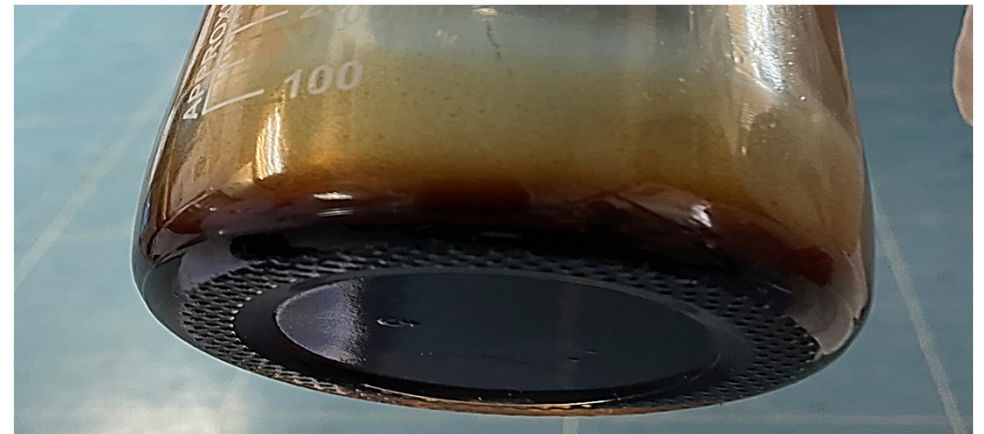


Pyro oil stability & aging, tested in INA, Development

The following properties of aging were monitored:

- Density
- Kinematic viscosity
- Oxidation stability
- Polymerization (monitored by distillation)
- Gum/sediments content
- Hydrocarbon content
- Phase separation

Pyro oil, pyro fractions and blends of motor fuels with pyro fractions were tested in longer period from production to eight months and one year



There is no standard for pyrolysis oil quality, only Standard Guide for Analysis of Waste Plastic Process Oil and Tire Pyrolysis Oil

Pyro oil stability & aging, tested in INA, Development

Sample (plastic origin) / Monitor time	Oxidation stability	Density, kg/m ³	Kinematic viscosity, mm ² /s	Gum/ Sediments content	Distillation	Hydrocarbon content	Phase Separation
Pyro oil, wild cut, 1Y	n/a	increase	increase	unchanged	changed	changed	no
Light pyro fraction, 8 months	decrease	unchanged	n/a	n/a	changed	n/a	no
Middle pyro fraction, 8 months	unchanged	increase	unchanged	n/a	unchanged	n/a	no
Blend Light Pyro fraction and Motor gasoline (3/97 wt.%), 8 months	decrease	increase	n/a	increase	changed	n/a	no
Blend Middle Pyro fraction and Diesel (3/97 wt.%), 8 months	decrease	unchanged	increase	increase	unchanged	n/a	no

Stability and storage of pyrolysis oil represent key technical challenges after processing

Co-processing of Pyro oil in HDS small-scale unit

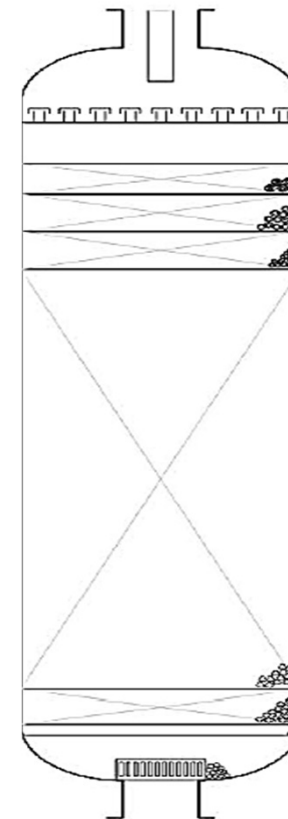
Main goal of co-processing test run

To investigate possibility of co-processing with pyro oil and examine effect of pyro oil on:

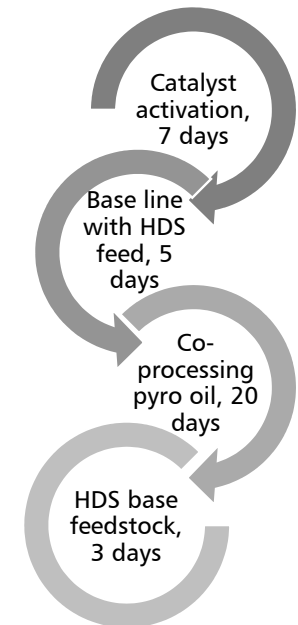
- the reactor operation
- process parameters
- catalyst activity
- material balance
- product yield and distribution

Main figures

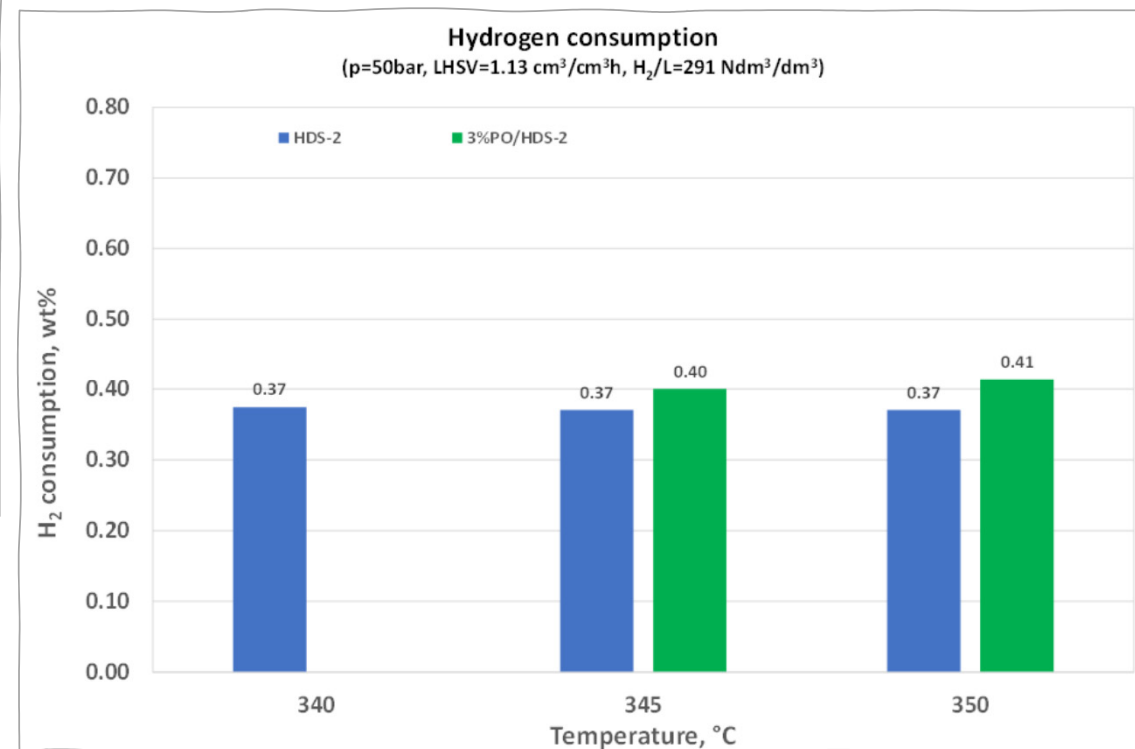
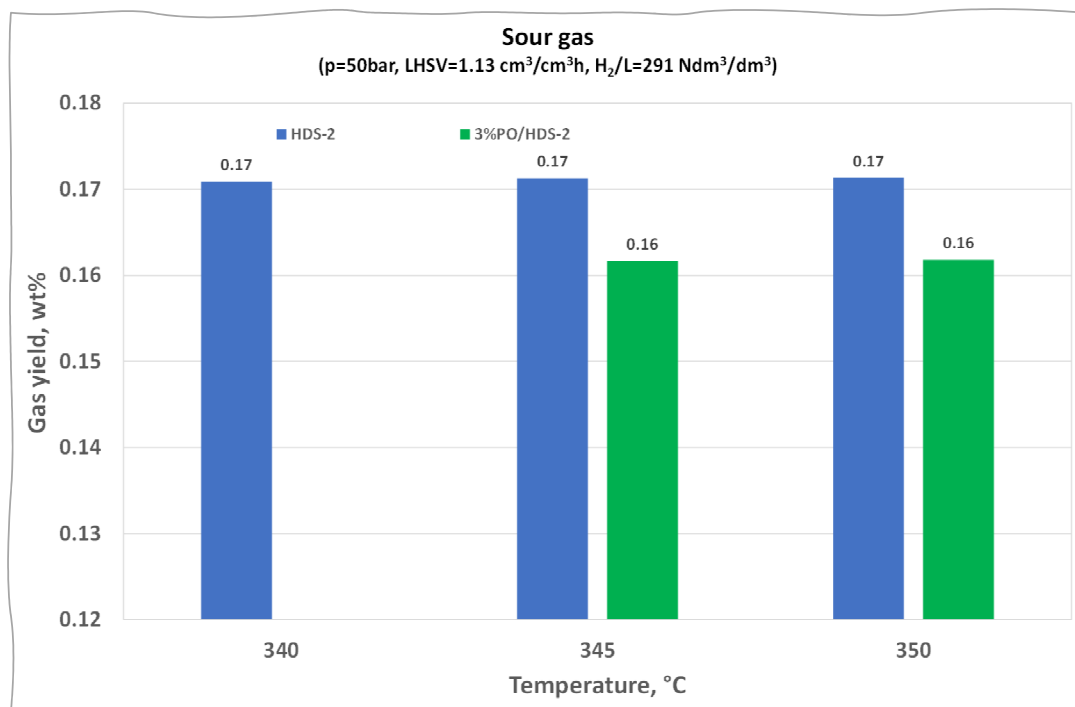
- **Type of apparatus:** lab. small-scale reactor, V=10 ml
- **Feedstock:** Pyro oil, waste plastic origin
- **Test run duration:** 35 days
- **Injection rate:** 3 % of pyro oil
- **Catalyst:** HDS Rijeka refinery catalyst, (NiMo/Al₂O₃)
- **Process conditions:** HDS2 unit, reactor 1



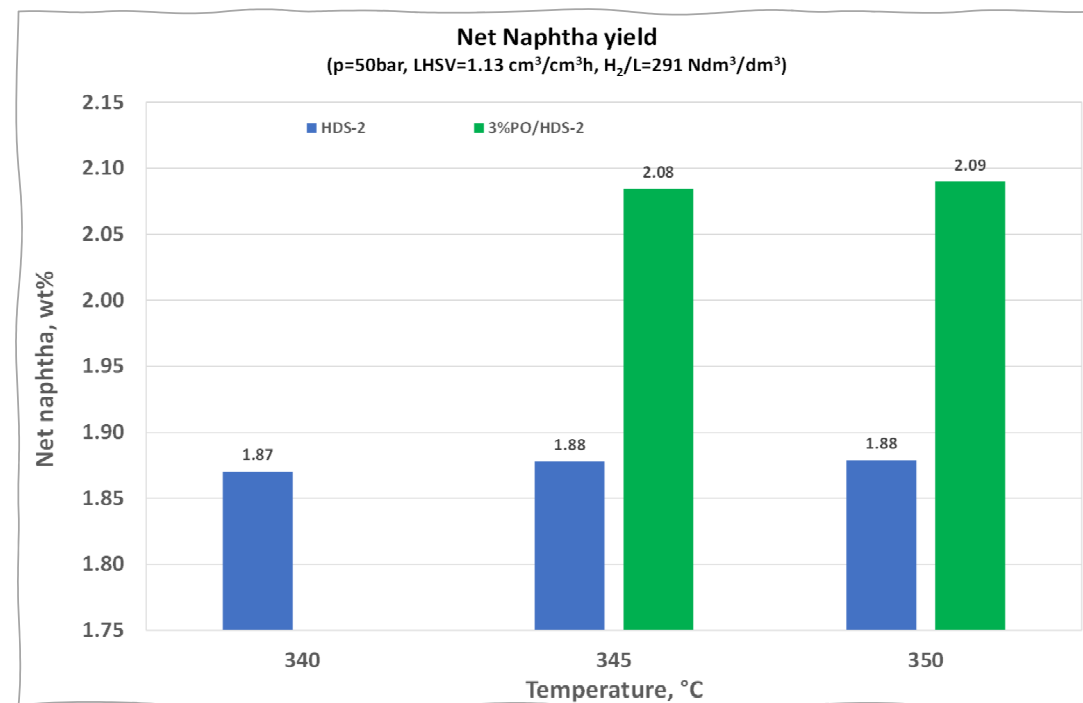
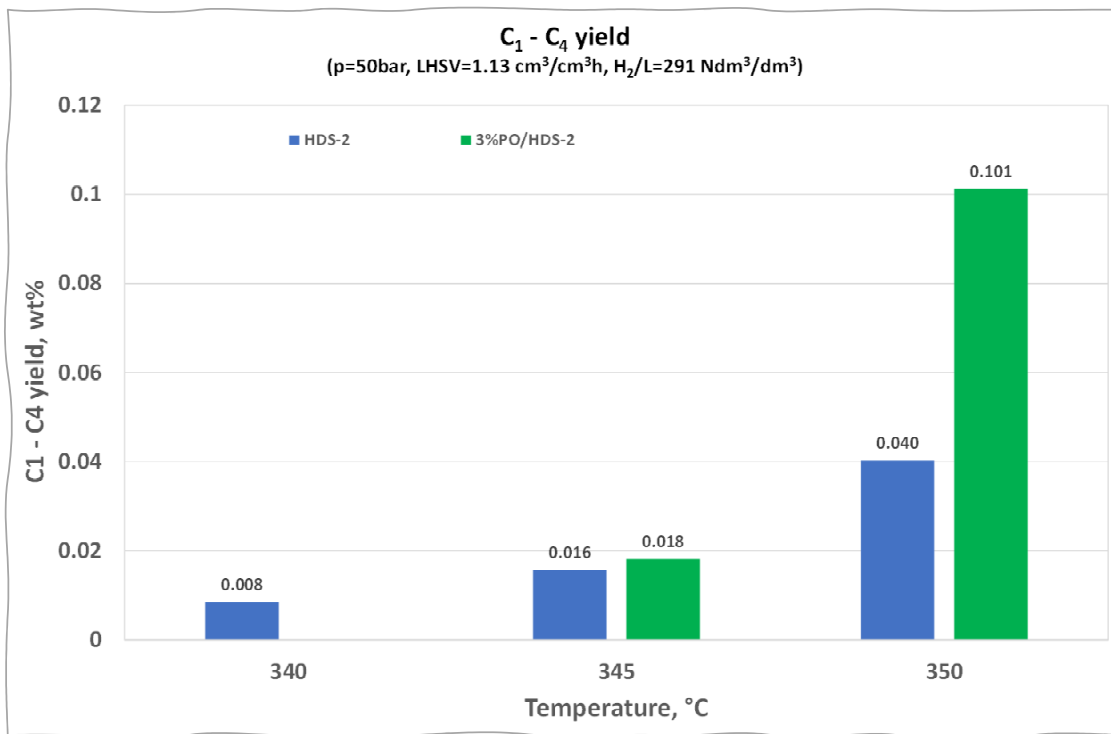
Testing steps



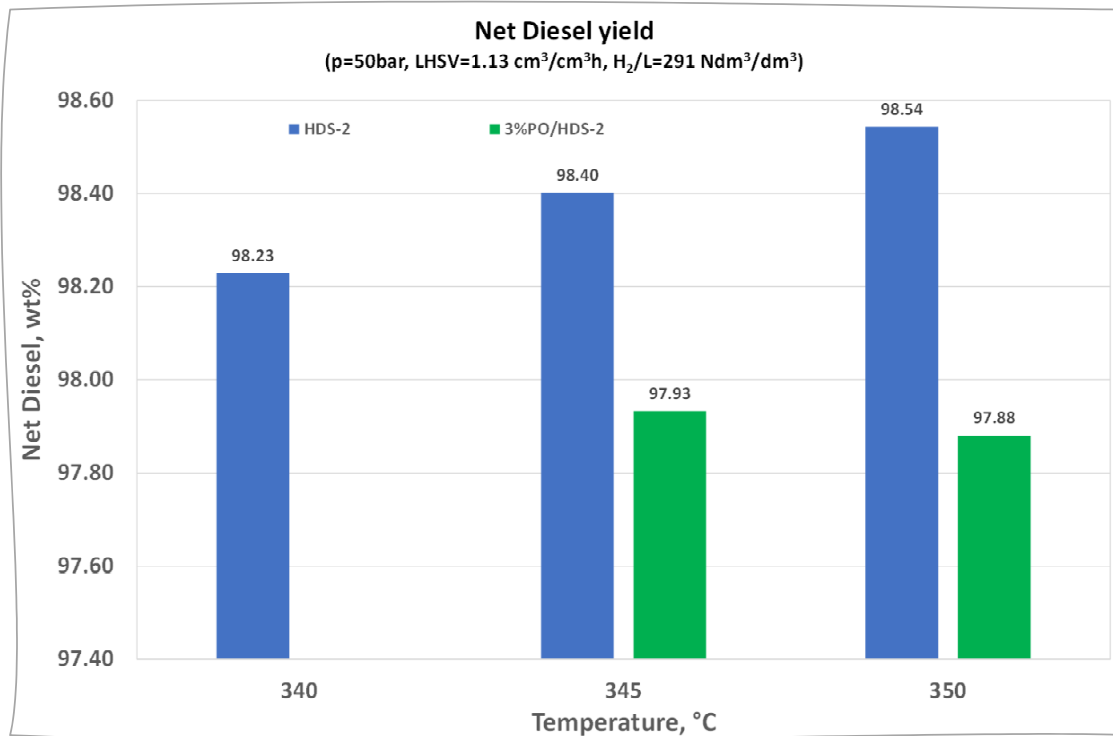
Co-processing of Pyro oil in HDS small-scale unit



Co-processing of Pyro oil in HDS small-scale unit



Co-processing of Pyro oil in HDS small-scale unit



Test run results

- Process parameters have been minorly changed
- The activity of the catalyst remained stable
- The hydrogen consumption was negligibly higher (below 1 wt. %)
- Yield of all products changed below 1 wt. %
- Yield of sour gas and diesel decreased, while yield of C1-C4 gas, and naphtha increased
- Diesel yield has dropped to 0,66 wt. % at 350 °C
- Sulphur content was below 5 ppm during all test
- The polyaromatic content and density values were slightly reduced

All properties of diesel are in accordance with EN 590 standard

Conclusions & Outlook

- Pyrolysis oil is a promising circular-economy feedstock
- Strong market growth expected

Industrial application



- Long-term stability and storage guidelines still required
- Scale-up from pilot to commercial operation

Further Development



- Up to 3 wt.% pyrolysis oil successfully co-processed
- No significant impact on process performance or diesel quality

Co-processing results



