Pyrolysis liquids from waste plastics
a fuel component in the circular economy

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A Glance at INSER

- Power Generation
  - Small Hydro
  - Biogas (manure)
  - Landfill Biogas
  - Solar PV
  - Biomass with gasification
  - Waste pyrolysis
- R&D
  - Gasification
  - Second Generation Biofuels

Plastic's fate

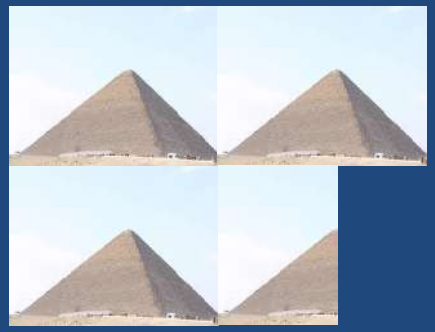
26 millions ton/year

29,7 % Recycled

39,5 % Energy recovery (incineration)

30,8 % Landfill

8M ton; equivalent to 100 Mbbl
8 G€=1,3 times budget UE
For youth employment policies



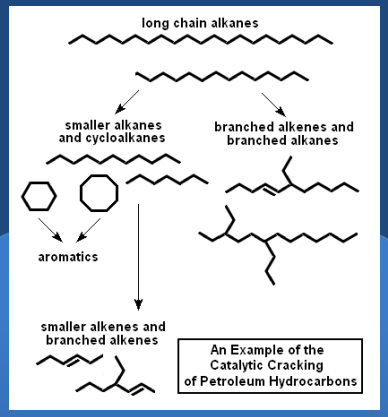
Plastic cannot be recycled endlessy:
How much recycled/recovered plastic ends up in landfills after its «2° life»??

EU Target: Near Zero Landfills within 2020

Sources: PlasticsEurope 2014

Catalitic Pyrolysis

INPUT
Mixed plastics
Unsorted/contaminated



Catalitic pyrolysis+ refining

Heating without combustion

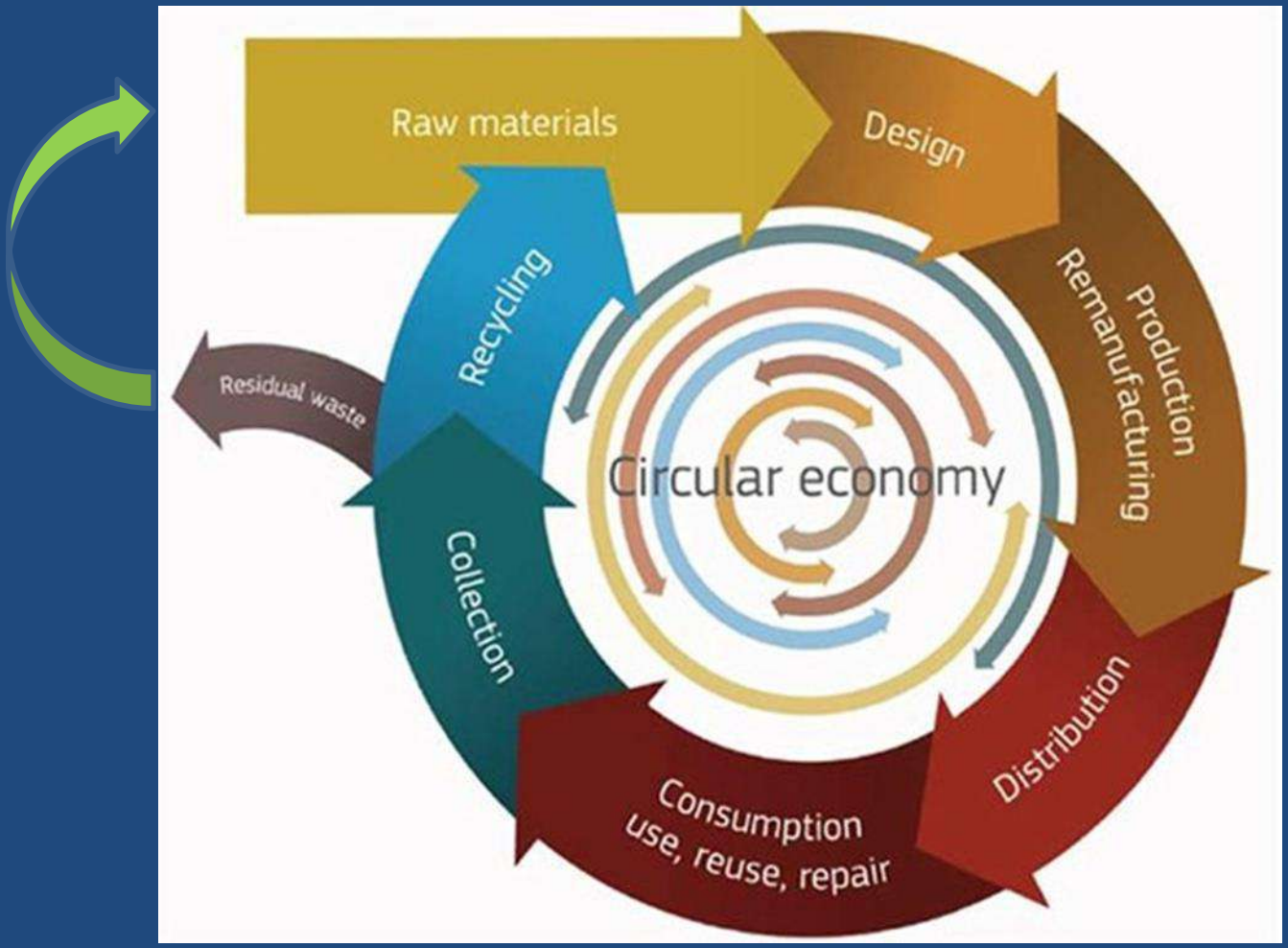
Transportation fuels
EN590 / EN228

Heating Fuel
UNI 6579

Marine Fuel
ISO 8217

«Chemical Recycling»

Circular Economy: a self regenerating system



Pyrolysis plant in South East Asia

Perfect circular economy concept

Plastic extracted from old landfill

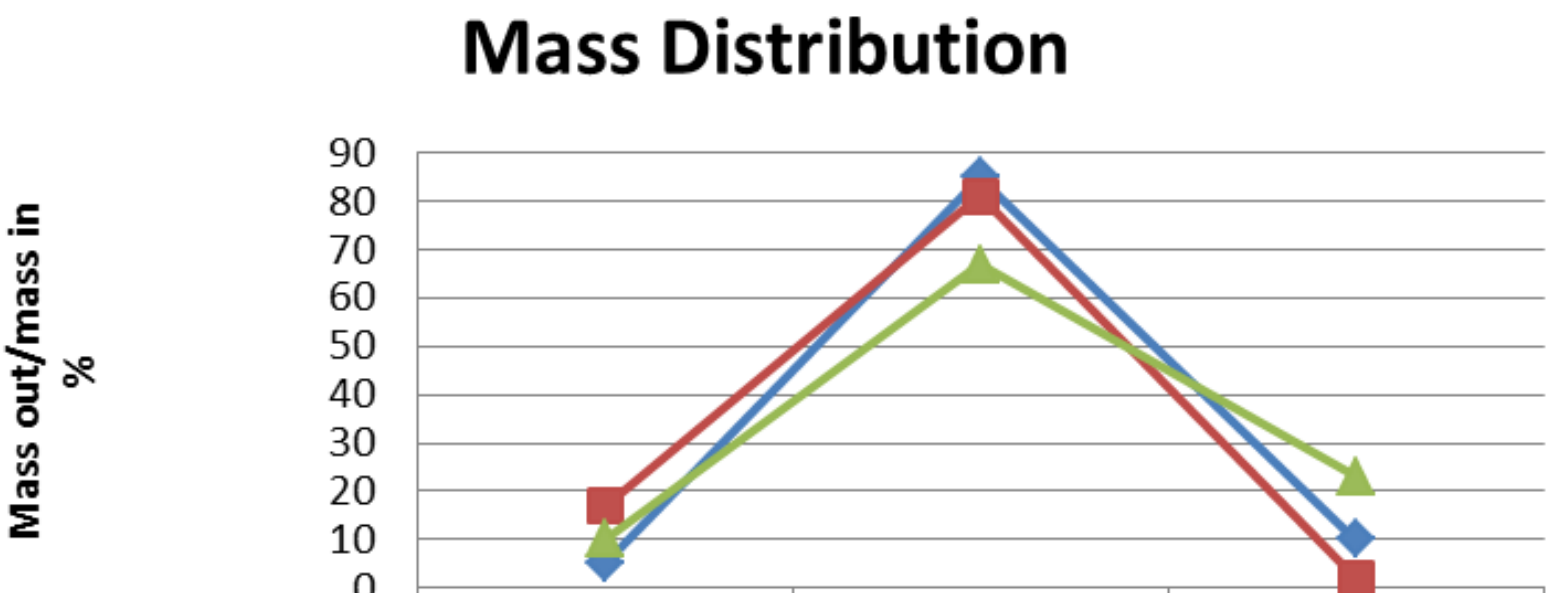
Pyrolysis

Refining unit

Fuels @ technical specs

Raw pyrolysis oil

Mass Balance



	gas	liquid	residue
Ref sample	5	85	10
PEX	17	81	2
Post consumer "sample 1"	10	67	23

Pyro oil for marine fuels

Marpol Annex VI (ECAs/SECAs)

	Year	Fuel Sulfur (ppm)	Fuel Sulfur (%)
European SECAs			
North Sea, English Channel	Current Limits	10,000	1
	2015	1,000	0.1
Baltic Sea	Current Limits	10,000	1
	2015	1,000	0.1
North American ECAs			
United States, Canada	2012	10,000	1
	2015	1,000	0.1
Global	2012	35,000	3.5
	2020[a]	5,000	0.5

[a] Alternative date is 2025, to be decided by a review in 2018.

Low S fuels required

Source: report alternative fuels for marine application IEA2013

Possible low S fuels

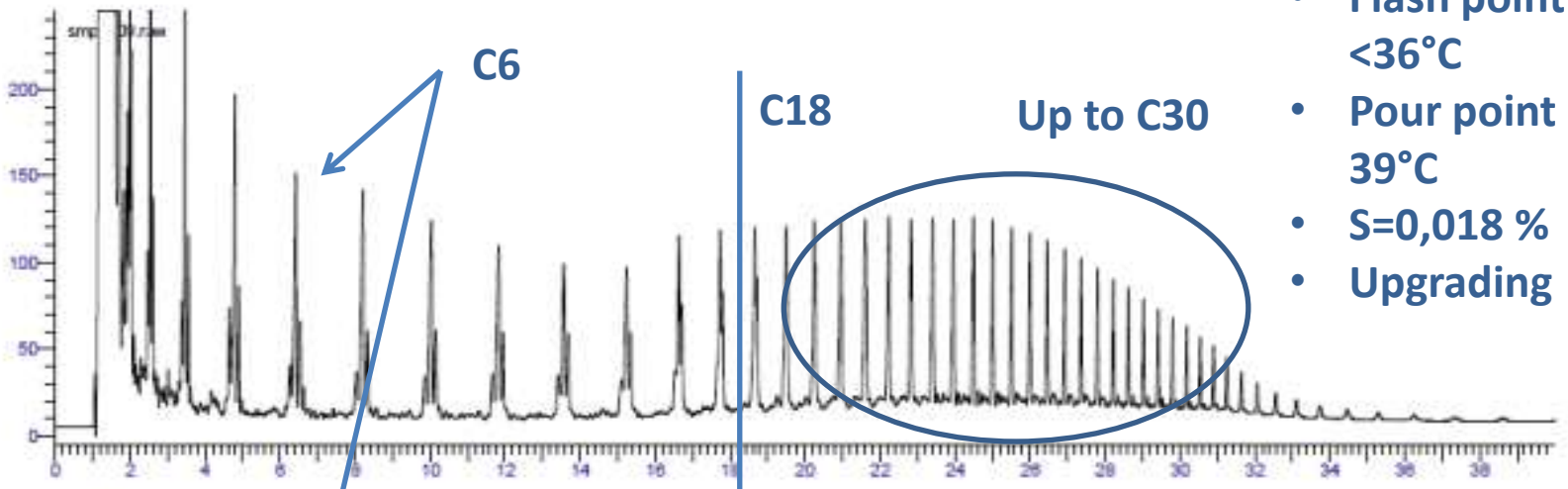
Feedstock			
Natural gas, bio-gas	Crude oil	Vegetable oils, animal fats, algae lipids	Biomass
Fuels			
CNG, LNG	IFO, LSFO, LPG, MGO	Biodiesel (FAME), HDRD (second-generation biodiesel)	BTL,[a] GTL, methanol, DME, pyrolysis oil, LBG

[a] CNG = compressed natural gas; BTL = biomass-to-liquid; GTL = gas-to-liquid; DME = dimethyl ether; and LBG = liquefied bio-gas.

Plastic waste derived fuel is an option

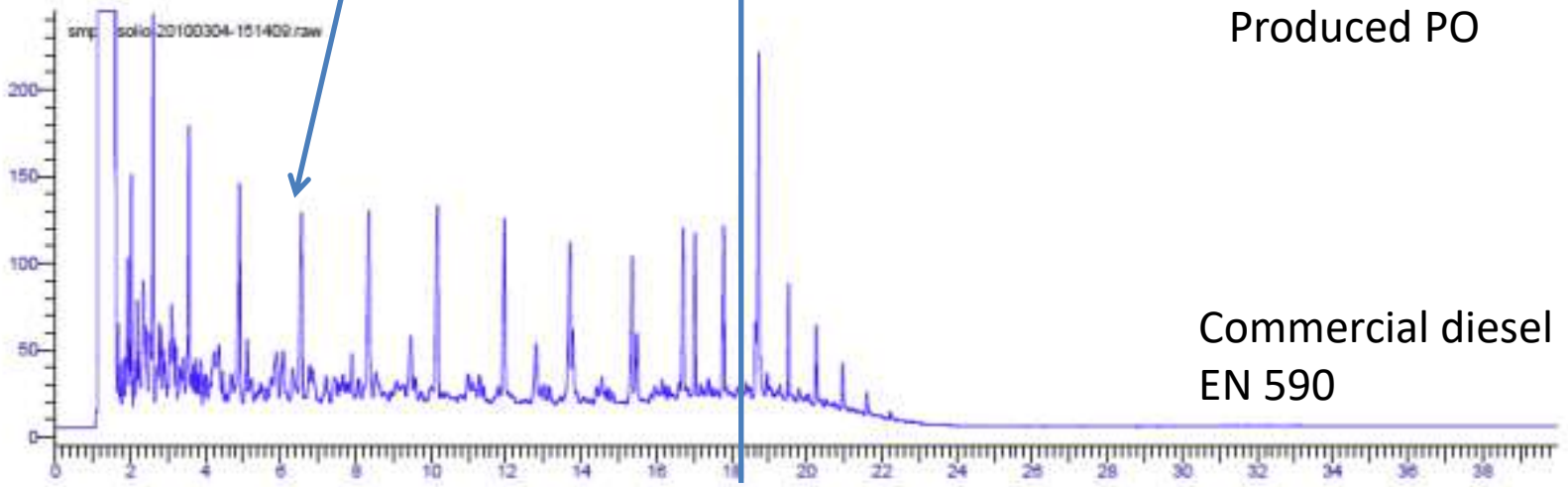
Source: report alternative fuels for marine application IEA2013

Raw plastic pyro oil



- Flash point <36°C
- Pour point 39°C
- S=0,018 %
- Upgrading

Produced PO



Commercial diesel EN 590

Upgrading of raw PO

- Distillation into 3 main cuts:
  - 0-170°C (150°C)
  - 170-370°C (150-350°C)
  - >370°C (>350°C)
- Stabilization
- Goal 1: transportation fuel EN590 compliant
- Goal 2: marine fuel ISO 8217 D class compliant
- Goal 3: cost effective 350-400 €/ton

Marine fuel candidate #1 (heavier cut)

Parameter	Value	Unit	Limits (ISO8217) DMX	DMA	DMB
Cinematic viscosity @40C	9.998	mm2/s	>1.4; <5.5	>2; <6	>2: <11
Flash point	149	°C	>43	>60	>60
Density @ 50°C	808.2	Kg/m3	--	<890	<900
S	59.3	mg/Kg	<10000	<15000	<15000
Acidic number	0.922	mg KOH/g	<0.5	<0.5	<0.5
Carbon residue	0.08	% (w/w)	--	--	0.3
Ash (775°C)	<0.005	%(w/w)	<0.01	<0.01	<0.01
Lubricity (HFRR)	325	µm	<520	<520	<520
H2O	<30	mg/Kg	--	--	<3000
Cloud point	>20	°C	<-16	--	--
Pour point	37	°C	--	0	6
IBP	307.7	°C			
10% (V/V) recovered	336.4	°C			
50% (V/V) recovered	384.1	°C			
FBP	>388	°C			

N.B. not optmized to suit ISO 8217: room for improvement

Data submitted for publication

Marine fuel candidate #2 (middle cut*)

Parameter	Value	Unit	Limits (ISO8217) DMX	DMA	DMB
Cinematic viscosity @40C	2.3	mm2/s	>1.4; <5.5	>2; <6	>2: <11
Flash point	48	°C	>43	>60	>60
Density @ 50°C (15°C)	(802.7)	Kg/m3	--	<890	<900
S	42.9	mg/Kg	<10000	<15000	<15000
Acidic number	--	mg KOH/g	<0.5	<0.5	<0.5
Carbon residue	0.05	% (w/w)	--	--	0.3
Ash (775°C)	<0.005	%(w/w)	<0.01	<0.01	<0.01
Lubricity (HFRR)	276	µm	<520	<520	<520
H2O	51	mg/Kg	--	--	<3000
Cloud point	--	°C	<-16	--	--
Pour point	-6	°C	--	0	6
IBP	307.7	°C			
% recovered @250	36.3	% (v/v)			
% recovered @350	93.8	% (v/v)			
95% (v/v)	355	°C			

* Also EN590 candidate

N.B. not optmized to suit ISO 8217: room for improvement

Data submitted for publication

Pyrolysis oil

Conclusions

- Circular economy concept viable for waste plastic pyrolysis
- Very low S fuels obtained from plastic waste, well below ECAs/SECAs limits (59ppm Vs. 1000ppm: 17 times lower!!)
- Candidate #1 compliant DMB except acidic number and pour point→further improvement by neutralization and stabilization
- Candidate #2 potentially already fully compliant DMX/DMA/DMB (acidic number and cloud point not determined), also candidate for EN590
- Pyrolysis process can be optimized for desired fuels type: throughput, efficiency, cost

Thank you

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