

T:CRACKER®

One Solution - Many Opportunities

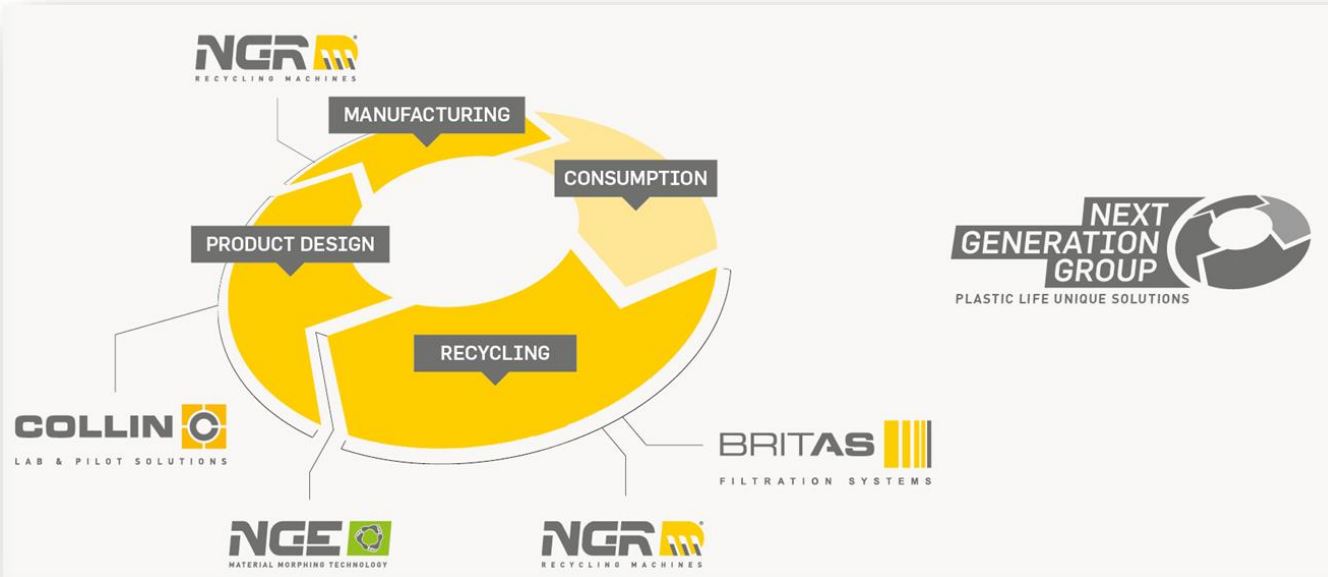
*...Pyrolysis as part of modern
Circular Economy...*

*...is Chemical Recycling of
plastic waste an option or
already a must?*



Dr. Andreas Hackl
NGE GmbH

Next Generation Group Overview...



Next Generation Recyclingmaschinen GmbH
HQ, Production & Customer Care Center Europe
4101 Feldkirchen, Austria

www.ngr.at

Number of Employees:
(NEXT GENERATION GROUP): 280
Annual Sales: 80 Mio €



Pyrolysis as thermal Recycling Process...

Definition: Pyrolysis as thermo-chemical process (200-900°C) to treat mainly organic Substances under absence of oxygen.

Waste incineration as classical thermal treatment process can be supported by pyrolysis as complementary technology



Pyrolysis Gas

- Average/high calorific gas
- Use of heat (e.g. process heat or steam) respectively to generate E-power
- Condensation → PyroOil

Pyrolysis Coke



- Significant mass- and volume reduction
- Good sortability (particle size, ferrous/non-ferrous etc.) resp. further direct use



A successful partnership...



JOHANNES KEPLER
UNIVERSITÄT LINZ

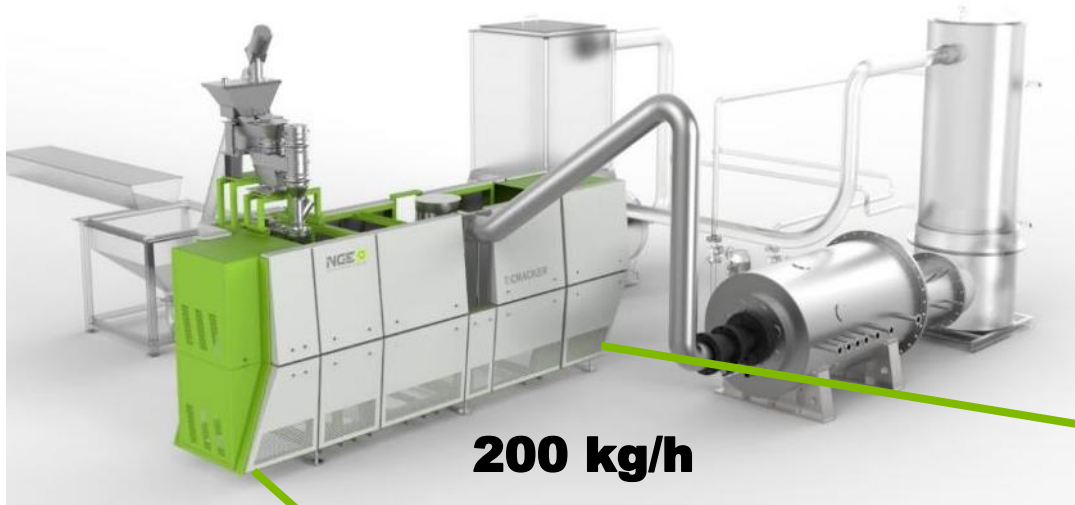
JKU



FFG
Austrian
Research Promotion Agency

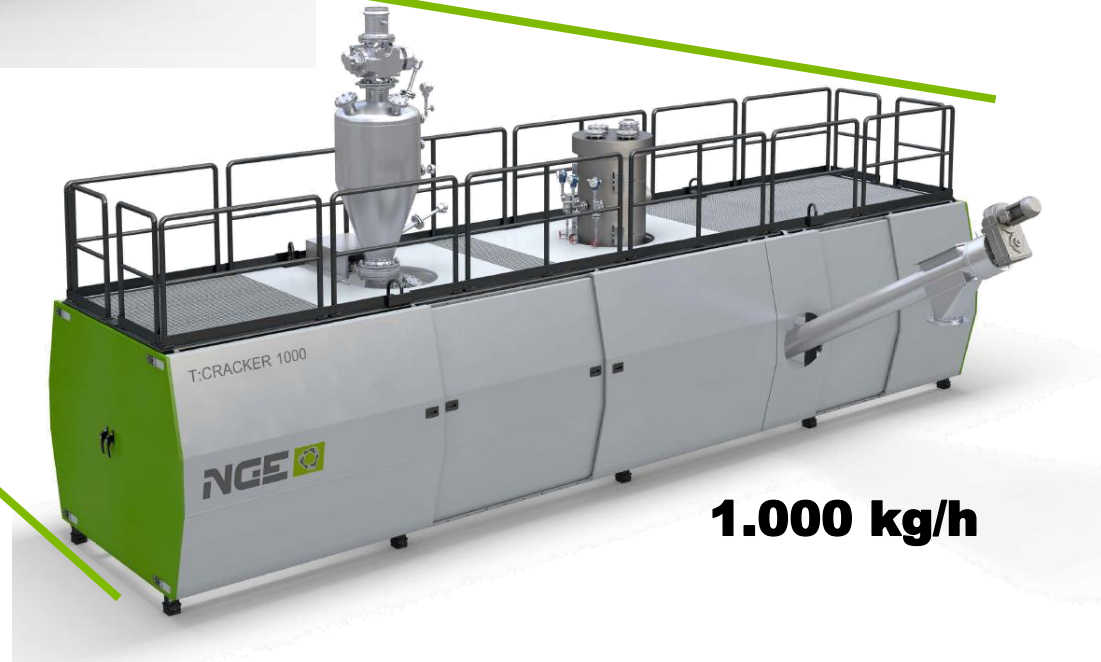


T:CRACKER – Modular plant design...



Modular concept for compact and flexible plant design ...

....from 200 kg/h up to 1.000 kg/h via one T:CRACKER unit



Industrial Pyrolysis Reactor T:CRACKER 1000

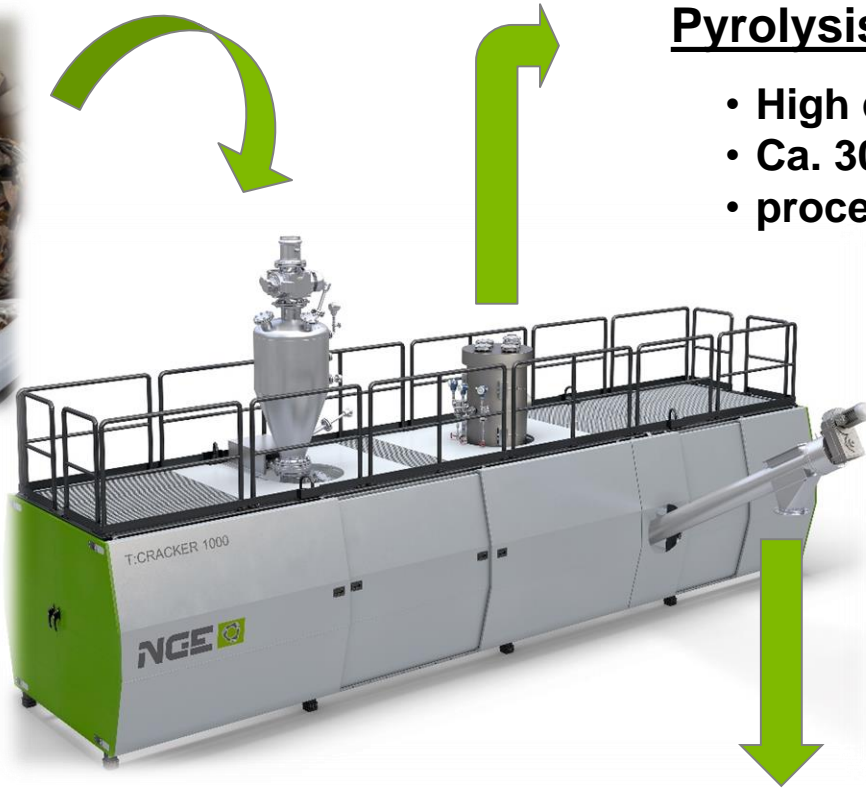


Plastic-2-Value

Alu Recycling from Laminates



Packaging Material
incl. Aluminium



Pyrolysis Gas

- High calorific Gas
- Ca. 30 MJ/kg
- process gas



PyroCoke

- Significant reduction in mass- und volume (80-90%)
- Good ability for separation (particle size, Metal/None-Metal etc.)

Plastic-2-Value

Niche Application CFRP Recycling

CFRP – from magic material to nightmare in disposal...Pyrolysis as Option!



Erste Gefährdungseinstufung der Berufsgenossenschaft Rohstoffe und chemische Industrie

- Untersuchungen der Schlacke einer SMVA nach Verbrennung von Carbonfaser-haltigem Material
- Identifikation von Carbonfasern bzw. Carbonfasersplittern < 3 µm

Fazit: Es wurden qualitativ Fasern gefunden, krebserzeugenden Stoffe eingestuft werden.



NDR die Nachrichten
Bundeswehr warnt vor Krebs durch Carbonfasern
von 08:00 Uhr am 12. April 2014
Carbonfasern (CFK) gelten als Material der Zukunft. Beim Bau von Flugzeugen sind sie unverzichtbar, lassen Autos fit und machen auch andere Bereiche noch sicherer. Aber: Carbonfasern haben auch eine gefährliche Seite. Nach Untersuchungen der NDR-Mitglieder sind sie in der Luft über den gesamten Norddeutschen Raum verbreitet. Bei der Verbrennung von CFK-Abfällen in Beseitigungsanlagen können sie in die Luft gelangen. Die NDR-Mitglieder haben festgestellt, dass sich CFK-Abfälle in der Luft über den gesamten Norddeutschen Raum verbreiten. Bei der Verbrennung von CFK-Abfällen in Beseitigungsanlagen können sie in die Luft gelangen. Die NDR-Mitglieder haben festgestellt, dass sich CFK-Abfälle in der Luft über den gesamten Norddeutschen Raum verbreiten.

ITAD Rundschreiben an die Mitglieder vom 1. Dezember 2014

Betreff: ITAD-Mitgliederinfo (Abfallnahme), Energetische Verwertung von CFK-Abfällen in Seelingshüttenwerkstatt (JrK)

Sehr geehrte Damen und Herren,
liebe Mitglieder,

In der Vergangenheit ist es vereinzelt (insbesondere bei Anlagen mit Elektrofiltern) zu technischen Problemen nach der Annahme und energetischen Verwertung von carbonfaserverstärkten Kunststoffen (CFK-Abfälle) gekommen.

Aufgrund des beobachteten eingeschränkten Ausbrandverhaltens von größeren Teilen kann es auch bei der Schlackenaufbereitung zu Störungen kommen.
Wir empfehlen Ihnen daher, die Anwesenheit von derartigen Abfällen sorgfältig zu prüfen.

Mit freundlichen Grüßen

ITAD
Industrielle Abfall- und Recyclinggesellschaft

sein. Denn die Untersuchungen zeigen, dass sich CFK ab 650 Grad in einen gefährlichen Partikelstaub verwandelt, der auch in die Lunge geraten kann. Bei diesen Temperaturen verändern sich die mikroskopisch kleinen Carbonfasern. Sie werden noch feiner. So bleiben sie nicht mehr in der Nasenschleimhaut stecken, sondern kommen tief in die Lunge.

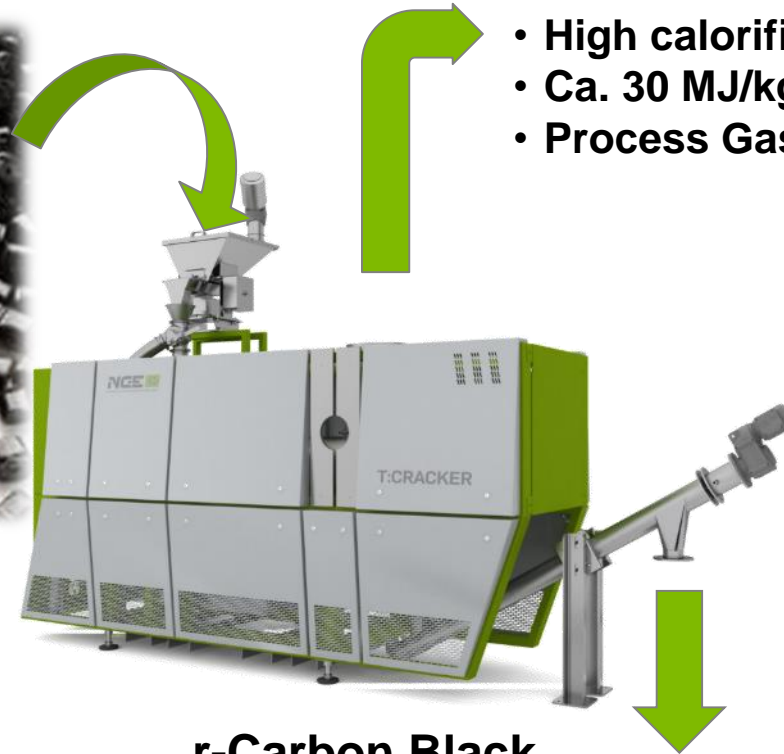


Recycled Carbon Fiber r-CF

Plastic-2-Value

Production Residues

Recycling of PET Masterbatch Material



Pyrolysis Gas

- High calorific Gas
- Ca. 30 MJ/kg
- Process Gas

r-Carbon Black

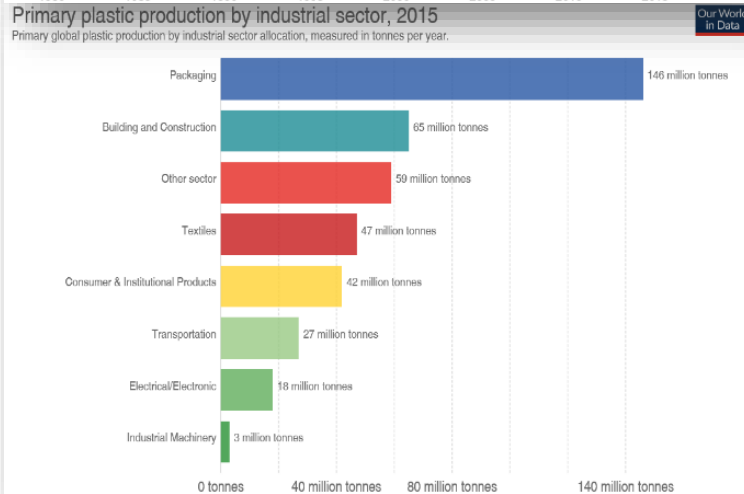
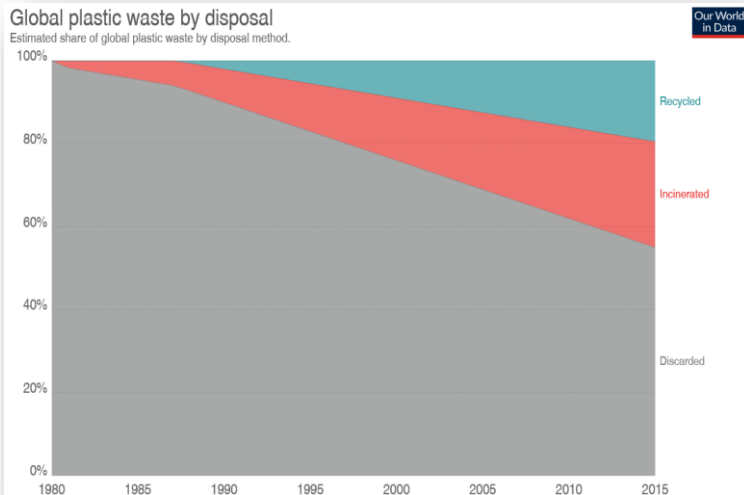
- C-content approx 95% !!
- Recycling of rCB
- value: 400-500 EUR/t



„Plastic Planet“ overview

How to achieve the recycling goals?

**Annual production of plastic:
360 mio t (2018); till 2050 it will
increase to >1,1 bn t**

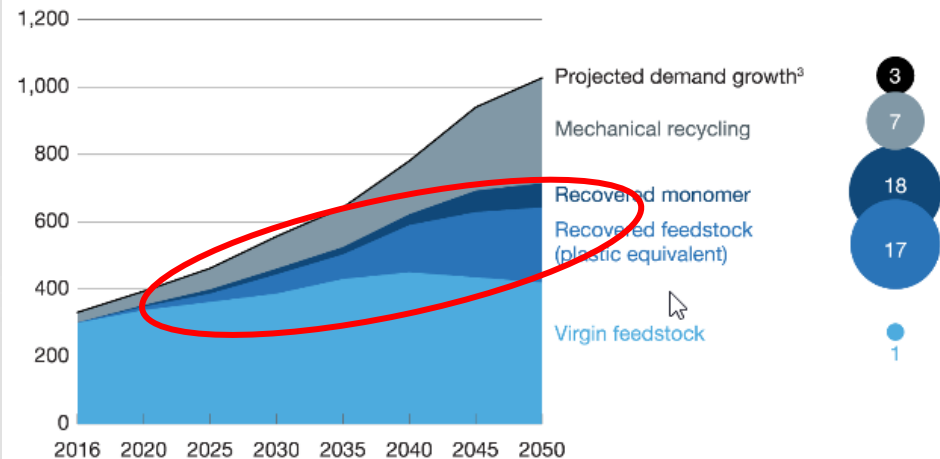


CHEMICAL RECYCLING AS MISSING LINK...?

By 2050, nearly 60 percent of plastics production could be based on plastics reuse and recycling.

Global polymer demand 2016–50 and how it could be covered, millions of metric tons¹

CAGR 2016–50,² %



¹Scenario based on a multi-stakeholder push to boost recycling, regulatory measures to encourage recycling, consistent progress on technologies, and \$75-per-barrel oil price.
²Compound annual growth rate. Mechanical recycling limited by downcycling and applicable materials, monomerization limited by applicability to condensation polymers only, pyrolysis limited by likely rise in input costs.
³After demand reduction, assuming annual global GDP growth of 3.1%.

McKinsey&Company

<https://www.mckinsey.com/industries/chemicals/our-insights/how-plastics-waste-recycling-could-transform-the-chemical-industry>

Plastic-2-Value

Thermo/Chemical Recycling (T/CR)

Available technologies:

- Plastic Energy (GB/ESP) – SABIC etc.
- ReOil (AT) - OMV
- Quantafuel (NOR) - BASF
- Plastic 2 Oil (USA)
- Neste (FIN) - REMONDIS

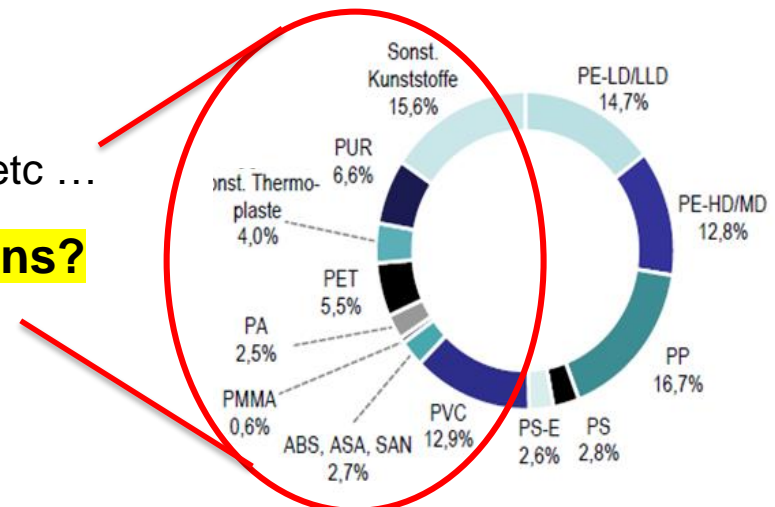


Process:

- **Anaerobic, thermal treatment** (=Pyrolysis) of solid input, melts or in combination with carrier liquids (high temperature solvents)
- After the cracking a **refining process** is needed to separate and **clean up the oil, gas and coke fraction**
- Input: **Polyolefins (PP, PE), PS**
- Unusable input : PET, PA, PVC, multilayers etc ...

→ **What should be done with this fractions?**

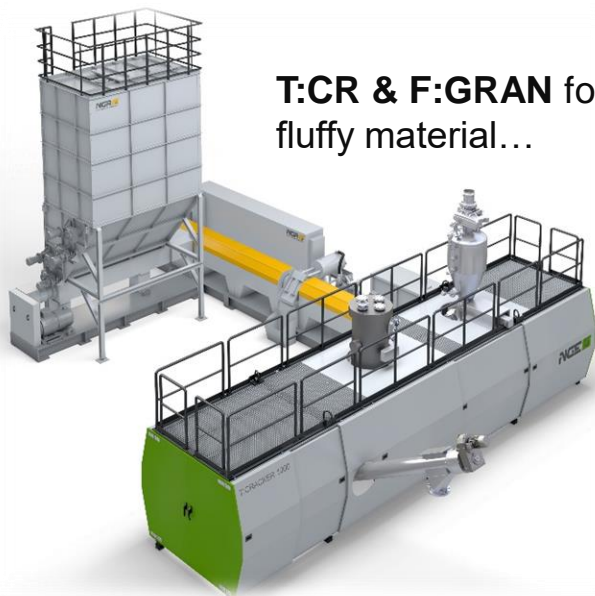
→ **Why not via decentralized solutions?**



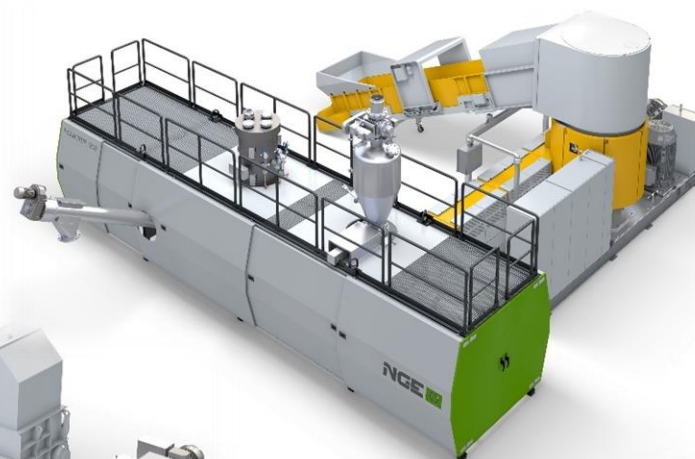
Plastic-2-Value

NGE & NGR Synergy for T/CR

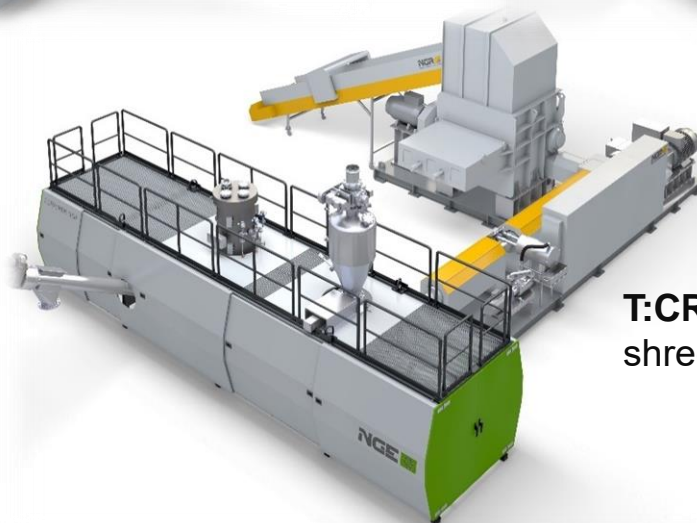
T/CR via decentralized plant setup...



T:CR & F:GRAN for handling of e.g. 2D and fluffy material...



T:CR & C:GRAN for handling of to be cutted and dried material...



T:CR & X:GRAN for handling of to be shredded material...

Thermo-chemical Plastic Conversion

Plastic-2-Gas → *Plastic-2-?*

“We start where others having their limits...”



Recycling of Post-Consumer Plastics



Rejects from Plastic Recycling



Packaging Material incl. Aluminium



Pyrolysis Gas

- Condensation to PyroOil ?
- High Calorific Gas (ca. 30 MJ/kg)
- Heat utilization (e.g. process heat or steam) → E-production

PyroCoke

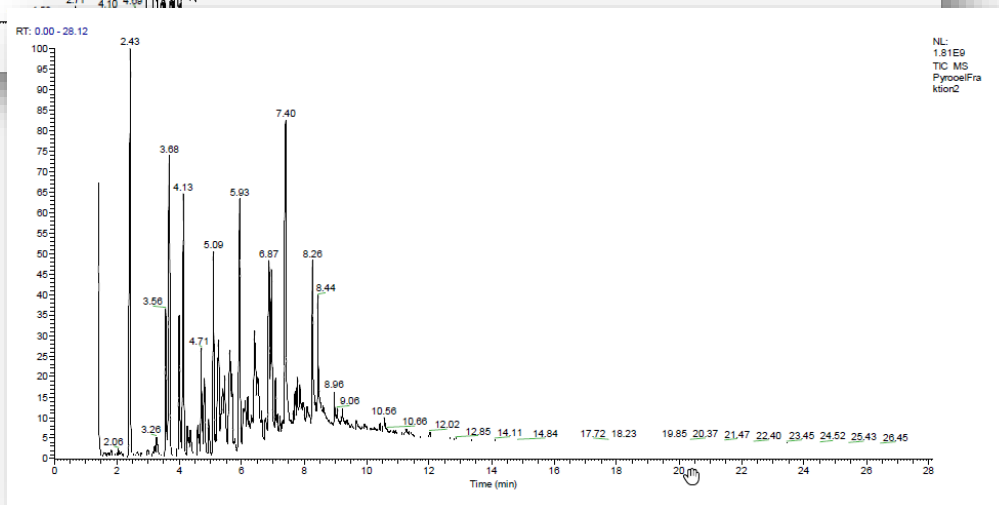
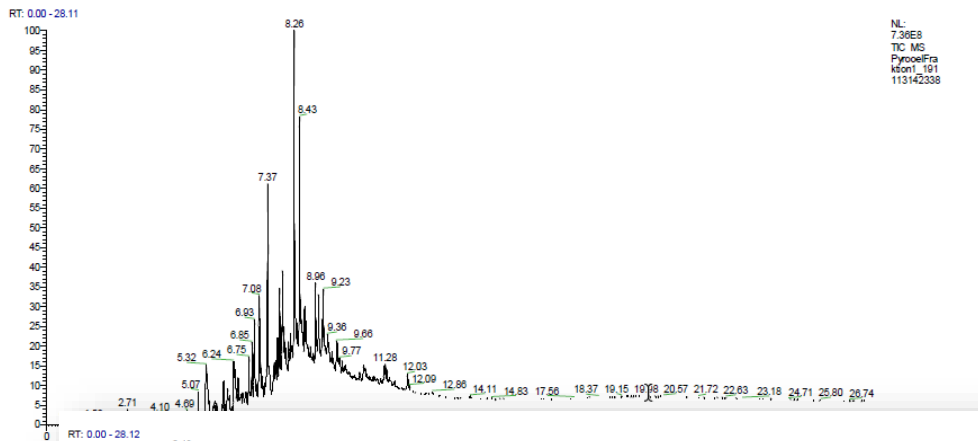
- Significant reduction in mass- und volume (80-90%)
- Good ability for separation (particle size, Metal/None-Metal etc.)

Plastic-2-Oil

NGE's 1st steps...



PyroOil condensed into Diesel from Al/PE laminates...



GC-MS Analytics of PyroOil:

- Significant amounts of Aromats (Xylene, Toluene, etc) Akylaromatics, Naphtalene (& Derivates) ...

Plastic treatment

Post-Consumer material

STATUS:

- amount of plastic will increase in general
- Complexity of used plastic(compounds) will increase; (e.g. multilayers etc.)
- → therefore plastic amount of not being recyclable will increase dramatically!
- Thermal treatment (=incineration) faces technical and capacity limits

OPTIONS & CHALLENGES:

- Thermo-chemical treatment becomes more and more attractive whereby the **utilization (thermal use or/and condensation)** of pyrolysis gas will be a core aspect to be considered in regards to the allocation and **prize level for inputs** as well for **outputs!**
- **Utilization of the coke** fraction in consideration of the input
- Management in regards of **quality** and **quantity** (composition, morphology, humidity etc.) and **logistics!**
- Permission coordination
- Building up of alliances between origin and end-user of material and energy
 - origins: plastic industry, collector and sorter, recycling companies...
 - Pot. End-user: energetically intensive industry with focus on gas...power plants, Metal, cement plants, paper mills, **Oil & Gas Companies**...

BIG ENOUGH TO INNOVATE, SMALL ENOUGH TO COOPERATE!



Next Generation Recyclingmaschinen GmbH (HQ, Production & Customer Care Center Europe)
Gewerbepark 22, 4101 Feldkirchen, Austria, Phone +43 (0) 7233 70 107-0, Fax -2, info@ngr.at, www.ngr.at

BritAS Recycling-Anlagen GmbH (Manufacturing)
Moselstrasse 50, 63452 Hanau, Germany, Phone +49 (0) 6181 9187-0, Fax -22, info@britas.de, www.britas.de

Dr. Collin GmbH
Sportparkstr. 2, 85560 Ebersberg, Germany, Phone +49 (0) 8092 20 96-0, Fax: +49 (0) 8092 20 86 2, collin@drcollin.de, www.drcollin.de