Pilot scale pyrolysis products

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The 24th Annual Tyre Recycling Conference
Focus on the future :Circular Economy

22 – 24 March 2017 - The NH Sablon Hotel, Brussels

AIM

- The aim of the paper is to present Pyrolysis of EoL tyres at

- **TRL 7** – *system prototype demonstration in operational environment*-

- offering the recycling sector an opportunity to see the *latest challenges and opportunities towards defining standards.*

Circular Economy

Tyre recycling is facing a number of challenges towards taking its place in the **Circular Economy**.

This work on Pyrolysis is exploring these challenges with the aim of identifying solutions and opportunities for recyclers especially in terms of

material and energy options

The concept of a circular economy

Ellen MacArthur Foundation

- A circular economy is restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times. The concept distinguishes between technical and biological cycles.

The concept of a circular economy and ELT's

Recycled tyres become secondary raw materials that go into new products.

As a result, the tyre circular economy is open and ELTs become an enabler for several other industries (from agriculture to mining, from construction to the food industry).

Slow Rotary Kiln Pyrolysis

Rotary Pyrolysis Technology and products will be presented along with evaluating their characteristics.

This can be part of the discussion on meeting demands for sustainable materials including

oil, pyrochar or other carbon materials

among others, as well as **metals** and textiles in various formats.

TRL 7

Data collected at **TRL 7** level for pyrolytic outputs from

DEPOTEC an EU LIFE+ project

will illustrate how this sector is promising as a means of generating high returns for those who manage to control the input and the output to obtain products with consistent standards within the environmental constraints set out in European and National environmental laws.

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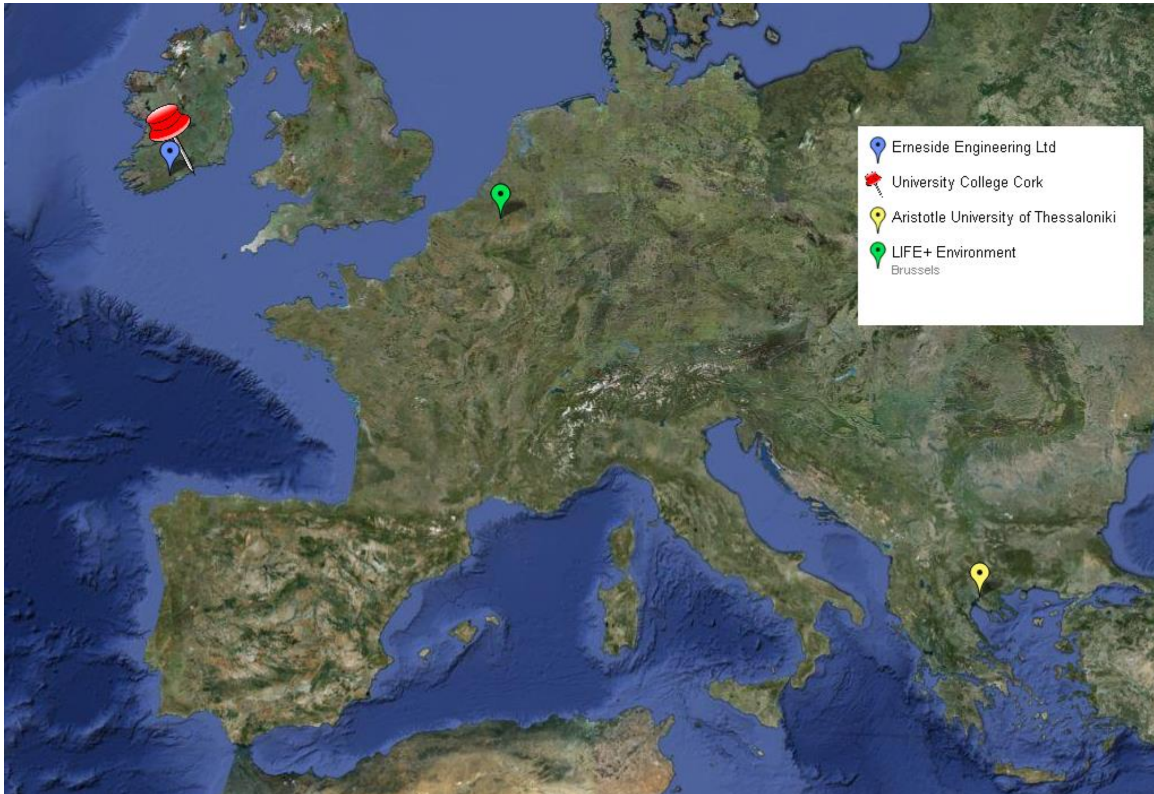
LIFE 10/ENV/IE/00695

DEPOTEC



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ETRA

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DEPOTEC TARGET

LIFE 10/ENV/IE/00695

With the cooperation of DEPOTEC's partners

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

erneside engineering

The project will be completed in 36 months
(05/09/2011 - 31/12/2015)

DEPOTEC

Sustainable
+
Environmental friendly process

Feedstock : ELT

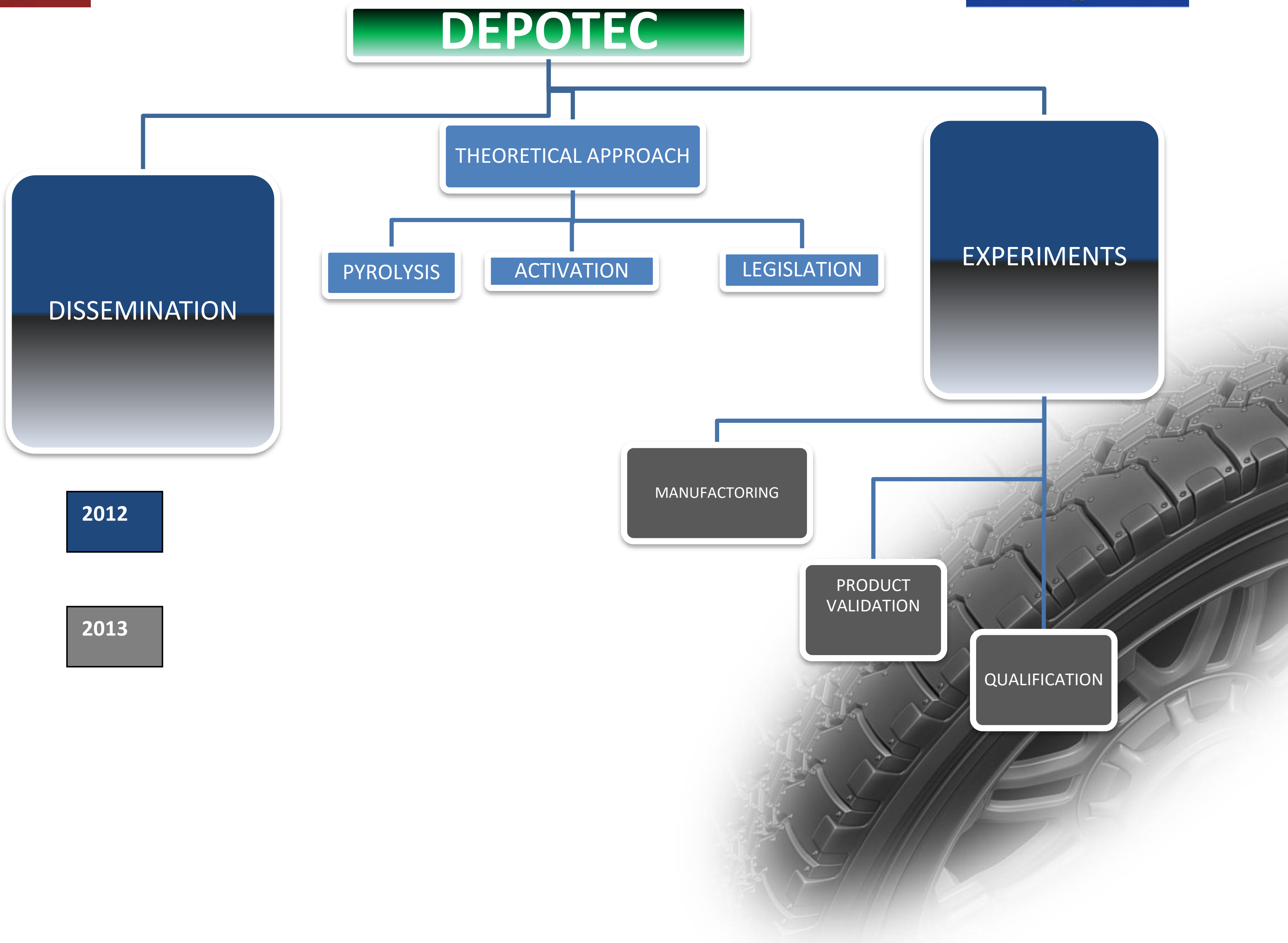
Low cost procedure

TARGET

High added value materials

CBp, Activated Carbon, Pesticide absorber

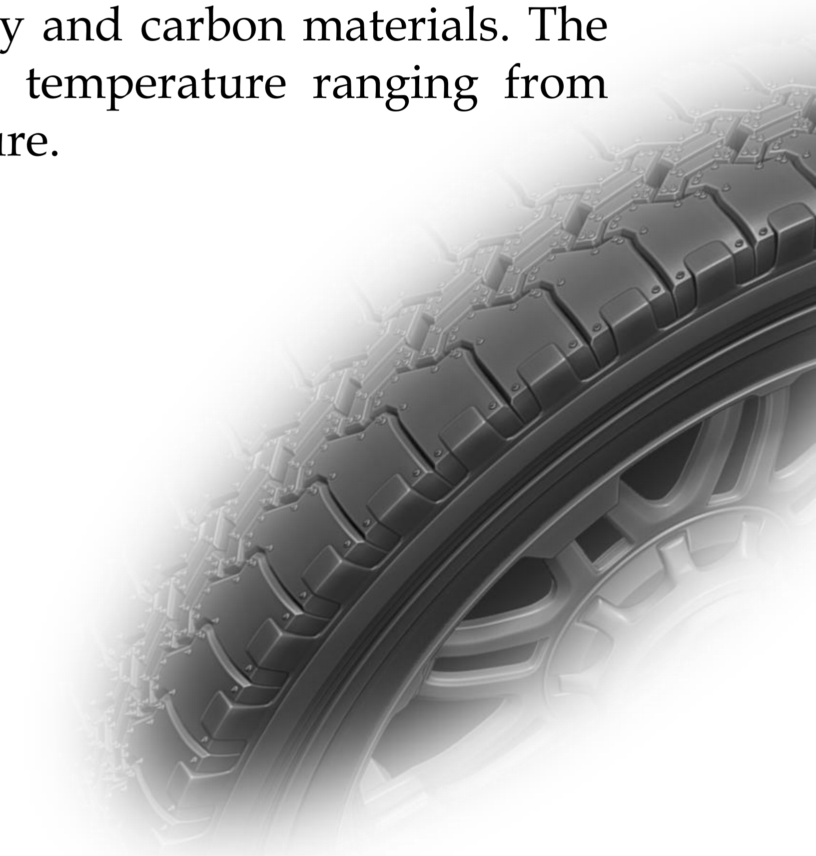
ETRA


DEPOTEC
THEORETICAL APPROACH
PYROLYSIS
ACTIVATION
LEGISLATION
DISSEMINATION
EXPERIMENTS
MANUFACTORING
PRODUCT VALIDATION
QUALIFICATION
2012
2013

PYROLYSIS OF ELT-KEY CHARACTERISTICS

- Several laboratory and bench scale (conventional or more innovative) tyre pyrolysis reactors are documented, while there are only few pilot/demonstration or industrial applications.

- Pilot units operated so far, are mainly based on batch rotary kiln reactors, aimed at producing both energy and carbon materials. The operation conditions reported, demand temperature ranging from 400°C to 600°C under atmospheric pressure.



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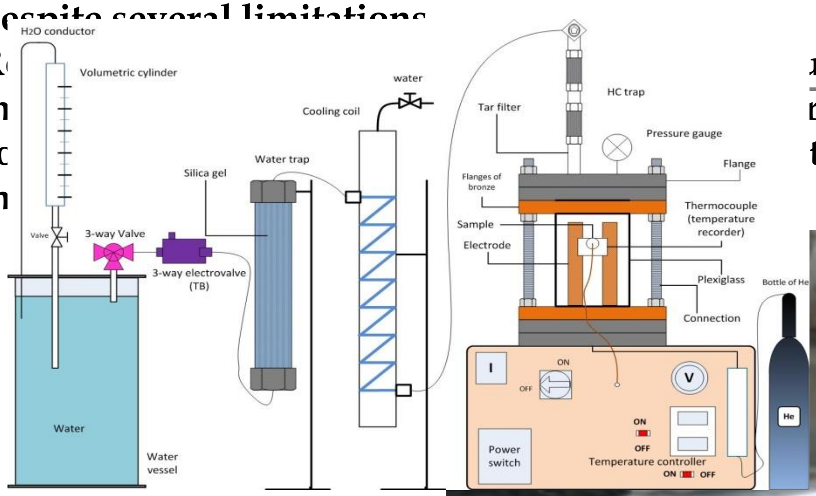
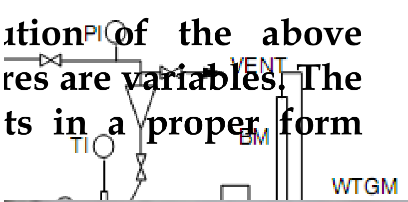
PYROLYSIS EXPERIMENTS at lab scale

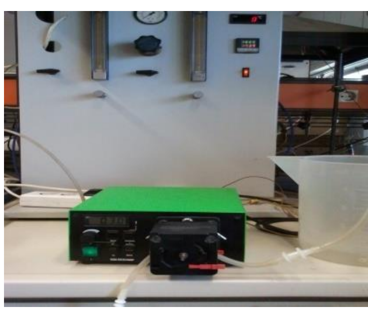
1. Laboratory captive sample reactor (High Heating rates). It is mostly used for kinetic parameter determination.
2. Laboratory fixed bed reactor(Moderate Heating rates-High Final Temperatures). More detailed collection of the products is achieved, despite several limitations.
3. R… ıtion of the above m… res are variables. The cc… ts in a proper form m…

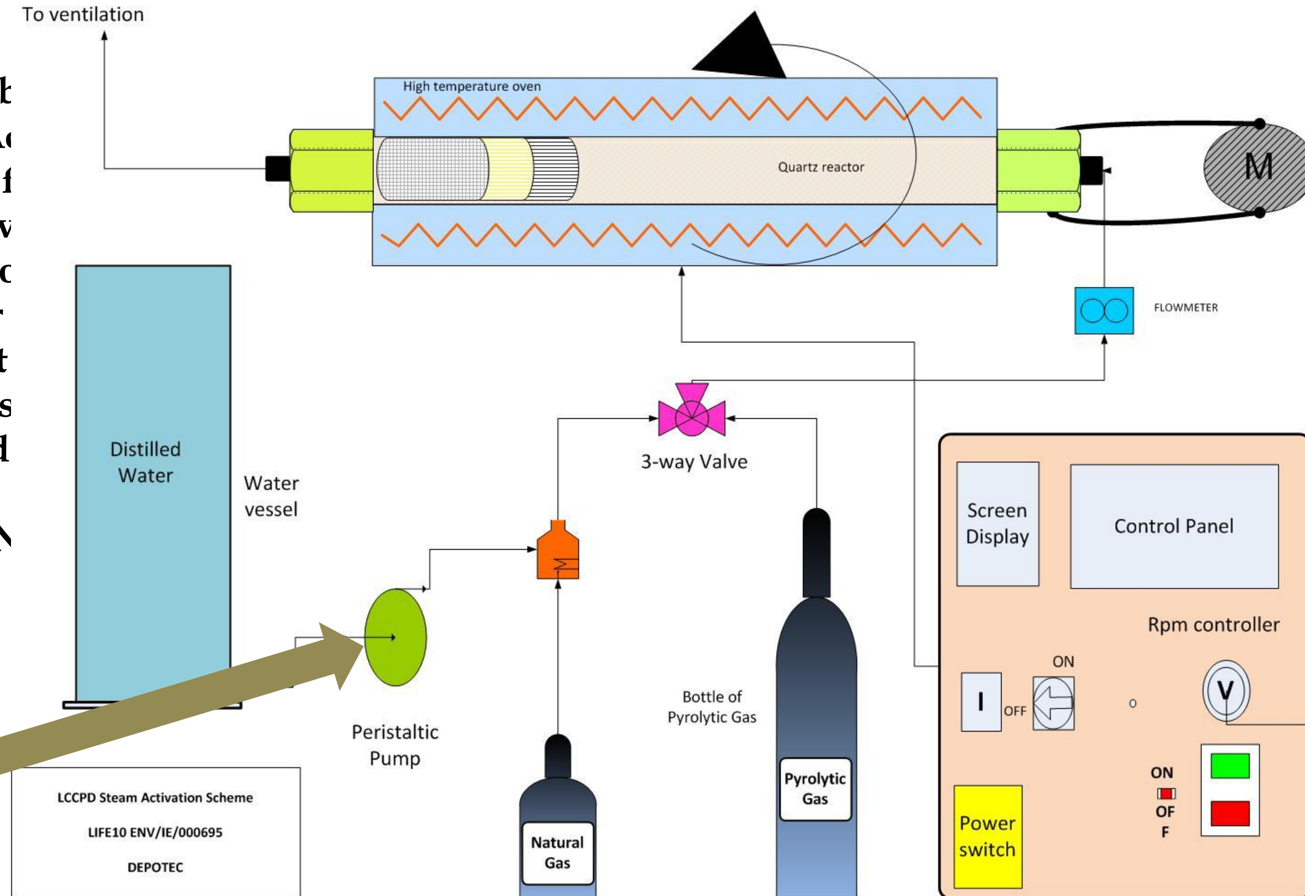




ACTIVATION EXPERIMENTS at lab

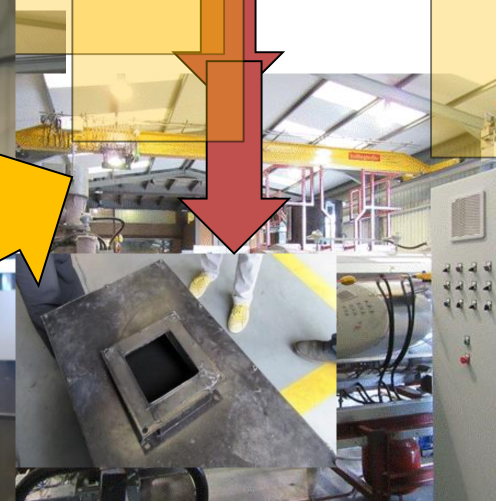
1. Laboratory fixed b… Temperatures). A… temperature and f… showed burnoff lev… surface in the area c…
2. Rotary kiln reactor … process in the exact …
3. Furthermore, the us… is also promoted … temperatures and … created problems. N…





Pyrolysis at pilot scale

Design and development of an integrated system



Scale up from laboratory to pilot

DEPOTEC LIFE+ END OF PROJECT WORKSHOP

Depolymerisation Technology for Rubber with Energy Optimisation to Produce Carbon Products

EU Life Project Reference: LIFE10 ENV/IE/000695

Wednesday 25th November 2015

The Anner Hotel, Thurles, Co. Tipperary, Ireland

DEPOTEC is supported by the LIFE financial instrument of the European Community

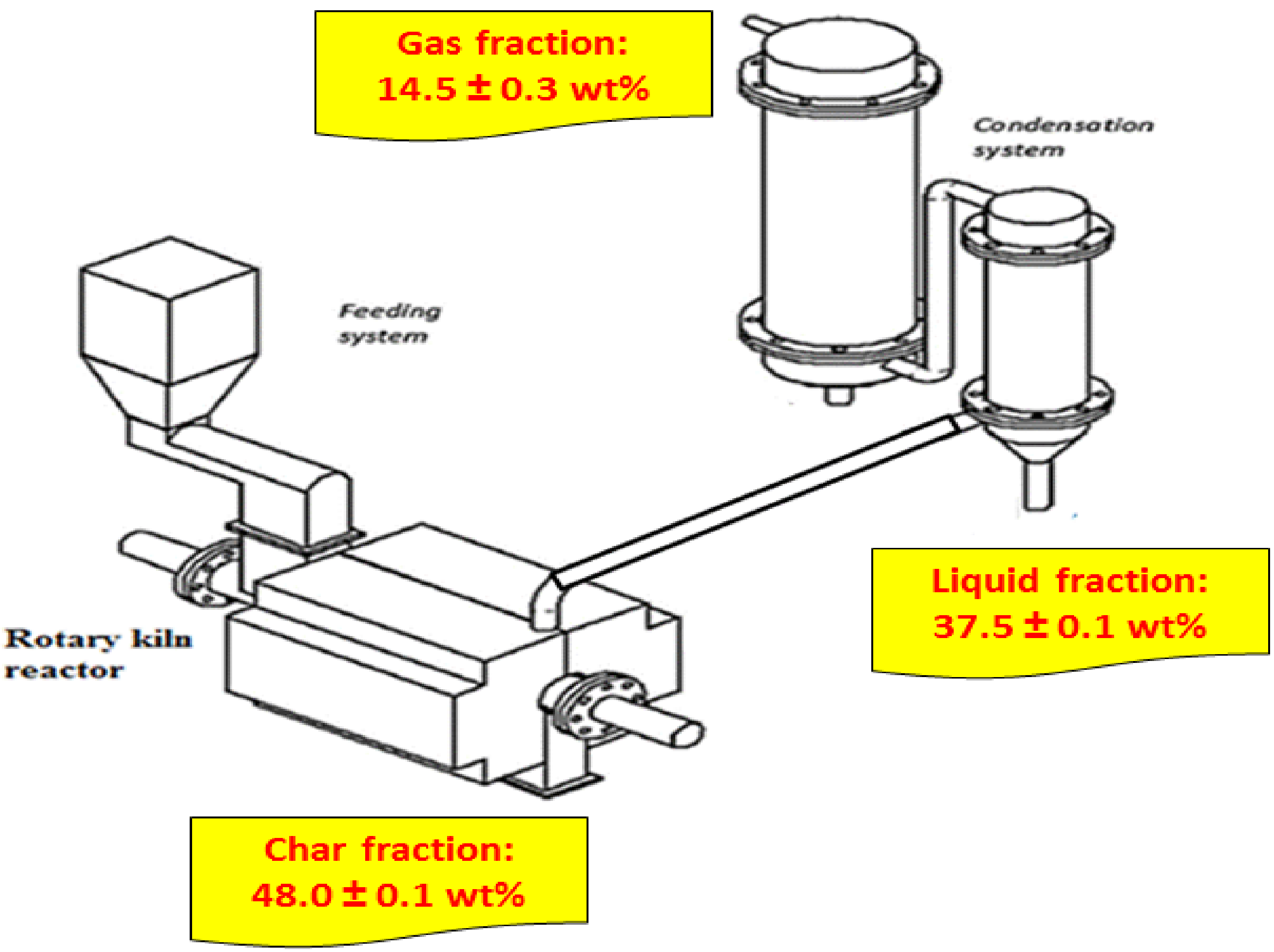
Characterisation of pilot scale pyrolysis products

Operating Conditions

Sampling of ELTs pyrolysis products

Tempe
Heatin
Reside
Contin

Selec
produ



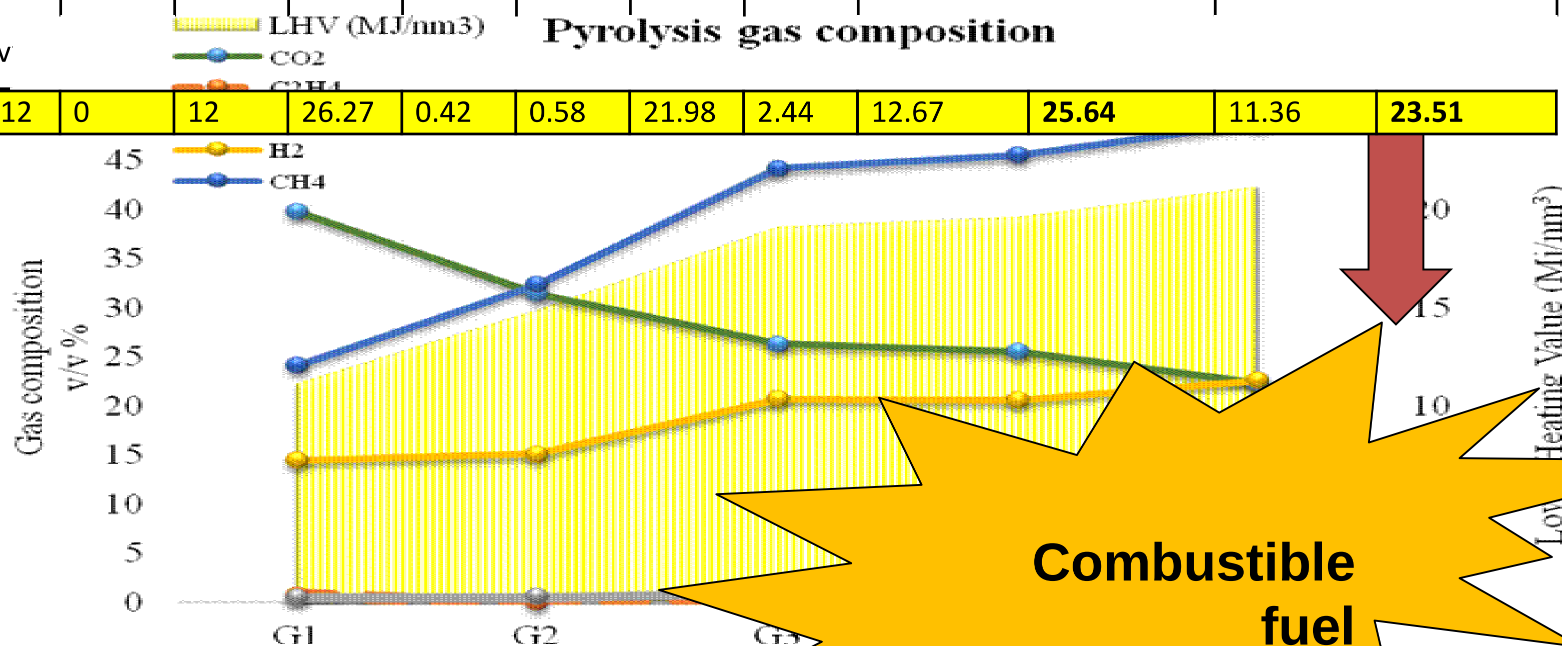
Gas
G1
G2
G3
G4
G5
G5

pilot

Gas product composition

Evolution of gas composition and gas LHV over sampling time

Sample	H_2 (v/v	CO	CO_2	CH_4	C_2H_4	C_2H_6	N_2	O_2	HHV (MJ Nm^{-3})		LHV (MJ Nm^{-3})	
G5	12.12	0	12	26.27	0.42	0.58	21.98	2.44	12.67	**25.64**	11.36	**23.51**



Combustible fuel

Sample G5

Exhibits comparable composition to the gaseous product from lab scale pyrolysis

Liquid product composition

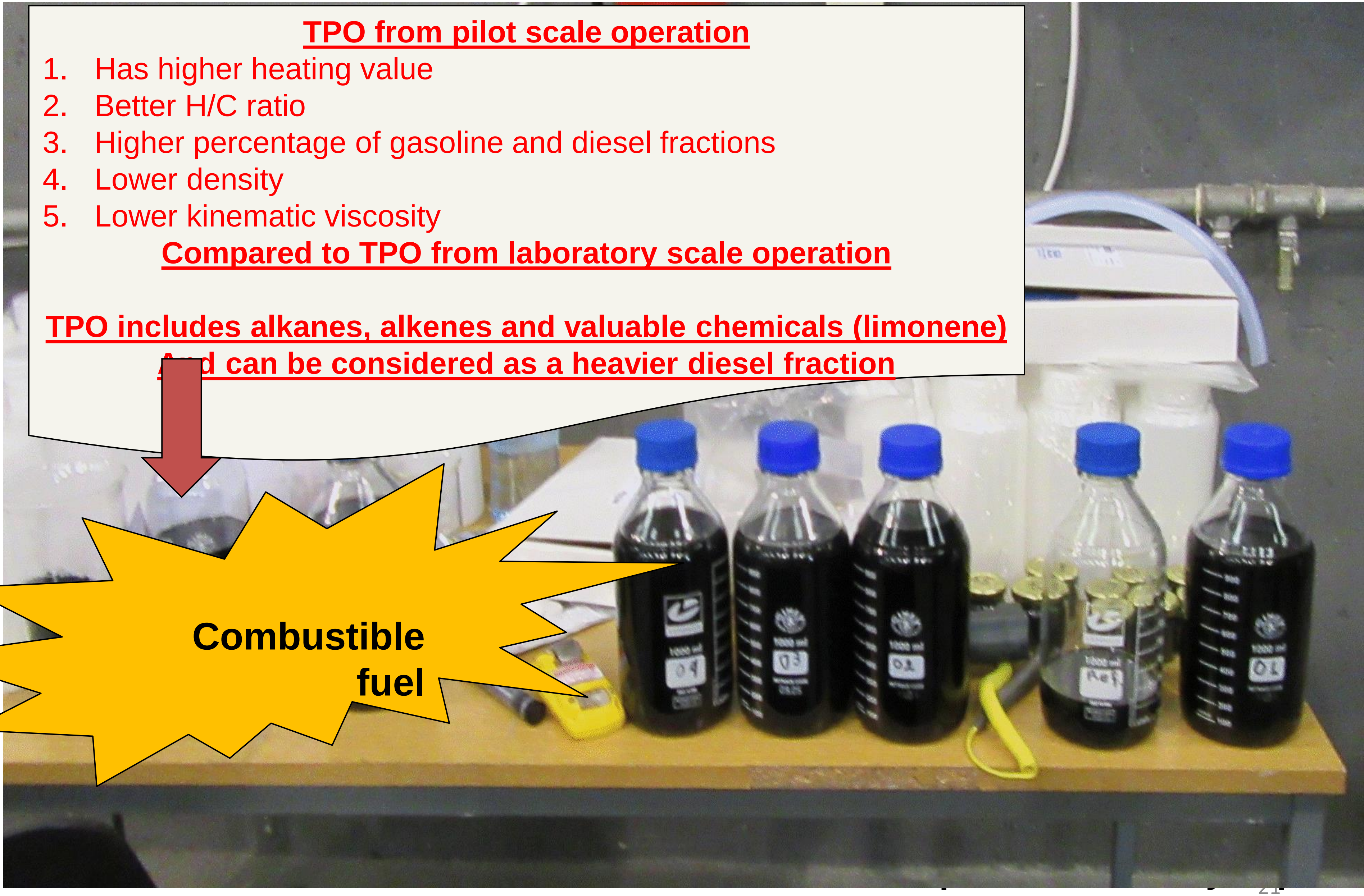
Elemental analysis

Sample	TPO-L5
Ultimate analysis wt. %	
C	86.04
H	12.47
N	n.d
S	0.54
H/C ratio	1.74
Heating value	
GCV (KJ/Kg)	44.22

Rheological characteristics

Sample	TPO-L5	Diesel
TPO density at 15°C (Kg L^{-1})	0.863	0.83
Kinematic viscocity at 40°C (cSt)	2.92	2.58

Scale up from laboratory to pilot



TPO from pilot scale operation

1. Has higher heating value
2. Better H/C ratio
3. Higher percentage of gasoline and diesel fractions
4. Lower density
5. Lower kinematic viscosity

Compared to TPO from laboratory scale operation

TPO includes alkanes, alkenes and valuable chemicals (limonene) And can be considered as a heavier diesel fraction

Combustible fuel

Solid product composition

ELTs char from pilot scale operation
Exhibits comparable characteristics
To ELTs char from laboratory scale operation

(i) Can substitute common fossil fuels to reduce the energy demand of the unit

(ii) Is comparable to low grade C ps

(iii) Can be used as precursor for AC production

HV (J Kg^{-1})
.30
.75

Porous characteristics of the obtained ELTs char

Sample	N_2 BET Surface Area (m^2 g^{-1})	Pore volume (cc g^{-1})	Pore diameter (nm)	ASTM classification
S5	50.82	0.39	303	N4xx
ELTs char (laboratory scale)	67.86	-	-	N4xx

1.High ash content

Commercial product

Depollution applications

Scale up from laboratory to pilot

ELTs-char based AC: Characteristics and proposed uses

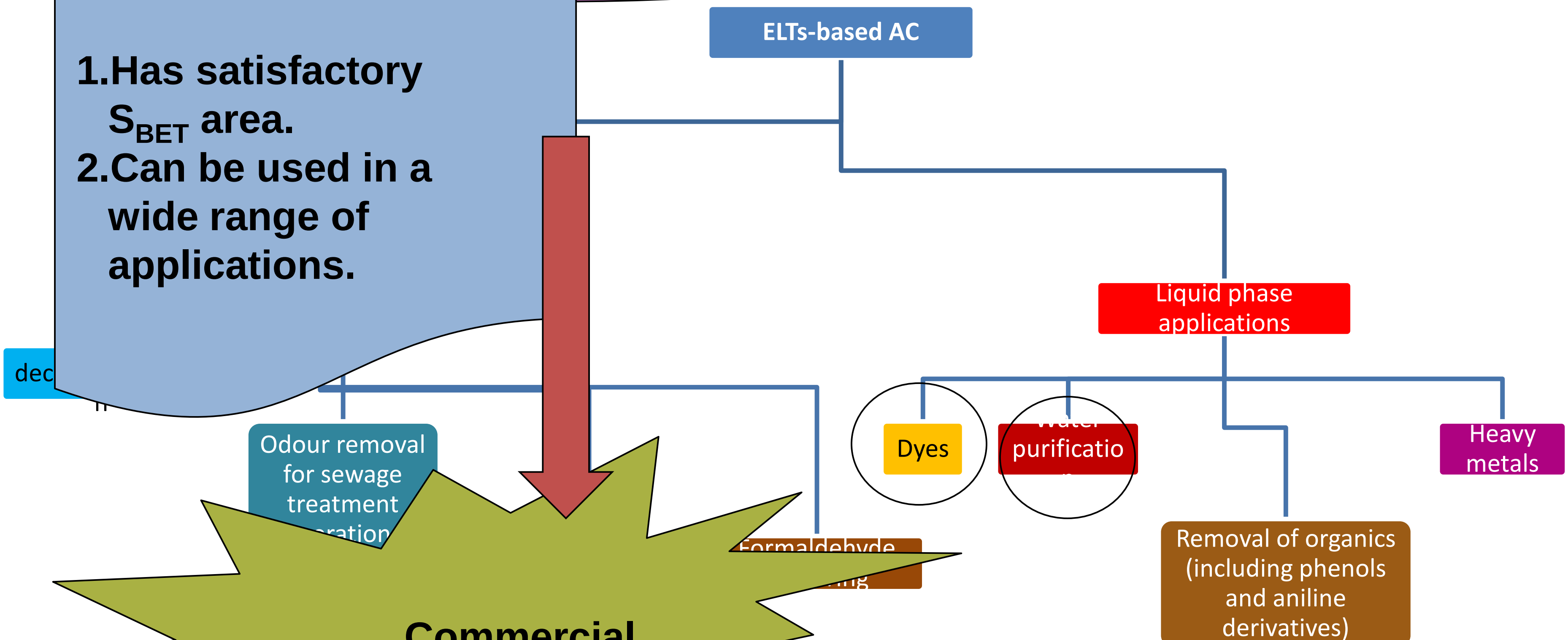
AC from ELTs char from pilot scale operation

1. Steam activation: 3 % lower BET surface area and 8 % lower yield.
2. KOH activation: 4.5 % lower BET surface area and 7.5 % lower

rom ELTs char from laboratory scale operation

The produced ELTs char based AC:

1. **Has satisfactory S_{BET} area.**
2. **Can be used in a wide range of applications.**



Commercial product

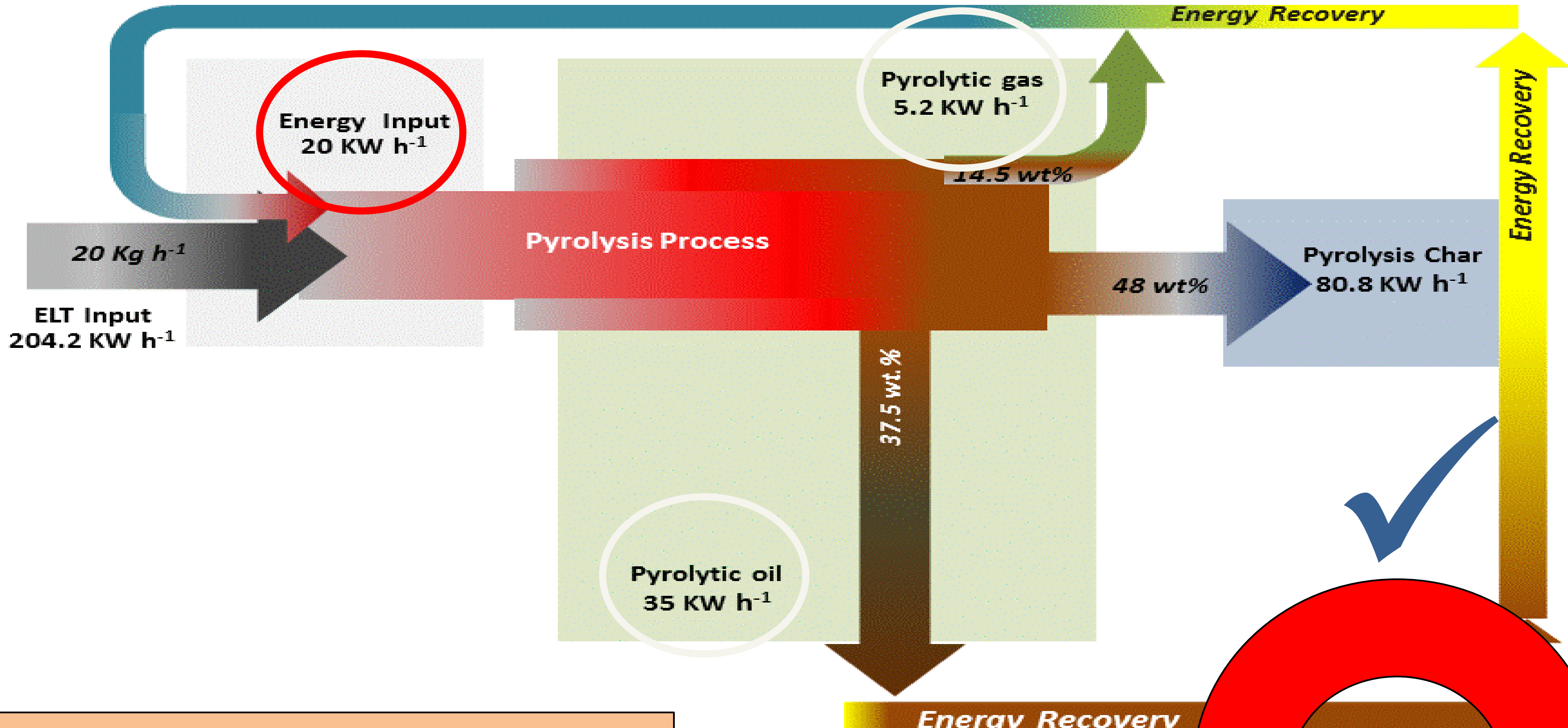
Scale up from laboratory to pilot

Steel

- The steel element recovered from all tyres is of an extremely high quality and is, when clean, in demand by the steel industry as scrap feedstock for the production of new steel.
- The lower the level of contamination of the
- steel, the higher the value.

Energy balance of the process

Sankey diagram of the pilot scale pyrolysis process (steady-state) with energetic valorization of gaseous and liquid products.



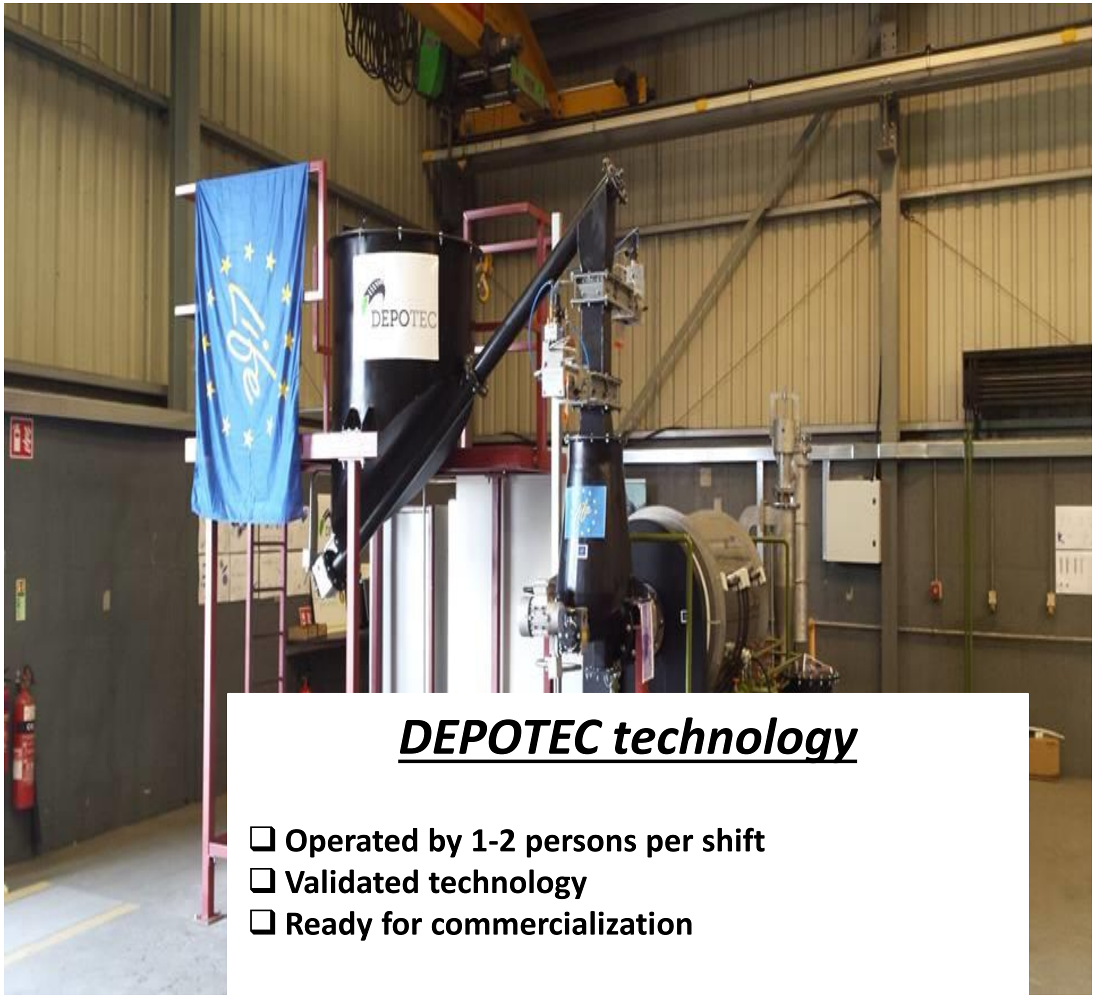
1. **Energy sustainable operation**
2. **Production of valuable products**
3. **Reduced CO_2 emissions**

Scale up from … pilot

Conclusions

DEPOTEC technology

- ❑ Can process up to 876 tonnes of ELTs annum^{-1} (continuous operation).
- ❑ Sustainable operation.
- ❑ Energy surplus is expected.
- ❑ 420 tonnes of char are produced.
- ❑ Char has a low value if not treated.
- ❑ Steam activation can be performed in the same reactor.
- ❑ In a continuous operation, 118 tonnes of steam prepared AC can be produced with a high surface area and considerable selling price.
- ❑ The obtained product yields and product characteristics are of high reproducibility and high accuracy



DEPOTEC technology

- ❑ Operated by 1-2 persons per shift
- ❑ Validated technology
- ❑ Ready for commercialization

Thank you for your attention