Flexible Energy Storage from Residual Biomass (Transport, Hydrogen and Power)

Brussels 9th Nov 2015

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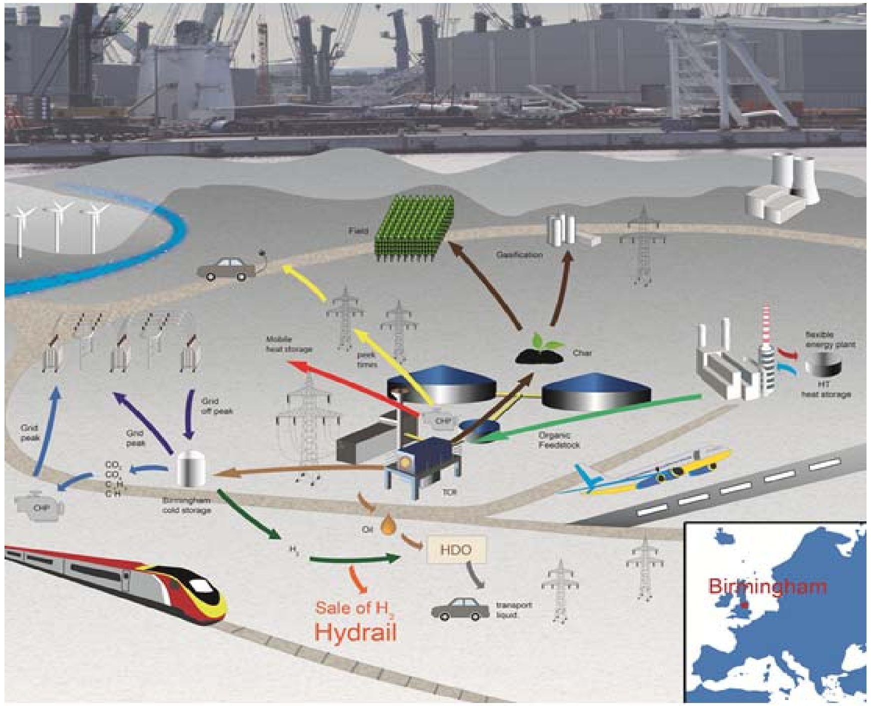
(Apologies)

Dr. Miloud Ouadi



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Fraunhofer
UMSICHT

The UMSICHT Institutes
Facts and Figures

Established	1990	Established	1990
Revenue 2012	30,4 Mio. €	Revenue 2012	4,1 Mio. €
Employees*	463	Employees	70

Oberhausen

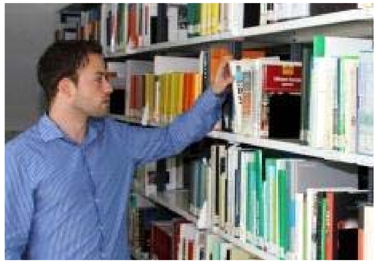
Sulzbach-Rosenberg

Our Services

TRL 1 → TRL 9

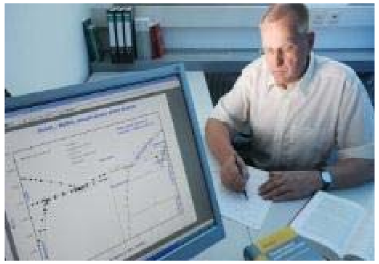
From the Idea…

Consulting & Studies



Construction

Development & Design



Pilot plant Operation

… to the Product

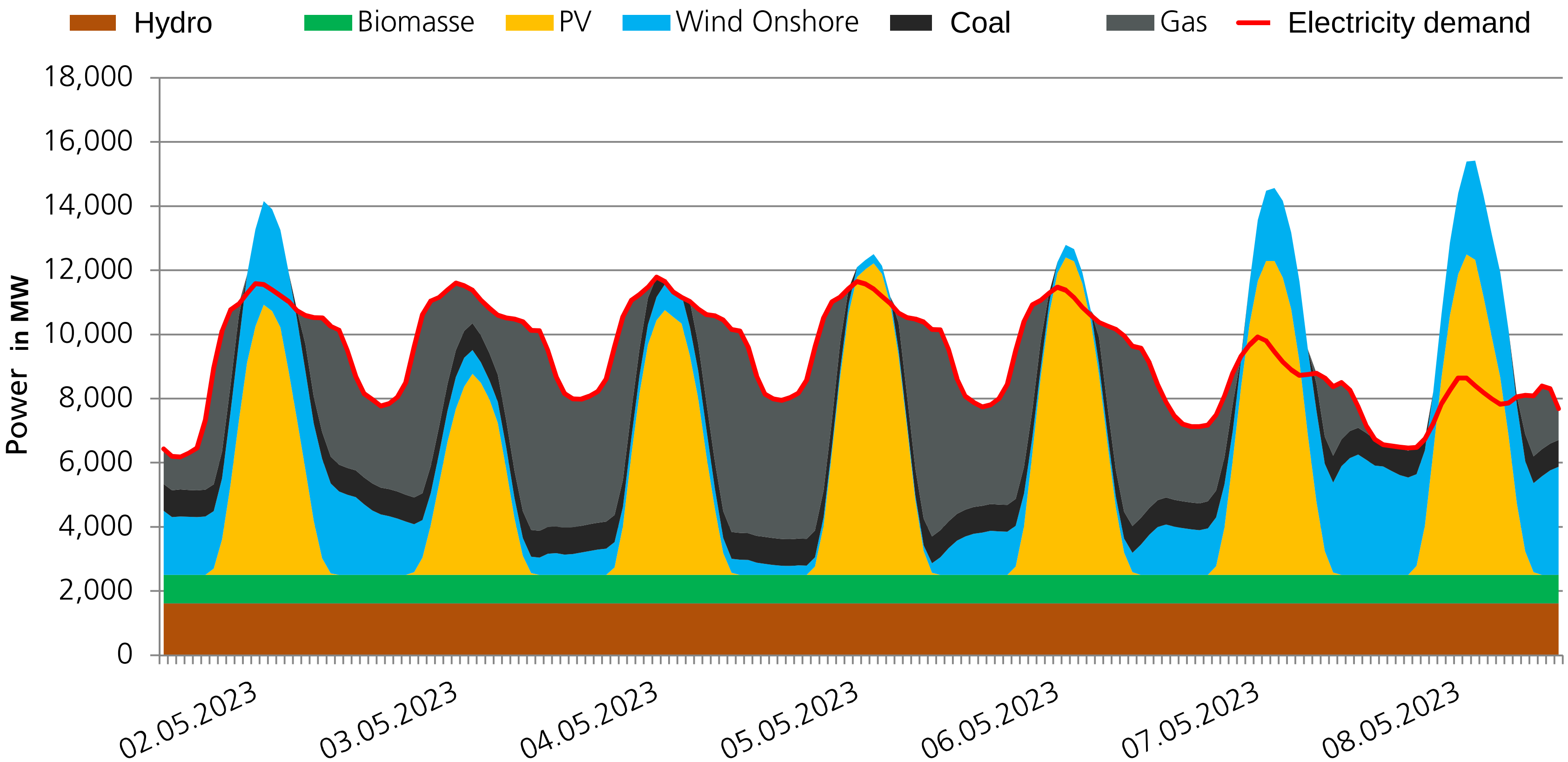
… Process-implementation

Our Topics

Thermal Conversion • Systems Analysis • Chemical Analytics • Energy Storage • New Materials

Fraunhofer

Energy Storage Challenge
Making Supply Meet Demand



Source: Fraunhofer UMSICHT

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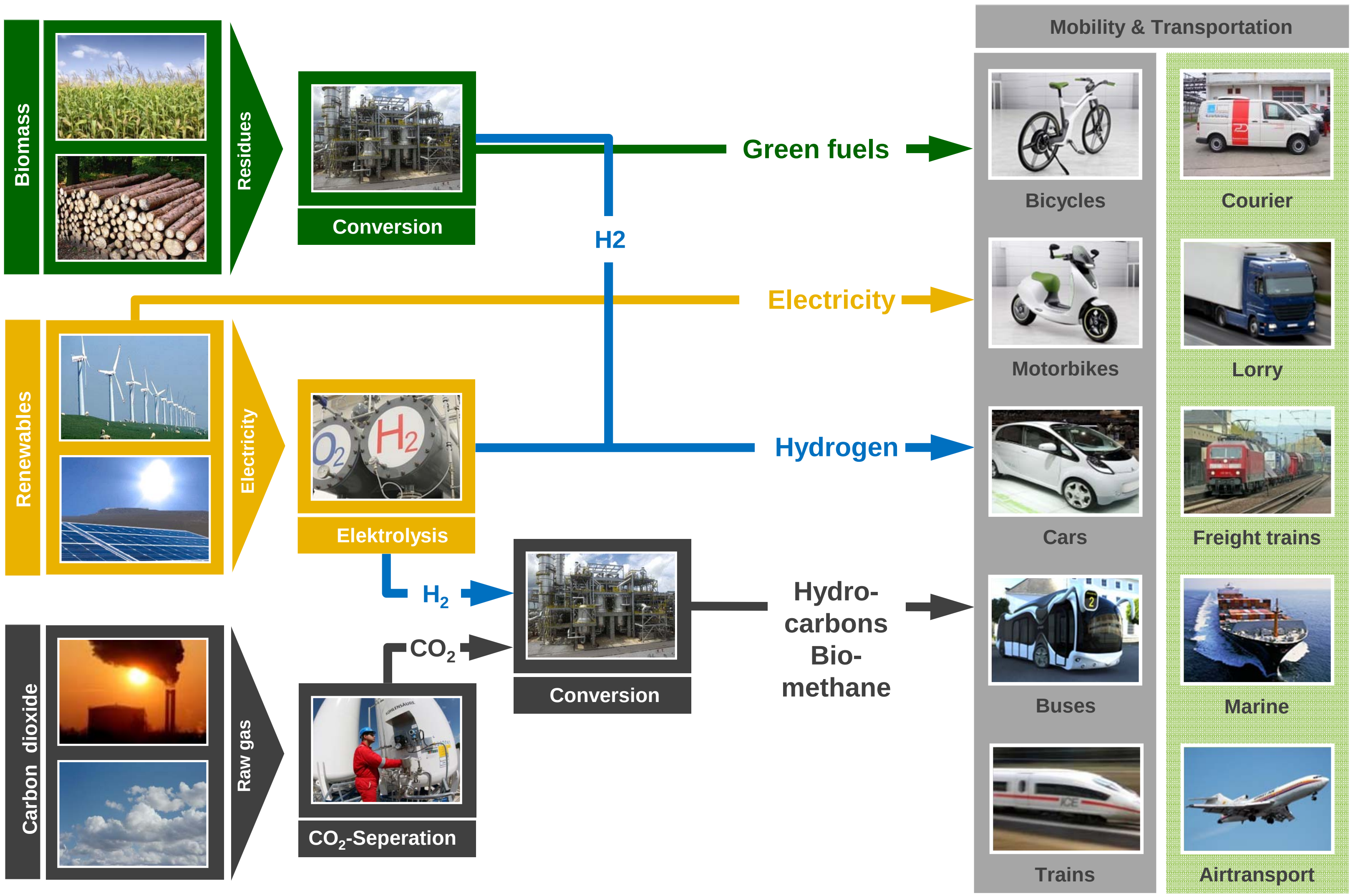
Sustainable Energy Vectors from Renewables



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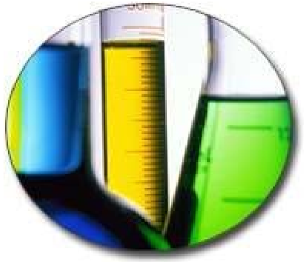
Energy Storage from Residual Biomass

Energy Storage



Biochemicals

H2 Rail

Diesel / Gasoline

H2 Vehicles

Power

Biomethane (SNG)

Heat

Biochar / Fertilisers

- M tonnes of organic wastes produced in Europe each year
- EU Landfill directive prohibits all organic wastes sent to landfill
- Significant energy potential locked within the structure of waste

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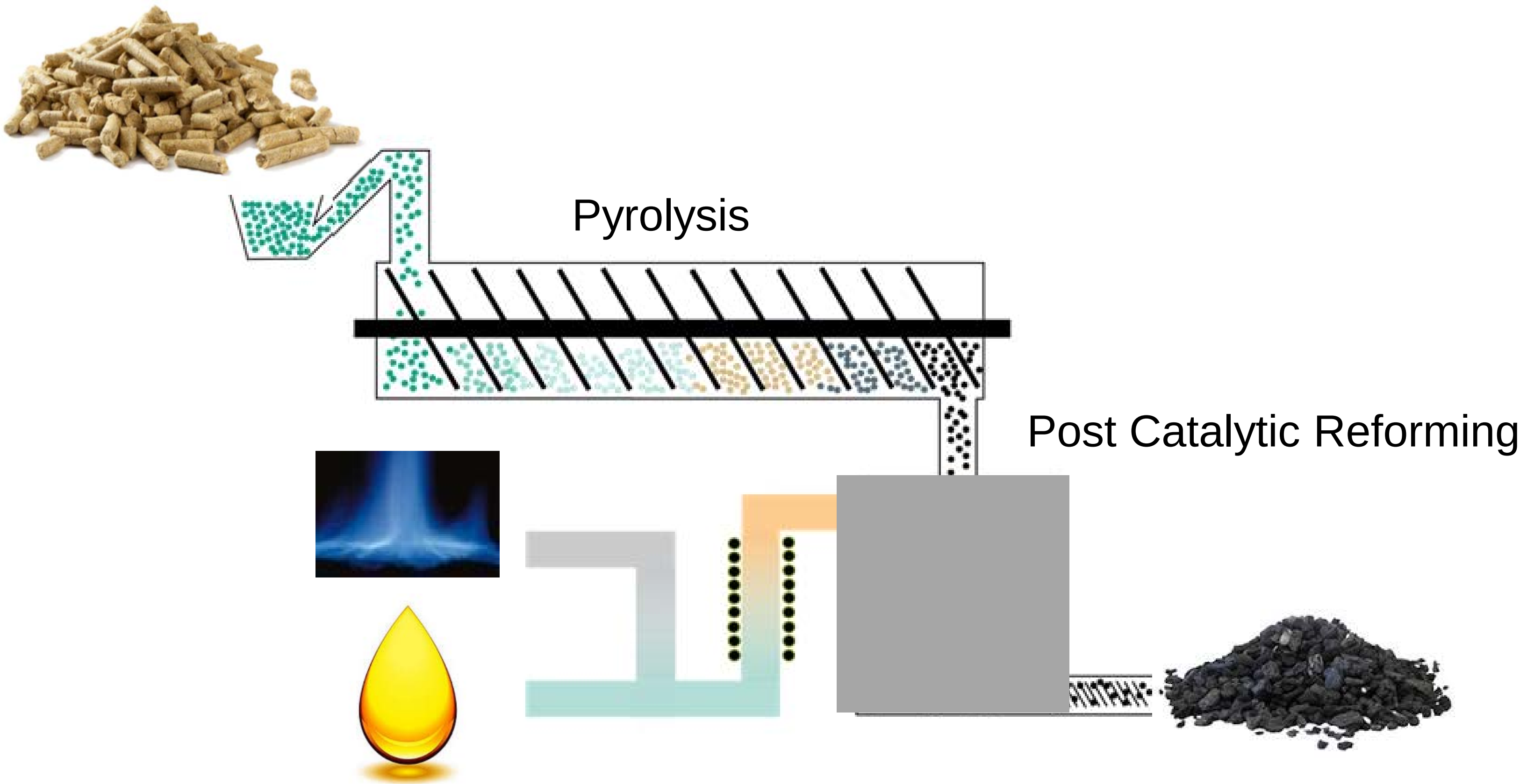
Thermo-Catalytic Reforming TCR®



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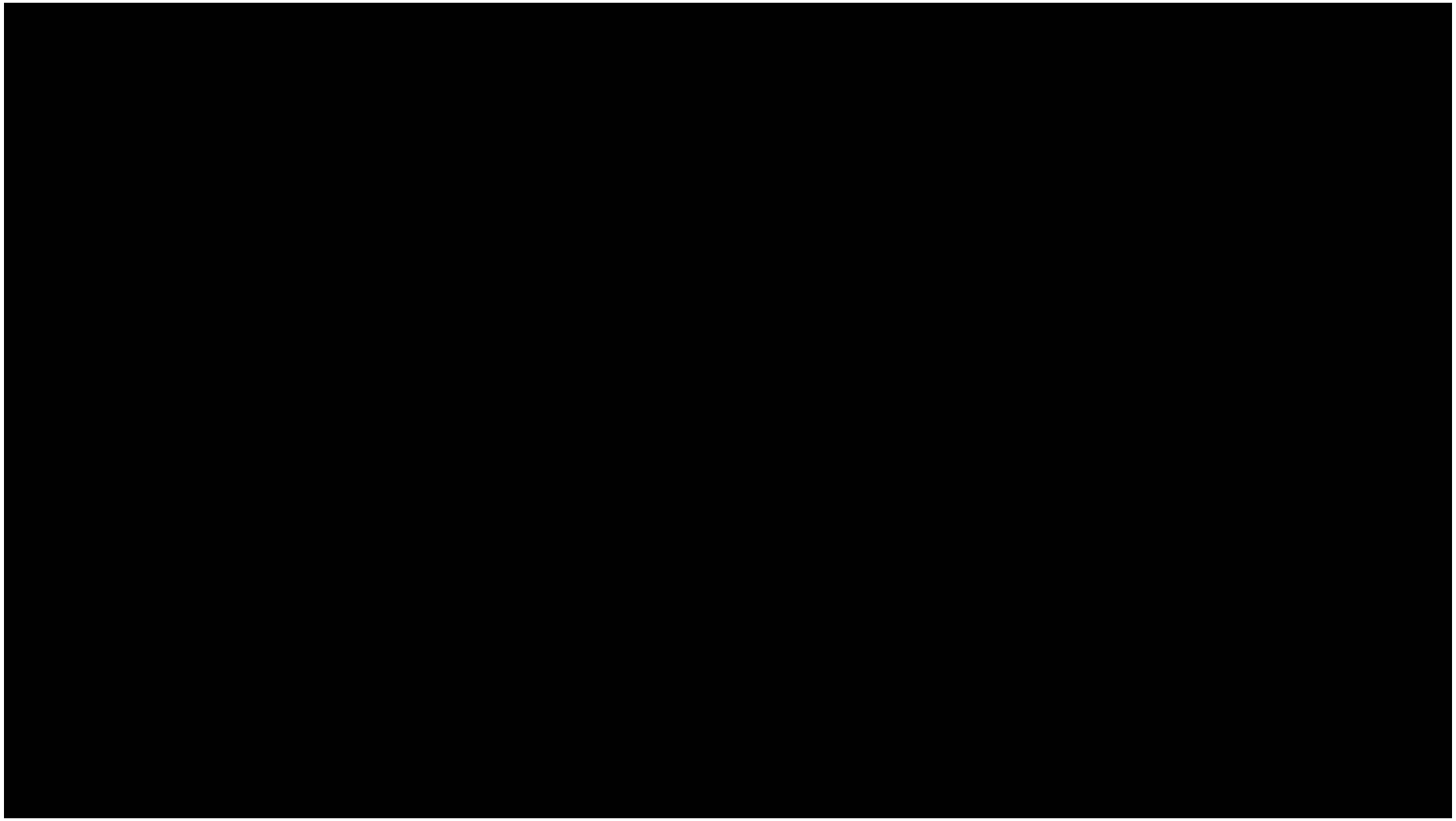
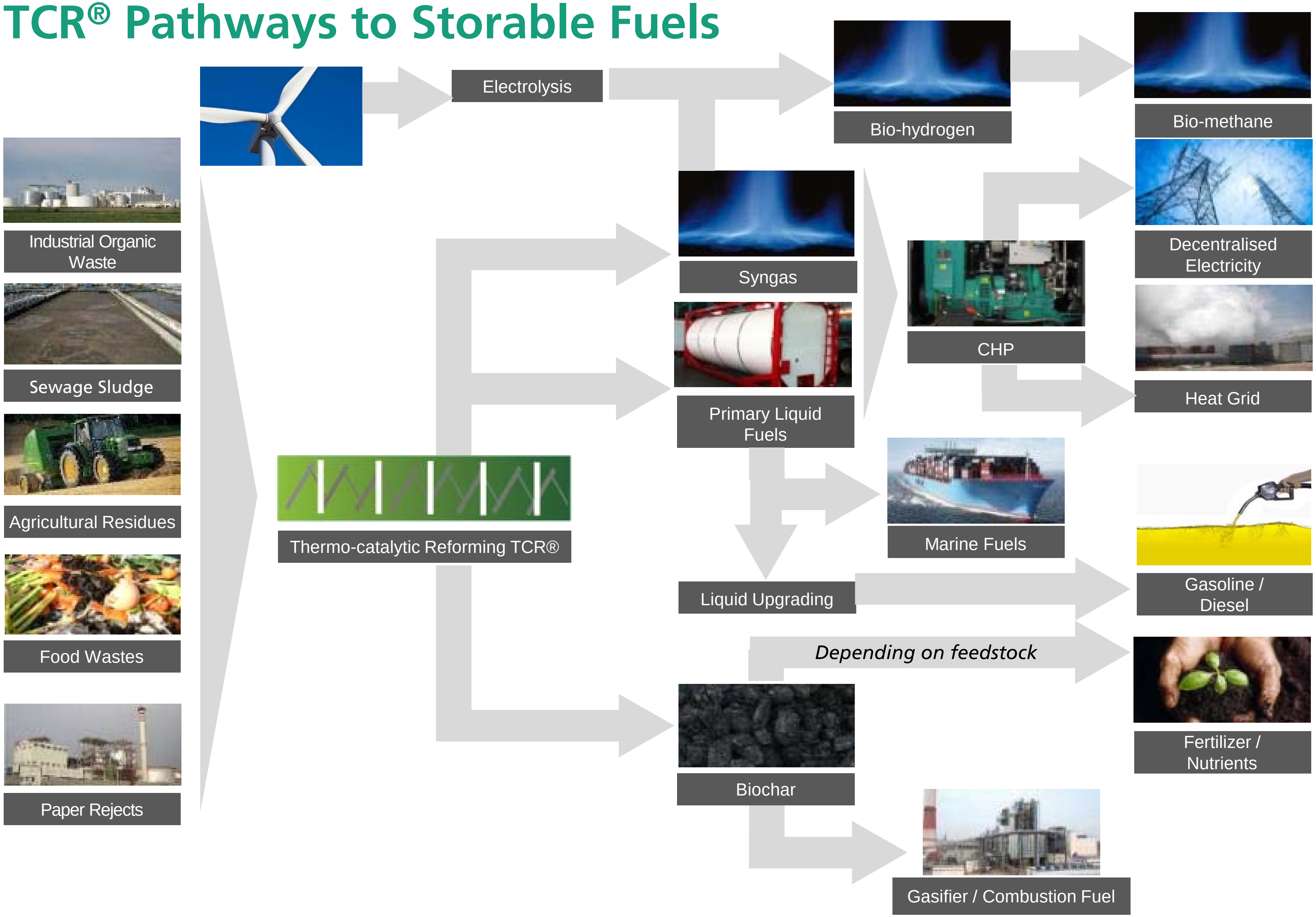
TCR ® Animation



TCR® Pathways to Storable Fuels



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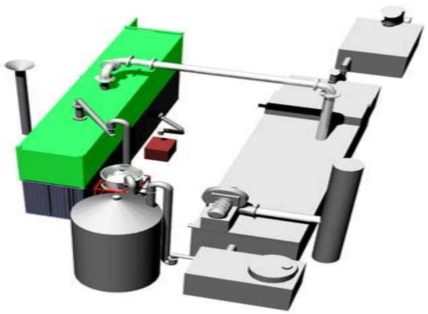
TCR®-Systems of Fraunhofer UMSICHT

Size: 2 kg per hour
Heat Source: Electrically heated
Design: Lab scale (TRL 3)
Purpose: Initial feasability testing of materials

Size: 30 kg per hour
Heat Source: Electrically heated
Design: Pilot scale (TRL-4)
Purpose: Long duration and CHP testing



Size: 300 kg per hour
Heat Source: Thermally heated (biomass source)
Design: Demonstration scale (TRL-5/6)
Purpose: Fully decentralised renewable CHP system

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Thermo-Catalytic Reforming Process - TCR ®

Target Feedstocks


Sewage Sludge


Woody Biomass


Straw Residues


Park & Garden Wastes

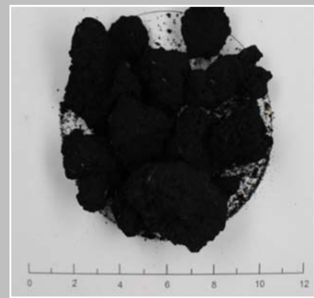

Leaf Litter & Weeds


Chicken Manure


Cattle Manure


Digestate


Compost Residues


Gasifier Residues


Paper / Plastics


Industrial Sludges


Biosludge


Food Waste


Separated MSW

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TCR® Product quality

BIO-OIL		SYNGAS		CHAR	
					
C	76.6 wt.%	H_2	35 ± 3 v/v%	C	65.0 wt.%
H	7.7 wt.%	CO	15 ± 2 v/v%	H	1.2 wt.%
N	2.2 wt.%	CO_2	25 ± 1 v/v%	N	1.5 wt.%
S	0.6 wt.%	CH_4	7 ± 2 v/v%	S	0.3 wt.%
O (diff.)	11.2 wt.%	C_xH_y	2 ± 1 v/v%	O (diff.)	2.2 wt.%
H_2O	1.7 wt.%	N_2 (diff.)	16 ± 2 v/v%	H_2O	0.7 wt.%
Ash	< 0.05 wt.%	HHV	11 MJ/m³	Ash	29.1 wt.%
TAN	4.9 mg KOH/g			HHV	23.9 MJ/kg
HHV	33.9 MJ/kg				

BIO-OIL
- miscible with fossil/bio fuels
- low tar content and acidity
- low fraction of non-volatiles

SYNGAS
- tar and dust free gas
- H_2 over 30 v/v%

CHAR
- high mechanical stability
- transportable and storable
- low-odour

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Upgraded Engine Ready TCR Fuels for Mobility

Results HDO

Oil properties after HDO

TCR® BIO-OIL

C	77.6 wt.%
H	8.0 wt.%
N	4.6 wt.%
S	0.6 wt.%
O (diff.)	7.0 wt.%
H_2O	2.2 wt.%
Ash	< 0.005 wt.%

LHV	34.0 MJ/kg
TAN	2.1 mg KOH/g
Viscosity	4,428 mm²/s
Density	1014.4 kg/m³
Flash point	47 °C

- miscible with fossil/bio fuels
- low tar content and acidity
- low fraction of non-volatiles

TCR® BIO-OIL, HDO

C	86.2 wt.%
H	13.0 wt.%
N	< 0.5 wt.%
S	0.01 wt.%
O (diff.)	< 0.7 wt.%
H_2O	0.003 wt.%
Ash	< 0.005 wt.%

LHV	42.25 MJ/kg
TAN	0.0 mg KOH/g
Viscosity	0,97 mm²/s
Density	815.7 kg/m³
Flash point	< - 20 °C

- Outstanding fuel quality

Results HDO

Anlaysis Diesel Fraction

Standard Value			Reference Product		TCR®-Product
Diesel EN 590				Diesel B7	Fractionated TCR®-HBO
min	max	**Property**	**Unit**	EN590	
51	-	Cetane Number		54	✓
820	845	Density at 15 °C	kg/m^3	842,5	✓
-	8	PAH	% (m/m)	4	n.a.
-	10	Sulphur	mg/kg	n.a.	✓
55	-	Flash point	°C	67	✓
-	0,01	Ash content	% (m/m)	n.a.	✓
-	200	Water content	mg/kg	n.a.	✓
Class 1	Class 1	Copper strip corrosion (3 hours at 50 °C)	Class	n.a.	✓
-	460	Lubricity at 60 °C	µm	165	✓
2	4,5	Viscosity at 40 °C	mm^2/s	3,3	✓
-20 (Winter)	0 (Summer)	CFPP	°C	n.a.	✓
-	< 65	Volume at 250 °C	%V/V		✓
85	-	Volume at 350 °C	%V/V		✓
-	360	95 %(V/V) recovered at	°C	360	✓
		Lower Heating Value	MJ/kg	42,49	✓
		Carbon	% (m/m)	86,5	✓
		Hydrogen	% (m/m)	13,4	✓
		Nitrogen	% (m/m)	n.a.	✓
		Oxygen	% (m/m)	0,1	✓

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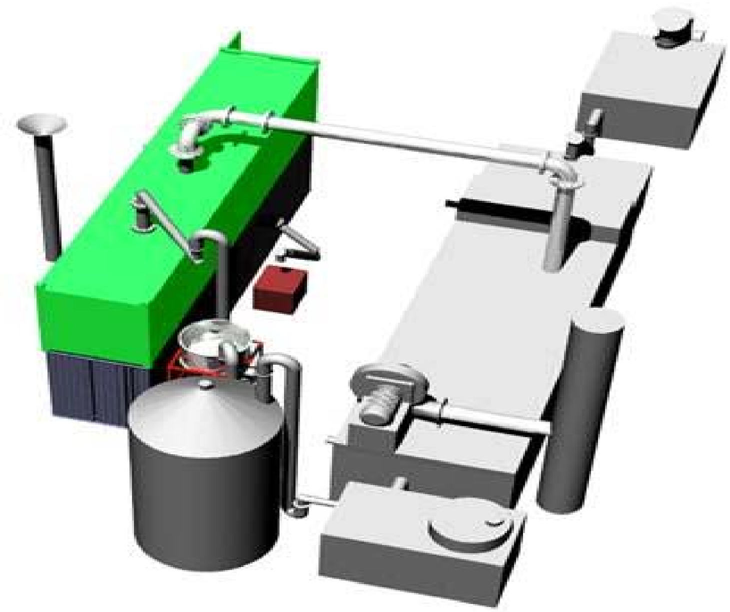
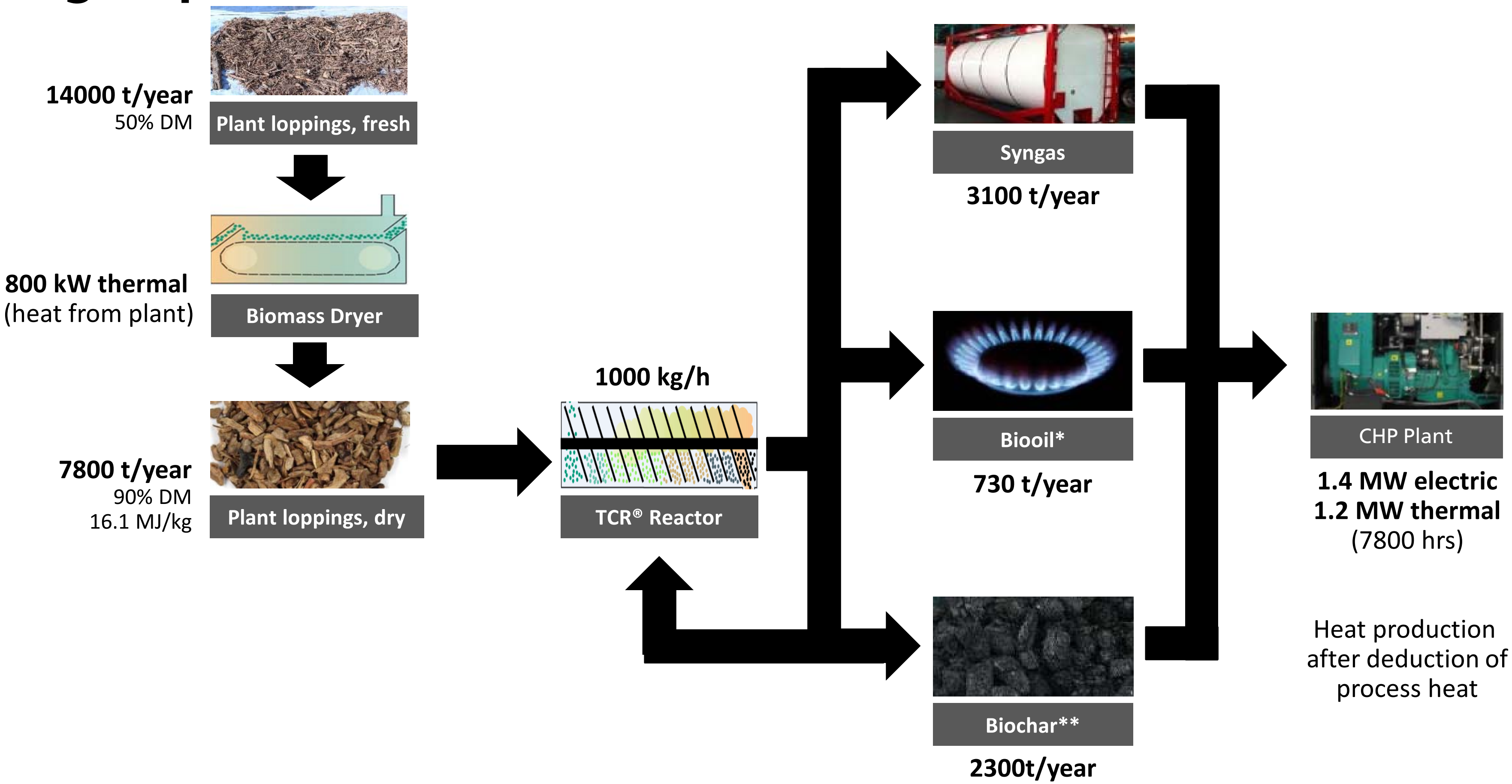
TCR Business Case



Illustrative Scenario – Loppings from landscaping activity (eg. Japanese Knotweed)



*	Biooil blended with 10-20% biodiesel
**	Biochar gasification providing fuel for process heat and combined heat and power generation
***	Additional production of approx. 1700 t/year process water and 500 t/year of ash for disposal

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Illustrative Scenario UK – Loppings from landscaping activity (eg. Japanese Knotweed)

This business case analysis is indicative. Actual profitability depends on feedstock, input, output prices, and plant performance. Analysis is based on estimates that require further validation.

Expenses	1.000 GBP/a
Consumables	82
Labour	188
Maintenance	225
Disposal	43
Adminstrative	137
Total	**675**

TCR® Plant	
Capacity	1000 kg/h
CHP Plant	1,5 MW el.
Investment	Approx. 4 mGBP

Revenue	1.000 GBP/a
Power	1036
Heat	92
Gatefee	205
Total	**1333**

Annual average values over a project duration of 20 years displayed

Input Price Assumptions:

- Landscaping loppings
  @ 15 GBP/t Gatefee
- Biodiesel @ 750 GBP/t

Results	1.000 GBP/a
EBITDA	658
Depreciation	178
EBIT	480
Return on Capital	**Approx. 13%**

Return on total capital before consideration of bank financing and possible subsidies.

Exchange Rate assumed: 0,73 EUR/GBP

Output Prices Assumptions:

- Power @ 100 GBP/MWh
- Heat @ 20 GBP/MWh
  (50% heat utilization)

Susteen Technologies GmbH

The Thermal Belt

Visionary concept for an energy integrated Birmingham

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