Waste to Energy

Technology Choices

Manila, June 2016

WASTE4FUEL

The Founders

Henrik Selstam, CEO

Business development and senior advisor. Master of Science in Engineering Physics at Chalmers, Sweden and several years of experience in setting up international organizations. With a background in the IT industry he established a small venture capital business investing in high-tech solutions in energy and fertilizing technology. The last 15 years he has been working very closely with Mr Fareid developing several industrial chemistry projects world-wide. Henrik's function in Waste4Fuel is business development and marketing.

Erik Fareid, CTO

Chemist with Masters Degree from the Norwegian Institute of Technology. He worked for a large Norwegian fertilizer company's research center for 10 years before he established himself as a self-employed with a focus on environmental initiatives in the industry. Broad experience in particular chemical industry and has among others led to commercial patents associated with cyanide production and CO2 reduction measures. Has been involved in several development and optimizing programs at a number of major players, among them Norsk Hydro.

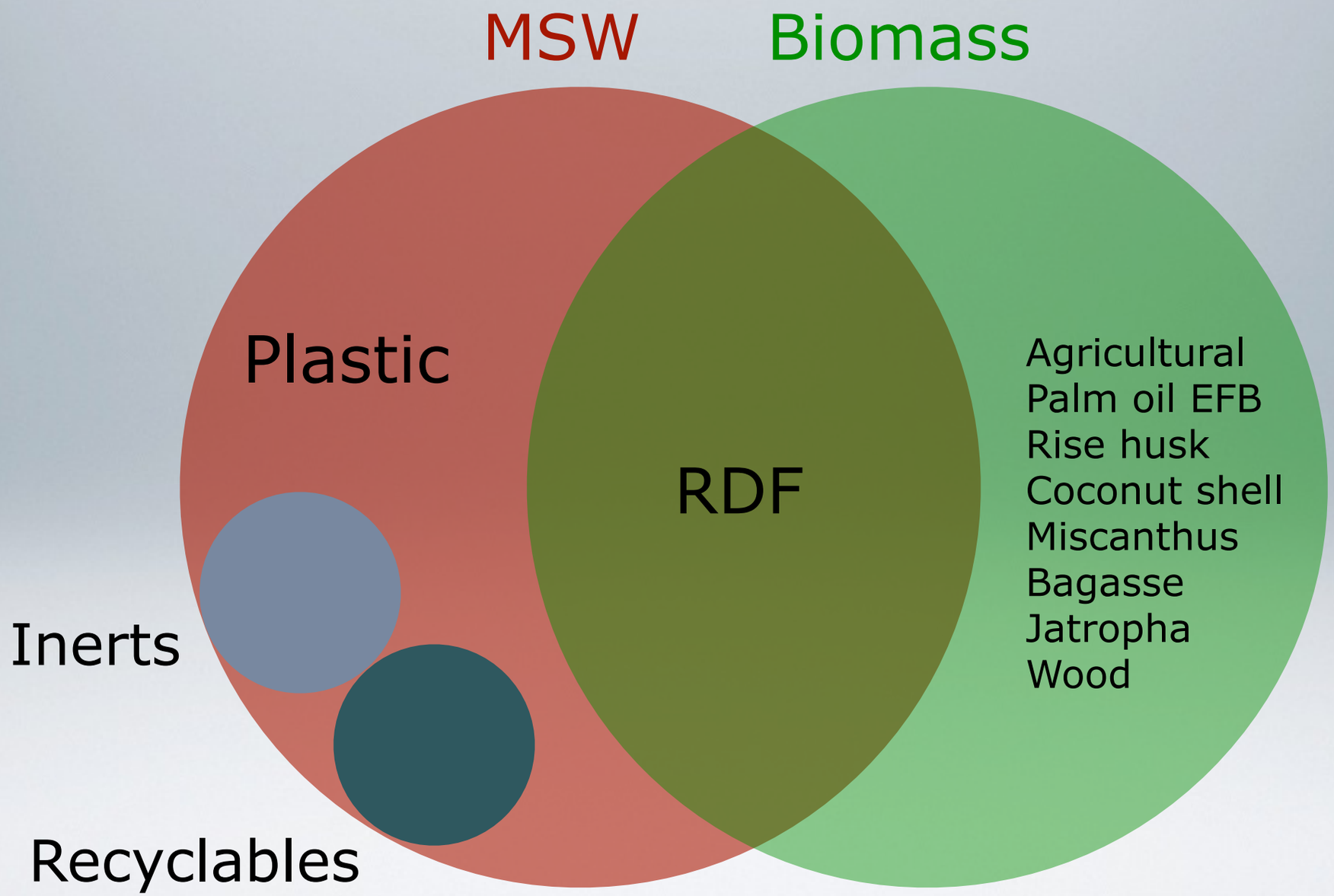
WHAT TO DO WITH THE WASTE?

Bury it!

Burn it!

Don’t talk about it!

WHAT IS WASTE?



Waste is a resource in the wrong place

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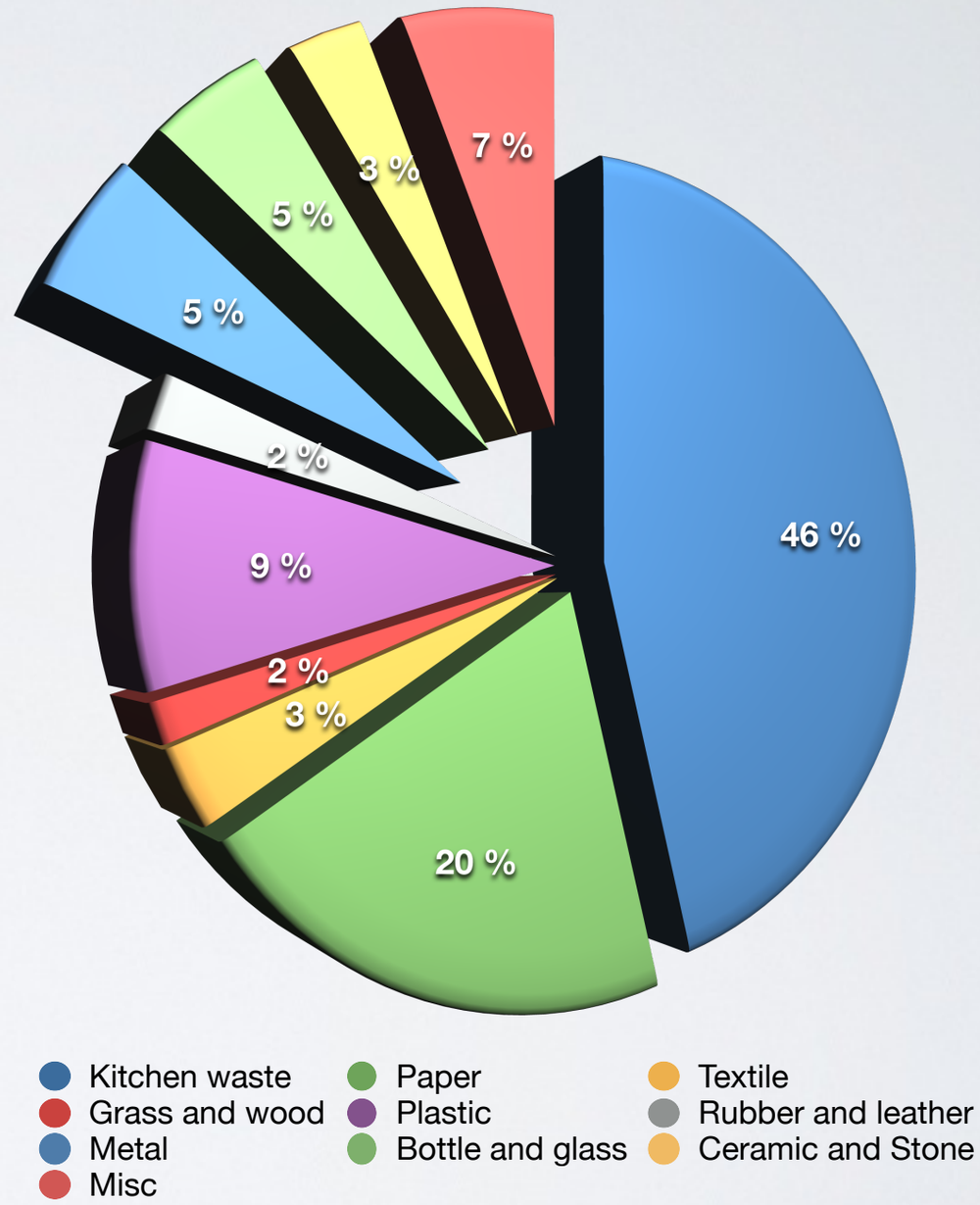
Typical Solid Waste Composition

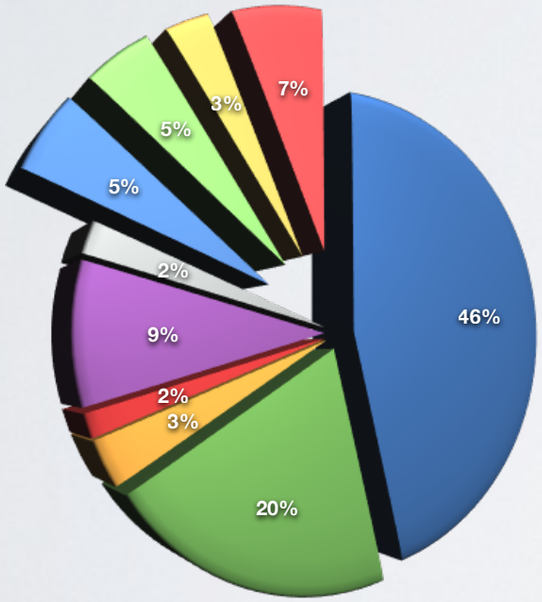
MSW Waste Composition	Athens
Combustable wastes	**81**
Kitchen waste	46,0
Paper	20,0
Plastic	8,5
Textile	3,0
Yard waste	1,5
Rubber and leather	2,0
Non-combustable wastes	**19**
Bottle and glass	4,5
Metal	5,0
Ceramic and Stone	3,0
Misc	6,5
Total	**100**



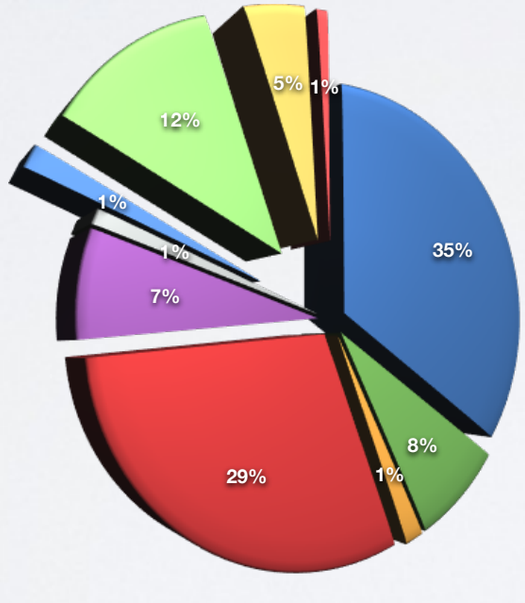
Example Athens 2010

WTE Comparison

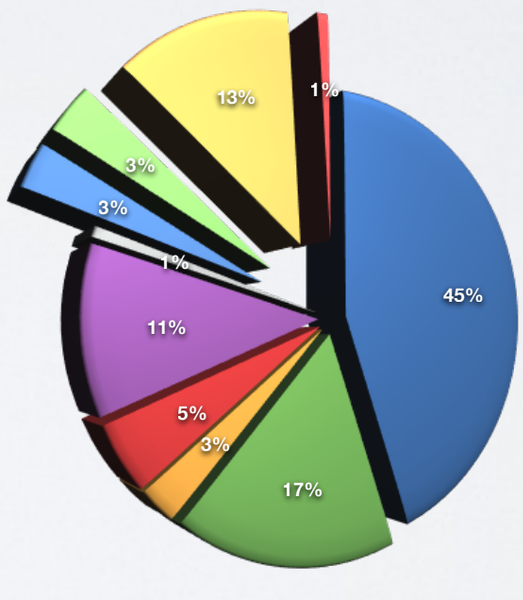
Market	MSW rate	MSW	Collect	Inerts	FE	NF	Water	Ener.	Heat	Price	Electr	Price	Income
	kg/cap/d	*tpd*			*$180*	*$1000*		*MJ/kg*	*MW*	*USD*	*MW*	*USD*	*USD per year*
Athens	1,1	110	90 %	15 %	2,6 %	0,3 %	30 %	21	8,4	0,02	**4,5**	0,2	**8 728 134**
Sofia	1	100	80 %	19 %	1,2 %	0,3 %	30 %	20	6,1	0,02	**3,3**	0,2	**6 409 006**
Montevideo	0,9	90	70 %	19 %	2,6 %	0,3 %	30 %	20	4,8	0	**2,6**	0,17	**3 637 826**
Katmandu	0,5	50	50 %	5 %	0,5 %	0,1 %	40 %	18	1,7	0	**0,9**	0,12	**913 541**



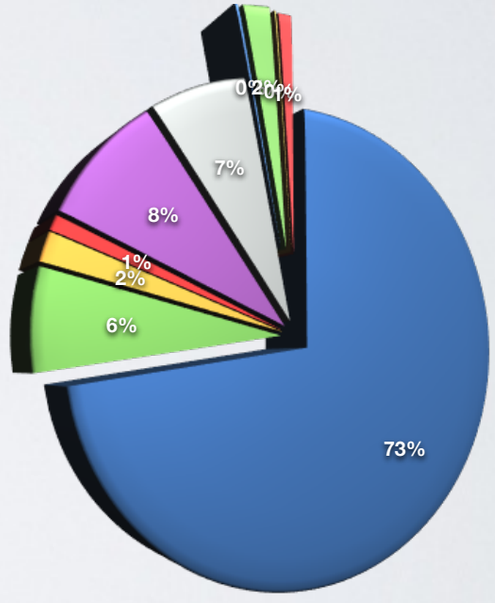
Athens



Sofia



Montevideo



Katmandu

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Refused Derived Fuel (RDF)

Sorting waste for Recycling (metals, plastic, paper)

Treatment of residues into pellets, briquettes

Gasification of residues for power production

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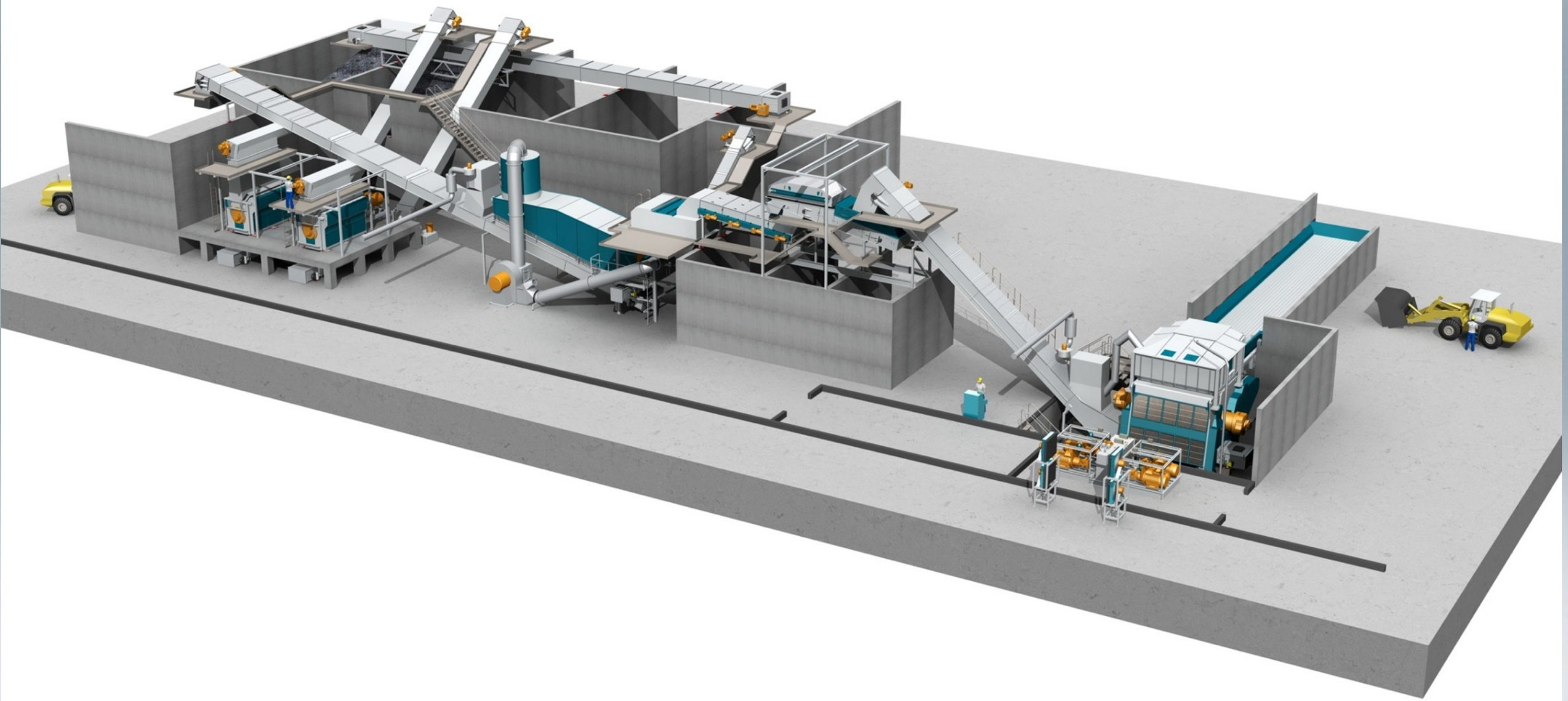
RDF Production



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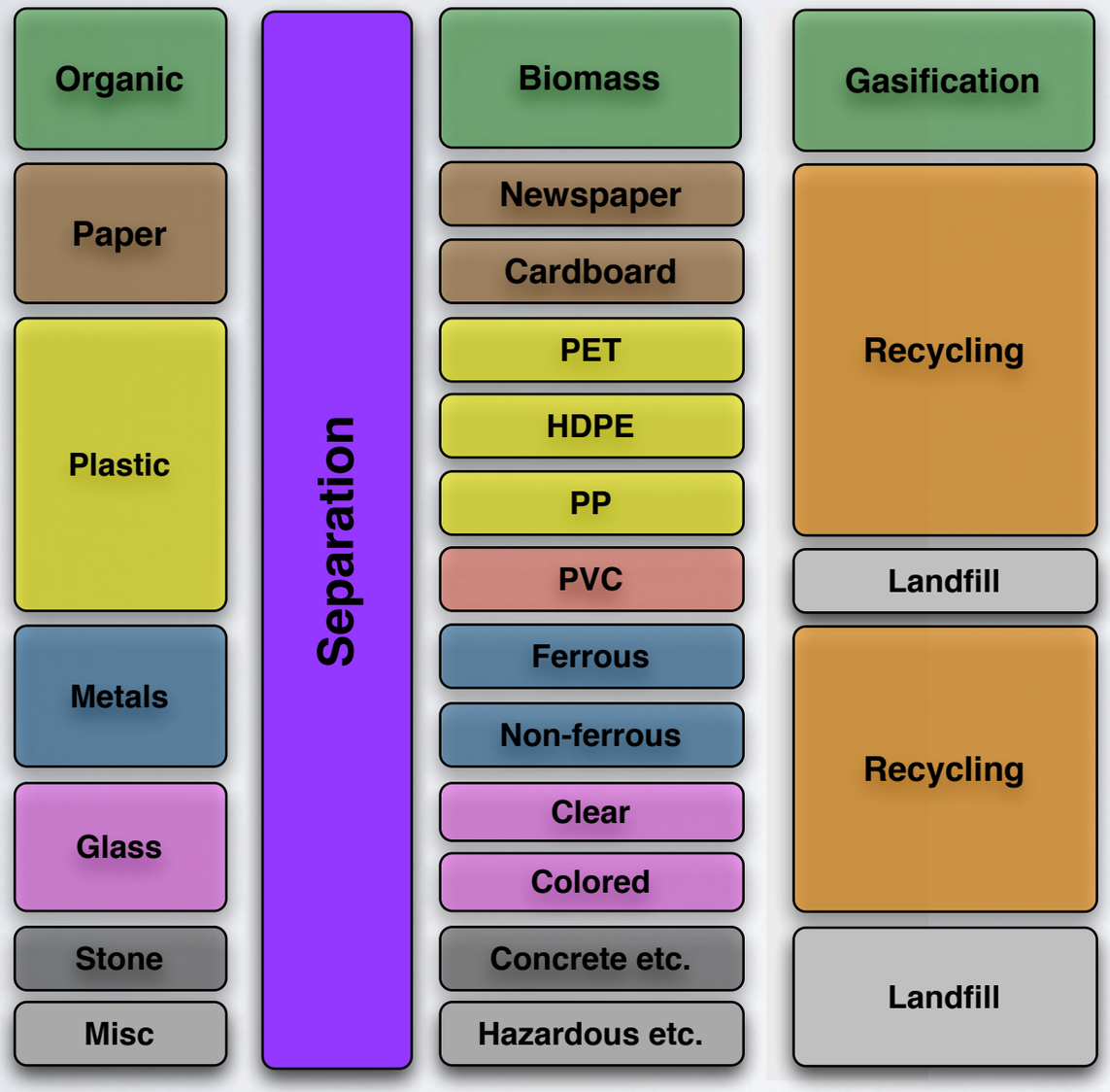
Combining Recycling and Bio-reforming



€80

€16

-€0,33

€52

-€10

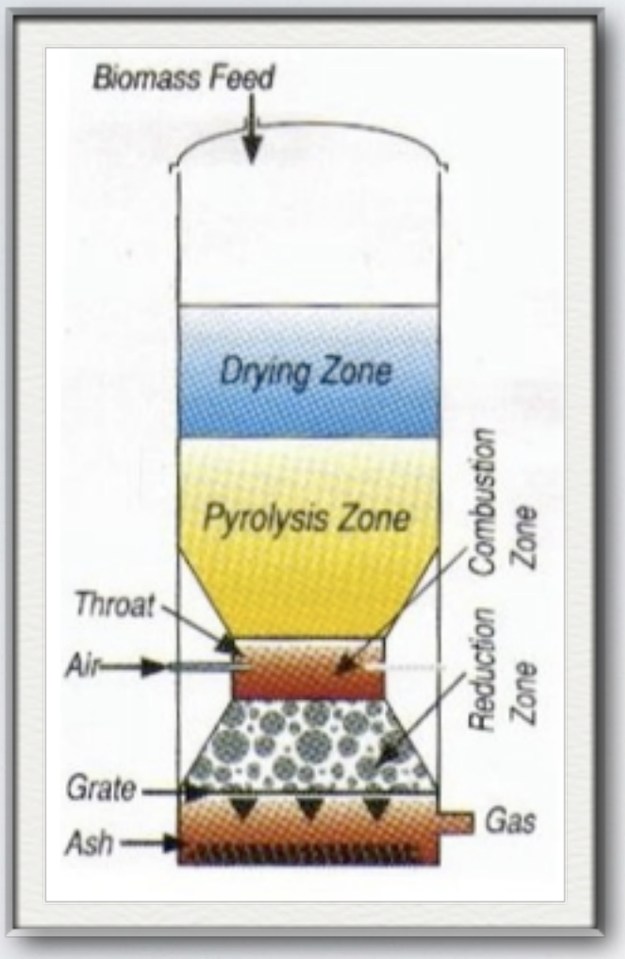
RDF reforming:

Total €137
per ton waste

PLASTIC FRACTIONS

- PE - polyethylene
- LDPE - low-density polyethylene
- HDPE - high-density polyethylene
- PP - polypropylene
- PS - polystyrene

GASIFICATION



- Thermal decomposition of organic material through the application of heat in the absence of oxygen
- Well known technology in new package
- Conversion of Carbon based waste into Syngas ($CO + H_2$) by controlling supply of Oxygen and/or steam at high temperature
- Syngas is a valuable product that could be used as fuel or converted into other high value products

GASIFICATION UNIT

final drying at 100°C

above air inlets heated wood pyrolyses at
250° to 450°C releasing its V.O.C.
(hydrocarbons)

carbonising to charcoal

charcoal within air stream
$C+H_2O \rightarrow CO+H_2$ and $C+O_2 \rightarrow 2CO$
then $H_2+1/2 \rightleftharpoons O_2$ and $2CO+O_2 \rightleftharpoons 2CO_2$
in equilibrium

air in

peak temperature: 1100°C
all free oxygen consumed

hot char below the reach of free oxygen
(685° to 885°C)
$C+H_2O \rightarrow CO+H_2$ and $C+CO_2 \rightarrow 2CO$

hot, syngas out

Drying Zone

minimal oxygen

Distillation and Carbonisation Zone

minimal oxygen

limited primary air

Oxidation and Combustion Zone

minimal free oxygen below here

hearth throat profile (one side)

minimal oxygen

Reduction Zone

grate

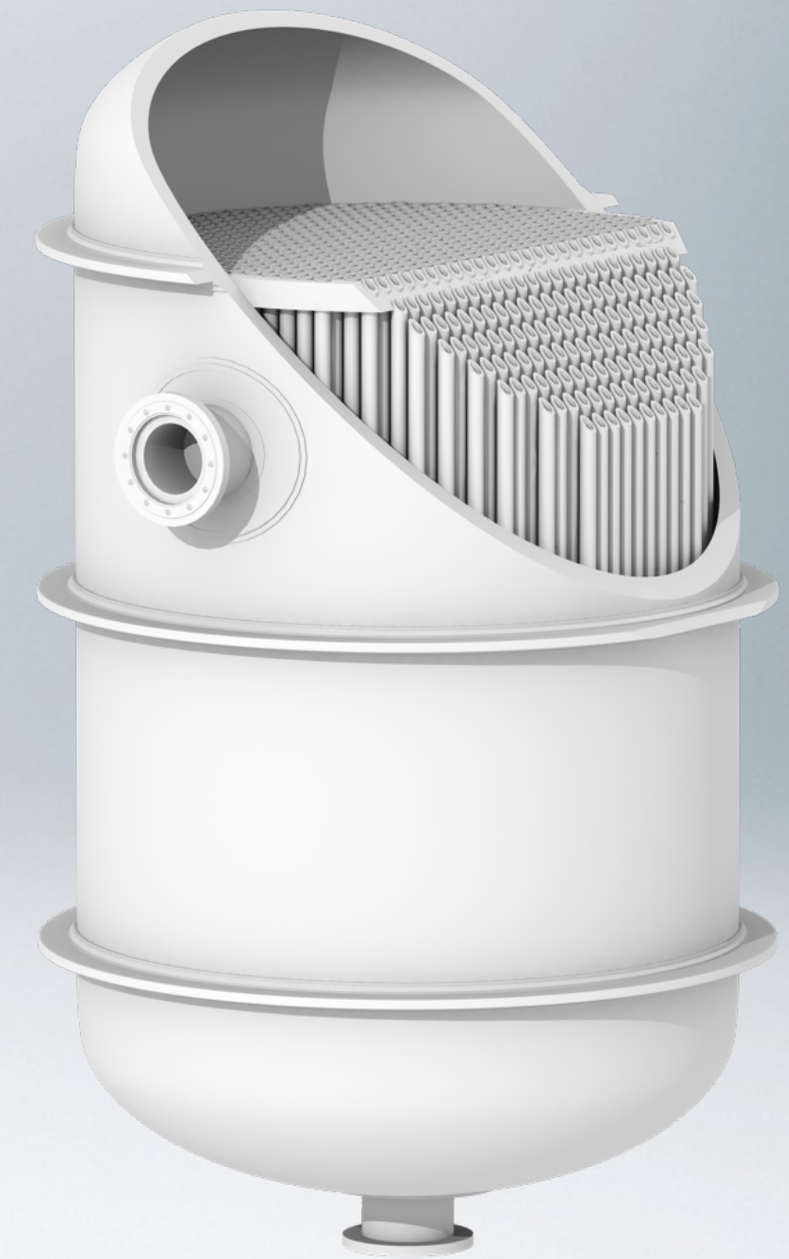
GASIFICATION VS. INCINERATION

- Gasification is superior to Incineration in regards to Environmental Gases
- Gasification with Generator Set has a higher efficiency than Combustion with Steam Turbine
- Syngas is superior as a waste product since it could be used as fuel as well as raw material
- Gasification assumes waste assortment which improves recycling
- Gasification units could be built in modules and are relatively small. For Electricity units conventional gas generators could be used. Combustion uses complex Steam Turbine generators

EMISSION TABLE FROM THERMAL GASIFICATION

Emission	ppm	kg/h	tpy	kmol/h	Nm
Nitrogen	*70 %*	*24 559*	*196 475*	*877.1*	*19 660*
Oxygen	*3 %*	*1 211*	*9 691*	*37.9*	*848*
Water	*11 %*	*2 571*	*20 565*	*142.8*	*3 201*
CO	*16 %*	*8 977*	*71 813*	*204.0*	*4 573*
CO	*50*	*1.77*	*14.1*	*0.063*	*1.41*
NOx	*35*	*2.03*	*16.3*	*0.044*	*0.99*
SOx	*1*	*0.081*	*0.6*	*0.0013*	*0.028*
Hg	*0.00048*	*0.000*	*0.0*	*0.0000*	*0.00001*
Cd	*0.0053*	*0.001*	*0.0*	*0.0000*	*0.0002*
Pb	*0.14*	*0.038*	*0.3*	*0.0002*	*0.004*
Exhaust				*1 261.8*	*28 282*

Gas-to-Liquid Fuel technology



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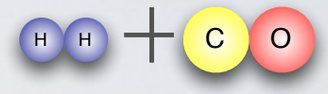
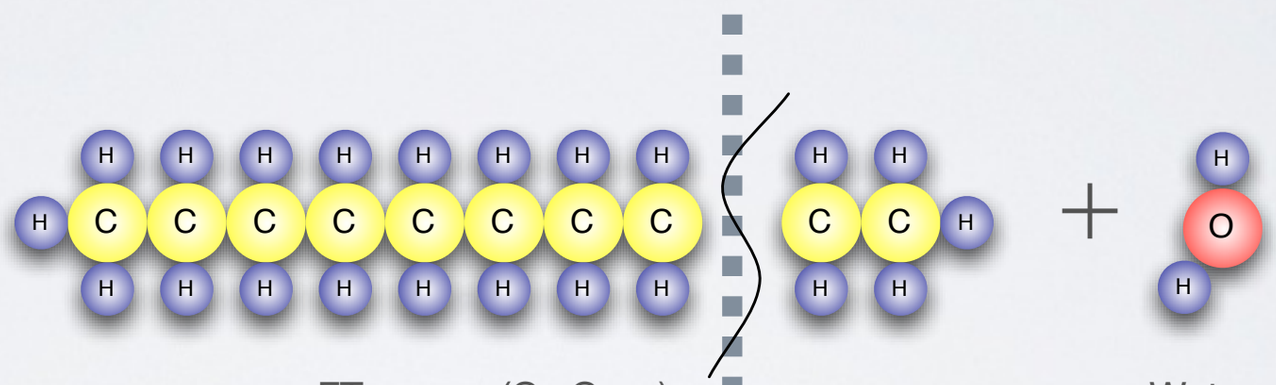
W4F Alkane Production

Step1: Syngas generation through reforming processes
(H_2 + CO)



Step 2: W4F Gas-to-Liquid Fuel selective process



FT-waxes (C_1-C_{138+})

Water

Naphta	Gasoline	Kerosene	Jet fuel	Diesel
C4-C10	C5-C10	C10-C13	C10-C13	C14-C20

$$(2n + 1)H_2 + nCO \longrightarrow C_nH_{(2n+2)} + nH_2O$$

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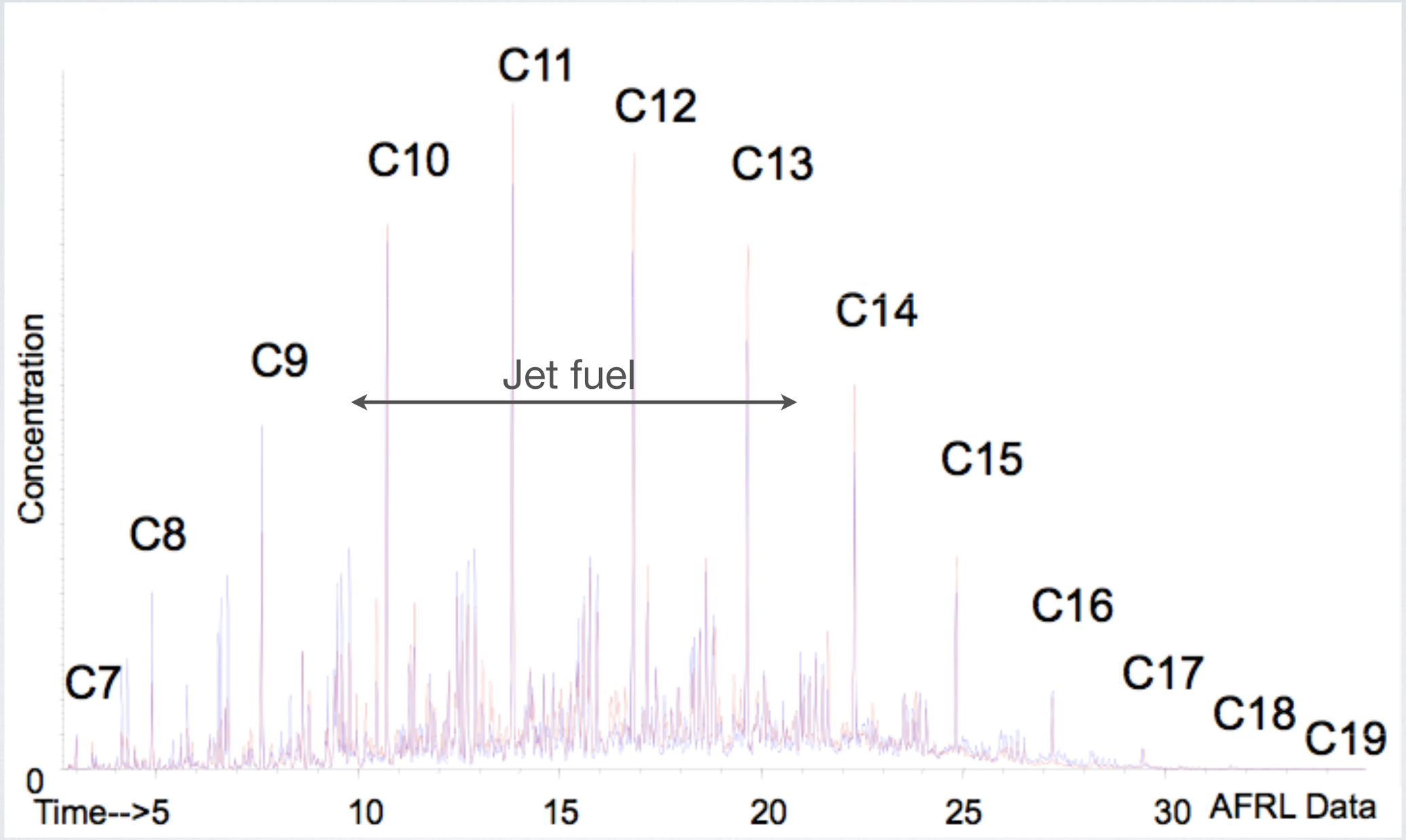
Fischer-Tropsch SPK

(Synthetic-Paraffinic Kerosene)



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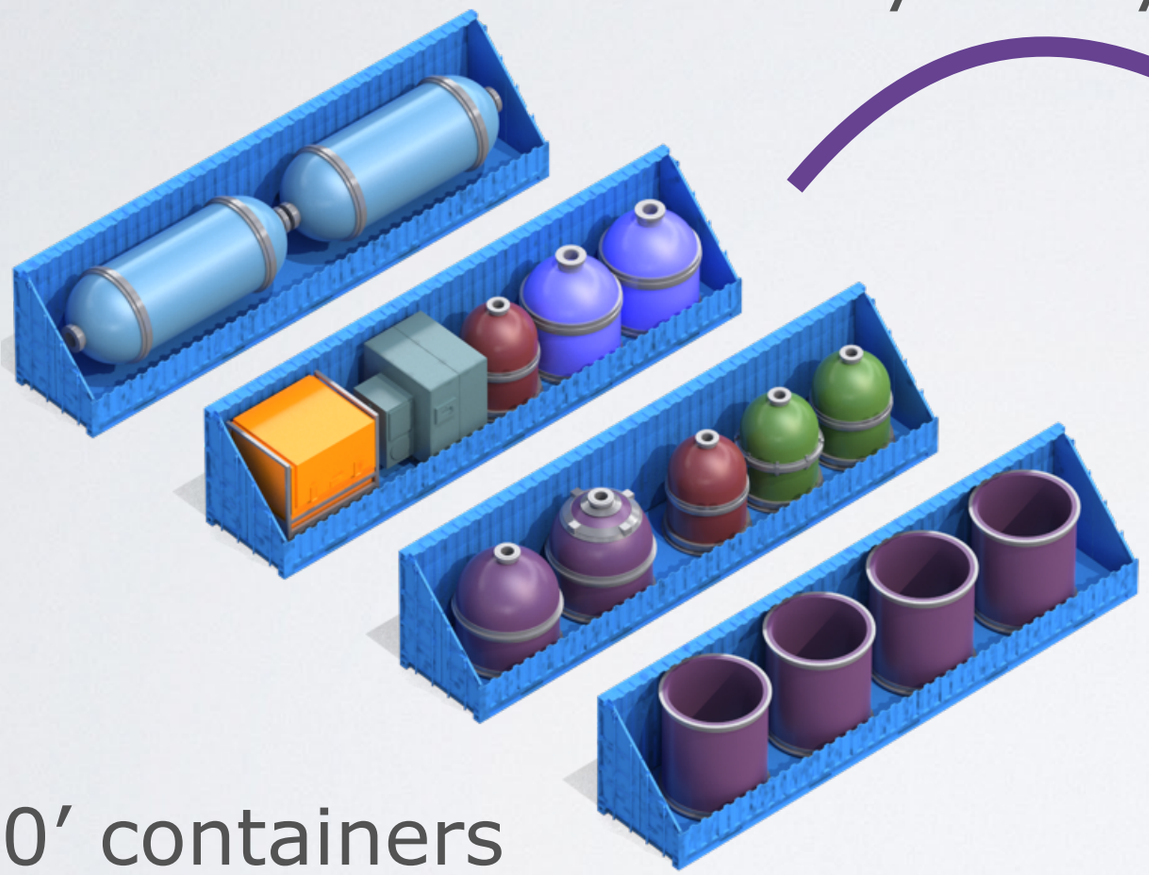
W4F GTL REACTOR

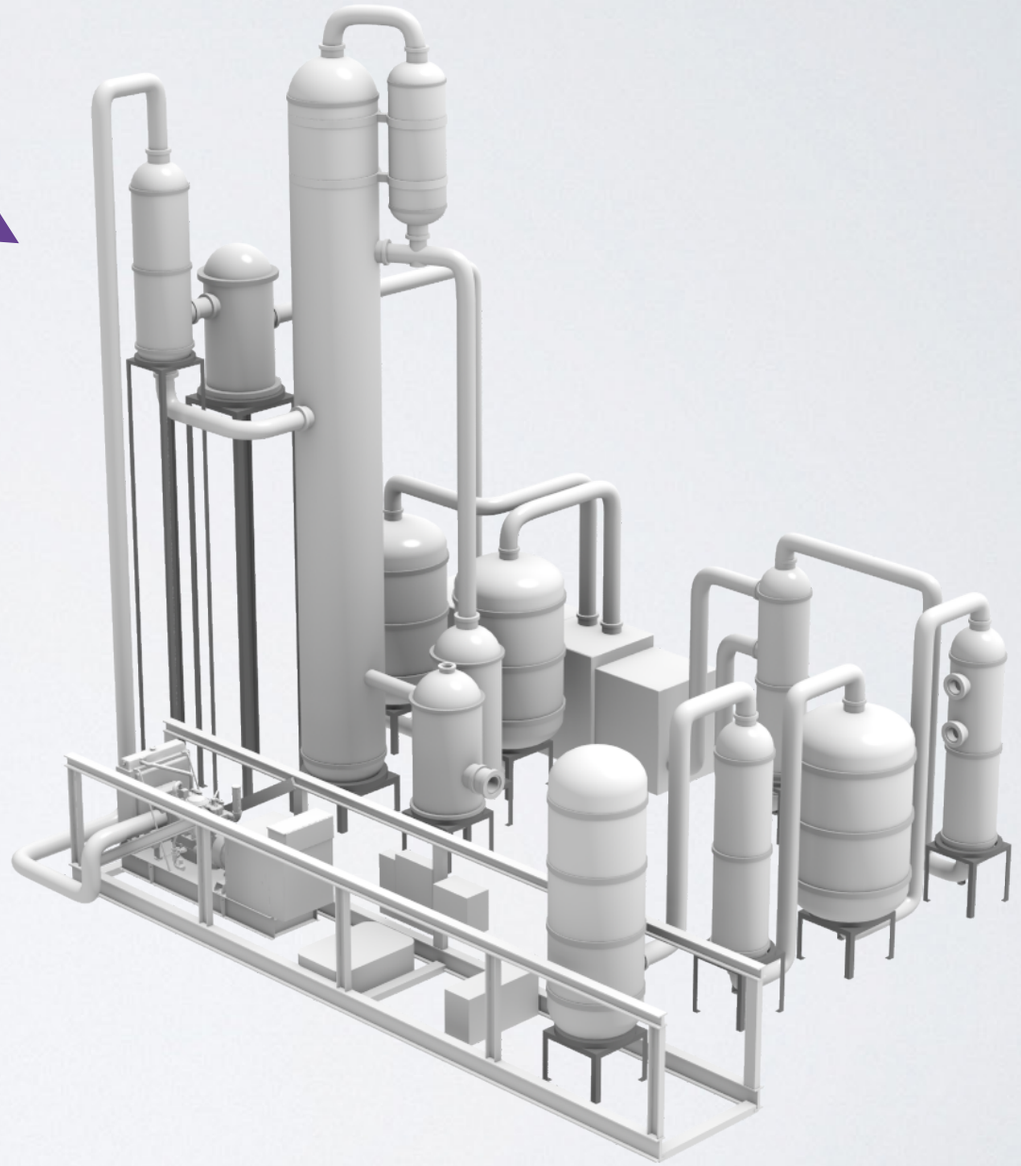
- Manufactured in Sweden
- Proprietary catalyst, patent to be applied 2016
- Gas-to-gas conversion
- Dimensions to fit 40’ container

Modular and semi-portable



40’ containers

3 months
key ready



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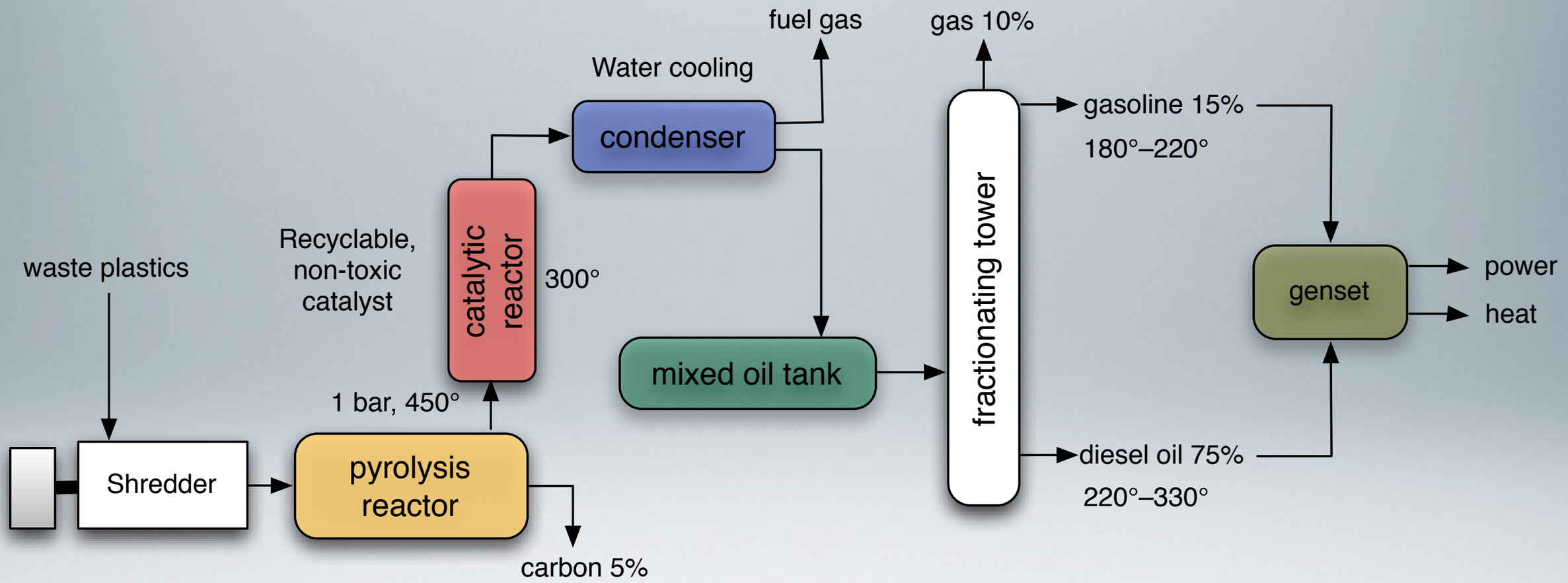
PTD plastic-to-diesel

- Better use of plastic waste (CO_2 neutral)
- Shorter route to synthetic diesel
- Shorter return of investment - low entry threashold
- In operation Q2 2016

PLASTIC REFORMING



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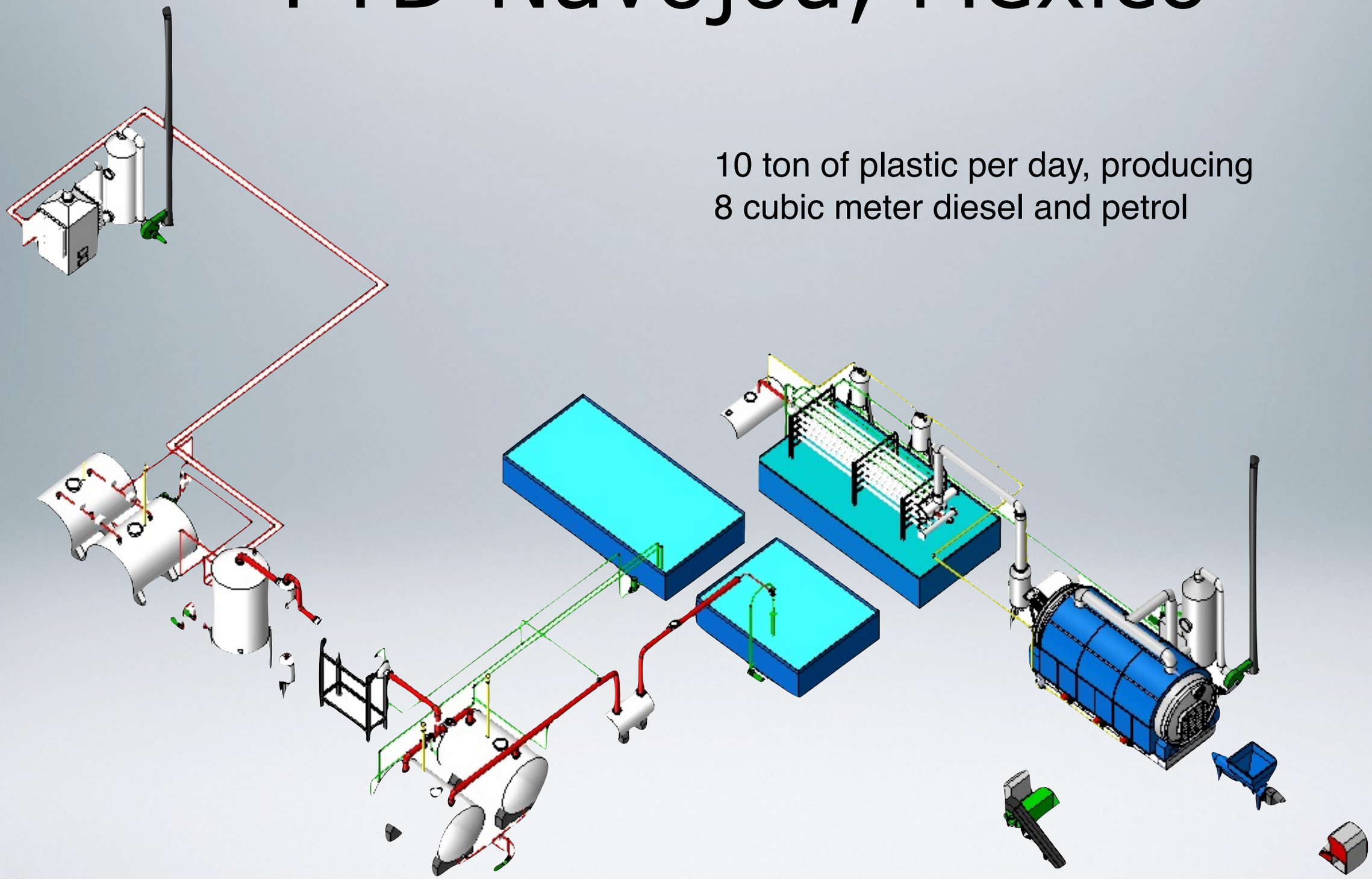
PTD Navojoa, Mexico

10 ton of plastic per day, producing
8 cubic meter diesel and petrol



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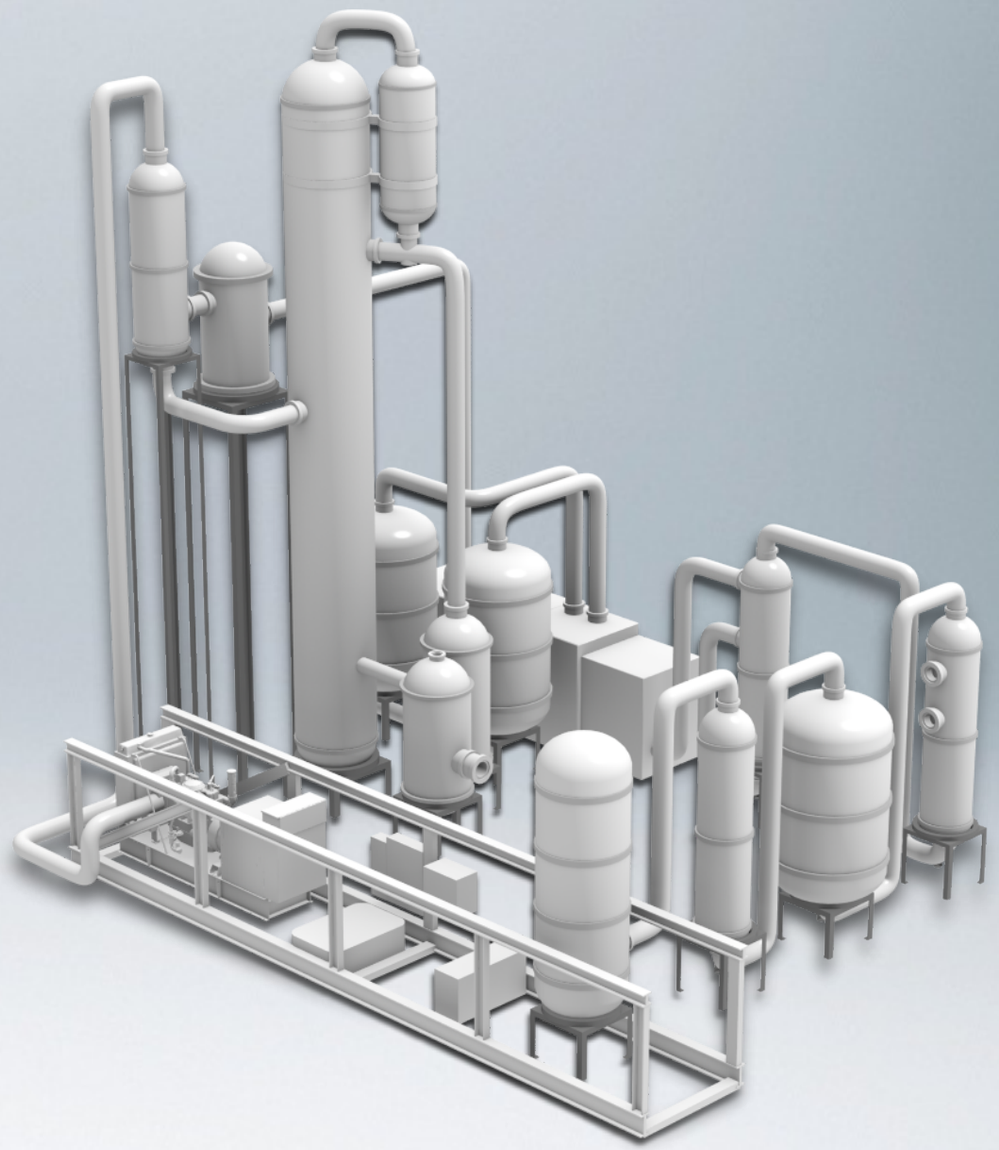
CURRENT INSTALLATION

Responsible treatment of a valuable end product



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