

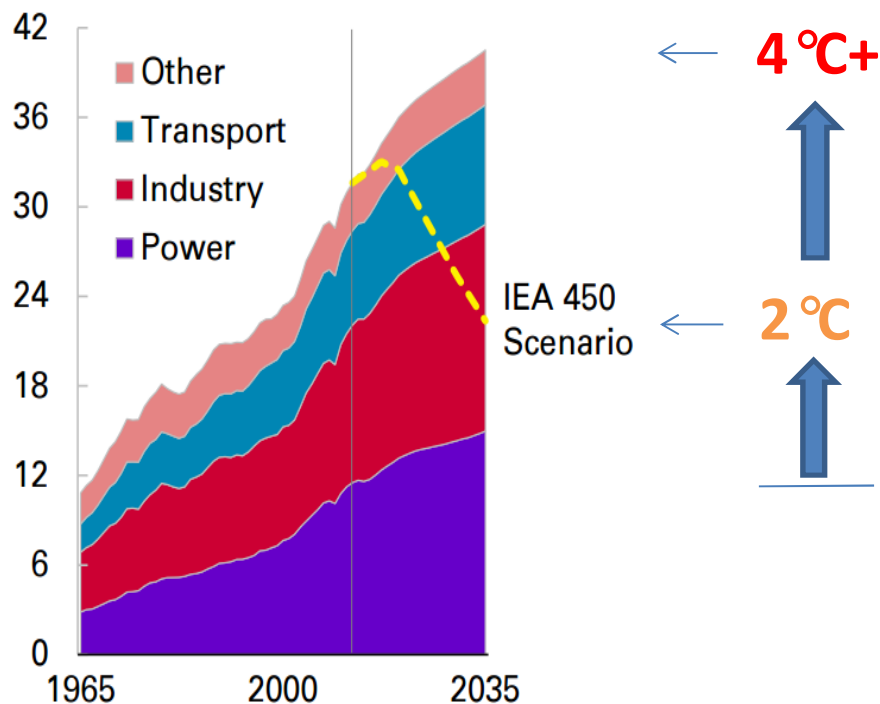
**The techno-economic viability of upcycling residual
waste into advanced biofuels:
A commercial demonstration plant case study using
Gasplasma® technology to convert to bioSNG**

4th International Symposium on
Enhanced Landfill Mining
5 - 6 February 2018
Belgium



The World Needs Low Carbon Energy Sources

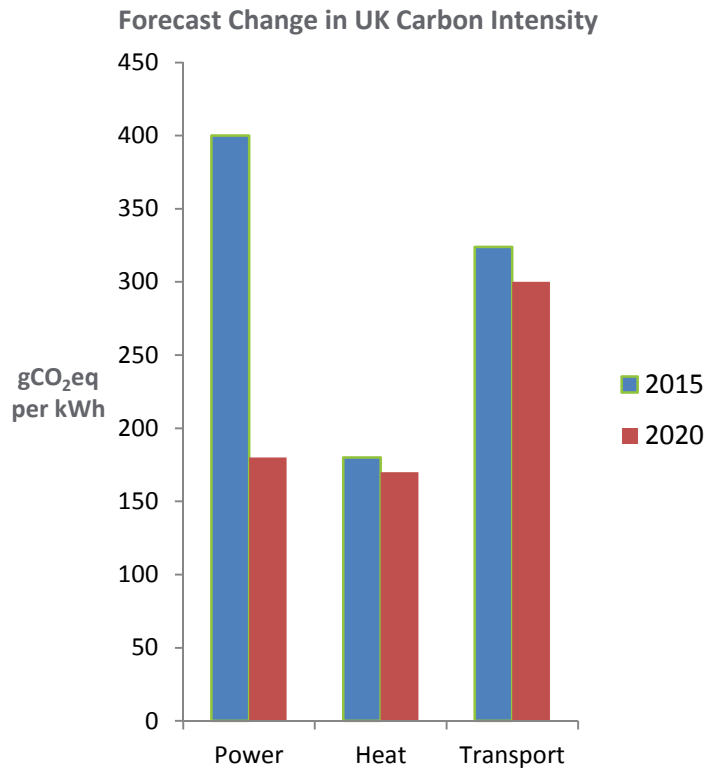
Billion tonnes CO₂



- Without intervention global warming will exceed 4°C
- Paris Agreement 2015 sets binding commitment on 195 countries to limit to 2°C
- Requires us to halve our projected CO₂ emissions
- **Sustainable fuels production from waste and agricultural residues must play significant role**



All Energy Sectors Need to Decarbonise



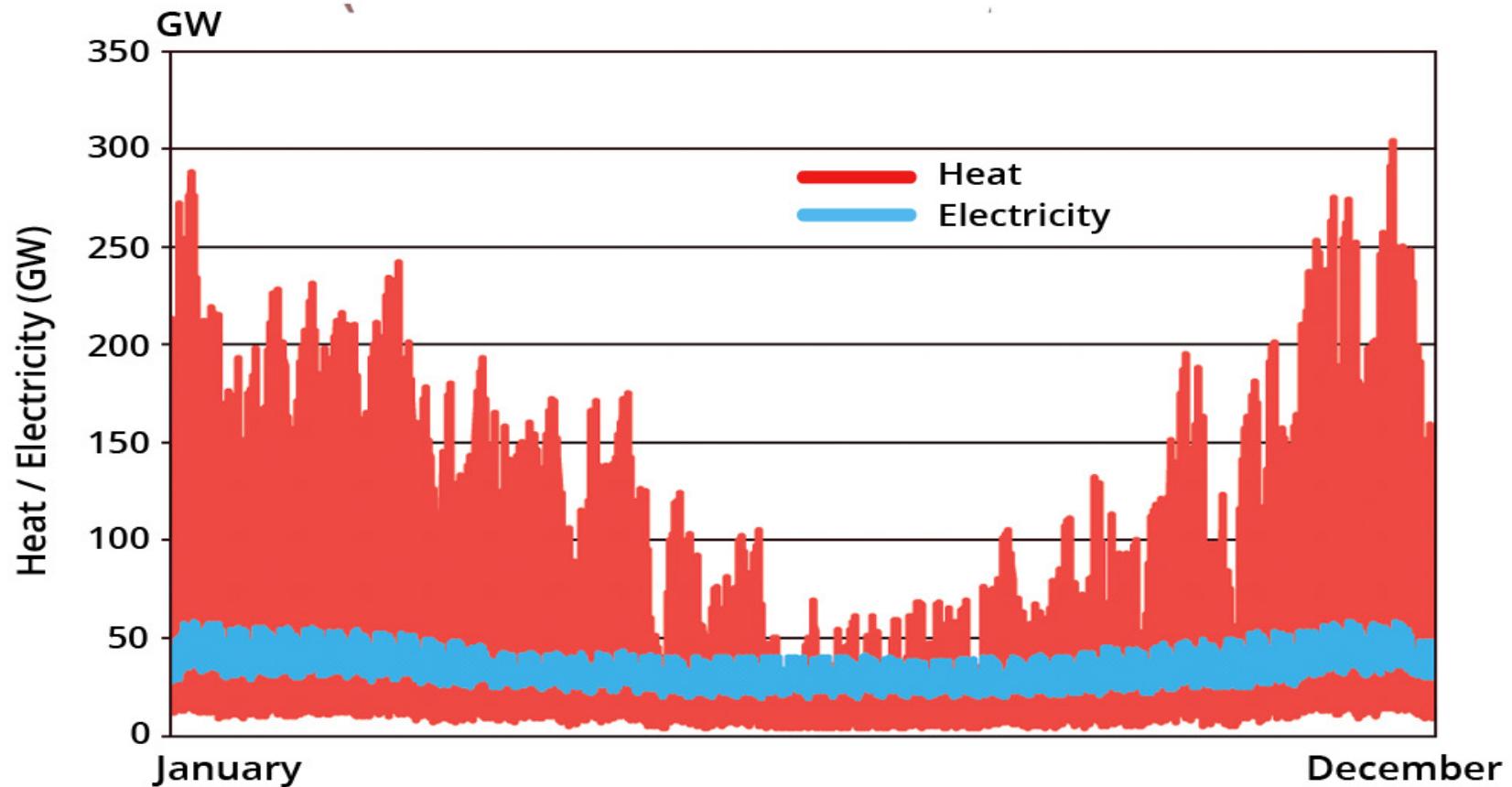
- All sectors must reduce carbon emissions
- **Electricity many options** (e.g. UK starting from 10th highest carbon intensity of power)



- **Decarbonising heat & transport far more challenging with few options**
- 1st gen. biofuels failed (e.g. Deforestation and ILUC) and production being capped
- **New breed of advanced fuels required**



Example of the challenge



UK peak half hourly gas demand is 533% peak electricity demand !



Disposing of Waste Sustainably is a Major Global Issue

	UK	Western Europe	Eastern, Europe and Canada	SE Asia, Middle East and Australia	Rest of the World
Residual waste (million tpa)	47	140	150	52	1,022
Waste incinerated (million tpa)	8	110	10	1	100

- No account taken of forecast **30% increase** in global population by 2050 and increase in wealth & consumption (“peak waste” 10 billion tpa?)
- No account taken of **landfill mining** (e.g. 500,000+ EU landfills), **doubles potential?**

“It’s a waste to waste waste !”

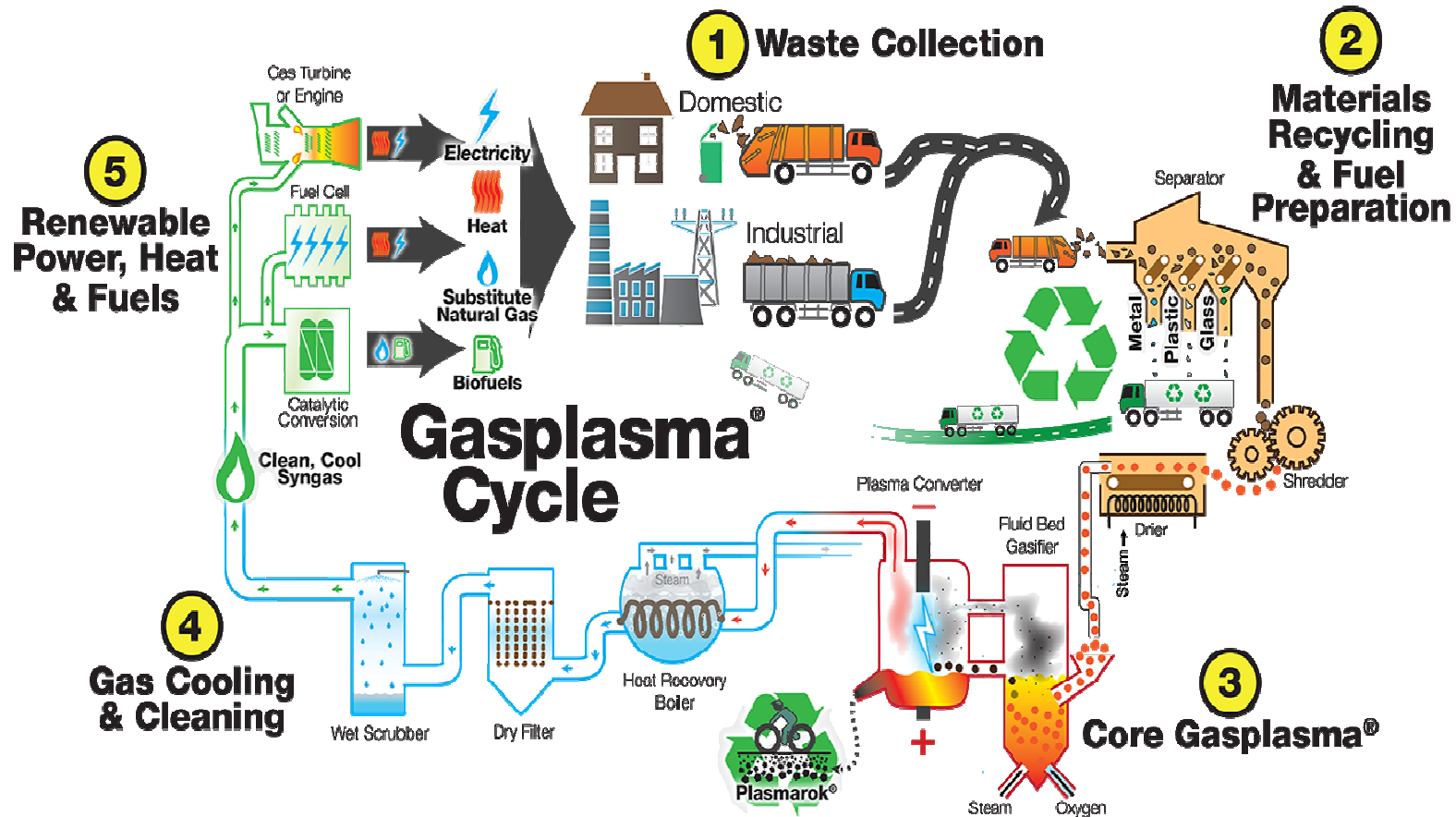


Other Abundant Waste Biomass Feedstocks

Feedstock	LHV (MJ/kg)	Current Feedstock Supply (wet Mt/yr)			Expansion Post 2020?			Current Price (£/t)
		UK	EU	Global	UK	EU	Global	
Bio-fraction of MSW	6.3	22	189	861	↓	↓	↑↑	-41 (-46 to -24)
Bio-fraction of C&I waste	7	25	133	560	↔	↔	↑↑	-41 (-46 to -10)
Bagasse	7.8	0	0	413	-	-	↑↑↑	8.5 (2.8 to 34)
Bark, branches, leaves	12.4	3.4	127	317	↔	↔	↑	39 (34 to 44)
Sewage sludge	0.5	35	632	1,069	↑↑	↑	↑↑↑	0 (-41 to 0)
Miscanthus	13.4	0.12	0.9	1.2	↑↑↑	↑↑↑	↑↑↑	53
Straw	15.0	7.4 - 11	72	885	↔	↓	↑↑	63 (48 to 75)
Wine lees	6.2	0.004	0.8	1.5	↔	↔	↑	54
Nut shells	16.4	0	0.8	10	-	↔	↑↑	67 (49 to 85)
Saw dust & cutter shavings	15.2	1.6	37	104	↔	↑↑	↑↑	67
Short rotation forestry	12.3	0	0	0	↑↑↑	↑↑↑	↑↑↑	42
Small round-wood	12.3	3.3	333	829	↔	↑	↑	32
Black and brown liquor	12.0	0.28	66	200	-	↑	↑	112 (0 to 175)
Husks	13.0	0	0.5	120	-	↔	↑↑	97 (80 to 110)
Short rotation coppice	12.3	0.04	0.3	9	↑↑↑	↑↑↑	↑↑↑	50
Cobs	12.4	0.01	3.6	36	↔	↔	↑↑	57 (46 to 68)
Crude glycerine	14.2	0.03	1.0	2.9	↔	↔	↑↑	253
Grape marcs	7.8	0.02	4.1	7.7	↔	↔	↑	54

Further doubles the opportunity and potential impact





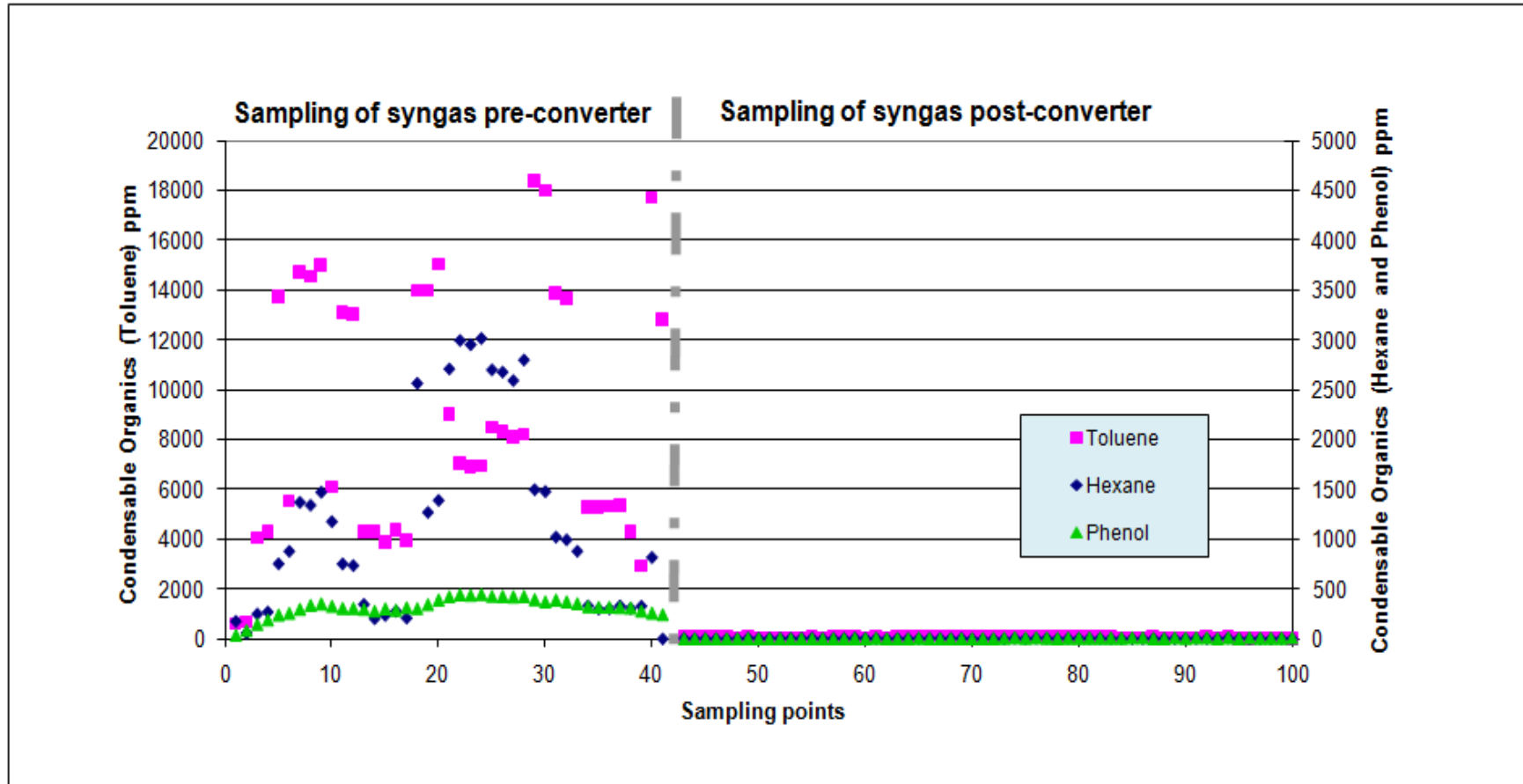
Ravenna Fluidised Bed Plant



Thyssen/Outokumpu
Plasma Facility

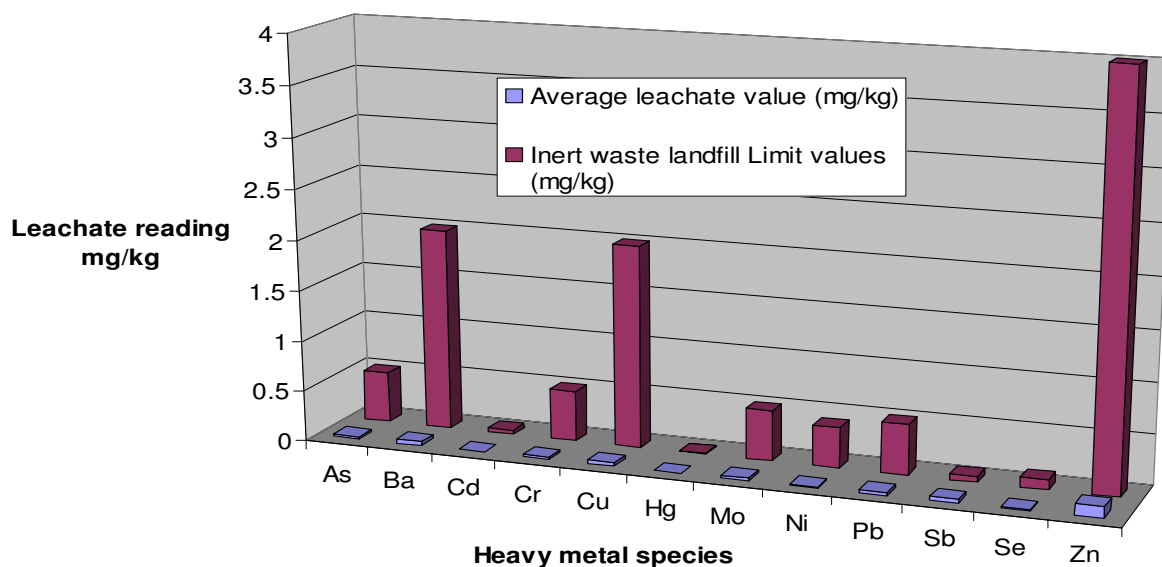


Gasplasma[®] Output 1: Ultra Clean Syngas



Gasplasma[®] Output 2: Plasmarok[®]

Summary of results for inert WAC limit compliance
BS EN 12457-3 Leaching tests on vitrified sample at particle size <4mm



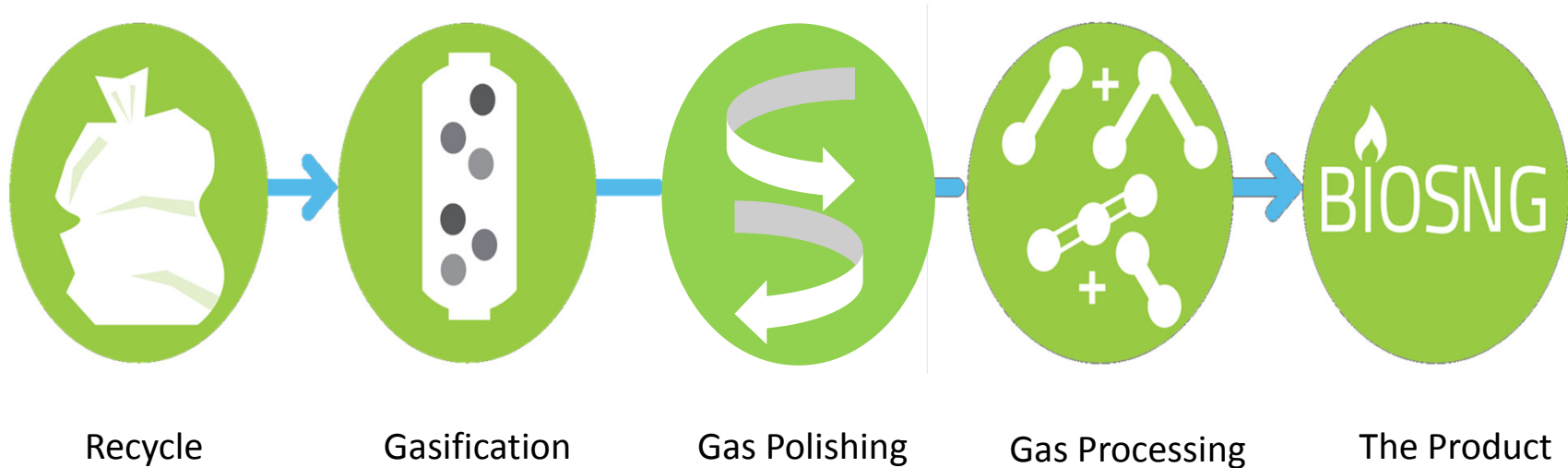
Mechanically strong
Extremely leach resistant
Product – not waste
(e.g. foam glass or rock
wool insulation)



Main constituents: Silica 37%; Lime 31% ; Alumina 16%
Others include: Iron Oxide; Titania; Magnesia; Sodium Oxide; Potash ; Phosphate



Ultimate Recycling – At Molecular Level



- **Innovative combination of established technologies**
- **65+% energy conversion efficiency v. 25% for incineration**
- **Equally suited to producing hydrogen and liquid fuels**



Delivered £5 Million Pilot Plant



- Delivered **on time and on budget**
- Producing **grid quality BioSNG** from municipal Refuse Derived Fuel (RDF)

nationalgrid
Gas Distribution

Cadent
Your Gas Network

 **Advanced**
Plasma Power

 *Progressive energy*

Carbotech
VIESSMANN Group

RIIO **NIC**
NETWORK INNOVATION
COMPETITION

 **BESTF**



World's First Commercial Scale Waste to BioSNG Plant



nationalgrid
Gas Distribution

Cadent
Your Gas Network

 **Advanced**
Plasma Power

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COMPETITION

 *Progressive energy*


**Department
for Transport**

cng services ltd

 **WALES&WEST**
UTILITIES

 **AIR LIQUIDE**

£25 million of funding from UK Department for Transport, Ofgem and Cadent



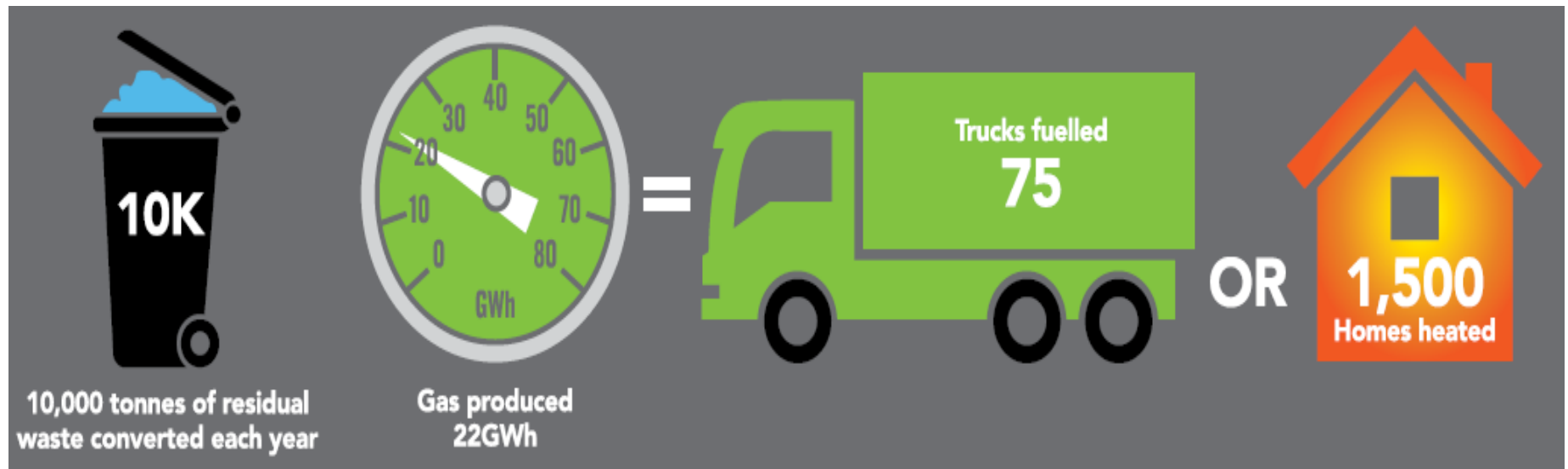
Full Chain Commercial Demonstration Facility



Operational Q2 2018



The Primary Outcomes for Plant under Construction

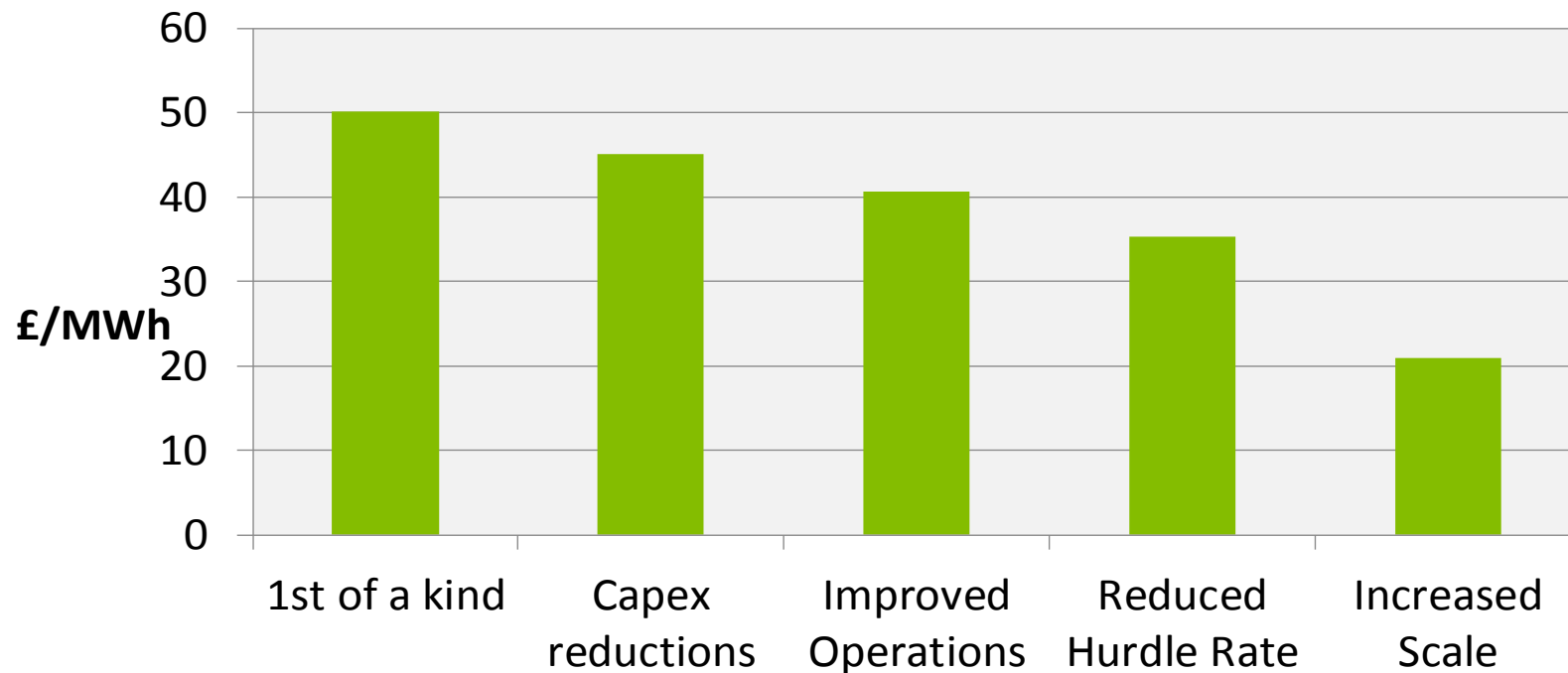


Commercial reference plant to enable construction of larger (100k+ tpa) facilities

UK potential for 100TWh p.a. or 35% of domestic heating demand



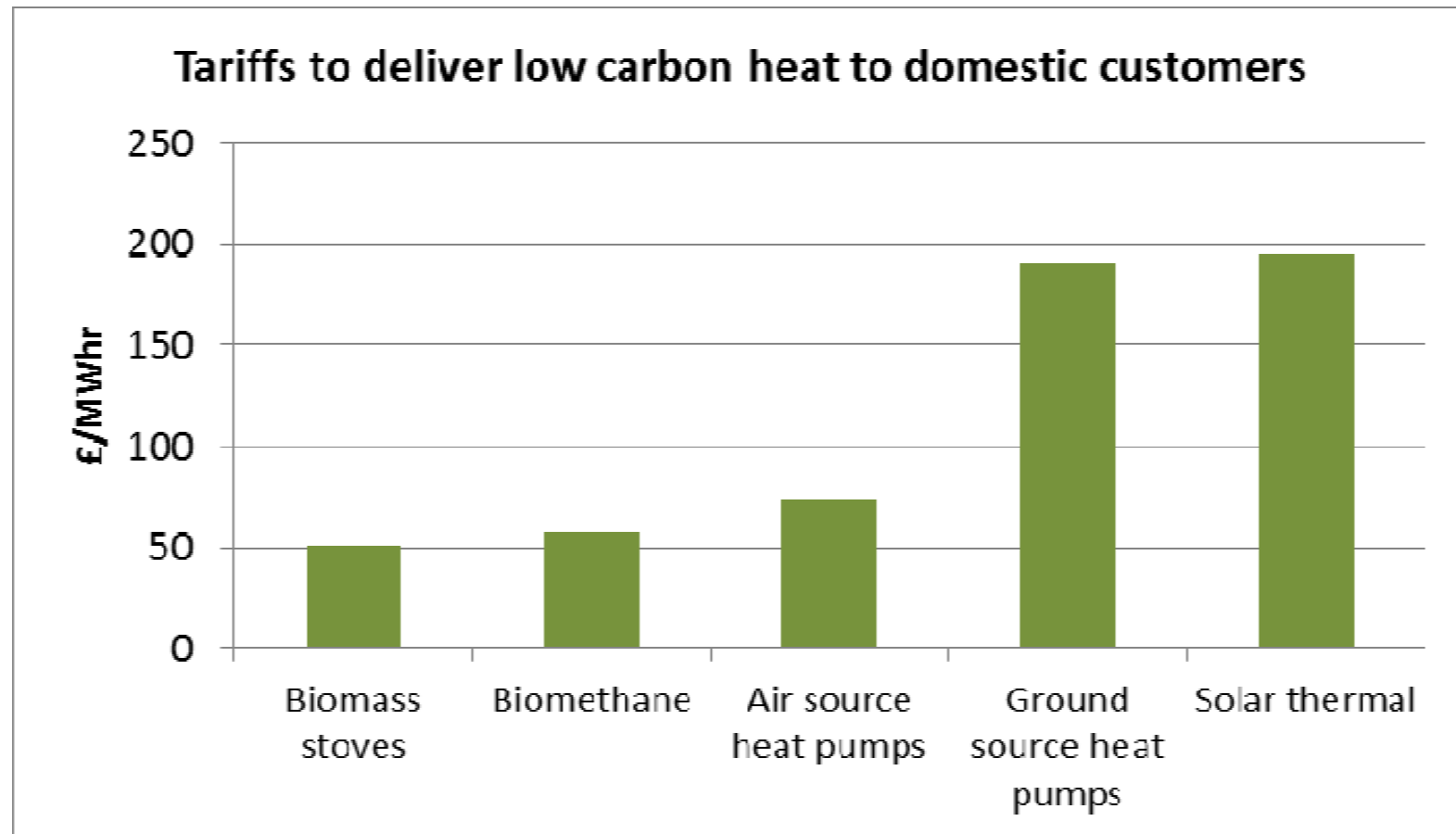
Commercial Performance to Maturity



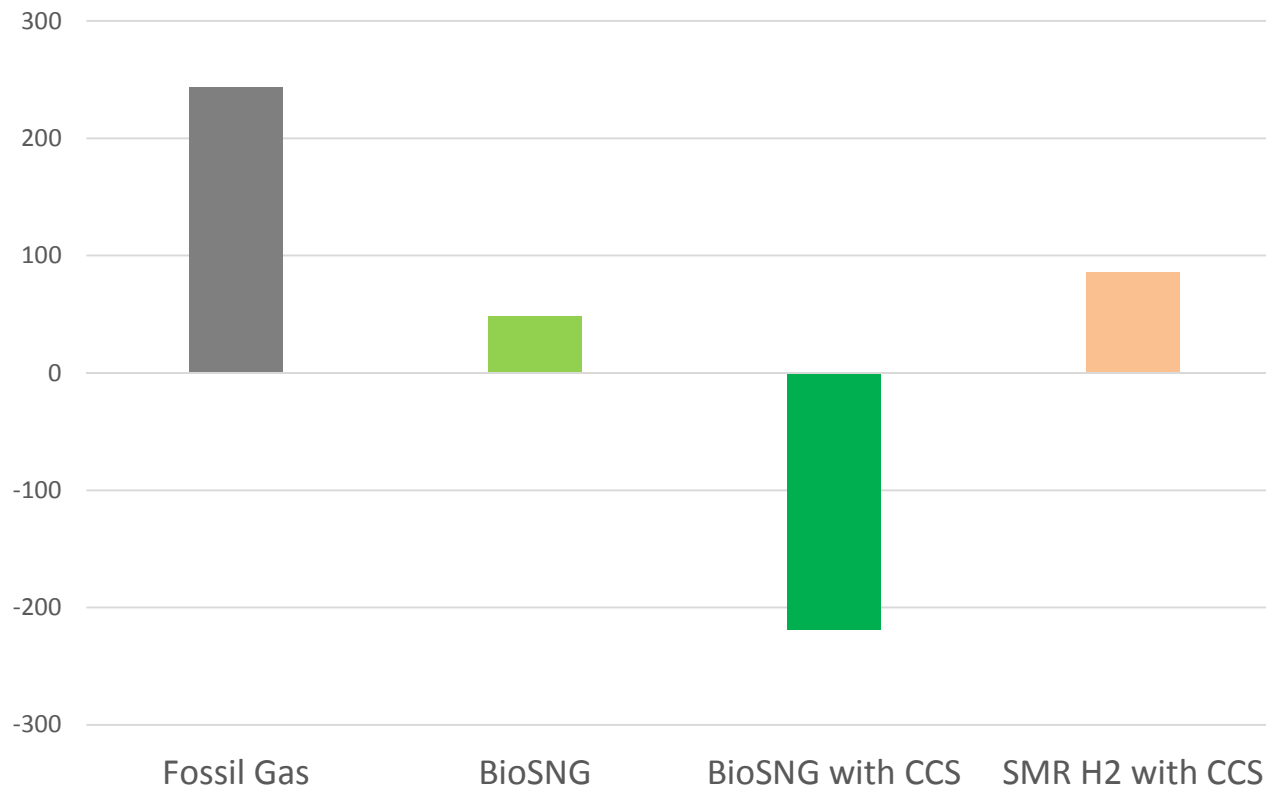
BioSNG from waste feedstock has the potential to deliver sustainable gas at a cost close to cost of fossil natural gas



Excellent Value for Money Compared to Alternatives

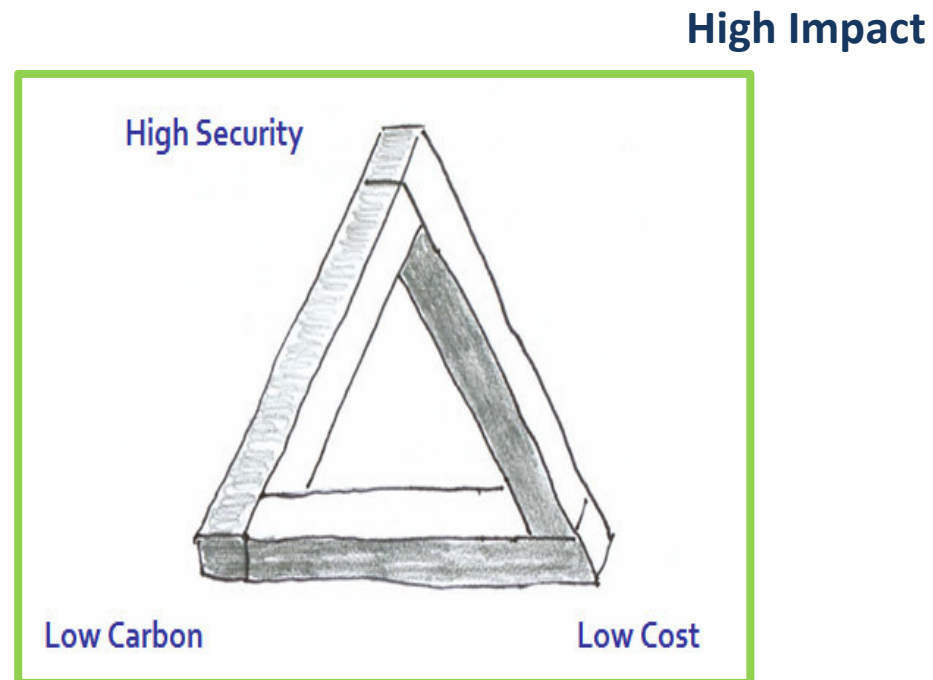


BioSNG is Low Carbon: 80% GHG Savings, 190% with CCS



In Summary

“Fuels from Waste Square the Energy Trilemma”





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Thank you

