Ricardo
Energy & Environment

Waste to Energy: transforming strategy into reality

Asia Clean Energy Forum 2017

Dr Adam Read
Practice Director
6th June 2017, Manila, Philippines


welcome
benvenuto
tervetuloa
fogadtatás
shalom
vítáme tě
καλώς ορίσατε
welkom
bienvenido
歡迎
swagata
välkommen
salaam
aloha
bienvenue
willkommen
환영합니다
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bem-vindos
namaste
ahlan'wa sahla
ようこそ
powitanie

A personal welcome - Dr Adam Read (lead facilitator)

- Practice Director @ Ricardo-Energy & Environment
  - *60 staff (UK based)*
- World-renowned expert
  - *waste & recycling service design, regional waste management strategies, waste technology selection & stakeholder engagement*
- 21 years of sector experience (UK & international)
  - *Middle East, Russia, Hungary, Poland, Costa Rica, Egypt, Australia, Thailand & the USA*
- Former Municipal Waste Officer
- Fellow of the CIWM
- Member of ISWA Communications WG

ISWA 2018
Kuala Lumpur, Malaysia

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QUESTIONS

Welcome to the Ricardo team ....

- Kathryn Warren – Waste Technologies Specialist
  - *13 years' experience (waste & and resource efficiency)*
  - *WtE technology procurement for municipalities*
  - *WtE policy and strategy*
  - *Feasibility and investor/technical due diligence*
  - *Renewable Heat (Technology and incentives)*

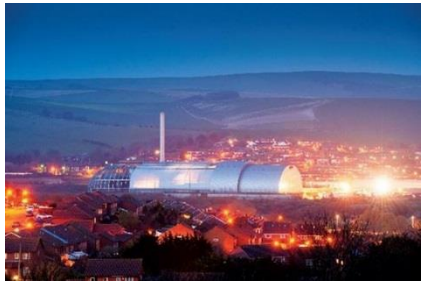
- Sujith Kollamthodi – Sustainable Transport Practice Director
  - *20 years' experience in transport sector*
  - *Fuel production and supply infrastructure*
  - *Advance biofuels for transport*
  - *Alternative fuels and emissions abatement*

Ricardo Energy & Environment

- Internationally-renowned consultancy focusing on clean energy and environmental issues
  - *Over 3,000 scientists, engineers and economists*
- Advisor to ADB, World Bank, development agencies and national governments on energy and environmental issues
- Lead Consultant to EU on transport sector emissions & modelling
- Transaction advisory support to governments and private sector in the establishment of new energy, waste and power projects
- Presented at ADB / ADFIAP workshop on the role of NDFIs to improve readiness for climate finance
- Ongoing support to numerous countries in the implementation of NDCs

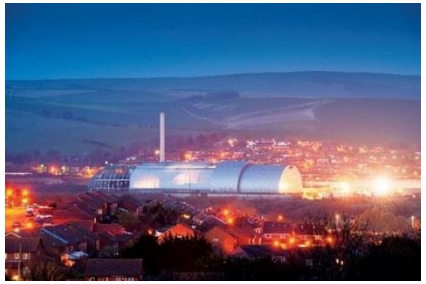
Our Waste to Energy track record

- South Australia / Cairo / Riyadh
  - *Waste management strategy & technology evidence base*
  - *Stakeholder engagement & capacity building*
  - *Legislation & regulation updates*
- Environmental Technology Institute
  - *Global waste to energy technology horizon scan*
- International Energy Agency
  - *Task lead 'integrating EfW into solid waste management'*
- Environmental Services Association
  - *Potential health & environmental effects of EfW facilities*
- UK Government
  - *Heat mapping opportunities to operate as EfW CHP*
  - *Principal auditor of Renewable Heat Incentive (RHI)*



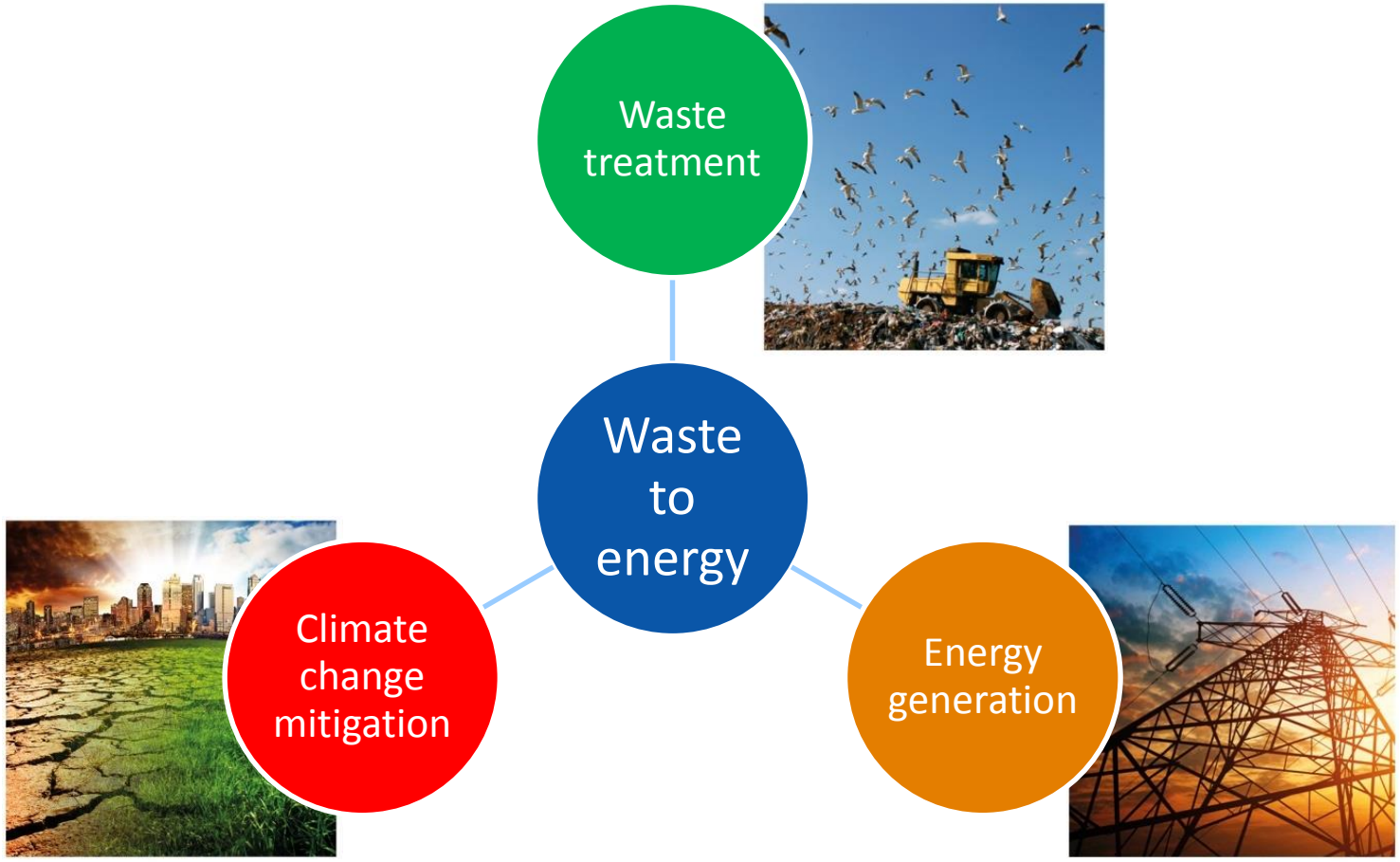
Our Waste to Energy track record

- Private Waste Companies & Investors
  - *Technology appraisals & due diligence (Australia)*
  - *Investor option assessments & feedstock studies*
- Transport sector projects
  - *Cost effectiveness of waste and gaseous fuels in transport*
  - *The role of biomethane and natural gas in the transport sector*
  - *Oversight of demonstration projects for advanced waste-derived renewable transport fuel production plants*
- ADB sponsored projects
  - *National Biomass Heat Supply Development Strategy for China*
  - *Peer review of Solid Waste Management strategy for Kolkata*
  - *Technology due diligence on advanced fuels in Mongolia*



Waste to Energy is more than a waste treatment solution

Waste to Energy offers a triple win .....



Today's workshop format

- We want this to be informal & flexible to suit your needs
  - *BUT we do have a very busy agenda so good time keeping will be key*
- Today's workshop has 2 key themes
  - *Opening remarks to set the scene in each session*
  - *Technology case studies & Q&A*

- This workshop requires your interaction
  - *Questions will be asked during the session*
  - *You will be invited to vote on these questions*
  - *After the workshop we will share all of the slides & feedback from the 'live voting'*

Workshop agenda

Time	Agenda
09.00 – 09.20	Welcome & Opening Remarks
09:20 – 10:30	Session 1: WtE - Heat and Power
10.30 – 11.00	Coffee break and networking
11.00 – 12.10	Session 2: WtE - Transport Fuels
12.10 – 12.30	Open debate and questions

Workshop etiquette

Phones on silent
Please let others speak
Get involved in the debates

Session 1: WtE – Heat and Power

Asia Clean Energy Forum 2017

Kathryn Warren
Principal Consultant
6th June 2017, Manila, Philippines

Global Mega Trends

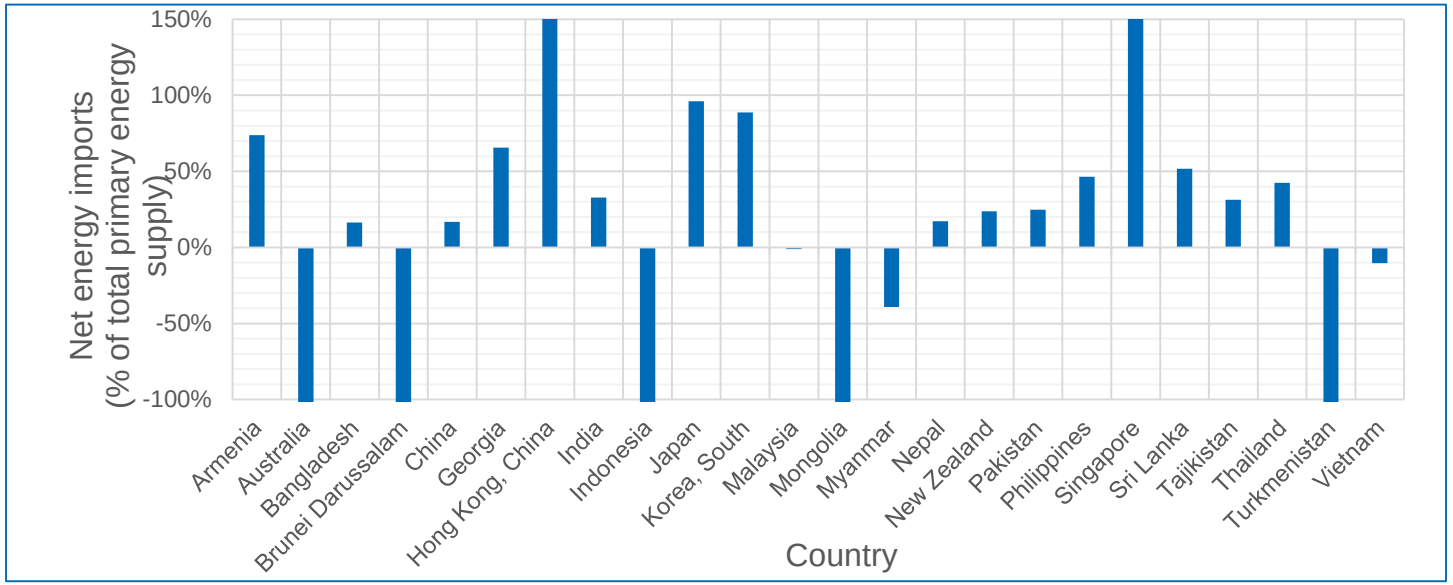
- Population growth continues

- The world is urbanising
  - *Cities will increase from 3.6bn people to 6.3bn in the next 40 years*
  - *Cities expect to house 2/3 of worlds people in 30 yrs*

- Putting strain on urban infrastructure resulting in poor environmental and public health
  - *AQ in China & India*
  - *Lower Life expectancy in Africa*

- Changing Consumer Behaviour (increasingly “Western”) is creating higher per capita waste generation

Energy supply issues in Asia



Source: *Key World Energy Statistics 2015,* IEA

- Many ADB member countries are dependent upon energy imports to meet demand for energy .....

Residual Waste Options - Power and Heat

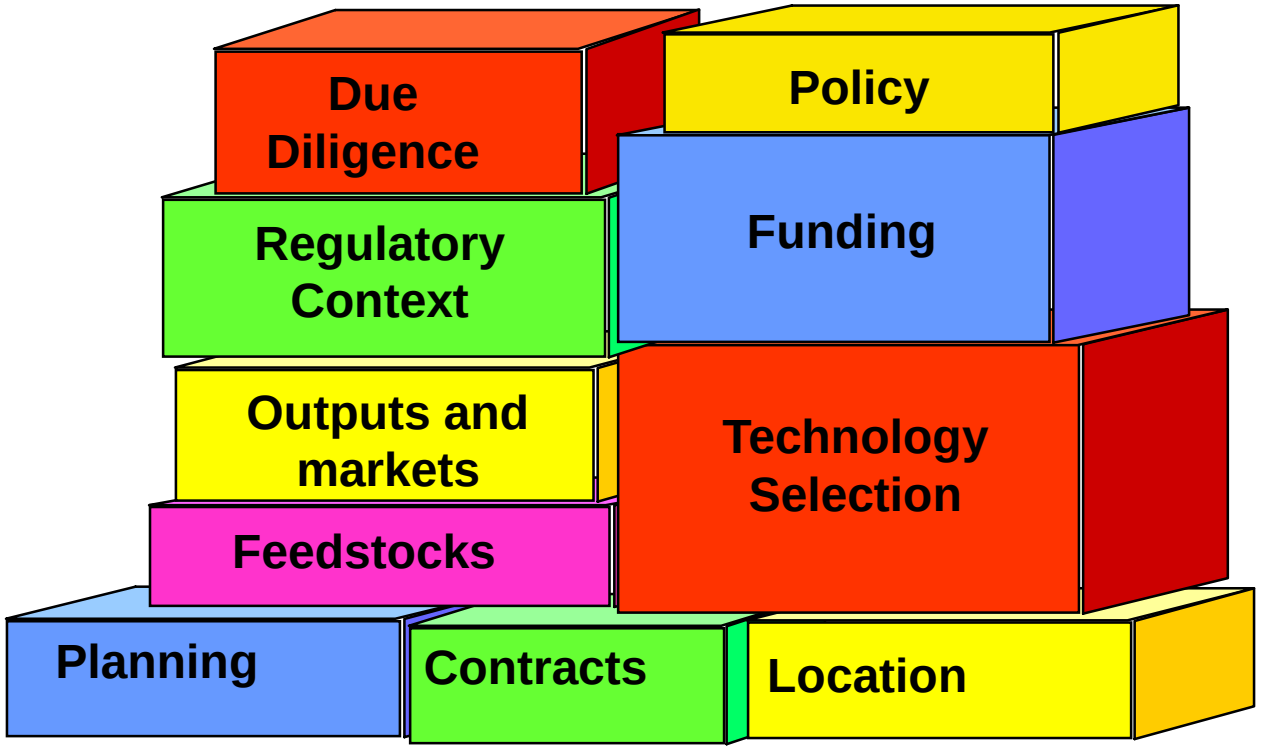
Biological Treatment

Thermal treatment

From Waste to Resource – Identifying the value in waste

- Producing Energy - heat/electricity
  - *Further utilisation of energy from waste*
  - *Advanced thermal treatment options*
- Producing Fuels
  - *Diesel / Petrol / Kerosene*
  - *Gas: bio-methane/ gas to grid*
  - *SRF to cement industry*
- Creating Products
  - *Chemicals*
  - *Hydrogen*
  - *Methane*

Building blocks



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QUESTIONS

CNIM: the approach for WtE market

Proven and robust thermal treatment of residual waste

ASIA CLEAN ENERGY FORUM 2017
Manila 6th of June 2017

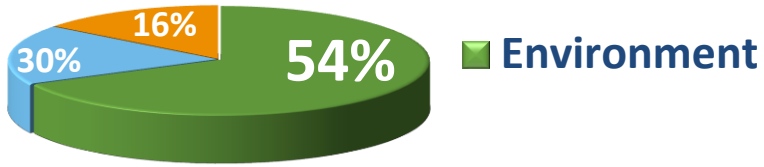
Jean Marc ERIGNOUX
Business Development Director for ASIA

jean-marc.erignoux@cnim.com

CNIM
INNOVATE AND ACT

CNIM Group - key figures

- French Family Owned Company
- 2015 revenue: **€ 727 million**
- Revenue **by sector**:



- Employees: 3,000
- Listed on the stock exchange since **1986**

For its Environment Business, CNIM has 5 MAIN ACTIVITIES :

1. **Turn Key EPC**
2. **Flue Gas Treatment**
3. **Retrofit of plants**
4. **O&M**
5. **Project (Co) Financing**

- For more than **50 years** , CNIM has Designed, Engineered and built more than **160 WTE** plants and more than **110 Biomass** Plants on all continents
- CNIM has designed and built more than **420 Flue Gas** Treatment units
- CNIM is **O&M 19 WTE** line across the world
- CNIM is **N°1 in Europe** for WTE EPC and likely in the **Top3 Worldwide**

How to build a WTE project ?

1 - Key fundamentals

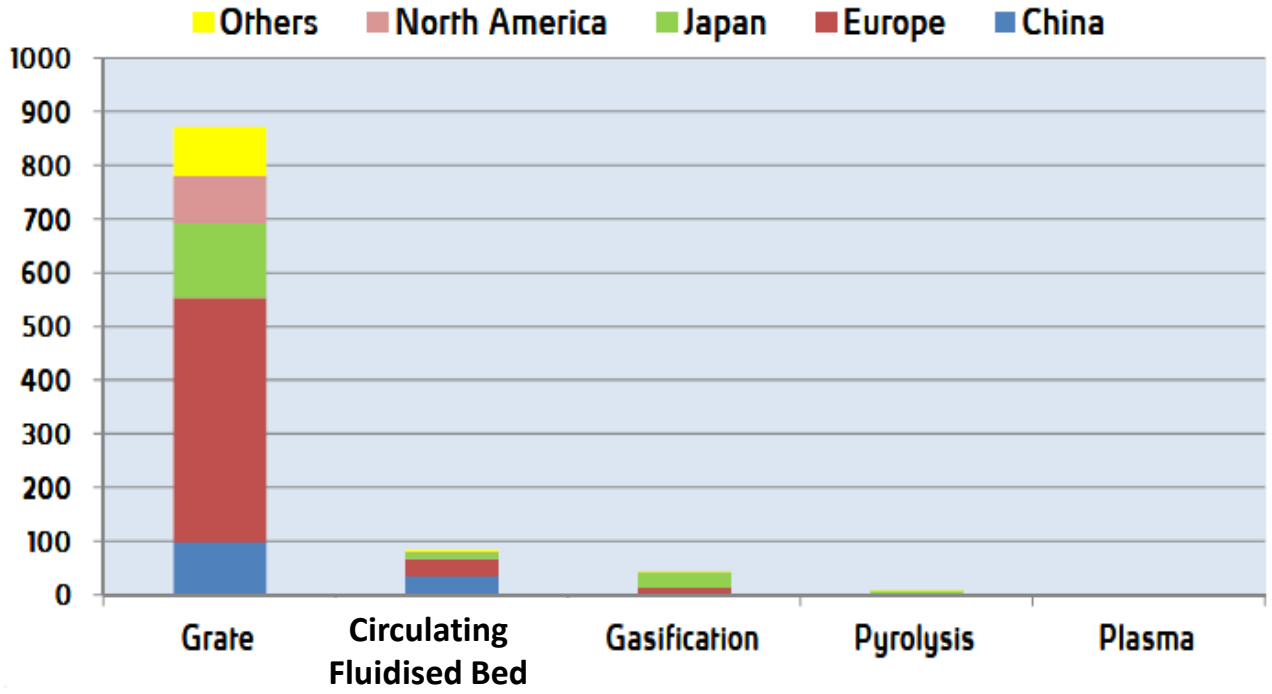
2 - Case Study

Conditions for a successful project

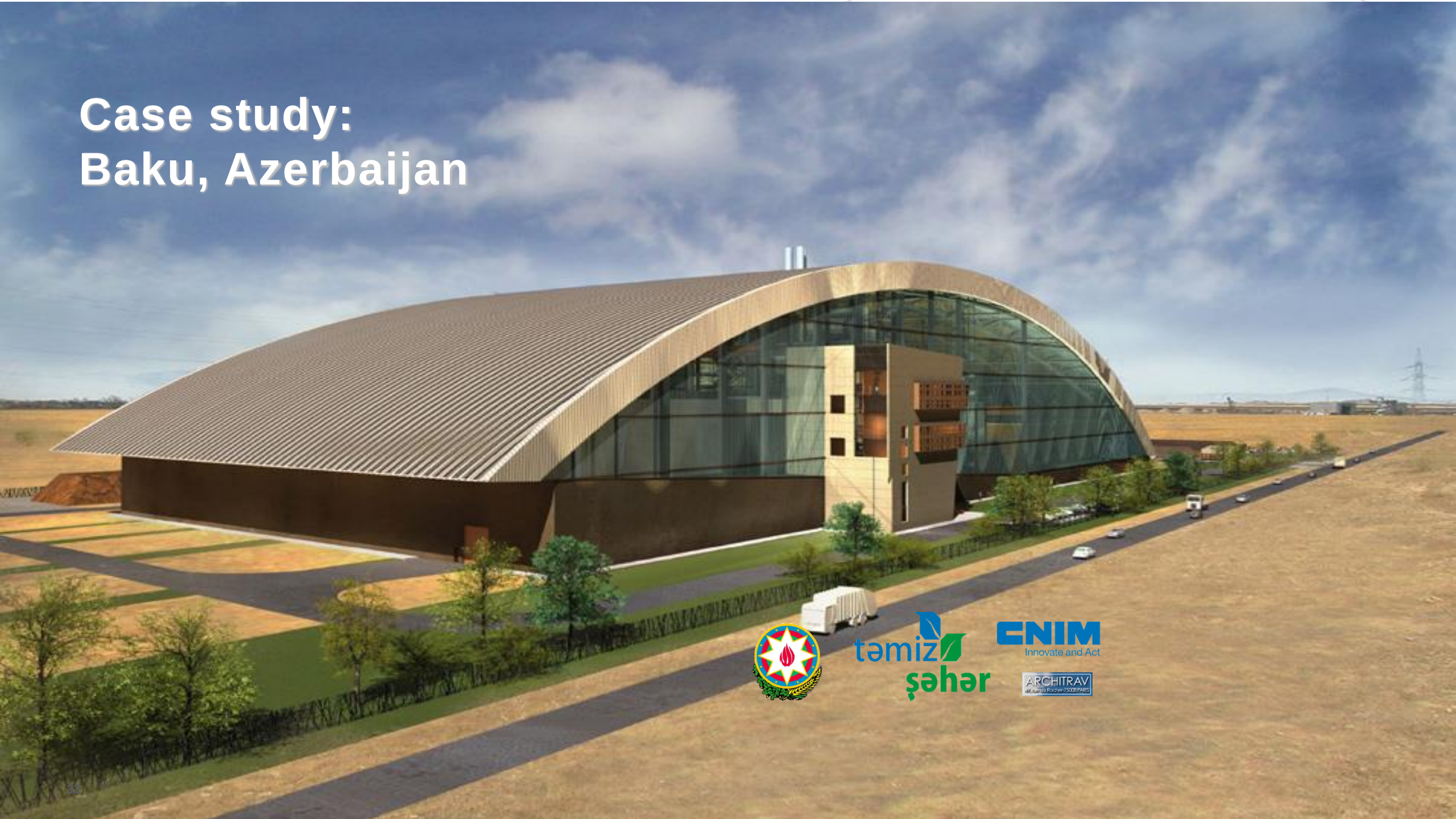
- Adapted, coherent and effective legislation
- Site
  - Public acceptance, access, availability of energy users
- Secured waste feedstock
  - Ownership, quality, quantity , origin, mix , seasonality
- Fair contracts
  - Electricity and/or heat sale : price, indexation, inflation, penalties, obligation, responsibilities…
  - Gate fee (never 0!) : price, inflation, penalties, obligation, responsibilities …
  - Appropriate procurement mode and (long-term) financing
  - Proven and robust Technology
  - Flexibility, availability, performances
- Risks understanding
- Experienced operator

Proven and robust technique

Number of plants in commercial operation (> 5t/h) - Source : Ecoprog

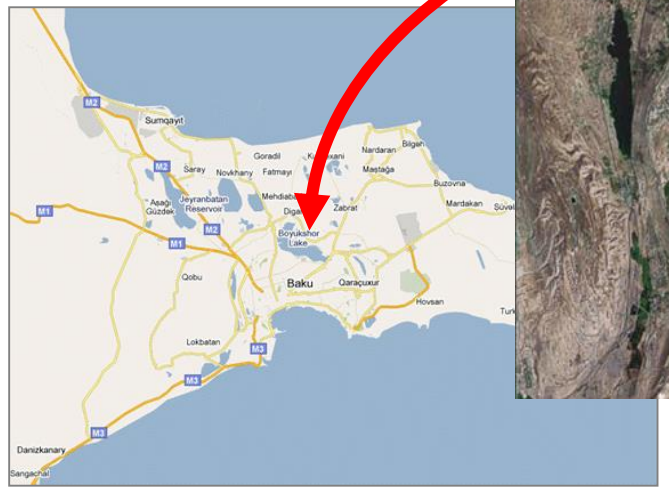


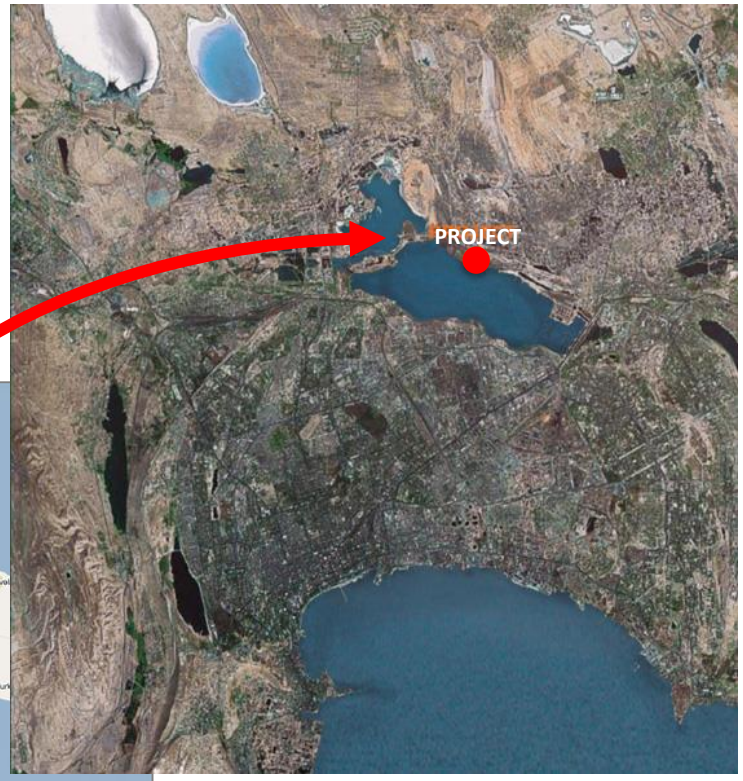
Case study:
Baku, Azerbaijan



Site Location

- Site : **BALAKHANI, Azerbaijan**
- A few km North to the city of BAKU
- Road nearby connected to main highway & secondary network





Initial situation

Baku / Balakhani Landfill in 2006 - 2007

An environmental “problem”

Project delivery

- 2007-2008:
  - Feasibility Study: Extensive engineering studies, waste characterization, site location, architectural concept … and in parallel legislation adaptation (collection, ownership...)
  - Tendering process and project development;
  - Technical, operational and legal negotiations.
  - EPC and O&M contract signature
  - Financing from the Azerbaijan State and Islamic Development Bank
- 2009-2013:
  - Official incorporation of Tamiz Şəhər (Azerbaijani State Waste management company)
  - Construction of a waste recycling facility;
  - Tamiz Şəhər takes over W-t-E plant assets.

November 2009

March 2011

May 2012

Proven and robust technique

- Grate-fired furnace with integrated boiler
- Very flexible
  - No preparation required
  - No left out (almost all sorting residues accepted)
  - MSW Similar waste accepted (Commercial & Industrial, Sewage sludges, Hospital waste …)
  - Very large possible NCV's (design 6-16 MJ/kg)
  - Wide NCV range in operation (grate diagram (6-12 MJ/kg)
  - Wide accepted range of pollutants (quality and concentration)
- High energy recovery efficiency (> 82-85%)
- High availability
  - > 8200 hr/y
  - Long life span (30-45 years)

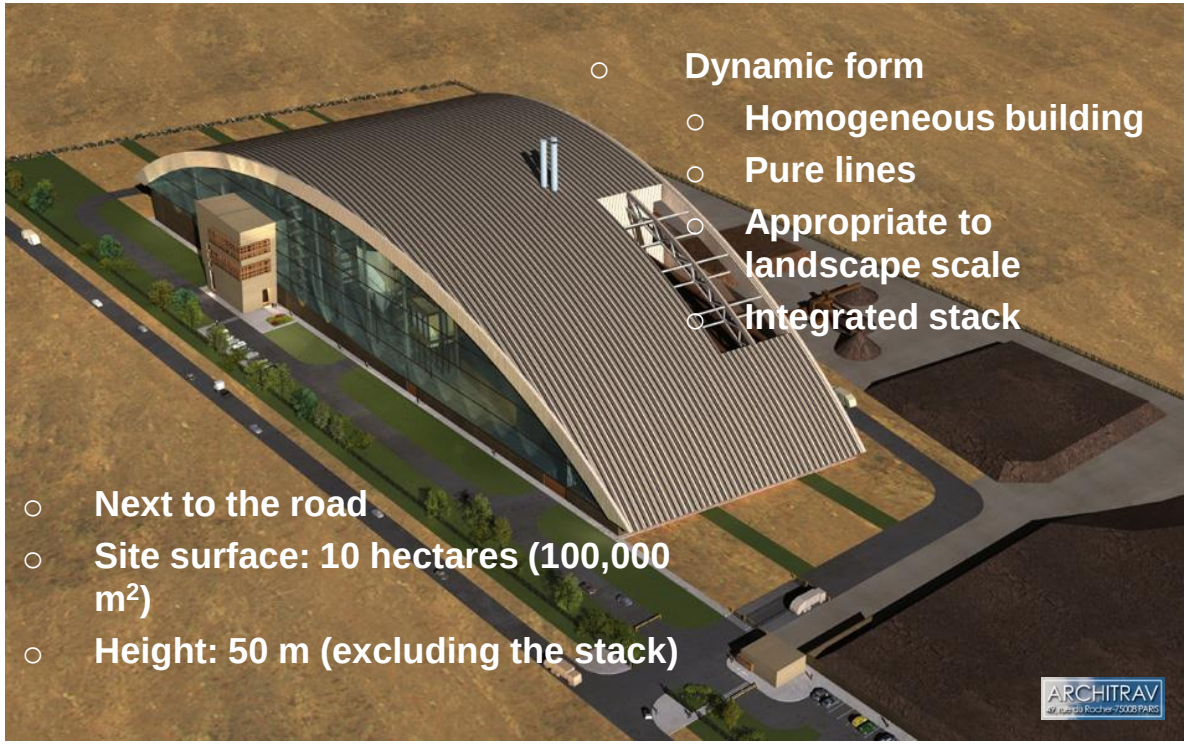
BAKU W-t-E plant (Azerbaijan)

CLIENT	Ministry of Economic Development of Azerbaijan and Təmiz Şəhər, a Fully state owned Joint Stock Company
Plant location	Balakhani, BAKU, Azerbaijan
CNIM contract	Design and Turnkey construction, Operation and Maintenance for 20 years (DBO)
Commissioned in	2013
TECHNOLOGIES	
Waste treatment	Mass-burn grate combustion
Grate type	CNIM/MARTIN reverse acting grate
Energy recovery	CNIM Vertical steam boiler and Condensing steam turbine
Flue Gas Treatment	LAB group CNIM FGT with semi-dry system - Injection of lime milk and activated carbon – Bag house filter and SNCR deNOx with urea injection in the furnace

Technical Data

Main technical data	
Annual capacity of Municipal Solid Waste and Clinical Waste incineration	500.000 t MSW/year +10.000 t CW/y
Number of lines	2 identical
Nominal NCV	8,5 MJ/kg
Thermal power	2 x 78 = 156 MW_{th}
Total nominal incineration capacity	2 x 33 = 66 t/h
Total steam production	184 t/h
Steam pressure	40 bar(a)
Steam temperature	400 ° C
Steam turbine power	40 MW_e

Architectural Concept



- Dynamic form
  - Homogeneous building
  - Pure lines
  - Appropriate to landscape scale
  - Integrated stack

- Next to the road
- Site surface: 10 hectares (100,000 m^2)
- Height: 50 m (excluding the stack)

Challenges - construction

- The construction staffing peaked at 1200 people (900 Azerbaijani, 300 Turkish).
- The W-t-E plant site covers 10 ha including 2,5 ha for the main building (250 x 100 x 50 m) and 2,5 ha for ash maturation
- The bunker is 75 meters long. The plant has a waste processing capability of 70 trucks per hour with a turnaround time of less than 20 minutes each.
- Other construction data:
  - Earthwork 90 000 m3
  - Reinforced concrete 37 000 m3
  - Cladding 17 000 m2
  - Roofing 6 000 m2
  - Roads 6 000 m2
  - Cabling 510 km

People

- Staff : 90 persons
  - Operation 50 people
    - 30 in Shift (6 x 5 people)
    - 20 (cleaners, guards, quality, bottom ash …)
  - Maintenance 25 people
    - Electricians, mechanics, monitoring and control experts, planners
  - Management and Administration 15 people
- Local employees : More than 80
- Shift supervisors trained on simulator then in plants operated by CNIM in France or UK
- Administrative and maintenance staff selected during the erection phase

Electricity-from-Waste

- Net to the grid and distributed to users : 231,500 MWh/a
- Which is the consumption of 100,000 Baku households
  - 20 % of Baku households consumption

European Commission ENDORSED the BAKU project as:

OFFICIAL PARTNER of the SUSTAINABLE ENERGY EUROPE Campaign

Potential risks ……

Typical risks sharing	"Lots"	"EPC"	"Private operation"	"BOT"	"Merchant plant"
1- Plant design & construction	Public	***Private***	***Private***	***Private***	***Private***
2- Performances & availability during operation	Public	Public	***Private***	***Private***	***Private***
3- Financing	Public	Public	Public	***Private***	***Private***
4- "Demand" risks (waste supply, laws,..)	Public	Public	Public	Public	***Private***
Risk :	***PUBLIC***				***PRIVATE***

Thank you

ASIA CLEAN ENERGY FORUM 2017
Manila 6th of June 2017

Jean Marc ERIGNOUX
Business Development Director for ASIA

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Energy from Waste – Benefits for the Asian Market

Wheelabrator Technologies

2017 Asia Clean Energy Forum

Phil Short, Senior International Development Manager

June 6, 2017

Wheelabrator TECHNOLOGIES

Wheelabrator Technologies

Company Profile

Key Stats

Second largest energy-from-waste player in the U.S.

Operating Performance:

- ~7.5m annual waste processing capacity
- 853MW combined electric generating capacity – enough to power 805,000 homes in addition to our operations
- 92.3% availability
- 17 certified VPP Star Worksites

Power Assets:

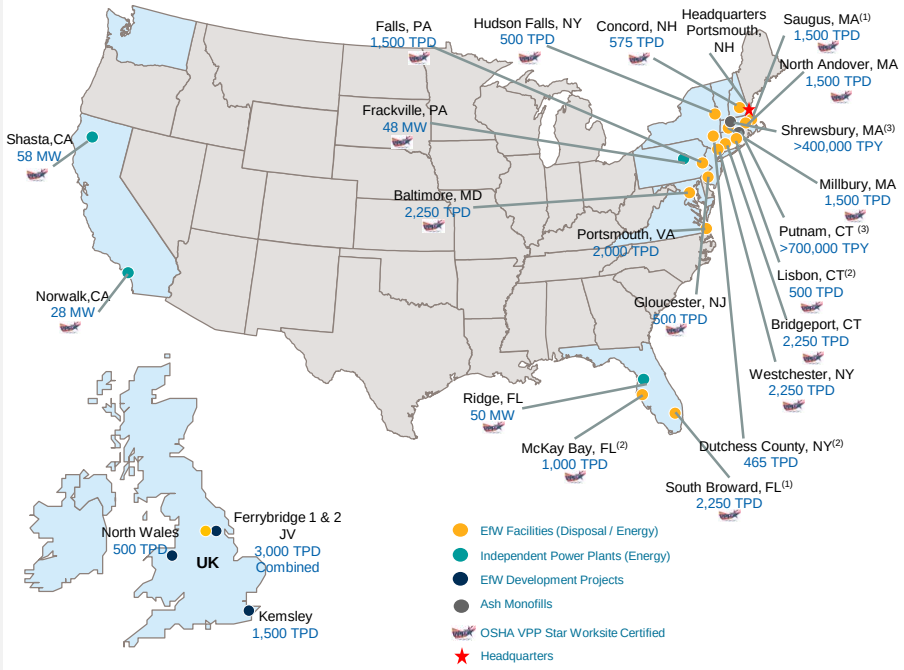
Fleet of 20 operating assets

- 16 operating EfW in U.S. & U.K.
- 4 independent power plants
- 3 development projects in U.K.

Non Power Assets:

- 4 ash monofills
- 2 advanced metals recovery in addition to in-plant systems

Operating Assets



Wheelabrator's Vision & Values

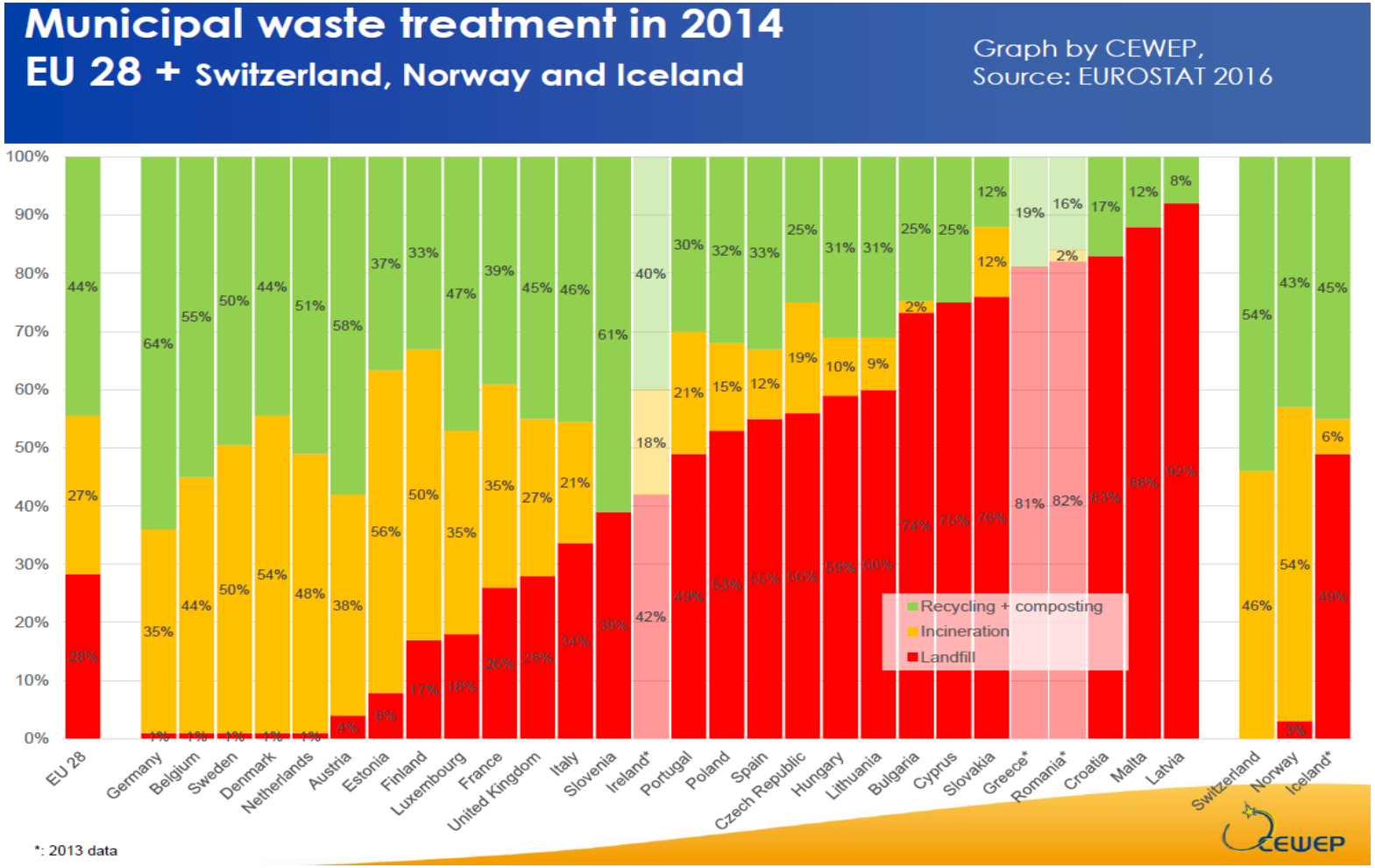
Being part of the solution, whatever that may be

Wheelabrator TECHNOLOGIES

"To Develop, Deliver and Realize The Potential of Clean Energy"

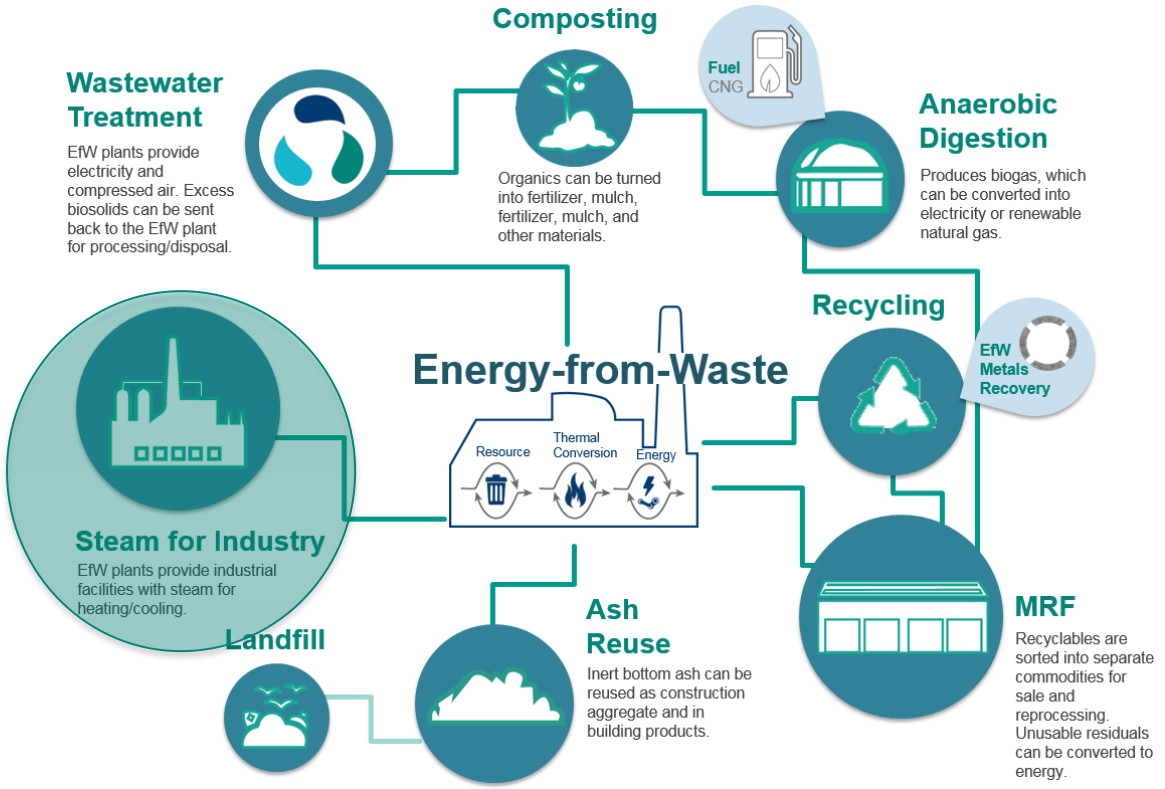
Energy-from-Waste & Recycling

Complementary Processes



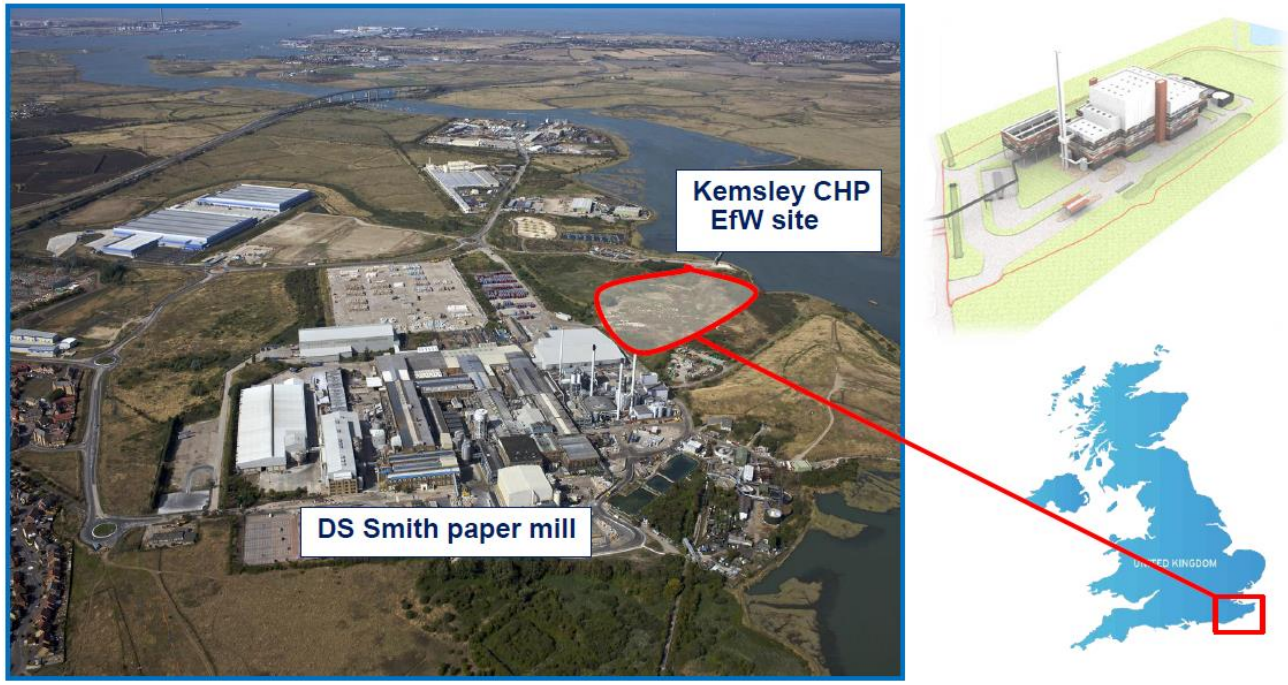
Energy-from-Waste Plays A Key Role

Integrated sustainable waste management system



CHP Case Study

Kemsley CHP Facility, Kent, UK



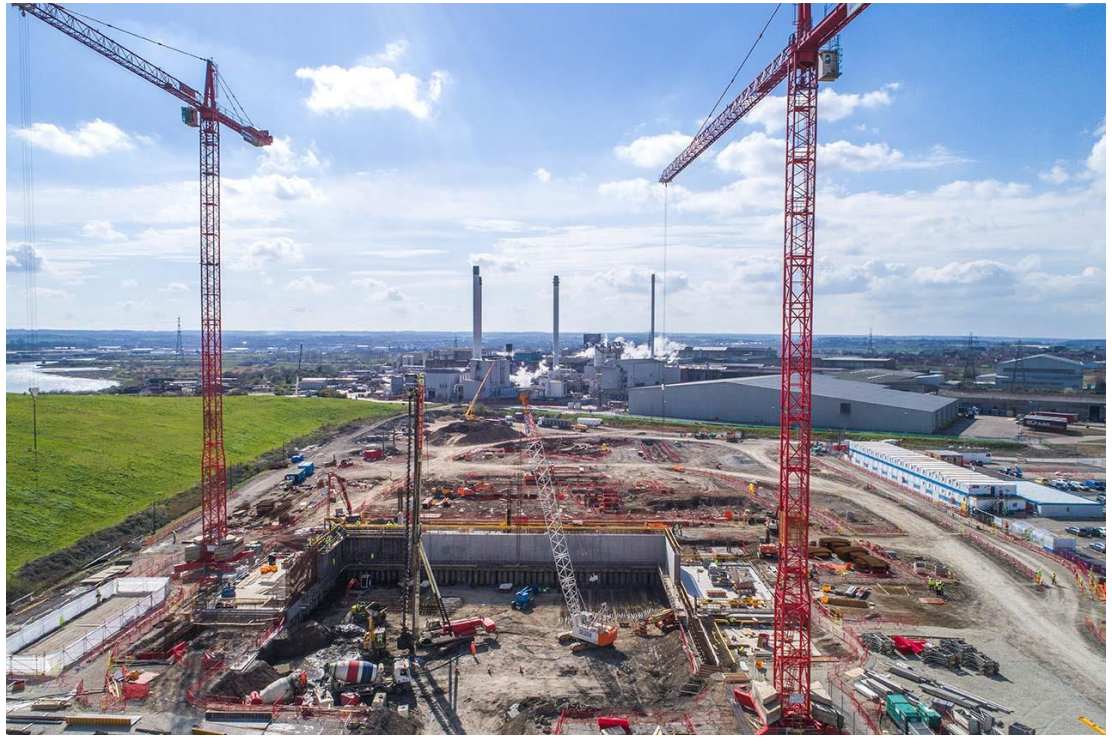
CHP Case Study

Kemsley CHP Facility, Kent, UK

- Kemsley (K3) CHP EfW is a merchant / privately contracted project located in Kent, S.E. England
- The EfW will act as the third power station (hence ‘K3’) supplying heat to the adjacent paper mill operated by DS Smith
- Electrical power will be sold to the National Grid
- Its combined heat and power (CHP) status makes the facility eligible for Government support and the project has secured a Contract for Difference subsidy for the renewable portion of the fuel
- The project is currently in construction and is due to be operational in 2019

CHP Case Study

Kemsley CHP Facility, Kent, UK

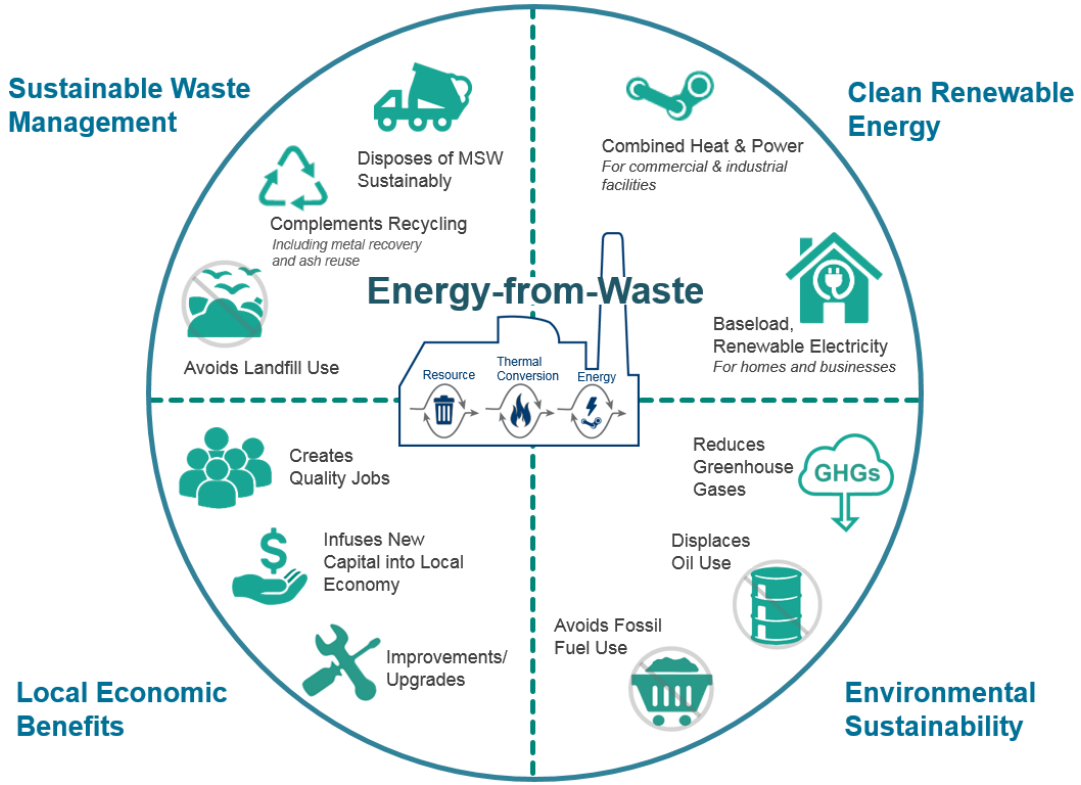


CHP Case Study

Kemsley CHP Facility, Kent, UK

Energy-from-Waste Drives Sustainability

Serving society's changing and diverse needs



THANK YOU

Phil Short

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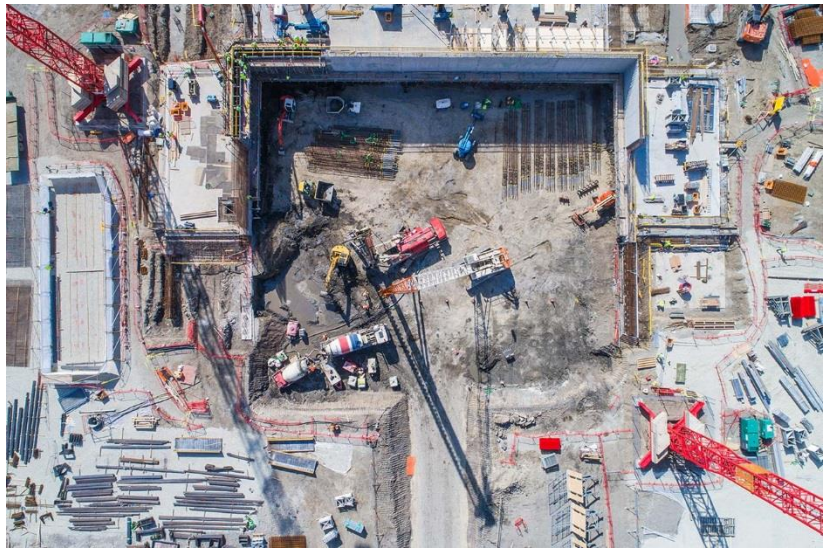
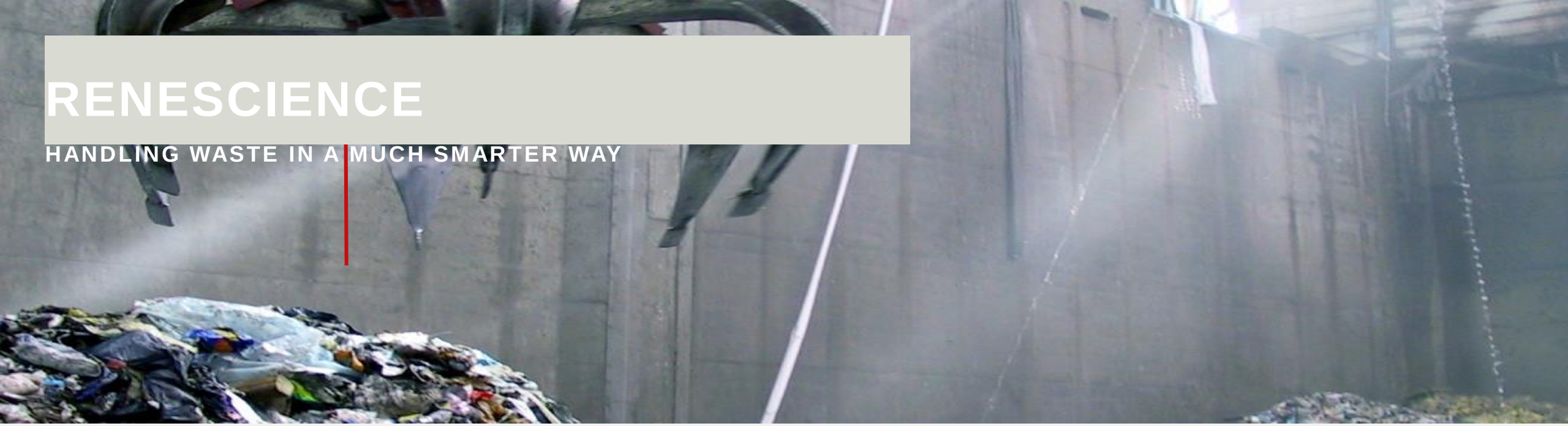




RENESCIENCE

HANDLING WASTE IN A MUCH SMARTER WAY

Lars Kruse

Global Sales Director,
New Bio Solutions,
Bioenergy & Thermal Power

June 6, 2017

larku@dongenergy.dk

DONG energy

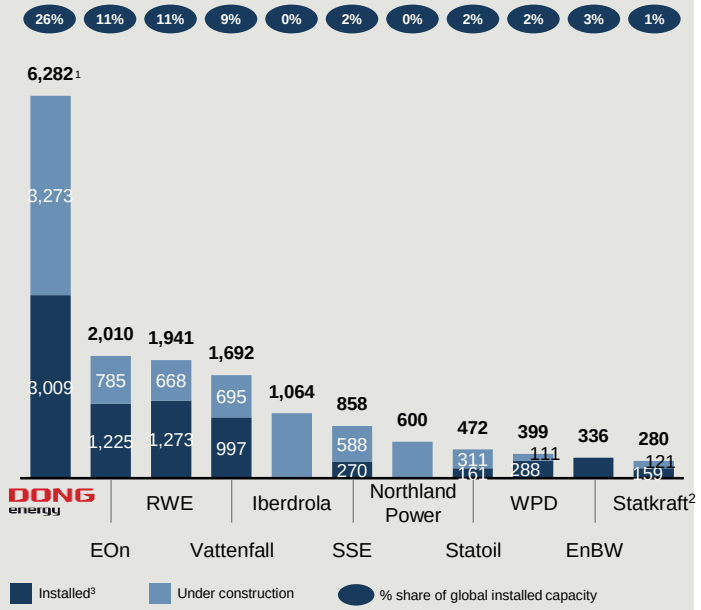
DONG Energy has transformed into a Green Company

Key figures Q1 2017:

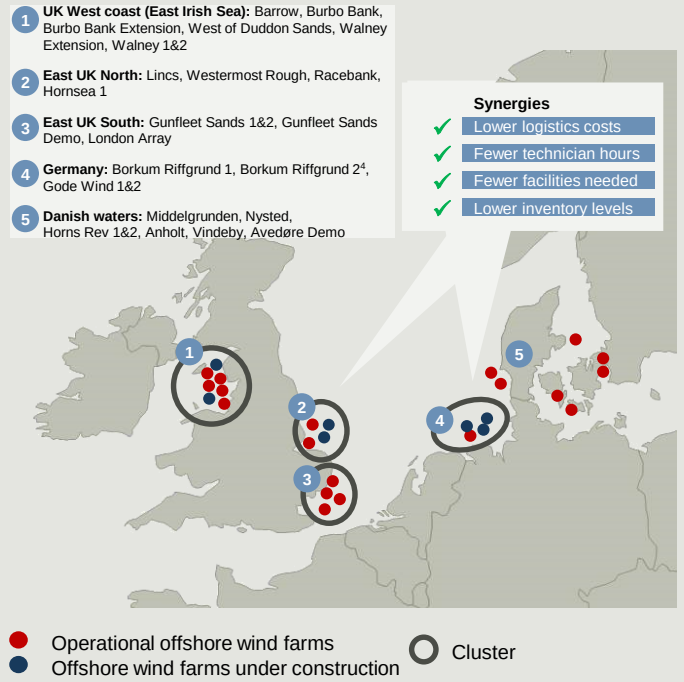
- USD 2.5 bn Revenue
- USD 0.5bn EBITDA;
- 2017 outlook USD 2.3 bn EBITDA
- ~6000 employees

DONG Energy pioneered the offshore wind industry and is today the global leader

Largest offshore wind player globally today
Global offshore wind capacity
MW



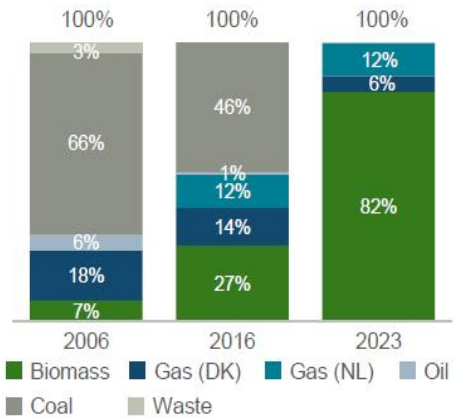
Wind Power's scale enables cluster synergies



Bioenergy & Thermal Power will exit coal by 2023

Biomass conversions facilitate zero coal from 2023

DONG Energy fuel composition (%)



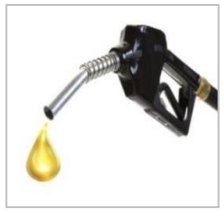
Coal may be used in force majeure circumstances

First major utility to fully exit coal

- Putting further action behind DONG Energy's vision for leading the energy transformation
- Heat customers support early coal phase-out

Global megatrends require new solutions to waste management

Global megatrends



Resource scarcity

- Optimise resource utilisation
- Reduce dependency on imported energy

Urbanisation

- Waste challenge for cities
- Increasing energy consumption per capita

Climate change

- Regional and national CO_2 reduction targets
- Government and private demand for green technologies

REnescience green credentials

Circular economy

Household waste is transformed into:

2/3 climate friendly recyclables and energy production:

- Recyclables
- Green gas
- Climate friendly power

1/3 environmentally friendly disposal/recycled of residue containing

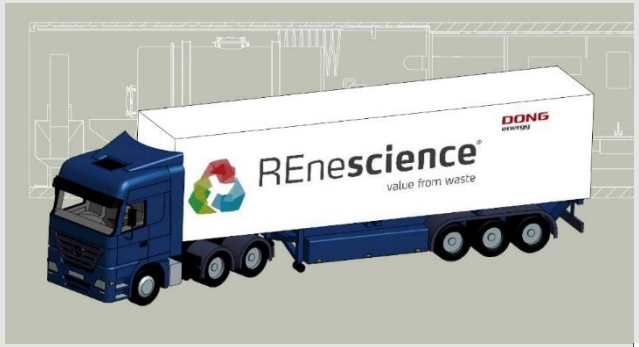
- Digestate

REnescience value from waste

DONG energy


REnescience
value from waste

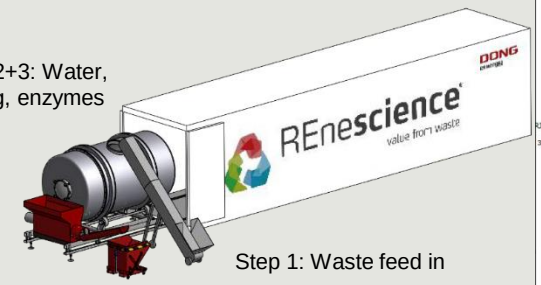
REnescience – Mobile Unit (REMO), tested Malaysian waste



Configuration:

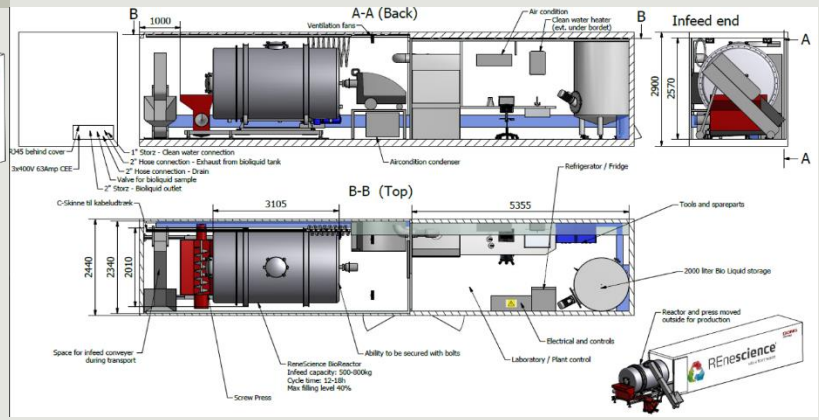
- Complete unit built in one 40” container
- Capacity: ~ 1 t/d MSW
- Technology: Batch reactor, and screw press
- Output: Bio Liquid and solids, focus primarily on biogas potential
- Built-in small-scale laboratory

Step 2+3: Water, mixing, enzymes



Step 1: Waste feed in

Step 4: Separation of liquid and solids



REnescience
value from waste

DONG energy

Mobile Testing Unit
Malaysia campaign

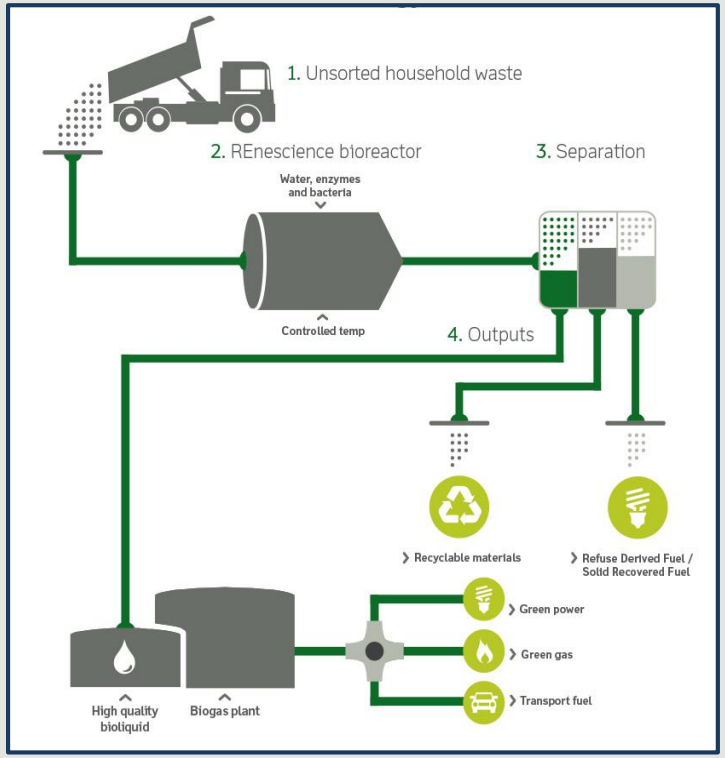
SRF/RDF

Biogas

REnescience
value from waste

DONG energy

REnescience – suitable for high moisture waste



REnescience value from waste

Bio-liquid

- Highly active for biogas production
- Storable and low dry matter
- Easily upgraded to green gas
- Easily burned for green power

2D fraction

- Plastic foils and textiles
- Adapt for storing and recycling
- Useable as SRF/RDF
- High calorific value

3D fraction

- Plastics and metals
- Potential for sorting and recycling
- Clean and dry product
- Can be mixed with 2D for SRF/RDF

DONG energy

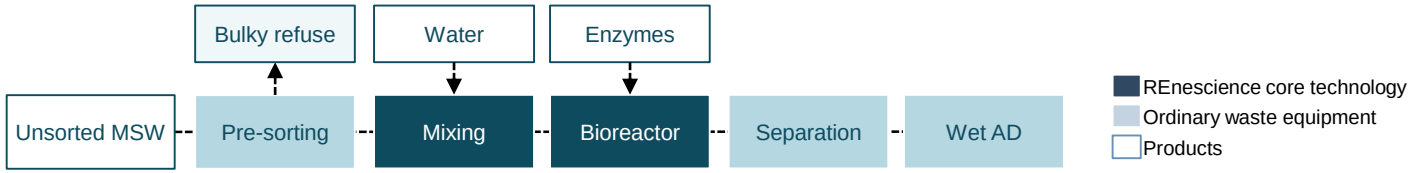
REnescience – Innovation and core technology

Enzymatic process

- Enzymes
  - Act as biological catalyst accelerating degradation of organic elements
  - Assay optimised to waste composition (dosage and cocktail)
  - Cleaning agent (e.g. elimination of labels and adhesives)
- Bio-liquid
  - Low viscosity
  - High biogas potential (high VS, high COD)
  - Limited/no suspended solids

Bio-mechanical separation

- Closed bio-reactor designed for optimal enzymes activity and waste throughput
- Non-thermal process
- Safe operations
  - No CH_4 emission before AD (pH<7)
  - Slow moving and rotating equipment
  - Continuous operations (no batch)
- Gentle process that does not require material shredding
- **Flexible back-end optimised according to market economics (recycling vs. energy recovery)**



REnescience
value from waste

DONG energy

Challenges of Energy Recovery from Waste

Asian perspective

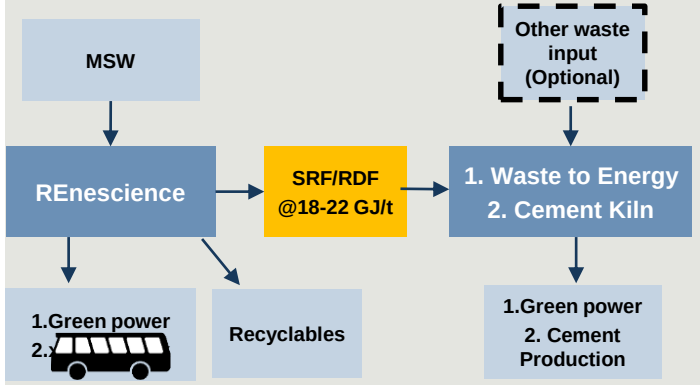
1. Low calorific value of waste
   - MSW contain high levels of organics fraction and moisture
   - Net calorific/heating value of waste (7-10 GJ/t) is much lower than fuels like natural gas and diesel

2. Composition of MSW
   - MSW is heterogeneous and quality of waste varies significantly

REnescience value from waste

Using REnescience as a pre-treatment can **increase overall efficiency of energy recovery** from waste whilst still achieving following :

- Volume reduction >90%
- Treating mixed MSW with low net calorific value
- Achieve recycling targets



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RENESCIENCE

HANDLING WASTE IN A MUCH SMARTER WAY

Lars Kruse & Sundus Cordelia Ramli

New Bio Solutions,
Bioenergy & Thermal Power
DONG Energy

June 6, 2017
Twitter : @DONGEnergy ; @sunramli

larku@dongenergy.dk ; sunra@dongenergy.dk

DONG energy

HARNESSING BIO-GAS ENERGY FROM KITCHEN WASTE FOR RENEWABLE AND SUSTAINABLE ENERGY

- Lead Researcher: Pema Youden
- Co-Researcher:Mr. Tshering, Basant Pradhan
- Supported by
  - AURG (2015-2016)
  - DRE (MoEA)
  - iGNHs (RUB)

OUTLINE

- Background
- Research Questions
- RESEARCH Output
  - Technical Overview
- Cost benefit analysis
  - Business case
- Feasibility of the project
  - How this could be replicated in other regions in Asia
- Challenges & Difficulties
- Conclusion

BACKGROUND

- Sustainable development (due to ecological, environmental and rapid depletion of natural resources)
- Global community and Country Policies are switching towards naturally renewable resources
- In CST 12.5 kW Solar-PV System is installed since 2014
- Biogas is an another renewable energy potential recognised in CST

RESEARCH QUESTIONS

- Compute biodegradable waste data ‘in campus’
- Study and Evaluate Anaerobic Digestion systems
- Design Anaerobic Digester
- Pilot the AD plant
- Cost benefit analysis

BIODEGRADABLE WASTE DATA IN CAMPUS

Average organic kitchen waste in kg (Year 2016)		
Two Semesters Data:	2294.34 kg/month	95 kg/Per Day(Avg')

AD SOLUTIONS

- Studied and Evaluated Anaerobic Digestion systems in the region
- Chosen TEAM (T ERI's Eenhanced Acidification and Methanation) technology with…..

PLANT CAPACITY (100 kg/day)						
Plant capacity (kg/day)	Waste density (kg/m3)	Volume (m3)	Water requirement (m3)-waste to water ratio -1:2	Total volume of reactor (m3)	Biogas yield (m3/kg)	Total gas generation (m3)
100	800	0.13	0.2	0.33	0.04	4

TECHNICAL OVERVIEW

- Biphasic TEAM Technology
- 1st Stage – Six Acidification Reactors
- 2nd Stage – BIOMETHANATION PHASE with UASB (Up-Flow Anaerobic Sludge Blanket)

PLANT OVERVIEW

INAUGURATED ON 16 March 2017

COST BENEFIT ANALYSIS (AFTER 3 MONTHS)

Sl.	Parameter		Average/day	Cost($)
	Input	Output		
1	Waste (kg)		100.17	0
2	Water (L)		210	1.2
3	Sodium Hydroxide (kg)		1	1.95
4	operator (Nu)		250	3.6
	Total input cost/day			6.75
5		Leachate (L)	189.53	
6		Bio fertilizer (kg)	60.29	9.0
7		Liquid Manure (L)	234.41	1.8
8		Gas (M^3)	3.13	2.7
	Total Income generated/day			13.5
Net Income/day				6.75
Net Income in year				2430
Plant cost				8824
Cost recovery				4 years

FEASIBILITY?

- In Bhutan
  - Institutions, Central School
  - Food Industries
  - Monasteries
  - Hotels and large cafeterias
- In other Asian regions
  - Please Contact TERI RESEARCH INSTITUTE

CHALLENGES & DIFFICULTIES

- Behaviour and psychological variables of participant and researcher
- Valuing the resources (limited experience)
- Implementation demands multi skills

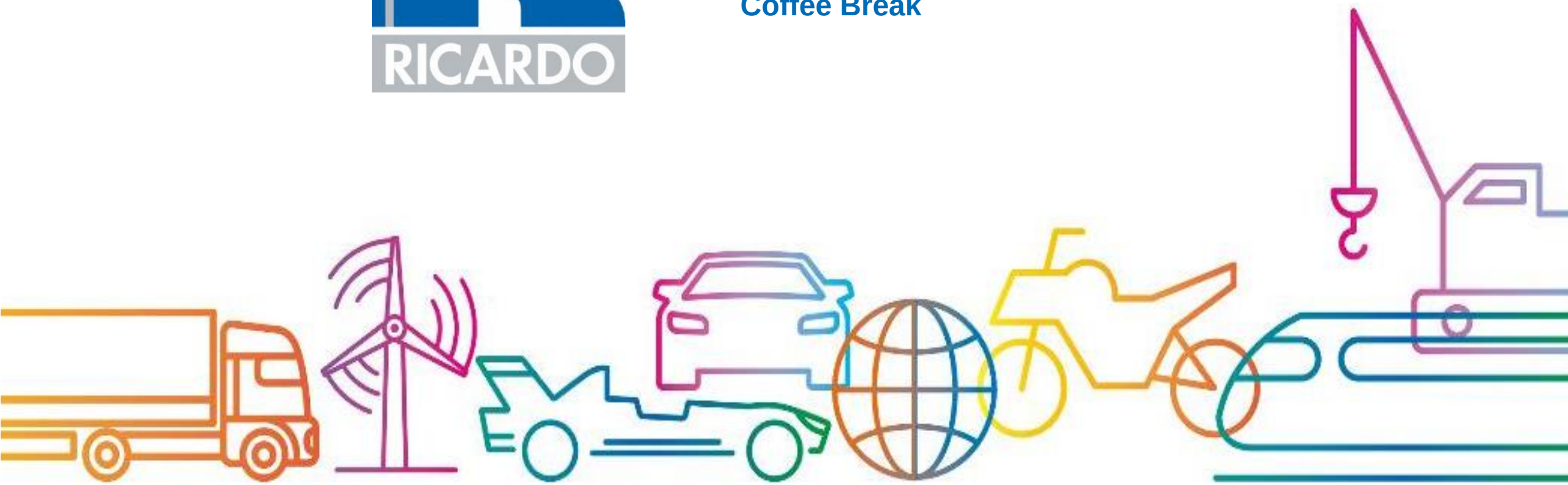
CONCLUSION

- Kitchen food waste which was going to landfill is now converted to bio gas, liquid manure and solid manure products

- Improved CST waste management system!!

THANK YOU ….

Coffee Break



Waste-derived transport fuels

6th June 2017

Ricardo
Energy & Environment

QUESTIONS

Waste-derived transport fuels

Sujith Kollamthodi

6th June 2017

Sustainability challenges facing the transport sector

- Transport is a significant contributor to global GHG emissions
- Also plays a major role in poor air quality in urban areas
- Energy security is also an issue - More than 95% of global energy for transport comes from petroleum-derived fuels
- Both supply-side and demand-side measures will be important for improving energy security and reducing environmental impact
- On the supply-side, alternative fuels will be important
  - *Electricity*
  - *Hydrogen*
  - *Renewable fuels (from crops and waste materials)*

Overview of waste-derived transport fuels

- Wide variety of different feedstocks can be used to produce different types of waste-derived fuels
- Examples include:
  - *Biodiesel produced from **used cooking oil (UCO)***
  - ***Anaerobic digestion** of organic waste material to produce **biomethane***
  - ***Fermentation of crop residues** to produce bio-alcohols*
  - ***Fermentation of food wastes** to produce bio-alcohols*
  - ***Gasification of refuse-derived fuel (RDF)** to produce ethanol*
  - ***Thermochemical processing of waste plastics** to produce heavy fuel oil and diesel*

Key factors when considering waste-derived fuels for the transport sector

- Is using the fuel in the transport sector the best option (e.g. would it be better used in the power or heat sectors)
- Are there sufficient financial incentives for operators to purchase waste-derived fuels instead of conventional fuels?
- Can the vehicle fleet use the resultant fuel?
- Has future demand for the fuel been secured?
- Is there sufficient financial backing to support the construction/operation of the necessary fuel production facilities?
- Has the sustainability of the fuel been properly assessed?

Advanced Plasma Power

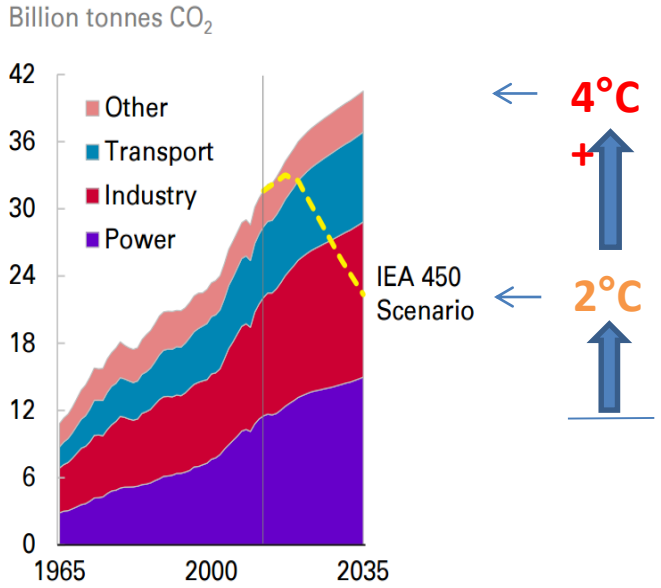
Transforming waste into energy and fuels™

Converting Waste Biomass into Transport Fuels using the Gasplasma® Process

Asia Clean Energy Forum 2017

Manila 5-8th June, 2017

The World Needs Low Carbon Energy Sources



- Without intervention global warming will exceed 4°C
- Paris Agreement 2015 sets binding commitment on 187 countries to limit to 2°C
- **Sustainable fuels production** from **waste** and **agricultural residues must** play **significant role**

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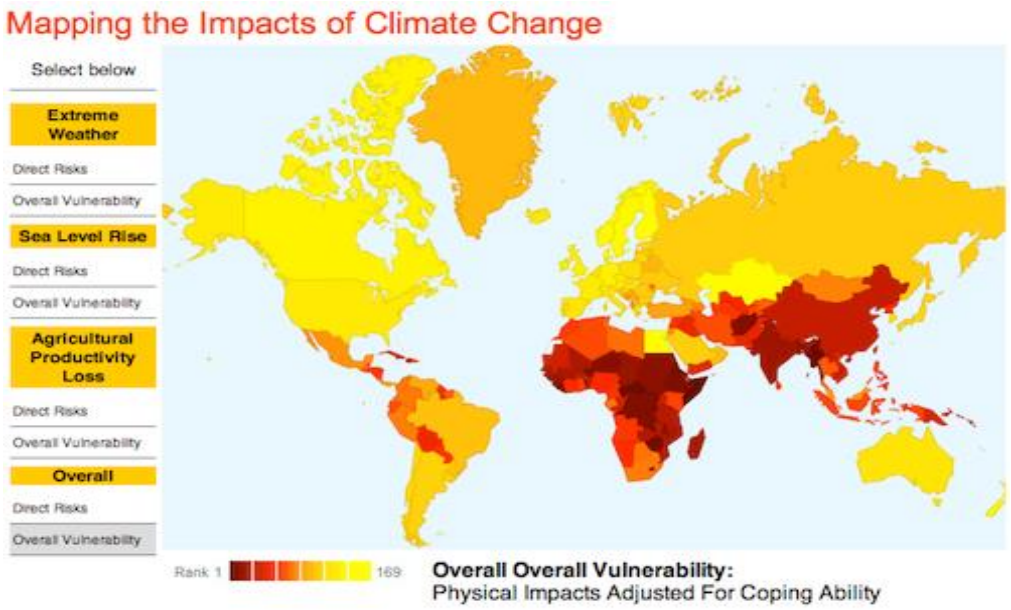
Climate Change Impacts most severe in Asia & Africa



Collective Global Responsibility to act now!

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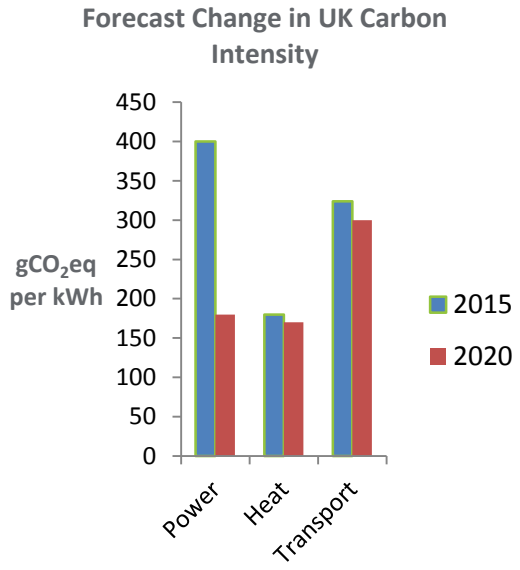
All Energy Sectors Need to Decarbonise



- 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**

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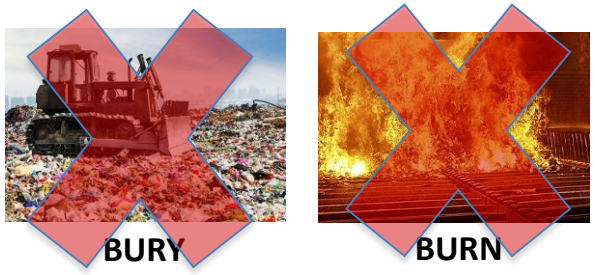
Disposing of Waste Sustainably is a Major Global Issue

	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
- No account taken of **landfill mining** (e.g. now included in EU Landfill Directive – 500,000+ landfills), **doubles opportunity**

"It's a shame to waste waste"



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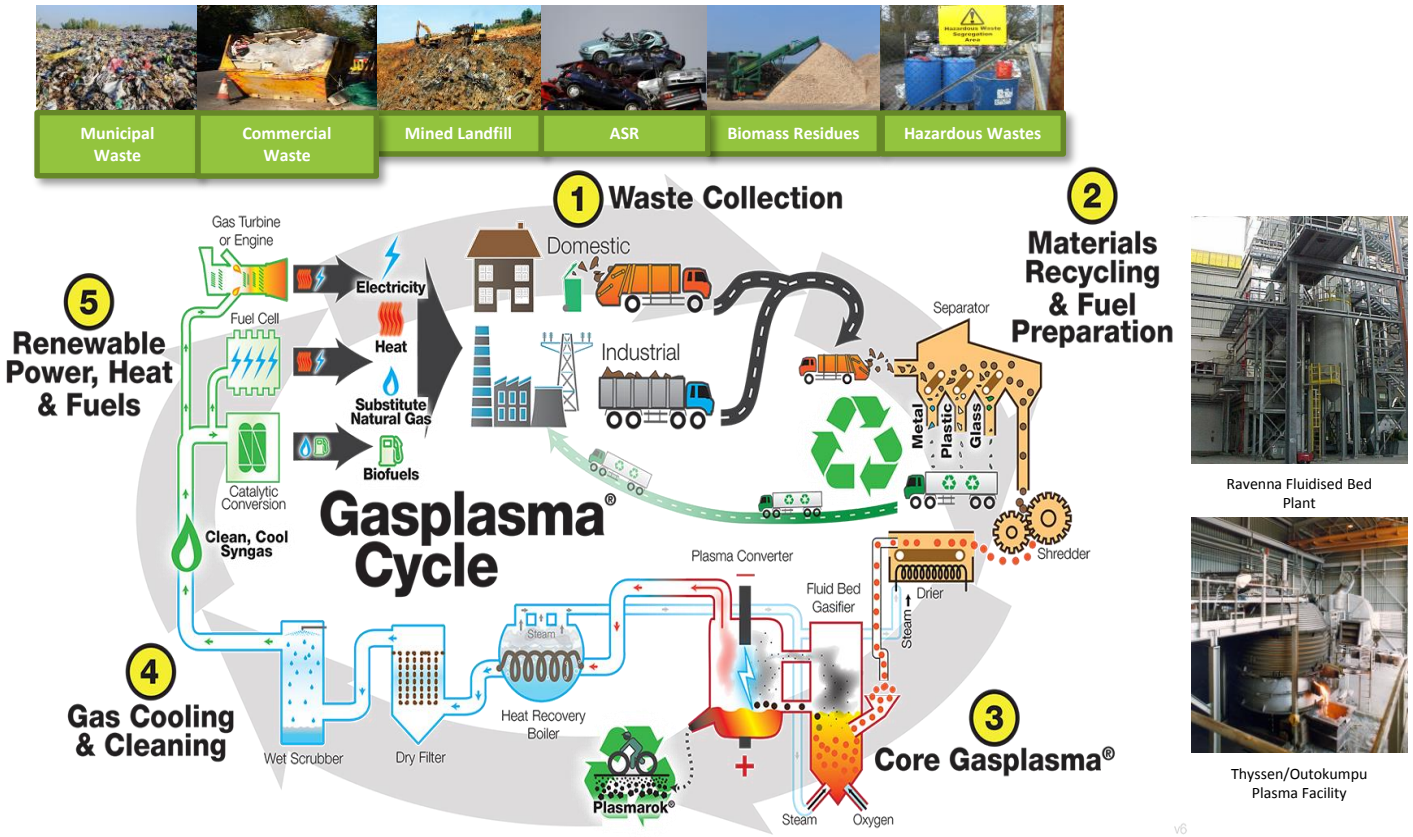
Other Abundant Waste Biomass Feedstocks

Feedstock	LHV (MJ/kg)	Current Feesdstock Supply (wet Mt/yr)			Expansion Post 2020?			Curent 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

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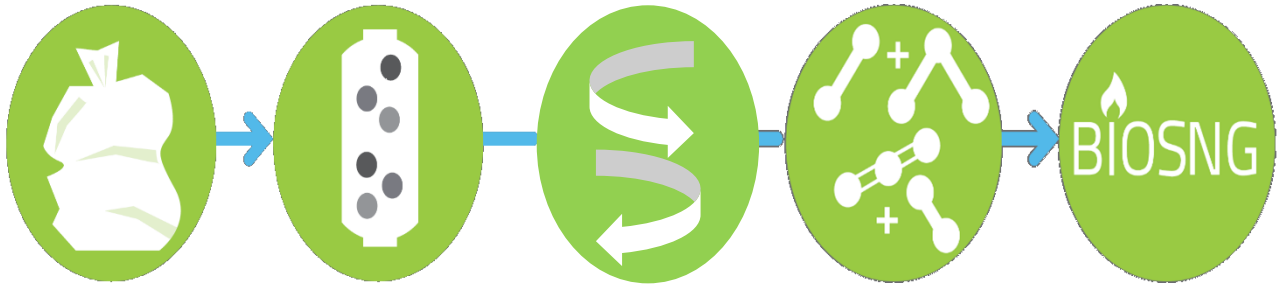
Ultimate Recycling – At Molecular Level



Recycle | Gasification | Gas Polishing | Gas Processing | The Product

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

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Delivered £5 Million Pilot Plant

- Delivered **on time and on budget**
- Producing **grid quality BioSNG** from RDF

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World's First Commercial Scale Waste to BioSNG Plant

nationalgrid Gas Distribution

Cadent Your Gas Network

Advanced Plasma Power

RIIO NIC NETWORK INNOVATION COMPETITION

Progressive energy

cng services ltd

Department for Transport

WALES&WEST UTILITIES

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

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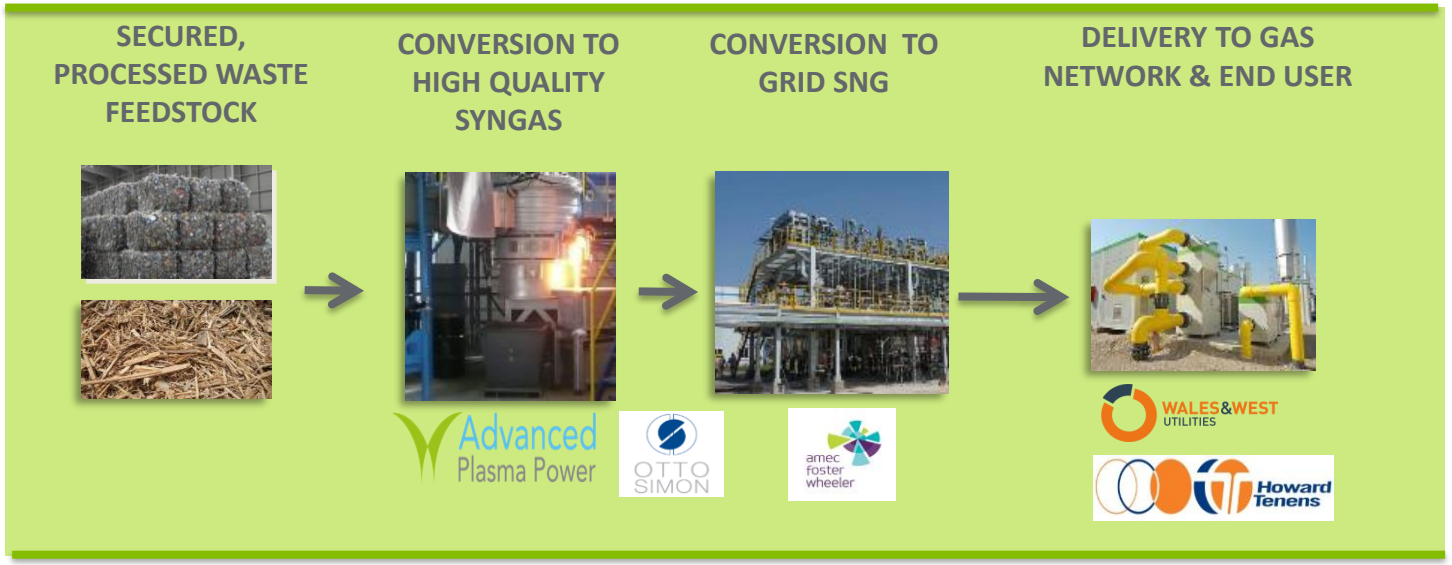
Full Chain Commercial Demonstration Facility



Operational Q1 2018

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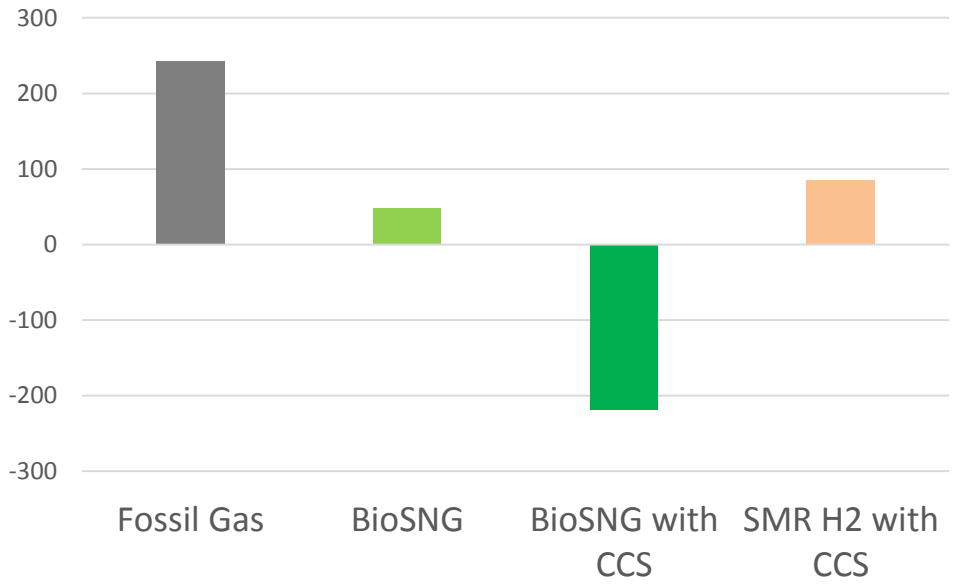
BioSNG is Low Carbon: 80% GHG Savings, 190% with CCS



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In Summary

"Fuels from Waste Square the Energy Trilemma"

High Impact

Advanced Plasma Power

Transforming waste into energy and fuels™

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Thank you

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BIOGAS

Applications

Flowchart

Process

Plants

Applications

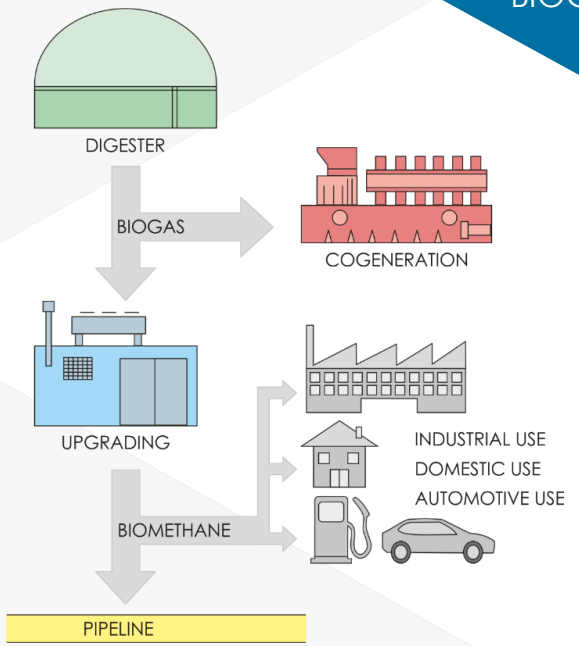
BIOGAS

BIOGAS IS OFTEN ALREADY AVAILABLE AS A WASTE PRODUCT

- Palm oil mills
- Seweage water treatment
- Landfill

UPGRADED TO BIOMETHANE IT CAN BE USED

- In the production process
- Transportation to other industries
- As a fuel for NGVs for the on site fleet, or sold public
- Pipeline reinjection



Biomethane applications

Industrial use

For supplying industries and services through reduction cabin

Pipeline reinjection

Dedicated gas filtration and compression to ensure the pipeline reinjection

Automotive

Gas filtration and compression for CNG stations

Private

Gas filtration and compression into utilities and services

Upgrading flowchart

BIOGAS

Process: biogas

BIOGAS

Process: biogas + biomethane

BIOGAS

STORAGE

DISPENSER

AIR-WATER COOLER

BIOMETHANE COMPRESSOR UNIT

ODORIZER

CONTROL PANEL

H2S REMOVING SYSTEM

BIOGAS COMPRESSOR UNIT

MEMBRANES

CONTROL PANEL

AIR-WATER COOLER

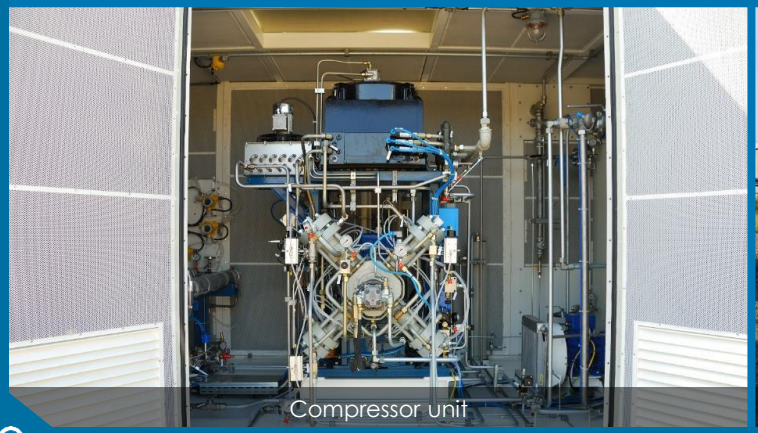
SCRUBBER

CHILLER-DRYER

Application in Italy

Upgrading system

Digester



Compressor unit

Dispenser with fuel manager

safe

▼ CNG ▼ OIL & GAS ▼ BIOGAS

▼ PRODUCTS ▼ SERVICES

Application in Malaysia


Plant


Filter and membranes


Palm oil

Dispenser

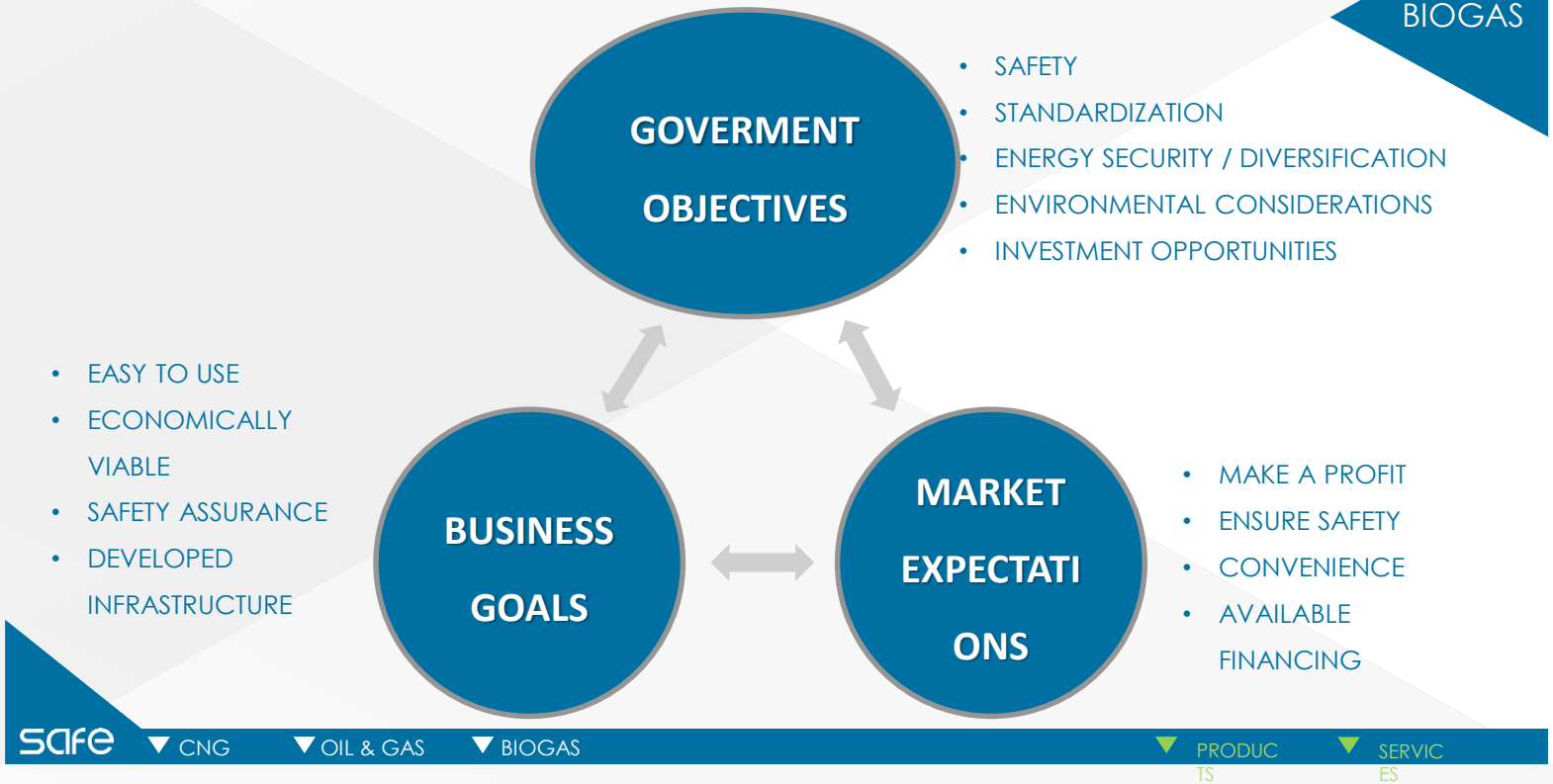
safe

▼ CNG ▼ OIL & GAS ▼ BIOGAS

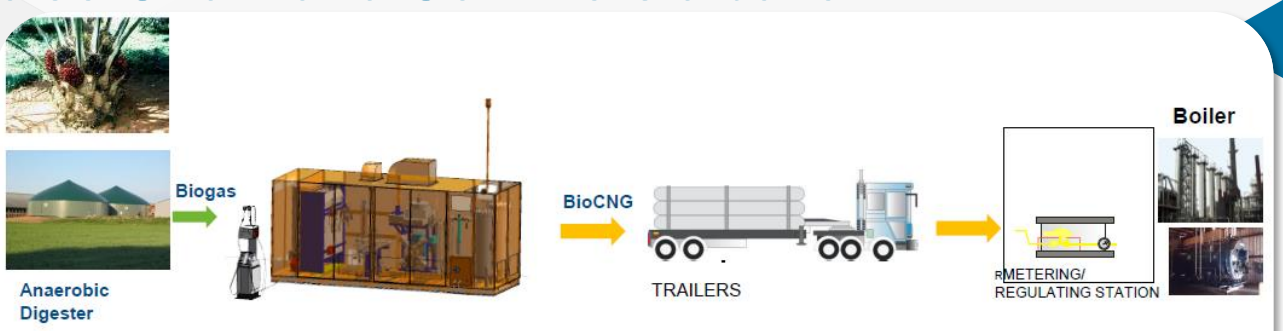
▼ PRODUCTS ▼ SERVICES

Successful Implementation

BIOGAS



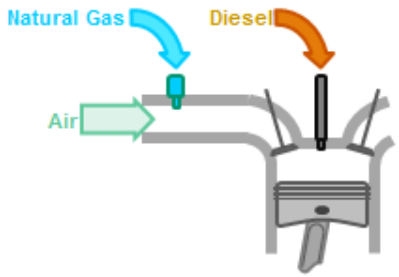
Value Chain and Commercialisation



Vehicles conversion to Diesel Dual Fuel DDF

Diesel Dual Fuel (DDF) is a system for the conversion of **Diesel engines** to work with a **mixture of Diesel oil** and **Gas.**

Dual Fuel conversion permits to exploit the advantages of CNG to diesel engines with a simple conversion, without being strictly conditioned by the availability of an adequate network of gas filling stations, since the vehicle can always switch back to the original fuel.



Natural Gas (NG) is mixed with air flow.
Diesel injection is reduced in quantity, and ignites the mixture of air and NG in combustion chamber.
During operation the system provides and controls the contemporary injection of CNG and Diesel oil in variable percentages according to engine Operating Point.

The Dual Fuel Engine is capable of running in both modes:
- **Diesel mode**
- **Dual Fuel mode**

In both modes the combustion cycle is diesel-type.

Vehicles conversion to Diesel Dual Fuel DDF

BIOGAS

Environmental

- Smoke reduction up to **40%**
- CO2 reduction up to **14%**
- Particulate Matter reduction up to **35%**
- Noise reduction up to **40%**

Performances:

- Strong **cost saving** (value depending from the fuel cost gap price)
- **Same performances** compared to the original engine in terms of torque/power and drivability
- Reversible: Switch back to original full diesel when needed
- Maximum flexibility in order to be easily adapted for different diesel engines
- Less CNG storage compared to Dedicated CNG vehicles
- Extended mileage compared to original Diesel system

Some DDF Applications

Application abroad (some) 2/2

BMC – 8.3l – 193kW

Turkey

Toyota Hilux – 2.5l – 75kW

Thailandia

Ford Cargo - 1721 – 8.2l – 158kW

Venezuela

THINK GAS TECHNOLOGY

THINK

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ACEF 6th June 2017

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Asia Clean Energy Forum 2017

VENTANA

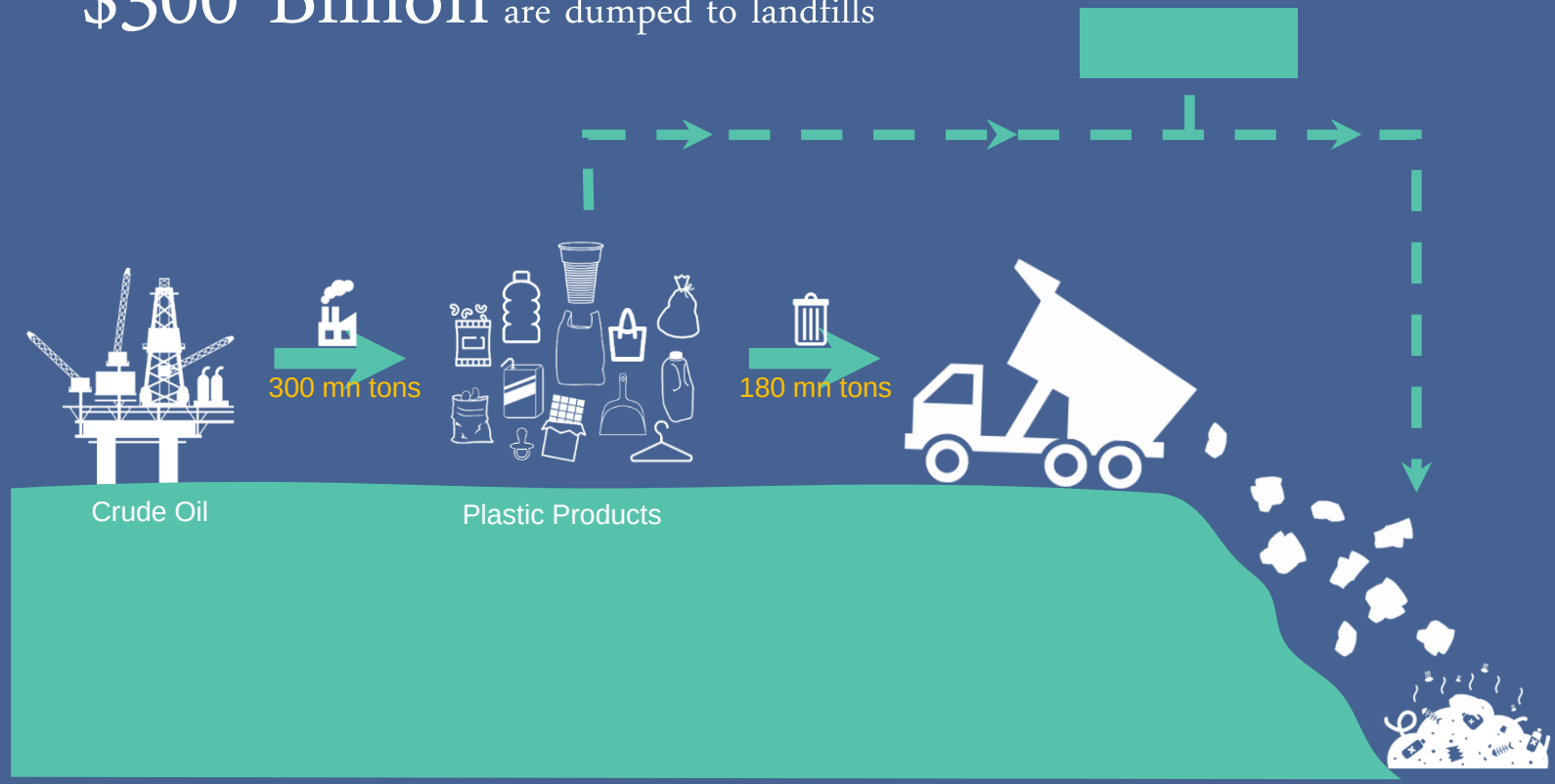
Amit Tandon
Founder & CEO

R&D Centre:
KK-16, HSIDC Estate
Kalka, India
www.ventanacleantech.com

Waste plastics to petroleum fuels

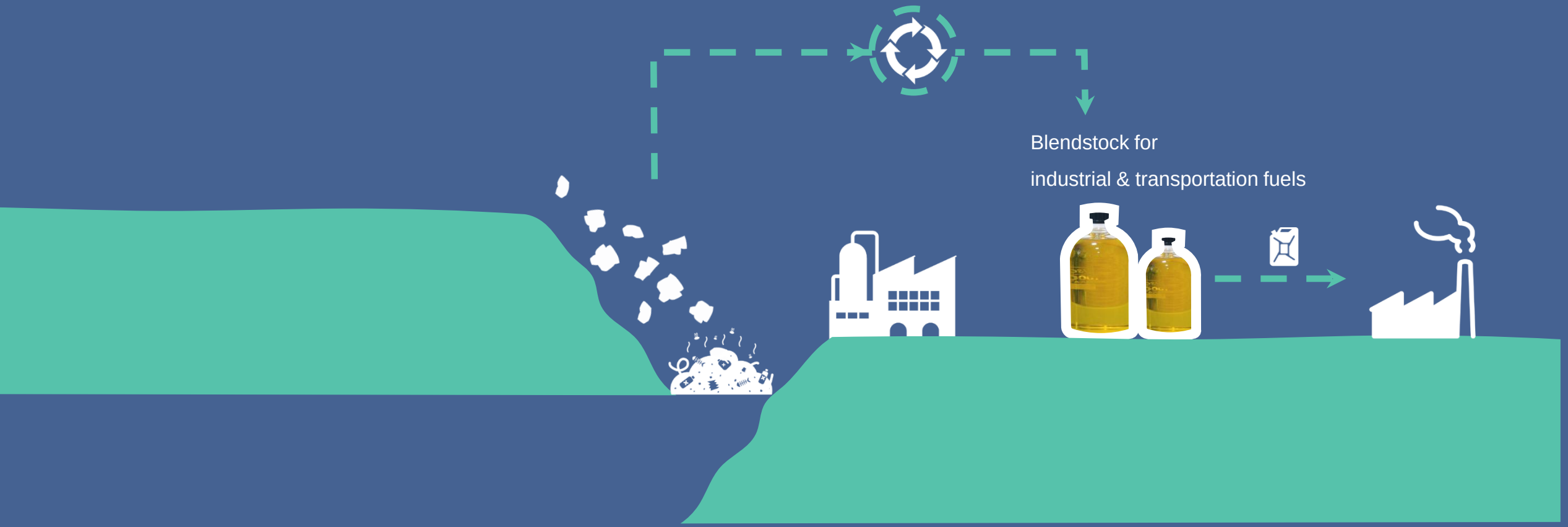
Every year **plastics** worth

$300 Billion are dumped to landfills



Ventana's patented technology converts

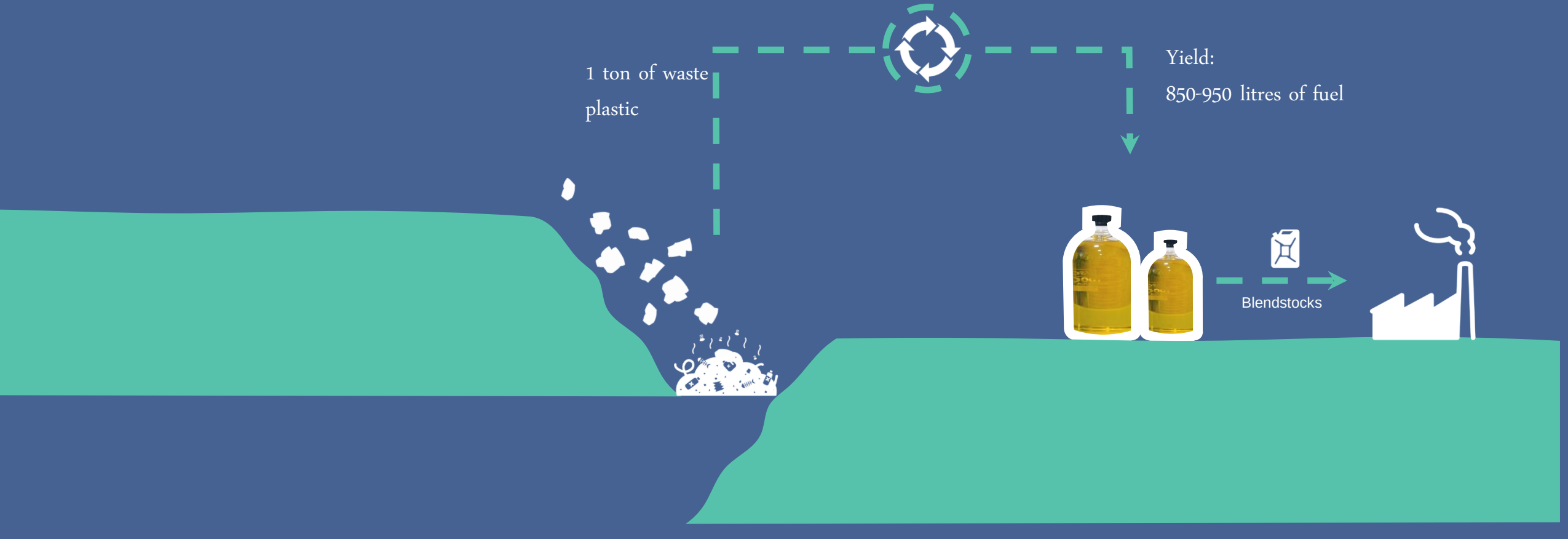
such waste plastics to high value petroleum fuels



End of life conversion for dirty, contaminated **non-recyclable** plastics

- Globally 60% of waste plastics are dumped to landfills every year.
- Minimal pre-processing required.

Technology generates high value blendstock fuels



Ventana's Plastic to Fuel plant (India)

Ventana's Plastic to Fuel plant (India)

Ventana's Plastic to Fuel plant (India)

Ventana's Plastic to Fuel plant (India)

Timeline

Commissioned India's first *fully continuous* plastic to fuel demo plant in 2016

75+ man-years R&D

2010 2011 2012 2013 2014 2015 2016

Gen 1

- Batch Process
- \+
- Syn-crude & heavy waxes

Gen 2

- Semi-Continuous
- \+
- Syn-crude, light & middle distillates

Gen 3

- Continuous Process
- \+
- Heavier hydrocarbons, waxes, lighter fuels

Gen 4

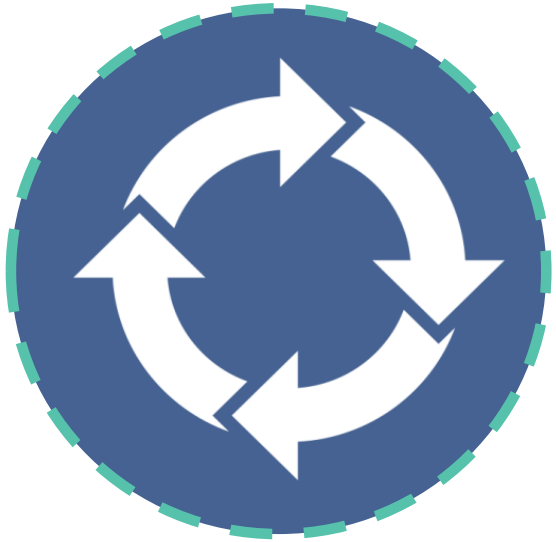
- Continuous Process
- \+
- Drop-in industrial fuels (~ industrial diesel)

Selling to Industry

Audited by Mott MacDonald

USPTO Patent

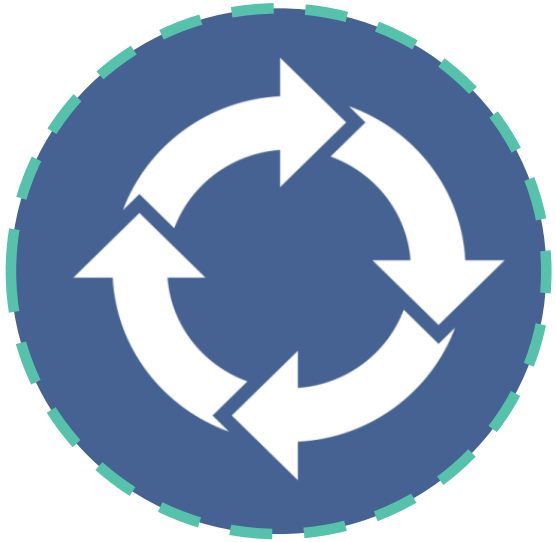
Why is a continuous process disruptive ?



Low CapEx

50 -75% reduction compared to batch processes

Why is a continuous process disruptive ?



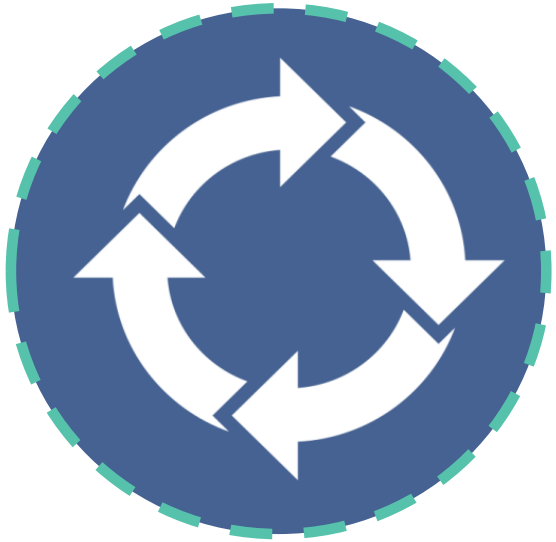
Low OpEx

Cost of conversion : Rs. 15-18 / litre

Retail value : Rs. 42 -45 / litre

** Direct costs (all-in) for 15 TPD plant in India

Why is a continuous process disruptive ?



Superior cashflows

50%+ EBIDTA Margin*

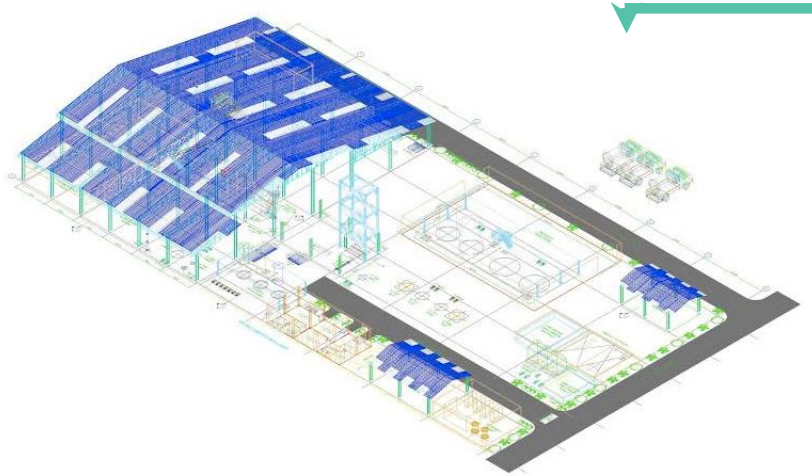
25%+ IRR(e)*

* 15 TPD plant in India

Partnerships

Ramky – India's largest waste management company

2015 — 2016 — 2017

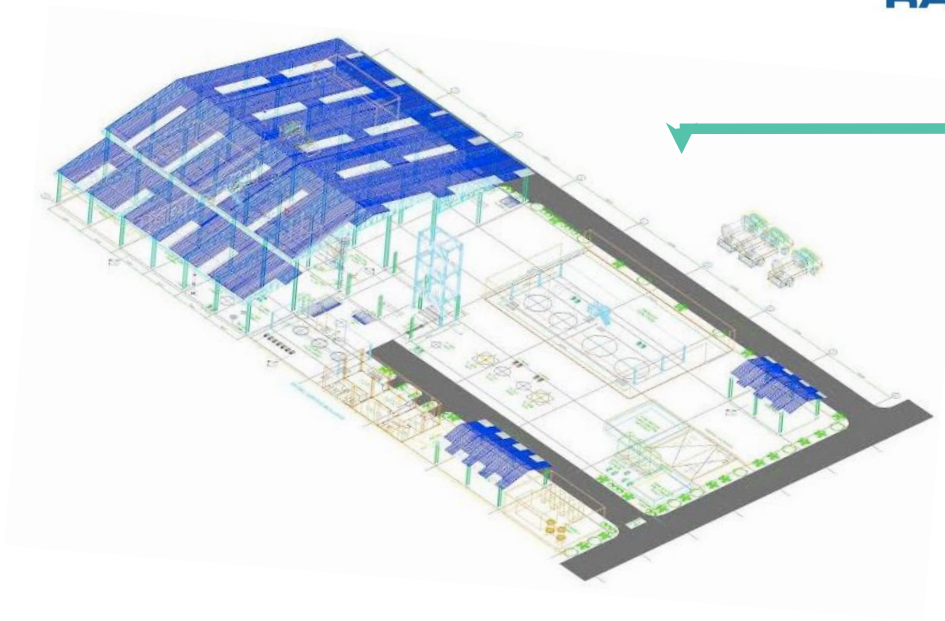


RAMKY GROUP — VENTANA

Upcoming plant

- Capacity: 15 TPD
- Co-located at Ramky's 300 acre waste management site at Hyderabad (India)
- Feedstock Cost : < $10/ton
- Duration of supply : 15 years
- IRR(e): >25%
- **EBIDTA: >50%**

15 TPD Plastic to Fuel Plant at Hyderabad (India)



Overview

- Plastics : 15 TPD, 4500 tons / yr
- Fuel generated : 4.0 million litres / yr
- CO_2 emission avoidance : 1800 tons / yr

Team

2010 2011 2012 2013 2014 2015 2016

Developed continuous process from scratch and achieved

250X Scale-up across 4 generations

Amit Tandon | **Founder & CEO**

10+ years with plastic-to-oil | Author of 5 relevant patents

Expertise with greenfield project development and technology R&D

Jonathan Michael | **CFO** (Consulting)

Financial expert with hardware companies in energy technology sectors | Ex CFO Solexel, Sonim, Solyndra, IXI

Dr. Ram Iyer | **VP Engineering**

PhD (Chemical Engineering)|Scale-up Specialist | 30+ years design, development, scale-up and commercialization of complex chemical plants & refinery units

+10 others

100+ years

combined relevant experience

Advisory Board

Dr. Edward Beardsworth, Ph.D.

Physicist and cleantech specialist.
Ex- Director at The Hub Lab and Jane Capital Partners

Larry Buckle

Inventor and senior executive having 30+ years of experience with engineering, development, operation and management of solid waste processing systems. Ex CTO - Organic Energy Corporation (California)

Eugene Jones

Serial Entrepreneur, 30+ years experience with waste management. CEO of Southern Waste Information Exchange, assisting businesses and municipalities with waste management since 1981 (Florida)

Doing good while doing well ☺

"Everyday, we receive several hundred tons of non-recyclable waste plastics across our waste management operations in India. We're happy to partner with Ventana to convert such low-grade plastics to high value petroleum fuels.

We see this as a win for both environmental sustainability as well as for the economic bottomline of our waste management operations.“

Goutham Reddy,
CEO Ramky Environment (India)

India Innovation Initiative Awardee

National Awardee
(from amongst 900 submissions)

Finalist at Cleantech Open
San Jose, California

Showcase

NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Denver

Cleantech San Francisco
San Francisco

CLEAN ENERGY FORUM
Spain

SXSW ECO
Austin

Plastic to Fuel - advantages

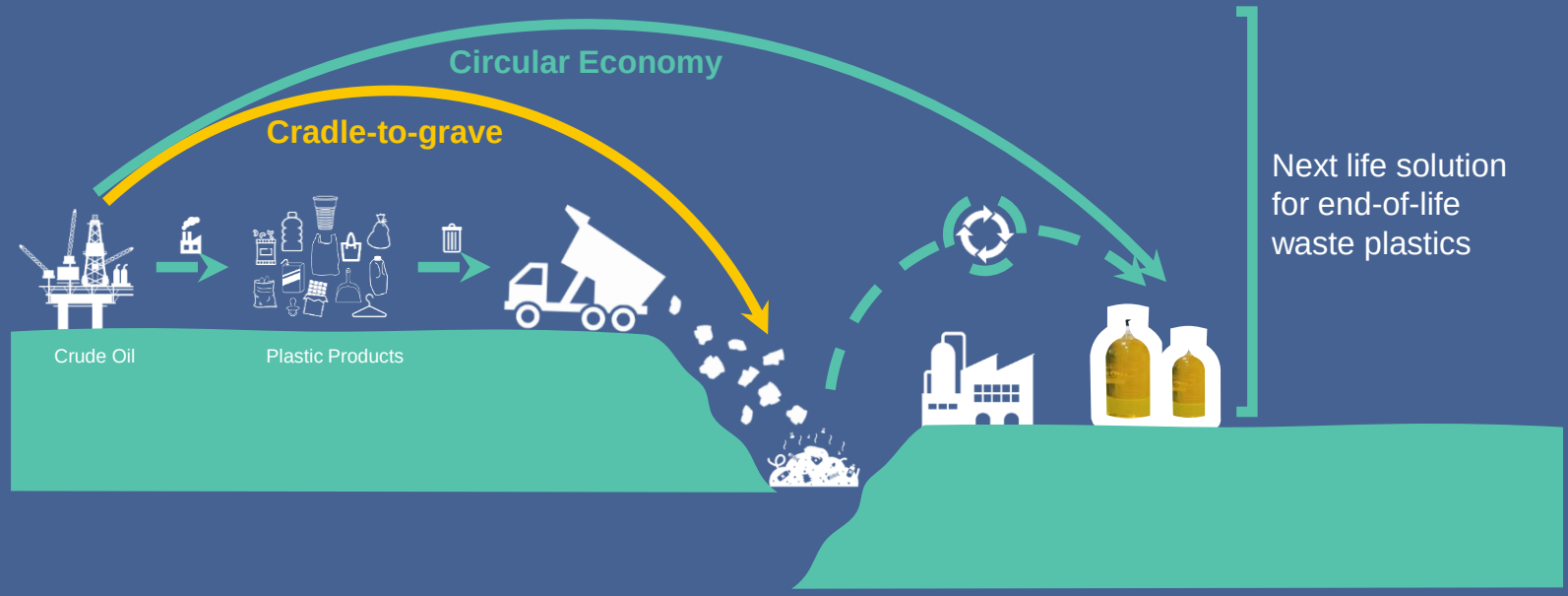
Ventana's technology enables:

Low Carbon Fuels
Every ton of plastic processed, helps avoid 0.3–0.4 tCO2e of GHG emissions

Landfill Diversion
Diverts waste from landfills - thereby increasing landfill life

Cleaner Cities
Helps mitigate problem of littered plastics and choking of underground sewers

Cleaner Oceans
Technology can be part of solution to help clean oceans of plastic litter



Asia Clean Energy Forum 2017

VENTANA

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Amit Tandon, CEO
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Jonathan Michael, CFO
jonathan.michael@ventanacleantech.com


Plastic to Diesel

Quantafuel PTL

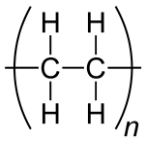
- Pyrolysis for processing waste plastics and converting them into usable and marketable liquid fuel products
- Quantafuel PTL has taken this technology to a new level; through our patented catalytic reactor the output is increased to 80 %, meaning that for each ton of waste plastic we can produce 850 liters of synthetic drop-in fuels.
- For each ton of plastic treated per hour there is a potential carbon emission reduction of 20,000 MT per annum based on the estimate of number of liters of fuel recovered from plastic wastes

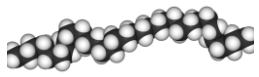
Plastics and Pyrolysis

Plastic Identification Code	Type of Plastic Polymer	Properties
01 PET	Polyethylene terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.
02 PE-HD	High-density polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas.
03 PVC	Polyvinyl chloride (PVC)	Versatility, ease of blending, strength, toughness.
04 PE-LD	Low-density polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.
06 PS	Polystyrene (PS)	Versatility, clarity, easily formed
7 OTHER	OTHER or O Other plastics, including acrylic, fiberglass, nylon, polycarbonate, and polylactic acid (a bioplastic), and multilayer combinations of different plastics	
9 or ABS	ABS Acrylonitrile butadiene styrene	

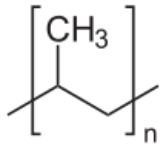
C_nH_{2n+2} → C_mH_{2m+2} + C_pH_{2p} + H_2 + C

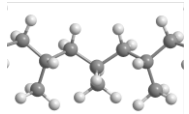
alkane (s) *alkane (g, l)* *alkene (g, l)* *hydrogen (g)* *char (s)*



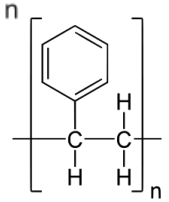


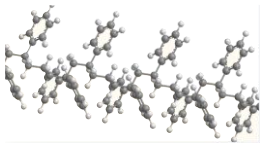
T_m 105–130 °C





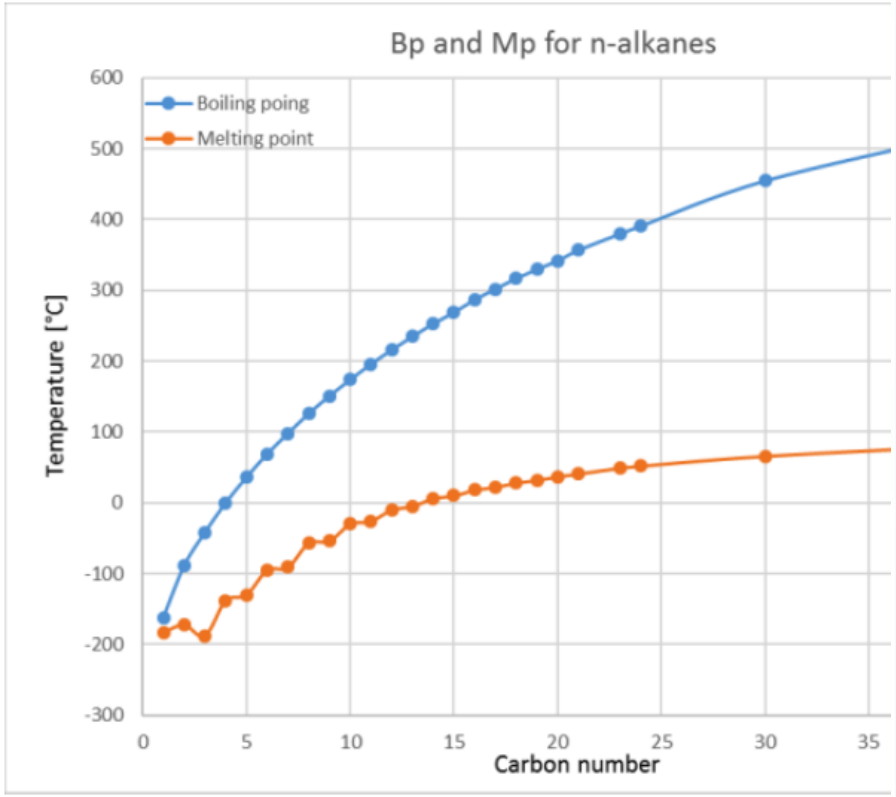
T_m 160–190 °C



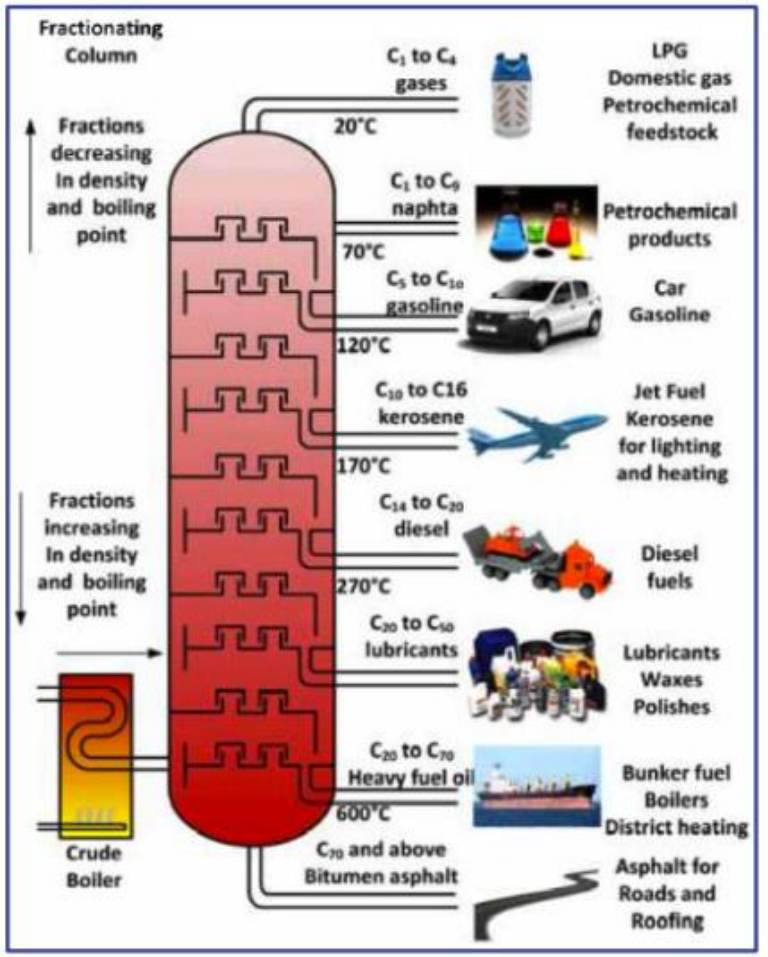


T_m 210–249 °C

Boiling of oil

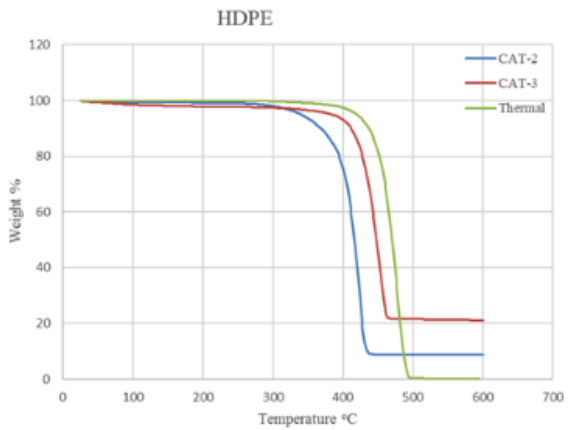


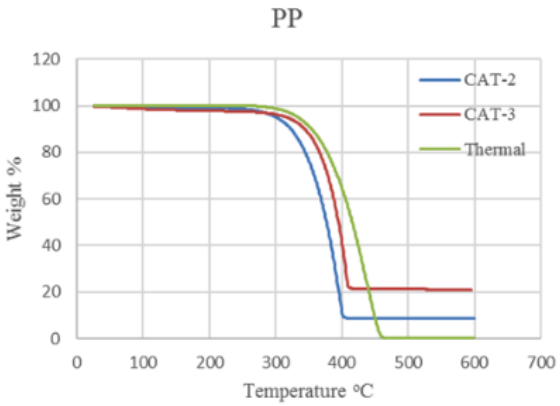
Boiling point and melting point for n-alkanes

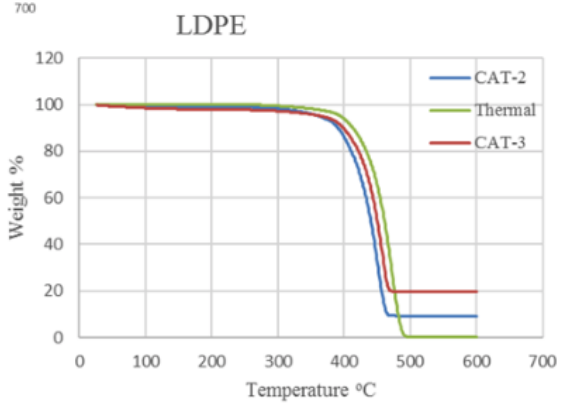


Typical hydrocarbon fractions from an oil refinery

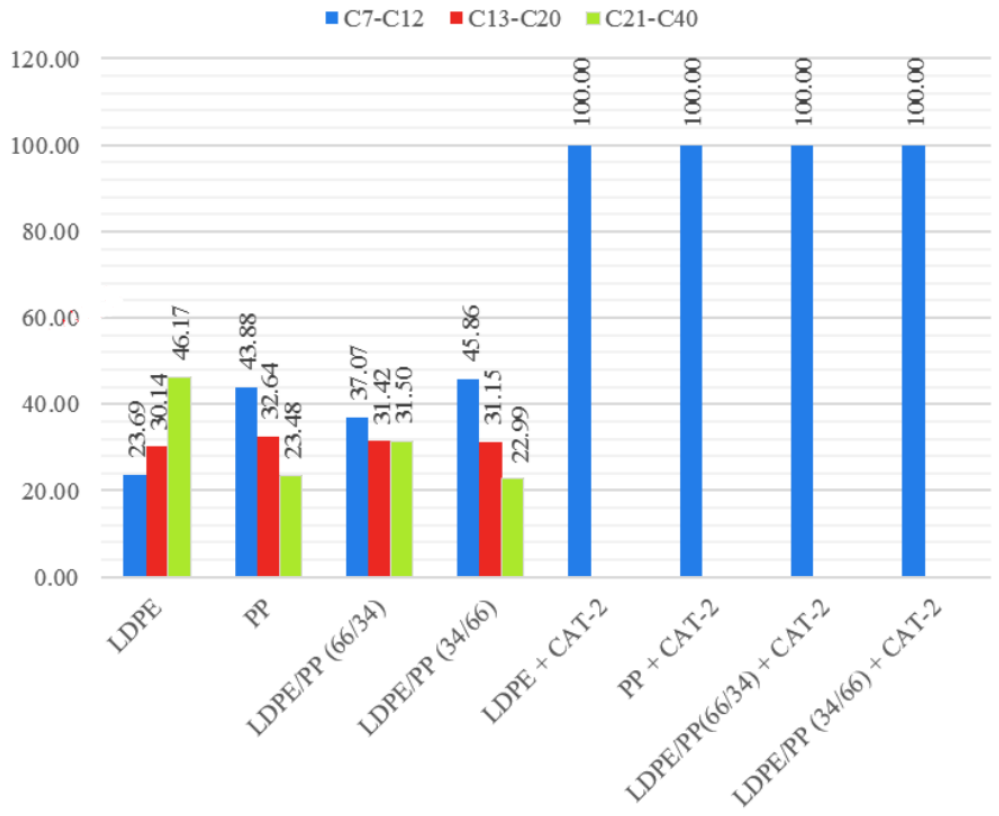
Catalyst effect



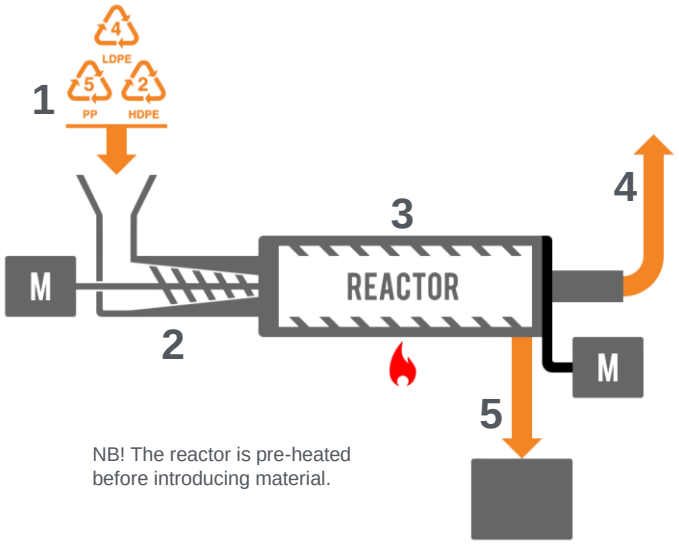




Catalyst vs. thermal



PTL working principle



NB! The reactor is pre-heated before introducing material.

1. Shredded material is continuously fed into the reactor. Maximum load 800-1200 kg/h (20-30 Mt/day) of plastic waste (mainly PE & PP).
2. Plastic material is fed into reactor by screw feeder that compresses and releases air from the feedstock before entering the reactor.
3. Reactor chamber rotates with vanes that pushes the material forward. Energy input is controlled individually for each section.
4. Pyrolysis gas is formed at a constant mass rate.
5. Carbon is disposed at end of reactor.

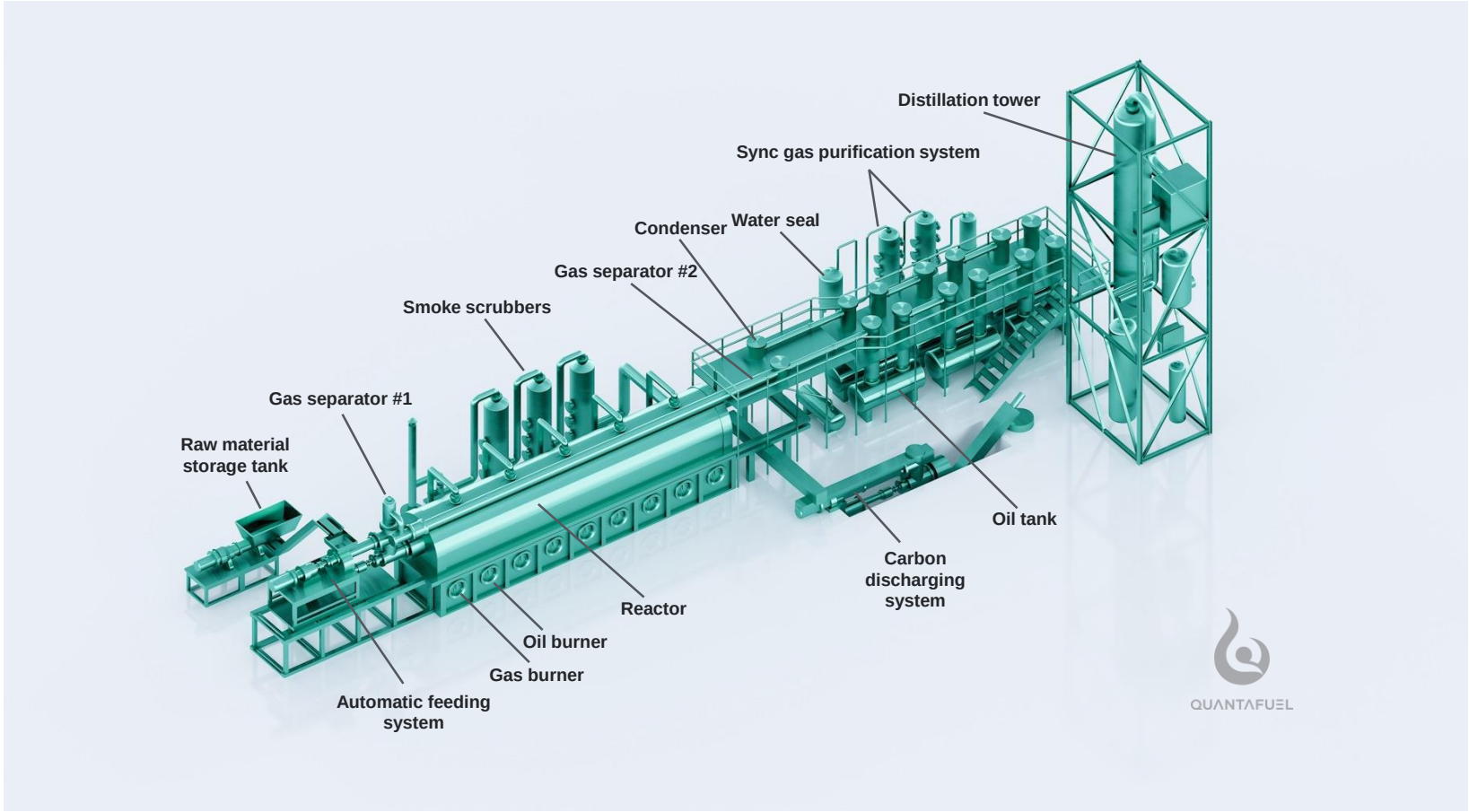
Navojoa plant, Mexico

Samples

Diesel	ASTM	Quantafuel
Flash point	Min 45 °C	62 °C
Sulphur content	Max 500 mg/kg	144 mg/kg
Viscosity at 40 °C	1,9 – 4,1	2,008 mm^2/s
Density at 15° C	0,82-0,85	0,825 kg/l
Cetane index	Min 45	52,93

Key figures

Up-time before cleaning/maintenance	20 – 90 days
Capacity (feedstock)	20 – 30 MT/day
Production capacity (fuel)	14 – 21 MT/day
Dimension	35 x 10 x 6 m
Weight (steel)	20 MT
Residence time for material	1 hr
Number of burners	6 – 9
Heat-up time	2 – 3 hrs
Number of operators needed	2


Distillation tower
Sync gas purification system
Condenser
Water seal
Gas separator #2
Smoke scrubbers
Gas separator #1
Raw material storage tank
Oil tank
Carbon discharging system
Reactor
Oil burner
Gas burner
Automatic feeding system
QUANTAFUEL

Marine Application

Conclusions

- Quantafuel Plastic Reforming Technology transforms waste plastic into drop-in fuels like diesel and gasoline
- The process is self-sufficient and environmentally friendly with minimal emissions of pollutants
- Quantafuel PTL proprietary catalyst tailor-make output and increases the yield of cleaner fuels
- Quantafuel PTL fuels does not degrade, has higher energy content and is less pollutive than other fuels


QUANTAFUEL

Ricardo
Energy & Environment

QUESTIONS

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Energy & Environment

SUMMARY AND DEBATE

Asia Clean Energy Forum 2017

Summary

- WtE not just about waste management!!
- Energy produced is a valuable domestic energy source contributing to energy self sufficiency
- Can contribute to renewable energy targets and decarbonise energy generation (long term goal globally)
- Can complement other renewable energy sources such as wind or solar (where appropriate) as non-intermittent
- Has a widespread portfolio of potential applications
  - *Electricity production*
  - *CHP (or district cooling)*
  - *Transport fuels*
  - *Substitute for natural gas*

What to consider for new technology – where are the risk /pit falls

- Benefits
  - *Efficiencies*
  - *Perception*
  - *Costs*
  - *Scale*
  - *Emissions*
- Reference sites
  - *Proven technology*
  - *Longevity*
  - *Reliability*

- EPC contractor – commissioning delays / snags
  - *Experience*
  - *Expertise*
- Revenues / Markets
  - *Products demand*
  - *Energy*
  - *Incentives (fluid)*
  - *Gate fees*

What is required for new technology investments?

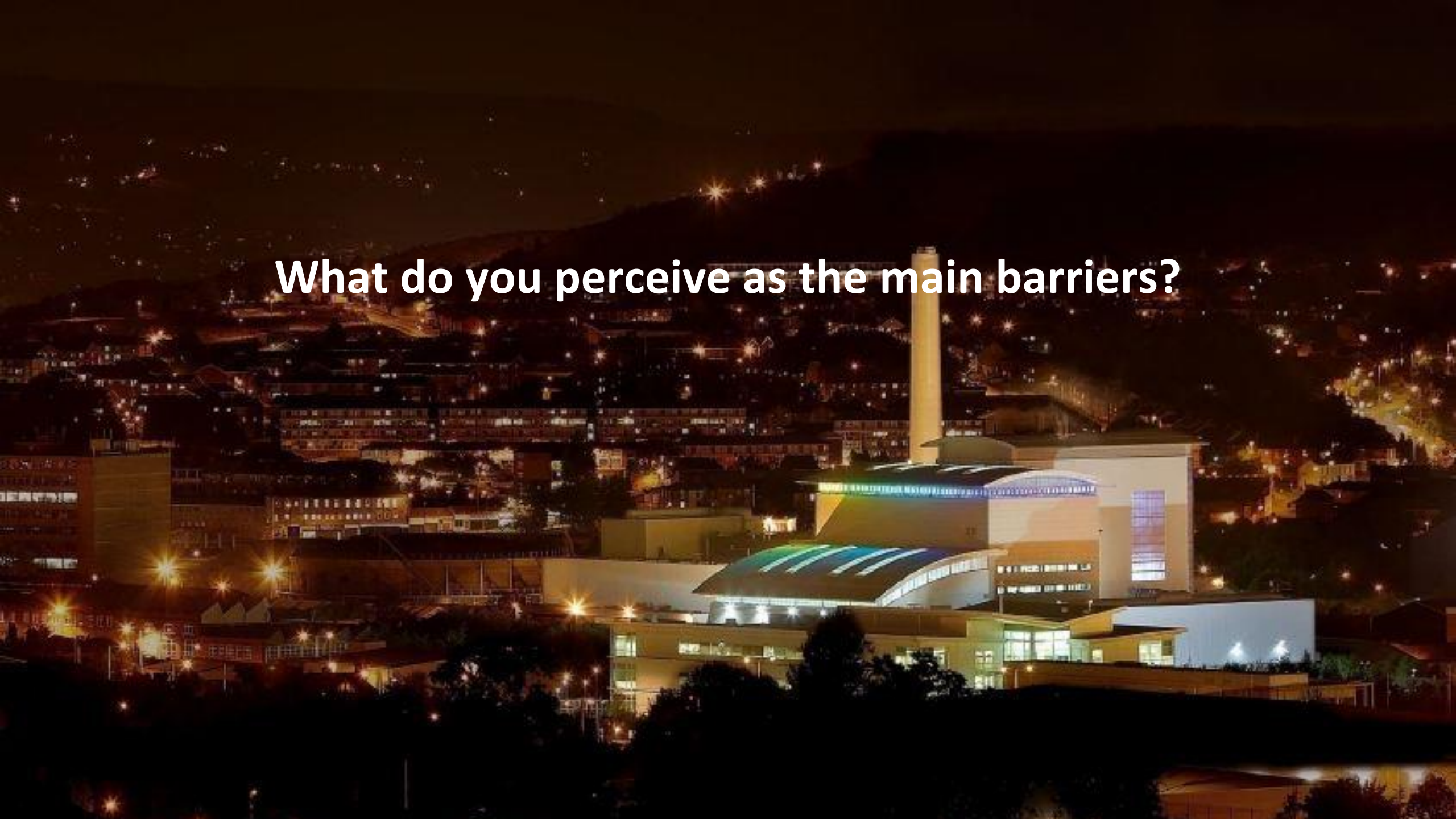
- New investments (due diligence) – independence
  - *Technology due diligence: acquisitions/new facilities*
  - *Technology fore-sighting*
  - *Feedstock identification & profiling*
  - *Business case development*

- Markets due diligence
  - *Market assessment: volumes of waste / prices / trends*
  - *Market drives: legislation/ policy / government direction*
  - *Competitor analysis / Pipeline reviews*

- Regulation projection
  - *Government policy review*
  - *Compliance auditing*
  - *Industry insight*


Is there sufficient incentives and clear policy for these technologies?

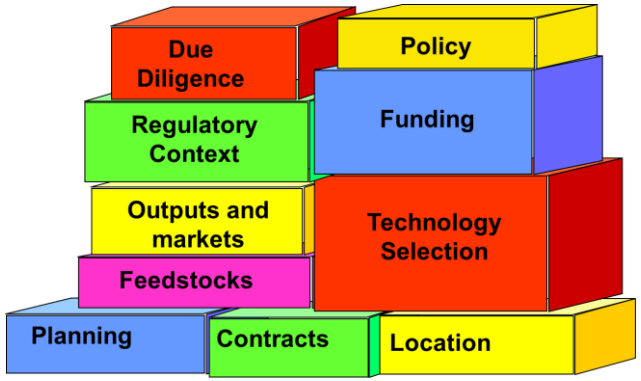
Is the right infrastructure being planned in your region?



What do you perceive as the main barriers?

Next steps

- Do you have a project you would like to get off the ground?
- Unclear what the first steps should be?
  - *Have you secured feedstock?*
  - *Have you selected your technology?*
  - *Have you got contracts in place?*
  - *Have you got funders on board?*
  - *Have you selected a site?*
  - *Is your solution compliant with local policies?*



We are here this afternoon and tomorrow!
Come and see us:
Tuesday - 71038 NW
Wednesday – 6256 W

Thank you

Adam Read

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