Advanced Gasification

R&D Approaches for Chemicals and Fuel Production

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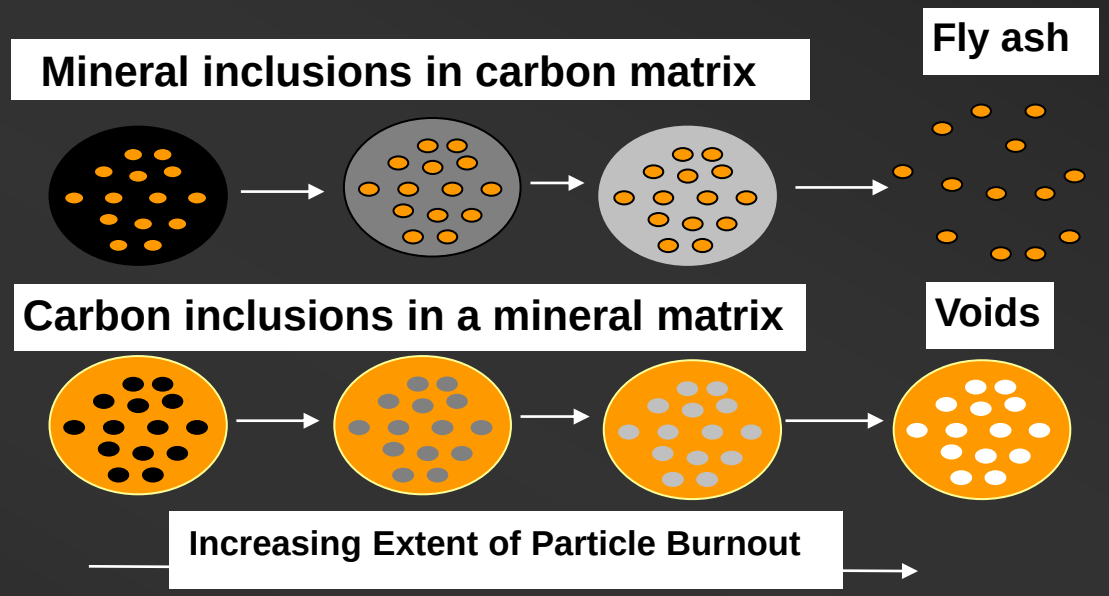
Overview

TANSA TECH LLC

Outline

- Mineral matter issues during Gasification
- Fluidized bed processes for handling high density fines in reactions
- Review of Microwave-intensified processes
- Scaling timelines of new technologies
- Thoughts on Ideation, Opportunities, “non-tech” discussion

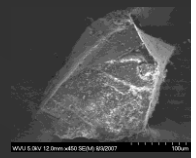
Pathways to Ash Generation*



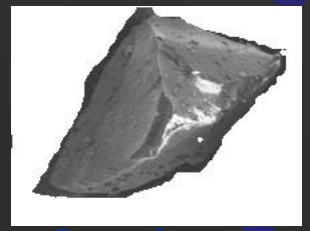
Ash deposition (bottom or flyash) depends on*

- Mineral matter distribution
- Mineral grain size

in CFBC



Coal + included minerals

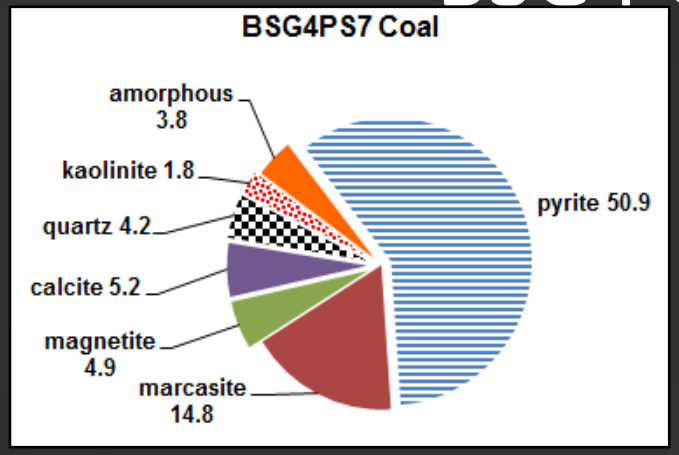


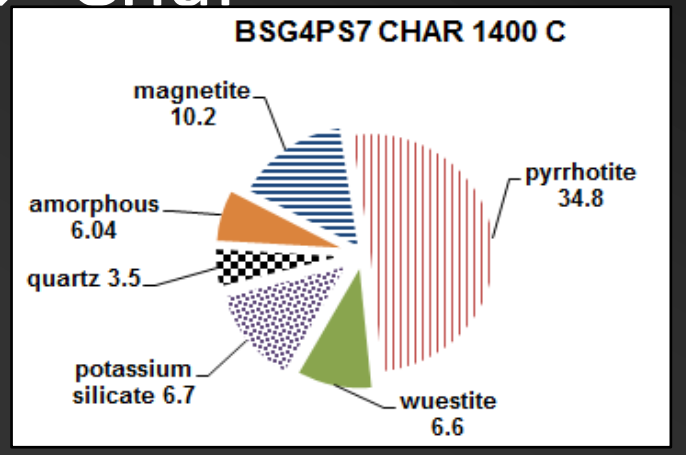
Complex mixture of organic and inorganic materials

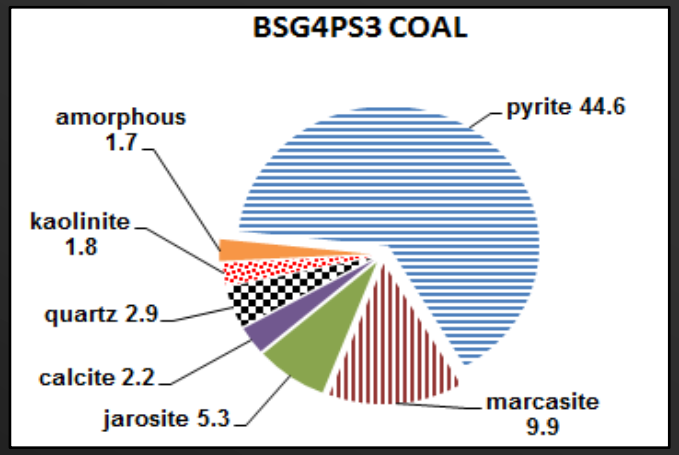
Excluded minerals

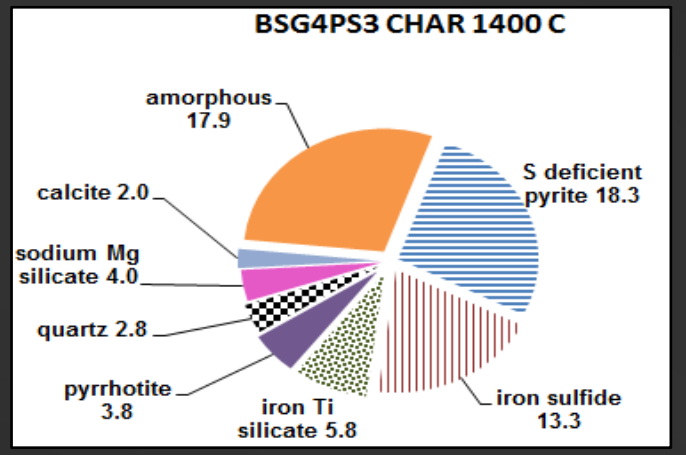
Grinding

BSG4 Coal → Char



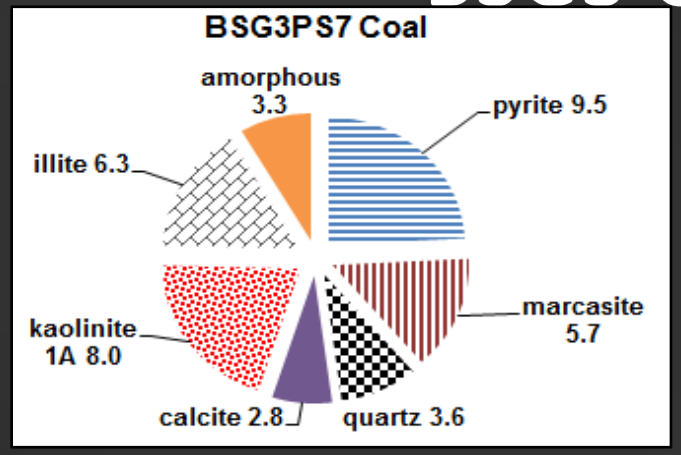


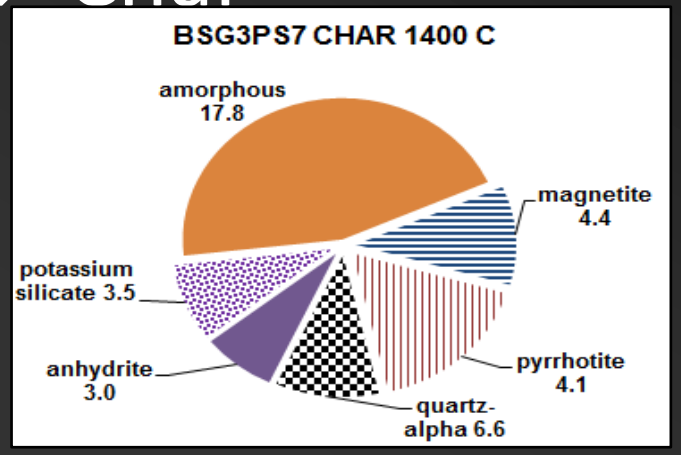


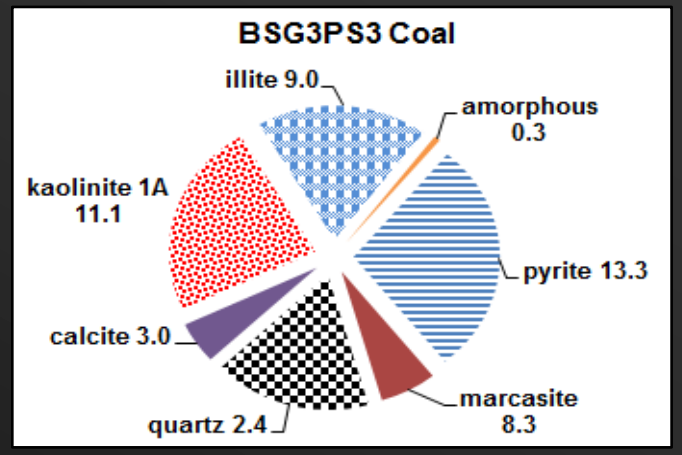


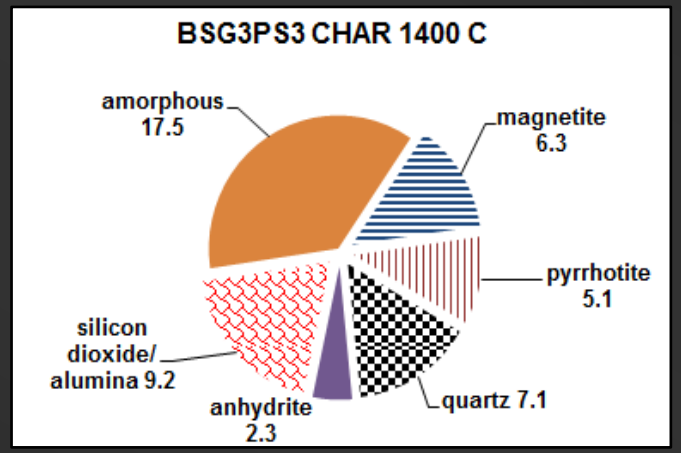
Change in crystalline mineral content only

BSG3 Coal → Char









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Change in crystalline mineral content only

Summary

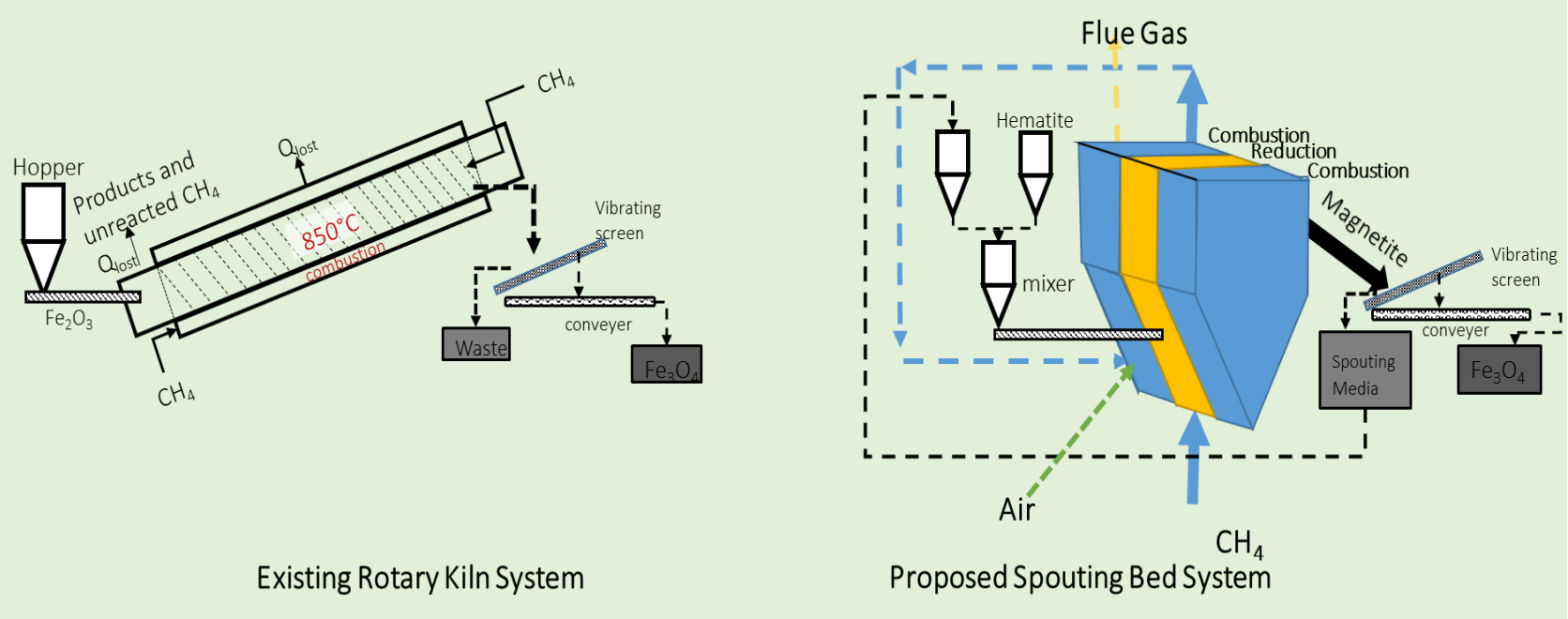
- Fractions rich in aluminosilicates and associated iron minerals form larger proportion of amorphous phases.
- Heavy fraction fines (fraction rich in excluded minerals) show increase in crystalline phases of non-iron minerals.
- Coal fractions where iron minerals associate with aluminosilicates show greater propensity to form amorphous phases.
- Chars from the coarse fractions of both the heavier density fractions show more intermediate phase minerals and higher amorphous content.

Spouted Bed Technology for Fine Solids

Key Players : SIOX LLC, NETL- USDOE, WVU

$$12\ Fe_2O_3 + 2\ CH_4 \rightarrow 8\ Fe_3O_4 + CO_2 + CO + 3H_2 + H_2O$$

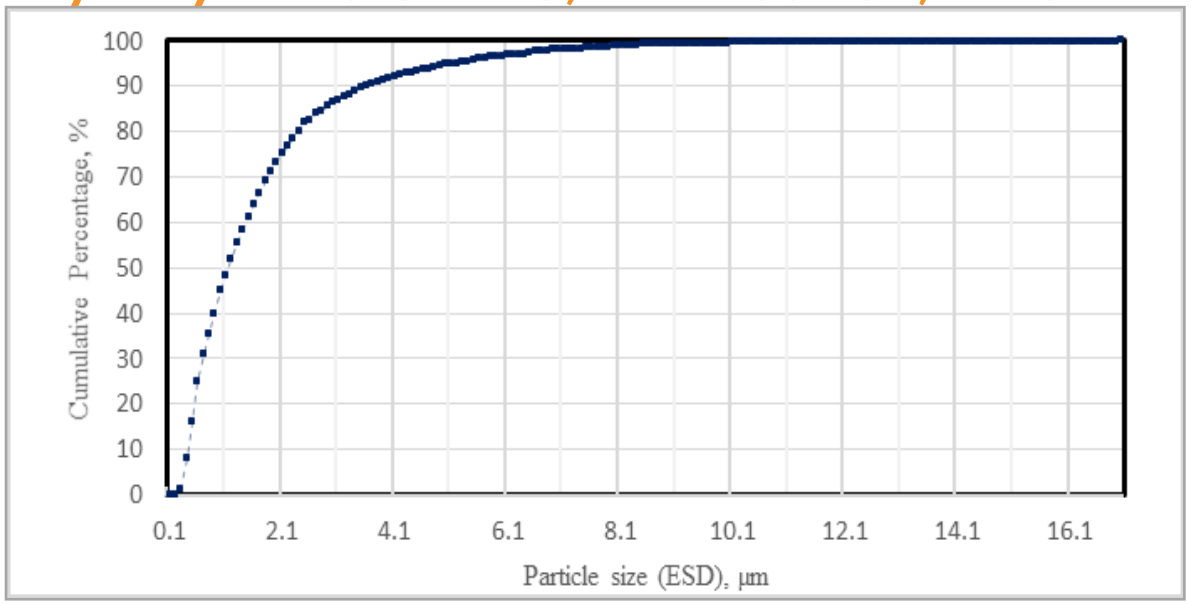
Hematite → Magnetite (while avoiding wustite formation)

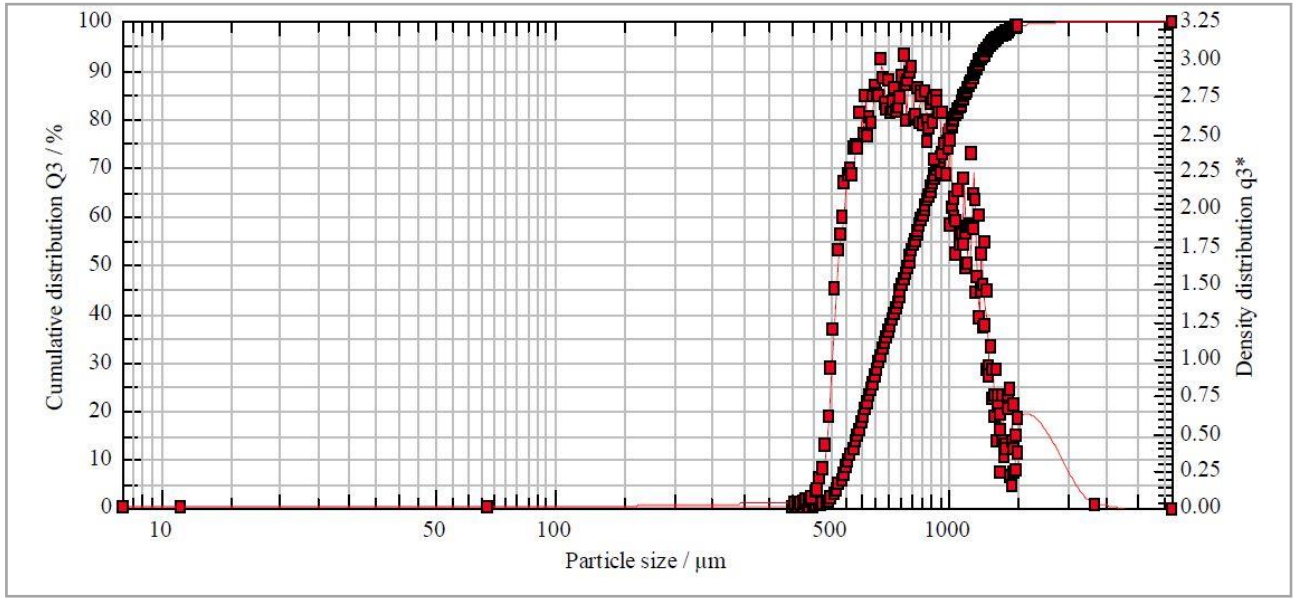


Iron and steel waste - Fluidized bed reducing reactors
– Magnetite formation (value addition)

Particle Sizing

Key Players : SIOX LLC, NETL- USDOE, WVU





	Hematite material	Coarse alumina
Diameter	1.61	768.61
Circularity	0.92	0.911
Aspect ratio	0.71	0.835
Bulk Density	606 kg/m^3	640-881 kg/m^3

Iron and steel waste - Fluidized bed reducing reactors – Magnetite formation

Spouted Bed Reactor for Hematite Reduction (Lab scale Unit)

Key Players : SIOX LLC, NETL- USDOE, WVU

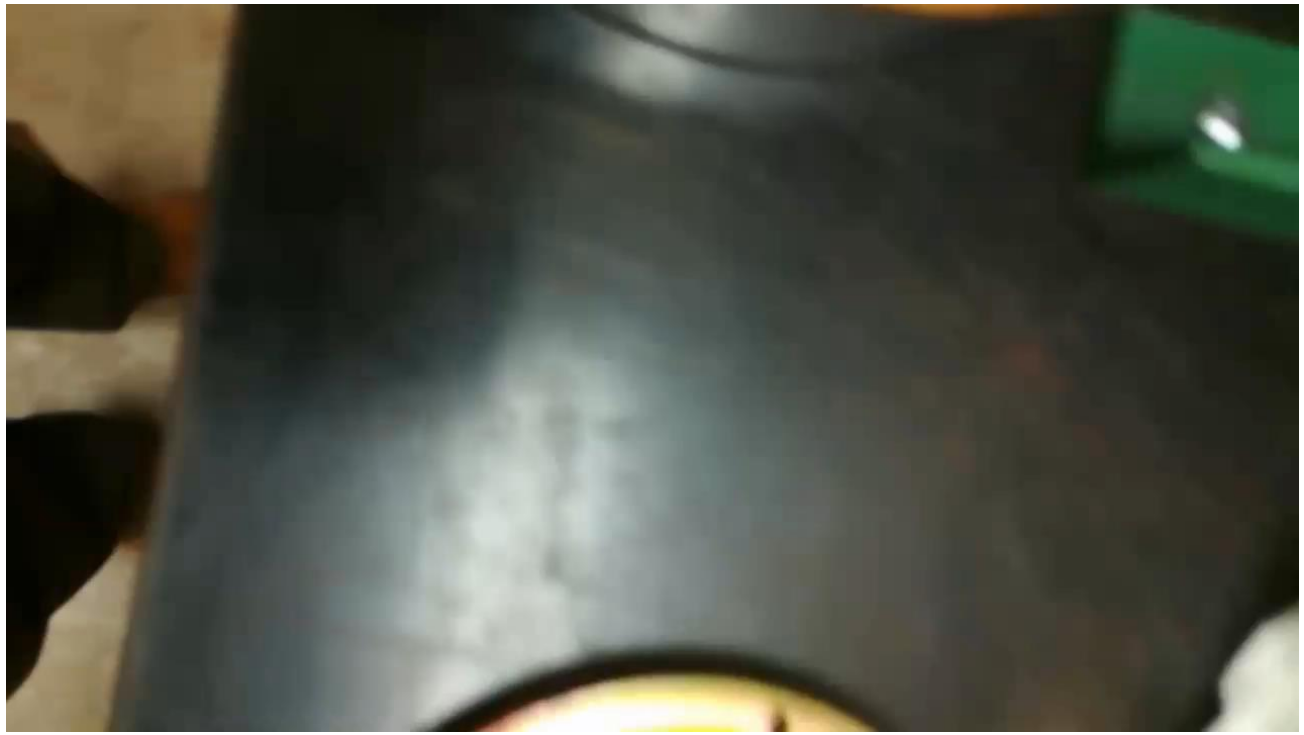
Features:

- Proprietary Composition of Alumina beads+ Reactive solids in Lockhopper for batch testing
- Externally, electrically heated vessels (T_{int}~1000°F)
- Nitrogen dilution can be varied in feed
- Product gases diluted with nitrogen to atmosphere <LEL
- Filter to collect elutriated fines
- Product lockhopper to remove samples
- Product gas analysis

Iron and steel waste - Fluidized bed reducing reactors – Magnetite formation (value addition)

Photo courtesy: NETL-MGN

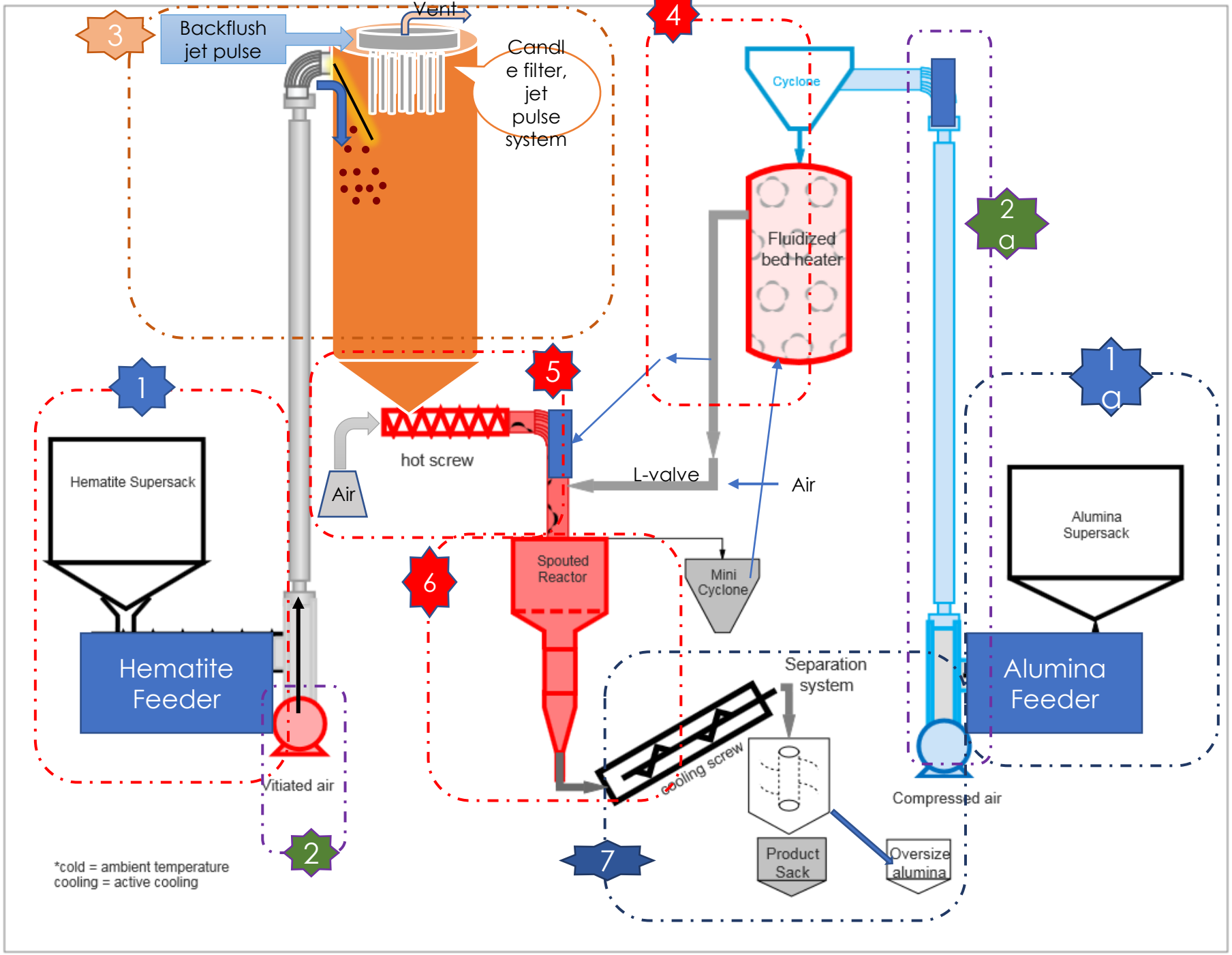
Magnetite - quick & dirty proof



quick and dirty proof of conversion

Pilot Scale
Spouted Bed Reactor for Magnetite fines

COURTESY
SIOX LLC & NETL-MGN



Modeling and Experiments

NETL + LSU – Lab scale microwave gasification process

Primary pyrolysis gases + Char of same sample → greater amounts of H_2 and CO

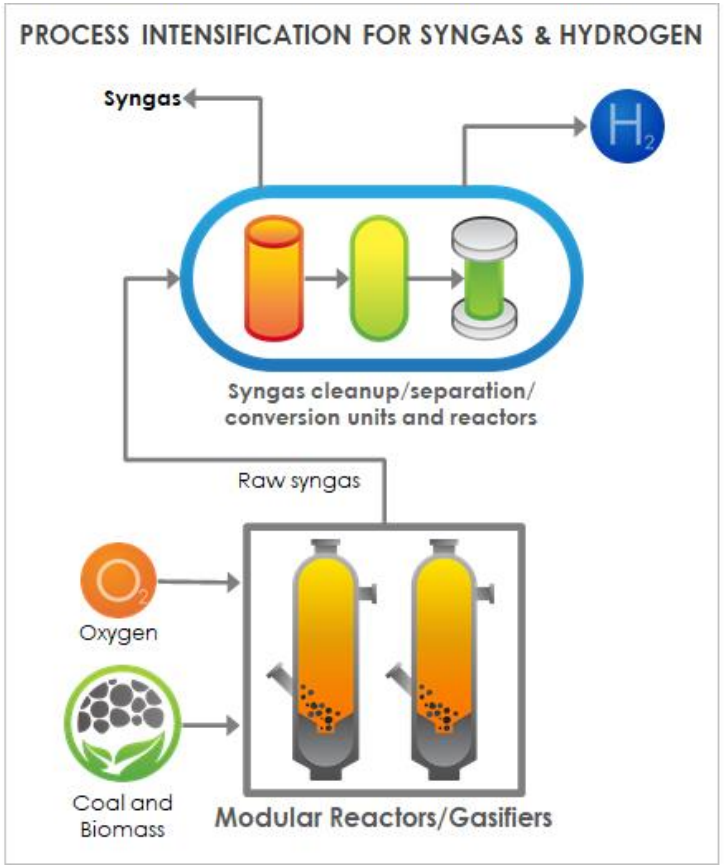
Microwave/Plasma assisted downdraft gasification on Biomass waste processing.

Endeavor gasification Italy.

Updraft gasifier- Lab scale and Demo scale. Commercial scale?

Feedstock – sewage sludge → Cogen (Heat + electricity+ biochar) , 200 kW_e (TRL – 5-6)

Southern Research, US Small-Scale Engineered High Flexibility Gasifier
(Non-catalytic plasma gasification) - details a bit later



Chemicals Production – Green Chemistry

Microwave-assisted Polycarbonate Production, Ammonia synthesis

NETL + LSU – Lab scale microwave gasification

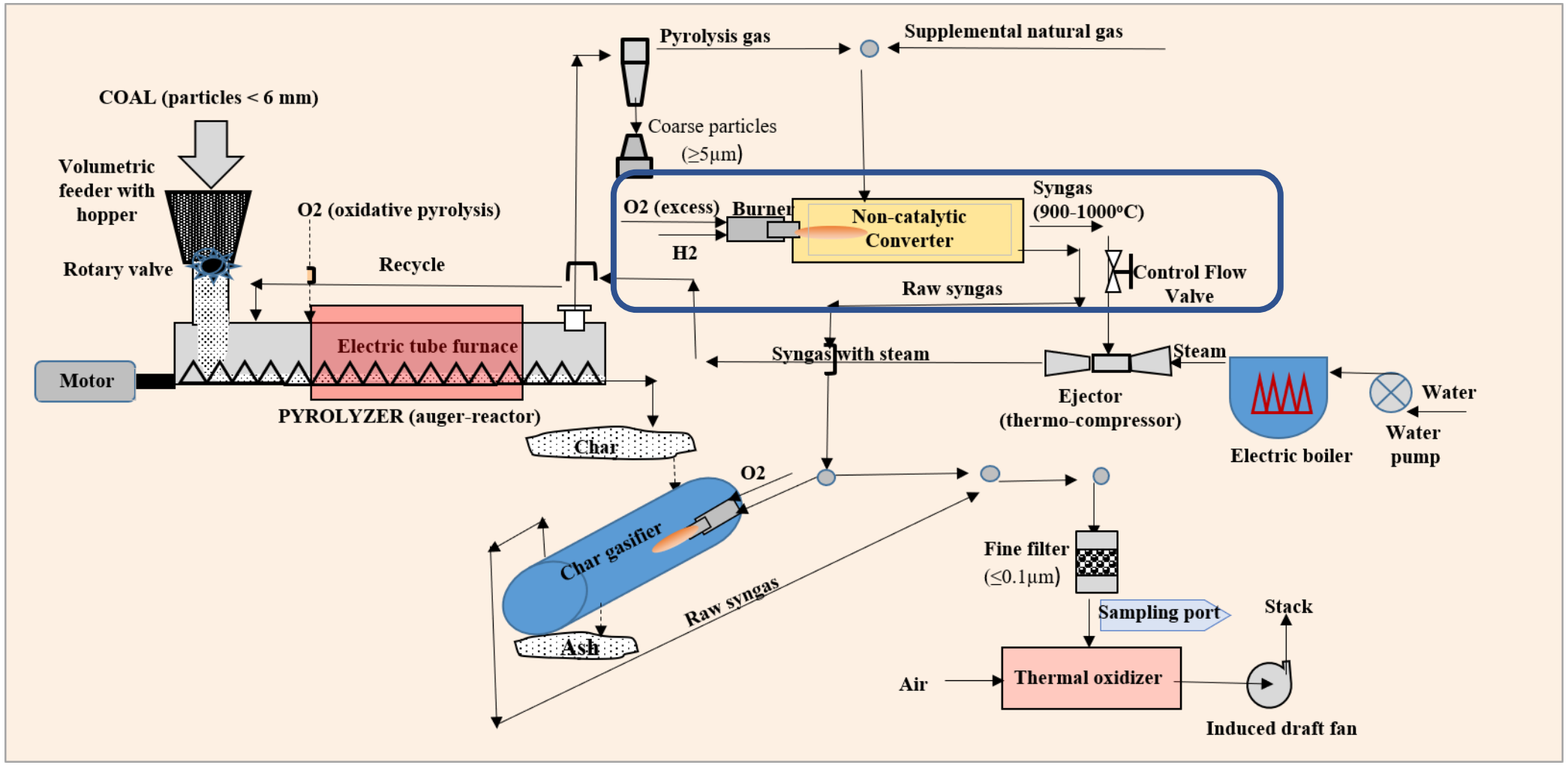
Microwave Ammonia Synthesis, cost advantages at small scale (~100-150MW input, 25-100tpd) Vs. large scale H-B process (~1000tpd). Tolerant to intermittent energy supply.

TEA Results: CAPEX for Ammonia Synthesis

60,000 tons NH_3/year scale

	Benchmark H-B	Base Case	Worst Case	Best Case
H_2 Treatment	5.21	2.15	2.15	2.15
NH_3 Synthesis Unit	6.19	2.95	16.99	2.35
NH_3 Recovery	5.73	16.58	28.25	16.58
NH_3 Compressors	11.2	8.13	14.48	8.13
OSBL	7.36	2.62	2.93	2.62
Total, $ million	35.70	32.43	63.91	31.84

Southern Research Highly Flexible (Plasma) Gasifier



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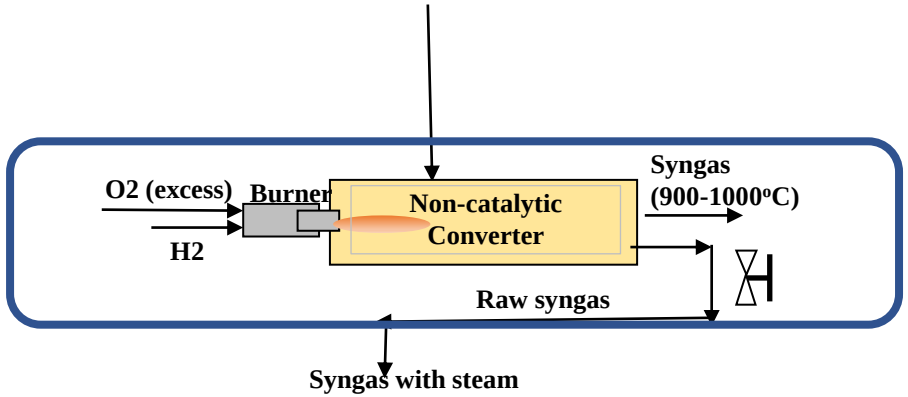


A timeline of scaling - Microwave Chemical Co., Ltd (Japan)

2009

Fuel, 2t/day production
Microwave reactor development

Scene at the Shimaya Business Incubator (Osaka)

Spring, 2011

Chemicals, 2t/day production
Microwave pilot plant launch

Scene at the Kobe Manufacturing Factory

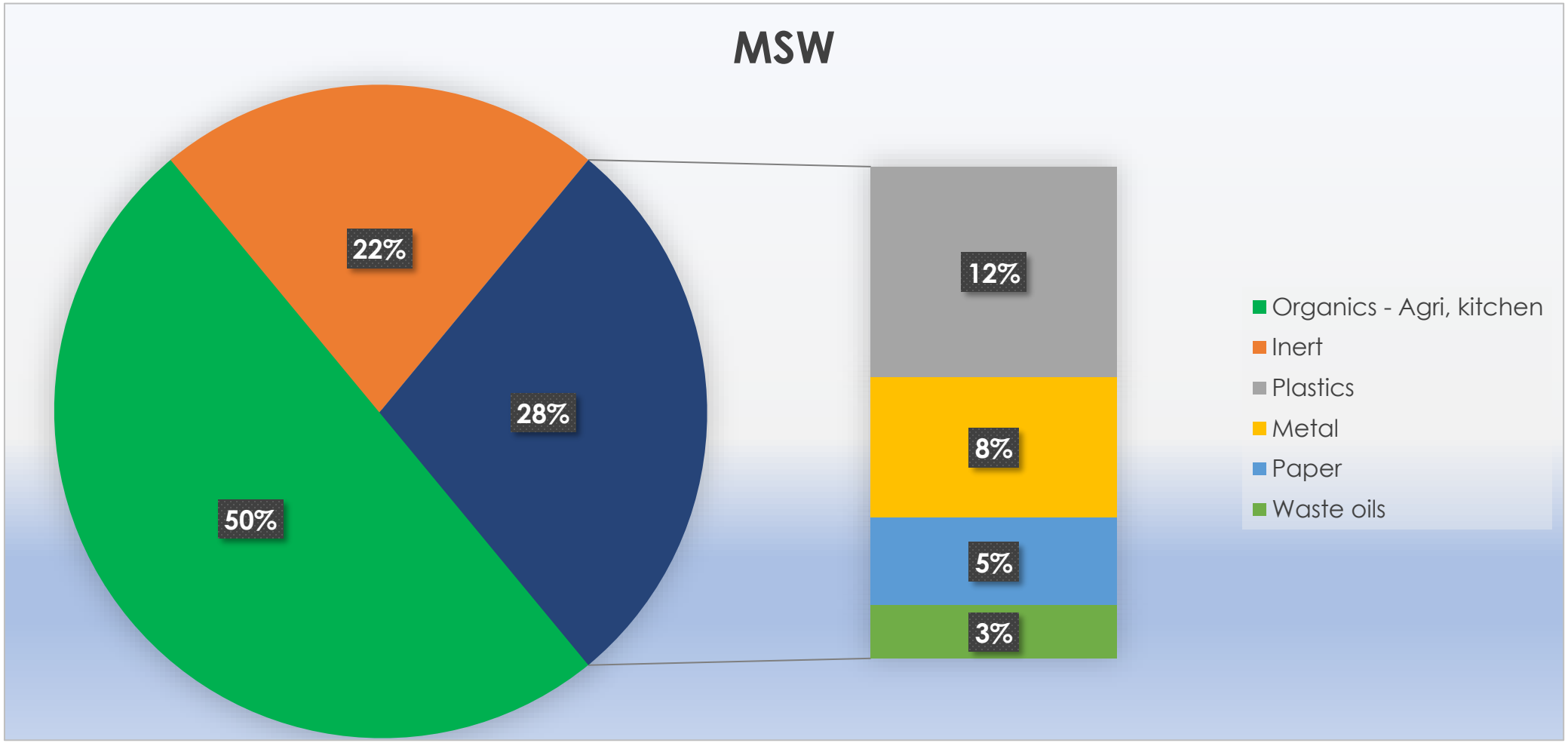
Spring, 2014

World's first large-scale microwave chemical plant
Chemicals, 10t/day production
M3K start-up

M3K, the world's first large-scale microwave chemical plant, completed in Suminoe, Osaka.

Municipal Solid Waste – Area of Opportunity in decarbonization?

Key Players



Delhi NCR Waste to Energy Existing Plants – "incineration"

Key Players

Name	Plant Capacity (MTD)	Electricity Generated (MW)	Status
Timarpur - Okhla WTE	1950	21	Operational
Ghazipur WTE	1300	12	Operational
Narela WTE	2500	24	Operational
Tehkand WTE, Biopower*	*2000*	*25*	Sep 2022
Proposed	*5000*	*?*	2023-2024

Tehkand Waste to Electricity Project Bio-chemical and Thermo-chemical conversion process, enzymatic decomposition of organic matter

Biomedical Wastes

SMA Industrial Area M/S Biotic Waste Solutions.

Nilothi plan - SMS Water Grace BMW Pvt Ltd.

Capacity - ~25 MT/day bio-medical waste

Advanced Gasification - Areas of Opportunity

"Story telling to policymakers/public"

- Broiler to Boiler
- Coconut to coke
- Sustainable Aviation Fuels (SAF)
- Refuse Derived Fuels (RDF)

Technology Readiness Levels
(TRL – US DOE)
Just Understand Gauge And Adjust for Delivery
(JUGAAD – India-Various parts, Mountain- WV)

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THANK YOU
FOR
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Heartfelt Thanks to

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