ADVANCES IN HYDROTHERMAL TREATMENT OF SEWAGE SLUDGE

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22nd October 2025

AtkinsRéalis

AGENDA

01 Drivers for Change
02 Introduction to Hydrothermal Processing
03 Global Deployment Examples
04 Metro Vancouver HTL Case Study
05 Gaps & Challenges
06 Conclusions

Introduction & Acknowledgements

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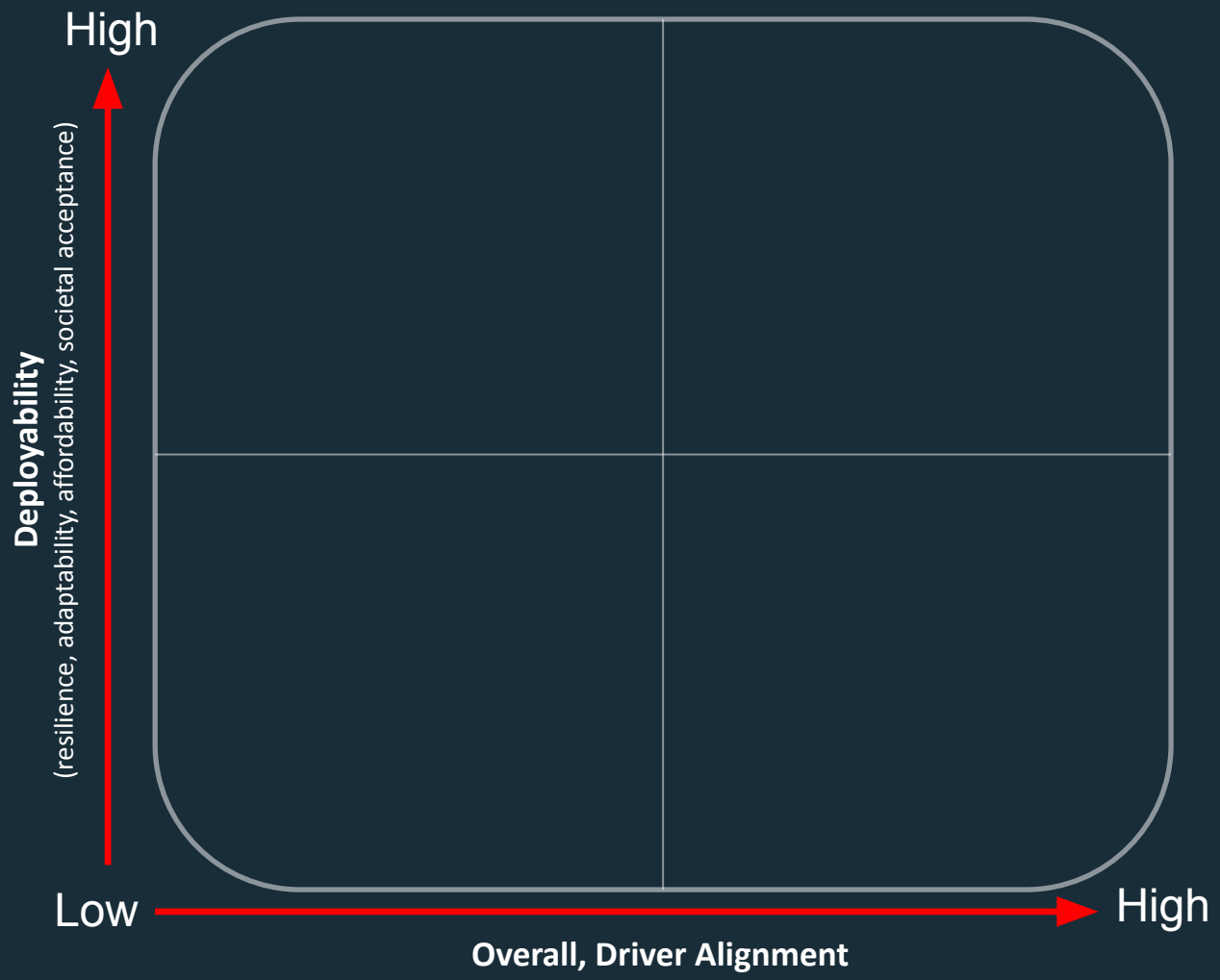
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

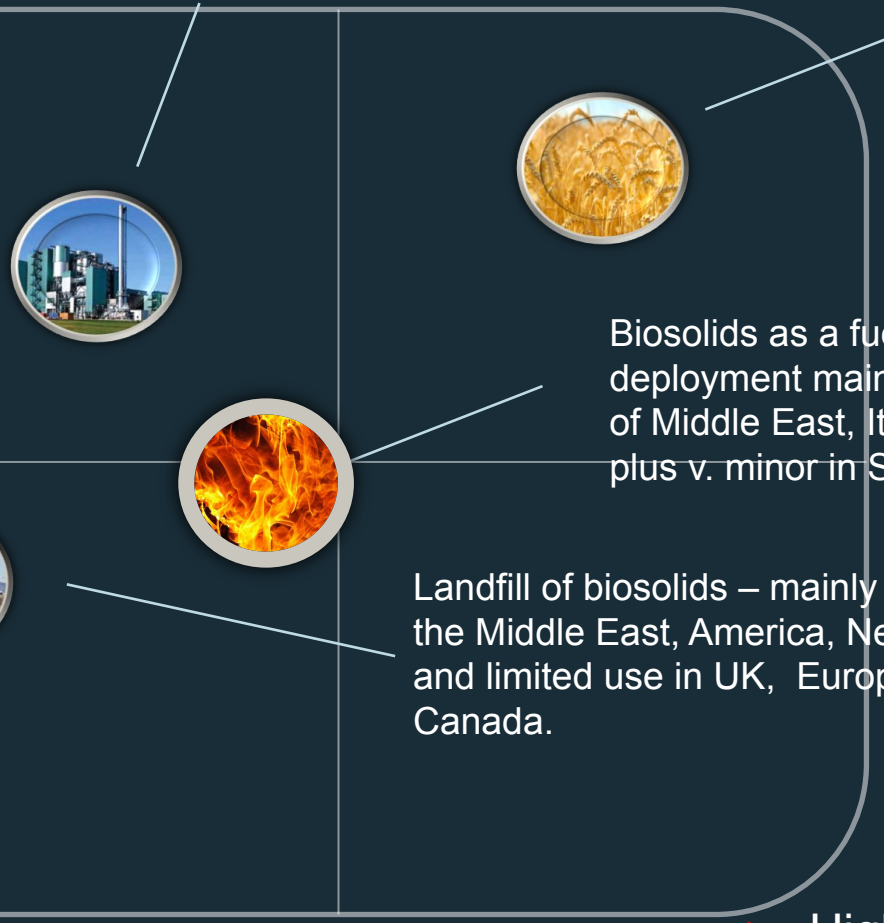
CURRENT PRACTICE



CURRENT PRACTICE

Incineration of biosolids – mainly deployed in Europe, less so in UK, and mixed in USA and Canada.

Recovery of biosolids to agriculture – relatively mature in regions including UK, Europe, Canada.



Biosolids as a fuel – limited deployment mainly Japan, parts of Middle East, Italy and USA, plus v. minor in Scotland.

Landfill of biosolids – mainly deployed in the Middle East, America, New Zealand and limited use in UK, Europe, and Canada.

High

Deployability
(resilience, adaptability, affordability, societal acceptance)

Low

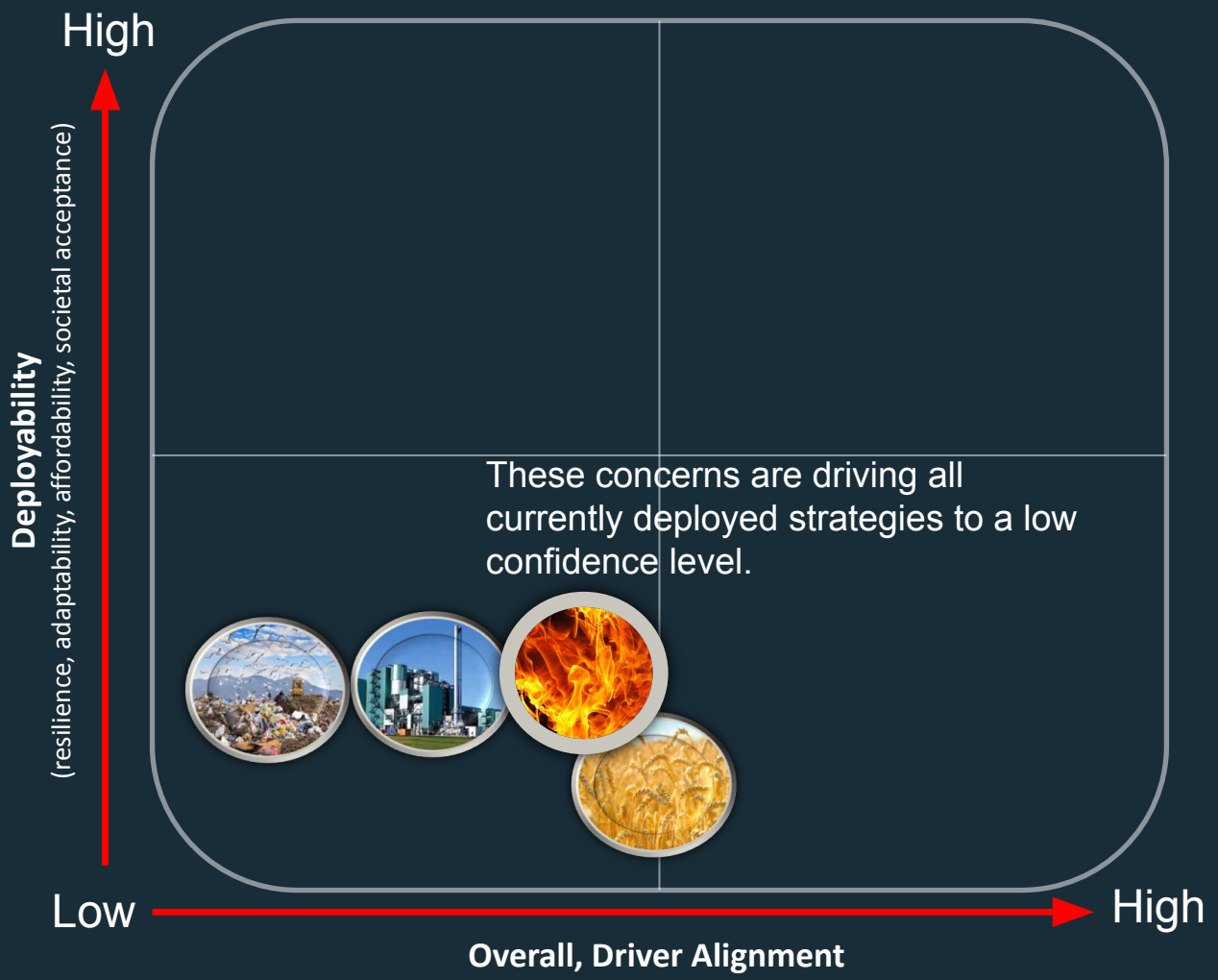
High

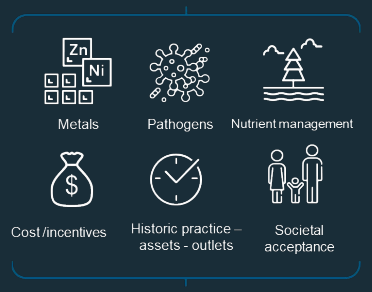
Overall, Driver Alignment

Main drivers for strategic positions

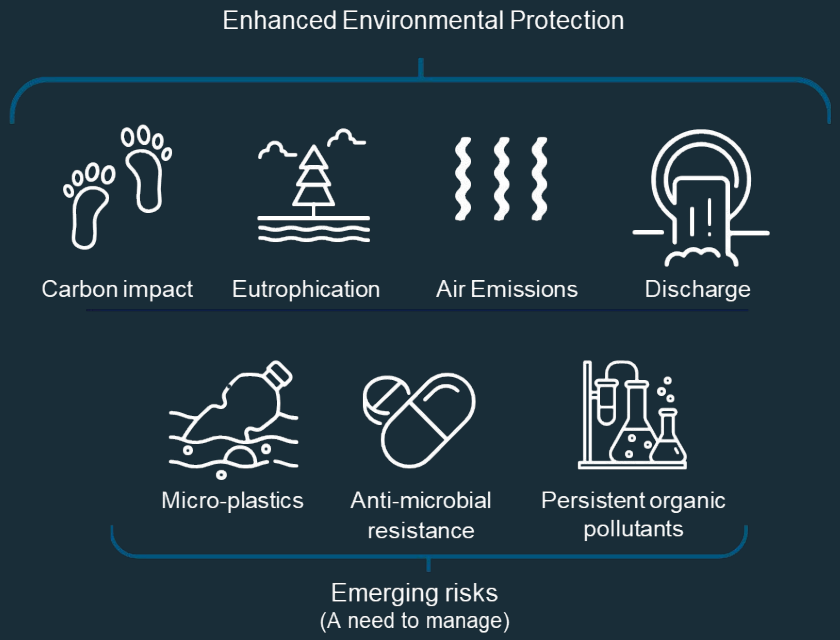
IMMEDIATE CHALLENGE

The predominately utilised strategies are under stress. Biosolids management is not a **choice** it's a **necessity** so we must have a sustainable, deployable strategy!



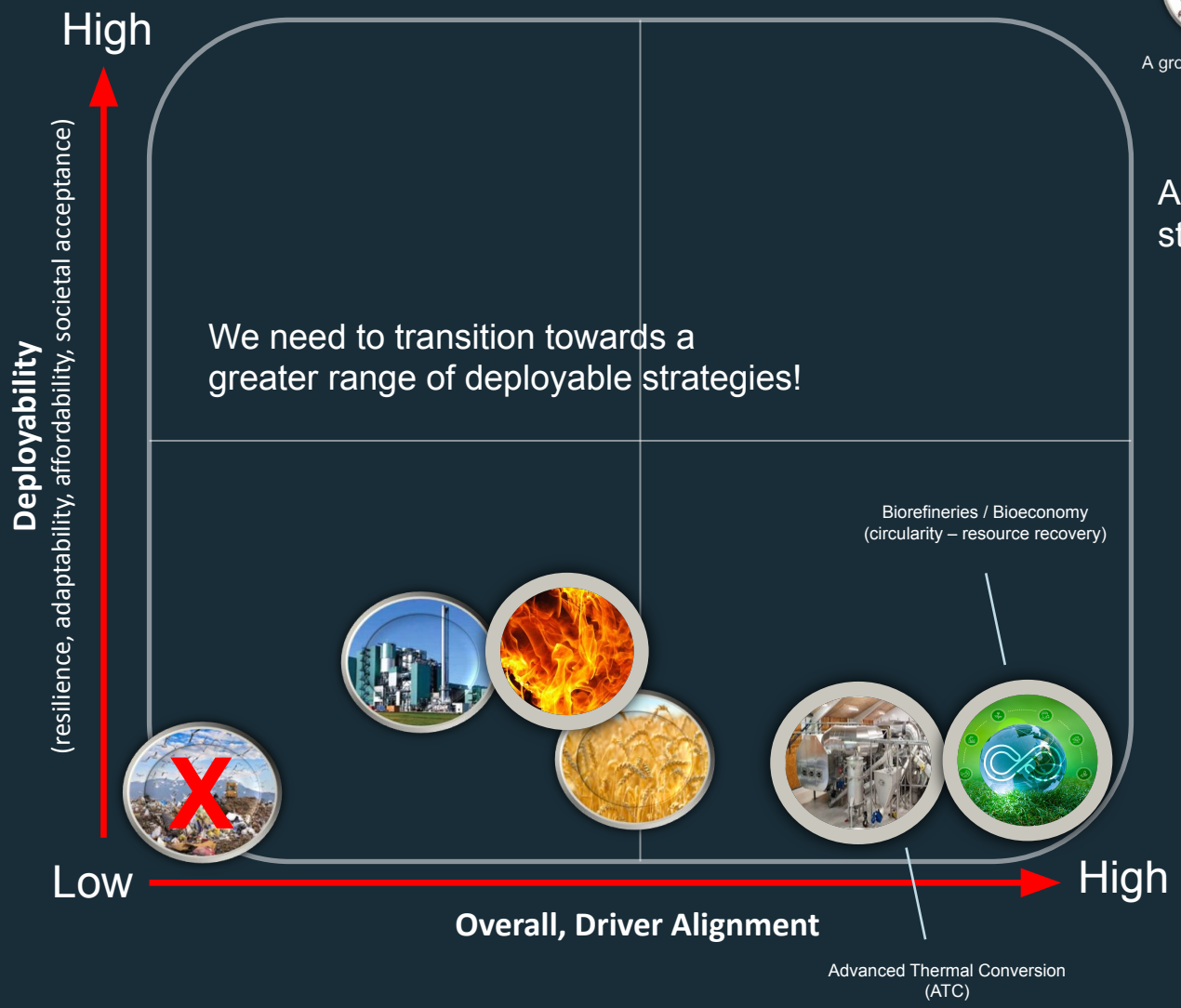


In addition to the historic drivers, we are witnessing an enhanced focus on the environment and increased perception concerns.



A CHANGE IN DIRECTION

We are at a pivot point - Two new focus areas, ATC and Biorefineries are developing, however, greater certainty is required to fully transition and deploy these strategies.



A changing world, and bespoke ambitions are moving the direction of strategies, and the technology solutions required to implement them.

BBC NEWS

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Science & Environment

Warning over 'dirty secret' of toxic chemicals on farmers' fields

AS

The Guardian

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Environment | Climate crisis | Wildlife | Energy | Pollution

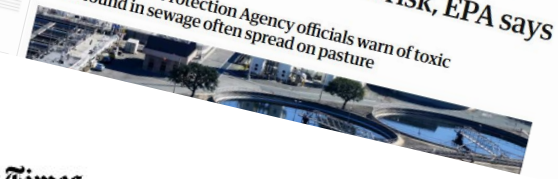
US Environmental Protection Agency

Associated Press

Tue 14 Jan 2025 15.45 GMT

Chemicals in sewage sludge fertilizer used on farms pose cancer risk, EPA says

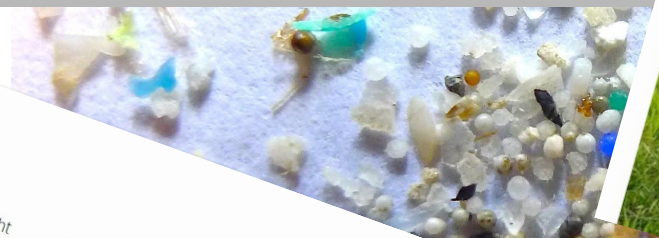
Environmental Protection Agency officials warn of toxic PFAS found in sewage often spread on pasture



The New York Times

In a First, the E.P.A. Warns of 'Forever Chemicals' in Sludge Fertilizer

Levels of PFAS in sewage sludge used as fertilizer can pose risks that sometimes exceed safety thresholds "by several orders of magnitude," the agency said.



Microplastics in sewage: a toxic combination that is poisoning our land

George Monbiot

Policy failure and lack of enforcement have left Britain's waterways and farmland vulnerable to 'forever chemicals'

ENDS REPORT

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EA faces legal action over microplastics in sewage sludge

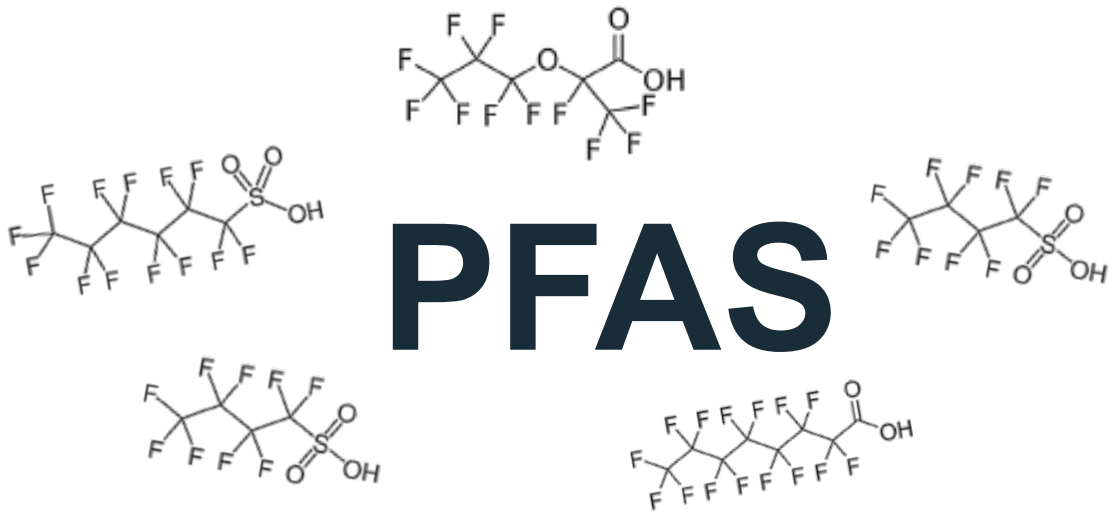
The Environment Agency (EA) and environment secretary Thérèse Coffey are facing legal action for abandoning a... legislate on sewage sludge spread on land which has been found to contain harmful levels of 'forever ch...

'Forever chemicals' found in Sydney sewage in food production

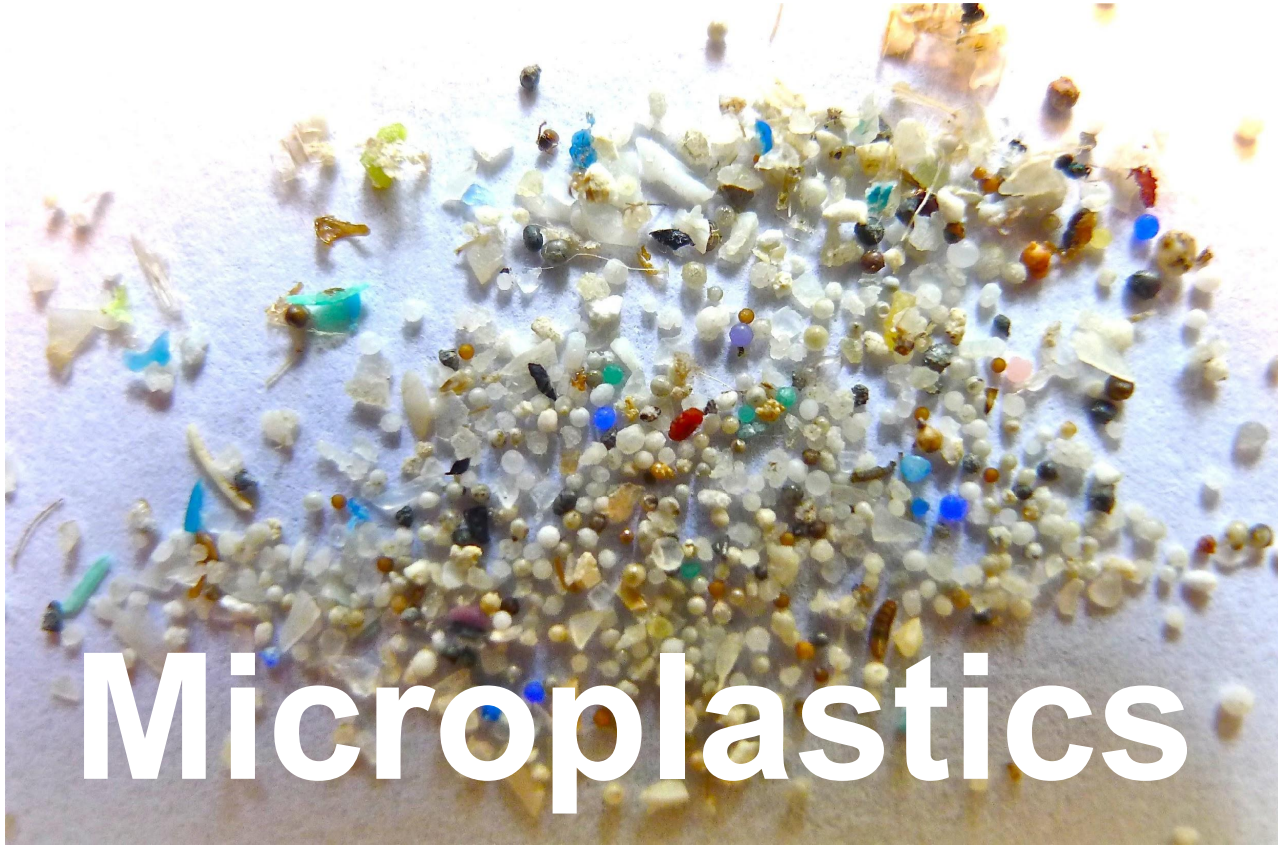
By Xanthe Gregory | By Joanna Woodburn | Mon 16 Dec | Stateline | Environmental Health

oplastics

Key substances of concern



PFAS



Microplastics

Advanced Thermal Conversion

Advanced Thermal Conversion (ATC)

Space Race

Advanced Thermal Conversion Overview

Pyrolysis

Biochar

Hydrothermal carbonisation (HTC)

Hydrochar & conc. effluent

Hydrothermal liquefaction (HTL)

Bio-crude oil & conc. effluent

Hydrothermal gasification (HTG)

Syngas & ash

Gasification

Syngas & char/ash

Dry ATC

Wet ATC

Hydrothermal Oxidation (HTO)

Ash & conc. effluent

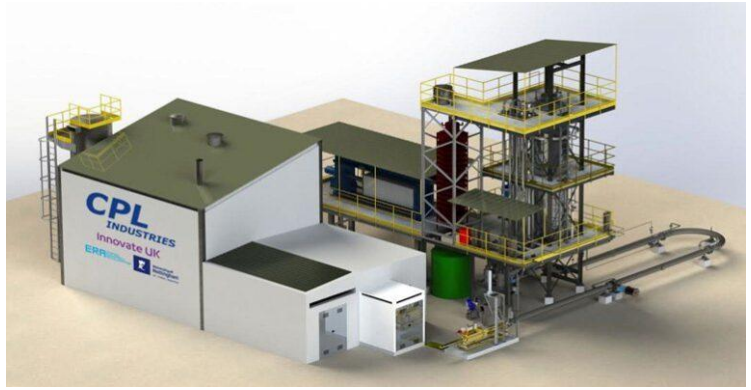
Incineration

Ash only

Super-critical water oxidation (SCWO)

Ash only

Advanced Thermal Conversion Overview



Example: CPL's HTC System

Wet ATC

Hydrothermal carbonisation (HTC)

Hydrochar & conc. effluent

<280°C; <50 bar
Zero O_2

Hydrothermal liquefaction (HTL)

Bio-crude oil & conc. effluent

280-374°C; >50 bar
Zero O_2

Hydrothermal gasification (HTG)

Syngas & ash

>374°C; >221 bar
Zero O_2

Hydrothermal Oxidation (HTO)

Ash & conc. effluent

<374°C; <221 bar
Unrestricted O_2

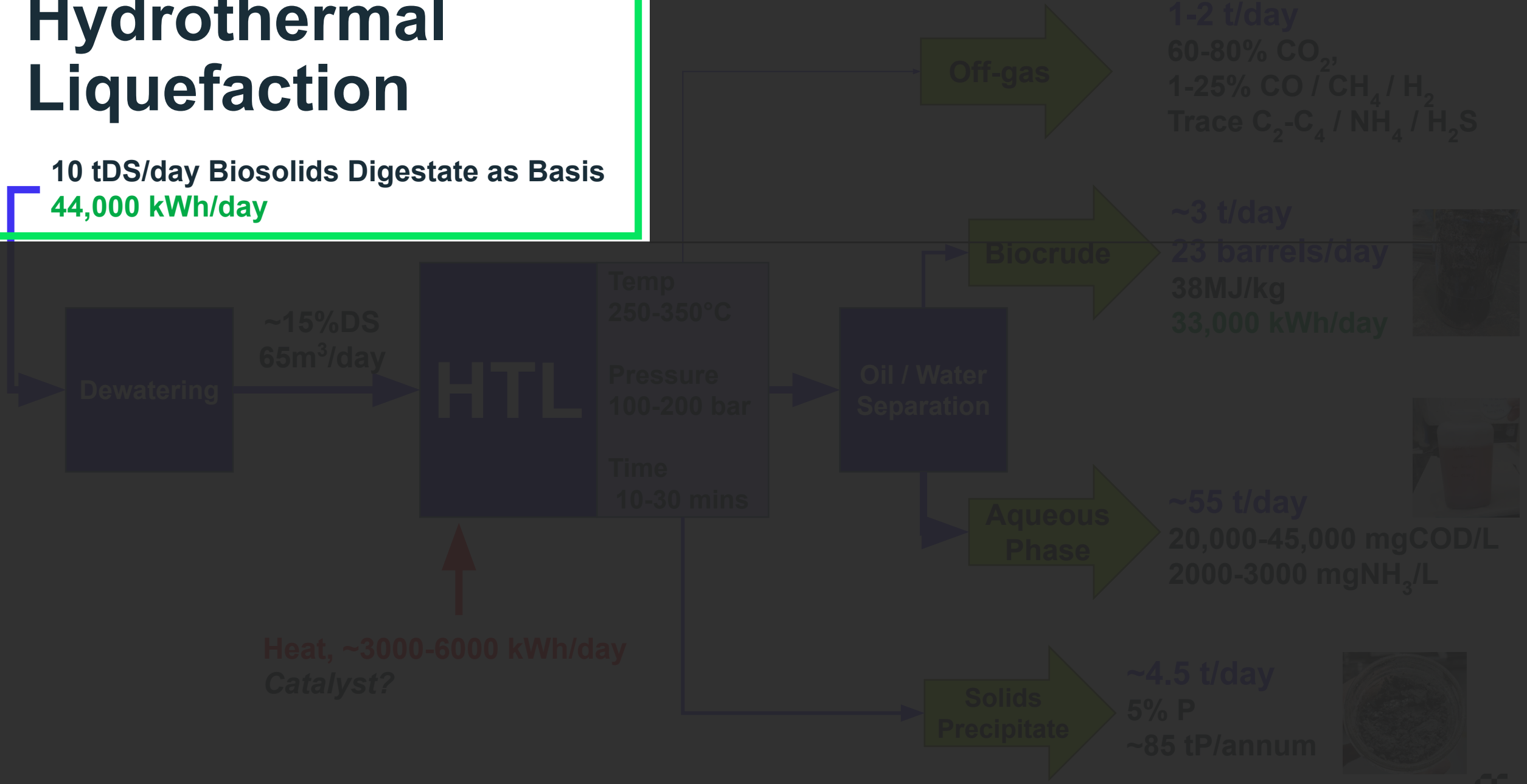
Super-critical water oxidation (SCWO)

Ash only

>374°C; >221 bar
Unrestricted O_2

Hydrothermal Liquefaction

10 tDS/day Biosolids Digestate as Basis
44,000 kWh/day



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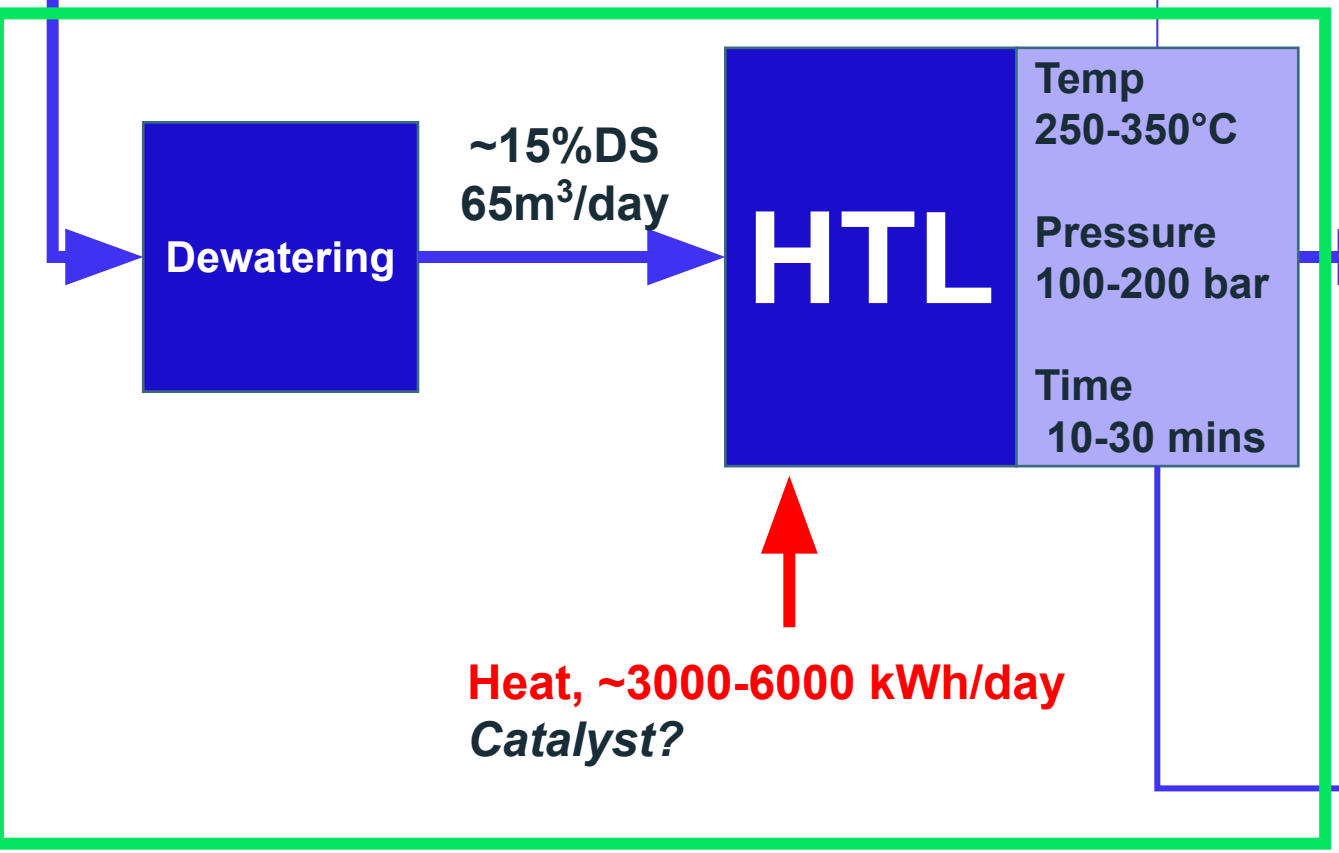

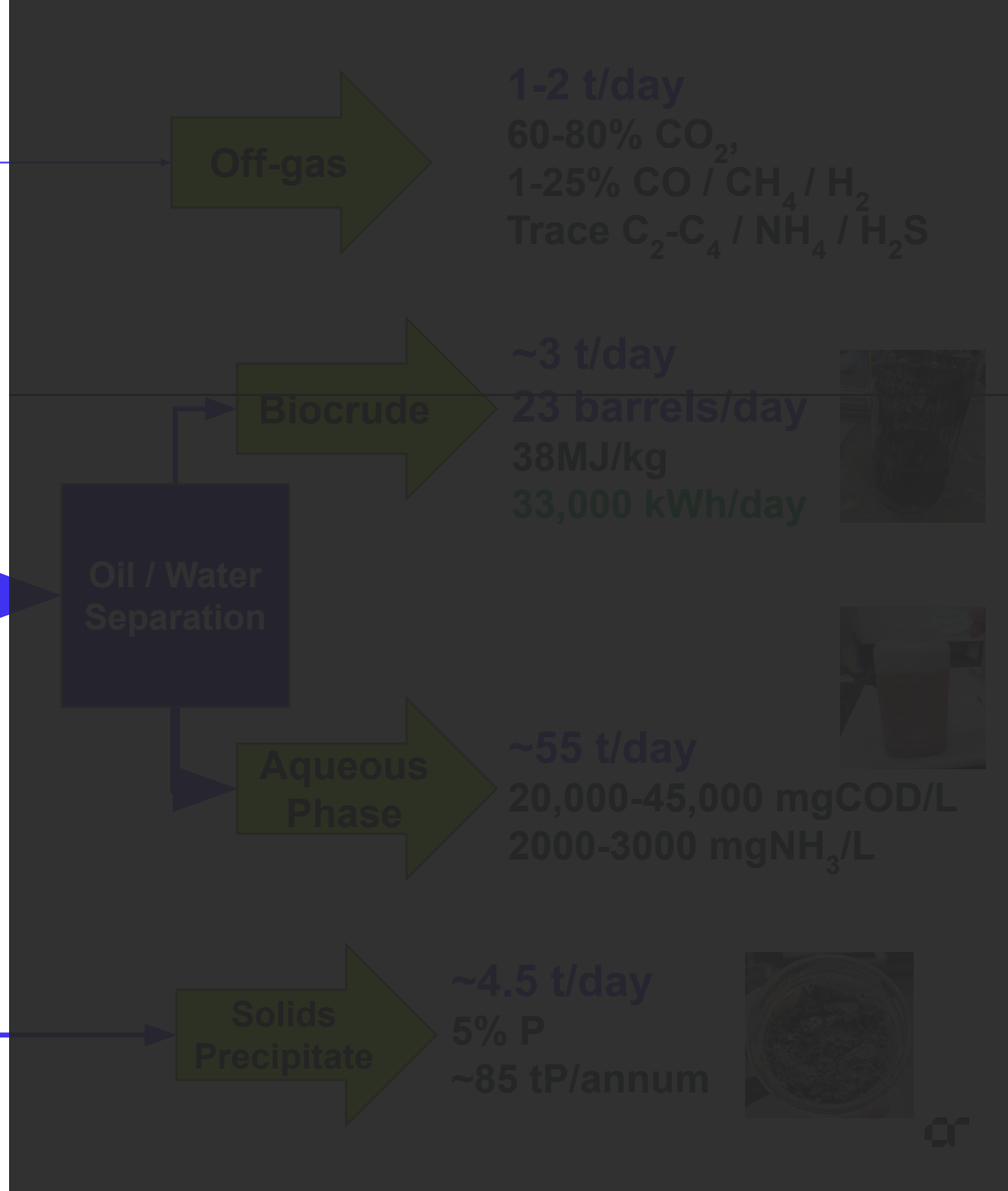

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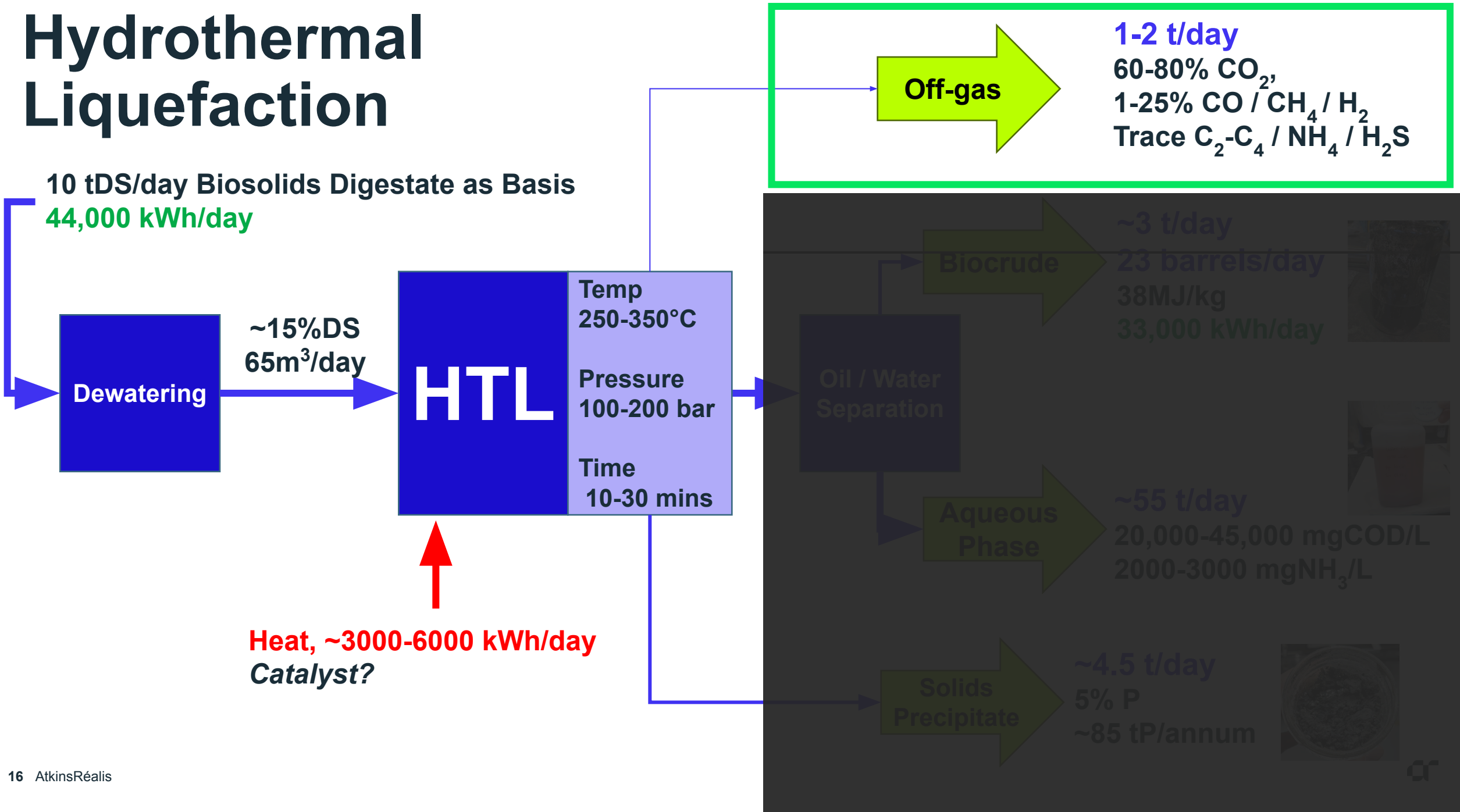


Hydrothermal Liquefaction

10 tDS/day Biosolids Digestate as Basis
44,000 kWh/day

Dewatering

~15%DS
65m^3/day

HTL

Temp
250-350°C

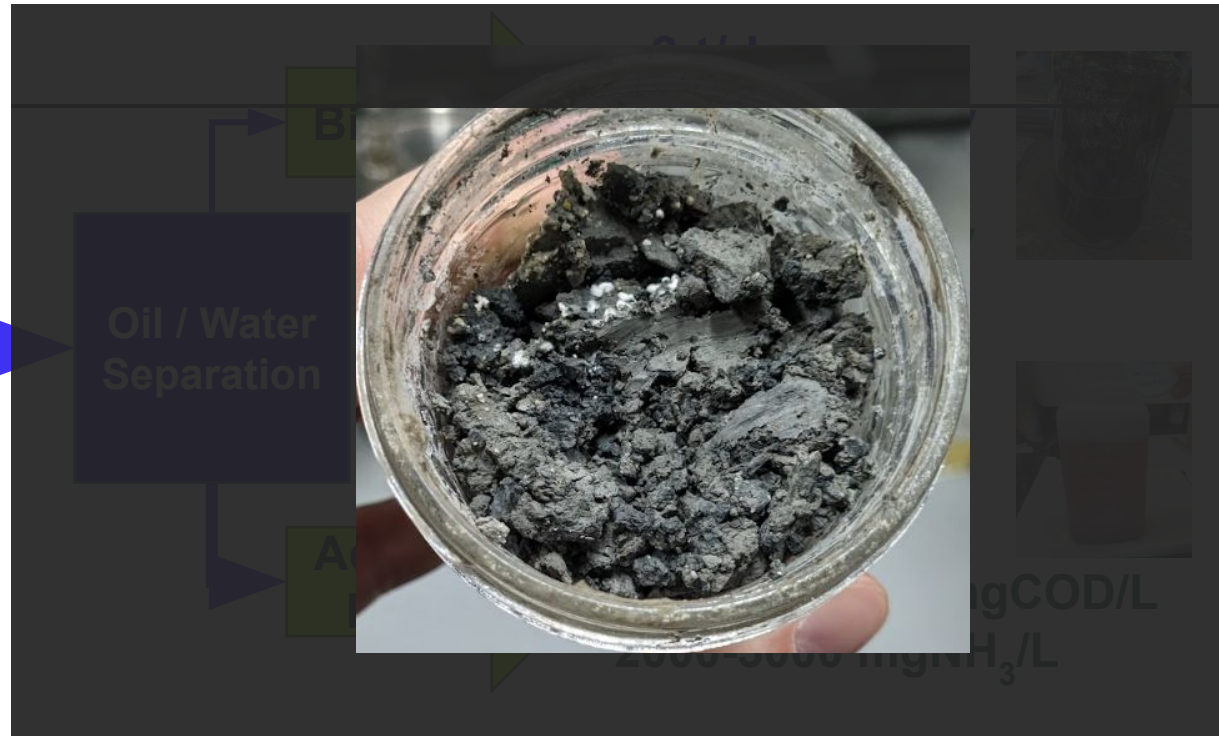
Pressure
100-200 bar

Time
10-30 mins

Heat, ~3000-6000 kWh/day
Catalyst?

Off-gas

1-2 t/day
60-80% CO_2,
1-25% CO / CH_4 / H_2
Trace C_2-C_4 / NH_4 / H_2S



Solids
Precipitate

~4.5 t/day
5% P
~85 tP/annum

Hydrothermal Liquefaction

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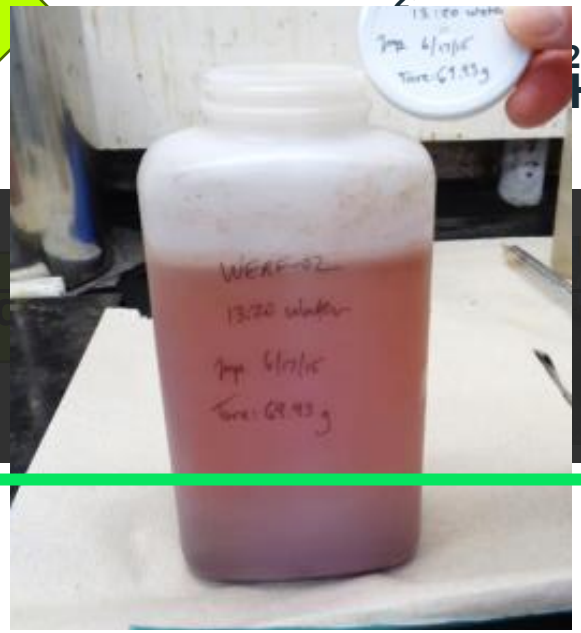

Oil / Water Separation

Aqueous Phase

~55 t/day
20,000-45,000 mgCOD/L
2000-3000 mgNH_3/L

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5% P
~85 tP/annum

Hydrothermal Liquefaction

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Catalyst?

Off-gas

1-2 t/day
60-80% CO_2,
1-25% CO / CH_4 / H_2
Trace C_2-C_4 / NH_4 / H_2S

Oil / Water Separation

Biocrude

~3 t/day
23 barrels/day
38MJ/kg
33,000 kWh/day

Aqueous Phase

~55 t/day
20,000-45,000 mgCOD/L
2000-3000 mgNH_3/L

Solids Precipitate

~4.5 t/day
5% P
~85 tP/annum

When Biocrude is Distilled, experience shows:

Biocrude

- Fuel Gas
- Naptha
- Gasoline
- **Paraffin Oil**
- Diesel Oil
- Lubricating Oil
- Fuel Oil
- Bitumen

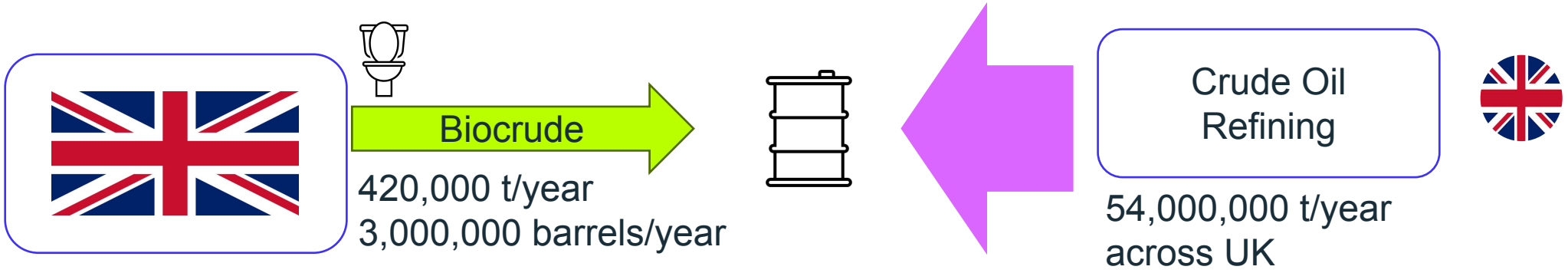
10-15% - light fuel gases

25% - jet fuel range

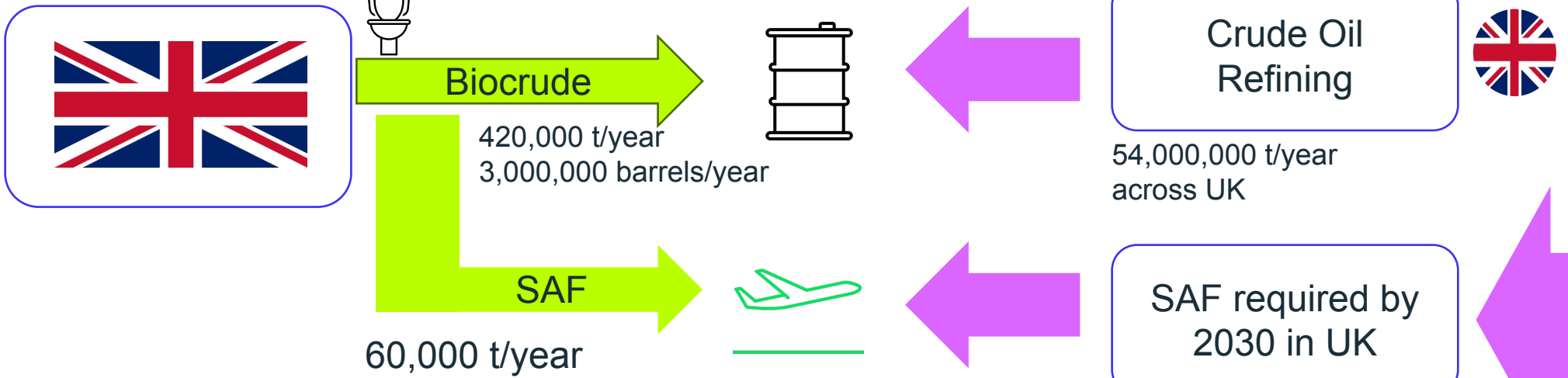
Hydrotreating / Cracking

+50% - heavy diesel range

Biocrude


Biocrude
420,000 t/year
3,000,000 barrels/year
Crude Oil
Refining
54,000,000 t/year
across UK

Biocrude



Has the potential to be higher ~200,000 t/year if biocrude refined further

1,150,000 t/year (based on current usage, may be lower in future)

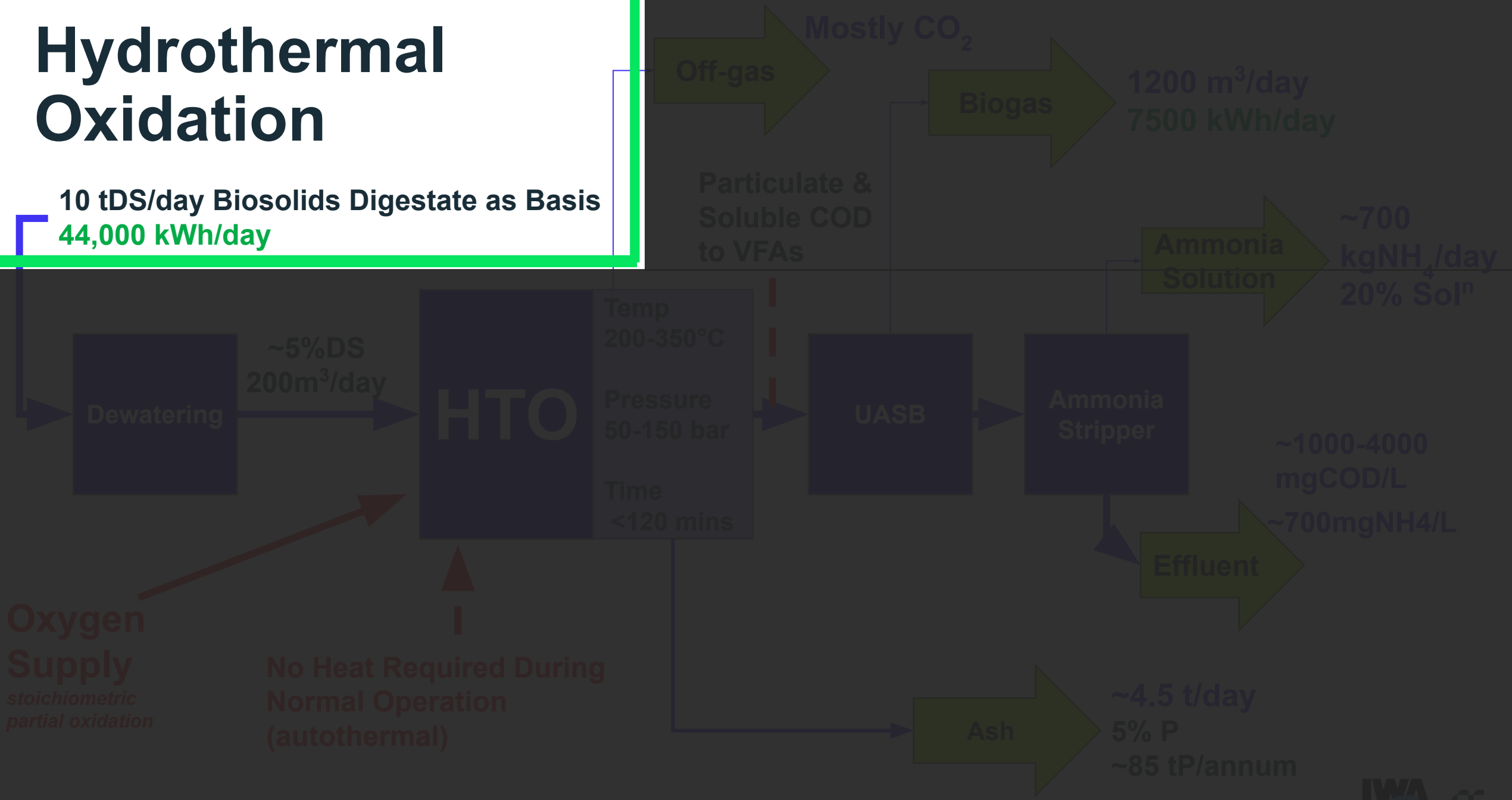
Waste Oils & HEFA Cap

Various SAF Mandates and Incentives Emerging Globally

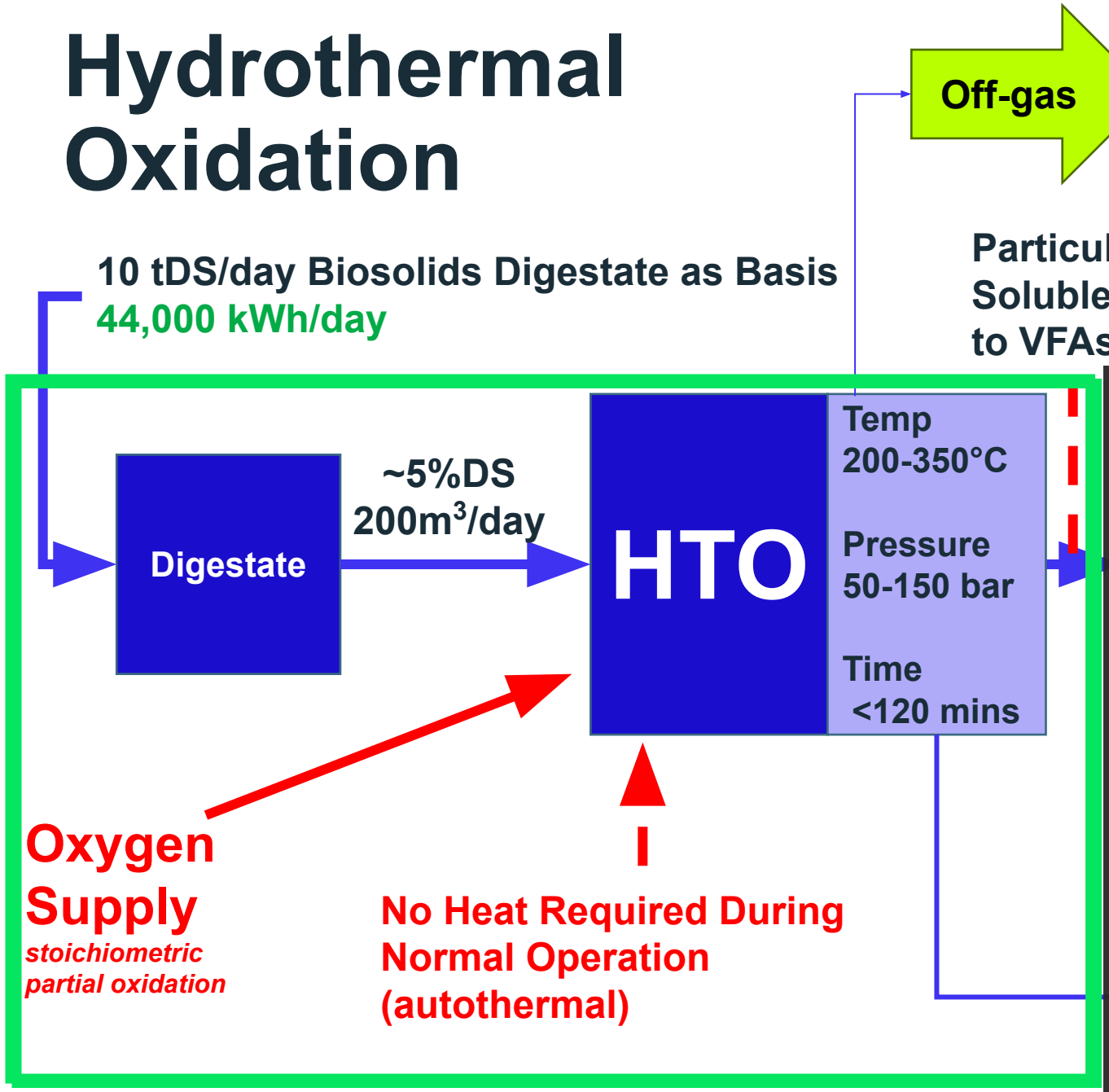
Hydrothermal Oxidation

10 tDS/day Biosolids Digestate as Basis

44,000 kWh/day



Hydrothermal Oxidation



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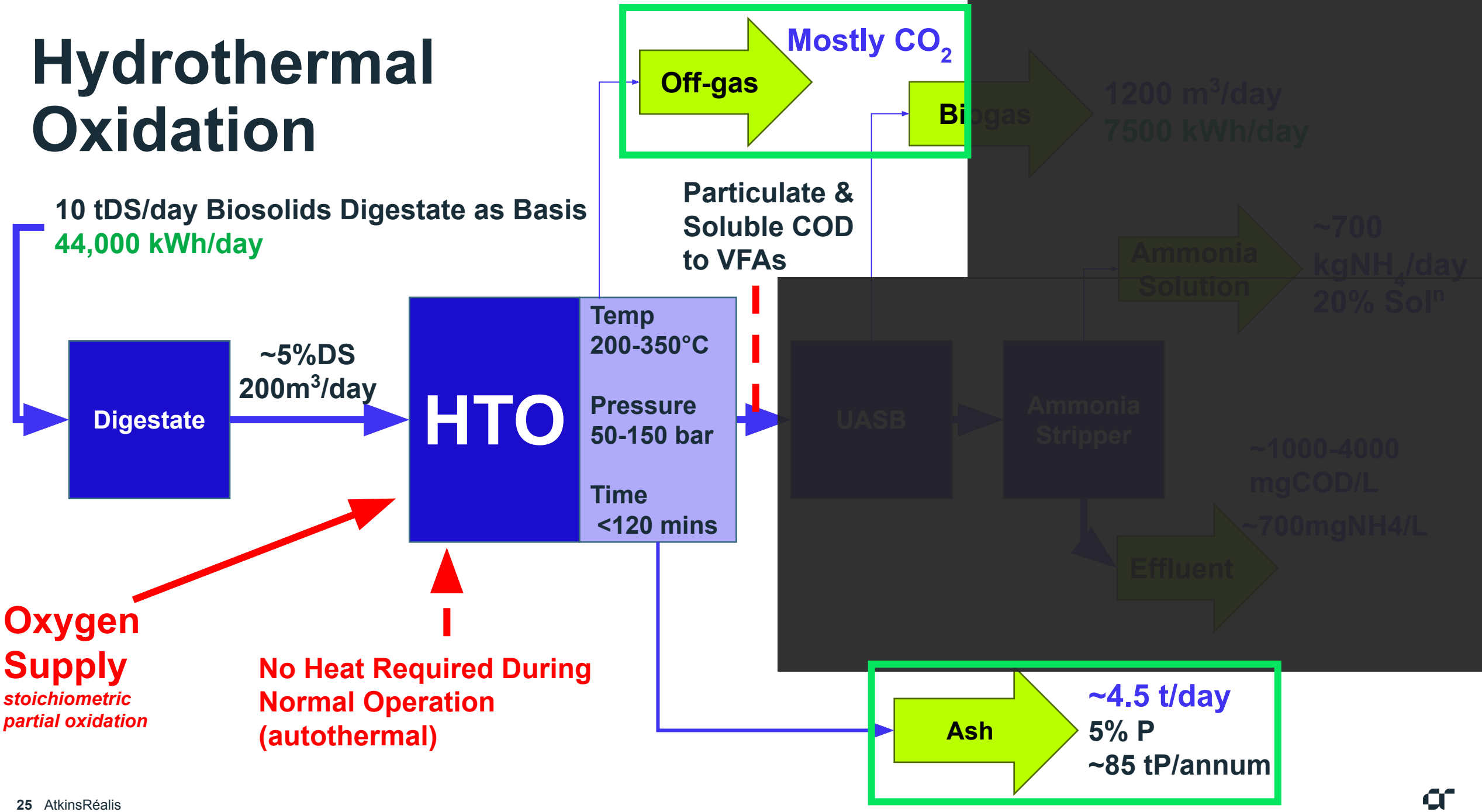

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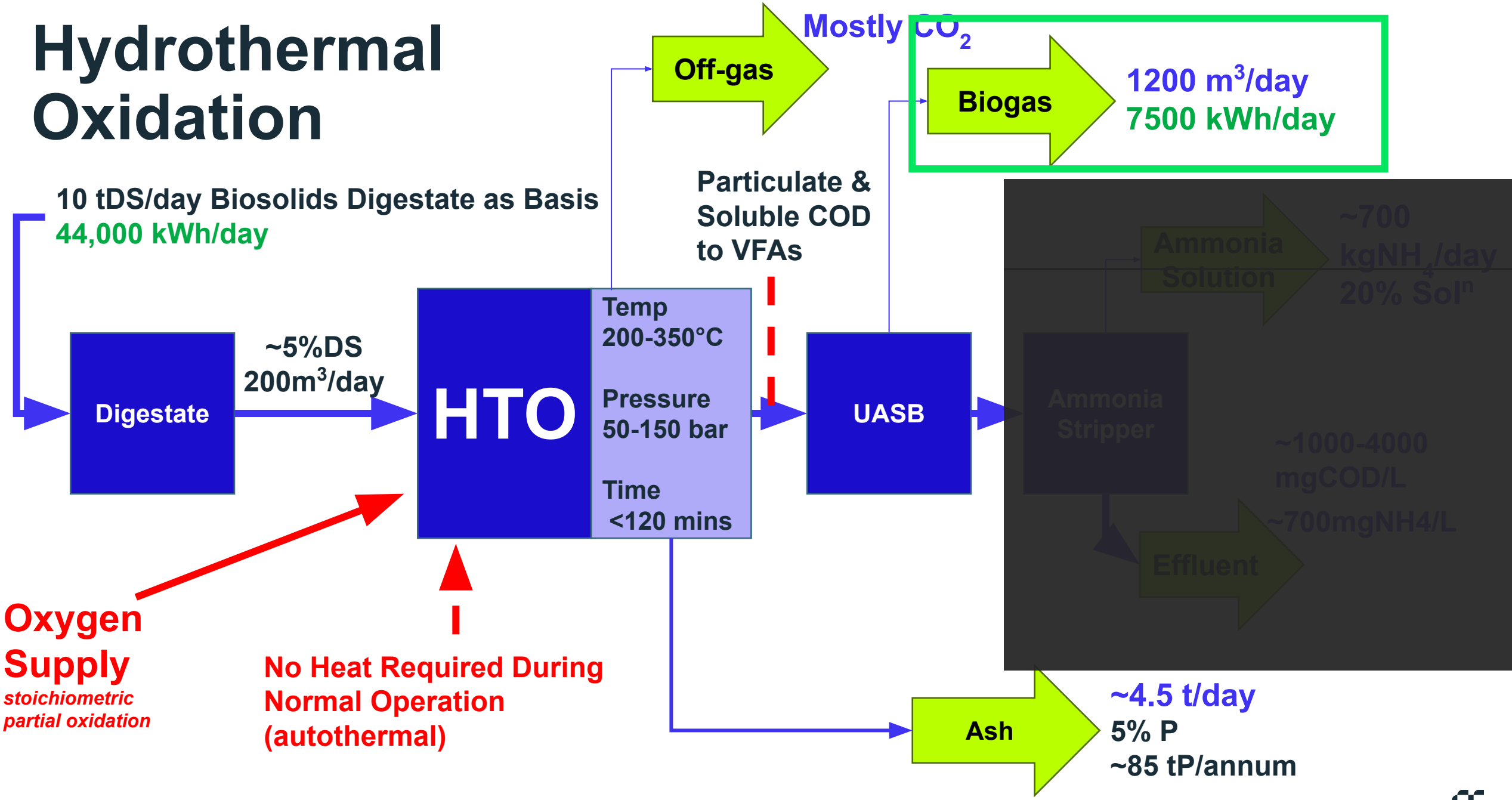

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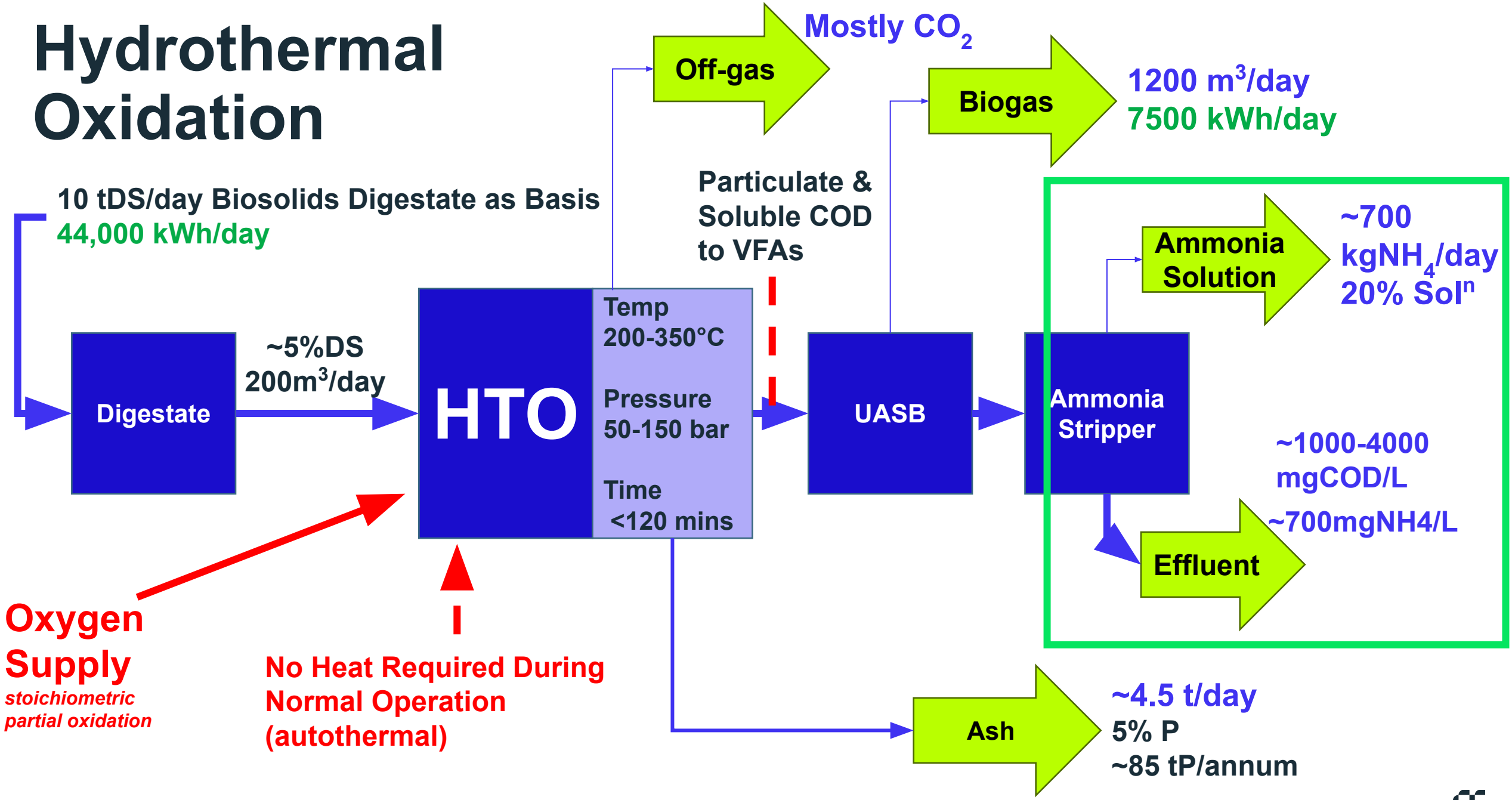


Key Points of difference

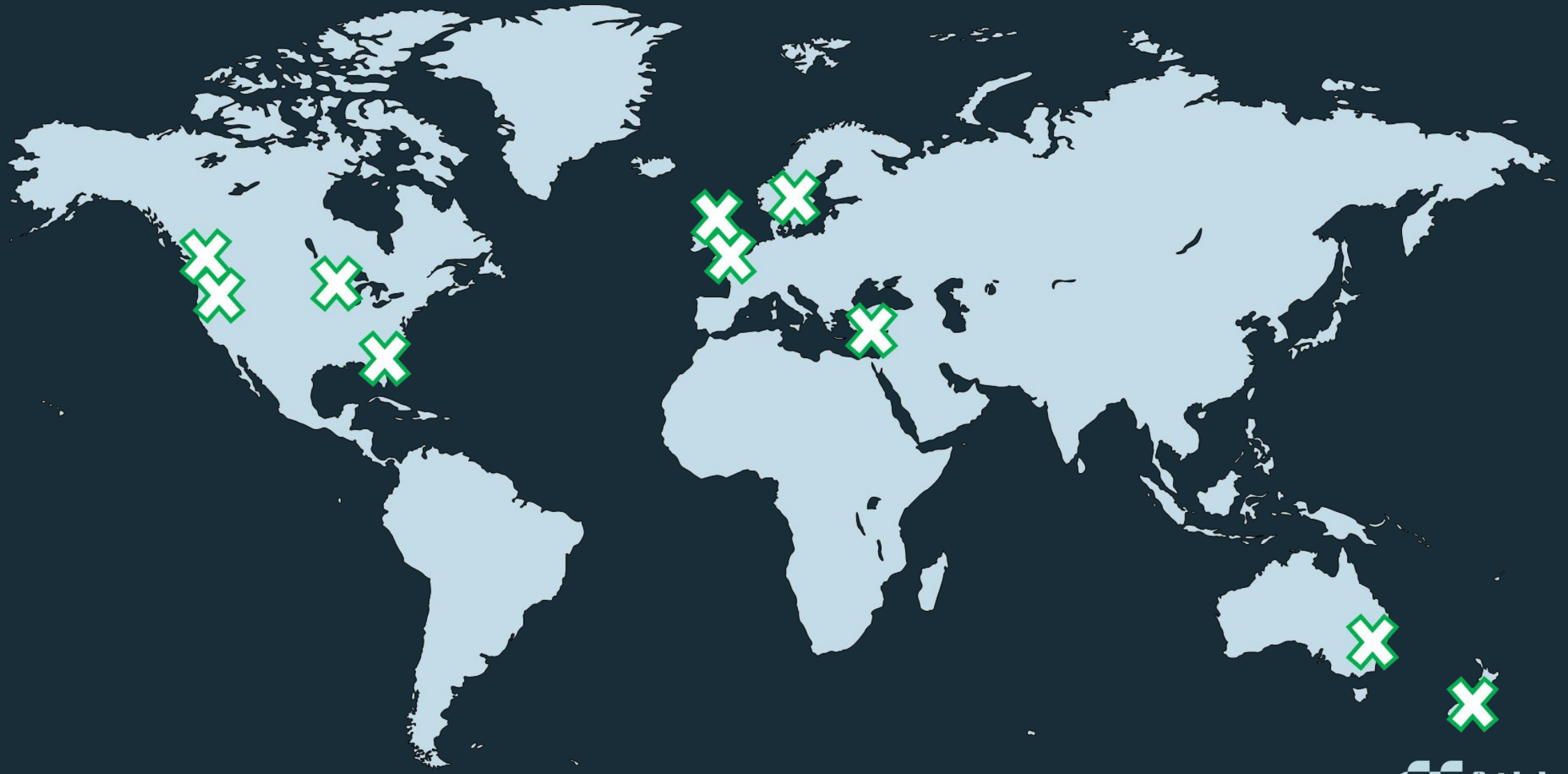
HTL

- No oxidising
- Raw or digested feed – typically a wet cake c.15% DS
- No need to thermally dry sludge after dewatering
- Outputs – Biocrude oil, ammonia rich aqueous liquor, hydrochar
- Products – Biocrude to SAF or other fuel grades, Hydrochar to construction or other markets, potential to treat or recover ammonia

HTO

- Oxidising
- Raw or digested feed – typically a liquid slurry at <6%
- No need to dewater or dry post treatment
- Integrates with downstream resource recovery processes*
- Outputs* – Ammonia Solution, P-rich Ash, Biogas

Global Deployment



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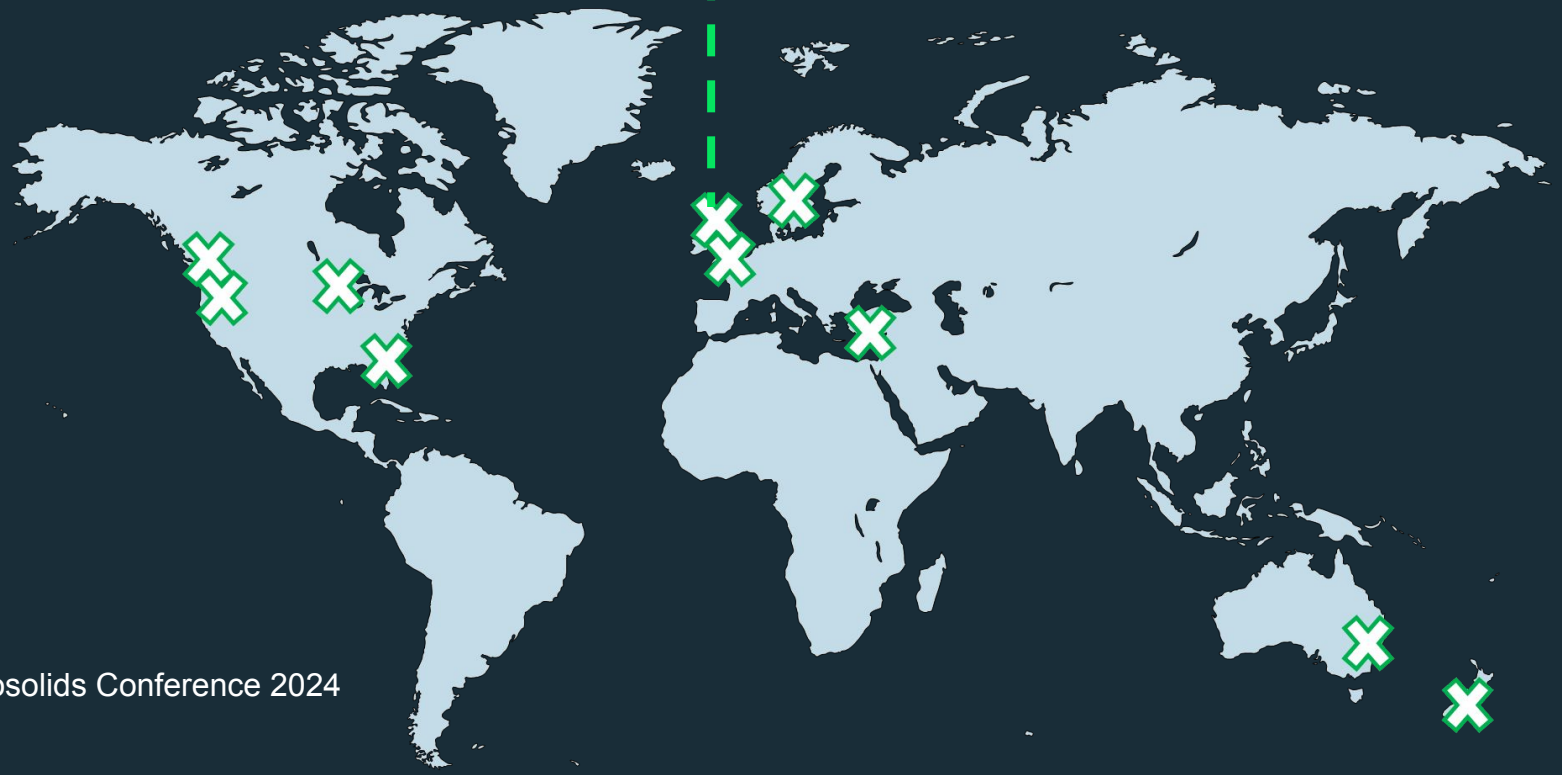
HTL Example

FIREFLY

525,000 tonnes
Initial offtake agreement with wizz

Key technology partnerships

Firefly Harwich



Source: Firefly European Biosolids Conference 2024

HTO Example

CETOGENIX

anglianwater

Ofwat Innovation Fund

Cranfield University

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Source: Cetogenix European Biosolids Conference 2024

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Case Study

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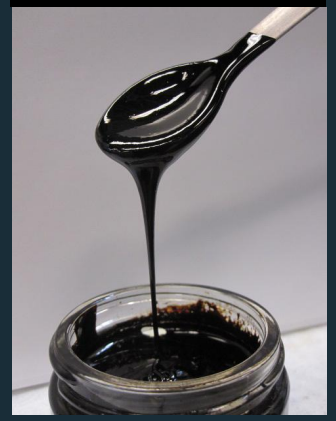
HTL Demonstration Facility at Annacis Island WWTP

Sludge feed
10 wet tonnes or
2 dry tonnes/day

HTL

Aqueous
8,000 L/day

Biocrude
750 L/day



Hydrochar
300 kg/day

Case Study

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Parkland Refinery will co-process the HTL biocrude

Fabrication of the HTL unit and site works are in progress

- Commissioning anticipated late 2026
- Operation planned for 2027 (one year of performance evaluation)

Test plan includes three feedstocks, all dewatered to 20% solids:

(ii) thickened screened primary sludge,
(iii) thickened waste secondary sludge, and
(iv) 50-50 mixture of both

Case Study

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Future vision - full-scale implementation at Iona Island WWTP

Gaps & Challenges

Scale up & Plug Flow (blockages)

Source: Pacific National Northwestern Laboratory

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Gaps & Challenges

Scale up & Plug Flow (blockages)

Off takers for outputs

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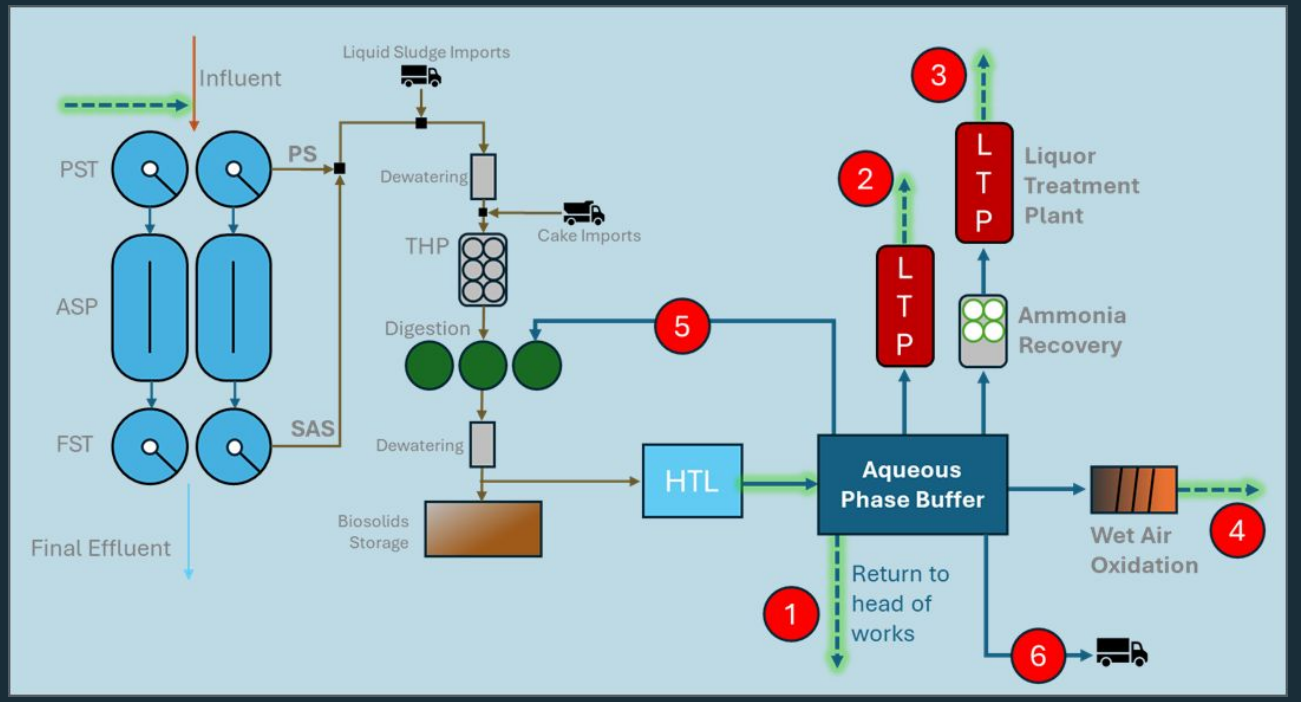
Gaps & Challenges

Scale up & Plug Flow (blockages)

Off takers for outputs

Integration Considerations



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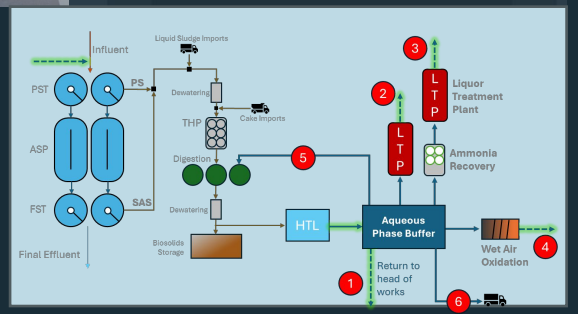
Gaps & Challenges

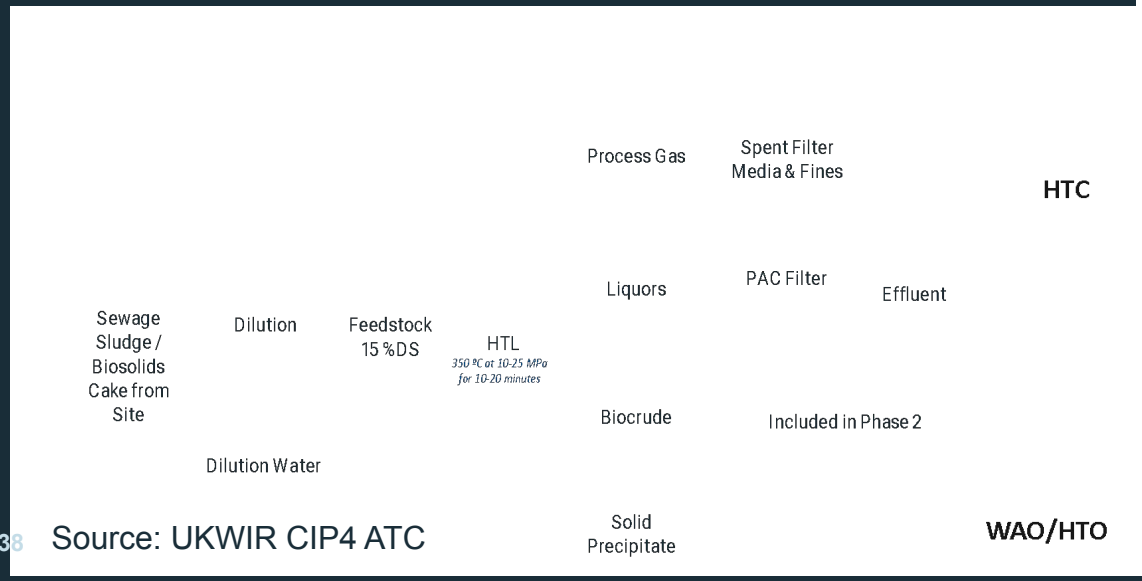
Scale up & Plug Flow (blockages)

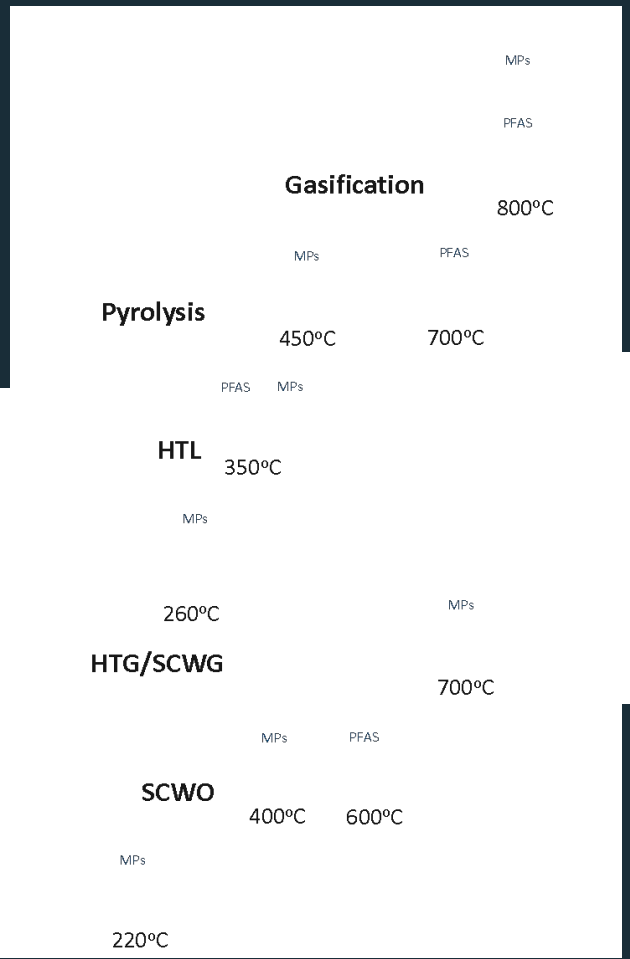
Off takers for outputs

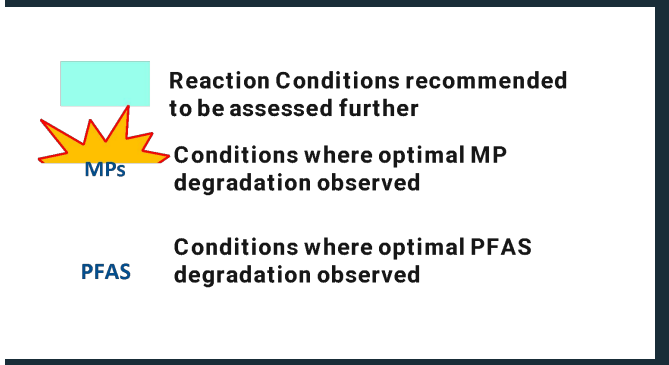
Integration Considerations

Fate of PFAS / Microplastics









Source: UKWIR CIP4 ATC

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Conclusions

Biosolids Management key risk to utilities – Global Issue

Biosolids to land risks, incineration not desirable

ATC has potential and no one size fits all. Potential to diversify biosolids management practises

There are uncertainties and unknowns – technical, operational, fate of contaminants and output markets

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