Early RNG Project Evaluation Tools

Will My Project Make a Profit?

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Nick Stonier, Jeff Zimmer

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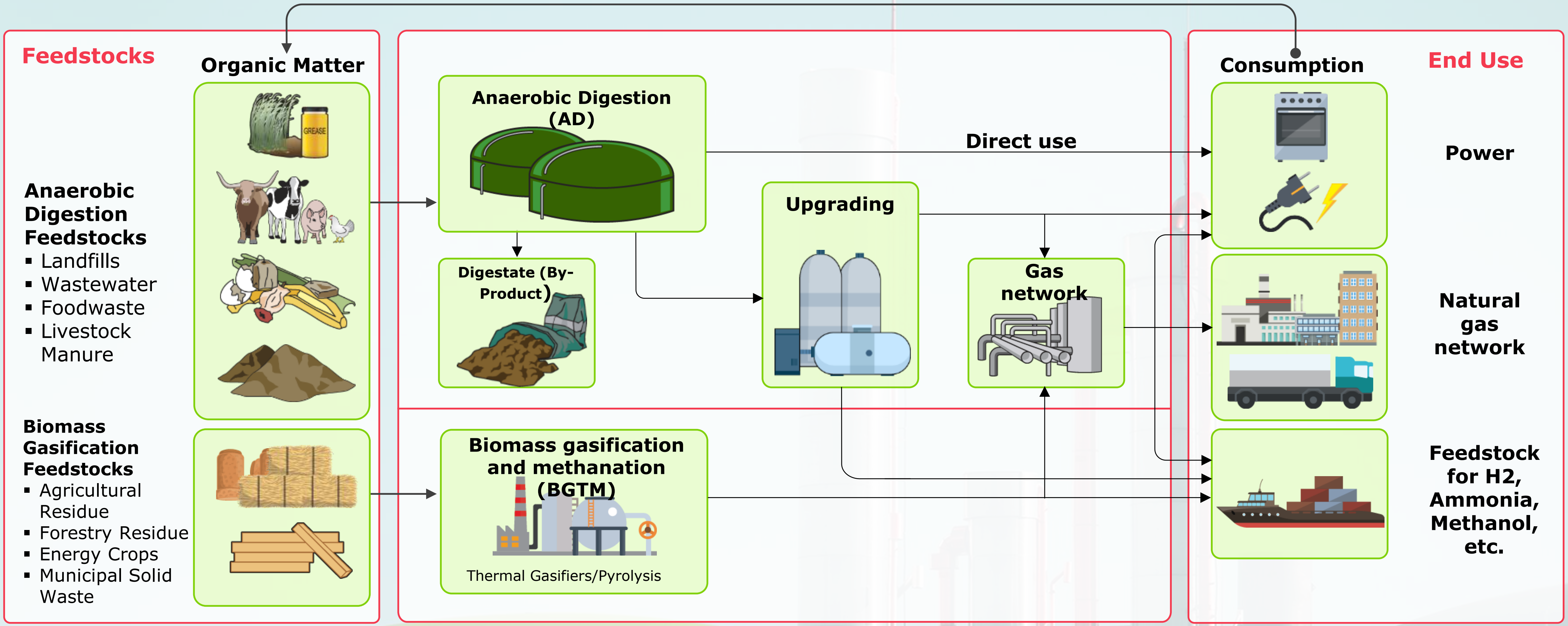
Outline

- Introduction
- Typical RNG Project Design
- Project Returns Factors
- Interdependency between technology decisions and returns
- Methodology
- Simple Example
- Case Study
- Summary

Introduction - Renewable Natural Gas Process



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Typical RNG Project Design Can Be Split into Different Process Blocks

- Plant Capacity
- Feedstock
- Material Handling / Separation
- Pre-Treatment/ Digestion
- Gas Upgrading
- Digestate Management
- Auxiliary

We will refer to these as "Process Technology Blocks"

Several technologies per process block depending on the plant capacity and the feedstock.

A project's profitability relies on four main factors

CAPEX

Project Cost to build the facility – Engineering, procurement, construction, commissioning, owner's costs.

OPEX

Cost to run the facility – power, water, consumables, labour, maintenance, licences, etc.

Revenue

Revenues from selling RNG, digestate or other tipping fees for taking in waste.

GHG Emissions

Lower GHG emissions often means a higher sell price.

Process Block and Project Returns Interdependency

Interdependence

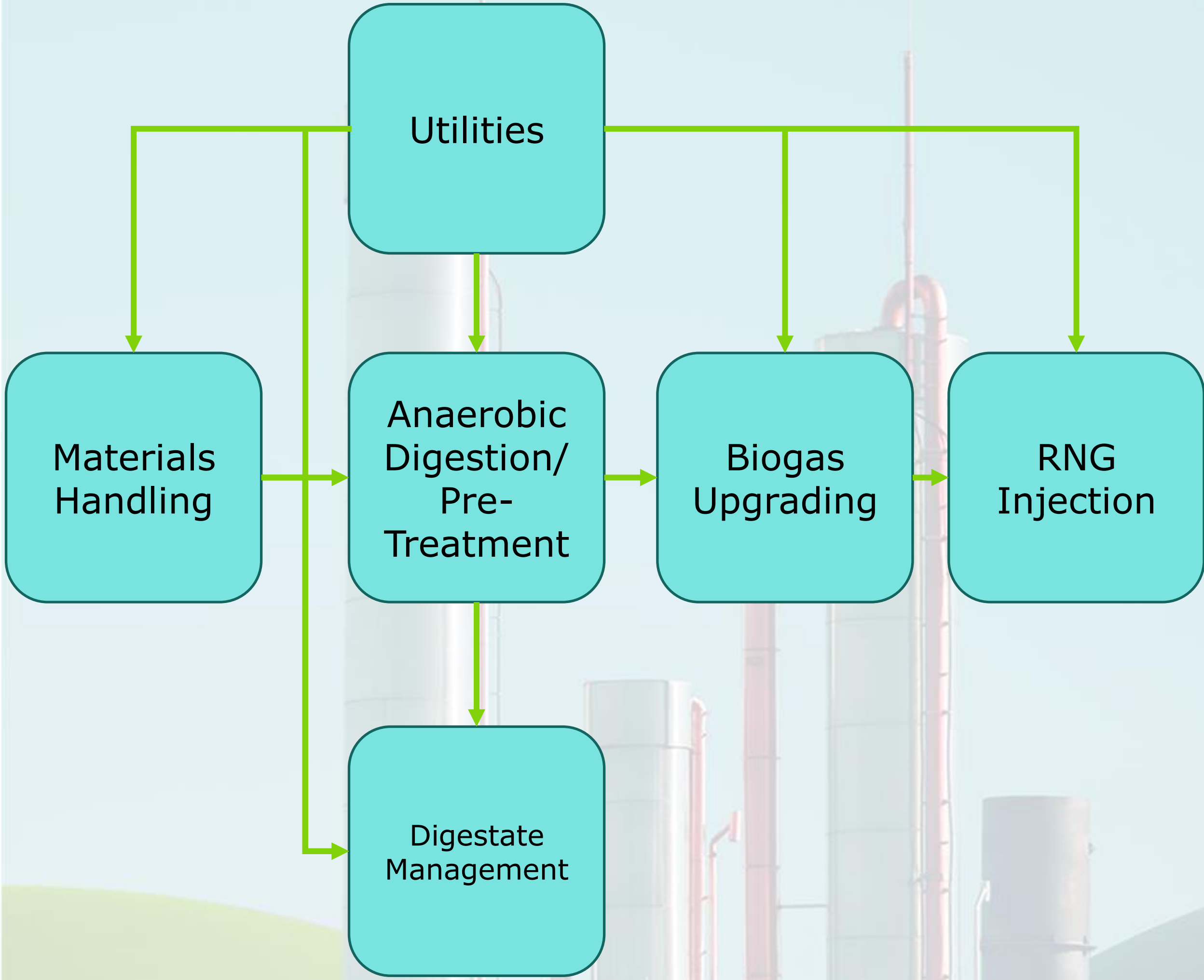
Each technology block is dependent on the others.

Technology Selection to Optimize Returns

Cheaper digester = less CAPEX but maybe less biogas and more OPEX.

Uncertainties

Choosing the right technology can be easy but project uncertainties (like feedstocks) and other interdependencies makes it more difficult.



Methodology – Correct technology selection early can Maximize Profits

1. List possible technologies for each process block for the feedstock
2. Each combination of technologies is one potential design
3. Ideally each design is tested but likely not possible
4. Reduce technologies to be considered
5. Engineer to a level of 5% for each design
6. Compare based on economic drivers – levelized cost of energy
7. Iterate as required

Plant Capacity	Feedstock	Material Handling / Separation	Pre-Treatment/ Digestion	Gas Upgrading	Digestate Management	Auxiliary
<150,000 GJ	Dairy Manure	Pumps	**CSTR**	**Membrane Separation**	**Screw Press**	**CHP/ Boiler**
150,000 – 250,000 GJ	**Food Waste**	Mechanical Separator	Plug Flow	PSA	Dissolved Air flotation	Odor Control
>250,000 GJ	Wastewater	Fiber Separation	Covered Lagoon	Water Wash	Secondary Digester	Centralized O&M Control
	Co-digestion	**Loader**	Mixed Plug Flow	Amine	Direct Irrigation	
				Cryogenic		

Simple Example – 1 feedstock – 1 size of facility
144 Designs can be reduced to 8 by applying the methodology

- 1 feedstock type, 1 facility capacity
- 4 main process blocks
- 144 different possible facility combinations
- Engineering judgement to shortlist

Initial Technology Matrix			
Materials Handling	Pre-treatment and Digestion	Digestate Management	Biogas Upgrading
Tech A	Tech D	Tech H	Tech K
Tech B	Tech E	Tech I	Tech L
Tech C	Tech F	Tech J	Tech M
	Tech G		Tech N

144 Different Designs

Shortlisted Technology Matrix			
Materials Handling	Pre-treatment and Digestion	Digestate Management	Biogas Upgrading
Tech A	Tech D	Tech H	Tech K
	Tech E		
		Tech J	
			Tech N

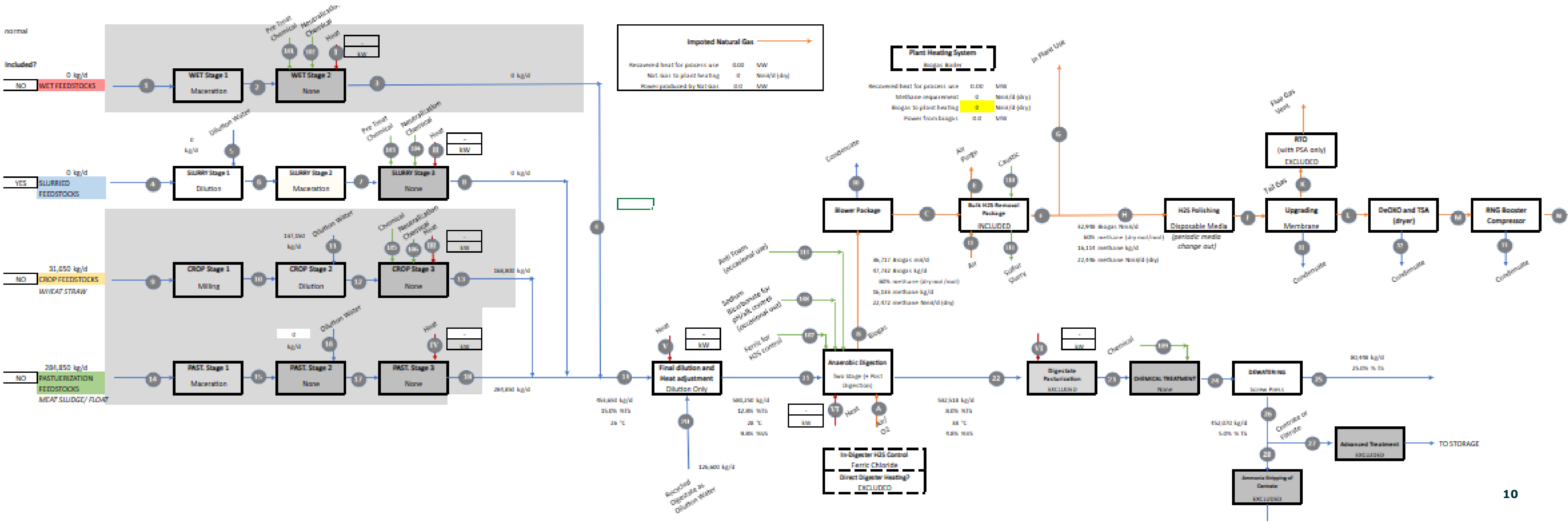
8 Different Designs

Simple Example – 1 feedstock – 1 size of facility
A limited number of technologies creates a limited number of process design options

Design #	Handling	Digestion	Digestate	Upgrading
1	Tech A	Tech D	Tech H	Tech K
2	Tech A	Tech D	Tech H	Tech N
3	Tech A	Tech D	Tech J	Tech K
4	Tech A	Tech D	Tech J	Tech N
5	Tech A	Tech E	Tech H	Tech K
6	Tech A	Tech E	Tech H	Tech N
7	Tech A	Tech E	Tech J	Tech K
8	Tech A	Tech E	Tech J	Tech N

Simple Example – 1 feedstock – 1 size of facility – Applying a tool to this methodology can efficiently generate quantifiable outputs for comparison

**Below is an example of Worley's BioAdvise tool to generate quick, 5% designs and quantifiable outputs. It can become complicated and often requires technical expertise and knowledge.



Simple Example – 1 feedstock – 1 size of facility
The results can point to most cost-effective design

This is the Lifecycle Cost of Energy (LCOE). It factors OPEX, CAPEX and GHG Emissions into a single number to easily compare results.

Design	Lifecycle Cost ($/GJ)*	RNG Yield (GJ/year
Design 1	44	250,000
Design 2	40	260,000
Design 3	46	265,000
Design 4	53	240,000
Design 5	62	280,000
Design 6	47	275,000
Design 7	51	255,000
Design 8	43	245,000

*Includes cost of GHG emissions. Values are indicative and don't reflect actual costs.

In this simple example, despite not having the highest RNG yield, Design 2 will likely be the most profitable due to lower overall lifecycle cost.

Simple Example – Extended to 5 Capacities – Apply sensitivity analysis to most promising designs, results may vary at different scales

Size 1	Size 2	Size 3	Size 4	Size 5
Design 1	Design 1	Design 2	Design 2	Design 2
Design 2	Design 2	Design 5	Design 5	Design 5
Design 8	Design 8	Design 6	Design 6	Design 6

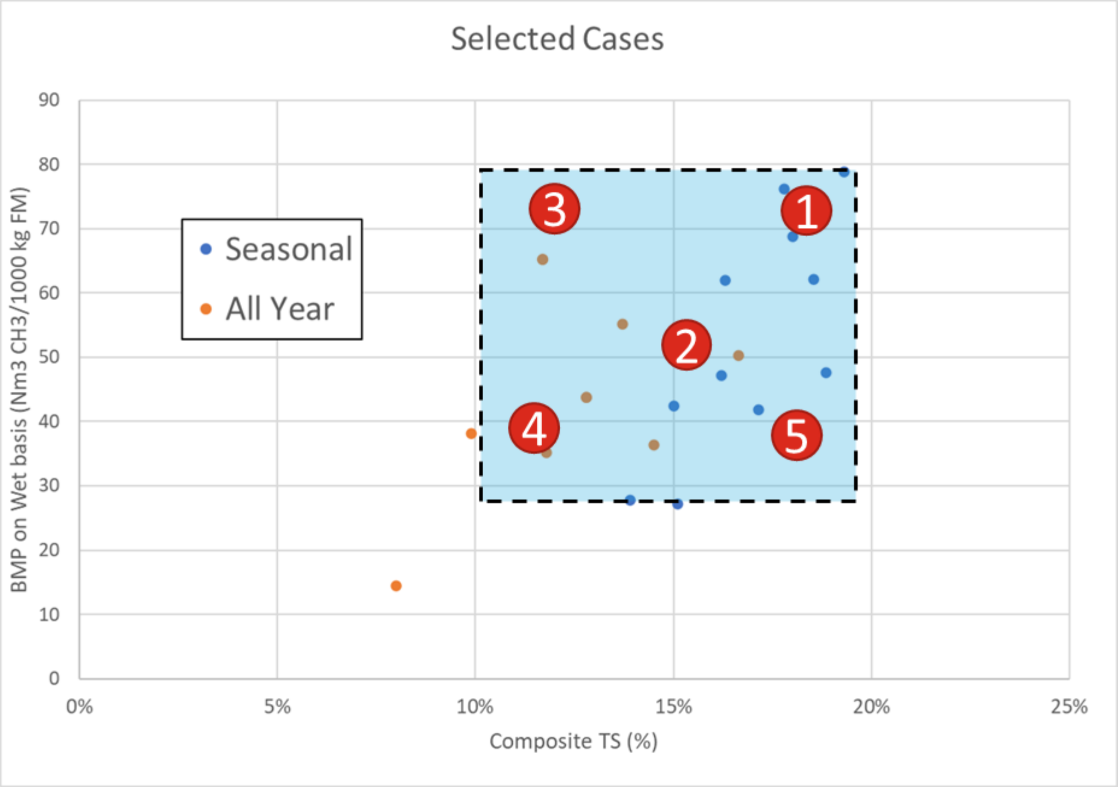
LCOE - $/GJ*				
Size 1	Size 2	Size 3	Size 4	Size 5
55	52	40	44	46
49	45	44	51	48
53	47	43	39	38
Design 2	Design 2	Design 2	Design 6	Design 6

*Values are indicative and don't reflect actual costs

Conclusion: The optimal design may differ depending on the facility capacity

Case Study– Applied methodology to reduce 50,000 possible designs to 60, which led to 5 optimal designs

- 20 different feedstock mixes in 10 different regions.
- Shortlisted technologies initially.
- Still left with 256 different design combinations for each feedstock mix in each region = 51,200 different designs.
- Engineering judgement reduced that down to 60 designs to test.
- Client had 5 designs optimized for each envelope of feedstock characteristics (shown to the right).
- Performed sensitivity analysis of 5 designs at +/- 50% capacity.
- Client now has a standard design that they know can apply to these different feedstocks volumes and mixtures, which allows them to proceed with projects quicker and more confidently.



Summary – Will My Project Make a Profit?

- Make the right technology decisions early.
- Process technology blocks are interdependent and decisions influence project returns
- Need to design each possible option to the right level to generate quantifiable outputs and compare results. options to obtain results to compare different designs.
- Do it yourself, find online tools, or hire an engineer
- Outputs should focus on key drivers – design that maximize revenues, minimizes is the optimal solution.
- Next steps - move forward through typical project execution process once optimal design selected.

Q&A

Brian Cox <brian.cox@bioenergy.org.nz>

Contact Us:
N: Nick Stonier
Energy Transition Manager, NZ
T: +64 21 930 332
E: Nick.Stonier@worley.com

Contact Us:
N: Jeff Zimmer
Director, RNG, North America
T: +1-780-906-8869
E: Jeffrey.zimmer@worley.com

worley.com

Contact Us:
N: Brian Cox
Executive Officer, BioEnergy Association
T: +64-27-477-1048
E: brian.cox@bioenergy.org.nz

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