Bennamann Gas Upgrading for Transport 15th June 2022

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Delivering a Local Clean Energy Revolution







THE BENNAMANN CYCLE – CAPTURING & REPURPOSING FUGITIVE METHANE



THE LOW HANGING FRUIT – FUGITIVE METHANE FROM SLURRY LAGOONS





- Slurry lagoons on diary farms act as a collector and concentrator of waste biomass
- A typical dairy farm produces six times more fugitive methane than it can use – Bennamann collects excess, sells and shares the profit
- A New Holland gas tractor running on fugitive methane takes the equivalent of 680 cars off the road annually
- Typical 150 head dairy farm produces 40,000kg of fugitive methane and is worth £10,000 £15,000 in cash and operational savings to the farm
- The equivalent carbon saving is 3440 tonnes

FUGITIVE METHANE – THE CHALLENGE AND THE OPPORTUNITY



	Geophysical properties		GWP-weighted share of global GHG emissions in 2010			
Kyoto gases	Atmospheric lifetime (year)	Instantaneous forcing (W/m²/ppb)	SAR (Kyoto)	WGI (20 and 100 year from AR5 & 500 year from AR4)		
<u> </u>	various	1 27 x 10 ⁻⁵	76 %	52 %	72 %	88 %
	valious	1.37 × 10	70 70	JZ /0	7370	00 70
CH ₄	12.4	3.63 x 10⁻⁴	16 %	42 %	20 %	7 %
N ₂ O	121	3.00 x 10 ⁻³	6.2 %	3.6 %	5.0 %	3.5 %
F-gases:			2.0 %	2.3 %	2.2 %	1.8 %
HFC-134a	13.4	0.16	0.5 %	0.9 %	0.4 %	0.2 %
HFC-23	222	0.18	0.4 %	0.3 %	0.4 %	0.5 %
CF₄	50,000	0.09	0.1%	0.1 %	0.1 %	0.2 %
SF ₆	3,200	0.57	0.3 %	0.2 %	0.3 %	0.5 %
NF ₃ *	500	0.20	not applicable	0.0 %	0.0 %	0.0 %
Other F-gases **	various	various	0.7 %	0.9%	0.8 %	0.4 %

METHANE IS RESPONSIBLE FOR 42% OF NEAR-TERM GLOBAL WARMING (IPCC 5th Assessment Report)

MINIMISING MANMADE FUGITIVE METHANE EMISSIONS WILL HELP SLOW THE ONSET OF NEAR-TERM CLIMATE CHANGE

METHANE IS A FUEL THAT CAN DIRECTLY REPLACE ALL FOSSIL FUELS, FURTHER REDUCING IT'S GLOBAL WARMING IMPACT



NF₃ was added for the second commitment period of the Kyoto period, NF₃ is included here but contributes much less than 0.1%.

* Other HFCs, PFCs and SF₆ included in the Kyoto Protocol's first commitment period. For more details see the Glossary (Annex I).

- Over 20 years a methane molecule absorbs and traps heat 86 times more efficiently than CO2
- Capturing 1 kg of fugitive methane effectively removes the equivalent of 86 kg of CO2 from atmosphere
- Methane is unique in that it's the only GHG that can power it's own capture and removal and then some!
- Captured fugitive methane offers an 86 fold GWP benefit over 'carbon neutral' feedstock derived biofuels
- Capturing fugitive methane <u>now</u> offers the potential to slow down the early onset of global warming

What is radically new about Bennamann's approach?





Conventional Natural Gas and LNG sector

Economies of scale and *geographical remoteness* demand a *continuous supply, centralised processing,* and distribution through a *piped grid network* or '*just in time' bulk LNG transportation*

This renders it:

- Vulnerable to geopolitics
- Sensitive to fluctuations in supply and demand
- Limited access to the *global* customer base



Local storage of cleaned biogas at source

Rapid mobile biogas upgrading shared between sites

Purification and liquefaction cooled by liquid nitrogen from existing supply chain

Local aggregation and distribution

Bennamann's local aggregation & distribution model model exploits

Local biogas storage and process preparation Rapid mobile biogas refining and liquefaction IoT monitoring control and networked logistics

This provides *de-integrated, de-centralised & de-synchronised* biogas processing, liquefaction and storage

Road transportation logistics for distribution/ sales.

That dramatically reduces capital cost, increases flexibility and provides resilience to fluctuations price and demand

Bennamann offers a secure and resilient global energy market for untapped sources of fugitive and biomethane with unrestricted access to the global customer base



KEY PIECES OF THE JIGSAW







75MM TANK CONNECTOR

PRODUCT PORTFOLIO: GAS CAPTURE – COVERED LAGOONS





Energy Independent Farm[™] Dairy Farm

How the Bennamann system works





Dairy Farm CO₂e Emissions Today & Tomorrow Bennamann



Before and After Energy Independent Farm[™] Implementation

CO₂e Output 150 Cow UK Dairy Farm - BEFORE

6t CO2e pa

Medium sized diesel tractor 1500 hours pa

TOTAL METHANE CO2e

REDUCTION (86kg CO₂e)

103t CO2e pa

Dairy using red diesel / heating oil for heat

Uncovered slurry lagoon (CH4 only)

Manure piles emitting CH4, N2O and CO2

FARM CO2e OUTPUT

(kg CH4 GWP20 86kg CO₂e)

131t CO2e pa

Manure piles

2387t CO2e pa

~4400

tCO₂e pa

BENNAMANN SOLUTION



CO₂e Output 150 Cow UK Dairy Farm - AFTER

THANK YOU

