

The 'Goldilocks principal'

- Just right
- Balance between extremes (psychology, communication, evolution)
- Sometimes too small
- Other lessons...





Contents lists available at ScienceDirect

#### **Journal of Cleaner Production**

journal homepage: www.elsevier.com/locate/jclepro



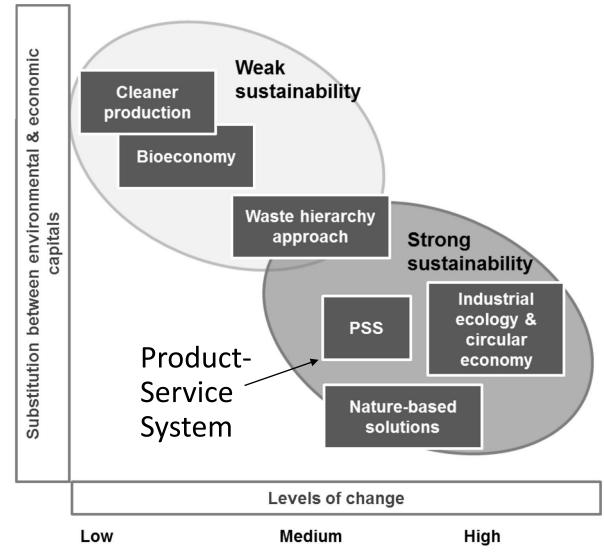
#### Green economy and related concepts: An overview

Eleonore Loiseau <sup>a</sup>, Laura Saikku <sup>b</sup>, Riina Antikainen <sup>b, \*</sup>, Nils Droste <sup>c</sup>, Bernd Hansjürgens <sup>c</sup>, Kati Pitkänen <sup>b</sup>, Pekka Leskinen <sup>b</sup>, Peter Kuikman <sup>d</sup>, Marianne Thomsen <sup>e</sup>

- Industrial ecology integrates sustainability into its economic systems
- Optimised energy, minimal waste and closed-loop material flows
- Includes industrial 'symbiosis', systems perspectives, the role of technology and dematerialisation

Medium

Low



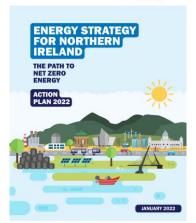
# Stronger Green Economy

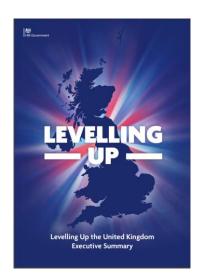
INGREDIENTS: 'Nature' resources, Circularity, Cooperation, Energy integration, Supply chains, Innovation, Skills, Finance, Research capacity, Infrastructure

**CONTAINS:** Farmed carbon







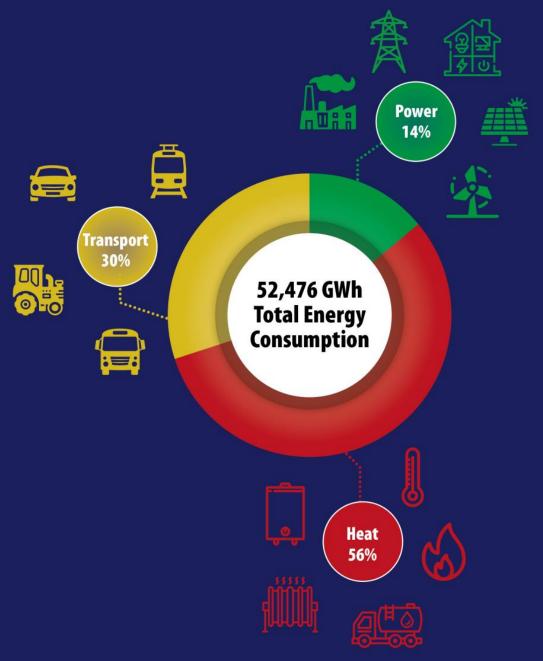






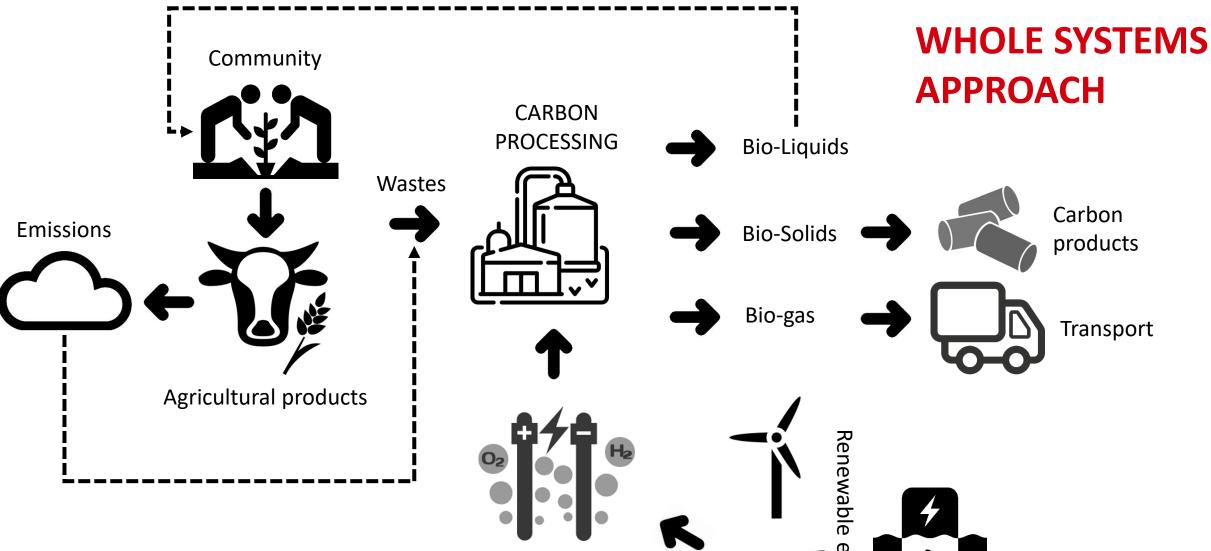
#### STRATEGY ALIGNMENT

- "A systemic transformation across the UK economy, is required to achieve net zero by 2050. [Emissions] will need to be compensated for by both nature-based and engineered greenhouse gas removals as a last resort." Net Zero
- "It aims to ensure we have an affordable, secure, and clean energy system for current and future generations. It specifically targets net zero carbon and affordable energy as part of our wider action to address climate change and deliver an economy that is ten times better than today through innovation" Energy Strategy
- "We will transform our economy by working proactively with businesses, communities and all parts of government to maximise funding and investment opportunities for Green Growth and promote innovation, skills, research and technology" Green growth
- "it is about the success of the whole country: realising the potential of every place and every person across the UK, building on their unique strengths, spreading opportunities for individuals and businesses" Levelling up



# Powering the Green Economy

- NI renewables in 2021-22 = 3,576 GWh (84%=wind, 47% of total power)
- 52,476 GWh ≡ 17 GW wind @ 35% Capacity factor (NI ≈ 1.3 GW)
- Electrification of transport/heat could reduce demand by ≈ 60%.

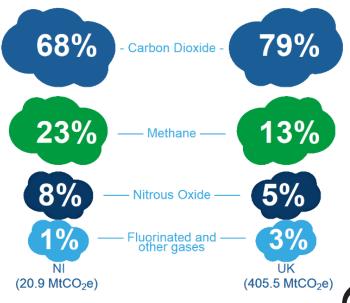


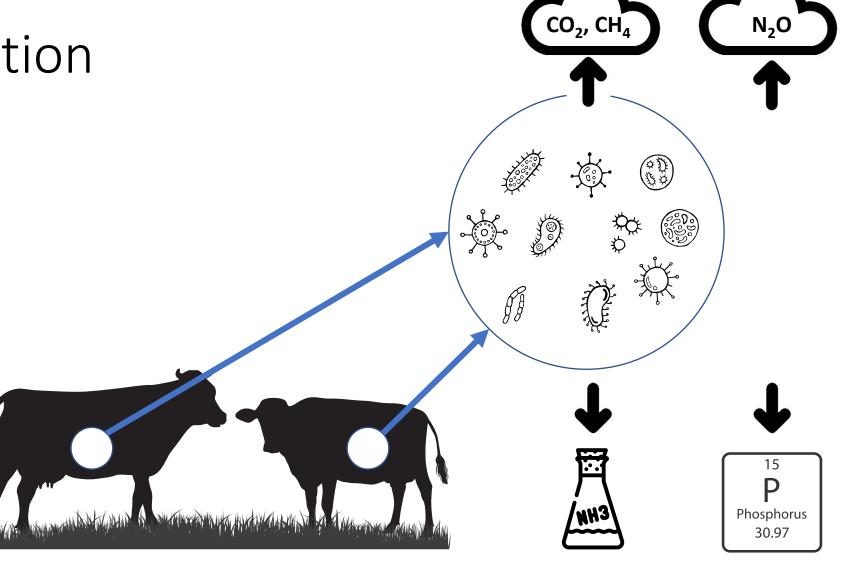






## Anaerobic digestion



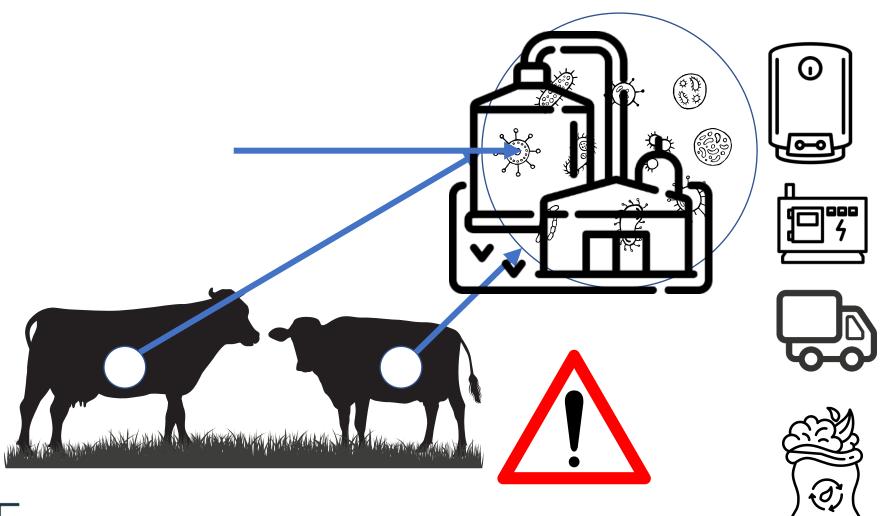






## Anaerobic digestion







Resource availability?

Secondary products?

IF WE WERE SERIOUS Supply chain? **ABOUT ANAEROBIC DIGESTION HOW MUCH OF AN IMPACT COULD IT MAKE?** 

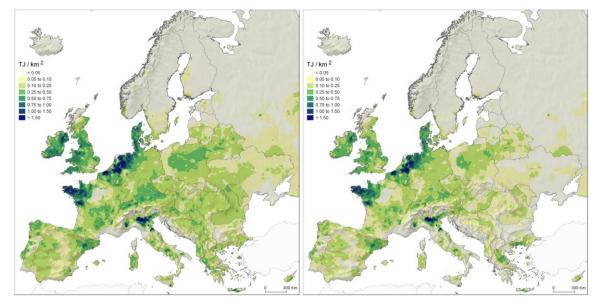
Decarbonisation potential?

Cost?

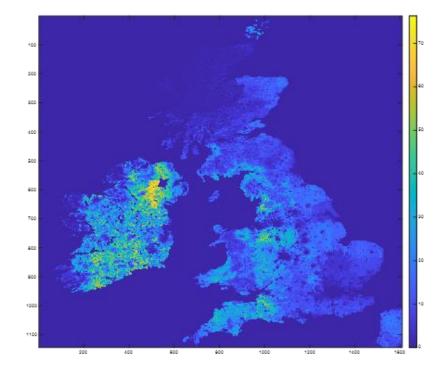
Pollution?



Unintended consequences?



Renewable and Sustainable Energy Reviews, 94, 915-930, (2018).



#### **LIVESTOCK NUMBERS 2021**

Cattle	1,681,991
Sheep	2,034,786
Pigs	716,798
Poultry	24,462,802



$$Number \times \frac{kg_{waste}}{head} \times captured \times \frac{kg_{vs}}{kg_{waste}} \times \frac{Gas(Nm^3)}{kg_{vs}} = Gas(Nm^3)$$

15 million Nm³ → 260 million Nm³ (Cattle, Pigs, Poultry)

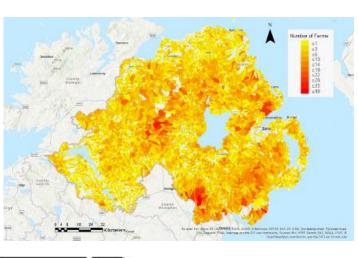
260 million  $m^3 \approx 2.53 \text{ TWh}$ 2021-22 Total renewable electricity (NI) = 3.57 TWh

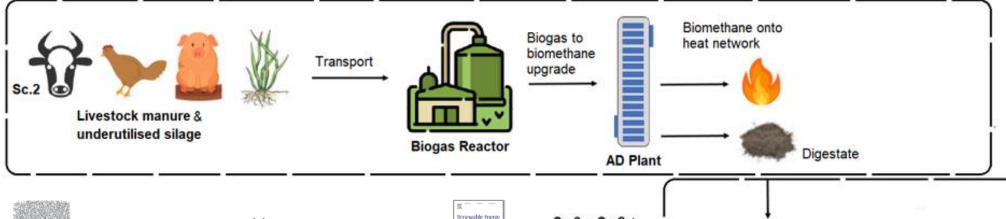
#### **RECENT WORK: 3 Considerations, 3 Scenarios**

1. Geospatial analysis of biomethane potential



- 2. Life Cycle Assessment
- 3. Consideration of secondary benefits/risks





ELSEVIER

Fyaluati

Renewable Energy
Volume 196, August 2022, Pages 343-357

Renewable Energy
to exhibit our or product
t

Sc.3 = Sc.2 + Pyrolysis step Pyrolysis

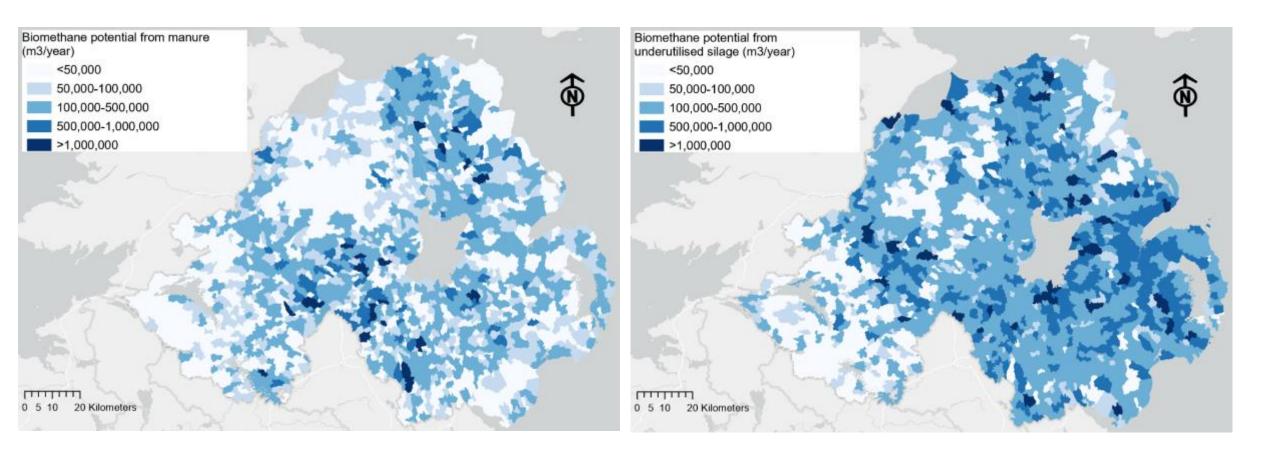
Bio-oil

Bio-char

Syngas to heat network

Evaluating the opportunity for utilising anaerobic digestion and pyrolysis of livestock manure and grass silage to decarbonise gas infrastructure: A Northern Ireland case study

Current gas demand ≈ 7.2 TWh



Housed Manure 253 million m<sup>3</sup> CH<sub>4</sub>

Underutilised Silage 500 million m<sup>3</sup> CH<sub>4</sub>

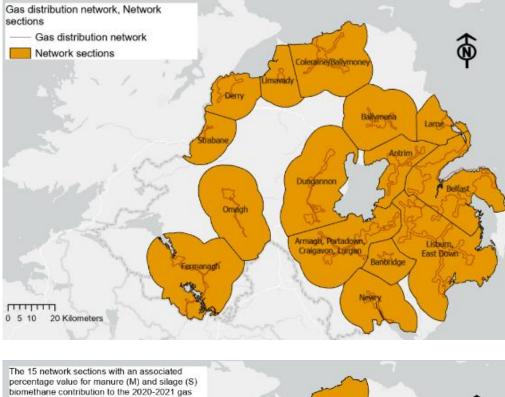
753 million m<sup>3</sup> CH<sub>4</sub>
7.5 TWh

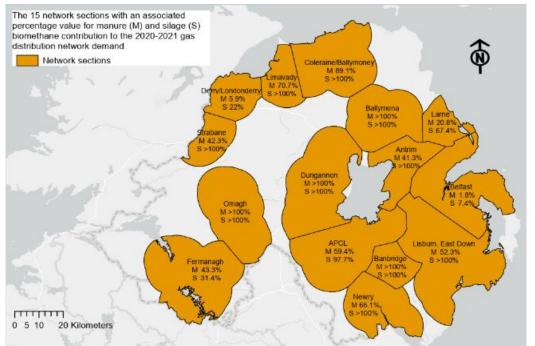
\*10km from gas distribution network

Manure in the zones: 209 million m<sup>3</sup> CH<sub>4</sub> 2.1 TWh 27.3% of gas demand

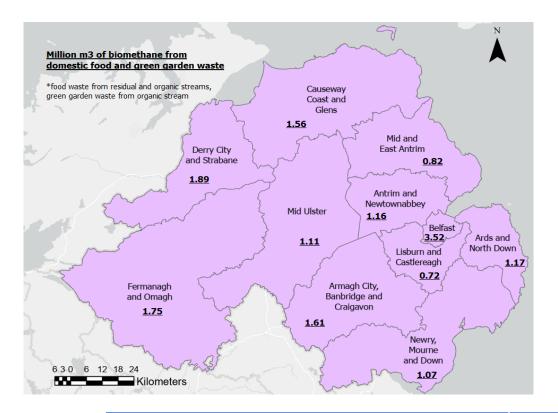
Silage in the zones: 418 million m<sup>3</sup> CH<sub>4</sub> 4.2 TWh **54.5% of gas demand** 

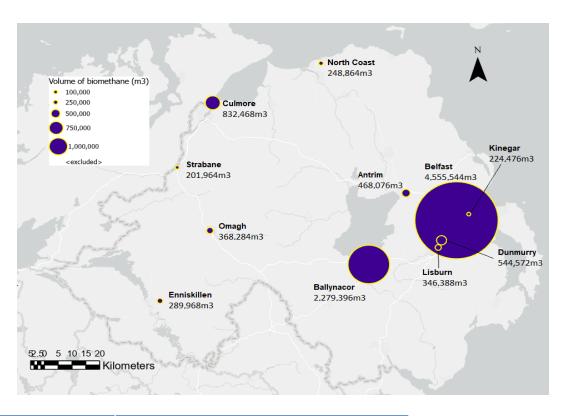
Total in the zones: 627 million m<sup>3</sup> CH<sub>4</sub> 6.3 TWh 81.9% of demand





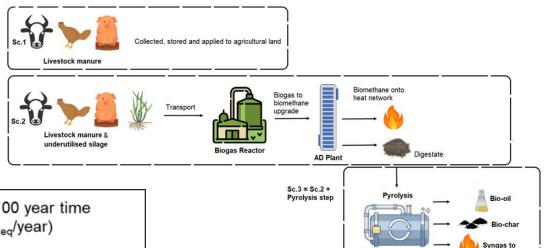
Out of the 15 zones 11 would have a surplus

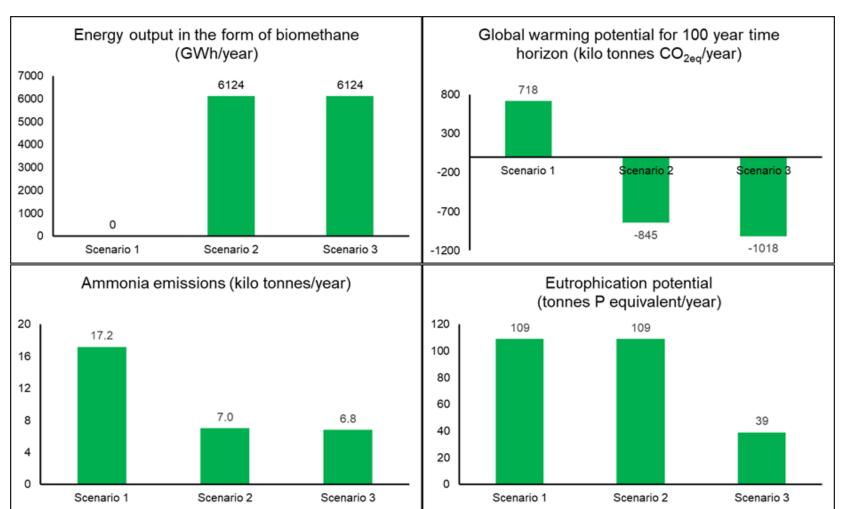




Feedstock	Quantity (t)	Biomethane (million m³)
Sewage sludge	160,869	10.36
Municipal food & garden	174,089	17.9
Manure from housed livestock	9,217,687	253
Excess silage	4,692,872	500
Total	14,245,518	781

#### **ADDITIONALITY**





Significant reduction in GWP

heat network

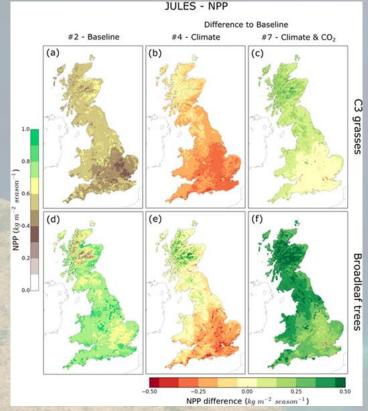
Ammonia emissions decreased by 10 kT/year

Biochar production estimated at 200 kT (retaining 64% of phosphorus from manure)

Availability of CO<sub>2</sub> for other industry/e-fuels

### CONCLUSIONS

- Significant opportunity for a mission based approach to decarbonisation in NI using a carbon cooperative concept
- Anaerobic digestion could produce enough biomethane to decarbonise (≈80%) gas infrastructure and be complementary to hydrogen
- NI climate, size, infrastructure just right



Ritchie et al (2019), Environmental Research Letters, Volume 14, Number 1











## Green Growth: Striking the Balance

Fuelling the Future Conference
Kevin Hegarty
20 October

Today we act. Tomorrow we thrive.

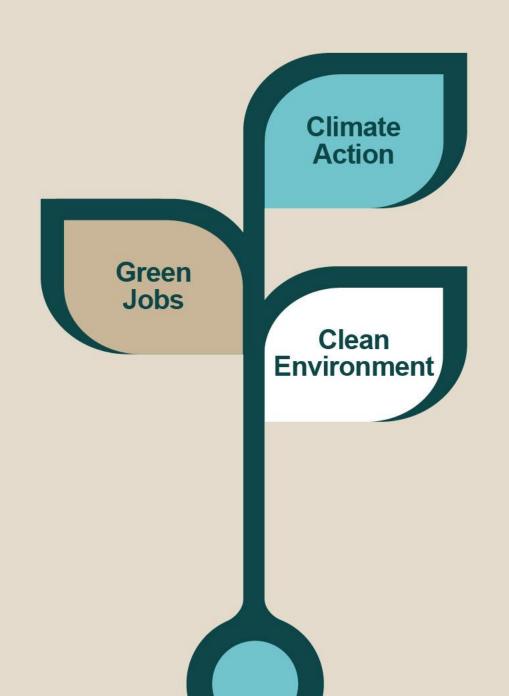




# What is Green Growth?

- Balancing Climate, Environment
   & the Economy.
- Developing the Strategy.
- Pathway to Net Zero by 2050,
  48% reduction by 2030.
- Executive Commitments.





#### **Climate Action**

Reduce greenhouse gas emissions through adaptation and mitigation measures.

#### **Green Jobs**

Develop a low carbon, inclusive, skilled workforce and a strong circular economy.

#### Clean Environment

Quality built environment, clean air and water, more sustainable land use, improved habitat and greater biodiversity.

#### **Executive Commitments**

1 Embedding Green Growth

2 Legislating for Change

**3** A Fair Transition

4 People First

5 Supporting Behavioural Change

6 Evidence Based Decision Making

7 Investing in Green Growth

8 Leading by Example

**9** Working With Others

**10** Measuring Progress







## Public Sector Leadership

**Use of Public Sector Assets:** 

- Public sector estate
  - Buildings
  - Fleet
- Public sector procurement
- Greater afforestation
- Use public land for renewable energy

WE HAVE A KEY ROLE IN 'MARKET MAKING' AND HELPING TO DEVELOP SUPPLY CHAINS

#### The Climate Change Act (Northern Ireland) 2022



ACT



Passed Final Stage in the Assembly on 9<sup>th</sup> March 2022.

Received Royal Assent on 6<sup>th</sup> June 2022.

NET **ZERO** 2050

Sets a target of net zero greenhouse gas emissions by 2050.

**Public** Body Reporting

**CARBON BUDGET** 

**CLIMATE ACTION PLAN** 

**NORTHERN IRELAND CLIMATE** COMMISSIONER

JUST **TRANSITION FUND** 



**SECTORAL PLANS** 

JUST **TRANSITION** COMMISSION

## Pathway to 2030







## Climate Action Plan

- Climate Action Plans, which will be produced every 5 years, is expected to align with carbon budget periods and will set out the actions to meet greenhouse gas emission targets.
- The target date for publishing the first Climate Action Plan is the end of December 2023. This will cover the first carbon budget period 2023 2027 and will look out to 2030, 2040 and 20250 targets.
- The current aim is to have a draft Climate Action Plan approved for public consultation by April 2023.







# Inter Departmental Biomethane Group

- DAERA
- DfE
- Dfl
- Utility Regulator
- Agri-Food and Biosciences Institute
- NI Water
- Strategic Investment Board
- > Case Study: Tully BioGas



## **Achieving Green Growth**

- Key enablers innovation, technology, skills, partnership, collaboration and leadership.
- Investment in innovation, technology and skills
  - Hybrid heat pumps
  - Understanding hydrogen blending and direct injection
  - E.g. Small Business Research Initiative (SBRI)
- Supporting strategies right across government all have a role to place e.g. 10x Economy, Energy, Skills, Housing, Transport, Agriculture etc.
- .....and so do you







## **Next Steps**

- Climate Action Plan
- Public Sector Leadership
- Collaboration
- Delivery







# DANISH BIOMETHANE EXPERIENCES

Gas Conference, Northern Ireland, 20.10.22

Torben Brabo, Energinet SVP, International Relations



Renewable Gas Conference:

Fuelling the Future

# REPOWER EU (WITH BIOMETHANE)

- In the REPowerEU Plan to reduce dependence on Russian fossil fuels, the European Commission has set out a target to increase the current European biomethane production from 3 bcm (2020) up to 35 bcm by 2030. This represents more than 10x increase.
- 35 bcm represents 20-25% of the European gas imports from Russia (pre Ukraine) and just under 10% of all gas consumed in the EU.
- By 2050, 30-40% of Europe's total gas consumption can be covered by sustainable biomethane.

## From 3 bcm biomethane production today to 35 bcm EU-27



Urgent need to diversify supply and reduce dependence on external gas providers

35 bcm represent 20% of current gas imports from Russia today

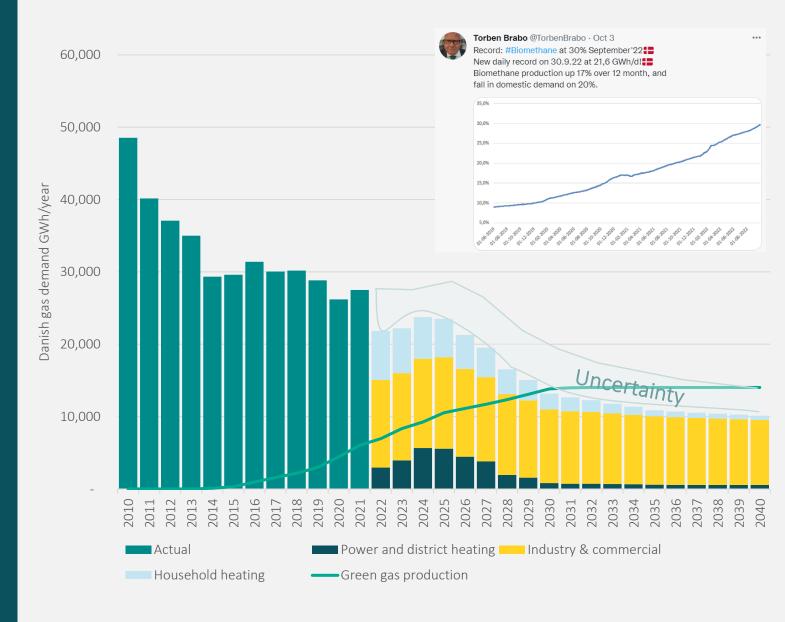




#### 100% GREEN GAS BY 2030

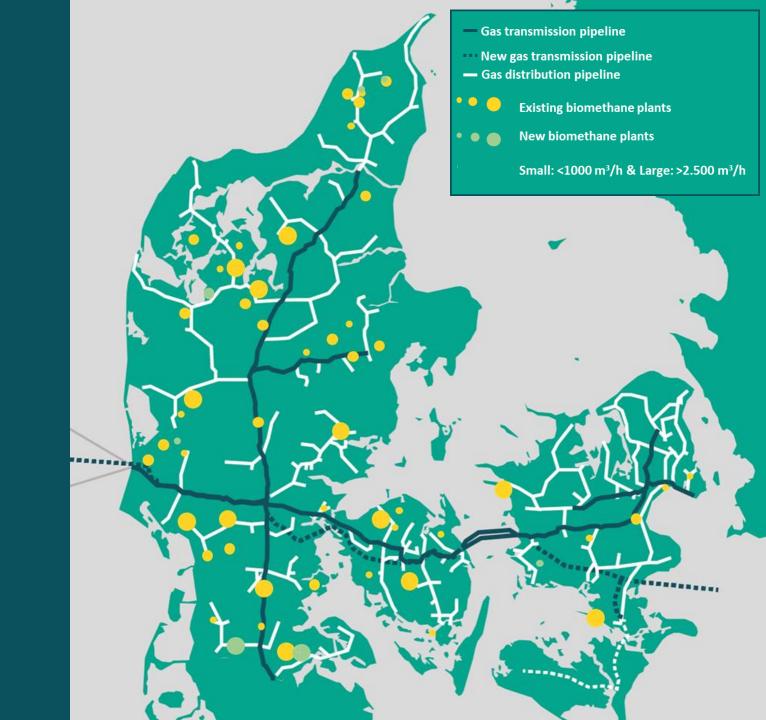
- Biomethane plays an essential role in the green transition of the gas system and for security of supply.
- The Danish Government aims for a 100% green gas coverage already in 2030 – a target which might very well be achieved even before.
- The current record for biomethane coverage of the total Danish gas consumption measured over 24 hours is 98.2%.

#### Historic and projected - demand and green gas production



# GAS GOES GREEN

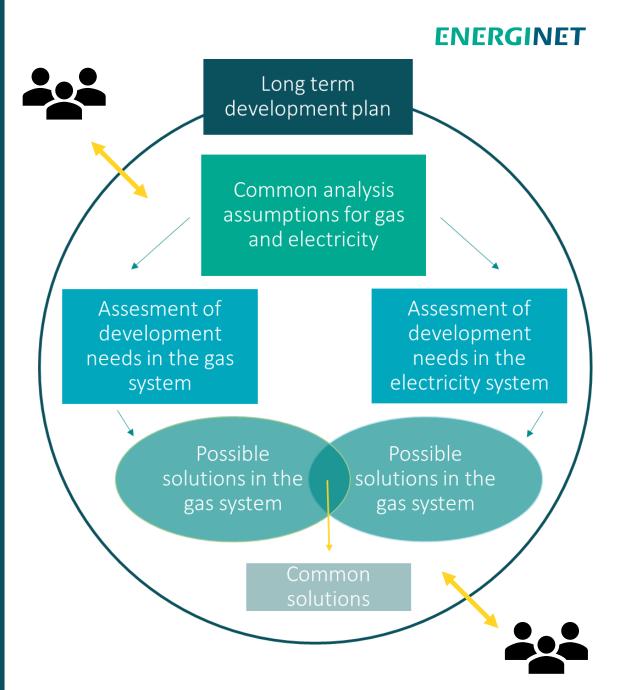
- 51 biomethane facilities
- 9 new biomethane facilities under construction
- 65 potential/rumoured biomethane facilities in pipeline
- Improvement of security of supply by decentralising supply





# NEW REGULATION NEW REQUIREMENTS NEW DEVELOPMENT PLAN

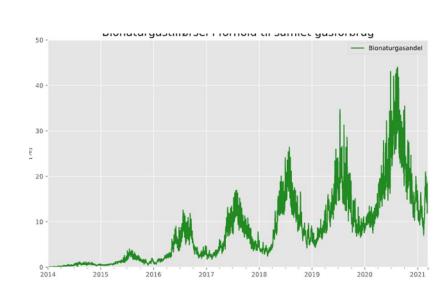
- Energinet's Long-Term Development Plan for Electricity and Gas
- Needs analysis and possible solutions
- 20 years outlook
- Danish Energy Agency Analysis Assumptions
- Stakeholder involvement led by Energinet
  - Including solutions by others





#### BIOMETHANE INTEGRATION IN NETPLAN

Biomethane constitute up to 40% of consumption on daily basis and reached a total of 17% in 2020. The share will increase to 100% at the latest in 2040.





- Production into low pressure grid, remodeling of flow
- Alternative use of infrastructure (cost efficient)
  - Local island systems
  - Integration of distribution grids
  - Reversed flow to higher pressure
- Operational focus
  - comparability to natural gas
  - oxygen level, deodorization

# CRITICAL ELEMENTS IN THE DANISH BIOMETHANE DEVELOPMENT:



#### CONSIDERING BYPRODUCTS FROM THE AGRICULTURAL SECTOR A RESOURCE (AND NOT WASTE)

 POLITICAL TARGET TO UTILIZE 50% OF THE MANURE TO SUPPORT THE SECTOR'S ROLE AS A SUPPLIER OF GREEN ENERGY.



SUBSTANTIAL SUBSIDIZATION
OF BIOMETHANE TO RAMP UP
PRODUCTION



#### TRANSPARENT COST SHARING FRAMEWORK MAXIMIZING INJECTION

- BIOMETHANE/UPGRADING PLANT FINANCE MANDATORY GRID CONNECTION AT NEAREST GRID.
- TSO/DSO FINANCE NECESSARY GRID REINFORCEMENTS.



# ADAPTION OF GAS QUALITY SPECIFICATIONS TO ACCOMMODATE BIOMETHANE INJECTION

 0.5% OXYGEN CONTENT ACCEPTANCE LEVEL TO ENSURE A COST-EFFECTIVE INTEGRATION OF LARGE AMOUNTS OF BIOMETHANE.



DOCUMENTING THE GREEN VALUE OF BIOMETHANE VIA A CERTIFICATE SCHEME SINCE 2011

#### SUBSIDY SCHEMES

#### 2012-2018

- Promotion of biogas:
  - Production of electricity.
  - Upgraded biogas delivered to the natural gas grid.
  - Use of biogas for process purposes in the industry.
  - Use of biogas as a transport fuel.
  - Use of biogas for heating purposes.
- Cut-off date (1 January 2020) to phase-out subsidy regime.

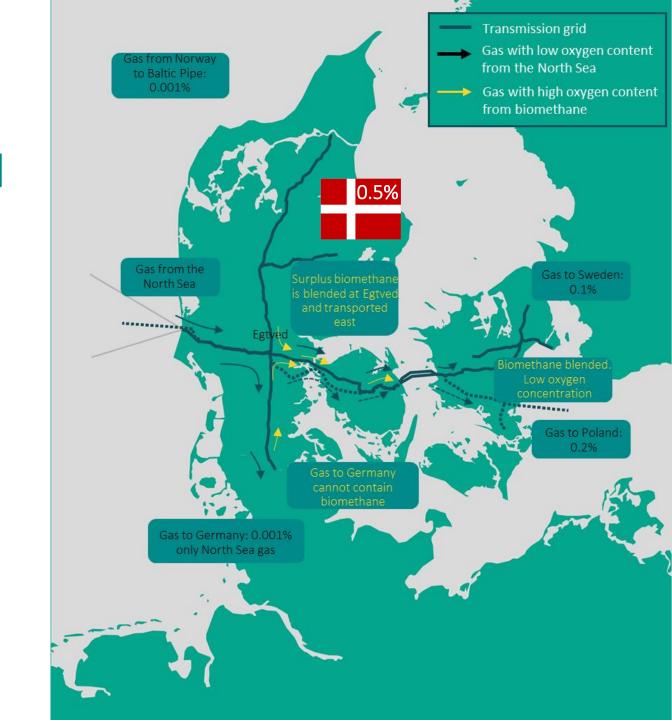
#### 2023-FUTURE

- Fixed subsidy for 20 years based on technology neutral (across green gases) open public tendering seeking to maximize CO2 reductions.
- Applicants with lowest bid for subsidy wins.
- A limited amount of subsidy is tendered each year.
- However, current market prices for natural gas is above previous subsidy scheme.

#### GAS QUALITY – OXYGEN

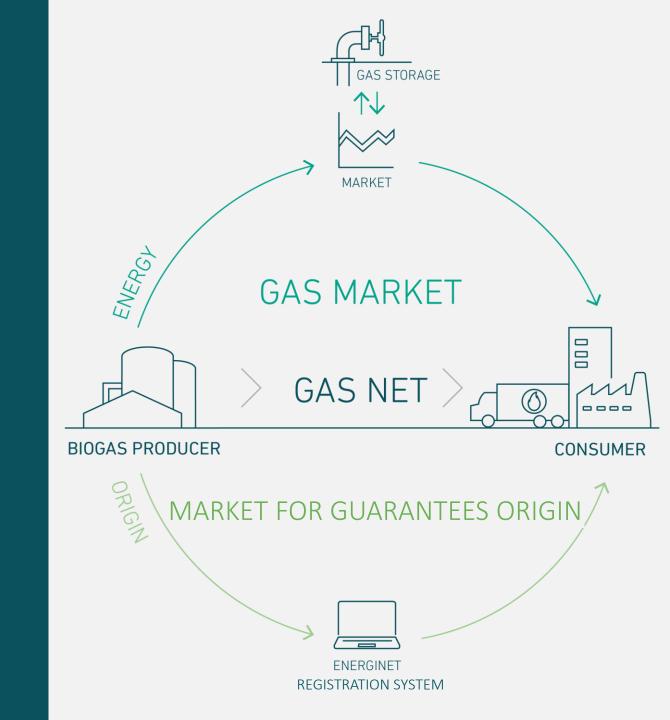
The Danish rules for biomethane allows for more oxygen-content than neighbouring countries.

- 2012/2013: Introduction of 0.5% oxygen content acceptance level to ensure a costeffective integration of large amounts of biomethane.
- Increased biomethane challenges the possibility for transit/export.
- Current procedure for mixing of biomethane with fossil gas is adequate.



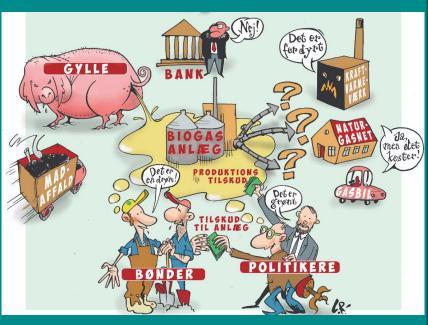
# GAS MARKET AND GUARANTEE OF ORIGIN ('GO') MODEL

- ✓ Renewable gas market model approved by Regulator (2010).
- ✓ Certificate model implemented (2011).
- ✓ Energinet appointed Issuing Body for Guarantees of Origin for renewable gases in grid (2021) incl. biomethane and hydrogen.
- ✓ Guarantee of origin for hydrogen being developed.



## INDUSTRIAL FRONTRUNNERS

It started in 2013 with wastewater and ice cream, pharmaceuticals and dairies.



#### GOVERNMENT PUSH

2020 Government invited industry to assess their own energy future.

Biomethane was a clear (socio-economic) "winner"



#### **INDUSTRY LEADS**

Since 2022, Danish Industry leads the biomethane development, with Danish Biogas Association.



#### Confederation of Danish Industry

05 05 22 • DI • PRESSEMEDDELELSE

#### Ny forening skal sætte turbo på grøn gas

DI Energi overtager 1. juni aktiviteterne i den 111 år gamle Dansk Gas Forening. Samtidig bliver der oprettet en ny sektion i DI Energi med navnet Grøn Gas. Det sker for at knytte industrien og gassektoren tættere sammen.

# THE DANISH BIOMETHANE DEVELOPMENT - 5 STEPS

#### STEP 3 "TRANSMISSION"

#### STEP 2 "UPGRADED"

### STEP 1 "LOCAL"

- Direct connection between production and consumption at a very small scale
- Subsidizing use of biogas in CHP generation
- Wet waste and residue resource from large agricultural sector used as feedstock. Considered a resource and not waste.

- Upgrading plants connected to distribution network, as biogas is upgraded to biomethane.
- Inclusion of biomethane in natural gas market model.
- Establishment of a national certificate register.
- 'Right to inject' policy.
- Subsidizing all uses of biogas.
- Transparent cost sharing framework maximizing injection.

#### Reverse flow from DSO to TSO network.

- Cut-off date for existing subsidy scheme.
- Coherence with "surrounding" legislation.
- Need for finding new feedstock sources.
- Demand pull certificates and sustainability schemes enables use in fuel quota regulation – e.g ETS and biofuel quota.

## STEP 4 "INTERCONNECTED"

- Cross-border flows of biomethane.
- Updating the quality standard for cross-border gas flows to allow for unhindered crossborder flow of biomethane.
- National green value exchange.
- Subsidies granted through technology neutral public tenders.
- Bilateral agreements on cross border trade of certificates.

## STEP 5 "CONTINENTAL" (FUTURE VISION)

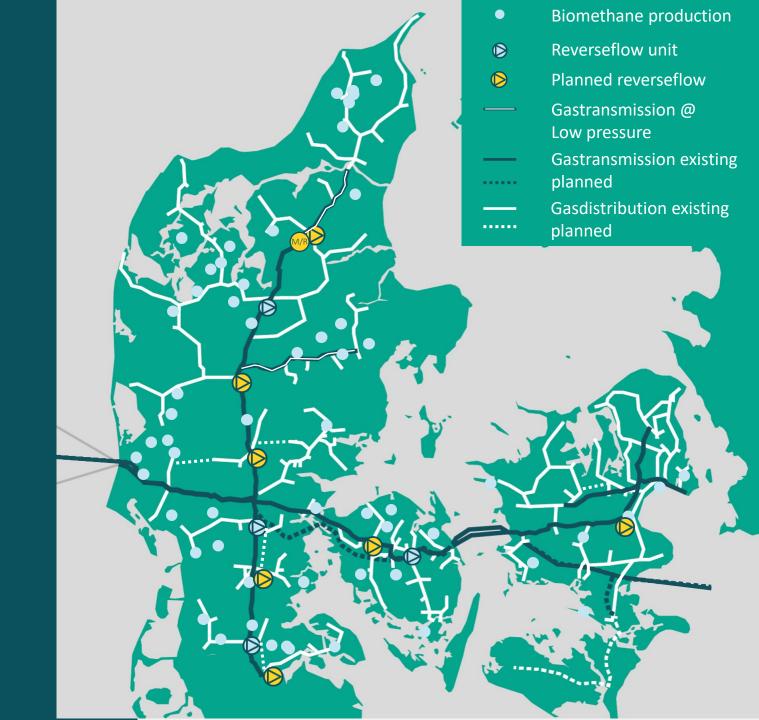
- Connection between regional transmission networks via transmission pipelines and LBG-shipping.
- Continental GO standard and scheme.
- Continental green value exchange.
- Claiming the green value where the gas is used.
- Subsidizing biomethane is not longer necessary in certain countries.
- Scarcity of land area and large dependence on the agricultural sector.

Link to Energinet's webpage on biomethane: https://en.energinet.dk/Gas/Biomethane#Info

Link to Energinet's full presentation "Danish Biomethane Experiences": https://en.energinet.dk/Gas/Biomethane/Danish-Biomethane-Experience

## THE CURRENT SYSTEM AND A FEW YEARS AHEAD

- Seven new reverse flow units under preparation
- Reduction of pressure in parts of transmission grid
- New low pressure pipelines connecting biomethane in a larger area with demand and reverse flow.





# FROM FARMS (1-3 MCM)



# TO INDUSTRIAL SCALE (10-50 MCM)











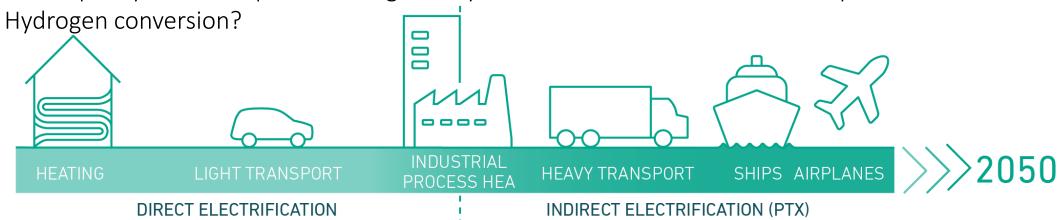


#### WHAT DOES THE FUTURE HOLD

The green transition enables rapid use of new technologies – how will they effect the gas system?

- Continued growth of biomethane with and without subsidies
- Continued utilization of CO2
- Methanisation of the CO2 in biomethane using hydrogen will boosts production
- Increased usage of gas for production of fuels:
   Gas to liquid, Power to X reduces the need for balancing.

Less capacity needed – parts of the grid may not be needed for methane transport?



# THANK YOU FOR YOUR ATTENTION