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Circular economy biogas systems

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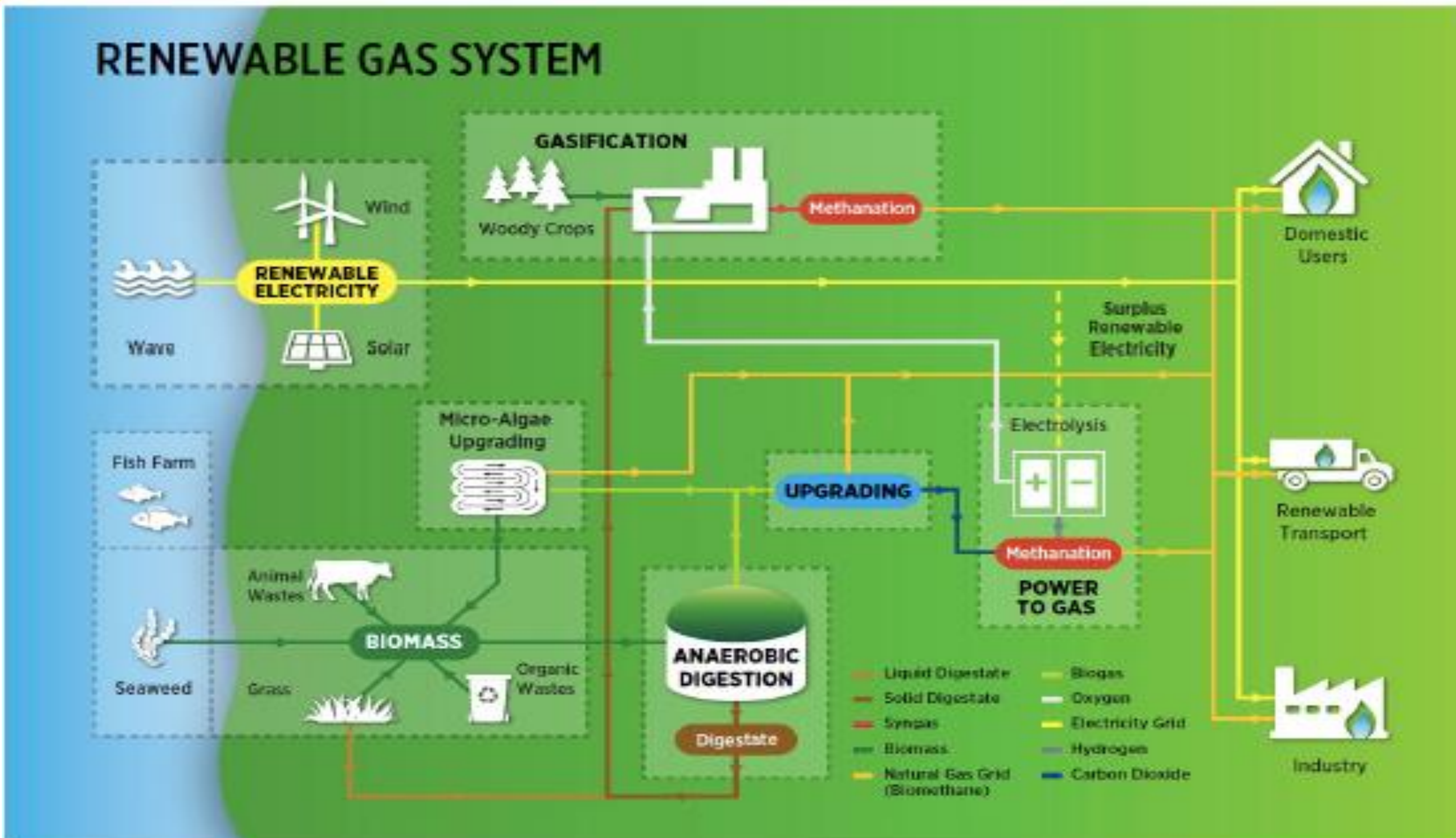
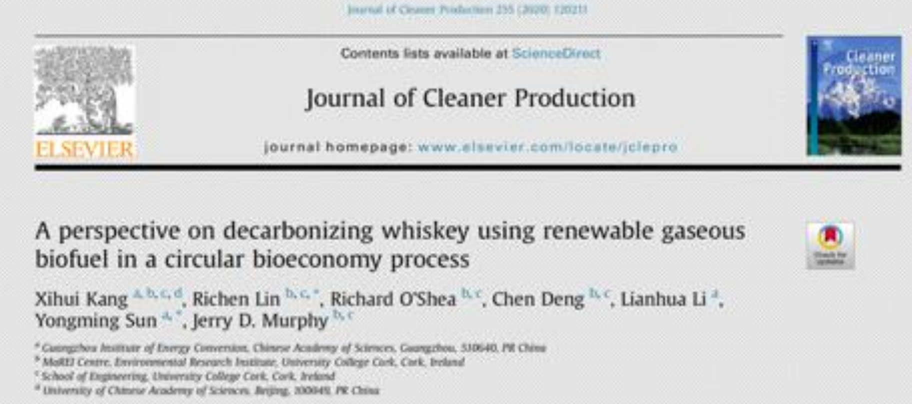
European Biogas Association e-Conference September 2 2020

We have renewable electricity; now we need Green Gas



Circular bioeconomy systems can treat waste and generate transport biofuel

Linkoping, Sweden fuels 65 buses, 10 waste collection lorries, 600 cars and a train from pig slurry, slaughter waste, & blood


Journal of Cleaner Production 255 (2020) 120211
Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro

A perspective on decarbonizing whiskey using renewable gaseous biofuel in a circular bioeconomy process

Xihui Kang [a,b,c,d], Richen Lin [b,c,*], Richard O'Shea [b,c], Chen Deng [b,c], Lianhua Li [a], Yongming Sun [a,*], Jerry D. Murphy [b,c]
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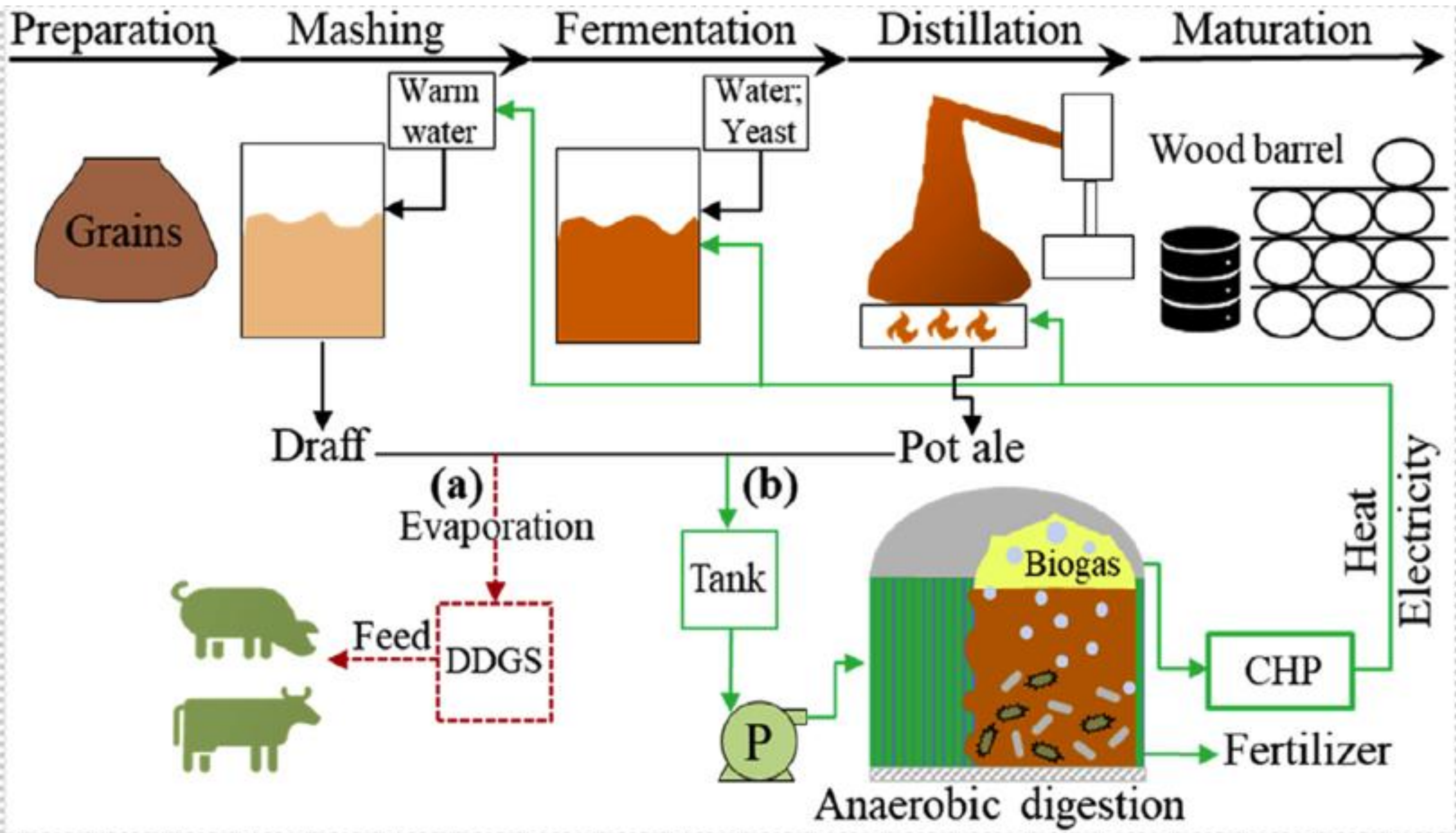
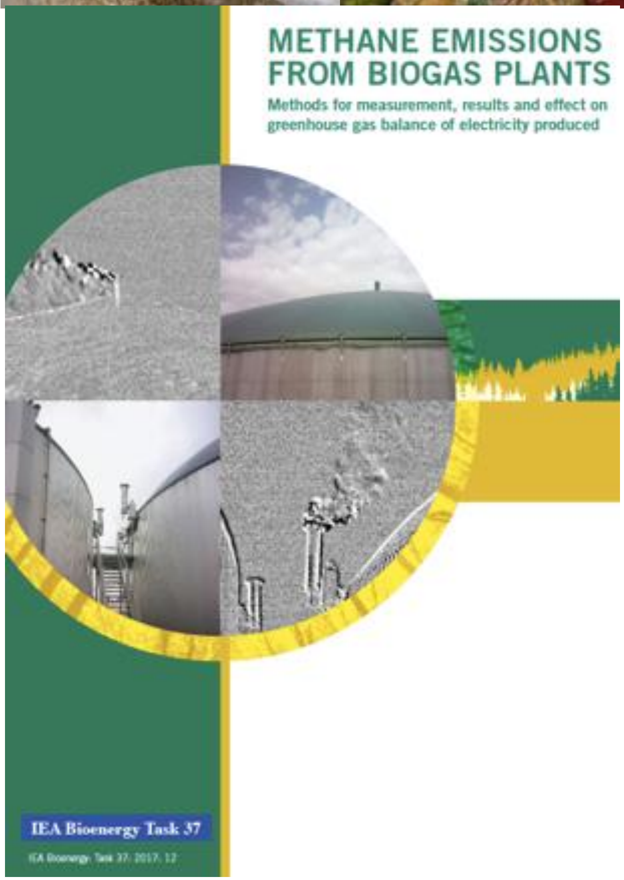
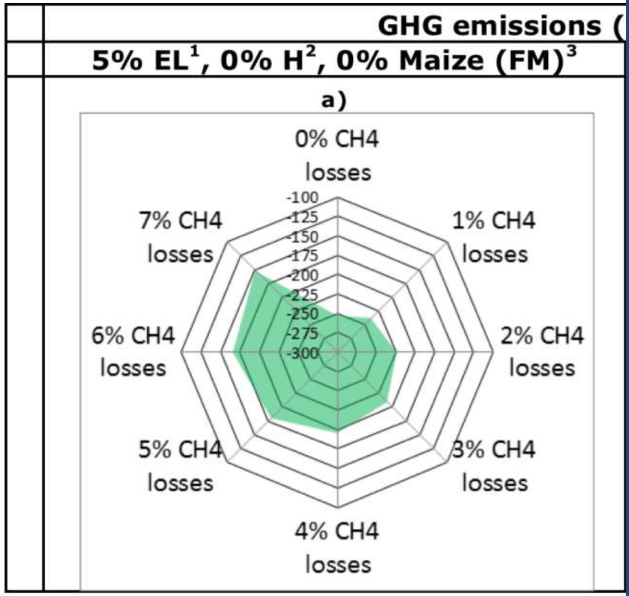
How do we decarbonize alcohol and dairies?









GHG negative biomethane for advanced transport biofuel.

Ideal for haulage and bus services.

California Air Resources Board awarded a Carbon Intensity score of -255 gCO2e/MJ for a dairy waste to vehicle fuel pathway.

Open slurry storage emits 17.5% of methane. At 2% methane slippage: biomethane from slurry GHG negative (-250 g CO2/MJ)

Use of electricity to make electrofuels

- Ireland has ca. 8 GWe electrical capacity, target of 30% RES-E by 2020
- Ireland has plans for 12 GWe off shore wind by 2030 leading to 70% RES-E
- Assuming 40% capacity factor then peak production 175% of average demand.
- Exacerbated by peak production at periods of low demand

Contents lists available at ScienceDirect

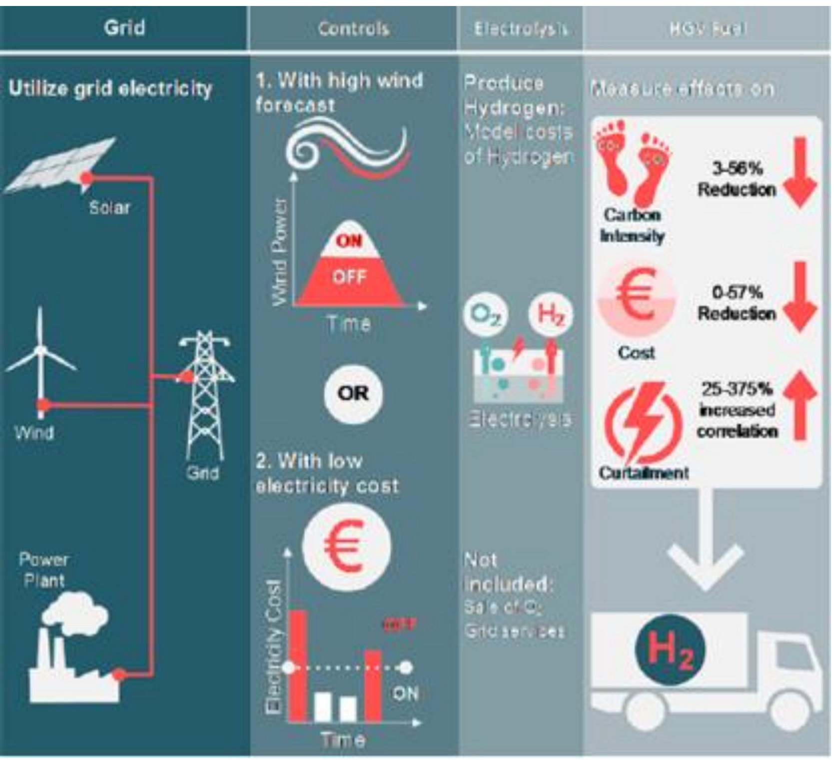
Applied Energy

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

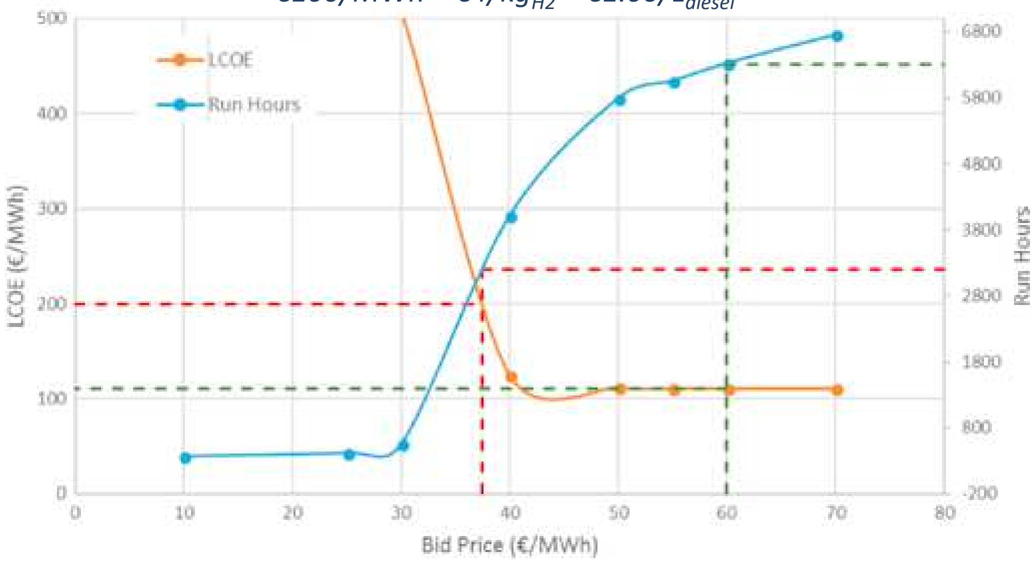
Power to hydrogen, run hours, price, sustainability

Are electrofuels a sustainable transport fuel? Analysis of the effect of controls on carbon, curtailment, and cost of hydrogen

Shane McDonagh[a,b,c,*], Paul Deane[a,b], Karthik Rajendran[a,d], Jerry D. Murphy[a,b]



$€100/MWh = €4/kg_{H2} \approx €1.00/L_{diesel}$



Conversion of electricity to hydrogen and on to methane

Audi E-gas at Wertle, Germany

Food waste biomethane

Production of hydrogen in 6 MW electrolysis

Production of methane via Sabatier

1000 Audi NGVs

Sabatier Equation: $4H_2 + CO_2 = CH_4 + 2H_2O$

Applied Energy 235 (2019) 1061–1071

Contents lists available at ScienceDirect

Applied Energy

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

Biomethanation

Biological methanation: Strategies for in-situ and ex-situ upgrading in anaerobic digestion

M.A. Voelklein*, Davis Rusmanis, J.D. Murphy

MaREI Centre, Environmental Research Institute (ERI), University College Cork (UCC), Ireland
School of Engineering, UCC, Ireland

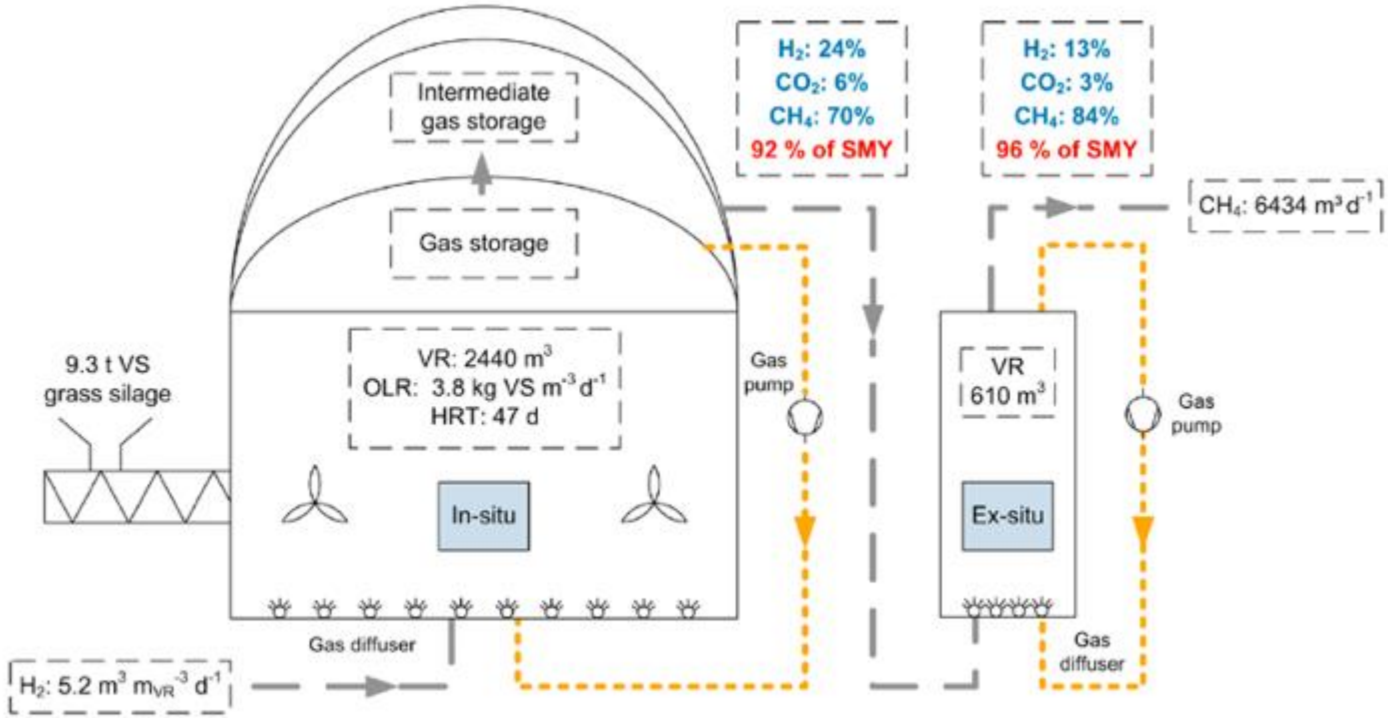
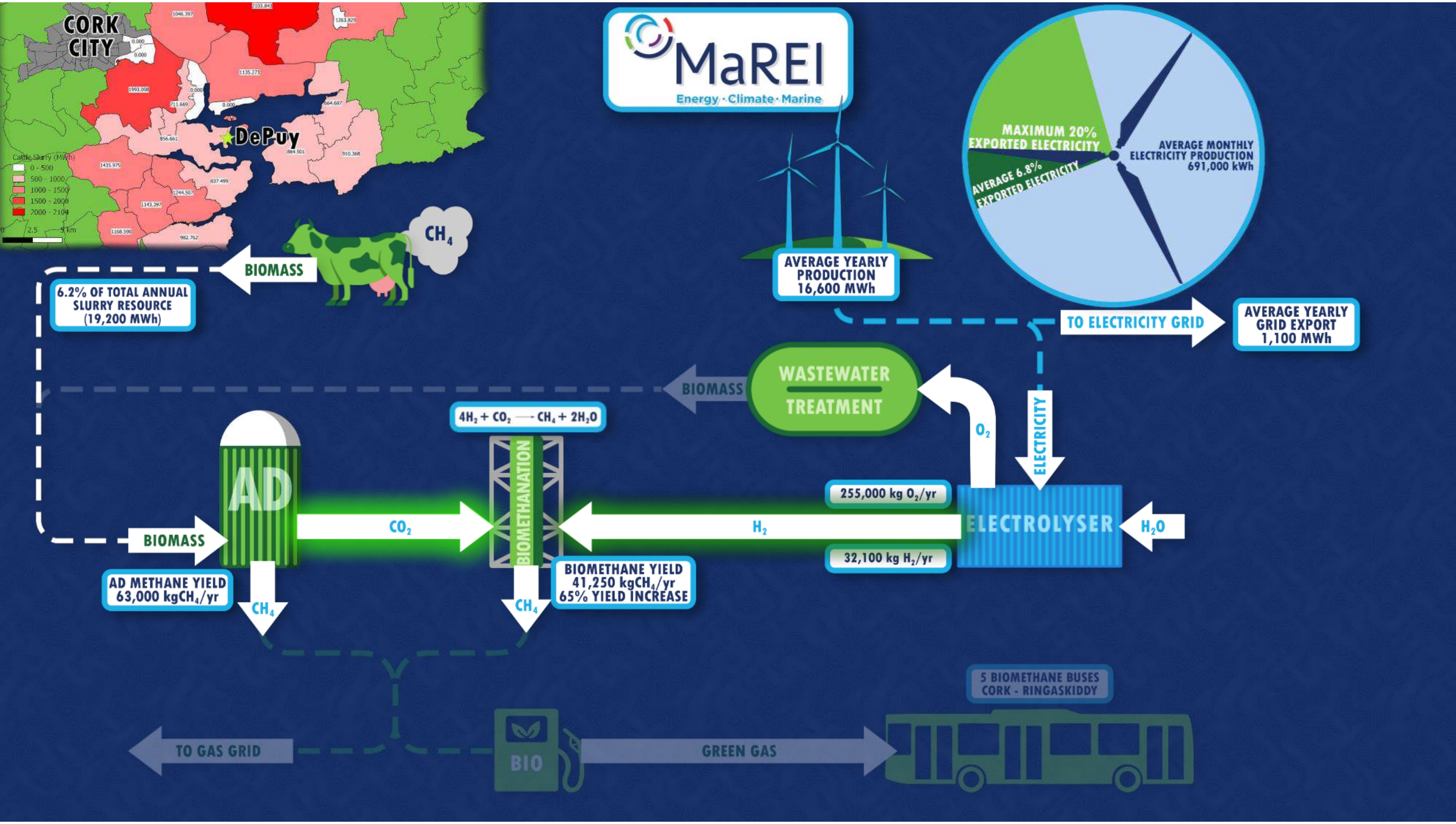


Fig. 7. Hybrid concept of sequential in-situ and ex-situ methanation with triple gas storage membrane on top of in-situ digester (SMY: specific methane yield, VR: reactor volume, OLR: organic loading rate, HRT: hydraulic retention time, VS: volatile solids).



CORK CITY
DePuy
Cattle Slurry (MWh)
0 - 500
500 - 1000
1000 - 1500
1500 - 2000
2000 - 2104
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MAXIMUM 20% EXPORTED ELECTRICITY
AVERAGE 6.8% EXPORTED ELECTRICITY
AVERAGE MONTHLY ELECTRICITY PRODUCTION 691,000 kWh
AVERAGE YEARLY PRODUCTION 16,600 MWh
TO ELECTRICITY GRID
AVERAGE YEARLY GRID EXPORT 1,100 MWh
CH_4
BIOMASS
6.2% OF TOTAL ANNUAL SLURRY RESOURCE (19,200 MWh)
WASTEWATER TREATMENT
BIOMASS
O_2
ELECTRICITY
$4H_2 + CO_2 \longrightarrow CH_4 + 2H_2O$
AD
BIOMETHANATION
CO_2
H_2
ELECTROLYSER
H_2O
255,000 kg O_2/yr
32,100 kg H_2/yr
BIOMASS
AD METHANE YIELD 63,000 kgCH_4/yr
BIOMETHANE YIELD 41,250 kgCH_4/yr 65% YIELD INCREASE
CH_4
CH_4
5 BIOMETHANE BUSES CORK - RINGASKIDDY
TO GAS GRID
BIO
GREEN GAS

iScience

CellPress

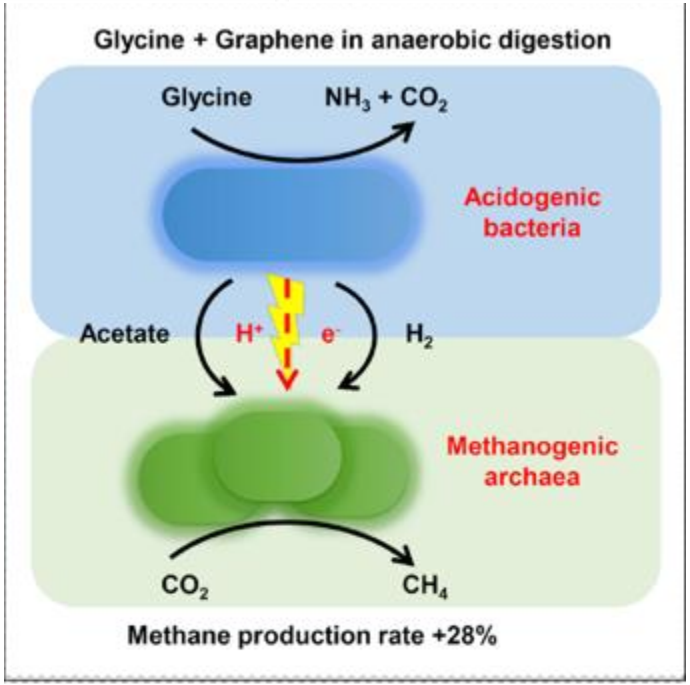
Article

Graphene Facilitates Biomethane Production from Protein-Derived Glycine in Anaerobic Digestion

Richen Lin,[1,2,7,*] Chen Deng,[1,2] Jun Cheng,[3] Ao Xia,[4] Piet N.L. Lens,[5] Stephen A. Jackson,[1,6] Alan D.W. Dobson,[1,6] and Jerry D. Murphy[1,2]


Direct interspecies electron transfer

Process	Reaction	$\Delta G_0'$ (kJ/mol)
Electron-producing reaction	1. MIET: $C_2H_5NO_2 + 2/3H_2O \rightarrow 2/3CH_3COO^- + 2/3H^+ + NH_3 + 2/3CO_2 + 1/3H_2$	−33.4
	2. DIET: $C_2H_5NO_2 + 2/3H_2O \rightarrow 2/3CH_3COO^- + 4/3H^+ + NH_3 + 2/3CO_2 + 2/3e^-$	−60.0



HIGHLIGHTS

Graphene led to an increase in peak bio-CH_4 production rate from glycine by 28%

Kinetic parameters had linear correlations with graphene addition (0.25–1.0 g/L)

Direct interspecies electron transfer (DIET) contributed to the improved performance

Renewable and Sustainable Energy Reviews 128 (2020) 109895

Contents lists available at ScienceDirect

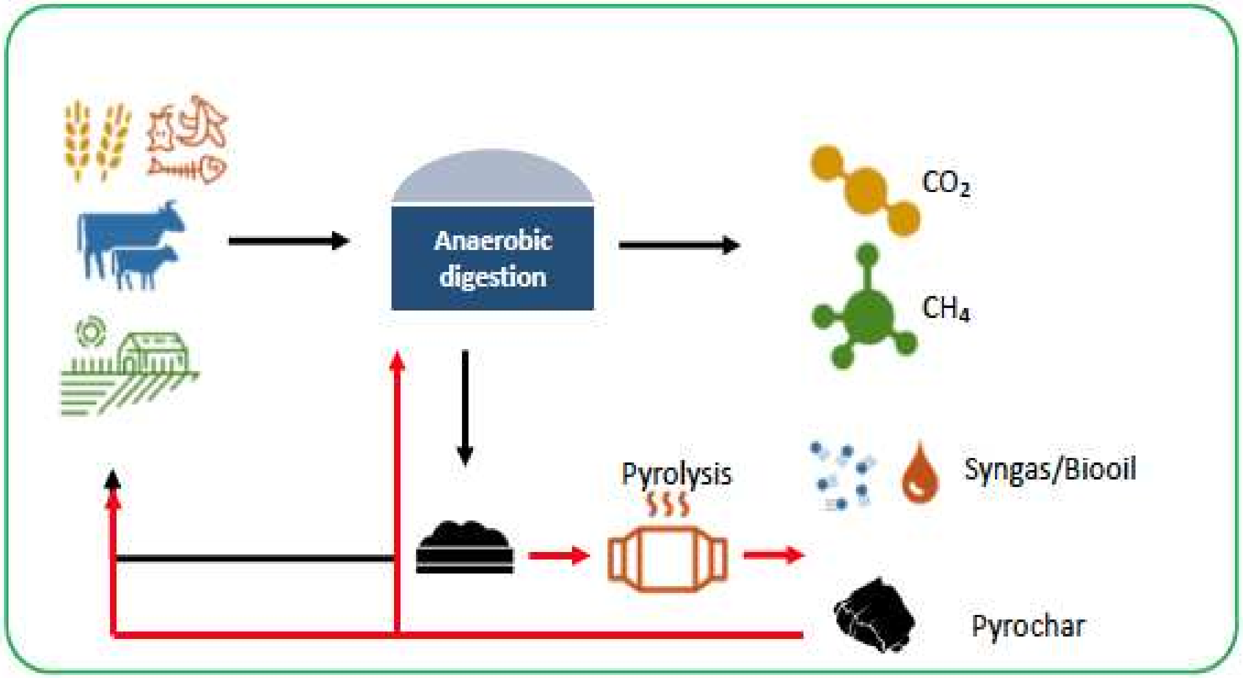
Renewable and Sustainable Energy Reviews

journal homepage: http://www.elsevier.com/locate/rser

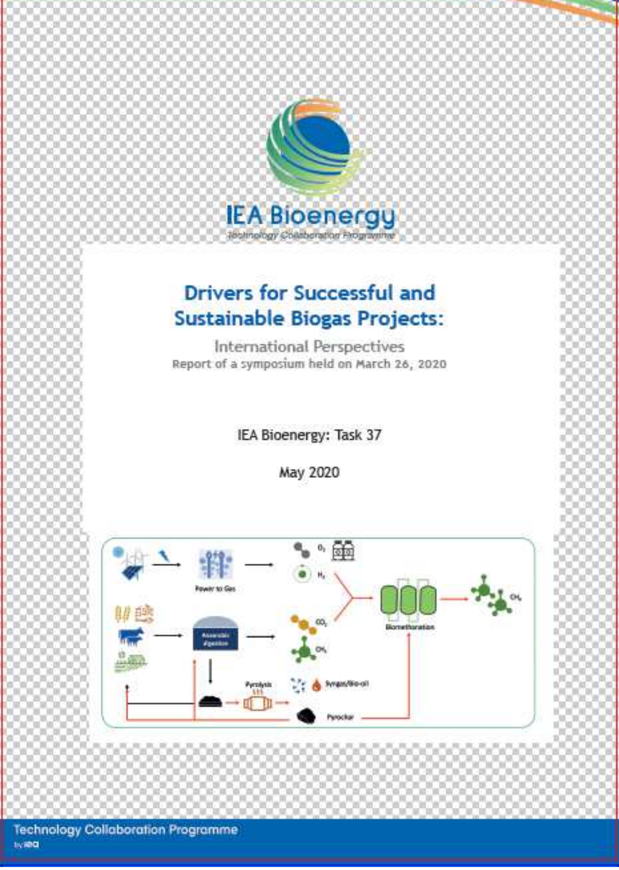
Improving gaseous biofuel yield from seaweed through a cascading circular bioenergy system integrating anaerobic digestion and pyrolysis

Chen Deng [a,b], Richen Lin [a,b,*], Xihui Kang [a,b,c,d], Benteng Wu [a,b], Richard O'Shea [a,b], Jerry D. Murphy [a,b]

[a] MaREI Centre, Environmental Research Institute, University College Cork, Cork, Ireland
[b] School of Engineering, University College Cork, Cork, Ireland
[c] Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou, China
[d] University of Chinese Academy of Sciences, Beijing, China



Increased biomethane yield of 17% while effecting a 26% decrease in digestate, reducing the amount of agricultural land required to spread digestate. Biochar achieved comparable performances to high cost graphene


IEA Bioenergy
Technology Collaboration Programme

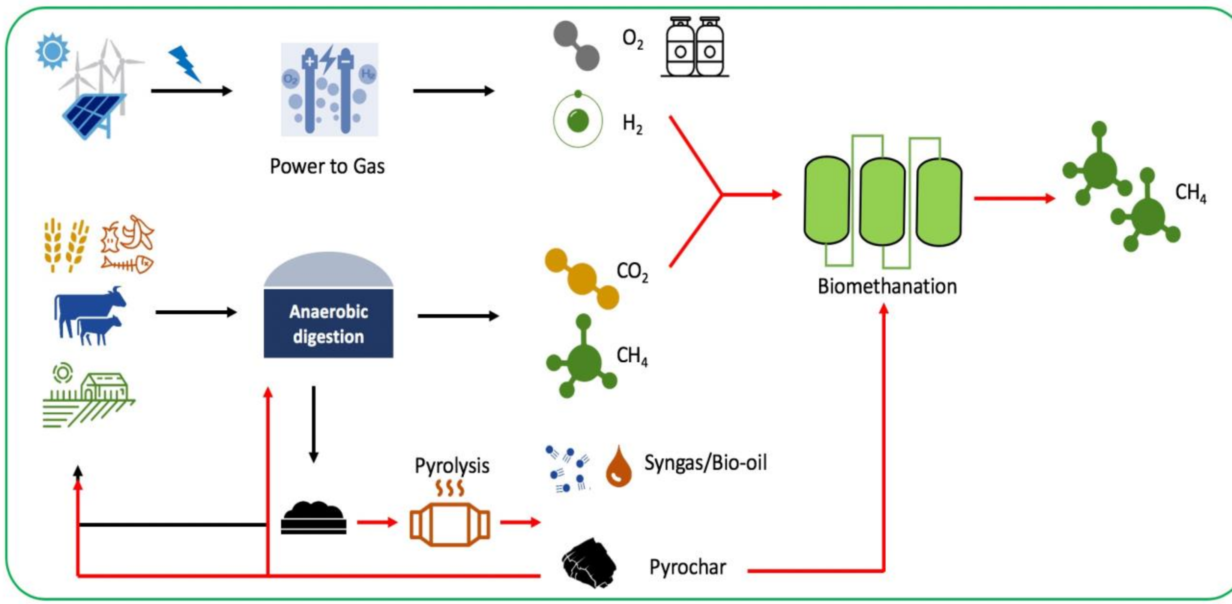
Drivers for Successful and Sustainable Biogas Projects:
International Perspectives
Report of a symposium held on March 26, 2020

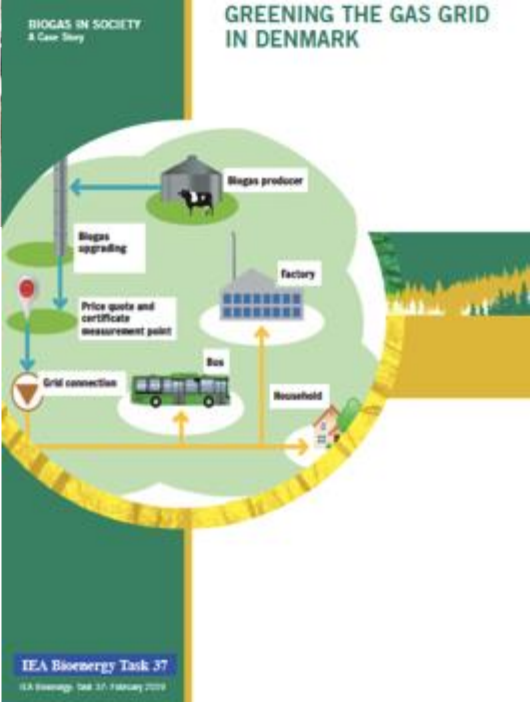
IEA Bioenergy: Task 37

May 2020

Technology Collaboration Programme

Advanced gaseous biofuel produced by integrating biological, thermo-chemical and power to gas systems in a circular cascading bioenergy system





Extent of Green Gas in Denmark

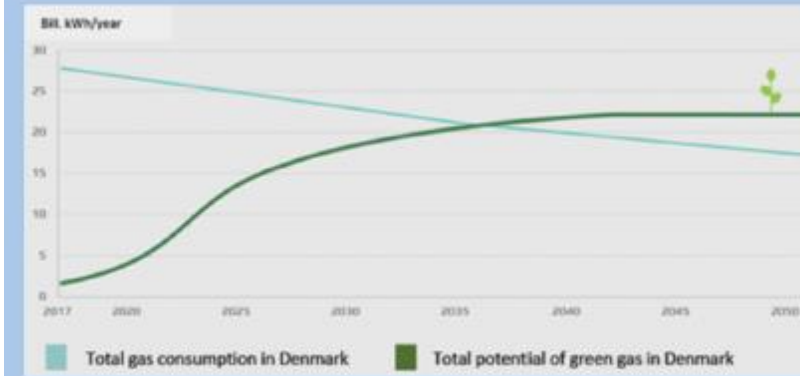
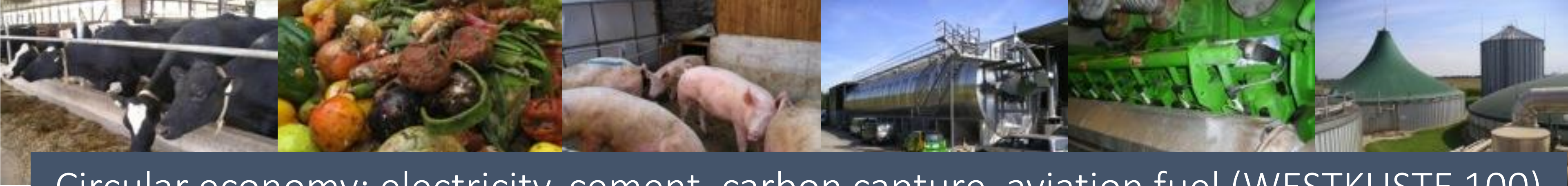


Figure 1: Gas consumption and potential of green gas in Denmark (from Green Gas Denmark)

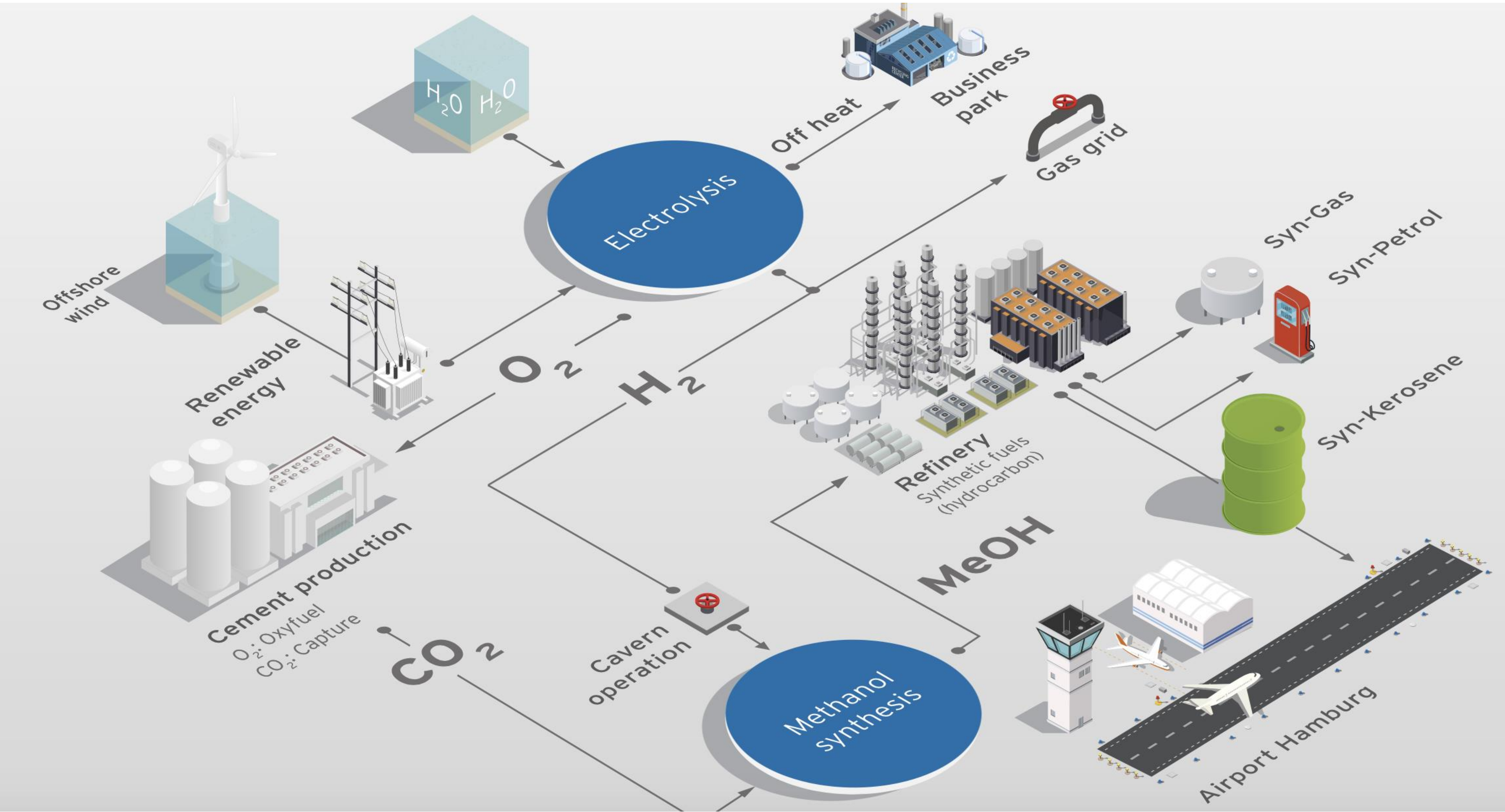
Figure 2: Grid connections for green gas in Denmark (yellow marks indicate connections established in 2017)

Figure 3: Holsted Biogas Plant, producing 20.7 million m³ gas / year. Source: Nature Energy

Denmark which at present intends decarbonising the gas grid with 72PJ of renewable gas by 2035. Addition of Power to Gas systems could see a resource of 100 PJ ,in advance of gas demand.



Circular economy: electricity, cement, carbon capture, aviation fuel (WESTKUSTE 100)




Bioresource Technology 304 (2020) 123027
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Bioresource Technology
journal homepage: www.elsevier.com/locate/biortech
Review
A perspective on novel cascading algal biomethane biorefinery systems
Archishman Bose[a,b], Richard O'Shea[a,b,*], Richen Lin[a,b], Jerry D. Murphy[a,b]
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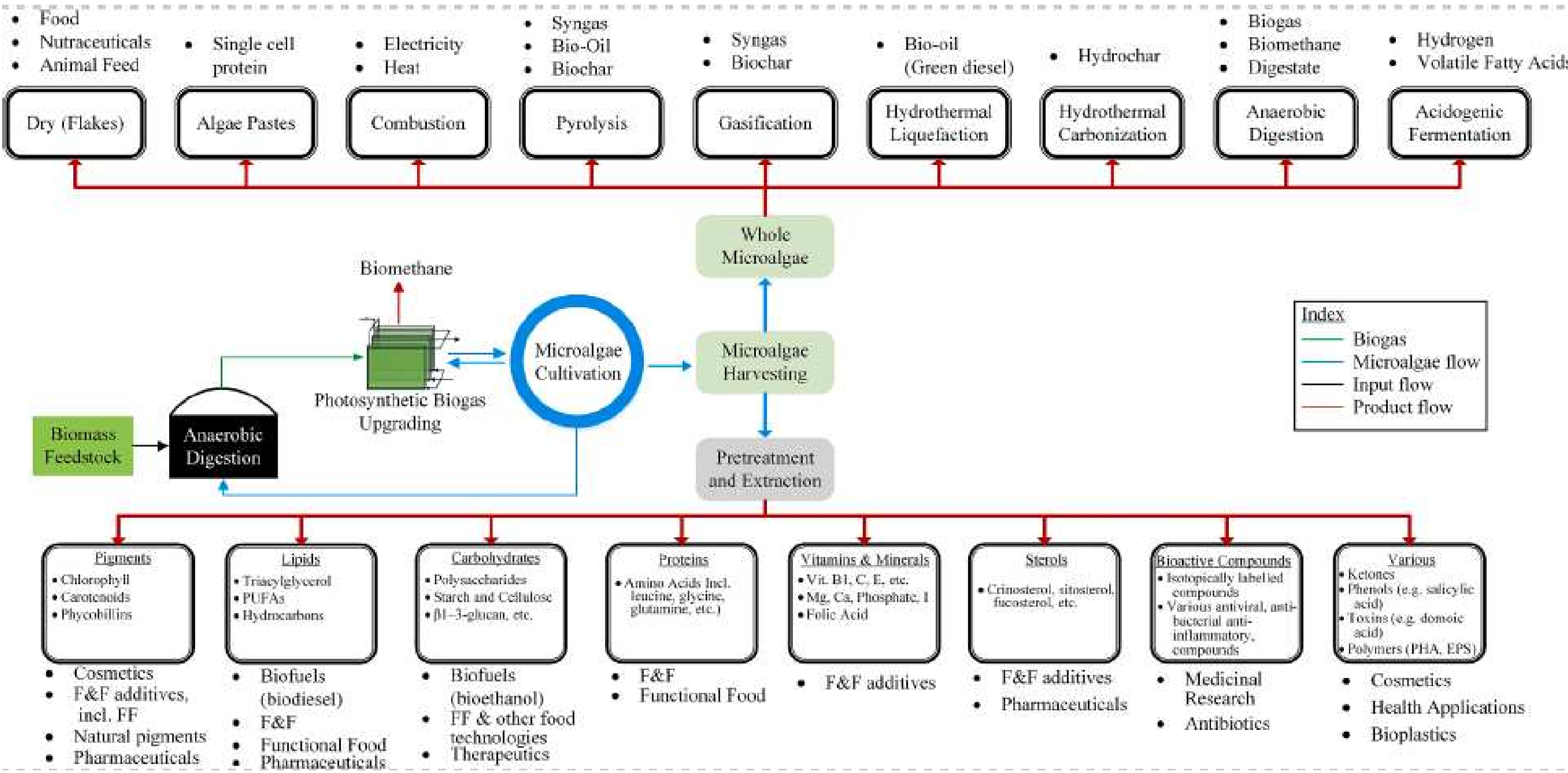
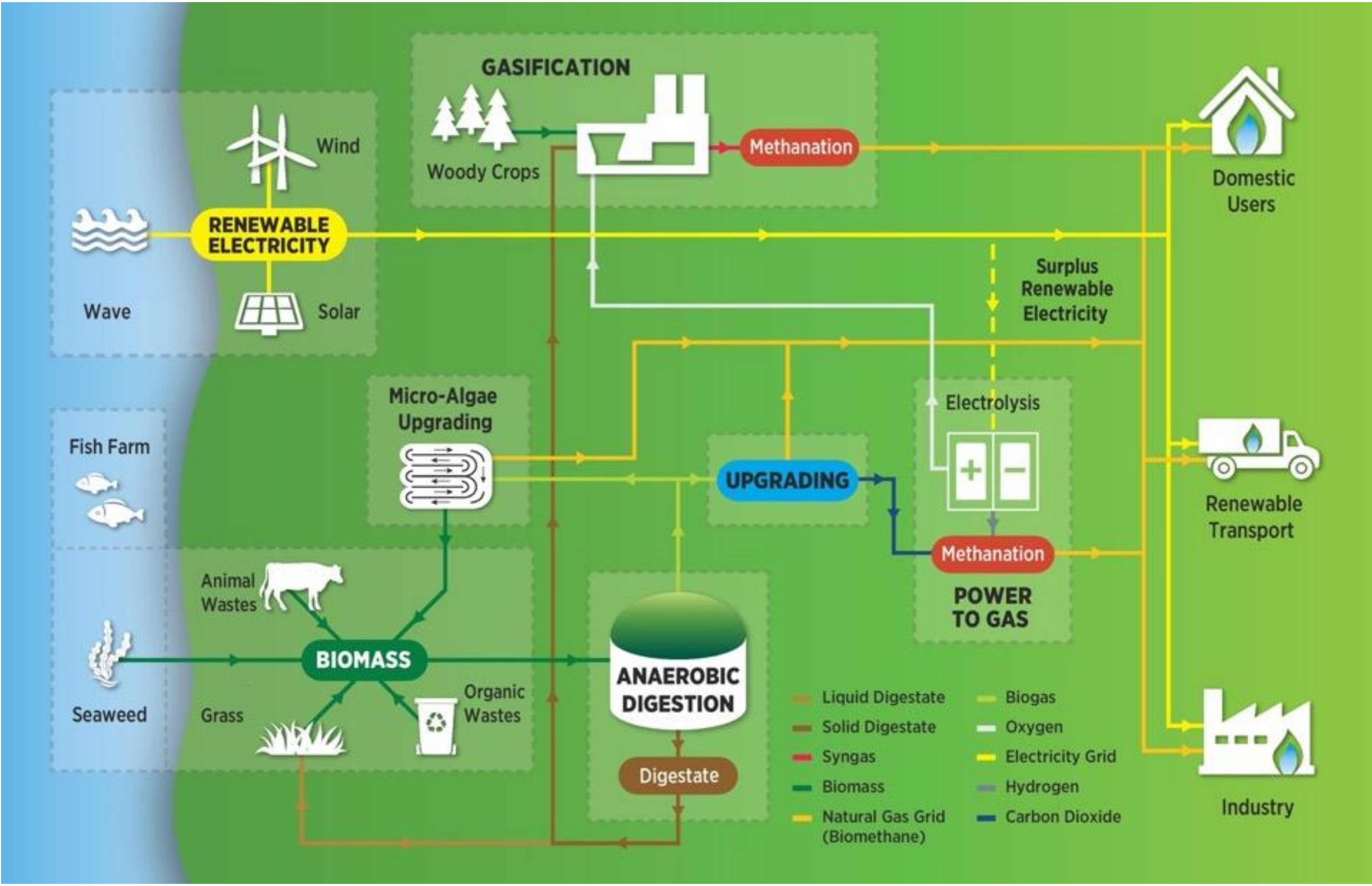
[b] School of Engineering, University College Cork, Cork, Ireland

Photosynthetic micro-algae upgrading of biogas to biomethane



Green Gas Technologies



marine governance
coastal &
marine systems
entrepreneurship
energy policy & modelling
community engagement
bioeconomy
industry engagement
marine ecology
blue growth
sustainable energy
offshore renewable energy
energy storage
leadership
marine ecology
materials & structures
energy management
observations & operations
engaged research
circular economy
climate action
bioenergy
energy
efficiency
energy transition
business
empowering