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Decarbonisation of whiskey production using circular economy bioenergy systems

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IEA Bioenergy
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FUNDED BY:
Ireland's European Structural and Investment Funds Programmes 2014-2020 Co-funded by the Irish Government and the European Union
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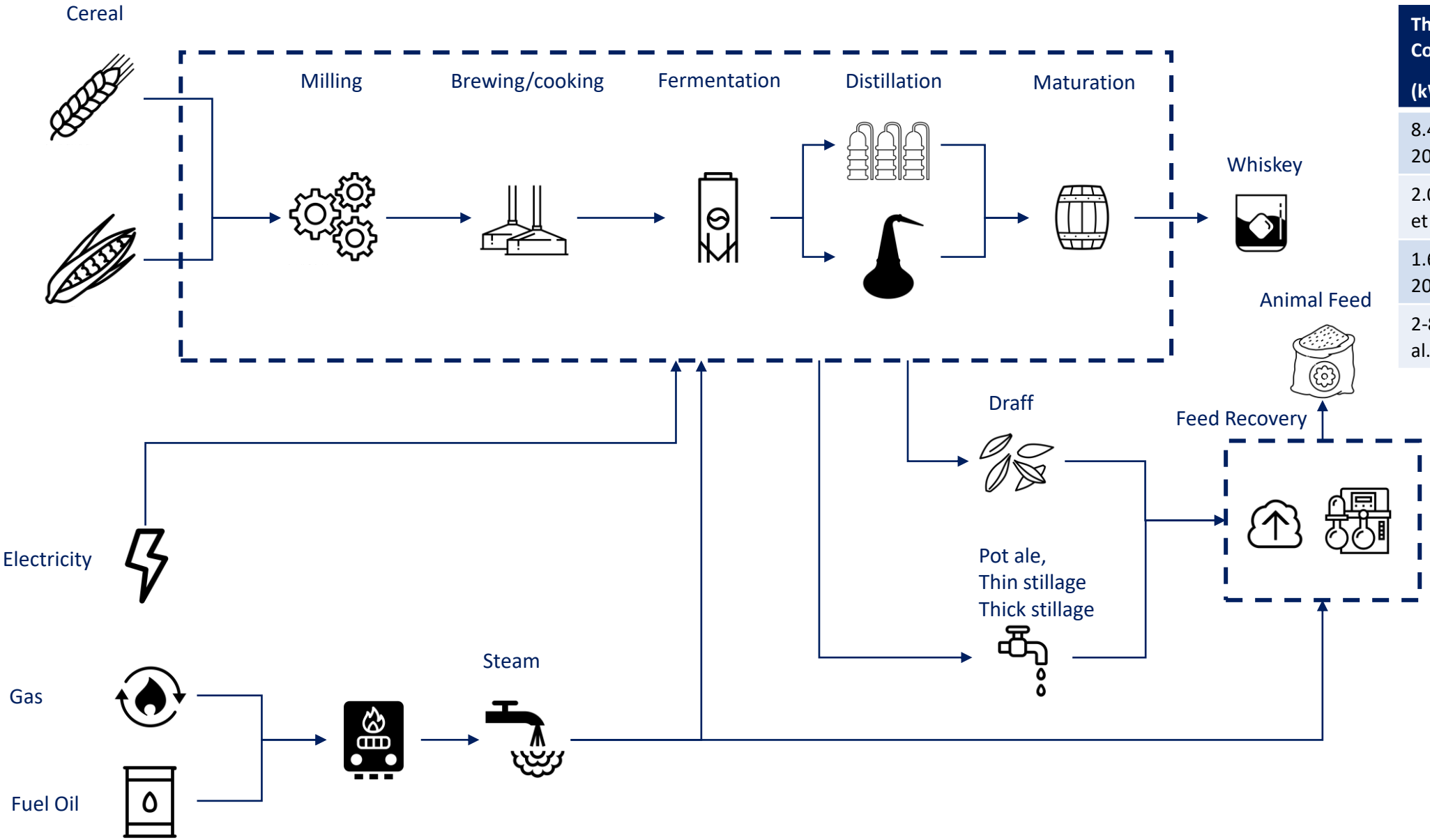
RESEARCH AREAS

- Marine Renewable Energy Technologies
- Materials & Structures
- Observation & Operations
- Coastal & Marine Systems
- Bioenergy
- Energy Policy & Modelling
- Energy Management

Whiskey Production: Process and Energy Use



Thermal Energy Consumption (kWh/L)	Electrical Energy Consumption (kWh/L)
8.46 (Kang et al., 2020)	0.37 (Kang et al., 2020)
2.0126 (Leinonen et al., 2018)	0.273 (Leinonen et al., 2018)
1.673 (AMIENYO, 2012)	0.273 (AMIENYO, 2012)
2-8.5 (German et al., 2019)	

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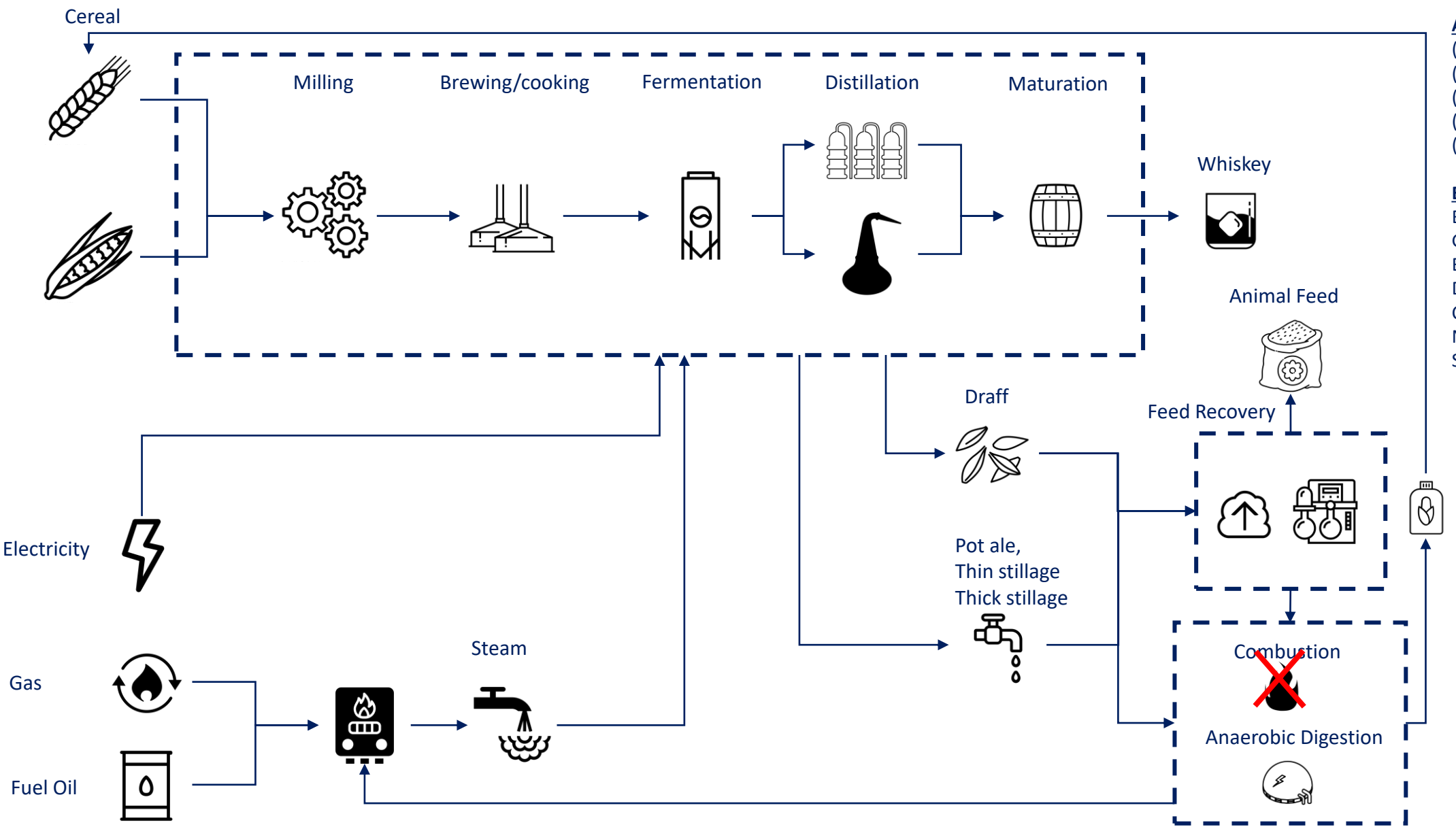
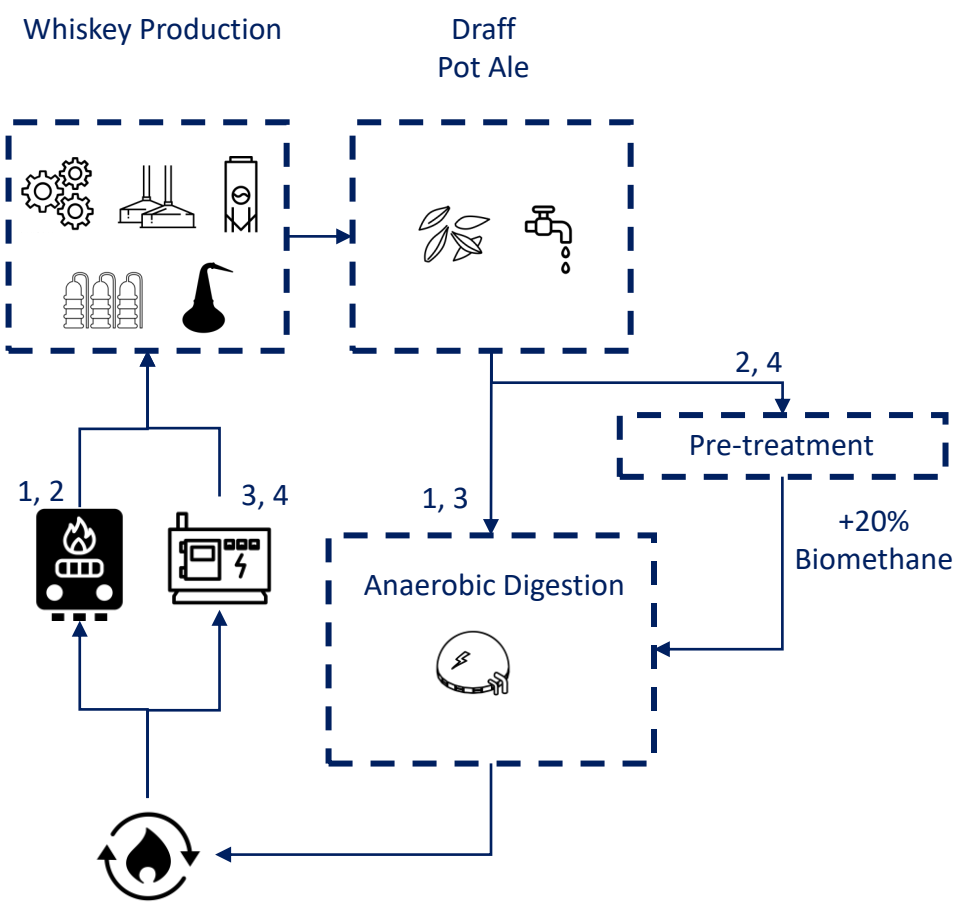
Whiskey Production: Bioenergy and the Circular Economy



Academic Literature
(Rutherford et al., 2003)
(Eriksson et al., 2016)
(Leinonen et al., 2018)
(Kang et al., 2020)
(O'Shea et al., 2020)

Example Plants
Balmenach, Scotland
Glendullan, Scotland
Bruichladdich , Scotland
Dalluaine , Scotland
Cameronbridge , Scotland
North British Distillery, Scotland
Slane Distillery, Ireland

A perspective on decarbonizing whiskey using renewable gaseous biofuel in a circular bioeconomy process (Kang et al., 2020)



Scenario 1
Biogas for heat. 46% of thermal demand. 42% CO_2eq reduction.

Scenario 2
Hydrothermal pre-treatment. Biogas for heat. 50% of thermal demand. 46% CO_2eq reduction.

Scenario 3
Biogas to CHP. 23% thermal demand, 408 % electricity demand, export excess to grid. 56% CO_2eq reduction.

Scenario 4
Biogas to CHP. 25% thermal demand, 446 % electricity demand, export excess to grid. 61% CO_2eq reduction.

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

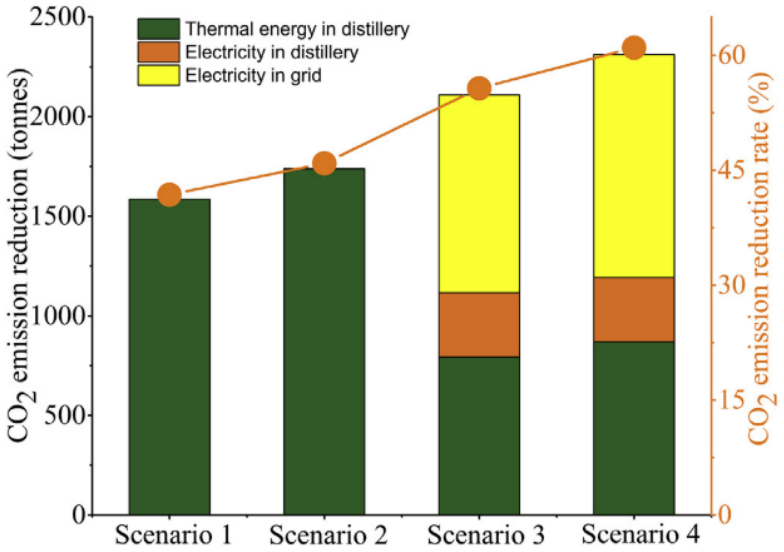
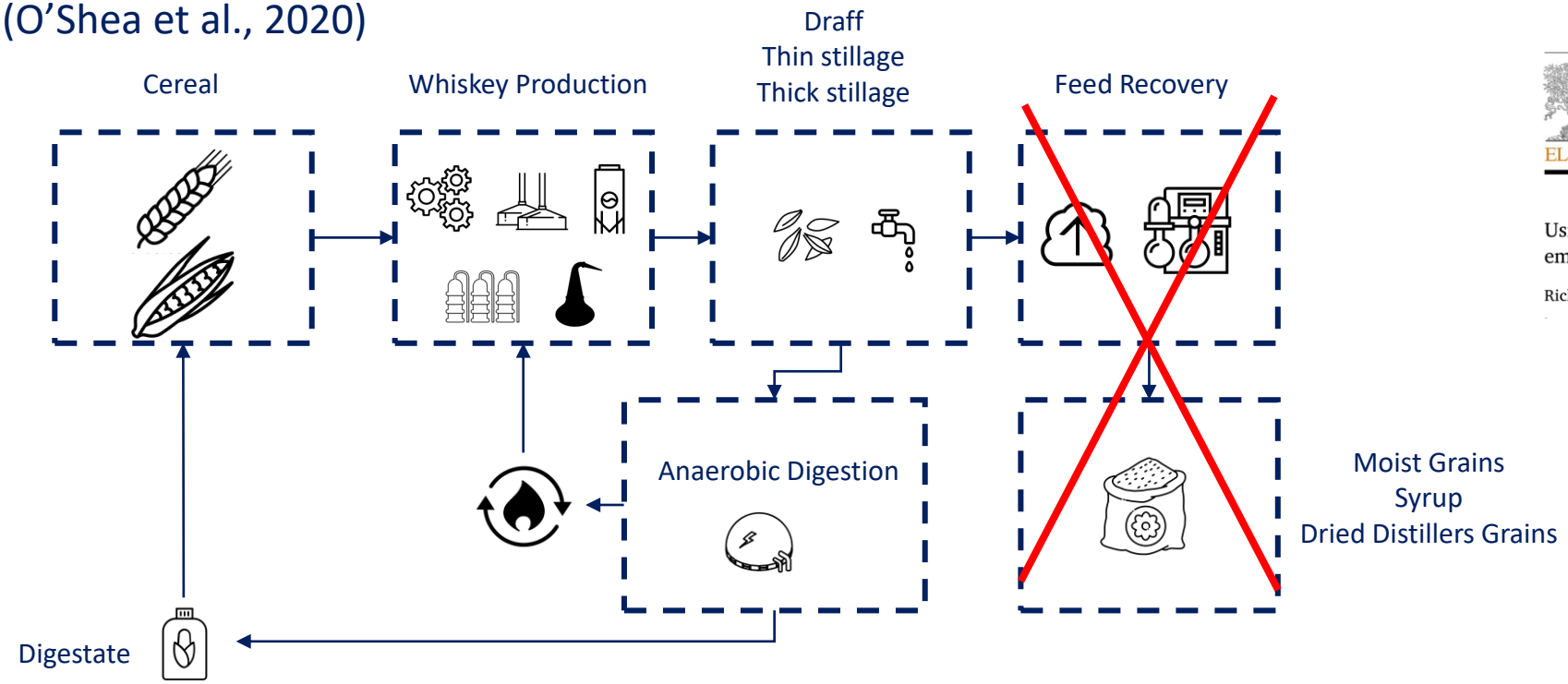
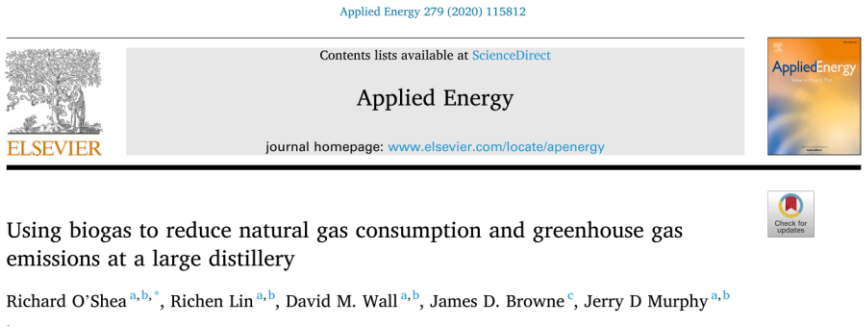


Fig. 4. Reductions in CO_2 emissions for different scenarios. Scenario 1: biogas only used for heat; Scenario 2: improved biogas (incorporating pretreatment of draff) only used for heat; Scenario 3: biogas used for heat and electricity and Scenario 4: improved biogas (incorporating pretreatment of draff) used for heat and electricity.

Using biogas to reduce natural gas consumption and greenhouse gas emissions at a large distillery: Benefits (O'Shea et al., 2020)




Applied Energy 279 (2020) 115812
Contents lists available at ScienceDirect
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Using biogas to reduce natural gas consumption and greenhouse gas emissions at a large distillery

Richard O'Shea [a,b,*], Richen Lin [a,b], David M. Wall [a,b], James D. Browne [c], Jerry D Murphy [a,b]

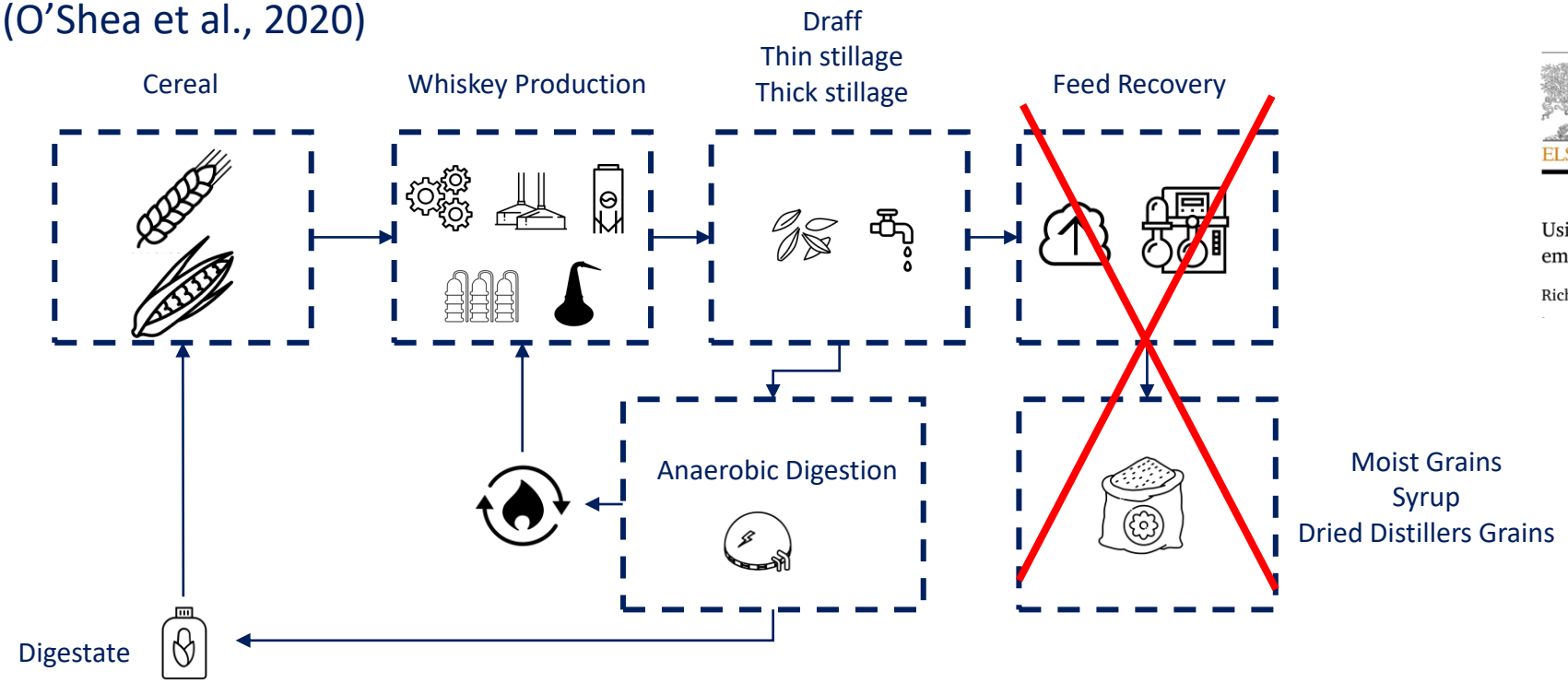
Scope 1 GHG Emissions (Fuel combustion)

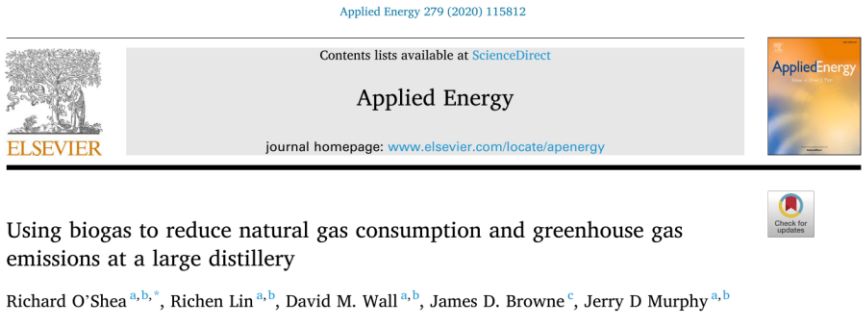
- 154 GWh/a of biogas
- 61% of current natural gas consumption
- 64% of natural gas consumption without feed recovery
- 27,748 tCO_2eq Scope 1 GHG saving
- 3,973 tCO_2eq Scope 3 GHG saving

Scope 3 GHG Emissions (Value Chain)

- 597,545twwt/a of digestate
- Replace 1,180 tCAN/a and 456 tPhosphorous/a
- 11,389 tCO_2eq/a Scope 3 saving

Using biogas to reduce natural gas consumption and greenhouse gas emissions at a large distillery: Drawbacks (O'Shea et al., 2020)

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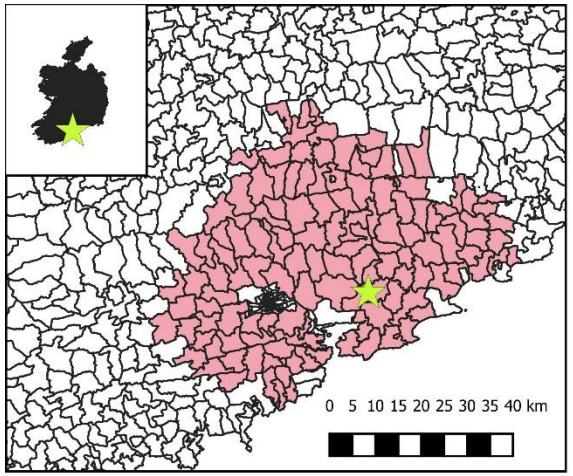
Digestate Logistics

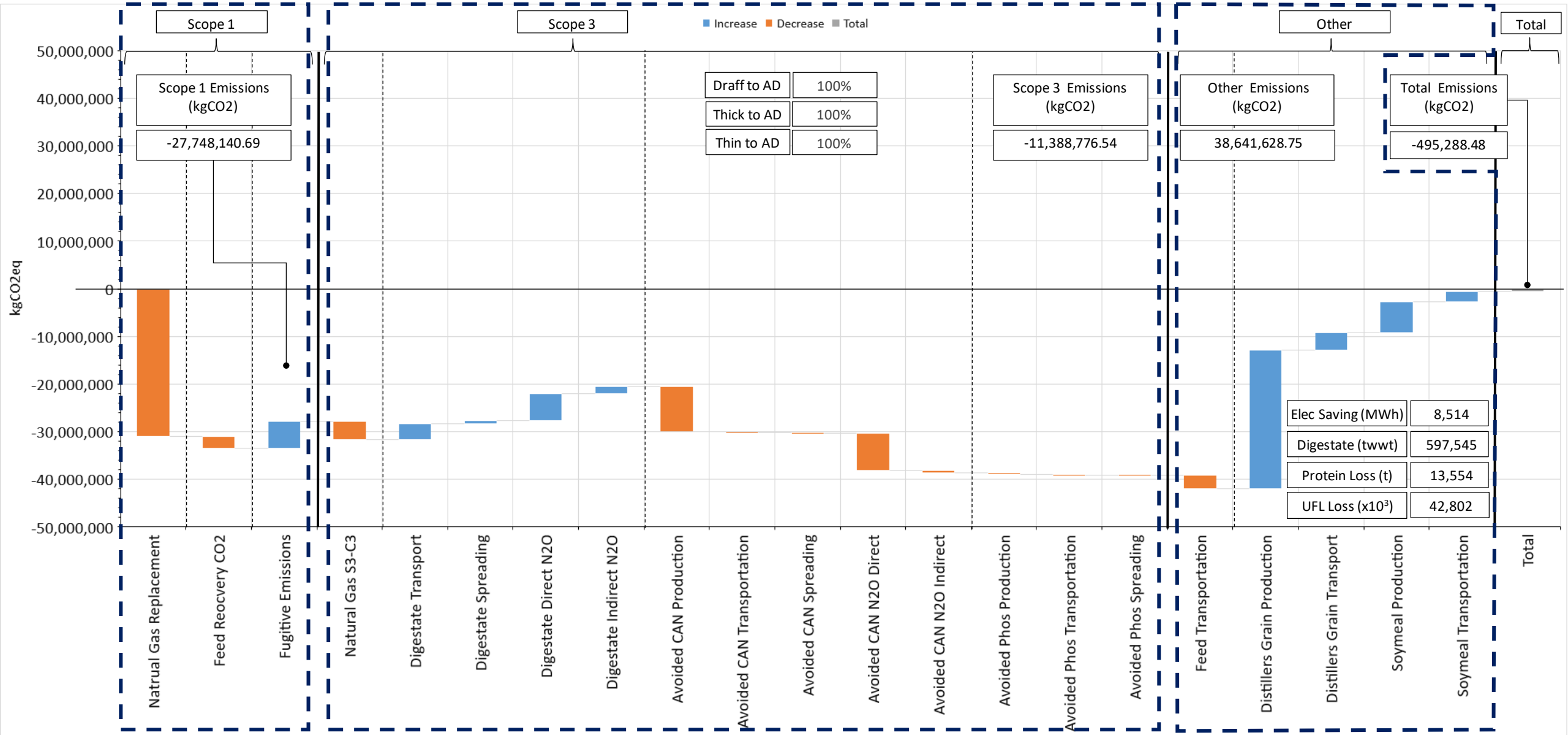
- Max transport distance 45-50km
- 50% of digestate to land within 25km
- Phosphorous limiting nutrient
- 541,884m^3 centralised storage. 249 trucks/hour (first application), 581 trucks /hour (second application)
- 126 decentralised tanks (500m^3-28,000m^3). 82 trucks/day throughout the year



Animal Feed

- Distillers grains (USA), 5% Irish imports in 2018: 32,646 tCO_2eq
- Soybean meal (Argentina), 2% Irish imports in 2018: 8,767 tCO_2eq

Using biogas to reduce natural gas consumption and greenhouse gas emissions at a large distillery: Balance? (O'Shea et al., 2020)



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Future Work: Achieving Balance?

$$r(\boldsymbol{f}(\underline{x}_j);\ p, w) = \left[\sum_{i=1}^{n}\left(w_i \boldsymbol{f}(\underline{x}_j) - w_i \boldsymbol{f}(\underline{x}^{UTOPIA})\right)^p\right]^{\frac{1}{p}}$$

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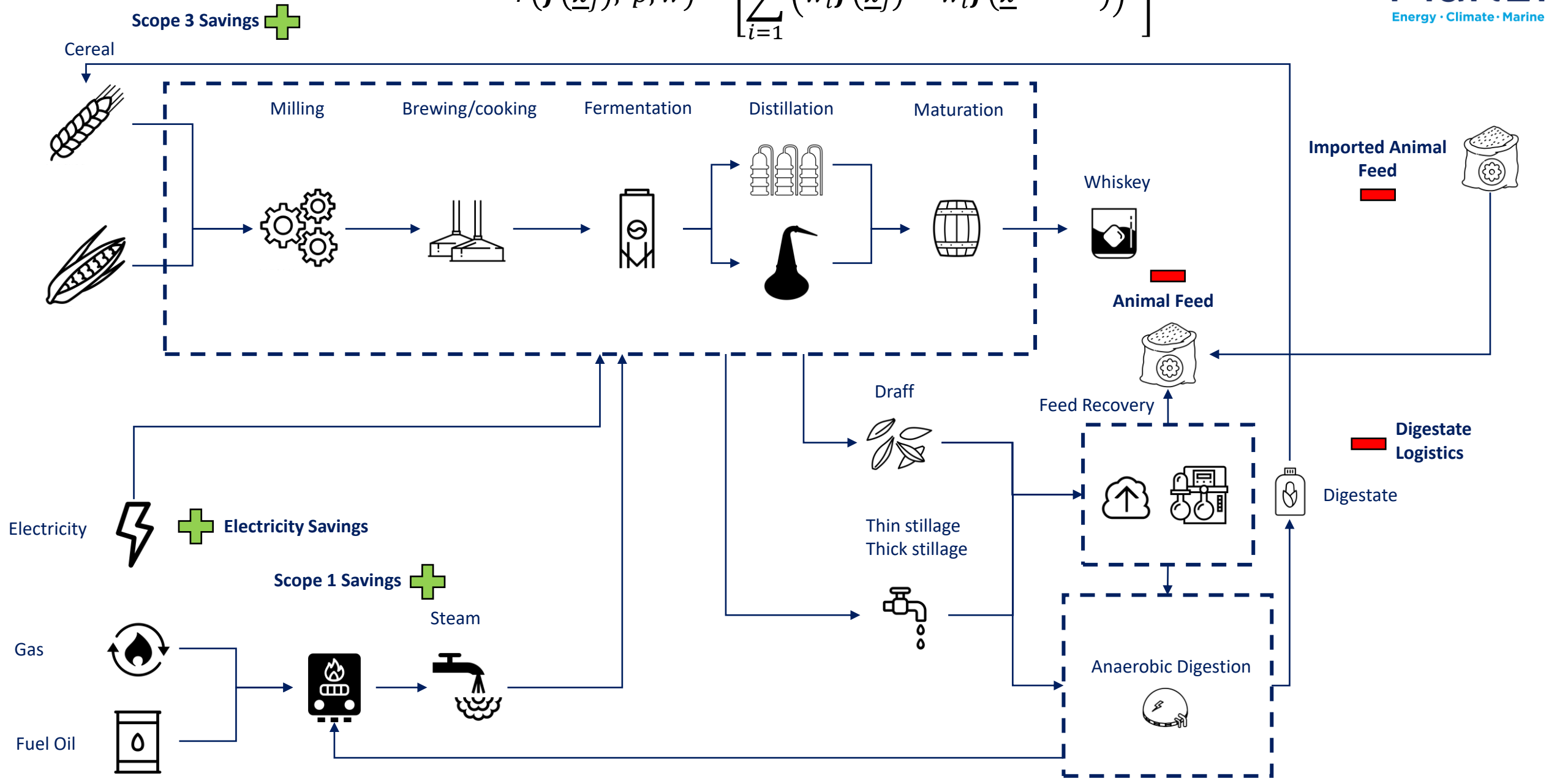

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