Agenda

- Specific aims of research
- Methodology
- Typical plant costs
- Current viability of mono-digestion
- Current viability of co-digestion
- Stochastic modelling
- Conclusions
On Farm Anaerobic Digestion - Barriers Thus Far

• Heat generated needs to be used onsite – demand?
  – Pig farms
• REFIT Ireland 15c kWh vs ROCs in N. Ireland 28c
• Complex planning process
Manure and Food Waste Co-digestion

<table>
<thead>
<tr>
<th>Food Waste</th>
<th>Pig Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stable digestion at high operating rates</strong></td>
<td></td>
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<tr>
<td><strong>Increased volumetric methane yields</strong></td>
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</table>

- Additional revenue stream for farmers in the form of gate fees
- Reduce GHG emissions from agriculture
- Increase renewable energy provision
- Non-landfill management route for food residues
N.B.

- ABP regulations do not permit on-farm co-digestion of food waste
- Adjacent, separate facility required.
- Higher digester construction and site civil costs
Rationale

- On-farm co-digestion plants in Ireland not common
- Need to analyse why, and how would they become profitable
- Focusing on a single co-substrate; Food waste (FW)
Aims

- The objectives of this study were
  - Identify and quantify the key revenue streams, capital, (CAPEX) and operational (OPEX) costs associated with mono- and co-digestion.
  - Assess the current financial viability of co-digestion (PM and FW) and mono-digestion plants using a deterministic model.
  - Present a methodology which can assess the sensitivity of overall profitability of co-digestion plants to changes in key revenue streams and operational expenses using stochastic modelling.
Methodology

- 6 scenario’s to be analysed

<table>
<thead>
<tr>
<th>Scenario No.</th>
<th>Farm Size (sows)</th>
<th>Digester tank size (m³)</th>
<th>CHP Size (MWe)</th>
<th>Substrates</th>
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</thead>
<tbody>
<tr>
<td>1m</td>
<td>521</td>
<td>1,500</td>
<td>0.05</td>
<td>Manure only</td>
</tr>
<tr>
<td>2m</td>
<td>2607</td>
<td>7,500</td>
<td>0.26</td>
<td></td>
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<tr>
<td>3m</td>
<td>5214</td>
<td>15,000</td>
<td>0.52</td>
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Revenues

• Biogas utilization via combined heat and power unit (CHP)
  – Heat used on-farm to displace the use of oil boiler
  – Electricity to grid via REFIT
    • € 0.15/kWh for plants with < 0.5 MWe, € 0.13/kWe > 0.5 MWe
• FW co-digestion drives methane yields and generates gate fees
  – limited in scenario c1 due to digester size; need to maintain feedstock solids concentration below 15-20%; 3000 t/year
  – c2, c3; the average amount FW treated by AD plants in Ireland (8500 t/year; derived from EPA figures)
Financial Metrics

• Return on Investment

• Net Present Value (NPV)
  – Accounts for the payback of CAPEX, cash flow based on OPEX & revenue, and the future value of current capital and cash flow (the discount rate)

• Internal Rate of Return
  – Profit made while accounting for reduction in value of the capital invested in the project during project lifetime
DETERMINISTIC ANALYSIS
Deterministic model

- Financial model based on fixed costs for capital expense (CAPEX), operational expense (OPEX) and revenues; static costs for
  - REFIT (€ 0.15/kWh or € 0.13/kWh)
  - Gate Fees (€30 /t)
  - FW availability (3000 t/a c1, 8,500 t/a c2 and c3)
  - Digestate disposal costs (€4/t up to 5kt, €7/t thereafter)
- Data for model generated from lab and meso-scale plant operation, and contacting plant operators and designers
- **CAPEX REMAINS HIGHLY VARIABLE!**
Plant costs-CAPEX

- Ex. Development, engineering, contingency and insurance costs
Plant costs-OPEX

- Ex. Depreciation, interest and insurance

<table>
<thead>
<tr>
<th>Plant Costs</th>
<th>Plant Capacity</th>
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</thead>
<tbody>
<tr>
<td>- OPEX</td>
<td>- Admin</td>
</tr>
<tr>
<td></td>
<td>- Electricity</td>
</tr>
<tr>
<td></td>
<td>- Labour</td>
</tr>
<tr>
<td></td>
<td>- Digester</td>
</tr>
<tr>
<td></td>
<td>- CHP</td>
</tr>
<tr>
<td></td>
<td>- Plant O+M</td>
</tr>
</tbody>
</table>

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Plant revenues

Revenue from Gate Feeds (€)
Annual Gross Revenue from REFIT (€)
Revenue from Heat Replacing Oil boiler (€)
Results-baseline scenario (deterministic model)
Conclusions

• >70% of revenues from co-digestion systems and all of the revenue from mono-digestion generated by REFIT
• Scenarios c1 and c2 viable with RoI’s of 126 % and 11 %, Internal Rate of Return (IRRs) of 20 % and 9 %
• Scenario c3, and all mono-digestion scenarios not viable
  – FW availability limits revenue generating potential; high CAPEX and OPEX
STOCHASTIC MODEL
Variability in market conditions need to be considered

- Cost of building and maintaining digesters is fixed
- Cost of disposing of digestate is highly variable
- When taking in food waste, plants gain additional revenue from gate fees from waste companies, and from the higher methane yields
  - The waste market is very competitive so gate fees vary a lot
  - The amount of waste available for treatment can vary also; as this effects methane yield AND revenue from gate fee, this is important
- Energy price (REFIT) may increase in future (currently half of what it is in UK)

Analysis of project viability must consider these variable costs
Stochastic model

• Analysis of the effect of possible changes in key inputs was undertaken via Monte Carlo simulation
  – The financial model was run 10,000 times, with the values for the variables changed randomly within Normal distributions
  – Parameters varied from worst case to best case scenario
  – The effect of these changes on 15 year NPV was recorded and analysed.
Variable distributions

• REFIT (mean €0.15, std. dev. €0.03)
• Gate Fees- (mean €30/t, std. dev. €10/t)
• Base digestate disposal costs- (mean €4/t, std. dev € 1.5/t)
• FW availability
  – c1; mean 3000t, std. dev 500t and truncated at 3000
  – c2; mean 8500t, std. dev. 5000t and truncated at 15000
  – c3; mean 8500t, std. dev. 5000t and truncated at 30000
Stochastic modelling conclusions

- Scenario c1 least impacted by changes in all parameters
- Scenario c2 and c3 highly sensitive to changes in FW availability
- Due to higher CAPEX and OPEX and the limited FW supply, scenario c3 remains unviable
  - unless large volumes of FW can be secured (which case significant profits can be realised)
- FW availability limits scale of on-farm PM and FW co-digestion
  - Working with local food processing facilities and waste management companies?
  - Alternative feedstocks
Conclusions

• Mono-digestion of PM not financially viable
• Farm of 521 sows co-digesting 3000t of FW per annum financially viable.
• Farm of 2,607 sows co-digesting 8,500 t of FW per annum was found to be financially viable, but strongly affected by market conditions
• FW availability limits the scale of on-farm biogas plants treating FW exclusively
Thank You

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