Economic viability of farm-based co-digestion of pig manure and food waste

28th March 2017

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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

	Food Waste	Pig Manure

Stable digestion at high operating rates
Increased volumetric methane yields
€€€€€€

- 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

Scenario No.	Farm Size (sows)	Digester tank size (m^3)	CHP Size (MWe)	Substrates
1m	521	1,500	0.05	Manure only
2m	2607	7,500	0.26	
3m	5214	15,000	0.52	

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

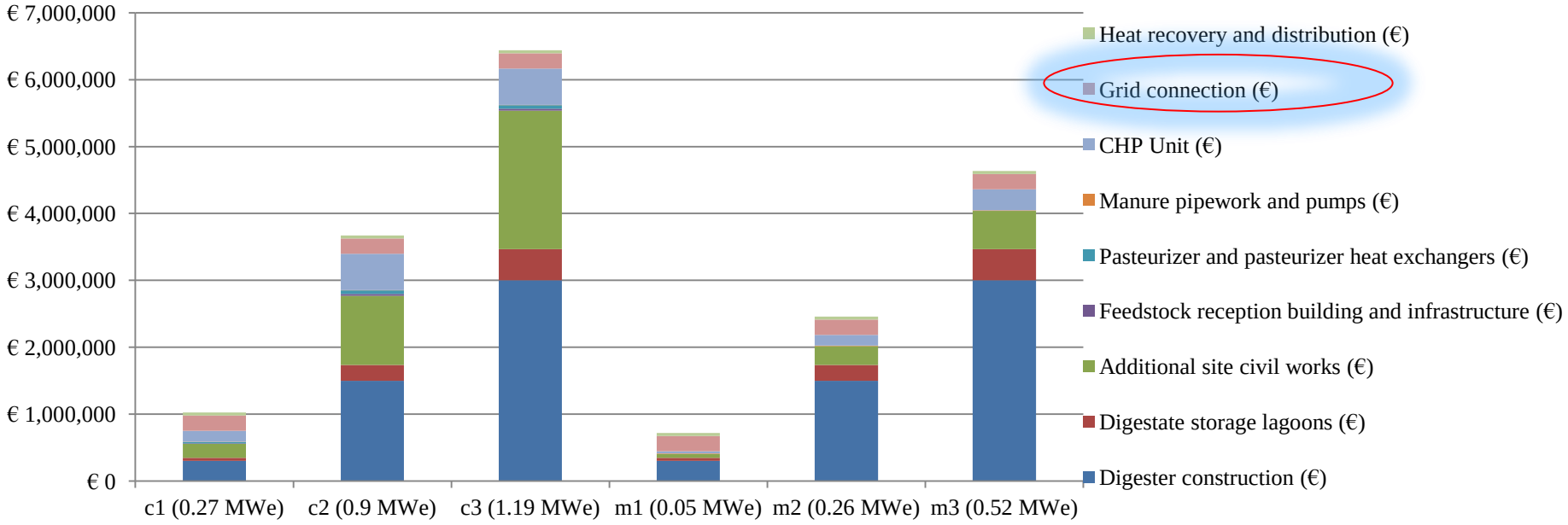
DETERMINISTIC ANALYSIS

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!**

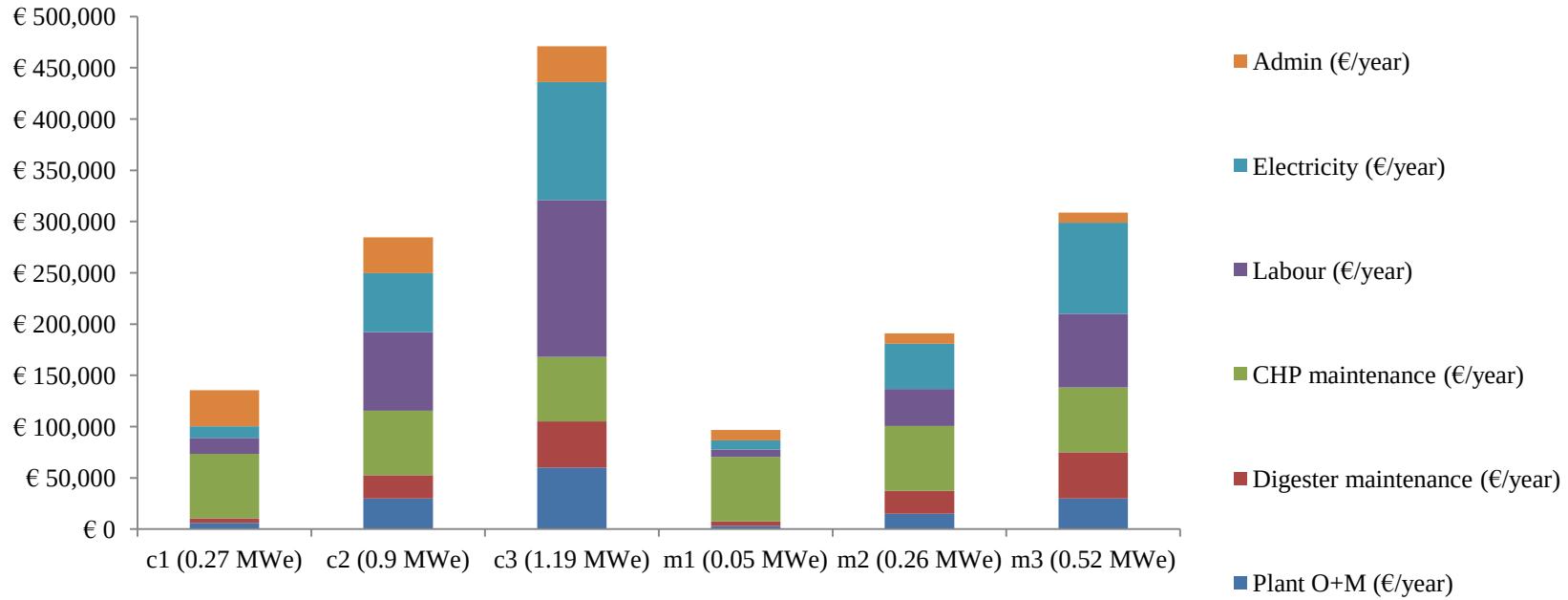
Plant costs-CAPEX

- Ex. Development, engineering, contingency and insurance costs

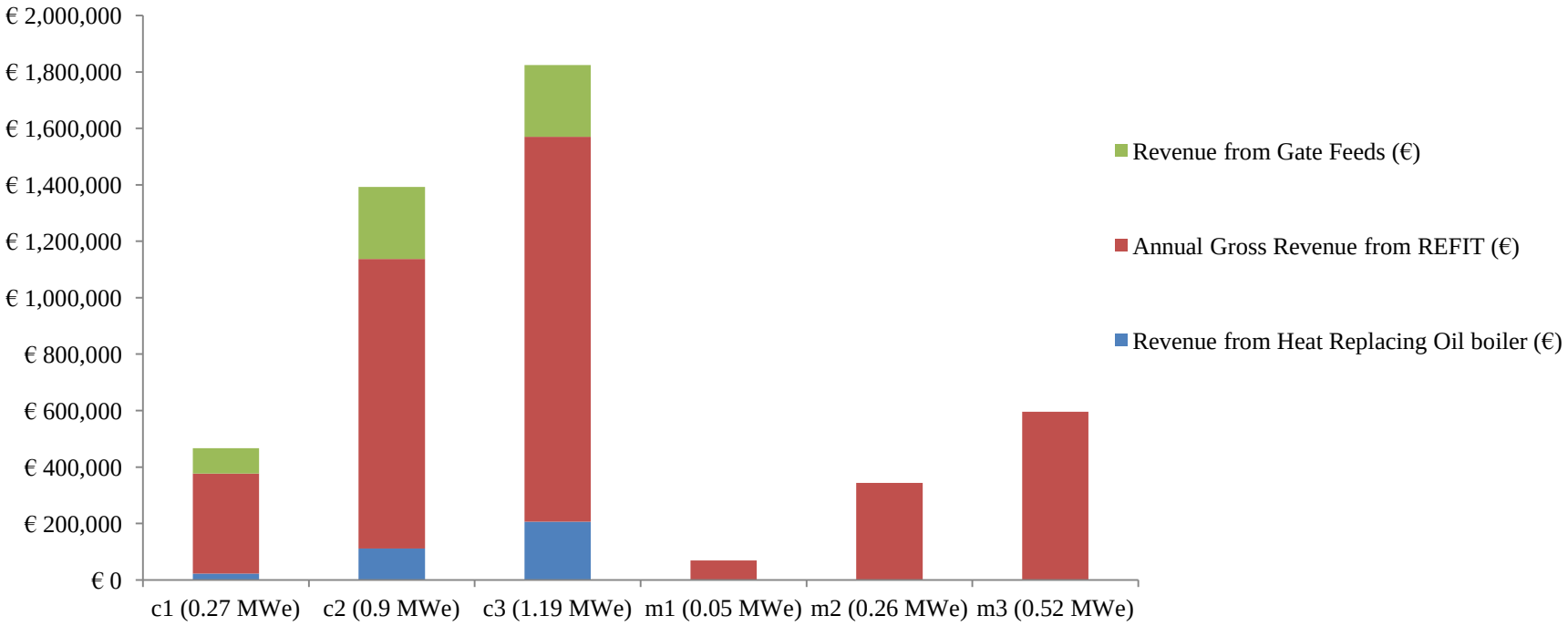


Plant costs-OPEX

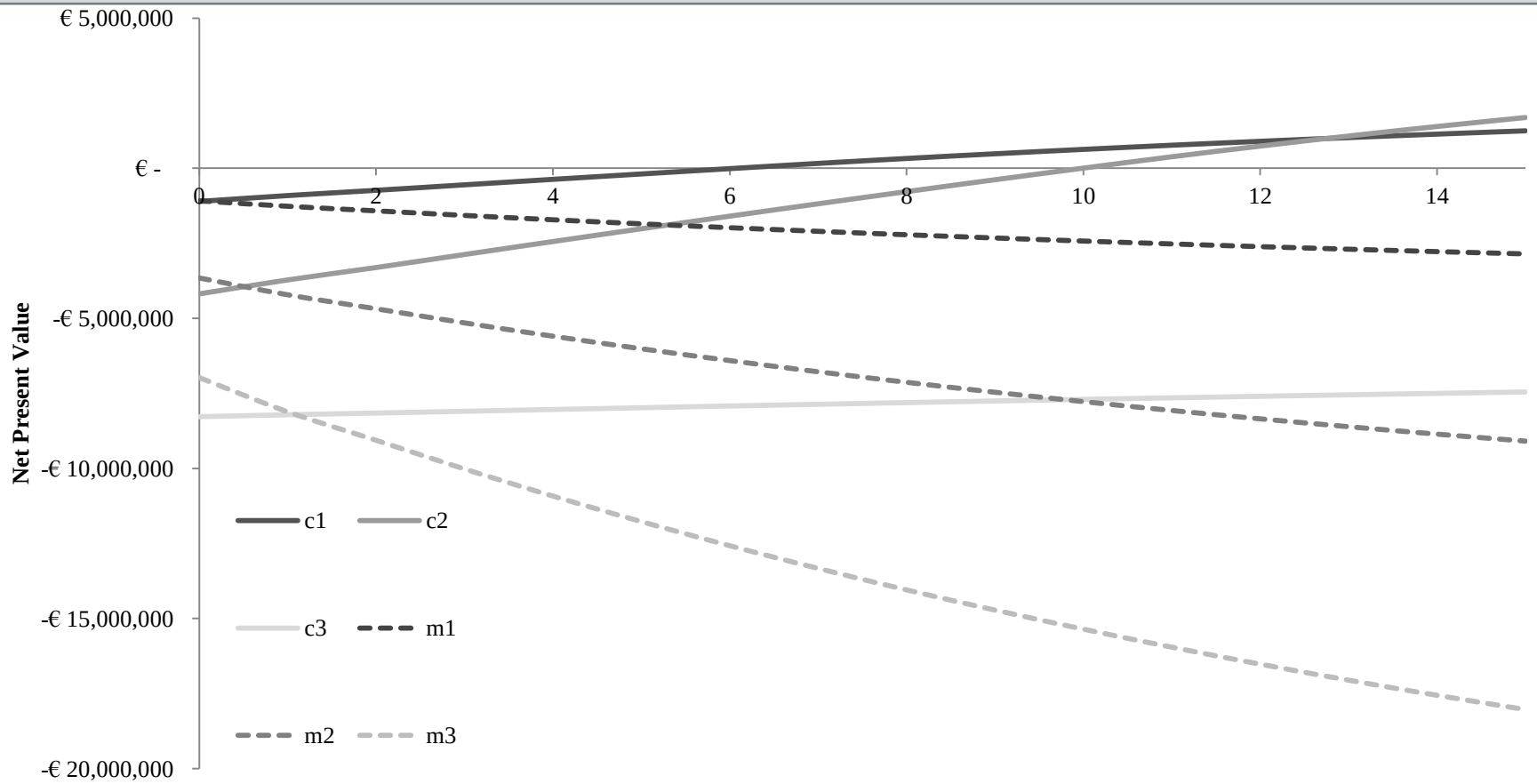
- Ex. Depreciation, interest and insurance



Plant revenues



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

Analysis of project viability must consider these variable costs

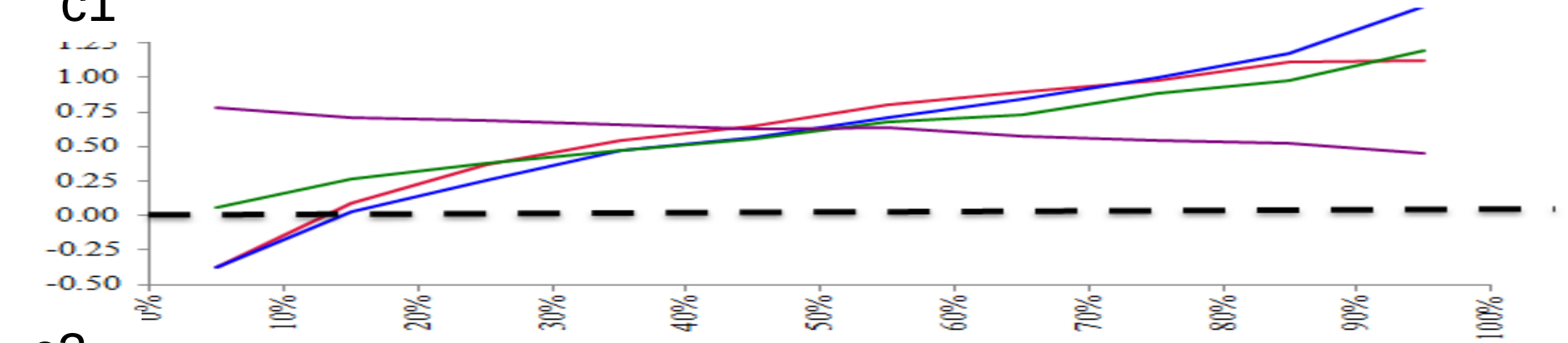
Stochastic model

- 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.

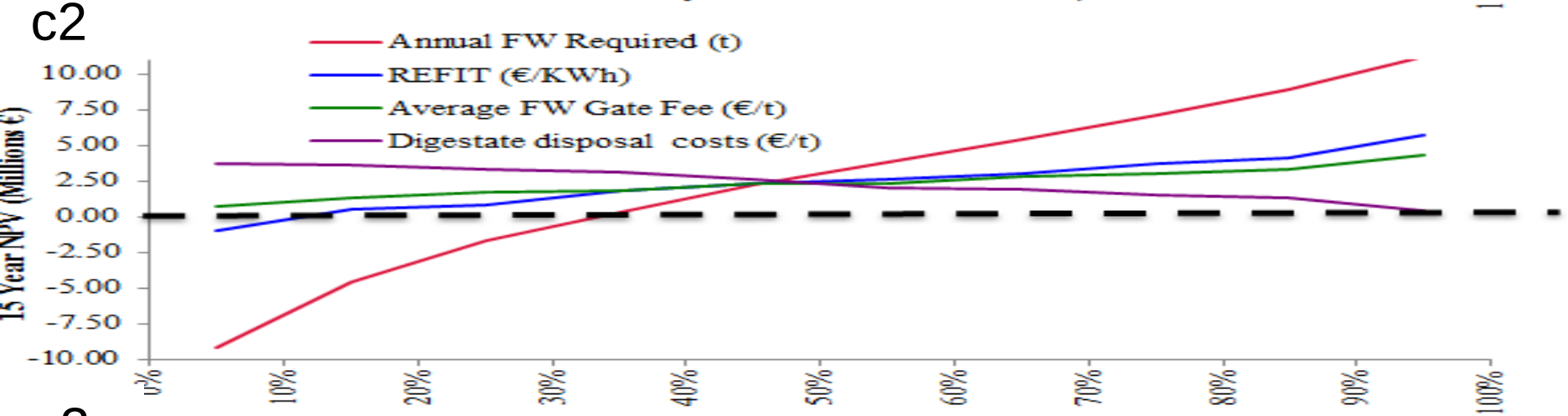
Variable distributions

- 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

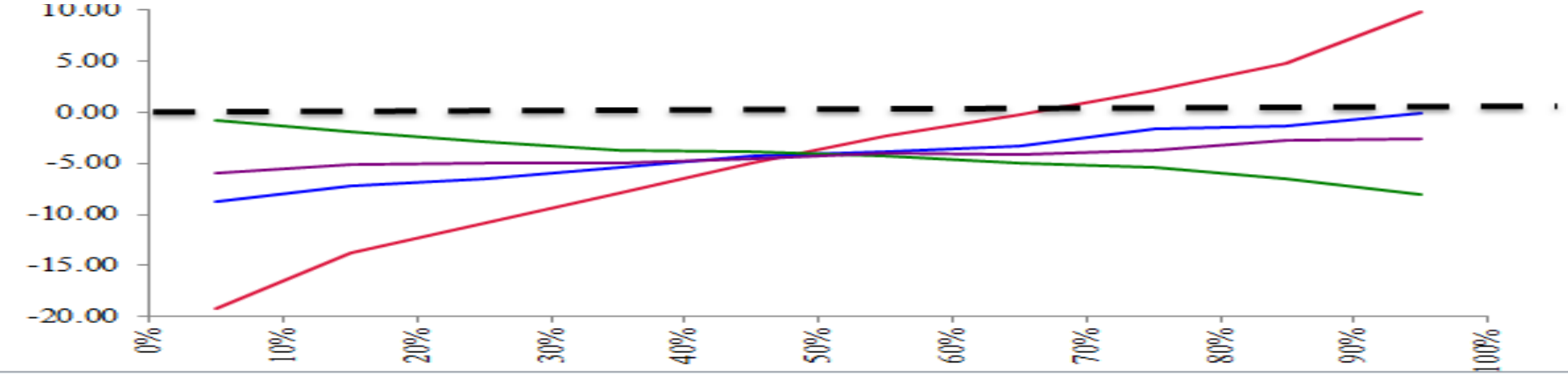
c1


1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

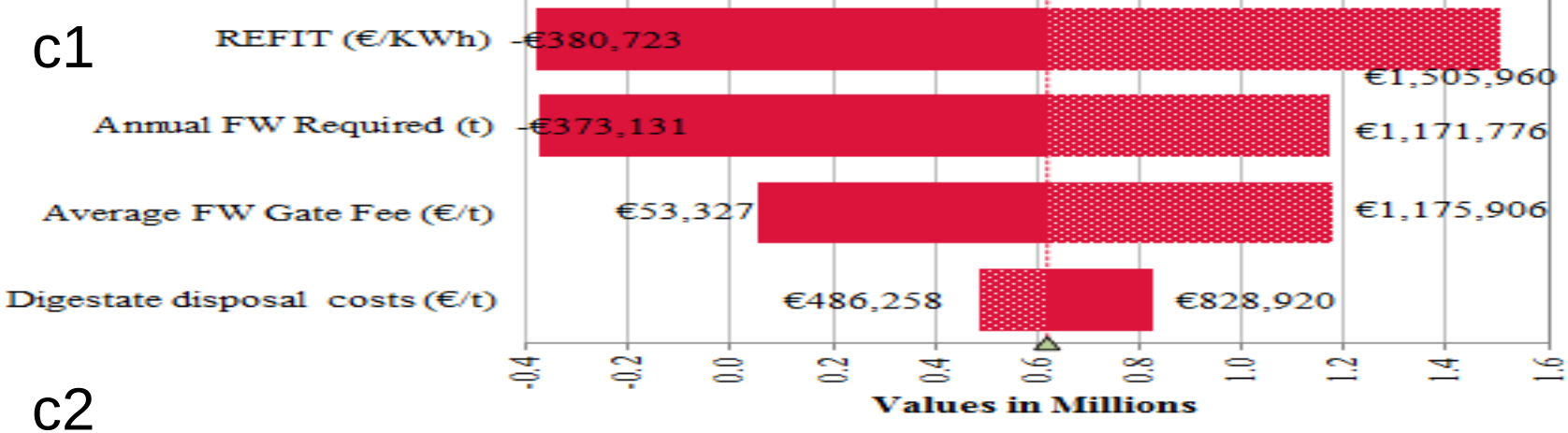
c2


Annual FW Required (t)
REFIT (€/KWh)
Average FW Gate Fee (€/t)
Digestate disposal costs (€/t)
15 Year NPV (Millions €)
10.00
7.50
5.00
2.50
0.00
-2.50
-5.00
-7.50
-10.00
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

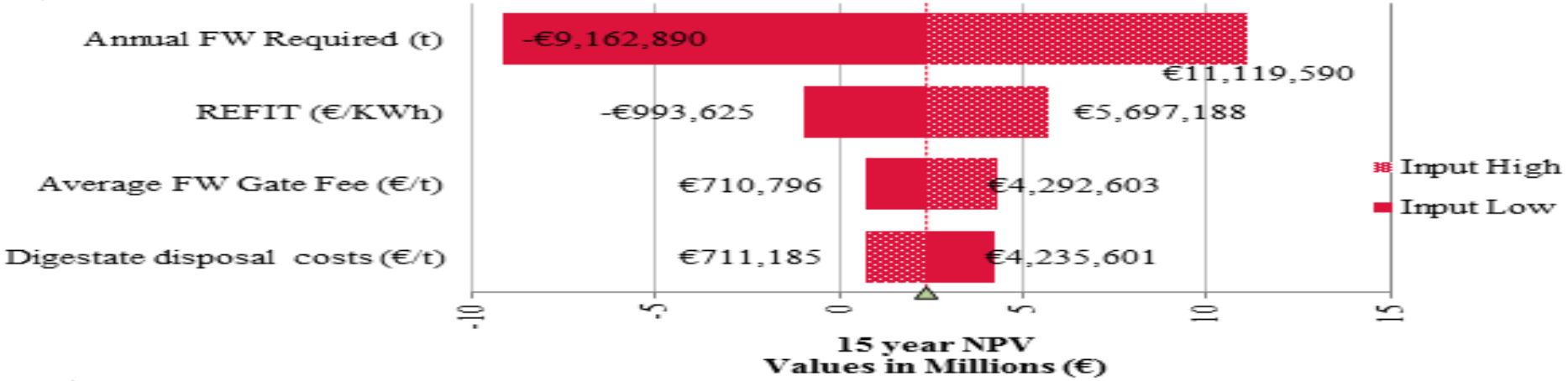
c3


10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

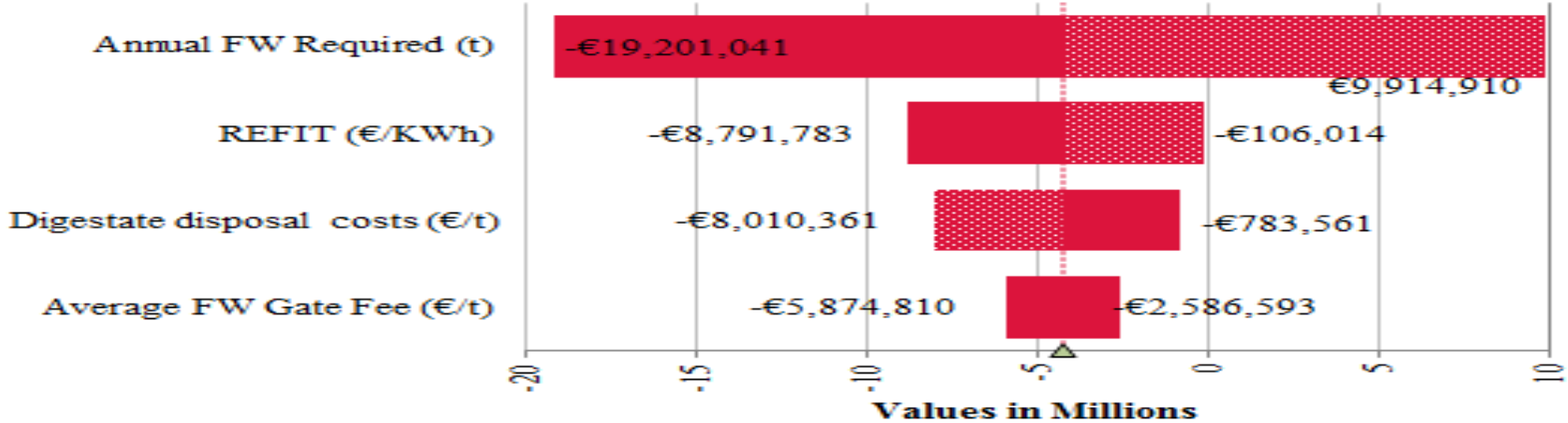
c1


REFIT (€/KWh)
-€380,723
€1,505,960
Anmual FW Required (t)
-€373,131
€1,171,776
Average FW Gate Fee (€/t)
€53,327
€1,175,906
Digestate disposal costs (€/t)
€486,258
€828,920
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Values in Millions

c2


Anmual FW Required (t)
-€9,162,890
€11,119,590
REFIT (€/KWh)
-€993,625
€5,697,188
Average FW Gate Fee (€/t)
€710,796
€4,292,603
Digestate disposal costs (€/t)
€711,185
€4,235,601
Input High
Input Low
-10
-5
0
5
10
15
15 year NPV
Values in Millions (€)

c3


Anmual FW Required (t)
-€19,201,041
€9,914,910
REFIT (€/KWh)
-€8,791,783
-€106,014
Digestate disposal costs (€/t)
-€8,010,361
-€783,561
Average FW Gate Fee (€/t)
-€5,874,810
-€2,586,593
-20
-15
-10
-5
0
5
10
Values in Millions

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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ACKNOWLEDGEMENTS

Funding for this Research was provided by Science Foundation Ireland (Ref: 12/IP/1519)

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