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The potential for co-digestion of food waste on farms

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Why digest on farms?

- Large volumes of animal manure mostly with a low biogas potential
- Manures responsible for a significant contribution to GHG emissions from agriculture
- Digestate is a safer and better organic fertiliser than untreated manure

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What are the barriers?

- Low volumetric biogas production means it is rarely economic to build and operate a digester for manure alone
- Previous uncertainties about regulatory control and costs of permits and exemptions

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Aim of co-digestion

- To improve the volumetric biogas production
- To balance the nutrient composition of the digestate and to compensate for nutrient export from the farm via agricultural products

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Advantages of co-digestion with food waste

- Very high energy content per unit of wet weight
- Can double or triple the volumetric biogas production of a slurry digester without increasing its size or capital cost

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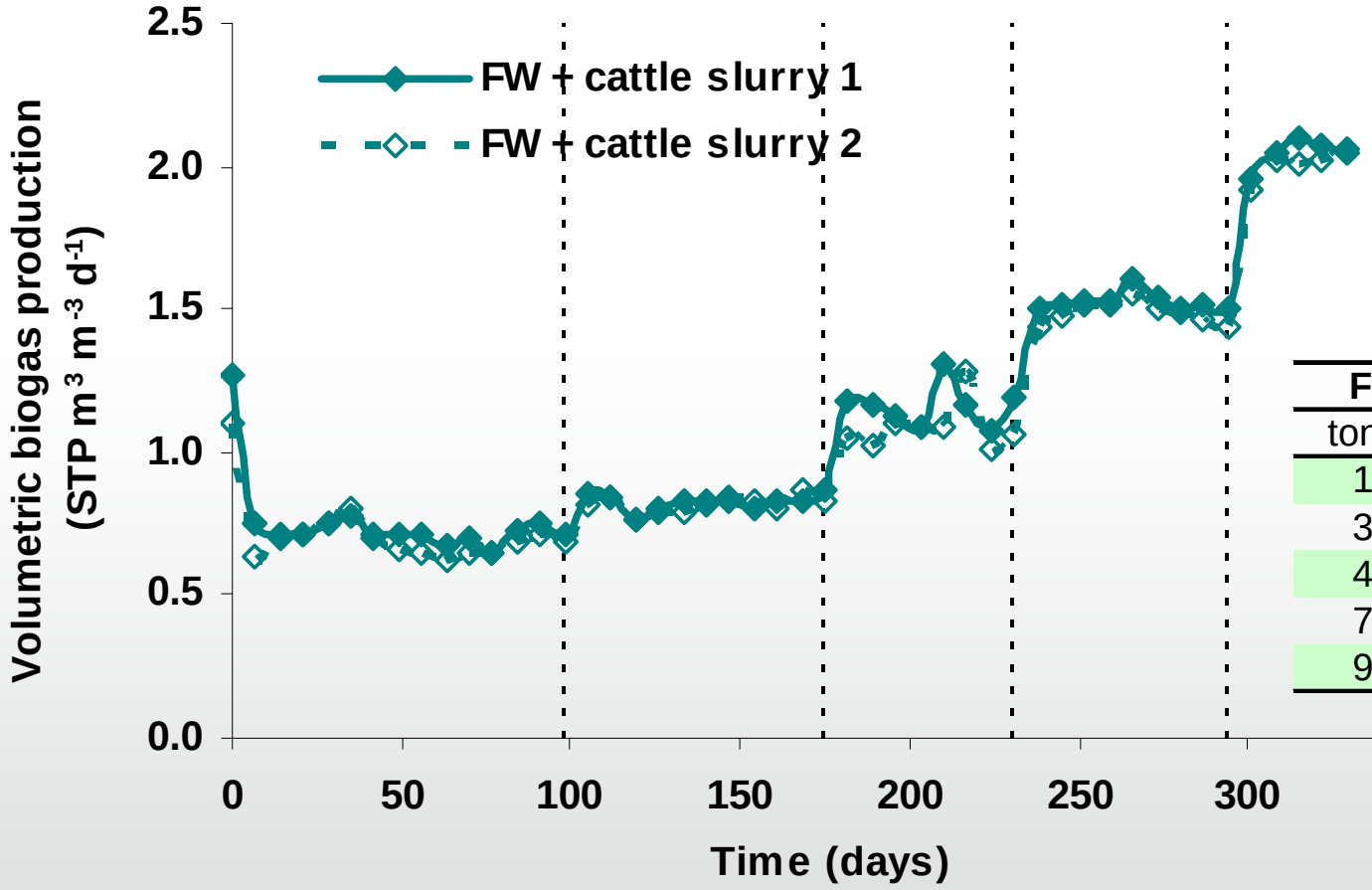
Experimental co-digestion results



FW	CS	HRT
tonnes WW/day		days
1.6	19.4	48
3.2	14.6	56
4.8	21.8	37
7.3	14.6	46
9.7	19.4	34

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Energy yield

CS ratio	m3 biogas/day	kW output
CS only	582	49.8
12.0	743	63.6
4.5	1318	112.8
2.0	2027	173.6

Assumes 35.7 MJ m^{-3} CH_4 and 59.2% CH_4, 35% electrical conversion, 100% operation

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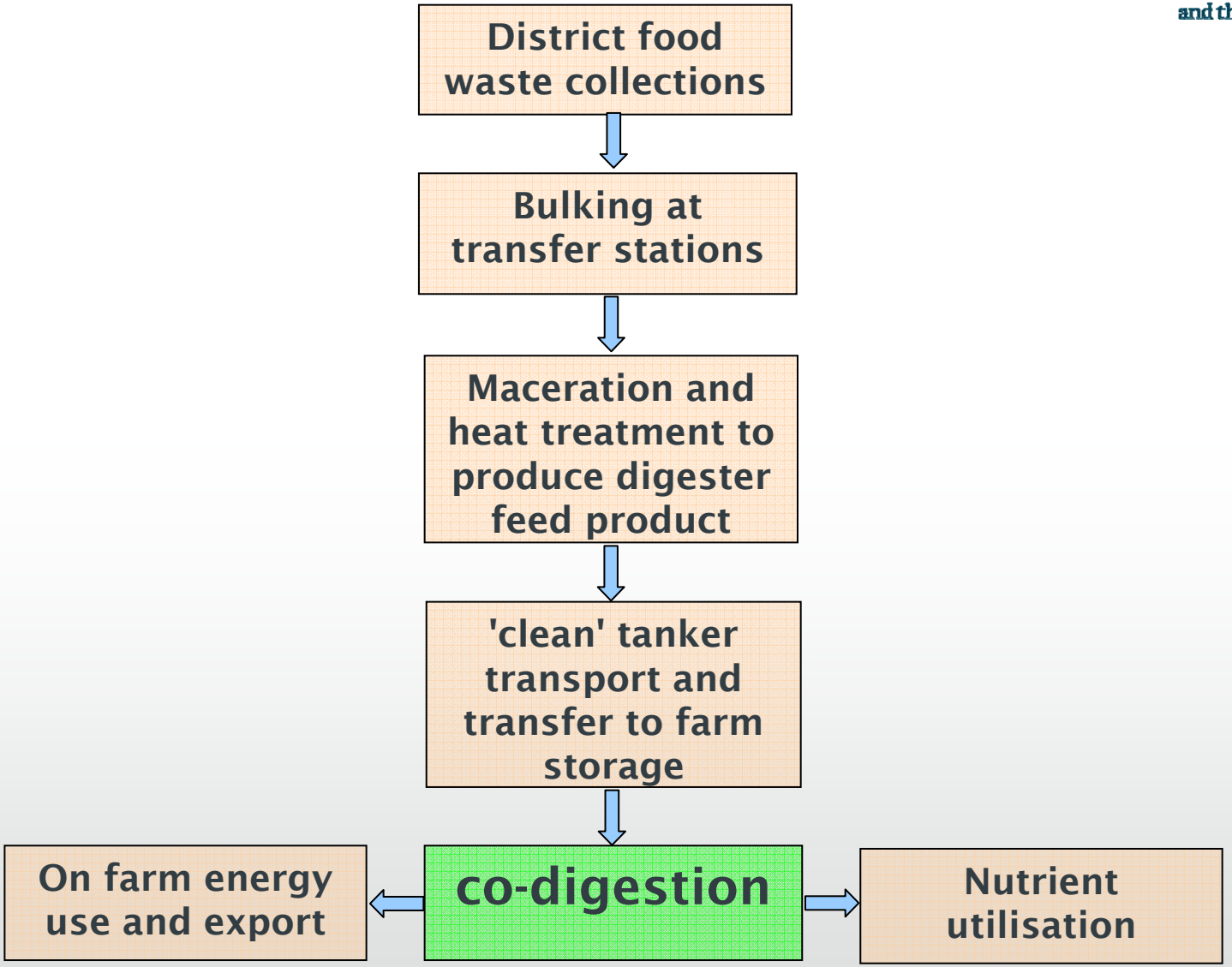
Preliminary model



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Case study for Hampshire

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Food waste generation

- Population
  - 1,720,500 people
  - 703,835 households
- Food waste generation potential
  - 180 kg/household-year (WRAP 2008)
  - 60% coverage
- Tonnage generated 76000 tonnes/year

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Dairy farms

- Total no. of dairy cows = 13273
- Cattle slurry produced = 19.4 m^3/cow-year
- Total cattle slurry = 257946 m^3/year

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Tonnes per year

Food waste	Cattle Slurry	Ratio
76000	257946	3.4

Conclusion: more cattle slurry than is needed for maximum production – but limiting factors (farmers who don't want to participate, cattle grazing outside, etc).

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Farm size

- 34 farms with over 200 cows
- 38 farms with between 100 and 200 cows
- 20 farms with between 70 and 100 cows
  - Average size ~144 cows/farm

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Digester design considerations

- Two sizes of farms
  - 150 cows and 2910 m^3 slurry/year
  - 300 cows and 5820 m^3 slurry/year
- Food waste required
  - 1455 and 2910 tonnes FW/year
  - 28 and 56 m^3/week

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Digester design and costing

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	150 cows	300 cows	Unit
Calculated digester volume	452	904	m3
Nominal volume	500	1000	m3
Food waste storage capacity	30	60	m3
Gas holder	35	35	m3
CHP	90	150	kW
Digester cost	220000	278000	£
CHP cost	138000	146000	£
Total	358000	424000	£

Not included: Slurry reception tank, post-digestion storage, site preparation, grid connection, connection of services – water & power, planning and permitting.

REA feed-in tariff lobbying price for 150 kW output digester £1.1M

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Digester design and costing

Projected income and savings for 300 cow unit

- Actual power output 128 kW
- Electricity sales based on double ROCs ~£170k/year (compared to £49k for CS only)
- Fertiliser savings
- 50% Grant Aid for building digester
- Pay-back period < 2 years or < 5 years based on REA estimate

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Centralised processing

- 76000 tonnes FW/year to process
- 3 sites where waste heat is available within waste hauling network
- 4 runs/day of batch pasteuriser at each site

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Centralised processing

- Stainless steel 30 m^3 pasteuriser and control system £54k
- Gate fee £40/tonne
- Payback period ~3 weeks
- Autoclaving potentially affordable

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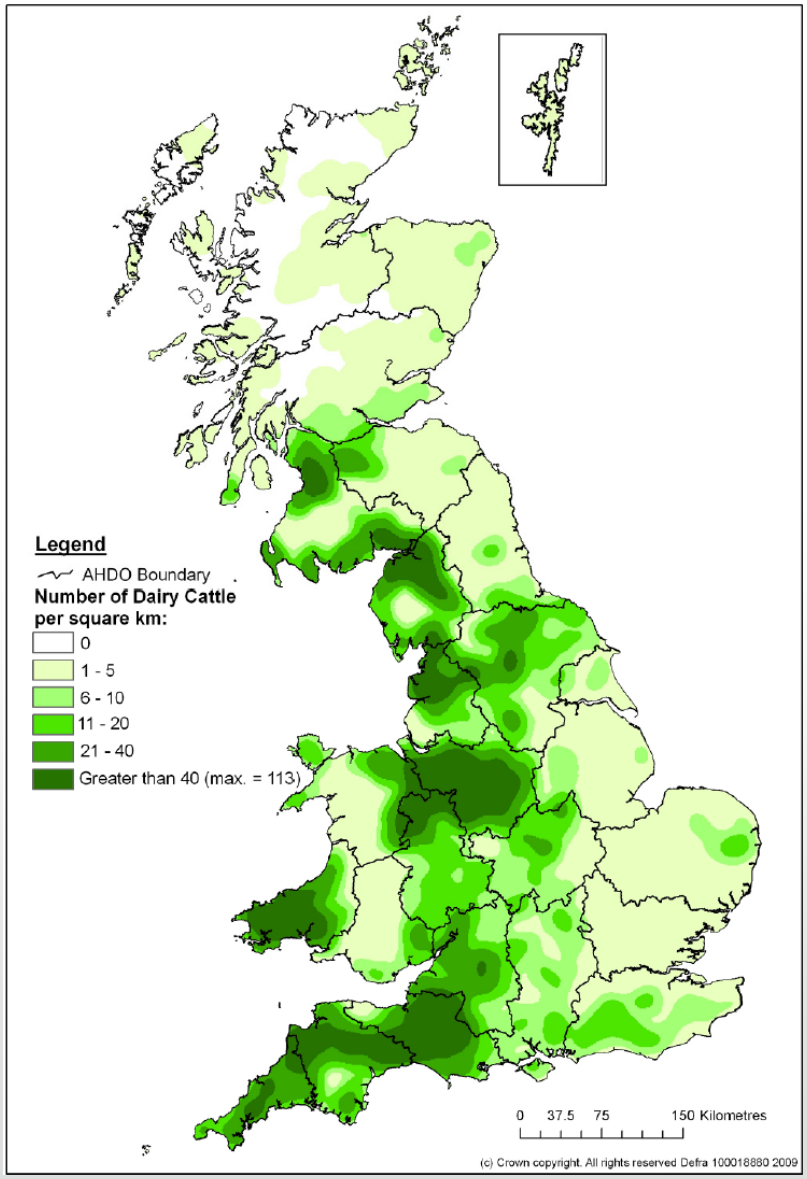
- Hampshire needs 26 x 300-cow dairy farms for its FW, so there are enough big farms without considering intermediate-size farms with 100-200 cows (38 no.)
- Somerset collects 25,000 tonnes FW/ year and would need around 8 x 300-cow dairy farms: it has 107 farms with more than 200 cows.



Fertiliser value

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- With the above FW:CS ratio, the fertiliser value of the digestate could exceed the needs of a typical farm producing crops to feed housed cattle

N (%)	P_2O_5 (%)	K_2O (%)
133	141	116

- If ratio is reduced to 1:4.5 this closely matches typical nutrient requirements (but reduces income from electricity and increases payback period)

N (%)	P_2O_5 (%)	K_2O (%)
97.8	108.1	98

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Annual GHG savings for 300-cow farm with a 2:1 CS:FW mix

- From fertiliser substitution 103 – 4.2 = 98.8 tonnes
- From improved manure management = 494 tonnes
- From fossil fuel substitution assuming UK mixed fossil fuel emissions factors = 581 tonnes
- TOTAL = 1173.8 tonnes

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Issues to be resolved

- Regulatory regime
- Contractual issues
- Operating costs
- Financing

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It is the most sustainable solution

....Go and do it!

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