Assessing, Capturing and Utilising Methane from Expired and Non-operational landfills

An EU LIFE+ project for 2012-2015

Lessons from ACUMEN – Managing Closed Landfills in austere times

Charles Wright

LANDSS Landfill Aftercare Forum, 21st October 2015

LIFE11 ENV/UK/000402

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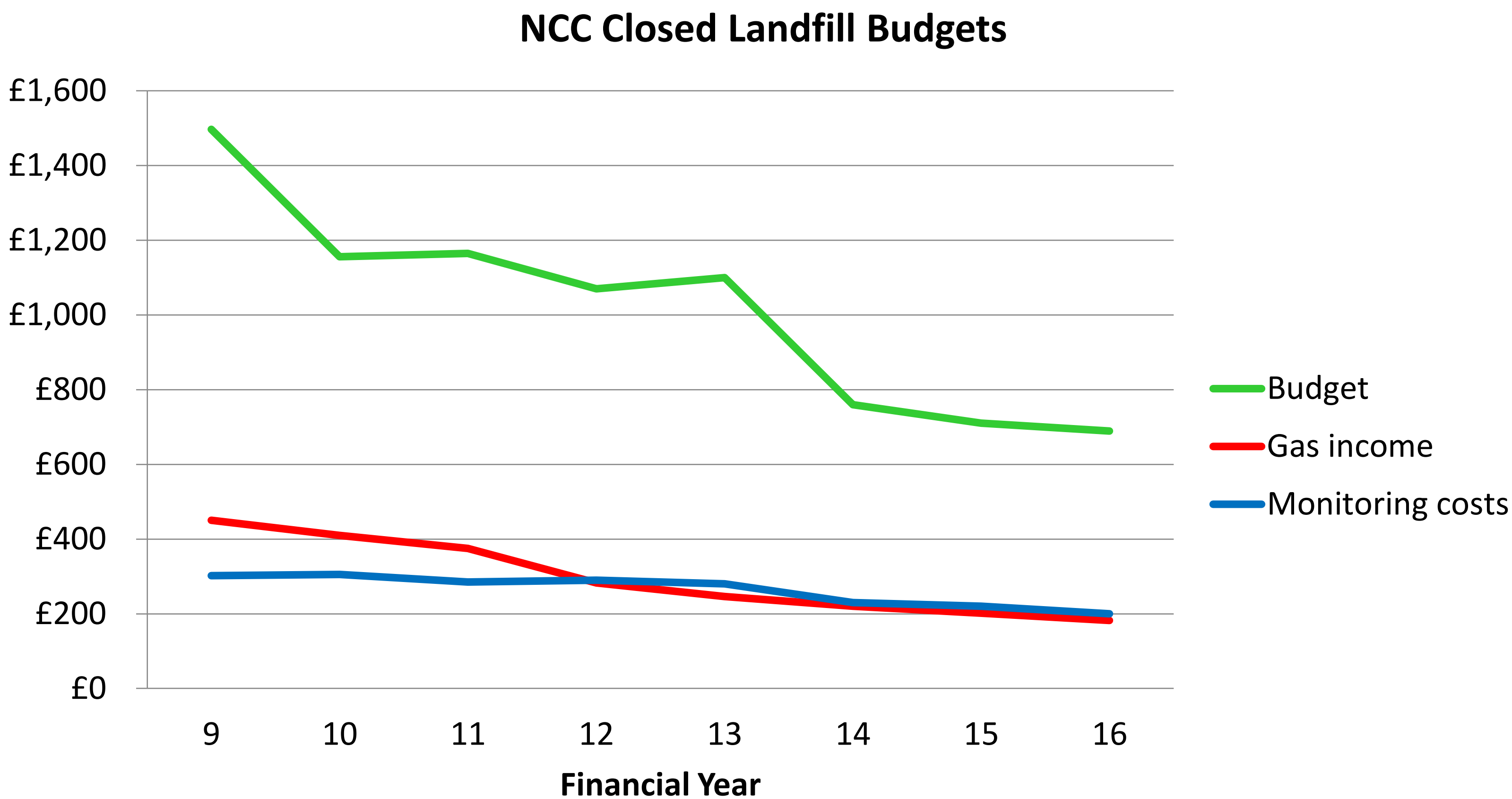
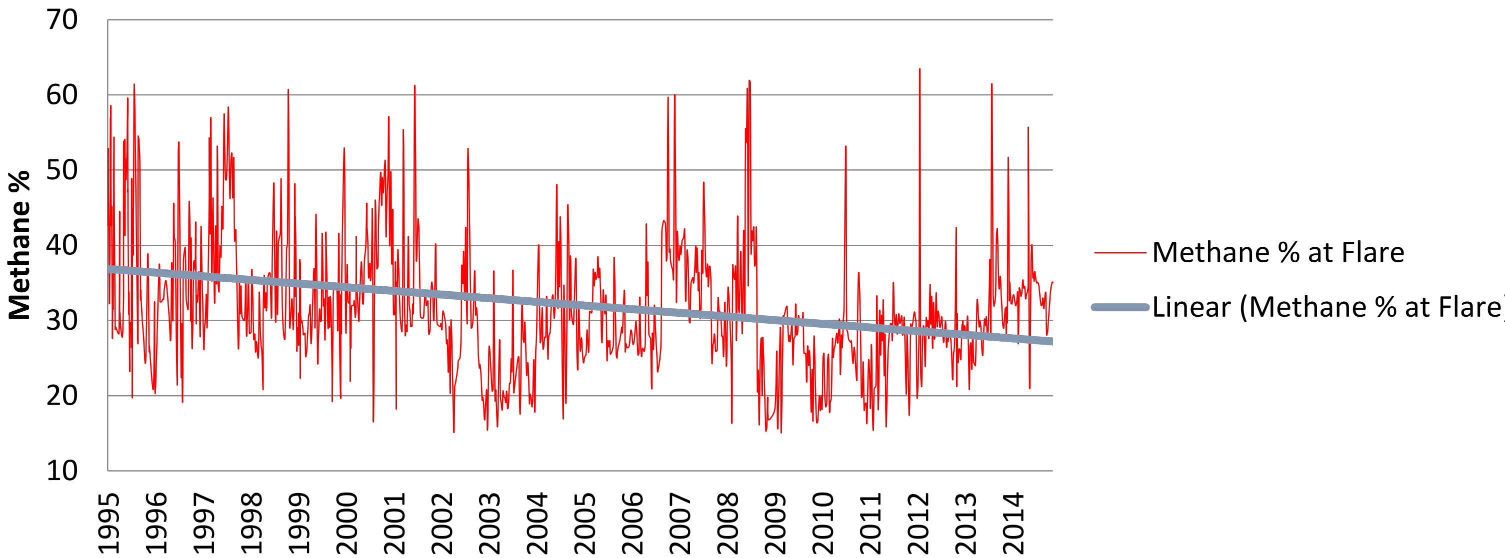
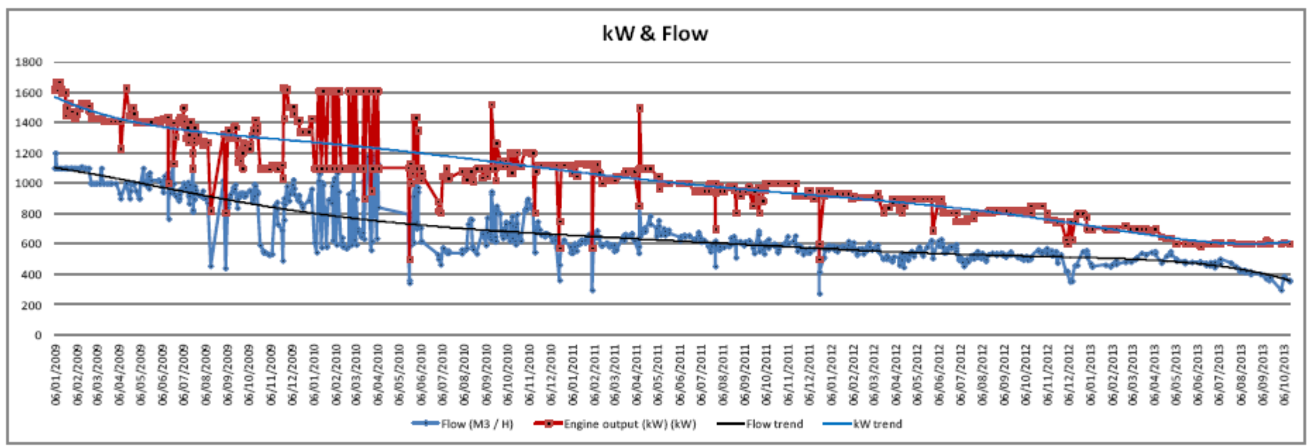

NCC Closed Landfill Budgets
£1,600
£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
9
10
11
12
13
14
15
16
Financial Year
Budget
Gas income
Monitoring costs

Lessons from ACUMEN – Managing closed landfills in austere times





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Why bother?

- Legal requirement
- It can all go horribly wrong!

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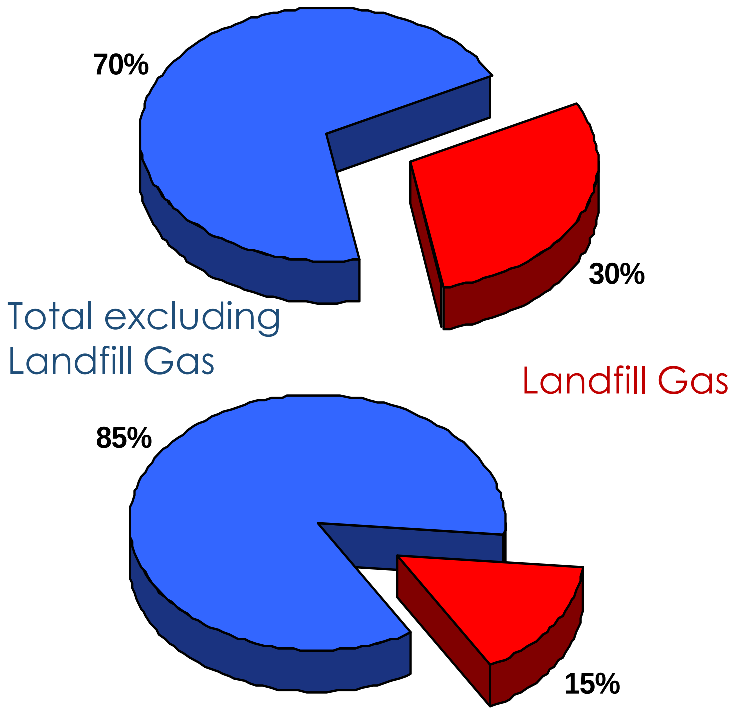
Why bother?

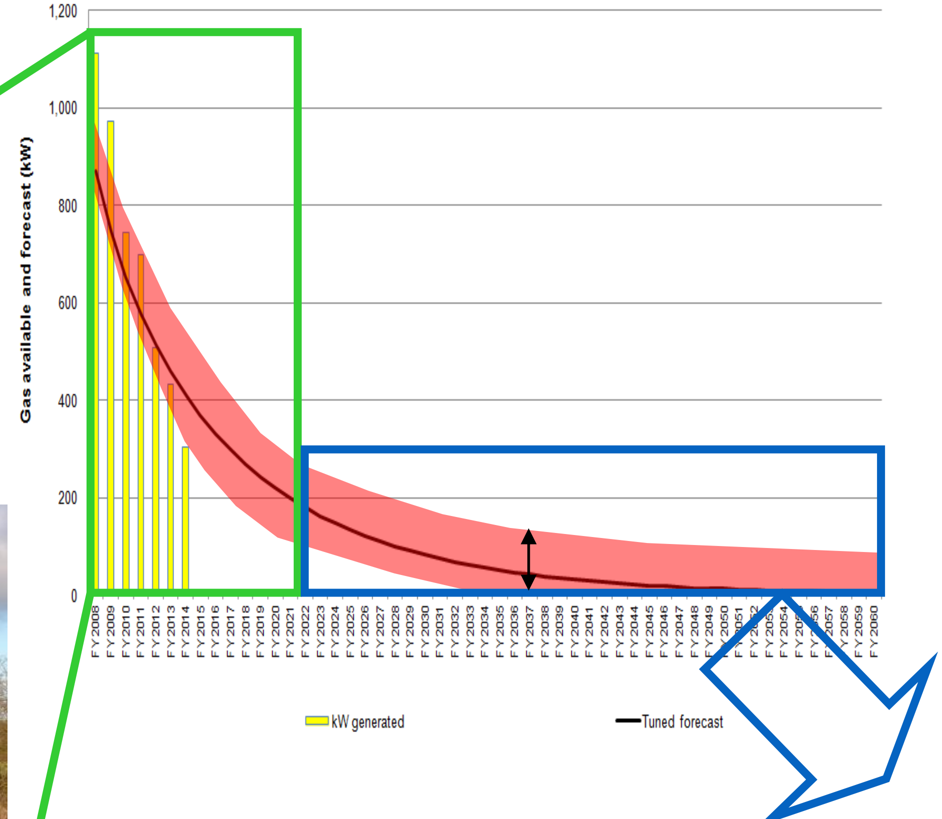
- Climate Change
  - Methane a major greenhouse gas - 25 times GWP of CO_2).
  - 3% of UK greenhouse gas emissions
  - 23,000 Closed Landfills in England and Wales
  - 15% of NCC Carbon emissions 2013/14

Base year 2009/2010



2013/2014

- Gas curve uncertainty



Solution uncertainty ?

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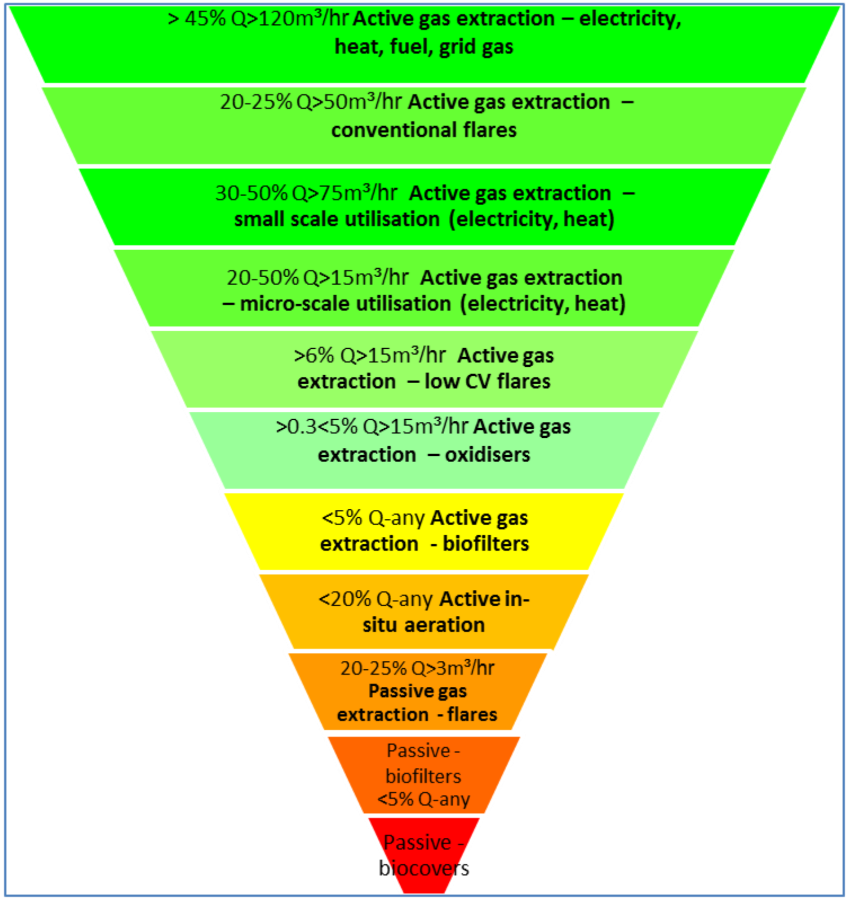
- ACUMEN – solutions:
  - Site characterisation
  - Site audit
  - Reduction of Greenhouse Gas Emissions
  - Multiple technological solutions
  - Improved gas safety
  - Income generation / cost reduction



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- Example site 1:
  - Environmental Permit, mix of containment and D&D
  - Incumbent gas contractor has given notice to leave
  - 120m^{3}h @35-40% CH_4
  - No persistent gas migration
- Solution:
  - Sugden End model
  - Small spark ignition engine ~ 100kW
  - Connection and ROCs
  - PPA
  - Financially viable

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▪Sugden End spark ignition engine emissions

Determinant	Units	Test 14/05/2015	Test 09/06/2015	EA Limit
Exhaust Gas: Temperature Velocity Flow rate (actual)	°C $m\ s^{-1}$ $m^3\ hr^{-1}$	520 25.3 1607	516 25 1596	n/a n/a n/a
Moisture	%	6.8	8.5	n/a
Oxygen	% v/v	5.9	6.8	n/a
Total VOCs (as carbon)	$mg\ m^{-3}$	401	664	1000
NOx (as NO_2)	$mg\ m^{-3}$	655	394	500
CO	$mg\ m^{-3}$	724	697	1400
Engine output	kWe	135	135	n/a
Engine Load	%	90	90	n/a

- Example site 2:
  - No Environmental Permit, D&D
  - No previous gas engine (flare)
  - 45m^{3}h @28-35% CH_4
  - No persistent gas migration

- Solution:
  - Docking model
  - Stirling engine ~ 4*7kW – step down with gas curve
  - Connection to 50kW transformer on site
  - Micro generation = 1.9 ROCs (at present)
  - PPA available
  - Financially viable

- Docking Stirling engine emissions

Determinant	Units	Test 29/09/14	Test 28/10/14	Test 09/12/14	Test 24/02/14	EA Limit
Exhaust Gas: Temperature Velocity Flow rate (actual)	°C $m\ s^{-1}$ m^3hr^{-1}	210.0 9.5 131	233.0 5.6 77	234 5.4 75	146 3.1 43	n/a n/a n/a
Moisture	%	26.8	19.3	19.1	7.7	n/a
Oxygen	% v/v	8.1	6.0	5.8	9.1	n/a
Total VOCs (as carbon)	$mg\ m^{-3}$	545	194	241	53	1000
Oxides of nitrogen (as NO_2)	$mg\ m^{-3}$	46	63	54	127	500
Carbon monoxide	$mg\ m^{-3}$	75	277	197	206	1400
Engine output	kW	7.3	6.95	7.5	7.0	
Engine load	%	81	77	83	78	

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- Example site 3:
  - No Environmental Permit, D&D
  - No previous gas engine (flare)
  - 2 gas lines, migration line 40m^{3}h @10-14% CH_4 main line 20m^{3}h @30-40% CH_4
  - No persistent gas migration
- Solution:
  - Mix of Docking and Strumpshaw or Otterspool model
  - Stirling engine ~ 2*7kW, Biofilter or Low Cal flare
  - Connection to 50kW transformer on site
  - Micro generation = 1.9 ROCs (at present)
  - PPA available
  - Financially viable?

Otterspool Low Calorific flare emissions

Determinant	Units	Test 1 27/03/14	Test 2 27/03/14	Test 3 01/05/14	Test 4 01/05/14	Test 5 02/05/14	Test 6 08/07/15	EA Limit
Moisture	%	7.1	8.5	2.3	3.4	6.4	5.9	n/a
O_2	% v/v	10.48	6.8	16.45	5.94	7.97	14.11	n/a
Temperature	°C	922	975	504	894	884	758	1000
VOC (as C)	mg m^{-3}	2.1	0.2	4.9	0.0	1.8	1.8	10
NOx (as NO_2)	mg m^{-3}	33.6	49.4	66.7	12.3	32.4	16.4	150
CO	mg m^{-3}	75.6	20.5	49.8	13.5	21.0	20.3	50
Gas flow rate	m^{3}hr^{-1}	240	240	40	252	164	50	n/a
CH_4	%	24.6	24.6	22.0	8.0	14.0	11.0	n/a

Strumpshaw biofilter design

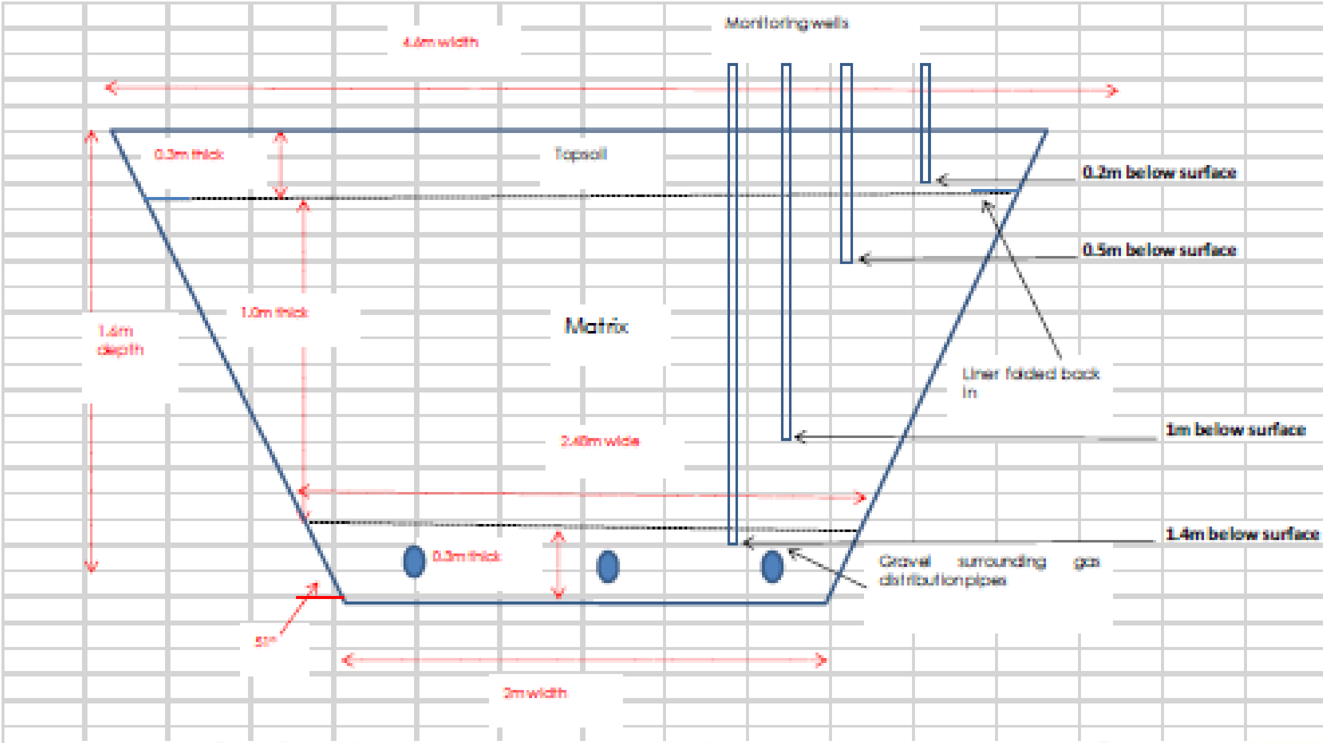

Figure 1 Diagram of biofilter monitoring locations

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Strumpshaw biofilter emissions

Determinant	Units	In-depth probe	Surface emission tests	Flux sheet
Inlet Methane Concentration	[% vol]	0.3 – 43		
Gas Flow Rate	[m^3h^{-1}]	25 – 90		
Methane removal efficiency	[%]	11 – 90	75	73%
Average methane removal efficiency	[%]	51% (median 58%)		

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- Business case to invest in generation?
  - In UK micro generation below 50kW export is 1.9 ROCs eligible.
  - Including other subsidies – 3.5 times higher sale price than wholesale price.
- Other considerations
  - Capital
  - Infrastructure improvements
  - Maintenance and servicing
  - Costs saved – electricity used, servicing old equipment
  - Risk – few contractors/investors currently interested!
  - Risk – few proven manufacturers

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- Investment options:
  - Borrow against Public Works Loan Board – O&M contract
  - Joint venture with tech provider/investor
  - Contract out.

	Direct investment	Joint Venture	Contract Out
Pros	Highest income Keep control	Some income	Lowest risk No costs
Cons	Highest risk Continued site costs	Shared risk	Little income

- The Future?
  - Full life solutions
  - Cost effective and cost offset
  - Reducing technology costs?
  - A new industry?
  - Loss of subsidies – death of a new industry?