Anaerobic Digestion

First steps in Developing an on farm AD project

Tom Knitter

SEI - Renewable Energy Information Office

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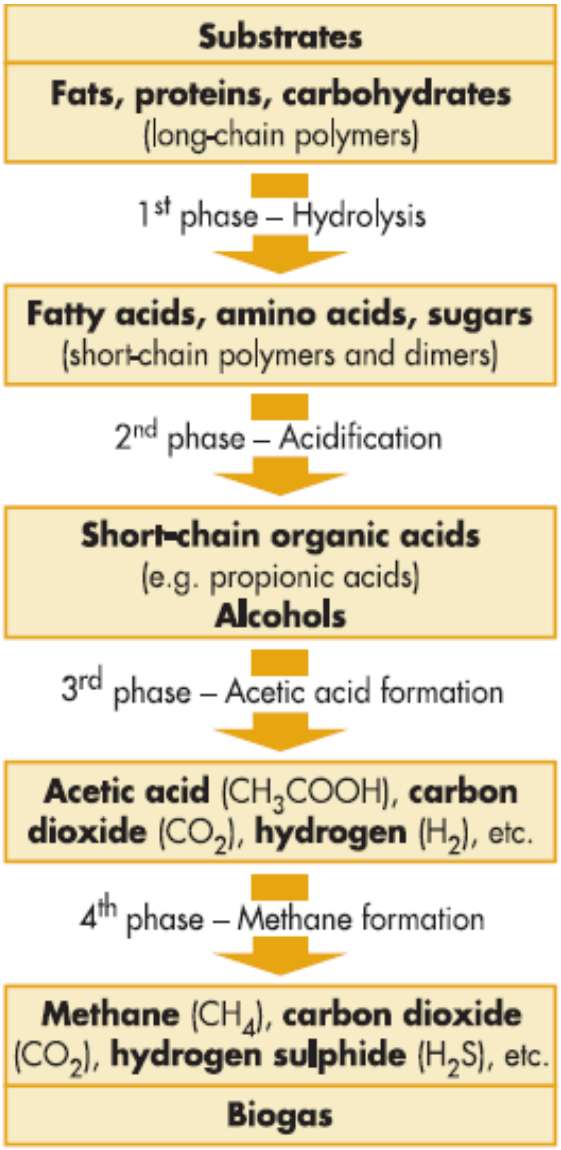
SEI REIO - Background

- **Created in 1995, based in Clonakilty, West Cork**
- **Established to promote the use of renewable resources and provide *independent* information and advice on the financial, social and technical issues relating to renewable energy development.**

Outline

- Introduction
- Developing an AD facility
  - First steps to consider, Example plant design
  - My experience operating plants, technique
- SEI's grant Aid and provided Information

Biology



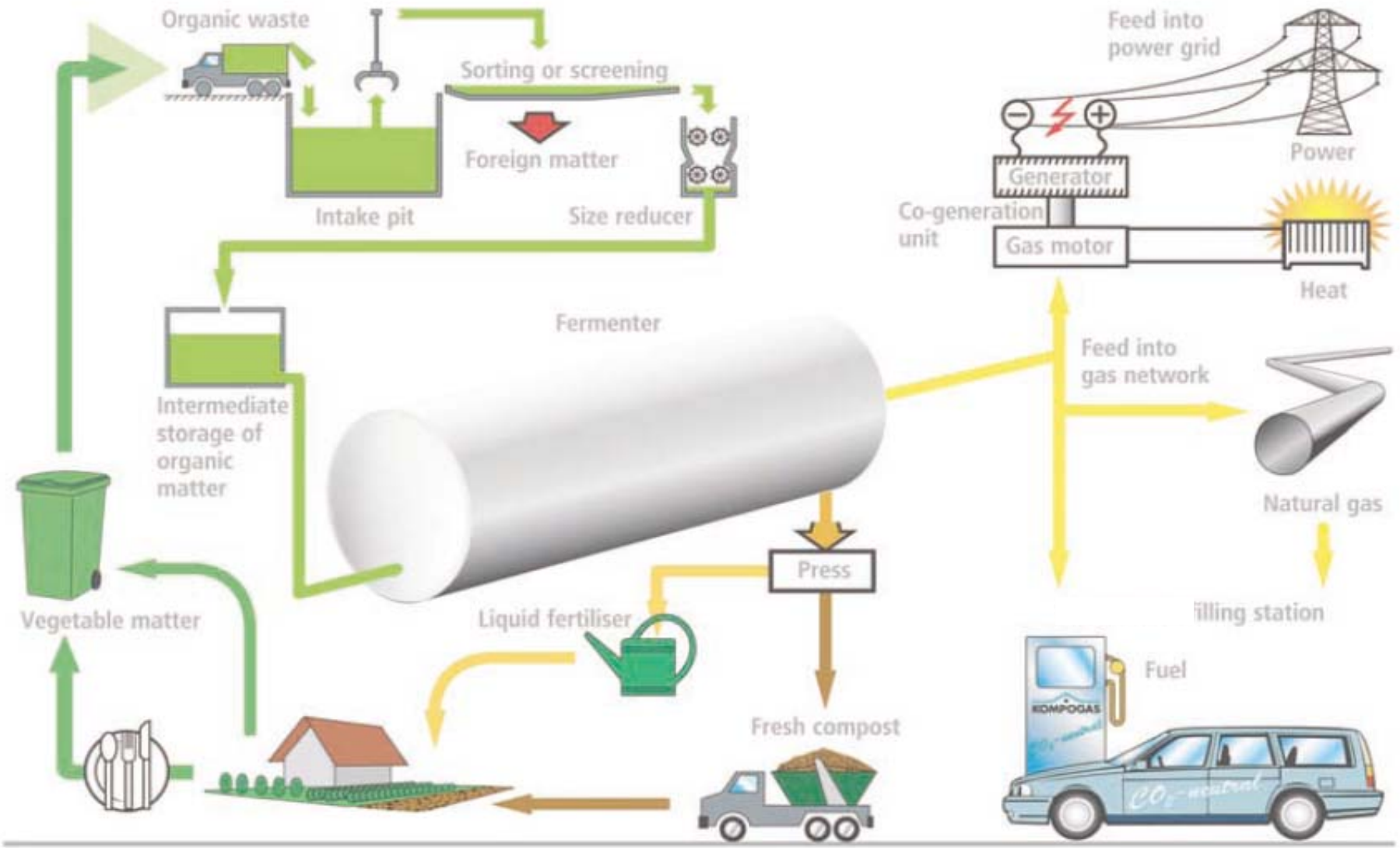
- **4 digestion steps by different enzymes and bacteria without oxygen**
- **End product: biogas, digestate**

Component	Chemical symbol	Concentration
Methane	CH4	50 - 75 % - vol.
Carbon dioxide	CO2	25 - 45 % - vol.
Water vapour	H2O	2 - 7 % - vol.
Oxygen	O2	< 2 % - vol.
Nitrogen	N2	< 2 % - vol.
Ammonia	NH3	< 1 % - vol.
Hydrogen	H2	< 1 % - vol.
Hydrogen sulphide	H2S	20 – 20.000 ppm

[ppm: Parts per million; % - vol.: volumetric percentage]

Source: FNR

Biogas – an Energy all-rounder



Source: IEA

Developing an AD plant

?...!

Developing a project is a long process!

Operating the plant:

- **What is my motivation for installing/operating a plant?**
- **Who is operating the plant (24/7 supervision necessary)?**

Developing an AD plant Feedstock

1. Feedstock

- **Availability and amount:**
  - What do I have, how much can I get?
  - stable amount over next months, year(s)?
- **Gate fee / price**
  - Stable for the next years? Costs calculated realistically
- **Regulations**
  - **Waste permission, DAFF (ABP), nutrient management plan of digestate**
- **Quality**
  - **gas yield / specific gas production, dry matter, organic dry matter**
  - **operating a plant viably depends highly income / costs**

→ **Sizing CHP unit**

→ **Sizing the plant and components / technique**

Input / gas production

	Dry solids	organic dry solids (data can vary)	gas-production per t fresh material	kWh / tonne input material	kW per t input material and Day
	% of Fresh material	% of DM	m3/t fresh material	kWh / t	kW/t FM d
Food waste	20.0	85	110	**225**	9.4
Cattle-dung	25.0	80	70	**143**	6.0
Cattle-slurry	8.0	80	20	**41**	1.7
Cereals / grains	85.0	95	541	**1105**	46.0
Chaff	85.0	90	360	**547**	30.0
Chicken litter / dung	40.0	75	126	**257**	10.7
Fat	95.0	87	827	**1687**	70.3
Glycerine*	100.0	95	713	**1200**	60.6
Old bread	65.0	95	432	**883**	36.8
Pig slurry	4.5	80	12	**24**	1.0
Residuals from vegetables	20.0	80	72	**147**	6.1
Sewage sludge	12.0	80	47	**96**	4.0

35 % electrical efficiency CHP, 21 MJ / m3, 55 % Methane content, 3,6 MJ / kWh

This table only intended to provide indicative results. All values are approximate and can vary extremely. Gas yields depend highly on dry matter content, storage feedstock, handling feedstock. For an exact calculation, feedstock testing is definitely necessary.

Indication Sizing an AD plant

- **2 basic main parameters:**
  - **Retention Time**: 35 d (slurry) – 100 d (energy crops)
  - feedstock remains in main digester(s)
    - Volume digester divided by input per day
      - 30 t Slurry/day (app. 50 kW), RT 40 days = 1200 m3
  - **Organic Loading Rate**: < 4.0 - 4.5 kg oDM/m3/d
    - How much organic dry matter (oDM) added per m3 per d
    - Overload system/technique/biology

$$\text{OLR (kg oDM/(m3 d)} = \frac{\text{Organic dry material added daily (kg oDM/d)}}{\text{Net volume digester (m3)}}$$

  - 30 t/d x 0.10 oDM/t = 3000 kg/1200 m3 = 2.5 kg/m3d
  - **RT and OLR depending on feedstock and plant system!**

Example feedstock

Feedstock per day	Power kW per day
20 t cattle slurry	30 kW
2 t dung	15 kW
2 t chaff	60 kW
2 t food waste	20 kW
1 t glycerin	50 kW
27 t/d	**175 kW**
10.000 t/a	

Example plant design

Design:

- 1 x digester 1200 m3net (RT = 45 d; OLR = app. 3 kg oDM/m3d),
- 1 x 185 kWe CHP (6 cylinder gas Otto, 210 kW th, incl. h.ex. and gas cleaning system)
- 2 x agitators (incl. FC)
- 2 - 3 x pump(s)
- 1 x feeding 6 m3 system
- reception area, mixing tank, disinfection unit
- existing storage tank (covered)

Production at 8200 hr/a:

1.45 Mio kWh el/a

1.70 Mio kWh th/a

energy for app. 350 households/a

Developing an AD plant Location

2. Location of plant

- **Plant integration in existing farm-network-infrastructure**
- **Possible location of plant**
  - **Heat demand, heat usage**
  - **what is situated nearby?**
- **Grid connection, distance**

3. Starting Planning (extract)

- **Get in contact with local authorities**
  - **Planners / planning section**
  - **Environmental section**
  - **Agricultural office / DAFF**
    - Which planning regulations/legislation?
      - Regulated by local authority (planning permission)
    - What is the content of this permission/legislation?
- **public consultation**
  - **neighbours**

Developing an AD plant

4. Consultant, Supplier, developer of feasibility study, plant components, plant design

- Experience, track record, reputation (financing!)
- Similar/same reference-plants … get in contact…
  - how well were these performing during the last years?
- Suitable equipment and design for feedstock (changing!)
- Compare supplier/developer
  - Price, Recommended plant design/dimension
    - OLR, RT, digesters
  - Trainings
  - Warranty, after sales, maintenance
  - Find out Operating costs!
- Feasibility/financial projection

Developing an AD plant

5. Financial projection

- availability of the plant (7500 - 8200 hr/a)
  - If not, oversized or too small

- What is my income?
- What are my costs?
  - Investment (3500 – 6000 Euro/kW)
- Comparing income and cost in ct/kWh
  - Analyzing income/cost

Financial projection

- **Income:**
  - Selling electricity (REFIT) and heat
  - Fertilizer value/selling fertilizer
  - Gate fee (?)
  - Grants
- **Running Cost, extract:**
  - Loan, interest (investment), Insurance
  - Maintenance/repair/spare parts plant components/CHP
  - Management/Administration
  - …

Analyze scenarios!

What if…?

Developing an AD plant Summary

1. **Feedstock (amount, quality, Gas prod.)**
   Sizing plant and CHP, design
2. **Location of plant**
3. **Planning**
   Local authorities
4. **Plant design, consultant / supplier**
   Feasibility study
5. **Financial projection**
   income/cost analyzing

⇨ **Developing steps take place at the same time**

⇨ **Calculate everything realistically!**

⇨ **Miscalculation could be fatal!**

Checklist on website:
http://www.sei.ie/Renewables/Bioenergy/Anaerobic_Digestion

Technical requirements

- **Main Components:**
  - Sorting / screening systems (organic waste)
  - Digester
  - Mixer / agitator
  - Pumps
  - Feeding systems for solid biomass
  - Combined Heat and Power (CHP)

- **Components must be suitable for feedstock!**

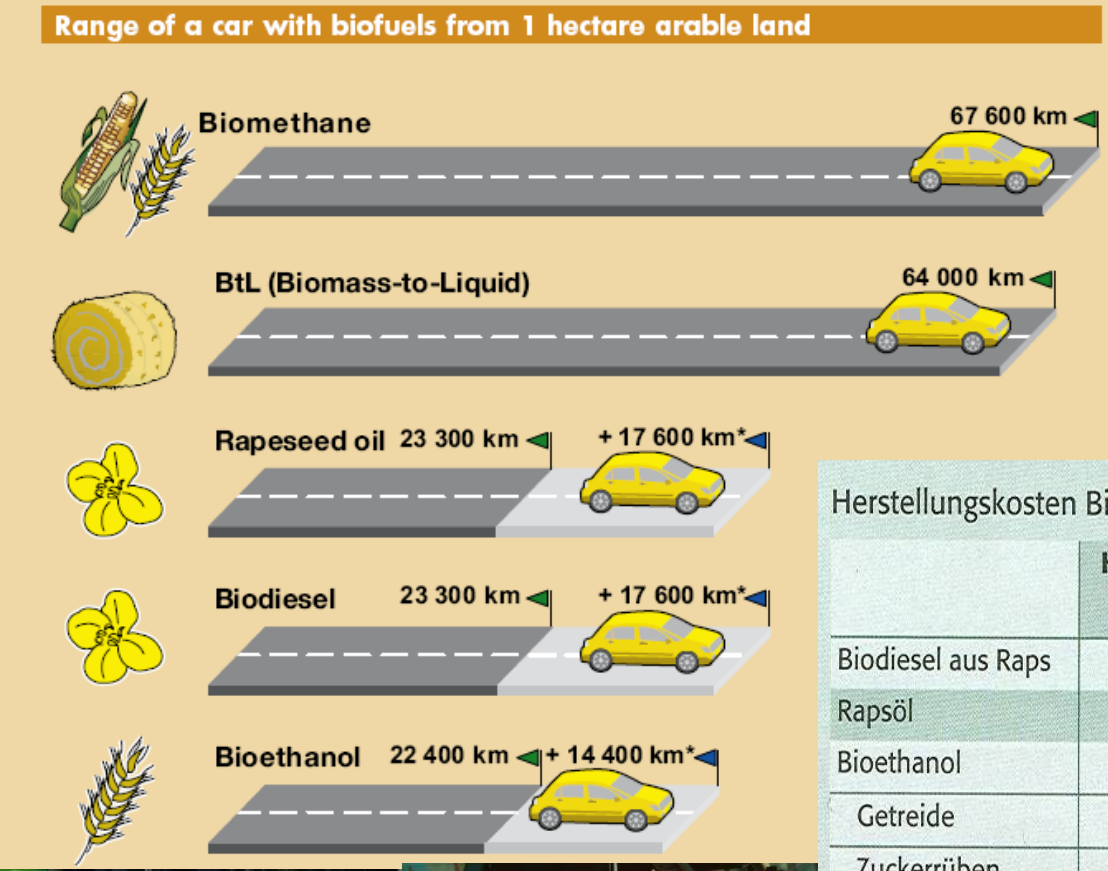
Upgrading Biogas

- **Upgrading to Biomethane**
  - CH4 content from 50-60% to > 95% (natural gas)
- **Utilization**
  - Injection gas-grid
  - Using as a vehicle fuel (natural gas engine)
- **According IEA upgrading Biogas in early commercial stage**
- **High amount of feedstock necessary**

Source Schmack Biogas AG, Haase

Vehicle fuel and production costs

Source: FNR, Meo Consulting



Herstellungskosten Biokraftstoffe

Production costs liquid biofuels

	Herstellungskosten (Euro/l)	Kraftstoff-äquivalente (Euro/l)	Herstellungskosten (Euro/GJ)
Biodiesel aus Raps	0,63	0,69	19,03
Rapsöl	0,49	0,51	14,17
Bioethanol			
Getreide	0,47	0,72	21,97
Zuckerrüben	0,57	0,88	27,00
Zuckerrohr (BRA)	0,22	0,34	10,39
Lignocellulose	0,64	0,98	30,00
BtL	1,00	1,03	29,90
Biomethan (Biogas)	1,04*	0,74	20,83

Quelle: meó Consulting Team

* (Euro/kg)

Grant programme Biomass CHP / AD_CHP

- **Launched January 2008, Duration End of 2010**
- **Indicative Budget of €5-8m, Biomass CHP, AD CHP**
- **Grant support:**
  - Grant support of up to 40% of the Feasibility study (CHP programme)
  - Grant of up to 30% of eligible costs/Investment costs
  - Cost cap on eligible costs defined in programme
  - Indicative grant cap per project → €1.5 million

Biomass CHP/AD_CHP

- **Eligible projects' characteristics (extract):**
  - New biomass CHP/AD_CHP installed in RoI
  - Primary energy savings (PES)
    - For <1 MWe → PES >0%
    - For ≥1MWe → PES >10%
  - High efficiency CHP complying with EU CHP Directive 2004/8/EC
- **Eligible costs (extract):**
  - Equipment (e.g. prime mover, fuel supply, processing and storage)
  - Mechanical/electrical connections of plant items
  - Specified building and civil engineering work

AD information

- **Application guide / form grant**
  - **Biomass CHP / AD_CHP: www.sei.ie/bio_chpgrants**
  - **CHP Feasibility Study: www.sei.ie/Grants/CHP/**

- **Provided AD Information**
  - **Calculator**
    - Input/feedstock, typical gas yields
    - Calculating main operating parameter, gas yields, kWh el. th.
      - Retention time, organic loading rate
  - **Literature f. ex. updated English-Handbook**
  - **Checklist developing a project**
  - **Guide Connection to the grid**
  - **Information Animal By products**

http://www.sei.ie/Renewables/Bioenergy/Anaerobic_Digestion

Contact

Thank you

Tom Knitter
SEI - Renewable Energy Information Office
Unit A, West Cork Technology Park, Clonakilty
tom.knitter@reio.ie
023-88 63237
087-68 27 688