Methane to Markets

Lesson 2b: Modeling Landfill Biogas Generation

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Gas Models

- Why model Landfill Biogas
  - Preliminary estimate of methane and energy production
  - Estimate of environmental emissions
  - Initial project capacity and costs
  - Provide a benchmark for project performance
- What a model does not do
  - Guarantee the amount of biogas
  - Guarantee that you can collect all the biogas

The familiar equation

Basic Gas model;

Annual Gas Production = $L_0 .M.(1- e^{-k})$

where:

- k = reaction rate constant ($Ln(2)/t_{1/2}$)
- L_0 = methane generation potential (m3/tonne)
- M = mass of degradable waste available

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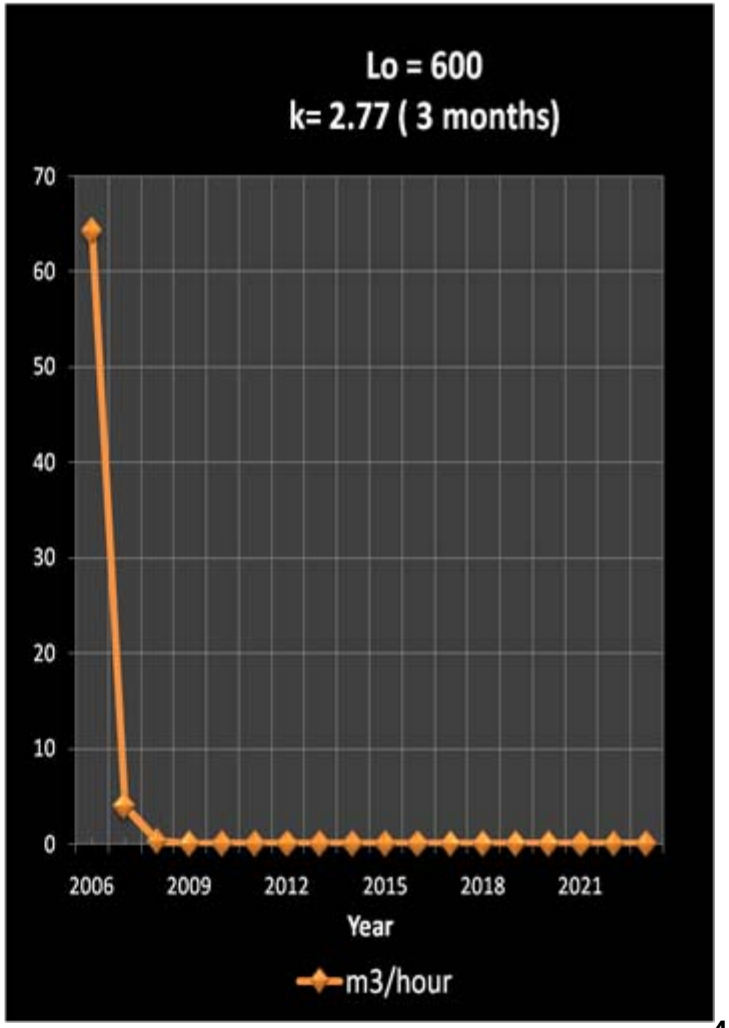
Exploring the variable - L_o

- Example
  - Perfectly degradable organic substrate
  - Perfect digester
  - Ideal conditions
- L_o = around 600m^3 / tonne Biogas
- Complete degradation in 3 months



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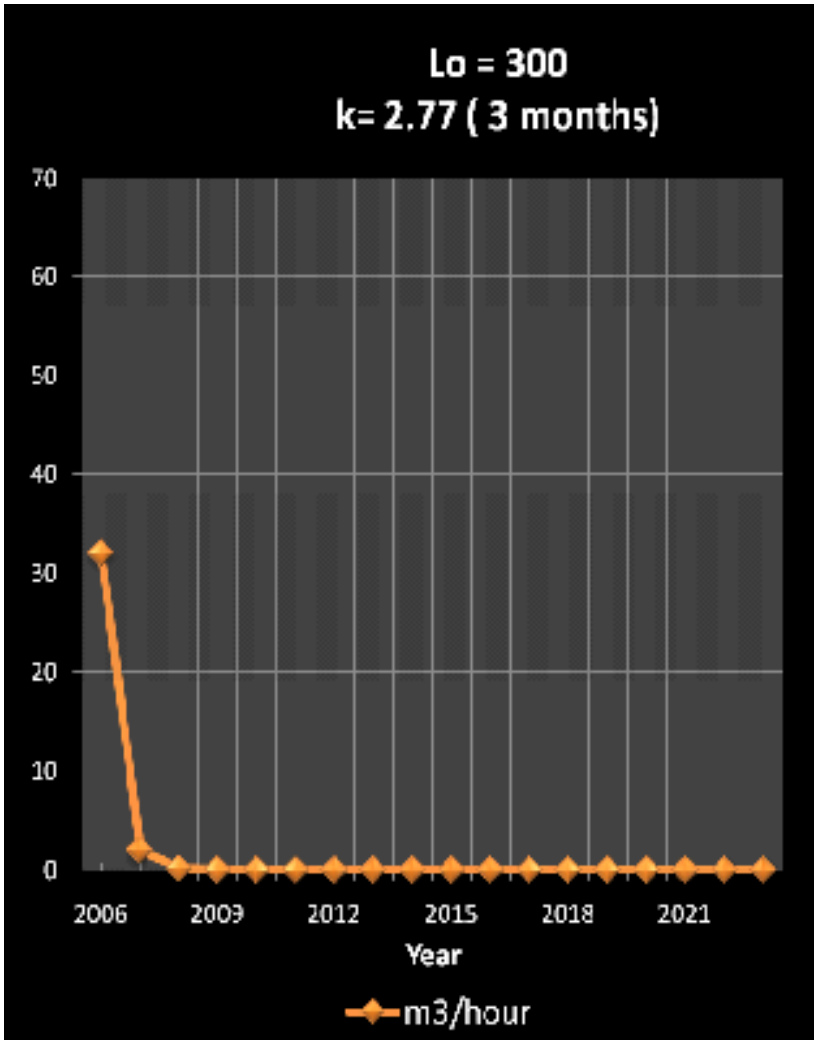
Exploring the variable - L_o

- But waste is not 100% degradable
- L_0 maybe 300m^3/tonne



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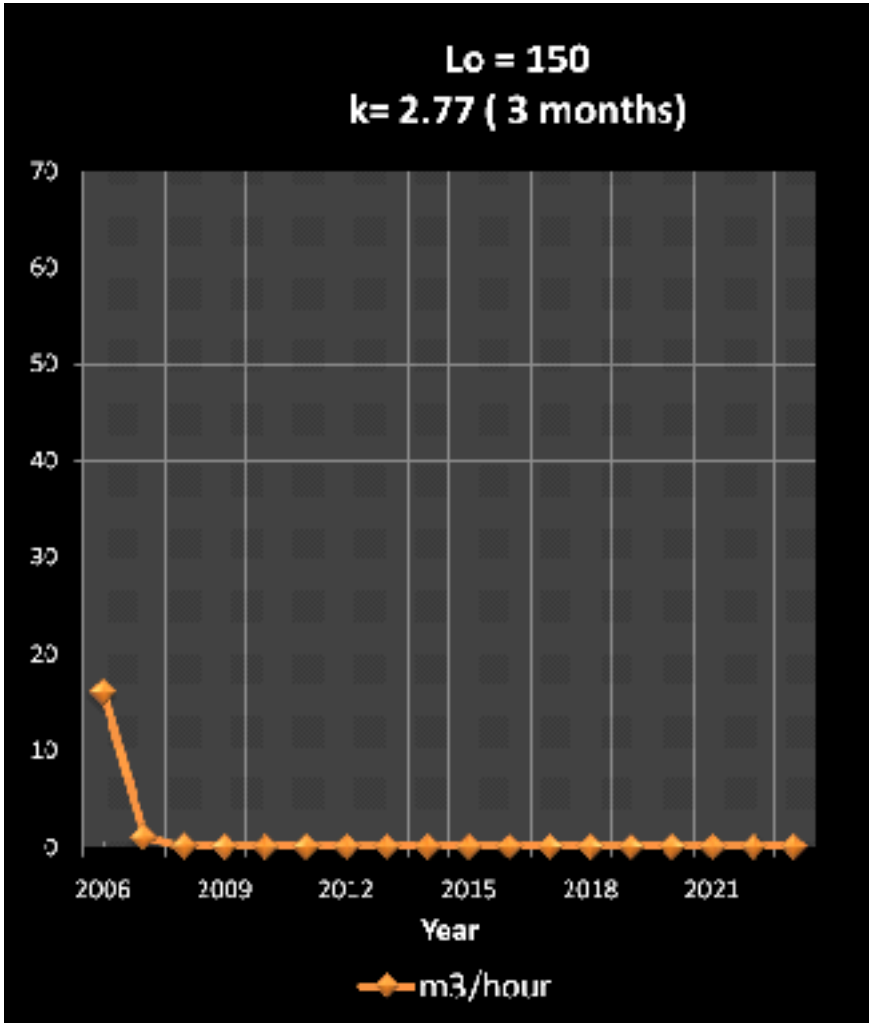
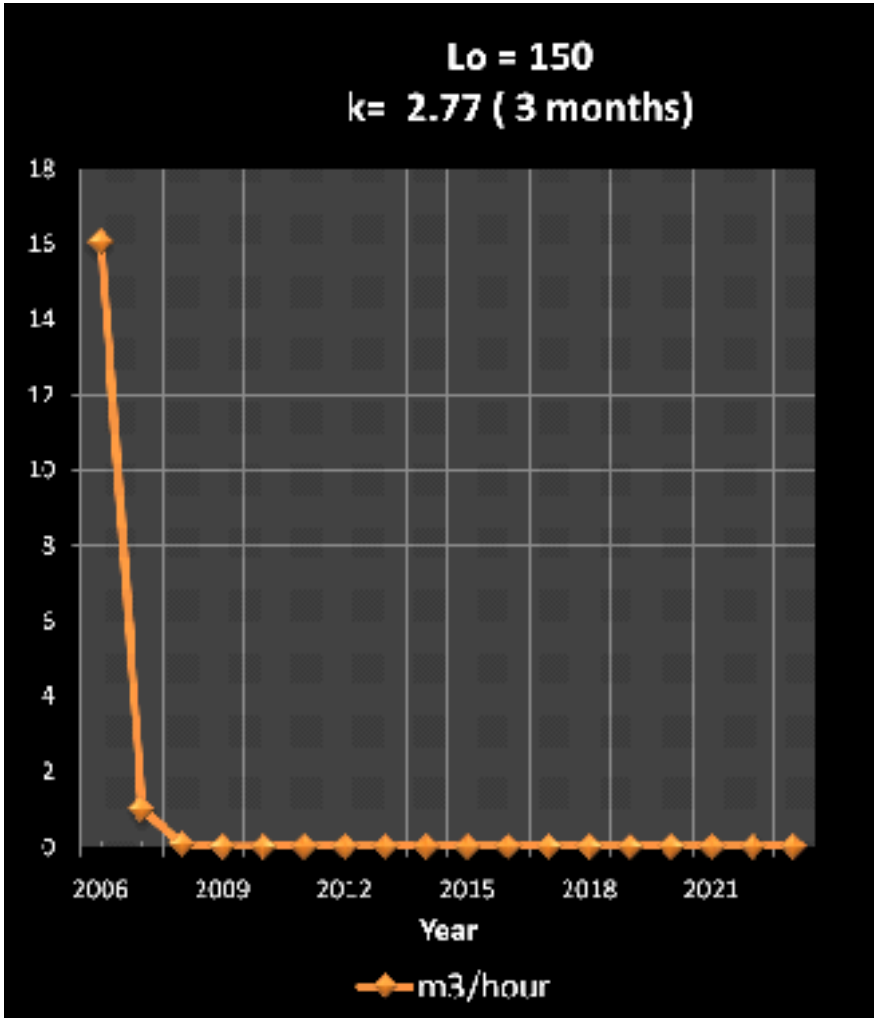
Exploring the variable - L_o

- But not all the organic material degrades
  - Particle size too big
- Acid conditions
  - Isolated from bacteria
  - Chemical inhibitors
- Perhaps L_0 should be 150m^3/tonne



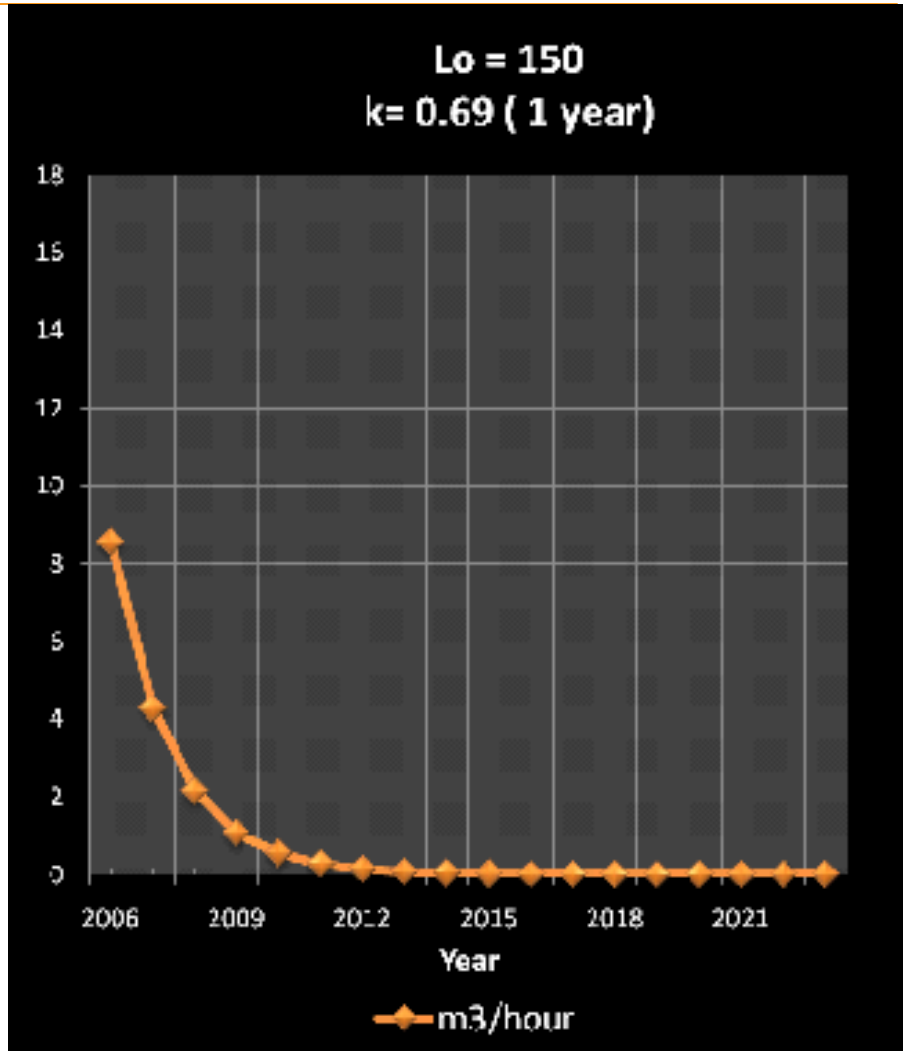
Exploring the variable - k

- In a perfect digester k is very high.
- In our example a half life of 3 months



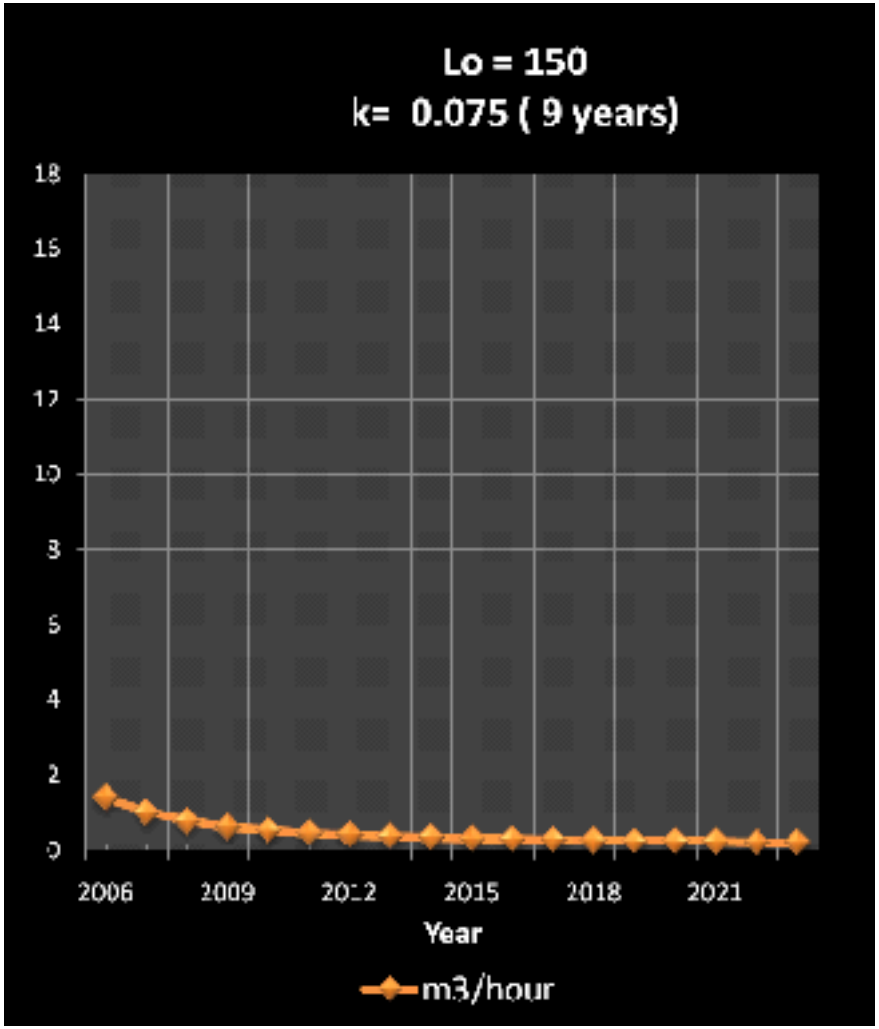
Exploring the variable - k

- In a perfect digester k is very high.
- In our example a half life of 3 months
- Landfill is NOT a perfect biodigester
- Perhaps half life = 1 year



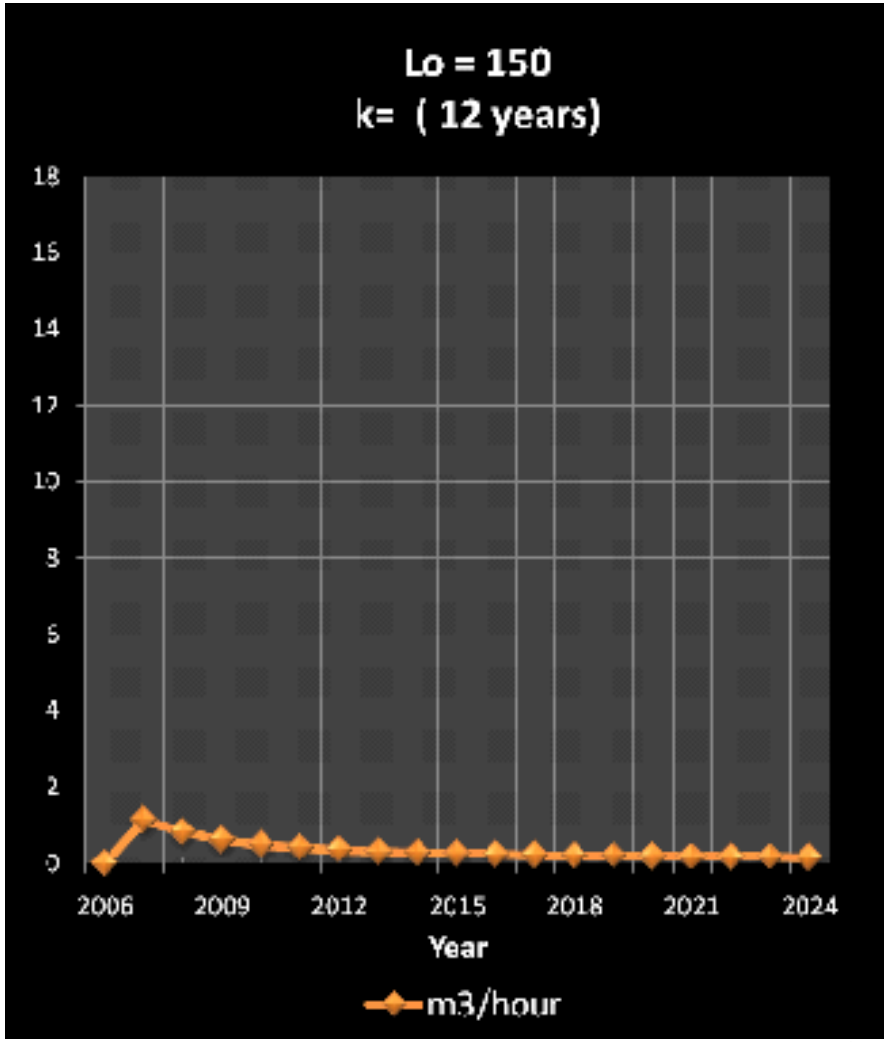
Exploring the variable - k

- BUT – all waste is not easily degraded
- Perhaps degradable waste is;
  - 10% Oils, fats & sugars – Rapid (Half life = 1 year?)
  - 10%Proteins, carbohydrates, starches – Moderate (Half life = 2 years?)
  - 30% Paper & Card, green waste – Slow (Half life = 10 years?)
  - 50% Others – very slow (Half Life = 50 years?)



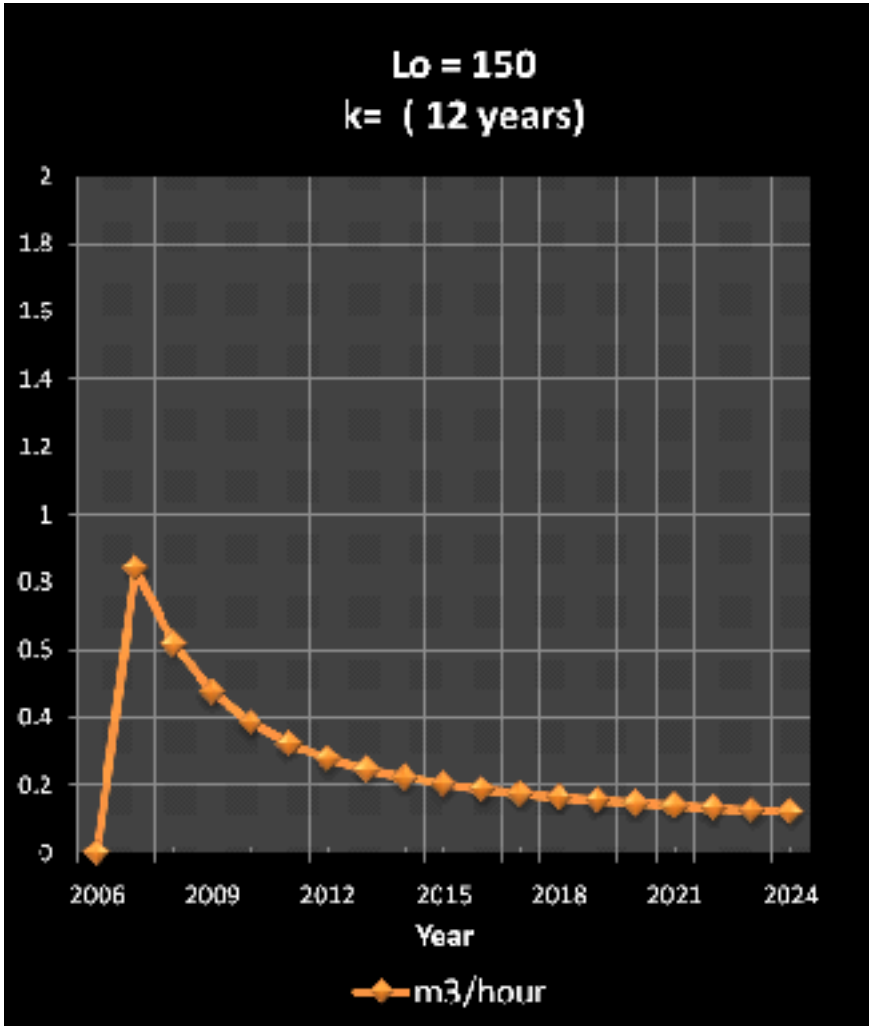
Exploring the variable - k

- But our 1,000 tonnes was deposited over 1 year!
- Maybe we should allow 6 months to reach full gas production



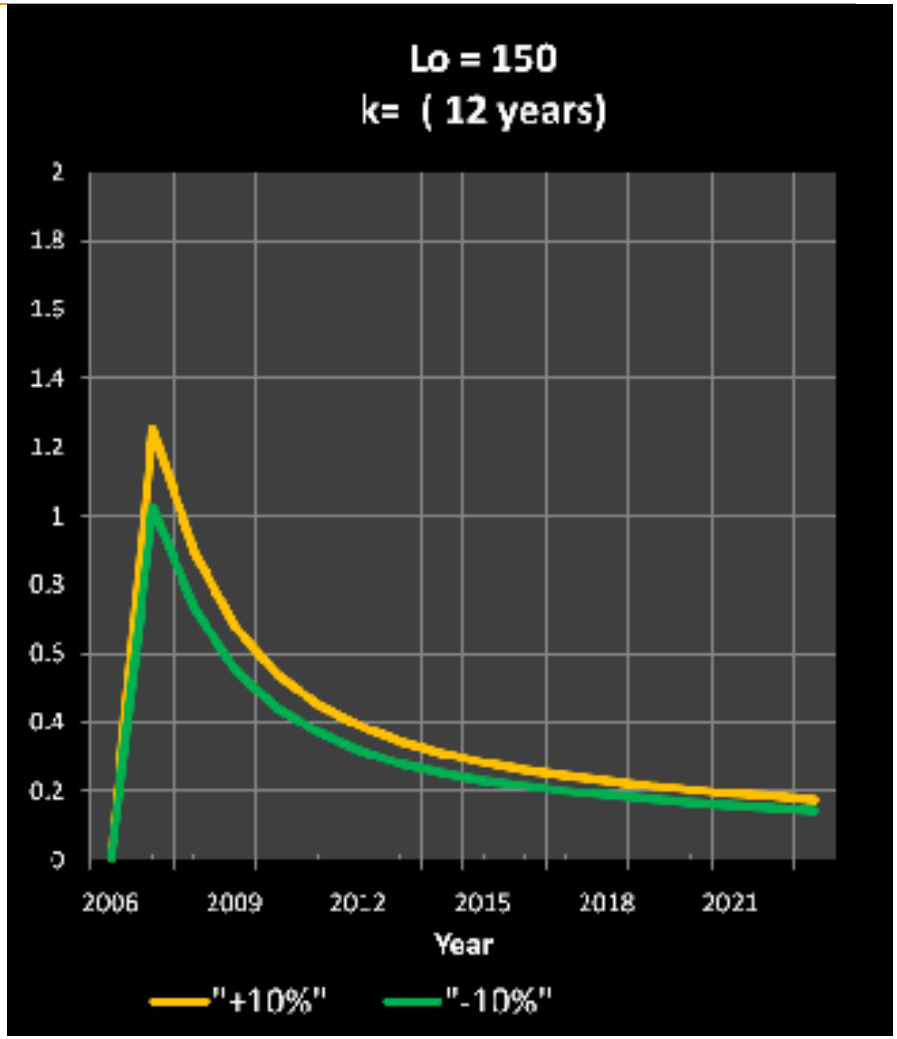
Are the numbers right?

- Perhaps the Mass is +-10%



Are the numbers right?

- Perhaps the Mass is +-10%?
- Perhaps the L_0 is +-10%?



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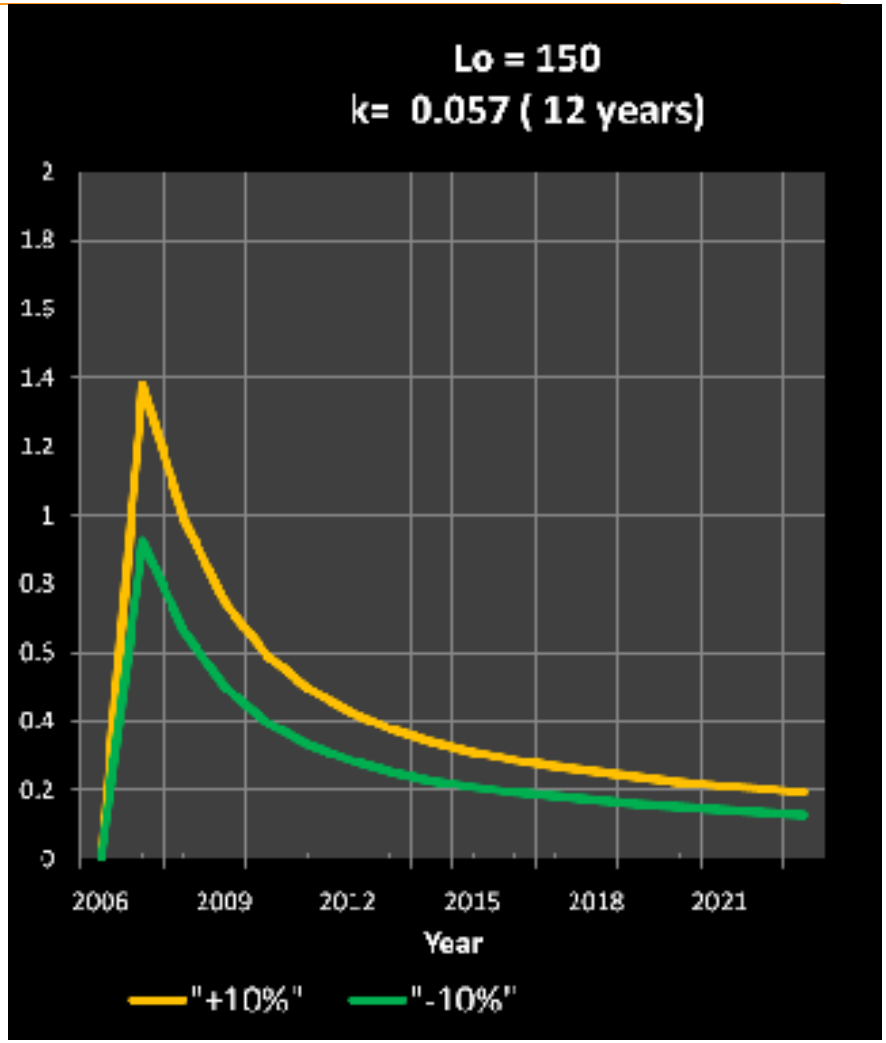
Are the numbers right?

- Perhaps the Mass is +-10%?
- Perhaps the L_0 is +-10%?
- Perhaps the k is +-10%



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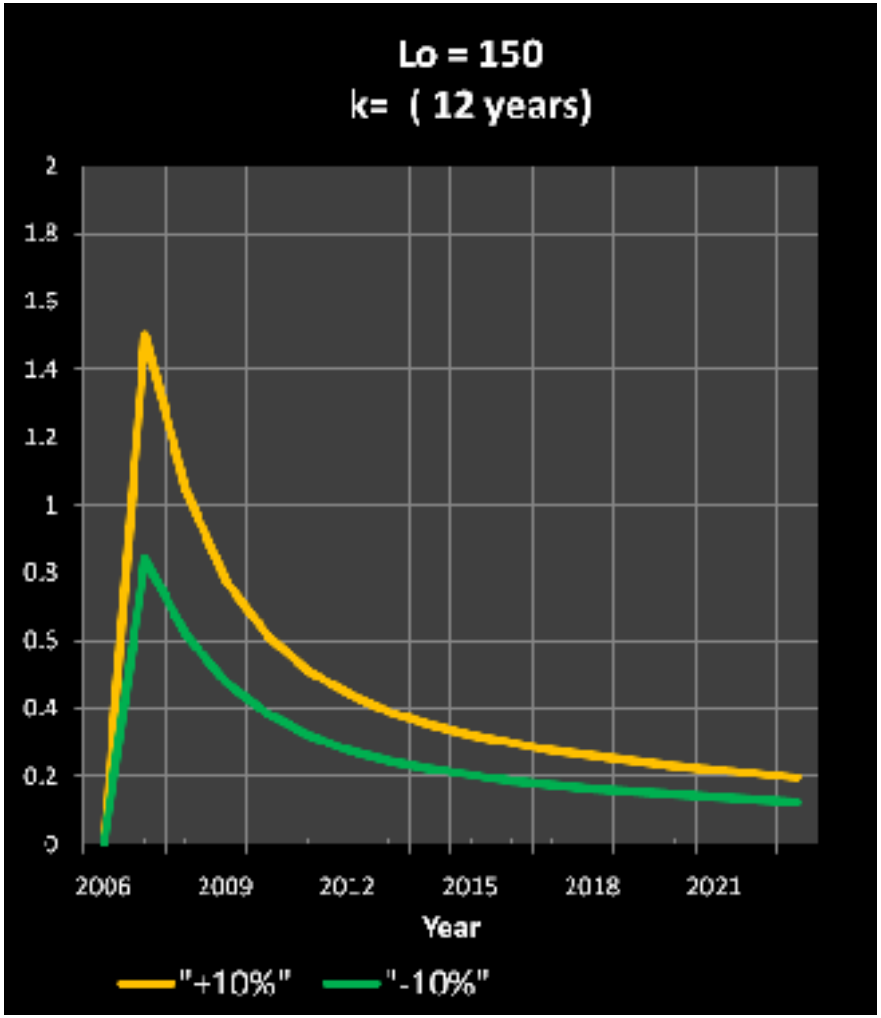
Are the variables right?

- Perhaps the mass is +-10%?
- Perhaps the L_0 is +-10%?
- Perhaps the k is

  +-10%
- Using reasonable assumptions throughout
- With a small error there is almost 100% difference in peak production



Other Waste Considerations

- Is there enough moisture in the waste?
  - Rainfall
  - Capping layer quality
- What is the waste temperature
  - Methanogenic bacteria need heat

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Is there something missing?

- Our model indicates the possible ***baseline***
- But we have not yet visited the site!
- So what factors should we look at on the site?

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Gas Recovery

Basic IPCC Gas model;
Annual Gas Production =

$$L_0 .M.(1- e^{-k})$$

Needs a collection efficiency factor;
Annual Gas Recovered=

$$\eta.L_0 .M.(1- e^{-k})$$

Collection Efficiency

η

A small factor with a BIG impact

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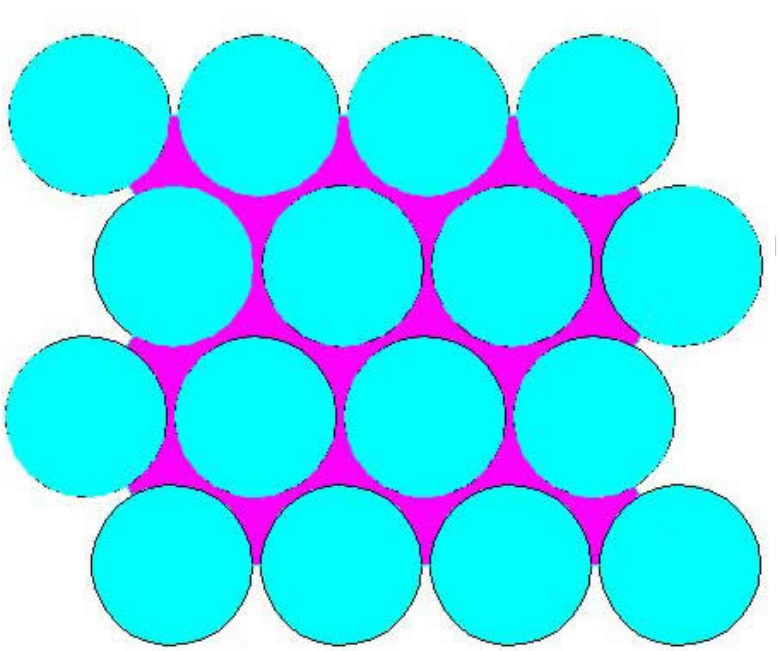
Is the site full of leachate?

Is the site full of leachate?

- High leachate levels affect the Radius of Influence (ROI) of extraction
- If ROI is estimated at 20m
- A 5% error reduces collection area by 10.7%



How long is the waste exposed?

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Are the gradients too steep?

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Or is the site too shallow?

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Are there site operations?

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And other factors?

- Air leakage
  - Is the applied vacuum limited by oxygen ingress
- Are all the gas wells performing normally
- APOLOGIES – I know the following slide is hard to read.

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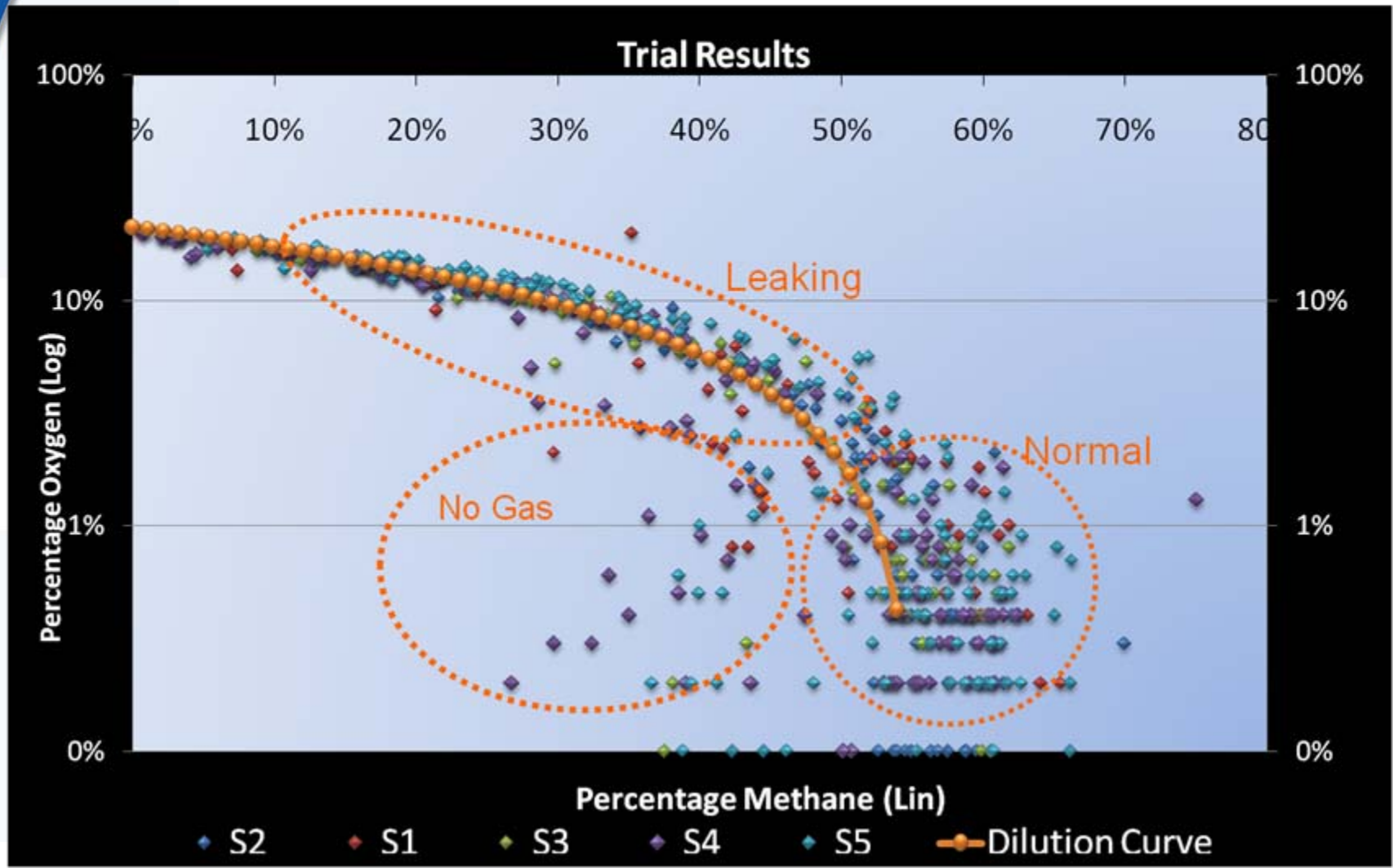
Field Measurements



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Other issues

- Volume correction for altitude and temperature
  - Are the gas pumps correctly rated?
  - Are flow meters corrected?
- Condensate drainage
  - Flow restrictions can occur
- Pressure drop in pipe work
  - Is there enough suction on the site

Are we collecting all the gas?

η – Collection Efficiency can't be modelled

- Reasonable assumptions are needed
- Adjustment based on history is required

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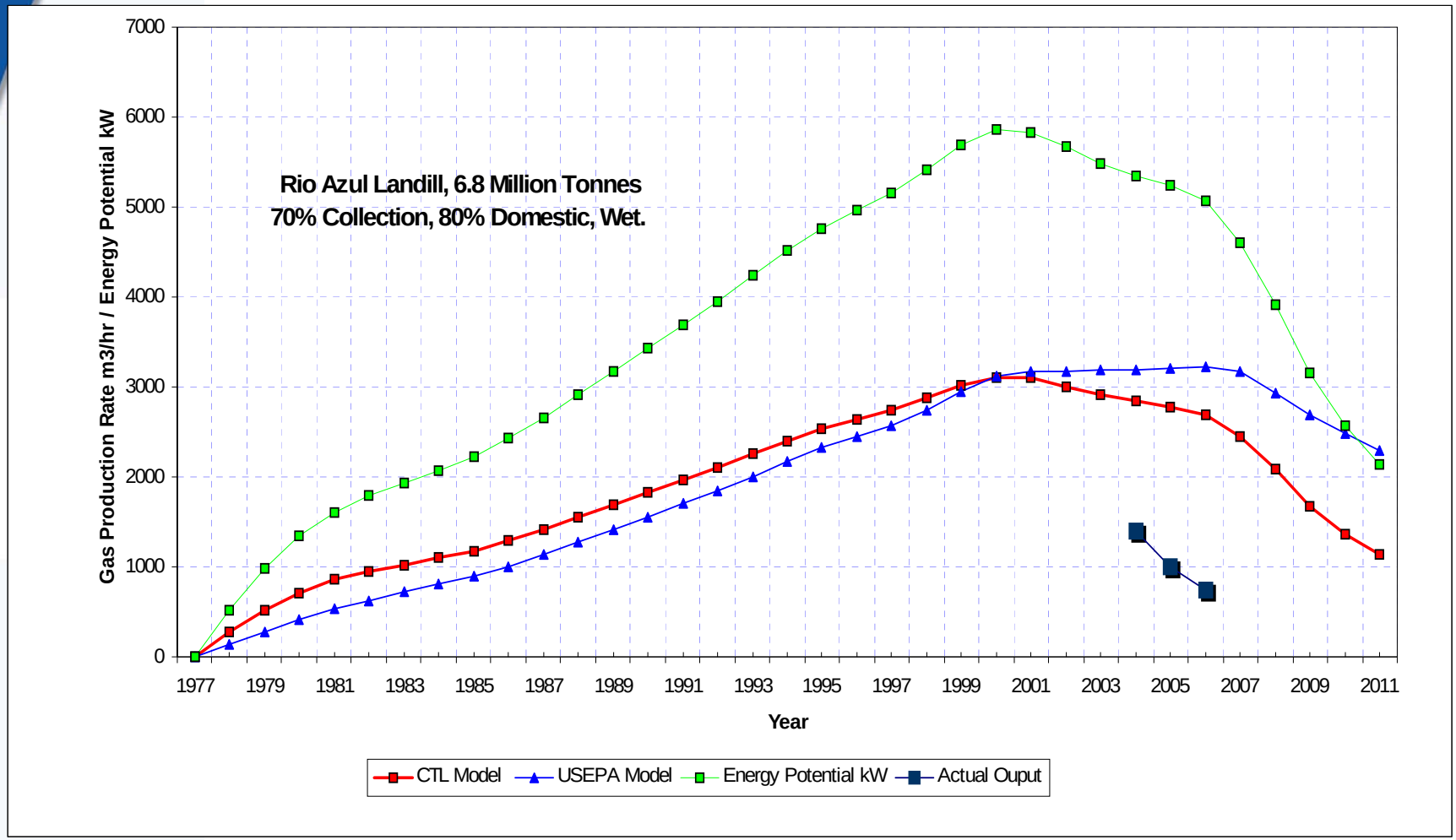
Rio Azul Gas Model



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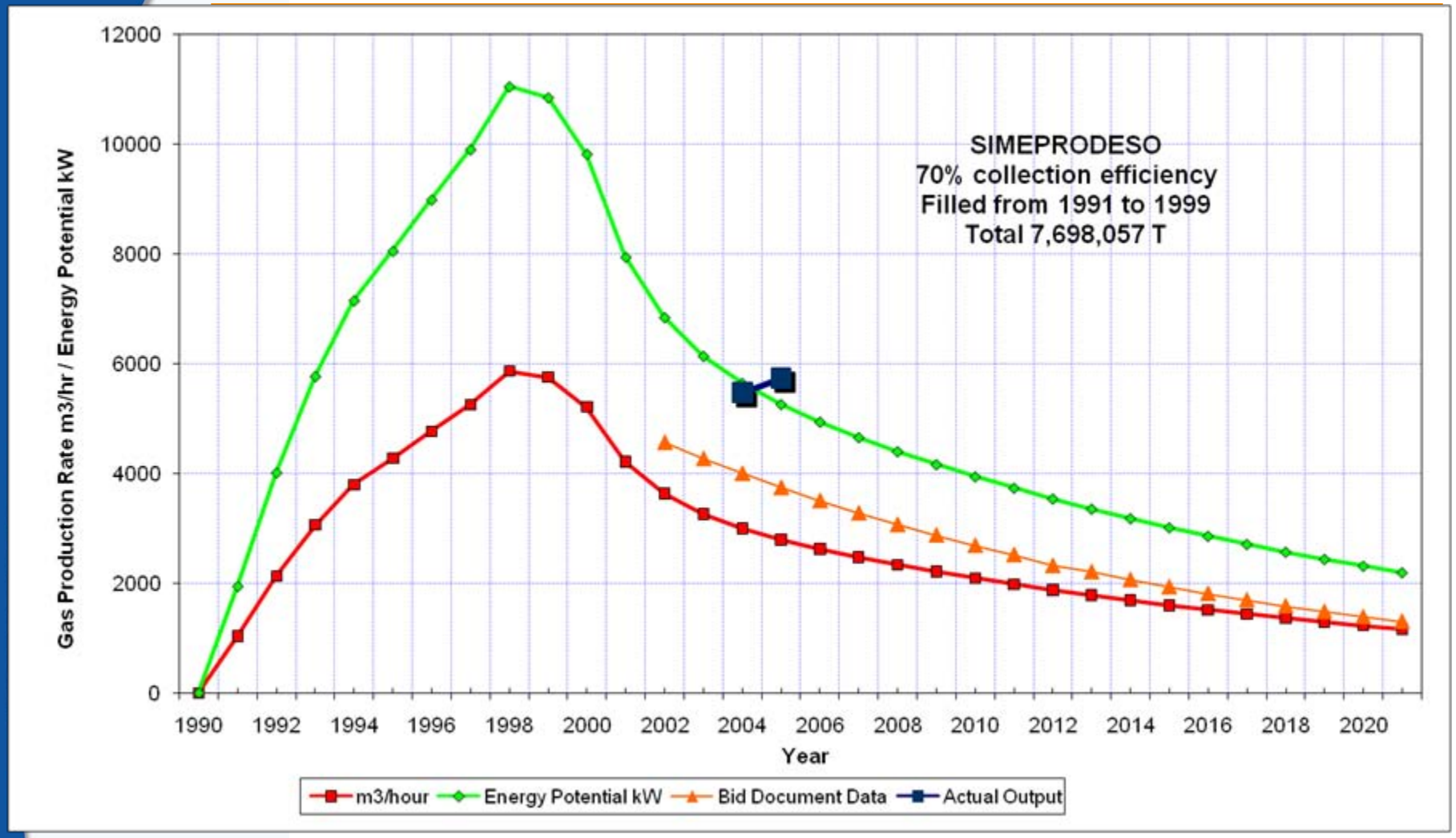
Simeprodeso Gas Model



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Gas Models - Summary

- May not adequately assess;
  - Site Conditions
  - Site Operations
  - Contractual terms
- Do not replace gas pumping trials
- Modelling requires actual and detailed knowledge of the site
- Take 50 gas models
  - On average they may be more or less correct .
  - !Any individual may be an order of magnitude wrong!

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Gas Models - Summary

- In Practice;
  - Gas Models can be quite good
  - Require to have detailed knowledge of the landfill
    - Waste
    - Engineering
    - Management
    - Environment
- CDM landfill gas projects are measured ‘ex-post’
- Often ‘what you get is what you get’ – and with experience that is usually pretty good!