Effects of Organics Diversion on Landfill Gas Generation and Comparison of Landfills and WTE

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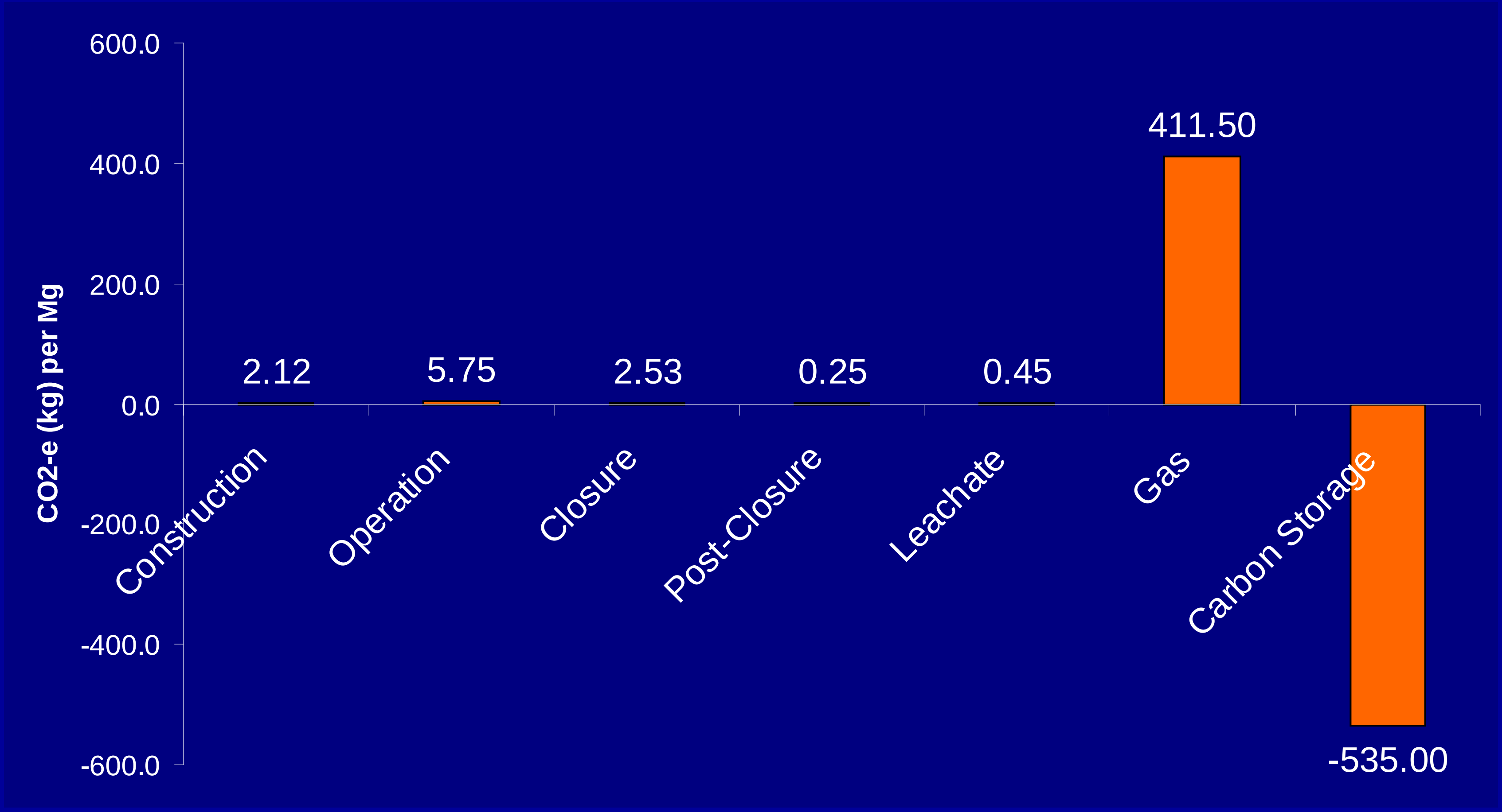
Introduction

- Prediction of landfill gas production and collection is critical
  - Financial viability of gas recovery projects
  - Estimates of landfill carbon footprint
    - Landfill gas and carbon storage dominate other aspects of landfill operation (construction, operation, closure, leachate management)
- Life Cycle Analysis
  - Landfills vs. WTE
  - Yard waste composting vs. daily cover

Relative Contributions to Landfill Carbon Footprint



Derived for a landfill that received 2 million Mg over 20 years

Introduction

- How does methane production change with changing waste composition?
  - Yard waste diversion
  - Increasing diversion of food waste
- We need to consider both k and L_0

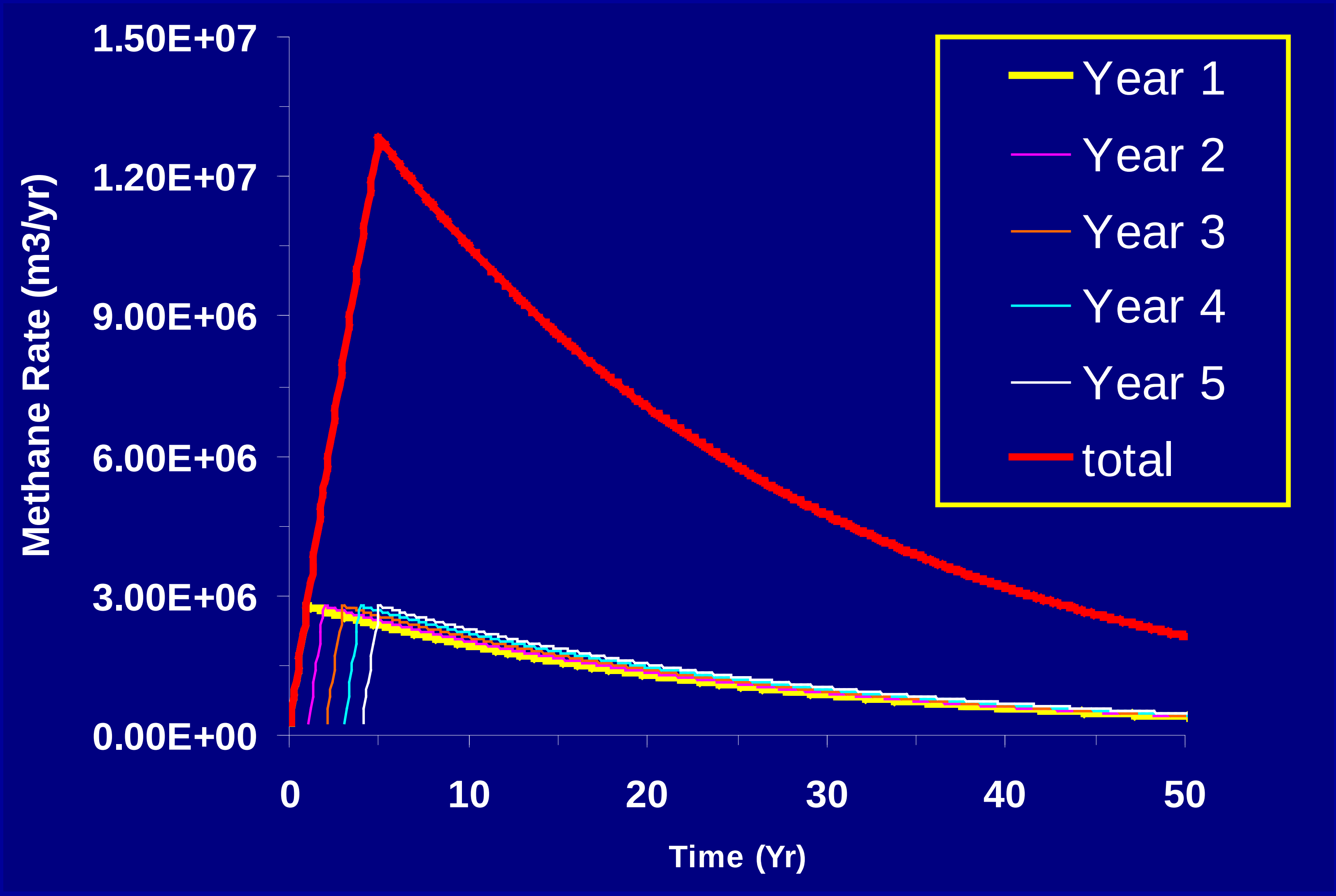
Landfill Gas Modeling

$$Q_n = k \cdot L_0 \cdot \sum_{i=0}^{n} \sum_{j=0.0}^{0.9} \frac{M_i}{10} \cdot e^{-k \cdot t_{i,j}}$$

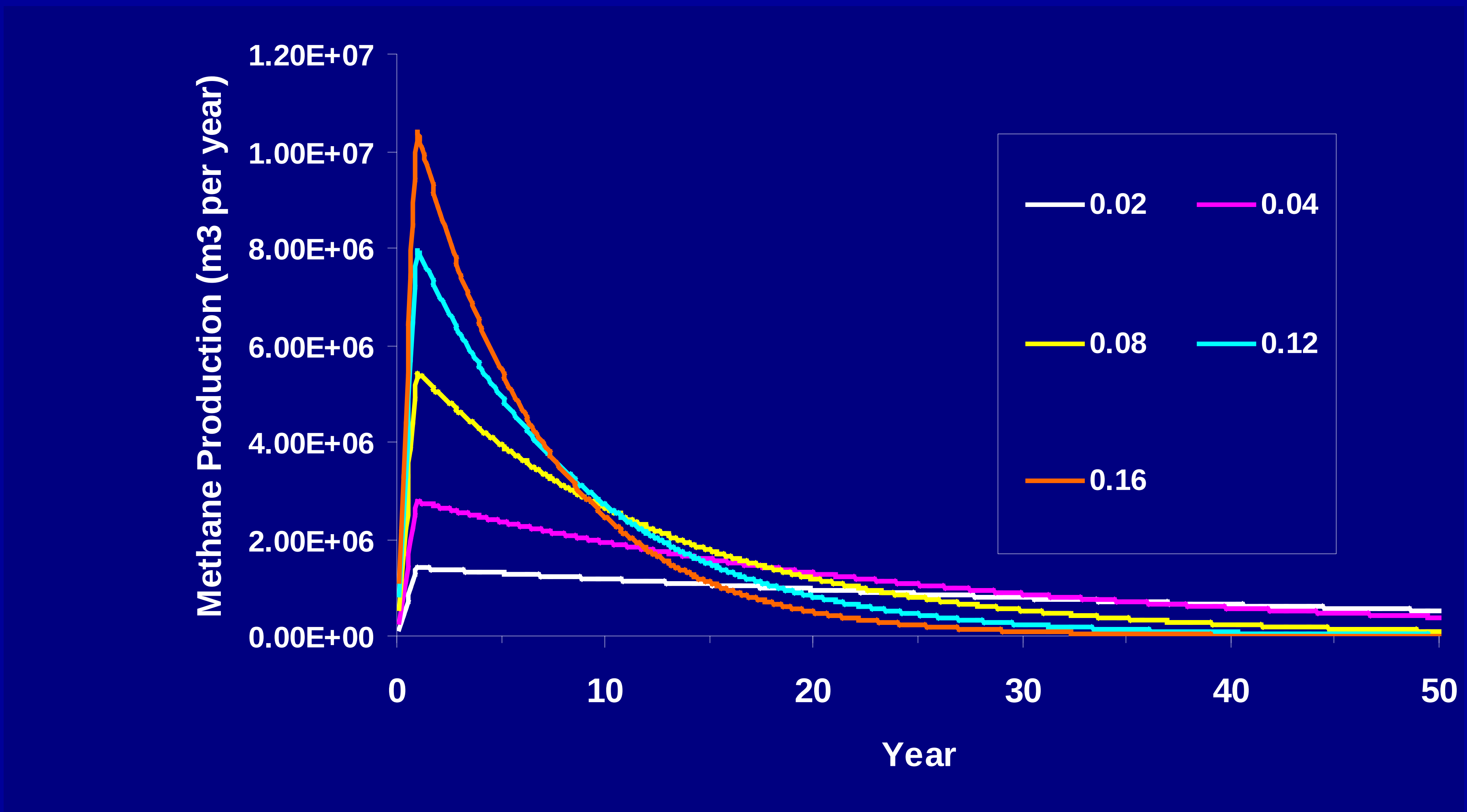
- Q_n is annual methane generation for a specific year t (ft^3 CH_4/yr);
- k is first order decay rate constant (1/yr)
- L_0 is total methane potential (ft^3 CH_4/ton of waste);
- M_i is the annual burial rate (tons)
- t is time after initial waste placement (yr);
- J is the deci-year time increment

Landfill Gas Emissions Model (LandGem)
http://www.epa.gov/ttn/catc/products.html#software

Methane Production Rate Curve for Five Years Waste



Effect of Decay Rate (k) on Methane Production



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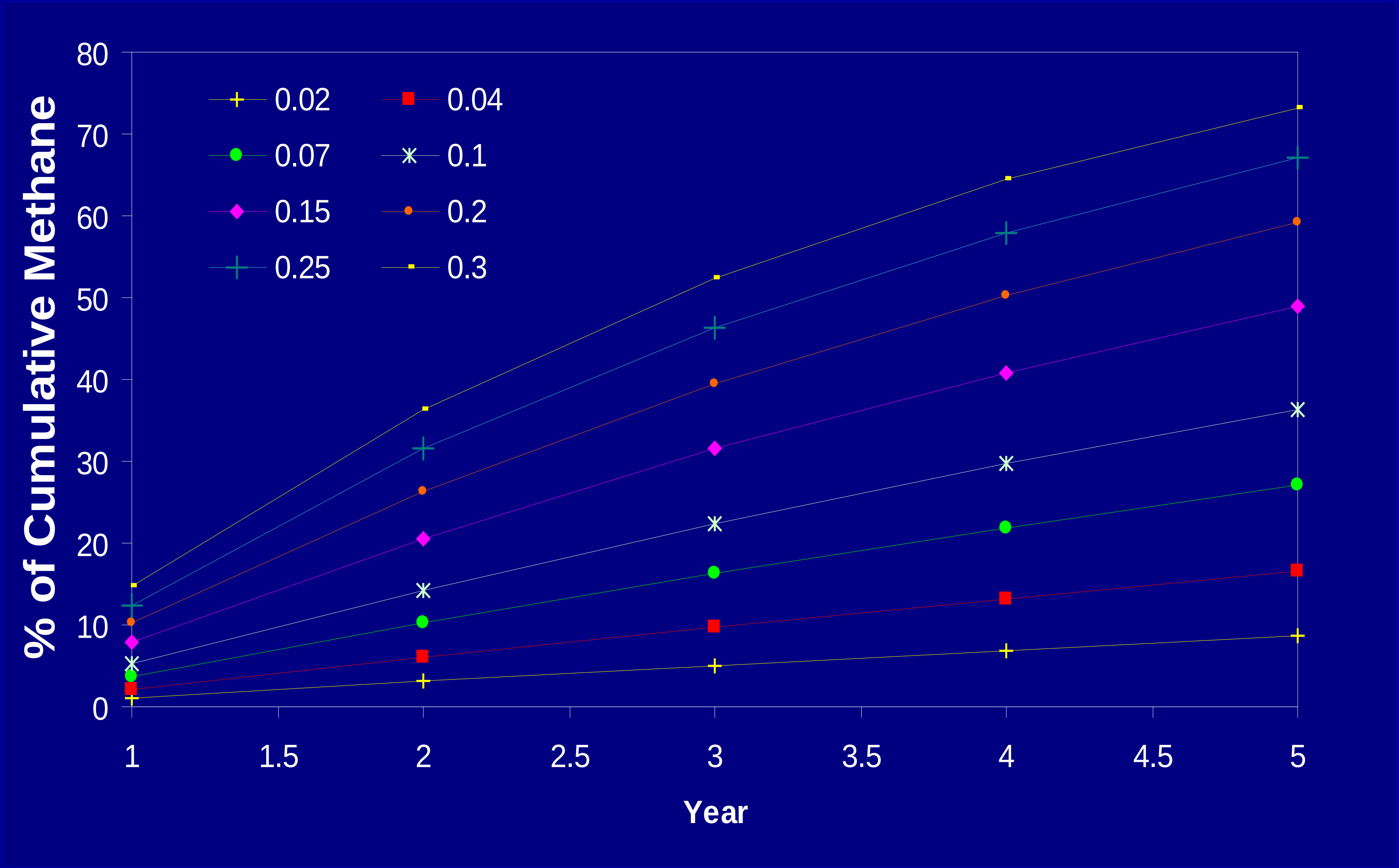
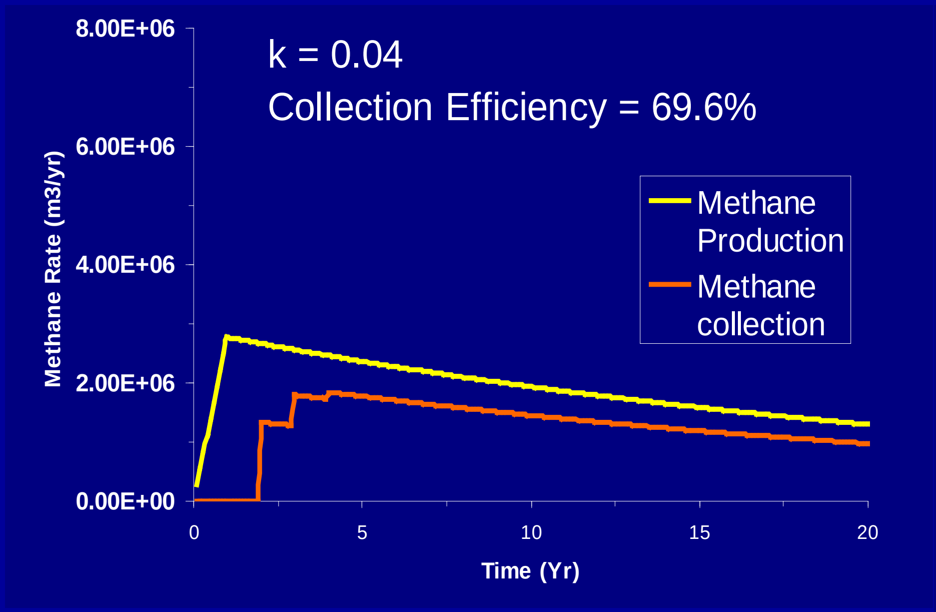
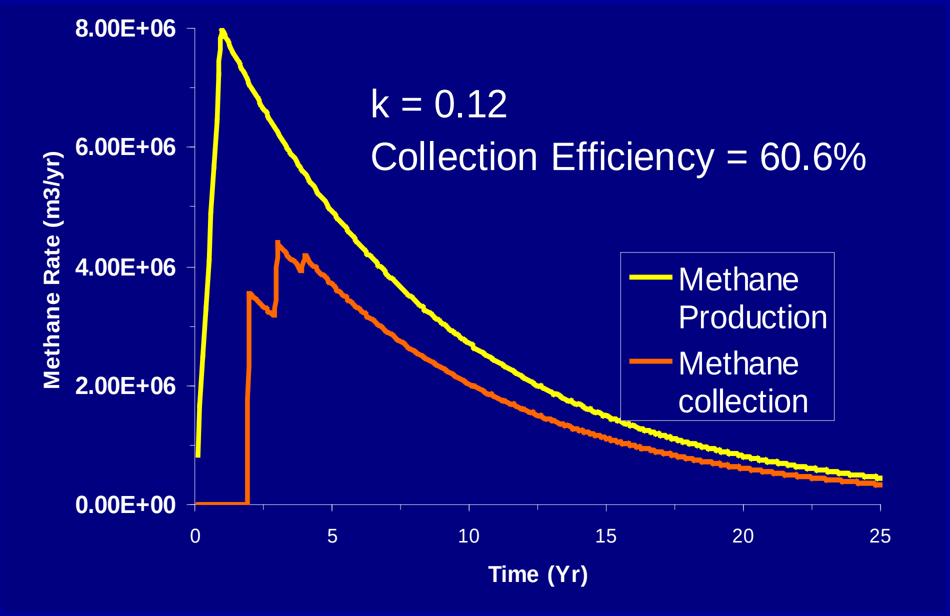


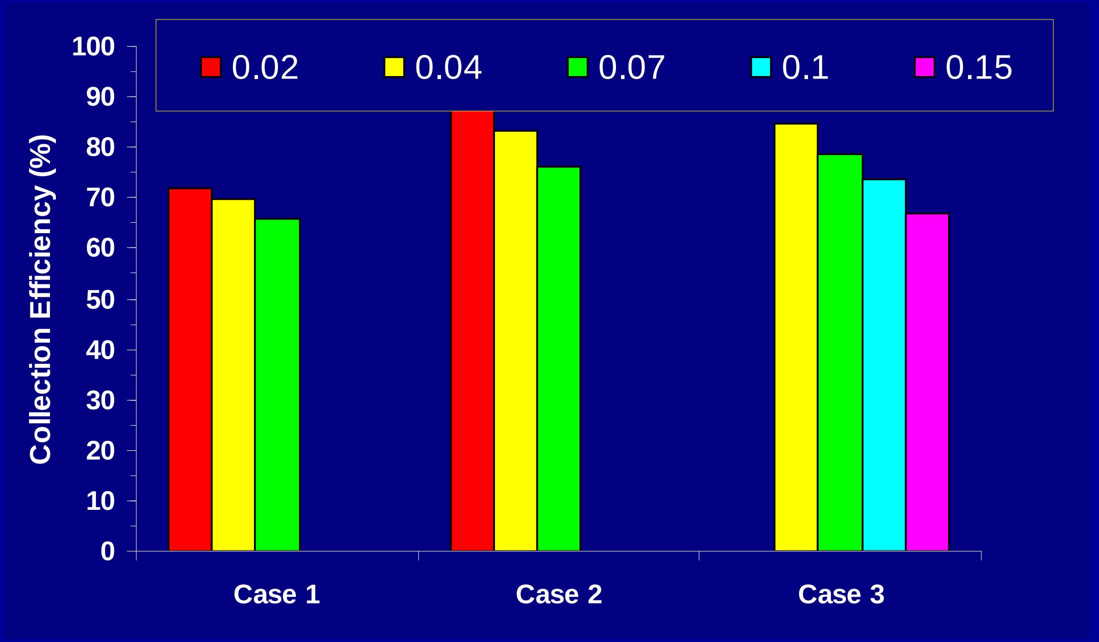
Effect of Decay Rate on Gas Collection





Temporally Averaged Collection Efficiencies (Barlaz et al., 2009)

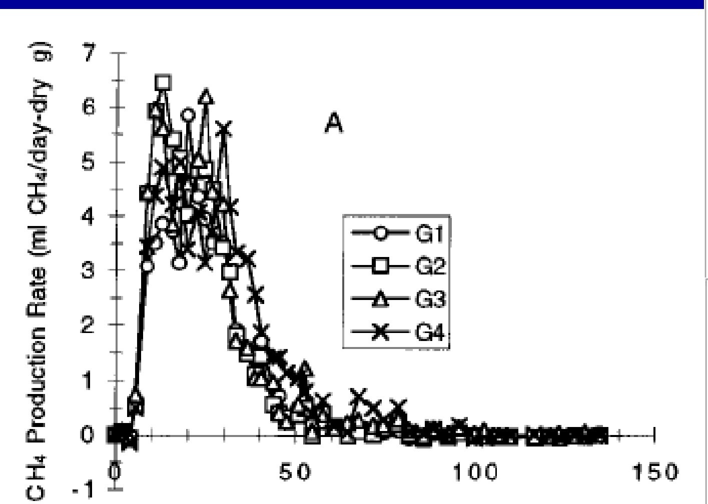
Case 1: Phased in collection	**Years 1-2: 0%** **Year 3: 50%** **Year 4: 70%** **Years 5-100: 75%**
Case 2: Phased in collection with improved cover	**Years 1-2: 0%** **Year 3: 50%** **Year 4: 70%** **Years 5-10: 75%** **Years 11-100: 95%**
Case 3: Aggressive Gas Collection; Bioreactor Operation	**Years 1-2: 25%** **Year 3: 50%** **Year 4: 70%** **Years 5-10: 75%** **Years 11-100: 95%**

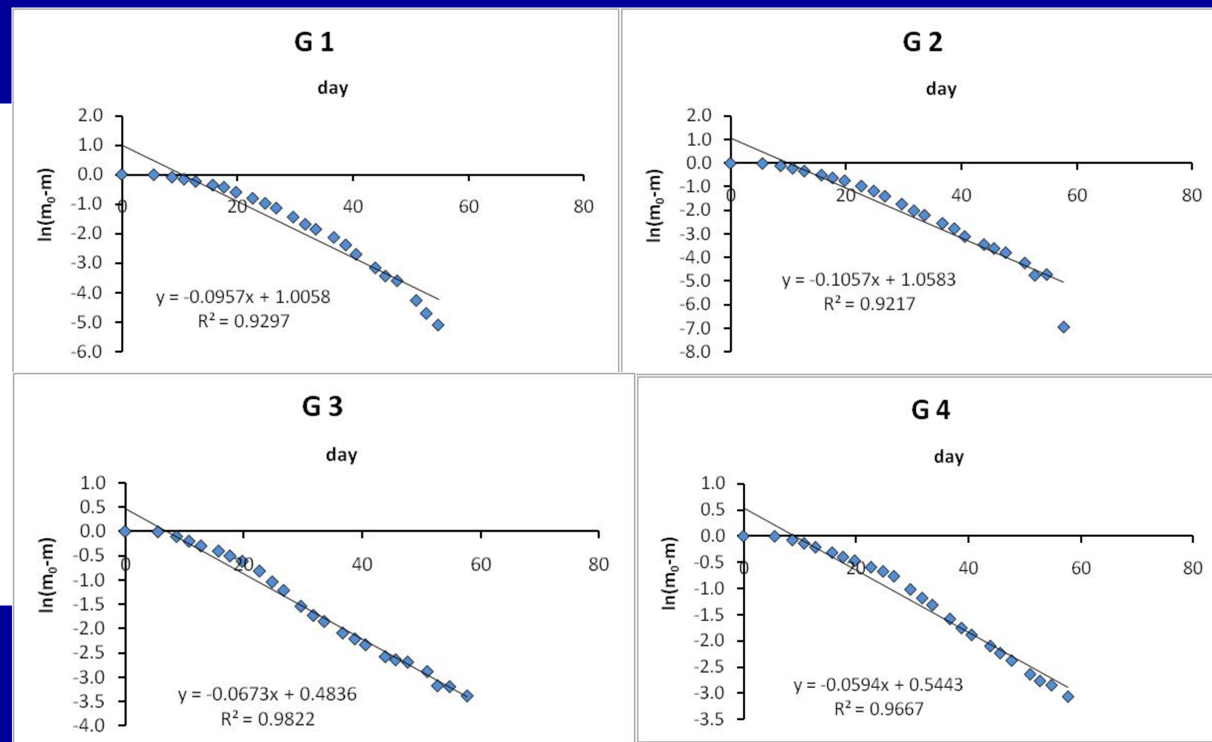


Derivation of Decay Rates for Individual Waste Components

- The decay rate has a significant influence on the amount of gas that can be collected for a given gas collection scenario

Lab-Scale Data





Conversion of Lab Rate to Field Rate

$$f \times \sum_{i=1}^{n} k_{lab,i} \times (wt.\ fraction)_i = k_{MSW}$$

- $K_{lab,i}$ is the average decay rate from the lab reactors
- Wt. fraction is the composition
- k_{MSW} (0.04) is the assumed decay rate in a landfill and will vary for different scenarios
- f is a fitting factor and the only unknown

Conversion of Lab Rate to Field Rate

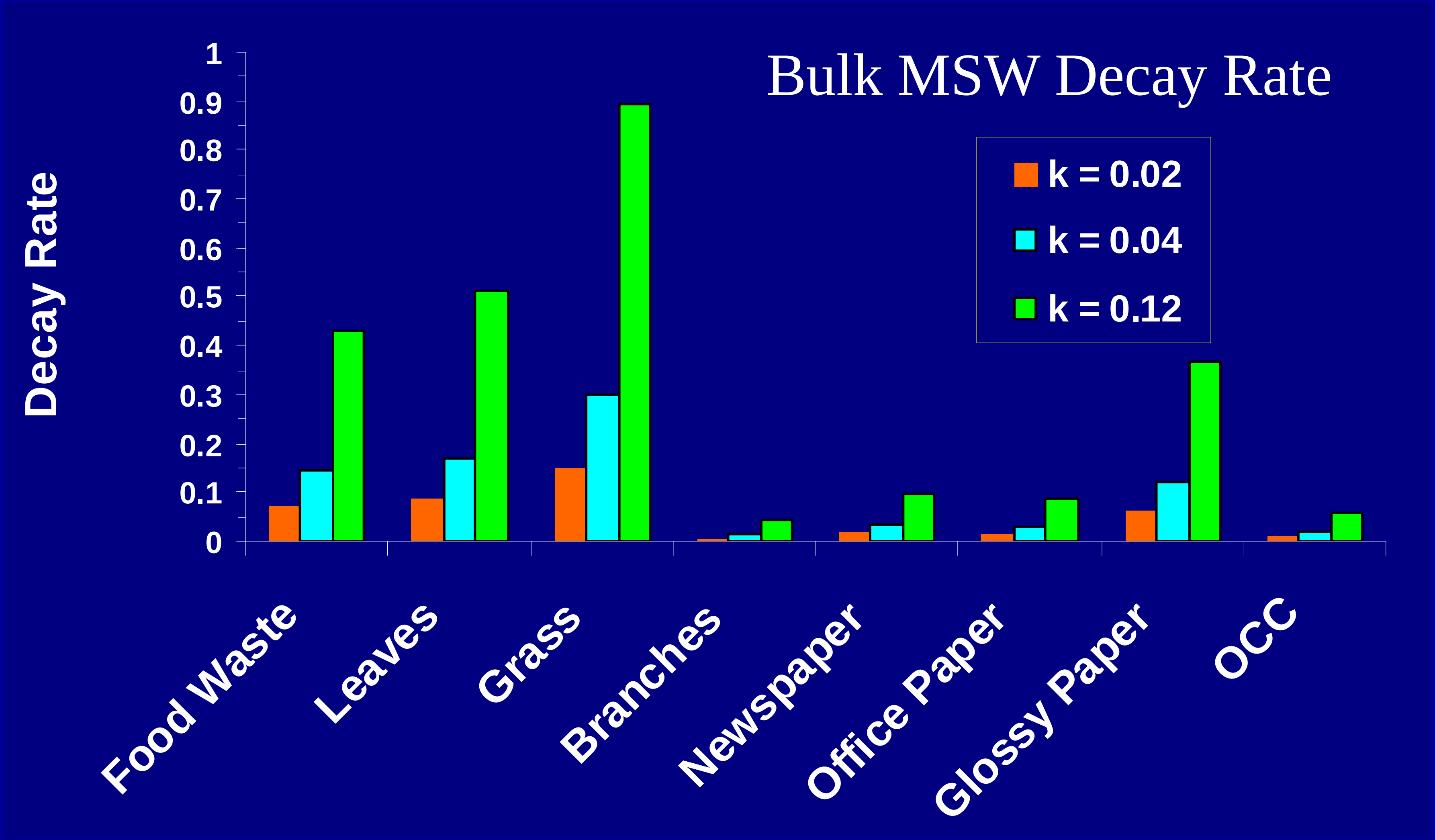
$$f \times \sum_{i=1}^{n} k_{lab,i} \times (wt.\ fraction)_i = k_{MSW}$$

- Once f is determined, $K_{field,i}$ is determined as:

$$k_{field,i} = f \times k_{lab,i}$$

- $K_{field,i}$ is specific to an assumed bulk MSW decay rate (e.g., 0.04)

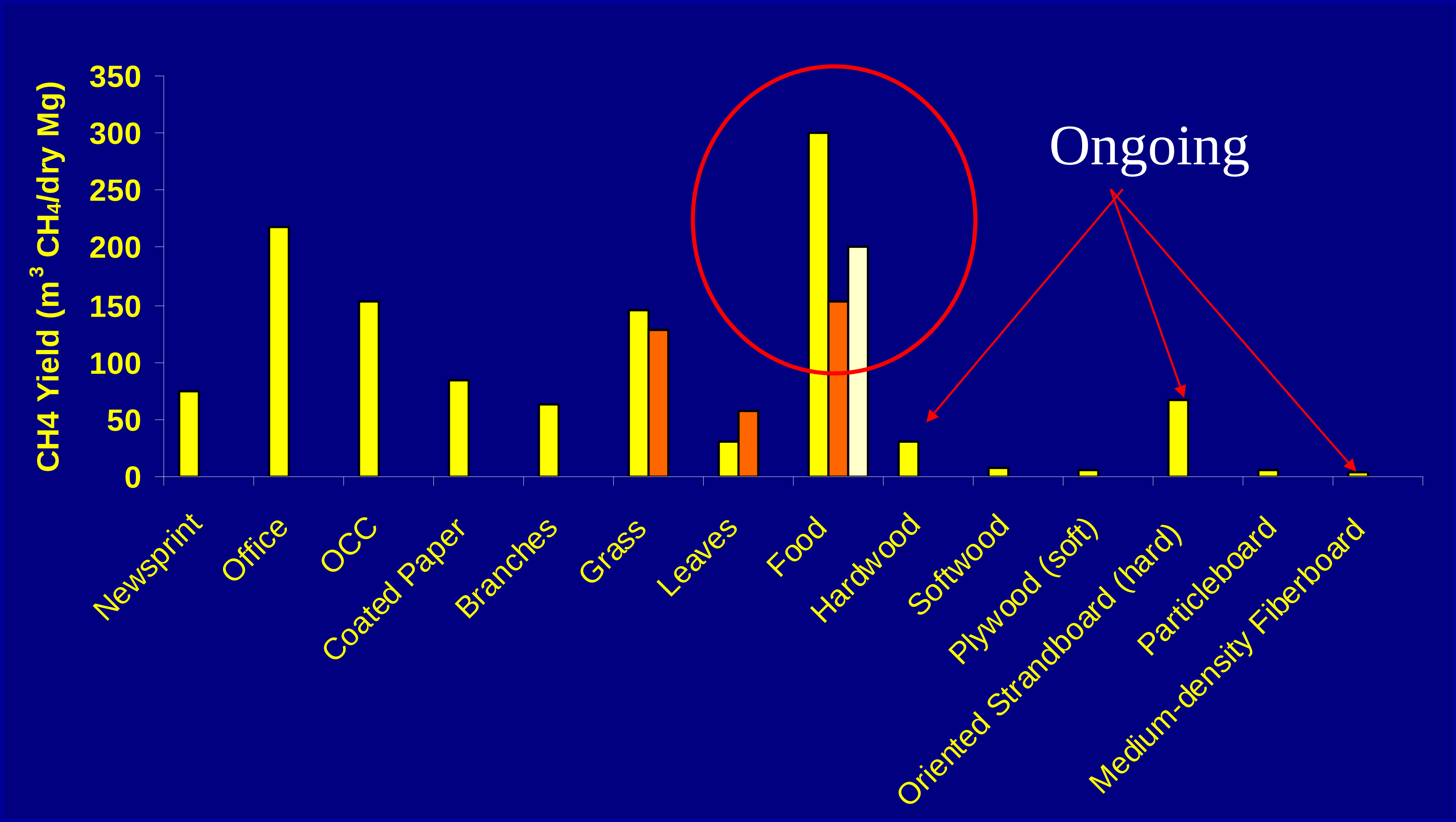
Calculated Field-Scale Decay Rates for Waste Components



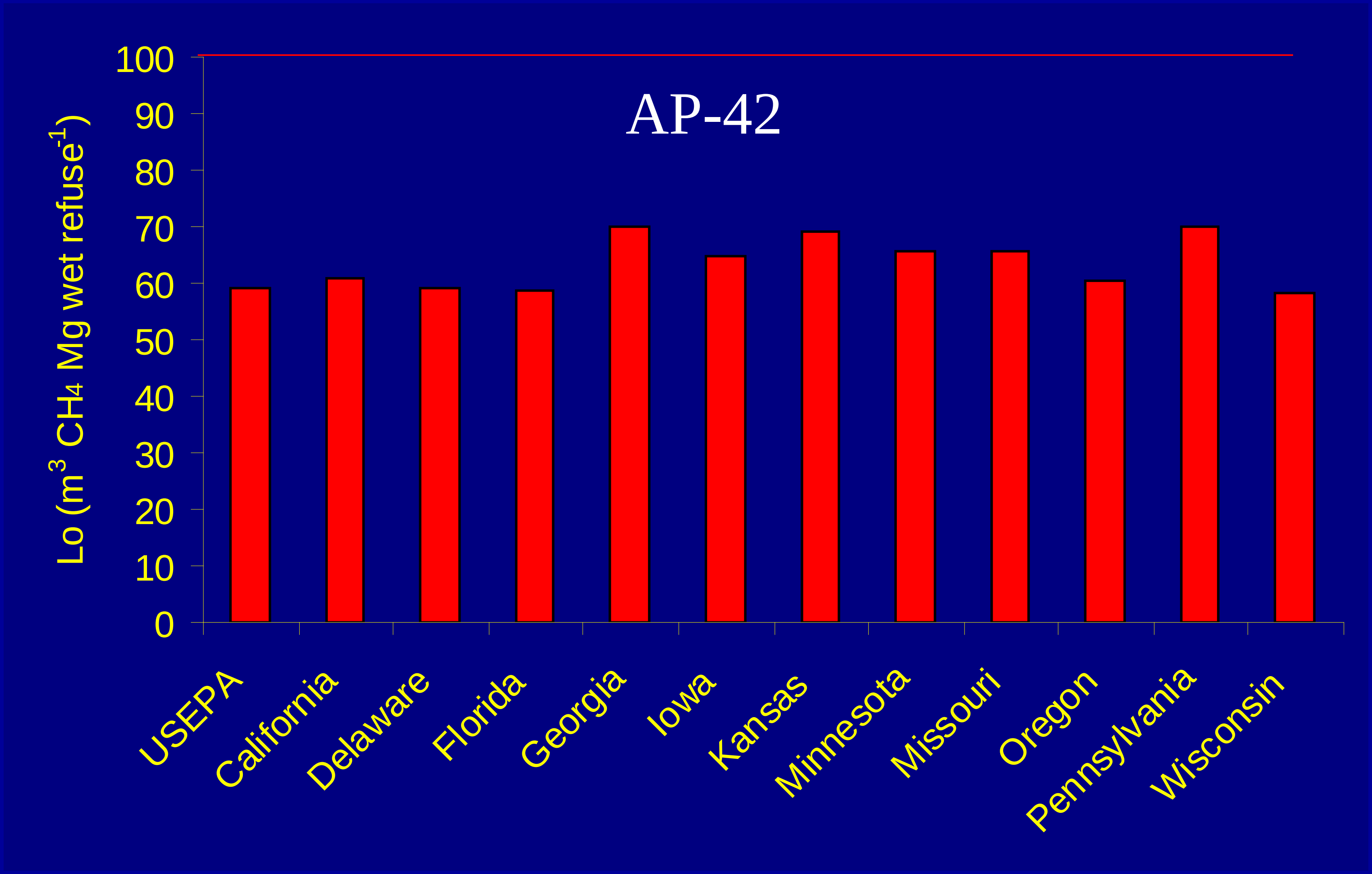
Decay Rate Observations

- Food waste, grass and leaves are the highest
- Decay rates were calculated for multiple waste compositions. The standard deviation (normalized by the mean) was ~ 27%.
- Uncertainty in the assumed bulk MSW decay rate remains

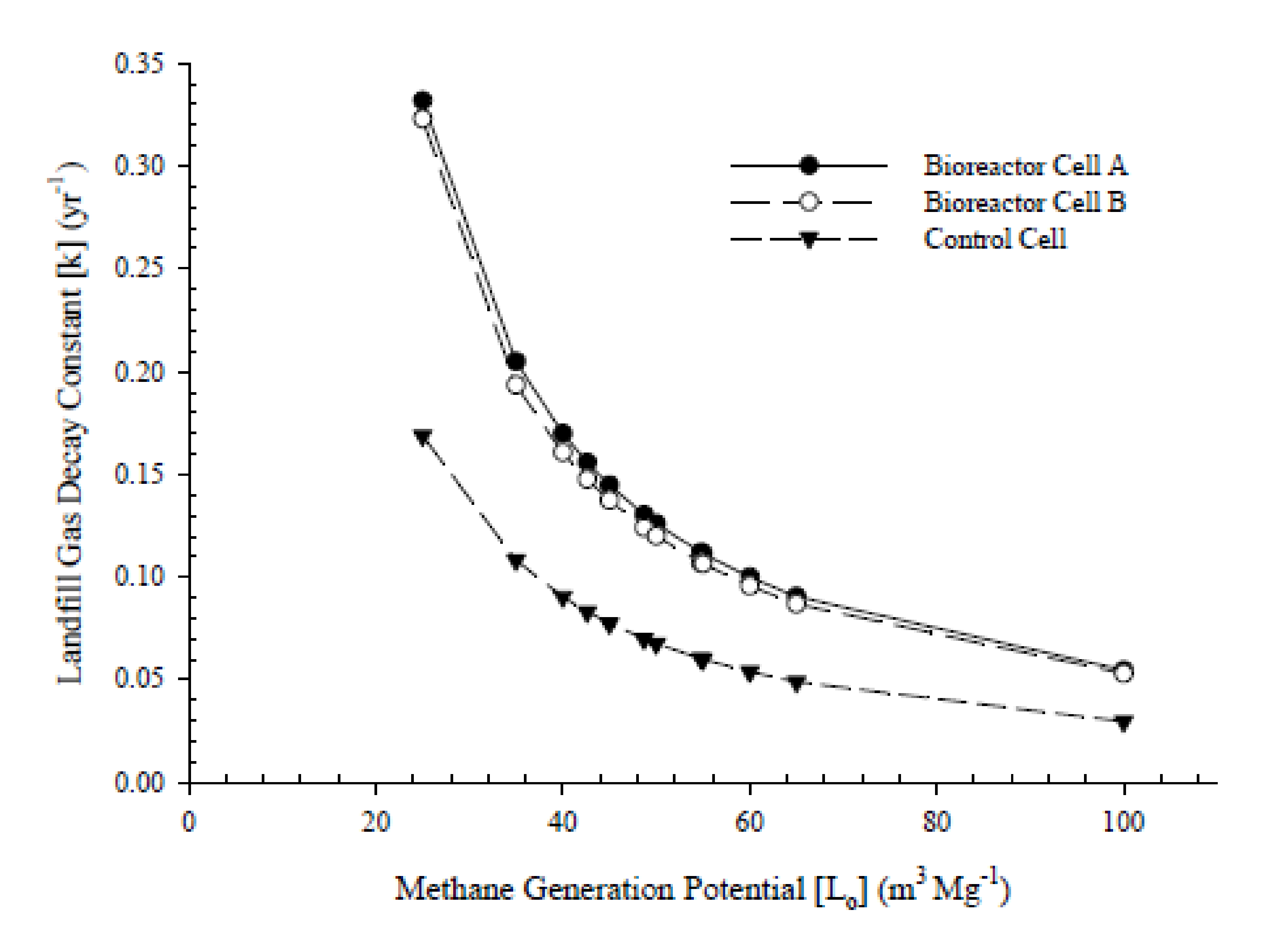
Requires knowledge of both k and L_0



Estimate of Bulk MSW L_0 from Waste Composition Data



Effect of Assumed L_0 on Estimate of k from Methane Collection Data



Explore the Effect of Waste Diversion on Methane Production

Case 1: Base Case (1 million metric tons/yr for 20 years)

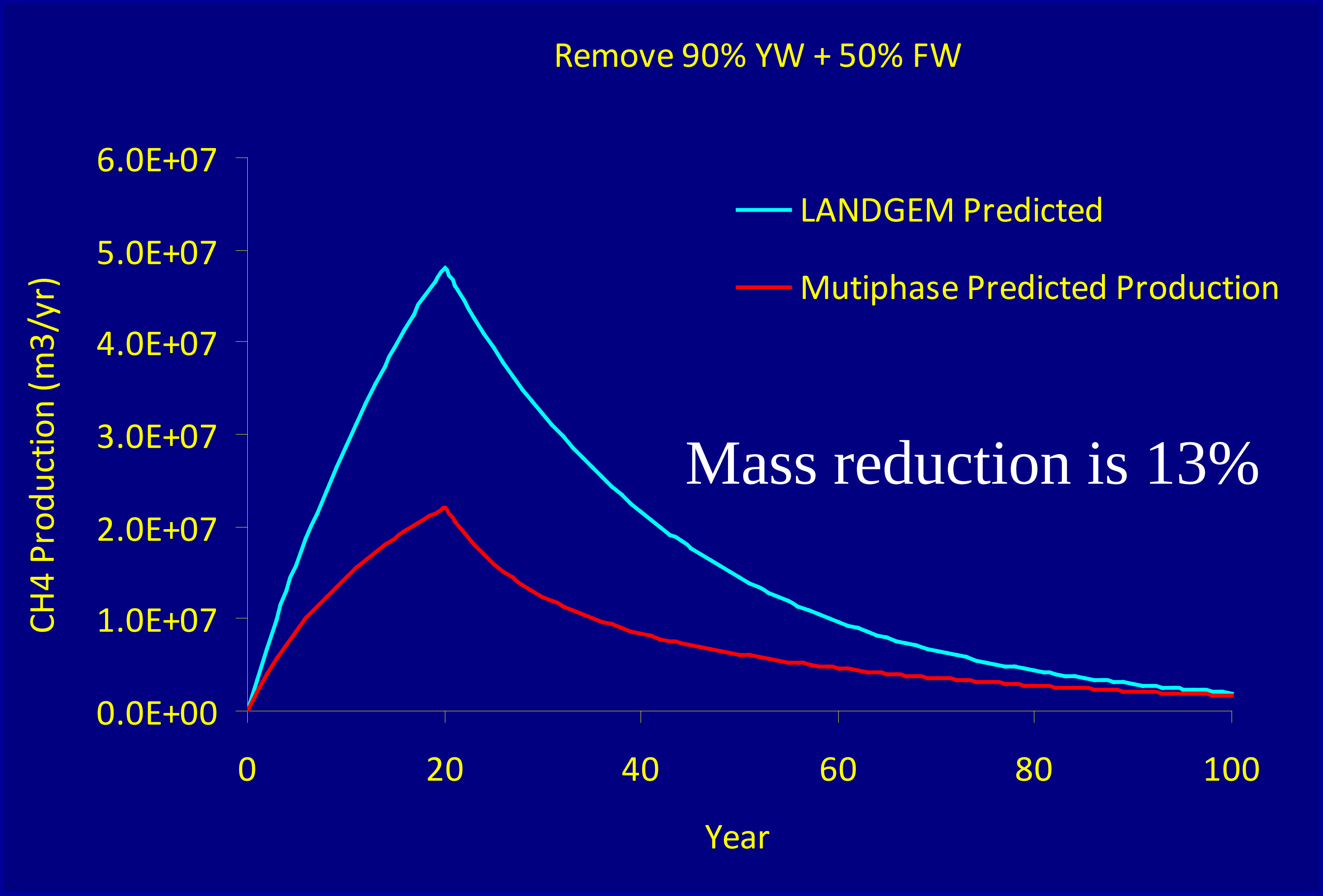
Case 2: 100% diversion of yard waste (930,000 ton/yr)

Case 3: 100% diversion of yard waste and food waste (800,000 ton/yr)

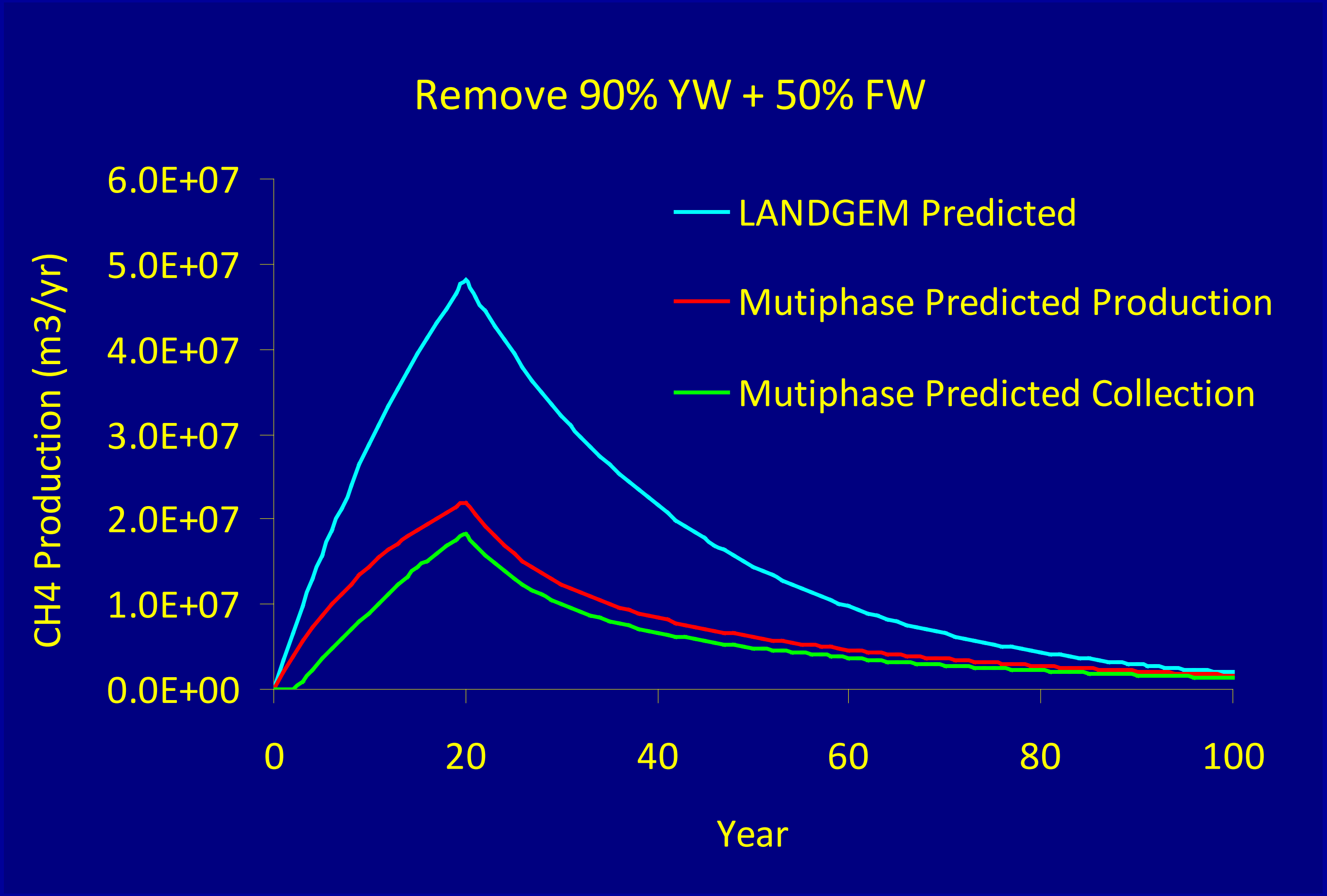
Case 4: 90% diversion of yard waste and 50% diversion of food waste (870,000 ton/yr)

Case 5: 50% of office and mixed paper (942,000)

Comparison of Landgem and Multiphase Model with Calculated L_0 = 48 m^3/ton

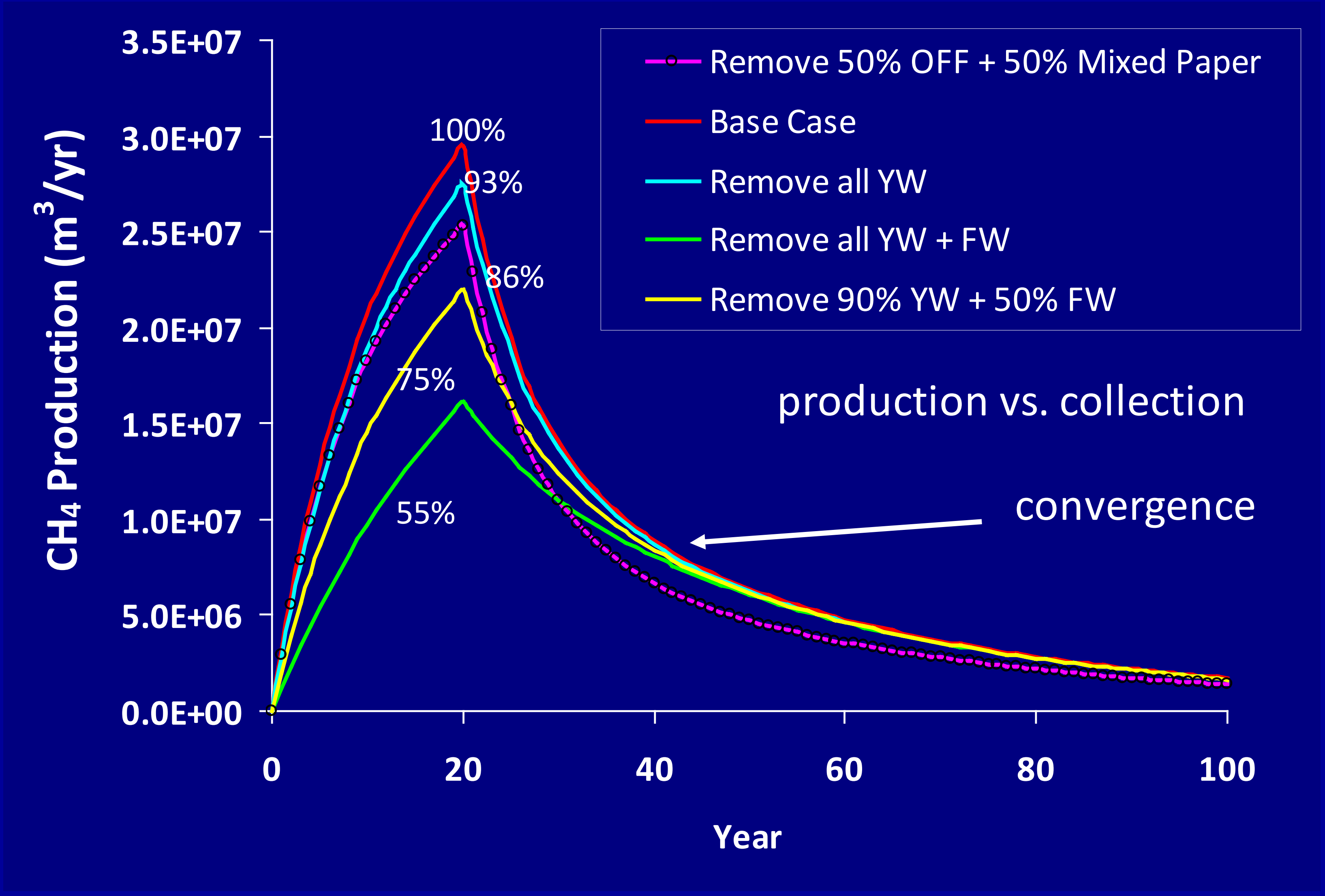


Comparison of Landgem and Multiphase Model with Calculated L_0 = 48 m^3/ton

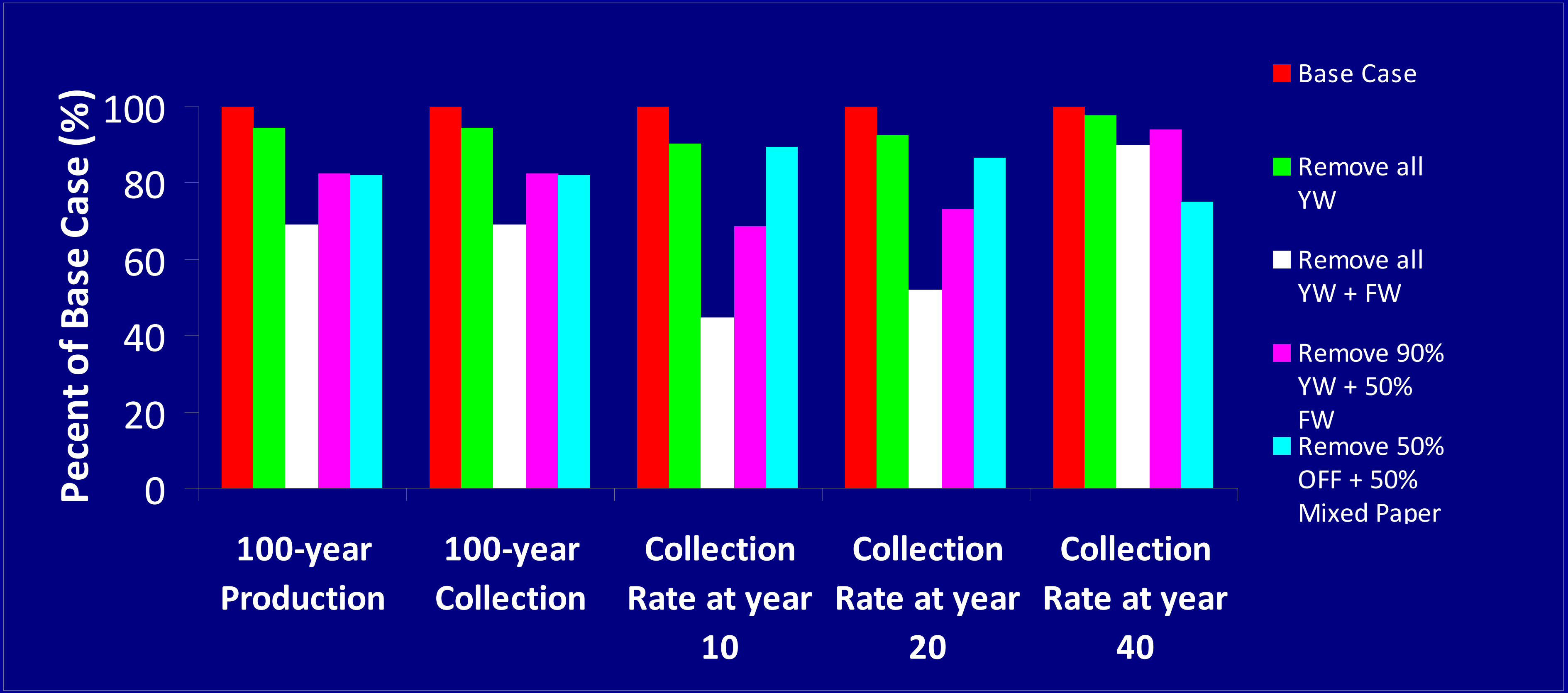


Collection Scenario
Years 1-2: 0
Year 3: 50%
Year 4: 70%
Years 5-10: 75%
Years 11-100: 95%

Effect of Diversion on Methane Production Rate



Effect of Diversion on Cumulative Methane Production



Conclusions and Implications

- Waste composition has a significant effect on gas collection
- Changing only the mass buried does not lead to good estimates of future gas production and collection
- Component specific decay rates allow better assessment of future gas production and collection

De la Cruz, F. B. and M. A. Barlaz, 2010, "Estimation of Waste Component Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data," Env. Sci. Technol., 44, 4722 – 28.

Life-Cycle Comparison of Landfills and WTE

- Review of 8 studies conducted in the US and Europe was uniform in showing that WTE is preferable to a landfill in consideration of:
  - Fugitive emissions from landfills
  - Avoided emissions associated with energy recovery from combustion
- Report is available on WTERT web site.

What to do with Yard Waste?
A Life-Cycle Comparison of Windrow Composting and the Use of Yard Waste as Alternative Daily Cover (ADC)

- Benefits of ADC:
  - Sequestered CO_2 (153 kg C per wet Mg of waste)
  - LFG collection (15.7 scm/Mg)
  - Avoided soil excavation (3 m^3/Mg)
- Windrow composting drawbacks:
  - High ammonia emissions (2.5 kg/Mg)
  - Little benefit from avoided production of fertilizer (3.5kg-N/Mg)

Results

- Results of study show ADC method to be more 'Eco-efficient' than windrow composting: lower cost and better for the environment.
  - MS Thesis and journal article

van Haaren, R., Themelis, N. J. and M. A. Barlaz, 2010, "LCA Comparison of Windrow Composting of Yard Wastes with use as Alternative Daily Cover (ADC)," accepted, Waste Management.

Questions

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