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Steps Towards Initiating LFG Utilization Projects in Developing Countries – Planning Process, LFG Models, and Managing Project Expectations

Alex Stege – SCS Engineers (Contractor for U.S. EPA LMOP)

LANDFILL METHANE OUTREACH PROGRAM

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Presentation Topics

- Challenges to implementing CDM landfill gas (LFG) projects:
  1. Site conditions in developing countries limit project potential
  2. Navigating the LFG project planning process:
  3. O&M issues: landfill, leachate, and LFG collection system
  4. LFG collection and control/utilization system design and installation
  5. LFG models and over-estimating LFG project potential
- CDM monitoring reports – project performance data
  - Causes of observed CER shortfalls from the list of challenges
- Avoiding over-estimating project potential – focus on improved LFG modeling

1. Site Conditions in Developing Countries

- Site conditions that limit LFG recovery rates:
  - Shallow waste depth, poor compaction
  - High food waste %, often rainy climates
  - Lack of soil cover and/or poor drainage lead to high leachate levels
  - Fires, waste pickers, site security

El Trebol Landfill, Guatemala City

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2. Project Planning Process

- Steps in the project planning cycle:
  - Site identification and initial screening
  - Project assessment
  - Pre-feasibility study
  - RFP and select developer
  - PDD
  - Project validation and registration

2A. Project Planning Process – Site ID & Initial Screening

- Site identification and initial screening
  - Engineered/ sanitary landfill or dump site?
  - Waste in place, age, composition
  - Disposal rates and remaining site capacity
  - Location and political/public acceptance

2B. Project Planning Process – Assessment Report

- Assessment report
  - Data collection:
    - Waste data: area, height, disposal rates, waste in place, future capacity, composition
    - Site conditions: climate, soil cover, liner systems, waste compaction, leachate levels, surface drainage, slope stability
  - Landfill visit to confirm/collect data and observe site conditions, particularly drainage and leachate accumulation
  - Model estimates of LFG generation and expected recovery
  - Assess potential utilization options – electricity generation, direct use, flaring for carbon credits

2C. Project Planning Process – Pre-Feasibility Study

- Project pre-feasibility study
  - Site visit for detailed data collection and field observations
  - Field testing recommended
    - Drilling test wells useful for measuring LFG flows, methane %, leachate levels
    - Pump tests can lower uncertainty, but they are of limited value for LFG model “calibration” unless long-term and large scale (very costly)
  - Model estimates of LFG generation and recovery
    - Professional with international modeling experience
  - Preliminary LFG system design for cost estimates
  - Capital and operating cost estimates for collection system, blower/flare station, electricity generation facility, LFG treatment and pipeline for direct use
  - Economic evaluation of project options
  - Environmental benefits and CERs
  - Conclusions and recommendations – viable project?

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Project Planning Process Issue: Gas Rights and Owner's Expectations

- Ownership of gas rights may be unclear
  - Multiple parties with claims
- Unreasonable expectations of owners
  - Owner may believe there is more gas than actually there
  - Expectations of high royalties for rights can deter developers
  - Project revenues may not fully cover site remediation costs
- Possible result: project delayed (less CERs) or never occurs

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2D. Project Planning Process – RFP for Project Developers & Investors

- Bid process for winning a project development contract often rewards optimistic estimates of CERs
  - Developers play off of owners' high expectations
  - Combines with poor understanding & high uncertainty of LFG modeling to overestimate project potential
- Solution is for LF owner to: a) have realistic expectations; and b) not rely on developer's projected revenues for evaluating bids
  - Have LFG pre-feasibility/modeling expert do CER estimates
  - Require bids based on $/CER rate
  - Require meeting performance standards including system completion schedules

2E. Project Planning Process – Developing a PDD

- LFG projects – use UNFCCC Methodology ACM0001 Version 11 and approved “tools”
  1. General description of project activity
  2. Description of emission sources w/in “project boundary”
  3. Identify baseline – currently flaring or required to flare?
  4. Establish “additionality” – would project create GHG emission reductions above BAU?
  5. Identify emission reductions = Baseline – project emissions
  6. Calculate emission reductions (“ex ante”)
  7. Description of monitoring plan
  8. Analysis of environmental impacts
  9. Stakeholders comments (minutes of meeting)

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2F. Project Planning Process – CDM Validation & Registration

- Validation – PDD reviewed by Designated Operational Entity
  - Checks if PDD meets all CDM requirements
  - If PDD approved by Executive Board, DOE finalizes validation
- Registration – formal acceptance of CDM project
  - Review by EB if requested
  - CDM project approved or rejected by EB

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3A. Operations & Management: Landfill & Leachate

- Lack of soil cover, liners, waste compaction, or controlled tipping areas
- Unstable side-slopes; potential for fires; uncontrolled public access
- No leachate management system (runoff control, drainage, treatment)
- Remediation required before collection system installation:
  1. Re-grade
  2. Close & install final cover
  3. Leachate and runoff control
  4. Site security

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3B. O&M: LFG System

- Ongoing system maintenance and monitoring program required to:
  - Maximize effective collection system function
  - Limit gaps in monitoring methane destruction
  - Manage limitations imposed by site conditions and system design

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4. LFG System Design and Installation

- Design issues:
  - Commitment of resources to system components and wellfield coverage appropriate for site conditions
    - Accounting for site geometry and management history
    - Closed vs. active site/cells – vertical vs. horizontal wells
    - Liquids (condensate and leachate) drainage issues, pumping and treatment requirements
    - Design to accommodate maintenance & monitoring
  - Timing/phasing of system expansions (active sites)
- Completeness of system installation
  - Delays in developing active disposal cells cause the loss of CERs from waste that produces the most methane
  - Leachate issues (high cost of treatment) can limit extent of site development

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5. LFG Models – Uncertainty and Overestimation

- LFG recovery projections (using LFG models) are basis of entire planning process
  - Main determinant of project feasibility & requirements
  - LFG modeling methods (U.S. EPA LandGEM 1st order model) well known but input assumptions uncertain:
    - Waste disposal rates and composition
    - Waste decay rate constant (k) = ln(2)/half-life ($year^{-1}$)
    - Ultimate methane yield (L_0) = m^3 CH_4/Mg waste
    - Collection efficiency = m^3 collected / m^3 generated (%)
  - International modeling poorly understood due to lack of data, uncertain methods of accounting for site conditions
- Historic overestimation of LFG recovery and CERs
  - Monitoring reports (actual project results when applying for CERs) indicate project performance
  - Compare to PDD model prediction – average ~50%

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CDM Project Performance as a % of Projected Recovery*

- 2003 - 1 project: 60%
- 2004 - 4 projects: 54%
- 2005 - 10 projects: 44%
- 2006 - 21 projects: 30%
- 2007 - 37 projects: 47%
- 2008 - 41 projects: 55%
- <u>2009 - 30 projects: 59%</u>
- **Overall average: 49%**

***Based on total actual CH_4 recovery from monitoring report data (available on the UNFCCC website for 60 CDM LFG projects as of 12/12/09) divided by total projected CH_4 recovery from PDDs. CER deductions for baseline, methane destruction efficiency, etc. were added to estimate CH_4 flows.**

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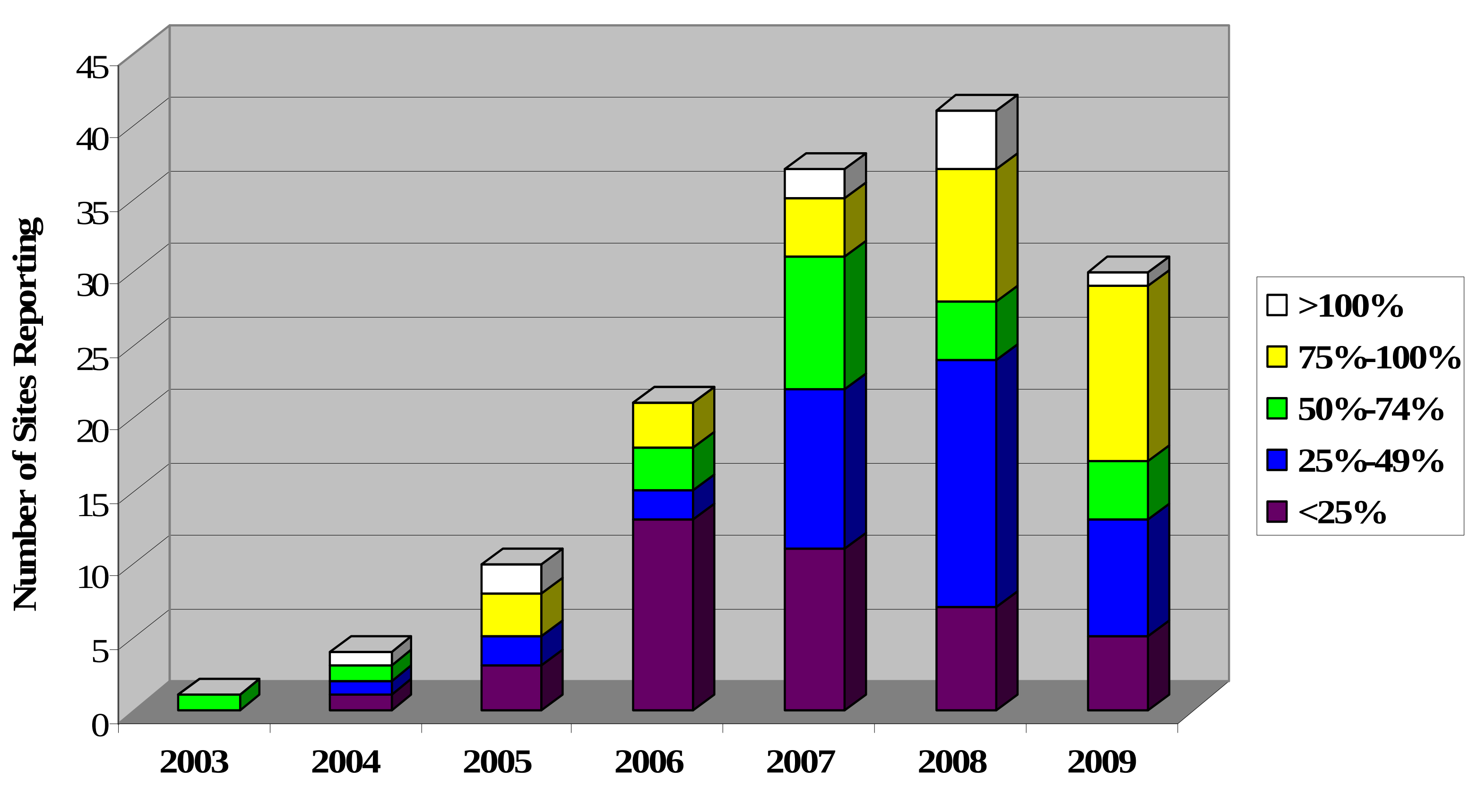
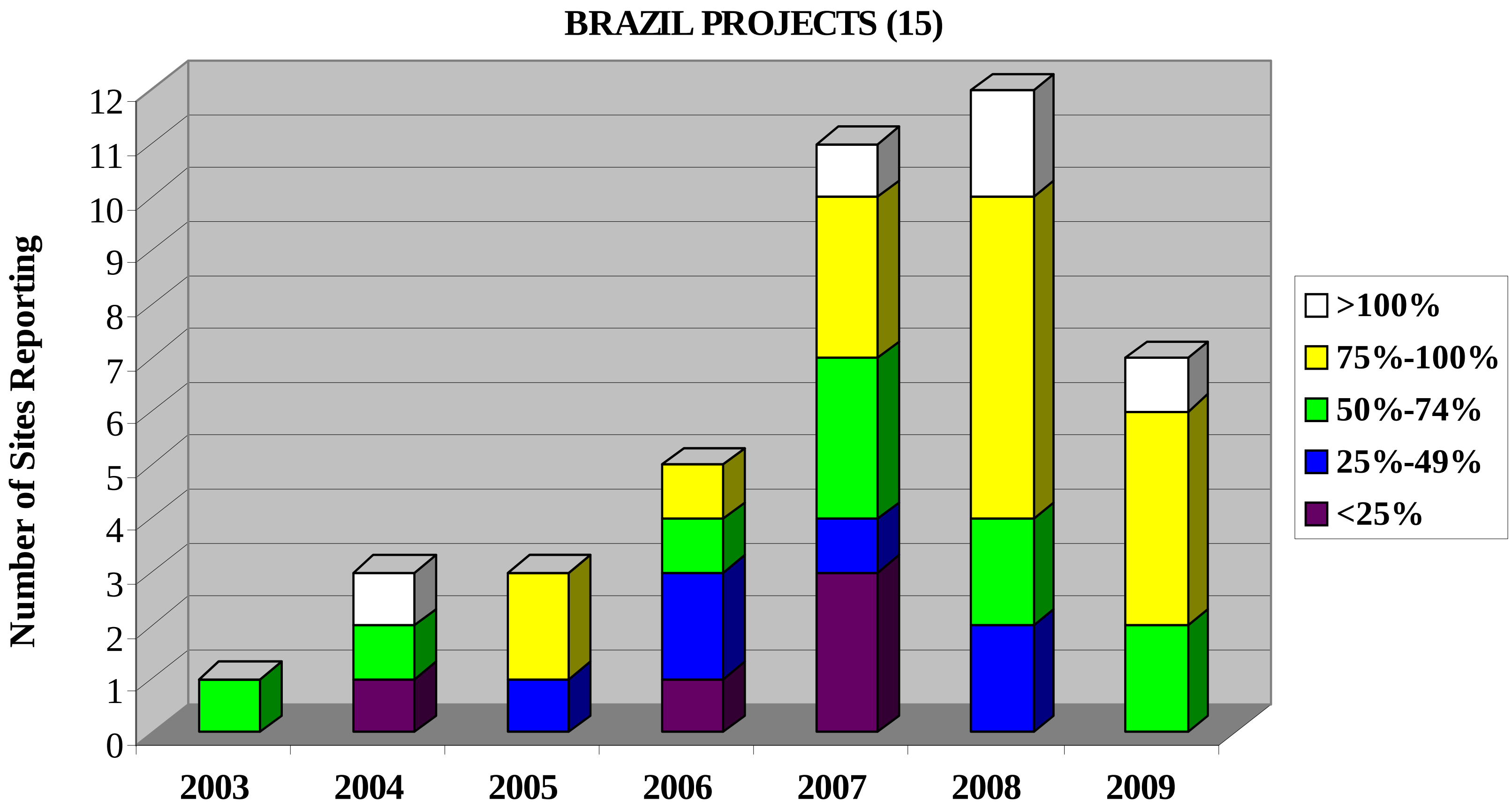
CDM Project Performance as a % of Projected Recovery



Actual Project Performance % of Projected Recovery - Brazil Projects (15)



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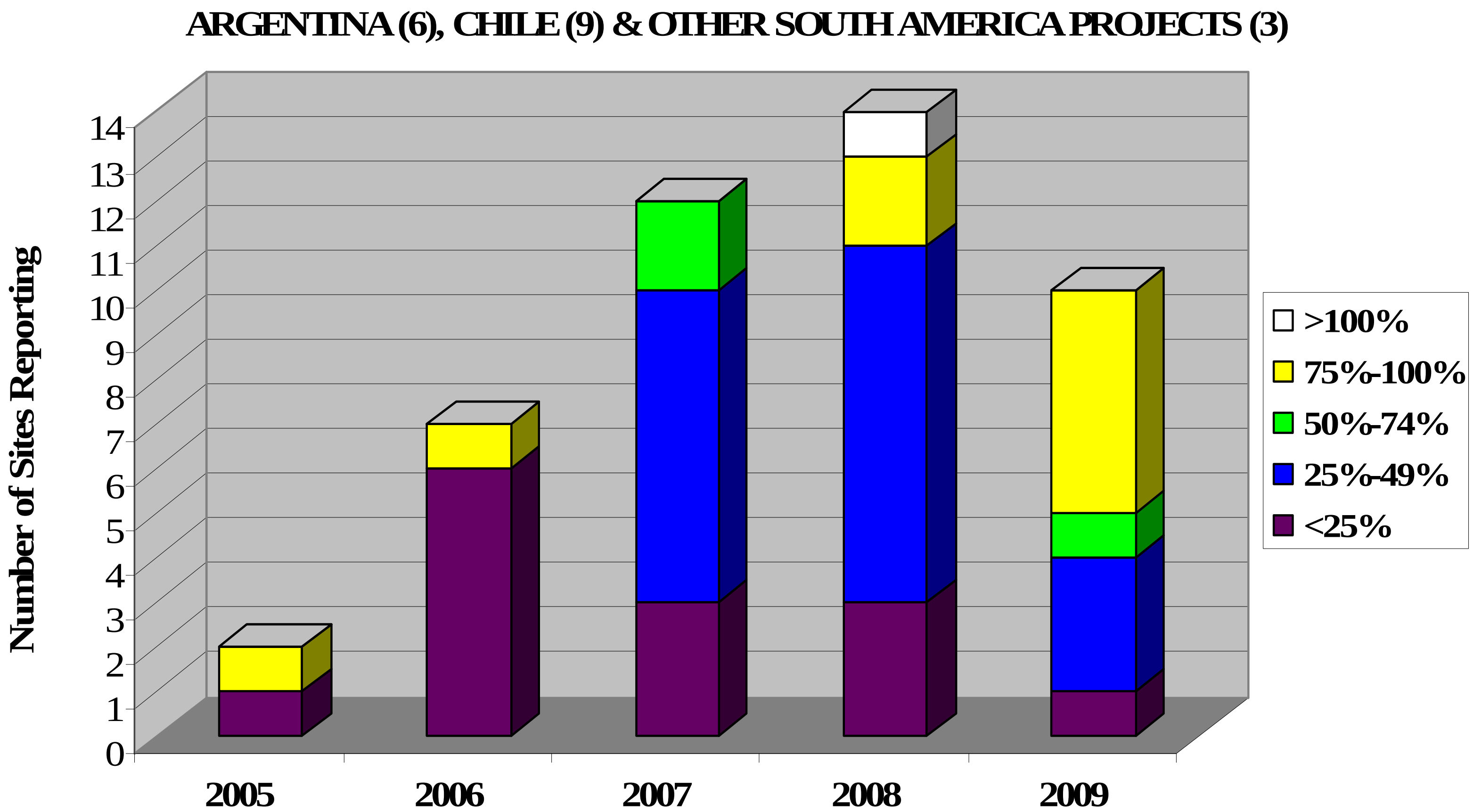
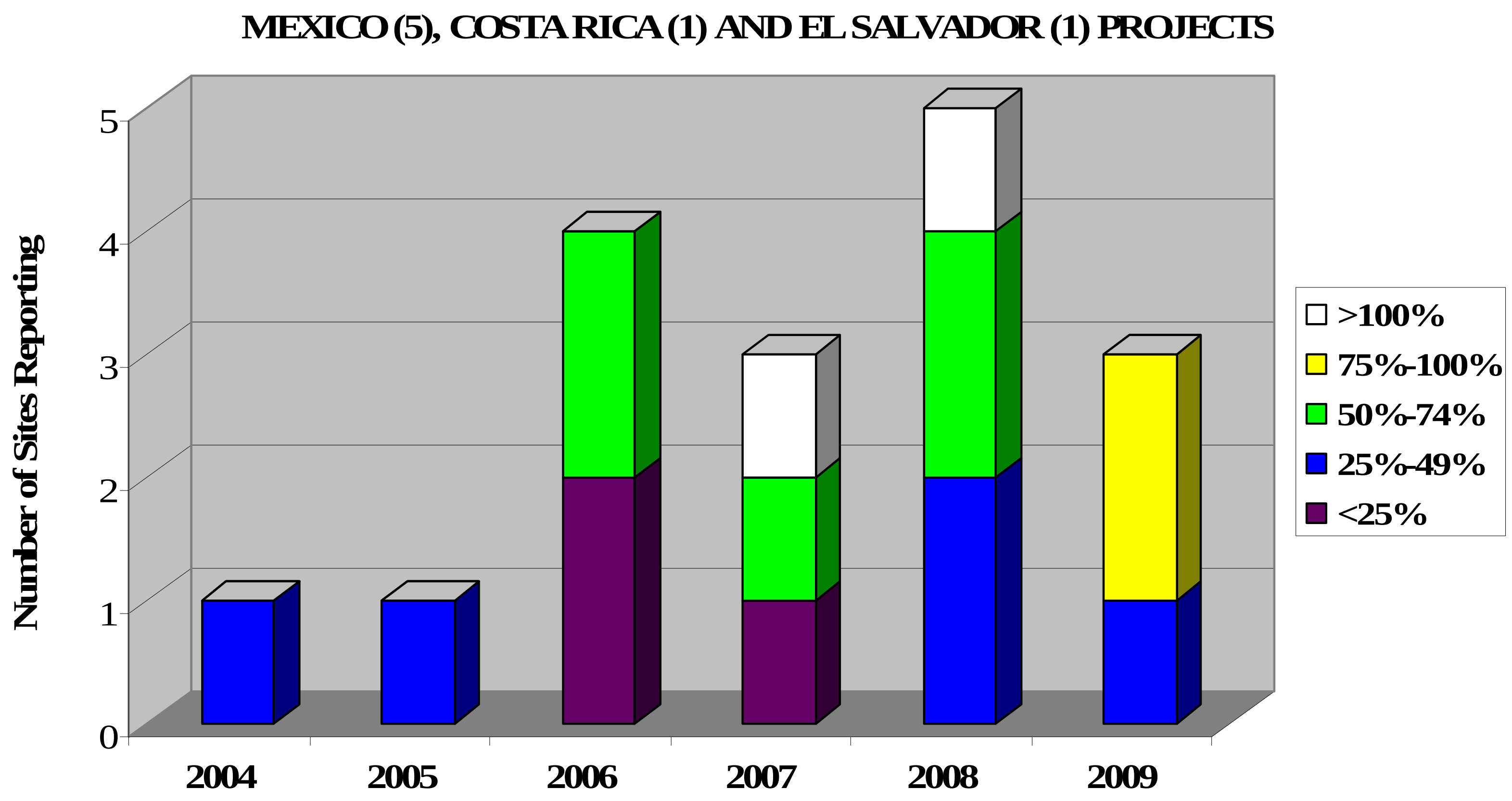
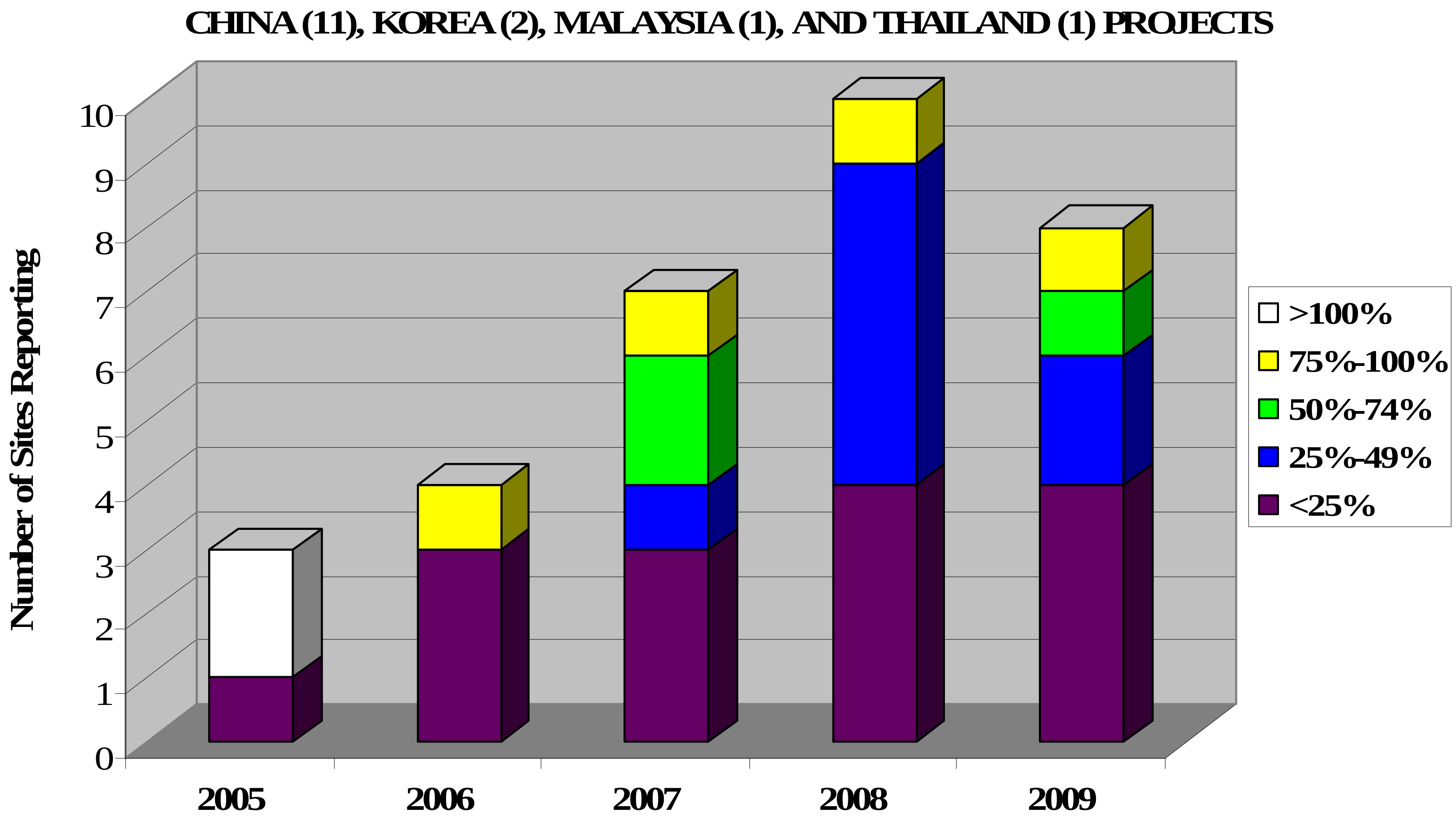
Actual Project Performance % of Projected Recovery – Argentina, Chile & Other South America Projects (18)



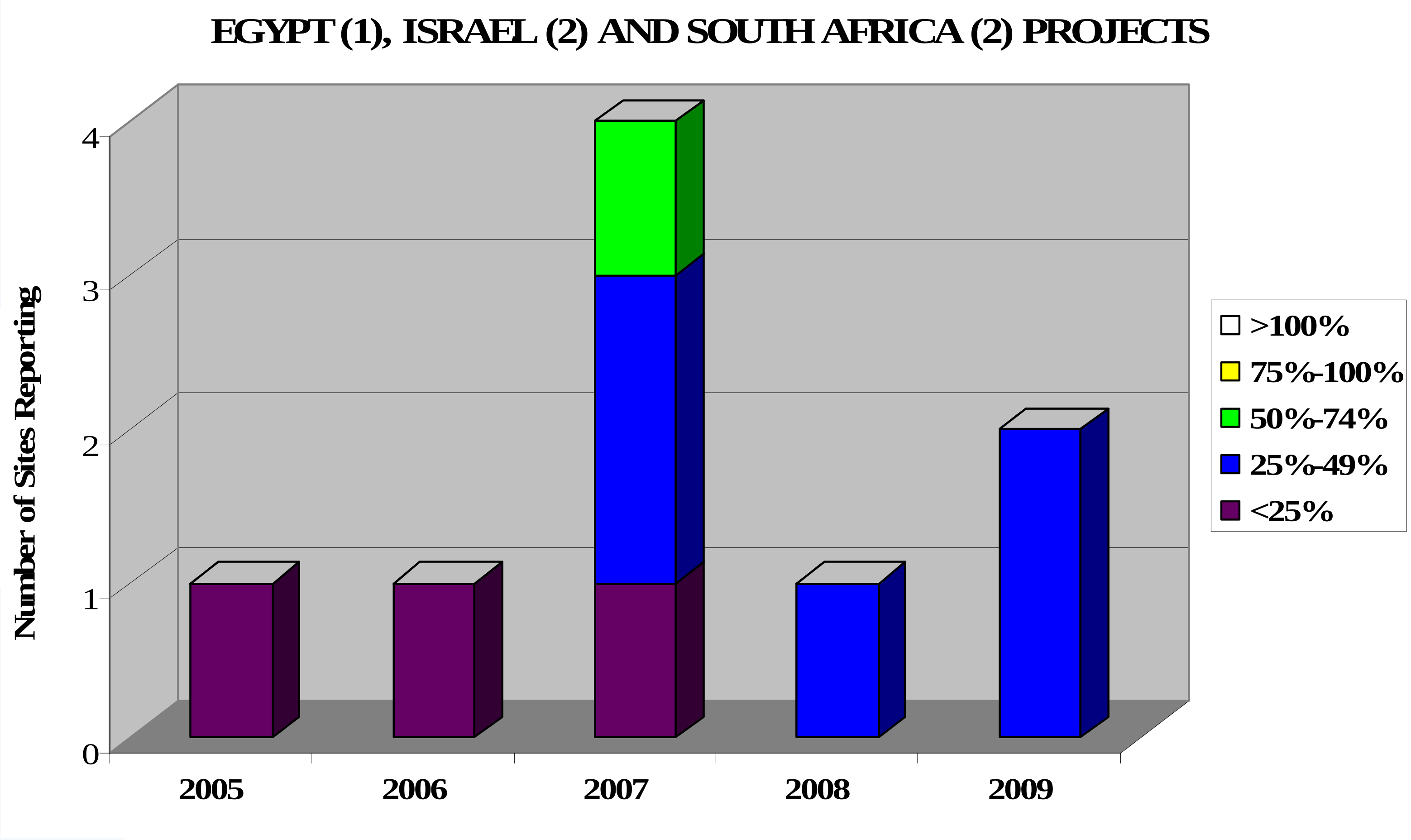
Actual Project Performance % of Projected Recovery – Mexico and Central America Projects (7)



Actual Project Performance % of Projected Recovery – Asia Projects (15)



Actual Project Performance % of Projected Recovery – Middle East and Africa Projects (5)



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Causes of Under-Delivery

- Bad LFG modeling practices
  - Failure of model assumptions to account for site conditions, reasonable system installation schedule
  - Project developer's lack of modeling expertise combined with incentives to overestimate CERs
- Site conditions and other challenges can hinder project implementation
  - LFG system design and O&M efforts may not be adequate to overcome difficult site conditions (e.g. leachate)
  - Delays in resolving political/financial issues and completing the planning and CDM process
  - Delayed or partial system installation causes large loss of LFG recovery and CERs
- How much of the CER shortfall was predictable/preventable?

LandGEM Shortcomings for International Applications

- U.S. EPA Landfill Gas Emissions Model (LandGEM) is based on U.S. waste composition
  - Other countries often have much higher % food waste
- Simple EPA model structure doesn’t work well with high food waste %
- Model provides only “wet” and “dry” U.S. k values
- Model provides estimates of LFG generation only, not recovery

Waste Composition & Climate in Developing Countries

- High food waste content:
  - Model L_0 needs to be adjusted to account for moisture content (inert %)
  - Fast decay rates (k) cause a steep decline in LFG generation after closure
  - Rapid waste decay = short time for capturing emissions
- Leachate buildup likely unless very dry climate

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IPCC Model (2006)

- International first-order decay model – improvements over LandGEM:
  - Assigns k values based on 4 climate categories
  - Uses different k values for each of 4 organic waste categories (avoids LandGEM single k problem)
  - Includes a methane correction factor (MCF) to account for aerobic decay in unmanaged sites
  - Recognized by UNFCCC for CDM and JI projects
- IPCC Model shortcomings
  - Developed as a global model
    - Limited ability to reflect conditions in individual countries
    - Uses continental scale default waste composition values
  - Only two precipitation categories (k varies continuously with precipitation)
  - No guidance on estimating collection efficiency

Collection Efficiency

- Estimated based on an evaluation of :
  - Site conditions impacts (soil cover, leachate, geometry, etc)
  - Collection system coverage and build-out schedule
- Estimated upper limits based on site management:
  - Engineered and sanitary landfills: ~60-95%
  - Open and managed dump sites: ~30-60%

Under-Performing Projects or Overly Optimistic Models?

- In many cases, overestimates can be traced to common (avoidable) model problems:
  - Model Lo value too high – e.g. U.S. (NSPS) default
  - Use of simple first order decay model with single k value
  - High collection efficiency assumptions
  - Site conditions' impacts not anticipated
- How much of the CER shortfall was predictable or preventable?

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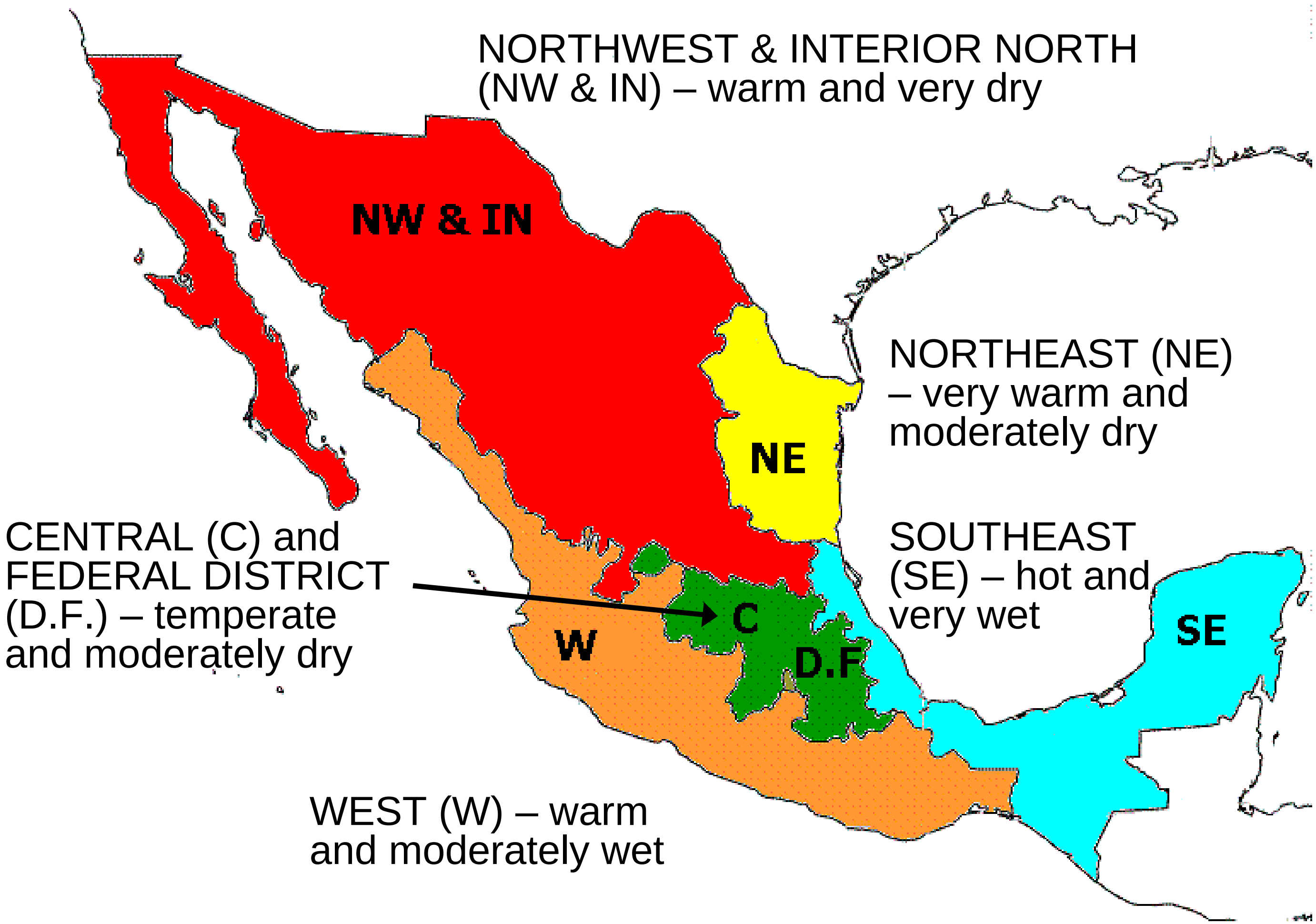
LMOP's Country-Specific LFG Models

- LMOP first recognized need for country-specific models in 2003 (Mexico model v. 1)
- 2007 – LMOP's Central America Biogas Model
- 2009 – LMOP released several country-specific LMOP models:
  - Ecuador LFG Model
  - China LFG Model
  - Thailand and Philippines LFG Models completed
  - Mexico LFG Model Version 2
  - Ukraine LFG Model
- SCS developed Central America, Mexico, and Ukraine LFG models

Mexico’s Climate Regions



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LMOP's Mexico LFG Model

- Model reflects Mexico's waste composition, climate, site conditions, and actual system performance at 4 project sites
  - Each state has default k and Lo values reflecting climate and average waste composition
  - Multi-phase model with 4 k values for different waste categories (similar to IPCC model)
  - Site visits and LFG flow data from 4 landfills used to validate model
  - User answers questions in input sheet – model automatically calculates waste disposal rates and collection efficiency
  - Calculated default inputs can be overridden with site-specific data

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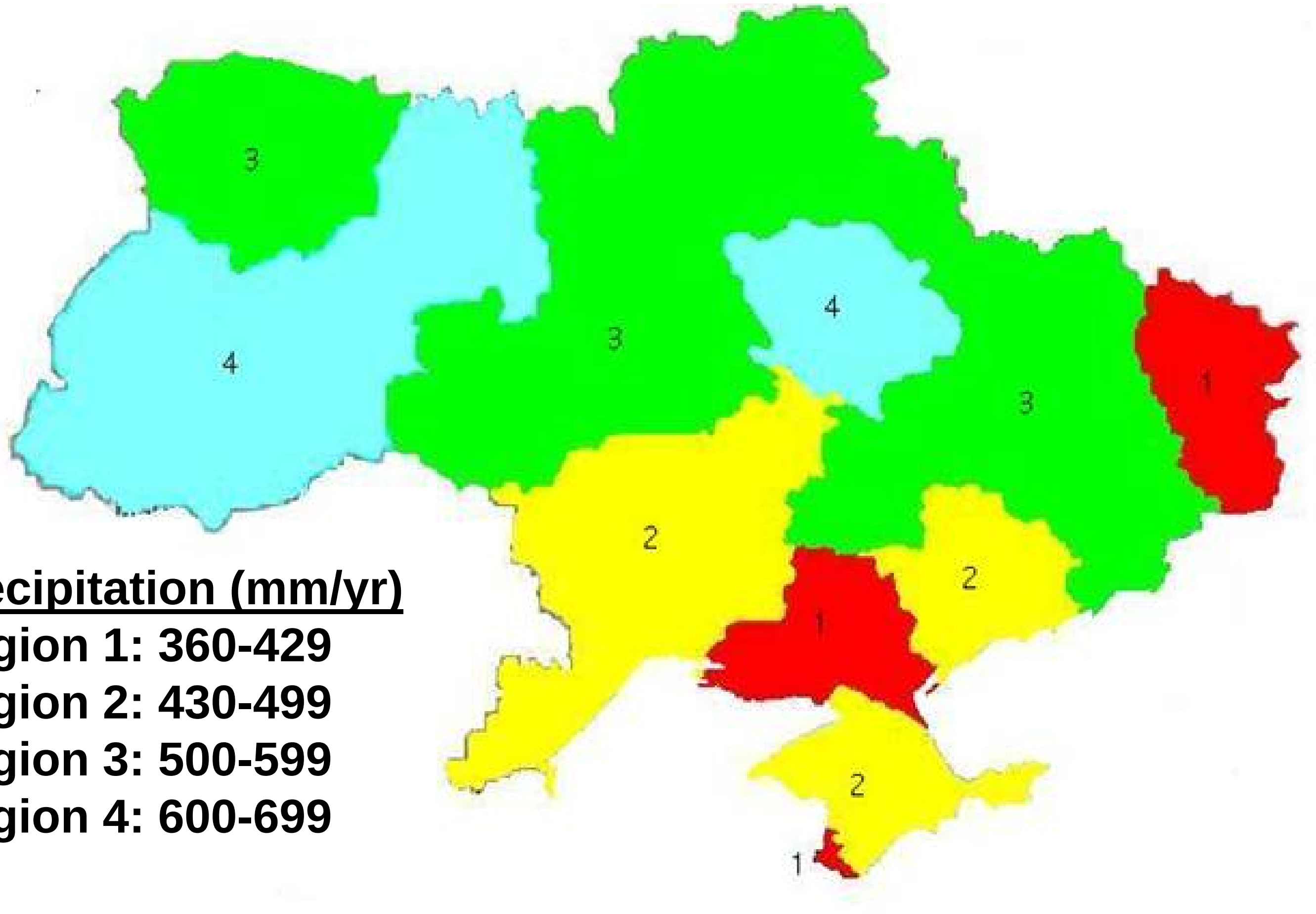
Ukraine’s Climate Regions



Precipitation (mm/yr)

Region 1: 360-429
Region 2: 430-499
Region 3: 500-599
Region 4: 600-699

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LMOP's Ukraine LFG Model

- Model reflects composition of wastes disposed in Ukraine's landfills
- Model reflects local climate – varies inputs (k) based on average precipitation
- Structure model to capture Ukraine conditions
  - Use 4 k model structure
  - Include adjustments to LFG generation and recovery to account for site conditions
- Allow model to run with simple user inputs
  - Waste disposal rates and collection efficiency calculated from user's answers to questions

Summary

- Reviewed challenges to CDM LFG project implementation that have contributed to CER delivery shortfalls
  - Monitoring data not meeting PDD expectations
  - Shortfalls often result from inappropriate LFG model assumptions
  - Impacts of site conditions and other challenges to project success were not anticipated
  - Latest monitoring data show improvements (Better modeling? More project experience? Bad projects fall off list?)

Conclusions

- Improved LFG modeling = project CER expectations that are achievable
  - RFP/bidding and selection process for project developers and investors can benefit from realistic assessment of project potential
- LMOP's country-specific LFG models:
  - Provide better accounting of waste composition and site conditions
  - Provide default collection efficiency assumptions that reflect likely challenges to collection system design and O&M

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For More Information:

- For more information about this presentation, contact Alex Stege at: astege@scsengineers.com
- LMOP's international LFG models are available at: www.epa.gov/lmop/ international/index.htm
- IPCC Model is available at: www.ipcc-nggip.iges.or.jp/ public/2006gl/vol5.htm