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Assessing Landfill Methane Utilization Project Potential at Disposal Sites in India

Alex Stege, SCS Engineers

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Landfill Methane to Markets Workshop

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Presentation Topics

- Assessing landfill methane utilization project potential at disposal sites in India
- International landfill biogas models
- Modeled biogas recovery for landfills in Delhi, Mumbai, Ahmedabad, and Kolkata using preliminary data
- Site visits to Hyderabad and Delhi landfills
- Preliminary estimates of biogas recovery and project potential based on data from landfill site visits

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Assessing Landfill Methane Project Potential

- Purpose of assessment study:
  - Preliminary screening tool to find sites suitable for full pre-feasibility study
  - Provides preliminary estimates of potential landfill biogas recovery rates
  - Examines landfill biogas project options
  - Identifies potential barriers to project implementation

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Elements of an Assessment Study

- **Site visit to collect data**:
  - Disposal rates – historical and future
  - Waste composition data
  - Landfill area, depth, liner, soil cover
  - Disposal practices, sequencing, compaction
  - Site security and scavengers
  - Leachate generation
  - Distances to potential end users, electricity substations
  - Identify potential landfill biogas ownership issues
- **Preparation of a landfill biogas model**
- **Discussion of project options: direct use, electricity generation, flaring only**
- **Discussion of barriers to project development**

Landfill Biogas Models – U.S. EPA

- **LandGEM**:
  - Landfill gas emissions model (v. 3.02, 2005) – first-order decay biogas generation equation:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

- Q_{CH_4} = Methane emission rate
- M = annual waste disposal (tonnes)
- k = methane generation (decay) rate (1/year)
- Lo = potential methane generation capacity (m^3/tonne)

  - Default k and Lo values developed for U.S. landfills: (regulatory vs. inventory; wet vs. dry sites)

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Landfill Biogas Models – U.S. EPA (LMOP)

- **Mexico Biogas Model** (EPA, 2003)
  - Model Lo derived from U.S. EPA inventory value based on Mexico's average waste composition
  - Model k values based on precipitation
    - Single k implies all waste types decay at same rate
    - Tends to over-estimate generation after closure
- **Central America Biogas Model** (available in April 2007)
  - Model Lo derived from Mexico Model value for each country based on waste composition
  - Model k values for wet (0.23/year) vs. dry (0.023/year) organic waste
    - Accounts for large differences in decay rates between waste types – more conservative post-closure projections

Landfill Biogas Models – IPCC

- **IPCC spreadsheet model** (IPCC, 2006)
  - Used to estimate country or region-specific methane emissions, but can be modified to model landfills
  - First order decay model with IPCC equation for methane generation per tonne of waste (Lo equivalent)
  - Default waste composition values are available for every region in the world
  - Assigns k values based on 4 climate categories (temperate wet and dry; tropical wet and dry)
  - Uses different k values for each of 4 organic waste categories
    - Limited range of values implies decay rates for different waste types effect each other

Landfill Biogas Models – Proprietary

- **Hybrid 1st Order Decay Model**
  - Derives Lo from U.S. value based on waste composition
  - Assigns 3 k values to organic waste fractions that vary with precipitation based on:
    - Fixed ratios of fast to medium to slow waste decay rates
      - High range of values (>IPCC Model ratios) based on laboratory studies
      - Implies different waste types' decay rates are independent of each other

Estimating Biogas Recovery – Collection Efficiency

- Model projects generation (or maximum recovery potential), not expected recovery
- Collection efficiency =

$$\frac{\text{Amount of landfill biogas collected}}{\text{Amount of landfill biogas generated}}$$

- Collection efficiency based on:
  - Facility type (sanitary landfill vs. unmanaged dump)
  - Waste depth, extent of soil cover, liners
  - Waste characteristics and leachate (permeability)
  - Type/design of collection system; extent collection system covers waste volume
  - Collection system operation

Landfill Biogas Recovery Rates

- Landfill biogas recovery = model estimate of generation x % collection efficiency
- Maximum achievable collection efficiencies:
  - Engineered and sanitary landfills: ~60-95%
  - Open and managed dump sites: ~30-60%

Landfill Biogas Modeling Challenges for India's Sites

- Assigning appropriate values for model k, Lo, and collection efficiency
  - Need to reflect India's waste composition
    - Developing countries have much higher % of food waste, lower % of paper and wood
  - Need to reflect India's climate
    - Account for very wet climate in tropical regions
  - Error in estimating collection efficiency can be >> error in model estimate of generation
    - Account for landfill design and operations, waste depth, and soil cover
    - Leachate nearly always a problem

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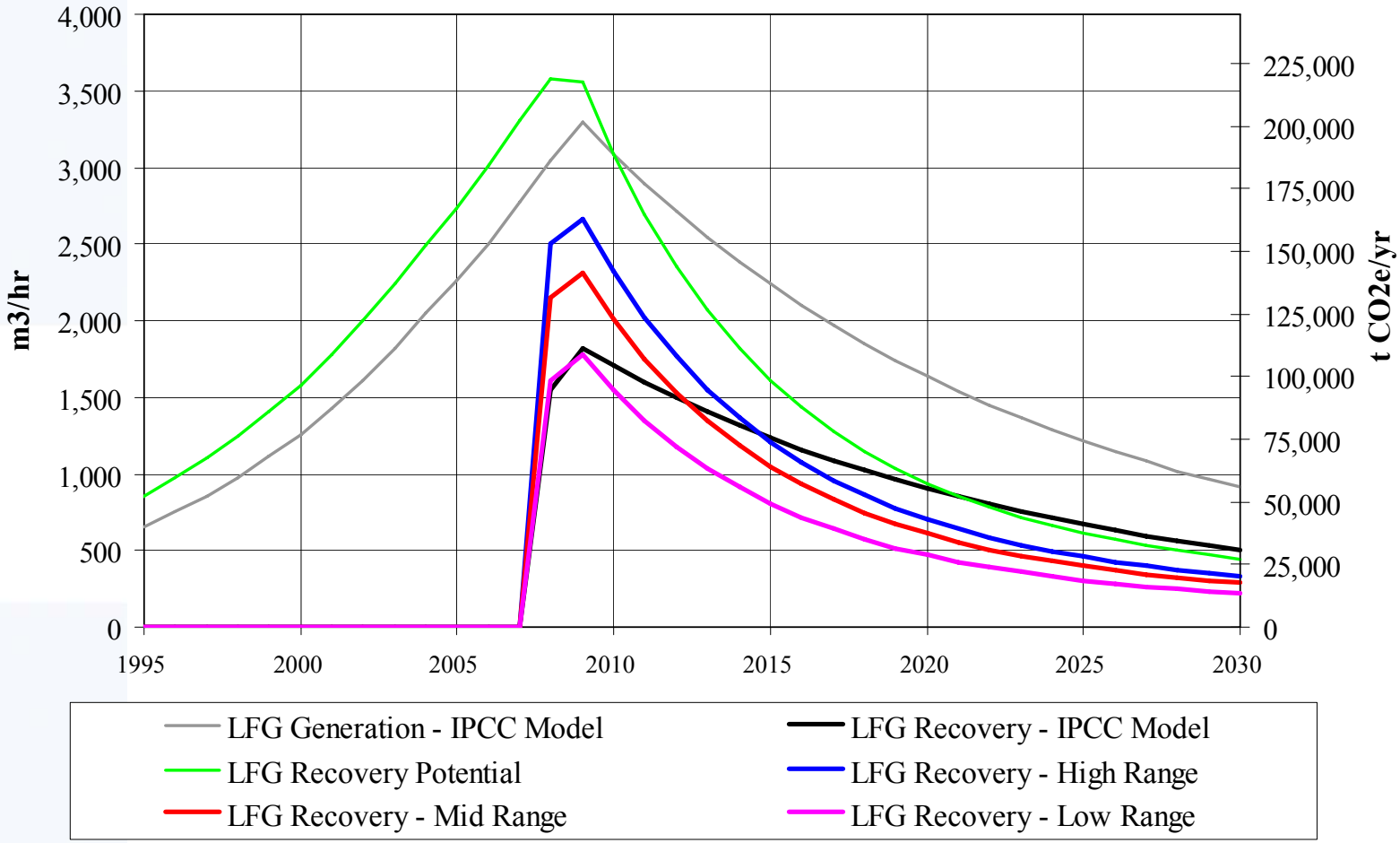
Landfill Biogas Generation and Recovery – Gazipur Landfill, Delhi



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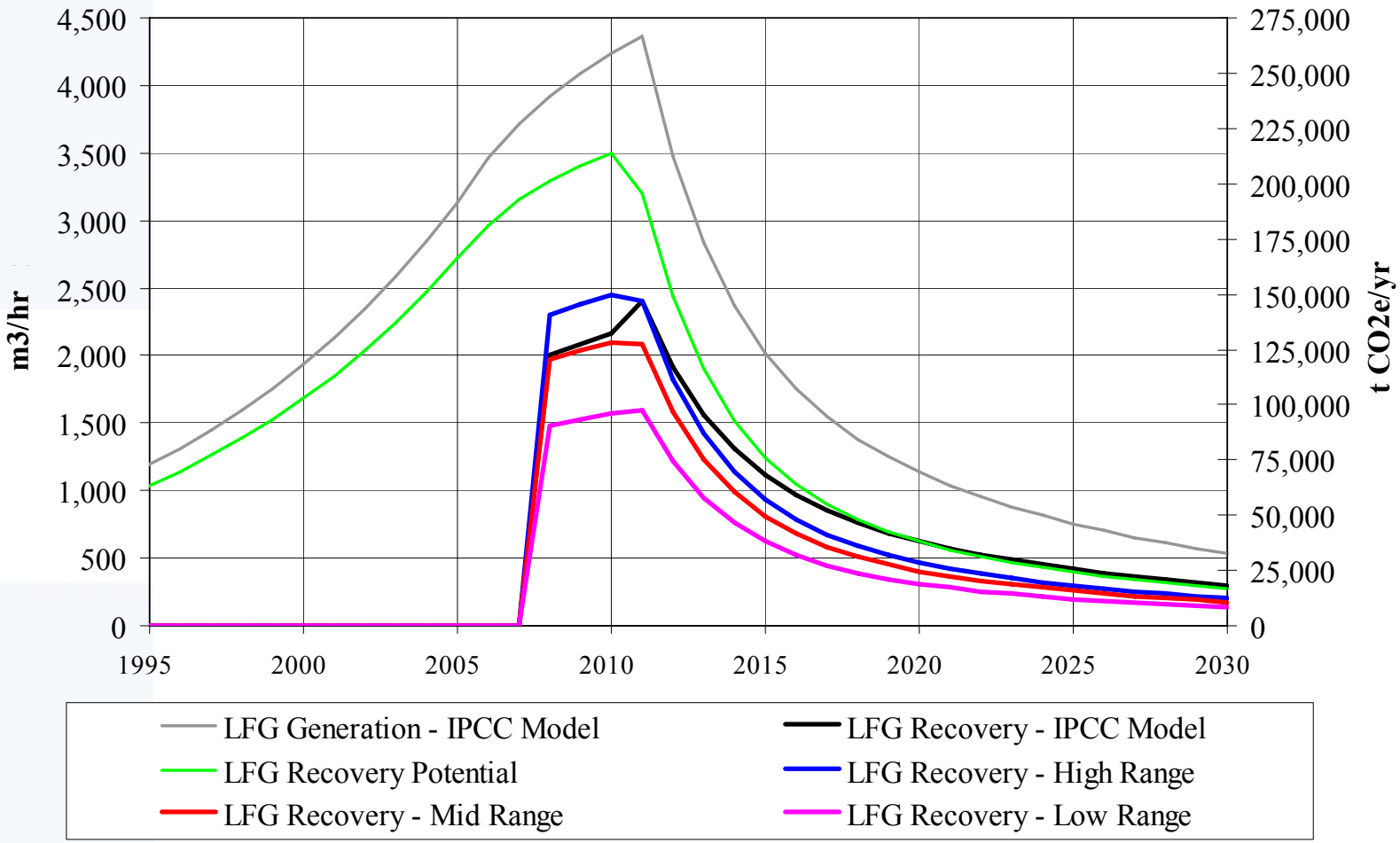
Landfill Biogas Generation and Recovery – Gorai Landfill, Mumbai



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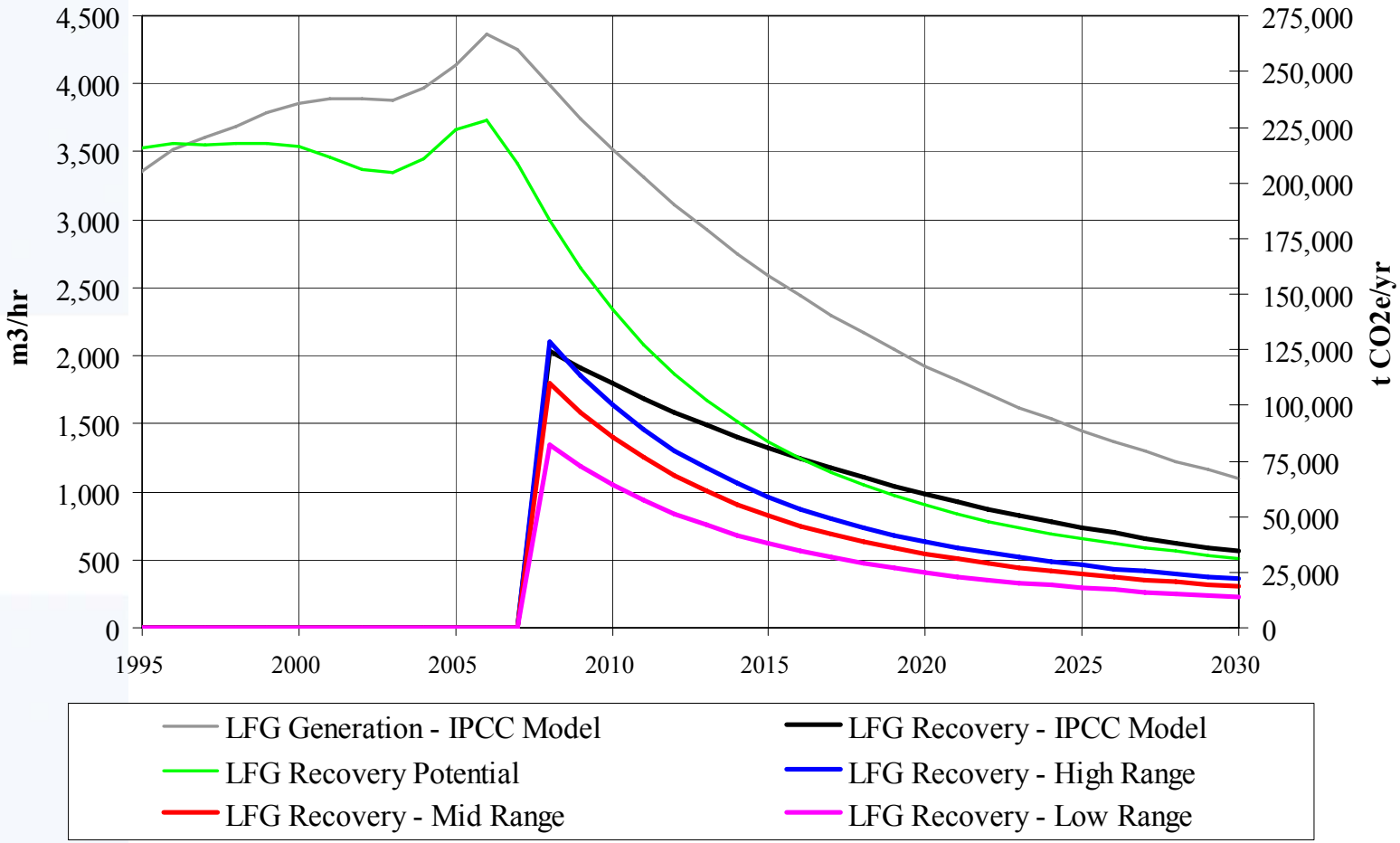
Landfill Biogas Generation and Recovery – Pirana Landfill, Amhedabad



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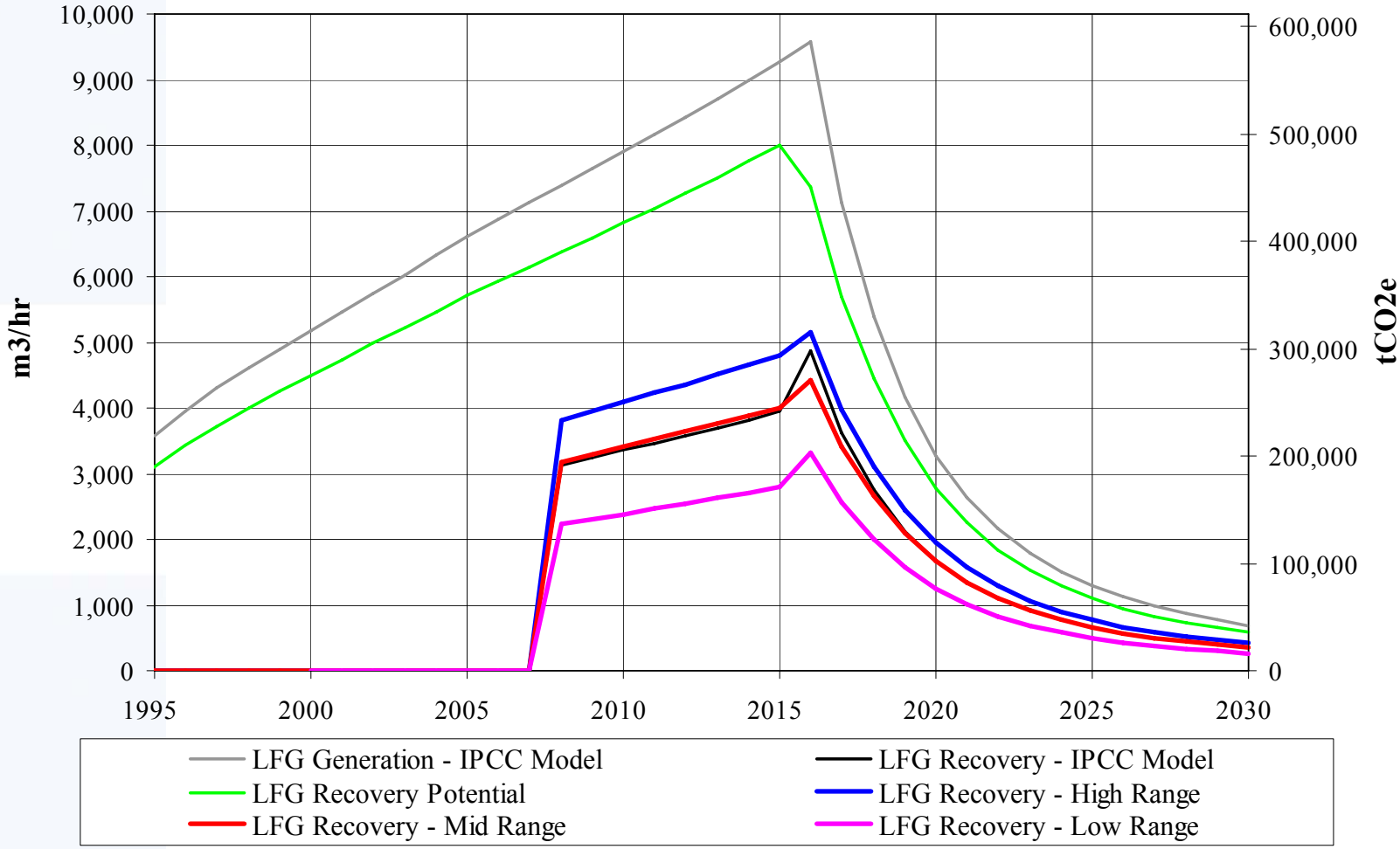
Landfill Biogas Generation and Recovery – Dhapa Landfill, Kolkatta



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Data Collected from Autonagar Landfill, Hyderabad

- **Waste disposal and composition data**
  - 400 – 1800 tonnes/day disposed (no records available)
  - Approximately 2.6 million m^3 volume remains today
  - Over 50% inert waste disposed 1984-1997
  - Site closed in 2005
- **Landfill characteristics:**
  - Waste area = 45 acres
  - Waste depth averages 10-15 m; no uniform depth
  - Limited waste compaction; density ~650 kg/m3
  - No soil cover, shallow depth, and fires created aerobic conditions – “semi-aerobic” dump site
  - Currently mining the LF for compost
- **Closest potential end users: truck transfer depot with maintenance, welding ~0.5 km**
- **Closest electrical substation = ~1 km**

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Landfill Site Visit - Autonagar Landfill, Hyderabad

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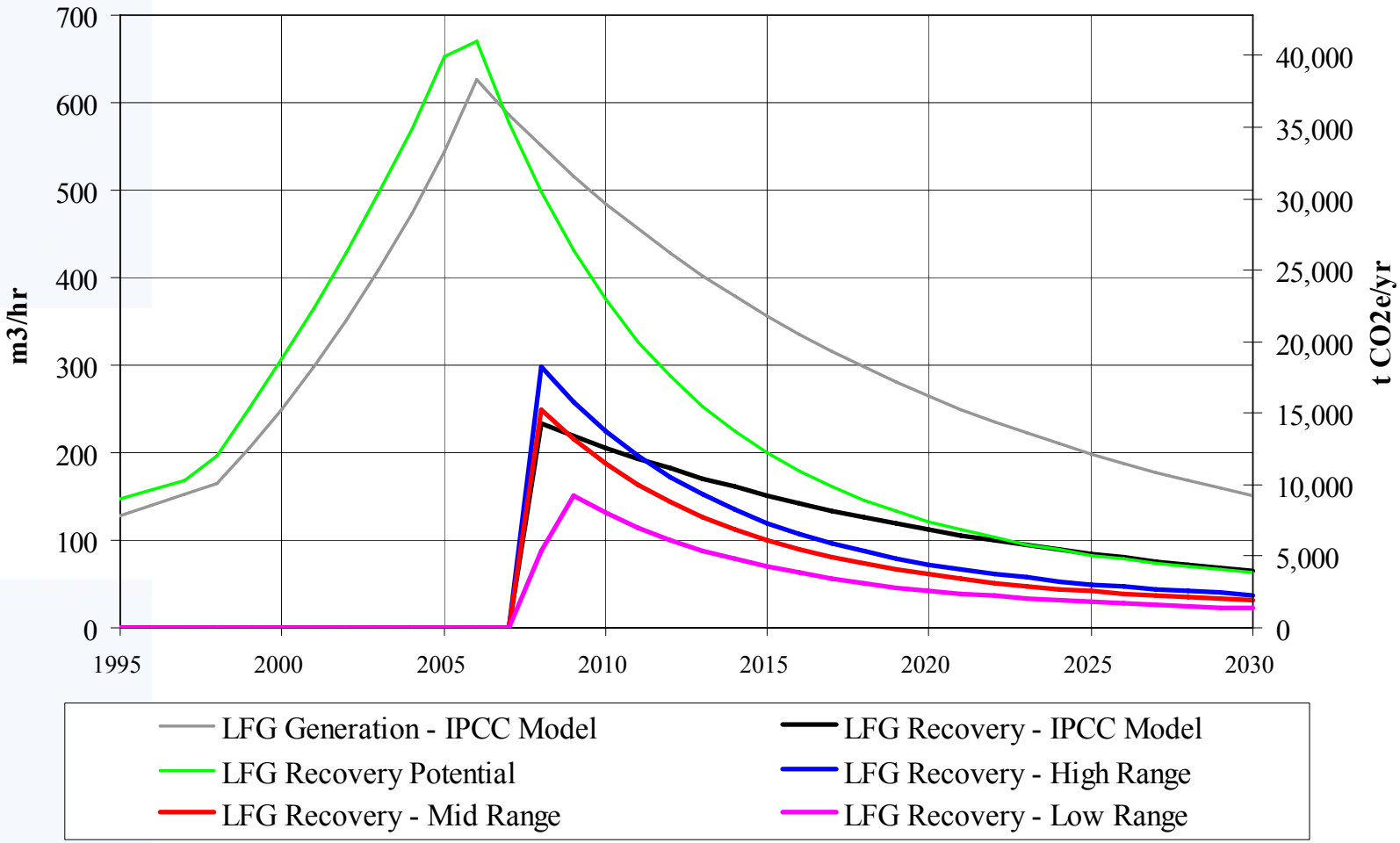
Landfill Biogas Generation and Recovery – Autonagar Landfill, Hyderabad



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Data Collected from Okhla Landfill, Delhi

- **Waste disposal and composition data**
  - Recent annual disposal rates (to be provided)
  - Approximately 5.7 million tonnes in place
  - Site expected to close in 2008
- **Landfill characteristics:**
  - Waste area = 54 acres
  - Waste depth averages 20-25 m; depth uniform over ~50% of site
  - Limited waste compaction; density range: 400-900 kg/m^3
  - No soil cover except C&D waste used
- **Closest potential end users: cement plant and hospital adjacent to site**
- **Closest substation = <0.5 km**

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Landfill Site Visit - Okhla Landfill, Delhi

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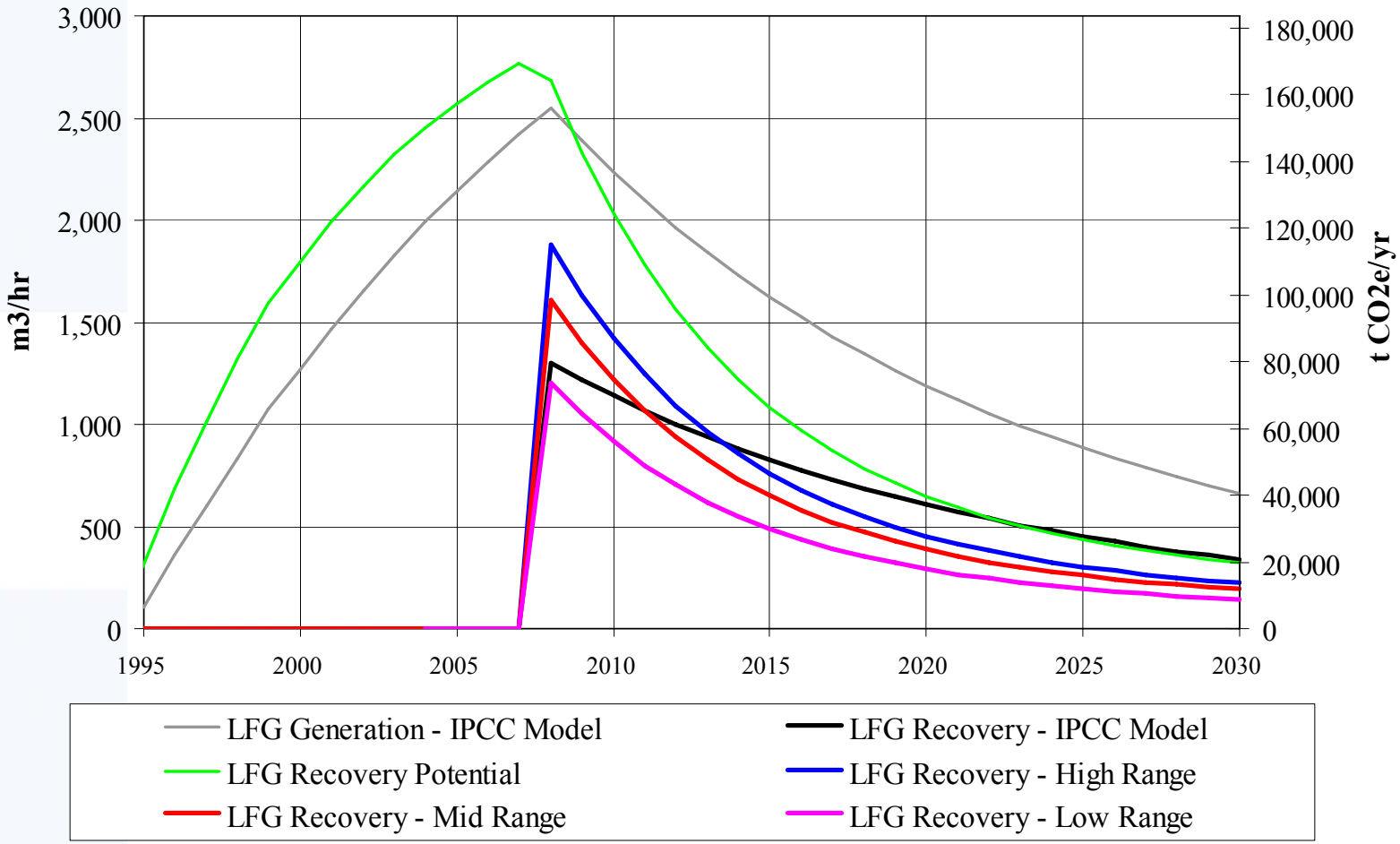
Landfill Biogas Generation and Recovery – Okhla Landfill, Delhi



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Conclusions

- **LMOP is developing assessments of landfill biogas utilization project potential for sites in India**
  - Prepared LFG generation and recovery model projections for sites in Delhi, Mumbai, Kolkatta, Hyderabad, and Ahmedabad
  - Conducted visits to two sites for additional data to assess project potential:
    - Autonagar Landfill (Hyderabad) – very limited project potential
    - Okhla Landfill (Delhi) – project potential may be good if site closed and remediated

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Conclusions

- **Models to estimate international landfill biogas generation and recovery are available:**
  - LMOP Mexico and Central America Biogas Models
  - IPCC Model
  - Models help lower uncertainty in estimating project potential, especially when site-specific data are available
- **Uncertainty estimating collection efficiency represents large potential source of error**
  - Site visits, followed up by field testing can provide site-specific information and lower uncertainties

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Next Steps and for More Information

- Complete Assessment Reports
- Decide if Pre-feasibility Study is to be conducted; select site; conduct study
- LMOP continuing to provide training to developing countries through M2M (www.methanetomarkets.org)
- Mexico Landfill Biogas Model currently available, Central America Landfill Biogas Model will be available at: www.epa.gov/lmop/international.htm
- IPCC Model available at: www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.htm

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Thank you!