Development of Application Procedure of the Tier 2 Methodology for CH_4 Emission from Korean Landfills

Seungdo Kim
Pyrolysis Research Laboratory
Dept. of Environmental System Eng.
Hallym University

Introduction

Hierarchy of Solid Waste Management in Korea

- Reduction
- Reuse
- Recycling
- Energy Recovery
- Incineration
- Landfill

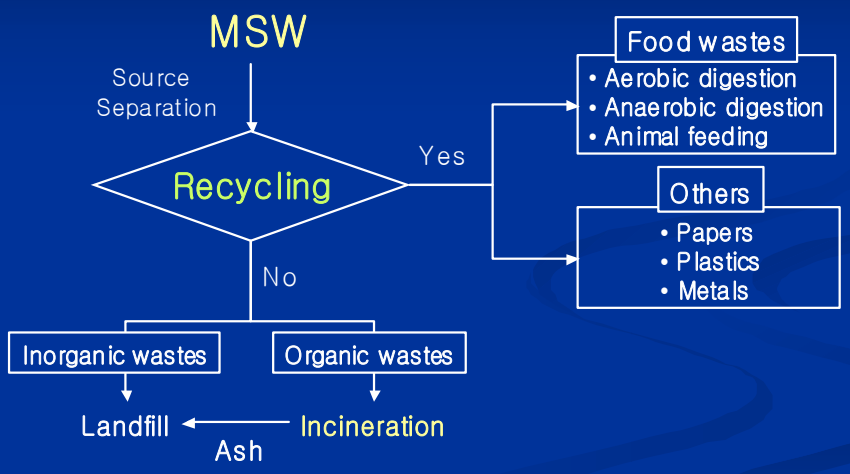
Treatment Trend of Municipal Solid Waste in Korea

Year	Landfill (%)	Incineration (%)	Recycling (%)
1995	72.3	4.0	23.7
2000	47.0	11.7	41.3
2005	31.0	23.0	46.0

MSW Compositional Generation Rate(2001 year)

Item			Generation	Landfill	Incineration	Recycling
Total (ton/day)			48,498.6	21,000.2	6,576.3	20,922.1
Municipal Solid Waste	Combustibles	Sum (ton/day)	28,663.6	15,550.6	6,475.7	6,637.3
		Food wastes (%)	32.81	34.31	8.93	56.76
		Papers (%)	16.78	62.53	35.64	1.83
		Woods (%)	7.01	52.56	45.19	2.25
		Rubber &Leather (%)	3.48	66.45	32.90	1.65
		Plastics (%)	7.25	66.90	31.42	1.68
		Others (%)	16.37	78.26	20.84	0.90
	Non-Combustibles	Sum (ton/day)	5,582.5	5,311.6	80.2	190.7
		Briquette ash (%)	1.76	91.52	—	8.48
		Metals & Glasses (%)	2.78	94.86	1.16	3.98
		Earth & Sand (%)	3.08	97.83	0.02	2.15
		Others (%)	8.67	95.02	2.32	2.66
	Recyclables	Sum (ton/day)	14,252.5	138.0	20.4	14,094.1
		Papers(%)	45.10	0.26	0.08	99.66
		Glasses (%)	15.47	1.34	—	98.66
		Metals (%)	19.82	0.40	—	99.60
		Cans (%)	4.44	2.38	—	97.62
		Plastics (%)	8.60	1.85	0.72	97.43
		Others (%)	6.56	4.51	0.72	94.77

Management Schemes of MSW in Korea

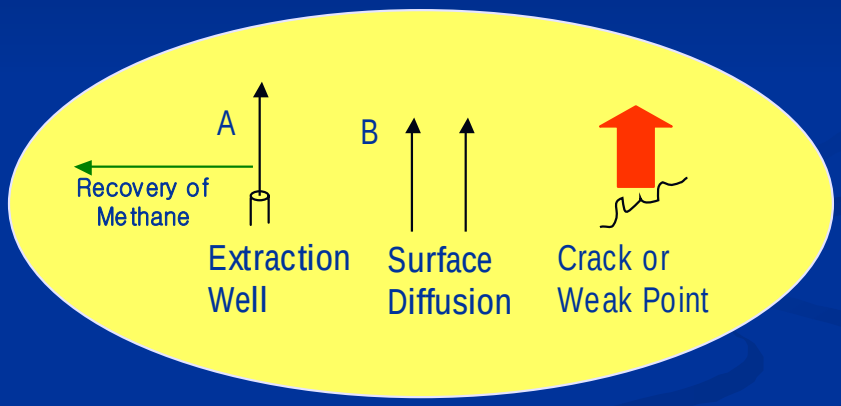


Estimation Methodology of CH_4 from Landfill : Tier 2

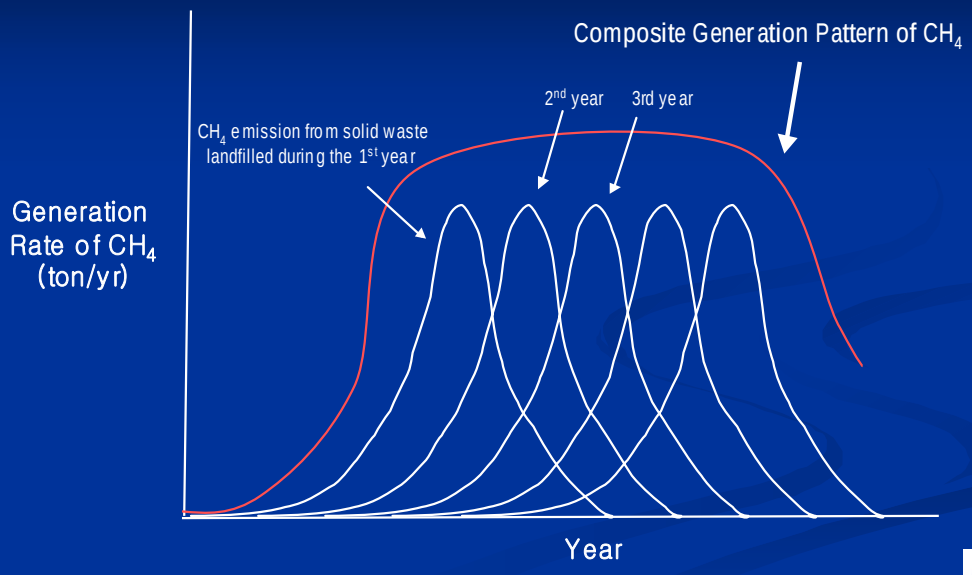
Questions to be Answered

- Why should we apply the Tier 2?
- How much the accuracy may be improved as a result of applying the Tier 2?
- What would be the most efficient approaches to adopt the Tier 2?

Methane Emission from Landfill: (1) Extraction Well, (2) Surface Diffusion



Emission Pattern of CH_4 from Landfill over time



Methodologies suggested by IPCC

- **Tier 1**

CH_4 (ton/yr) = (MSW_T x MSW_F x MCF x DOC x DOC_F x F x 16/12 –R) x (1-OX)

❖**Assumptions**

(1) CH_4 generated by the waste is released in the same year the waste is deposited

(2) Landfilled amount is relatively constant over time

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If waste disposal increases at about 2% per year over a 20~30 year period, the Tier 1 method would overestimate emissions by about 20~25%.

Methodologies suggested by IPCC

- **Tier 2**

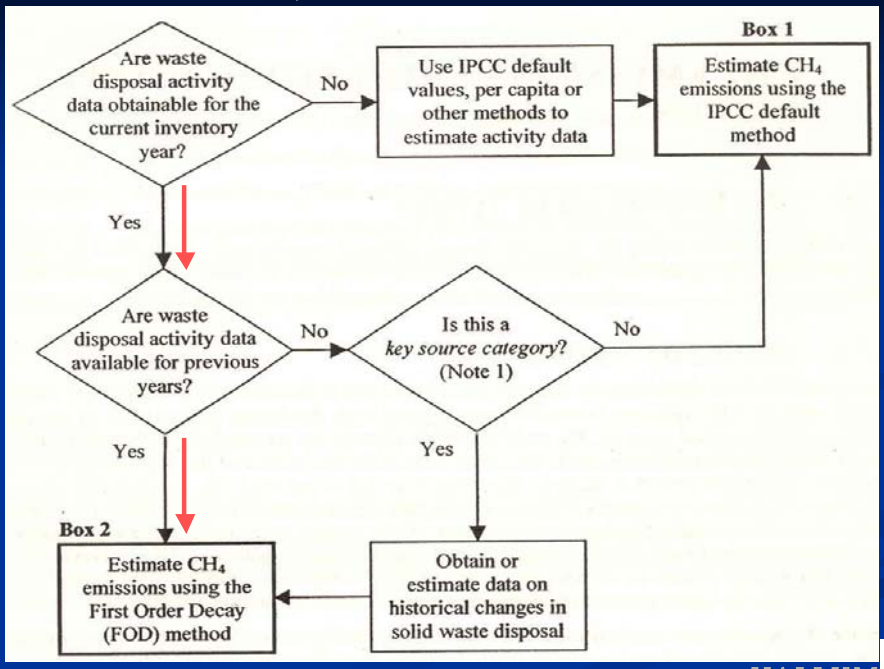
$$Q_{CH_4} = L_0 \times M_t \times \{\exp(-kc) - \exp(-kt)\}$$

L_0 : Methane Generation Potential
M_t : Annual amount of solid waste landfilled
k : Methane generation constant (yr^{-1})

❖**Basics**

(1) CH_4 is emitted over a long period of time rather than instantaneously
(2) First-order decay model has been broadly used to model generation rate of CH_4 from landfills

Decision Tree for CH_4 Emissions from Solid Waste Disposal Sites



What are the difficulties in applying the Tier 2?

- Lack of information on MSW landfilled previously
  - resulting in difficulty in estimating L_0 value
- Lack of information on how to measure the surface diffusion of CH_4
  - resulting in difficulty in estimating k value

Methane Generation Kinetics

Methane Generation Kinetic Equation

$$\frac{dM_{CH_4}}{dt} = k \cdot L_0 \cdot M_{sw}$$

Tier 2	$Q_{CH_4} = L_0 \times M_t \times \{\exp(-kc) - \exp(-kt)\}$
Revised Tier 2	$Q_{CH_4}(t) = \sum_{i=1}^{N} M_0(i) L_0(i) [\exp\{-k(t-i)\} - \exp\{-k(t-i+1)\}]$

Key Parameters for Tier 2 Methodology

- **L_0 (Methane Generation Potential)**
  - **L_0 = MCF x DOC x DOC_F x F x 16/12**
    - ✓ **MCF: 0.4~1.0**
    - ✓ **DOC: Country Specific Equation**

DOC(%) = 0.114 x FW + 0.320 x PA + 0.366 x WO + 0.571 x RU + 0.061 x SL + 0.114 x AN + 0.285 x OT

    - ✓ **DOC_F : 0.5~0.6**
    - ✓ **F: 0.4~0.6**

Key Parameters for Tier 2 Methodology

- **k (Methane Generation Constant)**

(1) First Methodology

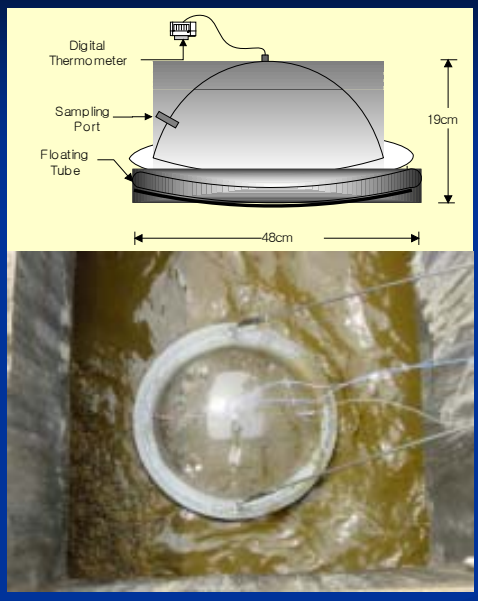
$$k = \frac{-\beta + \sqrt{\beta^2 - 4\alpha\gamma}}{2\alpha}$$

where

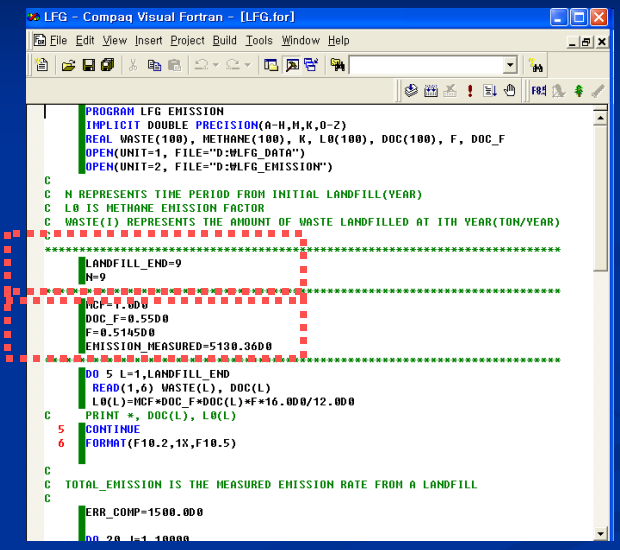
$$\alpha = \frac{c^2 - t^2}{2}, \beta = t - c, \gamma = \frac{Q_{CH_4}}{L_0 M_t}$$

(2) Second Methodology
Best fit to generation rate of CH_4 at a certain year

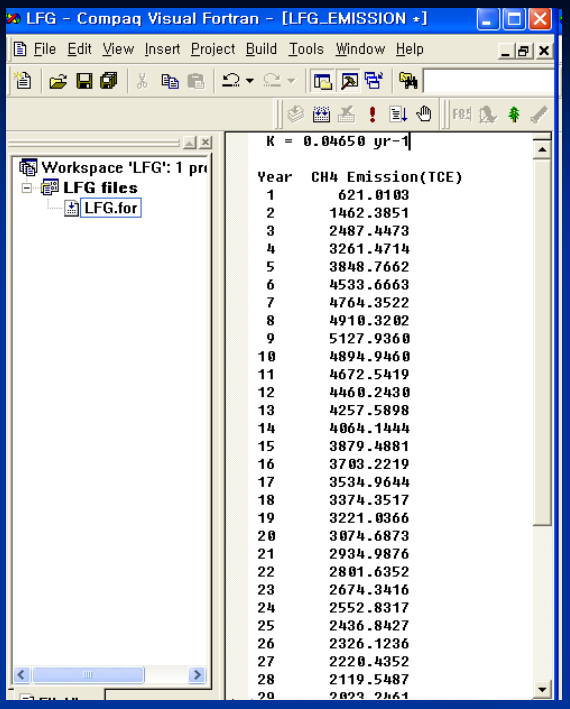
Surface Diffusion Measurements

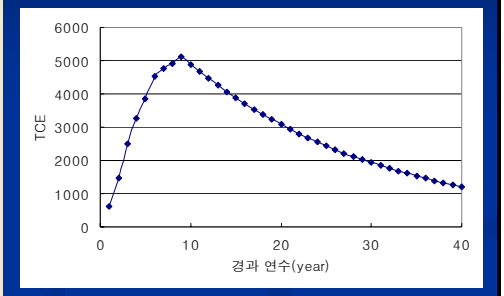


Fortran Code for Estimating *k* value



Fortran Output

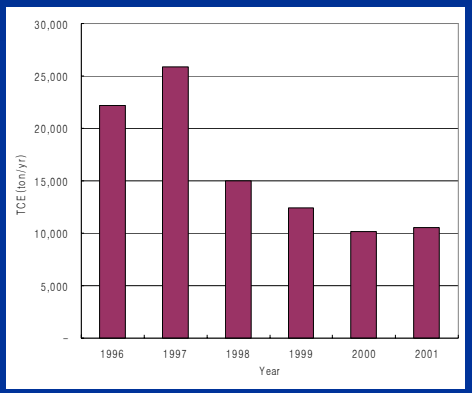




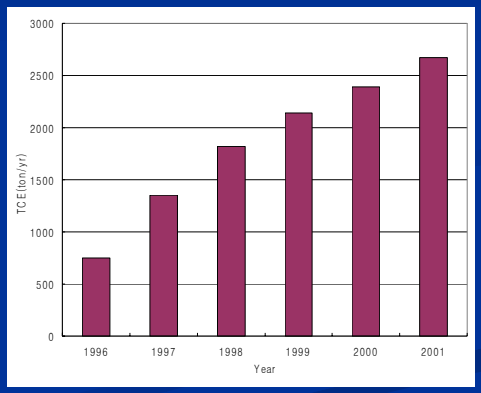
L_0 and K values for Korean Landfills

- L_0 : 0.15~0.30 ton-CH_4/ton-waste
- k : 0.04~0.09 yr^{-1}
  - IPCC default value : 0.05 yr^{-1}

Comparison of CH_4 emission from a Korean Landfill between Tier 1 and Tier 2



Tier 1



Tier 2

Estimation procedures for CH_4 emission by the Tier 2

Classification of landfills by characteristics

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Estimation of k values for characteristic landfills

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Estimation of CH_4 emissions form individual landfills

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Summation of CH_4 emission from individual landfills

Considerations on changing emission methodology from Tier 1 to Tier 2

- **Pre-requisites**
  - Collecting information on landfill histories of all landfills: landfill amount, compositions of solid wastes, and landfill period etc.
  - Monitoring the seasonal emission rates of CH_4 from the surfaces of representative landfills
- **Predicted Problems**
  - Uncertainty arising from the assumption of the landfill histories of non-sanitary landfills
  - Difficulty in data managements: QA/QC and UA

Thank you very much!