Quantifying the Sustainability of Waste Management Systems

WTERT
Scott M. Kaufman
smk2108@columbia.edu
Lenfest Center, Earth Institute
Department of Earth & Environmental Engineering
Columbia University
October 16, 2008
ASSUMPTIONS AND MOTIVATIONS
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• Disposal of municipal solid waste leads to significant environmental burdens
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• There is a desire to manage wastes sustainably
ASSUMPTIONS AND MOTIVATIONS

• Disposal of municipal solid waste leads to significant environmental burdens

• There is a desire to manage wastes sustainably

• We need goals and tools to measure progress towards sustainable waste management
OUTLINE

(1) Municipal Solid Waste Data & Metrics
(2) Measuring Sustainability
   • Resource Conservation Efficiency (RCE)
(3) Conclusions
OUTLINE

(1) Municipal Solid Waste Data & Metrics

(2) Measuring Sustainability
   • Resource Conservation Efficiency (RCE)

(3) Conclusions
CREATING A QUALITY METRIC
CREATING A QUALITY METRIC

- LF
- Waste to Energy
- Recycling
- Reuse
- Reduce

Least desirable
CREATING A QUALITY METRIC

Least desirable

LF

Waste to Energy

Recycling

Reuse

Reduce

Landfilling (64%)

Recycling (28.5%)

WTE (7.4%)
CREATING A QUALITY METRIC

Components of a Quality Metric

• Functional
• Robust
• Easy & quick to use
CREATING A QUALITY METRIC

Components of a Quality Metric
- Functional
- Robust
- Easy & quick to use

Why Develop a New Waste Metric?
- Quantify & benchmark sustainability
- Identify ways to improve systems
- Help set goals
- Track progress towards goals
OUTLINE

(1) Municipal Solid Waste Data & Metrics

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   • Resource Conservation Efficiency

(3) Conclusions
MOTIVATIONS AND BACKGROUND FOR RESOURCE CONSERVATION EFFICIENCY
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Assumptions Leading to Metric

• Life cycle energy inputs trend with environmental impacts
MOTIVATIONS AND BACKGROUND FOR RESOURCE CONSERVATION EFFICIENCY

• Life cycle energy inputs trend with environmental impacts

• Is life cycle energy in fact a good indicator for sustainability of waste systems?
  • Use of life cycle impact analysis

Assumptions Leading to Metric

Background Research
IS LIFE CYCLE ENERGY USEFUL AS A PROXY FOR A FULL LCA OF WASTE SYSTEMS?

CED vs EcoI99(H) Single Score

- Increasing energy inputs
- Life cycle Energy (MJ)
- EcoPoints
- Increasing environmental impact

$R^2 = 0.9686$
IS CUMULATIVE ENERGY DEMAND USEFUL AS PROXY FOR A FULL LCA?
THE RESOURCE CONSERVATION EFFICIENCY

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Waste newspaper...
THE RESOURCE CONSERVATION EFFICIENCY

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RCE_i = \left[ \frac{1}{\max_j \{E_i\}} \right]
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REFERENCE TABLE OF LIFE CYCLE ENERGY VALUES TO FACILITATE RCE ANALYSIS

- Set of values determined by literature search
- Allows easy application of resource conservation efficiency metric by policy makers & other waste management stakeholders

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<tbody>
<tr>
<td>Newspaper</td>
<td>12.7</td>
<td>5.5</td>
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</tr>
<tr>
<td>Kraft paper</td>
<td>13.3</td>
<td>5.5</td>
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<td>Recycling</td>
</tr>
<tr>
<td>Waxed OCC</td>
<td>0</td>
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<td>High Grade Paper</td>
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APPLICATION: COMPARING RCE VALUES BETWEEN TWO CITIES - HONOLULU & SAN FRANCISCO

San Francisco

- Recycles at high rate for US cities
- Does not utilize WTE for remainder
- High landfilling rates
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Honolulu

- Recycles at roughly the US average rate
- Relies heavily upon WTE for remainder
- Limited space (low landfilling rates)
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FIGURE 5a. WASTE MANAGEMENT PERCENTAGES
APPLICATION: COMPARING RCE VALUES BETWEEN TWO CITIES - HONOLULU & SAN FRANCISCO

Honolulu
• Recycles at roughly the US average rate
• Relies heavily upon WTE for remainder
• Limited space (low landfilling rates)

San Francisco
• Recycles at high rate for US cities
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FIGURE 5a. WASTE MANAGEMENT PERCENTAGES

FIGURE 5b. RESOURCE CONSERVATION EFFICIENCY
COMPARING TWO CITIES: SUGGESTED IMPROVEMENTS (RCE AS A DESIGN AID)

6b. WASTE MANAGEMENT PERCENTAGES

SAN FRANCISCO

HONOLULU

- SF BASE
- SF R1
- SF WTE
- H BASE
- H R1

- LF
- WTE
- Rec

- LF
- WTE
- Rec
COMPARING TWO CITIES: SUGGESTED IMPROVEMENTS (RCE AS A DESIGN AID)

Increased recycling scenario
COMPARING TWO CITIES: SUGGESTED IMPROVEMENTS (RCE AS A DESIGN AID)

6b. WASTE MANAGEMENT PERCENTAGES

SAN FRANCISCO

HONOLULU

Increased recycling scenario

Increased recycling + WTE scenario
COMPARING TWO CITIES: SUGGESTED IMPROVEMENTS (RCE AS A DESIGN AID)

6b. WASTE MANAGEMENT PERCENTAGES

SAN FRANCISCO

- SF BASE
- SF WTE

HONOLULU

- H BASE
- H WTE

Increased recycling scenario

Increased recycling + WTE scenario

Increased recycling scenario
COMPARING TWO CITIES: SUGGESTED IMPROVEMENTS (RCE AS A DESIGN AID)

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Increased recycling scenario
Increased recycling + WTE scenario

6b. RESOURCE CONSERVATION EFFICIENCY

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Increased recycling scenario
Increased recycling + WTE scenario
Increased recycling scenario
OUTLINE

(1) Municipal Solid Waste Data & Metrics
(2) Measuring Environmental Effectiveness
   • Resource Conservation Efficiency
(3) Conclusions
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• Allows stakeholders to easily and intuitively assess and make changes to waste strategies

• Shows that a combination of recycling & waste to energy is optimal
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Scott M. Kaufman
Lenfest Center for Sustainable Energy
Earth Institute
Dept. of Earth & Environmental Engineering
Columbia University
smk2108@columbia.edu

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