
Imperial College Laing O'Rourke Centre Distinguished Lecture

February 11, 2013

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Global Energy Assessment

Multi-stakeholder “IPCC of energy” 2008-2012
Focus on energy challenges, options, transitions
Assess linkages: access/poverty, development, security, health, climate
Policy guidance (normative scenarios)
First ever energy assessment of urbanization: KM18
Main Messages

1. The world is already today predominantly urban (~3/4 of final energy)
2. Rural populations are likely to peak at 3.5 billion and decline after 2020 (all long-term energy growth will be urban)
3. City dwellers have often lower direct energy and carbon footprints
4. Important deficits in urban energy and carbon accounting (embodied energy, import/export balance) jeopardize effective policies
5. Cities have specific sustainability challenges & opportunities (high density enables demand/supply management but calls for low waste/∼zero-impact systems)
6. Vast improvement potentials (>×2), but most require management of urban form and systemic change (recycling, cascading, energy-transport, land-use-transport systems integration,..)
7. Governance Paradox:
   - largest leverage from systemic change,
   - but requires overcoming policy fragmentation and dispersed, uncoordinated decision making
## How Urban is the World AD2000?

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Data Source</th>
<th>Range</th>
<th>References for uncertainty range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (1000 km²)</td>
<td>2929</td>
<td>1  313-3524</td>
<td>Schneider et al., 2009 range of GlobCover-GRUMP data</td>
</tr>
<tr>
<td>% of total</td>
<td>2.2</td>
<td>0.2-2.7</td>
<td></td>
</tr>
<tr>
<td>Population (million)</td>
<td>2855</td>
<td>2  2650-3150</td>
<td>Uchida &amp; Nelson, 2008 size threshold: 50,000-100,000</td>
</tr>
<tr>
<td>% of total</td>
<td>47</td>
<td>44-52</td>
<td></td>
</tr>
<tr>
<td>GDP (MER 2005$)</td>
<td>32008</td>
<td>1</td>
<td>not available</td>
</tr>
<tr>
<td>% of total</td>
<td>81</td>
<td>??</td>
<td></td>
</tr>
<tr>
<td>Final energy use (EJ)</td>
<td>239</td>
<td>1  176-246</td>
<td>this assessment</td>
</tr>
<tr>
<td>% of total</td>
<td>76</td>
<td>56-78</td>
<td>(see Section 18.4.1)</td>
</tr>
<tr>
<td>Light luminosity (million NLIS)</td>
<td>33</td>
<td>3,1</td>
<td>KM18 estimate</td>
</tr>
<tr>
<td>% of total</td>
<td>57</td>
<td>50-82</td>
<td></td>
</tr>
<tr>
<td>Internet routers (number in 1000)</td>
<td>592</td>
<td>4,1</td>
<td>KM18 estimate</td>
</tr>
<tr>
<td>% of total</td>
<td>96</td>
<td>73-97</td>
<td></td>
</tr>
</tbody>
</table>

Notes: MER: Market Exchange Rates, NLIS: Light Luminosity Intensity Sum (index)
Population by Settlement Type/Size

Number of agglomerations in 2005

- 13
- 30
- 340
- 3192
- ??

growth dominated by small & medium sized cities!
Path Dependent Urban Energy – Incomes

- Beijing 1985 - 2005
- Shanghai 1985 - 2005
- Singapore 1971 - 2005
- Hongkong 1971 - 2005
- Tokyo 1970 - 2005

TFC GJ/capita

GRP 1990 US$ PPP per capita
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Annex-I: Per Capita Urban Direct Final Energy Use

(red = above national average, blue = below national average)

$n=132$
Non-Annex-I: Per Capita Urban Direct Final Energy Use

(red = above national average, blue = below national average)

$n=68$
Direct and Embodied Urban Energy Use in Asian Cities

Energy Use (EJ)

- **Embodied**
- **Direct**

<table>
<thead>
<tr>
<th>City</th>
<th>Year</th>
<th>Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo</td>
<td>1990</td>
<td>3.5</td>
</tr>
<tr>
<td>Tokyo</td>
<td>1995</td>
<td>3.3</td>
</tr>
<tr>
<td>Beijing</td>
<td>1992</td>
<td>1.2</td>
</tr>
<tr>
<td>Beijing</td>
<td>1997</td>
<td>1.3</td>
</tr>
<tr>
<td>Shanghai</td>
<td>1992</td>
<td>2.2</td>
</tr>
<tr>
<td>Shanghai</td>
<td>1997</td>
<td>2.4</td>
</tr>
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China - Air Pollution (SO₂) Exposure

Tg SO₂ x million people

Hong Kong 2.3
Shanghai 1.4
Beijing 1.8
Europe – Energy Demand Densities
blue = renewable supply density threshold <0.5-1 W/m²
WEU >79% EEU >66% of energy demand
Gea KM18 Urbanization

Urban Energy and Exergy Efficiency

Secondary Energy: 43 TWh 100%

Final Energy: 37 TWh 85%

Useful Energy: 21 TWh 50%

Useful exergy as % of secondary primary

Geneva (CH) 23.2 15.5
Vienna (A) 17.2
Malmo (S) 21.2 12.7
London (UK) 11.3 6.2

trad. Mexican village 5.7
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Stylized Hierarchy in Urban Energy/GHG Drivers and Policy Leverages

1. Spatial division of labor (trade, industry structure, bunkers)
2. Income (consumption)
3. Efficiency of energy end-use (buildings, processes, vehicles, appliances)
4. Urban form (density ↔ public transport ↔ car ownership ↔ functional mix)
5. Fuel substitution (imports)
6. Energy systems integration (co-generation, heat-cascading)
7. Urban renewables

Decreasing order of importance

Increasing level of urban policy leverage
SynCity Simulations of Urban Policy Leverages

Baseline: Current Low Density (Sprawl) City with Low/Medium Buildings Efficiency (UK average) = 100 (144 GJ/capita)
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Contributing Authors:
(*Contributors to GEA KM18 city energy data base)

Resources:
Online: www.globalenergyassessment.org
Chapter 18 (main text)
Supporting material: GEA KM18 working papers and city energy data base