ICT innovation for sustainable urban infrastructures

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27-28 May 2009 Helsingør, Denmark
Urban Metabolism
Material Flow Analysis Methodology

Total Material Consumption

- Non metallic: 54%
- Others: 13%
- Biomass: 11%
- Fossil fuels: 4%
- Metallic minerals: 3%

Addition to Stock

- >30 years: 64%
- 0-1 year: 3%
- 2-10 years: 9%
- 11-30 years: 9%
Material flow analysis: What’s next?

- MFA
  - BIOMASS
  - FOSSIL FUELS
  - ...

- HOUSEHOLD
  - ONLINE SURVEY
  - HOME BASED SENSORS
  - SMART MEETERING
  - SMART PHONE ACTIVITY

- TRANSPORT

BEHAVIOUR MODELLING

UrbanSIM

POLICY OPTIONS for SUSTAINABLE URBAN METABOLISM
## Demand responsive pilots: 20 years of findings

<table>
<thead>
<tr>
<th>Technology driven</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct display on monitor separate from the meter</td>
<td>5% - 15%</td>
</tr>
<tr>
<td>Basic metering without separate direct display monitors</td>
<td>10% - 20%</td>
</tr>
<tr>
<td>Pay as you go (keypad meters, pre-payment)</td>
<td>15% - 20%</td>
</tr>
<tr>
<td>Ambient displays</td>
<td>up to 16%</td>
</tr>
<tr>
<td>Indirect displays (TV’s, PC’s, frequent billings)</td>
<td>0% - 10%</td>
</tr>
<tr>
<td>Disaggregated feedback with internal control or network operator control</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Contractual arrangements

<table>
<thead>
<tr>
<th>Contractual arrangements</th>
<th>up to 30% of reduction during peak demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Use</td>
<td></td>
</tr>
<tr>
<td>Critical Peak Pricing</td>
<td></td>
</tr>
<tr>
<td>Real Time Pricing</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Darby, 2006
The Need for ICT based Experimentation

• Drivers for change in energy use patterns are not well understood
• Most pilot studies have been developed as demonstration studies
• There is a need for scientifically designed experiments:
  – The covariance of different intervening variables needs to be taken in account: In an experiment many variables interact and contribute to change (household characteristics, affluence, price, communication channels)
  – Social segmentation is key to understand the effectiveness of the above on the test population
  – Follow the major drivers for behavior change, such as specific communication strategies, feedback and price signals, or man-machine interactions
  – Establish a control group, where the educational and technological change did not occur, maintaining the same social characteristics
The future – Intelligent Energy Networks, the energy software revolution
## Small scale scientific experiments

### Conceptual design

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Aggregation</th>
<th>Feedback</th>
<th>Price signals</th>
<th>Active / Passive</th>
<th>Optimization</th>
<th>System Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aggregated</td>
<td>Direct real time feedback</td>
<td>Yes</td>
<td>Passive</td>
<td>No</td>
<td>Internal</td>
</tr>
<tr>
<td>2</td>
<td>Disaggregated</td>
<td>Real time feedback</td>
<td>Yes</td>
<td>Active</td>
<td>At the level of the appliance</td>
<td>Internal</td>
</tr>
<tr>
<td>3</td>
<td>Disaggregated</td>
<td>Real time feedback</td>
<td>Yes</td>
<td>Active</td>
<td>At the level of the appliance</td>
<td>External</td>
</tr>
</tbody>
</table>

- **School**: Family 1, Family 2, Family ...

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*MIT Portugal*
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