Non industrial combustion plan: Pilot study conducted for SNAP 02 on the estimation of consumption and emissions

Carlo Trozzi

Larnaca (Cyprus), 10-11 May 2010
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TOPICS

- Guidebook Tier 1 Problems
- The need for a Tier 3 methodology
- Pilot study
### Guidebook Tier 1

**Emissions = fuel consumption * emission factors**

**Activity**

- ✓ 1.A.4.b Residential combustion
- ✓ 1.A.4.a/c, 1.A.5.a Non-residential combustion (institutional, commercial, agricultural and other)

**Fuel**

- ✓ Hard Coal and Brown Coal
- ✓ Natural Gas
- ✓ Liquid fuels
- ✓ Biomass

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Guidebook Tier 1 Problems

- Fuel consumption split between residential and non-residential is not always available (for example for some east Europe area) particularly for some fuel (wood, coal)
- EFs are defined only for generic liquid fuels but single fuel differ significantly

<table>
<thead>
<tr>
<th>Efs Boilers</th>
<th>SOx</th>
<th>NOx</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquified Petroleum Gases</td>
<td>0.22</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Kerosene</td>
<td>87</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>449</td>
<td>62,4</td>
<td>15,6</td>
</tr>
</tbody>
</table>

Liquid fuels consumptions

### 2007 World - Residential

- **Liquified Petroleum Gases**
- **Kerosene**
- **Gas/Diesel oil**
- **Residual Fuel Oil**

### 2007 World - Commercial and public services

- **Liquified Petroleum Gases**
- **Kerosene**
- **Gas/Diesel oil**
- **Residual Fuel Oil**

### 2007 OECD

<table>
<thead>
<tr>
<th>Category</th>
<th>Residential</th>
<th>Public Serv</th>
<th>Residential</th>
<th>Public Serv</th>
<th>Residential</th>
<th>Public Serv</th>
<th>Residential</th>
<th>Public Serv</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIquified Petroleum Gases</td>
<td>29%</td>
<td>12%</td>
<td>17%</td>
<td>10%</td>
<td>41%</td>
<td>14%</td>
<td>60%</td>
<td>23%</td>
</tr>
<tr>
<td>Kerosene</td>
<td>16%</td>
<td>14%</td>
<td>8%</td>
<td>0%</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Gas/Diesel</td>
<td>54%</td>
<td>65%</td>
<td>73%</td>
<td>86%</td>
<td>55%</td>
<td>68%</td>
<td>35%</td>
<td>68%</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>1%</td>
<td>9%</td>
<td>2%</td>
<td>4%</td>
<td>0%</td>
<td>16%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Sources: IEA Energy statistics

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Guidebook Tier 2

\[ \text{Emissions} = \text{fuel consumption} \times \text{emission factors} \]

defined for:

<table>
<thead>
<tr>
<th>Activity</th>
<th>/outdoor</th>
<th>boilers (&gt; 1 to ≤ 50 MWth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ 1.A.4.b Residential combustion</td>
<td>✓ Stoves</td>
<td>✓ Gas turbines</td>
</tr>
<tr>
<td>✓ 1.A.4.a/c, 1.A.5.a Non-residential combustion (institutional, commercial, agricultural and other)</td>
<td>✓ Water heater /boilers</td>
<td>✓ Reciprocating engines</td>
</tr>
<tr>
<td></td>
<td>✓ Pellet stoves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ Advanced stoves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ Manual wood boilers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ Automatic wood boilers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ Medium sized</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology</th>
<th></th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Fireplace/sauna</td>
<td></td>
<td>✓ Hard Coal and Brown Coal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Natural Gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Liquid fuels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Biomass</td>
</tr>
</tbody>
</table>

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Guidebook Tier 2 Activity data problems

- *Fuel consumption split between technologies is not available, particularly in residential sector*
- *Some statistical data about technology distribution can be available in member states*
- *Fuel consumptions split between technologies is not homogenous in the member states territories (difference between climatic region, urban vs rural, …)*
- *No control procedure is available about estimated subdivision of fuel consumption by technologies and activities*
Guidebook Tier 3

“Installation-specific emission estimation is not considered to be applicable for the activities detailed. However the Tier 3 methodology allows a modelling-based approach using more detailed appliance population data and applies more technology-specific emission factors — guidance on determining plant-specific emission factors is given in the Measurement Protocol. Relevant emission factors are also provided at Appendix A.”

TOO LITTLE !?!
Tier 3 goals

- Evaluation of fuel consumption on a more detailed geographical scale for example NUT3 (provinces or equivalent units) or LAU 2 (municipalities or equivalent units) of Nomenclature of Territorial Units for Statistics as established by Eurostat to:
  - Obtain more accurate estimates
  - Use of data to allocate emissions on the EMEP 50 km X 50 km grid
- Allocation of fuel consumption to different technologies
**Tier 3 Proposed methodology**

1. **Evaluate total fuel consumption from statistical sources**
2. **Compute energy requirements on climatic areas by energy models based on temperature models and census data**
3. **Allocate total fuel consumptions based on energy requirements**
4. **Use census data and/or specific survey for technologies allocation (promote more detailed census data sheets)**
A pilot study was conducted in Italy inside Genova province (NUTS 3 territory) to evaluate natural gas and other fuel consumption on LAU 2 (municipalities)
Pilot study

✧ Temperature trend assessed on an hourly basis, throughout the province on a grid of 1km x 1km by meteorological models for the reference year

✧ Evaluation of the heat demand of the houses for typology by energy model

✧ Evaluation of total requirements in all the municipalities using data on the stock of houses

✧ Validation of total computed value for gas with quantity distributed by the gas network

✧ Comparison of data for wood and liquid fuels with available statistics
Pilot study – Temperature model

- Evaluation of the hourly values of temperatures at 1 km x 1 km grid with two meteorological models (MM5 mesoscale model of PSU/NCAR and Calmet model)

- Assignment to each municipality the temperature of the mesh of City Hall (on national scale can be used 5 km x 5 km, 10 km x 10 km or larger grids depends on orography and climate)
Pilot study – Temperature validation

Comparison between daily average temperature computed and measured at Genova Airport

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Pilot study – Degree day

- **Evaluation of degree day** (is the sum, extended to all days of a conventional one-year period, of the positive differences between the conventional daily temperature, set in Italy at 20 °C, and the daily outside average temperature)

- **Use of degree day as input to energy model**
Task Force on Emission Inventory & Projection  
Expert Panel on Combustion and Industry  
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Pilot study

Municipality degree day

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Pilot study – Energy model

✧ The heating and hot water requirements of an “average” house was computed with DOCET model (made by Italy CNR / ENEA) in a series of simulations:

✧ in each municipality (using degree day specific to municipalities)

✧ for different types of housing (specific to municipalities) about:

✧ period of construction (old / new house)

✧ location (city center or isolated)

✧ type of structure
Pilot study – Energy model

- For a number of other parameters (external finish, top height, number of floors, wall thickness, window type, window area, etc.) were assigned default values (evaluated with a sensitivity study)

- Total consumption in all the municipalities was obtained by multiplying the heating requirements of an “average” house for the number of houses powered by natural gas, liquid fuels or firewood (source: ISTAT national population census)
Pilot study – Results

- For natural gas the following result was obtained as total provincial figure:
  - Model results $444,232,000 \text{ m}^3$
  - Total natural gas distributed by area network $472,313,000 \text{ m}^3$

- The comparison shows that the total calculated is 94% of the distributed quantity

- Given that the data of the gas distribution includes the consumption of small industrial plants, connected to city networks, the correspondence is very satisfactory
Pilot study – Results

ți For wood the following result was obtained as total provincial figure:

tı Model results 204.451 t
tı Allowed to cut firewood 15.350 t

ți The comparison shows that the total calculated is 1332% of the data reported in official statistics

ți In this case the calculated total is far higher than official figures as expected, but less than, data obtained by a survey conducted on the final consumer in other works:

tı Survey data 353.308 t
Conclusion

✧ **Gaps in EFs must be resolved**
✧ **The pilot study can be used to define a generalized methodology for compute fuel consumptions on large scale in the frame of TFEIP activities**
✧ **More census detailed number of installed facilities by type was useful**
✧ **It’s hard to find resources for this activity**