Case studies of energy savings calculation standards in France

IEA-DSM Task XXI: Standardisation of Energy Savings Calculation
3rd Experts Meeting
October 13-14 2010
Madrid, REE
Energy Savings Calculation (ESC) standards: overview

- **Energy saving certificates**: the most common and the broadest approach to energy savings calculation in France;

- **Other approaches**: mostly used by ESCO’s and consultants; not widespread yet
  
  - Measurement of energy consumption and calculation of energy savings resulting from upgrading of building
  
  - Methods for Energy Performance Contracting
  
  - Methods for defining the contribution of buildings occupants to the energy saving resulting from energy efficiency investments by the owner: new
  
  - Official calculation methods of energy performance diagnosis (DPE) (energy efficiency certificates for buildings) not really a method for calculating savings
Content

- Energy savings certificates
- Case of Compact fluorescent lamps (class A) in the residential sector
- Case of industrial Variable Speed Drive
- Case of retrofit wall insulation in the residential sector
Energy savings obligation and certificates in France (1/2)

- Introduced in July 2006 within an energy saving obligation for energy utilities exceeding a certain volumes of sales, with possibility of trading (“white certificates”)

- Energy savings defined as follows in the obligation:
  - In final energy
  - Cumulated over the lifespan of the equipment or action;
  - Discounted at 4%: both financial (economic value of ESC) and technical discount (gradual decrease in savings)
    - Savings express in kWh cumac

- Concrete implementation of energy saving obligations defined through various government decrees (6 as of September 2010)
First period (3 years) from July 1st 2006 to June 30th 2009:

- Obligation for energy suppliers with sales > 400 GWh/year for electricity, gas and heat and 100 GWh/year for LPG and all resellers of heating oil

- Overall national target 54 TWhcumac over 3 years (cumac = cumulated and discounted) (June 2006-July 2009) (electricity 30.99 TWh, gas 13.93 TWh, heating oil 6.84 TWh, LPG 1.53 TWh and heat 0.69 TWh)

Second period (officially endorsed in a new law in July 2010; new 3 years period to start in January 2011; transitory period since end of June 2009)

- Obligation extended to resellers of motor fuels

- Overall national target 345 TWhcumac over 3 years, of which 255 TWh for the companies having already an obligation over the first period ➔ multiplication by 4.7 compared to the first obligation
White certificates in France: standardisation of energy savings

- Ex-ante evaluation of energy saving (no measurement) for standard operations/equipment
- Existence of standard evaluations by energy saving operations/equipment
- Summary sheets publicly available on Ministry web site and in a printed Memento
- Detailed calculation sheets with all assumptions: restricted access for stakeholders

<table>
<thead>
<tr>
<th>Type of document</th>
<th>Documents</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATEE guide of standardised energy saving operations (includes the summary sheets by operation and all decrees) (~180 operations)</td>
<td>“Mémento du Club C2E”</td>
<td>September 2010 (6th edition)</td>
</tr>
<tr>
<td>On line summary sheets by operation on Ministry web site</td>
<td><a href="http://www.developpement-durable.gouv.fr/Les-Fiches-d-operations.html">http://www.developpement-durable.gouv.fr/Les-Fiches-d-operations.html</a></td>
<td>May 2010 (last update)</td>
</tr>
<tr>
<td>Technical sheet detailing the mode of calculation of energy savings for selected operations</td>
<td>Compilation of calculation sheets (unofficial, prepared by ADEME for IEA-DSM Task XXI)</td>
<td>2010</td>
</tr>
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</table>
White certificates in France: example of summary sheets for standardised energy savings operations

- Each summary sheet specifies:
  - the conditions of eligibility,
  - the conventional life time
  - the amount of energy savings certificates in final energy expressed in kWh cumac (cumulated and discounted at 4%):
    - example: savings with a freezer of A+ class, saving 50 kWh/year during 10 years are 420 kWh cumac (and not 50*10= 500kWh).

- Example of summary sheet: solar water heater:
  - Eligibility: need of a certification (CSTBat, Solarkeymark) and installation by certified companies (Qualisol).
  - Conventional life time: 15 years.
  - Amount of certificates according to climatic zone
    - H1 (North): 2 900 kWh cumac / m2
    - H2 (Centre): 3 500 kWh cumac / m2
    - H3 (South): 4 600 kWh cumac / m2
Standardisation of 182 operations and equipment

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number</th>
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<tbody>
<tr>
<td>Residential buildings</td>
<td>61</td>
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<tr>
<td>• Envelope</td>
<td>7</td>
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<tr>
<td>• Thermal equipment (e.g. boilers, water heaters, regulators)</td>
<td>44</td>
</tr>
<tr>
<td>• Equipment (e.g. refrigerator, lamps)</td>
<td>8</td>
</tr>
<tr>
<td>• Services</td>
<td>2</td>
</tr>
<tr>
<td>Tertiary buildings*</td>
<td>84</td>
</tr>
<tr>
<td>• Envelope</td>
<td>14</td>
</tr>
<tr>
<td>• Thermal equipment</td>
<td>51</td>
</tr>
<tr>
<td>• Equipment (e.g. lighting)</td>
<td>19</td>
</tr>
<tr>
<td>Industry</td>
<td>22</td>
</tr>
<tr>
<td>• Buildings</td>
<td>9</td>
</tr>
<tr>
<td>• Utilities</td>
<td>11</td>
</tr>
<tr>
<td>• Envelope</td>
<td>2</td>
</tr>
<tr>
<td>Networks</td>
<td>10</td>
</tr>
<tr>
<td>• Heat &amp; cold</td>
<td>5</td>
</tr>
<tr>
<td>• Public lighting</td>
<td>4</td>
</tr>
<tr>
<td>• Electricity distribution</td>
<td>1</td>
</tr>
<tr>
<td>Transport</td>
<td>5</td>
</tr>
</tbody>
</table>

* Separate file for large buildings in many cases
Results by type of standardised measures: overview

Total savings 127 TWh cumac, of which:
• 122.5 TWh (97%) from standardised operations
• 117.6 TWh from obliged utilities (93%)

Source: MEEDDAT / DGEC, September 2010

Results from 1st July 2006 to 31st July 2010
Results by type of standardised measures: ten most frequent measures

Results from July 2006 to July 2010  (Source: MEEDDAT / DGEC, September 2010)
Content

- Energy savings certificates
- Case of Compact fluorescent lamps (class A) in the residential sector
- Case of industrial Variable Speed Drive
- Case of retrofit wall insulation in the residential sector
Formula used for the calculation of annual gross energy savings: compact fluorescent lamps

Gross savings in year $t = \{ n_s \times \left[ \frac{1}{1000} \times (P_{\text{old}} \times h_{\text{old}} - P_{\text{new}} \times h_{\text{new}}) \right] \} \text{ in kWh}$

- $P_{\text{old}}$ = the capacity in W of the (old) bulbs
- $P_{\text{new}}$ = the capacity in W of the (new) CFL
- $h$ = burning hours
- $n_s$ = number of CFL units promoted/installed in year $t$
- $1/1000$ = conversion factor from W to kW

Notes: In red: calculation parameters
energy savings specified per object of assessment, i.e. per lamp installed or promoted
Baseline issues/ gross to net corrections: compact fluorescent lamps

- The baseline used for the energy savings calculations is a market average. It is assumed that on average a CFL replaces in 70% of the case an incandescent lamp and in 30% of the cases a CFL → Baseline incorporated in the gross to net calculation.

- The baseline is static; the discounting (during the lifetime calculation) is considered to somehow take into account a dynamic baseline.

- There is no correction for double counting, free riders, technical interactions, spillover effects or rebound effect.

- Net savings are equal to gross savings multiplied by a coefficient reflecting the market share of the efficient appliance (MSEFF):

  \[
  \text{Annual net savings in year } t = (1 - \text{MSEFF}) \times \text{gross savings in year } t \text{ in kWh}
  \]
Input parameters: compact fluorescent lamps

Annual net savings in year $t = (1- \text{MSEFF}) \times \{n_s \times \left[ \frac{1}{1000} \times (P_{\text{old}} \times h_{\text{old}} - P_{\text{new}} \times h_{\text{new}}) \right] \}$ in kWh

with:

- MSEEF = market share of the efficient appliance
- $P_{\text{old}}$ = the capacity in W of the (old) bulbs
- $P_{\text{new}}$ = the capacity in W of the (new) CFL
- $h$ = burning hours

Parameters Assumptions:
- MSEEF = 70%
- $P_{\text{old}}$ = 80 W.
- $P_{\text{new}}$ = 18 W.
- $h$ = 800 h (stable, i.e., does not change after the replacement)
Life time savings: compact fluorescent lamps

- The life time savings are not used for how long savings are accounted for, but for accounting the savings of the CFL promoted in year t.

- Life time of CFL Class A: 7.5 years (6,000 h over lifetime and 800 h/year → 6,000/800=7.5)

- The life time savings are discounted (saving in kWh cumac) with a discount rate of 4% → annual net savings are multiplied by a discount factor, function of the life time and discount rate. This results in the value of 6.626 for the discount factor (LT_{disc}) for CFL.

- Lifetime savings = \( LT_{disc} \times n_s \times 34.72 = 6.626 \times n_s \times 34.72 = n_s \times 230 \text{ kWh} \)

- This 230 kWh is presented as kWh cumac to clarify that this value is cumulated and discounted.
Content

- Energy savings certificates
- Case of Compact fluorescent lamps (class A) in the residential sector
- Case of industrial Variable Speed Drive
- Case of retrofit wall insulation in the residential sector
Formula used for the calculation of annual gross energy savings: industrial Variable Speed Drive

Gross savings in year $t = n_s \times PCES \times h$ in kWh

PCES = % of energy savings from the installation of VSD

$h$ = operating hours

$n_s$ = power in kW of motors in which VSD units are installed in year $t$

Notes: In red: calculation parameters

energy savings specified per kW of power rating installed or promoted
The baseline is incorporated in the gross to net calculation: net savings are equal to gross savings multiplied by a coefficient reflecting the market share of the efficient appliance (MSEFF) = gross savings * (1 - MSEFF)

Annual net savings in year t = (1 - MSEFF) * gross savings in year t in kWh

The baseline used for the energy savings calculations is a market average. For specifying the baseline, three types of motors uses are considered: ventilation, pumping and compressed air.

The baseline is static; the discounting (during the lifetime calculation) is considered to somehow take into account a dynamic baseline.

There is no correction for double counting, free riders, technical interactions, spillover effects or rebound effect.
Input parameters: industrial Variable Speed Drive (VSD)

- Annual net savings in year $t = (1 - \text{MSEFF}) \times n_s \times \text{PCES} \times h$ in kWh
  
  with:
  
  - MSEEF = market share of VSD
  - PCES = rate of energy savings from VSD
  - $h$ = operating hours

Parameters Assumptions:

<table>
<thead>
<tr>
<th>Application</th>
<th>MSEEF</th>
<th>PCES</th>
<th>Operating hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping</td>
<td>96.4%</td>
<td>30%</td>
<td>5 091</td>
</tr>
<tr>
<td>Ventilation</td>
<td>96.1%</td>
<td>30%</td>
<td>6 148</td>
</tr>
<tr>
<td>Compressed air</td>
<td>99.3%</td>
<td>15%</td>
<td>4 709</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application</th>
<th>Baseline market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping</td>
<td>3.64%</td>
</tr>
<tr>
<td>Ventilation</td>
<td>3.86%</td>
</tr>
<tr>
<td>Compressed air</td>
<td>0.69%</td>
</tr>
</tbody>
</table>
The life time savings are used for accounting the savings of the VSD promoted in year $t$.

- Life time of VSD: 10 years

The life time savings are discounted $\Rightarrow$ annual net savings are multiplied by a discount factor, function of the life time (10 years) and discount rate (4%). This results in the value of 8.44 for the discount factor ($LT_{disc}$) for VSD.

- Lifetime savings $= LT_{disc} \times n_s \times \text{annual savings}$
  $\Rightarrow$ for pumping $= 1472 = 8.44 \times n_s \times 1472 = n_s \times 12423$ kWh cumac

<table>
<thead>
<tr>
<th>Application</th>
<th>Life time savings (rounded) (kWh cumac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping</td>
<td>12400</td>
</tr>
<tr>
<td>Ventilation</td>
<td>15000</td>
</tr>
<tr>
<td>Compressed air</td>
<td>5900</td>
</tr>
</tbody>
</table>
Content

- Energy savings certificates
- Case of Compact fluorescent lamps (class A) in the residential sector
- Case of industrial Variable Speed Drive
- Case of retrofit wall insulation in the residential sector
Formula used for the calculation of annual energy savings: retrofit wall insulation in the residential sector

- Savings in year $t = n_s \times ES_{ij}$ in kWh

$ES_{ij} = \text{unitary energy savings per m}^2\text{ of insulation materials for climatic zone } i \text{ and heating fuel } j \text{ (electricity versus fuels based systems)}$

- Energy savings specified per m$^2$ of insulation materials installed or promoted
Formula used for the calculation of annual unitary savings: retrofit wall insulation in the residential sector

- \( ES_{ij} = x (U_0 - U_t) \times DD \times CC_i \times 24h \times IC \times EFF_j / 1000 \) in kWh

\( n_s = \) surface area of insulation materials promoted or installed in year \( t \)

\( U_t = \) U value after installation of insulation materials

\( U_0 = \) U value before installation of insulation materials (W/ m\(^2\)K)

\( R = \) thermal resistance of the insulation material (m\(^2\)K/W)

\( DD = \) Average number of degree days

\( CC_i = \) Climatic coefficient of climatic zone \( i \) (=1 for average)

\( IC = \) Intermittency coefficient and incidental gain

\( DD = \) Average number of degree days

\( EFF_j = \) Efficiency of heating system \( j \)

\( 1/1000 = \) conversion factor from W to kW

- As \( U_t = 1/(1/U_0+R) \), with \( R = \) thermal resistance of the insulation, the formula becomes:

\( ES_{ij} = \{U_0 - (1/[(1/U_0)+R])\} \times DD \times CC_i \times 24h \times IC \times EFF_j / 1000 \)
Baseline issues/ gross to net corrections: retrofit wall insulation in the residential sector

- The baseline used for the energy savings calculations is the stock average.

- The baseline insulation coefficient used for external wall is $U_o=3.3 \text{ W/ m}^2\text{K}$: it corresponds to a non-insulated wall.

- The baseline is static; the discounting (during the lifetime calculation) is considered to somehow take into account a dynamic baseline.

- There is no correction for double counting, free riders, technical interactions, spillover effects or rebound effect.

- Annual net savings in year $t = \text{gross savings in year } t \text{ in kWh}$
Input parameters: retrofit wall insulation in the residential sector

- Annual net savings = \( n_s \times \left\{ U_0 - \left(1/\left[1/(U_0) + R\right]\right)\right\} \times DD \times CC_i \times 24h \times IC/EFF_j / 1000 \) in kWh/m²

- Parameters Assumptions:
  - \( U_0 = \) U value before installation of insulation materials = 3.3 W/m².K
  - \( R = \) thermal resistance of the insulation material = 2.4 m²K/W
  - \( DD = \) Average number of degree days = 2450
  - \( IC = \) Intermittency coefficient and incidental gain = 0.5
  - \( EFF_j = \) Efficiency of heating system = 95% for electricity and 60% for fuel based heating
  - \( CC_i = \) climatic coefficient

<table>
<thead>
<tr>
<th>Climatic zone ( i )</th>
<th>Climatic coefficient ( CC_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>1</td>
</tr>
<tr>
<td>H1 (cold)</td>
<td>1.1</td>
</tr>
<tr>
<td>H2</td>
<td>0.9</td>
</tr>
<tr>
<td>H3 (south)</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Calculation of annual savings: retrofit wall insulation in the residential sector

- Annual net savings = $n_s \times \{U_0 - (1/[(1/U_0)+R])\} \times DD\times CC_i \times 24h \times IC/EFF_j / 1000$ in kWh/m²

- Annual net savings in year $t$ for average climate and for electricity
  $= n_s \times \{3.3 - (1/[(1/3.3)+2.4])\} \times 2450 \times 1 \times 24 \times 0.5 / 0.95 / 1000 = n_s \times 91$ kWh

- Annual net savings in year $t$ for average climate and for fuels
  $= n_s \times \{3.3 - (1/[(1/3.3)+2.4])\} \times 2450 \times 1 \times 24 \times 0.5 / 0.6 = n_s \times 144$ kWh

- Annual net savings in year $t$ by climatic zone and fuel

<table>
<thead>
<tr>
<th>Climatic zone $i$</th>
<th>Fuel</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>144</td>
<td>91</td>
</tr>
<tr>
<td>H1 (cold)</td>
<td>158</td>
<td>100</td>
</tr>
<tr>
<td>H2</td>
<td>129</td>
<td>82</td>
</tr>
<tr>
<td>H3 (south)</td>
<td>86</td>
<td>54</td>
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</table>
Life time savings: retrofit wall insulation in the residential sector

- The life time savings are used for accounting the savings of the insulation retrofit promoted/installed in year \( t \).
- Life time of insulation retrofit: 35 years
- The life time savings are discounted \( \Rightarrow \) annual net savings are multiplied by a discount factor, function of the life time and discount rate (4%). This results in the value of 19.4 years for the discounted lifetime (\( LT_{\text{disc}} \)) for insulation retrofit.
- Lifetime savings = \( LT_{\text{disc}} \times n_s \times \text{annual savings (rounded)} \) in kWh cumac

<table>
<thead>
<tr>
<th>Climatic zone ( i )</th>
<th>Fuel</th>
<th>Electricity</th>
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<tbody>
<tr>
<td>H1 (cold)</td>
<td>3070</td>
<td>1940</td>
</tr>
<tr>
<td>H2</td>
<td>2500</td>
<td>1600</td>
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<tr>
<td>H3 (south)</td>
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<td>1100</td>
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