New proposal for package labels using thermal solar system integration
• The proposed methodology aims to improve and simplify the calculation of the Water Heaters package label according to R 2013/811 and R 2013/812

• The new method avoids the use of the not always available $Q_{\text{nonSol}}$ value
Rationale

• The method is meant to calculate the package label efficiency in “combi” or systems that use solar energy to produce hot sanitary water (and not for heating purposes)

• The method uses available and reliable data such as GTY – Gross Thermal Yeld, as suggested by SHE proposal and a new (easily calculable) parameter that reckon for a good matching between the solar surfaces and the storage volume
The method

Considering a tapping profile as per R 2013/813, in terms of Primary energy consumption, the efficiency in hot water production is given, without solar contribution, by:

\[
\eta_{tot} = \eta_{backup} = \frac{Q_{non sol}}{E_{backup}} = \frac{Q_{ref} \cdot 220}{E_{backup}} = \eta_{wh}
\]

Where \( \eta_{wh} \) is characteristic parameter of the considered appliance.

Thus, the energy needed for a given tapping profile is:

\[
E_{Profile} = E_{backup} = \frac{Q_{ref} \cdot 220}{\eta_{wh}}
\]
Adding a solar system will reduce the energy of the backup appliance, and the overall efficiency can be viewed as a sum of two contributes:

\[
\frac{Q_{\text{ref}} \times 220}{E_{\text{profile}} - E_{\text{sol}}} = \eta_{\text{tot}} = \eta_{\text{wh}} + \eta_{\text{sol}}
\]

\[
\frac{Q_{\text{ref}} \times 220}{\eta_{\text{wh}} - E_{\text{sol}}} = \eta_{\text{wh}} + \eta_{\text{sol}} \quad \Rightarrow \quad \eta_{\text{sol}} = \frac{E_{\text{sol}} \times \eta_{\text{wh}}}{\frac{Q_{\text{ref}} \times 220}{\eta_{\text{wh}} - E_{\text{sol}}}}
\]
Esol calculation

Esol can be obtained from the GTY with several adjustments:

\[ E_{sol} = GTY \cdot m^2 \cdot c_{sizing} \cdot c_{thermal\_losses} \cdot c_{circ}. \]

Where:

\( GTY \) = Gross Thermal Yeld [kWh/m\(^2\)], Solar Keymark → possible to diversify several zones

\( m^2 \) = panel(s) surface

\( c_{sizing}, c_{thermal\_losses}, c_{circ} \) = coefficients →
$c_{sizing}$ allows for the proper matching between the solar panel(s) surface and the storage tank:

\[
\text{if: } \frac{V}{55 \cdot \text{tot}\_\text{surf}} < 1,1 \Rightarrow c_{sizing} = \frac{V}{55 \cdot \text{tot\_surface}}
\]

\[
\text{if: } \frac{V}{55 \cdot \text{tot}\_\text{surf}} > 1,1 \Rightarrow c_{sizing} = 1,166 - \frac{0,06 \cdot V}{55 \cdot \text{total\_surface}}
\]

55 = liters/m² optimal volume for 1 m² of absorbing panel surface
Graph of Csizing

Csizing

Csizing = 1 @ V = 55 l
and
Csizing = 1,1 @ V = 60,5 l

Tank too big results in low water ΔT and backup heater support is requested during tapping profile.

Tank too small: solar energy captured by panels is not completely stored.

X axis: Storage volume (liters per m²)

1 m² Solar panel

55 liters Storage tank
$c_{\text{thermal\_losses}}$ allows for thermal losses

Is calculated as per R 2013/811 Insulation class:

- $A^+ = 0.95$
- $A = 0.91$
- $B = 0.86$
- $C = 0.83$
- $D, G = 0.81$

If the storage tank is part of preferential heater, $c_{\text{thermal\_losses}} = 1$
$c_{circ.}$ Considers the power consumption of circulator(s) in the solar system:

We propose the values:

$c_{circ.} = 0,98$ for forced circulation systems

$c_{circ.} = 1$ for natural circulation systems
This method is only applicable to packages with a load profile M, L, XL and XXL and only if:

\[ E_{sol} \leq \frac{Q_{ref} \times 220}{\eta_{wh} \times \left( \frac{\eta_{wh}}{250} + 1 \right)} \]

Where:

250 is the maximum acceptable value of \( \eta_{sol} \).
Different values are also possible, to be discussed.
Results $\eta_{sol}$

**Blue**: values as per new method;

**Dark red**: values as per R 2013/811

Tapping profile M, Class C storage tank

<table>
<thead>
<tr>
<th>Storage volume (l)</th>
<th>Number of panels (2.51 m² each)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td></td>
<td>57</td>
<td>-8</td>
<td>57</td>
<td>21</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>74</td>
<td>18</td>
<td>141</td>
<td>37</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>70</td>
<td>9</td>
<td>717</td>
<td>21</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>59</td>
<td>-2</td>
<td>2616</td>
<td>5</td>
</tr>
</tbody>
</table>

Values calculated assuming $\eta_{wh} = 0.76$
Results $\eta_{\text{sol}}$

Blue: values as per new method;
Dark red: values as per R 2013/811

Tapping profile L, Class C storage tank

<table>
<thead>
<tr>
<th>Storage volume (l)</th>
<th>Number of panels (2.51 m² each)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>130</td>
<td>21</td>
</tr>
<tr>
<td>200</td>
<td>25</td>
</tr>
<tr>
<td>300</td>
<td>24</td>
</tr>
<tr>
<td>500</td>
<td>21</td>
</tr>
</tbody>
</table>

Values calculated assuming $\eta_{\text{wh}} = 0.76$
Blue: values as per new method
Dark red: values as per R 2013/811
Tapping profile **XL**, Class C storage tank

<table>
<thead>
<tr>
<th>Storage volume (l)</th>
<th>Number of panels (2.51 m² each)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>130</td>
<td>11</td>
</tr>
<tr>
<td>200</td>
<td>14</td>
</tr>
<tr>
<td>300</td>
<td>13</td>
</tr>
<tr>
<td>500</td>
<td>12</td>
</tr>
</tbody>
</table>

Values calculated assuming $\eta_{wh} = 0.76$
### Results $\eta_{sol}$

**Blue**: values as per new method  
**Dark red**: values as per R 2013/811  

**Tapping profile XXL, Class C storage tank**

<table>
<thead>
<tr>
<th>Storage volume (l)</th>
<th>Number of panels (2.51 m² each)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>130</td>
<td>9</td>
</tr>
<tr>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>300</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>9</td>
</tr>
</tbody>
</table>

Values calculated assuming $\eta_{wh} = 0.76$
Results (as a multiplying factor)

Tables show result as a value to added to $\eta_{wh}$ efficiency (see slide 5): 
\[
\frac{Q_{ref} \times 220}{E_{profile} - E_{sol}} = \eta_{tot} = \eta_{wh} + \eta_{sol}
\]

Results can be converted in a multiplying factor, as follows:

\[
\eta_{tot} = \eta_{wh} \cdot \eta_{sol2}
\]

Where: $\eta_{sol2} = 1 + \left( \frac{\eta_{sol}}{\eta_{wh}} \right)$

E.g. If $\eta_{wh} = 0.76$ and $\eta_{sol} = 30$ (profile XL, 2 panels, V = 800 l)

$\eta_{tot} = \eta_{wh} + \eta_{sol} = 76 + 30 = 106\%$.

$\eta_{sol2} = 1 + 30/76 = 1.39$

$\eta_{tot} = \eta_{wh} \times \eta_{sol2} = 76 \times 1.39 = 106\%$
Sometimes the $\eta_{wh}$ value is not available (e.g. heating only boiler used in hot sanitary water system, see also “Briefing 113201 Update Guidelines space-water heaters 20180115”, par. 6.4).

In This case …
Heating only appliances

For packages using a boiler space heater, the following calculation method is proposed:

\[
\eta_{\text{wh \_calc}} = \frac{Q_{\text{ref}}}{Q_{\text{fuel}} + CC \cdot Q_{\text{elec}} + Q_{\text{cor}}}
\]

Where:

\[
Q_{\text{fuel}} = (Q_{\text{ref}} + (24 - \frac{Q_{\text{ref}}}{P_4}) \cdot P_{\text{stby}}) \cdot \left(\frac{100}{\eta_4}\right)
\]

\[
Q_{\text{elec}} = Q_{\text{elec, on}} + Q_{\text{elec, stby}} = (24 - t_{\text{on}}) \cdot PSB + t_{\text{on}} \cdot el_{\text{max}}
\]

\[
t_{\text{on}} = (Q_{\text{ref}} + (24 - \frac{Q_{\text{ref}}}{P_4}) \cdot P_{\text{stby}}) \cdot \left(\frac{1}{P_4}\right)
\]

\[
Q_{\text{cor}} = -k \cdot (Q_{\text{fuel}} - Q_{\text{ref}})
\]

The adjustment factor \(k\) is to be chosen according to the table below:

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>L</th>
<th>XL</th>
<th>XXL</th>
</tr>
</thead>
<tbody>
<tr>
<td>(k)</td>
<td>0.23</td>
<td>0.23</td>
<td>0.23</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Finally:

\[
\eta_{\text{wh}} = \eta_{\text{wh \_calc}} \cdot 0.95
\]
Heating only appliances

For packages using a heat pump space heater, the following calculation method is proposed:

$$\eta_{wh\_calc} = f \cdot \frac{COP_{\text{rated}}}{CC} \cdot \frac{Q_{\text{ref}}}{Q_{\text{ref}} + S \cdot 24h}$$

The adjustment factor $f$ is to be chosen according to the table below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Outdoor air</th>
<th>Exhaust air</th>
<th>Brine</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>Average</td>
<td>Colder</td>
<td>Warmer</td>
<td>All</td>
</tr>
<tr>
<td>$f$</td>
<td>0.919</td>
<td>0.840</td>
<td>1.059</td>
<td>0.888</td>
</tr>
</tbody>
</table>

$COP_{\text{rated}}$: rated coefficient of performance at standard rating conditions at medium-temperature application (55° C outlet temperature) according to EN 14511 for air-to-water, brine-to-water, water-to-water heat pumps or to EN 15879 for direct exchange-to-water heat pumps.

$CC$: the value of the ‘conversion coefficient’ is 2.5.

Finally:

$$\eta_{wh} = \eta_{wh\_calc} \cdot 0.95$$