Electricity End-Use Efficiency in the Residential Sector

Anibal T. de Almeida
Electricity Consumption

- Industry: 41.3%
- Transport: 2.7%
- Agriculture: 1.7%
- Services: 25.5%
- Residential: 28.8%

EU-25
Domestic Appliances by Region

Total: 138.9 billion US $

Sales value %

- Europe: 36
- Former CIS: 4.7
- Middle East/Africa: 8.9
- South America: 6
- North America: 23.2
- Asia: 21.3

Source: GfK World Market Estimation
Domestic Appliances Electricity Consumption Breakdown

2004

- Refrigerators and freezers: 12%
- Washing machines: 15%
- Dishwashers: 4%
- Driers: 4%
- Room air-conditioners: 2%
- Electric storage water heater: 2%
- Electric ovens: 9%
- Electric hobs: 6%
- Consumer electronics and other equipment stand-by: 5%
- Lighting: 2%
- TV on mode: 1%
- Office equipment: 1%
- Residential electric heating: 3%
- Central heating circulation pumps: 1%
- Miscellaneous: 12%

EU-15
Energy Intensity in Residential Sector

*(Energy Consumption per dwelling)*

- France
- Germany
- Italy
- Norway
- Spain
- United Kingdom
- Greece
- European Union

- toe/dwelling
- 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02
## Average Electricity Consumption

<table>
<thead>
<tr>
<th>Country</th>
<th>Portugal</th>
<th>Belgium</th>
<th>Denmark</th>
<th>Greece</th>
<th>Bulgaria</th>
<th>Italy</th>
<th>Norway</th>
<th>Romania</th>
<th>France</th>
<th>Czech Rep.</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>In euros/month</td>
<td>50,0</td>
<td>92,1</td>
<td>78,0</td>
<td>52,3</td>
<td>23,8</td>
<td>54,2</td>
<td>146,9</td>
<td>18,9</td>
<td>87,5</td>
<td>39,1</td>
<td>51,7</td>
</tr>
<tr>
<td>In KWh/month (if known)</td>
<td>358,7</td>
<td>466,8</td>
<td>373,0</td>
<td>395,4</td>
<td>321,7</td>
<td>270,0</td>
<td>1692,5</td>
<td>145,2</td>
<td>808,3</td>
<td>354,8</td>
<td>289,5</td>
</tr>
</tbody>
</table>
Domestic Appliances

Although significant improvements in energy efficiency have been achieved in home appliances and lighting, the electricity consumption in the average EU-25 household has been increasing.

Such increase in the residential sector electricity consumption is associated with:

- higher degree of basic comfort and level of amenities (particularly in the new EU member countries)

- with the widespread utilization of relatively new types of loads whose penetration and use has experienced a very significant growth in recent years.
Domestic Appliances

Demand Outlook
Residential Appliances - EU 25 - Estimated

Adapted from: [Waide, P.]

ISR – Dep. de Engenharia Electrotécnica e de Computadores – Universidade de Coimbra
Domestic Appliances

Projected additional savings by end-use (estimated)

Adapted from: [Waide, P.]
Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe

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Supported by
Intelligent Energy Europe
Objectives

• Contribute to an increased understanding of the energy consumption in the EU-27 households for the different types of equipment, including the consumers’ behaviour and comfort levels;
• 12 countries are involved;
• To identify demand trends;
• Evaluation of the potential electricity savings that can already be implemented by existing means;
• Analysis of market transformation for different types of equipment;
• Policy recommendations for each type of equipment.
Results

• Updated European database on residential consumption, including Central and Eastern European countries;
• Innovative methodologies to combine the use of selective monitoring with wider-scale surveying;
• A user-friendly software tool to evaluate the energy performance of households;
• A set of policy recommendations for each type of equipment, which can lead to a successful market transformation and to provide cost-effective energy and carbon savings
Harmonised Monitoring and Survey Methodology

• Analysis of already existing studies, surveys, metering campaigns, databases, statistics, manufacturer's information, market information, etc., on energy consumption in the residential sector, focusing end-use equipment, operating modes

• Conducting households questionnaires (500 per country), addressing user behaviour

• Conducting detailed audit in 100 households per country, focusing demand load profiles in real situations.

• Conducting own measurements for a series of appliances/end-uses, especially to determine consumption in the standby and off modes of operation, because the available data is still relatively poor in this area.
Monitored Loads

- In western European countries emphasis is placed in electronic loads and lighting
- In southern countries air conditioning loads are going to be investigated
- In eastern countries white appliances are also measured
Do you have one or several refrigerators with/without a freezer compartment?

Ownership rate

- Portugal
- Belgium
- Denmark
- Greece
- Bulgaria
- Italy
- Norway
- Romania
- France
- Czech Rep.
- Germany

Legend:
- No refrigerator
- One refrigerator
- More than one
cold appliances

REMODECE Survey Results

Type of Refrigerator

Portugal  Belgium  Denmark  Greece  Bulgaria  Italy  Norway  Romania  France  Czech Rep.  Germany

Without freezer compartment  With freezer compartment

0% 20% 40% 60% 80% 100%
Cold Appliances

REMODECE Survey Results

Age Structure - Refrigerator without freezer

Portugal Belgium Denmark Greece Bulgaria Italy Norway Romania France Czech Rep. Germany

< 5 years 6 - 10 years More than 10 years Unknown
Cold Appliances

REMODECE Survey Results

Refrigerators without freezer compartment

Efficiency Class

Portugal
Belgium
Denmark
Greece
Bulgaria
Italy
Norway
Romania
France
Czech Rep.
Germany
Cold Appliances

REMODECE Survey Results

Refrigerators with freezer compartment

Efficiency Class

Portugal  Belgium  Denmark  Greece  Bulgaria  Italy  Norway  Romania  France  Czech Rep.  Germany

A+++  A++  A+  A  B  C  D  E  F  G  don’t know
Cold Appliances

REMODECE Survey Results

Age Structure - Freezer

- Portugal
- Belgium
- Denmark
- Greece
- Bulgaria
- Italy
- Norway
- Romania
- France
- Czech Rep.
- Germany

Legend:
- < 5 years
- 6 - 10 years
- More than 10 years
- Unknown
REMODECE Survey Results

Efficiency Class - Freezer

Portugal Belgium Denmark Greece Bulgaria Italy Norway Romania France Czech Rep. Germany

don’t know G F E D C B A A+
A++
Cold Appliances

Evolution of efficiency of refrigerators sold
Cold Appliances

Sales Units %
West Europe*

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Jan-Oct07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Ths. Units</td>
<td>10.888,5</td>
<td>11.118,2</td>
<td>10.964,5</td>
<td>11.721,0</td>
<td>11.774,9</td>
<td>11.772,4</td>
<td>12.402,4</td>
<td>10.326,8</td>
</tr>
</tbody>
</table>

* AT, BE, DE, ES, FR, GB, IT, NL, PT, SE

source: GfK MS
Cold Appliances

Sales Units % East Europe*

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Jan-Oct07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Ths. Units</td>
<td>1.130.4</td>
<td>1.171.5</td>
<td>1.315.5</td>
<td>1.567.8</td>
<td>1.546.2</td>
<td>1.485.1</td>
<td>1.682.8</td>
<td>1.545.0</td>
</tr>
</tbody>
</table>

* Source: GfK MS

**Legend:**
- A ++
- A +
- A
- B
- C
- D - G
- UNKNOWN

*CZ,HU,PL,SK*
Cold Appliances

Evolution of Energy consumption in refrigerators and correspondent savings in the EU

Source: [CECED]
Cold Appliances

Evolution of the EEI
(new model sale weighted average)

Note: A++ - EEI < 30
Cold Appliances

Identification of design options to improve energy efficiency

Current:

- increased door insulation
- increased cabinet insulation
- increased evaporator surface area
- increased condenser surface area
- increased evaporator heat capacity
- increased condenser heat capacity
- higher efficiency motors, compressors
- decreased door leakage (better gaskets)

Future:

- higher quality insulation - Vacuum Insulation Panels (VIPS), Gas-filled panels or alternative foaming agents
- low wattage fans to increase heat transfer at the evaporator and condenser
- variable speed, variable capacity, and also rated speed compressors
- optimised electronic control
- alternative refrigerants (i.e. refrigerant mixes);
- flow regulation valves
- alternative cycles including Lorenz and Sterling cycles
- optimized thermal balancing reducing the need for thermal compensation heaters in single compressor appliances
- two compressors
- two-way refrigerant control valves with twin evaporator system
Cold Appliances

Ambitious scenario for a 12 years product lifetime
EU-25

Adapted from [CECED]
REMODECE Survey Results

Dishwashers

Age structure - Dishwasher

< 5 years | 5 - 10 years | More than 10 years | Unknown
REMODECE Survey Results

Efficiency class - Dishwasher

Portugal Belgium Denmark Greece Bulgaria Italy Norway Romania France Czech Rep. Germany Hungary

A++ A+ A B C D E F G don’t know
Dishwashers Machines

REMODECE Survey Results

Usual filling of the appliance's capacity

- Portugal
- Belgium
- Denmark
- Greece
- Bulgaria
- Italy
- Norway
- Romania
- France
- Czech Rep.
- Germany
- Hungary

Legend:
- 25%
- 50% (half load)
- 75%
- 100%
Efficiency improvement for dishwashers Kwh/cycle – 12 place setting

In the last 10 years, evolution in dishwashers design has lead to energy and water savings greater than 30%.

Source: [Bertoldi, P.]
Market transformation of dishwashers in the EU
Sales of dishwashers in 2005, by energy class

Source: GfK MS
Dishwashers

Ambitious scenario consumption trends
EU-25

Adapted from [CECED]
In a similar manner to dishwashers, washing machines have also experienced very impressive evolution in the last decade.

**Calculated average energy and water (Blue Line) usage for a 5kg cotton wash by year of washing machine manufacture**
Market transformation of washing machines in the EU

Source: [CECED]
Washing Machines

REMODECE Survey Results

Age structure - Washing machine

- Portugal
- Belgium
- Denmark
- Greece
- Bulgaria
- Italy
- Norway
- Romania
- France
- Czech Rep.
- Germany

< 5 years | 6 - 10 years | more than 10 | Unknown

- Portugal: 40% < 5 years, 60% more than 10 years
- Belgium: 50% < 5 years, 50% more than 10 years
- Denmark: 60% < 5 years, 40% more than 10 years
- Greece: 30% < 5 years, 70% more than 10 years
- Bulgaria: 40% < 5 years, 60% more than 10 years
- Italy: 30% < 5 years, 70% more than 10 years
- Norway: 40% < 5 years, 60% more than 10 years
- Romania: 30% < 5 years, 70% more than 10 years
- France: 20% < 5 years, 80% more than 10 years
- Czech Rep.: 40% < 5 years, 60% more than 10 years
- Germany: 50% < 5 years, 50% more than 10 years
REMODECE Survey Results

Efficiency Class - Washing machine

Portugal Belgium Denmark Greece Bulgaria Italy Norway Romania France Czech Rep. Germany Hungary

A++ A+ A B C D E F G don’t know
In case of existence of ECO button, when is it used?

REMODECE Survey Results

Eco-button

Always  Sometimes  Never  Not applicable

Portugal  Belgium  Denmark  Greece  Bulgaria  Italy  Norway  Romania  France  Czech Rep.  Germany  Hungary
### Washing Machines

**Sales Units % West Europe**

- **2000**: 34.5%
- **2001**: 48.4%
- **2002**: 60.4%
- **2003**: 70.4%
- **2004**: 78.4%
- **2005**: 84.8%
- **2006**: 89.9%
- **Jan-Oct07**: 92.2%

**Source:** GfK MS

**Sales Ths. Units**
- **2000**: 10,213,3
- **2001**: 10,522,1
- **2002**: 10,706,9
- **2003**: 11,067,8
- **2004**: 11,594,4
- **2005**: 11,870,8
- **2006**: 12,428,3
- **Jan-Oct07**: 10,577,8

* AT, BE, DE, ES, FR, GB, IT, NL, PT, SE
Washing Machines

Sales Units % East Europe*

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Jan-Oct07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Ths. Units</td>
<td>1,141,6</td>
<td>1,182,4</td>
<td>1,253,3</td>
<td>1,489,2</td>
<td>1,579,8</td>
<td>1,530,8</td>
<td>1,680,6</td>
<td>1,491,2</td>
</tr>
</tbody>
</table>

- **A (incl. A+)**
- **B**
- **C**
- **D - G**
- **UNKNOWN**

*CZ,HU,PL,SK

Source: GfK MS
Washing Machines

Technical options to raise washing machine energy efficiency:
• Reduce water consumption during the washing cycle (the most efficient washers use only the amount of water clothes are able to absorb) through:
  o reduction of the clearance between drum and tub;
  o improving water level control;
• Improve thermal efficiency through reducing thermal bridges between the drum/tub to the outside world and especially to the stabilization weight (can save 100 Wh/cycle);
• Using a higher efficiency motor;
• Optimized heating and wash cycle duration.

Detergent dependant options:
• Optimized detergent dosing and wash temperature;
• Improved detergents with lower wash temperatures.
Washing Machines

Evolution of the EEI in KWh/Kg

(production weighted average)
Ambitious scenario consumption trends
EU-25

Adapted from [CECED]
Tumble Dryers

REMODECE Survey Results

Age structure - Tumble Dryer

- < 5 years
- 5 - 10 years
- more than 10
- Unknown

Countries: Portugal, Belgium, Denmark, Greece, Bulgaria, Italy, Norway, Romania, France, Czech Rep., Germany, Hungary
REMODECE Survey Results

Efficiency Class - Tumble Dryer

Portugal | Belgium | Denmark | Greece | Bulgaria | Italy | Norway | Romania | France | Czech Rep. | Germany | Hungary

0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100%

A+ | A | B | C | D | E | F | don’t know
REMODECE Survey Results

Frequency of use - Autumn

Frequency of use - Winter

Frequency of use - Spring

Frequency of use - Summer
Tumble Dryers

Compared to other electrical appliances, electric driers have probably the best energy savings potential using technical solutions.

- super-heated steam dryer using mechanical steam compression (not a mature technology yet);
- high efficiency dryers using heat pump systems optimized controls
- optimized air flow inside the dryer
- recovery of latent heat in the drying air
Tumble Dryers

High-efficient heat pump dryers consume only about half of the electricity of conventional condenser dryers.

<table>
<thead>
<tr>
<th>Consumption per kg laundry with 70% initial moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump Dryer</td>
</tr>
<tr>
<td>0.32 – 0.40 kWh</td>
</tr>
</tbody>
</table>

Source: [Bush, E.]

Supposed that 10% of the annually sold approximately 5 million tumble dryers would be high-efficient heat pump dryers (500'000 units), this would save in Europe between a 130 million kWh and a 160 million kWh. This corresponds to annual savings between 53'000 tons and 64'000 tons of CO2 (electricity generation mix: 400g CO2/kWh).
Ambitious scenario consumption trends
EU-25

Adapted from [CECED]
Sales of free standing cookers

<table>
<thead>
<tr>
<th>Year</th>
<th>10 of EU-15</th>
<th>6 of NMS-10&amp;CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>33.7%</td>
<td>39.2%</td>
</tr>
<tr>
<td>2005</td>
<td>34.55%</td>
<td>39.6%</td>
</tr>
</tbody>
</table>

- **Electrical**: 45.75% (2004), 44% (2005)
- **Mixed Fuel**: 11.2% (2004), 12.7% (2005)

Source: GfK MS
Heating up efficiency of cooktops

Source: [Breford, E.]
Gas vs. Electric Cooking

Electric Cooktops
Energy Efficiency

- Primary Energy: 100% (e.g. GAS)
- Power Generation losses: 45% (Heat)
- Power Plant output: 55% (Electricity)
- Energy used for Cooking: 80%

Total losses > 56%

Gas Cooktops
Energy Efficiency

- Primary Energy: 100% (Natural Gas)
- Losses: 50% (Heat)
- Energy used for Cooking: 50% (Heat)

Total losses ca. 50%

Adapted from [Breford, E.]
Sales of ovens in 2005, by energy class

source: GfK MS
Efficiency improvements

Gas
New developments in materials and design lead to efficiencies of up to 67% (against a minimum of 52% required by EU standards)

Electric
Induction elements can achieve as much as 90% efficiency (although special cookware is needed)

Oven
Optimization of temperature controls and improvement of thermal insulation can lead to important energy savings (~30%)
A class level - 0.8 kWh / test cycle
Average model - 1.2 kWh / test cycle
## Water Heating

<table>
<thead>
<tr>
<th>Water heater type</th>
<th>Efficiency (%)</th>
<th>Cost(^1) (€)</th>
<th>Annual energy cost(^2) (€)</th>
<th>Life (years)</th>
<th>Cost over 13 years(^3) (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional gas storage</td>
<td>57</td>
<td>380</td>
<td>537</td>
<td>13</td>
<td>7361</td>
</tr>
<tr>
<td>High-eff. gas storage</td>
<td>65</td>
<td>525</td>
<td>471</td>
<td>13</td>
<td>6648</td>
</tr>
<tr>
<td>Conventional oil storage</td>
<td>55</td>
<td>950</td>
<td>440</td>
<td>8</td>
<td>5420</td>
</tr>
<tr>
<td>High-eff. oil storage</td>
<td>66</td>
<td>1400</td>
<td>360</td>
<td>8</td>
<td>5680</td>
</tr>
<tr>
<td>Conventional electric storage</td>
<td>90</td>
<td>350</td>
<td>820</td>
<td>13</td>
<td>11010</td>
</tr>
<tr>
<td>High-eff. electric storage</td>
<td>95</td>
<td>440</td>
<td>760</td>
<td>13</td>
<td>10320</td>
</tr>
<tr>
<td>Demand gas</td>
<td>70</td>
<td>650</td>
<td>480</td>
<td>20</td>
<td>10250</td>
</tr>
<tr>
<td>High-eff., pilotless demand gas</td>
<td>84</td>
<td>1200</td>
<td>270</td>
<td>20</td>
<td>6600</td>
</tr>
<tr>
<td>Electric heat pump</td>
<td>300</td>
<td>2000</td>
<td>280</td>
<td>13</td>
<td>5640</td>
</tr>
<tr>
<td>Indirect water heater with efficient gas or oil boiler</td>
<td>79</td>
<td>600</td>
<td>300</td>
<td>30</td>
<td>9600</td>
</tr>
<tr>
<td>Solar with electric back-up</td>
<td>n/a</td>
<td>2500</td>
<td>250</td>
<td>20</td>
<td>7500</td>
</tr>
</tbody>
</table>

1 - Approximate cost, including installation

2 - Energy costs based on hot water needs for typical family of four and energy cost of €0.15/kWh for electricity, € 0.75/m3 for gas, and €0.40/litre of fuel oil.

3 - Future operation cost are neither discounted nor adjusted for inflation
Water Heating

Consumption trends
EU-25

[Graph showing consumption trends from 1975 to 2030 for EU-25, with a note for heat pump impact]
New electronic loads, such as entertainment, domestic computers, peripherals and communications are very important and have to be closely studied.

The market for this type of equipments is booming.

The present total EU consumption for home consumer electronics in stand-by is estimated to be about 36 TWh and is forecast to grow to 62 TWh by the year 2010.
Electronic Appliances

STANDBY POWER OF THE APPLIANCES
Average observed active powers for each type of analysed appliance

---

**ENERTECH**

- Refrigerator/Freezer
- Satellite
- Void
- CPU, socket
- Refrigerator
- Hi-Fi system
- VCR
- Fax machine
- TV
- Coffee maker
- Kitchen oven
- Vacuum cleaner
- Coffee maker
- Dish washer
- Kitchen oven
- Ironing machine
- Blender
- S wine
- Hair dryer
- Microwave oven
- Tape recorder
- TV antenna amplifier
- Toothbrush
- Clock radio
- Battery charger
- Alarm clock
- Gaming console

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**EURECO**

- Refrigerator/Freezer
- Satellite
- Void
- CPU, socket
- Refrigerator
- Hi-Fi system
- VCR
- Fax machine
- TV
- Coffee maker
- Kitchen oven
- Vacuum cleaner
- Coffee maker
- Dish washer
- Kitchen oven
- Ironing machine
- Blender
- S wine
- Hair dryer
- Microwave oven
- Tape recorder
- TV antenna amplifier
- Toothbrush
- Clock radio
- Battery charger
- Alarm clock
- Gaming console

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ISR – Dep. de Engenharia Electrotécnica e de Computadores – Universidade de Coimbra
Electronic Appliances

Estimated average ownership
2005
Electronic Appliances

Average power of the Domestic Entertainment end-uses

- DVD players and recorders
- Game/playstation consoles
- Home movie systems
- Audio HiFi
- Audio Compact
- Setup box
- LCD TV
- Plasma TV
- TV - Conventional

Power (W)

Off Mode
Active Standby
On
Electronic Appliances

Standby power of the Domestic Entertainment end-uses

<table>
<thead>
<tr>
<th>Device</th>
<th>Off Mode</th>
<th>Active Standby</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVD players and recorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game/playstation consoles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home movie systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audio HiFi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audio Compact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setop box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCD TV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasma TV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV - Conventional</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Power (W)
Examples of recent evolution in stand-by loads

Source: [Bertoldi, P.]
Electronic Appliances

Personal Computers

105 millions desktop
24 millions laptops
in EU-25
REMODECE Survey Results
REMODECE Survey Results

State - Laptop

Turned off with an on/off switch  standby %  On %
CRT Monitor Power Consumption

<table>
<thead>
<tr>
<th>Type</th>
<th>Active</th>
<th>Standby</th>
<th>Suspend</th>
<th>Off</th>
<th>Unplugged</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-15&quot;</td>
<td>61</td>
<td>53</td>
<td>19</td>
<td>3</td>
<td>0</td>
<td>MACEBUR (1998)</td>
</tr>
<tr>
<td>17-21&quot;</td>
<td>96</td>
<td>86</td>
<td>16</td>
<td>5</td>
<td>0</td>
<td>MACEBUR (1998)</td>
</tr>
<tr>
<td>17&quot;</td>
<td>90</td>
<td>26</td>
<td>9.2</td>
<td>4.3</td>
<td>N/A</td>
<td>Meyer and Schaltegger (1999)</td>
</tr>
<tr>
<td>19&quot;</td>
<td>104</td>
<td>31</td>
<td>13</td>
<td>4</td>
<td>N/A</td>
<td>Meyer and Schaltegger (1999)</td>
</tr>
<tr>
<td>21&quot;</td>
<td>135</td>
<td>43</td>
<td>14</td>
<td>4.7</td>
<td>N/A</td>
<td>Meyer and Schaltegger (1999)</td>
</tr>
<tr>
<td>Monitor (Average, Commercial and Industrial)</td>
<td>85</td>
<td>N/A</td>
<td>5</td>
<td>0.5</td>
<td>N/A</td>
<td>Kawamoto et al. (2001)</td>
</tr>
<tr>
<td>Display Terminal (Average, Commercial and Industrial)</td>
<td>75</td>
<td>N/A</td>
<td>5</td>
<td>0.5</td>
<td>N/A</td>
<td>Kawamoto et al. (2001)</td>
</tr>
</tbody>
</table>
CRT Monitor Power Consumption

<table>
<thead>
<tr>
<th>Viewing Size (in.)</th>
<th>Nameplate</th>
<th>Active</th>
<th>Standby</th>
<th>Suspend</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>7.5</td>
<td>2.5</td>
<td>0.7</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>14</td>
<td>20</td>
<td>6.7</td>
<td>1.9</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
<td>11.7</td>
<td>3.4</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>17</td>
<td>50</td>
<td>16.7</td>
<td>4.8</td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td>18</td>
<td>75</td>
<td>25.0</td>
<td>7.2</td>
<td>2.5</td>
<td>1.2</td>
</tr>
<tr>
<td>20</td>
<td>95</td>
<td>31.7</td>
<td>9.2</td>
<td>3.2</td>
<td>1.6</td>
</tr>
<tr>
<td>21</td>
<td>107</td>
<td>36</td>
<td>10.4</td>
<td>3.6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Note: Italic denote estimated values.
## Electronic Appliances

<table>
<thead>
<tr>
<th>Year</th>
<th>LCD PC</th>
<th>LCD Monitor</th>
<th>CRT Monitor</th>
<th>LCD Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>0.3</td>
<td>4.5</td>
<td>90.3</td>
<td>5.0%</td>
</tr>
<tr>
<td>2000</td>
<td>0.7</td>
<td>6.1</td>
<td>98.5</td>
<td>6.5%</td>
</tr>
<tr>
<td>2001</td>
<td>0.5</td>
<td>15.7</td>
<td>85.7</td>
<td>15.9%</td>
</tr>
<tr>
<td>2002</td>
<td>1.2</td>
<td>32.2</td>
<td>83.6</td>
<td>28.5%</td>
</tr>
<tr>
<td>2003</td>
<td>1.0</td>
<td>49.2</td>
<td>66.5</td>
<td>43.0%</td>
</tr>
<tr>
<td>2004</td>
<td>1.3</td>
<td>69.0</td>
<td>64.0</td>
<td>52.3%</td>
</tr>
<tr>
<td>2005</td>
<td>1.7</td>
<td>102.5</td>
<td>43.3</td>
<td>70.7%</td>
</tr>
<tr>
<td>2006</td>
<td>2.1</td>
<td>128.0</td>
<td>23.0</td>
<td>85.0%</td>
</tr>
<tr>
<td>2007</td>
<td>2.7</td>
<td>139.5</td>
<td>16.8</td>
<td>89.4%</td>
</tr>
<tr>
<td>2008</td>
<td>3.2</td>
<td>153.0</td>
<td>14.2</td>
<td>91.7%</td>
</tr>
<tr>
<td>2009</td>
<td>3.5</td>
<td>163.5</td>
<td>11.3</td>
<td>93.7%</td>
</tr>
</tbody>
</table>

The chart shows the growth in the number of units (millions) of electronic appliances from 1999 to 2009, with categories for LCD PC, LCD Monitor, CRT Monitor, and LCD Penetration. The data indicates a significant increase in all categories over the years.
Electronic Appliances

REMODECE Survey Results

State - Monitor

- Turned off with an on/off switch
- standby %
- On %

Countries: Portugal, Belgium, Denmark, Greece, Bulgaria, Italy, Norway, Romania, France, Czech Republic, Germany, Hungary
Electronic Appliances

REMODECE Survey Results

Router/hub

- Turned off with an on/off switch
- Standby %
- On %

Countries: Portugal, Belgium, Denmark, Greece, Bulgaria, Italy, Norway, Romania, France, Czech Rep., Germany, Hungary
What do you think the energy star label refers to?

knowledge on Energy Star

- Electromagnetic compatibility
- Use of recyclable material
- Electricity saving handling
- Low energy consumption
- Other
- Don’t know

Countries: Portugal, Belgium, Denmark, Greece, Bulgaria, Italy, Norway, Romania, France, Czech Rep., Germany, Hungary
When you buy an office appliance, do you choose one with Energy Star?

REMODECE Survey Results

Always | Sometimes | Never | Don't know

Portugal | Belgium | Denmark | Greece | Bulgaria | Italy | Norway | Romania | France | Czech Rep. | Germany | Hungary

0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100%
Boilers

An increase in household numbers, coupled with an increasing penetration of central heating systems makes plausible a rapid rise in the number of systems predicted to be in use across Europe until 2020:

- Gas-fired systems from 80 million to 116 million;
- Oil-fired systems from 27 million to 30 million.
Space Heating

Estimate of Consumption by components central heating systems

- Pumps
- Fans
- Other (Electronics, valves)
- Stand-by
Space Heating

Variable speed high efficiency pump

Standard fixed speed pump

76 kWh/year

217 kWh/year
Great energy savings can be achieved by the use of more efficient pumps and better control systems.

Circulator yearly energy consumption

Source: [Bistrup, N.]
EC - Permanent Magnet motor efficiency
Potential energy savings on reaching the technical potential in 2020, compared to the business-as-usual scenario and the 2004 reference case

Source: [Schwitzer, J.]
Heat Pumps

Heat pumps have a large and worldwide potential of reducing CO2 emissions by 1.2 billion tons (1 billion tons can be saved by residential and commercial heat pumps and a minimum of 0.2 billion tons by industrial heat pumps). This is about 6% of global emissions. This is one of the largest savings that a single technology can offer, and it is already in the market.
Space Heating

Primary Energy Ratio (delivered heat/primary energy) for different heat pump SEERs

PER comparison based on average European efficiency of fossil fuel generation
Space Heating

CO₂ Emissions per House

Oil heating
Gas heating
Gas and Oil heating assumed to be 100% efficient (to allow for maximum future advance in efficiency)
Heat pump (COP=4), CO₂/kWh electricity reduces in line with Role of Electricity scenario
Space Heating

Heat Pump Sales (2005)

20% of these systems also provide space cooling

Source: European Heat Pump Association
Future developments:

- high-efficiency motors and variable speed drives;
- more efficient compressors
- better control strategies
- environment-friendly working fluids;
- reduction of noise, standardization of hydraulic circuits;
- retrofit heat pumps for existing buildings with radiators (65°C);
Air conditioners constitute a major growing electrical end-use in the European Union. Driving factors for this growth are:

- Increasing affordability;
- Shifts in comfort culture, behavioural patterns and consumer expectation;
- Increase in internal heat loads (computers etc.);
- Increase in urban heat island phenomenon and a general trend towards higher temperature;
- Perception that comfort cooling contribute to higher productivity.
Daily load profile of air conditioning and lighting in a weekend day
Daily load profile of air conditioning and lighting in a working day

![Graph showing daily load profile of air conditioning and lighting in a working day](image_url)
Space Cooling

Air Conditioning Electricity Consumption – Main components
Design options to improve efficiency:

- improving the heat transfer of the condenser and evaporator(s) (20-60%)
- using a variable-speed compressor (inverter) (10-40%)
- lowering the temperature difference between the two and thereby raising the efficiency of the vapour-compression cycle
- using a higher-efficiency compressor (máx. 8%)
- using an electronic expansion valve (5%)
- improved refrigerant (<5%)
- using higher-efficiency fans (2%)
Space Cooling

Evolution of energy efficiency of split, non ducted, air-cooled air conditioners

Source: [MEEUP]
Space Cooling

Japan - Average COP: Room AC (for residential use)

source: JRAIA
Energy consumption for Lighting by sector
Today two technologies cover the majority of residential use - incandescent lamps (GLs) and fluorescent lamps (FLs). Incandescent technology includes classic bulbs, halogens and low voltage dichromic lamps. FLs include both linear fluorescent lamps and compact fluorescent lamps (CFLs).
Luminous efficacy by light source technology

- Incandescent
- Tungsten halogen
- T12 Fluorescent tube
- T8 fluorescent tube
- T5 fluorescent tube
- CFL with integrated ballast
- CFL with external ballast
- Mercury High-pressure
- Sodium Low-pressure
- Sodium High-pressure
- Metal halide quartz
- Metal halide ceramic
- Electrodeless Induction
- Electrodeless Excimer
- Electrodeless Molecular
- White LED
- White OLED

Source: Laborolec
Lifespan by light source technology
Historic and projected future efficacy improvements for White LEDs

Source: Laborolec
Previsão da Evolução do Rendimento

Eficiência (lm/W)

Ano

1990 2000 2010 2020

SSL Projectado
Fluorescente
Incandescente