Future Cooling Needs of Buildings
The Role of Ventilation

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The Air Conditioning Market

PENETRATION OF AIR CONDITIONING

The world air conditioning market has exceeded 100 billion US$ presenting a total increase close to 7 % compared to the previous year.

Almost 128,5 million units have been sold worldwide.

Most of the increase occurred in China and the Asia-Pacific zone where the global sales of air conditioning correspond almost 58 % of the world market.

China and Japan represent almost 83% of the total market in this area while important growth rates are observed in Myanmar, Vietnam, Hong Kong and Malaysia.
Cooling Energy Consumption

World Cooling Energy Consumption

1,25 PWh

Residential : 55 %
Commercial : 45 %

World Residential Energy : 23,7 PWh
Cooling : 0,68 PWh or 2,9 %

World Commercial Energy : 8,4 PWh
Cooling : 0,56 PWh or 6,7 %
Cooling Energy Consumption

Energy Intensity Residential Sector (kWh/m²)

1 2 3 4 5 6 7 8 9

Western Europe
Pasific Asia
Middle East And Northern Africa
Latin America
North America
Drivers Affecting Air Conditioning

- **FAMILY INCOME**
  - AC
  - GNP

- **CLIMATE**
  - AC
  - CDD

- **POPULATION SIZE**
  - AC
  - POPULATION

- **ENERGY EFFICIENCY**
  - AC
  - GNP

- **EQUIPMENT PRICE**
  - AC
  - PRICE

- **COST ELECTRICITY**
  - AC
  - PRICE
Drivers Affecting Air Conditioning Elasticity

Range of Air Conditioning Elasticities

Positive Impact

Negative Impact

Elasticity

PRICE ELECTRICITY PRICE EQUIPMENT EFFICIENCY CLIMATE INCOME
The Potential Impact of Climate Change

Air Conditioning Penetration depends on the Cooling Degree Days

![Graph showing the relationship between Cooling Degree Days (CDD) and climate maximum air conditioner saturation. The graph indicates an increase in air conditioner saturation as CDD increases.](image-url)
The Potential Impact of Climate Change

Existing Increase of the Cooling Load of Individual Buildings

\[ y = 1.2326x \]
The Potential Impact of Climate Change

Existing Increase of the Cooling Load of Buildings because of the Urban Heat Island

Global Energy Penalty per Person and per degree of the UHI intensity, GEPPPI

It has the same characteristics as the GEPP index while it includes the local UHI intensity as additional information.

Values of GEPPPI varied between 15 kWh/k for the Municipality of Athens to 154 kWh/K for Tokyo.

UHI triggers an average Global Energy Penalty per Person and per degree of the UHI intensity, GEPPPI, close to 68 kWh/p/K.
The Impact of Climate Change

Future Increase of the Cooling Degree Days
The Potential Impact of Climate Change

Existing Increase of the Cooling Load of Individual Buildings from 144 Case studies around the World

[Diagram showing the potential impact of climate change on cooling load, with axes labeled as follows:
- Y-axis: Increase of the Cooling Load, (kWh/m²/y)
- X-axis: Reference Cooling Load, (kWh/m²/y)
- Legend: Cooling Degree Days, with values ranging from 0 to 1200]
The Potential Impact of Population Increase

Forecasts of the United Nations about the Future Population
The Potential Impact of Increased Income

Air Conditioning Penetration depends on the Income Levels
The Potential Impact of Increased Income

Air Conditioning Penetration depends on the Income Levels
The expected increase of the total residential area between 2005 and 2050 is close to 500%.

The Potential Impact of Housing Size

How much the Future Size of Houses will be?
The highest increase rate of the commercial floor area between 2005 and 2050, is expected in North Africa and Middle East area, (549 %), the Central and Eastern Europe, (483 %), and South Asia, (471 %).

The smaller increase is expected in North America, (51 %).
The Impact of Advanced AC Technology

The Actual Efficiency of Air Conditioning

Comparison of European EER and COP with Japanese legislation showed that 90% of the models sold in Europe in 2006 did not comply with Japanese legislation despite the fact that many brands on the Japanese and the EU markets are identical.
The Impact of Advanced AC Technology

The Future Efficiency of Air Conditioning

EER

Gas Fired

Absorption

Gas Fired

Engine Driven

Scroll Type

Screw Type

Reciprocating Type

Centrifugal Type

2013 2020 2030 2040

2013 2020 2030 2040

2013 2020 2030 2040

2013 2020 2030 2040
The Impact of Advanced AC Technology

The Future Consumption of Residential Air Conditioning

Predicted Cooling Energy Consumption of the Residential Sector (TWh)

- ASIA
- EUR
- AMER
- AFR

2010
<table>
<thead>
<tr>
<th>Floor Area, (m²)</th>
<th>Low Development Scenario</th>
<th>Average Development Scenario</th>
<th>High Development Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>8E10</td>
<td>0-1</td>
<td>1-2</td>
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</tr>
<tr>
<td>13</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>0-1</td>
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<td>20</td>
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<tr>
<td>10</td>
<td>4</td>
<td>12</td>
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<tr>
<td>4</td>
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<tr>
<td>Improve Energy Performance Bldgs ( % )</td>
<td>10</td>
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<td>30</td>
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<tr>
<td>Increase of AC Efficiency ( % )</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Increase of AC penetration ( % )</td>
<td>4</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Temp Increase ( K )</td>
<td>0-1</td>
<td>1-2</td>
<td>2-3</td>
</tr>
<tr>
<td>Cooling Consumption , (kWh/m²)</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>The Future Consumption of Air Conditioning</td>
<td>The 2050 Cooling Consumption of Commercial Buildings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Future Consumption of Air Conditioning

The 2050 Cooling Consumption of Commercial Buildings

- Low Development Scenario
- Average Development Scenario
- High Development Scenario

Commercial Consumption for Cooling (kWh)

Floor Area, Consumption, CDD, Availability, AC Efficiency, Efficiency Bldgs

2010

200 %, 275 %, 350 %, 465 %, 360 %
## The Future Consumption of Air Conditioning

### The 2050 Cooling Consumption of Residential Buildings

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Floor Area, (m²/p)</th>
<th>Cooling Consumption, (kWh/m²)</th>
<th>Temp Increase (K)</th>
<th>Increase of AC penetration (%)</th>
<th>Increase of AC Efficiency (%)</th>
<th>Improve Energy Performance Bldgs (%)</th>
<th>Population</th>
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<tr>
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<td>30</td>
<td>10.8</td>
</tr>
</tbody>
</table>
The Future Consumption of Air Conditioning

The 2050 Cooling Consumption of Residential Buildings

Residential Consumption for Cooling (kWh)
The Future Consumption of Air Conditioning

The 2050 Cooling Consumption of Residential Buildings

Predicted World Cooling Energy Consumption Residential Sector 2050, (PWh)
The Potential Contribution of Ventilation

The Theoretical Contribution of Night Ventilation

- **Low Contribution** (≈ 10 kWh/m²/y)
- **Medium Contribution** (≈ 17 kWh/m²/y)
- **High Contribution** (≈ 21 kWh/m²/y)

![Graph showing the potential contribution of ventilation with different color gradients representing low, medium, and high contribution levels based on air flow rate and cooling load reduction.](image-url)
The Potential Contribution of Ventilation

Inappropriate Control and Management of HVAC Systems

Indoor Temperature (°C)

Indoor CO2 Levels

Low Temp Zone
Comfort Zone
High Temp Zone
Very High Temp Zone

Empty Room or Very High Ventilation
Reasonable Ventilation
Low Ventilation

<21°C: 5%
21-22°C: 6%
22-23°C: 1%

<21°C: 47%
21-22°C: 18%
22-23°C: 3%

68%
13%
12%

CONCLUSIONS

Local and Global Climate Change, increase of the world’s population and potential economic growth result in significant increase of the energy demand for cooling.

While, in 2010, the global cooling consumption of the residential sector represented almost 4.4% of the total heating and cooling needs of buildings, it is expected to increase up to 35% in 2050 and 62% in 2100.

In parallel, although the heating energy demand is expected to remain constant or slightly decrease in the future, the total heating and cooling consumption of residential buildings may increase up to 67% in 2050 and 166% in 2100 compared to the 2010 levels intensifying the global energy and environmental problems.
CONCLUSIONS

Higher energy consumption for cooling is strongly associated with a very significant increase of the peak electricity demand that oblige utilities to build additional power plants to satisfy the extra needs for electricity.

Significant future investments to increase the power capacity may raise the cost of electricity and put in strength the health and the quality of life of the low income and vulnerable population.
CONCLUSIONS

To face the problem of the future growth of the cooling energy needs and of the associated increase of climatic vulnerability, three major clusters of policy actions may be identified and proposed:

Actions Aiming to Mitigate the Global and Local Climate Change. Decrease of the greenhouse gas emissions and counterbalance of the urban heat island may significantly limit the amplitude of the temperature increase and the strength of the energy impact of the climatic change.

Policies aiming to reduce the sources and enhance the sinks of temperature anomaly, like the use of clean fuels and mainly of renewable sources for power generation, higher energy efficiency, rationalization of the energy demand, intelligent and efficient use of energy, smart and resilient technologies for cities, green energy distribution systems, in association with urban mitigation technologies like cool and green materials and reduction of the anthropogenic heat, could seriously reduce the future demand for cooling, and protect the vulnerable population during the extreme climatic events.
CONCLUSIONS

Actions aiming to adapt the Building Sector and improve its Energy Performance.

A massive energy rehabilitation of the existing building stock requires a further reduction of the cost of the energy efficient building technologies.

Given the actual technological status, the necessary investments to reduce drastically the global building energy consumption in the world, are tremendous.

It is characteristic that only in Europe, the necessary investments to achieve an almost 80% reduction of the building energy needs by 2050 are between 16-24 trillion Euros.

In parallel, the unprecedented urbanization and the increase of the population asks for the construction of billions of new buildings mainly in less developed, quite poor zones of the planet that unfortunately suffer the more the consequences of the climate change.

It is very crucial all these new buildings present significantly low energy consumption through the use of reduced cost energy efficiency technologies.
CONCLUSIONS

Actions aiming to Improve the Efficiency of Mechanical Air Conditioning and Alternative Cooling Technologies.

Although, the efficiency of the mechanical air conditioning systems has improved impressively, it is not sufficient to counterbalance the tremendous increase of the future cooling demand.

Breakthrough cutting edge technologies have to be developed through intensive scientific and industrial research.

In parallel, the performance of the alternative cooling dissipation technologies associated with the use of low temperature environmental sinks has to improve further in order to provide low cost and reliable coverage of a fraction of the cooling needs.