Zero emission strategies – the future of refrigeration, air-conditioning

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Drivers for cooling
Main drivers for RAC&HP demand & emission

- **Economic growth**
  (RAC&HP sector grows over proportionally fast - 2-3 times of GDP)

- **Demographic growth**
  (50% of global population will live in the tropics in late 2030s)

- **Climatic Conditions**
  (Amount Cooling/Heating/Humidity control needed)

- **Global Warming**
  (upto +50% in 2100)

- **Replacement of fuel heaters by heat pumps**
  (hot water, heating)

- **CO₂ intensity of energy supply**
  (Percentage of renewables)

- **Energy Sector Developments, Electricity Subsidies, Grids**
  (additional 1.7 bio. access to electricity)

- **Consumption Patterns, Lifestyles and Productivity needs**
  (comfort, food preservation, markets, fashion, leisure, hygiene, etc)

- **Regulations, Standards, Incentive Structures**

- **Others**, such as Compliance Requirements (MP, UNFCCC)
Consumption patterns

- Global GDP will triple by 2030
- Ca. 2 billion additional middle-income consumers by 2030
- Urbanisation growing
  - Already now more people live in cities than in rural areas;
  - Ca. 80% of buildings in 2050 are not yet built;

Choosing sustainable products is essential
Average Annual Temperature

http://www.sage.wisc.edu/atlas/maps.php?datasetid=35&type=&dataset=Average%20Annual%20Temperature&bandwidth=&includeRelatedLinks=1

Atlas Biosphere
<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tundra</td>
<td>Heat Pumps, Refrigeration</td>
</tr>
<tr>
<td>Humid Continental</td>
<td>Heat Pump, Refrigeration, A/C</td>
</tr>
<tr>
<td>Humid Sub-tropical</td>
<td>Refrigeration, A/C, some HP</td>
</tr>
<tr>
<td>Desert Dry</td>
<td>Refrigeration, A/C, Humidification</td>
</tr>
<tr>
<td>Tropical</td>
<td>Refrigeration, A/C, Dehumidification</td>
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</tbody>
</table>
RAC sector distribution in developing countries 2020 & 2030 (BAU scenario)

AC most important sector!!

RAC&HP demand almost doubles from 2020 to 2030 from 3.2 MTCO2 to 6.2 MTCO2

GIZ, Green Cooling Database, 2015
Relationship in % between direct and indirect emissions from RAC in developing countries (2012)
Relationship between Saving Potentials of Energy Efficiency, Energy Supply Intensity and HFC Phase out (GWP 100)
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- RAC Total CO2
- Total RE

CO2 Intensity
Relationship between Saving Potentials of Energy Efficiency, Energy Supply Intensity and HFC Phase out (GWP 100)

- RAC Total CO2
- Total RE
- Total EE
- Total HFC
- Total EE+RE

Years:
- 2015
- 2017
- 2019
- 2021
- 2023
- 2025
- 2027
- 2029
- 2031
- 2033
- 2035
- 2037
- 2039
- 2041
- 2043
- 2045
- 2047
- 2049

MtCO2eq:
- 1000
- 2000
- 3000
- 4000
- 5000
- 6000
- 7000
- 8000
- 9000
- 10000
Relationship between Saving Potentials of Energy Efficiency, Energy Supply Intensity and HFC Phase out (GWP 100)
Zero emission strategies
Technology Options for system innovation and emission reduction

- **Heat Loads**: Reduce heat loads
  - e.g. in the building sector (insulation, shading, natural ventilation)

- **Control needs**: Increase control efficiency
  - use free cooling/heating, improve quantified & quality assessment and planning

- **Drive Options**: Increase drive efficiency
  - Decarbonization of supplies (electric, thermal)

- **Fluid Heat Transfer**: Replace fluids with very low/no GHG options, optimize heat transfer
  - Eliminate system heat losses

- **Function**: Design functional units and consumption pattern
  - Adjust room temperature and reduce temperature lift

- **Controlled Air, Liquid & Object Conditions**: Smart controls
  - Introduce variable and precision controls
With increasing cooling needs
- Operational hours increase
- Annual Lifetime decreases
- Wear and tear increases
- Leak and energy consumption increase
- Expenditures on purchase and services
- Backup costs
- Load management

Specific Issues
- Innovative manufacturing for very humid/tropical or very hot (T3) climate
- Identify main consumption and supply alternatives (e.g. thermal)
Integrated concepts for RAC

Integrated concept will include:

- Climate, topography and environmental concepts.
- Building function and whole energy demands.
- Sustainability of the resources, energy and environmental impact.
- Adapt technology and engineering concepts suitable to desert, tropical and semi-tropical climates
- Include traditional architecture and know-how
Wind tower Masdar city

Louvres
Automated louvres, controlled by sensors, monitor the direction of the prevailing winds and are controlled to direct wind down the tower.

Mist Jets
These jets located at high level, humidify the air to make it cooler on the ground. It's an evaporative cooling device.
PASSIVE COOLING: Wind and Shading

- Sun shading devices
- Building orientation
- Maximum ventilation
- Choice of material
PASSIVE COOLING:
Wind and Shading in traditional South-East Asian Housing
Natural Cooling without Air conditioning:
New buildings in South East Asia following the traditional concept (Exhibit DAM, Frankfurt)
Naturally ventilated housing
Naturally ventilated mosque in Indonesia
Naturally ventilated housing
Key messages

• Cooling has impact on almost everyone.
• Even the most climate friendly business as usual based on conventional technologies for refrigeration and air-conditioning is possibly not good enough to manage growing demand.
• Innovation (new products, new concepts, …) needed.
• Inter-disciplinary, system-oriented approaches needed – not everything to be done by NOU.
Thank you very much!