National Energy Conference - Homes for Hot Weather

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Energy in Buildings and Communities Programme

Operating Agent IEA EBC Annex 68:
Indoor Air Quality Design and Control in Low Energy Residential Buildings


Shenzhen, IBR. Photo: Carsten Rode

Conditions in Denmark

5.5 mio. inhabitants

Winter temperature:

+4°C (Oct-May)

Summer temperature:

+17°C

Annual mean:

+8°C

What can we learn from Denmark on the development of energy efficient dwellings that are able to remain comfortable while withstanding extreme temperatures?

What is the key consideration in building homes that are more resilient to climate change?

Building physics & Case studies from around the world

Zero-energy house 1973

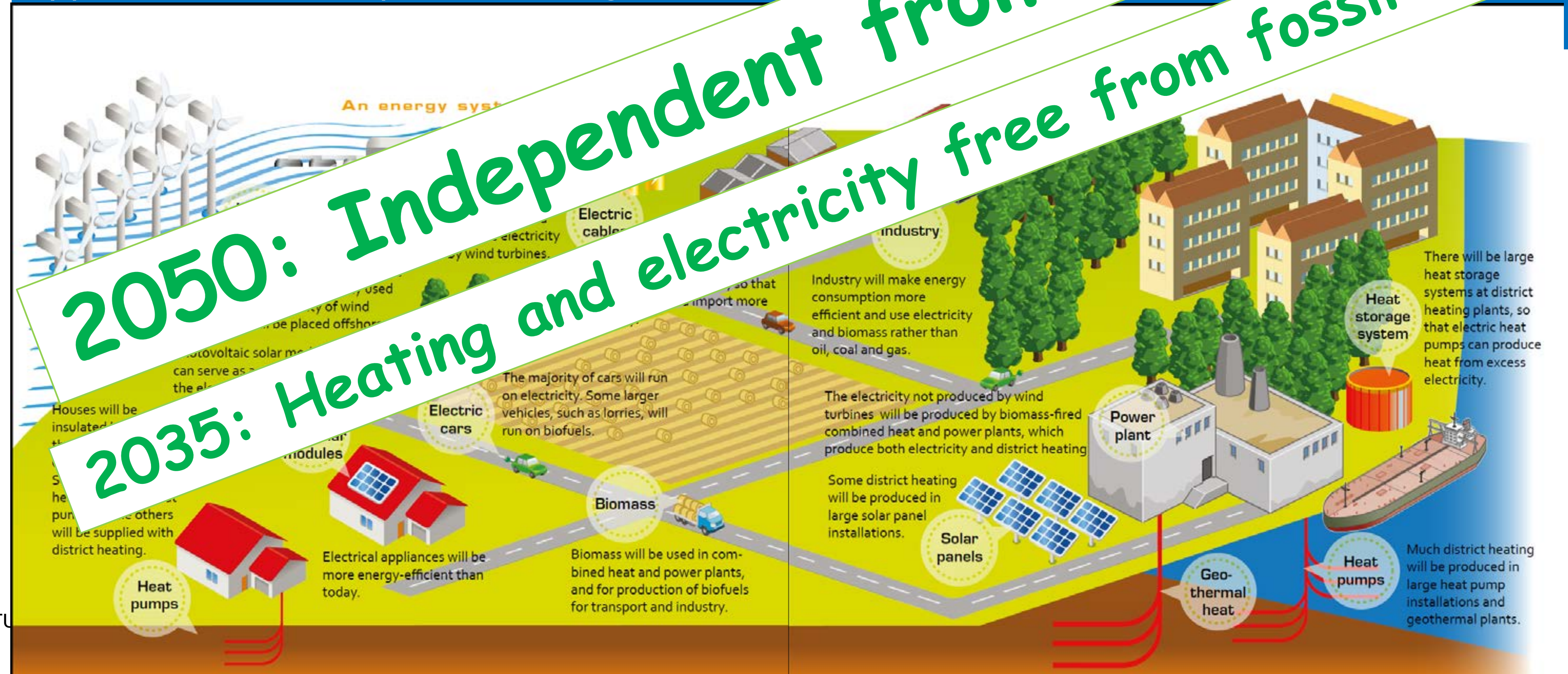
From the Danish Climate Commission (2010)

More efficient use of energy (by 2050)

Energy consumption in homes will be more efficient. Better insulation and efficient energy systems can reduce energy consumption for heating an average house by 60%, and cut average energy consumption by any electric appliance, from lamps to washing	Energy efficiency in industry and agriculture can be doubled. By usi… the energy for production of… amount of goods.

2050: Independent from fossil fuels

2035: Heating and electricity free from fossil fuels



Permissible Energy Consumption Residential Buildings

For heating, ventilation, (cooling), domestic hot water

BR 2010:

$$52.5\,kWh/m^2 + \frac{1650\,kWh}{A}$$

BR 2015:

$$30\,kWh/m^2 + \frac{1000\,kWh}{A}$$

BR 2020 (voluntary class for now):

$$20\,kWh/m^2$$

Development of high performance buildings

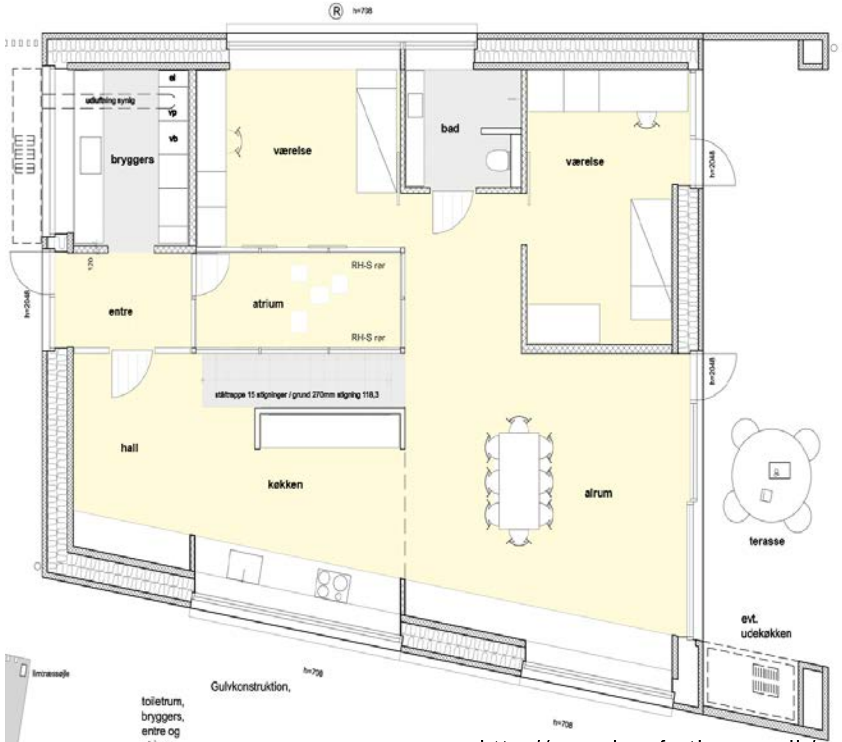
High energy performance buildings can be achieved by the following means:

- Building envelope based on
  - Insulation materials with lower thermal conductivity
  - Insulation materials in larger thicknesses ($U = 0.06\ W/m^2K$)
- Windows
  - Good glazing
  - New frame types
- Ventilation systems
  - Mechanical ventilation systems with heat recovery, efficient fans & ducting with low pressure loss
  - Natural ventilation
- Space heating and domestic hot water systems
  - Low temperature systems
- Lighting
  - Daylighting
  - New light sources
- Efficient fans and pumps
- Energy supply system
  - District heating
  - Heat pumps
  - Solar

Passive Houses
Comfort Houses, Vejle (2008)

http://www.komforthusene.dk/

Comfort Houses - experiences



http://www.komforthusene.dk/

- Energy targets more or less met
- Problems with overheating
  - Use solar shading, natural ventilation and thermal mass
- Problems with heating in winter
- User influence is important

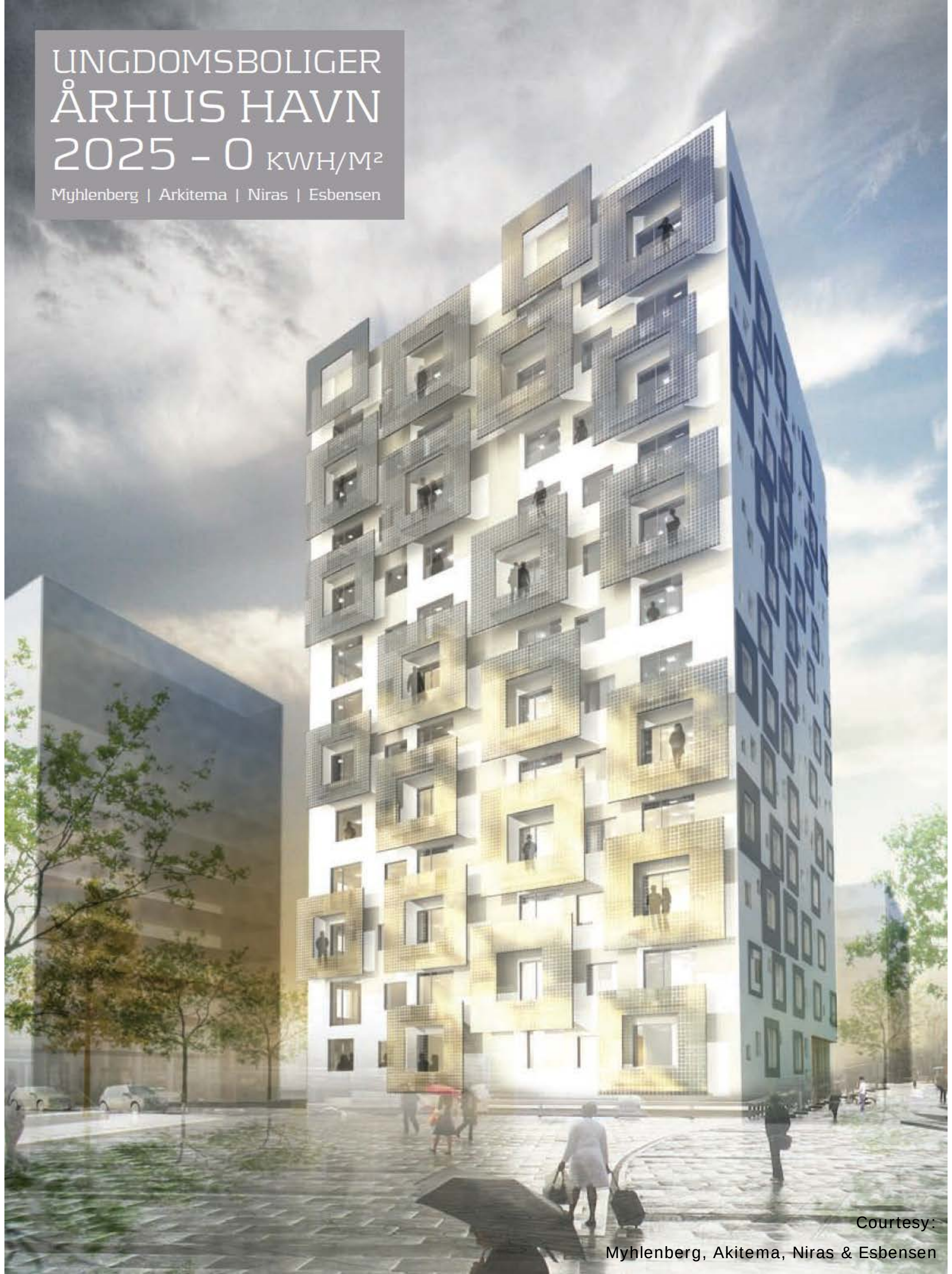
Harbour of Århus: High-rise building for young people (2013)

Energy consumption:

0 kWh/m^2

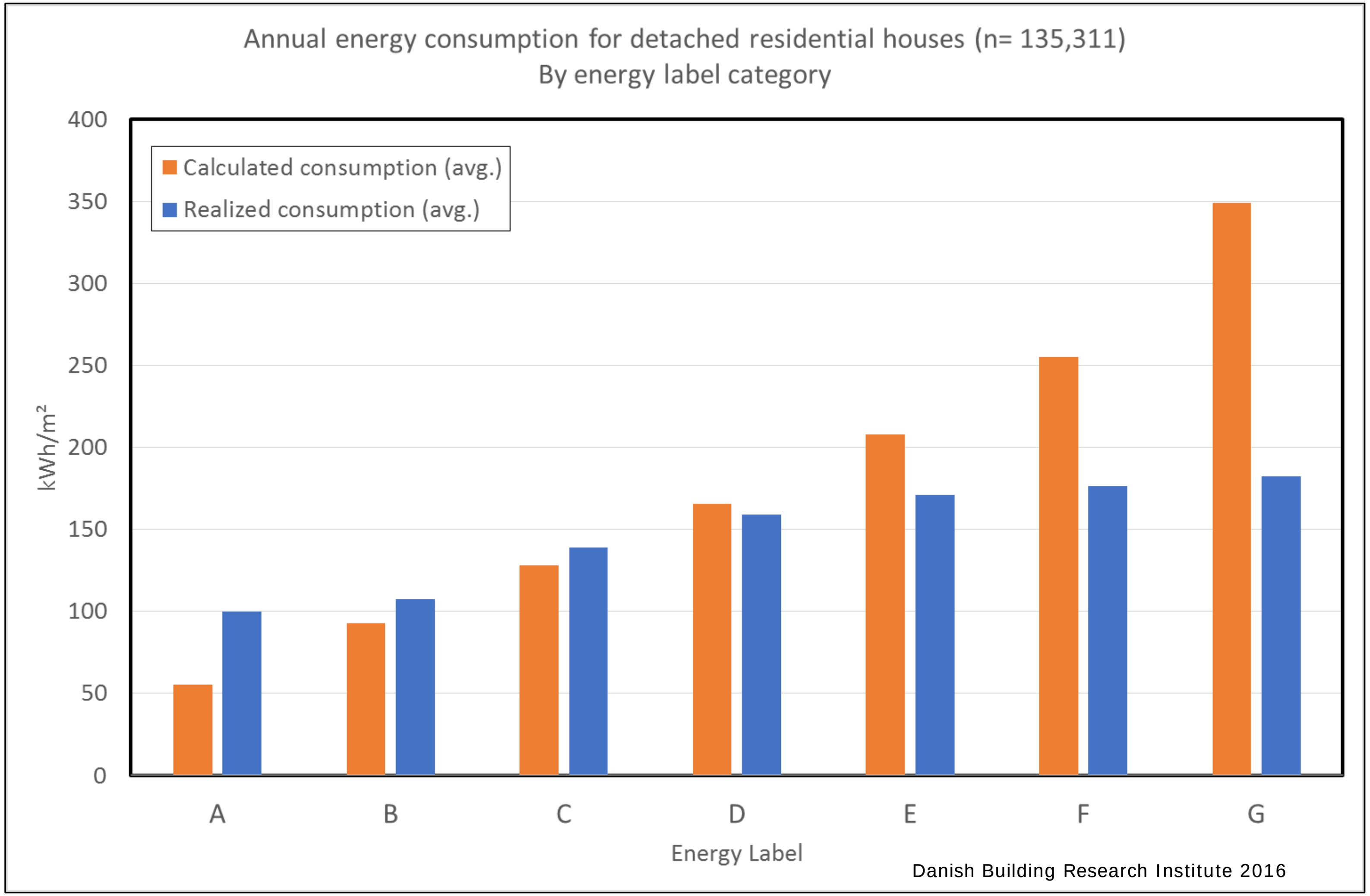
Challenges addressed:

- User behaviour
- Thermal indoor climate



Courtesy:
Myhlenberg, Akitema, Niras & Esbensen

Designed vs. Realized Energy Consumption



Australia (and Southern Europe)

Australian Energy Efficiency Handbook, 2016:

Building efficiency can impact winter mortality rates, and more than 2,600 deaths each year in Australia are associated with cold weather

Mortalities by cold are rare in Denmark !

Compared to Scandinavia, buildings in Southern Europe are poorer insulated, and in winter they may suffer from:

- Poor thermal indoor environments
- Dampness

www.casteloconstruction.info

Building tech tips for hot / dry or warm / humid climates
1 - Building envelope

Thermal Insulation

e.g. U-values from ASHRAE 90.1:

Construction type	U-value W / m²K
Roofs	0.15 – 0.27
Walls	0.53 – 3.30
Floors	1.26 – 1.99
Windows	1.82 – 4.71

Avoid thermal bridges.

Make air-tight.

Use thermal mass sensibly.

Ventilated structures.

Double skin facades /
transitional spaces with dynamic shades or blinds.

200 George St., Sydney, Mirvac. Photo: Carsten Rode

Building tech tips for hot / dry or warm / humid climates
2 – Reduce loads

Thermal

Use shades and roof overhangs to minimize direct solar gain.

Use light coloured facades to minimize indirect solar gain.

Reflective coatings may divert heat gains.

Maximum use of daylighting, e.g. by use of lightshelves and light colours.

Use LED lighting.

Use green facades (green roofs and facade plantation) to minimize warm temperatures on exterior surfaces

Use plantation in surroundings to provide shade.

Plan buildings to be located close to each other in order to provide shade.

Curitiba, Brazil. Photo: Carsten Rode

Building tech tips for hot / dry or warm / humid climates
3 – Reduce loads

Moisture

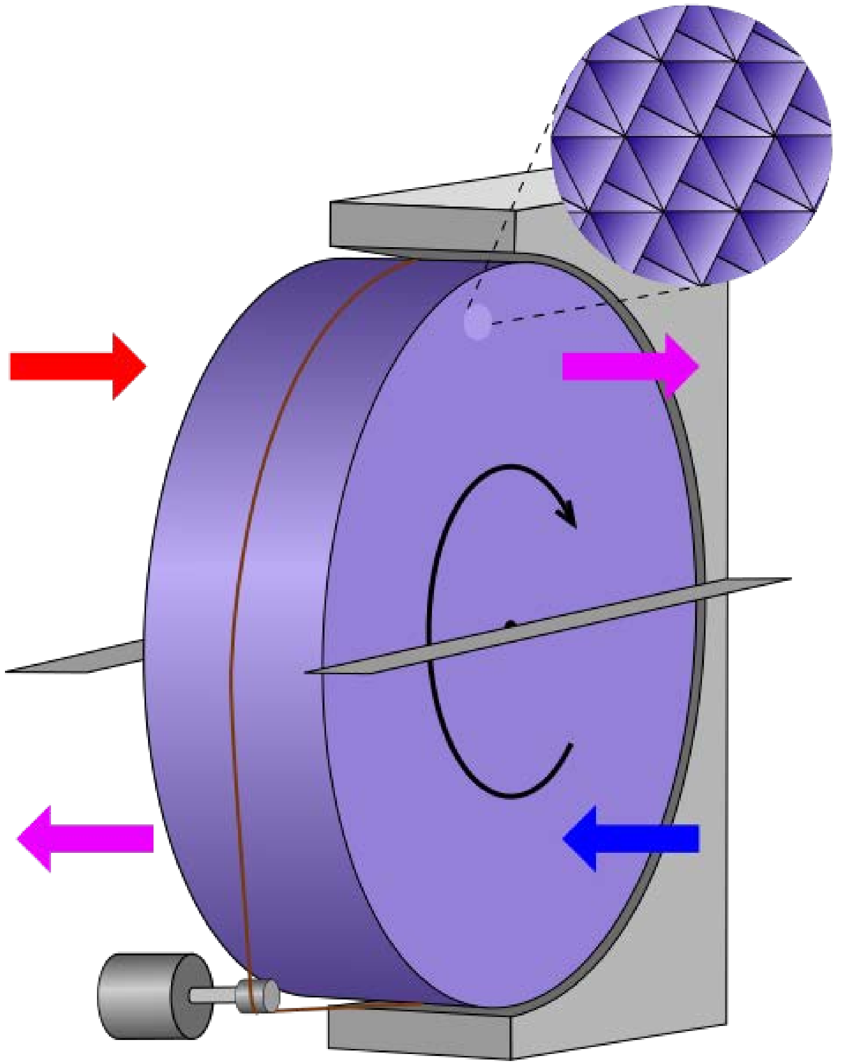
Keep the indoor environment as dry as possible.

Do not dry laundry indoors, and keep other household moisture sources at minimum.

Moisture safe building envelope (“Deflection-Drainage-Drying-Durability”)

Before possibly cooling the air, desiccate it.

Use rotary energy recovery systems / enthalpy wheels.



https://en.wikipedia.org/wiki/File:Rotary-heat-exchanger.svg

Building tech tips for hot/dry or warm/humid climates
4 – Windows

Avoid large window areas that cause a lot of direct solar gain.

Use windows with a high ratio between the Visual Transmittance and Solar Heat Gain Coefficient (VT/SHGC).

Use high R-framing.

Avoid big window areas to the east and west.

For low latitude locations, use windows predominantly on south and north oriented facades.

Photo: Heidi Rode

Building tech tips for hot / dry or warm / humid climates
5 – Ventilation

Use demand controlled ventilation.

Use cross ventilation, wind catchers, and possibly solar chimneys.

With mechanical ventilation systems: use energy recovery units.

Use night ventilation.

IEA EBC Annex 62: Ventilative Cooling.

Annex 62 State-of-the-art Review and http://catnaps.org/islamic/gulfarch4.html

Building tech tips for hot/dry or warm/humid climates
6 – Microclimate

Green facades (roofs and exterior wall claddings).
Exterior plantation.
Evaporative cooling.
Reflective coatings (beware of risk of glare).
Use of light colours (beware of risk of glare).
Urban landscape/building topology influence urban heating.

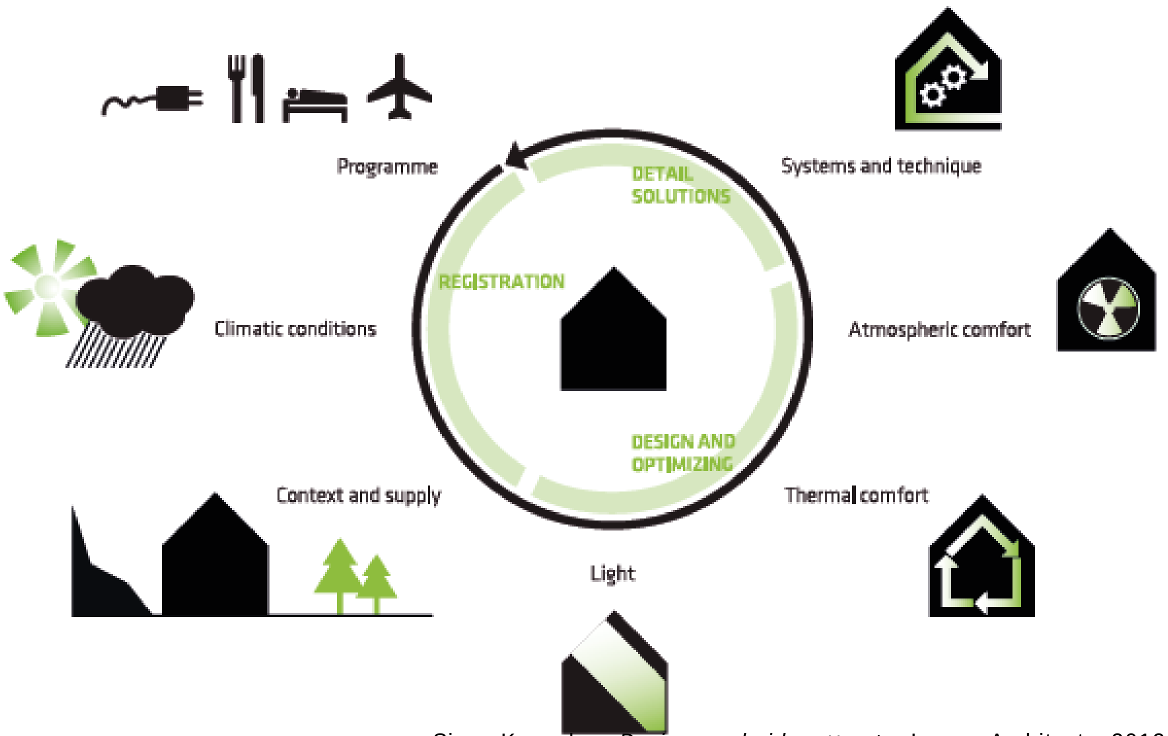
Indoor micro-climate: Use tall rooms and ceiling vents.

Building tech tips for hot / dry or warm / humid climates
7 – Design, construction and operation

Integrated design.

Commissioning.

Measuring, logging, and involvement of users and operators.



Signe Kongebro, *Design med viden*, Henning Larsen Architects, 2012

Building tech tips for hot / dry or warm / humid climates

8 – Adapt to the local climate


Sisimiut Greenland. Photo: Egil Borchersen

Design principles
Building layout

Hot / dry:

- Use compact, inward-facing buildings to reduce surface exposed to solar radiation.
- Orient large surfaces north-south. West-facing surfaces are the critical (for afternoons).
- Group individual buildings should closely together for mutual shading.
- Promote access to cooling and dust-free winds.
- Courtyards can create usable, protected outdoor spaces.
- For shading use projecting roofs, verandas, shading devices, trees, surrounding walls other buildings.

Warm / humid:

- Use open, outward orientated and elongated buildings to facilitate air movement.
- Large surface areas compared with the volume.
- Elongate buildings along east-west axis.
- Use wide spacing between buildings to allow for ventilation of external and internal spaces.
- Apply openness and shading around buildings.
- Protect vertical surfaces and openings without restricting air movement.
- Increase with the height of the building to benefit from wind.
- Architectural elements such as projecting roofs, verandas, shading devices, planting, etc. provide shade without restricting air movement.

Design principles
Roofs

Hot / dry

- Roof forms may support building physical function, e.g. a rounded and pitched roof may reduce heat gains during the day and increase heat release at night.
- Composite roofs can be of lightweight material with ceiling of dense material, and they may be separated into two independent roof structures.
- Ventilation openings in roofs remove hot air that would otherwise be trapped internally.
- Roof slopes should be orientated towards prevailing breezes to facilitate cooling
- Roofs sloping towards a courtyard flows downwards at night and can cool internal spaces.

Warm / humid

- The roof's main function is to act as an umbrella, providing shade and rain protection.
- Large roof overhangs protect walls and openings from heat gains and from splashes of rainwater.
- Pitched roofs provide rain protection and rainwater removal.
- Composite roofs and ceilings could be made of lightweight materials, but air that passes through the roof space should not be allowed to enter occupied spaces.

Design principles
Walls

East- and west-facing walls should be minimised because of exposure to solar radiation.

Hot / dry

- Heat gains in walls can be reduced by increasing their insulation value, thermal mass and shading provisions, and by functional zoning with unoccupied space as thermal barriers.
- Walls surrounding rooms used during the day should be massive, whereas walls of rooms used during the night should be of lightweight construction.
- In regions with large diurnal temperature variations thermal mass can balance the variations.
- With small external temperature variation, thermal mass should be limited to internal structures.
- Ventilation openings in walls facilitate night-time ventilation requirements.

Warm / humid

- In warm humid regions, walls should in general be of lightweight construction.
- Walls should be designed to maximise internal air movements and protect against radiation.
- Openness should be a dominant structural feature. Walls can be adjustable shading devices.
- The release of stored heat must be managed so as not to increase internal temperature.
- The outer surface of walls should be light in colour to reduce the absorption of heat.

Design principles
Floors

Hot / dry

- Floors that store heat are beneficial, e.g. if they are of heavyweight construction
- Ground floors should be solid and laid in direct contact with the ground.
- Buildings can include cellars or be built into the ground to take advantage of the ground's thermal properties.

Warm / humid

- Ground floors should have no contact with the ground.
- Raising the floor off the ground facilitates cooling by breezes and allows air to be cooled as it passes over vegetation below the building and thereby cools the floor.
- An elevated floor is advantageous in reducing impact due to heavy rains.
- The floor should be made of lightweight construction.
- Gaps between floorboards facilitate ventilation.
- If a solid floor is needed, it could have built-in ducts so thermal storage capacity is reduced and ventilation can be provided.

Design principles
Openings (considerations of daylight and glare)

Hot / Dry

- Direct sunlight should be avoided for thermal reasons, so keep openings small as possible.
- Diffuse internal light can be facilitated by screening, or openings towards a courtyard.
- Indirect and reflected light is the most appropriate form of daylighting. High openings reflect light with the ceiling. White-coloured ceiling diffuses interior light.
- Low openings can be used if they open to shaded green areas or non-glaring surfaces.
- Care must be taken that shading devices do not reflect light from glaring sources.
- Position openings so they are directed towards the sky (reduction of glare).

Warm / Humid

- The sky is a main source of glare, so openings should not be positioned towards the sky.
- Large openings are needed for cross-ventilation, but then roof overhangs or verandas can obstruct the view of the sky.
- Use shading devices to limit prevent having too much light. Louvered or adjustable shading devices are effective if they can reflect light from the ground towards the ceiling.

Design principles
Openings for ventilation (by wind and temperature)

- Openings for ventilation and daylighting purposes should be kept separate.
- Ventilation openings should be closed during the day when temperature is high.
- Ventilation openings should be open during night to remove of stored heat from structures.
- Openings for ventilation should be located at different heights to use stack effect for cooling.
- Ventilation openings should be located so air moves over the warmest internal surfaces.
- Solar chimneys may use solar heating to induce stack effect and to stimulate air movement under conditions of low wind.

Literature

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