Solar construction – Climate-appropriate construction in other climates

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If the climatic conditions in a region permanently or temporarily deviate from the range considered comfortable by users, measures must be taken to condition the interior climate to make the living environment pleasant. The task of climate-appropriate construction consists in ensuring comfortable interior conditions all year round with constructive means only, with a minimum use of fossil fuels and a maximum percentage of renewable energy.

Modern designs often ignore the fundamental climate-appropriate principles and then attempt to use high-tech systems (generally with significant consumption of fossil fuels, and sometimes with air conditioning systems which are found unpleasant) to compensate for incorrect construction physics decisions. In many countries, buildings are designed and built based on western models, even though they may already have led to construction physics problems in their countries of origin. In locations with warm external climates, the energy consumption of buildings considered unfavourable in European or American conditions increases significantly, as much of the energy must be used to cool the building. However, especially in countries in the sun belt, use of solar thermal cooling and air conditioning processes is a promising alternative to electrically powered chillers. Climate-appropriate construction, which fulfils the criteria of summer-time heat protection, can guarantee a more pleasant interior climate and save a lot of energy.

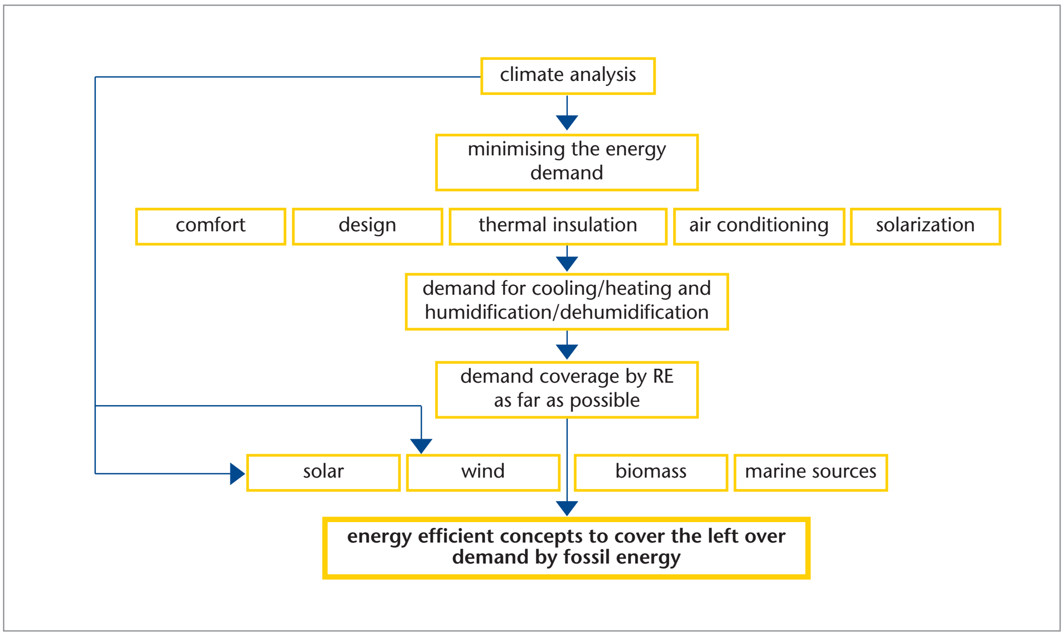
Unfortunately, architectural designs are transferred from one climatic region to another without a second thought, even if they are completely unsuitable there. The main reasons for these violations of the principles of climate-appropriate construction are historical and social:

- Historically, the inappropriate building styles were initially imposed by the colonial powers. They took possession of overseas territories and forced the construction style of their home countries on the inhabitants of the colonies against their will. For example, the building types appropriate and adapted for the climate in Holland are absolutely unsuitable for the former Dutch colony of Indonesia.
- Today, emerging countries manufacture and install technical systems in buildings which do not suit the local climate due to a naive belief in progress and a lack of knowledge of construction physics. The same applies for the uncritical application of European construction standards. Regulations which may be appropriate in Europe are not necessarily suitable for China or Taiwan. Local architecture, which grew organically over centuries in the respective climatic regions, is not appreciated or is disregarded by domestic architects. They want to be "modern" and imitate the designs considered so (e.g. glass and steel facades as built in America).

Principles of climate-appropriate construction

Depending on the climatic conditions in a region, the interior climate of a building must be adjusted in a way that pleasant conditions are provided for its users. Different comfort criteria and different measures are key for conditioning, depending on whether it is too cold or too hot outside. Figure 1 shows the step-by-step procedure for minimising the energy requirement. Step-by-step optimisation makes evaluation and prioritisation of the individual measures easier, and facilitates cost-benefit analysis.

Figure 1
Procedure for minimising the energy requirement for interior climate conditioning in buildings



In order to achieve the project target of minimum use of fossil fuels and maximum use of renewable energy, the following procedure is recommended:

First, the climatic conditions and the conditions due to the planned use are analysed on site. Adjusted for these conditions, the technical equipment of the buildings should be designed such that as little energy as possible is required for internal conditioning and any other requirements. While a solution optimised specifically for the local climate must be developed during planning of a building, the same potential savings may be utilised for the use-specific energy requirements as in Europe. Based on the concepts developed and taking the requirement figures of comparable premises into account, the expected overall energy requirements are determined.

In a further step, the renewable energy sources available at the project location are analysed and their suitability and economic feasibility for this project are evaluated. As a result, a recommendation of suitable systems and equipment and a mathematical estimate of the proportion of the overall energy requirement which can be supplied from renewable sources are drawn up.

Any remaining energy requirements are covered with conventional processes, whereby an environmentally sensible and economic combination with the renewable systems is the goal. This results in an optimal or multiple equivalent overall concepts for energy supply.

1st step: Climate factors and climatic conditions

A precise analysis of the climatic conditions on site is essential in determining the feasibility of a project in terms of energy and construction physics. Key external climatic factors which influence the energy requirements of a building are as follows:

- Temperature and relative humidity of the exterior air
- Irradiation intensity
- Wind and rain may be important if the external air or evaporation cooling are to be used to improve the indoor climate.

For apposite planning and construction, the factors arising from the local climatic conditions must be taken into account. The influences on the user's comfort, the safety of the buildings and the premature aging of construction materials must also be analysed.

2nd step: Energy optimisation of buildings

The main adjustments and construction physics influences are shown in *Figure 2*.

Accordingly, for a climate-appropriate building design, e.g. for a location in the United Arab Emirates, where climatic conditions require cooling but no heating, the following measures must be ensured:

- Favourable ratio of external surface to building volume (i.e. where possible, multi-storey, larger units)
- Preferable orientation of buildings from east to west as this results in the lowest irradiation effect (due to the extremely high sun)
- Minimise window surfaces, use double and triple glazing, avoid windows facing east or west due to the strong irradiation
- Preferably automatic shading, low SHGC (Solar Heat Gain Coefficient) values of windows reduce heating by the sun
- Good thermal insulation of the roof surfaces in particular
- Lightest possible colours for the external surfaces, to reflect more of the solar irradiation and absorb less
- Decrease the exchange of air in warm periods to prevent excessive heating of the building, ventilation system with heat recovery
- Avail in full of options for nocturnal ventilation (care is needed in high humidity areas)
- Where possible, urban developments should be planned such that streets are narrow and the buildings opposite one another provide shade.

3rd step: Efficient building conditioning and technical systems

According to the project targets, renewable energy should be used to cover as much of the energy demand as possible. The potential natural or renewable energy sources must be taken into consideration and their availability and respective possible energy supply potential must be evaluated based on technical and economic criteria.

As already stated in the introduction, as much of the energy required to generate cooling as possible should be provided from regenerative energy sources. As a result of the high solar potential which is available in many cases, the use of solar energy for conditioning buildings and open spaces should be investigated first. Use of photovoltaic systems for direct conversion of solar irradiation to energy makes sense in countries in the sun belt, due to the high availability of solar irradiation. For example, the annual total irradiation in Dubai is 2000 kWh/a m². That means that standard modules can produce yields of 100 MWh per annum on a surface area of approx. 500 m². The only problematic or limiting factor for use on site is soiling via sand and dust.

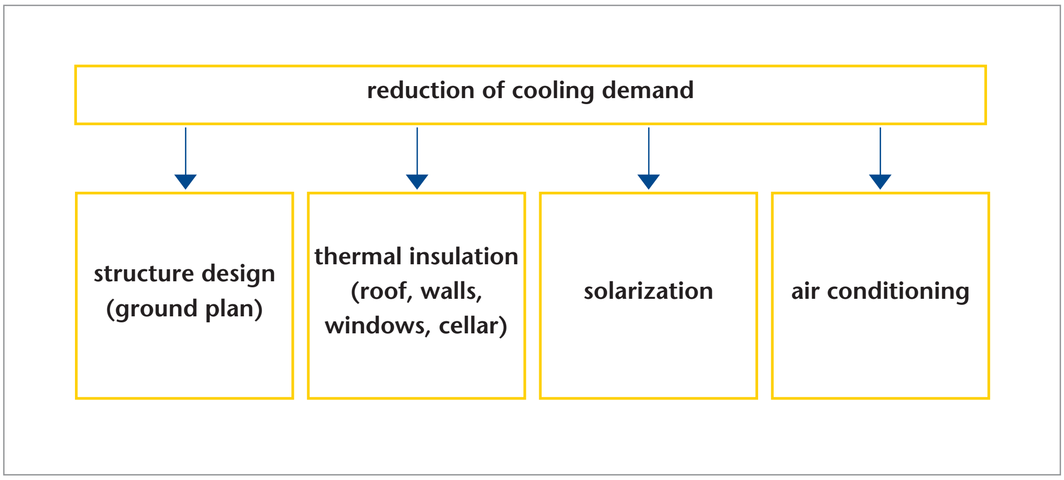


Figure 2
Construction physics influences and adjustment options for cooling energy of buildings

There is a variety of different thermally driven processes for generating cooling and providing fresh air conditioning using (solar) heat. In general, two types must be distinguished:

- Closed systems which provide cooling for comfort air conditioning in the form of cold water
- Open processes used to condition fresh air

Which of these processes is suitable for a particular application depends in particular on the climatic conditions (irradiation, external temperature, external air humidity) on site, in addition to the building design, building use and comfort requirements. High irradiation leads to great system loads, while high external temperatures and air humidity limit the performance of the systems due to the recooling required.

Conclusion

Climate-appropriate construction largely depends on constant consideration of the prevailing climate parameters during the building design phase.

The energy required for indoor climate conditioning can be significantly reduced via simple building measures. Studies show that the potential savings in building energy requirements can reach up to 75%. To achieve this, the various measures must already be taken into consideration as part of planning:

- Climate-appropriate building design
- Use of new energy-saving technologies
- Combination of high-efficiency systems for supplying power and cooling

Constructive measures in particular can only be changed to a minor extent after the fact. The design and combination of the system technology also requires comprehensive planning, as over or undersizing leads to a significant increase in the primary energy requirement or to a lack of conditioning in the interiors. Therefore: First, build appropriately for the climate, then install air conditioning appropriate for the building!