Federal Ministry
of Transport, Building
and Urban Development

Smart energy-efficient building design

Germany
Land of Ideas

INFINITE OPPORTUNITIES | GERMANY + INDIA 2011–2012

An exhibition organised by

Federal Ministry of Transport, Building and Urban Development

Smart energy-efficient building design

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Indo-German Urban Mela

Mumbai | Bangalore | Chennai

Germany – Land of Ideas

Imprint
Smart energy-efficient building design

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Content

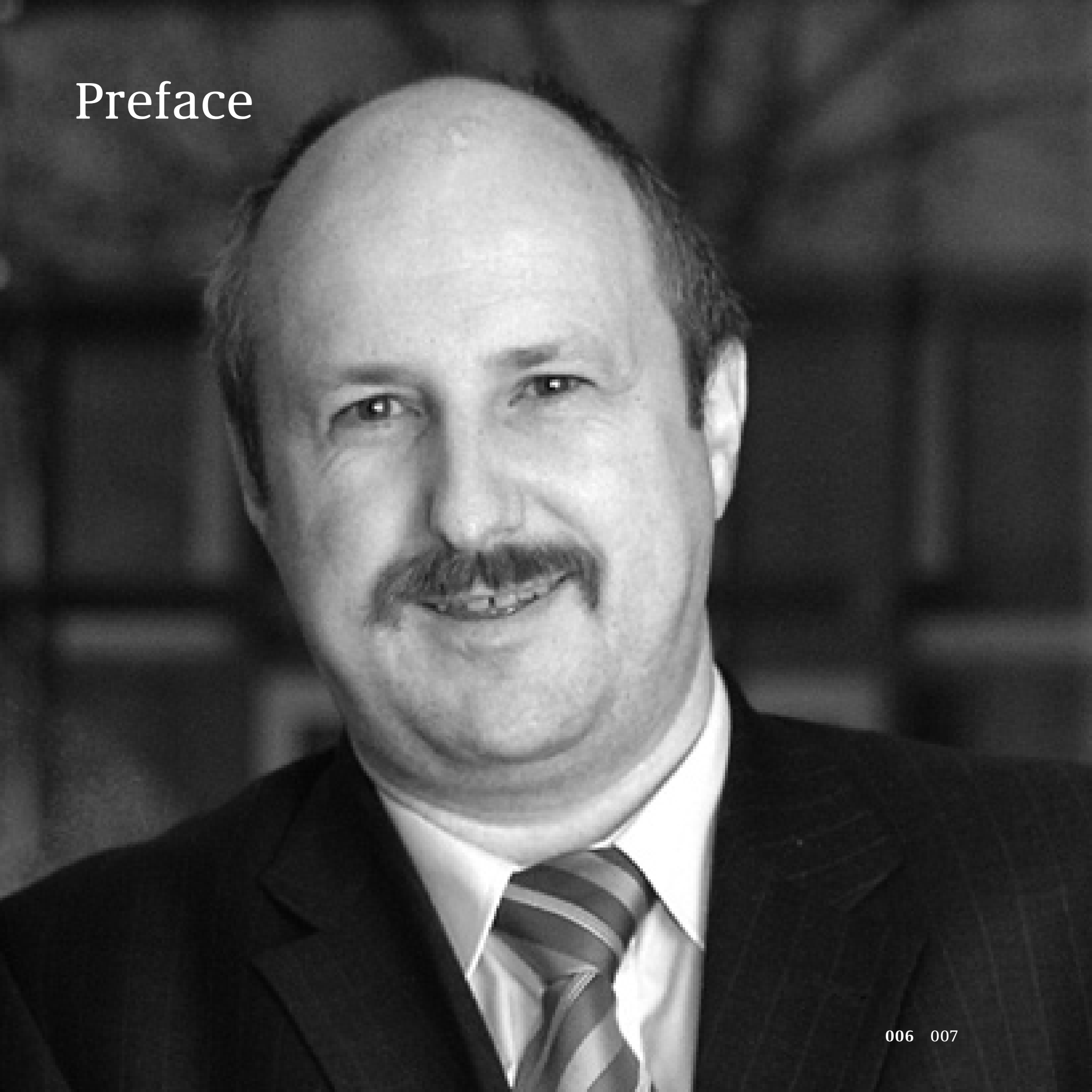
Greeting

Cities are the main pillars of worldwide development. This is where the issues of the future concerning economy, science, ecology and society are decided. Our pavilion shows the approaches pursued by Germany in central urban fields of action like energy, combat against climate change, architecture and mobility. For sustainable growth, modern technologies and progress we are focusing on reliable cooperation and creative innovation. And on a strong partnership with India.

Dr. Peter Ramsauer

Federal Minister of Transport, Building and Urban Development

Preface



In 2010, the Federal Government adopted an energy strategy. Following the Fukushima disaster and the decision to shut down nuclear power plants in Germany by 2022, this energy strategy has been reinforced once again.

Its major benchmarks are now:

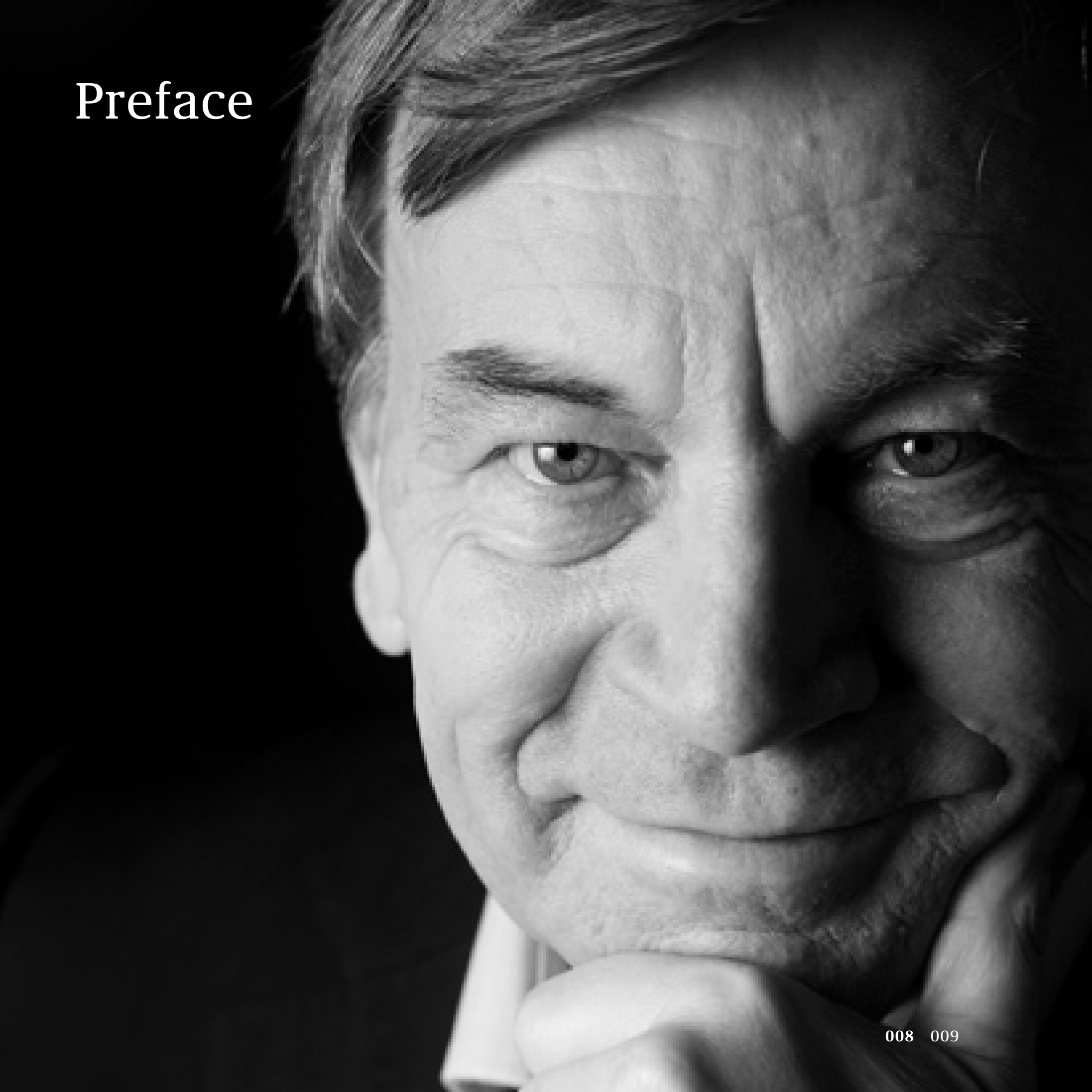
– reduce primary energy demand by around 80 % by 2050;
– reduce heating demand by 20 % by 2020;
– introduce “climate neutral buildings” in the new build sector, starting in 2020
– draw up a refurbishment roadmap for the building stock, with which the rate of refurbishment can be at least doubled.

To achieve aimes like “nearly zero energy buildings”, the relevant technologies and products must be made available. Therefore, within the framework of the “Future of Building” Research Initiative which was launched by the BMVBS, intensive research is being conducted in Germany in connection with the development of so-called “plus energy houses”. The surplus energy is, for example, to be made available for the improvement of electric mobility.

The slogan “My house – my filling station” is no longer a vision but will step by step become reality.

Hans-Dieter Hegner
Federal Ministry of Transport, Building and Housing, Berlin
Head of Division B 13
“Civil engineering, sustainable building, research in the building sector”

Preface



As architects and engineers we determine the built environment. We take decisions about the comfort of its inhabitants and the amount of energy needed to provide better living conditions. In common terms this process is associated with increasing energy demand, rapidly shrinking resources and great concerns for the future.

We can escape this situation by building smart buildings and smart cities. Their characteristics are climate-adapted building design and building envelopes, clever building construction and a good choice of materials, as well as energy-saving technologies and appliances. The site and the building envelope can provide more renewable energy than most buildings need. By connecting existing and new buildings at neighbourhood and city level, we can develop truly sustainable environments.

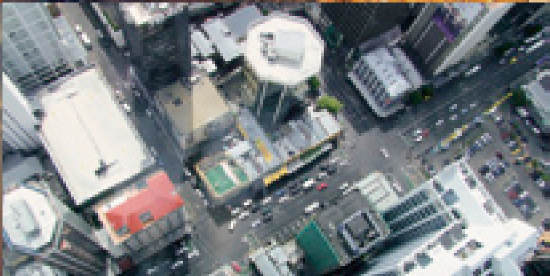
We need up-to-date educated and determined architects and engineers to make progress in this direction. Research and development lead the way. Pilot buildings and model cities provide experience and guidelines. A strong partnership with India will be extremely helpful to exchange ideas and philosophies, technologies and behavioural patterns.

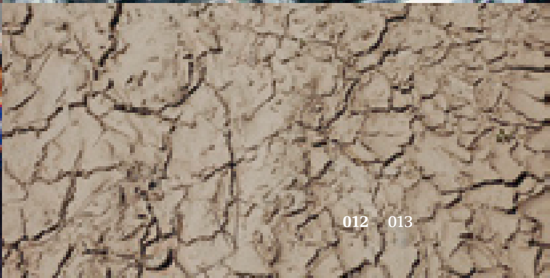
Prof. Manfred Hegger
Technische Universität Darmstadt,
Faculty of Architecture,
Energy Efficient Building Design Unit

Resources



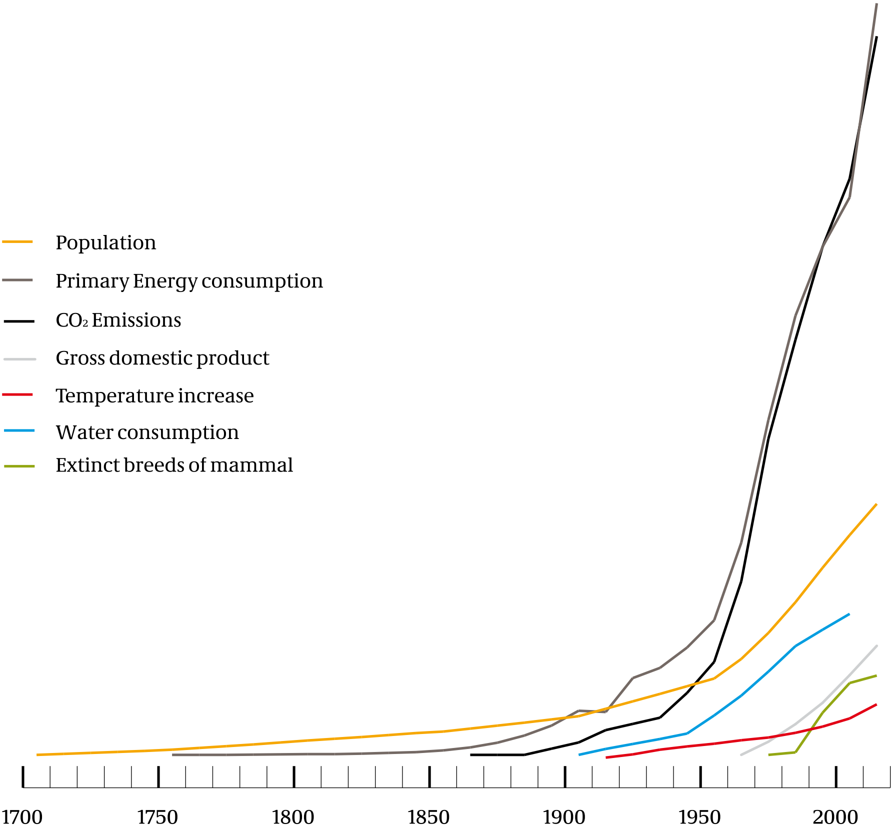




LAND USE	**140 ha/day** total green field use in Germany per day
CO_2 EMISSION	**40 %** of all CO_2 emissions are produced by the building sector
RESOURCE USE	**50 %** of all resources are used by the building sector
WASTE	**60 %** of all waste comes from the building sector
FOSSIL FUELS	**approx. 43 years** until oil supplies run out
URBANISATION	**70 %** of the world’s population will live in cities by 2050
GROWTH OF HUMANITY	**9.2 billion** people until 2050
CLIMATE	**+0.8 °C** increase of global temperature over the last 100 years

Global development data



Consumption of materials

The consumption of non-renewable materials increases with population growth, increasing wealth and open material cycles. A particularly significant factor is the use of construction methods with high demand for raw materials and low recycling rates. Reutilisation and building methods that allow for dismantling enable used materials to be reintroduced to the cycle. Ideally, they can be used again indefinitely. The construction sector offers a huge potential for preventing the unnecessary consumption of resources.

Carbon dioxide

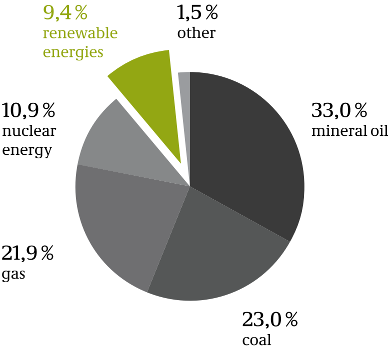
The Carbon dioxide (CO_2) emitted into the atmosphere has reached worrying concentration levels, and is a contributory factor to devastating natural disasters. The objective decided upon in Cancun in 2010, to limit global warming to 2°C (compared with 1990 levels) by 2050 looks like it could fail to be achieved. In order to succeed, an annual saving of 4.8% CO_2 must be achieved between 2012 and 2050. New building technologies and the more sparing use of natural resources in construction could make a substantial contribution towards achieving this objective.

Water

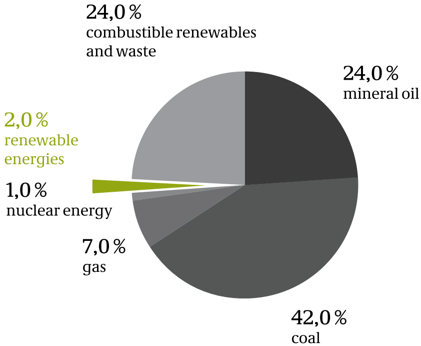
Only approx. 0.6% of the water found on the Earth is from freshwater sources and of drinking water quality. This resource is very unevenly distributed globally and further development is beset by substantial problems in many countries. Efficiency strategies for the resource of water are required worldwide to prevent shortages and conflicts. These include more sparing use, rainwater usage, reducing seepage, and recycling through the use of grey water in buildings and built districts.

Energy data

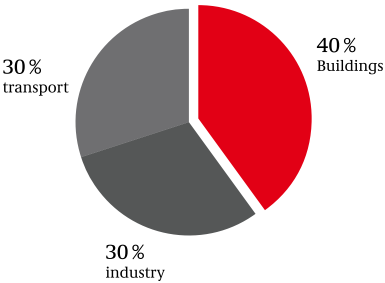
Energy mix in Germany (2010)



Energy mix in India (2009)



Energy user in Germany



Energy

Thermal and electrical energy are mainly generated by the combustion of natural resources. During the conversion of coal, oil gas and other fossil fuels, the majority of the energy obtained is lost in the form of waste heat, for example around 2/3 is lost in the generation of electricity. The use of fossil fuel-based energy systems is increasingly called into question by increasing raw material prices, uncertain availability, as well as the harmful effects on the climate. At the same time, the cost of renewable energy sources is falling, which means that not only do they help safeguard the global environment but in many sectors also represent the best alternative in terms of price.

Primary energy

Primary energy designates potentially-available and naturally-occurring energy in the form of oil, coal, sun or wind, prior to conversion.

Grey energies

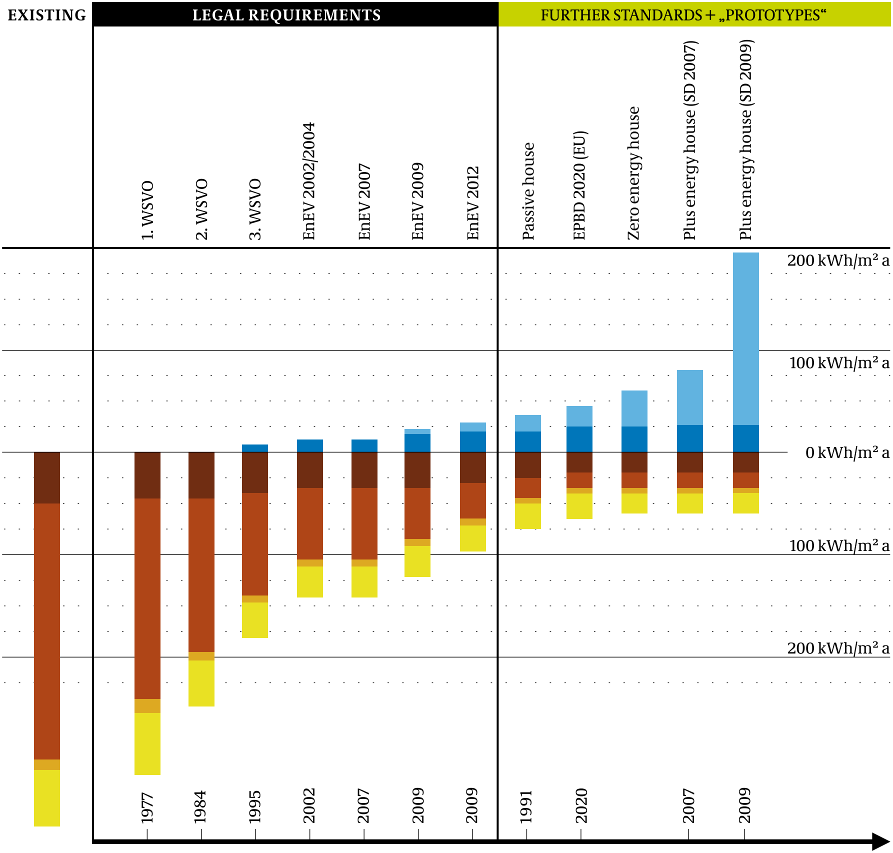
The energy required for the manufacture, maintenance and disposal of building materials and components is referred to “grey energy”. Considered over the whole life-cycle, in highly efficient buildings it contributes more to the environmental impact and the energy balance than the heating, cooling and electricity used in operating the building. A careful selection of the construction methods and materials can help considerably with energy savings. A long service life spreads the grey energies over a longer period, thereby reducing the energy budget and the effects on the environment.

Energy policies

Energy policies
in Germany and Europe

Energy-efficient building has been an integral part of building legislation in Germany since 1977. At the European level, the EU Energy Performance of Buildings Directive (EPBD) defines the requirements, which have been implemented in Germany by the Energy Conservation Orders (EnEV). Additionally quality standards beyond the legal requirements have been established in Germany. These include, for example, the nationally-promoted efficiency house, the passive house, the zero-energy and the plus-energy house.

Legal requirements on construction since 1977



EU Buildings Directive 2010/31/EU

Energy Performance of Buildings Directive (EPBD)

The European Energy Performance of Buildings Directive, EPBD, 2010/31/EU also forms the basis for the amendment to the German Energy Conservation Order, which is set to come into force in 2012.

The main objectives of the European Union by 2020 are:

- Reduction of greenhouse gas emissions by 20 % from 1990 levels
- 20 % increase in energy efficiency
- More than 20 % of the energy requirement for buildings to be from renewable sources

In addition, the “Nearly zero-energy building” standard should be introduced as a compulsory standard for public buildings from 01.01.2019 and for all buildings from 01.01.2021.

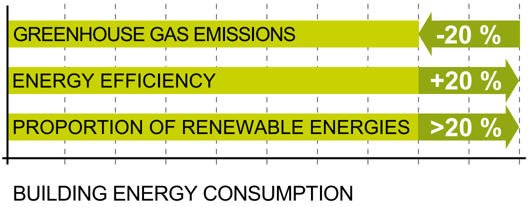
End energy consumption

- Hot water
- Heating
- Auxiliary power
- Household electricity

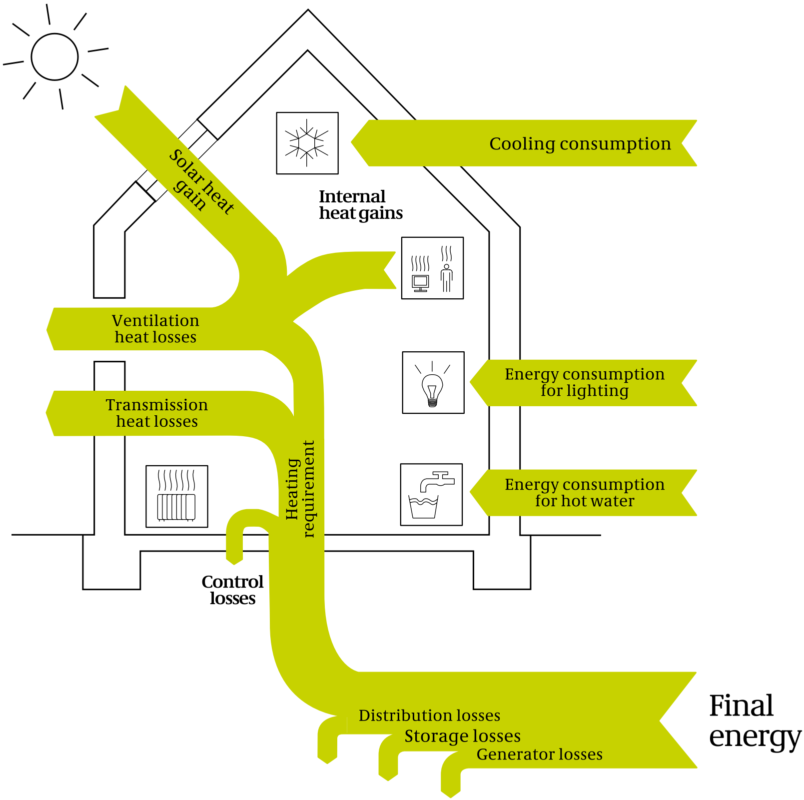
Final energy generation

- Renewable Heat
- Renewable electricity

EPBD – EU building directive 2010/31/EU



Balance of non-residential buildings according to EnEV 2009



Energy Conservation Regulations
EnEV

Since 2002, legal requirements have been in place that not only affect the building shell, but also the technical facilities.

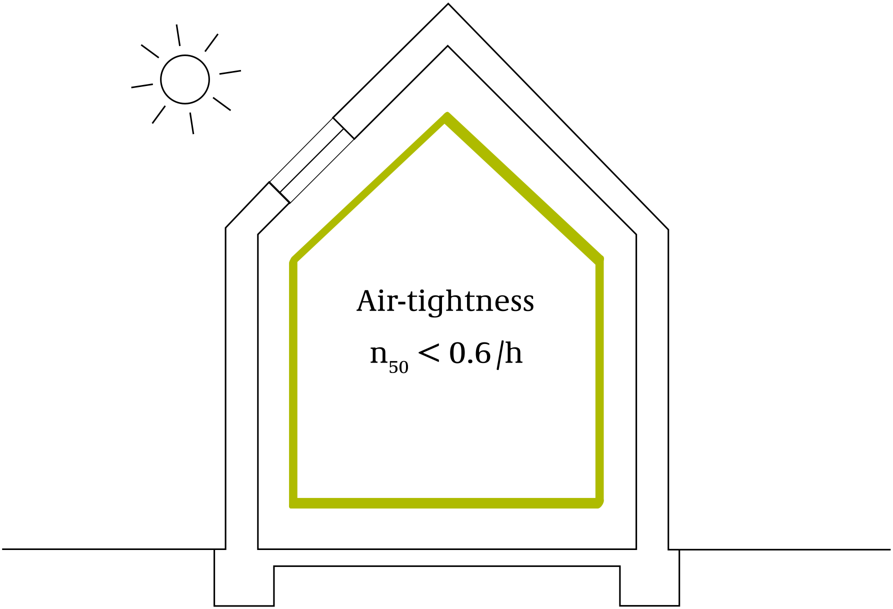
The requirements relate to:

- The transmission heat requirement [W/m² K]
- The specific primary energy requirement [kWh/m² a]

Both requirements are assessed by comparison with a reference building of the same building geometry constructed according to the Standard.
The primary energy requirement is shown in the buildings energy certificate in the form of a comparative scale. The coloured representation and the simultaneous application of various energy standards enable the energy quality of a building to be classified quickly and easily.

The EnEV procedure for residential buildings balances the annual heating requirement and energy needed to heat water. When assessing non-residential buildings in accordance with the EnEV, the cooling requirement and electricity needed for lighting are also balanced.

Passive House criteria



Heating requirement	< 15 kWh/(m^2 a)
or building heating load	< 10 W/m^2
Cooling consumption	< 15 kWh/(m^2 a)
Primary energy consumption	< 120 kWh/(m^2 a)
Excess temperature frequency	< 10 %
Ventilation with	**> 75 % WHR**
Electricity consumption	**max. 0.45 Wh/m^3**

Further Energy Standards
Efficiency House

The Efficiency House standards are supported nationally in Germany. Assistance is given to buildings that fall substantially below the EnEV requirements. The Efficiency House standards 70, 55 and 40 show the size of the primary energy requirement in relation to the legal requirements (percentage). The lower the energy requirement, the greater the grant assistance.

Further Energy Standards
Passive House

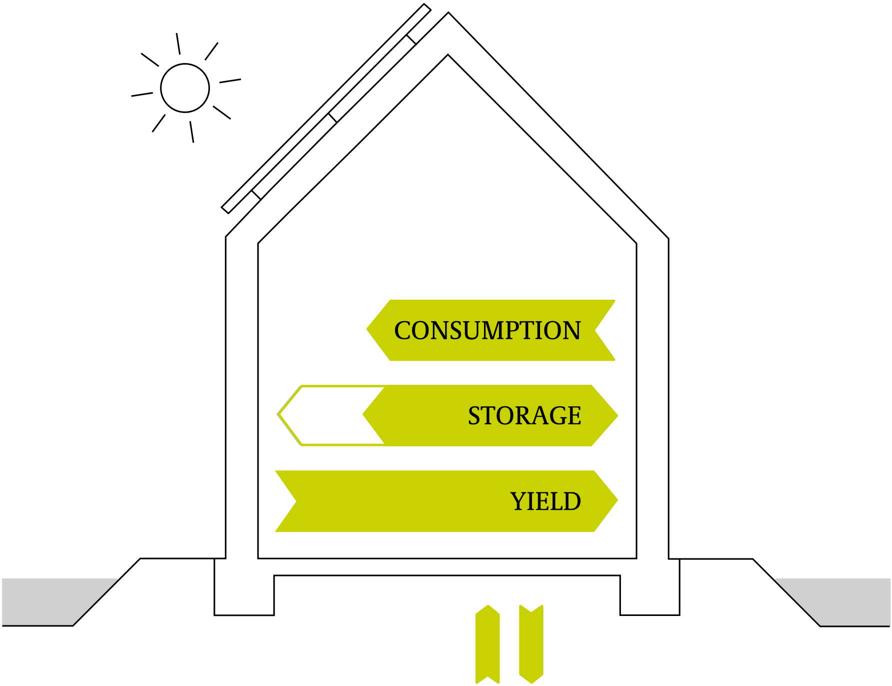
The Passive House standard was developed by the Passive House Institute in Darmstadt. The primary objective is to introduce structural measures to reduce the heating and primary energy requirements as far as possible, so that none of the usual fossil fuel-based heating systems are needed.

The main requirements are:

- Heating energy requirement $\leq$ 15 kWh/m² a (or alternatively heating load of 10 W/m²)
- Primary energy requirement, including lighting, ventilation and household electricity or power for work equipment $\leq$ 120 kWh/m² a

The corresponding balancing procedure (PHPP) takes account of most of the building's energy requirements and also includes the electricity needed for household appliances and work equipment.

Energy self-sufficient building



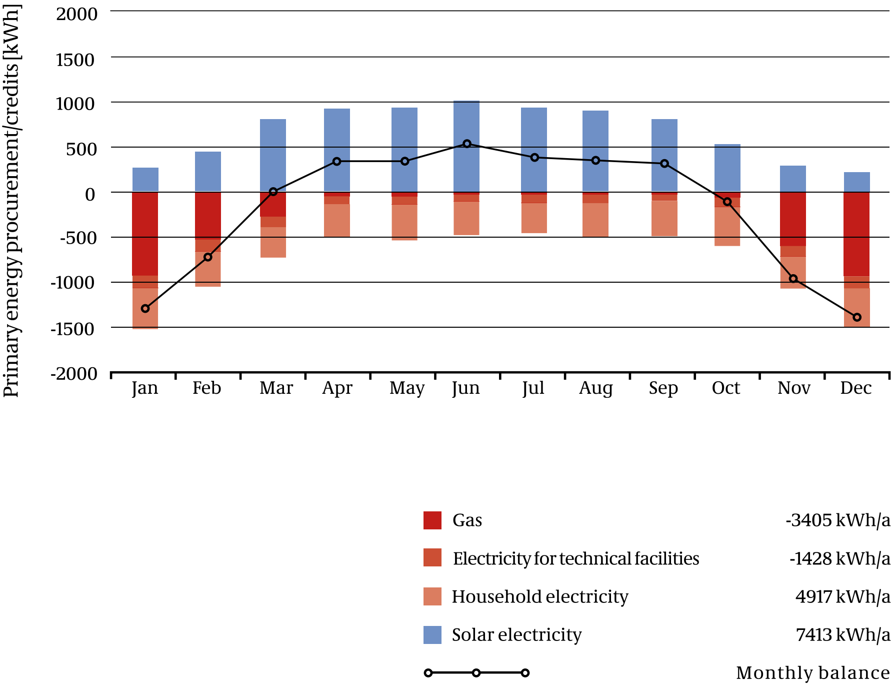
Further Energy Standards
Energy Self-Sufficient House

An energy self-sufficient house is not connected to a central energy supply. It ensures its own permanent supply by means of load management and local electricity storage methods.

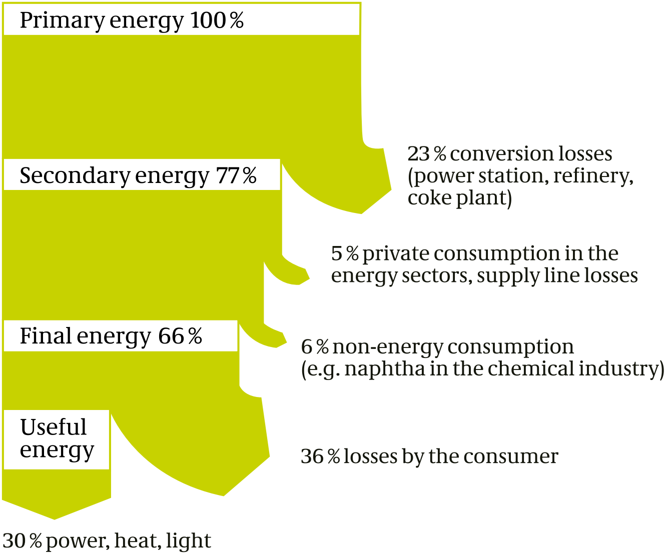
Further Energy Standards
Net Zero-Energy House / Net Plus-Energy House

A Net-Zero-Energy House generates over the year, as much renewable energy as it needs for heating, hot water and household electricity. A Plus-Energy House covers its own energy requirement and also, over the year, generates an additional net energy yield to be fed into an external energy network. The main criterion of the Plus-Energy standard is a negative annual primary energy requirement ($\Delta Q_P < 0$ kWh/m² a) and at the same time annual final energy consumption ($\Delta Q_E < 0$ kWh/m² a), including energy for lighting, household appliances and household processes.

Net Zero-Energy House



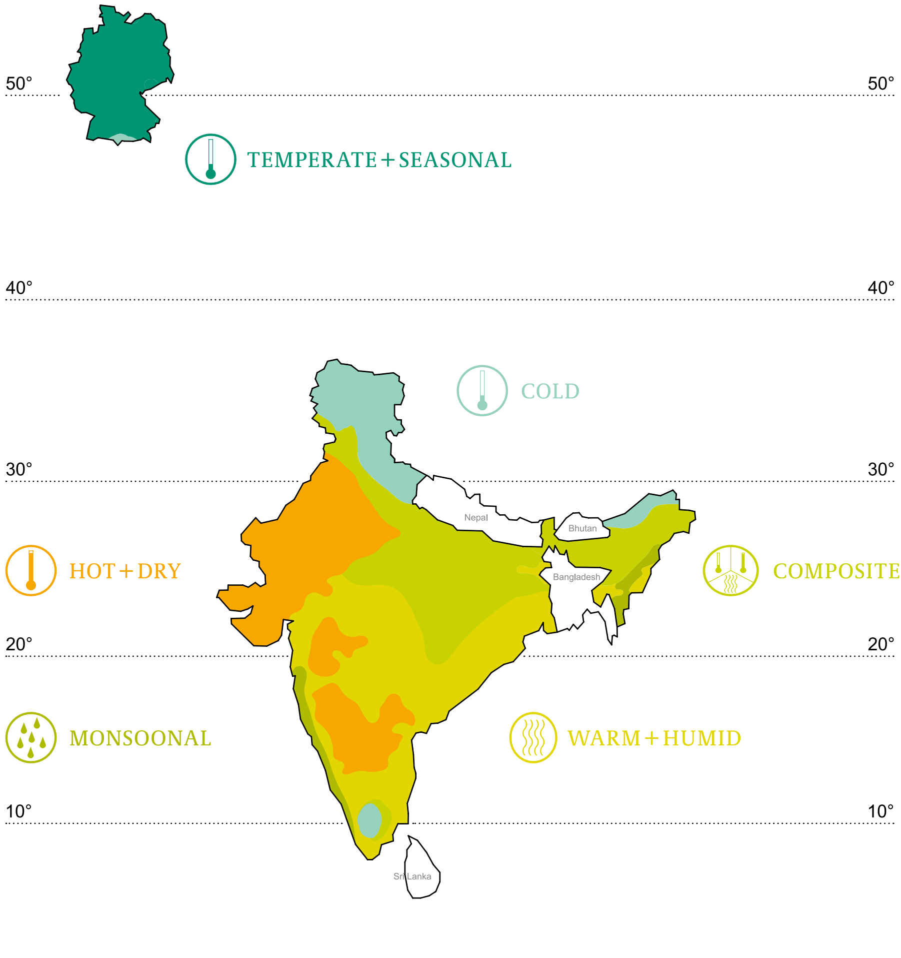
Energy flow from primary energy to useful energy



Climate

Climate zones
in Germany and India

The indian Subcontinent has four major different climate zones, while Germany is located in one major zone only. The analyses of climatic conditions and local energy potentials is crucial to the development of a sustainable and economic energy concept.


50°
50°
TEMPERATE + SEASONAL
40°
40°
COLD
30°
30°
Nepal
Bhutan
HOT + DRY
Bangladesh
COMPOSITE
20°
20°
MONSOONAL
WARM + HUMID
10°
10°
Sri Lanka

Climate zones in Germany

Temperate + seasonal

Overall, Germany has a warm, temperate and wet climate with westerly winds. Extreme fluctuations in temperature are rare. Rain falls throughout the year. Mild winters and moderate hot summers are the norm. Due to the seasonal difference the design criteria aim at resisting heat loss by insulation and infiltration and by promoting heat gains in directly admitting and trapping solar radiation in winter. In summer heat gains are reduced by adaptable shading and by promoting natural cooling and cross ventilation.

TEMPERATE + SEASONAL

Climate zones in India

Warm + humid

Characteristics are high temperatures and high humidity throughout the year. The wind is generally from one or two prevailing directions with speeds ranging from extremely low to very high. The main design criteria should be to reduce heat gain by shading, and to promote heat loss by maximizing natural cross ventilation. Dissipation of humidity is also essential in order to get a high comfort level.

Monsoonal

In addition to the generally high humidity, the monsoon means extremely high precipitation levels. Important design criteria are the removal of water during periods of heavy rain, the reduction of heat gains and humidity control. The risk of flooding and other adverse effects of bad weather on a building or site should also be taken into account.

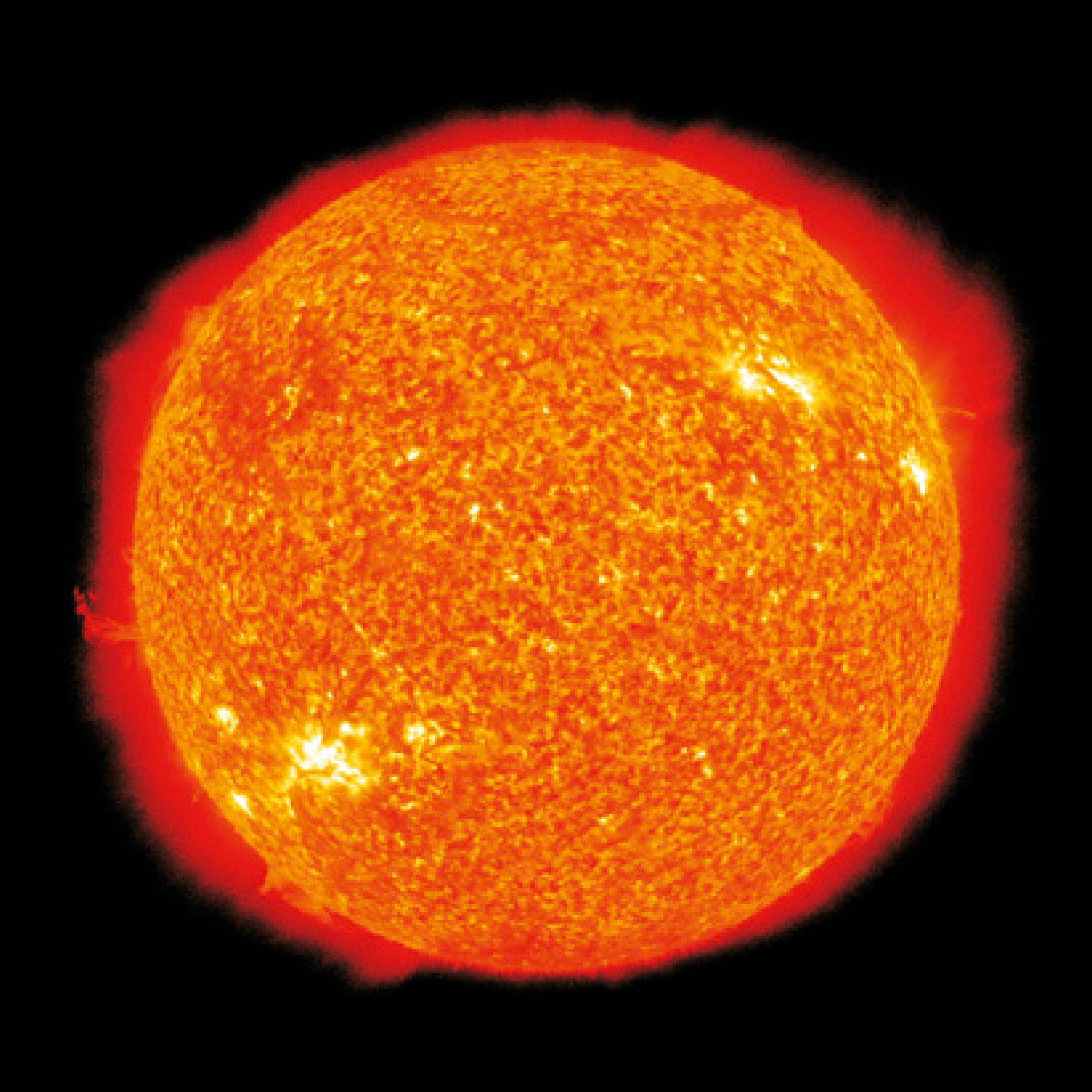
Cold

Typical for this climate are cold winds in winter and overcast skies for most part of the year except during the brief summer with clear and pleasant conditions. The main criteria for design in this climate aim at resisting heat loss and infiltration by insulation and at promoting heat gains by directly admitting and trapping solar radiation.

Hot + dry

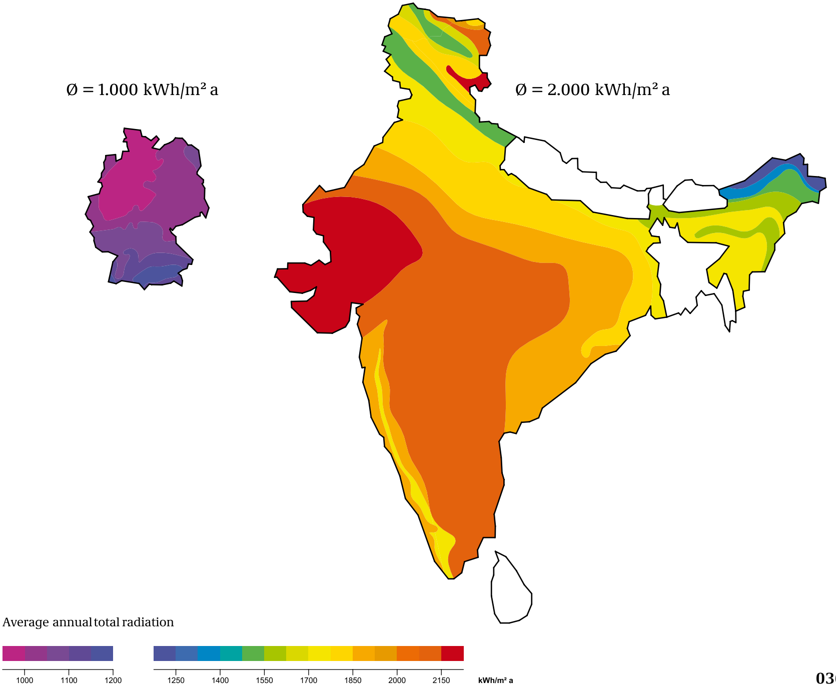
High solar radiation, generally clear skies, hot winds during the day in summers, in some regions sand storms and cool and pleasant nights are typical for this climate. Design criteria in this climate should consider efficient shading and the reduction of exposed areas, controlling and scheduling of ventilation as well as an increased thermal capacity.

Potentials



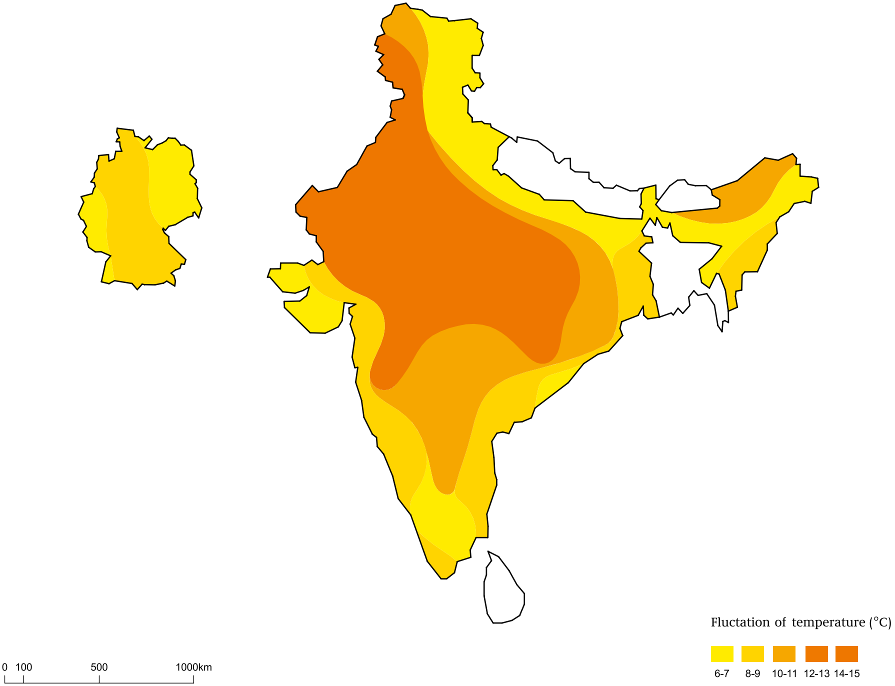
Solar radiation

The total annual global radiation varies by region and season. This high global potential may contribute through passive use (solar heat gain, maximisation of daylight) to reducing the additional energy consumption of buildings. In addition, active use can support the necessary heating, cooling or electricity production or completely replace them.



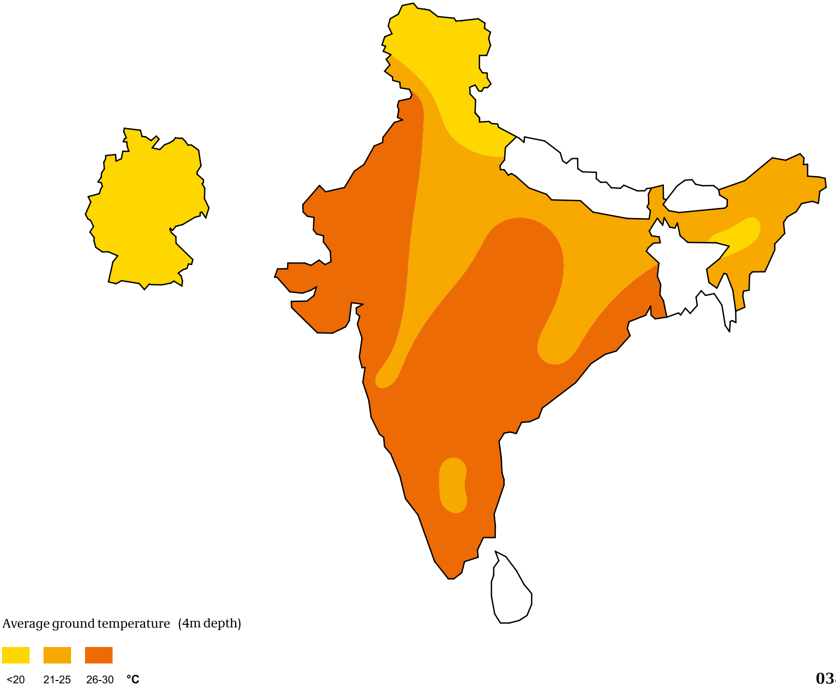
Temperature variations

The difference between the daily maximum and minimum temperatures varies depending on the location and season. As the outside temperature has a direct effect on internal temperatures and thus the heating/cooling requirement, buildings must be in a position not only to cope with these variations, but also to benefit from them. Heat storage masses and night ventilation can even out larger temperature variations, creating a balanced interior climate.



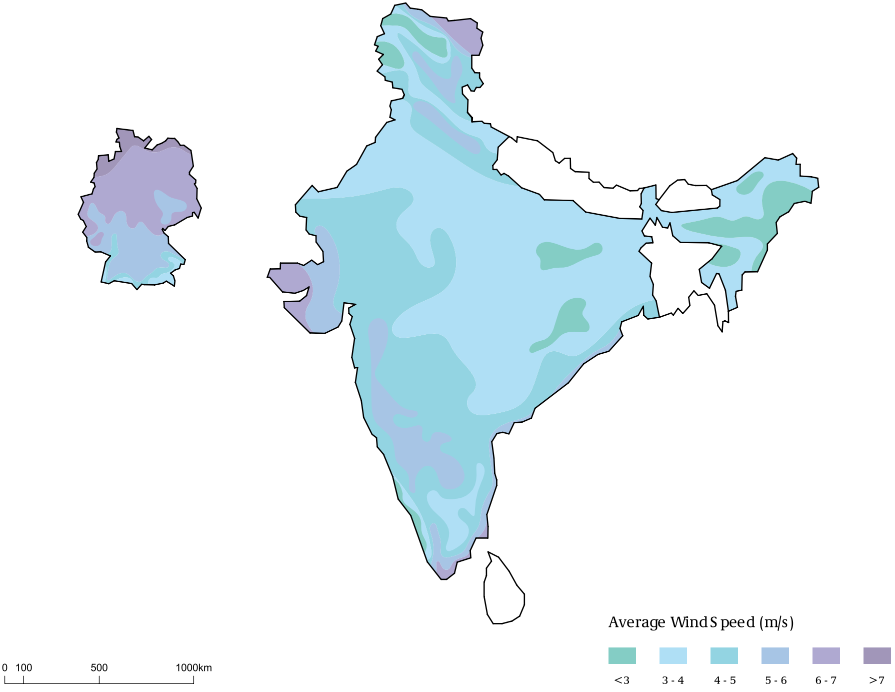
Ground temperatures

Ground temperatures near the surface are affected by external parameters, but are very slow to adjust. This constancy of temperature offers great potential for using ground warmth for heating or cooling, which can be augmented by using a heat pump.



Wind

A decisive factor in the planning of buildings is the prevailing wind direction and seasonal variations. The targeted orientation and arrangement of openings can contribute to providing natural ventilation and dissipating heat without substantial technical intervention.



Architecture

Traditional construction in Germany and India

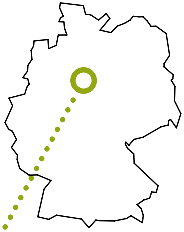
Over centuries, traditional indigenous construction methods have developed appropriate strategies for reacting to the specific climatic challenges.

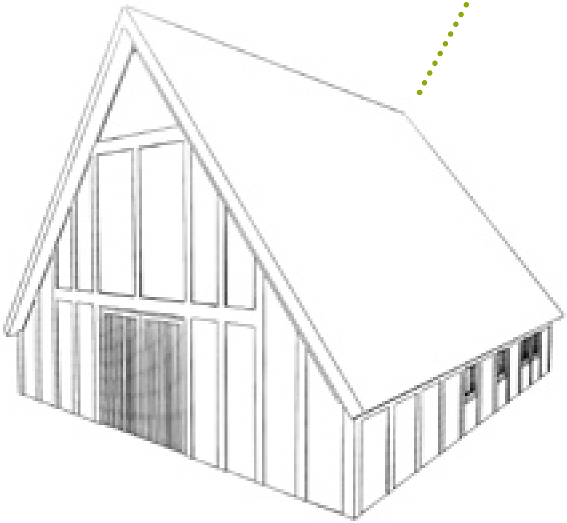

TEMPERATE + SEASONAL

Hallenhaus

Materials:
timber, clay, grass, glass

- Roof insulation using timber and grass
- Use of internal heat loads optimised: kitchen, animals
- Natural ventilation



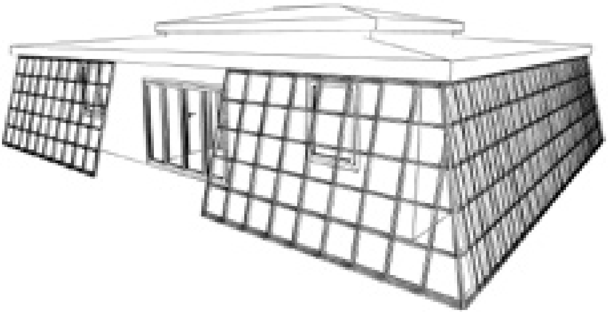


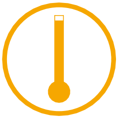
TEMPERATE + SEASONAL

Wachsendes Haus

Materials:
glass, steel, timber

- Optimised use of solar inputs
- Insulation by means of buffer zones
- Use of internal heat loads optimised
- Natural ventilation

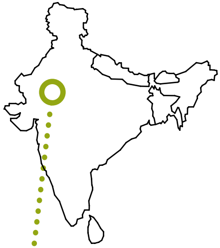


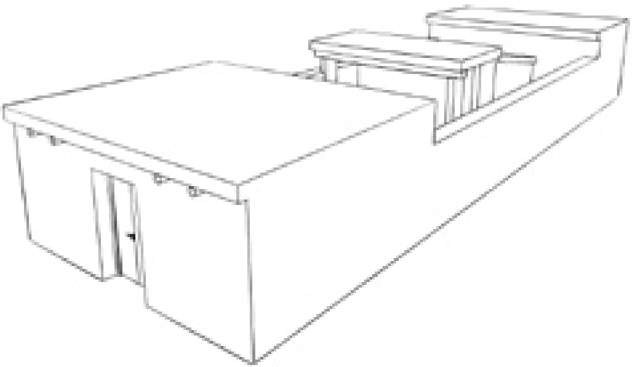


Jodhpur house

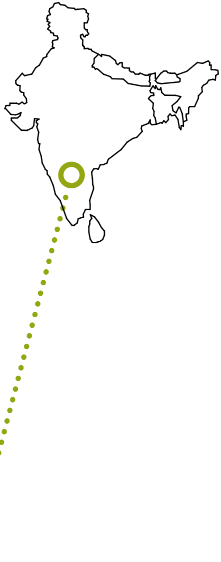
Materials:
clay, grass, timber, cow dung slurry

- Protection from solar overheating
- Roof insulation using timber and grass
- Storage masses for temperature and humidity control
- Drawing off heat: Natural ventilation



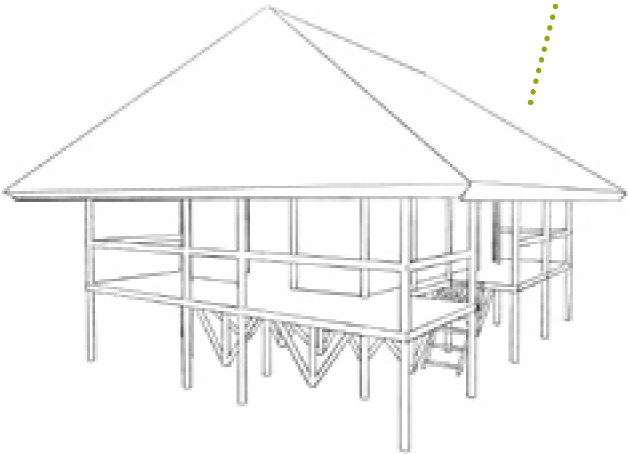


Dibrugarh house



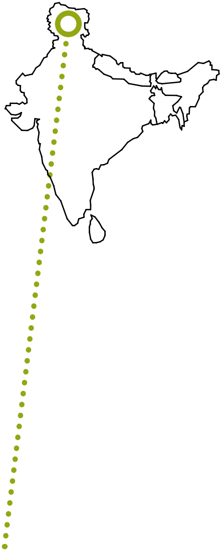
Materials:
bamboo

- Protection from solar overheating
- Reducing internal loads: outside kitchen
- Drawing off heat: Natural ventilation through walls, lightweight roof and elevated construction



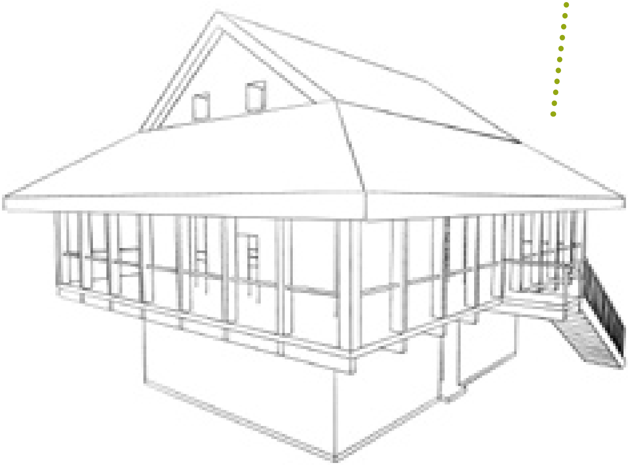
COLD

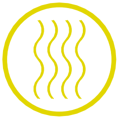
Kulu house



Materials:
clay, stone, timber, grass

- Optimised use of solar inputs
- Insulation by means of encircling buffer zones and thermally-efficient clay and stone walls
- Storage masses for temperature control
- Use of internal heat loads optimised: kitchen, animals



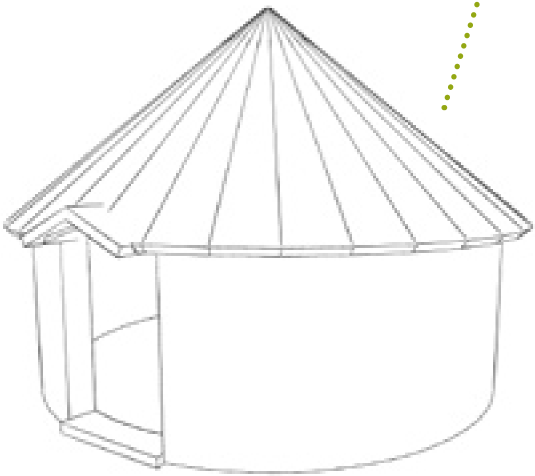


WARM+HUMID

Madras house

Materials:
bamboo, clay, cow dung slurry

- Protection from solar overheating
- Roof insulation using bamboo
- Storage masses for temperature and humidity control
- Drawing off heat: Cross ventilation in the roof area



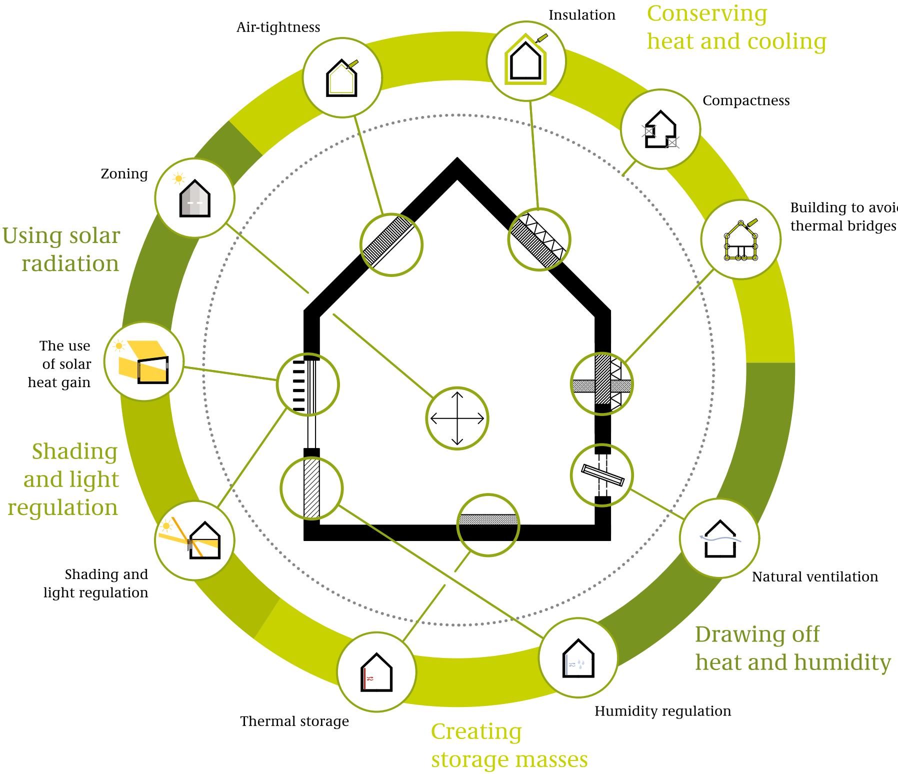
Building

Strategies for energy-efficient building

Structural measures

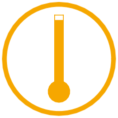
It is particularly efficient and cost-effective to reduce the energy consumption of buildings by means of passive, i.e. structural measures. The interior room climate can be self-regulating or optimised by simple intervention by the occupants. The energy consumption may be reduced by using energy-efficient appliances and lighting.
In Germany, household appliances are rated with an energy label of A (efficient) to D (inefficient, out-dated). The best appliances available on the market are classified as A+++. With the purchase of energy efficient appliances, the power consumption of a building can be reduced significantly. Simultaneously, the internal heat loads are minimized and thus reduce the cooling requirements.

Strategies for energy-efficient building



Conserving heat and cooling

Air-tightness

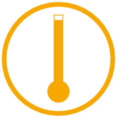


An airtight building shell contributes to keeping heat or coolness inside the building. Suitable materials for this purpose are reinforced concrete, plaster and sheeting. End points such as at windows, where materials change or penetration points should be planned and sealed carefully. Air-tightness safeguards against structural damage and ensures the efficient operation of ventilation systems with heat recovery. Air-tightness is checked by a pressure differential test, with a pressure difference between the interior and exterior space of 50 Pascal. (Target value $n_{50} \leq 0.6$ 1/h)

Conserving heat and cooling

Insulation

COLD



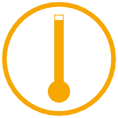
HOT + DRY

Thermal insulation stabilises the interior room temperatures and conserves heat or coolness within a building. It protects the building from transmission heat losses as well as from rapid heating due to solar radiation. The thermal insulation forms an enclosing shell of materials of low thermal conductivity ($\lambda < 0.04$ W/mK).
It may also be absorbent (porous concrete, lightweight bricks) or form the insulating layer in a multi-layer wall or roof construction. Windows and doors should also be designed to provide good insulation for energy conservation purposes. The insulation quality of a building can be defined as an average over the whole of the building shell (H_t' [W/m^2 K]). It is calculated from the individual values for components (U [W/m^2 K]), which in turn are obtained from the material values (λ [W/m K]).

Conserving heat and cooling

Compactness

COLD

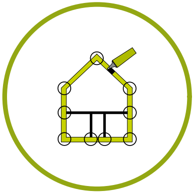


HOT+DRY

A low shell surface reduces transmission losses; projections and recesses should therefore be avoided. This also minimises the risk of thermal bridges. An optimised A/V_e [surface area to volume] ratio $[m^2/m^3]$ is therefore an important factor in the reduction of transmission heat losses.

Conserving heat and cooling

Building construction avoiding thermal bridges



COLD

HOT + DRY

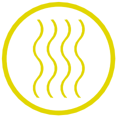
The building shell should have more or less equal insulation quality all round. Weak points are heat bridges, e.g. through reinforced concrete slabs, façade anchors or frames. The heat flow through the shell is accelerated here. Thermal bridges can be largely prevented by means of careful, detailed planning and implementation, in order to reduce transmission heat losses and to protect against structural damage.

Drawing off heat and humidity
Natural ventilation

Natural ventilation in the building dissipates solar and internal heat loads without additional technical intervention. Cross-ventilation or thermal activity augment the natural ventilation, provided the site layout and building design allow it. The orientation of the building in line with the prevailing wind direction, and the targeted use of pressure and temperature differences around the building, have a substantial effect on increasing the air change rate. Night ventilation supports the dissipation of heat loads.

Drawing off heat and humidity & Creating storage masses

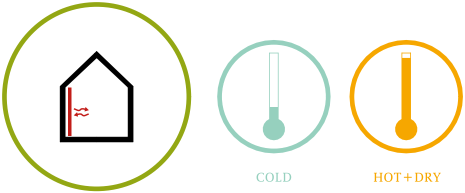
Humidity regulation


WARM+HUMID


MONSOONAL

There are limited passive options for dissipating humidity. Absorption in building materials (e.g. clay, plaster) is, however, possible and useful, especially in hot, humid regions and in combination with natural cross-ventilation. In regions with heavy rainfall (monsoon) the cooler rain can reduce the relative humidity by the evaporation effect of the raindrops.

Creating storage masses
Thermal storage



Materials with a high thermal storage capacity store heat, thereby evening out temperature peaks and giving out heat at a later time. Substantial “self-regulation” of the interior climate is possible, especially in moderate climate zones. There is a high potential for storage masses in massive structures without cladding (clay, masonry or reinforced concrete). Lightweight buildings can be given similar characteristics by the incorporation of stone-based or water-based storage media such as phase-change materials (PCMs). Combining storage media with natural cross-ventilation increases the comfort of the room. A prerequisite is a high temperature difference between day and night, preferably > 12 K.

Shading and light regulation

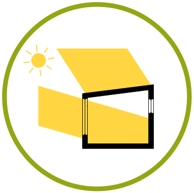
Shading and light regulation

WARM+HUMID MONSOONAL COLD HOT+DRY

Sun protection effectively reduces heat loads and reduces the risk of overheating as well as the cooling requirement. The choice of method (e.g. adjustable slats, shutters, fixed sun-shades, vegetation, etc.) also has a substantial effect on the use of daylight. Opaque shading elements (shutters, etc.) increase the use of artificial light. The best choice of sun protection depends on the location and orientation. In situations with high solar altitude, good use can be made of the building's own shading and that from neighbouring buildings. Attention should always be paid to the optimum use of daylight.

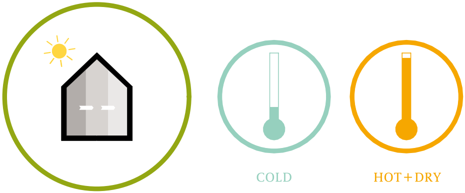
Shading and light regulation & Using solar radiation

The use of solar heat gain



The form of a structural body and its orientation in relation to the sun have a substantial effect on the solar gains (active and passive) and the summer heat protection requirement. These solar gains enter the room directly through openings in the façade or glazed panels. In cold and moderate climatic zones, glazed panels with a northerly orientation are kept small and provided with a very good heat transmission coefficient (U-value [W/m² K]). Larger glazed panels are located on south-facing elevations in order to benefit from solar heat gain. In hot climatic zones, the openings are kept to the minimum possible allowed by the daylight use considerations in order to reduce the solar heat loads for the building. The total energy transmittance of a glazed area (g-value [-]) is the determining factor for the rate of solar heat gain.

Using solar radiation
Zoning



The zoning of a building and orientation of the rooms have a great effect on the heating and cooling requirement of its users. In moderate climatic zones the gain occupied area is oriented towards the sun (linear zoning), or located centrally to reduce transmission heat losses. The natural air conditioning of the interior rooms can be optimised by using peripheral buffer zones.

Technologies

Strategies for energy-efficient building

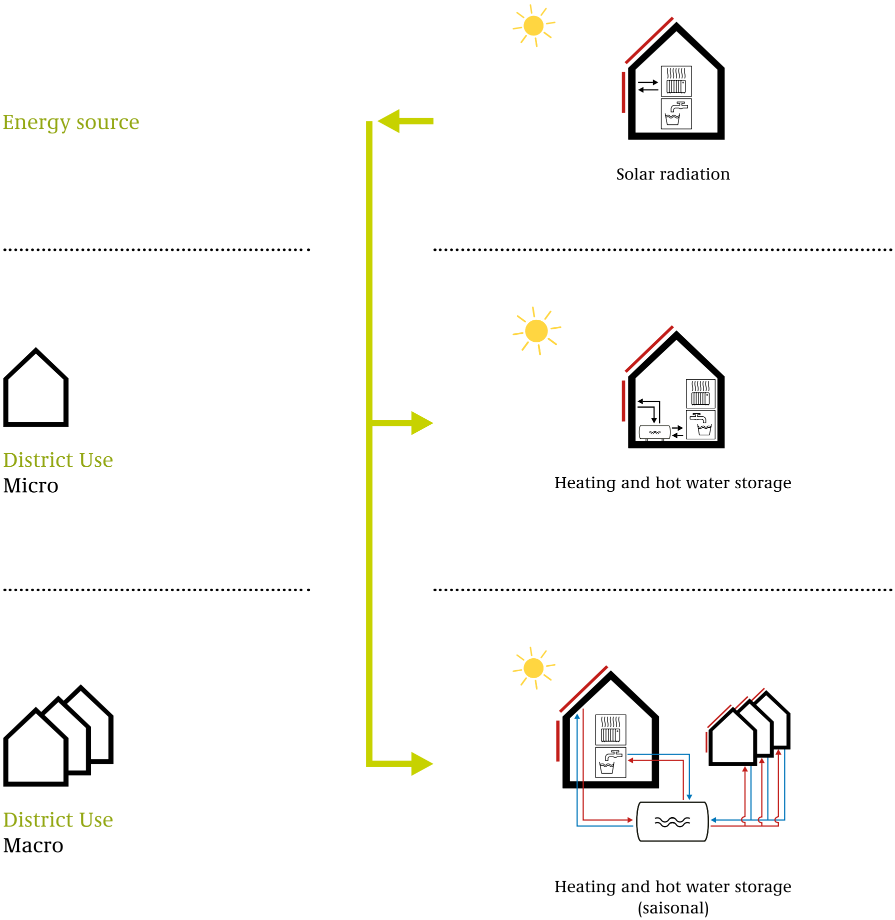
Technical measures

If the energy consumption of buildings is reduced through structural measures, the energy supply can be optimised by technical measures. In most Indian climate zones high potentials of renewable energies are available around buildings: solar radiation, geothermal energy, wind, etc. They can be easily used to cover the energy demands of the building and its users.

Using solar energies
Solar heating

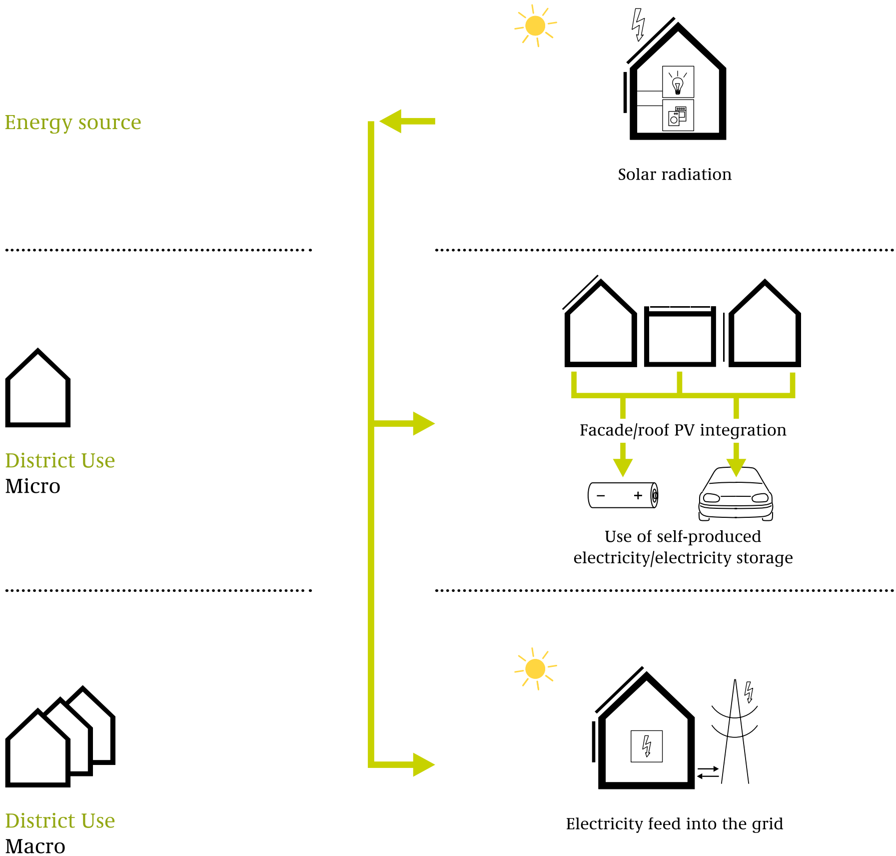
COLD

Collector panels collect energy for central heating or air conditioning and for heating water. The simplest collector types are open absorbers, with circulating water that is heated by dark encased pipes (e.g. hose beneath a black film, black water hose). More efficient designs include flat-plate collectors, vacuum tube collectors and concentrator collectors. The collectors can be installed in façades and roofs as building shell elements, saving additional costs. The potential for solar radiation is much higher in India than in Germany, which means that solar coverage of 100 % or more is conceivable. Cooling can also be obtained from solar radiation with the help of an absorption heat pump.


Energy source
Solar radiation
District Use
Micro
Heating and hot water storage
District Use
Macro
Heating and hot water storage
(saisonal)

Using solar energies
Photovoltaics

Photovoltaic modules use solar radiation to generate electricity. This can either be used directly in the building, stored there or fed into the public grid. In addition to the efficiency, angle of inclination and orientation to the sun, important factors for success also include good ventilation behind the modules and ensuring unshaded areas. Photovoltaic modules can be integrated very well into the building shell, taking over the function of the relevant shell elements (shading, water-bearing layer, etc.).

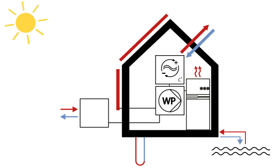

Energy source
Solar radiation
District Use
Micro
Facade/roof PV integration
Use of self-produced
electricity/electricity storage
District Use
Macro
Electricity feed into the grid

Using geothermal heat

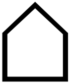
Heat pump

Heat pumps can help to make good use of the high potential offered by environmental energies (geothermal, exhaust air, groundwater). A heat pump operates on the same principle as a refrigerator, drawing energy from an environmental medium for both heating and cooling. The ground heat is transmitted via a heat exchanger to the water circuit of the heat pump with the assistance of solar-powered circuits in geothermal probes (> 100 m depth), heat exchangers (approx. 3 m depth) or coiled loop fields (2-3 m depth). It is particularly effective if the electricity needed is generated from a renewable source i.e. photovoltaics or wind.

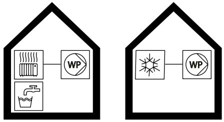
Energy source



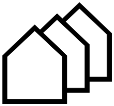
Geothermal heat, solar thermal,
heat exchanger, outside air, waste heat



District Use
Micro



Use of self-produced heat
and hot water/cooling

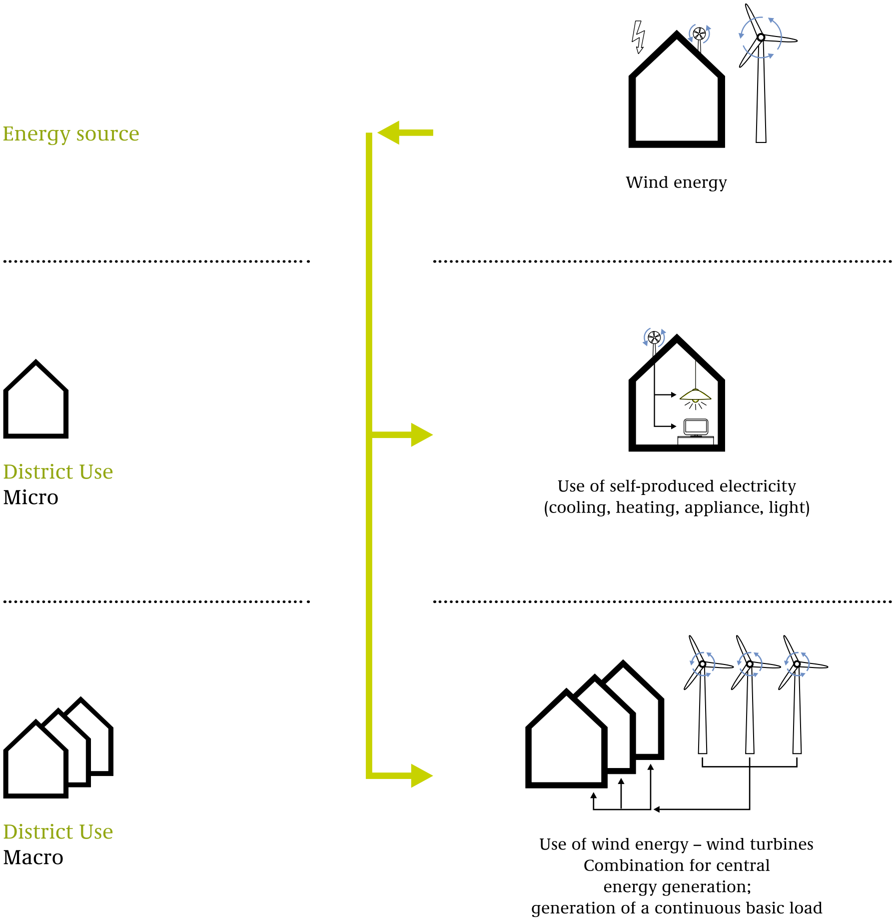


District Use
Macro

Using wind power
Wind Turbines

WARM+HUMID MONSOONAL COLD HOT+DRY

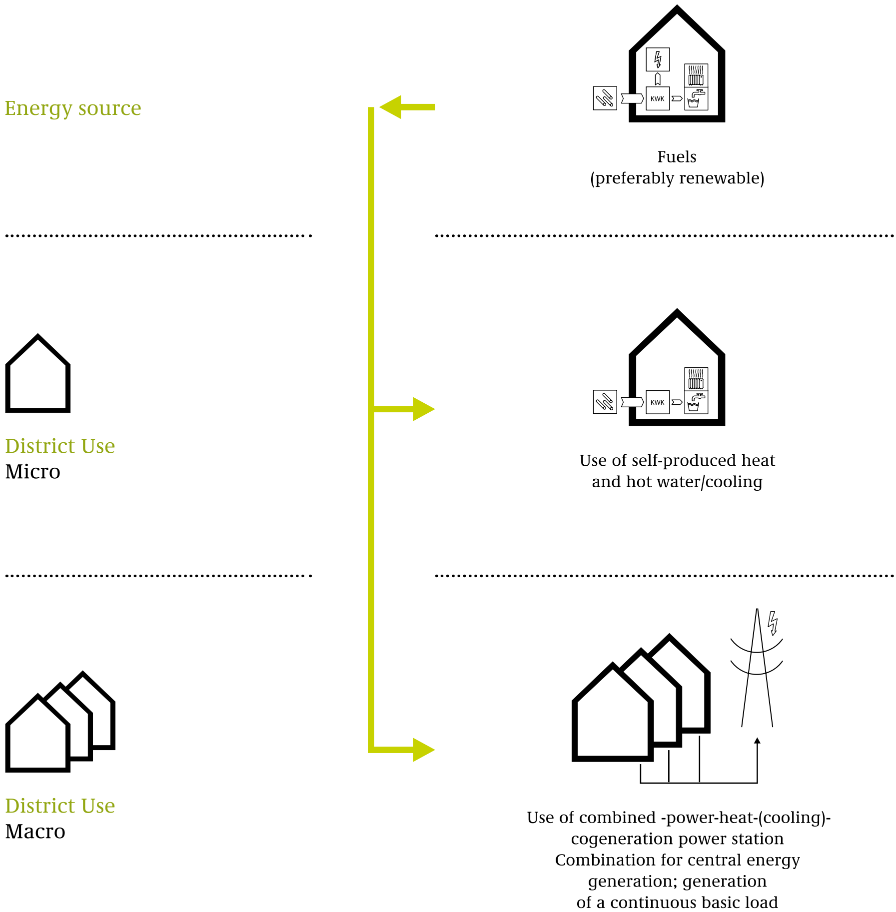
If sufficient wind is available, electricity can be generated using wind turbines. The efficiency depends on location, altitude and built density. Wind systems can also be effectively installed on or by buildings.


Energy source
Wind energy
District Use
Micro
Use of self-produced electricity
(cooling, heating, appliance, light)
District Use
Macro
Use of wind energy – wind turbines
Combination for central
energy generation;
generation of a continuous basic load

Combined (cooling) heat
and power plant ((C)CHP)

WARM + HUMID　MONSOONAL　COLD

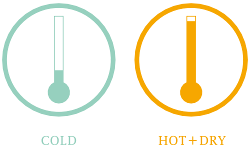
An electricity generator produces waste heat, which can be used for room heating and water heating. Biomass fuels such as biogas, etc., can also be used to operate the generator. As a continuous basic load is important for efficient implementation, systems of this type are usually used in non-residential buildings or in districts with high electricity and/or heating consumption. In residential areas, the basic load is provided by grouping together the individual buildings to form a local or district heating concept. Similarly, an absorption heat pump may be installed to use the waste heat to provide cooling.



Energy source
KWK
Fuels
(preferably renewable)
District Use
Micro
KWK
Use of self-produced heat
and hot water/cooling
District Use
Macro
Use of combined -power-heat-(cooling)-
cogeneration power station
Combination for central energy
generation; generation
of a continuous basic load

Minimising the ventilation heat consumption

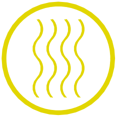
Heat recovery



In cold weather conditions, natural room ventilation using windows can cause high ventilation heat losses. A ventilation system with heat recovery uses a heat exchanger to recover the majority of the heat (approx. 80%) or cooling (approx. 60%). A well-insulated, airtight building shell is essential for this. Additional heating/cooling energy can be saved by pre-heating or pre-cooling the fresh air in the ground (ground ducts).

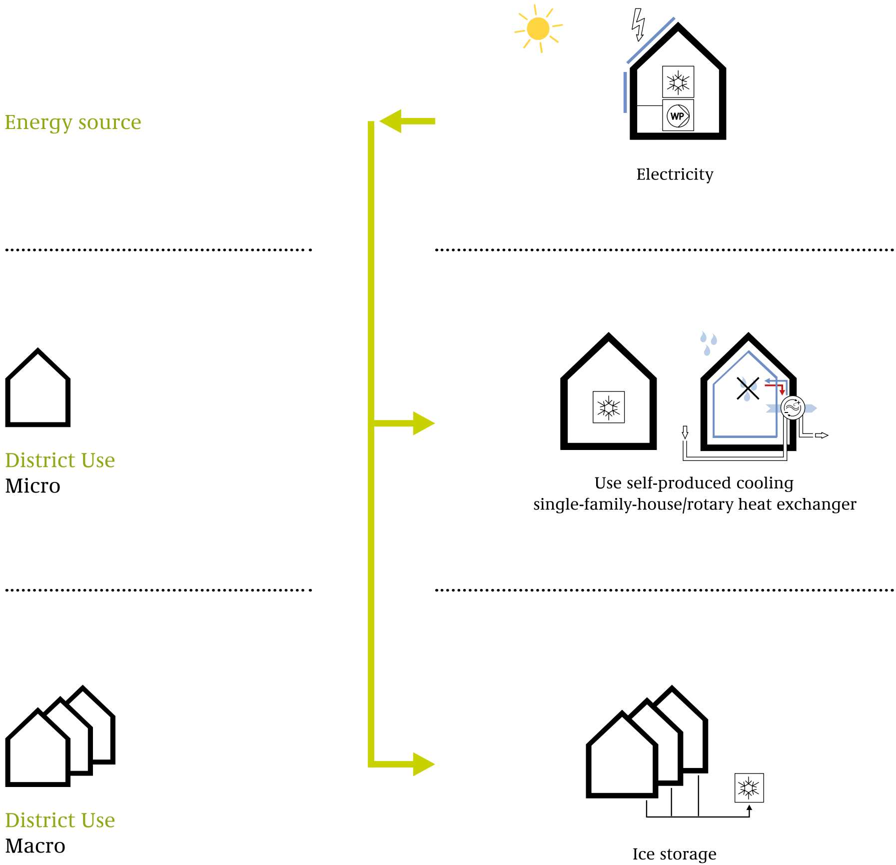

Energy source
Heating
Cooling
District Use
Micro
Use self-produced heating
single-family-house
District Use
Macro

Active cooling
Compression cooling


WARM+HUMID


MONSOONAL

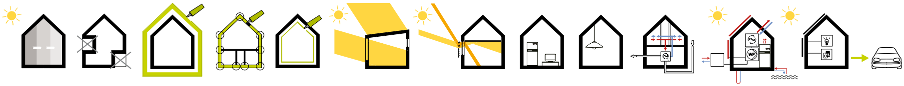
In warm, humid climates, good natural ventilation may be sufficient, but higher comfort levels can be achieved with air-conditioning systems. The electricity used should as far as possible be from renewable sources, e.g. photovoltaics or wind power. Additional active measures may also be used for dehumidifying a room, such as a rotary heat exchanger in the ventilation system. Cooling can also be provided from solar radiation with the help of an absorption heat pump.


Energy source
WP
Electricity
District Use
Micro
Use self-produced cooling
single-family-house/rotary heat exchanger
District Use
Macro
Ice storage

Best practice

Efficiency House Plus
Berlin

Strategies for energy-efficient building



Client

BMVBS

Architect

Werner Sobek Stuttgart GmbH & Co. KG

Energy concept

WSGreenTechnologies GmbH

Further information

www.bmvbs.de/effizienzhausplus

Timber and timber materials
biological cycle, utilisation of energy

Aluminium & steel
100% materials recycling, by melting down

PV system
return to manufacturer

Plate glass & window glas
100% materials recycling, by cleaning and melting down

PP/PE installation pipes
100% materials recycling, by melting down and chemical processing

Concrete foundations
100% materials recycling, processing to form new reinforced concrete

Cellulose insulation
biological cycle, utilisation of energy

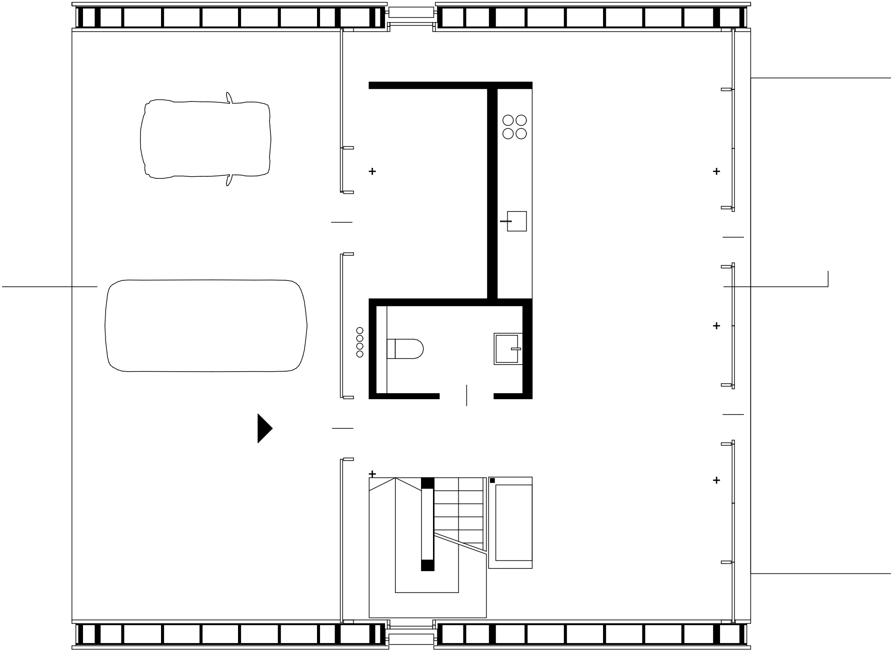
Plasterboard
100% materials recycling, processing to form new plasterboards

The Efficiency House Plus was developed as a pilot project for the “Forschungsinitiative Zukunft Bau” (Future Build Research Initiative) of the Federal Ministry of Transport, Building and Urban Development, in order to provide a perspective on the way forward for resource-saving and energy-efficient building construction in the EU.
The 130 m² single-family house also is a showcase for the technological links between a surplus-power-producing house and e-mobilty. It was opened on 7th December, 2011 in Berlin by the German Chancellor, Dr. Angela Merkel.

The energy concept combines approved and innovative components. An air-water-heat pump (5.8 kW) attains the necessary heat energy from the outside air. Building-integrated photovoltaic modules are a central aspect of the design. Integrated into the south-facing façade and mounted on the roof, these modules produce approx. 17 MWh which, viewed over the whole year, is sufficient electricity to cover the total energy demand of the building. The electricity produced by the house may be used immediately or later after an intermediate storage in the in-house battery.
In addition, the surplus is enough to charge two electric cars and an electric bicycle for a total annual distance of 29.000 km.

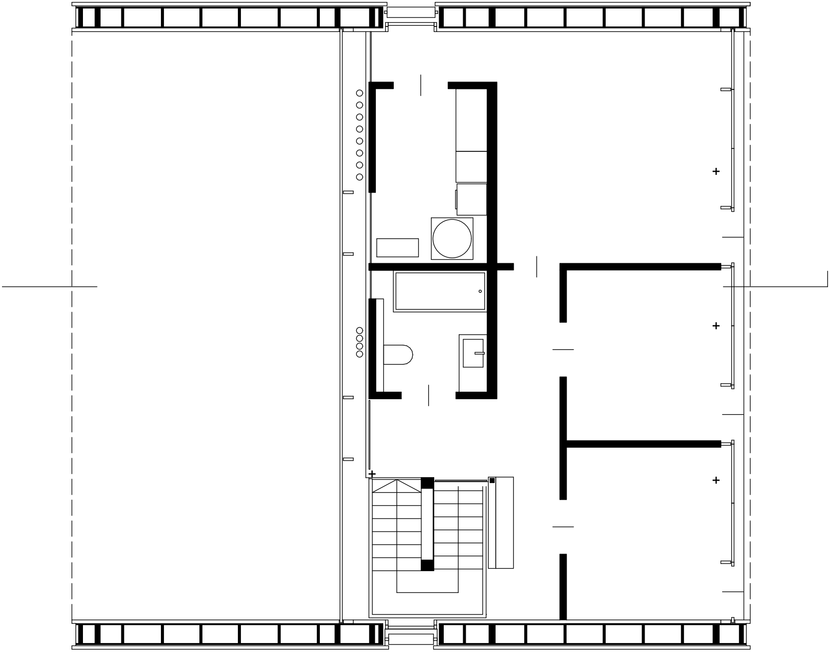
The pilot project shows how buildings will soon be making a crucial contribution to relieving the pressure on the environment. No aggregates were used in the construction materials. For most parts of the building bolts, click- or grip constructions came in operation. At the end of its useful life, the building can be dismantled, the components sorted and the vast majority of them recycled, i.e. returned to the materials cycle.
While in use, it effectively represents a raw materials depot, with the materials in “interim storage” until their next usage cycle.

Ground floor






1st floor



Federal Environment Agency
Berlin

Strategies for energy-efficient building

Ongoing development

Client

Federal Office for Building and Regional Planning

Architect

KERBL architekten + ingenieure

Energy concept

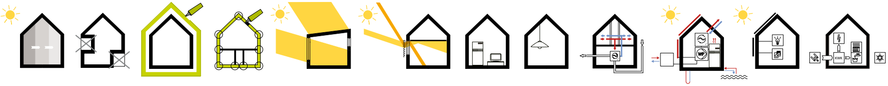
Schimmel Beratende Ingenieure

Further information

www.umweltbundesamt.de

Solar Factory 1
Kassel

Strategies for energy-efficient building



Client

SMA Solar Technology AG

Architect

HHS Planer + Architekten AG

Energy concept

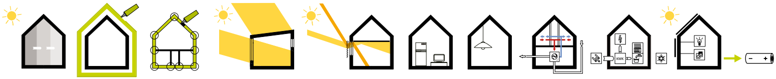
IB Hausladen, EGS-plan, deNET e.V.

Further information

www.hhs.ag/projekte--solar-factory-1.en.html

Solar Academy
Niestetal

Strategies for energy-efficient building



Client

SMA Solar Technology AG

Architect

HHS Planer + Architekten AG

Energy concept

Energydesign

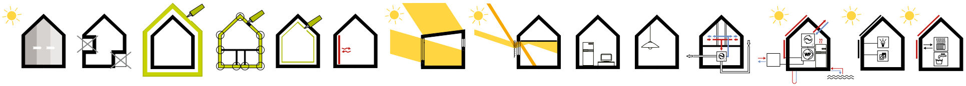
Further information

www.hhs.ag/projekte--solar-academy.en.html


SMA SOLAR | ACADEMY

Solar Decathlon 2007
Team Germany

Strategies for energy-efficient building



Client, Energy concept

Technische Universität Darmstadt,
Department of Architecture,
Energy-Efficient Building Design Unit

Architect

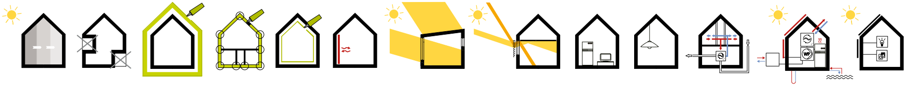
TU Darmstadt, Team Germany I

Further information

www.solardecathlon.de

Solar Decathlon 2009
Team Germany

Strategies for energy-efficient building



Client, Energy concept

Technische Universität Darmstadt,

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Energy-Efficient Building Design Unit

Architect

TU Darmstadt, Team Germany II

Further information

www.solardecathlon.de

Contact & List of illustrations
Smart energy-efficient building design

Contacts
BMVBS – Federal Ministry of Transport, Building and Urban Development, www.bmvbs.de
DGNB – German Sustainable Building Council, www.dgnb.de
KfW Entwicklungsbank, KfW.NewDelhi@kfw.de, www.kfw.de
HHS Planer + Architekten AG, www.hhs.ag

Sources – Texts
Federal Institute for Research on Building, Urban Affairs and Spatial Development: Federal Environment Agency | German National Tourist Board: P. 035.1 | Nayak, J.K., Prajapati, J.A.: P. 035.2–036 | Technische Universität Darmstadt, Faculty of Architecture, Energy Efficient Building Design Unit: Solar Decathlon 2007, Solar Decathlon 2009

Sources – Images
ESA – European Space Agency – P. 014, 022, 038 | bing.com: P. 015.1 | Hegger, Johannes P. 015.3, 015.7, 015.8 | HHS Planer + Architekten AG: Cover, P. 017, 019.1-3, 034-036, 039-042, 052 | KERBL architekten+ ingenieure P. 090 | Kounce, Eric: P. 015.5 | Meyer, Constantin: P. 044, 064, 092, 094 | Ott, Thomas: P. 080, 096, 098 | Technische Universität Darmstadt, Faculty of Architecture, Energy Efficient Building Design Unit: P. 023-025, 027, 029, 031-032, 045-050, 053-062, 066-078 | Vogel, Uwe: P. 015.4, 015.6 | Weisflog, Rainer (German Federal Archive): P. 015.2 Werner Sobek Stuttgart: P. 082-083, 085, 087 Federal Ministry of Transport, Building and Urban development: P. 086, 088

Data origin
BDEW – German Association of Energy and Water Industries: P. 019.1+3 | CUBE Engineering GmbH and Vortex SL. 2012, NCEP CFSR Reanalysis: P. 041 | DWD – Deutscher Wetterdienst: P. 040 | GeoModel Solar s.r.o.: P. 039 | IEA – International Energy Agency: P. 019.2 | Köppen-Geiger climate classification: P. 034 | U.S. Department of Energy: P.042, Prof. Dr.-Ing. Karsten Voss: P. 031, Federal Ministry of Transport, Building and Urban development: P. 084