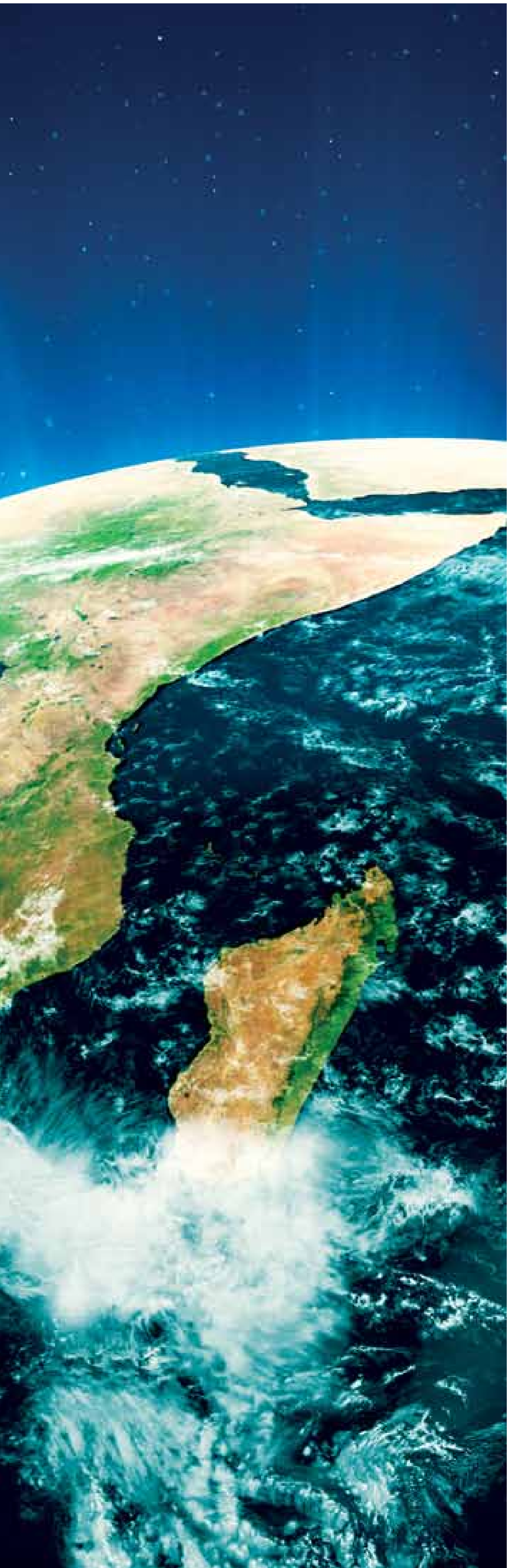
DESIGN STRATEGIES FOR SOUTH AFRICAN CLIMATES

There are many passive design strategies one can choose, as well as multiple technological interventions, when designing an energy-efficient and comfortable building. How do you know what will work the best? It is less about which one comes out on top and more about where the project is located.

WORDS MICHELLE LUDWIG



The most efficient building, regardless of solutions employed, will be one that has been designed to address the issues of its specific climate zone. Climate-responsive design addresses and utilises natural existing conditions to the best advantage before applying expensive and energy-requiring technologies. Some design strategies, however, remain relevant to all the climate zones, such as optimal orientation of the building, appropriate use of insulation, and solar control.

Climate is the weather conditions and patterns for a location, averaged over a long period. It is affected by latitude, altitude, topography, and proximity to bodies of water. The new SANS204-2 (2008) standard is organised into six climatic regions for South Africa in an effort to generalise deem-to-satisfy requirements for energy efficiency as part of the National Building Standards. While this simplification can be user-friendly, the Council for Scientific and Industrial Research (CSIR) has been investigating whether the resolution of the climate information is adequate to support optimal design in an emerging era of green building practice.

Headed by Dr Dirk Conradie, the CSIR team synthesised 20 years of weather data to create a new climate map with refined accuracy and which aligns with the widely-used Köppen-Geiger classification system that groups world climates into 30 types. Their research indicates South Africa has 13 different climate types. "The adoption of the South African Köppen-Geiger map will allow building designers to rapidly identify appropriate climate-responsive design techniques and will facilitate the computational performance modelling of buildings. This will be achieved by applying synthesised approximations of weather data where data is not available," according to the CSIR.

What follows is an abridged guide of the predominant climate types, specific design priorities and strategy responses.

HOT ARID DESERT

CLIMATE TYPE BWh

RELEVANT CITIES Messina, Uppington

This climate experiences very low precipitation and in some years, none at all. It is characterised by hot to exceptionally hot periods during the year. During cooler periods and with the lack of water vapor in the air, night temperatures can sometimes drop to freezing due to radiation losses. Therefore, high day temperatures with low night temperatures create a large diurnal temperature swing.

DESIGN PRIORITIES

- Keep hot temperatures out in summer
- Protect from summer sun
- Use evaporative cooling in summer
- Use thermal mass to flatten day-to-night temperature swings
- Use natural ventilation to cool in the spring and fall

Design example

Thermal mass such as brick, concrete, mud brick or rammed earth takes a long time to warm up due to its thickness and density. The heat transfer is slow, keeping the interior cool for the day. Once warmed towards the end of the day, it transfers its stored heat to the interior during the cooler night. This thermal lag effect tempers the extremes of the daily temperature swing.

01. A typical landscape displaying hot, arid desert in South Africa.

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SEMI-ARID STEPPE

CLIMATE TYPE BSk

RELEVANT CITIES Bloemfontein, Kimberley

This type is considered a cold, semi-arid climate typically found in continental interiors some distance from large bodies of water, and usually at higher elevations than the Hot Arid Desert. It features hot, dry summers and cold winters with the occasional snowfall. Major temperature swings occur between day and night. Rainfall predominantly occurs in summer.

DESIGN PRIORITIES

- Keep heat in and cold temperatures out during the winter
- Allow winter sun in
- Use thermal mass to flatten day-to-night temperature swings
- Protect from summer sun
- Use evaporative cooling in the summer

Design example

Dry summer climates are good for evaporative cooling as the dry air has capacity to absorb added humidity to bring the temperature down. Night ventilation cooling is also suitable, especially when it can cool some thermal mass and create "coolth" for the following day.

HUMID SUB-TROPICAL

CLIMATE TYPE Cfa

RELEVANT CITIES Durban

This climate has hot humid summers, mild winters and frequent thunderstorms. Humid Sub-Tropical climates have a warm and wet flow from the tropics that create warm and moist conditions in the summer, which is often the wettest season. South Africa's version features heavy oceanic influences resulting in milder temperatures; winter temperatures do not drop as low as in many other regions within the category. With the water vapor and clouds typical of this climate, the day temperatures are lower and night temperatures are higher, creating a small diurnal temperature swing.

DESIGN PRIORITIES

- Enable ventilation to both cool and remove excess moisture in the summer
- Protect from summer sun
- Avoid creating additional humidity during summer

Design example

High humidity precludes using evaporative cooling. Lightweight construction, as opposed to mass-based construction, will store less heat and cool off more quickly. Reflective and bulk insulation is a good idea.

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DRY-SUMMER SUBTROPICAL

CLIMATE TYPE Csb

RELEVANT CITIES Cape Town

Also known as a Mediterranean climate, it usually occurs on the western sides of continents between 30° and 45° latitude. Summers are hot and dry, except in the immediate coastal areas where they are milder and moderately humid due to the nearby presence of cold ocean currents. Winters are very rainy with mild to chilly temperatures. This climate has a large range for diurnal temperatures swings.

DESIGN PRIORITIES

- Keep heat in and cold temperatures out during the winter
- Allow winter sun in
- Keep hot temperatures out during the summer
- Protect from summer sun
- Use thermal mass to flatten day-to-night temperature swings
- Use natural ventilation to cool in the spring and fall

Design example

With the majority of rainfall occurring in winter, storing rainwater to offset summer irrigation is typically unfeasible. However, this intervention would be effective if there was a high regular demand for grey water within the building.

SUB-TROPICAL HIGHLAND

CLIMATE TYPE Cwb

RELEVANT CITIES Johannesburg

The subtropical highland climate exists in elevated portions of the world and is generally found in the interiors of continents at the mid-latitudes. Winters are noticeably cooler and dry, and summers can have high humidity and be very rainy. Heavy precipitation occurs during the summer because of the seasonal presence of unstable humid air masses that encourage the development of thunderstorms.

DESIGN PRIORITIES

- Keep heat in and cold temperatures out during the winter
- Allow winter sun in
- Protect from summer sun
- Use natural ventilation for cooling in summer

Design example

Dry winters have less cloud cover. This allows for more solar radiation, which is useful for passive solar heating strategies and active collection such as solar hot water heating that can also be used for space heating.

02. Camps Bay, Cape Town.

03. Johannesburg thunderstorm.

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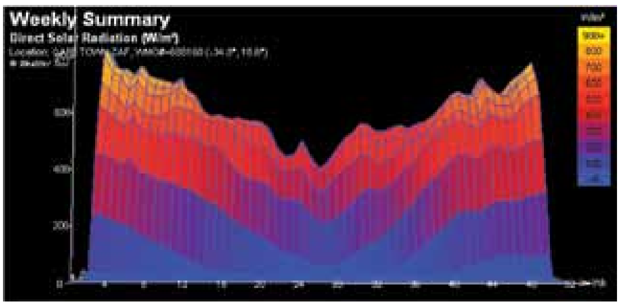
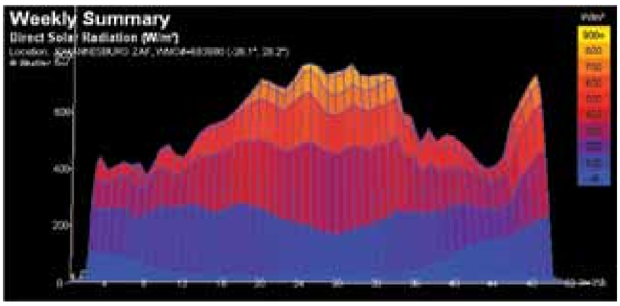
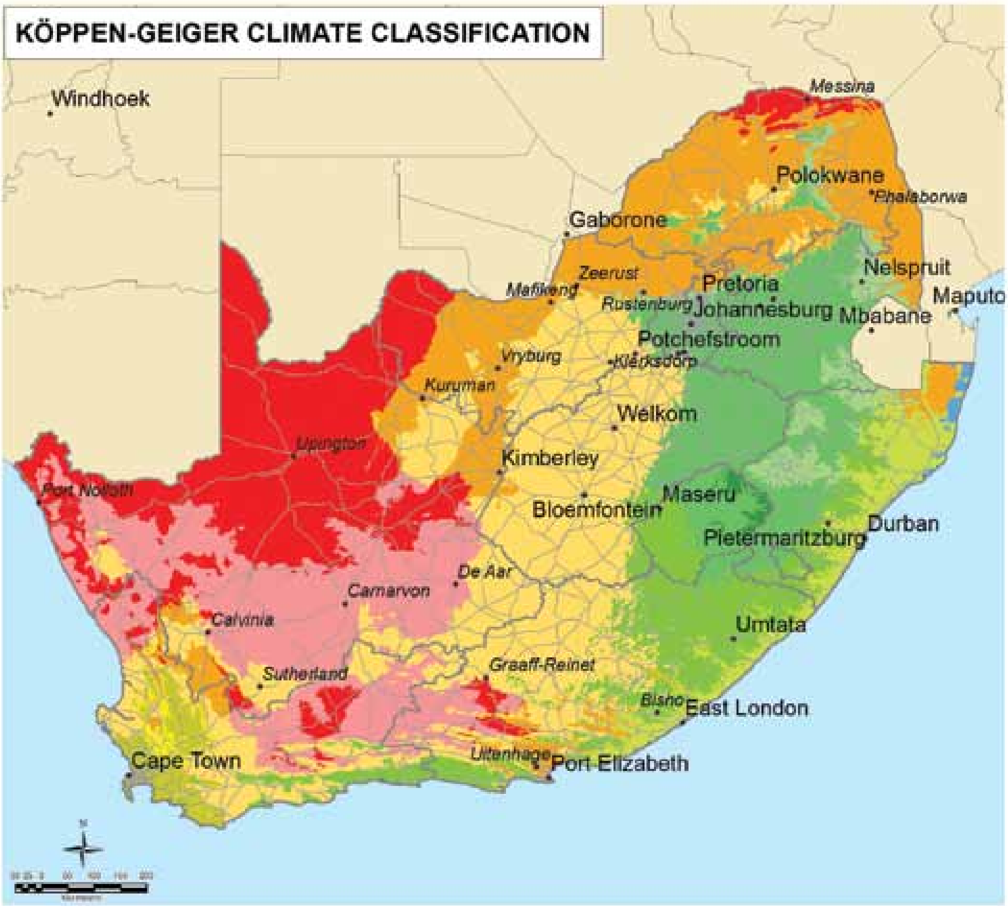




04. A comparitive weekly summary of direct solar radiation between Cape Town and Johannesburg



Aw Equatorial, Winter dry
BWh Arid, Desert, Hot arid
BWk Arid, Desert, Cold arid
BSh Arid, Steppe, Hot arid
BSk Arid, Steppe, Cold arid
Csa Warm temperate, Summer dry, Hot summer
Csb Warm temperate, Summer dry, Warm summer
Cwa Warm temperate, Winter dry, Hot summer
Cwb Warm temperate, Winter dry, Warm summer
Cwc Warm temperate, Winter dry, Cool summer
Cfa Warm temperate, Fully hummid, Hot summer
Cfb Warm temperate, Fully hummid, Warm summer
Cfc Warm temperate, Fully hummid, Cool summer

KÖPPEN-GEIGER MAP ©
CSIR, Built Environment Unit, Science and Technology Group

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01. Köppen-Geiger map of South Africa showing the various climate differences in the country.

DESIGN PRIORITY STRATEGIES

Keep heat in and cold temperatures out during the winter

- Use insulation in roof, walls, on below-grade walls and at the perimeter of slabs-on-grade.
- Use windows with double glazing or low-emissions coatings; minimise openings on the south facade.
- Locate rooms with lower temperature requirements (storage, garage, stairs, bedrooms) on the cooler southern side.
- Use closed combustion fireplaces with doors. Open fireplaces create an updraft, pulling warm room air out through the chimney.

Allow in winter sun

- Locate spaces that benefit most from solar heating, like living areas, on the north side.
- Plan for sun spaces or direct solar gain onto floors with mass and preferably dark in colour (NB: Need to also design to exclude this direct gain for summer).
- Use deciduous trees on the northeast and northwest, which shade in summer and lose their leaves in winter allowing the sun to pass through.
- Use active solar collection as a heating source via water-based heating typically installed in the floor.

Use thermal mass to flatten temperature swings between day and night

- Use building materials that have mass such as concrete, brick and stone as they have a high capacity for storing heat.
- Apply insulation on the outside of the thermal mass or within the wall.
- Interior mass will absorb heat from people during the day during summer.
- Design for night flush cooling by allowing windows or vents to be opened to allow cool air to enter and cool down the mass for the next day.

Keeping hot temperatures out during summer

- Include insulation (reflective and bulk) in the building envelope (walls, roof, foundation).
- Use few or small windows. A good rule of thumb is ratio of 30% window to solid wall.
- Use double glazing.
- Use light coloured or reflective surface materials, particularly on the roof and west facade, to reflect heat before it enters.
- Vegetated roofs act as insulation and keep the building's roof cool.

Protect from summer sun

- Build with minimal east and west facades, and shade them if possible. North-facing facades are easier to provide effective shading devices and south-facing facades generally do not need exterior shading devices.
- Avoid or minimise east and especially west facing windows if possible.
- Use plants, vines or trees to shade the building's exterior.
- Use the building form itself to shade openings such as balconies or overhangs.
- Roof eaves should be appropriately sized to shade windows in summer.
- Avoid light coloured ground cover or paving around the building to minimize reflected light and heat buildup.
- Use light coloured, reflective surface materials particularly on the roof and west facade.
- Use interior shading devices if exterior shading is not sufficient.
- Protect outdoor entertaining areas with shading or locate on the cooler northern side.

Ventilation for summer cooling

- Moving air cools people by passing over their skin, absorbing their heat and removing it. A breeze of 0.5 metres per second provides a cooling effect equal to a three degree reduction in temperature.
- Natural ventilation always requires an inlet and an outlet; employ openings on opposite sides of rooms.
- Minimise solid obstructions like walls or complicated paths. Open transoms above doors allow for air movement while still affording visual privacy.
- Use moderate-sized openings on the windward (breeze entry) side to reduce the internal wind speed and larger openings on the leeward (breeze exit) side to induce a flow.
- If openings are only possible on one wall, using low and high openings will be more effective than a single window.
- Orientate the building to catch prevailing breezes, direct breezes toward the building with landscaping or architectural elements.
- Situate main living areas at a higher level where wind velocity is greater.
- Use double height spaces, high ceilings, and open stairwells to facilitate vertical air movement and stratification – warm air will collect at the top.
- Employ ceiling fans to move air.

Use evaporative cooling in the summer

- This type of cooling works by adding moisture to the air to reduce its temperature. It is noteworthy that evaporative cooling will only work where the humidity is medium to low, such as arid climates. If the air is already full of moisture due to high humidity, such as summer conditions in Durban or Johannesburg, then there is not much capacity for adding more.
- Locate water features or pools in the path of incoming breezes.
- Transpiration by plants will contribute to cooling.
- Spray water into the air or onto a roof to cool it.
- Air conditioning that passes incoming air through wet fabric or similar medium.

Avoid creating additional humidity during summer

- Do not use evaporative cooling methods.
- Use drip irrigation instead of spraying into the air.
- Keep area around building dry, particularly ensure proper storm water management, drainage of land or use permeable paving to reduce standing water puddles.
- Minimise plants that transpire, use species native to dry climates such as succulents.
- Limit the generation of humidity from kitchens and bathrooms.

01. Roof should be light in colour so that heat reflective mitigates heat gain.

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