Figure 1: Urban heat modelling output

Sunshine sustainability modelling project

Digital Twin enabled Sustainable Sunshine Precinct Development

Our climate and energy systems are changing and the design of cities needs to adapt.

The Sunshine Sustainability modelling project simulated how Sunshine in future, as it accommodates growth and more density, may perform in 2050, under future climate and energy market conditions.

Sunshine is a priority precinct slated for significant transport infrastructure investment. The investment is expected to catalyse housing and jobs growth, which creates many opportunities, but also potential environmental challenges. The modelling project sought to understand these challenges and how they could be addressed at a place-based level.

The project aggregated data about future planning controls, open space, street designs, building standards and more, to create an integrated 3D model of the future Sunshine precinct. It simulated how the precinct would perform across four areas: urban heat; water and trees; embodied carbon; and energy.

The results show a variety of changes that could be made when planning for a precinct like Sunshine, to improve the liveability and climate resilience of streets and buildings.

Urban heat

Victoria is expecting an extra 10 to 20 heatwave days per year by 2050. The Sunshine Precinct currently has high urban heat risks due to a lack of permeable surfaces and trees, and low rainfall.

Modelling approach: A micro-climate simulation tool, Envi-met, was used to simulate how the urban environment would perform. It used input weather data based on CSIRO's climate projections for 2050.

Findings in Sunshine: Strategic use of irrigation and tree placement, and urban design to enable airflow, has the potential to reduce air temperature by 3.3°C, with maximum reductions of up to 10.9°C during extreme heat conditions.

Design solutions: Provide targeted irrigation corridors, maintain breezeways through road alignment, street design and built form controls, and create high tree canopy density on street sides with highest solar exposure. These can provide precinct-wide benefits, especially when designed as an integrated strategy.

RACE for 2030
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Water

Climate projections for 2050 point to a 13% decrease in annual rainfall and a 10% increase in evapotranspiration in Victoria, creating a widening gap between available rainfall and tree water demand.

This creates challenges for achieving urban greening, particularly in high density environments where available soil for trees is constrained.

Modelling approach: Excel and GIS calculations were used to understand soil and water availability and requirements. CSIRO projections of future local rainfall and evapotranspiration were used as key inputs.

Findings in Sunshine: A 3 metre verge (with structural soil), active and passive irrigation enabled creation of robust, overlapping street tree canopy. This tree canopy provided urban heat mitigation benefits in solar exposed areas.

Design solutions: For resilient street trees, provide adequate soil volumes in high priority areas. Drip irrigation is ideal, and efficient passive irrigation from the road into the verge is an essential infrastructure response.

Average climate at 2050 – Total water consumption of tree and rainfall (L/m2/year)

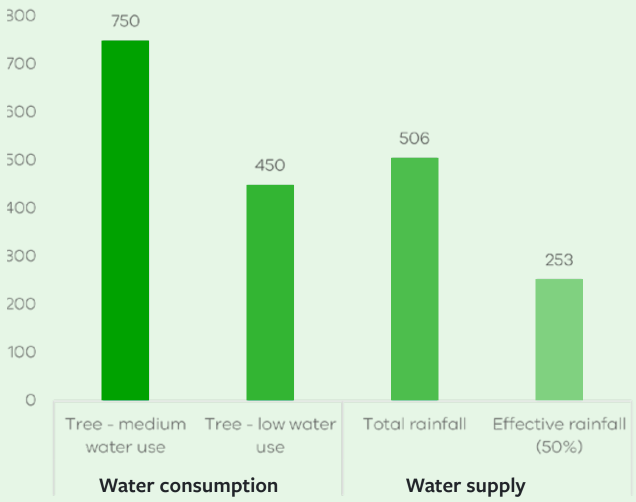

Figure 3: Future tree water demand and rainfall supply

Figure 2: GIS map of future trees

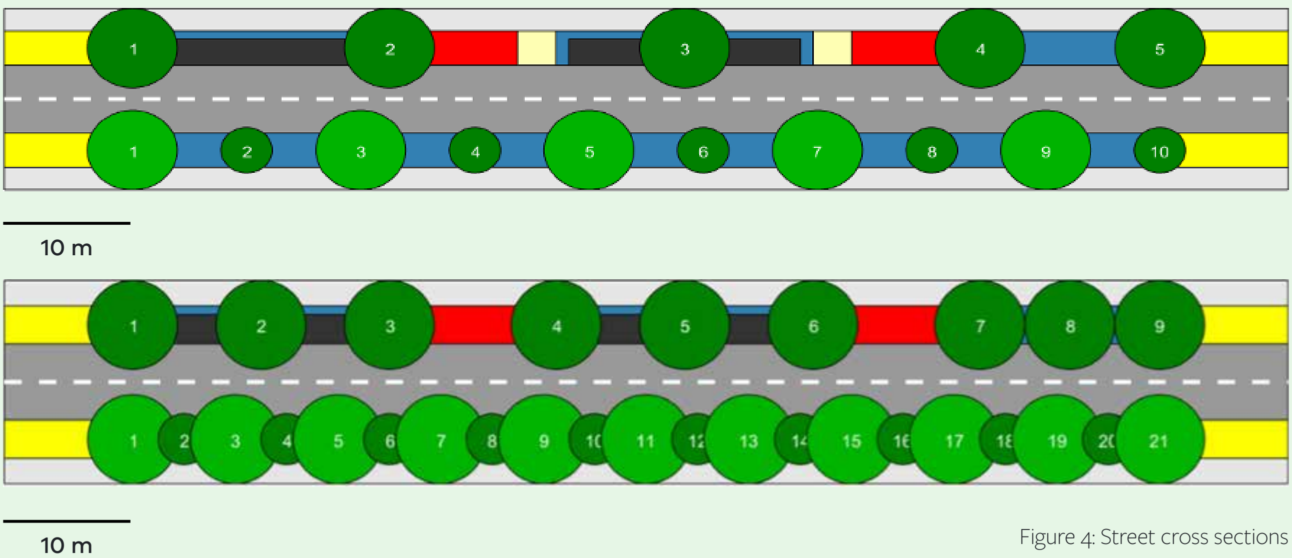

Figure 4: Street cross sections

Energy (built form)

Average temperatures in Victoria are expected to increase by 1.1 to 1.5 degrees by 2050, and hot days are expected to be 1 to 2 degrees hotter.

Modelling approach: Shading analysis and building energy load simulation were used to understand building energy requirements. CSIRO climate projections and National Construction Code standards were key inputs.

Findings in Sunshine: Increased temperatures in 2050 are projected to increase cooling loads by 50% in the precinct. At the same time, they will reduce heating loads, resulting in a net 2.58% increase in total thermal load.

For dense urban environments, building energy consumption shifts from building envelope control to urban morphology control. Increased shading levels at the precinct scale and the extent of narrow deep urban canyons that exacerbate heat retention mean higher density with a median height of 14 storeys has a thermal load 15.8% higher compared to a less intensive 8 storey median building typology due to compromised passive solar design outcomes.

Design solutions: Spatial diversity in built form can minimise overshadowing and heat retention, helping to optimise energy performance outcomes in higher density development.

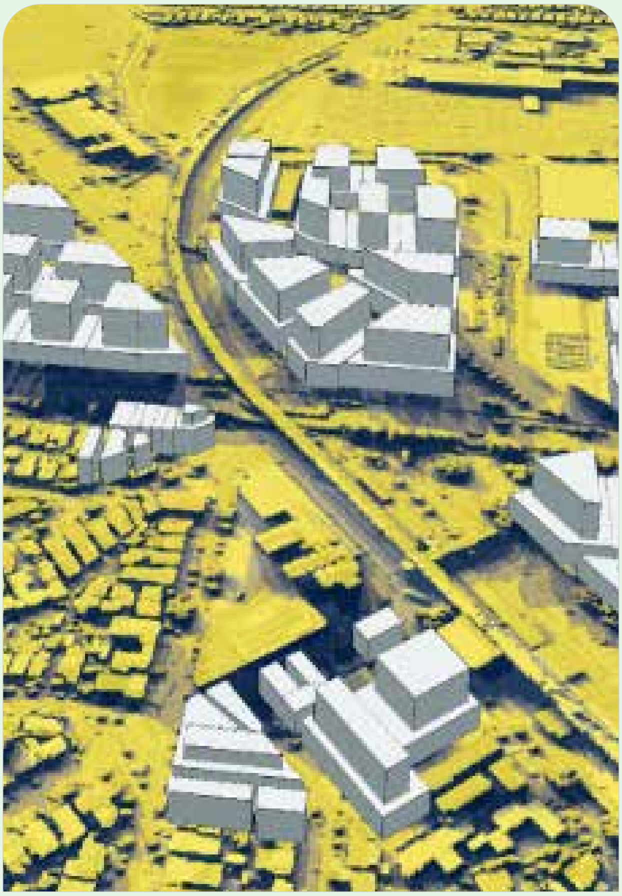

Figure 5: Built form shading analysis

Energy (grid)

Australia's electricity demand is forecast to almost double by 2050, according to the Australian Energy Market Operator. To meet this demand, as well as replace retiring coal capacity, the National Electricity Market will need to almost triple its supply capacity by 2050.

Modelling approach: an energy management system was developed to test options for energy use and storage. A power systems analysis was then done to understand impacts on the local electricity grid using local distribution network data.

Findings in Sunshine: An energy self-sufficiency rate of 30% to 45% is possible in a future Sunshine Precinct, within existing network constraints. Higher performance can be driven through less car parking (creating lower electric vehicle charging demand) and optimising built form to provide greater electricity generation potential compared to building loads.

Design solutions: Reduce car parking levels to manage future electric vehicle charging demand. Optimise urban form to reduce the extent of building overshadowing and limit heat retention. Deploy rooftop and facade photovoltaics (PV), batteries and smart energy management systems to support local energy generation and storage.

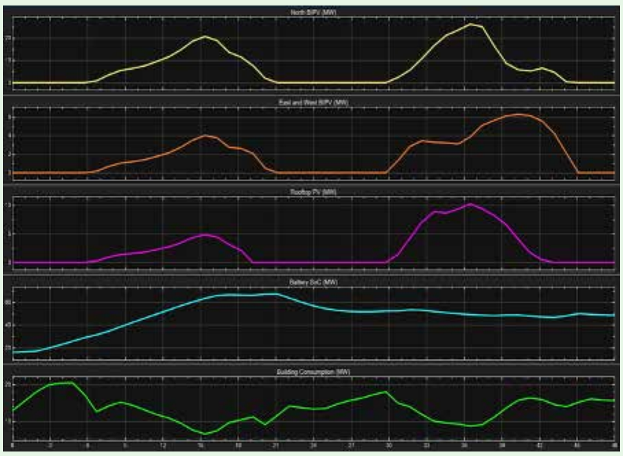

Figure 6: Electricity demand and supply dynamics

Embodied carbon

In 2019, embodied carbon made up 16% of Australia's built environment emissions, By 2050, this is expected to increase to 85% according to NABERS, as remaining emissions associated with buildings' operational energy demand decline sharply with the transition to renewable energy.

Modelling approach: A parametric model was used to estimate carbon footprint. Material use was estimated based on parameters in the precinct GIS model, and carbon associated with the materials then estimated based on environmental product disclosure statements.

Findings in Sunshine: Reductions of between 14% to 46% in building embodied carbon are possible, through interventions in built form and material selection.

Design solution: Reduce car parking to limit the embodied carbon associated with otherwise unusable floorspace. Use low carbon versions of conventional materials, such as concrete and steel. Consider using materials that can store carbon, such as mass timber.

Find out more

The Research Report and summary documents are available at: [vic.gov.au/sunshine]() and [racefor2030.com.au/publications]().

Or contact [Precincts@transport.vic.gov.au]() for further information.

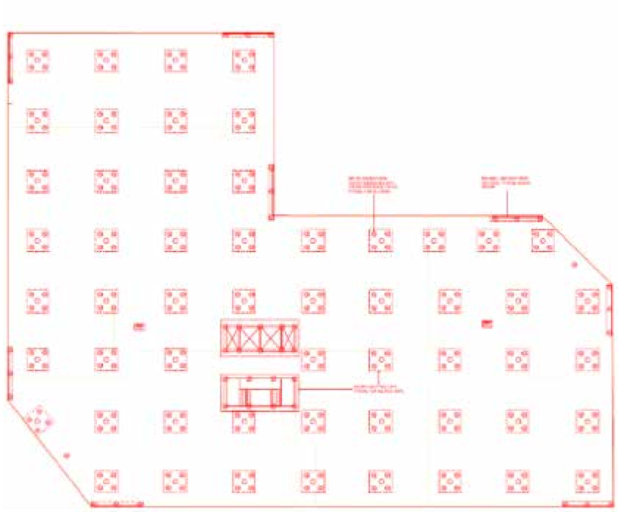

Figure 7: Internal building layout for sample building

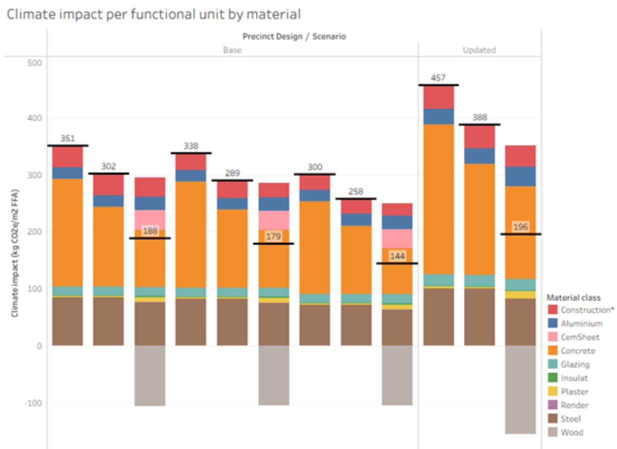

Figure 8: Material quantities and carbon impact of different scenarios.