Integrated Approach of Sustainability and Climate Change Adaptation in a Metro Project

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ABSTRACT

The new Melbourne Metro underground rail project will leave a legacy long into the future, with an estimated design life which will extend beyond 100 years. As such it is extremely important to consider the mitigation of any environmental impacts, providing a sustainable outcome. It is also essential to pre-empt required adaptation of buildings and infrastructure in the future against the impact of changes in the local climate. Designing a metro system in the age of climate change provides the opportunity to go beyond standard specifications and compliance requirements, creating innovative sustainable and climate resilient design outcomes. On the contrary, constructing an underground metro project presents various design challenges fuelled by complex constraints, many uncertainties and risks. This paper will review the methodology used to integrate environmentally sustainable principles and resilient design for climate change adaptation, within the concept development phase of the Melbourne Metro Underground Rail Project.

Keywords: Sustainability, Climate Change, Resilient Design, Transport Infrastructure, Urban Design, Built Environment

Introduction

The population of Melbourne is set to grow more than one million by 2030\(^1\). Latest statistics indicate that an estimated 4.08 million people residing in Melbourne\(^2\), and if the population increase continues with the same rate as per the average rate of population increase in Melbourne’s growth areas recorded between 2001 and 2006 of 4.1 per cent\(^3\), Melbourne will have an estimated population of 5.8 million in 2030.

An additional 600,000 dwellings will need to be accommodated over the next 20 years of which almost 316,000 dwellings are anticipated to be in Melbourne’s established areas. Higher population growth will occur in identified growth areas, with expected increase of dwellings by 284,000 over the next 20 years. The growth centres are located in North Melbourne, West Melbourne and South East Melbourne. This growth will require a change in the overall urban footprint of Melbourne city changing from a monocentric city with one major CBD centre, to a polycentric city with multiple CBD-like centres.

It is vital in the shaping of the city to include supported, interconnected and improved public transport services, that recognise the strong commuter function to CBD and inner-suburbs and allow services that serve city growth. Within the last decade public transport patronage has grown at a record rate as a result of Melbourne’s population boom, coupled with higher

\(^1\) Victorian Government, Dept of Planning and Community Development (2002). Melbourne 2030 - Planning for Sustainable Growth


\(^3\) Victorian Government, Department of Planning and Community Development (2008), Melbourne 2030; a planning update – Melbourne @ 5 million
petrol prices and recognition that the use of public transport will lessen the potential for climate change⁴. In response to these developments, the report „Investing in Transport, East West Link Needs Assessment‟, by Sir Rod Eddington; recommended that planning commence on the staged construction of a new Melbourne Metro (MM) rail tunnel, linking Melbourne’s booming western and south-eastern suburbs, and providing a major increase in the capacity of the rail network. A subsequent submission to Infrastructure Australia resulted in Australian Government funding being provided to commence pre-construction work for the Melbourne Metro project.

The MM project comprises of an underground rail network joining the existing Sunbury line in the vicinity of South Kensington in Melbourne’s west, passing beneath Parkville, Swanston Street in the heart of the CBD, and ending at Domain as a first stage, culminating in approximately 8 km of underground works, five underground stations at key locations throughout Melbourne and the provision for stabling yards and wider network improvements.

![Figure 1: Alignment of the proposed Melbourne Metro Underground Rail (Source: Department of Transport Victoria)](image)

**Project Brief**

The initial brief requested that all aspects of work should give consideration to the minimization of environmental and social impacts of construction, operation and maintenance, and that the design needs to consider future impacts of climate change. This requirement is supporting the Victorian Government Department of Transport’s aspiration to integrate environmental sustainability consideration into the design, construction and operation of all new projects⁵. The Victorian Government clearly indicated in its vision statement as part of the Transport Integration Act that Victoria aspires to have an integrated

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and sustainable transport system that contributes to an inclusive, prosperous and environmentally sustainable state.

The key challenges facing the New Melbourne Metro Underground Rail Project were the complex integration with the existing network, the planning of underground stations in congested urban areas whilst ensuring ease of connectivity with other modes of public transport, and at the same time considering the broader impact on communities, cityscape, social activities, economy and urban development, businesses prosperity and the quality of ambient environment space around stations. Supporting sustainable development, sustainable outcomes will be paramount, leaving a positive legacy 100 years hence for future generations.

Sustainability in Context
Sustainability is improving the quality of human life, while living within the carrying capacity of supporting eco-systems of the earth\(^6\). For humans, sustainability is the potential for long-term maintenance of well being, which has environmental, economic, and social dimensions. This is known as the triple bottom line principle. In 1994, John Elkington coined the phrase “The Triple Bottom Line” (TBL) to describe a foundational approach to sustainability. The Triple Bottom Line has since become a widely accepted principle for sustainability around the world. It says that success is measured not only by financial performance (the traditional bottom line), but by balanced achievements in environmental stewardship, economic growth and social responsibility.

Sustainable Development
Ecologically Sustainable Development represents one of the greatest challenges facing Australia’s governments, industry, business and community in the coming years. The Australian Government acknowledges the need for a sustainable future, and endorses the definition of Ecologically Sustainable Development to be “development which aims to meet the needs of Australians today, while conserving ecosystems for the benefit of future generations”\(^7\). To do this, we need to develop ways of using those environmental resources that form the basis of the economy in a way which maintains, and where possible, improves their range, variety and quality.

Environmentally sustainable design transforms these principles of sustainable development into tangible outcomes for specific projects. Environmentally Sustainable Design is the philosophy of designing physical objects in the built environment with consideration for the related infrastructure in order to comply with the principles of ecological, social, and economic sustainability. For the Melbourne Metro rail project, a specific methodology has been used to embed environmental sustainability in the design.

Methodology
Complex processes and challenges are involved in the design of a transport infrastructure project, especially where existing urban development needs to be considered. This provides the opportunity to demonstrate an integrated design approach. The following process has been used during the initial project evaluation and concept development phase, and needs to be revisited throughout each phase of the project:

1. Establish environmental sustainability goals and performance requirements for the project at the earliest stage possible by engaging members of the project design and delivery team as well as interested stakeholders;

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\(^7\) Australian Government (1992). National Strategy for Ecologically Sustainable Development
Identify specific planning, design and construction strategies and communicate these practices to the design team and stakeholders and include these strategies in the project plans and specifications;

Balance the environmental sustainability goals and strategies with planning, design and construction requirements to find integrated solutions, not tradeoffs or compromises, and to identify conflicts that may arise;

Resolve competing interests, address schedules and budget concerns both within the project and with other stakeholders relating to environmental sustainability.

Figure 2: Process of implementing the ESiD Framework

Integration Frameworks
In order to support the methodology of integrated sustainable design, guidance frameworks have been developed for both Environmental Sustainability in Design (ESiD) and Design for Climate Change (DfCC). The frameworks provide guidance for the fundamental principles to be considered to achieve sustainable outcomes during the initial concept design, and consequently throughout the life cycle of the project.

Environmental Sustainability in Design Framework
The ESiD Framework performance goals are based on the fundamental principles of the triple bottom line. The framework strives to promote outcomes beyond a standard “green project”. A green project focuses solely on the environmental stewardship component of the triple bottom line approach, such as reducing waste, minimizing carbon and water footprints, preventing pollution and conserving natural resources. An integrated sustainable design approach moves beyond this and not only includes green components, but also integrates those of economic growth, social responsibility, maintainability, durability and operational efficiency. This includes taking into account the broader impacts of sustainability on the urban environment around the metro system.

The following definition has been developed for demonstrating integrated sustainable design within the project:

“Environmental Sustainability in Design is an integrated approach, embedding its principles within the design, construction, operation, and reuse/removal of the built environment in an ecologically and energy efficient manner. This includes efficient use of natural resources and reduction of waste, and also translates into better building and infrastructure performance, supporting economical growth, improving operational efficiency by extending life and minimising maintenance requirements, saving in whole-of-life cost and providing a healthy and safe environment for patronage.”

The Environmental Sustainability in Design Framework uses six fundamental environmental sustainability categories to inform and guide the project planning, design and construction:

- Ambient environmental quality
- Community, biodiversity and heritage
- Energy end use efficiency
- Materials and waste
- Pollution control/localised impacts
- Water conservation

**Figure 3: ESiD Categories, work elements and aspects**

These categories summarize the principles integrated within each section of the project, applicable to each work element and the aspect of that category, for example rain water harvesting under the category of water.

**Climate Change**

Added to the complexity of sustainable development is the impact of climate change. The impacts of climate change if unchecked have potentially enormous economic, environmental and social implications for all Australians. Many changes in climate and extreme weather conditions are already being observed in Australia. Confronting a global shift in climatic conditions, Melbourne faces the impact of changes in temperature, rainfall, sea level rising and an increase in the number and severity of extreme weather events. Even with long term plans in action to influence the climate, such as measures to implement considerable cuts in greenhouse gas emissions, the lag in the climatic system means that in the short term the impacts are unavoidable and measures need to be implemented to build resilience and reduce vulnerability.

The Australian Government recognises that mitigation measures must be put in place to stabilising greenhouse gases at 450 ppm CO2e or lower is in Australia’s national interest, consistent with limiting global warming to around 2°C. However, the Government needs to consider what preparations it might need to take against the possibility that global agreements are less effective, and in the case of long-lived infrastructure, such as the Melbourne Metro Underground Rail, it is necessary to consider the possibility that temperatures may increase by 3-4°C, and that adaptation measures need to be put in place to be able to provide the continued and uninterrupted functioning of these major infrastructure systems. Acknowledging the need for adaptation, the Council of Australian Governments (COAG) developed a National Climate Change Adaptation Framework, which recognises that risks should be managed by, and implemented across sectors of

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10 Department of Climate Change (2010). Adapting to Climate Change in Australia: An Australian Government Position paper, DCC, Canberra
government, community, business and relevant stakeholders\textsuperscript{11}. Using the COAG adaptation framework and various other policies, papers and guidelines, the Melbourne Metro project team developed its methodology for climate change adaptation.

**Design for Climate Change Framework**

The Design for Climate Change methodology considers resilient design decisions which address measures of adaptation to impacts of a changing climate, where on the other hand mitigation measures are dealt with under the ESiD framework. The DfCC framework identifies possible risks caused by climate change and ensures that these are addressed during design. The DfCC methodology bases its principles on an integrated approach, which will ensure that the appropriate requirements are incorporated into the project.

Sustainability and climate change adaptation include requirements that normally do not go hand in hand. Considering sustainable outcomes on one hand and on the other integrating resilient design for climate change adaptation can be seen as competing interests. Base this framework’s methodology on the same principles as the ESiD, assisted in integrating and aligning the requirements from both sustainability and climate change adaptation.

Specific design parameters are defined within the Design for Climate Change framework, and are listed under the following categories:

- **Heat**: Increased temperature and more frequent heat waves
- **Weather**: Extreme rainfall, flooding and wind storm events
- **Dry**: Drought and less soil moisture
- **Sea**: Sea level rise and storm tides

These categories summarize the applicable climate change impacts taken into account within each section of the project, each work element affected and the risk identified. Key to the consideration of climate change impacts was to categorize the potential impacts in Melbourne, identifying adaption measures for increased temperatures and more frequent heat waves, extreme rainfall, flooding and wind storm events, extended periods of drought and less soil moisture, and sea level rise and storm surge tides. Melbourne is one of Australia’s major cities located at the coast. Almost a quarter of Australia’s population resides in Victoria, and a significant proportion lives along the urban coast of metropolitan Melbourne\textsuperscript{12}. The impact of sea level rise and tidal storm surges was thus considered as one of the risks for the project, caused by climate change impacts.

\textsuperscript{11} Council of Australian Governments (2007). National Climate Change Adaptation Framework, COAG, Canberra

\textsuperscript{12} Department of Climate Change (2009). Climate Change Risks to Australia’s Coasts: A first pass national assessment, DCC, Canberra
The DfCC framework reflects similar processes used in the UK for adapting to climate change impacts\textsuperscript{13}. Identifying possible design options for climate change adaptation follows the process of risk management in accordance with the Australian and New Zealand Standard for Risk Management AS/NZS 4360. A similar process of risk management relating to climate change has previously been used by the City of Melbourne\textsuperscript{14}.

![Risk Management Process adapted for Climate Change](image)

**Figure 5: Risk Management Process adapted for Climate Change (Source: Adapted from AS/NZ 4360:2004)**

**Project Outcomes**

The ESiD process and benchmarks were established to target an equivalent design outcome to a 6 Star environmental performance rating standard. During the concept development design phase, the ESiD framework recorded 79 sustainable initiative outcomes that have been included in the concept design, with a further 216 having been identified as potential initiatives to be included in subsequent design stages. Each outcome and initiative has a specific role in the reduction of the environmental impact of the MM infrastructure, stations and stabling yards. The key initiatives included in the concept design have been estimated to reduce emissions of 6,500 tonnes of CO2-E per annum, not including the significant savings anticipated from regenerative braking that is estimated to provide energy savings up to 30%.

Additional estimated environmental and energy savings through the introduction of the ESiD process include:

- Twin bored tunnels in place of the original plan for a single bored tunnel that will reduce waste by 50% and concrete usage by 50%;
- Cooling and heating energy demands from underground stations reduced from 100 MW to 8 MW and 3 MW respectively, resulting in annual savings of approximately 92 MW / annum;
- The use of alternative water sources and end use efficiencies on the underground stations saving the equivalent of 36 Olympic size swimming pools each year, a reduction in potable water use savings of 90,000 KL per year;

\textsuperscript{13} UK Climate Impacts Program (2003). Climate Adaptation: Risk, Uncertainty and Decision-making, London

\textsuperscript{14} Lorenz D, City of Melbourne (2008). Risk Management for Climate Change
Potential alternative energy sources identified to be considered in the next phases of the project, such as the provision of approximately 100 kW of Photovoltaic cells at the Stabling Yards delivering a 150 tonne annual reduction in CO2 emissions; Spatial allowance identified at the stations for potential installation of trigeneration systems which can act as district energy centres for the surrounding precincts, up to 5 MW of electricity generation per station. If realised in the future these trigeneration initiatives will potentially deliver $3.7 million in annual combined running cost savings (incorporating savings for wider precinct participating in the utilisation of trigeneration) with an environmental benefit of a 50,000 tonne annual reduction in CO2 emissions.

**Conclusion**
The development of sustainable communities and the delivery of sustainable transport infrastructures, which are resilient against climate change impacts, have been identified by the Australian Government as a key issue to the sustainable future of all Australians living in our growing cities. The integrated approach of sustainability and climate change adaptation in the Melbourne Metro underground rail project demonstrate that it is possible for project teams to address this key issue, and to consider all the complex decisions and design constraints in realizing a sustainable future in city growth along with its related infrastructure.

The Melbourne Metro project is a flagship contemporary development for the Melbourne region, which will also leave behind a legacy long into the future. This is similar for any transport infrastructure project in the city space, where modern conventional buildings generally have a 50-year lifespan, the infrastructure and interconnectivity of the urban environment will function significantly beyond this timeframe. As such, it is extremely important to consider the mitigation of any environmental impacts on the built environment and its related infrastructure, especially ongoing impacts. It is also essential to pre-empt the required adaptation of buildings and infrastructure in the future against possible impacts of changes in climate.