INNOVATIVE MODELLING AND VISUALISATION PLATFORM FOR SUSTAINABLE CITIES - MUTOPIA

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Abstract

Now more than half the world's population lives in towns and cities and this proportion will rise to nearly two thirds by 2030. Many cities worldwide are facing acute challenges, and therefore it is essential that all future developments are carried out on a sustainable footing. Through a web-based platform, MUtopia visualises and demonstrates in a quantifiable manner what impact a planned site development would have by representing best practice in all aspects of sustainable urban living on a relatively large scale. Sites may be new suburbs or rebuilt sections of the city large enough to require systematic planning. The project focuses on the development of an integrated modelling, analysis and visualization tool that helps the government and developers to make informed decisions to achieve such sustainable urban development and implementation. MUtopia integrates the streams of energy, waste, water and transport, based on land use, as well as social and environmental factors so that various planning scenarios or dependencies between factors can be tested. It is an integrated BIM and GIS tool. MUtopia would be an international first in an area of growing interest and need.

Keywords: Sustainable Cities, Modelling and Visualisation, Precinct Planning, Urban Infrastructure, Utilities Demand Modelling

1. Introduction

Most people now live in cities. In this century, cities will rapidly grow in size and complexity. Now, more than ever, there is a need to assess the future impact of engineering construction projects before they are built. Ensuring a building is structurally sound, or that a water pipeline system will carry a certain load is not enough: engineers must be able to assess the sustainability of their designs in terms of the triple bottom line. Environmental, social and economic indicators must be assessed and balanced.

Complicating the scenario is climate change. In the past decade, the stream flows supplying water to many cities around the world have reduced significantly. Action is being taken to counter such changes. For example, the Australian Government recently committed to reducing Australia's greenhouse gas emissions by 60 per cent below 2000 levels by 2050. On paper the equation is simple: reduce water consumption, energy usage and waste emissions whilst increasing the population. However, solutions will require much thought, clever design and innovative implementation.

Until recently, integrated assessment of environmental, economic and social indicators within a single system has occurred on an ad hoc basis. Only recently has the technological capacity emerged to enable multiple indicators to be visualized and analyzed at a detailed level over a large study area. MUtopia intends to utilize these technologies and contemporary engineering theory to enable the sustainability of future engineering construction projects to be tested.

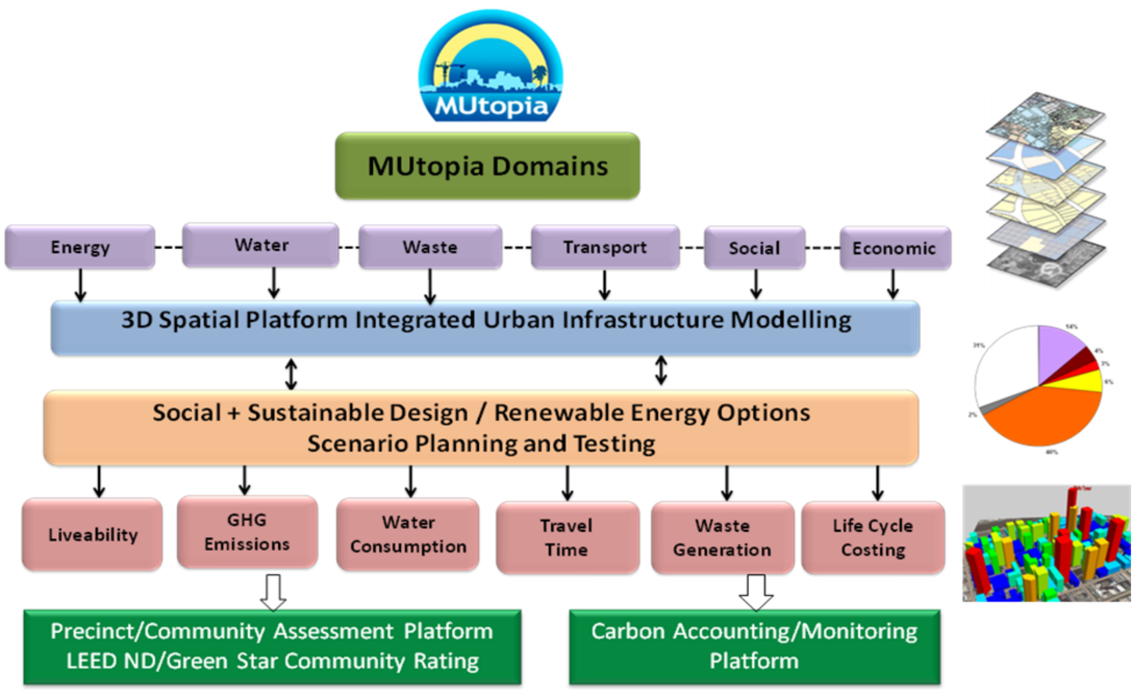

Figure 1: MUtopia Structure

Typically, new green or brown field urban developments are based on the use of general guidelines rather than objective quantification of key sustainability outcomes such as energy use, carbon emissions and water consumption. The result is poorly informed decision making that leads to patterns of urban development which are high cost, vulnerable and continue current patterns of environmental degradation and resource consumption. The MUtopia project represents a compelling opportunity to develop transition and future scenarios for sustainable urban development.

This project integrates the development of a visualization-modelling platform with the implementation of a new or retrofitted suburb that meets various criteria for environmental sustainability.

The project will not only assess the viability of introducing sustainability best practice from an engineering point of view (water recycling, thermal efficiency both passive and active, dwelling and transportation design, construction and maintenance etc.) but also aspects such as architectural and urban planning, sociological and community issues, economic modelling of the capital and operating costs and benefits of such an undertaking

MUtopia will quantify key sustainability performance across the four activity domains as follows (Figure 1):

- Energy: Solution sets include passive design, energy efficiency, energy storage, smart grid, demand response, behavioural change, renewable energy, central energy

- Water: Solution sets include conservation, capture, treatment and storage, stormwater mining, sewer mining, non-water technologies

- Food: Solution sets include private and public spaces for food production, closed loop processing of food and other organic wastes through on-site composting, digesters and waste-to-energy plants

- Urban futures: Solution sets include active transportation such as walking and cycling, public spaces for promoting social interaction and recreation

The modelling platform will allow testing of various transition and future scenarios at the whole-of-precinct level and will be able to extract data to assist in developing and accessing the performance of different components of scenarios (land use, individual buildings and infrastructure related to energy and water supply and use, waste management and transport systems) taking advantage of the unique platform scalability.

2. MUtopia Approach

MUtopia can be used to assess a whole city approach, a large precinct or, an individual suburban development in terms of all the above factors. Where the model is used to include wider whole-of-city and external factors, the platform can support a range of contemporary engineering questions. For example:

- What is the benefit of decentralised water supply in terms of energy usage, resource consumption, water supply augmentation, storm-water infrastructure requirements and storm-water quality, compared with desalination?
- What is the benefit of passive solar design in medium density housing developments, including interactions between buildings, compared with micro wind turbines and biogas?
- What are the environmental performance and mobility implications of medium density construction with commons green space centred on a highly interlinked public transport system compared with current practice?
- What would a Zero CO_2 emission city look like?

3. Modelling - Energy, Water, Waste, Transport

Buildings are categorised into residential (single, attached & multiunit dwellings) and non residential (commercial, office, retails, institutional & community). In order to estimate energy demand for the built environment, energy use is broken down into lighting, water pumping and heating, space heating and cooling, appliances such as kitchen appliances, laundry appliances and computer and entertainment equipment, etc. Energy supply modelling inputs are based around the location and available resources including roof area for solar and wind, building orientations and heights, terrain roughness and demand coefficients for co and tri generation modelling. The user may specify a number of requirements in order to select their power generation system including, annual demands, peak power, roof area and required carbon offset. Key outputs from the model include, typical day power generation profiles, annual electricity totals, GHG emissions per kWh and GHG emissions offset compared to grid connected pow5er.

The MUtopia modelling and visualisation framework is designed to provide a comprehensive assessment of the water cycle by fully integrating all the subsystems of water cycle and all the relevant interactions with other systems explicitly modelled in the platform.

The MUtopia platform provides modelling capability to simulate the urban water management system at multiple scales – dwelling, precinct, cluster, development. Urban water harvesting and pollution loads involve individual houses, wastewater flows and pollution load discharges are represented at catchment scale. Time scales may also vary from hours to days with some ecological impacts on catchment receiving waters which evolve in years.

Waste management is a key aspect to look at in infrastructure development and the evaluation of sustainable waste management options throughout its life cycle is becoming increasingly important. The planning and simulation covers the total life cycle from waste generation to the final treatment solution. For residential and non residential segments, various collection methods, transportation methods, material recovery and separation methods and treatment methods are considered across the total waste management cycle from the beginning to the end.

The scenario capability building offers the ability to visualise the output modelled with different scenarios, a scenario based on the current practice, another based on the immediate next best available solution and finally scenario which is consistent with the current global best practices. In transport these options are offered through split between various modes of transport mode. For example Cars 60%, Public Transport 18%, Walking 11%, Bicycles 7% and other 4%.

Some features of MUtopia are shown in Figures 2 to 5.

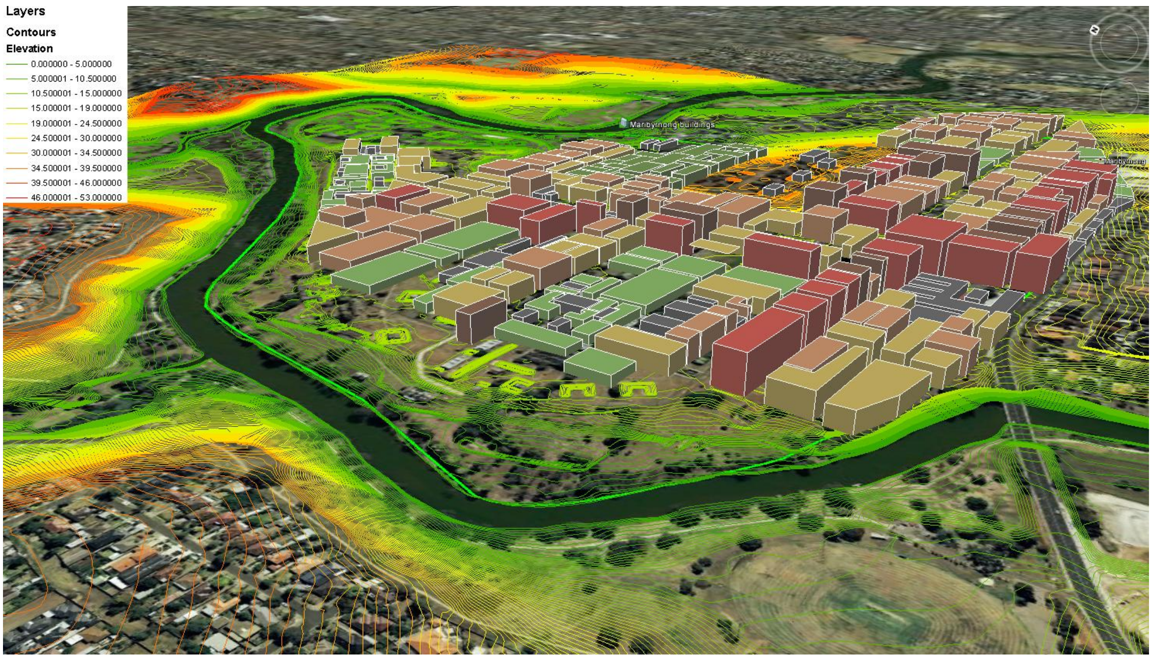

Figure 2: 3D Terrain Model

Figure 3: Geological Mapping

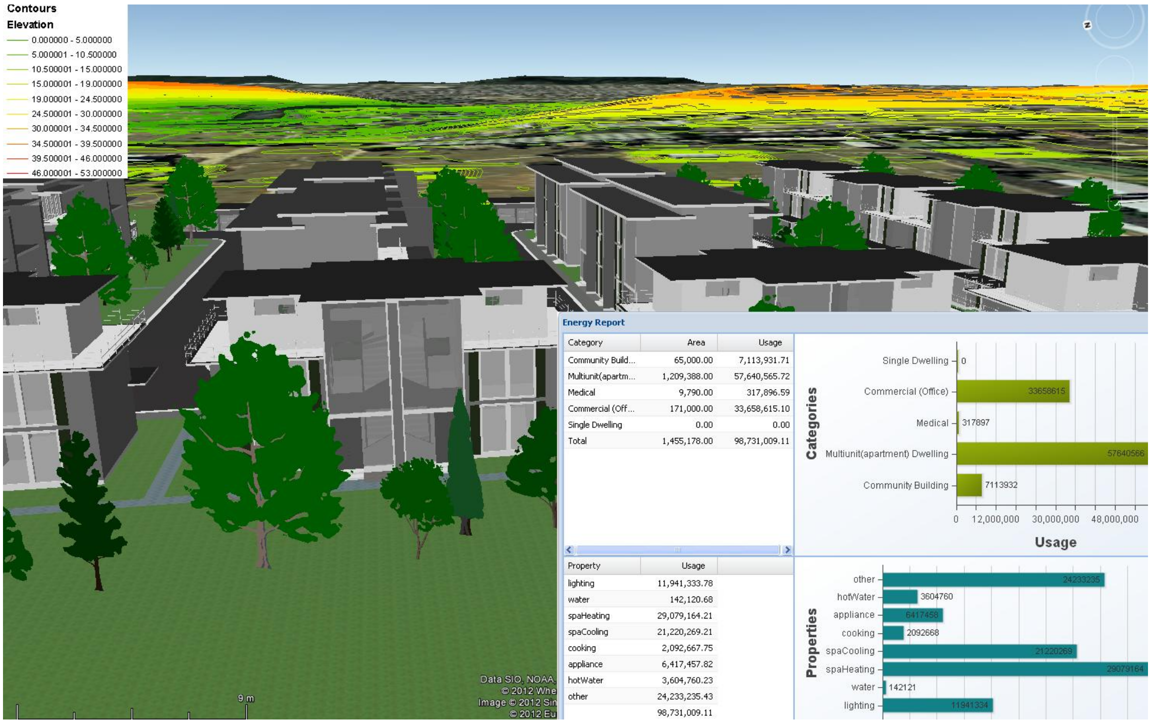

Figure 4: Energy Modelling

For example assume a new precinct has to be designed for a green field site with an area of approximately 130 Hectares. MUtopia can be used to check different scenarios for 8000, 10000 and 12000 dwellings. Some results are shown for different energy demand requirements. Two scenarios of Australian best practice (NABERS 7 star rating) and Global best practice (NABERS 8 star rating) are shown in Fig. 5 and Fig. 6.

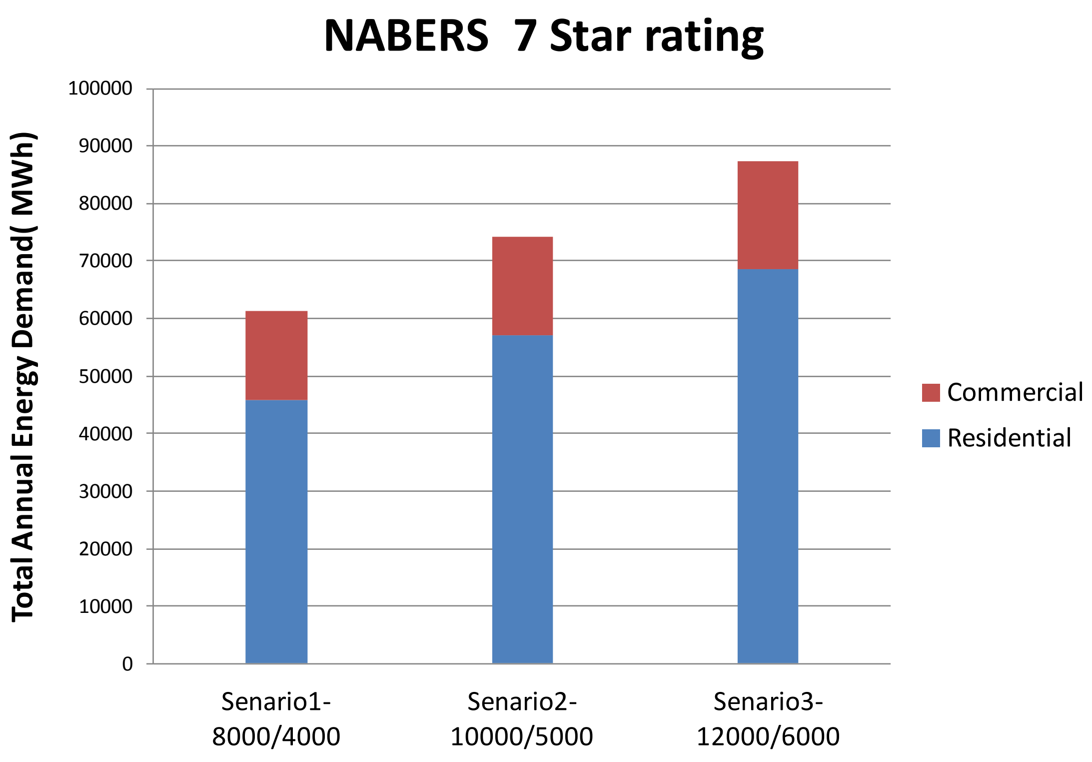

Figure 5: Australian Best Practice Scenario

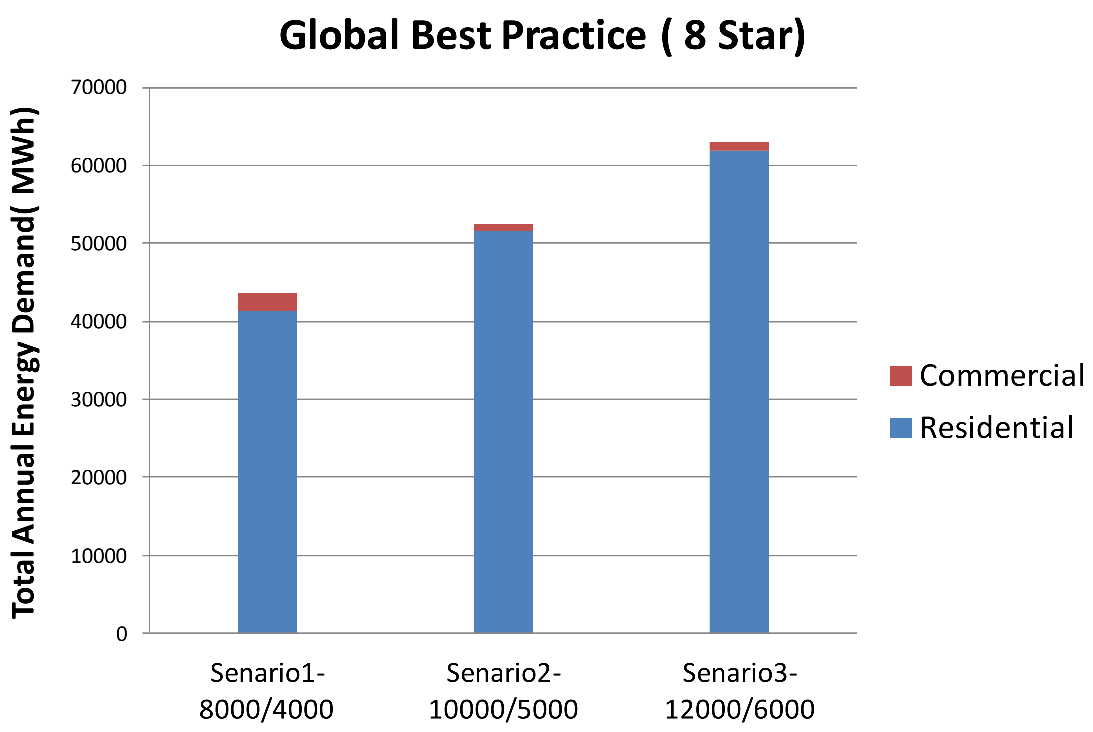

Figure 6: Global Best Practice Scenario

4. Concluding Remarks

MUtopia Planning tool was completed recently. It has been designed as a tool for master planning of new precincts with a view to identifying the best designs for sustainable living given particular sets of circumstances and assumptions. The analysis is aggregated at various scales ranging from small developments to cluster, precincts and larger scales. The platform enables the integration of energy, transport, waste and water modules and scenario planning. These can be displayed using its visualisation simulation capability to demonstrate the various layers of information such as: land use, transport network, terrain, geological, and master planning options showing building and design layouts. MUtopia can generate reports to show key sustainability performance metrics such as total energy usage, water consumption, waste generation, and transport related GHG, cost effectiveness of various scenarios. Different options can be tested such as “Business as Usual (BAU)”, “Australian Best Practice (ABP)” and “World’s Best Practice (WBP)” scenarios. The next phase of MUtopia will be designed as a tool to assist the final stage of master planning.