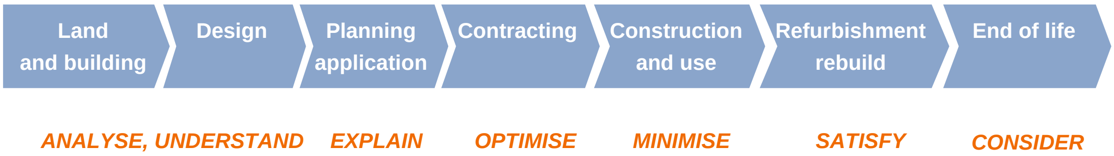


Arup – Integrated Resource Modelling (IRM): A tool for assessing sustainability performance of spatial and resource flow strategies in masterplanning

IRM Background

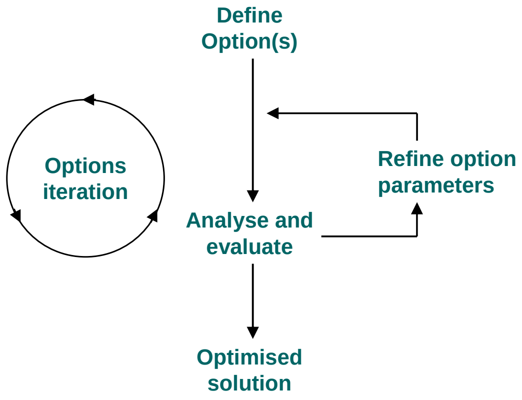
Arup's bespoke Integrated Resource Management (IRM) approach can be employed to support the development of, and evaluate, growth and design options for the project in terms of defined indicators and targets developed as part of the sustainability framework. The IRM model is essentially a systems analysis tool that adopts a Life Cycle Assessment (LCA) approach and applies this to regional or town/city masterplans, or at the project-specific development level.

The application of the IRM to support the design, development and evaluation of masterplans, growth studies, etc has provided numerous benefits. The tool was developed in response to Arup's recognition of the complexities of coordinating and integrating multidisciplinary inputs.

The main objectives of the IRM model are to:

- Align technical streams that input into the design of a masterplan to ensure that they are based on the same primary information and assumptions;
- Integrate technical streams so that they are responsive to all changes in the development process as they emerge;
- Ensure that the options for demand reduction are optimised;
- Ensure that strategies for alternative, more sustainable means of supply are exploited;
- Balance supply of resources and energy with the demand profile;
- Provide rapid performance assessment (i.e. performance in terms of defined KPIs) of a sustainable design against competing options, a Business as Usual ('BaU') benchmark or against sustainability targets;
- Use performance outputs to inform the design process in order to optimise design (design continuous improvement though an iterative process of define, evaluate, refine, optimise (see Figure 1).

Figure 1: Optimal design solution achieved through iterative process of evaluation and refinement.



Methodology

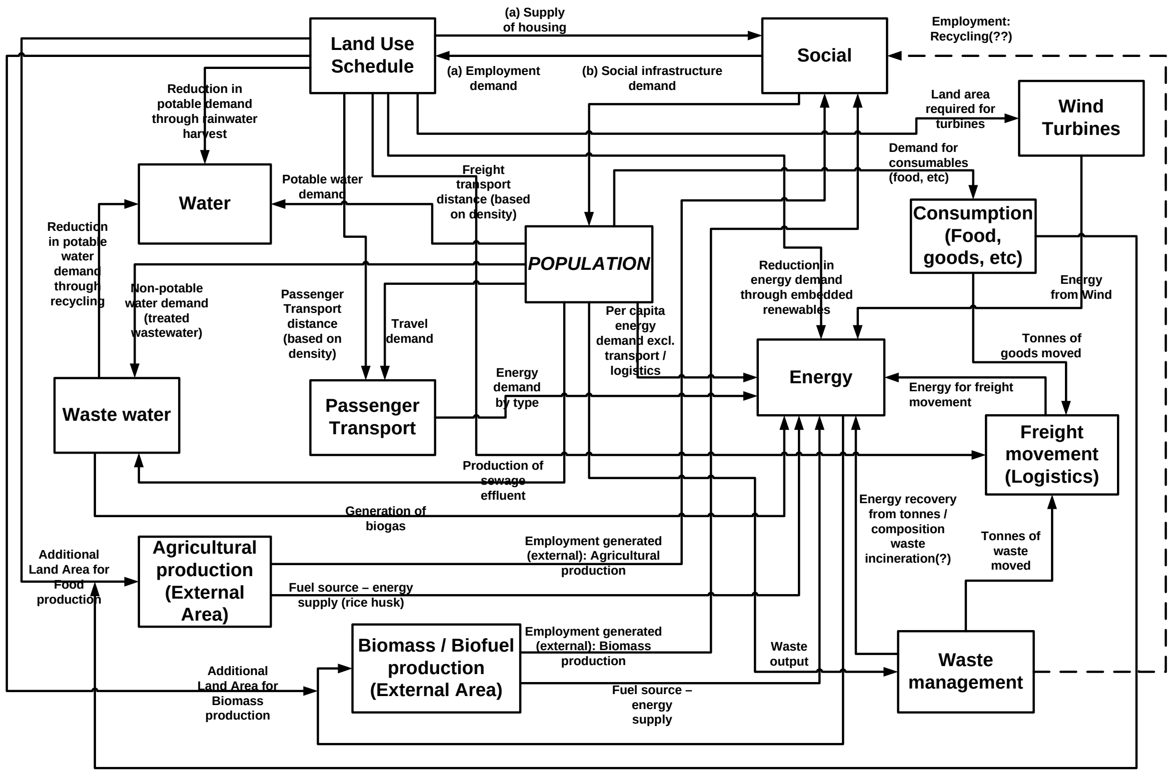
The IRM approach provides a methodology to streamline the complex process of masterplanning to achieve the best practicable outcome. The model does not substitute the need for technical design inputs; in fact it is designed specifically to capture the inputs of design specialists into a common data framework to facilitate inter-disciplinary data exchange between these technical discipline inputs recognising the complex interactions and 'feedback loops' resource flow issues that exist in regional and city/town systems. Through this mechanism, the aim is to reduce demand but also to 'close' resource flow loops.

Figure 2 is a high level summary diagram that shows the influence and interactions between different technical components in a masterplan system context, showing some of these feedback and closed loop mechanisms.

The IRM model assists inter-disciplinary implications to be taken into account. For example, principles of transport management generally include minimising the need for travel, reducing travel distances, achieving better use of public transport and other mass transport systems as well as encouraging walking, cycling, and alternative sustainable fuel technologies.

The use of the model to explore sustainability performance prompts appropriate questions in relation to 'what if' scenarios, for example, the mixture of land use and density of development that will ensure that travel distances from residential dwellings to places of employment and social infrastructure are minimised.

Figure 2. Influence chart illustrating a system representation of regional /city masterplans.



The IRM model can accommodate inputs in relation to, and provide performance outputs in response to, various technical components of a study or scheme including:

- Urban design and land use (including building typologies, density, etc);
- Primary growth issues (e.g. population, housing, employment);
- Water supply and waste water management requirements;
- Passenger transport;
- Production and consumption (industrial, food, etc);
- Logistics (i.e. movement of freight and waste);
- Buildings energy;
- Solid waste management.

The performance of an option is described in terms of a series of Key Performance Indicators (KPIs) linked to the objectives of the sustainability framework. The scope of possible KPI outputs is extensive, however it is recognised that there is significant importance in providing performance measures tailored to the specific requirements and objectives of the project. Examples of indicators include:

- Building energy demand (MWh/annum);
- NOx/SOx emissions (kg /annum);
- Passenger kilometres by bus (km/ annum);
- Municipal Solid Waste Composition (%, by type);
- Area of agricultural land lost through development (ha);
- Vehicle carbon dioxide emissions (tonnes CO_2 / annum);

By outputting KPI measures based on data captured in a common framework, it is possible to explore optimal solutions based on effective integration, rather than to rely on optimised technical solutions that are simply ‘bolted together’. Since the output of the IRM model is quantitative, it enables an objective assessment of the merits of different design solutions.

It is apparent from the indicator examples (above), that the IRM model output includes KPIs that provide an holistic account of the carbon footprint of a development that can also be disaggregated according to the source of emissions (e.g. energy use in buildings, transport emissions, waste management processes).

Since the IRM approach is founded on LCA but employed in a specific (masterplanning) context, the methodology adopted follows the requirements of the ISO 14040 and ISO14044 standards for LCA. This methodology is highly suited to sustainability assessment in that it takes an holistic view of impacts, including supply chain issues.

For example, carbon dioxide emissions are often taken as the direct emissions associated with the combustion of fossil fuels to derive the energy supply. Where biomass is used as a fuel source, this may show significant benefits. However, LCA will also take into account supply chain impacts associated with, for example, the use of fossil fuels to transport biomass to site, and fuels used in the cultivation and processing of the biomass.

By applying the LCA standard ‘rules’ rigorously, it also ensures consistency of approach, for example mapping out systems boundaries clearly, and ensuring transparency by documenting any assumptions required in the analysis. For example, when transport impacts are considered, does this include all transport associated with residents of a defined geographic area (including transport by these residents outside of the geographic area), or all passenger transport in the geographic region, whether by residents or visitors?

By applying LCA standards, these issues are explored systematically in relation to the required outcomes of the project and all assumptions documented. From this, it becomes apparent that the systems boundary and the geographic boundary of a study are not necessarily the same, since a holistic approach will include supply chain impacts and other indirect issues that potentially have a significant bearing on the overall performance of a particular design option.

Case Studies

Integrated Sustainable Urbanism - Dongtan masterplan (Client SIIC, China)

The Dongtan masterplan project is representative of the application of the Integrated Resource Management (IRM) model at a large geographic scale, comprising Phase I (630 hectares) of a new-build city development that will eventually cover some 86 km^2.

The site for Dongtan is located on Chongming Island, near Shanghai in China. Due to rapid expansion and constraints on economic development in China, the client’s aspirations were for a city with the capability to demonstrate a high level of sustainability performance in the broadest sense. The sustainability assessment framework that details the Objectives, Key Performance Indicators (KPIs) and Targets, encompassed the main dimensions of sustainability management, namely Social, Economic, Environmental and Natural Resources.

Energy demand and greenhouse gas emissions (GHGs) represented significant indicators in the model due to the energy demand associated with mixed residential, commercial and industrial developments. Consequently, the design options placed considerable emphasis on measures to reduce energy demand and to find alternative, more sustainable means of supplying energy.

The IRM model was employed to provide the link (via the KPIs) between the technical strategies (e.g. waste management , people transport, logistics, water building energy, etc) and the sustainability assessment framework (SAF). The model provided the means to capture multi-disciplinary technical data inputs and test the sustainability performance of design options in a rapid and iterative process that enabled different solutions to be compared and subsequently refined.

Included in the targets for Dongtan was an aspiration for a zero carbon city. Using the model, the team were able to test different design scenarios to derive a zero carbon solution taking into account all significant contributions to greenhouse gas emissions. This involved, for example, design measures to dramatically reduce energy use in buildings, employing mixed use and density scenarios to reduce the need for personal transport, and proposing the supply of energy primarily from wind turbines and biomass-fuelled CHP, together with the use of zero tailpipe emission personal transport vehicles.

Gallions Park – Feasibility for a Zero Carbon Development

Arup's Integrated Resource Management (IRM) modelling approach was used to support the assessment of different design scenarios/options to achieve an exemplary design zero carbon at Gallions Park.

While the IRM model has the capability to address a broad array of quantifiable sustainability performance indicators, this study focused specifically on carbon dioxide (CO_2) and other non-CO_2 greenhouse gas emissions arising from different aspects of energy consumption.

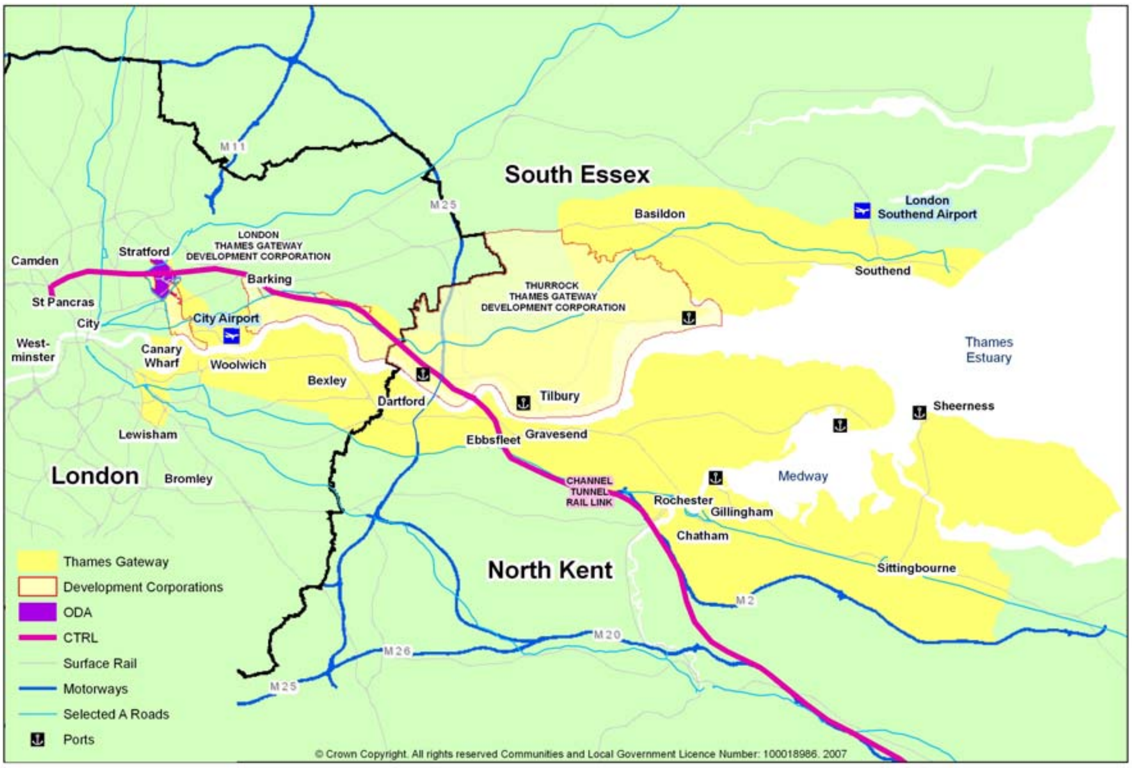
Whereas building greenhouse gas emission assessments are typically limited to consideration of energy-use-in-operation energy consumption and use this as the basis for defining 'zero carbon' or 'carbon neutral' developments, the scope of this assessment was broadened in line with the IRM approach of adopting a more holistic view of developments.

In addition to the energy-use-in-operation greenhouse gas emissions, the systems boundary included lifecycle impacts associated with, for example, embodied energy and the supply chain, as well as indirect effects due to the activities of residents, such as personal transport, consumption of goods and services, etc.

This approach is designed to address the requirements of a sustainability assessment that considers all direct and indirect impacts expressed on a per capita basis and uses data inventories linked to processes to provide greenhouse gas emission data associated with the energy demands of the development and its residents, and the technology with which it is supplied.

Thames Gateway Low Carbon Feasibility Study: Identifying and costing the measures to reduce carbon emissions in the Thames Gateway

Timescale: 2006 -2007



The client for this project, the Communities and Local Government (CLG), commissioned Turner & Townsend and Arup to undertake a study to examine the feasibility of achieving different levels (rates) of reduction in greenhouse gas emissions in the Thames Gateway over the time period of 2005 to 2050.

The work primarily focused principally on carbon emissions due to:

- Demand and supply of energy in buildings;
- Waste management, including recycling and energy from waste processes;
- Water demand and supply, including provision and treatment of potable water, and treatment of wastewater, as well as surface water treatment and discharge;
- Personal transport, for work, shopping, leisure and education, using a variety of public and private transport options;
- Logistics transport, to service the needs of demands by residents and industry located in the Gateway;
- Consumption of food and consumables by residents, and construction of housing.

The main objective of this study was to understand the magnitude of greenhouse gas emissions within and as a result of development of the Thames Gateway, and the likely changes that will be required, driven by new policies, to reduce the emissions relative to a defined target, and at what cost. John Prescott, MP, at the Think07 Conference (May 1st) on sustainability, regeneration and Innovation mentioned that if current trends continue (business as usual), carbon emission in the Gateway are likely to increase by 107% by 2050. Achieving a 60% reduction in emissions, in line with the Government's target, is possible we action is taken now.