# WATR7700 - Urban metabolism: resource and energy recovery systems (2 units)

**Integration module (Specialisation stream #2: Urban water)**

## Module description

As more than half of the global population live in urban environments, the sustainability of water dependent services including water supply, food and energy generation to urban areas is crucial. There is a need to reduce the linear flow through of water, material resources and energy, by promoting technologies and practices which achieve recovery, re-use and demand reduction.

This module challenges current patterns of water, energy and nutrient use in cities as inefficient and unsustainable. Emphasis is placed on understanding and evaluating the 'water' mass balance - a fundamental and powerful new way of quantifying the hydrological performance of cities. Through this course, this balance is used together with the coverage of technologies and management approaches to manipulate urban systems so as to improve 'metabolism' by reducing raw water intake and recovering and using the resources that wastewater carries, particularly energy, nitrogen and phosphorous. In doing so the course covers urban metabolism theory and more broadly resource efficiency and how they relate to sustainability, cities and water; mass balance modelling; Life Cycle Assessment and Input / Output modelling; water recycling and reuse; energy and nutrient recovery technologies; water-energy interactions in cities; issues surrounding the best scale for the recovery and re-use of water, energy and nutrients; urban agriculture and alternative production and consumption models as ways of improving the urban metabolism and consequently sustainability. A number of participatory approaches include an "integrated water-energy planning tournament" and hands on city building exercises are used together with field visits to build experience, understanding and tangible practical skills.

The aim of this module is to equip participants to be able to critically assess the resource efficiency and sustainability of cities across a range of scales; to be able to systematically quantify physical flows in complex urban systems; to construct and use urban metabolism models to characterise and evaluate options for improving urban sustainability.

This course comprises key skills that are important for a rigorous understanding of integrated water management problems.

Key topics include: resource efficiency, urban metabolism and sustainability; defining systems and subsystems; mass balance modelling; life cycle assessment; water recycling; energy recovery; nutrient recovery; urban agriculture; water-energy nexus; decentralisation.

## Module introduction

This module equips participants with the skills, tools and technologies for studying urban areas as systems with inputs and outputs (wastes); to critically assess the relationships between metabolic information and urban sustainability, and; to understand the strengths, weaknesses and opportunities of urban metabolism and more broadly resource efficiency as a framework for informing policy and management.

The module is developed in six major topics as follows:

- Overview of metabolism (the need for change, the inefficiency of cities, metabolic theory and principles);
- Modelling, measuring and evaluating direct flows of water, energy and nutrients (system boundaries, states, systems characterisation, mass balance analysis principles, techniques and challenges);
- The water-energy nexus; characterising and optimising water-energy flows (current and future trajectories of water-related energy, key points of intersection and influence);
- Modelling, measuring and evaluating indirect flows (techniques for quantifying and evaluating embodied flows of water, energy and nutrients);
- Options and technologies for recycling/regenerating water, energy and nutrients (technologies and other approaches);
- Integrating understanding of metabolism (measure metabolism, goal setting and communicating metabolism).

## Module delivery

- **Full-time** (on-campus) students, including international students, are required to enrol in the internal offering in Semester 2.
- **Part-time** (external) students are required to enrol in this module in Semester 4. The Semester 4 intensive six-day workshop is held at the beginning of the semester. The remainder of the module is taught externally online.

## Assumed background

The following modules are prerequisites for this module: 'New perspectives on project management', 'Science of water', 'Water, sustainability and development', 'Water governance and policy'.

## Learning objectives

After successfully completing this module participants are able to:

- Define systems by identifying appropriate system boundaries;
- Understand accumulation and the difference between steady-state and dynamic models;
- Conduct mass balances of water in cities across a range of scales (precinct through to city scales), characterising inputs, outflows and losses from a range of sources, and understand the diverse impacts of water mass balance on energy and related flows (e.g. greenhouse gas emissions);
- Understand and be able to critically appraise urban metabolic theory as a basis for delivering urban sustainability;
- Construct an urban metabolism model based on mass balance principles, urban metabolic theory and resource efficiency frameworks;
- Critically use urban metabolic theory and models to characterise and assess options for improving urban sustainability through improved water, nutrient and energy recovery;
- Describe and assess the strengths and weaknesses of key water management and resource recovery approaches and technologies for improving urban metabolism including recycling and energy and nutrient recovery;
- Appreciate the importance of engagement and collaboration in delivering changes to urban production and consumption behaviours and systems.

## Teaching staff

**Lead Lecturer:** Associate Professor Dr Steven Kenway (School of Chemical Engineering, The University of Queensland)

**Lecturer:** Dr Brian McIntosh (International WaterCentre)

**Lecturer:** Associate Professor Dr Steven Pratt (School of Chemical Engineering, The University of Queensland)

**Lecturer:** Dr Marguerite Renouf, The University of Queensland
**Lecturer:** Mr Joe Lane (Advanced Water Management Centre, The University of Queensland)

**Lecturer:** Phil Woods, Sydney Water

Brisbane river (photo: Brisbane Marketing)