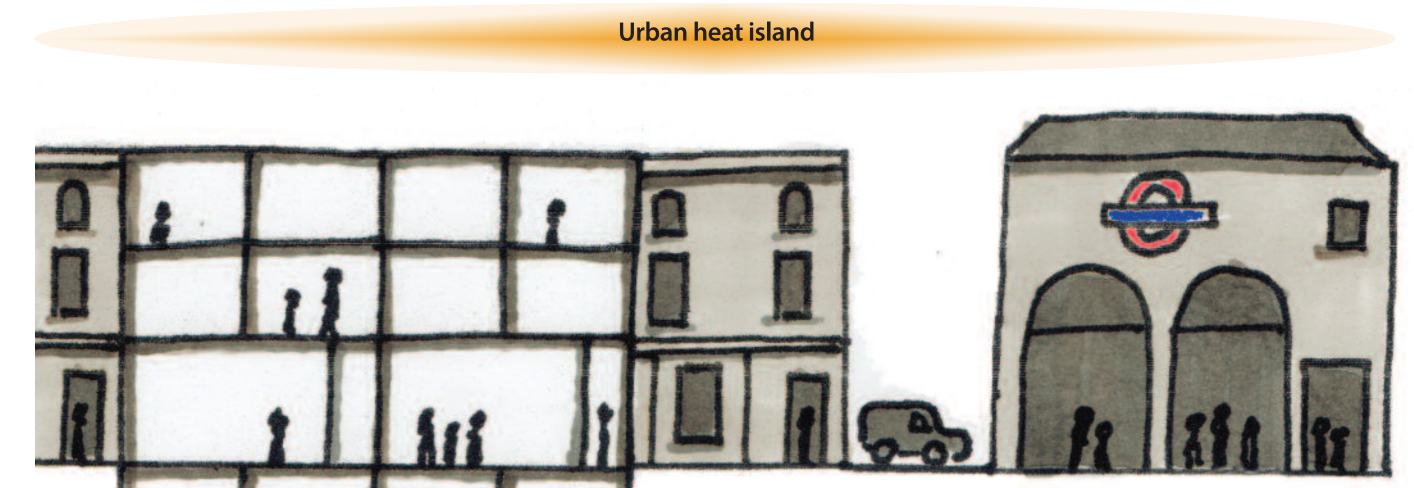
Planning in 3D: Optimising space and resources in city heat sources to hot spots for growing edible plants

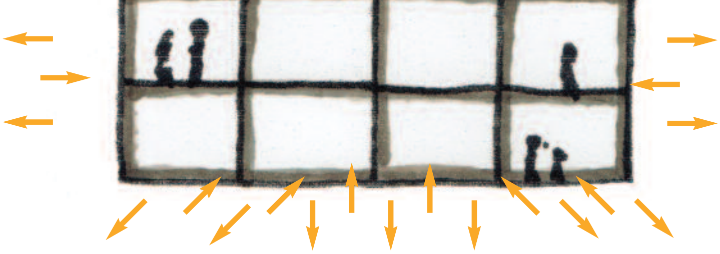
Introduction

With predictions of an additional 2.6 billion people living in cities by 2050 there is need for 3D planning of our urban areas to manage available space, energy, water and food resources optimally. Subsurface space in cities is already used for multiple purposes – infrastructure, transport and living – and will be further exploited in the future to help relieve land and energy shortages. The following two CSIC Cities projects, one above and one below ground, interact with the city's material and energy fluxes symbiotically to absorb and repurpose urban waste energy flows.

Below ground

Geology is a significant consideration in the development of the cityscape. CSIC researchers are working to identify suitable areas for increased exploitation of underground spaces, and explore optimal locations across cities for harnessing the geothermal potential of the ground. The goal is to increase utilisation of underground space in a sustainable and efficient manner to deliver city-wide energy efficient solutions.





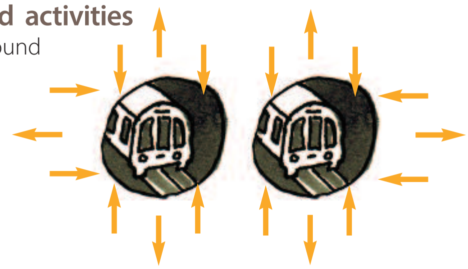
Transfer of heat between ground and basements

Effect of basements on ground temperature

CSIC is studying the effect of large increases in residential basements on the distribution of surrounding ground temperature. A pilot study of a few areas within central London was recently completed.

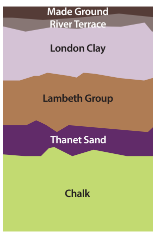
Effect of underground activities

Activities such as underground trains travelling through tunnels introduce additional heat which could be extracted and used elsewhere as 'smart' heat.



Geology

Dissimilar geologies of three distinct areas in London are being explored to consider how heated basements affect the surrounding ground temperature. This study combines British Geological Survey (BGS) data with numerical modelling. Constructing subterranean space creates changes in ground conditions: possible impact on water quality and structural mechanics of different soils.



Ground temperature

Undisturbed ground temperature in London at 5-6 metres is 12-14 degrees. The temperature of the ground just below the heated basements is warmer (18 degrees) and may be propagated as a free energy source and potential revenue stream.

3D geological mapping

The British Geological Survey (BGS) has supplied 3D geological maps of Greater London. These are being incorporated into numerical models to create an integrated appraisal of land viability and to capture the effect of basement living on different geologies and hydrogeologies. Mapping the range of ground temperature will identify potential sources of geothermal energy to inform subterranean planning and development.

Mapping underground temperatures

The information from this CSIC and BGS research project is key to considering the suitability and sustainability of utilising the ground as a source of heat. Currently no complete database on ground temperature in London exists. This project will produce a map of indicative ground temperatures (including influence of additional underground activities such as train tunnels).

Efficient use of geo-energy

Combining different purposes (offices – empty at night and houses – empty during the day) to use geo-energy will allow ground temperature to recover and maintain balance and long-term sustainability.

Next step

A series of geospatial queries aligned to future city scenarios can be identified, developed, and simulated using the integrated city model. This model could be applied where relevant 3D geological maps and data sets exist.

settings – from underground thermal

Above ground

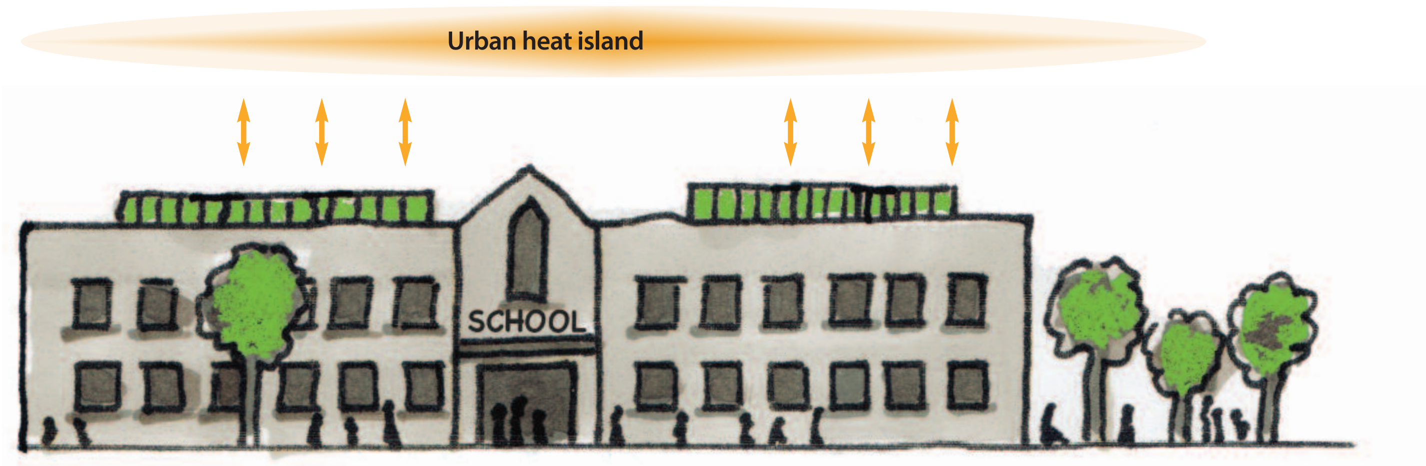
Energy demand for cooling in cities is set to rise by up to 30 per cent as cities get warmer. Cities create an 'urban heat island' effect where temperatures are higher than the surrounding rural areas. Increasing vegetation, for example, with green roofs, has been shown to reduce the urban heat island effect and, it follows, building energy consumption from cooling.

Urban planning to optimise a city's limited resources requires innovation above as well as below ground. London's high-cost land area is a barrier to urban farming. However empty rooftop space could be reused to grow edible plants, and also establish energy efficiencies within existing infrastructure. Researchers from the Energy Efficient Cities Initiative (EECi) and CSIC are exploring the potential for urban agriculture in schools where there is already an interest in growing edible plants. This project is developing a framework for integrating rooftop hydroponic greenhouses on schools to work in synergy with the buildings, essentially coupling the demands of a greenhouse (heat, water, CO_2), with the available resources in buildings (waste heat, rainwater, solar radiation, CO_2 from occupants).

Repurposing school rooftop space

Schools have regular occupation and resource consumption patterns. There is potential to reuse these resources for rooftop farms. Geospatial information is used to identify school buildings across the city that would benefit most from integrating a rooftop greenhouse. Repurposing flat rooftop space of London schools for hydroponic farms can have co-benefits between plants and building occupants.

> "It is important that we consider such city-wide synergistic planning solutions both for sustainability and utility. These are interlinked systems and therefore offer an amazingly rich multi-dimensional modelling exercise that requires 'out of the box' thinking.
>
> Dr Ruchi Choudhary, Head of Energy Efficient Cities Initiative and CSIC Investigator, University of Cambridge



To quantify the co-benefits between a rooftop farm and a building, both the effect of the surrounding area and the building energy use for heating and ventilation are being analysed by researchers. The aim would be to know how much food would be produced, how much waste resources from the building could be reused, and if it will improve the temperatures and air quality within the building.

Qualitative data input

CSIC researchers are designing a survey to identify the limitations and drivers for schools to adopt integrated rooftop greenhouses. Adding qualitative data to the quantitative model will help understand potential barriers or creative solutions in terms of benefits to the schools' students and teachers.

Next step

The quantitative potential impact and qualitative criteria inputs will guide the development of a geospatial (GIS) analysis tool to identify optimal locations for urban farming, and the outputs of its implementation city-wide.

Benefits to

City planners, asset owners, local authorities, citizens

Impact and value

- energy efficiency
- optimising sustainable utilisation of subterranean space
- potential air quality improvement
- positive impact on community, education, health and wellbeing

Project contact

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