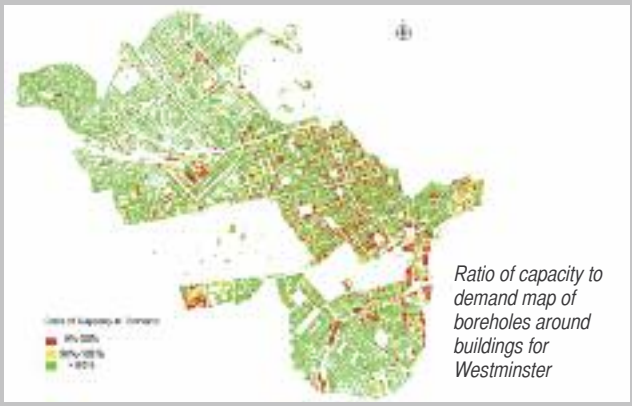
Saving energy: ground source heat pump (GSHP) applications at city scale

Ruchi Choudhary



Ratio of capacity to demand map of boreholes around buildings for Westminster

The project
The potential of low-grade geothermal energy for heating and cooling buildings and infrastructure at city scale is being investigated by CSIC with funding from BP. Planning this system at city scale could make a radical step change towards reaching medium to long-term renewable energy and CO_2 emission targets.

Applications
CSIC has developed a Geographical Information System (GIS)-based city-scale simulation model to estimate how many GSHPs could be installed in the city without losing control of the ground thermal capacity. The novel model is used to quantify the degree to which the system can contribute to meeting building energy demands. The case study is implemented for the whole of the City of Westminster in London.

In the model, building energy loads and thermal properties, underground temperatures and borehole installation designs are structured as fine-grained 3D data maps in order to measure in detail the distribution of GSHP capacity to demand. A highly efficient and robust simulation model results indicating where the highest GSHP potentials are and how to optimise the GSHP installations.

CSIC has also established a future options model for incorporating GSHP in multi-storey business premises and apartments. This model accounts for uncertainties such as energy prices, building energy loads and long-term GSHP performance.

Impact and benefits
- city scale planning can make a step change towards reaching medium to long-term renewable energy and CO_2 targets
- flexible solutions that embed future GSHP options can significantly contribute to sound financial performance
- CSIC research highlights when to invest in GSHPs, building design and underground space configuration, and the utilisation of low-grade geothermal energy under dense urban areas

"This study provided a detailed understanding of the links between GIS energy maps, possible layouts for GSHP closed loop boreholes and the ground heat storage system. It shows that GSHP systems can be run in densely populated areas without depleting the geothermal resource."

Duncan Nicholson, Vice Chairman of the Ground Source Heat Pump Association

Adaptive zoning: quantifying costs and benefits of major transport investments

Vassilis Zachariadis

Adaptive zoning model of journeys to work in the Greater South East

The project
CSIC research has transformed adaptive zoning from a heuristic spatial modelling tool into a spatial economic method based on robust theories of home and job location choices.

Our new economic interpretation of the adaptive zoning method enables it to be used for appraising the business cases of major transport infrastructure investment projects. CSIC's method is being implemented in a state-of-the-art land-use and spatial equilibrium model that not only tests for the direct effects in reducing car dependency and congestion/overcrowding, but also for indirect impacts including business productivity and housing demand.

Applications
CSIC's adaptive zoning approach translates location choice problems, which typically scale by the number of locations squared, into ones of near-linear scalability. Testing on adaptive zoning models of home-to-work trips in Southern England (with 3,250 job and home zones) suggests our technique can be as precise as existing methods with one tenth of computational time and memory.

This step change from existing modelling suites provides a new way to exploit increasing granularity in data on how people choose where to work, live, shop or spend leisure time, and produces more precise simulation of the effects of policy interventions.

Impact and benefits
CSIC's new adaptive zoning method:
- enhances spatial economic and transport modelling, making it possible to model in much higher spatial resolutions, while allowing a radically expanded study area and new geo-datasets
- develops significantly more realistic scenarios and produces outputs in a fraction of the time compared with existing models
- opens a new pathway towards cloud-based computing for model applications involving micro-agents

"Adaptive zoning breaks down long-standing computational barriers and sets new expectations for urban system modelling: to interrogate the national infrastructure as a system-of-systems without losing sight of the role of individual transport infrastructure assets and local planning decisions."

Dr Alex Hagen-Zanker, University of Surrey