Modelling London's Building Stock and Its Associated Energy Use

Professor Paul Ruyssevelt

University College London
Energy Institute

p.ruyssevelt@ucl.ac.uk

+44 7887726845

Seminar 57

Multiscale Building Energy Modelling, Part 9

Learning Objectives

Session Learning Objectives:

- Provide an overview of Urban Building Energy Model (UBEM) techniques and data sources
- Describe the use of regional building modeling as a forecasting tool
- Demonstrate the ability of 3D mapping techniques to provide wide-area geometrical information over urban and foliated scenes with evaluation of critical infrastructure (e.g. power line damage and flooding)
- Describe an approach for community-scale modeling using detailed whole-building energy models with use cases for district system optimization

Acknowledgements

Development team:

- Phil Steadman
- Steve Evans
- Daniel Godoy
- Rob Liddiard
- Ivan Korolija
- Dominic Humphrey

Funders:

Engineering and Physical Science Research Council

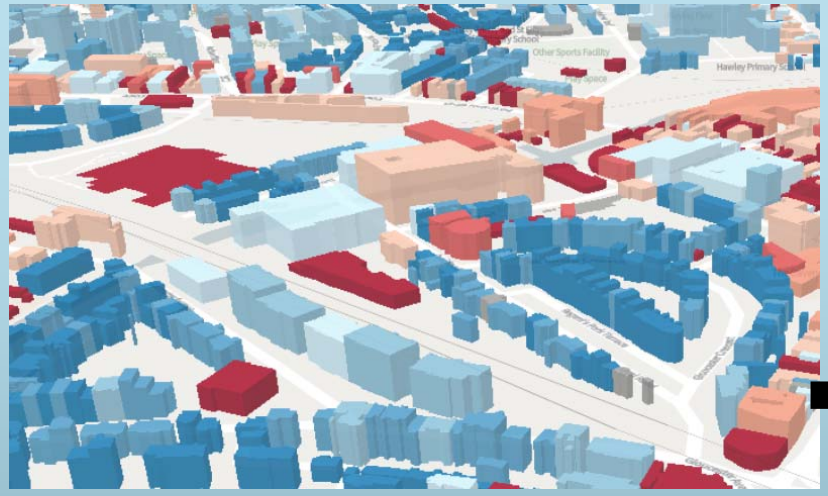
References:

- Centre for Energy Epidimiology: cee.ac.uk/3dstock, cee.ac.uk/simstock
- Centre for Reduction in Energy Demand Solutions (CREDS): www.creds.ac.uk/buildings-energy

Agenda

- Construction of the Urban Energy Model
- Can we model ‘buildings?’
- Allocating floor space, use type and energy meters
- Analysing floor space and use type
- Mapping building attributes
- Simulating performance, calibration and verification
- Conclusions

Building Stock and Energy Model



3DStock

Automatic generation of detailed built form from publicly available national datasets.

10+ years of development

Energy Plus

SimStock

Automatic generation of detailed simulation models to predict energy and environmental performance.

Built on Energy Plus

3DStock architecture

Valuation Office Agency

Non-domestic rating: Business Floorspace England and Wales

Building heights and domestic building floor areas

Environment Agency

Light Detection and Ranging (LIDAR)

Mastermap

Ordnance Survey

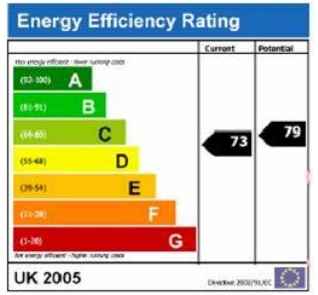
AddressBase

3DStock

Measured energy data

Department for Business, Energy & Industrial Strategy

EPCs & DECs



Land parcels & sites

Land Registry

Others:

- Experian
- UK Buildings
- Census
- ……

3D model of building stock

What is a building use type?

What happens when buildings meld?

Example:
A shop extends across the ground floor of two adjacent buildings.
Operated as one premises.
Probably supplied by one set of energy meters for electricity and gas (but these could also serve upper floors).

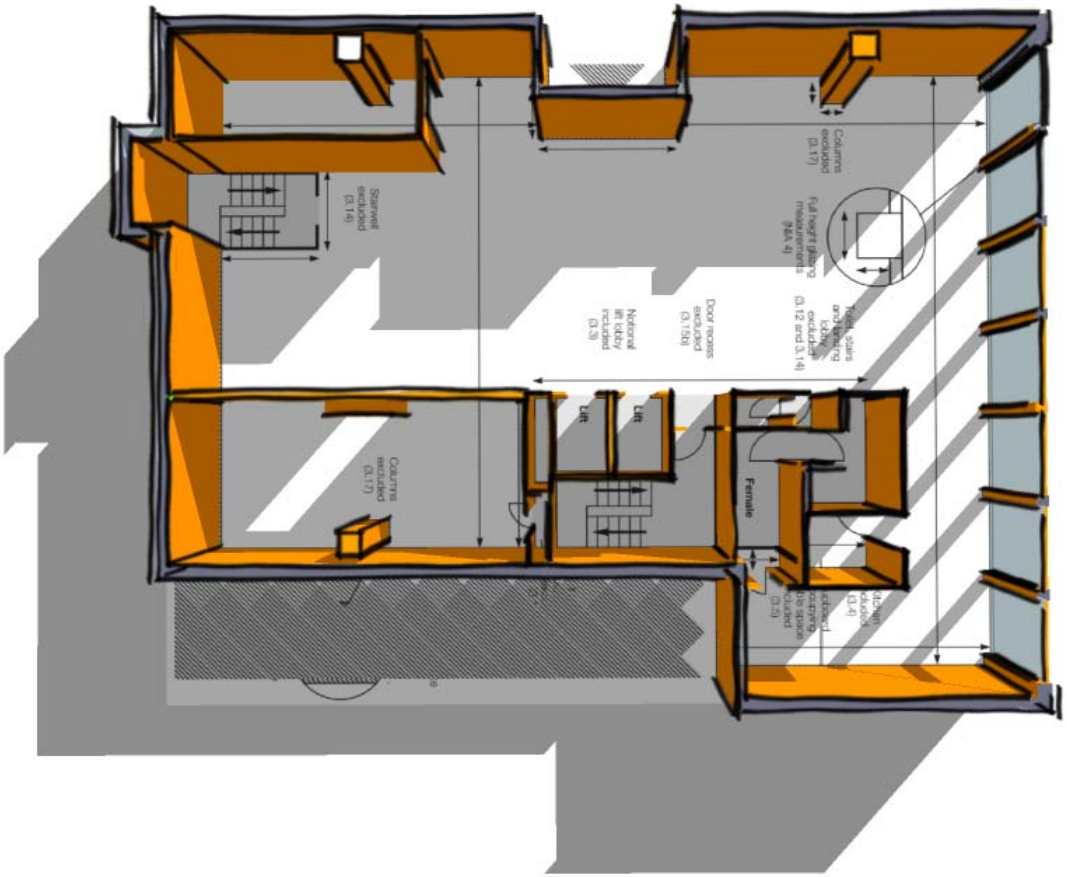
If the shop is split between buildings how can the energy use data be reconciled?

Solution: Self-Contained Unit (SCU)

SCU:
An envelope that wraps around a collection of buildings without dividing any of the associated premises and contains all the energy meters that relate to contained premises.

How do we know what is contained?

… for most premises types the Valuation Office Agency (VOA) **measure** and **classify** the rateable space



… which means we know the floorspace of each activity on each floor

	record_type character varying(2)	asst_ref bigint	uarn bigint	ba_code character varying(4)	baref character varying(25)	line smallint	floor character varying(50)	description character varying(240)	area numeric(8,2
109	02					6	Ground	Kitchen	3.4
110	02					7	Ground	Office (incl Reception)	52.7
111	02					8	Ground	Internal Storage	5.0
112	02					1	Ground	Retail Zone A	29.9

… and we can model average electricity consumption in each activity area, by end use

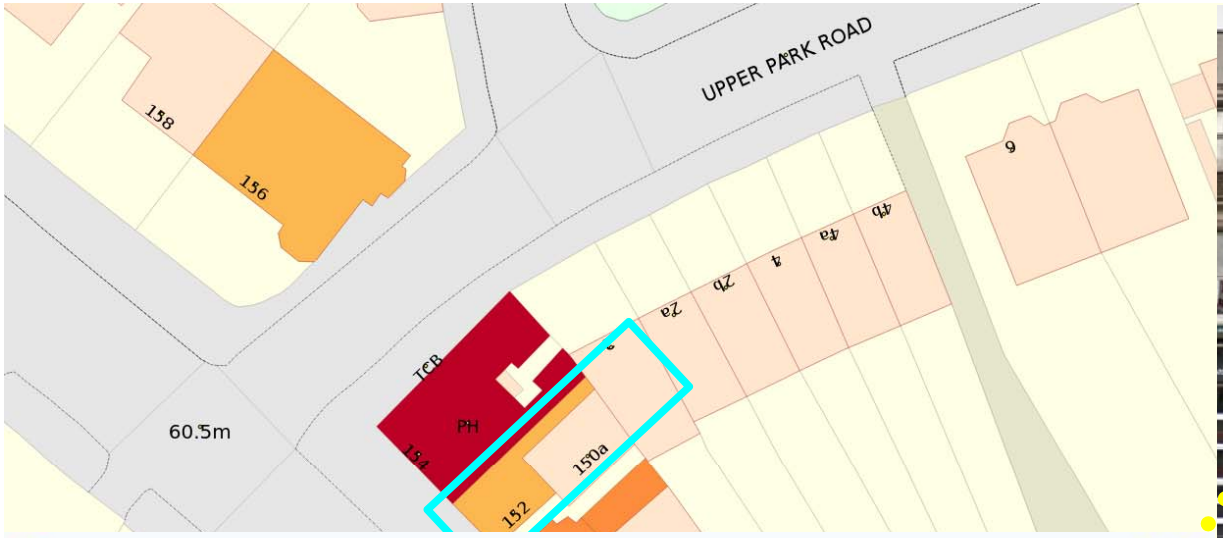
50)	description character varying(240)	area numeric(8,2)		
	Kitchen	3.46	Lighting, DHW, catering etc.	1,556 kWh per annum
	Office (incl Reception)	52.71	Lighting, computers, small power etc.	5,571 kWh per annum
	Internal Storage	5.03	Lighting, computers, DHW etc.	209 kWh per annum
	Retail Zone A	29.93		
			Total:	7,336 kWh per annum

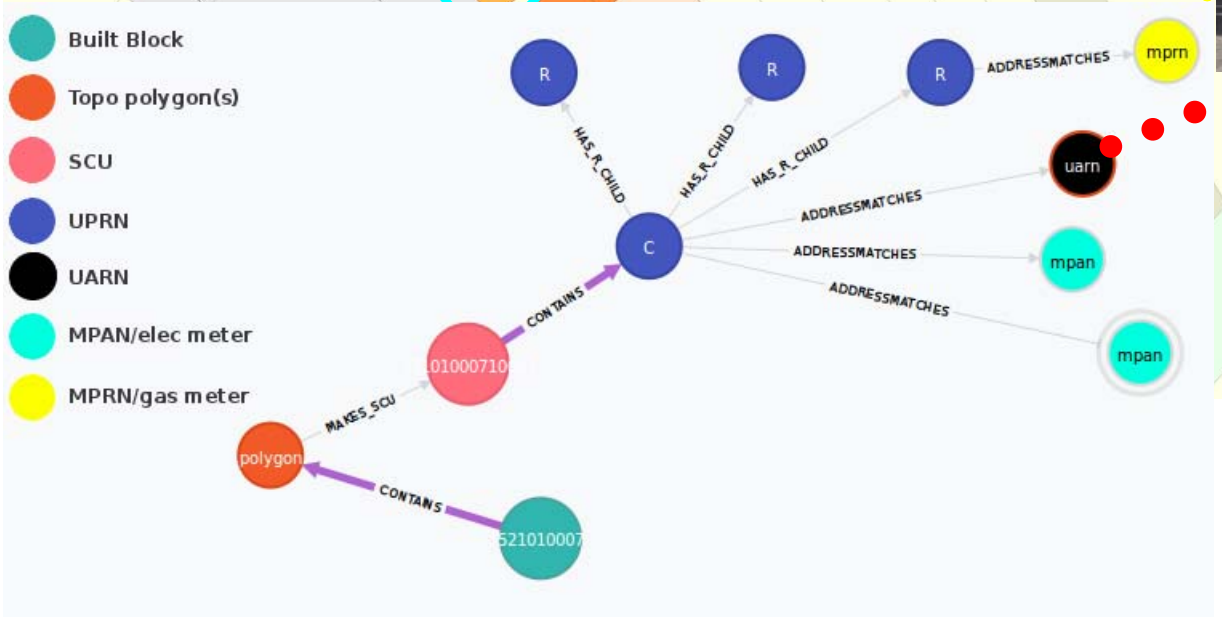
Domestic (residential) floor areas

… floor area not available from VOA, so LiDAR used to calculate:

	scu_id bigint	floor numeri	d_uprns_in_scuf bigint[]	toids_in_scuf character varying[]	f2f_heigh numeric(1	f2f_confid numeric(6,4	gea numeric	notes character varying(500)
1	52101124830014	2.0	{5097200}	{'osgb1000004051745'}	{296.70}	{10.1000}	60.00	(0.2.3) Agreement between LiDAR and the stratified floor count.
2	52101124830014	1.0	{5097198,5097199}	{'osgb1000004051745'}	{296.70}	{10.1000}	84.00	(0.2.3) Agreement between LiDAR and the stratified floor count.
3	52101124830014	0.0	{5097201}	{'osgb1000004051745'}	{296.70}	{10.1000}	92.00	(0.2.3) Agreement between LiDAR and the stratified floor count.

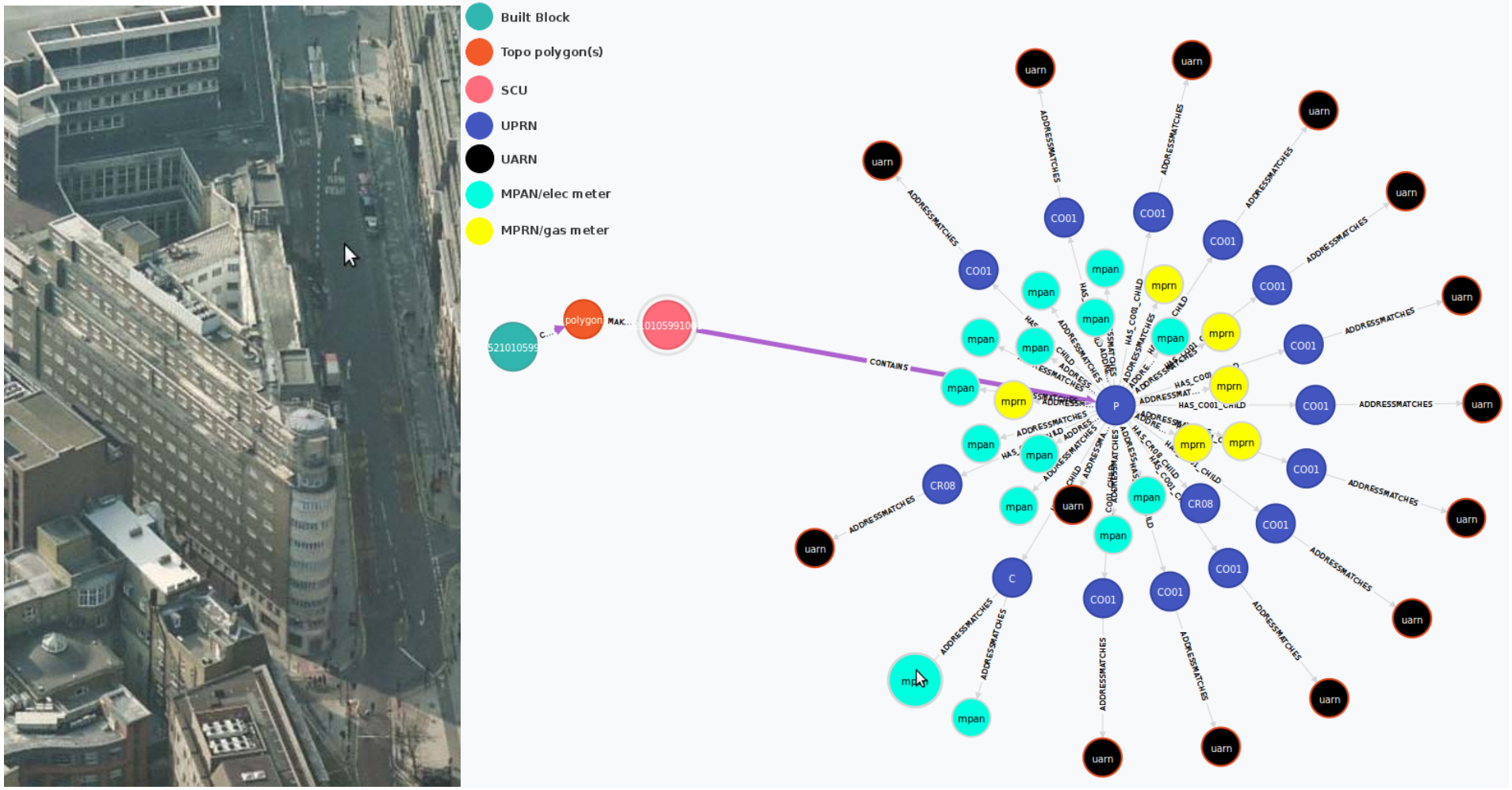
Matching energy meters to premises



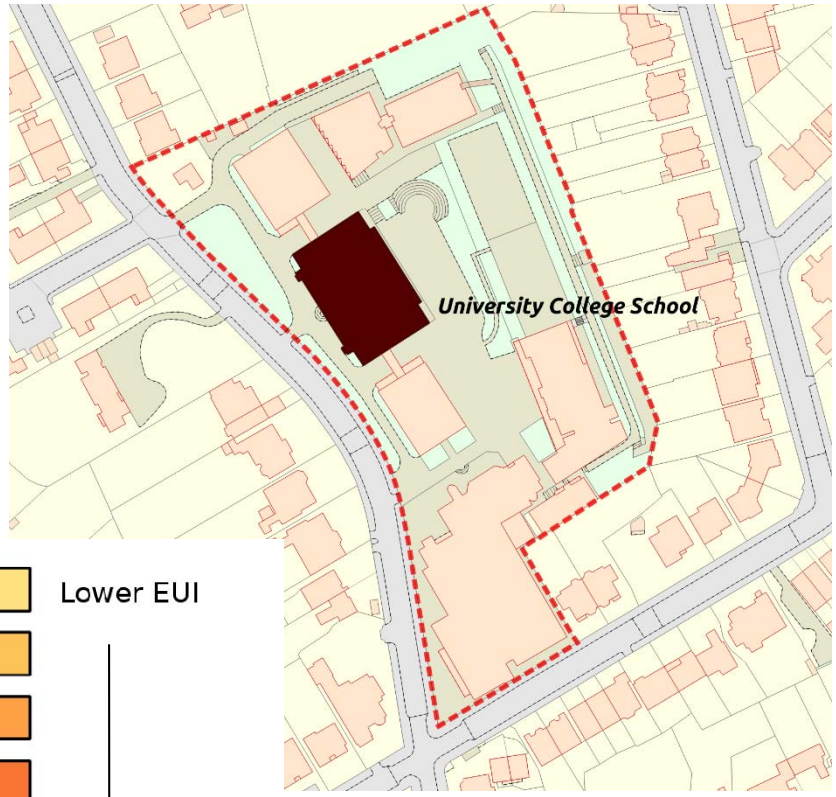


Relationships between meters, premises and buildings can be complicated with associations at various levels and often different between electricity and gas

Complexity often increases with size

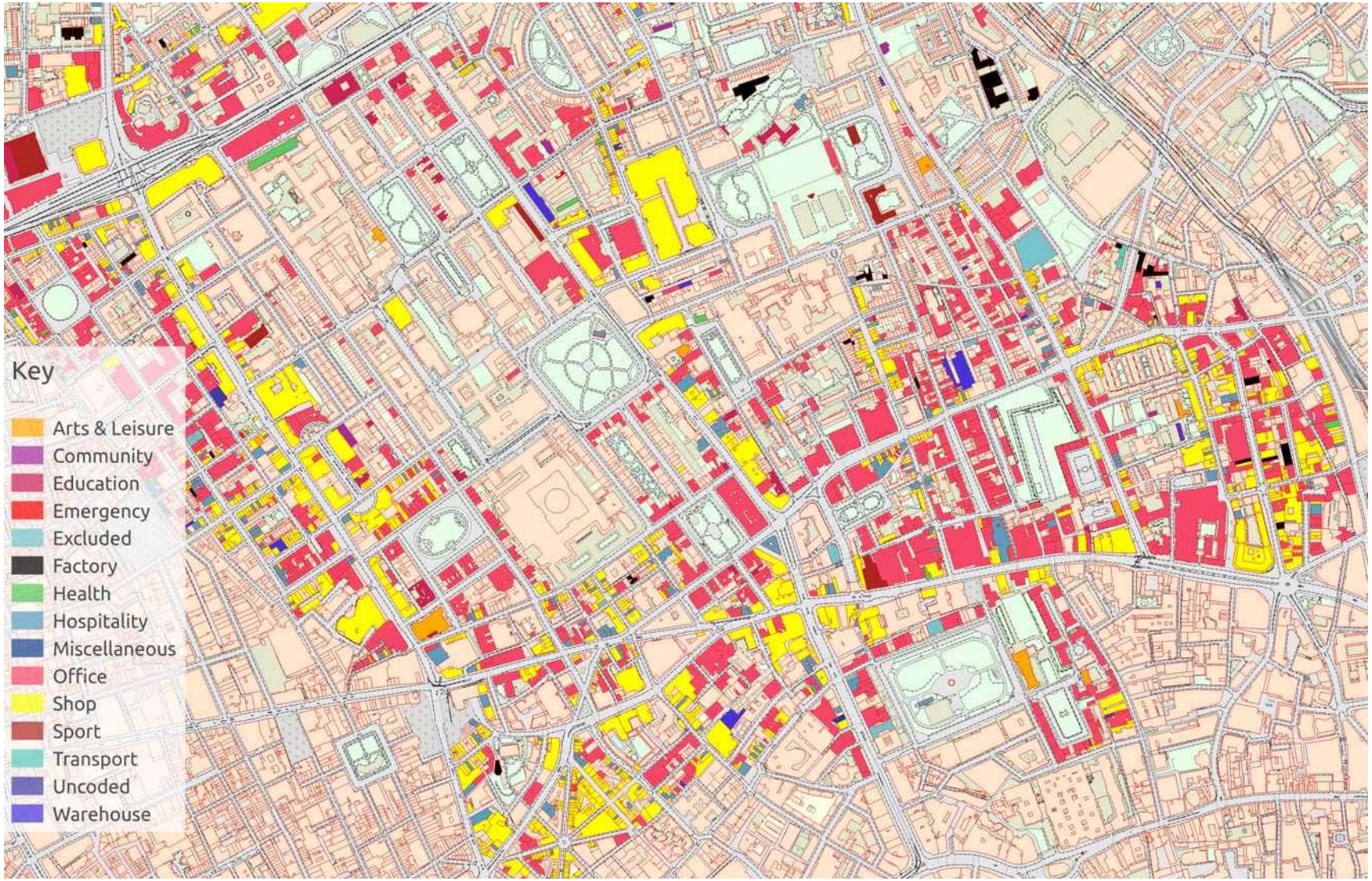


Not all buildings have addresses

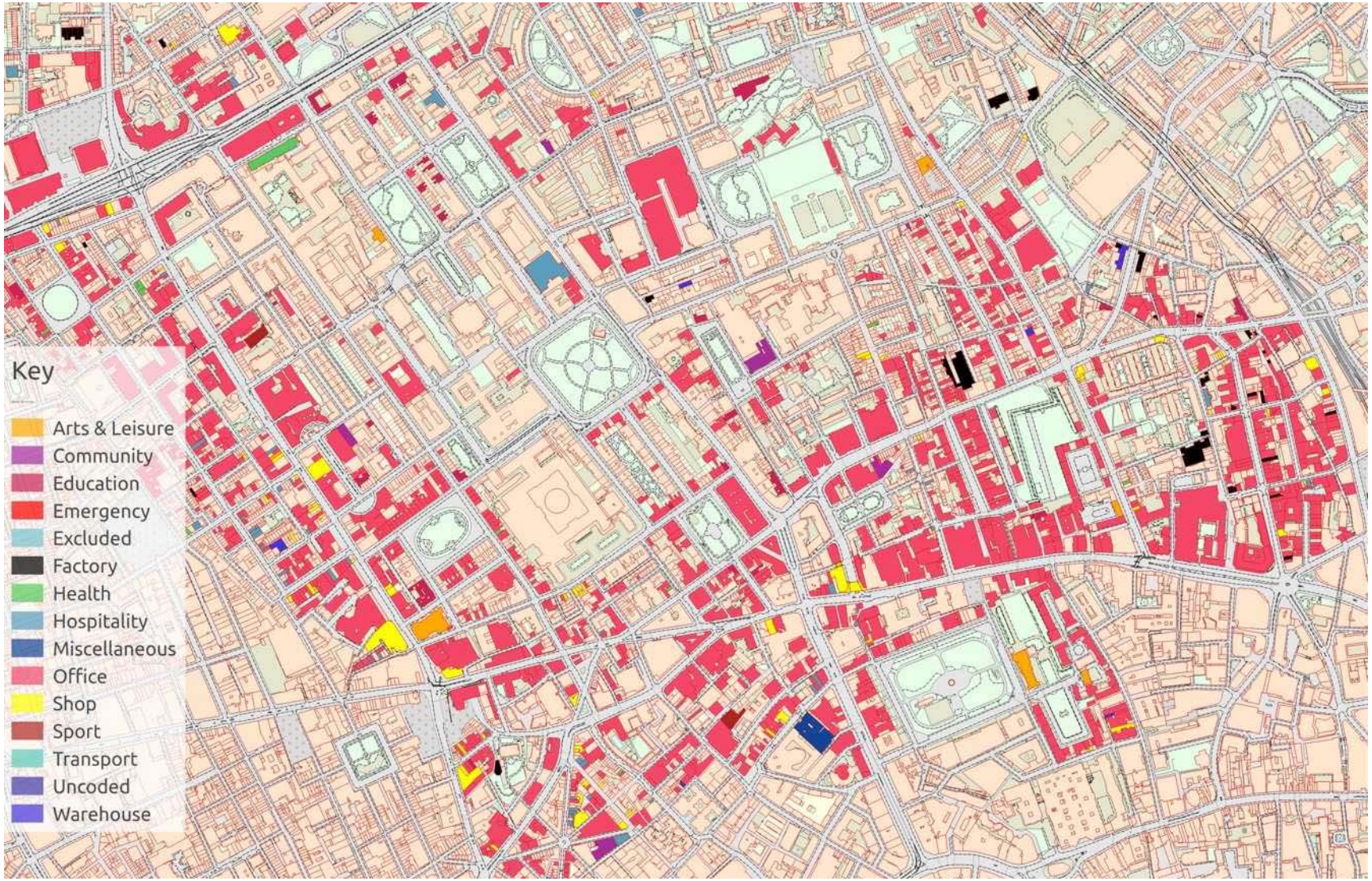


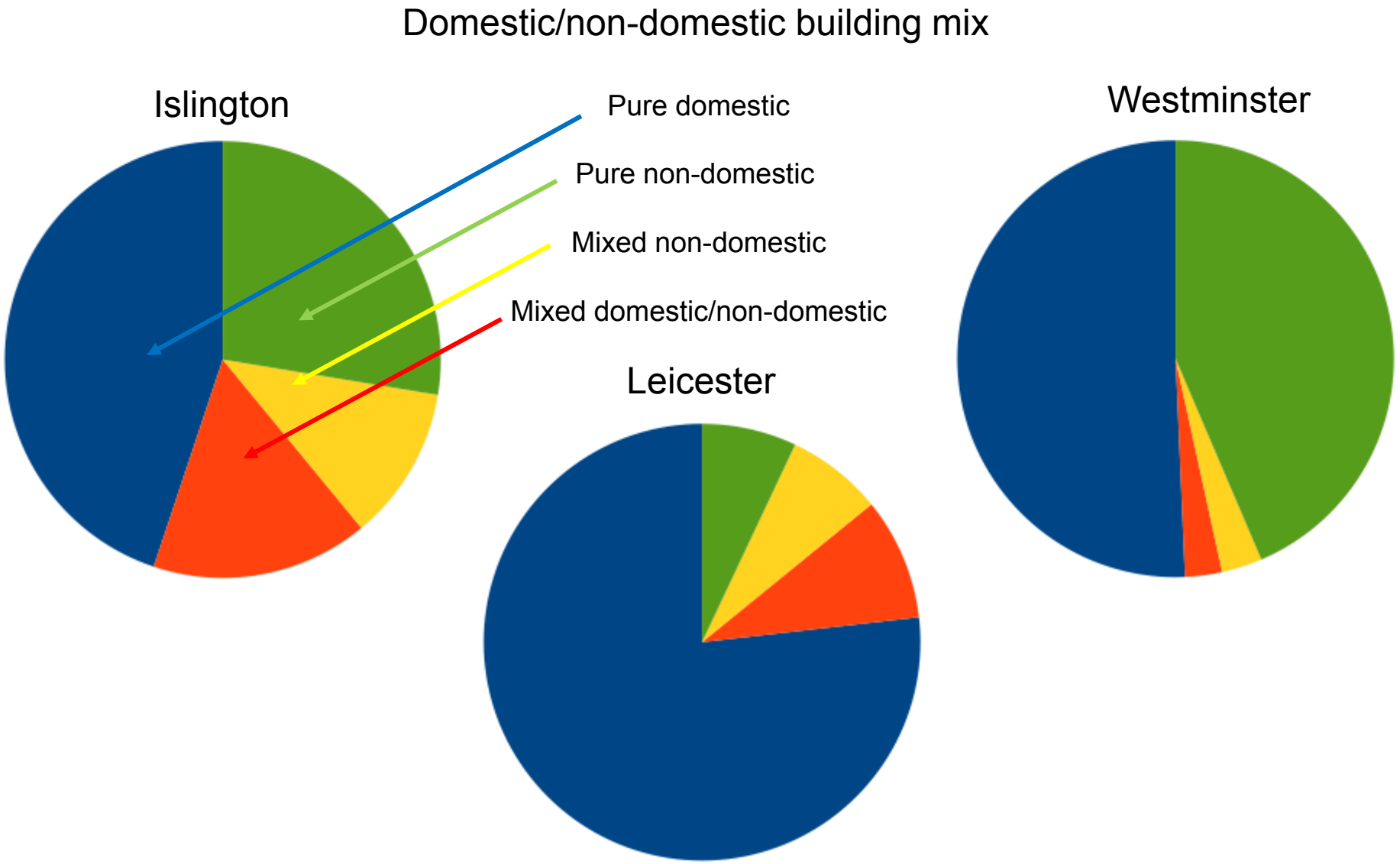
Associating all the energy use with the single addressed building on the left implies a very high Energy Use Intensity (EUI). 3DStock uses a number of datasets to identify and associate buildings that make up the premises served by the meters.

Central London **ground** floor level

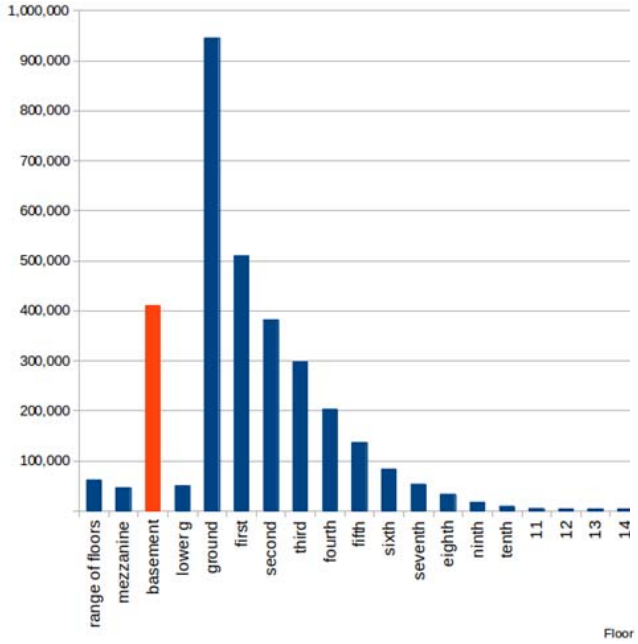


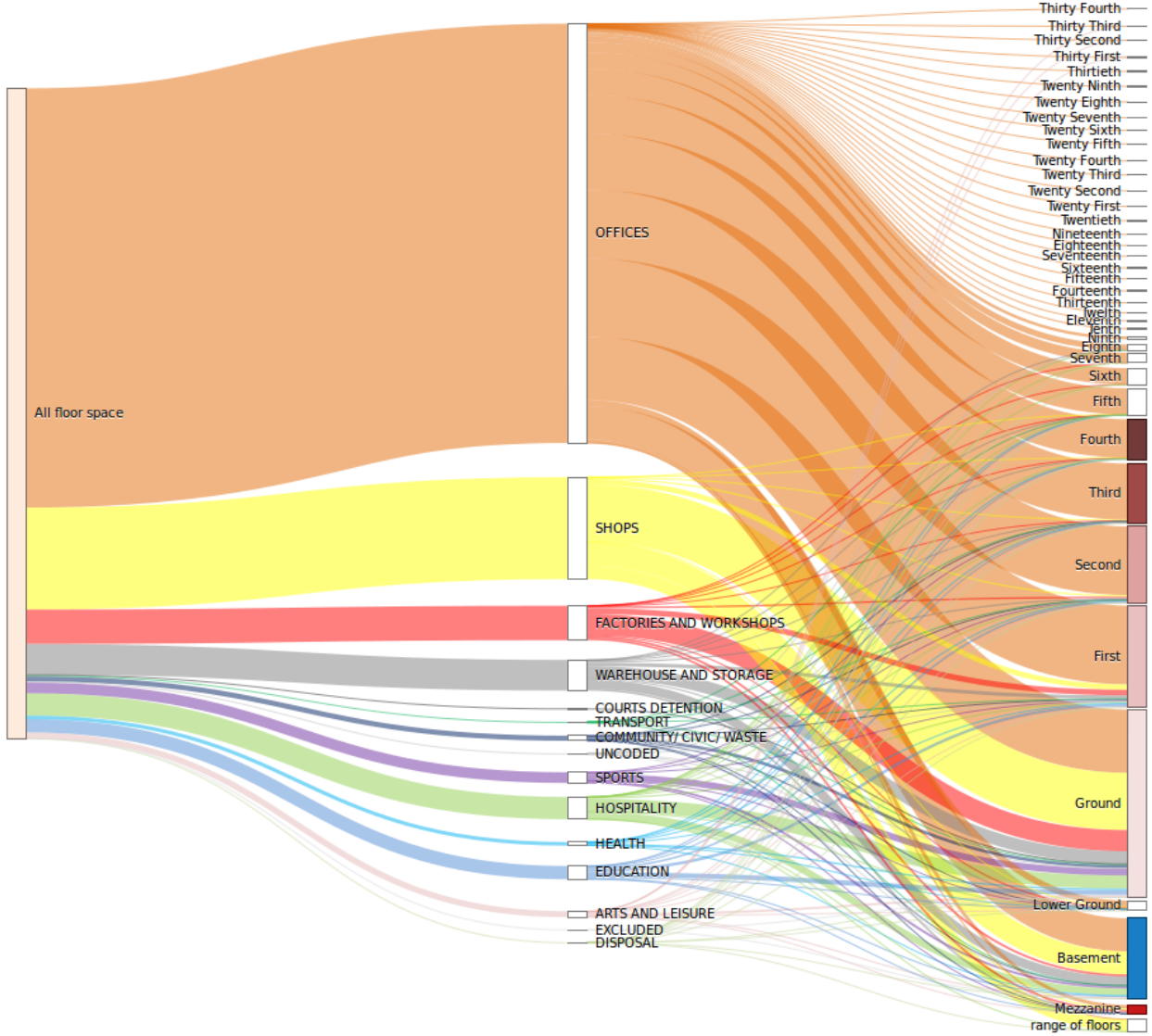
Central London **first** floor level




Domestic/non-domestic building mix
Islington
Pure domestic
Pure non-domestic
Mixed non-domestic
Mixed domestic/non-domestic
Leicester
Westminster

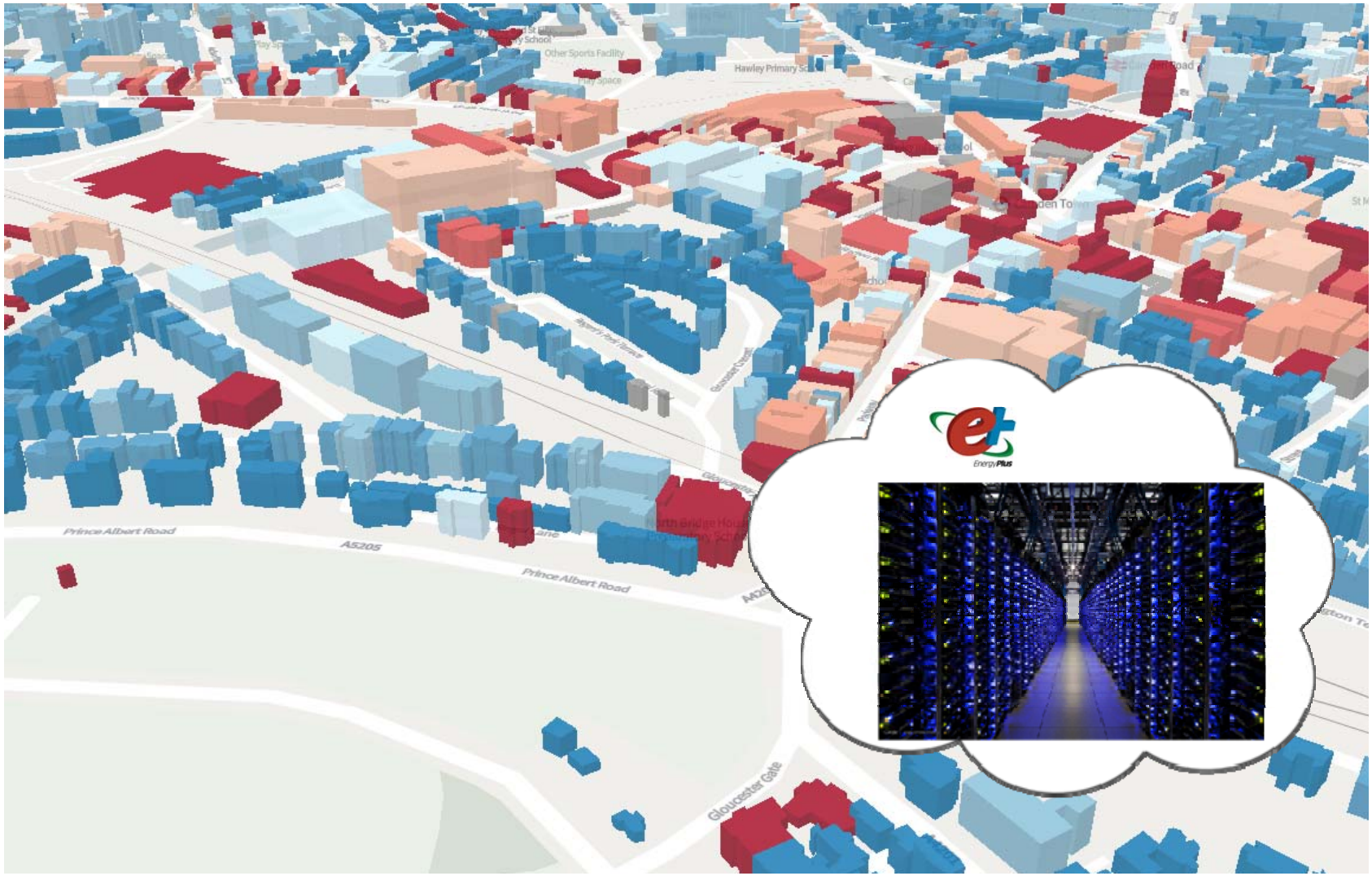
3D data allows detailed analysis of floor space





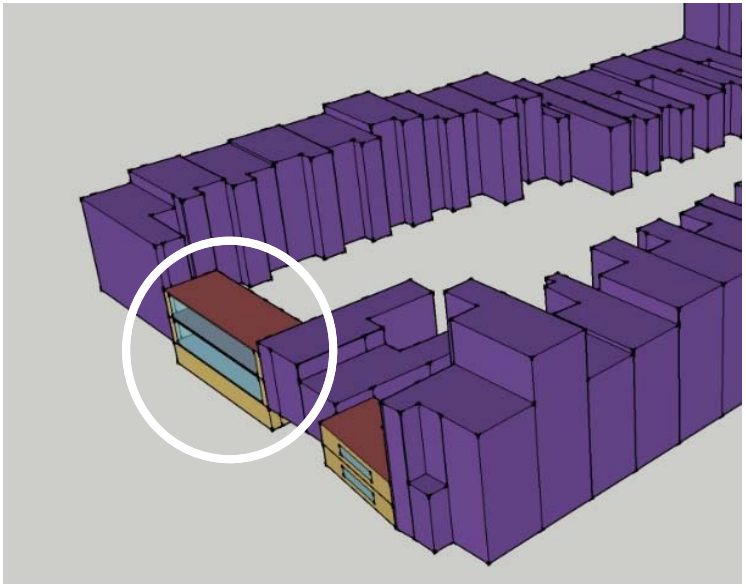
Application: district energy potential routes

SimStock


Prince Albert Road
A5205
Prince Albert Road
Gloucester Gate
EnergyPlus

SimStock: Automatic generation of Energy Plus Input Description Files (IDFs)

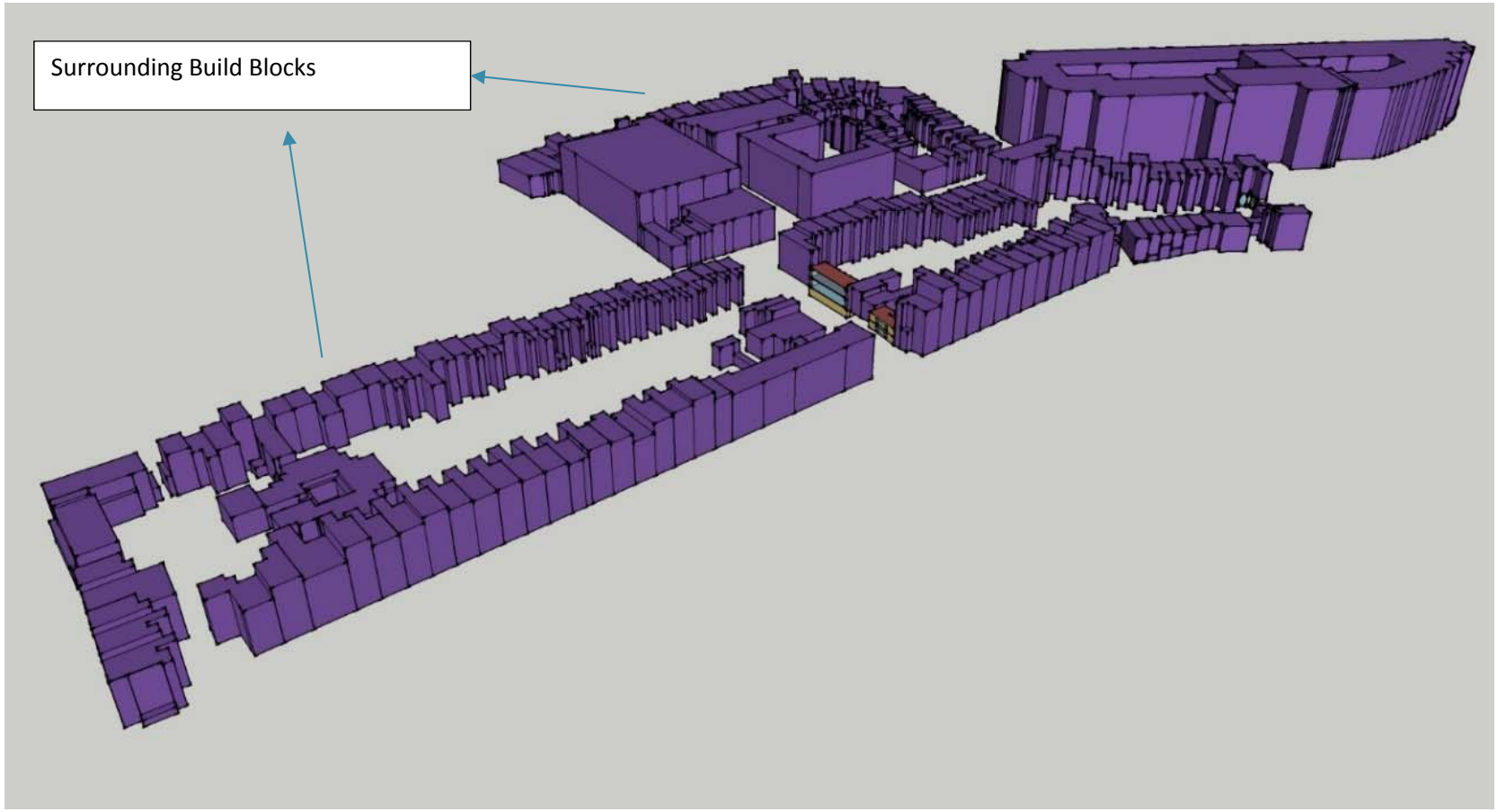
Built form divided into Built Blocks which contain a number of adjacent SCUs demarcated from each other by roads and other physical separations.



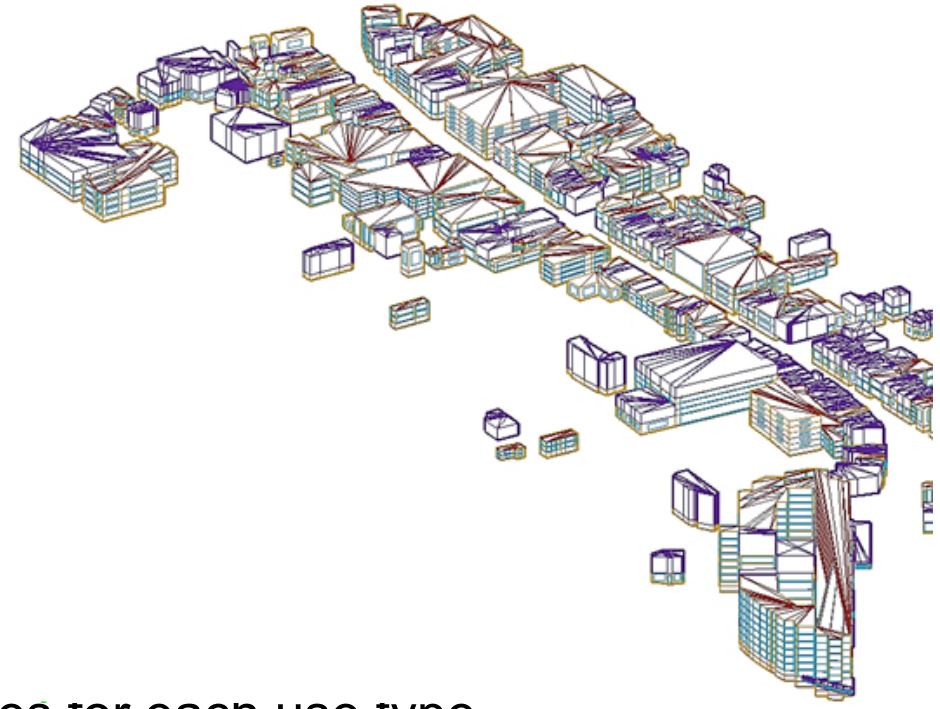
Each Built Block is comprised of a set of SCUs divided into zones each having a unique ‘use type’, eg: office, retail, residential, etc.

SimStock: Shading

Impact of shading from surrounding Built Blocks accounted for.



SimStock: Data sources



3DStock/LBSM:

- Floor area per floor
- Wall area / type
- Floor heights
- Shading

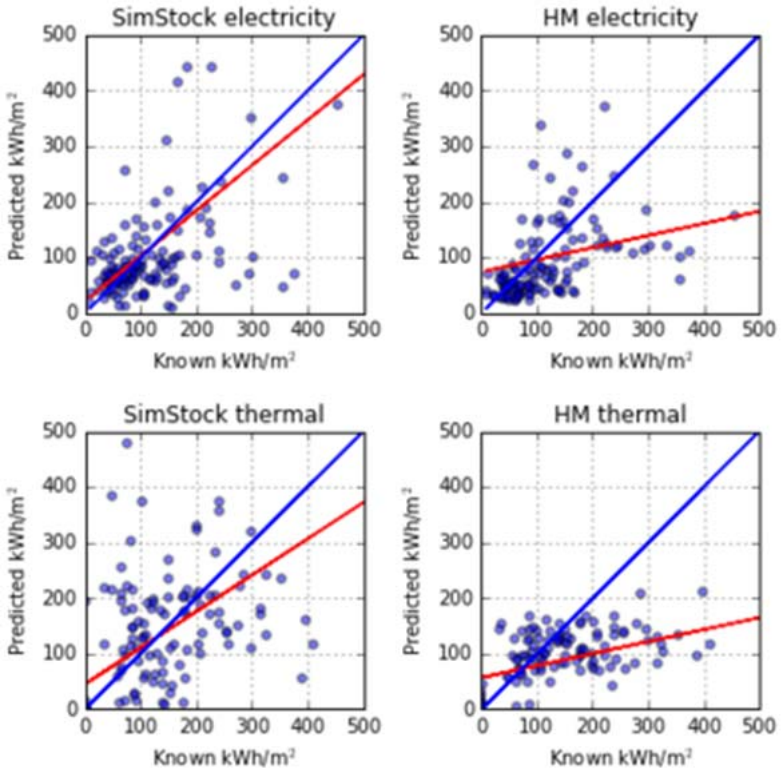
Other data

- Occupancy and operation profiles for each use type
- Window area related to age and materials
- Other details from NCM / SAP assumptions

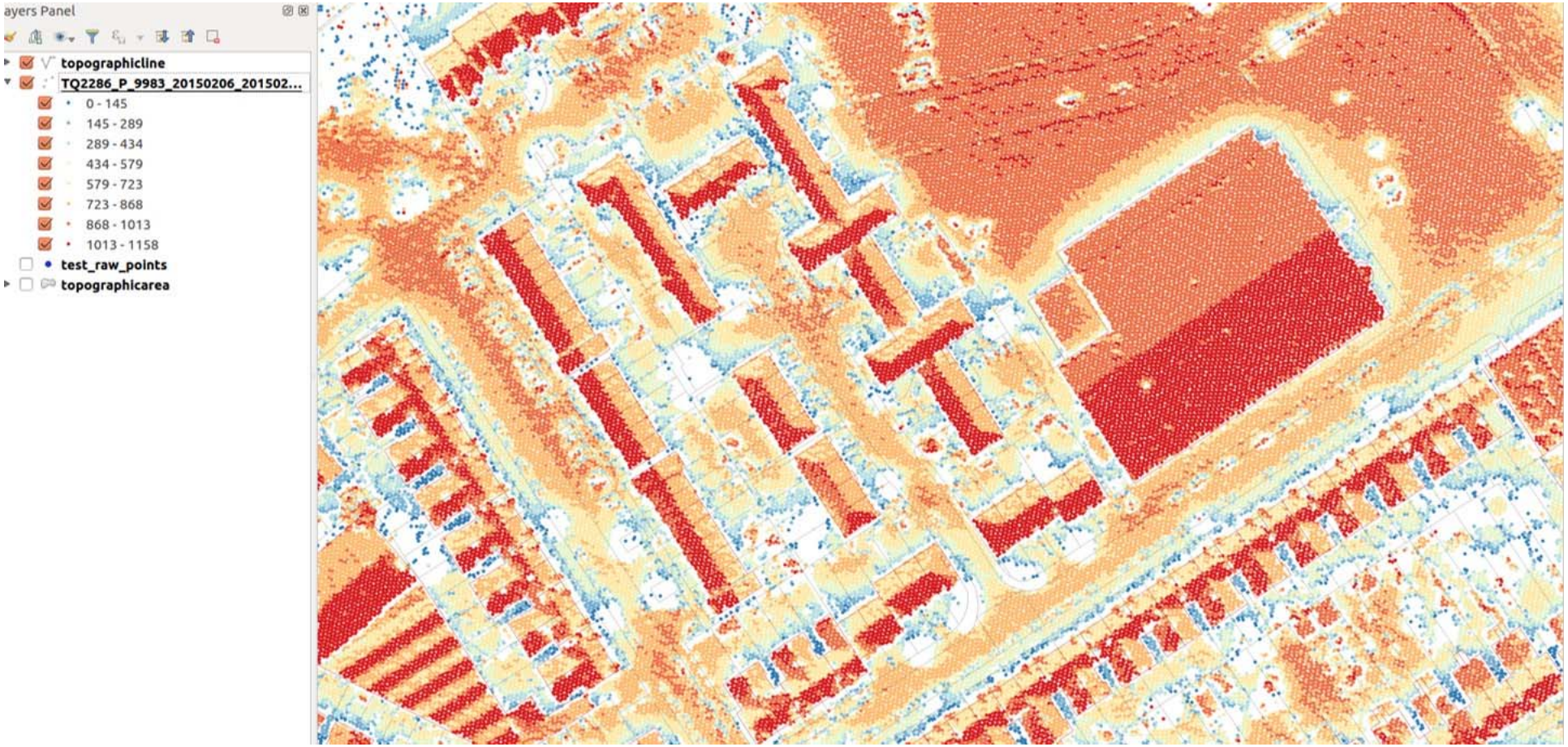
SimStock: Outptus

Model calibration

- Simulations trained against partial population using stochastic parametric analysis and genetic algolrithms
- Refined model tested on remaining population
- Comparisons made with semi-empirical models



Solar mapping – initial development



Conclusion

- Urban building and energy models can be built from existing, publicly available data.
- Use type analysis shows that urban areas are considerably mixed within single buildings and this has implications for modelling in detail.
- Association of energy performance certificates and display energy certificates allows first order area based energy analysis.
- Initial indication that automatically generated simulation models are feasible for large areas and provide credible results.

Questions?

Paul Ruyssevelt

p.ruyssevelt@ucl.ac.uk