

**SCU Mix legend**

- 1. Pure Non-domestic; single occupier
- 2. Multi Non-domestic; same activity
- 3. Non-domestic; multiple activities
- 4. Non-domestic & domestic: Non-domestic dominant
- 5 & 6. Domestic & non-domestic: neither dominant
- 7. Domestic & non-domestic: Domestic dominant
- 8. Pure domestic:  $\geq 10$  households
- 9. Pure domestic:  $>1$  and  $< 10$  households
- 10. Pure domestic: single household
- Not classified

# Modelling Building Stocks and Their Energy Use

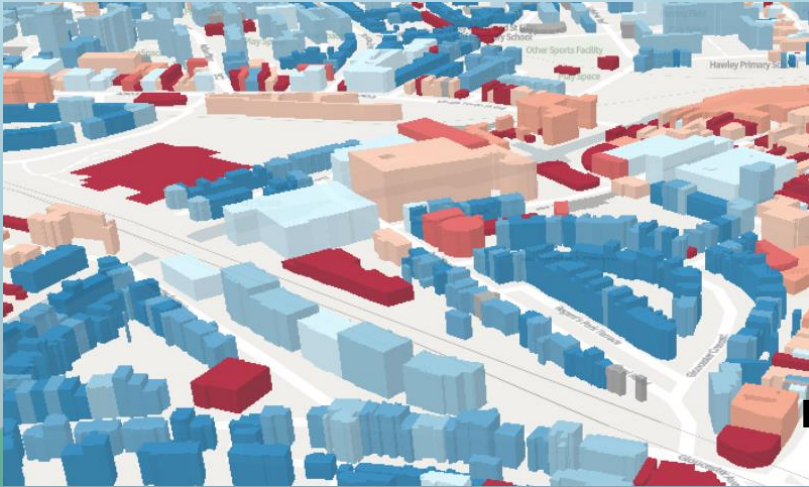
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• University College London Energy Institute

# 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



# London Building Stock Model (LBSM)



## 3DStock

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

10+ years of development



## SimStock


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

Built on Energy Plus

# 3DStock architecture

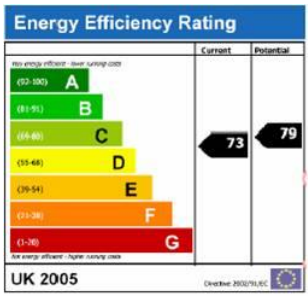


Valuation Office Agency  
Non-domestic rating: Business Floorspace England and Wales



Mastermap  
Ordnance Survey  
AddressBase

EPCs & DECs



Energy Efficiency Rating	Current	Potential
A (92-100)		
B (81-91)		
C (69-80)		
D (55-68)		
E (39-54)		
F (21-38)		
G (1-20)		

UK 2005

Building heights and domestic building floor areas



Environment Agency

Light Detection and Ranging (LIDAR)



## 3DStock

Land parcels & sites



Land Registry

Measured energy data



Department for Business, Energy & Industrial Strategy

Others:

- Experian
- UK Buildings
- Census
- .....



# 3D model of building stock



### SCU Mix class

- 1. Pure Non-domestic; single occupier
- 2. Multi Non-domestic; same activity
- 3. Non-domestic; multiple activities
- 4. Non-domestic & domestic: Non-domestic dominant
- 5 & 6. Domestic & non-domestic: neither dominant
- 7. Domestic & non-domestic: Domestic dominant
- 8. Pure domestic: >= 10 households
- 9. Pure domestic: >1 and < 10 households
- 10. Pure domestic: single household
- Not classified

Source: [Name of source](#)

# 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.





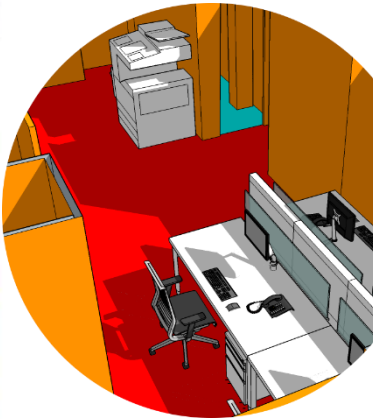
... which means we know the floorspace of each activity on each floor



	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



description	area		
character varying(240)	numeric(8,2)		
<b>Kitchen</b>	3.46	Lighting, DHW, catering etc.	1,556 kWh per annum
<b>Office (incl Reception)</b>	52.71	Lighting, computers, small power etc.	5,571 kWh per annum
<b>Internal Storage</b>	5.03	Lighting, computers, DHW etc.	209 kWh per annum
Retail Zone A	29.93		
Retail Zone B	22.82		
<b>Total:</b>			<b>7,336 kWh per annum</b>

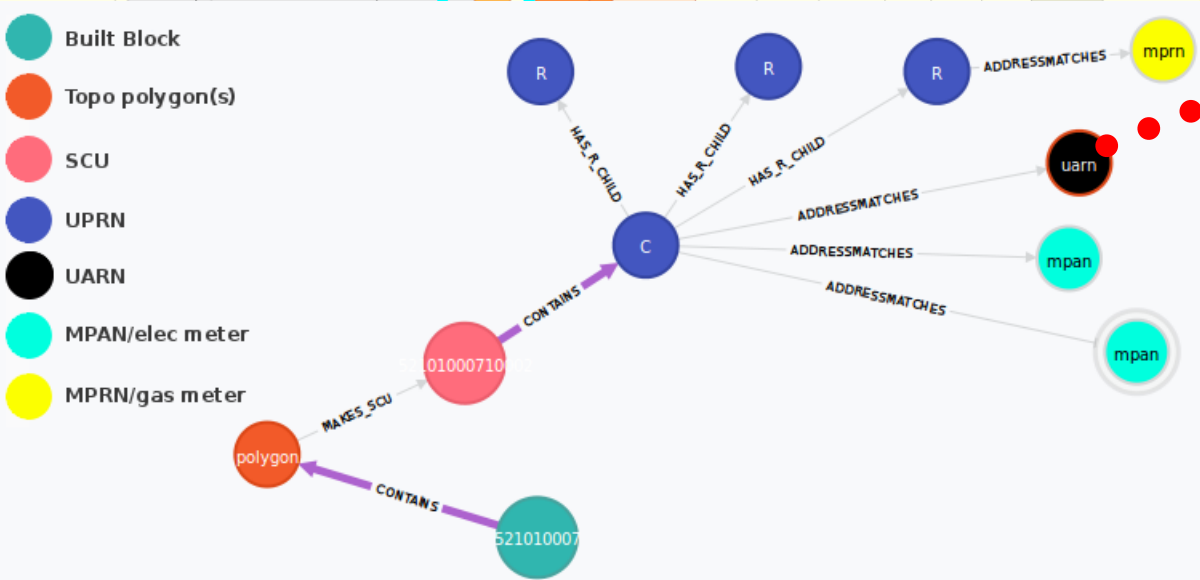
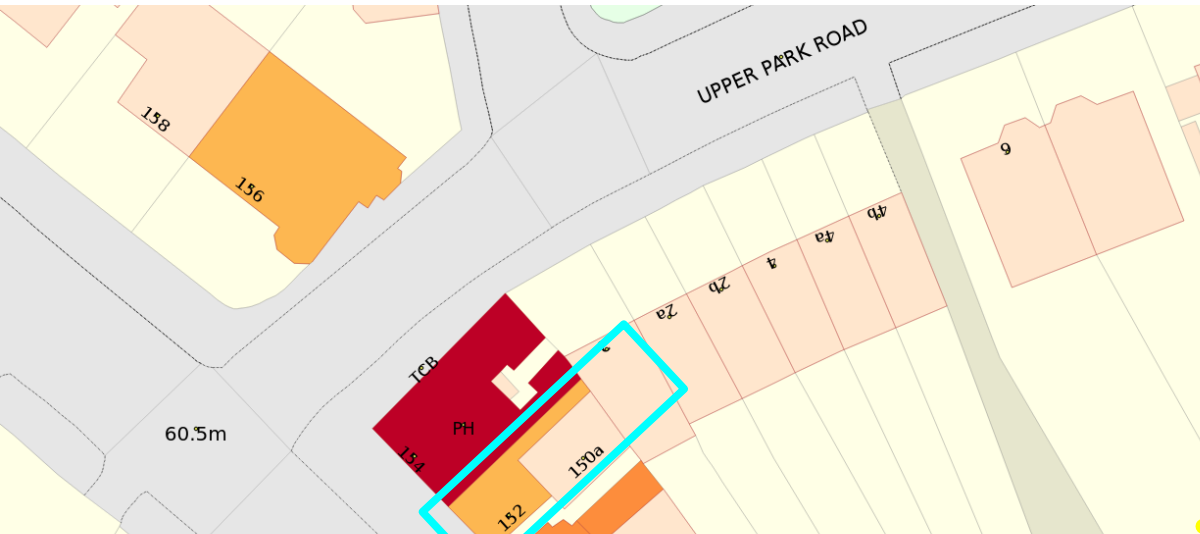
# Domestic (residential) floor areas

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



scu_id bigint	Floor numerical	d_uprns_in_scuf bigint[]	toids_in_scuf character varying[]	f2f_height numeric(1)	f2f_confid numeric(6)	geom 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.

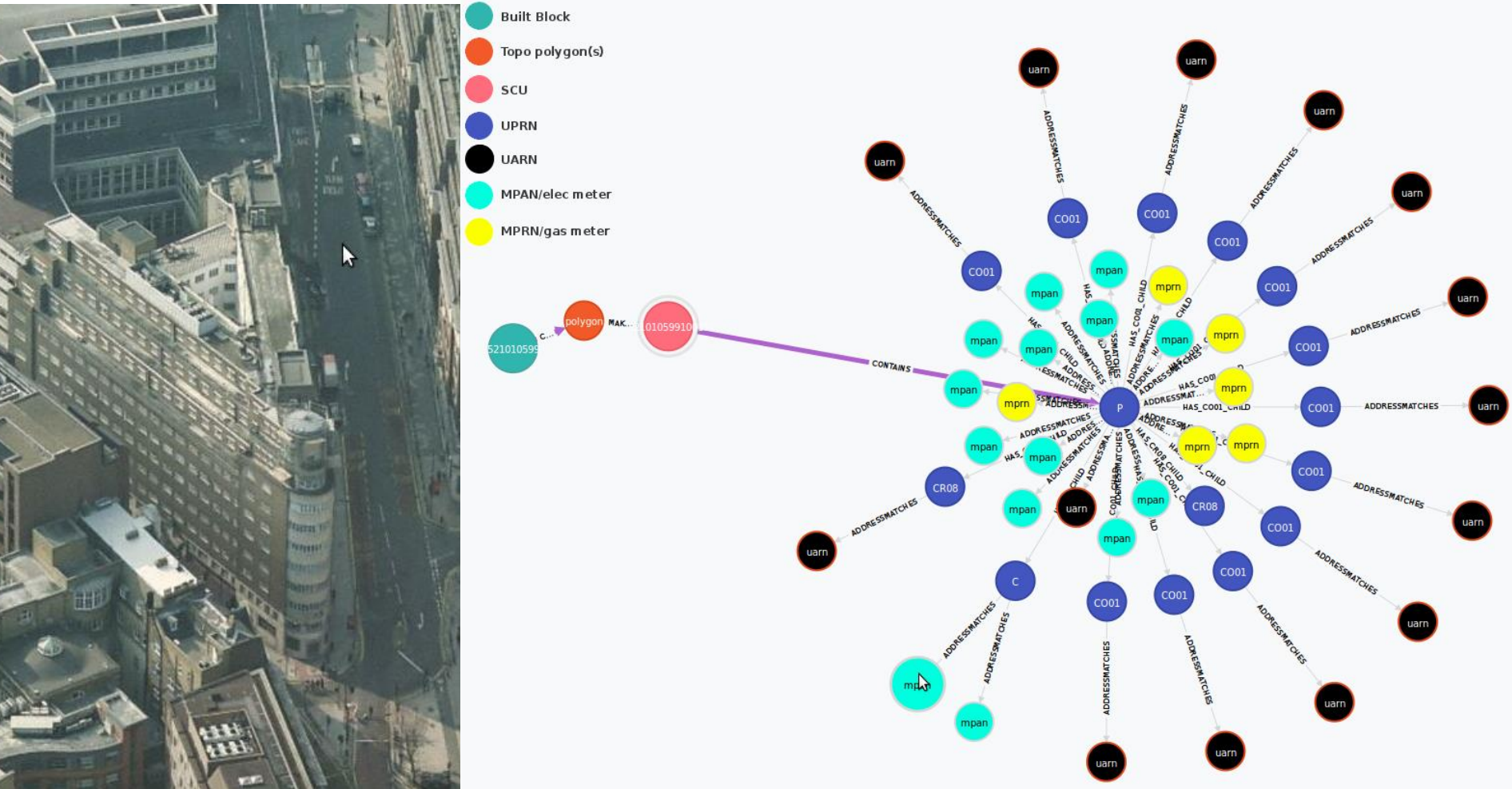
# Matching energy meters to premises



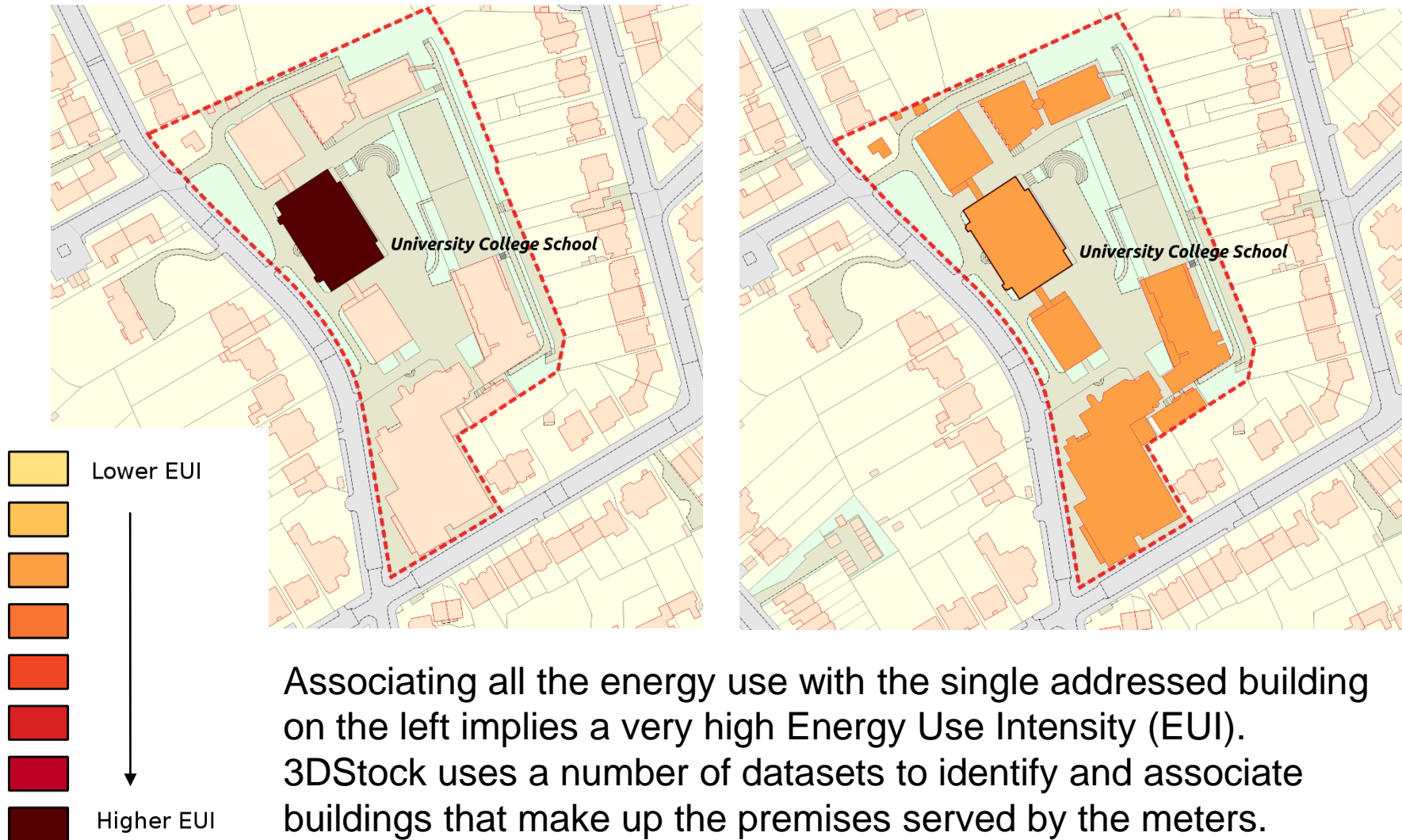
Relationships between meters, premises and buildings can be complicated with associations at various levels and often different between electricity and gas



# Complexity often increases with size



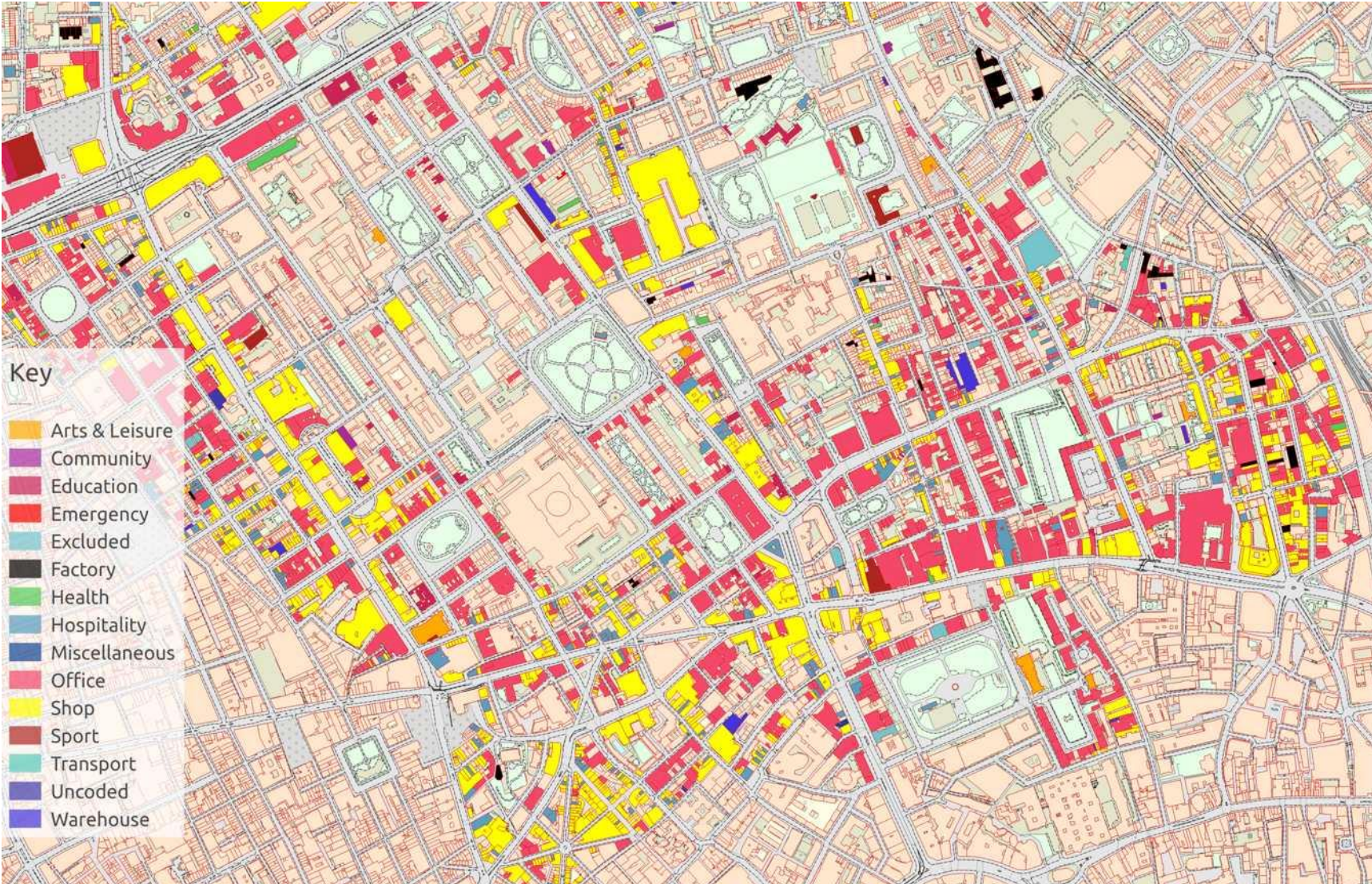
# Not all buildings have addresses



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.

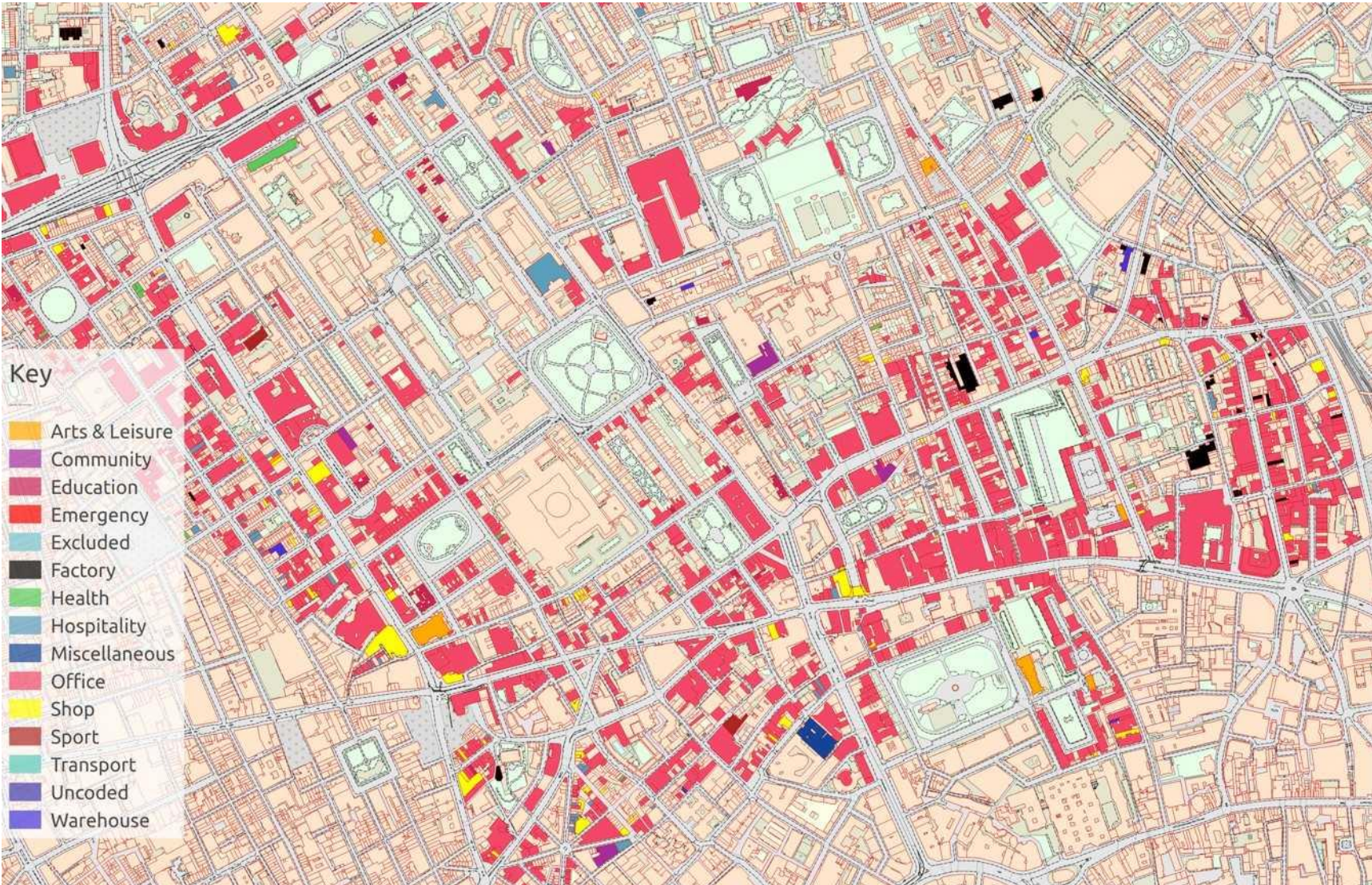


# Central London ground floor level



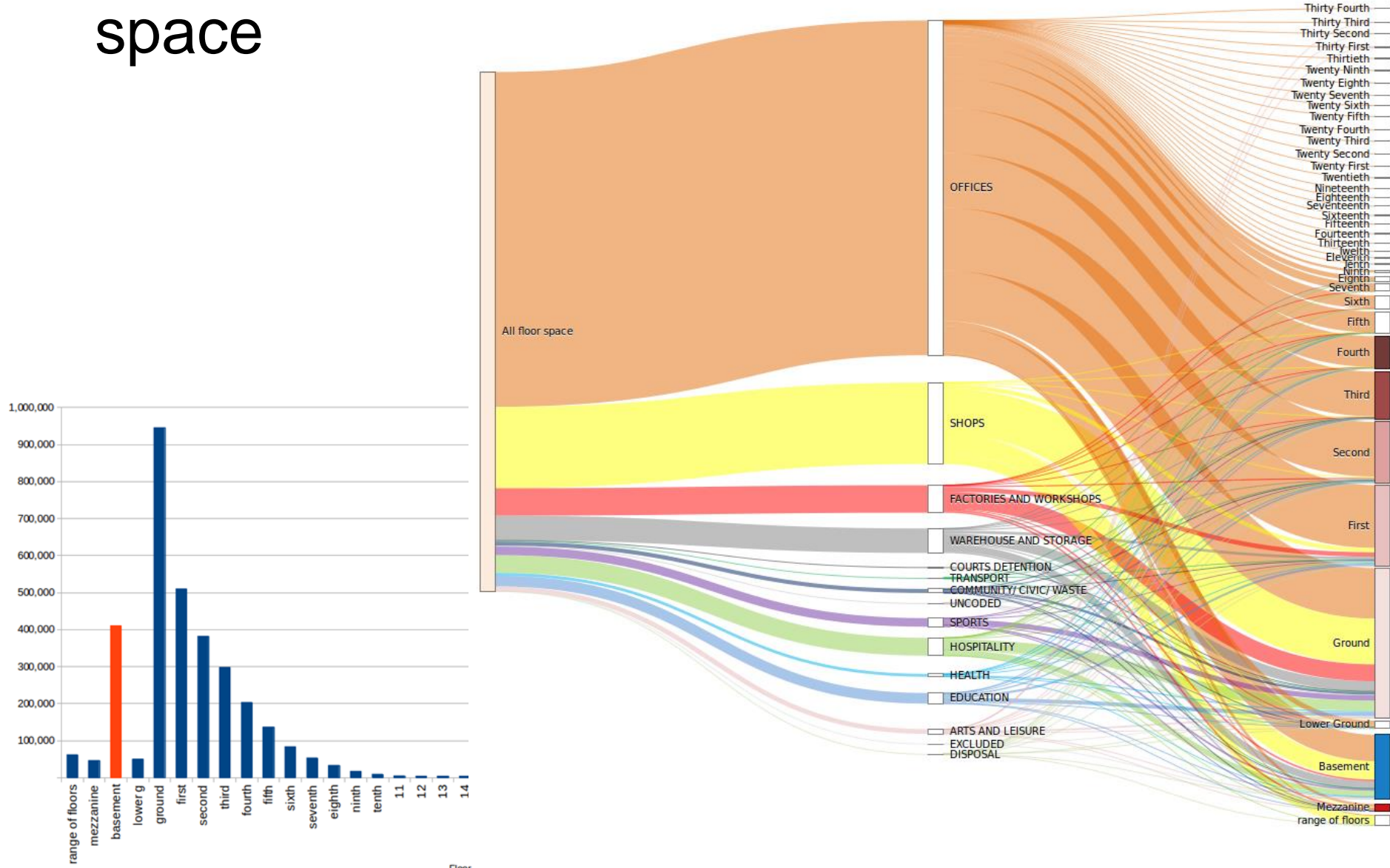


# Central London first floor level

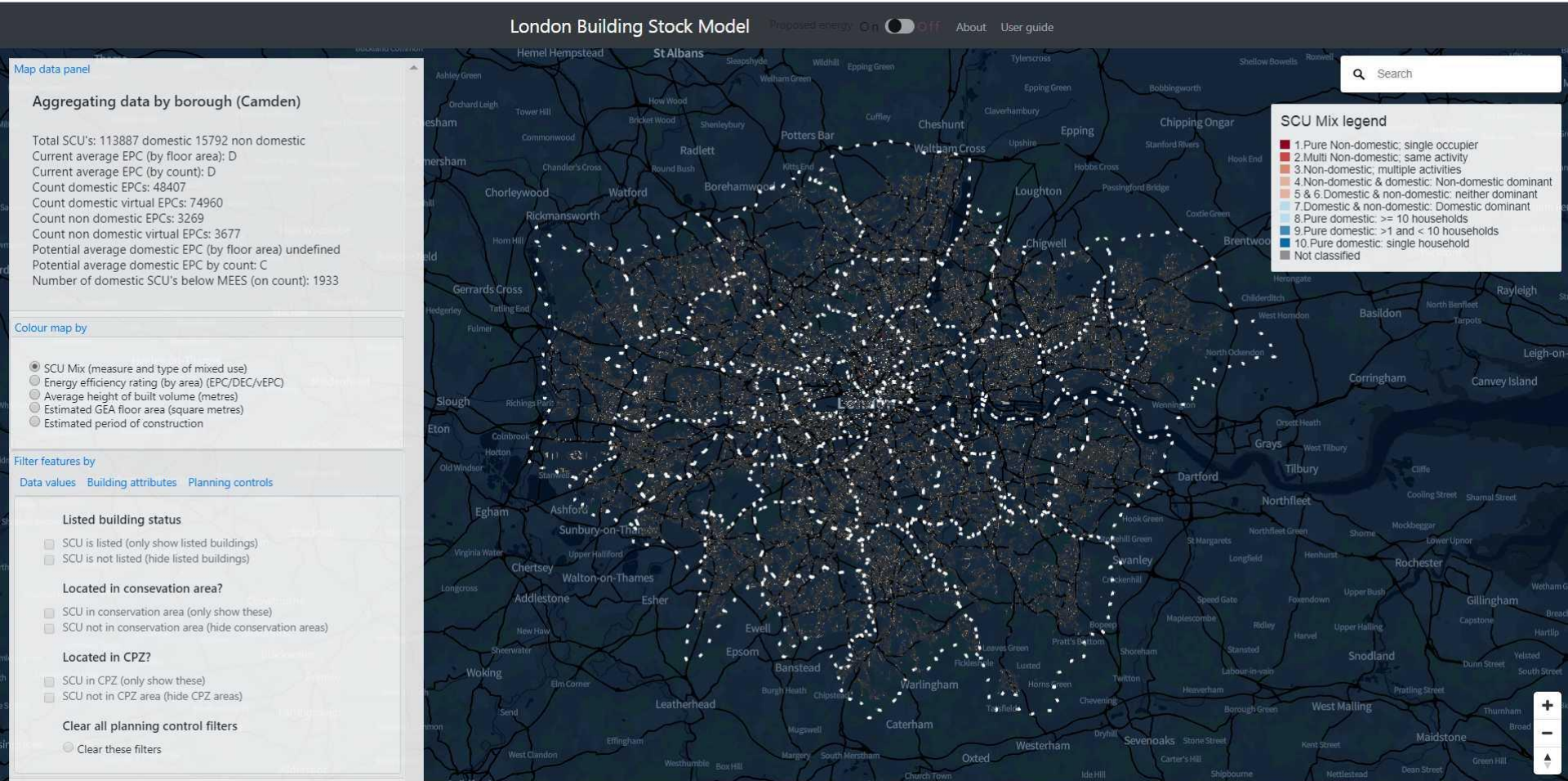




# 3D data allows detailed analysis of floor space

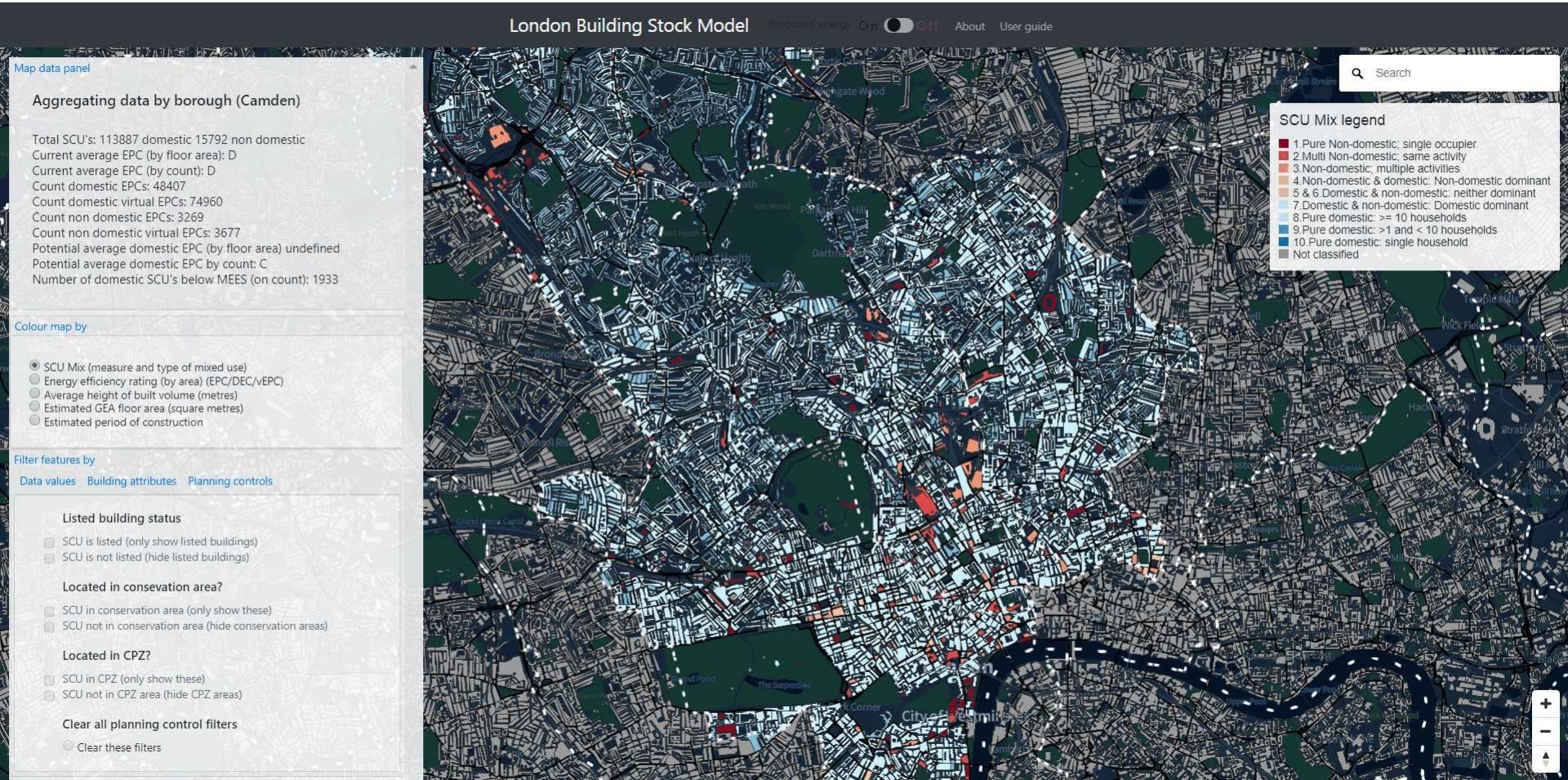


# LBSM current status

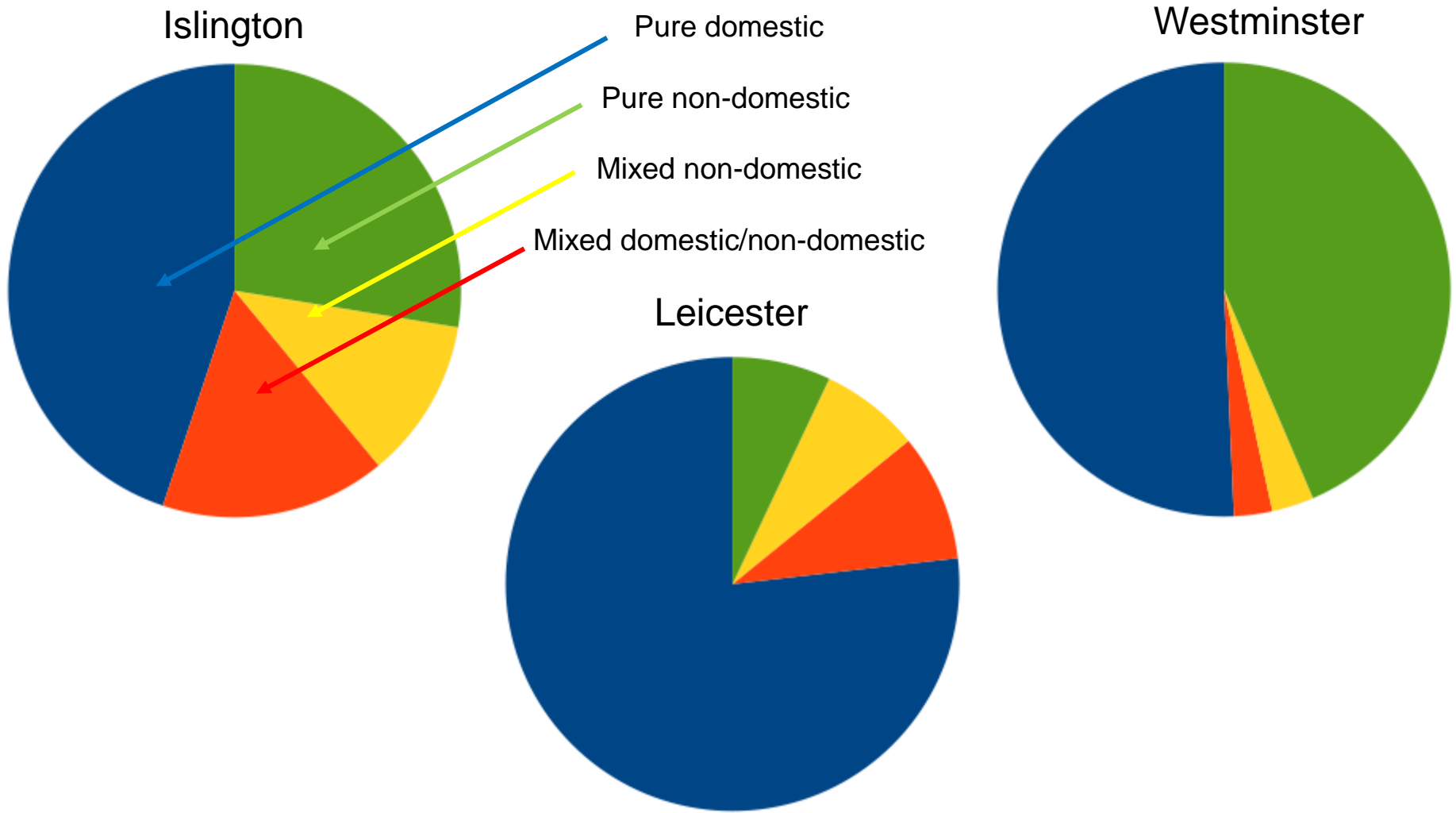




# Borough of Camden showing SCU mix



### Domestic/non-domestic building mix



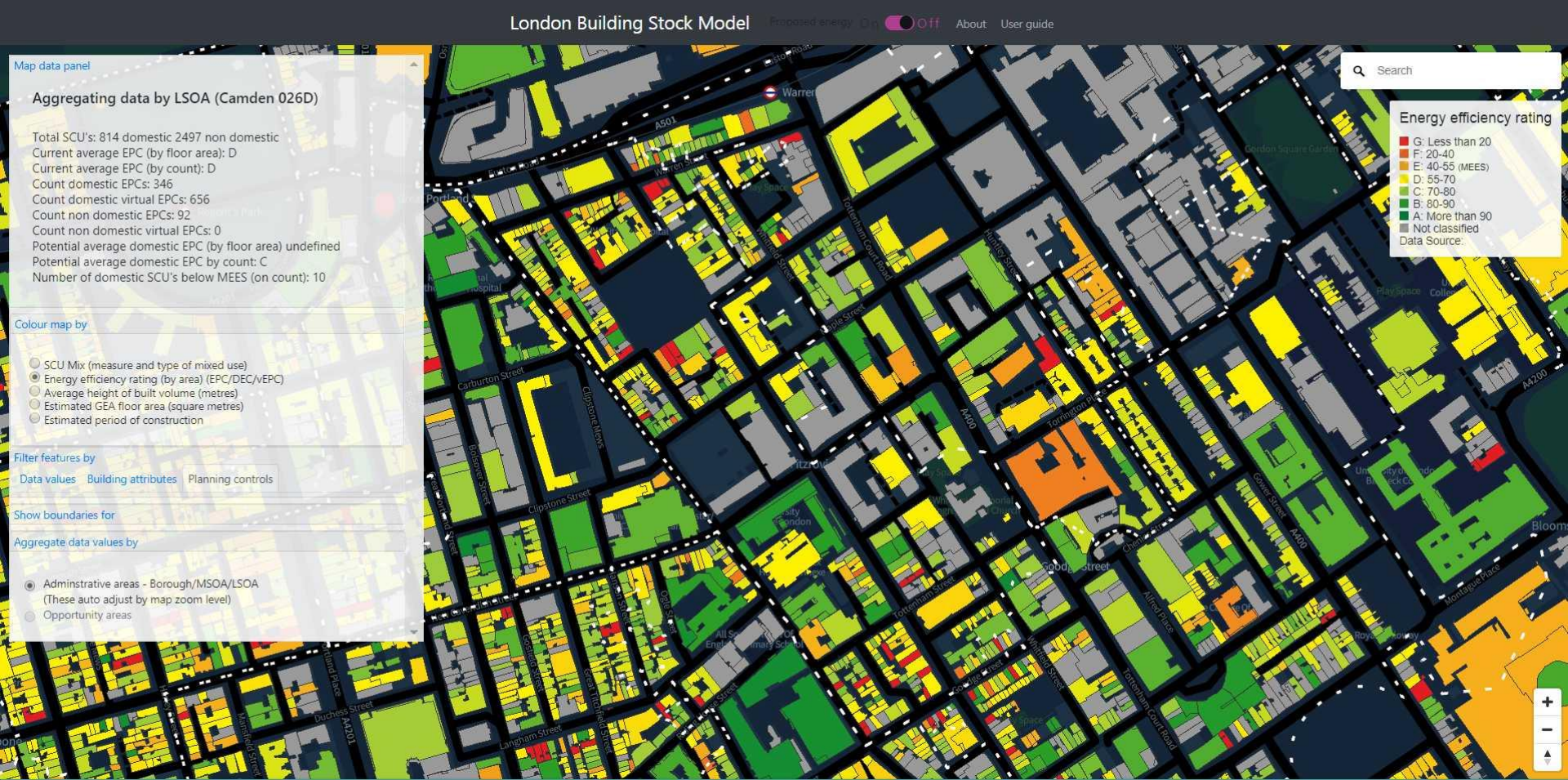


# Use type mix at Lower Super Output Area (LSOA)



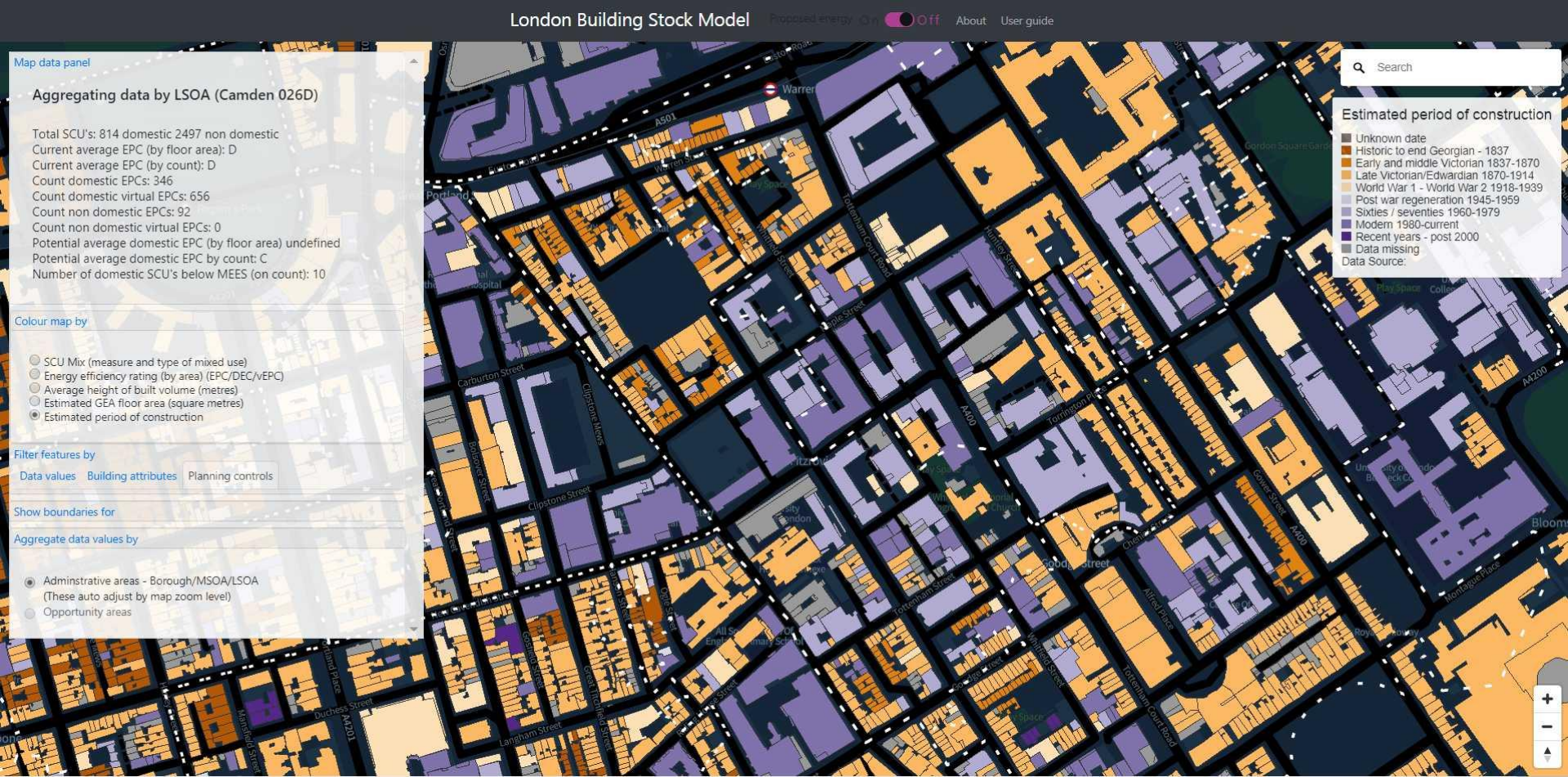


# Energy Performance Certificates (EPCs) at LSOA





# Period of construction at LSOA





# Detail available for each SCU

The screenshot shows the 'London Building Stock Model' interface. On the left, there are panels for 'Map data panel' and 'Colour map by'. The 'Map data panel' displays aggregated data for LSOA (Camden 026D), including counts for domestic and non-domestic SCUs, average EPC ratings, and potential average EPC ratings. The 'Colour map by' panel offers options like 'SCU Mix', 'Energy efficiency rating', and 'Average height of built volume'. The main map shows a street grid with buildings color-coded by energy efficiency. A popup window is open over a specific SCU, displaying its address and a JSON object of attributes. Red arrows point from text labels on the right to specific fields in the popup.

**London Building Stock Model** | Improved energy data |  Off | About | User guide

**Map data panel**

**Aggregating data by LSOA (Camden 026D)**

- Total SCU's: 814 domestic 2497 non domestic
- Current average EPC (by floor area): D
- Current average EPC (by count): D
- Count domestic EPCs: 346
- Count domestic virtual EPCs: 656
- Count non domestic EPCs: 92
- Count non domestic virtual EPCs: 0
- Potential average domestic EPC (by floor area) undefined
- Potential average domestic EPC by count: C
- Number of domestic SCU's below MEES (on count): 10

**Colour map by**

- SCU Mix (measure and type of mixed use)
- Energy efficiency rating (by area) (EPC/DEC/vEPC)
- Average height of built volume (metres)
- Estimated GEA floor area (square metres)
- Estimated period of construction

**Filter features by**

Data values  Building attributes  Planning controls

**Show boundaries for**

**Aggregate data values by**

- Administrative areas - Borough/MSOA/LSOA (These auto adjust by map zoom level)
- Opportunity areas

**158,159**  
TOTTENHAM COURT ROAD  
LONDON, W1T 7NH  
UPRN: 5134301

```
{  
  "agg_epc_current_energy_efficiency_by_count": 55,  
  "agg_epc_current_energy_efficiency_by_floorarea": 57,  
  "agg_epc_current_energy_rating_by_count": "D",  
  "agg_epc_current_energy_rating_by_floorarea": "D",  
  "agg_rvepc_current_energy_efficiency_by_count": 55,  
  "agg_rvepc_current_energy_efficiency_by_floorarea": 57,  
  "agg_rvepc_current_energy_rating_by_count": "D",  
  "agg_rvepc_current_energy_rating_by_floorarea": "D",  
  "attached_status": "ET",  
  "ba_code": "S218",  
  "c2_shop_count": 3,  
  "c2_shop_fs": 1564,  
  "calculatedareavalue": 570.46376,  
  "cnt_nd_uprns_in_scu": 3,  
  "cnt_warns_in_scu": 3,  
  "epc_d_rating_count_nondom": 3,  
  "epc_d_rating_floorarea_nondom": 1434,  
  "epc_e_rating_count_nondom": 2,  
  "epc_e_rating_floorarea_nondom": 153,  
  "estimate_total_floor_area_of_building": 1564,  
}
```

Head level address

Unique Property Ref No. (UPRN)

Current energy efficiency rating

Attached status (ET = End Terrace)

Number of premises

Floor area

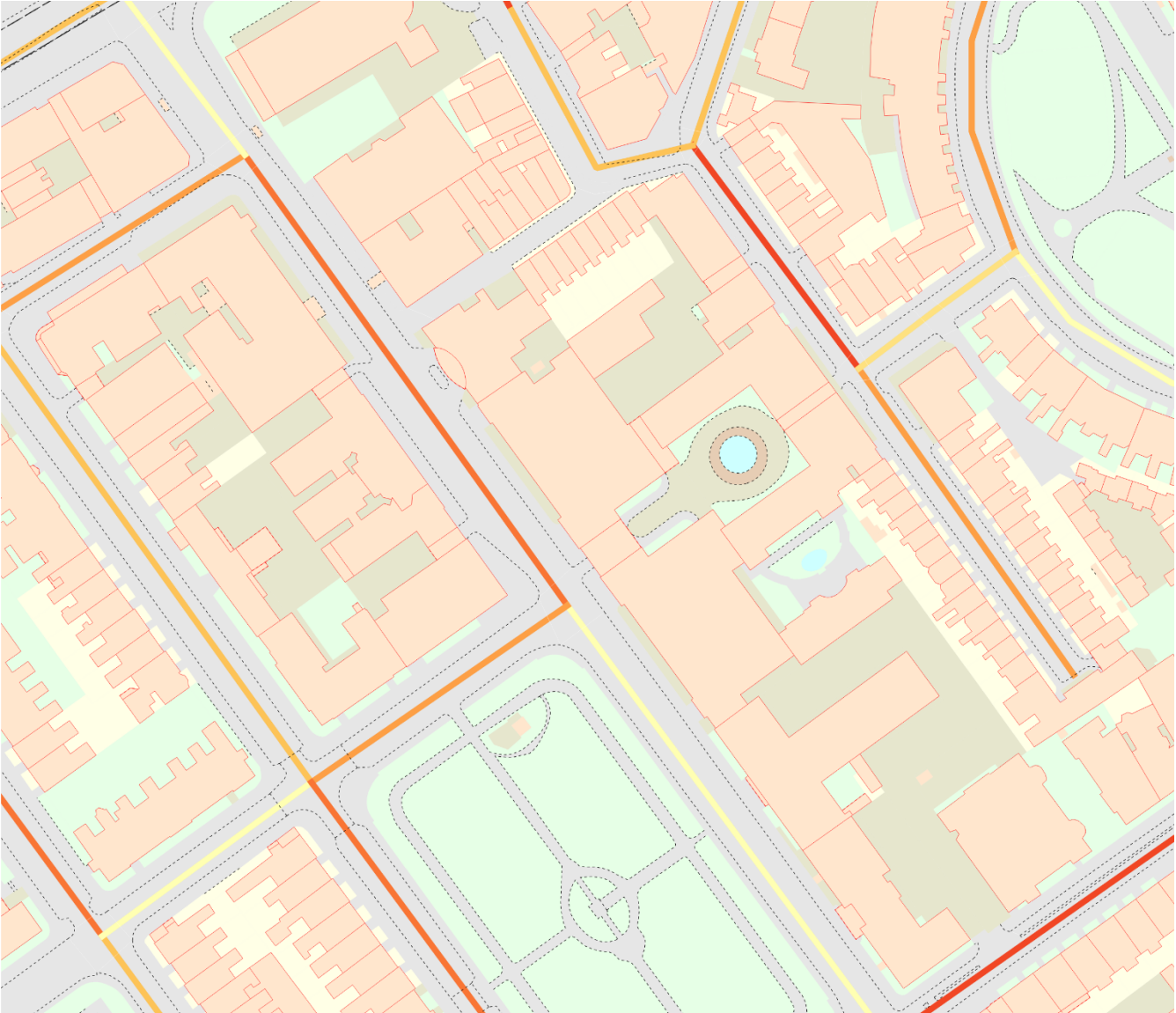
etc.....

# Application: district energy potential routes

Camden

MWh / m of segment length (pa)

- 0 - 1
- 1 - 2
- 2 - 4
- 4 - 6
- 6 - 9
- 9 - 20
- 20 - 100
- 100+



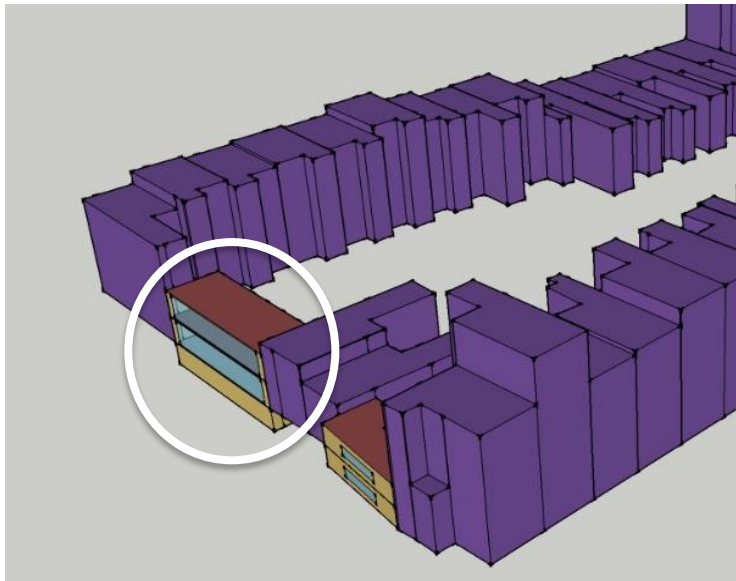


# SimStock



# 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.

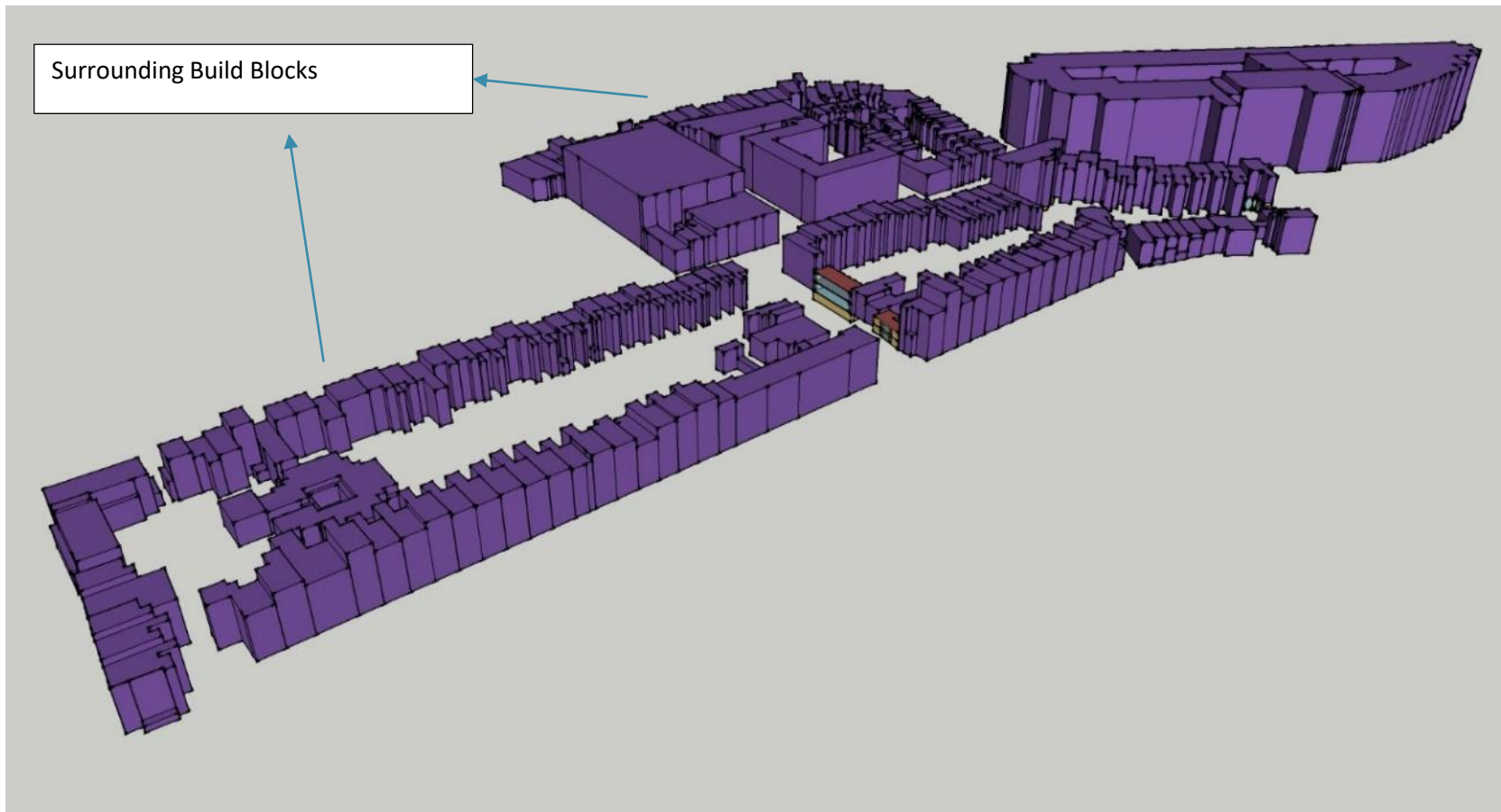


Each Built Block is comprised of a set of SCUs divided into zones each having a unique 'use type', eg: office, retail, residential, etc.



# SimStock: Shading

Impact of shading from surrounding Built Blocks accounted for.



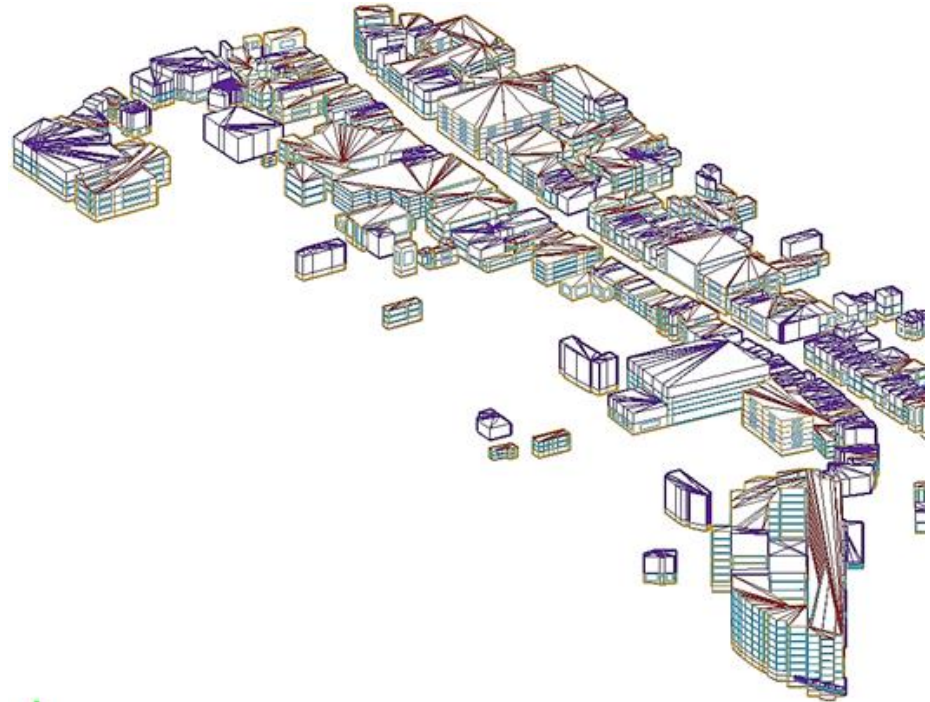
# SimStock: Data sources

## 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

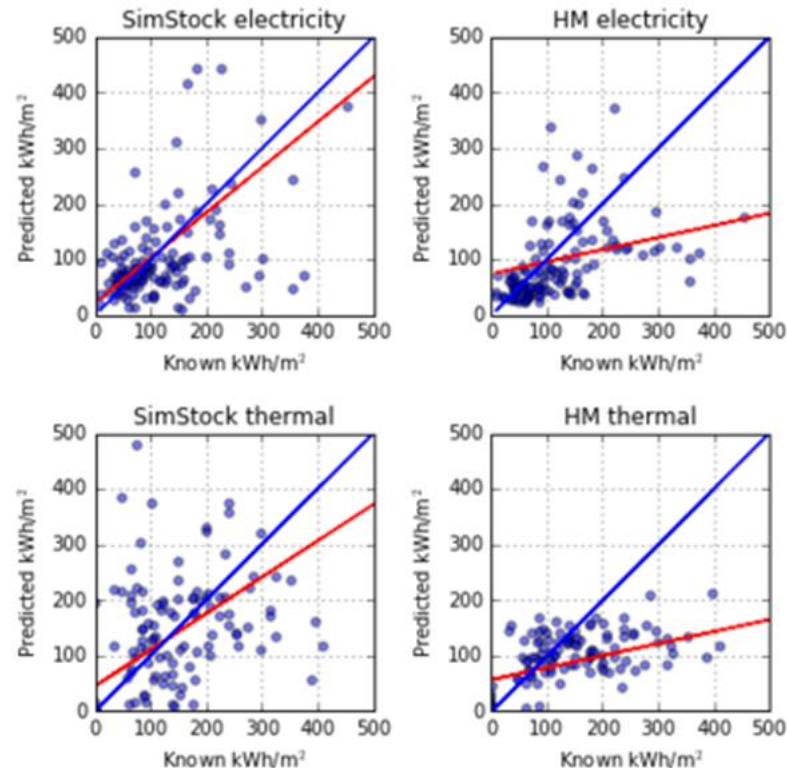




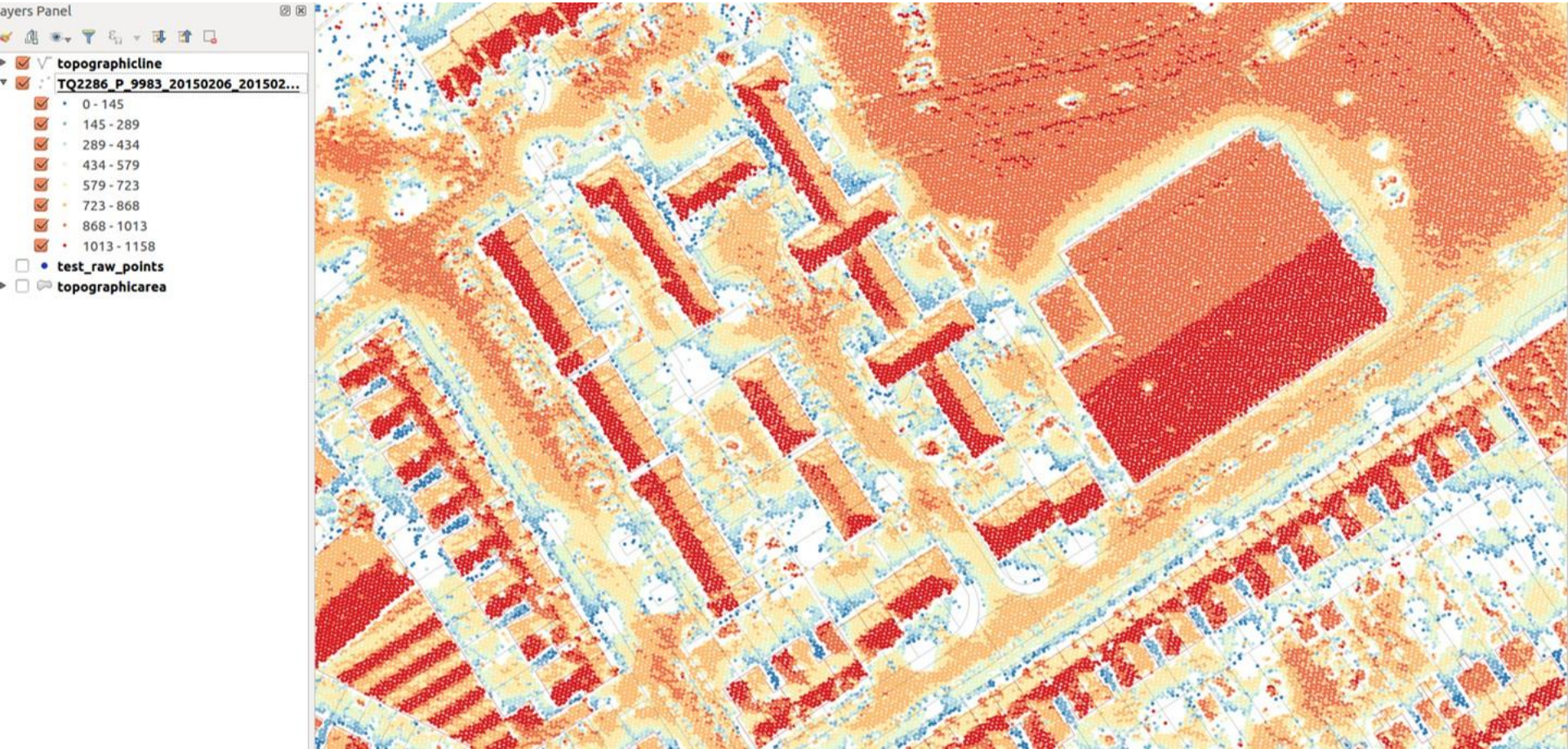
# SimStock: Output

## Model calibration

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



# Solar mapping – initial development





## Conclusions

- 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.

## Acknowledgements

### Development team:

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

### Funders:

Engineering and Physical  
Science Research Council

Greater London Council

### References:

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



# Questions?

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