



University of
Nottingham
Energy Institute

Energising Communities with Active Buildings

Prof Mark Gillott

Chair in Sustainable Building Design





Globally buildings and buildings construction sectors combined are responsible for 36% of global final energy consumption and nearly 40% of total direct and indirect CO₂ emissions.

Energy demand from buildings and buildings construction continues to rise, driven by improved access to energy in developing countries, greater ownership and use of energy-consuming devices, and rapid growth in global buildings floor area, at nearly 3% per year.





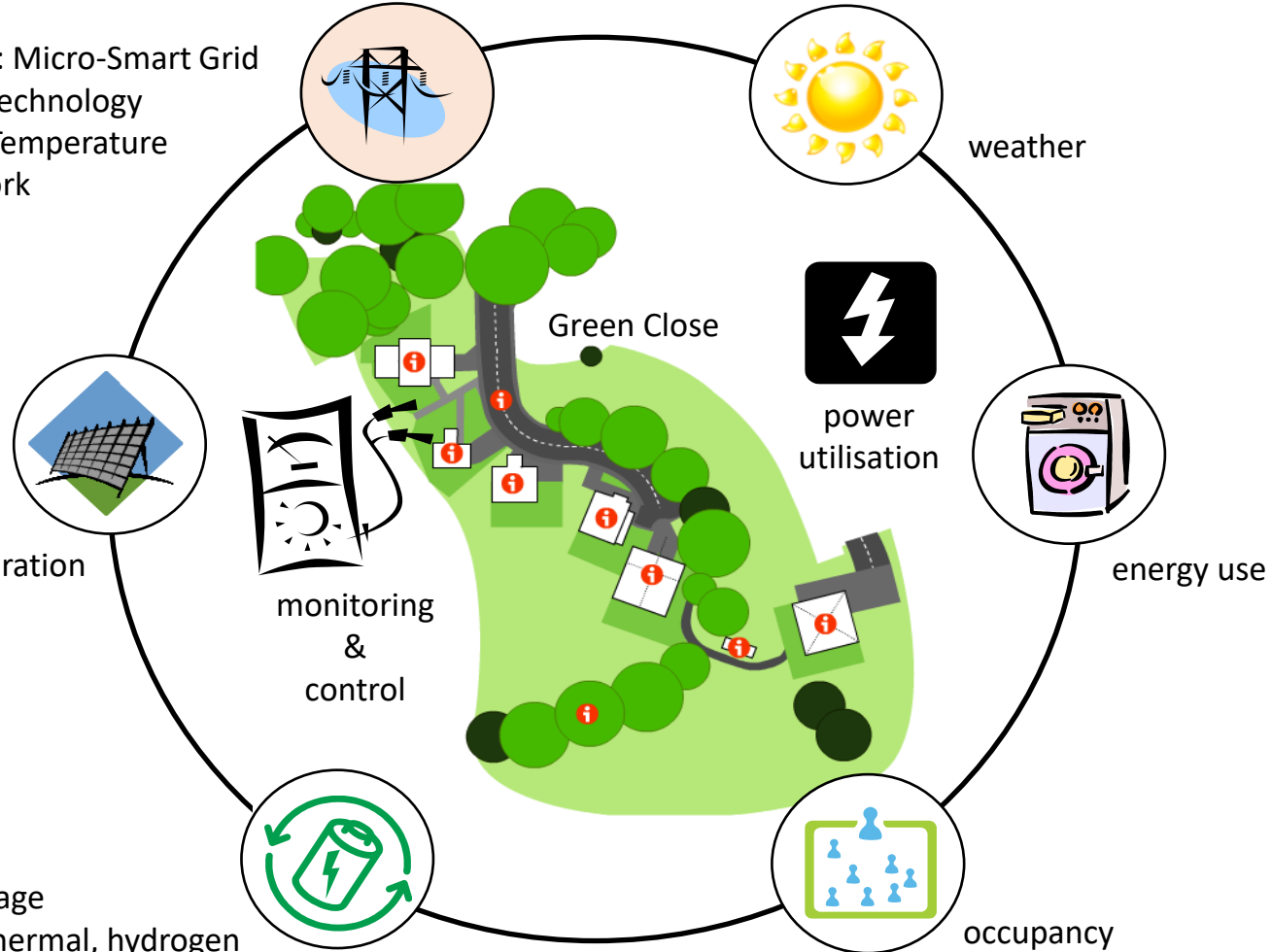
Creative Energy Homes (University of Nottingham)



ELECTRICITY: Micro-Smart Grid
With DSM technology
HEAT: Low Temperature
Heat Network

micro-generation

energy storage
Batteries, thermal, hydrogen





Why Community Energy?

THE LEADING MAGAZINE FOR UK RESIDENTIAL DEVELOPMENT AND REGENERATION

housebuilder

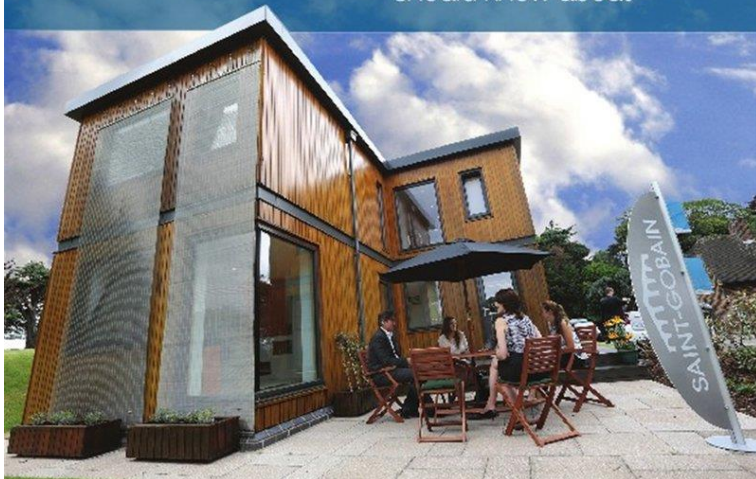
APRIL 2016

www.house-builder.co.uk

After zero

The Nottingham H.O.U.S.E

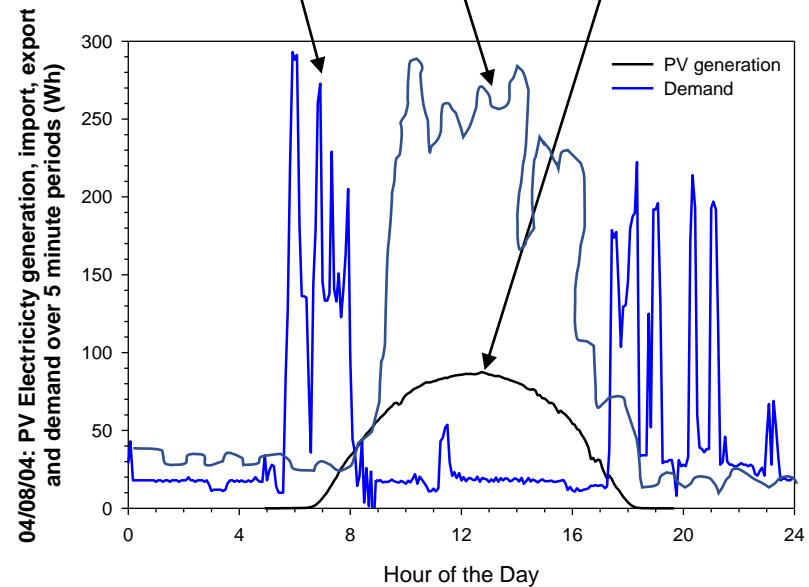
— a zero carbon home that housebuilders should know about



34p/kWh Oct 2022
circa 250g CO₂/kWh

Different typologies,
e.g. School

circa 2 -10 p/kWh
0gCO₂/kWh





Why Community Energy?

UK NEWS:
SEPTEMBER 2019



Fury over the fading benefits of solar power as thousands complain to finance watchdog that glass panels DON'T provide the rewards they were promised



- Financial Ombudsman has received 2,000 complaints from home-owners
- Barclays put aside millions to compensate those who bought mis-sold panels
- Brian Thompson, from Gateshead, took out £10,000 loan to pay for panels
- Was told by firm PV Solar UK that the panels would boost his pension
- Payments from power panels sent to National Grid not enough to pay loan cost





Nottingham Trent Basin

Energising Communities with Active Buildings





Nottingham Trent Basin

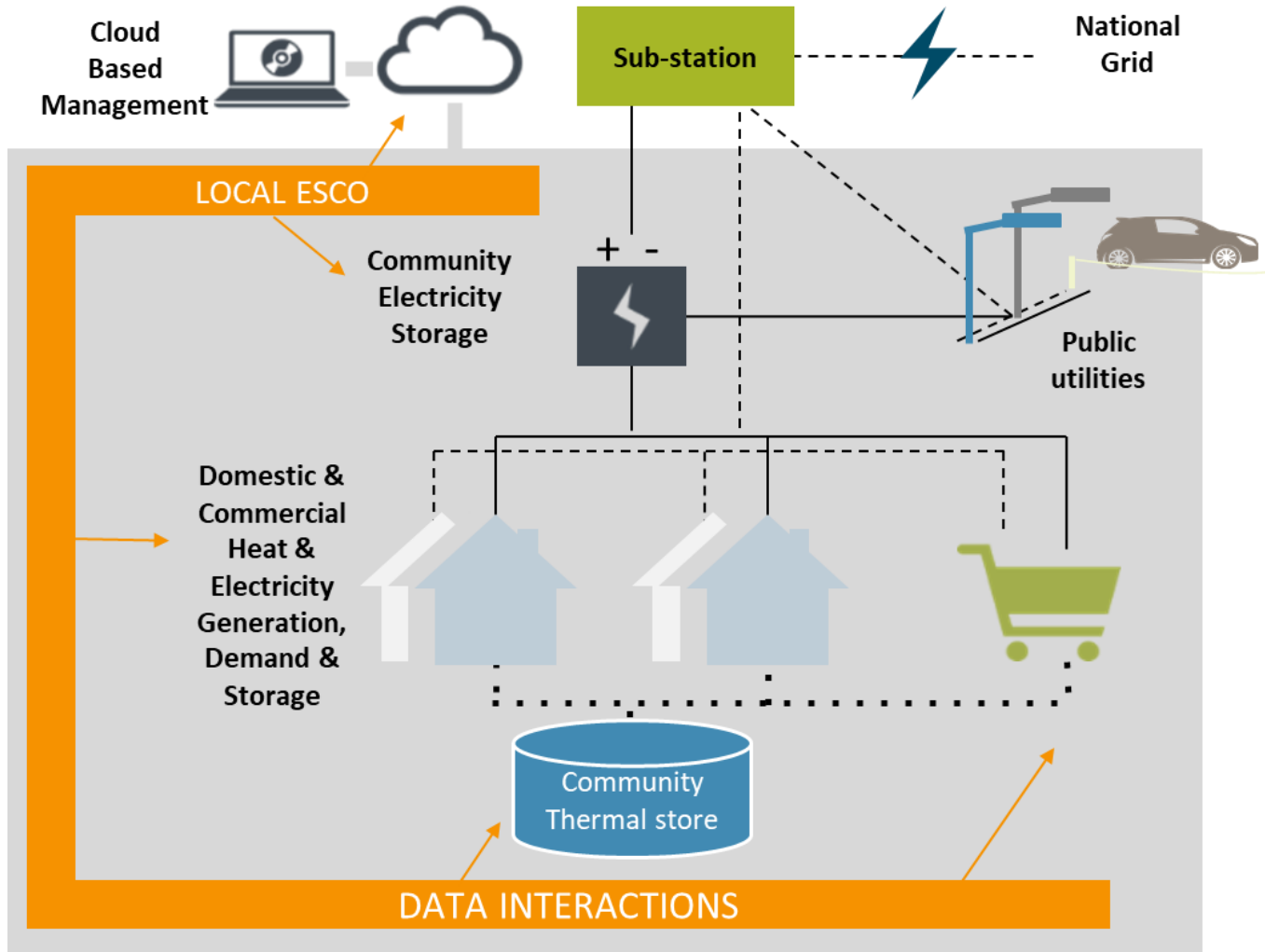
Project SCENE key messages

1. Currently NO business model in the UK for community energy that does not require additional subsidy
2. SCENE will **develop a 'subsidy free' commercial model** for new build residential developments
3. The demonstration integrates a new supply chain in a real commercial development, with consumer choice, at scale
4. Results will be disseminated as Business Model Templates that can be used by any developer or ESCO in the UK





Sustainable Community Energy Networks

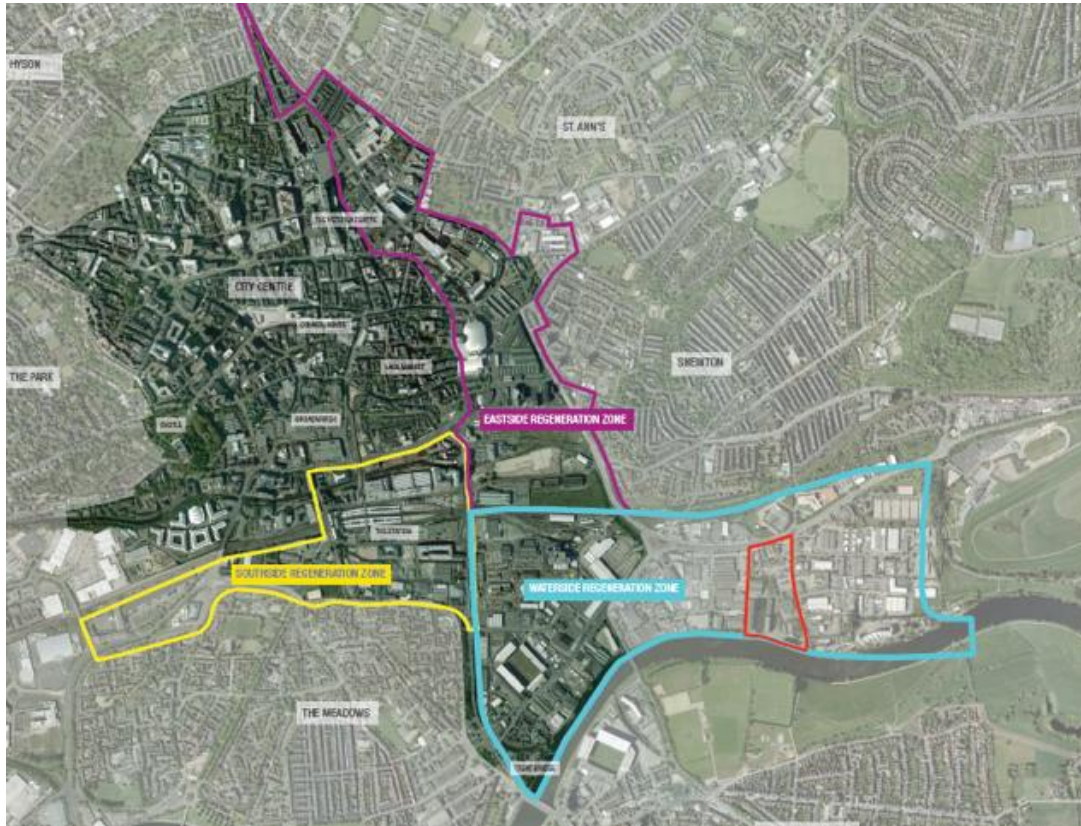


- SCENE will demonstrate scalable ESCO services
 - Trent Basin ESCO Ltd
- Potential to integrate other value streams such as assisted living, health care and security





Nottingham Trent Basin Development Site





Trent Basin Phases 1-5 Masterplan



Construction Phases





University of
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Energy Institute

Trent Basin





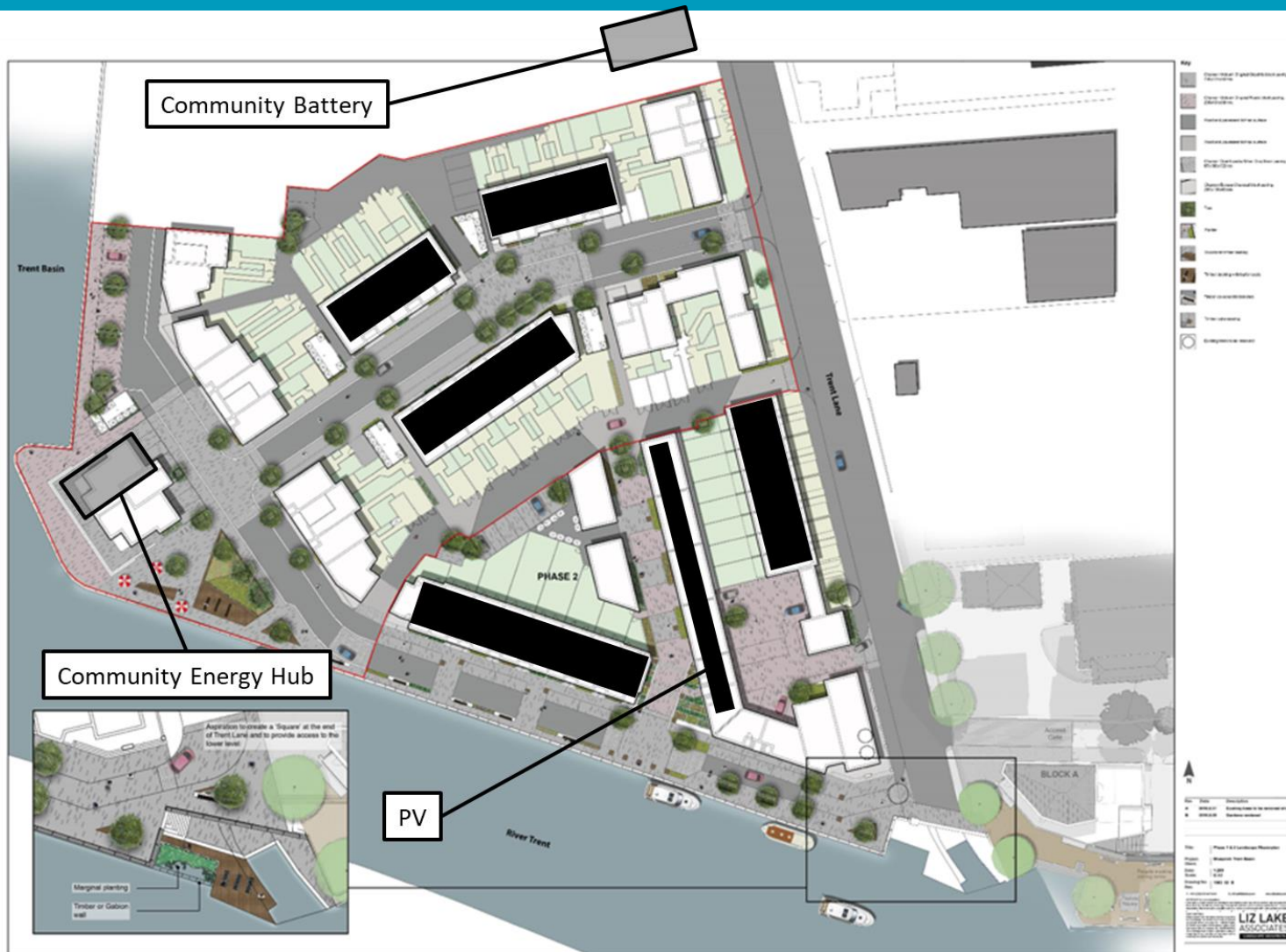
University of
Nottingham
Energy Institute

Trent Basin





Community Energy Assets



ERA Funded Energy Hubs – Generation, Storage & Use (*people*)





Community Energy Assets



Electrical Infrastructure
Local Power Networks



Community Battery
Located on Trent Lane Adjacent to Local Sub Station
Includes: Distribution boards, ring main and
Substation + Energy Centre – SCADA server,





Tesla 2.1MWh Battery - 500kW inverter



Low Voltage Distribution Panels



Weather Station



Enclosure - Security and Acoustic Fencing



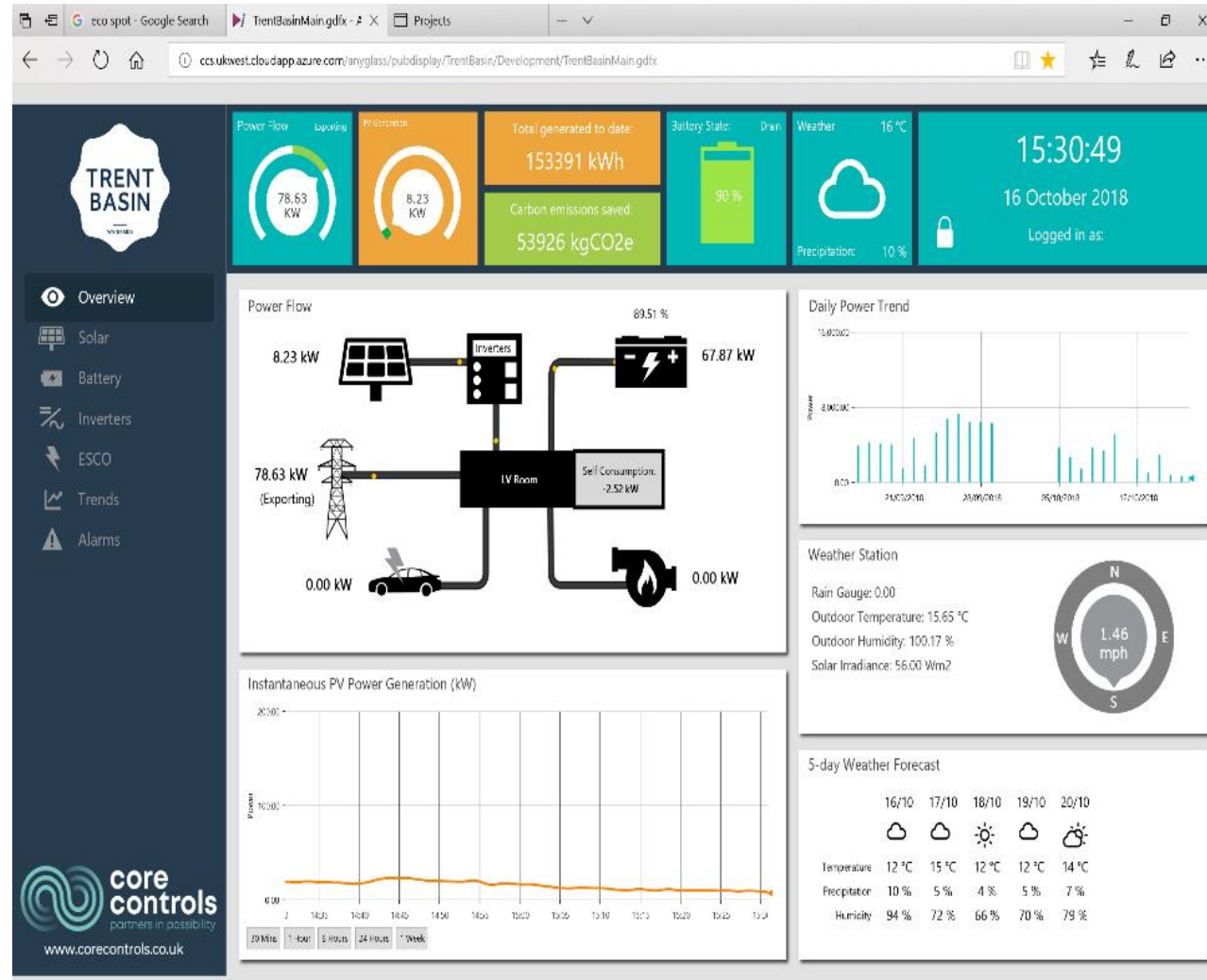
Energy Centre Sub Station





Meanwhile Use - Urban Solar Farm







3D Community Interaction Model





Consumer Engagement

Smart Speaker



Smart Phones



Tablets

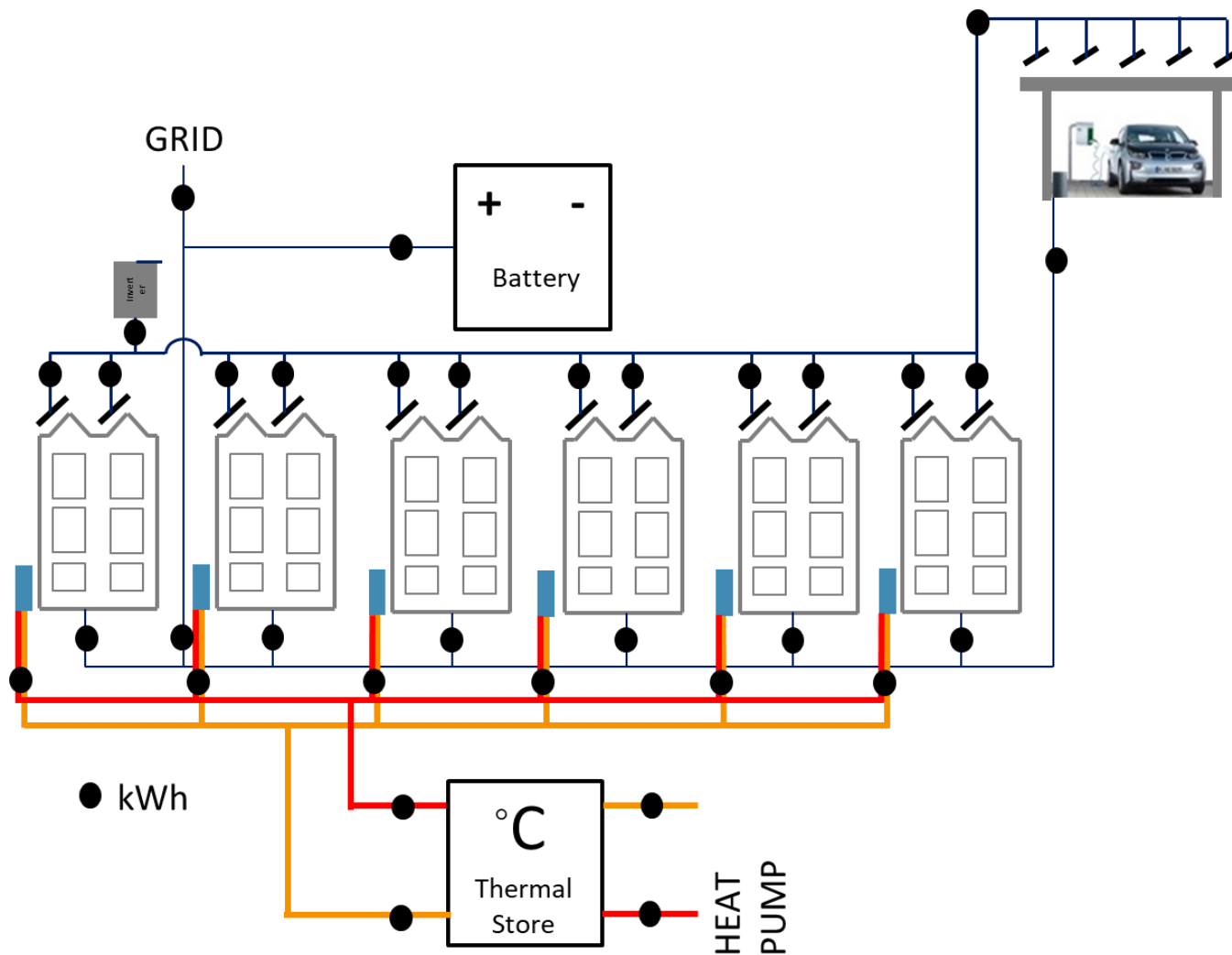


IHD





Monitoring - Community



Solar irradiance
Temperature
Humidity
Wind speed/direction
Rainfall

Site Weather Station





Monitoring - Homes

Temperatures

Relative Humidity

Carbon Dioxide

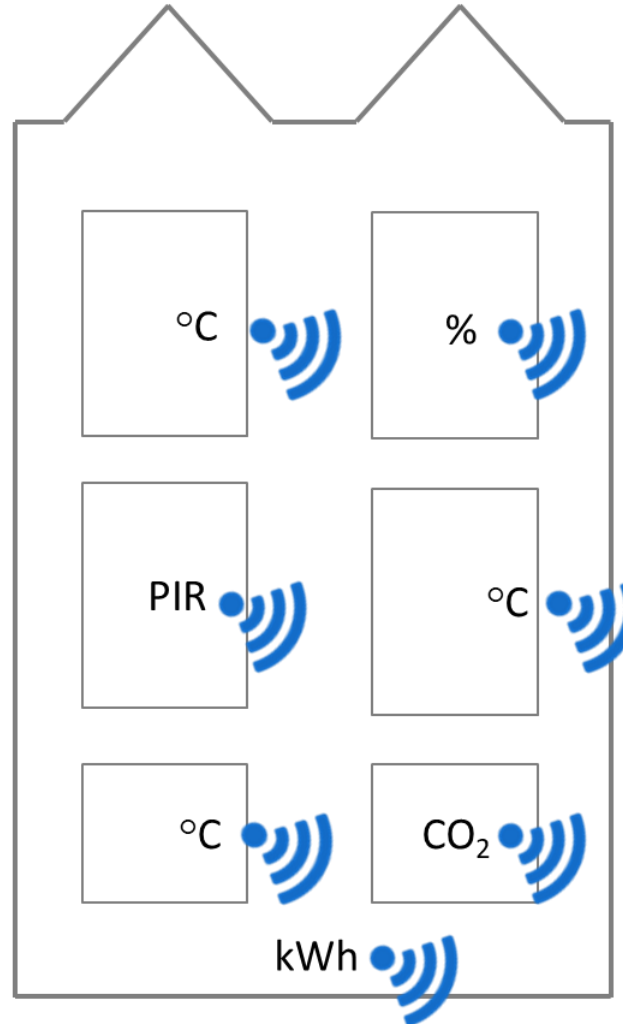
Occupancy

Electrical Energy

- Total Electricity
- Circuits
- Significant Appliances

Thermal Energy

- Hot Water
- Space Heating



CLOUD SERVER



Energy Centre





Smart Thermostat

The Honeywell Evohome system is an advanced heating system that allows control of individual rooms within the homes





Heat meters

To measure hot water and space heating energy use

Electricity Circuit Sub meters





Gateways

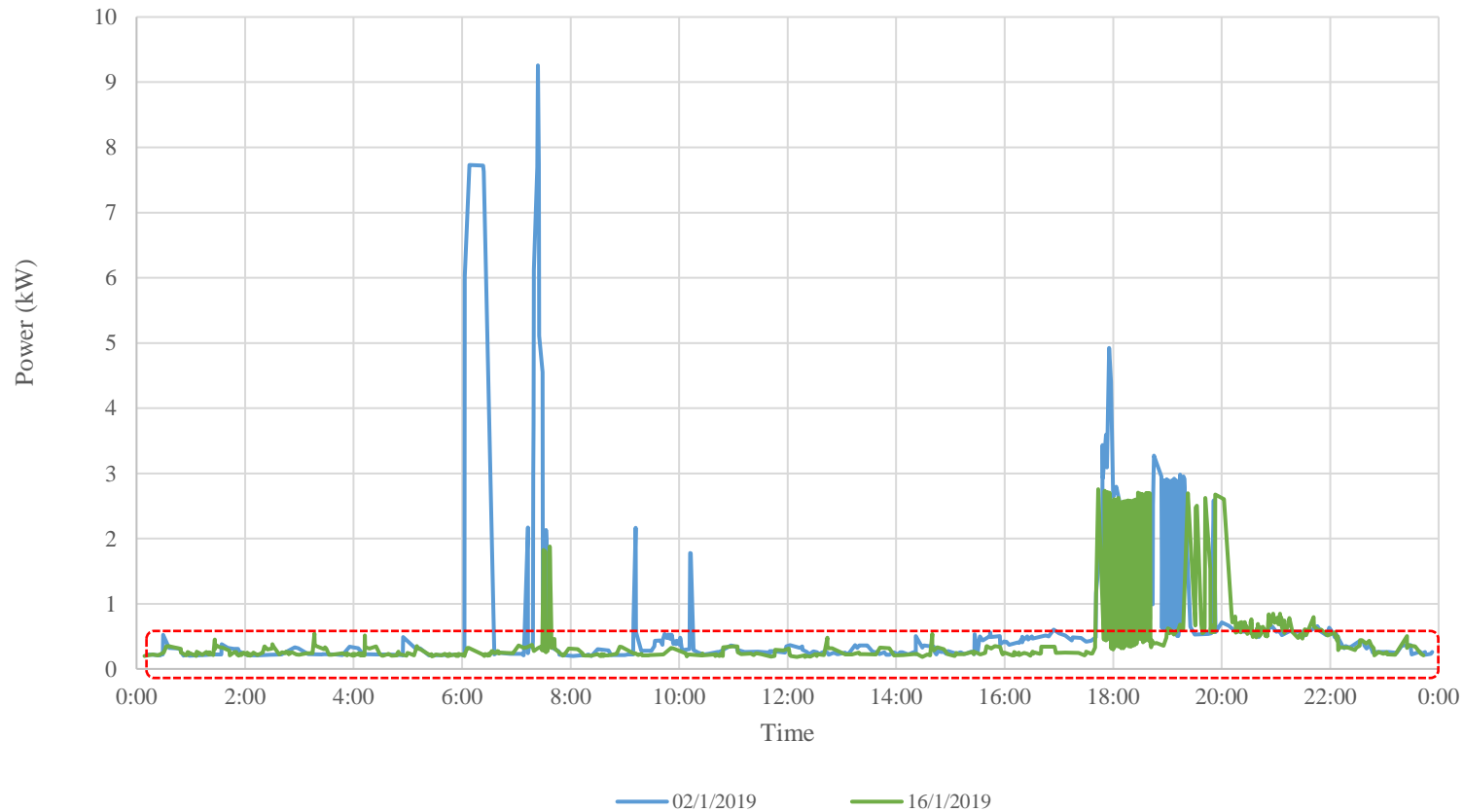
Much of the equipment installed in the homes uses low-power wireless technology to transmit the monitored data.

A gateway is required to listen for data transmissions and send them on to the project servers for further processing.



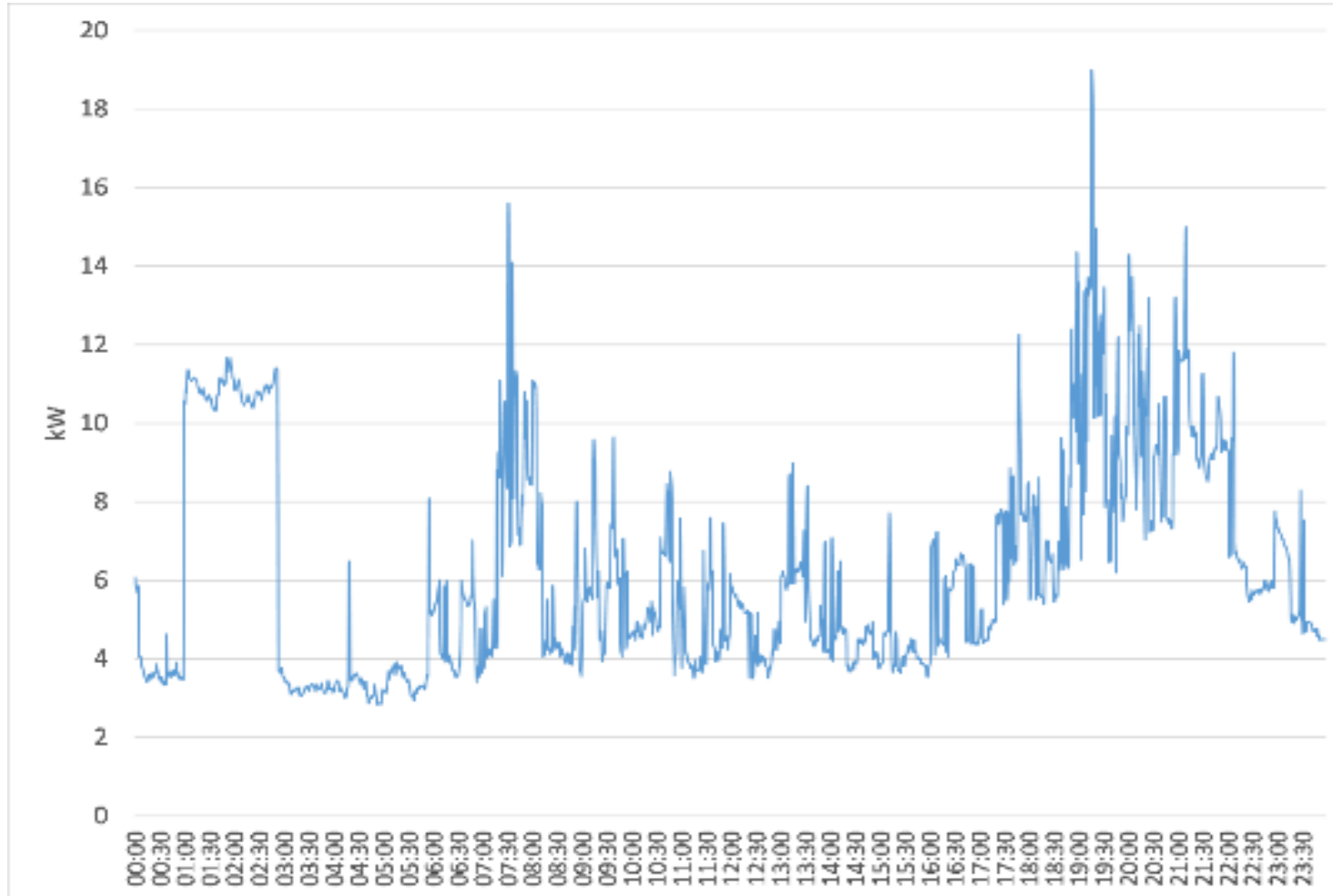


Example of house hourly electricity demand profile



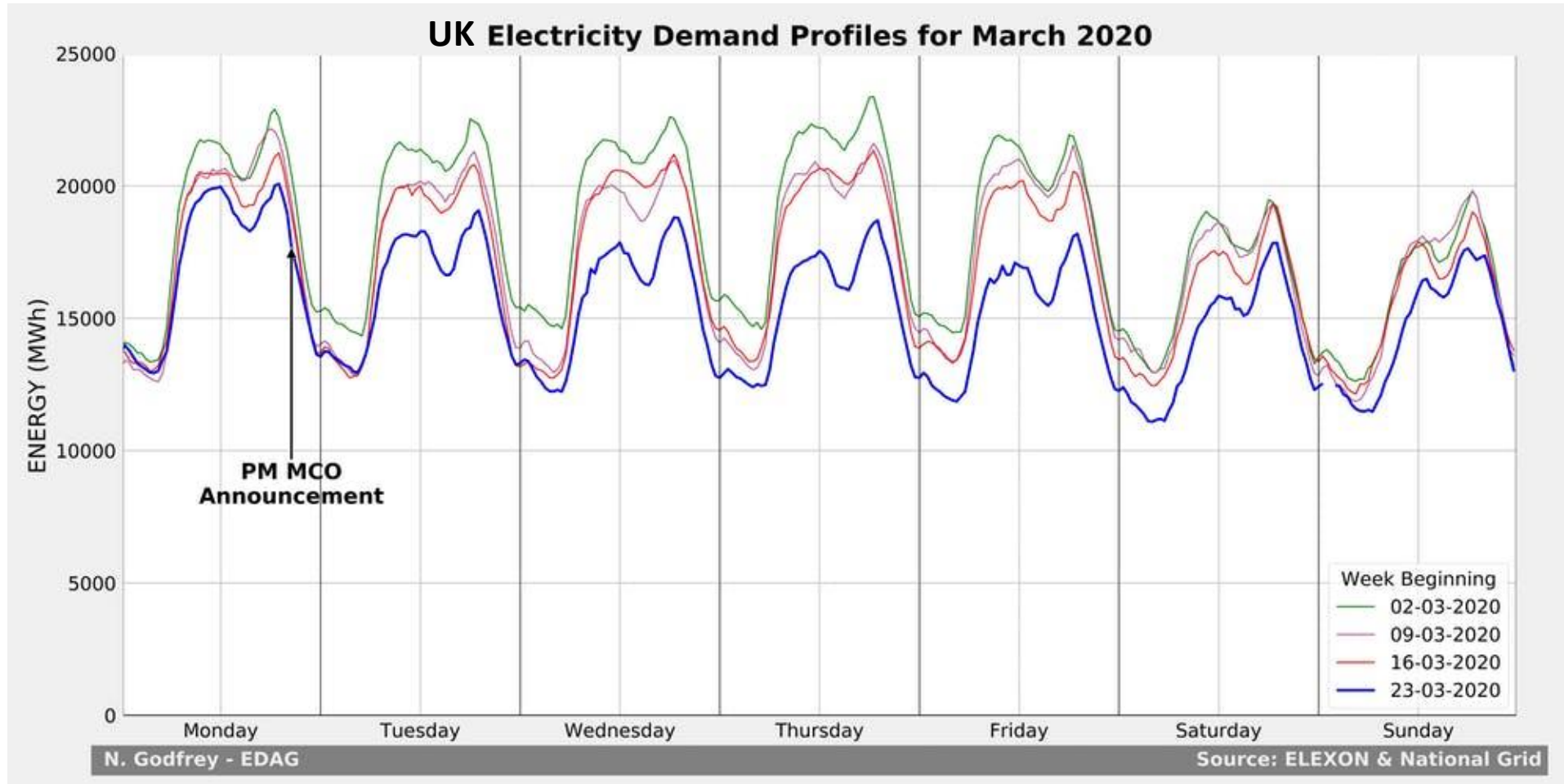


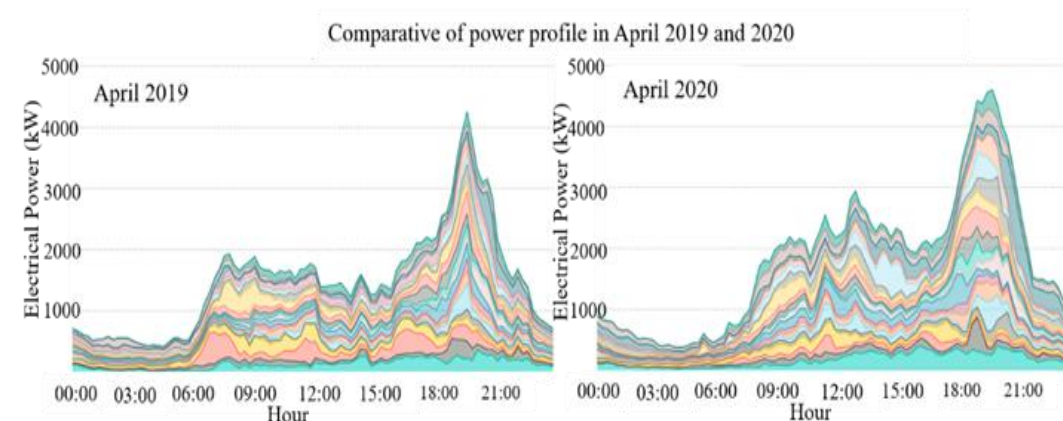
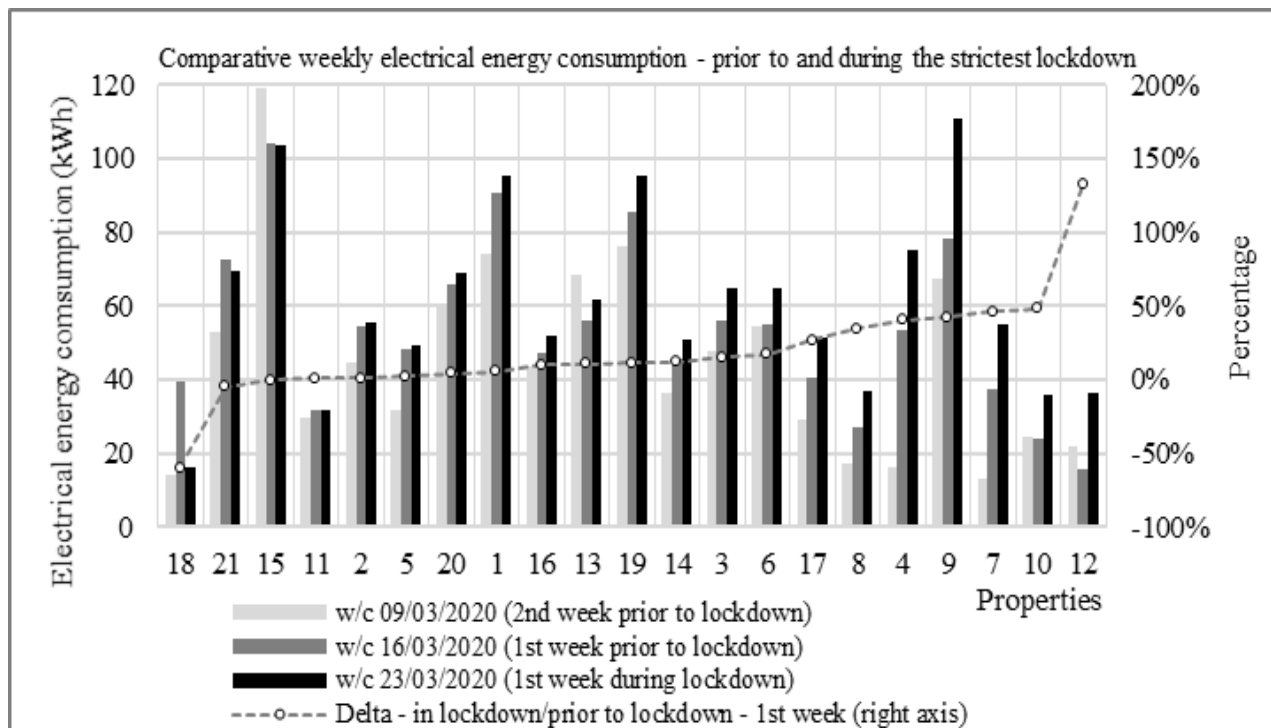
Home Monitoring – Sample Data





Covid-19 Lock Down Energy Behaviours





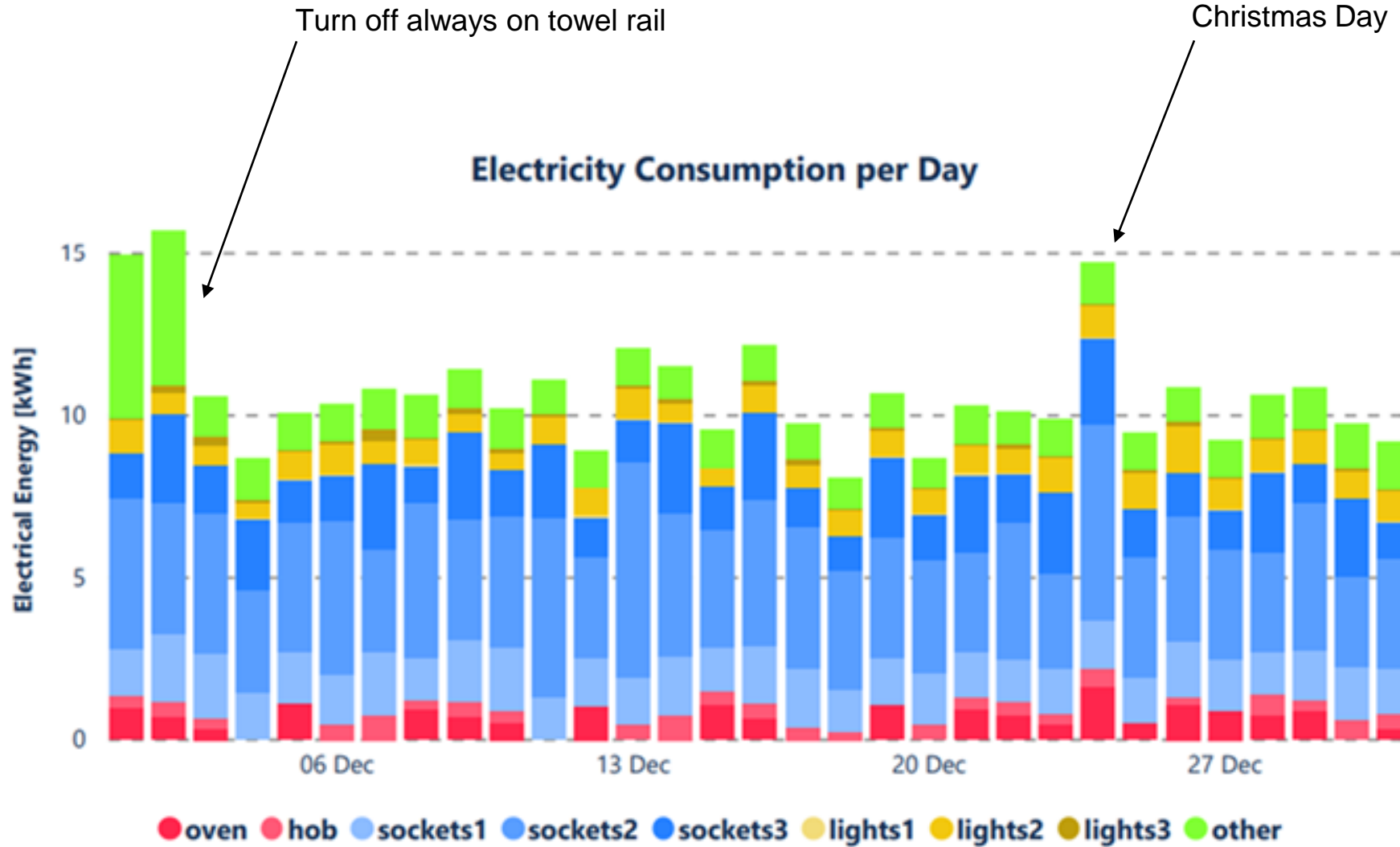
During 2020-2021 the households had an average increase in their annual average consumption of 17% when compared to 2019-2020

Tubelo, R., Naghiyev, E., Gillot, M., Rodrigues, L., & Shipman, R. (2021). Assessing the impact of lockdown due to COVID-19 on the electricity consumption of a housing development in the UK. In J. R. Littlewood, R. J. Howlett, & L. C. Jain (Eds.), Sustainability in Energy and Buildings 2021 (45-55). Springer. https://doi.org/10.1007/978-981-16-6269-0_4





Energy Behaviours





Reports for Home Occupiers



Setup	27 Participants	175 PV system [kWp]	500 Battery converter [kW]	2100 Battery capacity [kWh]	TBC EV chargers [kW]	Report produced on 01 October 2019
Stats	23,090 Imported [kWh]	33,325 Exported [kWh]	13,548 Generated [kWh]	106,715 CO2 saved [kg]	5,186 Community [kWh]	Currently showing September 2019

PV generated electricity to supply



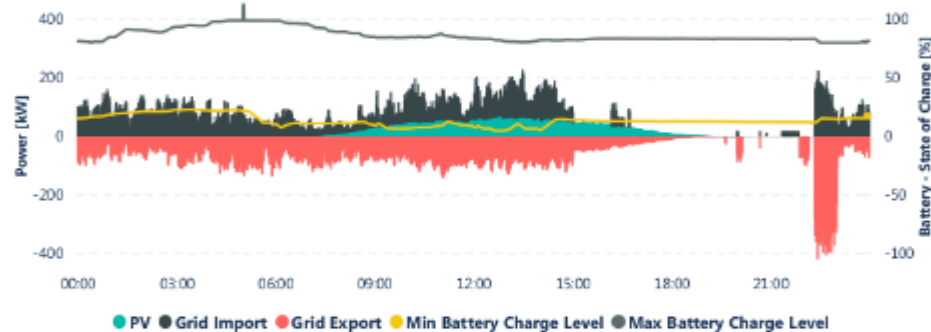
142%

of Homes in September 2019

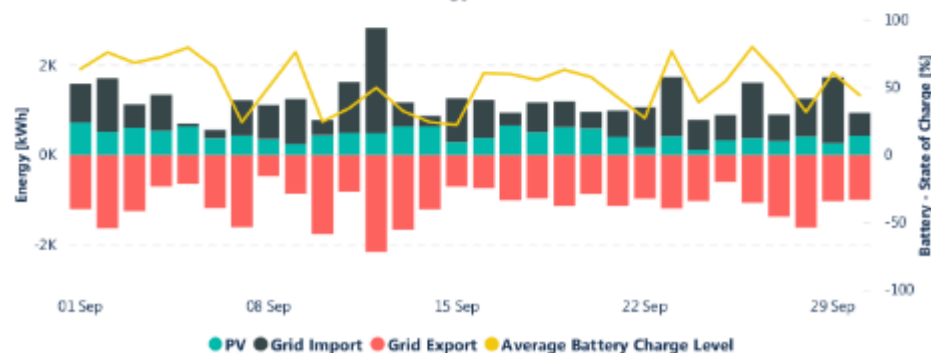
Outdoor Temperature Profile



Typical Power Profile



Energy Profile





Reports for Home Occupiers

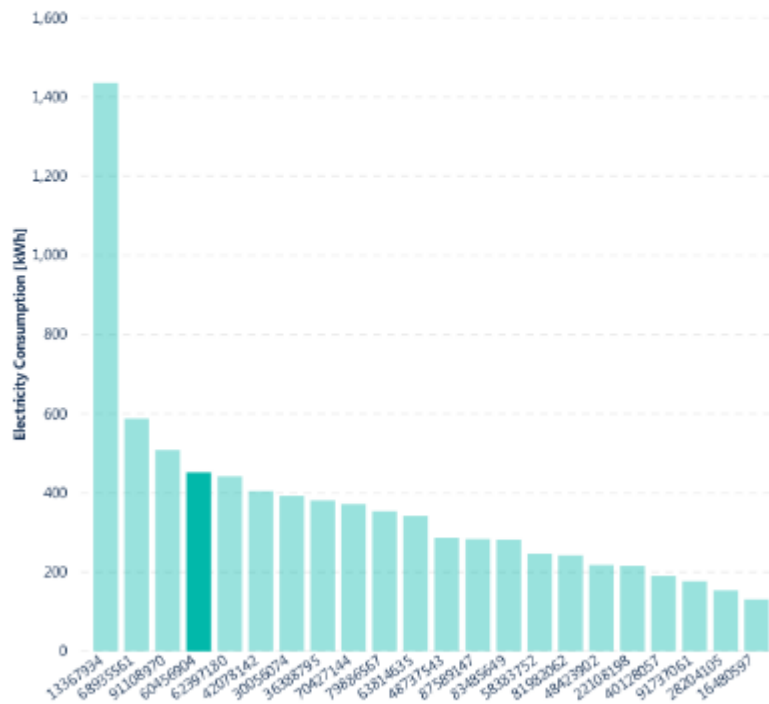


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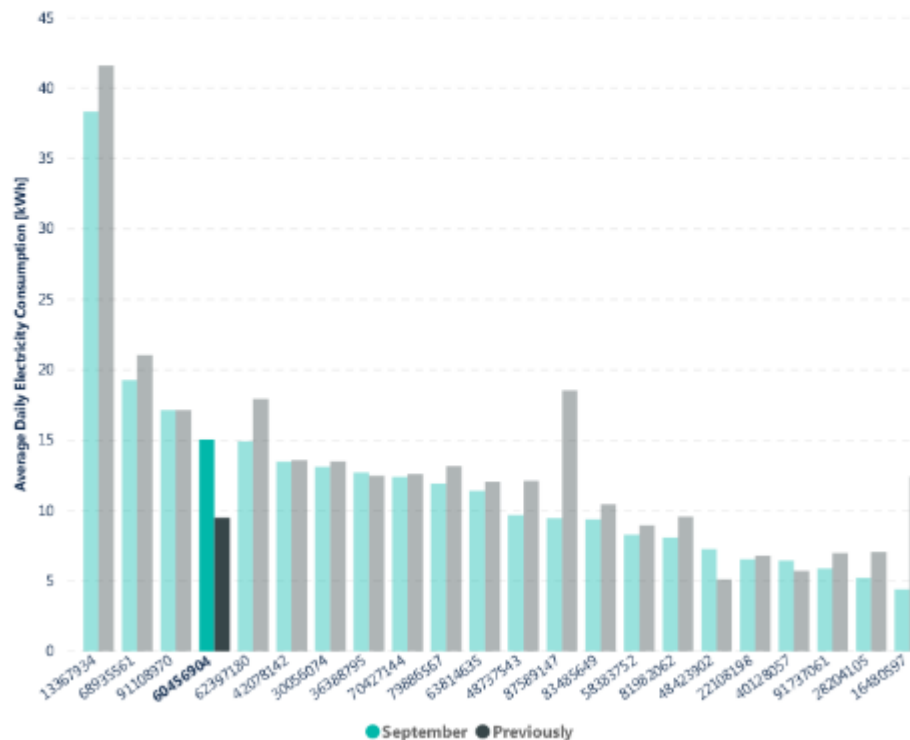
Report produce on
01 October 2019

Currently showing
September 2019

Electricity Consumption by Property



Comparison of Daily Electricity Consumption





SC&MP -> CIM: UoN | Device Data | scenedash.azurewebsites.net/devicedata

University web site | Staff Room | Engineering Staff R... | University Email | Libraries | Your IT Services | Office 365 Help | FM:Interact UoN Sp... | MyAnalytics | LANCET On The Web | SC&MP -> CIM: UoN | SC&MP -> CIM: UoN | The Active Building... | Reading



169254107159_157

233162 (40 Portside Street, NG2 4DN)

169254107159_157 (PowerTag - Main incoming supply)

Hourly

Daily

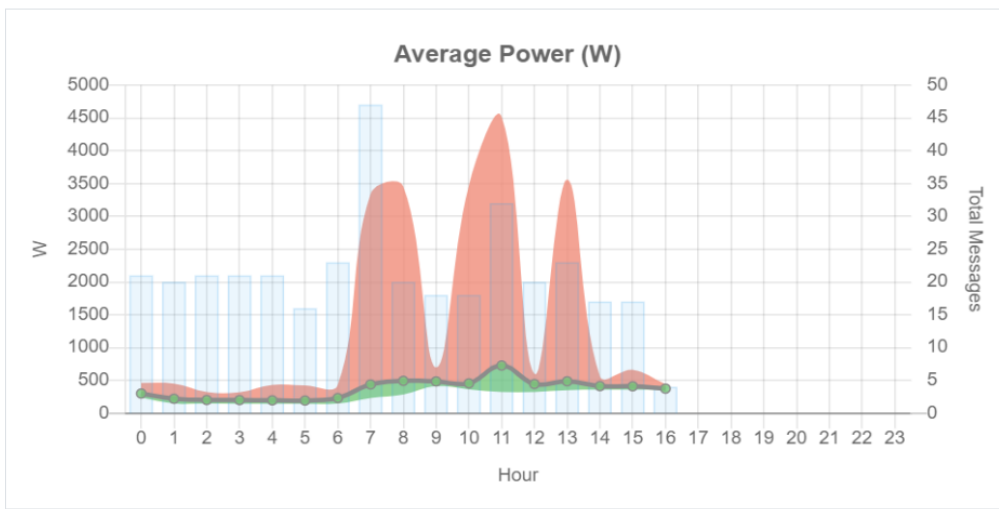
Weekly

Monthly

Yearly

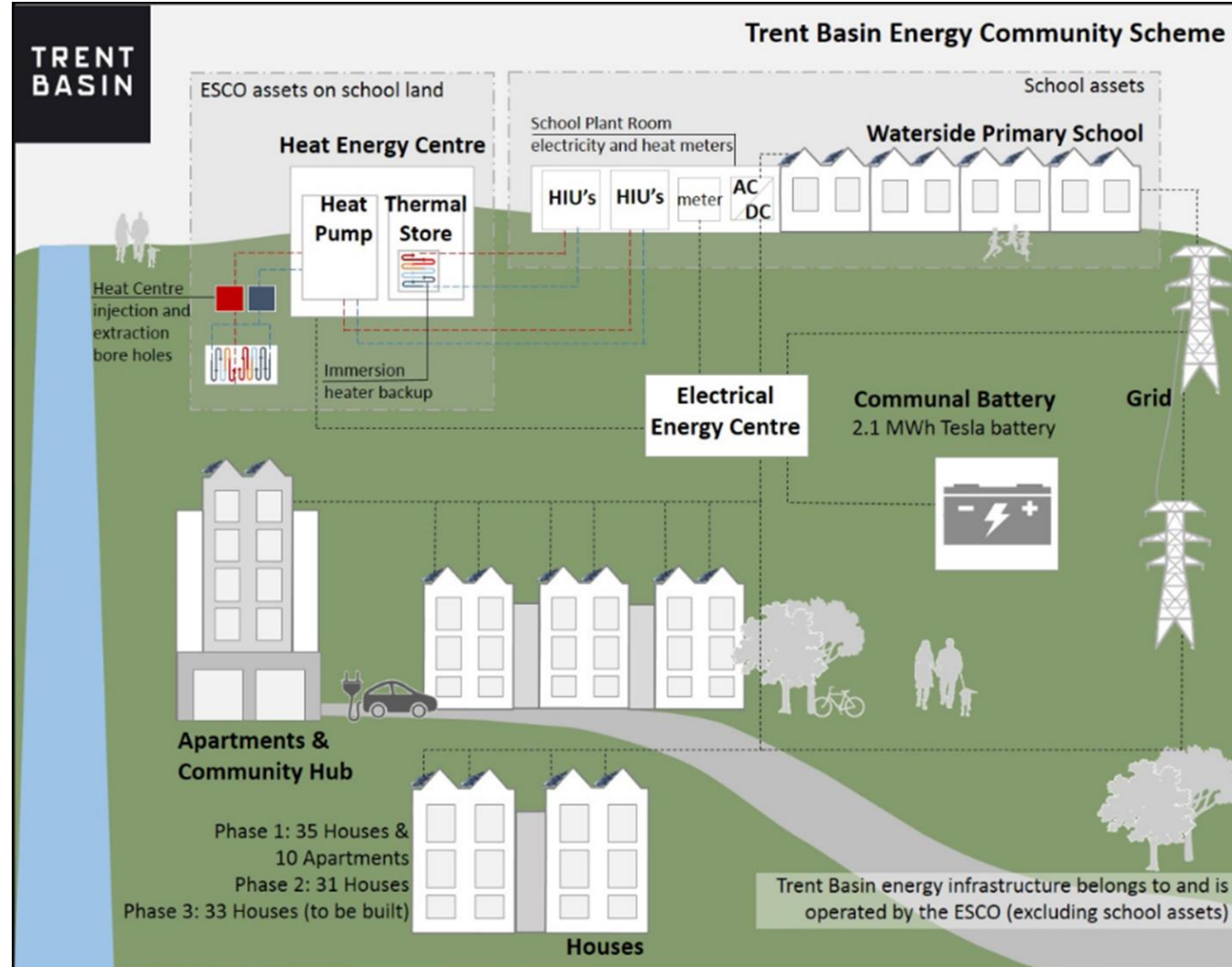
Choose date:

30/09/2021



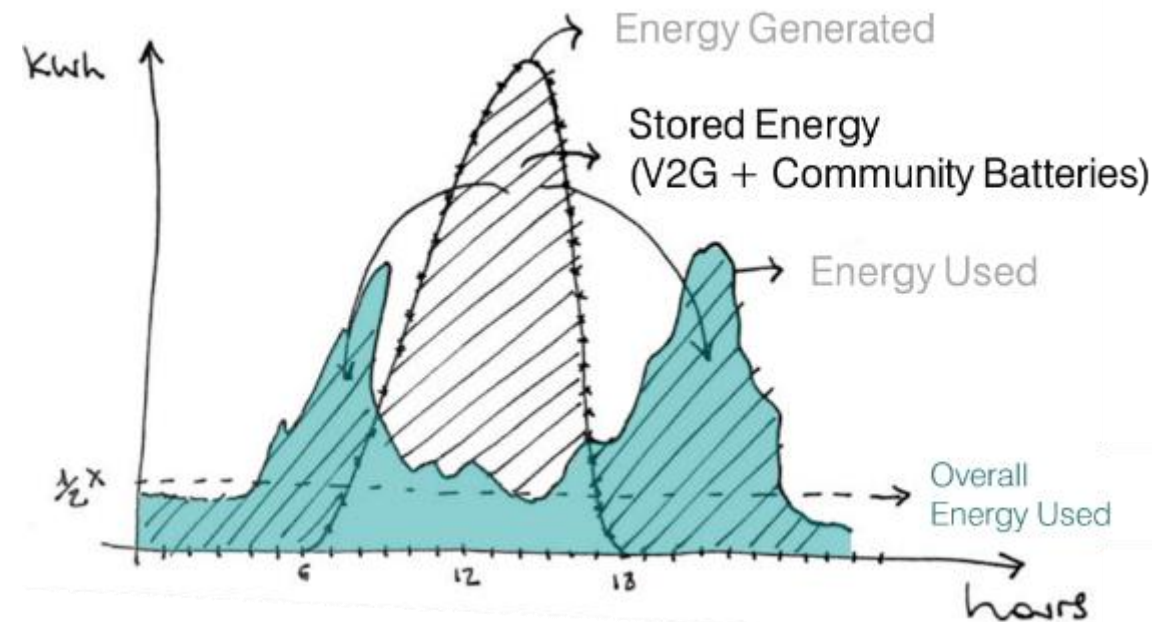
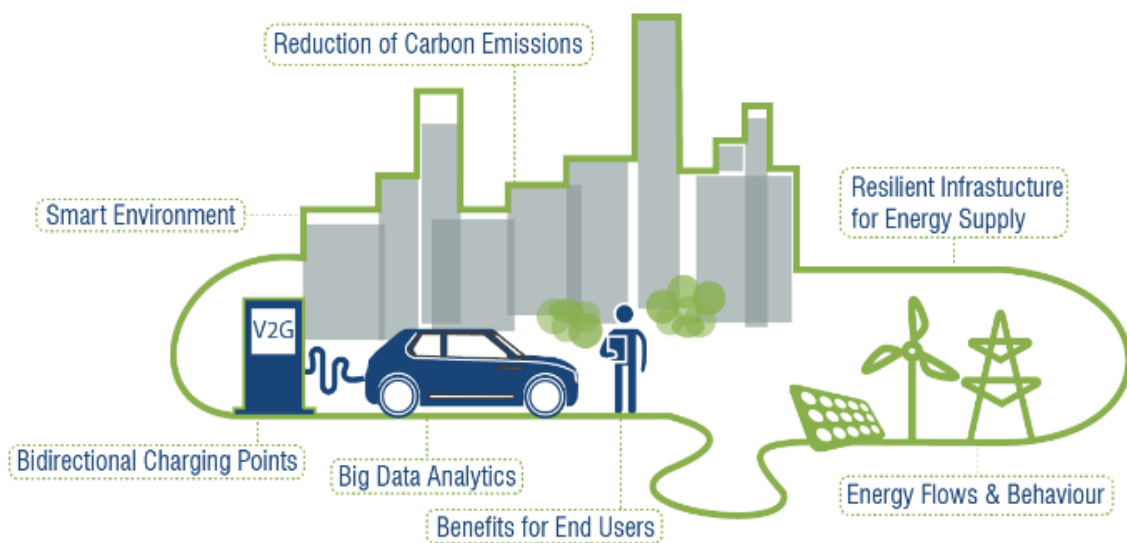


What next?





Vehicle-to-Grid (V2G)



SHIPMAN, R.; WALDRON, J.; NAYLOR, S.; PINCHIN, J.; RODRIGUES, L.; GILLOTT, M., 2020. [Where Will You Park? Predicting Vehicle Locations for Vehicle-to-Grid](#). *Energies* 2020, 13, 1933.

WALDRON, J., RODRIGUES, L., GILLOTT, M., NAYLOR, S., SHIPMAN, R., 2020. "Decarbonising Our Transport System: Vehicle Use Behaviour Analysis to Assess the Potential of Transitioning to Electric Mobility". In: 35th Passive and Low Energy Architecture Conference (PLEA): Planning post Carbon Cities, 1-3 September 2020, Coruna, Spain.

SALAZAR, J., WALDRON, J., RODRIGUES, L., 2019. Regulatory and policy framework for the uptake of renewable energy in the United Kingdom. In 18th International Conference on Sustainable Energy Technologies - SET2019, 20th – 22nd August 2019, Kuala Lumpur, Malaysia.

WALDRON, J., RODRIGUES, L., GILLOTT, M., NAYLOR, S., SHIPMAN, R., 2019. Towards an electric revolution: a review on vehicle-to-grid, smart charging and user behaviour. In 18th International Conference on Sustainable Energy Technologies - SET2019, 20th – 22nd August 2019, Kuala Lumpur, Malaysia.

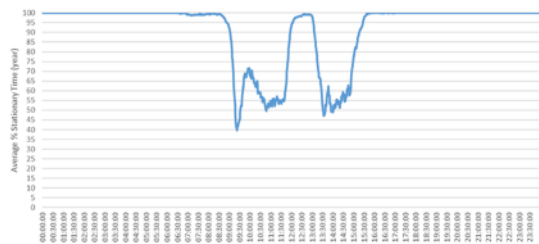




EV-elocity: our campuses are demonstrators



Stationary Time of Vehicles - Fleet 'X'



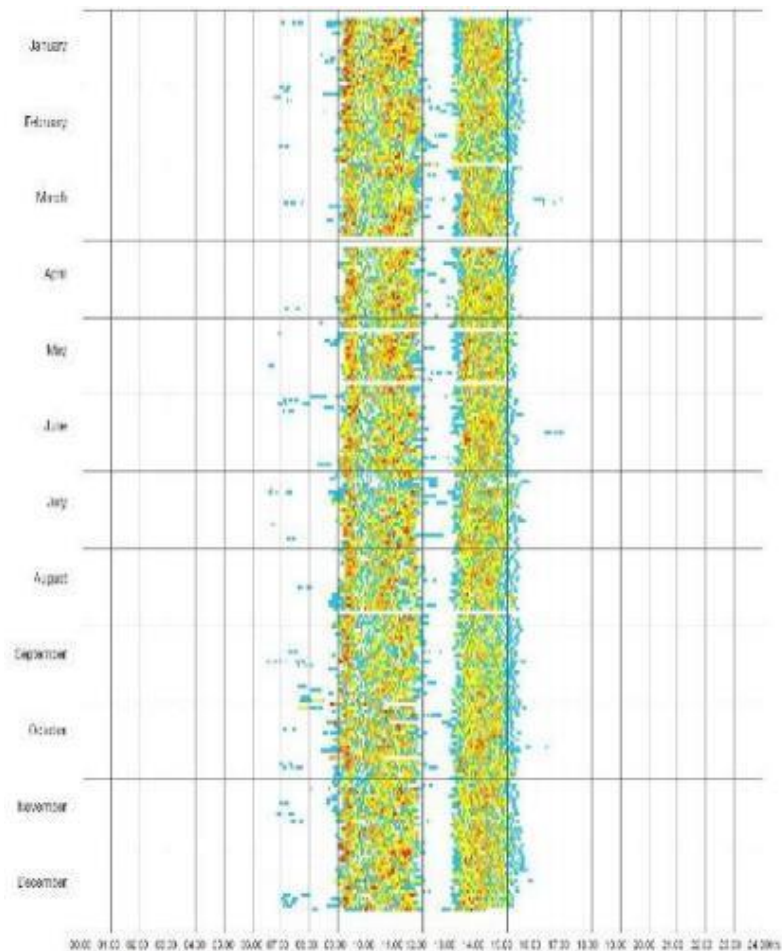
Stationary Time of the vehicles during 24 hours. 100% means that all the vehicles are stationary, as the percentage is lower, the probability of the vehicles to be in use at that time is higher.

Vehicle batteries are flexible energy storage as they can move energy around the city and release energy to the grid on demand.

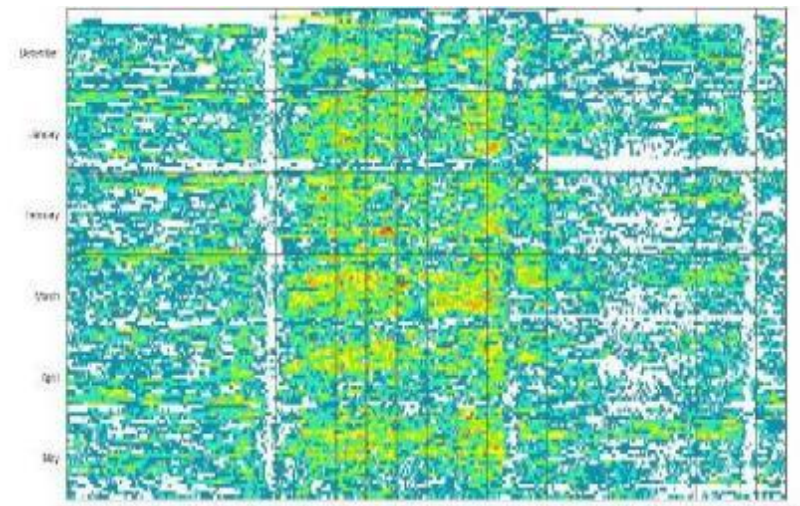
Stationary Time of Vehicles - Fleet 'Y'



It is required to understand the patterns of behaviour of different type of users to build a resilient infrastructure.



% WILDCAYS	
Vehicles	Simultaneous Use
0	01.7%
1	7.4%
2	8.8%
3	3.5%
4	11.8%



Number of vehicles operating

% WILDCAYS	
Vehicles	Simultaneous Use
0	27.3%
1	33.1%
2	23.7%
3	11.3%
4	3.6%
5	0.8%
6	0.1%
7	0.002%



Number of vehicles operating

% WILDCAYS	
Vehicles	Simultaneous Use
0	34.6%
1	35.8%
2	21.0%
3	7.0%
4	1.4%
5	0.2%
6	0%
7	0%



Location: Hallward Library
Use: University fleet



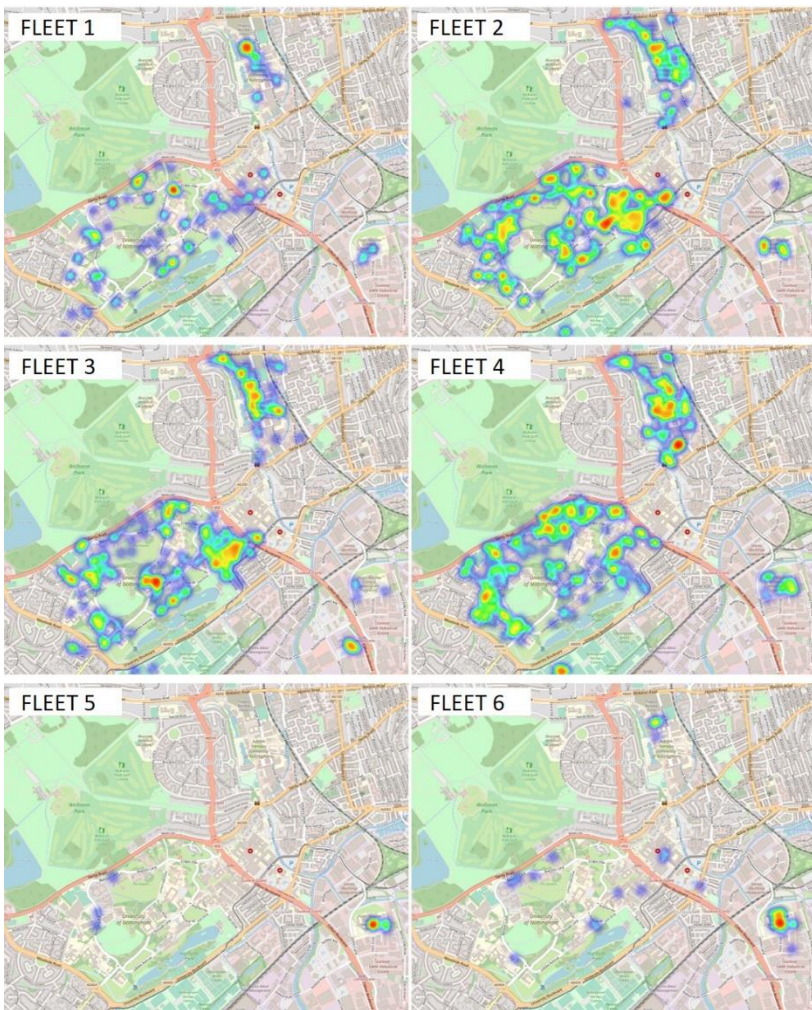
Location: Creative Energy Homes
Use: Integrating V2G & renewable energy generation



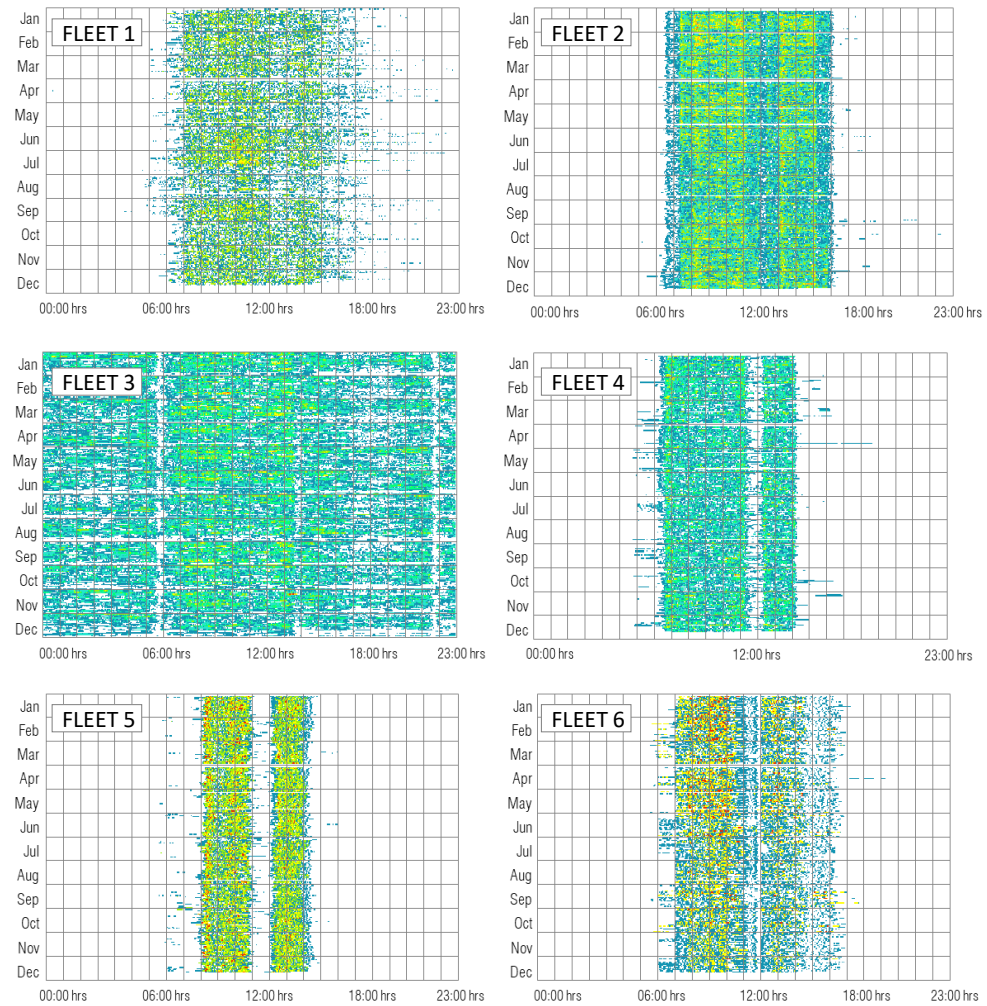


Behaviour data analysis

Long dwell location analysis (stops over 1 hr)



Fleet use patterns (simultaneous use of vehicles)



Vehicles Availability



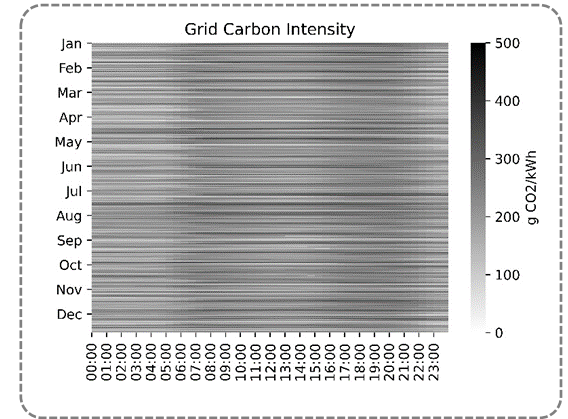
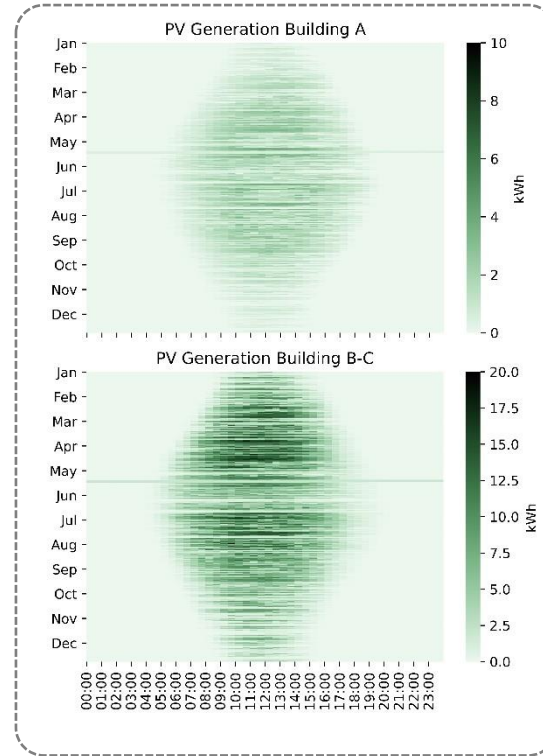
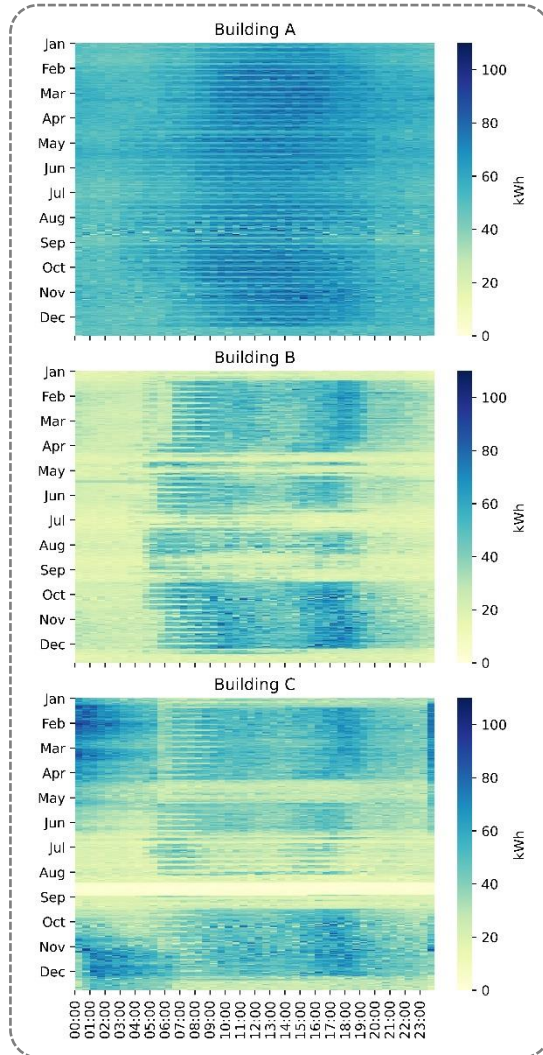
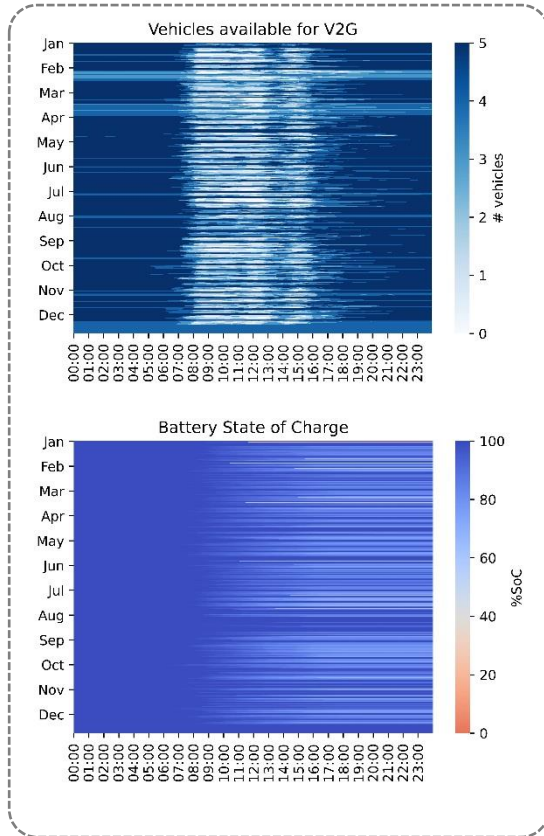
Building Energy Consumption



Renewable Energy Generation

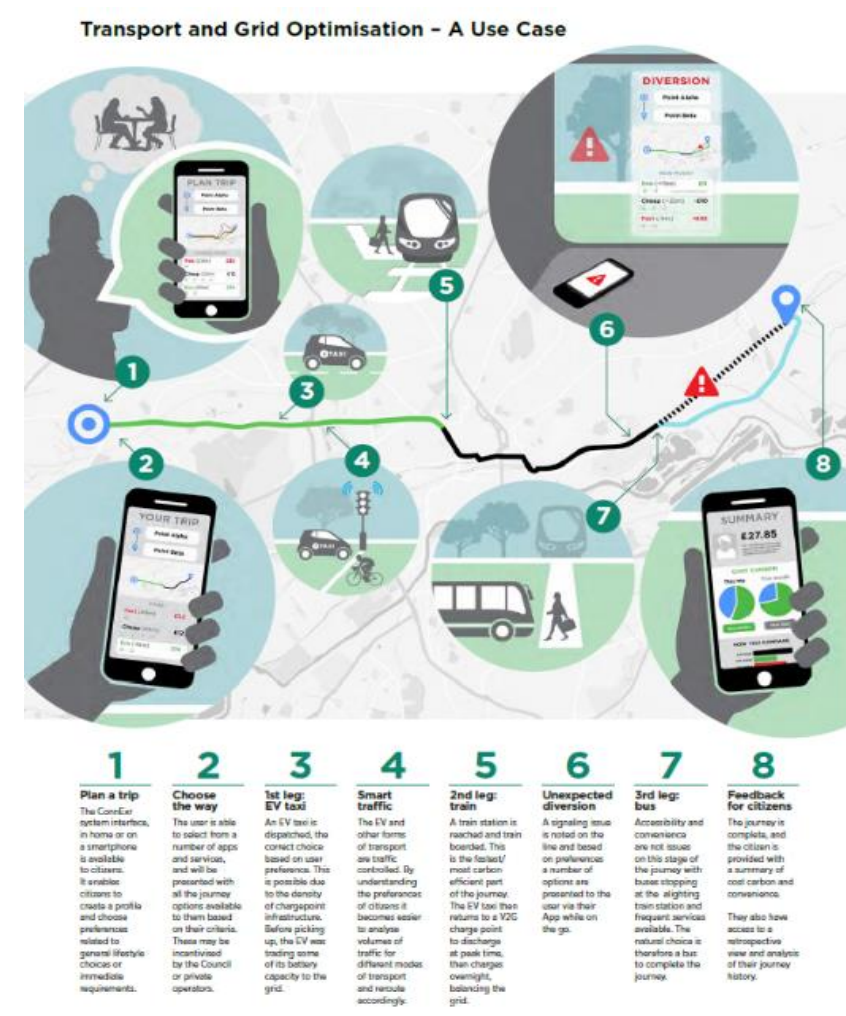
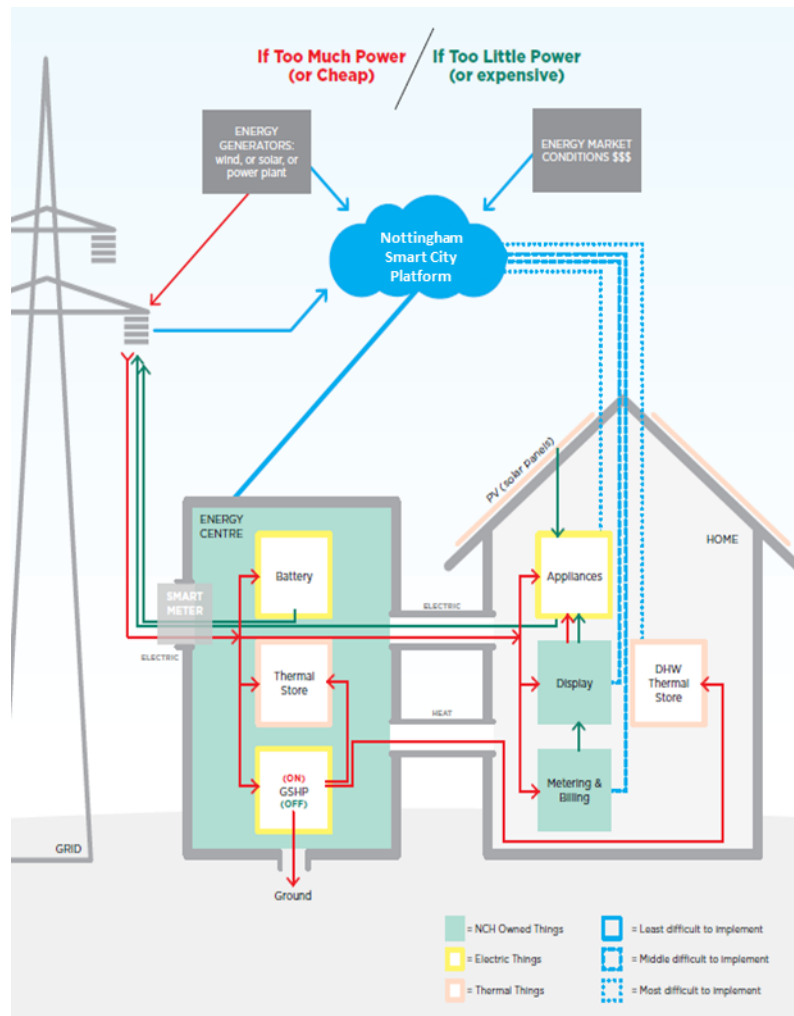
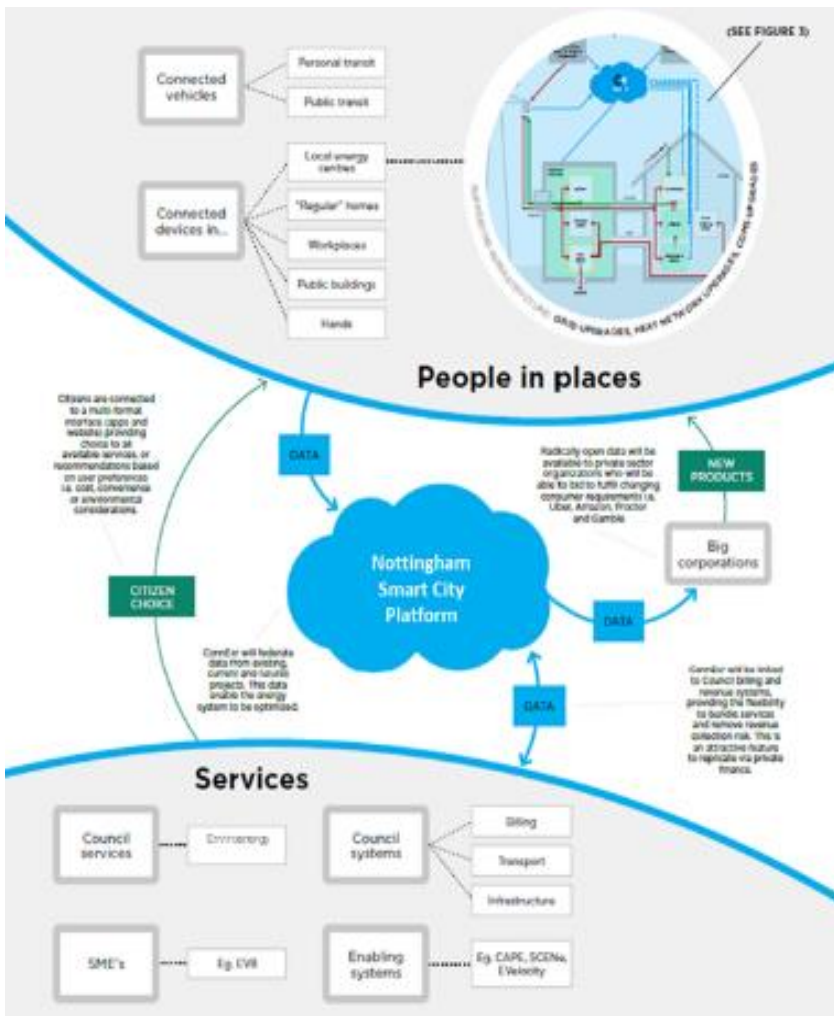


CO₂ Emissions





What next?





Thank you!

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