Digital Twin Technology

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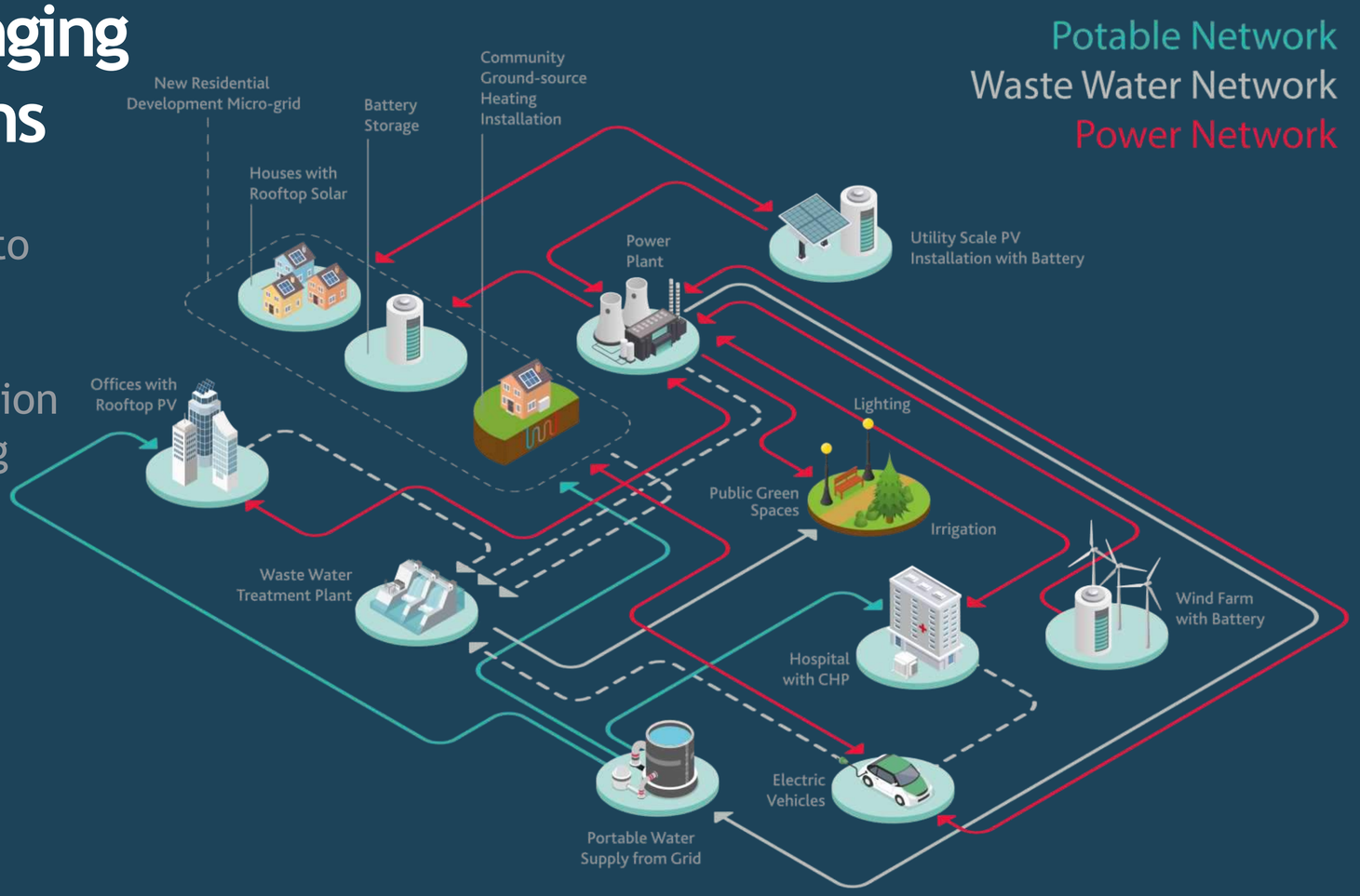
Addressing the rapidly changing world requires new solutions

Traditional energy supply systems are set to change.

Analyse the design, operation and integration of Distributed Resource Networks including heating, cooling, power & water.

New, more complex energy relationships require modelling.

Leverage 5G, Big Data, IoT, smart sensors and smart equipment.



The Difference between Digital Twin and BIM

BIM	Digital Twin
Gathers real-world Data	Gathers real-world data
Static Model	Dynamic Model
Repository of Data – information is attached to it	Responds to Data – produces predictions through simulation, AI and machine learning
Acts like ‘virtual reality’ glasses	Actually behaves like the real world counterpart

The Digital Twin

"a dynamic virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning and reasoning"

Bolton, McColl-Kennedy, Cheung, Gallen, Orsingher, Witell & Zaki, (2018)

The Digital Twin

Energy Efficiency should be the most important decarbonising strategy for the Built Environment.

To improve the Built Environment we need appropriate information and decision support tools to help people make the right decisions.

The simulation tools can help Communities reduce carbon emissions; energy, maintenance and capital costs whilst increasing operational efficiency through accurate Digital Twin simulation technology.

ICL Digital Twin (ICL-DT) leverages the best of both Building Simulation and AI

DT

Building Simulation predicts ‘answers’ using fundamental physics principles
The ICL replicates reality by simulating the physics of energy and heat flow throughout your ICL-DT.

Virtual data
The ICL-DT employs virtual sensors (vSensors™) to better inform decision making. The ICL-DT also has its own Virtual BMS (vBMS™) to interact with the vSensors™ just like the real world.

Hybrid Buildings
Time-series data can be imported into the ICL-DT to create a more accurate ‘hybrid’ model to facilitate good decision making.

Machine Learning uses large datasets to extrapolate ‘answers’
Helps fill in the data gaps in the ICL-DT and allows management of live data e.g. sensor anomalies, keeping the Digital Twin as accurate as possible to enable deeper energy savings.

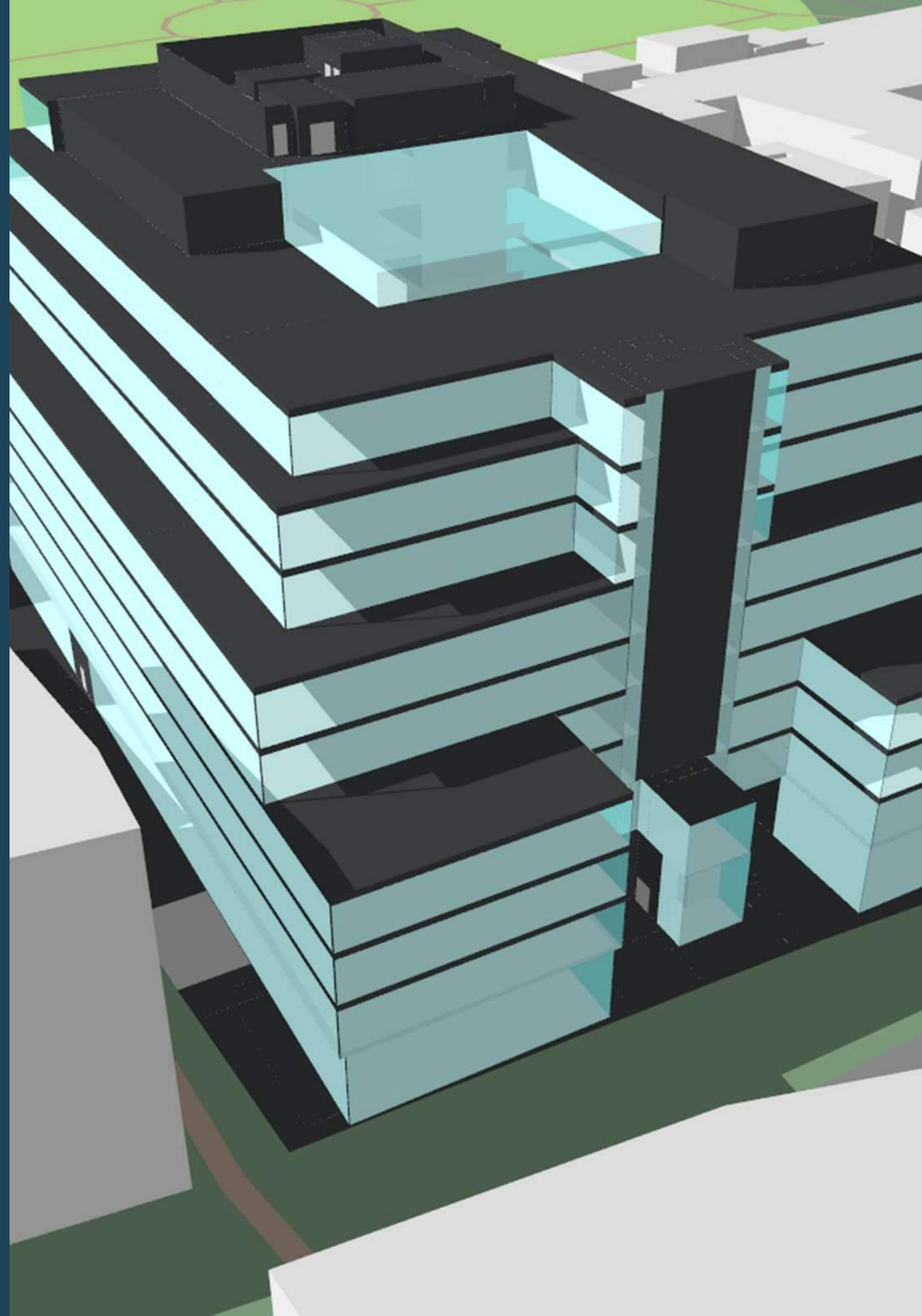
Building/City Simulation vs. Big Data/AI/Machine Learning

Building Simulation can **predict** a new ‘scenario’ and AI / Machine Learning requires data to derive the answer.

Building Simulation is the more powerful capability as it uses fundamental physics that **can simulate scenarios even when no prior data exists.**

AI/ML requires a large dataset to train AI and Machine Learning algorithms to **extrapolate** this data to make faster predictions based on complex data, at scale.

The ICL-DT leverages the best of both building simulation and AI/Machine Learning, allowing us to **more accurately control a building’s operation.**



Building/City Simulation vs. Big Data/AI/Machine Learning

Example: Feasibility of PV collectors for an existing building

- Building Simulation can help determine the size and location of the PV installation and battery.

	Total Demand	Total Generation	Total Imports	Total Excess	Total CO_2	Total Electricity Cost	Average Electricity Cost per home	Total Cost of Installations	Investment per home	Payback
	MWh	*MWh*	*MWh*	*MWh*	*Kg CO_2*	*£*	*£*	*£*	*£*	*years*
Base Case	893.00	584.21	624.56	315.77	320,397	99,929	1,211	-	-	-
With 250 kWh Battery	893.00	584.21	586.71	223.03	300,982	93,873	1,138	53,250	1,065	8.79
With 500 kWh Battery	893.00	584.21	504.35	195.56	258,729	80,695	978	106,500	2,130	5.54
With 1 MWh Battery	893.00	584.21	463.46	154.67	237,755	74,153	899	213,000	4,260	8.26
With 2 MWh Battery	893.00	584.21	432.39	123.60	221,815	69,182	838	426,000	8,520	13.86

ICL Digital Twin (ICL-DT)

Truly understand the performance of your community via your community ICL-DT

Import time-series sensor information from the community BMS into the ICL-DT's vBMS which can **investigate operational problems using AI and machine learning** providing alarms and alerts

Generate missing data to fill data gaps in information from buildings

Improve operational decisions with more accurate calibrated information

Scenario simulation - test ways to improve your community

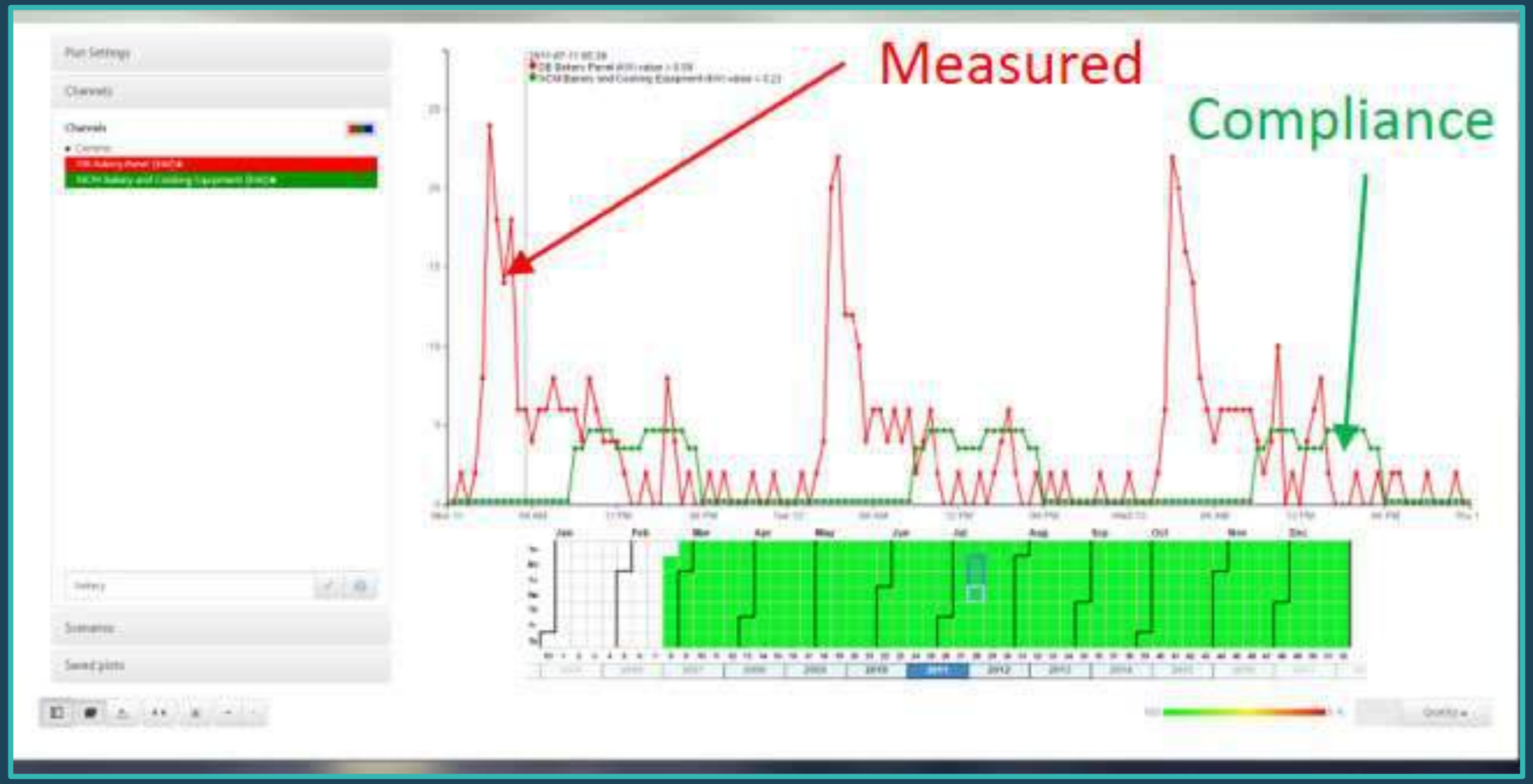
Create and share visually informative information to **facilitate decision making**

AI to help learn from the past to **optimise** the present and future sustainability of your community

Accurate Energy Demand: The Problem

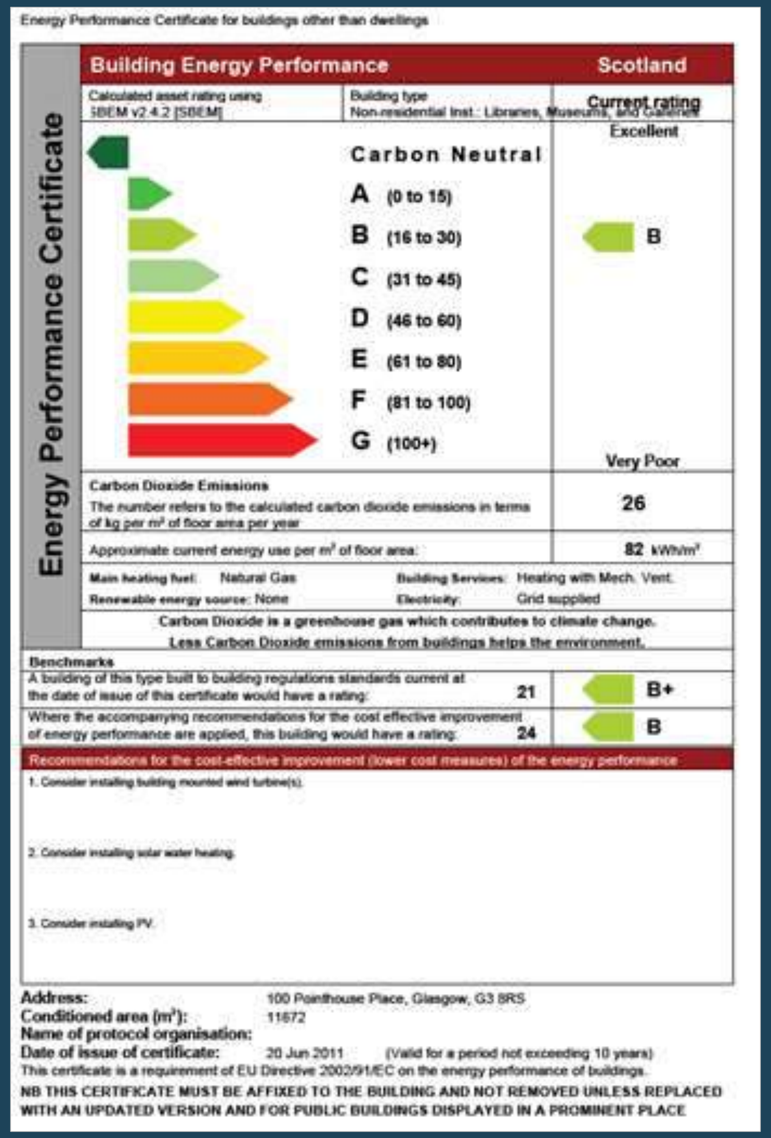
Performance Gap:

Actual
vs
Compliance



Compliance: Green vs Measured: Red

Riverside Museum, Glasgow



Energy Performance Certificate for buildings other than dwellings

Energy Performance Certificate

Building Energy Performance — **Scotland**

Calculated asset rating using SBEM v2.4.2 [SBEM]

Building type: Non-residential Inst.: Libraries, Museums, and Galleries

Current rating: Excellent

Carbon Neutral

A (0 to 15)

B (16 to 30)

C (31 to 45)

D (46 to 60)

E (61 to 80)

F (81 to 100)

G (100+)

Very Poor

B

Carbon Dioxide Emissions

The number refers to the calculated carbon dioxide emissions in terms of kg per m² of floor area per year: 26

Approximate current energy use per m² of floor area: 82 kWh/m²

Main heating fuel: Natural Gas — Building Services: Heating with Mech. Vent.

Renewable energy source: None — Electricity: Grid supplied

Carbon Dioxide is a greenhouse gas which contributes to climate change.
Less Carbon Dioxide emissions from buildings helps the environment.

Benchmarks

A building of this type built to building regulations standards current at the date of issue of this certificate would have a rating: 21 — B+

Where the accompanying recommendations for the cost effective improvement of energy performance are applied, this building would have a rating: 24 — B

Recommendations for the cost-effective improvement (lower cost measures) of the energy performance

1. Consider installing building mounted wind turbine(s).
2. Consider installing solar water heating.
3. Consider installing PV.

Address: 100 Pointhouse Place, Glasgow, G3 8RS
Conditioned area (m²): 11672
Name of protocol organisation:
Date of issue of certificate: 20 Jun 2011 (Valid for a period not exceeding 10 years)

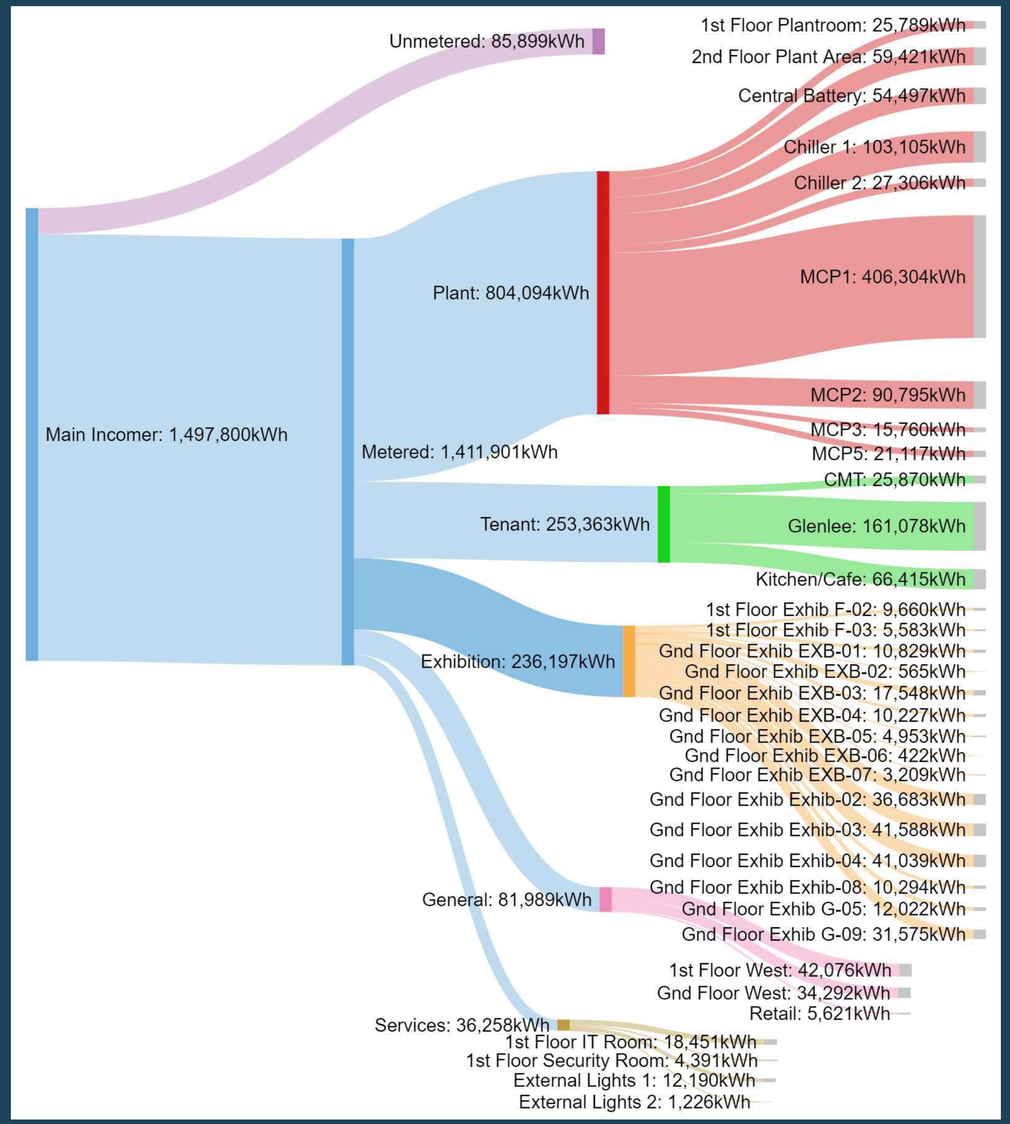
This certificate is a requirement of EU Directive 2002/91/EC on the energy performance of buildings.

NB THIS CERTIFICATE MUST BE AFFIXED TO THE BUILDING AND NOT REMOVED UNLESS REPLACED WITH AN UPDATED VERSION AND FOR PUBLIC BUILDINGS DISPLAYED IN A PROMINENT PLACE

Metered Energy Use x4-5 higher than EPC

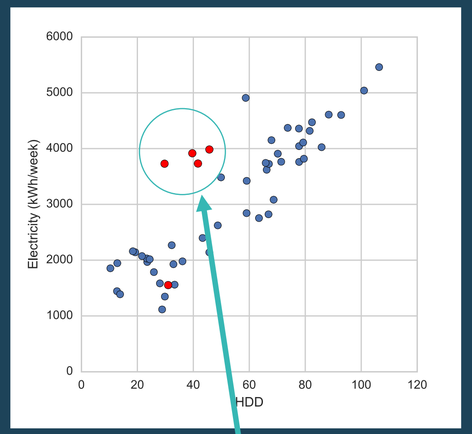
Riverside Museum, Glasgow

Submetered Energy:
Nov 2016 – Oct 2017

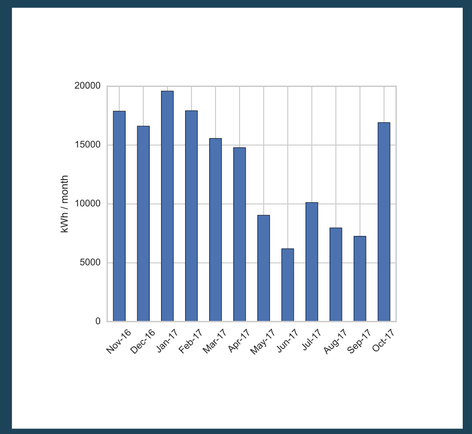


Riverside Museum, Glasgow

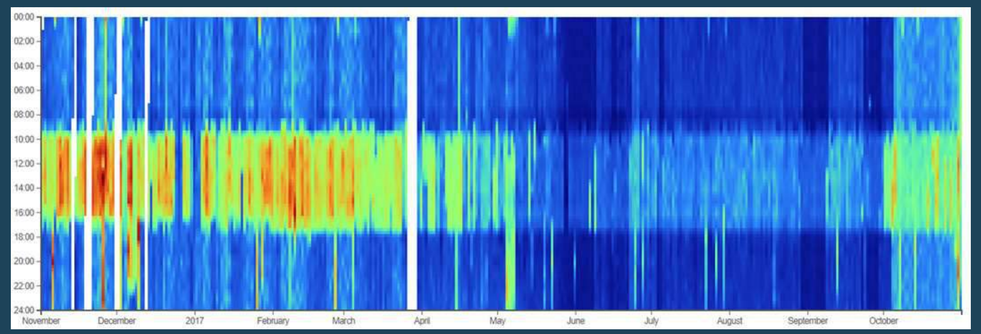
Glenlee Weekly Electricity vs Heating Degree Days



Glenlee Monthly Power Consumption

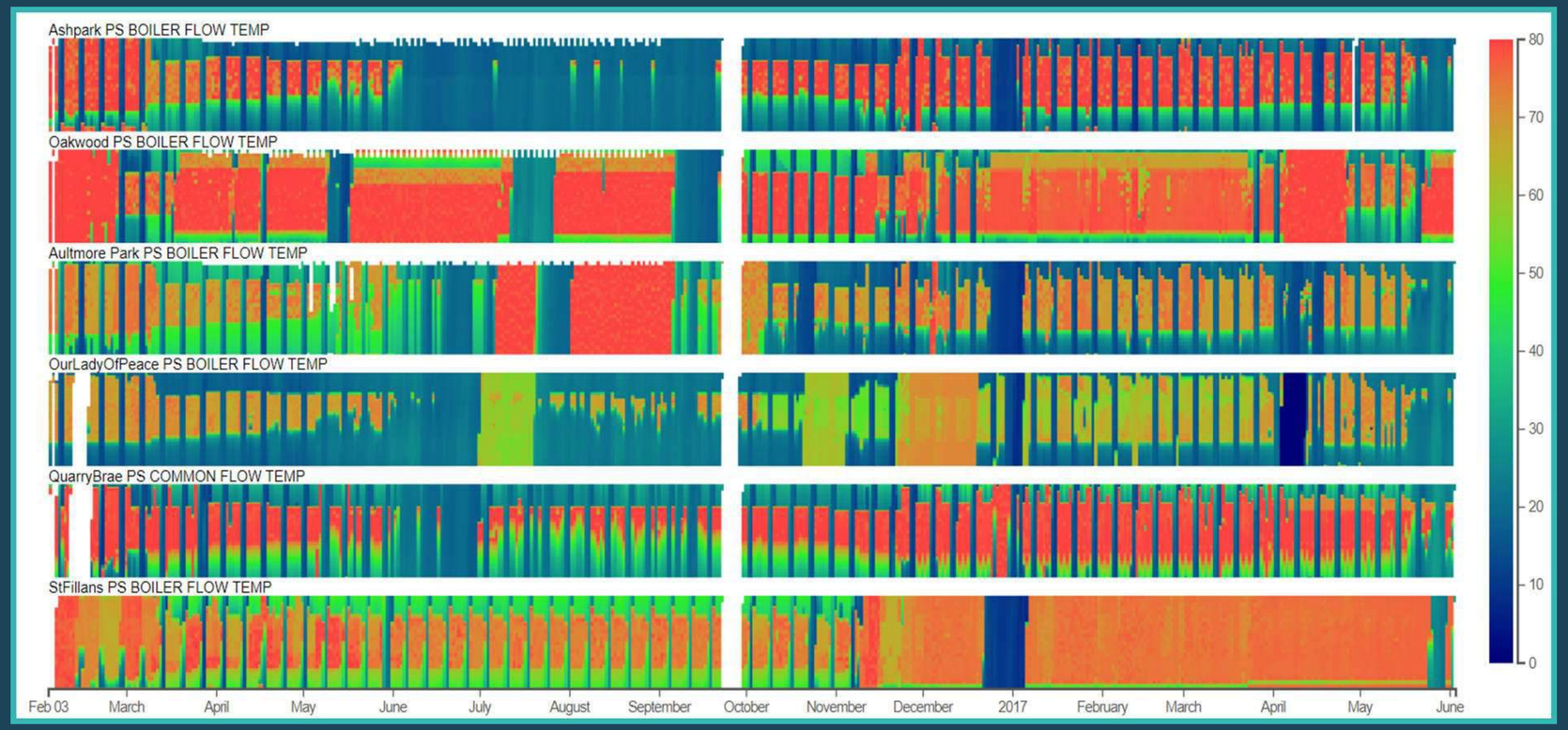


Power consumption increases in October 2017. The increase is much higher than would be expected based on the colder weather.



Glenlee Power Consumption Heatmap (Nov 2016 - Oct 2017)

iSCAN/Ci²: Collect & Investigate on one platform



Investigate

- 6 schools in Scotland: time-series of Boiler Flow Temperature
- Heat Map of Boiler Flow Temperature over 16 months
- Identify problems

CoS

Accurate Energy Demand: Calibration

Measurement & Verification (M&V)

Calibration:

- No Calibration
- Monthly Bills
- Time-series