CIBSE BSG

Linking Building Design Performance with BIM

Dr Sarah Graham

The Future of Building Simulation

14th May 2015

Digital Built Britain

Level 3 Building Information Modelling - Strategic Plan

February 2015

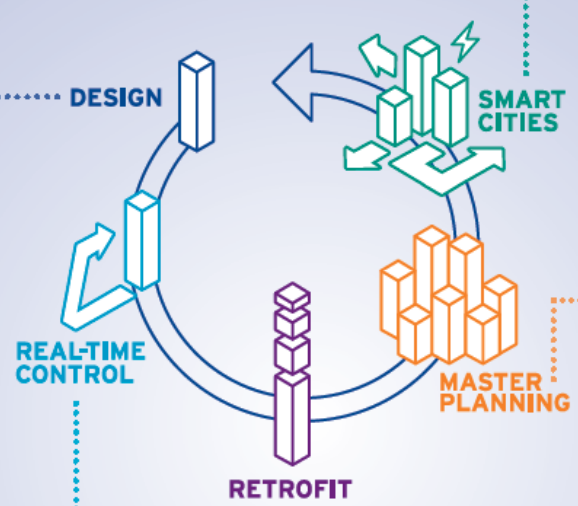
UCL

Digital Built Britain

IES Research and Development

IES is involved in all levels of research with respect to sustainable and environmental design for spaces, buildings, neighbourhoods and cities. Research is both singular and collaborative with a proven track record of working with industrial and academic partners on singular and collaborative research projects.

Our Vision



DESIGN

At IES, we are constantly pushing the boundaries of design and simulation technology. This includes integration with Building Information Modelling (BIM) and interoperability with other technologies in the design, construction and energy management sectors.

KEY POINTS

- Pushing the boundaries of design and simulation
- BIM & Interoperability
- Better Building Design
- Closing the Gap between Estimated and Actual Energy Consumption
- Optimisation for BREEAM & LEED & high performance buildings

COMPLETED PROJECTS
Optimise, IMPACT, LESSONS

SMART CITIES

With a focus on how a city can operate intelligently, we are investigating the interactions between a portfolio of buildings, the electricity grid and Renewable Energy Technologies. This includes demand response and tariff analysis and examining the interactions and connections of buildings at district level. Further investigation into the simulation of water and waste networks to maximise energy efficiency is also being carried out along with investigations into transport routes and the electric vehicle networks. The ultimate aim is to understand how the city performs as a set of sub-systems.

KEY POINTS

- Simulation of Portfolio of Buildings across a city
- District modelling and simulation
- Modelling the connections between Buildings, the Electricity Grid and Renewable Technologies
- Demand Response Analysis and Tariff Analysis
- Simulation of Water & Waste Networks
- Simulation of Transport Network and the EV Grid

LIVE PROJECTS
iUrban, CI-NERGY, GLASGOW FUTURE CITIES, People Friendly Cities

MASTERPLANNING

To bring design, operation and the smart city together, we are creating decision support tools for city architects and urban planners with respect to how to design their city and its subsystems at any stage of the cities life. This includes tools to inform urban development plans, tools to inform and incentivise the integration of Renewable Energy Technologies and ICT and Control Technologies and tools to optimise an existing cities systems and networks.

KEY POINTS

- Decision Making Tools for City Architects and Urban Planners
- 3D Visual City Simulation Tools
- Sustainable Urban Indicators for Energy Related Decision Making
- Connections with Simulation and Geographical Information & City Databases
- Whole Life Neighbourhood Analysis

LIVE PROJECTS
CitySUMS, INDICATE, FASUDIR, FORTISSIMO

REAL-TIME CONTROL

Here our research focuses on how the simulation environment can be exploited to intelligently control the building. This includes investigation into Model Based Control for Fault Detection Identification Analysis, Optimisation of the Building while in use and Predictive Control based on future weather data. The aim is to provide appropriate and accurate information to allow Energy Managers understand where inefficiencies are present and mitigate or eradicate these inefficiencies completely. This information will help to plan energy efficiency actions based on actual energy production and consumption, presented as real savings and end-user's comfort levels.

KEY POINTS

- Intelligent & Model Based Control
- Using Simulation for Fault Detection & Analysis
- Real-Time Optimisation & Control of Buildings
- Real-Time Prediction of Building Use
- Direct connections between Simulation Environment & BMS / Building Sensors

LIVE PROJECTS
VERYSchool, Energy in Time, EINSTEIN

RETROFIT

Our research for retrofit design and decision making focuses on how to use simulation to adapt and upgrade existing buildings to be sustainable and energy efficient throughout their lifetime. The aim is to provide tools that will assess the way in which current buildings are operated and help find solutions that will be adaptable over time, as well as for performance contracting.

KEY POINTS

- Retrofit Design & Decision Making
- Predictive Design for Performance Contracting
- SMART Buildings

COMPLETED PROJECTS
SCAN

LIVE PROJECTS
EASEE, HAR-WIN, UMBRELLA, RESSEEPE

RETROFIT FOR MANUFACTURING ENVIRONMENT

Further to this, IES is stepping outside the boundaries of just the building and is looking in particular at the manufacturing environment and the interactions between the manufacturing processes and the building environment.

COMPLETED PROJECTS
THERM

LIVE PROJECTS
REEMAIN

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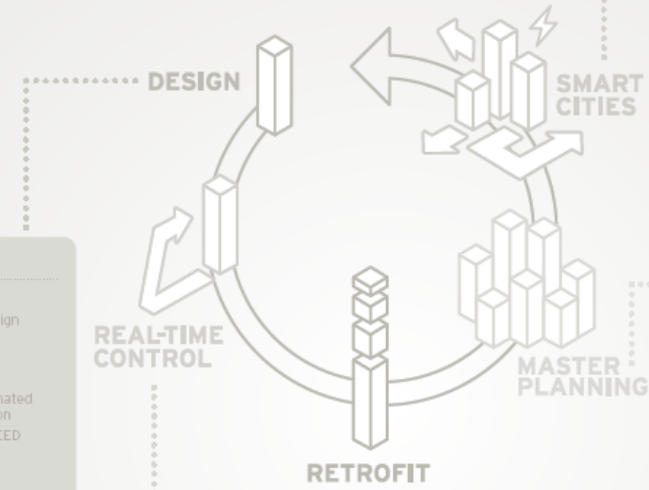

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Optimise, IMPACT, LESSONS

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DIR,

consumption, presented as real savings and end-user's comfort levels.

TURING

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t and the anufacturing environment.

SMART CITIES

Glasgow Future Cities – An App to allow building owners to understand how to reduce energy consumption and retrofit their buildings.

Glasgow CITY COUNCIL

Future of Building Simulation

PA5 1192 STAGE	STRATEGY	BRIEF	CONCEPT	DEFINITION	DESIGN	BUILD & COMMISSION	HANDOVER	O&M
INFORMATION MODEL	Design (Federated) Model					Construction Model		O&M Model
PRINCIPAL S.L ACTIONS		Briefing		Design Dev		Pre-handover	Initial Aftercare	1-3 Year Aftercare
OUTPUT	Strategies for Electricity, Gas, Water & District Heating and Cooling.	Oriented model to minimise energy, maintenance and replacement costs. Review existing resources	Services, Philosophy, Outline planning, Prelim P&L, BREEAM/CfSH.	Services, layout & zoning Energy, carbon & cost Interim P&L Update BREEAM/CfSH	Coordinated design, site layouts, GA's, Services & controls strategies, cost plan schedules.	As built model, Soft landings, Performance metrics.		Ongoing performance review and feedback.
HOW THE VE FITS	Masterplanning	VE for Architects – Climate – Bioclimate – Water – Renewables (natural resources) – Initial energy & carbon optioneering – Feasibility Studies	VE for Engineers – Compliance – Daylighting – Orientation – Glazing – Shading – Water – LZCT – IMPACT: materials, LCC/ LCA – FAQ – Comfort	VE for Engineers – Energy, carbon, cost – Compliance – Daylighting etc – ApacheHVAC: Autosize main plant components	VE for Engineers – Detailed – Final design – Final P&L & EPC – Final BREEAM – Final LCA/LCC – BREEAM/ CfSH	ERGON Enhanced commissioning & soft landings performance feedback (energy, carbon, cost, visual & thermal comfort controls etc.)		ERGON Feedback loop: capture metered data, compare with the design scenario, feed into subsequent designs.

Ref: Department for Business Innovation & Skills (BIS)
Local Government Model BIM Process Map Cabinet Office

Future of Building Simulation

"A process for the graduated handover of a new or refurbished building, where a period of professional aftercare by the project team is a client requirement – planned for and carried out from project inception onwards – and lasting for up to three years post-completion"

GCC PoC Buildings

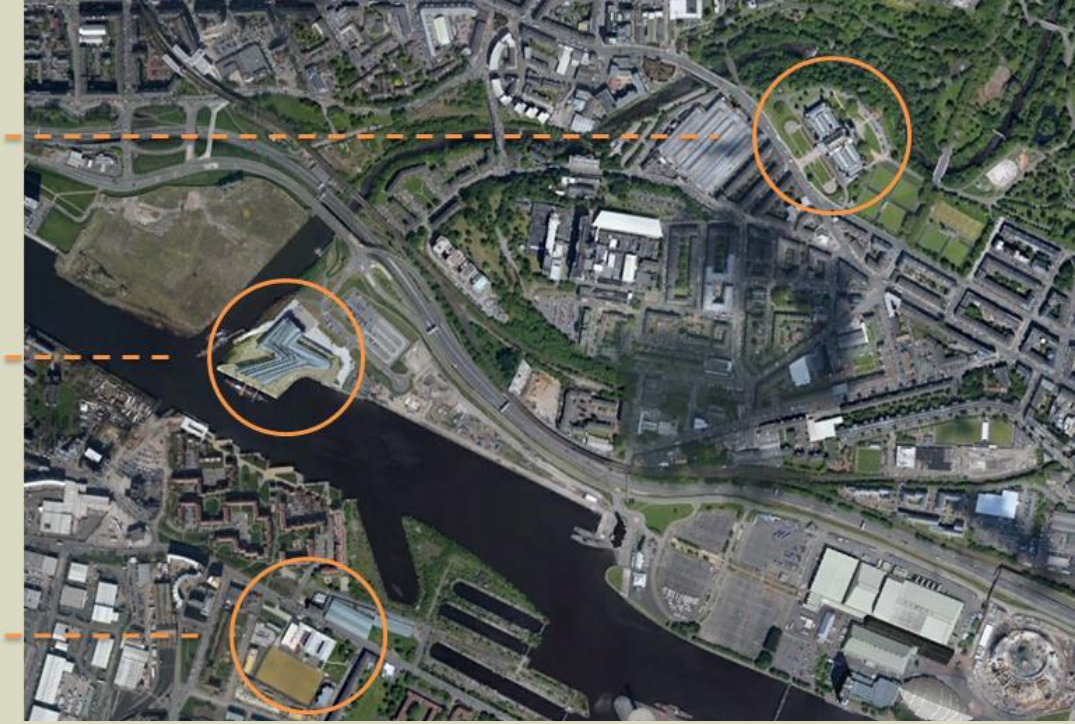
Buildings selected in order to provide a broad variety ty of functions.

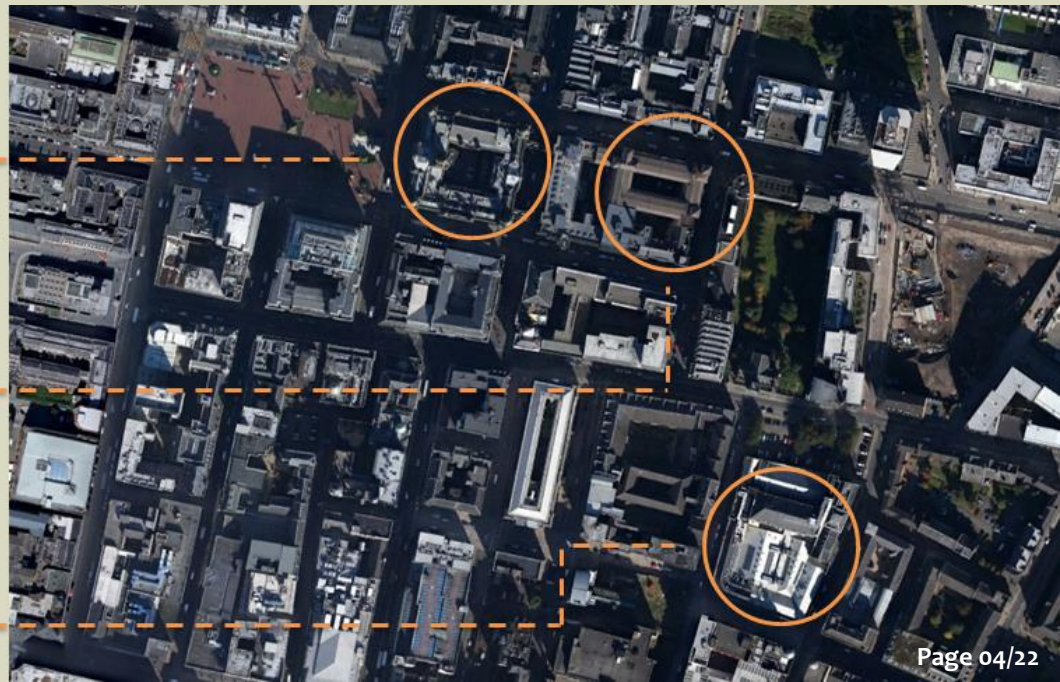
Use lessons learned on other buildings of similar type.

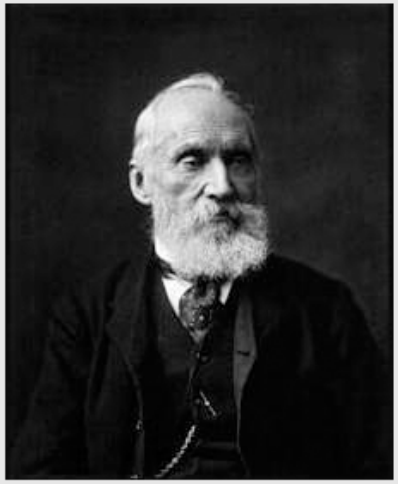
School
- **Riverside Primary School.**

Museums
- **Riverside Museum**
- **Kelvingrove Art Gallery**

Offices
- **Glasgow City Chambers**
- **Exchange House**
- **Collegelands**



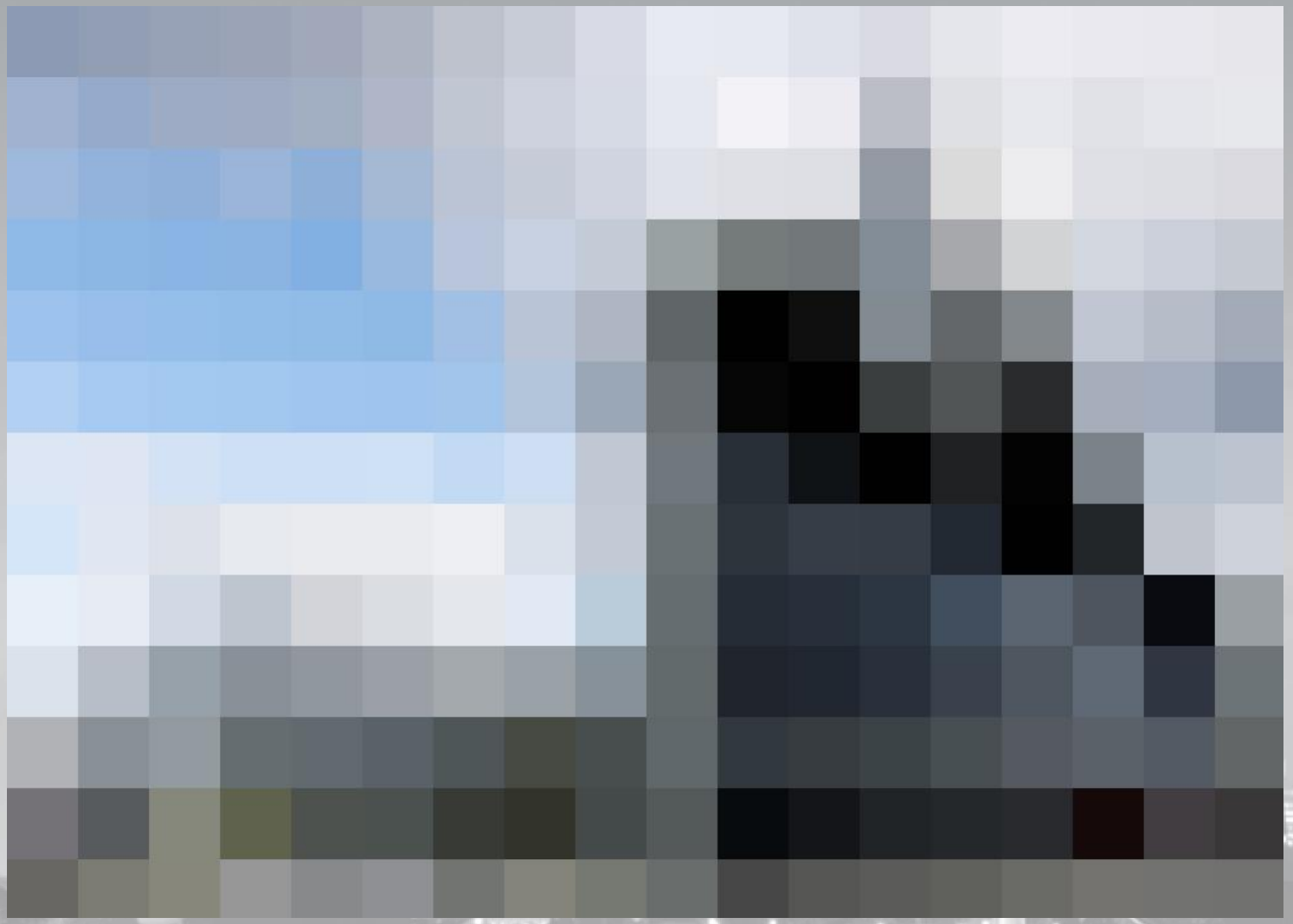


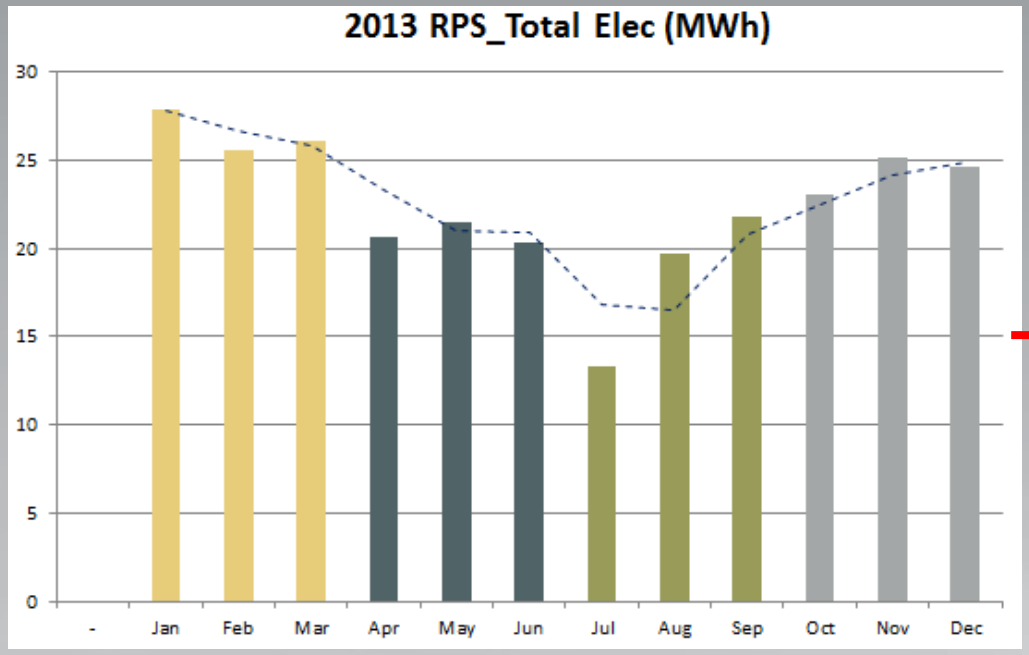


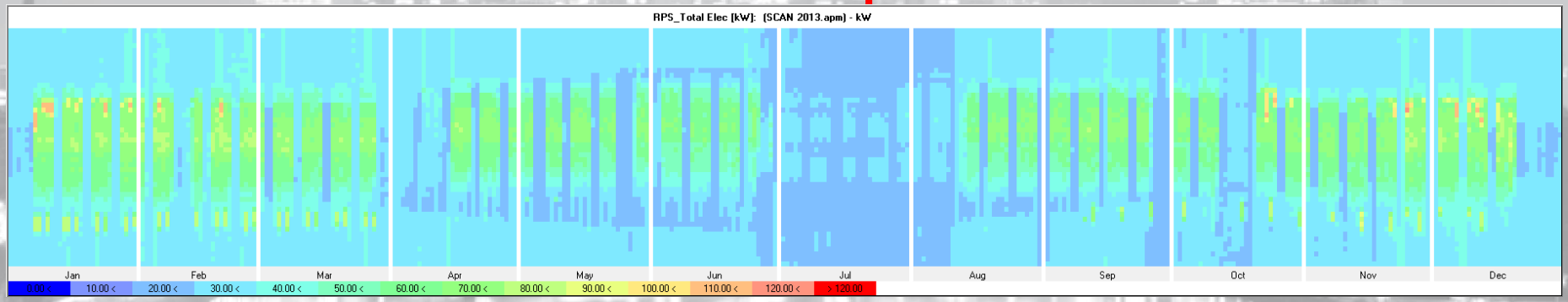
I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.

{Lord Kelvin}

- If you can measure what you are speaking about in numbers – then you know something about it!
- If you cannot express it in numbers – your knowledge is meagre & unsatisfactory
- With numbers (data!) you advance to the state of Science!
- **<u>If you can't measure it you can't improve it!</u>**




2013 RPS_Total Elec (MWh)
30
25
20
15
10
5
0
-
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


RPS_Total Elec [kW]: (SCAN 2013.apm) - kW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0.00 <
10.00 <
20.00 <
30.00 <
40.00 <
50.00 <
60.00 <
70.00 <
80.00 <
90.00 <
100.00 <
110.00 <
120.00 <
> 120.00

SOURCE DATA LOCATIONS

AMR
Automatic Meter Reading

BMS
Building Management System

+ Others

LMS
Lighting Management System

DES
Door Entry Systems etc

DATA FORMATS & TRANSLATIONS

Software >

SQL Database
CSV (Comma Separated Value)
XML
XSLT's
OBIX
JSON
NiagaraAX
Email / POP3

– – – – – – – – – – – – – – – – –

Hardware >

BACNet
ModBus
LonWorks

- Unlocking Fees by BMS Hardware Manufacturers
- A difference between an 'Open' and 'Truly Open' system

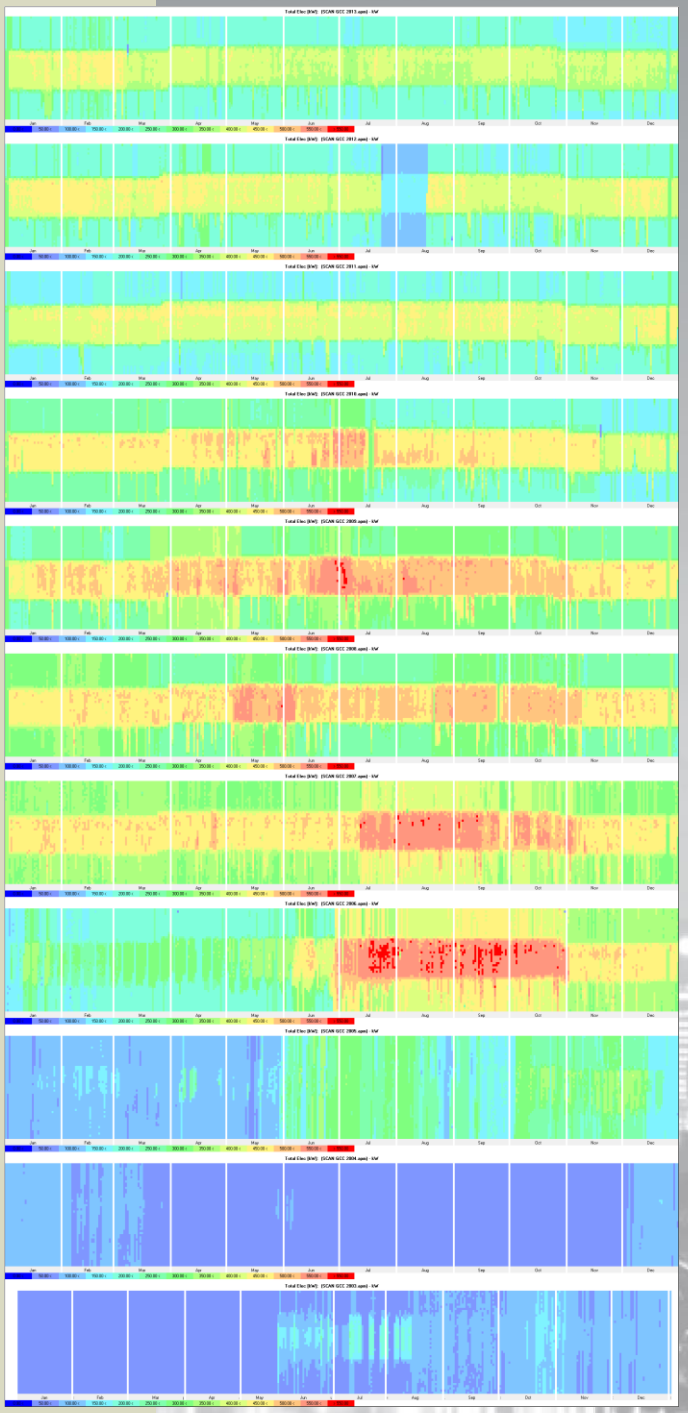
Smart-Metering

Main Incoming Utilities
- Electricity
- Gas

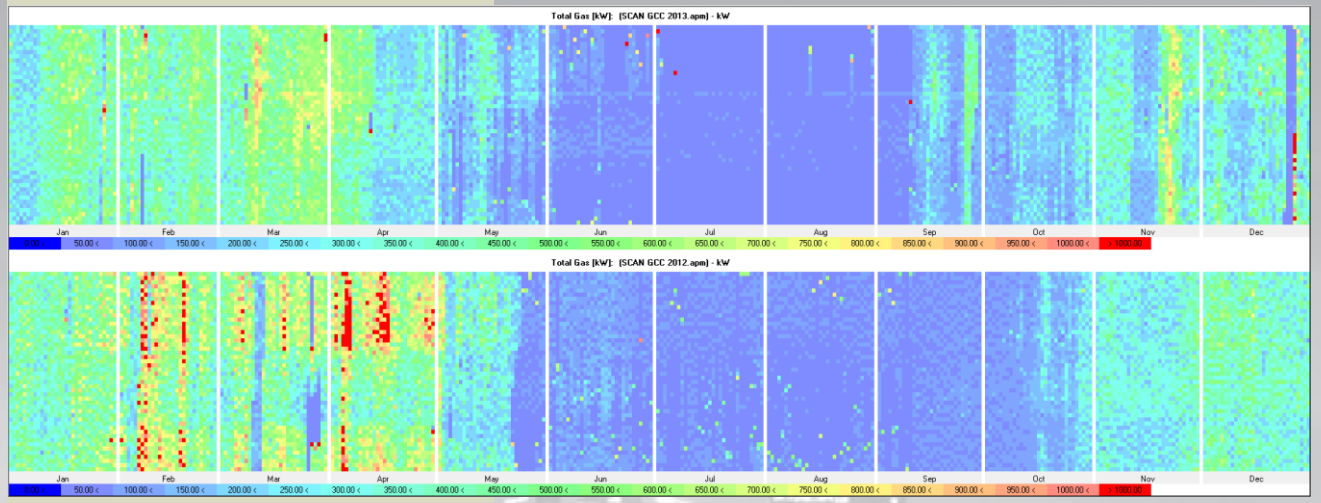
Automatic Meter Reading (AMR) Technology

Typically 6-yrs + of Electrical AMR at 30-min resolution

Is this Big Data?

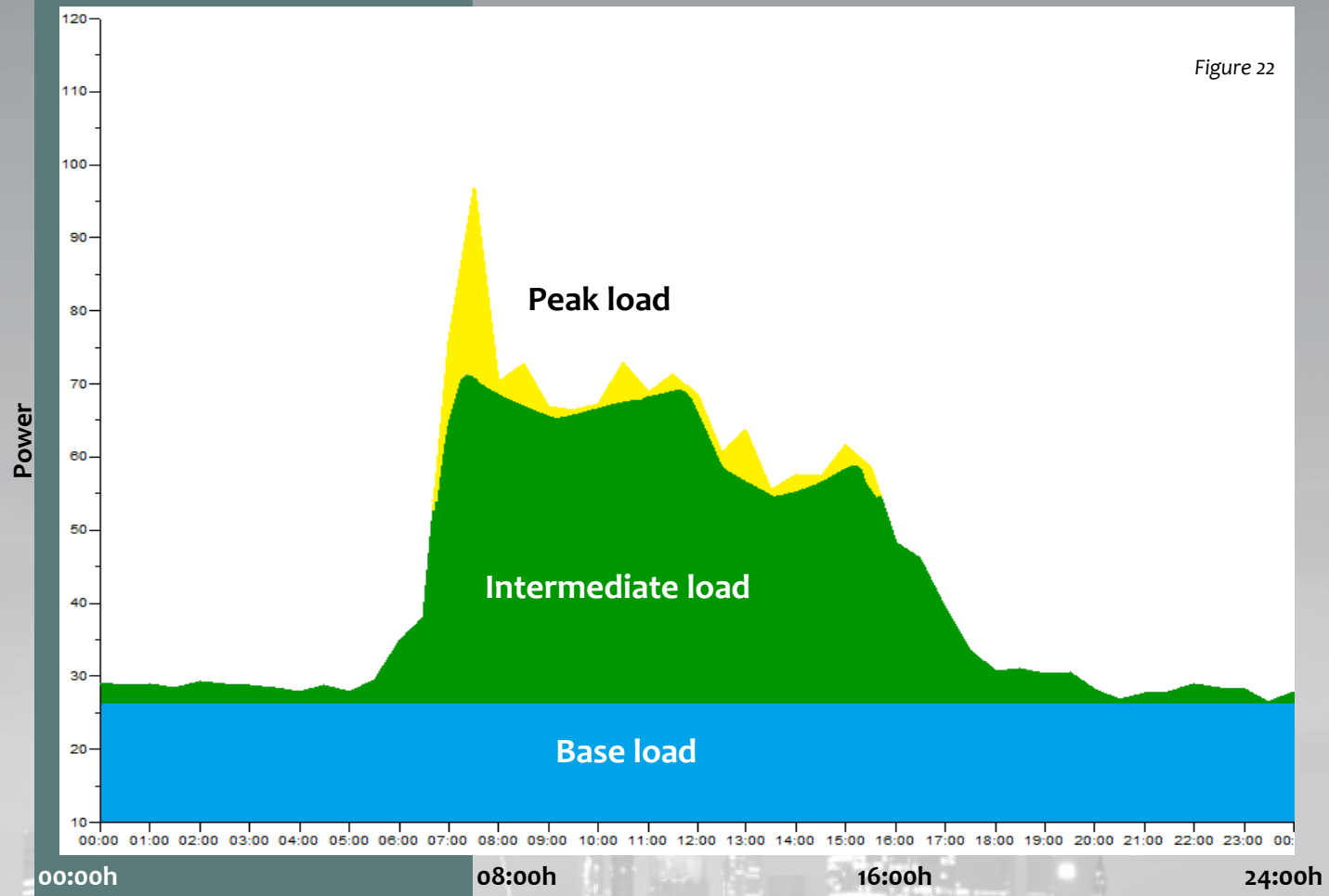


Less available on Gas AMR
Typically 2-yrs also at 30-min



Top: 2013 gas
Bottom: 2012 gas

Loads Analysis

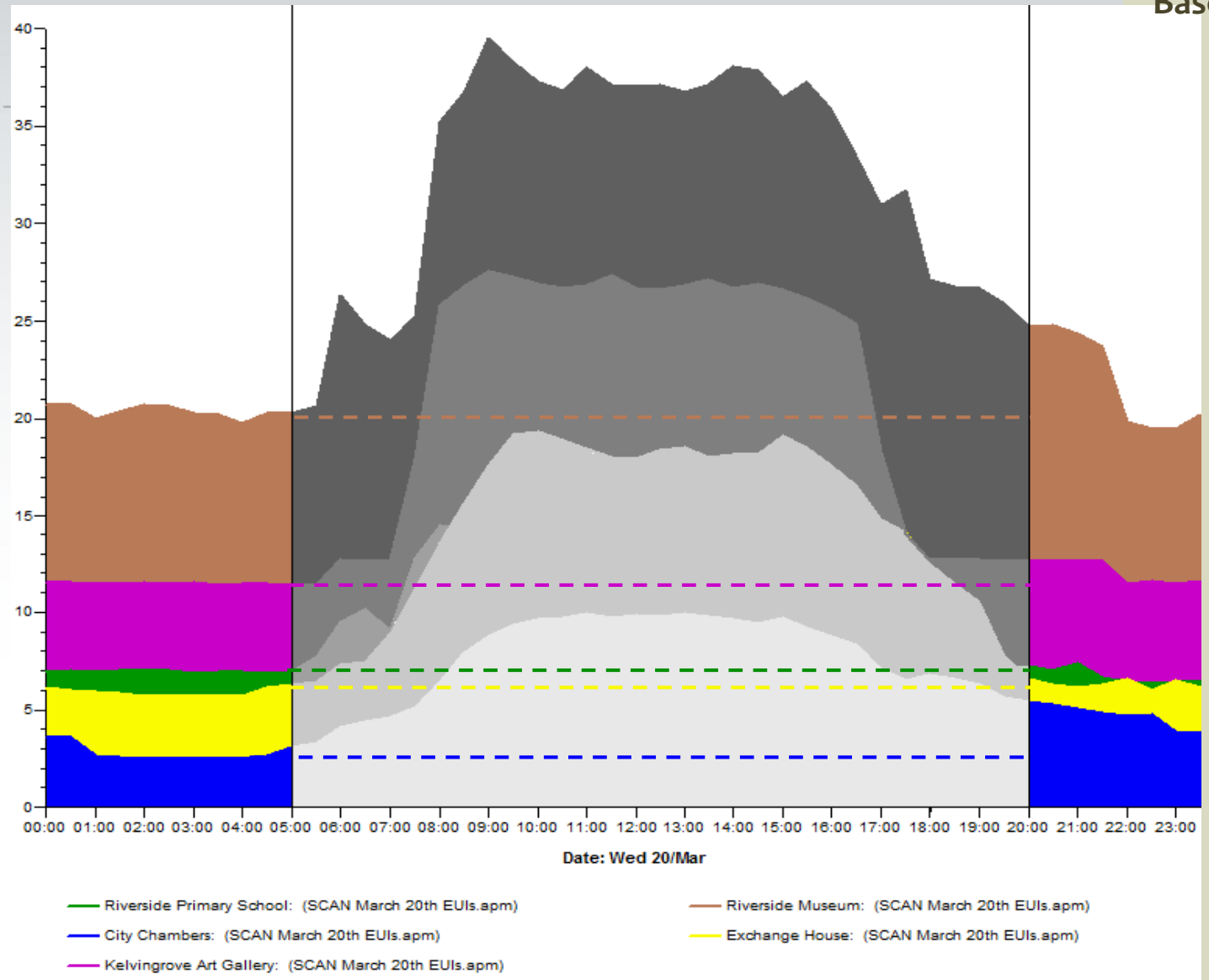


Base load is the minimum amount of power over a given period, that is, the basic amount of electricity that is always required on a 24/7 basis.

Intermediate loads comprise of typical daily power users (higher during occupied hours), e.g. display lighting, staff computers and equipment, kitchen equipment etc.

Peak loads are the daily fluctuation of electricity use e.g. typical HVAC response to fluctuations in external weather conditions.

Base Load Comparison



RM = 21 W/m²

KAG = 11.5 W/m²

RPS = 7.1 W/m²

EH = 6.5 W/m²

CC = 2.5 W/m²

Building Management System (BMS)

Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building's M&E HVAC equipment.

Typically x2 types of sensors within the BMS:

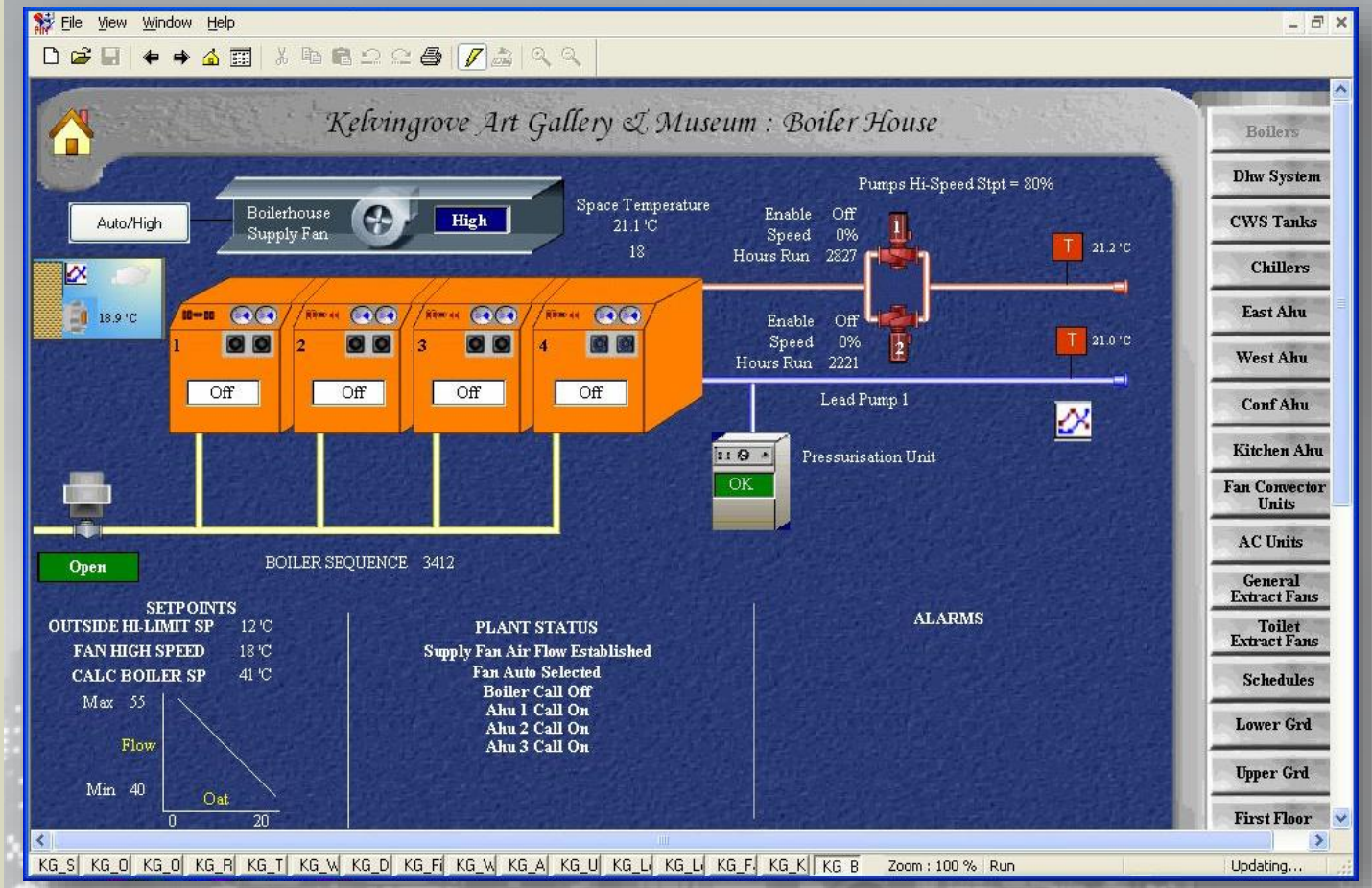
IEQ
+
MEP

Examples of IEQ:

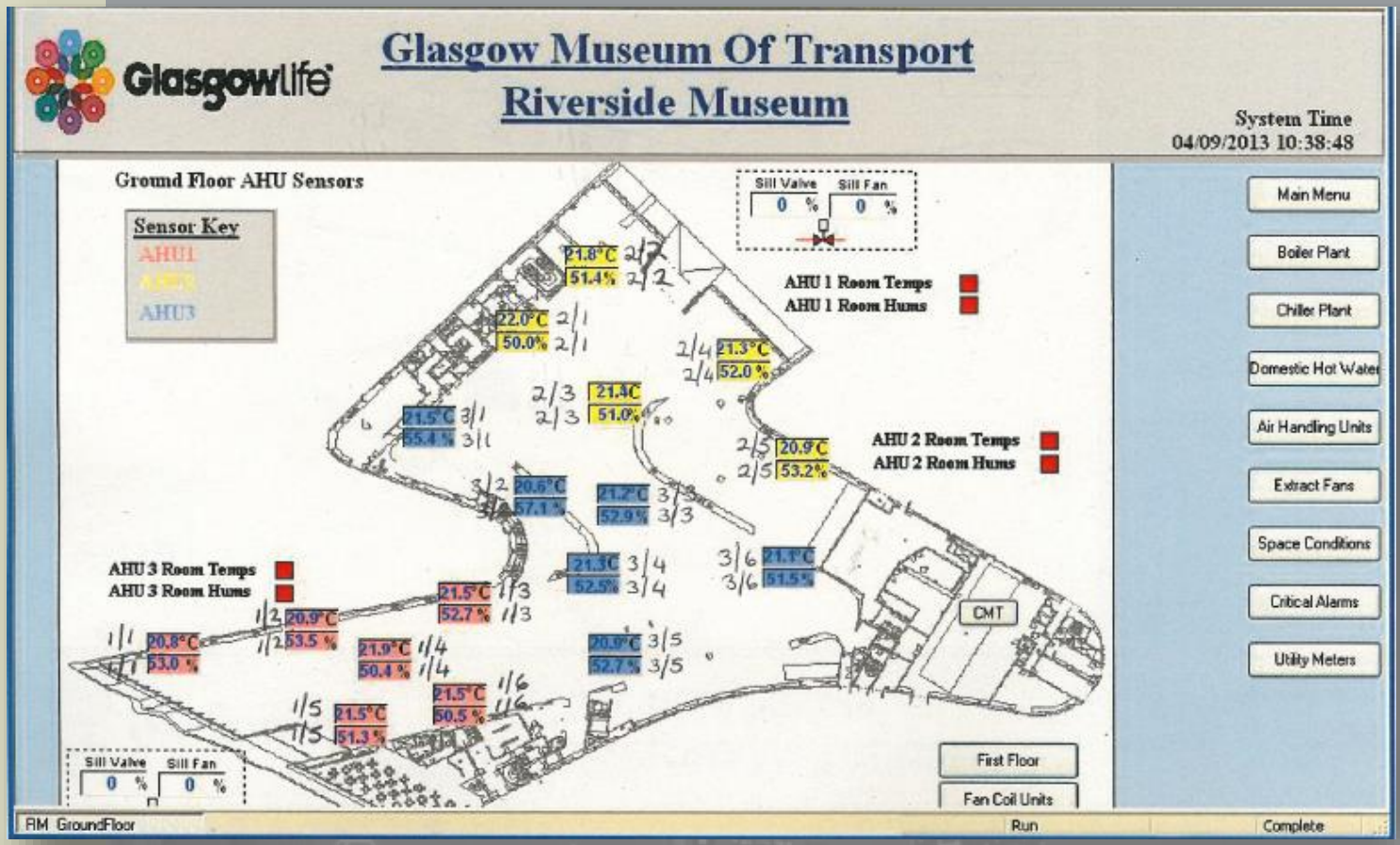
- Air Temperature Sensor
- Relative Humidity
- Carbon Dioxide (CO_2)

Examples of MEP:

- Boiler Flow+Return Temperatures
- Chiller Flow+Return Temperatures
- Pump On/Off Signals e.g. 1/0
- Fan On/Off Signals e.g. 1/0
- Valve Positions e.g. 0-100 %
- VSD Fan Speed e.g. 0-100%



IEQ Sensors


Glasgow Museum Of Transport
Riverside Museum
System Time
04/09/2013 10:38:48
Ground Floor AHU Sensors
Sensor Key
AHU1
AHU2
AHU3
Sill Valve
Sill Fan
0 %
0 %
AHU 1 Room Temps
AHU 1 Room Hums
AHU 2 Room Temps
AHU 2 Room Hums
AHU 3 Room Temps
AHU 3 Room Hums
21.8°C
51.4%
22.0°C
50.0%
21.3°C
52.0 %
21.4C
51.0%
21.5°C
55.4 %
20.9°C
53.2%
20.6°C
57.1 %
21.2°C
52.9 %
21.3C
52.5%
21.1°C
51.5%
21.5°C
52.7 %
20.8°C
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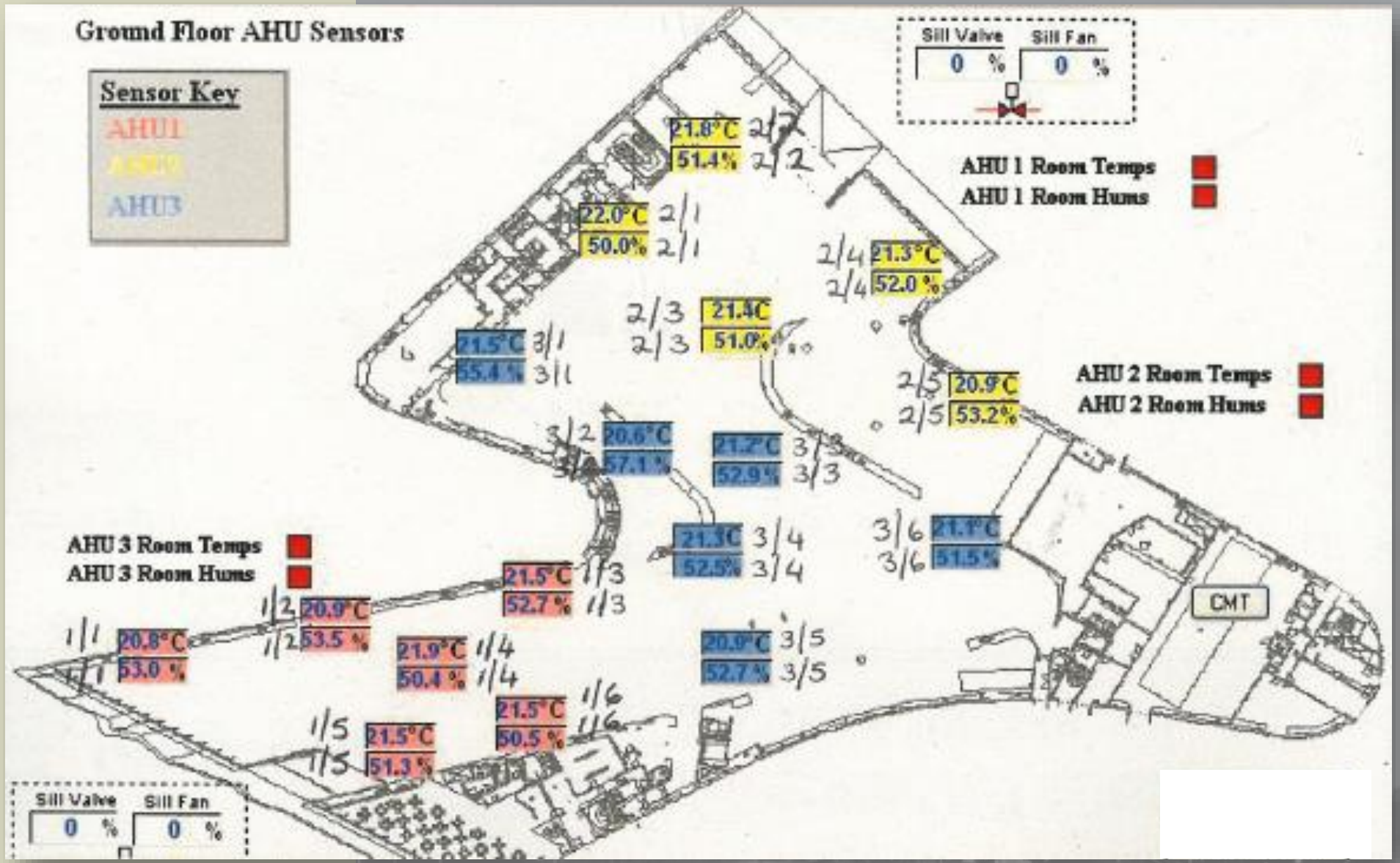
20.9°C
53.5 %
21.9°C
50.4 %
20.9°C
52.7 %
21.5°C
50.5 %
21.5°C
51.3 %
CMT
Main Menu
Boiler Plant
Chiller Plant
Domestic Hot Water
Air Handling Units
Extract Fans
Space Conditions
Critical Alarms
Utility Meters
First Floor
Fan Coil Units
RM GroundFloor
Run
Complete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AHU1
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Sill Valve
0 %
Sill Fan
0 %
AHU 1 Room Temps
AHU 1 Room Hums
AHU 2 Room Temps
AHU 2 Room Hums
AHU 3 Room Temps
AHU 3 Room Hums
21.8°C 2/2
51.4% 2/2
22.0°C 2/1
50.0% 2/1
21.3°C 2/4
52.0 % 2/4
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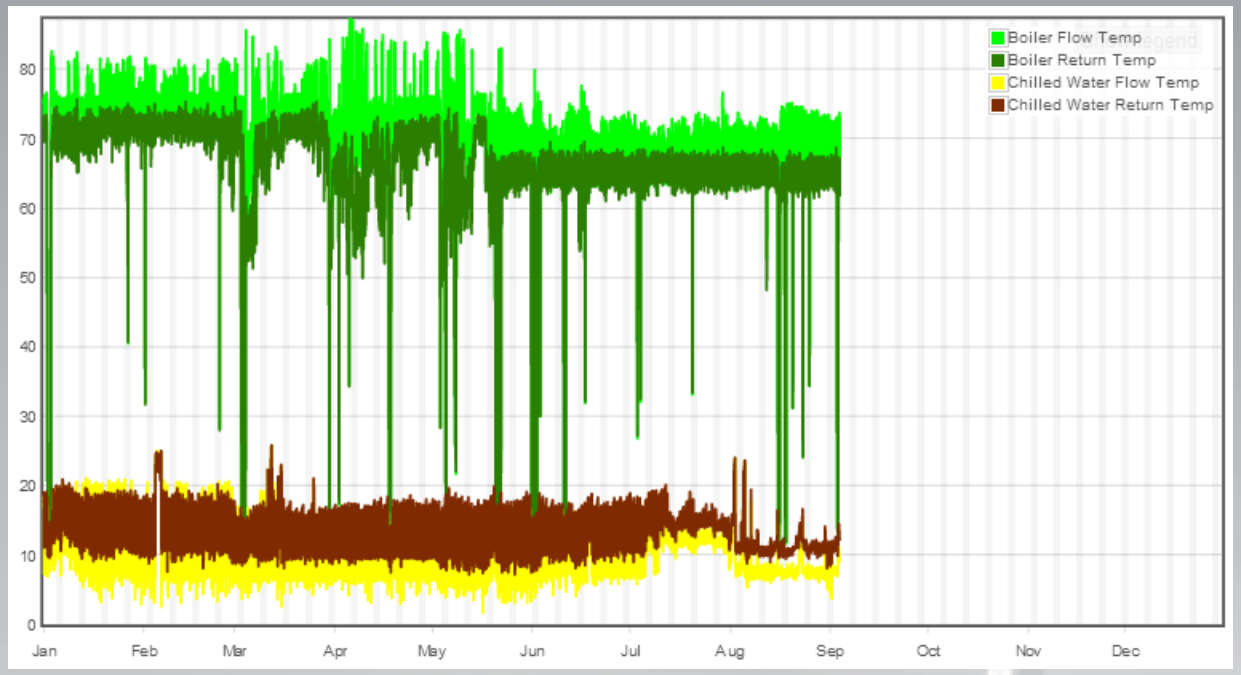
53.2% 2/5
20.6°C 3/2
57.1 % 3/2
21.2°C 3/3
52.9% 3/3
21.3°C 3/4
52.5% 3/4
21.1°C 3/6
51.5% 3/6
CMT
21.5°C 1/3
52.7 % 1/3
20.9°C 1/2
53.5 % 1/2
20.8°C 1/1
53.0 % 1/1
21.9°C 1/4
50.4 % 1/4
20.9°C 3/5
52.7% 3/5
21.5°C 1/6
50.5 % 1/6
21.5°C 1/5
51.3 % 1/5
Sill Valve
0 %
Sill Fan
0 %

MEP Sensors


Boiler Flow Temp
Boiler Return Temp
Chilled Water Flow Temp
Chilled Water Return Temp
0
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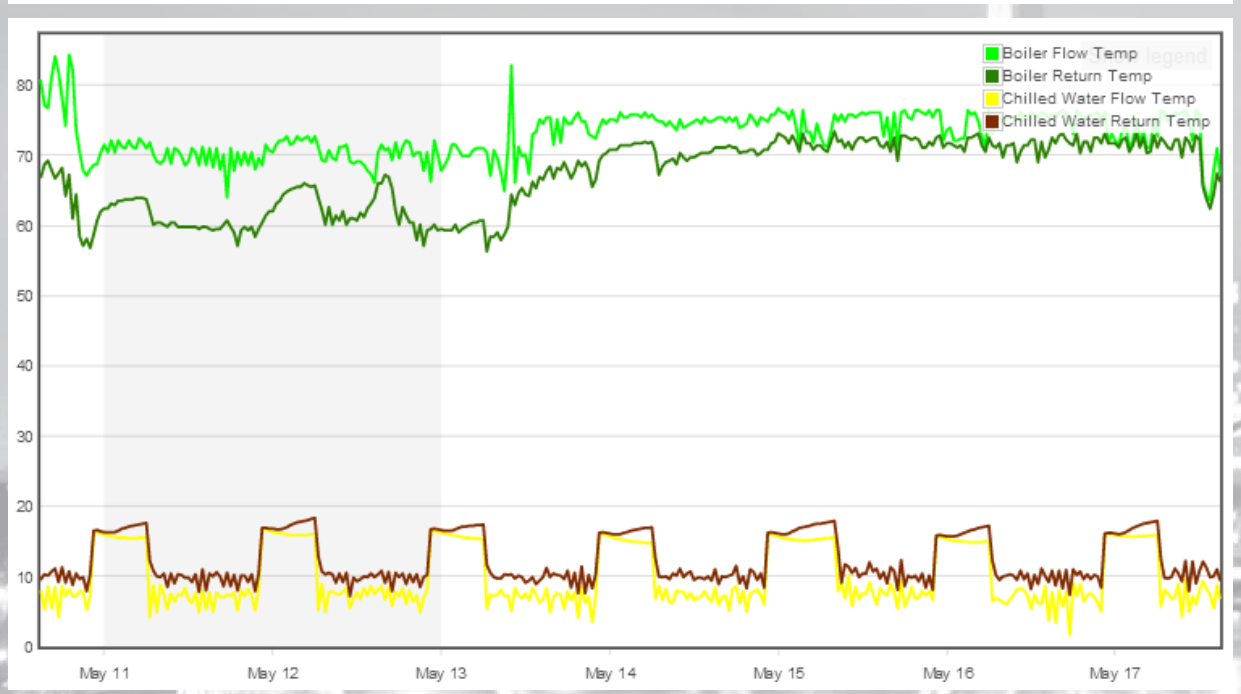
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Chilled Water Flow Temp
Chilled Water Return Temp
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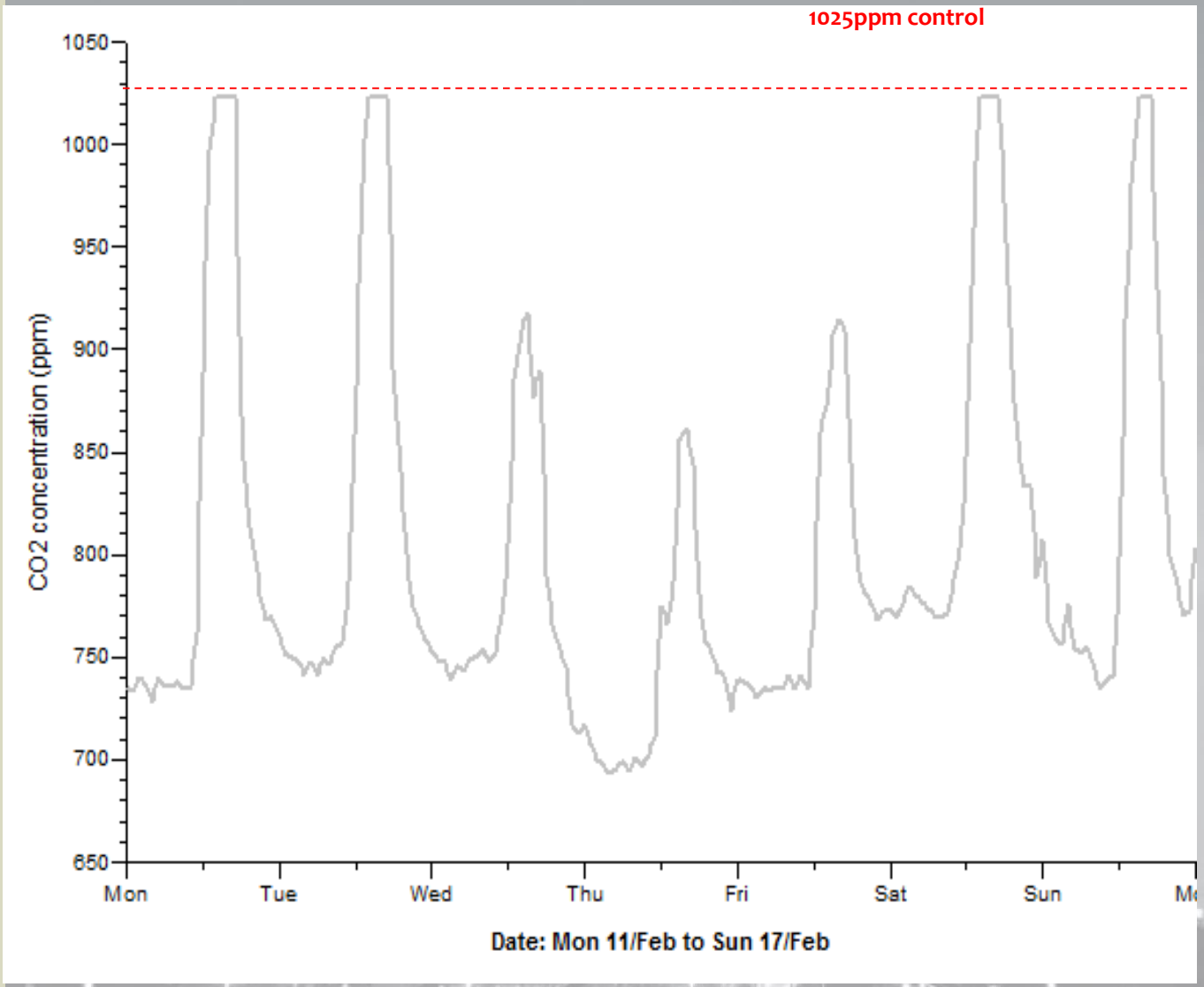
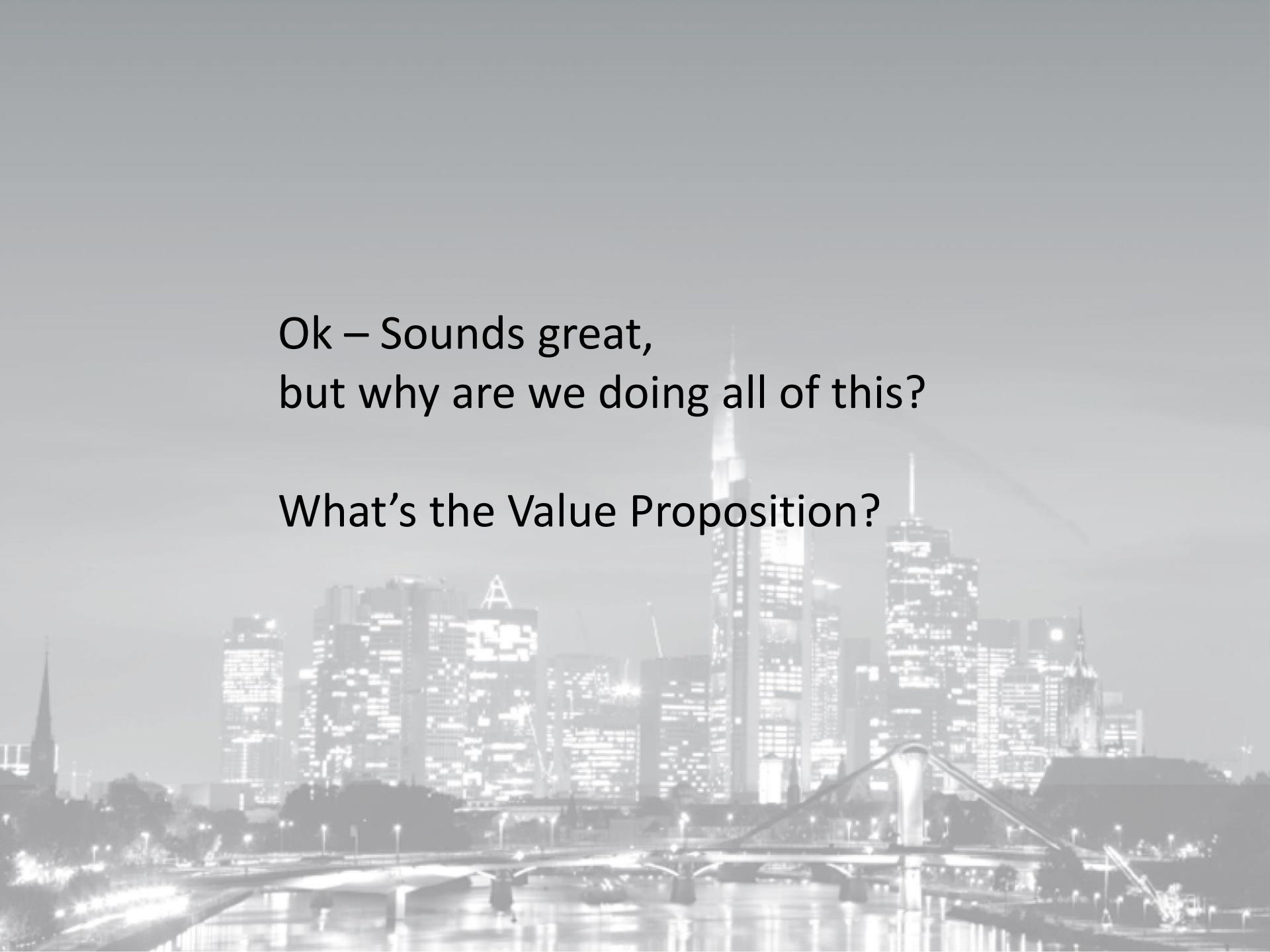
May 13
May 14
May 15
May 16
May 17

3. Building Management System (BMS) Cont.

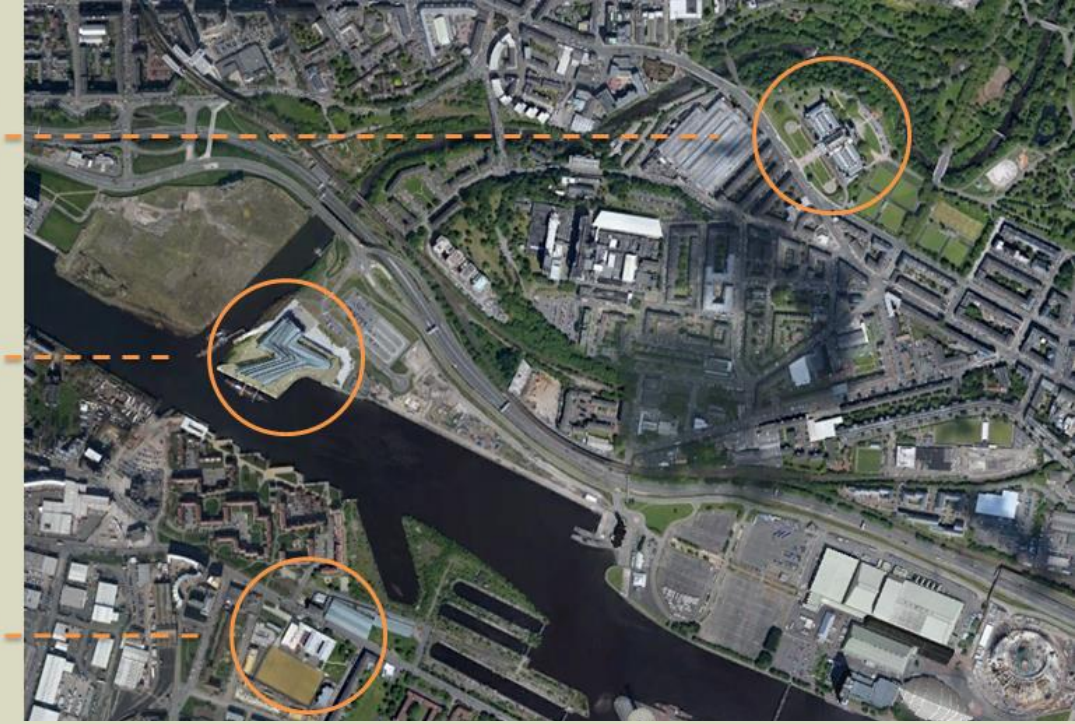


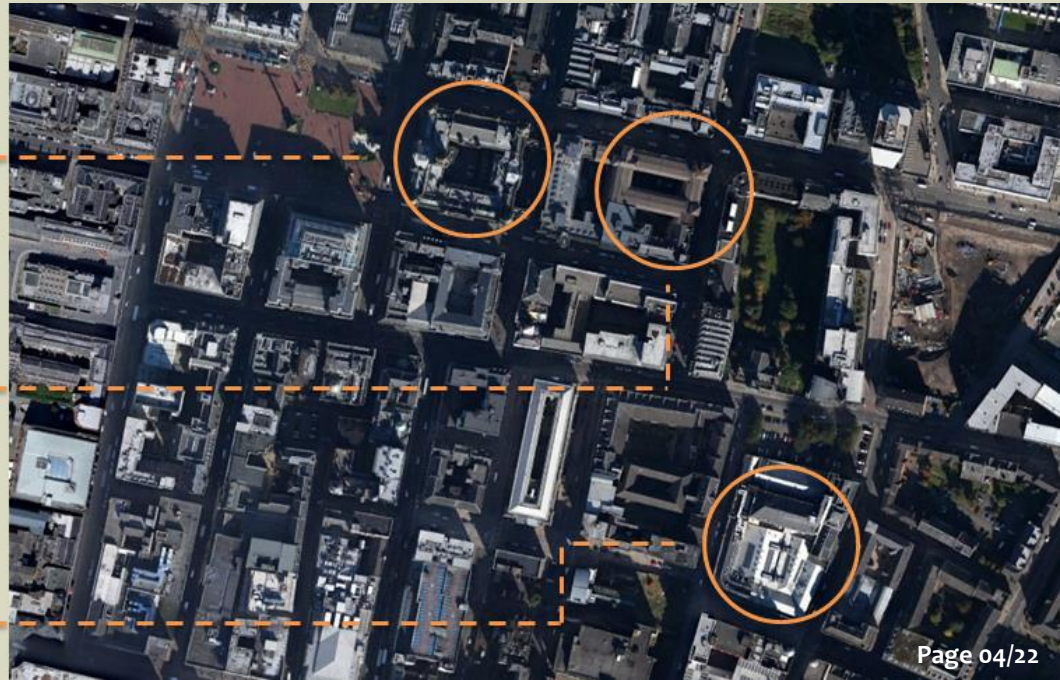


Ok – Sounds great,
but why are we doing all of this?

What's the Value Proposition?

GCC PoC Buildings



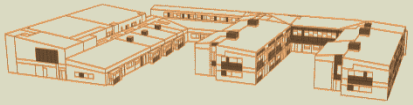


Energy Investment Strategy & ROI

GCC PoC Building	Target %	Annual Cost Saving £	CapEx Budget @ x3 year ROI	CapEx Budget @ x5 year ROI
Riverside Primary School	10.0%	£ 10 k	£ 30 k	£ 50 k
Riverside Museum	20.0%	£ 90 k	£ 270 k	£ 450 k
Kelvingrove Art Gallery	15.0%	£ 50 k	£ 150 k	£ 250 k
City Chambers	10.0%	£ 30 k	£ 90 k	£ 150 k
Exchange House	10.0%	£ 15 k	£ 45 k	£ 75 k
Collegelands	15.0%	£ 30 k	£ 90 k	£ 150 k
Total	**14.8%**	**£ 225 k**	**£ 675 k**	**£ 1 million +**

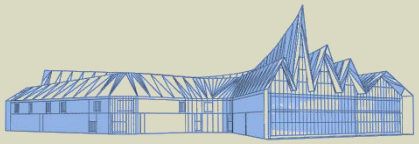
Annual Group Cost Saving = £225 k

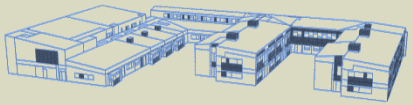
River Clyde
Conceptual
District Heating Scheme

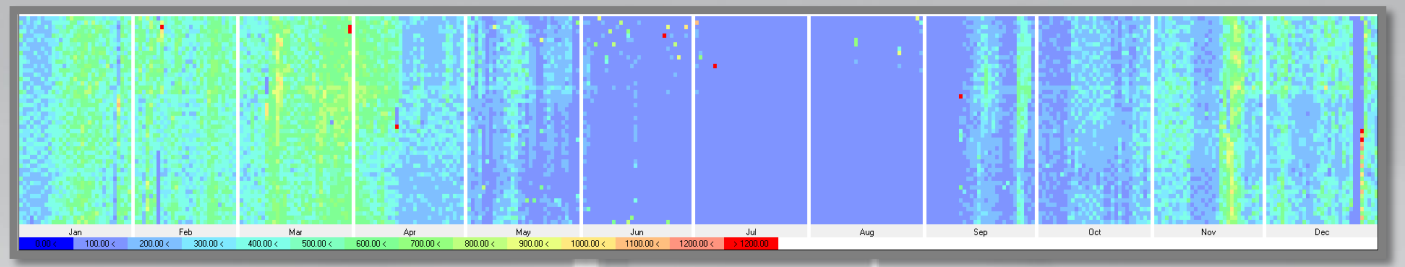


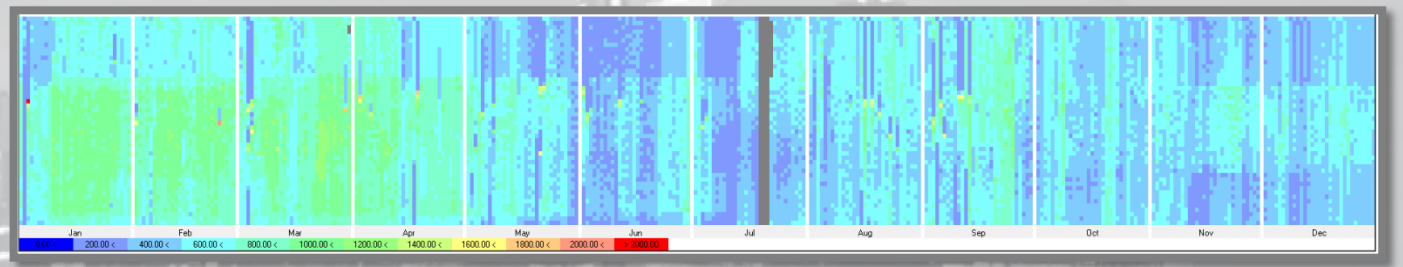
Heating Loads
Individual Building Profiles

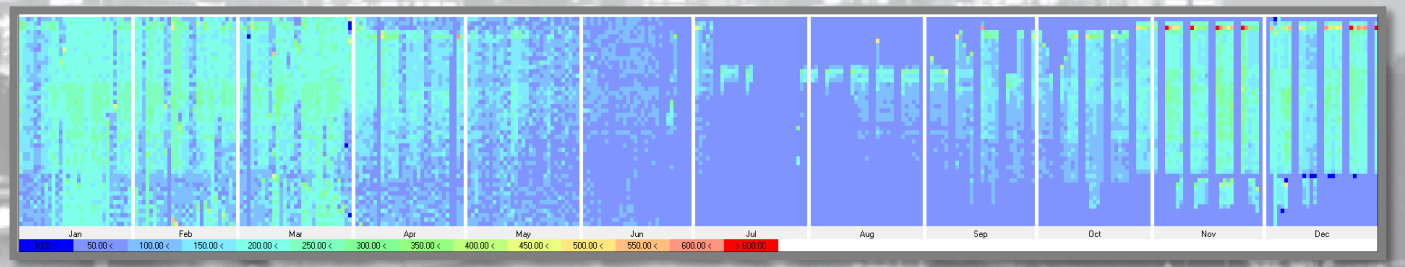
Heating profiles for each building are illustrated right in the form of heat maps.

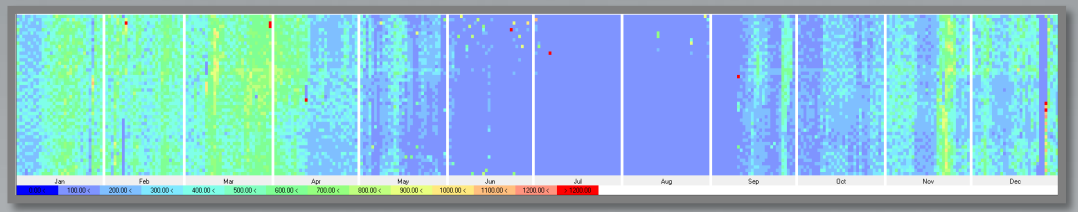








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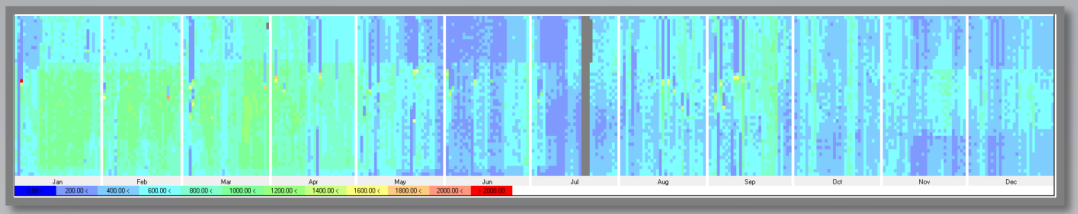
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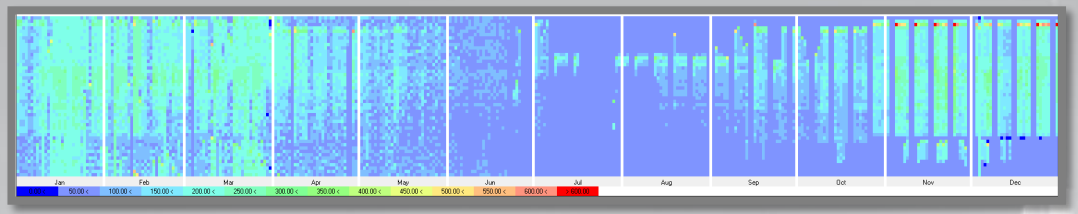
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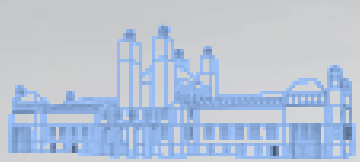

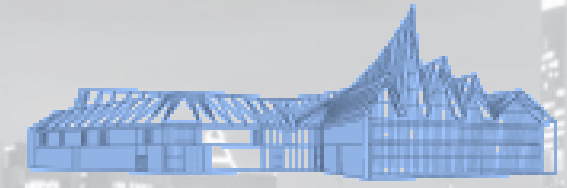

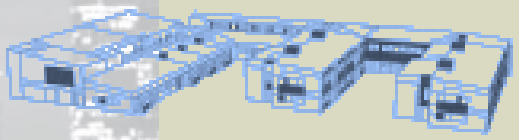

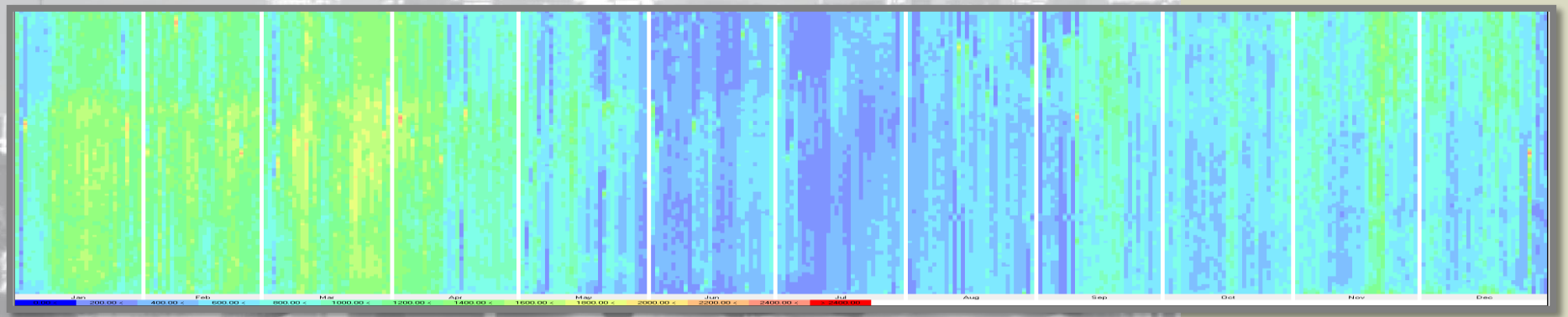
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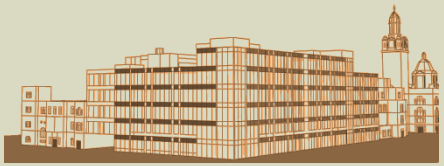
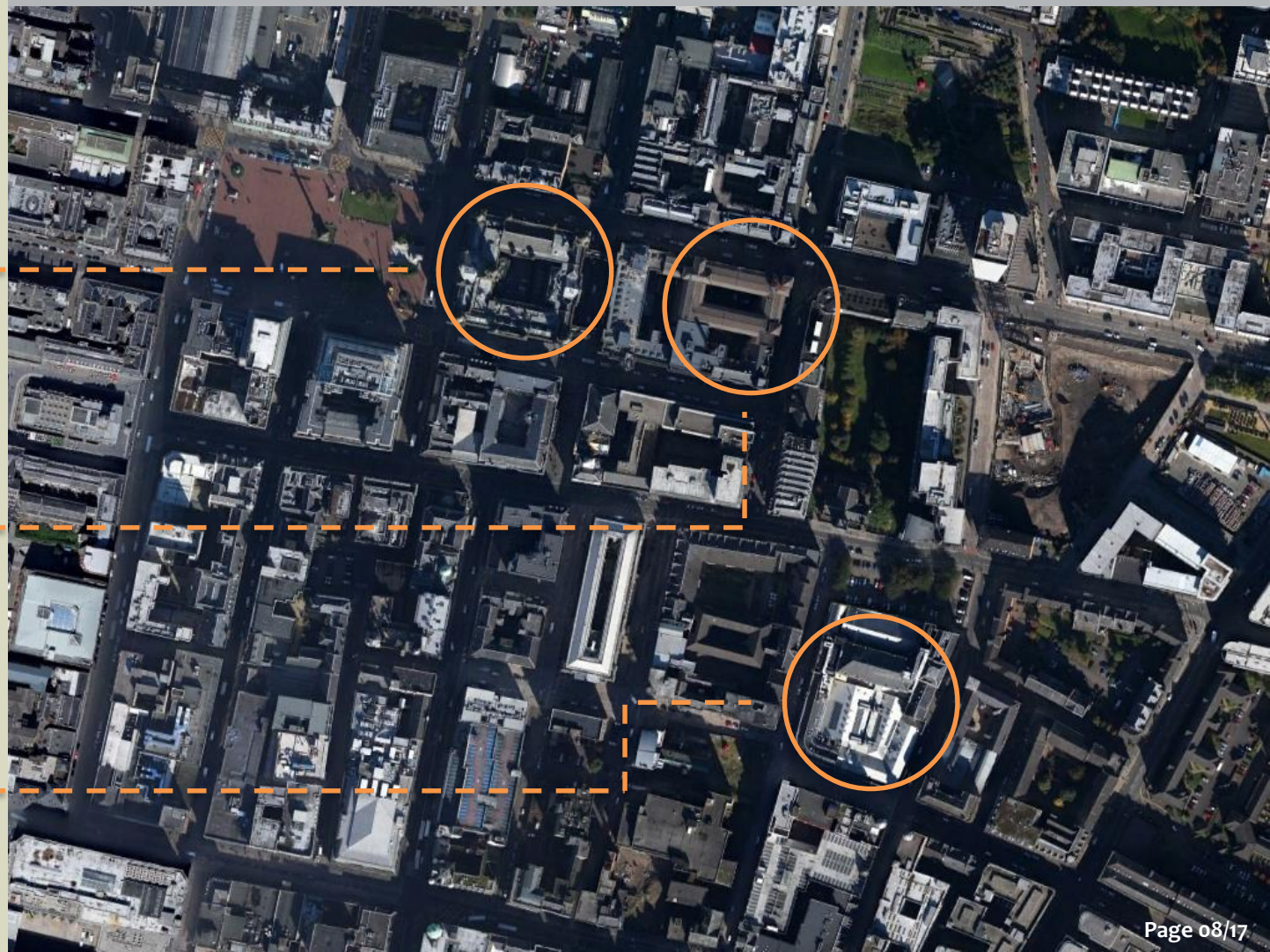
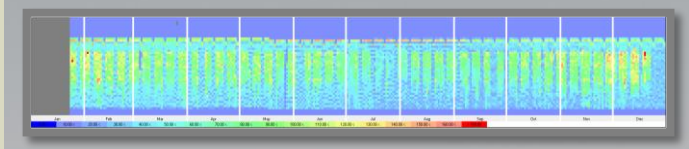
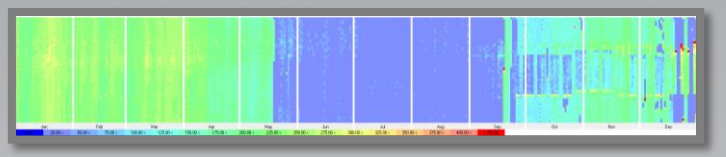
City Centre
Conceptual
District Heating Scheme

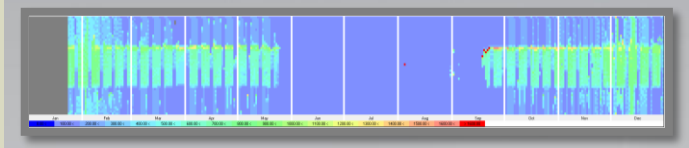


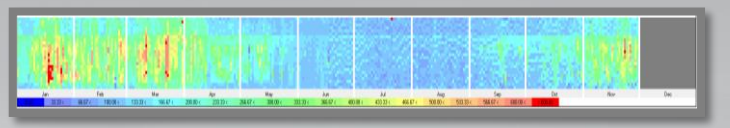


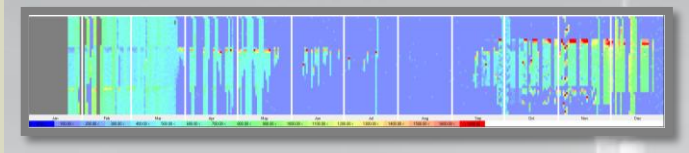
City Centre
Conceptual
District Heating Scheme

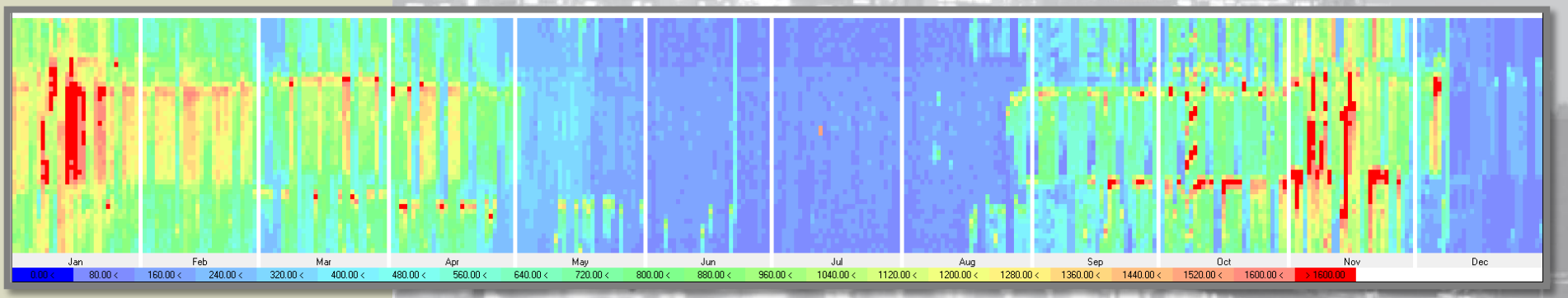






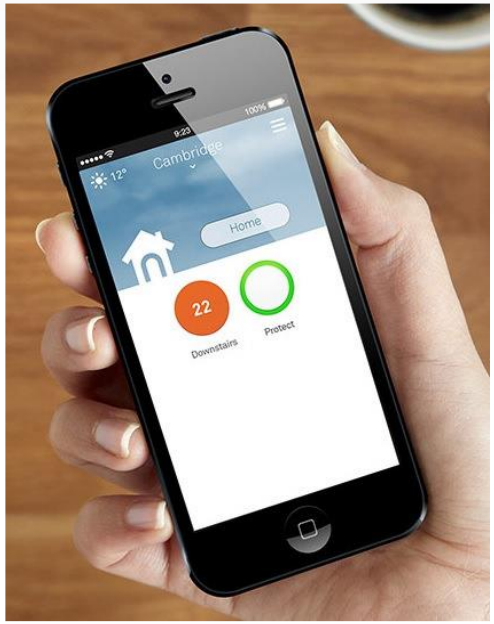






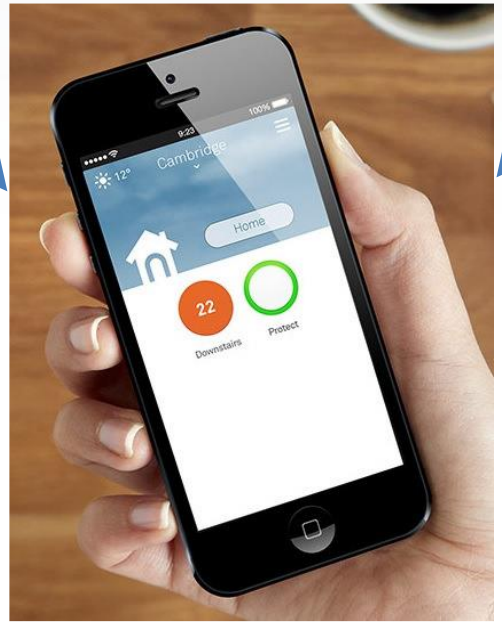
Future of Building Simulation

NEST Thermostat
- Easy to use
- Wifi connected
- Learning algorithms
- Cloud based control



NEST Protect
- Easy to use
- Wifi connected
- Cloud based control

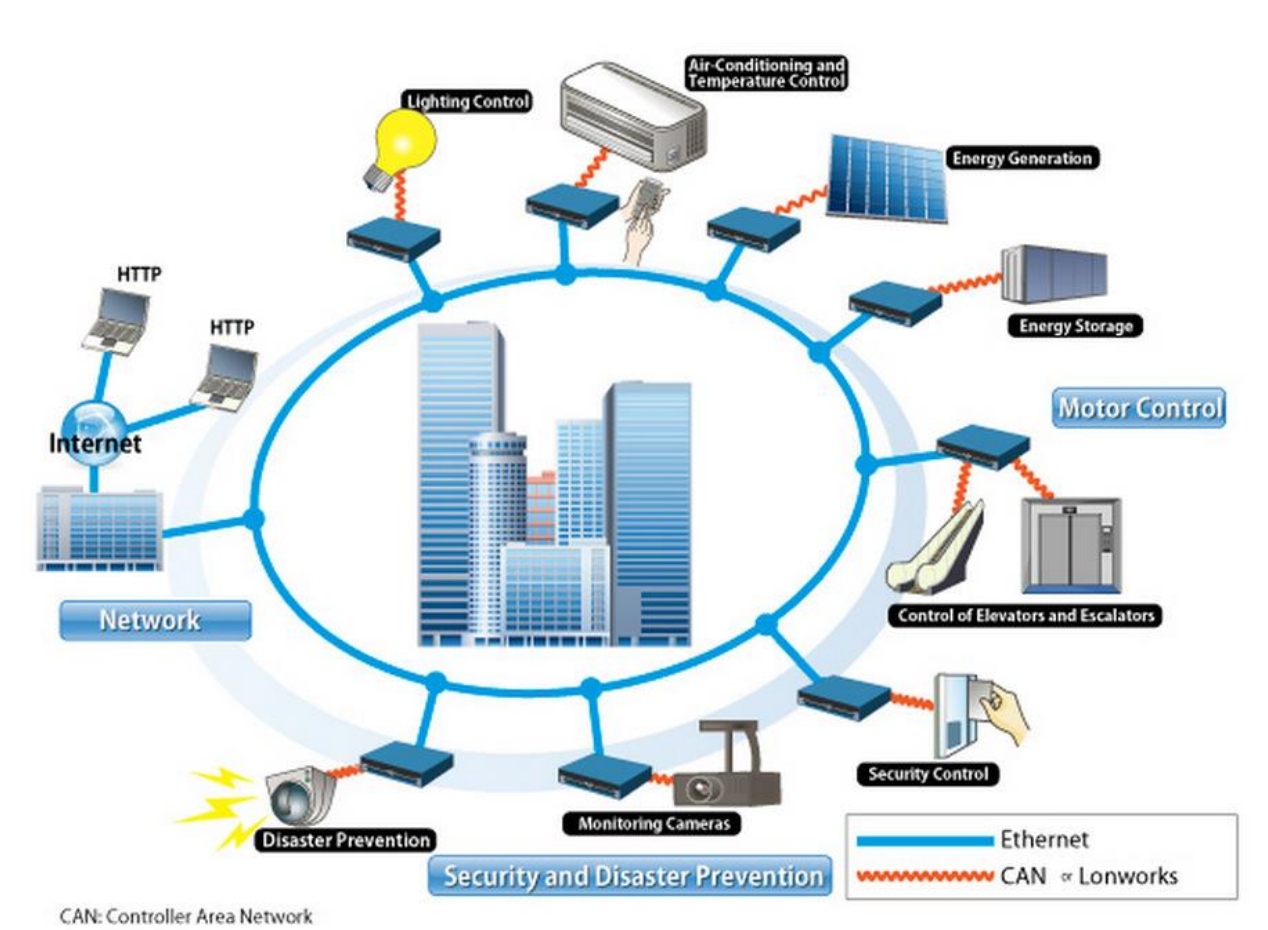
Future of Building Simulation



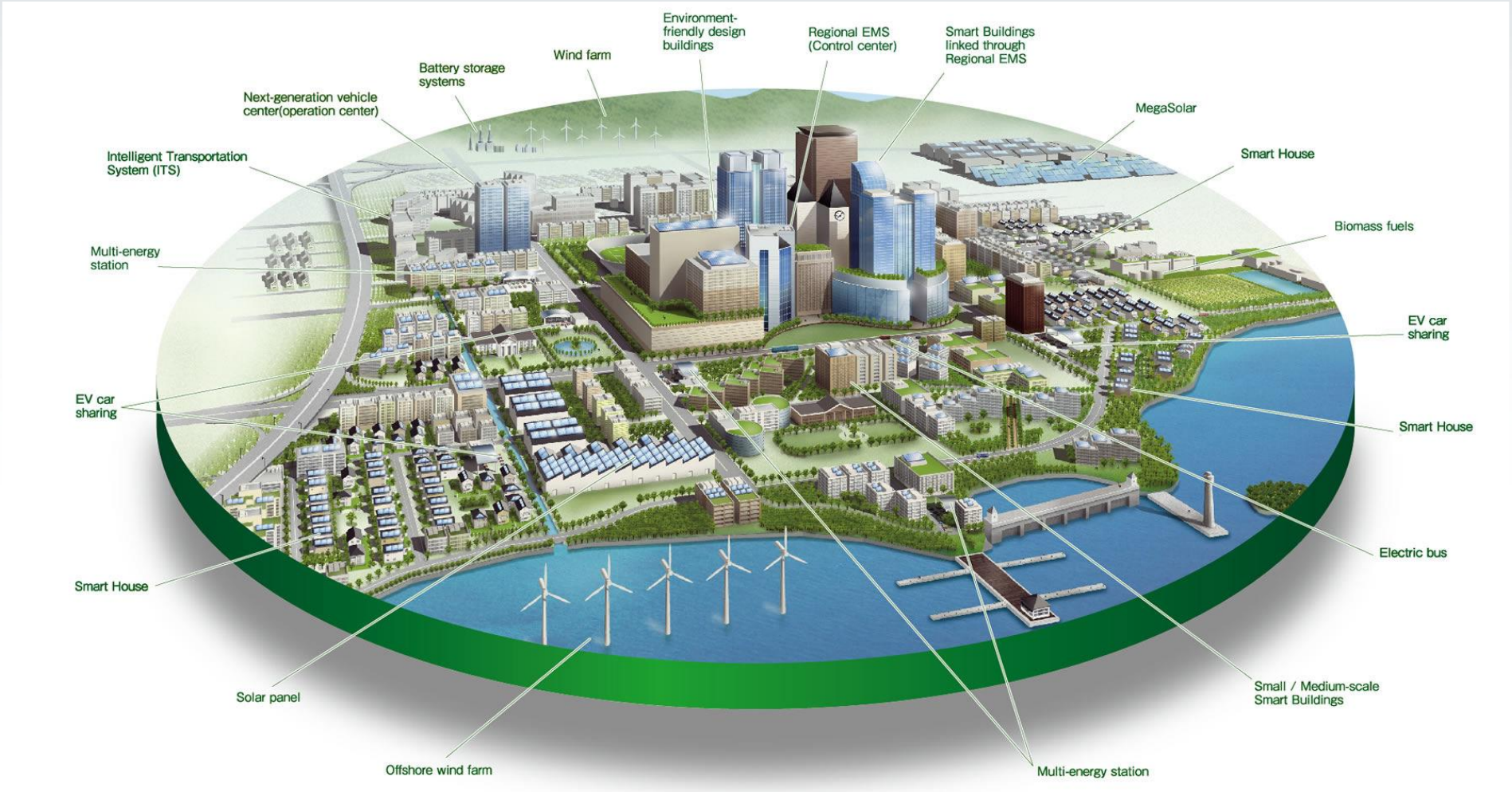
Benefit1:
if the smoke alarm sense fire and/or senses CO it will auto shutoff the boiler through the thermostat

Benefit2:
the smoke alarm has motion detectors. It can turn the boiler through the thermostat on when you get home

Future of Building Simulation



Future of Building Simulation



Driving Measureable Change for Sustainable Built Environments

Presentation by: Dr Sarah Graham
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