



# Continuous Energy Auditing

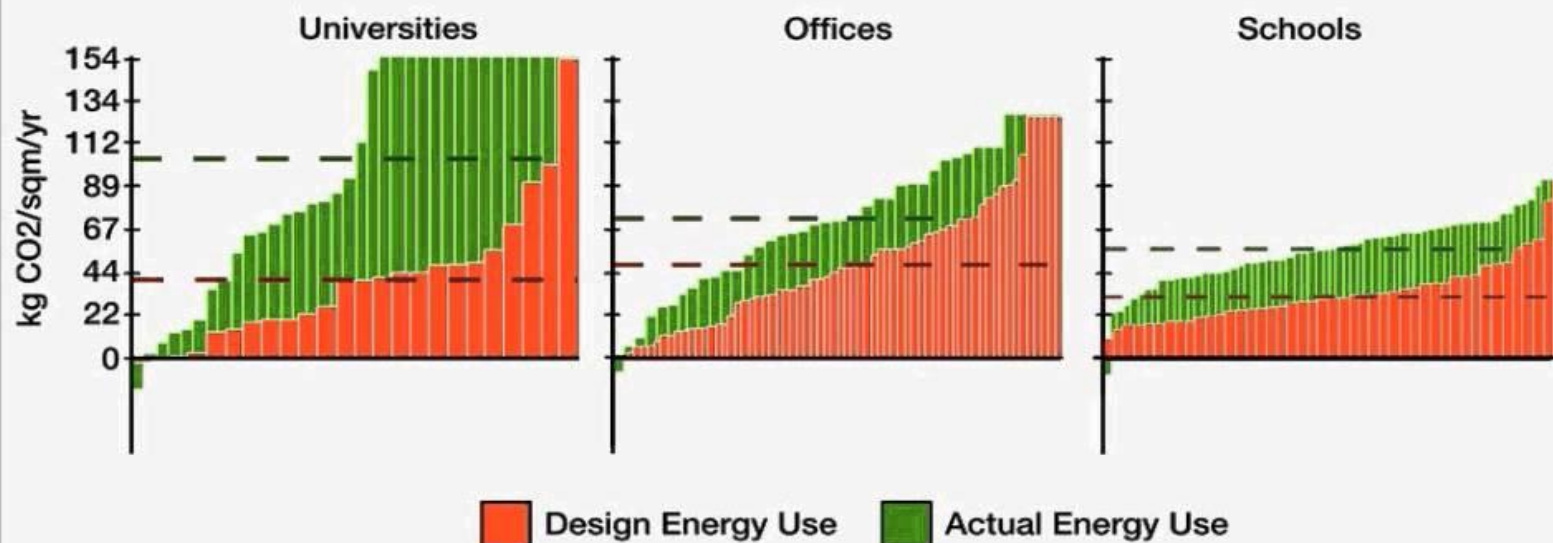


Dr. Alan McGibney, Dr. Susan Rea



# The Energy Performance Gap?

The performance gap : design + in use carbon figures



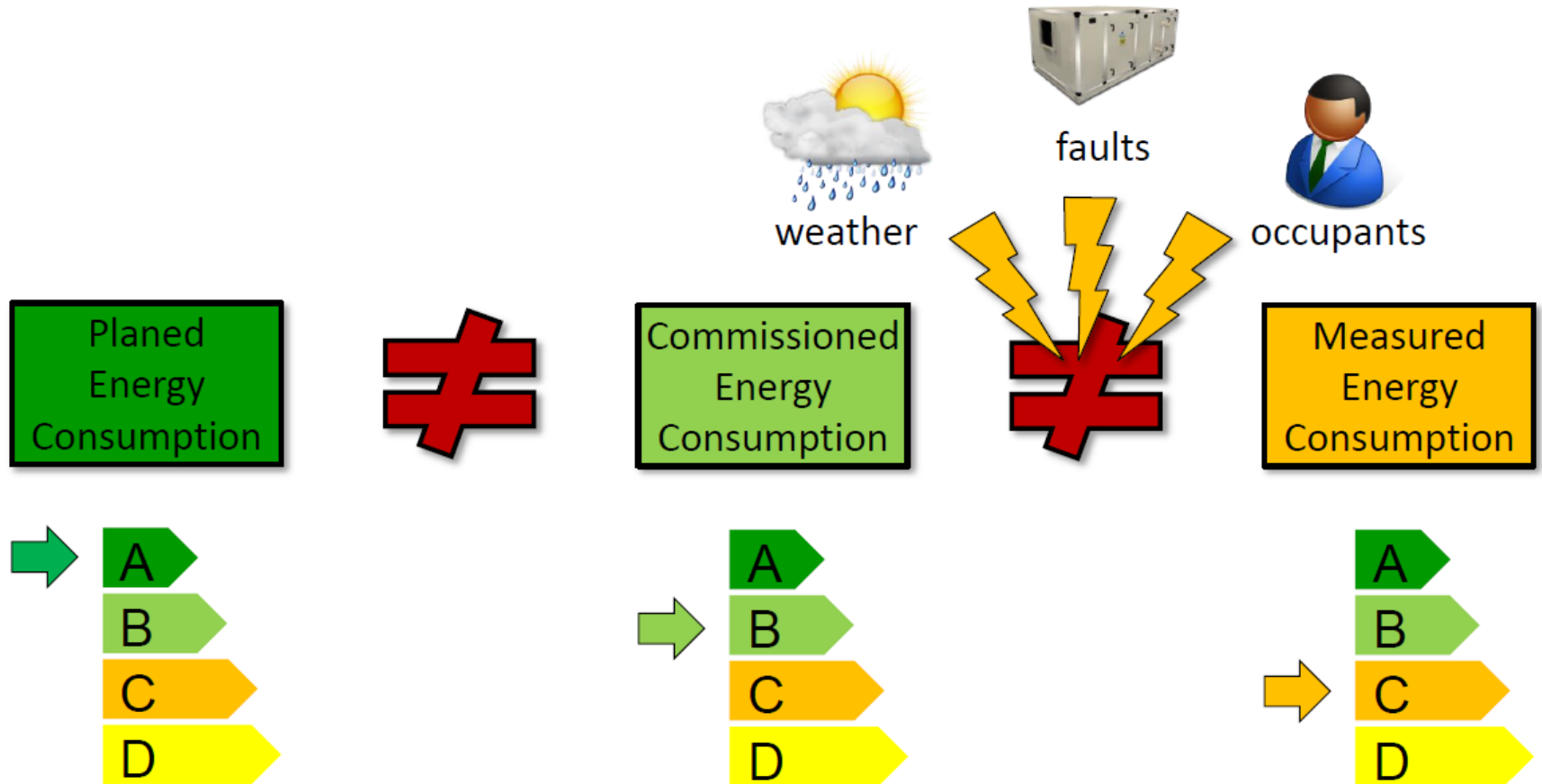
Source: 2Degrees - CarbonBuzz

<https://www.youtube.com/watch?v=Xtqb190DQy8>

FeildenCleggBradleyStudios



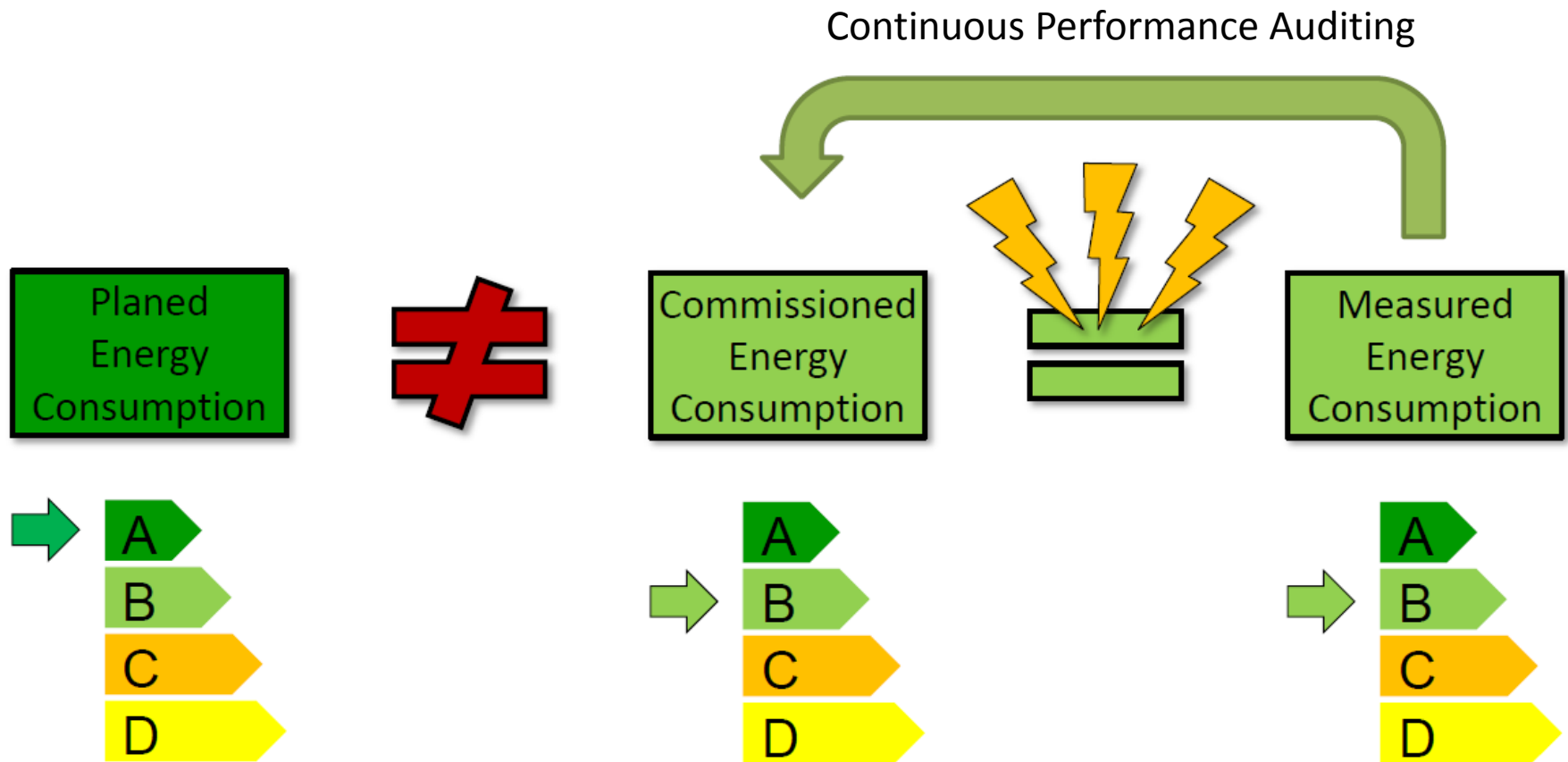
# TOPAs Objectives



Building energy performance predictions show *major differences to measurements*.  
This is even worse for building blocks.



# Challenges to be overcome



Tools and methods for measuring and analysing real building energy performance for FM and ESCOs.



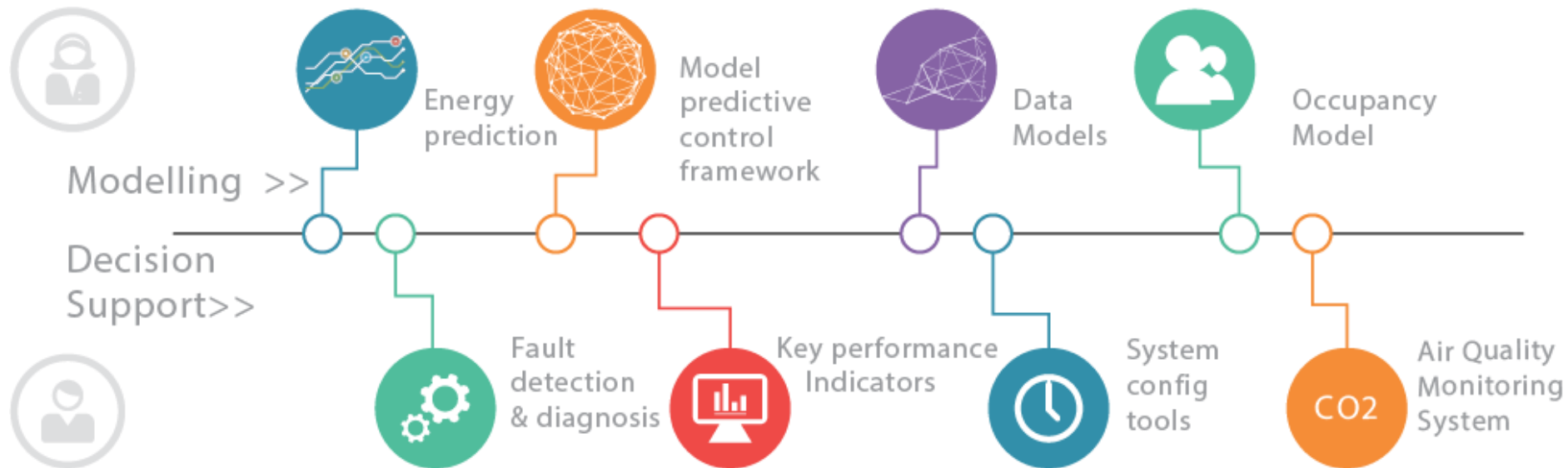
# The TOPAs Cognitive Loop







# The TOPAs Cognitive Loop

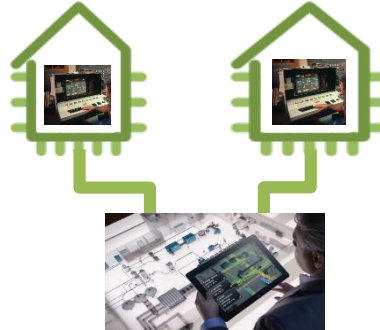




# IoT Architectures & Internet of Buildings



Standalone  
BMS

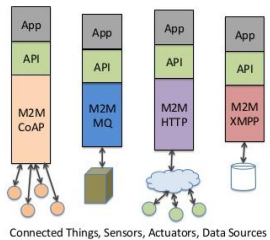


Managed  
Portfolio



Internet of  
Buildings

## IoT 1.0 – Things Connected to Apps

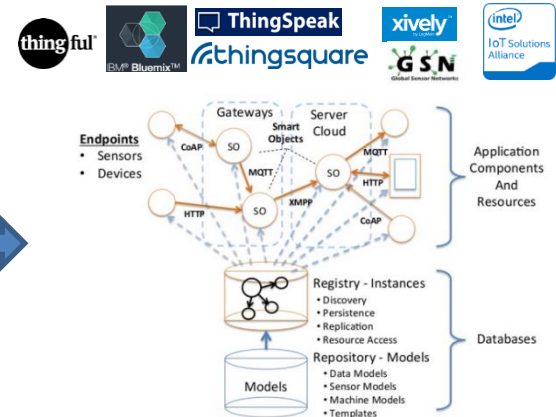
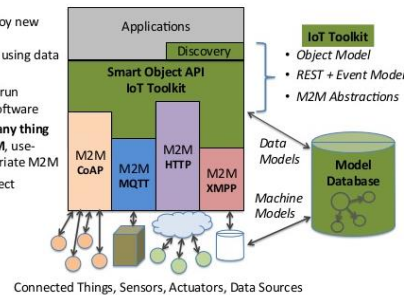


- App runs on single service – Single Points Of Failure
- Each app written to a custom API
- Diverse M2M is sometimes required but can inhibit interoperability
- Software, User data, and Things are trapped in **Silos**
- Difficult to connect new types of things and deploy new platforms
- Very difficult to share resources or connect across platforms
- Apps are not network-effect enabled



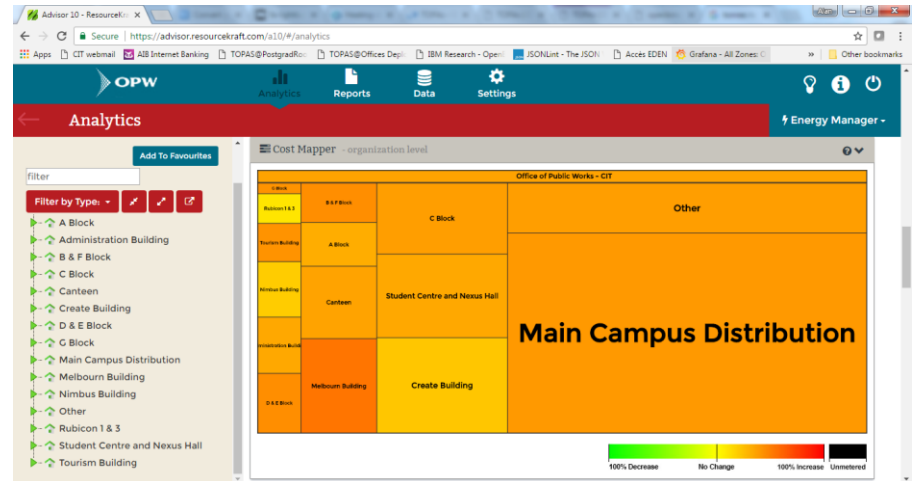
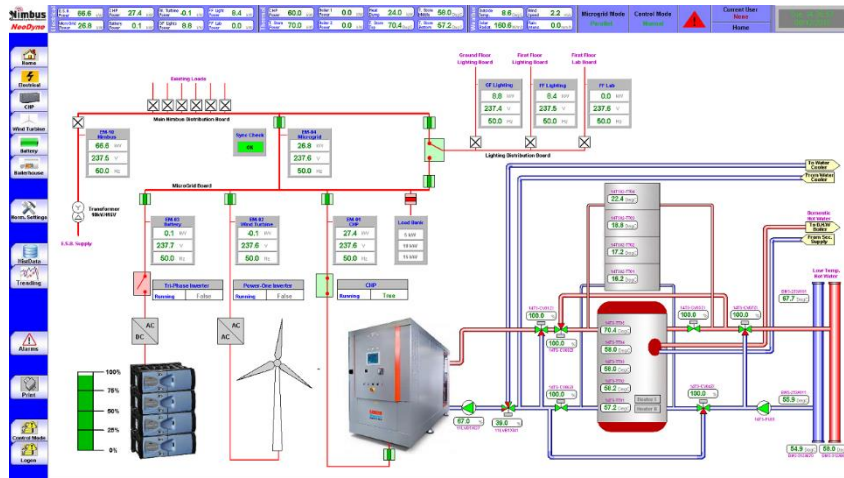
## IoT 2.0 – Interoperability

- Easy to deploy new things and applications using data models
- Write once, run anywhere software
- **Any app to any thing** via **any** M2M, use-case appropriate M2M
- Network effect enabled





# Edge Tier



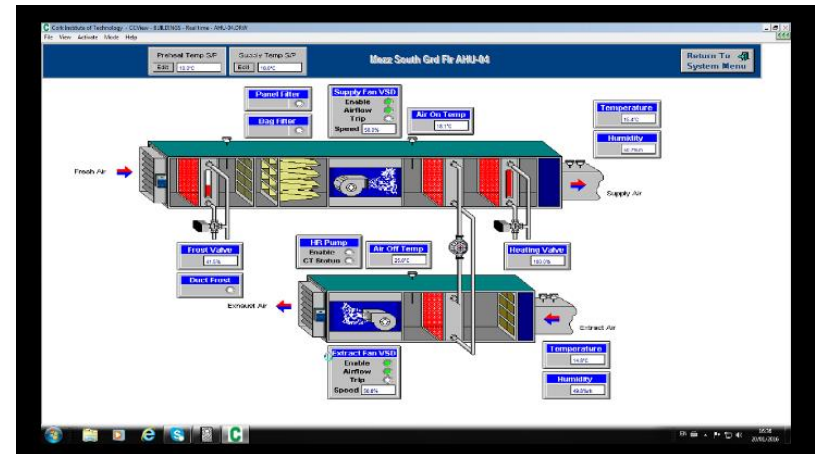
Description	Temperature	Local Setpoint	Setpoint Select	Active SP	Normal SP1	Exp SP1	2-Port Valve	Occ PR
Breakout Area RCV12	20.2°C	20.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Postgraduate Space RCV13	22.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Postgraduate Space RCV14	22.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Postgraduate Space RCV15	22.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Postgraduate Space RCV16	22.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Postgraduate Space RCV17	22.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Seminar Room RCV18	20.2°C	19.3°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Corridor Space RCV19	21.2°C	20.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R277 Principle Investigators Office RCV19	21.2°C	20.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R286 Senior Researcher Office RCV20	21.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R287 Administration RCV21	21.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Library RCV18	20.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C

Description	Temperature	Local Setpoint	Setpoint Select	Active SP	Normal SP1	Exp SP1	2-Port Valve	Occ PR
Lab Bottom - Prototyping Room RCV81	21.0°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Lab Middle - Integration & Test RCV82	21.0°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Lab Top - System Demo Room RCV83	21.0°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Lab Corridor RCV84	20.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R1857 Visiting Researcher Space RCV85	20.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R1848 Internship Room RCV86	20.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
R1846 Knowledge Transfer Room RCV87	20.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Foyer - Breakout / Demo Space RCV88	22.2°C	19.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C
Boardroom RCV11	21.2°C	20.0°C	17.0°C	17.0°C	17.0°C	24.0°C	24.0°C	24.0°C

Local Temp Adjust Setpoint Limits	Miscellaneous Occupancy Detectors (Monitoring Only)	Building Fabric Protection
Local Adjust Low SP: 19.0°C	Office R169	Fabric Protection SP: 10.0°C
Local Adjust High SP: 20.0°C	Tech Support Staff	Ground Floor Min Temp: 20.4°C
Deadband SP: 0.5°C	Office R266	First Floor Min Temp: 20.2°C
	Meeting Room R270	
	Office R273	
	Office R272	





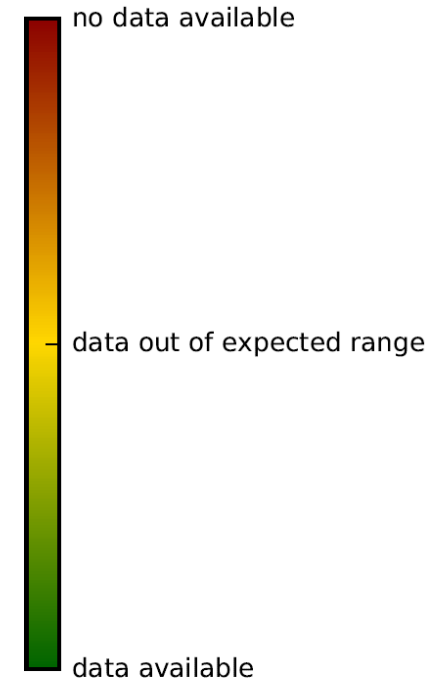
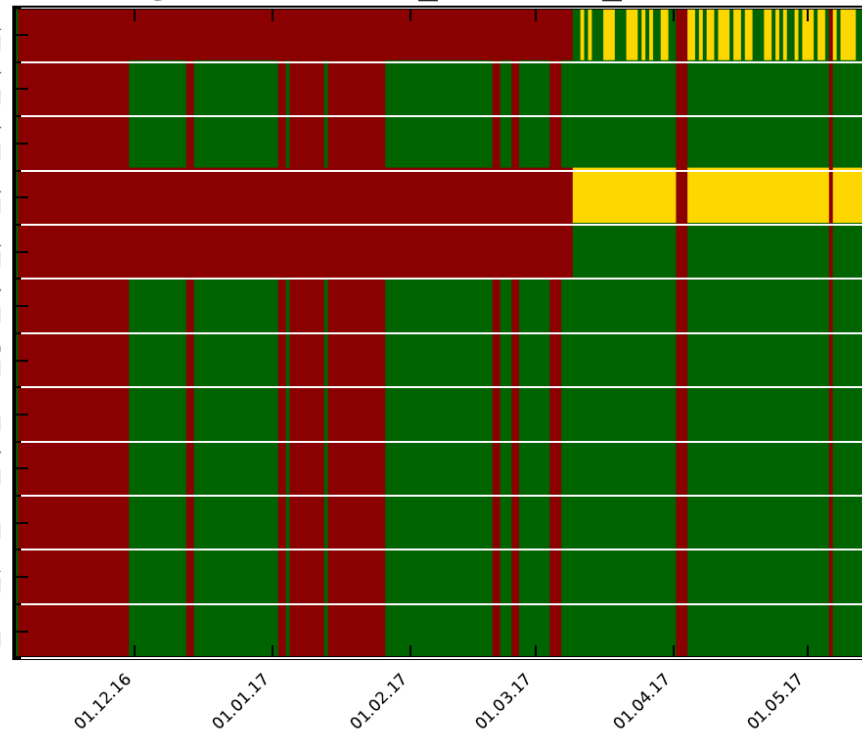


# Poor Data = Poor Decisions

## Quality Check: /02\_CIT/raw\_event/ #18

Sensornames

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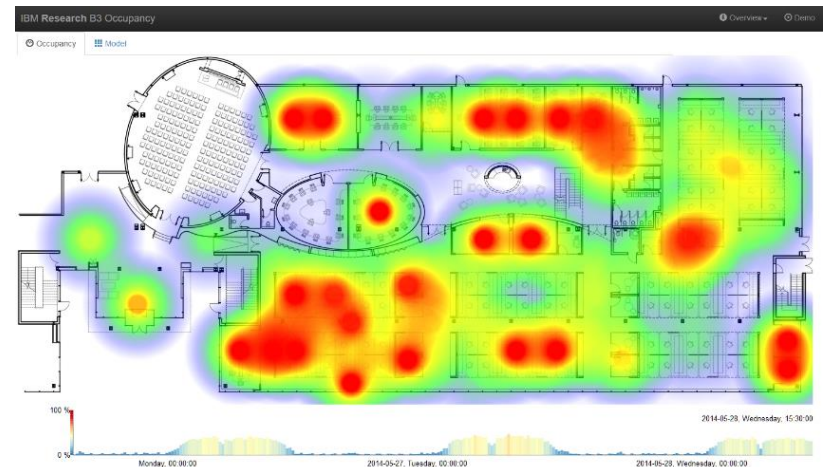
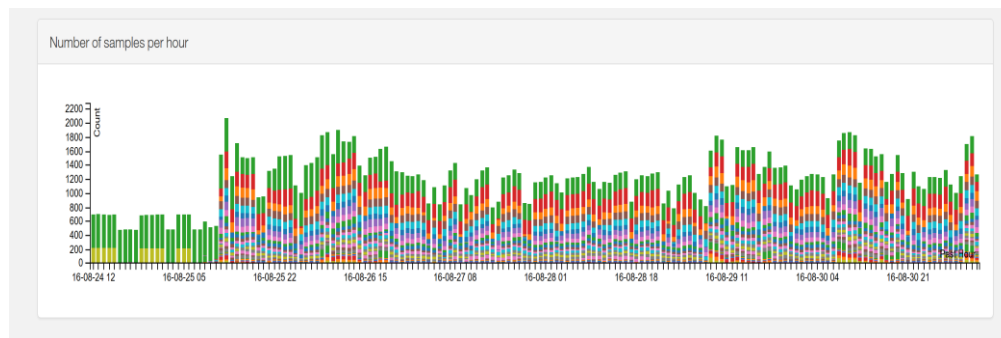
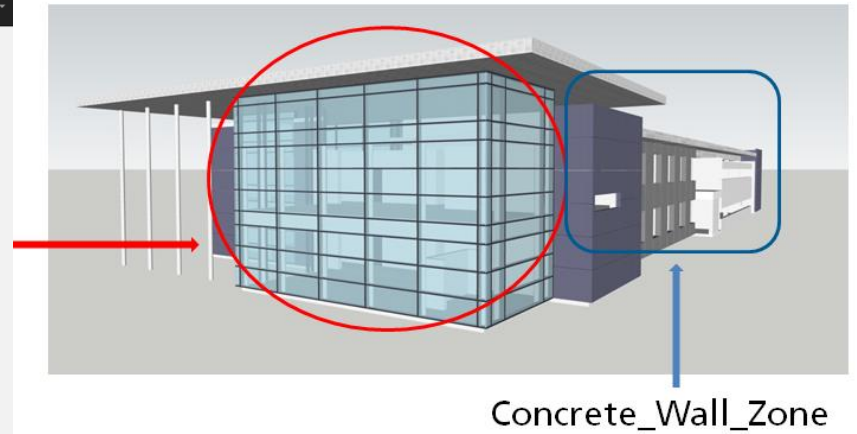
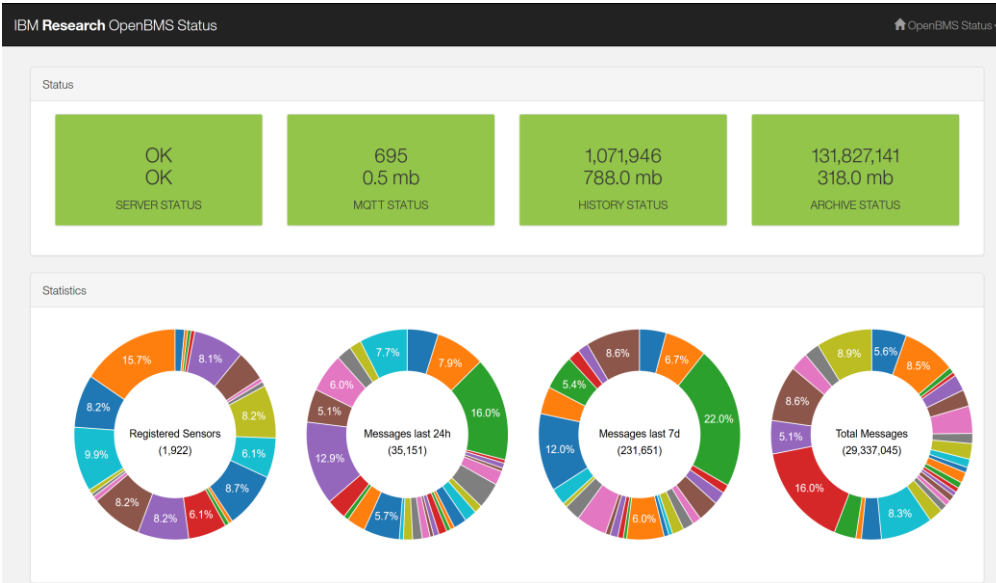


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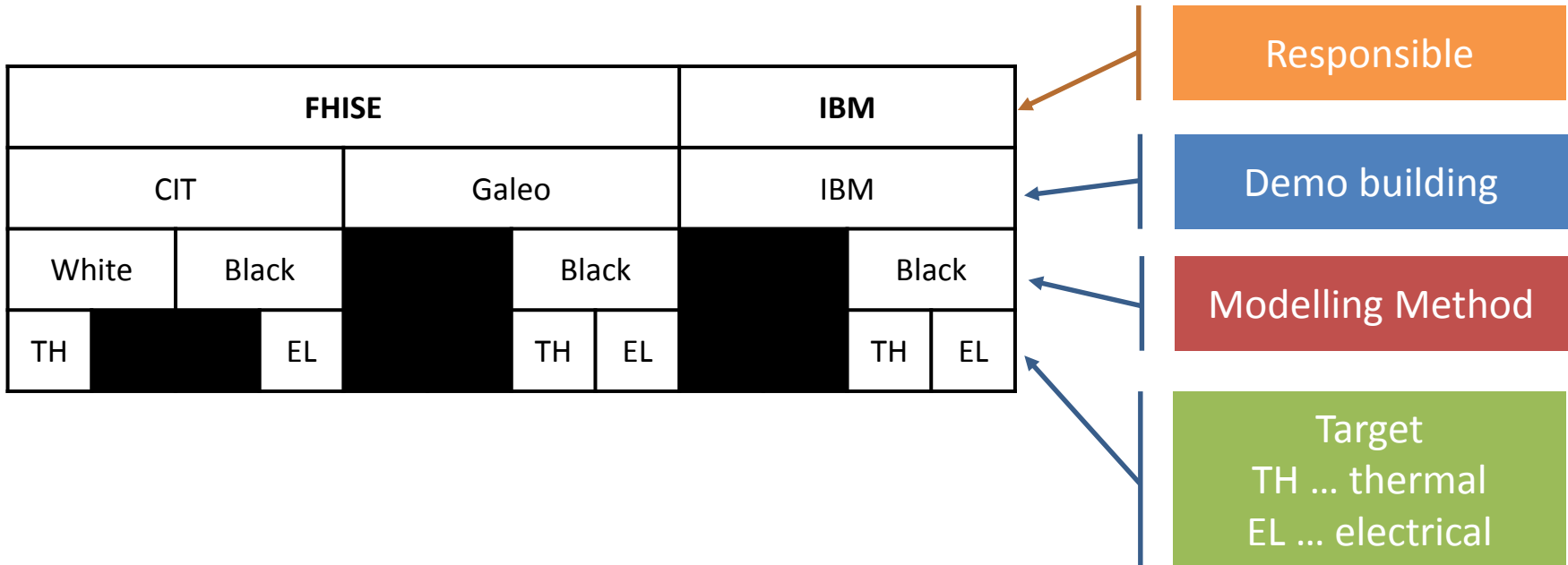


# Platform Tier





## Modelling Methods



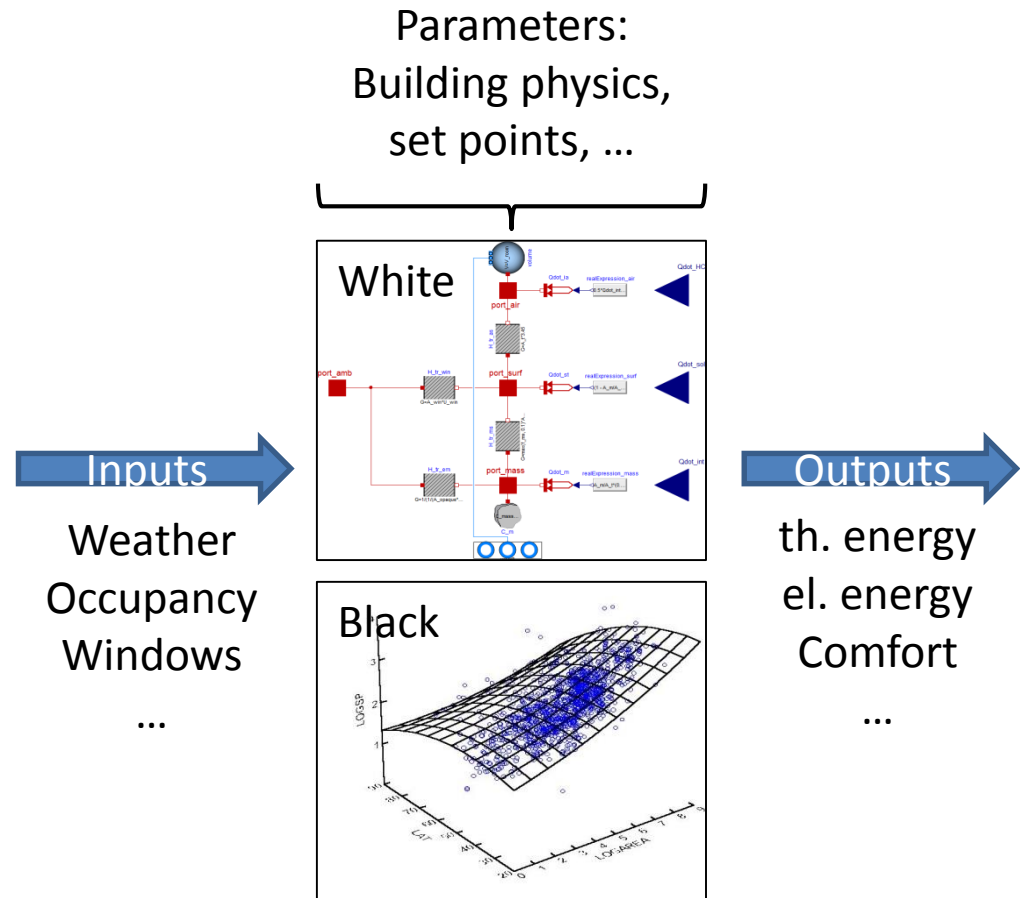
## Modelling Methods

- White Box Models

- Dynamic simulation (Dymola/Modelica)
- Physical models
- RC-networks
- Characteristic curves

- Black Box Models

- Gaussian Process Regression
- Multi-Linear Regression
- Support Vector Regression
- Random Forests
- K-nearest Neighbors



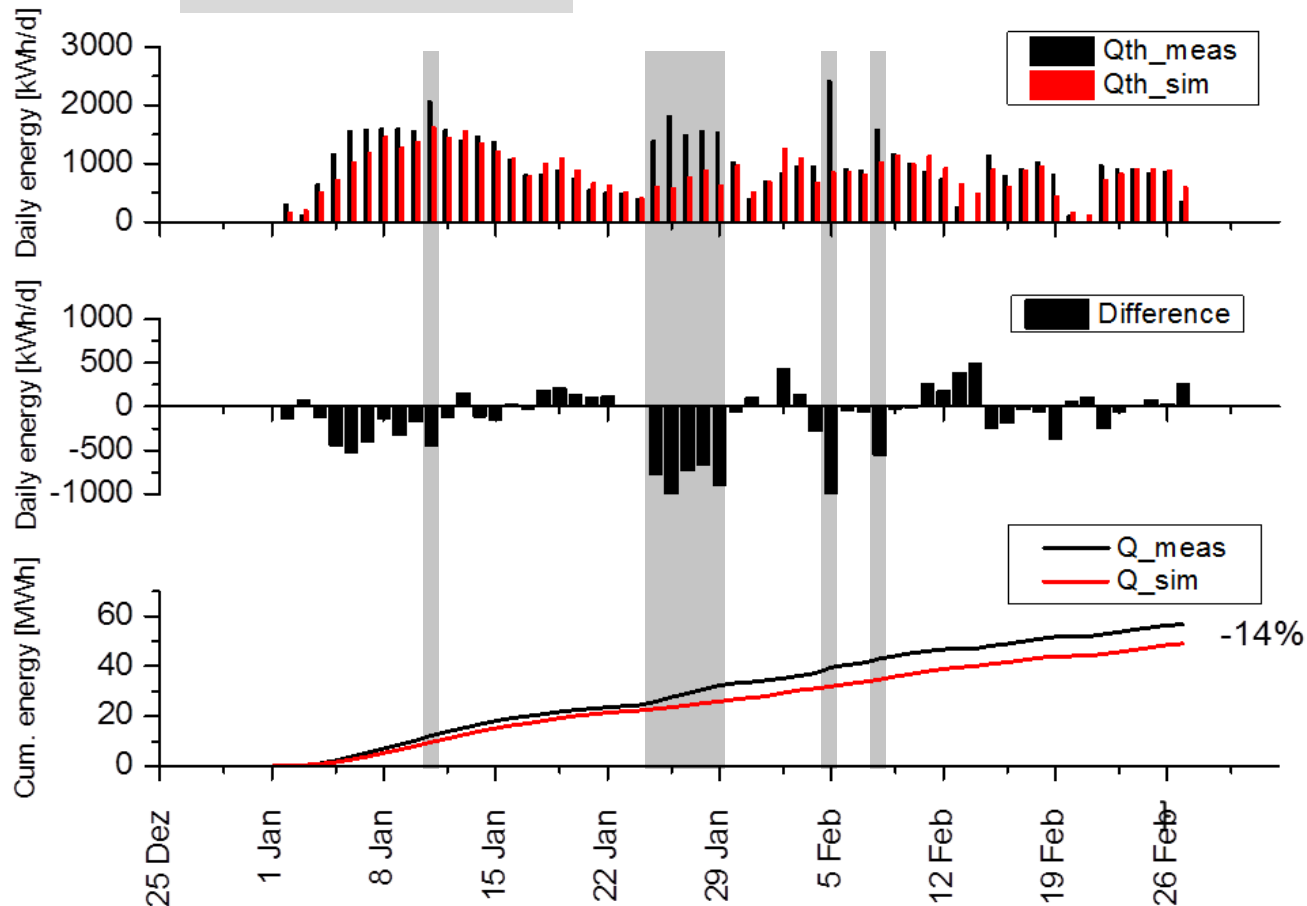


# Model-based energy consumption prediction

## Model Results

Unknown influences lead to increased energy consumption

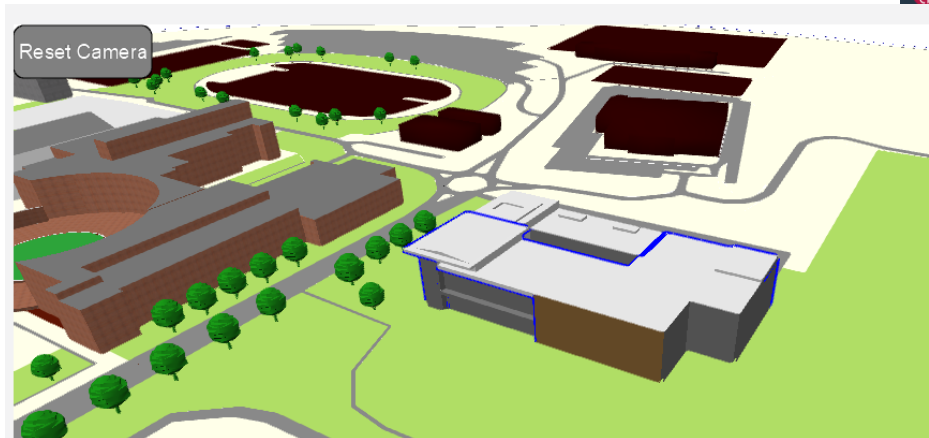
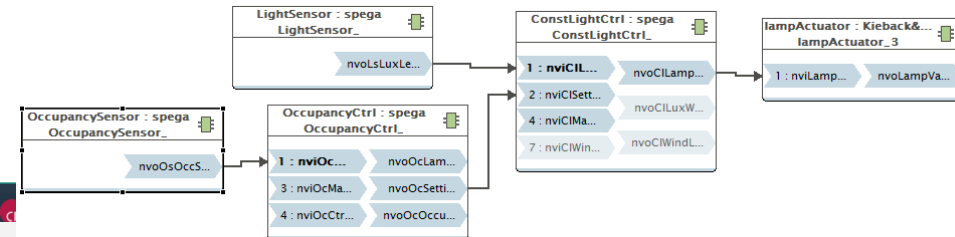
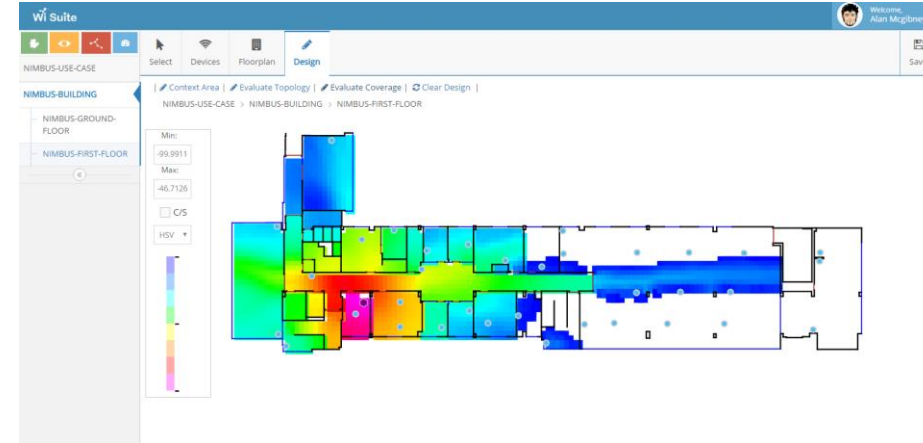
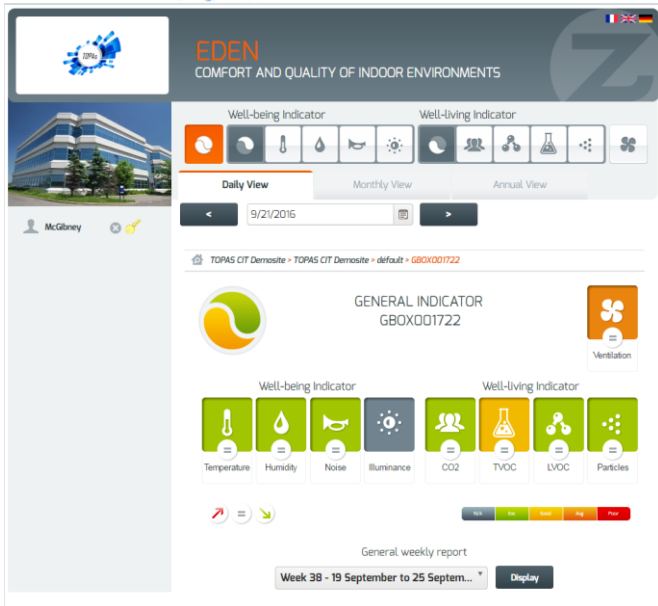
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White	Black			Black			Black
TH			EL		TH	EL	
							TH
							EL







# Enterprise Tier



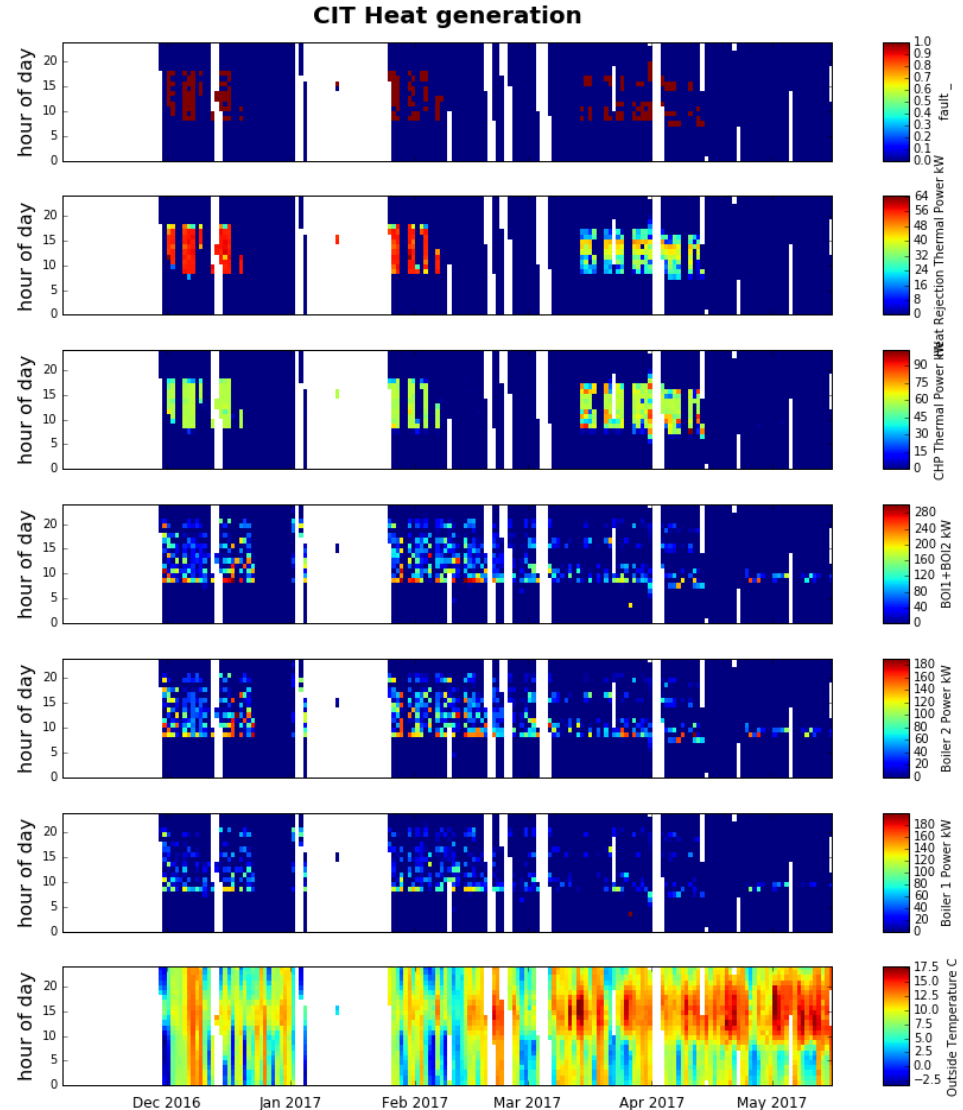


# Fault Detection and Diagnosis

## FDD rule-based system

### CIT building

- Heat Generation with Combined Heat & Power (CHP) and Boilers
- Low operation time of CHP
- Sequencing fault between CHP, Boilers and Heat Rejection
- Pumps operating at low delta T
- Too high return temperature to CHP
- Also: overheating faults of thermal zones
- ↪ estimated energy saving potential 5..10% (tbc)
- ↪ Organize Energy Conservation Measure with CIT Facility Manager





IBM Campus, Dublin

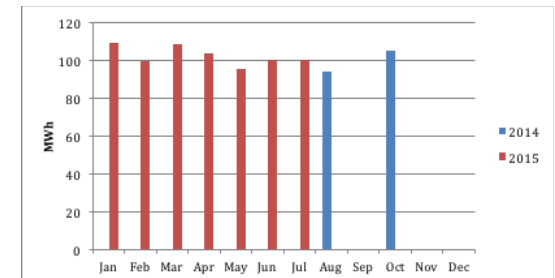
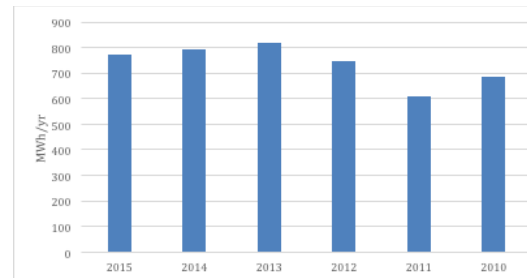
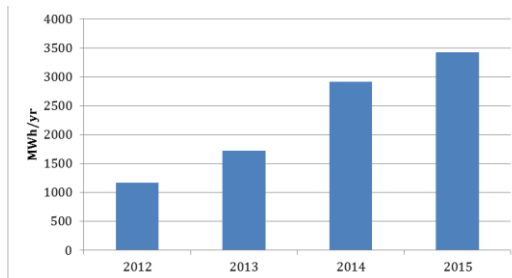


CIT Campus, Cork



Galeo, Paris

Baseline



Conclusions

- Improvements regarding the gas use in Building 3.
- Correlation between occupancy and energy consumption is evident
- Saving potential in out of hours night and weekend base load.

- Significant discrepancy between set points and actual temperature
- Need for continuous aligned control settings
- Saving potential in baseload and CHP heat dumping
- Microgeneration provides potential for load shifting

- There may be a potential to reduce the night time base load.
- Air Quality will be integrated in the control strategy.
- Further investigation and analysis is required



- 10% Gap reduction between predicted & actual energy use
- 20% Energy savings through the use of the TOPAs solution

# 3 P's – Plant, Process & People

## **Plant:**

Optimise the efficiencies of control systems, maximise the capabilities of automation systems, continuous auditing of equipment state.

## **Process:**

Continually assess and analyse how energy is used in buildings, influence schedules, eliminate wastage and maximise potential for energy savings

## **People:**

Consider people as “customers”, easiest solution is to switch everything off but this will not help people, impact productivity and will not encourage responsibility for energy savings



# Live Demo







# TOPAs Workflow

## TOPAs in Action

- **Phase 1:** System/Building connection & connectivity, data sensing & collecting, data transport & access - **SENSE**
- **Phase 2:** Data analytics, APIs & processes, services - **LEARN**
- **Phase 3:** Applications & services: gap reduction, energy saving, FDD, data presentation, intelligent interfaces – **ACT & OPERATE**

