Imperial College London

LAING O'ROURKE

Development of a Portable Wireless Sensor Network to Enhance Post-Occupancy Commissioning

Sarah Noye – s.noye11@imperail.ac.uk
Dr Robin North
Prof David Fisk

Laing O'Rourke Centre for System Engineering and Innovation
Imperial College London

ICEBO, 15-16 Sept 2014

Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014

Content overview

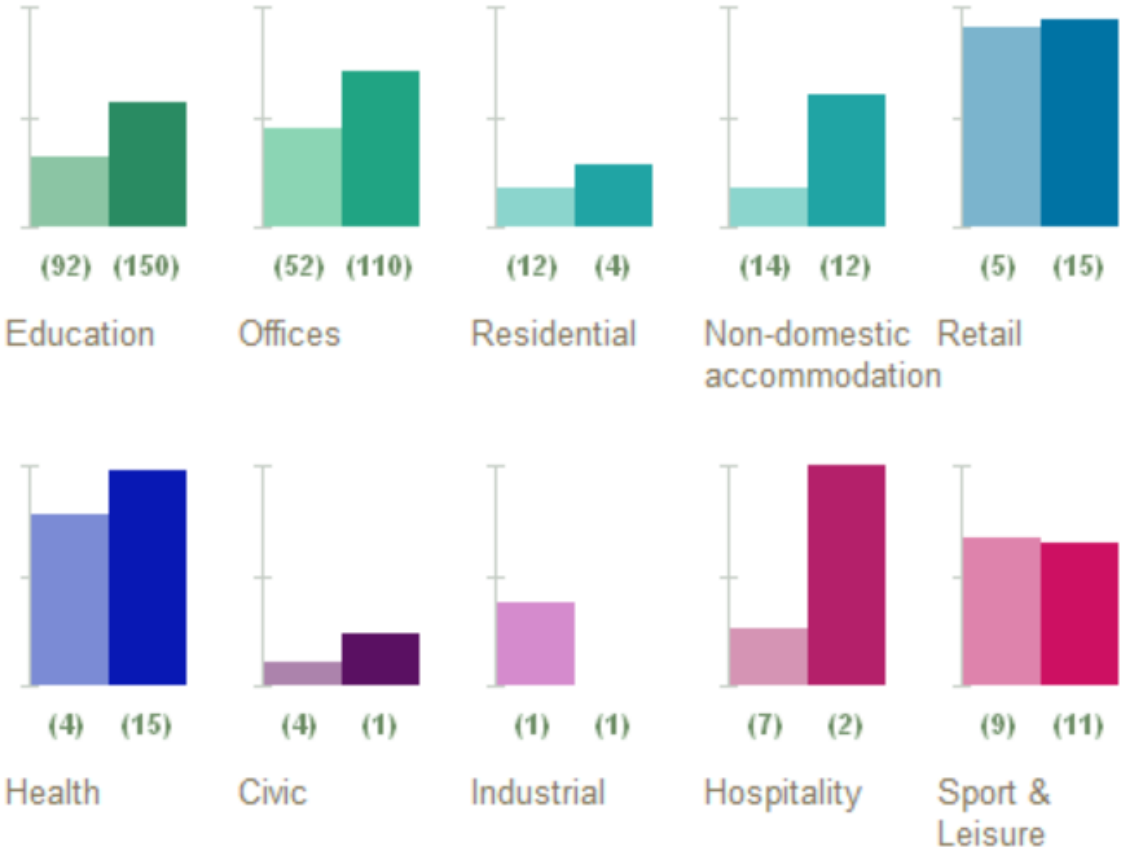
1. Research motivation and post occupancy commissioning (PO-Cx)
2. Pop-up monitoring™ system requirements
3. Initial experimental validation
4. Conclusions and further work

RESEARCH MOTIVATION AND PO-CX

Building energy consumption in use

Design

Predicted CO_2 emissions

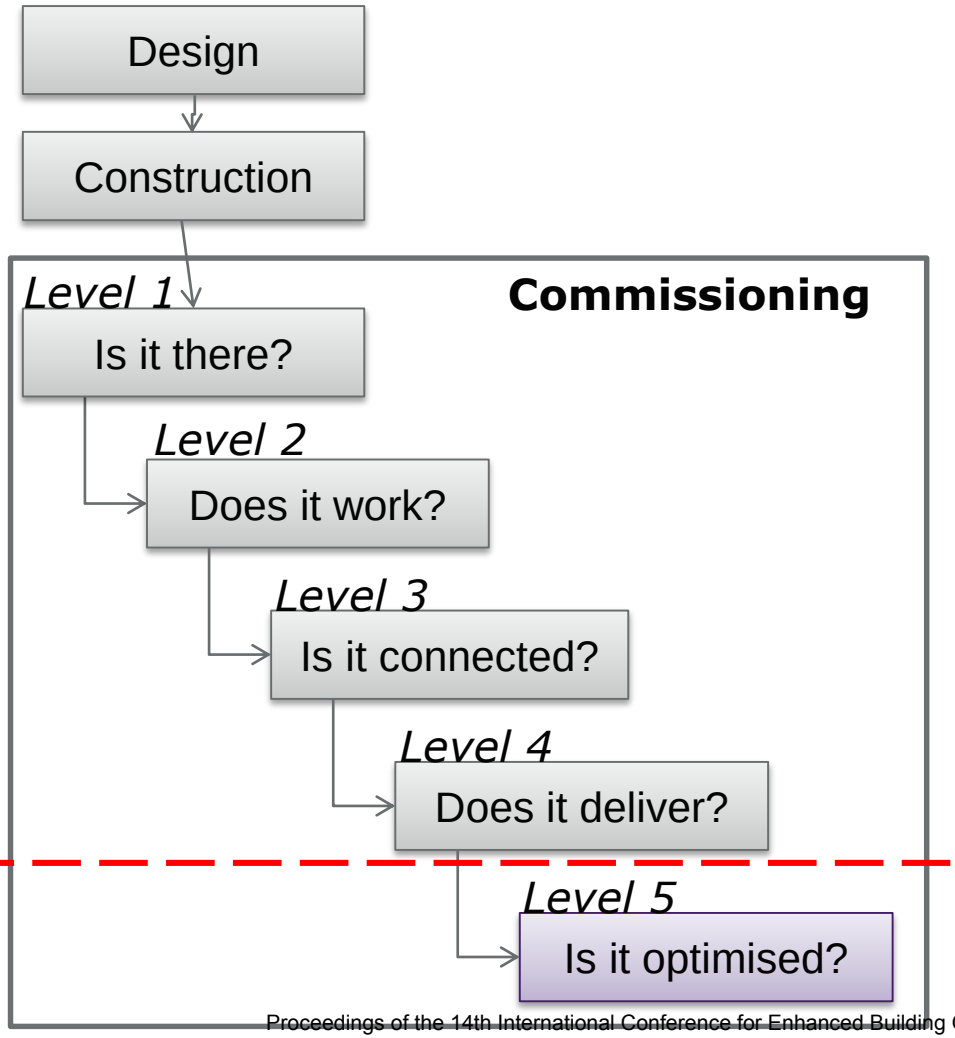


In-use CO_2 emissions from utility bills

There is a performance gap between as designed and as operated energy consumption

Source: www.carbonbuzz.org

Commissioning scope

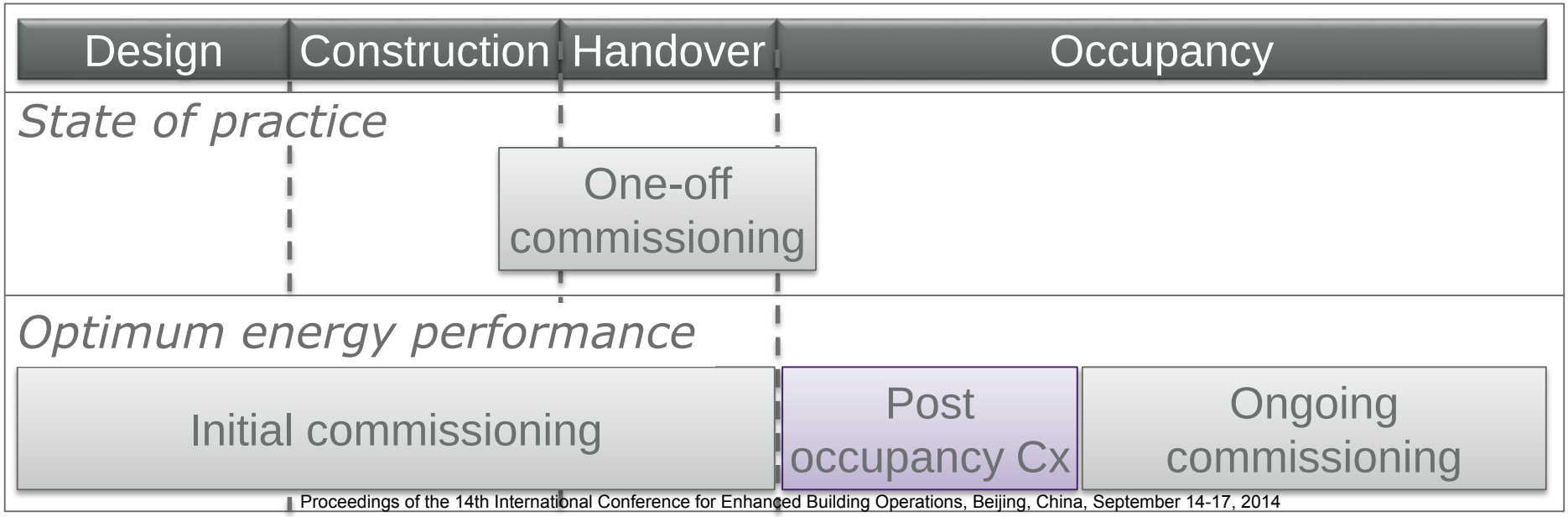


Question: Could commissioning for energy performance contribute to close the performance gap?

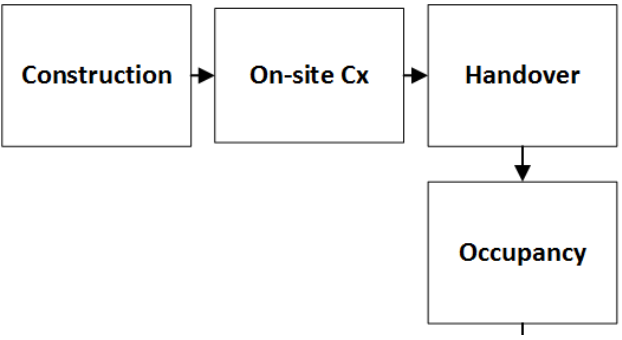
Source: Noye et al., CIBSE technical symposium, 2013

Commissioning

Problem: There is often not enough time during on site Cx for performance evaluation



Post occupancy commissioning (POCx)



Systems deliver flow rates and temperatures

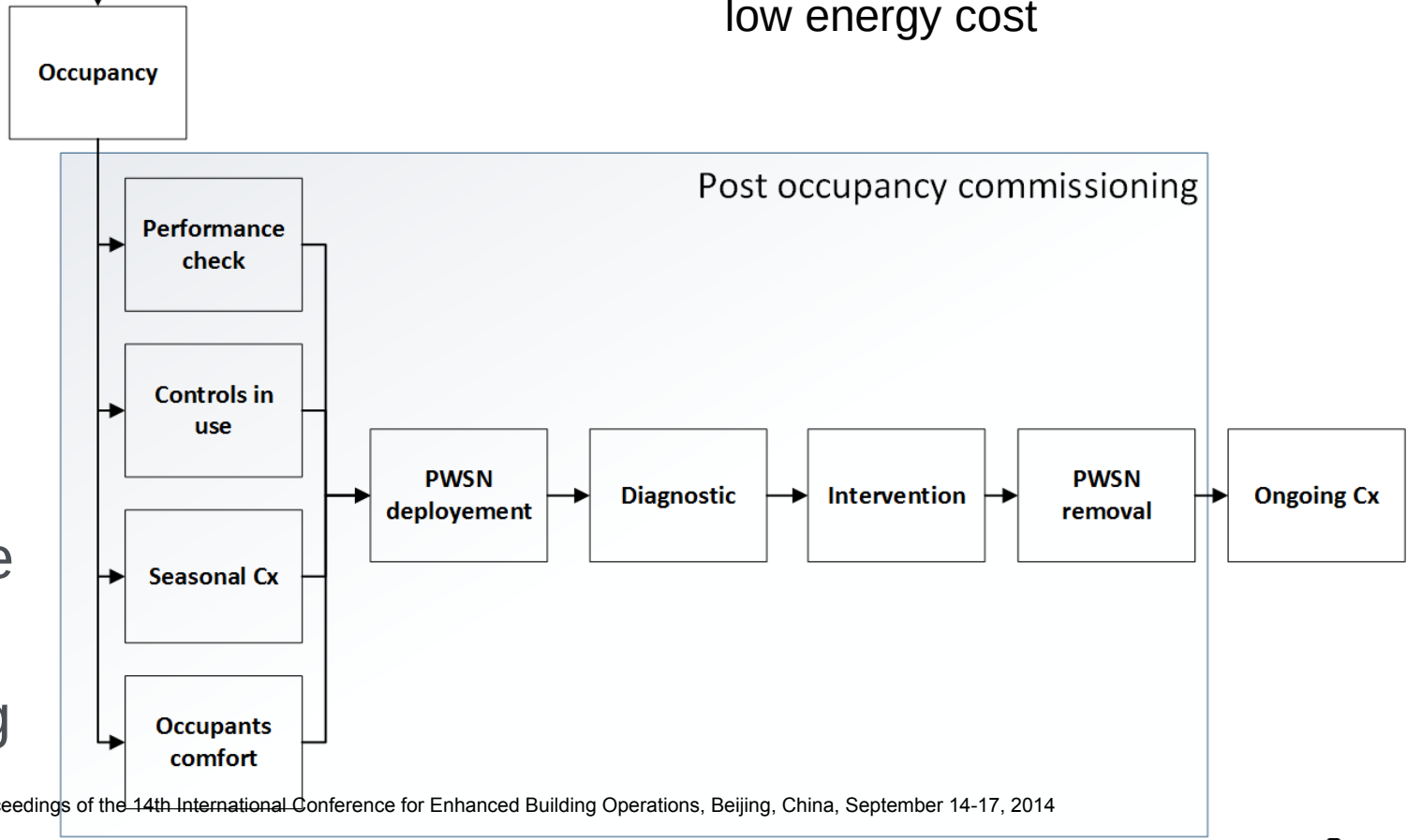
On-site Commissioning

- Balancing
- Setting to work
- Compliance
- Health and safety

Post occupancy commissioning (POCx)

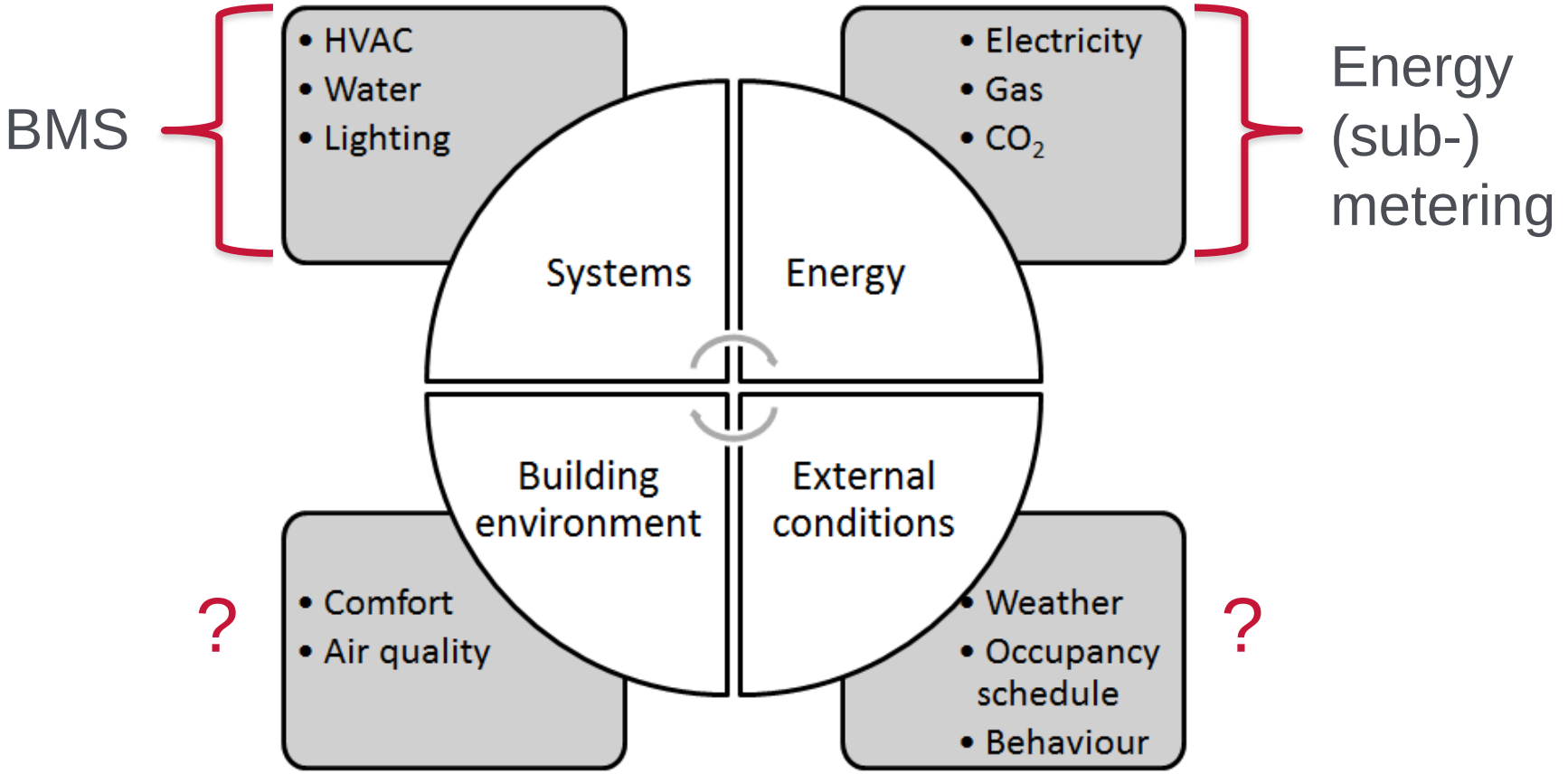
- Improved comfort
- Reduced energy wastage
- Client's brief compliance
- Better referencing for the contractor

Systems deliver comfort at low energy cost



POP-UP MONITORING™ REQUIREMENTS

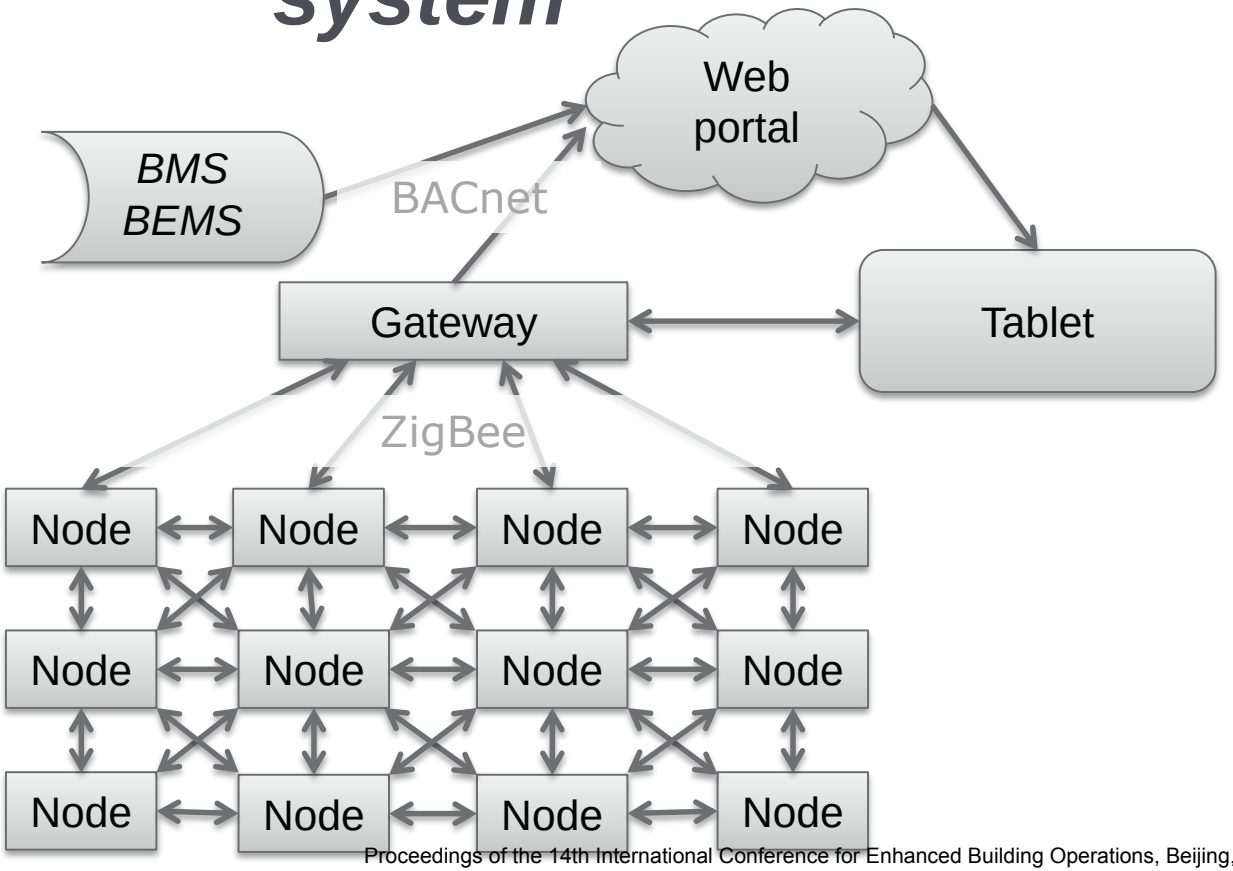
Building data



All those data need to be available to evaluate building performance

Wireless sensor network

Pop-up monitoring™ system



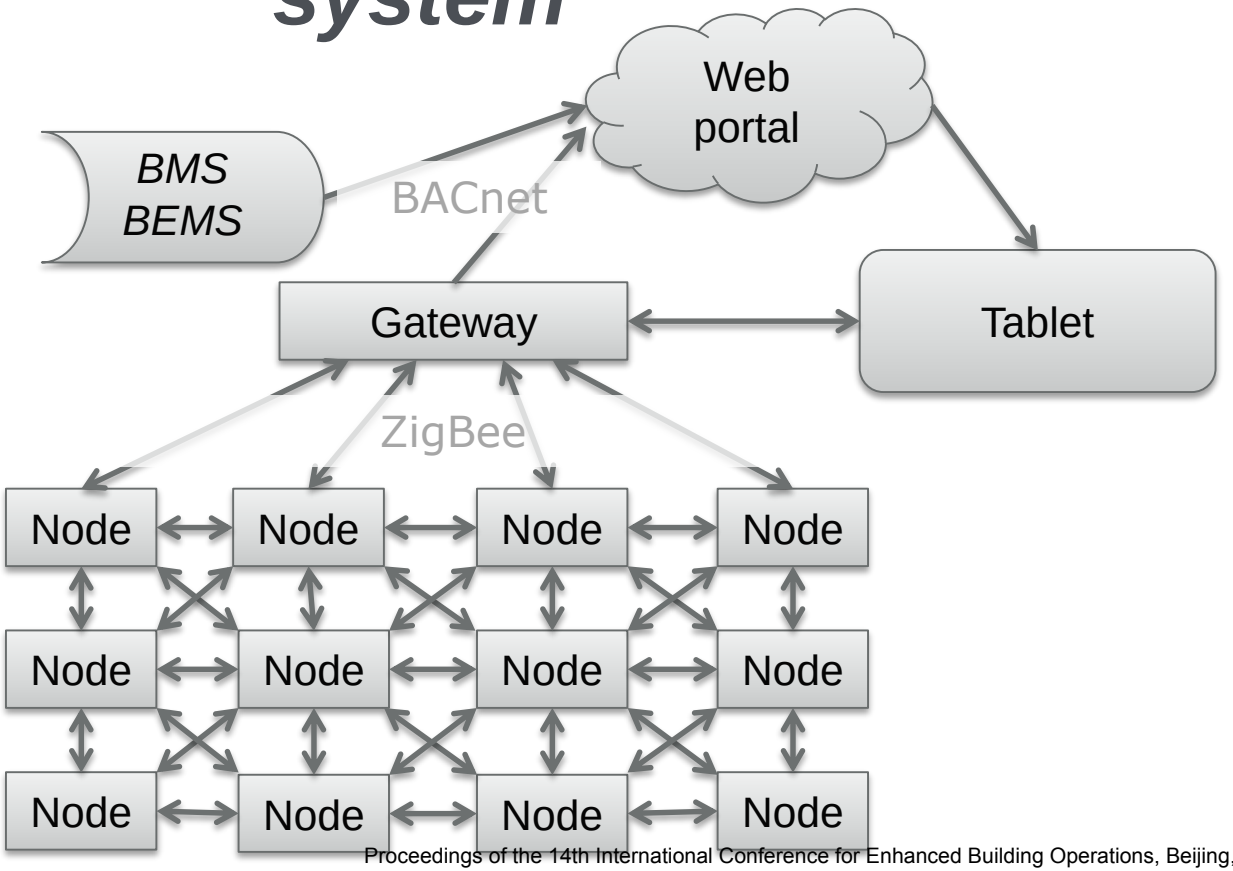
- *Affordable*
- *Wireless*
- *Self powered*
- *Easily deployable*
- *Scalable and flexible*
- *Non disruptive*

Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014

Source: Noye et al., CIBSE technical symposium, 2013

Wireless sensor network

Pop-up monitoring™ system



Cost

~ $150 x number of nodes (reusable on several projects)

+ installation

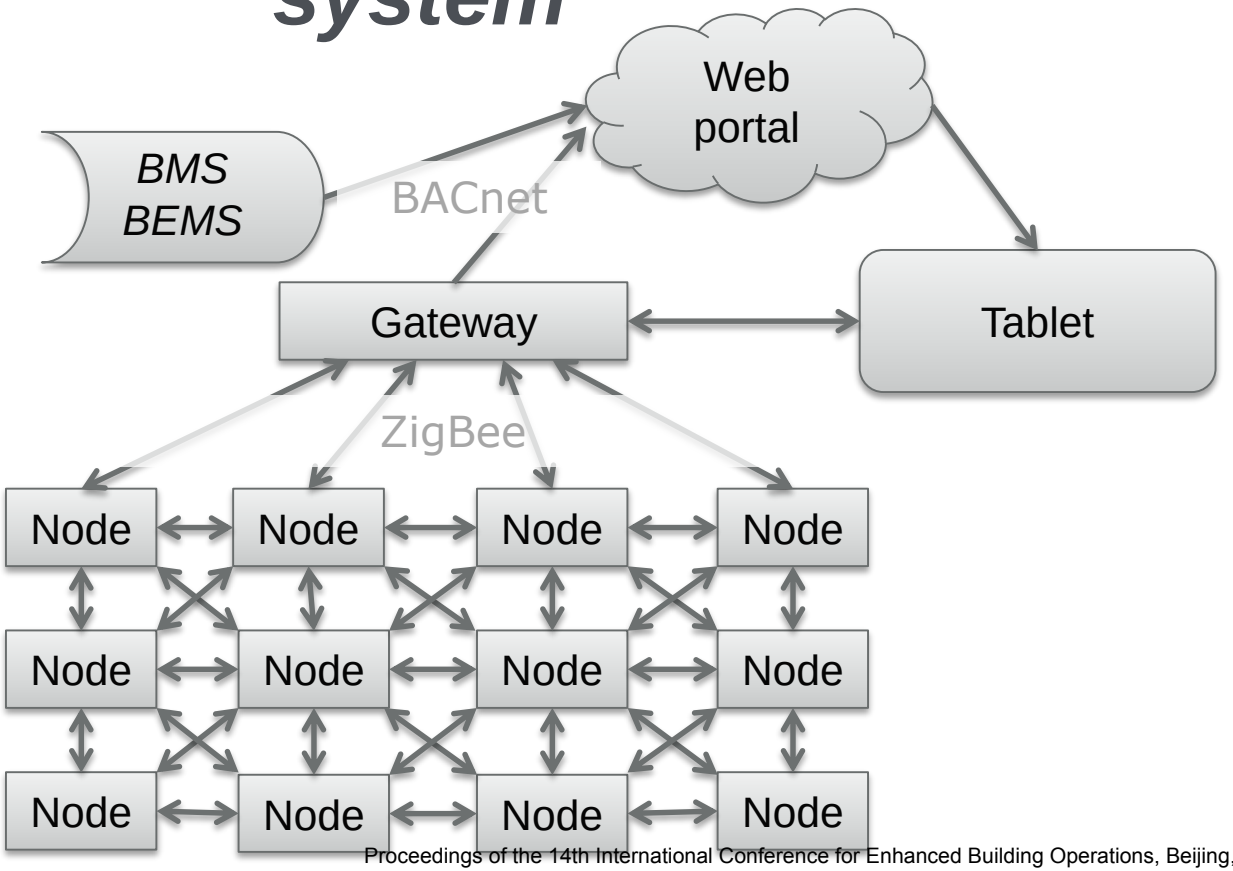
+ removal

Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014

Source: Noye et al., CIBSE technical symposium, 2013

Wireless sensor network

Pop-up monitoring™ system



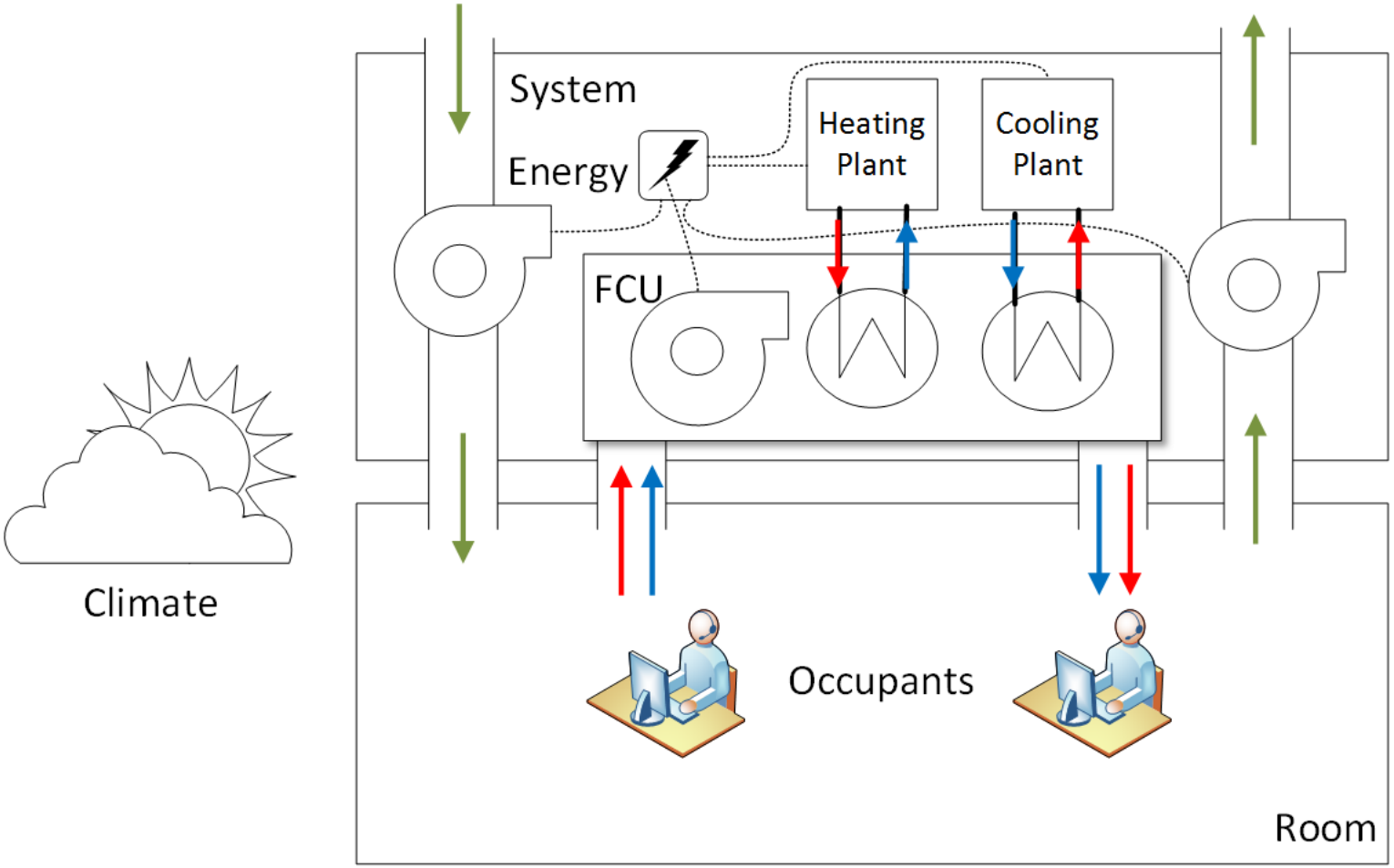
Battery life

- Up to 3 years depending on acquisition frequency
- Future: self harvesting sensor nodes

Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014

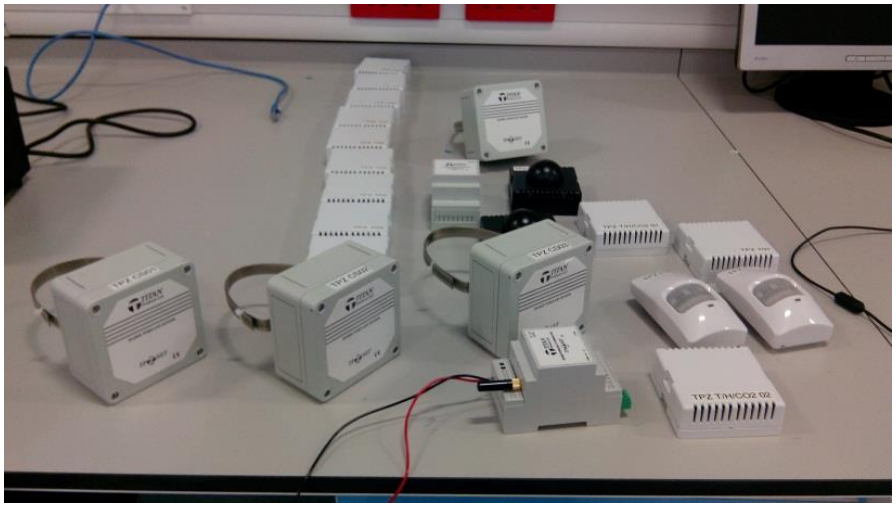
Source: Noye et al., CIBSE technical symposium, 2013

Ventilation feasibility study



Ventilation feasibility study

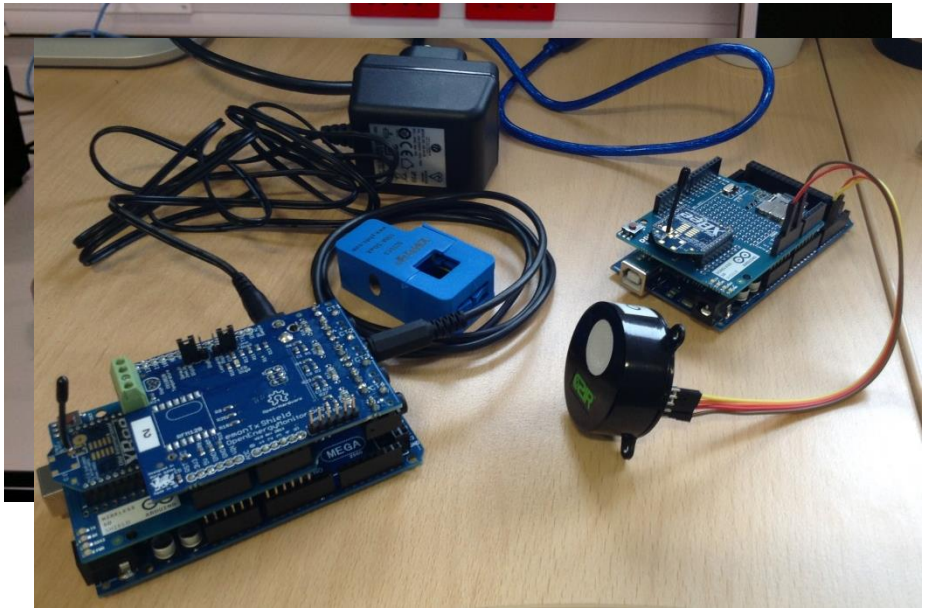
	Sensors	Parameter	Location
1	**Temperature**	**Temperature**	**Room**
2	**CO_2 Temperature Humidity**	**CO_2 level Temperature Humidity**	**Room**
3	**Radiant temp.**	**Radiant temp.**	**Room**
4	**Passive infra-red**	**Occupancy**	**Room**
5	Temperature CO_2 Humidity Air flow	Air temp. In/out CO_2 Air humidity Air flow	System
6	Current Voltage	Electric power	System
7	**Pipe temp.**	**Temperature**	**System**



Off the shelf sensors complemented with self developed sensors

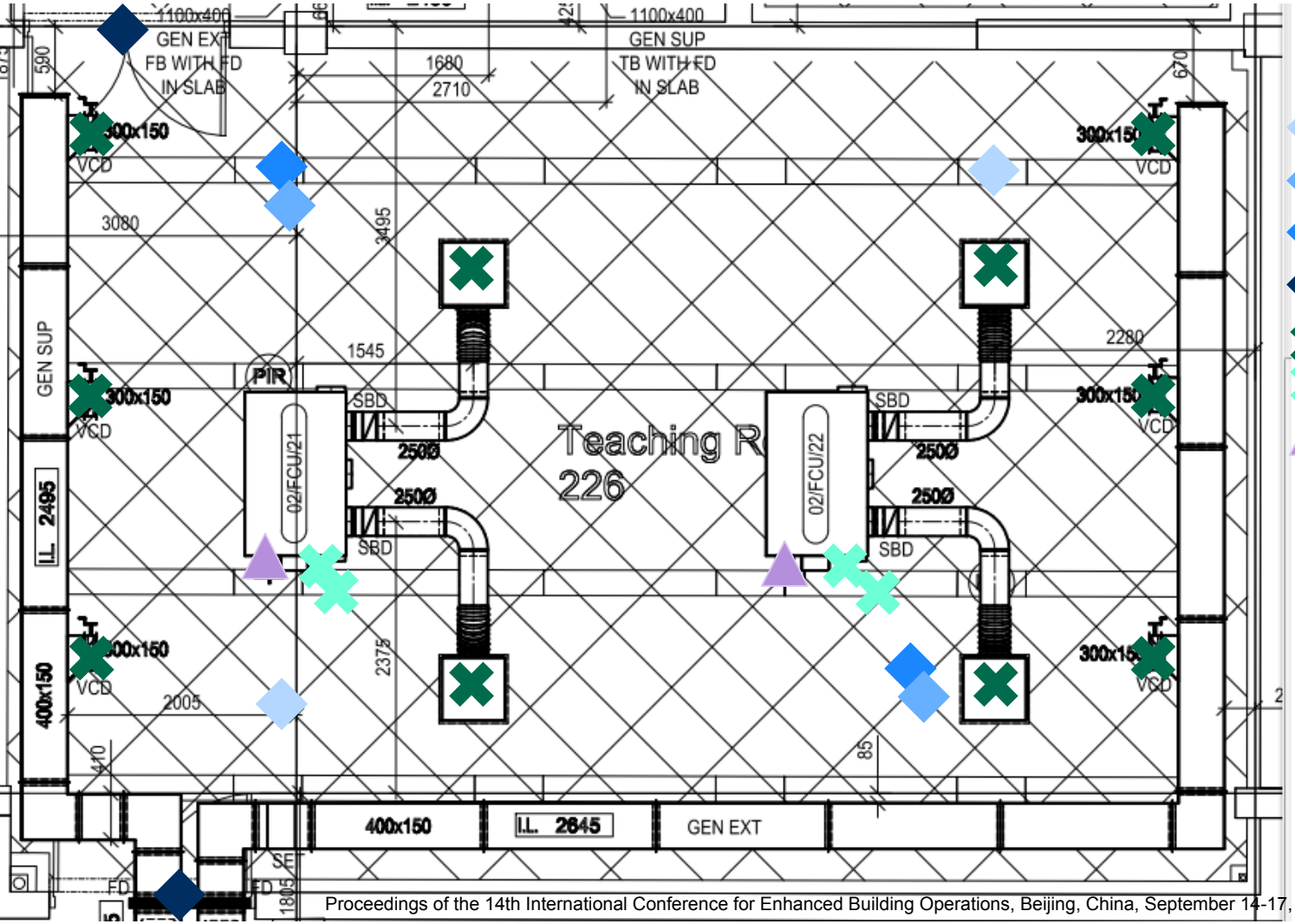
Ventilation feasibility study

	Sensors	Parameter	Location
1	Temperature	Temperature	Room
2	CO_2 Temperature Humidity	CO_2 level Temperature Humidity	Room
3	Radiant temp.	Radiant temp.	Room
4	Passive infra-red	Occupancy	Room
5	**Temperature** **CO_2** **Humidity** **Air flow**	**Air temp.** **In/out CO_2** **Air humidity** **Air flow**	**System**
6	**Current** **Voltage**	**Electric power**	**System**
7	Pipe temp.	Temperature	System



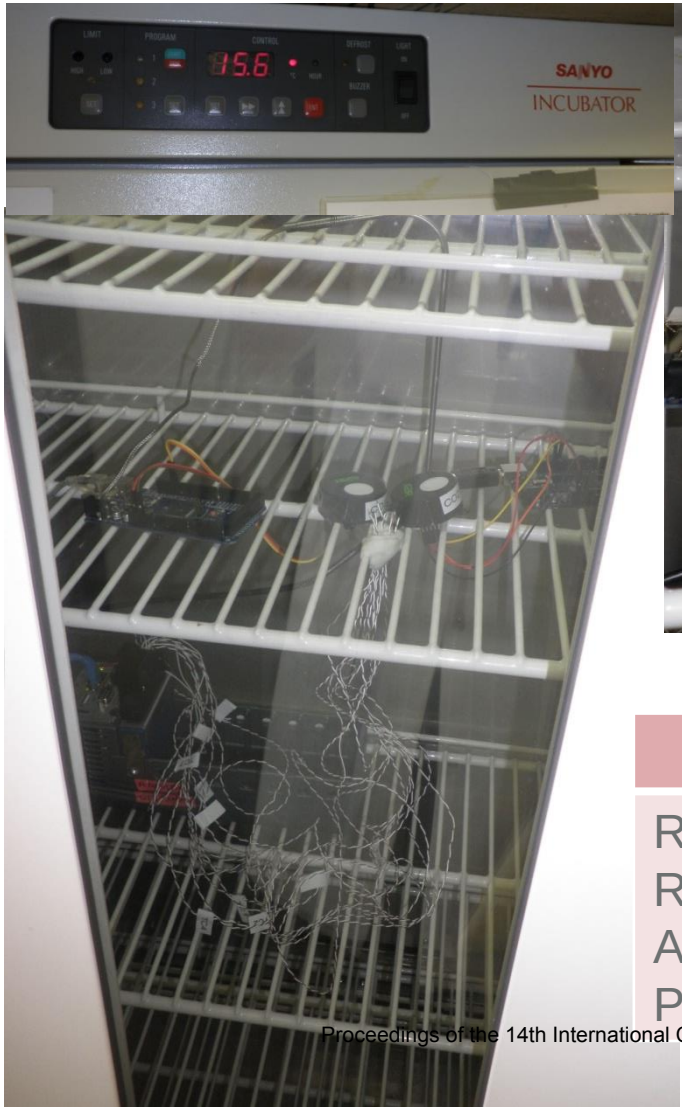
Off the shelf sensors complemented with self developed sensors

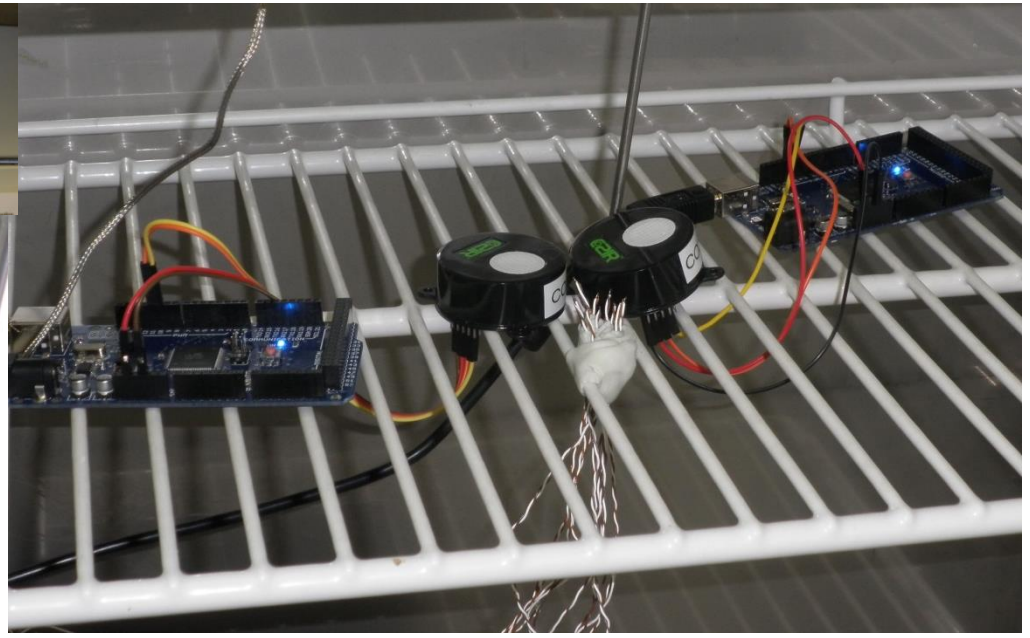
Ventilation feasibility study



INITIAL EXPERIMENTAL VALIDATION

Sensors characterisation - Temperature

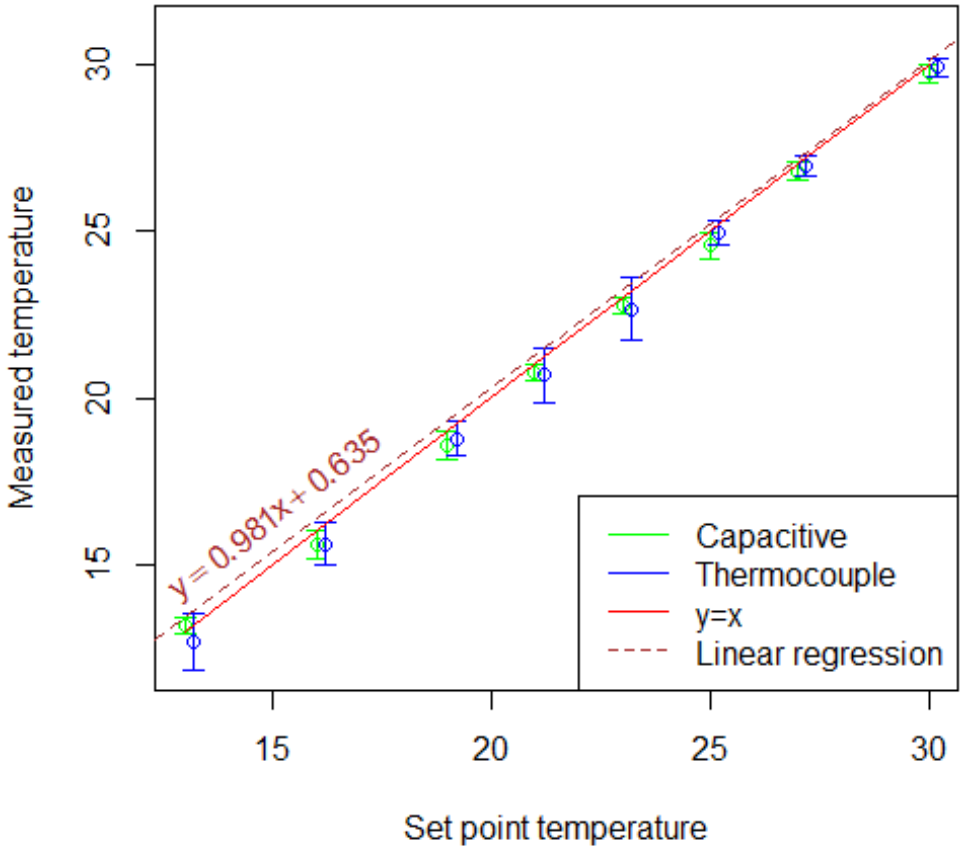




	Thermocouple	Capacitive
Range	-40 to 70 °C	-40 to 125 °C
Resolution	6 10-6 °C	0.04 °C
Accuracy	0.5 °C	± 0.3 to 0.8 °C
Power consumption		3.5 mW

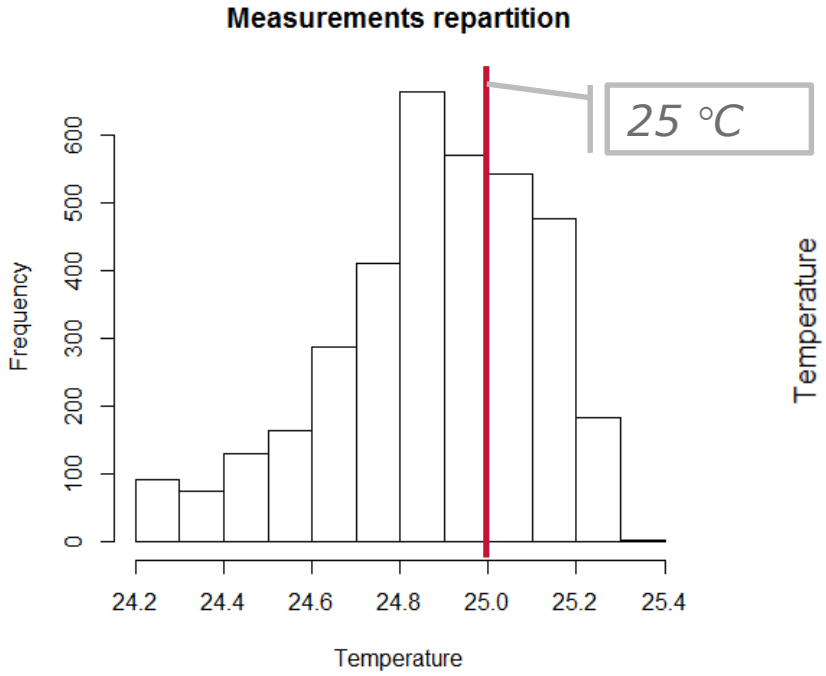
Sensors characterisation - Temperature

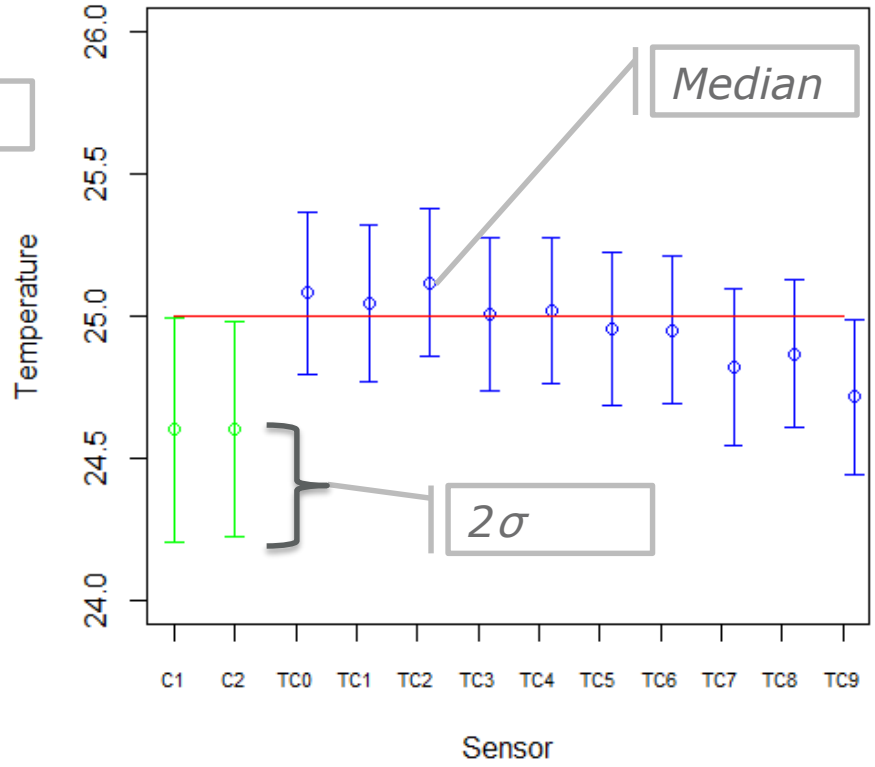
Variability of sensor readings at a set temperature in a controlled environment



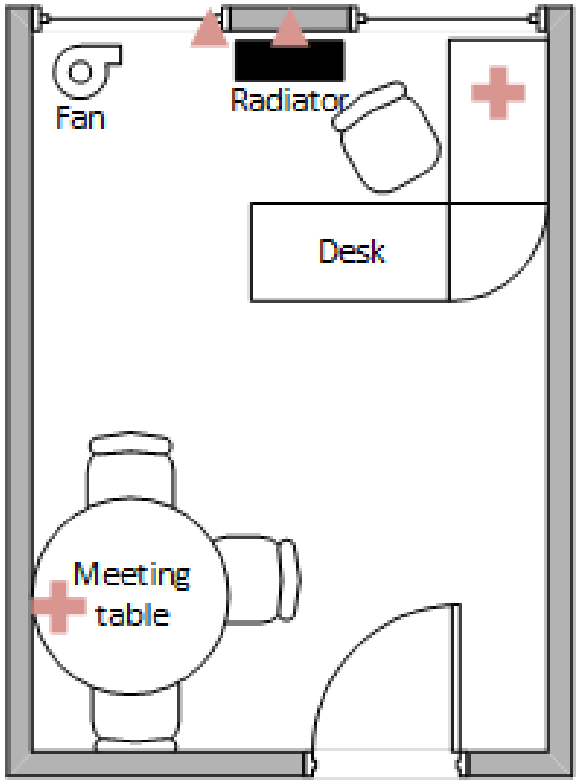
Sensors characterisation - Temperature

25 °C set point





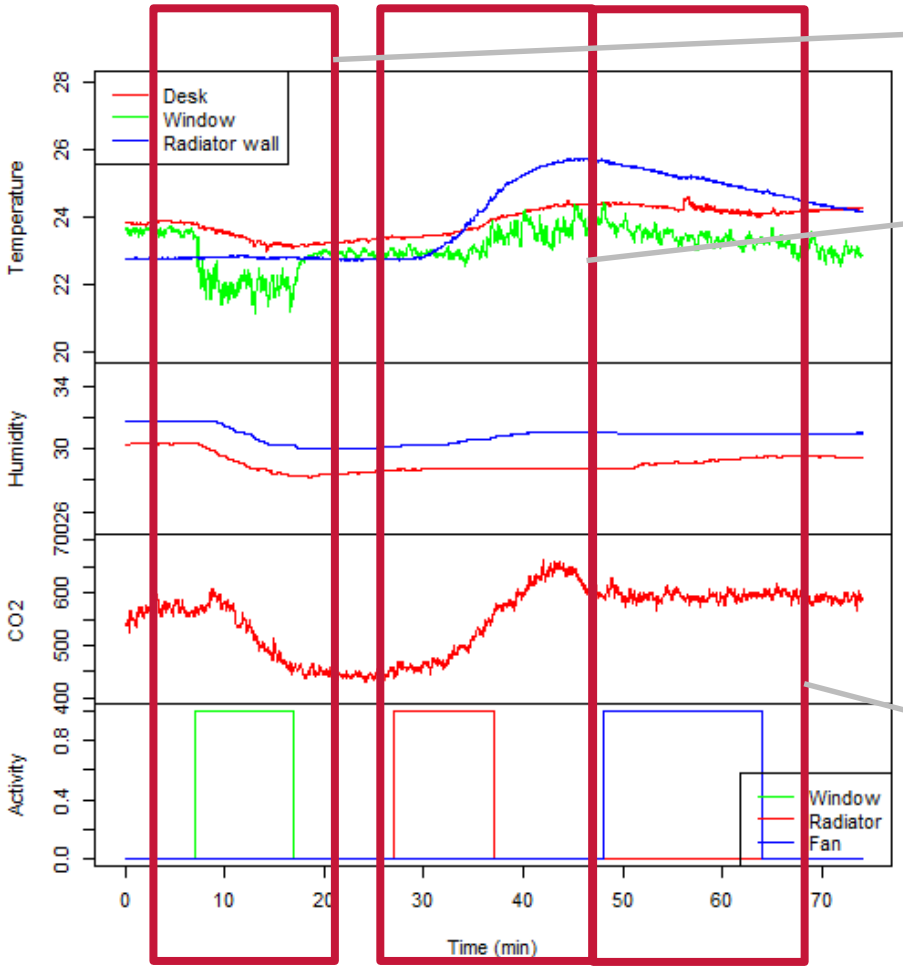
Office monitoring set up



Temperature sensor

Temperature, humidity and CO2 sensor

Controlled activity



Window open

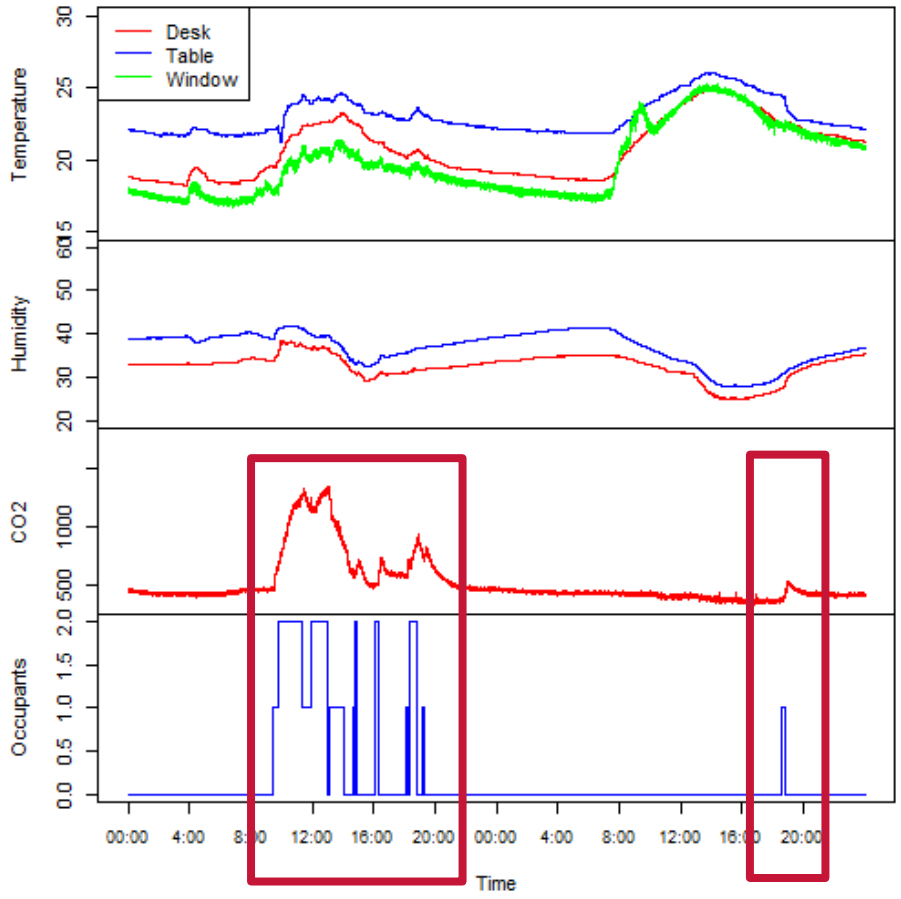
Radiator on

Controlled human activities related to thermal comfort

Fan on

Office monitoring

CO_2 levels and occupancy are closely related



Further steps

- Fault simulation
  - E.g.: FCUs fighting each other
- Real case deployments
  - E.g.: Teaching and research building
- Strategies for PO-Cx using pop-up monitoring™

Conclusion

- Truncated commissioning may contribute to the energy performance gap
- BMS might not have sufficient data for PO-Cx
- Rapid development of wireless sensor network technologies can provide low-cost data for pop-up monitoring™
- Initial characterisation test on low power sensors show suitable accuracy and the ability to detect relevant building properties for commissioning
- Deployment on major project this autumn

Sarah Noye – s.noye11@imperial.ac.uk

Thank you for your attention