Laboratory Energy Benchmarking TEMC 2012

Tim Dean

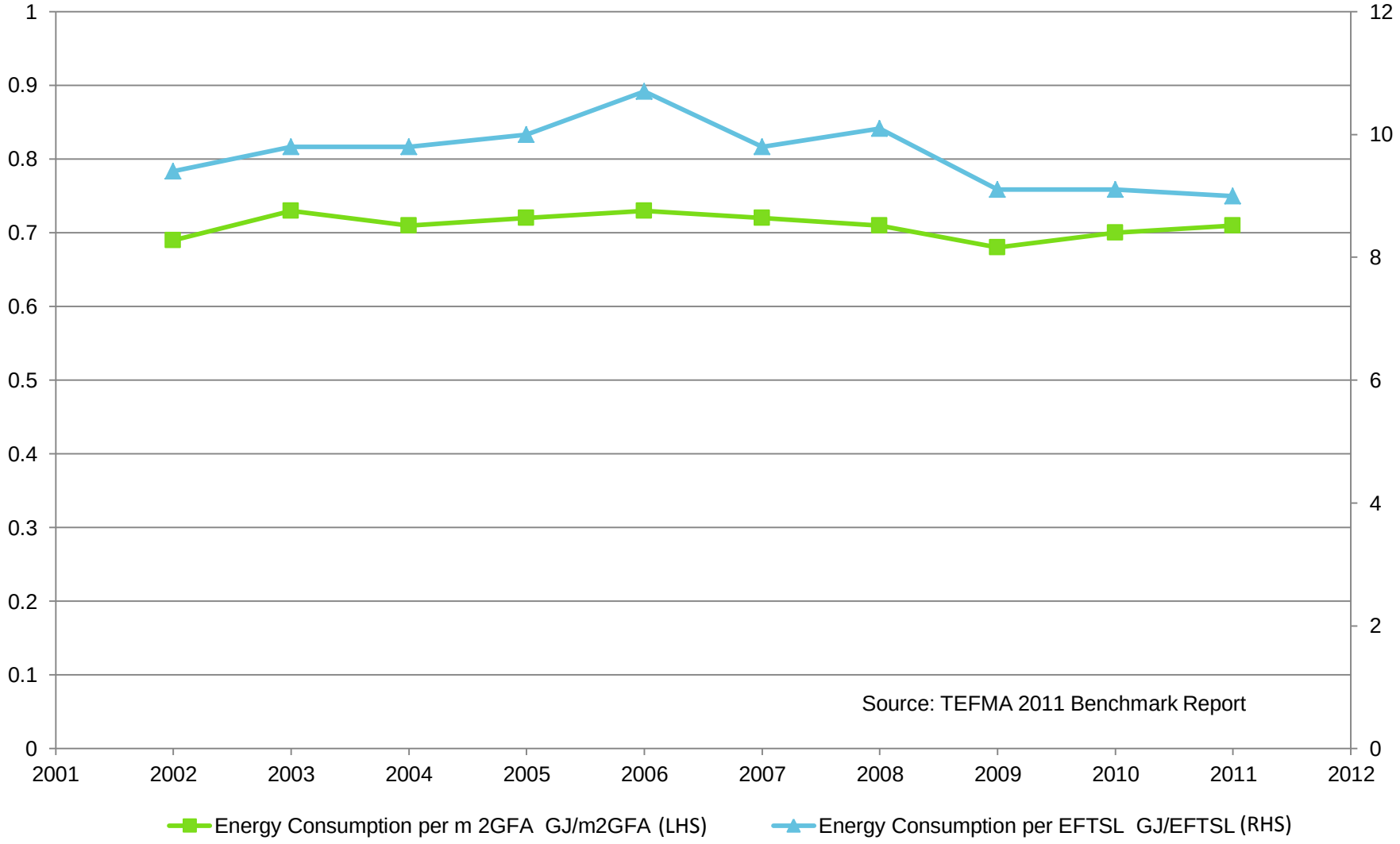
September, 2012

AECOM

Introduction

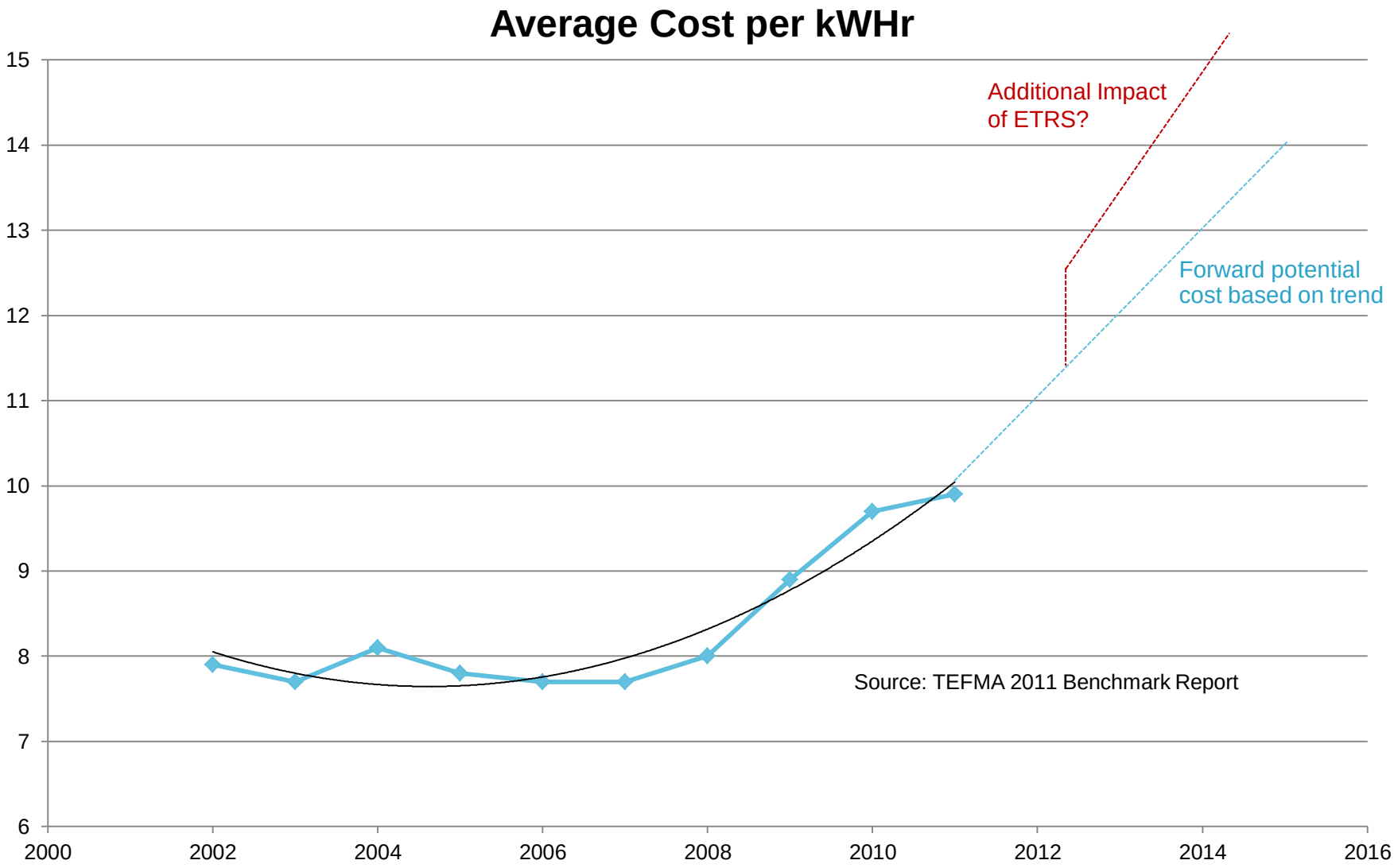
- Why do we care about laboratory energy benchmarking?
- Benchmarking programs worldwide
- Laboratory benchmarking study
- Applying the benchmarks
- Where to next…?

Why do we care about laboratory benchmarking?



Why do we care about laboratory benchmarking?

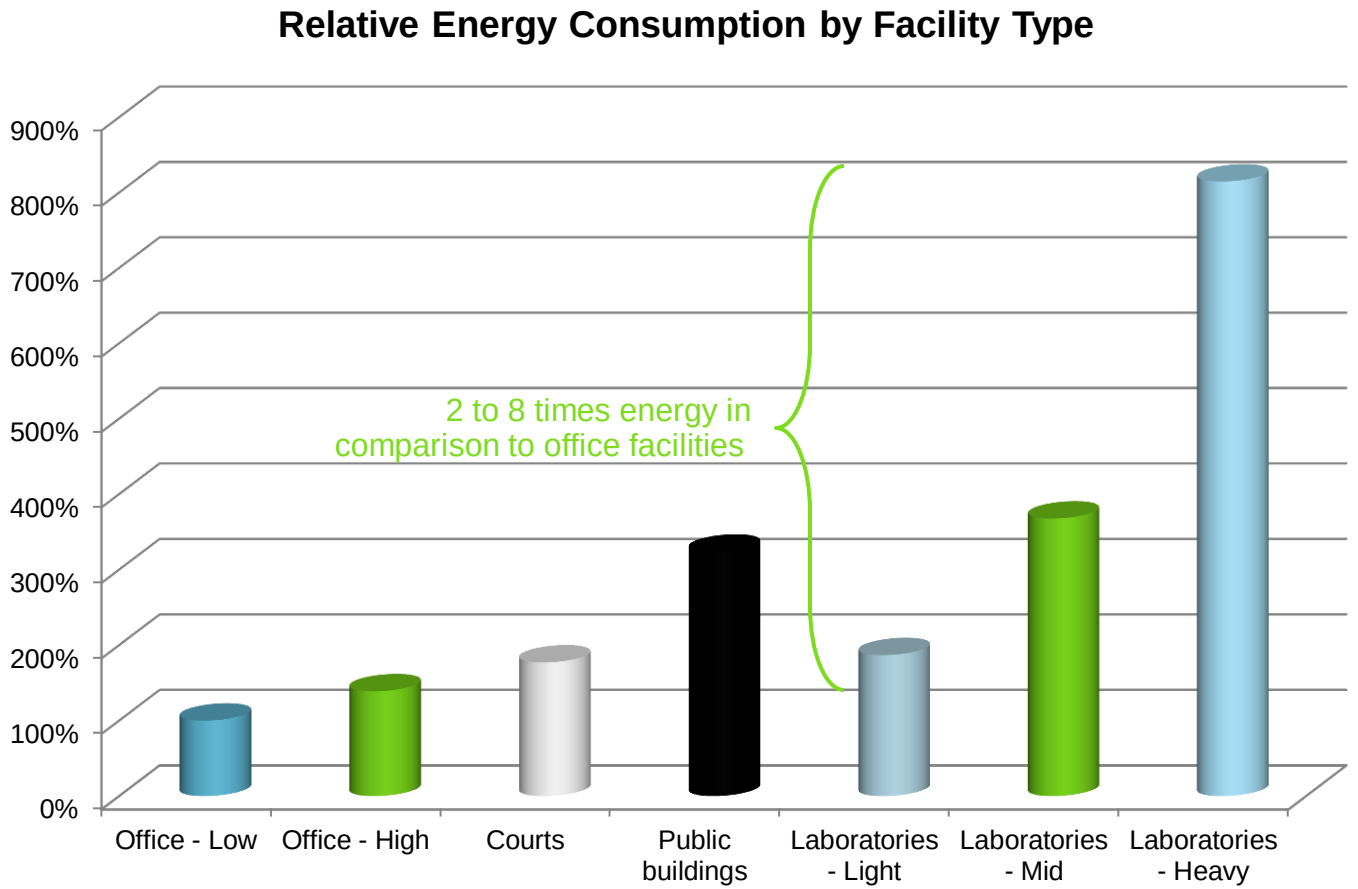
Why do we care about laboratory benchmarking?



Why do we care about laboratory benchmarking?

Laboratories consume energy

Lots of it.



Source: Energy Use in Australian Government Operations 2009-2010

Why do we care about laboratory benchmarking?

- Fume cupboards
- Exhausts
- Outside air requirements
- Pressurisation
- High internal loads
- Safety systems

Why do we care about laboratory benchmarking?

- Environmental responsibility
- Economic responsibility
- Social responsibility

Need to learn from the past and seek to improve

Benchmarking Programs for Laboratories

Benchmarking of Laboratories Worldwide

- Labs21
- HEEPI – Higher Education Environmental Performance Improvement program
- Green Star – Education includes some laboratory
- Building Code of Australia – Section J
- NABERS

Specific Loads

Benchmark	Labs21	HEEPI	Green Star	BCA
Lighting Density (W/m^2)	14 (~540lux)	N/A	*15*	14
Biology Plug Load Density (W/m^2)	188	N/A	*40*	N/A
Chemistry Plug Load Density (W/m^2)	188	N/A	*40*	N/A
Specific Fan Power (W/l/s)	1.27	N/A	N/A	1.14

Benchmarking of Laboratories Worldwide

green star Education v1

*green building council australia

Wet Labs

HVAC Model Operational Profile

- Published in 2010
- Profiles?
- Operation?

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	2.25	6	Off
1am	0	0	0	2.25	6	Off
2am	0	0	0	2.25	6	Off
3am	0	0	0	2.25	6	Off
4am	0	0	0	2.25	6	Off
5am	0	0	0	2.25	6	Off
6am	0.39	0.34	178	2.25	6	Off
7am	0.39	0.34	178	2.25	6	On
8am	2.63	2.25	27	15	40	On
9am	2.63	2.25	27	15	40	On
10am	2.63	2.25	27	15	40	On
11am	2.63	2.25	27	15	40	On
12pm	1.31	1.13	54	12	28	On
1pm	2.63	2.25	27	15	40	On
2pm	2.63	2.25	27	15	40	On
3pm	2.63	2.25	27	15	40	On
4pm	2.63	2.25	27	15	40	On
5pm	2.63	2.25	27	15	40	Off
6pm	0.92	0.79	77	3	8	Off
7pm	0.92	0.79	77	3	8	Off
8pm	0.92	0.79	77	3	8	Off
9pm	0.92	0.79	77	3	8	Off
10pm	0	0	0	2.25	2	Off
11pm	0	0	0	2.25	2	Off

Loads by Space Type

Benchmark (kWh/m² per annum)	Labs21	HEEPI	Green Star (HVAC & Lighting Only)	BCA
Office Space	N/A	N/A	10 – 96.3	180.6
Biology Laboratory	N/A	581	79.5 – 81.5	180.6
Chemistry Laboratory	N/A	439	79.5 – 81.5	180.6
Other Laboratory	N/A	278	79.5 – 81.5	180.6
Special Laboratory	N/A	N/A	79.5 – 81.5	180.6

Benchmarking of Laboratories Worldwide

- BCA doesn't provide much realistic guidance *for labs*
- Labs21
  - Design factors
  - Didn't look at lab types
  - Huge spread of benchmark possibilities
- Overall, limited differentiation of laboratory type
  - Biology
  - Chemistry – light/heavy
  - Specialist function / major equipment
  - Containment – PC 3 or 4
  - General

Benchmarking of Laboratories Worldwide

- Generally based on temperate or dry climates
- Limited granularity on space usage
  - Teaching
  - Office
  - Research
  - Production

So how do any of these benchmarks apply for a bio-research lab in Brisbane...?

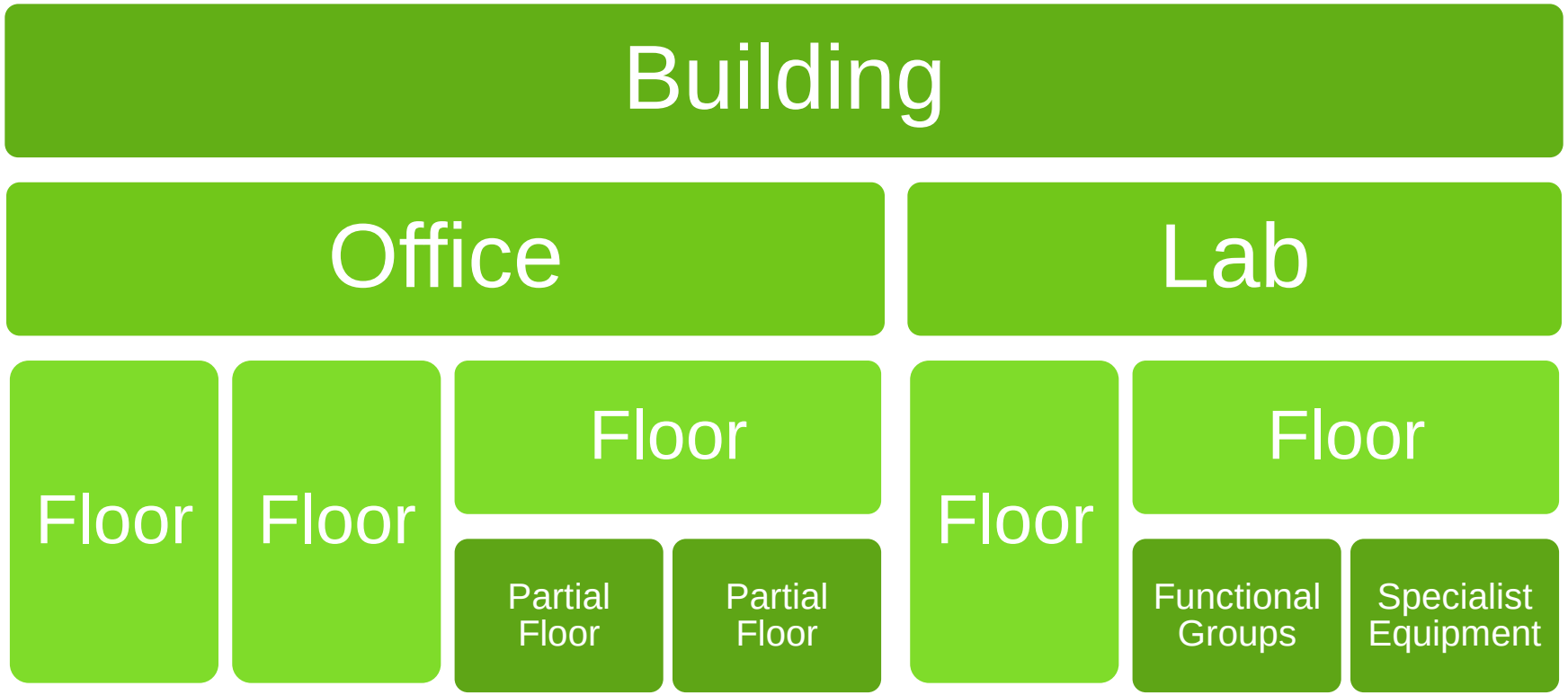

Laboratories Benchmarking Study

Laboratories Benchmarking Study

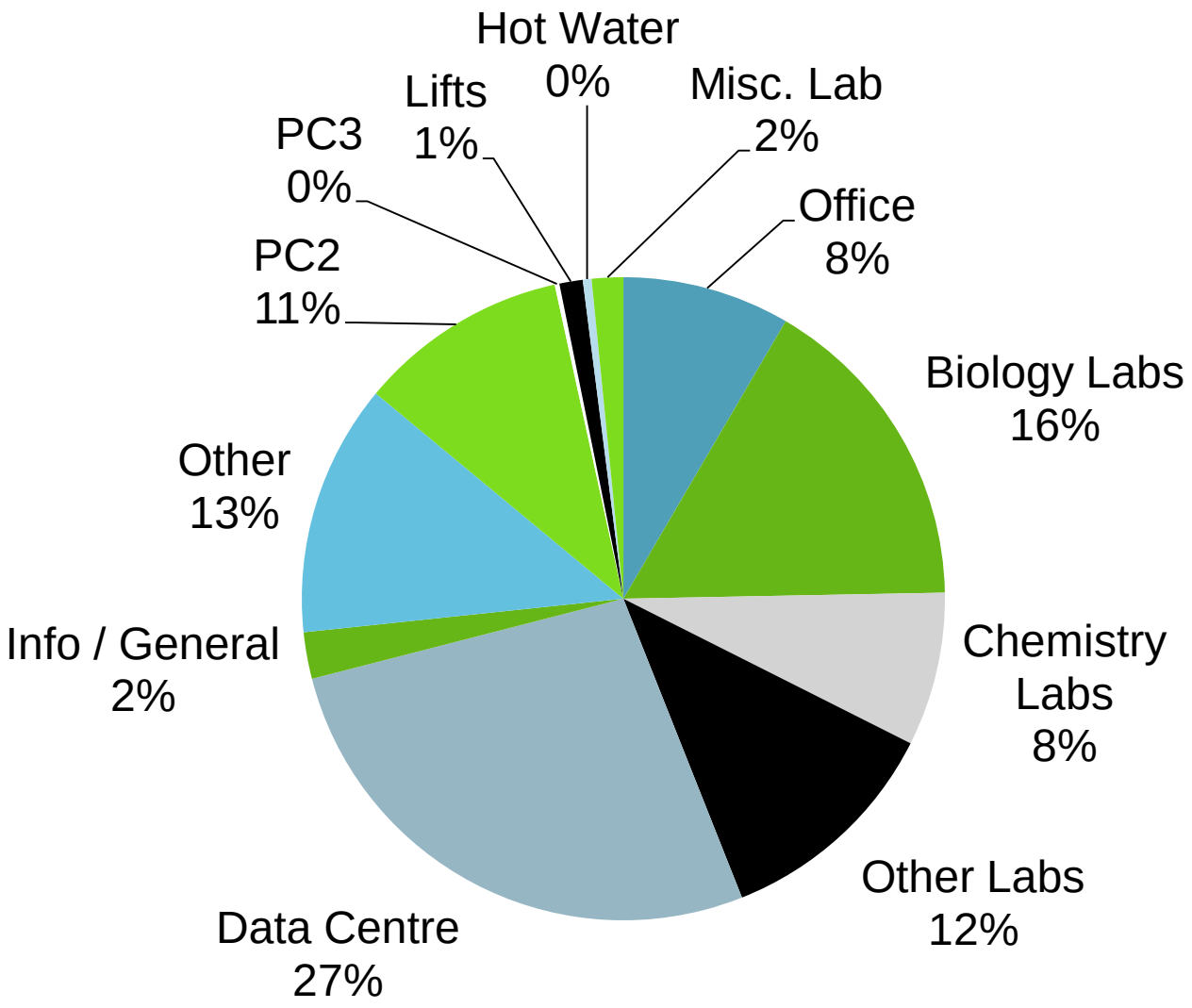
- Investigated eight laboratory facilities in Brisbane
- Site survey:
  - Energy – generally, site specific factors, major equipment
  - Operational aspects
  - User practices
  - Facility management and practices
- Collection of energy data *available*

Laboratories Benchmarking Study – Initial Findings

- Initial findings
  - Metering, sub-metering – breakdown?
  - Mixed value of data



Example data breakdown



Laboratories Benchmarking Study - Modelling

- Created a model of laboratory energy
  - Type of lab – biology, chemistry, containment, support, office..
  - Area
  - Number of fume cupboards
  - Equipment loadings
  - Lighting provision
  - Central plant provisions - estimated

- Normalised the model using data collected

Where we are at…

- Review Guidelines
- Audit Existing Facilities
- Create a Model
- *Validation*

Laboratories Benchmarking Study - Validation

Facility	Predicted MWh/yr	Actual MWh/yr	Predicted v Actual
A	6,488	7,008	93%
B	3,573	3,185	112%
C	7,501	7,683	98%
D	4,668	4,516	103%
E	14,473	17,775	81%
F	3,601	3,234	111%

Laboratories Benchmarking Study - Validation

- Major equipment has big impacts
- Lighting operation
- ‘Average’ for a facility doesn’t work

- How does this compare to benchmarks…?

Specific Loads

Benchmark	Labs21	HEEPI	Green Star	BCA	Reviewed Facilities
Lighting Density (W/m^2)	14 (~540lux)	N/A	N/A	14	19
Biology Plug Load Density (W/m^2)	188	N/A	N/A	N/A	359
Chemistry Plug Load Density (W/m^2)	188	N/A	N/A	N/A	341
Specific Fan Power (W/l/s)	1.27	N/A	N/A	1.14	*1.14*

Loads by Space Type

Benchmark (kWh/m² per annum)	Labs21	HEEPI	Green Star (HVAC & Lighting Only)	BCA	Reviewed Facilities
Office Space	N/A	N/A	N/A	180.6	220 (average)
Biology Laboratory	N/A	581	79.5 – 81.5	180.6	337-840
Chemistry Laboratory	N/A	439	79.5 – 81.5	180.6	697
Other Laboratory	N/A	278	79.5 – 81.5	180.6	224-476
Special Laboratory	N/A	N/A	79.5 – 81.5	180.6	399-900

Applying the Benchmarking

Where we are at…

- Review Guidelines
- Audit Existing Facilities
- Create a Model
- Validation
- Propose Benchmarks
- *Create a model for a new facility*

Model for New Facility

- Benchmarks are historical
- Improve on benchmarks?
  - Average?
  - Max? Min?
- Start with the ‘easy wins’
  - Fume cupboard usage
  - Lighting control
- Establish best practice targets

Model for New Facility – Best Practice Targets

Best Practice Target	Energy Density kWh/m²/yr
Biology Lab – Fume Cupboard Fan Load	6
Biology Lab – Fume Cupboard Make-up Load	58
Lab Lighting Load	43
Lab Small Plug Load	141
Installed Chiller Capacity	219
Installed Cooling Tower Load	5
Installed CHW Pump Load	10
Installed CW Pump Load	7

Model for New Facility – Best Practice Targets

Best Practice Target	Energy Density kWh/m^2/yr
Total CHW Plant Load	242
Total Other Lab Load	262
Total Biology Lab Load	303
Total Office Load	172

Model for New Facility

Impact:

- Biology labs – reduction of 40% average to best

- General labs – reduction of 30% average to best

- Overall target: 25+% improvement

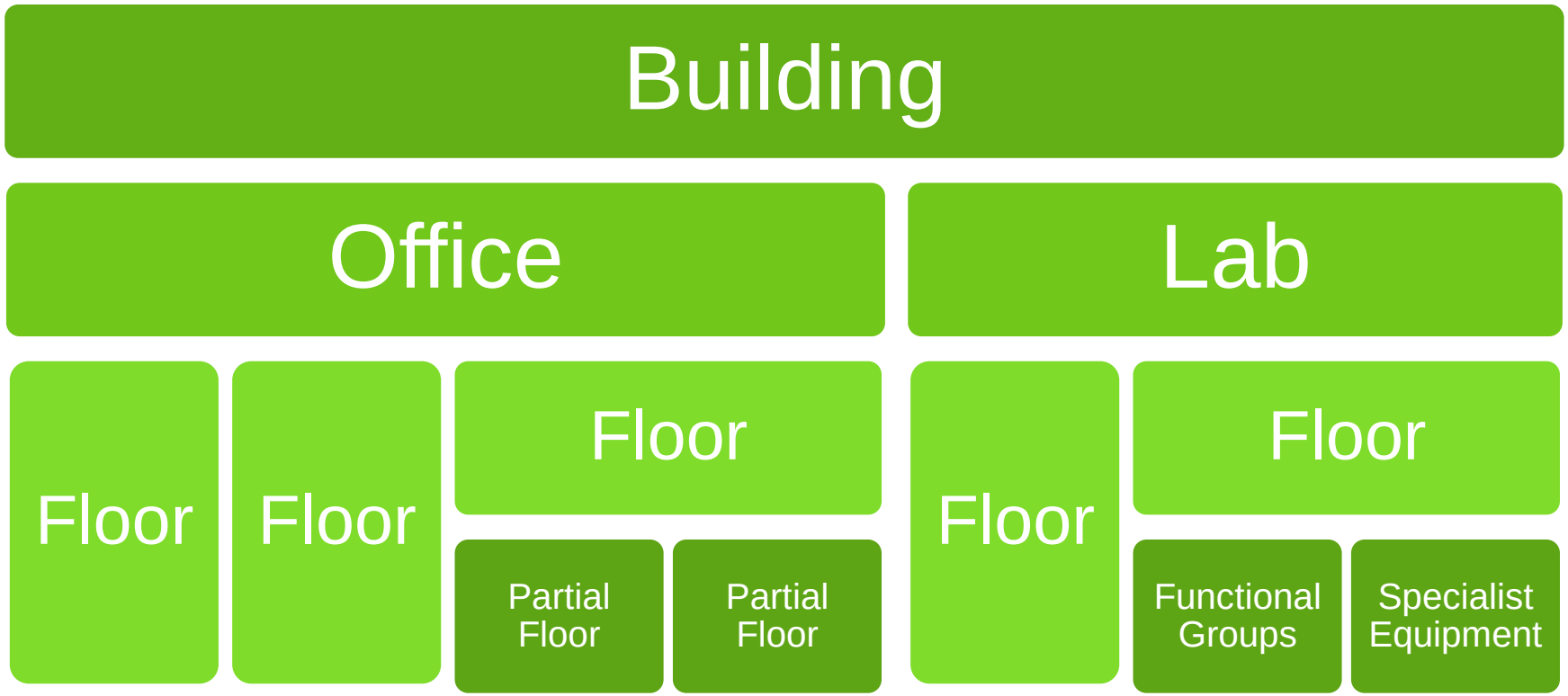
Where to next?

Where we are at…

- Review Guidelines
- Audit Existing Facilities
- Create a Model
- Validation
- Propose Benchmarks
- Create a model for a new facility
- *Review, refine and extend*

What you can't see may hurt you…

- Metering matters



- Monitor, Control and Influence

It’s not just the Engineering…

Out of control!

- Laboratory practices matter
- Education
- Positive reinforcement

It's not just the Engineering…

- Laboratory management programs. ie.
  - http://www.uq.edu.au/sustainability/green-labs-program
  - http://fsd.monash.edu.au/environmental-sustainability/how-you-can-help/monash-green-laboratories
  - http://sustainablecampus.unimelb.edu.au/campus_sustainability/lab/index.html
  - http://www.sustain.canterbury.ac.nz/what_can_you_do/labs.shtml
  - http://www.anu.edu.au/anugreen/?pid=58
- Equipment - http://www.i2sl.org/resources/toolkit/wiki.html
- http://www.international-sustainable-campus-network.org/

Where to next?

... we want to have a useful predictive tool

- Developing a more complex tool
  - Climate zones
  - Impact of facility changes
  - Broader input parameters
  - Energy calculator
  - Baseline assessment comparison
  - Capital and recurrent cost impacts

Where to next?

- Bigger sample
- More laboratory types
- Sharing

National database of laboratory performance

Thank You

Adriaan Window
e. adriaan.window@aecom.com
m. +61 402 883 942

Tim Dean
e. tim.dean@aecom.com
m. +61 439 371 063