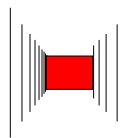


**COMPARISON OF NZ'S ENERGY EFFICIENCY REGULATION
AND VERIFICATION ASSUMPTIONS TO REAL BUILDING
LOADS AND OPERATION**

SHAAN CORY, ANDREW POLLARD, AND MICHAEL DONN

Introduction and significance

- ▶ *Typical, high and low* building load densities and patterns of use for commercial buildings in New Zealand
 - Office, Retail, Mixed/Other
- ▶ highlights *differences* between assumptions using the NZBC modelling verification method and what is occurring in real buildings.
- ▶ better *inform* building energy modelers about typical lighting and equipment end uses



Terminology

▶ Analysis:

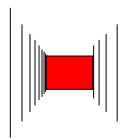
- Load Densities: measured load per square metre of monitored floor area
- Patterns of use: the daily use profiles of the load presented as the percentage of load 'on' at different time intervals throughout the day

▶ End-uses

- LPD: Lighting Power Density (only internal electric lighting)
- EPD: Equipment Power Density (all equipment, including office, miscellaneous, refrigeration, cooking etc...)
- HWPD: Hot Water Power Density (domestic use and commercial use)

▶ Scenario

- Typical: Median (50th percentile) load and pattern of use found across the sample of building premises
- High: 90th percentile
- Low: 10th percentile



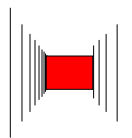
Terminology

▶ Building Type:

Office	Retail	Mixed/Other
Office-type use	Retailing use, Motor vehicle sales and services, Liquor outlets including taverns, Service stations, Tourist-type attractions	A mixture of office and retail use types. As well as, warehouses, and service buildings.

▶ Building Size:

Building Size	Small	Medium	Large
Building floor area range	5 to 649m ²	650 to 3,499m ²	Over 3,500m ²
Percentage of all commercial floor area	20%	40%	40%

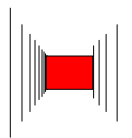


BEES

Floor Area Strata	S1	S2	S3	S4	S5	Total*
Minimum Floor Area	5m ²	650m ²	1,500m ²	3,500m ²	9,000m ²	
Maximum Floor Area	649m ²	1,499m ²	3,499m ²	8,999m ²		
Approximate Number of 'Buildings'	27,609	8,007	3,544	1,496	499	41,154
Percentage of Buildings	67%	19%	9%	4%	1%	100%
Total Floor Area (million m ²)	8.2	7.7	7.8	7.8	8.5	39.9
Percentage of Floor	21%	19%	20%	19%	21%	100%
Average Floor Area (m ²)	298	955	2,198	5,187	17,014	970

*Note: rows may not add due to rounding.

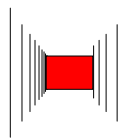
- ▶ Understand Non-Residential Buildings
 - Offices & Shops
 - Energy & Water
- ▶ Understanding the Complexities
- ▶ Planning for the Future
- ▶ Improving Design Guidance
- ▶ Contribute towards Codes & Standards



**Centre for Building
Performance Research**

Current Provisions and energy models

- ▶ NZS4243:2007 Provisions from Verification of compliance to NZBC
 - Only LPD – $12\text{W}/\text{m}^2$
- ▶ NZS4243:2007 Modelling Assumptions for Verification of compliance to NZBC
 - Internal gains from equipment
 - Patterns of use for lighting and equipment

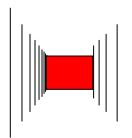


Collection of data

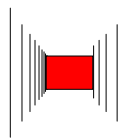
- ▶ Measured data at one minute intervals for a 2-3 week period in a representative sample of commercial buildings
- ▶ Samples consist of varying sizes for each building type

End-use	All buildings	Office	Retail	Mixed/Other
Lighting	101	35	29	37
Equipment	83	28	22	33
Hot Water	30	9	7	14

- ▶ Data processed to form:
 - Total monitored load (divide by floor area to obtain load density)
 - Average weekday and weekend patterns of use for each building

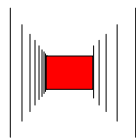
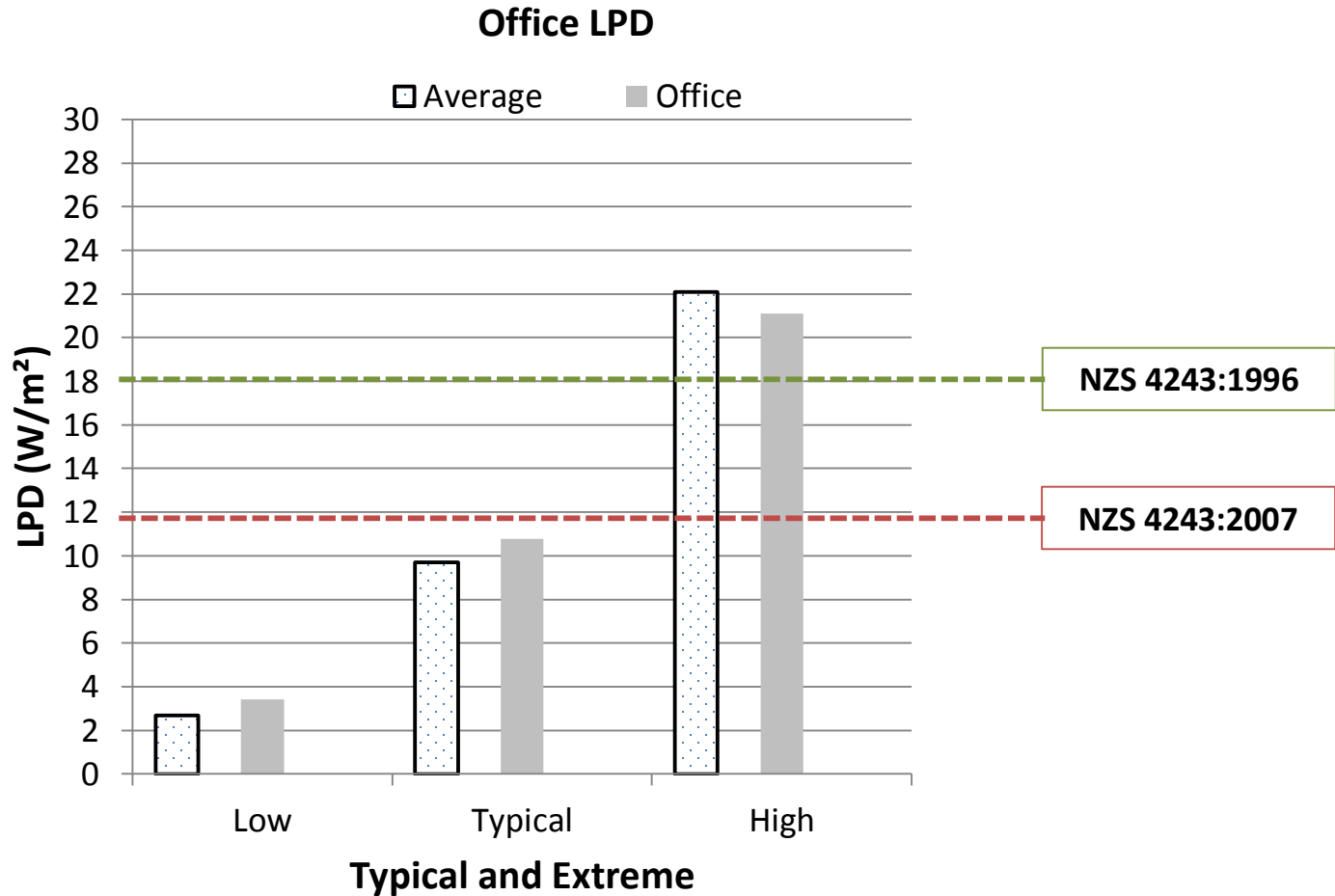


Lighting Power Densities

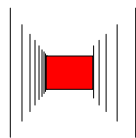
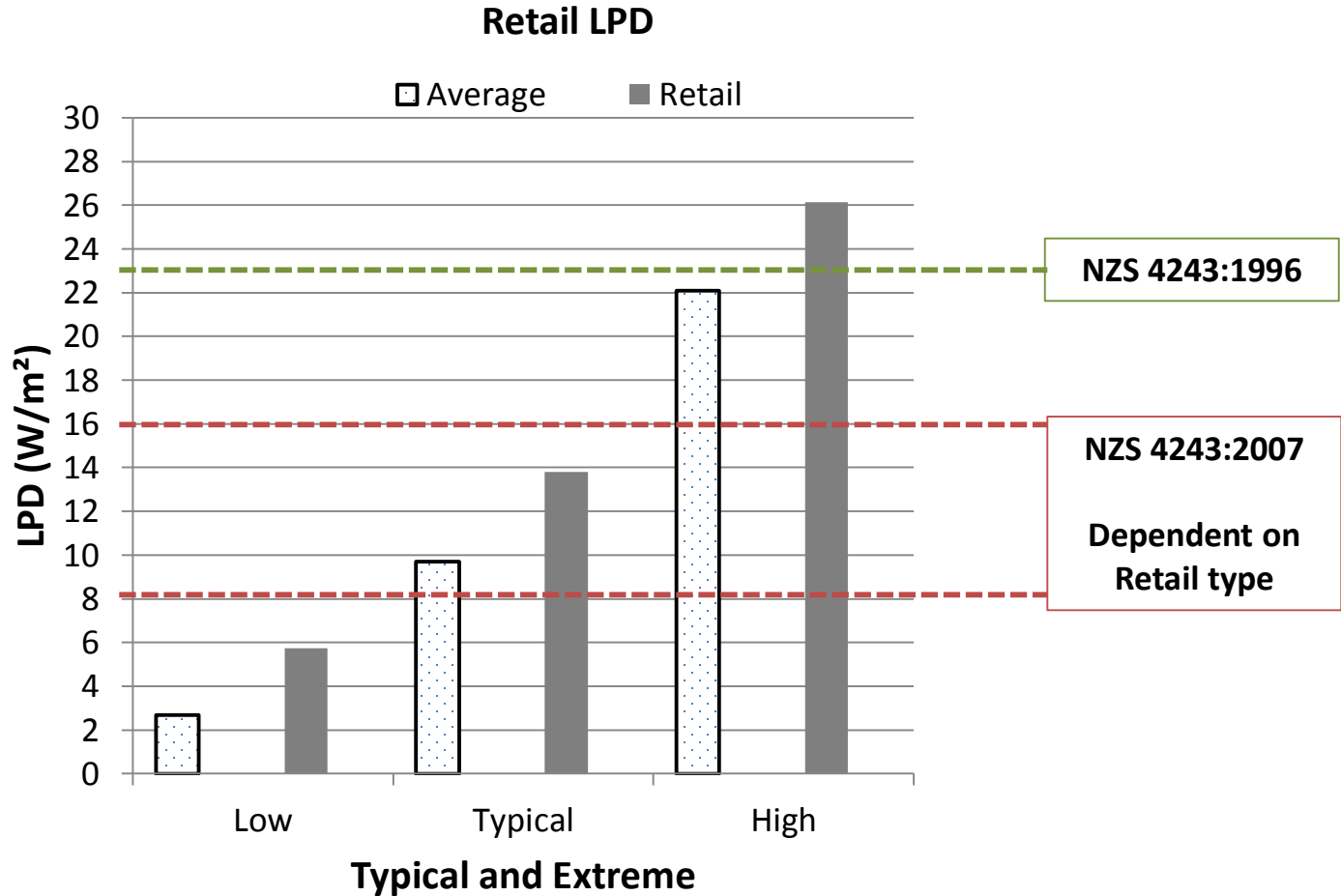


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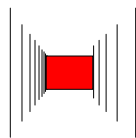
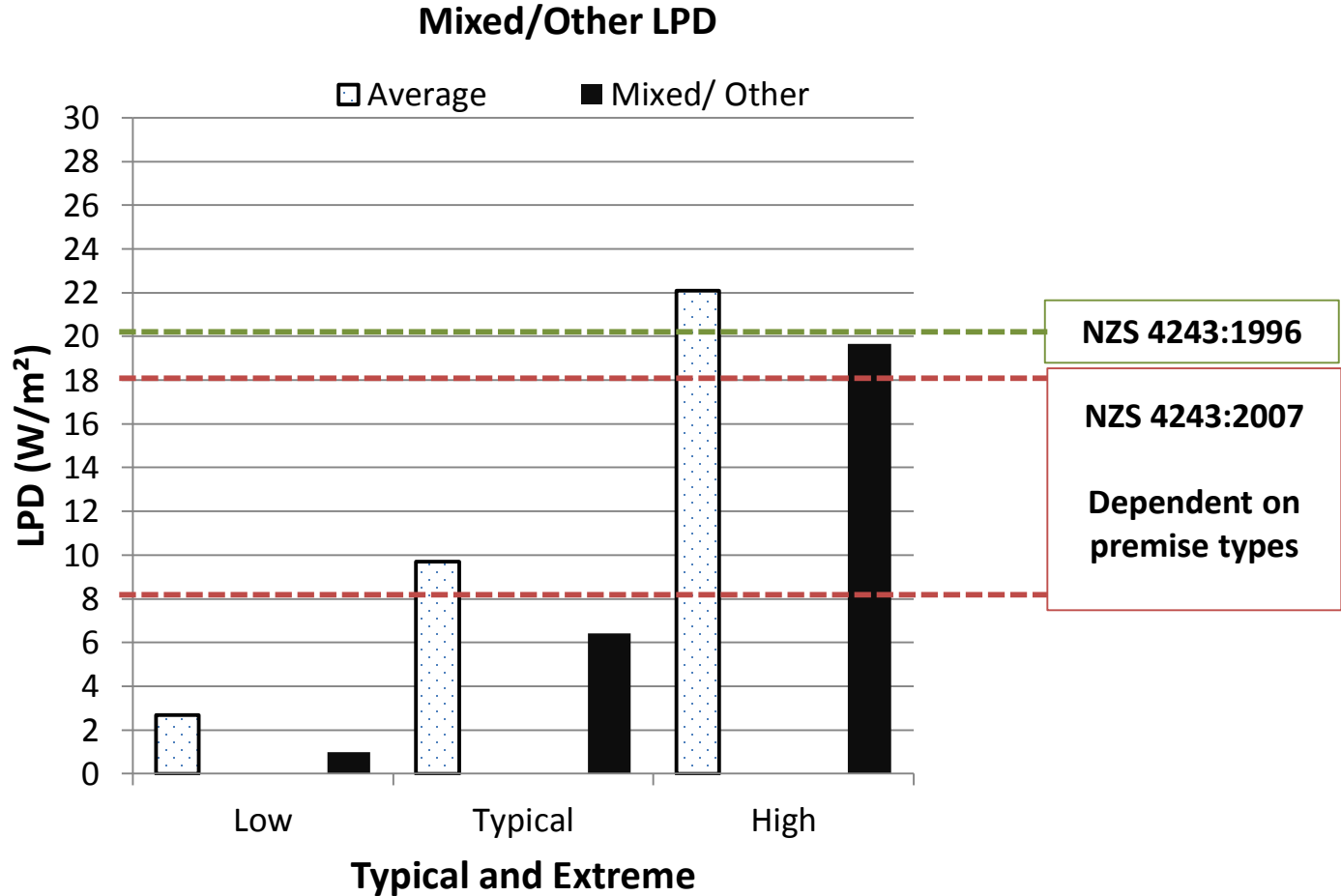
Lighting Power Densities



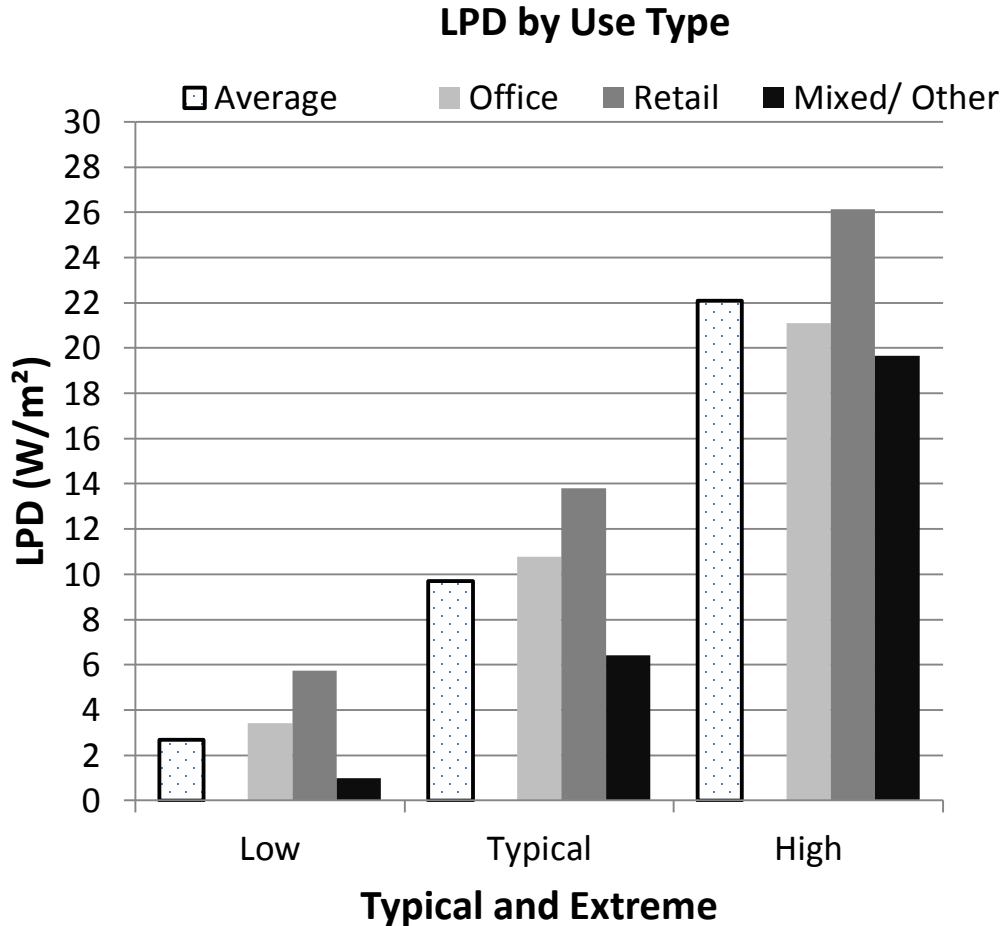
Lighting Power Densities



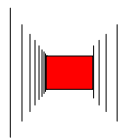
Lighting Power Densities



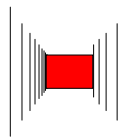
Lighting Power Densities



- ▶ Retail most lighting intensive, followed by Office
- ▶ High scenario is approx. double Typical figure
- ▶ Low is approx. 2-3 times less than Typical Value

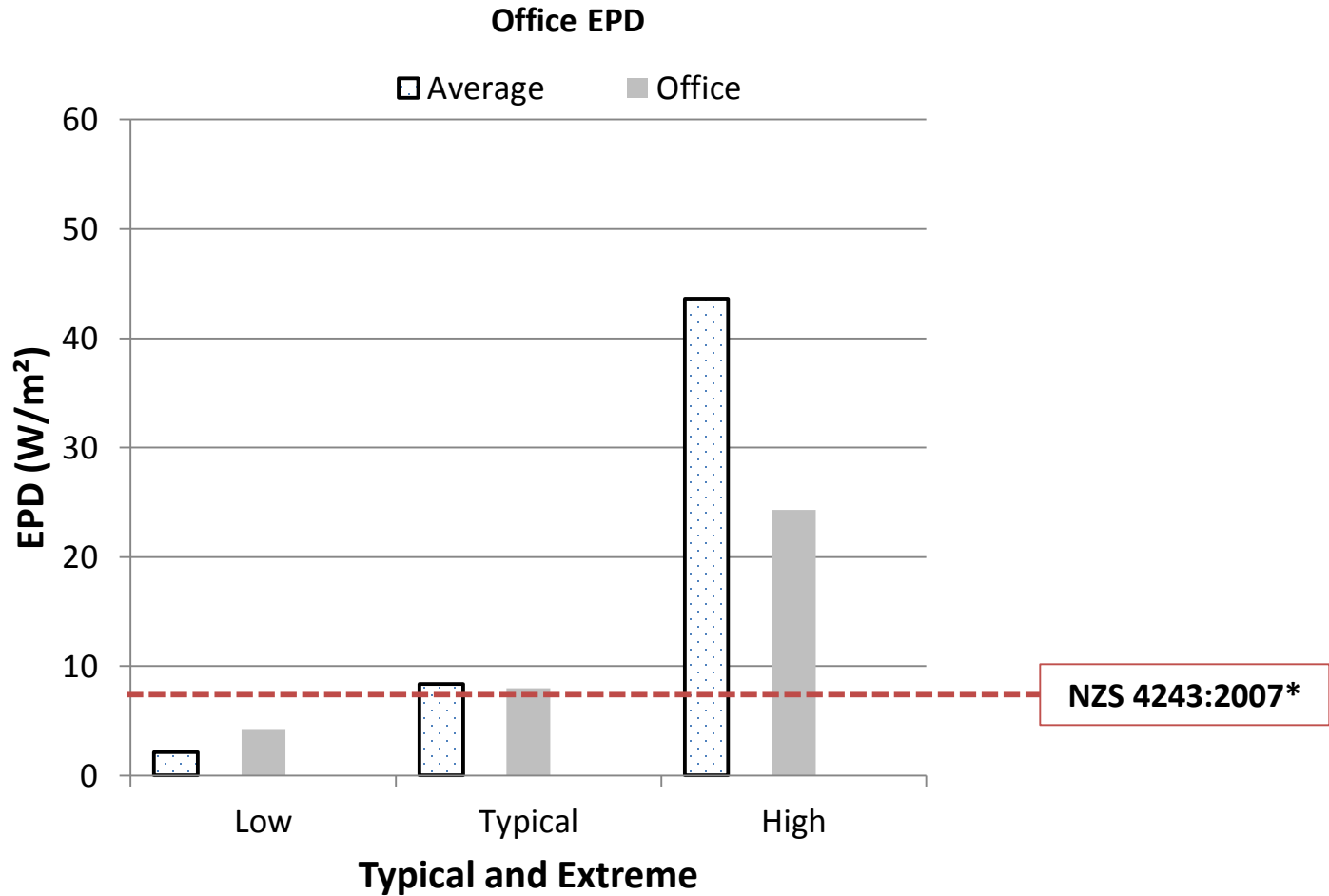


Equipment Power Densities

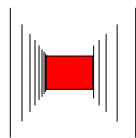


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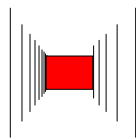
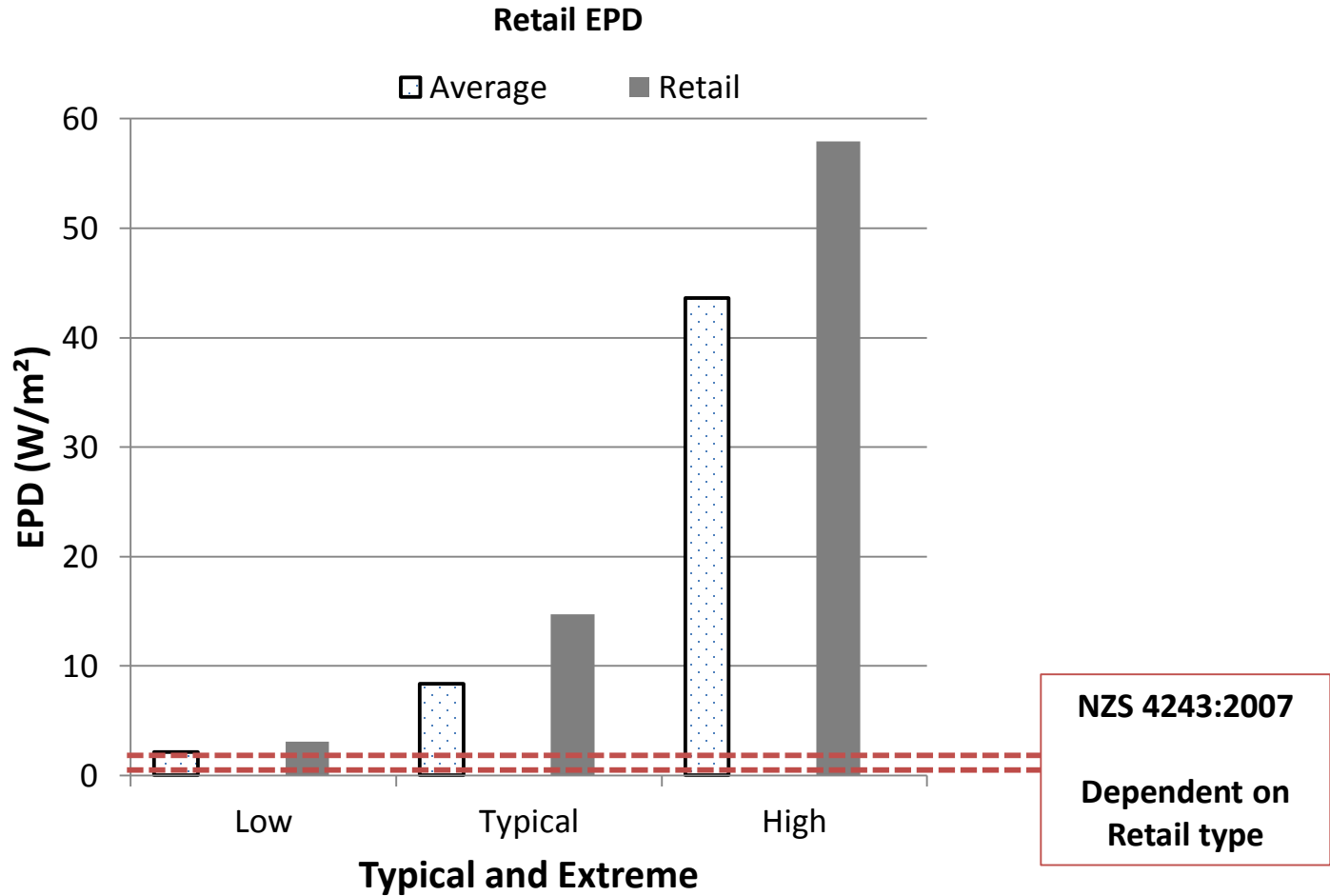
Equipment Power Densities



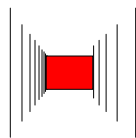
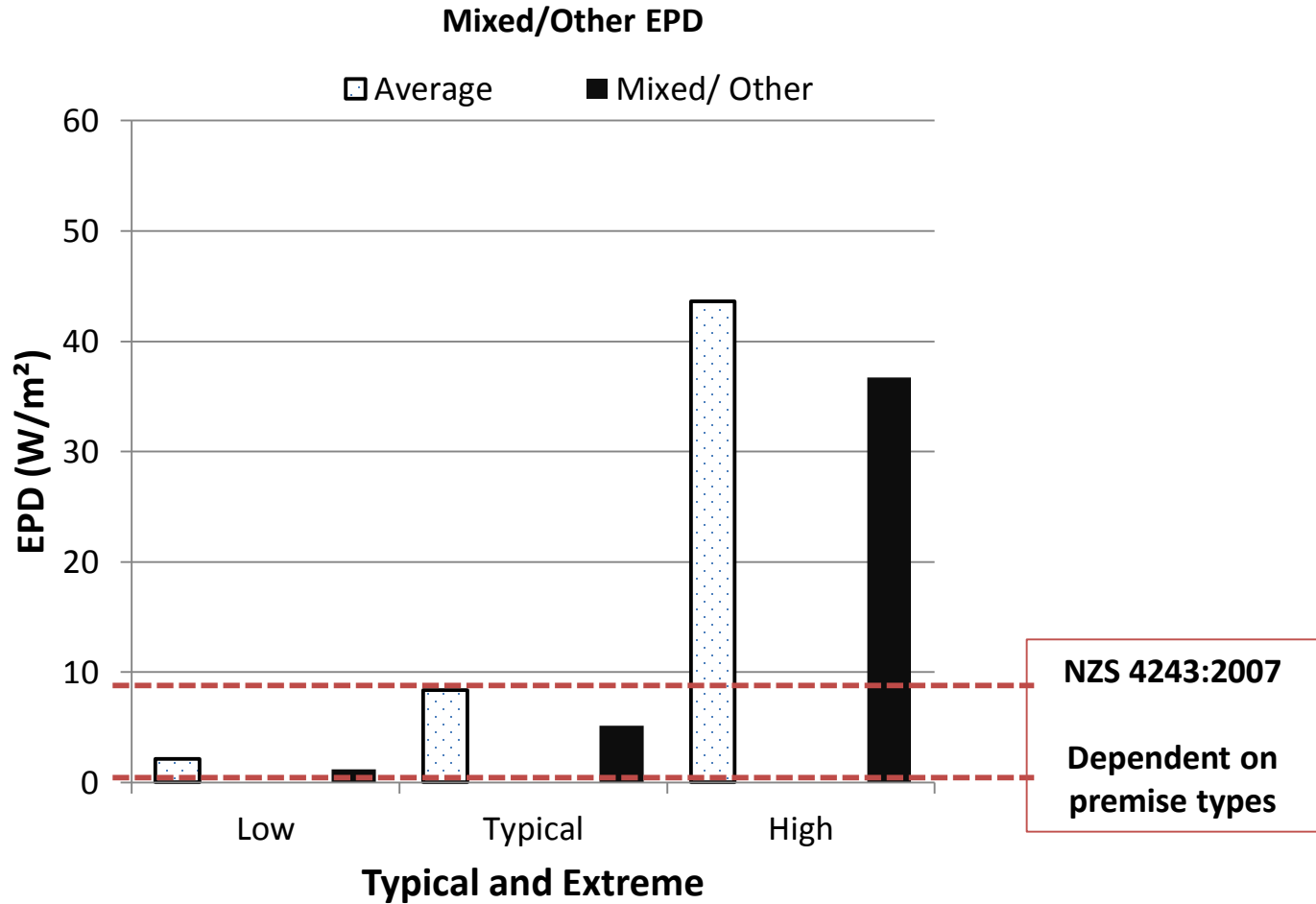
* Assumption



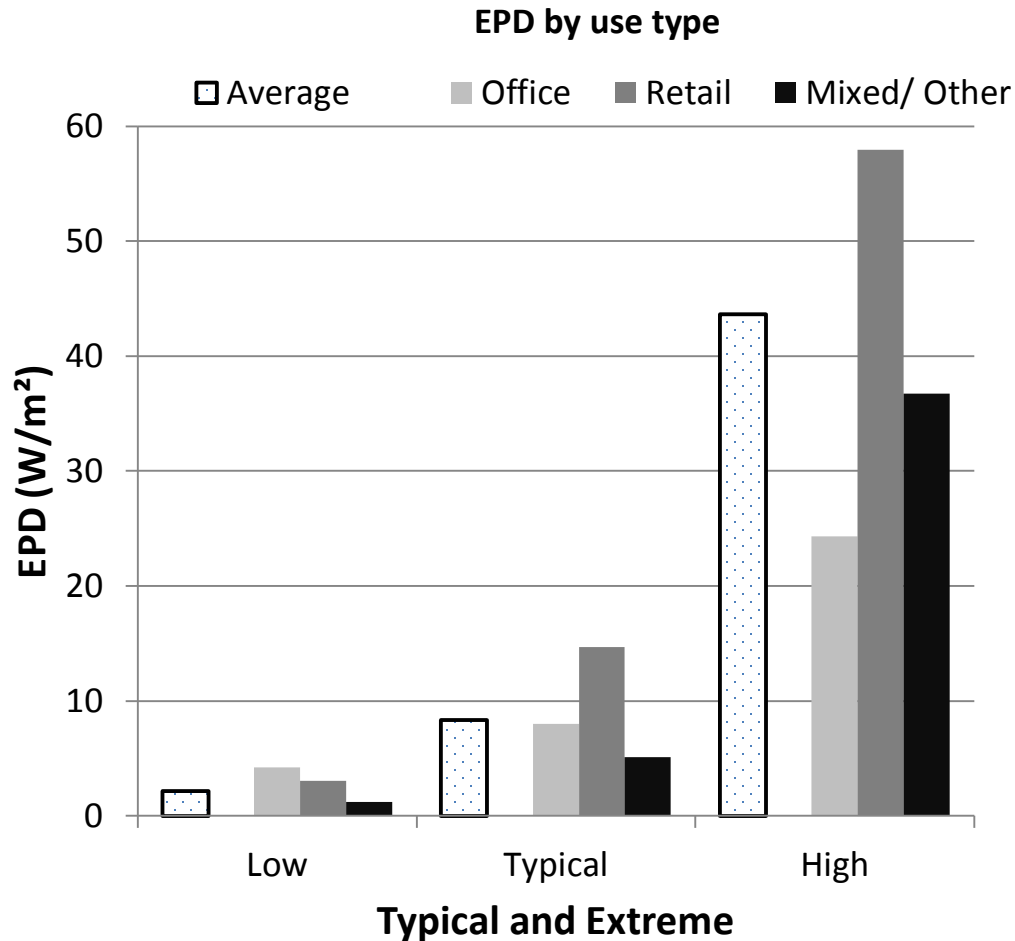
Equipment Power Densities



Equipment Power Densities



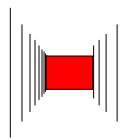
Equipment Power Densities



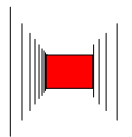
▶ Typically, Retail is most equipment intensive, followed by Office

▶ High scenario is approx. 2-6 times larger than Typical figure

▶ Low is approx. 2-5 times less than Typical Value

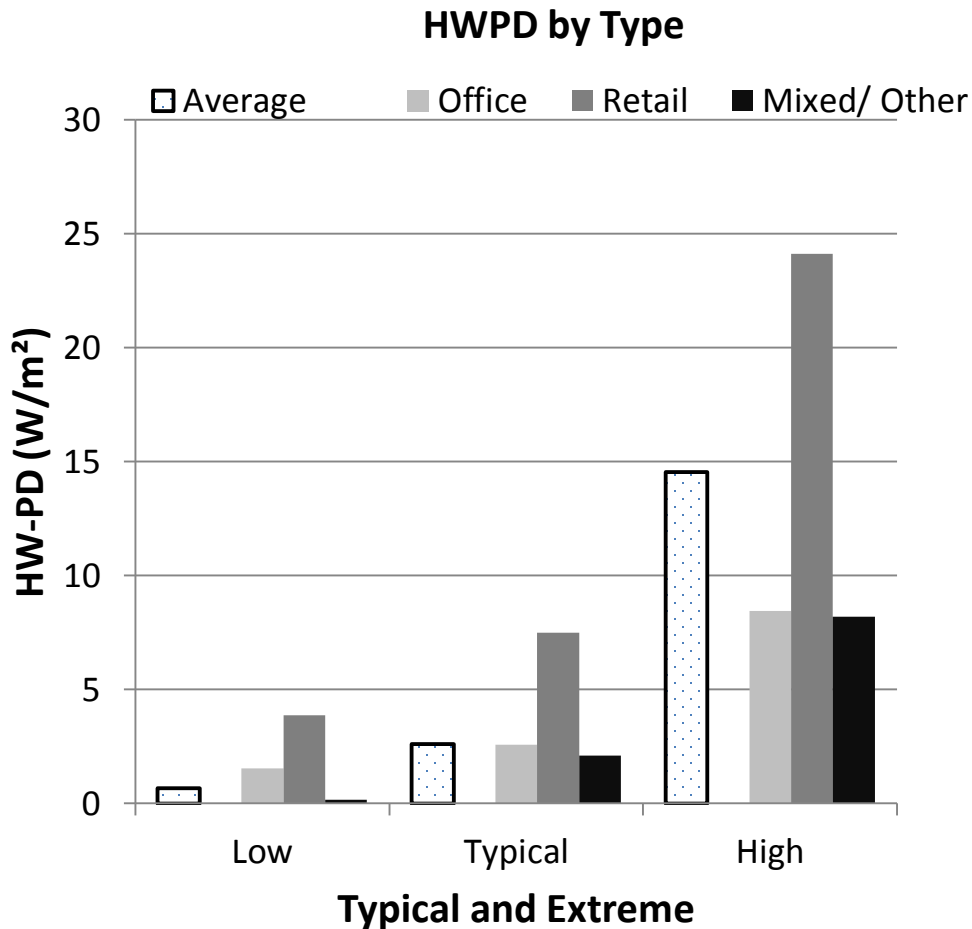


Hot Water Power Densities



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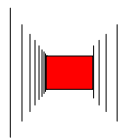
Hot Water Power Densities



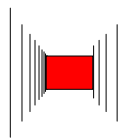
▶ No assumption provided in NZS4243

▶ Can be substantial in Retail

▶ Office and Mixed/Other have similar intensity



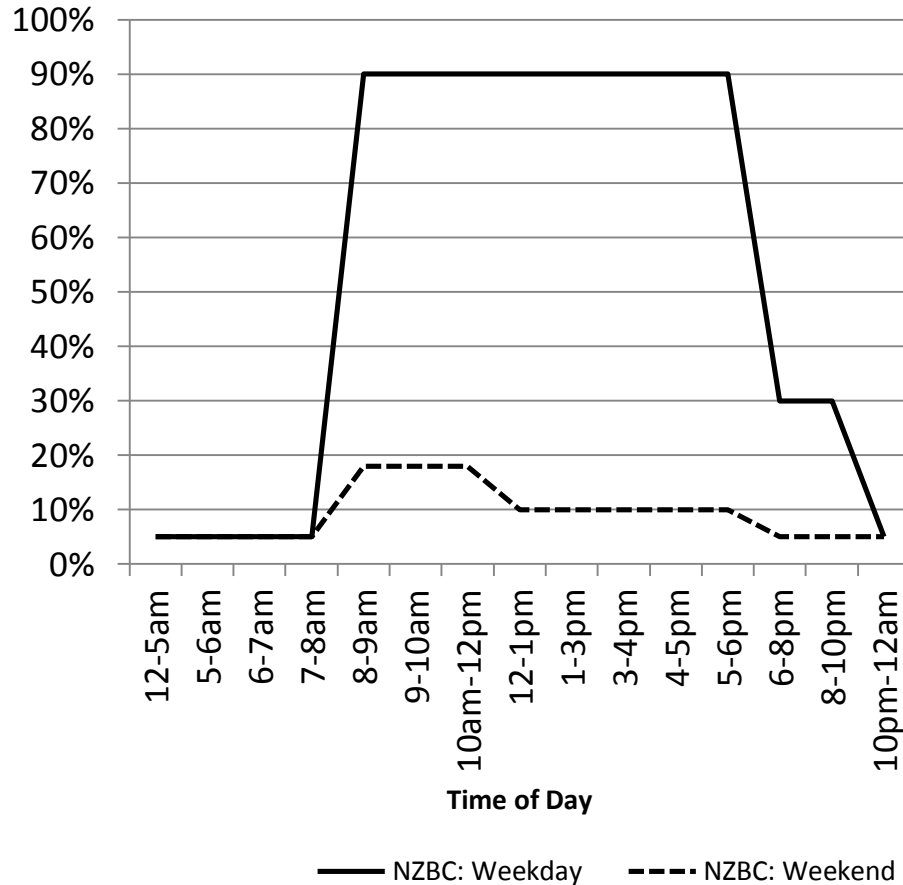
Lighting Operation patterns - Office



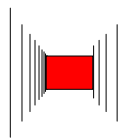
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Lighting Operation patterns - Office

NZS: Offices

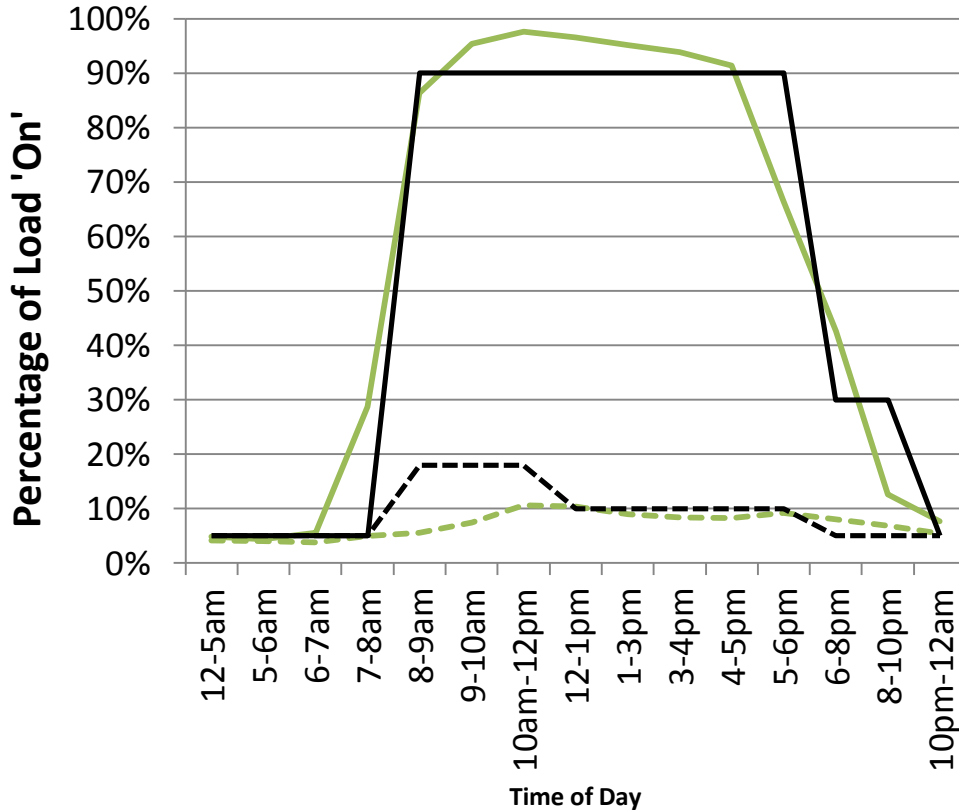


► NZS4243 Modelling
Prescription of how to model for Lighting
pattern of use



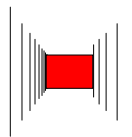
Lighting Operation patterns - Office

NZS VS Typical: Offices



- ▶ Typical patterns of use similar to NZS4243
 - Both weekdays and weekends
 - Both day and night

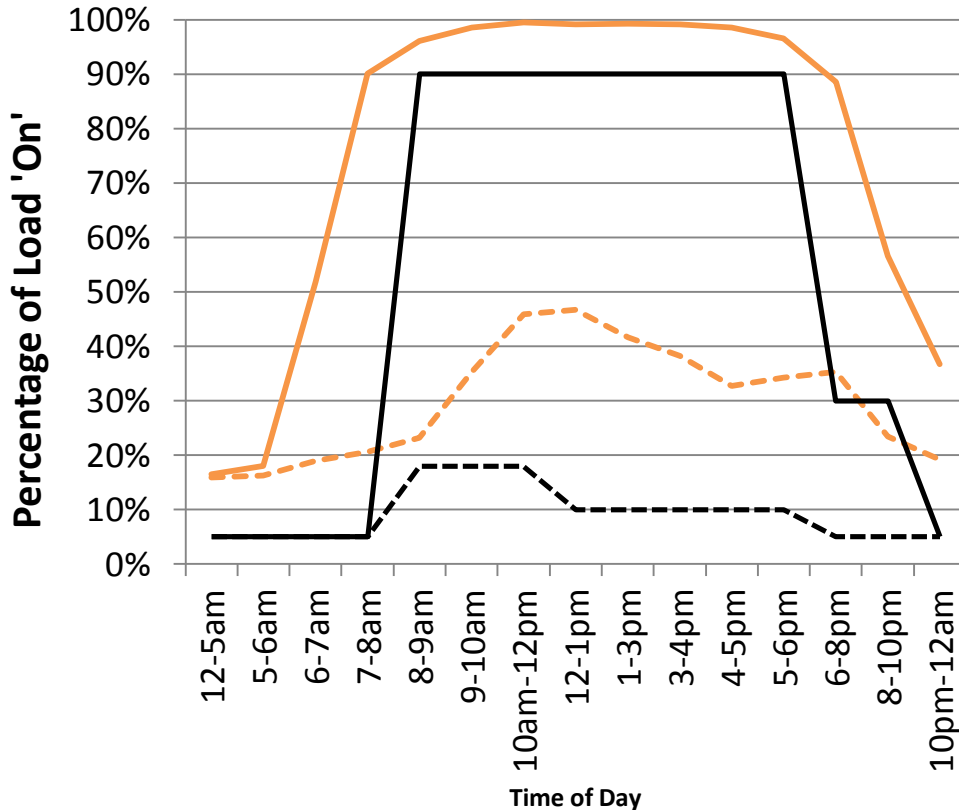
— Typical: Weekday — Typical: Weekend — NZBC: Weekday - - - NZBC: Weekend



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Lighting Operation patterns - Office

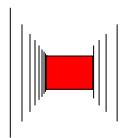
NZS VS High: Offices



► High patterns of use have:

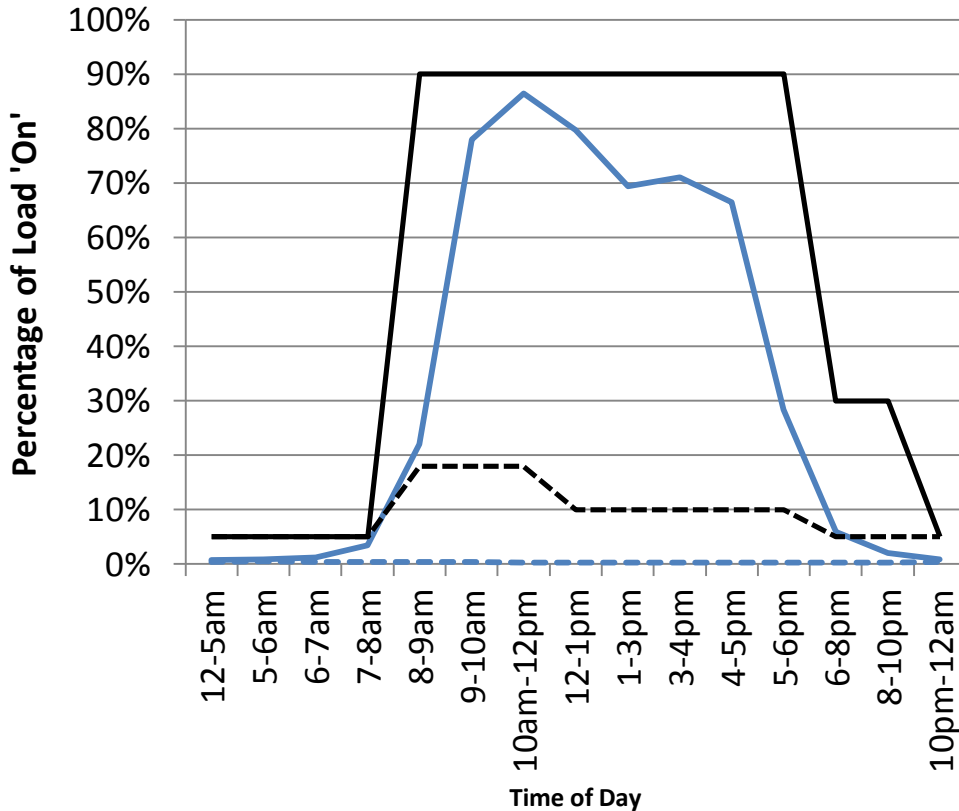
- longer peak load usage
- Higher night base load

— High: Weekday - - - High: Weekend — NZBC: Weekday - - - NZBC: Weekend



Lighting Operation patterns - Office

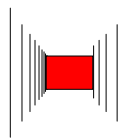
NZS VS Low: Offices



► Low patterns of use have:

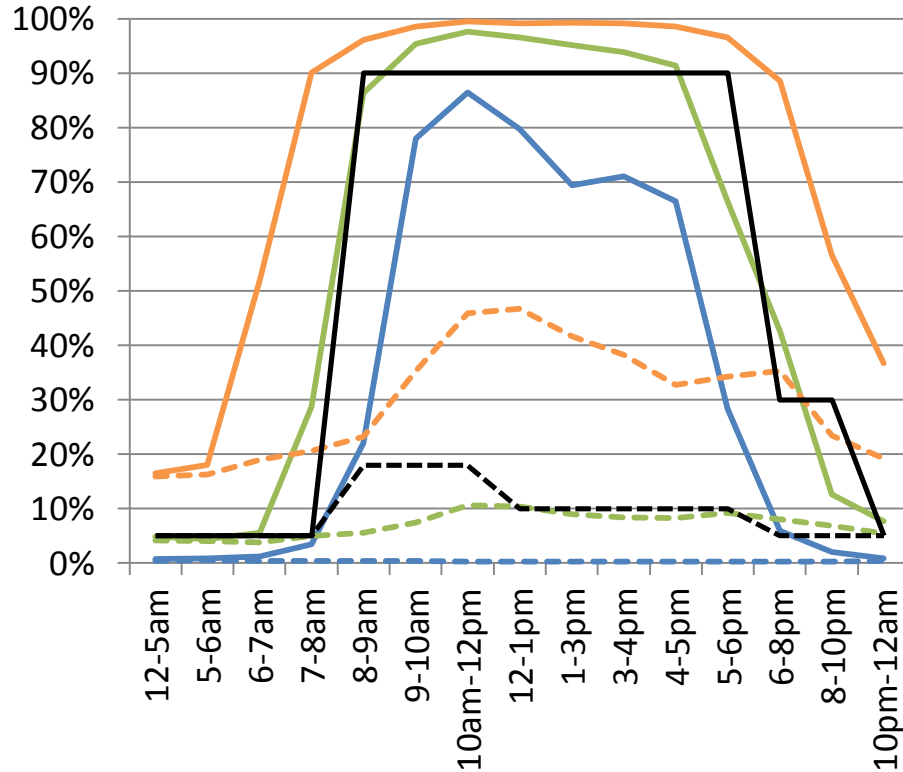
- lower peak load
- Less peak usage

— Low: Weekday - - - Low: Weekend — NZBC: Weekday - - - NZBC: Weekend



Lighting Operation patterns - Office

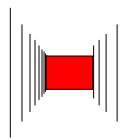
All Scenarios: Offices



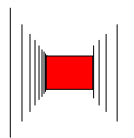
— Low: Weekday - - - Low: Weekend — Typical: Weekday - - - Typical: Weekend
— High: Weekday - - - High: Weekend — NZBC: Weekday - - - NZBC: Weekend

- ▶ What changes between scenarios are:
 - Hours peak load is 'On'
 - Night base loads

- ▶ NZS4243 close to Typical pattern



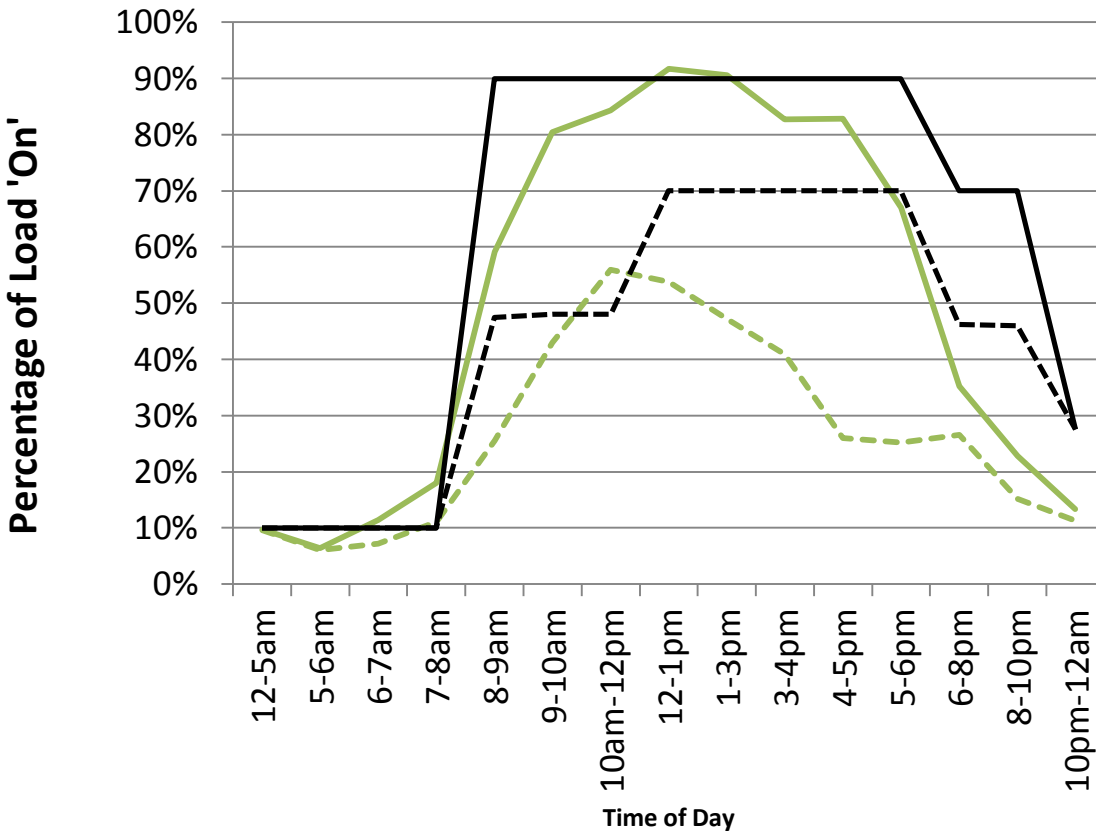
Lighting Operation patterns - Retail



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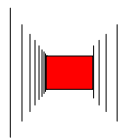
Lighting Operation patterns - Retail

NZS VS Typical: Retail



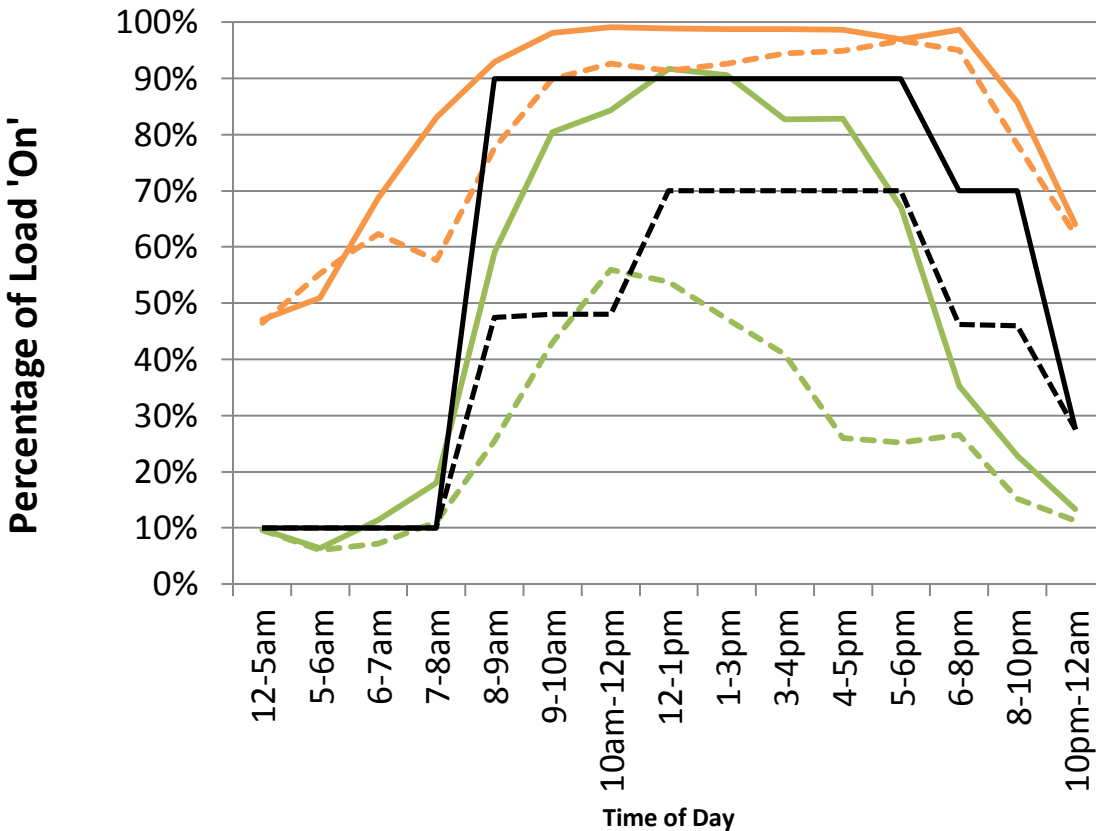
- ▶ NZS4243 assumption has longer usage of peak load when compared to typical pattern
 - Both weekday and weekend
- ▶ Overestimation of energy consumption

— Typical: Weekday — Typical: Weekend — NZBC: Weekday - - - NZBC: Weekend



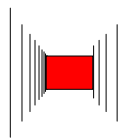
Lighting Operation patterns - Retail

NZS VS Typical VS High: Retail



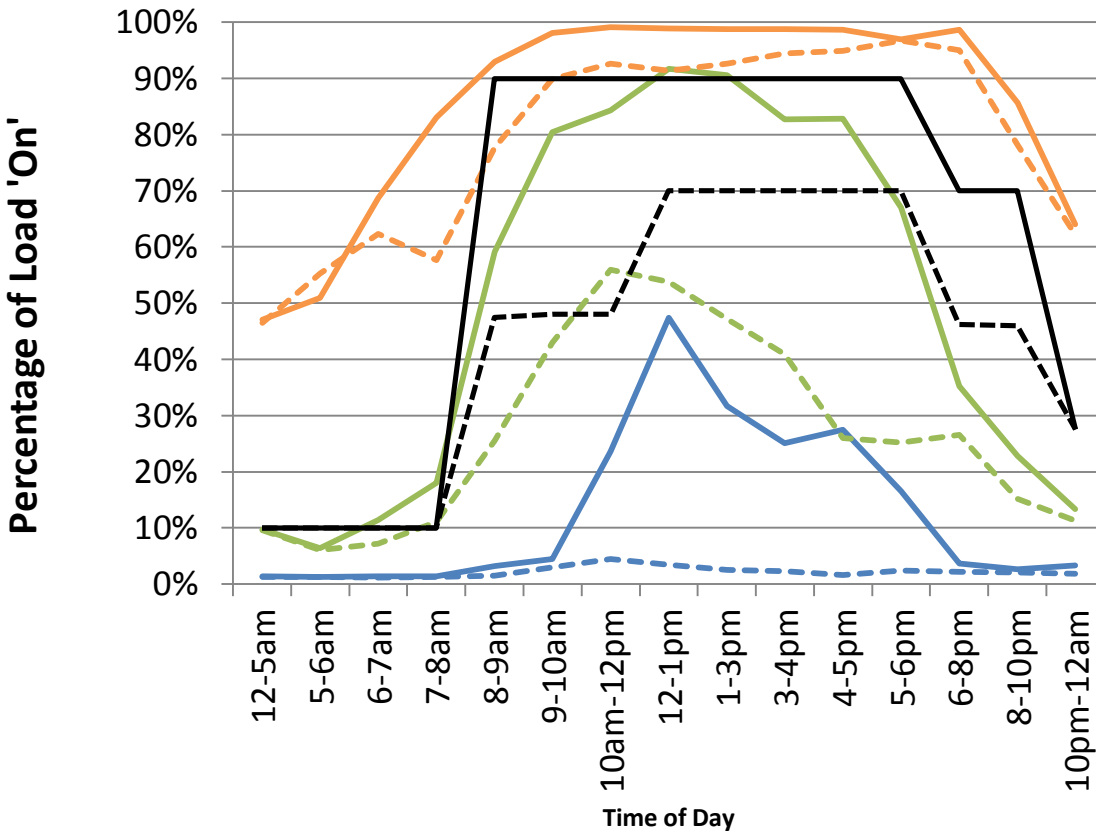
- ▶ High scenario has:
 - High peak load
 - Longer peak load hours
 - High night and weekend peak loads.

— Typical: Weekday
 - - - Typical: Weekend
 — High: Weekday
- - - High: Weekend
 — NZBC: Weekday
 - - - NZBC: Weekend

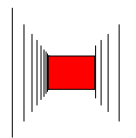


Lighting Operation patterns - Retail

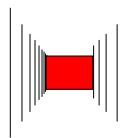
All Scenarios: Retail



- ▶ Low scenario has:
 - lower weekday peak load than typical weekend.
 - Very little weekend usage



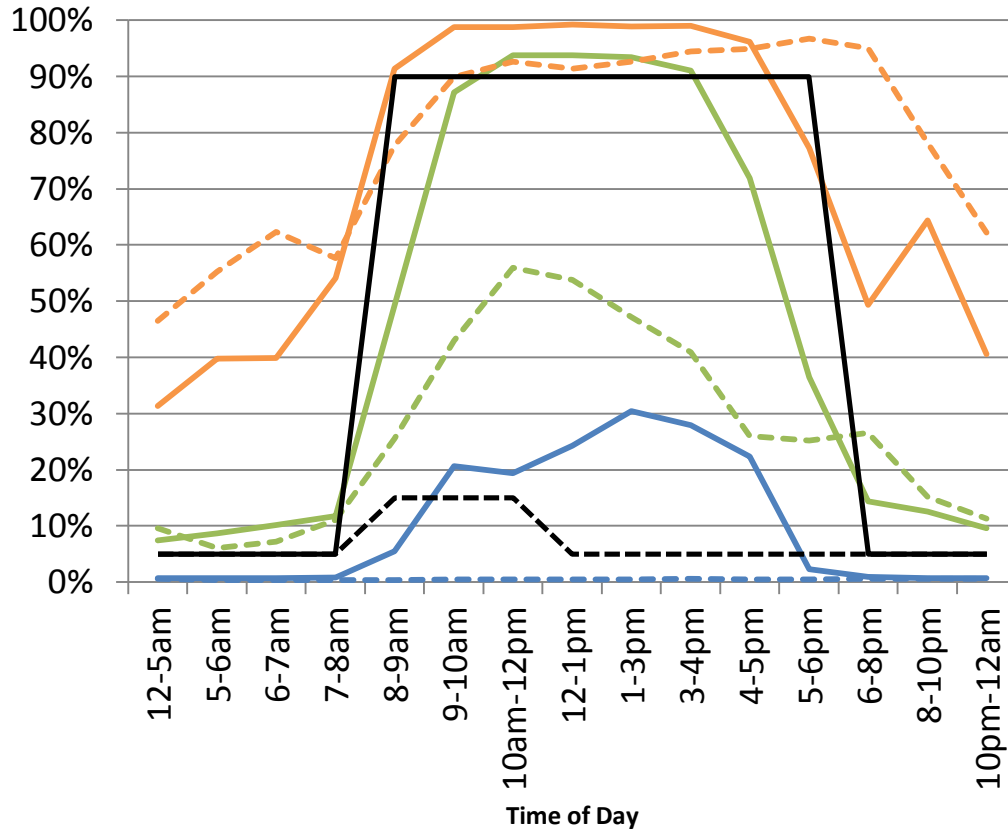
Lighting Operation patterns – Mixed/Other



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Lighting Operation patterns – Mixed/

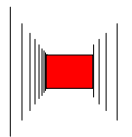
Mixed/Other



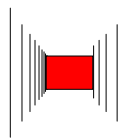
▶ Very Similar to Retail

▶ Main difference is Weekend Patterns have higher night time base load in Typical and High scenarios

- Low: Weekday
- - - Low: Weekend
- Typical: Weekday
- High: Weekday
- NZBC: Weekday
- - - NZBC: Weekend
- Typical: Weekend
- - - High: Weekend



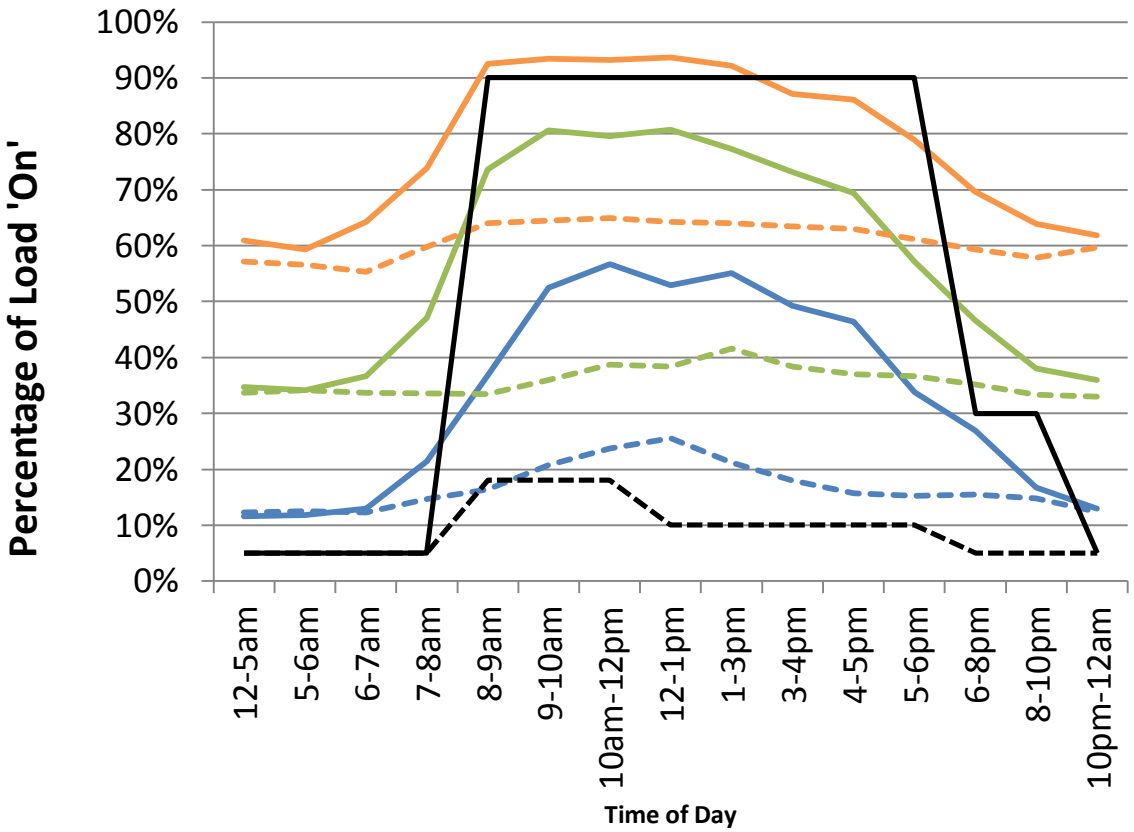
Equipment Operation patterns – Office



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Equipment Operation patterns - Office

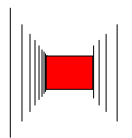
All Scenarios: Offices



▶ Typical has higher night usage, but less daytime peak load when compared to NZS4243 assumption

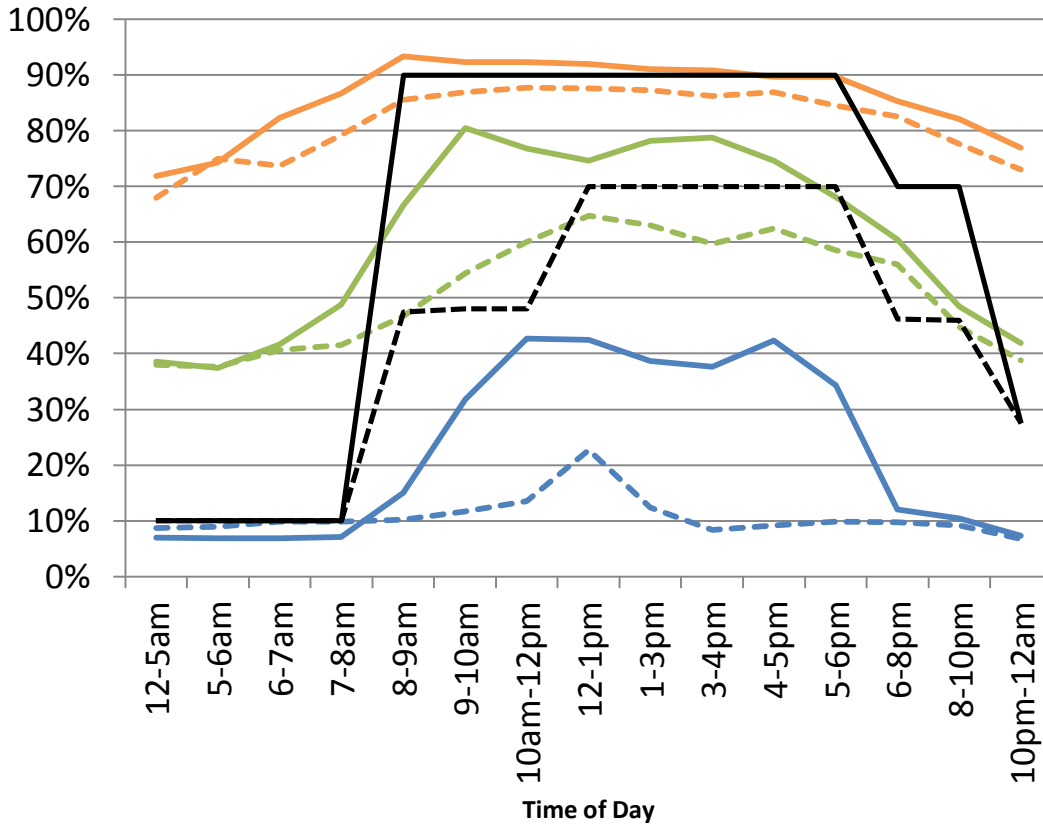
▶ Half of all equipment load is Typically left 'On' over night.

- Low: Weekday
- Typical: Weekend
- NZBC: Weekday
- - Low: Weekend
- - High: Weekday
- - NZBC: Weekend
- Typical: Weekday
- - High: Weekend



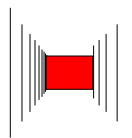
Equipment Operation patterns - Retail

All Scenarios: Retail



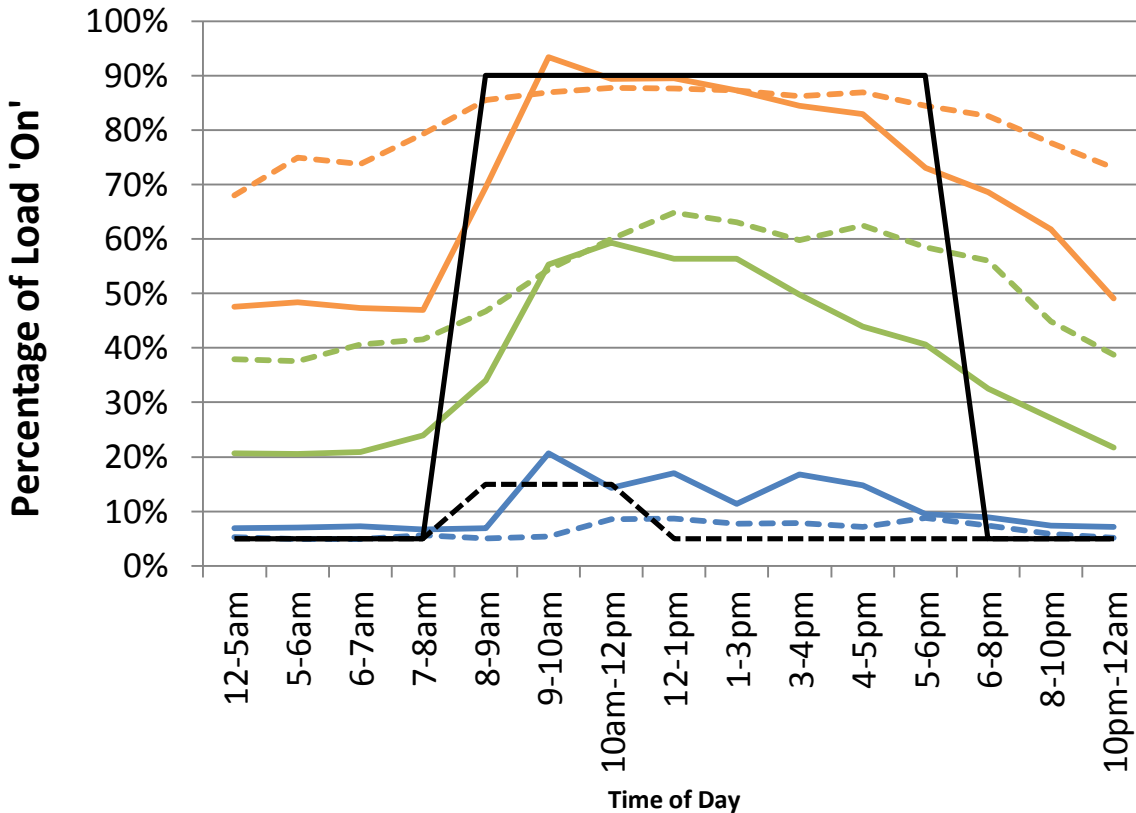
- Low: Weekday
- Typical: Weekday
- NZBC: Weekday
- Low: Weekend
- Typical: Weekend
- High: Weekend
- NZBC: Weekend

- ▶ Same situation as Offices:
 - higher night usage, but less daytime peak load when compared to NZS4243 assumption
 - Half of all equipment load is Typically left 'On' over night.

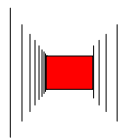


Equipment Operation patterns – Mixed/Other

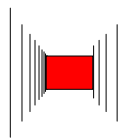
All Scenarios: Mixed/Other



- ▶ Similar to Office and Retail:
 - higher night usage, but less daytime peak load when compared to NZS4243 assumption
 - Weekend loads higher than weekday
 - Less daytime load

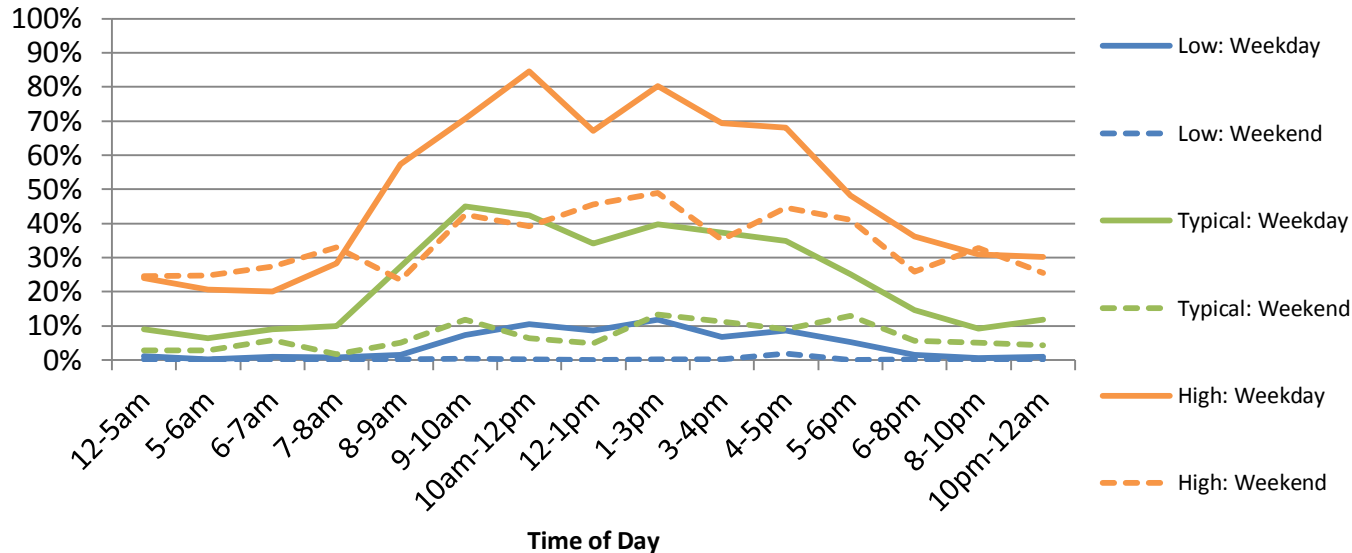


Hot Water Operation patterns – Office



Hot Water Operation patterns

Offices

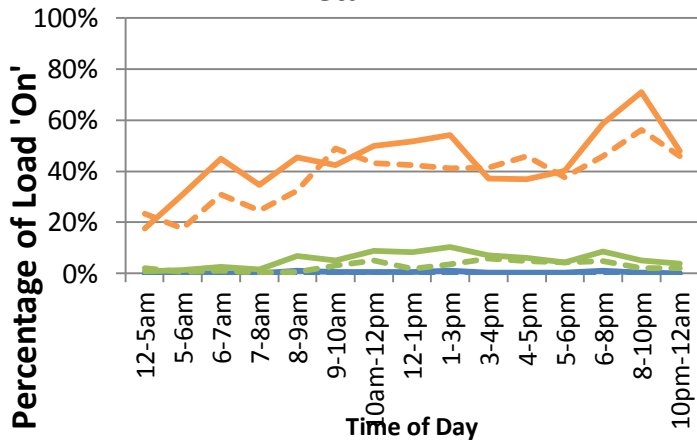


▶ Office peak during day

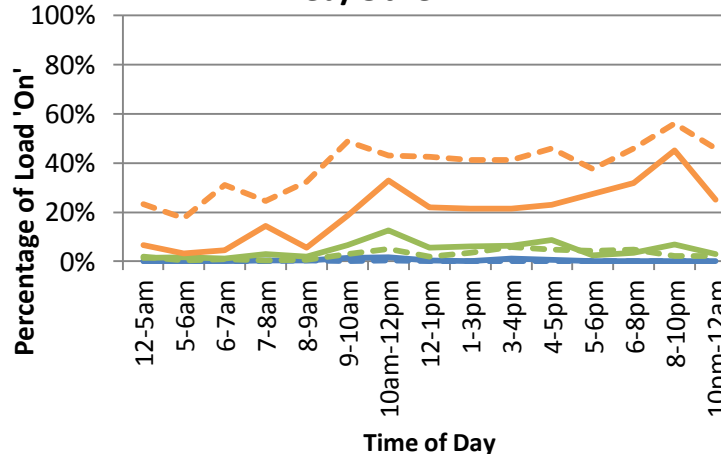
▶ Office typical is high than Retail and Mixed/Other

Retail

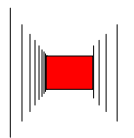
Time of Day



Mixed/Other



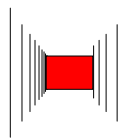
▶ High retail and mixed peak late at night



Conclusions

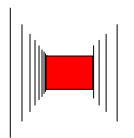
- ▶ NZS 4243 values for power densities and associated schedules are not representative of existing building design in New Zealand
 - NZS 4243 values for the LPD are indicative of the typical - suggests typical buildings are designed to meet code and no more
 - NZS 4243 values for Lighting patterns of use are not indicative of the typical building, except Office - Retail and Mixed/Other lighting patterns of use overestimate

- ▶ Real (typical) EPDs were significantly higher for Retail and Mixed/Other than NZS 4243 assumption.
 - Underestimation of equipment energy use
 - Not regulated, but maybe they should be?



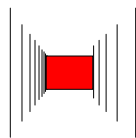
Conclusions

- ▶ If concerned about assumptions and want to test real extremes, an energy modeller could:
 - double the power densities
 - reduce power densities by a third
- ▶ Common perception that equipment is left 'on' during unoccupied hours is true.
 - Large potential for energy savings if equipment is turned off overnight in Offices
- ▶ Hot Water is typically a small consumer, but can be large



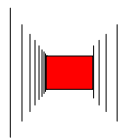
Future work

- ▶ Update the BEES template models to include:
 - Typical building load information
 - Typical HVAC systems
 - Size and construction
- ▶ Detailed end-use and/or appliance breakdown:
 - Refrigeration and cooking
 - computers, laptops, printers
- ▶ Detail building type breakdown:
 - Café, restaurant, fast food



Results in Tabular form

- ▶ **CBPR website published the Appendices of this paper**
 - Tables of LPD and patterns of use for energy models



Acknowledgements

- The BEES Team:

- **BRANZ** : Lynda Amitrano, Nigel Isaacs, Andrew Pollard, Peony Au, Lee Bint
- **CRESA**: Kay Saville-Smith, Ruth Fraser
- **Energy Solutions Ltd**: Rob Bishop

- Funders:



Ministry of Business,
Innovation & Employment



Energy Efficiency and
Conservation Authority
Te Tari Tiaki Pūngao