Energy



RADIANCE in Energy Codes & Standards

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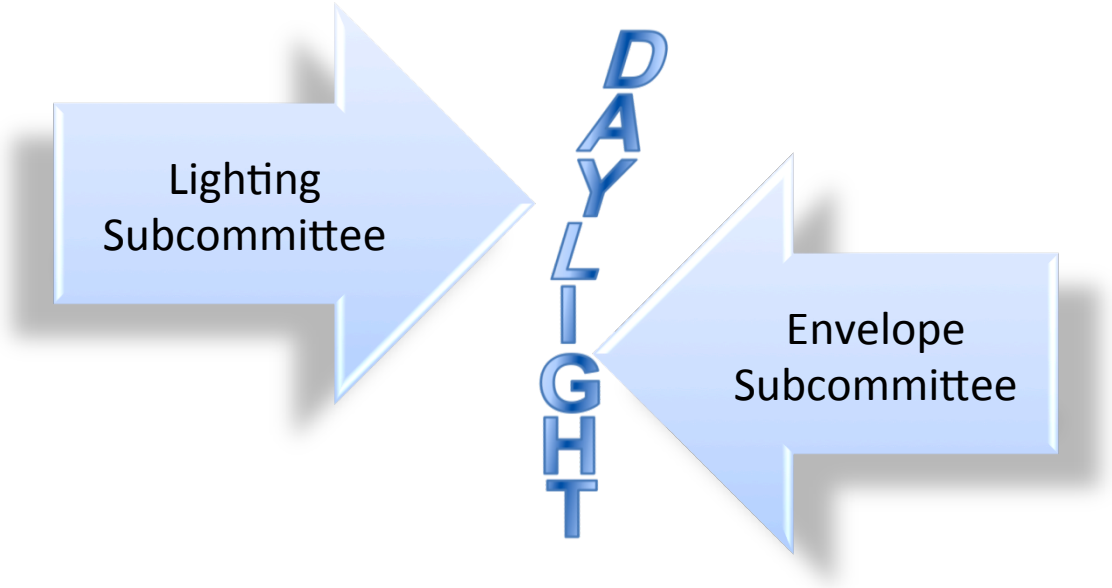
Difference in Simulations for Codes and Standards Development

Individual Building Design Development	Codes and Standards Development
Highly precise building definition	Generic building definition
Decision makers are building owners	Decision makers are committees
Internal review	Publicly review/vetting process
Cost effectiveness in context of owner's ability to pay	Cost effectiveness in context of strictly defined payback periods
Need to provide evidence of savings for that particular building	Need to provide evidence of savings in a defined building categories

Daylighting in Building Energy Codes

- Daylighting falls somewhere in between … Lighting and Envelope
  - Lighting engineers don't like that the sun never stays in place.
  - Mechanical engineers don't like the complexity daylighting adds to other building systems. *(… secretly wish buildings had no windows!!!)*



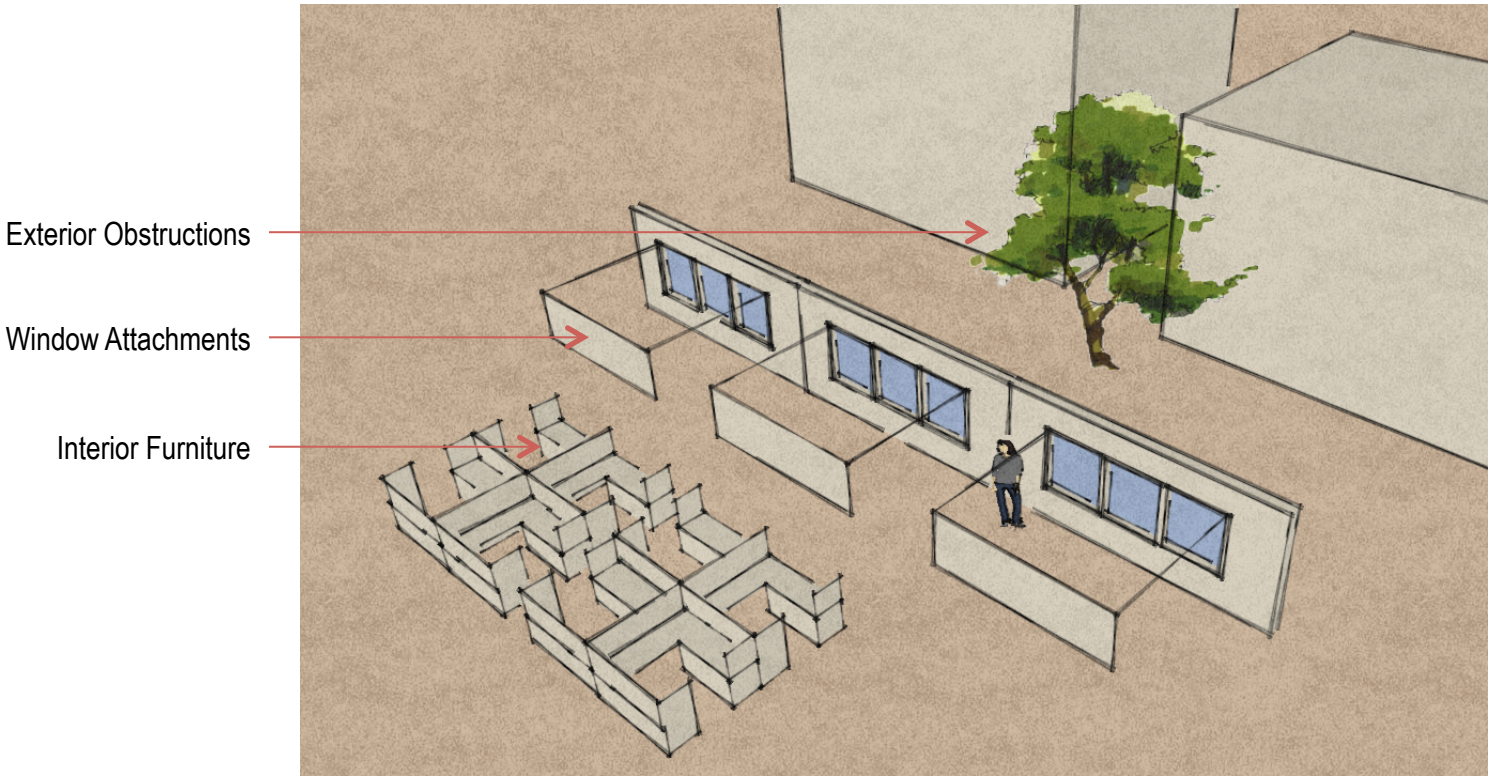
Development of Daylighting Codes

- Requires a better understanding of
  - Variability of daylight across time
  - Impact of variables such as
    - Blinds/shades operation
    - Exterior obstructions assumptions
    - Interior layout and furniture assumptions

- Whole bldg. simulation tools that allow end-users to evaluate their buildings daylighting performance against code baseline
  - Easy to use
  - Hard to mess up

Development of Daylighting Codes

- Typically done using DOE 2 or Energy Plus, which misses 3 key variables affecting daylighting

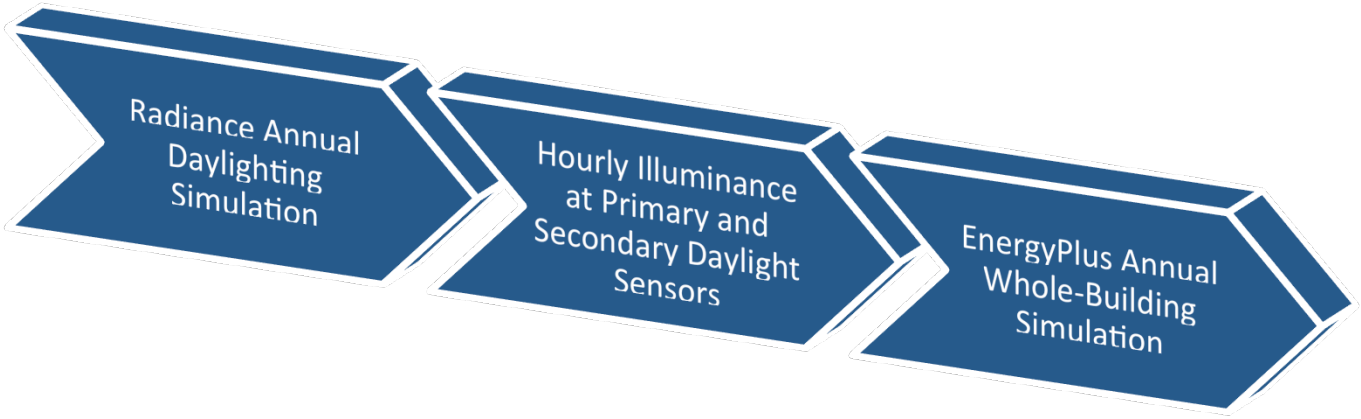


Daylighting in Building Energy Codes

- Recognizing this need ASHRAE created the "Daylighting Working Group"
  - Select members of both Lighting and Envelope subcommittees
  - Tasked with resolving envelope related issues
    - Prescriptive window properties for SHGC, VT, U-factor
    - Prescriptive limits on window to wall ratios
    - etc

    without undoing daylighting savings
  - PNNL and HMG (Now TRC) tasked with providing analysis to base code change proposals

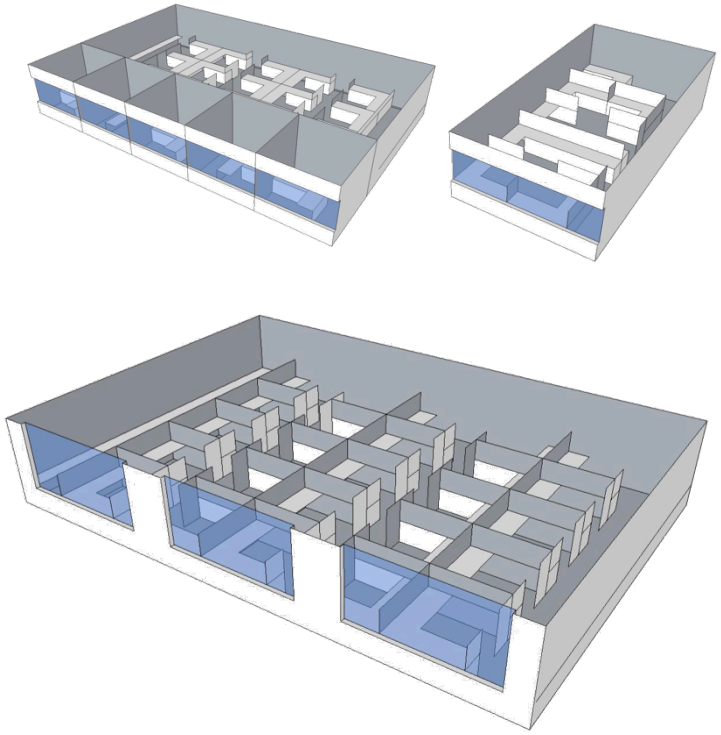
Simulation Methodology

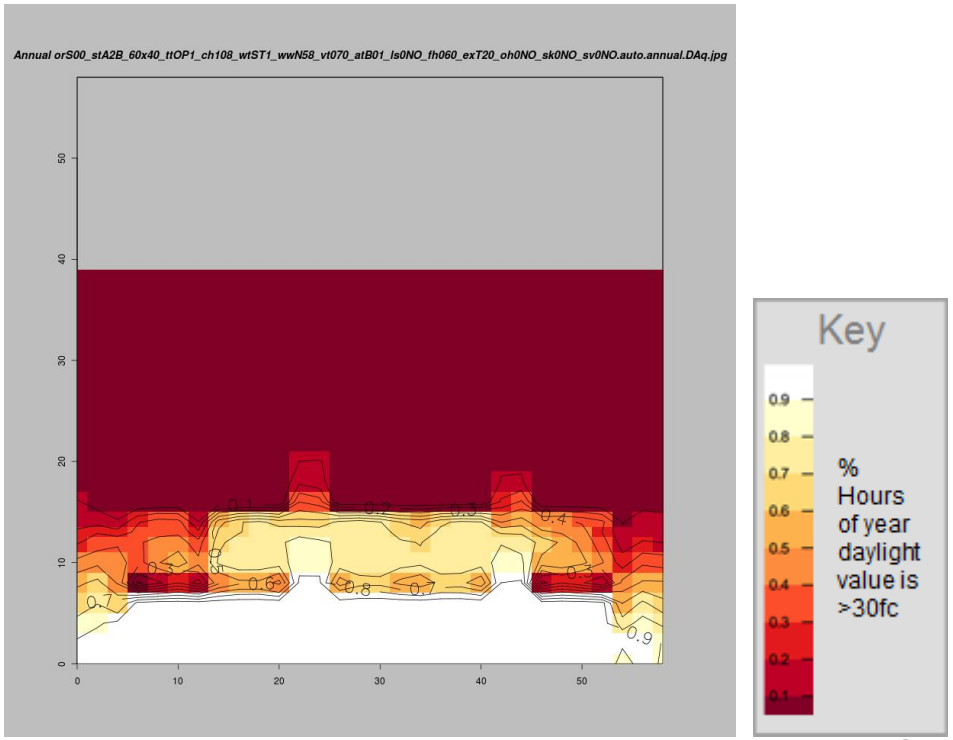


- Radiance 3-Phase Annual Simulation (Daylight only)
  - Output of 8760 hourly daylight illuminance
- EnergyPlus Annual Simulation (Whole Bldg)
  - Converted to 8760 daylight responsive ltg schedules
    - Separate ltg schedules for Primary and Secondary daylit zones
  - Run with new 8760 lighting schedules instead of in-built daylighting algorithm

Interior Furniture

- Generic office layouts created in Sketchup, converted to .rad

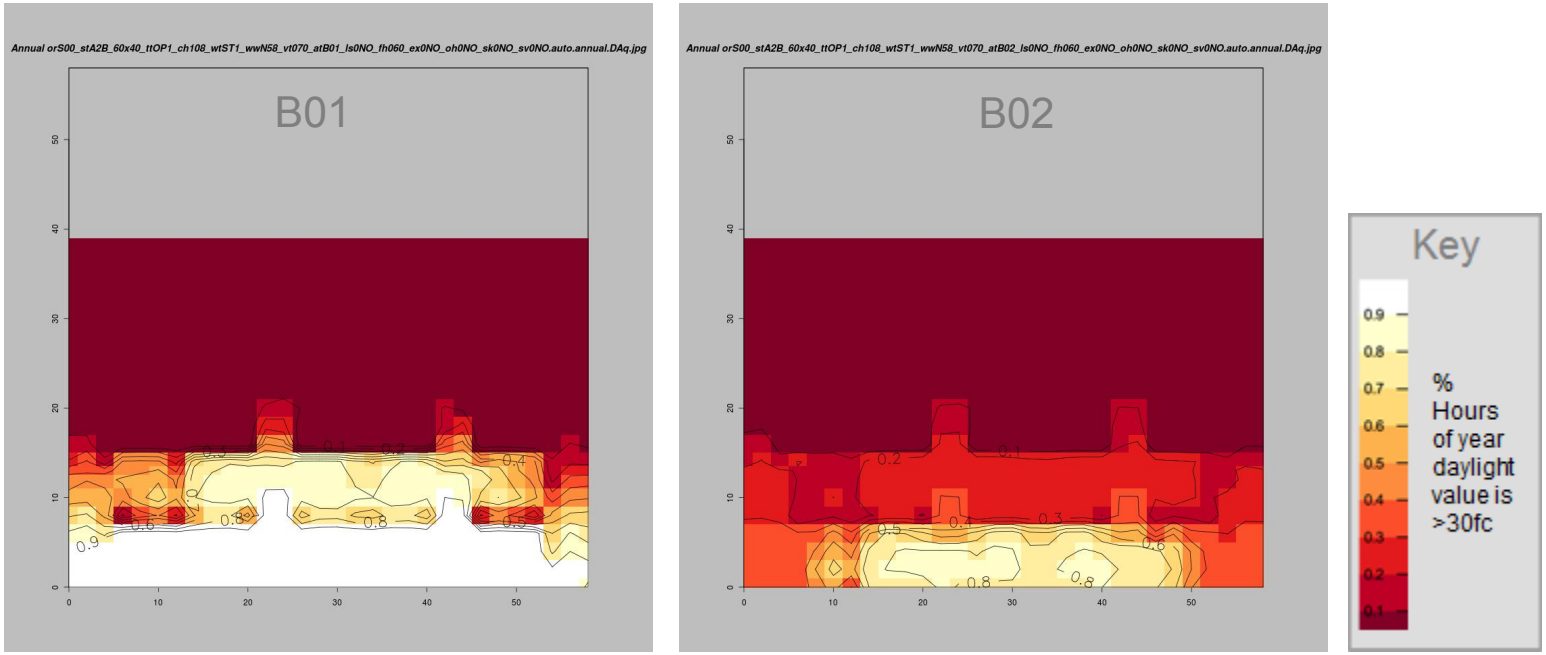




Blinds and Shades

- 2 Window Attachment Types
  BSDF files generated using Window 7
  - B01 – Light color blinds angled to just block direct sun (48°)
  - B02 – Dark color blinds angled further to close (60°)

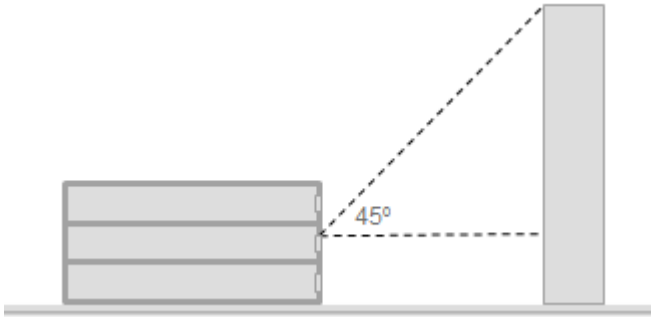
- Blinds operated using method prescribed for daylight metrics in IES LM-83



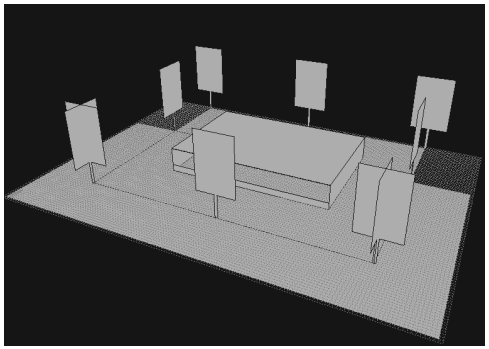
Exterior Obstructions

- Trees
  - 20% tree cover - typical for medium office buildings

  Based on CEUS Dataset analysis done by PIER Office Daylighting Potential Study
- Urban Obstructions
  - Modeled as a 45° profile angle from the head height of window on 2nd floor



Based on 'Window Systems for High-Performance Buildings' by Carmody et al. 2004

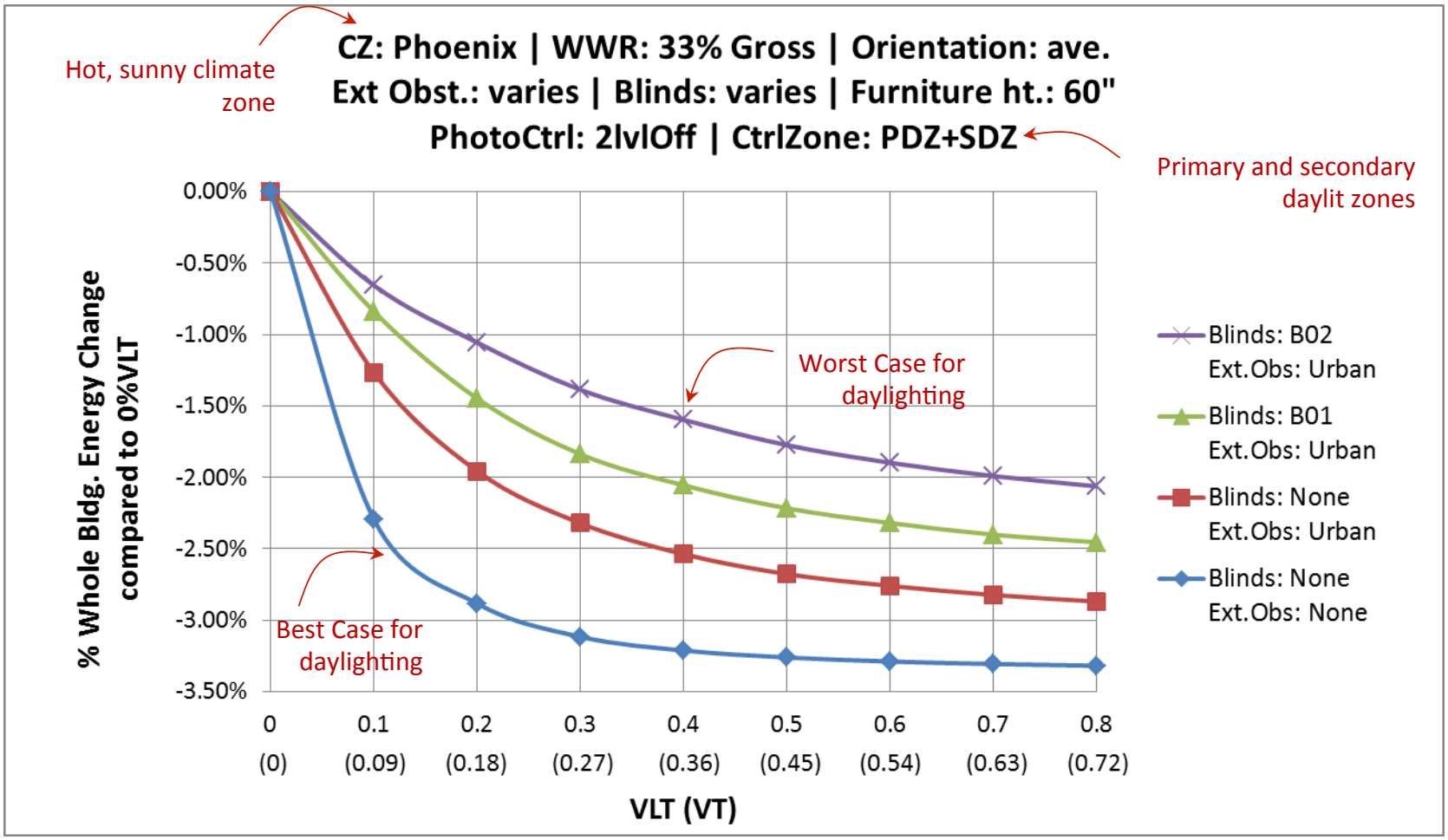


20% Trees Cover Applied Over a 60' x 40' Template Space

Analysis Set 1 – VLT Analysis

- Research Question
  - What is the impact of VT on daylighting and whole-bldg energy use?
    - Do assumptions for blinds and exterior obstruction, found in varying degree in most buildings, impact the results?
    - Do daylighting savings saturate at a VT value?

VLT Analysis Results



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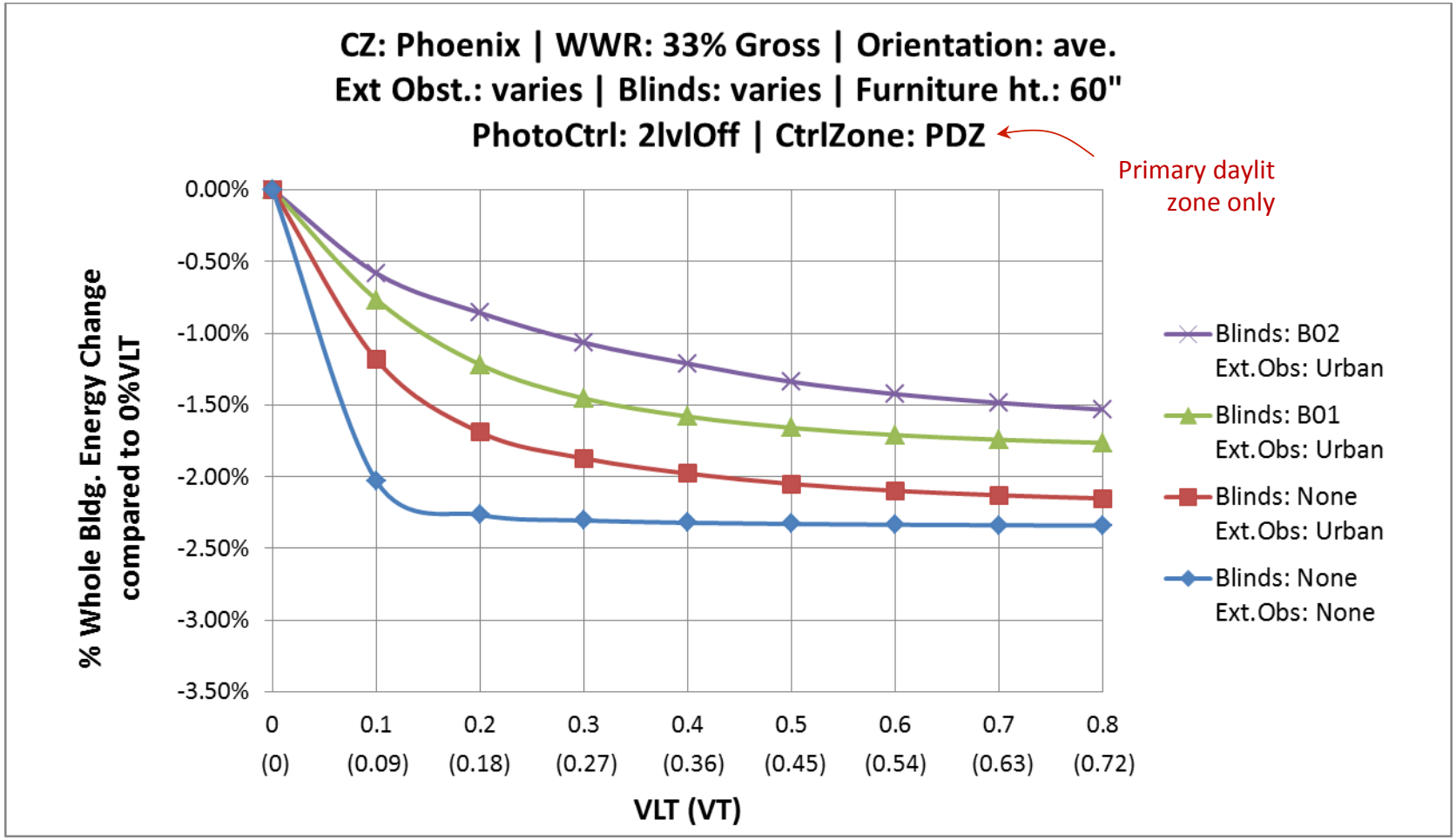

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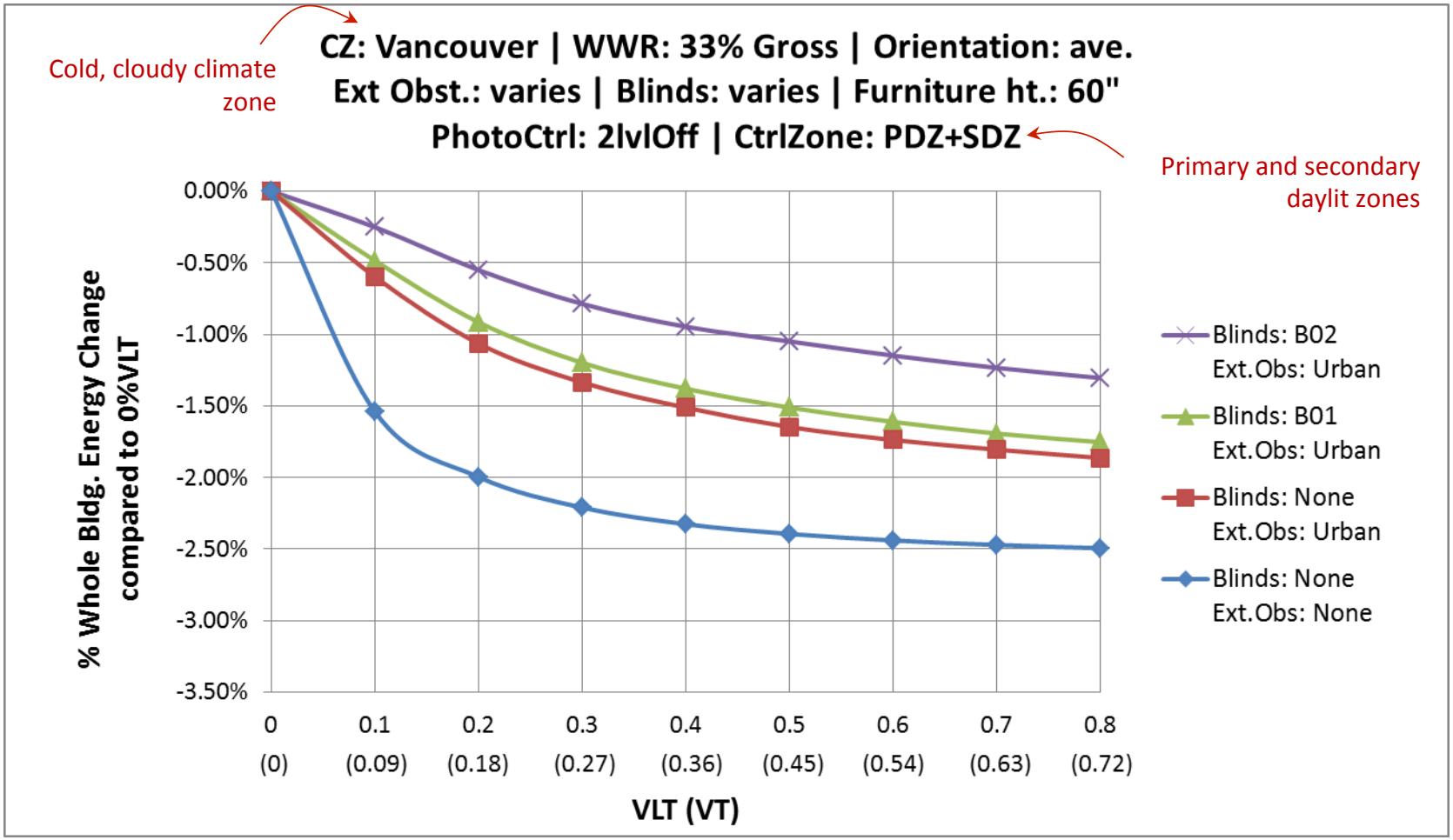

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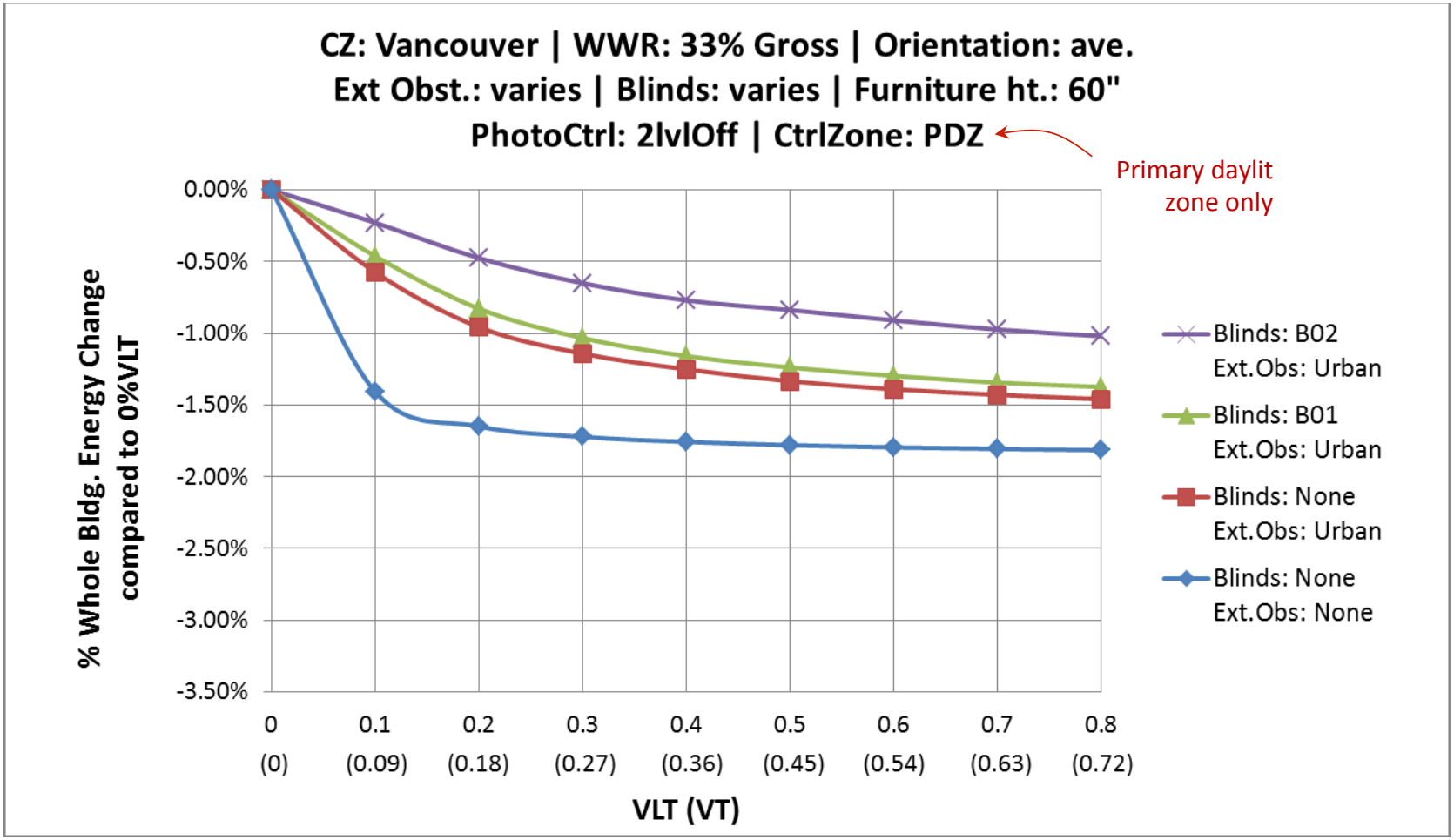

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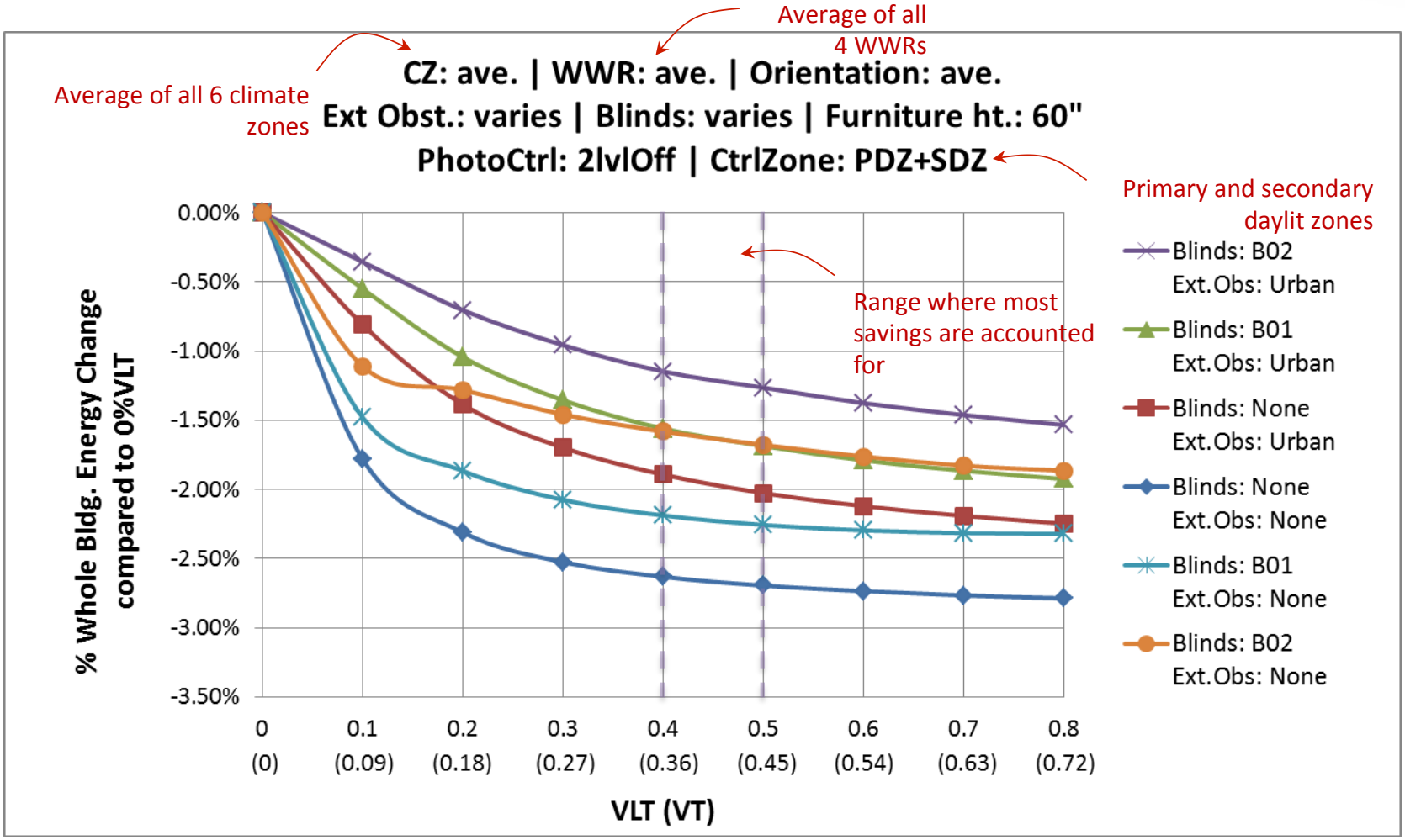


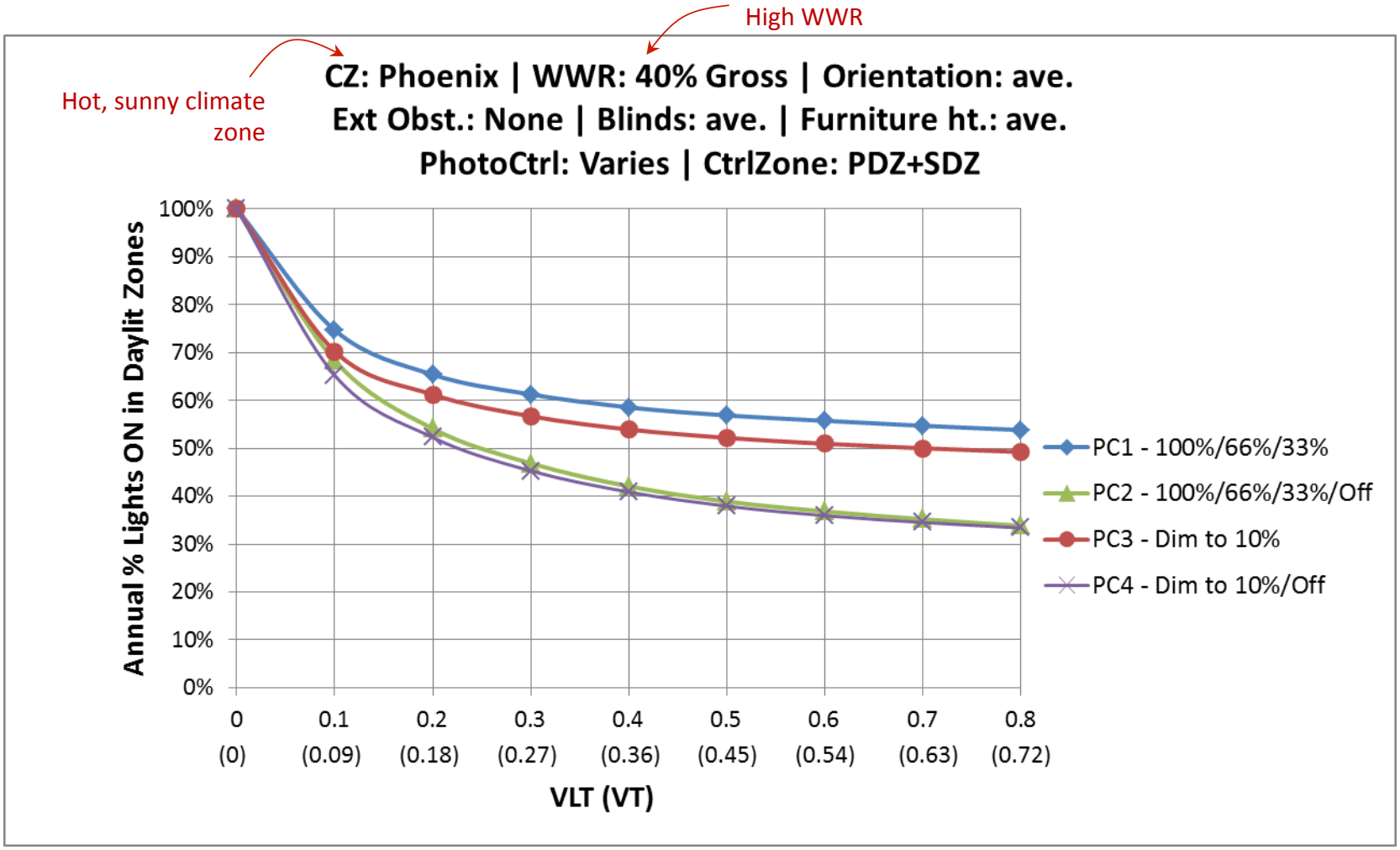
VLT Analysis – Code Proposal

- Existing code (ASHRAE 90.1-2010)
  - No requirement for VT
  - Requirement for VT/SHGC of 1.1 (addendum bb)
- Proposal
  - Add a requirement for ‘area weighted min VT’ of 0.40

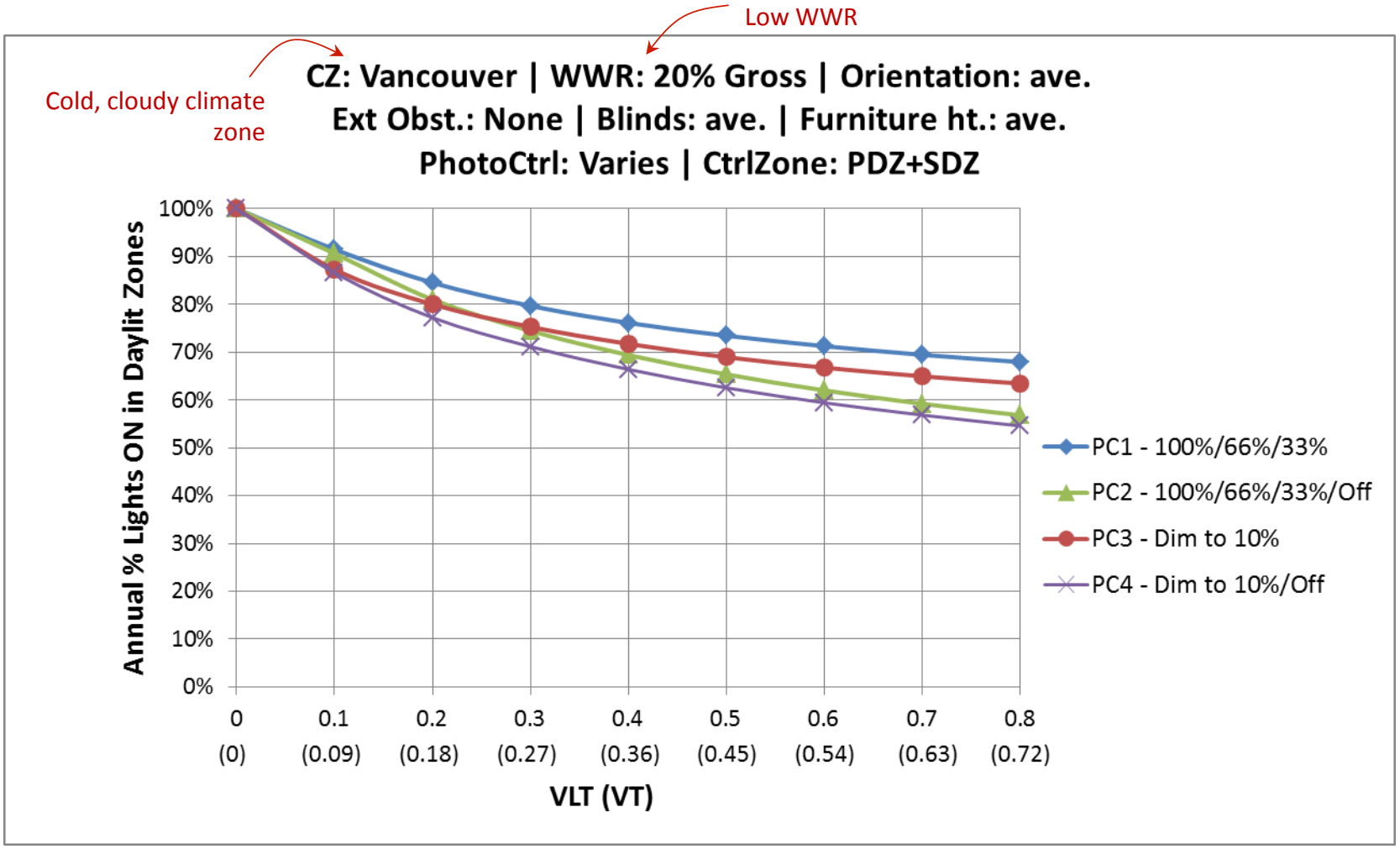
Analysis Set 3 - Photocontrol Performance

- Research Question
  - Does adding an “off” step requirement to the current photocontrol performance requirement increase savings?
    - How does 2-level plus off control’s savings compare to Dimming

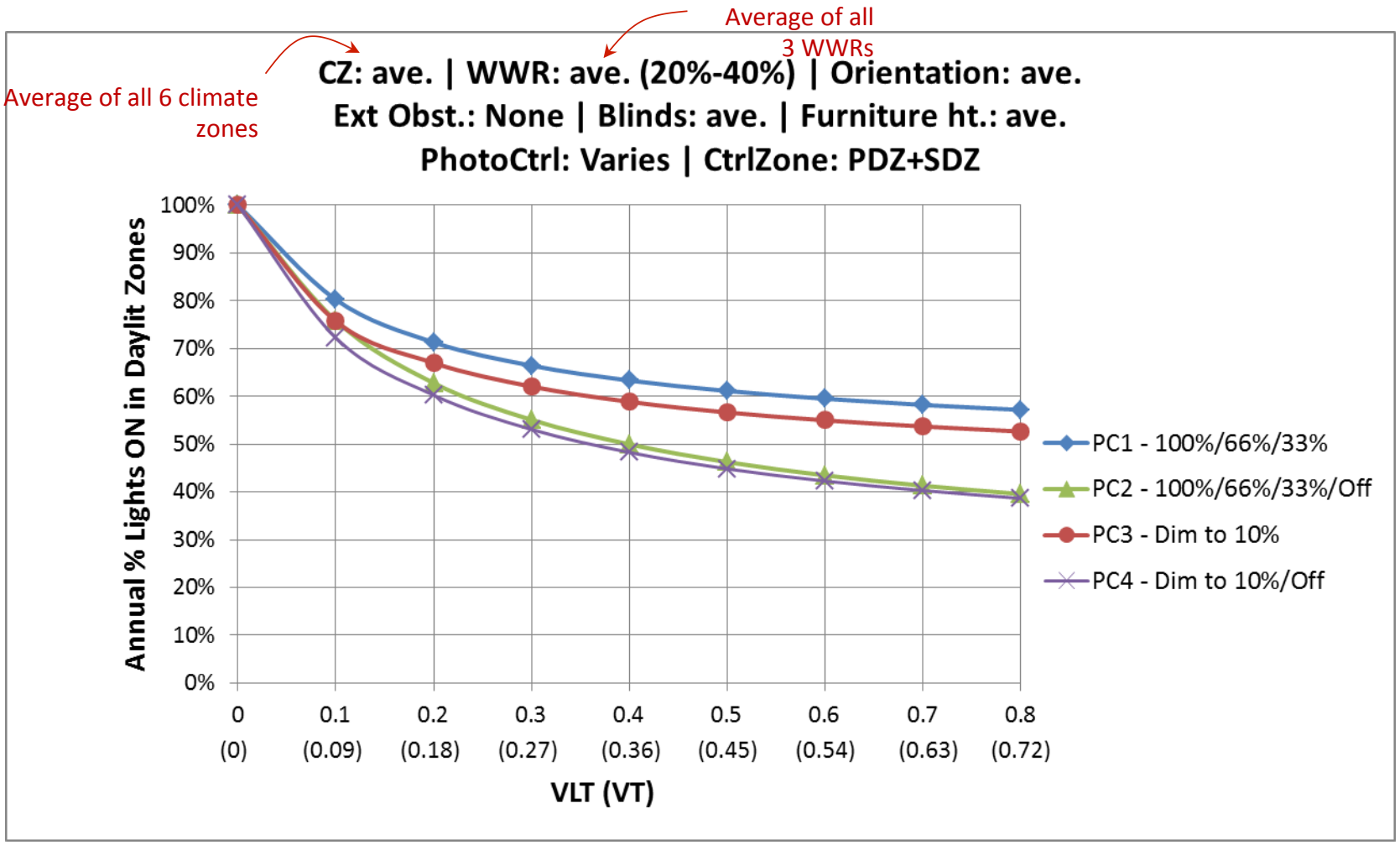
Photocontrol Performance – Results



Photocontrol Performance – Results



Photocontrol Performance – Results



Photocontrol Performance – Code Proposal

- Existing code (ASHRAE 90.1-2010)
  - Automatic daylighting controls required to have:
    - One controls step between 50% and 70% of lighting power
    - And another control step no greater than 35% of lighting power (including off)
- Proposal
  - Automatic daylighting controls required to have :
    - One controls step between 50% and 70% of lighting power
    - Another control step between 20% and 40% of lighting power
    - And a third control step that turns OFF all controlled lighting

ASHRAE 90.1 Code Change Proposals Summary

	Medium Office Building (33% WWR) Whole Bldg. Energy Savings Compared to ASHRAE 90.1-2010				
Photoctrls dimming+off	✓		✓	✓	✓
Photoctrls in pri. & sec. daylit zone	✓	✓		✓	✓
Min VT 0.42	✓	✓	✓		✓
Photoctrls threshold 120W	✓	✓	✓	✓	
Baltimore	3.95%	2.31%	2.68%	2.83%	1.17%
Chicago	3.20%	1.84%	2.16%	2.30%	0.92%
Houston	4.66%	2.77%	3.15%	3.44%	1.32%
Phoenix	5.21%	3.06%	3.46%	3.87%	1.54%
SanFrancisco	5.30%	3.16%	3.62%	3.89%	1.55%
Vancouver	3.60%	2.14%	2.53%	2.58%	1.04%
Ave. of 6 CZs	**4.28%**	**2.53%**	**2.91%**	**3.13%**	**1.25%**
Delta Savings		1.76%	1.38%	1.16%	3.04%

Compared to
ASHRAE 90.1-2010 assumptions:

Photoctrls 2 level (no off)

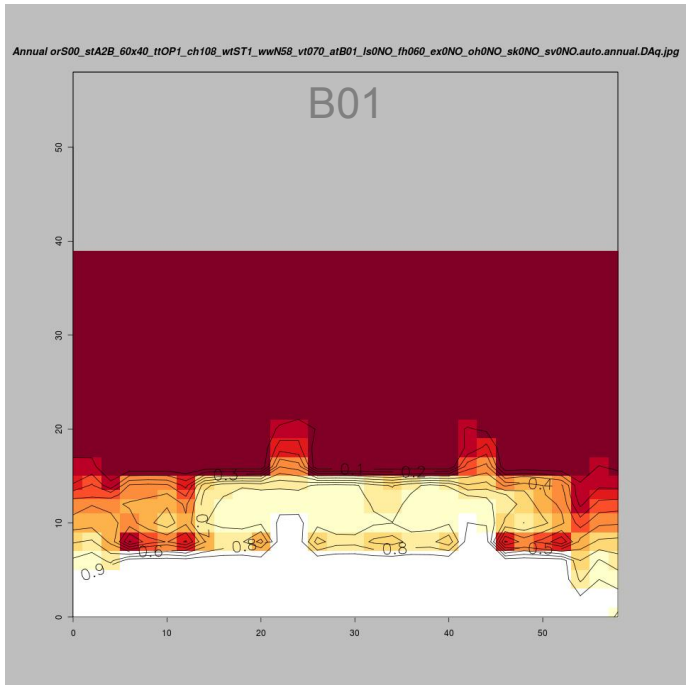
Photoctrls in pri. daylit zone only

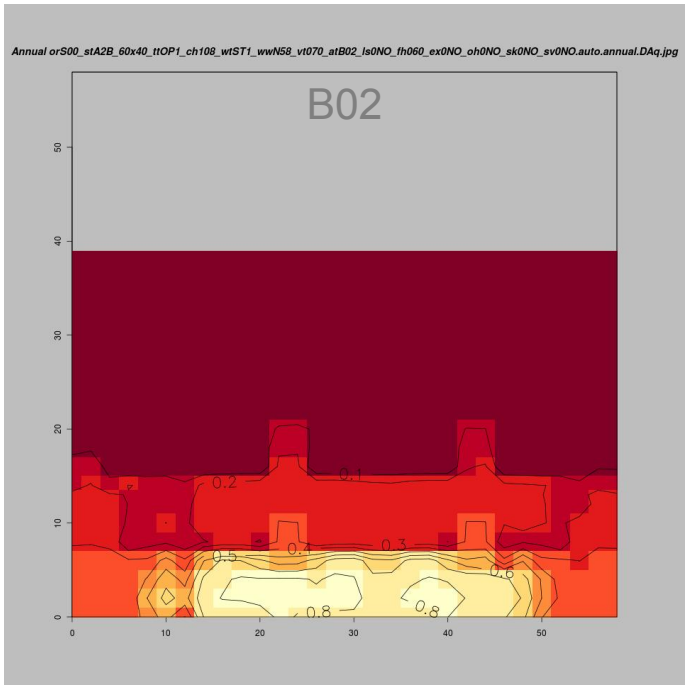
No Min VT (compared to 20% VLT)

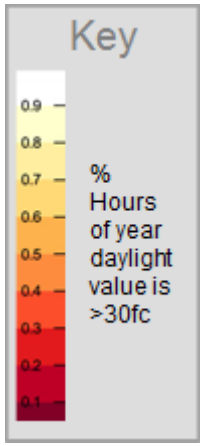
Photoctrls threshold 250 sf

Takeaways and Wishlist

- Types of blinds and shades …
  - Have a significant impact in daylight evaluation
    - But, there is no information of market share of blinds/shades types available!
    - Need a market assessment study of window blinds/shades



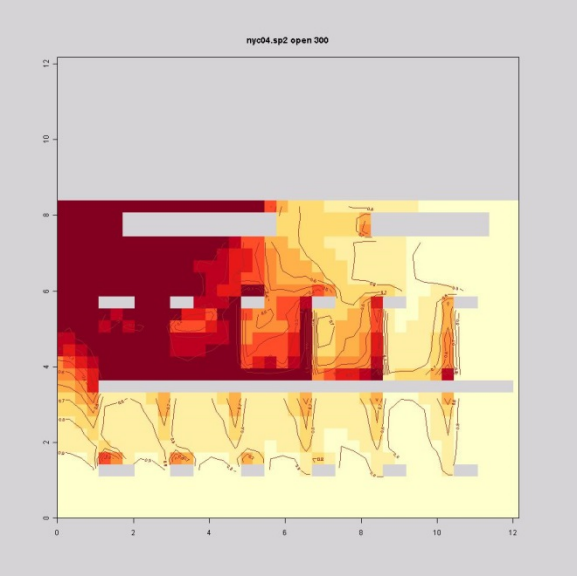




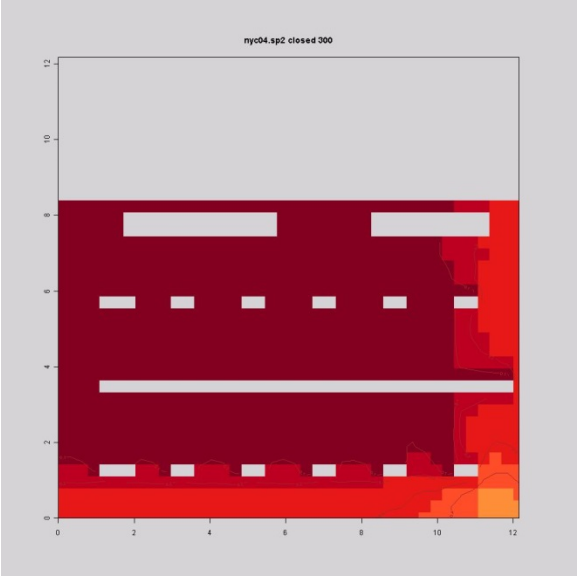
Takeaways and Wishlist

- Blinds operation …
  - Has one of the largest impacts on daylight!
    - But we have the least amount of empirical data on this!
    - LM-83 is a start, but we need more!

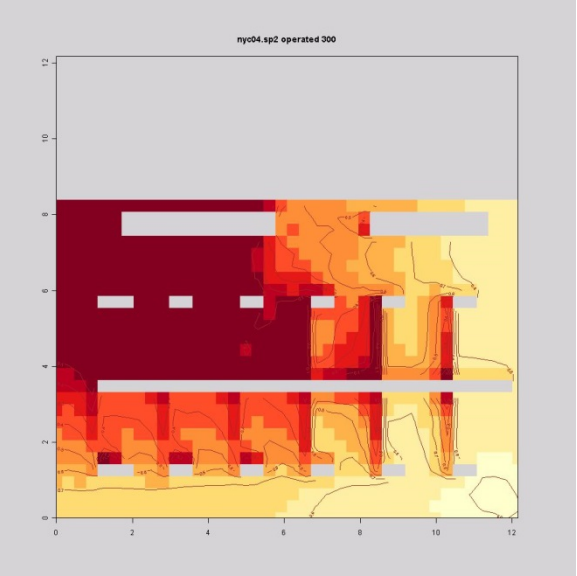
Blinds always open

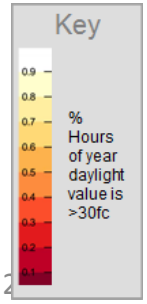


Blinds always closed



Blinds operated





Takeaways and Wishlist

- Radiance developments …
  - 3-Phase Method development has made it possible to provide analysis and develop code changes, previously not possible!
    - We now need Radiance 3-phase method (and 5-phase method) incorporated into code compliance software!
      - Easy to use
      - Hard to mess up
    - Yesterday … please!
  - Blinds and shades definitions in Energy Plus
    - We need an way to translate BSDF to IDF blinds/shades definition
  - Glare Analysis and glare metrics
    - Daylighting savings contingent on a glare free environment

Thank you

Questions?

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