HVAC and the Envelope

Towards to New Rules of Thumb

Steve Kemp | April 2015

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What climate are these building experiencing?

Denver

Edmonton

Honolulu

Toronto

Los Angeles

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From Envelope is King, to it's the HVAC stupid and back again

My early career

- It's all about the envelope
  - Heating and cooling loads are imposed primarily by the envelope, so let's start there!

It didn't take me long to find…

- HVAC design and specifications are terrible
  - Fix the stupid things that we're doing!

Today… Great envelopes enables great HVAC

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Typical Characteristics of High Performance HVAC

- **Separates ventilation from temperature control**
  - Humidity control through ventilation, local heating / cooling
- **Simple local controls**
- **Amendable to low temperature heating, higher temperature cooling**
  - Increases efficiency of primary equipment
  - Increases opportunity for using waste/free energy sources/sinks

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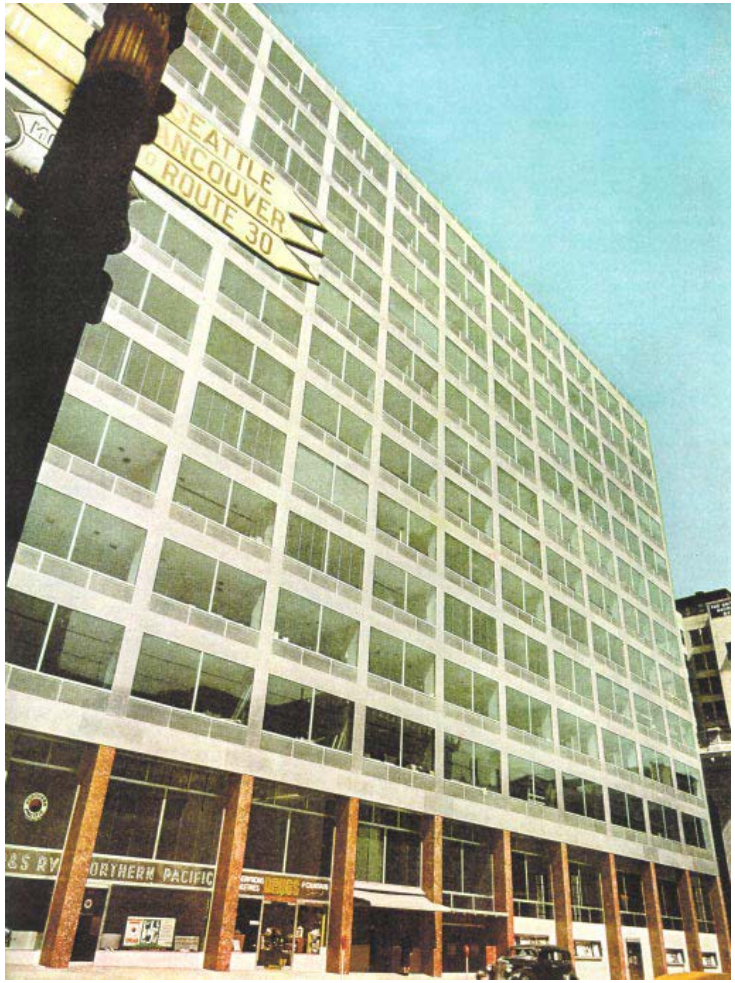
Equitable (now Commonwealth) Building in Portland

- **Modern Prototype of fully air-conditioned building**
- **Architectural Forum:**
  - “crystal and metal tower”
  - spectacular for “its huge areas of sea green glass”
- **A/C Installed to counteract the glazing**
  - It worked!
  - Maybe not the best precedent



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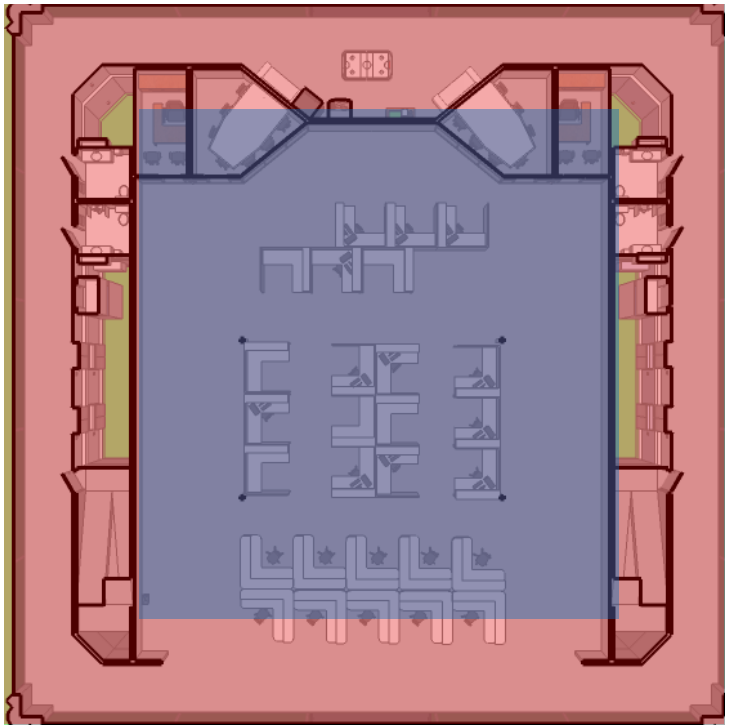
1950s-1960s Constant Air Volume and Perimeter Induction

- **Buildings created with large interior spaces**
  - needed year-round cooling
- **Perimeter needs both heating and cooling**
- **Ventilation needed everywhere**
- **Ventilation air rate typically less than required for cooling**



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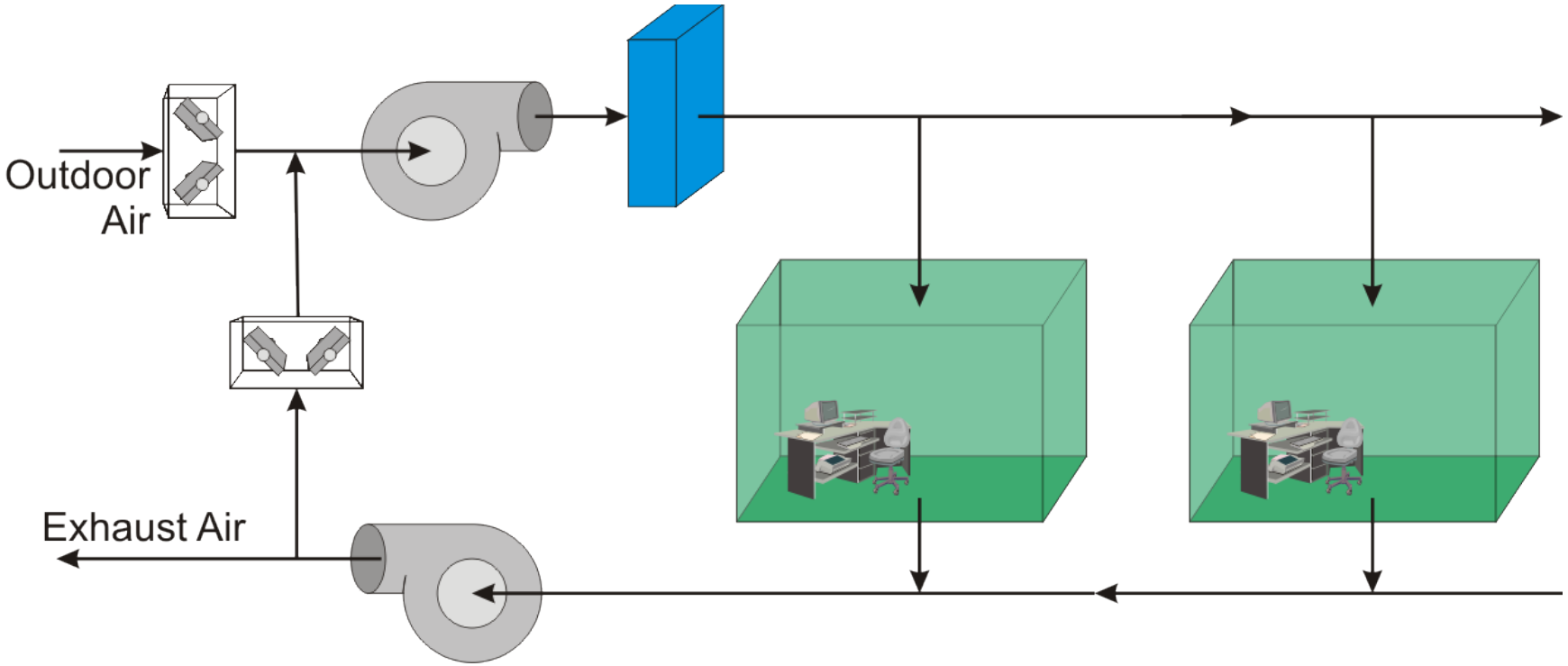
Interior: Constant Air Volume



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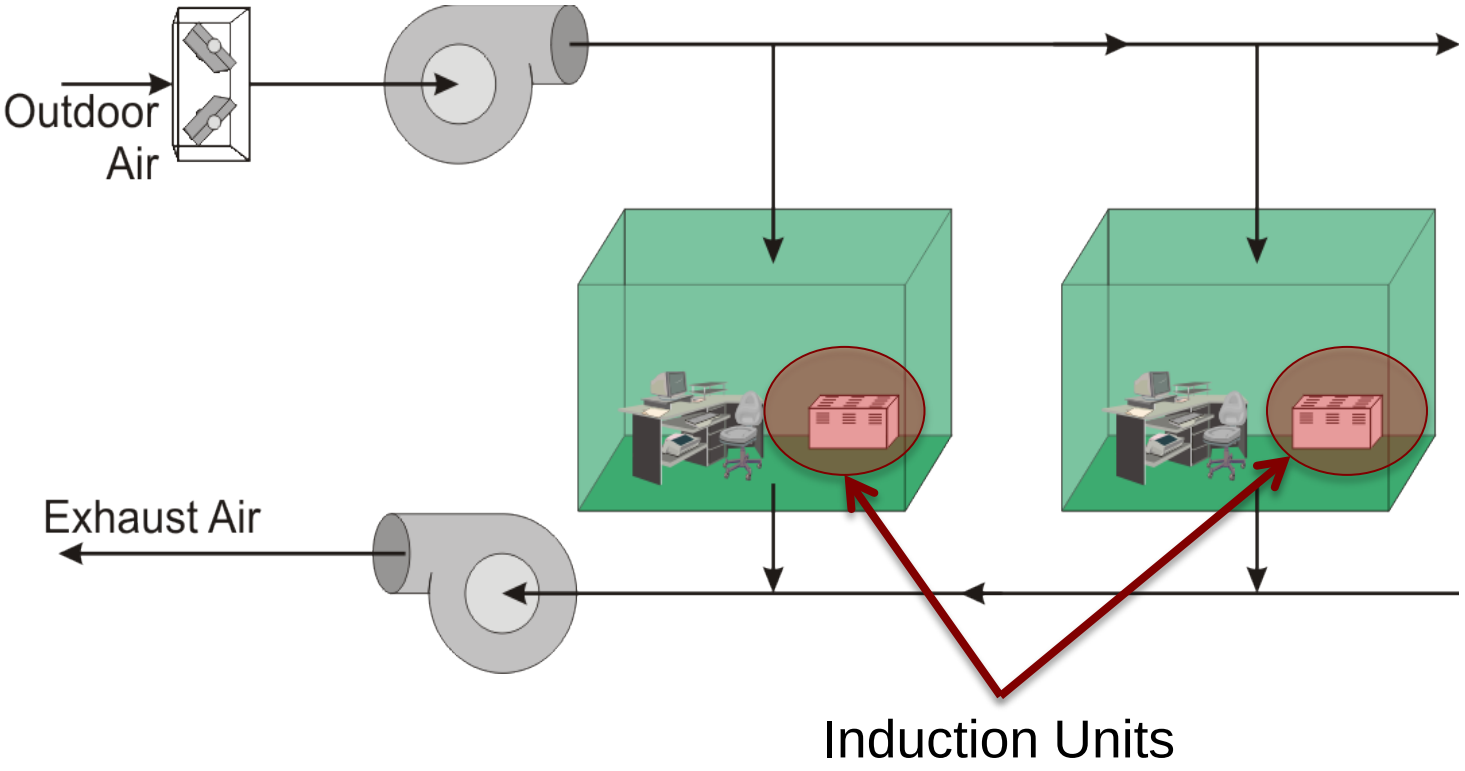
Perimeter: Constant Air Volume outdoor air only with Induction Heating/Cooling



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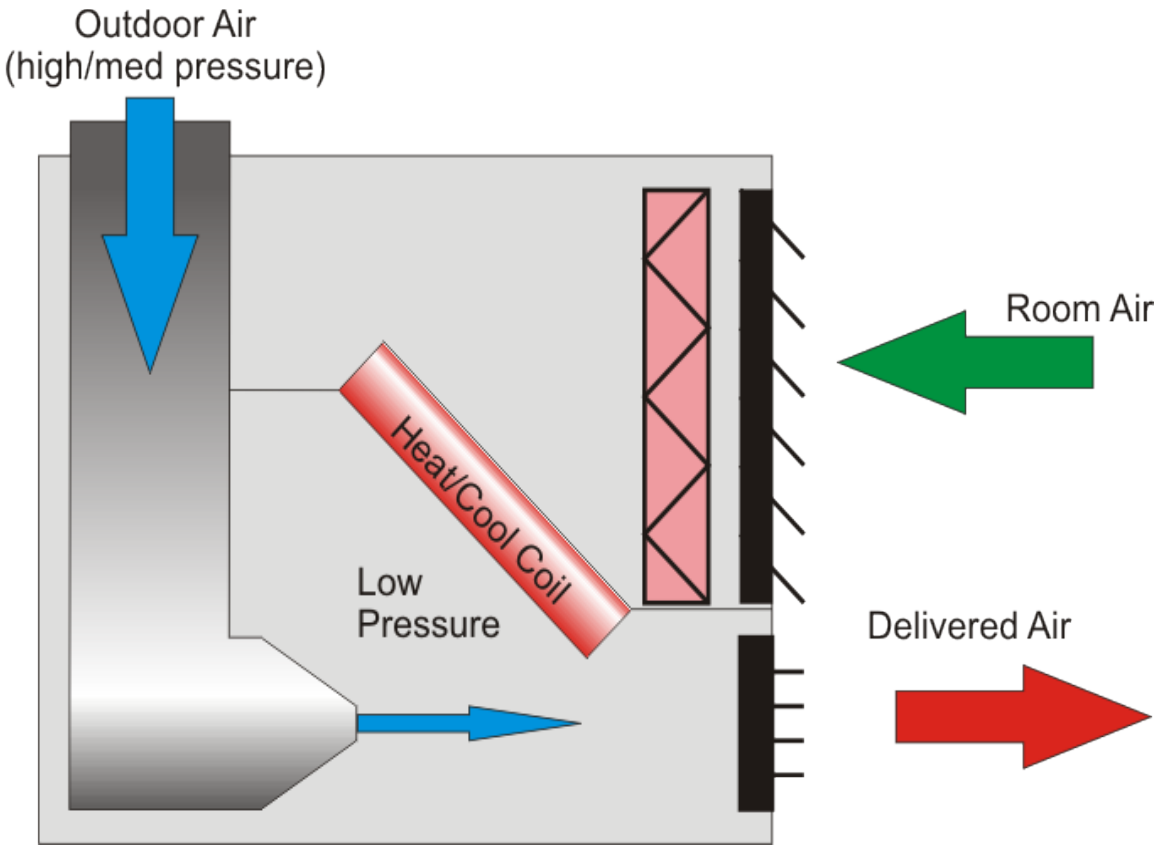
Induction Unit



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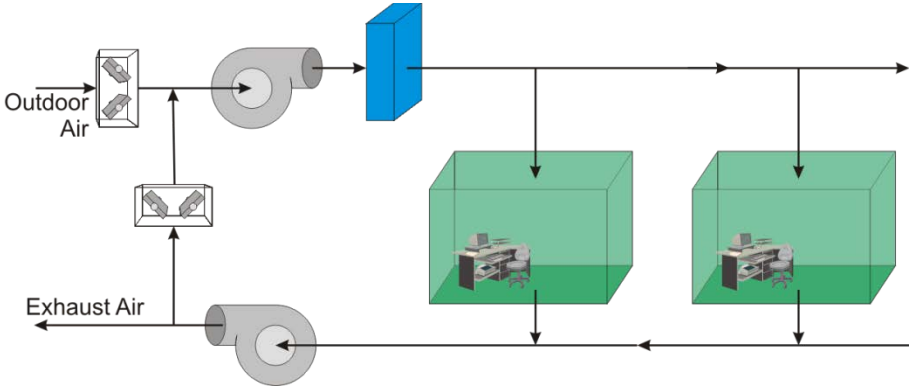
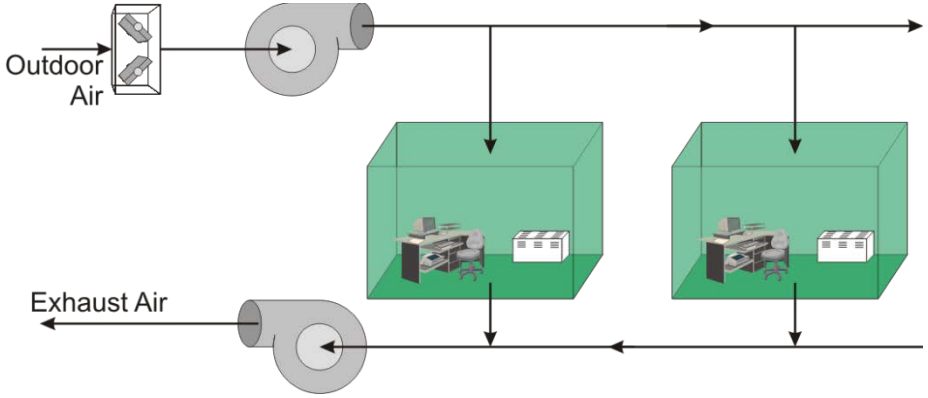
1950s-1960s Constant Air Volume and Perimeter Induction

- Heating and Cooling by air
- Economizer (free cooling) for interior during winter



Then….

- Construction costs increased
- Value Engineering!
- Induction units and perimeter air handler deleted to save first costs



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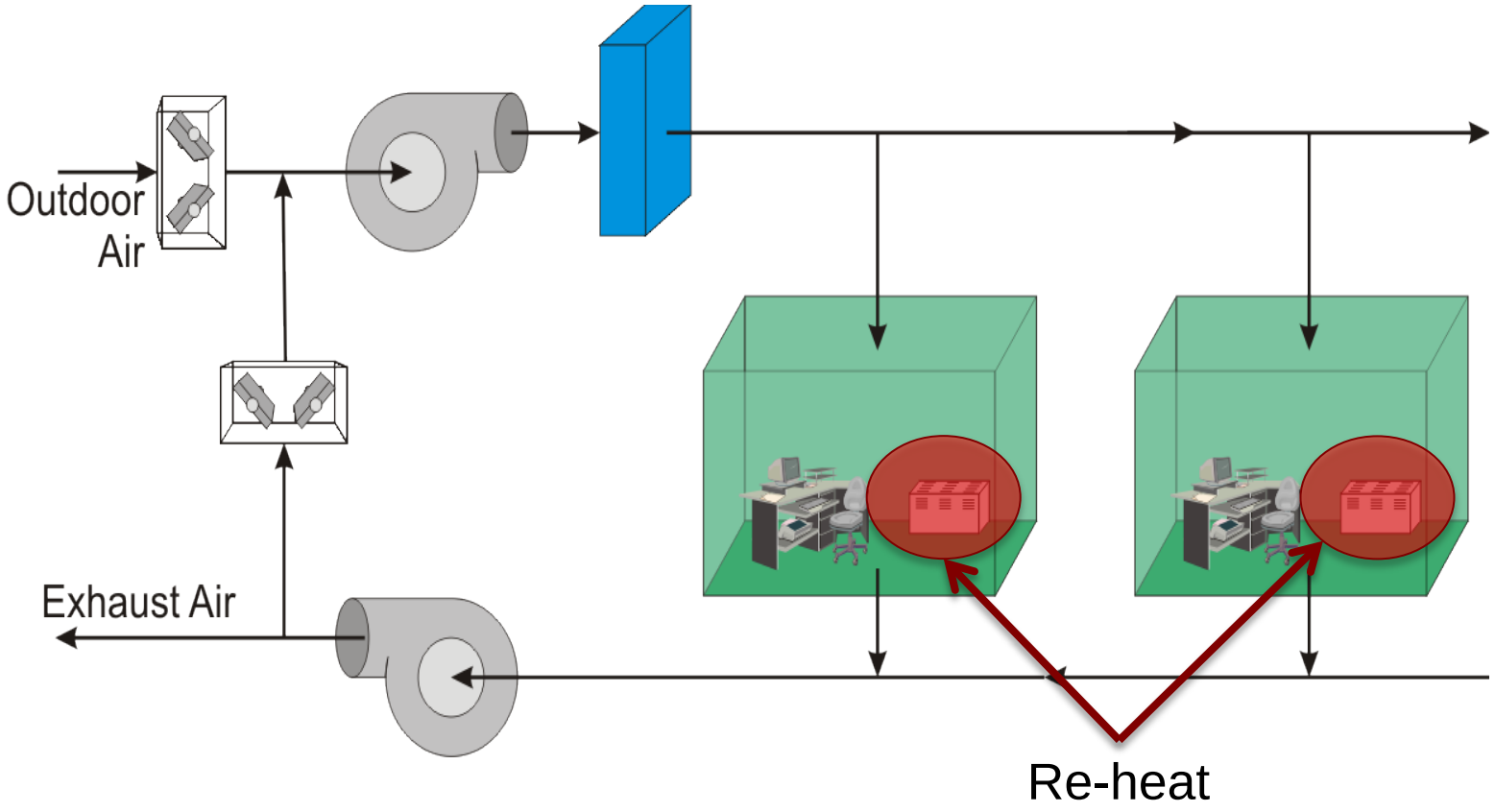
Which gave us CAV with Re-Heat



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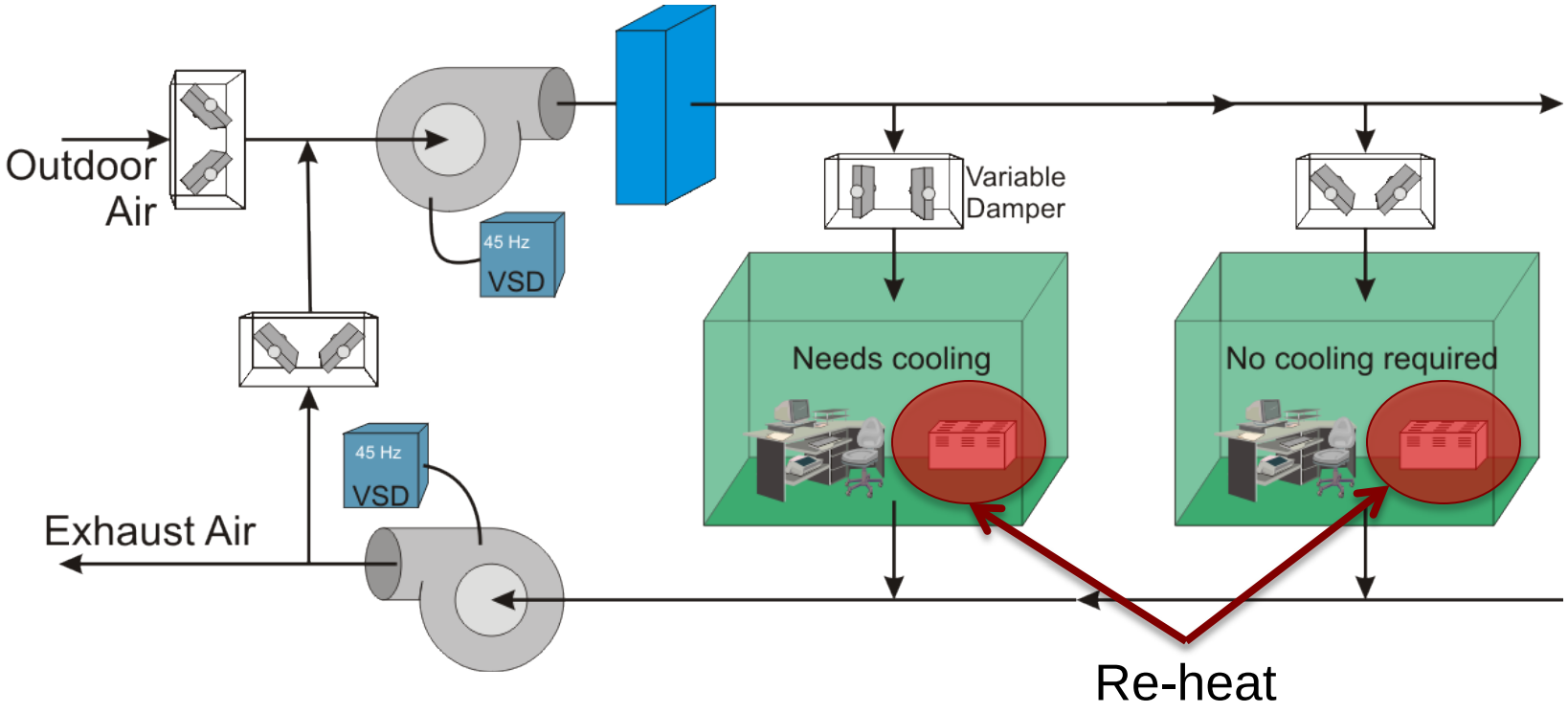
1970s until today: Variable Air Volume Systems

Perimeter heating (and re-heat) provided by baseboards or heating coil in fan-powered VAV box



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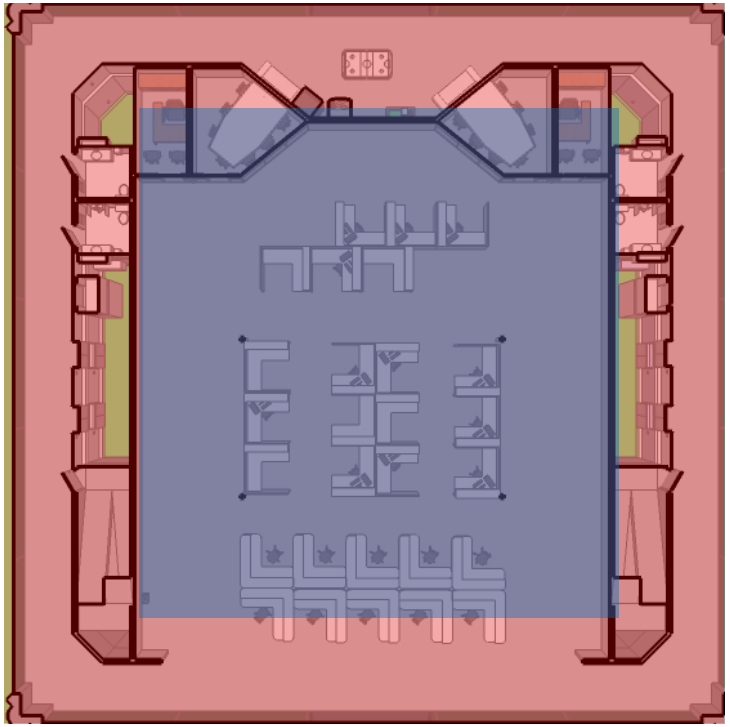
VAV Systems

- **Single air handler for both internal and perimeter spaces**
- **Air handler and duct work designed for max cooling condition**
  - Low pressure drop (resistance) at most operating conditions



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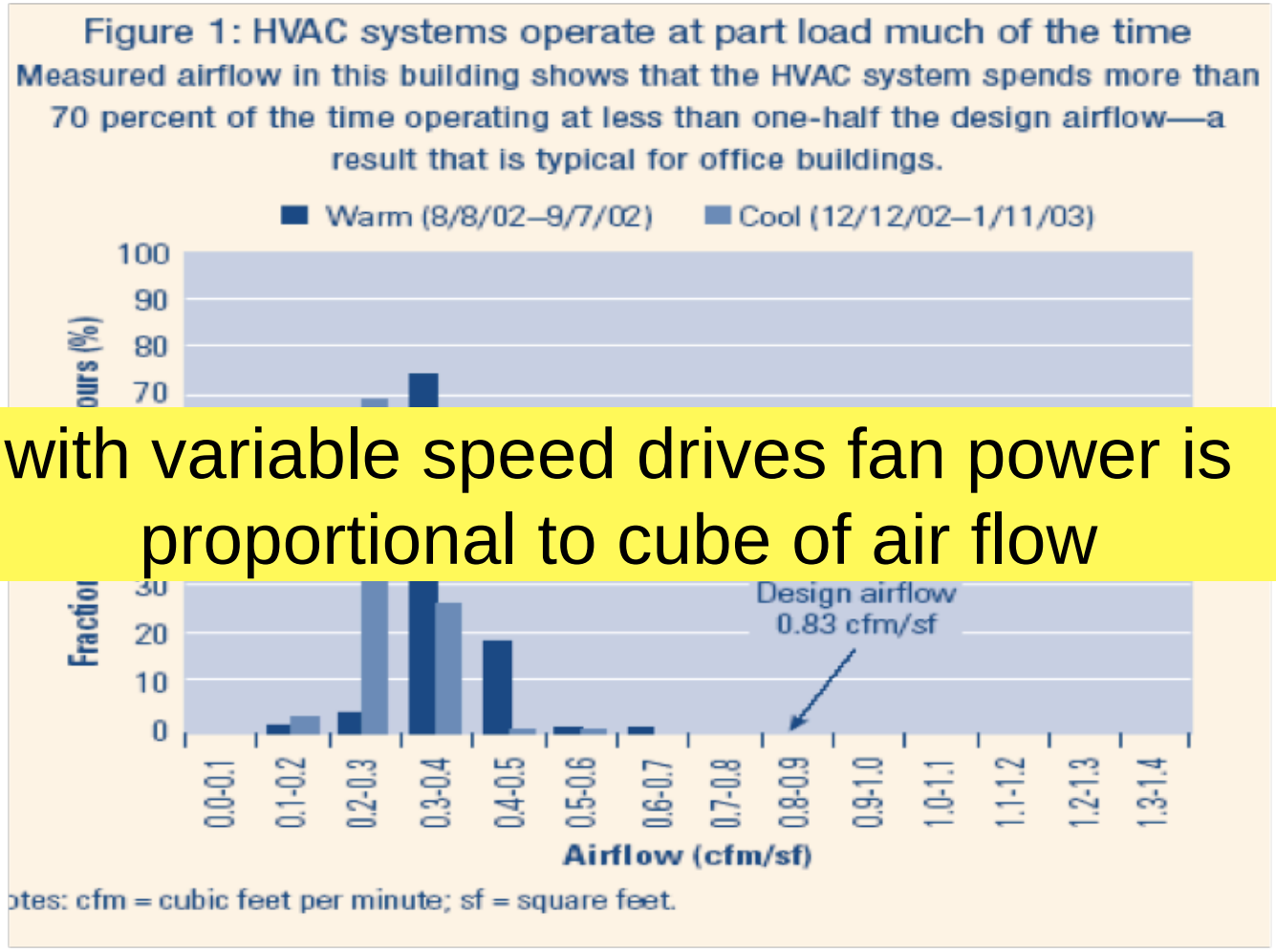
Significant Fan Power Savings over CAV



with variable speed drives fan power is proportional to cube of air flow

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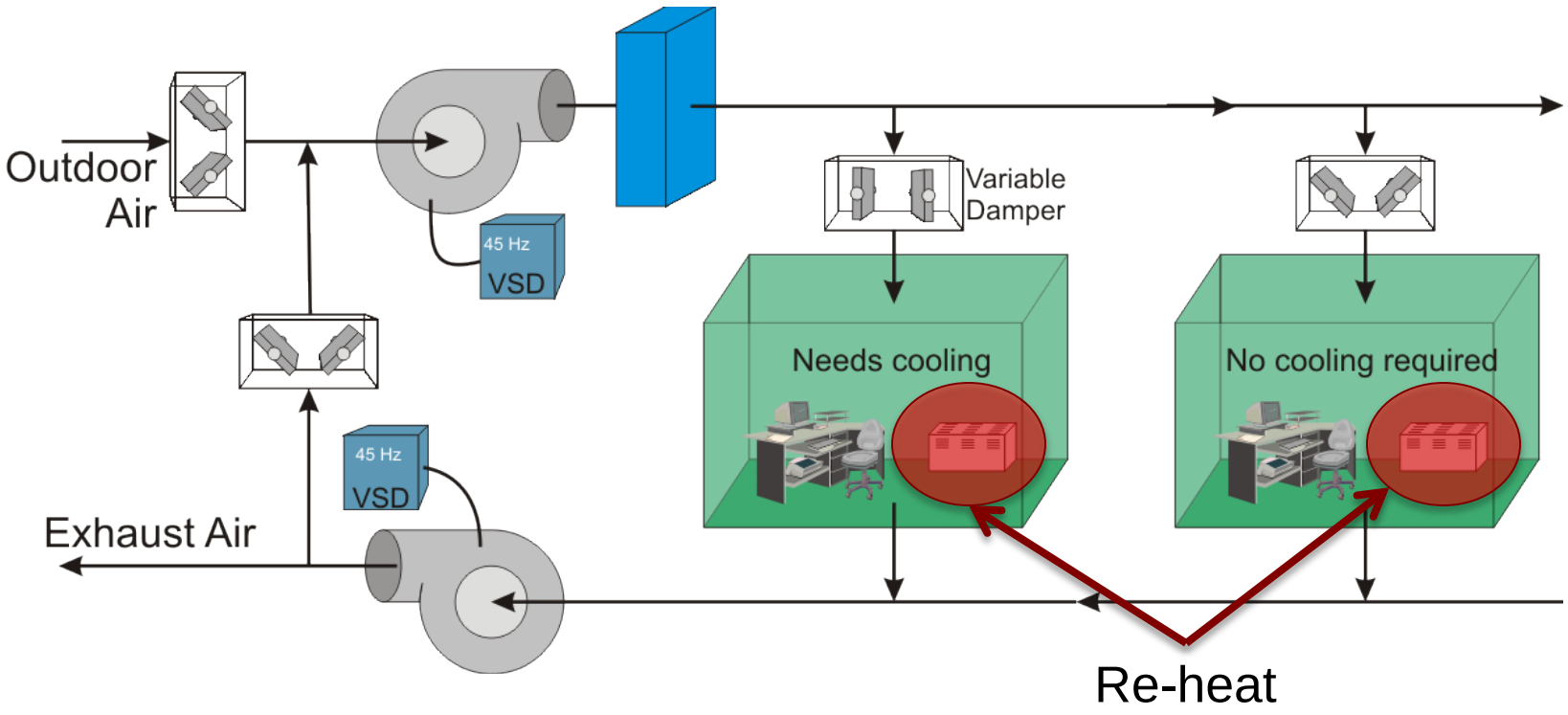
1970s until today: Variable Air Volume Systems



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Dedicated Outdoor Air Systems (DOAS)

Provide ventilation air independent of heating and cooling requirements

- optionally dehumidify for improved comfort

Excellent exhaust air heat recovery performance

No reheat!

2-pipe and 4-pipe fan coils

Radiant heating/cooling

Distributed heat pumps

Even and VAV-DOAS option

Etc…

No outdoor air economizer (free cooling)

- operable windows or cooling tower based economizer

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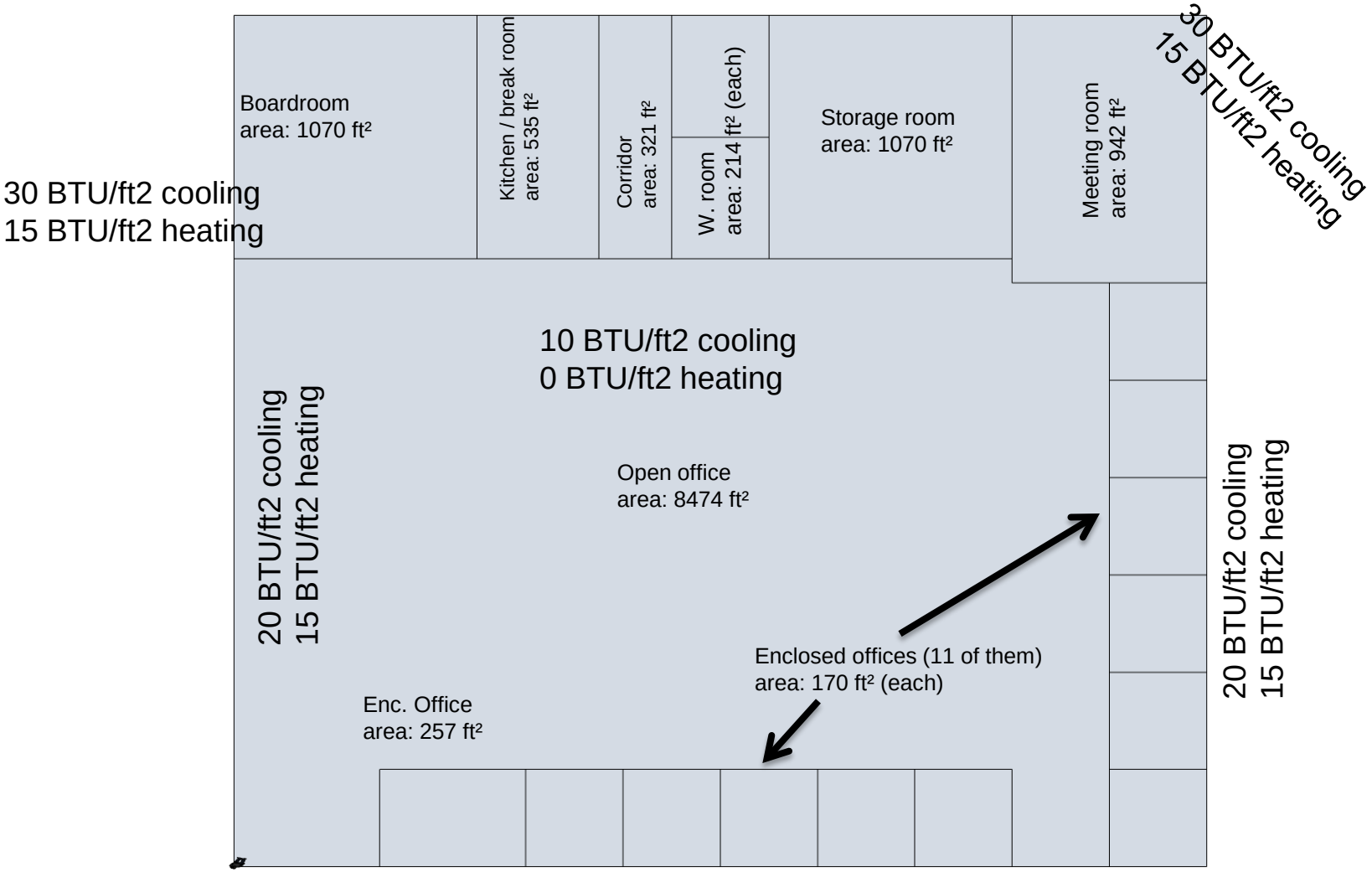
How does an HVAC Designer Look at a Floorplan?

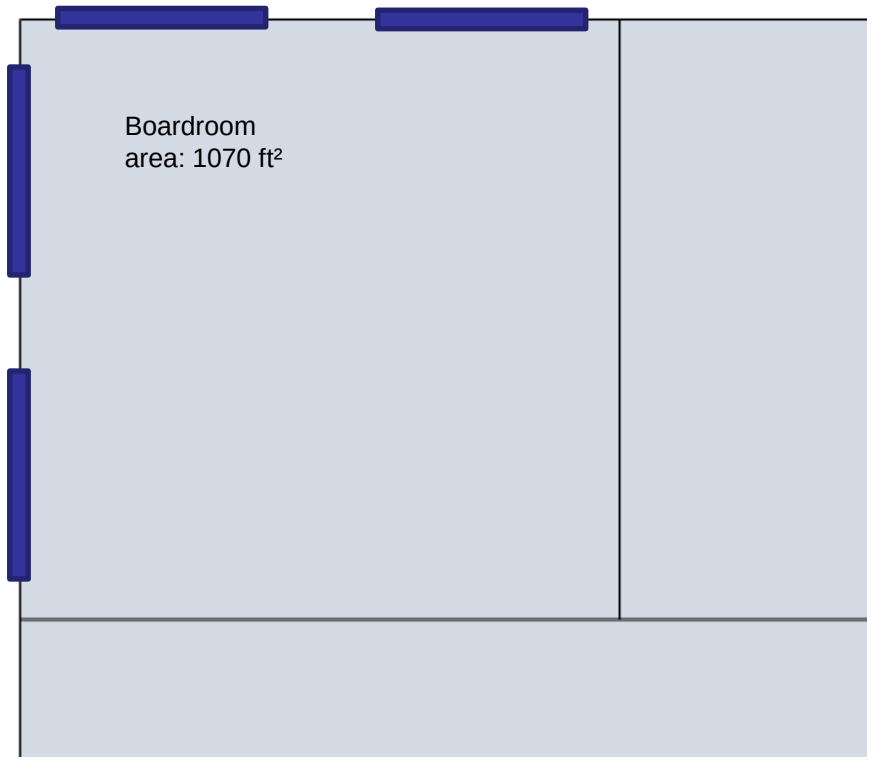


Perimeter Spaces Significantly Affected by Envelope

Internal Gains
- Lights
- Receptacles
- People

Solar Gains

Winter Heat Loss



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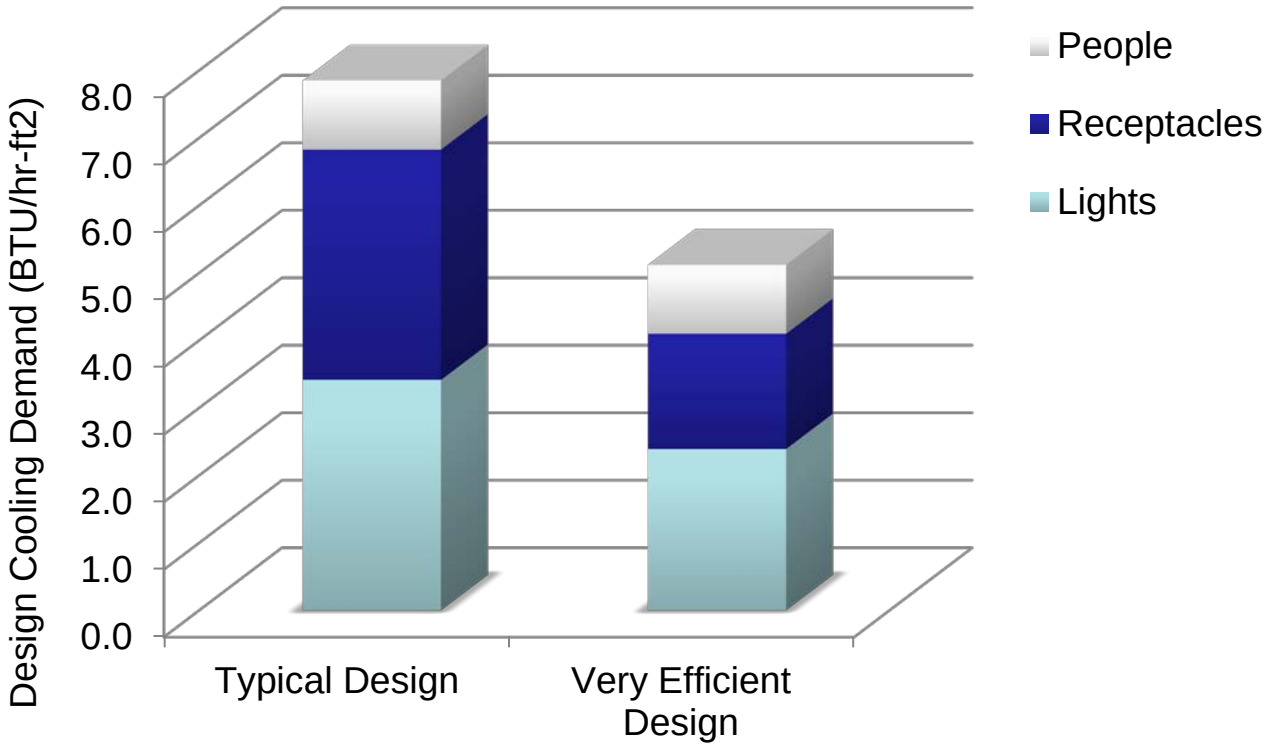
Cooling Loads: Lights, Receptacles, People



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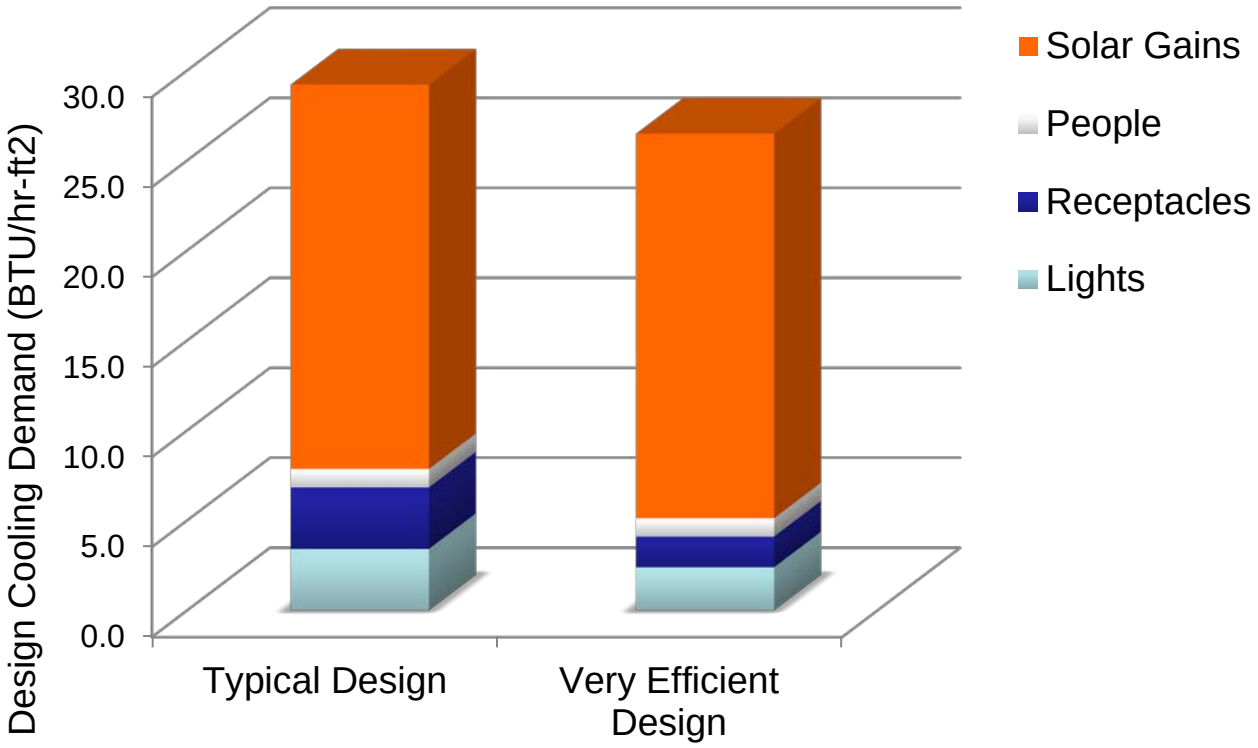
Cooling Loads: Lights, Receptacles, People, Solar

50% WWR and solar control low-e clear window



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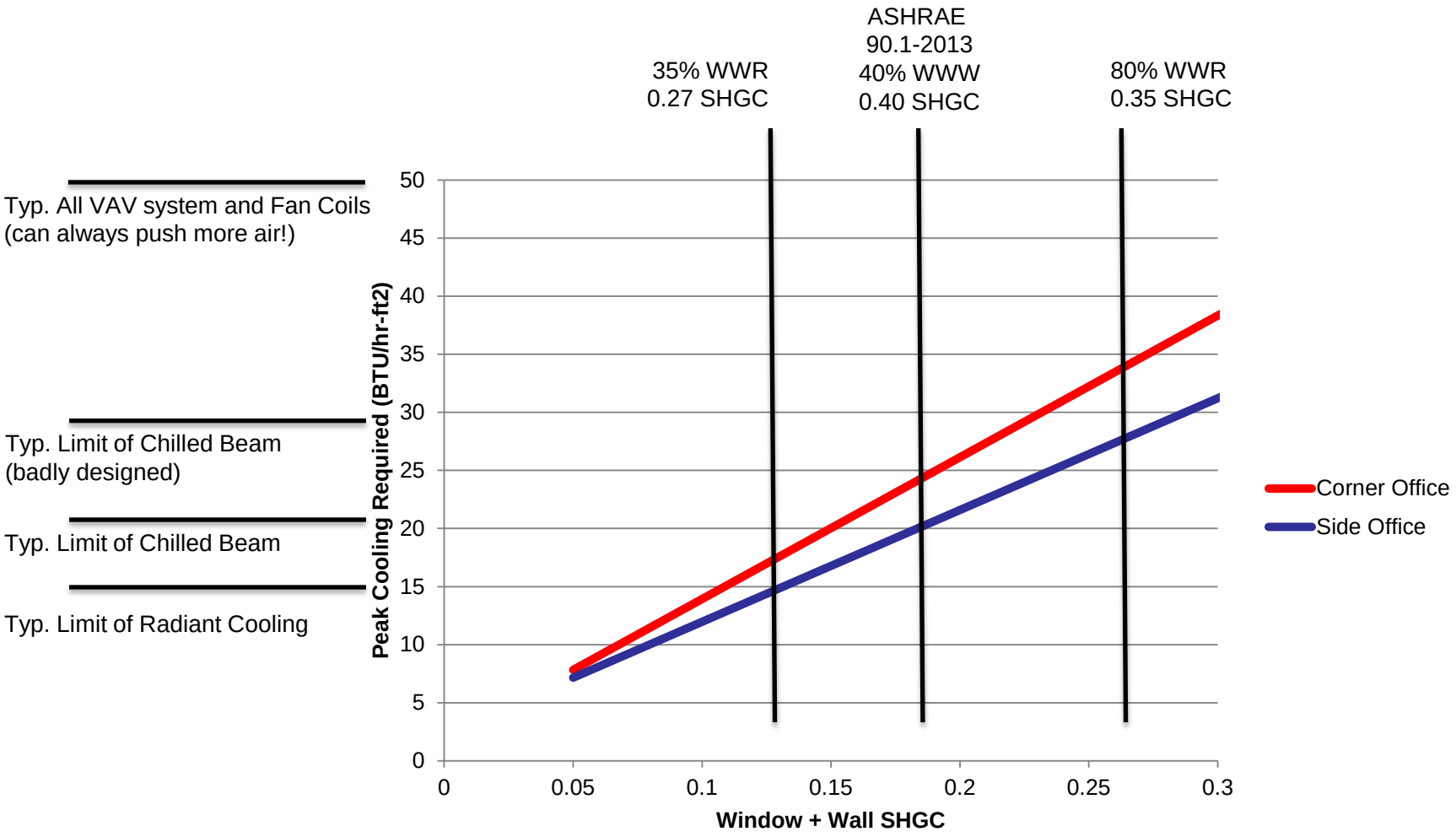
Interaction with HVAC



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Heating Loads: Kansas City

Toronto Office Tower
R-6 spandrel,
60% WWR of U-0.25

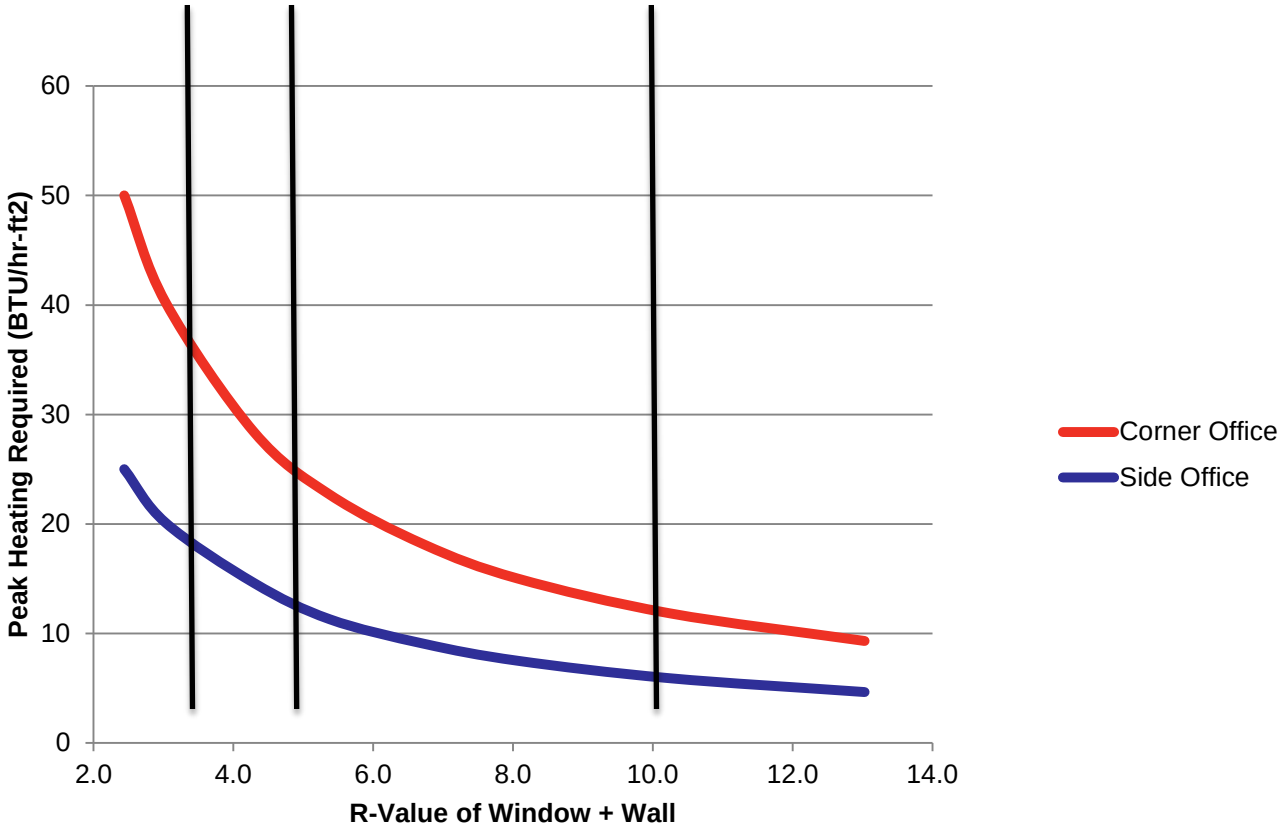
ASHRAE
90.1-2013
40% WWW
0.40 SHGC

What I want
R-20 Walls,
35% WWR of U-0.15

Typ. Limit of 180F Baseboard

Typ. Limit of Infloor Radiant

Typ. Cost Effective VRF Heat Pumps



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Great envelopes enables great HVAC

- Language matters: Are whole Wall + Window usefull?
  - for determining relevant heating/cooling system… YES
- Many low energy heating/cooling design have output limitations
- Architects and Engineers don’t have a common language / tool set to identify synergy performance goals

130 kWh/m2-an (42 kBTU/ft2-an)

69 kWh/m2-an (22 kBTU/ft2-an)

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