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MEASURED C&I BUILDING PRESSURES

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cee
Center for Energy and Environment

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Building Pressure Design

- ASHRAE recommends slight positive pressure between ~1.25 and 20 Pa to reduce infiltration
- Stanke and Bradley 2002 offer more specific guidance
  - Summer pressure of 12.5 Pa or up to 25 Pa for hot and humid climates
  - Winter depressurization of 0 to –5 Pa to reduce exfiltration and envelope moisture concerns
  - Perhaps –25 Pa to control the winter stack effect
- In Minnesota 12.5 Pa is a common goal to reduce cold drafts, space heating energy use, and frozen pipes

Building Pressure

- Building pressure control is not common
  - Only 2/16 buildings in this study have active pressure control
  - A constant difference between the outdoor air and exhaust/relief air flow rates is commonly used to obtain pressurization
- What are typical building pressures?
  - How does building pressure change with weather and HVAC operation?
- Critical for assessing energy and savings impacts of envelope leakage
- Characterize building pressures for representative MN buildings

Measuring Building Pressure

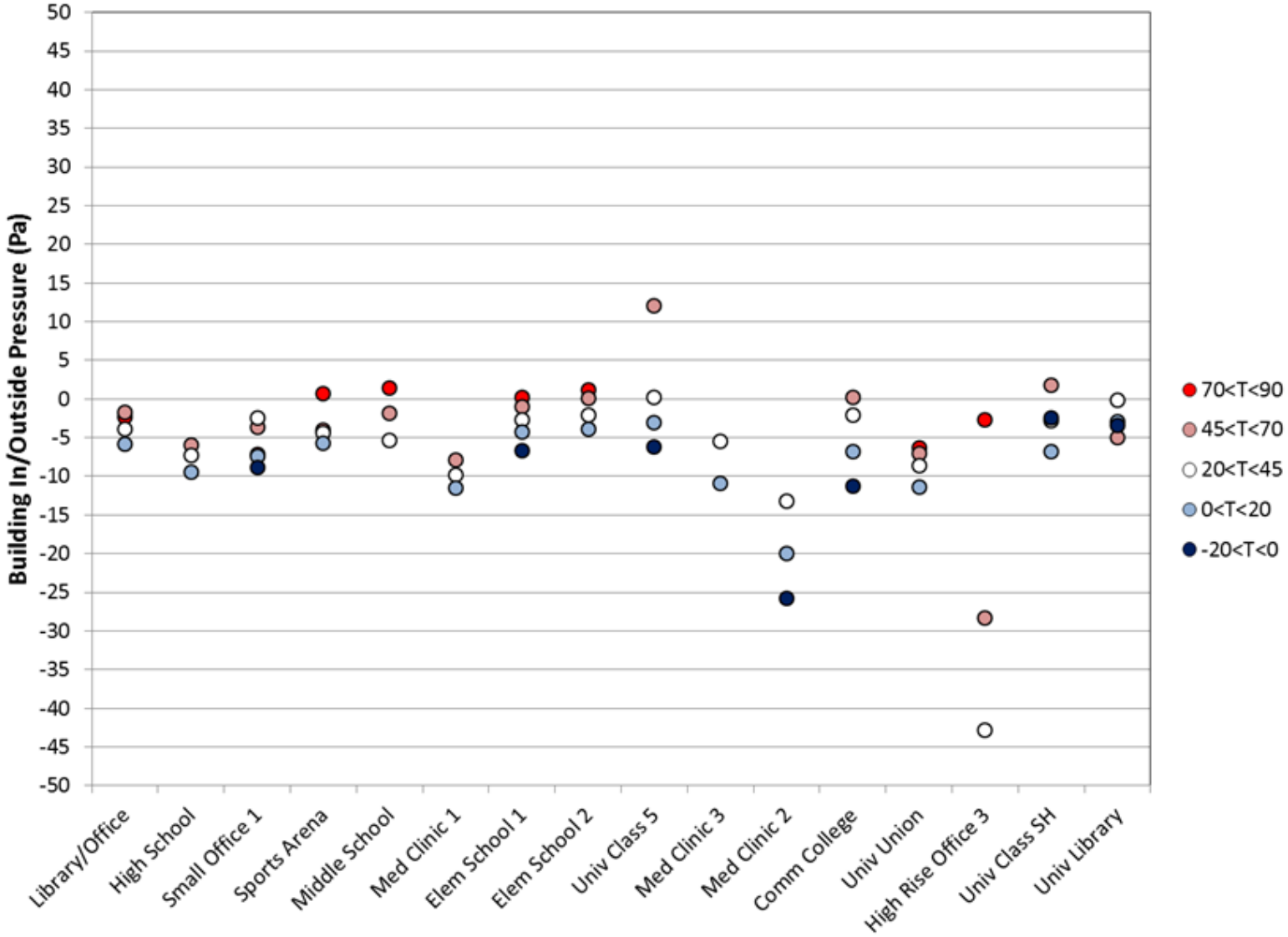
- Digital auto-zeroing manometer with storage left on site
- Outdoor static pressure sensor mounted 2 ft off roof surface
- Ground level outdoor pressure in warm months
- Indoor reference tube terminated in common area
- Data merged with BAS trend data, occupancy schedules, and weather data

Buildings

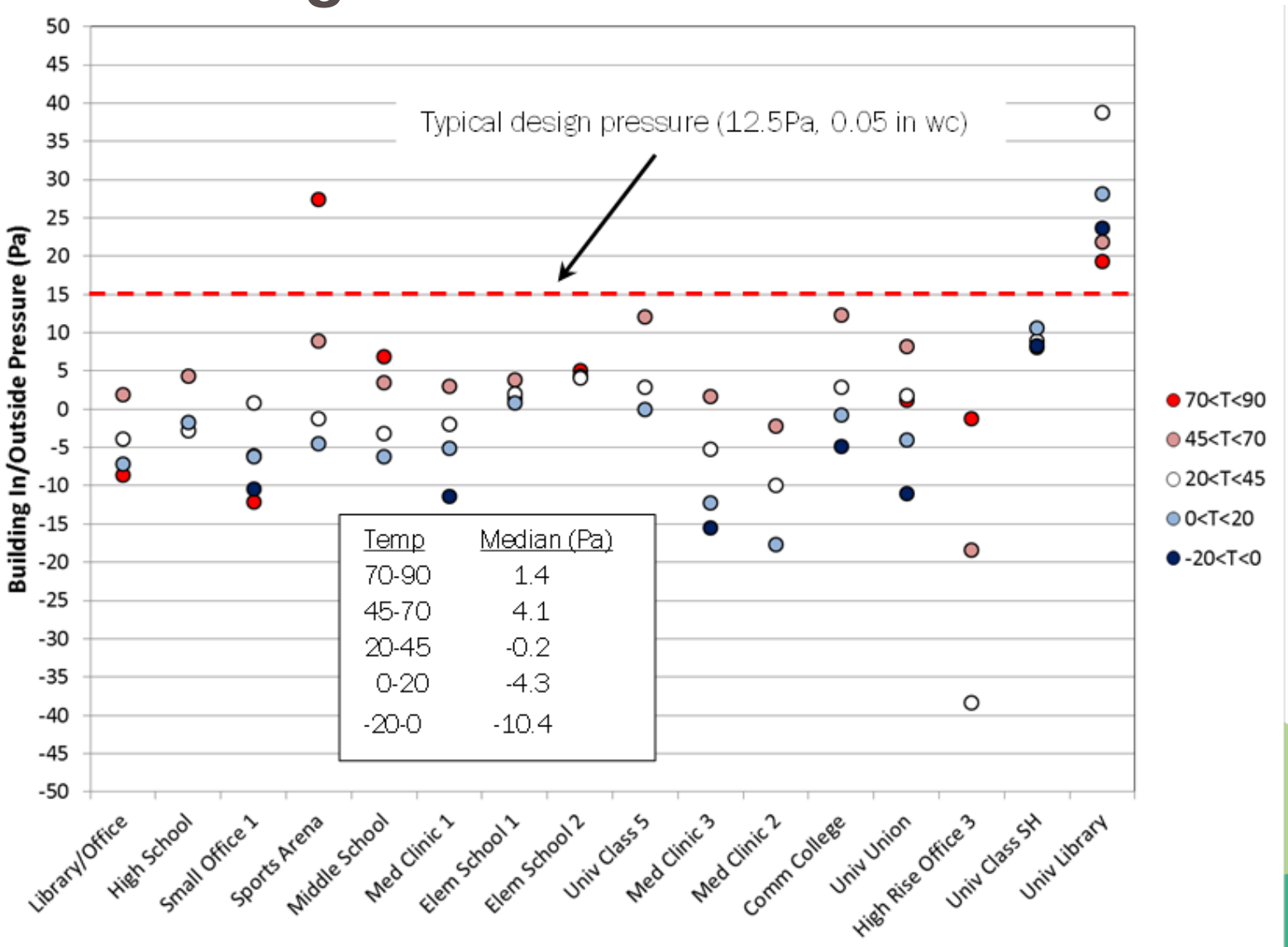
Table 1: Characteristics of monitored buildings

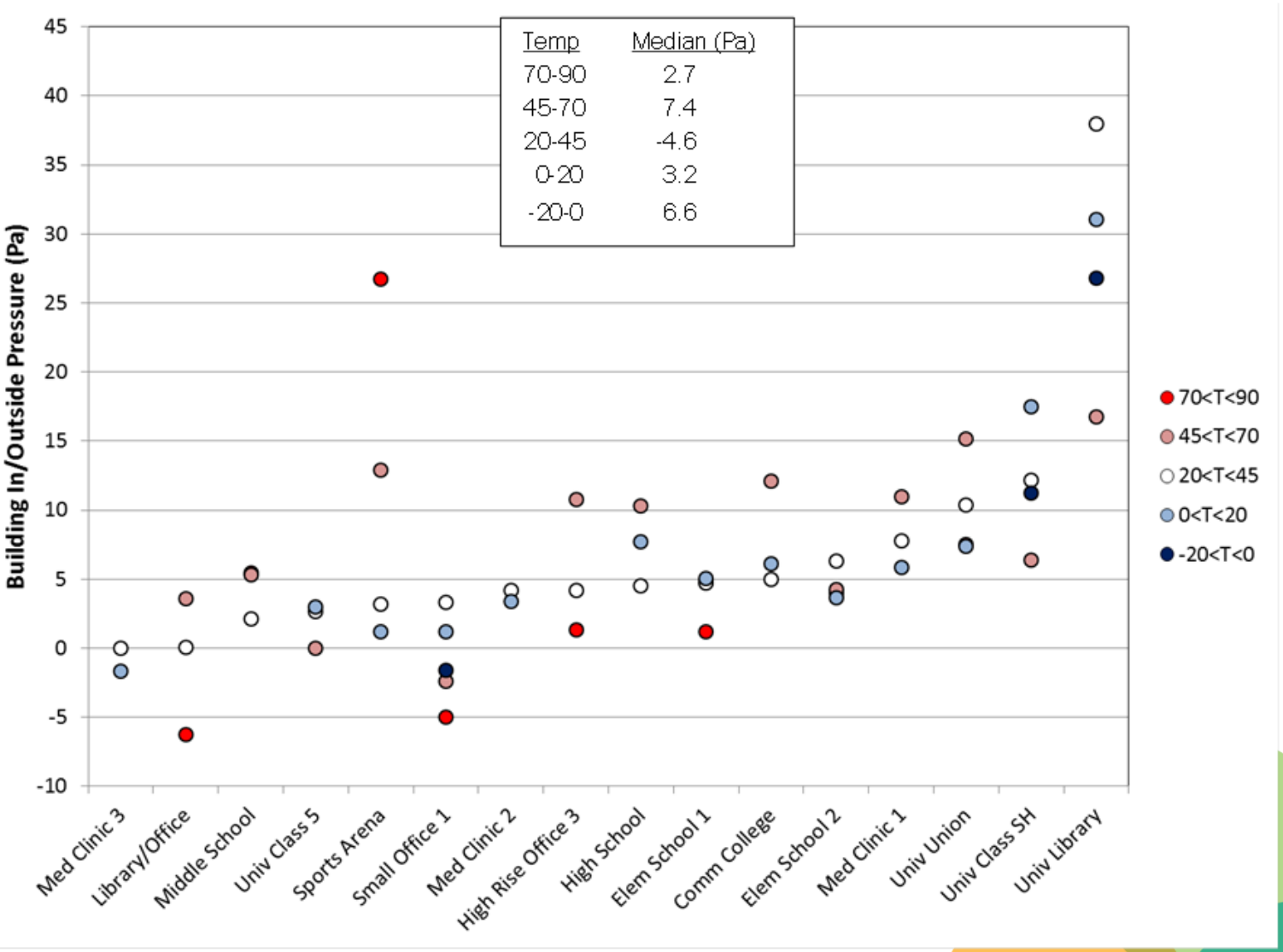
Site ID	Type	# stories	Const year	Floor Area (ft^2)	Outside Location	Building Ht. (ft)	Days Monitored
Univ Class 5	Inst	3	2008	66,783	Ground	52	8.5
Sports Arena	Inst	2	2000	142,951	Ground	25	47.7
Univ Union	Inst	2	1972	210,388	Ground	32.5	51.6
Univ Library	Inst	3	1967	246,365	Roof	40	96.9
Elem School 1	Inst	1	1951	59,558	Roof	21.5	88.8
Middle School	Inst	3	1936	138,887	Roof	36	40.2
High School	Inst	1	1976	289,909	Roof	28	12.3
Elem School 2	Inst	1	1965	60,000	Roof	18.25	48.6
Library/Office	Public	1	2007	55,407	Ground	21	129.0
Comm College	Public	2	1996	108,102	Roof	26	12.6
Univ Class SH	Inst	3	1948	177,951	Roof	36	41.1
High Rise Office 3	Office	23	1985	484,290	4th Floor	312	53.9
Med Clinic 1	Med	2	1960	47,805	Roof	26	32.2
Med Clinic 3	Med	4	1994	56,803	Roof	52	41.5
Med Clinic 2	Med	7	1968	268,408	Roof	78	44.0
Small Office 1	Office	1	1998	26,732	Ground	16.25	88.5

Building Pressure: HVAC OFF



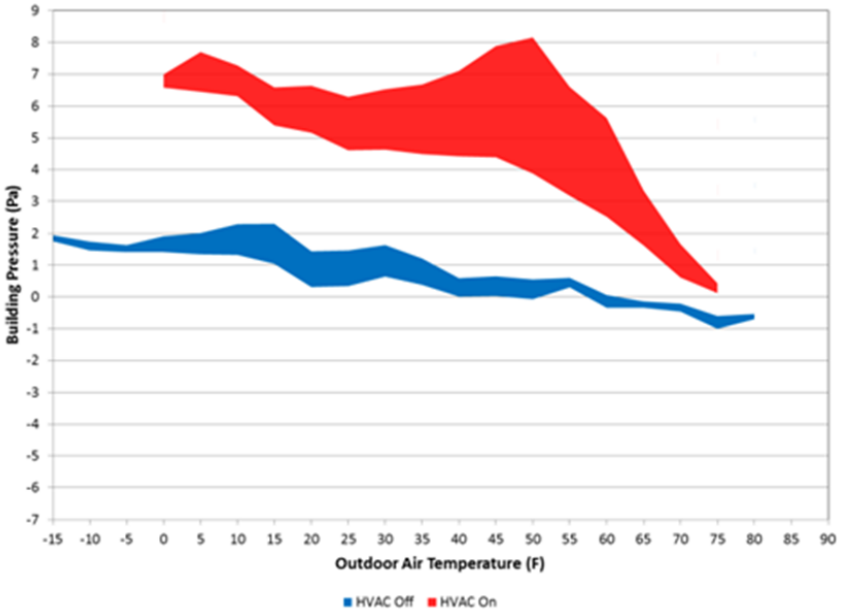
Building Pressure: HVAC ON



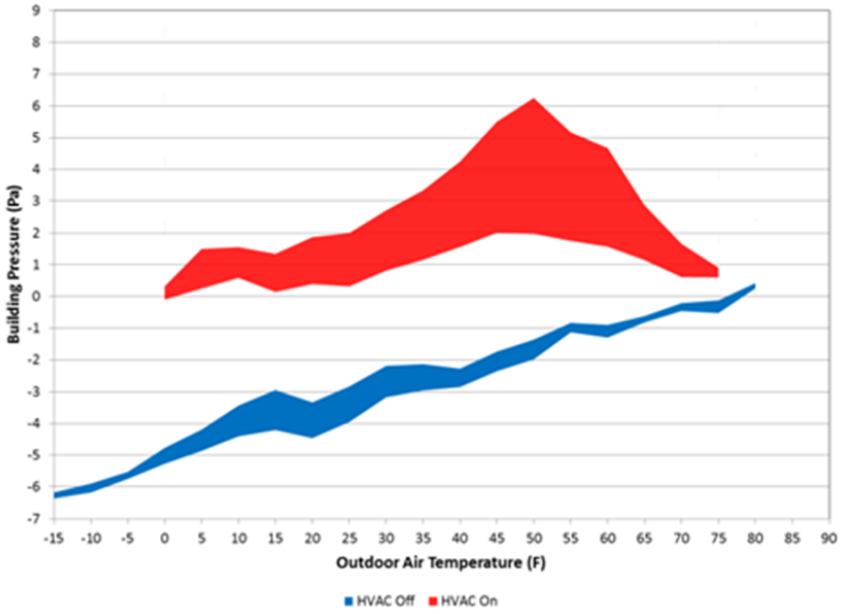

Temp
Median (Pa)
70-90 2.7
45-70 7.4
20-45 -4.6
0-20 3.2
-20-0 6.6
Building In/Outside Pressure (Pa)
45
40
35
30
25
20
15
10
5
0
-5
-10
Med Clinic 3
Library/Office
Middle School
Univ Class 5
Sports Arena
Small Office 1
Med Clinic 2
High Rise Office 3
High School
Elem School 1
Comm College
Elem School 2
Med Clinic 1
Univ Union
Univ Class SH
Univ Library
70<T<90
45<T<70
20<T<45
0<T<20
-20<T<0

Typical Pressure Distribution

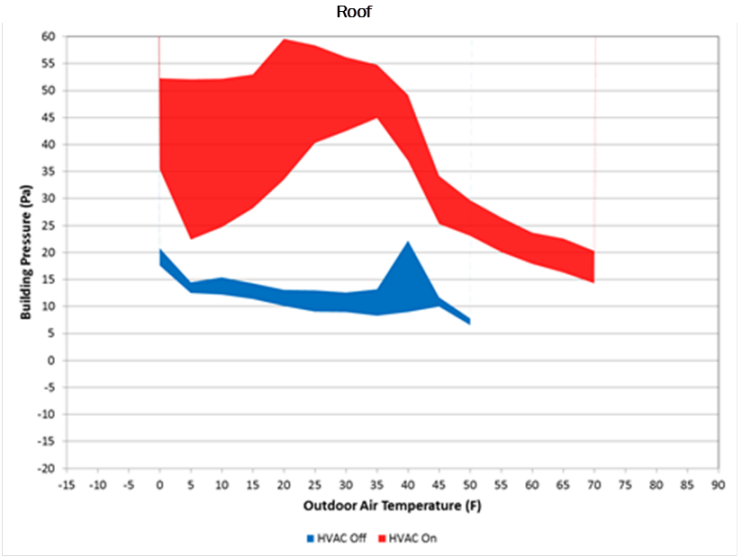
Roof

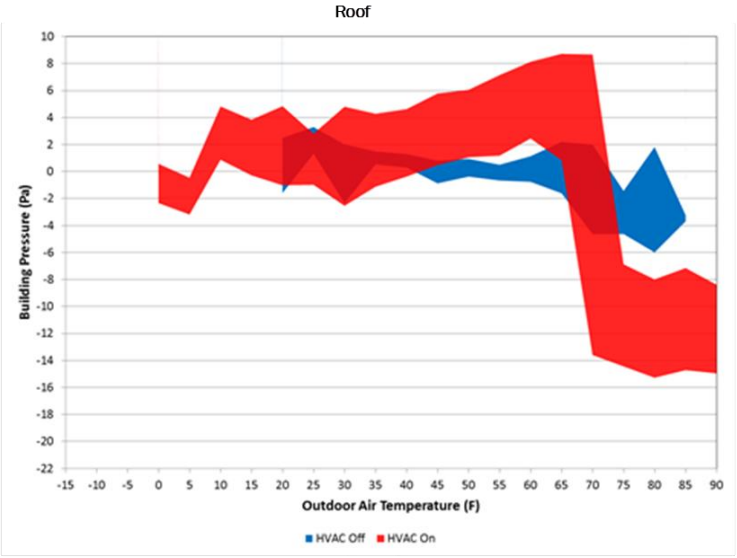


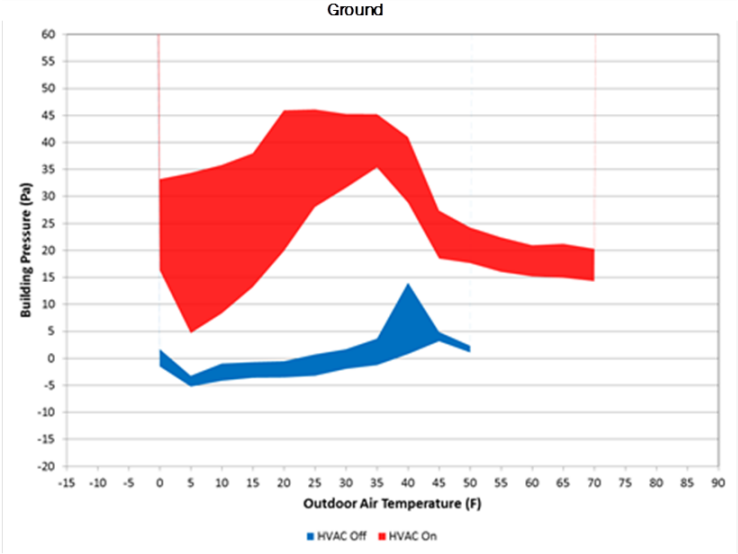
Ground

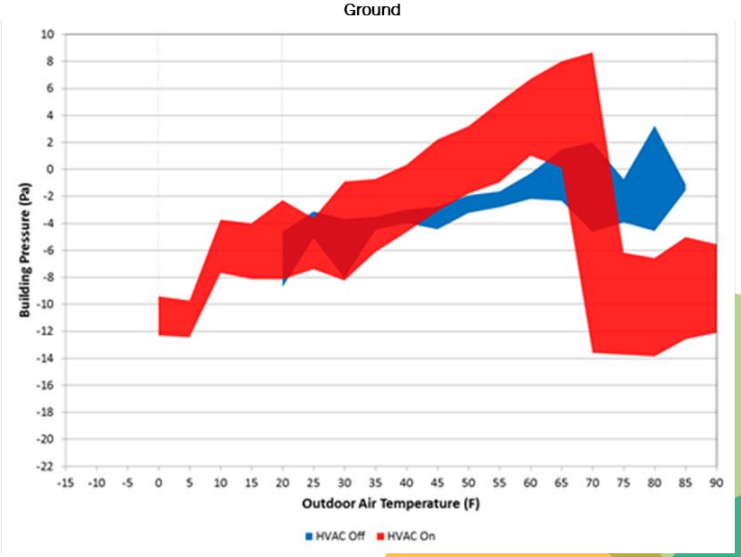


Consequences of HVAC operation



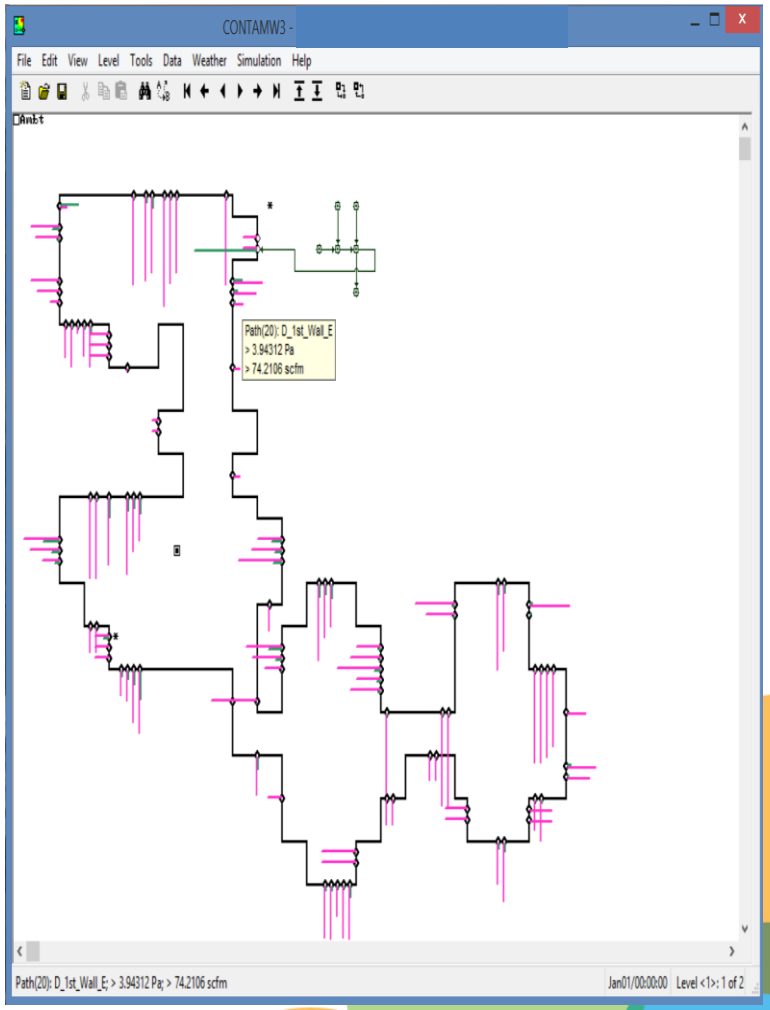


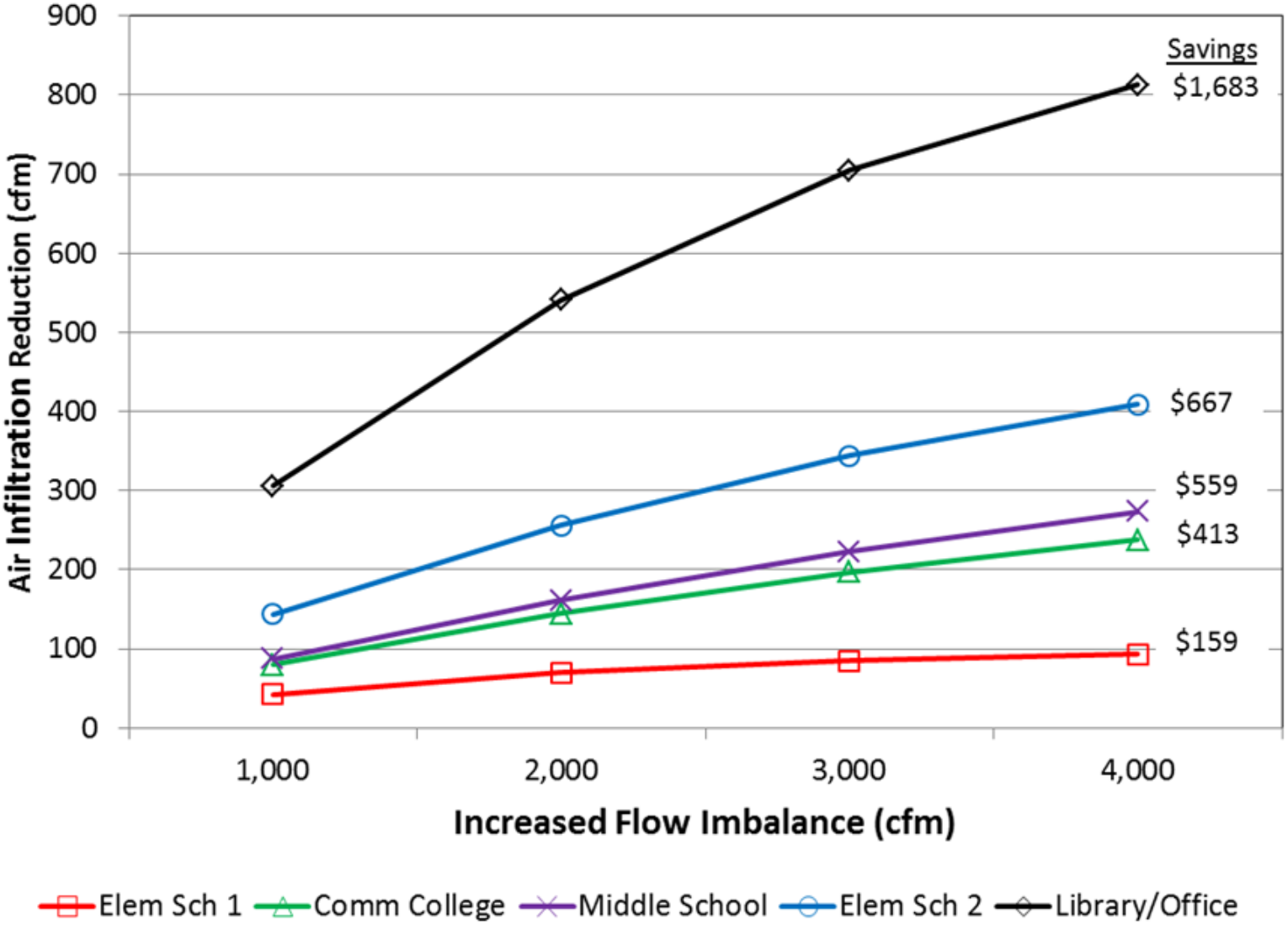




Air Infiltration and Energy Modeling

- CONTAMW model to evaluate the impact of HVAC imbalances on infiltration & loads
- Air leakage measurements for total leakage from all building exterior flow paths.
- Pressure measurements and physical dimensions to distribute the leakage
- Leaks were first distributed according to the location of exterior doors and mechanical systems
  - 1) Locate roof/wall interface leaks at building height
  - 2) Wall/window leaks distributed by wall area
  - Adjust vertical leakage distribution to match measured neutral pressure level with HVAC off
- Validated against measured building pressures




900
800
700
600
500
400
300
200
100
0
Air Infiltration Reduction (cfm)
Savings
$1,683
$667
$559
$413
$159
1,000
2,000
3,000
4,000
Increased Flow Imbalance (cfm)
Elem Sch 1
Comm College
Middle School
Elem Sch 2
Library/Office

Conclusions

- C&I HVAC system operation moderately pressurizes the building in both the heating and cooling seasons
  - Median average ground level pressure ranged from 4 Pa in warm weather to -10 Pa in cold weather
  - Only one of the 16 buildings consistently had one above recommended design
  - This is what you get with constant flow imbalance
- Short term measurements don't tell the picture
  - Seasonal variations in pressurization
  - Particularly susceptible to changing flows
- Modeling suggests simple reduction in relief air flow can improve pressurization and save $160 to $1,700 per year

Thanks!

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- More information, http://mncee.org