Energy Conservation Potential of Displacement Ventilation in Minnesota Climate Conditions

Minnesota Department of Commerce
Division of Energy Resources

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Outline

- Displacement Ventilation
  - Description
  - Research Motivation
- Technology Benchmark Analysis
  - Methodology
  - Results
- Market Acceptance and Understanding
- Summary

Displacement Ventilation

Characteristics

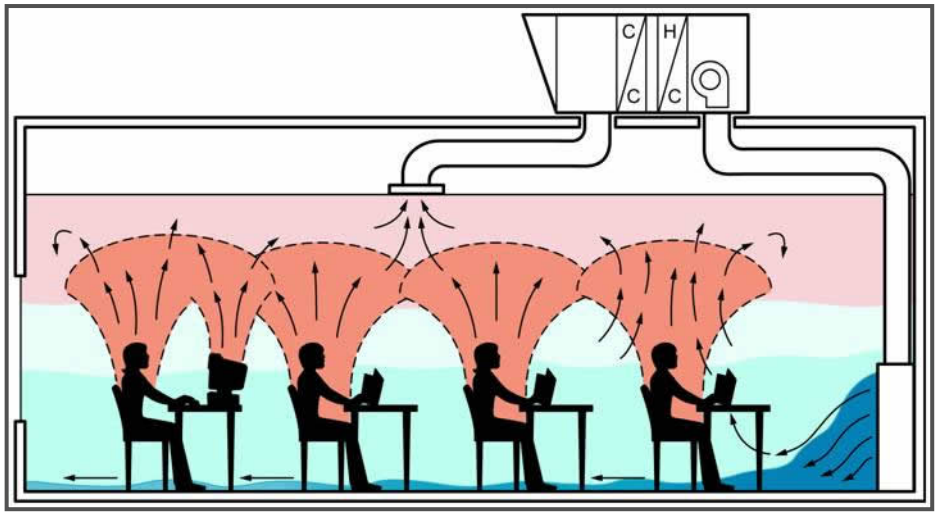
- Cool air (~65 °F)
- Low air speed < 0.5 ft/s
- Floor level
- Ventilation technology (not heating/cooling)
- Uncommon in US

Potential Benefits

- Improved air quality
- Fan energy savings
- Cooling savings
- Noise reduction

Appropriate for

- High ceilings (≥ 10 ft)
- Low activity (little air mixing)
- Examples: schools, offices, performance spaces



Energy Design Resources, 2010

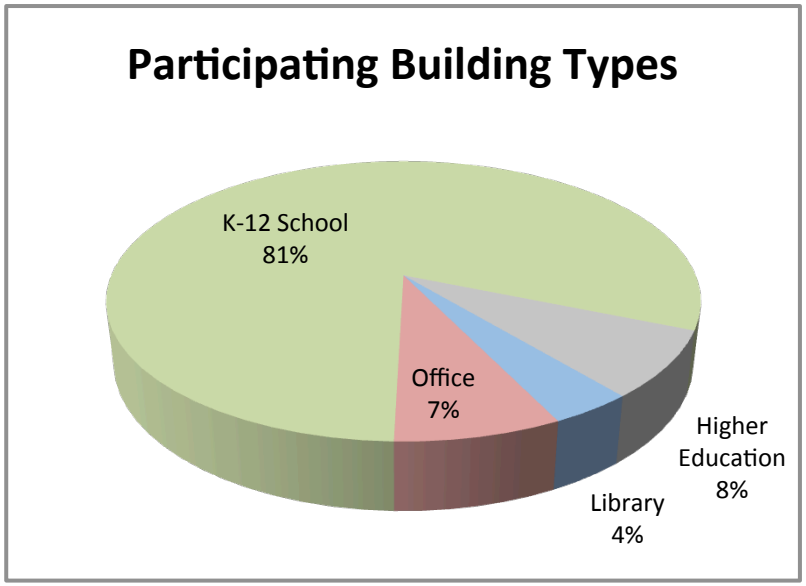
30-60% whole building energy savings (Bourassa et al. 2002)

Technology Benchmarking

- Enlist Building Owners
- Obtain Field Data
  - Energy Use
  - Building Characteristics
  - Owner Satisfaction Survey
- Adjust Energy Use for Additional ECMs
- Compare Data
  - National Benchmark (CBECS)
  - Other MN Buildings (B3 Benchmarking)

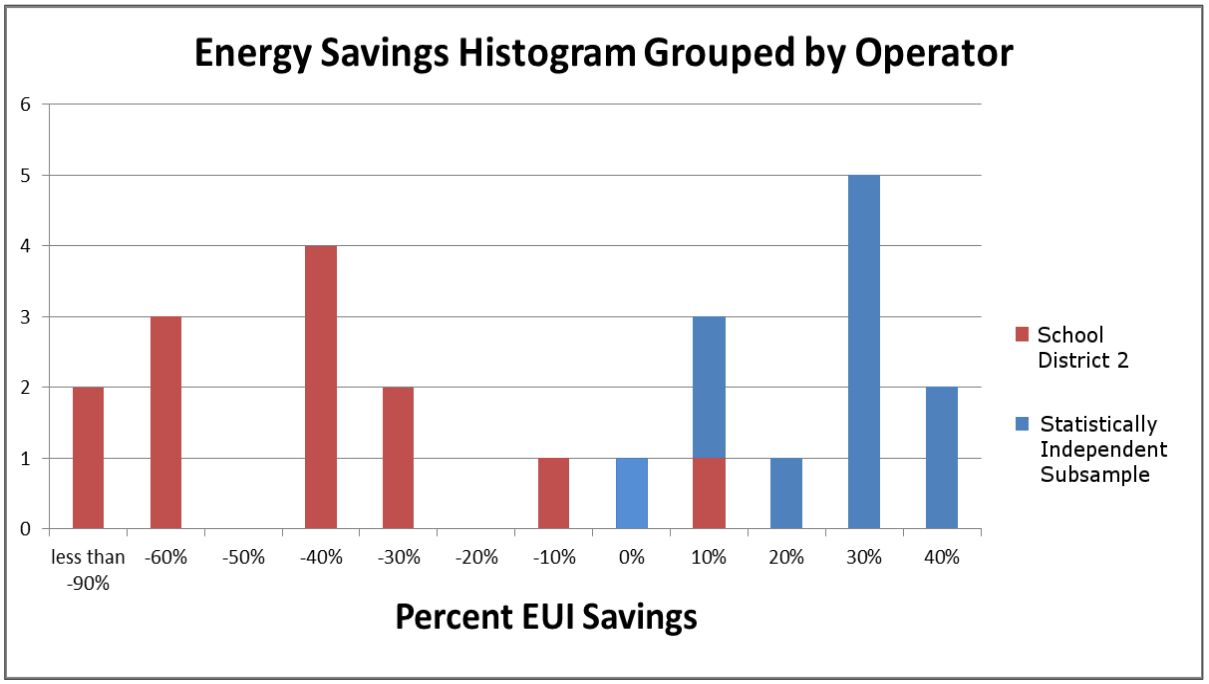
Building Sample

- 57 Candidate Buildings
  >7% were under floor systems (UFAD)
- 26 Completed Surveys Returned
- DV serves 86% of floor area (on avg.)



Energy Savings Variability

<0.1% chance that School District 2 data is representative of the general sample of DV-served buildings

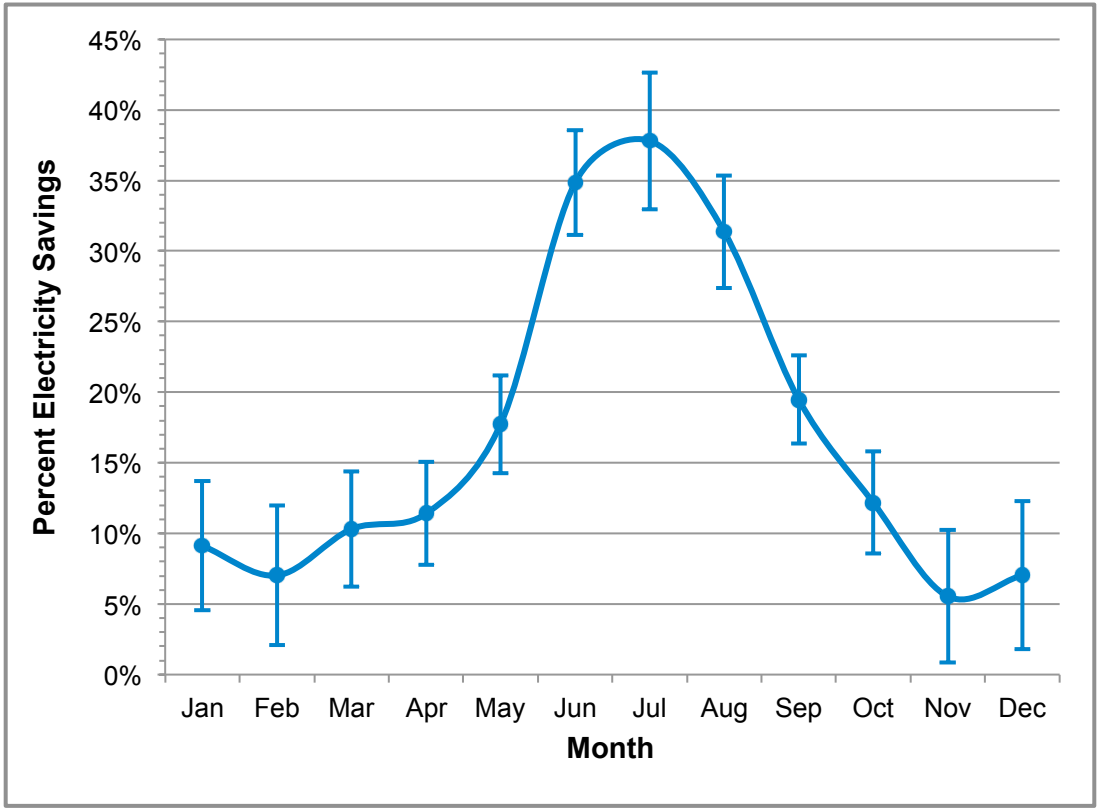


Underscores importance of design, operation

Monthly Energy Savings

School District 1

- 4 DV schools
- 36 non-DV schools
- 1-8 years utility data



Avg. annual electric savings 17±5%

Owner Satisfaction

5 Metrics Investigated

- Energy Performance
- Air Quality
- Occupant Comfort
- Operations
- Maintenance

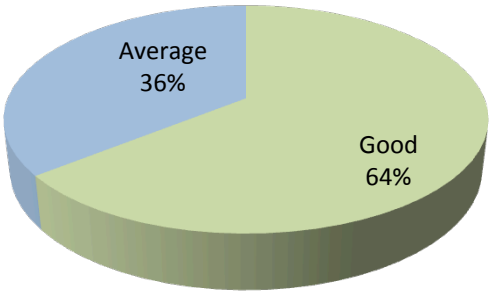
	USE TECHNOLOGY AGAIN		
	Spearman's Rho [r_s]	p-value	Correlation Strength
OCCUPANT COMFORT	0.79	6.8×10^{-4}	Very Strong, highly significant
MAINTENANCE	0.30	0.30	Moderate, less significant
ENERGY PERFORMANCE	0.24	0.41	Weak, barely significant
EASE OF OPERATION	0.24	0.41	Weak, barely significant
AIR QUALITY	0.23	0.41	Weak, barely significant

Findings

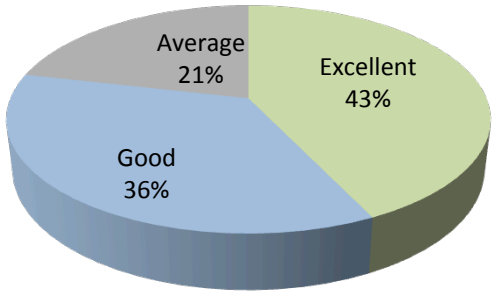
- Primary motivation for using DV is improved air quality (78.6%)
- Greater comfort observed in summer months
- Most owners would use again (correlated most strongly with perception of occupant comfort)

Owner Satisfaction (cont.)

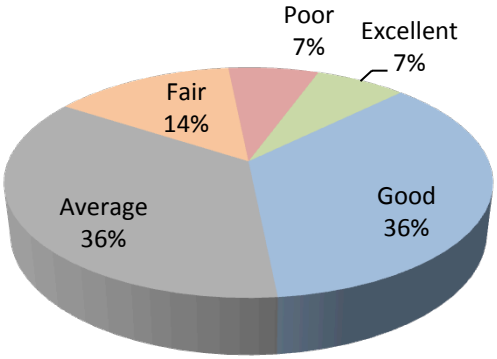
Energy Performance



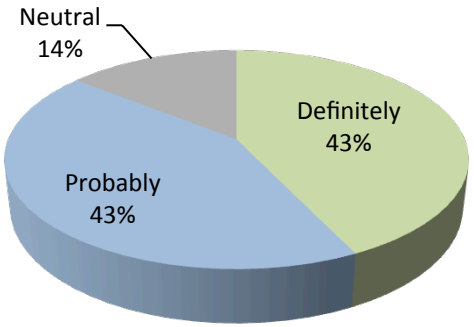
Occupant Comfort



Ease of Maintenance



Likelihood of Re-use



Technology Benchmarking Results Summary

Energy Savings

- Average annual EUI savings of 16 ± 4%
- Savings primarily achieved during summer months (cooling mode)
- Incorrect operation can jeopardize savings

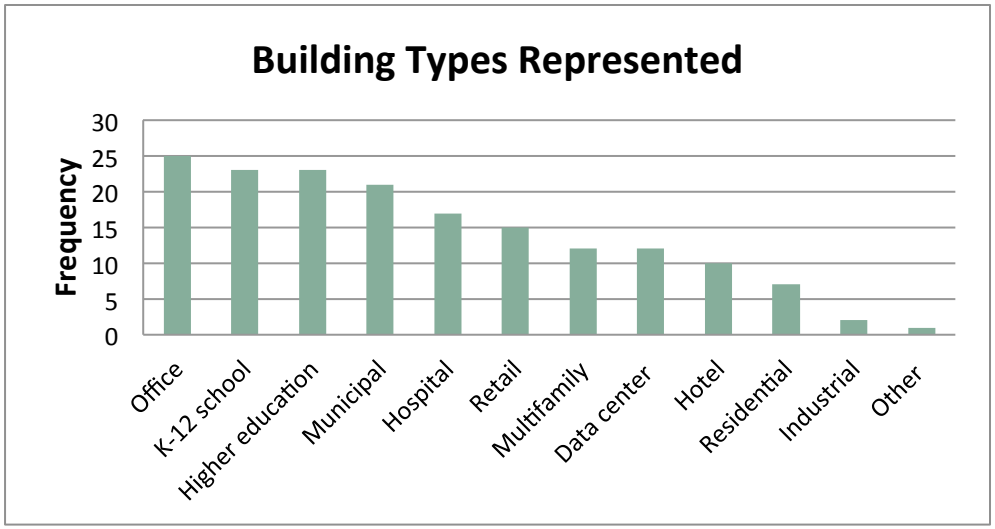
Owner Satisfaction

- Main reason cited for using DV is improved air quality
- Maintenance concerns are main source of any negative perceptions toward technology
- Most owners are satisfied and would use technology again

Market Acceptance

31 Professionals Surveyed

- Architects
- Commissioning Agents
- Energy Efficiency Consultants
- Mechanical Engineers
- Manufacturing Representatives



Demographics

Age 30-69 (average 50)
5-45 years experience
(average 24)
Project size 3,000-2,500,000 ft^2)
(average 200,000 ft^2)

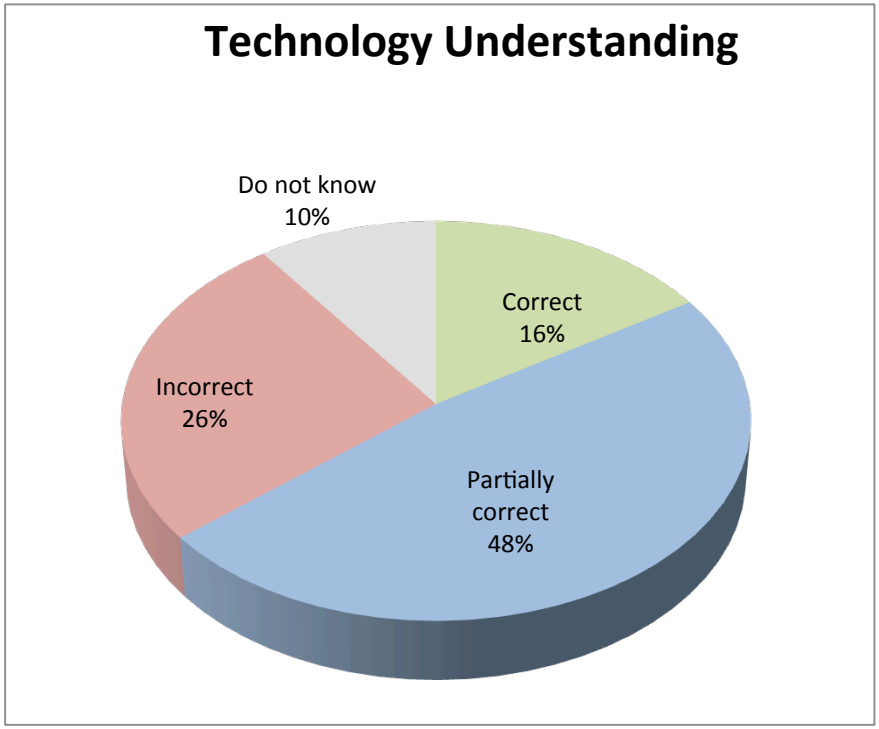
Represented Geographical Markets

PROJECT AREA	FREQUENCY
Duluth	2
Twin Cities	3
Other Minnesota	13
Other Midwest	7
Other National	5
Worldwide	1

Market Research Results

Familiarity / Understanding

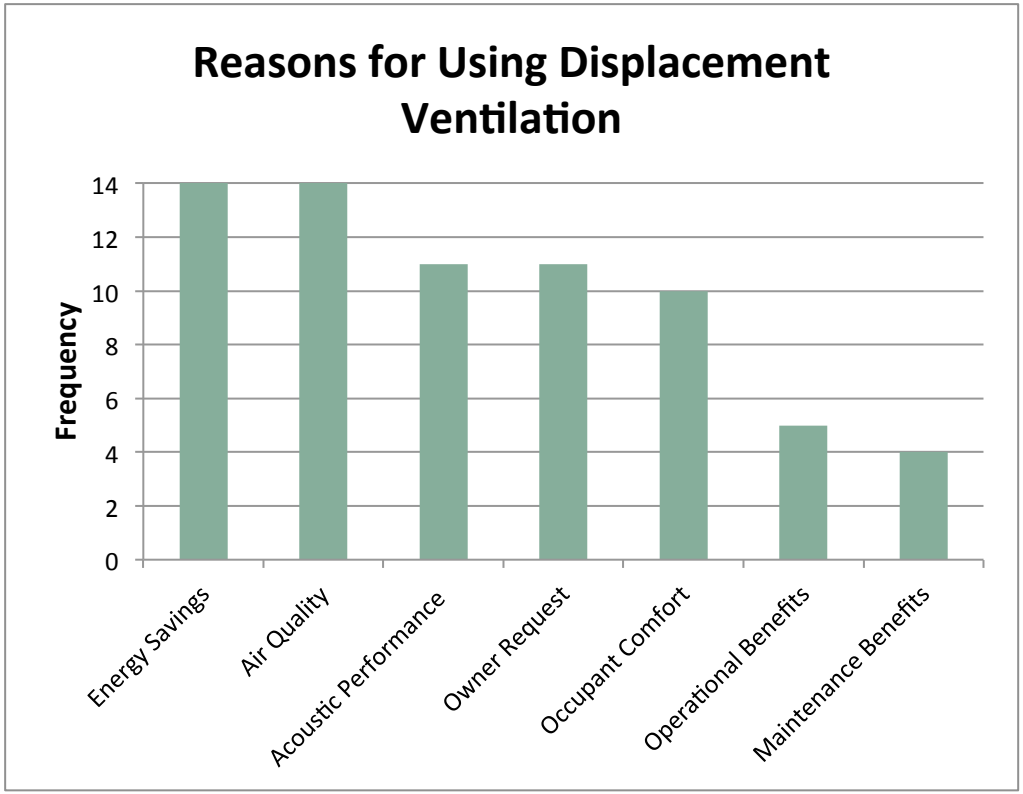
- "Somewhat familiar" (on average)
- 52% mentioned outside air
- One respondent indicated DV primarily for ventilation
- 10% made incorrect associations with heating



Market Research Results (Cont.)

Technology Use

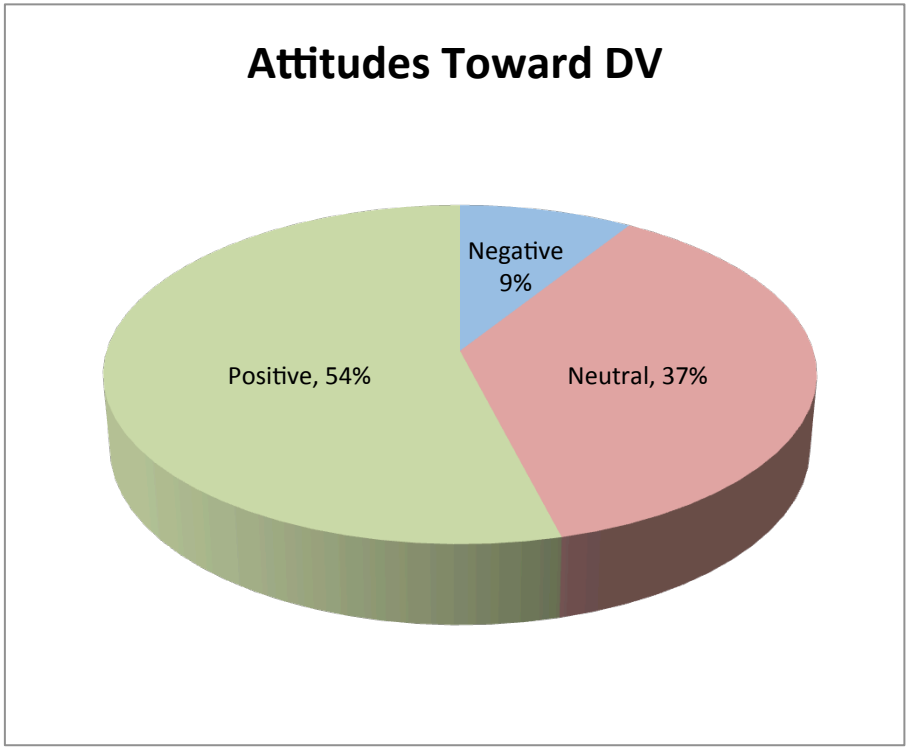
- 68% of respondents had used DV
- More than half described frequency of use as never or rarely
- Cost, lack of familiarity main reasons for non-use



Market Research Results (Cont.)

Attitudes toward DV

- 54% positively inclined
- Reasons: energy efficiency, air quality, acoustic performance
- Most frequent reason for negative inclination was lack of industry acceptance / market adoption



Market Research Results (Cont.)

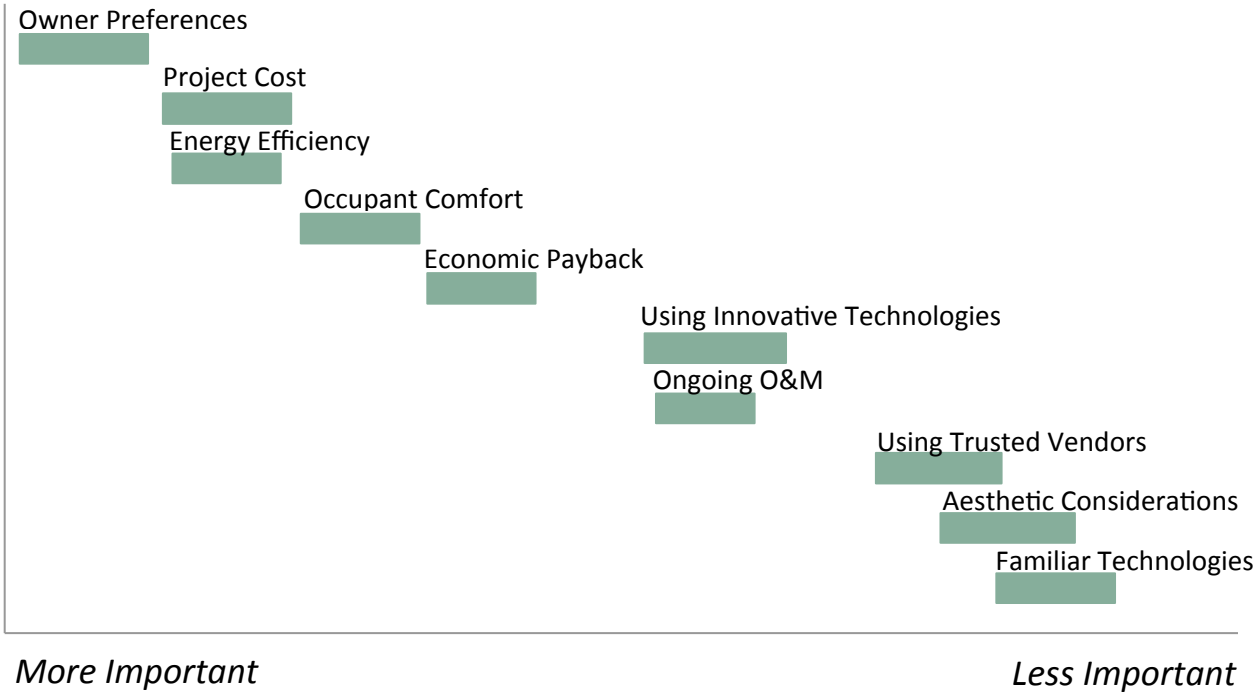
Perceived Characteristics

- Saves energy (84%)
- <10 year payback (74%)
- Costs more (54%)
- More difficult operation (56%)
- Architects (3/3) and energy engineers (3/4) “don’t know”
- Some ambivalence indicated

	OVERALL INCLINATION TOWARD DISPLACEMENT VENTILATION		
	Spearman’s Rho [r_s]	p-value	Correlation Strength
ENERGY USE	0.52	7.6×10^{-3}	Strong, significant
OPERATION	0.48	1.6×10^{-2}	Strong, significant
PAYBACK TIMESCALE	0.36	8.1×10^{-2}	Moderate, barely significant
MAINTENANCE	0.35	8.4×10^{-2}	Moderate, barely significant
COST	0.12	0.57	Very weak, insignificant
MAINTENANCE COST	0.06	0.77	Very weak, insignificant

Market Research Results (Cont.)

Project Influences



Owner preferences are the most influential factor reported

Market Research Results (Cont.)

Innovative Technology Comparison

- Innovative technologies widely used, positively associated
- Attitudes toward IT uncorrelated with attitudes toward DV
- Owner preference cited as reason for using IT by 58% of respondents – significantly more than DV

Lack of owner exposure to DV a barrier despite overall satisfaction of current owners

Summary

- Average annual EUI savings of 16 ± 4%, primarily achieved during summer months (cooling mode)
- Wide variation in achieved savings - incorrect design or operation?
- Despite general lack of exposure, most professionals had positive attitudes toward the technology
- Little market exposure and unfamiliarity with the technology are viewed as its greatest barriers
- Lack of owner exposure to DV a significant barrier despite overall satisfaction of current owners

Next Steps

- Investigate source of savings variations:
  - Design-related
  - Operation-related
- Identify optimal operation parameters
- Develop design and operational guides
- Disseminate to market