Building-Integrated Heat & Moisture Exchange

2014 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: **October, 2012**

Planned end date: **August, 2014**

Key Milestones

- Mid- & Full-scale Lab Tests; June, 2013
- Full-scale Demo; January, 2014
- System Documentation; July, 2014

Budget:

Total DOE $ to date: $1,037,812

Total future DOE $: $0 (committed to date)

Target Market/Audience:

Owners, developers, and operators of medium-large scale commercial, institutional & multi-use buildings in warm, humid climates.

Key Partners:

Lawrence Berkeley National Laboratory
dPoint Technologies, Inc.
Arup
ETH Zurich
Membrane Technology & Research, Inc.

Project Goal:

Design & demonstrate at increasing scales the energy benefits of large-scale, wall-integrated heat & moisture exchangers.

Characterize both the *ventilation* energy benefit as well as the *insulation* benefit of this *hybrid envelope/hvac technology*.

Purpose and Objectives

Problem Statement:

State-of-the-industry energy recovery ventilators (ERV's) offer low humidity exchange (ε_{latent} =0.45-0.65) with high attendant pressure penalties (200-350 Pa), resulting in low market penetration and limited impact.

Integrated ERV solutions could leverage multiple advantages to produce better a better ROI and reap more of the nearly 3 quads of potential US savings available annually.

Target Market and Audience:

The target market for AirFlow Panels™ includes developers, owners, and operators of commercial and multi-family residential buildings.

	Square Footage	Energy Savings Potential
New Construction	**108 B**	**0.72 Quads**
Renovation	**257 B**	**1.88 Quads**

2013 US Market Size *(maximum adoption potential)*

Purpose and Objectives

Impact of Project:

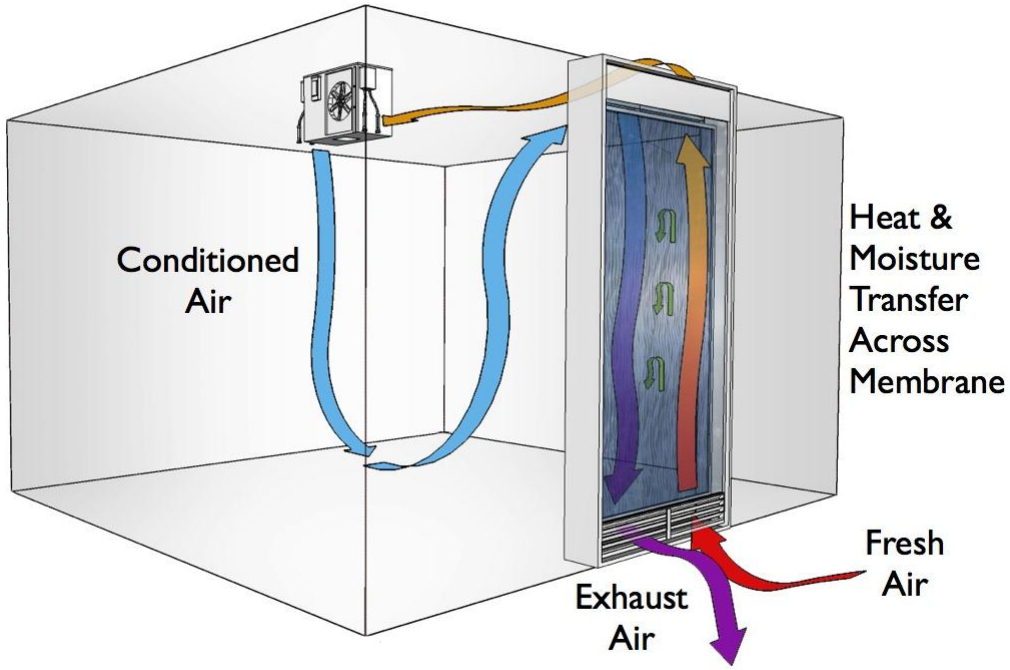
The key to achieving significant impact in energy savings is to overcome the resistance to adoption of ***decentralized outdoor air paths*** (as opposed to conventionally centralized) and ***combined*** **hvac and envelope functions** (as opposed to segregated).

Toward this goal, project deliverables include:

1. validated testing at various scales
2. operational installation demonstrating the benefits

Impact Trajectory

Approach



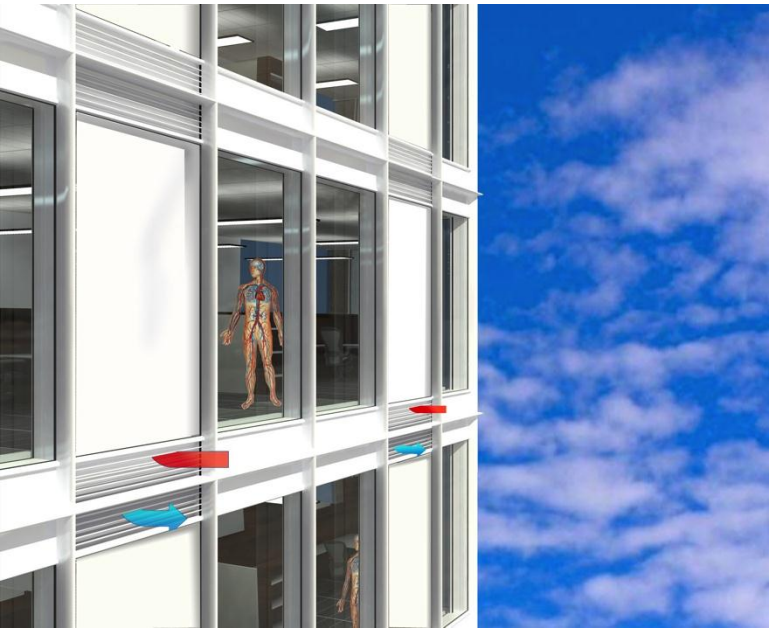
Approach:

The technology is a hybrid of two building system functions—HVAC and building envelope—integrated into a unified whole to achieve lower energy use at better economic returns.

Distinctive Characteristics:

- Large-scale air-air exchanger
- Polymeric membrane-based
- Higher transfer surface area
- Lower face velocity & pressure loss
- Manufactured in a panelized form
- Integrated into modular wall panels
- Simultaneous improvements to ventilation & envelope performance

Progress and Accomplishments



Key Issues:

I. Validating the coupled ventilation/envelope heat & moisture exchange

II. Assessing the feasibility of achieving theoretically predicted performance in practice.

III. Identifying and resolving pragmatic design & operation issues, including:

a. balance of system design
(e.g. fans, filters, dampers, etc.)
b. code/regulatory issues
(e.g. intake/outlet separation distances)
c. manufacturing methods
(e.g. cross-leakage, filer access, etc.)

Progress and Accomplishments

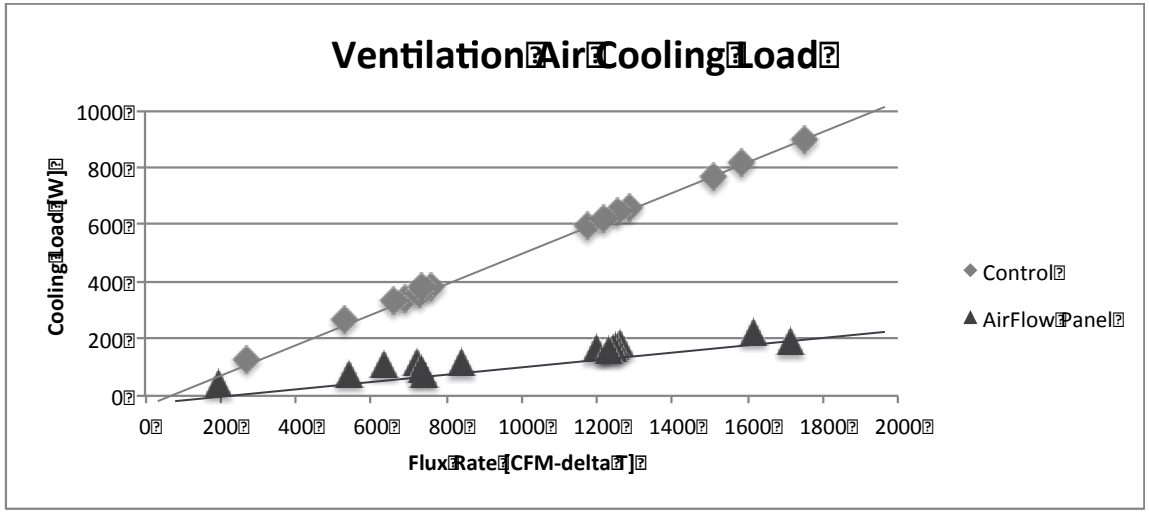
MILESTONE		PROPOSED		ACTUAL	
1 *Medium-scale laboratory test (Berkeley)*	**Dimensions**	3'-3" x 5'-3" x 3"		3'-0" x 4'-0" x 10"	
	AirFlow Rate	22 cfm		40-90 cfm	
	Supply Inlet	90 F	90% RH	66-89 F	88-97 %
	Exhaust Inlet	72 F	50% RH	54-58 F	54-85 %
	ε_{sens}	> 0.88		0.97-0.99	
	ε_{latent}	> 0.82		0.76-0.88	
	ΔP	< 80 Pa		53-113 Pa	
	Ueff	= 0.85 U_{actual}		0.75-1.1 U_{actual}	

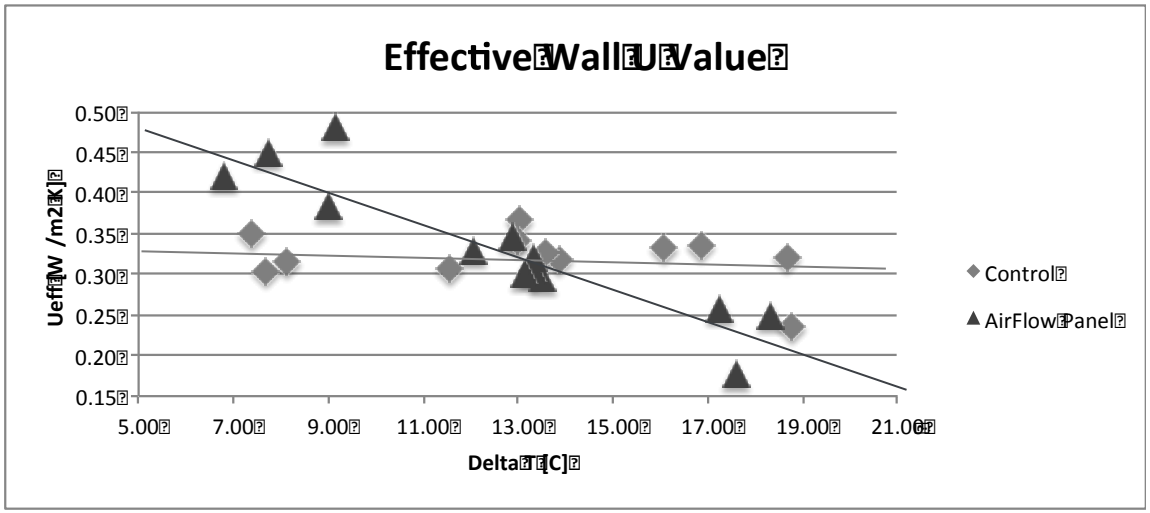
2 *Full-scale laboratory test (Berkeley)*	**Dimensions**	3'-3" x 5'-3" x 3"		5'-3" x 6'-6" x 3"
	AirFlow Rate	22-44 cfm		***Data measurements complete (April, 2014) Data Analyss in process.***
	Supply Inlet	90 F	90% RH	
	Exhaust Inlet	72 F	50% RH	
	ε_{sens}	> 0.88		
	ε_{latent}	> 0.82		
	ΔP	< 80 Pa		
	Ueff	= 0.85 U_{actual}		

3 *Full-scale operational demonstration (Singapore)*	**Dimensions**	3'-3" x 12'-0" x 3"		5'-3" x 12'-0" x 3"
	AirFlow Rate	22-44 cfm		***Data measurements in progress.***
	Supply Inlet	90 F	90% RH	
	Exhaust Inlet	72 F	50% RH	
	Fan Energy Reduction	> 0.88		
	Cooling Energy Reduction	> 0.82		

Progress and Accomplishments

Accomplishments: MILESTONE 1





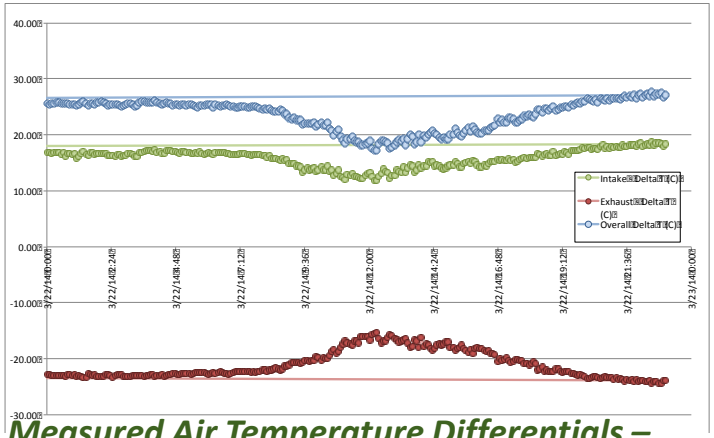
Medium-scale Lab Test

Measured Performance:

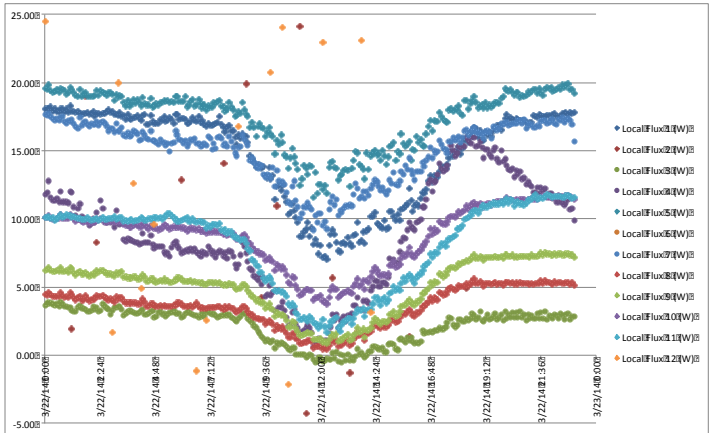
- $0.76 < \varepsilon_{latent} < 0.88$
- $53 < \Delta P < 113$ Pa
- U_{eff} improved 4-25% when $\Delta T > 12$ C

Progress and Accomplishments

Accomplishments: MILESTONE 2 Full-scale Lab Test



Measured Air Temperature Differentials – *currently processing raw data*



Measured Envelope Temperature Differentials – *currently processing raw data*

Progress and Accomplishments

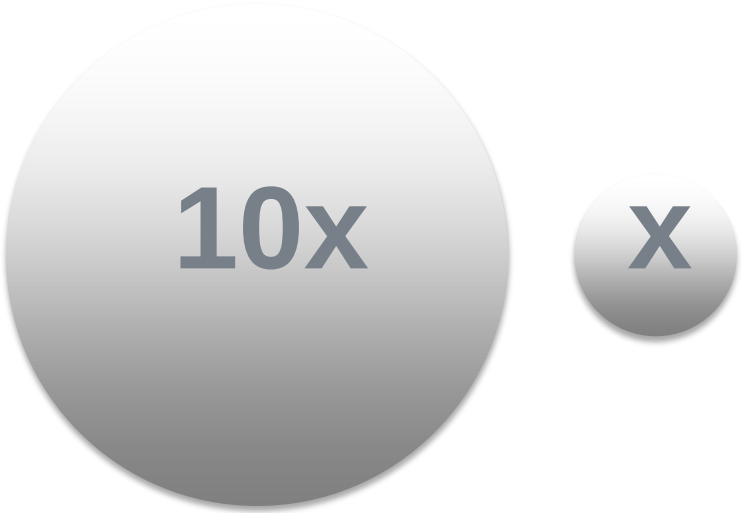
Accomplishments: MILESTONE 3

Full-scale Demonstration

ETH Zurich, Singapore–
currently collecting raw data

Progress and Accomplishments

Accomplishments: COMMERCIALIZATION

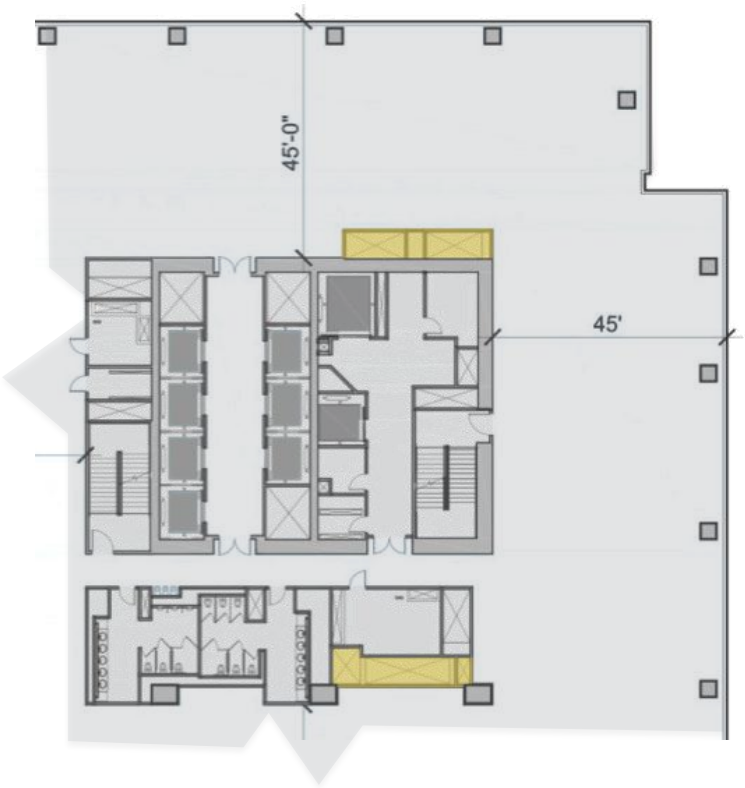


Conventional Air Con
[high condensation

AirFlow Panels ™
[low condensation]

Indoor Concentration of Airborne Mold

Source: Harvard School of Public Health, 2001



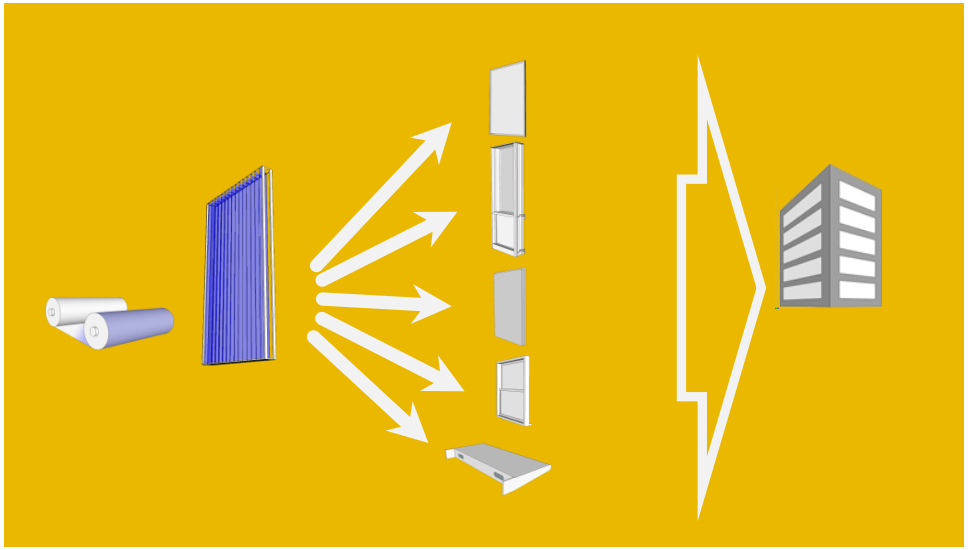
[1,000m² in 45-floor office]

Increased Leasable Floor Area

Source: Hudson Yards, New York

Progress and Accomplishments

Accomplishments: COMMERCIALIZATION

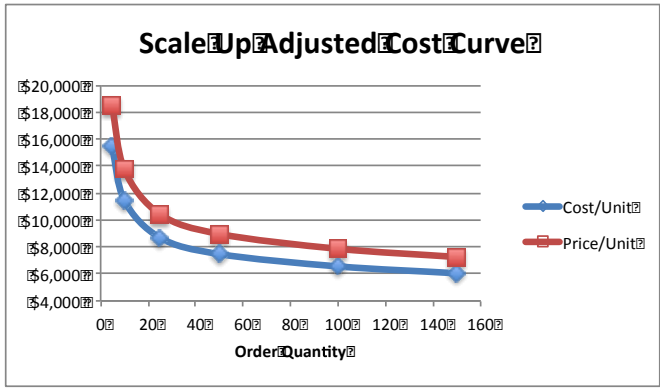


Pilot-scale Manufacturing Plan :

- bills of materials
- labor
- equipment
- cost targets

for manufacturing 5-100 units.

ORDER QUANITITY:	START-UP	PER ORDER	FIXED/MONTH	VARIABLE/UNIT
LABOR	$ 9,415	$ 8,209	$ 3,377	$ 406
MATERIAL	N/A	N/A	N/A	$ 8,667
EQUIPMENT	$ 4,618	N/A	N/A	N/A
OVERHEAD	$ 3,450	N/A	$ 2,841	N/A
TOTAL	$ 17,483	$ 8,209	$ 6,218	$ 9,073



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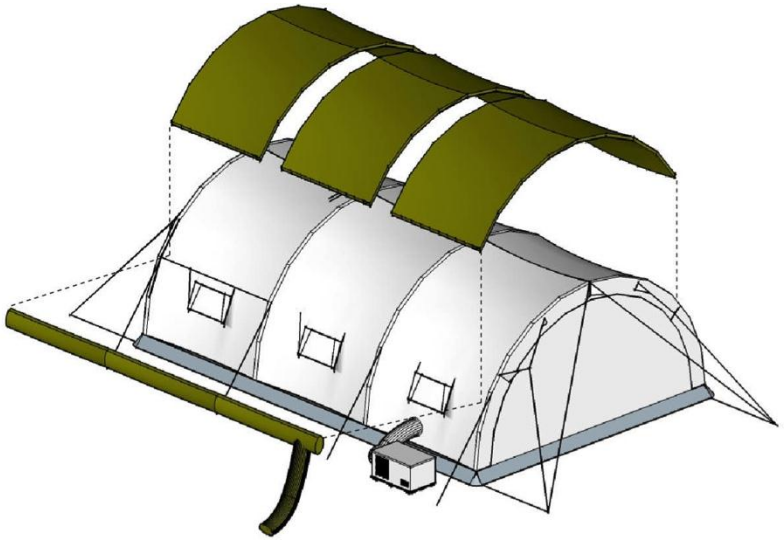
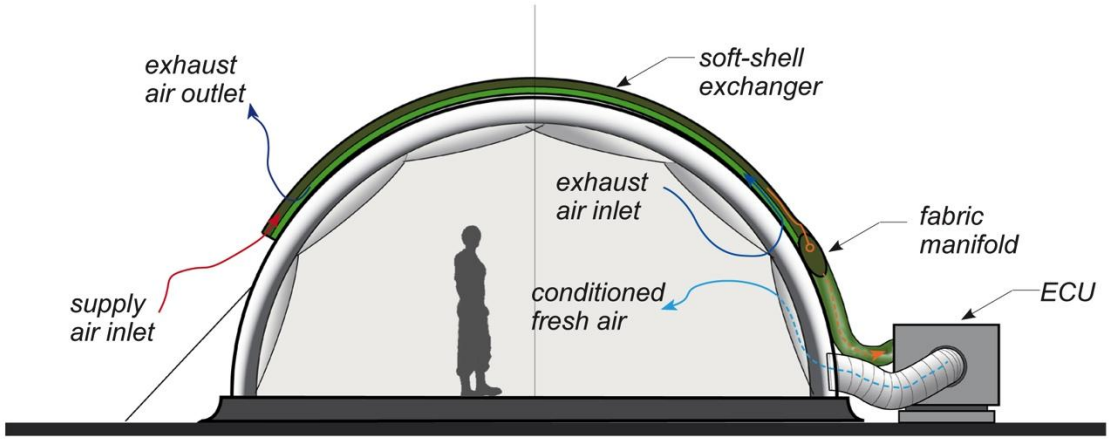
Progress and Accomplishments

Accomplishments: SPIN-OFF PRODUCT





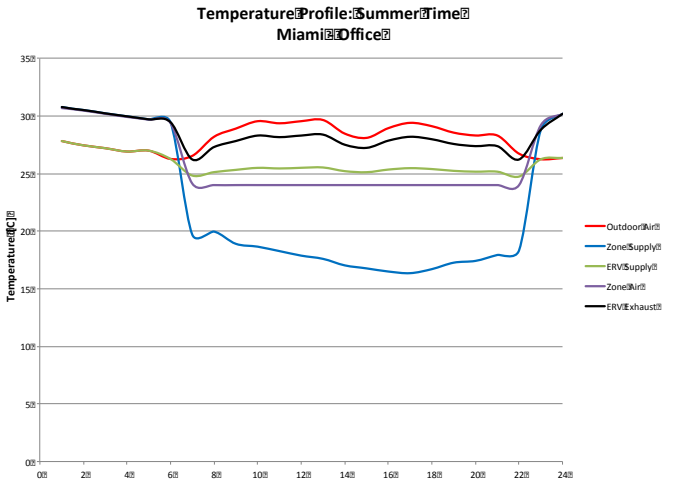
Progress and Accomplishments

Market Impact:

Projected annual savings [KWh/m² (% below baseline)

Zone	City	Office	School	Hospital	Residence
1	Miami	25.12 *22.4%*	55.03 *38.0%*	89.26 *27.5%*	26.24 *15.6%*
2	Atlanta	32.37 *27.7%*	58.46 *42.8%*	94.12 *32.1%*	47.84 *20.0%*
4	DC	37.38 *24.3%*	74.76 *41.1%*	128.28 *36.0%*	49.04 *14.4%*
7	Minneapolis	39.84 *31.0%*	91.81 *50.1%*	167.76 *48.5%*	54.2 *16.0%*

Potential Annual US Savings = 2.72 Quads



EnergyPlus simulation output

4 pilot installation discussions

strategic industry partner discussions

near term

manuf. study built into supply chain

sales partnership discussions

intermediate term

international sales partnership

scale up manuf.

long term

Impact Trajectory

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Project Integration and Collaboration

Project Integration:

- work with advanced building design teams (e.g. Rocky Mountain Inst.)
- collaborate with major building component manufacturers (confidential)
- participate in industry & regulatory road-mapping/planning
- Present in major industry forums (e.g. International Green Building Conf.)

Partners, Subcontractors, and Collaborators:

STTR Research Partner:

Lawrence Berkeley National Laboratory

- Theoretical Support
- Testing & Validation Lead
- Whole Building Simulation

Consultants:

dPoint Technologies

- Membrane Engineering

ARUP

- Envelope Engineering
- HVAC Engineering

Portland Ten

- Commercialization

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Next Steps and Future Plans

Communications:

- *Façade Tectonics Conference*, University of Southern California, 2011
- *International Green Building Conference*, Singapore, 2012
- *Eco-Expo Asia*, Hong Kong, 2012

Awards/Recognition:

- NOVA/Saint-Gobain Innovation Competition-*finalist*, 2012
- Defense Energy Technology Challenge-*finalist*, 2012
- Asia Pacific Clean Energy Challenge, *finalist*, 2012

Next Steps and Future Plans:

- Pilot project installations (goal = 3 installs in the coming year)
- Build sales pipeline
- Develop low-cost/high performance manufacturing methods
- Execute manufacturing strategy (2013 pilot study forms the basis)

REFERENCE SLIDES

Project Budget

		DOE	Cost Share
Project Budget:	Total:	$1,037,812	$202,120
	STTR Ph.1:	$ 99,979	$ 0
	STTR Ph.2:	$ 937,833	$202,120

Variances: STTR Ph. 2 Budget Period 1 (first year) was re-budgeted due to membrane manufacturing costs incurred earlier than anticipated.

Cost to Date: DOE: $907,900 (87%) Cost Share: $232,700 (115%)

Additional Funding: Currently sought (US DoD, US DOE, private investment, sales)

Budget History

FY2013-October 15, 2013 (past)		FY2014-October 15, 2013 (current)		FY2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$562,407	$140,393	$475,405	$92,307	tbd	tbd

Project Plan and Schedule

7 Quarter (21 month) Project Currently Funded
"GO" Decision Made at Quarter 4

Milestones:

1. Medium-scale prototype – 2-month delay due to design/fabrication complications
2. Large-scale prototype – 3-month delay in membrane care fabrication
3. Full-scale demonstration – 5 months early due to host site schedule coordination
4. System documentation – Ongoing development/refinement throughout project.