2018 Advanced ASHP Workshop Summary Report

UC Davis – Western Cooling Efficiency Center – December 6-7th, 2018

Christopher Dymond – Northwest Energy Efficiency Alliance
Dave Lis – Northeast Energy Efficiency Partnerships
Ian Blanding – Midwest Energy Efficiency Alliance

This report describes a workshop of utility and decarbonization NGO's that gathered at UC Davis to share knowledge about what we know about ASHPs, their future potential and begin collaborating on getting the products we need into the market over the next 5-12 years. Special thanks to the folks at the UC Davis' Western Cooling Energy Efficiency Center, Dr. Reinhard Radermacher and the Sacramento Municipal Utility District for their support of this workshop.

Contents

Event Summary

Over thirty organizations attended the event, representing utilities and NGOs (see attendance list) with representation from all parts of US and Canada. The primary goal of the event was to establish a coordinated effort to advance performance, metrics and data collection that form the basis of utility and decarbonization activities on heat pumps. The 1½ day event was source fuel agnostic, though given the limited current available natural gas driven heat pumps much of the discussion focused on the near term prospects for electrically driven air source heat pumps. The outcomes were as follows:

- Attendees are familiar with what others are doing and what is possible
- Agreement on what is needed to make a business case for improved metrics and testing
- Draft a "roadmap specification[2]" that defines the key elements desired in an advanced ASHP
- Commitment to collaboration on lab and field testing activities and specification development
- Process for coordinating activity going forward

The event began with a keynote presentation by Dr. Reinhard Radermacher of the University of Maryland one the technological improvements and potential for this technology and the potential as one of the top 3 solutions (electric vehicles, renewable generation, and heat pumps) to decarbonize our energy sources. Four subsequent presentations covered what is known about current heat pump performance, metrics and practical application for space heating and cooling in a variety of climates. These presentations provided solid context that our current ability to predict the energy savings potential of air source heat pumps is poorly represented by the AHRI 210/240 test procedure for SEER and HSPF.

During the remainder of the workshop attendees participated in a series of "World Café" exercises and breakouts that crafted vision and understanding of what utilities and decarbonization efforts needed from heat pumps in the 5-12 year horizon. This was then used to define the market and technology challenges that need to be overcome for these visons to become reality. During the final sessions attendees defined 4 focus areas. Committees were formed for each focus area where the top priorities, tasks, timelines, and dependencies were identified and placed in a summary table.

Feedback from attendees was very positive. People expressed a much better understanding of what is possible, current limitations of existing metrics, and a general agreement to continue collaborating on tasks through the committees. The next step opportunity where many of the participants will be gathering is at the 2019 Renewable Heating and Cooling Workshop hosted by NEEP in late May. A Dropbox™ location has been setup by NEEA where the interested can find copies of presentations given and the supporting documents.

Next Steps

No formalized structure was established, but genuine interest was expressed to form some kind of coalition or establish a "heat pump association" that can serve as a host for the collective collaboration needed. For the present, anyone who expressed interest in promoting better metrics, working with manufacturers on a 5-12 year roadmap specification and assisting with field and lab testing are now part of a loosely defined "**Advanced ASHP Coalition**".

Each of the four committee's agreed to continue collaborative coordination by hosting occasional conference calls in support of continue collaboration. The following are venues where some of the people involved hope to convene formal or informal meetings.

1. AHR Expo 2019 – Atlanta January 14th
2. NEEP Renewable Heating and Cooling Workshop - TBD
3. CEE Summer Workshop – TBD

Committees

Four different committees were established to pursue collaboration and provide guidance toward the overall goal. While there was a strong recognition that these focus areas were not sufficient to address all issues, it was agreed these 4 focus were the simplest structure for future collaboration on the broader overall goal of advancing real world performance and acceptance of air source heat pumps. The four committees and their volunteer members are shown below with names in **bold yellow** agreed to be committee co-leads.

Committee Members

Accurate Test Procedure	Equipment Roadmap Spec	Design & Install Spec	Consumer & Installer Understanding
Christopher Dymond	Jerine ahmed	**Mark Alatorre**	**Suzi Asmus**
Gary Hamer	Mark Alatorre	Suzi Asmus	Andrew Belden
Bruce Harley	Nick Dunfee	Mark Baines	Nick Dunfee
Marshall Hunt	**Christopher Dymond**	Andrew Belden	Todd Greenwell
David Lis	Todd Greenwell	Nick Dunfee	Owen Howlett
Joanna Mauer	Gary Hamer	Christopher Dymond	David Lis
Mark Modera	Bruce Harley	Bruce Harley	Cheryn Metzger
Jonathan Moscatello	Randall Higa	**Bruce Manclark**	Jonathan Moscatello
Reinhard Radermacher	**David Lis**	Cheryn Metzger	Brenda Pike
Mvuala Suami	Cheryn Metzger	Mark Modera	David Poderson
	Jonathan Moscatello		Arun Vedhathiri
	Chris Perry		David Poderson
	Reinhard Radermacher		Andrea Salazar
	Andrea Salazar		
	Mvuala Suami		
	Robert Weber		
	Jay Stien		

Summary Pages

Each groups established a leader, defined the end state vision, and identify top priority tasks, sub-tasks, and leads. The following 4 pages contain the contents of these initial collaborative meetings, the spreadsheet that contains these tasks, and committee member contacts and details can be found in the NEEA **Advanced ASHP Coalition** dropbox™.

Accurate Test Procedure

Problem	Existing Tests do not characterize cold weather performance, part load and variable capacity benefits of VCHPs						**Members**
Vision	In 5 years, CSA EXP07 is adopted and broadly used by insustry (regulators, mfrs, utility programs, cities						Christopher Dymond
Lead(s)	Muuala Suami						Gary Hamer
Key Challenges	Getting critical buy-in from market influencers (NRCan, CEC, ResNet, Hot2000, EE Program Mgrs)						Bruce Harley
							Marshall Hunt
Task	Subtasks	Start	End	Leader	Contributors	Notes	David Lis
Validate Test Procedure to field performance	Indetify min M&V spec for gathering central collection, anonamous data, etc.	Q1 2019		NEEA	BC Hydro	Bruce Wilcox, Ecotope, Frontier (Hugh Henerson)	Joanna Mauer Mark Modera Jonathan Moscatello
Secure Funds for Testing EXP07	create funding mechanism	Now			NRCan, CEC, IOU, MOU, NEEA, SMUD, LADWP		Reinhard Radermacher
Testing to Characterize 3Rs	Expand Lab Sites	Now		Cdymond		Will Firmware updates will not affect performance negatively	Mvuala Suami
- Repeatability	Round Robing testing	Ongoing				What equipment should be tested	
- Reproduceability	Compile and Analyze Data			Bharley		Involve Purdue, U.Maryland, UL Plano, EPRI, ATS	
Develop Value Proposition	Draft Value Prop						
- Manfuacturer	Outreach to Title 24, Resnet						
- Utility / EE Orgs	1:1 Meetings with Mfr			Cdymond			
- Codes & Standards	Devel ?? From test results			Bharley			
AEDM Process Application (alternative efficiency determination method)	Generic Tstat selection spec for non-proprietary control						
Other Notes							
1	Current EXP-07 test takes about 1-week to complete heat and cool testing and costs ~$30k ---- this could come down to $20k, but will not likely reach the ~$7k of the current HSPF + SEER testing						

Equipment Roadmap Spec

Problem	Imperfect and inconsistent specifications used by programs fail to effectively motivate manufacture's product development toward low energy/carbon solutions	**Members**
Vision	In 5 years, programs will broadly promote a consistent spect driving accelerated adoption of "high performing" ASHPs - target audience = manufactuers	Jerine ahmed
Lead(s)	Dave Lis & Christopher Dymond	Mark Alatorre
Key Challenges	Getting commitment from 1-3 key manufacturers that see this value and agree to collaborate	Nick Dunfee
		Christopher Dymond
		Todd Greenwell

Task	Subtasks	Start	End	Leader	Contributors	Notes	
Define Value Propositions	Draft VP	Jan-19					Gary Hamer
- Programs							Bruce Harley
- Manufactuers							Randall Higa
- Contractors							David Lis
- Customers							Cheryn Metzger
Test Value Props							Jonathan Moscatello
Meet with Manufacturers	Invitations			Cdymond			Chris Perry
	Initial Pitch	AHR Expo 19					Reinhard Radermacher
	Indentify enthusiastic						Andrea Salazar
	Go meet with them						Mvuala Suami
	Get feedback						Robert Weber
Define Elements of Specs		Q1 2019	Q1 2020	Cdymond	CEE		Jay Stien
- Data Reporting Needs					Manufacturers		
- Integrated Contols							
- Performance tiers							
- Product features							
Get Programs to adopt specifiations					CEE		

Other Notes	
1	

Design & Install Spec

Problem	Insufficient Undertanding of system design and best practices results in poor performacne and inadequate customer experience	**Members**
Vision	By 2020 a set of criteria and best practice guidelines for HVAC solutions are widely used that ensure 1) energy efficient, 2) grid supportive (alonetic) 3) application ap	Mark Alatorre
Lead(s)	Mark Alatorre, Bruce Manclark	Suzi Asmus
Key Challenges		Mark Baines
		Andrew Belden

Task	Subtasks	Start	End	Leader	Contributors	Notes	Nick Dunfee
Create Decision Tree	Decide Branches					check in early with manufacturers	Christopher Dymond
	branch order, climate,						Bruce Harley
Design use Cases	Prodcut					Use locall ICC training to disseminate design guidance	Bruce Manclark
	system types						Cheryn Metzger
	sizing						Mark Modera
Develop guidance for contractors	climate specifics needed			Utilities		need to closly collaborate with performance contractors	0
						encourage Pay 4 Performance programs	0
Develop Installation Specs						work with homebuilder associations	0
							0
Refine QA Specs							0
Get Industry Feedback						distributors, HVAC trades and Manufacturers	
Conduct Q/A on Program Efforts	installations, energy savings						0
	etc						0
Other Notes							0
1							0

Consumer & Installer Understanding

Problem	Products can be discourage to consumer & installers. How can we understand consumer and customer needs and motivators and counter public perception that HPs						**Members**
	cold and create a positive perception and preference for advanced ASHPs.						Suzi Asmus
Vision	Customers strongly prefer and desire heat pumps and are actively encouraged by knowegable contractors						Andrew Belden
Lead(s)	Suzi Asmus and Andy Belden						Nick Dunfee
Key Challenges							Todd Greenwell
							Owen Howlett
Task	Subtasks	Start	End	Leader	Contributors	Notes	David Lis
Research Customer and Installer	Lit Review		Dec-19	Andrea	Esource, CEE,		Cheryn Metzger
Perspectives and value proposition	Research Gap Analysis						Jonathan Moscatello
for various audiences	Conduct Research						Brenda Pike
Establish Heat Pump Association				NEEA/NEEP?		This is not only for consumer and installer understanding --- it would se	David Poderson
Develop Marketing Campaigns	Consumers						
	Installers						
Deploy Marketing Campaign				Heat Pump Assoc		Need to find funders - Manufacturers? Utilities, REEOs?, States	
					Carbon Neutral Cities alliance		
Follow-up and Feedback				Heat Pump Assoc			
							0
							0
Other Notes							
1	This team realized that for a broad market evaluation and general campagin, some kind of meta organization would be very valuable\						

Shared Resources

Shared Dropbox Folder

Following the event, NEEA established a dropbox folder where participants and invitees can find the presentations given, this report, and other supporting materials. Access to this dropbox is provide by contacting Christopher Dymond at NEEA (cdymond@neea.org).

A read only version can be found at the following link
https://www.dropbox.com/s/wluzw58302z5lx3/Advanced%20ASHP%20Workshop%20v14.pdf?dl=0

Workshop Attendees

First	Last	Organization
Mark	Alatorre	CEC or PG&E
Suzi	Asmus	NEEA
Panama	Bartholomy	Building Decarbonization
Ian	Blanding	MEEA
Scott	Blunk	SMUD
Abram	Conant	Proctor Engineering
John	Cymbalsky	DOE
Pierre	Delforge	NRDC
Debbie	Driscoll	NEEA
Nick	Dunfee	TRC Solutions
Christopher	Dymond	NEEA
Amy	Egerter	Rocky Mountain Institute
Jackie	Goss	Energy Trust
Todd	Greenwell	Idaho Power
Gary	Hamer	BC Hydro
Bruce	Harley	Bruce Harley Energy Consulting
Randal	Higa	SCE
Carl	Hiller	formerly EPRI
Owen	Howlett	SMUD
Walt	Hunt	EPRI
Marshall	Hunt	PG&E
Ely	Jacobson	MEEA
David	Lis	NEEP
Bruce	Manclark	Clearesult
joanna	Mauer	ASAP
Cheryn	Metzger	PNNL
Mark	Modera	UC Davis
Jonathan	Moscatello	TRC Solutions
Brenda	Pike	National Grid
Reinhard	Radermacher	University of Maryland
Andra	Salazar	Esource
Mvuala	Suami	NRCan
Robert	Weber	BPA
Bruce	Wilcox	Wilcox Consulting
Martha	Brook	California Energy Commission
Chris	Perry	ACEEE
David	Poderson	Xcel Energy

Invitation - Event Description and Context

What

This is a one-and-a-half-day invitation-only workshop on air-source heat pumps (ASHP) to share information and organize collective activities needed to advance ASHP technologies and improve market adoption.

Who

Utilities, energy efficiency organizations, research organizations and technology experts who are involved in program development, strategy, and business decisions that need or benefit from advanced heat pump solutions. No manufacturers will be present, as this workshop is intended to sort out priorities and interests of energy efficiency stakeholders. Technical skills not required, though most attendees are working on one or more aspects of heat pump technology and market development. (max = 30 people)

Why Now

Accelerating market adoption of advanced heat pumps offer enormous potential benefits for utilities and policy makers. The potential source energy savings of air source heat pumps by 2050 is roughly the same as electric vehicles and photovoltaics[1]. Technology shifts are occurring that could redefine residential and small commercial air source heat pumps (gas or electric energy source) and enable greater integration of renewable energy resources. How quickly these technology shifts occur and what data that they provide to customers, program managers, system operators, and their impact to utility load management and efficiency goals is uncertain will be determined by the collective actions that utilities and other market actors take. Event organizers see an opportunity to coordinate actions to influence manufacturers' product development in a way that could simplify the market, provide verified demand and energy savings, and lower total operational costs for end users.

The focus of this Workshop is to improved performance metrics/specifications for ASHPs. Current metrics and associated test procedures do not reliably provide accurate measures of actual ASHP performance, particularly the latest generation of variable capacity ASHPs. This workshop will share the latest lab and field metrics development work, and discuss what is needed to develop improved lab based real world whole building performance metrics. The hope is that these can form the basis of a "roadmap specification[2]" that define performance, data, features, climate-specific best practices, and enable interested parties to communicate this to manufactures and other trade partners with a common voice.

Desired Outcomes

The goal is to establish a coordinated US/Canadian effort to advance performance, metrics, and data collection that form the basis utility program activities on heat pumps.

- Attendees are familiar with what others are doing and what is possible
- Agreement on what is needed to make a business case for improved metrics and testing
- Draft a "roadmap specification[2]" that defines the key elements desired in an advanced ASHP
- Commitment to collaboration on lab and field testing activities and specification development
- Process for coordinating activity going forward

[1] 2019 "Market Transformation Potential of ASHPs", 2018 ACEEE Summer Study, C Dymond, S Nadel, D Lis, R Weber

[2] The term "roadmap specification" describes a multi-tiered, specification that outlines future targets, data, criteria. This is distinguished from a "market specification" like ENERGYSTAR that is a criteria based on current market conditions.

Workshop Agenda

Thursday	Activity
10:00 AM	Registration/Name Tags
11:00 AM	Welcome - Christopher Dymond Introductions – Each attendee presents 1 slide about their current ASHP work
12:00 PM	Lunch & Keynote: "ASHP Future Potential" - Dr. Radermacher Questions
1:30 PM	What we Know about performance of ASHPs Dave Lis - Introduction - metrics Mark Modera – Real-world field performance in the Lab Bruce Wilcox – Side by Side Field Testing Christopher Dymond - Recent ASHP studies Bruce Harley - Load based testing results - Purdue, UL, and ATS
3:30 PM	Cookies and Coffee Post-it Note Request - what else do we need to know? barriers to address? Invite people to organize post-it notes by category
4:00 PM	World Café – 12 years from now, what do we reasonably want from ASHPs 1. What do we want/need 5-12 years from now 2. what's missing, then highlight most essential components 3. create new sheet stating vision - succinct Report Out ---- 5min/table ----- each is part of the vision
5:30 PM	Western Cooling Efficiency Center – Lab Tour (Optional)
7:00 PM	No-host Dinner at Tres Hermanas Davis (Optional)

Friday	Activity
7:30 AM	Coffee, bagels, and scones
8:30 AM	Introduction - recap vision, goals for day, how day is structured Present Strawman Critical Path Challenges Framework
8:45 AM	ACTIVITY 1 - Confirm and Refine Strawman (categories from Day 1) group discussion
9:15 AM	ACTIVITY 2 - Critical path challenges 1. Challenges 2. Any other challenges, begin to prioritize 3. Priority challenges.
10:15 AM	BREAK
10:45 AM	ACTIVITY 3- Detail Tasks of top priorities 1. Activiites to address prioritiy challenges 2. Any other activities, importance, cost, difficulty, order/timing 3. Finishing out the prioritization Report-out: important near term activities
12:00 PM	LUNCH
1:15 PM	ACTIVITY 4 - Team Forming & Logistics Complete Worksheet Report-out
2:15 PM	Closing Discussion
2:45 PM	END

Photos of Breakout Notes

My Apologies for the uncoordinated nature of these photos – most of the work was summarized in the activity tables, but there are lots of good ideas in here – I just could not find the time to compile them.

Photo 1

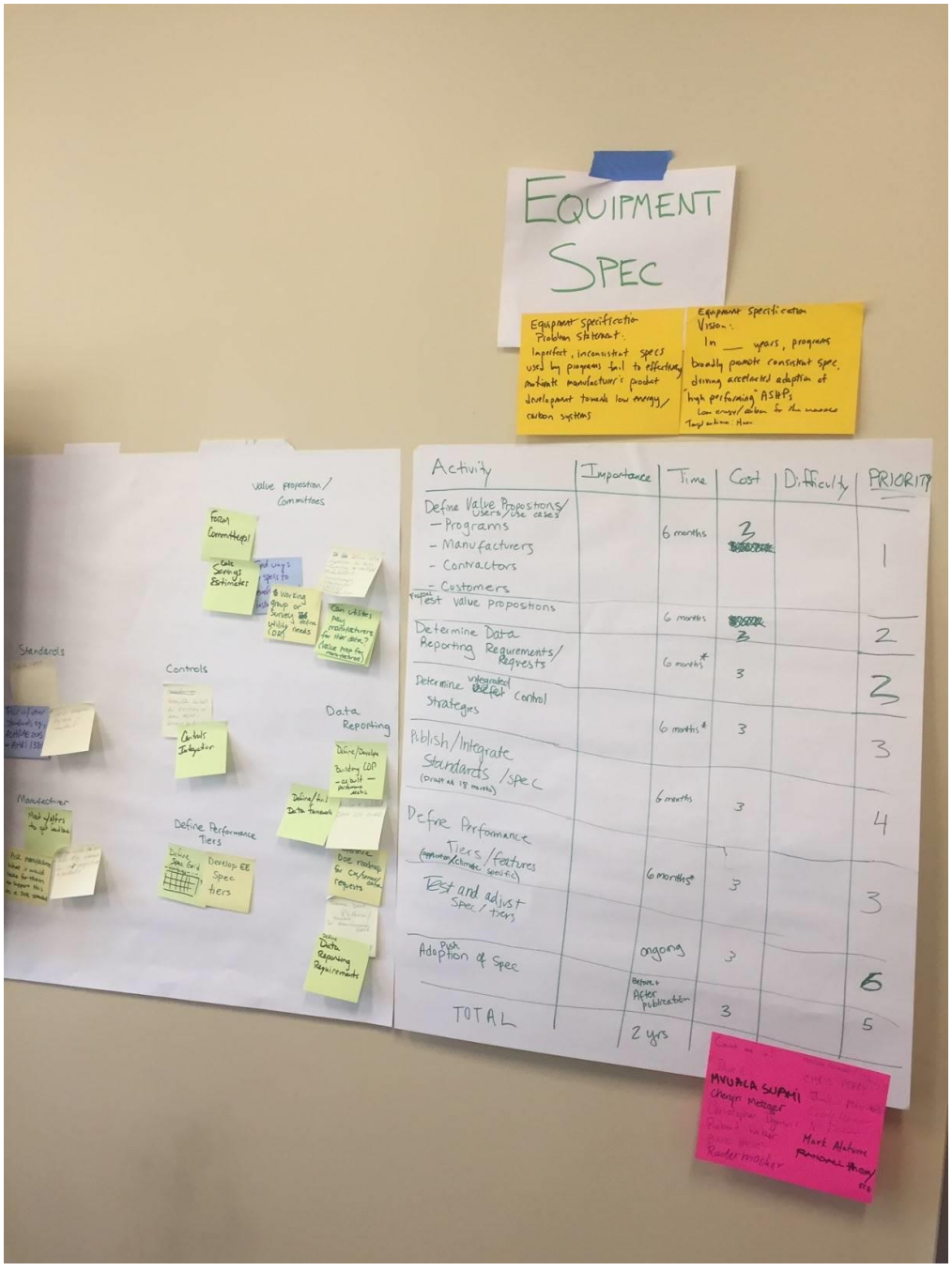


Photo 2

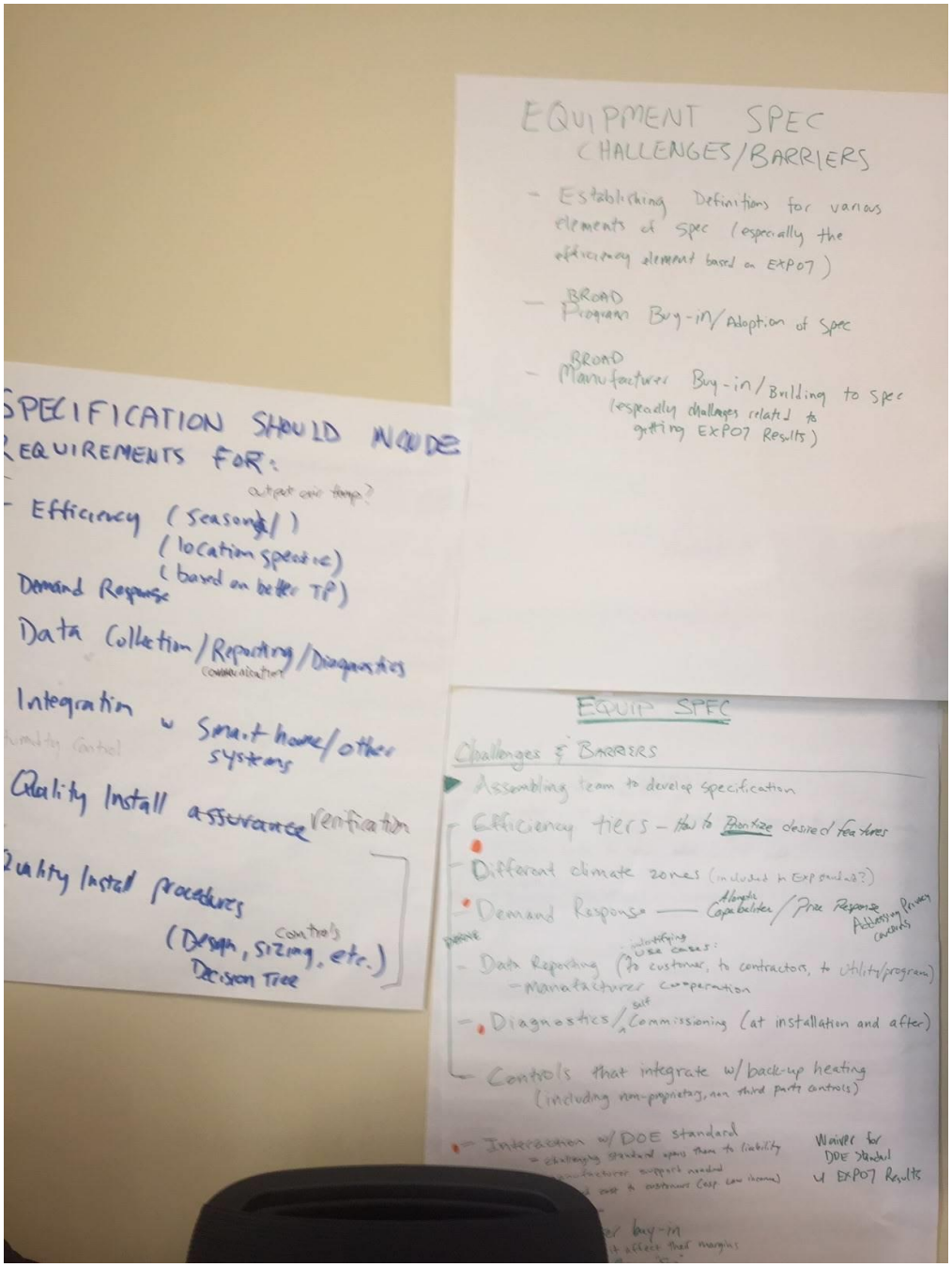

EQUIPMENT SPEC
CHALLENGES/BARRIERS
- Establishing Definitions for various elements of spec (especially the efficiency element based on EXPO7)
- BROAD Program Buy-in/Adoption of Spec
- BROAD Manufacturer Buy-in/Building to spec (especially challenges related to getting EXPO7 Results)
SPECIFICATION SHOULD INCLUDE REQUIREMENTS FOR:
- Efficiency (Seasonal) (location specific) (based on better TP)
Demand Response
Data Collection/Reporting/Diagnostics
Integration w Smart home/other systems
Quality Install assurance verification
Quality Install procedures
(Design, Sizing, etc.)
Decision Tree
EQUIP SPEC
Challenges & Barriers
Assembling team to develop specification
Efficiency tiers - how to Prioritize desired features
Different climate zones (included in EXPO7?)
Demand Response
Data Reporting (to customer, to contractors, to utility/program)
Manufacturer cooperation
Diagnostics/Commissioning (at installation and after)
Controls that integrate w/ back-up heating (including non-proprietary, non third party controls)
Interaction w/ DOE standard
Waiver for DOE Standard
EXPO7 Results

Photo 3

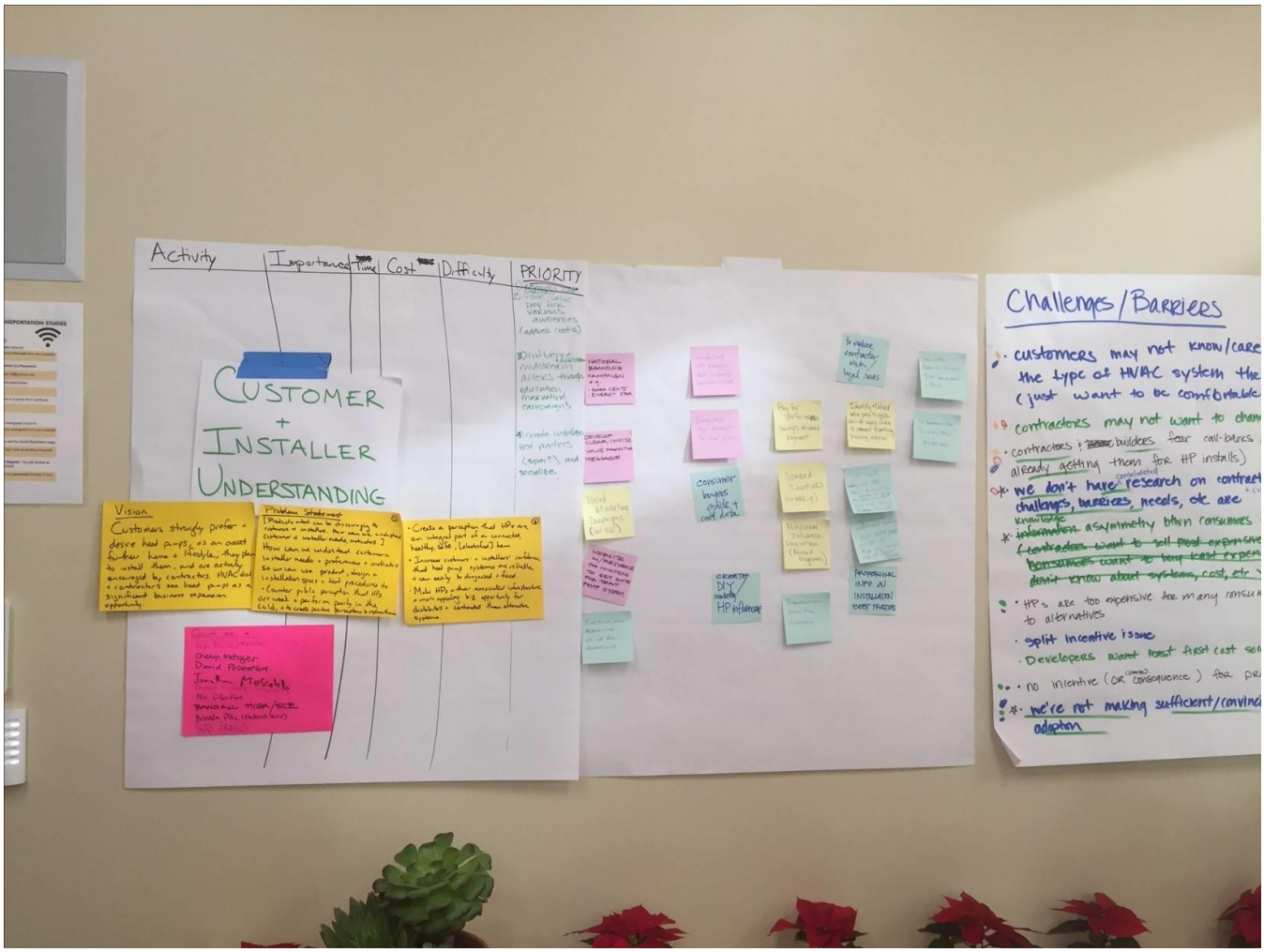

Activity
Importance
Time
Cost
Difficulty
PRIORITY
CUSTOMER + INSTALLER UNDERSTANDING
Vision
Problem Statement
Challenges/Barriers
customers may not know/care
contractors may not want to
we don't have research on
asymmetry
HP's are too expensive
split incentive issue
Developers
no incentive
we're not making sufficient/convinc
adoption

Photo 4

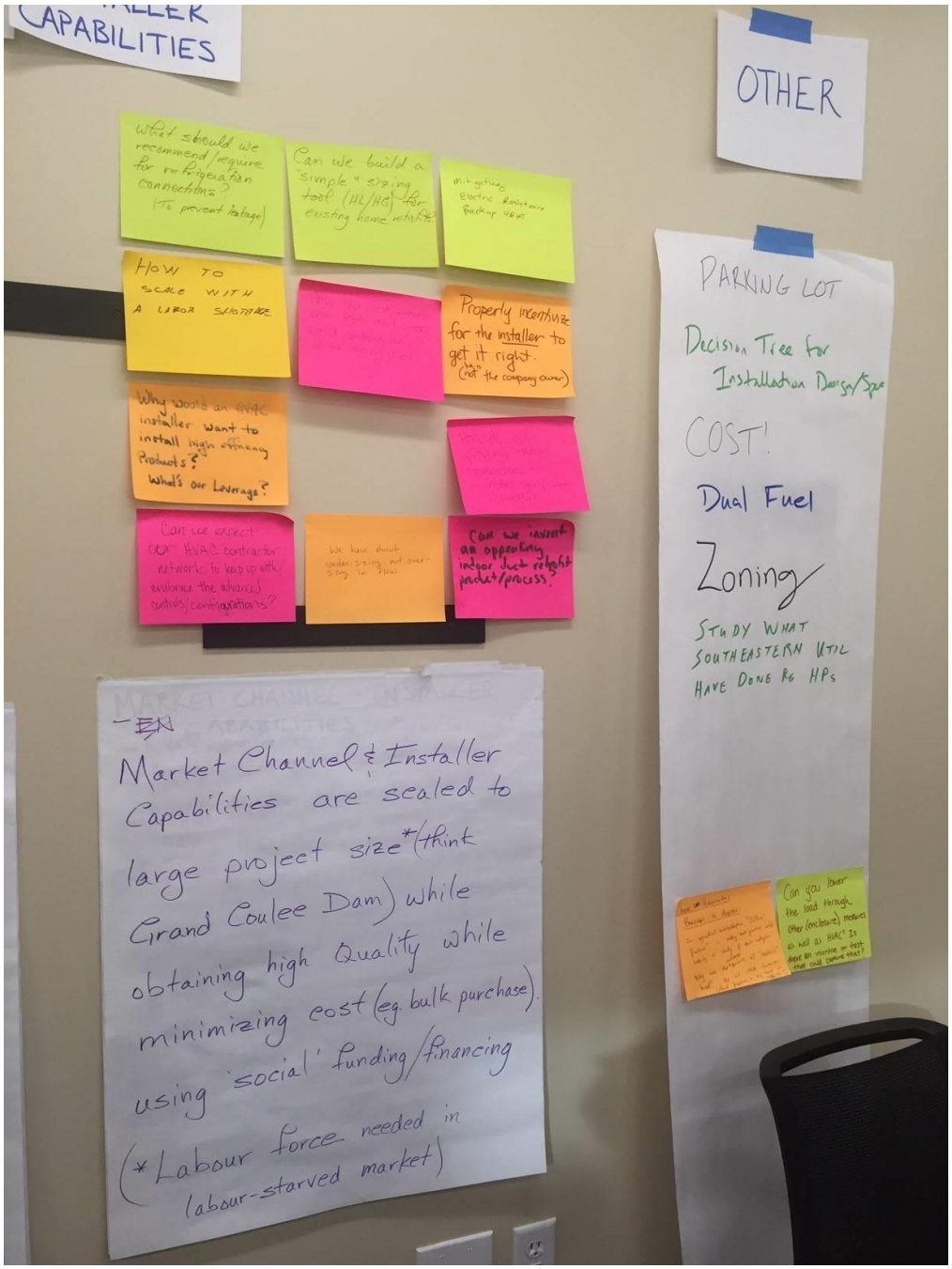

CAPABILITIES
OTHER
What should we recommend/require for refrigeration connections? (To prevent leakage)
Can we build a "simple" sizing tool (HL/HG) for existing home retrofits
mitigating electric Resistance Backup HEAT
HOW TO SCALE WITH A LABOR SHORTAGE
Properly incentivize for the installer to get it right. (not the company owner)
Why would an HVAC installer want to install high efficiency Products? What's our Leverage?
Can we expect our HVAC contractor network to keep up with/ embrace the advanced controls/configurations?
We have doubt under-sizing not over-sizing in NW
Can we invent an appealing indoor duct retrofit product/process?
PARKING LOT
Decision Tree for Installation Design/Spec
COST!
Dual Fuel
Zoning
STUDY WHAT SOUTHEASTERN UTIL HAVE DONE RE HPs
Can you lower the load through other (enclosure) measures as well as HVAC? Is there an incentive or code that could change that?
Market Channel & Installer Capabilities are scaled to large project size* (think Grand Coulee Dam) while obtaining high Quality while minimizing cost (eg. bulk purchase) using 'social' funding/financing
(*Labour force needed in labour-starved market)

Photo 5

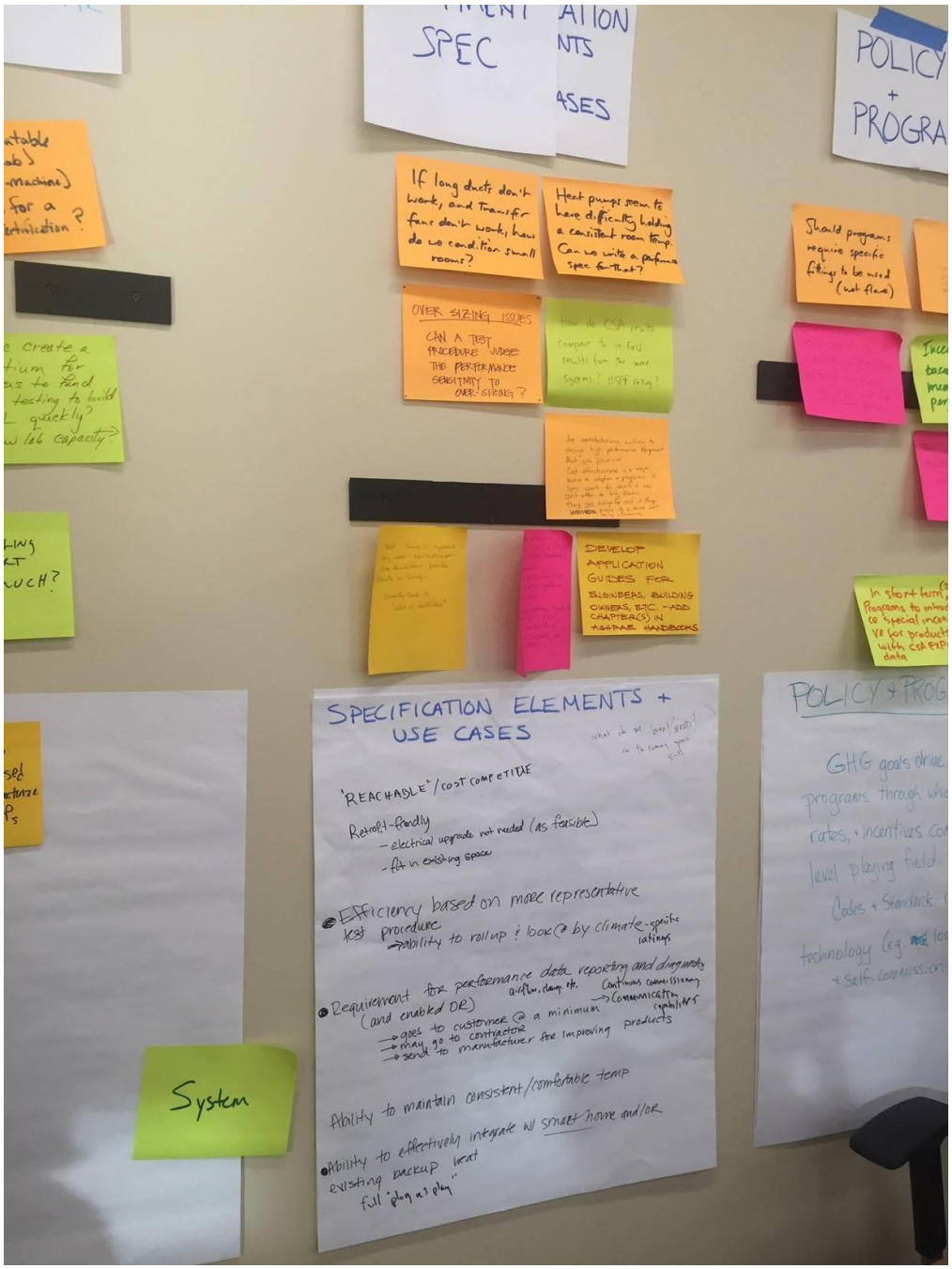

SPEC
POLICY
+
PROGRA
If long ducts don't work, and Transfer fans don't work, how do we condition small rooms?
Heat pumps seem to have difficulty holding a consistent room temp. Can we write a performance spec for that?
Should programs require specific fittings to be used (not flare)
OVER SIZING ISSUES
CAN A TEST PROCEDURE JUDGE THE PERFORMANCE SENSITIVITY TO OVER-SIZING?
DEVELOP APPLICATION GUIDES FOR ENGINEERS, BUILDING OWNERS, ETC. - ADD CHAPTER(S) IN ASHRAE HANDBOOKS
SPECIFICATION ELEMENTS + USE CASES
'REACHABLE'/COST COMPETITIVE
Retrofit-friendly
- electrical upgrade not needed (as feasible)
- fit in existing space
Efficiency based on more representative test procedure
→ ability to roll up & look @ by climate-specific ratings
Requirement for performance data reporting and diagnostics (and enabled DR)
→ goes to customer @ a minimum
→ may go to contractor
→ sent to manufacturer for improving products
→ Continuous commissioning → Communication capabilities
Ability to maintain consistent/comfortable temp
Ability to effectively integrate w/ smart home and/or existing backup heat
full "plug and play"
System
POLICY + PROG
GHG goals drive
Programs through
rates, + incentives
level playing field
Codes + Standards
technology (eg
+ self-commissioning

Photo 6 (with Jonathon M)

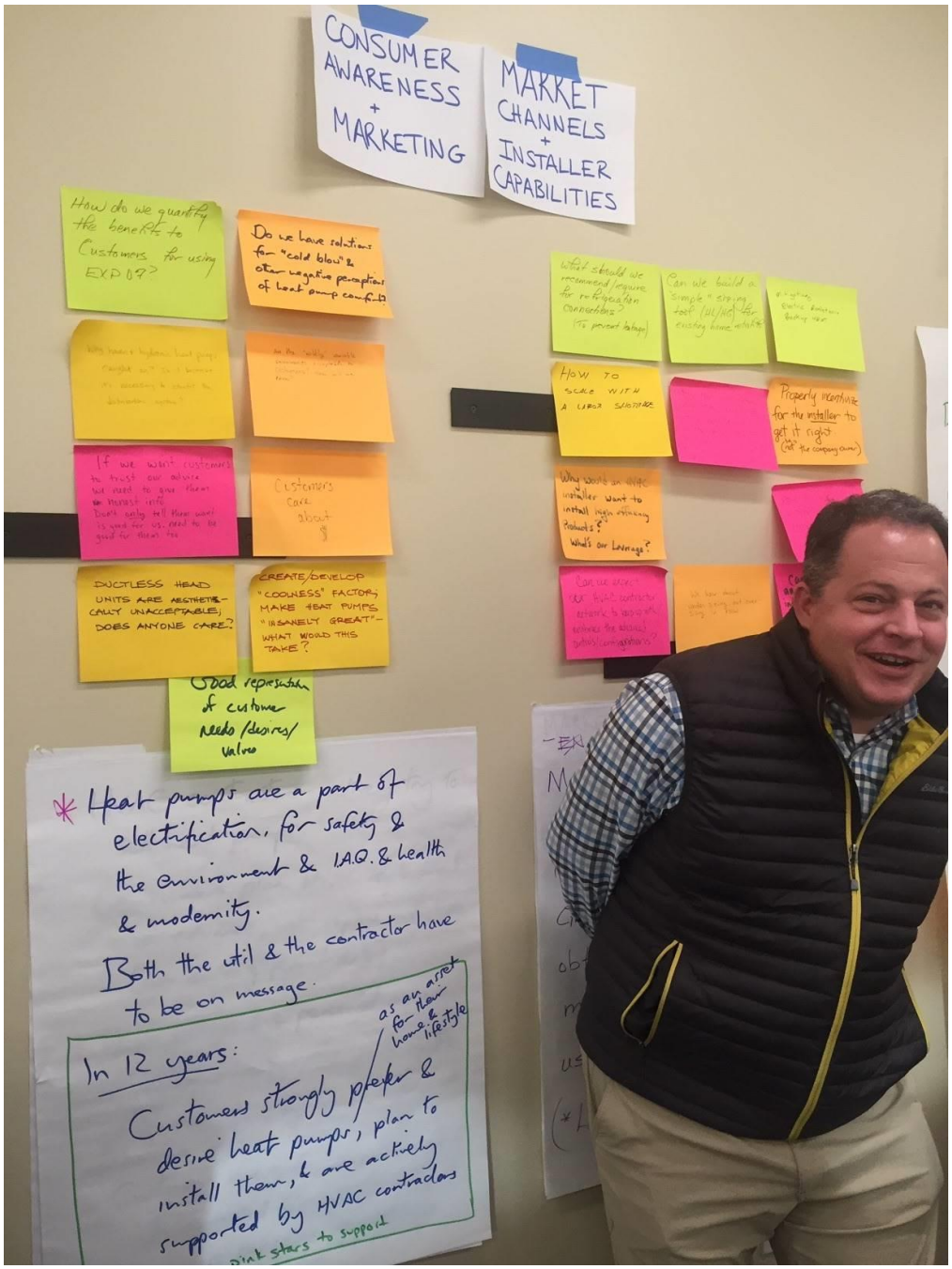
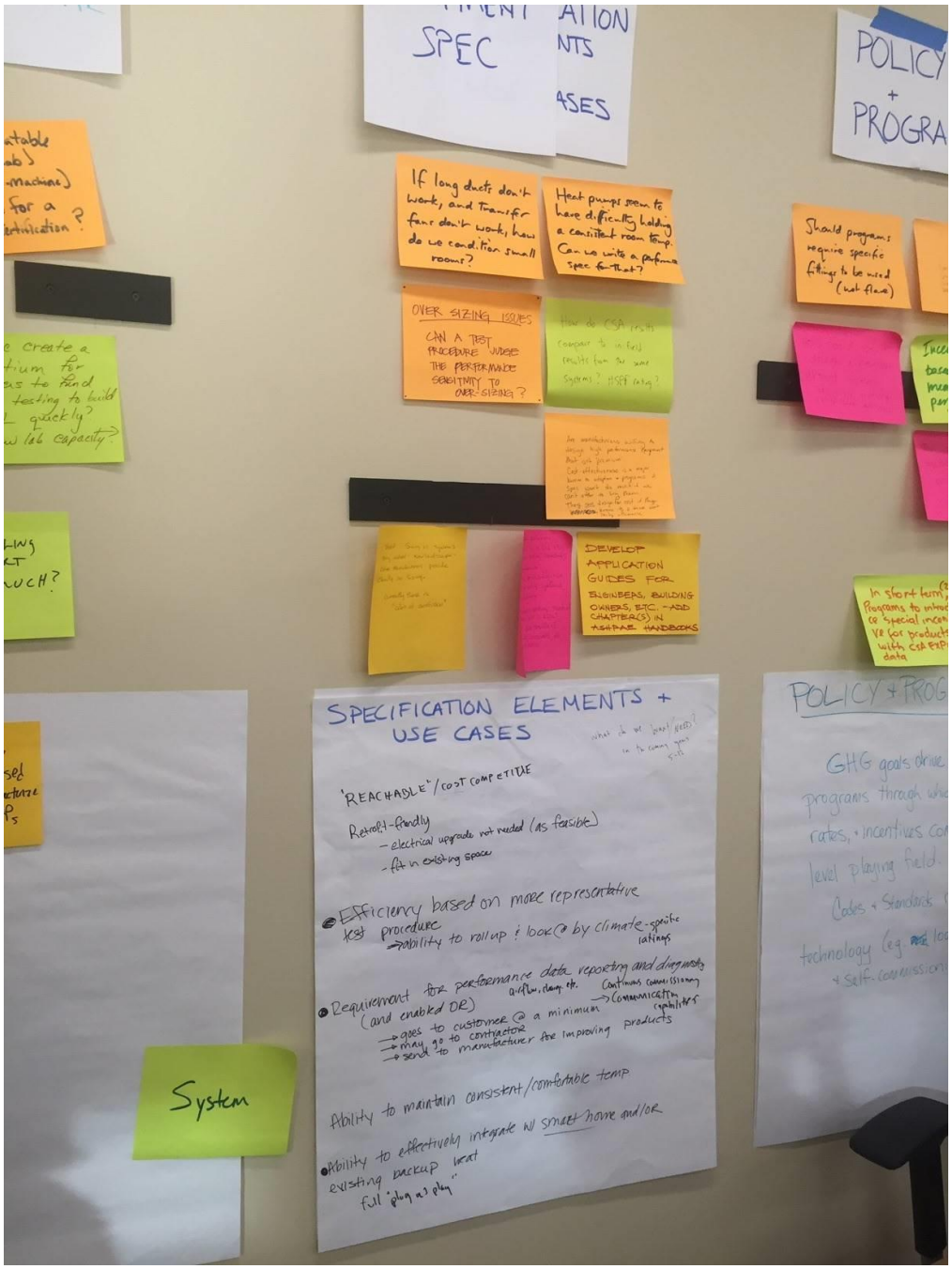


Photo 7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POLICY
+
PROGRA
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System
POLICY + PROG
GHG goals drive
technology (eg
+ self. commissioning

Photo 8

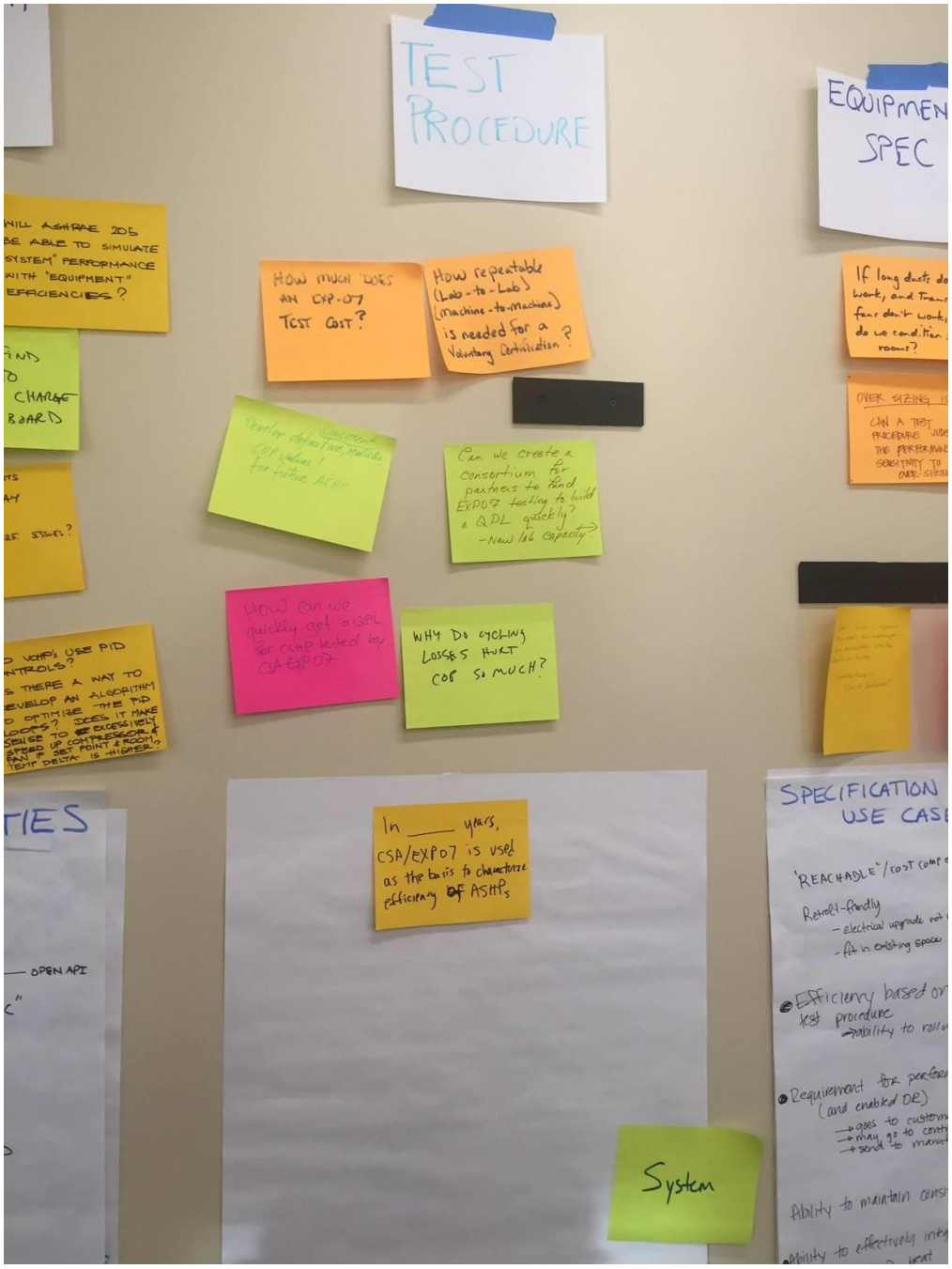

TEST PROCEDURE
EQUIPMENT SPEC
HOW MUCH DOES AN EXP-07 TEST COST?
How repeatable (Lab-to-Lab) (machine-to-machine) is needed for a Voluntary Certification?
Can we create a consortium for partners to fund EXP07 testing to build a QPL quickly? -New lab capacity
HOW can we quickly get a QPL for COMP tested by CSA EXP07
WHY DO CYCLING LOSSES HURT COP SO MUCH?
In ____ years, CSA/EXP07 is used as the basis to characterize efficiency of ASHPs
System
SPECIFICATION USE CASE
'REACHABLE'/cost comp
Retrofit-friendly
- electrical upgrade not
- fit in existing space
Efficiency based on test procedure
Requirement for perform (and enabled DR)
Ability to maintain
OPEN API

Photo 9

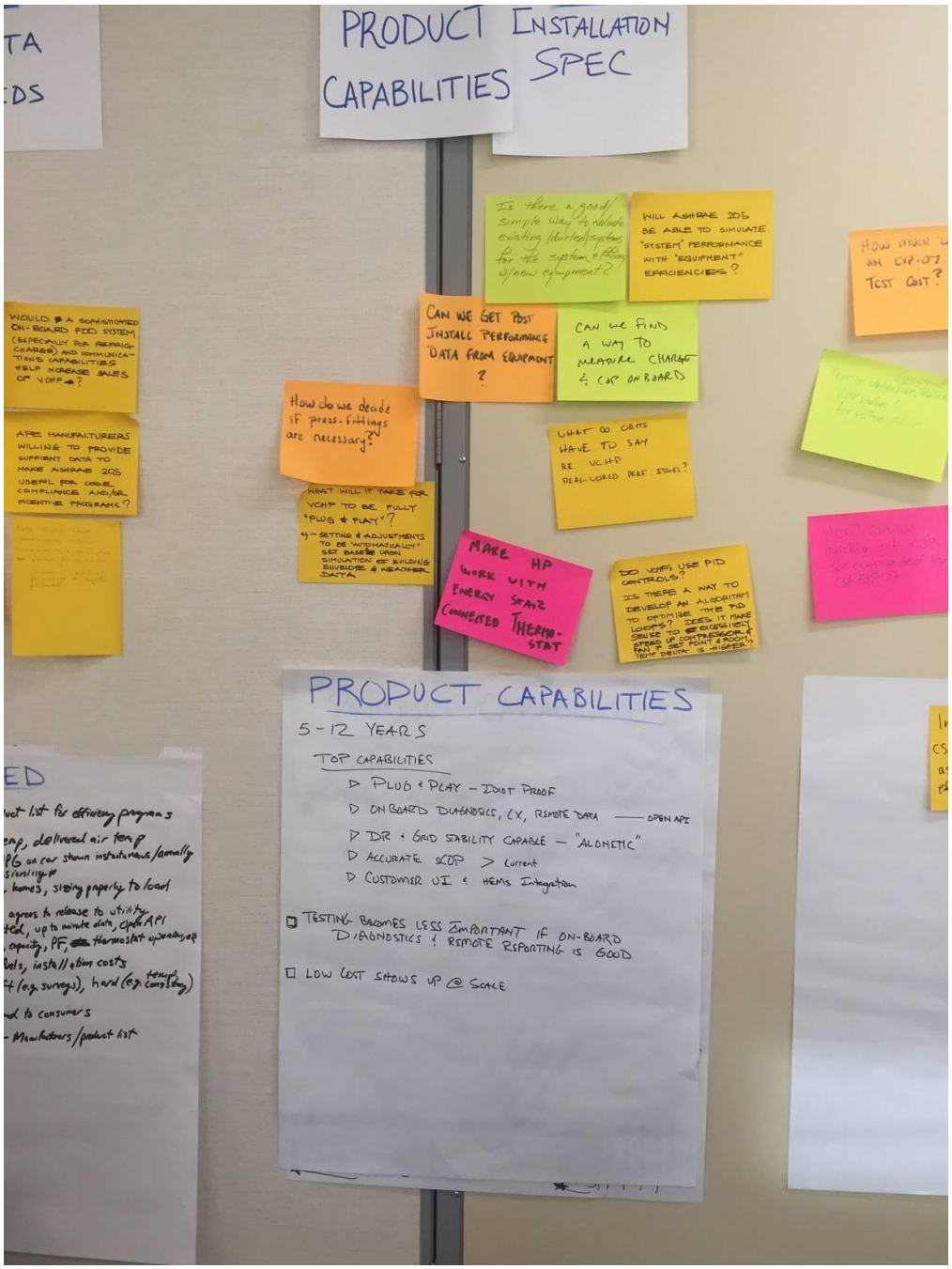

PRODUCT CAPABILITIES
INSTALLATION SPEC
Is there a good/simple way to validate existing (ducted) systems for the system efficacy w/new equipment?
WILL ASHRAE 205 BE ABLE TO SIMULATE "SYSTEM" PERFORMANCE WITH "EQUIPMENT" EFFICIENCIES?
CAN WE GET POST INSTALL PERFORMANCE DATA FROM EQUIPMENT?
CAN WE FIND A WAY TO MEASURE CHARGE & CAP ON BOARD
How do we decide if press-fittings are necessary?
WHAT WILL IT TAKE FOR VCHP TO BE FULLY "PLUG & PLAY"?
MAKE HP WORK WITH ENERGY STAR CONNECTED THERMO-STAT
DO VCHP'S USE PID CONTROLS?
PRODUCT CAPABILITIES
5-12 YEARS
TOP CAPABILITIES
PLUG & PLAY – IDIOT PROOF
ON BOARD DIAGNOSTICS, CX, REMOTE DATA — OPEN API
DR + GRID STABILITY CAPABLE – "ALOMETIC"
ACCURATE SCOP > current
CUSTOMER UI & HEMS Integration
TESTING BECOMES LESS IMPORTANT IF ON-BOARD DIAGNOSTICS & REMOTE REPORTING IS GOOD
LOW COST SHOWS UP @ SCALE

Photo 10

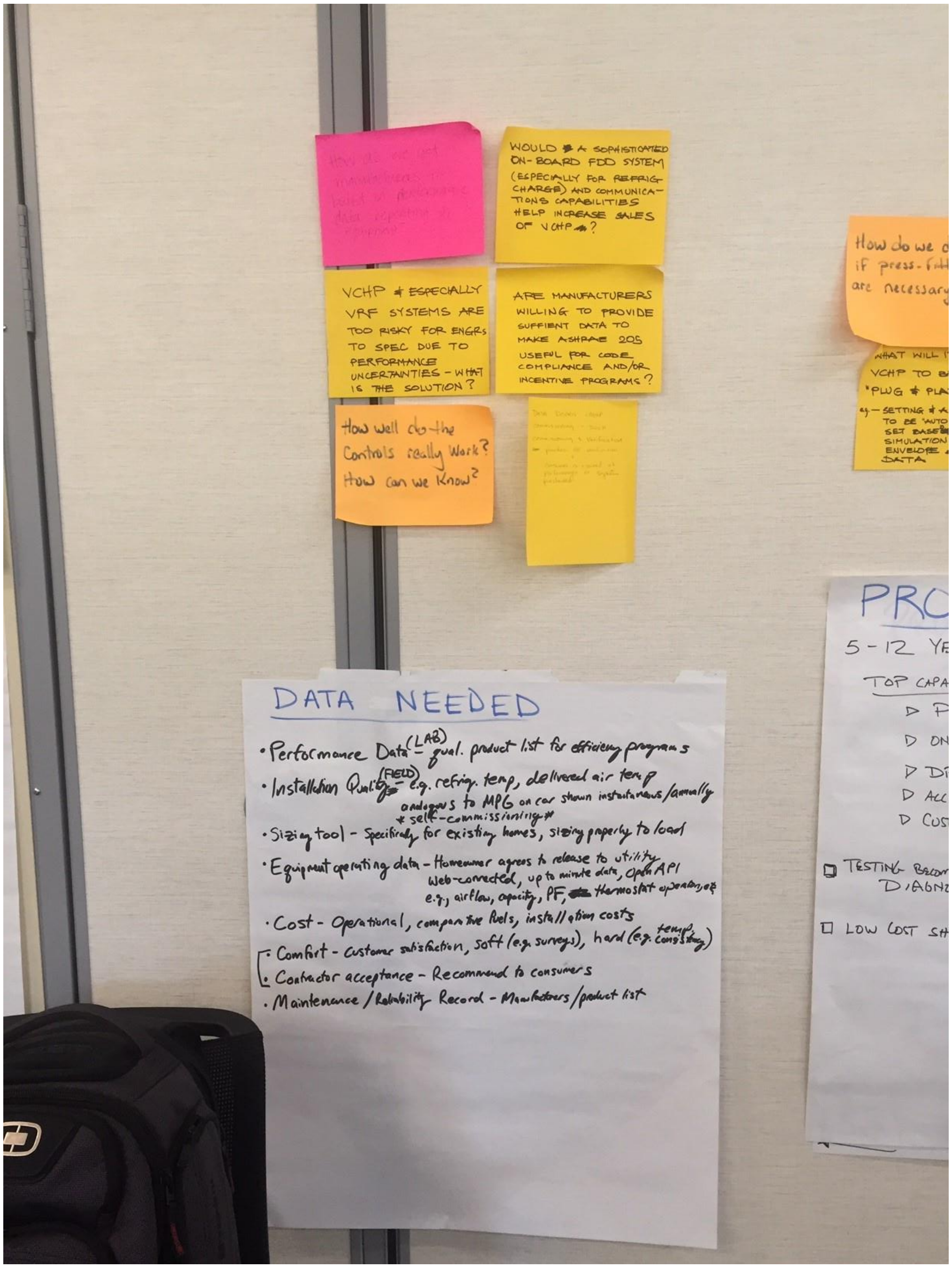
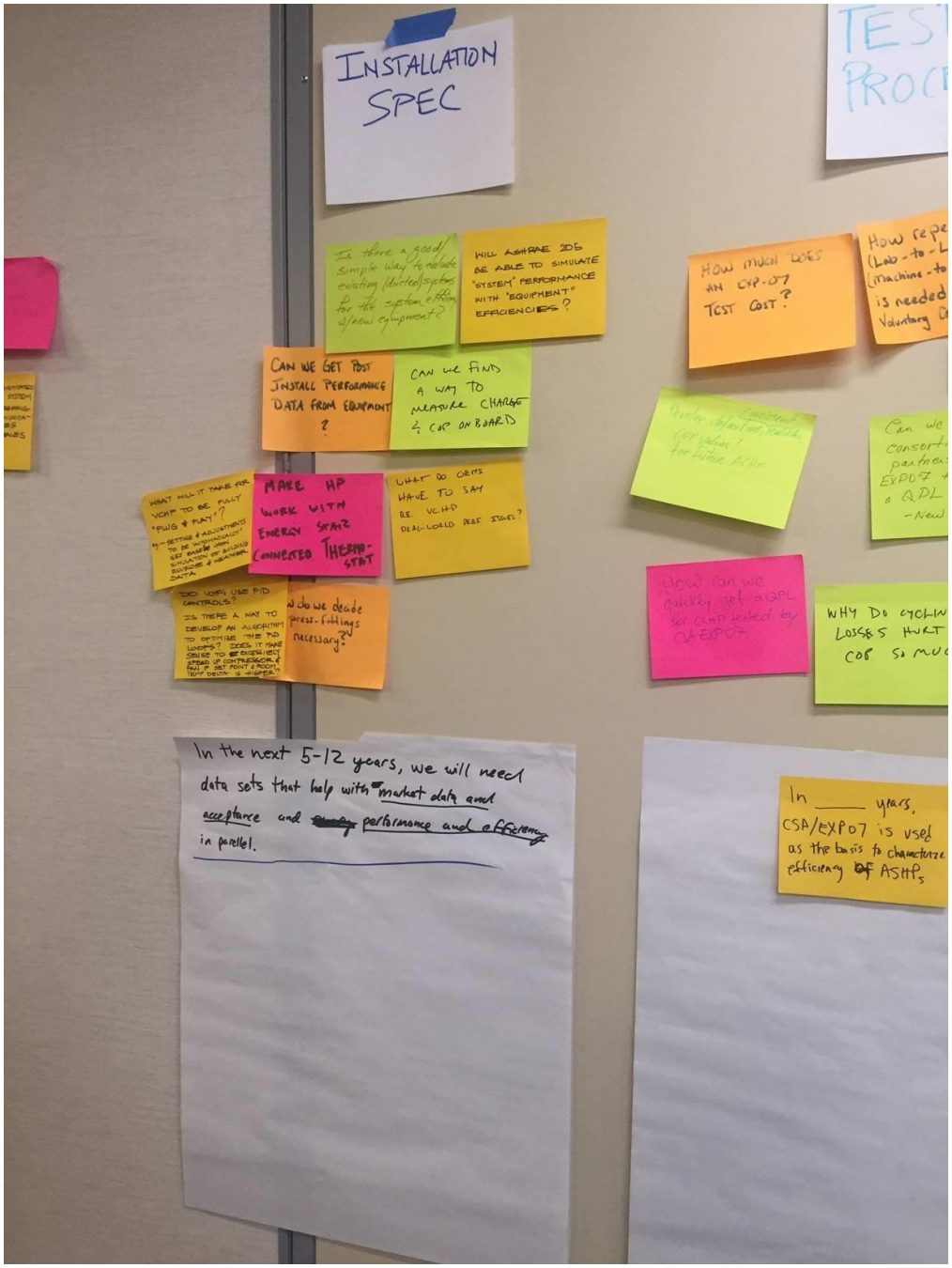

WOULD A SOPHISTICATED ON-BOARD FDD SYSTEM (ESPECIALLY FOR REFRIG CHARGE) AND COMMUNICATIONS CAPABILITIES HELP INCREASE SALES OF VCHP?
VCHP & ESPECIALLY VRF SYSTEMS ARE TOO RISKY FOR ENGRs TO SPEC DUE TO PERFORMANCE UNCERTAINTIES - WHAT IS THE SOLUTION?
ARE MANUFACTURERS WILLING TO PROVIDE SUFFIENT DATA TO MAKE ASHRAE 205 USEFUL FOR CODE COMPLIANCE AND/OR INCENTIVE PROGRAMS?
How well do the Controls really Work? How can we Know?
DATA NEEDED
• Performance Data (LAB) - qual. product list for efficiency programs
• Installation Quality (FIELD) - e.g. refrig. temp, delivered air temp
analogous to MPG on car shown instantaneous/annually
* self-commissioning *
• Sizing tool - Specifically for existing homes, sizing properly to load
• Equipment operating data - Homeowner agrees to release to utility
Web-connected, up to minute data, Open API
e.g., airflow, capacity, PF, thermostat operation, etc
• Cost - Operational, comparative fuels, installation costs
• Comfort - Customer satisfaction, soft (e.g. surveys), hard (e.g. temp. consistency)
• Contractor acceptance - Recommend to consumers
• Maintenance / Reliability Record - Manufacturers / product list
PRO
5-12 YE
TOP CAPA
TESTING
LOW COST

Photo 11


INSTALLATION SPEC
TEST PROC
Is there a good/simple way to relate existing ducted systems for the system effic. w/new equipment?
WILL ASHRAE 205 BE ABLE TO SIMULATE "SYSTEM" PERFORMANCE WITH "EQUIPMENT" EFFICIENCIES?
HOW MUCH DOES AN EXP-07 TEST COST?
How repe (lab-to-L (machine-to is needed Voluntary D
CAN WE GET POST INSTALL PERFORMANCE DATA FROM EQUIPMENT?
CAN WE FIND A WAY TO MEASURE CHARGE & COP ON BOARD
MAKE HP WORK WITH ENERGY STAR CONNECTED THERMOSTAT
WHAT DO CERTS HAVE TO SAY RE VCHP REAL-WORLD PERF STUDY?
Can we consort partner EXP07 a QPL -New
How can we quickly get AHRI for COP tested by EXP07
WHY DO CYCLIN LOSSES HURT COP SO MU
In the next 5-12 years, we will need data sets that help with market data and acceptance and performance and efficiency in parallel.
In ____ years, CSA/EXP07 is used as the basis to characterize efficiency of ASHPs