EMERGING TECHNOLOGY – MEASURES & COSTS ON THE CUTTING EDGE – 4/3/2018

NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS
FACILITATING PARTNERSHIPS TO ADVANCE ENERGY EFFICIENCY

energy & resource solutions

Q-Sync refrigeration fan

Smart phone controllable outlet

NEEP EM&V FORUM - INCREMENTAL COST STUDY
EMERGING TECHNOLOGIES PROJECT

Background

- An Outgrowth of the EM&V Forum's Incremental Cost Studies (ICS)
  - ICS Phases 1 - 4
  - ET did not meet criteria– fast moving markets and costs not stable
- Merges ICS and Forum's Emerging Technologies Work
  - EM&V methods for Emerging Technologies and Program Models
  - Ductless Heat Pump Performance
  - Electric Clothes Dryer Baseline Metering
  - Ductless Heat Pump Meta-Study
  - Power Strips

Sponsors

National Grid (MA & RI), AvanGrid (formerly United Illuminating), Eversource (MA, NH & CT), NYSERDA, Unitil, Cape Light Compact, Liberty Utilities, New Hampshire Electric Cooperative

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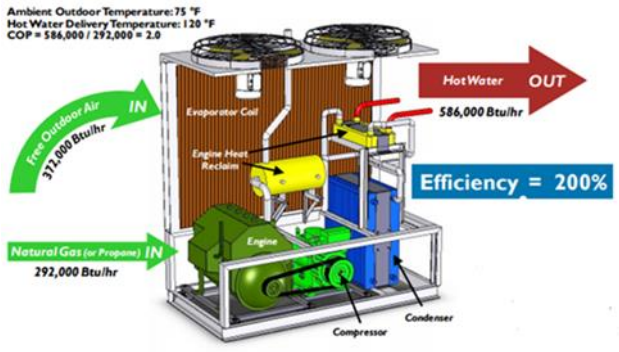
Study Goals

- Focus on ET measures
- Provide cost data
  - Recently introduced technologies
  - Technologies in beta/pilot stages
  - Measures that will enhance efficiency programs and/or replace retiring measures
- Identify baselines
  - New construction
  - Failed equipment baselines
- Report on observed cost trends
- Provide technical overview for each category



Natural gas fired heat pump water heater

USING THE REPORT FINDINGS

Intended audience: implementers, evaluators, planners and regulators, implementation contractors

Two component report

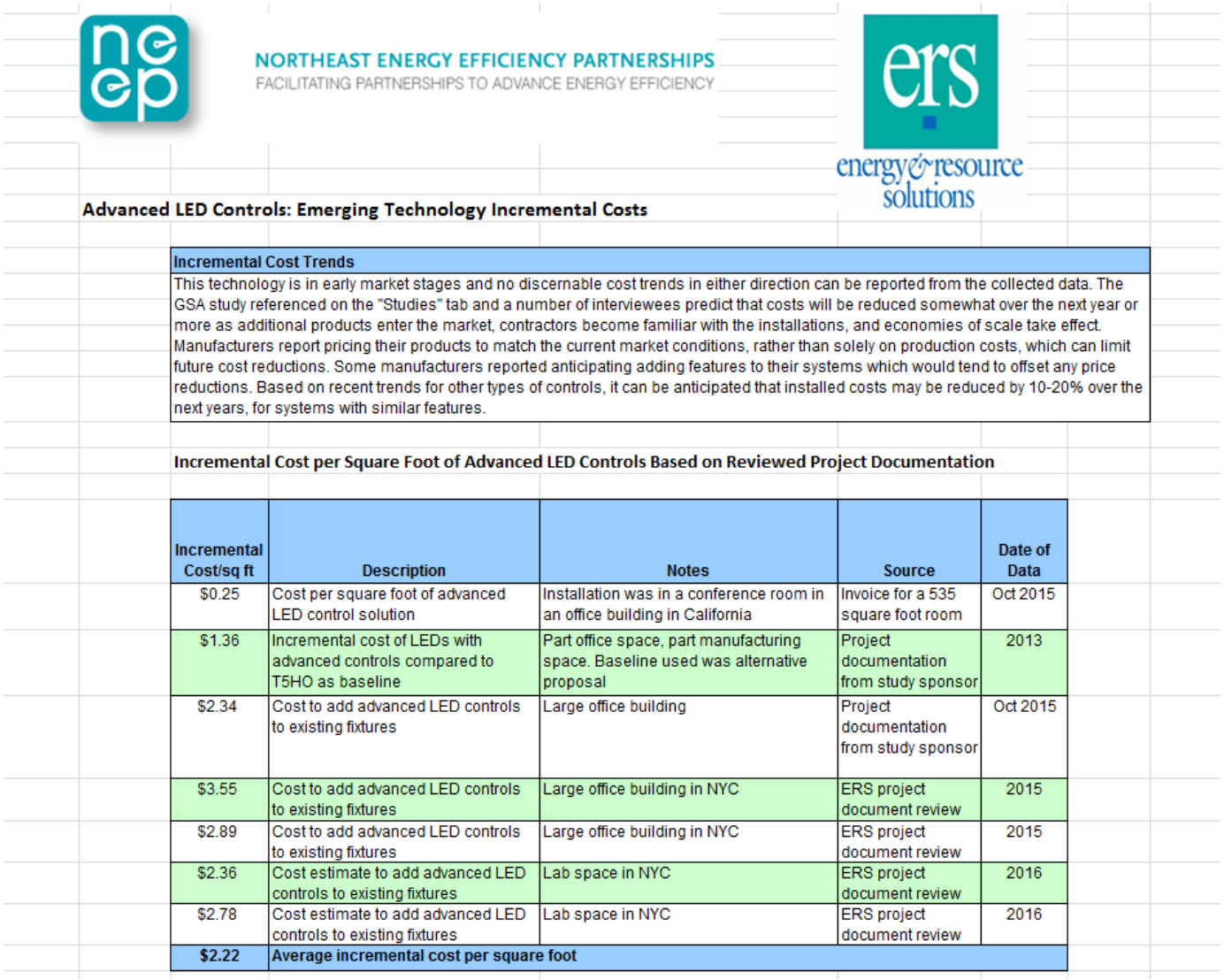
1. Final report document
   - Technology details
   - Applications & sectors
   - Market status
   - Incremental cost summaries
2. Incremental cost worksheets (one for each category)
   - Baseline and Emerging technology costs
   - Calculated incremental costs
   - Master Summary Workbooks combine all ICS results for one stop shopping on the NEEP website

Mitsubishi Kumo ductless mini-split heat pump cloud connected application

Using the report findings

- Inform pilot prescriptive and custom incentive programs
- Provide guidance for TRMs
- Inform cost-effectiveness calculations
- Identifying efficiency, demand response, and data collection opportunities

WORKSHEET SAMPLE



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Advanced LED Controls: Emerging Technology Incremental Costs

Incremental Cost Trends
This technology is in early market stages and no discernable cost trends in either direction can be reported from the collected data. The GSA study referenced on the "Studies" tab and a number of interviewees predict that costs will be reduced somewhat over the next year or more as additional products enter the market, contractors become familiar with the installations, and economies of scale take effect. Manufacturers report pricing their products to match the current market conditions, rather than solely on production costs, which can limit future cost reductions. Some manufacturers reported anticipating adding features to their systems which would tend to offset any price reductions. Based on recent trends for other types of controls, it can be anticipated that installed costs may be reduced by 10-20% over the next years, for systems with similar features.

Incremental Cost per Square Foot of Advanced LED Controls Based on Reviewed Project Documentation

Incremental Cost/sq ft	Description	Notes	Source	Date of Data
$0.25	Cost per square foot of advanced LED control solution	Installation was in a conference room in an office building in California	Invoice for a 535 square foot room	Oct 2015
$1.36	Incremental cost of LEDs with advanced controls compared to T5HO as baseline	Part office space, part manufacturing space. Baseline used was alternative proposal	Project documentation from study sponsor	2013
$2.34	Cost to add advanced LED controls to existing fixtures	Large office building	Project documentation from study sponsor	Oct 2015
$3.55	Cost to add advanced LED controls to existing fixtures	Large office building in NYC	ERS project document review	2015
$2.89	Cost to add advanced LED controls to existing fixtures	Large office building in NYC	ERS project document review	2015
$2.36	Cost estimate to add advanced LED controls to existing fixtures	Lab space in NYC	ERS project document review	2016
$2.78	Cost estimate to add advanced LED controls to existing fixtures	Lab space in NYC	ERS project document review	2016
$2.22	**Average incremental cost per square foot**			

WORKSHEET SAMPLE

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Data Collected in Researching Incremental Costs of Advanced LED Controls

Cost	Amount	Description	Notes	Source	Date
Incremental	$15-20	Incremental cost/fixture for manufacturer to add adv. LED ctrls	High estimate. Likely to decrease w/ volume increase. Value confirmed	Interview with Manufacturer A	Nov 2015
Incremental	$50-75	Incremental cost to add advanced LED controls to fixtures in the field	~3x the cost to integrate controls into the fixture at the manufacturer	Interview with Manufacturer A	Nov 2015
Incremental	65%	Estimated incremental cost of an advanced LED control solution	50% material cost, 10-15% labor cost	Interview with Manufacturer A	Nov 2015
Full	$250	Full cost of installing adv LED ctrl solution in private office	Likely around 200 sq ft	Interview with Manufacturer B	Nov 2015
Full	$50,000 - $200,000	Cost of installing adv LED ctrls in typical commercial office space	Varies based on finished desired and many other factors	Interview with Manufacturer B	Nov 2015
Full	$500,000	Price of an adv LED ctrl solution for 10 story comerical office building	Estimated, not based on specific project data	Interview with Manufacturer C	Nov 2015
Full	$5,000	Price/room of installing adv LED ctrls in 80 rooms in healthcare facility, with identical operation in	Commissioning is simpler when all rooms operate identically.	Interview with Manufacturer C	Nov 2015
Full	$6,000-6,500	Price/room of installing adv LED ctrls in 80 rooms in a healthcare facility, treating each room	Incremental price/room of individual operation is ~$1,250 per room compared to identical operation of all rooms.	Interview with Manufacturer C	Nov 2015
Full	10%	Percent of project cost that typically goes to commissioning and setup	Commissioning will be required with any adv LED ctrl solution	Interview with Manufacturer C	Nov 2015
Full	25-35%	Percent of project cost for integration with other systems	For retrofit or new construction scenarios with different brands of	Interview with Manufacturer C	Nov 2015
Full	$1.50/sq ft	High bound of advanced LED control soution	Includes 1 day of commissioning and 1 day of end user training.	Interview with Manufacturer C	Nov 2015
Full	$1.10-$1.20	Average cost per square foot of advanced LED control solution	Includes 1 day of commissioning and 1 day of end user training.	Interview with Manufacturer D	Dec 2015
Baseline	$0.90	Cost of a minimally code compliant solution supplied by Manufacturer D	Estimated, not based on specific project data	Interview with Manufacturer D	Dec 2015
Incremental	$16.88	Cost/fixture to add adv LED ctrls to LED troffer at the time of	Installation was in a conference room in an office building in California	Invoice for 535 sq ft room w/ 8	Oct 2015
Full	$257.63	Cost/fixture of LED troffer with an integrated adv ctrl solution	Total fixture cost including control. Installation was in a conference room in an office building in California	Invoice for 535 sq ft room w/ 8 fixtures.	Oct 2015
Incremental	$0.25	Cost per square foot of advanced LED control solution	Installation was in a conference room in an office building in California	Invoice for 535 sq ft room w/ 8	Oct 2015
Incremental	$1.36/ sq ft	LEDs with advanced controls compared to T5HO baseline	Part office space, part manufacturing. Baseline used was alternative proposal	Project documents from study sponsor	2013
Incremental	$2.34/ sq ft	Incremental cost of adding advanced LED ctrls to current system	This is for a large office building. Baseline is current system.	Eversource	Oct 2015
Incremental	$3.55/ sq ft	Cost to add advanced LED controls to existing fixtures	Large office building in NYC. Baseline is current system.	ERS project document review	2015
Incremental	$2.89/ sq ft	Cost to add advanced LED controls to existing fixtures	Large office building in NYC. Baseline is current system.	ERS project document review	2015
Incremental	$2.36/ sq ft	Cost estimate to add advanced LED controls to existing fixtures	Lab space in NYC. Baseline is current system.	ERS project document review	2016
Incremental	$2.78/ sq ft	Cost estimate to add advanced LED controls to existing fixtures	Lab space in NYC. Baseline is current system.	ERS project document review	2016
Full	$6.69/ sq ft	Retrofit existing fixtures to LEDs with advanced ctrls	Average cost of 25 projects at 25 stores in a northeastern grocery store chain	ERS project document review	2016

Overview of Study Findings

Overall scope

- Full & incremental costs
- Market status
- Technology details
- Efficiency program opportunities and barriers

Findings common to most

- Technology advancing rapidly
- Costs highly volatile
- Market competition is the main cost factor
- Incremental costs, although variable and volatile, are not dramatically high

Additional findings of note

- Heat pump market including VRF is expanding rapidly
- Advanced lighting controls – many systems and approaches
- Home energy management – many categories not achieving market success and/or not offering significant savings

TECHNOLOGY CATEGORIES

1. Variable capacity modulating and VRF heat pumps
2. Advanced LED lighting controls
3. Home energy management products, smart thermostats, and Tier II power strips
4. Advanced ultra-high efficiency roof top units (RTUs)
5. Integrated dual system control thermostats
6. Improved electric heat pump water heaters
7. Advanced refrigeration compressors
8. Compressed air system monitoring/diagnostics
9. Gas-fired heat pump water heaters
10. Synchronous motors (Q-Sync) for refrigerated cases

Refrigeration compressor

RESEARCH METHODOLOGIES

Approaches included:

- Pilot project research
- Web research
- Cost service research (Dodge data, etc.)
- Vendor and customer interviews
- Overseas market investigation
- Application of competitive pricing strategies
- Product cost-effectiveness strategies

Compressed air monitoring and control system

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RESEARCH METHODOLOGIES

	Technology Category	Program Project Data	Web Based Research	Cost Service Research	Market Actor Interviews	Overseas Market Research	Market Pricing Strategies	Cost-Effectiveness Model
1a	VRF heat pump – A/C	√	√	√	√			
1b	Multiple-zone variable capacity HP – modulating compressors	√	√	√	√			
2	Advanced LED lighting controls	√	√		√			
3a	Home energy management products		√		√			
3b	Tier 2 power strips	√	√		√			
4	Advanced/ultra-high efficiency rooftop packaged A/C (SEER >18)	√	√	√	√			
5	Integrated heat pump multi-system thermostatic controls		√		√		√	
6	Advanced compressors for commercial refrigeration	√	√		√		√	
7	Automatic compressed air system diagnostic monitoring		√		√	√		
8	Improved HP water heaters	√	√		√	√		
9	Natural gas heat pump water heaters	√	√		√	√		
10	Q-Sync motors for evaporator fans (proprietary QM Power product)		√		√		√	√

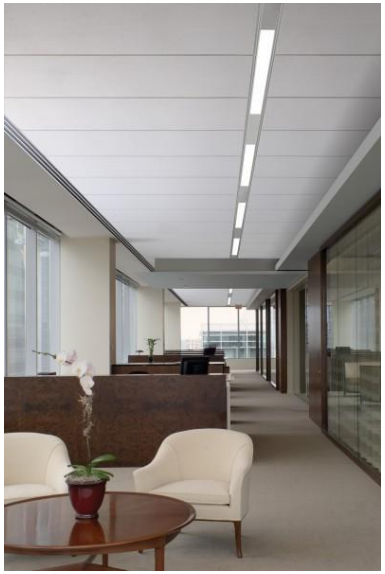
VARIABLE CAPACITY MODULATING AND VRF HEAT PUMPS

- **Application –** Commercial, industrial, multi-family
- **Baseline** – Non-modulating ASHP meeting current energy code requirements
- **Incremental cost**
  - $1,500 - $6,300 per ton; variable with project complexity
  - Approximate additional 17% cost for cold climate performance

- **Market**
  - Eligible for custom HVAC incentives
  - Fast growing
  - US manufacturers joining a market dominated by Asian firms
  - Full and incremental costs are declining
  - For larger (over 5 ton) VRF systems, costs are highly project specific and labor intensive

ADVANCED LED LIGHTING CONTROLS

- **Baseline** – For new construction and major renovations – baseline is the current energy code required controls. Code impact varies with space type and project type. When retrofitting controls to existing lighting systems, the baseline cost is typically $0. The projects we reviewed explicitly identified a baseline system.
- **Incremental cost**
  - Variable with project complexity, size of customer, other options
  - Averaged $2.22/ft^2
- **Market**
  - Pilot programs initiated in some territories
  - No discernable cost trends evident from recorded data
  - One study and multiple market actor interviewees expect prices to decline



Home Energy Management Products: Hubs, Networkable Lamps & Smart Thermostats

HEM Hubs & Networkable Lamps

- Baseline – hubs = no equipment; lamps = screw-in CFLs
- Incremental cost
  - Hubs; full cost = $60-100
  - Networkable lamps; incremental cost = $15-58
- Market - Fast growing – participation from major lamp manufacturers
  - Upstream incentives available in some territories

Smart Thermostats

- Baseline – Electronic programmable thermostats
- Incremental cost
  - Adaptive thermostat incremental cost; $195
  - Network controllable thermostat; $80-175
- Market - Dominated by a small number of manufacturers. Costs are stable and competitive across brands.
  - Upstream and prescriptive incentives typically available for adaptive models

Home Energy Management Products: Home Appliances & Tier II Power Strips

Networkable Large Home Appliances

- Baseline - similar appliance without communication capability
- Incremental cost
  - Kitchen range; $170
  - Refrigerator; $800
  - Washer; $200-270
  - Dryer; $150-270
  - Dishwasher; $270
- Market
  - No incentives available for network features
  - Volatile – product availability fluctuates
  - Emphasis on convenience rather than energy savings
  - Potential for demand response

Tier 2 Advanced Power Strips

- Baseline – none or simple non-controlling power strip @ $10
- Incremental cost - $30-70
- Market – activity mostly through utility direct install and upstream programs
  - Two major competitors
  - Home entertainment systems represent the dominant opportunity

Advanced Rooftop Units (RTUs) – SEER 18 and Above

- **Baseline** – RTUs meeting current energy code requirements
- **Incremental cost** - $360-560 per ton capacity plus some variable installation cost due to heavier equipment
- **Market**
  - NEEP sponsors report measure as not cost-effective in service territory climate zones
  - Only smaller size units available to date
  - Market actors predict little to no future cost reductions
  - Codes and standards to force baselines higher, lowering the incremental cost

INTEGRATED HEAT PUMP MULTI-SYSTEM CONTROL

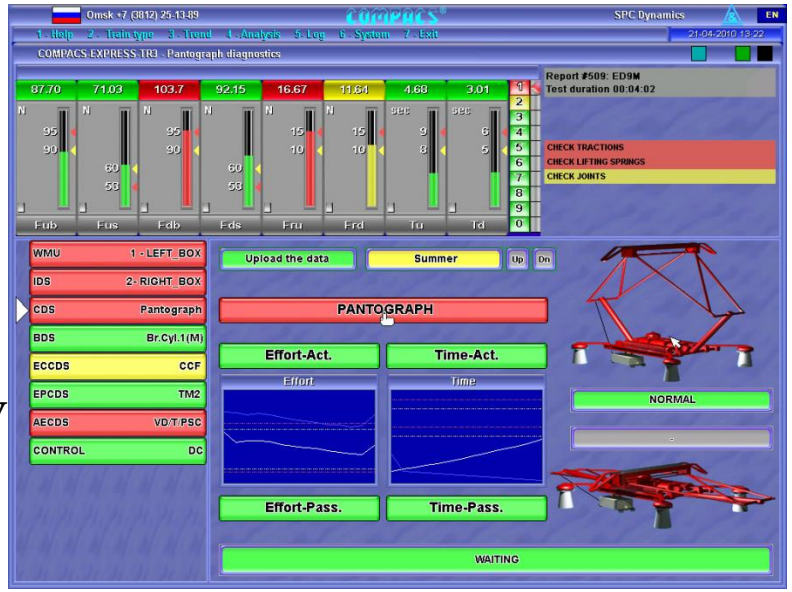
- **Baseline** – none for retrofit as heat pumps include standard control – programmable multi-stage thermostat for new construction
- **Incremental cost** - $365-660 per installed zone
- **Market**
  - No specific incentives offered; potential for enhanced control incentive
  - Immature market – nearly all mini-split ductless heat pumps installed with standard remote control
  - Manufacturers now focusing on "smart" thermostat interfaces rather than OEM thermostatic controls
  - Little demand outside of heating-dominated market as multiple systems not needed throughout most of US
  - Priced at what market will bear – small profit margins, so price expected to remain stable
  - Market to shrink as HP cold climate performance improves, and more systems provide 100% of heating

Advanced Compressors for Commercial Refrigeration

- **Baseline** – Centralized direct expansion unit @ $5,100 per ton
- **Incremental cost** - $640-2,200 per ton refrigeration
- **Market**
  - Some advanced system installations - pilot programs
  - Many advanced compressor technology types and brands are currently on the market
  - Cost of CO2 transcritical systems are expected to decline as number of installations increases
  - Energy savings often a secondary concern when deciding whether or not to move forward with one of these projects. First priority is often eliminating HFCs or reducing refrigerant charge to limit chances of HFC leakage

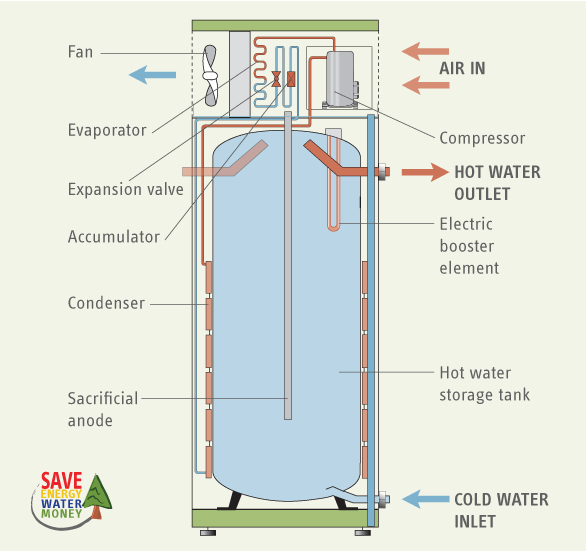
ADVANCED COMPRESSED AIR DIAGNOSTIC MONITORING

- **Baseline** – no networked monitoring equipment; compressors include standard analog gauges and controls
- **Incremental cost** – Project specific, average:
  - $7,800 for a simple system with ≤5 compressors
  - $17,500 for complex systems
- **Market**
  - Eligible for custom incentives, typically with compressor upgrade
  - Costs expected to decline with additional competition, or offer additional features for the same costs
  - Main barriers to installation are cost and ability to identify adequate downtime to install monitoring system



IMPROVED EFFICIENCY ELECTRIC HEAT PUMP WATER HEATERS

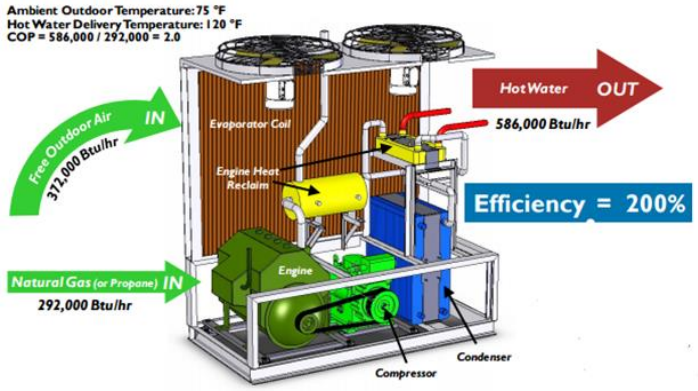
- **Note -** Higher efficiency through a combination of higher coefficient of performance (COP) and/or advanced control strategies
- **Baseline** – Standard electric storage water heaters
- **Incremental cost** – $1,000 to $2,100
- **Other**
  - For colder climates, HPWHs can offer improved performance with modifications to the standard controls systems
  - NEEA - "Northern Climate" specification



- **Market**
  - HPWH incentives offered – potential for 2nd tier
  - Several HPWHs are marketed in Europe with improved performance at increased costs; to date, on one of these products (Stiebel Eltron) is available in the US
  - Costs have been stable for two years and are expected to remain stable
  - Federal standards for electric storage water heaters are due to be updated which will reduce incremental costs

COMM. NATURAL GAS ENGINE POWERED HEAT PUMP WATER HEATERS

- **Baseline** – Project specific, typically fossil fuel fired boiler
- **Incremental cost** – $177/MBtu/h to $277/MBtu/h
  - Baseline, full, and incremental costs are very project specific



- **Market**
  - Typically eligible for custom incentives for displacing natural gas boilers
  - One product line; Ilios/Tecogen actively marketed in the US
  - Current price of natural gas and fuel oil depressing potential
  - Successful projects require large demand for hot water – industrial/institutional
  - Not well known in the US, difficult sales process

SYNCHRONOUS (Q-SYNC) MOTORS

- **Availability –** Fan/motor assemblies now available for small refrigeration cases – sizes for walk-in coolers are under development
- **Baseline** – Shaded pole motors – will shift toward ECM motors for some applications as IECC 2015 and 2018 are adopted
- **Incremental cost** - $169-231 per installed motor
- **Full cost**: Manufacturer currently sells direct to the OEM market at $110 (pre-market stage – no distributor mark-up or labor)
- **Market**
  - Qualifies for ECM incentives – now being piloted by grocery chains – no Q-Sync specific incentives offered
  - Immature market –not yet widely adopted
  - Proprietary patent protected product; one manufacturer (QM Power)
  - Manufacturer states that pricing is targeted to match ECM motor pricing

SUMMARY

- Many emerging technologies ready or near-ready for program inclusion
- Residential, commercial, and industrial sectors impacted
- Costs highly variable in some categories
- Advanced heat pump market including VRF and cold climate models is expanding rapidly
- Integrated LED and controls - many systems and approaches
- Home energy management – many categories not achieving market success and/or not offering significant savings, but may offer demand response opportunities
- Multiple research approaches needed to accurately estimate prices of pre-market products
- New products within and outside the product categories studies are being introduced continuously
- Continuous updates of pricing and product advancement needed

Heat pump clothes dryer

DISCUSSION – Q&A

Wood-fired power supply for LED light and battery charging

THANK YOU

Further information

- Report link
- http://neep.org/initiatives/emv-forum
- http://www.ers-inc.com/
- http://www.zondits.com/

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