



Study Objectives

- ✓ Identify the highest priority EULs to address
- ✓ Develop efficient, quick turn-around, and cost-effective approach and templates to use in future CT EUL studies
- ✓ Update EUL and RUL values for key measures
 - > **Effective Useful Life (EUL)** – the median number of years between installation and replacement
 - > **Remaining Useful Life (RUL)** – a curve or table based on the difference between median current age of operating equipment and its expected age at replacement*

*RUL needed for 2-part baselines – early replacement programs, etc. For RUL# years, the savings are Efficient vs. in-place/old equipment; for the next EUL# years, the baseline is efficient vs. “new standard” eqpt.

Task 1

Measure Selection

- ✓ Based on:
 - > PSD review
 - > Program tracking data
 - > Feedback from utility staff
- ✓ Priority-setting criteria:
 - > Savings impact of measures
 - > EUL availability/rigor of past EUL research
 - > Future trends of measure in programs
 - > Limitations of self-reported data collection (identification problem)

Group	EUL Measure	Total Installations (2011-2019)
1	Air Source Heat Pump	1,933
	Ductless Split Heat Pump	25,154
	Heat Pump Water Heater	14,796
2	Furnace (Natural Gas)	21,667
	Central AC	16,357
	Insulation	12,577*
3	Commercial Unitary HVAC	~2,000

CT X2001 Preliminary Results | Michaels Energy

Task 2

Sampling

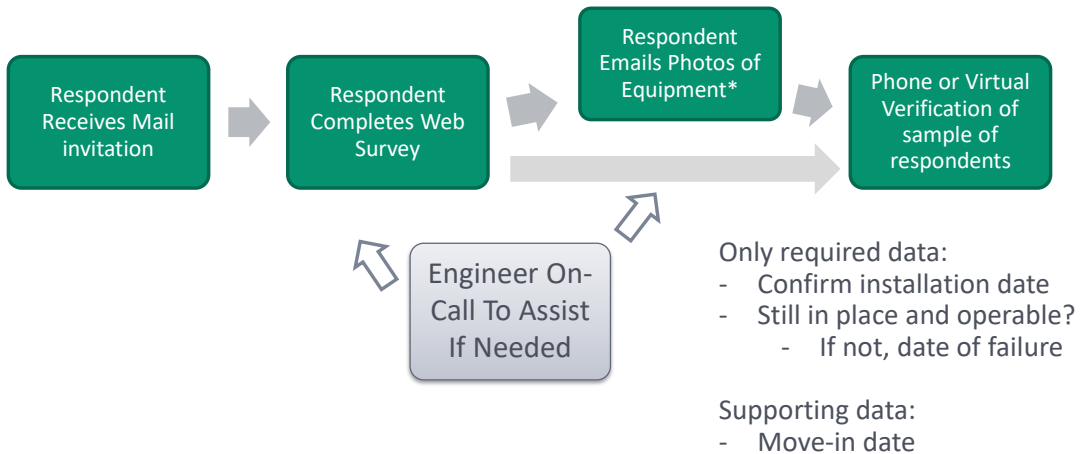
	2011	2012	2013	2014	2015	2016
ASHP	466	277	225	200	286	102
DHP	405	402	447	784	780	755
HPWH	87	162	338	226	35	434

- ✓ Sampled by premise to capture as many measures as possible
- ✓ Stratified by year of installation
 - > Ensures sufficient coverage by equipment age
 - > Oversampling of older equipment for greater chance of information on failure
- ✓ Measures installed in 2017-2019 were included in the HP NEB survey

CT X2001 Preliminary Results | Michaels Energy

Task 3 & 4

Data Collection



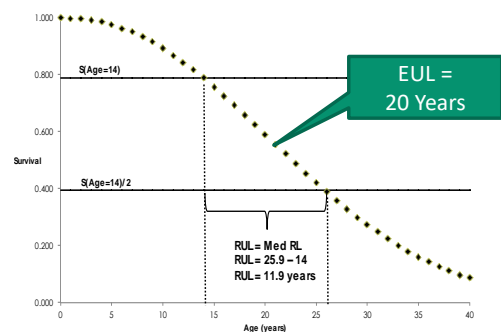
* Not essential to EUL analysis

CT X2001 Preliminary Results | Michaels Energy

Task 4

Measure Survival Analysis Methodology

- ✓ Equipment failures often follow an S-shaped curve called a Weibull distribution
 - > Few failures in early years and a long tail of a few survivors
- ✓ The survival function defines the probability of survival at each point in time
- ✓ EUL estimate is the time at which 50% (i.e., the median) of units are expected to survive



CT X2001 Preliminary Results | Michaels Energy

Results from EUL Measure Group 1

CT X2001 Preliminary Results | Michaels Energy

Task 4

Completed Surveys

	2011	2012	2013	2014	2015	2016	2017*	2018*	2019*	Total
ASHP	48	37	32	24	39	14	0	6	4	204
DHP	40	51	71	60	60	60	170	105	63	680
HPWH	17	27	51	25	3	48	21	14	35	241

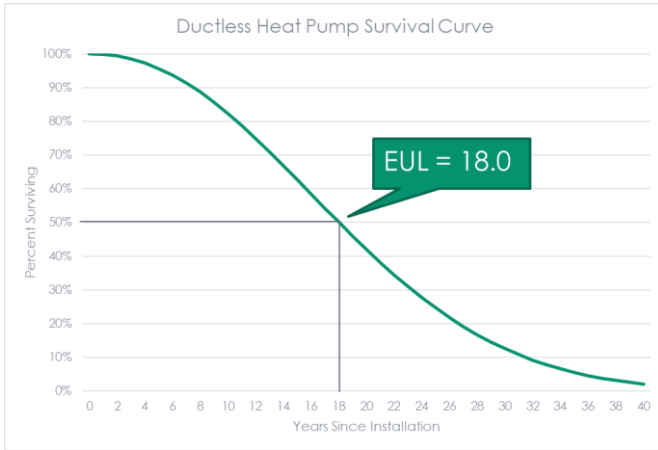
- ✓ Overall response rate of 11.1%
- ✓ Currently sending reminder postcards to early year participants to increase number of data points
 - > Additional completes will improve precision of results
- ✓ Measure Group 2 surveys to be fielded in late June

*From HP NEB Study

CT X2001 Preliminary Results | Michaels Energy

Task 4

Ductless Heat Pump

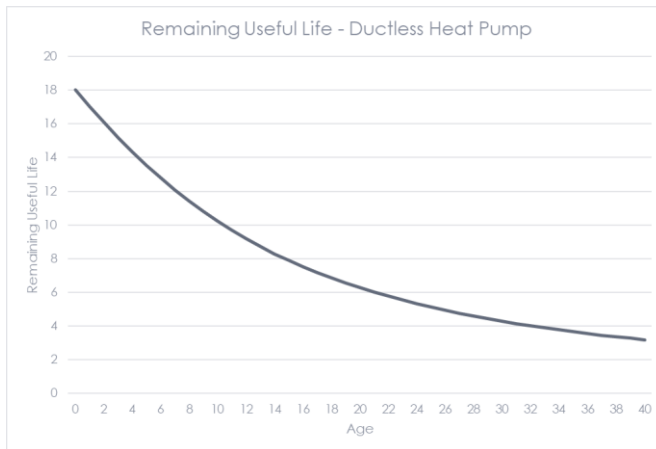


- ✓ Comparable to PSD value of 18 years
- ✓ 90% confidence interval = ± 5.2 years

CT X2001 Preliminary Results | Michaels Energy

Task 4

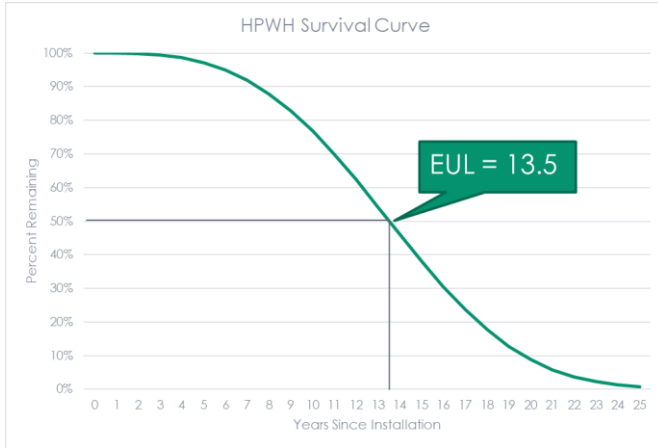
Ductless Heat Pump



CT X2001 Preliminary Results | Michaels Energy

Task 4

Heat Pump Water Heater

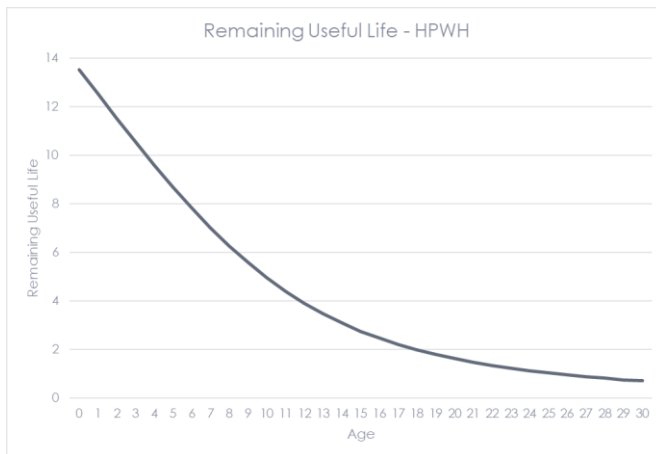


- ✓ Comparable to PSD value of 13 years
- ✓ 90% confidence interval = ± 3.6 years

CT X2001 Preliminary Results | Michaels Energy

Task 4

Heat Pump Water Heater



CT X2001 Preliminary Results | Michaels Energy



Additional Info

Task 4

Advantages of this EUL Project Design

- ✓ Most EUL studies are conducted using ONE program year of installations.
 - > Must wait a few years for FAILURES – EUL studies are completely dependent on failures happening
 - > Then wait more years for more failures. Multiple studies, long elapsed time to gain EUL estimate
- ✓ This study leverages program data
 - > Uses many (9+) years of participants immediately. Early installations provide source of failures NOW; no need for a second follow-up study.
 - > Proven methodology in other jurisdictions (but not for Utility measures)
 - Utility program data provides installation date and equipment type - key pieces of data that need validation in non-utility applications
- ✓ Results:
 - > Less costly and FASTER than panel approach that tracks equipment over multiple years

 CT X2001 Preliminary Results | Michaels Energy

Task 3 & 4

Data Collection Approach

- ✓ No-touch approach
 - > Recruitment through a mail push-to-web survey
 - > Customer answers: if failed* (Y/N), when failed, and age if not-yet-failed (sufficient for EUL statistical analysis)
 - > Customer uploads picture of equipment (and relevant info)
 - Pictures are not required, but will help validate response
 - > Michaels engineers can assist virtually if needed
 - > \$25 incentive for residential respondents
- ✓ Phone or virtual verification for a sample of respondents
 - > On-site unlikely possible before June, but will be included in future template

 * "Failed" – No longer in place and operable.
 Survey will collect limited information on why

CT X2001 Preliminary Results | Michaels Energy

Task 4 Quality Control

- > We asked respondents to email pictures of equipment and nameplate
- > Engineers used these pictures to verify:
 - Equipment Type
 - Age (if mfg date on nameplate)
 - Apparent working order of equipment



CT X2001 Preliminary Results | Michaels Energy

Task 4 Preliminary Quality Control Results

Measure	Total	Provided Pictures	Provided Pictures (%)	Not Verified	Not Verified (%)
ASHP	200	45	23%	1	2%
DHP	365	73	21%	1	1%
HPWH	168	46	27%	3	7%
Total	733	164	22%	5	3%

CT X2001 Preliminary Results | Michaels Energy

Task 4

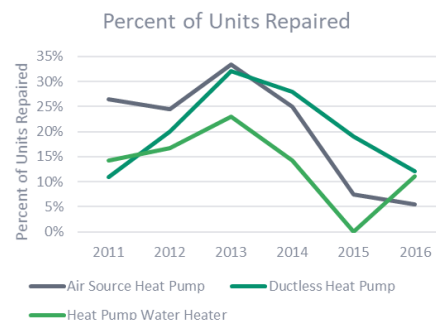
Additional Quality Control

- > Michaels will conduct phone/virtual verification with a sample of respondents to verify survey responses
- > Additional QC outreach to select respondents with questionable responses
- > Reconciliation of survey responses with program tracking data

CT X2001 Preliminary Results | Michaels Energy

Repaired Equipment

- ✓ Overall, 21% of ASHP/ DHP and 16% of HPWH were repaired
- ✓ Larger share of older systems have been repaired, but some noise in data



CT X2001 Kickoff | Michaels Energy