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Memo

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This memorandum presents several examples of the methodology that would need to be applied to integrate the results of the Ex Ante Measure Cost Study (MCS) into the DEER database and the associated Remote Ex Ante Database Interface (READI).[1]

Overview of MCS Cost Models

The primary analytic framework used in the MCS was hedonic price modeling – a regression-based analysis of retail unit prices that allows the price effect of individual features to be estimated in isolation from all other product features. In the context of estimating incremental measure costs, hedonic models were used to isolate the price effect of energy efficiency features and performance. In total, the MCS study team estimated 75 hedonic price models which covered 38 measure groups. The draft MCS results and report were released for stakeholder review on March 11, 2014 and the final MCS results and report were published on June 10, 2014. Comprehensive documentation of the data collection methods, data cleaning methods, and data analysis methods, as well as findings and recommendations are provided in the final report.[2]

In this memorandum, we provide an overview of the methodology that would need to be applied to integrate the *results* of the MCS into the DEER database and READI. At a high level, this methodology would simply involve entering the "parameter values" from the DEER measure definitions into the respective MCS cost models in order to generate ex ante measure cost values

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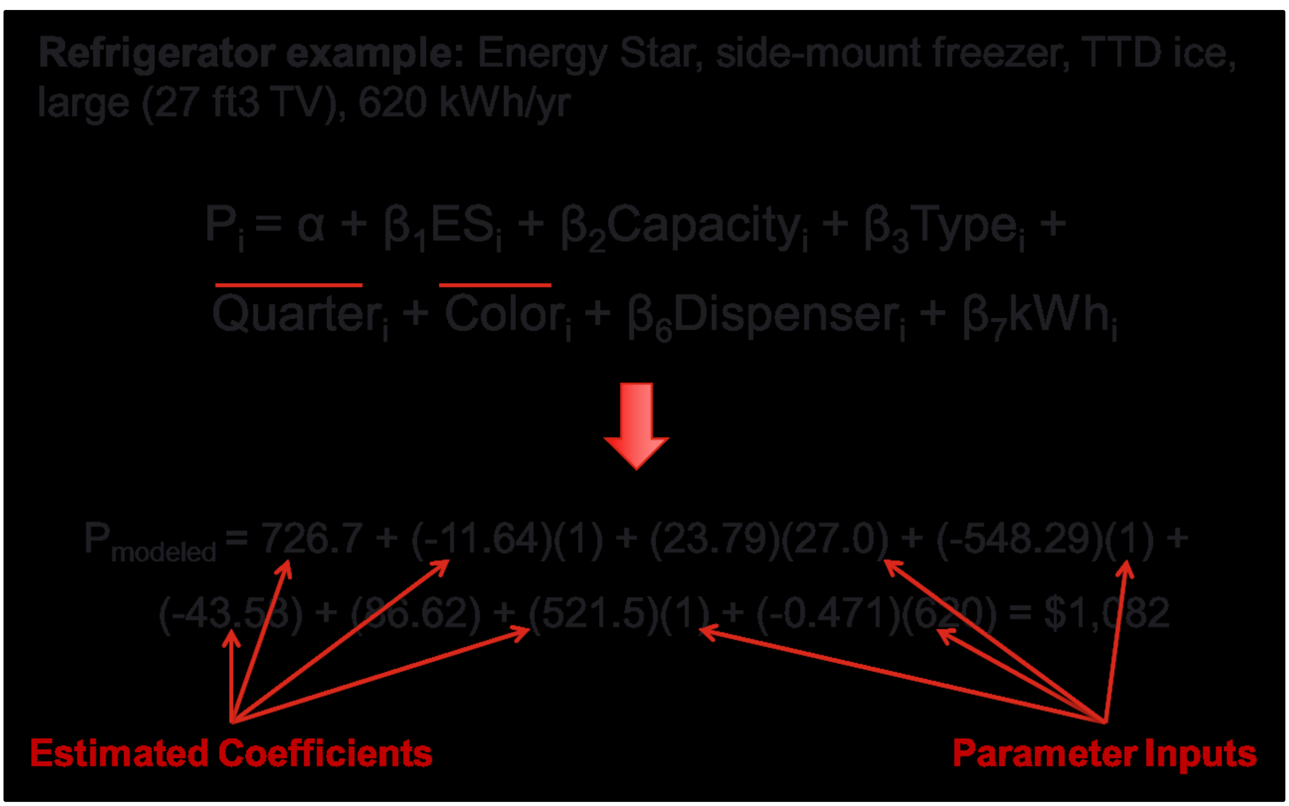
1 This work is also referred to as Work Order 017 in the portfolio of 2010-2012 EM&V studies.

2 http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf

that align directly with the ex ante energy savings values in DEER. More specifically, this would involve the following steps:

- Mapping the variables in the MCS cost models to those in the current DEER measure definitions
- Interacting the parameter values from the DEER measure definitions with the coefficients estimated from the MCS to estimate average unit prices
- Using the MCS results to estimate labor and non-labor installation costs where necessary for incremental cost accounting (e.g. dual baseline measures, add-on measures)
- Using appropriate incremental cost accounting to calculate specific ex ante incremental costs for as many DEER measures as possible, given the data available from the MCS

An example of the "variable mapping" and "parameter-coefficient interaction" steps is shown in the graphic below. For refrigerators, the MCS developed a generalized cost model where unit price (P) is described as function of Energy Star compliance, capacity, type, quarter of sale, exterior color, through-the-door water/ice dispenser, and rated annual kWh energy consumption. The regression produces coefficients (β) for each term on the right-hand side of the equation, as well as an intercept (α). Once the model is specified, estimating the average price for a specific unit is a simple matter of interacting the parameter inputs (e.g. Energy Star-compliant, side-mount freezer, 27 ft3 capacity, 620 kWh/yr, etc.) with the estimated coefficients as shown below.



It should be noted that when developing the cost models, the MCS study team prioritized inclusion of variables that were present in DEER definitions available during time of study (DEER 2011, READI v1.0.4) in order to allow cost estimates align directly with the ex ante energy savings values in DEER. In cases where DEER variables were not included in final MCS cost models, the reason was either that those variables did not contribute to statistically significant price effects for the technology in question or that those variables were collinear with other key DEER variables in the cost model.[3]

As noted above, the incremental costs for some types of measures must also include labor and non-labor installation costs. Specifically, these cases include: 1) replace-on-burnout (ROB) measures with "cross-technology baselines", 2) early replacement measures where dual baseline accounting must be used, and 3) add-on measures.

To further illustrate how the results of the MCS would be used to produce ex ante incremental costs that align with current DEER measure definitions, the remainder of this memorandum provides detailed examples of five cases that we believe are representative of the spectrum of measure types currently in DEER:

- ROB measures with no incremental labor costs;
- ROB measures with incremental labor costs due to "cross-technology baselines";
- Early replacement measures with incremental labor costs;
- Early replacement measures with incremental labor and other non-labor installation costs; and
- Add-on measures with incremental labor costs.

Example #1: Refrigerators

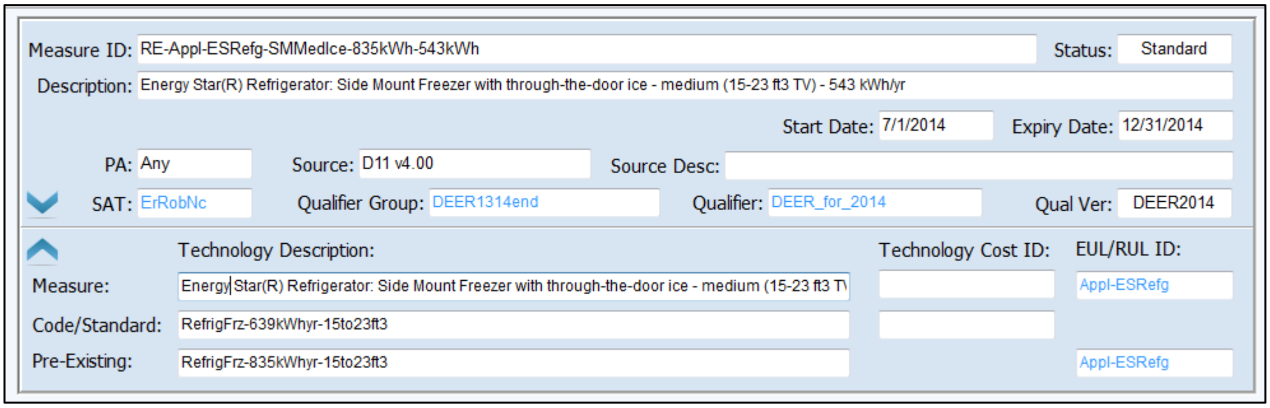
Energy Star-qualified residential refrigerators are an example of a replace-on-burnout (ROB) measure where the incremental measure cost is simply the difference in unit price between a new program-eligible product and a new, standards-compliant baseline product with the identical set of features (except efficiency performance). In these cases, the baseline is determined by code, and installation labor costs are identical between the measure case and the code case, i.e. installation labor costs cancel in the incremental cost calculation.

Below we illustrate how the MCS cost models would be used to calculate the incremental cost for specific refrigerator measures (and all analogous ROB measures) in DEER.

3 For an extended overview of the model development process including a discussion of collinearity, see section 2.5.2 in the MCS final report.

Measure Definition from READI v.2.2.0

For each refrigerator measure in DEER, a specific measure and baseline definition is provided in READI. Below is a screenshot of one specific refrigerator measure: an Energy Star refrigerator with side-mount freezer, through-the-door ice, 15-23 ft3 total volume, and 543 kWh/yr rated energy consumption installed instead of a code-compliant refrigerator with the same features except 639 kWh/yr rated energy consumption.



MCS Cost Model for Refrigerators

The table below (extracted from Table 3-3 in the MCS final report) shows the variables included in the MCS cost model for refrigerators. As the table shows, the MCS cost model includes all of the variables included in the DEER measure definition, as well as two other variables (calendar quarter of sale and exterior color) that help explain differences in retail unit prices. For the latter two variables in the MCS cost model that are not included in the DEER measure definition, the estimated coefficients are "rolled up" to their market-average values using the sales weights included in the price data set and treated as constants.

For the variables that are included in the DEER measure definitions (Energy Star, capacity, door configuration, dispenser, rated annual kWh consumption), calculating average unit price is simply a matter of multiplying the estimated coefficients (as shown in the table below) by their parameter values and summing all terms.[4] For the measure case, the parameter values would be: Energy Star=1, capacity=19 ft3, door config=side-by-side, dispenser=1, and rated kWh=543 kWh/yr.[5] For the baseline case, the parameter values would be the same with the exception of rated kWh set to 639 kWh/yr instead of 543 kWh/yr.

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4 Note that one must include the intercept estimated in each model in the summation. In the case of refrigerators, the value of the intercept is $727.

5 Note that 19 ft3 is the mid-point in the 15-23 ft3 capacity range specified in DEER. We chose to use 19 ft3 here for illustrative purposes, but any value within the stated capacity range can be used.

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
Refrigerators (full size residential)	ENERGY STAR	Binary	Yes	-11.64	-1.03	11.34	N/A	-11.640
			No	0.00	--	--	N/A	0.000
	Capacity (Total volume ft3)	Continuous	7.8 - 31	23.79	17.60	1.35	N/A	23.790
	Type	Categorical	Freezer on Bottom	0.00	--	--	N/A	0.000
			Freezer on Top	-391.09	-24.90	15.74	N/A	-391.091
			French Doors	308.33	18.40	16.78	N/A	308.330
			Side-by-Side	-548.29	-29.20	18.75	N/A	-548.290
	Quarter	Categorical	1	0.00	--	--	0.129	-43.578
			2	-34.90	-3.90	8.86	0.271	
			3	-42.00	-4.90	8.53	0.361	
			4	-79.30	-8.70	9.08	0.239	
	Color	Categorical	White	0.00	--	--	0.395	86.623
			Bisque	71.51	2.51	28.51	0.009	
			Black	14.77	1.92	7.71	0.185	
			Other	169.17	6.17	27.42	0.010	
			Stainless	250.38	32.31	7.75	0.312	
			Stainless Look	40.00	3.96	10.10	0.090	
	Dispenser	Binary	Yes	521.50	42.90	12.15	N/A	521.500
			No	0.00	--	--	N/A	0.000
	kWh/yr	Continuous	253 - 728	-0.47	-5.20	0.09	N/A	-0.471

Incremental Cost Calculation

Because the installation labor in the measure and code cases is identical in this type of ROB situation, the incremental cost is simply the difference in unit price strictly due to efficiency performance, as summarized in the table below.

	Equipment Spec, Installation Scenario	Unit Price	Installation Labor Cost	Total Installed Cost
MCS baseline installed cost	Non-EStar, side-by-side, TTD ice, 19 ft3 TV, 639 kWh/yr	$894.00	N/A	$894.00
MCS full measure installed cost	EStar, side-by-side, TTD ice, 19 ft3 TV, 543 kWh/yr	$927.57	N/A	$927.57
MCS incremental measure cost		***$33.58***	***N/A***	***$33.58***

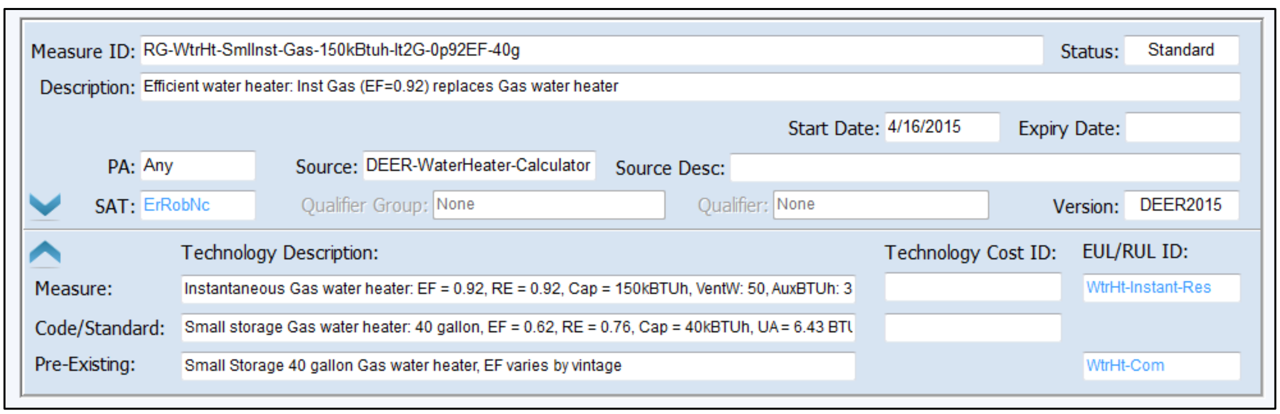
Example #2: Instantaneous Gas Water Heater

Instantaneous gas water heaters are an example of an ROB measure where the installation labor requirements in the measure case and the baseline case are not identical, since the measure case involves installation of different technology (instantaneous water heater) than the baseline case (storage water heater). The total incremental cost calculation, therefore, also must to take into account incremental installation costs.

Below we illustrate how the MCS cost models and MCS labor cost estimates would be used to calculate the incremental cost for these types of "cross-technology baseline" ROB measures in DEER.

Measure Definition from READI v.2.2.0

Below is a screenshot of a specific instantaneous water heater measure in DEER: a 150 kBTUh capacity unit with an energy factor (EF) of 0.92 and a recovery efficiency (RE) of 0.92 installed instead of a code-compliant, 40-gallon gas storage water heater with an EF of 0.62 and an RE of 0.76.



MCS Cost Model for Gas Water Heaters

The table below (extracted from Table 3-11 in the MCS final report) shows the variables included in the MCS cost models for instantaneous gas water heaters and small storage gas water heaters. As the table shows, the MCS cost models include the two key variables included in the DEER measure definitions (capacity and EF), as well as other variables that help explain differences in unit prices. For the variables in the MCS cost models that are not included in the DEER measure definition, the estimated coefficients are "rolled up" to their market-average values using corresponding market data derived from the 2012 CLASS. Note that these "roll up" weights are only applied to coefficients that are statistically significant, i.e. those with t-statistics greater than 2.

As before, calculating average unit price is simply a matter of multiplying the estimated coefficients (as shown in the table below) by their parameter values and summing all terms.[6] For the measure case, the parameter values would be: capacity=150 kBTUh and EF=0.92. For the baseline case, the parameter values would be: capacity=40 gallons, EF=0.62, and forced draft=0. Note that although RE is specified in the DEER definitions of both the measure and baseline units, variations in RE do not have a statistically significant impact on price.

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
Tankless WH	Energy Factor	Continuous	82 - 92 (.82-.92)	13.98	2.97	4.71	N/A	13.980
	Capacity (kbtuh)	Continuous	120-250	5.55	8.47	0.66	N/A	5.550
	Rheem	Binary	Yes	-119.99	-2.60	46.15	0.313	-37.497
			No	0.00	--	--	0.688	
Small Storage Gas WH (<= 75,000 BtuH and EF rated)	Energy Factor	Continuous	0.58-0.7	2332.51	2.32	1005.12	N/A	2332.506
	Rated Volume (gallons)	Continuous	30-65	9.07	2.08	4.36	N/A	9.068
	Forced Draft	Binary	Yes	473.20	5.17	91.47	0.315	148.972
			No	0.00	--	--	0.685	
	Manufacturer	Categorical	AO Smith	-163.91	-0.95	173.27	0.000	0.000
			Bradford-White Co.	0.00	--	--	0.000	
			Rheem	4.63	0.05	100.95	0.000	
			State Industries	-33.31	-0.35	94.80	0.000	

MCS Labor Costs for Gas Water Heaters

As noted above, since the measure case involves installation of different technology (instantaneous water heater) than the baseline case (storage water heater), the total incremental cost calculation must also to take into account incremental installation costs. The table below (extracted from Table 4-13 in the MCS final report) shows the per-unit installation labor costs for these respective technologies. Note that installation labor hours for instantaneous water heaters is expressed as a function of the gallons per minute (GPM) rating of the unit rather than the kBTUh capacity rating, since GPM is a closer proxy for the physical size (and weight) of the unit. For the example below, we used assumed a 150 kBTUh unit has an average GPM rating of 6.0. Note also that the average mark up for installation labor associated with instantaneous water heaters (as estimated in RSMeans) is slightly higher than that for storage water heaters.

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6 Note that one must include the intercept estimated in each model in the summation. For tankless water heaters, the value of the intercept is -$1,300. For small gas storage water heaters, the value of the intercept is -$1,248.

Technology	Installation Dimension/Scenario	Common Unit	Labor Hours per unit	Labor Hourly Rate	Labor Cost per unit	Markup	Total Non-equipment costs ($/unit) excluding fixed costs
Small Storage Gas WH (<= 75 kBtuH and EF rated)	30-100 gal atmospheric gas storage WH labor hours and rates	unit	H = 0.0315(gal) + 2.9443	$64.62	$271.68	21%	$328.73
Tankless WH	Natural gas/propane 3.2 - 9.5 GPM	unit	H = 0.1395(gpm) + 3.4545	$64.62	$277.31	26%	$349.41

Incremental Cost Calculation

For this type of "cross-technology baseline" ROB measure, the total incremental cost reflects both the difference in unit price due to efficiency performance, as well as the difference in installation labor costs, as summarized below. Note that markups of 25% and 15% are applied to the estimated average unit price of the measure and baseline units, respectively, since all of the MCS cost model inputs for these technologies were distributor prices.

	Equipment Spec, Installation Scenario	Unit Price	Installation Labor Cost	Total Installed Cost
MCS baseline installed cost	Storage WH, 40-gallon, EF=0.62	$817	$329	$1,146
MCS full measure installed cost	Tankless WH, 150 kbtuh, EF=0.92	$976	$349	$1,325
MCS incremental measure cost		***$159***	***$20***	***$179***

Example #3: CFL MSB A-lamp

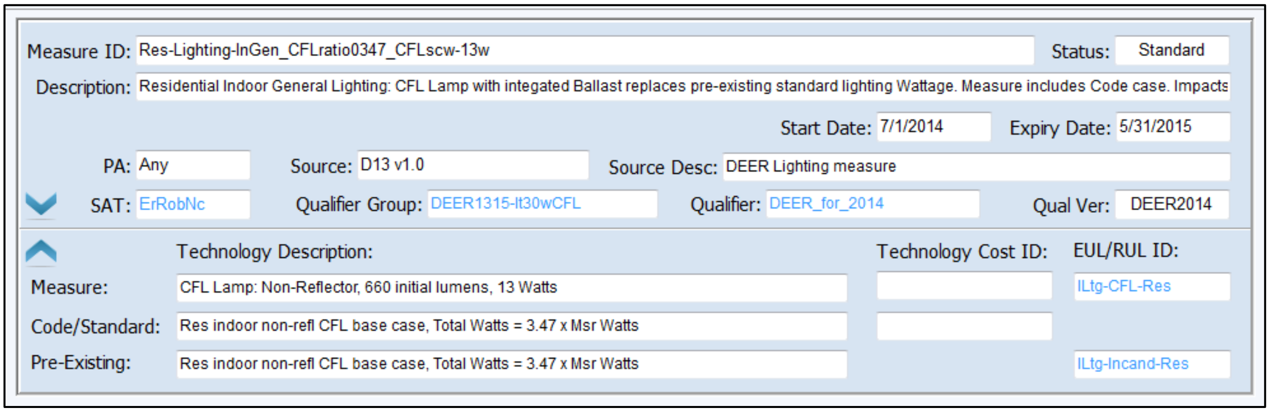
Medium screw-based (MSB) CFL A-lamps are an example of an early retirement (ER) measure where, in the context of large-scale commercial lighting retrofit, the dual baseline accounting of incremental costs requires installation costs to be included in the incremental costs included over the remaining useful life (RUL) period. In contrast, since installation costs are identical between the measure case and the code/standard practice baseline case, installation labor costs cancel in the incremental cost calculation for the effective useful life (EUL) period.[7]

Below we illustrate how the MCS cost models and MCS labor cost estimates would be used to calculate the incremental cost for these types of early replacement measures in DEER.

[7] Technically, the second period in dual baseline framework is the period between when the removed equipment would have reached the end of its useful life and the end of the useful life of the new equipment installed at time zero. For simplicity, we refer to this second period as the EUL period.

Measure Definition from READI v.2.2.0

Below is a screenshot of a specific CFL twister measure in DEER: a 13 watt, 660 lumen integral-ballast CFL twister lamp replacing a functioning existing 45 watt incandescent A-lamp.[8]



MCS Cost Models for MSB Lighting

The table below (extracted from Table 3-8 in the MCS final report) shows the variables included in the MCS cost models for MSB lighting. As the table shows, the MCS cost models include the key variable included in the DEER measure definitions (wattage), as well as other variables that help explain differences in unit prices.[9] For the variables in the MCS cost models that are not included in the DEER measure definition, the estimated coefficients are "rolled up" to their market-average values using corresponding market data derived from the 2013 Retail Lighting Shelf Survey (RLSS). Note that these "roll up" weights are only applied to coefficients that are statistically significant, i.e. those with t-statistics greater than 2.

As before, calculating average unit price is simply a matter of multiplying the estimated coefficients (as shown in the table below) by their parameter values and summing all terms.[10] For the measure case, the parameter values would be: A-lamp=0 (i.e. CFL twister), three-way=0, dimmable=0, utility discount=0, rated life=10,000 hours, and watts=13. For the baseline case, the parameter values would be: EISA=1, three-way=0, rated life=1,500 hours, and watts over 30=15.

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8 45 watts is equal to the DEER "delta watts" shown in the screenshot above (3.47) multiplied by the specified CFL wattage (3.47 x 13 watts = 45 watts).

9 Note that in both the incandescent and CFL cost models, lumen output was highly collinear with lamp wattage and therefore was removed as an explanatory variable from the respective model specifications.

10 Note that one must include the intercept estimated in each model in the summation. For incandescent A-lamps, the value of the intercept is $2.13. For CFL A-lamps and twisters, the value of the intercept is $3.04.

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
Incandescent A-Lamp	Channel	Categorical	Home Improvement	0.00	.	.	0.036	0.237
			Drug Store	0.99	14.91	0.07	0.096	
			Grocery	0.25	3.09	0.08	0.151	
			Hardware	0.42	7.15	0.06	0.140	
			Mass Merchandise	0.13	2.03	0.06	0.356	
			Membership Club	0.42	0.89	0.47	0.000	
	EISA	Binary	Yes	0.33	4.02	0.08	N/A	0.334
			No	0.00	.	.	N/A	0.000
	Package size: 2 or more	Binary	Yes	-1.69	-21.56	0.08	0.919	-1.551
			No	0.00	.	.	0.081	
	Package size: 3 or more	Binary	Yes	-1.16	-20.36	0.06	0.789	-0.912
			No	0.00	.	.	0.211	
	Three-way	Binary	Yes	0.46	4.90	0.09	N/A	0.462
			No	0.00	.	.	N/A	0.000
	National brand	Binary	Yes	0.83	11.17	0.07	0.718	0.599
			No	0.00	.	.	0.282	
	Expected Life (1000s of hours)	Continuous	.6-15	0.20	6.63	0.03	N/A	0.199
	Watts over 30	Continuous	0 - 120	0.01	5.16	0.00	N/A	0.009
	Watts over 75	Continuous	0 - 75	-0.01	-3.21	0.00	N/A	-0.009
CFL A-Lamps and Twisters	Channel	Categorical	Home Improvement	0.00	.	.	0.105	-0.150
			Drug Store	1.22	11.58	0.11	0.063	
			Grocery	-0.37	-2.60	0.14	0.325	
			Hardware	1.13	11.46	0.10	0.087	
			Mass Merchandise	-0.30	-3.18	0.09	0.179	
			Membership Club	-1.02	-4.79	0.21	0.146	
	A-lamp Indicator	Binary	Yes	1.84	18.16	0.10	N/A	1.841
			No	0.00	.	.	N/A	0.000
	Package size: 2 or more	Binary	Yes	-1.81	-21.60	0.08	0.756	-1.365
			No	0.00	.	.	0.244	
	Package size: 4 or more	Binary	Yes	-1.13	-11.08	0.10	0.425	-0.480
			No	0.00	.	.	0.575	
	Three-way	Binary	Yes	6.75	35.65	0.19	N/A	6.751
			No	0.00	.	.	N/A	0.000
	Dimmable	Binary	Yes	5.81	42.95	0.14	N/A	5.805
			No	0.00	.	.	N/A	0.000
	National brand, no	Binary	Yes	1.11	14.52	0.08	0.473	0.527

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
	utility discount		No	0.00	.	.	0.527	
	Utility discount, A-Lamp	Binary	Yes	-3.52	-5.40	0.65	N/A	-3.515
			No	0.00	.	.	N/A	0.000
	Utility discount, Twister	Binary	Yes	-1.80	-7.34	0.25	N/A	-1.804
			No	0.00	.	.	N/A	0.000
	Expected Life (1000s of hours)	Continuous	1-15	0.06	3.54	0.02	N/A	0.062
	Watts	Continuous	4-55	0.07	10.05	0.01	N/A	0.067
	Watts over 25	Continuous	0-30	0.09	4.69	0.02	N/A	0.094

MCS Labor Costs for MSB Lighting

As noted above, since the measure case involves replacing existing, still-functioning equipment higher-efficiency versions of the same equipment, so the total incremental cost calculation must also take into account installation costs over the RUL period. The table below (extracted from Table 4-13 in the MCS final report) shows the per-unit installation labor costs for these respective technologies. Note that installation labor hours, labor rates, and markups for installation of incandescent A-lamps and CFL twisters are identical.

Technology	Installation Dimension/Scenario	Common Unit	Labor Hours per unit	Labor Hourly Rate	Labor Cost per unit	Markup	Total Non-equipment costs ($/unit) excluding fixed costs
Incandescent A-Lamps	Labor hours and rates	lamp	0.08	$58.27	$4.64	24%	$5.75
CFL A-Lamps and Twisters	Labor hours and rates	lamp	0.08	$58.27	$4.64	24%	$5.75

Incremental Cost Calculation

For this type of early replacement measure, the total incremental cost calculation differs for the RUL and EUL periods. For the RUL period, total incremental costs reflect both the difference in unit price, as well as the installation labor costs of the measure, as summarized below. For the EUL period, total incremental costs reflect only the difference in the unit price between the measure and the baseline.

	Equipment Spec, Installation Scenario	Unit Price	Installation Labor Cost	Total Installed Cost
MCS baseline installed cost	Incandescent A-lamp, EISA-compliant, 1,500 hr rated life, 45 watts	$1.27	$5.75	$7.02
MCS full measure installed cost	CFL twister, 10,000 hr rated life, 13 watts	$3.06	$5.75	$8.81
MCS incremental measure cost (RUL)		***$3.06***	***$5.75***	***$8.81***
MCS incremental measure cost (EUL) [11]		***$1.79***	***$0***	***$1.79***

Example #4: Water-Cooled Chiller

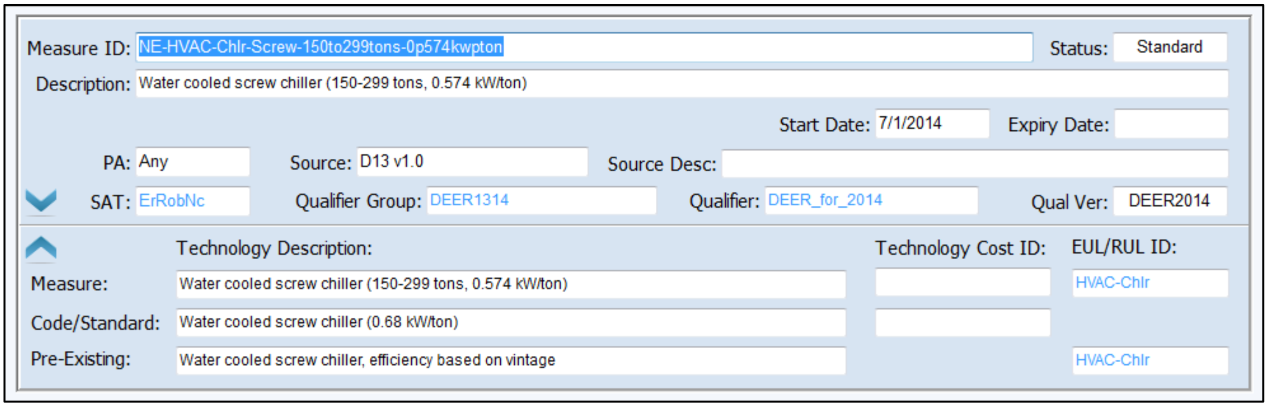
Water-cooled chillers are an example of an early retirement (ER) measure where the dual baseline accounting of incremental costs requires both labor-related and other non-labor related installation costs to be included in the incremental costs included over the remaining useful life (RUL) period. In contrast, since installation costs are identical between the measure case and the code/standard practice baseline case, installation labor costs cancel in the incremental cost calculation for the effective useful life (EUL) period.

Below we illustrate how the MCS cost models and MCS labor cost estimates would be used to calculate the incremental cost for these types of early replacement measures in DEER.

Measure Definition from READI v.2.2.0

Below is a screenshot of a specific water-cooled chiller measure in DEER: a 150-299 ton, 0.574kW/ton, water-cooled screw chiller replacing a less efficient, functional water-cooled screw chiller of the same capacity.

[11] Note that in the case of CFLs, since the rated life of CFLs is so much longer than the incandescent lamps they replace, the baseline installed cost for the EUL period would technically need to reflect the cost of replacing incandescent lamps at multiple points in time to cover the EUL of the CFL lamp. In the dual baseline framework, those future baseline costs would then need to be properly discounted to account for the time value of money. In this sense, what is shown in the table above are the time zero incremental costs for the RUL and EUL period.


Measure ID: NE-HVAC-Chlr-Screw-150to299tons-0p574kwpton
Status: Standard
Description: Water cooled screw chiller (150-299 tons, 0.574 kW/ton)
Start Date: 7/1/2014
Expiry Date:
PA: Any
Source: D13 v1.0
Source Desc:
SAT: ErRobNc
Qualifier Group: DEER1314
Qualifier: DEER_for_2014
Qual Ver: DEER2014

	Technology Description:	Technology Cost ID:	EUL/RUL ID:
Measure:	Water cooled screw chiller (150-299 tons, 0.574 kW/ton)		HVAC-Chlr
Code/Standard:	Water cooled screw chiller (0.68 kW/ton)		
Pre-Existing:	Water cooled screw chiller, efficiency based on vintage		HVAC-Chlr

MCS Cost Model for Water-Cooled Chillers

The table below (extracted from Table 3-17 in the MCS final report) shows the variables included in the MCS cost models for water-cooled chillers. As the table shows, the MCS cost models include the three key variables included in the DEER measure definitions. As before, calculating average unit price is simply a matter of multiplying the estimated coefficients (as shown in the table below) by their parameter values and summing all terms.[12] For the measure case, the parameter values would be: capacity=200 tons, kW/ton=0.574, and compressor type=screw. For the baseline code case, the parameter values would be: capacity=200 tons, kW/ton=0.680, and compressor type=screw.

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
Water-Cooled Chillers (excluding centrifugal VSD)	Capacity (tons)	Continuous	59.9-550	251.29	8.45	29.74	N/A	251.293
	kW/ton	Continuous	0.478-0.769	-200329.95	-3.52	56925.61	N/A	-200329.951
	Compressor type	Categorical	Centrifugal	-18496.30	-2.93	6309.64	N/A	-18496.303
			Screw	0.00	--	--	N/A	0.000
			Scroll	-4315.70	-0.58	7472.94	N/A	-4315.696

MCS Labor Costs for Water-Cooled Chillers

As noted above, since the measure case involves replacing existing, still-functioning equipment higher-efficiency versions of the same equipment, so the total incremental cost calculation must take into account installation costs over the RUL period. For ER measures involving large capital equipment such as chillers, these installation labor costs can vary widely depending on the location and conditions of the installation site (e.g. roof mount vs. ground mount). Additionally, there are also significant other non-labor installation costs that must be taken into account as

[12] Note that one must include the intercept estimated in each model in the summation. For water-cooled chillers, the value of the intercept is $163,883.

well. In the case of water-cooled chillers, these non-labor installation costs include crane rental, engineering/survey, project management, permits, insurance, bond, contingency, and warranty.

The table below (extracted from Table 4-10 in the MCS final report) shows the per-unit installation labor costs, per-unit miscellaneous costs, and miscellaneous fixed costs for water-cooled chiller installations.

Technology	Installation Dimension/Scenario	Common Unit	Labor Hrs per unit	Labor Hourly Rate	Labor Cost per unit	Misc Costs per unit	Misc Fixed Costs (per project)	Markup	Total Non-equipment costs ($/unit) excluding fixed costs
Water-Cooled Chillers (excluding centrifugal VSD)	100 ton ground mount Labor and non-equipment costs	tons	1.145	$71.49	$81.86	$203.9031	$1,400.00	25%	$357.20
	200 ton ground mount Labor and non-equipment costs	tons	0.788		$56.30	$179.9490	$2,150.00		$295.31
	300 ton ground mount Labor and non-equipment costs	tons	0.605		$43.25	$155.0163	$2,750.00		$247.84
	100 ton basement Labor and non-equipment costs	tons	1.585		$113.31	$215.6396	$5,000.00		$411.19
	200 ton basement Labor and non-equipment costs	tons	1.058		$75.60	$185.5025	$5,500.00		$326.38
	300 ton basement Labor and non-equipment costs	tons	0.740		$52.90	$159.1166	$6,250.00		$265.03
	100 ton roof mount Labor and non-equipment costs	tons	1.330		$95.08	$214.7769	$3,250.00		$387.33
	200 ton roof mount Labor and non-equipment costs	tons	0.855		$61.13	$183.0231	$4,000.00		$305.19
	300 ton roof mount Labor and non-equipment costs	tons	0.673		$48.14	$157.4424	$4,750.00		$256.98

Incremental Cost Calculation

For this type of early replacement measure, the total incremental cost calculation differs for the RUL and EUL periods. For the RUL period, total incremental costs reflect both the difference in unit price, as well as the total installation costs (labor and non-labor) of the measure, as summarized below. For the EUL period, total incremental costs reflect only the difference in the unit price between the measure and the baseline. Note that a 20% markup is applied to the estimated average unit price of both the measure and baseline units since all of the MCS cost model inputs for these technologies were distributor prices.

	Equipment Spec, Installation Scenario	Unit Price	Installation Labor Cost	Non-Labor Installation Cost	Total Installed Cost
MCS baseline installed cost	Water-cooled screw chiller, 200 tons, 0.680 kW/ton, roof mount	$93,500	$15,281[13]	$50,756[14]	$159,538
MCS full measure installed cost	Water-cooled screw chiller, 200 tons, 0.574 kW/ton, roof mount	$118,982	$15,281	$50,756	$185,020
MCS incremental measure cost (RUL)		***$118,982***	***$15,281***	***$50,756***	***$185,019***
MCS incremental measure cost (EUL)		***$25,482***	***$0***	***$0***	***$25,482***

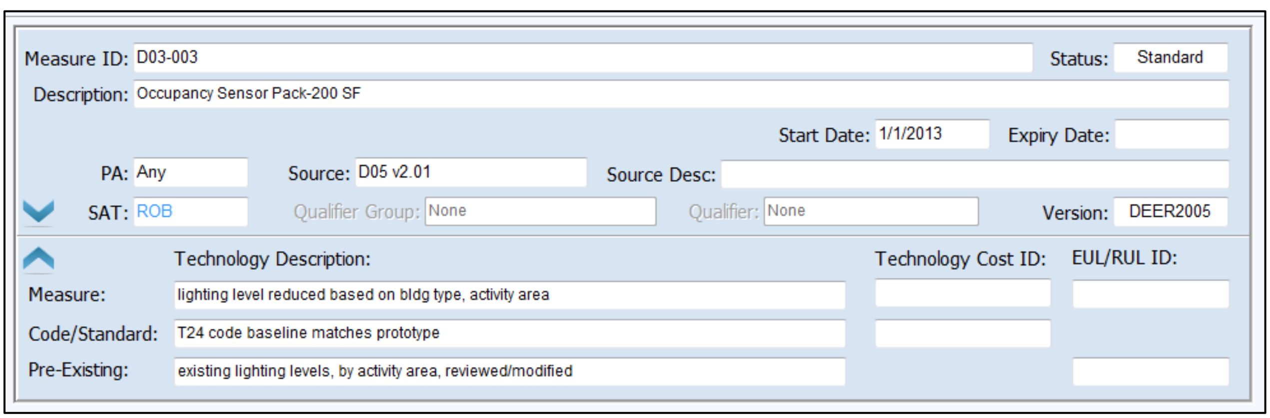
Example #5: Occupancy Sensor

Occupancy sensors are an example of an add-on measure where the incremental measure cost is equal to the full installed cost of the measure. In these cases, the baseline condition is the absence of the measure, so no baseline costs need to be accounted for.

Below we illustrate how the MCS cost models would be used to calculate the incremental cost for a specific occupancy sensor measure (and all analogous add-on measures) in DEER.

Measure Definition from READI v.2.2.0

Below is a screenshot of one specific occupancy sensor measure: an occupancy sensor pack that provides 200 ft2 of sensing coverage.


Measure ID: D03-003
Status: Standard
Description: Occupancy Sensor Pack-200 SF
Start Date: 1/1/2013
Expiry Date:
PA: Any
Source: D05 v2.01
Source Desc:
SAT: ROB
Qualifier Group: None
Qualifier: None
Version: DEER2005
Technology Description:
Technology Cost ID:
EUL/RUL ID:
Measure: lighting level reduced based on bldg type, activity area
Code/Standard: T24 code baseline matches prototype
Pre-Existing: existing lighting levels, by activity area, reviewed/modified

13 200 tons * 0.855 hrs/ton * $71.49/hr * 1.25 = $15,281.

14 (200 tons * $183.0231/ton + $4,000) * 1.25 = $50,756.

MCS Cost Model for Occupancy Sensors

The table below (extracted from Table 3-14 in the MCS final report) shows the variables included in the MCS cost model for occupancy sensors. As the table shows, the MCS cost model includes the key variable included in the DEER measure definition, as well as a host of other variables that help explain differences in unit prices. For the variables in the MCS cost model that are not included in the DEER measure definition, the estimated coefficients are "rolled up" to their market-average values using the weights reflected in the price data set and treated as constants. For the key variable that is included in the DEER measure definitions (ft2 coverage), calculating average unit price is simply a matter of multiplying the estimated coefficient (as shown in the table below) by its parameter values and summing all terms.[15] For the measure case, the parameter value would be coverage=200.

Technology	Variable	Type	Values	Model Coefficients	t-stat	s.e.	Weights for Roll-up to DEER/WP	DEER/WP-equivalent Coefficients
Occupancy Sensors	Coverage (ft2)	Continuous	90 - 2,152	0.00	0.36	0.01	N/A	0.006
	Battery Powered	Binary	Yes	-60.55	3.35	18.07	0.050	-3.028
			No	0.00			0.950	
	Solar Powered	Binary	Yes	49.27	2.21	22.33	0.025	1.232
			No	0.00			0.975	
	Outdoor	Binary	Yes	178.88	14.08	12.71	0.075	13.416
			No	0.00			0.925	
	Two Loads	Binary	Yes	101.15	5.91	17.13	0.050	5.058
			No	0.00			0.950	
	Ultrasonic	Binary	Yes	42.36	5.14	8.24	0.375	15.885
			No	0.00			0.625	
	12 volt	Binary	Yes	-49.53	2.22	22.33	0.025	-1.238
			No	0.00			0.975	
	18 volt	Binary	Yes	48.54	4.10	11.83	0.075	3.641
			No	0.00			0.925	
	24 volt	Binary	Yes	-49.33	4.15	11.88	0.500	-24.665
			No	0.00			0.500	
	120 volt	Binary	Yes	-34.27	3.00	11.42	0.300	-10.281
			No	0.00			0.700	
	277 volt	Binary	Yes	-29.37	2.56	11.46	0.275	-8.077
			No	0.00			0.725	

15 Note that one must include the intercept estimated in each model in the summation. In the case of occupancy sensors, the value of the intercept is $117.42.

MCS Labor Costs for Occupancy Sensors

As noted above, since the measure case involves installing a technology to work with existing systems, the total incremental cost is the full installed cost and therefore must take into account installation labor costs and non-labor installation costs. The table below (extracted from Table 4-6 in the MCS final report) shows the per-unit installation labor costs for these respective technologies. For add-on measures like occupancy sensors, installation labor costs can vary widely depending on the location and conditions of the installation (e.g. wall-mounted vs. ceiling-mounted sensors). In the specific case of occupancy sensors, there are also other non-labor installation costs that must be taken into account as well, such as removal and disposal of the manual switches.

Technology	Installation Dimension/Scenario	Common Unit	Labor Hours per unit	Labor Hourly Rate	Labor Cost per unit	Miscellaneous Costs per unit	Markup	Total Non-equipment costs ($/unit) excluding fixed costs
Occupancy Sensors	Wall mounted labor	sensor	1.1946		$67.55		26%	$91.85
	Wall mounted disposal and taxes	sensor				$5.34		
	Ceiling mounted labor	sensor	1.5098		$85.38			$124.11
	Ceiling mounted disposal and taxes	sensor				$13.12		
	Fixture integrated labor	sensor	1.1355		$64.21			$90.46
	Fixture integrated disposal and taxes	sensor				$7.58		
	Labor rate	sensor		$56.55				

Incremental Cost Calculation

For this type of add-on measure, the total incremental cost reflects the total installed cost of the measure, including unit price, installation labor costs, and non-labor installation costs, as summarized below. Note that a 26% markup is applied to the estimated average unit price of the measure units since all of the MCS cost model inputs for these technologies were distributor prices.

	Equipment Spec, Installation Scenario	Unit Price	Installation Labor Cost	Non-Labor Installation Cost	Total Installed Cost
MCS baseline installed cost	Manual switches	N/A	N/A	N/A	N/A
MCS full measure installed cost	Occupancy sensor, 200 ft2 coverage, wall mount	$138.20	$85.12	$6.73	$230.05
MCS incremental measure cost		***$138.20***	***$85.12***	***$6.73***	***$230.05***