DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Product: High Efficiency Air Conditioning

Description:

Prescriptive rebates will be offered for new cooling equipment. Rebates for most measures are dependent on size and on meeting a minimum efficiency. Plan A is defined as central air conditioning (CAC) or air-source heat pump (ASHP) systems installed in new homes, existing homes without CAC or ASHP systems or homes with CAC or ASHP systems that are inoperable or unrepairable. Plan B is for existing CAC or ASHP systems that are operable or made operable for a reasonable cost ($500 to $1500). The equations for calculating savings are identical between Plan A and Plan B, but the baseline unit efficiencies are different as described below. Ground Source Heat Pumps will be rebated with a Quality Install (appropriate for GSHP) in new homes or when replacing electric resistance heating equipment in existing homes. For new Mini-Split Heat Pumps (MSHP) it is assumed that the MSHP is being installed in either new construction or to supplement an existing heating and cooling system. The MSHP rebate is intended to incent customers to install a high efficiency MSHP rather than the code level baseline unit.

Algorithms:

Conversions:

Seasonal Energy Efficiency Ratio (SEER)	= Total seasonal cooling output (kBtuh) / Total electrical input (kWh); for estimating seasonal performance
Energy Efficiency Ratio (EER)	= Rated cooling output (kBtuh) / Rated electrical input (kW) for equipment tested at 95F estimating peak cooling performance; ~~EER = -0.02 x SEER^2 + 1.12 x SEER . This equation relating EER to SEER applies to all equipment in this product, and will be used if EER rating is not available. (Reference 1)~~
HSPF	= Total seasonal heating output (kBtuh) / Total electrical input (kWh); for estimating seasonal performance
kW/ton	= 12 / Energy Efficiency Ratio
Heating Seasonal Performance Factor (HSPF)	= 3.412 x Heat Energy Output (Btu) / Energy Input to Compressor (Btu)
Coefficient of Performance (COP) Heating	= Heat Energy Output (Btu) / Energy Input to Compressor (Btu) or HSPF / 3412 x 1000
For Cooling by Split System Air Conditioners and Air Source Heat Pumps and Ground Source Heat Pumps:	
kW_No_QI_Standard (Plan A and Plan B)	= Size x 12/(EER_Standard x (1 - Sizing_Loss))
kW_No_QI_Eff	= Size x 12/(EER_Eff x (1 - Sizing_Loss))
kW QI_Standard (Plan A and Plan B)	= Size x (1 - Sizing_Loss_QI) x 12/EER_Standard
kW QI_Eff	= Size x (1 - Sizing_Loss_QI) x 12/EER_Eff
kW_No_QI_New_Home_Standard_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_New_Home x 12/(EER_Standard x (1 - Sizing_Loss))**
kW QI_New_Home_Eff_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_New_Home x (1 - Sizing_Loss_QI) x 12/EER_Eff**
kW_No_QI_Existing_Home_Standard_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_Existing_Home x 12/(EER_Standard x (1 - Sizing_Loss))**
kW QI_Existing_Home_Eff_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_Existing_Home x (1 - Sizing_Loss_QI) x 12/EER_Eff**
kWh_No_QI_New_Home_Standard	= Size x EFLH_New x 12/(SEER_Standard x (1 - Loss_No_QI_New))
kWh_No_QI_Existing_Home_Standard	= Size x EFLH_Existing x 12/(SEER_Standard x (1 - Loss_No_QI_Exist))
kWh_No_QI_New_Home_Eff	= Size x EFLH_New x 12/(SEER_Eff x (1 - Loss_No_QI_New))
kWh_No_QI_Existing_Home_Eff	= Size x EFLH_Existing x 12/(SEER_Eff x (1 - Loss_No_QI_Exist))
kWh_No_QI_New_Home_Eff_GSHP	= **GSHP_**Size **x GSHP_Cooling Ratio_New_Home** x EFLH_New x 12/(SEER_Eff x (1 - Loss_No_QI_New_GSHP))
kWh_No_QI_Existing_Home_Eff_GSHP	= **GSHP_**Size **x GSHP_Cooling Ratio_Existing_Home** x EFLH_Existing x 12/(SEER_Eff x (1 - Loss_No_QI_Exist_GSHP))
kWh QI New Home_Standard	= Size x EFLH_New x 12/(SEER_Standard x (1 - Uncorr_Loss_New))
kWh QI New Home_Eff	= Size x EFLH_New x 12/(SEER_Eff x (1 - Uncorr_Loss_New))
kWh QI Existing Home_Standard	= Size x EFLH_Existing x 12/(SEER_Standardf x (1 - Uncorr_Loss_Exist))
kWh QI Existing Home_Eff	= Size x EFLH_Existing x 12/(SEER_Eff x (1 - Uncorr_Loss_Exist))

kWh QI New Home_Eff_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_New_Home x EFLH_New x 12/(SEER_Eff x (1 - Uncorr_Loss_New))**
kWh QI Existing Home_Eff_GSHP	**= GSHP_Size x GSHP_Cooling Ratio_Existing_Home x EFLH_Existing x 12/(SEER_Eff x (1 - Uncorr_Loss_Exist))**
New Equipment Electrical Energy Savings_New_Home (Customer kWh)	= kWh_No_QI_New_Home_Standard - kWh_No_QI_New_Home_Eff
New Equipment Electrical Energy Savings_Existing_Home (Customer kWh)	= kWh_No_QI_Existing_Home_Standard - kWh_No_QI_Existing_Home_Eff
New Equipment Electrical Energy Savings_New_Home_GSHP (Customer kWh)	= kWh_No_QI_New_Home_Standard - kWh_No_QI_New_Home_Eff_GSHP
New Equipment Electrical Energy Savings_Existing_Home_GSHP (Customer kWh)	= kWh_No_QI_Existing_Home_Standard - kWh_No_QI_Existing_Home_Eff_GSHP
New Equipment Electrical Demand Savings (Customer kW)	= kW_No_QI_Standard - kW_No_QI_Eff
New Equipment Electrical Demand Savings _New_Home_GSHP (Customer kW)	**= kW_No_QI_New_Home_Standard_GSHP - kW QI_New_Home_Eff_GSHP**
New Equipment Electrical Demand Savings _Existing_Home_GSHP (Customer kW)	**= kW_No_QI_Existing_Home_Standard_GSHP - kW QI_Existing_Home_Eff_GSHP**
~~Quality Install Electrical Energy Savings New Home_Standard (Customer kWh)~~	~~= kWh_No_QI_New_Home_Standard - kWh QI New Home_Standard~~
Quality Install Electrical Energy Savings New Home_Eff (Customer kWh)	= kWh_No_QI_New_Home_Eff - kWh QI New Home_Eff
~~Quality Install Electrical Energy Savings Existing Home_Standard (Customer kWh)~~	~~= kWh_No_QI_Existing_Home_Standard - kWh QI Existing Home_Standard~~
Quality Install Electrical Energy Savings Existing Home_Eff (Customer kWh)	= kWh_No_QI_Existing_Home_Eff - kWh QI Existing Home_Eff
Quality Install Electrical Energy Savings New Home_Eff_GSHP (Customer kWh)	= kWh_No_QI_New_Home_Eff_GSHP - kWh QI New Home_Eff_**GSHP**
Quality Install Electrical Energy Savings Existing Home_Eff_GSHP (Customer kWh)	= kWh_No_QI_Existing_Home_Eff_GSHP - kWh QI Existing Home_Eff_**GSHP**
Quality Install Electrical Demand Savings (Customer kW)	= kW_No_QI_Eff - kW_QI_Eff

Quality Install Incremental Cost	= Quality_Install_Cost_Existing_Home - Size x AC_Cost_Per_Ton x Sizing_Loss_QI (or minimum value of $75)

Present Value ($)	=Future Value * (1+rate) ^ (number of periods * -1)

For Heating by ~~Forced Air Electric Resistance Heating, and Air Source Heat Pumps and~~ Ground Source Heat Pumps:	
kW_No_QI_Standard	= **GSHP**_Size x (1 + Sizing_Loss) /Standard_COP / 3412
kW QI_Eff	= **GSHP**_Size / GSHP_COP / 3412
kWh_No_QI_New_Home_Standard_GSHP_Heating	**= Btu_Heat_New / 3412 x 3.412 /(HSPF_Standard_ASHP x (1- Loss_No_QI_New_GSHP))**
kWh_No_QI_Existing_Home_Standard_GSHP_Heating	**= Btu_Heat_Exist / 3412 / (Standard_COP_electric resistance heater X (1-Loss_No_QI_Exist_GSHP))**
~~kWh_QI_New_Home_Standard~~	~~= Btu_Heat_New / 3412 x 3.412 / (HSPF_Standard x (1 - Uncorr_Loss_New))~~
~~kWh_QI_Existing_Home_Standard~~	~~= Btu_Heat_Exist / 3412 / (1 x (1 - Uncorr_Loss_Exist))~~
kWh_QI_New_Home_Eff_GSHP_**Heating**	= Btu_Heat_New / (GSHP_COP x (1 - Uncorr_Loss_New)) / 3412
kWh_QI_Existing_Home_Eff_GSHP_**Heating**	= Btu_Heat_Exist / (GSHP_COP x (1 - Uncorr_Loss_Existing)) / 3412
New Equipment Energy Savings_New_Home_**GSHP_Heating**	= kWh_No_QI_New_Home_Standard_GSHP_Heating - kWh_QI_New_Home_Eff_GSHP_Heating
New Equipment Energy Savings_Existing_Home_**GSHP_Heating**	= kWh_No_QI_Existing_Home_Standard_GSHP_Heating - kWh_QI_Existing_Home_Eff_GSHP_Heating

Electrical Energy Savings (Gross Generator kWh)	= Customer kWh / (1-TDLF)
Electrical Demand Savings (Gross Generator kW)	= Customer kW x CF / (1-TDLF)
Electrical Energy Savings (Net Generator kWh)	= Gross Generator kWh x NTG
Electrical Demand Savings (Net Generator kW)	= Gross Generator kW x NTG

For Cooling by Mini-Split Heat Pumps (MSHP):

New Equipment Electrical Energy Savings (Gross Annual kWh Saved at Customer)	=(Size x EFLH x (12/SEER_Standard - 12/SEER_Eff))/(1-Loss_No_QI_MSHP)
New Equipment Electrical Demand Savings (Gross kW Saved at Customer)	= Size x (12/EER_Standard - 12/EER_Eff)

For Heating by Mini-Split Heat Pumps (MSHP)

New Equipment Electrical Energy Savings (Gross Annual kWh Saved at Customer)	=(Size_Heat / 1000 x MSHP_EFLHH x (1/HSPF_Standard - 1/HSPF_Eff))(1-Loss_No_QI_MSHP)

For Both Heating and Cooling by Mini-Split Heat Pumps (MSHP)

New Equipment Electrical Energy Savings (Gross Annual kWh Saved at Customer)	= Cooling Electrical Energy Savings + Heating Electrical Energy Savings

Variables:

Size	= The new equipment capacity in tons for cooling, provided by customer
EFLH_New	= The Equivalent Full Load Hours of cooling load. We will use 488 for new homes which is the cooling load of a 2460 SF new home in CO. All homes were modeled with a 2.5 ton SEER 13 AC unit. Ton-hrs cooling was determined by modeling (Reference 4)
EFLH_Existing	= The Equivalent Full Load Hours of cooling load. We will use 383 for existing homes which is the cooling load of a 2206 SF existing home in CO. All homes were modeled with a 3 ton SEER 10 AC unit. Ton-hrs cooling was determined by modeling (Reference 4)
Btu_Heat_New	= The annual heating load in Btu. We will use 37400000 for new homes which is the heating load of a 2460 SF new home in CO. Btu heating was determined by modeling (Reference 4).
Btu_Heat_Exist	= The annual heating load in Btu. We will use 70200000 for new homes which is the heating load of a 2206 SF exsiting home in CO. Btu heating was determined by modeling (Reference 4).
SEER_Standard (Plan A)	= Seasonal Energy Efficiency Ratio of baseline equipment, based upon the minimum Federal standard for efficiency as manufactured. For residential AC units we will use 13 SEER. For ASHP we will use 14 SEER. For GSHP we will us a 13 SEER AC unit. For MSHP we will use the federal standard of 14 SEER.
SEER_Standard (Plan_B)	= Seasonal Energy Efficiency Ratio of existing equipment based upon the minimum Federal standard for efficiency manufactured between 1992 and 2006. For existing residential AC units, we will use 10 SEER.
SEER_Eff	= Seasonal Energy Efficiency Ratio of High Efficiency equipment that the customer will install, provided by the customer. For GSHP the this may be provided as EER and will have to be converted to SEER.
EER_Standard (Plan A)	= EER of standard equipment, based upon the minimum Federal acceptable efficiency. We will use 11.18 based on the federal standard 13 SEER and the conversion listed above. For MSHP, we will use 8.28, based on converting the 14 SEER to EER using a curve fit from AHRI database data (see EER_Eff)
EER_Standard (Plan B)	= EER of existing equipment, based upon the 1992 to 2006 minimum Federal acceptable efficiency. We will use 9.2 based on the federal standard 10 SEER and the conversion listed above.
EER_Eff	= EER of High Efficiency that the customer will install, provided by customer. ~~If value is not provided by the customer we will use the conversion listed above. For forecasting purposes the EER for MSHPs will be determined by the following empirical formula based on AHRI information: = (-0.0003*(SEER/ton)^3 + 0.0101*(SEER/ton)^2 + 0.5264*(SEER/ton) - 0.0233)*tons~~
GSHP_EER	= EER of High Efficiency that the customer will install, provided by customer. If not provided we will assume EER of 14.1.
GSHP_SEER	SEER of High Efficiency that the customer will install, provided by customer. If not provided we will assume ~~SEER of 19~~ **SEER = EER.**
Standard_COP	= Coefficient of Performance of electric resistance heater = 1.00 The COP of an airsource heatpump in an existing home = 2.26 The COP of an airsource heatpump in a new home = 2.4. For GSHP Heating Existing Home use Electric Resistance Heater COP. For GSHP Heating New Home use Air Source Heat Pump New Home COP.

GSHP_COP	= Coefficient of Performance of GSHP equipment that the customer will install, provided by the customer. We will use COP if EER is not available. Baseline GSHP COP assumed to be 3.3.
HSPF_Standard	= Heating Season Performance Factor for a new Air Source Heat Pump. The HSPF of an airsource heatpump (ASHP) in an existing home = 8.2
GSHP_Size	= Size of Ground Source Heat Pump, provided by customer.
Size_Heat	= Heating Capacity of Mini Split Heat Pump, in BTU/h, provided by customer
MSHP_EFLHH	= Mini-Split Heat Pump Equivalent Full Load Hours Heating: The equivalent number of hours that MSHP equipment would be running at Full Load over the course of the year for heating. We will use 1013 EFLH, from the Residential Heating program for an existing home that is the average of a weatherized and non-weatherized home
HSPF_Standard	= Heating Seasonal Performance Factor (HSPF) of standard equipment, based upon the minimum Federal standard for efficiency as manufactured. For MSHP we will use 8.2 HSPF.
HSPF_Eff	= Heating Seasonal Performance Factor (HSPF) of High Efficiency equipment that the customer will install, provided by the customer
Sizing_Loss_New_Home	= Specific losses from non-QI that affects peak load = 0%
Sizing_Loss_Exist_Home	= Specific losses from non-QI that affects peak load = 2.5%
Sizing_Loss_QI	= Reduction in equipment size due to quality install = 10%
Uncorr_Loss_New	= Uncorrectable duct leakage losses. For new homes = 0%
Uncorr_Loss_Exist	= Uncorrectable duct leakage losses. For existing homes = 12.7%
Loss_No_QI_New	= Efficiency of average unit lost due to improper installation for new home. We will use 9% which is the summation of the following losses: Equipment sizing = 0 Refrigeration Charge = 7% Improper air flow = 2% Duct leaks = 0%
Loss_No_QI_Exist	= Efficiency of average unit lost due to improper installation. We will use 33.1% which is the summation of the following losses: Equipment sizing = 2.5%, Refrigeration Charge = 7%, Improper air flow = 2%, Duct leaks = 21.6%
Loss_No_QI_New_GSHP	= Efficiency of average unit lost due to improper installation for new home with GSHP. We will use 2% which is the summation of the following losses: Equipment sizing = 0 %, Refrigeration Charge = 0% , Improper air flow = 2% Duct leaks = 0%
Loss_No_QI_Exist_GSHP	= Efficiency of average unit lost due to improper installation for existing home with GSHP. We will use 26.1% which is the summation of the following losses: Equipment sizing = 2.5 %, Refrigeration Charge = 0% , Improper air flow = 2% Duct leaks = 21.6%

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Loss_No_QI_MSHP, Loss_QI_MSHP	= Loss_No_QI_MSHP and Loss_QI_MSHP will be equal to 0%.
CF	= Coincidence Factor, the probability that peak demand savings will coincide with peak utility system demand. 90% will be used for new homes and 90% will be used for existing homes. GSHP and MSHP heating CF values will be 0
3.412	= Conversion between BTU/h and Watts
3412	= Conversion between BTU/h and kilowatts
12000	= Conversion between BTU/h and tons
Measure Life	= Measure life is taken at 15 years for all Plan A cooling equipment and 7.5 years for all Plan B cooling equipment, Quality Installations (Reference 2), and WCCD. Plan Life for GSHP is 20 years (Reference 3). Measure life for MSHP is 18 years (Reference 9)
TDLF	Transmission-Distribution Loss Factor = 7.69%, the percentage loss of electricity as it flows from the power
NTG	Net-to-gross; we will use 67.6% for AC units which is calculated from High Efficiency AC Program Evaluation conducted in 2012. We will use 100% for GSHP.
Western Cooling Control Device (WCCD)	Savings Deemed for retrofit based on internal analysis at 73 kWh and 0.13 kW
Future Value	Estimated cost of the standard replacement equipment at expected end of life of current equipment
Rate	Assumed interest rate. 7.88% used for discounting the future purchase price and 2.57% used for inflation to
Number of Periods	Number of years expected until existing equipment end of life
Incremental operation and maintenance cost	= 0 - conservative approach, taking no credit for improved mean time between failure.
Incremental Capital Cost	Incremental cost of efficient equipment. Values listed in table 1 below. Values will be scaled existing or new homes. Plan A and Plan B incremental capital costs include $167 for new homes and $462 for existing homes for quality install. (Reference 6)
Plan B Baseline Cost	The present value of a SEER 13 unit eight years in the future was calculated using a 10-year average inflation
GSHP Incremental Cost Split	Incremental Costs were split according to percentage of annual energy used for heating (81%) and percentage of annual a energy used for cooling (19%).
Quality_Install_Cost_Existing_Home	See Table 1
AC_Cost_Per_Ton	See Table 1

Table 1a. Incremental Capital Costs

SEER	AC Base Cost per Ton	Incremental Cost per Ton	ASHP Base Cost per Ton	Incremental Cost per Ton	GSHP Base Cost per Ton	Incremental Cost per Ton
13 SEER	$ 423				$ 423	
14/14.5 SEER	$ 515	$ 92	$ 778			$ 584
15 SEER	$ 607	$ 184	$ 960	$ 183		
16 SEER	$ 699	$ 276	$ 1,143	$ 366		
17 SEER	$ 791	$ 369	$ 1,326	$ 548		

Table 1b. Incremental Capital Costs - Early Retirement (Plan B)

SEER	Incremental Cost per Ton AC	Incremental Cost per Ton ASHP
13 SEER		
14/14.5 SEER	$ 181.02	$ 417.42
15 SEER	$ 263.93	$ 581.90
16 SEER	$ 346.85	$ 746.38
17 SEER	$ 429.76	$ 910.88

Quality Installation Measures	New Home	Existing Home*
	$ 117	$ 287

*note the above equation (Quality Install Incremental Cost) regarding Existing Homes

Mini-Split Heat Pump	Current Year Purchase Price	Incremental cost per ton Cooling
Mini-Split Heat Pump (15-20 SEER, 9-12 HSPF)	$ 3,301	~~$ 374~~ $ 336.75
Mini-Split Heat Pump (21-26 SEER, 9-12 HSPF)	$ 3,536	~~$ 608~~ $ 555.94

Incremental costs for unit sizes not listed will be interpolated/extrapolated from listed values

Incremental costs for GSHP to High Efficient GSHP will use the incremental cost table for standard A/C Units. This is due to a GSHP to HE GSHP the loop cost are the same so that cost is ignored. When the baseline system has electric resistance heat or is an air source heat pump the cost for the ground loop is included. The cost to install a GSHP loop is approximately $2,005 per ton.
Minisplit Costs from Reference 8

Provided by Customer: Plan A and Plan B	Verified during M&V
New cooling equipment type	Yes
New cooling equipment size (tons)	Yes

Table 2. Plan B baseline present value

Discount Rate		7.88%
10 Yr. Avg. Inflation Rate		2.57%
SEER =	13	3 Ton Unit

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

New cooling equipment efficiency (SEER, EER)	Yes
Type of home (Existing or New Construction)	Yes
Type of Existing Heating system (GSHP)	Yes
MSHP heating efficiency (HPSF)	Yes
Primary use, cooling or heating (MSHP)	
Provided By Installing Contractor: Plan B or GSHP	
Make, model and serial number from existing condensing unit	
Unit SEER and/or EER rating or COP for GSHP as given by the manufacturer	

2016 Cost	$ 1,269	NPV Cost
2017	$ 1,301	$ 1,206
2018	$ 1,335	$ 1,147
2019	$ 1,369	$ 1,090
2020	$ 1,404	$ 1,037
2021	$ 1,440	$ 986
2022	$ 1,478	$ 937
2023	$ 1,516	$ 891
2024	$ 1,555	$ 847

$ 282.46

M&V Process	
Evidence of Manual J load cal'cs and equipment sizing	Yes
Acceptable refrigerant charge	Yes
Acceptable air flow at coil	Yes
Acceptable range of duct leakage	Yes

Assumptions:

Baseline equipment meets applicable minimum Federal standards for efficiency
Baseline equipment installation (for QI) has 33.1% efficiency losses
Baseline equipment installation in Existing Homes has 26.75% efficiency losses
High efficiency equipment exceeds minimum Federal standards for efficiency
Installed equipment does not operate at optimum efficiency until a Quality Installation is completed.
To qualify for a rebate, each piece of equipment must meet the minimum EER and SEER requirements. The customer should provide both the EER and SEER values for the particular piece of equipment. If the customer is unable to provide both values, the value(s) not provided will be calculated using the equations shown above. If a value is not provided by the customer, the calculated value still must meet the minimum requirement.

10-year Average Inflation Rate = 2.57% (InflationData.com)
CO Weighted Average Cost of Capital = 7.88%

Average Cost of Central AC Repair=$750 (EEBC)
GSHP New Home REMRATE Modeling = Larger , more tightly built, better insulated new home was modeled with GSHP COP of 3.3

GSHP Existing Home REMRATE modeling = Smaller, less tightly built, poorly insulated existing home was modeled with GSHP of 3.3.

GSHP Installed Loop Cost/Ton = $2004 per loop per Ton

GSHP Baseline Equipment Cost combines AC unit and electric resistance heating

GSHP appropriate Quality Install savings included in modeling

No Heating kW saving are claimed for GSHP or MSHP during winter, only summer cooling kW savings are claimed.
Assumed $50 each for contractor to complete right sizing calculations and air flow work on AC and HP units.

References:

1. For equation to convert SEER to EER "Building America, Research Benchmark Definitions, 2010", see p. 10. http://www.nrel.gov/docs/fy10osti/47246.pdf
2. ASHRAE, 2007, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. For estimated life of GSHP see http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640 (indoor components up to 25 years; ground loop =50 ye
4.Building loads were estimated using Building Energy Optimization (BEOpt) software version 2.5.0.0. The model was run Jan 2016. See "Model Data New" and "Model Data Existing" tabs for assumptions.
5. For losses with air flow see Neme, Proctor, Nadel, ACEEE, 1999. Energy Savings Potential From Addressing Residential Air Conditioner and Heat Pump Installation Problems. http://aceee.org/research-report/a992
6. Costs obtained from "2010-2012 WO017 Ex Ante Measure Cost Study Final Report", by Itron, May 2014. These are used in the DEER 2016 database.
7. DOE Appliance Standards Website, Residential Central Air Conditioners and Heat Pumps. https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75
8. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
9. MSHP equipment life is from Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures; http://library.cee1.org/content/measure-life-report-
10.For assumptions on GSHP efficiencies and conversion from EER to SEER see "ENERGY STAR Geothermal Heat Pumps Key Product Criteria"; www.energystar.gov
11 For losses with equipment sizing see ENERGY STAR Quality Installation. https://www.energystar.gov/index.cfm?c=hvac_install.hvac_install_index
12.For assumptions on duct leak losses see "NREL 2011 Measure Guideline Sealing and Insulating Ducts in Existing Homes". http://www.nrel.gov/docs/fy12osti/53494.pdf
13.For assumptions on losses related to overcharge or undercharge on refrigerant see "Sensitivity Analysis of Installation Faults on Heat Pump Performance", by P. Domanski, et. al., Sept 2014. http://www.acca.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=f02c1f61-4d1d-4a24-971d-cc9ea3e626b2&forceDialog=0