DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Product: High Efficiency Air Conditioning

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) systems installed in new homes, existing homes without CAC systems or homes with CAC systems that are inoperable or unrepairable. Plan B is for existing CAC 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.

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)
kW/ton	= 12 / Energy Efficiency Ratio
Coefficient of Performance (COP)	= EER / 3.413 or, EER = 3.413*COP
Coefficient of Performance (COP) Heating	= Heat Energy Output (Btu) / Energy Input to Compressor (Btu)
For Split System Air Conditioners and Air Source Heat Pumps and Ground Source Heat Pumps	
New Equipment Electrical Energy Savings (Customer kWh)	= Size x EFLH x (12/SEER_Standard - 12/SEER_Eff) / (1-Loss_No_QI)
New Equipment Electrical Demand Savings (Customer kW)	= Size x (12/EER_Standard - 12/EER_Eff)
Quality Install Electrical Energy Savings (Customer kWh)	= Size x EFLH x (12/SEER_Eff) x (1/(1-Loss_No_QI) - 1/(1-Loss_QI))
Quality Install Electrical Demand Savings (Customer kW)	= Size x (12/EER_Eff) x (1 - ((1-Loss_No_QI) / (1-Loss_QI)))
GSHP Cooling Electrical Energy Savings (Customer kWh)	=(GSHP_Size/2) x EFLH (12/SEER_Standard - 12/GSHP_SEER) / (1-Loss_No_QI)
GSHP Cooling Electrical Energy Savings (Customer kW)	=GSHP_Size x (12/EER_Standard - 12/GSHP_EER)
GSHP Heating Electrical Energy Savings (Customer kWh)	=GSHP_Size x GSHP_EFLHH x (12/EER_Standard - 12/GSHP_EER) / (1-Loss_No_QI)
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
Present Value ($)	=Future Value * (1+rate) ^ (number of periods * -1)

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Variables:

Size	= The new equipment capacity in tons, provided by customer
EFLH	= Equivalent Full Load Hours. The Equivalent number of hours that equipment would be running at Full Load over the course of the year. We will use 490.4 EFLH which was determined by modeling a home in Denver with a 3 ton 13 SEER AC unit. The resulting kWh were divided by the connected load to derive the EFLH value. Modeling used ESPRE simulation model which is an EPRI product.
GSHP_EFLHH	= Ground Source Heat Pump Equivalent Full Load Hours Heating: The equivalent number of hours that GSHP equipment would be running at Full Load over the course of the year for heating. We will use 846 EFLH for new homes and 1,419 for existing homes. GSHP EFLHH was determined by REMRATE modeling of a new and an existing home adjusted for Denver Degree Days. The resulting kWh were divided by the connected load to derive the EFLHH value.
SEER_Standard (Plan A)	= Seasonal Energy Efficiency Ratio of standard equipment, based upon the minimum Federal standard for efficiency as manufactured. For residential AC units, we will use 13 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
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.
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.
GSHP_EER	= EER of High Efficiency that the customer will install, provided by customer.
GSHP_SEER	**= EER/0.95**
Standard_COP	= Coefficient of Performance of electric resistance heater = 1.00 The COP of an airsource heatpump in an existing home = 2.0 The COP of an airsource heatpump in a new home = 3.1.
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 3.1
GSHP_Size	=Size of Ground Source Heat Pump, provided by customer. We will divide size by 2 for GSHP cooling calculations based on REMRATE modeling of a new and an existing home adjusted for Denver Degree Days. The resulting kWh were divided by the connected load to derive the EFLHH value.

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Loss_No_QI Loss_No_QI_GSHP	Efficiency of unit lost due to improper installation. This is the Baseline condition for Quality Installations. We will use 30.5% which is the summation of the following losses: Equipment sizing = 3%, Refrigeration Charge = 13%, Improper air flow = 7%, Duct leaks = 7.5%. ~~The losses for heating are only the duct leakage losses (7.5%).~~ Loss_No_QI_GSHP will be equal to the 7% improper air flow + 7.5% duct leaks = 14.5%.
Loss_QI	Efficiency of unit lost due to improper installation. All non-QI losses will be eliminated with quality install in a new home so the Loss_QI for a new home will be 0. In existing homes and all Plan B installations, all non-QI losses will be eliminated except for the duct leakage losses. Duct leakage losses in an existing home will be cut in half resulting in a Loss_QI for existing homes of 3.75%. Savings will be reduced for quality installation according to the percentages above when it is determined through M & V that one or more facets of quality installation (equipment sizing, refrigeration charge, proper airflow, duct leakage) fall outside the acceptable range according to industry standards.
CF	= Coincidence Factor, the probability that peak demand savings will coincide with peak utility system demand. 0.90 will be used for prescriptive AC rebates. For GSHP the average CF of .50 will be used.
Measure Life	Measure life is taken at 14 years for all Plan A cooling equipment, 7 years for all Plan B cooling equipment, and 7 years for Quality Installations (Reference 2). Plan Life for GSHP is 20 years (Reference 3).
TDLF	Transmission-Distribution Loss Factor = 7.69%, the percentage loss of electricity as it flows from the power plant to the customer, calculated using factors from Enhanced DSM Filing SRD-2
NTG	Net-to-gross; we will use ~~89%~~ 67.6% for AC units which is calculated from High Efficiency AC Program Evaluation conducted in 2012. ~~historical A/C sales data for 2007~~. We will use 100% for GSHP.
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 calculate the future purchase price based on current cost.
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 for different equipment sizes. Plan A and Plan B incremental capital costs include $200 for quality install.
Plan B Baseline Cost	inflation rate. The inflated value was then discounted back to present value using Xcel's Weighted Average Cost of Capital for Colorado. An average repair cost of $750 was then added to the present value to arrive at the baseline cost used to establish the incremental costs for the various options. See Table 2 for calculations.
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%).
Federal Tax Incentive:	30% of installed Cost of Energy Star Certified GSHP

Table 1. Incremental Capital Costs

Unit Description	Current Year Purchase Price	Incremental Cost per ton Plan A	Incremental Cost Plan A	Baseline Plan B Cost	Incremental Cost per ton Plan B	Incremental Cost Plan B
13 SEER 3 ton unit	$ 4,329	NA	NA	NA	NA	NA
14 SEER 3 ton unit	$ 4,948	NA	NA	$ 3,949	$ 333.00	$ 999
14.5 SEER 3 ton unit	$ 5,050	$ 240	$ 720	$ 3,949	$ 366.83	$ 1,100
15 SEER 3 ton unit	$ 5,222	$ 298	$ 894	$ 3,949	$ 424.83	$ 1,274
16 SEER 3 ton unit	$ 5,569	$ 413	$ 1,239	$ 3,949	$ 539.83	$ 1,619
17 SEER 3 ton unit	$ 6,002	$ 558	$ 1,674	$ 3,949	$ 684.83	$ 2,054
18 SEER 3 ton unit	$ 6,435	$ 702	$ 2,106	$ 3,949	$ 828.83	$ 2,486

Unit Description	Current Year Purchase Price	Incremental cost per ton Cooling	Incremental Cost per ton Heating	Incremental cost cooling	Incremental cost heating
GSHP 14.1 EER 3.4 ton unit*	$ 9,770	$ 262	$ 1,117	$ 891	$ 3,799
GSHP 14.1 EER 6 ton unit*	$ 16,790	$ 262	$ 1,117	$ 1,572	$ 6,704

* Current Year Purchase Price for GSHP units is discounted by Federal Tax Incentive.

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.

Provided by Customer: Plan A and Plan B	Verified during M&V
New cooling equipment type	Yes
New cooling equipment size (tons)	Yes
New cooling equipment efficiency (SEER, EER)	Yes
Type of home (Existing or New Construction)	Yes
Type of Existing Heating system (GSHP)	Yes
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	

Table 2. Plan B baseline present value

Discount Rate		7.88%	
10 Yr. Avg. Inflation Rate		2.57%	
SEER=	13	3 Ton Unit	
2009 Cost=	$ 4,329	Inc. Cost	3119.24287
2010	$ 4,440	$ 4,440	
2011	$ 4,554	$ 4,222	
2012	$ 4,671	$ 4,014	
2013	$ 4,792	$ 3,816	
2014	$ 4,915	$ 3,629	
2015	$ 5,042	$ 3,450	
2016	$ 5,171	$ 3,281	

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M&V Process		2017	$ 5,304	$ 3,119
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			

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Assumptions:

Baseline equipment meets applicable minimum Federal standards for efficiency
Baseline equipment installation (for QI) has 30.5% 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)
Federal Tax Incentive: As part of the American Recovery and Reinvestment Act of 2009 a Federal Tax Incentive of 30% of the installed cost of a new Ground Source Heat Pump system is available to taxpayers through 2016.
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 during winter, only summer cooling kW savings are claimed.

Changes from 2011:

No changes

References:

1. Building America, Research Benchmark Definitions, p. 9
2. ASHRAE, 2007, Applications Handbook, Ch. 36, table 4, Comparison of Service Life Estimates
3. http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640 (indoor components up to 25 years; ground loop =50 years)