

Best Practice – SEER, EER, HSPF, and AFUE Degradation

Date: Revised May 2020

Subject: Calculation of SEER, EER, HSPF, or AFUE Degradation for aged HVAC systems.

Problem or Question: We are assessing an apartment complex containing air conditioners installed during the early 1980s. We know the SEER on these units should be degraded because of age, but how can we do that accurately, safely, and properly?

Discussion: It is possible to degrade the SEER, EER, HSPF, or AFUE efficiency ratings of existing units to reflect the efficiency reduction caused by age *when allowed by program guidelines*. Follow the program specific guidance below to determine if degradation is allowed and which maintenance factors can be utilized in the degradation process. In an effort to simplify calculations, the Department has provided a “Degradation Calculator” on the Program Guidance webpage. With accurate input and maintenance factor selection, the degradation calculator will automatically calculate the degraded efficiency rating.

Guidance utilized from the National Renewable Energy Laboratory (NREL) published booklet *Building America Performance Analysis Procedures for Existing Homes* (BAPA) outlines how to degrade the efficiency of an aged central heating and/or cooling system. This publication can be obtained at the hyper-link below and the process identified within this Best Practice should be used whenever SEER, EER, HSPF, or AFUE degradations are utilized. Link to the NREL publication: <http://www.nrel.gov/docs/fy06osti/38238.pdf>

Tables within the booklet can help to determine base SEER, EER, HSPF, or AFUE ratings for existing units based on the type of the system. Additionally, degradation formulas are provided that utilize the original efficiency, maintenance factor, and age to provide a degraded efficiency.

It is important to note that this best practice replaces any previous guidance on ways to determine existing efficiencies for older units.

Air Conditioning or Heat Pump SEER/EER/HSPF Degradation

When determining the degraded SEER, EER, and HSPF efficiency ratings of existing central systems, NREL’s BAPA booklet states: “The default air-conditioner and heat-pump efficiencies in **Table 8** may be used if the actual efficiency cannot be calculated or measured. Base values for SEER, EER, and HSPF were obtained from the engineering analysis of appliance standards for air conditioners and heat pumps (DOE 2002), and from the LBNL Energy Data Sourcebook (Wenzel et al. 1997). Default efficiencies for equipment not listed in the table may either be interpolated or estimated by referring to the original references. Adjustments to efficiency related to age and quality of maintenance shall be applied in accordance with **Equation 2**. Performance degradation rates for cooling systems are based in part on a study done by LBNL for the California Energy Commission (Matson et al. 2002).”

DOE or DOE/LIHEAP leveraged units Maintenance Factor Selection

- DOE & DOE/LIHEAP leveraged WAP units we are required to use the “Annual Professional Maintenance” M-factor listed in the tables per WPN guidance.

LIHEAP units utilizing the Priority List have two options when selecting the Maintenance Factor

- Utilize the “Annual Professional Maintenance” **M**-factor listed in the tables.
- Utilize of the “Seldom or Never Maintained” **M**-factor as long as the action can be justified with clear documentation and support. Documentation should include information gathered from client interviews, photo documentation, etc. and be retained in the client file to support this decision.

Maintenance Factor Note – The default recommendation is to use the “Annual Professional Maintenance” **M**-factor in the tables. Use of the “Seldom or Never Maintained” **M**-factor remains an option (***for LIHEAP only***) if proper documentation and support allows for this choice. Client file documentation and support should include information gathered from client interviews, photo documentation, and assessment notes.

Equation 2: $EFF = (Base\ EFF) * (1 - M)^{age}$

Base EFF = Typical efficiency of Pre-Retrofit equipment when new

*M = Maintenance Factor (***see maintenance factor selection guidance above***)*

Age = Age of equipment in years. “

For example, if you are assessing a 16-year old HVAC system that had an original SEER of 10 you would calculate: $SEER = (10) * (1 - 0.01)^{16} = (10) * (.99)^{16} = (10) * (.851458) = 8.5146$ is the current SEER of existing unit.

Table 1 below provides typical original SEER of older equipment to be used in the NREL applied formulas. Identify the age of the existing system and original SEER. With the information gathered from that table, then use the equation above to determine the degraded SEER/EER of the equipment.

**Table 1
Typical SEER Ratings Based Off Manufacture Date**

Year of System	Original SEER
1980 and before	6.5
1981 – 1991	8
1992 – 1999	10
2000 – 2008	12
2009 – 2013	14
2014 – 2015	14.5
2016 – 2020	15

Table 8. Default Air-Conditioning and Heat-Pump Efficiencies

Type of Air-Conditioning or Heat-Pump Equipment	Base SEER	Base EER	Base HSPF	Maintenance Factor (M): Annual Professional Maintenance (<i>Allowed for all Programs</i>)	Maintenance Factor (M): Seldom or Never Maintained (<i>Option for LIHEAP units utilizing PL</i>)
Split central air conditioner, two-speed reciprocating compressor, electronically commutated air handler motor (ECM), thermostatic expansion valve (TXV), fan coil	14	10.5		0.01	0.02
Split central air conditioner, single-speed scroll compressor, ECM air handler motor, cased coil	12	10.8		0.01	0.03

Type of Air-Conditioning or Heat-Pump Equipment	Base SEER	Base EER	Base HSPF	Maintenance Factor (M): Annual Professional Maintenance (Allowed for all Programs)	Maintenance Factor (M): Seldom or Never Maintained (Option for LIHEAP units utilizing PL)
Split central air conditioner, single-speed reciprocating compressor, PSC air-handler motor, cased coil (after 1991)	10	9.3		0.01	0.03
Split central air conditioner, single-speed reciprocating compressor, PSC air-handler motor, cased coil (1981-1991)	8	7.7		0.01	0.03
Split central air conditioner, single-speed reciprocating compressor, PSC air-handler motor, cased coil (before 1981)	6.5	6.4		0.01	0.03
Split heat pump, single-speed scroll compressor, ECM air handler motor, TXV valve	14	10.5	8.0	0.01	0.03
Split heat pump, single-speed reciprocating compressor, PSC air-handler motor (after 1991)	10	9.3	7.1	0.01	0.03
Split heat pump, single-speed reciprocating compressor, PSC air-handler motor (1981-1991)	8	7.7	6.6	0.01	0.03
Split heat pump, single-speed reciprocating compressor, PSC air-handler motor (before 1981)	6.5	6.4	6.0	0.01	0.03
Packaged central air conditioner, single-speed reciprocating compressor, PSC air-handler motor	10	9.1		0.01	0.03
Packaged heat pump, single-speed reciprocating compressor, PSC air-handler motor	10	9.1	6.8	0.01	0.03

Source: <http://www.nrel.gov/docs/fy06osti/38238.pdf>

Gas Appliance AFUE Degradation

DOE or DOE/LIHEAP leveraged units

- DOE and DOE/LIHEAP leveraged units are not allowed to utilize any form of Degradation for gas units. Gas units must utilize actual readings taken from the combustion analyzer. For non-working units please contact Department training staff for case-by-case guidance.

LIHEAP units utilizing the Priority List have the following options

- Utilize the actual efficiency readings from the combustion analyzer during the onsite assessment and degrade the AFUE utilizing the degradation formula listed below in **Equation 1**.
- Utilize guidance provided in NREL's BAPA booklet which states: "Default furnace or boiler system efficiency may be calculated using **Equation 1** in conjunction with the parameters in **Table 6** if the actual efficiency of the equipment is unknown and cannot be readily obtained through field-testing. Typical base values for AFUE were obtained from the ASHRAE HVAC Systems and Equipment Handbook (ASHRAE 2004a), the 1987 EPRI Technical Assessment Guide (EPRI 1987), and the Technical Support Documents for the NAECA appliance standards (DOE 2004a). Default AFUE values for system configurations not listed in **Table 6** may be estimated using these references. Estimates of degradation rates are partly based on the E-Source Space Heating Technology Atlas (E-Source 1993)."

Equation 1: AFUE = (Base AFUE) * (1-M)^{age}

Base AFUE = Typical efficiency of Pre-Retrofit equipment when new

M = Maintenance Factor (see Maintenance Factor note below)

Age = Age of equipment in years. "

For example, if you are assessing a 16-year old furnace that had an original AFUE of 76 you would calculate:

$$AFUE = (76) * (1 - 0.005)^{16} = (76) * (.995)^{16} = (76) * (.92293) = 70.143$$

is the current AFUE of the existing unit.

Maintenance Factor Note (LIHEAP only) – The default recommendation is to use the “Annual Professional Maintenance” **M**-factor in the tables. Use of the “Seldom or Never Maintained” **M**-factor remains an option (for LIHEAP only) if proper documentation and support allows for this choice. Client file documentation and support should include information gathered from client interviews, photo documentation, and assessment notes.

Table 6: Default Furnace and Boiler System Efficiencies; “Gas” Refers to Either Natural Gas or Propane

Type of Space-Heating Equipment	Base AFUE*	Maintenance Factor (M) Annual Professional Maintenance	Maintenance Factor (M) Seldom or Never Maintained
Condensing gas furnace	90	0.005	0.015
Gas furnace, direct-vent or forced-draft combustion, electronic ignition, in conditioned space	80	0.005	0.015
Gas furnace, natural-draft combustion, vent damper, electronic ignition, in conditioned space	78	0.005	0.015
Gas furnace, natural-draft combustion, standing pilot light, in conditioned space	75	0.005	0.015
Gas furnace, natural-draft combustion, standing pilot light, no vent damper, in unconditioned space	64	0.005	0.015

* Combined Appliance AFUE (CA_{AFUE}) for combo systems.

Source: <http://www.nrel.gov/docs/fy06osti/38238.pdf>

Recommendation Summary: If allowed by program guidelines, subrecipients can utilize the above formulas or tables to calculate the current degraded AFUE, SEER, HSPF, or AFUE ratings of existing central unit(s). The Department also provides a Degradation calculator to simplify the calculations at: <https://www.tdhca.state.tx.us/community-affairs/wap/docs/Degradation-Calc.xlsx>. Make sure you maintain a copy of the calculator to document the degraded values in the client file.