DAIKIN U.S. CORPORATION
475 Fifth Avenue, 21st Floor, New York, NY 10017 USA
Phone: (212) 340-7400 Fax: (212) 779-5925

January 21, 2021

VIA ELECTRONIC FILING
Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building, 2nd Floor
400 North Street
Harrisburg, PA 17120

Re: Phase IV Energy Efficiency and Conservation Plans

Dear Secretary Chiavetta:

Daikin U.S. Corporation (DUS) welcomes the opportunity to provide comments on the Phase IV Energy Efficiency and Conservation Program Plans submitted by utility companies, including:

- Duquesne Light Company at Doc. No. M-2020-3020818
- Metropolitan Edison Company at Doc. No. M-2020-3020820
- PECO Energy Company at Doc. No. M-2020-3020830
- Pennsylvania Electric Company at Doc. No. M-2020-3020821
- Pennsylvania Power Company at Doc. No. M-2020-3020822
- PPL Electric Utilities Corporation at Doc. No. M-2020-3020824
- West Penn Power Company at Doc. No. M-2020-3020823

Daikin Industries, Ltd. (DIL) is the world's number one air conditioning company and is a leading innovator and worldwide provider of advanced, high-quality air conditioning and heating solutions for residential, commercial and industrial applications. With more than 95 years of operation, DIL has sold millions of systems throughout 140 countries. From our earliest models to the futuristic designs of today, our commitment to innovation is the hallmark of DIL. DIL's products have high levels of efficiency, which is best shown in our environmentally friendly inverter-driven heat pumps.

DIL's subsidiaries manufacture and sell residential HVAC equipment in the United States under the brands Daikin, Goodman, and Amana. Those same subsidiaries also maintain a network of more than 200 installing contractors and operate six distribution locations throughout Pennsylvania.

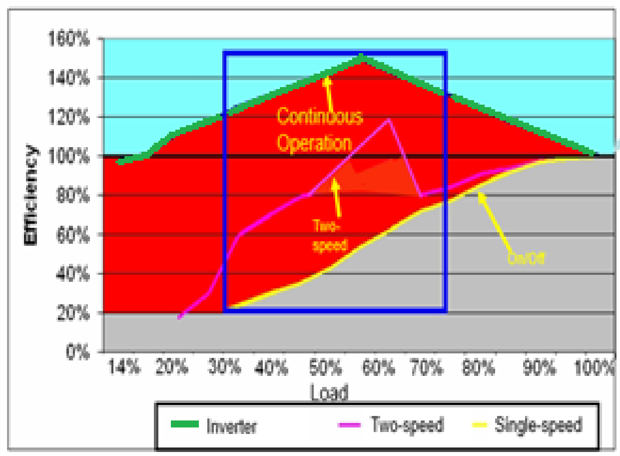
Throughout this comment, it will become clear how inverter HVAC equipment operates differently, why EER is not an appropriate metric to apply to inverter HVAC equipment, and why inverter HVAC equipment provides more annual energy consumption savings and peak energy savings than is currently being attributed in Pennsylvania Public Utility Commission's (PUC) Technical Reference Manual (TRM). Most importantly, Daikin encourages the PUC and utilities to consider removing the full-load EER metric as a requirement for rebate eligibility for inverter HVAC equipment in the residential programs.

Inverter Technology

Inverter HVAC equipment doesn't operate like traditional single-speed HVAC equipment which is simply either on or off. Instead, inverter HVAC equipment modulates the capacity of the equipment to precisely meet the heating or cooling load at any given time. The United States Environmental Protection Agency (U.S. EPA) notes that inverter equipment and modulating systems specifically provide additional customer comfort advantages by following load, provide further energy efficiency improvements, and provide unique advantages for demand response[1].

The benefits of inverter HVAC equipment are most prevalent when it operates at part-load capacities (i.e., less than 100% capacity). When operating at part-load, it can be significantly more efficient. As shown in Figure 1, inverter equipment's efficiency increases significantly as its load reduces below 100%. This exceeds the performance of both single-speed and two-speed equipment as load reduces. According to computer simulations, validated by the Electric Power Research Institute (EPRI), when variable speed HVAC equipment reduces its cooling capacity by 25% it results in a 43% reduction in power consumption while for single-speed equipment it would yield only a 25% reduction in power consumption[2].

Figure 1: HVAC Equipment Efficiency at Various Part-Loads



Adoption of inverter HVAC equipment worldwide has increased dramatically over the past decade[3]. In Europe, inverter product adoption has doubled from 2009 to 2018 and now represents 84% of all air conditioners. In China, adoption rates have increased nearly ten-times from 2009 to 2018, now representing 76% of all air conditioner sales. Adoption of inverter HVAC equipment has lagged in the United States as compared to other regions, with adoption rates doubling from 2009 levels and comprising 16% of air conditioner sales in 2018. With this trend, we expect inverter HVAC equipment to play a larger and growing role in helping Pennsylvania achieve its energy efficiency and conservation program goals.

---

[1] U.S. EPA, ENERGY STAR Residential Air Source Heat Pump and Central Air Conditioning Equipment Version 6.0 Discussion Guide dated August 3, 2018, https://www.energystar.gov/sites/default/files/CAC_ASHP_Version%206_Discussion%20Guide.pdf

[2] HRAI and AHRI, Letter to U.S. EPA Regarding ENERGY STAR Residential Air Source Heat Pump and Central Air Conditioning Equipment Version 6.0 Discussion Guide dated September 21, 2018, https://www.energystar.gov/sites/default/files/AHRI_HRAI_Comments_CAC_ASHP_Discussion%20Guide_09%2021%202018.pdf

[3] Daikin, Promoting the Use of Inverter Products, https://www.daikin.com/csr/environment/climatechange/inverter.html

Efficiency Metrics

The seasonal efficiency metrics such as Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) are used to estimate annual energy savings for Air-Conditioner and Air Source Heat Pump measures. The additional full load metric, Energy Efficiency Ratio (EER), does not thoroughly address the benefits of inverter technology, especially for products that are capable of providing demand response. In fact, according to National Resource Defense Council (NRDC), "current test procedures do not adequately capture the impact of a variable capacity unit's control logic, which can have a large impact on efficiency"[4].

The test procedures are prescribed by the Air-Conditioning, Heating & Refrigeration Institute's (AHRI) Standard 210 / 240 which require the full-load EER metric to be calculated based on the equipment's capacity and input power at fixed outdoor temperatures of 95°F dry bulb / 75°F wet bulb and indoor temperatures of 80°F dry bulb / 67°F wet bulb. As such, the full-load EER metric does not appropriately take into account the full benefits on offer from inverter systems. Inverter HVAC equipment under those same real-world conditions will modulate its capacity to meet the precise cooling load to maintain comfort. Therefore, the benefit of inverter HVAC equipment is realized in the real-world application and use, but not necessarily recognized in the test procedure for the full-load EER metric.

The U.S. EPA acknowledges that EER requirements present a barrier to wider adoption of variable speed equipment.[1] Today, the full-load EER testing procedures only consider one fixed capacity of inverter HVAC equipment, and does not acknowledge that equipment's ability to modulate its capacity. By modulating its capacity, the equipment will operate more efficiently in the real-world when faced with full-load EER conditions. As such, the application of the full-load EER metric to inverter HVAC equipment is not indicative of the true performance under peak conditions. This issue is even further exacerbated by mechanical contractor's preference to oversize equipment, meaning many installations with inverter HVAC equipment may never operate at 100% cooling capacity. As outlined in Figure 1, when inverter HVAC equipment is oversized it will operate at part-load and in a more efficient manner than the full-load EER metric would indicate. According to EPRI, "the link of EER and building performance is not straightforward" and that "high EER systems do not necessarily manage peak (and there is data to show that)"[5].

[4] NRDC, NRDC Comments on ENERGY STAR Program Requirements for Air Source Heat Pump and Central Air Conditioner Equipment Version 6.0, Draft 1 dated May 23, 2019, https://www.energystar.gov/sites/default/files/NRDC%20Comments%20on%20CACASHP%20Draft%201%20V6.0.pdf

[5] EPRI, Comments to U.S. EPA Regarding ENERGY STAR Residential Air Source Heat Pump and Central Air Conditioner Equipment Version 6.0 Discussion Guide, https://www.energystar.gov/sites/default/files/EPRI_Comments_CAC_ASHP_Discussion%20Guide_10%204%2018.pdf

Meteorological Conditions in Pennsylvania and Efficiency

Daikin reviewed Typical Meteorological Year version 3 (TMY3) historic weather data for four important Pennsylvania locations, including Philadelphia, Pittsburg, Wilkes-Barre, and Erie. TMY3 data was produced by the National Renewable Energy Laboratory (NREL).[6] TMY3 weather data typifies meteorological conditions and is based on data collected over a 30-year period (1976-2005) and represents a year of typical climatic conditions for every hour of the year. As shown in Table 1 for Philadelphia, Pittsburg, Wilkes-Barre and Erie respectively, Daikin observed that TMY3 data shows that only 0.4%, 0.0%, 0.0%, and 0.1% of all cooling season hours or 0.1%, 0.0%, 0.0%, and 0.02% of all hours in a year were at or above full-load EER conditions (i.e., 95°F outdoor temperatures or higher).

Table 1: Cooling Seasonal Bin Fractions for TMY3 Data throughout Pennsylvania

Bin	Temp. Range (F)	Representative Temp. (F)	Federal Test Procedure Fractional Bin Hours	Philadelphia TMY3 Fractional Bin Hours[6]	Pittsburg TMY3 Fractional Bin Hours[6]	Wilkes-Barre TMY3 Fractional Bin Hours[6]	Erie TMY3 Fractional Bin Hours[6]
1	65-69	67	0.214	0.246	0.297	0.332	0.380
2	70-74	72	0.231	0.285	0.304	0.346	0.277
3	75-79	77	0.216	0.211	0.189	0.217	0.164
4	80-84	82	0.161	0.147	0.146	0.083	0.128
5	85-89	87	0.104	0.079	0.059	0.019	0.038
6	90-94	92	0.052	0.028	0.004	0.002	0.013
7	95-99	97	0.018	0.004	0	0	0.001
8	100-104	102	0.004	0	0	0	0

Further, this TMY3 data indicates that weather in all four Pennsylvania locations is milder than the weather conditions used when calculating SEER for HVAC equipment. For example, the federal test procedure used to determine SEER assumes 2.2% of all cooling season hours are in bin numbers seven and eight (these represent temperatures in the range of 95-99°F and 100-104°F respectively). The TMY3 data for all four locations range from 0.4% to 0.0% of all cooling season hours are in those same bins. The weather data in Table 1 indicates that all four Pennsylvania locations experience a higher number of hours in lower temperature bins (i.e., bins 1 and 2), therefore inverter HVAC equipment should perform more efficiently relative to the SEER metric rated in accordance with the federal test procedures.

Lastly, Daikin reviewed hourly weather data for a set of more recent weather data which is publicly available[7], which includes five more recent years 2015, 2016, 2017, 2018 and 2019, as shown in Tables 2, 3, 4 and 5. In all these years for all four locations, the bin fractions observed in bins seven and eight (i.e., temperatures observed above 95°F) were significantly less than those used in the federal test procedure. Over the recent five years for Philadelphia, Pittsburg, Wilkes-Barre, and Erie respectively, 0.17%, 0.18%, 0.06% and 0.00% of all cooling hours were at or above full-load EER conditions (i.e.,

[6] https://nsrdb.nrel.gov/data-sets/archives.html
[7] Location ID: 1206635 (Philadelphia), 1064999 (Pittsburg), 1183577 (Wilkes-Barre), 1062499 (Erie) - https://maps.nrel.gov/nsrdb-viewer/

95°F outdoor temperatures or higher) as compared to the 1.8% used in the federal test procedure. This further demonstrates the point that full-load EER conditions are exceedingly rare throughout the Commonwealth of Pennsylvania.

Overall, the review of TMY3 data and more recent weather data indicates that there are very few hours at full-load EER conditions in Pennsylvania. Daikin hopes that the PUC along with the utilities would consider removing the EER requirement for inverter HVAC equipment in the residential HVAC program for central air conditioners and air source heat pumps.

Table 2: Cooling Seasonal Bin Fractions for Recent Weather Data for Philadelphia, PA

Bin	Temp. Range (F)	Rep. Temp. (F)	Federal Test Procedure Fractional Bin Hours	2015 Bin Fractions[7]	2016 Bin Fractions[7]	2017 Bin Fractions[7]	2018 Bin Fractions[7]	2019 Bin Fractions[7]
1	65-69	67	0.214	0.221	0.187	0.228	0.230	0.262
2	70-74	72	0.231	0.304	0.280	0.323	0.309	0.284
3	75-79	77	0.216	0.223	0.219	0.228	0.218	0.191
4	80-84	82	0.161	0.170	0.168	0.153	0.154	0.157
5	85-89	87	0.104	0.052	0.074	0.048	0.069	0.092
6	90-94	92	0.052	0.029	0.066	0.020	0.020	0.013
7	95-99	97	0.018	0.000	0.007	0.001	0.000	0.001
8	100-104	102	0.004	0.000	0.000	0.000	0.000	0.000

Table 3: Cooling Seasonal Bin Fractions for Recent Weather Data for Pittsburg, PA

Bin	Temp. Range (F)	Rep. Temp. (F)	Federal Test Procedure Fractional Bin Hours	2015 Bin Fractions[7]	2016 Bin Fractions[7]	2017 Bin Fractions[7]	2018 Bin Fractions[7]	2019 Bin Fractions[7]
1	65-69	67	0.214	0.251	0.198	0.258	0.296	0.317
2	70-74	72	0.231	0.292	0.291	0.313	0.263	0.261
3	75-79	77	0.216	0.228	0.200	0.215	0.186	0.183
4	80-84	82	0.161	0.146	0.153	0.153	0.144	0.151
5	85-89	87	0.104	0.048	0.091	0.047	0.083	0.076
6	90-94	92	0.052	0.035	0.063	0.015	0.025	0.013
7	95-99	97	0.018	0.000	0.004	0.000	0.004	0.000
8	100-104	102	0.004	0.000	0.000	0.000	0.000	0.000

Table 4: Cooling Seasonal Bin Fractions for Recent Weather Data for Wilkes-Barre, PA

Bin	Temp. Range (F)	Rep. Temp. (F)	Federal Test Procedure Fractional Bin Hours	2015 Bin Fractions[7]	2016 Bin Fractions[7]	2017 Bin Fractions[7]	2018 Bin Fractions[7]	2019 Bin Fractions[7]
1	65-69	67	0.214	0.244	0.197	0.274	0.279	0.325
2	70-74	72	0.231	0.304	0.299	0.347	0.319	0.307
3	75-79	77	0.216	0.236	0.212	0.244	0.219	0.192
4	80-84	82	0.161	0.149	0.182	0.112	0.128	0.138
5	85-89	87	0.104	0.037	0.076	0.015	0.049	0.035
6	90-94	92	0.052	0.029	0.034	0.008	0.004	0.003
7	95-99	97	0.018	0.000	0.001	0.000	0.002	0.000
8	100-104	102	0.004	0.000	0.000	0.000	0.000	0.000

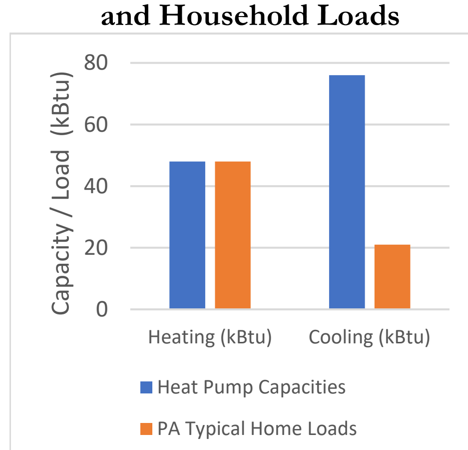
Table 5: Cooling Seasonal Bin Fractions for Recent Weather Data for Erie, PA

Bin	Temp. Range (F)	Rep. Temp. (F)	Federal Test Procedure Fractional Bin Hours	2015 Bin Fractions[7]	2016 Bin Fractions[7]	2017 Bin Fractions[7]	2018 Bin Fractions[7]	2019 Bin Fractions[7]
1	65-69	67	0.214	0.296	0.196	0.321	0.263	0.317
2	70-74	72	0.231	0.418	0.349	0.388	0.344	0.371
3	75-79	77	0.216	0.198	0.269	0.227	0.229	0.213
4	80-84	82	0.161	0.074	0.157	0.061	0.135	0.090
5	85-89	87	0.104	0.015	0.027	0.003	0.028	0.009
6	90-94	92	0.052	0.000	0.001	0.000	0.001	0.000
7	95-99	97	0.018	0.000	0.000	0.000	0.000	0.000
8	100-104	102	0.004	0.000	0.000	0.000	0.000	0.000

Application of Full-Load EER to Air-Source Heat Pumps (ASHP)

Heat pump adoption throughout the Mid-Atlantic United States is accelerating rapidly and they are being relied upon more and more for year-round comfort. Heat pumps can provide efficient heating and cooling for all the climate conditions experienced in Pennsylvania and as such, they are being sized and used accordingly.

Figure 2: Heat Pump Capacities and Household Loads



According to Northeast Energy Efficiency Partnership's (NEEP) cold-climate air source heat pump database, on average heat pumps have a 30% higher cooling capacity (at 95°F outdoor conditions) as compared to its heating capacity (at 5°F outdoor conditions). For example, if a typical heat pump could produce 48 kBtu of heat at 5°F, it would produce 76 kBtu of cooling at 95°F. This relationship between cooling and heating capacity is the direct opposite of what Pennsylvania climate requires; typically, the Pennsylvania climate requires homes to have heating loads which are approximately 2.3 times larger than that of the cooling load[8]. For example, a home with a heating load of 48 kBtu would likely have a cooling load closer to 21 kBtu.

Given these typical conditions, heat pumps will likely have significant additional capacity during peak cooling conditions and therefore would not typically operate at rated conditions or full-load EER conditions. When operating at steady state during these peak cooling conditions, it is more likely that inverter-driven heat pumps will operate at capacities of 25-30% which would result in the equipment operating with significantly higher efficiency than indicated by the equipment's EER rating as demonstrated in Figure 1.

[8] NEEP, Figure 1 in Assessment of Residential and Small Commercial Air-Source Heat Pump Installation and Best Practices in Cold-Climates - June 2017 https://neep.org/sites/default/files/AssessmentofResandSmallCommASHPInstallationPracticesinCold-Climates.pdf

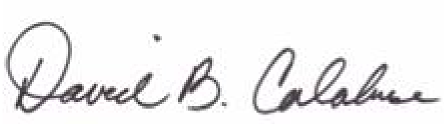
The use of full-load EER in the Residential HVAC Program's eligibility criteria for inverter HVAC equipment limits customer choice and increases the cost to install the measure while providing no real benefit to the utilities, electric grid, or ratepayers.

Summary

Inverter HVAC equipment provide additional customer comfort and use advantages by following the appropriate load profile, providing energy efficiency improvements, and providing unique advantages for demand response. Today's testing procedures and efficiency metrics do not appropriately account for inverter equipment's controls which can have a large impact on efficiency: high EER HVAC equipment do not necessarily provide the grid benefits expected. Inverter HVAC equipment represents a growing share of HVAC equipment installed in Pennsylvania, and as such, the eligibility criteria for inverter HVAC equipment should be handled separately than non-inverter HVAC equipment. Specifically, the full-load EER metric should not be included in the equipment eligibility requirements for inverter HVAC equipment.

Daikin welcomes the opportunity to work with the PUC and utilities to share our knowledge of inverter HVAC equipment, further demonstrate the benefits of this technology, and develop an appropriate methodology for developing eligibility criteria for inverter HVAC equipment. Please reach to Jon Hacker at jon.hacker@daikinus.com with any questions or requests.

Sincerely,



David B. Calabrese
Senior Vice President, Government Affairs
Daikin, U.S. Corporation