



Memorandum

PY2019 TRM Update Recommendations

To: Ameren Missouri
From: Opinion Dynamics Evaluation Team
Date: October 31, 2019
Re: PY2019 Technical Reference Manual/Deemed Savings Table Updates

This memorandum presents our PY2019 recommendations for updates to Ameren Missouri’s deemed savings tables. Included in this update are parameters for four prioritized residential measure groups and one prioritized business measure group, based on their expected contribution to overall portfolio energy savings for PY2019-2021 (see Table 1). In addition, we reviewed select parameters of interest to Ameren MO, including EFLH for ductless heat pumps and ground source heat pumps, as well as proposed updates to ECM measures, based on PY2018 evaluation work.

Table 1. Prioritized TRM Measures

TRM Measure Name	Percent (%) of Portfolio Gross kWh Savings (PY2019-2021)
Residential Measures	
3.4.2 Air Source Heat Pump Including Dual Fuel Heat Pumps	27%
3.4.8 Central Air Conditioner	17%
3.5.1 LED Screw Based Omnidirectional Bulb	20%
3.5.2 LED Specialty Lamp	
Business Measures	
2.6.3 LED Bulbs and Fixtures	85%

Table 2 (next page) outlines our recommended updates, if any, for each of the prioritized measures. Following the table, we provide additional information supporting our recommendations.

Data Sources

Opinion Dynamics leveraged the following materials in support of the recommended updates:

- Technical reference manuals (TRM) from neighboring jurisdictions, specifically Illinois, Arkansas, Wisconsin, Indiana, and Iowa
- Additional TRMs, including New York, Pennsylvania, and New Jersey
- ENERGY STAR program requirements and criteria specifications
- U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS)

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- Code of Federal Regulations (CFR)
- 2015 International Energy Conservation Code (IECC)

Recommendations

Table 2 summarizes our recommended updates.

Table 2. Priority 1 Parameters Reviewed as Part of the PY2019 TRM Updates

Parameter	Update Recommended?	Recommendation / Explanation
3.4.2 Air Source Heat Pump Including Dual Fuel Heat Pumps		
Effective Full Load Cooling Hours (EFLH_cool)	Yes	<ul style="list-style-type: none"> ▪ Retain current EFLH values for SF and MF ▪ Add new EFLH_cool values for MF properties with comprehensive envelope upgrades (see additional detail below).
Effective Full Load Heating Hours (EFLH_heat)	Yes	<ul style="list-style-type: none"> ▪ Retain current EFLH values for SF and MF ▪ Add new EFLH_heat values for MF properties with comprehensive envelope upgrades (see additional detail below).
Baseline SEER	No	<ul style="list-style-type: none"> ▪ The baseline SEER value used in the Ameren Missouri TRM aligns with the most recent Code of Federal Regulations (CFR) 430.32 dated 8/19/2019.
Efficient SEER	No	<ul style="list-style-type: none"> ▪ The lowest efficient SEER value in the deemed savings tables is 15, which reflects the ENERGY STAR Program Requirements for “Central Air Source Heat Pumps and Central Air Conditioners” v5.0.
Existing SEER	No	<ul style="list-style-type: none"> ▪ The current value of 8.33 is reasonable, given PY2018 data and degradation (see additional detail below).
Household factor (HF)	No	<ul style="list-style-type: none"> ▪ Retain current Household Factor of 100% for SF and 65% for MF units.
EUL	No	<ul style="list-style-type: none"> ▪ Deferred for review in PY2020.
Incremental Cost	(Yes)	<ul style="list-style-type: none"> ▪ Opinion Dynamics reviewed revised incremental cost calculations proposed by Ameren MO and agrees with the updates.
3.4.8 Central Air Conditioner		
Effective Full Load Cooling Hours (EFLH)	Yes	<ul style="list-style-type: none"> ▪ Retain current EFLH values. ▪ Add new EFLH_cool values for MF properties with comprehensive envelope upgrades (see additional detail below).
Baseline SEER	No	<ul style="list-style-type: none"> ▪ The baseline SEER value used in the Ameren Missouri TRM aligns with the most recent Code of Federal Regulations (CFR) 430.32 dated 8/19/2019.
Efficient SEER	No	<ul style="list-style-type: none"> ▪ The lowest efficient SEER in the deemed savings tables is 14. SEER 14 units are not currently offered through the HVAC Program but may be offered in the low income programs. SEER 14 is above the Missouri baseline of SEER 13.
Existing SEER	No	<ul style="list-style-type: none"> ▪ The current value of 8.33 is reasonable, given PY2018 data and degradation (see additional detail below).

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Parameter	Update Recommended?	Recommendation / Explanation
Household factor (HF)	No	<ul style="list-style-type: none"> ▪ Retain the current Household Factor of 100% (unit capacities account for reduced loads in MF households).
EUL	No	<ul style="list-style-type: none"> ▪ Deferred for review in PY2020.
Incremental Costs	(Yes)	<ul style="list-style-type: none"> ▪ Opinion Dynamics reviewed revised incremental cost calculations proposed by Ameren MO and agrees with the updates.
3.5.1 LED Screw Based Omnidirectional Bulb & 3.5.2 LED Specialty Lamp		
Baseline wattage	Yes	<ul style="list-style-type: none"> ▪ The baseline wattages in the Ameren MO TRM are in line with other TRMs, including IL-TRM v8.0, and ENERGY STAR standards, but the deemed savings table values are not reflective of the PY2018 evaluation. ▪ Apply values obtained through the PY2018 program tracking data and the ENERGY STAR qualified product list (QPL), if significantly different from current values.
Efficient wattage	Yes	<ul style="list-style-type: none"> ▪ The baseline wattages in the Ameren MO TRM are in line with other TRMs, including IL-TRM v8.0, and ENERGY STAR standards, but the deemed savings table values are not reflective of the PY2018 evaluation. ▪ Apply values obtained through the PY2018 program tracking data, if significantly different from current values.
Average hours of use	No	<ul style="list-style-type: none"> ▪ Hours of Use for residential applications is in line with a 2017 IL Statewide LED Lighting Logger study conducted by Opinion Dynamics.
Waste heat factors (WHF)	No	<ul style="list-style-type: none"> ▪ The current WHFs are based on the findings of the PY2013 LightSavers Impact and Process Evaluation. While WHFs of below 1.0 are unusual, they are based on an Ameren Missouri specific study and reflect the high saturation of electric resistance heating in Ameren Missouri's service territory. As such, we do not recommend any updates.
EUL	No	<ul style="list-style-type: none"> ▪ Deferred for review in PY2020.
Incremental cost	No	<ul style="list-style-type: none"> ▪ No update recommended.
2.6.3 LED Bulbs and Fixtures		
Waste heat factors	Yes	<ul style="list-style-type: none"> ▪ We recommend assigning all exterior lighting measures a value 1.00 in accordance with the 2017 Missouri statewide TRM.
Incremental cost	No	<ul style="list-style-type: none"> ▪ Incremental costs are in line with the IL-TRM v8.0.

Effective Full Load Hours

As part of our review of parameters for air source heat pumps (ASHP)/dual fuel heat pumps and CAC measures, Opinion Dynamics reviewed current deemed effective full load hour (EFLH) values for heating and cooling. To ensure consistency between the various heat pump measures, Opinion Dynamics also reviewed EFLH assumptions for ground source heat pumps (GSHP) and ductless heat pumps.

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To assess EFLH heating values for ASHP/dual fuel HPs, Opinion Dynamics reviewed Cadmus' findings from the PY2018 HVAC evaluation. To address EFLH cooling values for all measures and EFLH heating values for GSHPs and ductless HPs, we conducted a review of regional TRMs, specifically, Iowa, Arkansas and Illinois.

The proposed EFLH updates, outlined below, focus on older values that were based on secondary data sources and assumptions. We do not propose updates to EFLH values for single family and multifamily CAC, ASHPs, and dual fuel heat pumps that were based on the 2017 HVAC Program evaluation report and underlying metering study.¹ A new metering study, planned for PY2020, will provide additional insights for future EFLH updates.

Our review resulted in the following findings and recommendations:

- Current CAC, ASHPs, and dual fuel HP EFLH values for single family and multifamily properties are reasonable and do not require updating.
- Current GSHP EFLH heating values (2,009 hours) are higher than expected. While GSHP and ASHP technologies differ, their general operating conditions are similar, i.e., household type, unit capacity. We recommend aligning GSHP EFLH heating values with those used for ASHP. (See additional detail on this recommendation in the next section.)
- Current ductless HP EFLH heating (1,496 hours) and cooling (869 hours) values are higher than expected. They currently align with ASHP assumptions, but ductless HPs are typically smaller in capacity and used in conditioning specific spaces or zones in homes (i.e., zonal conditioning). As a result, we recommend adjusting EFLH values to reflect these operating conditions. Recommended values in Table 3 are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri city's (St. Louis, Cape Girardeau, Kansas City) partial year PY2019 installations.
- The deemed savings tables currently do not have different EFLH values for MF properties with comprehensive envelope upgrades. MF households having received such upgrades will have reduced conditioning needs compared with other MF households. We therefore recommend adding EFLH values for MF properties with comprehensive envelope upgrades. The recommended values in Table 3 are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri city's (St. Louis, Cape Girardeau, Kansas City) partial year PY2019 installations.

Recommended EFLH values are summarized in Table 3. Values with recommended updates are bolded.

¹ Based on Cadmus' 2013-2016 metering study and 2017 survey of program participants. See 'Ameren Missouri Heating and Cooling Program Impact and Process Evaluation'.

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Table 3. EFLH Updates for PY2019

Measure	Single Family (SF)		Multifamily (MF)		MF (CompEnv) ^{a b}	
	Heat	Cool	Heat	Cool	Heat	Cool
CAC		869		869		632
Air Source HP	1,496	869	1,496	869	510	632
Dual Fuel HP	1,119	869	1,119	869	510	632
Ground Source HP	1,496 ^c	869				
Ductless HP ^b	1,034	635	1,034	635	393	417

^a EFLH values for MF units that have received or previously implemented comprehensive envelope measures.

^b Update is based on capacity and application assumptions, with climate adjustments

^c Update to synchronize with ASHP value

Reduction of GSHP Full-Load Heating Hours

While GSHP was not a priority measure for review in PY2019, we did recommend an update to EFLH values to ensure consistency with other HVAC measures. Below, we present the rationale for our recommendation.

- The previous EFLH heating value of 2,009 hours came from the ENERGY STAR Heat Pump calculator, which cites EPA 2002 as the source of the EFLH values. **The calculator does not provide additional information on rigor of the EPA 2002 reference or the methods used to calculate the 2,009 hours.**
- Cadmus conducted a HP metering study as part of the 2016 evaluation report but was only able to meter a single GSHP. The metering study provided two important findings used in assessing GSHP EFLH values. **First, Cadmus was unable to provide an EFLH update for GSHP** because of uncertainty surrounding GSHP performance factors, such as staging strategies, and a lack of actual metered data. **Second, Cadmus updated the EFLH heating hours for ASHP from 2,009 hours to 1,496 hours.**

While Cadmus suggested that EFLH heating values should be “significantly higher” for GSHPs than ASHPs, we feel the reasoning is not strong enough to support keeping the GSHP EFLH heating value at 2,009 hours. Notably, Cadmus bases their claim in part on monthly billing information for survey participants and not actual metered data. Additionally, Cadmus notes that GSHPs can operate more hours in colder weather because of their system design and typical efficiency. While GSHPs can operate efficiently at lower temperatures, ASHPs can also run at lower outdoor temperatures, but experience a reduction in their effective capacity, consequently resulting in an increase of runtime to produce the needed heat. **Ultimately, the metered ASHP data is representative of EFLH values for both ASHPs and GSHPs.**

- In our review of TRMs, regionally and nationally, we found that EFLH heating values for ASHP and GSHP are commonly equal. Moreover, prior to the 2016 HVAC program evaluation report, the EFLH heating values for both ASHP and GSHP were equal at 2,009 hours in the Ameren MO TRM. **We recommend that EFLH heating values for ASHP and GSHP be equal until better data suggests a deviation.**
- We leveraged Illinois TRM v7.0 EFLH assumptions and methods for ASHP and GSHP measures. EFLH values are derived from ENERGY STAR Calculator estimates adjusted for Illinois’ climate and then extrapolated from northern Illinois to southern Illinois. We applied the same logic to extrapolate from a 3-IL city average to three representative MO cities in Ameren’s territory, namely St Louis, Kansas City, and Cape Girardeau. The resulting ASHP EFLH heating value was lower than the 1,496 hours

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observed in the 2016 metered data, but we determined that primary data should outweigh secondary research. **However, our calculated EFLH value reaffirmed that the 2,009 full load hours is an overestimate of actual heating loads in Missouri.**

- We also looked at EFLH heating values from a practical perspective. The EFLH heating value for Rockford Illinois, the northern most climate zone in Illinois' TRM, is 1,996 hours, slightly below the 2,009 hours provided by the EPA 2002 reference. Additionally, the 30-year Normals (1981-2010) heating degree days (HDD) for Rockford is 5,351. St. Louis' 30-year Normals HDD is 3,528, or 34% lower than Rockford's. **This further supports our conclusion that the 2,009 full load hours is an overestimation of actual heating loads in Missouri.**

Application of New EFLH for MF (CompEnv)

The proposed EFLH updates summarized in Table 3 include a new EFLH category for multifamily (MF) households, called MF (CompEnv). The MF (CompEnv) category accounts for MF buildings where the envelope has been comprehensively upgraded, resulting in lower demand on the HVAC system. Because we have not yet seen program tracking data for the MF programs, we do not know exactly what information on envelope upgrades will be tracked, including both recommended and completed upgrades. As such, we provide the following general guidance for the use of the new MF (CompEnv) category.

A MF building is classified as MF (CompEnv) under the following conditions:

1. The incented project includes comprehensive envelope measures; or
2. The building does not require envelope measures because it is already sufficiently insulated and air sealed.

All other MF buildings are classified in the general MF EFLH category, and include the following scenarios:

1. Comprehensive envelope measures were recommended but not completed;
2. Comprehensive envelope measures were recommended but only minor measures were completed; or
3. Comprehensive envelope measures were not recommended even though the building is not sufficiently insulated and air sealed.

We define "comprehensive envelope" as a project that must include one installed ceiling or floor insulation measure, and one additional envelope measure from the following: air sealing, duct insulation, duct repair (duct sealing and repair), or an additional ceiling or floor insulation, but cannot be of the same type as the initial required insulation.

A "minor envelope" project is any other project addressing the building's envelope that does not meet the comprehensive envelope project requirements but did install at least one envelope measure.

If blower-door testing is conducted, an infiltration reduction of 30% or more would indicate a comprehensive envelope project.

Future program tracking data should include sufficient information to verify classification of measures as MF (CompEnv), including installed and recommended envelope measures.

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Existing SEER for CAC and ASHP

The deemed savings value of 8.33 for the SEER of the replaced equipment (“existing SEER”) for ASHP and CAC measures is lower than values found in other regional TRMs and the Code of Federal Regulations (CFR) (see Table 4).

Table 4. Comparison of Existing SEER Values

Source	Effective Year	Existing SEER	
		Assumptions	Notes
Ameren MO Appendix F	2019	ASHP/DFHP = 8.33 CAC = 8.33	PY2017 evaluation (based on metering and modeling)
2018 IA Statewide TRM	2018	ASHP = 9.12; CAC = 8.6	Average nameplate efficiencies from Ameren IL PY3-PY4 (2010-2012)
IL-TRM v8.0	2020	ASHP = 9.3; CAC = 9.3	Applies nameplate plus a 1% derating factor for every year since manufacture of the existing unit OR Default value of 9.3 based on 2018 metering study (Opinion Dynamics & Cadmus ²)
AR TRM Version 8.0	2019	ASHP = 10; CAC = 10	Federal standards prior to 2015
IN TRM Version 2.2	2015	ASHP = 11.15; CAC = 11.15	TRM is outdated
MN TRM Version 2.2	2019	ASHP = actual; CAC = actual	Requires existing SEER be collected by contractor. Default to 13 SEER when unknown.
10 CFR 430	pre-2006	ASHP = 10; CAC = 10	Federal minimum standards
	2006 to 2015	ASHP = 13; CAC = 13	

One reason for the lower Appendix F SEER value is that the value comes from measured SEER values of existing equipment, which includes in-situ performance degradation. Of the other TRMs, only Illinois incorporates performance degradation. However, Illinois also applies a derating factor on the *efficient* unit, assuming that there is also a reduction in performance of the efficient unit once installed outside of lab conditions.

Review of PY2018 program tracking data for the Residential HVAC Program shows average nameplate SEER values for existing equipment between 9.8 and 10.2 for various CAC and heat pump measure groups. Applying a performance degradation factor of 1.44% per year (as found in the 2017 evaluation) results in an in-situ

² Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See ‘AIC HVAC Metering Study Memo FINAL 2_28_2018’.

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SEER value of 8.3 after approximately 12 years. Since 12 years is a reasonable assumption for the average age of replaced units, we recommend maintaining the existing SEER assumption of 8.33.

Table 5. PY2018 Average SEER Values of Replaced Units

Measure Group	Average SEER of Replaced Equipment	Number of Units
CAC	9.8	14,590
ASHP	9.9	1,628
DFHP	10.2	67
GSHP	10.1	79

Household Factors (HF)

We recommend maintaining current household factors (HF) for CAC and ASHP/dual fuel HPs. **For ductless heat pumps, however, we recommend updating the MF household factor to 100%.** Ductless HPs are assumed to have similar capacities in SF and MF households and would have similar EFLH making the application of a HF unnecessary.

Table 6. Household Factors (HF) for Select HVAC Measures

Measure Type	Current HF	Recommendation	Reason
ASHP & Dual Fuel HP	SF - 100% MF - 65%	SF - 100% MF - 65%	No update recommended. MF HF of 65% because TRM assumes same capacity SF and MF units.
CAC	SF - 100% MF - 100%	SF - 100% MF - 100%	No update recommended. MF HF of 100% because TRM already assumes smaller capacity for MF units.
Ductless HP	SF - 100% MF - 65%	SF - 100% MF - 100%	The need to account for MF homes is unnecessary because systems are assumed to be of similar capacity in SF and MF applications.

***Bold** text indicates a change from the current household factor (HF)

ECM

Ameren Missouri asked Opinion Dynamics to review Cadmus' PY2018 evaluation results for ECMs and provide feedback on whether (1) Opinion Dynamics plans to apply these results in the PY2019 evaluation and (2) these results should be incorporated into the deemed savings tables. In specific, the question was around the mode of operation of ECMs, i.e., auto or continuous mode. Additionally, Opinion Dynamics conducted a review of all ECM measure parameters in the Ameren Missouri TRM to identify other potential areas for improvement.

As part of the PY2018 participant survey, Cadmus explored the operating mode of HVAC equipment before ECM installation as well as the propensity of participants to alter the operating mode following installation. Results indicate that 82% of participants reported operating their HVAC systems in "auto" mode before and after the ECM installation, 11% operate in "continuous" mode (equivalent to 6,132 to 8,760 hours annually) before and after, while the remaining 7% reported an increase in "continuous" mode operation. The pre- and post-intervention operating mode is key to quantifying energy savings from an ECM motor. Positive savings

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result when a homeowner maintains the operating mode after the ECM is installed or moves from continuous to auto operation. Conversely, a change in operating mode from auto to continuous results in negative savings.

Currently, the program tracking data provides information for efficient case operating mode but does not specify if the baseline condition was also continuous operation mode. As a result, it is possible for an installed ECM motor to operate in continuous mode in the post-installation case, but have operated in auto mode in the pre-installation case, which would result in negative savings for the ECM measure. The reverse is also possible. Since the program tracking data currently does not provide adequate information to make this determination, **our recommendation is to assume “auto” operation mode in the pre- and post-installation scenarios.**

Additionally, we assessed other parameters, specifically the percent of ECMs installed on ASHPs and the percent of ECMs installed on systems with central cooling, by comparing partial PY2019 Residential HVAC program tracking data to Appendix F assumptions. This comparison shows that a TRM assumption of 79% of ECMs installed on equipment with central cooling, compared to 85% in the program tracking data. Conversely, the TRM assumes 16% of ECMs installed on ASHPs, compared to 11% in the program tracking data. While the partial PY2019 values deviate from TRM assumptions by approximately five percentage points, we find that the values are reasonably close. Therefore, we do not recommend updating these parameters. Results are presented in Table 7.

Table 7. Distribution of PY2019 ECM Equipment Configurations (Partial Year)

ECM Equipment	PY 2019 Partial Program Tracking Data						TRM % Yes	Diff (PY2019-TRM)
	Yes	No	Unknown	% Yes	% No	% Unknown		
ECM w/ Central Cooling	4,020	530	180	85%	11%	4%	79%	6%
ECM w/ ASHP	522	2,630	1,578	11%	56%	33%	16%	-5%