### Air Sealing

###### Description

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door. The algorithm for this measure can be used when the program implementation does not allow for more detailed forecasting through the use of residential modeling software.

Prescriptive savings are provided for use only where a blower door test is not possible (for example in large multi family buildings).

This measure was developed to be applicable to the following program types:  RF.

If applied to other program types, the measure savings should be verified.

###### Definition of Efficient Equipment

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

###### Definition of Baseline Equipment

The existing air leakage should be determined through approved and appropriate test methods using a blower door. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

###### Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[[1]](#footnote-2)

###### Deemed Measure Cost

The actual capital cost for this measure should be used in screening.

###### Loadshape

|  |
| --- |
| Loadshape R08 - Residential Cooling |
| Loadshape R09 - Residential Electric Space Heat |
| Loadshape R10 - Residential Electric Heating and Cooling |

###### Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM’s Forward Capacity Market.

CFSSP = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 68%[[2]](#footnote-3)

CFSSP = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[[3]](#footnote-4)

CFPJM   = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[[4]](#footnote-5)

Algorithm

###### Calculation of Savings

###### Electric Energy Savings

***Methodology 1: Blower Door Test***

Preferred methodology unless blower door testing is not possible.

ΔkWh = ΔkWh\_cooling + ΔkWh\_heating

Where:

ΔkWh\_cooling = If central cooling, reduction in annual cooling requirement due to air sealing

= [(((CFM50\_existing - CFM50\_new)/N\_cool) \* 60 \* 24 \* CDD \* DUA \* 0.018) / (1000 \* ηCool)] \* LM

CFM50\_existing = Infiltration at 50 Pascals as measured by blower door before air sealing.

= Actual

CFM50\_new = Infiltration at 50 Pascals as measured by blower door after air sealing.

= Actual

N\_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

=Dependent on location and number of stories:[[5]](#footnote-6)

| **Climate Zone (City based upon)** | **N\_cool (by # of stories)** | | | |
| --- | --- | --- | --- | --- |
| **1** | **1.5** | **2** | **3** |
| 1 (Rockford) | 39.5 | 35 | 32.1 | 28.4 |
| 2 (Chicago) | 38.9 |  | 31.6 | 28 |
| 3 (Springfield) | 41.2 |  | 33.4 | 29.6 |
| 4 (St Louis, MO) | 40.4 | 35.8 | 32.9 | 29.1 |
| 5 (Paducah, KY) | 43.6 | 38.6 | 35.4 | 31.3 |

60 \* 24 = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD = Cooling Degree Days

= Dependent on location[[6]](#footnote-7):

|  |  |
| --- | --- |
| **Climate Zone (City based upon)** | **CDD 65** |
| 1 (Rockford) | 820 |
| 2 (Chicago) | 842 |
| 3 (Springfield) | 1,108 |
| 4 (Belleville) | 1,570 |
| 5 (Marion) | 1,370 |

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [[7]](#footnote-8)

0.018 = Specific Heat Capacity of Air (Btu/ft3\*°F)

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[[8]](#footnote-9):

| **Age of Equipment** | **SEER Estimate** |
| --- | --- |
| Before 2006 | 10 |
| 2006 - 2014 | 13 |
| Central AC After 1/1/2015 | 13 |
| Heat Pump After 1/1/2015 | 14 |

LM = Latent multiplier to account for latent cooling demand[[9]](#footnote-10)

| **Climate Zone (City based upon)** | **LM** |
| --- | --- |
| 1 (Rockford) | 3.3 |
| 2 (Chicago) | 3.2 |
| 3 (Springfield) | 3.7 |
| 4 (St Louis, MO) | 3.6 |
| 5 (Paducah, KY) | 3.7 |

ΔkWh\_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

= (((CFM50\_existing - CFM50\_new)/N\_heat) \* 60 \* 24 \* HDD \* 0.018) / (ηHeat \* 3,412)

N\_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level:[[10]](#footnote-11)

| **Climate Zone (City based upon)** | **N\_heat (by # of stories)** | | | |
| --- | --- | --- | --- | --- |
| **1** | **1.5** | **2** | **3** |
| 1 (Rockford) | 23.8 | 21.1 | 19.3 | 17.1 |
| 2 (Chicago) | 23.9 | 21.1 | 19.4 | 17.2 |
| 3 (Springfield) | 24.2 | 21.5 | 19.7 | 17.4 |
| 4 (St Louis, MO) | 25.4 | 22.5 | 20.7 | 18.3 |
| 5 (Paducah, KY) | 27.8 | 24.6 | 22.6 | 20.0 |

HDD = Heating Degree Days

= Dependent on location:[[11]](#footnote-12)

| **Climate Zone**  **(City based upon)** | **HDD 60** |
| --- | --- |
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[[12]](#footnote-13):

|  |  |  |  |
| --- | --- | --- | --- |
| **System Type** | **Age of Equipment** | **HSPF Estimate** | **ηHeat (Effective COP Estimate)= (HSPF/3.413)\*0.85** |
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| 2006 - 2014 | 7.7 | 1.92 |
| 2015 on | 8.2 | 2.40 |
| Resistance | N/A | N/A | 1 |

3412 = Converts Btu to kWh

For example, a 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2 (1.92 including distribution losses), has pre and post blower door test results of 3,400 and 2,250:

ΔkWh = ΔkWh\_cooling + ΔkWh\_heating

= [((((3,400 – 2,250) / 31.6) \* 60 \* 24 \* 842 \* 0.75 \* 0.018) / (1000 \* 10.5)) \* 3.2] + [((3,400 – 2,250) / 19.4)) \* 60 \* 24 \* 5113 \* 0.018 / (1.92 \* 3,412)]

= 182 + 1199

= 1,381 kWh

ΔkWh\_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms \* Fe \* 29.3

Fe = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[[13]](#footnote-14)

29.3 = kWh per therm

For example, a well shielded, 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250 (see therm calculation in Natural Gas Savings section:

ΔkWh = 109.1 \* 0.0314 \* 29.3

= 100 kWh

***Methodology 2: Prescriptive Infiltration Reduction Measures[[14]](#footnote-15)***

Savings shall only be calculated via Methodology 2 if a blower door test is not feasible. Cooling savings are not quantified using Methodology 2.

ΔkWh\_heating = (ΔkWhgasket \* ngasket + ΔkWhsweep \* nsweep + ΔkWhsealing \* lfsealing + ΔkWhWX \* lfWX) \* ADJRxAirsealing

Where:

ΔkWhgasket = Annual kWh savings from installation of air sealing gasket on an electric outlet

|  |  |  |
| --- | --- | --- |
| **Climate Zone (City based upon)** | **ΔkWhgasket / gasket** | |
| **Electric Resistance** | **Heat Pump** |
| 1 (Rockford) | 10.5 | 5.3 |
| 2 (Chicago) | 10.2 | 5.1 |
| 3 (Springfield) | 8.8 | 4.4 |
| 4 (Belleville) | 7.0 | 3.5 |
| 5 (Marion) | 7.2 | 3.6 |

ngasket = Number of gaskets installed

ΔkWhsweep =Annual kWh savings from installation of door sweep

|  |  |  |
| --- | --- | --- |
| **Climate Zone (City based upon)** | **ΔkWhsweep / sweep** | |
| **Electric Resistance** | **Heat Pump** |
| 1 (Rockford) | 202.4 | 101.2 |
| 2 (Chicago) | 195.3 | 97.6 |
| 3 (Springfield) | 169.3 | 84.7 |
| 4 (Belleville) | 134.9 | 67.5 |
| 5 (Marion) | 137.9 | 68.9 |

nsweep = Number of sweeps installed

ΔkWhsealing = Annual kWh savings from foot of caulking, sealing, or polyethlylene tape

| **Climate Zone (City based upon)** | **ΔkWhsealing / ft** | |
| --- | --- | --- |
| **Electric Resistance** | **Heat Pump** |
| 1 (Rockford) | 11.6 | 5.8 |
| 2 (Chicago) | 11.2 | 5.6 |
| 3 (Springfield) | 9.7 | 4.8 |
| 4 (Belleville) | 7.7 | 3.9 |
| 5 (Marion) | 7.9 | 3.9 |

lfsealing = linear feet of caulking, sealing, or polyethylene tape

ΔkWhWX = Annual kWh savings from window weatherstripping or door weatherstripping

| **Climate Zone (City based upon)** | **ΔkWhWX / ft** | |
| --- | --- | --- |
| **Electric Resistance** | **Heat Pump** |
| 1 (Rockford) | 13.5 | 6.7 |
| 2 (Chicago) | 13.0 | 6.5 |
| 3 (Springfield) | 11.3 | 5.6 |
| 4 (Belleville) | 9.0 | 4.5 |
| 5 (Marion) | 9.2 | 4.6 |

lfWX = Linear feet of window weatherstripping or door weatherstripping

ADJRxAirsealing = Adjustment for air sealing savings to account for prescriptive estimates overclaiming savings[[15]](#footnote-16).

= 80%

###### Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh\_cooling / FLH\_cooling) \* CF

Where:

FLH\_cooling = Full load hours of air conditioning

= Dependent on location[[16]](#footnote-17):

| **Climate Zone**  **(City based upon)** | **Single Family** | **Multifamily** |
| --- | --- | --- |
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |

CFSSP = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[[17]](#footnote-18)

CFSSP = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[[18]](#footnote-19)

CFPJM = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[[19]](#footnote-20)

Other factors as defined above

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2.0, has pre and post blower door test results of 3,400 and 2,250:

ΔkWSSP = 182 / 570 \* 0.68

= 0.22 kW

ΔkWPJM = 182 / 570 \* 0.466

= 0.15 kW

###### Natural Gas Savings

***Methodology 1: Blower Door Test***

Preferred methodology unless blower door testing is not possible.

If Natural Gas heating:

ΔTherms = (((CFM50\_existing - CFM50\_new)/N\_heat) \* 60 \* 24 \* HDD \* 0.018) / (ηHeat \* 100,000)

Where:

N\_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone and building height[[20]](#footnote-21)

| **Climate Zone (City based upon)** | **N\_heat (by # of stories)** | | | |
| --- | --- | --- | --- | --- |
| **1** | **1.5** | **2** | **3** |
| 1 (Rockford) | 23.8 | 21.1 | 19.3 | 17.1 |
| 2 (Chicago) | 23.9 | 21.1 | 19.4 | 17.2 |
| 3 (Springfield) | 24.2 | 21.5 | 19.7 | 17.4 |
| 4 (St Louis, MO) | 25.4 | 22.5 | 20.7 | 18.3 |
| 5 (Paducah, KY) | 27.8 | 24.6 | 22.6 | 20.0 |

HDD = Heating Degree Days

= dependent on location[[21]](#footnote-22):

|  |  |
| --- | --- |
| **Climate Zone**  **(City based upon)** | **HDD 60** |
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |

ηHeat = Efficiency of heating system

= Equipment efficiency \* distribution efficiency

= Actual[[22]](#footnote-23). If not available use 72%[[23]](#footnote-24).

Other factors as defined above

For example, a 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250:

ΔTherms = ((3,400 – 2,250)/19.4) \* 60 \* 24 \* 5113 \* 0.018) / (0.72 \* 100,000)

= 109.1 therms

***Methodology 2: Prescriptive Infiltration Reduction Measures[[24]](#footnote-25)***

Savings shall only be calculated via Methodology 2 if a blower door test is not feasible.

Δtherms = (Δthermsgasket \* ngasket + Δthermssweep \* nsweep + Δthermssealing \* lfsealing + ΔthermsWX \* lfWX) \* ADJRxAirsealing

Where:

Δthermsgasket = Annual therm savings from installation of air sealing gasket on an electric outlet

|  |  |
| --- | --- |
| **Climate Zone (City based upon)** | **Δthermsgasket / gasket**  **Gas Heat** |
| 1 (Rockford) | 0.49 |
| 2 (Chicago) | 0.47 |
| 3 (Springfield) | 0.41 |
| 4 (Belleville) | 0.33 |
| 5 (Marion) | 0.33 |

ngasket = Number of gaskets installed

Δthermssweep = Annual therm savings from installation of door sweep

|  |  |
| --- | --- |
| **Climate Zone (City based upon)** | **Δthermssweep / sweep**  **Gas Heat** |
| 1 (Rockford) | 9.46 |
| 2 (Chicago) | 9.13 |
| 3 (Springfield) | 7.92 |
| 4 (Belleville) | 6.31 |
| 5 (Marion) | 6.45 |

nsweep = Number of sweeps installed

Δthermssealing = Annual therm savings from foot of caulking, sealing, or polyethlylene tape

| **Climate Zone (City based upon)** | **Δthermssealing / ft**  **Gas Heat** |
| --- | --- |
| 1 (Rockford) | 0.54 |
| 2 (Chicago) | 0.52 |
| 3 (Springfield) | 0.45 |
| 4 (Belleville) | 0.36 |
| 5 (Marion) | 0.37 |

lfsealing = linear feet of caulking, sealing, or polyethylene tape

ΔthermsWX = Annual therm savings from window weatherstripping or door weatherstripping

| **Climate Zone (City based upon)** | **Δthermssx / ft**  **Gas Heat** |
| --- | --- |
| 1 (Rockford) | 0.63 |
| 2 (Chicago) | 0.61 |
| 3 (Springfield) | 0.53 |
| 4 (Belleville) | 0.42 |
| 5 (Marion) | 0.43 |

lfWX = Linear feet of window weatherstripping or door weatherstripping

ADJRxAirsealing = Adjustment for air sealing savings to account for prescriptive estimates overclaiming savings[[25]](#footnote-26).

= 80%

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: RS-SHL-AIRS-V06-160601

1. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007 [↑](#footnote-ref-2)
2. Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory. [↑](#footnote-ref-3)
3. Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’. [↑](#footnote-ref-4)
4. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year. [↑](#footnote-ref-5)
5. N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult “Infiltration Factor Calculations Methodology.doc”. [↑](#footnote-ref-6)
6. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. [↑](#footnote-ref-7)
7. This factor's source is: Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31. [↑](#footnote-ref-8)
8. These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. [↑](#footnote-ref-9)
9. Derived by calculating the sensible and total loads in each hour. For more information see Bruce Harley, CLEAResult “Infiltration Factor Calculations Methodology.doc”. [↑](#footnote-ref-10)
10. N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult “Infiltration Factor Calculations Methodology.doc”. [↑](#footnote-ref-11)
11. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F. [↑](#footnote-ref-12)
12. These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps. [↑](#footnote-ref-13)
13. Fe is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% Fe. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference. [↑](#footnote-ref-14)
14. Prescriptive savings are based upon “Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps).” Middletown, CT: KEMA, 2010. Accessed July 30, 2015, (<http://www.energizect.com/sites/default/files/Final%20WRAP%20%20Helps%20Report.pdf>) and adjusted for relative HDD of Bridgeport/Hartford CT with the IL climate zones. See ‘Rx Airsealing HDD adjustment.xls’ for more information. [↑](#footnote-ref-15)
15. Though we do not have a specific evaluation to point to, modeled savings have often been found to overclaim. Further VEIC reviewed these deemed estimates and consider them to likely be a high estimate. As such an 80% adjustment is applied, and this could be further refined with future evaluations. [↑](#footnote-ref-16)
16. Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, <http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf> p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. [↑](#footnote-ref-17)
17. Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory. [↑](#footnote-ref-18)
18. Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’. [↑](#footnote-ref-19)
19. Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year. [↑](#footnote-ref-20)
20. N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult “Infiltration Factor Calculations Methodology.doc”. [↑](#footnote-ref-21)
21. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in “Statistical Analysis of Historical State-Level Residential Energy Consumption Trends,” 2004.. [↑](#footnote-ref-22)
22. Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (<http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf> or by performing duct blaster testing. [↑](#footnote-ref-23)
23. Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses. [↑](#footnote-ref-24)
24. Prescriptive savings are based upon “Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps).” Middletown, CT: KEMA, 2010. Accessed July 30, 2015, (<http://www.energizect.com/sites/default/files/Final%20WRAP%20%20Helps%20Report.pdf>) and adjusted for relative HDD of Bridgeport/Hartford CT with the IL climate zones. See ‘Rx Airsealing HDD adjustment.xls’ for more information. [↑](#footnote-ref-25)
25. Though we do not have a specific evaluation to point to, modeled savings have often been found to overclaim. Further VEIC reviewed these deemed estimates and consider them to likely be a high estimate. As such an 80% adjustment is applied, and this could be further refined with future evaluations. [↑](#footnote-ref-26)