PHIUS Technical Committee
ERV/HRV modeling protocols

Idealized HRV's and ERV's:

To begin with, let's discuss what an ideal HRV/ERV would do in terms of sensible heat transfer in both the wintertime and summertime:

Wintertime (outside air is cooler than inside air): an ideal HRV/ERV would transfer all of the sensible heat energy between inside and outside, AND it would return/retain all of the "waste" heat from the motors to the house/building. In order to return as much of the waste heat from the motors to the house as possible, the motor locations would be on the "house" side of the HRV/ERV (see figure 1)

Summertime (outside air is warmer than inside air): an ideal HRV/ERV would transfer all of the sensible heat energy between inside and outside, AND it would "reject" all of the "waste" heat from the motors to the outside. In order to reject as much of the waste heat from the motors to the outside as possible, the motor locations would be on the "outside" side of the HRV/ERV (see figure 2)

Assuming that one could not seasonally adjust the location of the fan motors, it is clear that any given HRV/ERV will tend to favor either wintertime efficiency ("house" side motors), or summertime efficiency ("outside" side motors), or split the difference (one motor on each side).

And, of course, the HRV/ERV would do all of this using as little energy as possible to operate the fan motors.

Background:

The previous energy modeling rules for PHIUS+ certified projects required using the certified heat transfer efficiency rating from an HRV/ERV's PHI (Passivhaus Institut Germany) certificate, or, in the case of non-PHI-certified products, taking the manufacturer's listed heat transfer efficiency, less 12 percentage points. The PHIUS Technical Committee realized that the 12 percentage point "downgrade" of non-PHI-certified units was arbitrary – in some cases justified and in other cases putting quality, non-PHI-certified units on unequal footing with their PHI-certified counterparts. In addition, the PHIUS Technical Committee recognized that there is an existing HRV/ERV certification program in North America managed by the Home Ventilation Institute (HVI) that has many excellent attributes. The committee decided to investigate the differences between the PHI and "HVI" testing/rating methods and attempt to develop a new energy modeling protocol that would retain modeling accuracy while providing a more level "playing field" for all manufacturers.

Description of HVI and PHI's key rating metrics:

HVI's Sensible Recovery Efficiency (SRE) formula:

Temperature difference between outside air and supply leaving temperature, less exhaust air transfer, less supply fan energy, less case heat transfer, less case air leakage…divided by: temperature difference

between inside and outside, plus exhaust fan energy. SRE is an attempt to develop true wintertime heat recovery efficiency for just the HRV core and "box", independent of the internal gains caused by the fan motor/s.

9.3.3.1
The sensible heat-recovery efficiency shall be calculated as follows:

$$E_{SHR} = \frac{\left(\sum_{i=1}^{n} M_{s,i} \times C_p \times \left(t_{5,i} - t_{1,i}\right) \times \Delta\theta\right) - Q_{SF} - Q_{SH} - Q_C - Q_D - Q_L}{\left(\sum_{i=1}^{n} M_{max,i} \times C_p \times \left(t_{3,i} - t_{1,i}\right) \times \Delta\theta\right) + Q_{EF} + Q_{EH}}$$

(from C439-09: "Standard laboratory methods of test for rating the performance of heat/energy-recovery ventilators")

PHI's "N-eff" formula:

Temperature difference between indoor temperature and exhaust air leaving temperature, plus total energy input…divided by temperature difference between inside and outside. N-eff is an attempt to develop true wintertime heat recovery efficiency for the entire machine, including the effects of the fan motors.

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})}$$

(from Passivhaus Institut: "Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems for Certification as "Passive House suitable component")

<u>Digging deeper – PHI & HVI methods – likes + dislikes:</u>

What we like about the PHI methods:

- Measuring temperature at the exhaust air stream leaving the HRV is a rigorous test of HRV wintertime performance. Any difference in temperature between the air leaving the HRV and the air entering the HRV is regarded as waste.
- PHI <u>certification</u> requires high heat recovery <u>and</u> excellent fan efficiency (W/cfm). Product selection is simplified in cold climates by choosing from a list of products that meet preset performance thresholds.

- Though a particular metric is not required for PHI certification, PHI testing does include acoustical testing. Sound attenuation guidance is provided for PHI certified units that exceed the threshold of 35dB(A).

What we don't like about PHI testing –

- While PHI tests for cross leakage, it appears that no adjustments are made in the calculations if the test result meets their criteria of 3% or less.
- N-eff assumes all power input is converted into an internal gain. This is questionable for any HRV, but especially for units with either motor on the "outside" side of the machine.
- N-eff is not appropriate for energy modeling in summer conditions. Internal gains from the motor are not a benefit in summer! In addition, sensible heat transfer will be lower in most summertime conditions since the temperature difference is smaller.
- PHI moisture recovery testing for ERV's is only done for cool/cold outdoor conditions.
- PHI efficiency listing is for the average flow rate of the airflow range provided on the PHI certificate. However, in real life, the efficiency is better at the lower range of the flow rate and worse at the higher range of the flow rate.
- PHI does not provide a procedure for regularly sampling production units to ensure they meet the specs, or providing a challenge procedure.

What we like about HVI/AHRI testing –

- HVI's SRE calculations mathematically adjust for exhaust air transfer ("cross leakage"), case heat transfer and case leakage
- HVI listings are for a specific airflow…most units have multiple listings at various airflows
- HVI provides an optional listing for summertime performance
- HVI listings are readily available for 100+ products
- "Off the shelf" units are randomly tested by HVI. There is also a challenge procedure for manufacturers to challenge each other's data.
- AHRI testing is very similar (though not identical) to HVI testing

What we don't like about HVI/AHRI testing –

- There are mediocre units that have high apparent sensible effectiveness (ASE) due to high fan power (supply and exhaust), exhaust air transfer, mass airflow imbalance, case air leakage and/or case heat transmission. In these cases, the high ASE can trick practitioners into thinking the unit is highly efficient. The ASE value is not a good tool for product comparison.
- HVI summer condition testing lumps together sensible and latent heat transfer performance into a single metric called "total recovery efficiency (TRE)". Practitioners would be better served by separate metrics for sensible and latent recovery efficiency.
- While SRE is a good measure of an HRV's "core" efficiency, it is not the best metric to use in energy modeling, since it does not include the effects of fan motor energy.

After this analysis, some discussion and debate, the PHIUS Technical Committee moved to alter the energy modeling procedures for PHIUS+ projects:

1. For units with HVI certification, use an adjusted SRE for winter performance by adding back the fan power to the SRE equation (add supply fan energy to the numerator, deduct exhaust fan energy from the denominator). This method provides for a mathematical adjustment for exhaust air transfer and case heat transfer, while avoiding double counting fan energy. See spreadsheet for calculations. For units with multiple airflow rating points and efficiencies, PHIUS staff will develop appropriate guidance for selecting the correct efficiency rating to use in modeling.

2. For units with HVI certification, summertime performance shall be used for projects in climate zones 1A, 2A, 2B and 3B. Additional conversations with HVI are required in order to separate summertime sensible and latent heat transfer (these are currently combined into a single value in HVI's listings). Until these further calculations can be made, consultants should use the adjusted SRE for winter performance (see #1, above) in their energy modeling.

3. For units with only PHI certification, use the PHI efficiency for winter performance, as long as the design airflow is within the range listed on the PHI certificate. Summertime performance TBD.

4. For units without HVI or PHI certification, use the status quo – "manufacturer's stated for efficiency (which is typically ASE), less 12 percentage points".

5. For commercial units with AHRI certification, use the "Net sensible" and "Net Latent" efficiencies from the AHRI certified rating. All AHRI certified units are rated at 100% airflow and 75% airflow. It is our understanding that AHRI is developing methods for estimating a performance curve for AHRI certified units at various airflows. In the meantime, PHIUS has developed a simple "straight line curve" spreadsheet that shall be used to estimate the performance of these units at airflows other than at the AHRI rated airflow points. See "AHRI-listed ERV performance extrapolation.xls."

In all cases, actual in-field fan power will be measured and used in the final energy model. Project teams are advised to be conservative in their pre-certification fan efficiency assumptions.