Changes to PHIUS+ energy modeling rules for HRV's and ERV's

PHIUS Technical Committee
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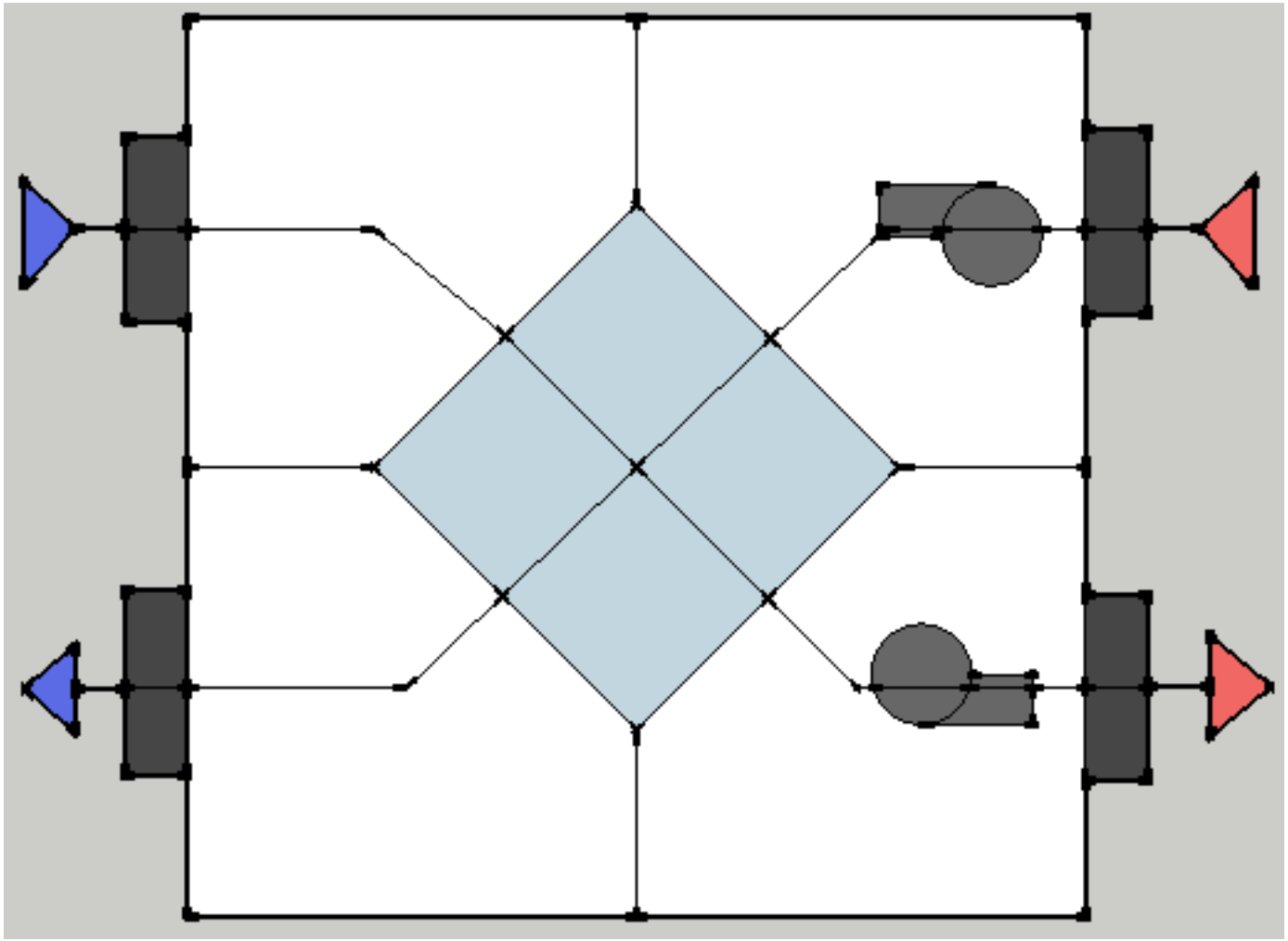
Which one is the best HRV?

Unit #1: PHI N-eff = 80%, 0.42 W/cfm
Unit #2: ASE = 98%, 1.00 W/cfm
Unit #3: SRE = 85%, 0.38 W/cfm

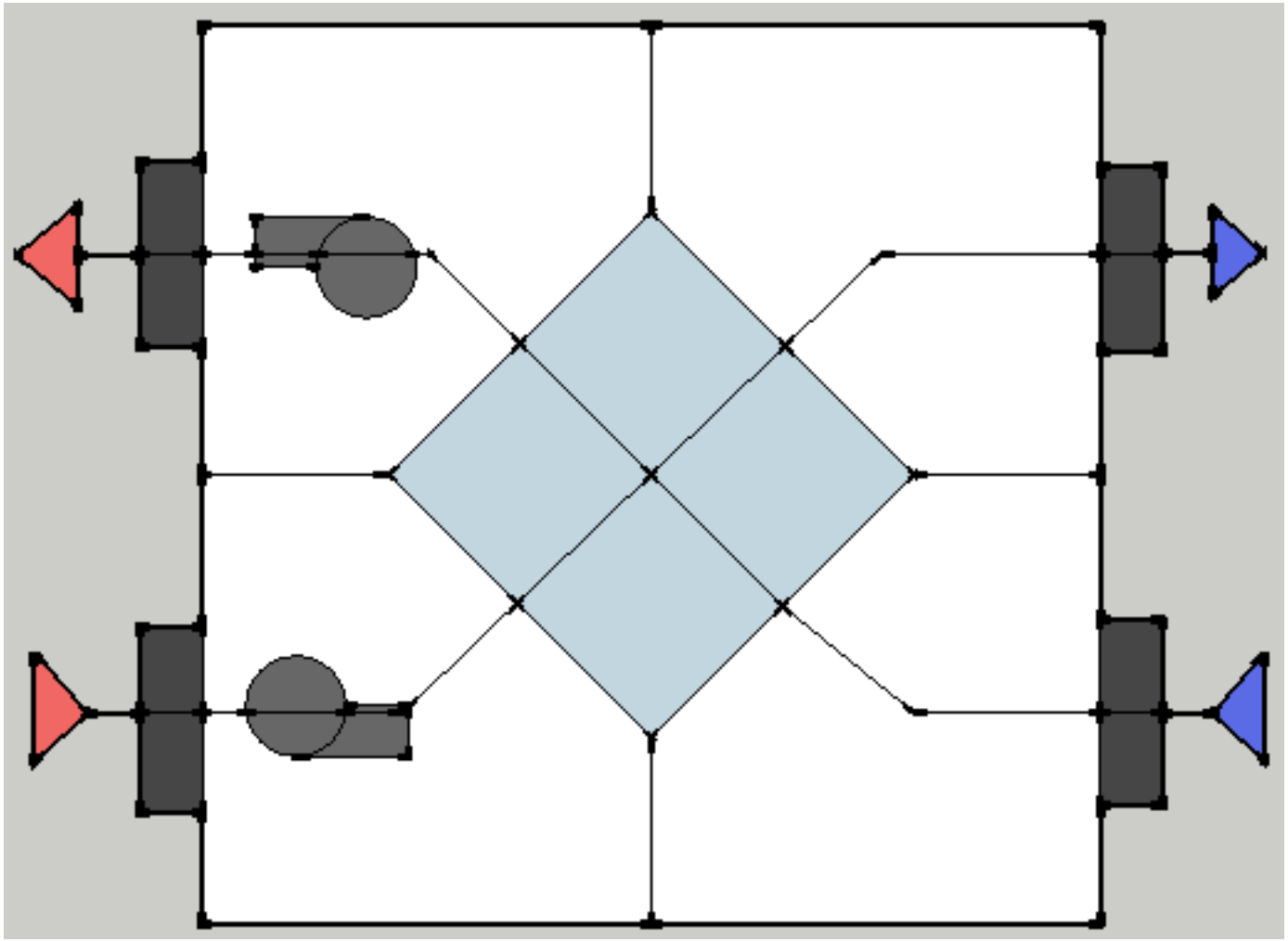
Ideal ERV/HRV - Winter

OUTSIDE

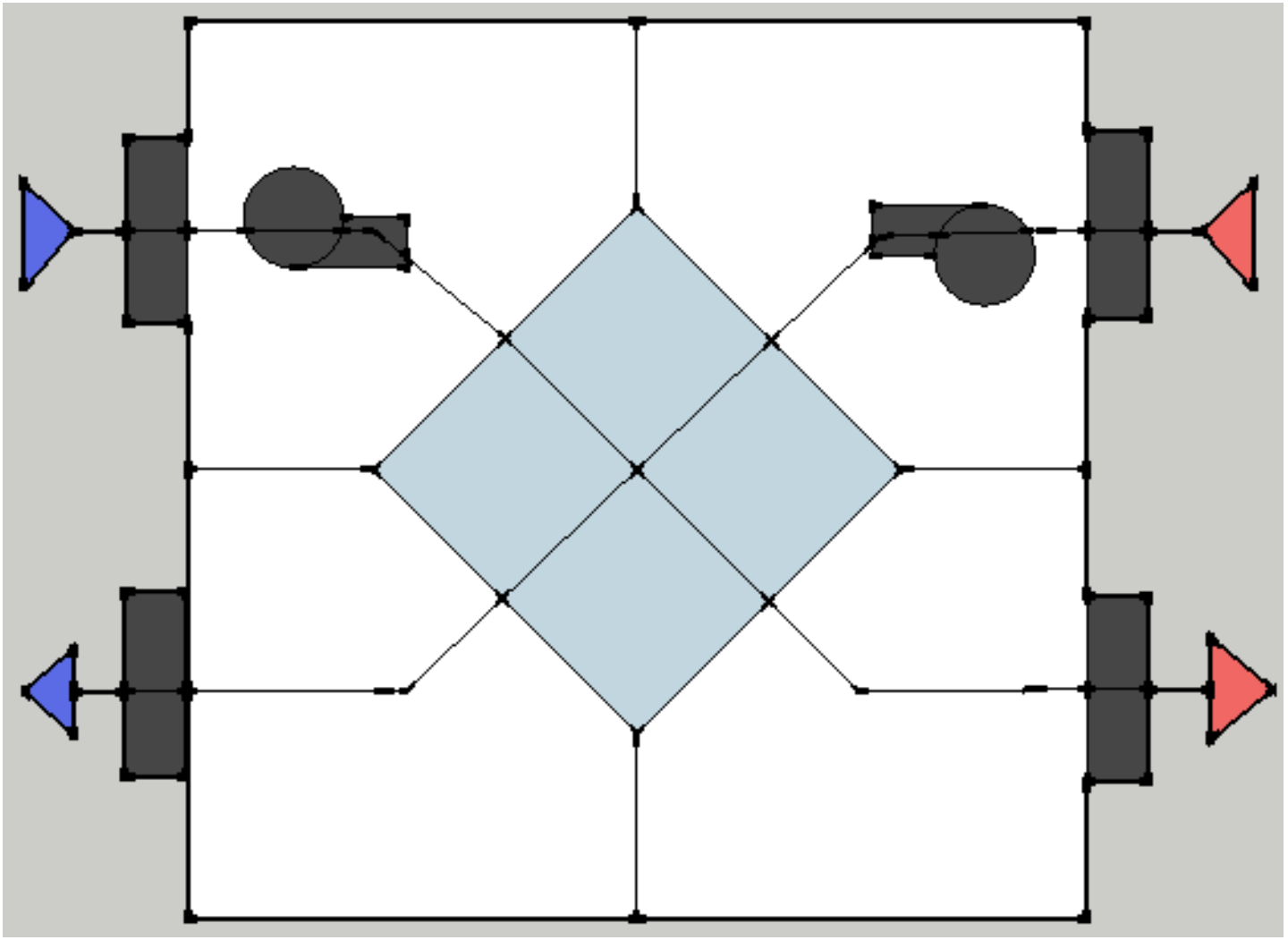


HOUSE

Ideal ERV/HRV - Summer



Common North American configuration



Background – the current energy modeling rules

"Current German accreditation testing procedures for verification units for residential use often produce unrealistically positive test results. If reliable measured values are not available, or a certificate is not presented, then the values are calculated by ***subtracting 12%*** from the accreditation test results."
-PHPP user manual

Investigation Goal:

Develop a new energy modeling protocol that:

a) Retains (or improves!) modeling accuracy

b) Provides a more level “playing field” for all manufacturers

Additional Goal:

Give practitioners the information they need to make more informed choices.

Remember: the best ERV's/HRV's have very high heat transfer and very low power input

Background – PHI Certification

N-eff >= 75%

Electrical efficiency <= 0.45 $W/m^3.hr$ (~0.76 W/cfm)

Minimum filtration requirements (F7 / G4)

Minimum supply air temperature >=16.5C (~62F)

Provide least three ventilation levels

Cross leakage <=3%

Acoustical testing required, but no threshold required

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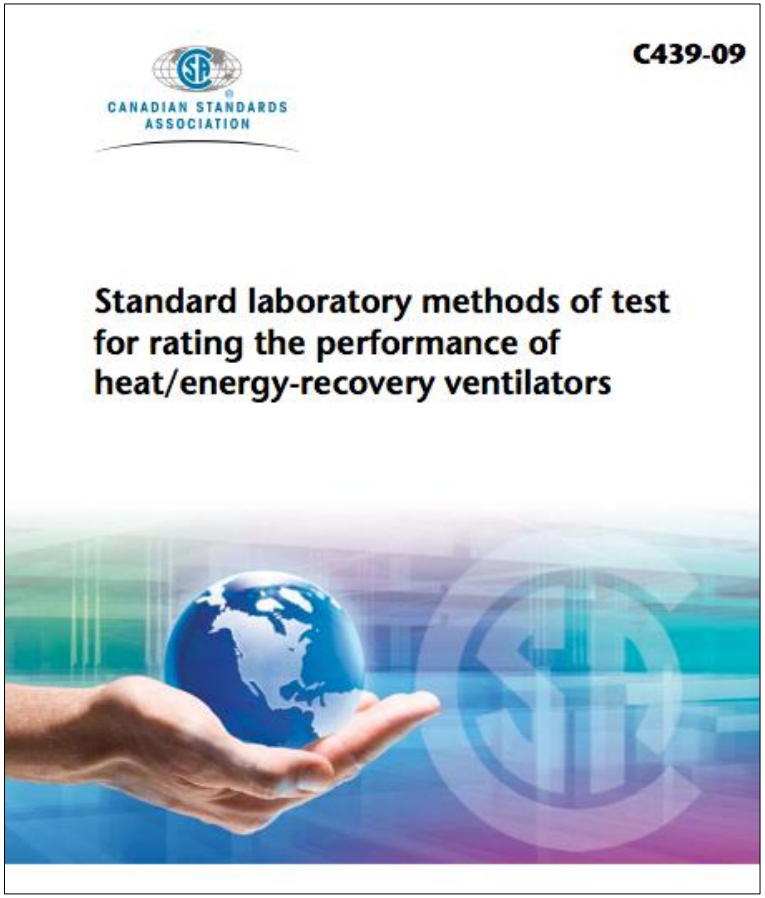
Background – Home Ventilation Institute (HVI) + CSA C439-09

HVI certifies performance ratings…but there's no threshold criteria for "certification"



PHI's "N-eff" Equation:

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

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(Indoor Temp - Exhaust air Temp) + (power input / mass airflow)

(Indoor Temp - Outside Temp)

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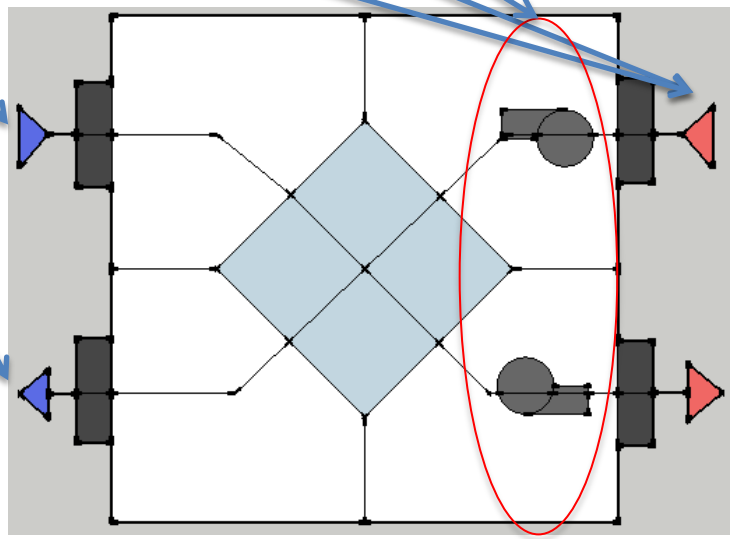

HVI (CSA C439) ASE Equation
“Apparent Sensible Effectiveness”

$$\varepsilon = \frac{M_s \times (X_1 - X_2)}{M_{min} \times (X_1 - X_3)}$$

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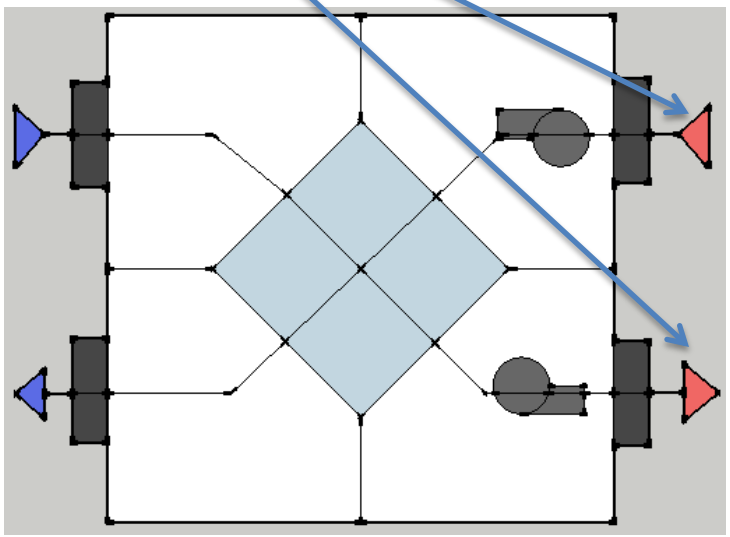
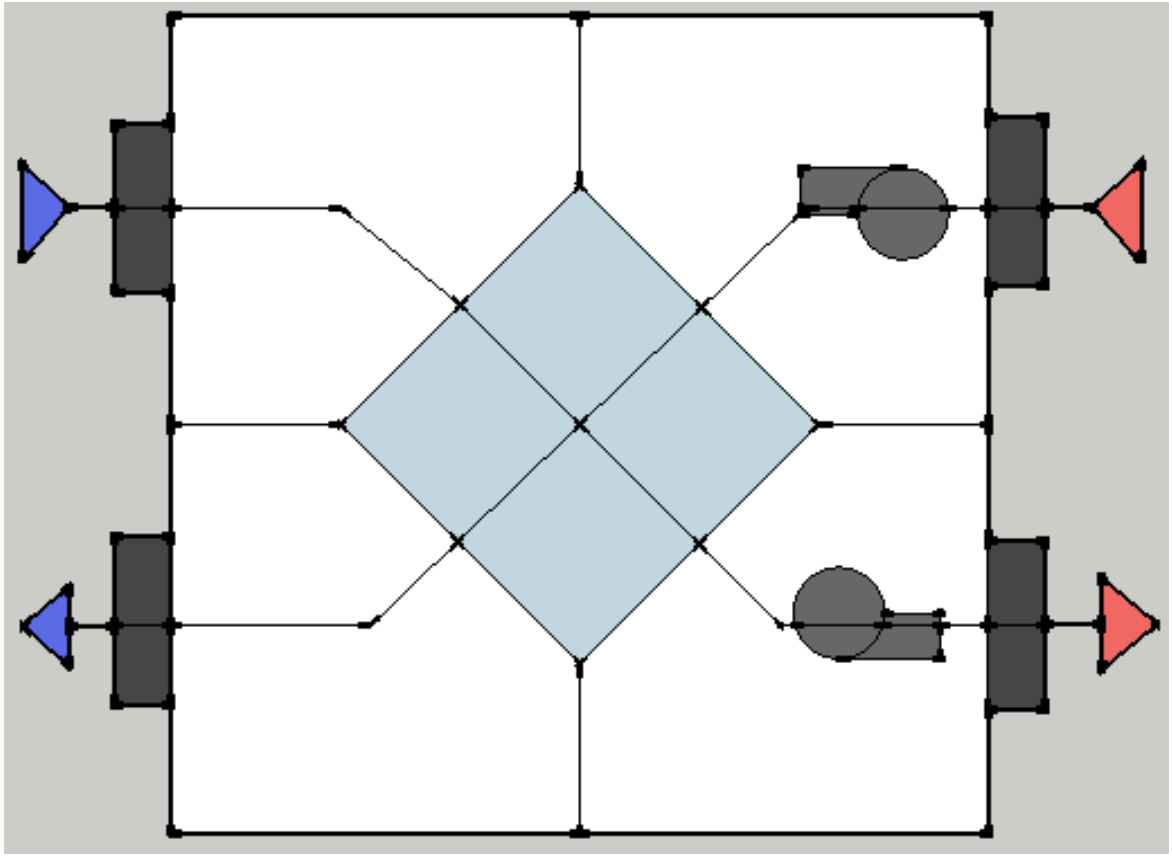


Things that tend to inflate ASE…



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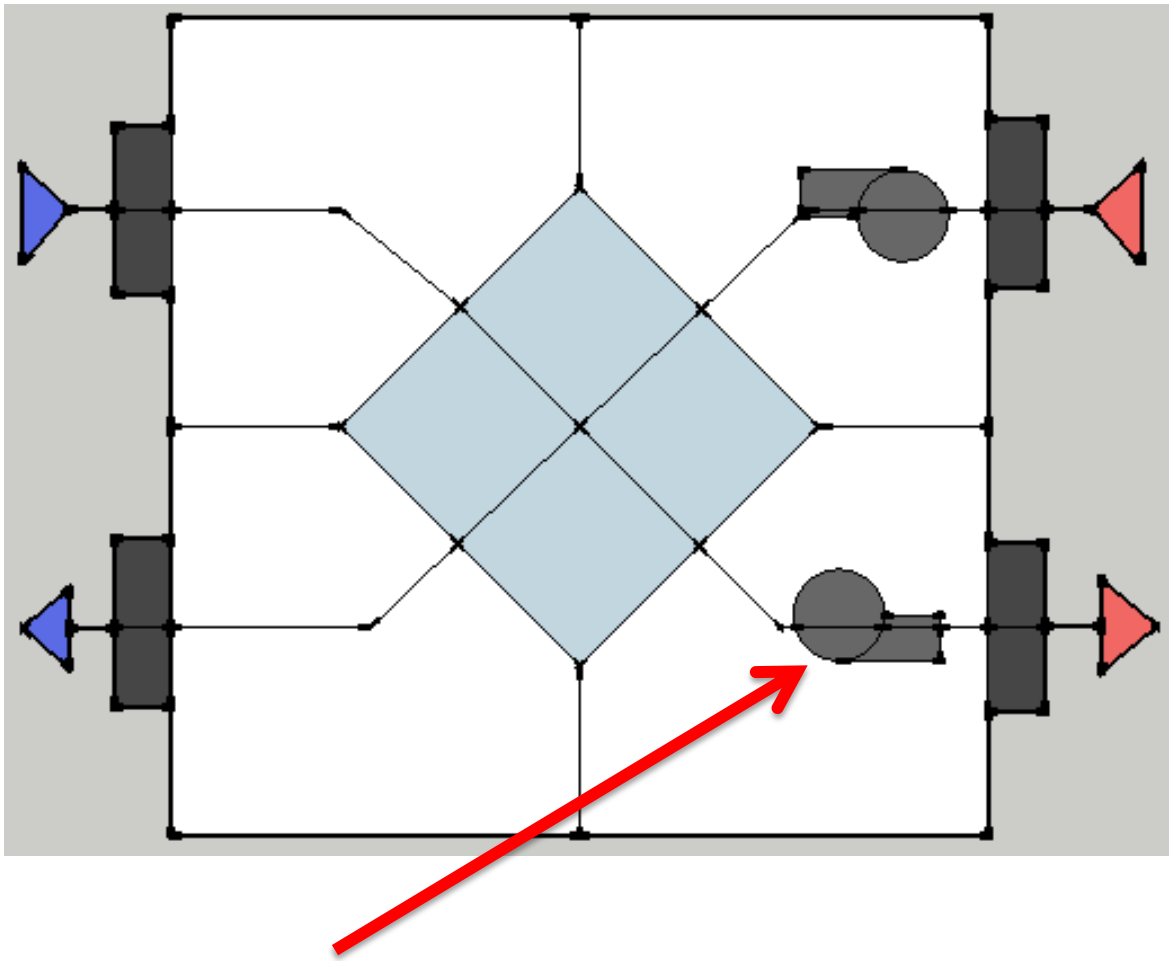
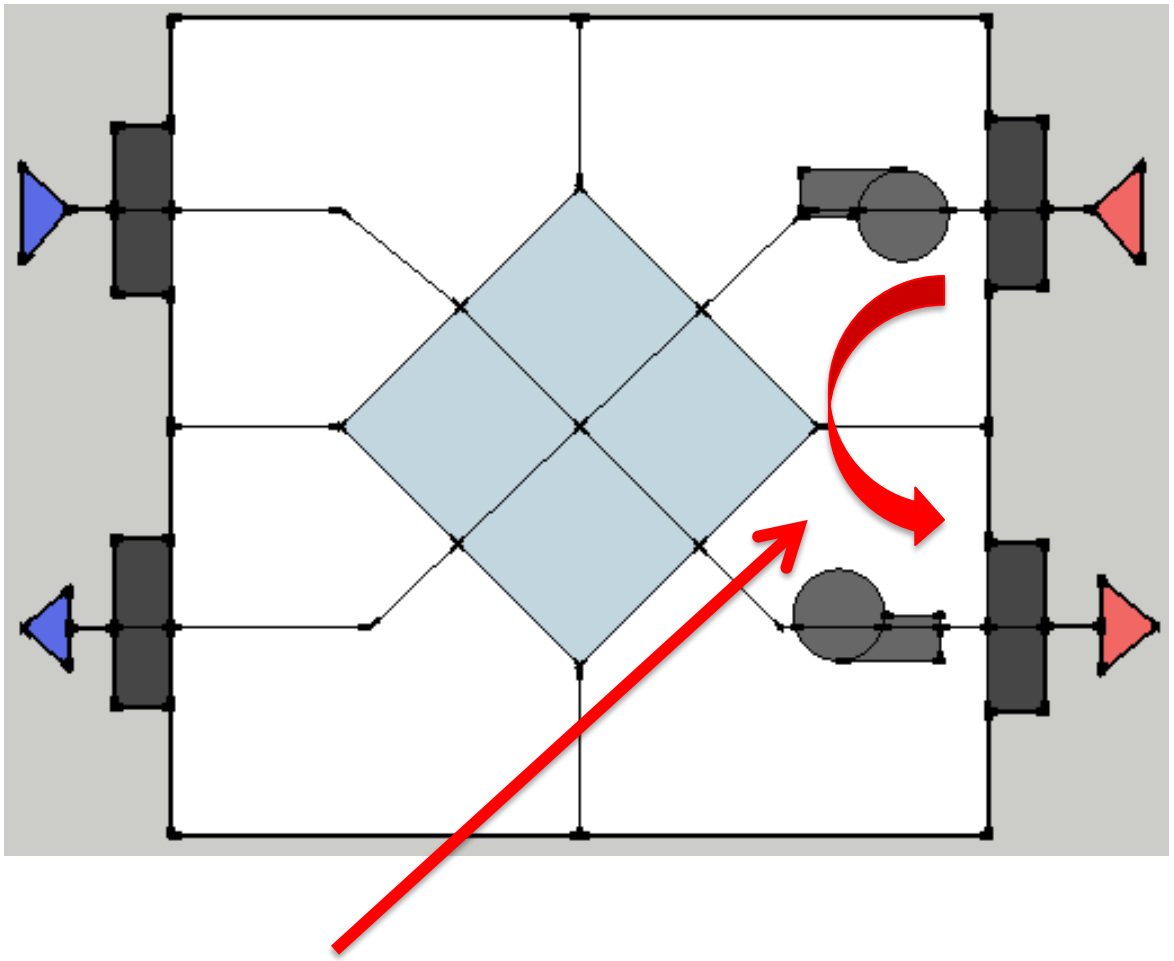


Inefficient fan motors – aka “post-heater”

Things that tend to inflate ASE…



Exhaust air transfer – aka “cross leakage”

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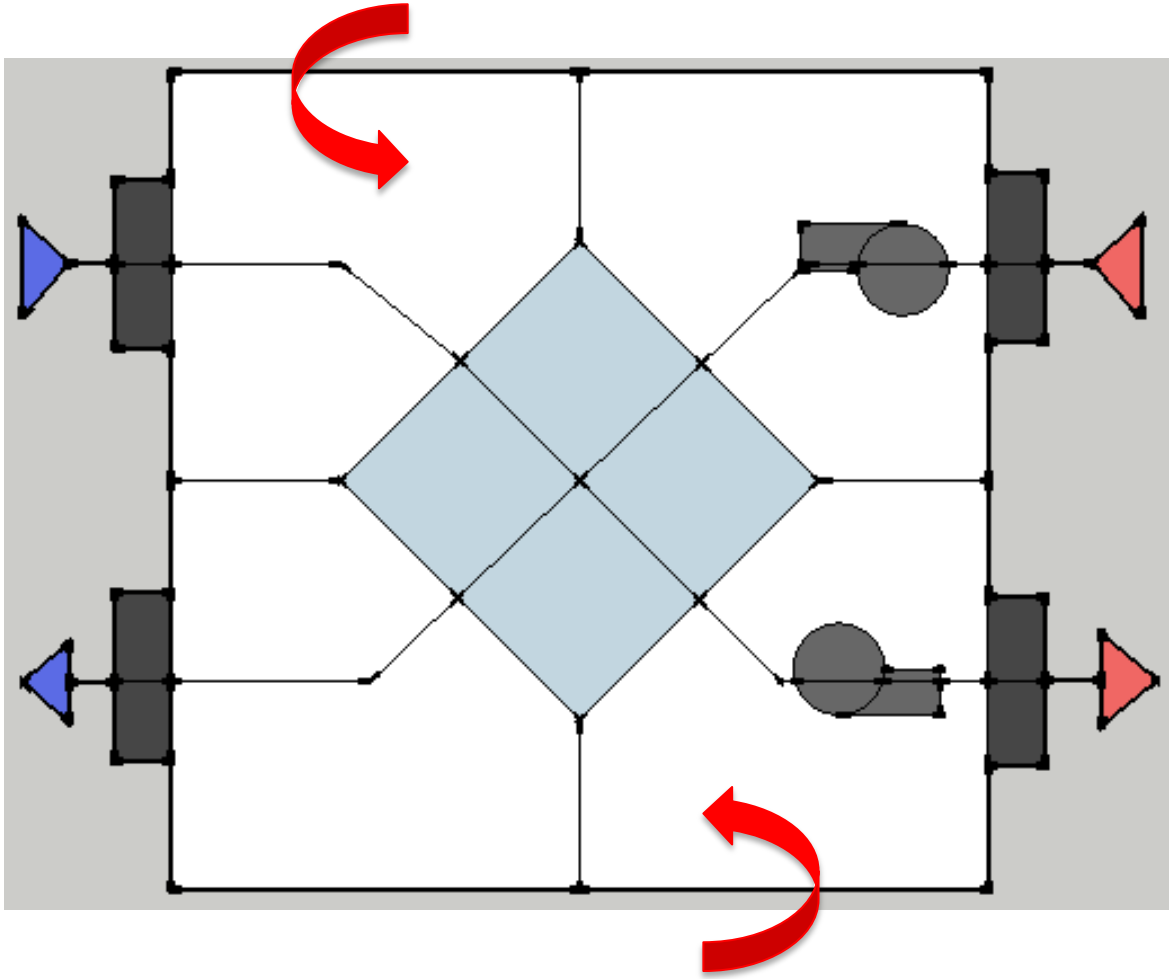

Air leakage across the case

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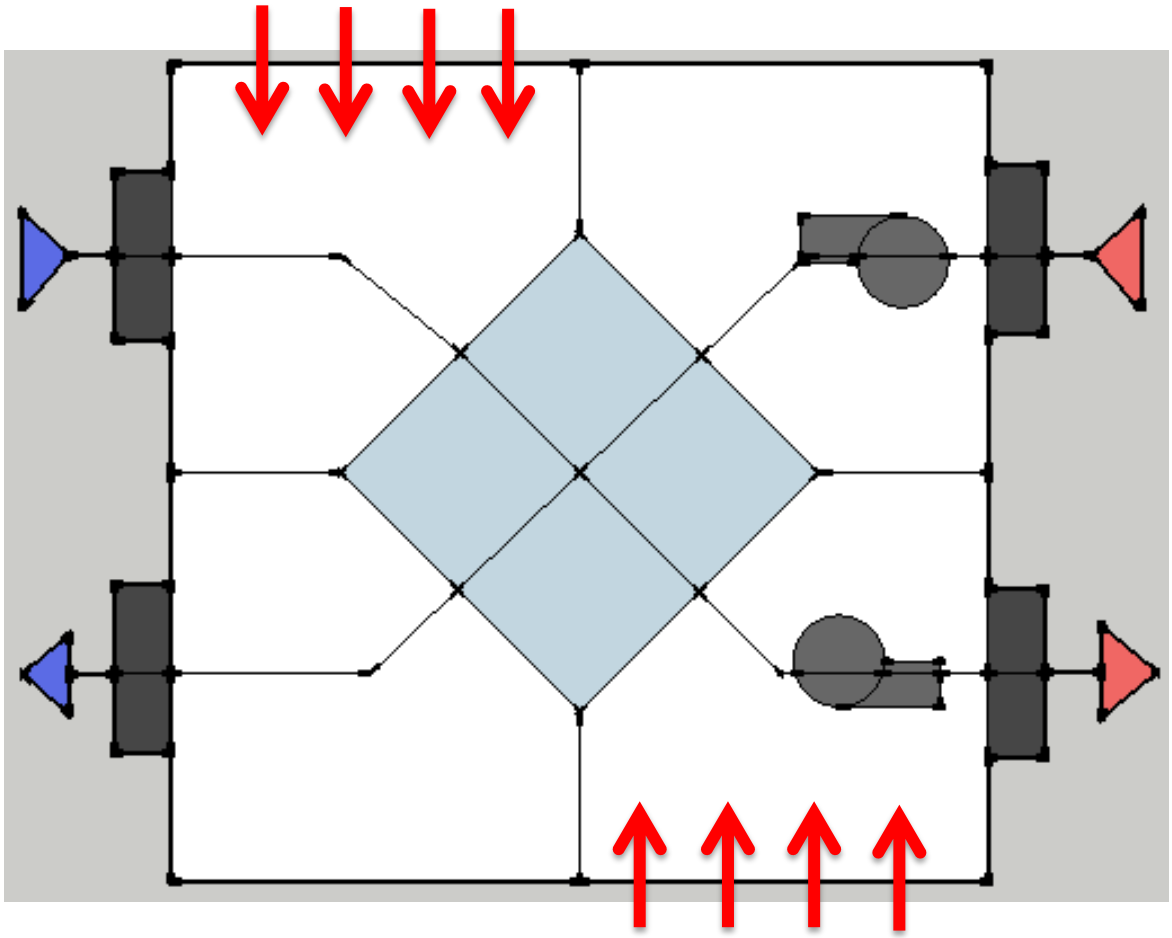
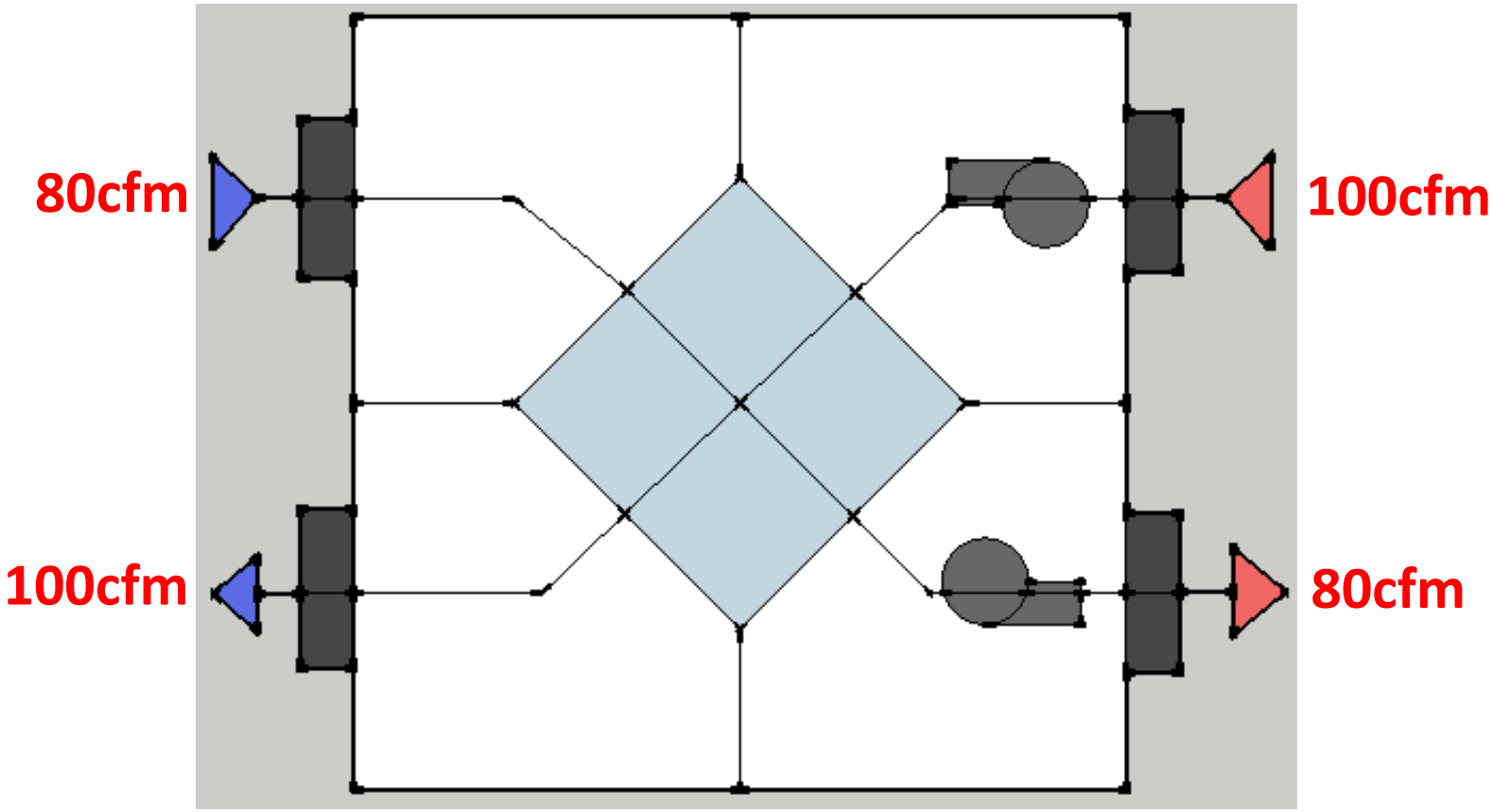


Heat transmission through the case

Things that tend to inflate ASE…



Intentional mass airflow imbalance during lab testing


ASE

HVI (CSA C439) – SRE Equation "Sensible Recovery Efficiency"

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

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SRE = ASE, adjusted for:

a) Cross-leakage

b) Fan energy

c) Case air leakage

d) Case heat transfer

e) Mass airflow imbalance

PHI – What we like…

- 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 – What we like…

- PHI certification requires high heat recovery and excellent fan efficiency (W/cfm). Product selection is simplified for practitioners in cold climates by choosing from a list of products that meet this performance thresholds.

PHI – What we like…

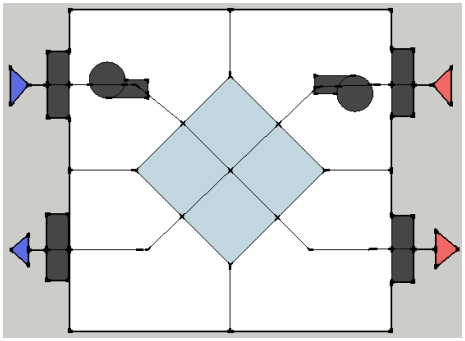
- Though a particular threshold is not required for PHI certification, PHI testing does include acoustical testing. Sound attenuation guidance is provided for PHI certified units that exceed the threshold of 35dB(A).

PHI – What we don't like…

- 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.

PHI – What we don't like…

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



- N-eff assumes <u>all</u> power input is captured as an internal gain. This is questionable for any HRV, but especially for units with either motor on the "outside" side of the machine.

PHI – What we don't like…

- N-eff is not appropriate for energy modeling in summer conditions. Internal gains from the motors are not a benefit in summer!

  In addition, sensible heat transfer efficiency will be lower in most summertime conditions since the temperature difference is smaller.

PHI – What we don't like…

- PHI moisture recovery testing for ERV's is only done for cool/cold outdoor conditions.

PHI – What we don't like…

- 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 end of the range and worse at the higher end of the range.

PHI – What we don't like…

- PHI does not provide a procedure for regularly sampling production units to ensure they meet the specs, or provide a challenge procedure.

HVI – What we like…

- HVI's SRE calculations mathematically adjust for exhaust air transfer ("cross leakage"), case heat transfer and case leakage and mass airflow imbalance.

HVI – What we like…

- HVI listings are for a specific airflow…most units have multiple listings at various airflows

HVI – What we like…

- HVI provides an optional listing for summertime performance

HVI – What we like…

- HVI listings are readily available for 100+ products

HVI – What we like…

- “Off the shelf” units are randomly tested by HVI. There is also a challenge procedure for manufacturers to challenge each other’s data.

HVI – What we like…

- AHRI testing for “commercial” units (over ~400cfm) is very similar (though not identical) to HVI testing

HVI – What we don't like

- There are mediocre units that have high apparent sensible effectiveness (ASE) due to high fan power (supply and exhaust). 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 – What we don’t like

- 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.

HVI – What we don't like

- 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.

PHIUS Technical Committee – new energy modeling protocol

- 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).

PHIUS Technical Committee – new energy modeling protocol

- 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

PHIUS Technical Committee – new energy modeling protocol

- 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.

PHIUS Technical Committee – new energy modeling protocol

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

PHIUS Technical Committee – new energy modeling protocol

- For commercial units with AHRI certification, use the "Net sensible" and "Net Latent" efficiencies from the AHRI certified rating.

PHIUS Technical Committee – new energy modeling protocol

- 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 preliminary model fan efficiency assumptions.

Implications for a sample of products – those commonly seen in North American passive houses and otherwise…

Brand Name	Model	NET AIR FLOW (cfm)	"Adjusted SRE" for use in PHIUS+ modeling	W/cfm	"COP" (heat recovered, including fan energy recovered / power input)

Brand Name	Model	NET AIR FLOW (cfm)	"Adjusted SRE" for use in PHIUS+ modeling	W/cfm	"COP" (heat recovered, including fan energy recovered / power input)
Zehnder	NOVUS300HRV	97	92%	0.27	42
Zehnder	CA350HRV	99	89%	0.32	34
Zehnder	CA550HRV	182	85%	0.44	24
Venmar	AVSHRVEKO1.5	81	76%	0.40	24
Zehnder	CA350ERV	100	77%	0.42	23
RenewAire	EV90P	90	84%	0.49	21
RenewAire	EV90	90	76%	0.51	18
Lifebreath	195ECM	117	82%	0.57	18
.....					
Venmar	HRV2600	94	72%	2.01	5

Next Steps…

- Publish/maintain list of modified SRE data for all units listed in HVI.
- Get HVI to publish modified SRE (and W/cfm and COP?) in the future
- HVI Summer Performance – split out sensible + latent performance
- Change modeling tools to allow separate inputs for winter performance and summer performance
- Modeling/rating for ductless HRV? (Lunos, et al)
- Modeling/rating for refrigerant based ERV? (CERV…et al?)

Thank you for your attention!

Questions?

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