StreamSAVE+

Heat recovery in ventilation

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Heat recovery in ventilation

StreamsavePLUS

Streamlining Energy Savings Calculations in the EU Member States

https://streamsaveplus.eu/

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Heat recovery in ventilation

Content

- Subject – HR in VU
  - Intro
  - Energy balance
- Methodology
  - Scope & Definitions
  - Background, Assumptions & Boundary conditions
  - Calculation of TFES-EPEC-GHG
  - Overview of Costs
- Conclusion
- Q&A

- *References*
- *Abbreviations*

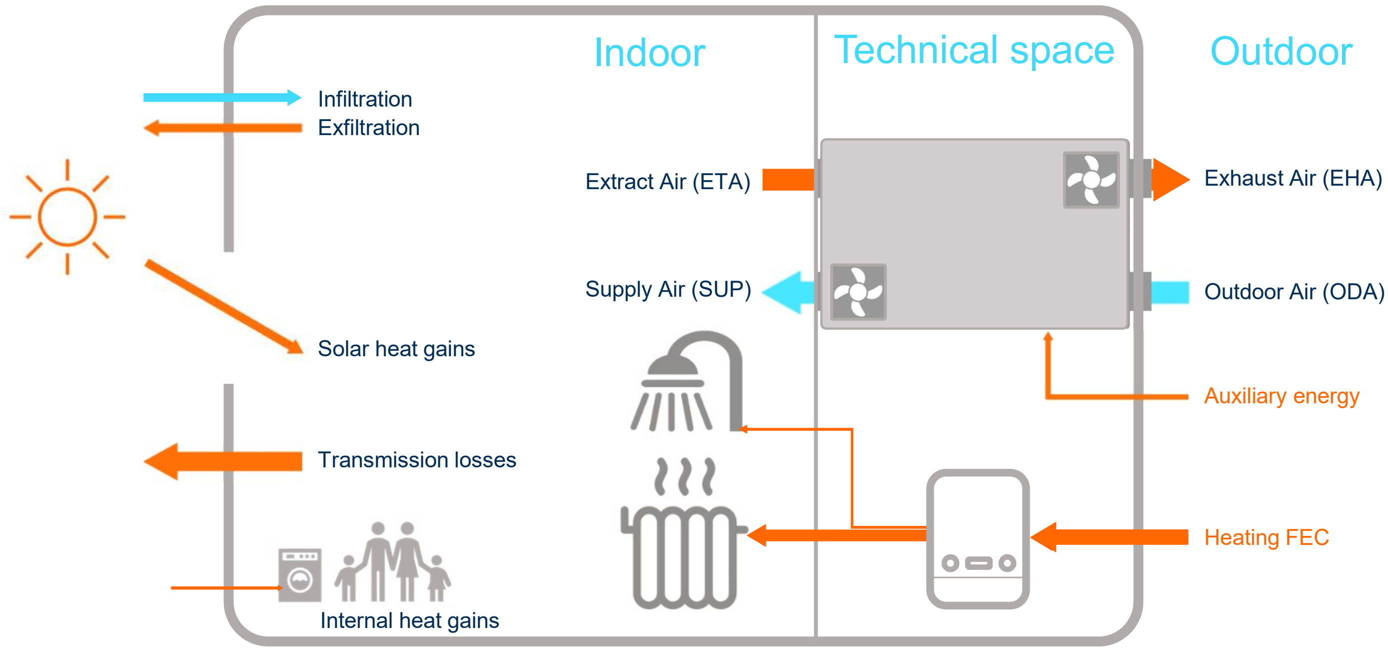
Energy saving via Heat Recovery in Ventilation Units

Subject

- StreamSAVE+ Priority Action: **Heat recovery in ventilation systems**
  - ➢ Bottom-up methodology: Calculation of energy savings achieved via HR in VUs.
    - ➢ Support MS in the implementation of Art. 4 & 8 of the EED (EU/2023/1791) via streamlined methodologies
    - ➢ Energy savings (Final & Primary) - GHG savings – Overview of Costs
  - ➢ StreamSAVE+ Deliverable: 'D2.2 Extended guidance on savings calculation methodologies' Chapter 5: 'Chapter 5. Savings calculation for heat recovery in ventilation systems'

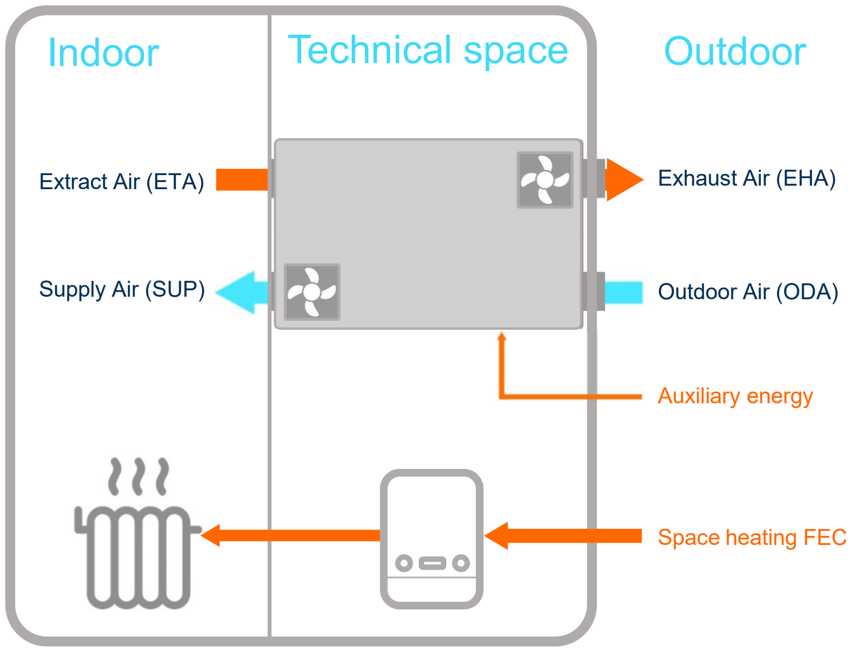
Energy saving via Heat Recovery in Ventilation Units

Subject - Schematic representation of the energy balance (winter mode)



Energy saving via Heat Recovery in Ventilation Units

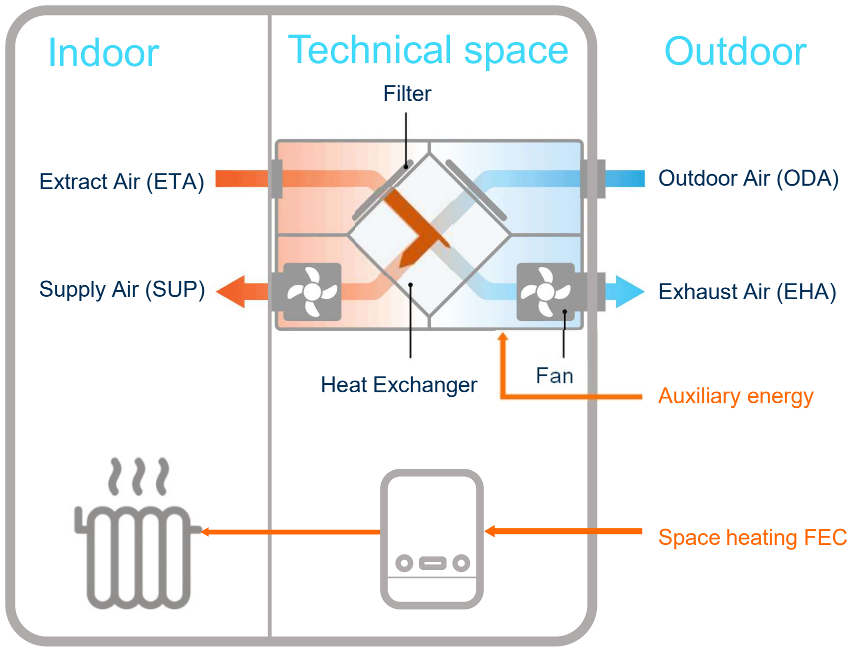
Subject - Schematic representation of the energy balance (winter mode)



Energy saving via Heat Recovery in Ventilation Units

Subject - Schematic representation of the energy balance (winter mode)

- Energy saving via Heat Recovery in Ventilation
  - Reduction of space heating energy demand
  - Increase in auxiliary energy use
    - Fans, controls, defrosting
  - Usually combined with other improvements
    - Building envelope energy performance
    - Component air tightness
    - Increased fan efficiency
    - Smart controls



https://redimond.com/services/mechanical/heat-recovery/
https://www.svgrepo.com/svg/15275/heating

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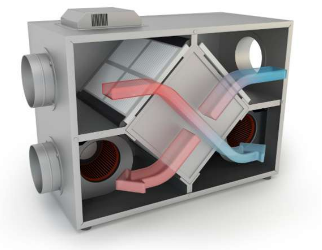
Methodology - Scope & Definitions

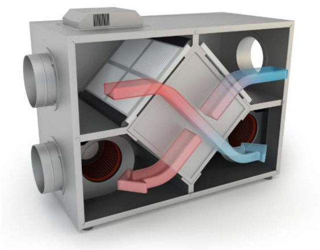


- Following **Ecodesign requirements on Ventilation units** (EU) 1253/2014 (EC, 2014)

- Definitions
  - A heat recovery system is a part of a **bidirectional ventilation unit equipped with a heat exchanger** designed to transfer the heat contained in the (contaminated) exhaust air to the (fresh) supply air.

Heat recovery in ventilation

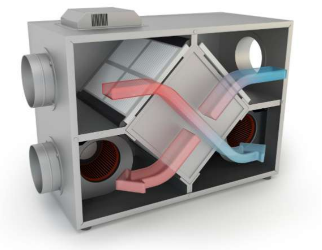
Methodology - Scope & Definitions



- A central or local **bidirectional ventilation unit** comprising at least **two fans** (exhaust and supply, each consisting of an impeller and electrical motor), two **filters** and a **casing** with a **heat recovery system** consisting of
  - In case of recuperative heat exchanger: **plate or tubular heat exchanger**;
  - In case of regenerative heat exchanger: **rotating wheel**, including material allowing latent heat transfer, a drive mechanism, a casing or frame and seals to reduce bypassing and leakage of air;
  - In case of **run-around heat recovery system**s: a heat transfer system (connecting the heat recovery device on the exhaust side and the device supplying the recovered heat to the air stream on the supply side of a ventilated space);
  - In case of a **thermal bypass** facility: additional solutions to circumvent the heat exchanger of control the heat recovery performance (for example: summer box, rotor speed control, control of air flow).

Heat recovery in ventilation

Methodology - Scope & Definitions



- Scope: VU with HR
  - Compliant with legislation (Ecodesign etc.) and good practice
  - Technology types:
    - Excluded
      - VUs exclusively for operating in **specific conditions**
        - Hazardous environments / for safety purposes
        - Range hoods.
      - VUs that include a heat exchanger and a **heat pump**.
    - Included
      - LBVUs, CBVUs and CHRV

  → Distinction between **Runaround HR systems** and **Other HR systems**

  → For cost calculations further distinction between **LBVU**, **CBVU** and **CHRV**.

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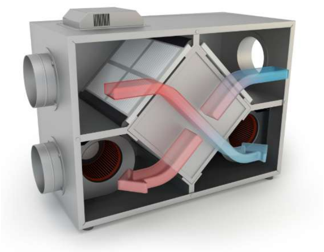
Methodology - Scope & Definitions



- Scope
  - Region
    - EU (3 zones)
  - Building types:
    - Residential & Non-residential
    - Retrofitted & Non-retrofitted
  - Interventions
    - Replacement of VU (with or without HR) at end-of-life or prior occasion by VU with HR
    - Introduction of VU with HR (in situations with natural or no ventilation)

Heat recovery in ventilation

Methodology - Background

- Screening of existing methodologies

Streamsave+ Desired features				Res & Non-res (Separate)	Final; incl. $\eta_{sys,SH/SC}$ (final to net)	Stock average	Yes	No	No	No	Yes
Source	**Parameter**	**Equation**	**Unit**	**Res/Non-res**	**Energy level**	**Baseline**	**Efficiency of HR**	**Ele use for VU**	**Thermal losses of VU**	**Defrosting**	**Corr for heat gains**
(EU) 1253/2014	Specific energy consumption	$SEC = t_a \cdot pef \cdot q_{net} \cdot MISC \cdot CTRL^x \cdot SPI - t_h \cdot \Delta T_h \cdot \eta_h^{-1} \cdot c_{air} \cdot (q_{ref} - q_{net} \cdot CTRL \cdot MISC \cdot (1-\eta_t)) + Q_{defr}$	[kWh/(m².a)]	Res	Primary	Nat ventilation	Yes	Fans, motors, controls	Yes	Yes	Yes, via ΔTh
(EU) 1253/2014	Thermal efficiency of a non-residential HR system	$\eta_{t\_nrvu} = (t_2'' - t_2')/(t_1' - t_2')$	[-]	Non-res	Net	n.a.	Yes	No (although part may be in re	n.a.	n.a.	n.a.
(EU) 1253/2014	Internal Specific Fan Power	SFP_{int}	[W/(m³/s)]	Non-res	Final	n.a.	No	Fans only	No	No	n.a.
MultEE (D2.1)	Total final energy savings	$TFES = A * h * \beta * t * c * \rho * \Delta T * \eta * n$	[kWh/a]	Res & Non-res	Final*	VU without HR	Yes	No	No	No	No
Czech Republic	Total final energy savings general formula	$TFES = (FEC_{before} - FEC_{after}) \times rb \times so \times fr \times lt$	[kWh/a]	n.a.	Final	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
France	Total final energy savings	$TFES = S_A \times S \times cf$	[kWh/a]	Non-res	Final	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hungary	Total finaly energy savings	$TFES = 0{,}35 \cdot V \cdot n_{LT} \cdot (\eta_{new} - \eta_{old}) \cdot Z_{LT} \cdot (t_{bef} - 4) \times rb \times so \times fr \times lt$	[kWh/a]	Res & Non-res	Final*	n.a.	Yes	n.a.	n.a.	n.a.	Yes (via measuring)
Latvia	Total finaly energy savings	$TFES_y = n \times A \times b \times L \times t \times c \times \rho \times \Delta t \times \eta$	[kWh/a]	Res & Non-res	Final*	VU without HR	Yes	No	No	No	No
Lithuania	Net heat demand of VU with HR	$Q_{ve,i,m} = 10^{-6}\, L_{v,m,i}\, \rho_a c_{pa} (\theta_{v,m,i} - \theta_{e,m})(1 - \eta_{hr,m,i})(t_m - 1)\, 24\, h_{w,m,i}/168 + Q_{el,m,i,m}$	[kWh/month]	Res & Non-res	Net	VU without HR	Yes	No	Yes	No	Yes (via measuring)
Luxemburg	Annual energy savings produced by the measure	$VEEP = \frac{Q_c \times e_c - q_v \times V}{1000}$	[MWh/a]	Res/Non-res	Final	VU without HR	Yes	Fans only	not clear	not clear	not clear
Luxemburg	Annual energy savings produced by the measure	$Q_c = 0{,}35 \cdot 65 \cdot (\eta_{VMC,après} - \eta_{VMC,avant}) \cdot V$	[MWh/a]	Res/Non-res	Final	VU w or wo HR	Yes	No	No	No	not clear
Slovenia	Total finaly energy savings	$TFES_i = \frac{A \cdot h \cdot \beta \cdot t \cdot c \cdot \rho \cdot \Delta T \cdot \eta \cdot N}{3600}$	[kWh/a]	Res	Final*	VU without HR	Yes	No	No	No	not clear
[Laverge J. et al.; 2012]	Total annual heat recovered per unit of flow rate	$q_{HR} = 29376 \cdot e \cdot HDD$	[Jh/m³]	Res	Net	VU without HR	Yes	No	No	No	Yes, HDD
[Laverge J. et al.; 2012]	Additional electricity use of fans per unit of flow rate	$24 \cdot 365 \cdot \Delta SFP \cdot f$	[Jh/m³]	Res	Primary or other	n.a.	No	Fans only	No	n.a.	n.a.
Own developed option 1	Total final energy savings (HR in VU)	$TFES_{HR} = [n * (\eta_{HR} - \eta_{before}) * A * h * ACH * \rho_{air} * c_{p,air} * \Delta T * t_{SH}/\eta_{SH}] * f_{BEH}$	[kWh/a]	Res & Non-res	Final	VU w or wo HR	Yes	No	No	No	Yes
Own developed option 2	Total final energy savings (SH and/or SC)	$TFES_x = FEC_{floor,before,x} \cdot A \cdot \left[1 - \left(\frac{1-\eta_{HR}}{1-\eta_{before}} \cdot \frac{H_V}{H_T+H_V} + \frac{H_T}{H_T+H_V}\right)\right] \cdot f_{BEH} \cdot cf_x$	[kWh/a]	Res & Non-res	Final	VU w or wo HR	Yes	No	No	No	Yes
Own developed option 1a or 2a**	Total final energy savings (Aux)	$TFES_{aux} = (FEC_{before,aux} - FEC_{after,aux}) \cdot f_{BEH}$	[kWh/a]	Res & Non-res	Final	VU w or wo HR	No	Fans (,...)	No	Yes/No	n.a.

*Only for assumption of 100% system efficiency of space heating/space cooling, otherwise net/demand level

** Potentially to be applied in addition to option 1 or option 2

***EOL: end of life

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Methodology – Assumptions & Boundary conditions

- Assumptions
  - Only the contribution of the heat exchanger to the energy performance improvement of space heating is taken into account via the **thermal efficiency of the heat exchanger**.
  - Deemed savings methodology
    - Default values assumption of the before situation reflect a baseline situation that
      - Corresponds with the stock averages for residential or non-residential buildings.
      - Already reflect improvements due to earlier legislation - Ecodesign requirements

Heat recovery in ventilation

Methodology - Calculation

- Total Final Energy Savings

$$TFES_{HR} = \left(FEC_{before} - FEC_{after}\right) * f_{BEH}$$

$$FEC_{Before} = (1 - \eta_{HR,before}) * A * h * ACH * \rho_{air} * c_{p,air} * \Delta T * t_{SH}/\eta_{SH}$$

$$FEC_{After} = \frac{1 - \eta_{HR,after}}{1 - \eta_{HR,before}} * FEC_{Before}$$

- Effect on Primary Energy Consumption

$$EPEC = FEC_{Before} \cdot \sum_{ec}(share_{ec,Before} \cdot f_{PE,ec}) - FEC_{After} \cdot \sum_{ec}(share_{ec,After} \cdot f_{PE,ec})$$

- GreenHouse Gas savings

$$GHGSAV = \left[FEC_{Before} \cdot \sum_{ec}(share_{ec,Baseline} \cdot f_{GHG,ec}) - FEC_{After} \cdot \sum_{ec}(share_{ec,Action} \cdot f_{GHG,ec})\right] * 10^{-6}$$

Energy savi[…]tilation Units

Indicative values

$\eta_{HR,after}$	[dmls]
Run-around heat recovery system	0.68
All other types of heat recovery system	0.73
$\eta_{HR,before}$	**[dmls]**
Building stock average efficiency of heat recovery – Residential	0.044
Building stock average efficiency of heat recovery – Non-residential	0.381
A	**[m²]**
Residential	95.079
Non-residential	900.0
h	**[m]**
Residential	2.9
Non-residential	4.0
ACH	**[m³/h/m³]**
Residential	0.30
Non-residential	0.39
ρ_{air}	**[kg/m³]**
Density of air	1.293
$c_{p,air}$	**[kWh/(kg.K)]**
Specific heat of air	0.000279
ΔT	**[°C]**
Cold climate (North)	14.5
Average climate (West)	9.5
Warm climate (South)	5
t_{SH}	**[h]**
Cold climate (North)	6,552
Average climate (West)	5,112
Warm climate (South)	4,392
η_{SH}	**[dmls]**
Residential	0.75
Non-residential	0.75
f_{BEH}	**[dmls]**
Residential	0.80

- Scope: following the scope of EU 1253/2014
  - BVUs with heat exchanger
  - Not those including heat pump technology (exhaust air as a source of an air source heat pump)

Heat recovery in ventilation

Methodology - Calculation

- Overview of Costs

Investment cost		[Euro2024/unit]
Residential	CBVU New built	4,915
	CBVU Renovation	6,350
	CBVU Replacement	n.a.
	LBVU New built	1,415
	LBVU Renovation	1,415
	LBVU Replacement	n.a.
Non-residential	CBVU/CHRV New built	30,063
	CBVU/CHRV Renovation	33,045
	CBVU/CHRV Replacement	8,408
Variable operational costs	**[Euro2024/year]**	
Costs of reduced fuel input	Energy prices from chapter 1.2.1 (fuel prices before/after)	
Fixed operational costs		**[Euro2024/unit/year]**
Residential	CBVU	67
	LBVU	29
Non-residential	CBVU/CHRV	175
[a]	**Lifetime**	
Technical lifetime	15	

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Conclusion

- A methodology for the calculation of the energy savings via heat recovery in ventilation systems is available to support MS in the implementation of Art. 4 & 8 of the EED (EU/2023/1791)
  - Broadly applicable; Scope ~ Ecodesign requirements for VUs (EU 1253/2014)
  - It accounts for the space heating energy savings due to the energy transfer between the extracted air and the outdoor air through the heat exchanger in the ventilation unit.
  - Input: National and case specific values are preferred, default values are available*
  - Output: TFES, EPEC, GHGSAV, Overview of Costs

➢ A full description of the methodology is available in StreamSAVE+ D2.2

➢ Calculation tool will be available via the StreamSAVE+ platform (expected autumn 2025).

* except for f_{BEH} of non-residential buildings

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- Thank you!

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Abbreviations

- CBVU: Central Bi-directional Ventilation Unit (applicable to residential and non-residential buildings)
- CHRV: Central Heat Recovery Ventilation (applicable to non-residential buildings)
- EPEC: Effect on Primary Energy Consumption
- EU: European Union
- FEC: Final Energy Consumption
- GHG: GreenHouse Gas
- HR: Heat Recovery
- LBVU: Local Bi-directional Ventilation Unit (applicable to residential buildings)
- PA: Priority Action (related to the StreamsavePLUS project)
- TFES: Total Final Energy Savings
- VU: Ventilation Unit

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