



**AALBORG UNIVERSITY**  
DENMARK

**Aalborg Universitet**

## **CLIMA 2016 - proceedings of the 12th REHVA World Congress**

*volume 9*

Heiselberg, Per Kvols

*Publication date:*  
2016

*Document Version*  
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*  
Heiselberg, P. K. (Ed.) (2016). *CLIMA 2016 - proceedings of the 12th REHVA World Congress: volume 9*. Department of Civil Engineering, Aalborg University.

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# An Analysis of Air Handling Units' Energy Efficiencies According to ErP (Energy Related Products) Directives

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## Abstract

*This paper describes the requirements stated in ErP (Eco Design) Directives 2009/125/EC, and implications of ErP legislations.*

*While the old EuP Directive (former Eco-Design Directive) was covering products that directly used energy, the new ErP Directive (replacement of EuP Directive) covers all energy using and energy related products (the products that do not directly use energy but effect the use of energy such as insulation materials).*

*ErP Directive was aimed to be a framework for reduction of energy consumption of covered products from the design stage throughout production, transport, packaging and so on. Products that comply with this directive are authorized to carry the CE marking. The CE mark covers energy efficiency requirements as well as product safety requirements.*

*ErP Directive is divided into lots that covers various groups of products. AHUs are grouped into Lot 6: Air Conditioning and Ventilation of directive. Electric motors and fans are grouped into Lot 11: Electric Motors (IEC) Regulation 640/2009, Fans Regulation 327/2011.*

*In this paper, requirements for conformity of AHUs and related components with ErP Directive, implications of related ErP legislations will be presented.*

## 1. Energy Efficiency and Directives

With the increasing industrialization and globalization, the energy becomes very vital in our daily lives. Since energy resources are limited and extracting energy from those limited sources becomes more expensive, most of the authorities are searching ways for efficient use of energy.

Energy efficiency; reducing energy consumption and eliminating energy wastage are among the main goals of the European Union (EU) over past years. EU support for improving energy efficiency will prove decisive for competitiveness, security of supply and for meeting the commitments on climate change made under the Kyoto Protocol. There is significant potential for reducing consumption, especially in energy-intensive sectors such as buildings, manufacturing, energy conversion and transport.

For this purpose energy labelling standards and rules for equipment applied. Later; replacement of EuP (Energy using Products) directives with ErP (Energy related Products) directives came into consideration.

The European ErP-Directive 2009/125/EC (Energy-related-Products-Directive), also called the Eco-Design Directive, defines the minimal requirements for energy-related products. The objective of the ErP-Directive is the reduction of energy consumption and the CO<sub>2</sub>-emission rates as well as an increase of the overall share of renewable energies. This directive applies for all products placed on the market within the European Economic Area (EEA). Exports from the European Community (EC) are not affected by the ErP-Directive.

Relevant for the AHUs is the EC-Directive 1253/2014/EC that came into force on November 26th 2014. Within the framework of this directive and as of January 1st 2016, new requirements concerning the energy efficiency of AHUs will apply within the European Economic Area (EEA).

The directive applies to ventilation units that exchange used air (impurified by persons or building emissions) in a building or part of a building by use of ambient air -typically for those persons present. This does not include applications, during which at least one air flow is defined by an industrial or production process.

AHUs with nominal air volumes  $\geq 1.000 \text{ m}^3/\text{h}$  will be deemed non-residential ventilation units (NRVU). AHUs  $< 250 \text{ m}^3/\text{h}$  count as residential ventilation units (RVU). The declaration for units between 250 and  $1.000 \text{ m}^3/\text{h}$  are left up to the manufacturer. In general, other requirements apply to residential ventilation units than to non-residential ventilation units.

AHUs that are delivered on and after January 01 2016 (delivery to the construction site) must comply with the ErP Directive. As of January 01 2018, the next step will further tighten the requirements. In the year 2020, additional tightening up is scheduled.

The following segments have been exempted from the regulation's area of application:

- Swimming Pools (discharge of the evaporated mass flow)
- Agricultural Applications (greenhouses, stables)
- Kitchen Exhaust Air (grease and steam extraction in commercial kitchens)
- Data Centers, Server Rooms (heat removal of the ICT-Equipment)
- Machine Exhaust Air (garage exhausts air)
- Clean Rooms, OP-Rooms (recirculating air units)
- Heat Removal (compressor rooms, TV-studios)
- Halls with Industrial Ovens (foundries, forging plants)
- Paper Industry
- ATEX (explosive areas)
- Air Heaters (share of recirculated air  $\geq 90\%$  in case of heating; ambient air/exhaust air  $\leq 10\%$ )
- Air Coolers

## 2. The Requirements for non-Residential Ventilation Units (NRVU)

### 2a. Unidirectional Ventilation Unit (UVA)

Table 1. Unidirectional Ventilation Unit descriptions

|  |  |
|--|--|
|  | <p><b>Supply or extract air unit</b></p> <p>One direction air flow reference configuration:</p> <ul style="list-style-type: none"> <li>• 1 air flow</li> <li>• 1 filter F7</li> <li>• 1 fan</li> </ul> |
| <p>ODA : Outdoor Air,      SUP : Supply Air<br/> ETA : Extract Air,      EHA : Exhaust Air</p> |  |

Table 2. Requirements for Unidirectional Ventilation Unit

| ErP - Tier  |                  | ErP 2016                   | ErP 2018                   |
|---|------------------|----------------------------|----------------------------|
| Fan efficiency<br>$\eta_s$ [%]  | $P_M \leq 30$ kW | $6.2 \times \ln(P_M) + 35$ | $6.2 \times \ln(P_M) + 42$ |
|   | $P_M > 30$ kW    | 56.1                       | 63.1                       |
| Internal SFP value (reference configuration)<br>$SFP_{int\ max}$ [W / m <sup>3</sup> / s] |                  | 250                        | 230                        |
| Variable speed drive from ventilator  |                  | required                   | required                   |
| Filter pressure switch  |                  | -                          | required                   |

### 2b. Bidirectional Ventilation Unit (BVU)

Table 3. Bidirectional Ventilation Unit descriptions

|  |  |
|--|--|
|  | <p><b>Combination unit supply and extract air unit</b></p> <p>Two directions air flow reference configuration:</p> <ul style="list-style-type: none"> <li>• 2 air flows</li> <li>• 1 filter F7 (ODA)</li> <li>• 1 filter M5 (ETA)</li> <li>• Heat Recovery System</li> <li>• 2 fans</li> </ul> |
|--|--|

Table 4. Requirements for Bidirectional Ventilation Unit

| ErP - Tier  |                             | ErP 2016                  | ErP 2018                           |                                    |
|---|-----------------------------|---------------------------|------------------------------------|------------------------------------|
| Heat Recovery System (HRS) with thermal bypass facility                                   |                             | required                  | required                           |                                    |
| Thermal dry efficiency (EN 308) $\eta_t$ [%]  | Run-around-coils HRS        | 63                        | 68                                 |                                    |
|   | Other HRS                   | 67                        | 73                                 |                                    |
| Internal SFP value (reference configuration)<br>$SFP_{int\ max}$ [W / m <sup>3</sup> / s] | Run-around-coils HRS        | $q < 2\ m^3/s$            | $1,700 + E - 300 \times q / 2 - F$ | $1,600 + E - 300 \times q / 2 - F$ |
|   |                             | $q \geq 2\ m^3/s$         | $1,400 + E - F$                    | $1,300 + E - F$                    |
|   | Other HRS                   | $q < 2\ m^3/s$            | $1,200 + E - 300 \times q / 2 - F$ | $1,100 + E - 300 \times q / 2 - F$ |
|   |                             | $q \geq 2\ m^3/s$         | $900 + E - F$                      | $800 + E - F$                      |
| Efficiency bonus E Heat Recovery System [W / m <sup>3</sup> / s]                          | Run-around -coils HRS       | $(\eta_t - 63) \times 30$ | $(\eta_t - 68) \times 30$          |                                    |
|   | Other HRS                   | $(\eta_t - 67) \times 30$ | $(\eta_t - 73) \times 30$          |                                    |
| Filter correction F [W / m <sup>3</sup> / s]  | Reference configuration     | 0                         | 0                                  |                                    |
|   | Filter M5 is missing        | 160                       | 150                                |                                    |
|   | Filter F7 is missing        | 200                       | 190                                |                                    |
|   | Filters M5 + F7 are missing | 360                       | 340                                |                                    |
| Variable speed drive from ventilator  |                             | required                  | required                           |                                    |
| Filter pressure switch  |                             | -                         | required                           |                                    |

### 3. Consequences of ErP Directive

The tightened requirements of the ErP-Directive have far-reaching consequences for both AHU manufacturers and designers. This is clearly illustrated by the following example. Under the same general conditions for example, an AHU that was designed for 2015 looks completely different than a solution that complies to the ErP-Stage 2016 or even the ErP-Stage 2018.

As shown in Table 14, the main difference between 2015, 2016 and 2018 designs is the increase in the cross sectional area (2015 > 2016: %34, 2015 > 2018: %67) and in consequence to that; decrease in air velocity (constant air flow) therefore the economy in fan power requirement (2015 > 2016: %20, 2015 > 2018: %28) and energy use (2015 > 2016: %21, 2015 > 2018: %35)

#### General Conditions

- Combined supply and exhaust air unit
- Air flow volume: 10,000 m<sup>3</sup>/h (Supply Air) / Air flow volume: 10,000 m<sup>3</sup>/h (Exhaust Air)
- Filters F7 (ODA), Filters M5 (ETA)
- HRS-System: Run-around coils system
- Additional Components:  
1 air-heater and 1 damper in the supply air, 1 damper in the exhaust air
- EC-Fans

#### Air Conditions (DIN EN 308)

- Outdoor Air: 5° C, 0 % relative humidity
- Exhaust Air: 25° C, 0 % relative humidity

### 3a. AHUs according to current conditions (2015)

Table 5. Drawing of AHU according to current conditions (2015)

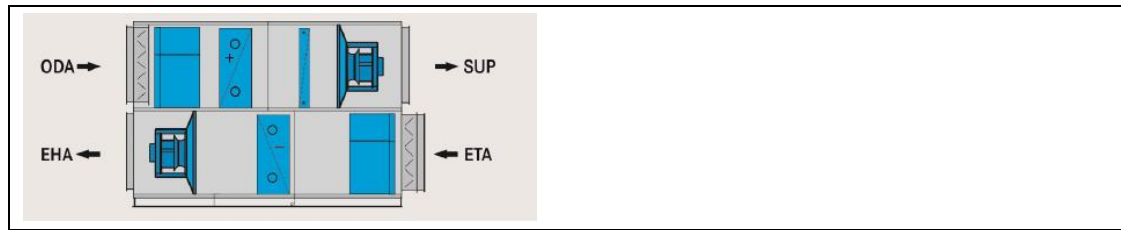


Table 6. Technical Data of AHU according to current conditions (2015)

| Height [mm]                               | Depth [mm] | AHU cross section [m <sup>2</sup> ]        | Velocity in the filter chamber [m / s] | Total stat. pressure drop supply air [Pa] | Total stat. pressure drop extract air [Pa] |
|---|------------|--|--|---|--|
| 2,116                                     | 1,304      | 1.12                                       | 2.4                                    | 1,010                                     | 854  |
| Absorbed electrical power supply air [kW] |            | Absorbed electrical power extract air [kW] |  | Thermal efficiency                        | SFP <sub>int</sub> BVU                     |
| 4.42                                      |            | 3.74                                       |  | 55  | 1,574                                      |

Table 7. ErP Conformity of AHU according to current conditions (2015)

| Thermal efficiency $\eta_t$ [%] |               |        | SFP <sub>int</sub> BVU [W / m <sup>3</sup> / s] |               |         | ErP - Tier    |
|---------------------------------|---------------|--------|---|---------------|---------|---------------|
| Real value                      | Maximal value |        | Real value                                      | Maximal value |         |               |
|                                 | 2016          | 2018   |   | 2016          | 2018    |               |
| 55 %                            | ≥ 63 %        | ≥ 68 % | 1,574   | ≤ 1,400       | ≤ 1,300 | not complying |

### 3b. AHUs according to 2016 ErP Directive

Table 8. Drawing of AHU according to 2016 ErP Directive

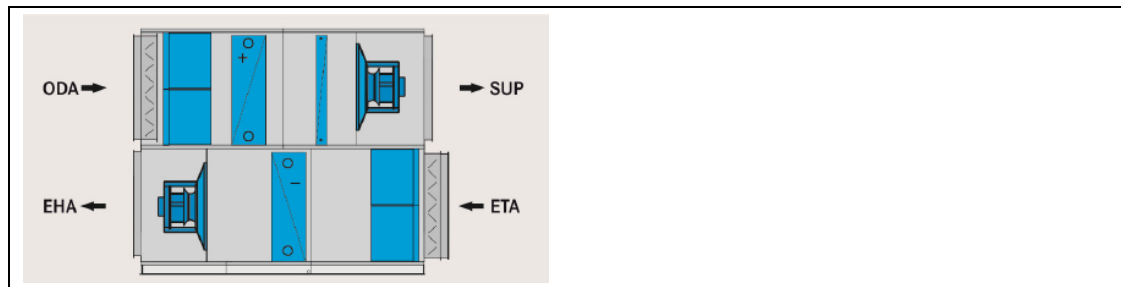


Table 9. Technical Data of AHU according to 2016 ErP Directive

| Height [mm]                               | Depth [mm] | AHU cross section [m <sup>2</sup> ]        | Velocity in the filter chamber [m / s] | Total stat. pressure drop supply air [Pa] | Total stat. pressure drop extract air [Pa] |
|---|------------|--|--|---|--|
| 2,728                                     | 1,304      | 1.498                                      | 1.8                                    | 777                                       | 728  |
| Absorbed electrical power supply air [kW] |            | Absorbed electrical power extract air [kW] |  | Thermal efficiency                        | SFP <sub>int</sub> BVU                     |
| 3.36                                      |            | 3.14                                       |  | 63  | 1,027                                      |

Table 10. Conformity of AHU according to 2016 ErP Directive

| Thermal efficiency $\eta_t$ [%] |               |        | SFP <sub>int</sub> BVU [W / m <sup>3</sup> / s] |               |         | ErP - Tier |
|---------------------------------|---------------|--------|---|---------------|---------|------------|
| Real value                      | Maximal value |        | Real value                                      | Maximal value |         |            |
|                                 | 2016          | 2018   |   | 2016          | 2018    |            |
| 63 %                            | ≥ 63 %        | ≥ 68 % | 1,027   | ≤ 1,400       | ≤ 1,300 | ErP 2016 ✓ |

### 3c. AHUs according to 2018 ErP Directive

Table 11. Drawing of AHU according to 2018 ErP Directive

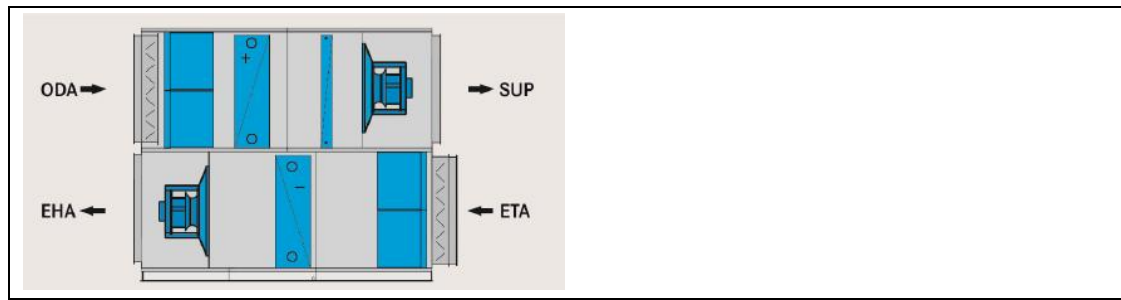


Table 12. Technical Data of AHU according to 2018 ErP Directive

| Height [mm]                               | Depth [mm] | AHU cross section [m <sup>2</sup> ]        | Velocity in the filter chamber [m / s] | Total stat. pressure drop supply air [Pa] | Total stat. pressure drop extract air [Pa] |
|---|------------|--|--|---|--|
| 2,728                                     | 1,610      | 1.873                                      | 1.4                                    | 689                                       | 656  |
| Absorbed electrical power supply air [kW] |            | Absorbed electrical power extract air [kW] |  | Thermal efficiency                        | SFP <sub>int BVU</sub>                     |
| 2.97                                      |            | 2.83                                       |  | 68  | 803  |

Table 13. Conformity of AHU according to 2018 ErP Directive

| Thermal efficiency $\eta_t$ [%] |               |        | SFP <sub>int BVU</sub> [W / m <sup>3</sup> / s] |               |         | ErP - Tier |
|---------------------------------|---------------|--------|---|---------------|---------|------------|
| Real value                      | Maximal value |        | Real value                                      | Maximal value |         |            |
|                                 | 2016          | 2018   |   | 2016          | 2018    |            |
| 68 %                            | ≥ 63 %        | ≥ 68 % | 803   | ≤ 1,400       | ≤ 1,300 | ErP 2018 ✓ |

### 4. Comparison of the Three Unit Concepts

Table 14. Comparison of the Three Units

| ErP - Tier                                       |   | ErP 2016      | ErP 2018      |
|--|---|---------------|---------------|
| Size of the AHU                                  | Height x Depth [mm] (AHU 2015: 2,016 x 1,304)                         | 2,728 x 1,304 | 2,728 x 1,610 |
|  | Increase of the AHU cross section in comparison with the AHU 2015 [%] | 34            | 67            |
| Investment costs in comparison with the AHU 2015 | Increase from total costs [%]   | 15            | 28            |
|  | Increase from HRS costs [%]   | 43            | 50            |
|  | Increase from casing costs [%]  | 6             | 22            |
| Energy costs in comparison with the AHU 2015     | Costs economy for the energy use [%]                                  | 21            | 35            |
|  | Costs economy for the ventilator use [%]                              | 20            | 28            |

### Acknowledgment

I wish to express my sincere thanks to REHVA, Eurovent, RLT, Robatherm, TTMD and İSKİD for providing me the necessary documents and informations.

I also thank to Clima 2016 Scientific and Organization Committee for giving me this opportunity for presenting this paper.

I am also grateful to my lovely husband who encouraged me to make a research on this topic, and helped me for editing this paper.

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