Fair consumption-based attribution of ventilation costs –

An end to the area formula for users with variable volume flows and different usage times

Jens Amberg, Managing Director of Luftmeister GmbH

For many years, if a number of tenants share an air conditioning system, it has been standard practice to allocate ventilation costs using a formula based on the area of each unit in m² or square feet. Take the example of two different tenants in a shopping centre: a chemist and restaurant have the same area and pay the same contribution towards ventilation costs. However, the chemist has to be kept cool all day in high summer while the restaurant is open in the cool of the evening and receives greater ventilation per square meter.

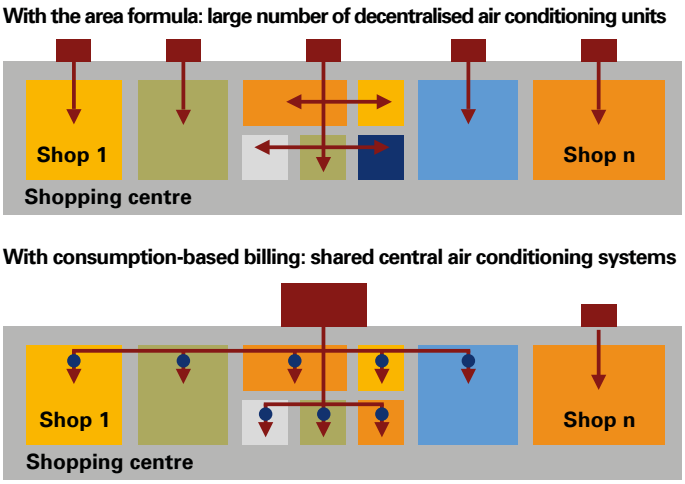


Fig. 1: Air conditioning systems in a shopping centre – consumption-based billing encourages the use of large, efficient systems.

Many large shops feel this area formula is unfair because it assumes equal needs in situations where real-world requirements clearly differ. Investors and planners of shopping centres and office complexes have noticed that "large tenants" are increasingly insisting on having a separate air conditioning system to ensure they are only billed for the resources they actually consume. This applies, in particular, to retail chains, which face this problem in a large number of locations. Nonetheless, this approach means that not only total investment in air conditioning systems but also operating costs will be noticeably higher. After all, a large central air conditioning system is able to supply conditioned air significantly more cheaply than several smaller plants.

Consumption-based allocation of ventilation costs – based on the new VDI 2077 Sheet 4

For over 25 years, the German Heating Costs Ordinance has regulated the attribution of costs for a heating system shared by a number of users. By law, these costs must be billed to each user according to his actual consumption. Currently, no such regulations, laws or guidelines exist for ventilation and air conditioning systems.

A working group from the Association of German Engineers (VDI) has dedicated itself to developing a new guideline in order to close this loophole. Guideline VDI 2077 Sheet 4 will serve as a model for these regulations. Of course, the contents of this guideline can only be presented in detail once they have been finalised and published. However, experts agree that it should include the aspects described below.

New air conditioning systems, which are shared by a number of tenants AND

- provide variable volume flows at different times for individual users OR
- are used by individual tenants at different times

require a ventilation measurement concept, which attributes ventilation costs based on actual consumption. Consumption-based attribution can then also be agreed for legacy systems but this should probably be left to the discretion of the contract partners.

So how can the area formula be replaced in practice by a consumption-based method? VDI 2077 Sheet 4 will take a differentiated approach and include a number of scenarios. However, it will pay special attention to the concept of an air energy meter. The function and mechanism of this meter is described below, using the Luftmeister® as an example.

Functionality of the Luftmeister® EZ (air energy meter)

The Luftmeister® EZ is the world's first air energy meter and will be launched in 2016. It is able to measure the air volume flow in air conditioning or process air systems with a high degree of accuracy – specifically volume flow and mass flow. This air flow rate values are continuously added to produce a so called air meter V (units: [kg] or [m³]).

In addition, the Luftmeister® EZ measures the energy content of the air using the EN 55 enthalpy sensors. Fig. 3 shows how it works: the Luftmeister® EZ multiplies the

Fig. 2: Luftmeister® measures air energy and bills the tenant for the costs fairly based on his actual consumption

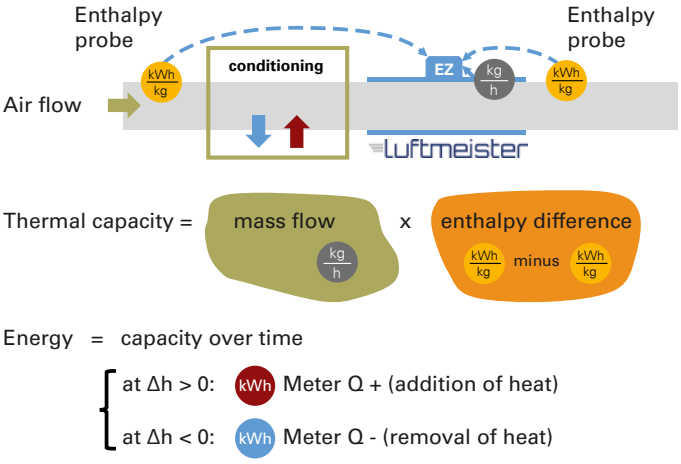


Fig. 3: Luftmeister® EZ measures the energy and thermal capacity of the air

mass flow [kg/h] of the air by the increase/decrease in enthalpy [kWh/kg]. In other words, it measures how much energy is added or removed between two points in the air duct system. The thermal capacity of the air [W]measured in this way is integrated (added) over time; the result is a thermal energy value [MWh]. The system differentiates between phases in which enthalpy increases and those in which it decreases. When enthalpy increases, the energy value is credited to the "heat supply account" Q+. When enthalpy decreases the energy value is assigned to the "heat removal account" Q-. In this way, it is possible to calculate the heating and cooling costs for every individual consumer over any given period of time.

Using the three independent meters (volume of air V, heat supply Q+, heat removal Q-) in the Luftmeister® EZ, it is now possible to calculate and bill ventilation costs fairly and accurately. Specifically, costs relating to electricity, heating and cooling can be isolated and attributed separately as shown in Fig. 4.

An optional legal-for-trade version of Luftmeister® will also be available. Especially in situations where billing is complicated, it is helpful for parties to be able to depend on a process, which is legal-for-trade in every aspect. In addition, legal-for-trade meters make it possible to offer an "air contracting" service – the consumer only pays the contractor for the actual volume of air he consumes and its effective conditioning.

Consumption-based billing in practice

Take the practical example of an office complex with a total floor area of 5400 m². How are the ventilation costs attributed here using the area based formula? And how would consumption-based billing using the Luftmeister® EZ change the situation? The total area is divided into 10 rental units of between 300 and 800 m².

Table 1 shows the specific ventilation cost variables for the building over recent years. Fig. 5 shows the application of the formula presented in Fig. 4.

Parameter	Value, Unit	Parameter	Value, Unit
Total floor area	5400 m²	Power requirement (ventilators)	30 MWh/a
No. of zones	10	Specific electricity costs	190 €/MWh
Zone areas	300 to 800 m²	Electricity costs for AC system	5700 €/a
Total volume flow	20000 m³/h	Heat requirement, thermal	415 MWh/a
Cooling requirement, thermal	275 MWh/a	Specific heating costs	90 €/MWh
Electricity requirement, cooling	90 MWh/a	Heating costs	37350 €/a
Specific electricity costs	190 €/MWh		
Cooling costs	17100 €/a	**Total costs of AC system media**	**60150 €/a**

Tab. 1: Specific ventilation cost variables for the building in this example (office complex)

The air for the whole building is treated in a central air conditioning system. Fig. 6 shows a diagram of the system: the central air conditioning unit pre-conditions a volume flow of 20000 m³/h using recuperative heat recovery and adiabatic cooling of return air. Conditioning is then completed within the central air conditioning unit via a heating and a cooling coil. The climate conditions of the air inflow volume flows in each zone are individually adjustable within a permitted range.

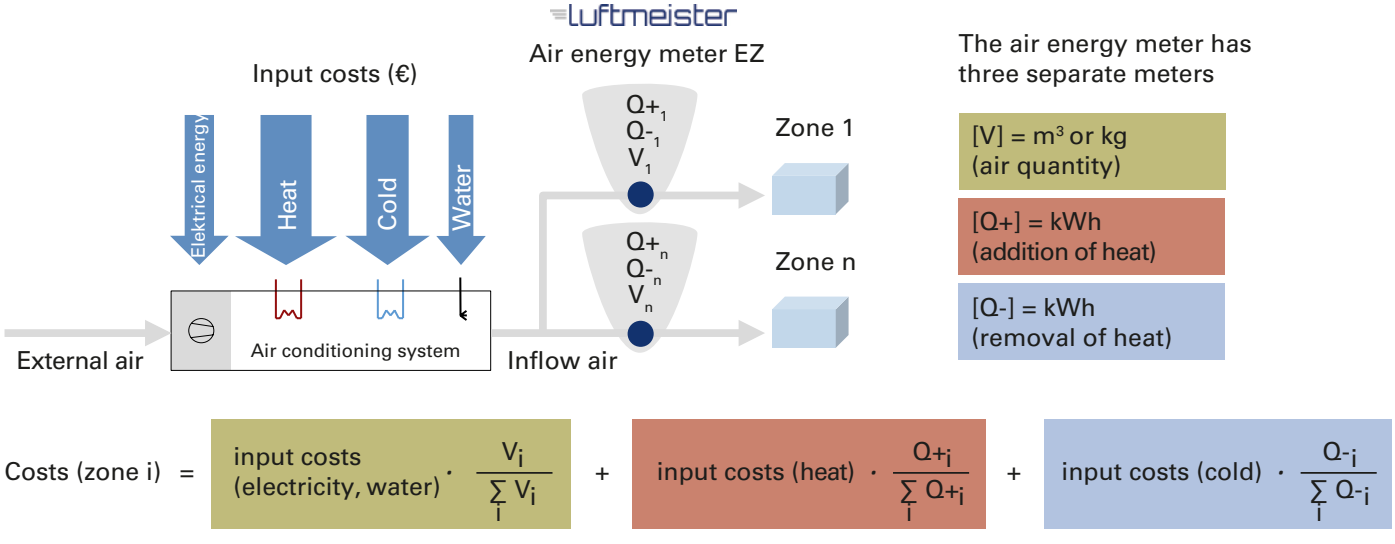
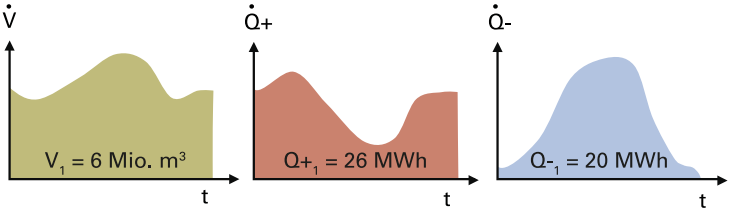


Fig. 4: Consumption-based billing of ventilation costs using air energy meters

Annual consumption per zone	V [Mio. m³]	Q+ [MWh]	Q- [MWh]
Zone 1	V_1 = 6	$Q+_1$ = 26	$Q-_1$ = 20
...	...	...	...
Zone 10	V_{10} = 18,6	$Q+_{10}$ = 60	$Q-_{10}$ = 39
Total	120	415	275

Volume flows $\dot{V}$ and thermal capacity $\dot{Q}+$, $\dot{Q}-$ vary over time and are added up by the meters V, Q+ and Q-. Here is a simplified representation of the yearly chart for Zone 1:



K_1 = 5 700 € x (6 / 120) + 37 350 € x (26 / 415) + 17 100 € x (20 / 275) = (285 + 2 340 + 1 244) € = 3 869 €

K_{10} = 5 700 € x (18,6 / 120) + 37 350 € x (60 / 415) + 17 100 € x (39 / 275) = (884 + 5 400 + 2 425) € = 8 709 €

Fig. 5: Example of consumption-based billing of ventilation costs using air energy meters (see also Table 2 for the values)

Decentralised heating and cooling coils in the air inflow ducts guarantee the correct post-conditioning.

How can consumption-based billing replace the area formula as a basis for attribution of ventilation costs? Fig. 7 shows the intended measurement sites:

- Heating energy meters (H) add together the quantities of heating energy [MWh] supplied to the central air conditioning unit and the individual zones (heating coils in the air inflow ducts). These meter readings represent the energy added to warm the air.
- Cooling energy meters (K) add together the quantities of cooling energy [MWh] supplied to the central air conditioning unit and the individual zones (cooling coils in the air inflow ducts). These meter readings represent the energy removed to cool the air.
- Water meters (W) record the quantity of water [m³] added to the adiabatic exhaust air cooling system. This meter reading, too, represents a removal of energy to cool the air.
- Electricity meters (S) record the electrical energy [MWh electrical]. This meter reading represents the energy supplied to drive the ventilators.

All these meters record the input variables. They are evaluated for each billing period and attributed the appropriate charge per unit in €. With the help of ten Luftmeister® EZ units and eleven enthalpy probes, these amounts are now allocated to the ten users.

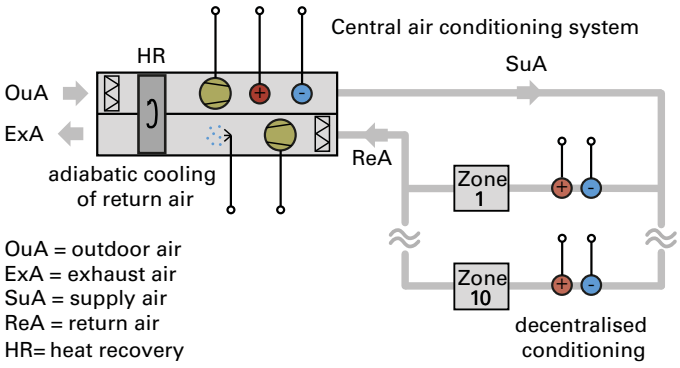


Fig. 6: System schematic for the sample project (office complex with 10 rental units)

Table 2 shows a comparison of the bills for the sample project based on the area formula and on consumption. For the area formula, the contribution towards costs per m² is calculated using historical values (see Table 1).

The consumption-based formula is shown in Fig. 4. For example, using consumption-based allocation of costs, Zone 1 pays a 16 % higher contribution towards ventilation costs than under the area formula because it consumes a relatively high level of cooling and/or heating energy. The difference in the annual bill is after all 527 €.

Savings soon pay for the costs of the Luftmeister® measurement system

With consumption-based billing, each rental unit benefits directly from energy savings it achieves – when using the area formula these were barely noticeable for the individual tenant. Consequently, Luftmeister® "internalises" the process of energy management: Each individual now contributes to the overall saving through his own consumption behaviour – and profits directly from the cost savings.

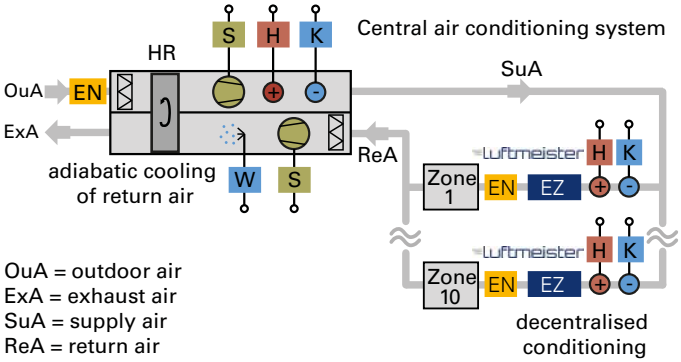
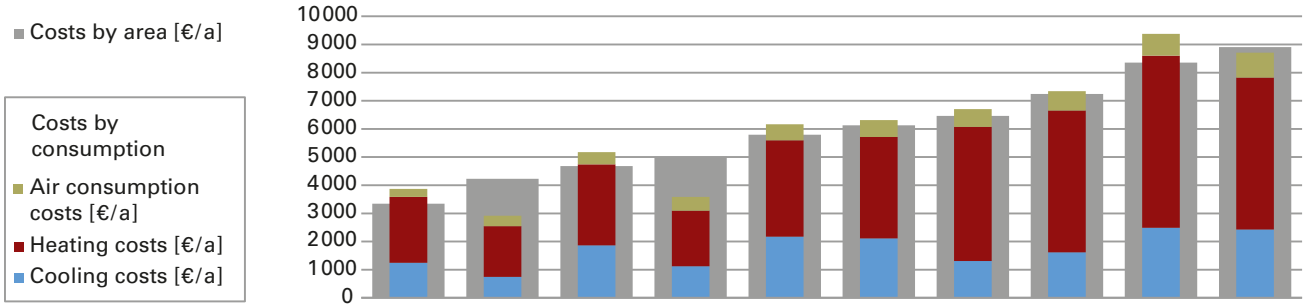


Fig. 7: Measurement site concept for the sample project



		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Summe
Area	Area per zone [m²]	300	380	420	450	520	550	580	650	750	800	**5400**
	Ventilator electricity costs [€/a]	317	401	443	475	549	581	612	686	792	844	**5700**
	Heating costs [€/a]	2075	2 627	2905	3113	3597	3804	4012	4496	5188	5533	**37350**
	Cooling costs [€/a]	950	1 203	1330	1425	1647	1742	1837	2058	2375	2533	**17100**
	Costs by area [€/a]	**3342**	**4231**	**4678**	**5013**	**5793**	**6127**	**6461**	**7240**	**8355**	8910	**60150**
Cosump-tion	Air consumption [million m³]	6	7,8	9	10,2	12	12,6	13,2	14,4	16,2	18,6	**120**
	Heat consumption Q+ [MWh]	26	20	32	22	38	40	53	56	68	60	**415**
	Cold consumption Q- [MWh]	20	12	30	18	35	34	21	26	40	39	**275**
Consump-tion charge	Air consumption costs [€/a]	285	368	428	485	570	599	627	684	770	884	**5700**
	Heating costs [€/a]	2340	1800	2880	1980	3420	3600	4770	5040	6120	5400	**37350**
	Cooling costs [€/a]	1244	747	1865	1119	2176	2114	1306	1617	2487	2425	**17100**
	Costs by consumption [€/a	**3869**	**2915**	**5173**	**3584**	**6166**	**6313**	**6703**	**7341**	**9377**	**8709**	**60150**
Comparison*	Change in costs per rental zone (consumption instead of area) Consumption [%]	+16	-31	-11	-29	+6	+3	+4	+1	+12	-2	**±0**
	Increase / reduction in bill (consumption instead of area) [€/a]	527	-1316	495	-1429	373	186	242	101	1022	-201	**±0**

Tab. 2: Comparison of area based and consumption-based ventilation costs (*The comparison refers only to the first billing year and does not yet take into account the savings that will result in subsequent years).

What level of savings can individual tenants realistically expect to achieve in practice over a number of years using the consumption-based approach described above? Based on experience with other media, energy agencies suggest the potential savings could realistically be in the range of 10-25%. The following factors mean these savings could also be achieved by using Luftmeister® in air conditioning systems:

- The individual user is informed about the true consumption-based ventilation costs, he is more cost-conscious in setting the climate parameters for his premises (less cold in the summer, less warm in the winter, less extreme humidity values and, if selectable, also adjusted volume flows, e.g. reduced during off-peak times)
- The operator is able to implement improvements in regulation technology based on operating data provided by the Luftmeister®, e.g. relating to the heat recovery function.

As the enthalpy measurement sites are located directly in the supply air duct for each rental unit, the tenant is only charged for the quantity of effective energy and volume of air he actually uses. It is therefore (and this is fundamentally important for creating savings) in the operator's interest to supply this energy and air efficiently

The operator is directly motivated to optimise the design and regulation of the air conditioning system and alsoto minimise losses along the air ducts. Assuming total annual costs of 60150€/a, reducing consumption by 10-25% in this sample project would generate an annual saving of approx. 6000 to 15000 €. A Luftmeister® system, which would cost approx. 25000 € for the sample project described, would therefore have paid for itself in 1.5 to 4 years.

Luftmeister® offers further potential benefits

However, this estimated calculation completely omits the additional benefits of using the multitalented Luftmeister®:

- Hygiene control (monitoring flows, dew points and filters)
- Flow regulation (controlling dampers/flaps)
- Energy management (supplying energy flow values for continuous performance monitoring and optimisation).

Regardless of whether the property is a shopping centre or office complex, there are good reasons for both investors and engineering consultants to agree on the benefits of using the Luftmeister®. For an investor, it can be used to provide further evidence of the importance of sustainability in his properties. At the same time, planners can be confident that they are creating solutions with a viable future using tomorrow's technology today. And last but not least, tenants and facility managers will welcome a fair legal-for-trade system for billing ventilation costs based on consumption data.

Luftmeister GmbH
Ottenstraße 2
D-79199 Kirchzarten
Deutschland

www.luftmeister.de
amberg@luftmeister.de
Tel. +49(0)7661 / 38498–85
Fax +49(0)7661 / 38498–89