VOCs (Volatile Organic Compounds) determine mixing gases? our lives

- Anatomy of air
- CO_2 / VOC dependencies in the indoor air
- Meaningful measurement and control
- Energy savings through Demand Controlled Ventilation (DCV)
- Practical examples for reducing energy costs

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Anatomy of air

Clean air consists of 21% oxygen, 78% nitrogen and 1% argon.

When indoor air conditions come noble gases, carbon monoxide, carbon dioxide (CO2) and mixed gases, so-called Volatile Organic Compounds (VOCs) are added with different proportions. To assess the air quality in terms of our health, the latter two are the most important: CO2 because of its historical importance as a conductance in the ventilation industry and VOCs because of their influence on the health and well-being.

VOCs and their impact on the indoor air

- known are 5,000 to 10,000 different VOCs
  VOCs are in indoor air Hydrocarbon compounds from two main sources:

- Organic Effluente (vapors) from human breathing,
  Perspiration and digestion
- Exhalations of building materials and home furnishings

Polluted air causes illness

- Cause of eyestrain, headaches, fatigue and dizziness, which under the term SBS (Sick Building Syndrome = Building Conditional disease syndrome)

Sick in hospitals ...
Pile in a building symptoms, such as nasal irritation and Constipation, Itching and burning of the eyes, hoarseness of the throat, skin irritation and general symptoms such as headache, fatigue and concentration problems, may be the so-called SICK Building Syndrome (SBS) act. As varied as the symptoms so varied are the causes of SBS. is held responsible currently the coincidence of different factors such. as a unfavorable air temperature, incorrect lighting, chemical and biological pollutants to psychological factors such as stress or lack of recognition at work. SBS is a phenomenon of the last 10-15 years and also with the increase of man-made materials with corresponding emissions (carpeting, office furniture) and the brought increased use of artificial climate control in connection.

Polluted air causes illness

Up to 40% of all building occupants complain of such mood disorders.
The symptoms described are very difficult objectively verifiable.
Many people who suffer from it, have major problems, the relationships it relies.

For a long time was not observed that much higher indoors pollutant concentrations may occur than in the outside air.

Unlike in the past is being built closer today and it will be more chemicals in Interiors introduced. Exposure to pollutants inevitably leads to increased load of room users.

After all, most people hold about 90% of their lives on indoors.

The economic losses due to building related illness (loss of working hours, poor motivation, health insurance costs, deductibles, etc.) are estimated at billions of dollars, but still appear to in any statistics.

Office and living spaces

Unlike the industrial sector, in the limits (as Maximale- workplace
Concentration) protect workers, there are for office and residential spaces no clear
Rules for the valuation of pollutants.

A transfer of limits of the living area is not possible, because here, too
Children, elderly and sick people are concerned, also for more than eight hours
Day that the charge may be exposed.

Fresh air must be pure

When showering, cooking and washing creates humidity, the outside
must escape.
Approximately every two hours you should again renew the room air.
In older buildings, leaky windows and cracks take over under the doors already
a portion of this air exchange.
In well-insulated houses contrast reaches no air
through joints and cracks.

The airtight a building is, the more important is regular and conscious airing of rooms.

CO2 / VOC dependencies in the indoor air

CO2 a single gas thousands as deputy VOCs?

Reliable sensor technology was originally developed for CO2.
This historically was the conductance for indoor air quality.
Thus, by Max von Pettenkofer originally in
19th century introduced CO2 levels of quality today
in many international standards ventilation validity.

In the absence of a unified industry standards for determining
the VOC concentration in the ambient air, has the AppliedSensor
iAQ (intelligent Air Quality) series developed on the basis of reverse
Metabolic control (Reversed Metabolic Rule = RMR) technology works.
Applied CMR sensor technology leads the measured VOC values
on CO2 equivalents in back ppm units, thus achieving compatibility
to existing CO2 ventilation standards.

Classification of indoor air quality

<table>
<tr><th>CO_2 [ppm]</th><th>Luftqualität</th></tr>
<tr><td>2100</td><td rowspan="6">Poor ??

Very dirty?

Room air
ventilation required ??</td></tr>
<tr><td>2000</td></tr>
<tr><td>1900</td></tr>
<tr><td>1800</td></tr>
<tr><td>1700</td></tr>
<tr><td>1600</td></tr>
<tr><td>1500</td><td rowspan="5">Means ??

dirty?

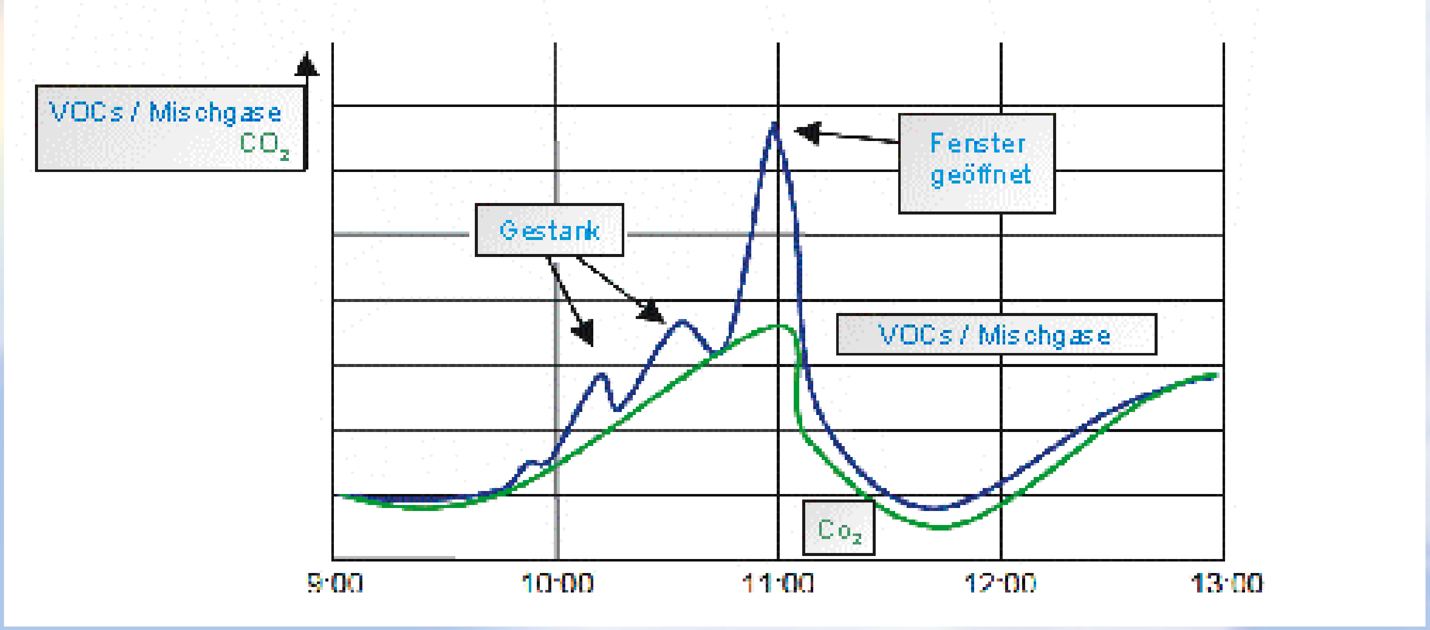
Room air
ventilation recommended ??</td></tr>
<tr><td>1400</td></tr>
<tr><td>1300</td></tr>
<tr><td>1200</td></tr>
<tr><td>1100</td></tr>
<tr><td>1000</td><td rowspan="2">Satisfying</td></tr>
<tr><td>900</td></tr>
<tr><td>800</td><td rowspan="2">Good</td></tr>
<tr><td>700</td></tr>
<tr><td>600</td><td rowspan="3">Outstanding</td></tr>
<tr><td>500</td></tr>
<tr><td>400</td></tr>
</table>

Effects of elevated CO2 levels

Although human CO2 production historically a significant role
plays in modern ventilation technology, CO2 has, especially in low
Concentrations only a relatively small impact on the people:
Decades of experience with submersibles, as well as on the ISS
Confirm (International Space Station) investigations performed,
that increased CO2 concentrations of 1% (10,000 ppm)
no lasting negative effects on human have well-being.

Due to lack of suitable VOC sensor CO2 sensors were used in the
Past but as an adequate indicator of indoor air quality,
because the amount of CO2 proportional to the human metabolic rate and
approximately proportional to the total amount of VOCs (Total VOCs = TVOCs),
provided that these were human breathing, perspiration and
Digestion produces (metabolic control / Metabolic Rule).

CO2 and VOCs recorded during a meeting



Meaningful fairs

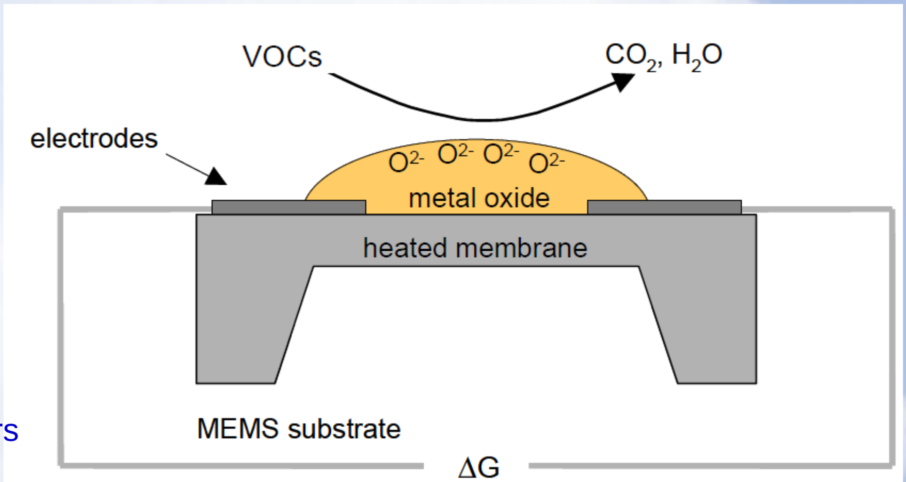
application	commercial buildings						residential building		
	office	Meeting room	restaurant	gym	Toilet	kitchen	living room	bedroom	bathroom
main event(s)	breath, odors	breath, odors	breath, odors, humidity	breath, odors	odors	Gerüche, humidity	breath, odors,	breath, odors, humidity	humidity
humidity sensor	-	-	0	-	-	0	-	0	+ +
CO2 Sensor	+	+	+	0	-	-	+	+	-
VOC Sensor	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	0

The market offers a variety of air quality measurement principles for the control of ventilation systems. Typical representatives are motion detectors, CO2, humidity and VOC sensors. The table compares the Performance of the latter three technologies under different aspects and provides the advantages of the VOC intelligent Air Quality technology out clearly.

Working principle of the air quality sensor

Working principle of a metal oxide gas sensor

- When metal oxide sensor, the electrical conductivity of a semiconducting metal oxide nanocrystalline is measured, which is deposited on a heatable substrate. The operating temperature is typically in the range of 300-400 ° C.
- The doping of the metal oxide with precious metals positively affects the sensitivity to combustible gases (VOCs, carbon monoxide, natural gas), and makes it possible to adapt the sensor material to the needs of the application.
- Are VOCs contained in the air, they will be burned at the sensor surface partially or completely by the oxygen of the metal oxide. The in this process released in semiconductors electrons lead to an increase in electrical conductivity.
- Finally, the metal returns due to the incorporation of oxygen in the air again in its initial state, the conductivity resumes the initial value.



Energy savings through Demand Controlled Ventilation

There are many ways to achieve energy savings with ventilation. Ventilation systems can permanently, with constant air volume (CAV), statistical, variable air volume (VAV) and operated as needed (DCV).

For demand oriented ventilation in turn can be of a variety of control variables (movement, CO_2, VOCs and humidity) selected or combined.

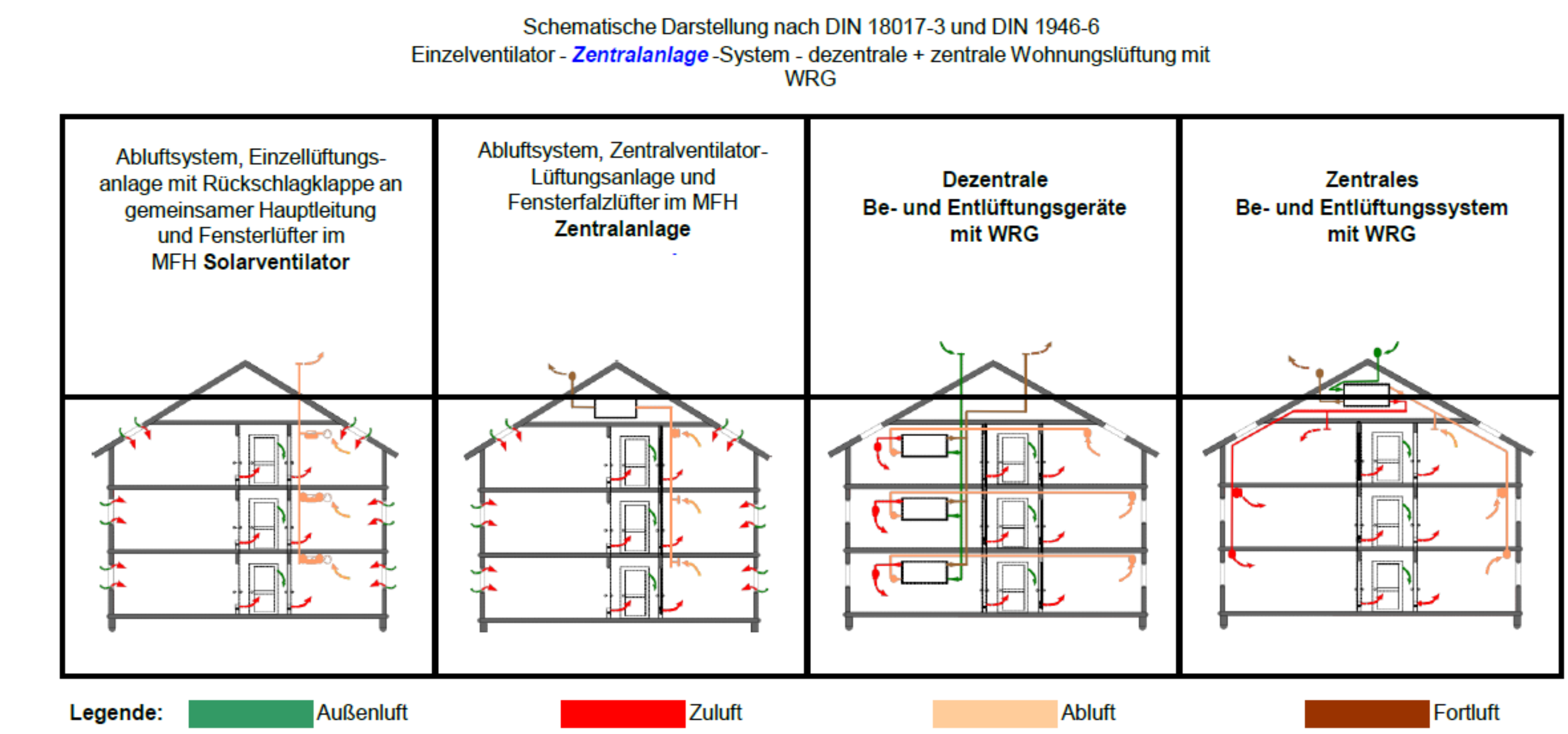
Example: In a gym, the operating time of the timer-controlled ventilation system could be reduced through the use of a VOC sensor by 24%. This corresponds to a saving of about 60% of energy costs. In addition, the air quality had improved following a survey of the Centre visitors even significantly.

Tailored ventilation with VOC iAQ technology means excellent air quality at minimum cost.

Practical examples for reducing energy costs

Project Solar Fan

Comparison of cost accounting systems for housing



Vergleich Investitionskosten für Anlagen nach DIN 18017-3 und DIN 1946-6
Einzelventilator – _ *Zentralanlage*-System – dezentrale + zentrale Wohnungslüftung mit WRG

Die Ermittlung der Vergleichszahlen beruht auf Befragungen in Wohnungsbauunternehmen, Ingenieurbüros und ausführenden Firmen.
Dabei handelt es sich um komplett installierte Lüftungstechnik, elektrische Bauteile (ohne Elektroinstallation), notwendige Brandschutzbauteile und erforderliche Leitungssysteme.

Alle Werte zuzüglich der gesetzlichen MwSt.

	Einzelventilator mit Solar	**Zentralanlage mit Solarventilator**	**Dezentrale Be- und Entlüftungsgeräte mit WRG** (je Wohnung)	**Zentrales Be- und Entlüftungssystem mit WRG** (je 10 Wohnungen)
Beispiel: **100 WHG mit je 2 Anschlüssen + vorb. Brandschutz + Leitungssystem**	je WHG 2 Geräte, mit Feuchtesensor / VOC	2 Wandfortluftautomaten je WHG, mit Feuchtesensor / VOC 10 Anlagen mit je 10 Wohnungen 2 Absaugstellen	Je WHG 1Gerät mit WRG mit Zu- + Abluftelemente und Steuerung	1 Gerät für 10 WHG mit Zu- + Abluftelemente und Steuerung
Kosten je Wohnung Marktanalyse und Submissionsergebnisse	ca. 1200 €	ca. 1200 €	ca. 4.200 bis 4.900 €	ca. 3.200 bis 3.800 €
Kosten f. Nachströmeinrichtung je WGH 6 Fensterlüfter	ca. 300 bis 500 €	ca. 300 bis 500 €	---	---
Gesamtkosten je WHG	ca. 1.500 bis 1.800 €	ca. 1.500 bis 1.800 €	ca. 4.200 bis 4.900 €	ca. 3.200 bis 3.800 €
Investition für 100 WHG	**ca. 150.000 bis 180.000 €**	**ca. 150.000 bis 180.000 €**	**ca. 420.000 bis 490.000 €**	**ca. 320.000 bis 380.000 €**

Achtung Investitionskosten sind ohne Kapitaldienst (Zinsen und Tilgung) gerechnet!

Vergleich **Energiebedarf**, **Betriebskosten** (ohne Investitions- und Wartungskosten der Anlagen!):
Einzelventilator – Zentralanlage -System – dezentrale + zentrale Wohnungslüftung mit WRG

Alle Ergebnisse sind ca.-Werte im Neuzustand!	**Einzelventilator mit Solar**	**Zentralanlage mit Solarventilator**	**Dezentrale Wohnungslüftung mit Wärmerückgewinnung** (je Wohnung)	**Zentrales Wohnungslüftungssystem mit Wärmerückgewinnung** (jeweils 10 Wohnungen)
Reduzierte/Nennlüftung 22 Std.	ca. 10 W/Anschluss	0 W/Anschluss	ca. 65 W/Anschluss	ca. 500 W
Intensivlüftung 2 Std.	ca. 20 W/Anschluss	3 W/Anschluss	ca. 80 W/Anschluss	ca. 750 W
Duchschnittliche Luftleistung	60 m³/h je WE	50 m³/h je WE	150 m³/h je WE	120 m³/h je WE
Energieverbrauch in 24 Std.	**ca. 260 Wh/Anschluss**	**ca. 6 Wh/Anschluss**	**ca. 1.590 Wh/Gerät**	**ca. 12.500 Wh/System**
100 Wohnungen mit je 2 Anschlüsse: Elektroenergieverbrauch pro Tag	**Bei Solar = 0 kWh** **52 kWh**	zuzüglich Stromverbrauch 10 Dachventilatoren 70 W x 24 h **18 kWh / Bei Solar = 0 kWh**	**159 kWh**	**125 kWh**
Elektroenergieverbrauch pro Jahr	**18.980 kWh / 0 kWh**	**6.570 kWh / 0 kWh**	**58.040 kWh**	**45.625 kWh**
Heizölverbrauch pro Jahr	**... Luftleistung [m³/h] * 5.400 h/a * 0,00034 kWh/m³K * 15 K * 0,1 l/kWh = Lüftungswärmeverlust [l Heizöl]** 5.400 h/a = Heizperiode (225 Tage), 0,00034 kWh/m³K = Wärmetransport von 1 m³ Luft bei 1 Kelvin Temperaturunterschied, 15 Kelvin = mittlere Temperaturdifferenz innen zu außen in der Heizperiode, 0,1 l/kWh = Heizölverbrauch zur Erzeugung von 1 kWh Wärme			
	16.524 l	**13.770 l**	**41.310 l**	**33.048 l**
Stromkosten pro Jahr** **Heizölkosten pro Jahr*****	4.745 € / **0 €** + 12.724 €	1.643 € / **0 €** + 10.603 €	14.510 € + 31.809 €	11.406 € + 25.447 €
Energiekosten pro Jahr	**17.469 € / 12.724 €**	**12.246 € / 10.603 €**	**46.319 €**	**36.853 €**
Energiekosten 10 Jahren**	**174.690 € / 127.240 €**	**122.460 € / 106.030 €**	**463.190 €**	**368.530 €**
	** Stromkosten 0,25 €/kWh (Stand 2012)		*** Heizölkosten 0,77 €/l (Stand 2012)	

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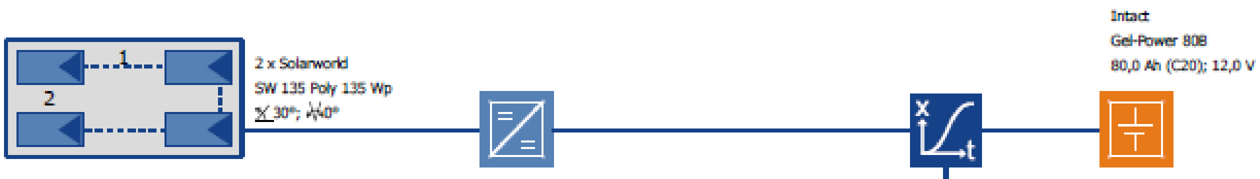
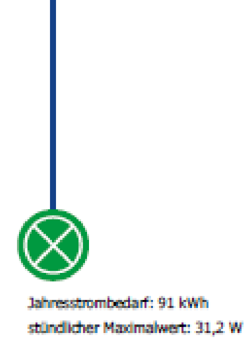
Vergleich Inspektions-/Wartungskosten, Betriebskosten und Gesamtkosten
Einzelventilator – Zentralanlage-System – dezentrale + zentrale Wohnungslüftung mit WRG

	Einzelventilator	Zentralanlage	Dezentrale Be- und Entlüftungsgeräte mit WRG (je Wohnung)	Zentrales Be- und Entlüftungssystem mit WRG (je 10 Wohnungen)
Beispiel: **100 WHG mit je 2 Anschlüssen + vorb. Brandschutz + Leitungssystem**	je WHG 2 Geräte, davon 1 mit Feuchtesensor VOC / Temperatur	2 Wandfortluftautomaten je WHG, mit Feuchtesensor, VOC 10 Anlagen mit je 10 Wohnungen 2 Absaugstellen	Je WHG 1Gerät mit WRG mit Zu- + Abluftelemente und Steuerung	1 Gerät für 10 WHG mit Zu- + Abluftelemente und Steuerung
Investitionskosten für 100 WHG	**ca. 150.000 – 180.000 €**	**ca. 150.000 – 180.000 €**	**ca. 420.000 – 490.000 €**	**ca. 320.000 – 380.000€**
Inspektions-/Wartungskosten/WHG nach DIN 18017 / 1946-6	2 – 4 x Jahr ca. 40 bis 80 €/WHG	2 x Jahr ca. 40 €/WHG	2 x Jahr ca. 250 €/WHG	2 x Jahr anteilig ca. 40 €/WHG + WRG 1.500 €
Wartungskosten für 100 WHG/Jahr	**ca. 4.000 €**	**ca. 4.000 €**	**ca. 27.500 €**	**ca. 5.500 €**
Energiekosten für 100 WHG/Jahr	**ca. 17.469 € / 12.724 €**	**ca. 12.246 € / 10.603 €**	**ca. 46.319 €**	**ca. 36.853 €**
Betriebskosten für 100 WHG/Jahr	**ca. 21.500 € / 17.000 €**	**ca. 16.300 € / 14.600 €**	**ca. 63.800 €**	**ca. 42.400 €**
Betriebskosten für 100 WHG in 10 Jahren ****	**ca. 215.000 € / 170.000 €**	**ca. 163.000 € / 146.000 €**	**ca. 638.000 €**	**ca. 424.000 €**
Gesamtkosten in 10 Jahren Investition + Wartung + Energie******	**ca. 330.000 € / 320.000 €**	**ca. 313.000 € / 296.000 €**	**ca. 1.058.000 €**	**ca. 744.000 €**
	Hinweis: Durch höhere Luftleistungen der WRG ergibt sich kein Vorteil bei den Wärmeverlusten!			

**** **Achtung Alle Kosten sind <u>ohne Kapitaldienst</u> (Zinsen und Tilgung) gerechnet!**

Basics calculations solar fan





Standort:	Hannover	
Klimadatensatz:	Hannover (1981-2010)	
PV-Leistung:	270,0	Wp
PV-Brutto-/Bezugsfläche:	2,00 / 2,00	m²

PV-Generator Einstrahlung:	2.284,2	kWh
PV-Gen. erzeugte Energie:	265,09	kWh
Konverter Energie:	205,70	kWh
Verbrauch Bedarf:	91,104	kWh
Verbrauch solar gedeckt:	82,830	kWh
Verbrauch nicht gedeckt:	8,3	kWh

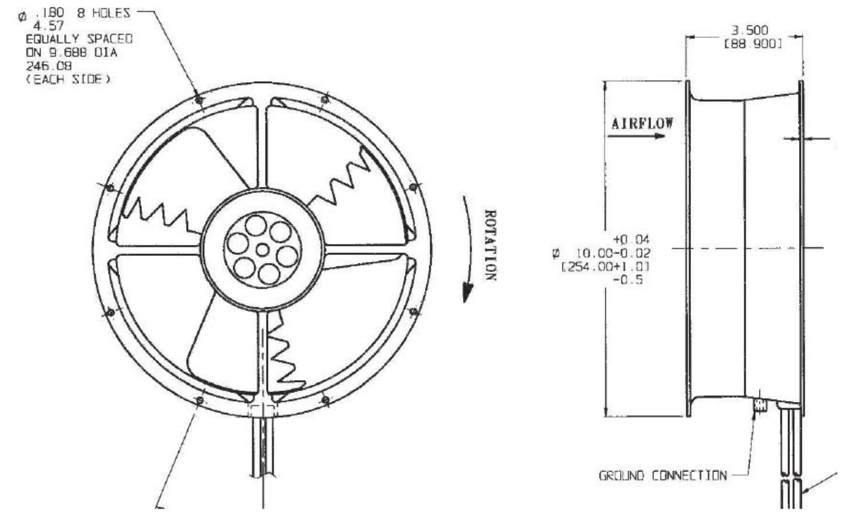
Solarer Deckungsanteil:	90,9	%
Performance Ratio (Anlagennutzungsgrad):	26,8	%
Spez. Jahresertrag:	306,8	kWh/kWp
Vermiedene CO2-Emissionen:	51	kg/a
Systemnutzungsgrad:	3,6	%
PV-Generator Nutzungsgrad:	11,6	%

Die Ergebnisse sind durch eine mathematische Modellrechnung ermittelt worden. Die tatsächlichen Erträge der Photovoltaikanlage können aufgrund von Schwankungen des Wetters, der Wirkungsgrade von Modulen und Wechselrichter und anderer Faktoren abweichen. Das obige Anlagenschema ersetzt nicht die fachtechnische Planung der Photovoltaikanlage.

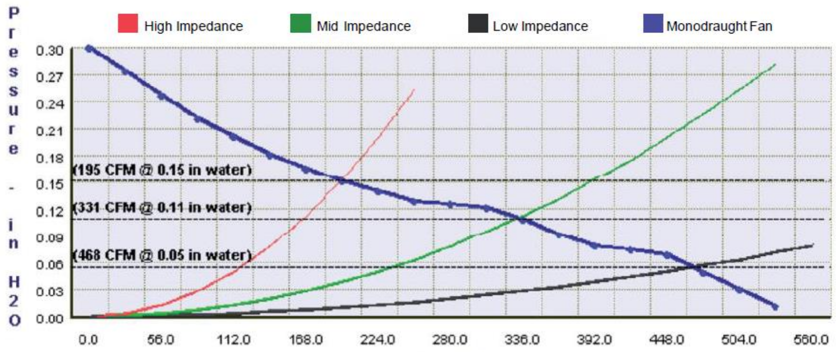
Specifications solar fan - motor

SOLA-BOOST® solar assisted natural ventilation system fan Specification

Mechanical Drawing:



Fan Performance Curve:



Motor:

Nominal Voltage	= 24 vdc
Operating Voltage Range	= 8 - 28 vdc
Nominal Running Current	= 1.200 amps
Locked Rotor Current	= 3.000 amps
Running Power	= 29.0 watts
Average Speed	= 1650 rpm
Bearings	= Ball
Air Flow	= 200 l/s

Construction:
Venturi: Die-Cast Aluminum, Black
Propeller: Polycarbonate, Black, UL 94V-0

Life Expectancy:
This fan is designed for continuous duty life of 60,000 hours.

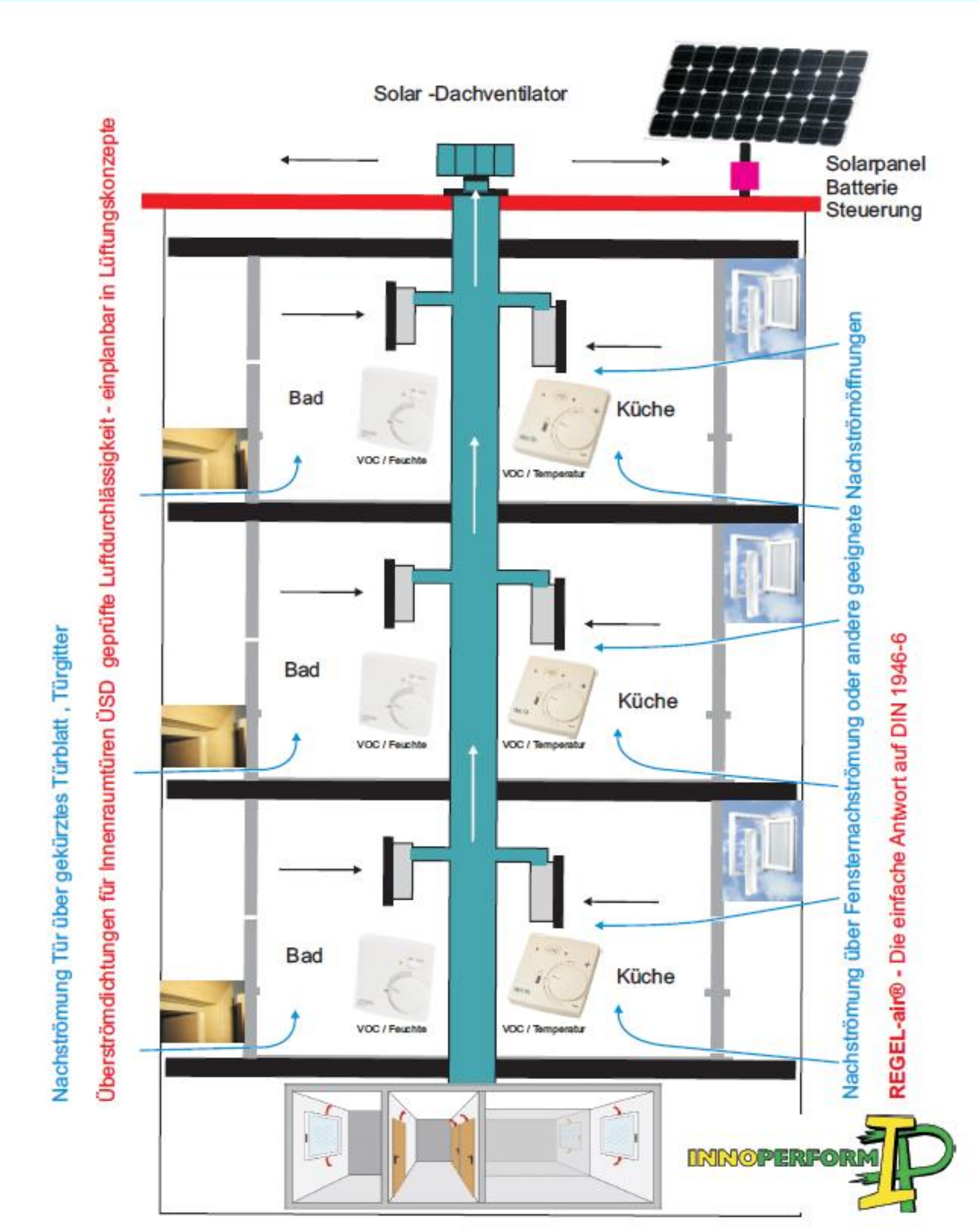
Features:
Brushless DC Motor
Locked Rotor
Protection Polarity
Protected
Automatic Restart Capability
Operating Temperature: -10°C to 70°C

Connection:
Red – DC +
Black – DC -
Blue/White – Tachometer
Yellow – Speed Control

Acoustic:	Half Speed	Full Speed
1m distance –	45 dBA	47 dBA
3m distance –	* dBA	43 dBA
5m distance –	* dBA	* dBA

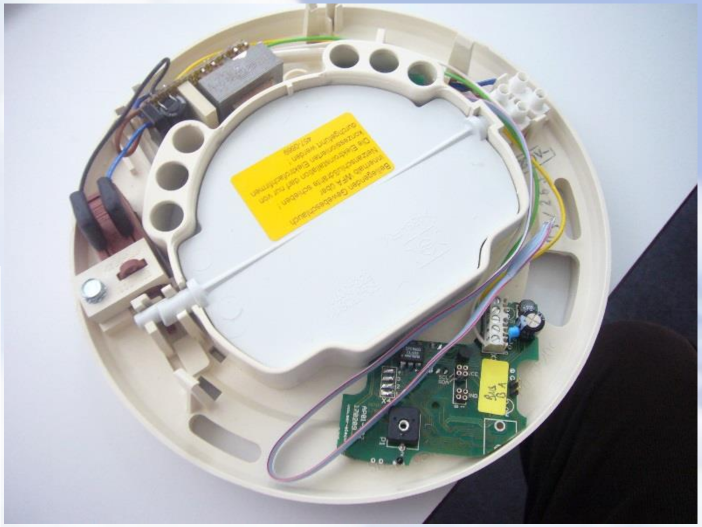
Less than 40dBA shown *

Air quality control in conjunction with solar exhaust fans



Prices for control

Cost per controller and room 100 EURO
Costs for evaluation approximately 120 EURO
These costs may lower in numbers
fail and may be based on specifications definition
the requirements are determined



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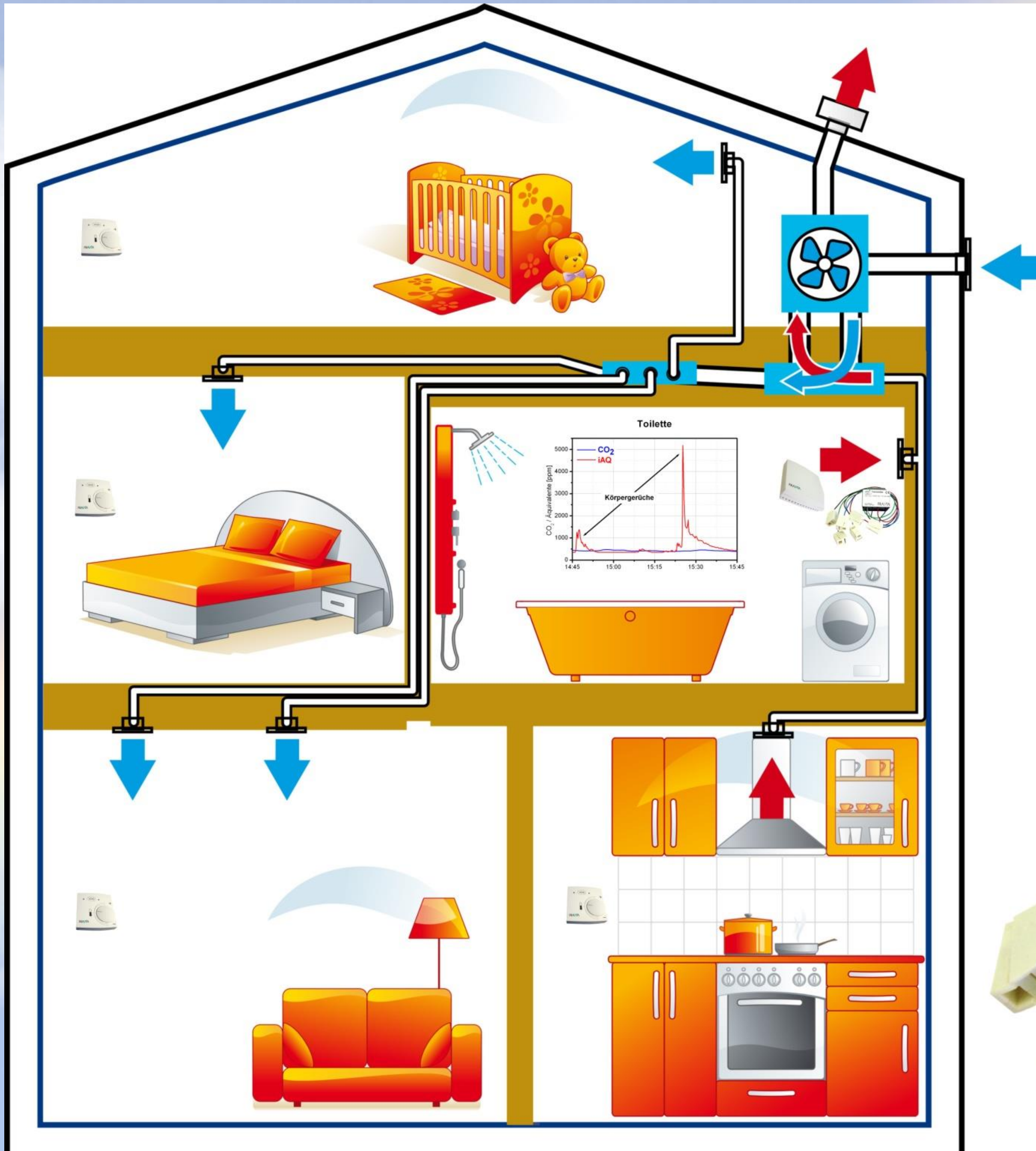
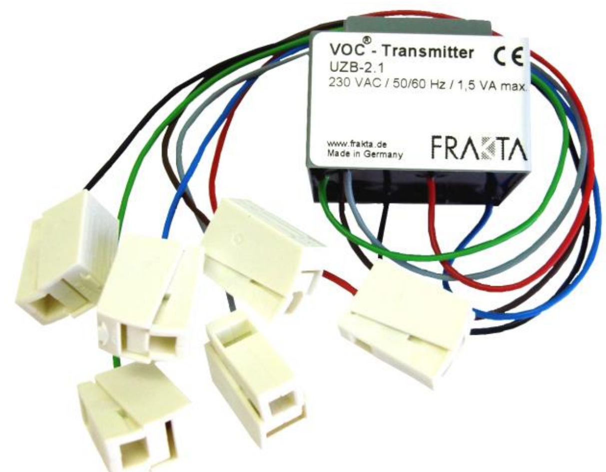


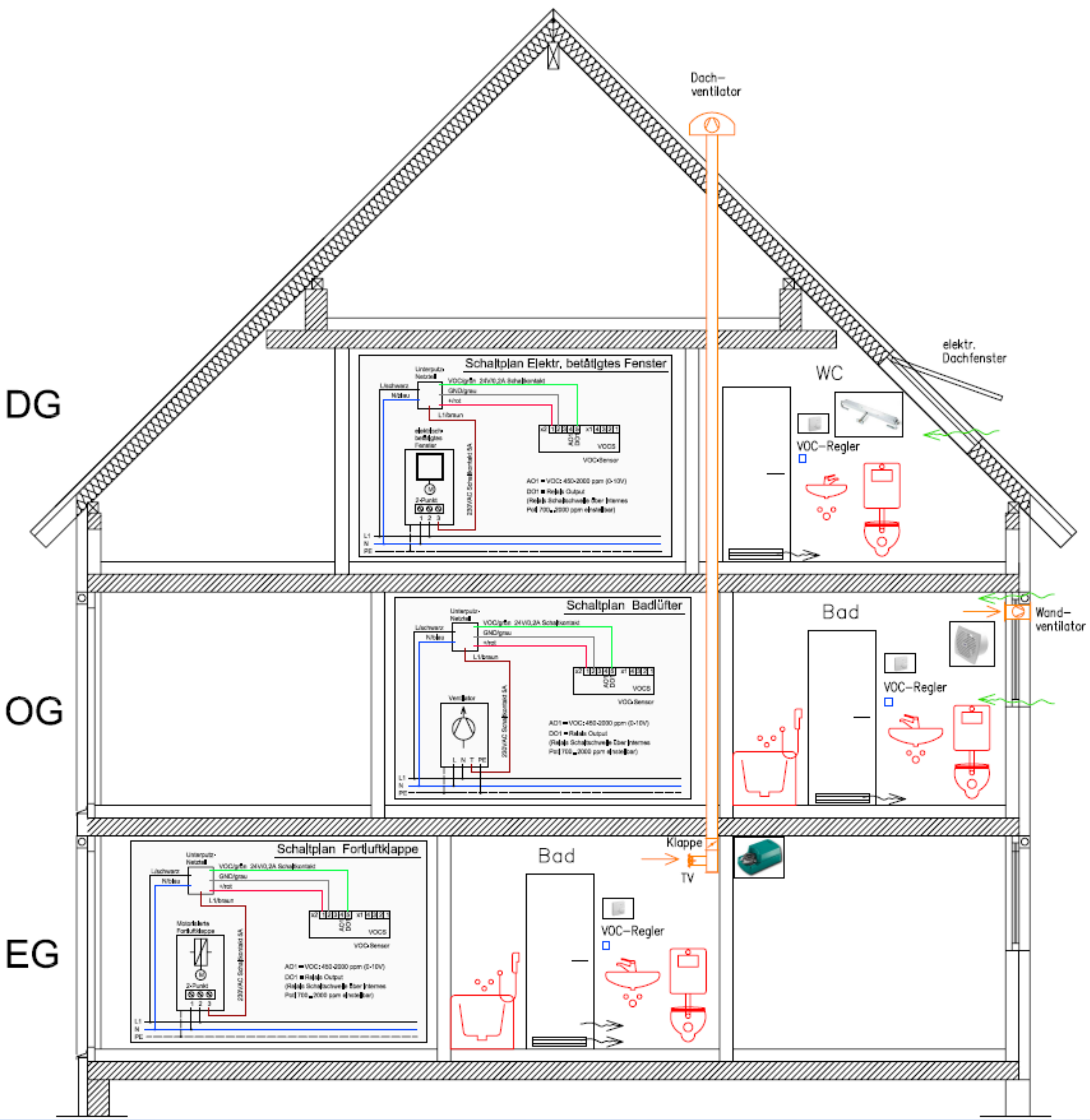
Toilette
CO2
iAQ
Körpergerüche
CO2 / Äquivalente [ppm]

VOC
+
–
FRAKTA

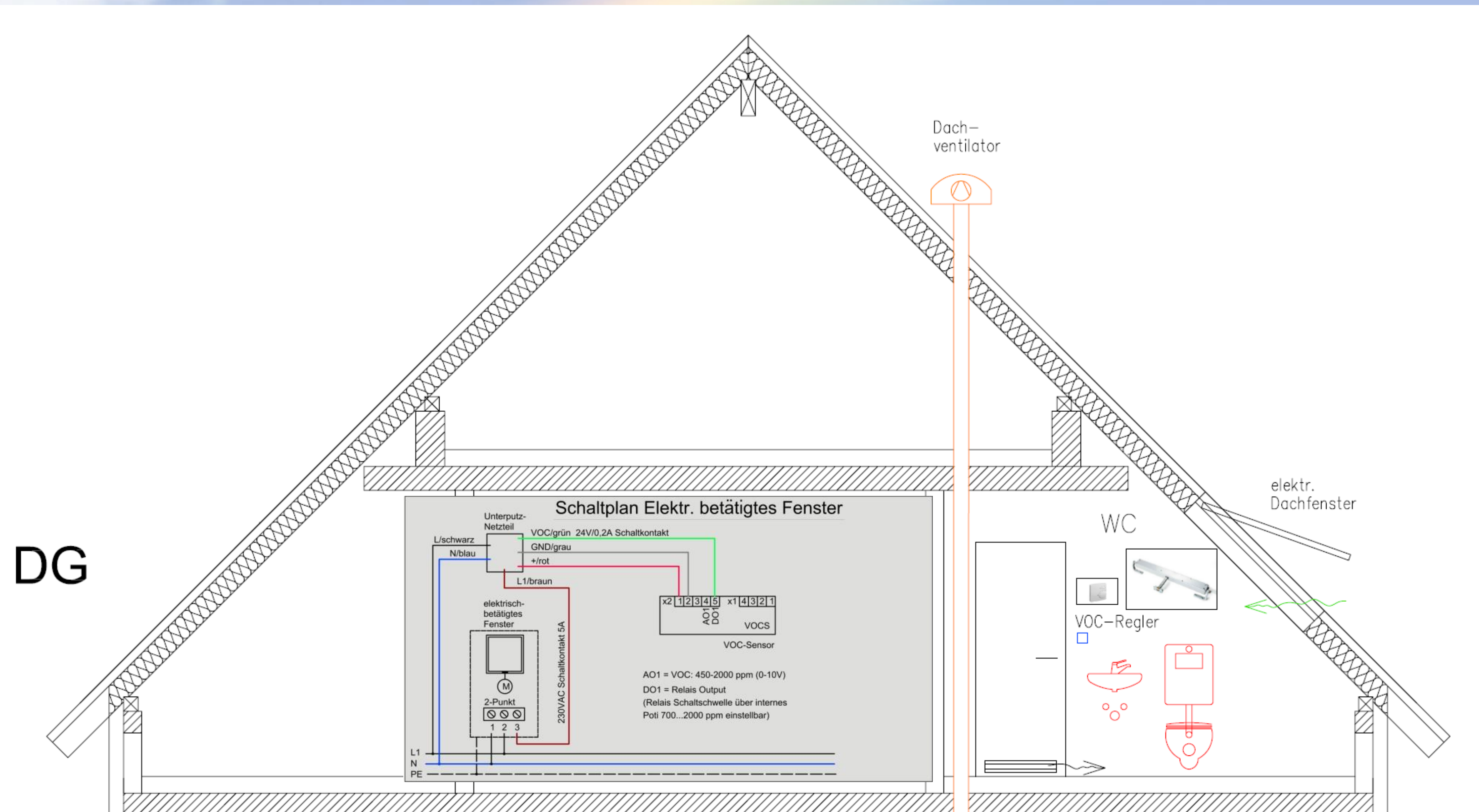


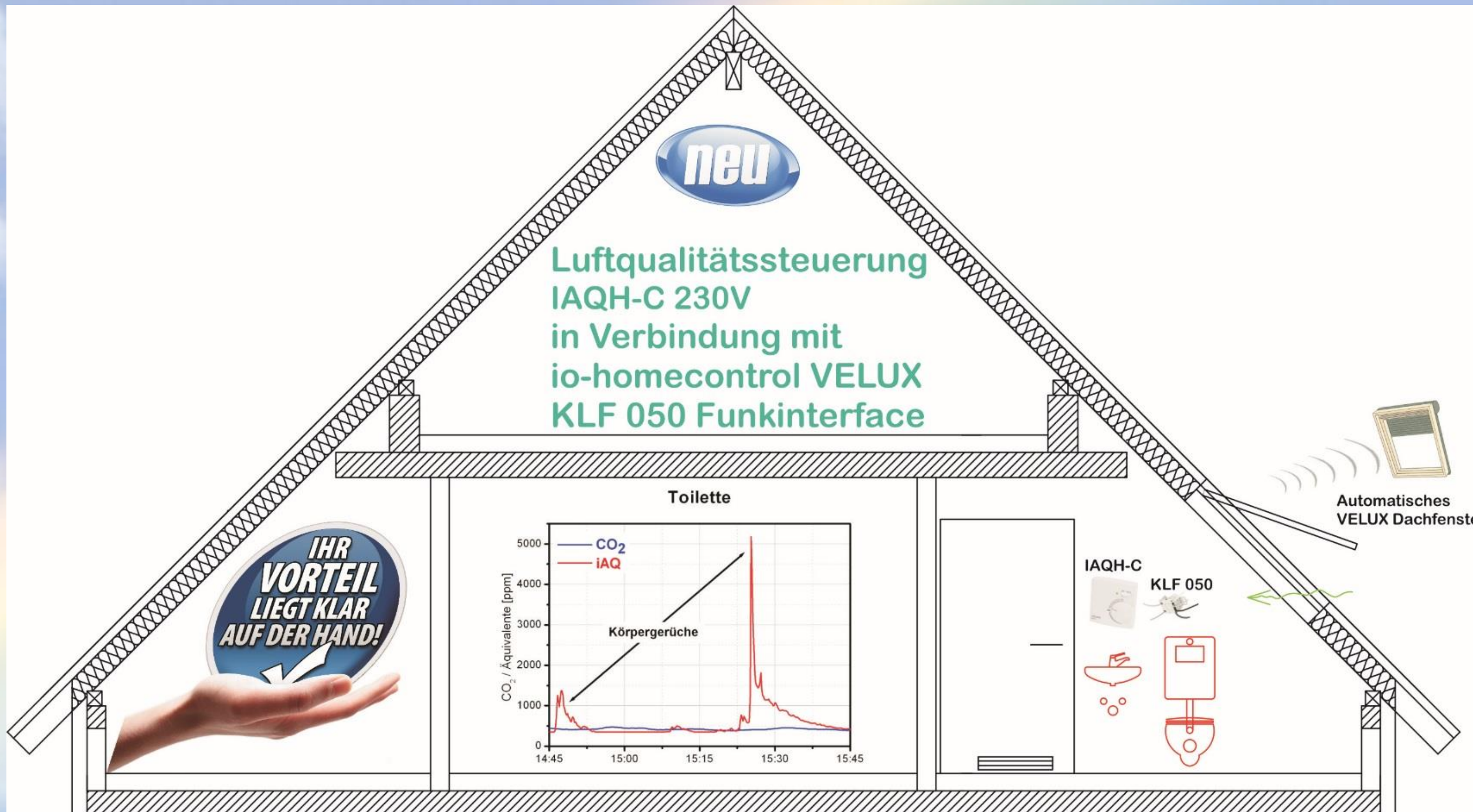
VOC® - Transmitter
UZB-2.1
230 VAC / 50/60 Hz / 1,5 VA max
CE
www.frakta.de
Made in Germany
FRAKTA

Demand-airing - The goal



Electric window control

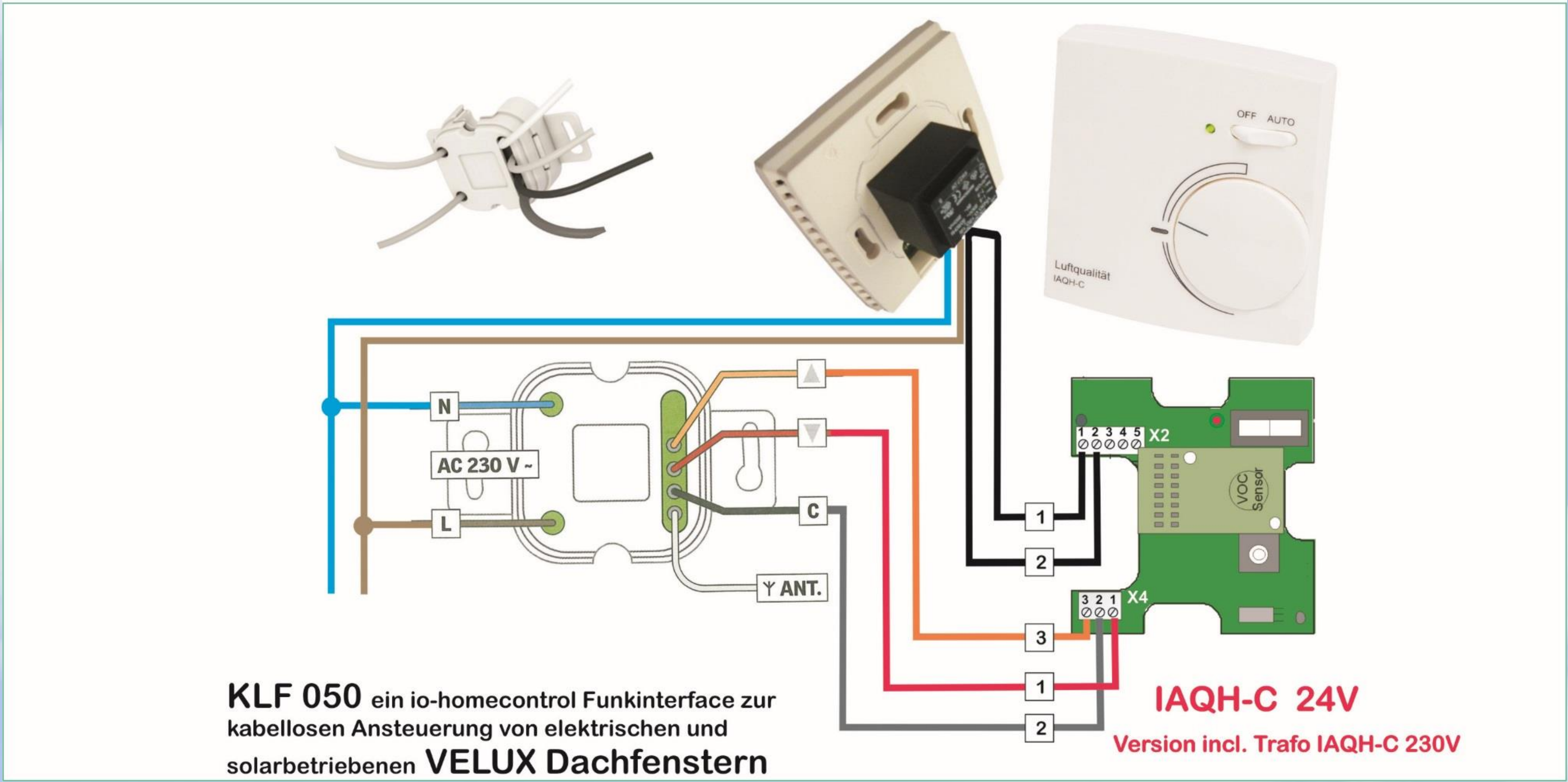




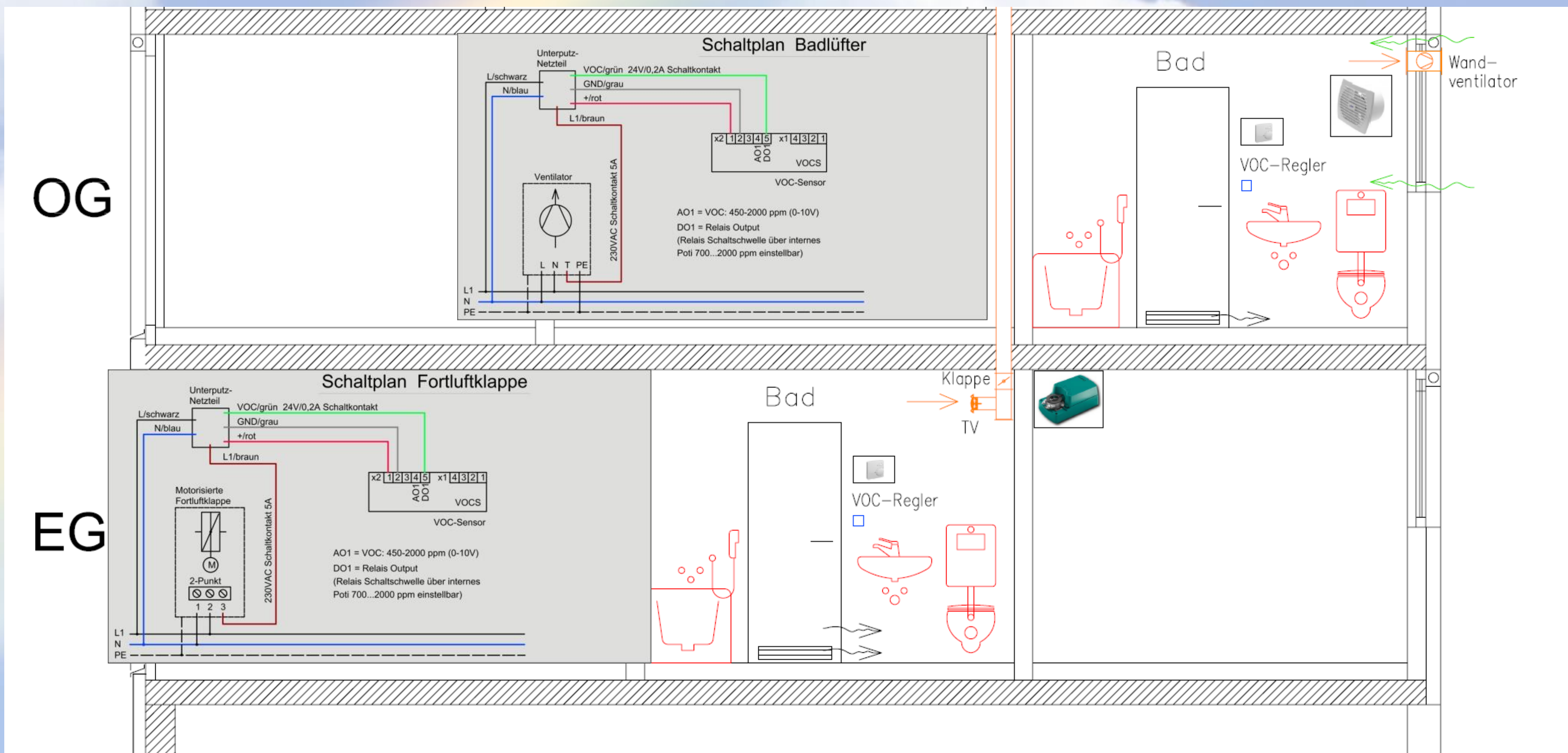
Stellrad Position	Luftqalität Co2 Äquivalenz	Relative Feuchte	Fenster Lüftung
Strich oben	**900 ppm = sehr gut**	**55 %**	**häufiger**
Strich mittig	**1200 ppm = gut**	**65 %**	**normal**
Strich unten	**1600 ppm = befriedigend**	**75 %**	**seltener**

VELUX roof windows control

FRAKTA = VELUX Partner



Internal WCs, baths



Feel-good atmosphere for all at all times
Highest indoor air quality at any time

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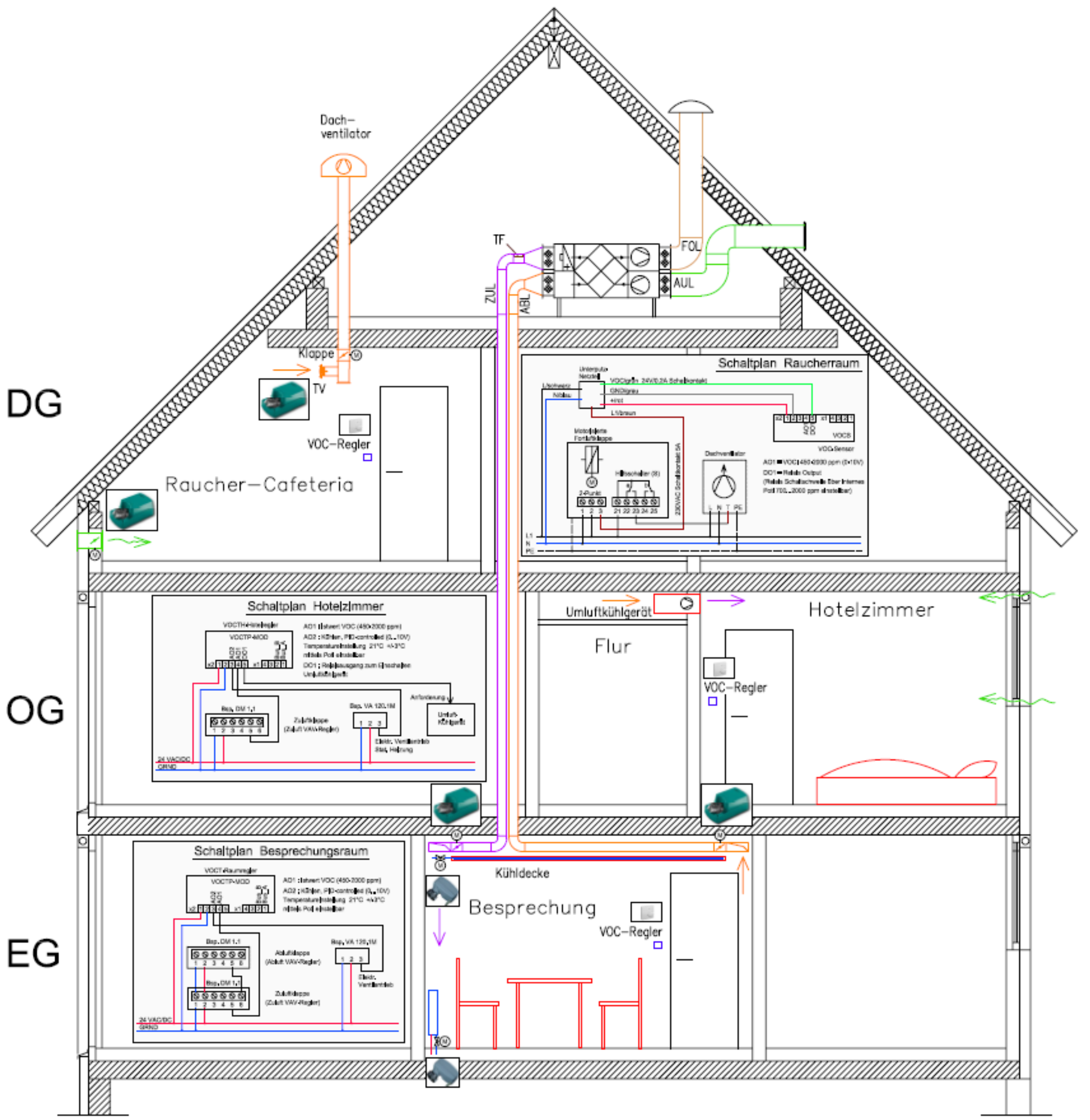
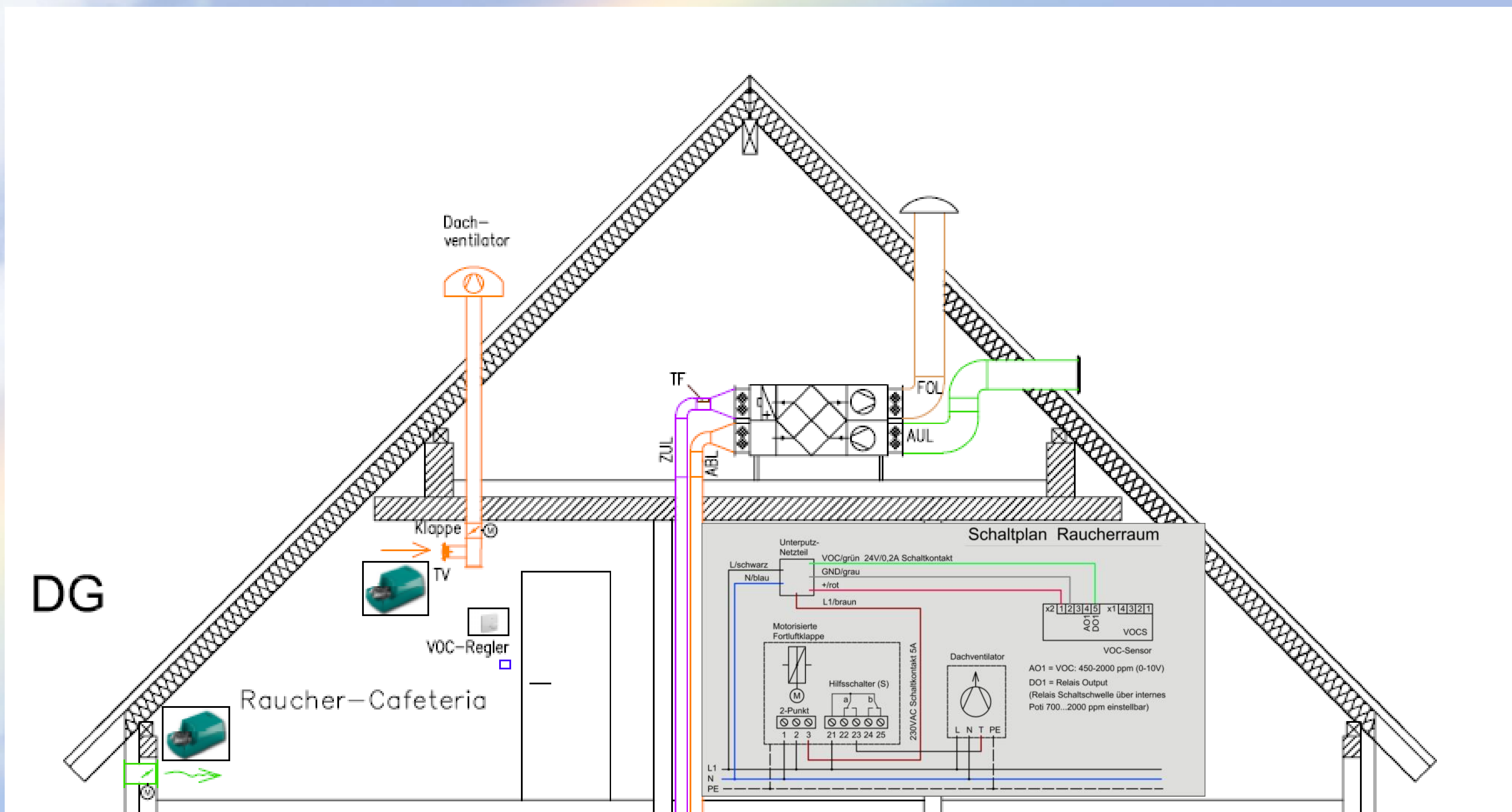
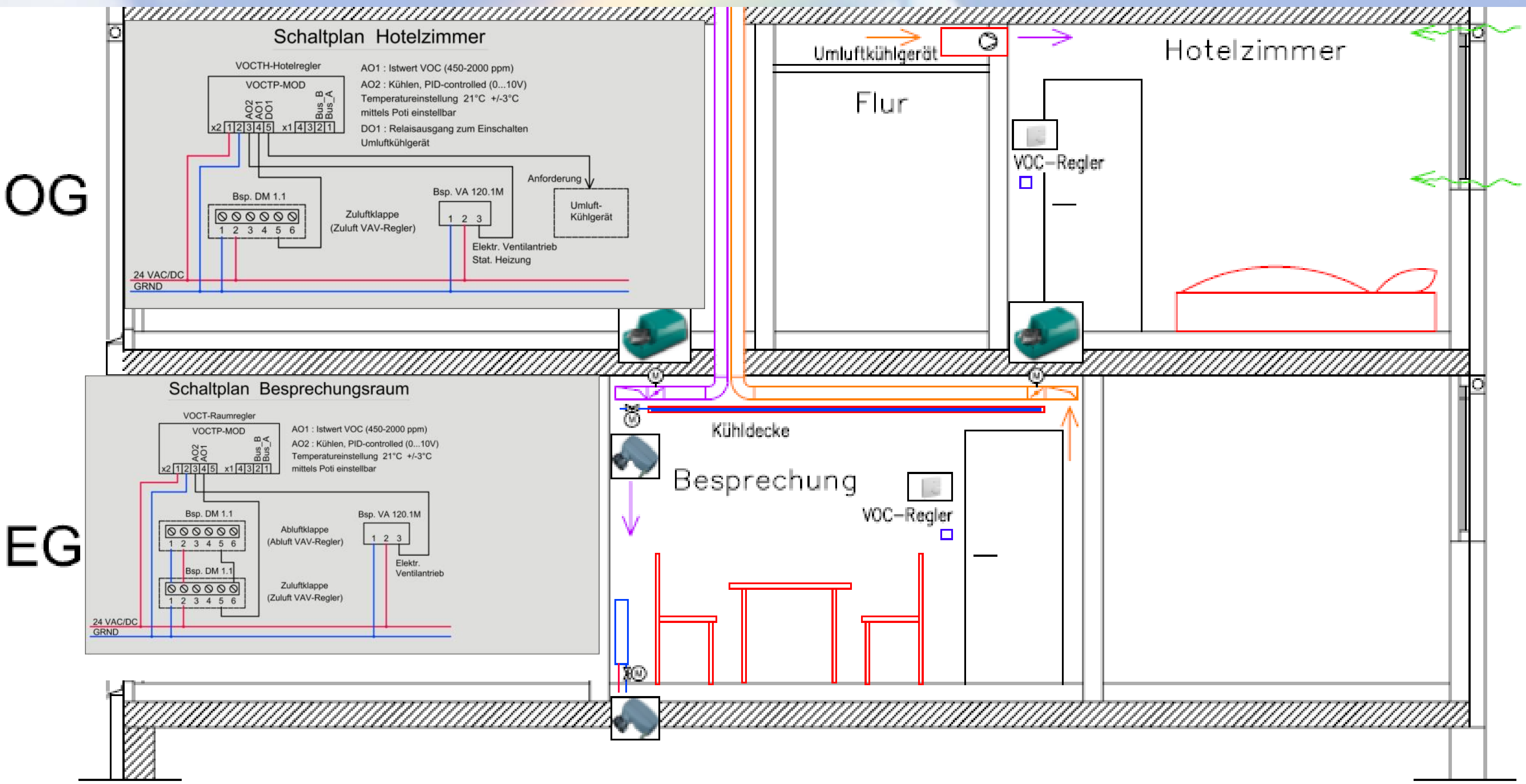


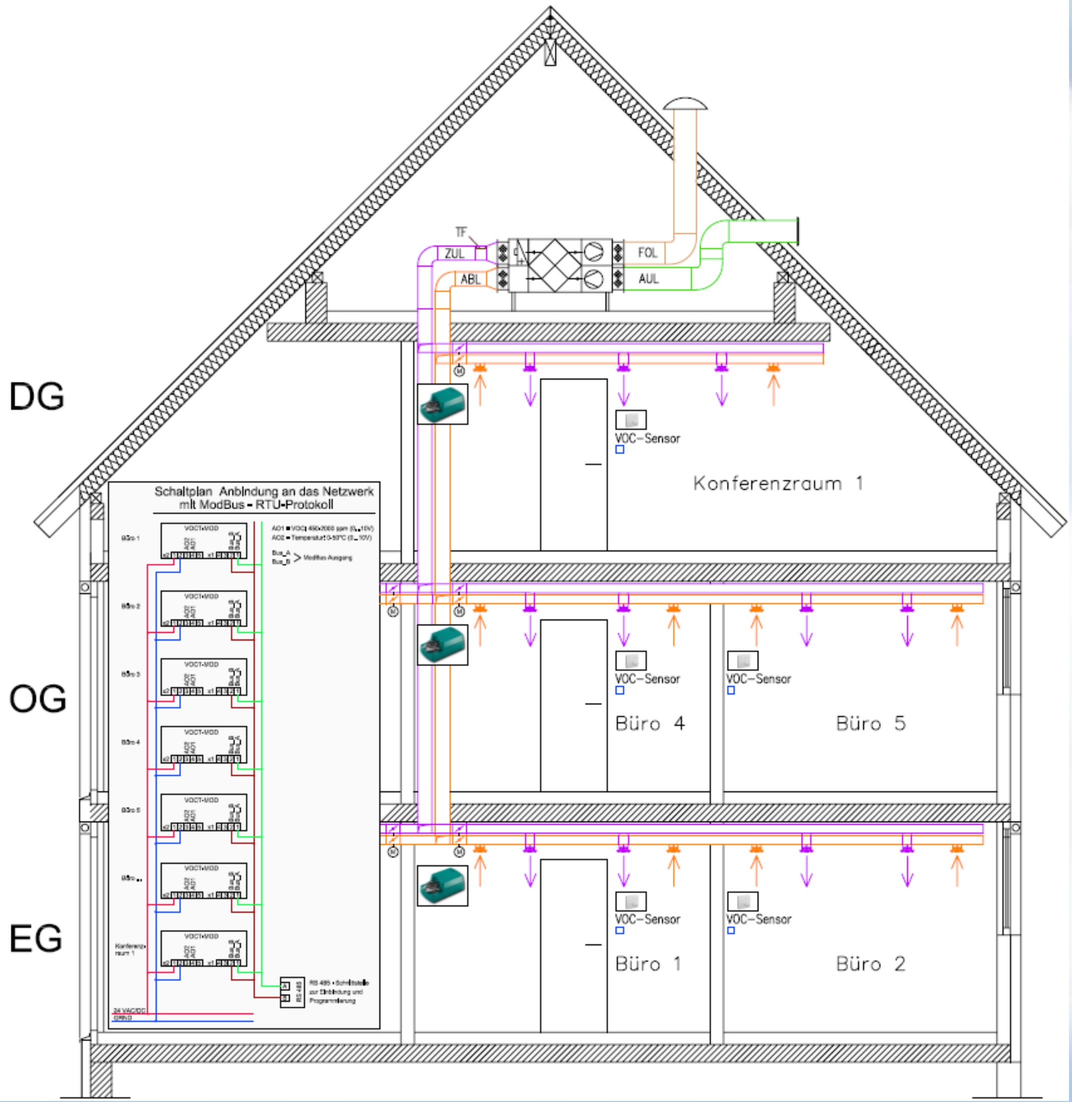
Smoking cafeterias

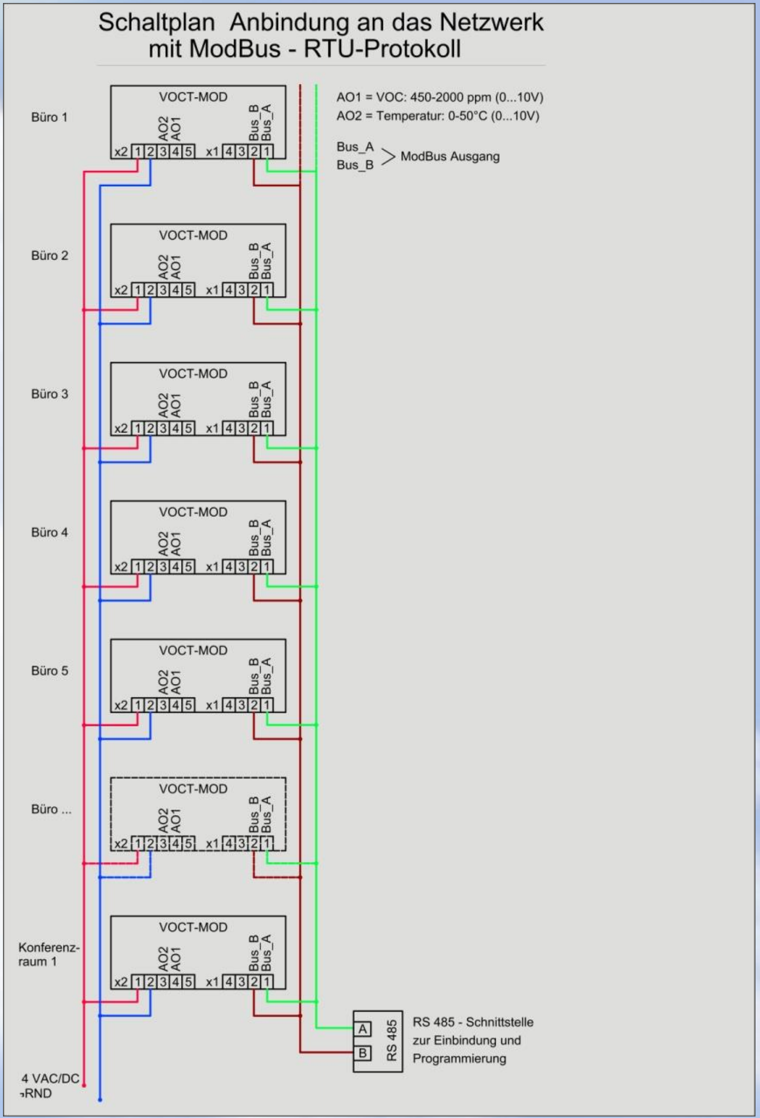


Hotel and meeting rooms



Saving energy at all times of the day detect mixed gases and use resources as needed





Technical specifications

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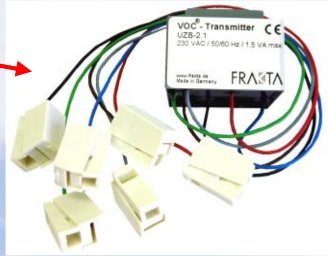
Eigenschaften
Messbereich: 450 - 2000 ppm VOC
Interne automatische Selbstdiagnose mit Autokalibration
Kalibrationsintervall > 5 Jahre
Analogausgang (OUT 1) 0 - 10 V (450 - 2 000 ppm VOC)
Analogausgang (OUT 2) 0 - 10 V (0 - 50°C)
Digitale Schnittstelle RS 485 (ModBus),
Zwei digitale Ausgänge
Temperaturregelung mit Potentiometer
Status LED

Typen	Versorgung	Messbereich	Ausgangssignal
VOCT-MOD Sensor	24V AC/DC	450-2000 ppm 0-50 °C	0-10 V / ModBus 0-10 V / ModBus
VOCTP-MOD Regler	24V AC/DC	450-2000 ppm 0-50 °C	0-10 V / ModBus 0-10 V / ModBus
KVOCT-MOD Kanalsensor	24V AC/DC	450-2000 ppm 0-50 °C	0-10 V / ModBus 0-10 V / ModBus
UZB-2.1 UP- Netzteil	230V AC		Relaiskontakt für Lüfter oder Antrieb
VOCS Sensor	24V AC/DC	450-2000 ppm	Relaiskontakt



The sensors are also available on request with BacNet interface

USB Stick for monitoring indoor air quality at home

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Thank you for your attention!