



BOSCH

Invented for life



NORDIC[®]
SEMICONDUCTOR



Bosch Sensortec's BME680

4-in-1 integrated environmental sensor

Nordic Partner Webinar

with Bosch Sensortec

December 2019

Duration: 50-60 min

Today's hosts

Petter Myhre



Product Marketing
Engineer



Dr. Richard Fix

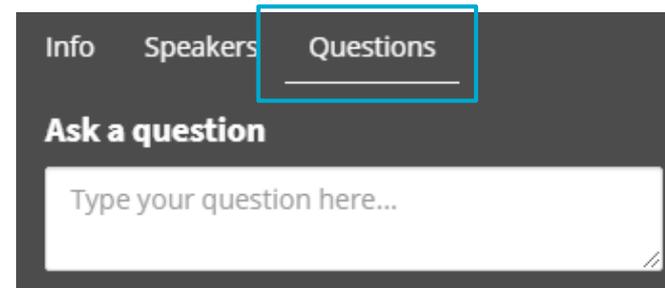


Senior product manager

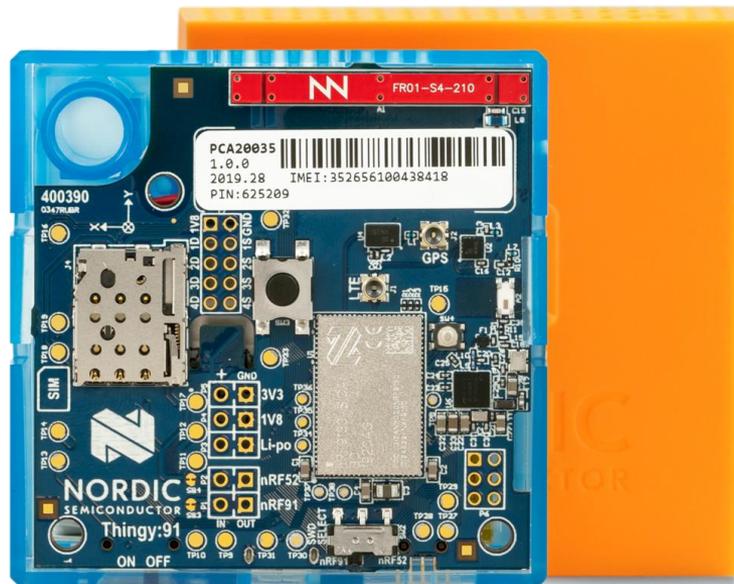


Practicalities

- Duration: 50-60 mins
- Questions are encouraged!
- Please type your question in the Questions tab on the right sidebar
- All questions are anonymous
- We will answer questions towards the end
- If you have more questions:
 - Go to DevZone for Nordic related questions
 - Go to Bosch Sensortec Community for BME680 related questions
- A recording of the webinar will be available together with the presentation at webinars.nordicsemi.com

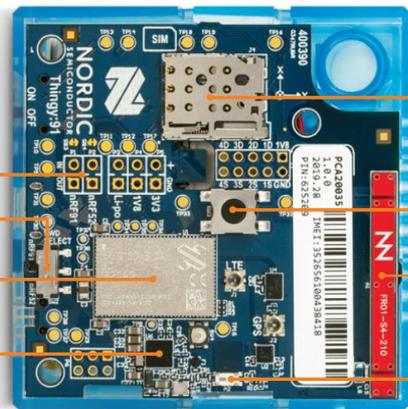


What is Nordic Thingy:91?

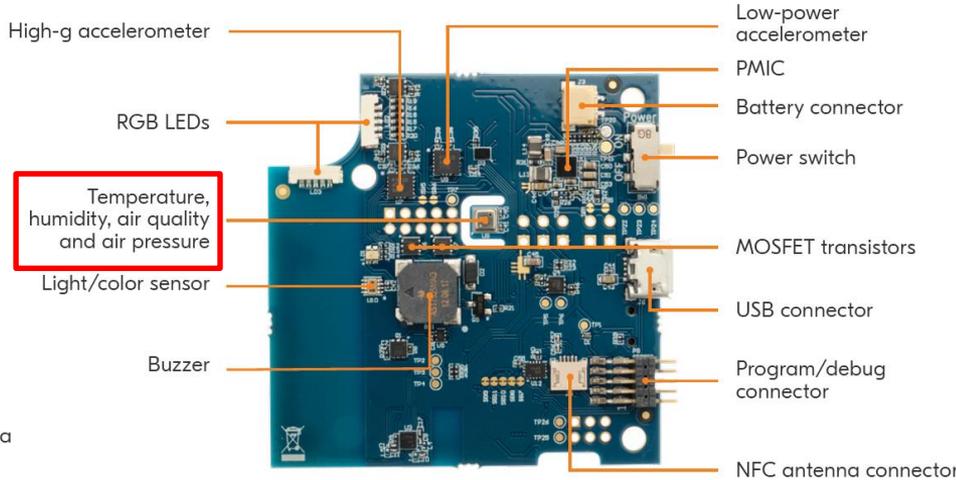


- Cellular IoT prototyping platform for the nRF9160 SiP, perfect for asset tracking PoCs
- Supports LTE-M, NB-IoT, GPS
- Supports Bluetooth LE and NFC
- User-programmable button and RGB LEDs
- Environmental sensor for temperature, humidity, air quality and air pressure, plus a color and light sensor
- High-g and low-power accelerometers
- Rechargeable Li-Po battery with 1440 mAh capacity
- Bundled with a eSIM card from iBasis preloaded with 10 MB

Bosch BME680



- Current measurement
- Program/debug device selection switch
- nRF9160 SiP
- nRF52840 WLCSP
- Nano/4FF SIM card slot
- Button
- LTE-M/NB-IoT/GPS antenna
- 2.4 GHz antenna



- High-g accelerometer
- RGB LEDs
- Temperature, humidity, air quality and air pressure
- Light/color sensor
- Buzzer
- Low-power accelerometer
- PMIC
- Battery connector
- Power switch
- MOSFET transistors
- USB connector
- Program/debug connector
- NFC antenna connector

Agenda

1. **Bosch Sensortec** – Who we are
2. **Environmental sensing** – Air quality
3. **Indoor** – Smart building applications
4. **Outdoor** – Smart city applications
5. **Summary**

The Bosch Group: four business sectors

Technology to enhance quality of life

	<p>€ 78.5 billion euros in sales</p>	 <p>409,881 associates</p>
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Mobility Solutions

 - ▶ One of the world’s leading providers of mobility solutions

- 

Industrial Technology

 - ▶ Leading in drive and control technology, packaging, and process technology

- 

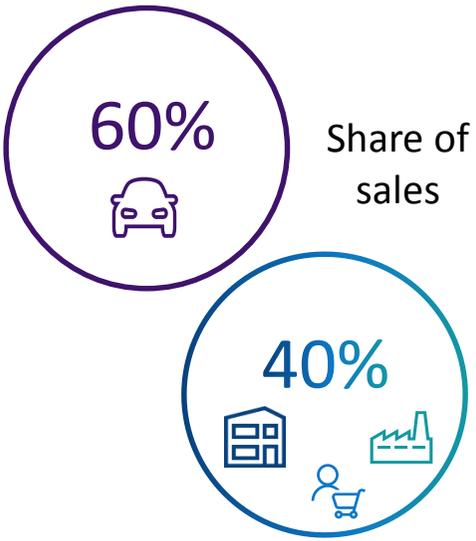
Energy and Building Technology

 - ▶ One of the leading manufacturers of security and communication technology
 - ▶ Leading manufacturer of energy-efficient heating products and hot-water solutions

- 

Consumer Goods

 - ▶ Leading supplier of power tools and accessories
 - ▶ Leading supplier of household appliances

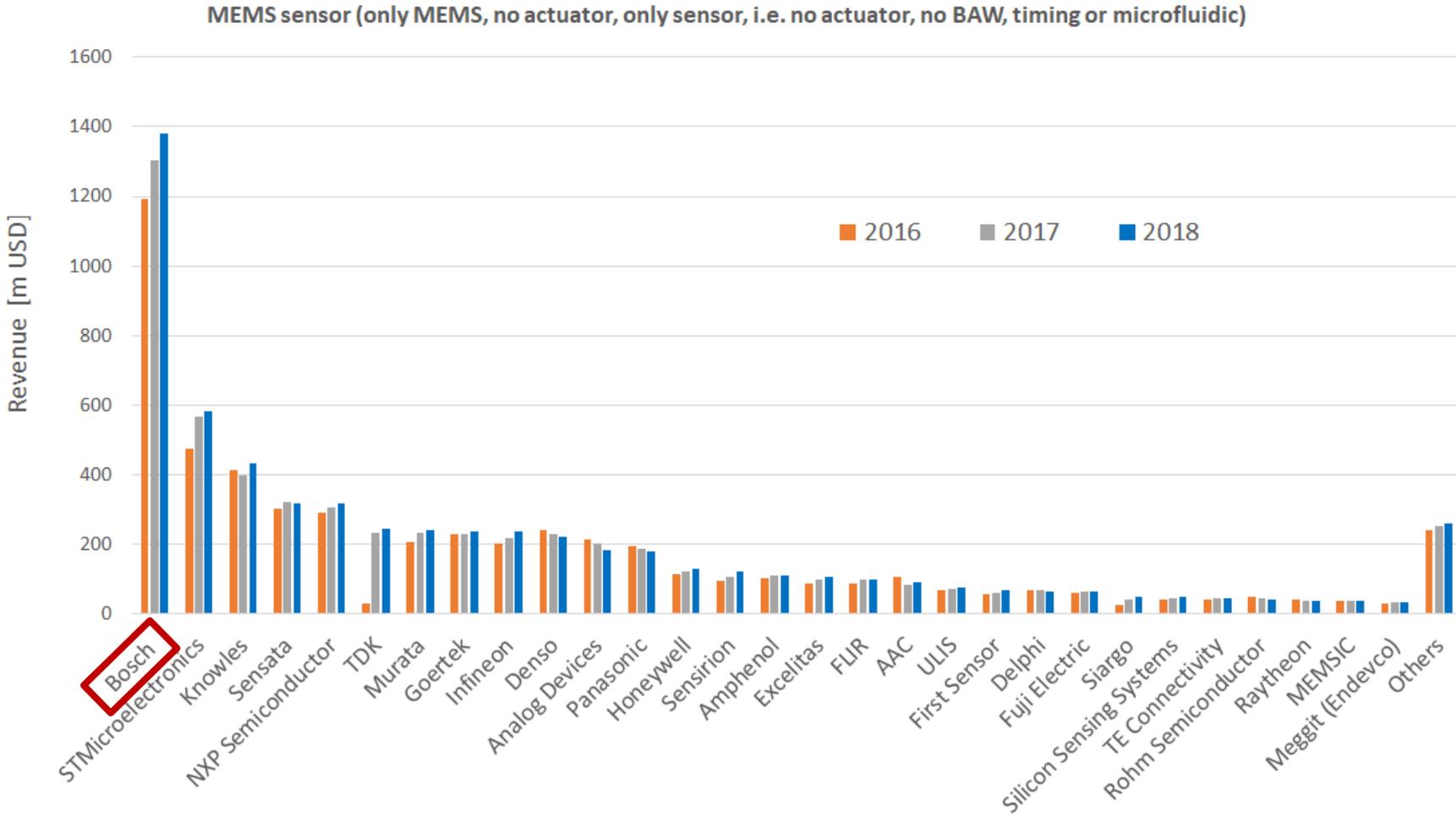


* As of 12.18

* Figures adjusted for extraordinary effects resulting from changes in the consolidated group and methodological changes and depreciation and amortization resulting from purchase price allocation.

IHS Markit data

Bosch is market leader in MEMS sensors



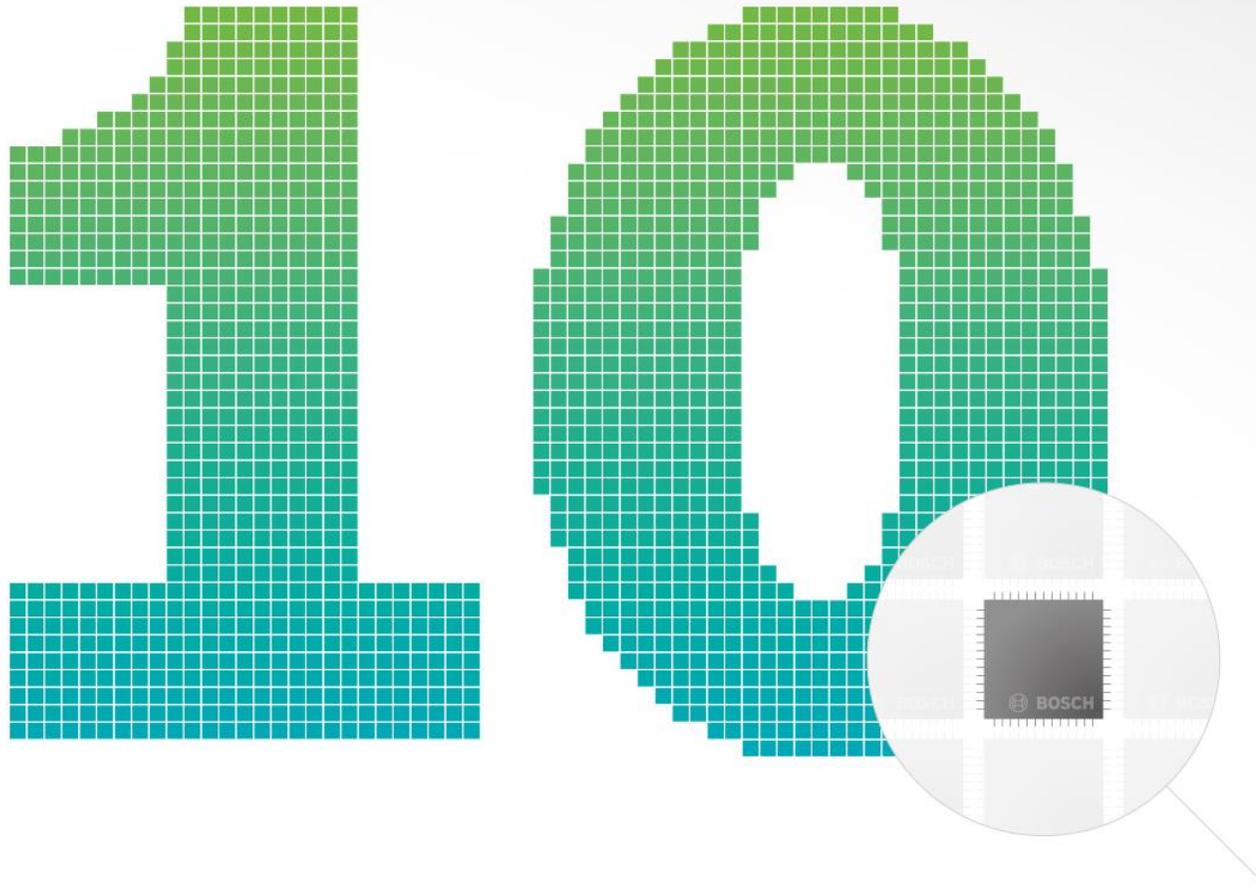
Source: IHS Markit, MEMS & Sensors Competitive Analysis Database 2019





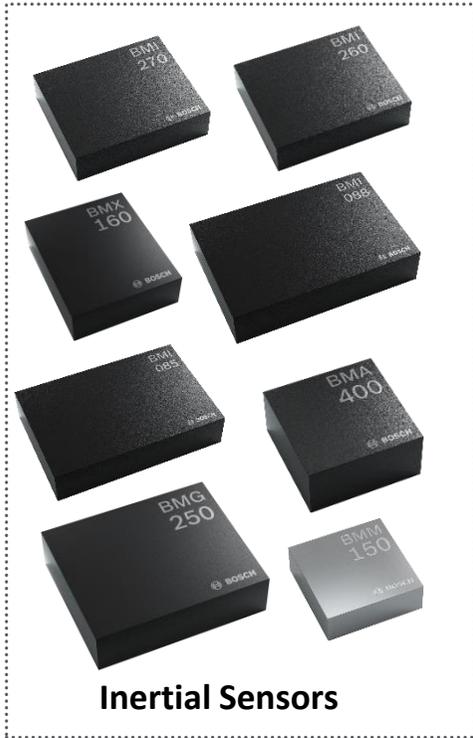
BOSCH

Invented for life



Ten billion
superheroes
in chip format

Today's state-of-the-art portfolio



Inertial Sensors



Environmental Sensors



Smart Sensors



Optical Microsystems

The next dimension for mobile and IoT devices

Add sense!

see



Camera

hear



Microphone

feel



Touchscreen
& inertial sensors

smell



Environmental
sensor

Agenda

1. **Bosch Sensortec** – Who we are
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Environmental sensing

Air quality matters for people all over the world

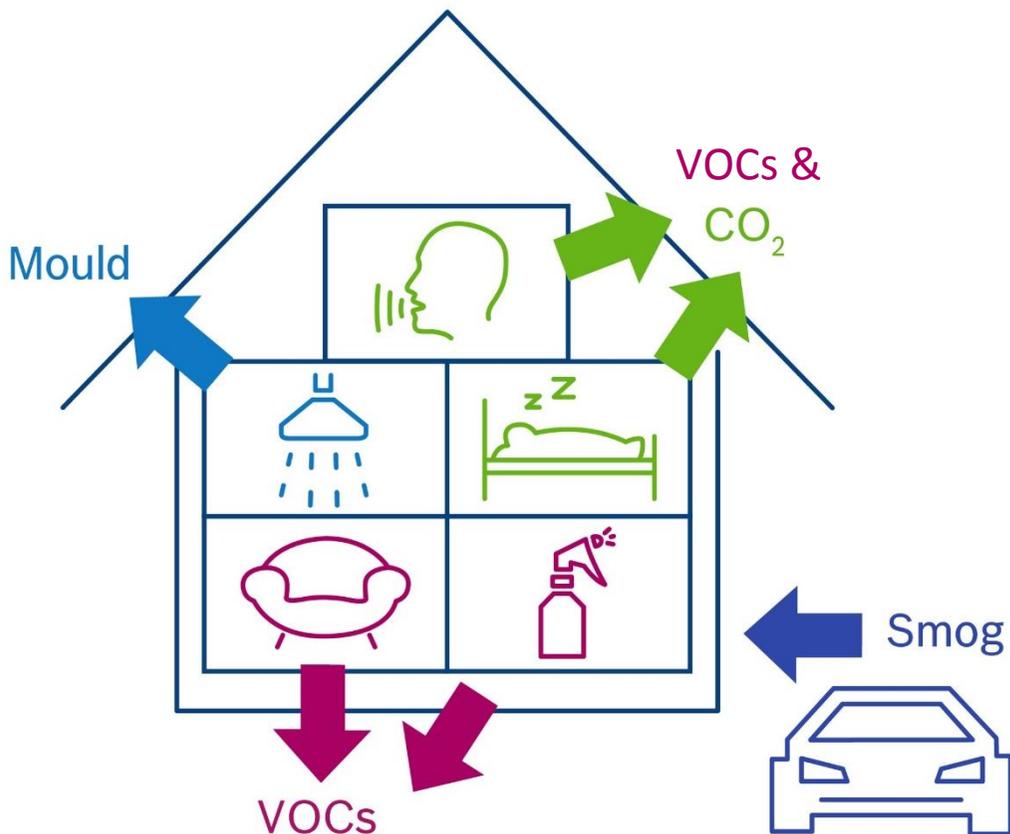


- ▶ Bad air quality is a major health risk for people all over the world
- ▶ Official measurement stations record air quality only in their immediate proximity
- ▶ Official stations measure only the outdoor concentration
- ▶ Official data are averaged over time – instantaneous information is missing
- ▶ Indoor concentration is largely unknown

World Health Organization expects pollution problems to increase world wide until 2040

Environmental sensing

Air quality also matters indoors



Humans:

- ▶ Breathe in more than 10.000 l/day
- ▶ Spend 1/3 of their life in sleeping rooms
- ▶ Stay 90 % of their life in buildings

Indoor air quality:

- ▶ Strongly impacts health and well-being
- ▶ Influences personal productivity
- ▶ Major source of bad air quality are Volatile Organic Compounds (VOCs) and particulate matter

Environmental sensing

What are Volatile Organic Compounds?

1,1,1-Trichloroethane, 2,2,4-Trimethylpentane, 4-Methylheptane, Cyclopentane, n-Butylbenzene, 1,1,2,2-Tetrachloroethane, 2,2,5-Trimethylhexane, 4-Methyloctane, Cyclopentene, Nonane, 1,1,2-Trichloroethane, 2,2-Dimethylbutane, Acetylene, Decane, n-Propylbenzene, 1,1-Dichloroethane, 2,2-Dimethylhexane, Benzene, Dibromochloromethane, Octane, 1,1-Dichloroethylene, 2,2-Dimethylpentane, Benzylchloride, Bromoform, o-Xylene, 1,2,3-Trimethylbenzene, 2,2-Dimethylpropane, Bromochloromethane, Dichloroethane, p-Cymene, 1,2,4-Trichlorobenzene, 2,2,4-Trimethylpentane, Bromodichloromethane, Nonane, Pentane, 1,2,4-Trimethylpentane, 1,2,4-Trichlorobutane, Bromoform, EDB, Propane, 1,2-Dichlorobenzene, 2,3-Dimethylpentane, Dimethylmethane, Ethane, Propylene, 1,2-Dichloroethane, 2,4-Dimethylhexane, Bromotrichloromethane, Chlorobenzene,

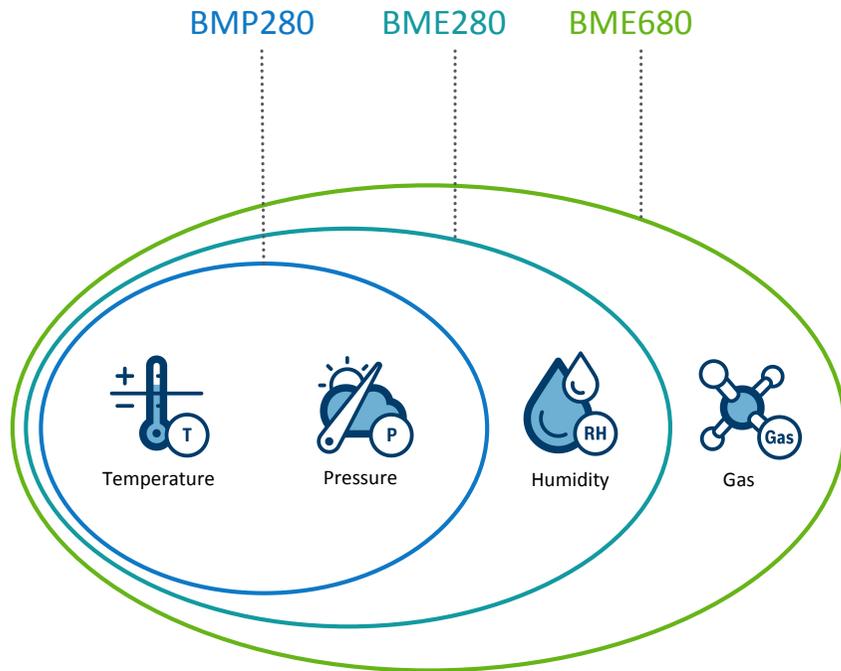
VOCs are any compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participate in atmospheric photochemical reactions.

Hexane, trans-2-Heptene, 1-Butyne, 2-Methylhexane, cis-1,4-Dimethylcyclohexane, Hexylbenzene, trans-2-Hexene, 1-Decene, 2-Methylpentene, cis-2-Butene, trans-2-Octene, 1-Heptene, 3,6-Dimethyloctane, cis-2-Heptene, Isobutane, trans-2-Pentene, 1-Hexene, 3-Ethyltoluene, cis-2-Hexene, iso-Butylbenzene, trans-3-Heptene, 1-Methylcyclohexene, 3-Methyl-1-pentene, cis-2-Octene, Isopentane, cis-3-Methyl-2-pentene, 1-Methylcyclopentene, 3-Methylheptane, cis-2-Pentene, Isoprene, trans-4-Methyl-2-pentene, 1-Nonene, 3-Methylhexane, cis-3-Methyl-2-pentene, iso-Propylbenzene, Trichloroethylene, 1-Octene, 3-Methyloctane, cis-3-Methyl-2-pentene, p-Xylene, Undecane, 1-Pentene, 3-Methylpentene, cis-4-Methyl-2-pentene, Methylcyclohexane, Vinylchloride, 1-Propyne, 4-Ethyltoluene, Cyclohexane, Methylcyclopentane, Total VOCs, 2,2,5-Trimethylbutane, 4-Methyl-1-pentene,

BME680's gas sensor can detect nearly all VOCs as well as other gases in our air!

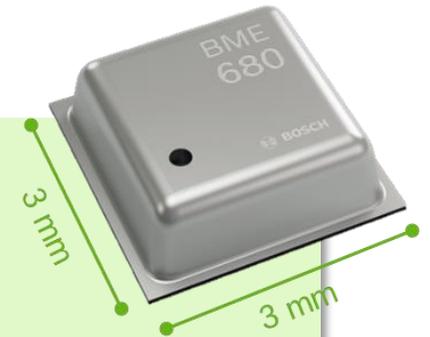
BME680: The 4-in-1 solution

Integrated Pressure, Temperature, Humidity and Air Quality



The BME680 measures

- ▶ **Temperature** – by the voltage change of a silicon diode
- ▶ **Pressure** – by the resistance change due to the elongation of a thin membrane
- ▶ **Humidity** – by the relative permittivity change of a polymer-based capacitor
- ▶ **Gas** – by the conductivity change of a metal oxide due chemisorption of gas species

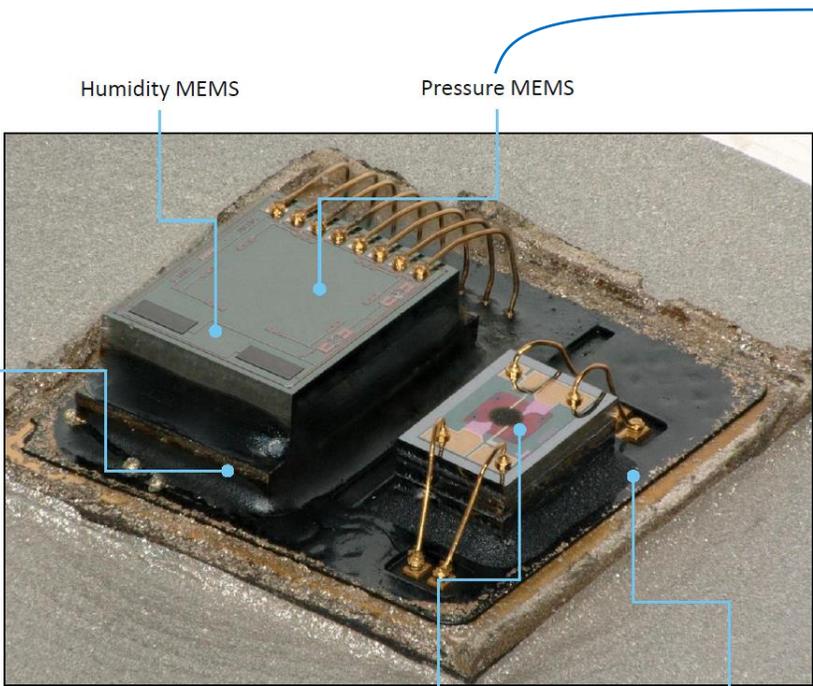
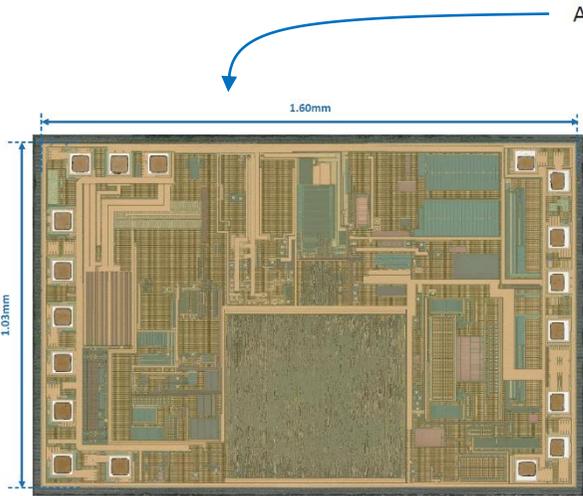


The BME680 includes all functionalities (incl. ASIC signal processing)

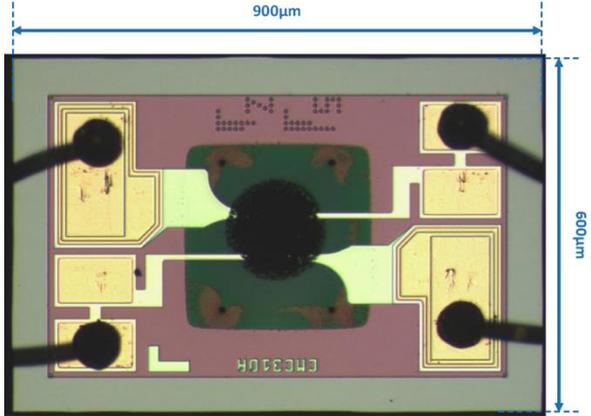
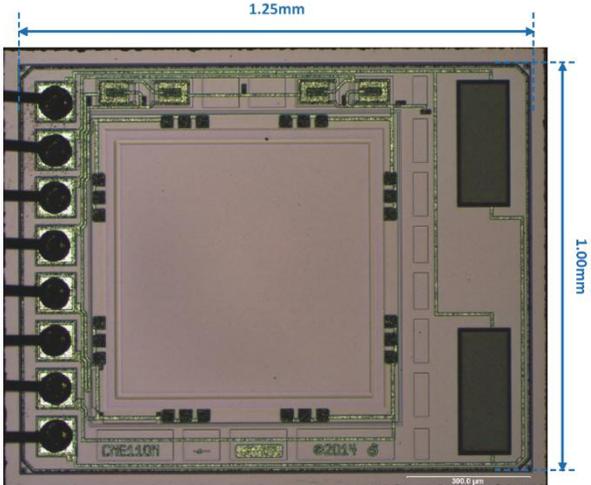
Environmental sensing: example BME680 gas sensor

System architecture

System-In-Package (SIP) with 3 x 3 mm² footprint for pressure, temperature, humidity and air quality measurement.



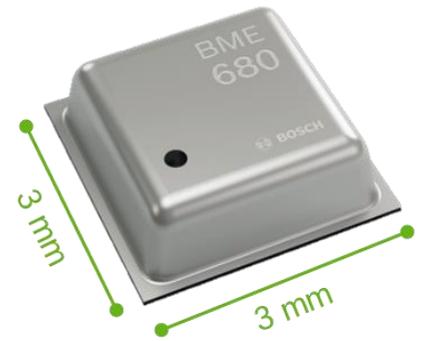
BME680 w/o lid*



* Source: Bosch BME680 Environmental Sensor, MEMS report by A. Lahrach, System Plus Consulting, July 2017

BME680

Integration guidelines



▶ Voltage & battery dimension

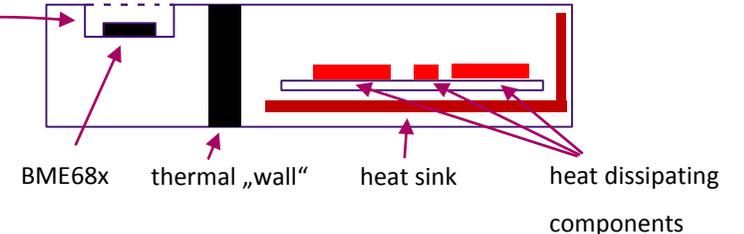
- ▶ Apply 1.8 V (best for both efficiency and low heat dissipation), but also higher voltages possible
- ▶ Average current is 0.1 mA in ULP (24/7 use), 1 mA for LP mode and 12 mA for DC / scan mode

▶ Positioning

- ▶ Thermally decoupled, separated from any other internal heat source (μ C, Wifi, SD card, battery, ... best not on same PCB)
- ▶ has to be well connected to ambient air temperature (to have good temperature/humidity measurement)

▶ Gas exchange

- ▶ Allow good air exchange with ambient air
- ▶ Separate BME68x from gas volume inside housing
- ▶ Use membrane for water protection if necessary (e.g. IP67 or better)



▶ Materials:

- ▶ Don't use outgassing VOC materials (e.g. 3D-printed plastics) or siloxanes (e.g. silicone sealings) → thermoplastic elastomers

▶ More details:

- ▶ Consider BME68x HSMI: https://ae-bst.resource.bosch.com/media/tech/media/application_notes/BST-BME680-HS000-05.pdf
- ▶ Consider SW requirements & supported μ C / platforms: <https://www.bosch-sensortec.com/>

Index for Air Quality (IAQ)

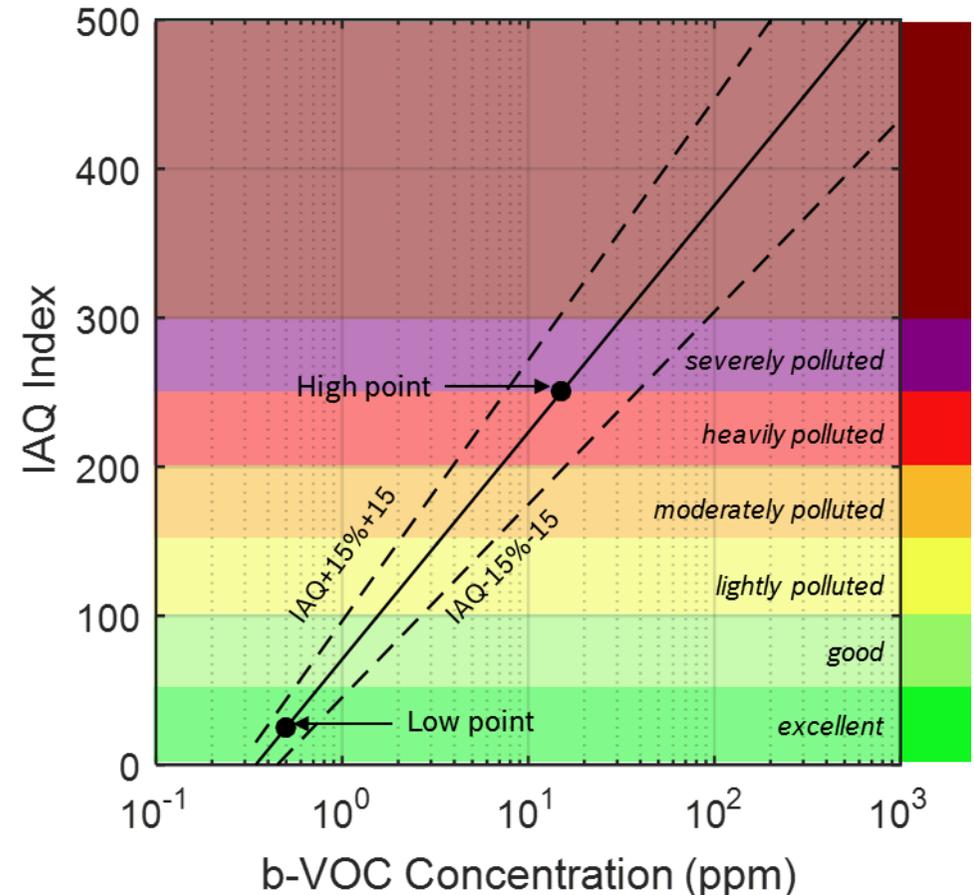
BME680 environmental sensing software

Key features

1. Precise calculation of barometric **pressure**, ambient air **temperature** and ambient **relative humidity** outside the device.
 - Compensated influence of gas sensor heater and heat sources within packaged system.
2. Precise calculation of the **Index for Air Quality (IAQ)** level:
 - Compensated influence of humidity and temperature on gas
 - Scaling based on recommendation of the UBA*
 - Sensor-to-sensor deviation is within $IAQ \pm 15\% \pm 15$



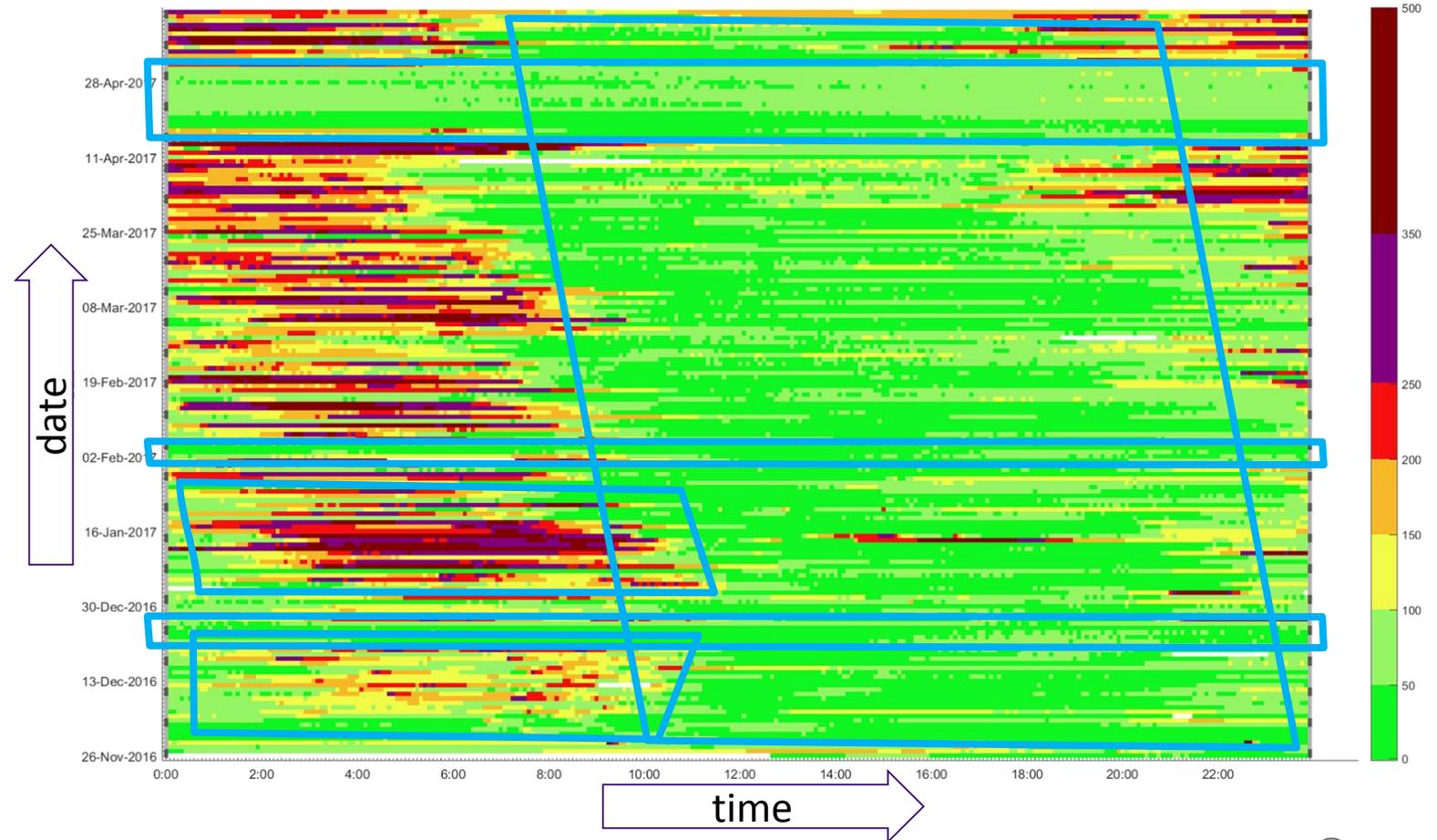
Sensor software platform
for supporting wide variety of applications



Environmental sensing: smart home with ventilation system

Air quality in a bedroom

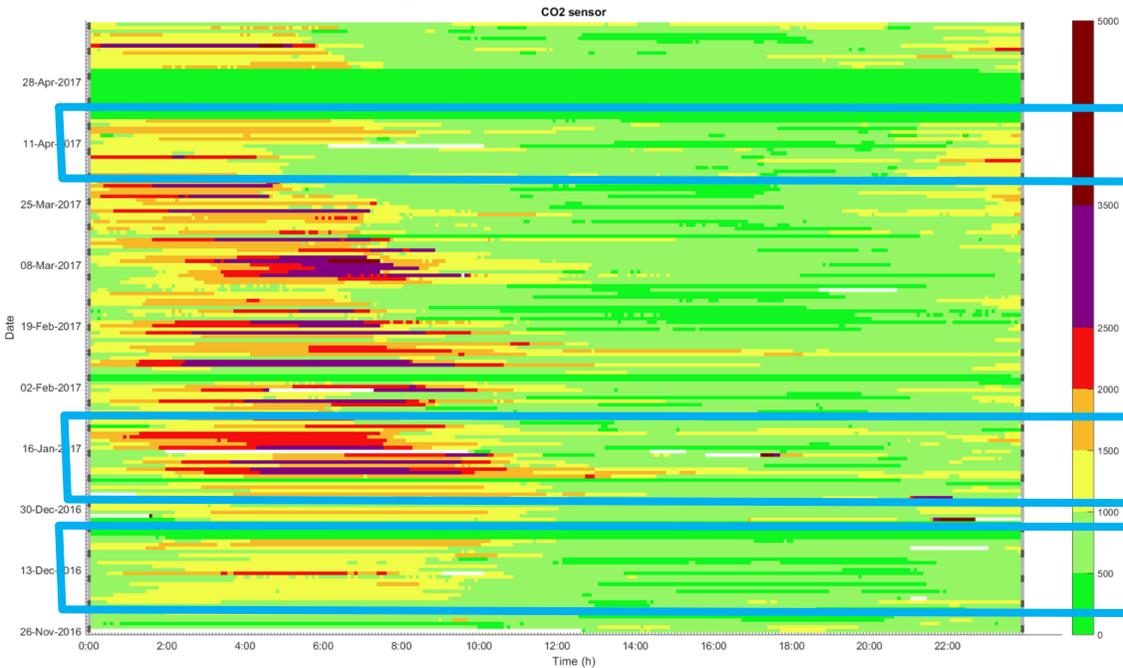
- ▶ The graph shows the air quality data over 6 months in a bedroom (with ventilation system).
- ▶ The measurement data correlates well with the user's perception, presence and the ventilation rate.



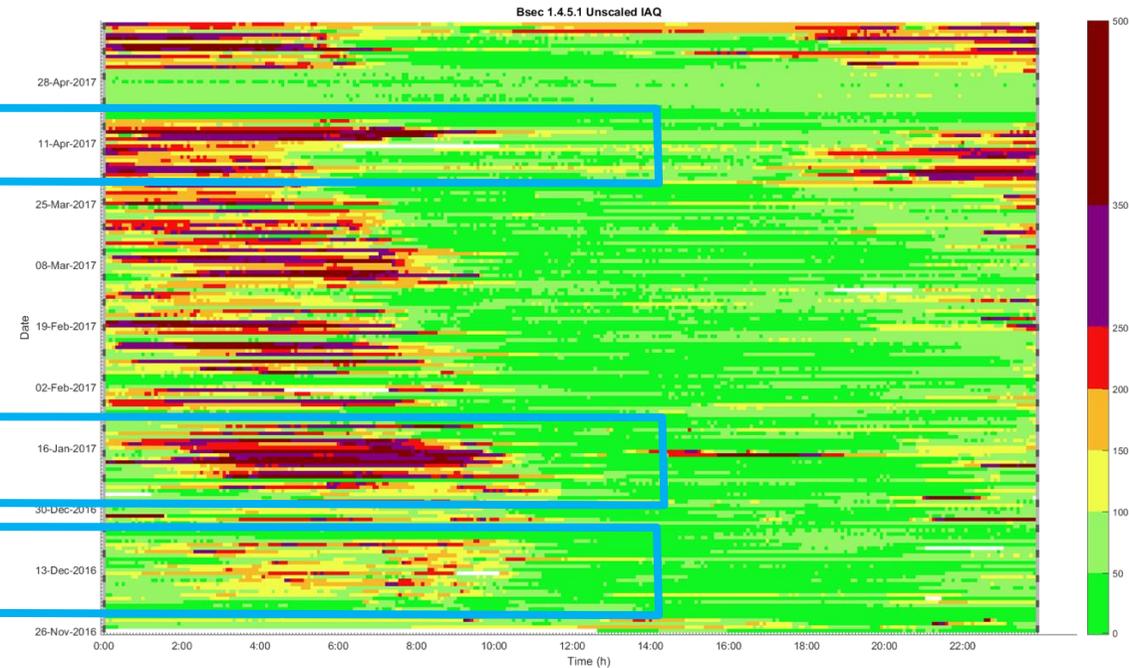
Environmental sensing: smart home with ventilation system

Bedroom: CO₂ Sensor vs. VOC sensor Indoor Air Quality (IAQ)

CO₂ sensor (optical)



VOC sensor (BME680)

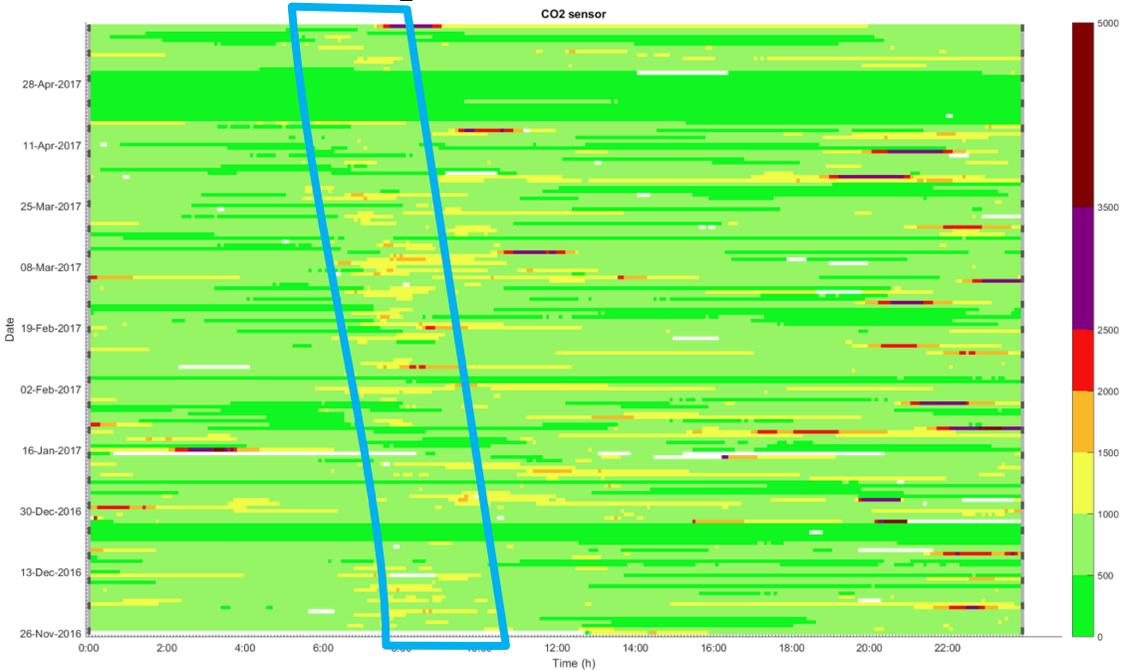


- ▶ Overall, well correlated data, since both CO₂ and VOCs are in the human's exhaled breath.
- ▶ The VOC sensor additionally detects other reasons for bad air, e.g. smells / human metabolism.

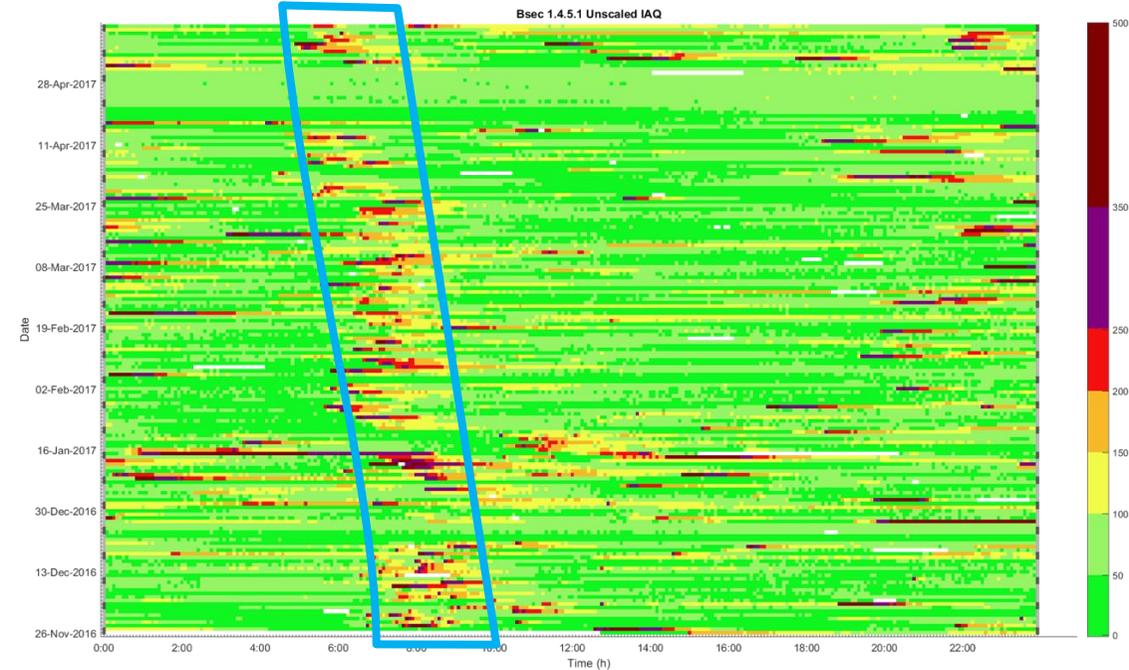
Environmental sensing: smart home with ventilation system

Bathroom: CO₂ Sensor vs. VOC sensor Indoor Air Quality (IAQ)

CO₂ sensor (optical)



VOC sensor (BME680)



- ▶ A CO₂ sensor can measure when people are present (esp. for a longer time, e.g. taking a bath), but does not detect smells and short events. A VOC sensor **detects everything**.

Agenda

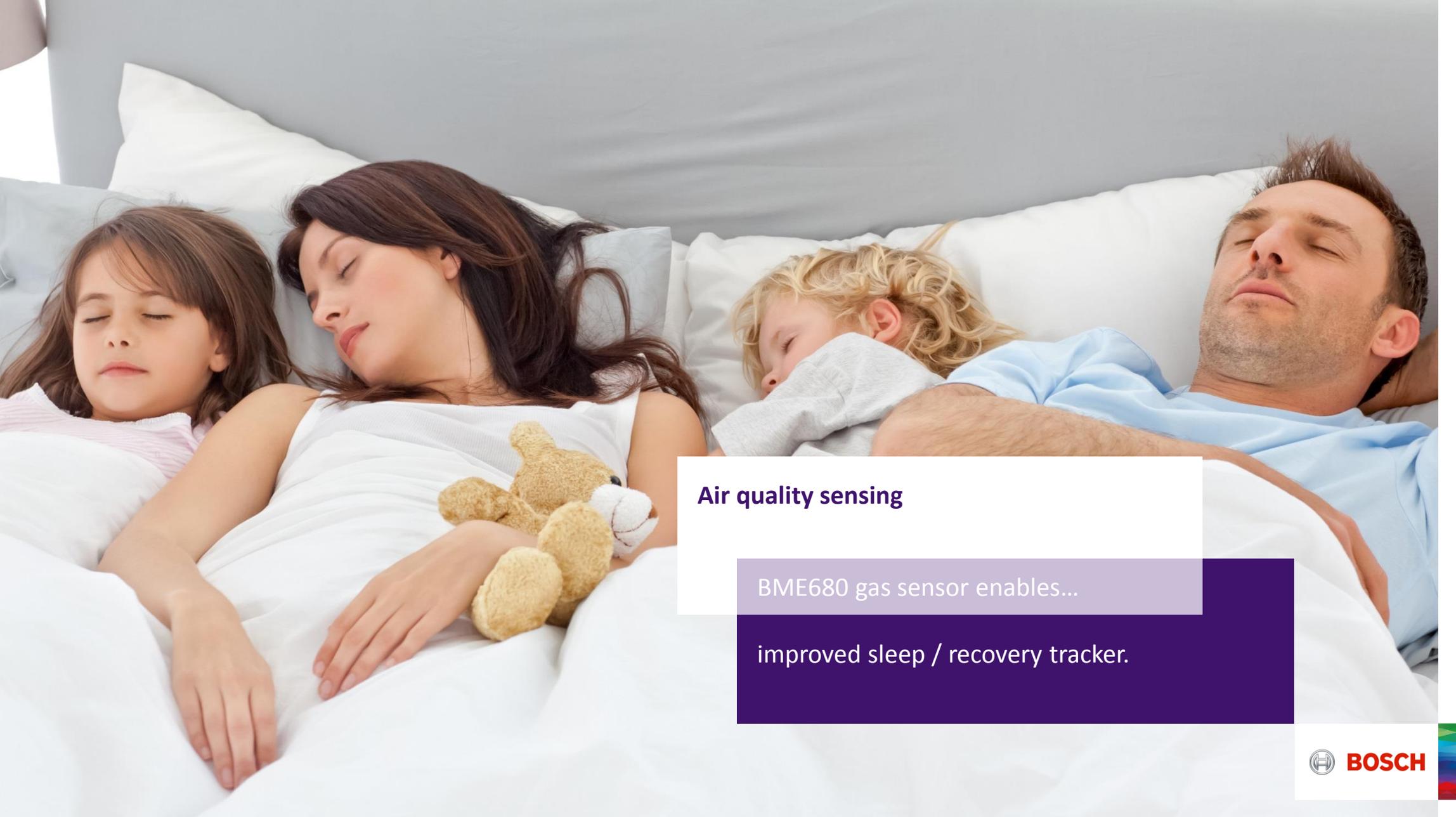
1. **Bosch Sensortec** – Who we are
2. **Environmental sensing** – Air quality
3. **Indoor** – Smart building applications
4. **Outdoor** – Sports & smart city applications
5. **Summary**

Air quality sensing

BME680 gas sensor enables...

indoor air quality.





Air quality sensing

BME680 gas sensor enables...

improved sleep / recovery tracker.



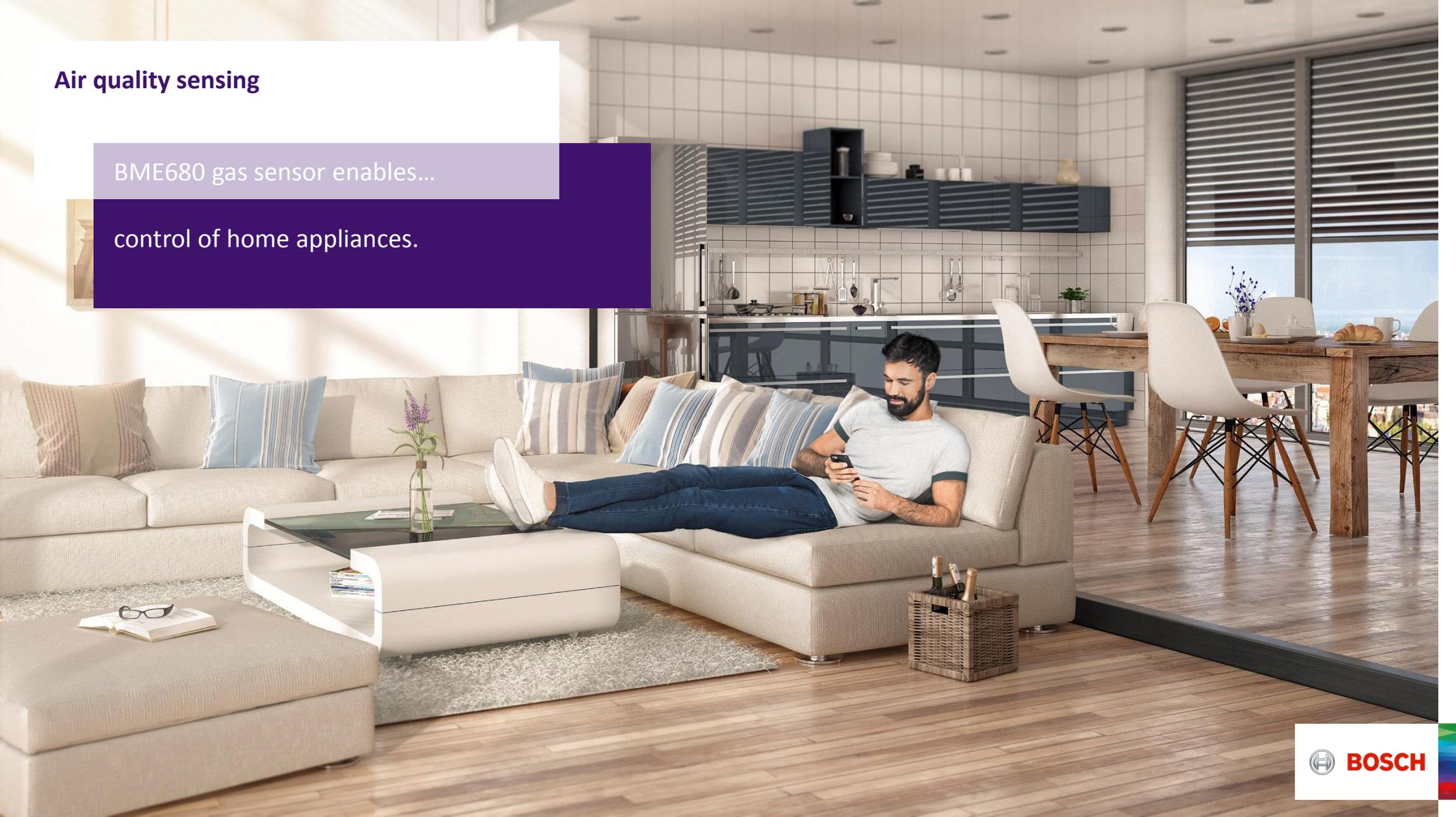
Gas measurement in wearables

BME680 gas sensor enables...

baby monitoring.

Air quality sensing

BME680 gas sensor enables...
control of home appliances.



Indoor – smart building solutions

The center of smart homes: smart speakers

By connecting a BME680,

- ▶ Temperature
- ▶ Humidity
- ▶ Air quality measurement

becomes available in the smart home system to inform and automatically react (e.g. by routines).



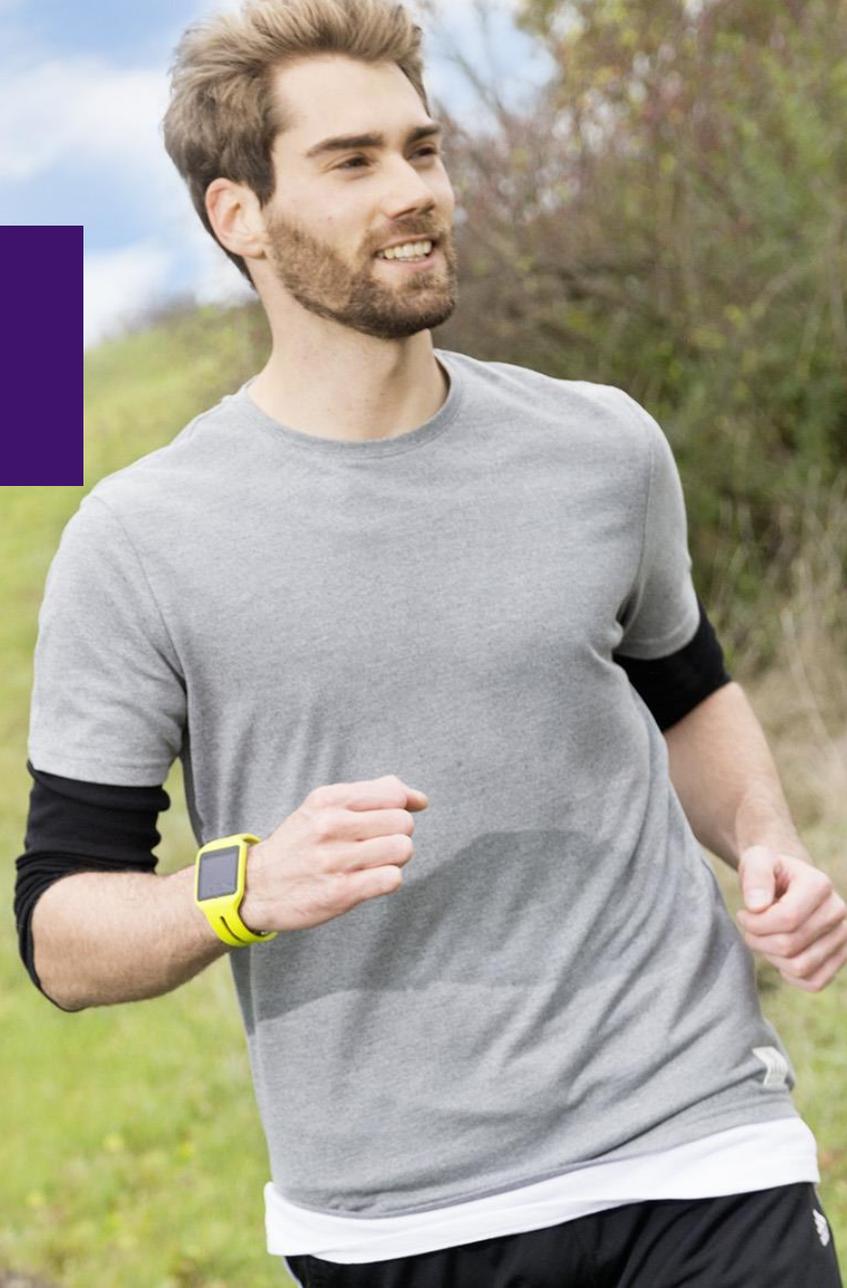
Agenda

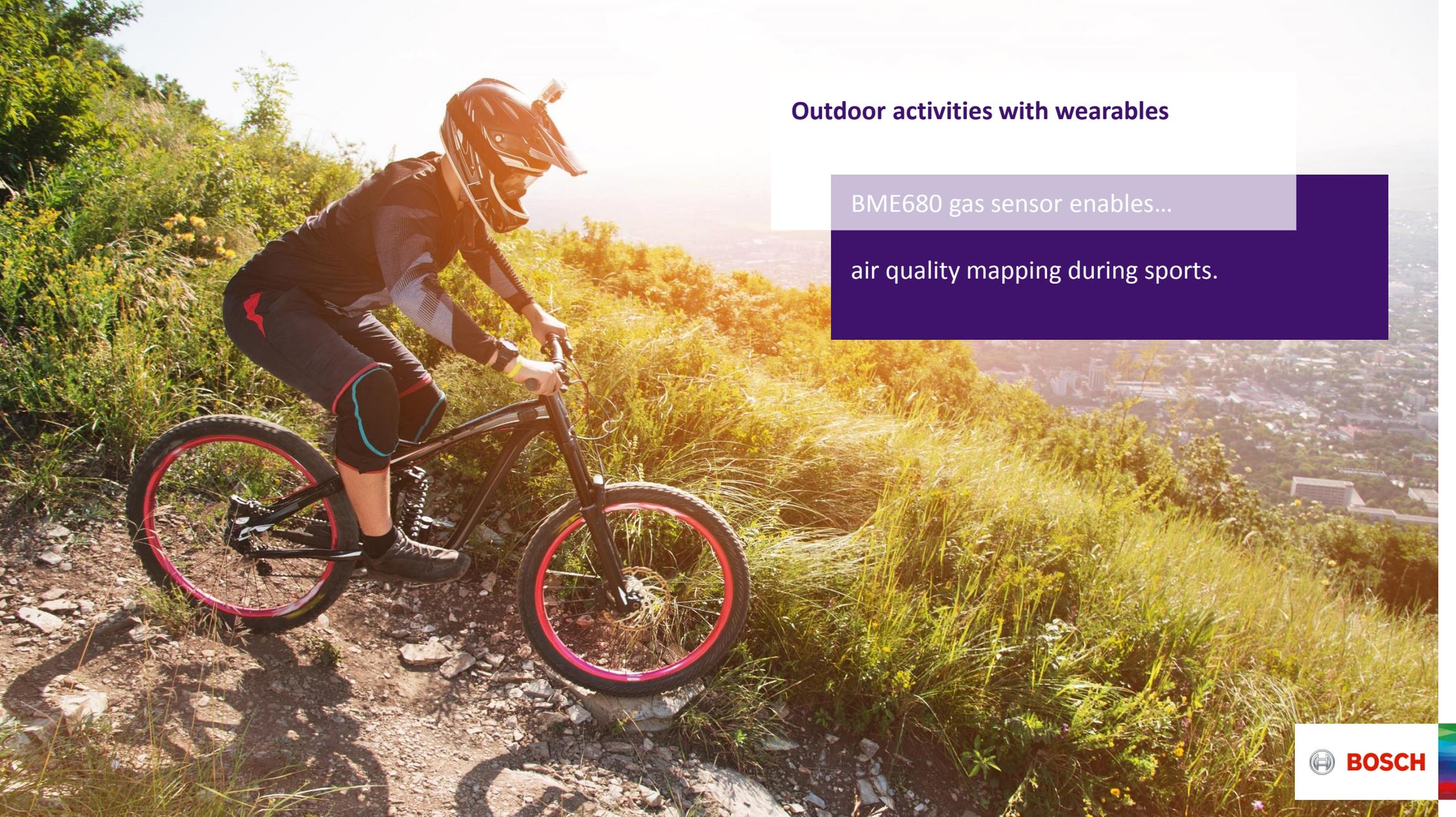
1. **Bosch Sensortec** – Who we are
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Altitude tracking in wearables

BMP/BME pressure sensors enable

precise step counter, distance and calories tracker.



A person wearing a black helmet with a camera mounted on top, a black long-sleeved shirt, and black shorts with red and blue accents is riding a black mountain bike with red-rimmed wheels on a dirt trail. The trail is on a grassy hillside overlooking a city. The scene is brightly lit, suggesting a sunny day.

Outdoor activities with wearables

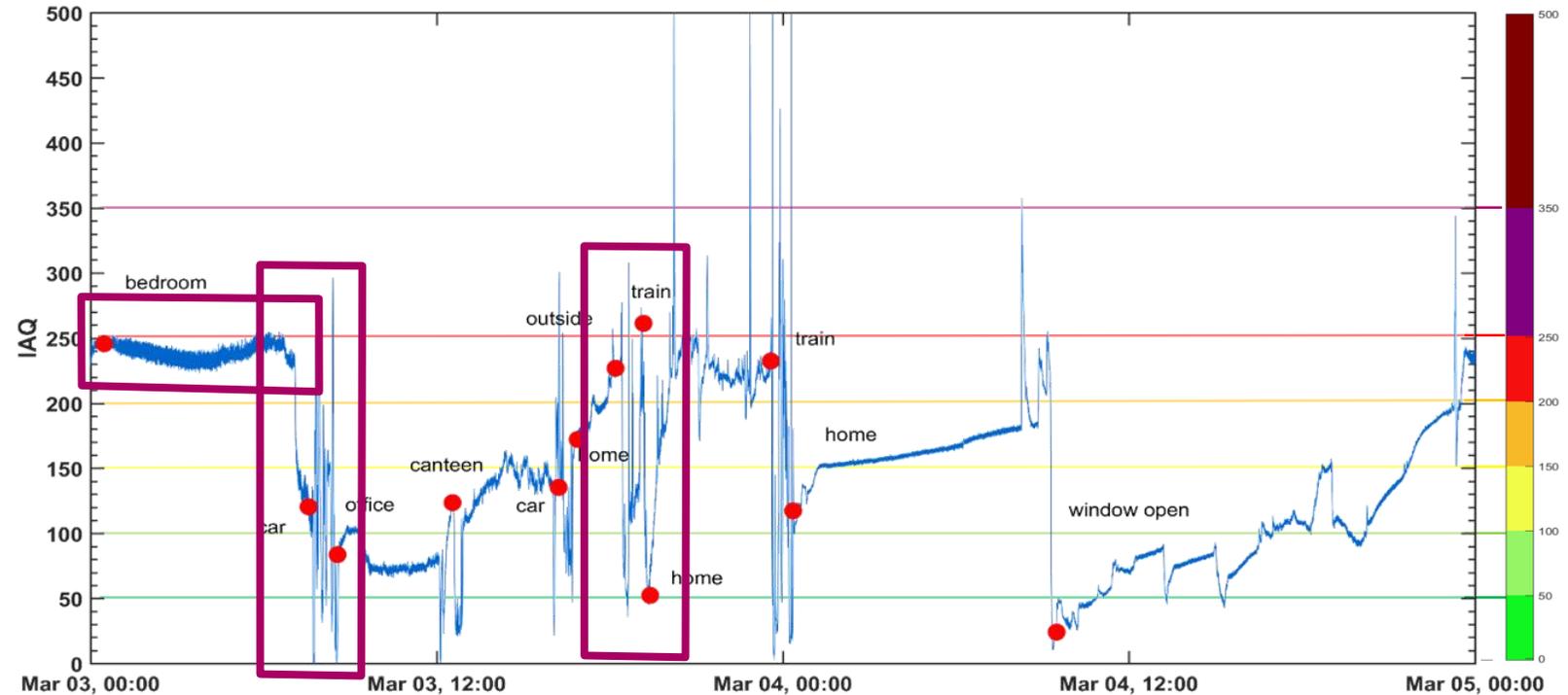
BME680 gas sensor enables...

air quality mapping during sports.

Outdoor & smart city applications

Air quality by mobile devices

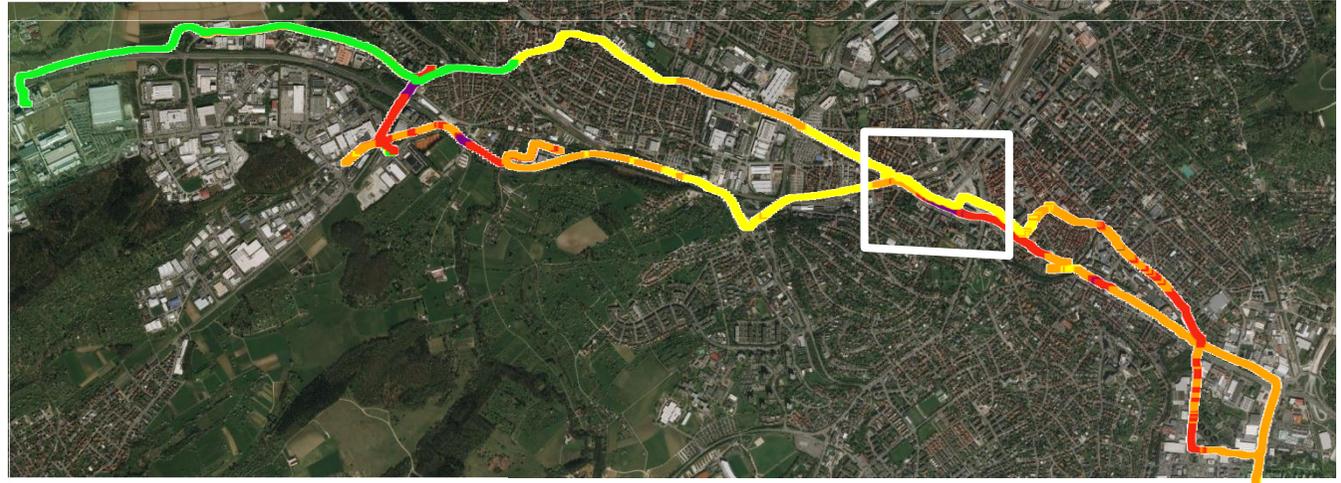
- ▶ The plot shows the personal air quality for two days, measured by a mobile device.
- ▶ Air quality is always a **highly localized** and time-dependent value, since it can quickly **change by orders of magnitude**.



Outdoor & smart city applications

Air quality information for everyone

Individual devices can give personal information for the current location.



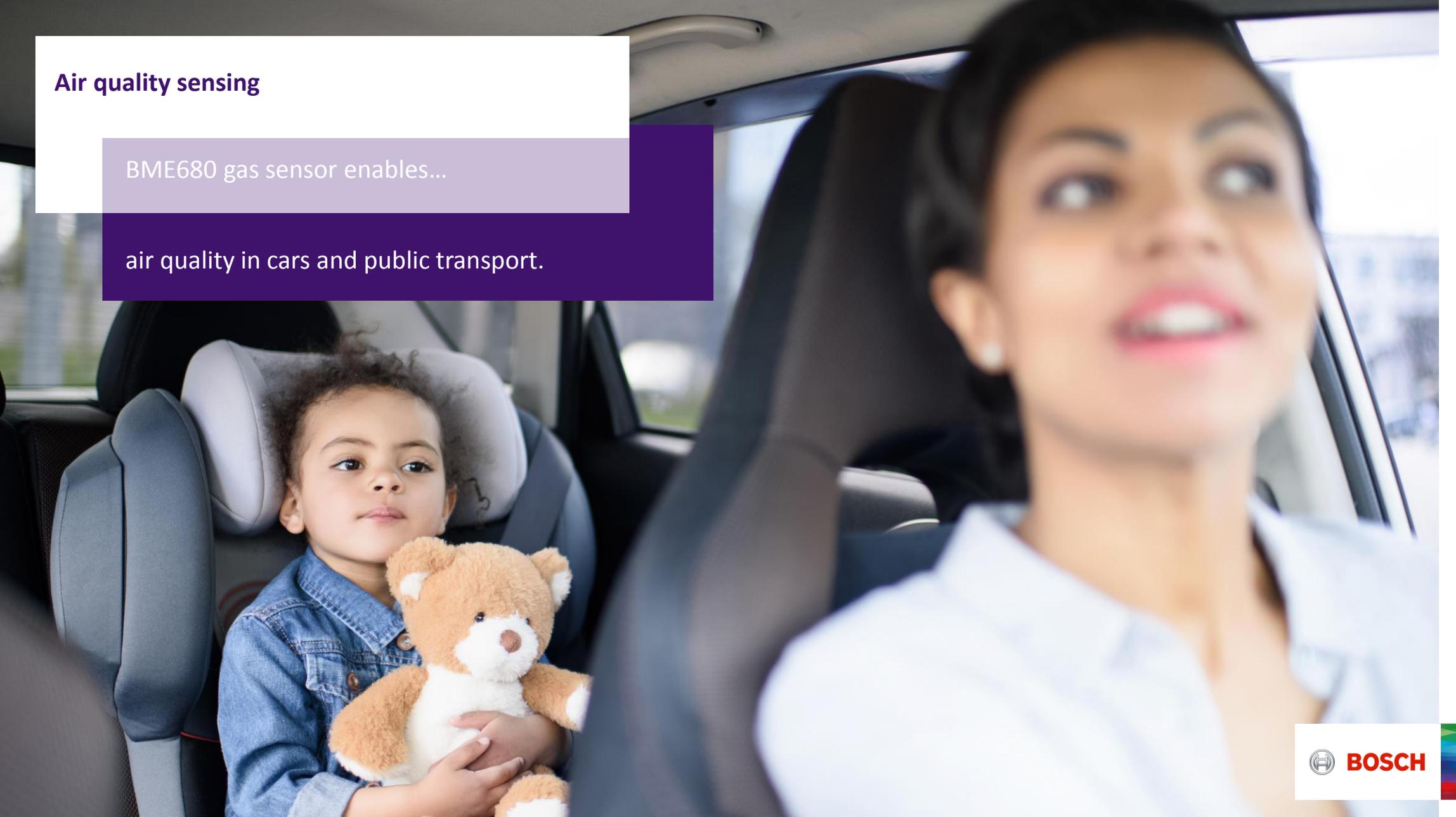
Sensor networks can give information 24/7 for a whole area

- ▶ Enables forecasts
- ▶ Everybody can benefit every time!

Air quality sensing

BME680 gas sensor enables...

air quality in cars and public transport.



Air quality sensing

BME680 gas sensor enables...

Air quality information in cities.

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Conclusion

With MEMS sensing solutions
from **Bosch Sensortec**:

- ▶ all important **environmental parameters** for climate and well-being can be measured by one tiny system-in-package.
- ▶ **Air quality** can be measured 24/7 in buildings and mobile devices.
- ▶ **Connected outdoor devices** enable new applications for individuals as well as smart cities.



Bosch Sensortec Community



If you have further questions regarding the BME680, then join our Bosch Sensortec Online Community!



THANK YOU
VERY MUCH!



BOSCH SENSORTEC



[@BoschMEMS](https://twitter.com/BoschMEMS)



www.bosch-sensortec.com



<https://community.bosch-sensortec.com>