Webinar:
Indoor Air Quality Monitoring: LoRaWAN® IoT Solutions and Real-life Deployments.

LoRaWAN™

Actility   AXENOVA   birdz   VEOLIA   nanoSense

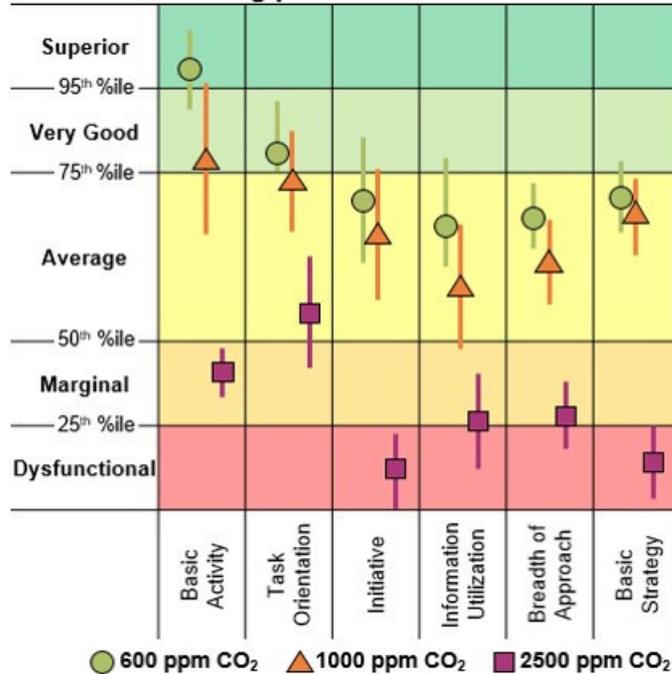# *INTRO: Indoor Air Quality (IAQ) webinar*

Olivier Hersent, CEO

March 2021

- We spend **90%** our our time indoors

- IAQ has a measurable impact on **cognitive performance**

- **Poor IAQ is harmful**, particularly to those suffering chronic respiratory and/or cardiovascular diseases

Actility

CO2 –Impact on cognitive performance

• **CO2 concentration is a key indicator of air quality.** The higher the CO2 value in a building, the less comfortable it becomes for the people inside. In poorly ventilated rooms, the **CO2 concentration increases rapidly.**

• Current statistics, such as from the U.S. Environmental Protection Agency (EPA), show that **people spend almost 90% of their time indoors**. Indoor concentrations are often 2× to 5× higher than typical outdoor concentrations.

Optimization of air quality in rooms is essential for more healthy and productive indoor living and working conditions.

Impact of CO_2 on human decision making performance

| | Superior |
| 95th %ile |
| Very Good |
| 75th %ile |
| Average |
| 50th %ile |
| Marginal |
| 25th %ile |
| Dysfunctional |

Basic Activity · Task Orientation · Initiative · Information Utilization · Breadth of Approach · Basic Strategy

○ 600 ppm CO2   △ 1000 ppm CO2   ▪ 2500 ppm CO2

In a space of about 4m2 occupied by only one person, the CO2 value rises from 500ppm to more than 1,000ppm in just 45 minutes. This can cause headaches, drowsiness, and poor concentration, often resulting in reduced productivity.

From 2,000ppm onward, even the cognitive abilities of humans are influenced, and there is a significant risk to health at higher levels.

BE Royal Decree of 2 May 2019 well-being code at work :
The employer must take the necessary technical and/or organizational measures to ensure that the concentration of CO2 in the workplace is generally less than 900 ppm.

Actility

Ventilation performance – Impacting Risks COVID-19

- High amount of CO2 in the air, means also a **high number of aerosols**. A high concentration of aerosols increases the **risk of infection** for everyone else in the room.

- When a person infected with the **coronavirus** coughs, speaks, or sneezes, a spray consisting of droplets and aerosols is generated, which **penetrates air in the room and then spreads.**

- Non-ventilated indoor spaces can increase the likelihood of **aerosol transmission of Covid-19.** Insufficient ventilation may lead to a long-range airborne transmission of the **virus and opportunistic infection**.
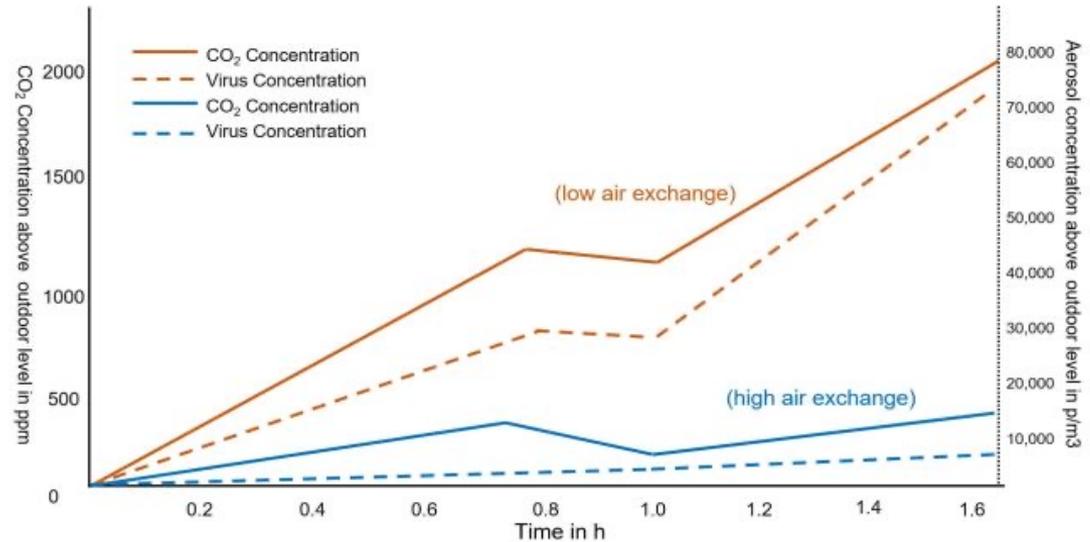
Indoor climate plays a key role in health protection, as pathogens remain in rooms for hours at typical air exchange rates in residential and office buildings. Air renewal take considerable time. As such, an increase in the fresh air supply is recommended.

CO2 levels in rooms and enclosed spaces may be used as a proxy for COVID-19 transmission risk

Actility

Indoor air quality affects children's performance at school

Examples of Positive Impact

↑ In a study of 100 US elementary classrooms, there was a **2.9% and 2.7% increase** in math and reading scores, respectively, for each litre per second per person increase in ventilation rates **9**

Higher ventilation rates have been associated with faster and more accurate student responses for colour, picture memory and word recognition **10**
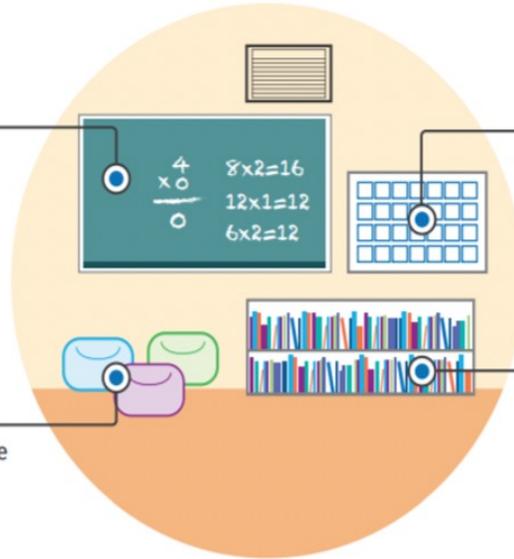
Examples of Negative Impact

↑ A **1000 parts per million (ppm)** increase above ambient levels of CO_2 has been linked to a **10-20% increase in days** away from school **11**

Every 100 ppm increase in CO_2 was associated to roughly one-half day per year reduction in school attendance **12**

$8 \times 2 = 16$
$12 \times 1 = 12$
$6 \times 2 = 12$

Actility

Education

Schools and Universities

Public Buildings

Governmental   *Airports*   *Hospitals*

Smart Buildings

Offices   *Co-Working*   *Logistics*

Services

Hotels & Restaurants   *Shopping centers*

Theaters & Cinemas

Actility

LoRaWAN™

LPWAN (Low-Power Area Network) is the new segment of wireless communications that specifically caters to IoT use cases that require battery-operated sensors and network coverage well-beyond 100s of meters

For most buildings IAQ sensing is installed as a retrofit. LoRaWAN eliminates the wiring cost and provides robust coverage

Low Power, Long Range - While technologies like Bluetooth LE, Zigbee, and Z-wave have provided a low-power but short-range solution, and long-range has been covered by 2.5/3/4G albeit in a power-hungry way, LoRaWAN™ perfectly addresses long-range and low-power communications problem space has been looking for a standard technology with a strong ecosystem.
Open Standard - LoRaWAN™ is an open standard from the LoRa Alliance, ensuring there is no vendor lock-in - which is key for long terms assets.
Unlicensed band – LoRaWAN™ uses unlicensed bands, providing flexible options to connect your assets , via public connectivity services,private networks or both leveraging LoRaWAN roaming capabilities.
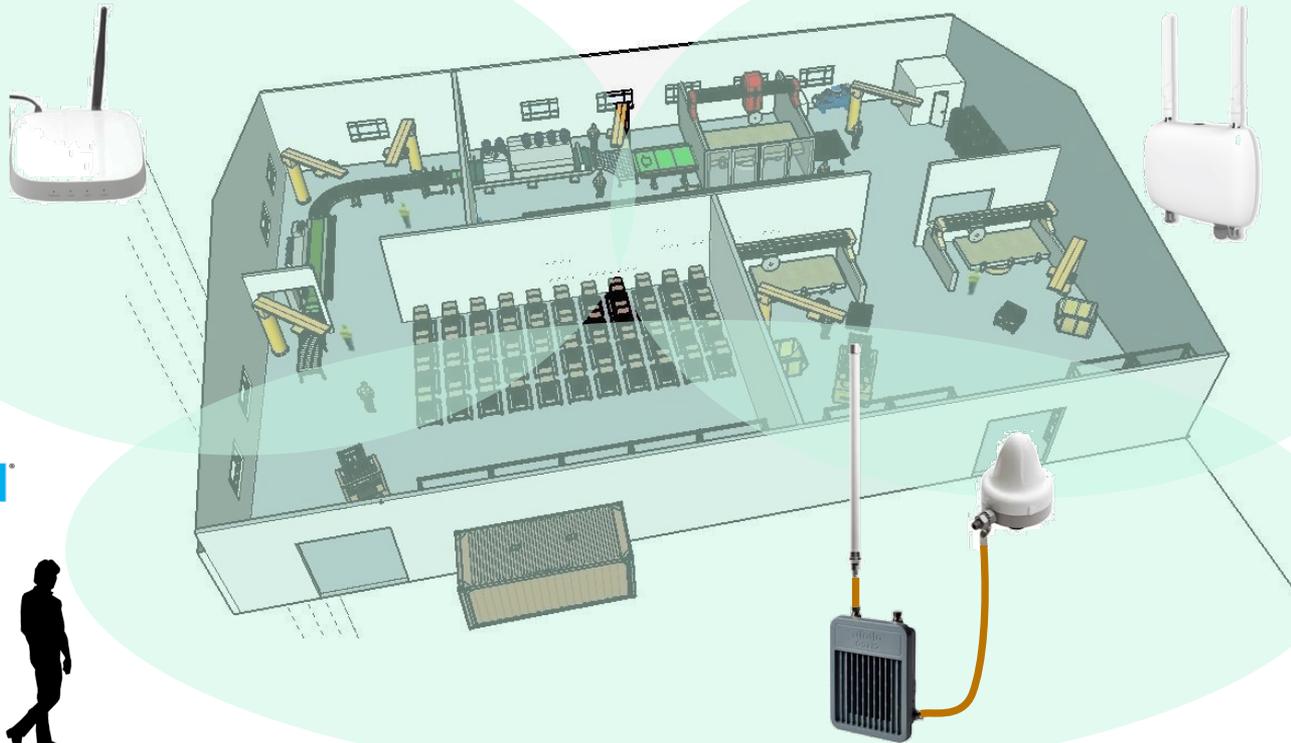**Mass ecosystem –** The LoRaWAN ecosystem is rich of 1000+ references, addressing the widest variety of use-cases ready to be deployed on your horizontal connectivity infrastructure.
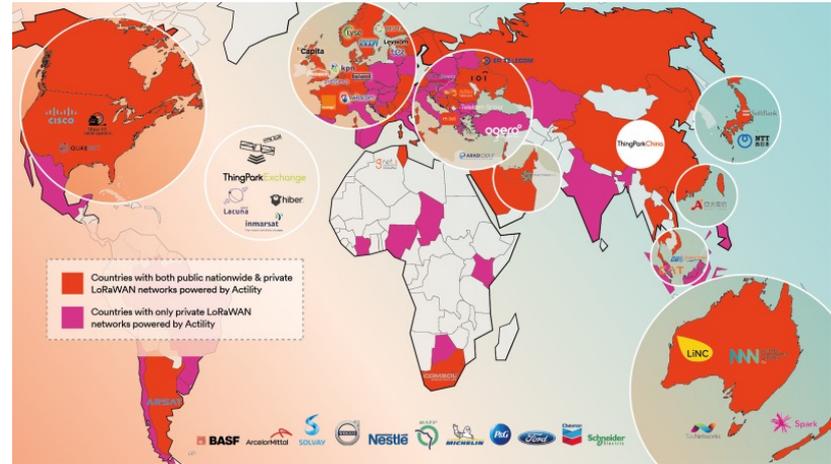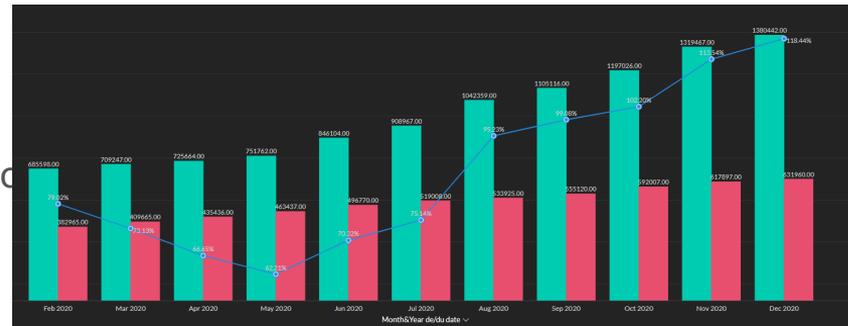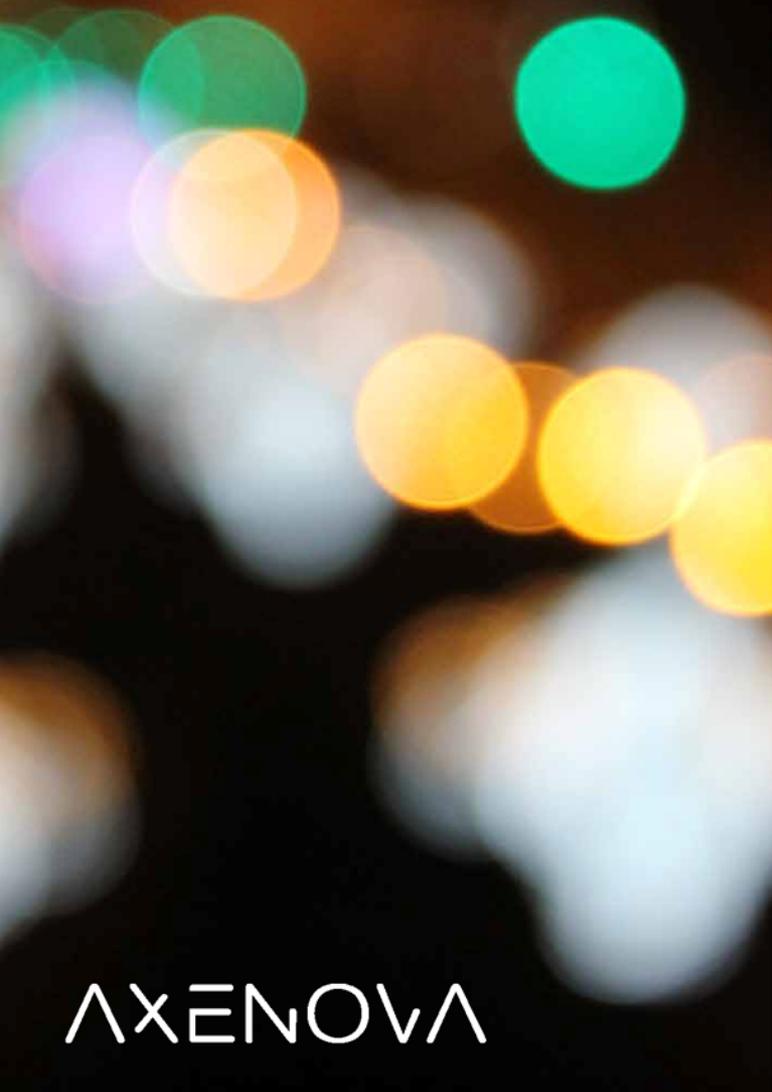
Actility

LoRaWAN

Actility

- Public operators
- IaaS private networks
  - → Offices
  - → Retail
- On-Premise private networks
  - → Industrial
  - → Sensitive sites
- Public/Private roaming (TEX)
- OEMs
- Any LoRaWAN gateway brand

- , and OEMs, and interface with all GWs and all clo
- share growth index
-

Actility

COVID-19
Transmission Problem

An aerosol is a light, extremely tiny particle that emerges from the lungs when an individual exhales. Aerosols travel much further than droplets. When one hears the term "airborne" **transmission in the context of coronavirus, aerosols are the cause**. The danger of **aerosols is that they can linger in the air longer** and farther than the heavier droplets, which can only remain in the air for a matter of seconds.
This makes **poorly ventilated spaces especially dangerous**. Researchers have confirmed that unmasked individuals in closed spaces without proper ventilation have spread COVID-19 to others.
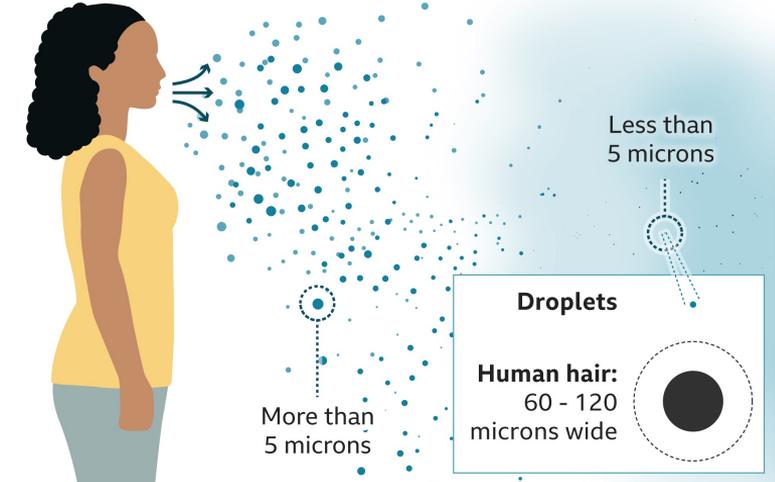
The difference between droplet and airborne transmission

Droplet transmission
Coughs and sneezes can spread droplets of saliva and mucus

Airborne transmission
Tiny particles, possibly produced by talking, are suspended in the air for longer and travel further

Less than 5 microns

More than 5 microns

Droplets

Human hair: 60 - 120 microns wide

Source: WHO

BBC

AXENOVA

CO2 measurement is an economical system that **allows us to know if** the chosen **ventilation system is sufficient** or not.

The maximum recommended value of CO2 will depend on the room, its occupation and the activity carried out.

But in general all the studies agree that the risk of contagion rises a lot when the value of CO2 concentration in the open air is doubled (approximately 420 ppm).

CO2 Actual Value

850

600

586 ppm

2000
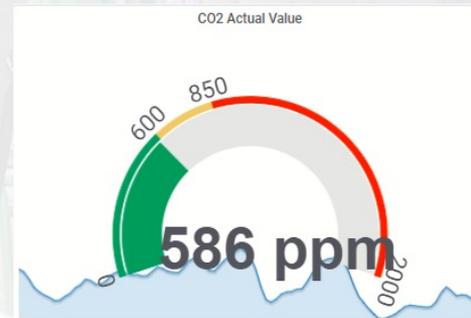
"… Ventilation is an essential tool to control the pandemic. All classrooms should have a CO2 meter… "
STECyL (Union of Teaching Workers of Castilla y León)

AXENOVA

Room 1

CO2

Room 2

CO2
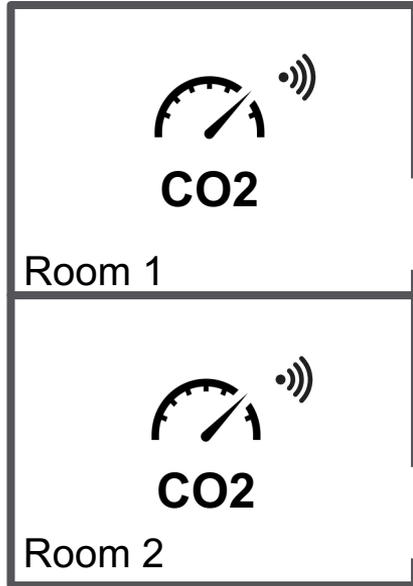
CO2 Metering data
(+ temperature & HR)

Monitoring Center

App with online information

Real Time Data

Historic Data

Online Platform, reporting,
alarms, settings

AXENOVA

Devices **Building 1**
Gateway

Devices **Building 2**
Gateway

Devices **Building n**
Gateway

IP (AES 128)

IP (AES 128)

IP (AES 128)

Actility Network & Integration Server

MQTTS

Axenova Platform

Monitoring Center

App

Online Platform

LoRaWAN Network
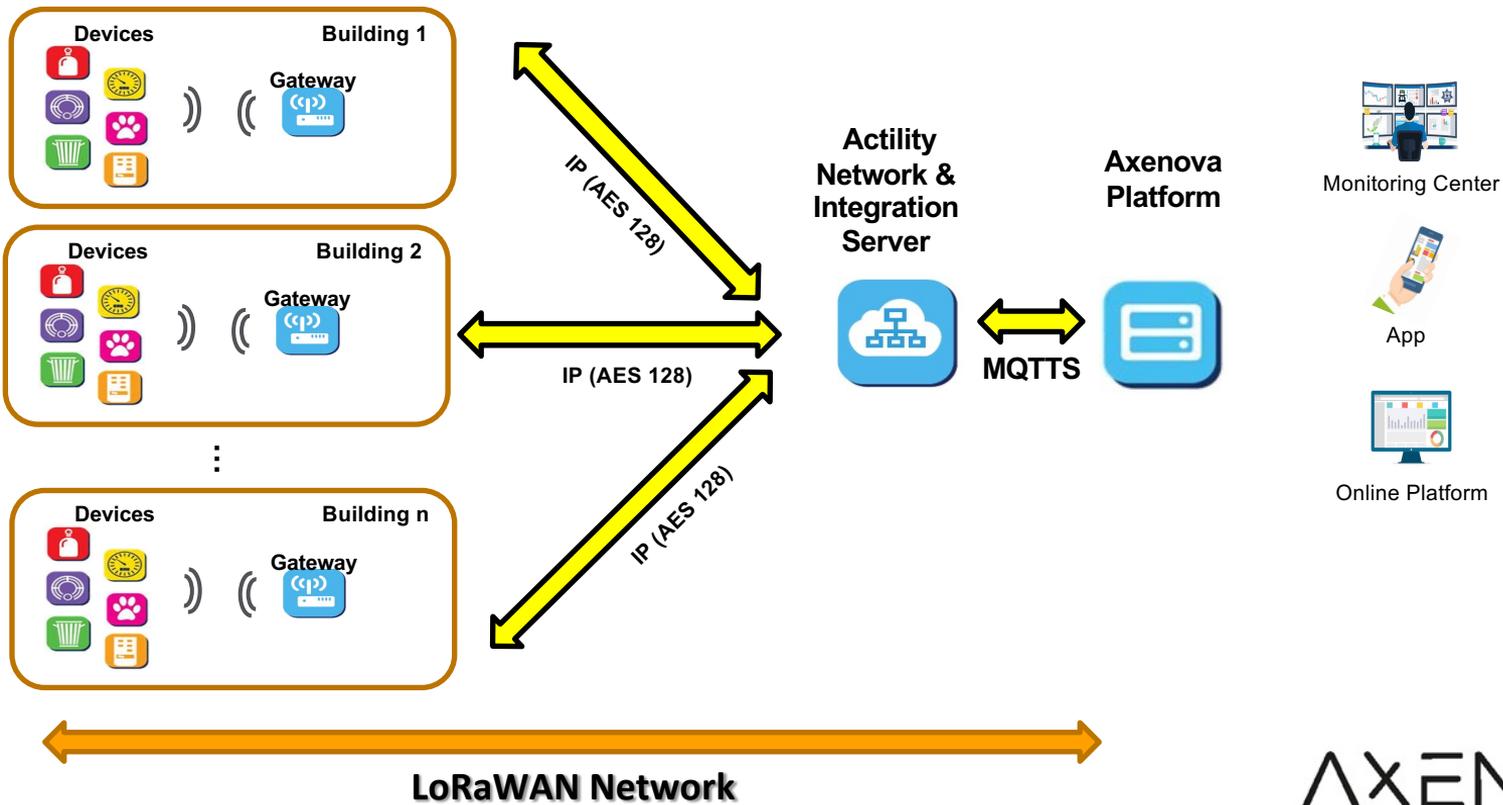
AXENOVA

CO2 Sensor (+ Temp + HR)
LoRaWAN AXE–CO2-1.1

Cabinet options: indoor 80x80 mm (photo) / outdoor IP65 (totally dust-tight, protected against ingress of water in all directions).

Power options: 110-220 Vac / AA lithium battery / AA or AAA alkaline batteries.

Operating temperature: -10 to 75 ° C.

LoRaWAN 1.0.2 compliant radio, Low-Power Wide Area Network (LPWAN) RF module,

Antenna: 1dBi gain internal ceramic. 3Bi external option. Internal UFL connector.

Data transmission security: AES-128

Other sensors: CPU voltage and temperature sensors.

Battery voltage monitoring. Radio link monitoring RSSI and SNR.

Sensor	Parameters	Range	Units	Error Max.
Silicon Labs Si7021	Temperature	–40 a 125 °C	°C	±0.4 °C
	HR	0 a 100 %RH	%RH	±3 %
Ams TSL2591	Lux	0 a 88000 Lux	Lux	±1 %
Amphenol T6715	CO2 Concentration	0-2000 / 0-5000	ppm	±30 ppm ±3% of reading

Offices

Public Attention

Restaurants & Hotels

Classrooms
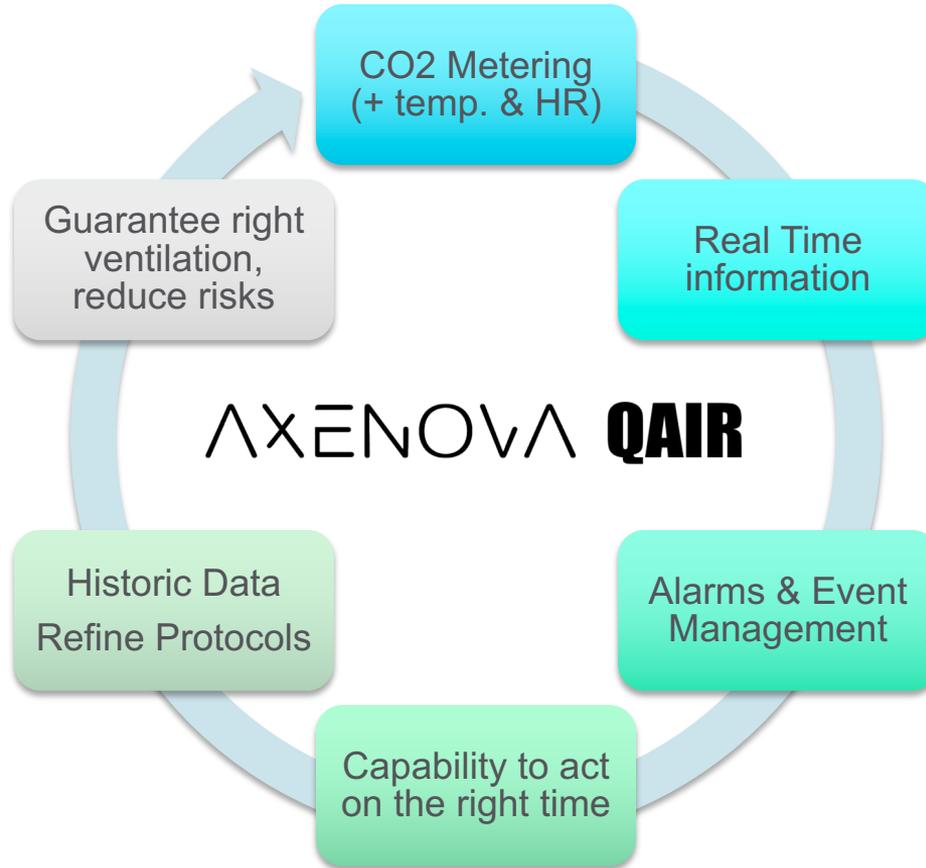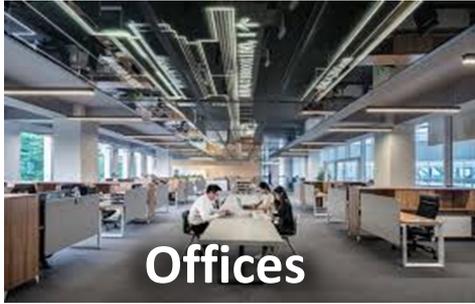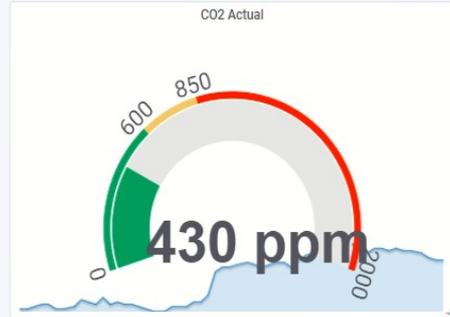
AXENOVA

Ready to deploy, quick to setup

Low cost, high scalability

SaaS On Cloud, prepared to be easily integrated with external systems

Based on open LoRaWAN technology

Axenova supports its Clients with a professional team with high technical knowledge and vast field experience

AXENOVA

advantages

VEOLIA

NanoSense **birdz**

Guaranteeing Good Indoor Air Quality

SUMMARY

Guaranteeing Good Indoor Air Quality

01

Air Quality Solutions
Mireille RAHMEH
Air Expertise Cluster VEOLIA

02

Monitoring of IAQ in buildings
Olivier MARTIMORT
Nanosense

03

Data integration and analysis
Pierre Emmanuel DUBOIS
Birdz

Air Quality Solutions

Mireille RAHMEH
Air Expertise Cluster

Air Quality Solutions
Veolia's offer

3 SERVICE INITIATIVES FOR A BETTER **I**NDOOR **A**IR **Q**UALITY

AIR CONTROL
PERMANENT EVALUATION AND MANAGEMENT OF THE AIR QUALITY

AIR PERFORMANCE
MANAGE THE INSTALLATIONS AND GUARANTEE AIR QUALITY

AIR HUMAN
INVOLVE STAKEHOLDERS IN IMPROVING AIR QUALITY

ASSESSING AIR QUALITY

EVALUATION OF VENTILATION SYSTEM

MAKE INFORMATION ABOUT AIR QUALITY ACCESSIBLE AND UNDERSTANDABLE

IDENTIFYING POTENTIAL SOURCES OF POLLUTION

IMPROVING PRACTICES AND INSTALLATION OPERATIONS

INVOLVE THE USERS IN PROBLEM-SOLVING

RECOMMENDING SUITABLE SOLUTIONS

GUARANTEEING RESULTS AND TRACKING PERFORMANCE

TAKE INTO ACCOUNT THE PERCEPTIONS OF THOSE INVOLVED

Air Quality Solutions
Raincy's schools

France
Schools - Le Raincy

Air Control | Air Performance + | Air Human
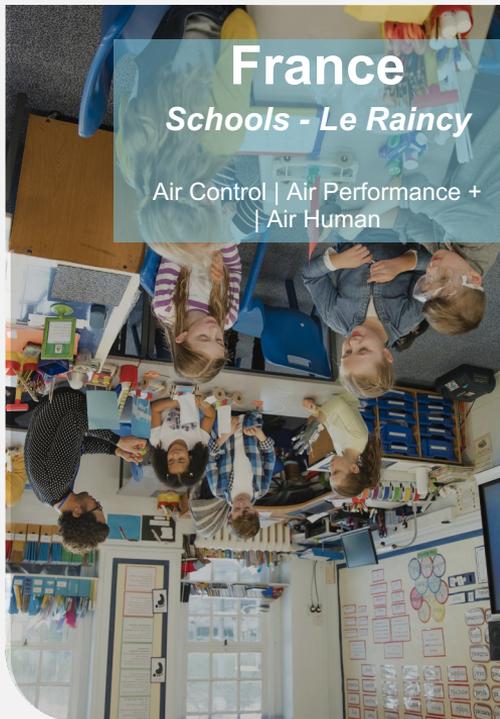
> Challenges

- Improve and guarantee air quality at two elementary schools with no ventilation systems
- Equipment installed without disruption to teaching
- Accessible information about air quality in the schools

> Solutions

- Audit of buildings and installation of a network of 30 indoor air quality sensors
- Installation of filtering and air renewal solutions to guarantee air quality
- Work carried out in two weeks during school holidays
- Real-time monitoring of installation performance to meet the highest CO_2 and $PM_{2.5}$ standards
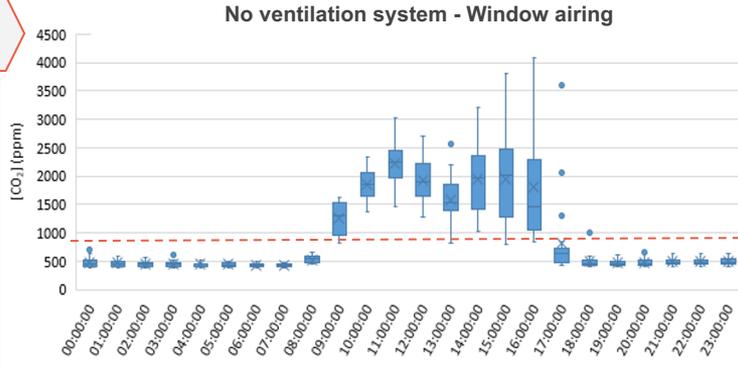
> Benefits

- First schools to guarantee indoor air quality for all pupils
- Parents and children informed and aware of the positive impacts of air quality
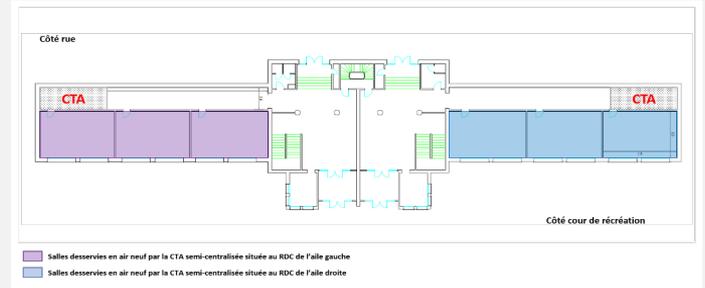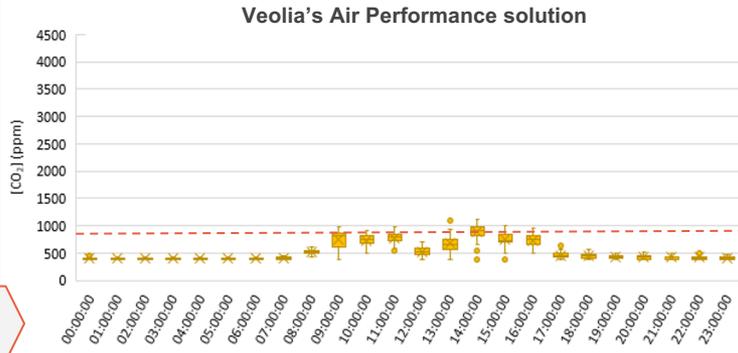
Air Quality Solutions
Raincy's schools

1

No ventilation system - Window airing

2

Veolia's Air Performance solution

Côté rue

CTA

CTA

Côté cour de récréation

Salles desservies en air neuf par la CTA semi-centralisée située au RDC de l'aile gauche
Salles desservies en air neuf par la CTA semi-centralisée située au RDC de l'aile droite

Reducing the "ICONE" index from 4 (unventilated room) **to 0** (well ventilated room)

The 1000 ppm CO_2 threshold **was guaranteed**

Air Control
COVID

Science

Media

Why stores should be checking CO2 levels to keep us safe

CO2 monitors suggested as tool to protect teachers and pupils
IRELAND

How CO2 sensors might help us return to 'normal'

Monitoring CO2 to assess risk of indoor airborne SARS-CoV-2 transmission

Good IAQ Matters: Now and Into a Post-COVID Future

How CO2 monitors and ventilation can help us out of lockdown

The coronavirus is airborne. Here's how to know if you're breathing other people's breath.

In a major new pandemic trend, people are turning to carbon dioxide monitoring devices to help assess ventilation quality

Gouvernement

MINISTÈRE DE L'ÉDUCATION NATIONALE, DE LA JEUNESSE ET DES SPORTS
Liberté Égalité Fraternité

PROTOCOLE SANITAIRE

ANNÉE SCOLAIRE 2020-2021

Guide relatif au fonctionnement des écoles et établissements scolaires dans le contexte COVID-19

Février 2021

VEOLIA's solution

CO_2 alert level = 800 ppm

LoRa

Reliable air quality monitors with Led indicators

Mail and sms **real-time alerts**
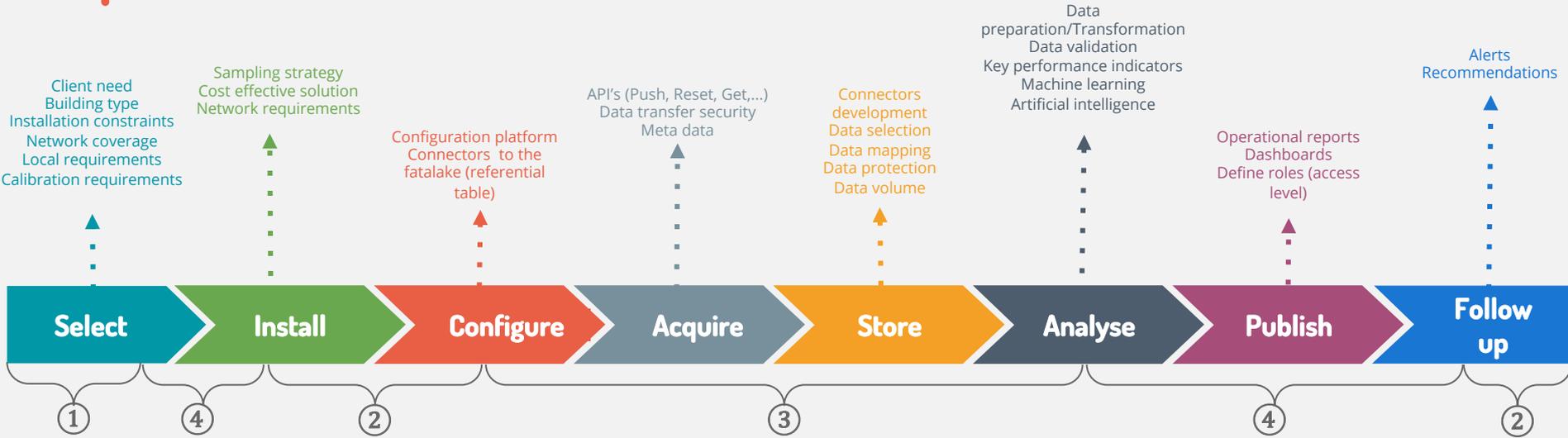
Automatic **reporting** and data visualisation

Monitoring of other parameters influencing the virus transmission risk

Internet of Things
Based Solutions

VEOLIA

Select:
Client need
Building type
Installation constraints
Network coverage
Local requirements
Calibration requirements

Install:
Sampling strategy
Cost effective solution
Network requirements

Configure:
Configuration platform
Connectors to the
fatalake (referential
table)

Acquire:
API's (Push, Reset, Get,...)
Data transfer security
Meta data

Store:
Connectors
development
Data selection
Data mapping
Data protection
Data volume

Analyse:
Data
preparation/Transformation
Data validation
Key performance indicators
Machine learning
Artificial intelligence

Publish:
Operational reports
Dashboards
Define roles (access
level)

Follow up:
Alerts
Recommendations

Select	Install	Configure	Acquire	Store	Analyse	Publish	Follow up

① ④ ② ③ ④ ②

4 main stakeholders

① IAQ monitors manufacturer
NanoSense

② Building operator
VEOLIA

③ Data manager
birdz

④ IAQ experts
VEOLIA

WORKING TOGETHER FOR A BETTER AIR QUALITY

For more information
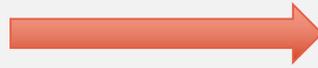
→ **airquality.veolia.com**
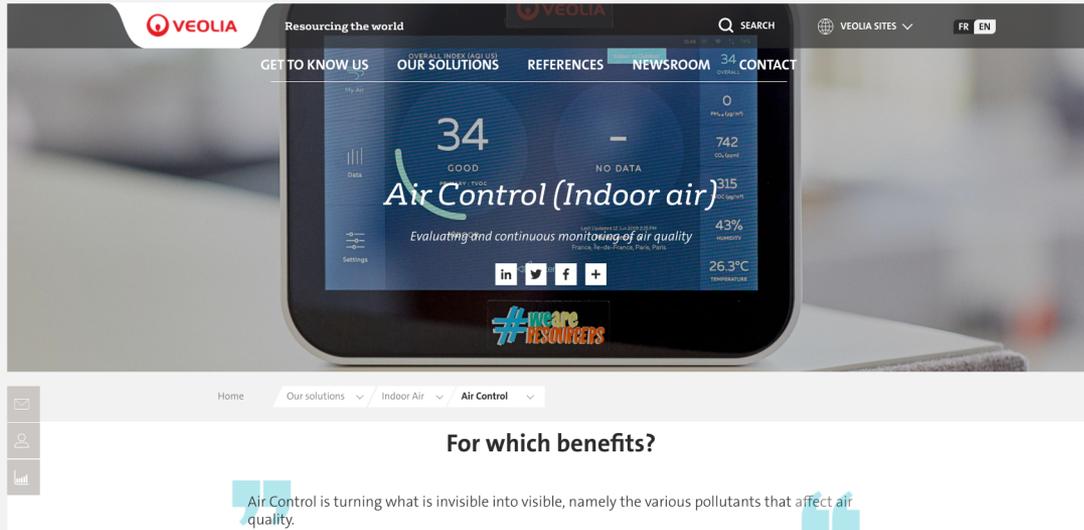
Air Control Covid

NanoSense
IAQ Modular Probes

E4000NG

- CO2
- VOC
- T°
- RH
- Vent. Control
- T° Control
- OTC

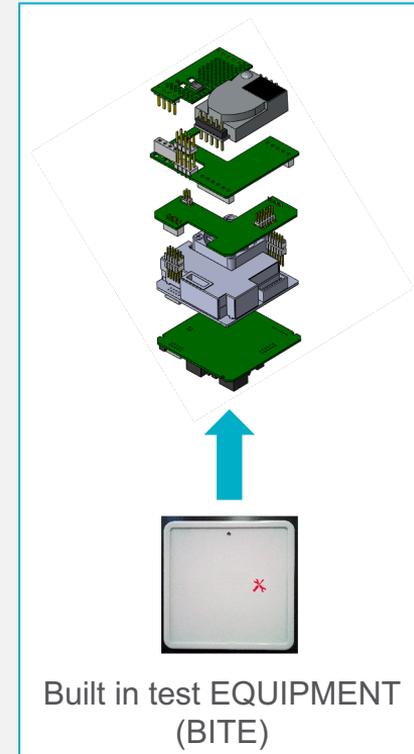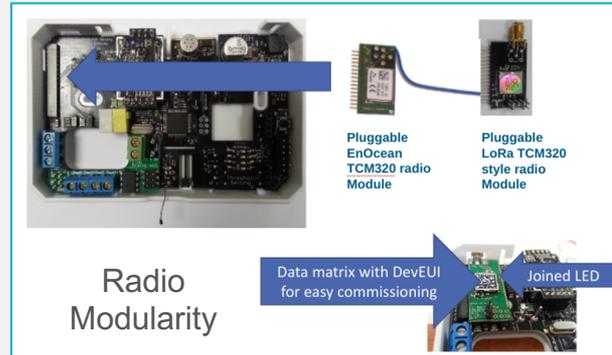**P4000NG**

- PM1
- PM2.5
- PM10
- Vent. Control

EP5000

- Lux and Light T°
- Noise
- Barometric
- Vent. Control
- T° Control
- OTA/OTC

- CO2
- VOC
- PM1, PM2.5, PM10
- T°
- RH

32

NanoSense
IAQ Probes main features

- Multi sensors (auto calibration)

- Multi protocols (even combined)

- Multi criteria remediation control algorithms

- 10 years sensors lifespan (count down onboard sensors modules)

- Maintainability:
    - Plug and play replaceable sensors
    - FRU design (Field Replaceable Unit)
    - Built in test with FRU identification
    - MTBF > 42 years

- Low Life Cycle Cost

Built in test EQUIPMENT (BITE)

Pluggable EnOcean TCM320 radio Module

Pluggable LoRa TCM320 style radio Module

Radio Modularity

Data matrix with DevEUI for easy commissioning

Joined LED

Airlab Challenge
Laureate ⭐⭐⭐⭐

CHALLENGE MICROCAPTEURS 2018

NanoSense
• E4000NG • E5000M • P5000 • QAA-M

Mann + Hummel
• OURAIR SPS208

Azimut-Monitoring
• RAM000X

PILOTER ET GÉRER L'AIR DANS UN BÂTIMENT

AIRLAB

MICROSENSORS CHALLENGE 2019

LAUREATE 2019
*AIRLAB SOLUTIONS
MICROSENSORS International Challenge PARIS

NanoSense
• E4000NG • E5000RE

IQAir
• AIRVISUAL PRO+

Kaiterra
• LASER EGG

AIRLAB

NANOSENSE E4000NG

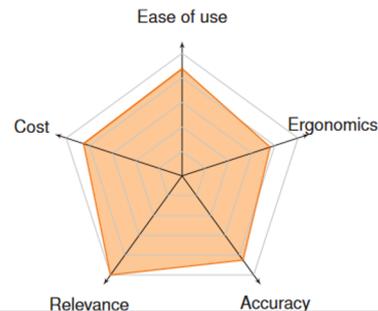Use for which the evaluation was the best : Monitoring and awareness in indoor air

Jury's opinion

IA ⭐⭐⭐⭐☆

This device is to be used for indoor air quality monitoring or awareness and can be supplemented with other Nanosense sensors. It has a design that is very well adapted for easy integration with building equipment. The quality of the CO_2 measurement is excellent and the VOC measurement is good. It is a device whose price is attractive, even when factoring in the subscription for the Pando2 data visualization interface. Its setup however requires some specific technical skills and should be done by a professional.

Evaluation

Ease of use

Ergonomics

Accuracy

Relevance

Cost

Measured pollutants

- ○ CH_2O
- ○ CO
- ☑ CO_2
- ☑ VOC
- ○ H_2S
- ○ NH_3
- ○ NO
- ○ NO_2 (NO_x)
- ○ O_3
- ○ PM_1
- ○ $PM_{2,5}$
- ○ PM_{10}
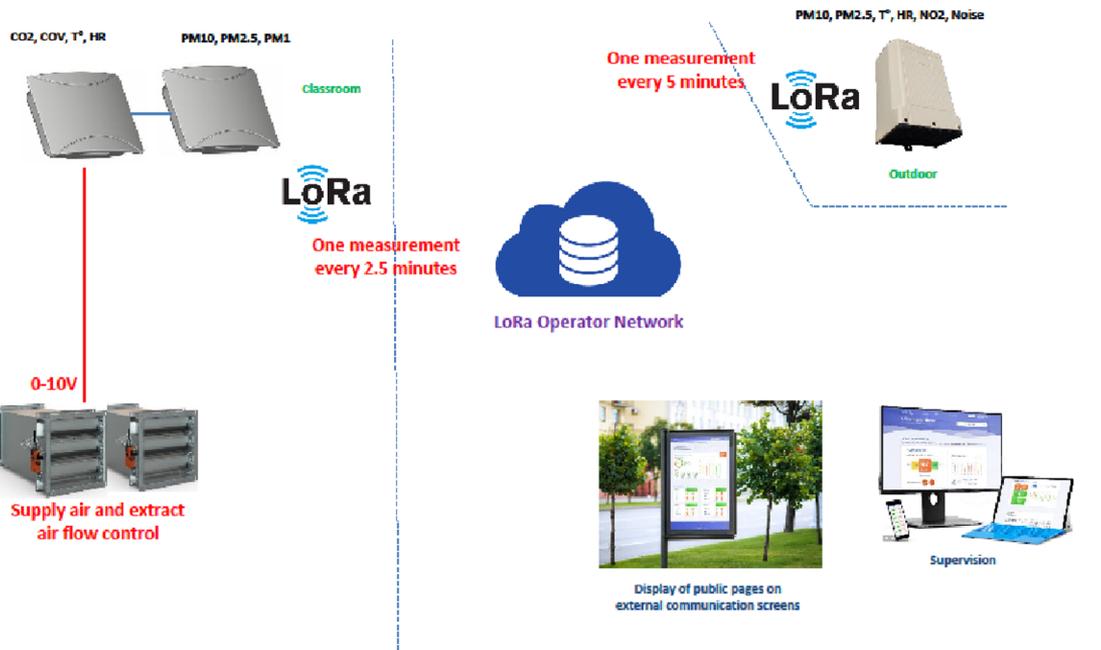- ○ SO_2
- ○ Particle number (concentration)

Other measurements

NanoSense
Radio Choice

- **Wi-Fi :** Forbidden by law in French kindergarten

- **EnOcean** allowed but:

    ○ We gave up on large building due to range limitation despite repeaters
    ○ Requires local gateways with IP connections

- **Sigfox** allowed but : No downlink and no private network possible

- **LoRa** allowed :

    ○ Validated on various POC
    ○ Private network allowed for higher transmission rate
    ○ One gateway by building

LoRaWAN
Operated Architecture

CO2, COV, T°, HR   PM10, PM2.5, PM1

Classroom

One measurement every 2.5 minutes

LoRa Operator Network

0-10V

Supply air and extract air flow control

PM10, PM2.5, T°, HR, NO2, Noise

One measurement every 5 minutes

Outdoor

Display of public pages on external communication screens

Supervision

Advantages

- Minimum wiring
- Remote commissioning

Drawbacks

- Limited transmission rate
- Network subscription cost
- No OTA
- Reliability is operator coverage dependent

Private LoRaWAN
Architecture

Advantages

- Minimum wiring
- Highly reliable
- High transmission rate
- No network subscription
- Potential probe OTA firmware update (new LoRa feature to be implemented)

Drawbacks

- Requires Internet access (or 4G router)

Importance of
IAQ/OAQ monitoring

Outdoor/indoor relationship of particulate matter and Filtration efficiency

VOCT increase during night (Ventilation system is turned Off at night)
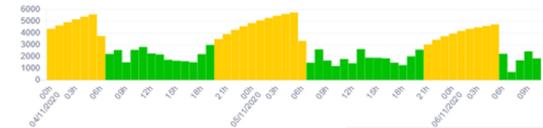
Good CO$_2$ control but too dry (winter)

Other
REx

Experiments Goals

1. Guarantee good indoor air quality in schools
2. Take into account the feedback from the educational community
3. Ensure permanent IAQ monitoring
4. Acquire the knowledge bases necessary for mass deployment

1

800 ppm CO2 LED warning against COVID pandemic

2

Without HVAC, manual window opening requires dynamic IAQ LED display (real time measurement not compatible with battery operated probes)

3

With operated LoRa, emission rate setting via downlink allows one measurement per minute during working hours

Data integration and analysis

Pierre Emmanuel DUBOIS
Birdz

Birdz at a glance
Environmental smart solutions for digital cities

- **Experience in IoT** : 20 years
- Birdz brand since 2017
- Following the merge of :
    - m2ocity (2011)
    - Homerider Systems (2000)
- **170 employees**
- 4 sites:
    - Paris (Fra)
    - Lyon (Fra)
    - Bordeaux (Fra)
    - Neuchâtel (Swi) with Neroxis

- **7 000 000** devices delivered
- **3 400 000** connected and operated devices
- **3 300** municipalities serviced with IoT connectivity
- **38 000 000** messages issued daily
- **352 620 000** data extracted daily
- Oldest IoT in operation : **18 years**

ENERGY **WASTE** **WATER** **MUNICIPAL** **INDUSTRY** **COMMERCIAL**

Lost in the IoT jungle
The challenges of IoT integration

Hundreds of possible sensors, each one having its own data format

Variety of network offering, with different operators and interfaces

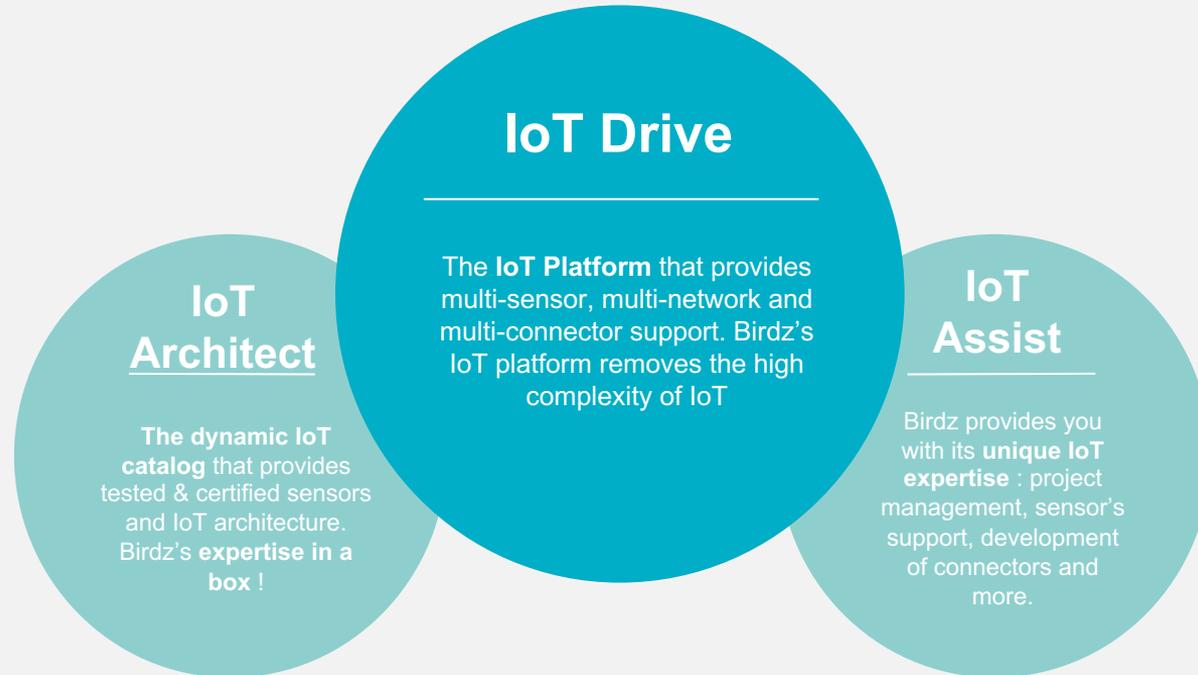No interoperability means vendor lock-in

Technical IT players have no business expertise

Business experts have no technical expertise

Environmental IoT platform offering by Birdz
3 services to accelerate your IoT projects

IoT Drive

The **IoT Platform** that provides multi-sensor, multi-network and multi-connector support. Birdz's IoT platform removes the high complexity of IoT

IoT Architect

The dynamic IoT catalog that provides tested & certified sensors and IoT architecture. Birdz's **expertise in a box** !

IoT Assist

Birdz provides you with its **unique IoT expertise** : project management, sensor's support, development of connectors and more.

Bridging the gap between IoT and business
with an agile, scalable & secured solution platform

The IoT Drive data platform

Converting IoT requirements into operational environmental use cases

- ✓ full SaaS solution
- ✓ fully secured
- ✓ plug & play
- ✓ cloud or on premise hosting
- ✓ available for all BUs

Agnostic from...

- ✓ sensors manufacturers
- ✓ network providers
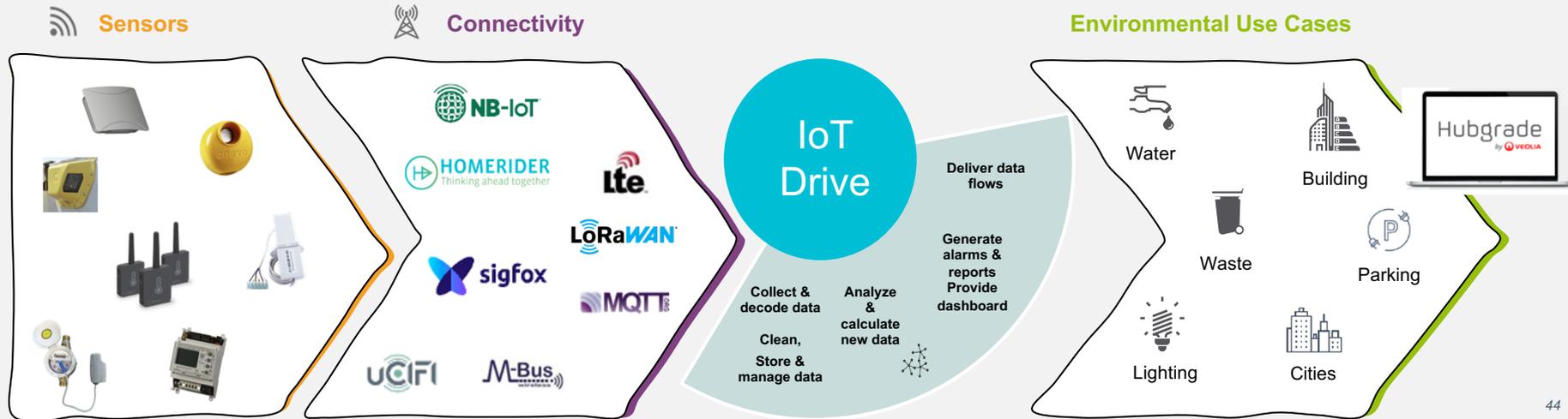- ✓ software applications
- ✓ use cases

Sensors

Connectivity

Environmental Use Cases

NB-IoT

HOMERIDER
Thinking ahead together

LTe

LoRaWAN

sigfox

MQTT

UCIFI

M-Bus
wireless

IoT Drive

Collect & decode data

Clean, Store & manage data

Analyze & calculate new data

Deliver data flows

Generate alarms & reports Provide dashboard

Water

Building

Waste

Parking

Lighting

Cities

Hubgrade
by VEOLIA

44

Illustration of an IoT Drive deployment for Veolia Germany
End-to-end IoT solution for 3 business use cases

Water Metering
40 pulse metering sensors from CODEA (CZ) hooked on Itron and Sensus water meters, pushing UDP packets on the NB-IOT network
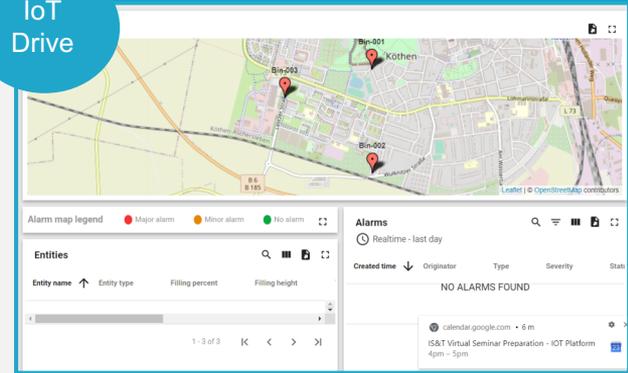
Water Pipeline Leak
50 noise sensors from SEBA pushing data once a day through MQTT on NB-IoT network

Waste Containers
4 waste filling level sensors from TEKELEK (UK) pushing UDP packets on NB-IoT network

NB-IoT

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LoRaWAN

Translating proprietary data

Cleaning data

Compute new data and attributes

Connect device to assets

Online business dashboards

IoT Drive

IoT Assist

Project management, interface with sensor manufacturers, development of connectors and translators, dedicated APN with Telekom, development of dashboards

Guaranteeing Good Indoor Air Quality

LE RAINCY SCHOOLS SUCCESS STORY EXAMPLE
WORKING TOGETHER FOR A BETTER AIR QUALITY

①	②	③	④
IAQ monitors manufacturer	**Building operator**	**Data manager**	**IAQ experts**
NanoSense	VEOLIA ENERGIE	birdz VEOLIA WATER	VEOLIA OFIS
Supply of IAQ probes. Support to ensure the proper functioning of the equipment	Installation of the IAQ probes and the ventilation systems. Maintenance	Data collection and integration. Supply of private LoRaWAN connectivity	IAQ audits. Evaluation of the solution. Raising awareness of the occupants