Deployment of sensor networks: what are the impacts for commercial buildings?

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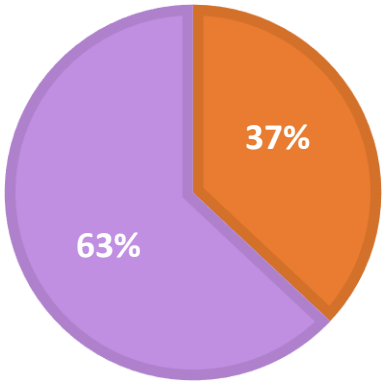
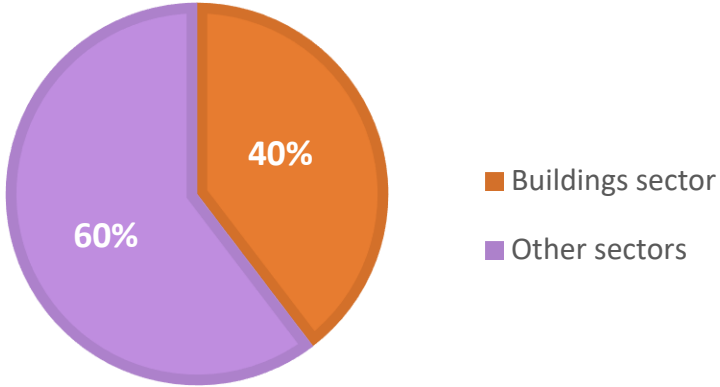
Context

FINAL ENERGY CONSUMPTION OF BUILDINGS RELATIVE TO OTHER SECTORS, 2022

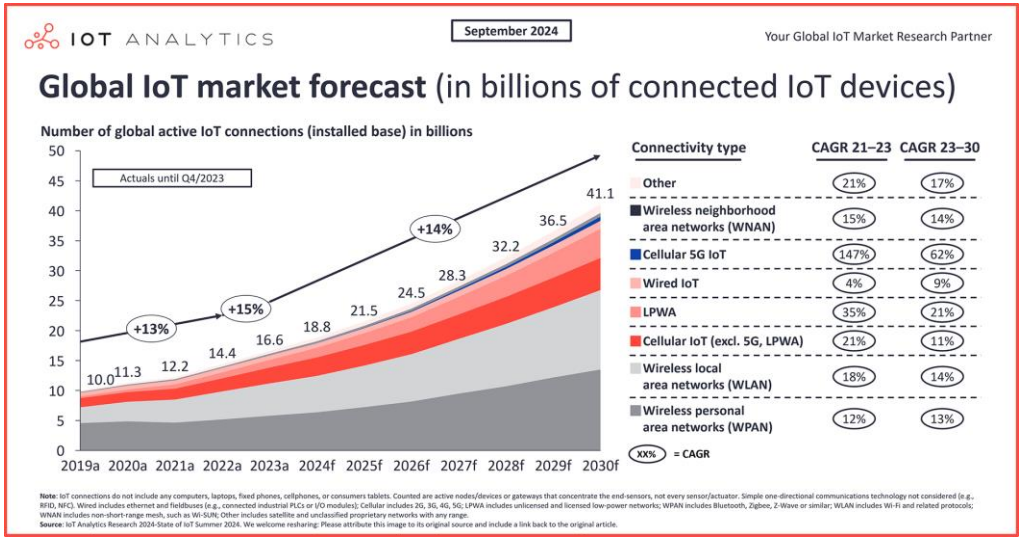


GLOBAL CO_2 EMISSIONS FROM BUILDINGS RELATIVE TO OTHER SECTORS, 2022



[1] IEA. https://www.iea.org/commentaries/the-energy-efficiency-policy-package-key-catalyst-for-building-decarbonisation-and-climate-action

Context



The number of IoT devices continues to grow, and the use of these materials, including the network aspect, accounts for 21% of the carbon footprint.[2]

The deployment of sensor networks in buildings aims to reduce their impact by controlling the energy consumption.

[1] IoT Analytics. https://iot-analytics.com/number-connected-iot-devices/
[2] ADEME/ARCEP. Assessment of the digital environmental footprint in France in 2020, 2030 and 2050.

How can we quantify the environmental impact of connected building systems that aim to assist in decarbonization efforts through digital and electric technologies?

Usecases

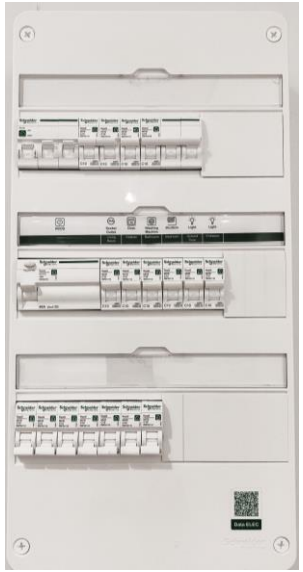
Connected electric panel

Connected home

Connected building

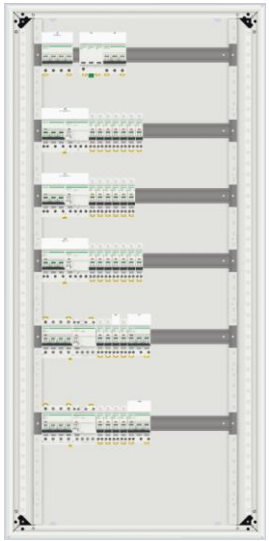
Perimeter :

envelope + protection + cables + measuring

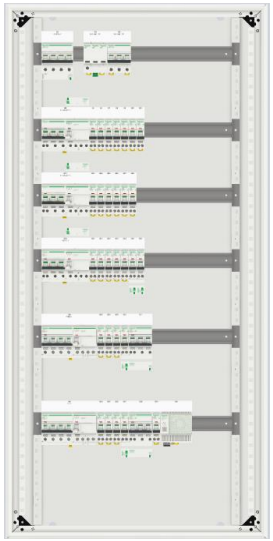


Electric switchboards, option 1

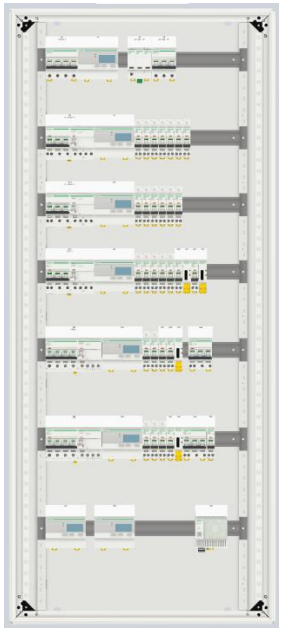
Reference without power meters



Wireless power meters IEEE 802.15.4



Wired power meters Modbus RS485



Electric switchboards, option 1

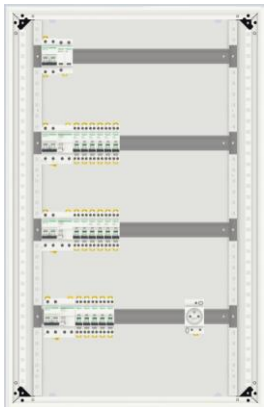
Presented at Algotel-Cores 2025

3-phase distribution
37 switches (38 if PAS added)
12 powermeters (5 are 3-phase)

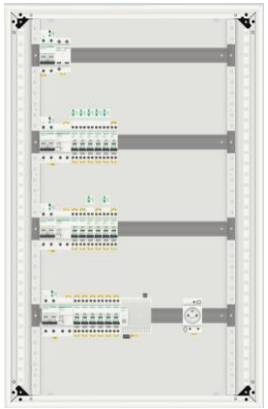
Moving forward we'll adress single-phase solutions, for smaller tertiary establishments.

Electric switchboards, option 2

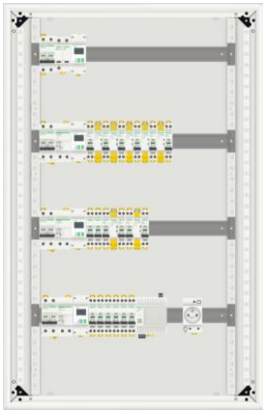
Reference without power meters



Wireless power meters IEEE 802.15.4



Wired power meters Modbus RS485



Single-phase installation
21 switches (22 if PAS added) and 11 powermeters

Real life establishments

In-loco visits and interviews to get accurate data

Grocer

Surface: 76.5 m²

Annual elec consumption (avg): 7524 kWh

Year-surface: 98.35 kWh/m²

Altitude: 200m

Location: Grenoble, France

Cheese shop

Surface: 84.7 m²

Annual elec consumption (avg): 8856 kWh

Year-surface: 104.55 kWh/m²

Altitude: 200m

Location: Grenoble, France

Mini-market 1

Surface: 180 m²

Annual elec consumption (avg): 24315 kWh

Year-surface: 135.08 kWh/m²

Altitude: 1000m

Location: Plateau des Petites Roches, France

Mini-market 2

Surface: 150 m²

Annual elec consumption (avg): 44627 kWh

Year-surface: 297.5 kWh/m²

Altitude: 1500m

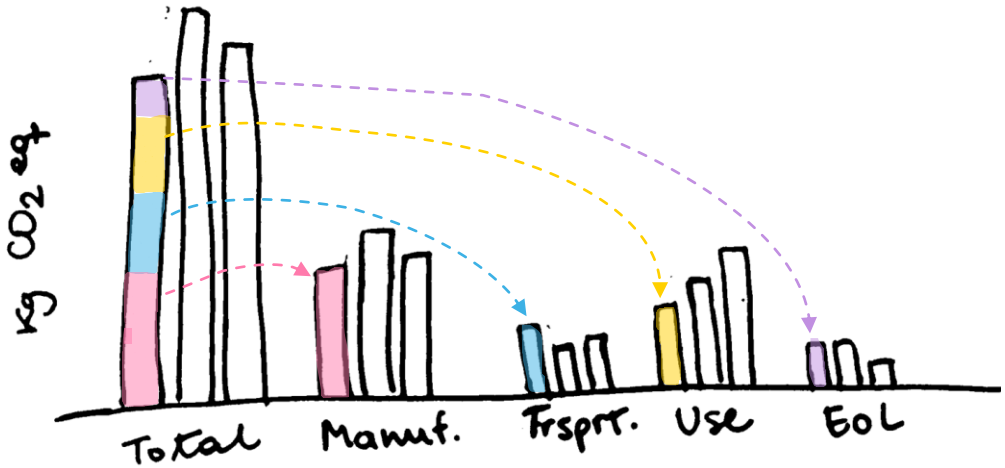
Location: Valmeinier, France

Total switchboard footprint

Calculation

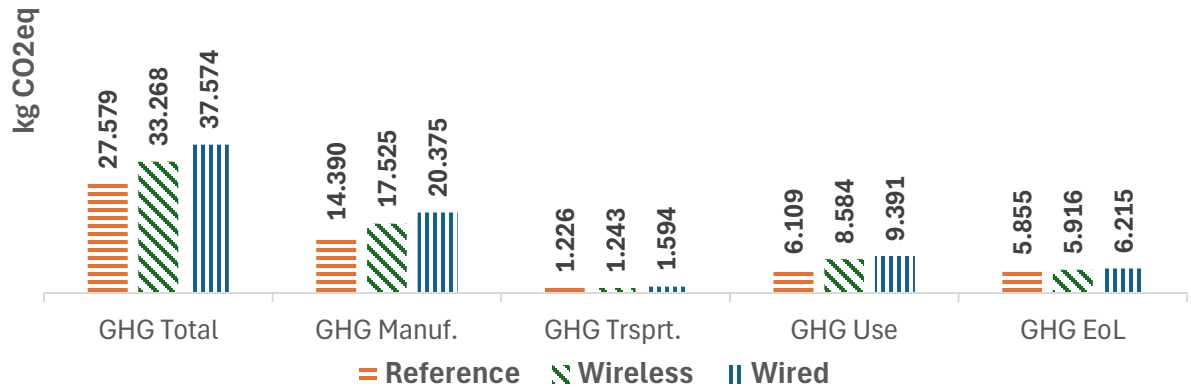
$$\text{Total } CO_2 \text{ Footprint} = \sum_{i=1}^{N} \left(\frac{\sum_{p=1}^{\text{LCA phases}} CO_2 \text{ Fp of Phase}_{p,i}}{\text{Service Life}_i \text{ (years)}} \times \text{Quantity}_i \right)$$

Expected results



Total switchboard footprint (yearly)

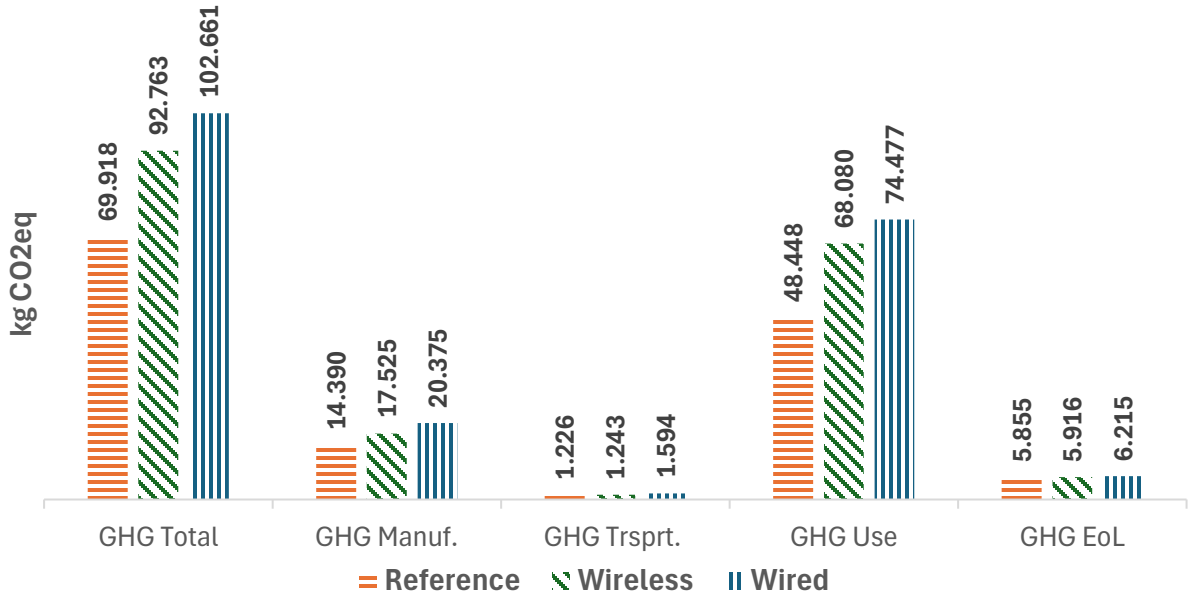
Approximated carbon footprint of the panels in kg CO_2eq, France (PIM)



Disclaimer: Values may vary based on the LCA software versions.

Total switchboard footprint (yearly)

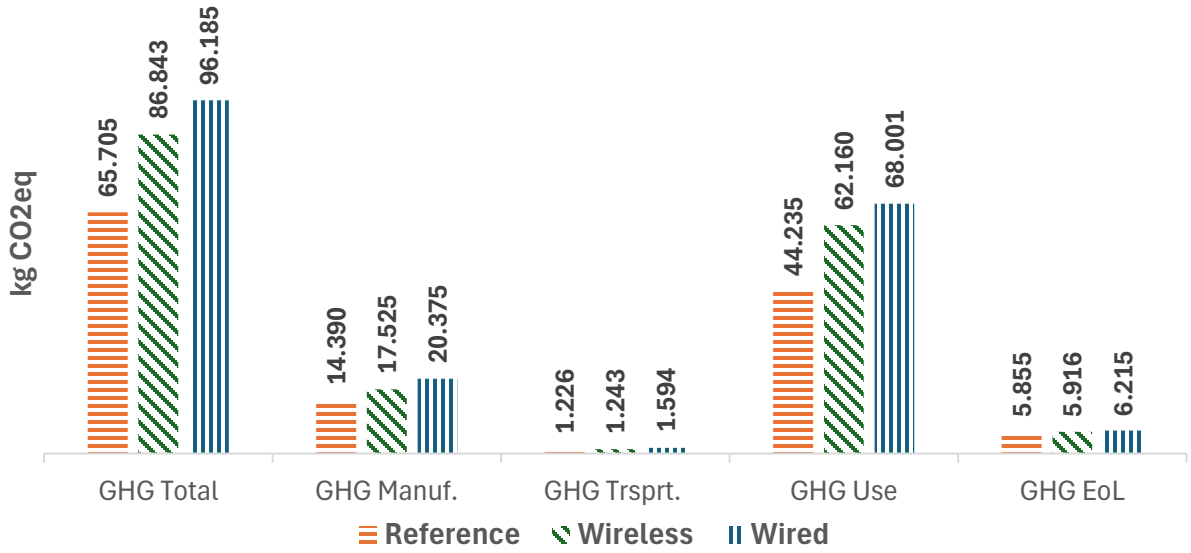
Approximated carbon footprint of the panels in kg CO_2eq, Germany (PIM)



Disclaimer: Values may vary based on the LCA software versions.

Total switchboard footprint (yearly)

Approximated carbon footprint of the panels in kg CO_2eq, Europe Average (PIM)



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Yearly CO2 footprint - connected products only

Approximated cost in kgCO2eq

Region / Connectivity	France	Germany	Europe
Wireless	5.69	22.8	21.1
Wired	10	32.7	30.5

Approximated cost for the connected products and its accessories only, subtracting from the total the cost from the reference panel

Every establishement needs to have an electrical panel, independently of energy management efforts

Disclaimer: Values may vary based on the LCA software versions.

Yearly approx. cost for connectivity

Establishment	Average yearly electric consumption	France		Germany		Europe Average	
		diff wireless 5.69kqCO2eq 98.1kWh	diff wired 10kqCO2eq 172kWh	diff wireless 22.8kqCO2eq 54.3kWh	diff wired 32.7kqCO2eq 77.8kWh	diff wireless 21.1kqCO2eq 50.2kWh	diff wired 30.5kqCO2eq 72.6kWh
Grocer	7524 kWh FR: 436.4kgCO2eq DE: 3461kgCO2eq EU: 3160kgCO2eq	1.30%	2.29%	0.66%	0.94%	0.67%	0.96%
Cheese shop	8856 kWh FR: 513.6kgCO2eq DE: 4073.7kgCO2eq EU: 3719.5kgCO2eq	1.10%	1.94%	0.56%	0.80%	0.57%	0.82%
Mini-market 1	24315 kWh FR: 1410.3kgCO2eq DE: 11184.9kgCO2eq EU: 10212.3kgCO2eq	0.40%	0.71%	0.20%	0.29%	0.20%	0.30%
Mini-market 2	44627 kWh FR: 2588.3kgCO2eq DE: 20528.4kgCO2eq EU: 18743.3kgCO2eq	0.22%	0.38%	0.11%	0.16%	0.11%	0.16%

Disclaimer: Values may vary based on the LCA software versions.

What does the consumption represent

Wireless and wired solutions in France

Device	Power	Wireless 98kWh equivalent	Wired 172kWh equivalent	Source
Electric wall heater	2kW	49 h	86 h	[letsaveelectricity.com]
TV	100W	980 h	1720 h	[electricalampere.com]
Laptop	65W	1508 h	2646 h	[electricalampere.com]
Microwave	1kW	98 h	172 h	[electricalampere.com]
LED bulb	10W	9800 h	17200 h	[electricalampere.com]
Incandescent bulb	60W	1633 h	2866 h	[daftlogic.com]
Positive cold room	190W	22 days	38 days	[hvacspareparts.com]
Negative cold room	375W	11 days	19 days	[hvacspareparts.com]
Cash register	25W	3920 h	6880 h	[posmanuf…ed.com]

What does the consumption represent

Wireless and wired solutions in Germany

Device	Power	Wireless 54.3kWh equivalent	Wired 78kWh equivalent	Source
Electric wall heater	2kW	27 hours	39 hours	[letsaveelectricity.com]
TV	100W	543 h	780 h	[electricalampere.com]
Laptop	65W	835 h	1200 h	[electricalampere.com]
Microwave	1kW	54.3 h	78 h	[electricalampere.com]
LED bulb	10W	5430 h	7800 h	[electricalampere.com]
Incandescent bulb	60W	905 h	1300 h	[daftlogic.com]
Positive cold room	190W	12 days	17 days	[hvacspareparts.com]
Negative cold room	375W	6 days	8.7 days	[hvacspareparts.com]
Cash register	25W	2172 h	3120 h	[posmanuf…ed.com]

Predictive maintenance

Power meters track real-time electrical consumption and highlight deviations immediately.

By comparing actual usage to expected daily ranges, operators can detect anomalies long before equipment failure.

Taking cold rooms as an example,

- Bad door gaskets (bad door sealing) can waste 10–20% of cooling energy.
- Poor condenser heat rejection (blocked coil, failing fan, dirty condenser), field studies show condenser inefficiency can increase energy consumption by 10–30%

Source: https://www.idealfreezer.com/blog/cold-room-design-tips-for-optimal-efficiency520

Conclusions

- Both maximum scenarios are in France, and option 2 was a better system for smaller operations, representing at most (approximately) 1.30% for wireless solution and 2.29% for wired

- Energy consumption tracking can also help with predictive maintenance, identifying equipment that is consuming more than expected

- Moreover, for the first two establishments, less points of measure could be envisioned, deploying a system better dimensioned for such operations and reducing yearly CO2 footprint

- Future work: shift to a more technical approach, network simulation for energy use and CO2 calculation

Electricity mix data used

For calculation of GHG Use Phase

France	0.058	kgCO2eq/kWh
Germany	0.46	kgCO2eq/kWh
Europe Average	0.42	kgCO2eq/kWh

Source: ADEME – Base Empreinte ®

Thank you!

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