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WHITE PAPER

Measuring Waste Heat in Buildings

A first step toward heat recovery

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ABSTRACT

Buildings release large amounts of thermal energy that has already been paid for, through process heat, exhaust air, wastewater, flue gas and many other pathways. Recovering it before adding new energy can lower costs and emissions, reduce the size of new systems and ease pressure on electricity grids. Yet most buildings cannot say how much energy they lose, where it is lost, or when. This paper explains what waste heat is, why measurement is the necessary first step toward recovering it, and how low-cost wireless sensors based on LoRaWAN can provide the real-time data needed. It also sets out the limitations of this approach and the value the data creates for building owners, engineers, operators and the wider energy system of cities.

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What is waste heat?

Electricity grids worldwide are under growing strain. Heating is being electrified, cooling demand is rising and new loads such as data centres are coming online. In many cities, grid capacity is becoming a hard constraint on new development and retrofits. Before adding new energy to a building, the most accessible supply is often the energy it already uses and then throws away: its waste heat.

Every unit of energy that enters a building, whether as electricity, gas or another fuel, is ultimately converted into thermal energy. Some of it is delivered through the building's heating, cooling and ventilation systems. The rest, wasted along the way through processes, inefficiencies and system design, is waste heat. The knowledge and technology to reduce it already exist globally: well-engineered systems can capture and reuse waste heat within the building, reducing how much energy must be bought from the grid or other sources.

In the Nordic countries, for example, long, harsh winters have made these design principles and technologies standard practice. Buildings and districts there are designed to use every available thermal source on site, such as exhaust air, wastewater and heat from cooling and IT equipment, before adding new energy. The same thinking can be applied anywhere.

COMMON SOURCES OF WASTE HEAT AND HEAT LOSS



Combustion flue gas

From boilers and water heaters.



Exhaust air

Warm air in winter and cooled air in summer, vented by ventilation fans.



Cooling heat rejection

From chillers, cooling towers and refrigeration.



Wastewater

From showers, kitchens and laundry.



Process heat

From server rooms, compressors, kitchens and other equipment.



Distribution losses

From hot and chilled water piping and tanks.

Capturing the lowest-hanging fruit

Waste heat recovery starts from energy a building already pays for, which makes it one of the most cost-effective first steps toward lower energy use. Its value is greatest when existing systems are due for replacement, as that planned capital can be invested in more efficient system design and technologies rather than like-for-like replacements that lock in today’s inefficiencies for another 20 to 40 years. Recovering waste heat pays off in several ways:

Smaller new systems	Heat that can be recovered does not need to be produced. Accounting for it at the planning stage can reduce the size of new heat pumps, boilers or chillers, and the investment that comes with them.
Lower operating costs	Every unit of heat recovered is one the building no longer buys as fuel or electricity.
Lower emissions	Less fuel burned and less electricity drawn means a smaller carbon footprint, which matters more as building performance standards tighten in markets around the world.
Freed-up grid capacity	A smaller electrical load can delay or avoid costly upgrades to a building’s grid connection, increasingly a bottleneck in electrification projects.
Greater resilience	A building that meets more of its own thermal needs is less exposed to energy price swings and supply disruptions.

Some buildings already use basic forms of heat recovery, but making full use of waste heat is not yet standard practice. A major reason is that most buildings have no clear picture of how much energy they are losing, where it is lost, or when.

03 · THE GAP

Why measurement comes first

Designing systems that reduce waste requires an accurate picture of how a building operates. Heating and cooling systems are sized for design conditions, meaning assumed occupancy, weather and schedules, which rarely match day-to-day operation. Real-time data on actual performance is the most reliable basis for optimization.

Most buildings do not have this data. Meters and utility bills show how much energy is consumed, not where it is lost. Building management systems are designed to maintain set temperatures, not to show inefficiencies such as simultaneous heating and cooling, or energy rejected in one place while it is needed in another. Energy audits capture a single point in time and often rely on simulations that are only as accurate as their assumptions.

Measuring waste heat with wireless sensors

Wireless sensor networks offer a practical way to gather this data. Sensors that communicate over LoRaWAN (Long Range Wide Area Network) are designed for long-term, low-maintenance monitoring, and can be installed without the cost and disruption of permanent metering. Several characteristics make them well suited to measuring waste heat:

Non-invasive installation

Sensors clamp or strap onto existing pipes, ducts and equipment, with no new cabling, pipe work or system shutdowns. They can be moved or reused as systems are upgraded.

Long battery life

Sensors typically run for 8–10 years on a single battery, so little maintenance is needed once they are installed.

Frequent readings

Data is sent every 5–15 minutes, enough to show how waste heat varies across the day and the seasons.

Scalable networks

Each reading is small, so a single gateway can handle data from several buildings. In practice, range extenders are often needed to keep every sensor connected through dense construction and basements.

HOW A TYPICAL NETWORK IS CONNECTED

Sensors

On pipes, ducts and key equipment



Range extenders

Where walls and basements block the signal



Gateway

One can serve several buildings



Analytics platform

Real-time data, accessible remotely

A typical deployment measures temperatures and flow rates on the building's main energy streams: exhaust air, flue gas, hot and chilled water, and cooling equipment. It also tracks the electricity use of key equipment and outdoor conditions. These are simple measurement points, but together they give a clear picture of how the building actually operates and how much thermal energy is available to recover. They also show when that energy is available, which determines whether recovered heat can be matched with a demand for heat elsewhere in the building.

Limitations to consider

LoRaWAN sensing is a practical way to measure waste heat, but it is not a replacement for every type of metering. Understanding its limits helps set the right expectations and design the right deployment.

Live data, not billing-grade data

The sensors provide live, measured data. Because they measure from outside pipes and ducts, variables such as installation and surface conditions can skew individual readings, so the data is not billing-grade. While not exact, the level of accuracy is sufficient to identify and size recovery opportunities, and trending readings over time smooths out irregular data points.

Monitoring, not control

LoRaWAN is designed for small, infrequent data packets. It suits monitoring at intervals of minutes, not real-time control of building systems, which remains the role of the building management system.

Coverage takes planning

Concrete, steel and basements weaken the signal, so most buildings need range extenders or additional gateways. A site survey before installation avoids gaps in the data.

Placement matters

Accuracy depends on where and how sensors are installed: straight pipe runs for flow meters, good thermal contact and insulation for temperature sensors, and representative locations in ducts.

Within these limits, LoRaWAN offers a fast, low-cost first look at how a building really operates. It is often the step that justifies more detailed metering, or a recovery investment, later.

What the data enables

With real-time data on waste heat, recovery becomes a planned investment rather than an assumption. The value extends beyond the individual building to the wider energy system around it.

Within the building

Measured data turns an invisible loss into a quantified opportunity, in energy and in money.

BUILDING OWNERS AND INVESTORS

Prioritize the opportunities with the strongest return, and give lenders and funding programs the evidence they need to back a project.

ENGINEERS AND DESIGN TEAMS

Assess whether measured conditions support specific retrofit measures before committing to detailed design. Real operational data reduces reliance on detailed energy modeling for early-stage opportunities, improves model accuracy and allows new systems to be sized on measured conditions rather than design assumptions. After upgrades, consistent before-and-after data streamlines measurement and verification (M&V), with comparable baselines across buildings.

OPERATORS AND COMMISSIONING TEAMS

Gain remote visibility into true operating conditions, even in buildings without a building management system. Continuous data simplifies commissioning and retro-commissioning, reveals inefficiencies such as simultaneous heating and cooling, enables ongoing system tuning and reduces the need for extensive on-site diagnostics.

TENANTS AND OCCUPANTS

Benefit from lower energy costs and more stable indoor conditions.

Across districts and cities

When many buildings are measured, the data shows where surplus heat and heat demand sit close together, and how energy flows across a neighbourhood.

UTILITIES AND GRID OPERATORS

Lower electric capacity requirements through recovered heat, and plan grid investment for electrification with better demand data.

THERMAL NETWORK PLANNERS

Identify zones of thermal energy supply and demand to guide the coordinated development of heat sharing and district thermal energy networks.

PUBLIC AGENCIES AND POLICYMAKERS

Gain visibility into building performance, energy waste and decarbonization potential across the building stock to inform climate policy and building performance standards.

Conclusion

Waste heat is one of the most accessible energy resources in the built environment. It is already on site, already paid for and, in most buildings, largely unmeasured. As buildings around the world replace ageing heating and cooling systems, and as grids come under growing pressure, recovering that energy before adding new supply is an increasingly practical place to start.

The first step is understanding what is actually happening in the building. Low-cost wireless sensing makes that step simpler and less disruptive, providing the real-time data needed to design, finance and operate systems that make the most of the energy a building already has. At a larger scale, the same data helps connect buildings that have surplus heat with those that need it.

Key takeaways

- 1 Waste heat is an overlooked resource.** Every building releases energy it has already paid for, through process heat, exhaust air, wastewater, flue gas and many other pathways.
- 2 Measurement comes first.** Design conditions rarely match real operation, and conventional meters, building management systems and audits do not show where energy is lost.
- 3 Recover before you add.** Using the energy already on site lowers costs and emissions, reduces the size of new systems and eases pressure on the grid. System upgrades are the best moment to do it.
- 4 Wireless sensors make measurement practical.** LoRaWAN sensors are non-invasive, long-lasting and quick to deploy. Within their limits, they give a clear picture of actual conditions and the thermal energy available to recover.
- 5 The value extends beyond the building.** The same data supports better design, operation and investment decisions in each building, and helps utilities, planners and public agencies plan for heat sharing and thermal energy networks across cities.