Can you achieve Zero Energy Buildings?

EVALAN

Introduction

The Dutch government has become unquestionably committed to encourage the creation of energy neutral buildings. To that end, it has implemented changes in construction standards.

Current measures aiming to slow down climate change affect new constructions, leading to higher than ever overall cost of a building's footprint. To compensate for this, buildings with self-generated energy schemes are becoming subsidized, making it much more appealing for the construction sector to build energy neutral residential and commercial buildings. But how do you prove that the houses are energy neutral? With the Internet of Things (IoT) you can monitor energy consumption in detail and demonstrate your building meets the requirements. In addition, IoT can help gain an updated picture of the condition of specific building components. When complaints arise, it quickly becomes clear whether there is an equipment problem or whether there are other causes. IoT also enables you to better manage maintenance and thus save costs. We therefore have every reason to build energy-neutral residential or non-residential buildings and monitor them with IoT.

Would you like to know how IoT can help you make your buildings greener? Book a meeting with one of our IoT experts!

In this whitepaper, we will discuss:

1. Green Buildings on the rise

It is no surprise that investors have become exceedingly interested in Green Buildings due to the lucrative savings in overall energy costs, and the support these get in subsidies from governments. The interest is deepened by changing legislation and the need to stay ahead of it, rather than passively waiting for environmental directives to become mandatory. Furthermore, Morgan Stanley's research shows that investing in sustainable real estate is profitable. Green Buildings represent more value than conventional buildings[1], are energy efficient, and use 11% less water on average[2]. As a result, the total operational costs of these buildings can drop by up to 37%[3], and a demonstrably sustainable building can be worth up to 43% more[4].

The Building Technology Office of the US Department of Energy (DOE) estimates that the annual energy savings in the commercial sector could rise to 29 percent.[5] This can be achieved by using state of the art sensors, implementing IoT technology to measure and monitor overall performance, controlling and operating climate systems remotely, and automating predictive maintenance.

[1] USGBC Partners with Dodge Data and Analytics to Release World Green Building Trends Report 2016, Marisa Long
[2] Benefits of Green building, USBGC
[3] Green Buildings: A Finance and Policy Blueprint for Emerging Markets, IFC 2019
[4] A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties, Niina Leskinen, Jussi Vimpari, Seppo Junilla, 2020.
[5] Innovations in Sensors and Controls for Building Energy Management, U.S. Department of Energy, 2020

Gaining insight into building use with sensors

A beneficial way to keep track of energy consumption is through IoT in buildings, also known as Building IoT or B-IoT. From measuring the temperature and humidity, and automating heating and cooling in rooms, to remotely monitoring whether doors or windows are open, and thus adjusting climate controls accordingly, building managers can gain insight into efficient energy use. Memoori predicts that the global use of IoT in buildings will grow annually by 7.3 to 11.6 percent in the period 2019-2025.[6]

With B-IoT, sensors connect to each other and to the internet making it possible to collect data about the conditions of a building from almost any location, including temperature, humidity, equipment state, but also overall energy use and energy production of solar panels, for example. By measuring these parameters, it becomes easier to monitor and adjust energy consumption according to the demand of the building's occupants. B-IoT can also play a role in the condition and maintenance of systems. Through predictive maintenance techniques, B-IoT can be used to determine the condition of in-service equipment and to predict when maintenance should be performed. This way of "smart managing" a building facilitates cost savings as maintenance is only performed when needed, instead of routinely.

A demonstrably sustainable building can be worth up to 43% more.

[6] Innovations in Sensors and Controls for Building Energy Management, U.S. Department of Energy, 2020

2. From Energy Performance Coefficients to NZEB: The Business Case

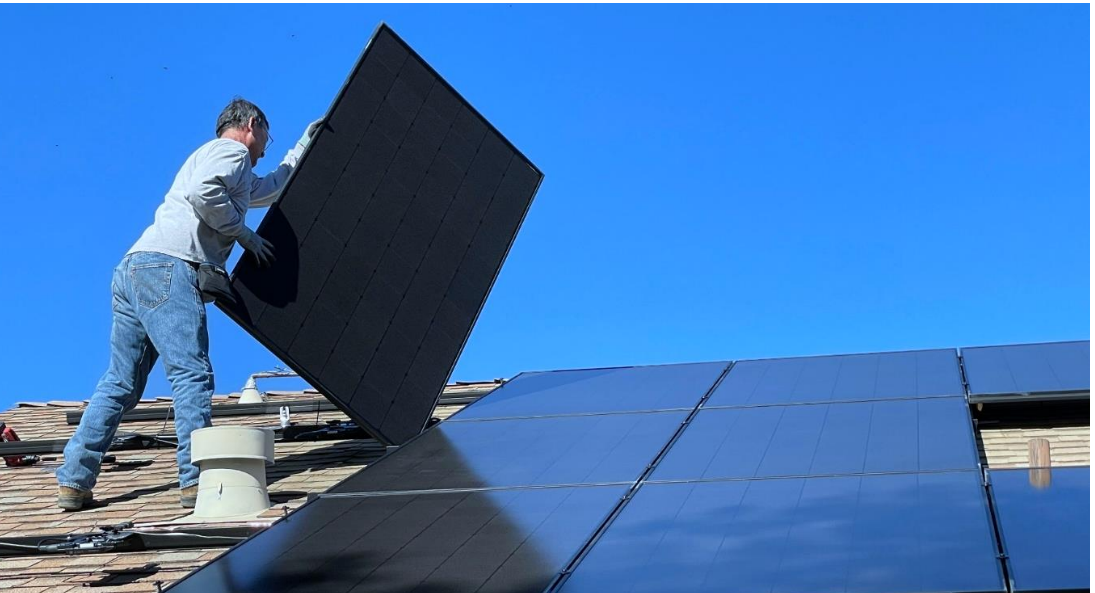
From 2021, the Energy Performance of Buildings Directive required EU countries to ensure that all new buildings were *nearly zero-energy buildings* (NZEB), and the European Union has now proposed to move forward to zero-emission buildings by 2030. Currently, under the *nearly zero-energy* standards, the energy performance of a building is calculated based on three energy performance indicators. However, these NZEB standards are based on design calculations made before the building is constructed. They do not consider how occupants make use of a building.

With B-IoT, it is possible to determine if the calculations made during the design phase were correct and if the design estimates correspond to the actual energy consumption. These insights are important for future developments. With the knowledge acquired from using B-IoT, corrections can be made if needed. Measurements showing that the standards are met will make the building more valuable in the long term. Moreover, most financial contributions made available by governments to stimulate energy neutral construction are linked to the current annual energy use, and not to the investments in construction. B-IoT provides many benefits, particularly in monitoring the actual output of NZEB indicators 1 (energy requirement) and 3 (minimum share of renewable energy).

NZEB1: Energy requirement

NZEB1 is based on the ratio between floor area and maximum energy consumption. The energy requirement is also determined by architectural matters such as the orientation of the building and the equipment used to heat, cool, and light the building. NZEB1 is thus calculated based on design and does not always reflect the actual conditions of the building. For example, if the equipment is not properly configured or not adjusted to actual operational requirements, a modern high-tech heat pump could use more energy than a traditional heating system. If unused rooms are cooled or heated, the energy consumption will be unnecessarily high in relation to the actual occupancy. And if blinds do not automatically close on hot days, the air conditioning could work overtime.

In short, achieving progress beyond the NZEB1 standard depends on more than simply insulating your building better. It involves being able to monitor the energy consumption of all rooms and having the ability to make targeted adjustments. In this white paper, we will discuss the diverse types of IoT sensors which provide you with needed insight into the actual energy consumption of the different rooms in a home or a building.



NZEB3: The share of renewable energy

NZEB3 is based on the ratio between fossil fuel use and usable floor area. Like the previous indicator, it is also a calculation based on design that can deviate significantly from the actual practice. Who monitors whether solar panels achieve the maximum output? Who measures whether solar collectors gather the necessary amount of sun (based on the calculations)? These are also parameters that can be monitored with IoT and are made visible in a dashboard. Automated alerts can be sent if, for example, a solar panel is underperforming.

NZEB3 also uses a “TO July” parameter, which refers to a standard that newly constructed buildings need to meet to ensure that even during the hottest month of the year the temperatures in the building are at an acceptable level. However, this design standard says little about how the building will actually perform. For example, if occupants do not correctly switch a heat pump to the cooling operation, but turn the air conditioning on instead, the amount of energy that is used is higher than necessary. In short: data is knowledge; and with B-IoT, operators can control and improve everything in their buildings.

The business case of energy monitoring with IoT

It is becoming clear to housing corporations, commercial building owners and investors that B-IoT can help them achieve design sustainability targets and save costs. In that sense, B-IoT is more frequently becoming part of the building's design specifications. However, the business case for additional investments in sensors, controls, communication equipment and other elements of the B-IoT system is not always easy to convey, as the estimation of potential returns is a crucial element of any business case. If the business case is made on the NZEB standards alone, then the actual energy consumption usually tends to be underestimated. Since, as described above, these NZEB standards are based on design calculations and say little about actual energy usage.

Include running costs in the budget

The only way to get a realistic business case is to include the running costs in the budget. This way of thinking is still new in residential and commercial construction. In infrastructure projects, the lead contractor is often also responsible for maintenance periods that can stretch to ten or twenty years after completion. As a result, contractors, project supervisors, and other parties involved make design choices based on lifetime costs, not only on construction costs. A large glass facade in a train station may look beautiful, but the costs of the monthly window cleaning can considerably add up. That is why developers tend to look for solutions that can lower maintenance costs, or invest (during the construction phase) in technology that can save them costs later. B-IoT and remote monitoring of assets means a higher initial investment but savings in the long term.

Payback period of two years on average

In both residential and commercial construction, stakeholders —such as contractors, architects, and project developers— need to meet the NZEB standards. These standards do not include requirements to invest in remote monitoring and controlling, nor do they take into consideration how building spaces are actually used in practice. Nonetheless, monitoring and controlling are the exact actions that provide the data needed to prove compliance with energy performance standards and to receive financial compensations for achieving the energy targets. With the resulting annual savings, investments in B-IoT are typically recovered within two years.

The average payback period depends on the type of project

This average payback period is an estimate. The actual amounts of investment and savings depend on each building and the chosen B-IoT implementation. The figure below shows some building-related factors that influence the payback period.

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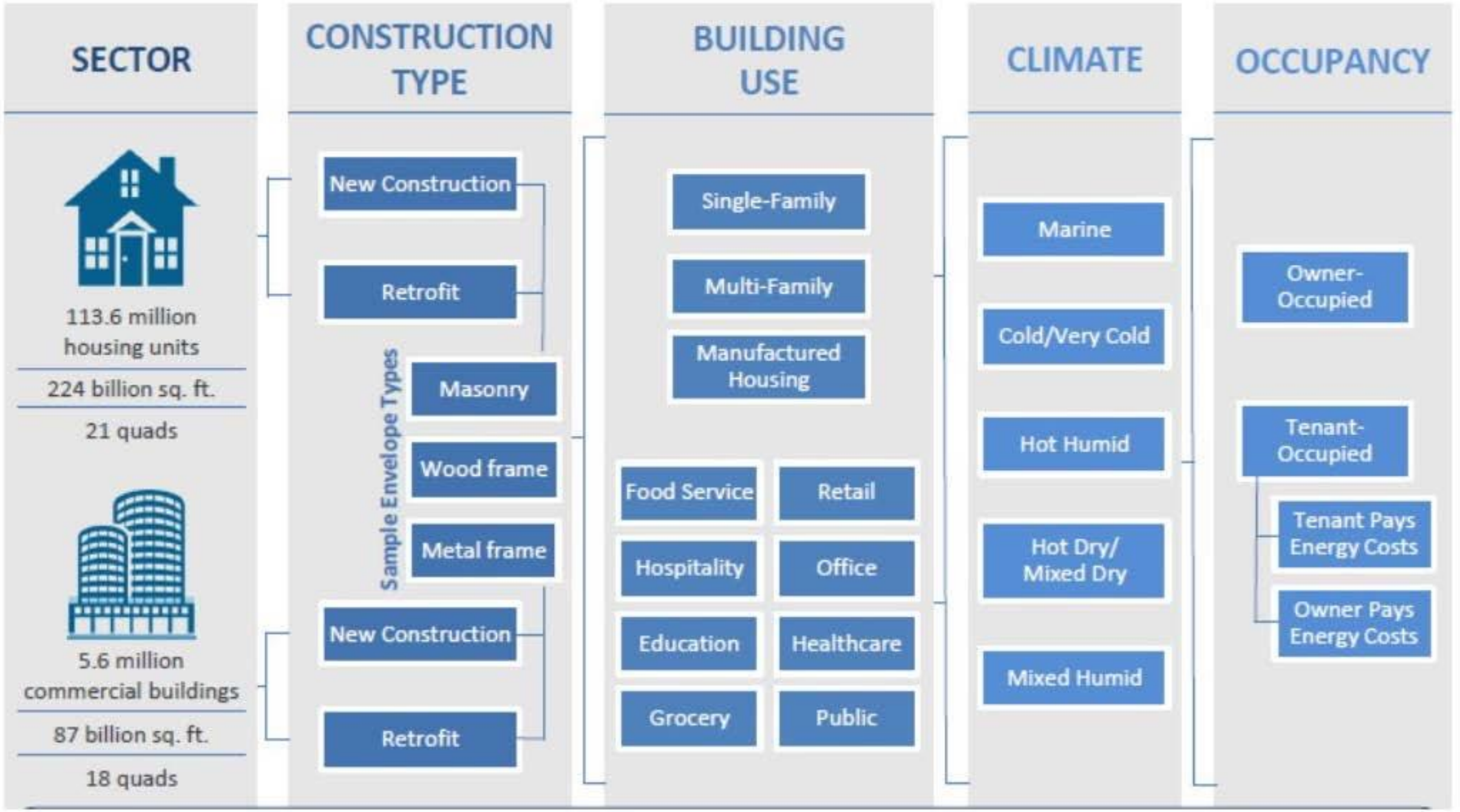


Source: Innovations in sensors and controls for building energy management report from the US Department of Energy.

Evalan can support you in determining the actual savings that can be achieved with B-IoT for your project.

3. Monitoring and adjusting energy consumption with B-IoT

There are several ways in which Building IoT can monitor energy consumption. The following are some of them.

The Smart Meter and energy consumption meters

The Smart Meter is the most used method in residential construction. It provides rough measurements of a building's energy consumption. Other types of energy meters can provide more accurate energy consumption data, including at home-appliance level (e.g., the energy consumption of a computer, television, or refrigerator), and can be installed into existing infrastructure. Having the capability to collect and store this information makes it possible to compare energy consumption over periods of time, and energy performance between different buildings or houses. This allows you, for example, to see how using appliances efficiently influences your general energy consumption or the combined effect of solar panels and a sunny year on your energy bill. MilieuCentraal[7] estimates that having active insight, through smart meters, into energy use leads to savings of 2.7 percent on electricity and 2.8 percent on gas.

[7] Inzicht in je energierekening, Slimme meter, MilieuCentraal

Sensors that provide insight at room level

When it comes to commercial construction, having broad insight into the energy consumption of the entire building is not enough to reduce energy use. Commercial buildings, such as offices, need to focus more on room performance. Several types of sensors are available to help with this. They measure, among other things, the following parameters:

- Temperature and humidity
- Space occupancy
- VOC (volatile organic components)
- PM (particulate matter)
- CO2
- Light intensity
- Contact (for example, to register whether a door or window is open)
- Carbon monoxide levels
- Consumption per device

Most B-IoT devices can measure several of these parameters simultaneously. The sensors can be connected to the existing installations and used for automated control schemes that take into consideration the actual use of the building.

Predictive maintenance

Finally, it is important to know whether the equipment used to reduce energy consumption (e.g., solar collectors) or the equipment used to generate energy (e.g., solar panels) is adequately working. Do they perform at maximum efficiency? Are the control settings of radiators or underfloor heating correct? How well are solar panels functioning? By recognizing patterns in time series data and comparing daily operations with those patterns, maintenance requirements can be identified early. This is predictive maintenance. With embedded software or IoT, you can monitor your equipment and adjust it when needed.

4. More benefits of a data driven building

Monitoring energy consumption has become part of the broader trend of smarter data use. After all, the digital revolution has made it increasingly easy to collect, analyze and gain new insights through data. Furthermore, experience in other markets shows that new insights are being found in more areas than initially thought.

Plan maintenance better

For example, in the industry market a lot of experience has already been gained with predictive maintenance. Companies that monitor the performance of their machines with IoT achieve significant maintenance savings. Today, most equipment used to heat or cool buildings is already supplied with sensors that measure key parameters, such as water pressure or pump speed of heating systems. These sensors send a signal when some parameter goes above or below threshold values. It is also possible and important to combine different data sets, as problems tend to appear after minor abnormalities (e.g., deviations in the temperature of the water flowing in and out of a central heating boiler, or gradual increases in a boiler's power consumption). Even when each key parameter remains below threshold values, by looking at various parameters together, the overall patterns could still indicate that

maintenance is required. This could act as an advanced warning, where maintenance may not be needed today but will be required in the next weeks or months. These insights can make planning maintenance more efficient, leading to better resource use, and help to prevent operational failures.

Getting the most out of your equipment

Combining different indicators could also provide better insight into how equipment is used. It happens far too often that high-tech equipment is used incorrectly, resulting in failure to reach energy-saving goals. With the combination of different indicators, and issues that can be detected with the help of big data analytics, you can achieve insight into how your equipment is operating. Adjustments that result from these analyses could be simple and could make a significant difference to the performance of the building operations.

Better insight into the use of a building

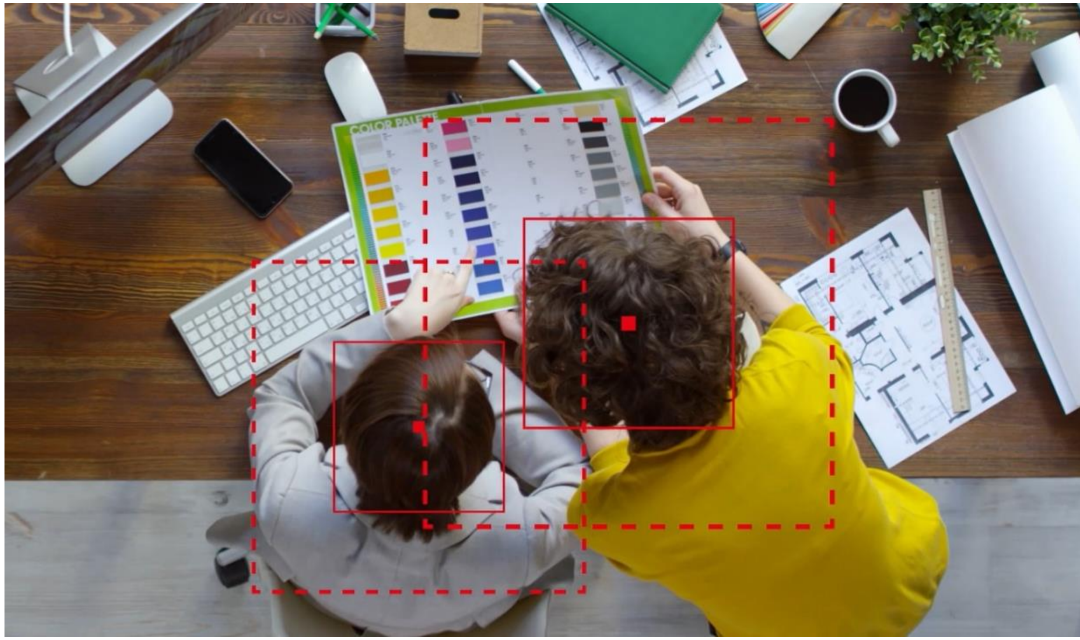
Going a step further would mean using smart Machine Learning algorithms (which make use of all collected data) to find patterns in the measurements taken via tens of thousands of sensors. Machine Learning algorithms can find correlations that are not otherwise visible. These correlations could be used to define new control settings of the equipment in the building; settings could even be adjusted in real-time if the use of the building changes from one day to the next.

Companies that monitor the performance of their machines with IoT achieve significant maintenance savings.

Cut costs without cutting corners

Experience in other sectors shows that after receiving the first tangible results from advanced data analysis, people want to know and do more. Some of the usual questions include "what if we also measure this, could we then do...?" The exact ideas and questions that arise depend on the use and energy goals of the people using a unique building, which leads them to need unique insights about it. An example that demonstrates one of the unforeseen side effects of data analysis comes from the Chemical Industry. In the mid-1970s the chemical industry started paying much more attention to its safety because of several major accidents. The systems and methods that were implemented to monitor incidents and to improve safety ended up leading to significant understanding of production and work processes, and thus to their improvement. With the acquired knowledge it became possible, for example, to improve production throughput, increase on-stream time, reduce unscheduled outages, and to increase quality.

In the example, the focus on safety led the companies to gain more knowledge about the processes and systems they used, to document better, to improve communication, and to work more accurately. While companies initially considered the investments in higher safety standards as additional costs, they found that these unexpected benefits greatly outweighed those investments and deliver a positive return to investment (ROI).



The same will occur when the monitoring systems are added to buildings. Even by keeping it basic at the beginning —with the installation of an infrared sensor or a more advanced object recognition sensor to measure whether a room or workspace is in use— insights into the actual occupancy of a building will increase. This will not only improve the building's energy management, but other processes as well, including cleaning more efficiently (why would you clean areas that have hardly been used?), closing floors if the occupancy rate allows it, or making efficient use of rooms.

Some organizations have even been able to postpone new construction plans because they realized that the occupancy rate on the existing campus was far from reaching its limit. In short, savings can be achieved in more areas than just energy consumption. Which areas? That depends entirely on the building, its use, and your creativity to do more with data.

Each building needs unique insights, based on their daily use and energy goals.

5. Six preconditions for success

The number of sensors needed to gain detailed insight into a building's energy consumption depends on the type of building. For detailed insight on a house, depending on its size, you would need to equip it with ten to hundred sensors. In a large office building, the numbers can increase to thousands of IoT devices. In a campus, hospital, or factory building, it could be tens of thousands.

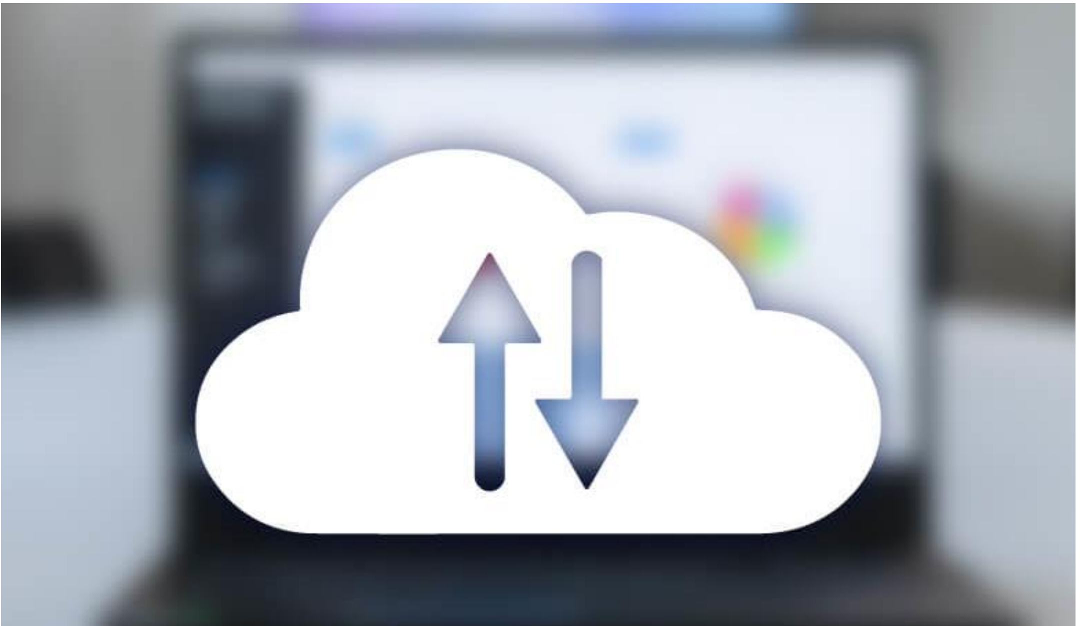
Mounting a sensor and then measuring the results is not that difficult. Sending the data from one sensor to the monitoring environment in the cloud is also not overly complicated. But collecting data from tens of thousands of sensors, uploading this data to the cloud continuously, and managing this IoT infrastructure reliably, is complex. Creating dashboards that provide aggregated data and actionable advice for users is also no easy task. The work is for specialist, as the challenges lie in several areas.

1. Security

IoT devices remain in use for years, which is why they must also be prepared for future risks. The variety of IoT devices is significant, and the sensors are used everywhere: inside and outside of buildings. As hundreds of thousands of IoT sensors are required for a larger site, even one compromised device would be enough to enter the (company) network. By following the right engineering practices and techniques this can be prevented. This entails meticulous work that requires experience. In that sense, the system must not only be safe today, but also be safe tomorrow. Devices need to be prepared for firmware updates, with tools that enable automation of this process and perform this remotely (over-the-air), reliably and instantly.

2. Reliability and scalability of cloud connectivity

In large environments where tens to hundreds of thousands of IoT devices are required, the IoT system must be scalable and reliable. It is not just a matter of getting enough bandwidth. To manage this system effectively, routine tasks need to be performed automatically. Uploading new firmware to IoT devices is not only a critical feature to maintain security, but also to ensure that the devices still comply with all standards, which change periodically. To effectively automate firmware uploads, the system needs to keep track of the current firmware version of each device.



The system should also be able to determine whether a new firmware transfer was successful (and not interrupted by a connection error). The device itself should revert to the previous version if the update was not successful. This feature is not visible to users and is, therefore, not always considered when choosing IoT solutions. The availability of this functionality, along with a few other critical ones, determines the long-term success of the IoT system. It is thus necessary to be able to monitor and manage the entire system down to sensor level.

3. Able to work with the most used communication protocols

B-IoT sensors and devices use different communication protocols, such as Modbus, Zigbee, Z-wave, P1, M-BUS, LoRa and Bluetooth. During the design phase of a building, the communication protocols can be defined. But no one knows what the future holds. Innovative technology that uses a different communication protocol may be developed. It is thus important to equip buildings with IoT gateways that support many protocols.

4. Future proofing the IoT devices

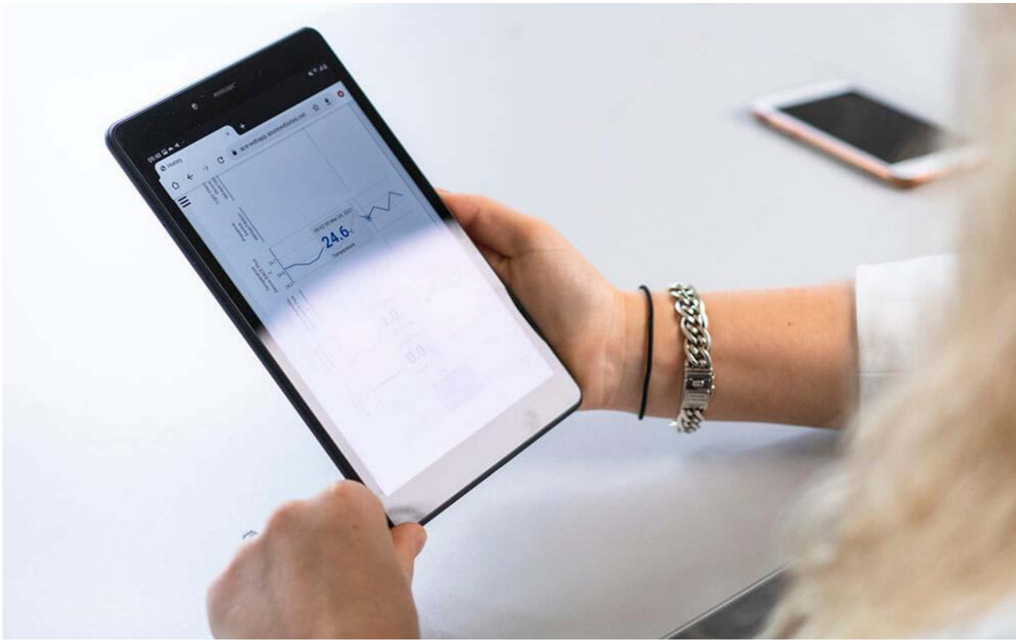
Another important consideration is future sustainability. New buildings are expected to remain in service for decades, thus equipment installed inside the buildings should also last for many years (at least fifteen and preferably longer). In that sense, any IoT system in a building should be future proof as well. This means that it should be able to support future use cases, including those that have not been identified yet.

5. Operations Technology way of thinking

An Operations Technology (OT) approach is important to the success of IoT. Perhaps the biggest pitfall is that many people who work in the IoT world have an IT background. However, an environment with ten to hundreds of thousands of IoT devices is more related to the world of OT. OT is typically based on working with PLCs (programmable logic controllers) and SCADA systems (supervisory control and data acquisition). These systems are designed for optimum implementation of measurement and control technology and, although there are also similarities, the starting points are often different than in IT. IoT corresponds more to the specific characteristics of an OT environment than an IT environment.

6. Meaningful dashboards with actionable information

Finally, the collected data is only useful if you can convert it into meaningful and actionable information. Dashboards can provide high-level insight into the building's energy



performance and allow you to track a room or device. When these dashboards provide more than insight into generic KPIs by displaying data on the performance of one specific building, part of the building, or one operational unit, they add even more value.

In many cases, aggregated data adds more value than segregated one. The temperature in a room can be 20 degrees, a value that is within expectation, but if the heating is on and the windows are open at the same time, it is a completely different situation. In short, the dashboards will have to provide insights into pooled data. Creating such dashboards is more than just a technical challenge. After all, the various data sources must come together on one platform that can read all those values properly. The consists in determining which data aggregation provides added value and then developing algorithms for it.

Dashboards deliver even more benefits by comparing real-time values with historical data and data from comparable buildings or installations. For new buildings, dashboards can make increasingly better predictions over the years as more historical data is collected. It is precisely these predictions that ensure that you can make timely adjustments.

By following the right engineering practices and security techniques, breaches can be prevented. It is meticulous work that requires experience.

6. What can Evalan do for you?

Our advice to anyone facing a new construction or renovation project is: delve into the possibilities of IoT. Achieving zero energy buildings and the government-required standards is easy when you monitor the actual use of a building. This way you can determine whether the building complies with these standards and adjust, as necessary.

IoT is a proven technology and although B-IoT is still relatively new, there are several successful examples in different sectors, which are now monitoring their processes better, managing their assets more intelligently and maintaining their machines before they break, through IoT. Evalan works with companies from several industries and has extensive experience in applying IoT in different fields.

We have always been at the forefront of developments, also in real-estate. Our Smart Building technology was the first B-IoT system implemented at scale, and spun-out as a successful separate company (bGrid). Evalan recently launched the IoT connector BACE, a ready to deploy gateway that builds a connection between any asset and the cloud. BACE includes all functions that are needed in a state-of-the-art IoT system: security, reliability, scalability and future ready. Evalan also created a unique IoT device that works as a multifunctional sensor, thus measuring several key parameters inside a building.

In addition, we have partnerships with associations that are necessary in the IT ecosystem. Such as cloud specialists and companies that can develop the right machine learning algorithms to detect patterns in large quantities of IoT data, as well as deviations from those patterns. Such deviations may indicate that people have started to use the building differently or that equipment needs maintenance (e.g., boiler, air conditioning, heat pump, or solar panels).

Would you like more information about this topic? We are happy to make an appointment with you to discuss the options.

Evalan BV
Sarphatistraat 638
1018 AV Amsterdam
The Netherlands

T. +31 20 779 03 44
E. info@evalan.com
I: evalan.com
T: @EvalanBV
L: www.linkedin.com/company/evalan

EVALAN