WHITE PAPER

Embedded energy metering of Emax 2 and Tmax XT

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Introduction

Embedded energy metering of Emax 2 and Tmax XT
What does it mean? A use case application example to understand the benefit of Circuit Breakers embedded metering functionality.

With growing awareness of environmental sustainability, it has become increasingly important to pay attention to the sustainability and efficiency of electrical power distribution.

The sustainability journey starts measuring the energy consumed.
By doing so, we can identify areas where we can reduce energy consumption.

Scope of the document

The purpose of this document is to provide a comprehensive overview of the embedded metering capabilities of Emax 2 and Tmax XT, supporting implementation decisions and promoting the adoption of this technology.

This document can be divided in two sections

1) Explanation of what embedded metering entails and the main differences according to IEC 61557-12

2) Embedded metering real examples of CO^2 and cost savings (Application)

The document does not address the revenue grade metering topic. Emax 2 and Tmax XT are not revenue-grade-certified meters.

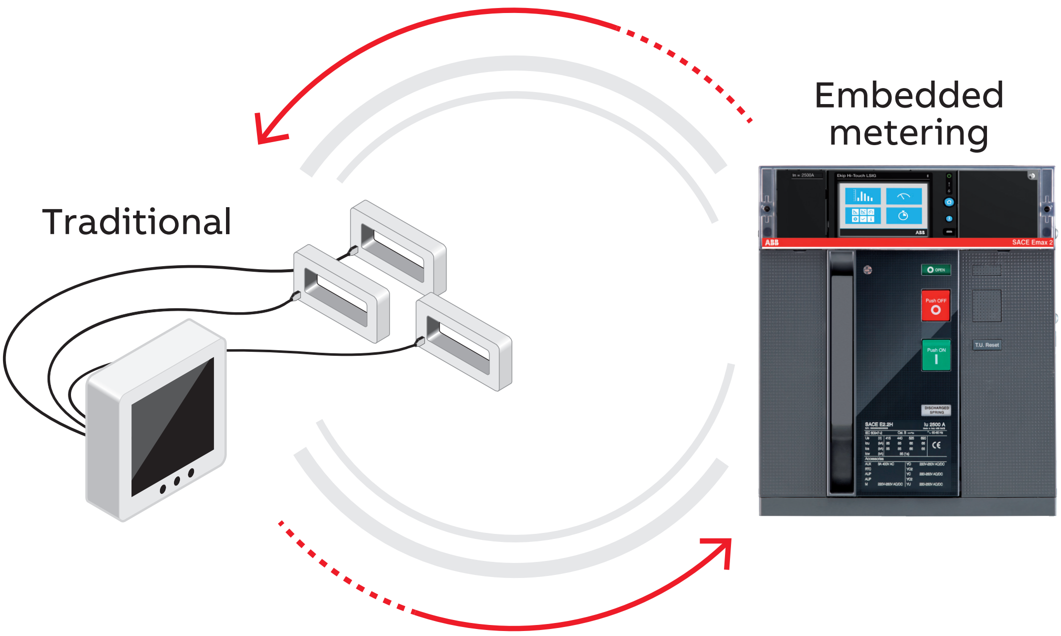
Starting from the requirements

When it comes to energy metering accuracy, we often start from the project specifications and then identify products that will allow us to reach the accuracy goal.

An example of specification could be:
the accuracy of the system will be class 1, as defined in IEC 61557-12. The system will measure the following parameters: active energy; reactive energy; apparent energy; active power; reactive power; apparent power; frequency.

We have two possible options for fulfilling this requirement: with an external meter; or by leveraging a circuit breaker's embedded metering functionalities.

Requirement: system accuracy class C according to the standard



IEC 61557-12 fundamentals

Embarking on the journey to comprehend embedded metering necessitates a foundational understanding of the IEC 61557-12 standard.
This pivotal document outlines the specifications for Power Metering and Monitoring Devices (PMDs), which are integral to maintaining electrical safety in low voltage networks. It meticulously defines the parameters for measuring various electrical aspects, including energy consumption, power quality, and system efficiency. Moreover, the standard introduces the concept of Equipment embedding Power Metering and Monitoring Functions (EPMF), signifying devices that seamlessly incorporate measurement capabilities in accordance with both their designated product standards and the IEC 61557-12. Delving into this standard is essential for industry professionals aiming to achieve uniformity and precision in power monitoring, thereby enabling data-driven decisions.

Starting current, Ib and In are terms used in the IEC 61557-12 standard, which defines the requirements for power measuring and monitoring devices (PMD) and equipment that incorporate such functions (EPMF).

These terms refer to the following concepts:
Starting current is the minimum current that the PMD or EPMF must be able to measure with a certain accuracy. It depends on the device's active or reactive energy class. For example, for class 0.5S, the starting current is 0.2% of the nominal current (In).

Ib (base current) is the reference current used to define the operating conditions of the PMD or EPMF. It corresponds to the nominal current (In) or half of it, depending on the type of load (balanced or unbalanced).

The base current is used to calculate the device's measurement uncertainty.
In (nominal current) is the maximum current that the PMD or EPMF can measure continuously without damaging itself. It is a parameter that characterizes the device's performance and must be declared by the manufacturer.

Table 8 of IEC 61557-12 shows the intrinsic uncertainty limits for different classes of active energy measurement under various power factor conditions. The table has four columns: the class of the PMD or EPMF; the power factor; the intrinsic uncertainty limit at Ib; and the intrinsic uncertainty limit at In.

In below table it is possibile to see in the red column values for PMD Dx, like Emax 2 and Tmax XT. In green column it is possible to se which are the treshold for an external power meter. in the white columns we can see the accuracy required for different accuracy classes (C).

Table 8 – Intrinsic uncertainity table for active power and active energy measurement

Specified measuring range		Power factor [c]	Intrinsic uncertainity limits for PMD of function performance class C [a b]		Unit
Value of current for direct connected PMD Dx	Value of current for sensor operated PMD Sx		for $C < 1$	for $C \geq 1$	
$2\ \%\ I_b \leq I < 10\ \%\ I_b$	$1\ \%\ I_n \leq I < 5\ \%\ I_n$	1	± 2,0 x C	No requirement	%
$5\ \%\ I_b \leq I < 10\ \%\ I_b$	$2\ \%\ I_n \leq I < 5\ \%\ I_n$	1	No requirement	± (1,0 x C + 0,5)	%
$10\ \%\ I_b \leq I \leq I_{max}$	$5\ \%\ I_n \leq I \leq I_{max}$	1	± 1,0 x C	± 1,0 x C	%
$5\ \%\ I_b \leq I < 20\ \%\ I_b$	$2\ \%\ I_n \leq I < 10\ \%\ I_n$	0,5 inductive 0,8 capacitive	± (1,7 x C + 0,15) ± (1,7 x C + 0,15)	No requirement No requirement	%
$10\ \%\ I_b \leq I < 20\ \%\ I_b$	$5\ \%\ I_n \leq I < 10\ \%\ I_n$	0,5 inductive 0,8 capacitive	No requirement No requirement	± (1,0 x C + 0,5) ± (1,0 x C + 0,5)	%
$20\ \%\ I_b \leq I \leq I_{max}$	$10\ \%\ I_n \leq I \leq I_{max}$	0,5 inductive 0,8 capacitive	± (1,0 x C + 0,1) ± (1,0 x C + 0,1)	± 1,0 x C ± 1,0 x C	%

Text definitions and tables are taken from IEC 61557-12 or summarized from IEC 61557-12.

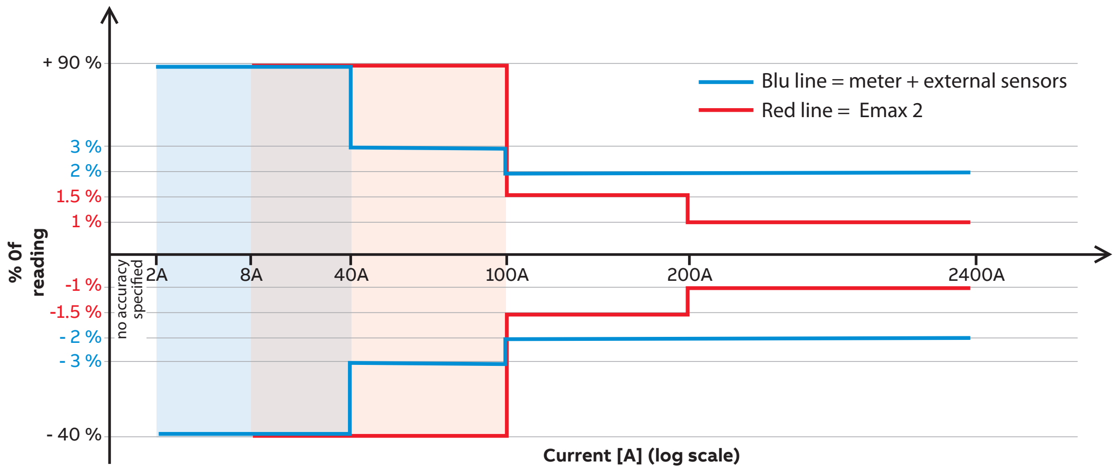
Graphic representation

In the following pages, we will compare a E2.2 with class 1% accuracy, an external power meter with high performance current sensors and and external power meter used low performance current sensors.

To assess system accuracy in the case of an external meter with current sensors, the root mean square formula has been used.

CB vs external meter + low performance current sensors

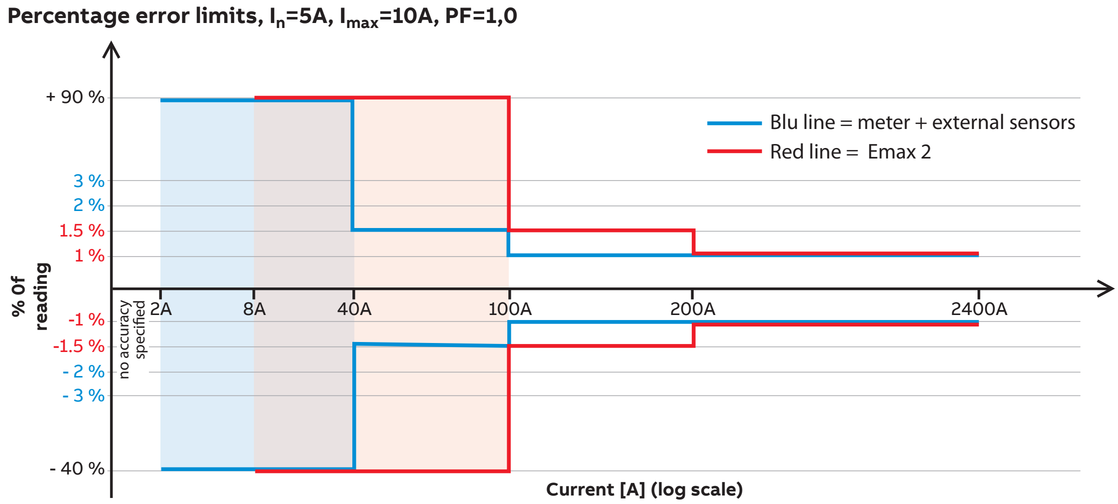
Percentage error limits, I_n=5A, I_{max}=10A, PF=1,0



In this case, there is an advantage to using the external meter in the window from 2% to 5% of the nominal current. However, the benefit in terms of accuracy is not negligible in the other windows, where the embedded solutions are the best option.

Graphic representation

CB vs external meter + high performance current sensors



In this case, there is a light advantage in terms of accuracy when using the external meter in the windows from 2% to 5% of the nominal current.

Depending on the power flow, it can be an advantage to replace the meter with an embedded power monitoring function.
This will lead to footprint, CO2 and cost savings. An example can be found at the end of this document.

Conclusions

Embedded metering advantage

In the specification, we speak about system accuracy.
This means the accuracy of all the devices must be taken into account:

Accuracy of CT + accuracy of the meter = system accuracy for PMD Sx

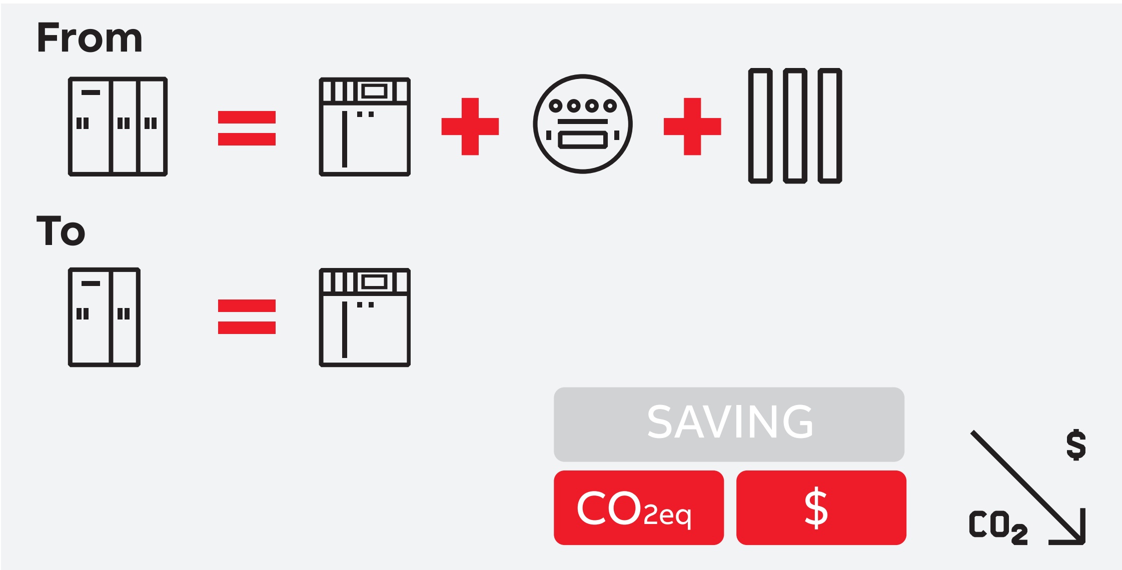
Accuracy of the device = system accuracy for EPMF Dx

For a current higher than 5% of Ib, to achieve the same accuracy of an EPMF Dx, a high-accuracy current transformer must be used. The table below makes this clearer.

It is possible to read the accuracy of the power meter on the x-axis, and the accuracy of the transformers and the relative system accuracy on the y-axis. For EPMF Dx (Emax 2), the accuracy of the system is 1% if a 1% package is activated.

System accuracy

Accucacy CT	**high**	2	1	0,5	0,5	0,2
	medium	3	2	1	0,5	0,5
	low	3	3	3	2	2
Accuracy Meter		**2**	**1**	**0,5**	**0,2**	**0,1**



Learn more about our circuit breakers with embedded power monitoring function: Emax 2 and Tmax XT

Tmax XT catalog **Emax 2 catalog**

Applications example

Value proposition

Metering plays a pivotal role in optimizing energy usage and enhancing operational efficiency in shopping malls.
It allows efficient resource management that impacts costs, sustainability, and tenant satisfaction.

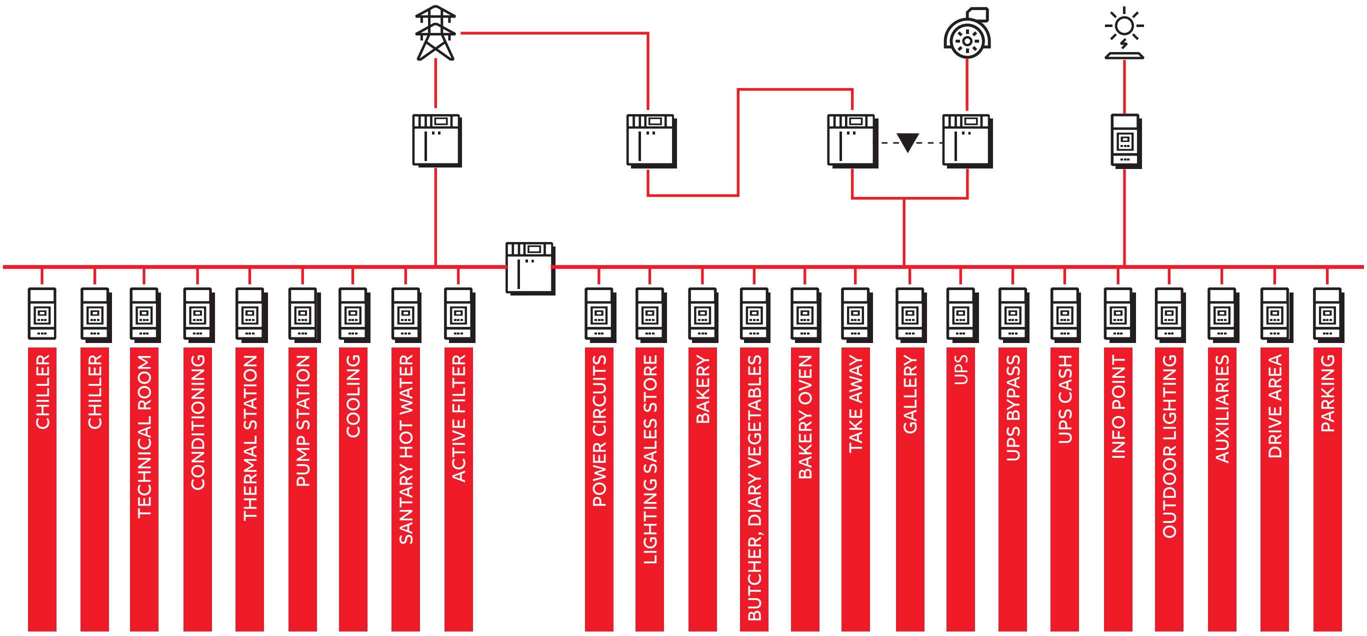
Power metering in the food and retail segment is used for:

- the detection of anomalies which might indicate equipment malfunctions or leaks
- energy efficiency and carbon footprint reduction
- cost reductions by optimizing energy usage
- easy compliance with environmental regulations
- data-driven decisions.

We analyze the case of a shopping mall using electrical energy from a utility as a primary source.

To increase sustainability and reduce energy costs, a photovoltaic system is installed on the rooftop. The use of a diesel generator is foreseen only in the event of a lack of power supply.

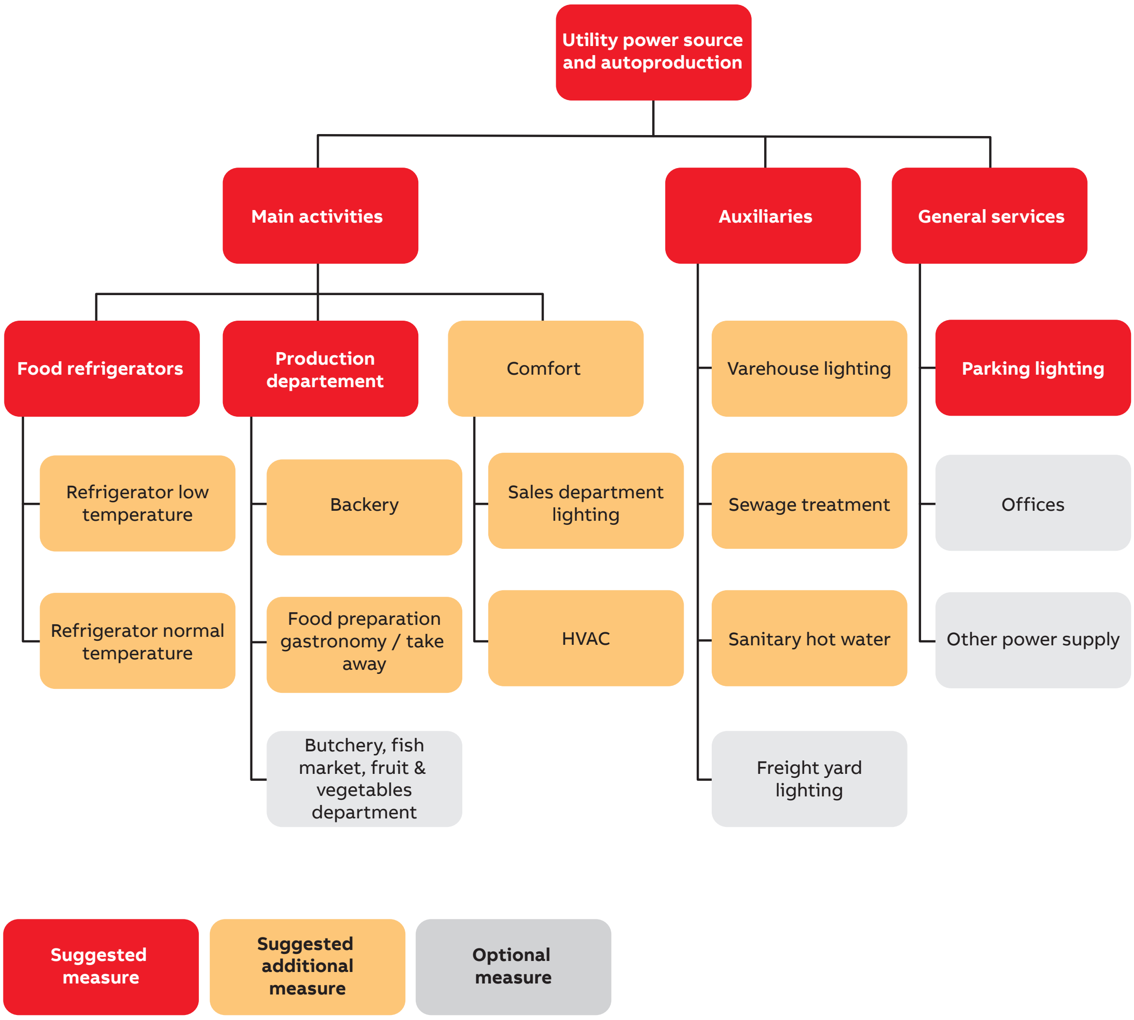
Figure 1. Simplified single line diagram for a shopping mall.



In the following major guidelines for energy efficiency in the food and beverage retail segment, the main “energy carriers” to be represented in the efficiency assessment are the food refrigeration system, the food processing or preparation departments (processing departments such as bakery, kitchen/delivery, butcher, fishmonger, etc.), the lighting of the sales and warehouses, the lighting of indoor or outdoor car parks, and air conditioning (heating and cooling).

Applications example
Value proposition

Figure 2. Example of scheme to indicate measuring points in food & beverage retail construction.



In dealing with a greenfield project, it is advisable to provide sufficient measuring points to ensure the feasibility of future efficiency studies, avoiding the need to install additional meters.
The use of embedded meters enables multiple measuring points to satisfy all needs of further analysis.
Each circuit breaker can satisfy both protection and metering requirements, without the need for any other device or current transformer. Installation has never been simpler.

Thanks to the Ekip relay, it is also possible to add metering functionality exactly when required, simply by unlocking the functionality, without any impact on switchgear assembly. However, the benefits are not limited to installation.

Let’s have a look at this project case study to evaluate all the benefits.

Reduction of transportation carbon footprint
Transportation CO_2 emissions are not only associated with vehicles and fuel.
To significantly reduce the transportation carbon footprint, it is necessary to put in place a combination of strategies, without forgetting the reduction of material usage in each industry and segment.

The reduction of components leads to less raw material use in product manufacturing, as well as a smaller number of products, requiring less energy for transportation and resulting in lower emissions during shipping, less packaging, and container logistics optimization.
For the considered shopping mall project, using an embedded metering solution enables a reduction of shipping goods volume of about $0.02 m^3$, which is the space occupied by 18 traditional external meters, each with three current sensors and one switchboard column, corresponding to an emissions reduction of about 5 kg CO_2/km [1].

[1] For air cargo transportation: [Truck CO2 Emissions Per Km Calculator: Find Semi Truck Carbon Footprint (8billiontrees.com)]

Cost savings
Reducing components also means a reduction in the total cost of installation, both in terms of product purchase and installation time and costs. For the considered shopping mall project, it is estimated there will be savings of about USD 13,000 compared with a traditional solution.

Reduction of CO_2 emissions
Each product has a carbon footprint. This means that throughout the product's life cycle greenhouse gas (GHG) emissions are produced or consumed. This encompasses emissions from raw materials extraction, manufacturing, storage, use, and disposal.

A reduction in the number of devices in an electrical installation system enables a carbon footprint reduction. In the shopping mall project, a reduction of 614 kg of CO2 emissions can be calculated.

Quality improvement
Downtime can be costly in industrial settings. An accurate instrumentation design ensures that sensors, meters, and control devices provide reliable data. When measurements are precise, maintenance teams can quickly identify issues, troubleshoot, and restore operations without prolonged interruptions.

Accuracy isn't just about numbers; it directly impacts the safety, reliability, and performance of electrical installations. Investing in accurate design and measurement pays off in the long run. For our case, we estimate a potential saving of more than USD 1000 due to a reduction in downtime for repairs.

Stock optimization
Another saving concerns stock. A smaller number of devices can be translated into stock optimization. In our project, we can estimate a stock saving of up to USD 60.

Considering all the above benefits, providing embedded metering instead of traditional external meters on the main distribution board will result in total value generation of up to USD 13k.

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