WHITE PAPER

Data center

Energy efficiency and management

Index

1. Introduction

Having a highly efficient data center is a very demanding task. Two of the main challenges are: building a highly efficient data center, and having the right degree of information coming from measurements to take the correct action.

Today, data centers consume around 3 percent of the energy produced globally. Some forecasts predict that this figure will reach 20 percent by 2025 [1].

Those predictions are driven by the huge growth in data centers, estimated at 50 percent between 2017 and 2023 [2].

To permit this growth without greatly increasing CO_2 emissions, green and efficient data centers are vital.

The most important parameters defining the energy efficiency of data centers come from ASHRAE and The Green Grid, entitled Power Usage Effectiveness (PUE) [3]. PUE is calculated in the following way:

Data Center PUE
(Power Usage Effectiveness)

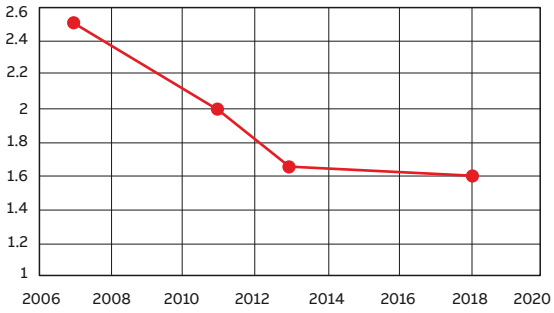
$$PUE = \frac{\text{Total facility energy}}{\text{IT energy}}$$

Total facility power

Power losses	Cooling	+	IT equipment
- batteries	- chillers		- servers
- transfer switch	- chilled water pump		- storage
- UPS	- cooling towers		- Telco
- PDUs	- condenser pumps		- etc
- transformers	- dry coolers		
- rack distribution units	- CRACs & CRAHs		
- breaker panels	- fans		
- distributed wiring	- humidifiers		
- lighting	- in-row coolers		
- generators	- in-rack coolers		
- etc	- in chassis cooling		
	- etc		

According to the study performed by the Uptime Institute, [4] the PUE levels of data centers have been decreasing over the years.
To keep up with this trend, it is necessary to take actions to increase the efficiency of data centers during their operating life.

PUE values fall gradually

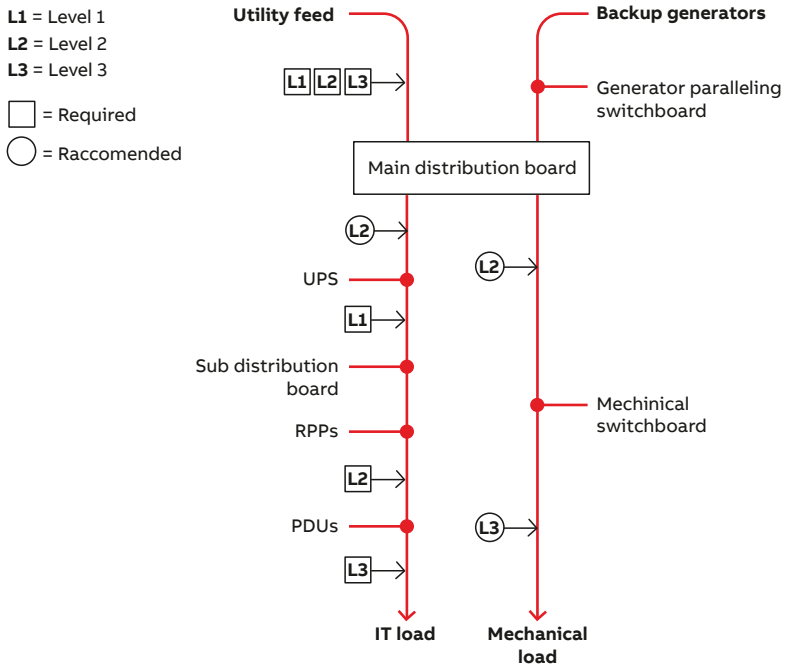


Along with this, another very important parameter is the measurement level, which depends on the placement of the measurement devices [5].

Three levels of the PUE measurement

Measurement		Total facility energy	IT equipment energy	Measurement interval
Level 1 (L1) Basic	Required	Utility input	UPS output	Monthly
	Recommended	Utility input	UPS output	Weekly
Level 2 (L2) Intermediate	Required	Utility input	PDU outputs	Daily
	Recommended	Utility input UPS input/output Mechanical inputs	PDU outputs	Hourly
Level 3 (L3) Advanced	Required	Utility input	IT equipment input	15 minutes
	Recommended	PDU outputs	input	15 minutes or less

Placement of the measurement equipment



The EN50600-2-2 standard for data centers requires the measurement of voltage, current, power, energy and power factor to an accuracy of 1 percent.

Additionally, it recommends the measurement of current and voltage total harmonic distortion (THCD and THVD) [5].

With this in mind, it is easy to conclude that energy efficiency is not easy, and it is of paramount importance to have the right measurements. These include:

- The right placement of the measuring devices
- High measurement precision
- Fast and simultaneous data acquisition

Finally, the data acquired needs to be analyzed and represented in the right way.
Only if all the requirements are satisfied can the owner of the data be sure that the measured PUE value reflects the reality.

If there is even a small variation in the measured PUE value, the data center owner risks many consequences. Here are some examples:

- It is impossible to correctly measure the data center energy efficiency,
- It is difficult to allocate the power to the IT loads,
- Planning installation upgrade timely and effectively is impossible.

ABB offers a flexible and unique solution that meets all customers' measurement requirements, while ensuring correct, class 1 accuracy measurements.

With the right information, it is easy to have correct power monitoring and capacity planning, and to improve the energy efficiency of a data center.

2. Energy efficient data center with ABB

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ABB Ability EDCS

Highly efficient ABB devices ensure the highest efficiency for power distribution, including transformers, UPS systems, cables, and protection and switching devices. Thanks to a UPS efficiency of 97.4 percent, highly efficient power supply products and the right power supply design, the usual **20 percent power distribution losses can be cut to just 5 percent.**

For further efficiency increases, ABB offers measurement, monitoring and control solutions. Ekip devices with embedded metering are capable of measuring and controlling all electrical parameters on all distribution levels with high flexibility and class 1 accuracy according to the IEC 61557-12 standard. Having embedded functionalities offers the following advantages:

- No need for additional relays and measurement devices, which provides simplicity and time saving
- High level of flexibility thanks to seven embedded communication protocols
- Simple and effective cloud connectivity (e.g. cloud connection in only ten minutes)
- Increased reliability thanks to fewer devices and connections
- Fast design, installation and integration.

Most important information from the devices can be easily visualized and monitored from the ABB Ability Electrical Distribution Control System (EDCS) cloud platform, which provides simplicity and flexibility.

ABB has tailored solutions for any PUE level defined by data center standards, allowing the right data center management to further increase overall energy efficiency.

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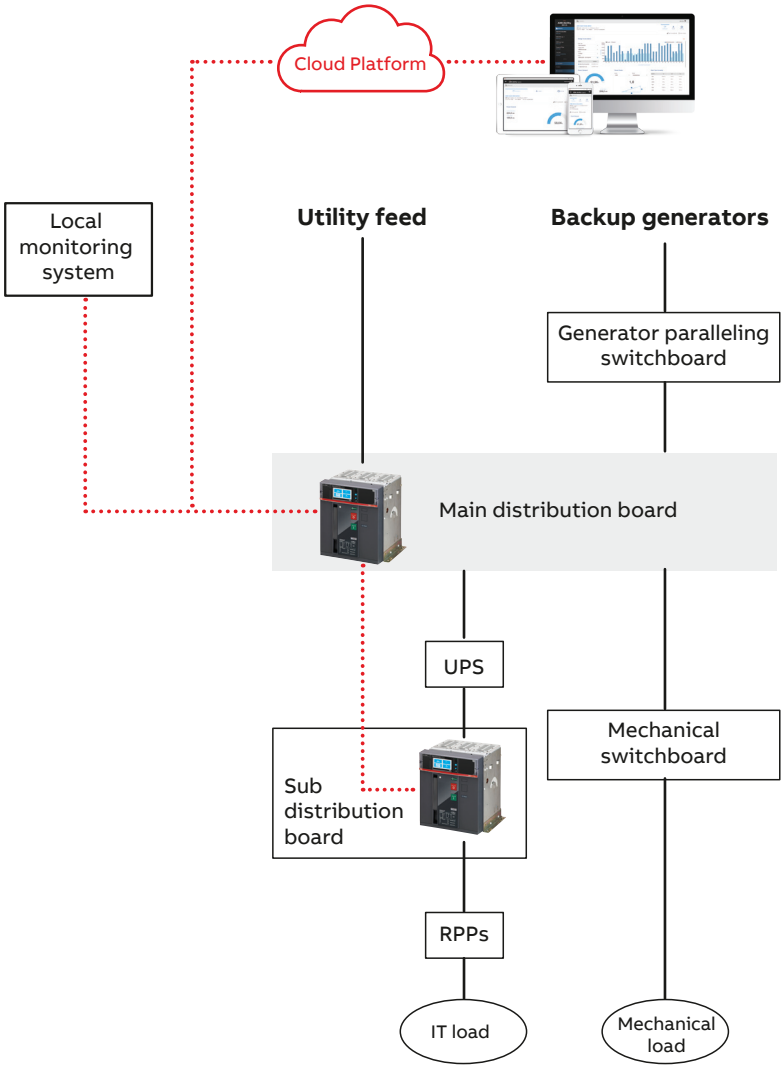
Communication with SACE Emax 2 cbs

2.1. Basic data center monitoring solution

To achieve basic level of the measurements, two circuit breakers can be used without any additional measuring device.
Two Emax 2 circuit breakers measure all the electrical parameters (current; voltage; frequency; active, reactive and apparent power and energy;



power factor; peak factor; THVD; THCD) to an accuracy of 0.5 percent (currents, voltages) or 1 percent (power, energy) of the UPS output and the facility input.
The two circuit breakers are connected through the Modbus TCP communication protocol. Modbus TCP communication protocol is available as a cartridge module placed directly on top of the circuit breaker (no additional space and connections are required). The measurements are directly transferred to the cloud using an Ekip com hub module directly inserted to the Emax 2 circuit breaker.

This kind of setup takes less than ten minutes. In this way, all the information is available from the ABB Ability EDCS cloud platform and accessible from any location and any device with internet access. In addition to the connection to the cloud, it is also possible to connect the measuring devices (circuit breakers) to the local DCIM installed and configured on the premises and to use the available information in a customized way.

The cloud-based ABB Ability EDCS computer software enable users to monitor and analyze all the information they need, which are being refreshed every 30 seconds. With the preconfigured dashboard for data centers, the users can see all the information about their data center, such as PUE, input and output power, energy trends, peak power, and more.

There is also a high level of flexibility, as the user can adjust the information that is displayed. Additional features available include predictive maintenance, control functions, alerts and alarms, scheduled reports, and many more. Finally, if there is a local DCIM supervision system, it is possible to easily fetch data directly from the ABB Ability EDCS platform and integrate it into the DCIM system via an API.
Thanks to the possibility to access the information from any location of multiple data center sites, it is possible to compare the efficiency of different sites and to take the right steps to improve efficiency.

Although this solution is simple and has a low initial cost, very little information about the energy consumption of the data center is available, since only two measurement points are installed.
Consequently, there is little room for improving the overall efficiency and reliability of the data center.

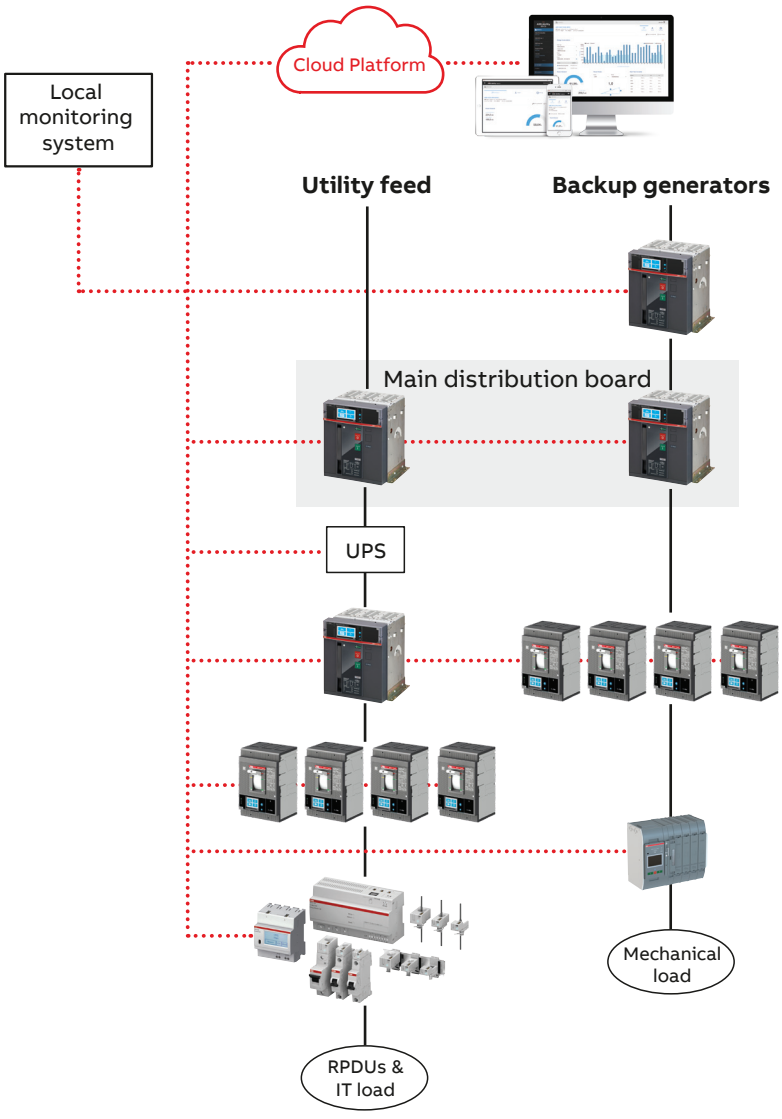
The added value of energy efficiency can be seen through very low losses of the distribution devices used (e.g. the **UPS has an efficiency of 97.4 percent**). In this way, the power supply losses of a 1 MW data center are cut from the usual 20 percent down to 5 percent, thanks to the highly efficient power supply solution.

2. Energy efficient data center with ABB

2.2. Advance data center monitoring solution

In order to get a clear picture of the overall operations of a data center to obtain the right basis for taking action to further improve the energy efficiency and reliability of the data center, the right number and level of measuring devices should be applied.

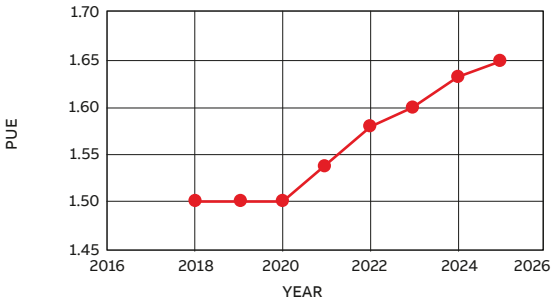
Taking into account ABBs wide range of devices capable of recording the measurements, monitoring and communication, this becomes an easy task. The devices communicate with each other as well as with any external device to provide unique information to the data center operator.



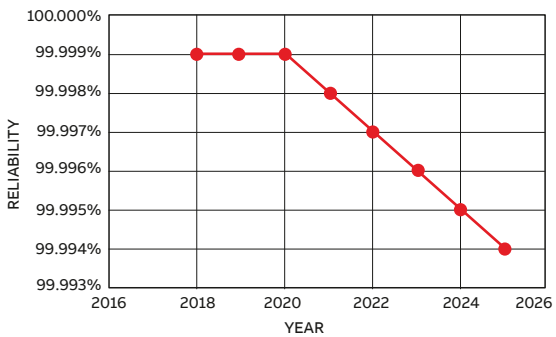
In this case, the same considerations regarding the measurements, software and communication explained in the previous case can be taken into account.
Now, the measurements are performed by all the protection devices and the CMS 700 system. As before, the information is available in the cloud and locally.
The safety of the data is ensured thanks to the highest possible level of cybersecurity, developed in collaboration with Microsoft. This allows very flexible, easy and precise computation of the PUE value.
Thanks to the grouping of the load feature, it is possible to customize the plant overview in a fast and flexible manner. For example, all the protection devices protecting the cooling load can be grouped together so that the values of the cooling load consumption can be seen, while keeping the visibility of the individual values as well.

Although data centers are constructed to have the highest energy efficiency, this value can decrease over the years (PUE increases) due to the aging of the equipment and the facility, as well as non-optimal operation. In order to avoid this and to keep up with the trend of decreasing the PUE value, the correct actions should be taken.

Yearly data center PUE value without actions taken



Reliability



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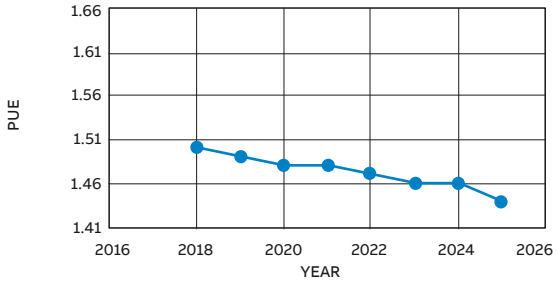
LV Predictive Maintenance

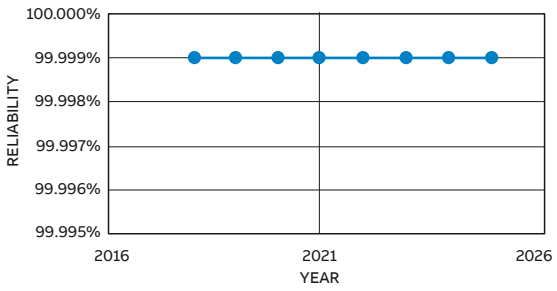
With high precision, a high number of measurement points, and information about the equipment status, the equipment that consumes the most energy can be easily identified and the correct action can be taken. In this way, it is easy to make cost-effective changes that improve the overall efficiency of the data center.

Additionally, with information about the performance of each piece of equipment in the data center, it is easy to make equipment choices when updating existing data centers, thus truly respecting the concept of modularity.

Yearly data center PUE value with actions taken basded on measurements and monitoring



Reliability



Since the measurements are performed on all the equipment, it is very easy to track the energy consumption of any part of the data center.

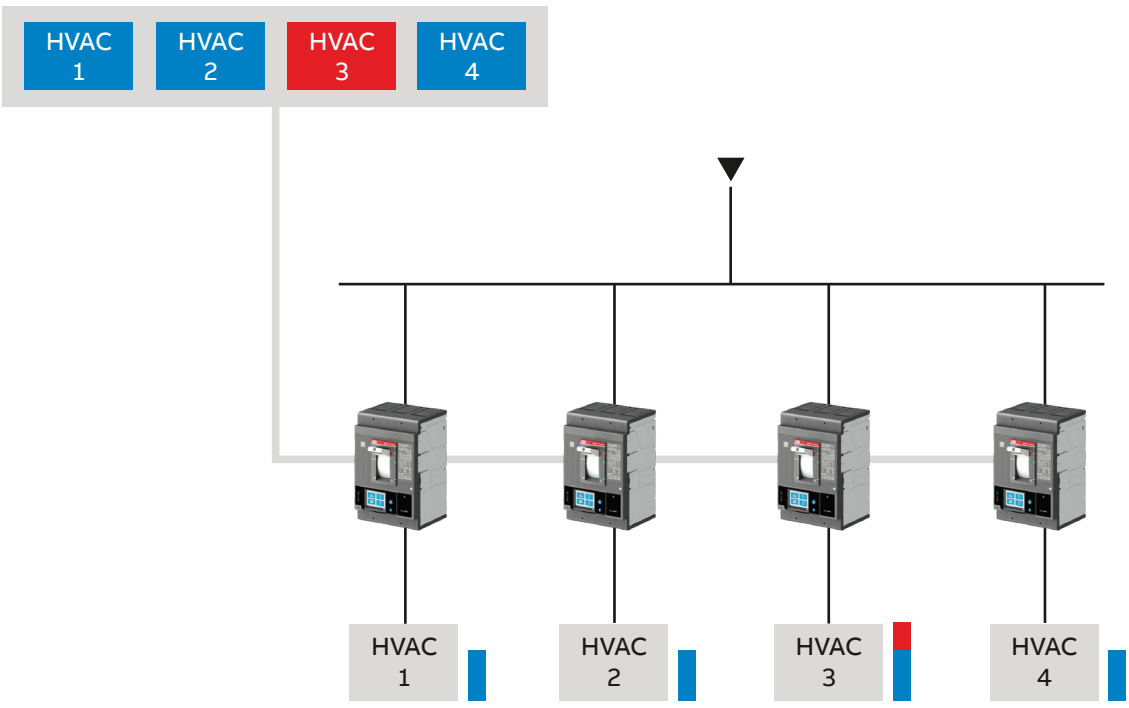
Just by looking at the measurement information, it is easy to see whether some part of the data center is consuming more energy than usual. In this way, any equipment that is not functioning properly can be immediately repaired or replaced, retaining high efficiency.

For example, if there is a hotspot in the data center, the cooling equipment responsible for this part will automatically increase the energy consumption to maintain a stable temperature.

The only way to recognize this kind of issue is by measuring the consumption of every cooling device. Thanks to the precision measurement capabilities of all ABB protection devices from 1 A up to 6,300 A there is no need for special devices or installation to satisfy the previously mentioned requirements.

Thanks to the unique predictive maintenance feature available on air circuit breakers, it is possible to plan maintenance in advance.

If we assume that the maintenance work takes two hours and, and that the circuit breakers have a lifetime of 25 years. In traditional case, the maintenance on ACBs is required each year (25 times during the ACB lifecycle), while, using the predictive maintenance feature this number becomes 9.

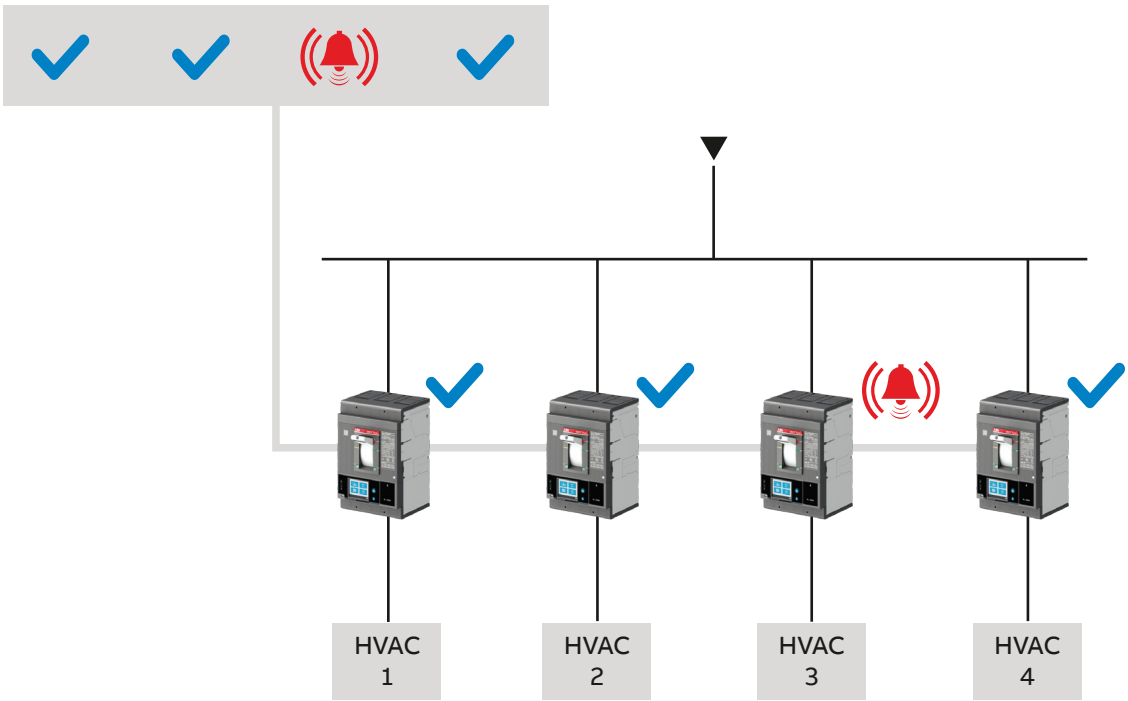


2. Energy efficient data center with ABB

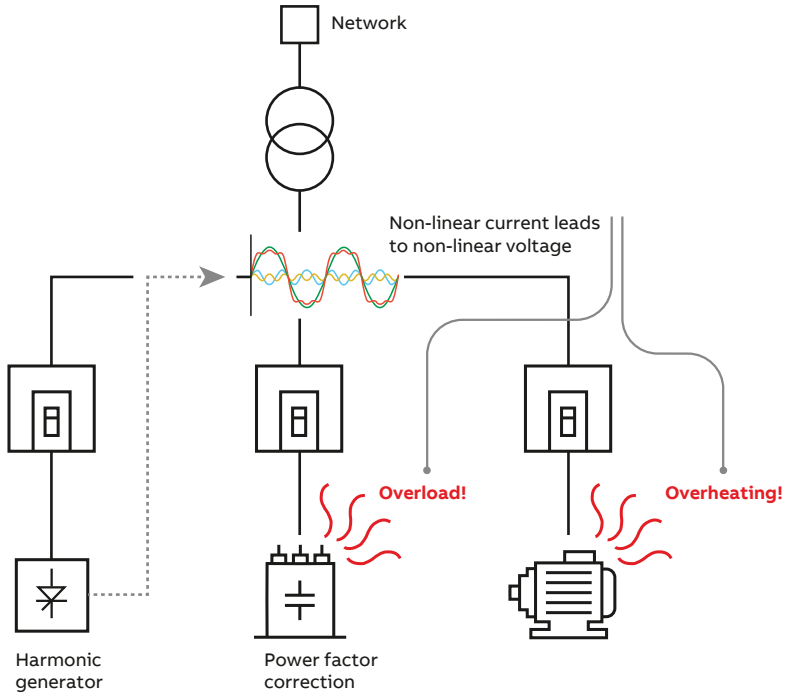
Based on previous information and taking the typical maintenance costs, our calculations show that we can easily save up to 43 percent on the maintenance costs for each device.
This represents only one example about the savings that can be made thanks to predictive maintenance feature.
The previously mentioned values can vary depending on many factors, such as environmental conditions, number of operation and number of short circuit interruptions.
Additionally, with precise details about the health of each device and regular maintenance, the reliability of the whole plant is increasing dramatically, thus avoid the extremely high costs of a data center outage, which can cost as much as $2.4 million [6].

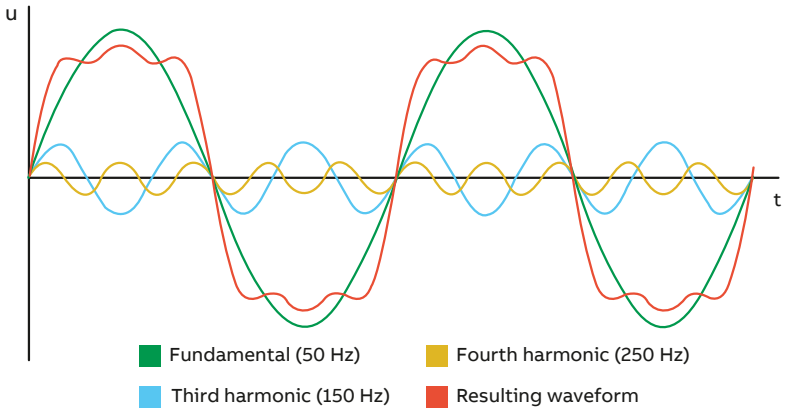
Predictive maintenance is based on the information from the devices (environmental condition, operating conditions, events and effect of performed maintenance) and a complex algorithm that runs in the cloud through ABB Ability EDCS. Additionally, all the devices continuously perform self-checks. If they detect any abnormal conditions, the device issues an alarm, to ensure the continuity of the operation and increase reliability.

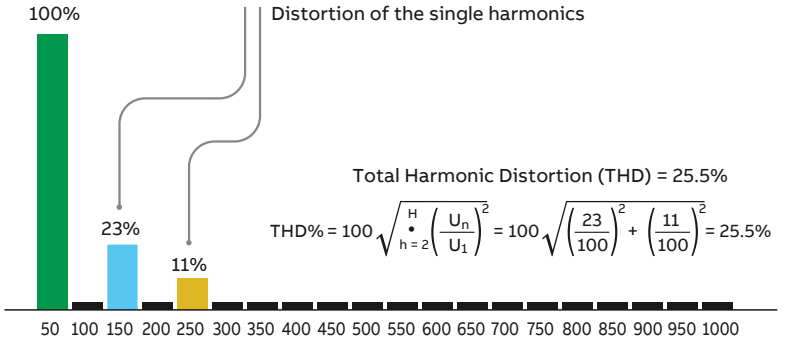
Finally, the customer can set upper and/or lower thresholds for any parameter (e.g. current, voltage, or power) of any device (e.g. circuit breaker or automatic transfer switch (ATS) device), that will automatically trigger alarms.



According to the latest report from Uptime Institute [4], the PUE levels of data centers are decreasing, but there is also a decrease in overall reliability. It is clear that the solutions outlined here can only increase the reliability of data centers, overcoming the issues reported in the study.







Another way to improve the energy efficiency of a data center is to reduce distribution losses.
For all types of data center, ABB offers equipment that can decrease power distribution losses down to 5 percent. Additionally, having a high number of measurement devices provides clear insights into the causes of distribution losses, offering the possibility to optimize the distribution to increase the efficiency. Let's take the example of measuring the losses from the UPS.
A DPA 250 S4 UPS has an efficiency of 97.4 percent; this means that the losses are 2.6 percent. Measuring this value with a low-accuracy device will not provide any useful data.
However, thanks to ABB's highly precise devices, it is possible to obtain precise information about distribution losses.
IT equipment installed in data centers can produce power quality issues causing harmonic distortion in the network.
Harmonics will cause additional losses and reliability issues. This can be overcome by placing suitable filters inside the network. However, to correctly select and locate the filters, it is necessary to have the right information about the source and level of the harmonic distortion. ABB equipment can perform measurements up to the 50th harmonic without additional devices, providing the right information and enabling these improvements.
Additionally, the same equipment can monitor other aspects of power quality, such as average voltage, spikes or short interruptions in voltage, voltage imbalances between phases, and other issues, bringing additional increases in energy efficiency and reliability.

ABB's devices have power quality meters embedded, and thanks to this, power quality measurements can be performed at any point of a data center power supply distribution. Some suggested measurement points could be:

- Utility entrance, to monitor the overall power quality

- Power distribution units (PDUs) to recognize which group of IT cabinets is producing the power quality issues.

In this way, the power quality problems could be easily solved.
The mechanical load can consist of power drives, which can also be the source of harmonics; thus, in order to be sure where the issue is coming from, it is advisable to locate power quality measurement devices at the mechanical level. Finally, the power quality can be measured also at the other data center levels, which will give a clear picture of any power quality issues.

3. Increase the efficiency of the existing data center

In one of the latest data center studies [7] it is discovered that over next three years, responders said that on average, 12.8 data centers per organization will be renovated.

Adding the previously explained trend about data center efficiency increase, one of the main drivers for data center renovation is energy efficiency. The efficiency increase can justify high data center service cost, which represents around 15% of data center total cost of ownership (TCO) [8].

Retrofitting

Ekip UP

All the previous solutions for data center efficiency increase are explained based on the design of a new data center. However, the same solutions are applicable also for the existing data centers, using the advanced ABB's solution which are allowing the upgrade of the existing installation. ABB has a wide portfolio of the service solutions which can fit any type of installation providing high level of flexibility and ensuring time and cost saving thanks to advanced technologies.

There are three main ways in which the existing installation could be adjusted to apply the solutions explained for new installation.

Depending on how the existing installation is realised and the level of changes the data center owner is willing to apply high, medium or light impact on the installation can be done.

3.1. Retrofitting of the protection devices

In case of retrofitting, the protection devices are completely changed with new devices, which have measurement and connectivity capabilities.

Thanks to ABBs advance retrofitting solutions, the time needed for upgrading the installation is minimal, thus the availability is maximised.

With the minimal possible impact to the installation the data center is equipped with the newest generation of circuit breakers which have the lowest losses and can perform the class 1 accuracy measurements and connectivity to the both, on sight monitoring system, and ABB Ability EDCS. In this way the highest efficiency of a data center is ensured.

3.2. Upgrade of the installation

The metering and connectivity capabilities of the protection devices can be "unlocked" without virtually any impact to the existing installation.

This is done by using the digital unit called Ekip Up. Thanks to open-style current sensors, Ekip Up ensures a plug&play installation for every low voltage systems. It can be connected to any protection device regardless if it uses the electronic or thermo-magnetic trip unit.

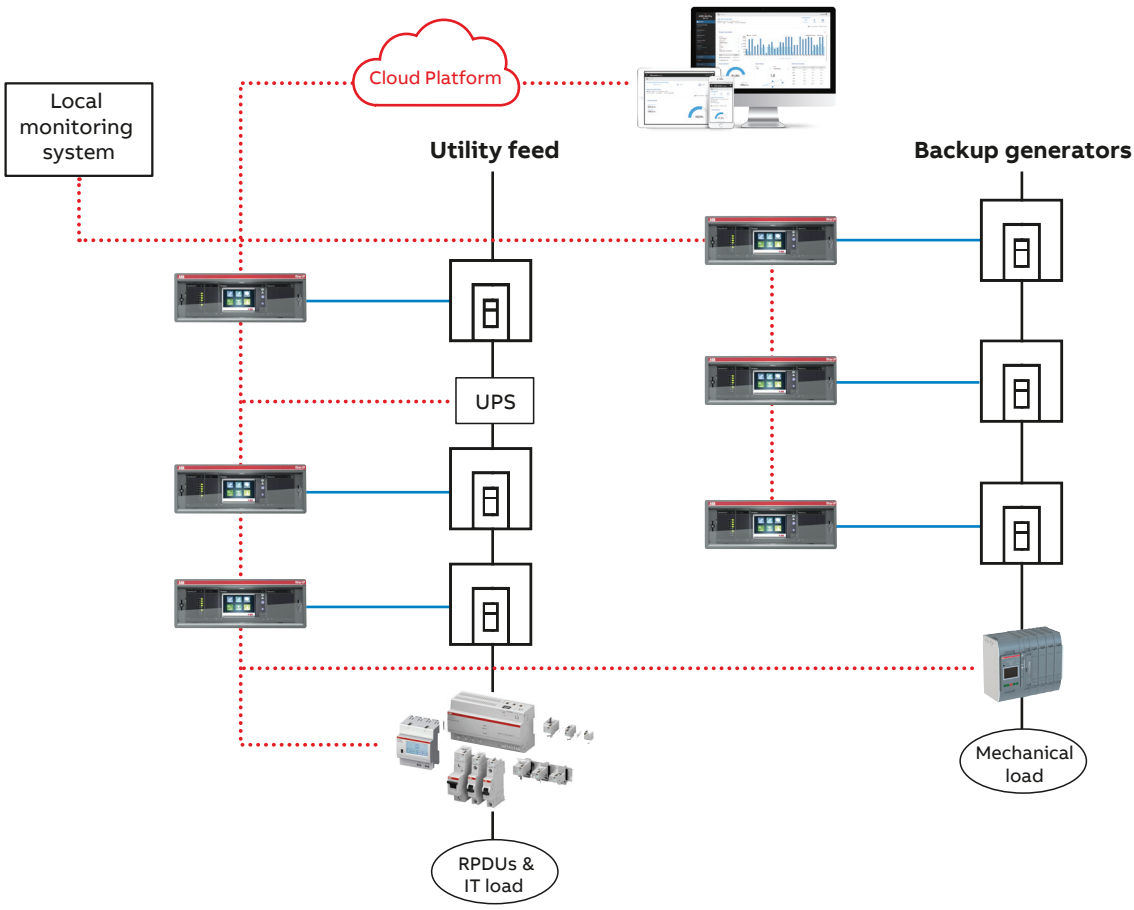
In this way, everything previously explained for the new installation becomes valid also for the existing installation, thanks to the connection of Ekip Up digital units.

Connection of the Ekip Up to the installation not just allows the monitoring and connectivity, but also provides the advance protection functionalities, same ones available with the new protection devices.

3.3. Complete flexibility for the new installation

In case where the installation is already equipped with newest devices with measurement capabilities, the adjustments to the installation are possible thanks to device cartridge modules.
For example, the data center user can add or change cartridge modules without any impact to the installation. Additionally, new features of ABB Ability EDCS (e.g. predictive maintenance) can be added any time by user itself. In this way, the data center user has the complete flexibility to change or add new functionality any time without any impact.

Plug & Play module



4. ABB devices for energy efficiency

Circuit breakers

This section presents an overview of the most important ABB devices that can be used for measuring and monitoring inside data centers..

4.1. Emax 2 and Tmax XT family of circuit breakers and Ekip UP

ABB Emax 2 and Tmax XT circuit breakers range from 160A up to 6300A. As well as offering protection functionality, they can be used for measuring and monitoring.

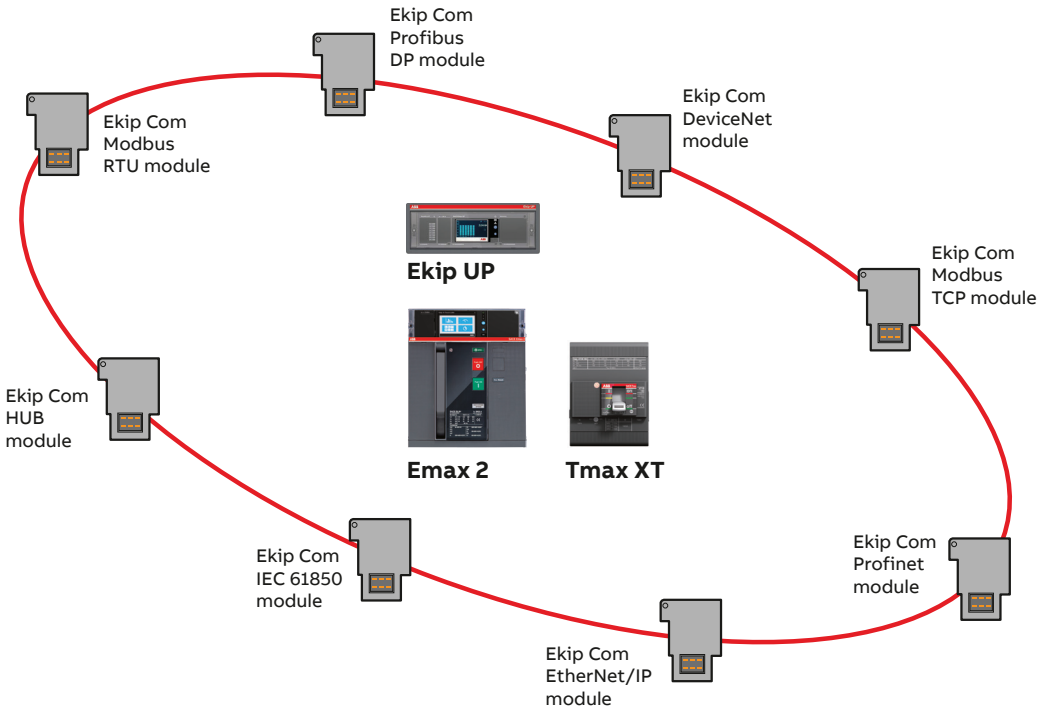
The Ekip Architecture on full range of circuit breakers unlocks high accuracy measurements, embedded in devices, for all electrical parameters (current; voltage; frequency; active, reactive and apparent power and energy; power factor; peak factor; THVD; THCD) to an accuracy of 0.5 percent (currents, voltages) or 1 percent (power, energy).

This includes Class 1 accuracy for power and energy measurements according to IEC61557-12 standard.

In addition, Ekip UP digital unit is designed to upgrade existing installations giving them same capabilities of the Ekip trip units in terms of metering, protection and control.

Thanks to open-style current sensors, Ekip UP ensures a plug&play installation for every low voltage systems.

In order to collect, transfer and monitor the parameters being measured, the Emax 2, Tmax XT and Ekip Up can be equipped with seven different communication protocols.



DPA UPS

DPA 250 S4

As previously explained, using the Ekip Com Hub module, it is possible to connect to the internet and to have all the information available through the ABB Ability EDCS software.

Thanks to all these features, the Emax 2, Tmax XT and Ekip Up devices are perfect for any type of data center, capable of providing all the functionalities that the related standards require.

4.2. DPA UPS product line for data centers

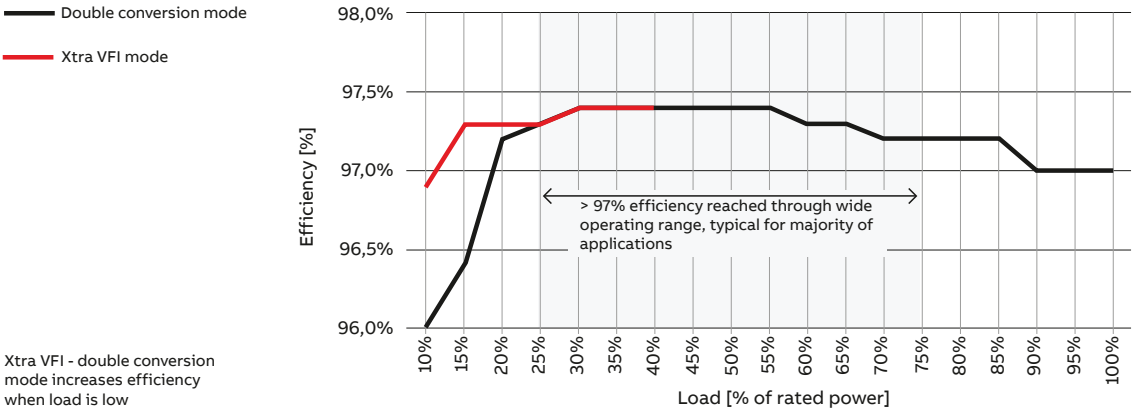
ABB's DPA UPS product line is designed to serve the data centers of the future and all the models in the family are built with a focus on energy efficiency, reliability and modularity.
The most recent UPS unit – the DPA 250 S4 – has a module efficiency of 97.6 percent and a system efficiency of 97.4 percent.

This means that your UPS will use about 30 percent less power, reducing energy losses and operational costs.
The Xtra VFI feature maximizes efficiency under low loads by dynamically adjusting the number of active modules that your critical IT equipment requires.

All DPA models are capable of measuring input voltage, input frequency, battery capacity and autonomy, as well as output voltage, power and current.
Based on these values, the UPS can also send alerts if any of the values are above or below defined limits.

All this information is available locally, on the DPA display, as well as remotely using the Modbus communication protocol.

Finally, all those measurements are also available in the cloud through ABB Ability EDCS.



Xtra VFI - double conversion mode increases efficiency when load is low

4. ABB devices for energy efficiency

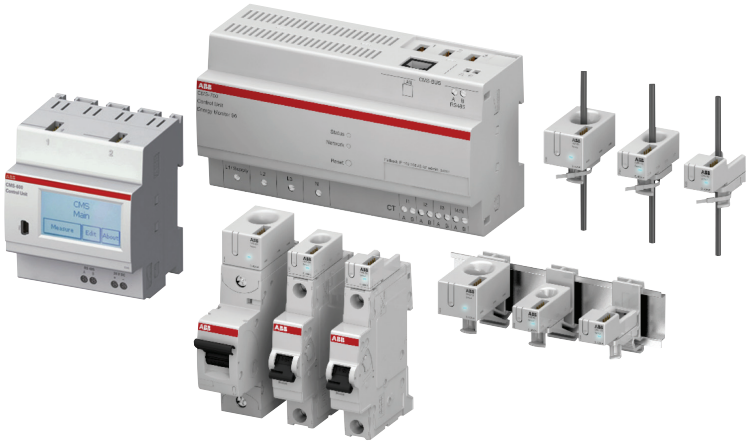
CMS-700

4.3. CMS-700

The CMS-700 system allows measurement of currents up to 160 A.
It consists of a control unit and sensors, allowing easy monitoring of all data center distribution lines. It measures current, voltage, power factor, THD (U, I), energy and power to an accuracy of 0.5–1 percent.

The measurement devices can be easily fitted into the electrical circuit in any location where the measurement is to be performed.

The system uses an open-loop Hall-effect sensor or the giant magnetoresistance (GMR) effect, depending on the sensor used.



There are three different devices that can be used for these measurements:



Current sensors	**CMS-12X**	**CMS-10X**	**CMS-20X**
Principle	Open core, GMR	Solid core, Hall effect	Solid core, Hall effect
Accuracy of full scale	±1.0 percent	±0.5 percent	±0.5 percent
Ranges	80 A / 40 A / 20 A	80 A / 40 A / 20 A	160 A / 80 A / 40 A
Application	Retrofit and new installations	New installations	New installations

Any of these devices can easily be connected through the unique bus to the CMS-700, which can be placed on the DIN rail. This unit allows storage and transfer of data through many different protocols and/or to the ABB Ability EDCS using the Modbus TCP communication protocol.

Control Units	**CMS-700**
Number of Branch Current Sensors to be connected	96 (3 x 32)
Connectivity	LAN: Modbus RTU, Modbus TCP/IP, SNMP v1, v2, encrypted v3 RS485: Modbus
Available Data Mains	Current, voltage, power factor, THD (U, I), energy and power
Data Storage	Integrated data storage
Data Export	Automatic CSV data export

—
TruONE ATS

—
Ekip Signalling 3T

—
Slimline XR

4.4. TruONE ATS

The new TruONE is the world's first true all-in-one automatic transfer switch, engineered to incorporate switch and controller in one seamless unit. It has a range between 200 A and 1600 A and the possibility to provide a variety of measurements.

With level 4 controls, the TruONE is capable of measuring currents, voltages, active, reactive and apparent power and energy, THVD, and THCD. As with the Emax 2, Tmax XT and Ekip UP, the TruONE can be equipped with communication modules in order to send data to remote locations and the ABB Ability EDCS.

The available communication protocols are: Modbus RTU, Modbus TCP, PROFIBUS, PROFINET, EtherNet/IP, and DeviceNet.

4.5. Ekip 3T signalling measurement module

The Ekip Signalling 3T module makes it possible to measure and monitor environmental conditions.

The module can be directly placed on the circuit breaker and digital units (in the same way as the communication modules).
This module has three inputs for PT1000 temperature measurement sensors and one analog input of 4–20 mA that various sensors can be attached to. The information from those sensors gives precise environmental information for predictive maintenance.

Additionally, this information is available remotely, using one of the communication protocols above and/or through the ABB Ability EDCS computer software.

Possible locations for the temperature measurement sensors include the busbar system, distribution board, and transformer, as well as environmental measurements. The analog input can be used, for example, for measuring humidity.

4.6. Slimline XR

The Slimline XR switch disconnector fuse with ratings between 63 A and 630 A fulfils all increasing demands in the industry for safe energy distribution.

As with circuit breakers, the Slimline XR is capable of monitoring fuse status, voltages, currents, active and reactive power, power factor, energy, temperature, fuse status, and switch position.
It is equipped with the Modbus RTU communication protocol, which allows easy integration with monitoring systems and/or the ABB Ability EDCS.

Additionally, SlimLine XR offers an integrated motor (as option) for remote or local operation. The motor operation unit is 100% integrated inside the SlimLine XR.

4. ABB devices for energy efficiency

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M4M

4.7. M4M network analyzer

The new M4M network analyzer range provides accurate real-time monitoring of the power quality KPIs to enhance reactivity to the events on the electrical system, helping to avoid any operational impact and uncoordinated maintenance.

Available in two families, M4M 20 and M4M 30 ensure Class 0,5 accuracy according to IEC 61557-12 and IEC 62053-22 standards, representing the perfect choice for submetering inside sub-distribution boards and power quality monitoring in main distribution boards and power centers.

In data centers, M4M allows to fully monitor power quality and power reliability, easily detecting where harmonics are created and preventing damages to installed equipment.

EQ Meters support a wide voltage range as well as a wide temperature range.
They can also be equipped with built-in serial communication interfaces for M-Bus or Modbus RTU (RS-485).

The range comprises direct and indirect, one and three phase meters up to 80A; they support reading a wide range of values such as active, reactive and apparent power, current, voltage, frequency, power factor and harmonics.

4.8. EQ meter

ABB's EQ meters are high-performance, modular DIN rail-mounted electricity meters that are safe, easy to install and can be integrated with existing and future electrical installations.

They are designed to fulfill any type of sub-metering requirement. MID-approved EQ meters are certified and have verified meter accuracy, which is a critical factor in establishing fairness in cost allocation.

The low rated or base currents of these products ensures high dynamic performance with superior accuracy even at low currents.

5. References

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