Smart Alarms

Alarming is one of the most essential parts of VCOM Cloud. Users are able to identify problems leading to yield losses and further actions can be triggered. The new VCOM Cloud Smart Alarms revolutionize the way how alarms are generated and how users can interprete and process alarms.

As in many industries with big data, machine learning also leads to an evolution in how problems of PV plants can be identified reliably and how alarms can be processed optimally.

The core challenges operators and technical asset managers meet today, when they evaluate their workflows and processes related to alarming:

- The expectation of PV plant owners related to the quality of O&M increase steadily. As a consequence, economical aspects play a more and more relevant role when it is about solving plant failures.
- False alarms and redundant alarms need to be reduced to zero for reducing the effort for manual evaluations to a minimum
- The alarm configuration needs to be child's play. Due to the market speed, many new colleagues join the industry and O&M teams. The quality of alarming should not rely on their shoulders. The machine has to take over.
- Renewable portfolios are growing rapidly. For scaling the business, effective alarming solutions are an integral part to double and triple portfolios without the need to increase the team size at the same extent

VCOM Smart Alarms is the answer for these challenges.

The newest data management and machine learning technologies allow us today to understand the normal behavior of an inverter as a main component of a photovoltaic system, which then leads to an improved / better insight into the behavior of the system itself. With this approach, possible losses as well as respective root causes can be detected in a more intelligent way.

In this sense, all the benefits of machine learning and all the profits / gains of the available / generated data lead to an efficient, modern monitoring system that only creates alarms that matter.

Thus, the new alarming in VCOM will bring a better identification of critical technical issues on the portfolio and provide the user with the respective technical error codes from the respective devices. This ensures an easier cause recognition of the observed issue.

Added Value for O&M Teams and Technical Asset Managers

No redundancy: One affected component – One alarm

- The component-based approach leads to a crystal-clear overview of defective components
- One root cause does not lead to several alarms and therefore the virtual desk is kept clean

Scaling business by prioritizing failures economically

- The component-based alarming approach enables the user to identify inverter outages, including the designation of the affected inverter, directly within the new portlet Alarms
- By getting an overview of the affected power and the resulting losses, actions can be prioritized easily based on internal standards and contractual O&M obligations

Ergonomic user interface

- New user interface to facilitate the alarm configuration (standard alarms, user-defined alarms as well as simple rules to configure an Email notification for specific alarms)
- New Alarm Portlet to keep the right focus
- New drag & drop function linking the two portlets Alarms and Tickets to optimize the processing of alarms and to create the best user experience

Increasing alarm quality and reducing the risk of employee fluctuation: Simple & intelligent alarm configuration

- No need for manual pairing configuration of each inverter to detect issues leads to reduced complexity
- Target value of each inverter based on machine learning algorithm, or an automatic inverter comparison
- No need to adjust manually the alarm configuration in case of new installed inverters onsite
- Onboarding of new colleagues with less experience can be speeded up without losing quality

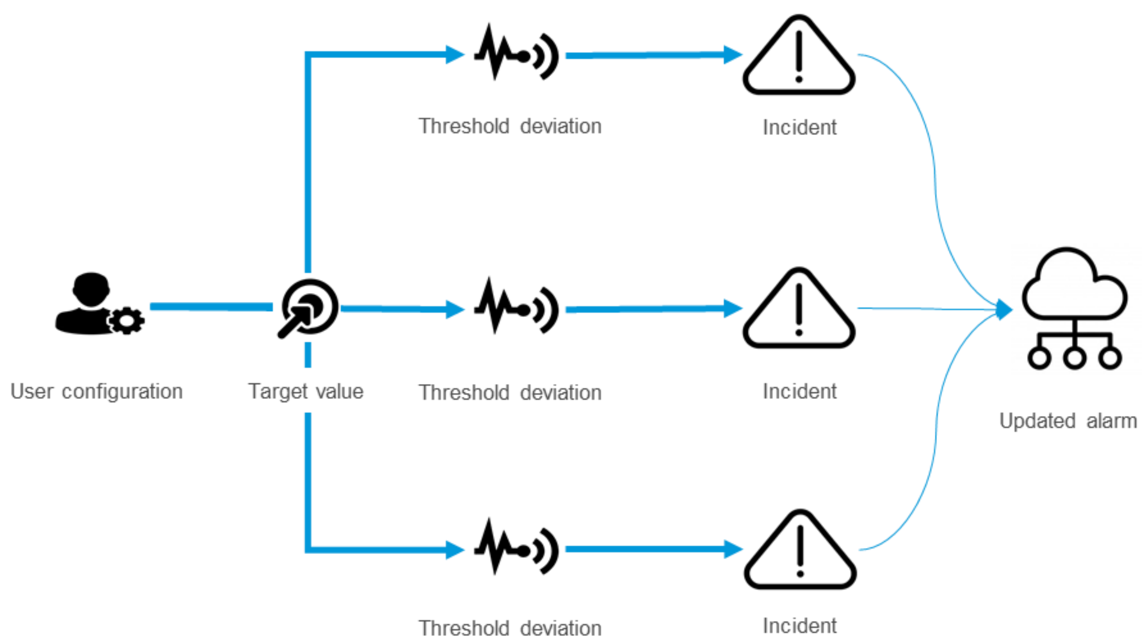
Alarm configuration page

Misproduction alarms

Misproduction alarms notify the user about the variance between expected and actual values on system and inverter level. Therefore, several methods are implemented to estimate the theoretical production (called “Simulation”) of the system under normal operating mode:

- Machine learning based simulation
- Physical simulation model
- Automatic inverter comparison

This alarm is triggered in case of a deviation between the target value and the measurement value when the minimal threshold value exceeds the alarm category “normal”.



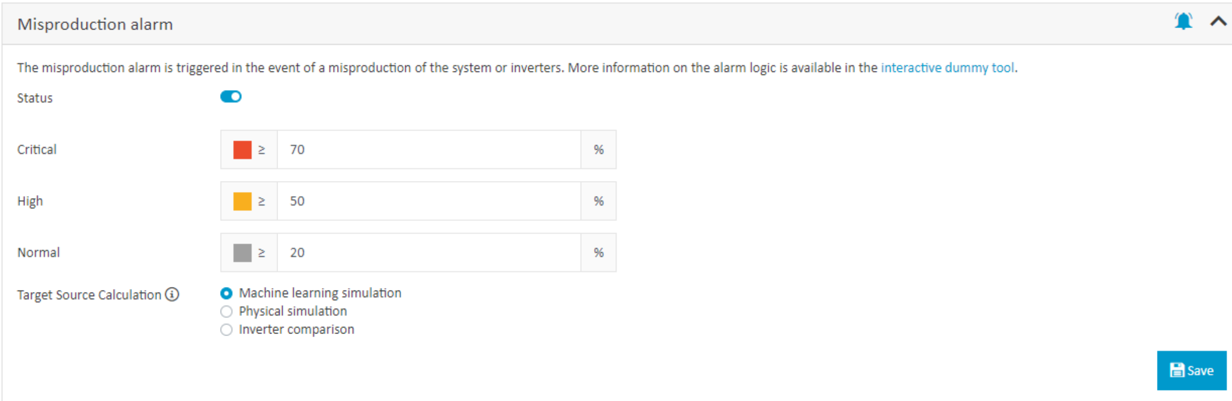
The target value as well as the comparison to the measurement value is being calculated both for the whole system and for each inverter after every data input on interval basis.

Depending on the observed deviation, three different alarm severities can be defined using the respective threshold values:

- Critical
- High
- Normal

If the deviation changes over time, the severity of the respective alarm is automatically updated accordingly.

For further information, a dummy tool is available in the user interface in VCOM:



As the alarm is triggered based on the target value, three different methods have been implemented and can be selected as a source for the alarm generation:

- Machine learning simulation
- Physical simulation
- Automatic inverter comparison

We recommend using the method “Machine Learning Simulation” for the best results and best improvements of your alarm generation.

Machine learning based simulation & Physical simulation model

meteocontrol is simulating the expected power (on plant and inverter level) on an interval base by considering

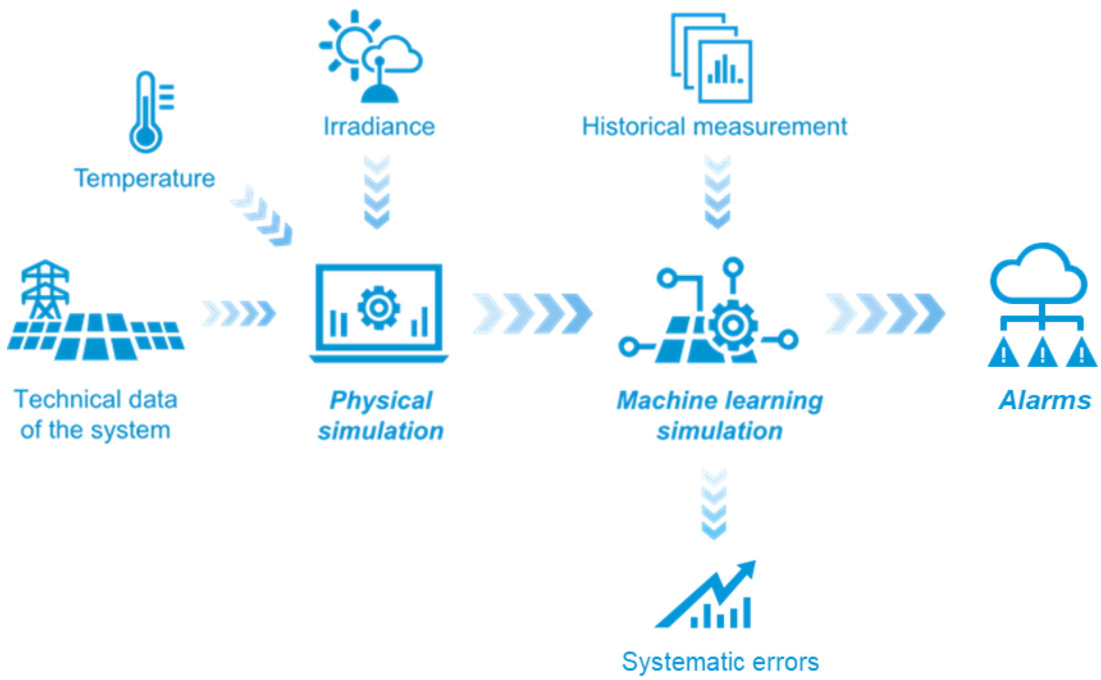
- Measured irradiance on module inclination
- Measured irradiance for each system orientation
- Module temperature
- Overall factor for losses based on assumptions/experience to cover mismatch losses, annual efficiency factor of the inverter, cabling, etc.

The concept is based on calculating a power target value after every data input, considering each orientation of the system. The system is split into several subsystems depending on the orientation of the plant: e.g., if a plant is mounted on an east / west orientation, two subsystems will be considered in the simulation. In this documentation, the "orientation subsystem" refers to each orientation of the plant.

The aim is to consider the corresponding irradiance per orientation for the power target value calculation. Therefore, several "irradiance sources" are considered for the calculation.

General input parameters for the simulation:

- System Configuration: Site data, Orientation, Tilts, Inverter power, module power
- Irradiance
- Ambient Temperature

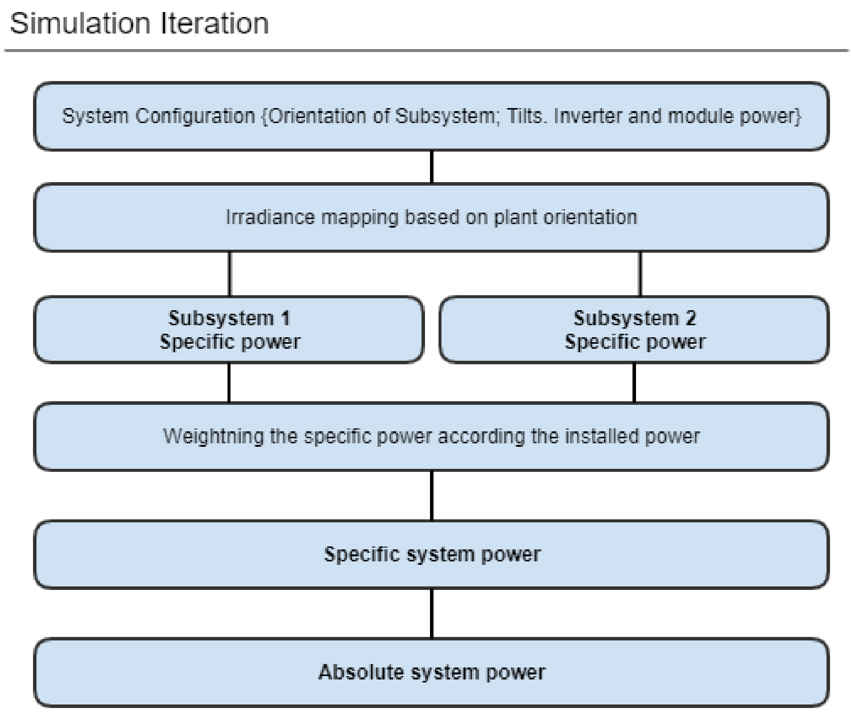


Physical model

To gather the necessary data from the system configuration (the orientation and the tilts of the system), the specific power (module and inverter) is calculated in a first step for each "orientation subsystem". The new simulation is then based on irradiance values for each "orientation subsystem".

Technically, the algorithm is defined as follows:

- System configuration is retrieved
- Orientation subsystem is defined
- Installed sensors in the plant are mapped to the respective orientation subsystem
- Consider Temperature values are considered
- Specific power for each orientation subsystem is calculated
- The values from the inverters as well as the installed power of the modules are used to calculate the specific yield per each orientation system
- Target value per interval on system level is calculated as a specific value
- Target value per interval on system level is calculated as an absolute value



Sensor data

- Every subsystem is simulated with the irradiation from the sensor most similar to it
- Similarity between subsystems and sensors is determined by calculating the correlation between the sub-system's power measurements and the sensor radiation value.
- The implemented algorithm can detect automatically following special cases
    - Multiple sensors for the same orientation
        - Use median from the sensor values
    - Sensor assignment is not yet possible. (To the corresponding subsystem - For example because the sensor is not yet in operation and the necessary data basis is missing)
        - Use the median of all sensors
    - No sensor value for a given orientation of the subsystem
        - Use the closest sensor to the actual alignment

Machine Learning

Machine learning algorithms analyze the historical measurement data of the plant and optimize the physical simulation. This reduces the deviation between the measured power and the expected power to achieve the most accurate results possible for the target value.

The training for the calibration of the model is deployed as follows

- Based on the last 30 days as training data. Start of the training period is equal to the initialization time

This is only implemented for "trainable" systems. Trainable systems are defined to have at least 70% valid (not a number / null / missing) day-time data entries. The number of day-time values is defined as 50% of all possible measurement values in the selected period.

A set of at least two weeks of valid training data must be available in the database.

In case of missing valid training data, the ML optimized simulation wouldn't be available, and an information message is displayed in the configuration page.

Automatic inverter comparison

In this case, for the target value source the inverters are compared with each other automatically considering the respective input configuration. For this purpose, all inverters based on the orientated ratios of their inputs are grouped. Then, the best performing (highest normalized power) inverter is established as the reference for other inverters in that group. Then, its normalized power is considered as target value for the respective compared inverters.

Use case 1: Matching configurations

Subsystem	Input 1	Input 2	Input ratio
Inverter 1	120 kWp @ 95°/20°	120 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 2	60 kWp @ 95°/20°	60 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 3	120 kWp @ 95°/30°	120 kWp @ 275°/30°	1 @ 95°/30°:1 @ 275°/30°
Inverter 4	60 kWp @ 95°/30°	60 kWp @ 275°/30°	@ 95°/30°:1 @ 275°/30°

In that scenario we would form two groups

Group 1: Inverter 1 and Inverter 2 (1:1 ratio of 95°/20° and 275°/20°)

Group 2: Inverter 3 and Inverter 4 (1:1 ratio of 95°/30° and 275°/30°)

Use case 2: Multiple configurations that don't match another configuration

Subsystem	Input 1	Input 2	Input ratio
Inverter 1	120 kWp @ 95°/20°	120 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 2	60 kWp @ 95°/20°	60 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 3	120 kWp @ 95°/30°	120 kWp @ 275°/30°	1 @ 95°/30°:1 @ 275°/30°
Inverter 4	60 kWp @ 95°/30°	60 kWp @ 275°/30°	1 @ 95°/30°:1 @ 275°/30°
Inverter 5	60 kWp @ 95°/20°	120 kWp @ 275°/20°	1 @ 95°/20°:2 @ 275°/20°
Inverter 6	40 kWp @ 95°/20°	120 kWp @ 275°/20°	@ 95°/20°:3 @ 275°/20°

In this scenario, the VCOM Cloud would form three groups

Group 1: Inverter 1 and Inverter 2 (1:1 ratio of 95°/20° and 275°/20°)

Group 2: Inverter 3 and Inverter 4 (1:1 ratio of 95°/30° and 275°/30°)

Group 3: Inverter 5 and Inverter 6 (rest)

Use case 3: Single configuration that doesn't match any other configuration

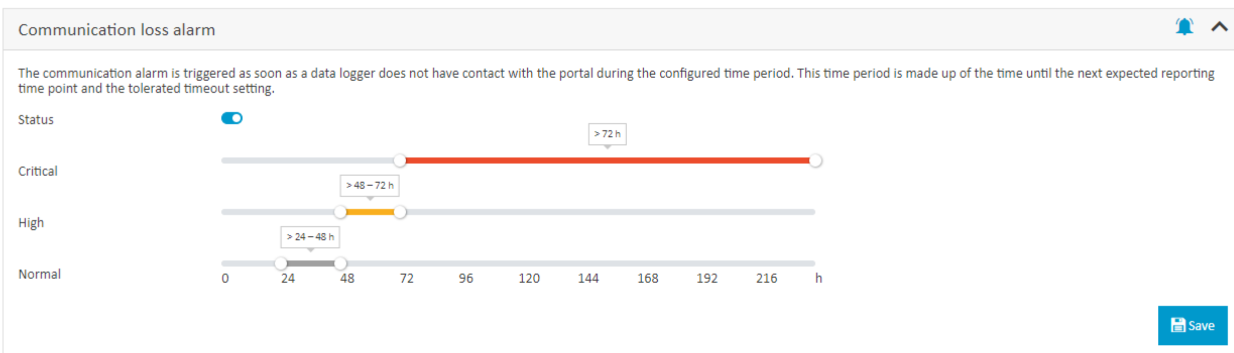
Subsystem	Input 1	Input 2	Input ratio
Inverter 1	120 kWp @ 95°/20°	120 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 2	60 kWp @ 95°/20°	60 kWp @ 275°/20°	1 @ 95°/20°:1 @ 275°/20°
Inverter 3	120 kWp @ 95°/30°	120 kWp @ 275°/30°	1 @ 95°/30°:1 @ 275°/30°

In that scenario, the algorithm would form only one group which contains all inverters as there wouldn't be any reference for Inverter 3 otherwise.

Communication loss alarms

Communication loss alarms reflect the loss of the communication between the VCOM Cloud and the data loggers on site.

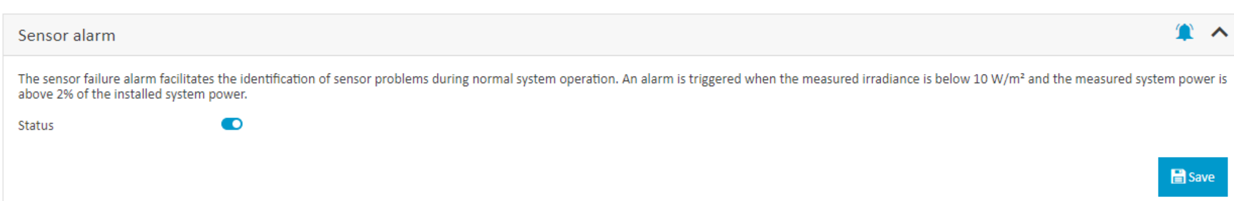
The sliders in the configuration section provide the users with the possibility to define the minimal duration of the communication loss to trigger the alarm with the severity “Normal”. The longer the communication loss lasts, the more critical the alarm becomes. The alarm severity can be adapted based on the defined duration of communication loss (severities “High” & “Critical”)



The displayed durations on this section are based automatically on the contact interval of the loggers on site with VCOM: In case a datalogger is communicating every 24 hours with the servers of meteocontrol, the minimal communication loss duration to trigger the alarm is 24 hours with a severity “Normal” as displayed in the screenshot above.

Sensor alarms

Sensor alarms reflect non-valid irradiance data during normal operating mode of the system. The alarm is triggered when the measured irradiance is below 10 W/m² and the measured system power during the same interval is above 2% of the installed system power.

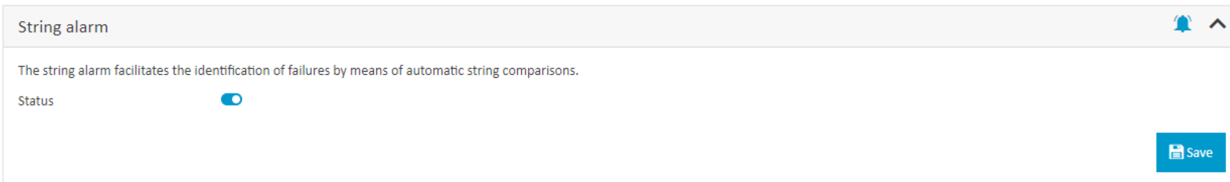


String alarms

String alarms reflect outages of single strings of a string combiner box or of inverter inputs.

During daytime, when at least one string of the string combiner box is measuring more than 10% of its nominal current, other strings are considered in outage when they are measuring no current.

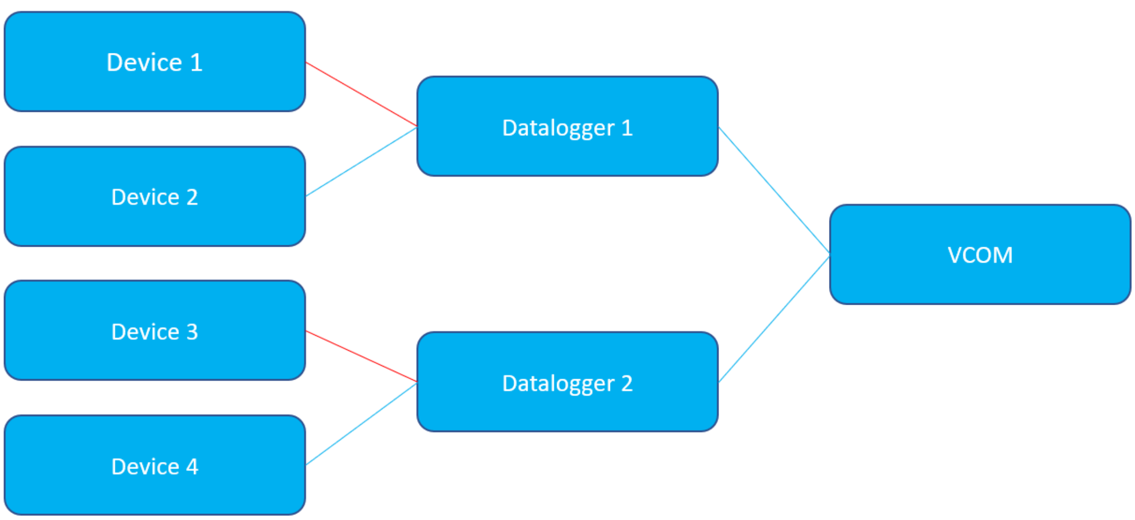
For systems equipped with string combiner boxes, if all strings of one combiner box are in outage, all the string alarms are grouped into one single outage alarm of the affected string combiner box in order to minimize the overall number of alarms and create maximum transparency for the user.

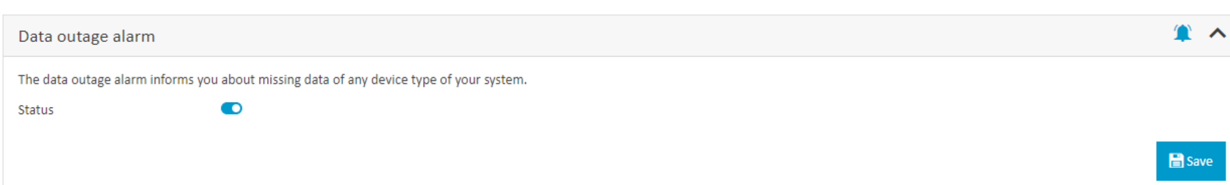


Data outage alarms

If dataloggers are communicating with VCOM and no device data are imported, data outage alarms are created for the respective device. The following use case illustrates a normal communication between the datalogger and the VCOM, while two devices are not sending data in the bus communication to the datalogger. In this case, two different data outage alarms will be generated for the respective devices and are being displayed on the alarm portlet.

The implemented alarm is applied to all available device categories in VCOM.





Alarm conditions

Alarms active

The three different radio buttons allow the user to define when the alarms should be triggered in case of an observed deviation in the backend.

- **Always:** Alarms are triggered and updated 24/7
- **Sunrise to Sunset:** Alarms are triggered/updated only between Sunrise and Sunset based on the local time zone of the plant
- **Fixed time range:** User-defined time range in which the alarms should be triggered/updated

Threshold value for irradiance

The user can define an irradiance threshold value for the creation of the alarms.

In addition to the time configuration of the alarms, the user has the possibility to ignore deviations between the simulation in time periods where the measured irradiance is below the threshold value of the irradiance.

In this way, it is possible during days with low irradiance to "avoid" alarms which would not have an impact on the global energy generation of a PV system. At the same time, the alarm generation stays active for days with higher irradiance.

Alarm delay

The alarm delay defines when an alarm should be triggered/updated in case of an observed and persistent deviation.

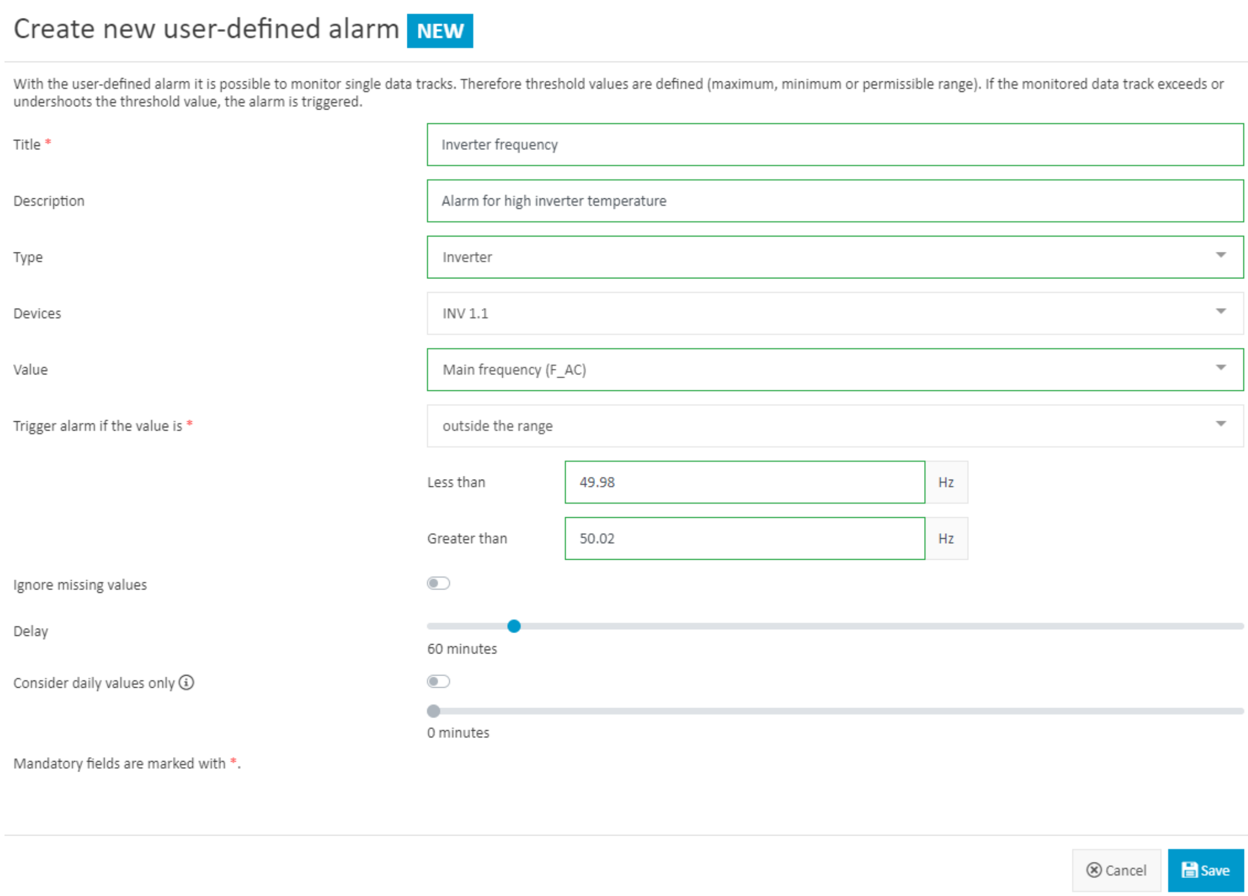
This function is very helpful to avoid automatic alarms during deviations that occur only in a short period of time.

This function also emphasizes that the system can generate only the alarms which are relevant for our users and should thus be highlighted.

User-defined alarms

With the user-defined alarm it is possible to monitor single data tracks of every device. Therefore, threshold values are defined (maximum, minimum or permissible range). If the monitored data track exceeds or falls below the threshold value, the alarm is triggered.

The defined delays and conditions for the alarm creation (daily values) are applied specifically for the respective user-defined alarm.



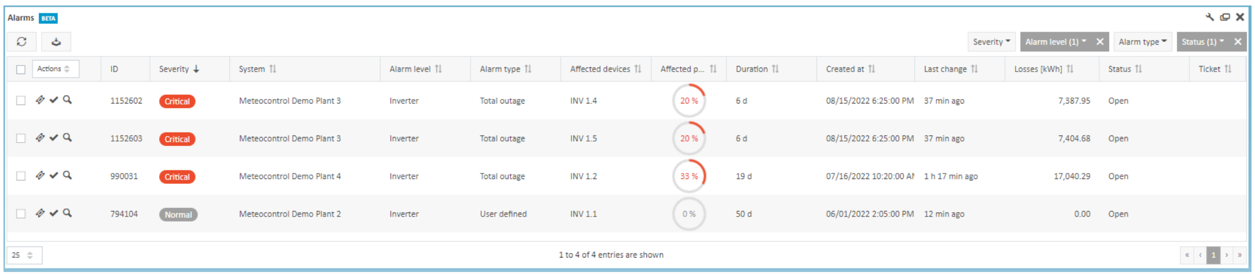
Alarms portlet

The created alarms are displayed on the new portlet “Alarms”.

As avoiding any redundancy in the alarm creation is a main goal of smart alarms, the displayed alarms are updated on the new portlet if the issue is being detected by the system and the state of the alarm is set on “open”.

Different dynamic indicators are available in the tabular view of the new portlet to detect following information:

- What is the severity of the alarm?
- When was the alarm created for the first time?
- How long is the issue being detected by VCOM?
- Is the alarm still relevant since its creation date?



Actions	ID	Severity	System	Alarm level	Alarm type	Affected devices	Affected p...	Duration	Created at	Last change	Losses [kWh]	Status	Ticket
	1152602	Critical	Meteocontrol Demo Plant 3	Inverter	Total outage	INV 1.4	20 %	6 d	08/15/2022 6:25:00 PM	37 min ago	7,387.95	Open	
	1152603	Critical	Meteocontrol Demo Plant 3	Inverter	Total outage	INV 1.5	20 %	6 d	08/15/2022 6:25:00 PM	37 min ago	7,404.68	Open	
	990031	Critical	Meteocontrol Demo Plant 4	Inverter	Total outage	INV 1.2	33 %	19 d	07/16/2022 10:20:00 AI	1 h 17 min ago	17,040.29	Open	
	794104	Normal	Meteocontrol Demo Plant 2	Inverter	User defined	INV 1.1	0 %	50 d	06/01/2022 2:05:00 PM	12 min ago	0.00	Open	

25 — 1 to 4 of 4 entries are shown — 1

For this purpose, the alarm portlet displays the following information in a tabular view:

Action

- Create a ticket based on the respective alarm
- Close an alarm

Severity

The displayed severity on the portlet is defined based on the configuration of the respective alarm and reflects the last update of the alarm:

- Critical
- High
- Normal

Plant

- Relevant to use the portlet on portfolio level
- Makes it easier for the user while scrolling the portlet on portfolio level to identify the concerned plant

Alarm level

The alarm level provides the information whether the issue is affecting the whole performance of the system or only single devices:

- Plant level for issues affecting the overall performance or communication of the whole system
- Inverter level for issues affecting the overall performance of each inverter
- Datalogger mainly for communication issues
- String level for issues affecting the overall performance of each string
- Sensor level for issues affecting the overall performance of each sensor

Alarm types

- Misproduction for alarms on system or inverter level
- Total outage for alarms on system, inverter, or string level
- Communication loss for alarms on system or datalogger level
- Sensor outage for sensor alarms
- User-defined alarms

Affected inverters

- The designation of the affected inverter for alarms on inverter level

Affected power

- Percentage to reflect how the alarm affect the total production of the plant. This value is calculated from alarms on system or inverter level and is being calculated from the deviation between the target value and the measurements of the respective alarm.

Use case: A system is set up with 10 inverters with the same input configuration and nominal power. In case of an outage of one inverter, the affected power will be displayed as 10 %.

Duration

- The duration reflects the period where the system is detecting issues based on the configuration of the alarms.
- If an alarm is detected for several days, only timestamps where the issue is processed by the system are considered for the duration, excluding therefore e.g., timestamps during night for inverter misproduction issues.

Use case:

Day 1: An alarm has been detected at 4 p.m. und updated until 6 p.m.

Day 2: The same issue has been detected again at 8 a.m. and the alarm updated until 11 a.m.

In this case, the duration of the alarm is equal to 5 hours in total.

Creation

- Timestamp of when the alarm is triggered for the first time

Last update

- Timestamp of when the alarm has been updated for the last time
- This is an important indicator to highlight the information whether the alarm is still relevant or not.

Losses

- Estimated losses which are calculated from the deviation between the target value and power measurements over the period where the alarm has been updated and the issue detected by VCOM Cloud

State

- Open
- Closed

Filters

As the new portlet “Alarms” is available on portfolio as well as on system level, different filters are available to facilitate / streamline the alarm handling and the fault detection.

- **Severity** to display e.g., only critical alarms
- **Alarm level** which allows e.g., displaying only alarms on system level if the portlet is being used on portfolio level
- **Alarm type** to display specific device categories or alarm types
- **Status** to display e.g., only alarm with status open