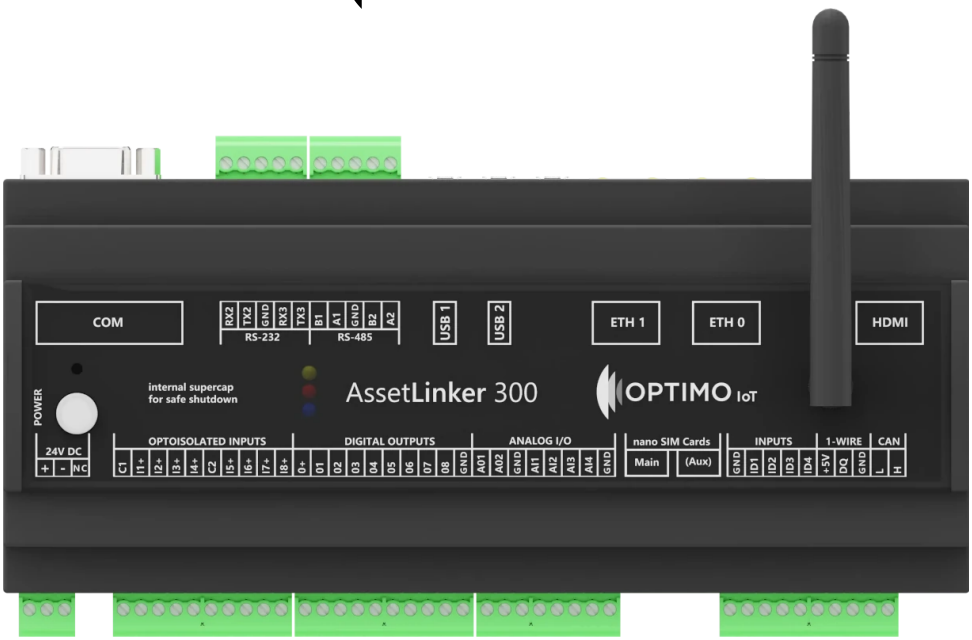

AssetLinker 300 User Manual

Comprehensive Guide to Setup and Configuration

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1. Documentation Optimo IoT

Optimo IoT offers a comprehensive platform for collecting, analyzing, and visualizing data from connected devices and sensors. The platform includes an IoT gateway (AL300) that handles local data acquisition using various industrial communication protocols (Modbus, OPC-UA, MQTT, etc). For more information about the AL300 gateway and the platform's features, visit the official website optimoiot.it or our online store store.optimoiot.it.

The platform is independently accessible through:

- integrated local web server in the AL300 gateway (`http://<gateway_ip_address>/`)
- Optimo IoT cloud platform (`https://cloud.optimoiot.it/`)

Both offer an intuitive web interface for configuring, managing, and visualizing the acquired data.

Once logged in, you can navigate between two main environments:

- **Dashboard**: view and edit the pages where the acquired data is displayed.
- **Configuration**: manage the gateway configuration, data sources, users, and other settings.

To switch between the two environments, use the icon in the top right bar.

What do you want to do?

- Install and connect the AL300 gateway
- Activate and configure the AL300 gateway
- Use and share cloud dashboards
- Learn about the logical structure of the platform

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2. Optimo IoT Resource types

2.1 Asset

All resources (plants, dashboards, users, devices, variables, alarms, etc) managed by the Optimo IoT platform are organized in a tree structure called "Asset tree". This structure allows to represent in a hierarchical way the physical or logical organization of the resources, making it easier to navigate and manage them.

The `Asset tree` is composed of nodes (called *assets*). Each asset can have one or more child assets. Each asset can be of a different type. The available types are:

- **Company**: represents the main company or organization
- **Gateway**: represents an Optimo IoT gateway (AL300)
- **Device**: represents a connected device (e.g. PLC, sensor, etc)
- **Point**: represents a measurement point or a specific sensor connected to a device
- **Machine**, **Plant**, **Building**, **Site**, **Room**, **Process**, **Subprocess**, **Tenant**, **Group**: represent logical or physical groupings of assets, useful to organize and categorize resources based on the company structure or specific needs.

The branches of the `Asset tree` under each **Gateway** are part of the gateway configuration itself and are automatically synchronized with the **Gateway**.

2.2 Variables

`Variables` are quantities whose value changes over time. They are stored as time series whose values can be saved in the cloud or locally on the gateway, and then displayed in dashboards. Some variables are *alarm* variables: for these it is possible to set email or SMS notifications upon activation.

Each variable is associated with at least one asset in the `Asset tree`. It is usually automatically associated with the device that acquires it in the field, but it can be associated with other assets (e.g. departments, machines, etc)

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2.3 AL300 Gateway configuration

The AL300 gateway configuration includes:

- the portion of the `Asset tree` under the **Gateway** itself
- network settings and communication interfaces
- configuration to communicate with data sources, read their variables (e.g. PLC, Modbus devices, OPC-UA, etc) and save the read values
- metadata associated with the acquired variables

Configure both locally and remotely

The configuration can be modified both locally, by accessing the gateway's web interface, and remotely through the Optimo IoT cloud platform.

In both cases, changes are **automatically synchronized** between the gateway and the cloud platform. In case of conflicts (e.g. changes made simultaneously while the gateway was offline), the configuration present on the gateway takes precedence over the one in the cloud.

2.4 Users

Each user is associated with an `Asset` in the `Asset tree`. Each user has access to all assets (and therefore variables) under the one they are associated with.

2.5 Dashboards

A dashboard is a set of pages organized in a hierarchical menu. Each page shows widgets of various types (charts, tables, indicators, maps, etc). Dashboards are fully customizable by users with `Administrator` access.

Cloud `Dashboards` are linked to an `Asset` in the `Asset tree`. The user is shown the dashboard associated with the asset they are linked to. If the asset does not have an associated dashboard, the dashboard is searched among the child assets. If no dashboard is found, the dashboard associated with the parent asset is shown, and so on up the tree until the root.

Locally, there is instead a single dashboard.

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3. Gateway AL300

3.1 Quick start

3.1.1 Hardware installation

Power on the AssetLinker300 and optionally insert the data SIM, as described in the chapter Installation

3.1.2 Access local web interface

The following information is printed on the package:

- username and password for the local web interface
- factory configuration of the eth0 network port (10.10.10.10./24)
- factory configuration of the eth1 network port (auto)
- SSID and password with QRCODE for WiFi access

> **Note**
>
> By default, the LTE modem is active and, if a nanoSIM data with disabled PIN is inserted in the `(Main)` slot, the gateway will automatically connect to the Optimo IoT cloud, making the connection to the local web interface unnecessary

There are 3 ways to access the local configuration interface:

1. with ethernet cable
2. via WiFi
3. with HDMI screen, mouse and keyboard (deprecated, this possibility will be removed in the next releases)

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3.1.2.1 Connection with network cable

1. configure the PC network port to be able to communicate with the gateway IP address (eg ip: 10.10.10.3 / subnet mask: 255.255.255.0):

- guide for Windows
- guide for Mac

1. connect to the gateway with an ethernet cable to the ETH 0 port
2. open the browser and visit http://10.10.10.10/
3. enter username and password

3.1.2.2 Connection via WiFi

The default settings keep active for the first 5 minutes of gateway power-on a WiFi network of the type `OptimoIotGw-XXXX`. To connect, you can scan the QRCODE with your smartphone/tablet or enter SSID and password on your PC.

Once connected, the gateway web interface will open automatically (http://optimoiot.gw). If for 5 minutes no device connects to the WiFi network, it will be deactivated

3.1.2.3 Connection with HDMI monitor, mouse and keyboard [DEPRECATED]

By connecting a monitor to the HDMI port and a mouse and keyboard to the two USB ports, you can access the web interface directly. The gateway also supports, with some limitations, HDMI+USB touchscreens

3.1.3 Configuration of network settings and data sources

Once you have logged in, you can access all the settings described in the chapter Device Settings

We recorded a video in which we quickly present:

- the configuration of a Modbus TCP data source
- the creation of a simple dashboard for a photovoltaic system

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3.2 Installation

3.2.1 AssetLinker300

3.2.1.1 Safety Instructions

> **Warning**
>
> Failure to observe the essential precautions and safety guidelines outlined below can cause serious harm to people and property. For safe and trouble-free operation, it is crucial to adhere to all safety instructions and information contained in this manual.
>
> Pay particular attention to the specific safety instructions provided in other sections of this manual as well.

3.2.1.1.1 QUALIFIED PERSONNEL

Only qualified and competent personnel are authorized to work with the AL300 (AssetLinker300). Such personnel must meet the following requirements:

- Be familiar with the installation, assembly, commissioning, and operation procedures of the AL300.
- Possess the appropriate qualifications for the tasks to be performed.
- Know and be able to apply all local regulations, directives, and laws related to accident prevention

3.2.1.1.2 DEVICE

The hardware and software of the AL300 must never be modified in ways not specifically described in the installation manual.

Note: Any unauthorized modification will result in the immediate nullification of all warranty claims and exclusion of liability by the supplier.

3.2.1.1.3 SCOPE OF APPLICATION

The AL300 is an electrical communication device. It is suitable exclusively for installation inside electrical cabinets or other closed and similar operating environments.

3.2.1.1.4 ASSEMBLY AND DISASSEMBLY

The AL300 must be handled according to these rules:

- Connect or disconnect all plug-in terminals only when the AL300 is turned off (not powered).
- Remove the AL300 from the installation only when the device is turned off.

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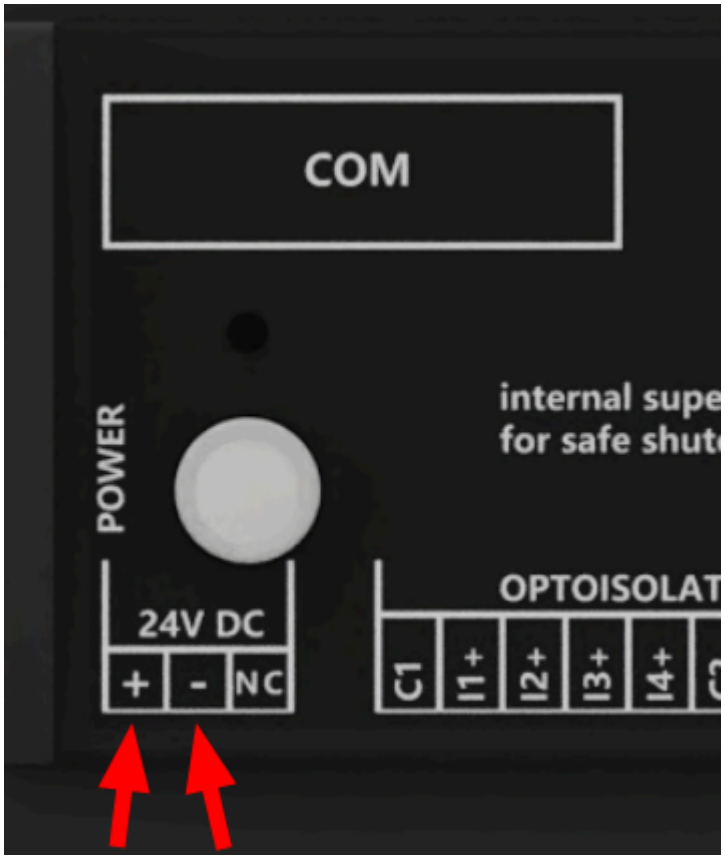
3.2.2 AssetLinker300

3.2.2.1 Electrical connections

AL300 must be powered with 24V DC (min 20, max 32V). The only two terminals to connect are 24VDC+ and 24VDC-. The NC terminal should be left unconnected.



Once the connection to the power supply is made, AL300 takes about 2 minutes to charge the UPS (super capacitors). Only once this operation is completed does the system start up and in about a minute it becomes fully operational.

3.2.2.1.1 UPS

The UPS can keep the device on for about 45 seconds during power outages. It is useful for:

- surviving voltage drops of less than a second
- shutting down the device in a controlled manner
- sending a power failure alarm (future firmware release)

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3.2.3 SIM card insertion

Warning!

When opening the case, be very careful, as it is attached to the base by the 4G antenna cable. With sudden movements, the cable could come off and it would be very difficult to reattach it (slot M of the 4G module)

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To insert a SIM card, you need a flathead screwdriver. The SIM must be in nano format and the PIN must be disabled.

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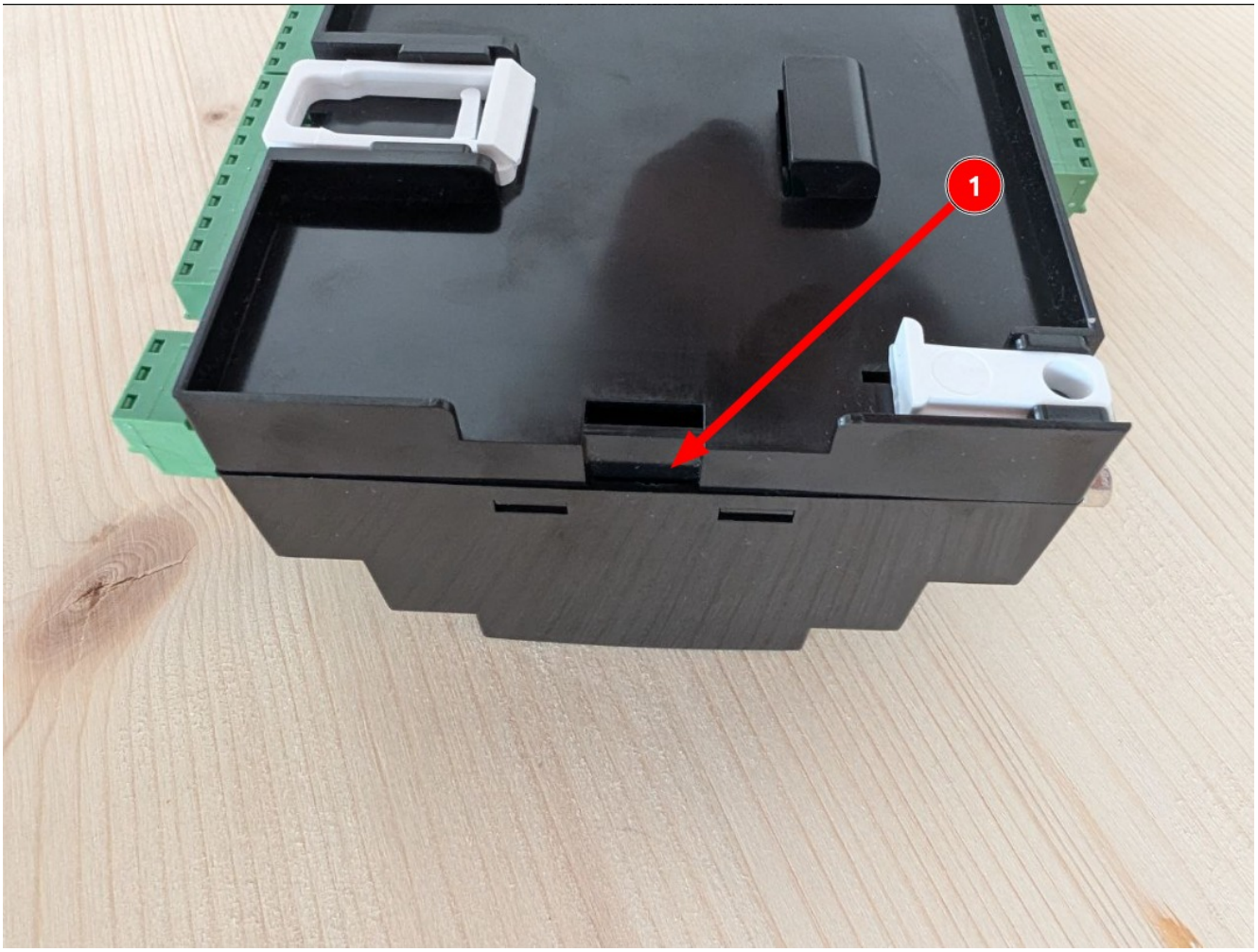
- open the case by inserting the screwdriver and levering, first on one side of the AL300, then on the other



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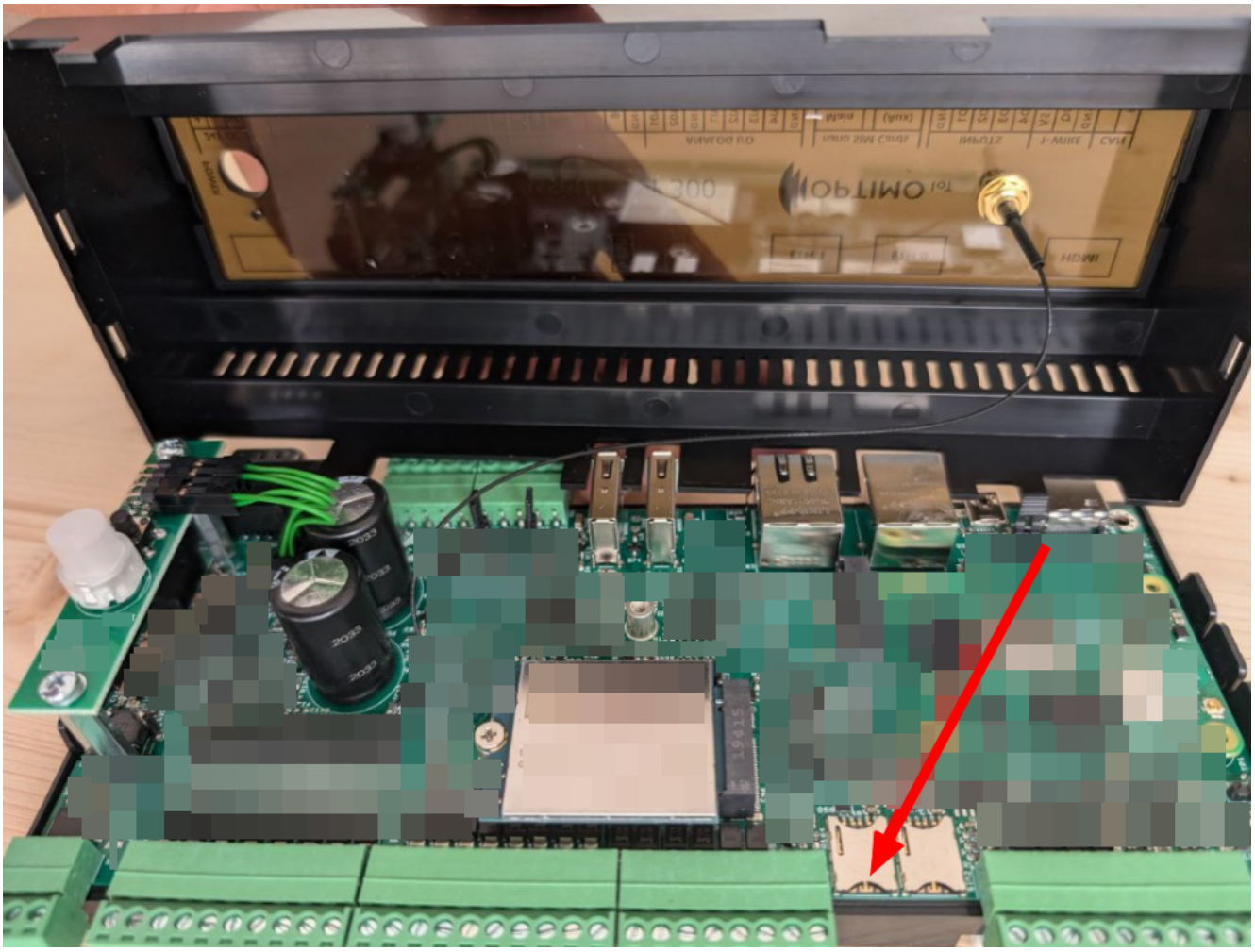
• insert the SIM into the left slot (indicated as Main on the cover)



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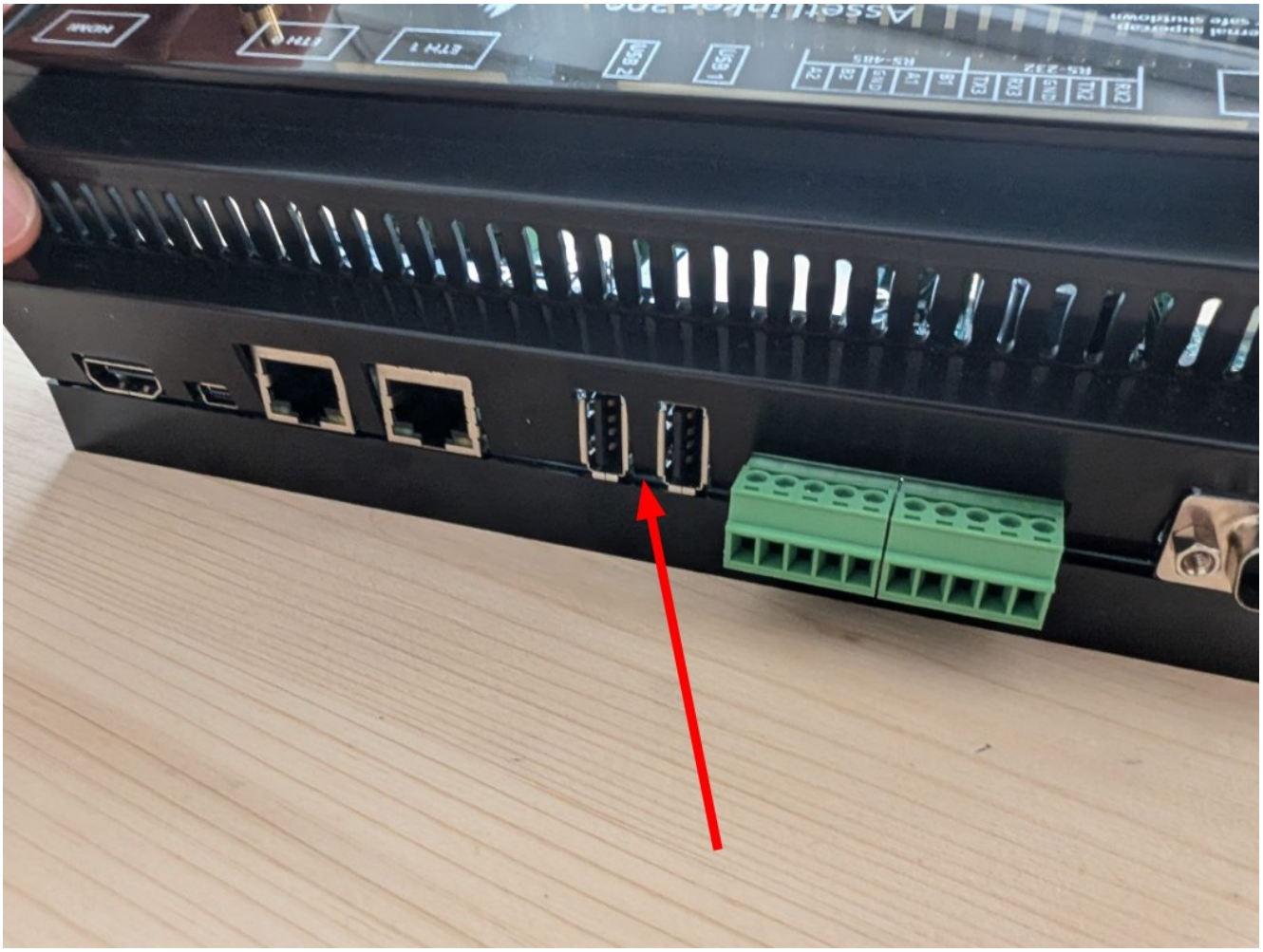
• close the cover starting from the alignment of the USB port profile



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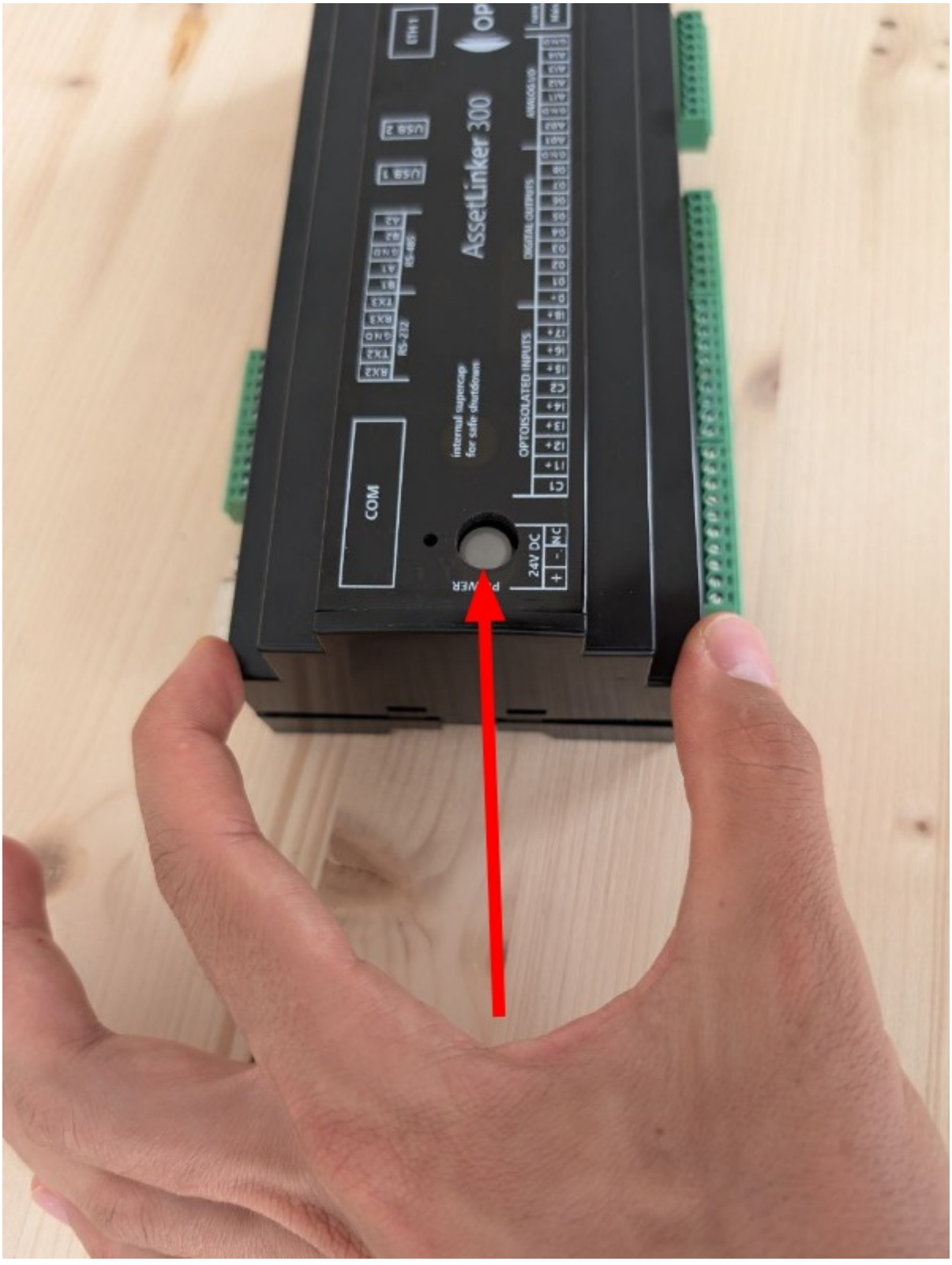
• then align the hole for the front button



• press evenly trying to keep the case parallel to the board

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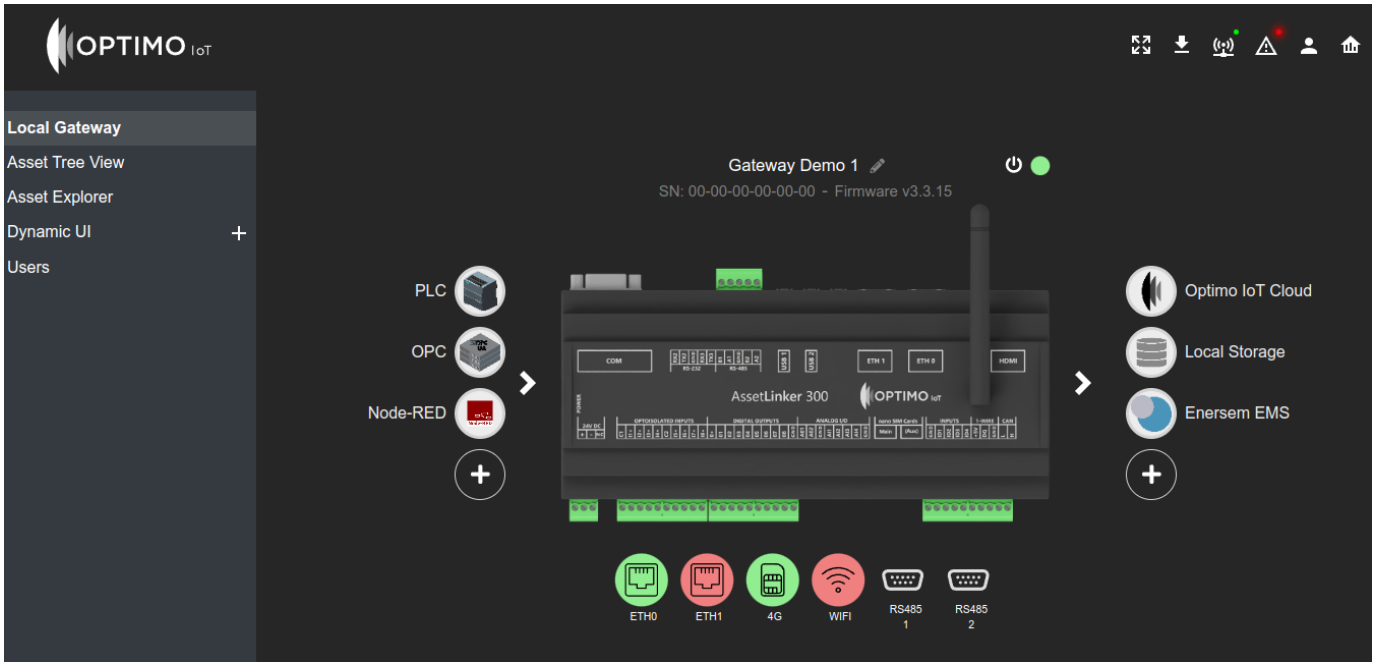
3.3 Device settings

3.3.1 Main view



3.3.1.1 Access

Once logged in, you can access the settings page by clicking on the `Settings` icon ⚙ at the top right. This page is only available for users with administrative permissions.

3.3.1.2 Status information

When the page loads, you can immediately see this information:

- serial number of the gateway
- installed firmware version
- status of the network interfaces

On desktop, you need to hover the mouse pointer over the gateway image to have all the information available

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3.3.1.3 Network interfaces

Below the image of the AL300, the available network interfaces are listed. When you hover the mouse, for each one it indicates:

- the status:
  - green: configured and connected
  - red: configured but not connected
  - gray: disabled
- the IP address
- (only for WiFi) the name of the network it is connected to
- if the interface is used for the internet connection (`Default gateway`)

By clicking on each interface you can manage its settings. For more information, see the specific pages:

- Ethernet network ports
- WiFi card
- LTE modem

On this page the requirements that networks providing internet access must have for the gateway to connect correctly to the cloud are reported

3.3.1.4 RS485 serial interfaces

By clicking on the respective icons, you can configure the parameters of the two available serial ports (e.g. Baudrate, parity, etc). These settings are inherited by any configured RS485 devices.

3.3.1.5 Data sources and destinations

The icons on the sides of the gateway allow you to view, manage and add:

- data sources - on the left (e.g. PLC, modbus and OPC-UA devices, etc)
- data destinations - on the right (e.g. cloud platform, local storage)

3.3.1.5.1 ADDING A NEW DEVICE

You can add devices, compatible with the purchased license, by clicking on the `Add` button ➕

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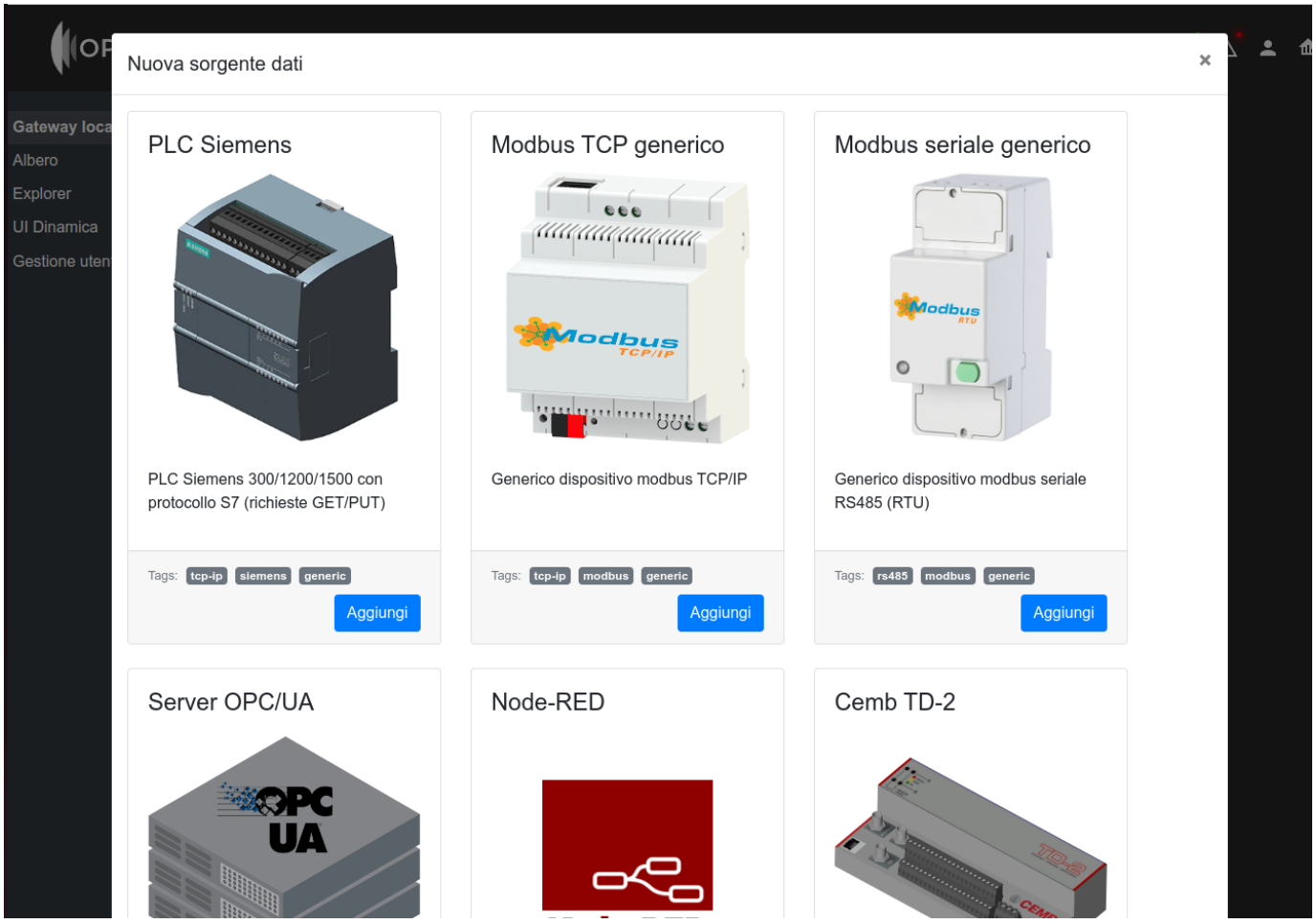
You can then select the type of data source to add and configure it through a guided procedure



Subsequently, connection parameters will be requested (e.g. IP address), the choice of variables to acquire and how to store them.

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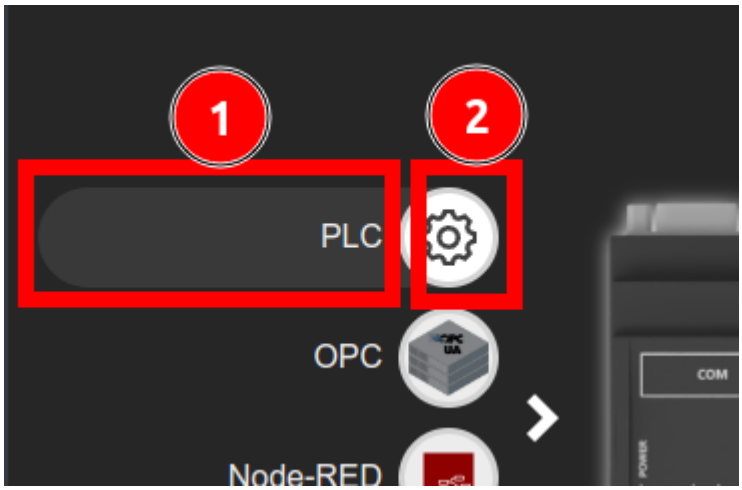
Here are the currently supported devices and their configuration guides.

3.3.1.5.2 STATUS AND MODIFICATION OF AN ALREADY CONFIGURED DEVICE

You can view the status of the device and configure it or have diagnostic information by hovering the mouse cursor over the respective icon



1. Information on the current status (connection, variable values)
2. Modification of settings and advanced diagnostics

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3.3.2 Network

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3.3.2.1 Ethernet

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Each interface can be:

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- enabled or disabled

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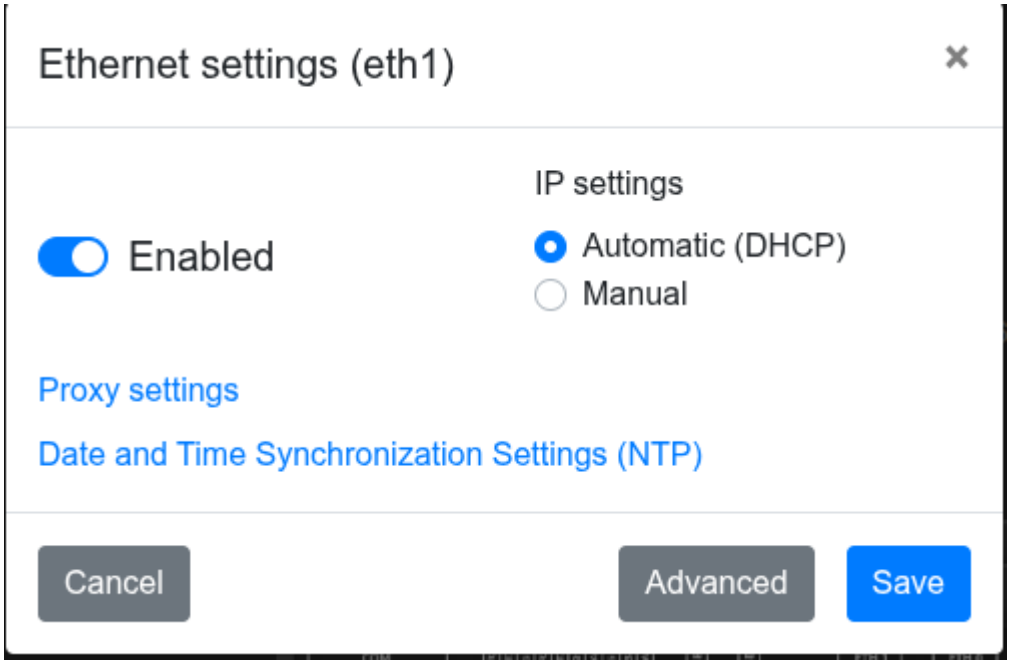
- if enabled, the type of IP settings can be configured:
  - automatic (with DHCP server)



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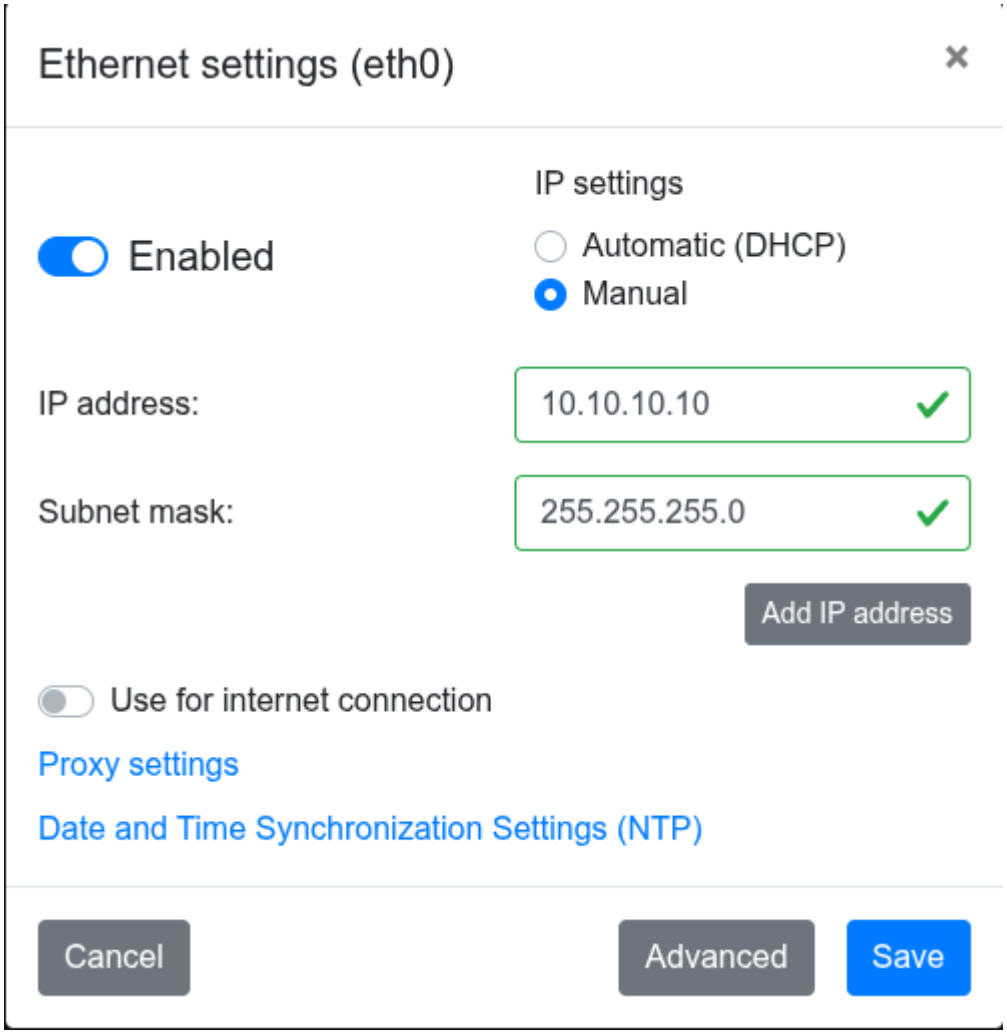
- manual



3.3.2.1.1 MANUAL SETTINGS

In addition to IP address and subnet mask, it is possible to enable the interface for internet connectivity. In this case, it is necessary to specify the router address (Default Gateway) and optionally up to two DNS servers to use.

It is possible to assign more than one IP address to the same interface

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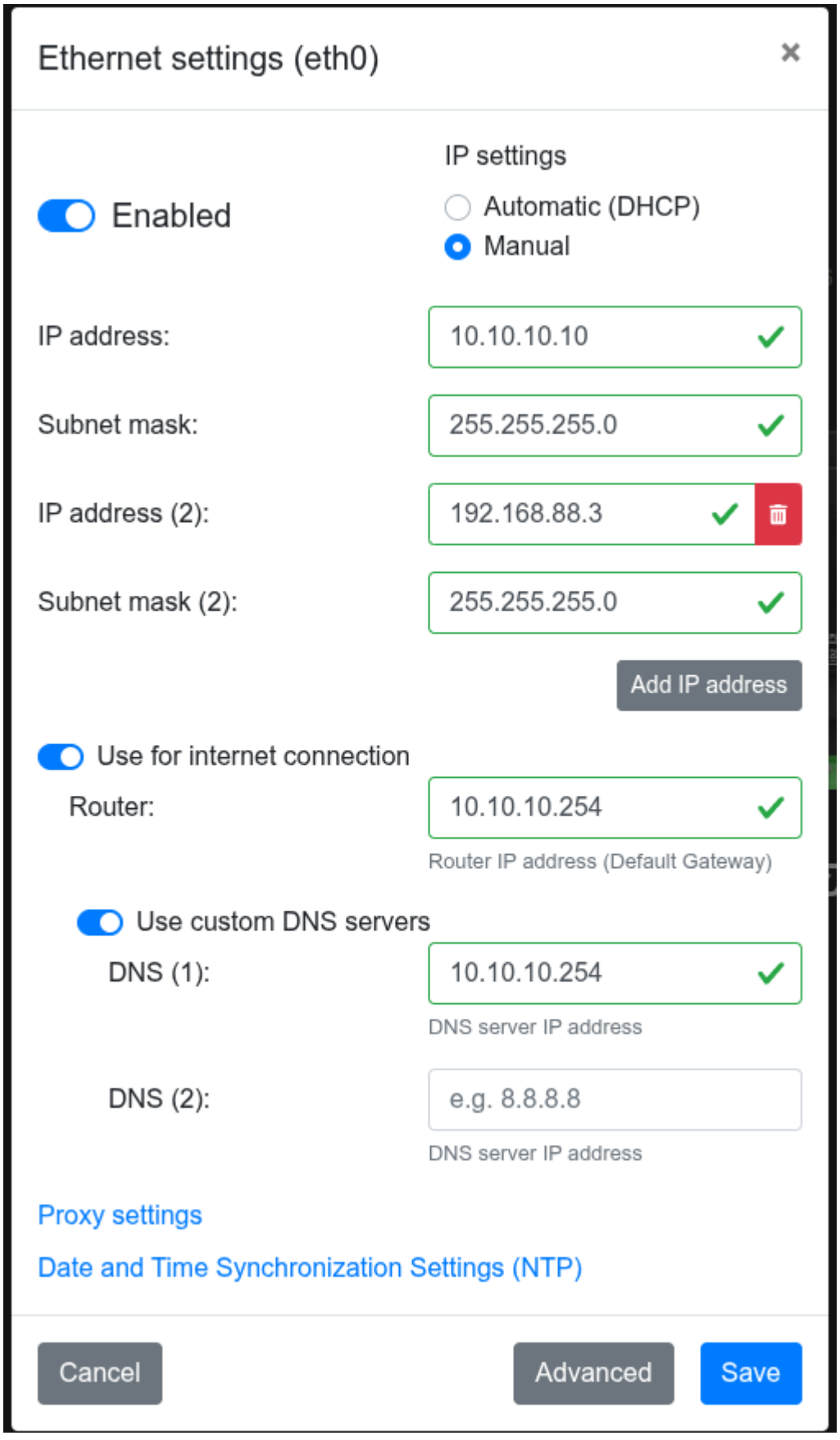

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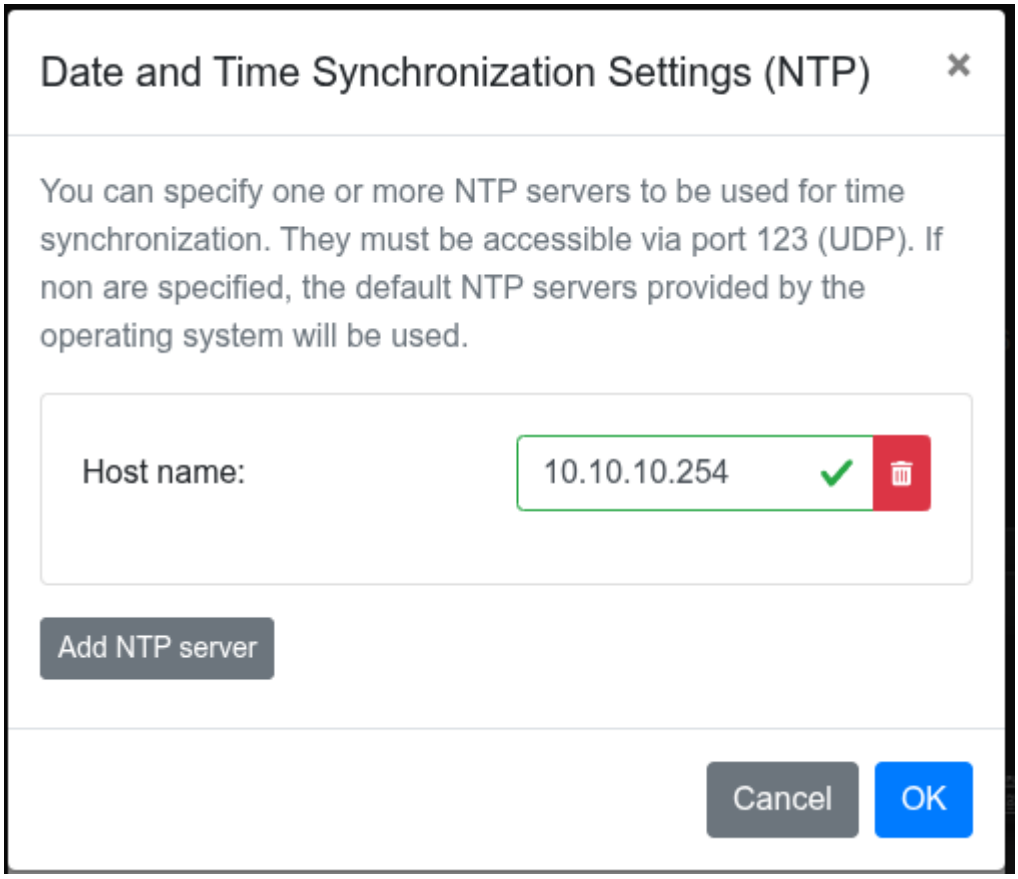
3.3.2.1.2 NTP (DATE AND TIME SYNCHRONIZATION)

(available from firmware version 3.8.6)

If the AL300 is not connected to the internet or a firewall blocks outgoing requests on the UDP port, it is possible to specify a custom NTP server. The server with the specified IP is used in addition to a list of predefined servers.



3.3.2.1.3 PROXY

It is possible to use a proxy server for the internet connection. It is possible to specify more than one server. If the first one fails, the next one will be used. If no proxy server is specified or all proxy servers fail, network requests will be made directly through the router.

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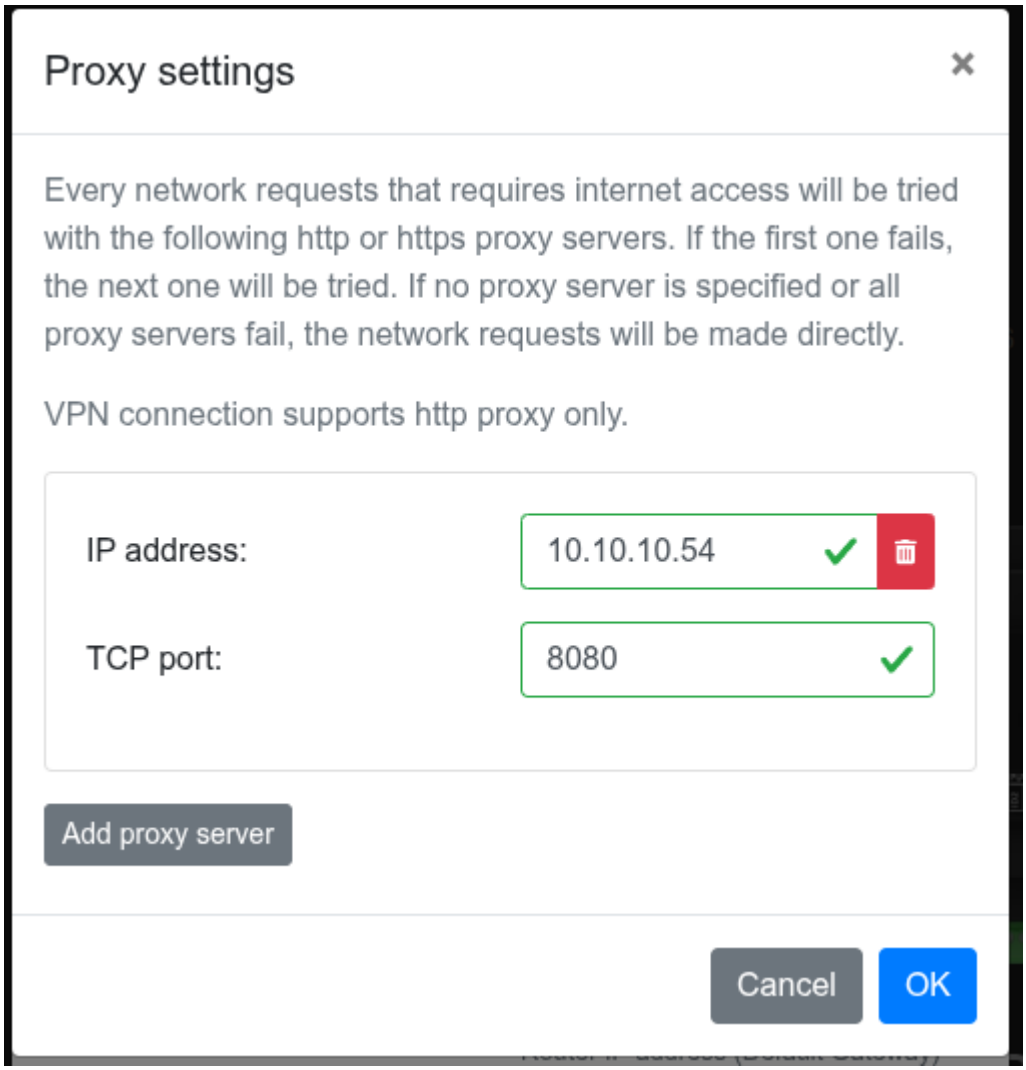

Note

The VPN connection only supports http type proxies

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3.3.2.2 WiFi

Thre tabs are available:

- Available networks
- Saved networks
- WiFi Access Point

3.3.2.2.1 AVAILABLE NETWORKS

When opening the page, the available WiFi networks are searched and listed. You can connect to WiFi networks that are:

- open (without password) or WPA (with password)
- the connection to the network must automatically provide access to the Internet: `captive portals` or other additional methods of authentication via browser are not supported

Note

Once the gateway has been connected to a network, remember to click the `Save` button, to avoid losing the connection at reboot

3.3.2.2.2 SAVED NETWORKS

Here the saved WiFi networks are listed. If you want to delete one, you must first disconnect from that WiFi network

3.3.2.2.3 WIFI ACCESS POINT

The WiFi Access Point functionality allows the gateway to create a WiFI network to which other devices (e.g. user's PC/tablet/phone) can connect to access the configuration interface.

By default, this functionality is active (with an SSID that includes the last 4 characters of the gateway's serial number and a randomly generated password) for the first 5 minutes after the gateway starts. After this time, in the absence of connected devices, the WiFi network is turned off.

You can disable this functionality, change the automatic deactivation time, change the SSID and password of the network.

Note

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The gateway cannot be simultaneously connected to a WiFi network and keep the Access Point active for the connection of other devices! You can set which of the two modes has priority

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3.3.2.3 Modem LTE

AL300 has an integrated modem that allows you to connect to the internet in the absence of other existing networks. To connect via LTE, you need to:

- have a data SIM (nanoSIM format)
- make sure you have disabled the SIM PIN
- (recommended) try the SIM on a phone and make sure there is credit available and that it allows you to browse the internet
- connect the antenna to the `RP-SMA` connector on the front cover of the gateway
- insert the SIM into the gateway following these instructions

According to the default settings, an APN is automatically selected and, in the absence of other internet connections via ethernet/WiFi, the modem is activated and the gateway connects to the cloud

3.3.2.3.1 SETTINGS

You can:

- manually specify an APN (useful for SIMs from some virtual operators). The APN is a configuration parameter specific to each mobile connectivity operator
- choose whether to keep the modem always on, always off, or to monitor other internet connections and activate it only if these are not present or not working properly
- choose whether to suspend the VPN service to reduce data consumption (useful if the cost per MB of traffic is high)
- enable the sending of configuration commands via SMS

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3.3.2.4 Firewall

To connect to the Optimo IoT Cloud, the network to which the AL300 is connected must allow outgoing traffic to the internet on the ports listed below.

- TCP 443:
  - monitoring data
  - VPN service (optional)
- TCP 8883: if open for outgoing traffic, it is used for sending monitoring data instead of 443 (lower data consumption)
- UDP 53: DNS. Alternatively, it is possible to specify an internal DNS server for the company network
- UDP 123: NTP (date/time synchronization), in case the VPN service is not active. The gateway has an RTC with a battery. If the port is not open for outgoing traffic in the long term (years), there may be time drifts on the order of seconds. If in the very long term (more years) the RTC battery runs out and the gateway is restarted, the correct time may be lost

> **Note**
>
> It is not necessary (in fact, it is not recommended) that the gateway has a public IP address or that it is reachable from outside the local network

If the company network has a firewall that needs to be configured to allow outgoing traffic to some specific FQDN, it is possible to request the list by sending an email to info@optimoiot.it

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3.3.3 Sources

3.3.3.1 Intro

3.3.3.1.1 INTRODUCTION

We call data sources those devices (e.g. sensors, PLCs) that make available to AL300 some variables whose values can be read by AL300. Some data sources also support writing values (e.g. setpoints, thresholds, commands).

AL300 supports two modes of configuration of the communication with these devices:

1. **generic driver**: allows you to use a protocol freely, thus supporting any device from any manufacturer
2. **plug&play driver**: allows you to acquire specific devices with minimal configuration. AL300 already knows their characteristics and the available variables

3.3.3.1.2 GENERIC DRIVERS

The supported protocols are:

- Modbus RTU (on RS485)
- Modbus TCP
- S7 protocol (Siemens PLC)
- OPC UA
- LoRaWAN
- Ethernet IP (for Rockwell PLCs)
- Ethernet IP (generic)
- BACnet

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3.3.3.1.3 PLUG&PLAY DRIVERS

We add several devices every month and this list is always growing. Among the currently supported devices we have:

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- `Cemb TD-2` : Central unit for two accelerometers with Tacho for speed reading
- `Cemb Cube` : Triaxial accelerometer
- `Algodue UPM209 RS485` : Three-phase network analyzer for measuring and storing electrical parameters
- `Algodue UPM209 TCP` : Three-phase network analyzer for measuring and storing electrical parameters
- `Algodue UPM309 RS485` : Three-phase network analyzer for measuring and storing electrical parameters
- `Algodue UPM309 TCP` : Three-phase network analyzer for measuring and storing electrical parameters
- `Algodue UEM80 TCP` : Compact three-phase energy meter with 4 DIN modules for measuring energy in industrial and civil environments
- `Algodue UEM80 RS485` : Compact three-phase energy meter with 4 DIN modules for measuring energy in industrial and civil environments
- `Algodue UEM1P5 TCP` : Compact single-phase energy meter with 1 DIN module for measuring energy in industrial and civil environments
- `Algodue UEM1P5 RS485` : Compact three-phase energy meter with 4 DIN modules for measuring energy in industrial and civil environments
- `Algodue UEM40 RS485` : Compact three-phase energy meter with 4 DIN modules for measuring energy in industrial and civil environments
- `Caleffi Conteca Easy` : Direct heat meter for heating and air conditioning systems
- `Schneider iEM-3000` : Single-phase and three-phase DIN guide energy meters
- `Schneider MicroLogic` : MicroLogic control unit for ComPact NSX, PowerPact H-, J-, and L-frame, ComPact NS, PowerPact P-, and R-frame or MasterPact NT/NW circuit breakers.
- `Schneider PM5000` : Compact and versatile meters for network management and energy cost applications
- `Thytronic NA60` : Thytronic NA60 general protection relay (software version 3.91)
- `Thytronic NA10` : Thytronic NA10 general protection relay (software version 3.72)
- `Overdigit EX04AIO` : 4-channel analog input/output module
- `Overdigit EX08AI` : 8-channel analog input module
- `Overdigit EX1608DD` : 16 inputs and 8 digital output module
- `Telematica MB880-X` : External Modbus/RTU, Modbus/TCP converter for Iskra MT880 meters

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- `SMC Air Management` : Monitors machine standby conditions (when production stops) and automatically reduces pressure. Reduces unnecessary air consumption.
- `Milesight CT101 Current Transformer` : It is a LoRaWAN® enabled device with an innovative non-invasive quick installation. It accurately estimates energy consumption with a sampling rate of up to 3.3 kHz and calculates cumulative ampere-hours every second
- `Milesight AM102 2-in-1 IAQ Sensor` : Provides real-time and basic data on indoor air temperature and humidity
- `Milesight WS101 Smart Button` : The Milesight WS101 is a compact, battery-powered LoRaWAN® smart button designed for wireless control, action triggering, and alarm sending
- `RAK7201 WisNode 4K Button` : The button is suitable for a variety of Smart Home applications: entertainment system control, light control, a snooze button for your alarms, or a remote trigger. With long-range wireless connectivity, incredible battery life, and four programmable buttons, there are plenty of applications where this device can fit
- `Milesight EM300 Temperature and Humidity Sensor` : Provides real-time and basic data on indoor air temperature and humidity
- `NEON TS Temperature Sensor` : LoRaWAN temperature sensor for ATEX environments
- `NEON TT Temperature Transmitter` : LoRaWAN temperature sensor for ATEX environments through connection to an industrial thermocouple or RTD.
- `FRER NANO / QUBO` : Three-phase network analyzer for measuring and storing electrical parameters. Supported models: Q52...(NaNo) / Q72/96 (Qubo) / MCUP0H
- `Gavazzi EM24` : Three-phase network analyzer for measuring and storing electrical parameters
- `Network ping` : Network diagnostics through ICMP ping
- `Comet TX` : Temperature, humidity, pressure, CO2 sensor
- `Solis Inverter FV grid-tied` : Solis grid-tied photovoltaic inverter of all powers with Modbus RTU/RS485 connection
- `Milesight UC100 IoT Controller` : Reads up to 32 Modbus RTU devices, acting as a converter from Modbus RS485 to LoRaWAN®. Designed for remote control and data acquisition.
- `EnergyTeam X-Meter RS485` : Three-phase network analyzer for measuring and storing electrical parameters
- `EnergyTeam X-Meter TCP` : Three-phase network analyzer for measuring and storing electrical parameters
- `Ametek Baseline 9100` : Gas chromatograph for EtO | VOC | BTEX. It uses a TCP connection to read real-time values from 16 channels

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- `Kohler DEC 3500` : Control unit for Kohler generators

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3.3.3.2 Generic

3.3.3.2.1 MODBUS RTU PROTOCOL

Modbus RS485 (also commonly called Modbus RTU) is a widely used serial communication protocol in industrial settings, especially for interfacing with meters, inverters, energy counters, and other automation devices. The RS485 bus allows multiple devices (up to 32) to be connected on a single serial line, using a daisy-chain connection capable of covering long distances. It allows reading and writing variables (registers) on connected devices.

The AL300 Gateway can act as a Modbus master, querying slave devices connected to the RS485 bus.

Physical connection

AL300 has two independent RS485 ports, allowing it to behave as a Modbus master and query Modbus slave devices.

Port 1:

- A1
- B1
- GND

Port 2:

- A2
- B2
- GND

Configuration

1. Choose the data source `Generic Modbus RTU`

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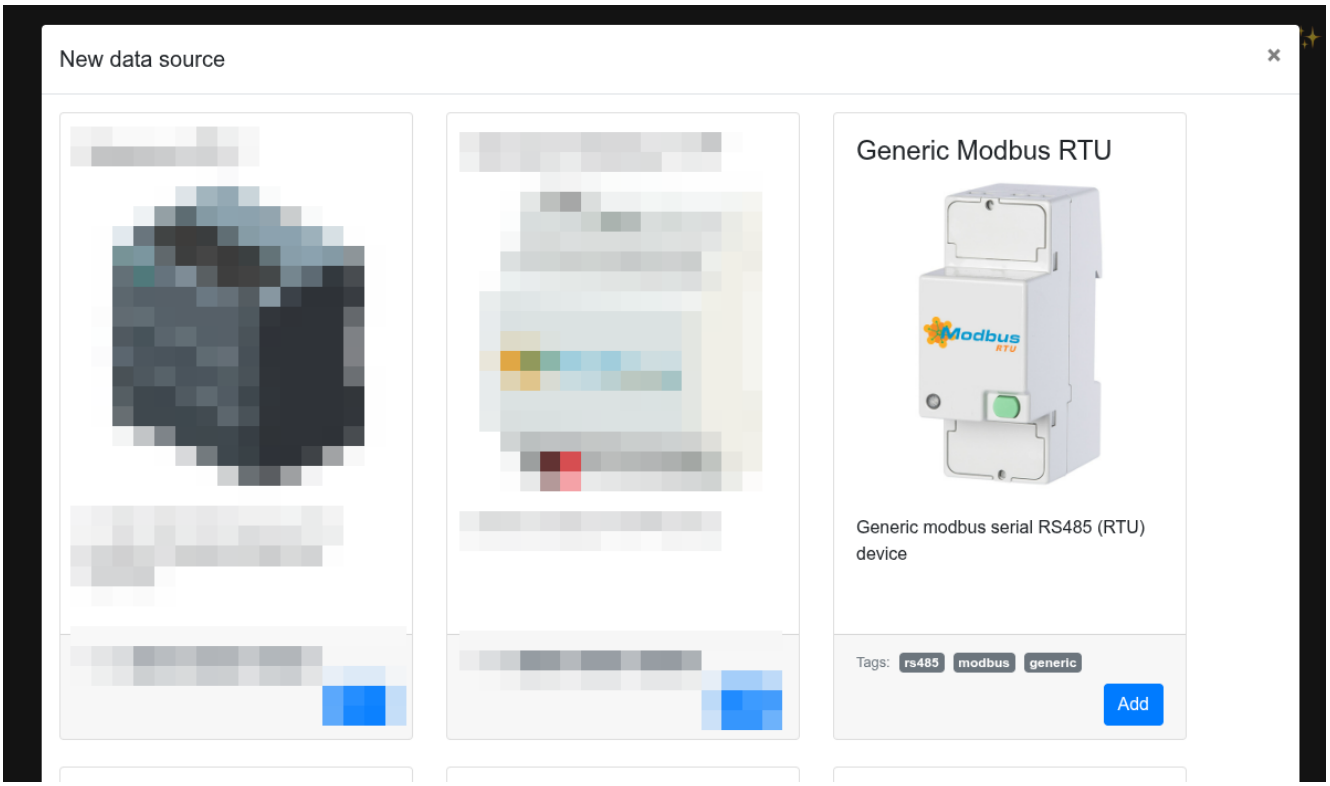
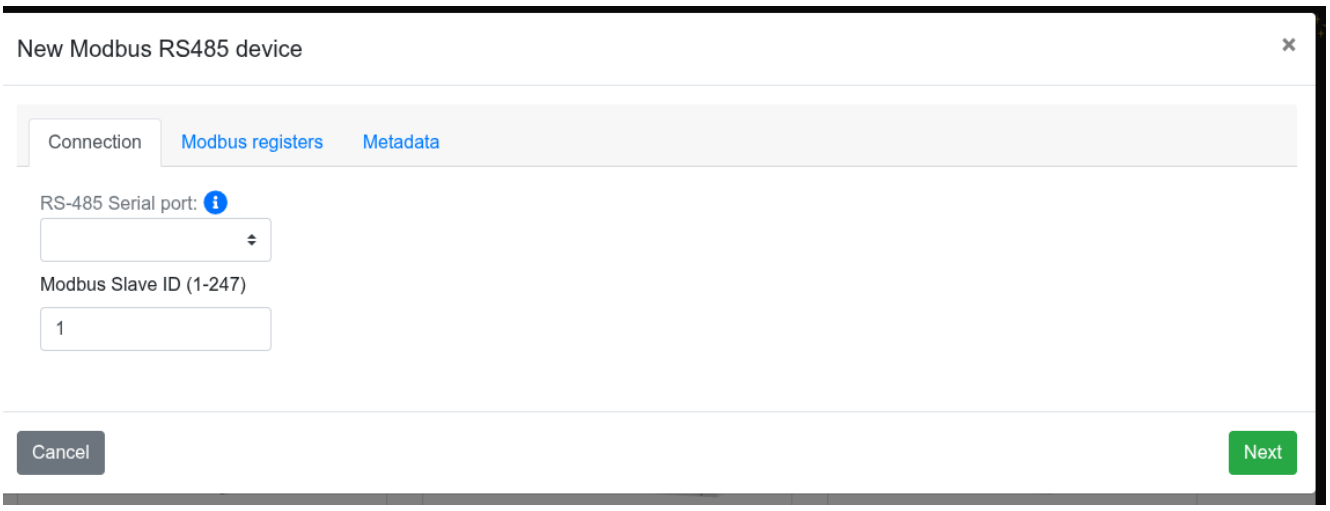


2. Select the serial port to use (1 or 2) and the id of the Modbus slave to query. To modify the serial port parameters (Baudrate, parity, stop bits) see here. To proceed, you need to have the documentation (register table) provided by the Modbus slave manufacturer.



3. Choose whether to use register (1-based) or address (0-based) numbering and set the byte order and, if necessary, word order (in the documentation they are indicated as `big endian` / `little`

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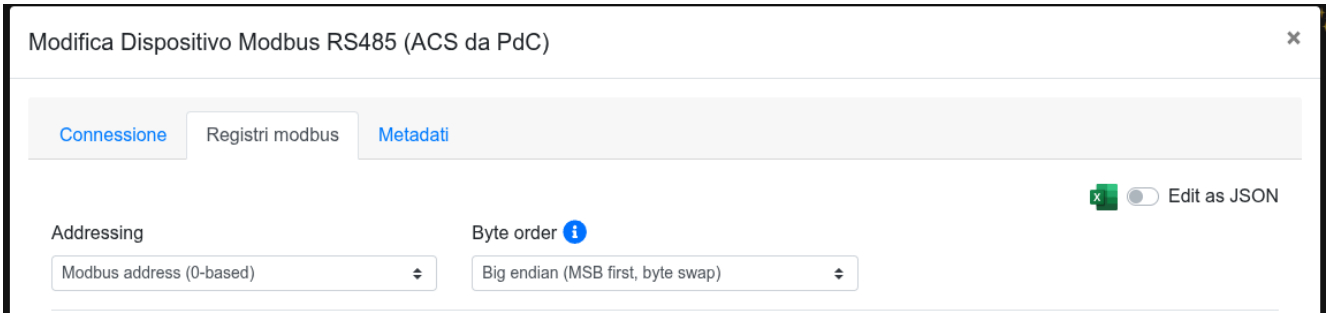
`endian` or `LSB (least significant byte)` / `MSB (most significant byte)`).



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4. Click on `Add variable`. To import or modify the table massively, see bulk configuration. For each variable of interest, you can set:

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- Name and metadata (see here for more details)
- Topic. It can be:
  - Info: connection information (device disconnected variable and read error variable)
  - Holding registers: modbus functions 3 (read) and 6/16 (write)
  - Input registers: modbus function 4 (read)
  - Coils: modbus functions 1 (read) and 5/15 (write)
  - Discrete inputs: modbus function 2 (read)
- Address/Register: It can be expressed in decimal or hexadecimal and can be indicated as address (0-based) or register (1-based) depending on the `Addressing` setting above the table.

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For each register, you need to set the correct encoding (data type). The available data types are:

- `8bit_uint` : unsigned integer of 8 bits
- `16bit_uint` : unsigned integer of 16 bits
- `32bit_uint` : unsigned integer of 32 bits
- `64bit_uint` : unsigned integer of 64 bits
- `8bit_int` : signed integer of 8 bits
- `16bit_int` : signed integer of 16 bits
- `32bit_int` : signed integer of 32 bits
- `64bit_int` : signed integer of 64 bits
- `8bit_bsint` : signed integer of 8 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `16bit_bsint` : signed integer of 16 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `32bit_bsint` : signed integer of 32 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `64bit_bsint` : signed integer of 64 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `16bit_float` : floating point number of 16 bits (half-precision)
- `32bit_float` : floating point number of 32 bits (single-precision)
- `64bit_float` : floating point number of 64 bits (double-precision)
- `string` : string of ASCII characters (you need to specify the length in characters)
- `bits` : array of bits (you need to specify the index from 0 to 15 of the bit within the register)

- Scale (see here for more details)
- Save to (see here for more details)

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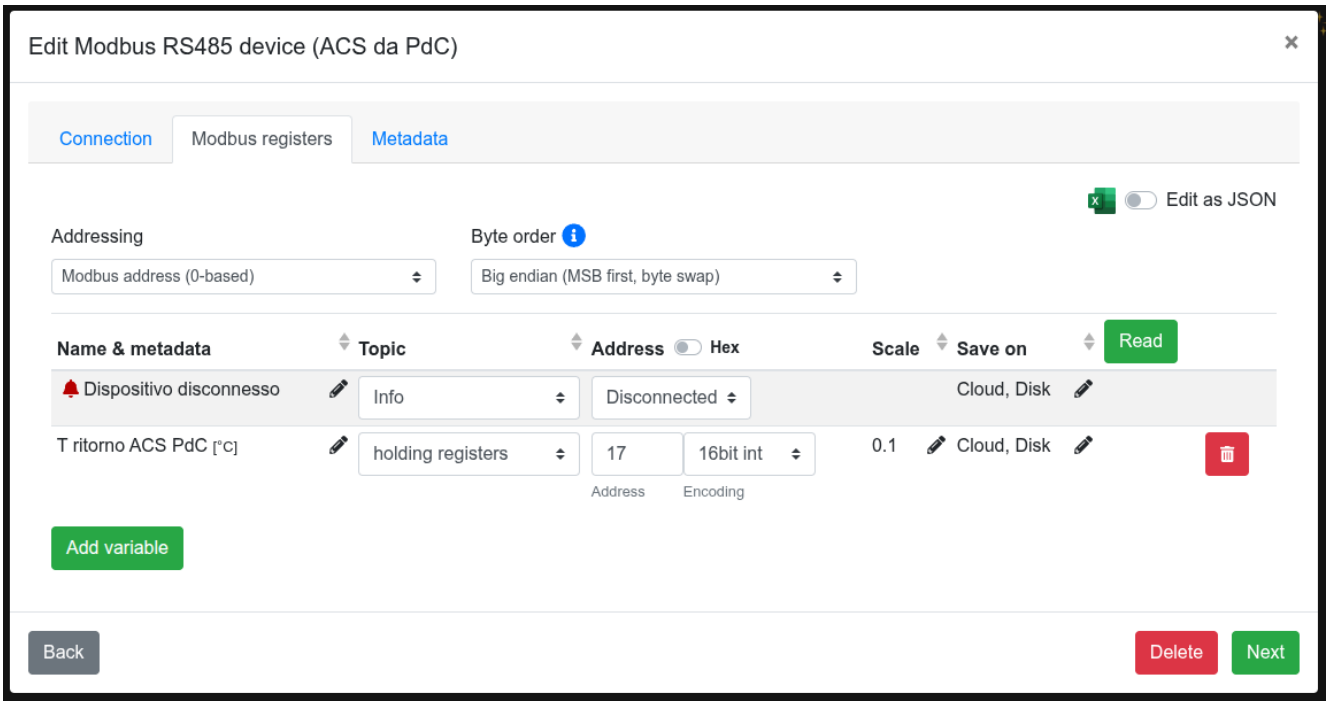
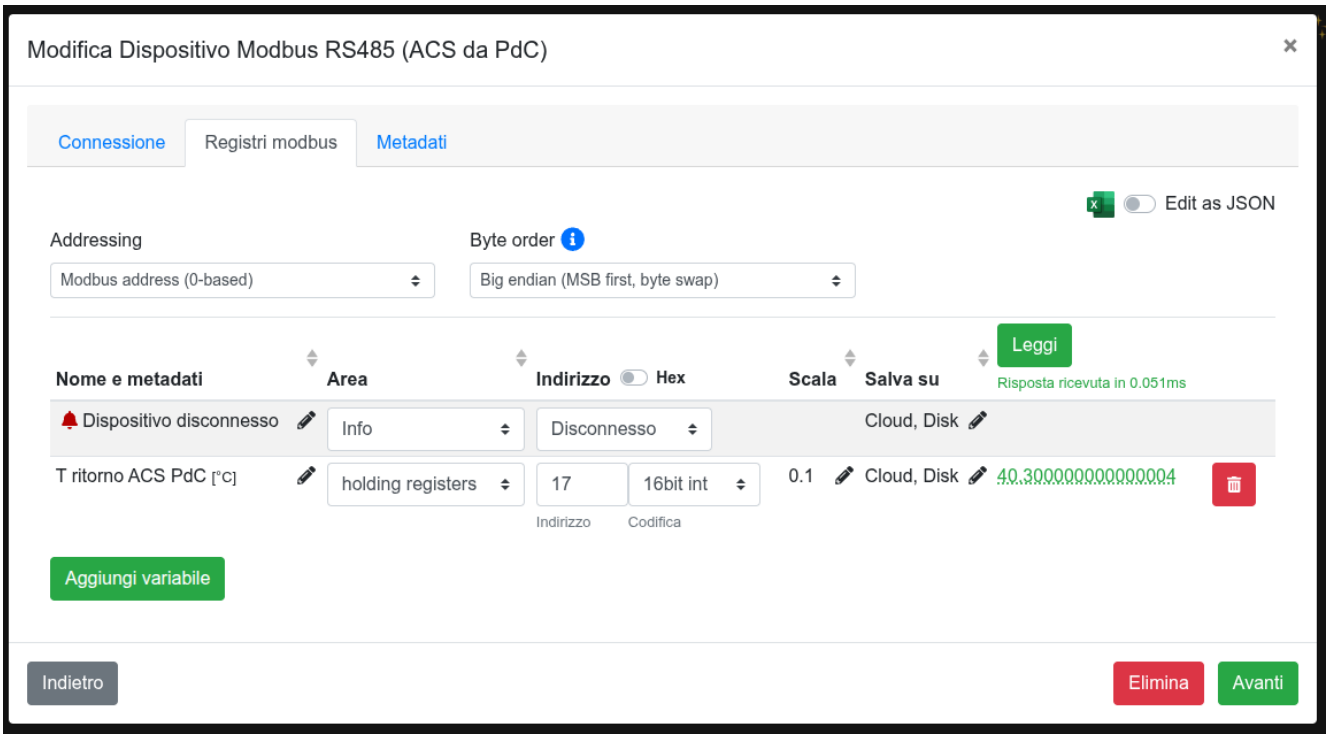


5. Perform a read test of the variable just created by clicking on the `Read` button in the action column. If the reading is successful, the value read will be shown in the column.



6. Repeat steps 4 and 5 for all variables of interest, then click on `Next` to go to the `Metadata` tab.
7. Here you can give a name and an optional description to the data source. You can also indicate where to insert the data source within the device hierarchy. In this way, you can organize devices into logical groups (e.g. departments, production lines, buildings, etc).

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8. Click on `Save`. Once the window is closed:
   - if you are using the local web interface, the changes have been successfully applied
   - if you are operating through the cloud, the configuration has been saved and placed in a sending queue. Until the configuration is applied, a ⚠️ yellow triangle will be shown at the top of the AL300 configuration page.
     - if the AL300 is online, it is sent immediately to the AL300.
     - if the AL300 is offline, it will be sent when the connection is re-established.

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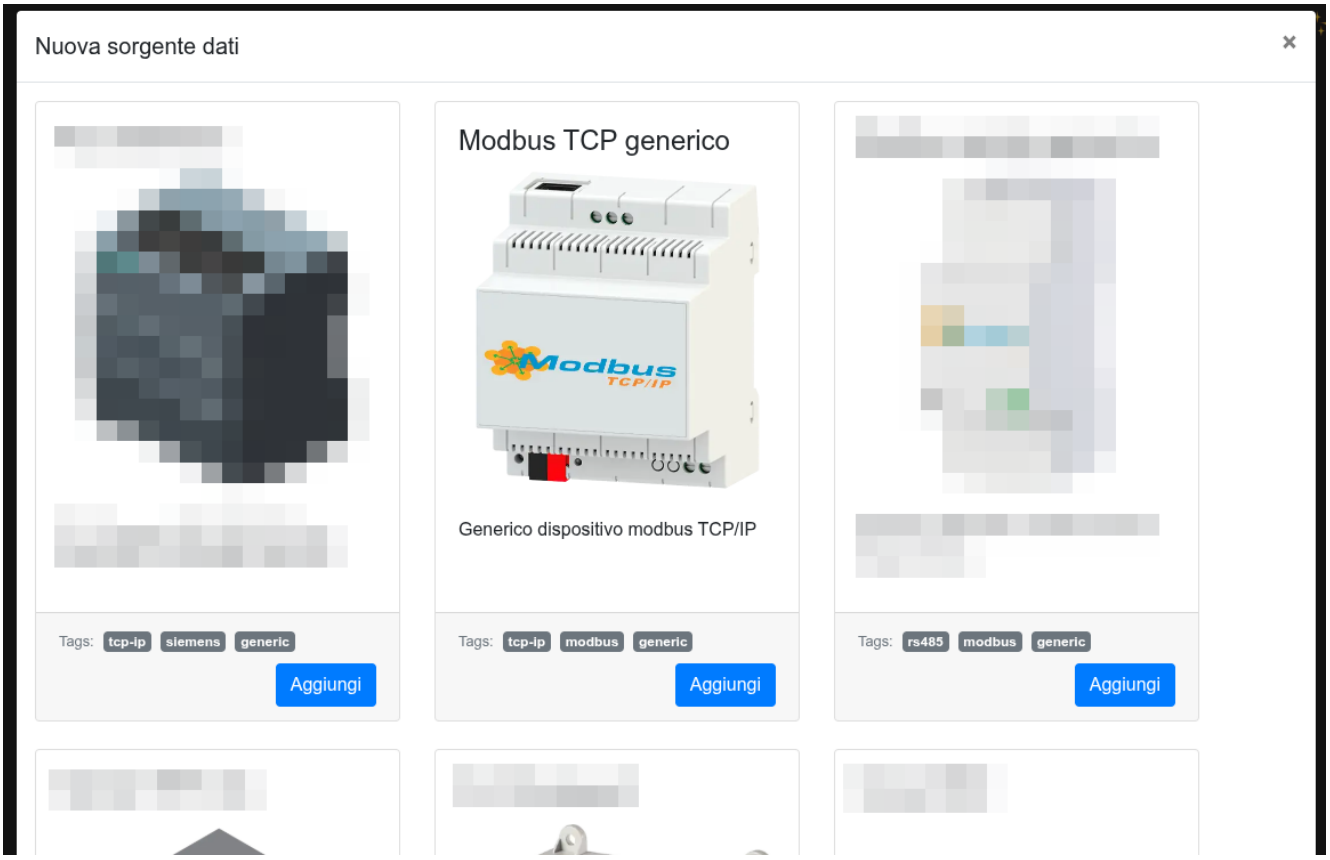
3.3.3.2.2 MODBUS TCP PROTOCOL

Modbus TCP is a variant of the Modbus protocol that uses the TCP/IP network (usually ethernet) for communication between devices. It is widely used in industrial settings for interfacing with meters, inverters, energy counters with RJ45 port. It allows reading and writing variables (registers) on connected devices.

The AL300 Gateway can act as a Modbus TCP master, querying slave devices connected to the Ethernet network.

Configuration

1. Choose the data source `Generic Modbus TCP`



2. Enter the IP address of the modbus slave. You can test the network connection by pinging the device (using the `Ping` button) and verify that the modbus slave is up and running (TCP port open) using the `TCP connect` button. To proceed, you need to have the documentation (register table) provided by the Modbus slave manufacturer.

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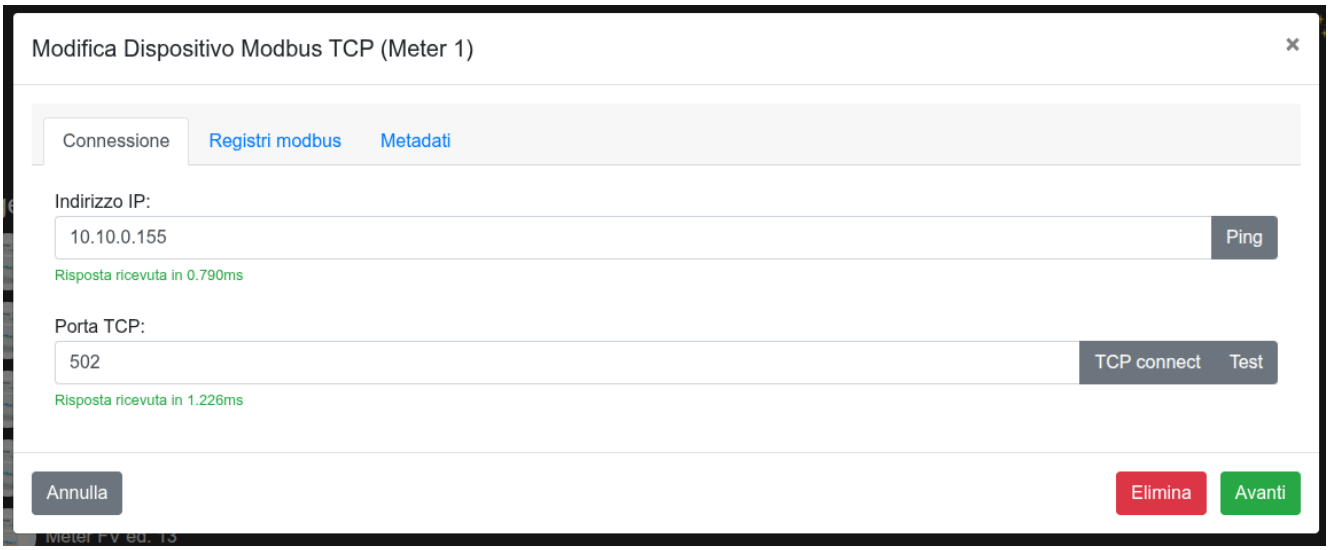
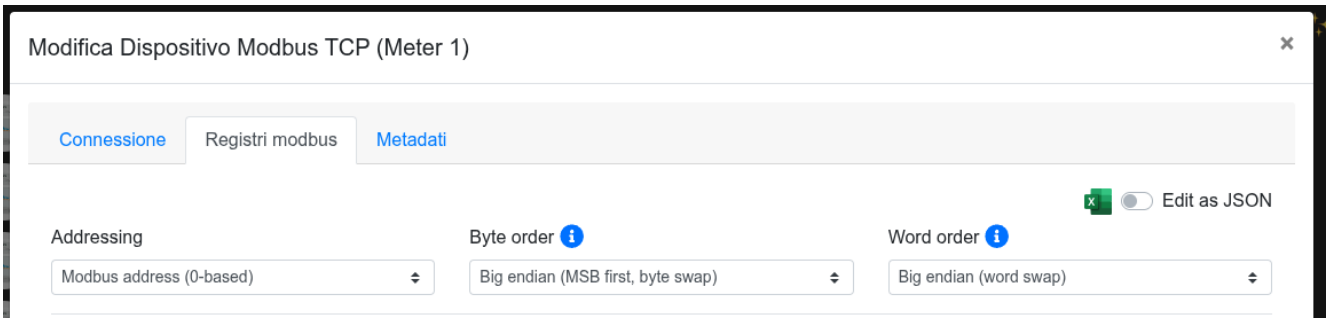


3. Choose whether to use register (1-based) or address (0-based) numbering and set the byte order and, if necessary, word order (in the documentation they are indicated as `big endian` / `little endian` or `LSB (least significant byte)` / `MSB (most significant byte)`).



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4. Click on `Add variable`. To import or modify the table massively, see bulk configuration. For each variable of interest, you can set:

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- Name and metadata (see here for more details)
- Topic. It can be:
  - Info: connection information (device disconnected variable and read error variable)
  - Holding registers: modbus functions 3 (read) and 6/16 (write)
  - Input registers: modbus function 4 (read)
  - Coils: modbus functions 1 (read) and 5/15 (write)
  - Discrete inputs: modbus function 2 (read)
- Slave ID: identifier of the modbus slave to query. It is often ignored by TCP slaves, but in some cases (e.g. modbus TCP/Rs485 converters) it must be set correctly.
- Address/Register: It can be expressed in decimal or hexadecimal and can be indicated as address (0-based) or register (1-based) depending on the `Addressing` setting above the table.

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For each register, you need to set the correct encoding (data type). The available data types are:

- `8bit_uint` : unsigned integer of 8 bits
- `16bit_uint` : unsigned integer of 16 bits
- `32bit_uint` : unsigned integer of 32 bits
- `64bit_uint` : unsigned integer of 64 bits
- `8bit_int` : signed integer of 8 bits
- `16bit_int` : signed integer of 16 bits
- `32bit_int` : signed integer of 32 bits
- `64bit_int` : signed integer of 64 bits
- `8bit_bsint` : signed integer of 8 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `16bit_bsint` : signed integer of 16 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `32bit_bsint` : signed integer of 32 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `64bit_bsint` : signed integer of 64 bits, most significant bit indicates the sign (0=positive, 1=negative)
- `16bit_float` : floating point number of 16 bits (half-precision)
- `32bit_float` : floating point number of 32 bits (single-precision)
- `64bit_float` : floating point number of 64 bits (double-precision)
- `string` : string of ASCII characters (you need to specify the length in characters)
- `bits` : array of bits (you need to specify the index from 0 to 15 of the bit within the register)

- Scale (see here for more details)
- Save to (see here for more details)

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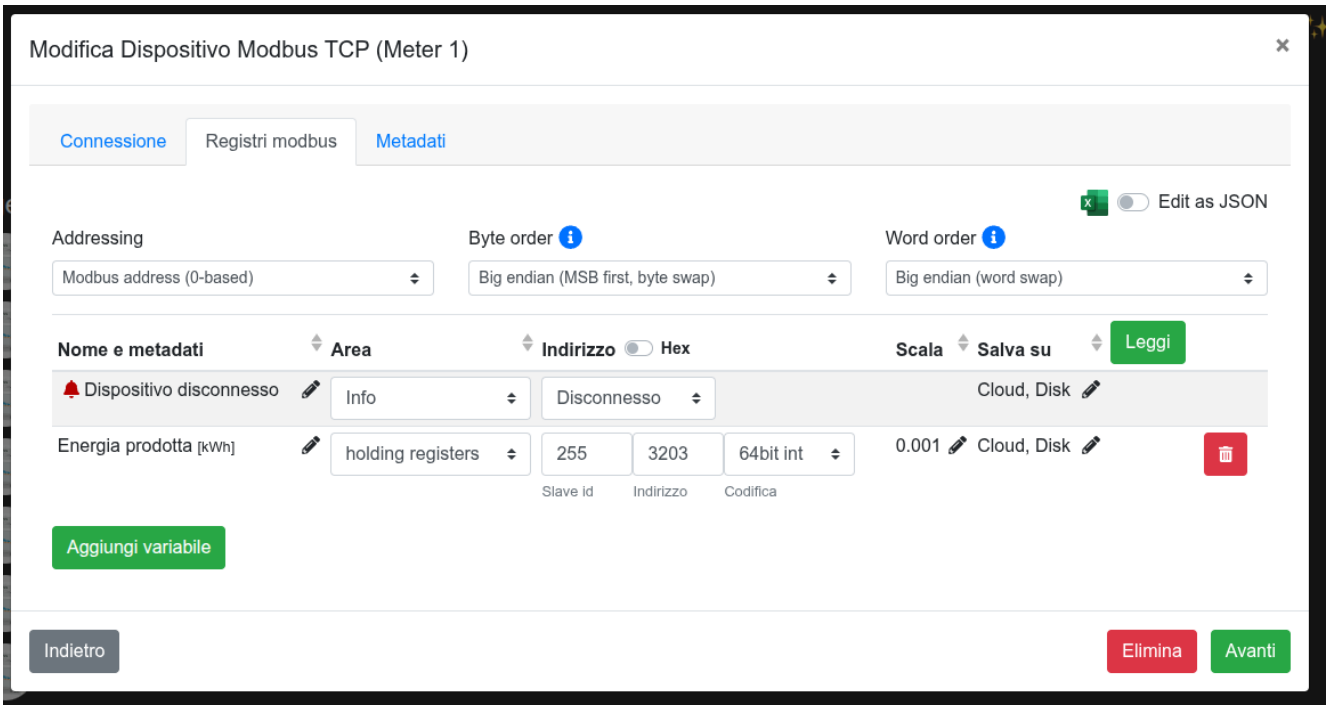
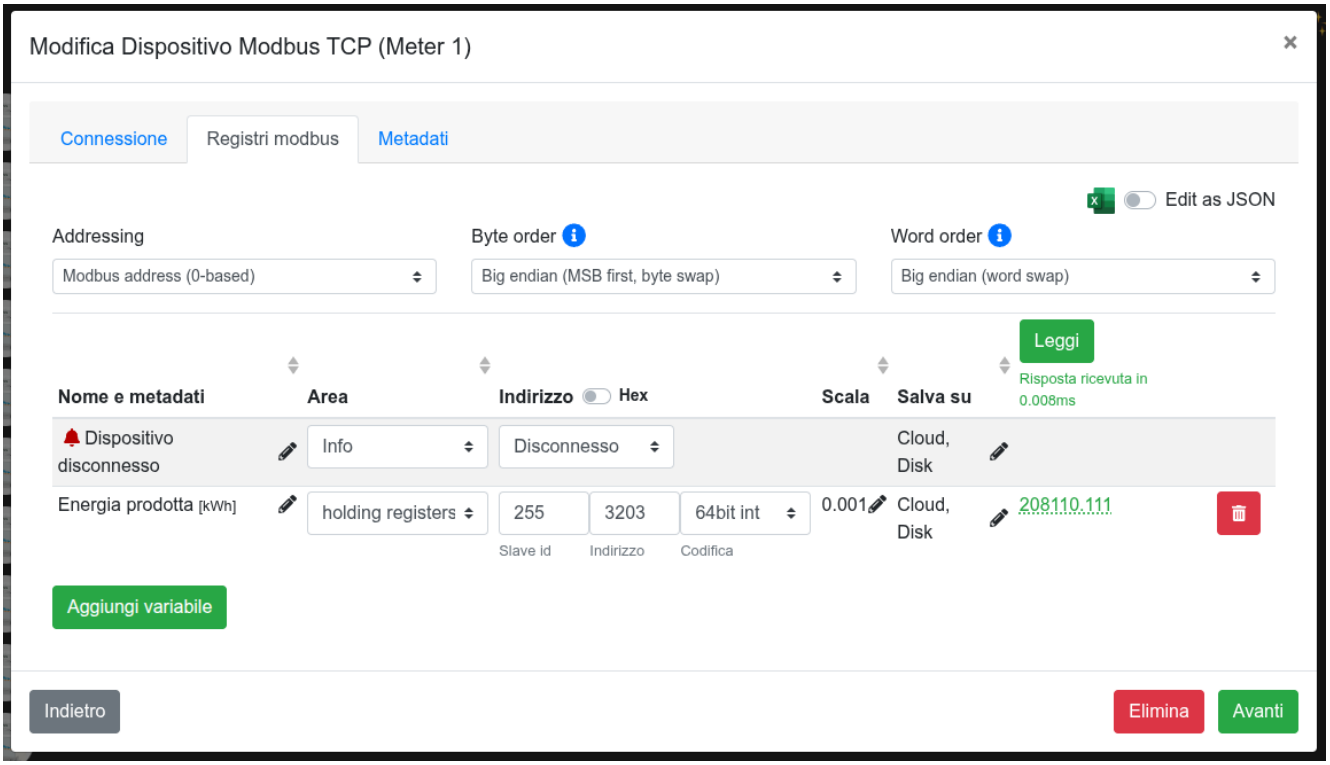


5. Perform a read test of the variable just created by clicking on the `Read` button in the action column. If the reading is successful, the value read will be shown in the column.



6. Repeat steps 4 and 5 for all variables of interest, then click on `Next` to go to the `Metadata` tab.
7. Here you can give a name and an optional description to the data source. You can also indicate where to insert the data source within the device hierarchy. In this way, you can organize devices into logical groups (e.g. departments, production lines, buildings, etc).

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8. Click on `Save`. Once the window is closed:
   - if you are using the local web interface, the changes have been successfully applied
   - if you are operating through the cloud, the configuration has been saved and placed in a sending queue. Until the configuration is applied, a ⚠️ yellow triangle will be shown at the top of the AL300 configuration page.
     - if the AL300 is online, it is sent immediately to the AL300.
     - if the AL300 is offline, it will be sent when the connection is re-established.

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3.3.3.2.3 SIEMENS S7

S7-300 and S7-400 CPUs

For S7-300 and S7-400 CPUs no particular configuration is required.

It has also been successfully tested with the Hilscher Netlink NL50 profibus converter.

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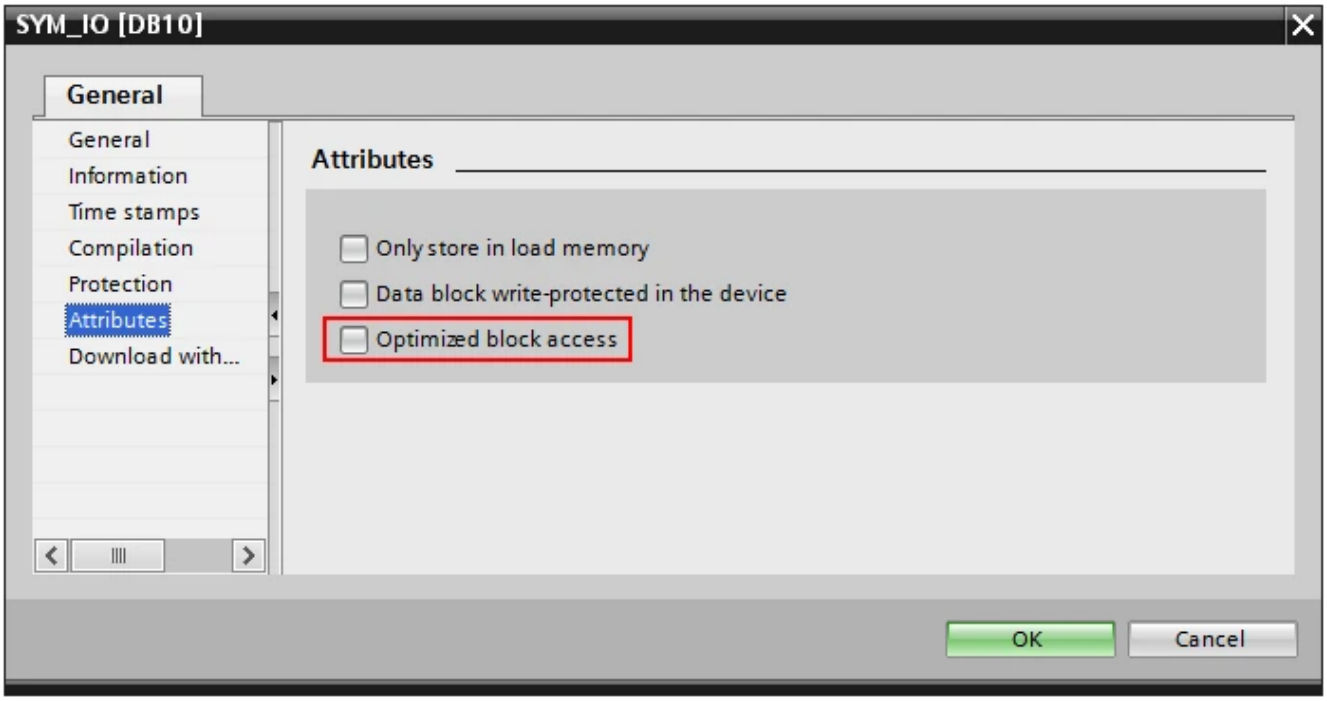
S7-1200 and S7-1500 CPUs

For S7-1200 and S7-1500 CPUs it is necessary to ensure these conditions:

- Optimized access to the blocks (DB) of interest must be disabled



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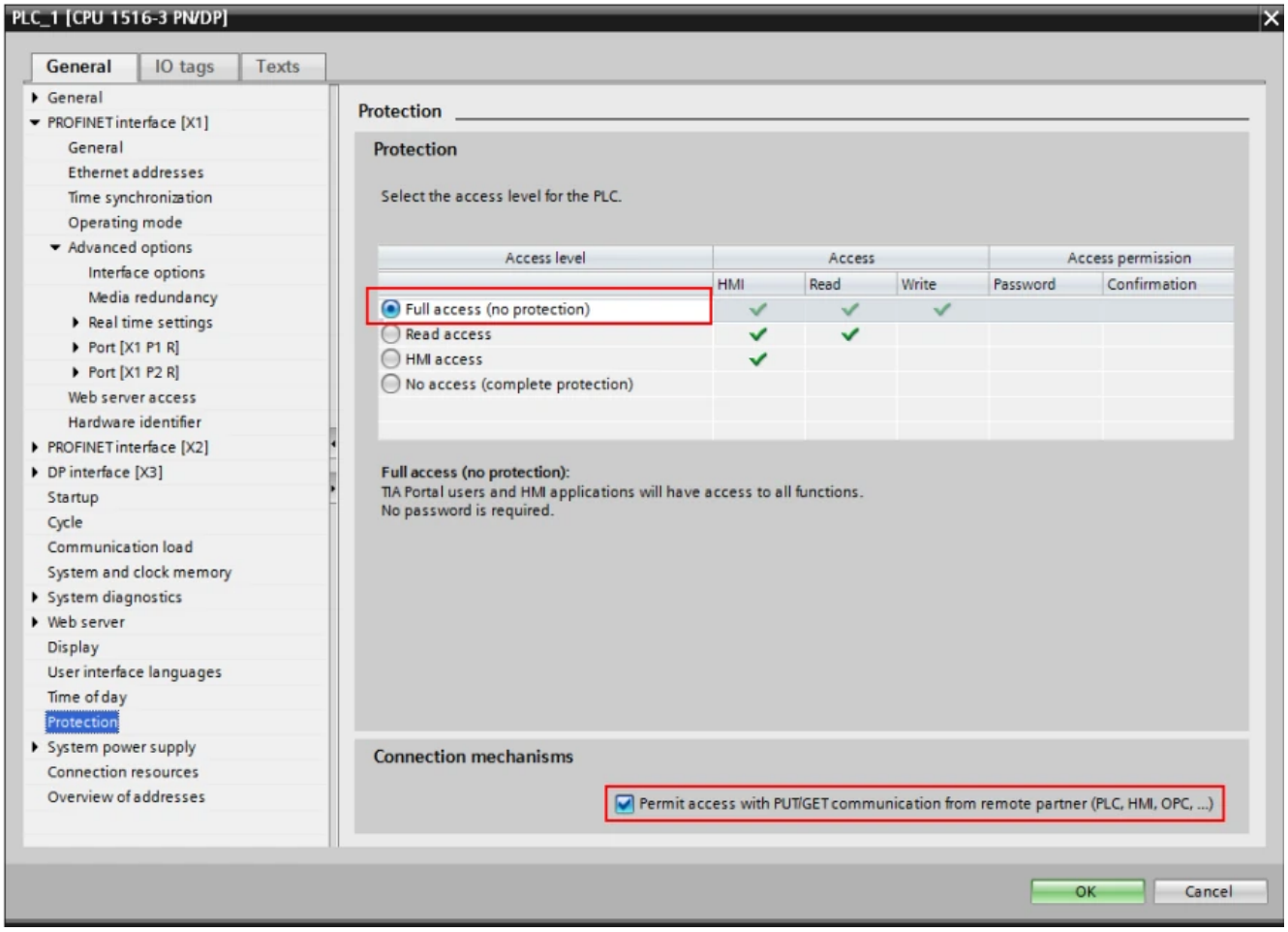
- The access level must be 'full' and GET/PUT requests must be enabled:



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Configuration

Siemens S7 Protocol

The S7 protocol (RFC 1006 info1, info2) is a proprietary communication protocol used by Siemens PLCs for data exchange with the CPUs of the S7-300, S7-400, S7-1200 and S7-1500 series. It allows reading and writing variables (bits, bytes, words, double words) on connected devices.

Requirements

Read this page to prepare the CPU for communication.

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Configuration

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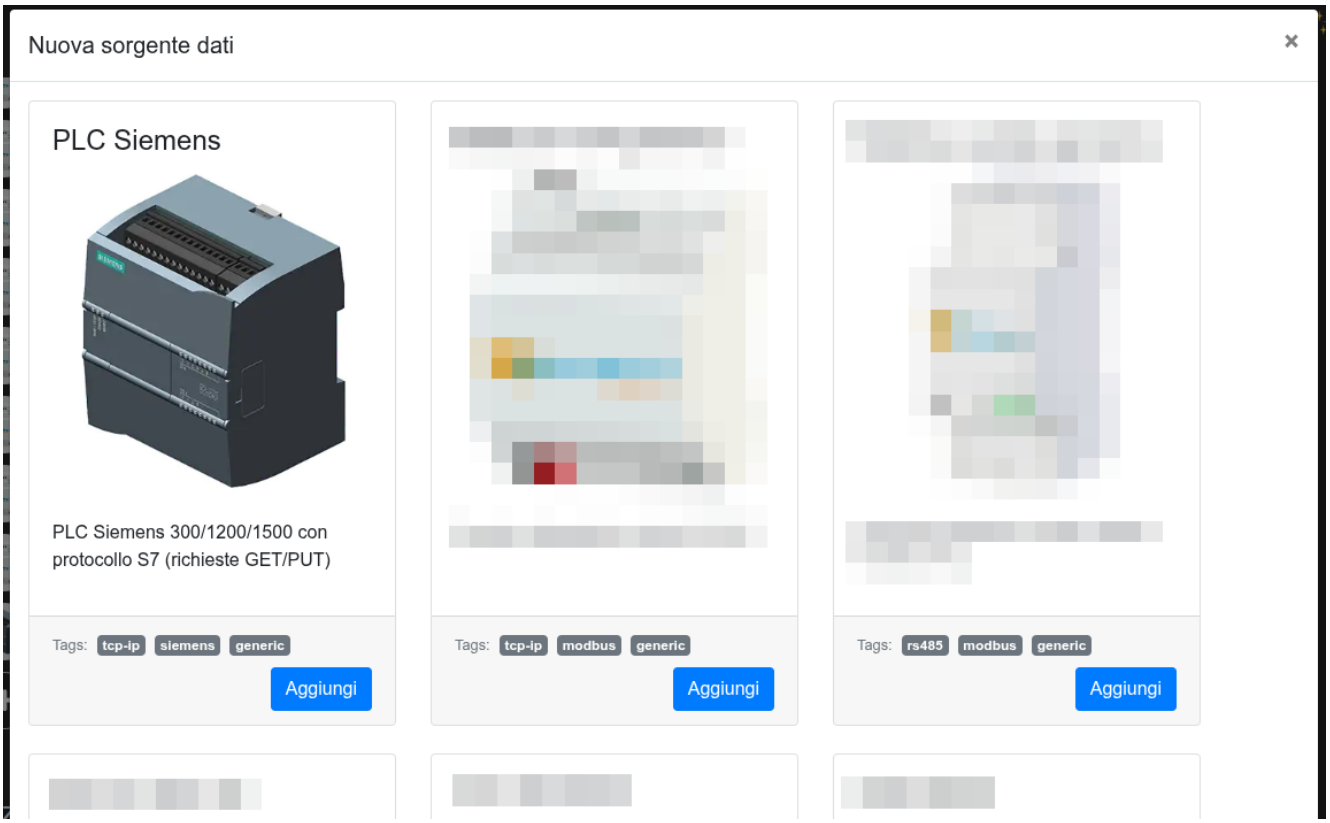
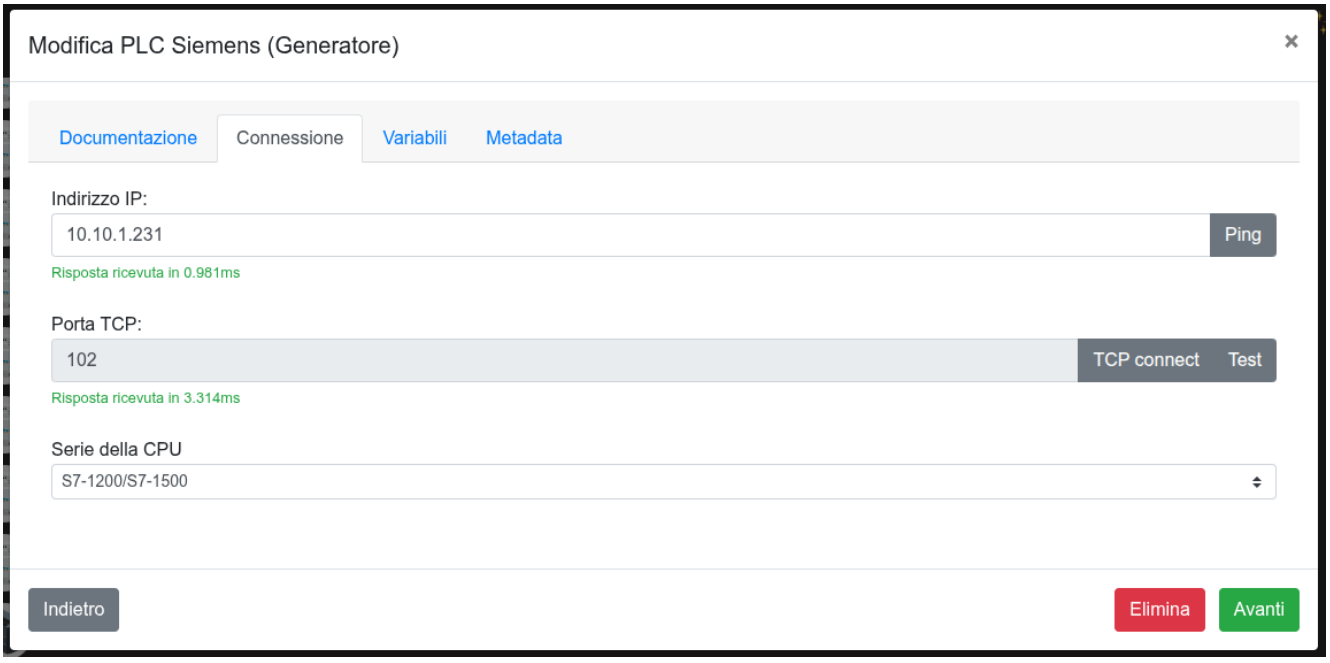
1. Choose the `Siemens PLC` data source



2. Enter the IP address of the PLC. You can test the network connection by pinging the device (using the `Ping` button), check that the PLC accepts TCP connections on port 102 using the `TCP connect` button and verify the S7 connection using the `Test` button. Select the series of CPU to connect to (`200/400` or `1200/1500`).



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3. Click on `Add PLC tag`. To import the variables of a DB from the TIA Portal project see DB definition import. To bulk import or edit the table, see bulk configuration. For each variable of interest you can set:

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- Name and metadata (see here for more details)
- Topic. It can be:
  - Info: connection information (`Device disconnected` and `PLC not in RUN`)
  - DB: data contained in the Data Blocks (DB) of the PLC
- DB number. Visible in the TIA Portal project.

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- S7 type. The available data types are:
  - `REAL`
  - `INT`
  - `DINT`
  - `UINT`
  - `UDINT`
  - `BYTE`
  - `WORD`
  - `TIME_OF_DAY` in milliseconds
  - `DATE` in unix timestamp
  - `DTL` in unix timestamp, assuming the PLC works in UTC
  - `DTL_LOCAL` in unix timestamp, assuming the PLC works in local time
  - `DATE_AND_TIME` in unix timestamp, assuming the PLC works in UTC
  - `DATE_AND_TIME_LOCAL` in unix timestamp, assuming the PLC works in local time
  - `TIME` in milliseconds
  - `BOOL`
  - `STRING`
  - `FSTRING`
  - `WSTRING`
  - `CHAR`
  - `WEEKLY_STARTSTOP_SCHEDULE` (custom schedule)
  - `TIME_H_M_S` in milliseconds, decoded from 3 `UINT` (hours, minutes, seconds)
  - `TIME_H_S` in milliseconds, decoded from 2 `UINT` (hours, seconds)
  - `TIME_H_M` in milliseconds, decoded from 2 `UINT` (hours, minutes)
  - `TIME_M_S` in milliseconds, decoded from 2 `UINT` (minutes, seconds)
- Byte: offset within the DB in bytes
- Bit: for `BOOL` types, 0-based index (0-7) of the bit within the byte
- Scale (see here for more details)
- Save to (see here for more details)

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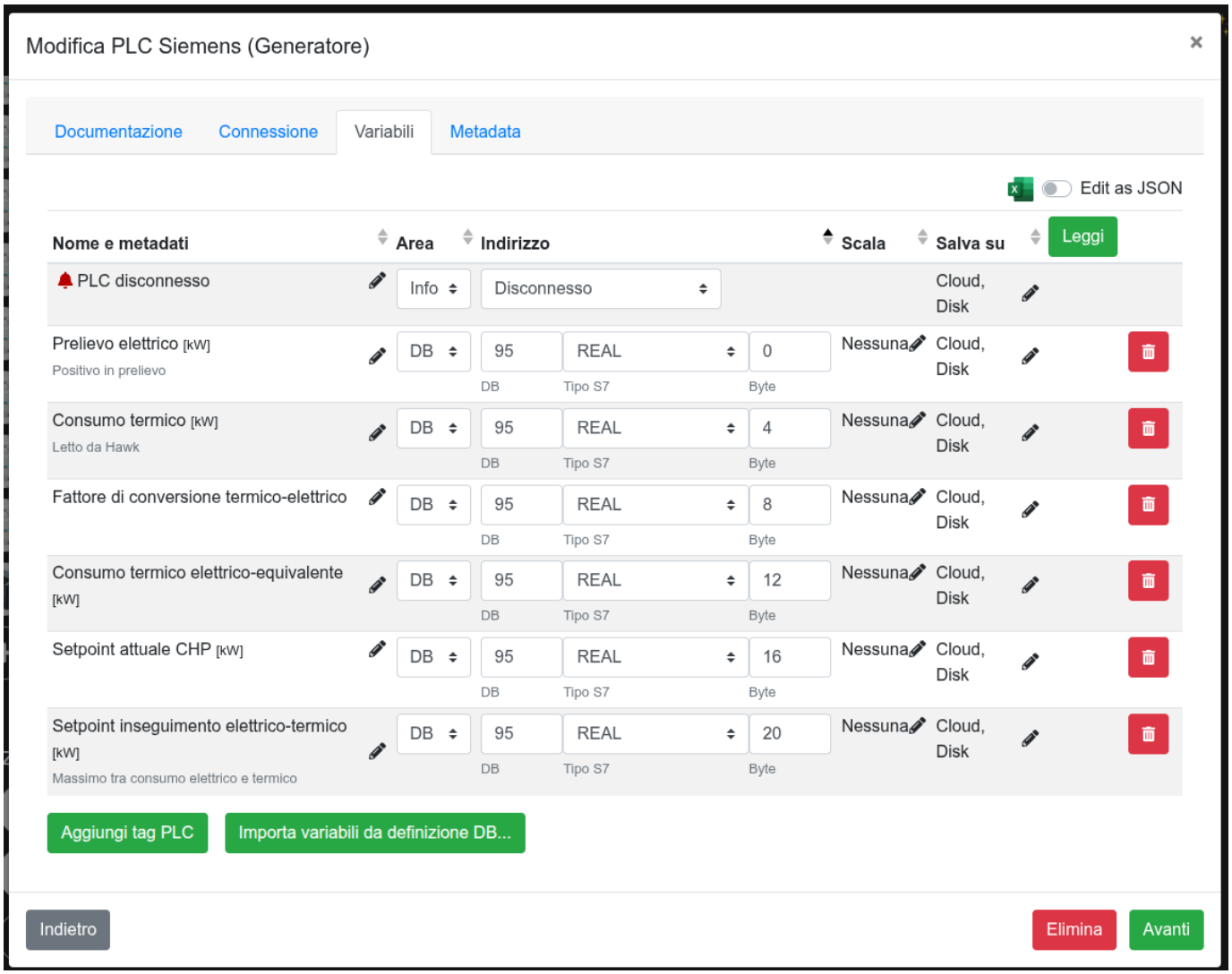

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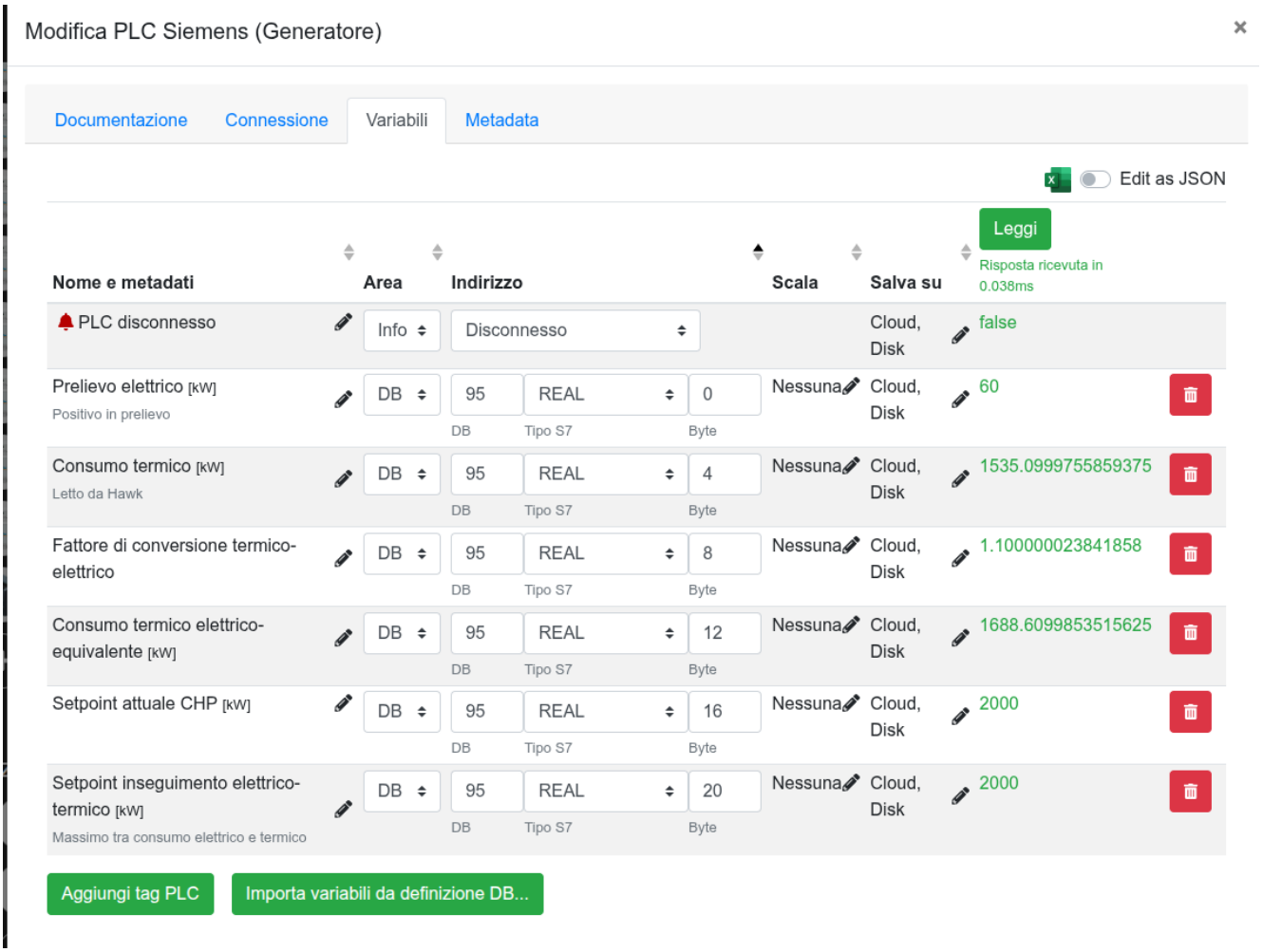
1. Perform a read test of the newly created variable by clicking on the `Read` button in the actions column. If the read is successful, the value read will be shown in the column.



2. Repeat steps 3 and 4 for all variables of interest, then click on `Next` to go to the `Metadata` tab.
3. Here you can give a name and an optional description to the data source. You can also indicate where to place the data source within the device hierarchy. This way you can organize devices into logical groups (e.g. departments, production lines, buildings, etc).

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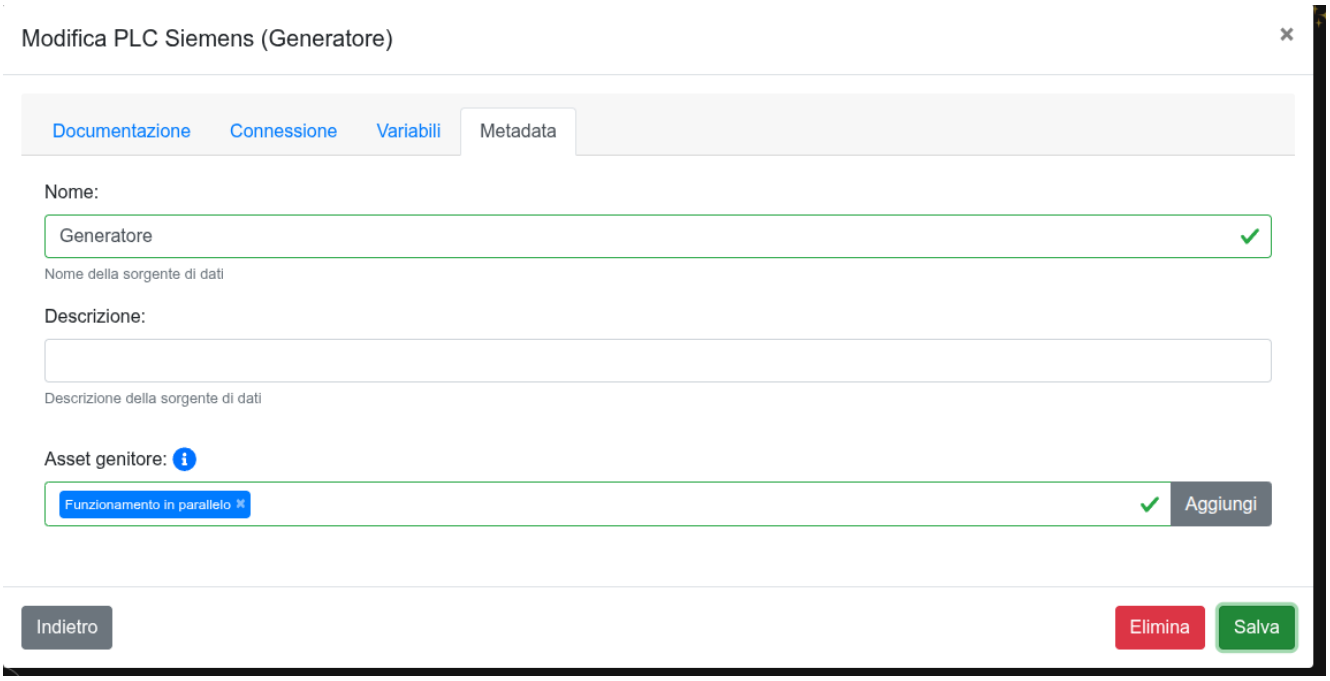

4. Click on `Save`. Once the window is closed:
   - if you are using the local web interface, the changes have been successfully applied
   - if you are operating through the cloud the configuration has been saved and placed in a sending queue. Until the configuration is applied a ⚠️ yellow triangle will be shown at the top of the AL300 configuration page.
     - if the AL300 is online then it is sent immediately to the AL300.
     - if the AL300 is offline it will be sent when the connection is re-established.

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DB definition import

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It is possible to import the definition of a DB if you have access to the TIA Portal project loaded on the Siemens PLC.

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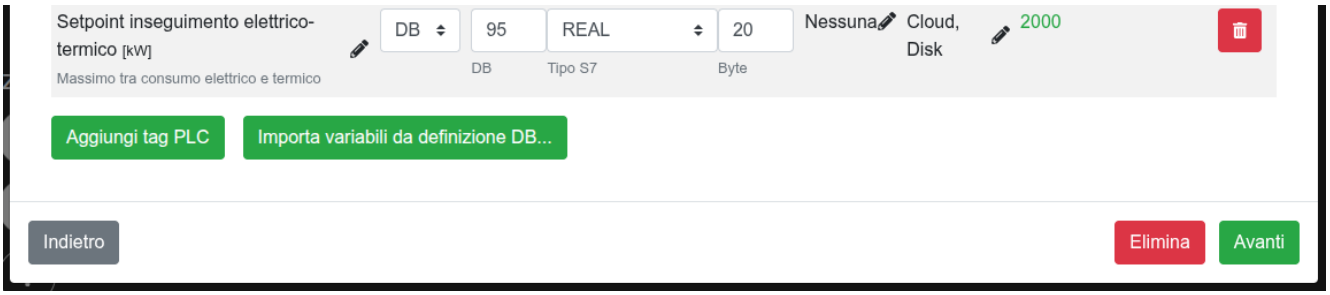
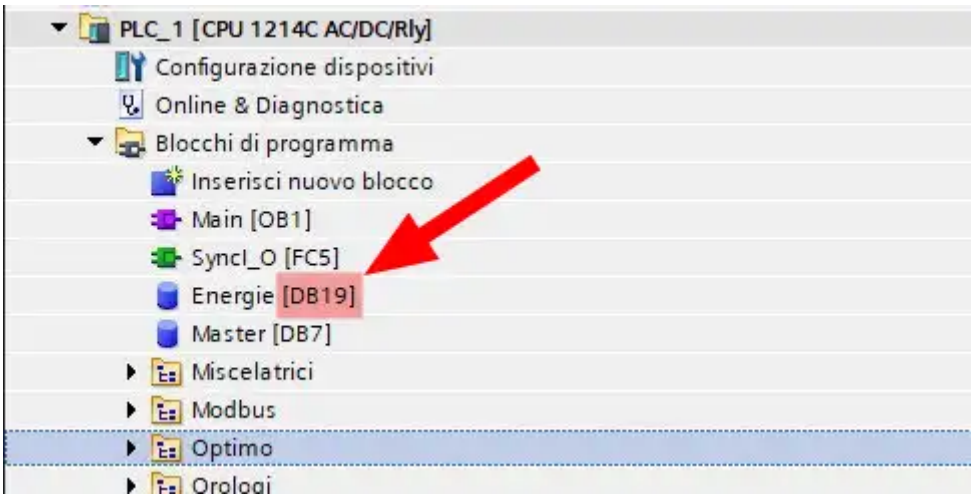
1. Click on `Import variables from DB definition`



2. Open the PLC project with TIA Portal

3. Identify the DB of interest



4. Insert the DB number in the form

5. Right click on the DB (1) and select 'Copy as text' (2):

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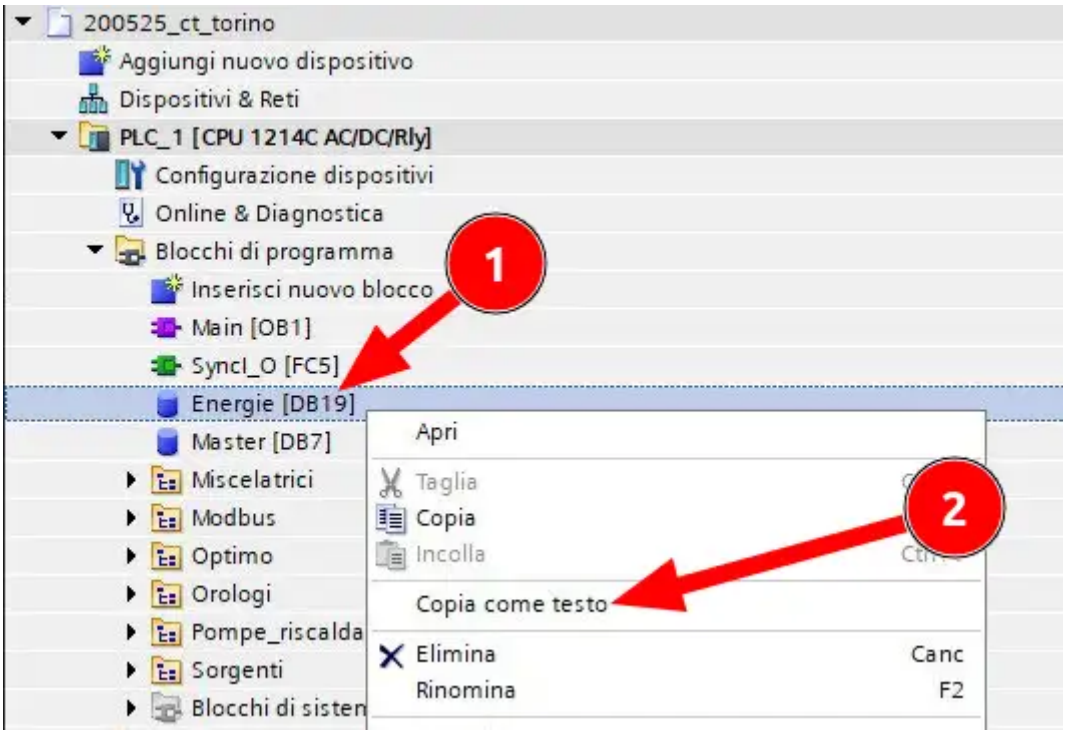

6. Paste the copied text into the form:

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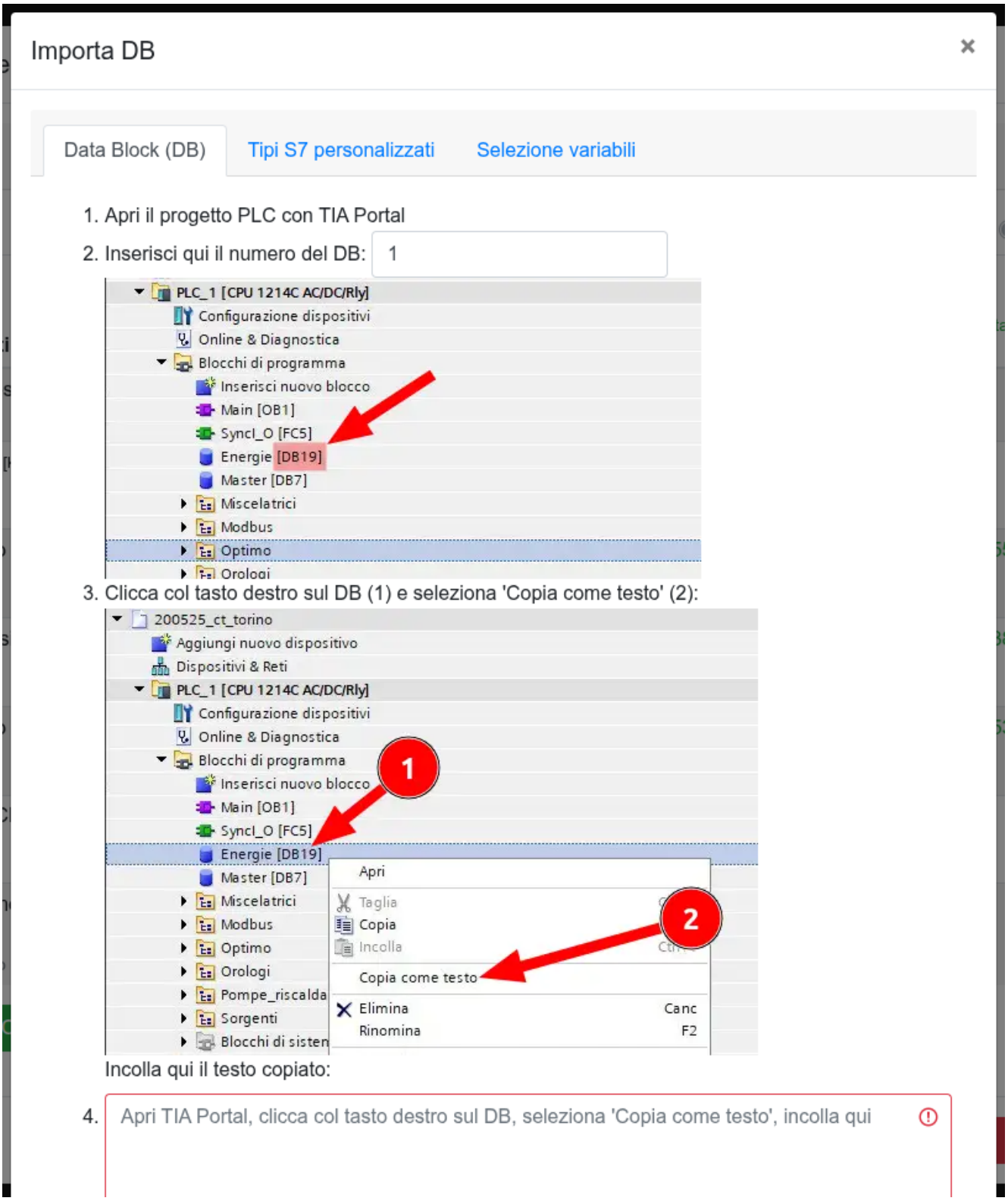

7. If the DB contains only standard data types, then it is possible to do a read test, delete the variables that are not of interest and click on `Add`

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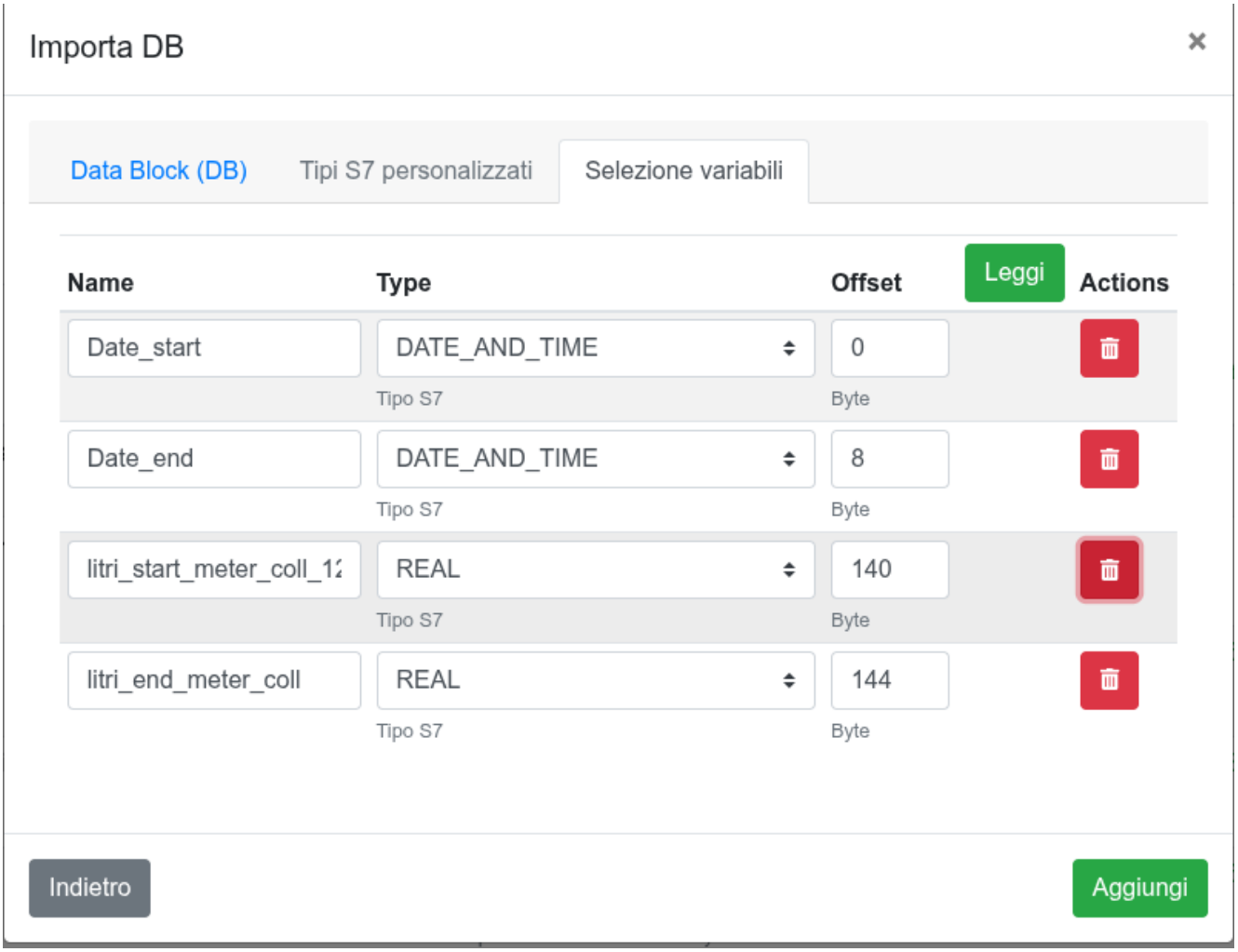

8. If the DB contains some custom data types, you will be asked to provide the definition for each custom data type.

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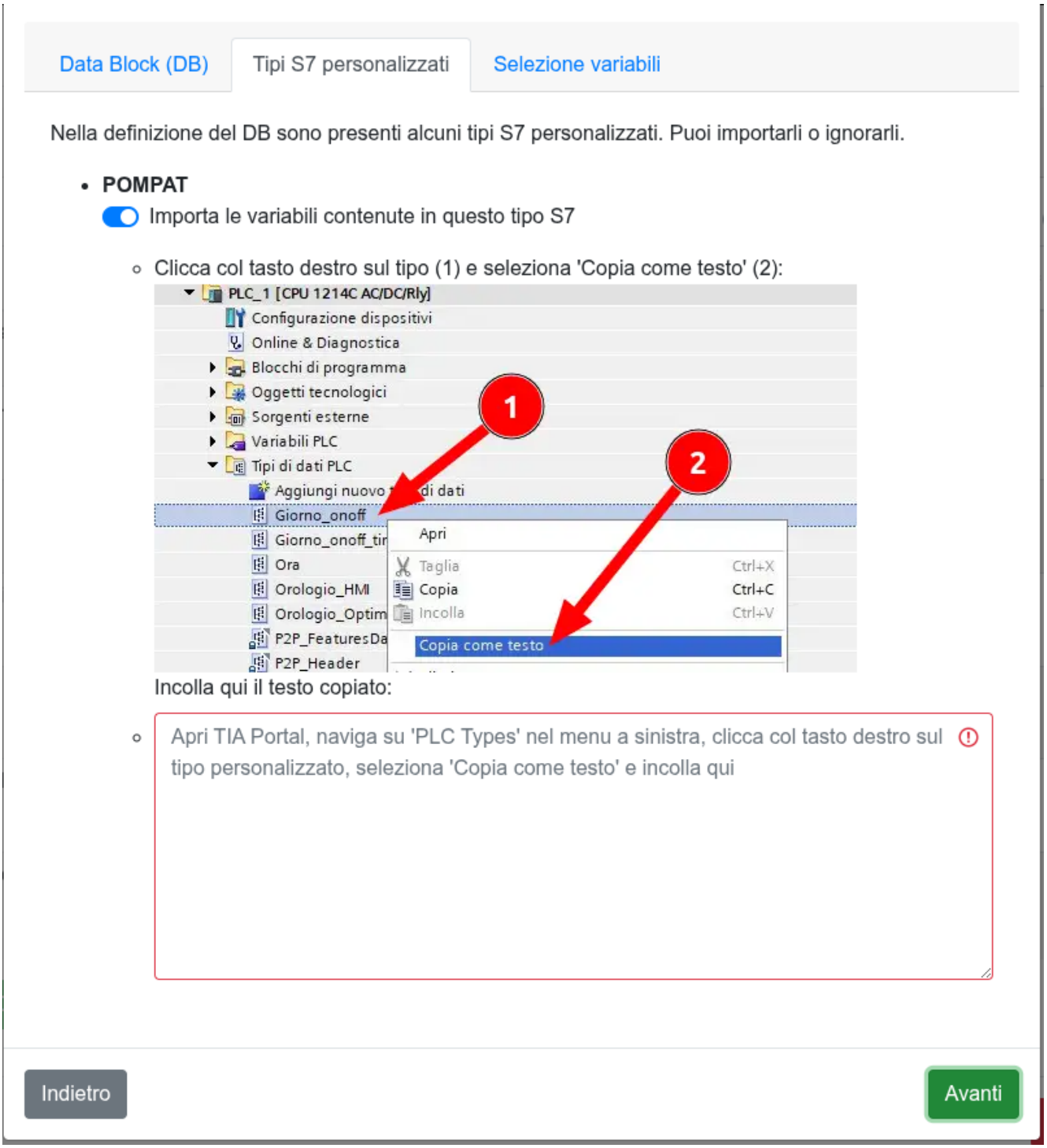

If you are not interested in importing the variables of the custom data type you can proceed further. It is still required to insert the size in bytes of the custom type

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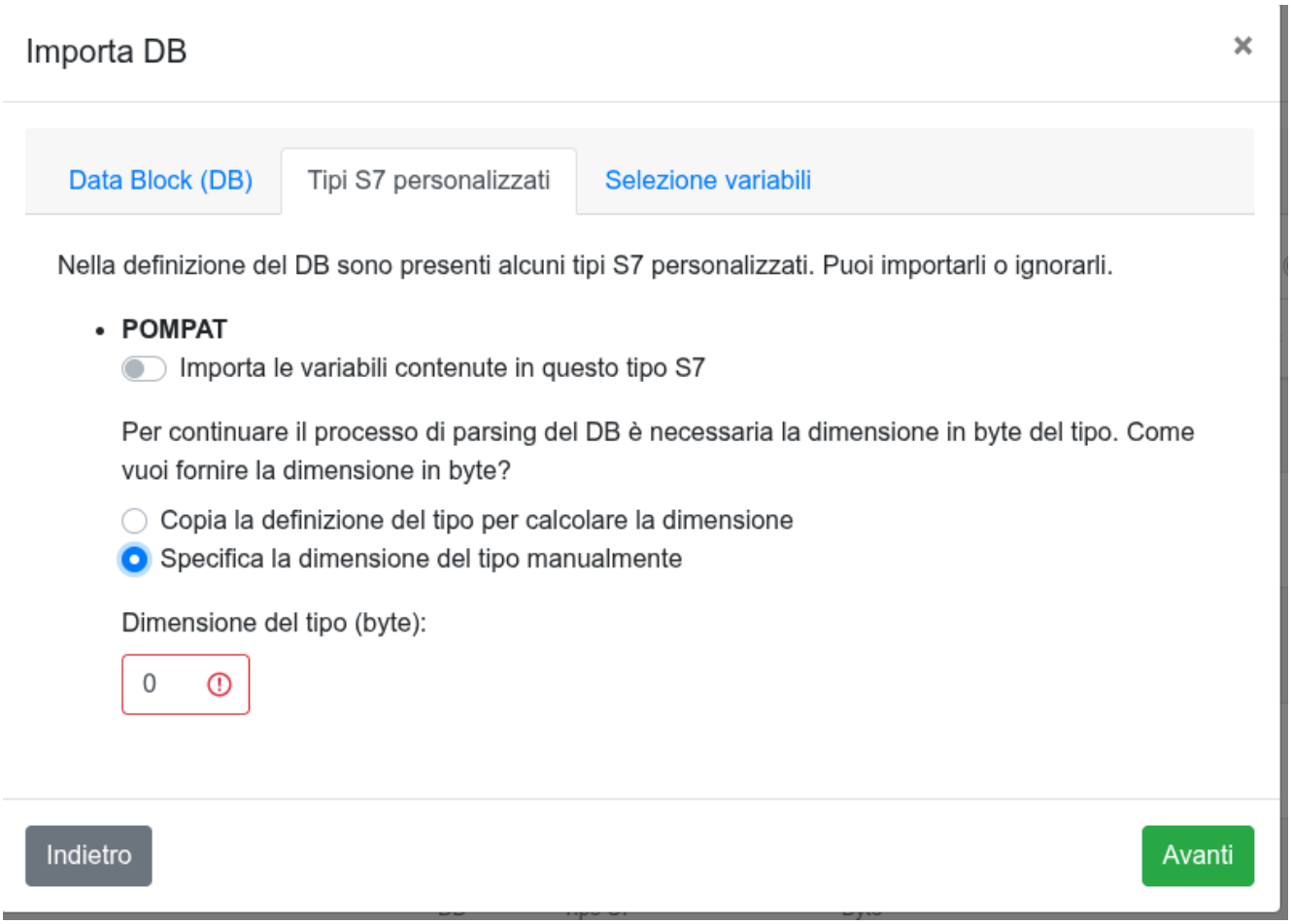

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3.3.3.3 Common settings

3.3.3.3.1 METADATA

Edit metadata

For each variable it is possible to specify additional metadata, which describes it in more detail. This metadata is optional and is useful to better characterize the variables and improve the creation and use of dashboards and data export. The available fields are explained below.

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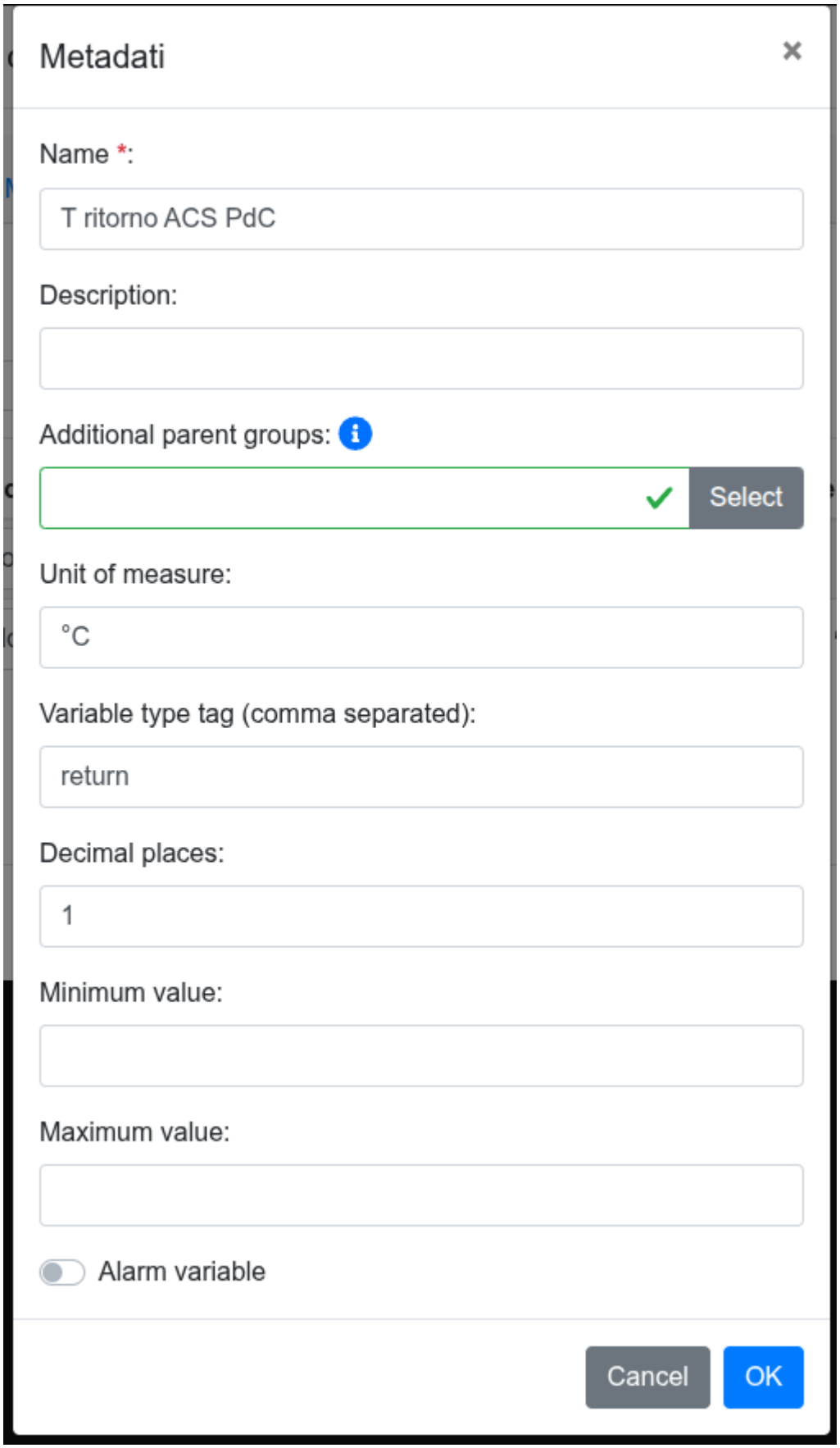

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Name and description

The name is shown in the graphs and lists of variables. The description is optional and is shown as a tooltip when hovering over the variable name. Both can be up to 45 characters long.

Additional parent groups

Optional, for advanced users. It is possible to specify one or more additional parent `assets` for the variable. By default each variable is a child of the `asset` data source it belongs to. By specifying additional parent `assets`, the variable will also be associated with them. This allows you to organize the variables more flexibly and group related variables in one place even if they are acquired through different physical devices.

Unit of measure

Optional. Specify the unit of measure (without spaces). It is shown in the graphs and tables next to the variable value.

Tags

Optional, for advanced users. Used in the generation of dynamic templates to classify variables.

Decimal places

Optional. Specifies the number of decimal places to show in graphs and tables. If not specified, all decimal places are shown.

Minimum and Maximum

Optional. Specifies the start and end of the variable scale. Used in some graphical widgets to define the range of values shown.

Alarm

Specifies whether the variable is an alarm variable. For alarm variables, it is possible to configure the reception of notifications upon activation.

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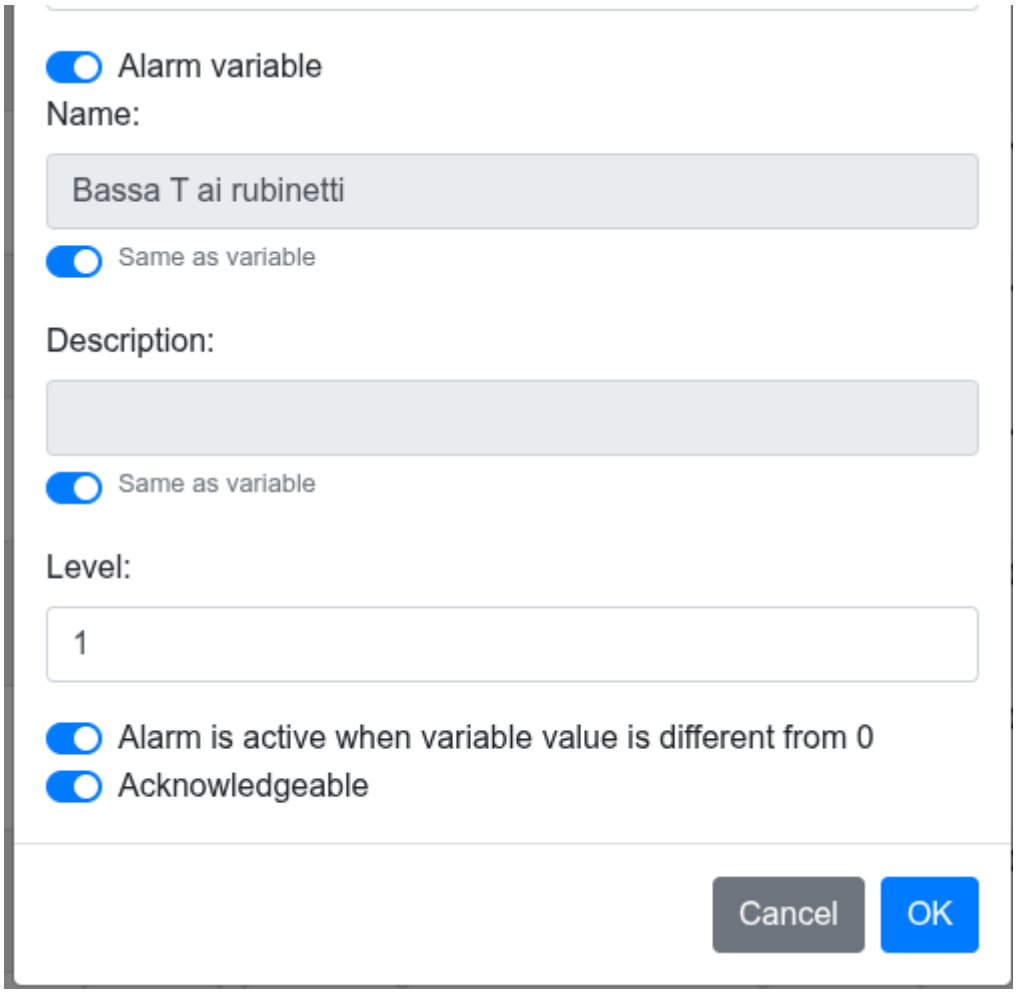
You can specify:

- `Name`. Usually it is the same as the variable name. In case the logic of the variable is reversed, it is possible to specify a different name for the alarm (e.g. variable name: "Operation OK", alarm name: "Operation NOT OK"). This name will be shown in notifications.
- `Description`. Optional, as for `Name`
- `Level`: allows you to indicate the severity level of the alarm. The available levels are 1 (not severe) and 2 (severe). The level determines the graphical rendering of the alarm in dashboards and notifications.
- `Alarm logic`: allows you to specify whether the alarm is considered active if the variable value is `truthy` (`1`, `true`, numbers > 0, etc) or `falsy` (`0`, `false`).
- `Acknoledgeable`: if enabled, the alarm can be manually acknowledged by the user, to keep track of already examined alarms.



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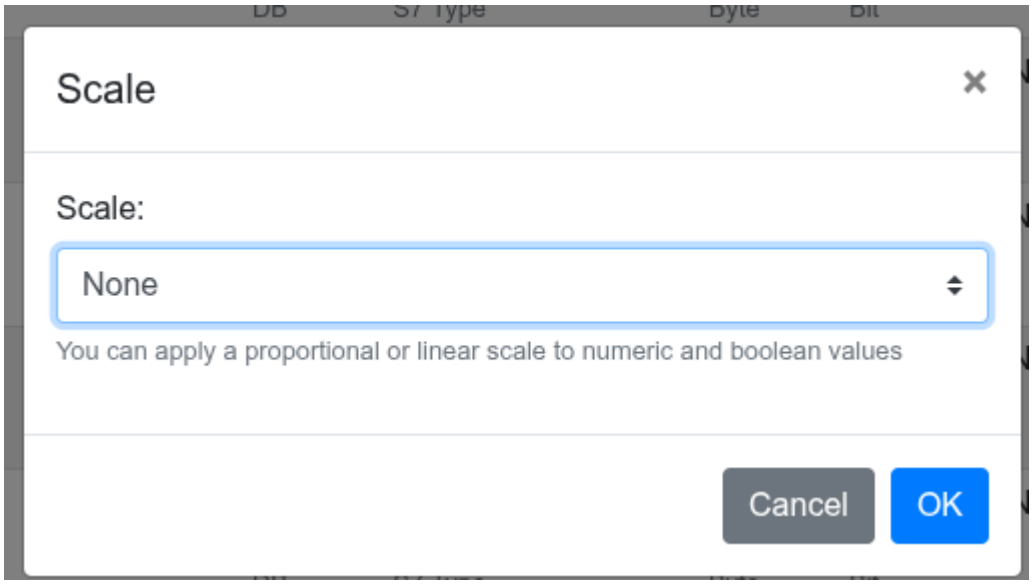
3.3.3.3.2 SCALE

Value scaling

It is possible to specify a linear transformation of the value acquired from the variable. The following options are available:

- None: the acquired value is used as is
- Proportional: the acquired value is multiplied by a scale factor
- Linear interpolation: the acquired value is transformed through a linear interpolation function defined by multiple points

None



Proportional

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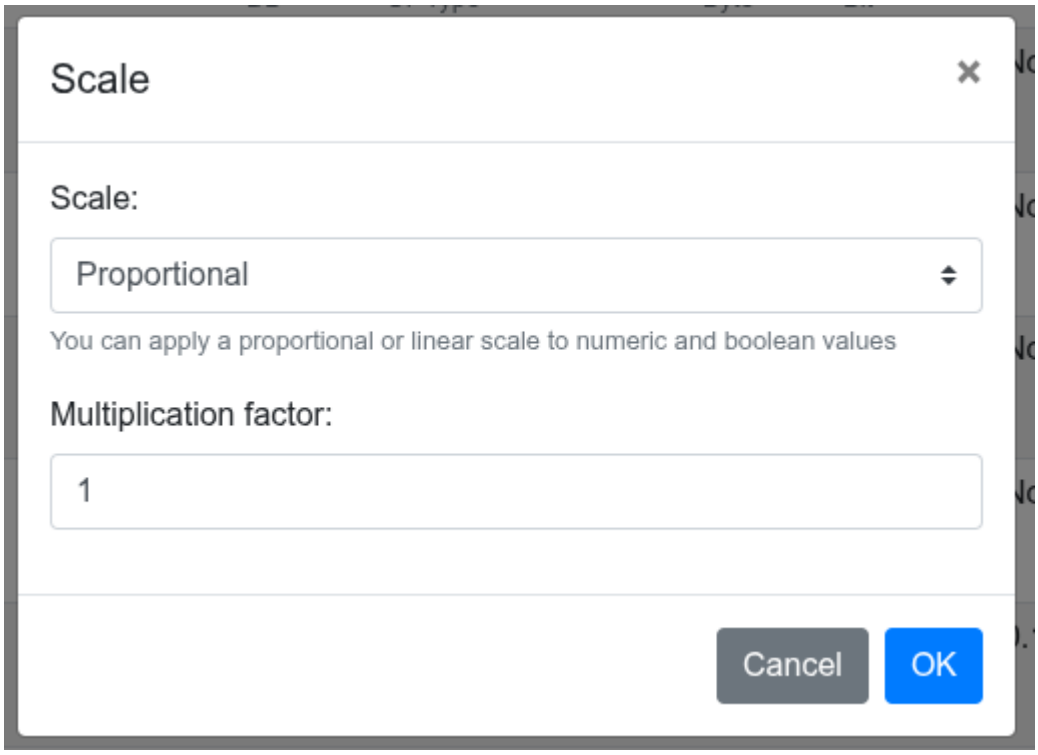

Linear interpolation

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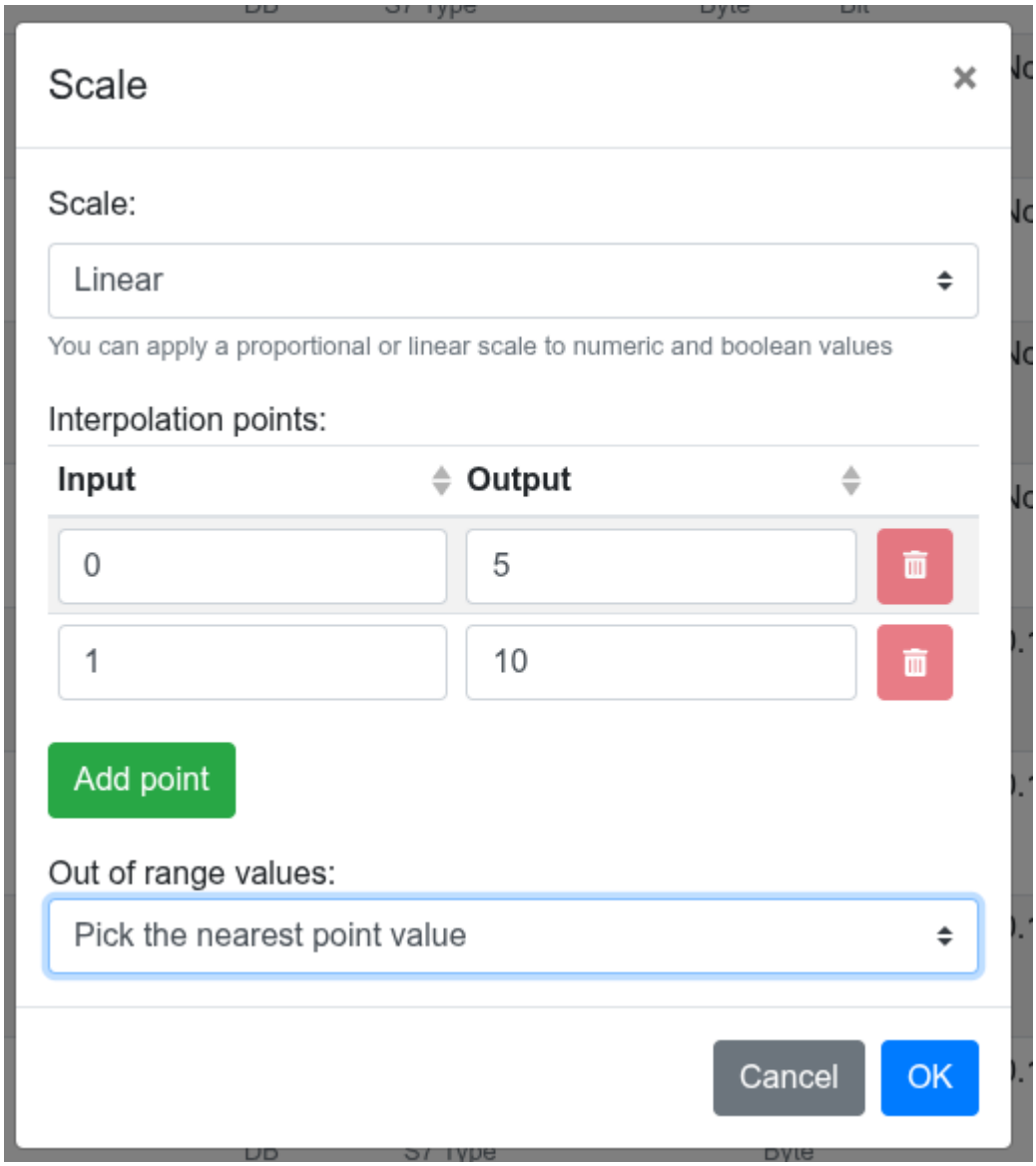

For each variable value (column `Input`), it is possible to specify the corresponding value after scaling (column `Output`). It is possible to add and remove points (at least two are necessary).

It is possible to specify what to do for values outside the specified range:

- `Clamp`: values outside the range are brought to the specified minimum or maximum value
- `Extrapolate`: values outside the range are calculated through the equation of the line defined by the two closest points
- `Ignore`: values outside the range are considered null

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3.3.3.3.3 SAVE OPTIONS

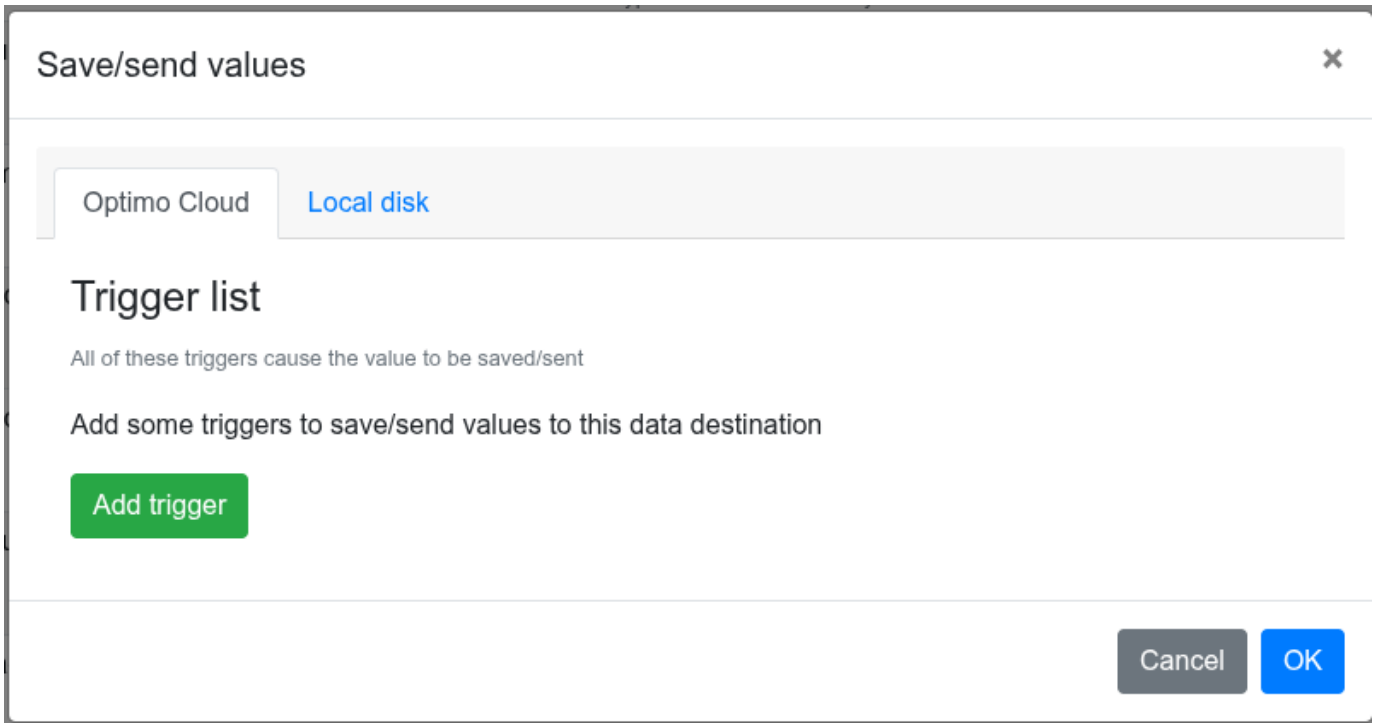
Data sinks

For each data sink it is possible to specify one or more save triggers. The always available data sinks are:

- Local: data is saved in the internal memory of AL300
- Optimo Cloud: data is sent to the Optimo cloud

Save triggers

To add a trigger, click on `Add trigger`.



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Each trigger can be activated by different conditions, can have a rate limiter and can be subject to particular conditions.

- Trigger name: arbitrary, used only in this configuration page.
- On change: the trigger is activated when the value of a variable changes. The variable can be the same variable associated with the trigger or one or more arbitrary variables. Useful for booleans and setpoints.
- On positive change: the trigger is activated when the value of a variable changes from a `falsy` value (e.g. `0`, `false`, etc) to a `truthy` value (e.g. `1`, `true`, numbers > 0, etc). The variable can be the same variable associated with the trigger or one or more arbitrary variables. Useful to save on activation of one or more alarms
- On delta: the trigger is activated when the value of a variable changes by more than a threshold compared to the last saved value. The threshold can be specified as a percentage of the absolute value or as a percentage of the variable scale range
- Periodically: the trigger is activated at regular time intervals (e.g. every 5 minutes) expressed in seconds. If you use numbers that are divisors of the minute / hour / day (e.g. 60, 300, 900, 3600, 86400) the trigger will be aligned to standard time intervals (e.g. every exact hour, every day at midnight, etc)
- Skip null values: if enabled, the trigger will not be activated if the variable value is `null`
- Log trigger reason: for advanced users. If enabled, every time the trigger is activated, in addition to the variable value, the reason for the trigger activation is also saved (e.g. "change", "delta", etc).
- Rate limiter: for advanced users. Allows you to limit the maximum frequency of trigger activation. Useful to avoid too frequent saves in case of very "noisy" variables. For example, you can limit the trigger to 3 activations per hour.
- Condition: for advanced users. Allows you to specify a condition on the value of another variable that must be true for the trigger to be activated. Supported conditions are: equal to, not equal to, greater than or equal to. Useful to save data only when a particular event is active (e.g. an alarm).

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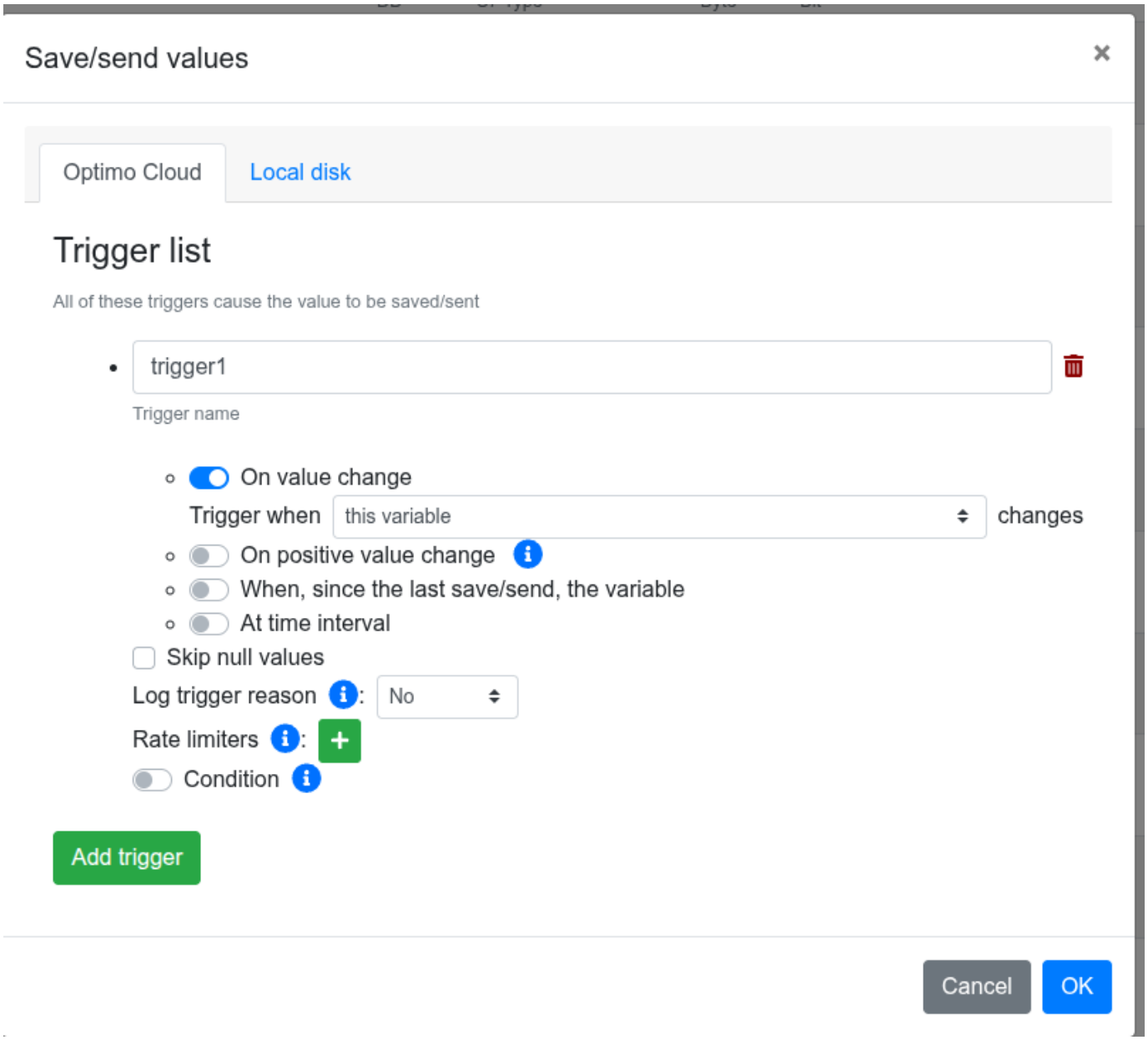

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3.3.3.3.4 BULK CONFIGURATION

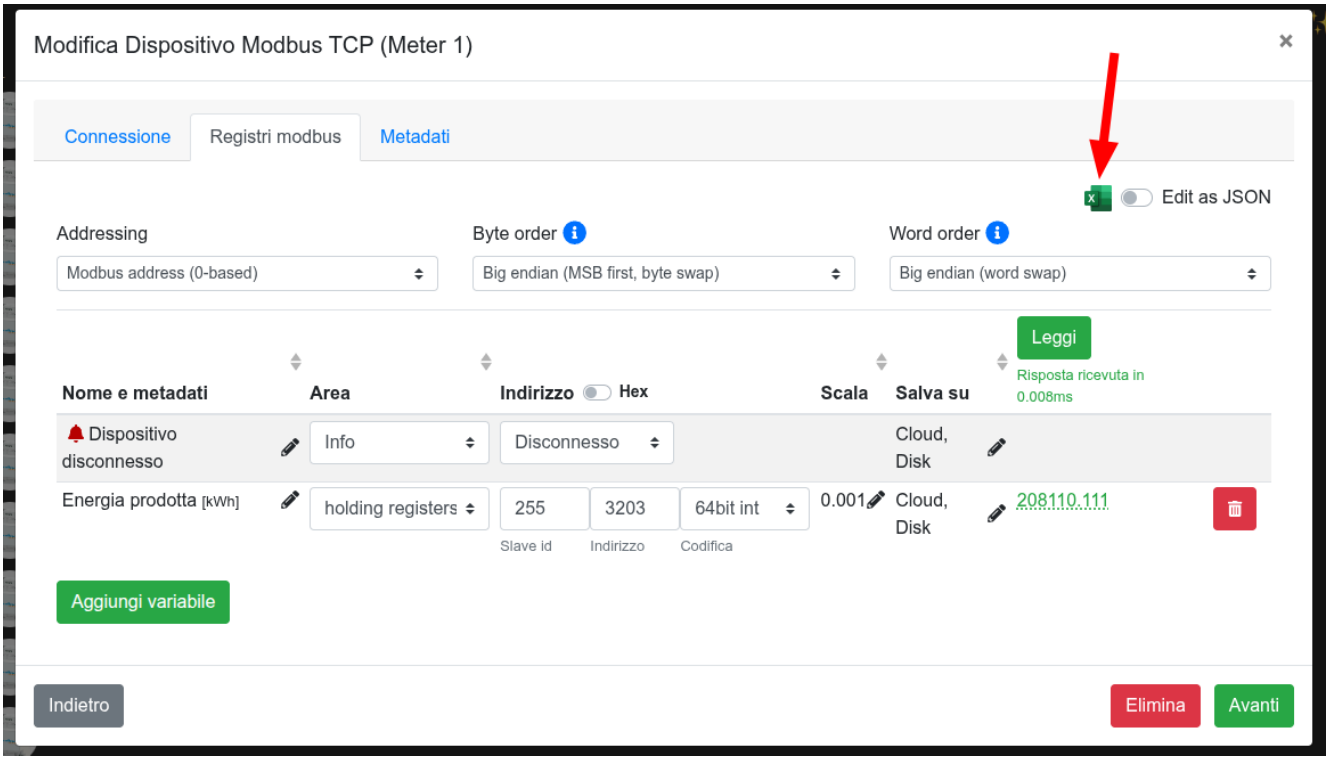
To modify the list of variables of a configured data source, you can use:

- Excel/Spreadsheet: copy the table of variables into a spreadsheet, modify it and paste it back into the web interface
- JSON: directly modify the configuration structure in JSON format

> **Note**
>
> This is useful for advanced users or when working with many variables. We always recommend entering two or three variables manually before proceeding with bulk modification, in order to have reference examples to start from.

Edit with Excel/Spreadsheet

1. Click on the `Edit with Excel` icon



2. Click on `Copy to clipboard` to copy the table of variables

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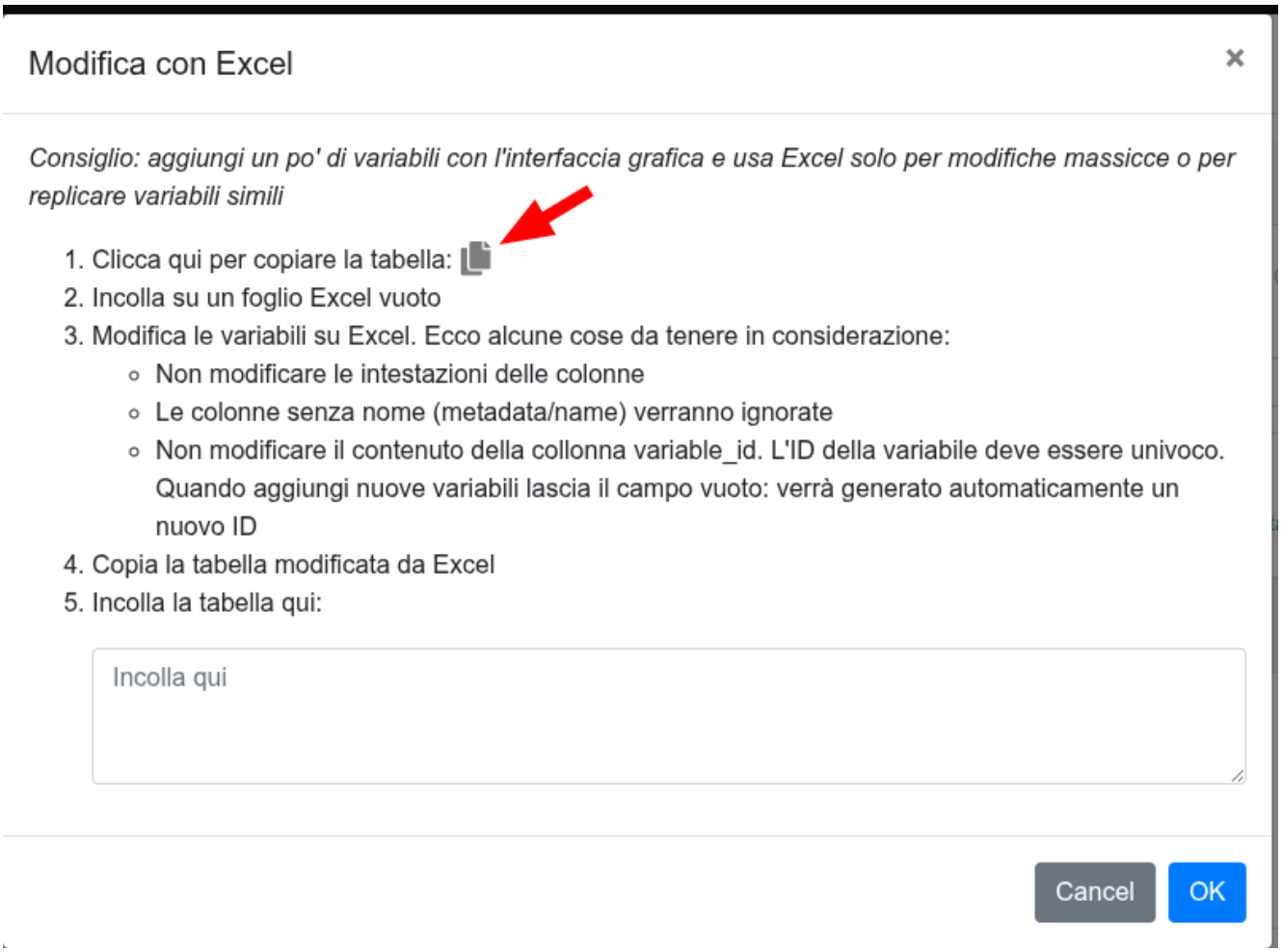
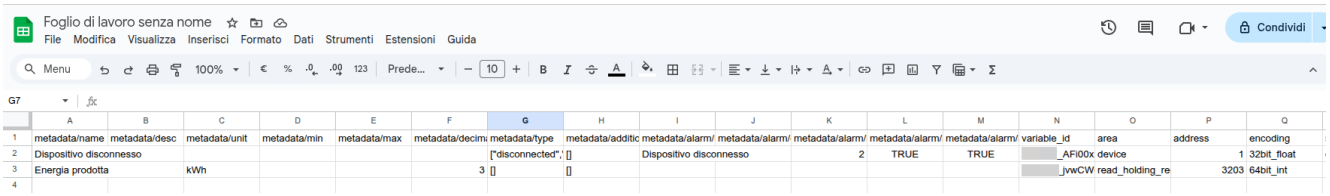


3. Paste the table into a spreadsheet (Excel, LibreOffice Calc, Google Sheets, etc) and modify it according to your needs. Some things to keep in mind:
   - Do not modify the column headers
   - Rows without a name (`metadata/name`) will be ignored
   - Do not modify the content of the `variable_id` column. The variable ID must be unique. When adding new variables, leave the field empty: a new ID will be generated automatically



4. Copy the modified table from the spreadsheet (select the entire sheet and press `CTRL+C`) and paste it into the indicated space

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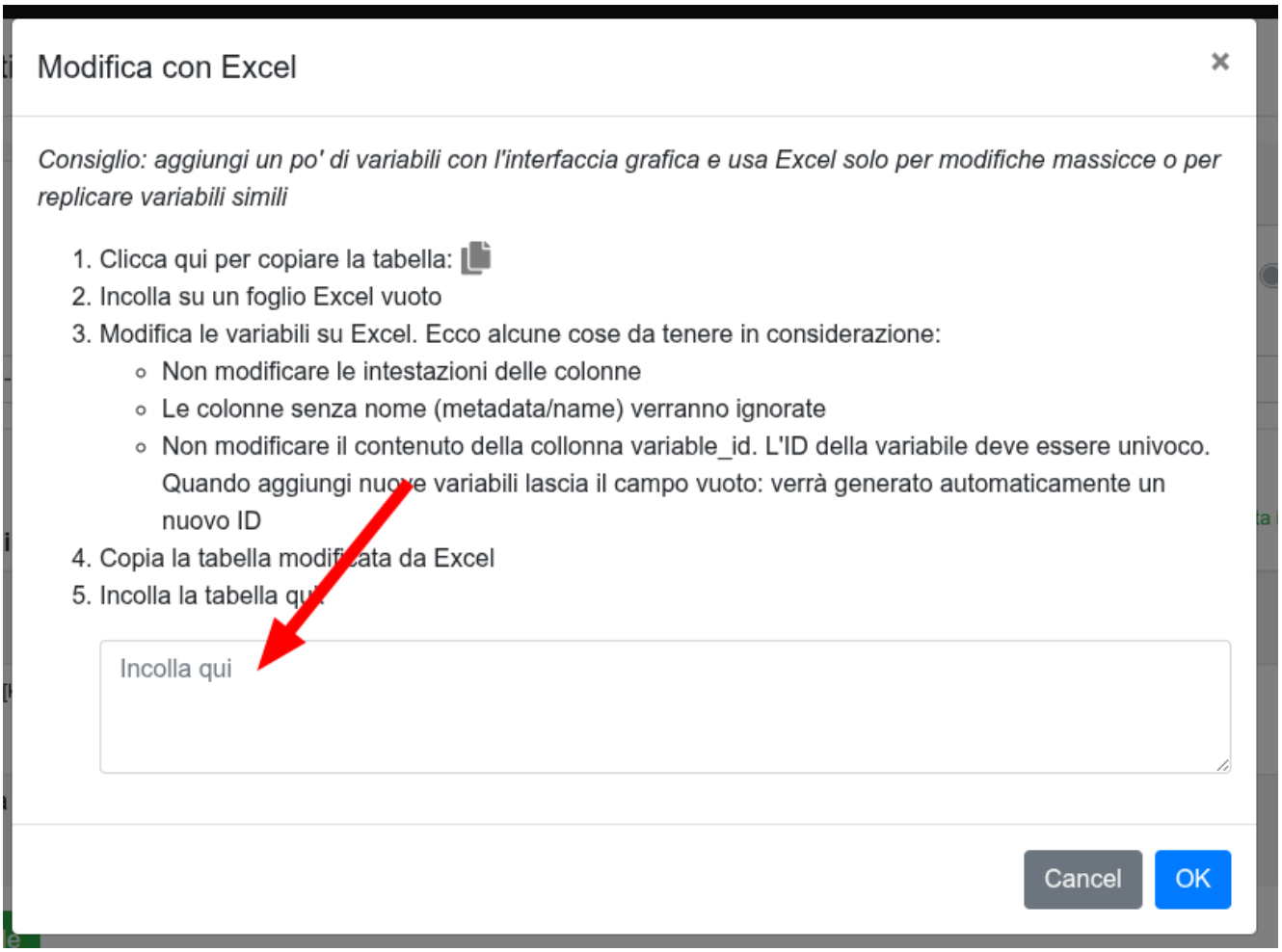

5. Review the new variables listed, resolve any errors and confirm.

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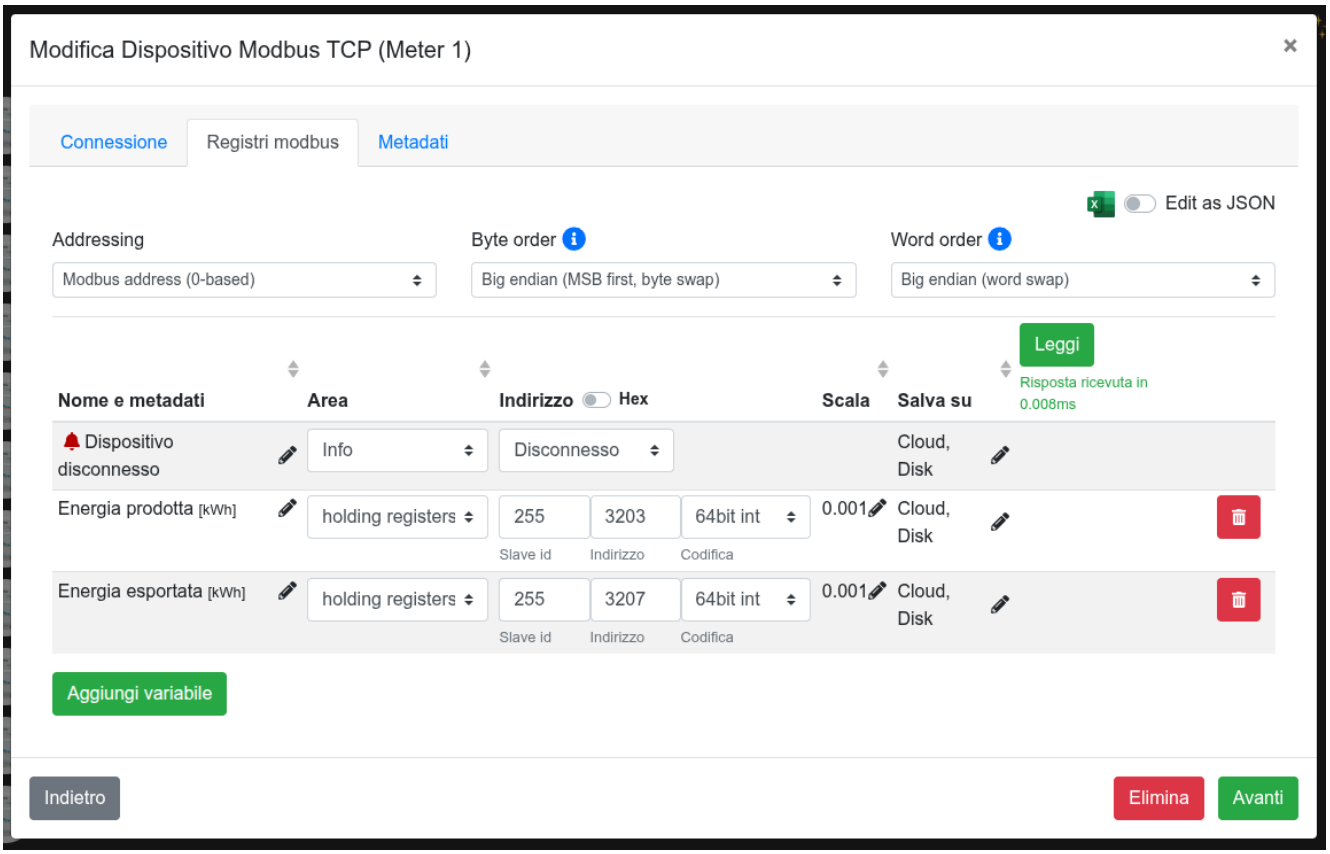
6. The inserted/modified variables will now be visible in the variable table of the data source.



Tip

If you are configuring several data sources from which you always acquire the same variables (e.g. multiple Modbus meters with the same registers), you can create an Excel/Spreadsheet file with the variable table starting from the first one configured. Remember to delete the content of the `variable_id` column cells. For each additional source, you just need to paste the same Excel file. This way you save time and reduce the risk of configuration errors.

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3.3.4 Sinks

3.3.4.1 Intro

3.3.4.1.1 INTRODUCTION

We call data sinks the final destinations of the data acquired by AL300.

3.3.4.1.2 SUPPORTED SINKS

AL300 supports the following data sinks:

- **Optimo IoT Cloud**: sends data to the Optimo IoT cloud
- **Local storage**: saves data in the internal memory of the AL300. This data can be:
  - exported or viewed locally
  - queried through SQL clients
- **OPC UA Server**: expose data through an integrated OPC UA server

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3.3.5 License

3.3.5.1 Introduction

Starting from firmware version v3.5.0, a licensing system has been introduced for the use of data sources. You can check the status of the licenses used by clicking on the button:

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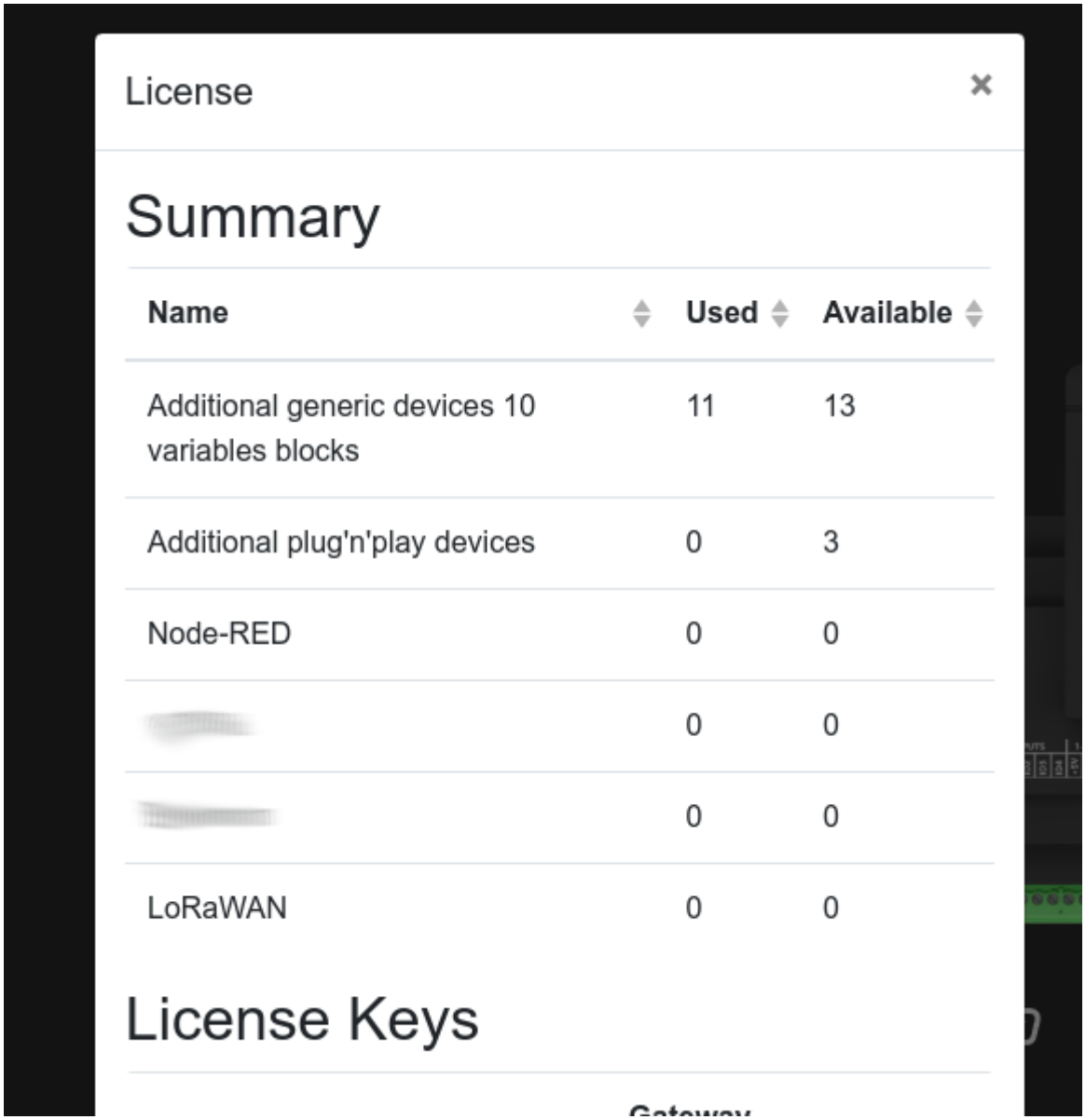
A summary is shown that represents the current situation:



To meet the required requirements (column `Used`), you can add one or more license tokens. License tokens are provided by Optimo IoT. To request a new token, write to info@optimoiot.it.

3.3.5.2 Adding a license token

You can add a token provided by Optimo IoT both in the cloud and locally by clicking on `Add`:

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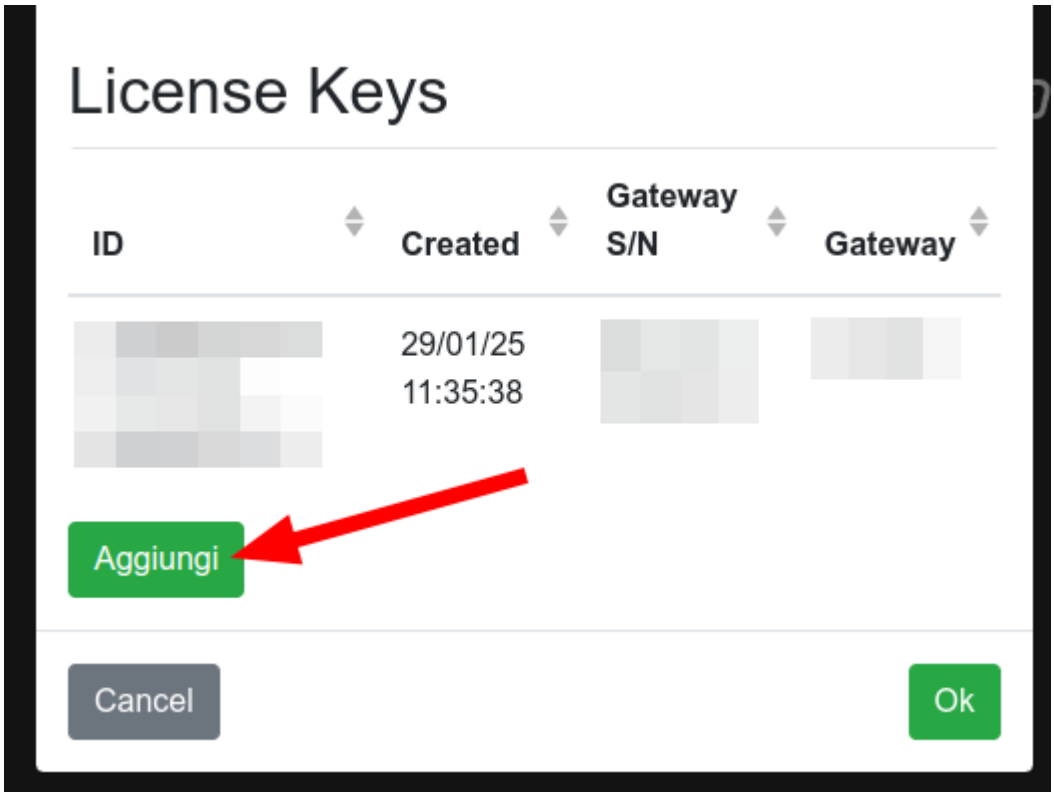
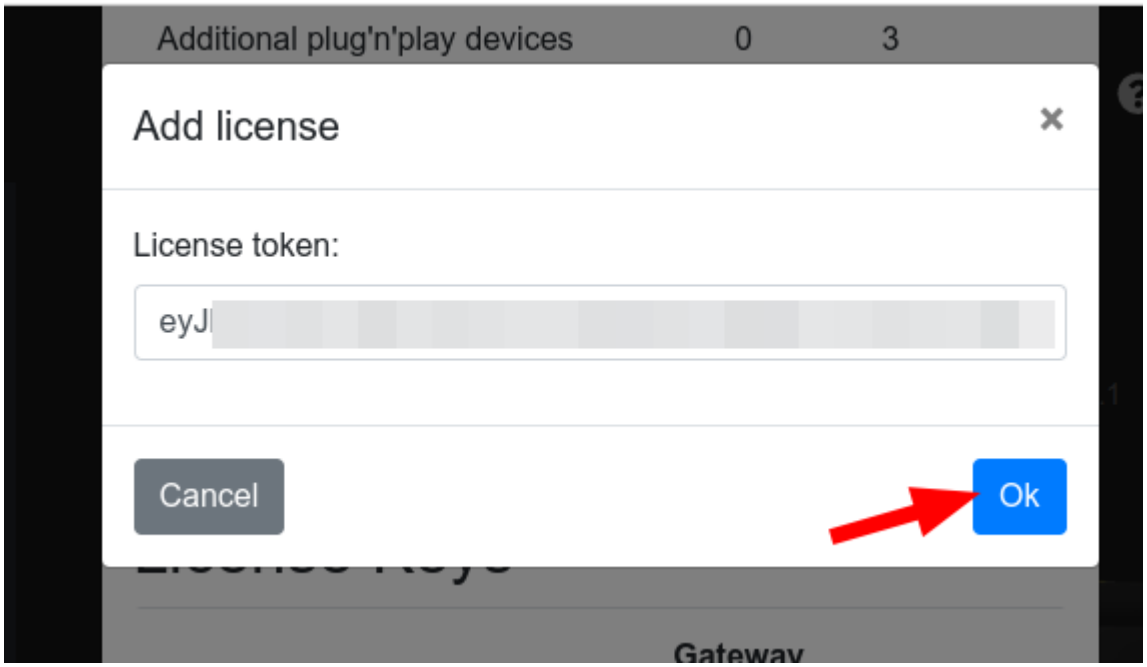


Paste the token provided by Optimo IoT, click `Ok` and then `Save`:



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3.4 Firmware upgrade

It is possible to update the gateway firmware in 3 ways:

1. remotely (OTA) through the Optimo cloud platform
2. connecting through the local network to the gateway
3. physically accessing the gateway and inserting a USB stick

To use methods 2 and 3, you need to download the update package from the cloud platform, as described in the dedicated section.

3.4.1 1. OTA update

Follow the procedure described in the Cloud section

3.4.2 2. Upload via local web interface

- connect to the local network of the gateway (WiFi or ethernet)
- visit the page `http://<<gateway IP address>>:8085/` (e.g. http://10.10.10.10:8085)
- click on the white box and select the update package

3.4.3 3. Upload through a USB mass storage

- copy the update package to a USB mass storage (N.B.: it is important that the file is in the main folder of the storage device, and **not** in a subfolder)
- insert the mass storage into any of the two USB ports of the gateway
- wait 5 minutes
- remove the mass storage from the USB port

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3.5 Factory reset

Starting from firmware version 3.4.1 it is possible to reset the device to factory settings.

> **Warning!**
>
> This procedure resets all settings (network, devices, credentials) to factory settings and irreversibly deletes all acquired data (time series, alarms, etc)

1. create, in the root folder (not in a subfolder) of a USB stick an empty file called `DANGER_factory_reset_START.txt`
2. power off the AL300 (alternatively, turn it off with the Power button)
3. insert the USB stick into one of the two USB ports of the AL300
4. power on the AL300 (alternatively, turn it on with the Power button)
5. AL300 will detect the configuration file, perform a reset and reboot. At the end of the procedure you can access the Web UI again using the IPs and credentials contained in the original package

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3.6 Buttons & leds

3.6.1 Power LED

In this table the meaning of the LED incorporated in the front button is reported: | Power LED | UPS status | System status | | ---------- |
---------- | ---------- | | 250 ms off, 250 ms on | The UPS is charging | OFF | | Always on | The UPS is charged | ON | | 250 ms off, 100 ms on | External power failure detected. After 0.5 seconds in the absence of external power, the controlled shutdown of the system begins | ON | | 900 ms off, 100 ms on | Shutdown in progress. The UPS is discharging | ON | | Always off | Charging or discharging. Not in use | OFF |

3.6.2 Physical buttons

3.6.2.1 Power

The front button is not generally useful. If pressed for two seconds, it turns off the Gateway in a controlled manner without the need to turn it off. When the Gateway is turned off in this way to start it later **it will be necessary to press the front button again** (turning it off and on again will not start it)

3.6.2.2 Reset

The reset button is not generally useful. It can be pressed with a needle through the small hole in the case and is only used to immediately remove power from the system (bypassing the UPS and instantly shutting down the system **in an uncontrolled way**)

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3.7 Onboard I/O

3.7.1 I/O on board

AL300 provides:

- Digital I/O:
  - 8 optoisolated digital inputs
  - 4 dry contact digital inputs
  - 8 digital outputs
- Analog I/O:
  - 4 0-10V analog inputs
  - 2 0-10V analog outputs

3.7.2 Digital inputs and outputs

Digital inputs can be used as pulse counters. The minimum pulse duration and the minimum period between one pulse and the next are 10-50 milliseconds, depending on the number of monitored inputs and the overall load of the AL300.

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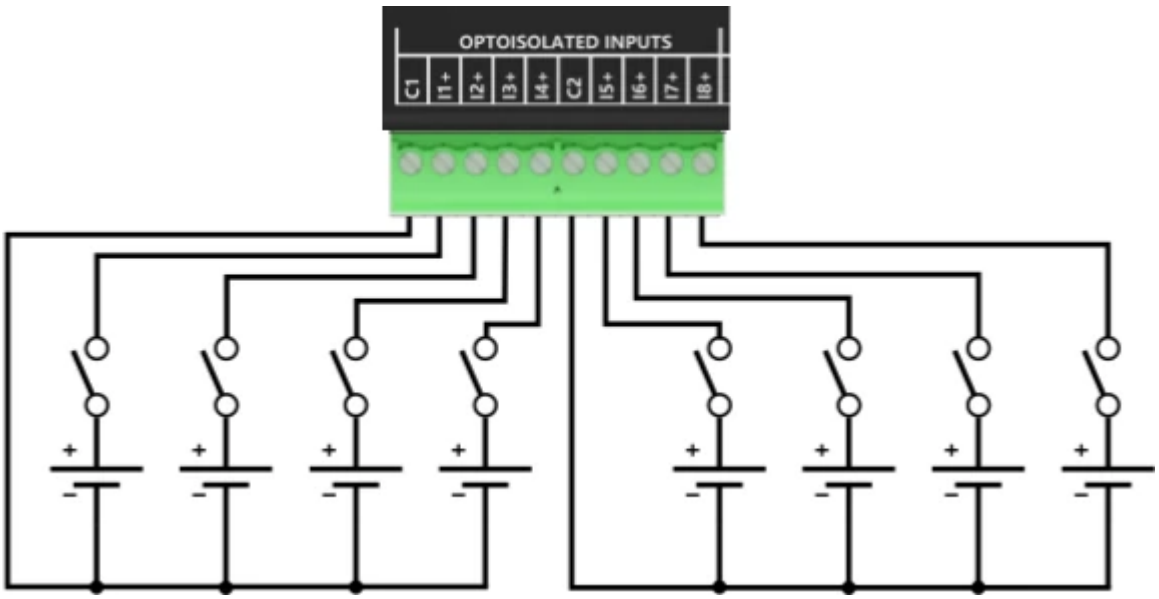
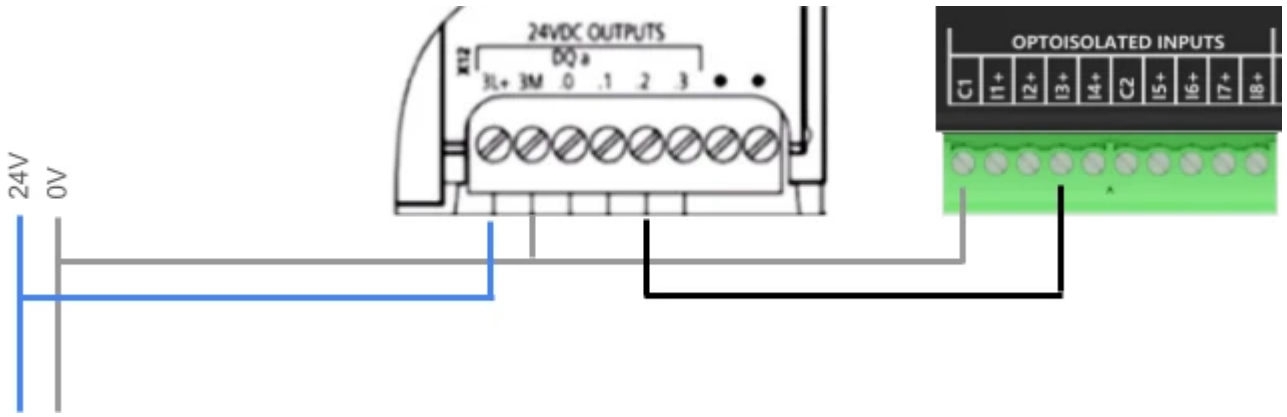
3.7.2.1 Optoisolated inputs



Parameter	Value
Quantity of inputs	8
Low-level input voltage	0 - +5 V DC
High-level input voltage	+10 ... +28 V DC
Isolation voltage	5 kV RMS
Input resistance	>=10kOhm

3.7.2.1.1 EXAMPLE OF CONNECTION TO SIEMENS S7-1200 CPU (1214C)



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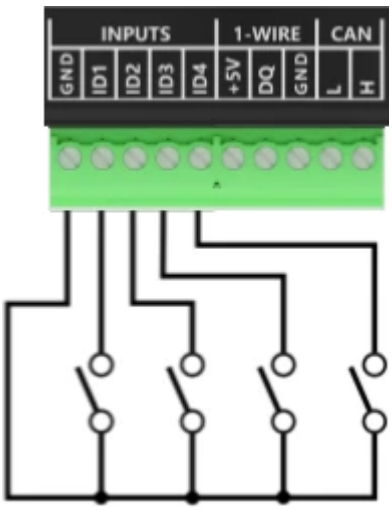
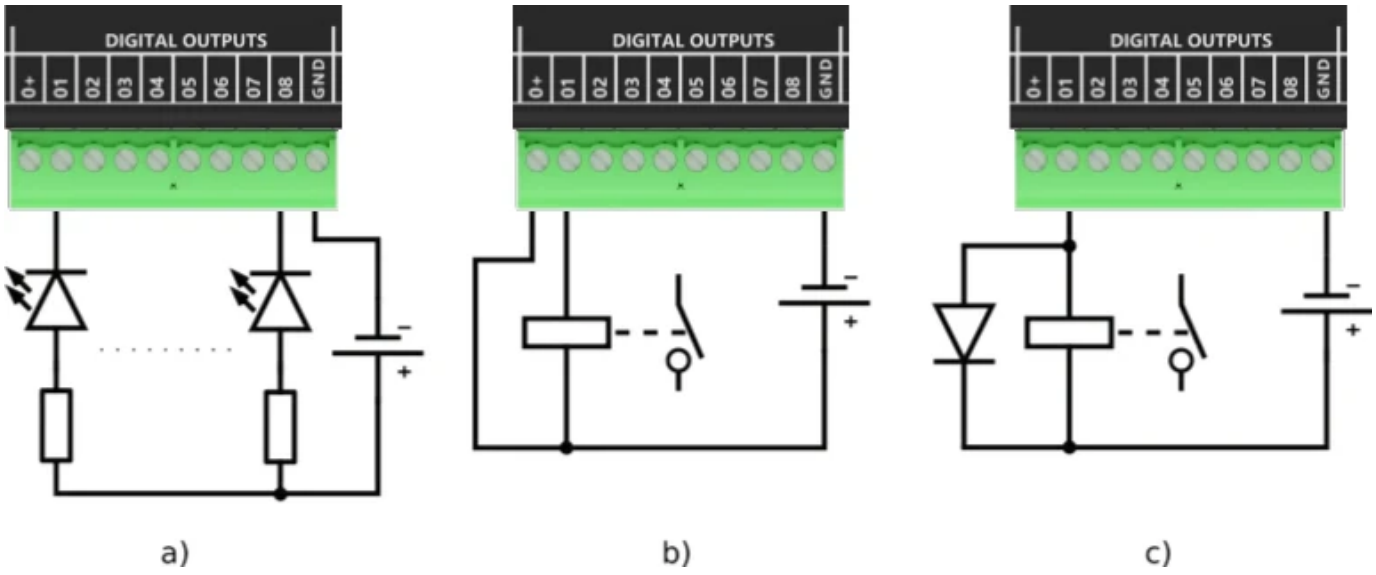
3.7.2.2 Dry contact inputs



3.7.2.3 Digital outputs

AL300 has 8 open-collector digital outputs. This figure shows the recommended connection of LEDs (a) and relays (b,c) to the open-collector outputs. The internal diodes protect the output transistors from transient voltage spikes (b). In the case of long cables to the relay, the connection with an external diode is recommended (c).



Parameter	Value
Quantity of outputs	8
Maximum current	500 mA
Maximum voltage	28 V DC

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3.7.3 Analog inputs and outputs

AL300 has 4 0-10V analog inputs and 2 0-10V analog outputs.

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4. Cloud

4.1 Dashboard cloud

4.1.1 Login

After an administrator user has created your account, open cloud.optimoiot.it to log in for the first time.

If you have not logged in yet or if you have forgotten your password, you can click on the *Forgot password* button to recover it. You will be asked to enter the email address with which the administrator registered you, on which you will then receive a confirmation code.

4.1.2 Navigation

You can navigate using the left menu, expanding the tree of pages

4.1.3 Top bar

Through the top bar, you can access several additional features: (image)

4.1.3.1 Data export

You can export the recorded data in raw or aggregated form, with different formats. By clicking on the button shown, the following steps are proposed:

1. select the devices for which to export the data in the tree
2. filter the variables by unit of measure
3. choose the variables to export among those previously filtered
4. set the type of aggregation and the output format

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4.1.3.1.1 AGGREGATION

The raw data can be acquired at variable frequencies (e.g. every minute, every quarter of an hour or on change). You can export the raw data, as they are in the database, by selecting "None" as the type of aggregation.

On the other hand, it can be useful to export some elaborations made on this data, aggregated by a defined time step (e.g. hour, day, week, month).

The types of aggregation are various and selectable from the drop-down menu. By selecting one, a brief description is shown that explains how it works.

4.1.3.1.2 FILE TYPE

You can choose between:

- Simple: a single csv file, recommended for most exports
- Structured: a compressed zip file that contains several csv files. Recommended for massive exports of many variables over extended time intervals (e.g. years, especially if not aggregated)

4.1.3.1.3 ADVANCED SETTINGS

You can choose different options, including the date and time format (and time zone), the decimal separator (comma or point) and the type of csv file

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4.2 Notifications

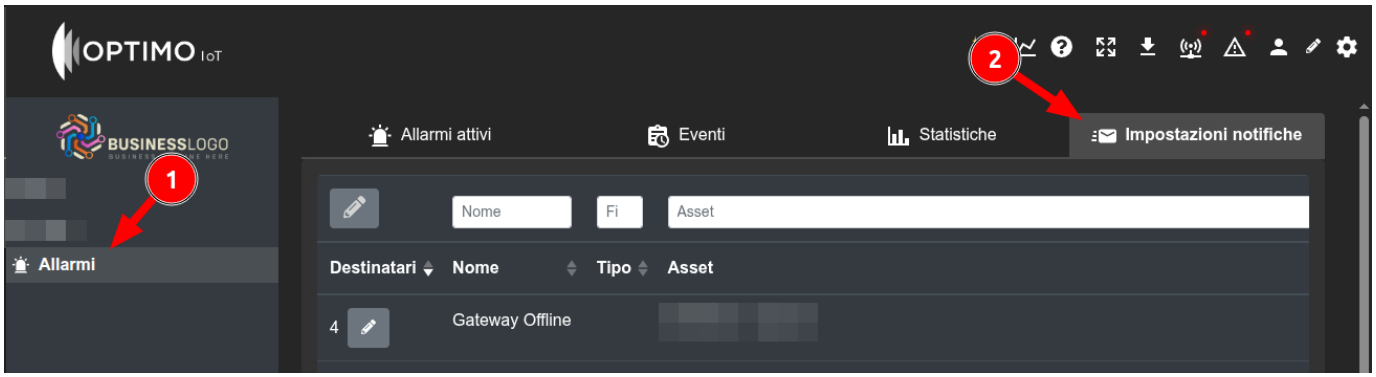
Optimo IoT can send email or SMS notifications when alarm variables are triggered.

Alarm variables can be:

- connection status variables (e.g. Gateway connected to cloud, Modbus device connected to gateway, etc)
- status variables acquired from sensors and devices (e.g. heat pump alarm) (see Configuration of alarm variables)
- virtual variables processed periodically by the cloud platform (e.g. daily average temperature above a threshold)

To modify the notification settings, you need to be a user with administrator privileges.

Access the alarm page from the left menu of the dashboard:



4.2.1 Configuration for single alarm variable

Choose the row in the table corresponding to the alarm variable of interest and click on the pencil icon to open the edit window.

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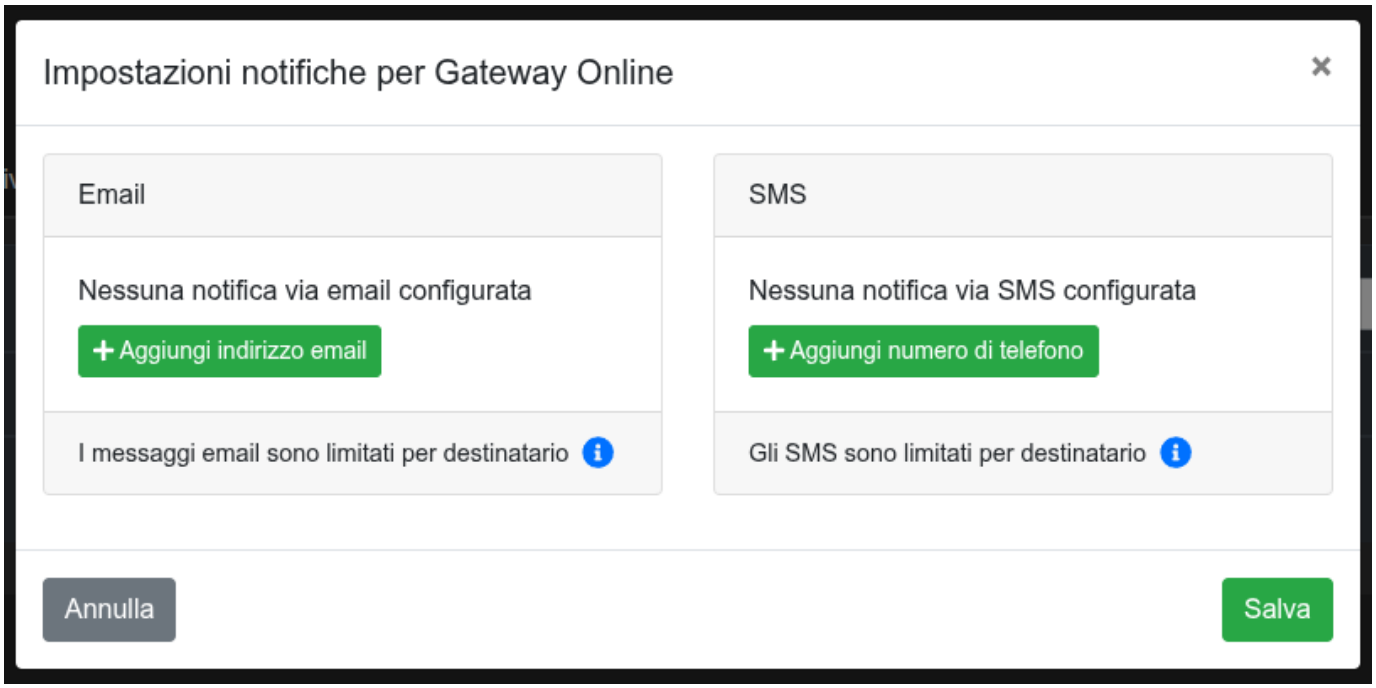

4.2.1.1 Recipients and sending limits

Add the email addresses or phone numbers to which to send the notifications.

To prevent an incorrect configuration of an intermittent alarm from filling the recipient with too many messages, the following sending limits are applied per recipient:

Period	SMS limit	Email limit
Hour	2	10
Day	4	20
Week	5	50
Month	15	100

The last message will explain to the recipient that their limit has been reached. Only for email notifications, a link is also sent to reset the count and continue receiving notifications.

4.2.1.2 Single smart filters

If occasional false alarms occur, you can configure a strategy to reduce unnecessary notifications related to the specific variable.

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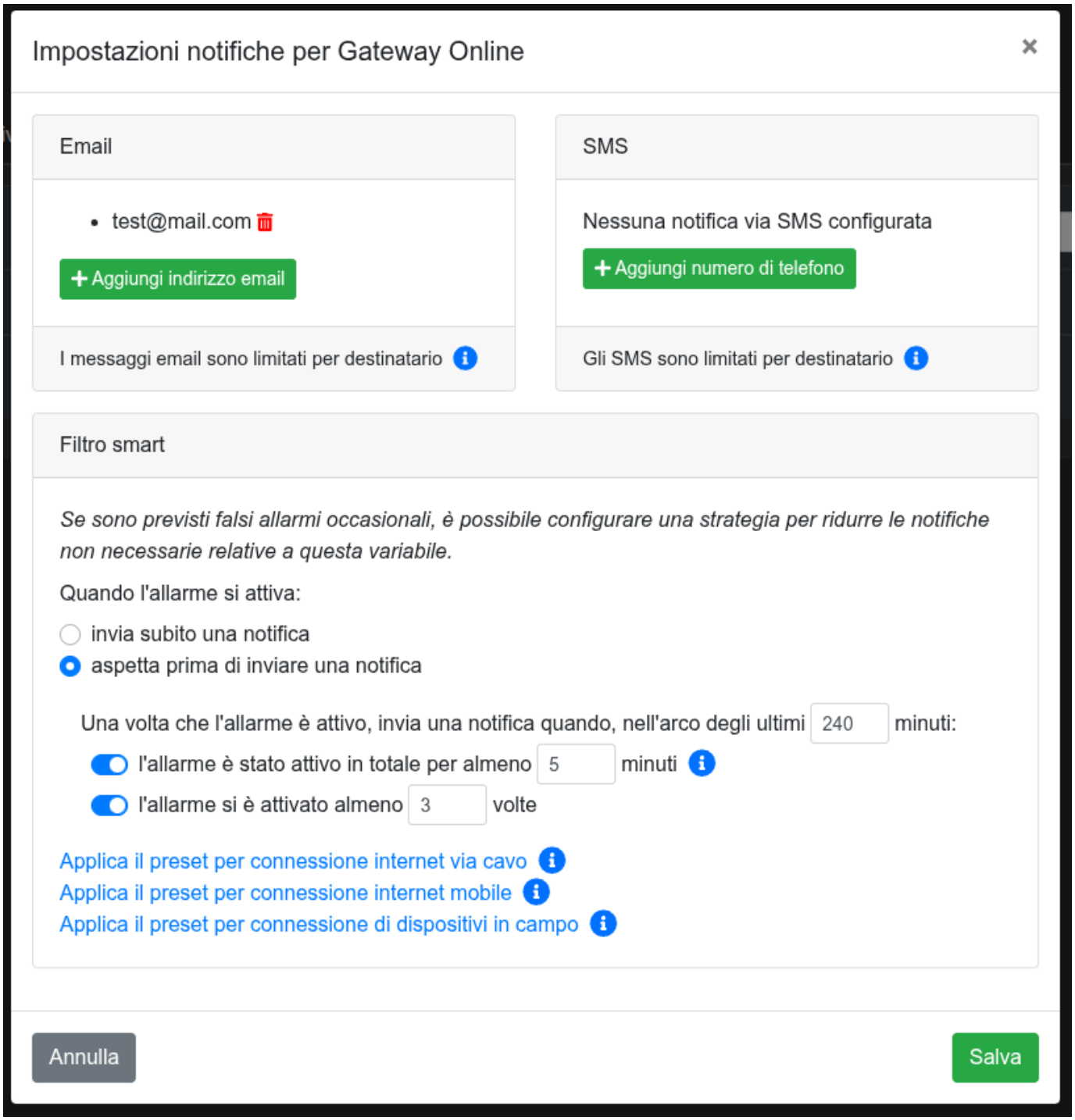

By default, notifications are sent immediately when the alarm is triggered.

It is possible to delay the sending of the notification.

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In the example above, once the alarm condition is detected, the system will continuously check every minute the situation of the previous 4 hours. The notification is sent if one of these conditions is verified:

- if in that period the alarm was active for at least 5 minutes (in total, possibly considering multiple activations cumulatively)
- if in that period the alarm was triggered at least 3 times (regardless of the duration of each activation)

More information on smart filters is available in the Smart filters section later in this page.

4.2.2 Bulk configuration

Click on the pencil icon in the table header to open the massive edit window.

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4.2.2.1 Variable selection

It is possible to filter the alarm variables to be modified in bulk based on various criteria:

- belonging asset
- type of alarm
- fine selection (alarm by alarm)

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1. Select one or more assets to which the variables to be modified belong

2. Select one or more types of alarm to modify

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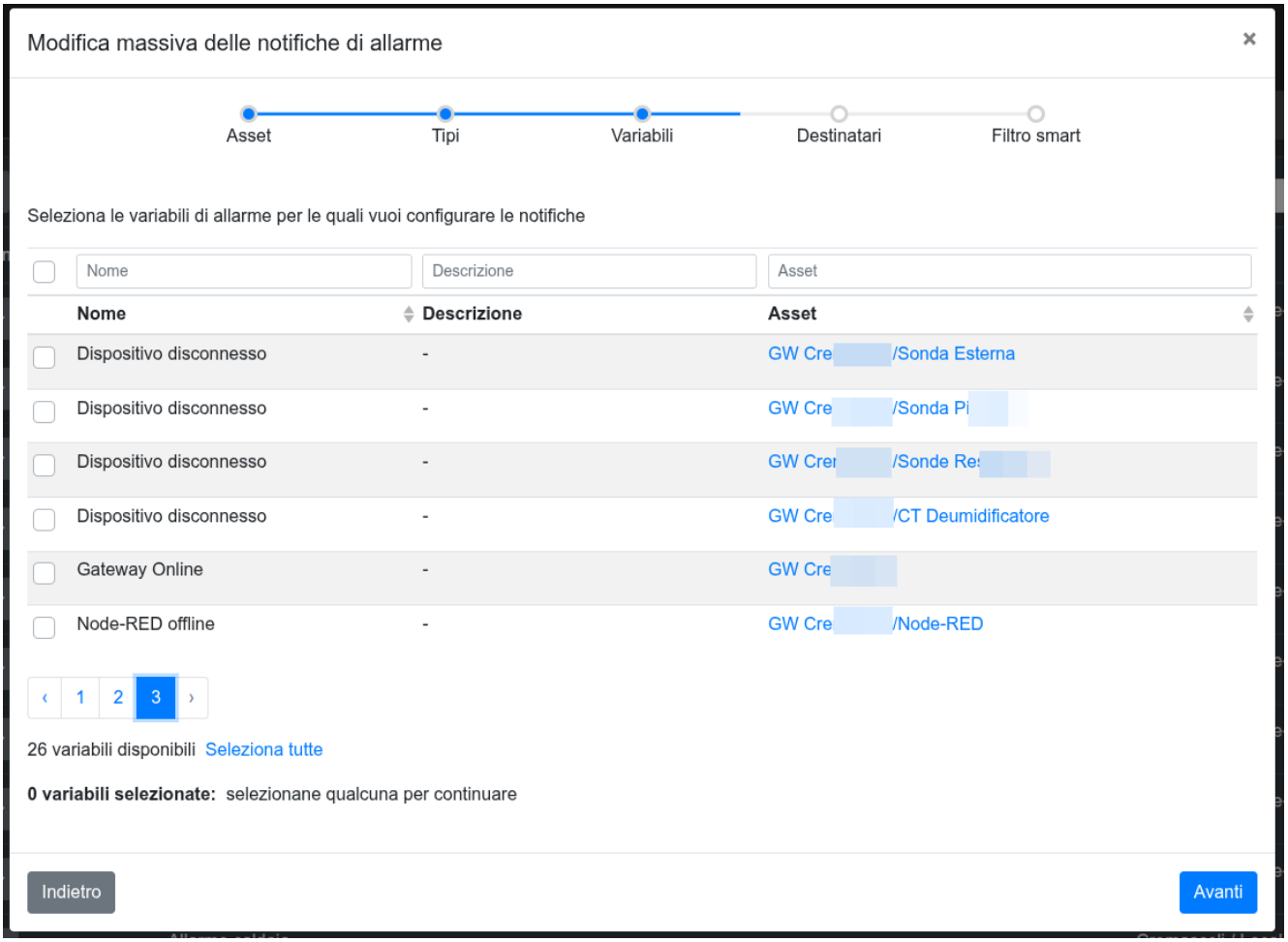
3. Select the alarm variables to be modified among those filtered in the previous steps



4.2.2.2 Recipients

4.2.2.2.1 ADDING NEW RECIPIENTS

If no recipients were configured for the notifications of the selected alarm variables, the recipient table will be empty:

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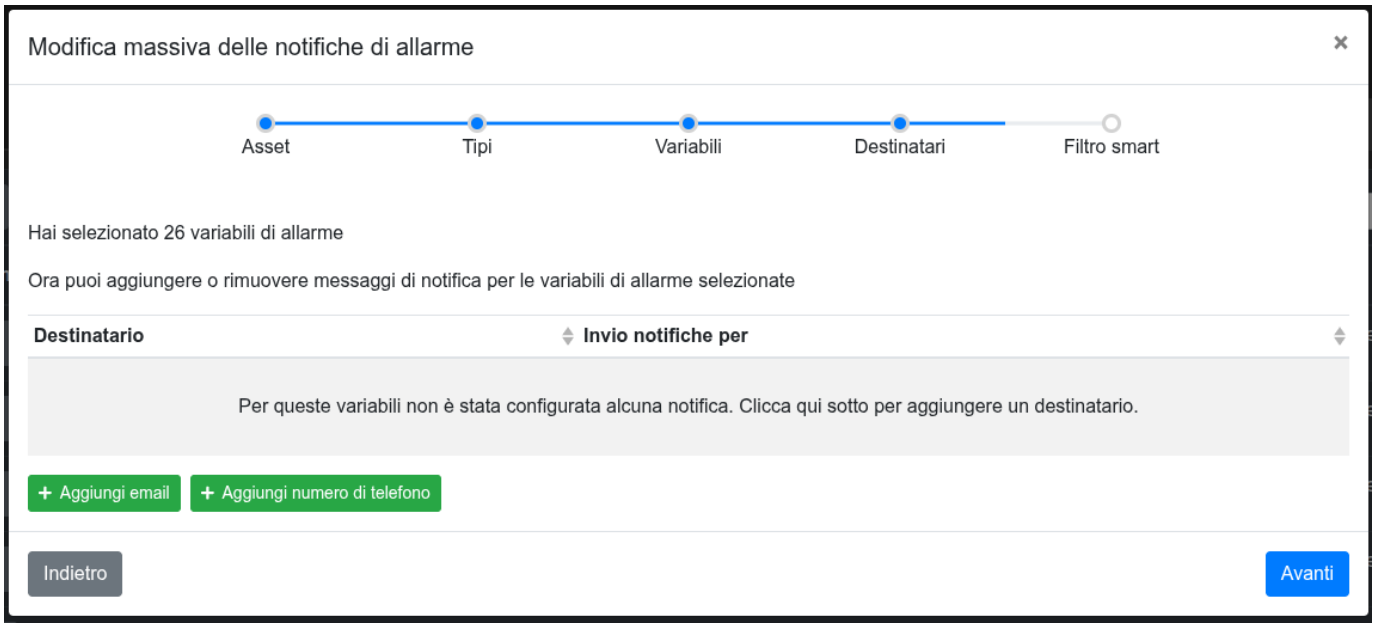

You can add them by clicking on `Add email` or `Add phone number`.

4.2.2.2.2 MODIFYING EXISTING RECIPIENTS

If instead recipients were already configured for the notifications of the selected alarm variables, the table will show the recipients configured for at least one of the selected variables:

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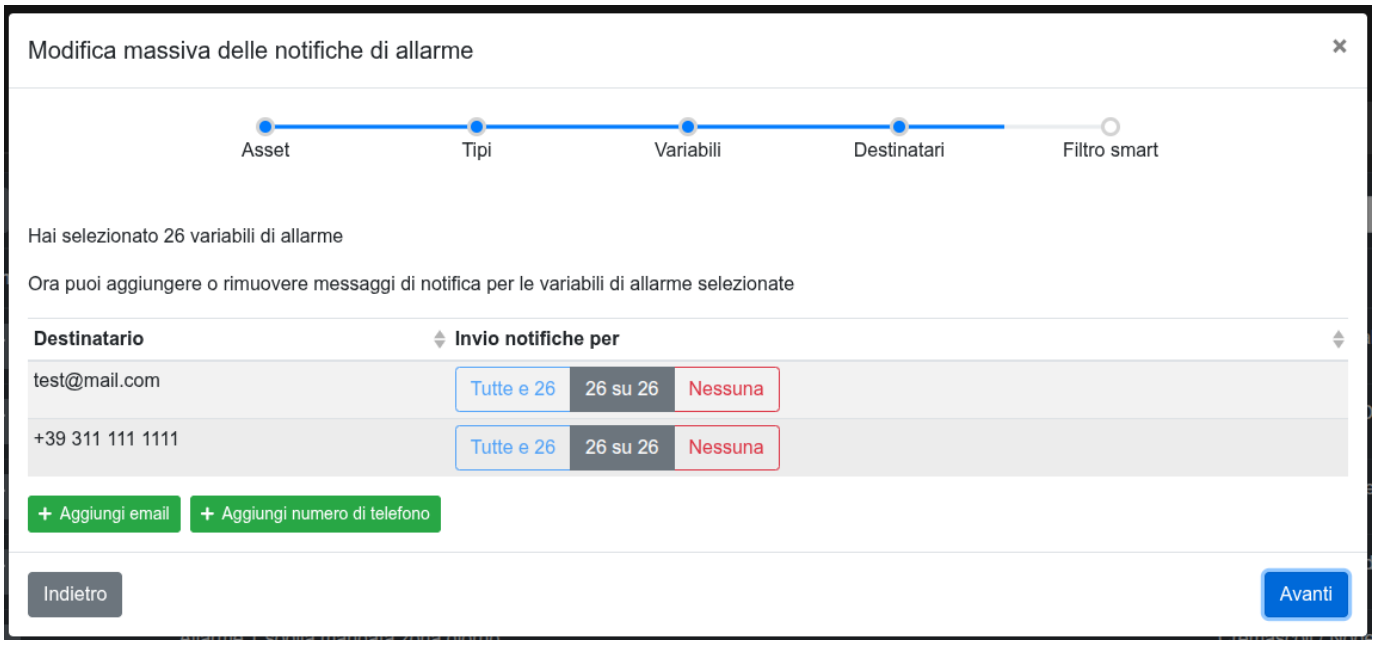

For each existing recipient, you can extend the notifications to all selected variables by clicking on `All 26` or remove the recipient from the selected variables by clicking on `None`.

4.2.2.3 Multiple smart filters

In the next step, you can configure the smart filters for the selected alarm variables

4.2.2.3.1 ADDING SMART FILTERS

If no smart filters were configured for the selected alarm variables, the filter section will be empty:

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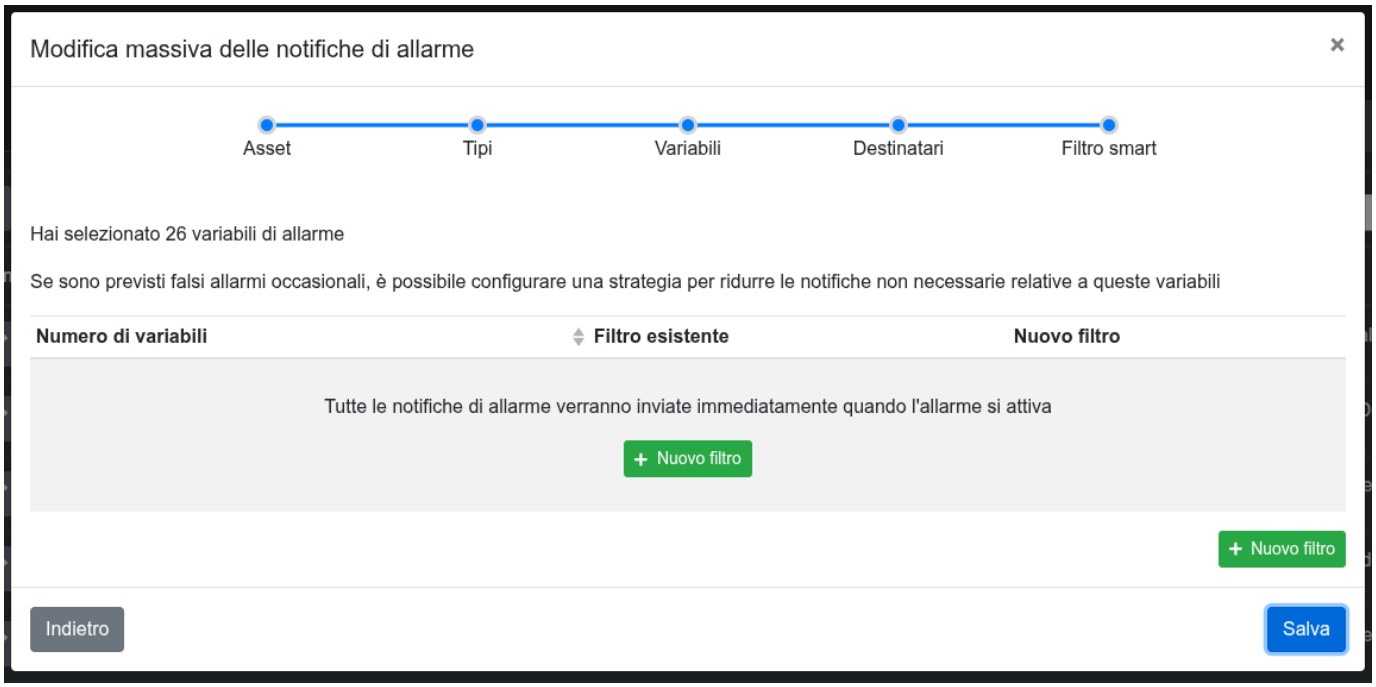

You can add one by clicking on `New filter`. The smart filter configuration window will open. For more info on how smart filters work, please refer to the Smart filters section above.

The created filter will be applied to all selected alarm variables.

4.2.2.3.2 MODIFYING EXISTING SMART FILTERS

If instead smart filters were already configured for the selected alarm variables, the table will show the filters configured for at least one of the selected variables:

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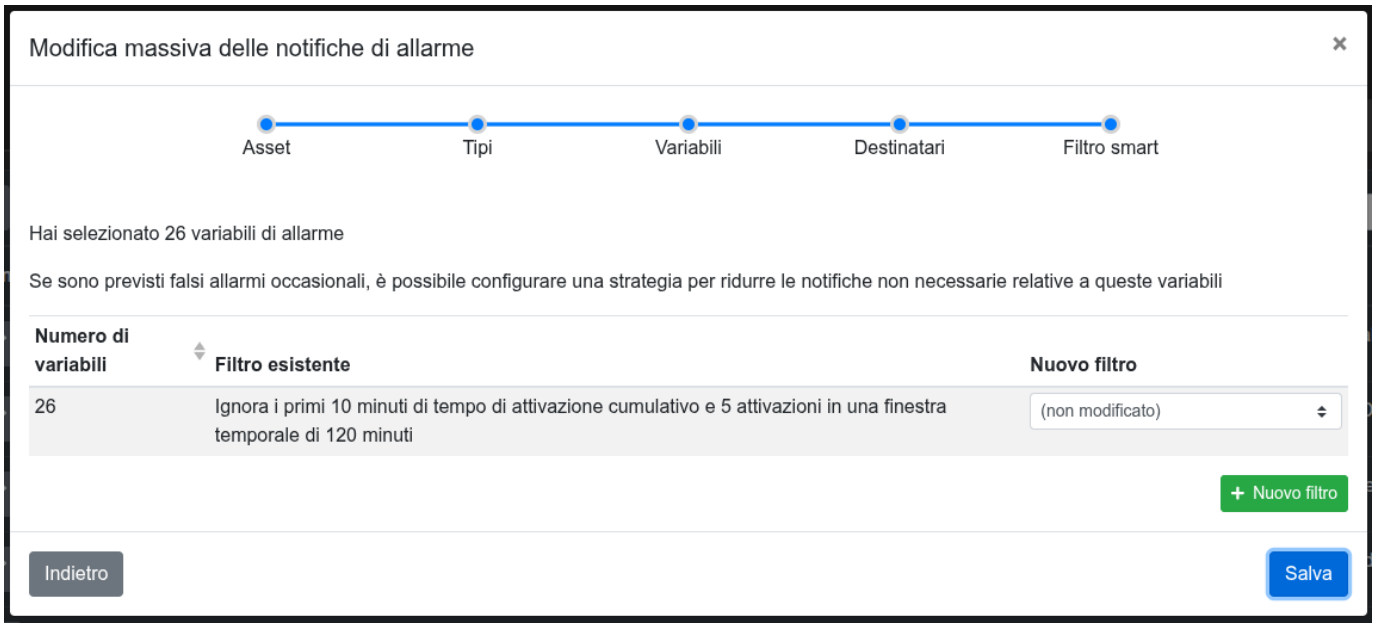

For each existing filter, you can leave it unchanged or modify it by choosing from the drop-down menu a filter to apply. To add a new filter, click on `New filter`.

4.2.3 Smart filters

Some examples of smart filter configurations and their effect are shown.

The parameters in the first three columns are those settable by the user, namely:

- W (`window [min]`): the time window that the system considers to evaluate whether to send the notification, in minutes
- D (`duration [min]`): after this cumulative time of alarm activation in the `W` window is exceeded, the notification is sent
- C (`count`): after this number of alarm activations in the `W` window is exceeded, the notification is sent

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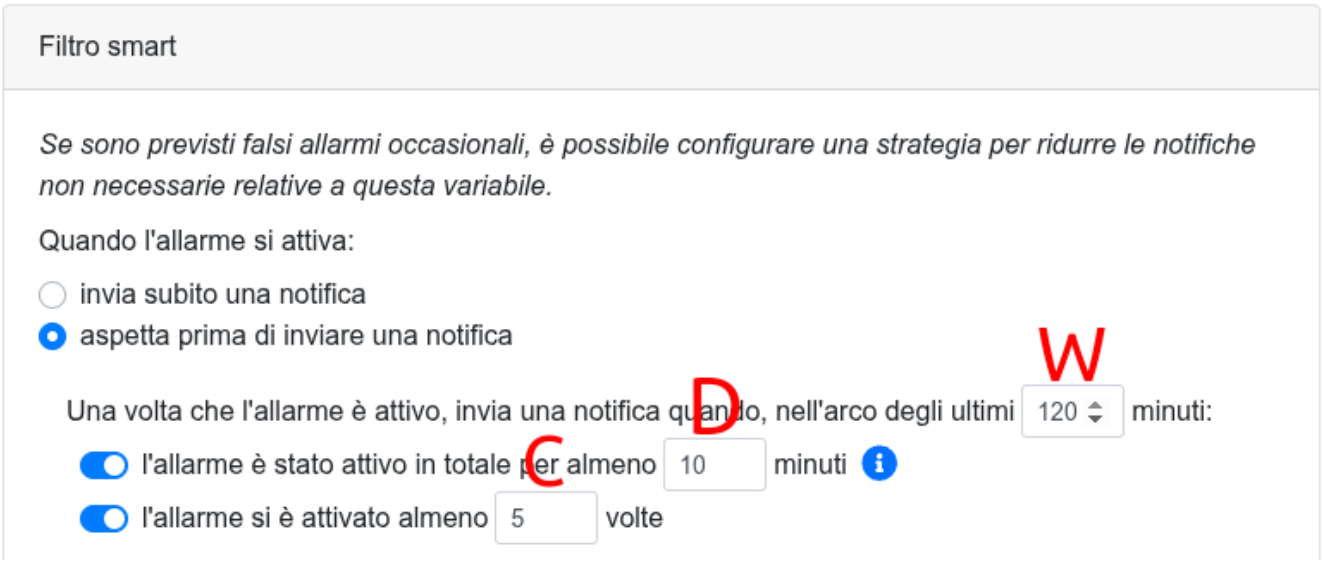

4.2.3.1 Example 1

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4.2.3.2 Example 2

4.2.3.3 Example 3

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4.3 Virtual Cloud Variables

We call virtual variables those variables that are not acquired directly from a sensor or device connected to an Optimo IoT AL300 Gateway.

Variables calculated in dashboard widgets

Most of the widgets that can be used to form dashboards internally support the display of data calculated based on one or more variables through arbitrary formulas. For this use, it is not necessary to create virtual variables as described in this chapter

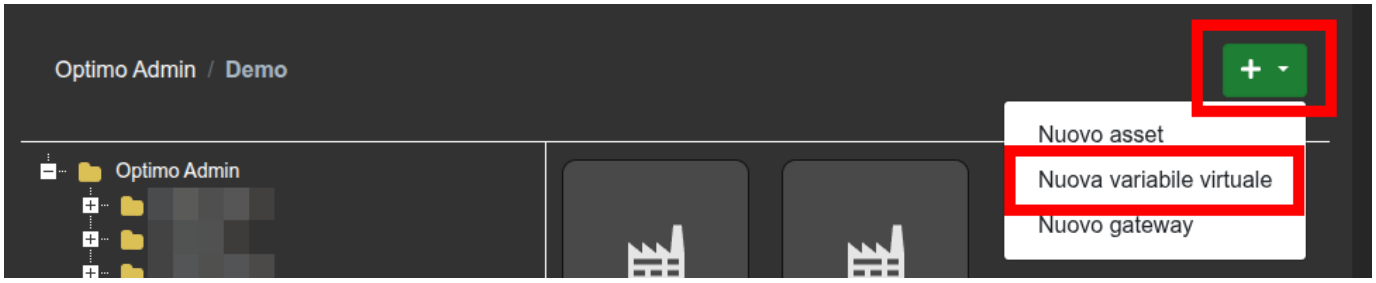
Virtual variables calculated within the AL300

Within the AL300 Gateways, it is possible to use Node-RED to create local virtual variables managed solely by the AL300. The virtual variables described on this page are instead created and processed by the Optimo IoT cloud platform.

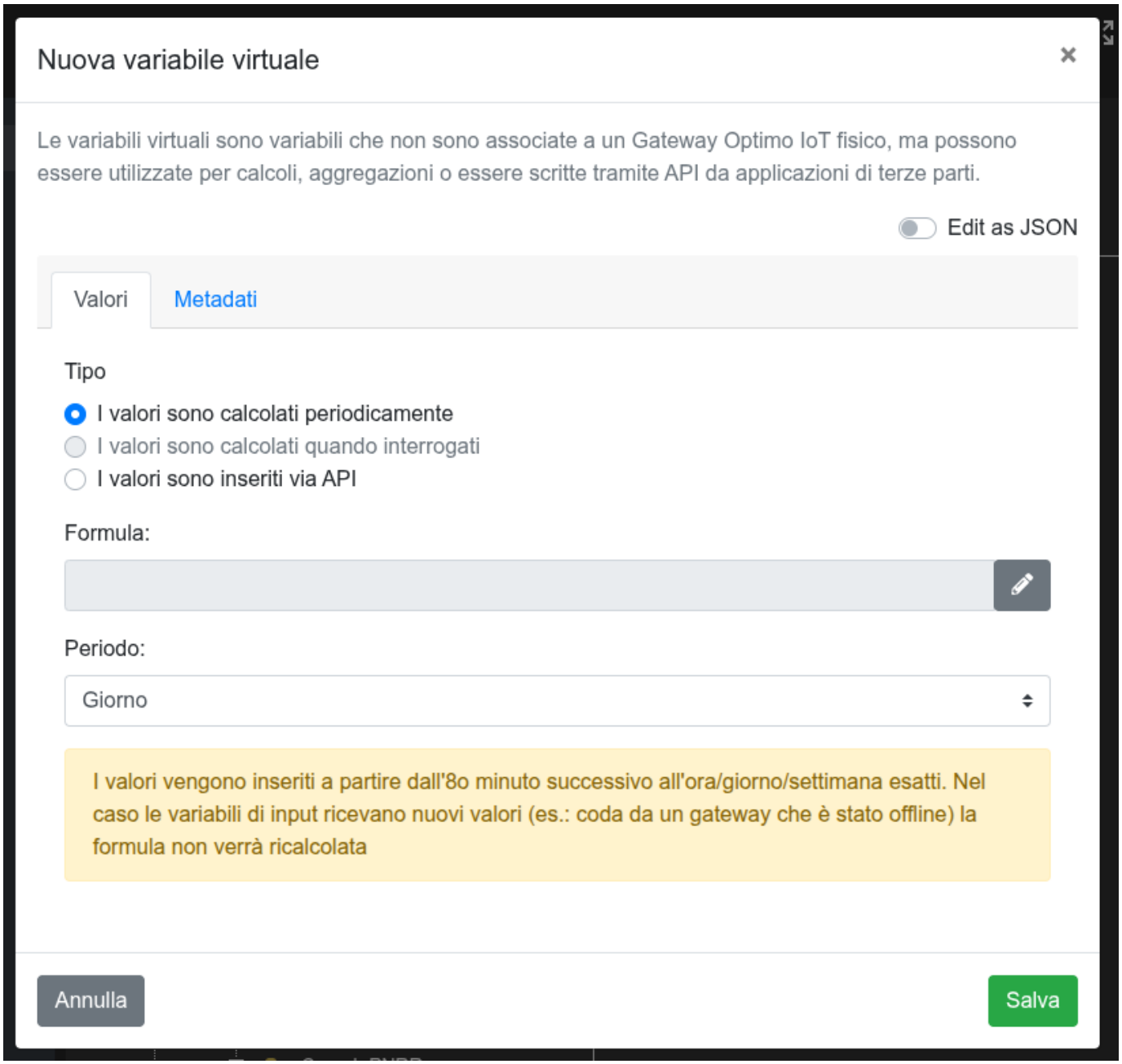
There are three types of virtual variables, based on how their values are populated:

1. **Variables with values calculated periodically by the cloud platform**, based on mathematical or logical formulas involving other variables (e.g. daily average temperature, alarm status based on multiple sensors, etc.)
2. **Variables with values calculated when queried**, based on mathematical or logical formulas involving other variables (e.g. difference between two temperatures, alarm status based on multiple sensors, etc.)
3. **Variables with values entered via API** (e.g. market prices, weather conditions, status of an external device, etc.) that can be used to create more complete dashboards

Virtual variables can be created from the Asset Explorer:



Copyright © Optimo IoT 2025



Since they cannot be associated with a specific AL300, this possibility is given only for assets that are not part of the hierarchy of an AL300 Gateway.

4.3.1 Variables with values calculated periodically

With the specified frequency, the Optimo IoT Cloud executes the formula specified by the user and saves the result as the value of the variable.

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The possible frequencies are:

- hourly
- daily
- weekly

Within the formula, it is possible to use as input variables statistics (e.g. average, minimum, maximum, sum, count, etc.) calculated on other variables in a time interval defined relative to the moment of execution of the formula (e.g. last hour, last day, last week, last month, etc.).

Here are some examples of what can be the value of a variable:

- the maximum value of the temperature detected by a set of sensors in the last hour
- `0` if the temperature of a set of sensors in the last 12 hours has always been below a threshold, `1` otherwise (useful for creating an alarm)
- calculate the sum of the energy consumed by the general meters of different establishments in the last day

4.3.1.1 Formula

Click on the pencil icon to open the formula editor. To define the formula, you must first specify the input variables and then write the mathematical or logical expression that involves them.

4.3.1.1.1 INPUT VARIABLES

Each input variable is the result of a statistic calculated on a variable acquired by the cloud platform in a time interval defined relative to the moment of execution of the formula.

Click on "Add input variable":

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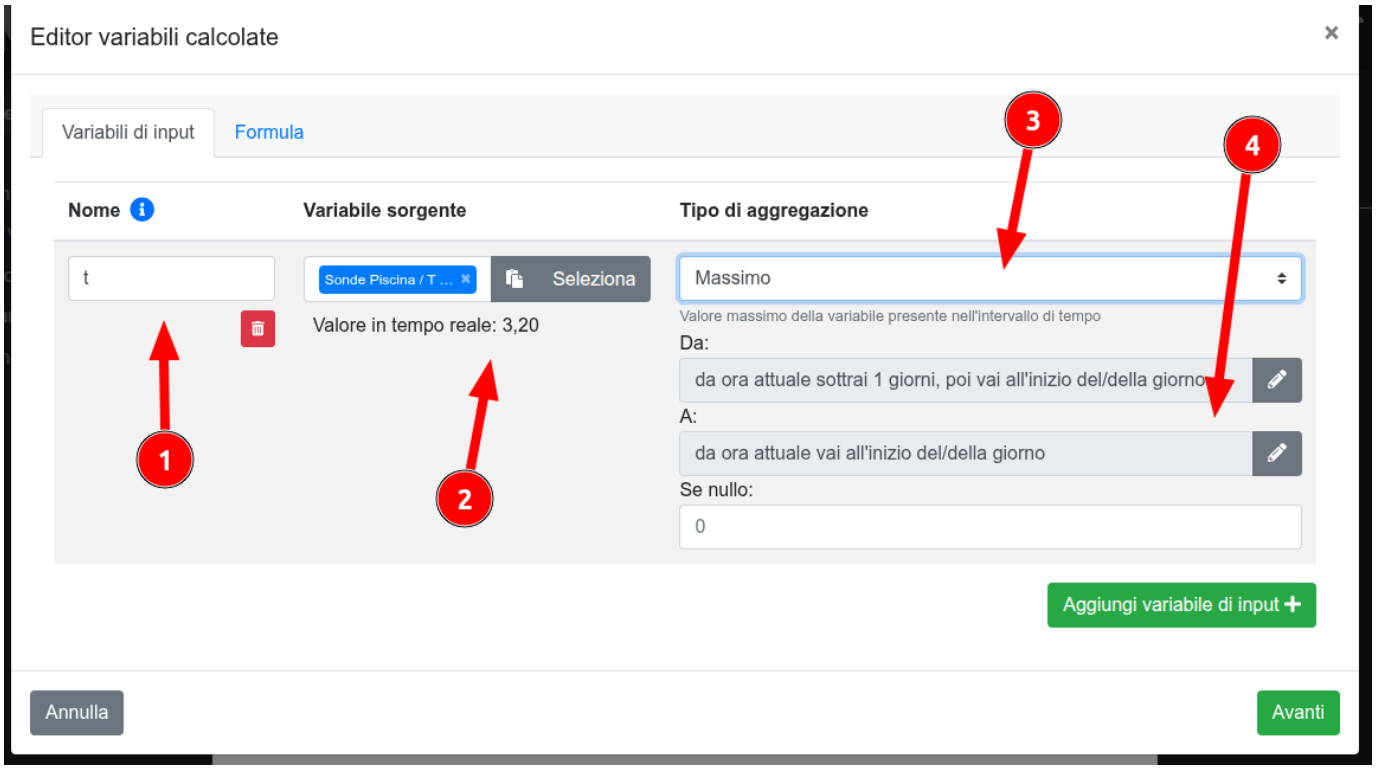

Specify:

1. the name to use in the formula to refer to it
2. the variable on which to calculate the statistic (it can be any variable acquired by the cloud platform)
3. The type of statistic to calculate (e.g. average, minimum, maximum, sum, count, etc.). Here is the complete list.
4. the time interval on which to calculate the statistic (e.g. last 3 hours)

It is also possible to specify a value to use in case there are no values of the variable on which to calculate the statistic (e.g. no data acquired in the specified time interval).

4.3.1.1.2 EXPRESSION

Once the variables are defined, you can write the expression.

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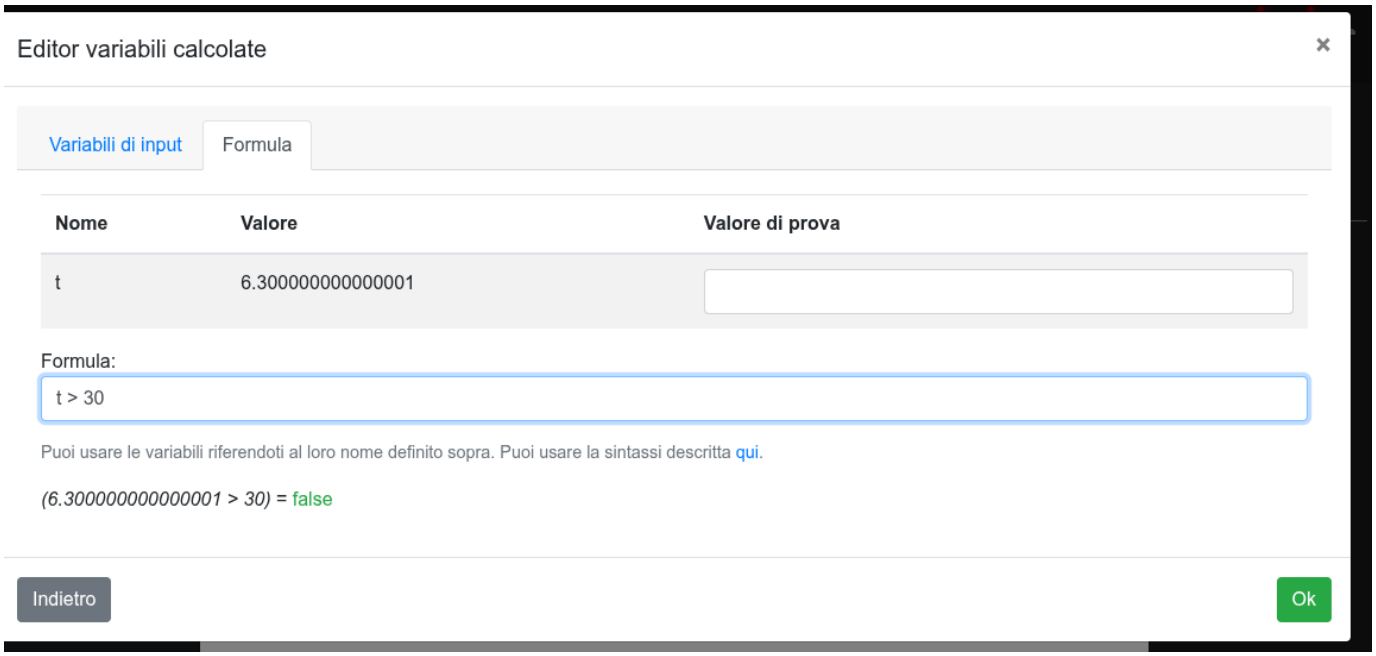

You can view in real time the values of the input variables and the final result obtained. You can simulate arbitrary input values to check the functioning of the formula.

The syntax of the expression is described here.

4.3.2 Variables with values calculated when queried

The use of this type of virtual variable is not made publicly available to all customers

4.3.3 Variables with values entered via API

Once the variable is created, it is possible to insert historical or real-time values using the `/injest` endpoint described in the HTTP API documentation.

If the virtual variable is configured as an alarm variable, the values entered via API can also cause the sending of alarm notifications

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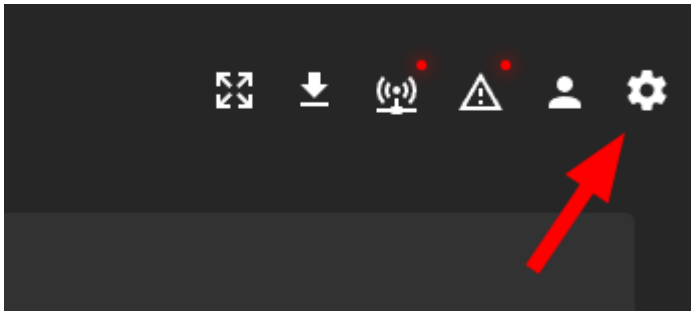
4.4 Settings

4.4.1 Access

Navigate to cloud.optimo.it. For more details read the Login chapter.

Click on the button



If the button is not visible, it means that you do not have administrator permissions. Contact the person who created your account to ask for information and possibly modify the settings.

4.4.2 Navigation

Depending on the user's level, they can see all or only some of the following menus:

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4.4.3 Tree

A graphical representation of the hierarchical structure of the assets is shown. By clicking on each asset, it is opened in the Asset explorer

4.4.4 Explorer

From this interface it is possible to navigate between the assets. The interface is similar to a file explorer (e.g. Windows Explorer). It is possible to modify the name, description, type and geolocation of each asset.

For Gateway type assets, it is possible to access the configuration page by clicking on the 3 dots and then on *Configure*.

4.4.5 OTA updates

It is possible to view the history of firmware for Optimo IoT Gateways released, view the versions in use in the gateways and start the update remotely (OTA) or locally For more information and instructions consult the specific page

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4.4.6 VPN Tunnel

It is possible to view the active VPN tunnels on all Gateways and consult the history of activated tunnels. For more information and instructions consult the specific page

4.4.7 Reporting

For some companies it is possible to view the renewal status of cloud subscriptions

4.4.8 Dynamic UI

Through this interface it is possible to modify in real time the dashboards seen by users

4.4.9 User management

It is possible to modify, disable and delete users.

4.4.9.1 User creation

It is possible to create infinite users with permissions equal to or lower than their own, by clicking on the "New" button

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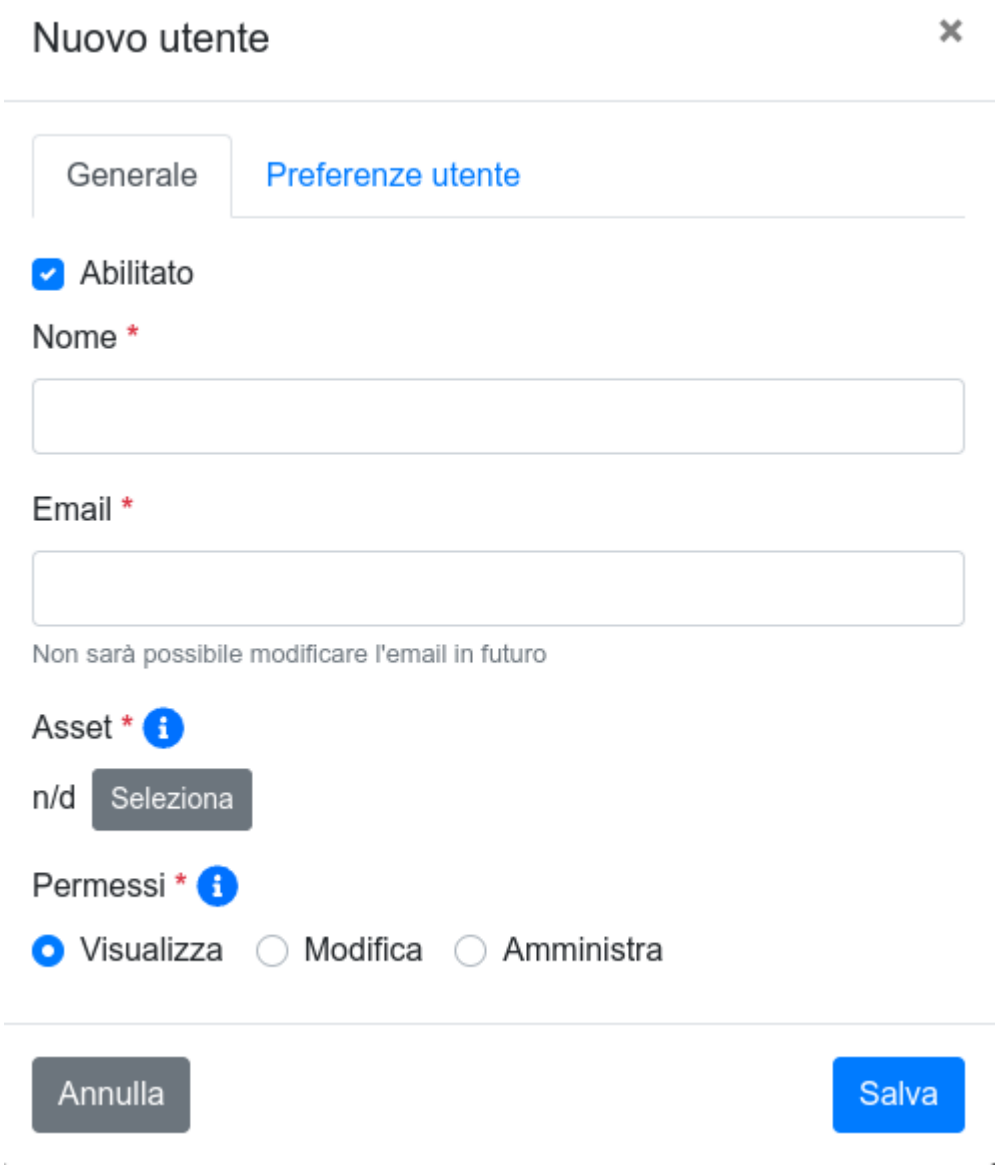

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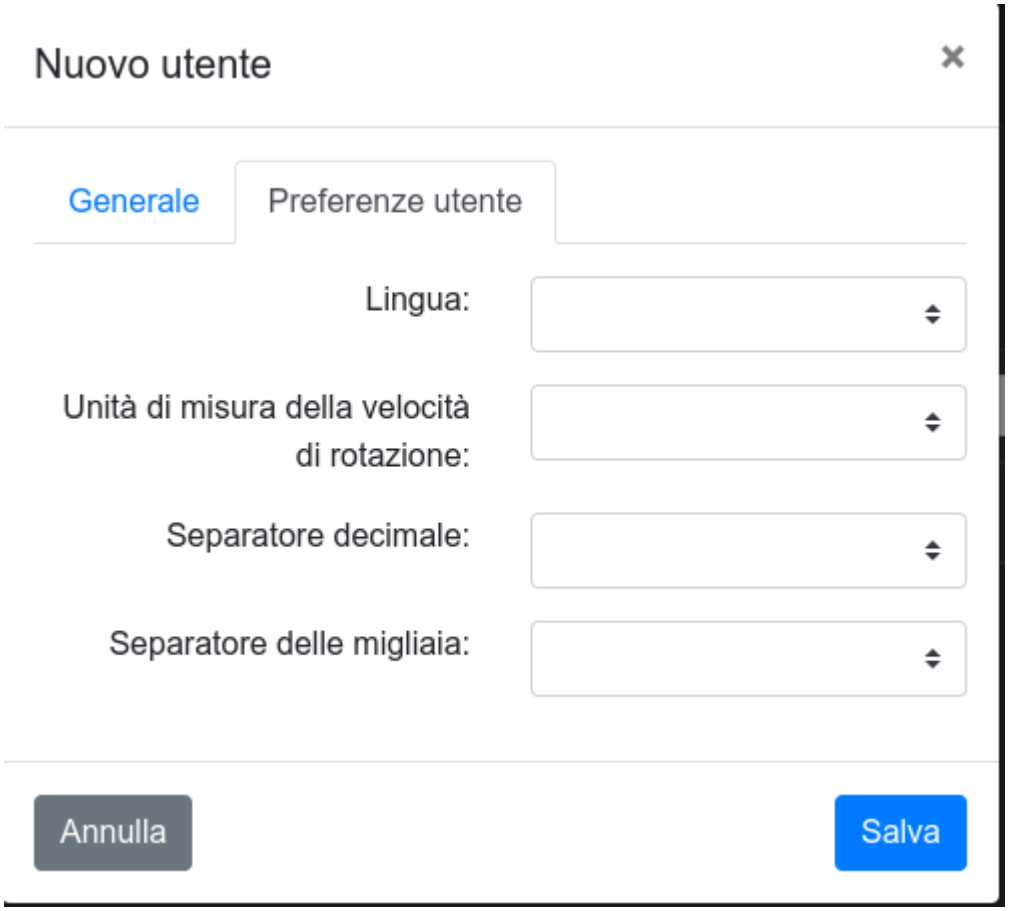
For each user it is essential to specify:

- name (first and last name)
- email address (all lowercase): it will be necessary for login and is the only way through which the user can recover their password
- asset: it is the asset that determines which variables and assets the user has access to. **Only for some assets is a dashboard specified!** associate users only to these assets, unless there are superior assets able to generate dashboards for the child assets.
- permissions:
  - Viewer: can access to variable values (e.g. measurements, alarms, etc)
  - Editor: `Viewer` permissions + can edit setpoints of variables of connected devices
  - Administrator: `Editor` permissions + can edit the configuration of the gateway and the dashboard, and manage users and assets

It is also possible to specify the preferences that the user himself can then modify:



Once created, the user can recover the password independently as specified in Login

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This is a draft message to send to newly created users:

> Hello XXXXX,
>
> you can access the Optimo IoT cloud platform for the XXXX plant by opening the site cloud.optimoiot.it and using the following login credentials:
>
> - Email: the email address to which you receive this message, written all lowercase
> - Password: click on *Forgot password* to recover it. During the procedure a verification code will be sent to the email address above

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4.5 Integration

4.5.1 API HTTP

Optimo IoT provides an HTTP API that can be used to interact with the platform data programmatically, for example in machine learning pipelines, external reporting systems or integrations with other software.

The HTTP API supports these operations:

- reading historical data in full or in aggregated form
- sending commands and setpoints in the field through the AL300 IoT Gateways
- inserting external data into the system, to be displayed in the dashboards (Cloud only)

The API is made available both by the cloud platform and by the AL300 IoT Gateways.

The complete documentation of the HTTP API is available at the following link: HTTP API Documentation.

Note

In the cloud version, requests are limited to 2400 requests per day per user

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4.5.2 Knime

4.5.2.1 What is KNIME

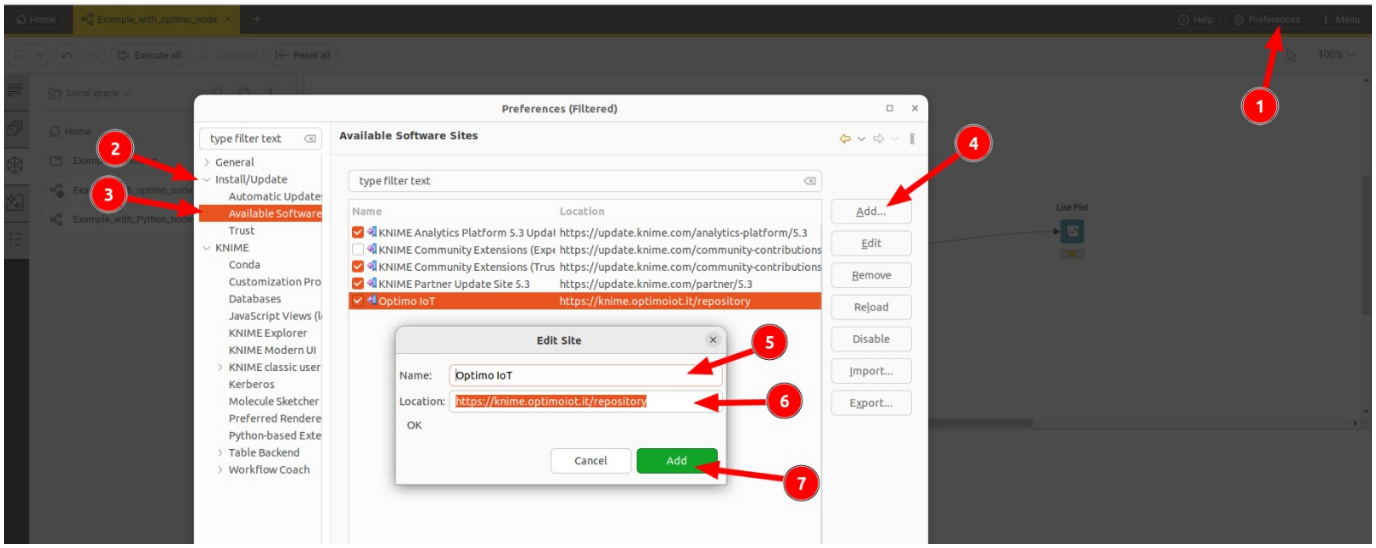
KNIME Analytics Platform is a free and open source low-code/no-code software that allows anyone, regardless of experience level, to make sense of data.

Optimo IoT has developed an extension to access the data of the Optimo IoT Cloud platform directly in KNIME flows.

4.5.2.2 Installation

4.5.2.2.1 ADDING THE OPTIMO IOT REPOSITORY

Follow the steps shown in the image to add the repository `https://knime.optimoiot.it/repository`



1. Click on "Settings"
2. Open the "Install/Update" menu
3. Open the "Install Software Repositories" submenu
4. Click on Add
5. Enter the name of the repository (`Optimo IoT` , or any name you like)
6. Enter the repository url: `https://knime.optimoiot.it/repository`
7. Click on Add

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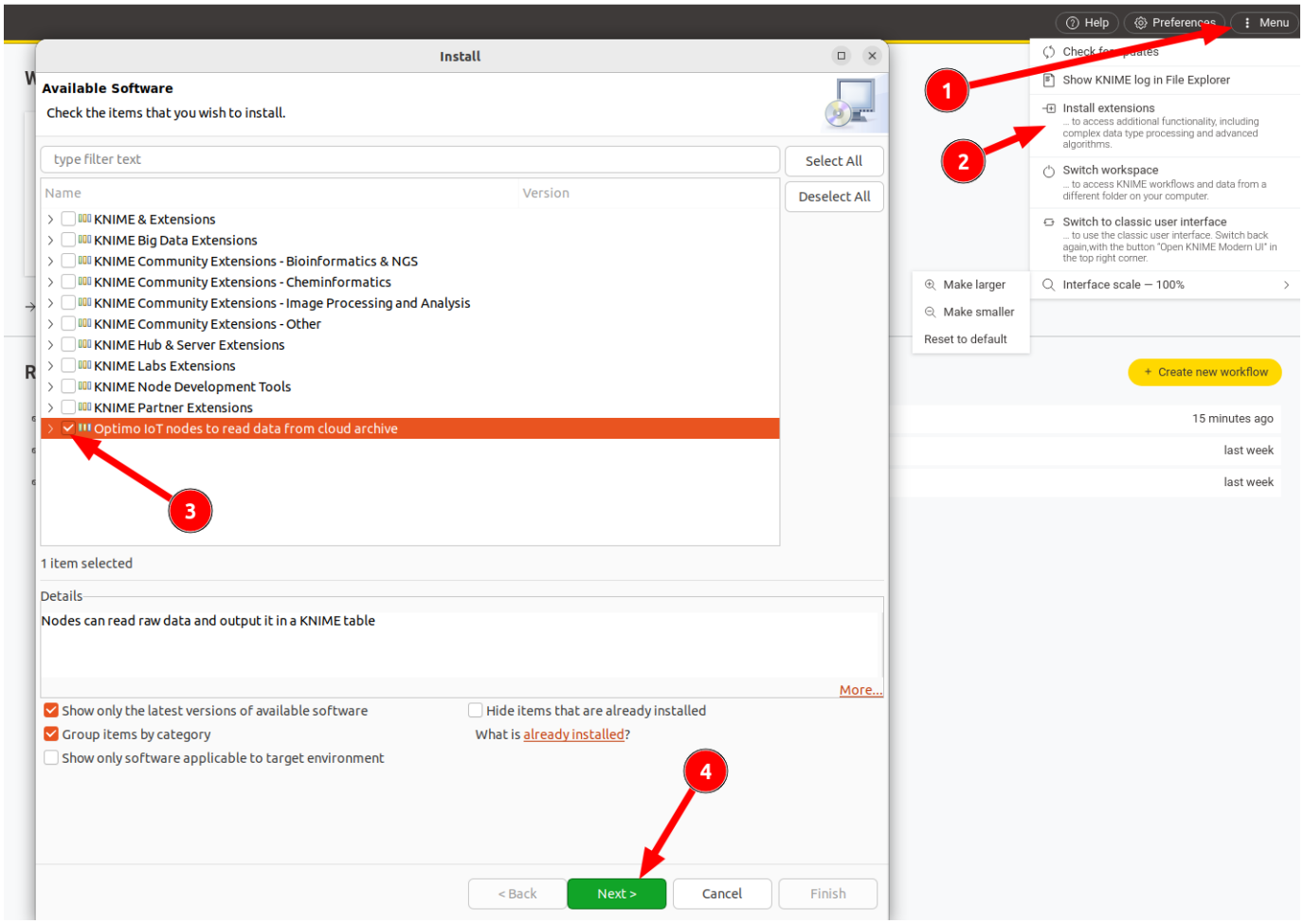
4.5.2.2.2 INSTALLING THE EXTENSION

Follow the steps shown in the image to install the extension



1. Click on "Menu"
2. Click on "Install extensions"
3. Check "Optimo IoT nodes"
4. Click on Next
5. Follow the rest of the guided procedure:
    a. Click on Finish
    b. Select the repository as trusted
    c. Restart KNIME

4.5.2.3 Using the nodes

For a working example, download a sample project from here.

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Warning!

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When sharing Knime flows with other users, the credentials to access cloud.optimoiot.it must be shared. Delete or empty the `Optimo IoT API credentials` node before sharing a flow.

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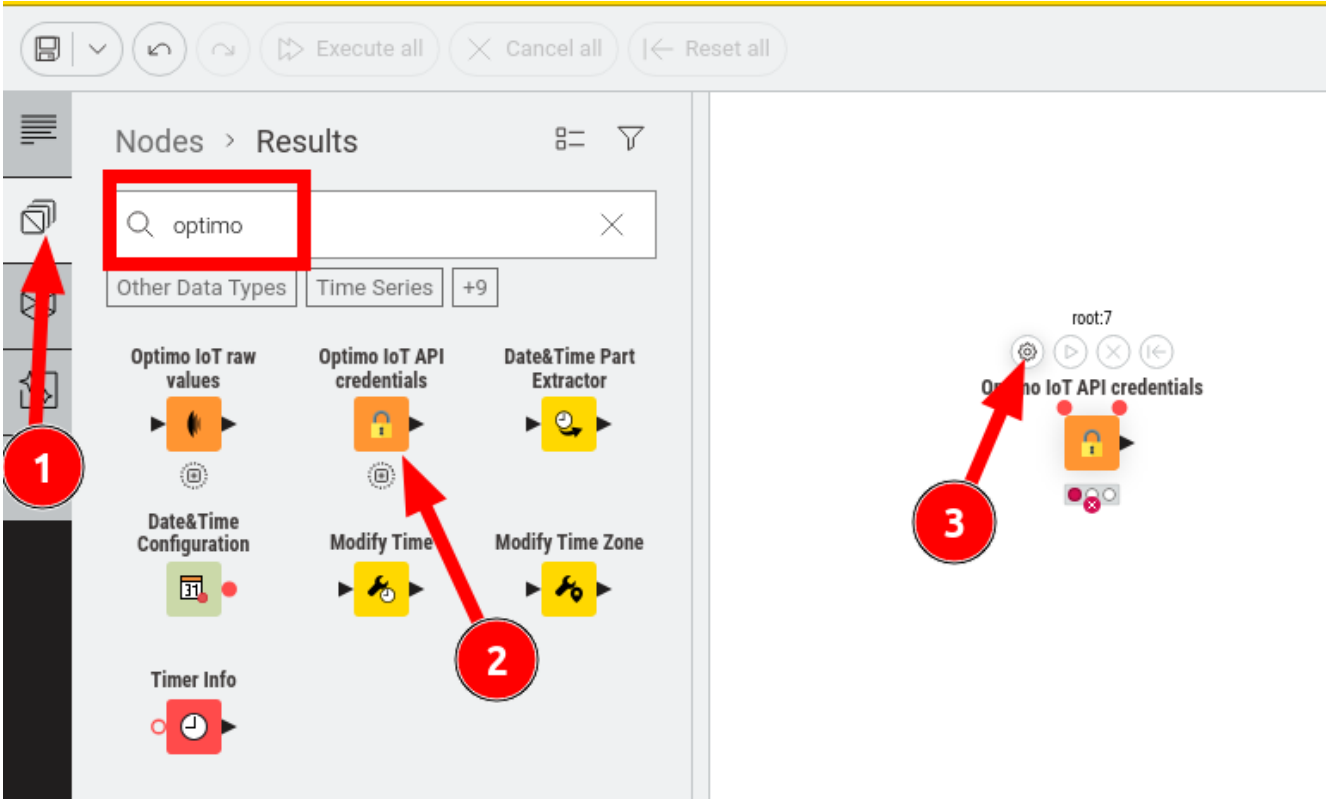
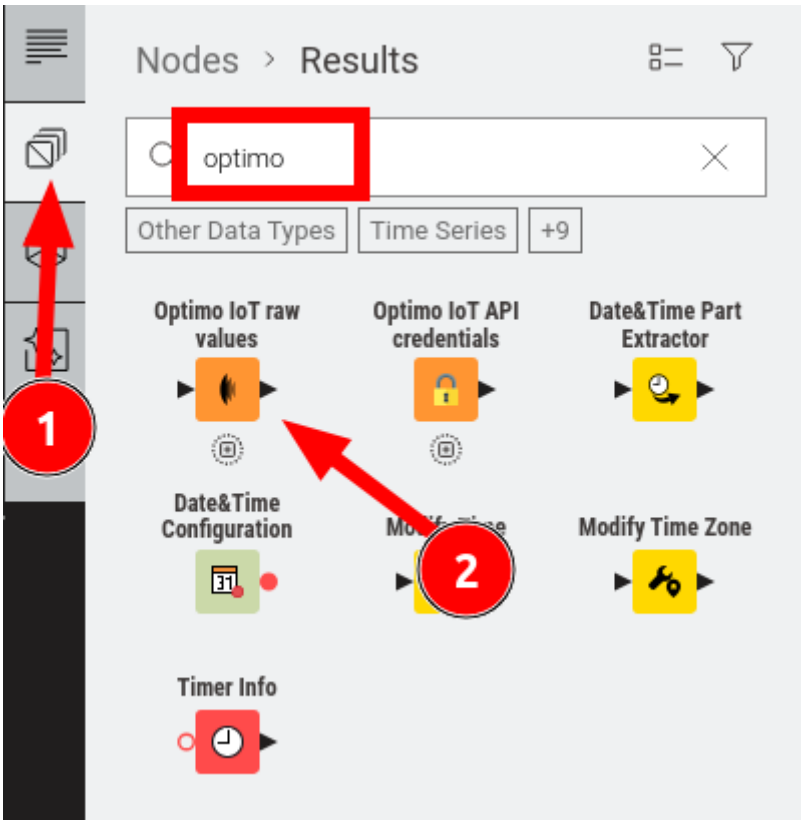
1. Insert a node of type `Optimo IoT API credentials`, and enter the API keys. To obtain them, write to info@optimoiot.it



2. Insert a node of type `Optimo IoT raw values`



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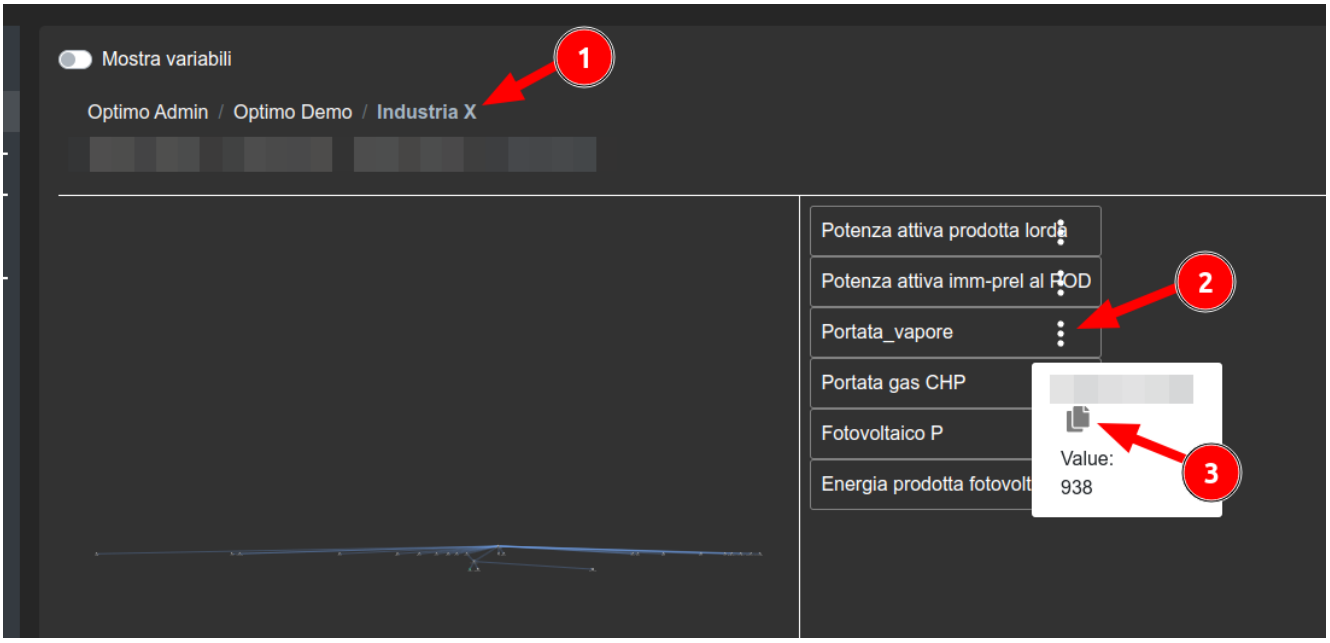
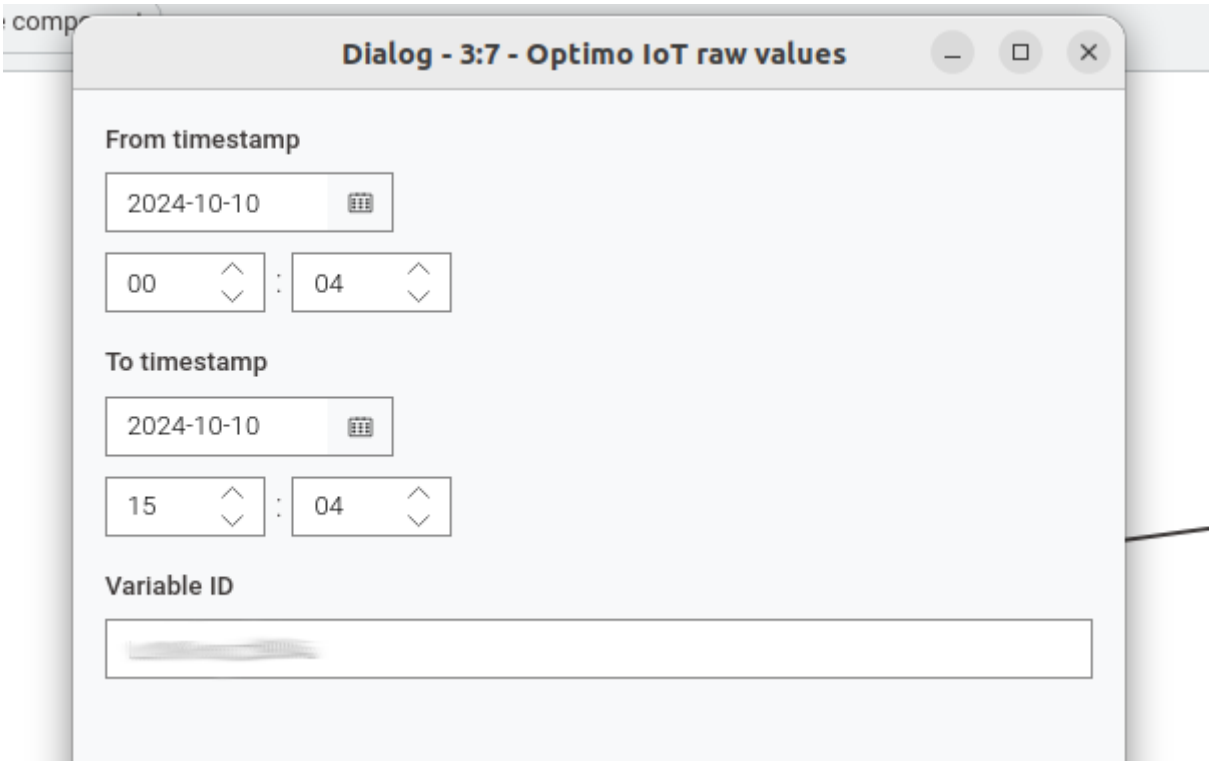
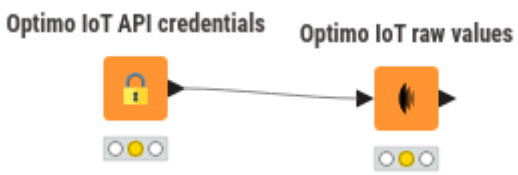
3. Copy the variable id from cloud.optimoiot.it



4. Configure the node, entering the time range and pasting the variable id copied at point 4



5. Connect the two nodes



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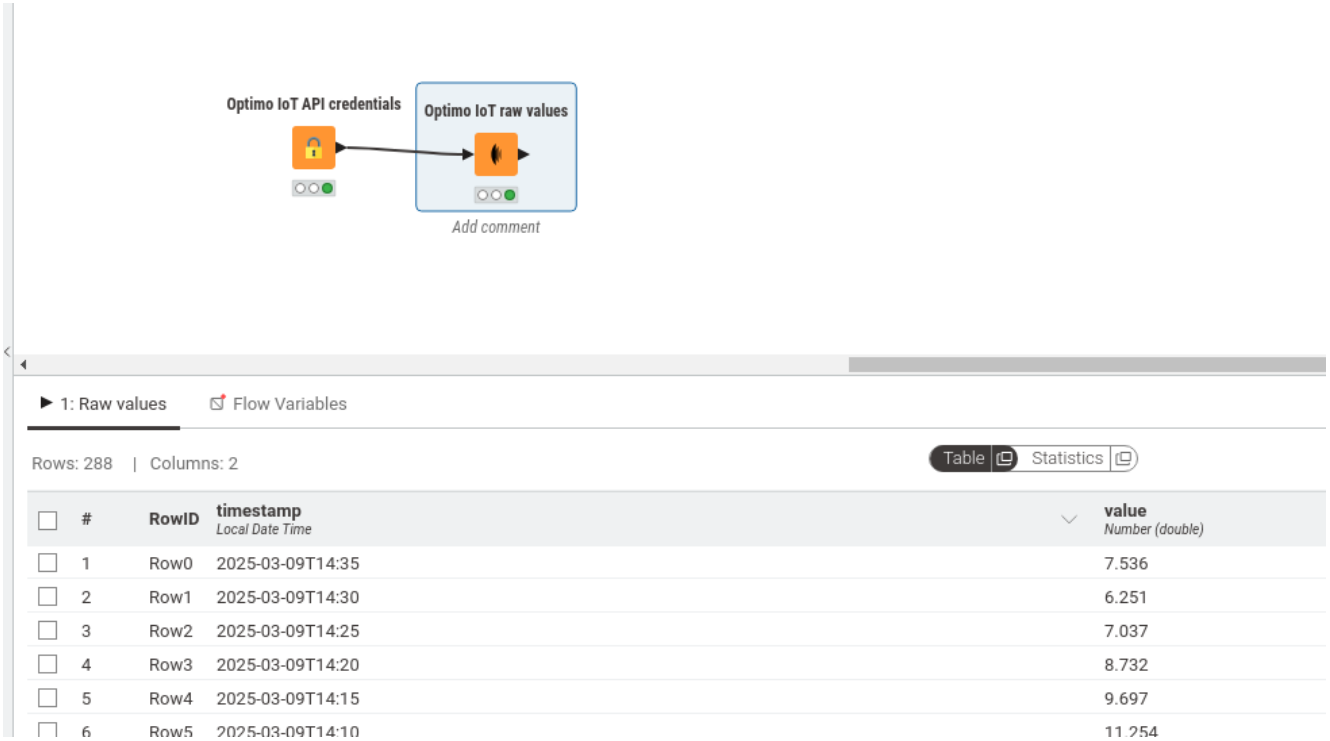
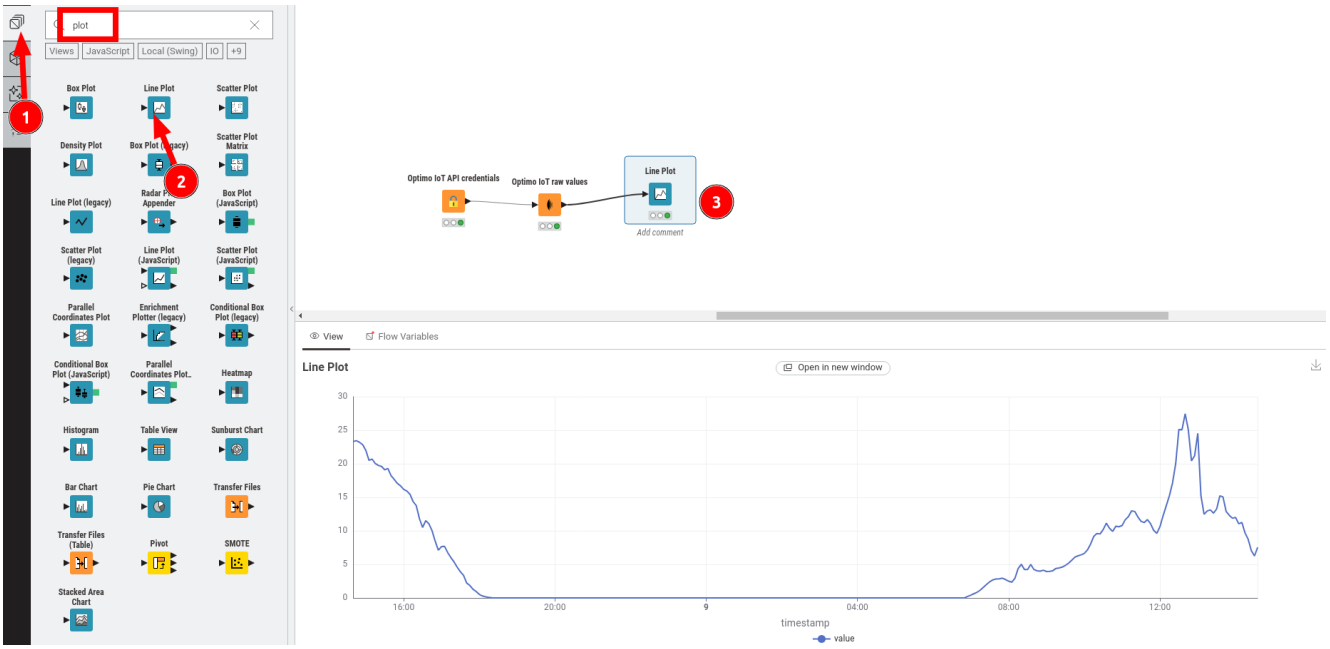
6. Execute the nodes. A table with the columns `timestamp` and `value` will be emitted



7. Add, connect and execute a `Line Plot` node to get a chart



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4.6 Remote access VPN

If enabled, the AL300 Gateway allows users to create a secure remote access VPN connection to the devices connected to the Gateway itself. This is useful, for example, to connect and modify the program of a PLC remotely.

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4.6.1 Creation and download of certificate and VPN client (only for the first time)

To access this functionality, you need to have administrator permissions.

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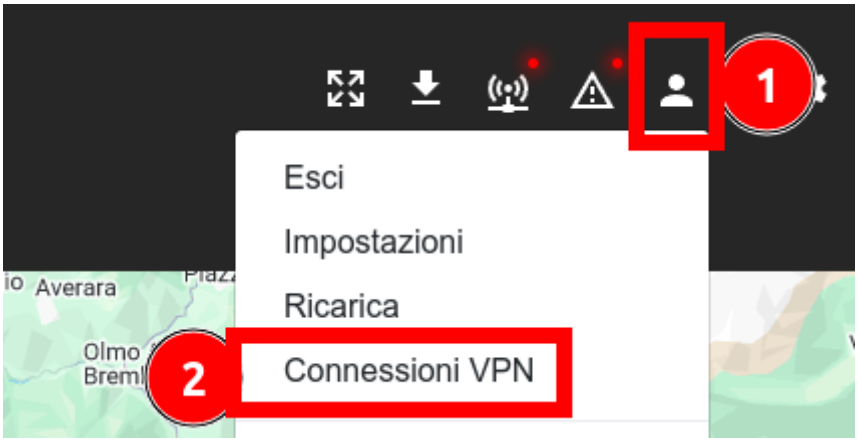
1. open the VPN menu



2. if it has never been done, you need to create your certificate for VPN access

3. download your certificate and install the VPN client following the instructions provided

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4.6.2 Creation of VPN tunnel

VPN access does not give access to any device. For each device you want to connect to, you need to create a *VPN tunnel*. Each VPN tunnel is automatically deleted after 10 minutes of inactivity:

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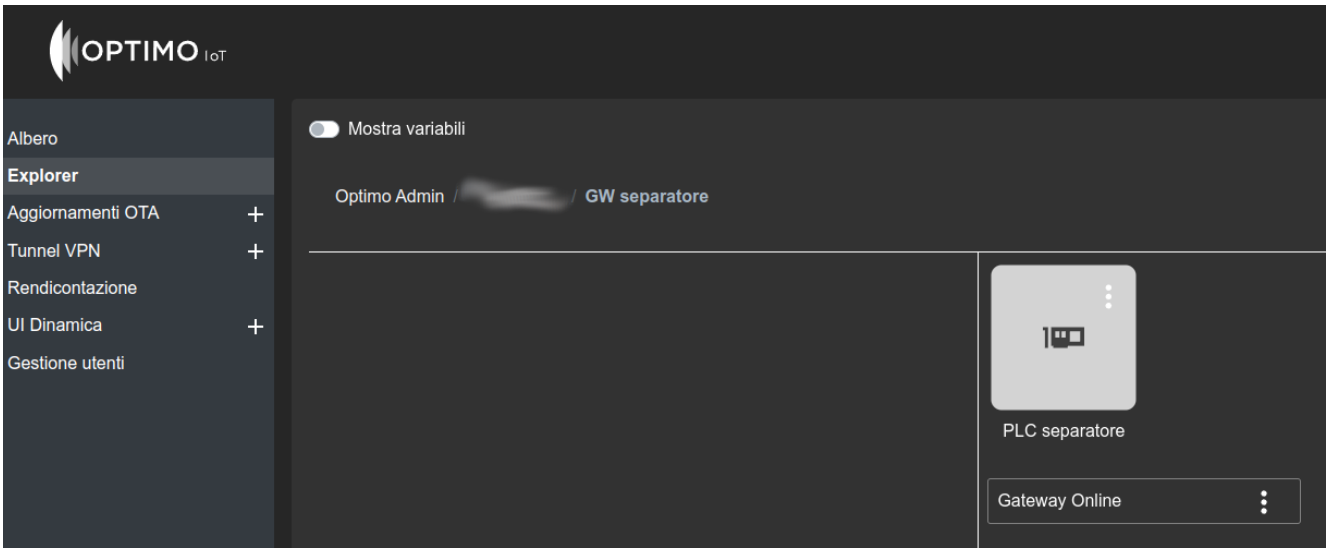
1. Open the *Asset Explorer*:

   a. Go to the configuration interface

2. Open the *Explorer* menu

2. Navigate to the AL300 Gateway of interest, until you see the device you want to connect to (e.g. PLC)



3. Click on the 3 dots of the device

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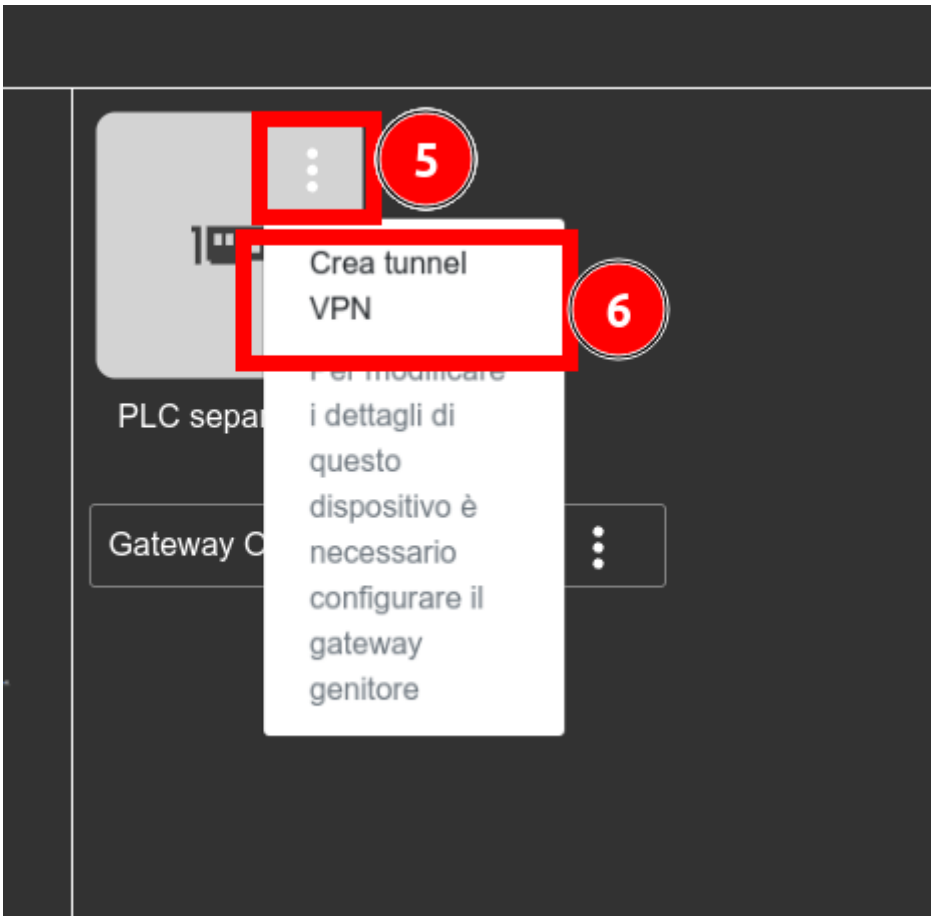

4. Click on *Create VPN tunnel*
5. Confirm the creation of the VPN tunnel. You can choose whether to query the device with the destination IP address (local IP of the device), or whether to use a virtual IP
    - **Keep destination IP address**: useful for TIA Portal. It requires a subsequent disconnection and reconnection of the PC to the VPN because the tunnel is received by the user's PC
    - **Virtual IP**: useful for web interfaces of devices in the field, or when you need to connect to different devices with the same IP connected to Gateways in separate local networks

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6. If you chose to *Keep the destination IP address*, disconnect and reconnect your PC to the VPN
7. You can now ping or reach the web interface of the device. For use with TIA Portal choose the TAP adapter network interface

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4.6.3 Diagnostics and troubleshooting

In case of problems, you can analyze the operating status of the *VPN tunnel*.

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1. check that the device responds to pings (instructions). If it responds to pings, the VPN is working correctly. Check the application parameters (e.g. IP in the browser)
2. check that your PC is connected to the VPN. The procedure is different depending on your VPN client

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3. check the status of the VPN tunnel in the *VPN menu*:

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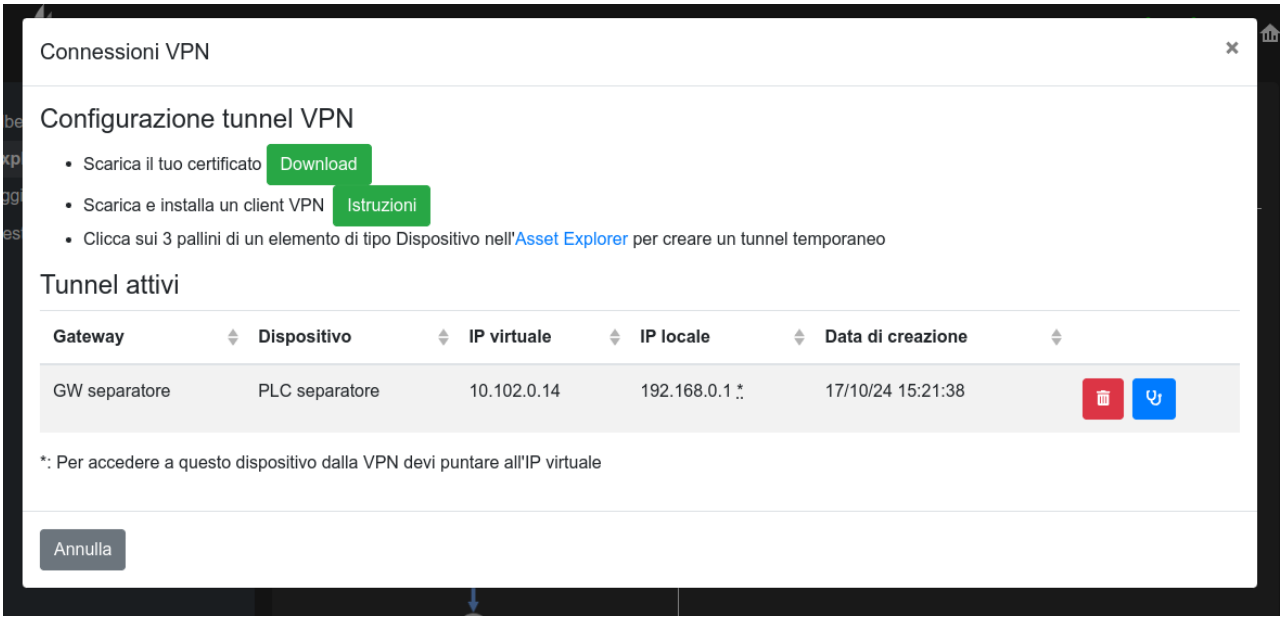
a. open the list of active tunnels



b. click on the diagnostics icon for the tunnel to be tested

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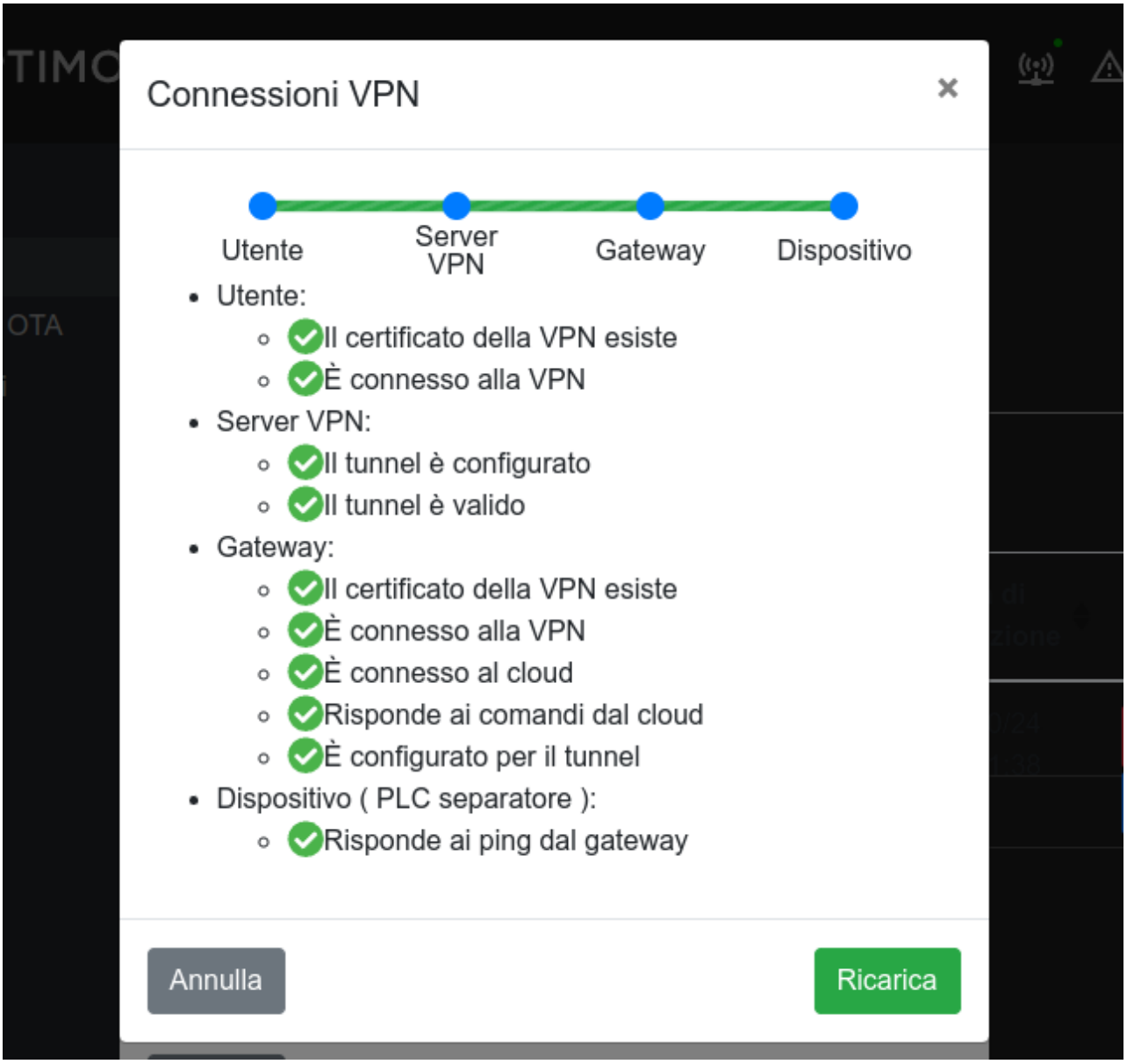
c. check that all checks have been successful. To solve some problems, it may be necessary to delete and recreate the tunnel



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4.7 AL300 Firmware Upgrade

It is possible to upgrade the AL300 Gateway firmware directly from the cloud interface (Over The Air update). If the AL300 is offline or with a data plan for which the download of 300MB is too expensive, it is possible to download the update file and upload it manually.

During the update phase, the Gateway remains fully operational. At the end of the update phase, the gateway is automatically restarted. The downtime caused by a firmware update is therefore around 60 seconds.

Internet connection or power supply not guaranteed? No problem

The AL300 operating system is stored in two twin A-B partitions. While one is running (A), the update is installed on the other (B). Only at the end and verification of the update of the second partition (B) the Gateway is automatically restarted and will run the second partition (B). In case of interruption of installation (lack of internet, lack of power, etc.) the gateway continues to operate with the partition in use (A).

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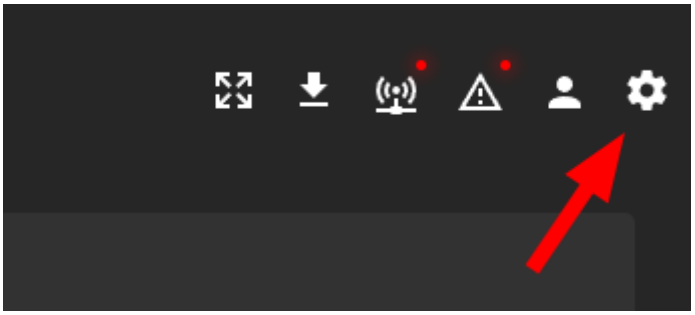
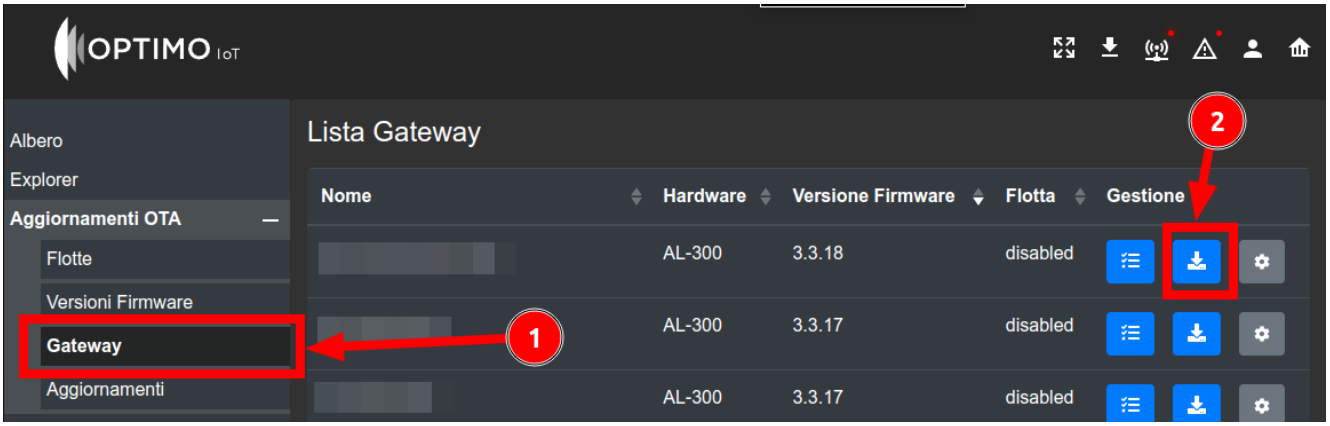
4.7.1 Firmware version selection

To access this feature you need to have administrator permissions.

1. open the settings homepage



2. open the `Ota Update` menu and click on the corresponding AL300 Gateway icon



3. select the new version from those available

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4.7.2 Over The Air (OTA) update

Note

This procedure causes the download of about 300-350MB of data from the Gateway's internet connection. If it is connected to the internet via a SIM data with limited traffic, make sure that there is a sufficient traffic volume in the active plan, and that any auto-recharge automations are not too slow to keep up with the download process. If mobile data traffic is too expensive, it is recommended to update the Gateway through the procedure described in the next chapter.

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1. if the Gateway is connected to the cloud it is possible to select the `Online (OTA)` update type, then click on `Update`

2. Wait for the update download

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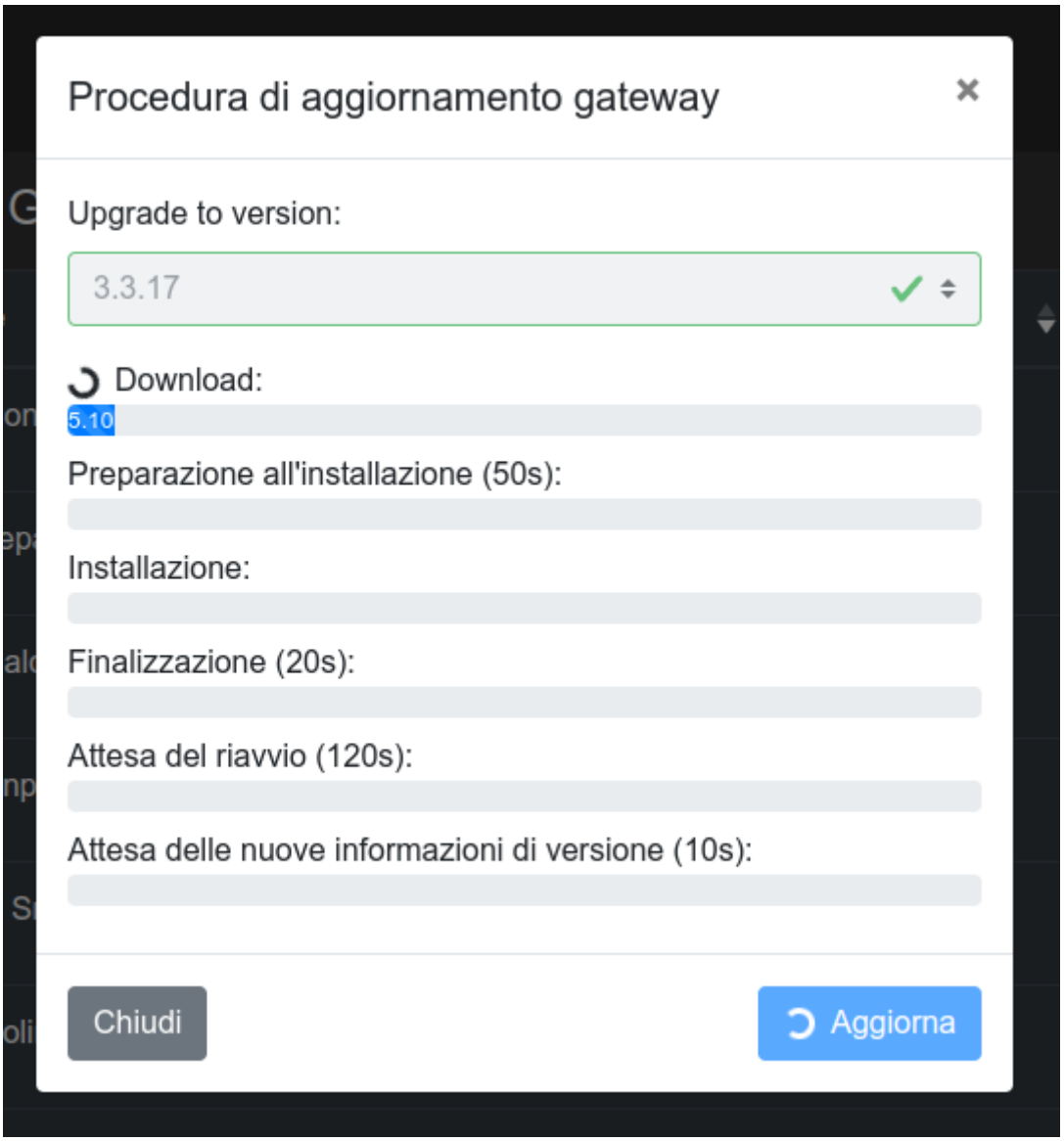

3. Wait for the Gateway reboot

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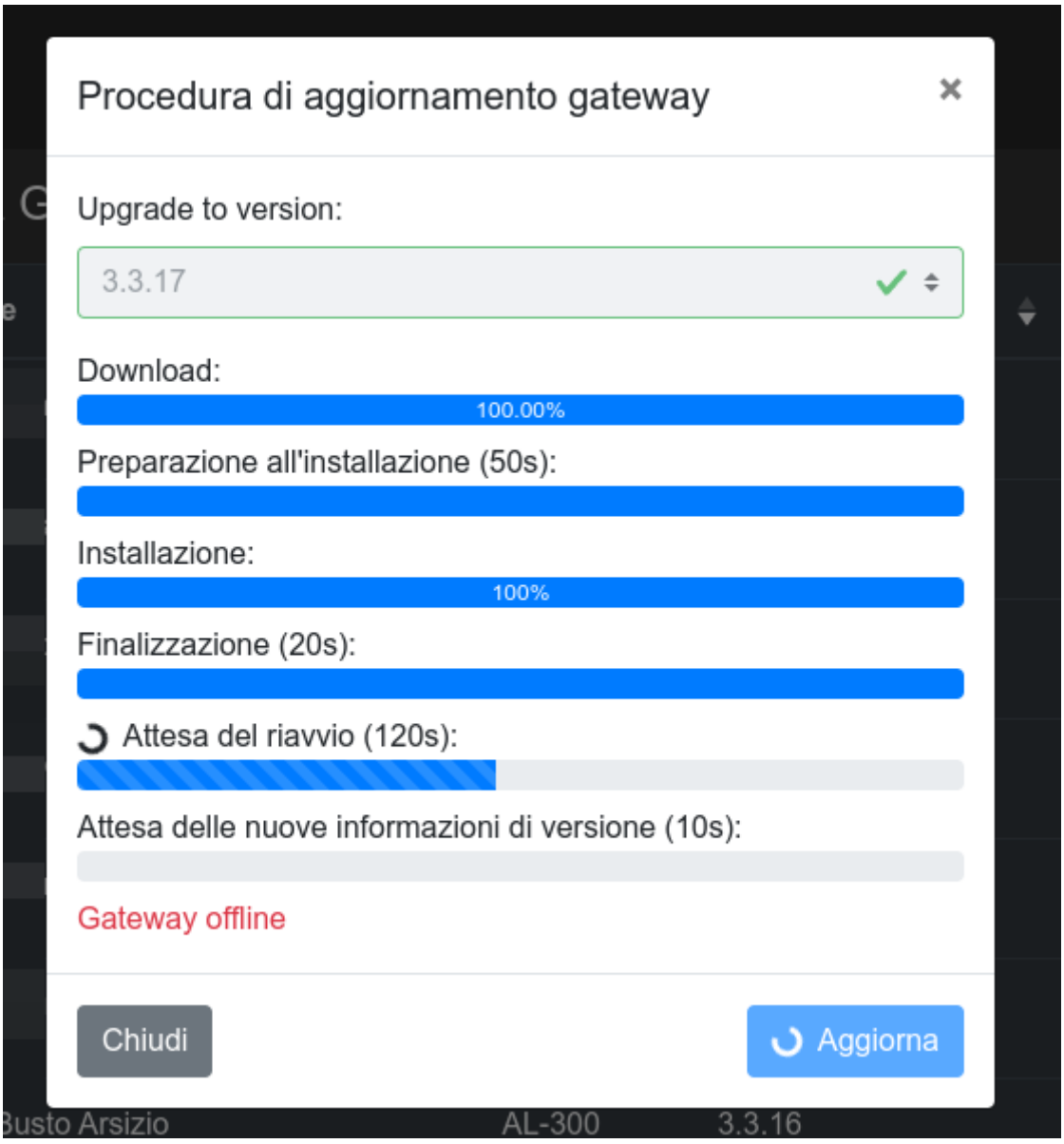

4. Update completed

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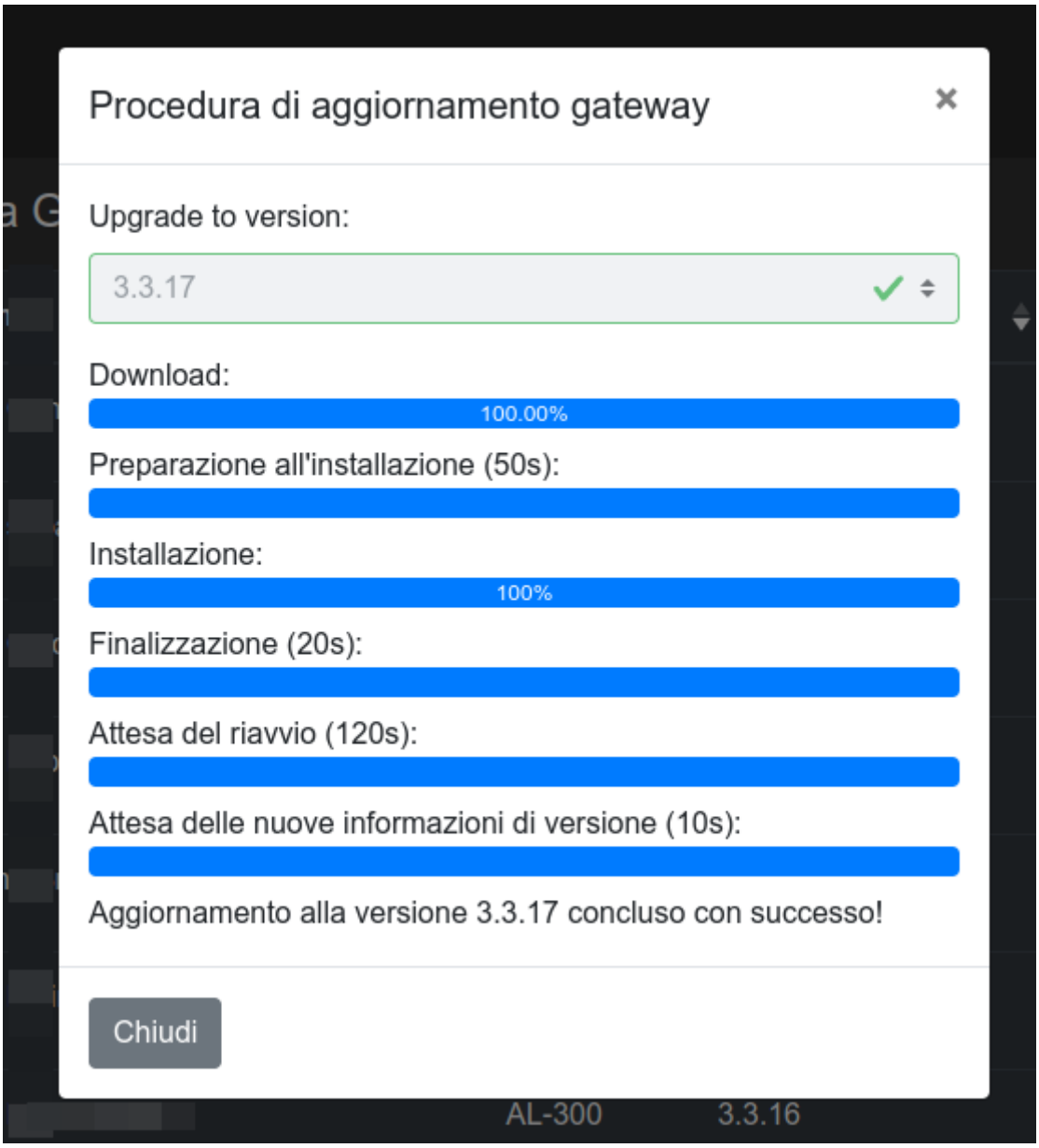

4.7.3 Local - offline update

1. if the Gateway is not connected to the cloud or the connection to the cloud is too limited in download volume, it is possible to select `Offline` and download the update package.

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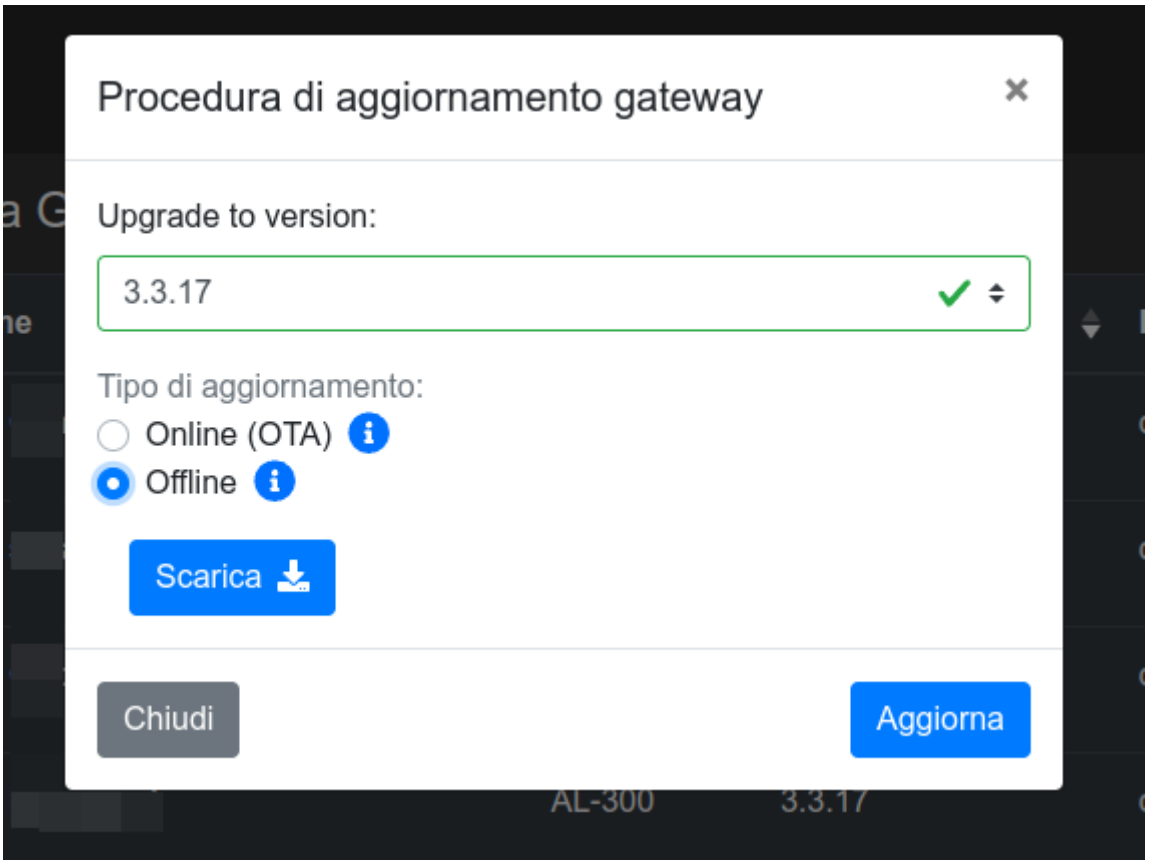

2. upload the update file to the AL300 through one of the methods described in the dedicated chapter

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5. Dashboard

5.1 Formula

Many widgets available to the user to build their dashboard support custom formula defined by the user.

Here is the full documentation of the supported syntax.

5.1.0.1 Expression Syntax

The parser accepts a pretty basic grammar. It's similar to normal JavaScript expressions, but is more math-oriented. For example, the `^` operator is exponentiation, not xor.

5.1.0.1.1 OPERATOR PRECEDENCE

Operator	Associativity	Description
(...)	None	Grouping
f(), x.y, a[i]	Left	Function call, property access, array indexing
!	Left	Factorial
^	Right	Exponentiation
+, -, not, sqrt, etc.	Right	Unary prefix operators (see below for the full list)
*, /, %	Left	Multiplication, division, remainder
+, -, ||	Left	Addition, subtraction, array/list concatenation
==, !=, >=, <=, >, <, in	Left	Equals, not equals, etc. "in" means "is the left operand included in the right array operand?"
and	Left	Logical AND
or	Left	Logical OR
x ? y : z	Right	Ternary conditional (if x then y else z)
;	Left	Expression separator

5.1.0.1.2 UNARY OPERATORS

The parser has several built-in "functions" that are actually unary operators. The primary difference between these and functions are that they can only accept exactly one argument, and parentheses are optional. With parentheses, they have the same precedence as function calls, but without parentheses, they keep their normal precedence (just below `^`). For example, `sin(x)^2` is equivalent to `(sin x)^2`, and `sin x^2` is equivalent to `sin(x^2)`.

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The unary `+` and `-` operators are an exception, and always have their normal precedence.

Operator	Description
-x	Negation
+x	Unary plus. This converts it's operand to a number, but has no other effect.
x!	Factorial (x _ (x-1) _ (x-2) _ … _ 2 * 1). gamma(x + 1) for non-integers.
abs x	Absolute value (magnitude) of x
acos x	Arc cosine of x (in radians)
acosh x	Hyperbolic arc cosine of x (in radians)
asin x	Arc sine of x (in radians)
asinh x	Hyperbolic arc sine of x (in radians)
atan x	Arc tangent of x (in radians)
atanh x	Hyperbolic arc tangent of x (in radians)
cbrt x	Cube root of x
ceil x	Ceiling of x — the smallest integer that's >= x
cos x	Cosine of x (x is in radians)
cosh x	Hyperbolic cosine of x (x is in radians)
exp x	e^x (exponential/antilogarithm function with base e)
expm1 x	e^x - 1
floor x	Floor of x — the largest integer that's <= x
length x	String or array length of x
ln x	Natural logarithm of x
log x	Natural logarithm of x (synonym for ln, not base-10)
log10 x	Base-10 logarithm of x
log2 x	Base-2 logarithm of x
log1p x	Natural logarithm of (1 + x)
not x	Logical NOT operator
round x	X, rounded to the nearest integer, using "grade-school rounding"
sign x	Sign of x (-1, 0, or 1 for negative, zero, or positive respectively)
sin x	Sine of x (x is in radians)
sinh x	Hyperbolic sine of x (x is in radians)
sqrt x	Square root of x. Result is NaN (Not a Number) if x is negative.
tan x	Tangent of x (x is in radians)
tanh x	Hyperbolic tangent of x (x is in radians)
trunc x	Integral part of a X, looks like floor(x) unless for negative number

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5.1.0.1.3 PRE-DEFINED FUNCTIONS

Besides the "operator" functions, there are several other functions.

Function	Description
random(n)	Get a random number in the range [0, n). If n is zero, or not provided, it defaults to 1.
fac(n)	n! (factorial of n: "n _ (n-1) _ (n-2) _ … _ 2 * 1") Deprecated. Use the ! operator instead.
min(a,b,…)	Get the smallest (minimum) number in the list.
max(a,b,…)	Get the largest (maximum) number in the list.
hypot(a,b)	Hypotenuse, i.e. the square root of the sum of squares of its arguments.
pyt(a, b)	Alias for hypot.
pow(x, y)	Equivalent to x^y. For consistency with JavaScript's Math object.
atan2(y, x)	Arc tangent of x/y. i.e. the angle between (0, 0) and (x, y) in radians.
roundTo(x, n)	Rounds x to n places after the decimal point.
map(f, a)	Array map: Pass each element of `a` the function `f`, and return an array of the results.
fold(f, y, a)	Array fold: Fold/reduce array `a` into a single value, `y` by setting `y = f(y, x, index)` for each element `x` of the array.
filter(f, a)	Array filter: Return an array containing only the values from `a` where `f(x, index)` is `true`.
indexOf(x, a)	Return the first index of string or array `a` matching the value `x`, or `-1` if not found.
join(sep, a)	Concatenate the elements of `a`, separated by `sep`.
if(c, a, b)	Function form of c ? a : b. Note: This always evaluates both `a` and `b`, regardless of whether `c` is `true` or not. Use `c ? a : b` instead if there are side effects, or if evaluating the branches could be expensive.

5.1.0.1.4 ARRAY LITERALS

Arrays can be created by including the elements inside square `[]` brackets, separated by commas. For example:

```
[ 1, 2, 3, 2+2, 10/2, 3! ]
```

5.1.0.1.5 CONSTANTS

The parser also includes a number of pre-defined constants that can be used in expressions. These are shown in the table below:

Constant	Description
E	Euler's number
PI	PI (π)
true	Logical `true` value
false	Logical `false` value

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5.2 Aggregation types

In different elements of the Optimo IoT system it is possible to calculate statistics on the values of a variable (dashboard widgets, calculated variables, http API).

In this page the available functions are listed.

5.2.1 Point statistics

5.2.1.1 Average

Arithmetic mean of the values of the variable present in the time interval

5.2.1.2 Sum

Sum of the values of the variable present in the time interval

5.2.1.3 Count

Count of the number of values of the variable present in the time interval

5.2.1.4 Maximum

Maximum value of the variable present in the time interval

5.2.1.5 Minimum

Minimum value of the variable present in the time interval

5.2.1.6 1st percentile

Value below which 1% of the values of the variable present in the time interval are located

5.2.1.7 1st quartile

Value below which 25% of the values of the variable present in the time interval are located

5.2.1.8 Median

Value below which 50% of the values of the variable present in the time interval are located

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5.2.1.9 3rd quartile

Value below which 75% of the values of the variable present in the time interval are located

5.2.1.10 99th percentile

Value below which 99% of the values of the variable present in the time interval are located

5.2.2 Variations

5.2.2.1 Count of rises

Count of the number of times the value of the variable present in the interval was higher than the previous recorded value (if not present in the interval, the first value prior to the interval is considered)

5.2.2.2 Count of falls

Count of the number of times the value of the variable present in the interval was lower than the previous recorded value (if not present in the interval, the first value prior to the interval is considered)

5.2.2.3 Incremental positive difference

Sum of the positive values of the difference between the value of the variable present in the interval and the previous recorded value (if not present in the interval, the first value prior to the interval is considered). Useful for variables in kWh, m3, L of incremental meters (eg electricity, gas, water) for which you want to know the variation in the interval

5.2.3 Integrals and times

5.2.3.1 Integral

Integral of the variable over time in the interval. The continuous function to be integrated is constructed by considering at each instant of the interval the last valid value (if not present in the interval, the first value prior to the interval is considered)

5.2.3.2 Weighted average

Weighted average over time of the interval of the values of the variable. The continuous function to be integrated is constructed by considering at each instant of the interval the last valid value (if not present in the interval, the first value prior to the interval is considered)

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5.2.3.3 Time on

Time in which the variable was ON (value greater than zero) in the interval. The last valid value is considered at each instant of the interval (if not present in the interval, the first value prior to the interval is considered). Boolean values are considered as 0 or 1

5.2.3.4 Count of alarm activations

Only for alarm variables. Count of the number of alarm activations in the interval

5.2.3.5 Boolean weighted average

Weighted average over time of the interval of the ON state (value greater than zero) compared to OFF (value equal to zero) of the variable. The continuous function to be integrated is constructed by considering at each instant of the interval the last valid value (if not present in the interval, the first value prior to the interval is considered). Boolean values are considered as 0 or 1

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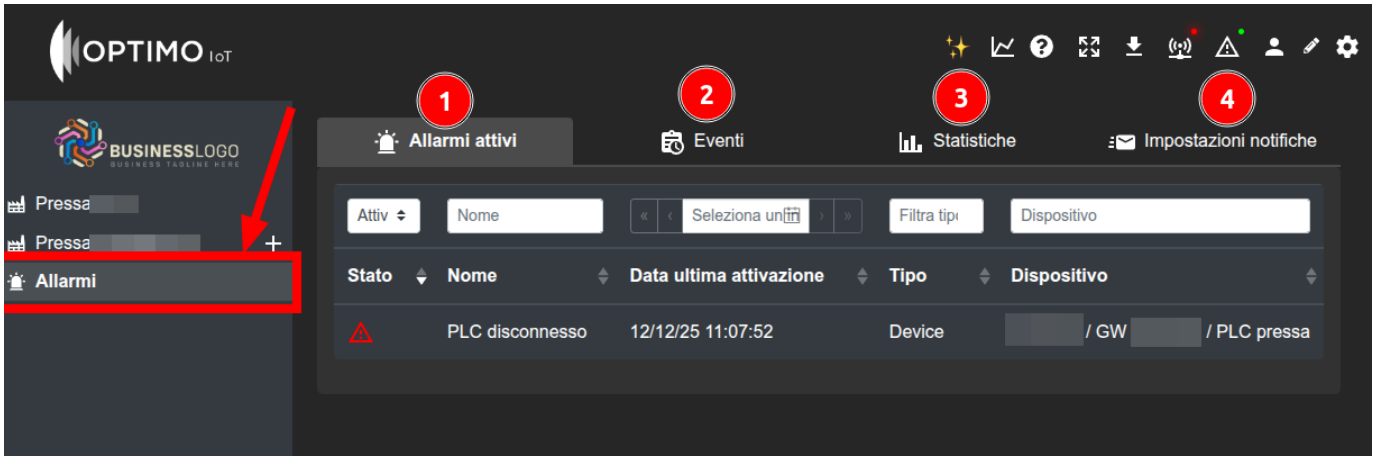
5.3 Alarms

In the dashboards, there is a dedicated page for viewing the status of alarms, their history, and managing notifications.



The page is divided into 4 tabs:

1. **Active Alarms**: shows the list of currently active alarms
2. **Events**: shows the history of alarms (activations, deactivations, management)
3. **Statistics**: shows statistics on alarms (number of activations per day) in a bar chart
4. **Notification Settings**: allows you to configure email and SMS notifications when specific alarms are activated

5.3.1 Active Alarms

The tab shows the list of active alarms, with the following information:

- current status (active or inactive). By default, the filter for this column shows only active alarms, but it can be modified to also display inactive alarms
- name of the alarm
- date of last activation
- type of alarm (lost connection to device or specific device alarm)
- device associated with the alarm (e.g., machine, plant, etc.)

You can filter and sort the table based on all available columns.

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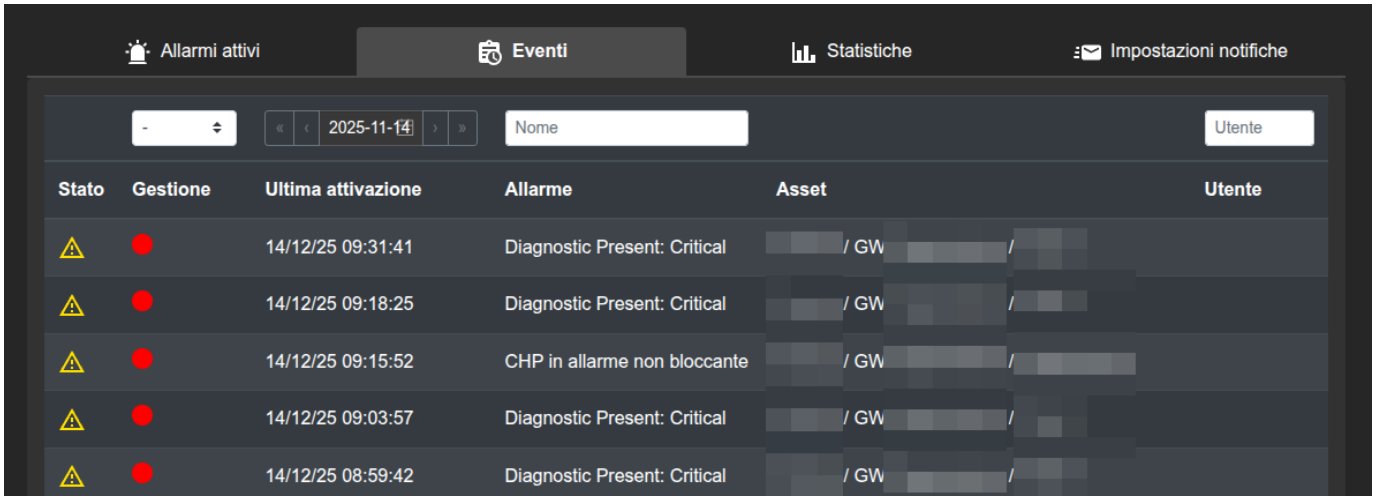
5.3.2 Events



The tab shows the history of alarm activations, with the following information:

- **Status**: current status (active or inactive)
- **Management**: status of the management of the alarm activation. It can be:
  - Not taken in charge
  - Taken in charge
  - Resolved
- **Activation Date**: activation date
- **Alarm**: name of the alarm
- **Asset**: device associated with the alarm (e.g., machine, plant, etc.)

By clicking on each row of the table, you can view further details about the event:

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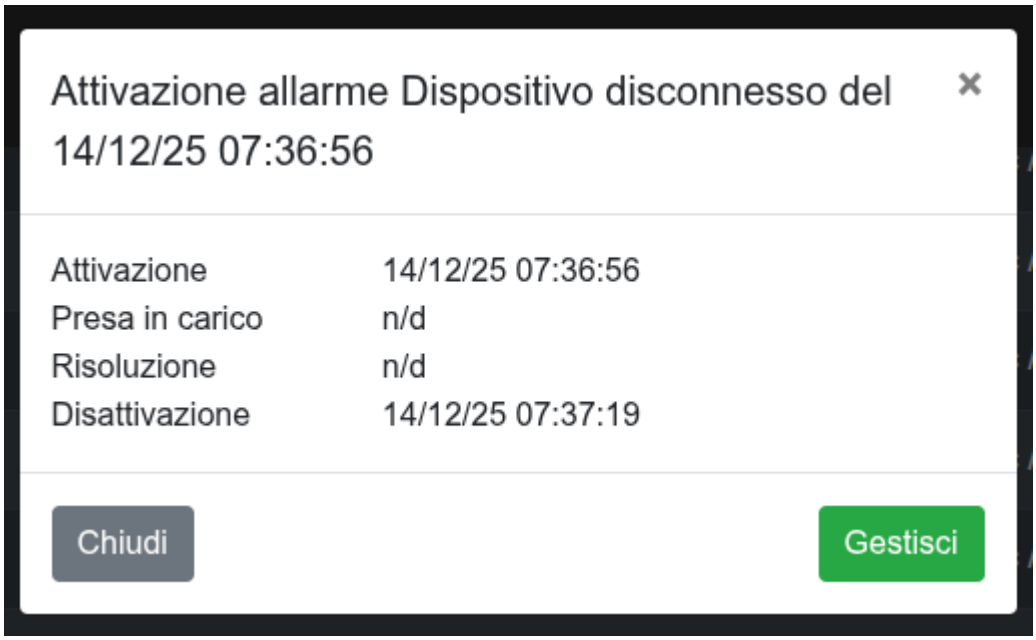
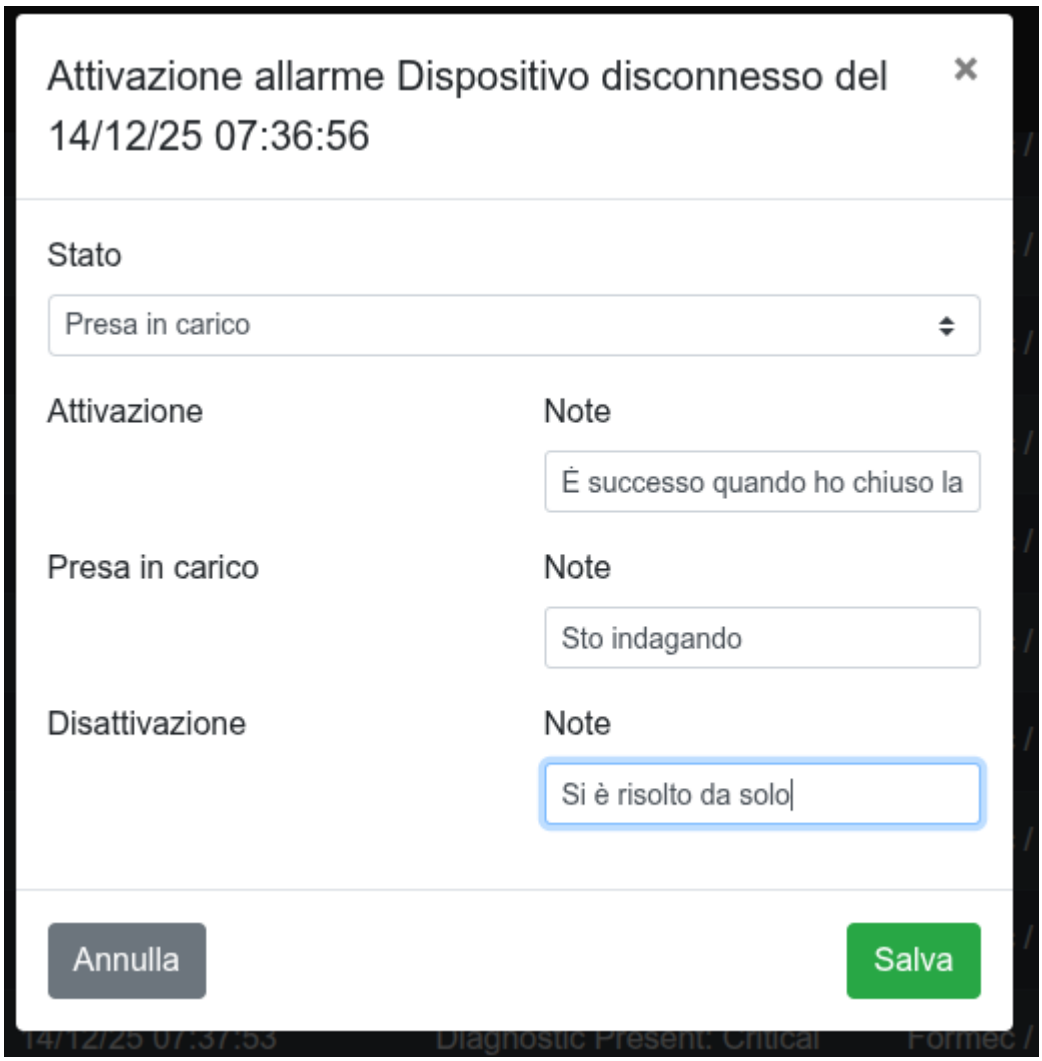


By clicking on `Manage`, you can update the management status of the event and enter notes to keep track of the actions taken:



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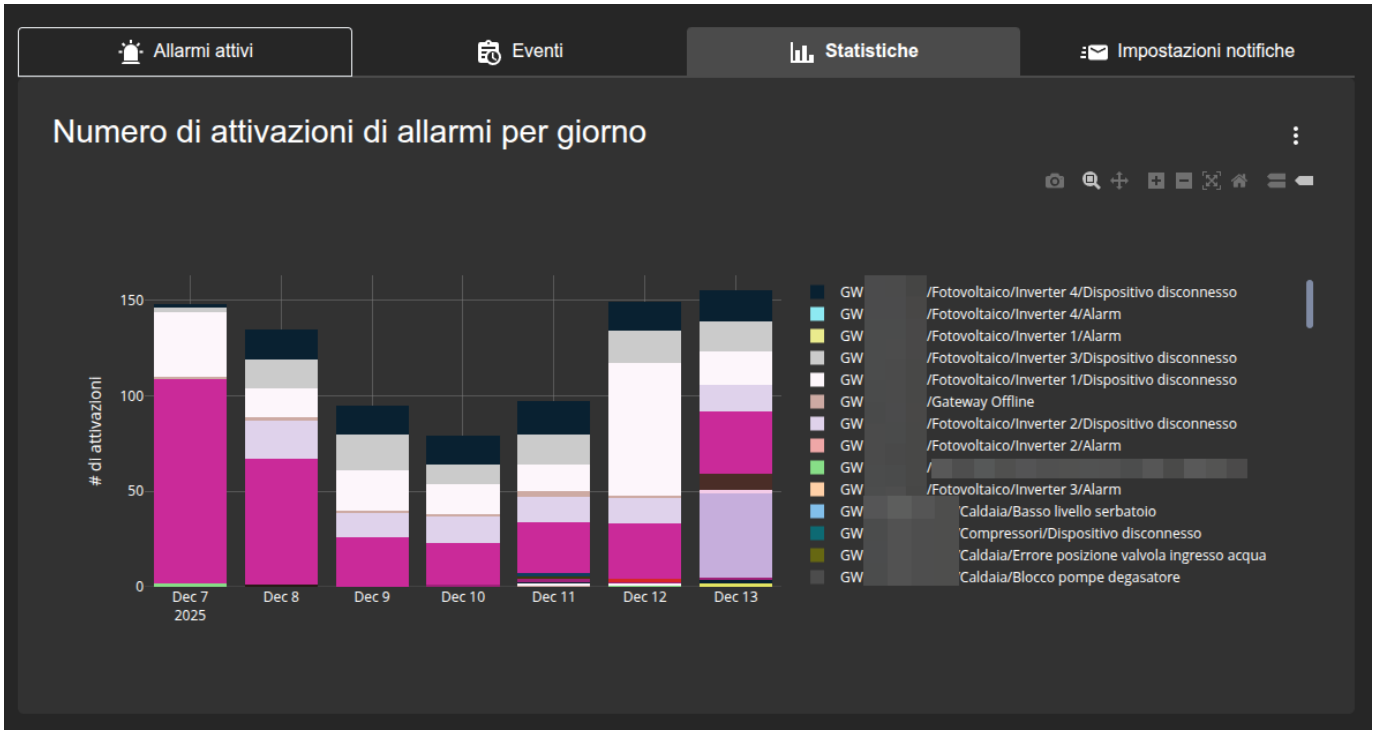
5.3.3 Statistics



The tab shows a bar chart with the number of alarm activations per day. You can view the number of activations for each individual alarm by selecting it from the legend on the right side of the chart.

5.3.4 Notification Settings

See chapter Notifications.

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