STAY·ON
ENERGY MANAGEMENT

Energy Management System

iEMS

White Paper

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1 Introduction

1.1 iEMS Definition

An Energy Management System (EMS) is a system for monitoring and controlling energy flows in any system. It is a superior unit that plans the operation of the system, contains rules and/or creates schedules for the operation of individual devices under its control.

iEMS is a system dedicated to energy management in installations equipped with:

- generation installations,
- energy storage system,
- electric vehicle chargers,
- energy consumers.

The main purpose of the system is to optimize energy costs. Correct shaping of the device's operation profile in relation to dynamically changing prices of purchase and sale of electricity allows for minimizing purchase costs and maximizing revenue from the sale of energy. The iEMS system uses for this purpose:

- Prediction of energy balance (load profiles and PV generation),
- Energy price profile.

The heart of iEMS is the optimizer, which uses the above data to determine the schedule of energy storage and load storage that maximizes the economic result.

iEMS also allows the installation to be coupled with demand side response aggregators, so that the customer can derive additional benefits from the temporary reduction of energy consumption.

In addition, iEMS performs technical functions such as:

- guardian of power,
- reactive power compensation,
- Equalization of currents.

The areas of iEMS application are, m.in:

- households and farms,
- public buildings,
- commercial and office buildings,
- hotel and catering facilities,
- Factories
- RES generation units,
- and other installations with manageable sources and consumers.

A typical iEMS application is a consumer installation equipped with a local PV installation and energy storage.

1.2 Advantages of iEMS

In the face of increasing dynamics of energy price changes, a passive approach to energy consumption and production leads to increased costs and reduced profits. A key strategy to reduce energy costs is to shift energy consumption to price valleys and energy generation to peaks. In particular, the installation of a local PV source is becoming less and less profitable – excess production is correlated with a low market price of energy.

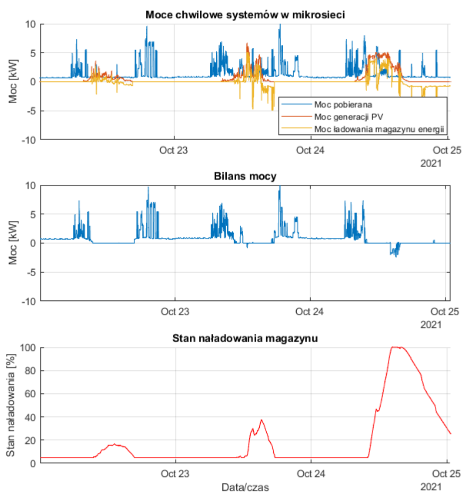
Solving this problem requires a proactive approach to energy management. A potential solution is the installation of an energy storage facility that collects surplus production from RES and then supplies them to consumers. Conventional strategies are based only on the energy balance at the connection and do not take into account the dynamics of energy prices or the profiles of energy production and consumption.

Unlike a typical surplus balancing strategy, the iEMS system, thanks to advanced algorithms, sets an economically optimal schedule for the energy storage.

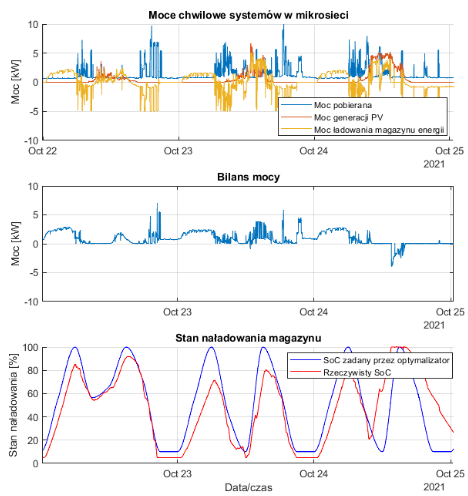
In addition, in the optimization process, iEMS takes into account technical limitations resulting from the conditions of connection to the power grid on the one hand, and from the operating parameters of the energy storage that affect its service life on the other. As a result, the energy storage controlled by the iEMS system is characterized by an extended service life.

The example below illustrates the operation of iEMS in a prosumer installation using the G12 tariff. In the case of simple balancing, the energy storage remains discharged most of the time, which not only adversely affects its lifetime, but also does not allow for the implementation of the backup power supply function. iEMS uses arbitrage to minimize peak tariff purchases (a 20% reduction in energy costs over balancing has been demonstrated) and avoids extreme battery states of charge (extends battery life).

Balancing

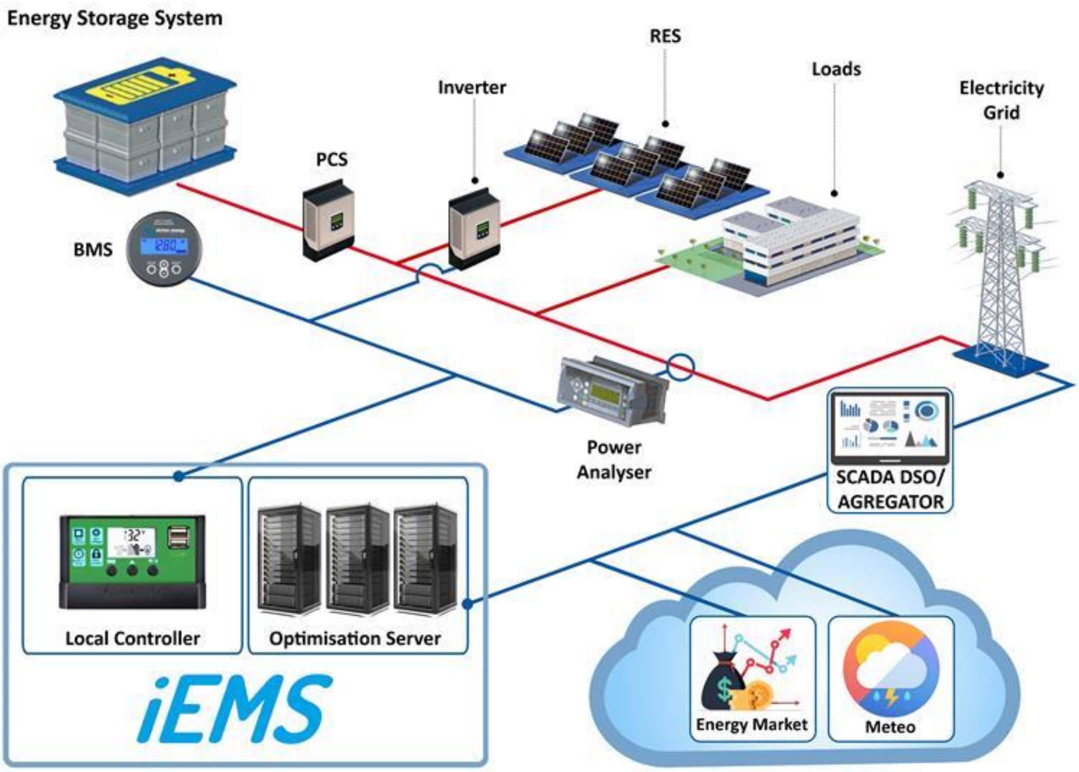


iEMS



2 Architecture

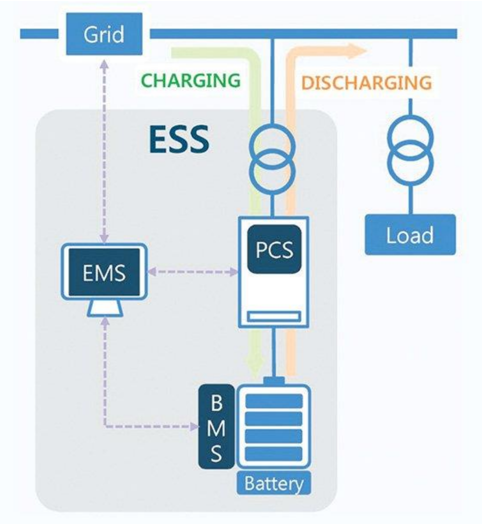
The iEMS structure is based on a client-server architecture. The physical location of the customer's installation is where the local controller is located, connected to the user's infrastructure. The controller has a permanent connection to the cloud service, which is the central point of the system. The cloud service is responsible for the processing and presentation of data from the installation, as well as for setting the schedules of equipment operation.



2.1 Local Driver

Depending on the application, the local controller has the form of an industrial computer or a PLC. Its tasks are primarily:

- Implementation of physical communication with the components of the installation:
  - Network analyzers and/or meters,
  - Battery BMS, battery inverters,
  - Photovoltaic inverters, data loggers,
  - EV Charging Stations,
- Monitoring and short-term archiving of data from components, ongoing data sending to the cloud,
- Implementation of warehouse and charging station work schedules,
- Current regulation taking into account technical limitations:
  - Power gatekeeper with the use of storage, and in a critical situation, limiting PV power or disconnecting loads,
  - Reactive power compensation, network current symmetrization.



2.2 Cloud

The cloud service is the focal point of the iEMS system. Its tasks are primarily:

- Local Controller Connectivity
    - Receiving data from devices
    - Sending device configurations and schedules
- Archiving, presentation and analytics of data from devices
- Collection of data from the energy market/trading companies, signals from service aggregators and forecasts from weather services
- Execution of predictive and optimization algorithms
- Implementation of the user interface
- User authorization based on access levels

The cloud service archives data from the installation with a time resolution of 1 minute.

2.3 Algorithms

The iEMS system performs its functions thanks to the use of advanced algorithms. Planning is carried out 24 hours or more in advance and requires the use of prediction of future operating conditions of the installation.

In order to predict the amount of generation from PV installations, the cloud uses data from weather services and calculates the course of generation over time. In addition, a prediction of the waveform of the energy consumption is performed. It uses machine learning algorithms based on historical collection runs. From the above information, the predicted course of the energy balance at the grid connection is synthesized.

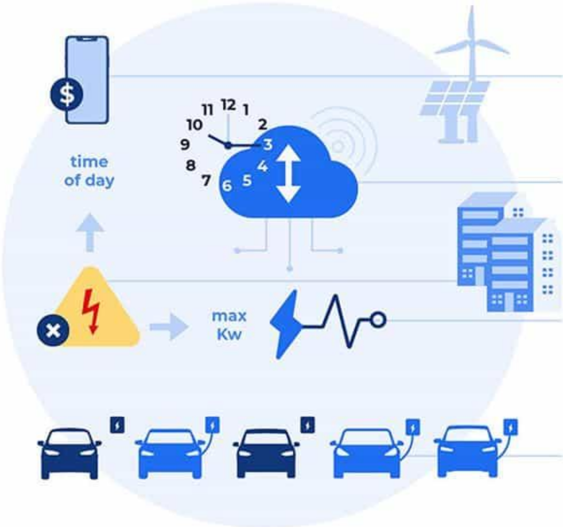
Then, the optimization algorithm, taking into account the volatility of the balance and energy prices over time, determines the schedule of energy storage and possible vehicle charging. The function of the optimizer's goal is to maximize profit, taking into account not only the costs of energy, but also the costs of energy storage related to its operating conditions.

The result of the optimizer's operation are schedules of warehouse and loader work for the next 24 hours. These are sent to the local controller for implementation.

The algorithm can use energy price courses in the form of:

- Multi-zone tariffs,
- Information from the day-ahead market,
- Other source of prices indicated by the customer.

The optimization algorithm uses information about the technical limitations of the storage (power, capacity, limit states of charge) and the grid (the maximum available power consumed and fed into the grid). The user has the ability to influence the level of 'aggressiveness' of the storage system's operation strategy by balancing between short-term profit and degradation of the energy storage capacity.



After receiving the schedule, the local controller strives to implement it. Since it is natural for discrepancies to occur between the prediction and the actual operating conditions, the controller uses fuzzy control rules to gently adapt to the current data. At the same time, the local controller is responsible for responding to hard physical constraints occurring in real time.

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3 User Interface

The default way of interaction between the user and the iEMS system is the website.

Other forms of access can be developed at the customer's request, e.g. a local HMI panel.

3.1 Website

The website is available at:

https://iems.stay-on.pl/

3.1.1 Login and user accounts

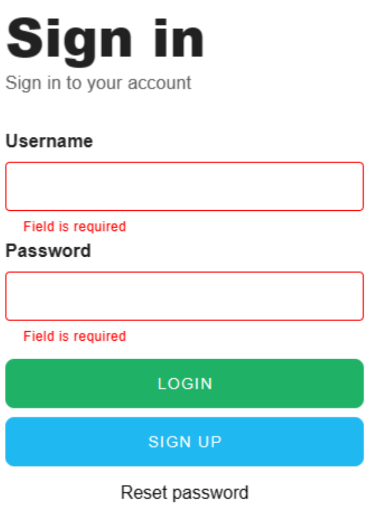
The service is available only to registered users.

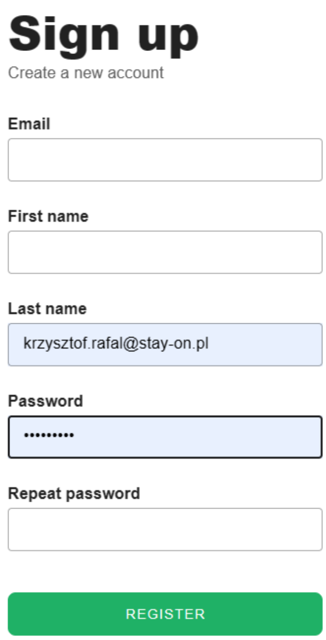
For new users, it is required to create an account using the SIGN UP function.

The account is activated by the administrator. One of the following access levels is assigned to the account:

- *user* – read-only access to current parameters and installation history – intended for the user
- *service* – as above + the possibility of modifying the installation parameters and viewing service panels – intended for technical services dealing with the commissioning and maintenance of the installation
- *Manager* – service level with access to many installations – intended for the manager of many installations, e.g. an installation company, aggregator or cooperative/cluster operator

The administrator also assigns access to specific installations to the user account.



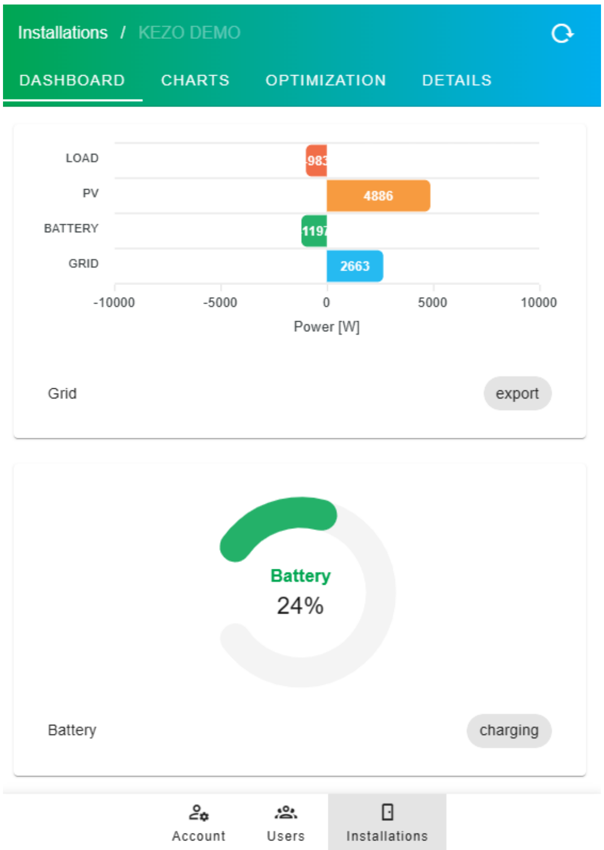


After logging in, the user is transferred to the home page, where the installations assigned to him can be displayed.

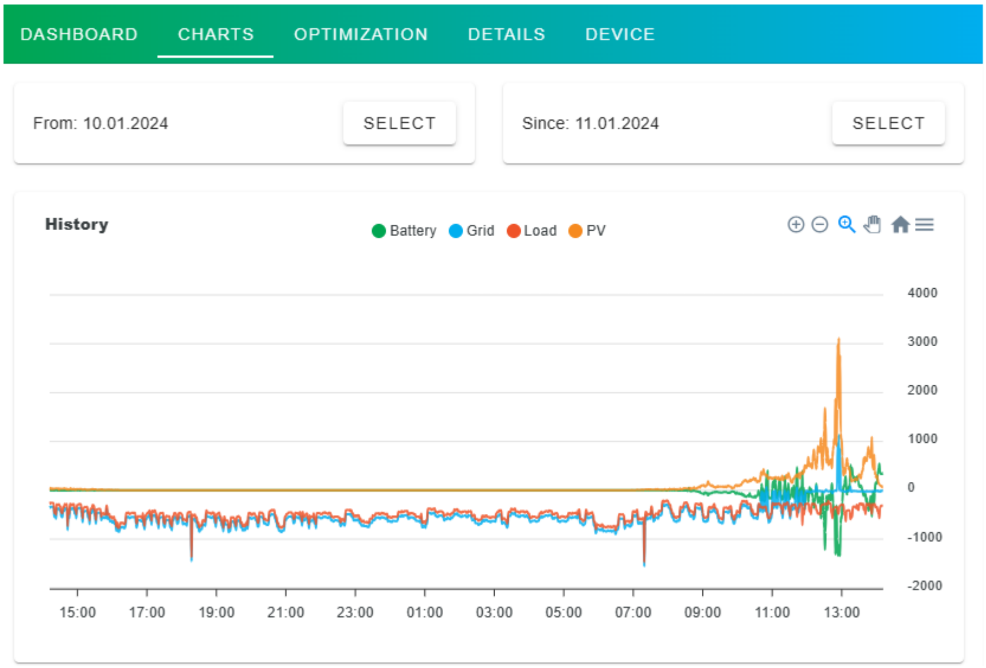
3.1.2 User Panels

A user with the user level assigned has access to the following panels after logging in and selecting installation:

- *DASHBOARD* – allows you to view the current energy flows in the system and the battery charge status. The data is refreshed every 1 minute.



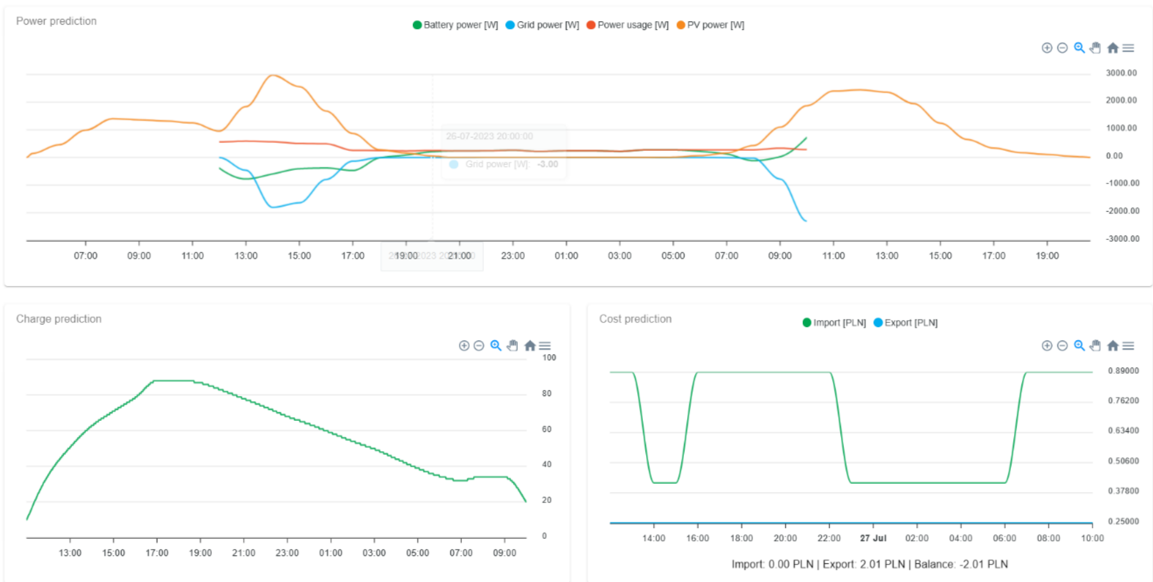
- *CHARTS* – preview of historical power profiles in the system with the ability to select a date range



3.1.3 Service panels

From the service level on the website, the following panels are available:

- *OPTIMIZATION* – preview of the prediction of generation and consumption processes as well as the planned warehouse work schedule



- *DETAILS* – preview and editing of system parameters and settings

Schedule mode	Custom
Schedule ID	ec9b2c67-6382-4088-97f8-568f4d969026
Last report	11.01.2024, 14:21:05 (18 seconds ago)
Last update	9.01.2024, 11:46:32 by krzysztof.rafal@stay-on.pl

Commands

Send schedule RUN

PV + NEW MODULE

Tracker

ID	37710630-60d0-413b-9110-10c5f1f75487
Name	Tracker
Installed power (DC) [kW]	9.24
Tracker	true
Latitude	53.8758
Longitude	22.3724
Azimuth	0
Declination	30

- *EVENTS* – event and error log preview

Module class	Module ID ↑	Type	Active	Code	Message	Timestamp
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	22	Cloud Standby	12.02.2024, 13:55:54
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	24	Cloud Stop	12.02.2024, 14:03:56
TFI	761950d0-09db-44f8-8caa-0c73283d081a	Event	true	19	Standby Standby	12.02.2024, 13:25:18
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	22	Cloud Standby	12.02.2024, 13:53:23
TFI	761950d0-09db-44f8-8caa-0c73283d081a	Event	true	17	Standby OFF	12.02.2024, 13:26:18
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	3	Manual Operation	12.02.2024, 13:23:17
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	22	Cloud Standby	12.02.2024, 13:57:55
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	3	Operation	12.02.2024, 12:39:41
ESS	c21d5b3d-b692-4276-8d1d-d4cf61189bf9	Event	true	12	Local Standby	12.02.2024, 14:27:01

- *DEVICE* – current preview of the full list of parameters transferred from individual devices

ID	4eba9593-eba7-4c75-8acf-53c86d818ed6	
Firmware version		
Online	true	11.01.2024, 14:28:05

ESS

1

C1	12
C2	0
E_daily_charge	0.3
E_daily_discharge	0
E_total_charge	2143.3
E_total_discharge	1865.3
I1	2.94
I2	0
P1	159

3.2 API

iEMS has the ability to create external APIs for cooperation with external entities, e.g. to exchange data with external SCADA systems, download price data, DSR signals, etc.

Currently, the following are implemented:

- there is a mechanism for directly setting the energy storage schedule from the level of external systems,
- access to historical data from the installation.

4 Applications

4.1 All-in-one systems

iEMS is an integral part of the fully integrated energy supply systems developed by STAY-ON series:

- ***PFH*** – Power for Home
    - IP20 Enclosure
    - Hybrid inverter 5 - 12 kW
    - LFP batteries 10 - 30 kWh
- ***PFBi*** – Power for Business indoor
    - IP20 Enclosure
    - Hybrid inverter 20 - 50 kW
    - LFP batteries 30 - 60kWh
- ***PFBo*** – Power for Business outdoow
    - IP54 Built-in
    - Hybrid inverter 30 – 100 kW
    - LFP batteries 60 – 240 kWh

In the PFH and PFB warehouses, a local controller in the form of an industrial computer is built-in. iEMS is designed in these products for commissioning and parameterization by a trained installer.

4.2 Industrial installations, energy storage paired with RES

iEMS in industrial-scale systems is a part of the control and automation system of the generation installation responsible for planning the energy storage operation schedule.

The method of integration and the communication protocol are agreed individually.

4.3 Public buildings, energy cooperatives

On the basis of the iEMS system, dedicated solutions for public buildings and energy communities are developed.

Development work on extending the functionality of iEMS is carried out as part of Horizon 2020 projects:

- Serene (h2020serene.eu)
- H2020 Sustenance Project