REDUXI · KNOWLEDGE BASE

Reduxi AI strategies

Self-learning control algorithms in the Reduxi EMS that forecast, optimise and control batteries, PV, EV chargers and heat pumps. Primary objective: profit optimisation.

- Reduxi EMS · AI Energy Manager
- ⏱ Optimisation in rolling 15-minute intervals
- At least 14 days of historical data



Power chart in 15-minute view with the AI forecast

Text description of this image

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1 What are Reduxi AI strategies

Reduxi AI strategies are a set of intelligent, self-learning control algorithms embedded in the Reduxi EMS (Energy Management System). They forecast, optimise and autonomously control energy flows across connected assets such as batteries, PV, EV chargers and heat pumps.

The primary objective is profit optimisation.

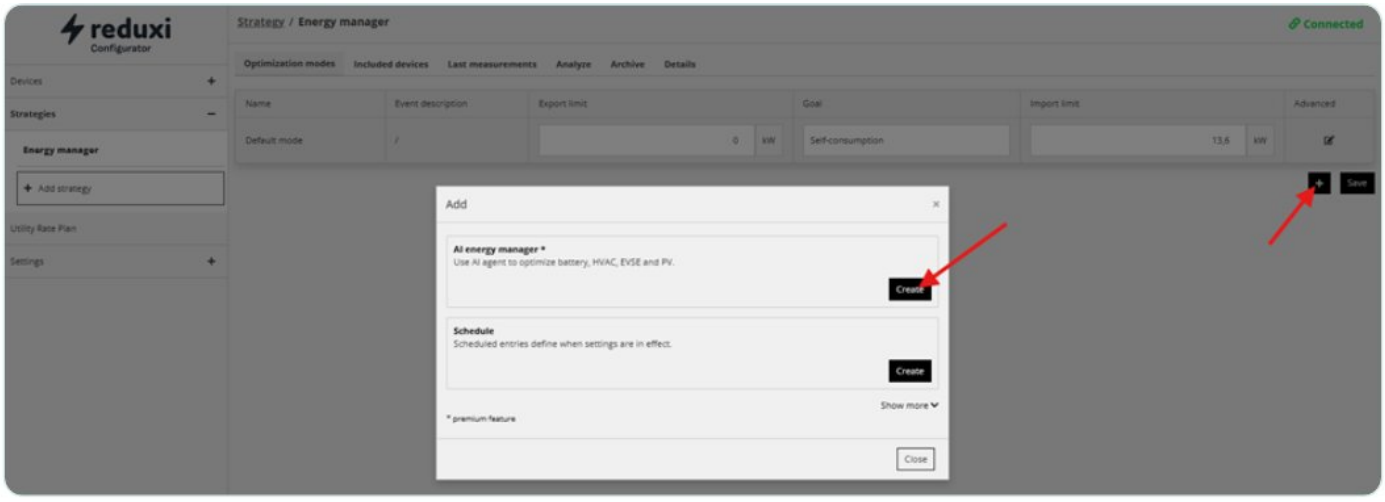
1.1 Core definitions

- **Forecast** is a prediction of future energy flows, including load, PV production, EV usage and grid exchange. It is derived from historical measurements and external inputs such as weather conditions, time of day and usage patterns.
- The objective is to **optimise when to consume, store or export energy**. For example, the battery charges during periods of low prices or high PV production and discharges during high-price intervals. Electricity market prices (SPOT, ToU) are a key input to this process.
- The **optimisation runs in rolling 15-minute intervals**. It continuously updates decisions based on the latest system state and forecasts.
- The AI strategy controls devices indirectly: it sends setpoints to the **controller, which manages all included devices in real time**.
- The system continuously learns from new data and updates its models and optimisation behaviour accordingly.

2 Initial configuration of AI strategies

2.1 Adding AI strategy

The AI strategy (optimisation mode) is added in the Energy Manager strategy. Click the **+** icon and select **AI Energy Manager**.



Adding the AI Energy Manager strategy

Text description of this image

Configure the strategy parameters and save. More about the configuration is in the device-specific sections (see **Point 5**).

2.2 AI strategy conditions checklist

To enable an AI strategy, the following conditions must be met:

- [ ] A strategy is set with an **AI optimisation mode**. **Only one AI strategy can be active** at a time.
- [ ] A **price list** is configured.
- [ ] **Geolocation is set.**
- [ ] **Region, country, timezone and currency are defined.**
- [ ] The controller is online and connected to the Reduxi cloud.
- [ ] The **devices have the relevant parameters configured**, for example battery SOC, capacity and power limits.
- [ ] The location has at least **two weeks of historical data** (PV, load, grid, etc.) so that reliable forecasts can be generated. See Point 2.3 for the behaviour without sufficient history.
- [ ] A valid **AI licence** is active.
- [ ] After all parameters are set, **wait at least 15 minutes** for the AI strategy to appear in the cloud app and start controlling devices.

> ℹ️ **How to recognise a working AI strategy**
> A successfully configured AI strategy shows its forecast to the right of the **Forecast** line. An example is shown below.



Forecast displayed to the right of the Forecast line

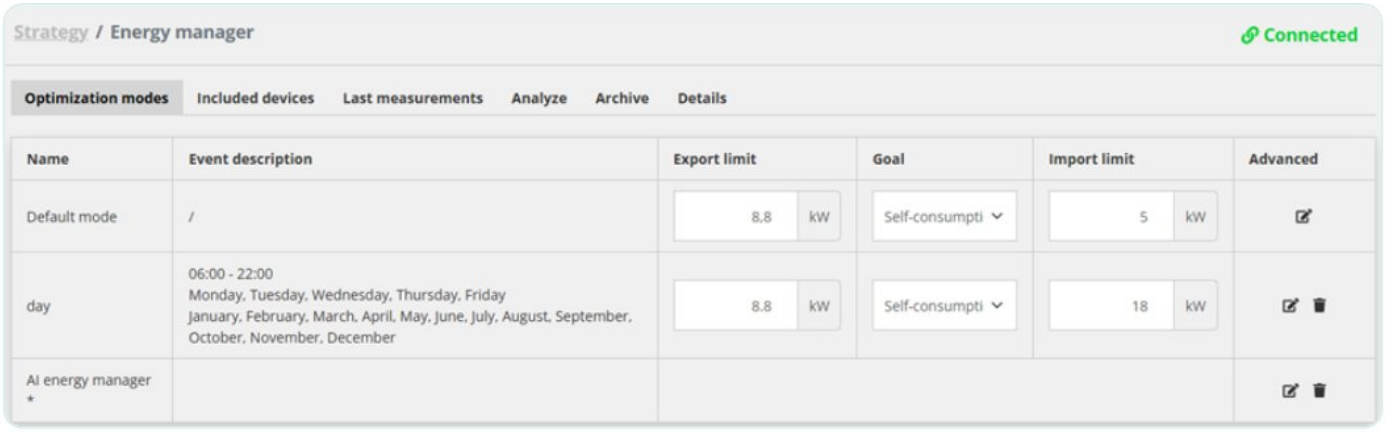
Text description of this image

2.3 Advanced notes and options

- AI optimisation can run alongside default and schedule modes. The system can then behave differently at different times of day based on your settings. A typical example is different settings or limits during the day and at night.

The AI keeps to the limits of the active mode

The AI optimisation overrides the goal and other settings of the Default and Schedule modes, but never their import and export limits. It always stays within the limits of the mode that applies at that moment: the Schedule mode inside its time window, the Default mode outside it. In the screenshot below, the AI works within import 18 kW and export 8.8 kW from 06:00 to 22:00, Monday to Friday (schedule "day"), and within import 5 kW and export 8.8 kW at all other times (Default mode).



AI optimisation next to default and schedule modes

Text description of this image

- Negative price optimisation does not need separate configuration. The AI optimisation mode already handles it when PV is configured accordingly.
- Set grid limits so that the system can reach the desired goal. For example, if the grid limit is 10 kW but the normal consumption is 100 kW, the optimisation target cannot be met. The user must define the limitation accordingly.
- If the AI optimisation cannot be achieved because of restrictive grid limits, the system automatically falls back to the configured default optimisation mode (e.g. self-consumption) as defined in the UI.
- Reduxi can control devices only to the extent that they follow control signals correctly. If a device does not respond as expected, verify its behaviour with the manual control modes. For example, some PV power plants cannot be curtailed, some batteries do not follow the requested setpoint, and in hybrid inverter systems PV and battery control are often coupled. Reduxi adapts to these constraints, but the limitations remain.
- Reduxi AI strategies coordinate all included devices towards a shared optimisation objective. You define which device categories are included (for example battery storage) and which are excluded (for example HVAC systems). We recommend including all categories, because this brings the highest value when everything works towards a common goal.
- Included devices are actively managed by the AI and participate in the optimisation. Excluded devices operate independently under their own control logic and are not affected by the strategy.

Behaviour with limited historical data (first ~2 weeks)

- When there is not enough data for forecasting, no PV, load or grid forecasts are available.
- If both import and export are allowed, the AI performs energy arbitrage.
- If either import or export is restricted, the AI switches to self-consumption mode.
- After enough historical data is available, the system switches to regular AI mode automatically.

2.4 Update rates

- The AI strategy is recalculated every 15 minutes. At the same interval, the updated strategy is deployed to the controller, using the latest system state, weather data and inputs.
- Once deployed to the controller, the strategy is executed locally in real time. It reacts immediately to measurements and grid conditions.
- If a strategy is reconfigured, activation and the initial forecast calculation take up to 15 minutes.

3 Energy consumption and production forecasting

Accurate forecasting of energy consumption and production is essential for the performance of AI strategies.

The Reduxi forecasting model uses geolocation data, historical behaviour and weather inputs (mainly solar irradiation and temperature). It predicts future energy flows for the next day and beyond.

The forecast is provided in 15-minute intervals. You can view it in the power chart, in the 15-minute view.

3.1 Photovoltaic (solar) power plant production forecast

PV production depends on historical behaviour, time of day and year, and weather input, mainly irradiation and temperature.

To simplify the configuration, Reduxi does not require the installed power, surface area or orientation of the PV power plant. These characteristics are inferred automatically from historical PV production.

> **Minimum history**
> For an accurate forecast, a minimum of 14 days of historical data is required.

3.2 Consumption (load) forecast

The consumption forecast also uses historical data and weather inputs.

In addition, the model accounts for usage patterns such as time of day (for example lower consumption at night) and day of week (for example weekdays and weekends).

Consumption forecasting is the most complex part. It must account for less predictable behaviour within short timeframes, for example starting large machines in industrial environments or starting an EV charging.

At the moment, all loads are forecast together, including EV charging and HVAC. This will be improved in future versions.

4 Battery power forecast

Battery power is the part of the system that can be actively controlled.

Its forecast is derived from optimisation goals such as peak shaving and cost optimisation. More details are in the following sections.

4.1 Grid baseline forecast

The grid-level forecast of consumption and production is essential for effective system control. It defines the expected energy exchange with the grid. All AI optimisation is built around it.

The grid forecast is important because:

- Deviations from the expected baseline can lead to costs.
- Consumption and production must stay within grid constraints, such as import and export limits or fuse limits.

The baseline forecast enables the AI to:

- **reduce grid import and use the battery instead**
- **shift consumption to manage peaks and avoid exceeding limits**

For services such as flexibility or balancing, the baseline forecast is also the reference point, because:

- it enables flexibility services as a deviation from the baseline
- it determines potential penalties or rewards

5 Description of AI strategies per category

AI strategies can control all device categories to achieve a common objective. The following sections describe the functionality of each category.

5.1 AI strategy for battery (BESS)

Battery Energy Storage Systems (BESS) maximise savings and earnings in the following modes:

- **Energy arbitrage.** Charge the battery when energy prices are low. Use or sell the stored energy when prices are higher.
- **Charge from grid, discharge to load.** If discharge to the grid is not allowed, the battery discharges to cover the consumption. The battery charges from the grid in the low-price intervals and is used later when prices are higher. This shifts consumption and reduces costs.
- **Charge from PV, discharge to grid.** If charging from the grid is not allowed, the battery charges from PV. The energy can later be sold at higher prices. This increases the value of solar production compared to direct feed-in.

In all three modes, the Reduxi BESS AI module calculates the optimal time windows for charging and discharging. It considers:

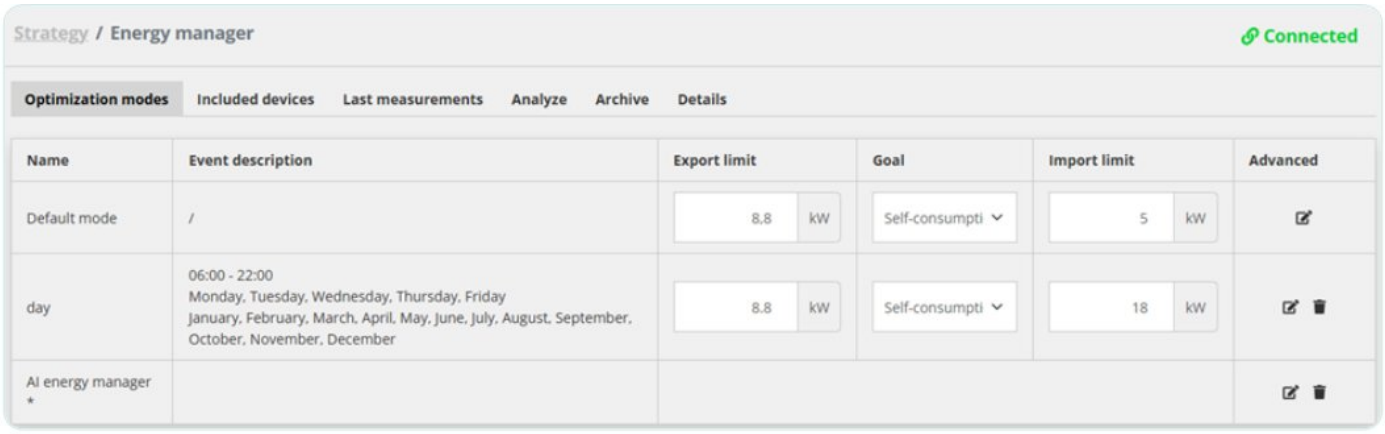
- Energy buying price, including all specified fees, network charges and other components. The price must be defined in advance in the cloud app.
- Energy selling price, including all specified fees, network charges and other components.
- PV production, consumption and grid forecast.
- Grid and battery power limits.
- Battery charge and discharge losses, and battery degradation cost.

Examples:

- The energy price is low at 12:00 and high at 20:00. The battery charges around 12:00 and discharges around 20:00.
- It considers grid and battery power limits. If the grid limit is low and the required charging energy cannot be reached in a shorter time, the charging period is extended, for example from 11:00 to 15:00.
- It considers the PV production forecast and charges the battery from PV instead of from the grid, or from a combination of both.
- If the price difference is too small to cover the charge and discharge losses and the battery degradation cost, the battery does not perform the charge/discharge cycle.

5.1.1 BESS AI configuration

The screenshot shows the AI BESS configuration.



AI BESS configuration

Text description of this image

- **Arbitrage or grid-restricted mode.** The operating mode is determined by the grid charge and discharge restrictions. With the UI switches, you configure the system for pure arbitrage or for optimisation that respects grid import and export constraints.
- **Min savings/earnings per kWh.** To account for battery degradation, define the minimum savings or earnings that a cycle must generate. If the expected value is below this threshold, the battery is not used. This protects battery lifetime. A typical recommended value is `0.02 EUR/kWh`. It is estimated with this calculation: cost of the battery / total energy over battery lifetime = 50,000 EUR / (10,000 cycles × 250 kWh) = 0.02 EUR/kWh.
- **Capacity reserved to cover load.** The forecast is never ideal. A percentage of the battery capacity can be reserved to cover local consumption and prevent exceeding grid limits.
- **Capacity reserved for surplus (PV) production.** Similarly, a percentage of the battery capacity can be reserved for PV surplus production, in case the PV produces more than planned.
- The optimiser also considers the energy loss during charging and discharging. The loss of the complete charge and discharge cycle is estimated at 8%.

5.1.2 BESS AI SOC range excursions

AI optimisation remains in control at all times, even when the battery SOC moves outside the default preferred AI SOC range. If the system determines that charging from the grid is not possible and the current SOC is lower than MIN AI SOC, the AI optimisation operates within the MIN and MAX SOC limits defined in the strategy, instead of the AI SOC limits.

Below the low SOC limit for AI

If increased load consumption would cause the export limit to be crossed (requiring peak shaving) and the SOC drops below the low AI SOC limit, the system starts charging automatically. There are two scenarios:

SOC significantly below the MIN AI SOC value: the system calculates the charging needs over a longer time horizon. It identifies the most cost-effective charging windows based on current and forecast spot prices.
SOC has only just crossed the MIN AI SOC value: the system starts charging during the next 15-minute interval. This is the more common case, because the AI continuously aims to stay within the default AI SOC range and reacts as soon as it detects that the limit has been crossed.

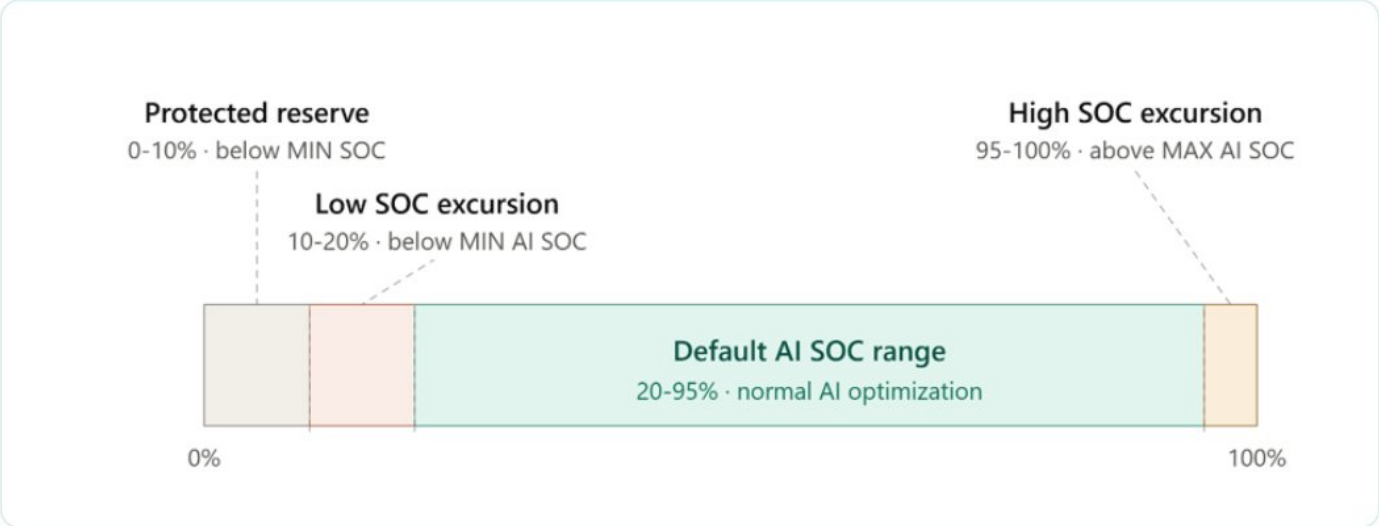
Above the high SOC limit for AI

If the SOC exceeds the MAX AI SOC limit, the excess energy is stored until an optimal time frame arises, either for self-consumption or for selling to the grid.

Special case: grid-only charging with insufficient PV

If the system is allowed to charge the battery only from the grid and PV production is lower than the site load, the battery is not charged. It remains in standby and is used only for peak shaving, until the SOC reaches the MIN SOC value defined for the battery.

Illustration of all segments of operation:



All segments of operation

Text description of this image

5.2 AI strategy for PV

The PV AI strategy works best in combination with a battery. PV production is then stored in the battery and reused in periods of high energy prices.

If no battery is involved, the PV AI strategy still maximises the profit:

- When the energy price is positive, the PV production covers the load and any surplus is exported to the grid up to the export limit.
- When the sell price of energy is negative but the buy price is positive, the system works as self-consumption with zero export. The PV production covers the load but does not export to the grid.
- When both the buy and the sell price of energy are negative, the mode is set to max-consumption. PV production is stopped, because it would otherwise result in losses.

5.3 AI strategy for EV charging (EVSE)

The AI strategy for EV charging is the most advanced strategy in the Reduxi AI strategy portfolio.

See the full description in this article: **EVSE AI Strategy for Smart EV Charging**

5.4 AI strategy for heat pump control (HVAC)

The HVAC AI strategy reduces energy costs without compromising comfort. Buildings have high thermal inertia. Heating and cooling can be shifted in time with only a small impact on indoor conditions.

When controlling heat pumps, Reduxi uses the operating modes the device supports, such as OFF, ECO, NORMAL and BOOST. The heat pump then operates within its designed control logic. This maintains optimal efficiency and protects the inverter. Operation remains safe and does not negatively impact equipment lifetime.

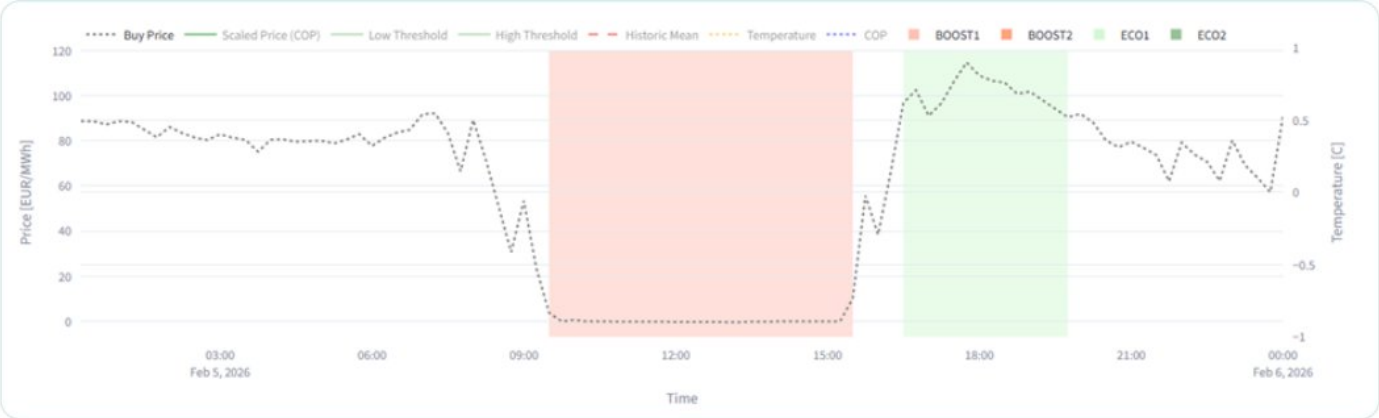
The heat pump savings are achieved in two ways:

a. Price-based optimisation

Energy prices vary throughout the day. Reduxi increases heat pump operation when prices are low and reduces it when prices are high.

For example, if electricity is more expensive between 17:00 and 20:00, the system can pre-heat the building slightly before this period. During the expensive hours, it reduces consumption and maintains comfort through the thermal inertia of the building.

This simulated example shows how the heat pump increases energy use during low-price intervals and reduces consumption during high-price intervals. The dotted grey line represents the energy price.



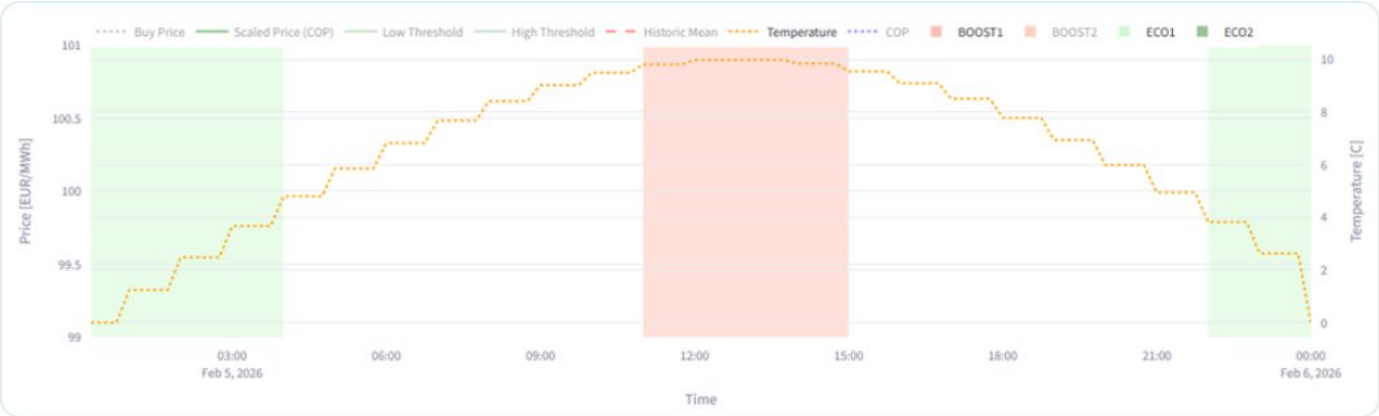
Price-based optimisation: the dotted grey line is the energy price

Text description of this image

b. Weather-based optimisation

Heat pumps operate more efficiently at higher outdoor temperatures. This is defined by the Coefficient of Performance (COP). Reduxi uses weather forecasts to shift heating to periods with more favourable conditions. This improves efficiency and lowers costs, again without affecting comfort.

This simulated example shows how the heat pump reduces energy use during the night and increases power during warmer daytime hours to improve efficiency. The dotted orange line represents the temperature forecast.



Weather-based optimisation: the dotted orange line is the temperature forecast

Text description of this image

6 Examples of AI strategies in practice

Key information for the AI strategy is visualised in the Charts view. Use the power chart in 15-minute resolution. The view includes:

Upper graph

- Historical power measurements: **yellow** = PV production, **green** = site consumption, **blue** = battery power, **orange line** = grid exchange
- Forecast from the current time until the end of the day

Bottom graph

- **Red** = energy purchase price, including all defined fees
- **Green** = energy selling price, including all defined fees
- Prices must be preconfigured in the cloud web application



Power chart with forecast (upper graph) and prices (bottom graph)

Text description of this image

6.1 Example: a typical example with a battery and PV



Battery and PV, segments A to E

Text description of this image

- **A** – charging the battery during the night at low prices while keeping the grid limit at 240 kW
- **B** – discharging the battery to the grid at high prices
- **C** – using solar production to cover consumption at the location
- **D** – charging the battery from forecast solar production during a low-price period (forecast)
- **E** – discharging the battery to the grid at high prices (forecast)

6.2 Example: utility scale PV (dedicated location to PV production)



Utility scale PV, segments A to D

Text description of this image

- **A** – discharging the battery to the grid at high prices
- **B** – low-price period. Charging the battery purely from solar, with 0 kW at the grid, which means no import and no export
- **C** – after the battery is full, exporting PV energy to the grid
- **D** – discharging the battery to the grid during the three high-price intervals to maximise earnings

6.3 Example: household location with zero feed-in

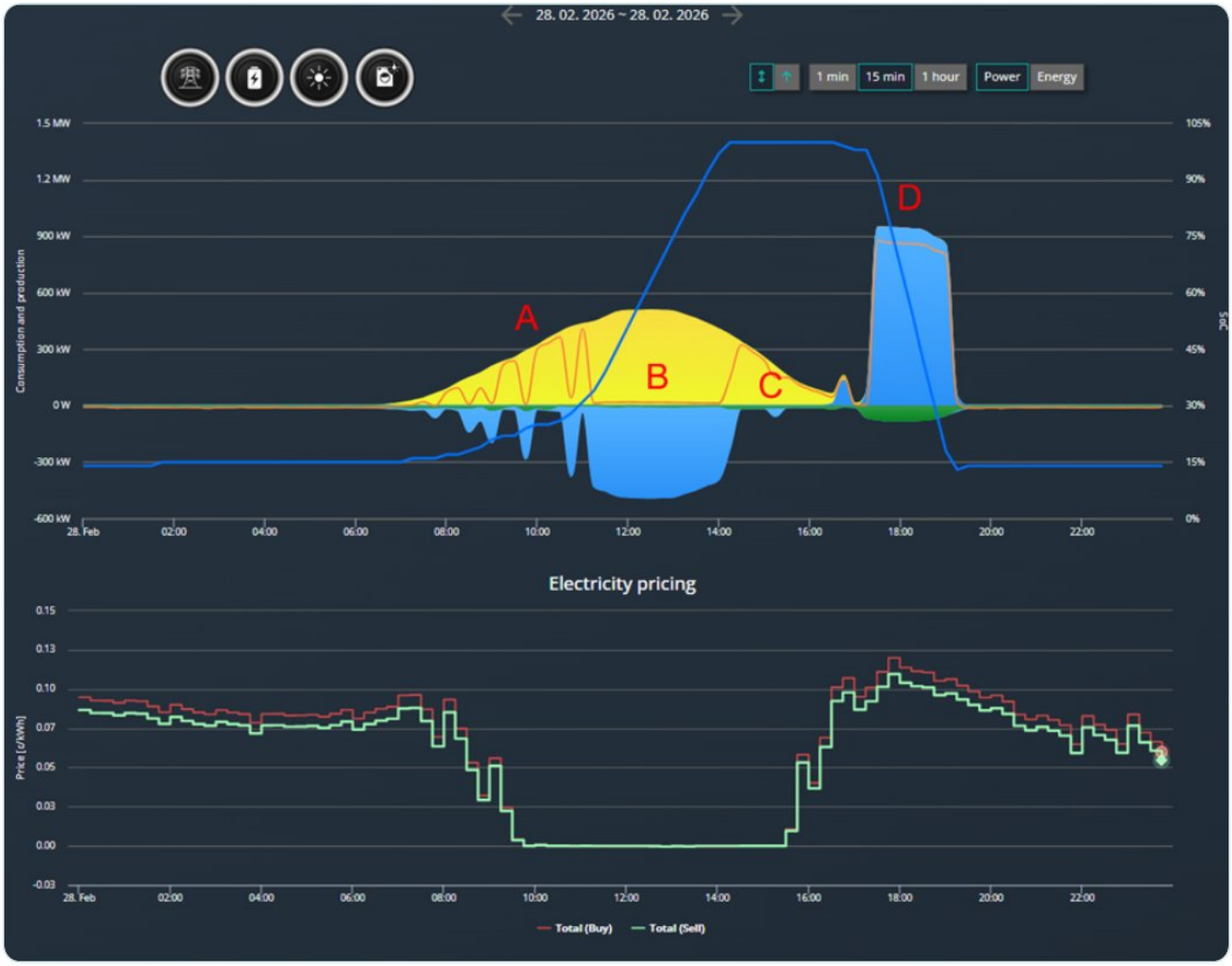


Household with zero feed-in, segments A to D

Text description of this image

- **A** – charging the battery from the grid while keeping the grid limit at 6 kW
- **B** – discharging the battery to reduce grid import during high-price periods
- **C** – charging the battery from the grid and solar, with a maximum grid exchange of 6 kW, to store energy for the expensive evening hours
- **D** – discharging the battery during the expensive evening hours. No export to the grid is allowed due to the feed-in limit

6.4 Example: utility PV

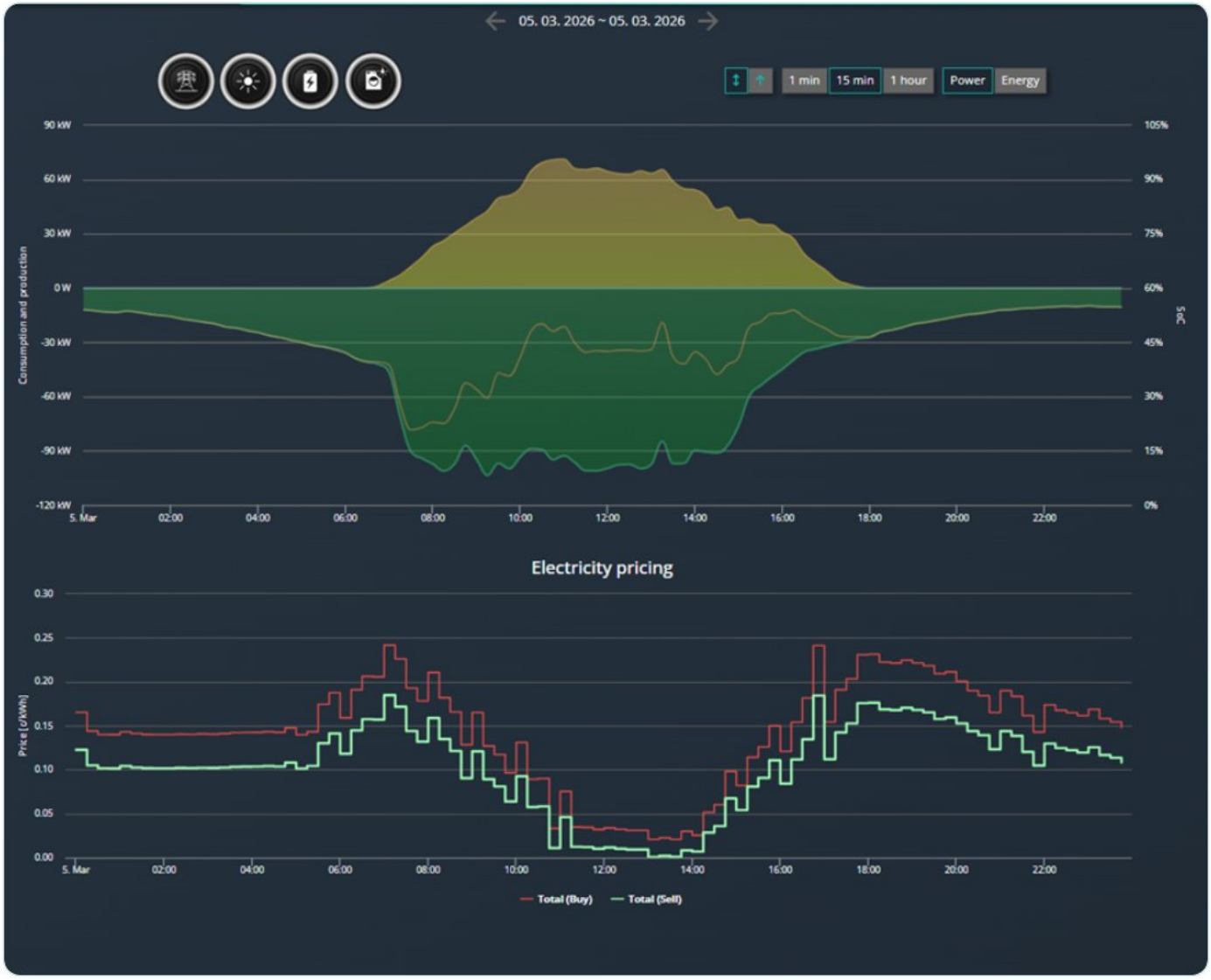


Utility PV, segments A to D

Text description of this image

- **A** – intervals in which PV energy is either exported or stored in the battery. This depends on the cost in 15-minute intervals
- **B** – low-price period, purely charging the battery
- **C** – after the battery is fully charged, exporting PV production to the grid
- **D** – exporting the stored energy during high-price periods

6.5 Example: consumption forecast of a production location with 7:00–15:00 working time



Load forecast and solar production forecast

Text description of this image

The chart shows a typical load forecast of a company with working hours from 7:00 to 15:00. It also shows a typical solar production forecast. The two forecasts are used to plan energy use accordingly.

✓ Summary

Concept and setup (Points 1–2): AI strategies forecast, optimise and control all included devices. Add the AI Energy Manager strategy, meet the conditions checklist and wait 15 minutes.

Forecasts (Points 3–4): PV, load and grid baseline forecasts need at least 14 days of history. The grid baseline is the reference for all optimisation.

Strategies per device (Point 5): BESS, PV, EV charging and heat pump each have their own AI logic and settings.

Examples (Point 6): Charts with segments A to E show how the AI charges, discharges, exports and plans load.

→ Common issues

ISSUE	SOLUTION
The AI strategy does not appear in the cloud app	Check the conditions in Point 2.2: price list, geolocation, region, country, timezone, currency, online controller and AI licence. Then wait at least 15 minutes.
No forecast is shown	The location needs at least two weeks of historical data. Until then no PV, load or grid forecasts are available (Point 2.3).
The optimisation target is not reached	The grid limits are too restrictive. The system falls back to the configured default optimisation mode (Point 2.3).
A device does not follow the AI setpoints	Verify the device with the manual control modes. Some PV plants cannot be curtailed and some batteries do not follow the requested setpoint (Point 2.3).

→ Related articles

Matching guides from the Reduxi knowledge base:

EVSE AI Strategy for Smart EV Charging

Full description of the AI strategy for EV charging.

Device setup guides

All step-by-step guides for connecting devices to the Reduxi Controller

Strategies for the Reduxi Controller

Energy manager and other strategies explained