

Taking charge: Autarco's seamless solution for evolving energy markets

Introducing our Energy Management System



1. Executive Summary

The transition from fossil fuels to sustainable energy sources is transforming global energy markets, significantly impacting the European electricity grid. Renewable energy sources, including solar and wind, are becoming increasingly prominent in electricity supply. This shift, while beneficial for reducing reliance on fossil fuels, introduces challenges due to the decentralized and variable nature of renewable energy generation. Periods of overgeneration, particularly during favorable weather conditions, strain the grid, with moments where energy generation exceeds energy consumption.

In response to these challenges and expanding on Autarco's over 14 years of experience in providing complete grid-tied PV systems, Autarco introduces a seamlessly integrated solar solution that combines solar PV systems, battery storage and an advanced Energy Management System (EMS). Designed to be simple, the system is easy to understand, install and expand, ensuring that consumers can adopt advanced energy technologies without unnecessary complexity.

Simple

Designed to be simple, the system is easy to understand, install and expand. Consumers can adopt advanced energy technologies without unnecessary complexity, starting with a basic solar PV system and seamlessly adding a battery, switching to dynamic pricing or enabling PV curtailment and other EMS functions whenever they want.

Profitable

This solution addresses and capitalizes on grid imbalances and ensures financial viability for consumers. It is inherently profitable, enabling strong financial returns by optimizing energy use, reducing dependence on volatile market prices, and turning grid challenges into consumer opportunities. Despite changing market conditions, Autarco solutions continue to demonstrate significant financial benefits, reinforcing the profitable nature of our approach.

Safe

At Autarco, data security is at the core of our integrated energy solutions. Our ecosystem of solar PV, battery storage and EMS is designed not only to work seamlessly together, but also to protect the integrity and confidentiality of system data. All our customer data that is processed in the Autarco ecosystem, stays within the EU on our own servers. By embedding security into every layer of our platform, we ensure that customer information and system performance data remain safe and reliable.

At Autarco, we strive to achieve €0 energy bills for homes and businesses everywhere, by delivering renewable energy technologies and seamless services that are simple, profitable and safe by design.

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2. Evolving energy markets

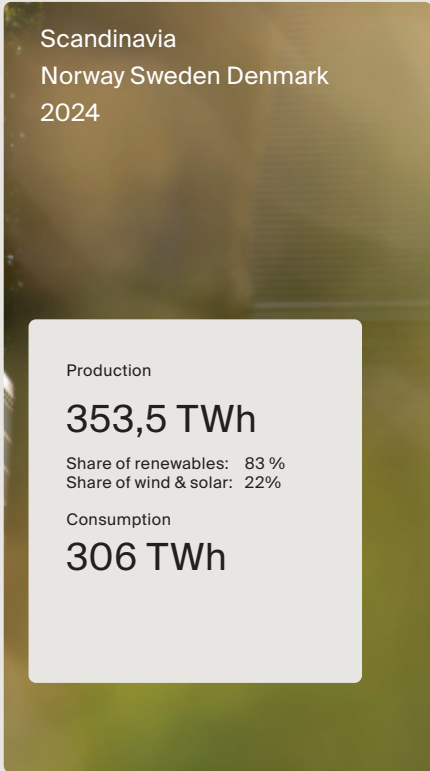
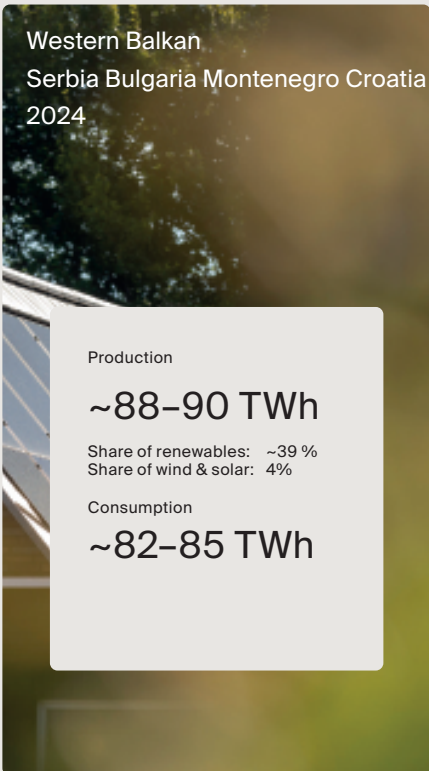
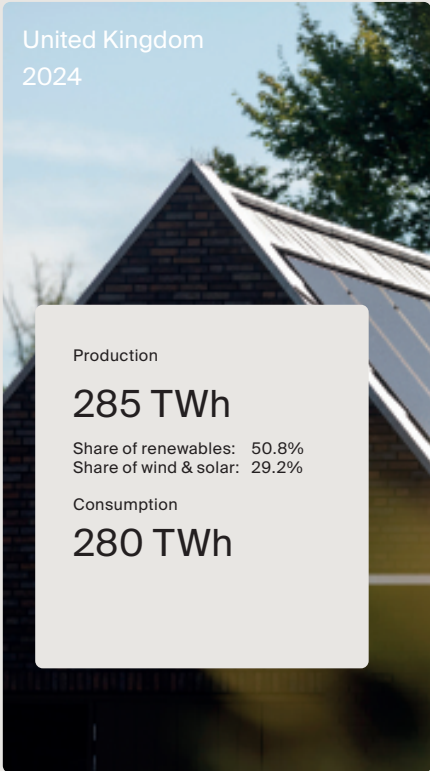
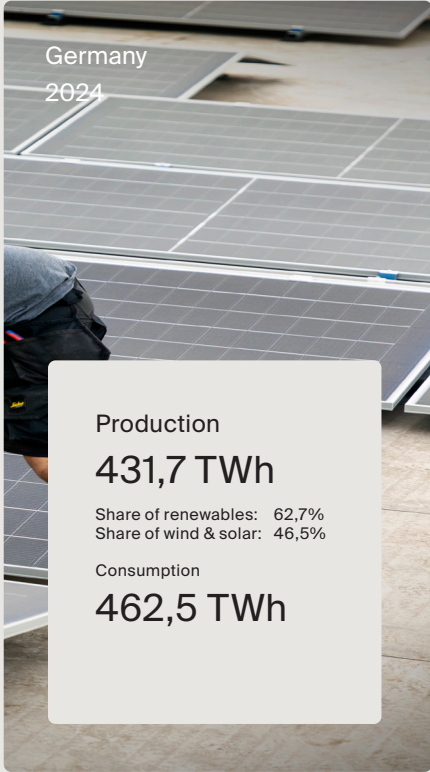
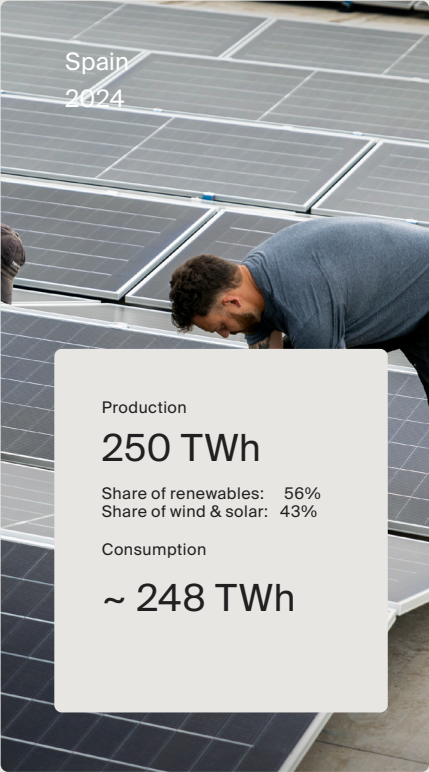
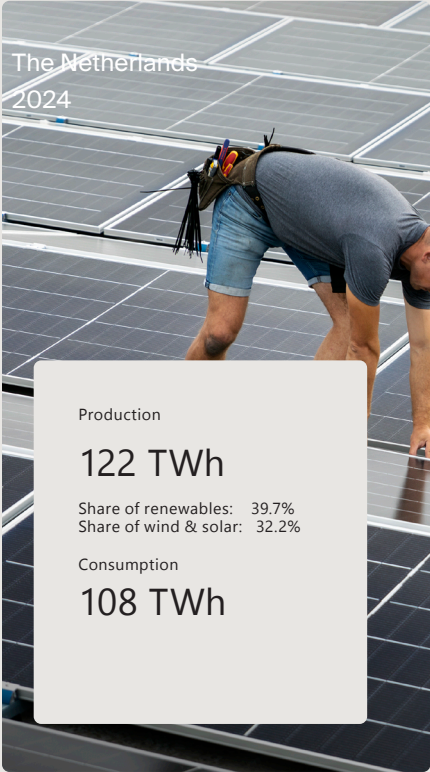
As the world transitions from fossil fuels towards sustainable energy sources, the composition and dynamics of energy markets change. One of the most important consequences is the increasing pressure on European electricity grids due to energy imbalances. As such, in the Netherlands in 2024, the peak load was around 19 GW, while installed solar power was about 22 GW and wind power was about 11 GW. ¹ These figures are expected to grow further each year. Generally, renewable energy is taking up a larger portion of the total energy supply, reducing the reliance on fossil energy. In the Netherlands, renewable energy accounted for around 50% of the electricity mix in 2024, surpassing half of total generation for the first time, and it is expected to continue growing in the coming years ².

2.1 Key numbers in the European market

The EU-wide share of electricity from renewable sources rose to approximately 45.3 % in 2023³. Wind and hydropower remained the largest contributors accounting for about 38.5 % and 28.2 % of renewable electricity respectively while solar PV provided around 20.5 %³. Across the EU, renewable sources generated 50 % of electricity in the first half of 2024⁴. To get a better sense of the current context in European energy markets, we analyzed domestic electricity production and consumption in the Netherlands, Spain and Germany for 2024.



Yearly electricity production and consumption per country



2.2 Growing grid challenges

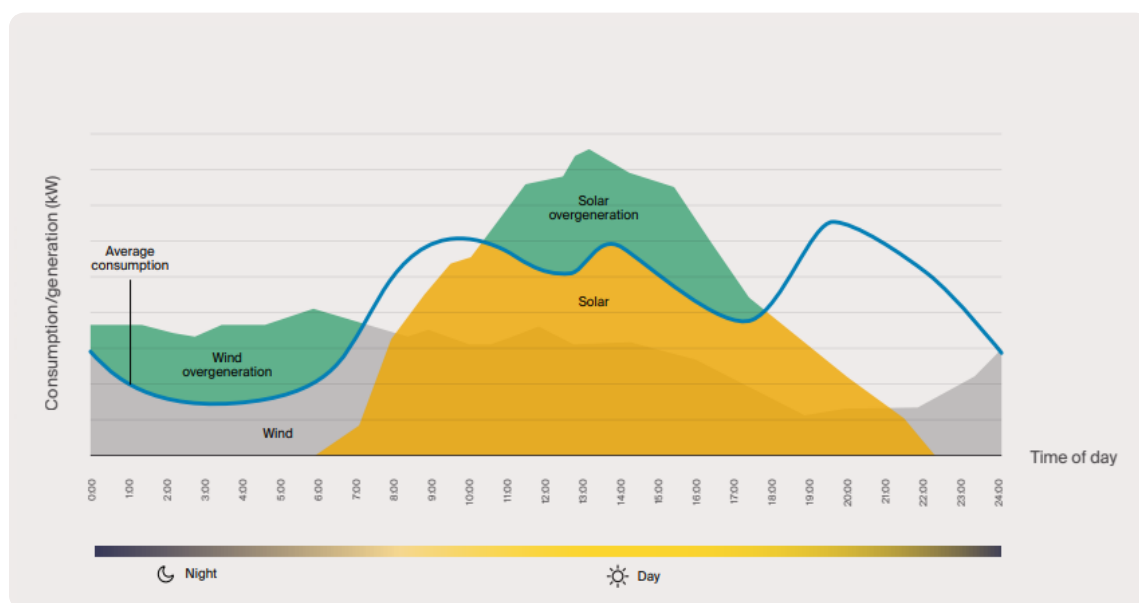
2.2.1 The effect of energy generation on the grid

The electricity grid requires a constant balance between supply and demand, meaning that consumption of energy (drawing energy from the grid) needs to equal the generation of energy (feeding into the grid) at the same moment. This is because the grid lacks the capability to store energy. Failing to maintain this balance between energy consumption and generation at a given moment results in failures in the operation of the grid and thus should be avoided.

Transmission System Operators (TSOs) are tasked with this challenge. They manage the overgeneration of energy by charging energy providers who have themselves failed to manage the balance in their portfolio at that moment. This balance has traditionally been managed by adjusting the output of fossil fuel generators in response to consumption patterns, because those types of generators can react rather easily to consumption patterns that are harder to affect. The fossil fuel generators would thus modify their power output following consumption.

While the introduction and subsequent rise of renewable energy has many benefits, there are some drawbacks for the management of the grid. The reason is that the generation of renewable energy is much more decentralized and thus less controllable than that of fossil fuels. Furthermore, the energy generation from solar and wind is much more variable, as it depends on the weather, leading to certain periods of overgeneration. Those are periods with a lot of sunshine and a lot of wind. As a consequence, these periods can disrupt the grid, which happened for example in June 2023 in the Netherlands. During those moments, the energy generation exceeded the national consumption for 140 hours⁵.

Overgeneration from solar and wind energy



In the Netherlands in particular, with the presence of a net energy metering (NEM; “salderingsregeling” in Dutch) scheme, this is exaggerated, as owners of residential solar systems are incentivized to maximize their energy export to the grid. During sunny hours where overall energy consumption is low, this puts extra pressure on the grid. So, the higher the generation of energy when demand for energy consumption is low, the more difficult the grid management becomes.

2.3 The need for Energy Management

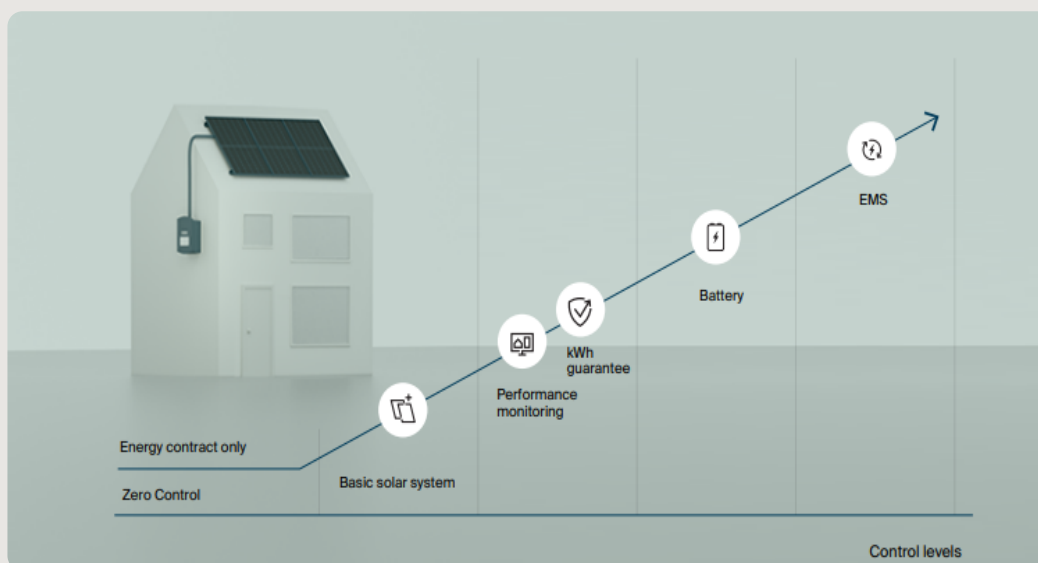
Thus, in the current energy markets across Europe, the grid is becoming increasingly overexerted, which can lead to extra costs for solar system owners who export to the grid. With over 14 years of experience and a portfolio of successful projects across Europe, Autarco delivers a complete solar solution that integrates solar systems, battery storage, and our Energy Management System (EMS). With this solution, we cover all key functions and provide support as expected from a single trusted brand. Energy management can be complex, but with Autarco, everything is managed under one brand, with clear guidance on what is supported. We assist with troubleshooting, initial installations, provide straightforward manuals, remote support, and integration options when needed. These solutions help ensure reliability and financial benefits, even as energy markets change.



3. Autarco's seamless solar solutions

The solution to the aforementioned problems, as well as those that might arise in the future, is moving from a grid-tied solar PV system to a total solar solution that includes a battery and energy management. These total solar solutions allow the consumer to generate energy, store for future use, and optimally use their own energy. From smart inverters to intelligent software: all parts in our system fit together seamlessly. These solutions are scalable, starting from a standard solar PV system, expanding both hardware and software along the way to reach a full Energy Management System. At Autarco, we give you, the rooftop owner, maximum control of your solar solution and thereby allow you to have maximum control of your energy bill, without having to do any of the work yourself.

The customer can determine the level of control by expanding the solution to optimally benefit from market conditions.



3.1 Standalone solar PV

Autarco is a total PV system brand, manufacturing all main components that are needed to install a turnkey system including modules, inverters, mounting systems and monitoring hardware. Despite recent and upcoming market changes, solar PV systems by themselves remain a worthwhile investment for rooftop owners. Even without NEM in the Netherlands, or with extra costs being charged to solar system owners by energy providers, this option remains financially sound. Energy consumers who choose for solar PV generate their own energy and therefore can significantly reduce their energy bill. They will have less demand for electricity from the grid and can be compensated when exporting their generated energy to the grid. While NEM is present in the Netherlands, this is even more relevant, as each kWh exported will be subtracted from the total amount of imported electricity.



The upfront investment of a standalone solar system is still relatively low, especially given that solar PV has never been cheaper than today. While the payback period can increase from ~5 years to ~7 years due to market changes (such as NEM ending in the Netherlands), the savings significantly outweigh the cost. The self-use as well as export to the grid of generated energy cause a strong reduction of the consumer's monthly energy bill, irrespective of the market conditions, resulting in savings for decades. This is especially true considering the increasing warranty periods, as many Autarco panels now come with a 25 year warranty.

3.2 Avoiding export penalties with solar PV and dynamic energy contracts

In changing markets where consumers are being penalized for exporting their generated energy to the grid, in terms of constraints or associated costs (like increasingly introduced in the Netherlands), dynamic energy contracts become increasingly attractive for energy consumers with solar systems. Dynamic energy contracts, as opposed to fixed ones, are based on energy prices that fluctuate over time, following actual market prices.

3.2.1 What are dynamic energy prices?

A dynamic tariff is an energy pricing plan where rates fluctuate. This price affects both the price of buying energy, that is taking it from the grid, and selling energy, when generated energy is exported into the grid. Some homeowners might already be familiar with a simple variable rate plan, known as time-of-use, where rates differ between day and night. The key distinction between time-of-use and dynamic tariffs is the frequency of rate changes. Unlike time-of-use plans that have a few fixed rates each day, dynamic tariffs are based on hourly market prices for electricity, often referred to as day-ahead spot prices. In some markets, these prices are broken down even further, to 30 or 15 minute intervals.

In Europe, electricity is traded on central marketplaces. A significant one is the EPEX day-ahead spot market, where energy is traded every 15 minutes for the next day based on supply and demand. Daily auctions determine the new 15 minute spot prices for the following day, announced about 11 hours in advance.

These prices, influenced by energy supply and demand, accurately reflect renewable energy conditions. Prices are low during sunny summer afternoons when demand is low and solar generation is high, as well as during stormy winter nights with high wind energy generation. Prices rise when demand is high, and renewable generation is low, such as on dark or cloudy working days.

Overgeneration of renewable energy can even drive prices to become negative, which is an increasing trend. Negative prices occur when the market needs to eliminate excess energy. During these moments, consumers can be paid to use energy and might be limited or penalized for exporting energy onto the grid. These negative prices help balance the grid and address overgeneration.

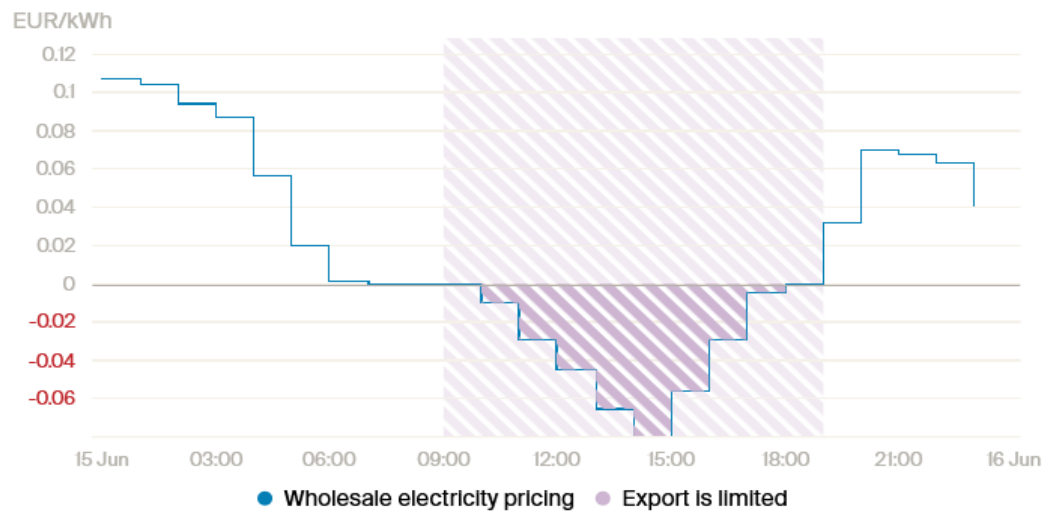


Switching to a dynamic energy contract is especially interesting as a consequence of the introduction of a charge by the energy providers, the return cost, associated with exporting self-generated energy to the grid. Consumers with a dynamic contract avoid these charges, which can currently add up to €25 to a household's monthly energy bill.

3.3 Avoiding losses with Autarco's PV curtailment solution

With a dynamic energy contract, consumers can be subject to negative energy prices. When energy prices are negative, exporting self-generated energy to the grid results in costs for the consumer. At the same time, importing energy from the grid during moments of negative prices can be attractive and result in bonus payments from certain energy providers. Negative prices occur more frequently and happen during moments of overgeneration. This is why consumers with dynamic contracts benefit from Autarco's PV curtailment. This solution automatically adjusts the solar energy export to the grid when prices drop below zero. The solar system will limit its production so that no excess solar energy is exported to the grid during those times, thereby avoiding costs for the consumer.

Energy management

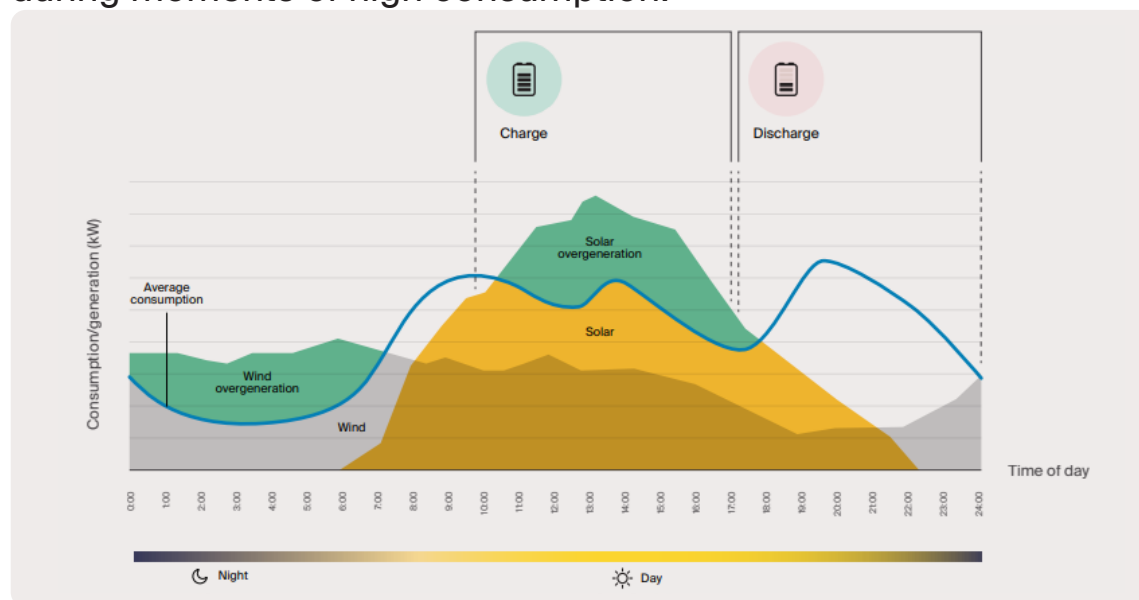


Consumers with a dynamic energy contract benefit from Autarco PV curtailment through savings on their energy bills by avoiding export penalties during moments of negative energy prices that occur in the market. These monthly savings are even higher when consumers are financially rewarded by their energy provider for importing energy during those moments.

3.4 Avoiding penalties, gaining freedom: solar PV and battery solutions

As mentioned, the main solution for overgeneration is increasing the self-consumption of generated solar energy. The key product for achieving this is battery storage. By adding a battery to your solar solution, you can store excess energy locally. The battery will charge when local generation exceeds local consumption, instead of exporting this energy to the grid. This solution mitigates export penalties and promotes the use of green energy. At a later moment, when local energy generation is low and local consumption is high, the battery will discharge and the previously generated energy will be used, instead of having to draw energy from the grid.

The battery improves self-consumption of generated energy by charging during moments of overgeneration and discharging during moments of high consumption.



Adding a battery to the solar solution includes additional upfront investment in the battery, which extends the payback period of the total system. In return, the consumer will experience extra savings on their monthly energy bill, as self-consumption increases through the ability to store generated energy for later use. The height of savings depends on the size of the solar system and the battery.

3.5 Unlocking the full potential of solar PV and battery storage powered by EMS

The next step, increasing consumer's control over their energy bills even further, involves an expansion of the features of Autarco Energy Management, in addition to PV curtailment. With the presence of a battery, the dynamic tariffs can be used to optimize energy use and storage, reducing reliance on the grid and increasing savings. This means that the battery charges and discharges optimally. With smart charging, the battery charges during moments of overgeneration as well as moments when consumption and market prices are low. During negative price moments, the solar system no longer needs to limit production during moments of negative prices, but can instead store excess energy locally. In turn, the battery discharges when consumption levels are high and local generation is insufficient, especially with high market prices.

Smart charging is based on local energy generation, consumption and market prices.

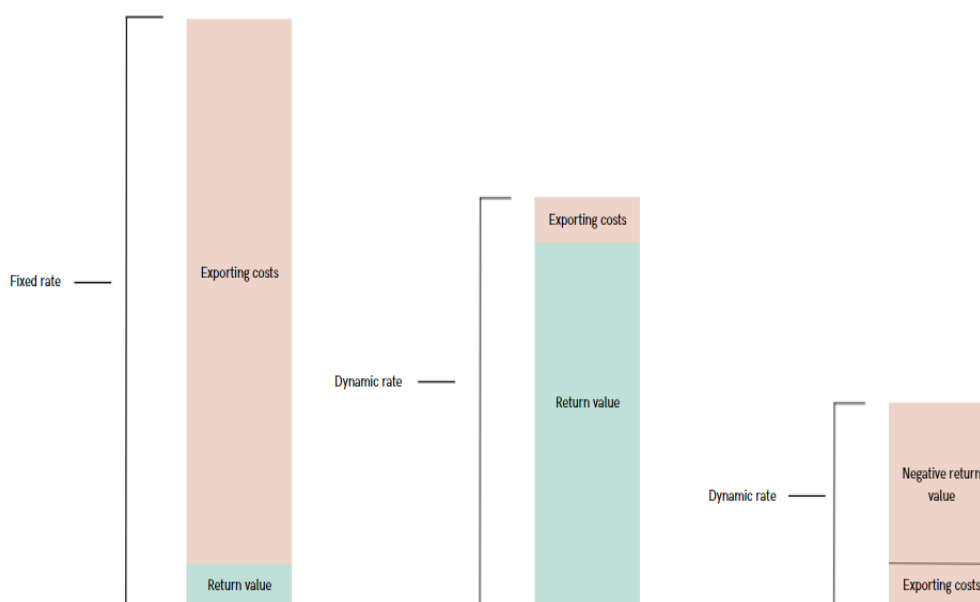


Additional energy management features, such as smart charging, improve the consumer's self-consumption, maximize export profits and minimize costs. The size of the total system determines the height of the monthly savings. The addition of Autarco Energy Management can reduce the payback period of the total system through its significant savings on the consumer's energy bill by taking advantage of low-price periods and selling energy during high-price periods.

3.5.1 Saving on export costs

Switching from a fixed to a dynamic energy contract can significantly reduce export costs. This is because the export tariffs under dynamic contracts are generally lower than those of fixed contracts. While the average value per kWh may be lower in a dynamic setup favorable for self-consumption but less advantageous for large volumes of exported energy, the overall result is that consumers in markets such as the Netherlands can achieve meaningful savings on export costs and secure higher compensation for the energy they do export.

However, as outlined in Chapter 3.3, dynamic contracts also introduce the challenge of volatility. At certain times, dynamic tariffs may turn negative, leading to situations where consumers must pay to export their surplus energy.



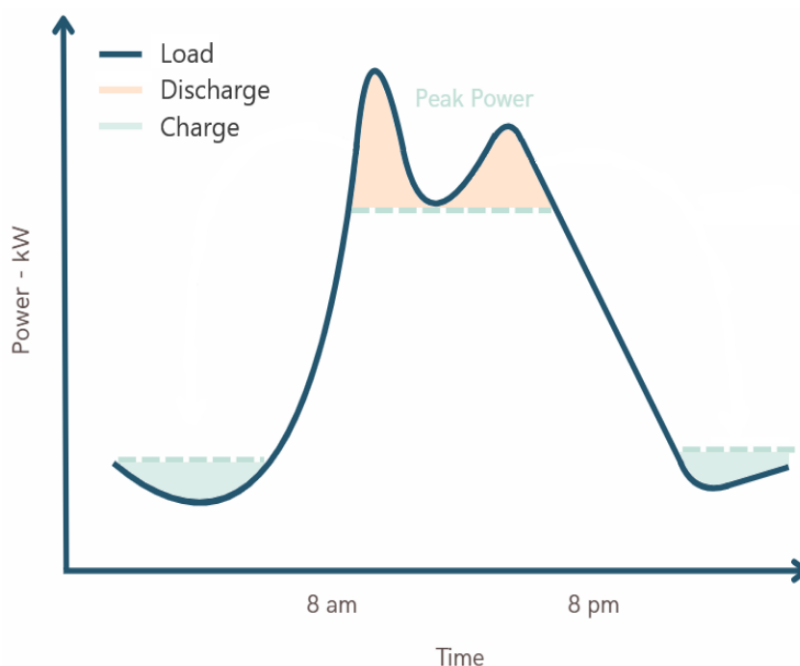
An Energy Management System (EMS), combined with battery storage, optimizes energy flows to maximize financial and operational benefits. While a battery alone provides value by storing excess solar energy for use at night, an EMS goes further. It actively manages when the battery charges, how much energy is produced (through PV curtailment), and when to prioritize self-consumption versus export.

For example, during periods of overproduction, exporting may still be profitable early in the day but can become costly later when export prices turn negative. The EMS shifts charging to those later hours, ensuring energy is stored instead of exported at a loss. In this way, the EMS minimizes export costs and unlocks savings that would not be possible with battery storage alone.

3.6 Peak Shaving

Peak shaving is a powerful energy management feature enabled by battery storage systems, designed to effectively extend the capacity of your current grid connection and optimize energy usage.

The core principle of peak shaving is straightforward yet impactful: when grid demand exceeds a defined threshold, the system automatically discharges stored energy to supplement the load. Once demand drops back below the lower threshold, the system stops discharging and begins recharging the battery, ensuring it's prepared for future peaks



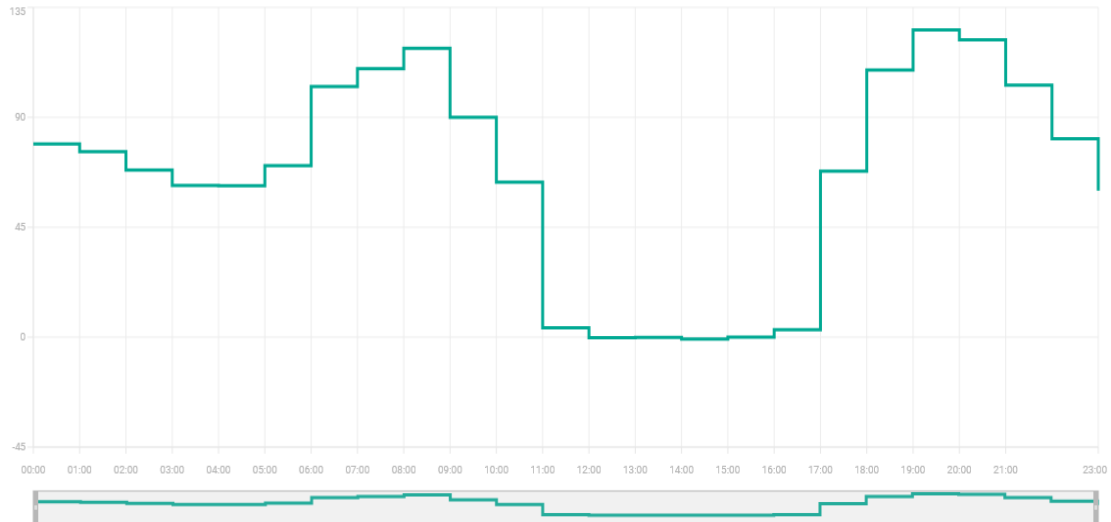
3.6.1 Summer & Winter

There is a common misconception that an Energy Management System (EMS) only provides benefits during the summer months. It is true that summer brings high levels of PV generation, leading to fluctuations in both grid stability and energy prices. However, EMS delivers just as much value during the winter.

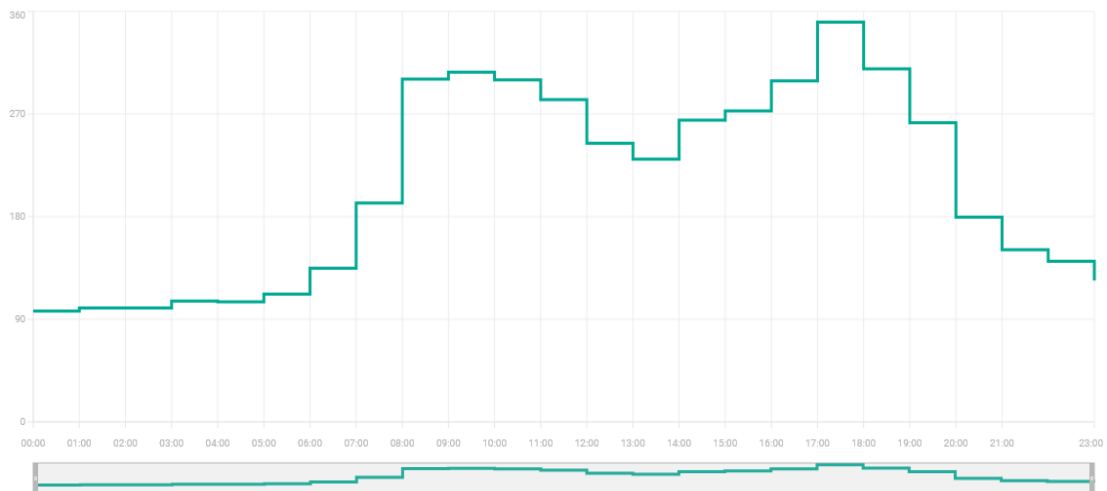
In colder months, electricity consumption rises significantly due to increased use of heat pumps and boilers. This seasonal demand shift is clearly reflected in consumption profiles and market prices.

The example below shows a typical day in the energy market during the summer, highlighting how EMS can respond to these dynamics.

During the summer, energy prices are typically very low around midday when PV production is at its peak. In contrast, prices rise sharply during the morning and evening demand peaks, creating strong price differences within a single day.



In winter, the pattern shifts. Both prices and consumption are highest during daytime hours, when heating demand drives overall electricity use. At night, consumption is more stable, which generally results in lower and less volatile prices.



An Energy Management System (EMS) automatically adapts to seasonal changes, optimizing energy flows on a daily basis according to consumption patterns and dynamic market prices. This ensures that the benefits of EMS are not limited to sunny months with high PV generation. Even during periods of lower solar production, the EMS identifies the most cost-effective moments to charge from the grid, allowing consumers to continue profiting from the lowest available energy prices.

4. Conclusion

The shift towards renewable energy is reshaping the energy landscape, presenting both opportunities and challenges for European energy consumers. The increasing prevalence of decentralized and variable renewable energy sources, such as solar and wind, necessitates advanced solutions to maintain grid stability and manage costs.

Rather than bolting together multiple component brands, Autarco addresses these challenges with seamlessly integrated solar solutions that combine solar PV systems, battery storage and advanced energy management. These scalable solutions not only mitigate the issues of overgeneration and grid imbalance but also deliver meaningful financial benefits.

By offering technology that is simple to adopt, inherently profitable to operate and safe by design, Autarco empowers energy consumers to take charge of their energy future. The result is long-term financial stability, resilience in an evolving market, and a clear path towards €0 energy bills for homes and businesses everywhere.

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