nymea:energy

The operating system for intelligent car chargers

White Paper

Introduction

With the market for electric vehicles booming, the charging infrastructure for the private sector is also booming - over 80% of electric vehicles are charged at home or at work.
Charging stations for home use - from here referred colloquially as ‚wallbox' - are the electrical interface from the vehicle to the grid and thus a very important component in the low-voltage grid. It is not for nothing that the grid operators want digital interfaces to be able to influence the charging processes.

The run for market share started years ago. In the meantime, there are hardly any physical distinguishing features between the offers.
Good differentiation can only be achieved with digital innovation.

The typical digital applications are:

- PV surplus charging
- smart charging with dynamic electricity tariffs (spot market)
- Blackout prevention
- Dynamic charging management (distributing the available power to all charging points)
- State of charge (SoC) readout via car manufacturer APIs or ISO15118
- User management RFID/app
- billing of charging for employees
- bidirectional charging
- smartphone apps and/or dashboards
- open APIs for communication with higher-level EMS systems, network operators or billing platforms.

Image 1 The transition from a simple wallbox to an intelligent wallbox is quick and of high quality with the help of the nymea:energy framework.

The market potential

An ever larger part of the population is dealing with energy issues. Electric vehicles, photovoltaic systems and battery storage are increasingly becoming mass products (commodities).
Due to the great upswing in electric mobility, many millions of charging stations are being installed in garages. A wallbox is therefore a very suitable "carrier medium" for introducing digital energy innovations to end customers. The demand for intelligent charging stations has exploded.

We claim:

A wallbox is the entry point to an intelligent energy system.

By successively expanding the software, an intelligent wallbox can "grow" into a simple home energy management system.
The wallbox is therefore not a dumb socket, but a platform for energy-related services.
The conventional complicated and expensive energy managers on the top-hat rail become obsolete through intelligent, integrated solutions that are already supplied with the intelligent charging station as a software add-on.

Of course, this approach could also be applied to other devices such as PV inverters or heat pumps. But we believe that wallboxes will become commodity products, which one buys as naturally as a washing machine. They will not only become cheaper, but will probably also be replaced more often than the other devices mentioned. The wallbox is therefore - at least from today's perspective - a perfect "technology carrier".

Possible combinations

The core of nymea:energy is embedded software. So the code runs on a physical device on site - mostly as part of the firmware. Running and communicating on the local network offers a number of advantages, which you can read about in this section.

The following product variants are possible accordingly:

nymea:energy runs on an external device – e.g. the nymea:energy Gateway.

nymea:energy runs on a Linux-Module (SoM), that is integrated in the wallbox.

nymea:energy runs as firmware application of a Linux-based wallbox.

The first variant - the use of an external device - is omitted from this white paper. You can find any detail for the retrofit solution under https://www.nymea.energy/b2c. We focus on those variants that are integrated into the wallbox and thus enhance the wallbox as a product.

The basis for a future-proof wallbox

Hardware

Many manufacturers have chosen the path of optimising their margins by keeping bill-of-material as low as possible. Most wallboxes can be controlled via ModBUS RTU / TCP or an IP protocol. This functionality marks the end of the digital functional range. The wallboxes can be integrated into higher-level systems (HEMS) through an interface - but they cannot be a higher-level system.
However, small Linux computers are increasingly being built into the newer devices. High-performance hardware has a somewhat higher price, but these devices can be provided with software upgrades for years, which massively increase the functional range of a wallbox - and thus also the digital upselling potential.
It is obvious that a wallbox sold in 2023 should be a software-defined product: the life cycle of a wallbox is probably 10 years or more. And during this period, e-mobility will experience a digital upheaval, like telephones have since the first iPhone.
Most customers - provided they are aware that they are buying a future-proof product - will gladly accept the extra price.

Software

After the decision about future-proof hardware has been made, it is also important to choose a software platform that is as future-proof as possible.
Software development costs a lot of time and money, and there are also a lot of technological risks that are often difficult to assess.
nymea:energy offers future-proofness and comes with a wide range of basic functions. It saves thousands of developer hours.

nymea:energy is based on the open consumer IoT platform nymea.io, which is already used in many modern IoT products. The software can control dozens of devices regardless of their interfaces, APIs and protocols and has all the tools, libraries and services necessary for a modern IoT product. In addition, there is a framework for user interfaces, with which beautiful and performant end-user apps can be created in a short time.
Most of the technical risks can be eliminated, as the solution has been in use for years with a large number of products.
The time-to-market for nymea:energy based products is typically less than one quarter - sometimes even only a few weeks.

Basic requirements

The wallbox has a Linux-compatible charge controller, a Linux module (SoM)[1], that is connected to the mainboard, or a single-board computer that is built into the wallbox housing. If this is not yet the case, nymea GmbH can offer SoM/SBC solutions or refer you to high-quality and reputable partners.

Installation

nymea:energy is (co)installed into this Linux system. Fortunately, the software has a low resource requirement. The memory requirement varies with the number of installed interfaces / features and is only between 10 and 30 megabytes. Most of the installed Linux modules are therefore completely sufficient. By the way, the nymea stack can be offered for all common Linux platforms (Yocto, Debian, Gelin, ...).
As soon as the software is installed and correctly configured, it can already be controlled with a smartphone app: Gladly In the app stores (search for ‚nymea' and ‚nymea:energy').

Integration of the wallbox' functionality

In order for the internal functions of the charging station to be controlled by nymea:energy, an integration plug-in must be written. This plugin communicates either through the firmware's programming interface (HAL[2]), or via ModBus with the charge controller.
This integration is typically created within a few working days by a NYMEA expert - but it can also be done by any third party.

Rebranding

If desired, the entire nymea:energy app can be adapted to individual design specifications or completely customised in terms of structure and feature set. The nymea GmbH team will be happy to advise you on the possibilities.

[1] SoM oder System on Module
[2] HAL = Hardware Abstraction Layer

Topology

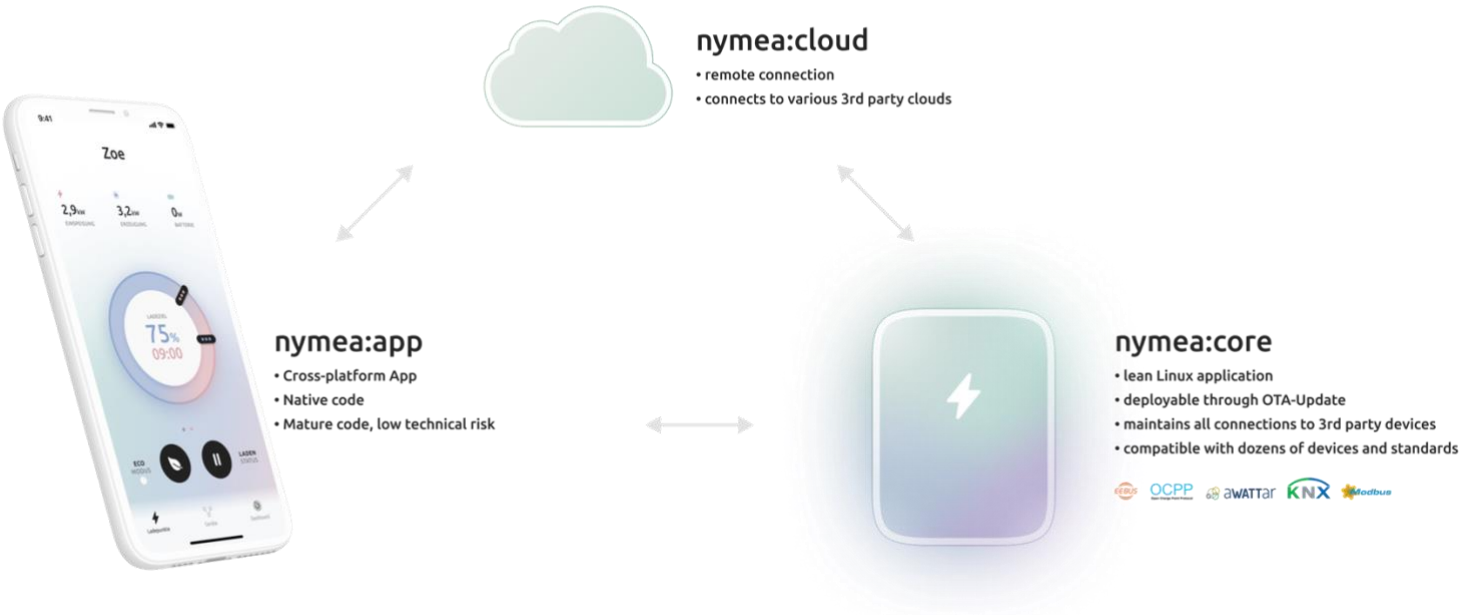


Image 2 Topology of the nymea framework

nymea:core

The central building block of the framework is, as the name suggests, the nymea:core. This server application handles the communication and control of all devices to be connected.

nymea:core is a very mature communication stack that has been under development since 2013 and has been successfully used commercially since 2016.

- Thousands of deployments
- Proven and stable
- Austrian company maintains and services the stack
- Lean framework, very easy to extend
- Open source (!)
- Growing platform

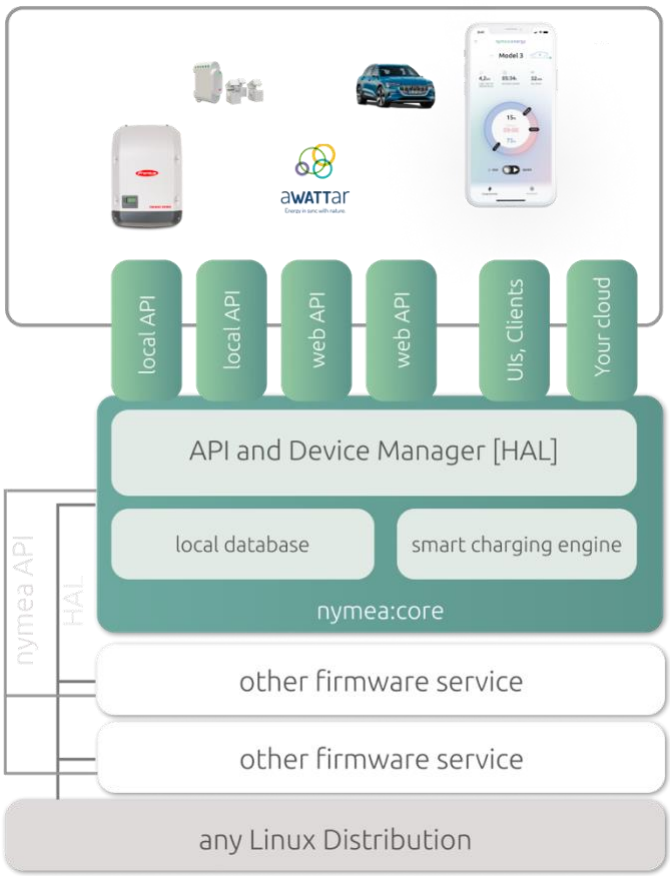


Image 3 nymea:core – the central server application that is "embedded" in the product

Local operation "on the edge" has the following advantages compared to cloud solutions:

- Complete sector coupling is only possible locally. Field buses and protocols such as ModBus TCP/RTU, UDP, MQTT, Loxone, etc. can usually only be addressed unhindered in the local network. The majority of devices on the market can only be controlled locally.
- No cloud connection necessary for functional operation
- Fast response times
- Fail-safe
- Privacy-by-design, as all data is only stored locally

App

The nymea:energy app is a derivative of the nymea:app, which can be ported to all common platforms. The frontend is based on cross-platform Qt, so it runs as native code on the end device and therefore runs very smoothly. The fast connection establishment and the mature code are very conducive to the user experience. The app can be adapted well to various requirements as a white-label variant and placed in the app stores as an independent product app. A white-label variant can be placed in the app stores in record time.

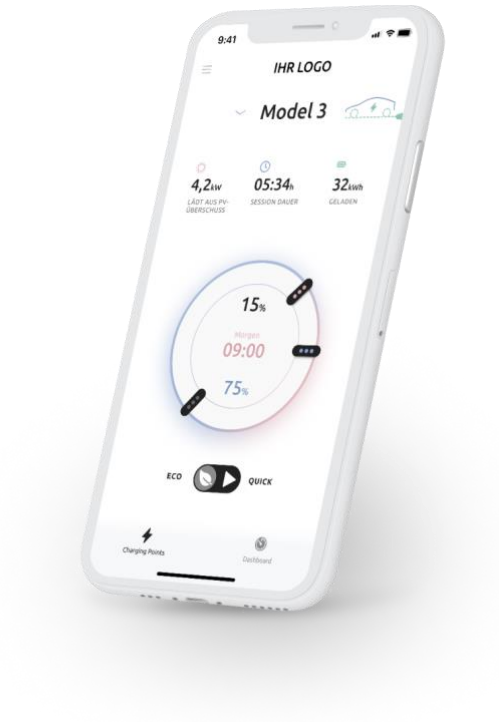


Image 4 Symbolic representation of the nymea:energy app

Cloud

Although the functional part is independent, a minimalist cloud application fulfils two important functions:

- Remote connectivity
- Connection to higher-level cloud backends

nymea:energy from the user's point of view

Setup

The setup process is shown at www.nymea.energy:

- The network is set up. Depending on availability, you can choose between
  - Wifi and
  - Ethernet.
- The local network is automatically scanned for PV systems.
  - If no PV system is found automatically, the manual guided PV system setup is started.
- The local network is automatically scanned for Meters.
  - If no Meter is found automatically, the manual guided Meter setup is started.
- If a smart meter tariff is applicable, the user can enable it.
- The electric vehicle is coupled to the system. If this is not possible, the battery capacity is entered manually.

Daily use

The user story is a defined process that starts every time the user connects the car to the charging station:

- The user receives a notification. Clicking on this notification opens the home screen of the app:
  - The state of charge of the battery (in %) (if the SoC is not read out via Car-API).
  - When should the car be charged and to what percentage.
  - Wie soll der Ladestand zur Zielzeit sein.

The user can switch between two modes at any time:

- Quick: load as quickly as possible, with consideration for load limitation (blackout prevention enabled)
- Eco (PV surplus and/or smart meter tariff): Charging is done with PV surplus if possible. Depending on the desired charging goal, the system will determine an optimal schedule.

Features

Integration of the existing measuring equipment

The information underlying PV surplus charging is the measurement of the current flow at the grid transfer point. A meter measures the current flow at the root and is therefore also called a root meter. Most PV surplus charging solutions are therefore delivered with a meter.

In most cases, a meter is already installed in the PV system – native support of nymea:energy eliminates the need to install another meter. nymea:energy is one of the very few providers that supports the majority of PV inverters on the market and reads meters that are already installed (e.g. Fronius Smart Meter, Kostal Smart Meter, etc.). The list of integrations is available at https://www.nymea.energy/integrations.

This not only saves the cost of an additional metre, but also the installation in the control cabinet, which results in a further significant cost reduction.

If there is no meter yet, we recommend the Shelly 3EM, as it is relatively easy to install and transmits the data via WiFi in the local network. No wiring is necessary.

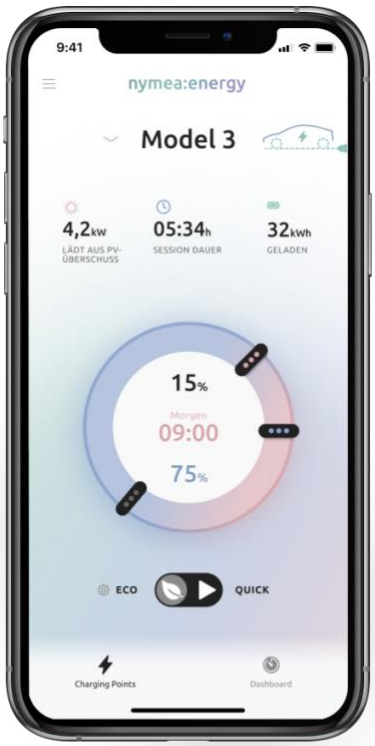
oder

Image 5 Symbolic images of PV inverters or measuring devices

Eco Mode (PV Surplus and/ or dynamic energy tariff)

Eco Mode is the intelligent mode of nymea:energy. Machine learning, weather forecasts and historical charging data are used to create a timetable for each charging point. Eco mode has the following advantages and takes the following factors into account:

- A minimum charge ensures the short-term availability of the vehicle for emergencies.
- A separate dashboard in the app shows the amount of energy of the "cheap" PV electricity that was used.
- In practice, charging is rarely done exclusively with PV power, as 6 amps per phase is the minimum charging power in most cases. Instead, the system will charge the car with as much PV electricity in the electricity mix as possible. The amount of electricity drawn from the grid can be chosen by the user.
- All respective data is not stored in a cloud, but locally on the actual device. This guarantees 100% privacy. The system fetches data from the network, but no data is sent to the network.



Why is PV surplus loading becoming more and more interesting?

- The feed-in tariff is unattractive in most countries.
- The economic efficiency of a PV system increases with self-consumption. There are no grid fees, taxes and other charges for "home-produced" electricity.
- Grid electricity has become particularly expensive recently - since then, having your own PV system has become even more economical.

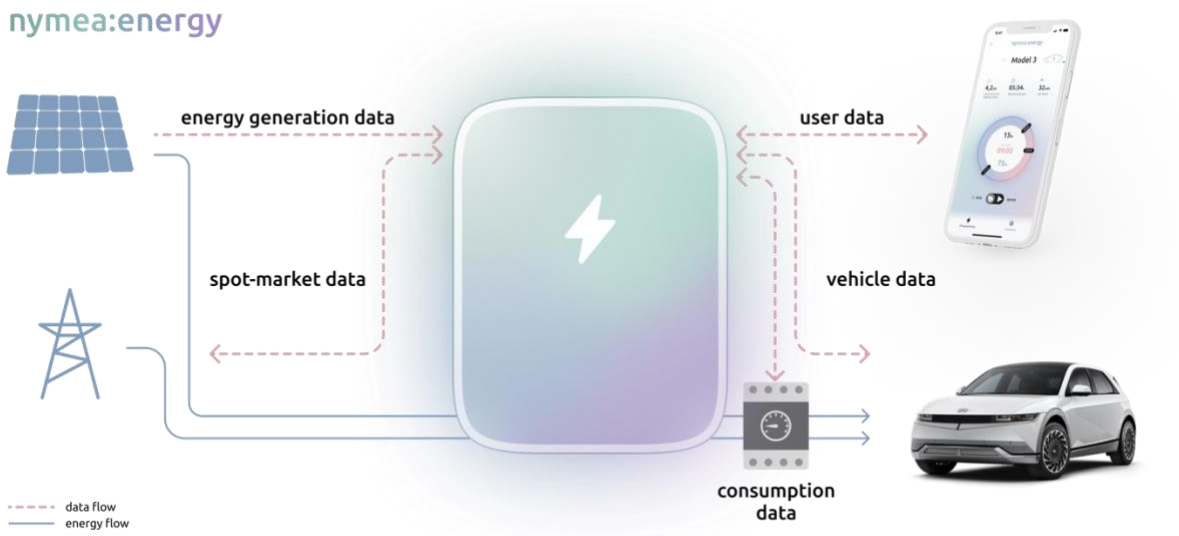


Image 6 Communication and energy flow during charging with dynamic power sources

Why is spot market shopping becoming more and more interesting?

Those who do not have their own PV system can still benefit from the fluctuating, cheap, renewable energy. This is done via spot market tariffs. The spot market tariffs - also often called "smart meter tariffs" in Austria - require a smart meter so that the grid operator can measure and allocate electricity consumption in small time intervals. The spot market is an electricity exchange in which electricity tariffs are calculated and charged at very short notice (24 hours).

The prices of the EPEX Spot power exchange are the basis for most dynamic electricity prices.

When charging via dynamic electricity tariffs, grid fees and tax must be paid as usual. Just a few years ago, the fluctuations of the EPEX Spot prices were marginal - making the offer of dynamic tariffs largely unattractive.

Today, the electricity market experiences massive fluctuations - which is why billing on an hourly (or sometimes even quarter-hourly) basis has become very attractive.

The example below from "aWATTar hourly" shows that the gross prices can differ by up to 40 cents. Thus, in the optimal case, around 30 euros can be saved on a full charge of an electric vehicle.
In Eco mode, nymea:energy shifts charging to a favourable period.

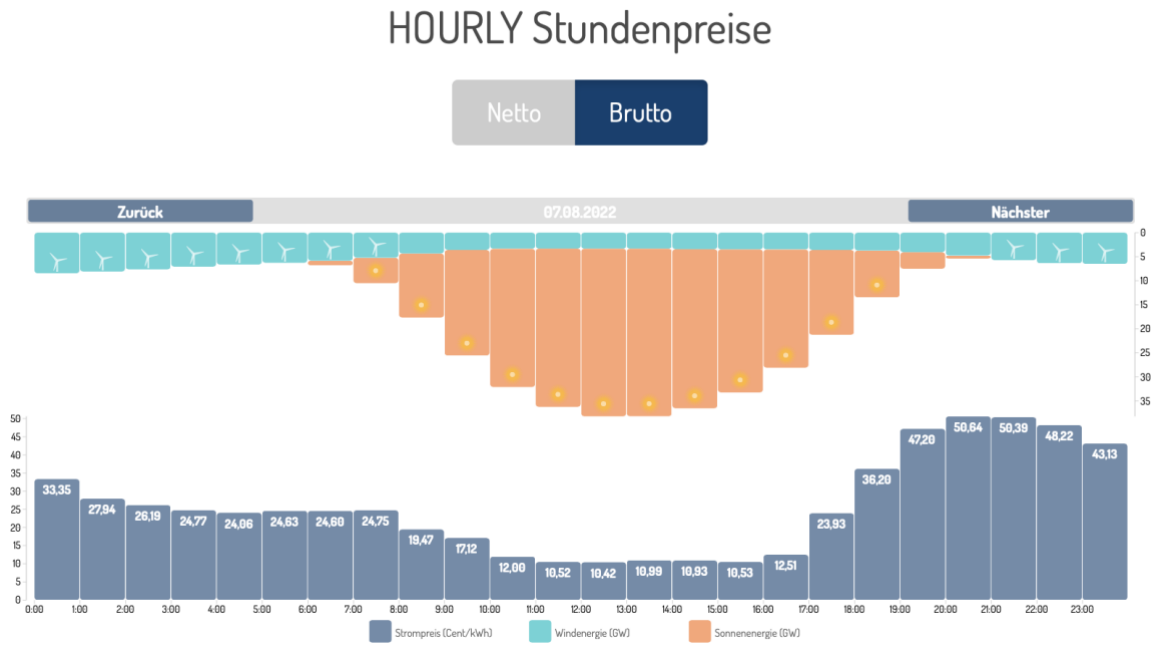


Image 7 Electricity prices in the aWATTar hourly tariff as of 7 August 2022

The large fluctuations occur due to the large share of cheap, renewable energy and the prevailing problems in the energy market due to dependencies on energy suppliers from abroad.
Charging with spot tariffs therefore not only has a positive effect on the economic balance of the vehicle user, but it is an incentive to use and expand renewable energy sources at all levels. In addition, the purchase of renewable energy at the time it is generated has a very positive impact on Europe-wide grid stability.

Load management (Blackout prevention)

The grid connection can be overloaded when several charging stations or other larger consumers are operated in parallel. Therefore, load management is mandatory.
With nymea:energy, the load is automatically regulated and limited. Load management is active in both Comfort and Eco modes.
If there is no meter to measure the total current at the connection, the system will always limit the load if two or more charging processes are active:

- In an active charging process → full power.
- With two or more active charging processes → equal distribution.Das Anschlussmaximum wird beim Setup konfiguriert.

If a meter is available, all electrical loads can be operated until just below the load limit. If the load at the house connection increases abruptly - for example by switching on a household appliance - the charging currents are immediately reduced by the necessary proportion.

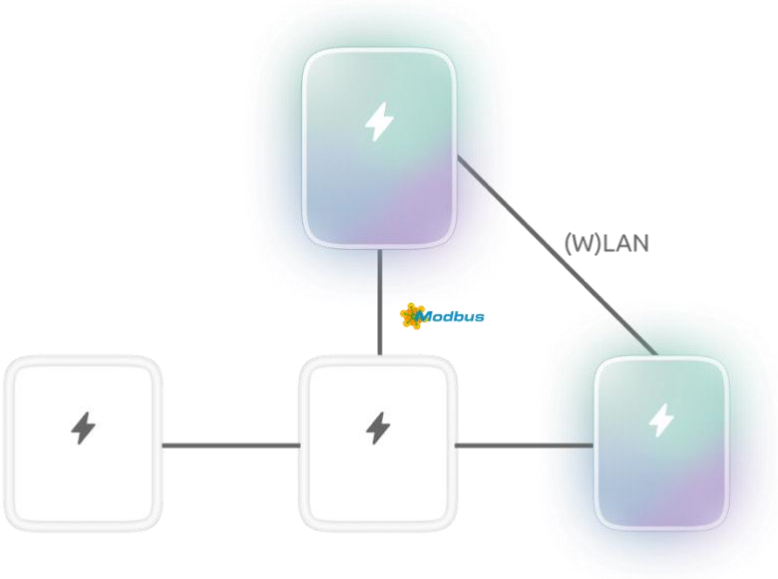
Dynamic charge management

nymea:energy can not only be used for excess PV charging, but also for dynamic charging and load management in the semi-public sector (e.g. in the car parks at the office). Each user of the charging park can use the nymea:energy app to configure the charging point / vehicle / charging destination and use the charging infrastructure without any worries.

The allocation of energy quantities takes place on the basis of the set charging destination at each charging point.
nymea:energy automatically calculates the individual charging profiles for each charging point. In addition to the maximum total power, PV surplus, spot market tariffs, power limits of the vehicles / wallboxes / charging cables and other factors are taken into account.

A PV system or a spot market tariff is not a prerequisite.

nymea:energy is the leader in terms of price/performance ratio for modern, dynamic charging solutions. Any charging station connected to nymea:energy can be used.


(W)LAN
Modbus

Integrations

Available integrations

An up-to-date list including documentation can be found at
https://www.nymea.energy/integrations

Photovoltaic-Inverter / Meter

- Fronius
- SMA
- Kostal
- SolarEdge
- Huawei
- Sunspec (fast alle PV Inverter, sowie einige Zähler und Batterien)

Chargers

- KEBA
- Wallbe / Compleo / Scapo
- Webasto Live
- go-eCharger
- Schrack i-Charge
- Mennekes
- Easee
- …

Meters

- All smart meters that are coupled with the PV inverter
- Sunspec-capable meters
- Shelly EM3 (WiFi based for retrofitting)
- B+G SDM 630 and more ModBus TCP/RTU based meters

Cloud-based APIs

- aWATTar
- OpenWeatherMap (Wetterprognosen)

This list of integrations is only a relevant excerpt. The integration list is constantly being expanded.

New Integrations

Integrations ("nymea Integration Plugins") can be created relatively quickly and easily by nymea GmbH, by external service providers or in-house.
All documentation is publicly available:
https://nymea.io/documentation/developers/write-plugins

The quickest and therefore probably cheapest option is to commission the experts at nymea GmbH with this.

Roadmap

Stand: 21. March 2023
The roadmap for the end-user product nymea:energy can be found here:
https://www.nymea.energy/roadmap

Further major integrations are planned - the order of implementation depends on the requirements of the B2B partners:

- EEBus
- CLS / HAN for interfacing with the German Smart Meter Gateway
- Matter - Smart Home Integration

Vision

Now that several million BEVs will be connected to the grid in just a few years, a new energy storage class in the terawatt range is emerging.
However, the standards to address this collective electricity storage digitally and reliably are still missing. Only a very small proportion of home charging stations can be addressed via OCPP or from the cloud. The nymea software is a state-of-the-art IoT stack, which allows us to react very quickly to new standards or platforms.
With each nymea-based product, a new, controllable "cell" is created in the collective memory. We expect nymea:energy to take a significant share of the collective electricity storage market in a few years and thus to serve the grid (operator) on a global scale.

Competition

The market for intelligent charging solutions is rapidly gaining momentum. Here we list some example products that are in direct or indirect competition with nymea:energy.

Smart Chargers with PV surplus charging capabilities

- Zappi https://myenergi.de/produkte/zappi-wallbox/
- Wallbox.com www.wallbox.com
- Smappee https://www.smappee.com/ev-wall/
- SMARTFOX Pro https://youtu.be/rwAMYXt8X4o
- openWB https://openwb.de/main/
- KEBA PV-Edition

External energy managers

Open Source bzw. Software-only

- evcc.io www.evcc.io
- openEMS www.openems.io

Systemlösungen

- GridX www.gridx.ai
- Smartfox https://www.smartfox.at

Cloud-Lösungen

- Clever-PV https://clever-pv.com
- EV-Autocharge https://www.ev-autocharge.com/

Reputation

The nymea GmbH team has been working on the nymea framework since 2013. The software is already used in over 50,000 products.
The team has extensive know-how in interoperability (buses, protocols, APIs), embedded systems and user experience. Having involved dozens of man-years of effort and constant perfection, the nymea platform has very few comparable platforms that are so well suited to intelligent embedded energy management systems.
Nymea is also based on Qt/C++ and is perfectly suited for embedded Linux systems due to its small footprint. Comparable platforms such as openEMS need dozens or even hundreds of MB of RAM, which is rarely installed for cost reasons.
Apart from the technical platform, there is a lot of practical experience with digital business models based on IoT products - so the managers of nymea GmbH can also bring a lot of validated knowledge into product management in a strategic context.
With the exception of pure open source projects, there is no other company that can offer such a mature overall package for a state-of-the-art IoT product.

Window of Opportunity

We expect that only a few companies will be able to deliver the functionalities discussed in this document within the next few months.
Those providers who strengthen their position as digitalisation leaders today will enjoy comparatively high sales figures in the coming years.

We look forward to a non-binding and pleasant initial discussion. Of course, we would also be happy to show you our technologies.
Write to us at energy@nymea.io!