

Unleashing Bidirectional Charging

Protocols, Challenges, and Strategies with EVerest



About me

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Background in electrical engineering
Working @ PIONIX on EVerest since
2021



PIONIX

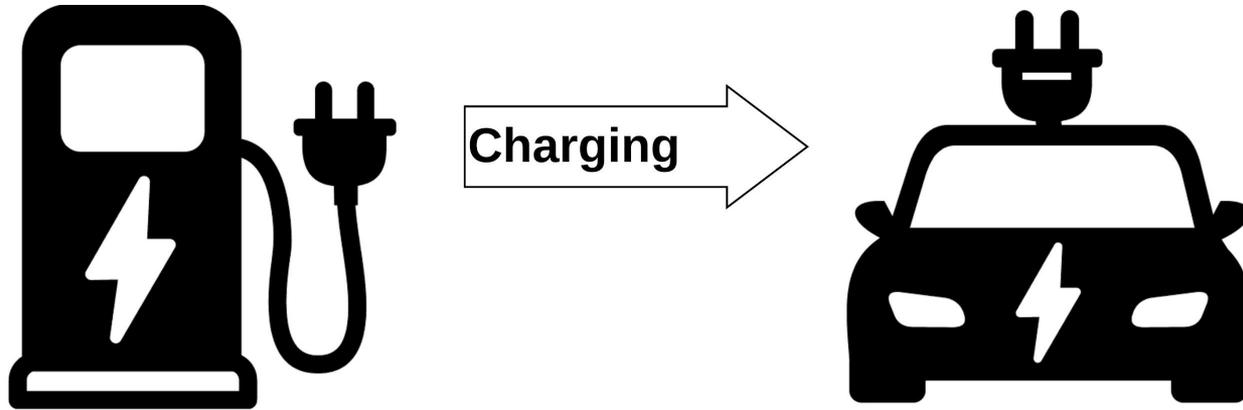


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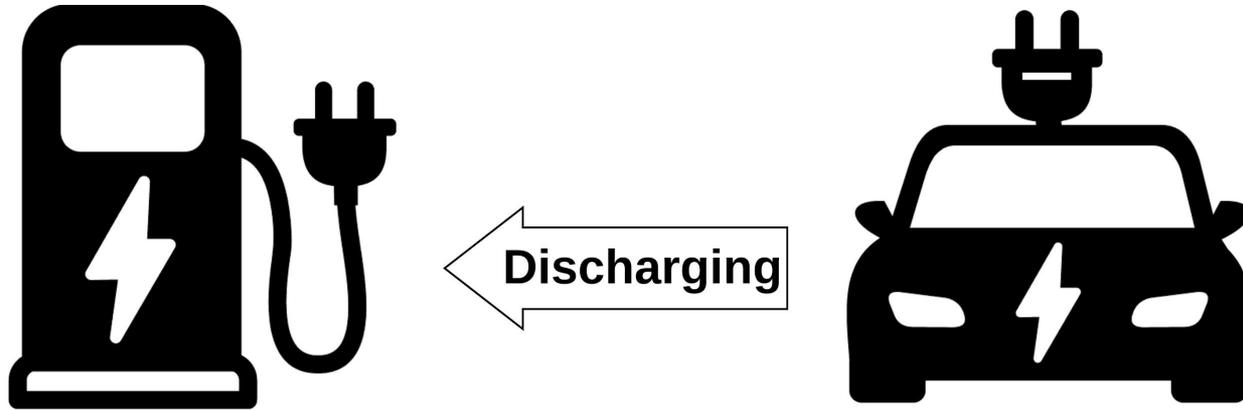
- What is bidirectional charging and why should I do it?
- Charging and Discharging Strategies
- The entire impact chain of bidirectional charging
 - EEBUS
 - ISO 15118
 - OCPP
- Energy Management in EVerest
- Conclusion

What is Bidirectional Charging?

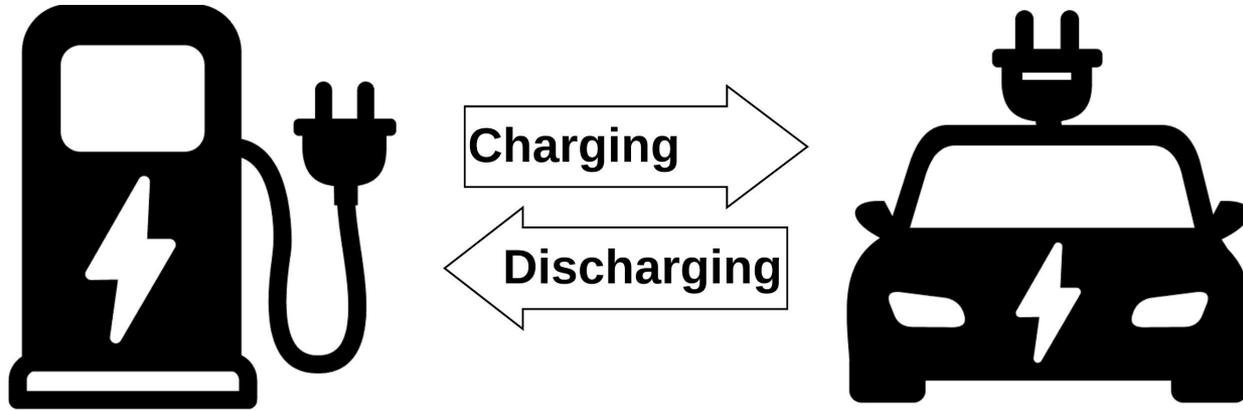
What is bidirectional charging?



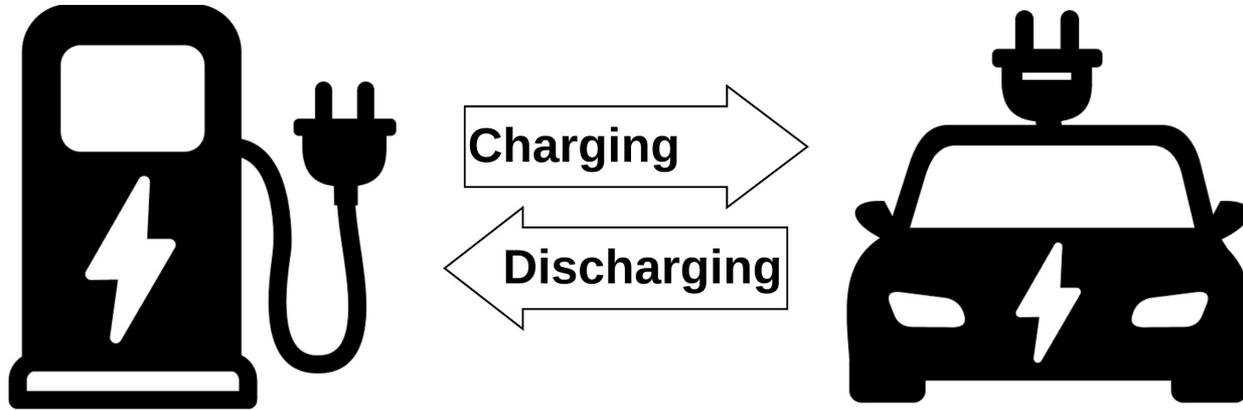
What is bidirectional charging?



What is bidirectional charging?



What is bidirectional charging?



Bidirectional Charging

Why should I do Bidirectional Charging?

Why should I do bidirectional charging

- 1 **Climate Change** → We need an energy transition
 - 2 **Renewable Energies** → More solar & wind power integration
 - 3 **Decentralized Smart Grid** → Small producers, flexible energy use
 - 4 **Grid Stabilization** → Balancing fluctuations, supporting stability
- 💰 **Price Optimization** → Charge when electricity is cheap
 - ⚡ **Emergency Power Supply** → Energy security for your home
 - 🔋 **EV as Power Bank** → Energy at camping ground 🏕️

Charging and Discharging Strategies

Charging and Discharging Strategies

Fast Charging



Charging and Discharging Strategies

Electric Vehicle

Minimal Charging Power	2,3 kW
Maximal Charging Power	50 kW
Battery Size	75 kWh



Charging and Discharging Strategies

Fast Charging

Arrival Time	0 h
SOC at 0h	10 kWh (~13%)
External Restriction after 30 min	20 kW
Target SOC	75 kWh (100%)

Goal:

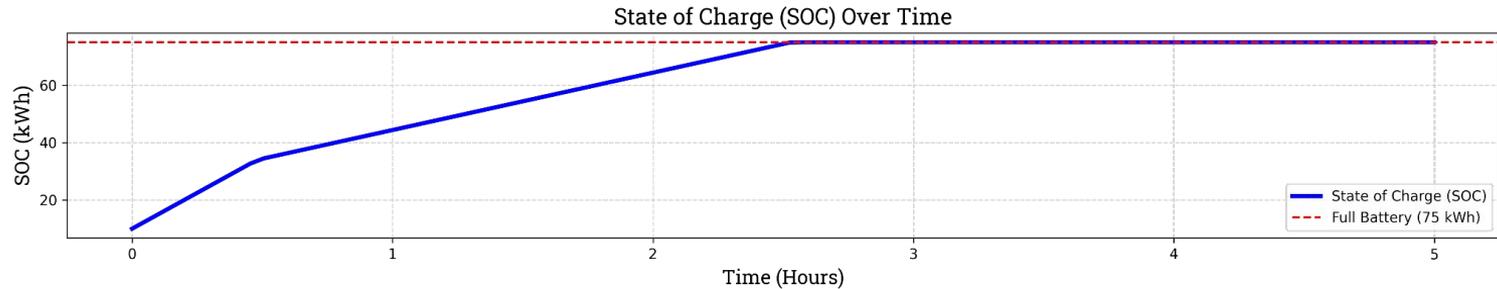
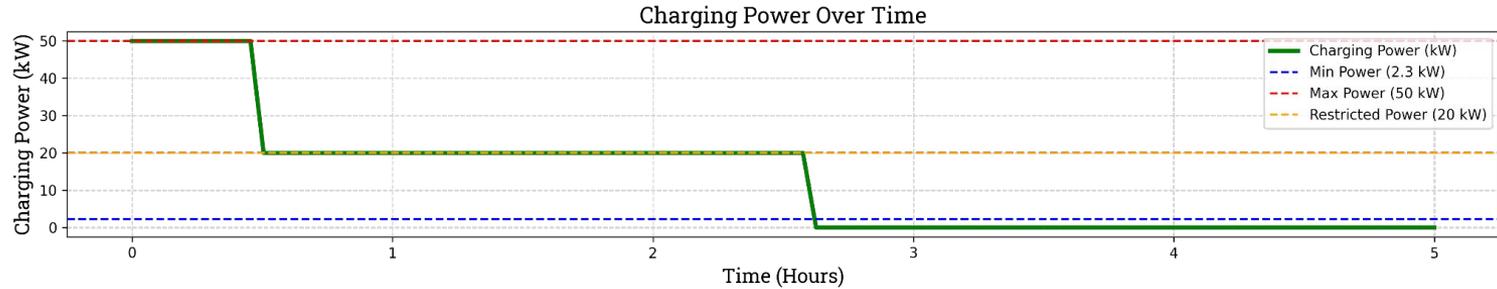
Charge EV as fast as possible

Strategy:

Charge with maximal available power until EV reaches SOC of 75 kWh (100%)

Charging and Discharging Strategies

Fast Charging



Charging and Discharging Strategies

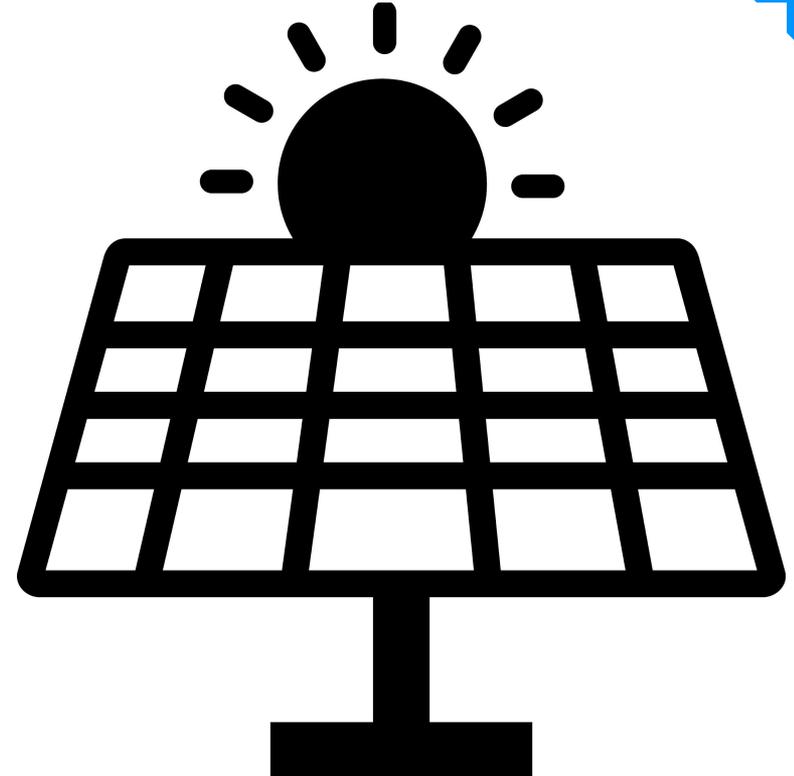
Optimize PV consumption with other consumers



Charging and Discharging Strategies

Photovoltaic System

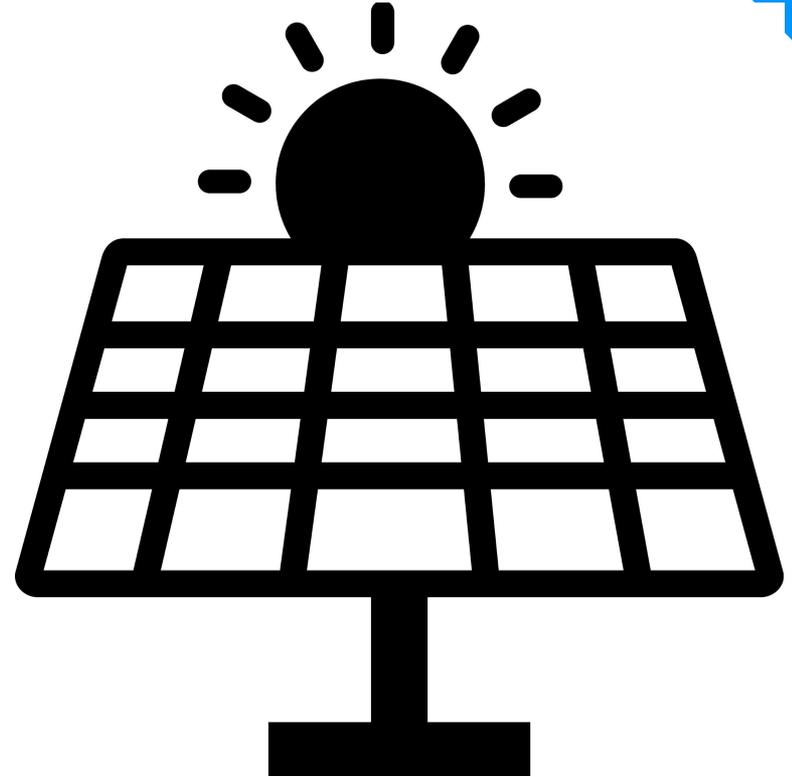
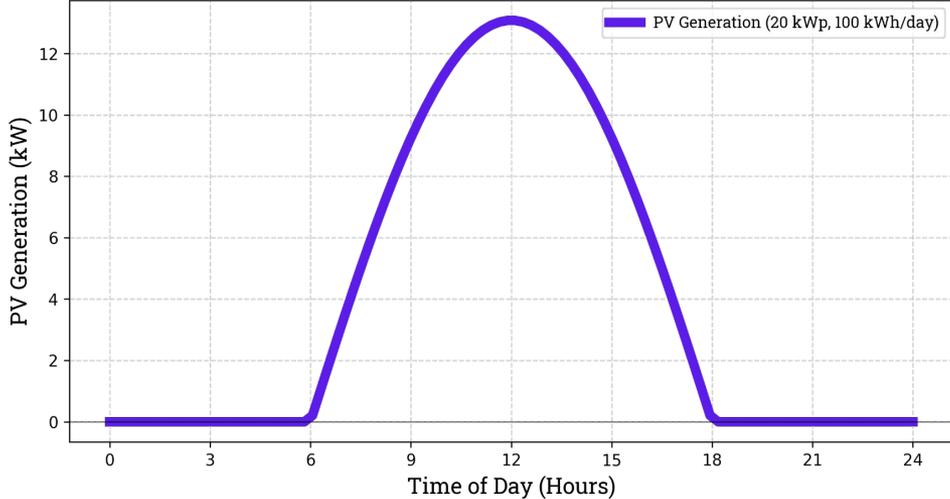
Peak Power	20 kWp
Daily Energy Yield (summer)	100 kWh/day



Charging and Discharging Strategies

Photovoltaic System

Typical PV Generation Pattern Over 24 Hours for a 20 kWp System (summer)



Charging and Discharging Strategies

Optimize PV consumption with other consumers

Arrival Time	11 h
SOC at 11h	10 kWh (~13%)
Max Charging Power	20 kW

Goal:

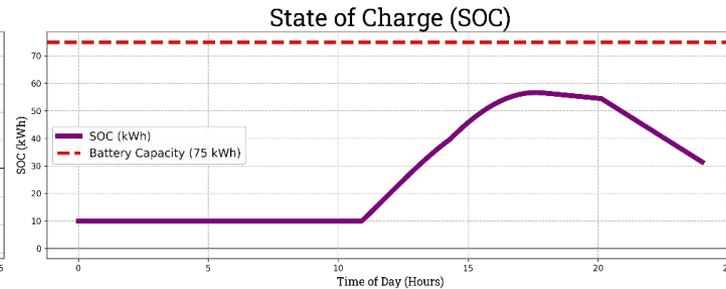
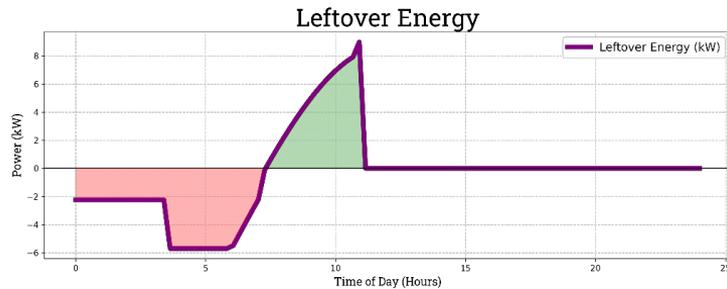
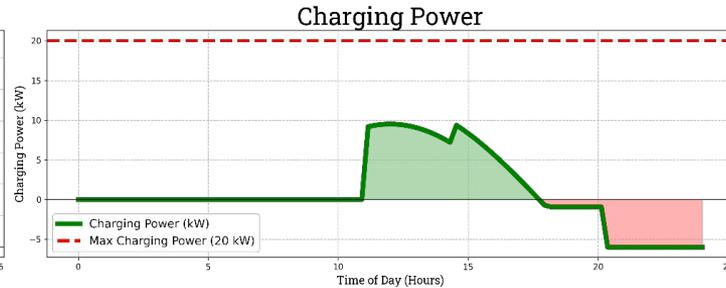
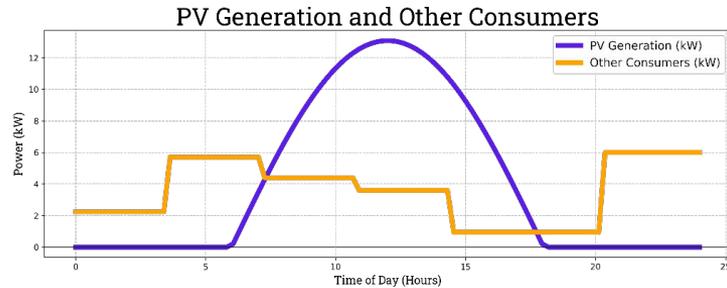
Use as much PV produced energy as possible

Strategy:

Charge with
 $\text{leftover_power} = \text{pv_production} - \text{other_consumers}$
Discharge if
 $\text{leftover_power} < 0 \text{ kW}$

Charging and Discharging Strategies

Optimize PV consumption with other consumers



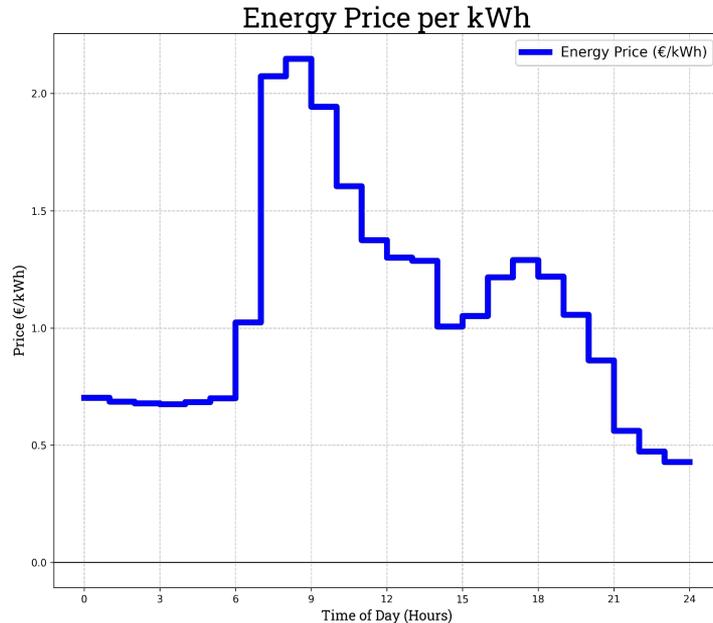
Charging and Discharging Strategies

Price Optimization with fixed departure time



Charging and Discharging Strategies

Energy Market



Charging and Discharging Strategies

Price Optimization with fixed departure time

Arrival Time	10 h
SOC at 11h	10 kWh (~13%)
Max Charging Power	20 kW
Planned Departure Time	22h
Target SOC	75 kWh (100%)

Goal:

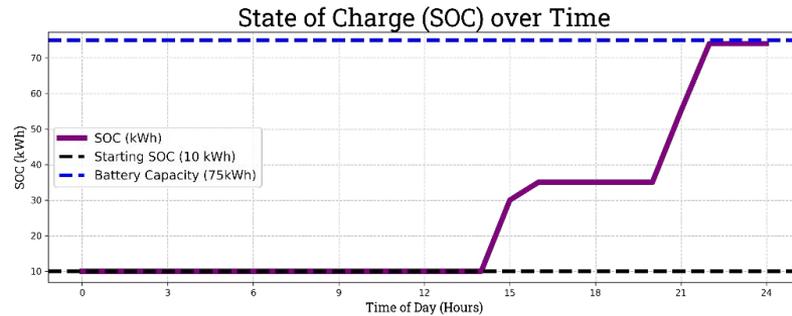
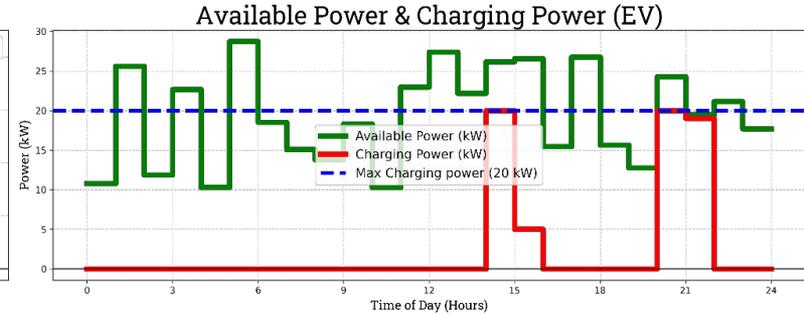
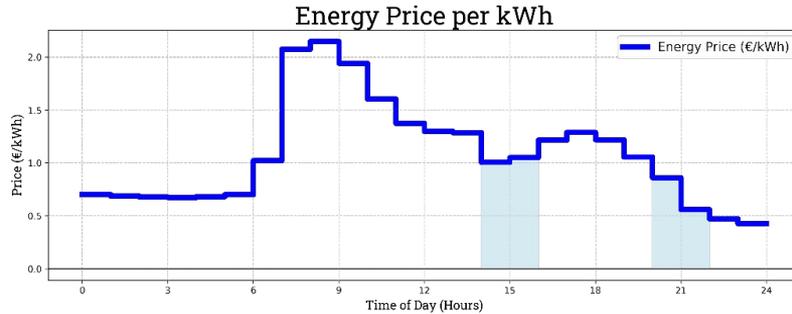
Charge the EV until planned departure time as cheap as possible

Strategy:

1. Checkout energy prices until departure time
2. Plan charging curve
3. Charge in cheapest intervals

Charging and Discharging Strategies

Price Optimization with fixed departure time



Charging and Discharging Strategies

Grid Support



Charging and Discharging Strategies

Grid Support

Arrival Time	10 h
SOC at 11h	50 kWh (~67%)
Max Charging Power	30 kW
Minimal SOC	30 kWh
Maximal SOC	70 kWh

Goal:

Use the EV to stabilize the energy grid

Strategy:

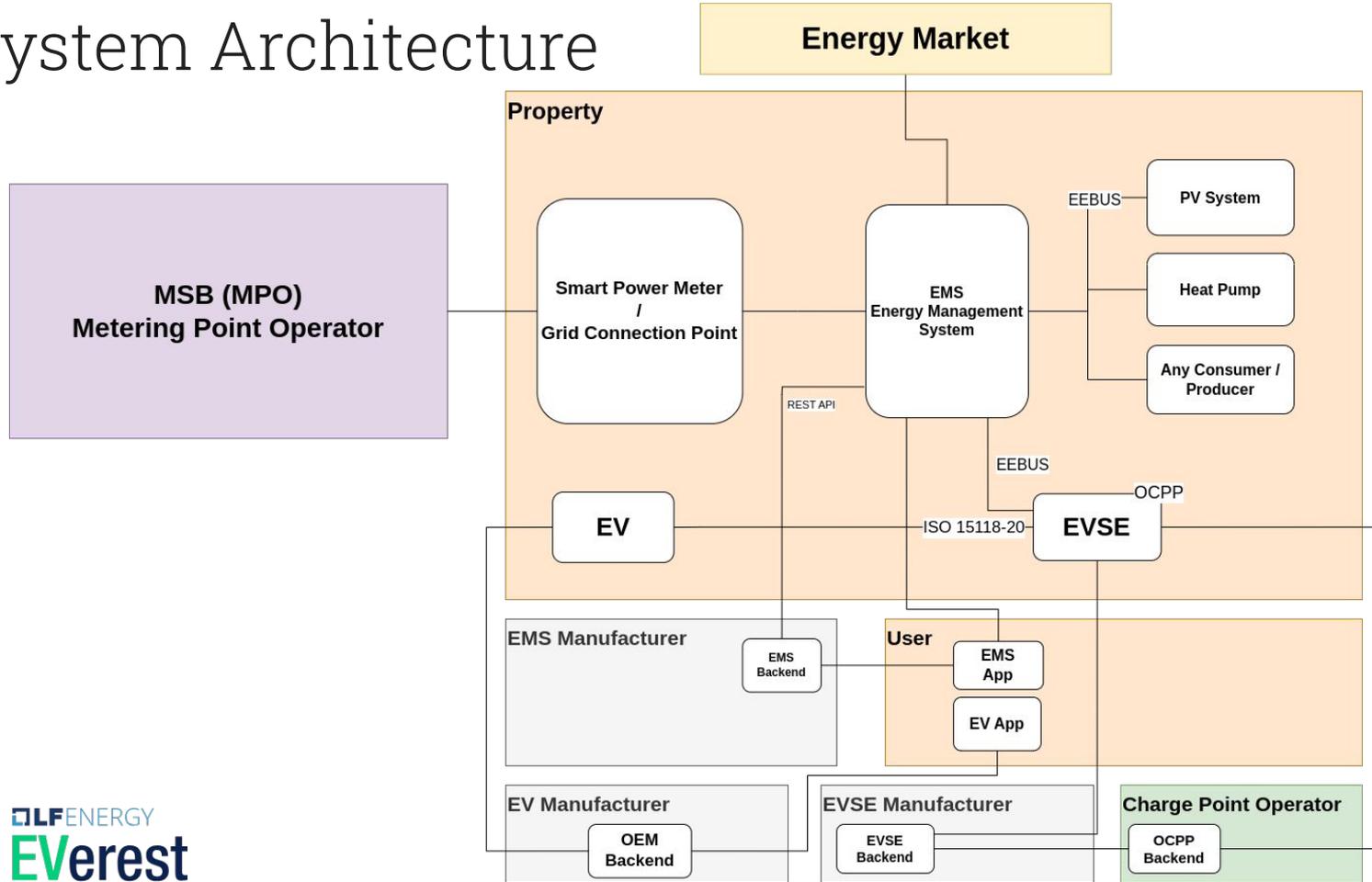
Charge, if grid produces too much energy.

Discharge, if grid produces too less energy

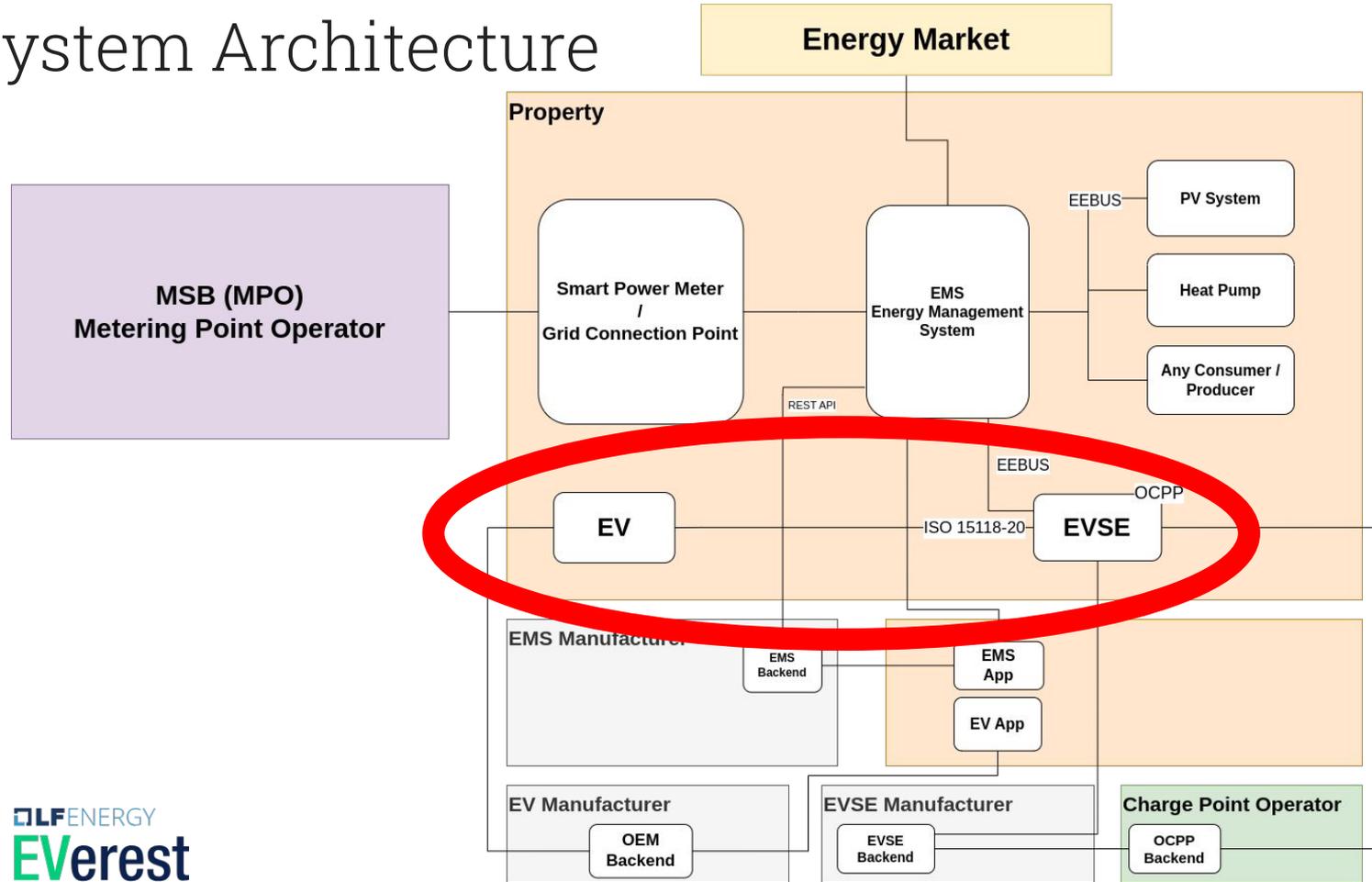
System Architecture

the entire impact chain of bidirectional charging

System Architecture



System Architecture



System Architecture - ISO 15118

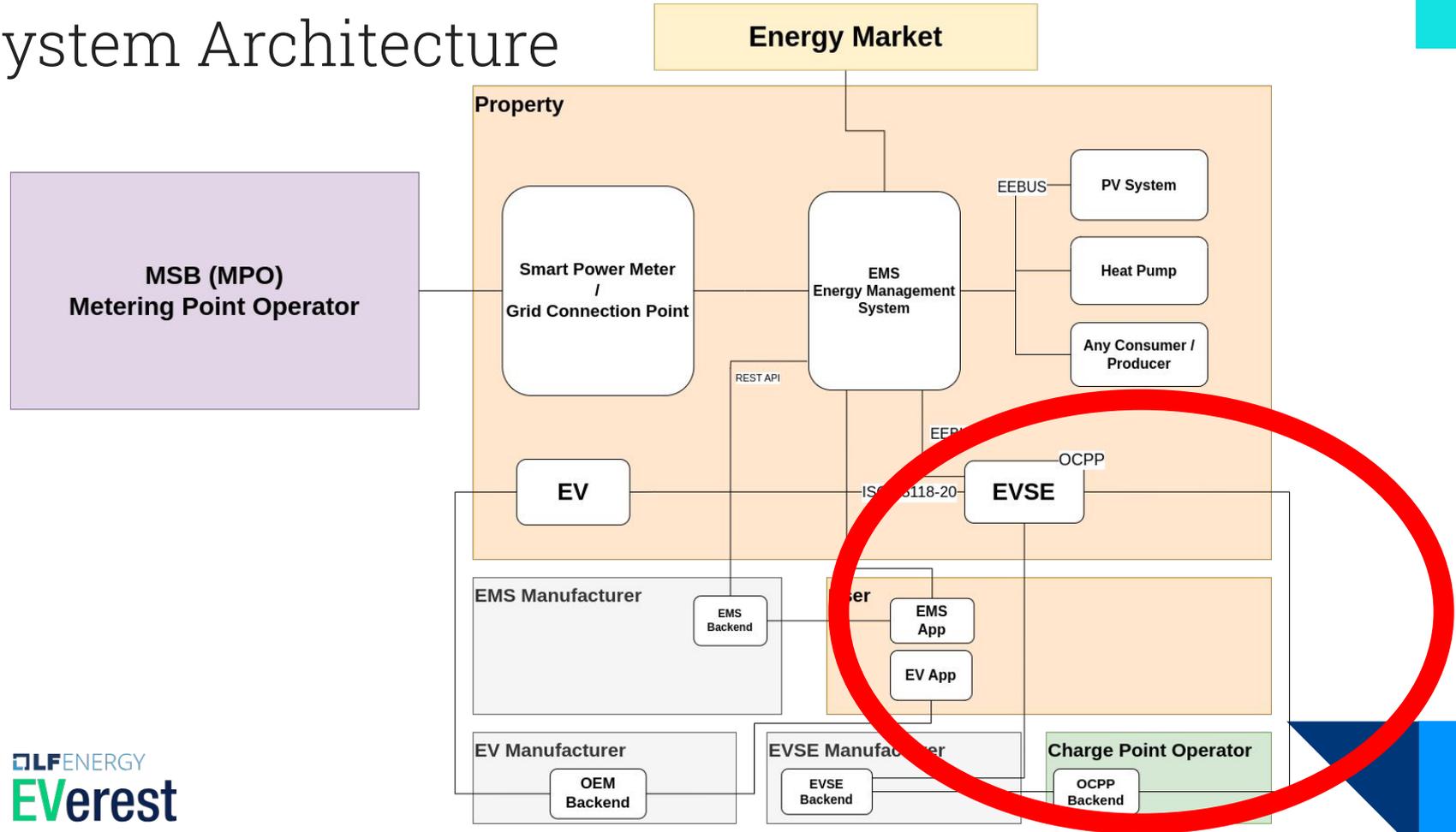
- Communication Interface between EV and EVSE
- Defines Procedure of Charging Session
- Provides tooling for
 - Smart Charging
 - Bidirectional Charging

ISO 15118

System Architecture - ISO 15118

	DIN 70121	ISO 15118-2	ISO 15118-20
Start / Stop	✓	✓	✓
AC	✗	✓	✓
DC	✓	✓	✓
AC Bidi	✗	✗	✓
DC Bidi	(✗)*	(✗)*	✓
Smart Charging	✗	✗	✓
Pause / Resume	✗	✗	✓

System Architecture



System Architecture - OCPP

What is OCPP?

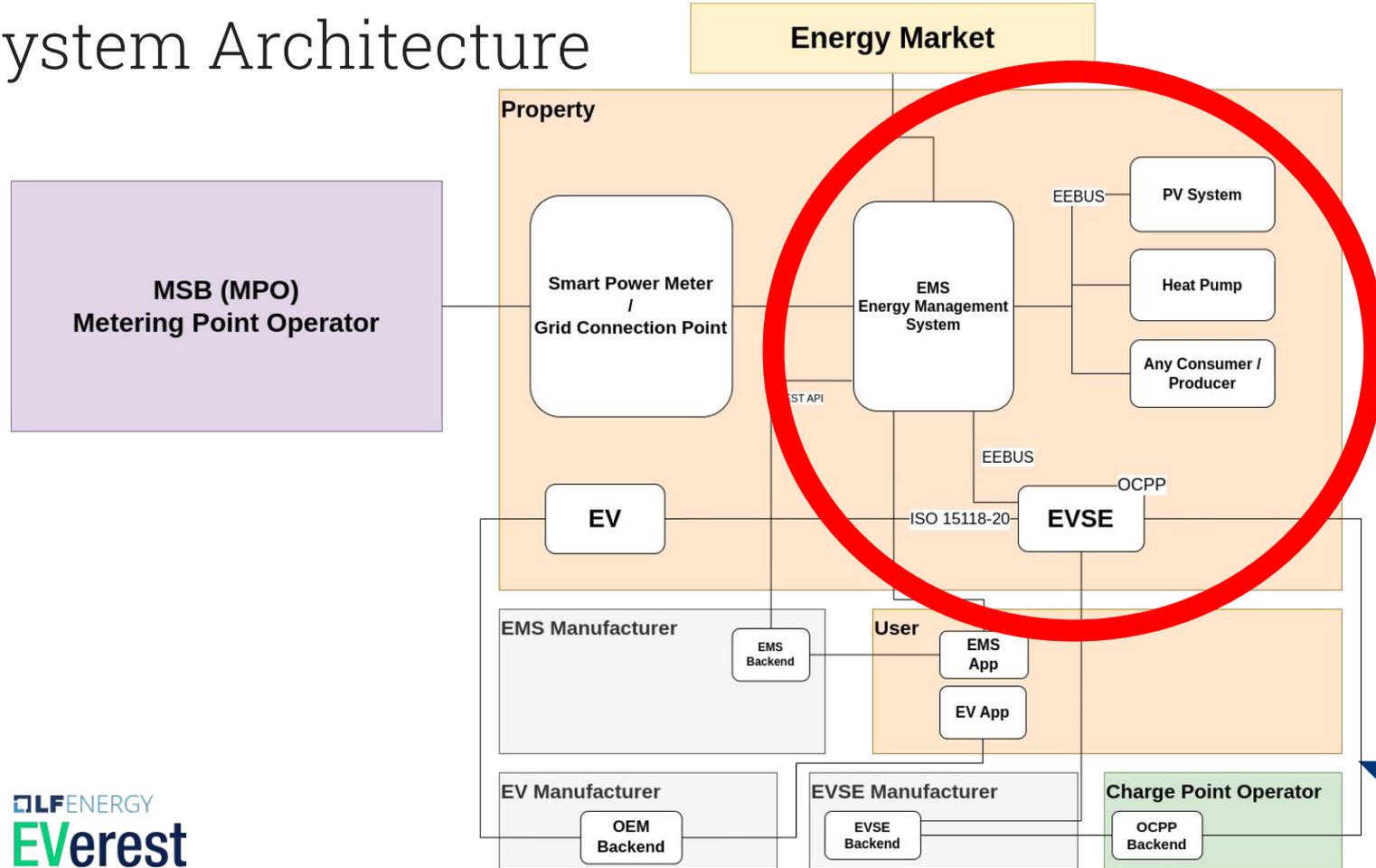
- Open standard protocol for communication between EV charging stations and central systems

What Does OCPP 2.1 Bring?

- New Features for Smart Charging
- Support for bidirectional charging

OCPP

System Architecture



System Architecture - EEBUS

- Communication Interface for Energy Management
- Enables interaction with grid
- Defines device behaviour within energy management



System Architecture - EEBUS

Use Case: Limitation of Power Consumption

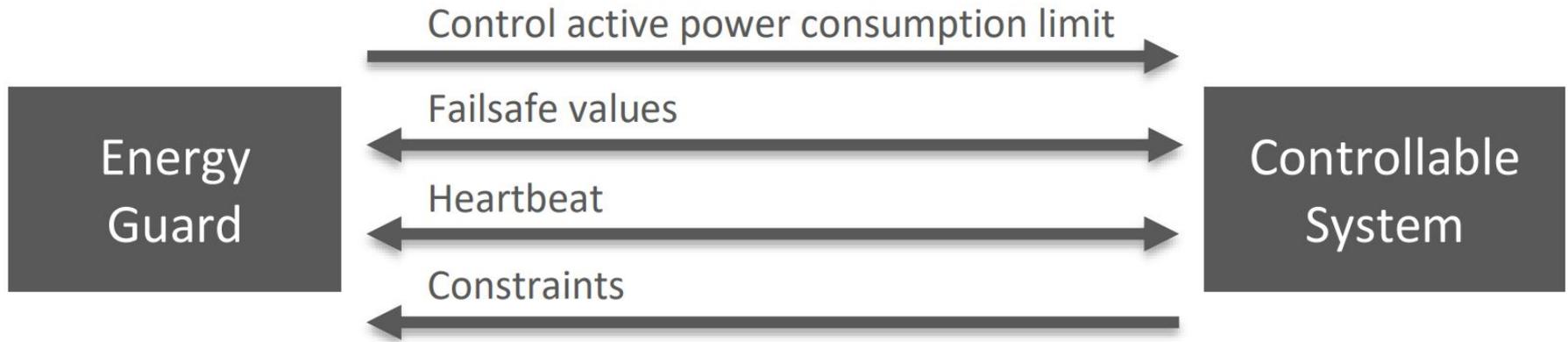


Figure 1: High-Level Use Case functionality overview

System Architecture - EEBUS

Use Case: Coordinated EV Charging

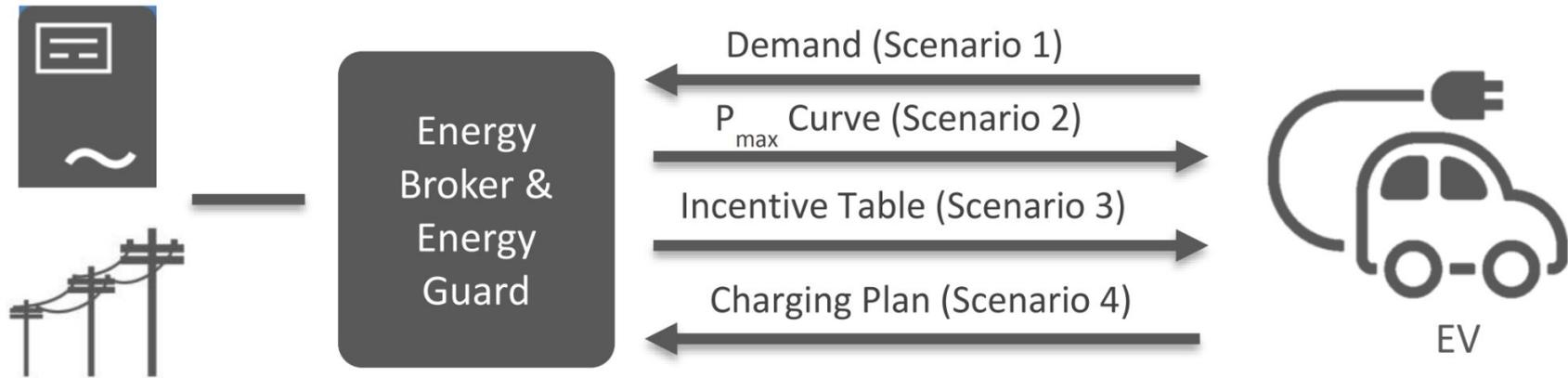


Figure 1: High-Level Use Case functionality overview

System Architecture - EEBUS

Use Case: Optimization of Self-Consumption

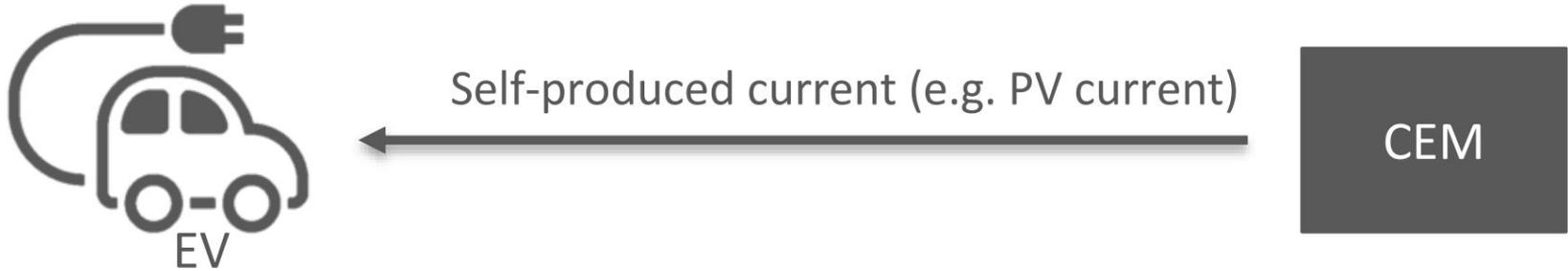
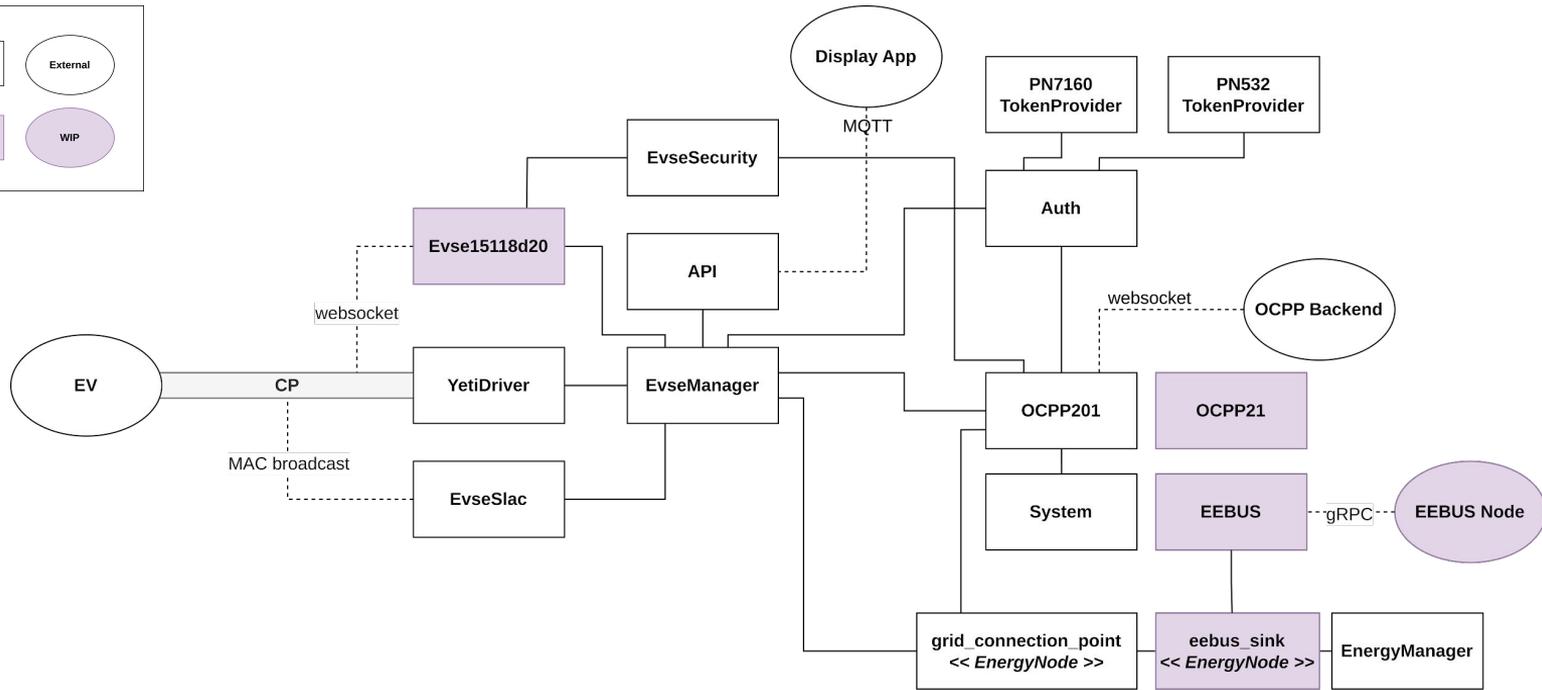
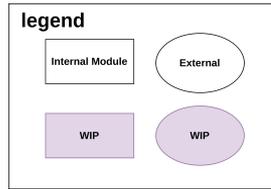


Figure 1: High-Level Use Case functionality overview

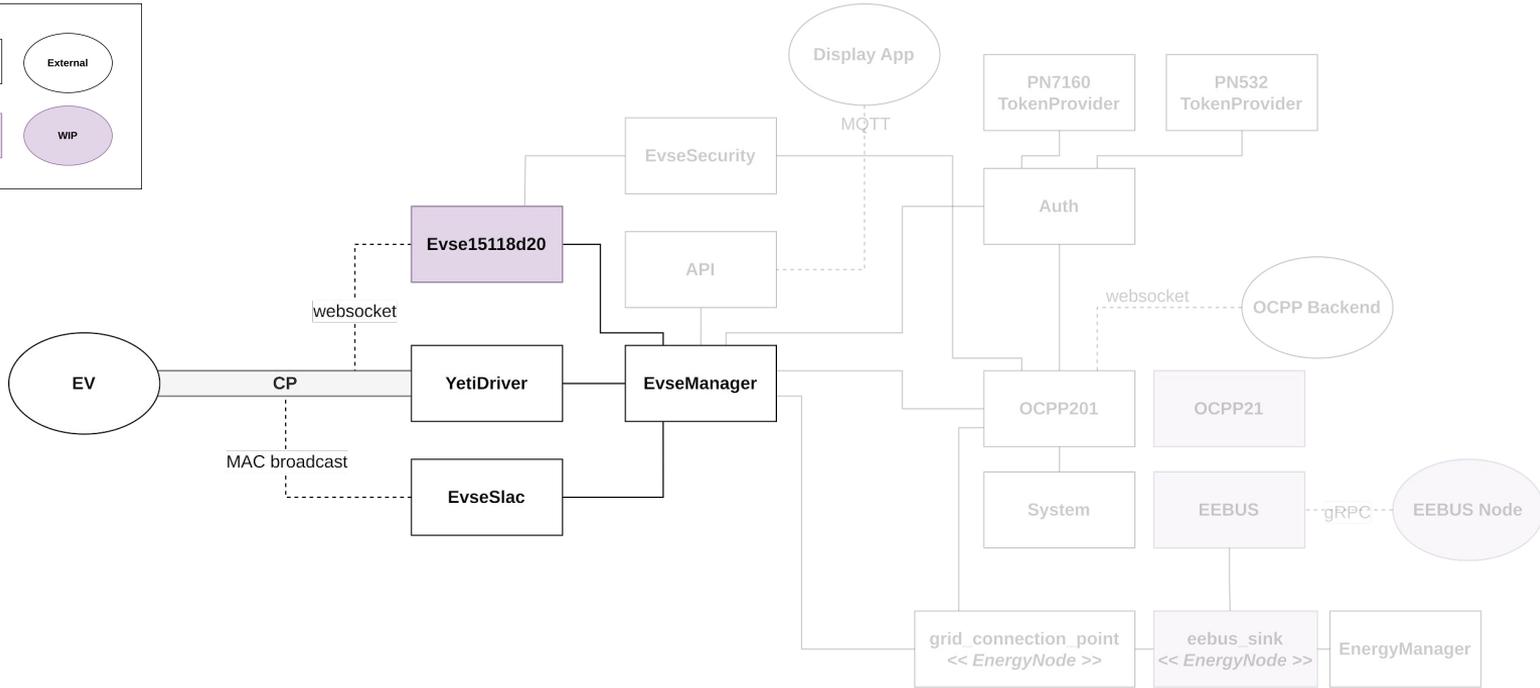
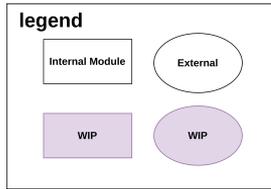
Energy Management in EVerest

EVerest's internal architecture

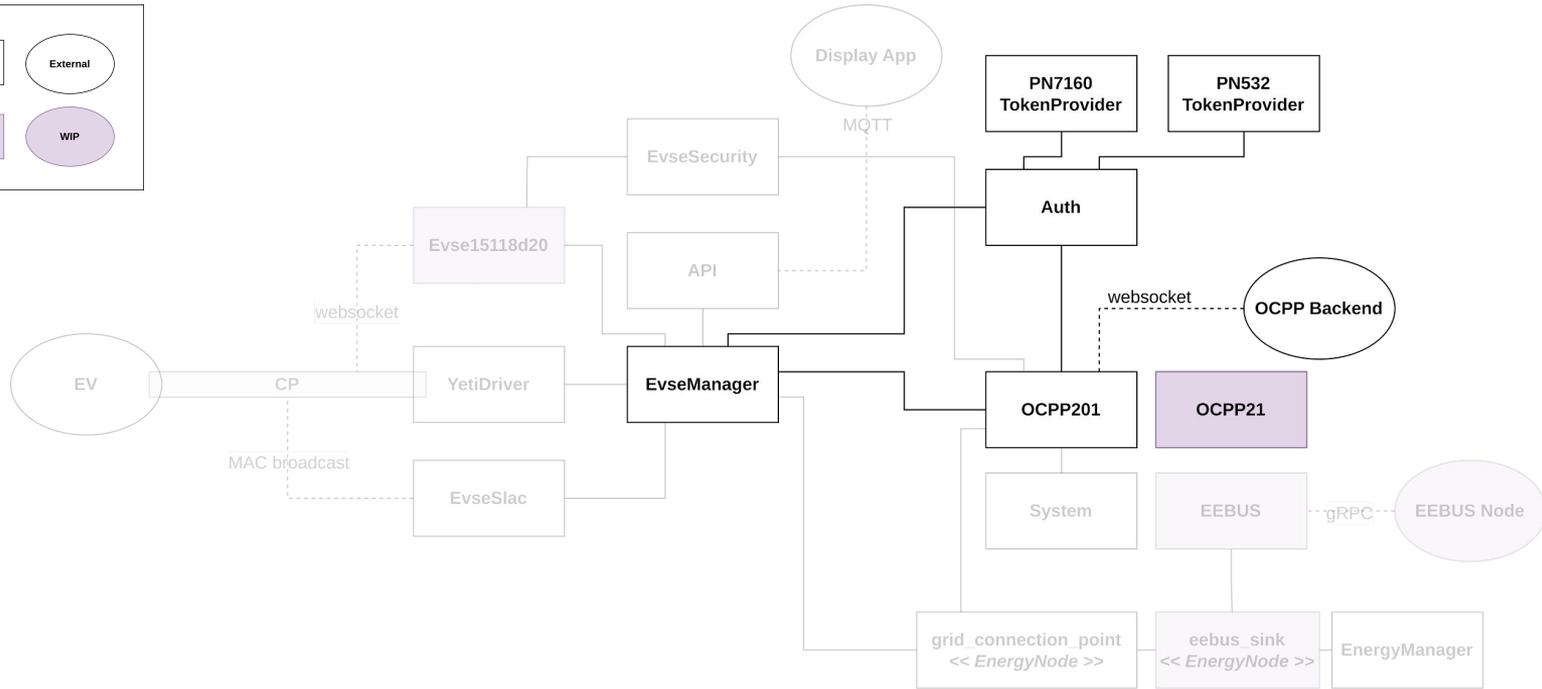
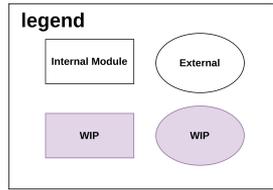
EVerest's internal architecture



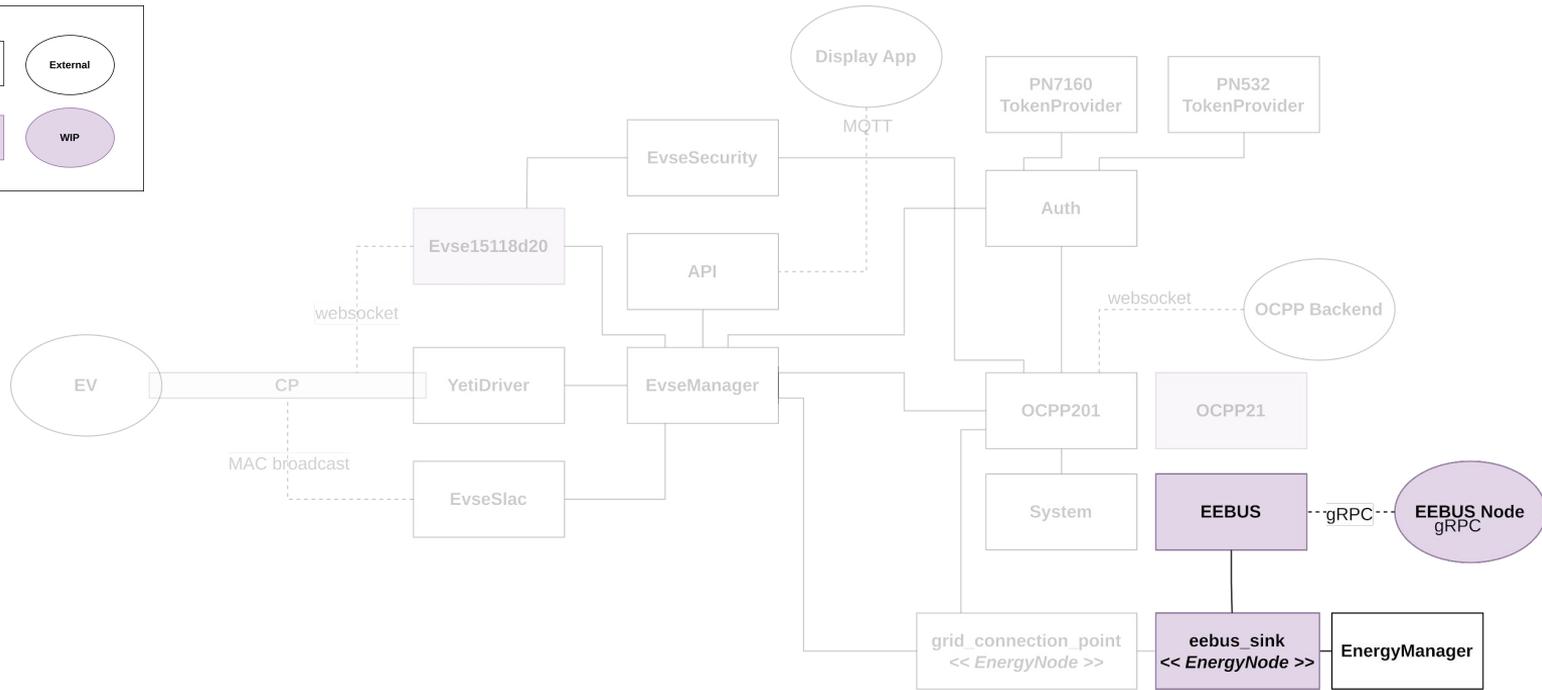
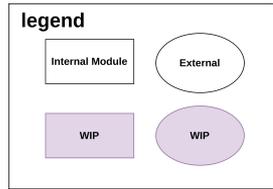
EVerest's internal architecture - ISO 15118



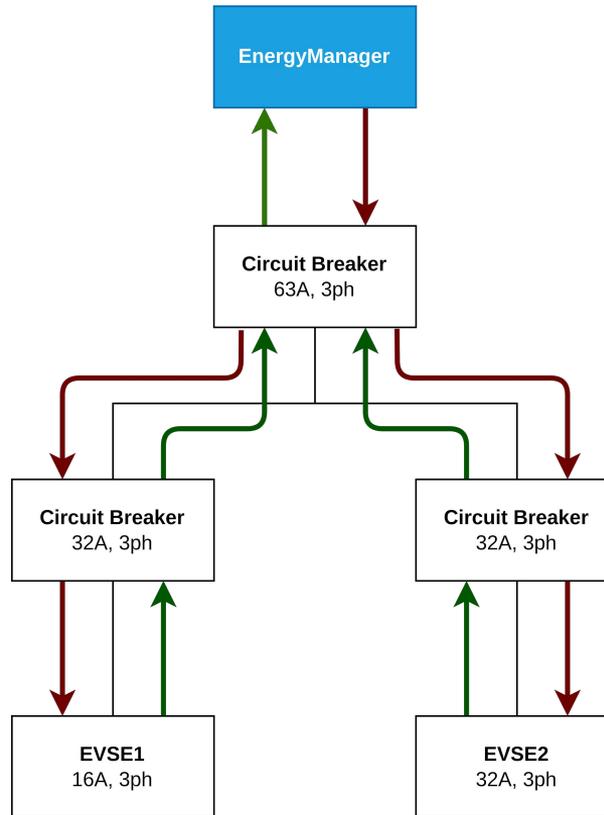
EVerest's internal architecture - OCPP



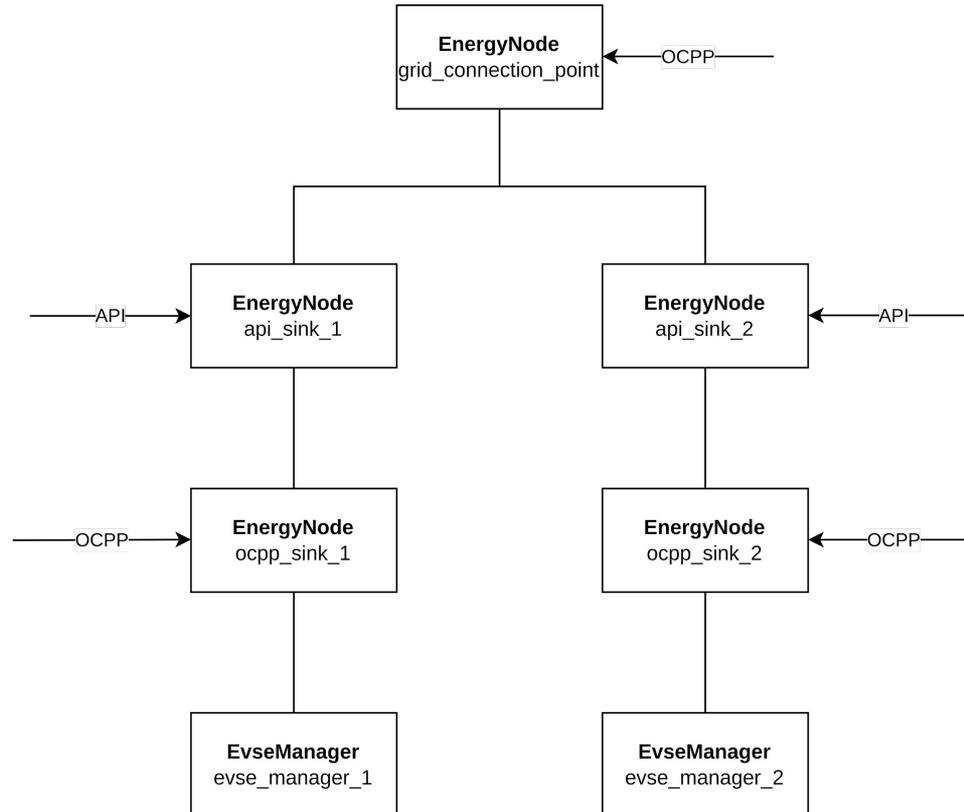
EVerest's internal architecture - EEBUS



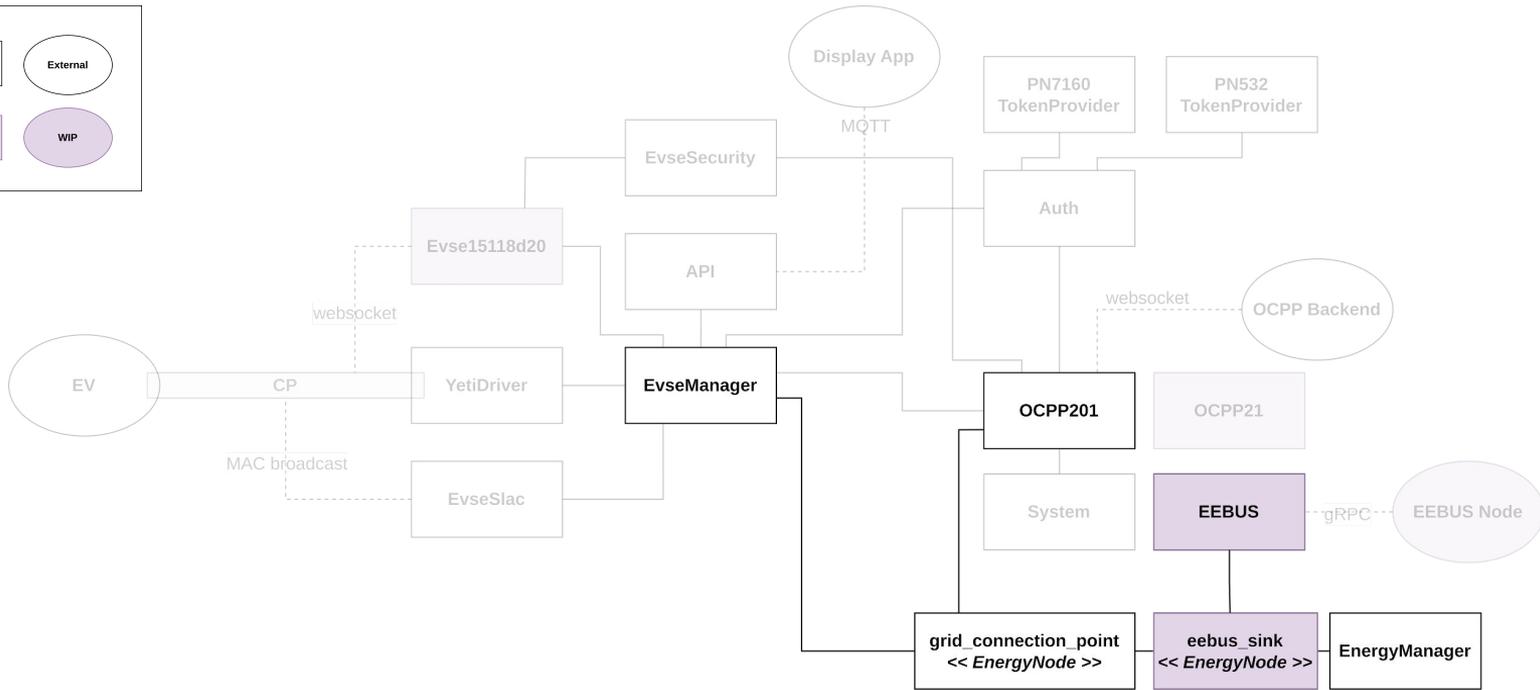
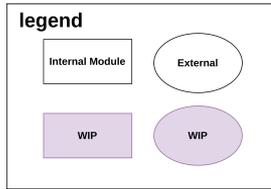
Energy Management inside EVerest



Energy Management inside EVerest



EVerest's internal architecture - Energy Tree



Conclusion

Today's Problems



Conclusion - Today's Problems

EVs and EVSEs in the field don't speak ISO 15118-20

- There are no publicly known EVs that fully implement ISO 15118-20
 - There are a couple of proprietary solutions to enable bidirectional charging
- There are only a few charging stations implementing ISO 15118-20

We continuously test the cars available on the market, see

<https://github.com/EVerest/logfiles>

Conclusion - Today's Problems

Open Standards doesn't mean Open Implementations

- By default, there are no open source feature-complete implementations of protocols like OCPP, ISO 15118, or EEBUS.
- Protocols like EEBUS come with a lot of overhead and do not allow for a simple implementation

Everest targets to implement those protocols or to integrate existing open implementations

Open Software



EVerest

- Open Source implementations are included in EVerest
 - DIN 70121
 - ISO 15118-2
 - libiso15118
 - ISO 15118-20 EVSE side (WIP)
 - ISO 15118-20 EV side for testing (WIP)
 - libocpp
 - OCPP 1.6
 - OCPP 2.0.1
 - OCPP 2.1 (WIP), already first charging sessions

Other Open Source Projects

- Open Source implementations that are integrated in EVerest
 - EEBUS enbility/eebus-go (integration is WIP)
- Open Source implementation for OCPP backend
 - CitrineOS (2.0.1 & 1.6 wip)
 - steve (1.6)
 - maeve (1.6 & 2.0.1)

Hardware Running EVerest

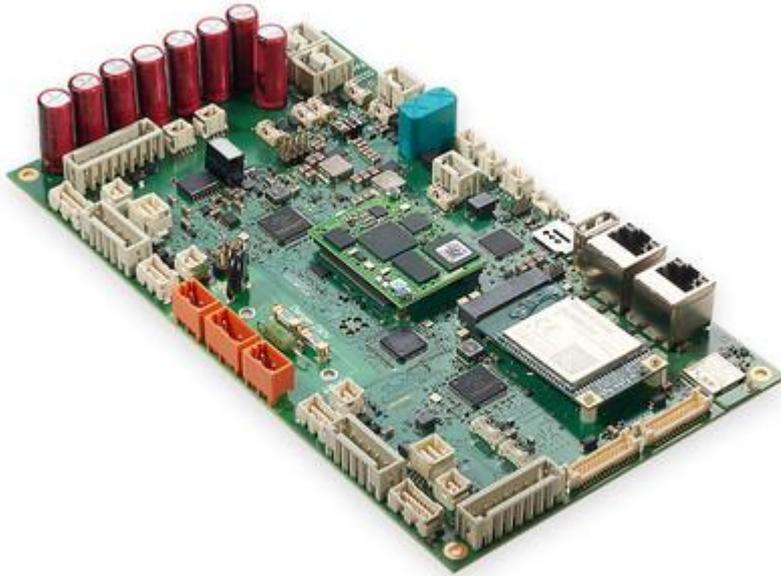


Known EVerest based charger

- Mahle chargeBIG
- Qwello - CP21 & CP22
- Pod Point - Solo 3s
- Enteligent - TLCEV
- Voltpost
- Qwello - Retrofit Kits
- Jule (at least for testing)

More than 10.000 chargers in the field at private locations

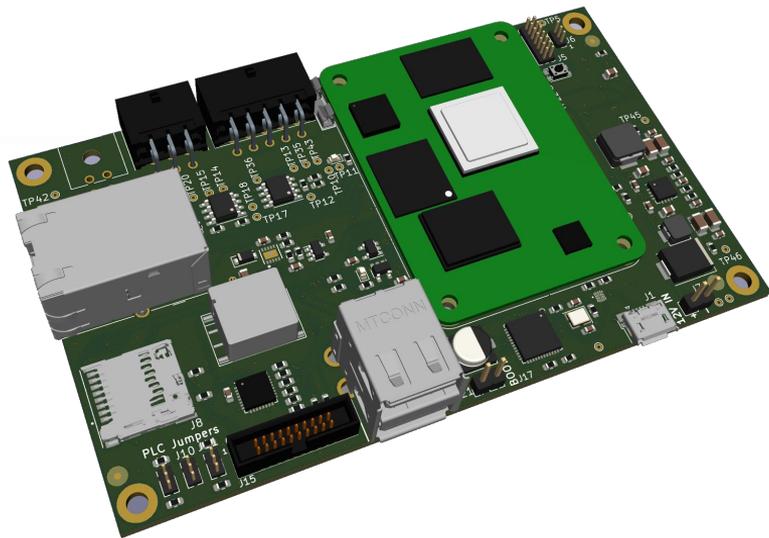
phyVERSO®-EVCS



- Charge Controller for AC/DC (Dual Port)
- Bidirectional Charging
- Runs EVERest (Linux based)
- Linux is Yocto based
- Ethernet, WLAN, BLE, LTE, Modbus, CAN
- Dual-Display via LVDS
- Available at <https://www.phytec.de/produkte/fertige-geraete-oem/phyverso-evcs>



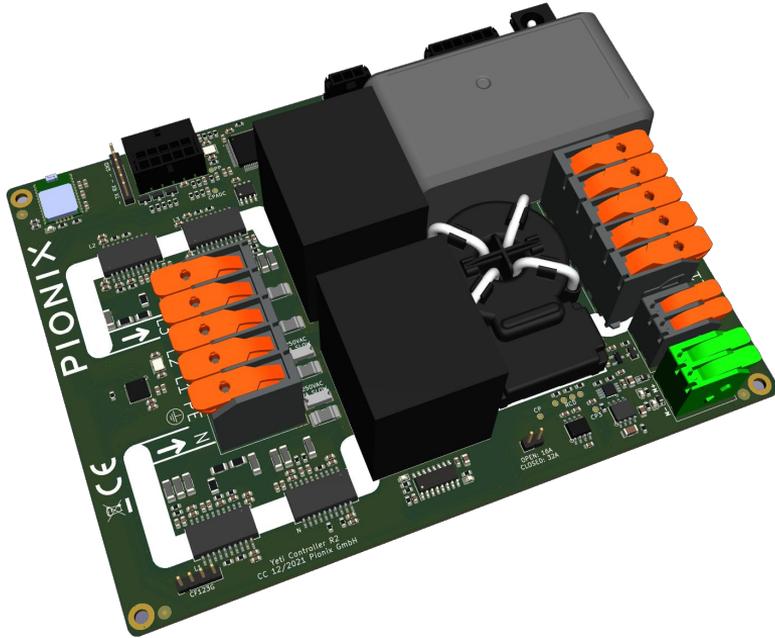
YAK



- Raspberry Pi CM4 carrier board
- CAN, RS485, UART, USB, LAN
- Display connector
- PLC modem
- Runs Everest (Linux based)
- Open Hardware:
<https://github.com/PionixPublic/reference-hardware>
- Available at
<https://shop.pionix.com/products/yak-platine-kit>



YETI



- 2x 40A AC relays with feedback
- RCD, AC power meter
- CP signal generation and processing
- Full AC “powerpath”
- DC is possible
- Responsible for safety: instance who decides to switch on relays
- Open Hardware and Firmware: <https://github.com/PionixPublic/reference-hardware>
- Available at <https://shop.pionix.com/products/yeti-platine-kit>



Join the Movement – Get Involved!



Low entry barrier



Multiple Open Source projects to contribute to



Join our Working Group Calls – Open for everyone



Help shape the future of energy management & EV charging



Bring your ideas, ask questions, and start contributing!

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Q&A session in the hallway

Thanks

