Unleashing Bidirectional Charging

Protocols, Challenges, and Strategies with EVerest

LF ENERGY 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?

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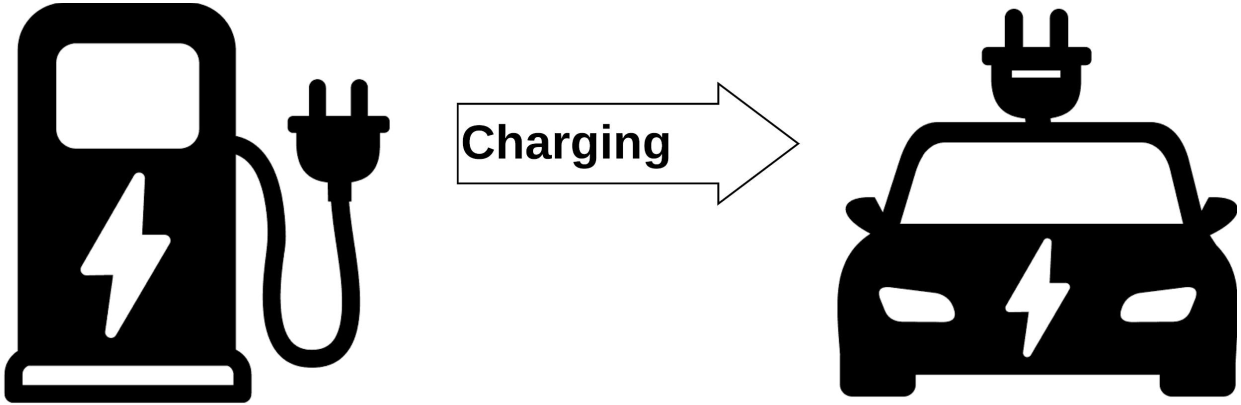
What is bidirectional charging?



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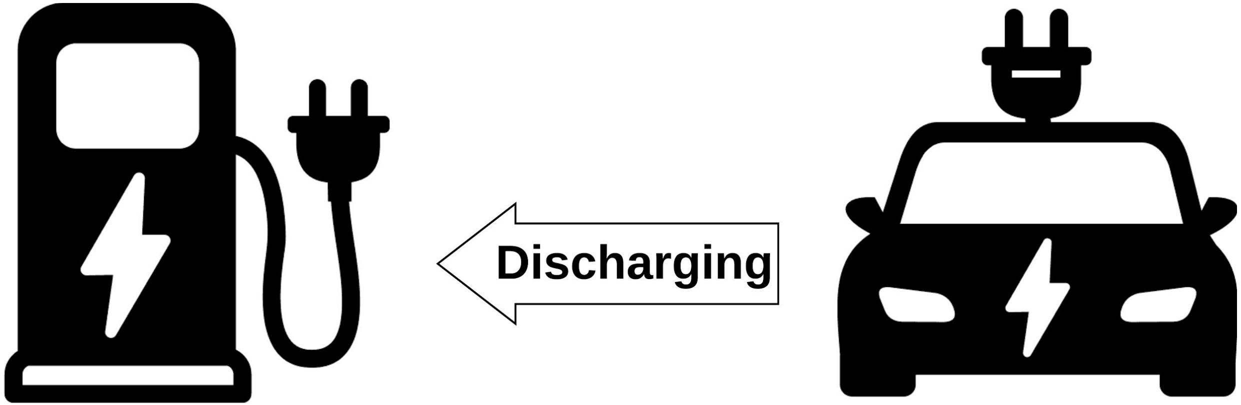
What is bidirectional charging?



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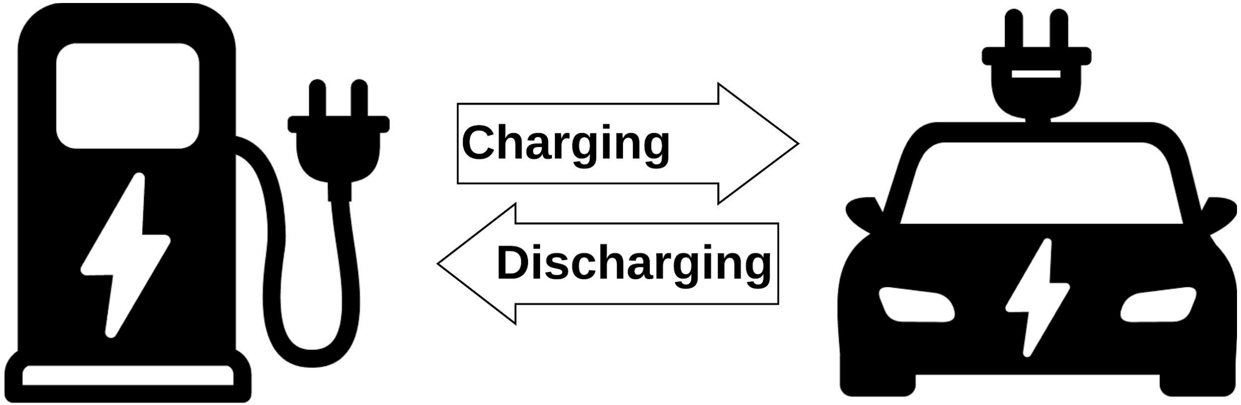
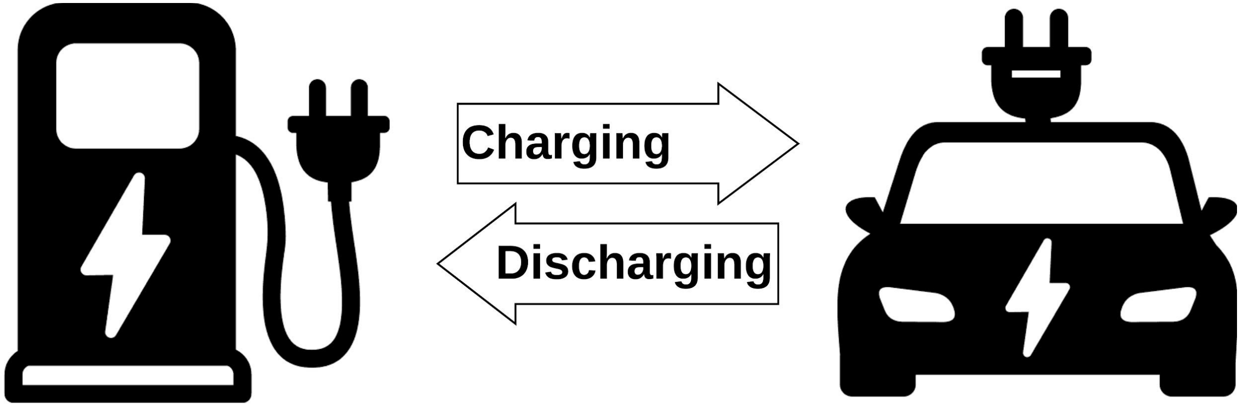
What is bidirectional charging?



What is bidirectional charging?



Bidirectional Charging

Why should I do Bidirectional Charging?

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Why should I do bidirectional charging

1️⃣**Climate Change** → We need an energy transition
2️⃣**Renewable Energies** → More solar & wind power integration
3️⃣**Decentralized Smart Grid** → Small producers, flexible energy use
4️⃣**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

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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

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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%)

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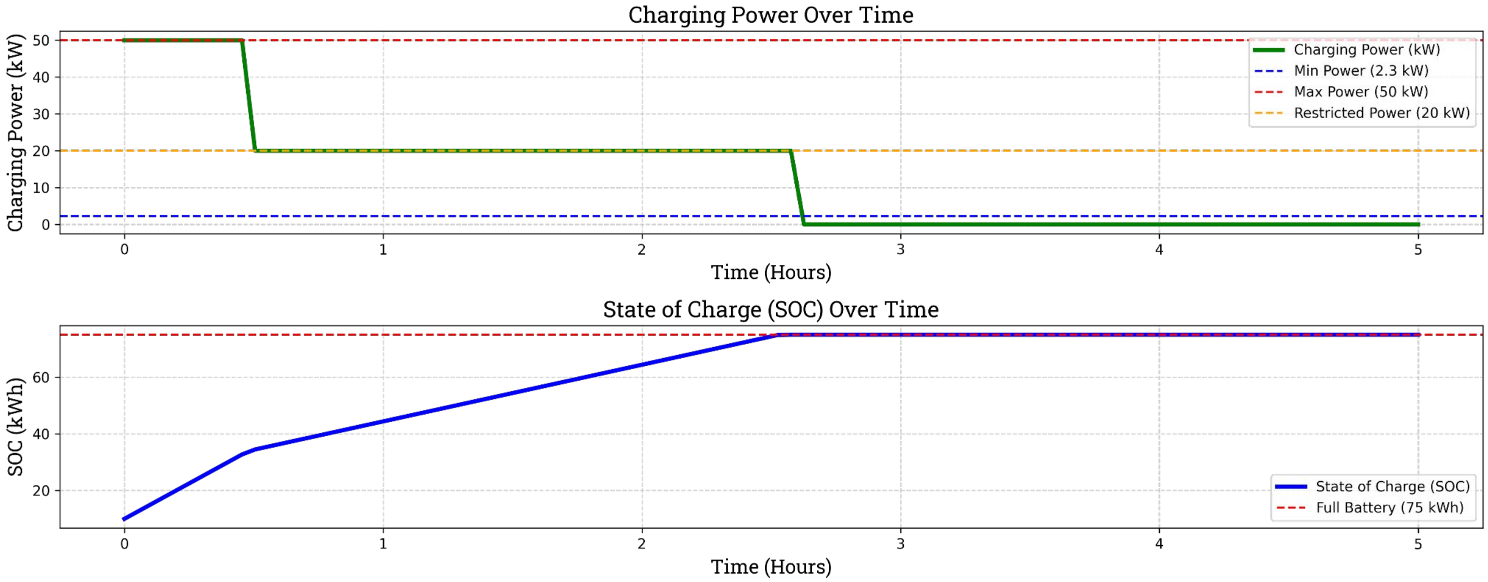
Charging and Discharging Strategies

Fast Charging



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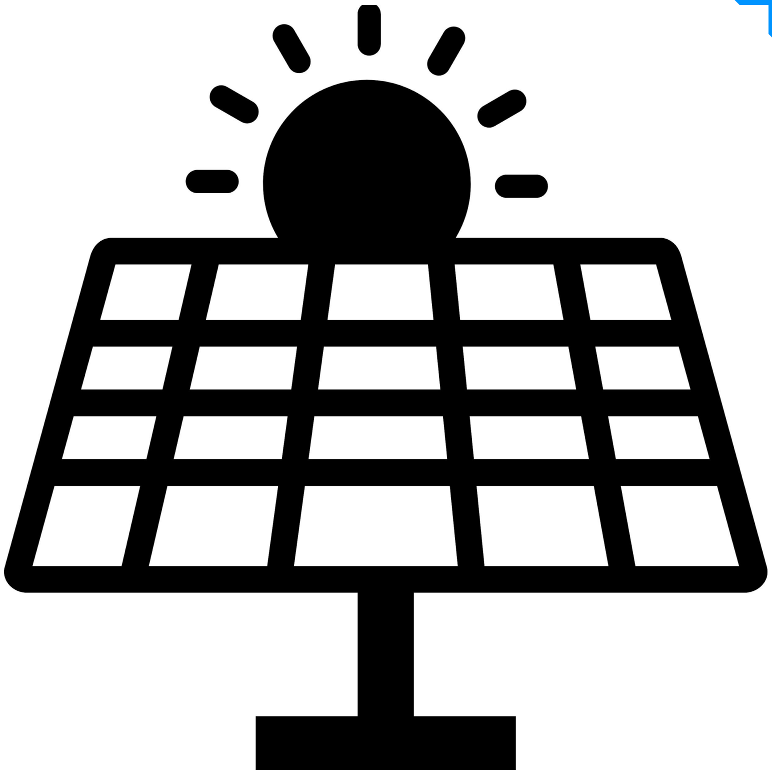
Charging and Discharging Strategies

Optimize PV consumption with other consumers

Charging and Discharging Strategies

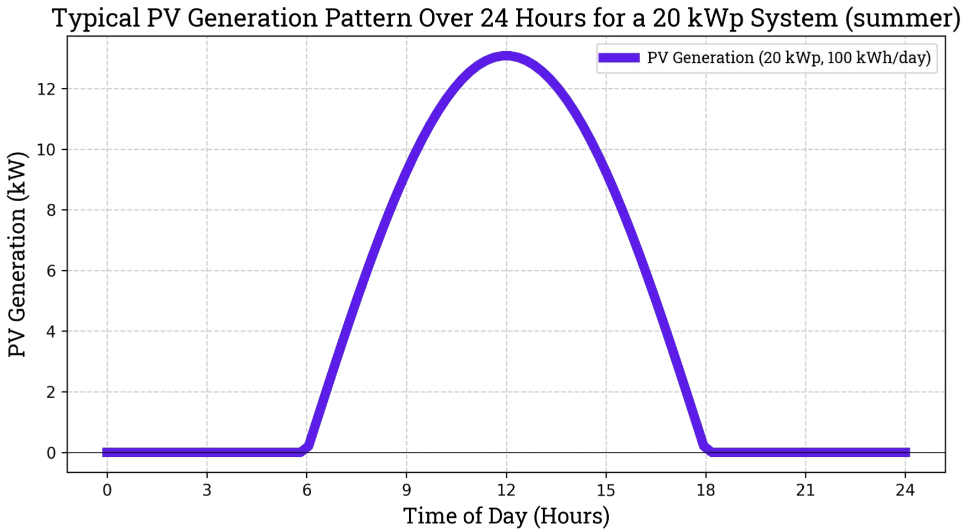
Photovoltaic System

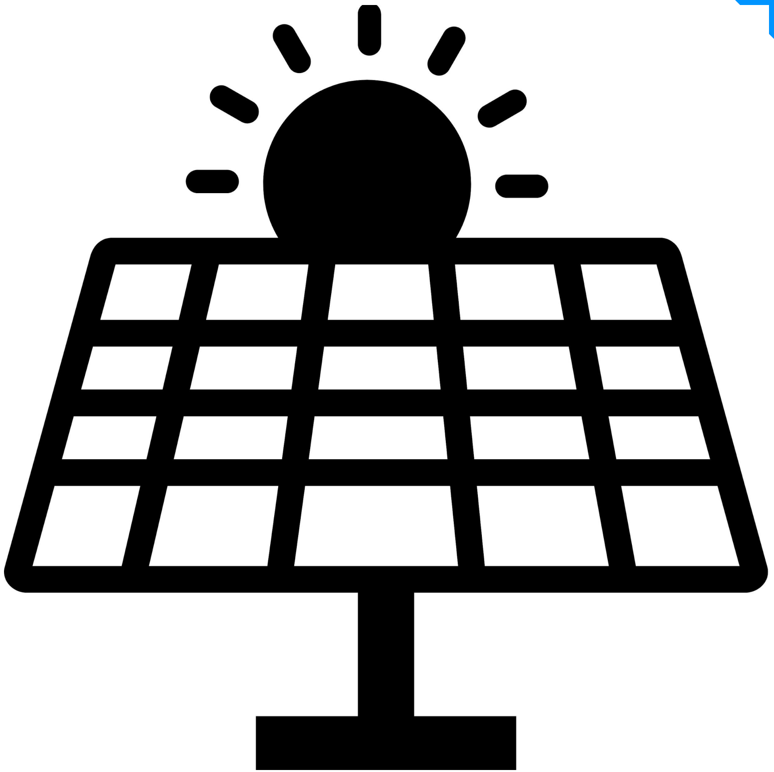
Peak Power	20 kWp
Daily Energy Yield (summer)	100 kWh/day



Charging and Discharging Strategies

Photovoltaic System





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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

leftover_power = pv_production - other_consumers

Discharge if

leftover_power < 0 kW

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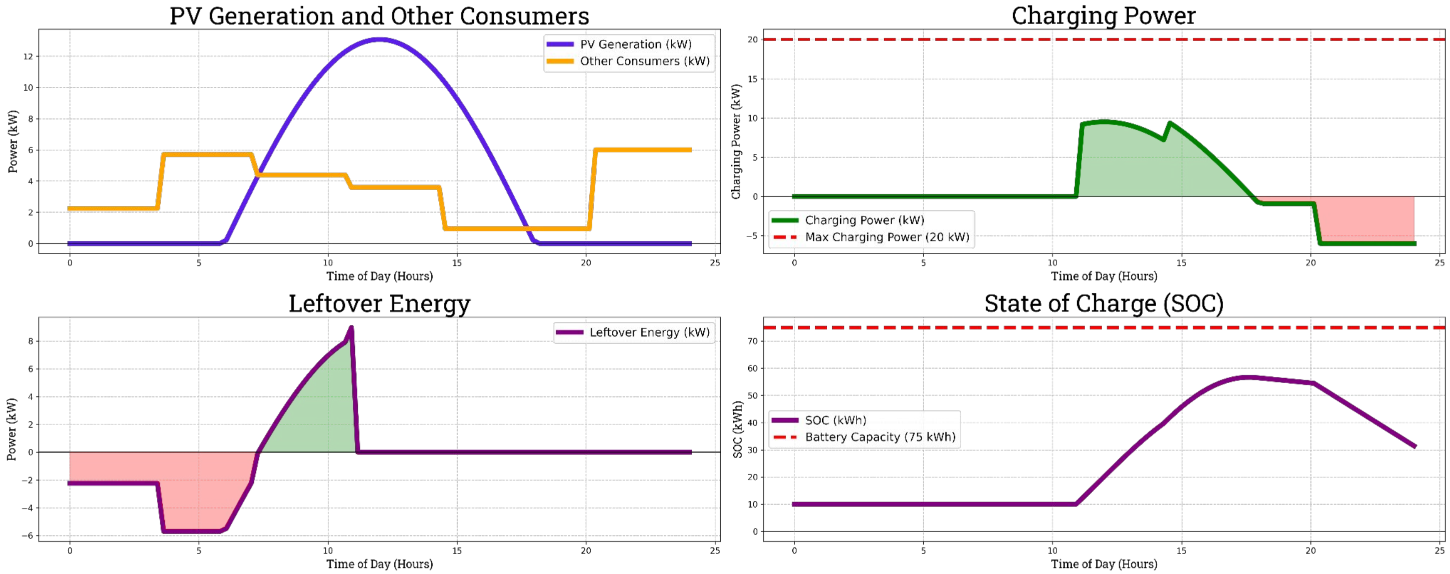
Charging and Discharging Strategies

Optimize PV consumption with other consumers

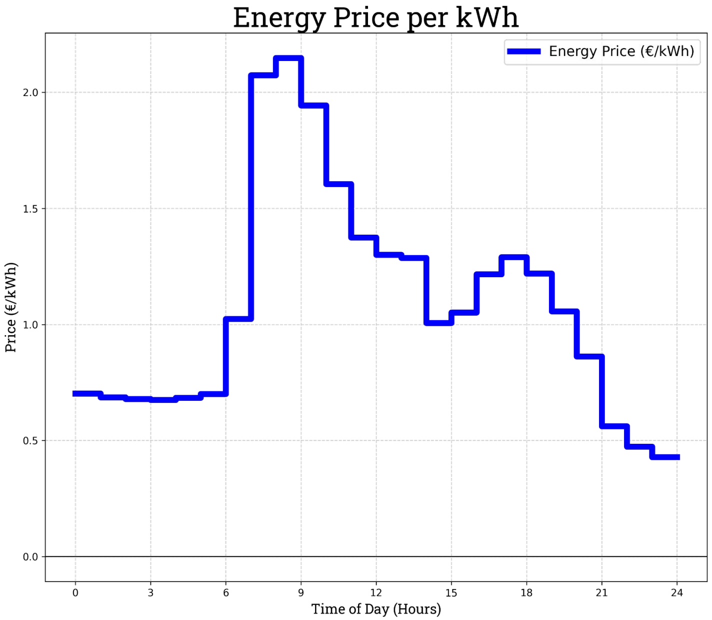


Charging and Discharging Strategies

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

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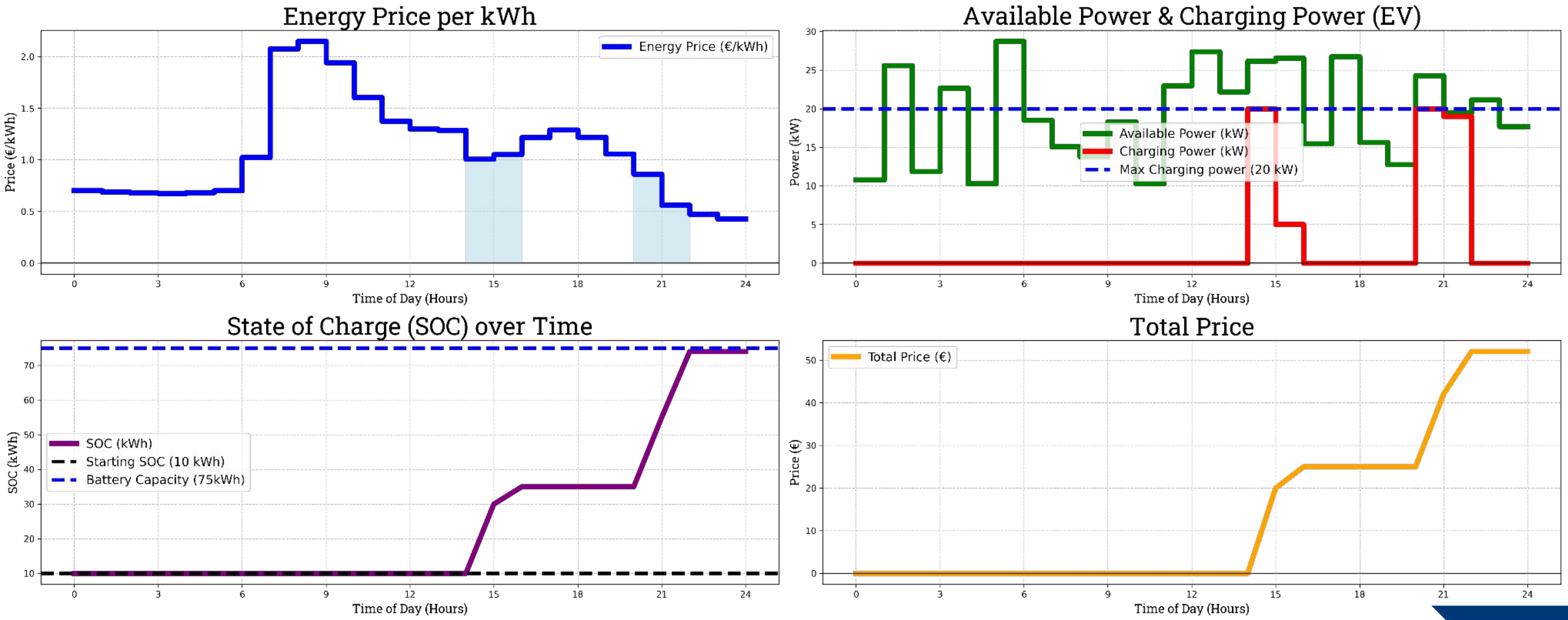
Charging and Discharging Strategies

Price Optimization with fixed departure time



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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

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System Architecture

the entire impact chain of bidirectional charging

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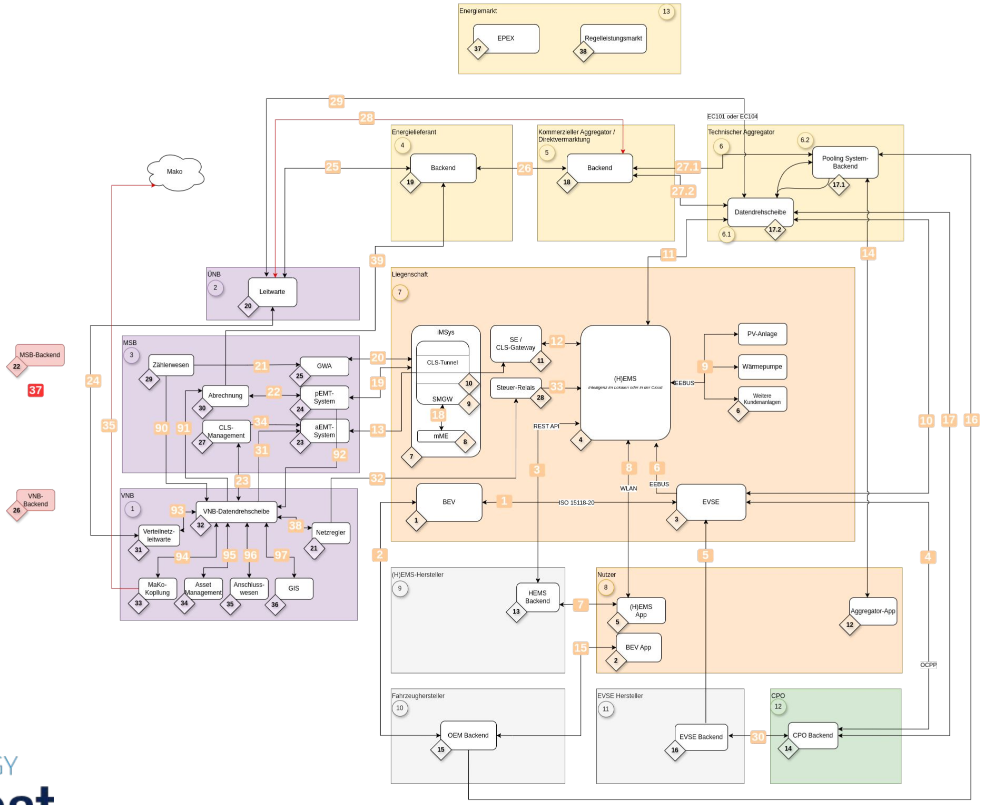
System Architecture



Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

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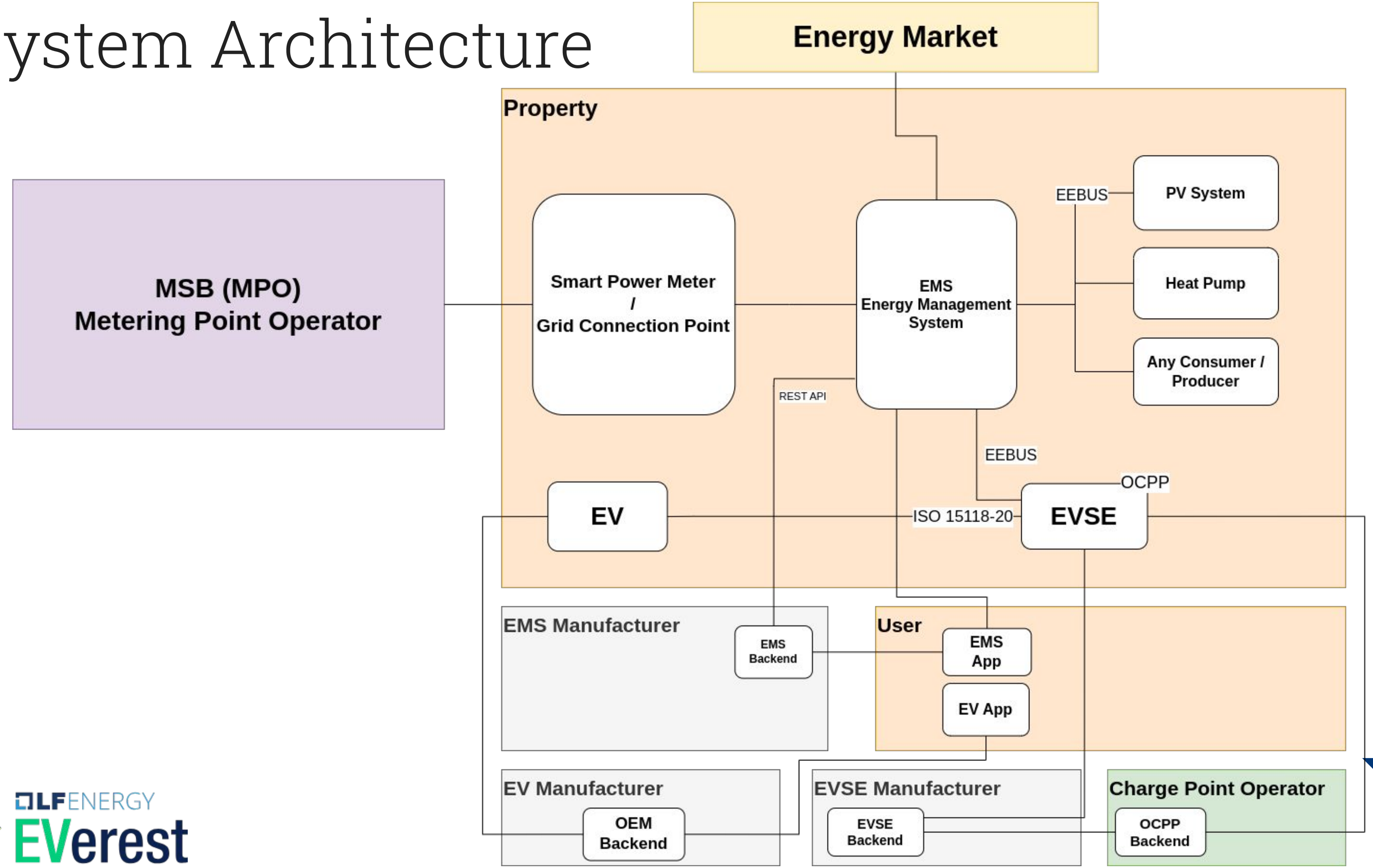
System Architecture



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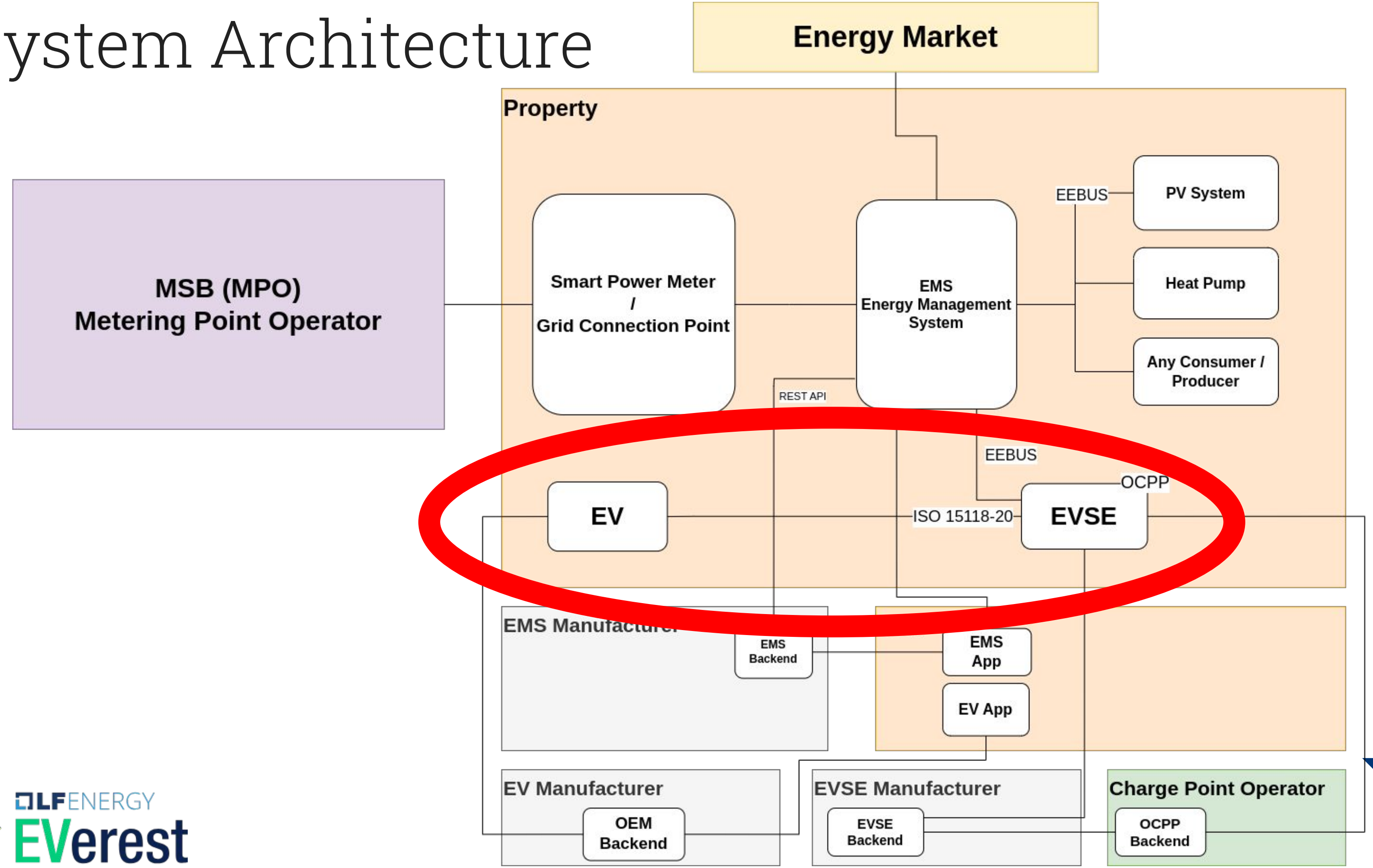
System Architecture



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System Architecture - ISO 15118

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

ISO 15118

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System Architecture - ISO 15118

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

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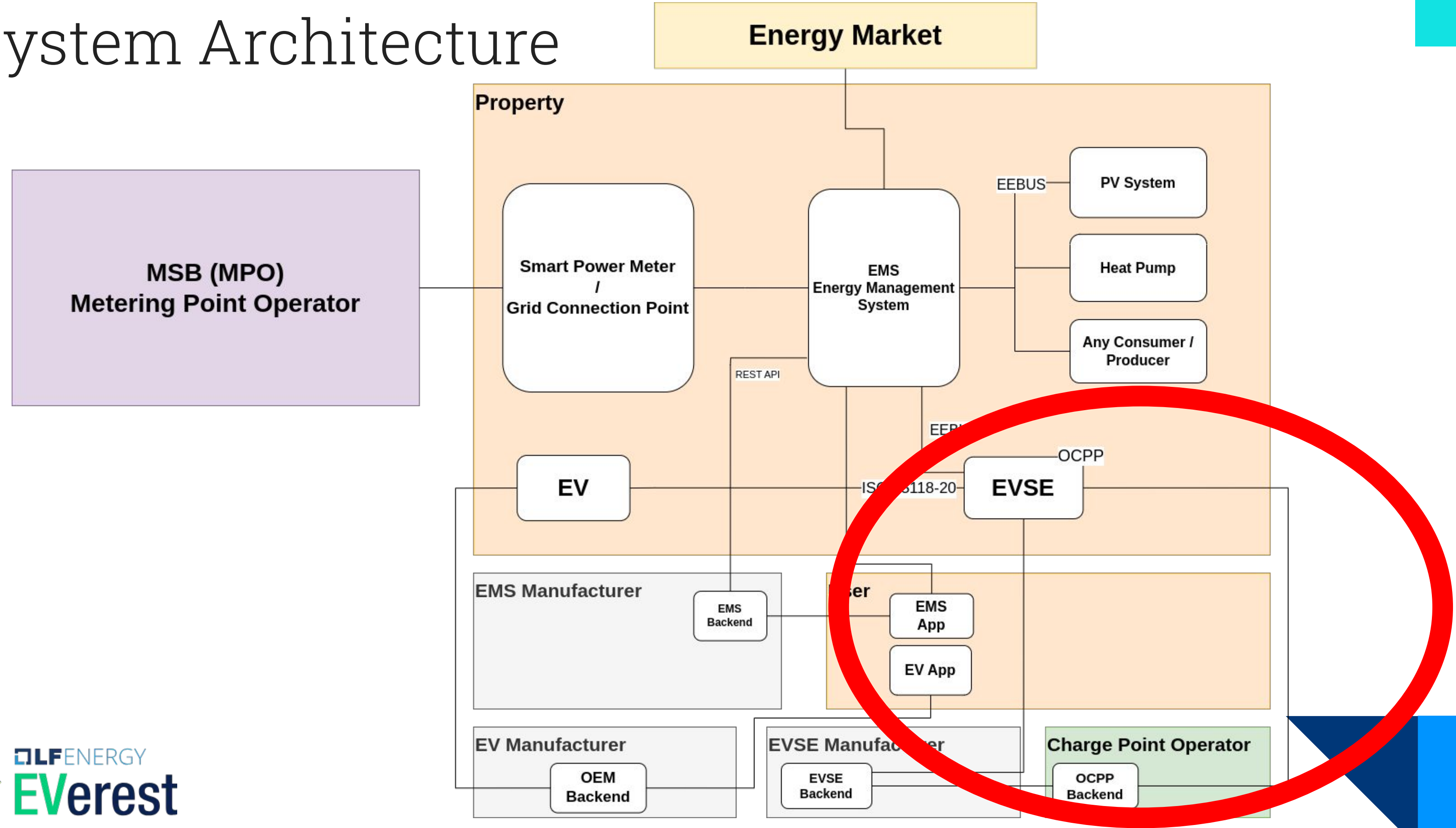
* with hacks, or non standard

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

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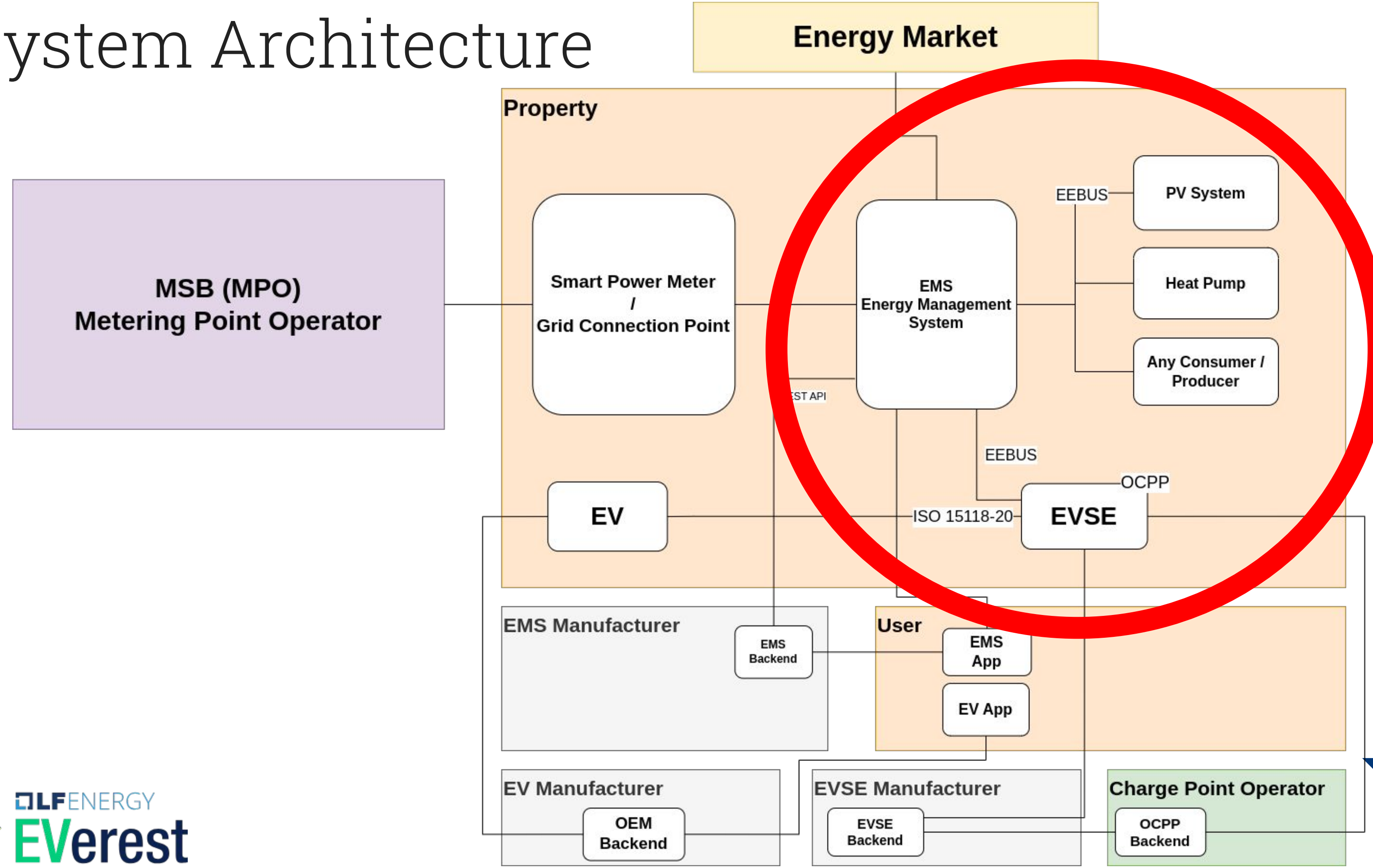
System Architecture



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System Architecture - EEBUS

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

Source: www.eebus.org, www.eebus.org/terms-of-use/

System Architecture - EEBUS

Use Case: Limitation of Power Consumption

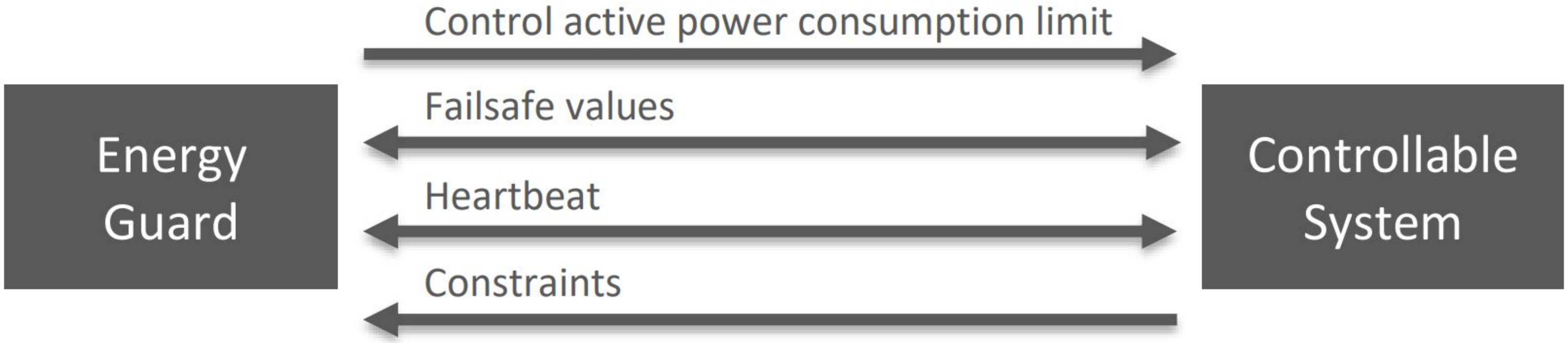


Figure 1: High-Level Use Case functionality overview

Source: www.eebus.org, www.eebus.org/terms-of-use/

System Architecture - EEBUS

Use Case: Coordinated EV Charging

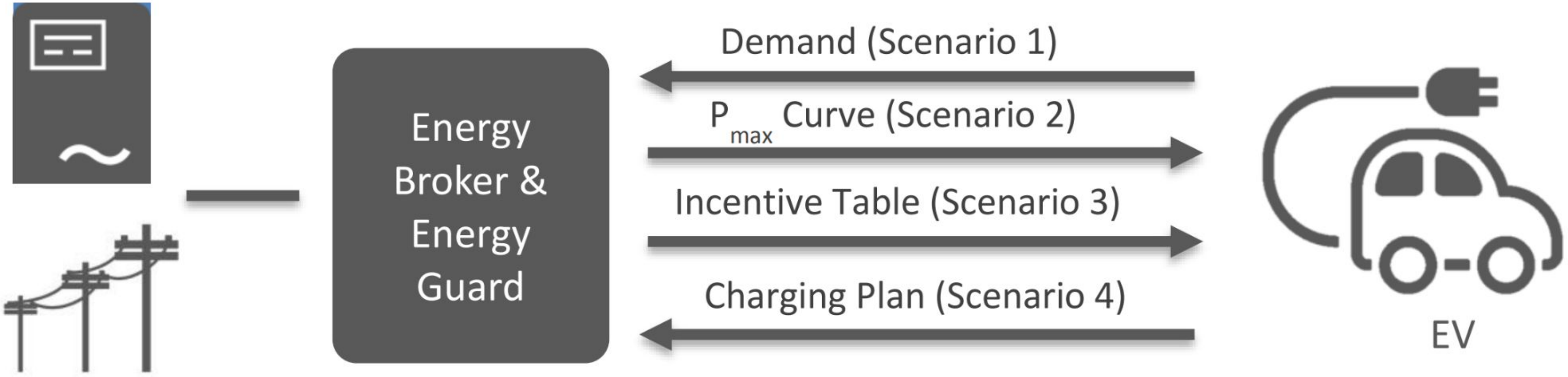


Figure 1: High-Level Use Case functionality overview

Source: www.eebus.org, www.eebus.org/terms-of-use/

System Architecture - EEBUS

Use Case: Optimization of Self-Consumption

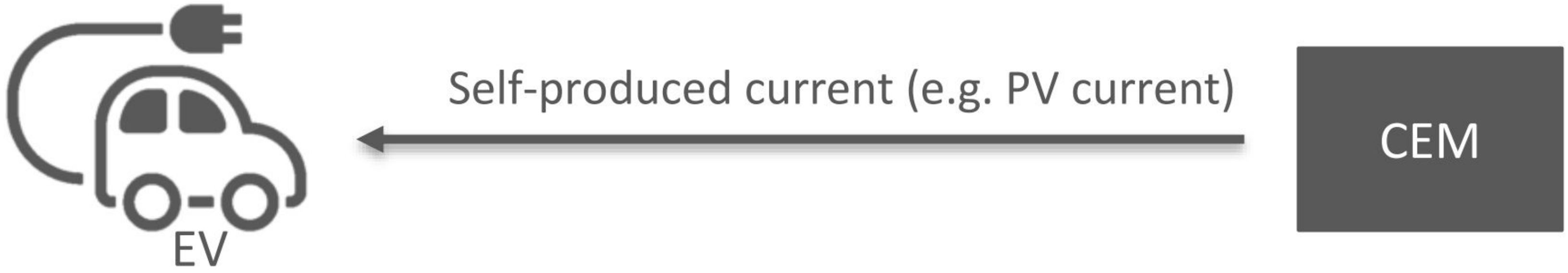


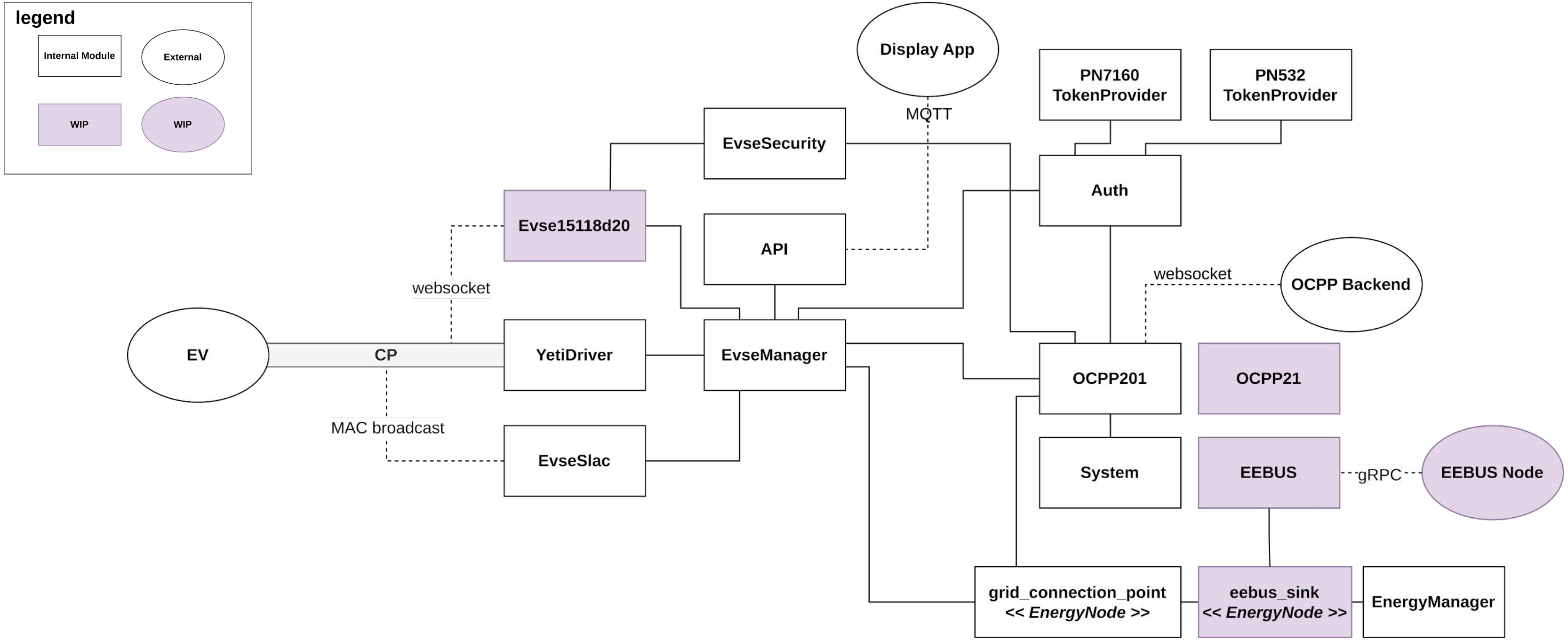
Figure 1: High-Level Use Case functionality overview

Source: www.eebus.org, www.eebus.org/terms-of-use/

Energy Management in EVerest

EVerest's internal architecture

EVerest's internal architecture



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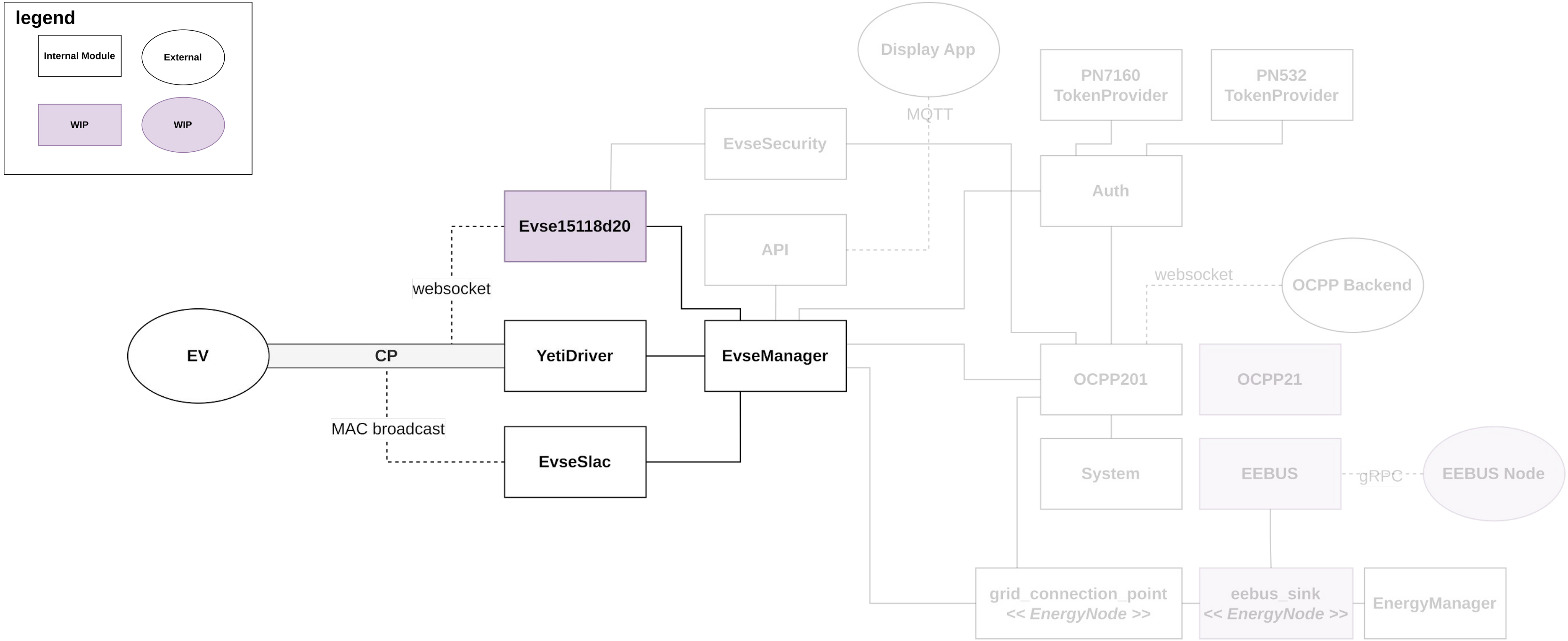
EVerest's internal architecture - ISO 15118



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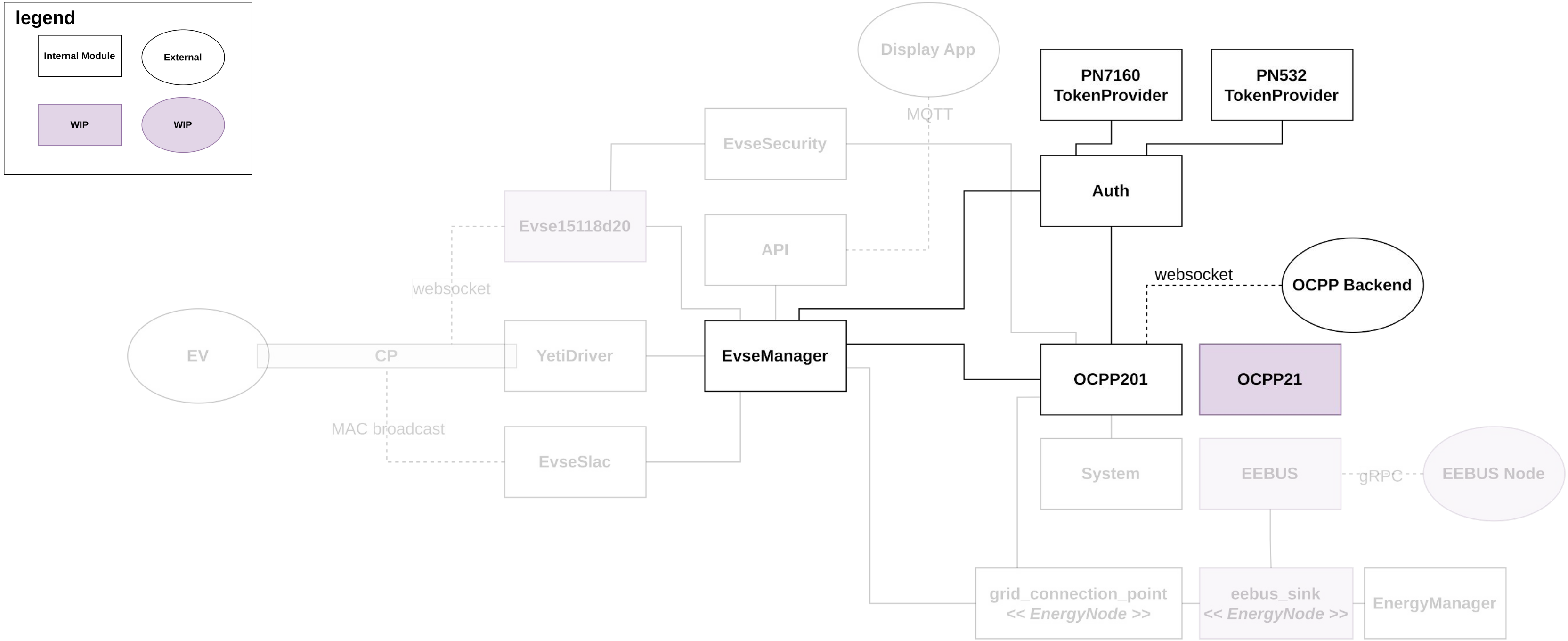
EVerest's internal architecture - OCPP



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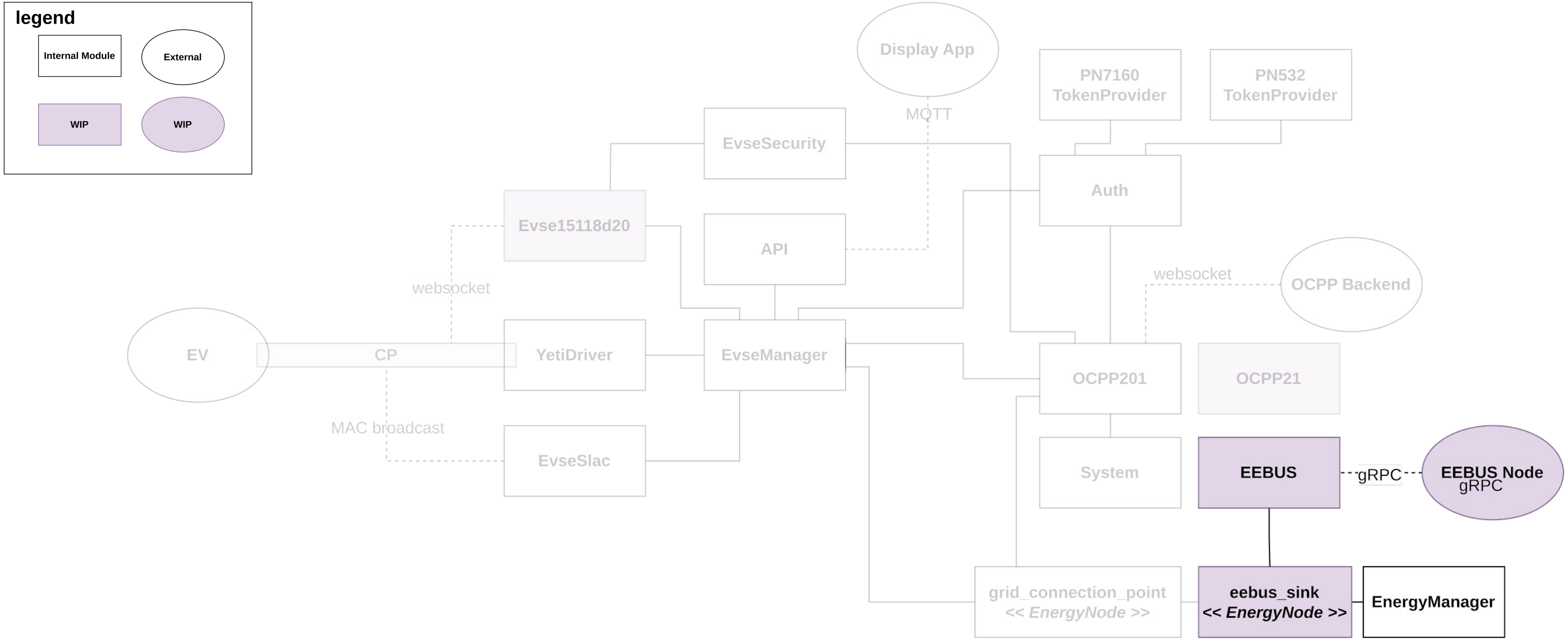
EVerest's internal architecture - EEBUS



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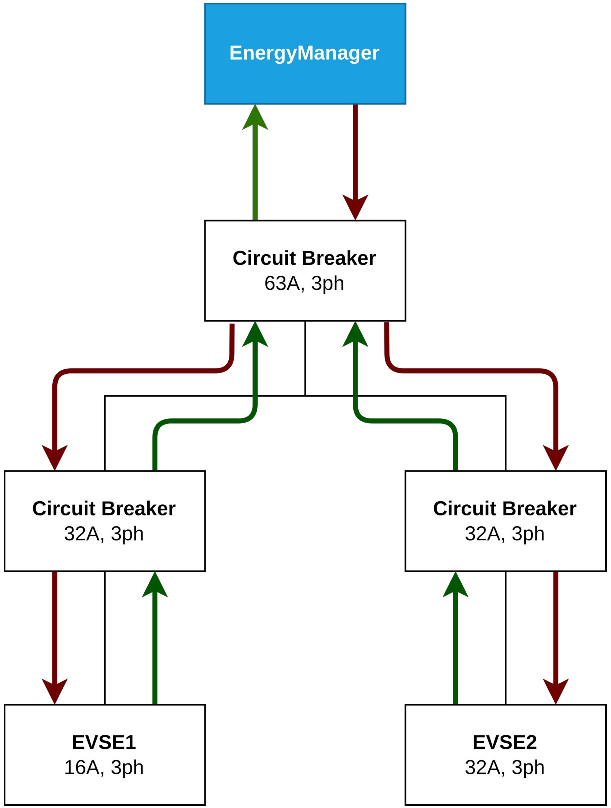
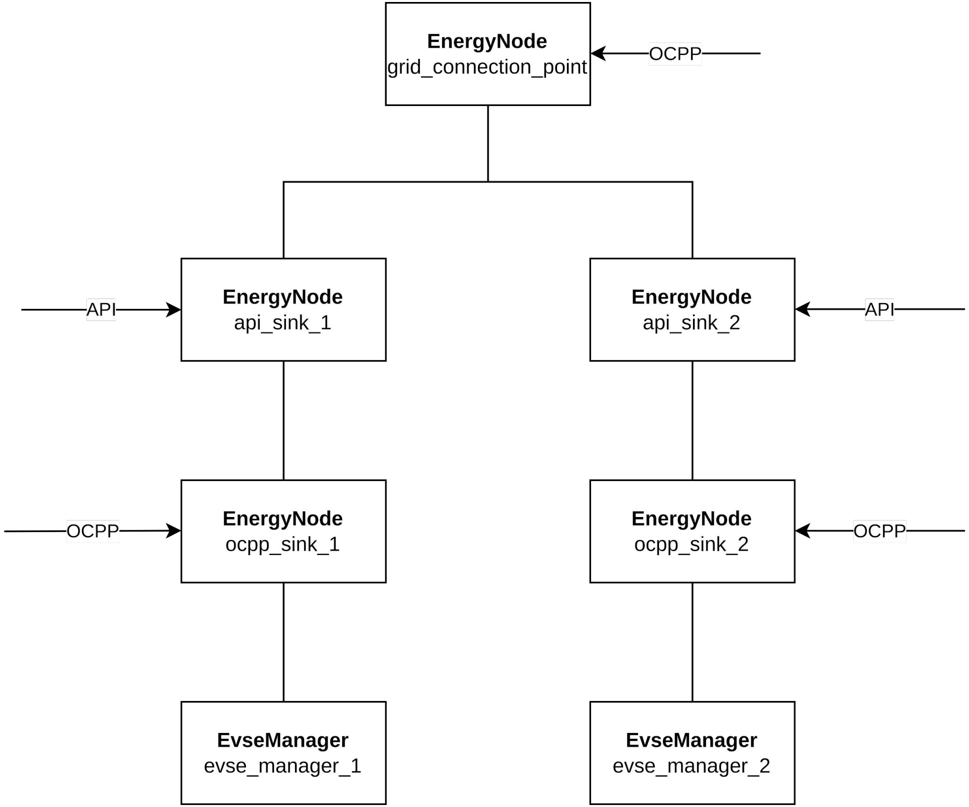
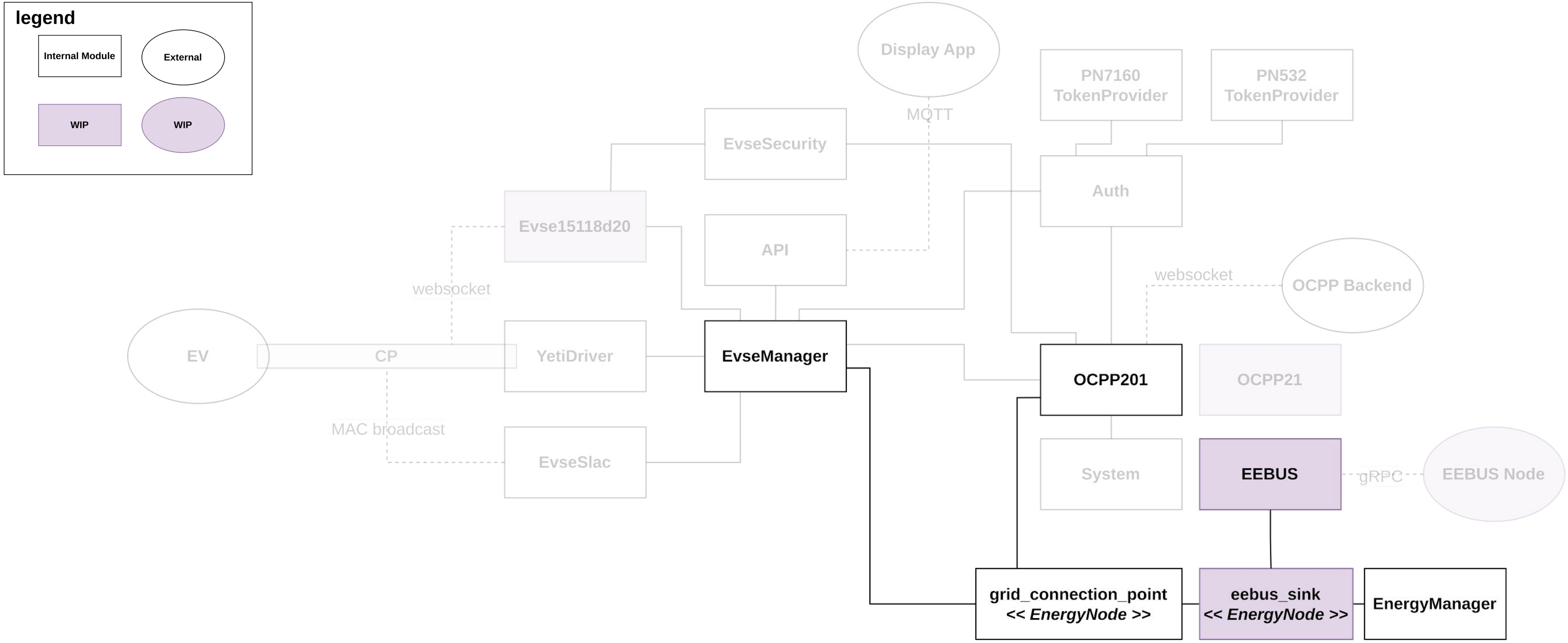
Energy Management inside EVerest



Energy Management inside EVerest



EVerest's internal architecture - Energy Tree



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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

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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

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Open Software

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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

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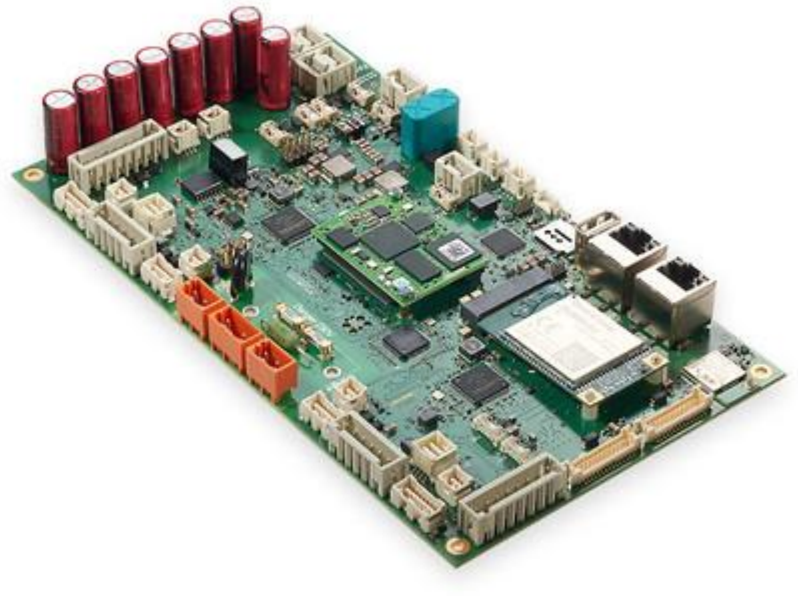
Known EVerest based charger

- 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

SCAN ME

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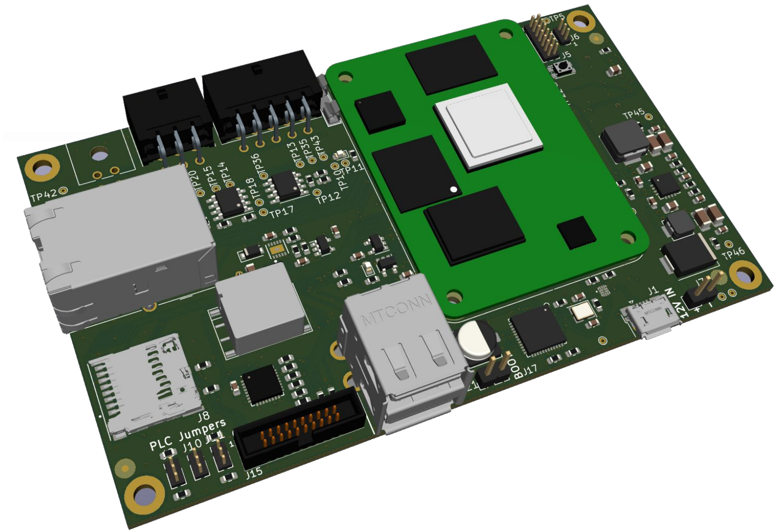
YAK



- 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

SCAN ME

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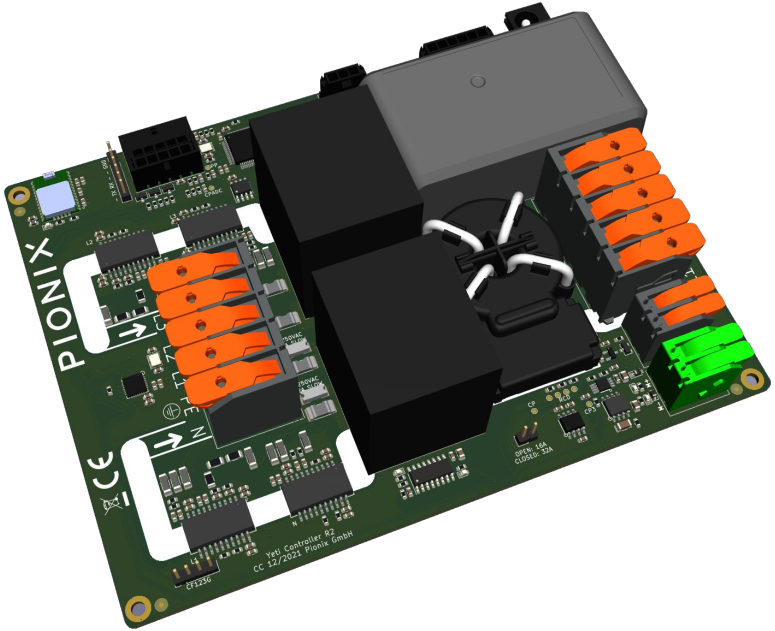
YETI



- 2x 40A AC relais 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

SCAN ME

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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

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Thanks

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