/ Perfect Welding / Solar Energy / Perfect Charging

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DOES EV CHARGING WITH PV MAKE SENSE?

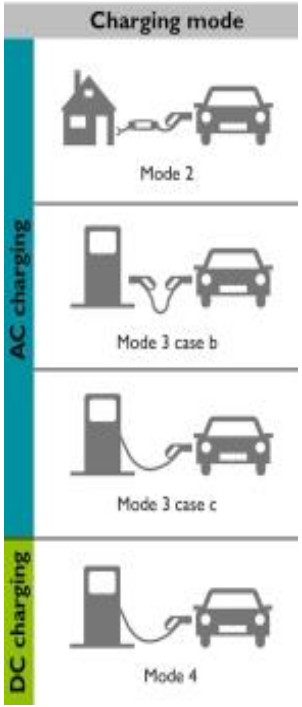
AGENDA

- / Charging options – How to charge my EV at home?
- / Charging power – The concern of long charging times.
- / Facts & Figures – About distance, capacity and charging time
- / Fronius Solutions – Which control options are available?
- / Profitability – Is EV charging with PV economical?

How to charge my EV at home?

Charging options

CHARGING MODES - OVERVIEW



Charging device

ICCB cable – up to 22 kW
In-cable-control-box

250€ - 1.200€

Wallbox – up to 43,5 kW

700€ - 2.000€

Fast charging station – up to 170 kW
(Chademo, Combo, Type 2)

~20.000€

RESIDENTIAL CHARGING DEVICES

1. Charging socket: using ICCB-cable

/ 1-phase 230VAC socket: > 2,3 kW with a CEE Cara socket

Charging power **1,4 - 3,7 kW** (6 / 10 / 12 / 16 A)

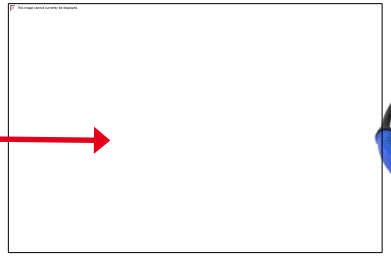
/ 3-phase socket (ICCB cable including RCD Typ B)

Charging power **4,1 - 22 kW** (6 / 10 / 12 / 16 /32 A)

2. Charging from a Wallbox

Charging power 1-phase **1,4 - 4,6 kW** (20 A)

Charging power 3-phase **4,1 - 22 kW** (32 A)



CHARGING PLUGS ON EVS

Charging plugs

Kia
Mitsubishi
Nissan
Toyota

Audi
BMW
Mercedes
Opel
Renault
VW
Tesla
Hyundai
Volvo

Steckertypen

Type 1 plug
1-phase- AC charging up to 7,4 kW
Japan / US

Type 2 plug
1or 3-phase- AC charging up to 43,5 kW
EU standard

Combo 1 or 2 plug
AC and DC charging up to 170 kW
Combined plug , EU standard

CHAdeMo
DC charging up to 150 kW
Japan

Charging mode:

Mode 2
AC-charging with ICCB cable

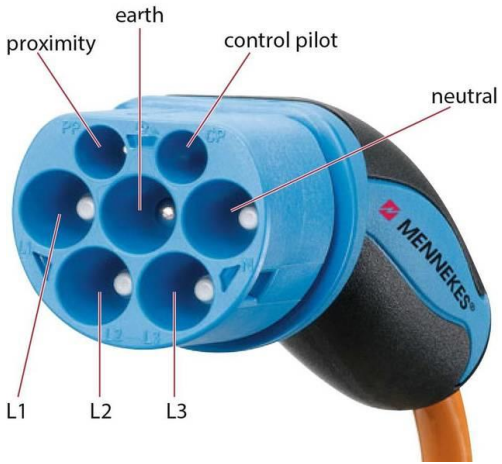
Mode 3
AC-charging with Wallbox

Mode 4
DC fast charging

TYPE 2 PLUG - NEW STANDARD 2016

Proximity PIN:
Resistor in cabel (100 - 1500Ohm)
Defines the max. current of the cable

Control pilot PIN:
PWM Signal - EV status information
- EV Ready signal (on / off)
- Max. current



No advanced communication between EV and charging station (AC charging)!

E.g.: Information of SOC isn't communicated.

The concern of long charging times

Charging power

EXPERIENCES OF EV AND PV OWNER'S

The concern of long charging times

- / High charging power at home is **NOT** necessary!
- / Comfort is **NOT** effected by moderate charging power!
- / Moderate charging power can save money!

Why?

- / No need for fast charging at home (especially for new EVs with >30kWh capacity)
  - / EVs are not empty when arriving at home
- / "Slow charging" is sufficient to ensure a fully charged EV in the morning

  100km → 3,7kW 1-phase → <5h

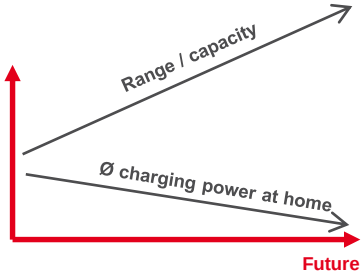
EXPERIENCES OF EV AND PV OWNER'S

The concern of long charging times

- / High charging power at home is not necessary!
- / Comfort is NOT effected by moderate charging power!
- / Moderate charging power can **SAVE money**!

Why?

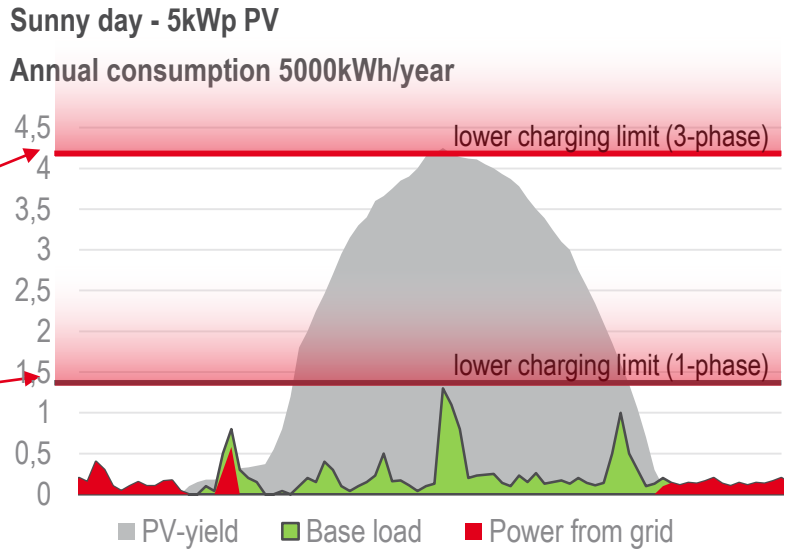
- / Low charging power increases self consumption rate
- / Peak power related electricity tariffs
- / Charging power limits from grid operators



Development towards lower average charging power at home

CHARGING POWER WITH PV SYSTEM

- Wallbox can't control charging current
  - Max. limit of current is sent to EV
  - EV usually follows the limit
- Max. limit of charging current is sent by PWM
  - In the range of **6A** to 80A
  - 3 phase: **4,1kW** to 22 kW
  - 1 phase: **1,4kW** to 7,4 kW



3 phase charging is unfavorable for rather small PV systems (<5kW)

3 phase charging including stepless control doesn't make sense at all!

CHARGING POWER WITH PV SYSTEM

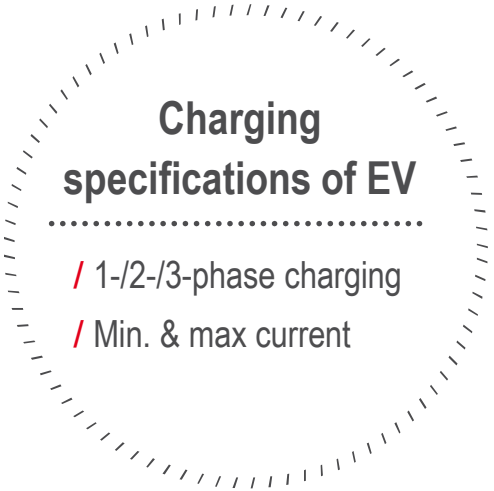
1 phase charging suits better to small PV systems

Realistic max. charging current

- / 6A to 16A (32A) (unbalanced load)
- / 1 phase 1,4kW to 3,7 kW (7,4 kW)

But:

- / No fast charging possible
- / Unbalanced loads



About distance, capacity and charging time

Facts & Figures

FACTS AND FIGURES – EV RANGE + CONSUMPTION

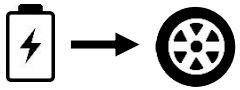
/ **Calculation of the max. range of the EV:**

$$Max.\,Range = \frac{Battery\ capacity}{Consumption} \cdot 100$$

/ **Example (e-Golf):**

$$Max.\,Range = \frac{35{,}8kWh}{15kWh/100km} \cdot 100 = \mathbf{238km}$$

/ Consumption also strongly depends on:
- / Way of driving (highway, etc.)
- / Ambient temperature (the colder the less capacity is available)
- / Additional consumers (air-conditioning)



15 kWh per 100km

/ **Charging capacity for AC charging @ 90% efficiency**

17 kWh per 100km

FACTS AND FIGURES – CONSUMPTION PER DAY

/ **Energy consumption per day:** $$Consumption\ per\ day = \frac{Consumption}{100} \cdot Distance$$

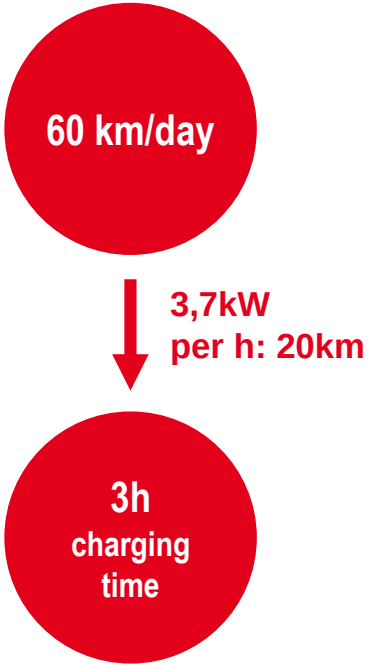
/ **Example** (e-Golf, **60km/Tag**): $$Consumption\ per\ day = \frac{17\ kWh/100km}{100} \cdot 60km = \mathbf{\sim 10kWh}$$

60 km/day
~10 kWh

FACTS AND FIGURES – RANGE AFTER 1 HOUR

- Range after 1 hour of charging at home by charging power
  - Assumption: 17 kWh/100km consumption

Info	Charging power	Range [km]
min. charging power (1-phase)	1,4 kW	~ 10 km
Schuko plug (1-phase)	2,3 kW	~ 15 km
Standard charging power (1-phase)	3,7 kW	~ 20 km
min. charging power (3-phase)	4,2 kW	~ 25 km
max. charging power (3-phase)	11 kW	~ 60 km



HOUSEHOLD – ELECTRICITY CONSUMPTION

Household:

Electricity demand per household ..... **~5000 kWh/a**

Distance per year (1 car) ..... 17.500 km

Consumption per day ..... 8 kWh

Additional energy demand for EV ..... **~3000 kWh/a**

Typical size of PV & storage systems

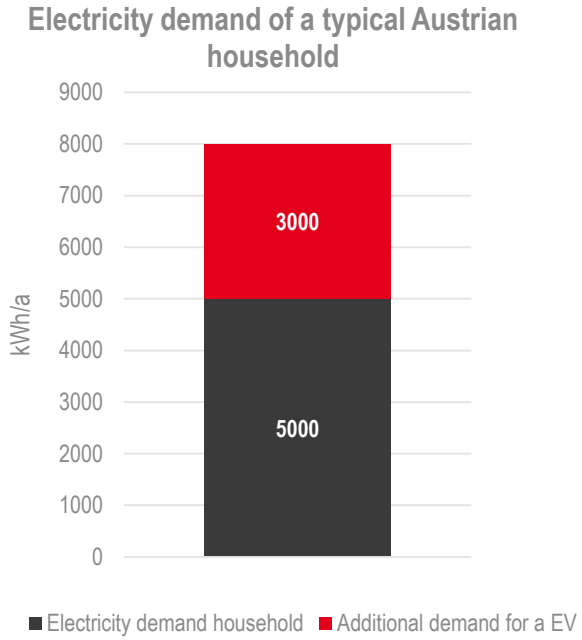
PV System size ..... **~5 kWp**

Additional PV for EVs ..... **~3 kWp**

Storage capacity without EV..... **6 – 7 kWh**

Additional capacity with EV (evening charging) ..... **6 – 8 kWh**

PV + storage systems will increase!



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How to combine PV and EV perfectly?

Fronius Solutions

CONTROL OPTIONS

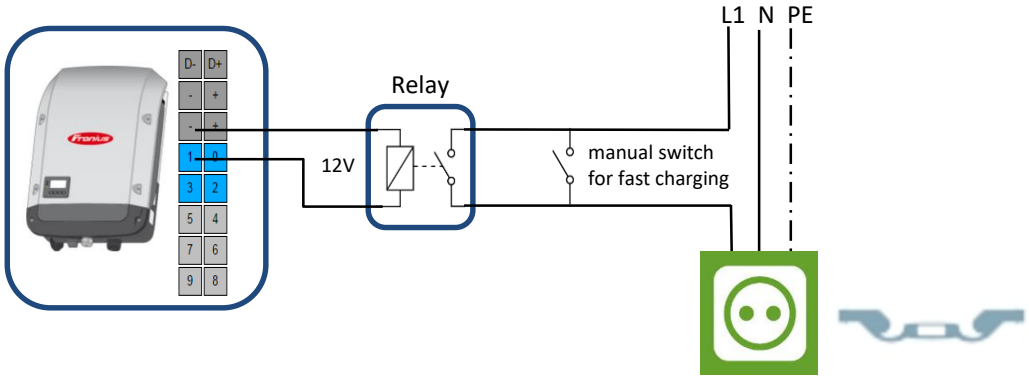
No control	Controlled by Fronius Datamanager	Stepless Control
Charging with standard Wallbox	**Charging with a controlled Wallbox**	**Charging with a stepless controlled Wallbox**
Charging starts when EV is plugged in	EV is charged when sufficient PV energy is available	Stepless control by external load management
Standard Wallbox or ICCB cabel required	Wallbox incl. “charging enable input” or controlled socket incl. ICCB cabel required	Wallbox + external load management required

* Cost/ Savings in 5 years

CONTROLLED BY FRONIUS DATAMANAGER

Control of a charging socket

- / 12V relay activates a socket when PV power is available (day charge)
- / Night time charging mode: Ensures fully charged EV in the morning
- / Manuel switch for fast charging
- / 1-phase or 3-phase power point socket

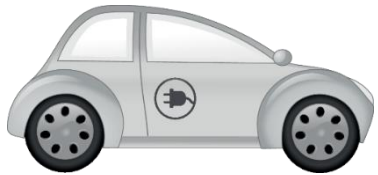


Advantages

- \+ Easy, cheap and effective solution
- \+ Charging current is adjustable (with suitable ICCB cable)

Disadvantages:

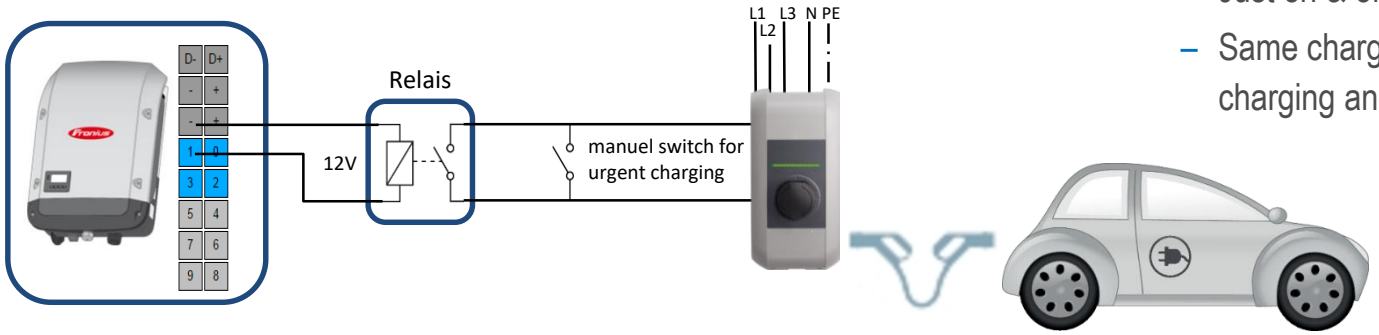
- – Just on & off control possible
- – Switching the socket for several times can cause problems at some EVs



CONTROLLED BY FRONIUS DATAMANAGER

Control of a Wallbox

- / 12V relay activates the “charging enable input” from the Wallbox when PV power is available (day charge)
- / Night time charging mode: Ensures fully charged EV in the morning
- / Manual operation switch for urgent charging



Advantages

- \+ Easy and effective solution
- \+ Switching the Wallbox for several times doesn’t cause problems

Disadvantages:

- – Just on & off control possible
- – Same charging current for PV charging and urgent charging

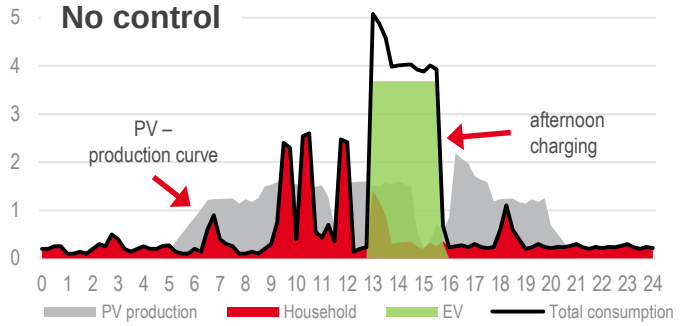
CONTROLLED BY FRONIUS DATAMANAGER

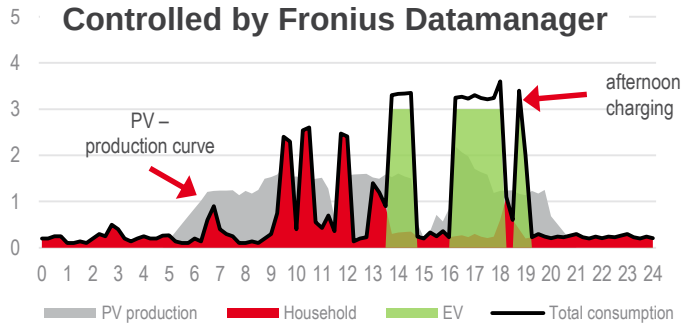
Comparison to “No control”

- / Higher self consumption rate
- / Night charging to ensure minimum charging capacity
  - / Use of cheap night time electricity tariff (evening charging or bad weather)

Example: Afternoon charging, cloudy

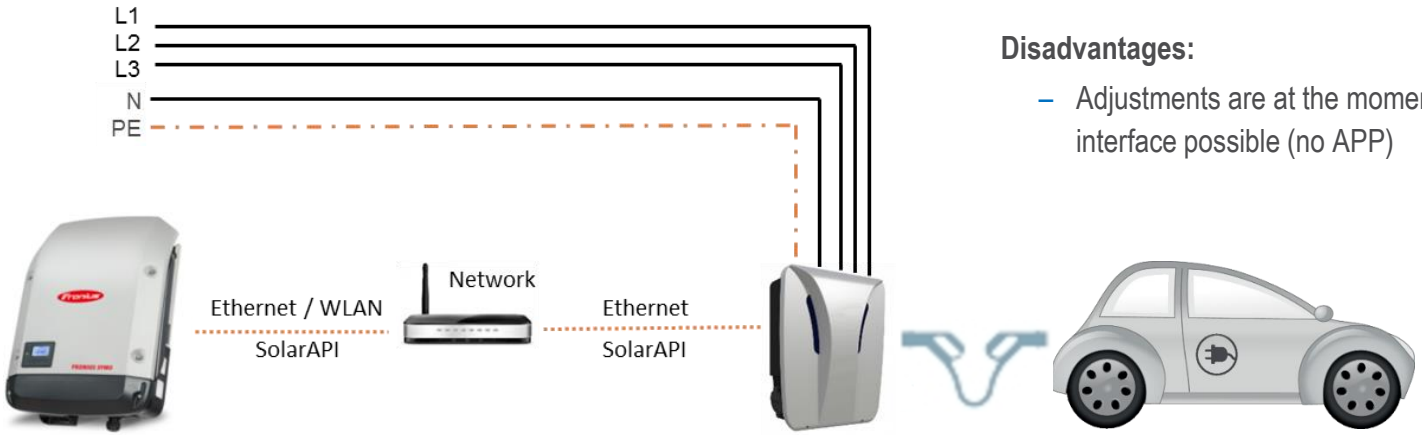
Range @17 kWh/100km	60 km
Charging capacity	10,2 kWh
PV energy charged in the EV directly	
No control	**1,7 kWh**
Controlled by Fronius Datamanager	**4,4 kWh**





STEPLESS CONTROL - ECHARGE CPH1

- / Stepless control
- / The integrated controller (eCB1) is used for load management
- / Communication via home network: SolarAPI
- / Link: http://echarge.de/



Advantages

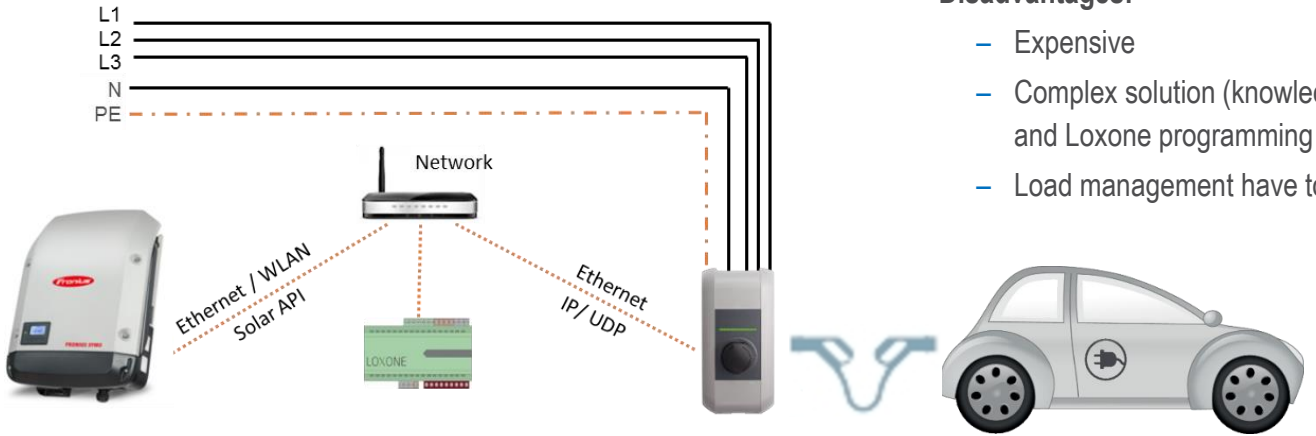
+ Neat and tidy solution / design
+ Highest self consumption rate
+ Easy to install / easiest solution incl. stepless control

Disadvantages:

– Adjustments are at the moment just via web interface possible (no APP)

STEPLESS CONTROL - LOXONE - KEBA

- / Stepless control
- / Loxone is used for load management
- / Communication via home network
  - / Fronius Inverter – Loxone: Solar API
  - / Loxone – Keba Wallbox: IP/UDP



Advantages

- \+ Neat and tidy solution / design
- \+ Individual load management can be implemented
- \+ Integration in the SmartHome

Disadvantages:

- – Expensive
- – Complex solution (knowledge in network technology and Loxone programming is necessary)
- – Load management have to be programmed

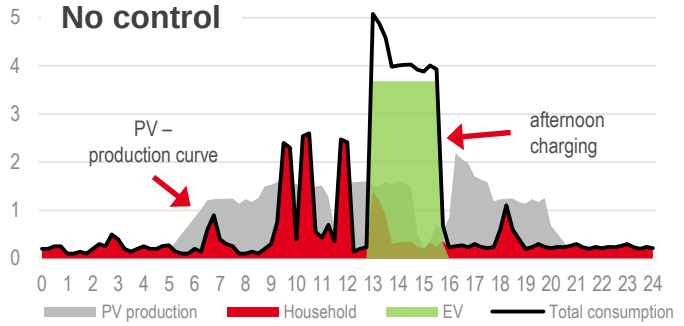
STEPLESS CONTROL

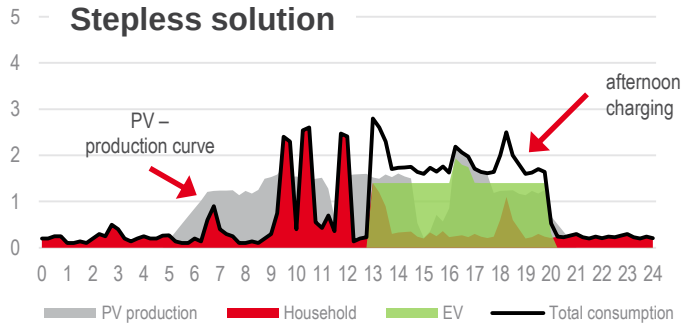
Comparison to “no control”

- / Highest self consumption rate
- / EV is charged with min. charging power below 1.4kW surplus energy (optional)

Example: Afternoon charging, cloudy

Range @17 kWh/100km	60 km
Charging capacity	10,2 kWh
PV energy charged in the EV directly	
No control	**1,7 kWh**
Controlled by Fronius Datamanager	4,4 kWh
Stepless control	**6,1 kWh**





Is EV charging by a PV economic?

Profitability

ASSUMPTIONS

- / PV system: 6 kWp
- / Daily range: 60 km per day
- / Consumption: 17 kWh/100 km
- / Energy per day: 10.2 kWh
- / Charging power: 3.7 kW; 1 phase

- / Electricity tariff: 28 Cent/kWh
- / Feed in tariff: 12 Cent/kWh
- / Night tariff: 25 Cent/kWh
- / Price increase: 3 % per year

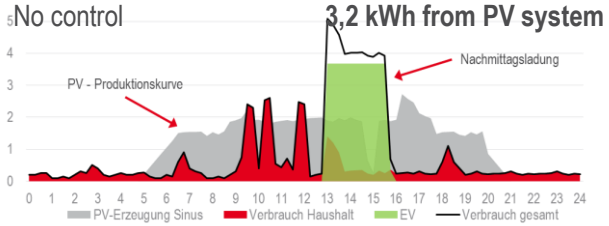
/ Investment costs:

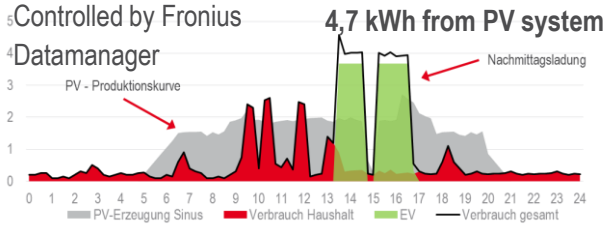
Costs (Wallbox + Installation)	Wallbox	Installation	Sum	
No control	700 €	400 €	1.100 €	eCharge cPµ1
Controlled by Fronius Datamanager	700 €	500 €	1.200 €	eCharge cPµ1
Stepless control	1.250 €	600 €	1.850 €	eCharge cPH1

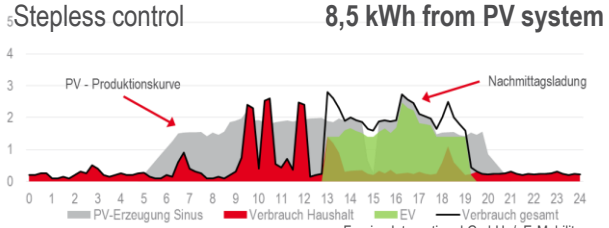
SIMULATION: SAVINGS

- Simulation of the EV charging by different control options:
  - No control
  - Controlled by Fronius Datamanager
  - Stepless control
- Calculation of the higher self consumption rate and the savings depending on:
  - Control option
  - User behaviour

Example: Cloudy day, afternoon charging





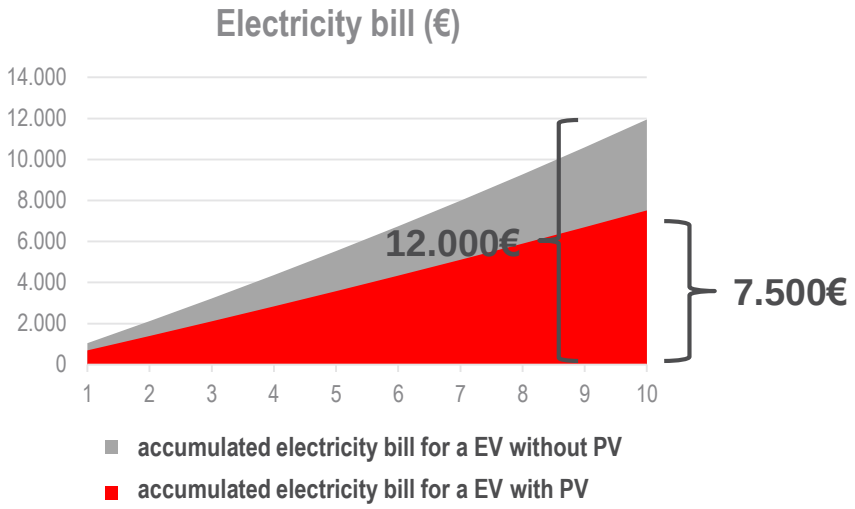


DOES EV CHARGING WITH PV MAKE SENSE?

Electricity costs comparison of an EV:

- / Without PV
- / PV + stepless control

Savings due to PV system*	first year	after 10 years
No control	€ 210	**€ 2600**
Controlled by Fronius Datamanager	€ 280	**€ 3500**
Stepless control	€ 350	**€ 4500**



*with the assumptions: 60km distance per day; 6kWp; user behaviour: part time)

DOES EV CHARGING WITH PV MAKE SENSE?

Savings after deduction of the investment costs (Wallbox + Control Option) after 10 years:*

No control	€ 1.500
Controlled by Fronius Datamanager	€ 2.300
Stepless control	€ 2.600

YES! CHARGING OF THE EV WITH PV DOES MAKE SENSE!

YES! INTELLIGENT CONTROL OF CHARGING THE EV MAKES SENSE!

*with the assumptions: 60km distance per day; 6kWp; user behaviour: part time)

DOES CONTROL OF THE EV CHARGING MAKE SENSE?

Savings depend on:

- Distance per day: higher distance per day → higher savings
- User behaviour: Is it possible to charge the EV during daytime? → higher savings
- PV system size: bigger PV system → higher savings
- Additional factors: load profile, charging power settings, EV capacity, etc.

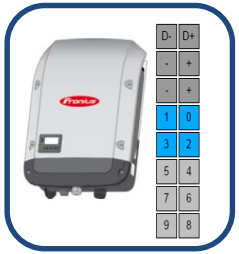
Additional advantages of controlled EV charging:

- Load peaks are avoided (load related electricity tariffs)
- Additional reduction of electricity costs due to the use of cheap night tariffs

Summary

SUMMARY

Controlled by Fronius Datamanger



Perfect for customers,

- Who are looking for a simple and effective solution.
- Who are interested in a cheap solution with a short payback time.
- Who already use / wants to use a flexible electricity price (cheap night tariffs).
- Who prefer a ICCB cable instead of a Wallbox.

SUMMARY

Stepless Control by eCharge cPH1

Perfect for customers,

- / Who are looking for a simple solution offering stepless control.
- / Who want additional options related to charging modes and charging power.
- / Who set a focus on very high self consumption.

SUMMARY

Stepless control by Keba – Loxone


Perfect for customers,

- Who want a SmartHome solution.
- Who prefer a individual load management adjusted to their special situation.
- Where costs are not the most important factor.

Experience with Loxone and in general with load management is necessary!