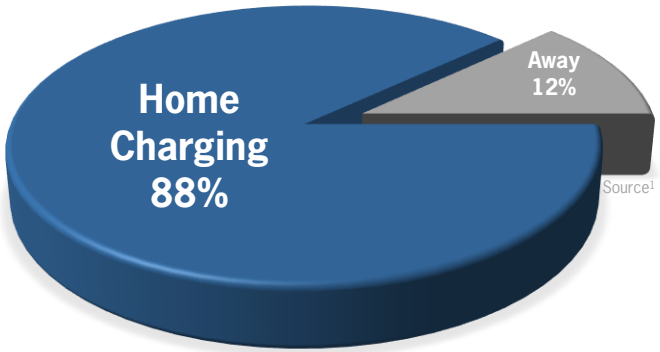
PORSCHE

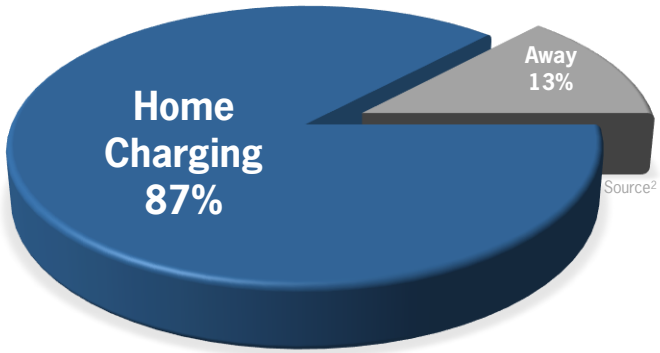
Beyond the EVSE

EV Integration into Energy Management Systems

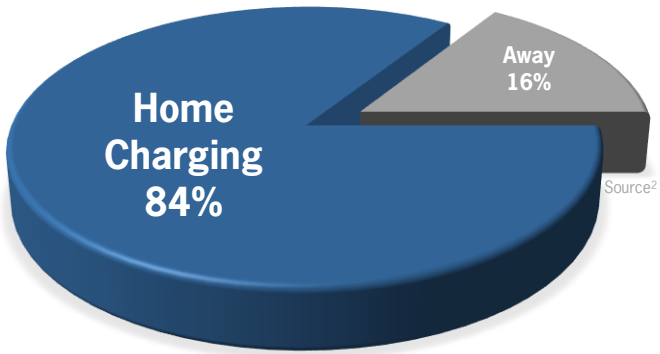
According to various studies, the majority of EV charging takes place at home regardless of the segment or class of vehicle



Tesla Model S



Chevrolet Volt

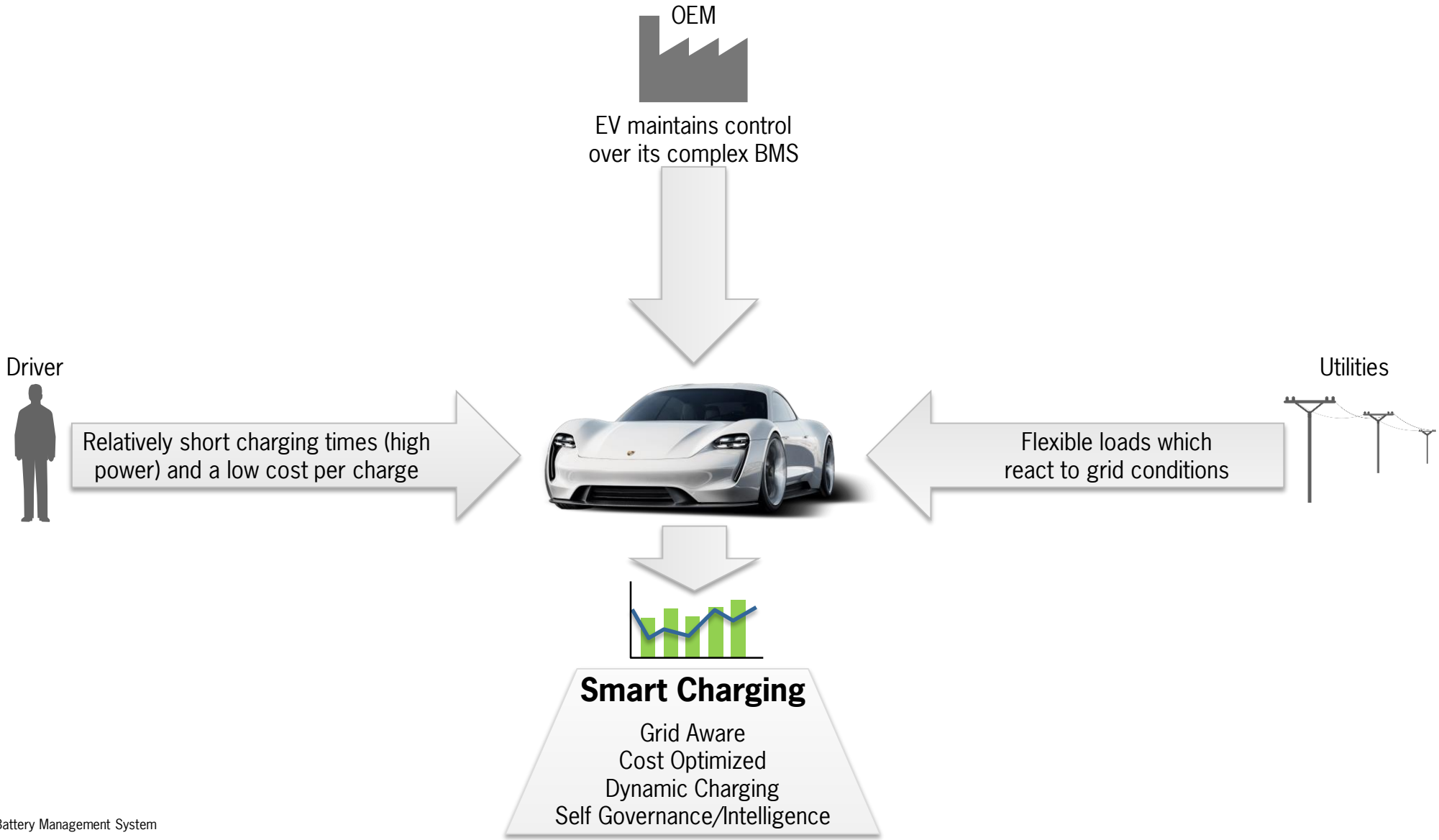


Nissan Leaf

Although these figures may slightly change with the advent of **High Power Charging** infrastructures and **long range BEVs**, the majority of **drivers are expected to continue charging their EVs at home**.

Source[1]: http://assets.fiercemarkets.net/public/smartgridnews/PlugInsights_U.S._PEV_CHARGING_STUDY_2013_media_copy.pdf
Source[2]: https://avt.inl.gov/sites/default/files/pdf/arra/SummaryReport.pdf

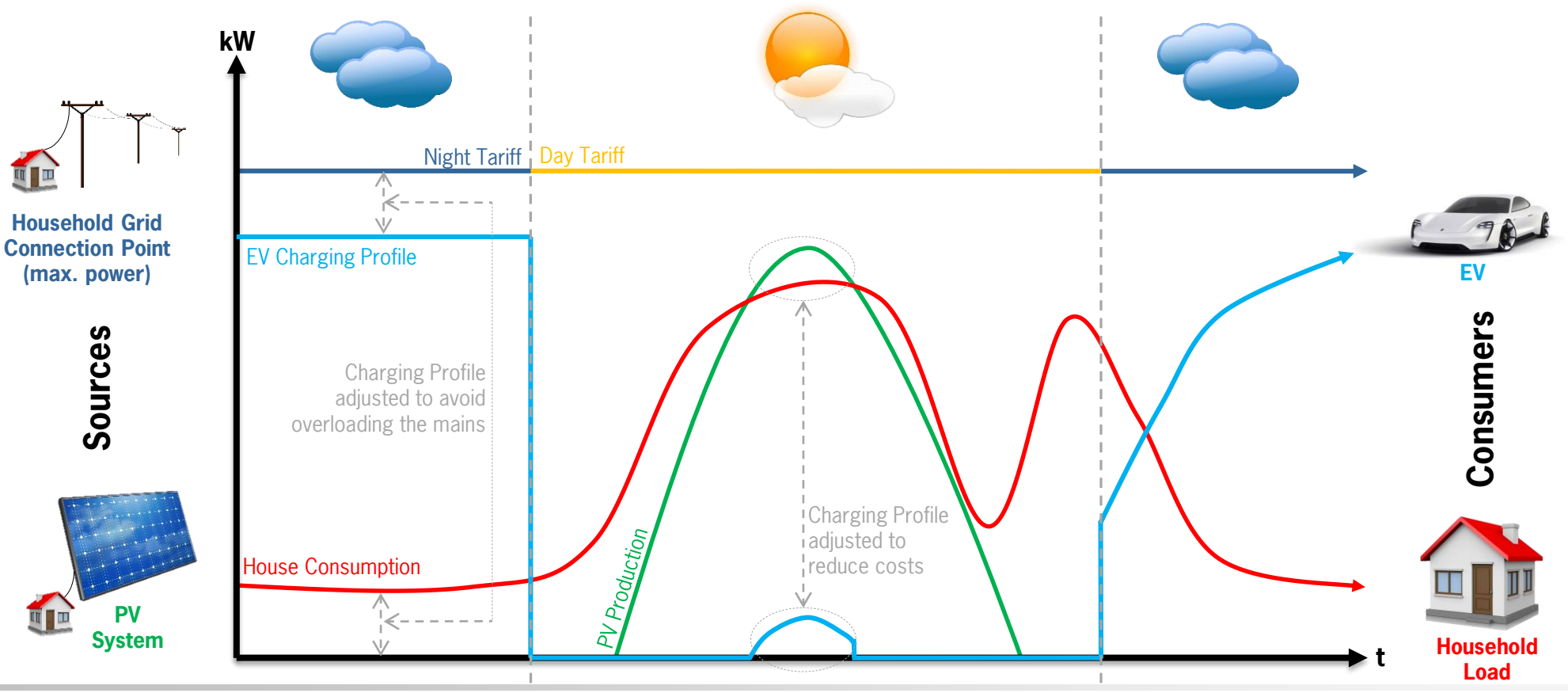
What's needed for Home Charging?



BMS = Battery Management System

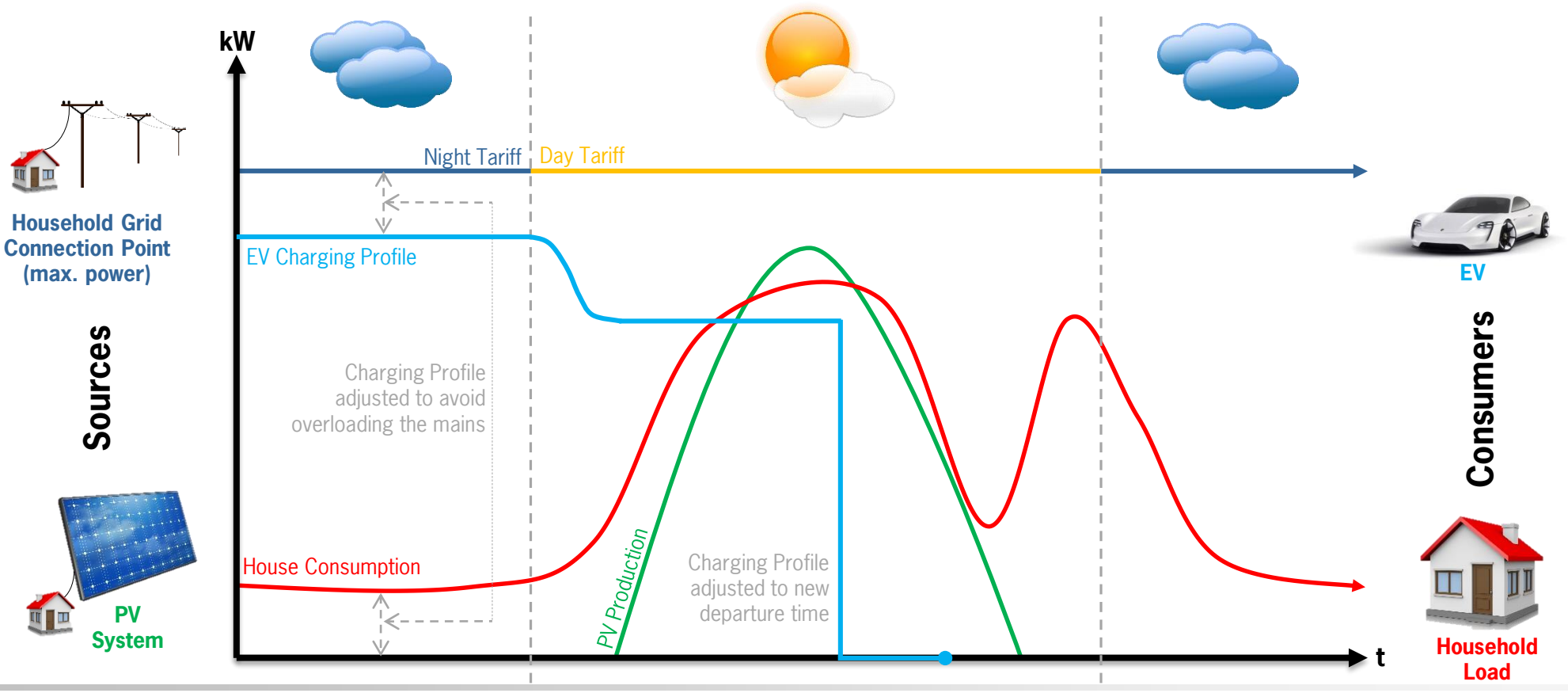
What is Smart Charging?

There is no standard definition for “Smart Charging”, but for simplification we can think of it as **intelligently and dynamically adjusting the EV’s Charging Profile based on various factors** such as grid conditions, financial aspects, and the driver’s needs.

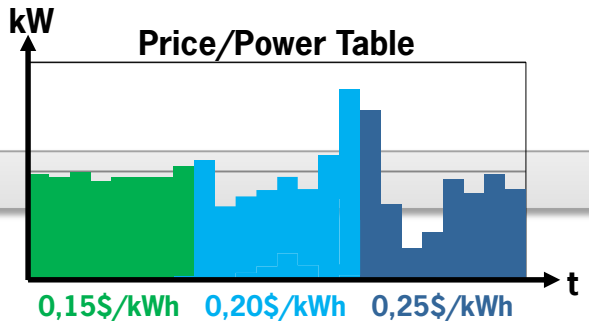


What is Smart Charging?

There is no standard definition for “Smart Charging”, but for simplification we can think of it as **intelligently and dynamically adjusting the EV’s Charging Profile based on various factors** such as grid conditions, financial aspects, and the driver’s needs.



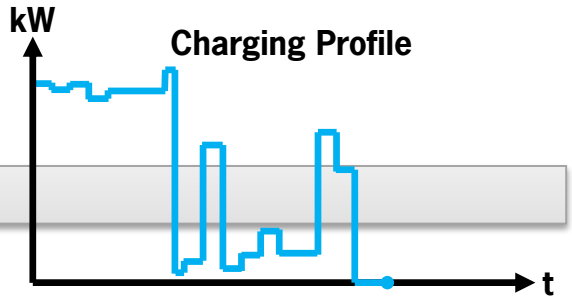
ISO/IEC 15118 Supports Smart Charging with the use of Price/Power Tables



The EVSE sends a **Price/Power Table** to the EV

Price/Power Tables describe the availability of power and the (relative) cost of energy

The EV creates a **Charging Profile** based on the information in the Price/Power Table, its BMS, and the driver defined settings



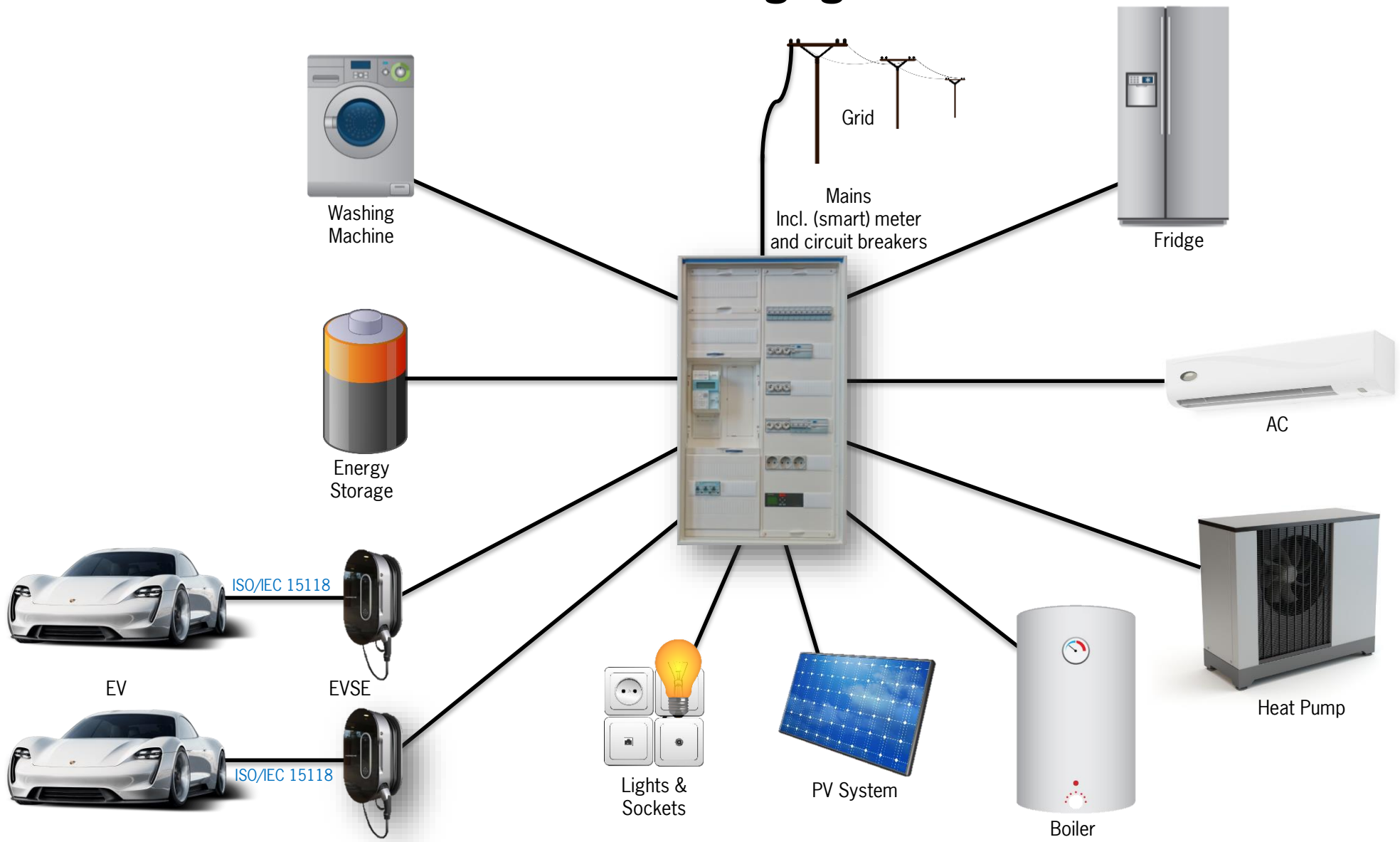
Charging Profiles describe the EV's planned charging power over time

Negotiation

Charge Loop

After this negotiation, the EVSE will **provide power** to the EV allowing the battery to charge

What's needed for residential Smart Charging?



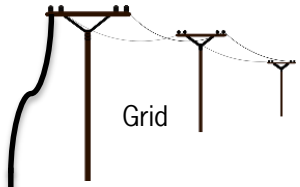
What's needed for residential Smart Charging?

The Problem with Telematics:

- **No information** about the building's private network load is available
- A telematics **link** may not always be available
- "Private **Roaming**" is not supported

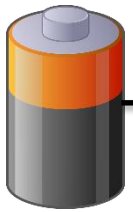
(I charge at your house! What's your tariff? How much power can I draw and when? …)

Grid & Tariff Information via Telematics



Mains
Incl. (smart) meter
and circuit breakers

Fridge



Energy Storage

AC

EV

ISO/IEC 15118

EVSE

ISO/IEC 15118

Lights & Sockets

PV System

Boiler

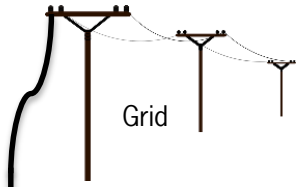
Heat Pump

What's needed for residential Smart Charging?

Residential **Smart Charging** requires an Energy Management System (**EMS**) which supplies the EVSE with private network information such as tariffs and power availability

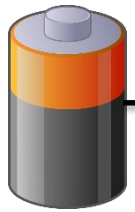

Washing Machine

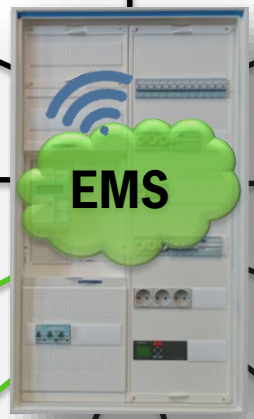

Utility Backend (e.g. Grid & Tariff Information via Smart Meter)



Mains Incl. (smart) meter and circuit breakers


Fridge


Energy Storage




AC


EV

ISO/IEC 15118


EVSE

Tariff and power information


EV

ISO/IEC 15118


EVSE


Lights & Sockets


PV System


Boiler


Heat Pump

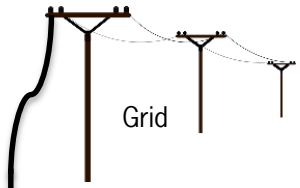
What's needed for residential Smart Charging?

Residential **Smart Charging** requires an Energy Management System (**EMS**) which supplies the EVSE with private network information such as tariffs and power availability

Don't forget, **E-Mobility is not the only EMS use-case!!!**

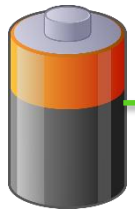

Washing Machine


Utility Backend (e.g. Grid & Tariff Information via Smart Meter)



Mains Incl. (smart) meter and circuit breakers


Fridge


Energy Storage


AC


EV

ISO/IEC 15118


EVSE

Tariff and power information


EV

ISO/IEC 15118


EVSE


Lights & Sockets

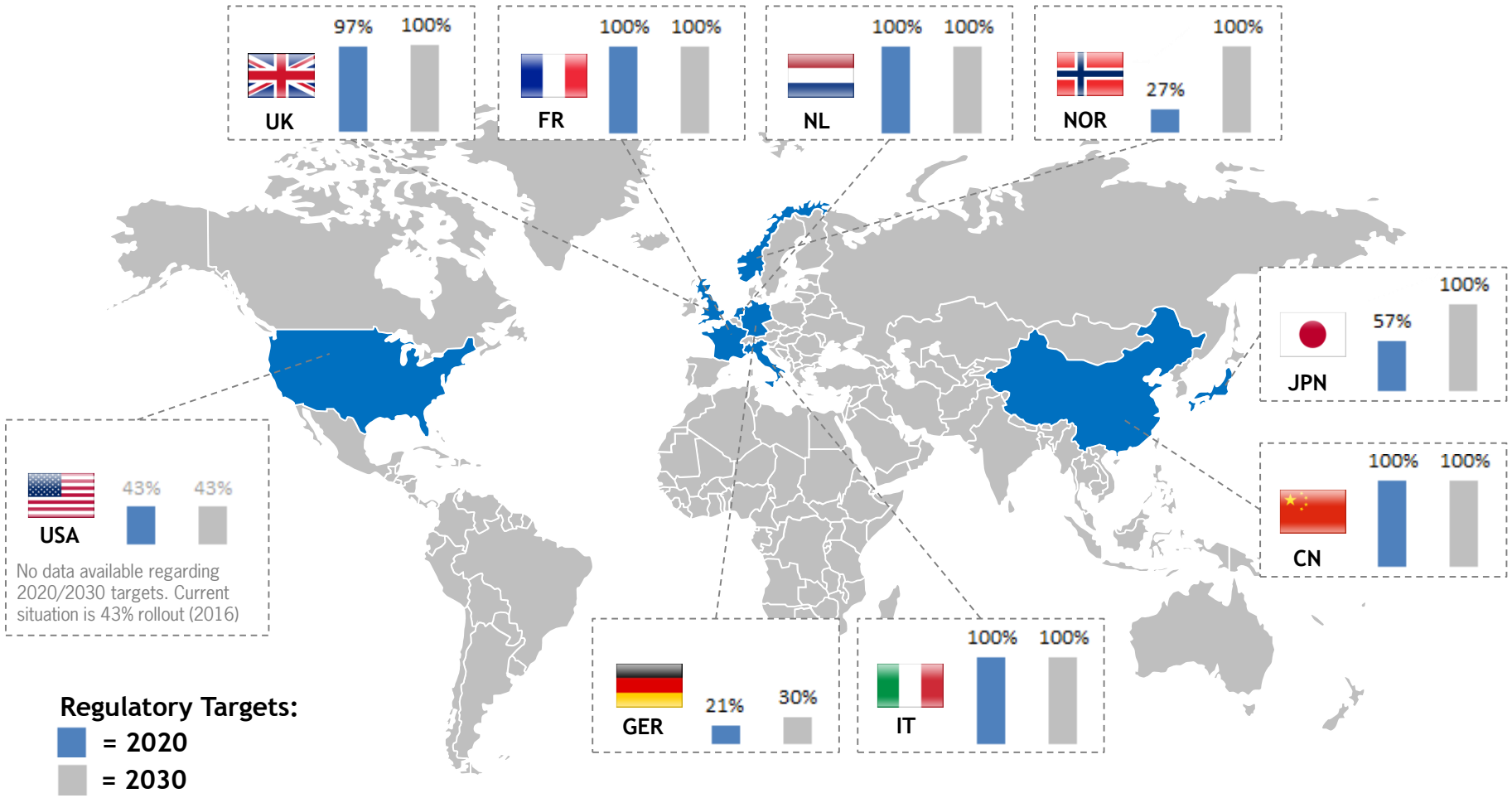

PV System


Boiler


Heat Pump

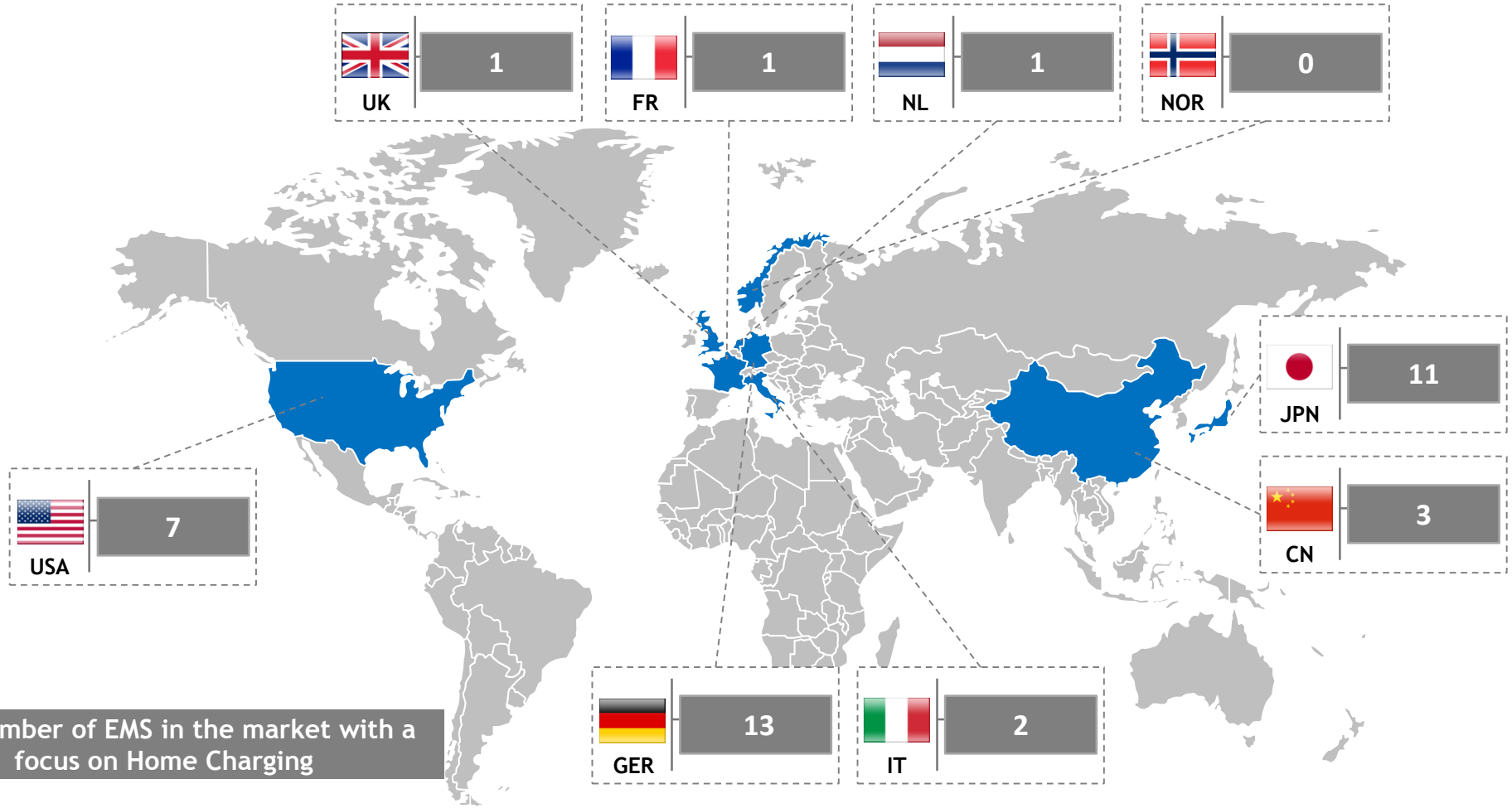
Let's take a quick look at the landscape…

The rollout of residential "2-way" Smart Meters brings with it the possibility of Smart Grid features such as Demand Response and Dynamic Tariffs



Source: P3 Group (2016) | A "2-way" Smart Meter is able to communicate with the utility provider as well as within the home

EMS availability with Home Charging support is still pretty scarce



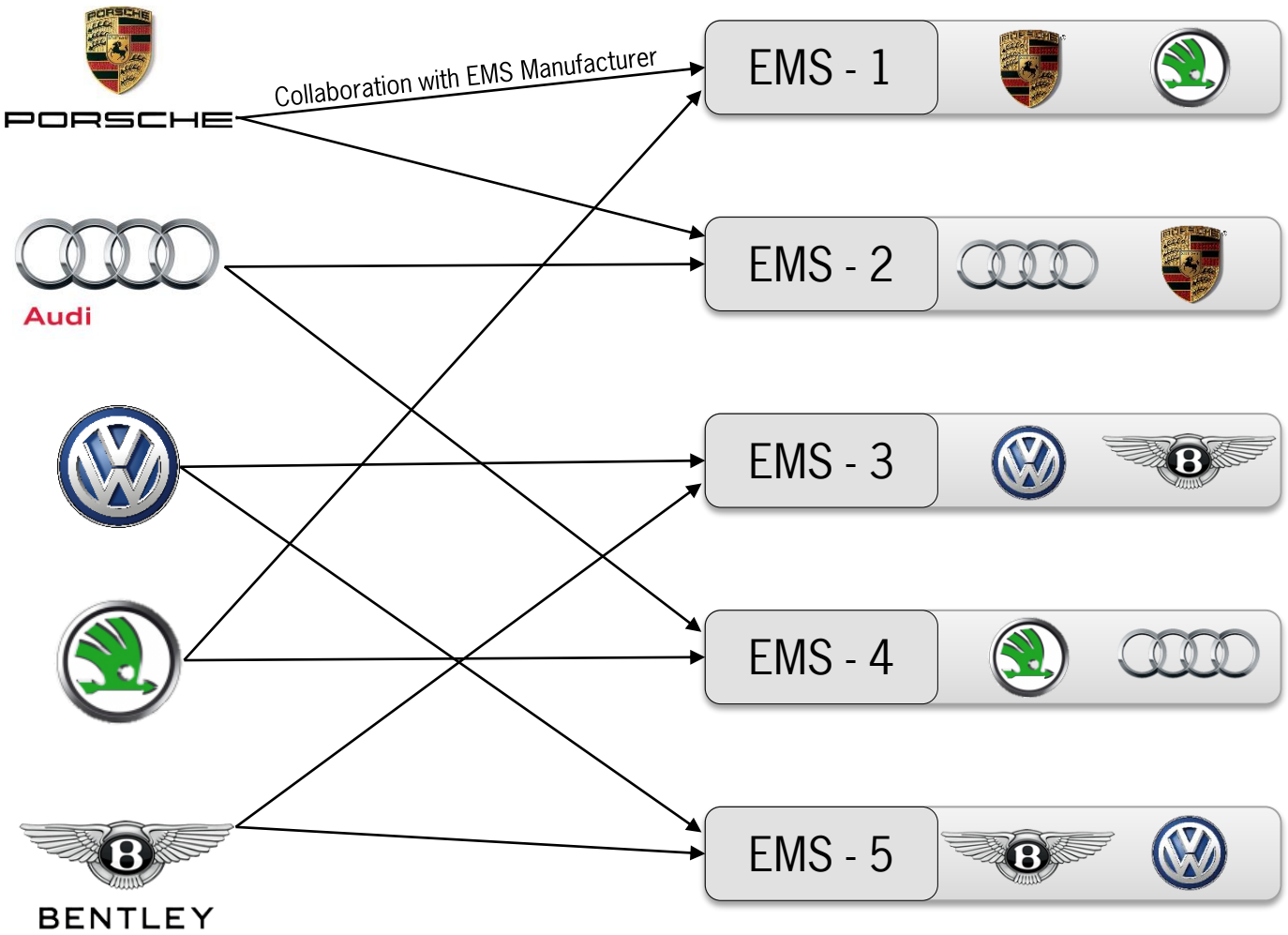
Legende:

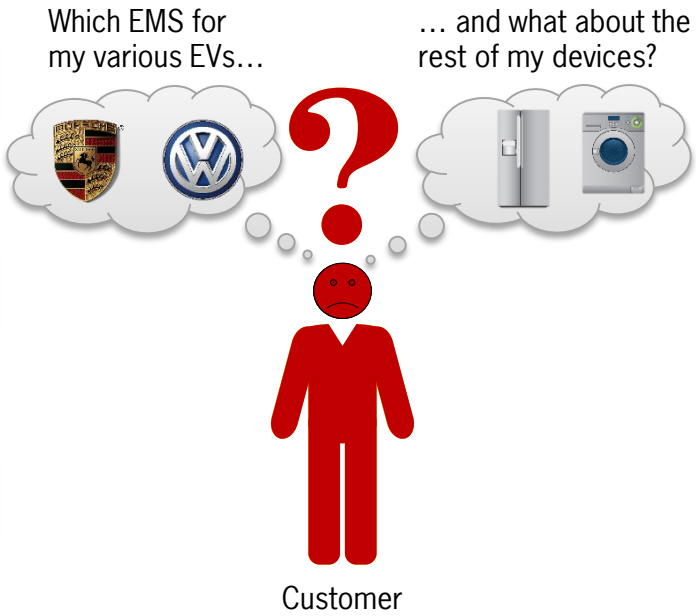
x = Number of EMS in the market with a focus on Home Charging

Most, if not all, of these HEMS use proprietary protocols and are not sold worldwide

Source: P3 Group (2016)

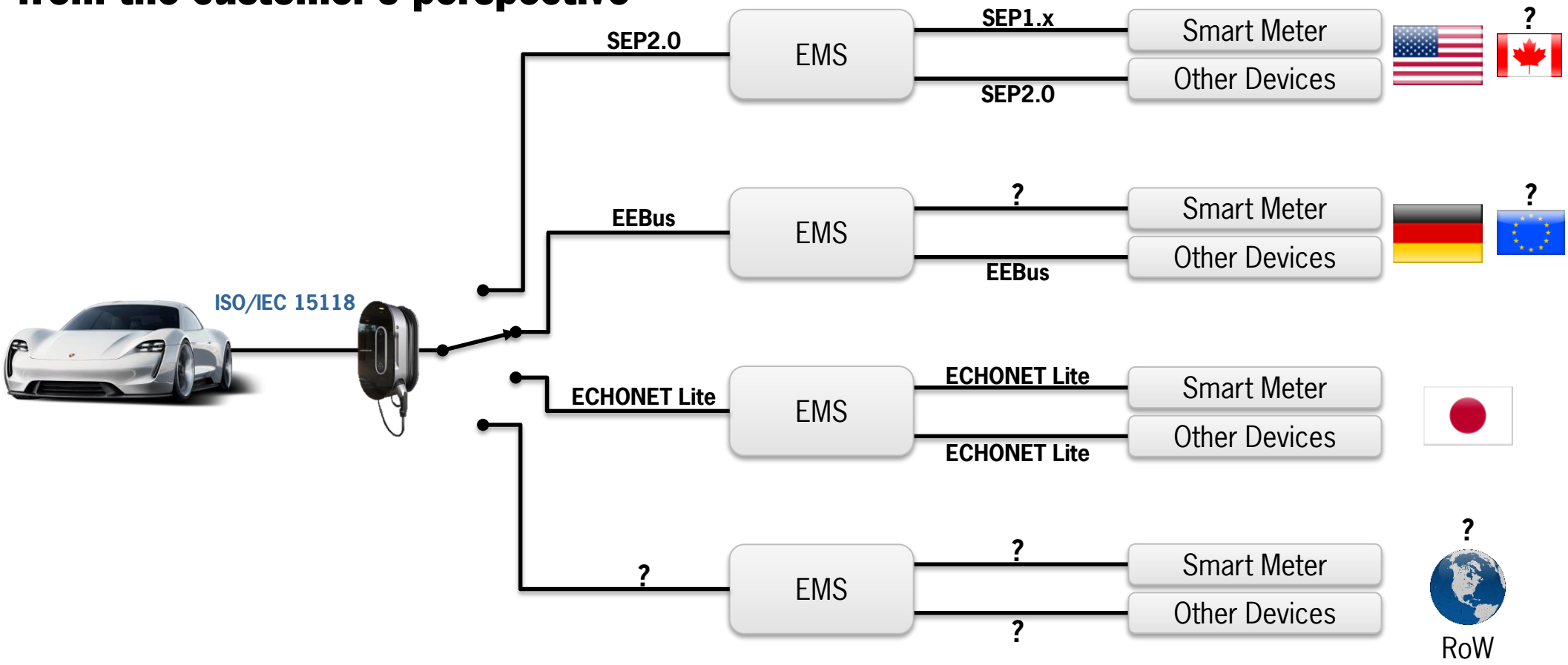
Today, most OEMs offer their customers proprietary solutions with very limited interoperability which leads to customer dissatisfaction





EMS = Energy Management System

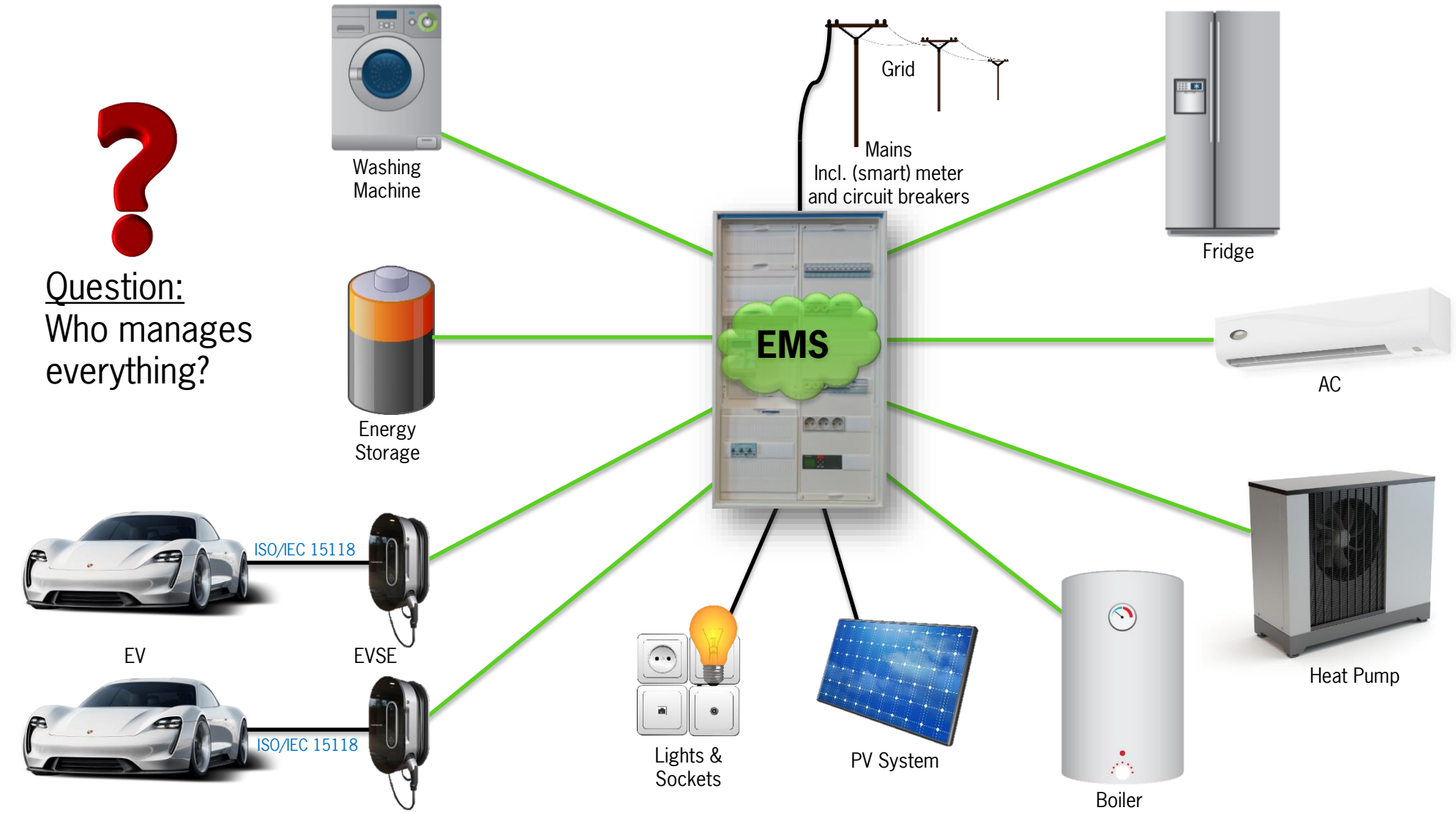
Multiple EMS standards already exist which further hinders interoperability from the customer's perspective



There's **no standard EMS protocol**, however, as we strive towards Smart Homes, Smart Devices and Smart Grids, this will become more paramount. It's doubtful that there ever will be a single EMS protocol, but **limiting the number of protocols will help accelerate the development and adoption of smart EMS technologies.**

OK, back to the point…

As we approach the era of Smart Grids, Smart Home and Smart Energy, we expect to see all large energy consumers connected to the home via an EMS



Option 1: A central intelligence contained within the EMS

- Load size
- Set mode/program
- State within the mode/program
- All program/mode characteristics
- Necessity to run now
- Target water temp.
- Actual water temp.
- …

Washing Machine

Utility Backend (e.g. Grid & Tariff Information via Smart Meter)

Grid

Mains Incl. (smart) meter and circuit breakers

- Target temp. fridge
- Actual temp. fridge
- Target temp. freezer
- Actual temp. freezer
- Cooling characteristics
- Freezing characteristics
- Necessity to cool now
- Necessity to freeze now
- …

Fridge

- SoC
- BMS characteristics
- Batt. temp
- Batt. aging characteristics
- Efficiency as a function of power
- Peak power
- Rated power
- …

Energy Storage

- Target temp.
- Actual temp.
- Cooling characteristics
- Necessity to cool now
- Set mode/program
- …

AC

EMS

- SoC
- SoC Min.
- SoC Target
- SoC Max
- BMS characteristics
- Batt. temp.
- Batt. aging characteristics
- Efficiency as a function of power
- Departure time
- Necessity to charge now
- …

EV

ISO/IEC 15118

EVSE

EV

ISO/IEC 15118

- Target temp.
- Actual temp.
- Max. volume
- Actual volume
- Heating characteristics
- Necessity to heat now
- …

- Target temp.
- Actual temp.
- Heating characteristics
- Heating schedule
- Necessity to heat now
- Set mode/program
- …

Heat Pump

Lights & Sockets

PV System

Boiler

Option 1: A central intelligence contained within the EMS

In order for this this work on a large scale, the EMS needs to know a significant amount of device and domain specific information.

For example:

- What type of device is it?
- What are its electrical characteristics?
- What are its power demands now?
- What will its power demands be later?
- What are the consequences of pausing or delaying the device now?
- What are the consequences of pausing or delaying the device later?
- What program or mode is it currently in?
- At what point in the current program or mode is it?
- …

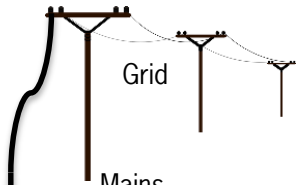
Additionally, the EMS would need to know all these parameters for all models of all makes of device to ensure interoperability!

Option 2: A price based EMS with distributed intelligence is easily scalable and domain agnostic

There's no need for the EMS to know any domain specific parameters of it's "clients". It simply creates an energy marketplace where sinks and sources buy and sell energy. A type of "**eBay for energy**". By playing with the ***price elasticity***, the **prioritization of consumers is achieved automatically and dynamically.**

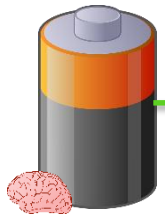
Washing Machine

Utility Backend (e.g. Grid & Tariff Information via Smart Meter)

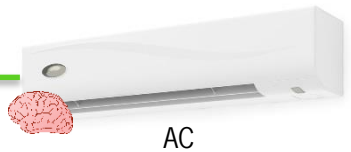


Mains Incl. (smart) meter and circuit breakers

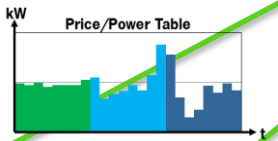
Fridge



Energy Storage



AC



EV

ISO/IEC 15118

EVSE

ISO/IEC 15118

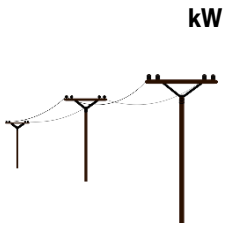
Lights & Sockets

PV System

Boiler

Heat Pump

The EMS acts as a local *Energy Aggregator*. It determines how much power is available for Smart Energy Devices.



kW

Grid Price/Power Table
(via Smart Meter)
29c/kWh

t

Forecasted Household Load

Forecasted PV Output
12c/kWh
(Net metering price)

Energy Storage Discharge Schedule
15c/kWh

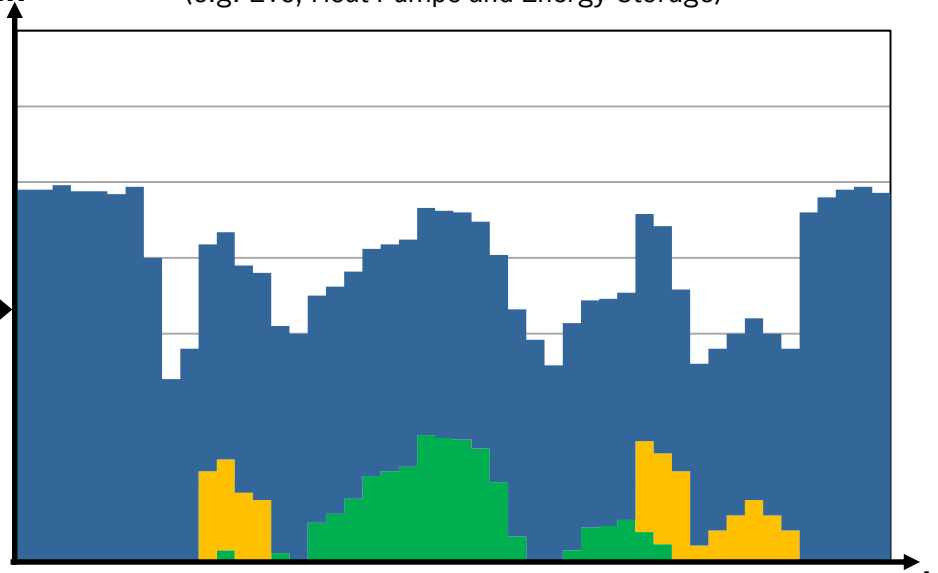
\+

\-

\+

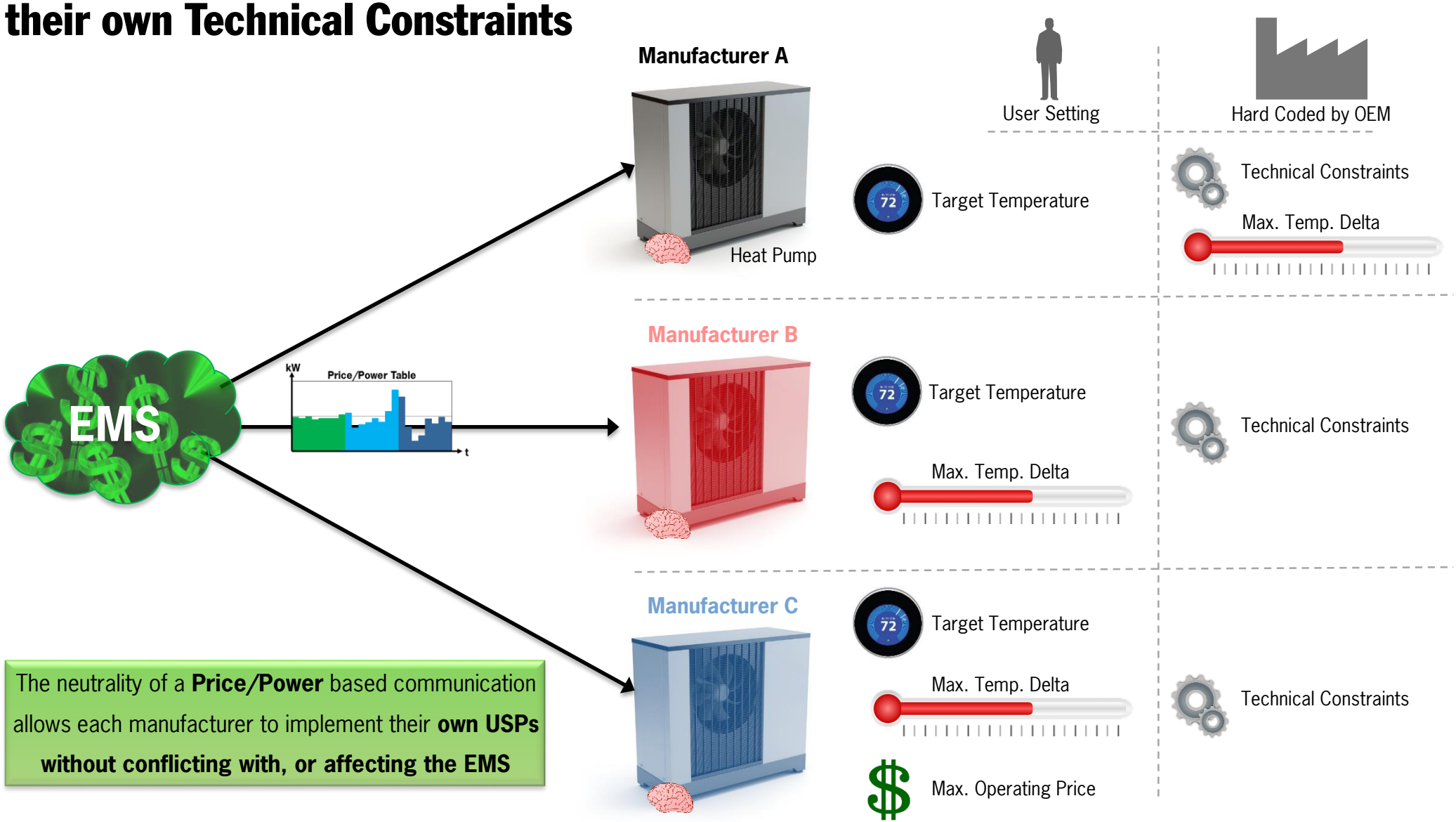
\+

EMS Price/Power Table for "Smart Energy Devices"
(e.g. EVs, Heat Pumps and Energy Storage)



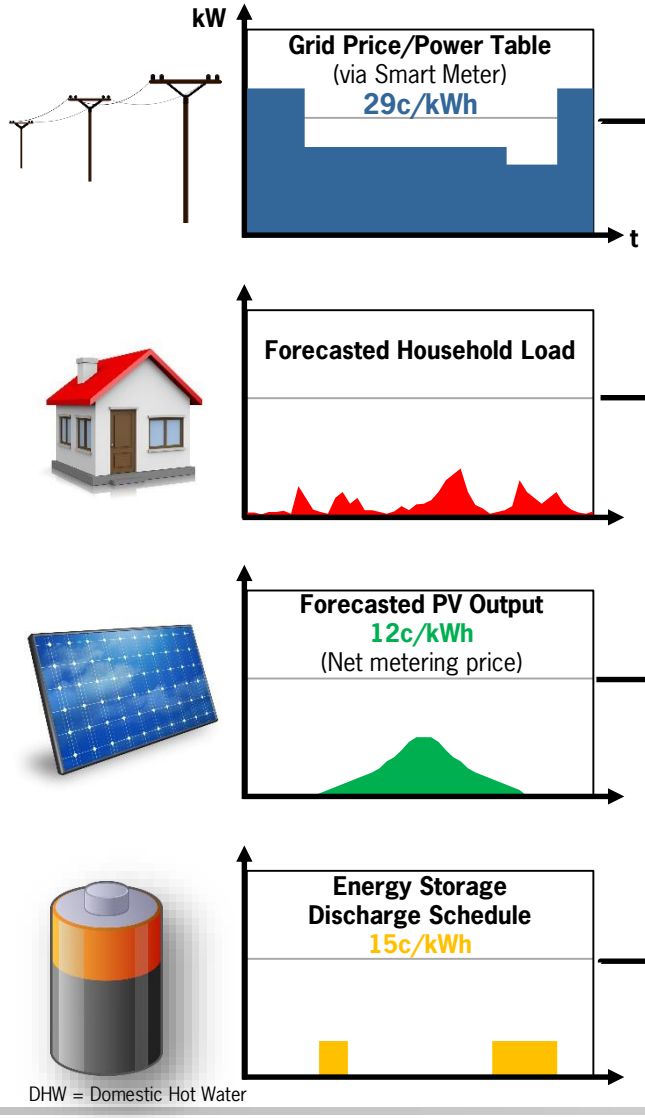
12c/kWh | 15c/kWh | 29c/kWh

EMS clients buy, and even sell, energy based upon User Defined Setting and their own Technical Constraints



The neutrality of a **Price/Power** based communication allows each manufacturer to implement their **own USPs without conflicting with, or affecting the EMS**

The beauty of the system is that although a dedicated HMI can be used, it's really not needed!



The user defines his temperature needs via the HVAC system.
- Heating schedule
- Temperature (range)
- Other conditions

→ The heating system's HMI is the tried and tested thermostat (or app)

The user defines his mobility needs via the EV.
- Departure time
- Range
- Other conditions

→ The EV's HMI is the tried and tested Infotainment system (or app)

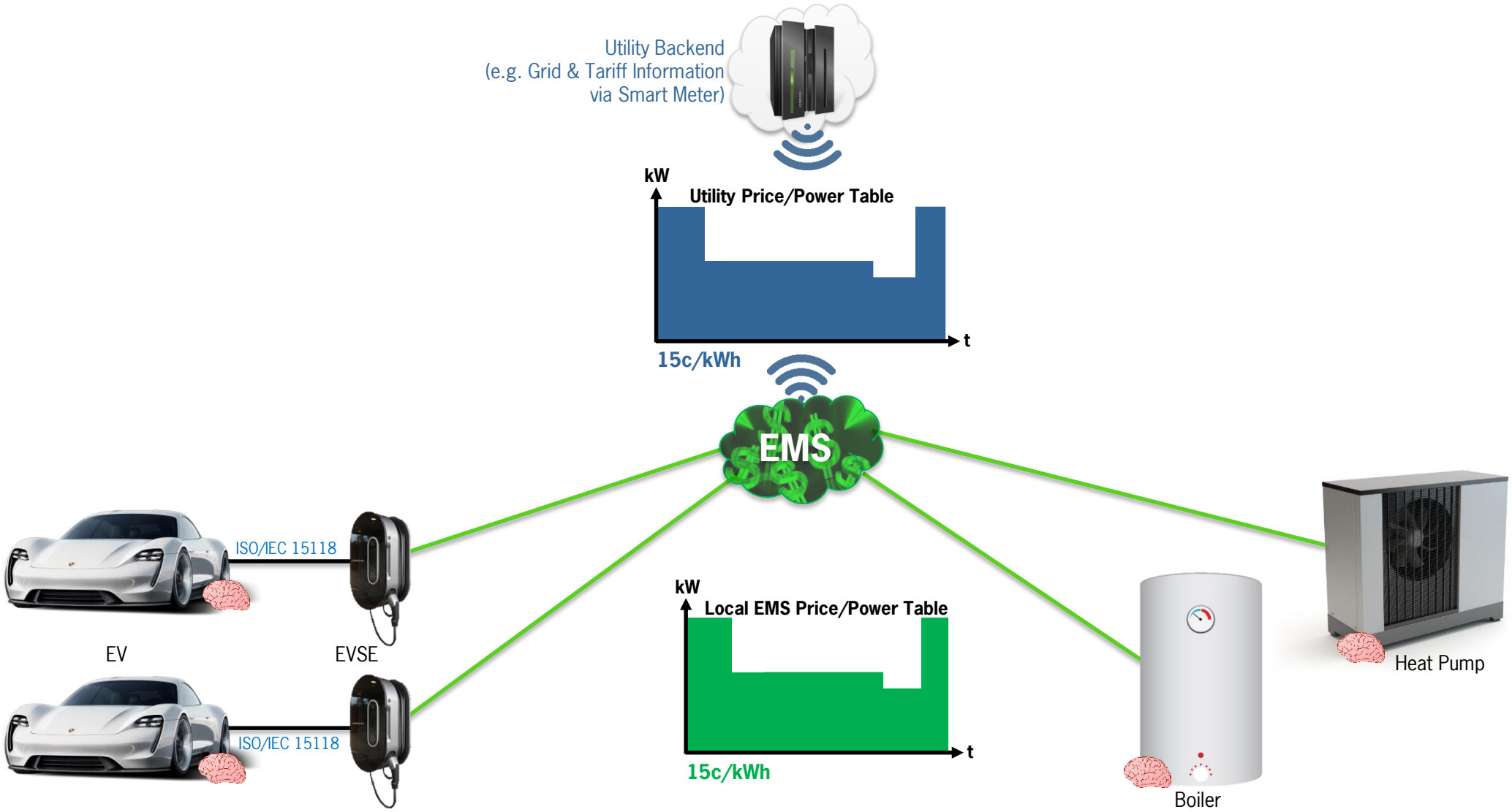
The user defines his DHW needs via the boiler.
- Schedule
- Temperature (range)
- Other conditions

→ The boiler's HMI is the tried and tested boiler (or app)

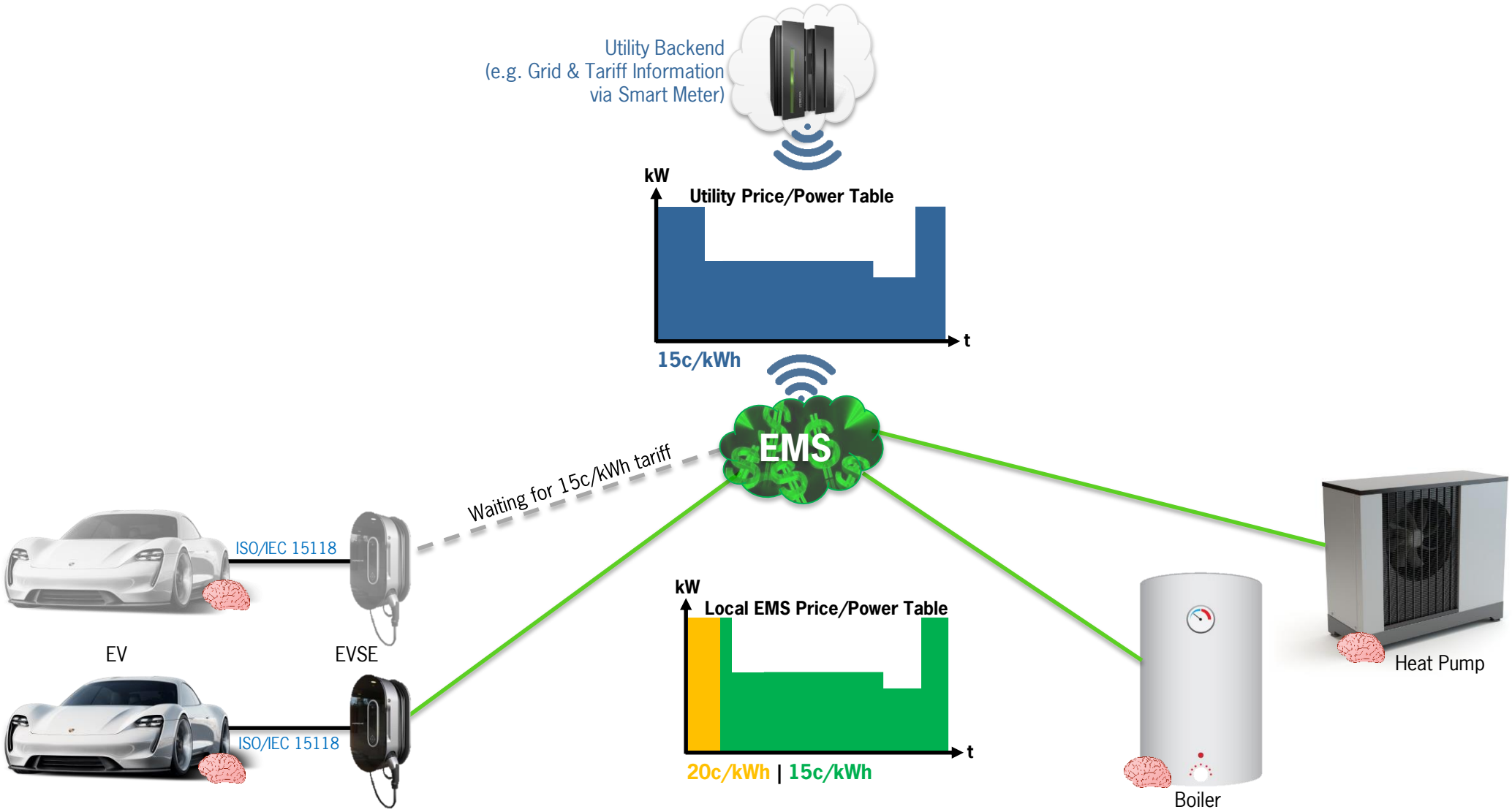
Of course, an "all-in-one" app could be used as a central HMI, but this has nothing to do with energy management via Price/Power Tables

DHW = Domestic Hot Water

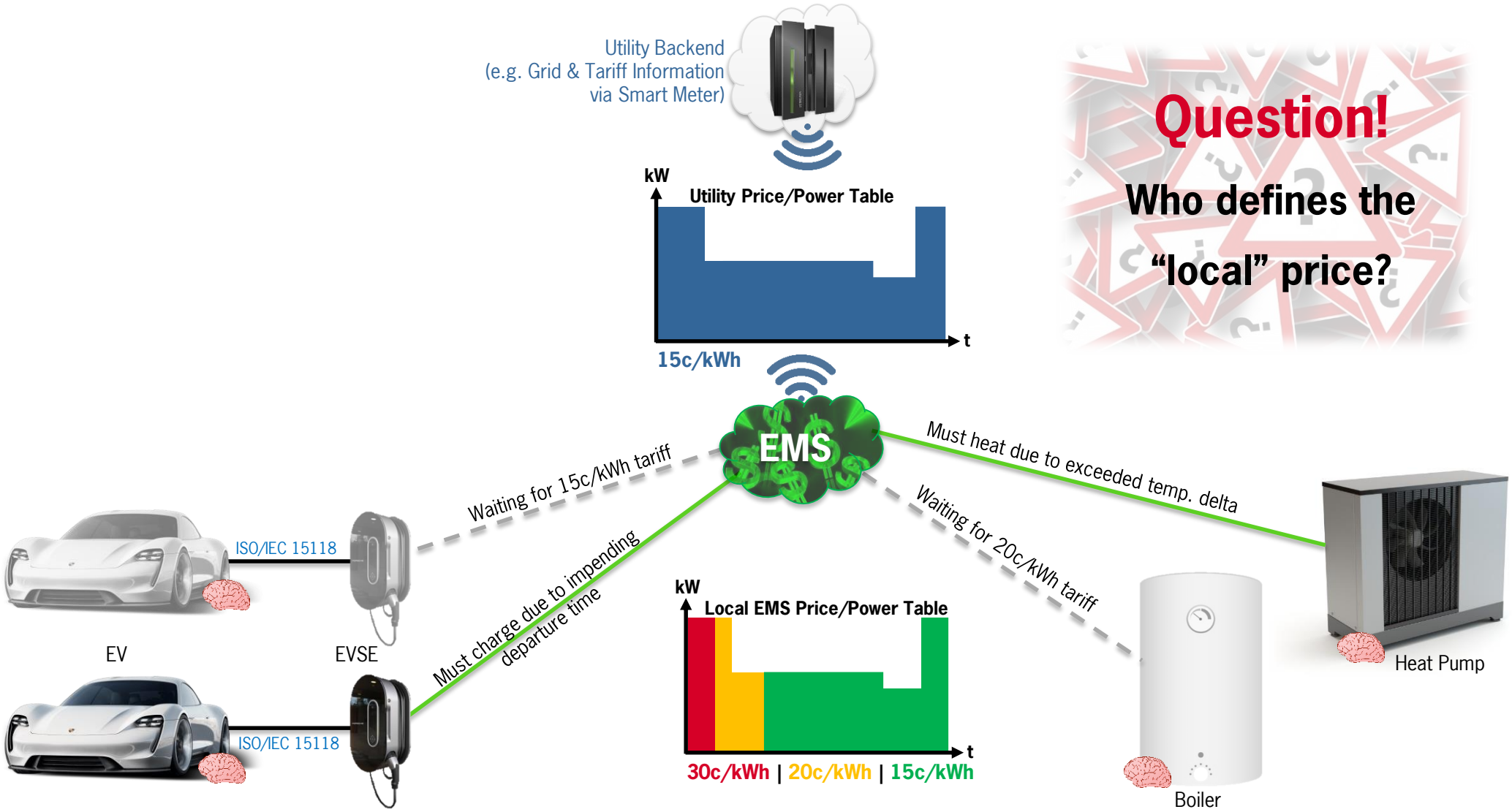
By utilizing the effects of *price elasticity*, the EMS can manipulate the local Price/Power Table to achieve Energy Management



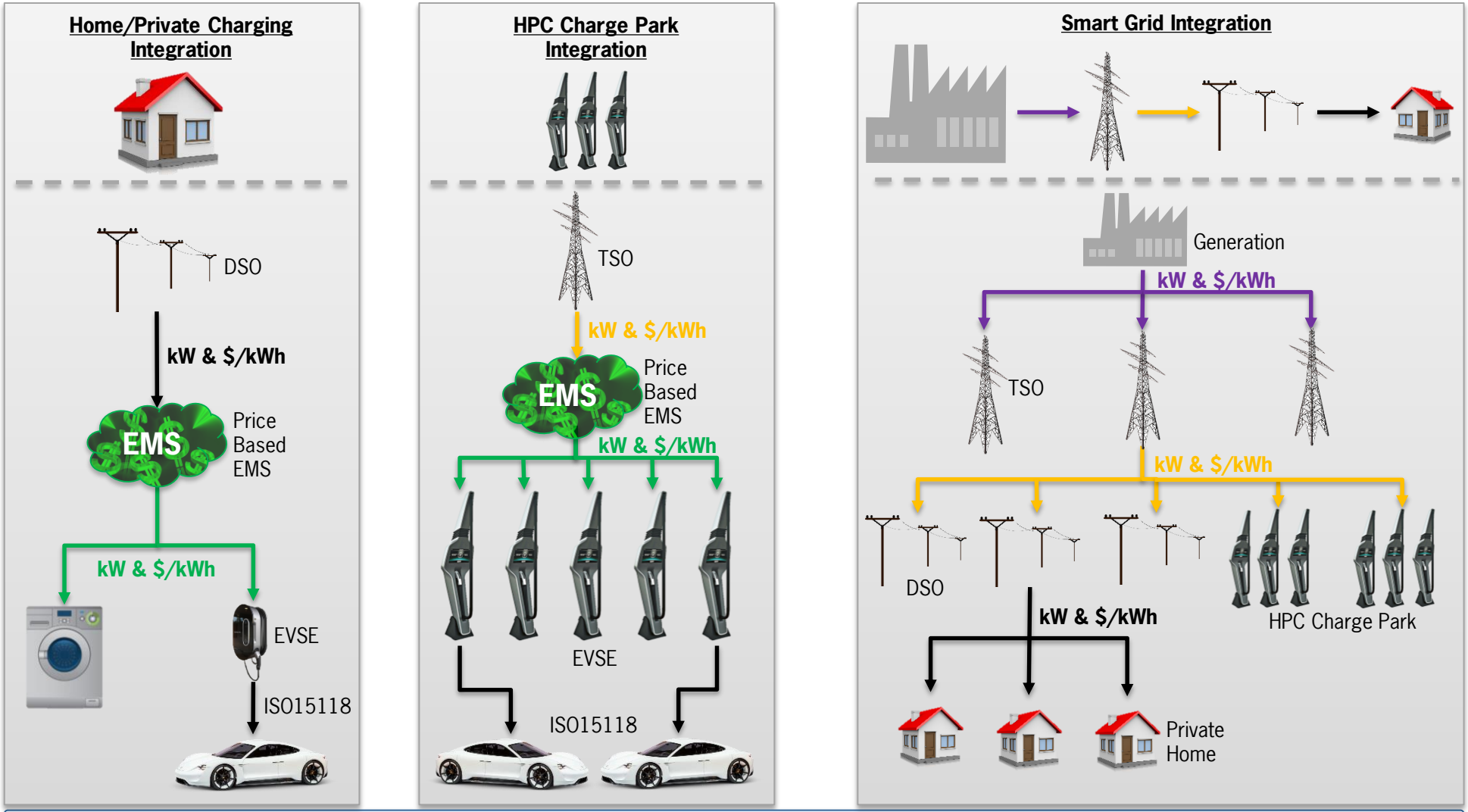
By utilizing the effects of *price elasticity*, the EMS can manipulate the local Price/Power Table to achieve Energy Management



By utilizing the effects of *price elasticity*, the EMS can manipulate the local Price/Power Table to achieve Energy Management

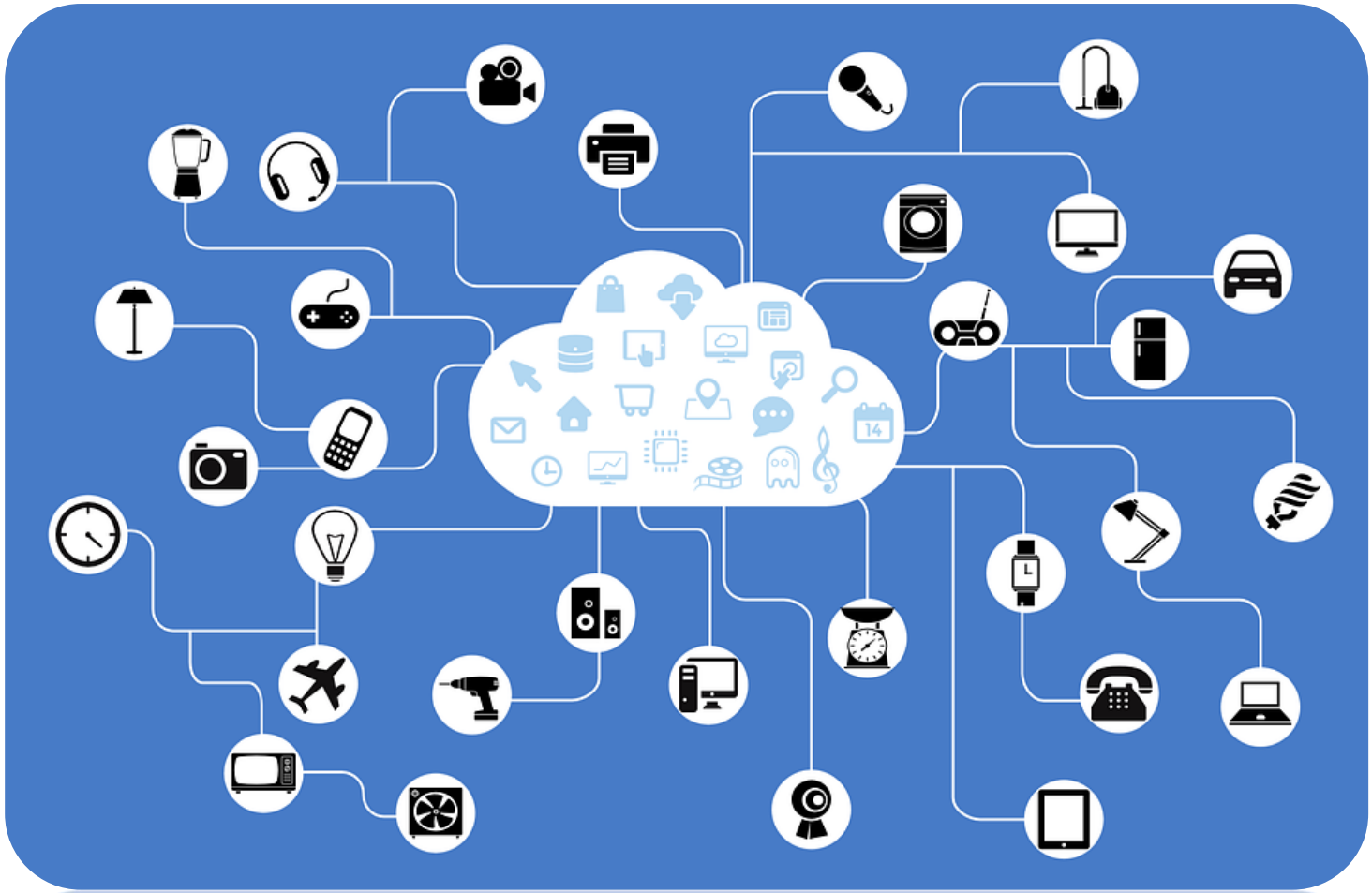


… and it scales too!



Using a price based management system, each layer of the grid manages its subsequent layer based on Price/Power Tables

How does all of this fit into the “Smart Home”?



EMS & Smart Home… What's the difference?

Smart Home

Home Energy Management System

(HEMS)

Main Focus:

- Load management, savings & efficient use of renewables
- Price & Power optimization

- E-Mobility
- HVAC
- Energy Storage
- Self Generation
- ::
- Smart Grid

Home Automation System

(HAS)

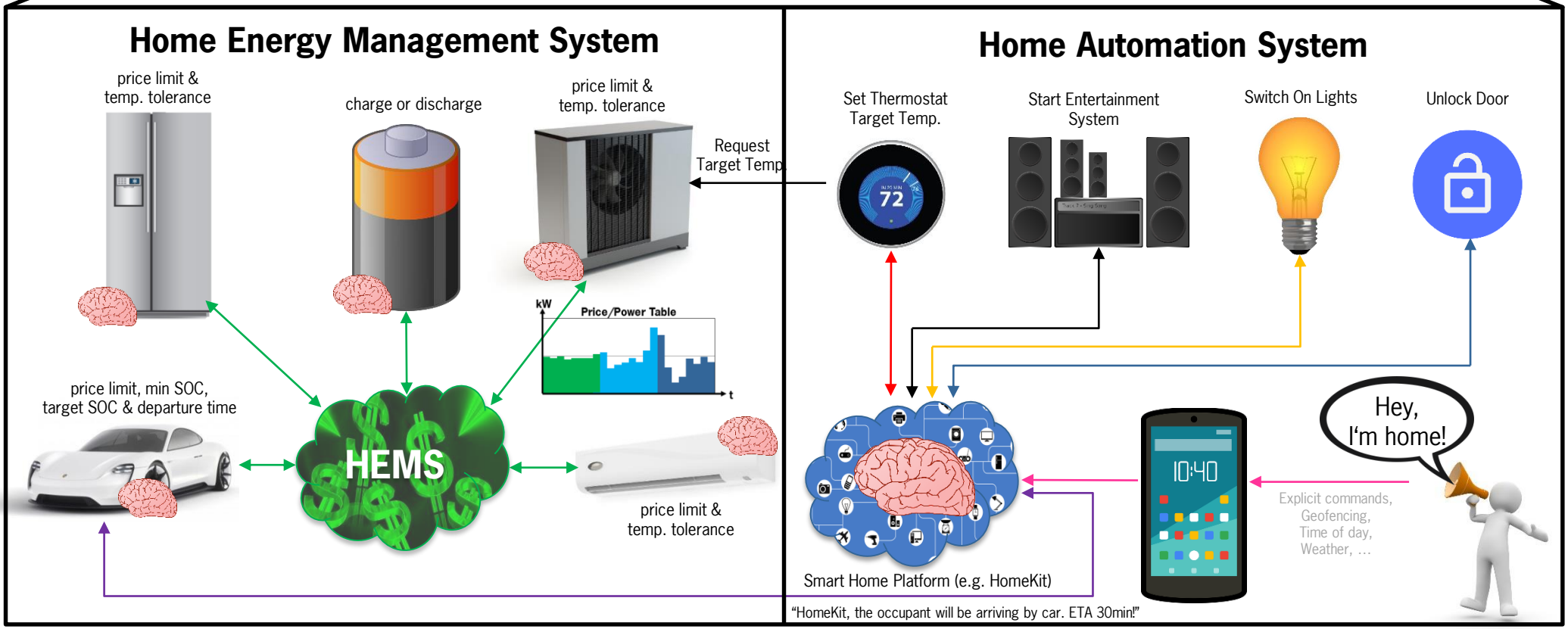
Main Focus:

- Multi-domain control & automation
- Peace-of-Mind, comfort & savings

- Entertainment
- Health
- Monitoring & Security
- Lighting & Ambiance
- ::
- Assisted Living

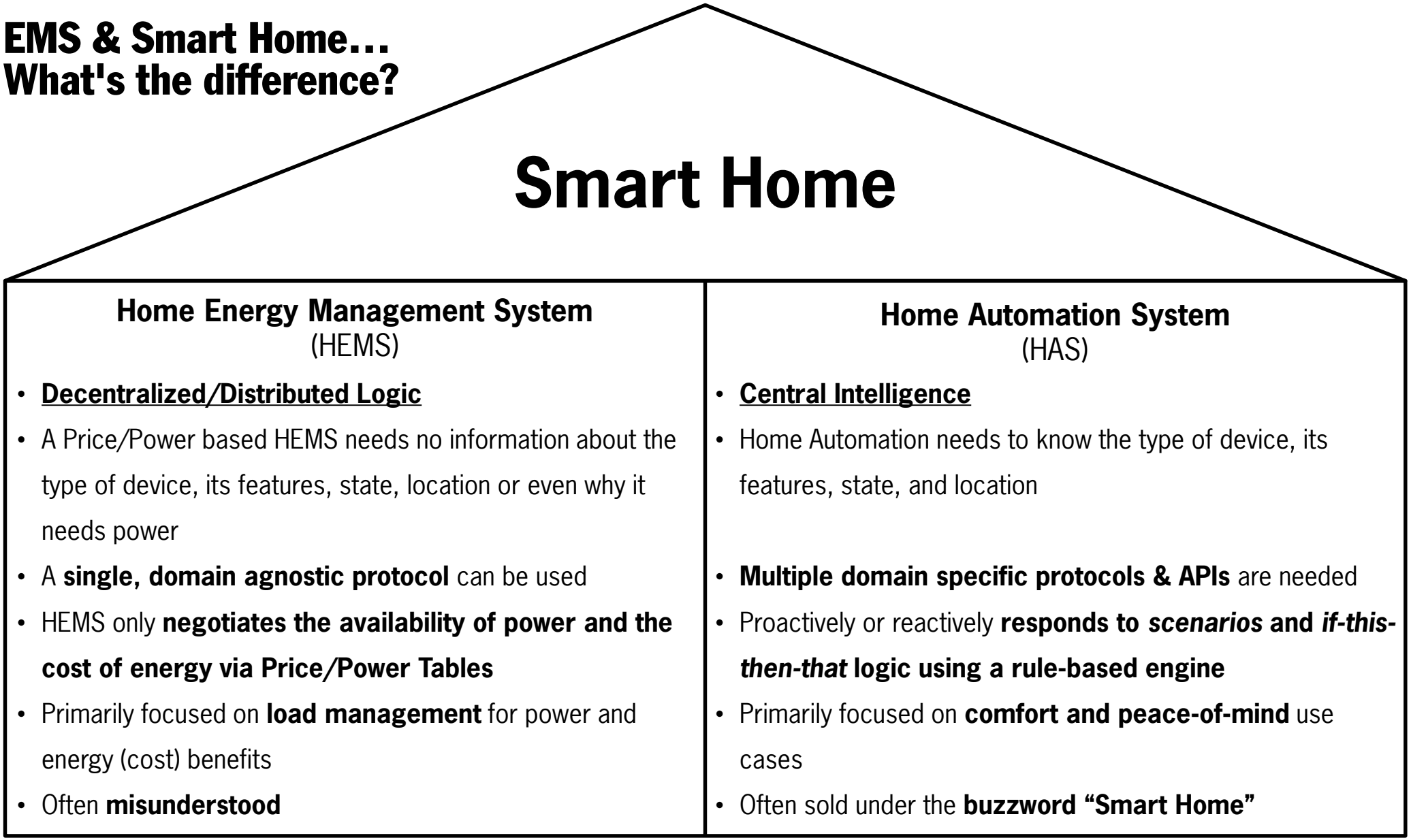
EMS & Smart Home… What's the difference?

Smart Home



HEMS = Home Energy Management System

EMS & Smart Home… What's the difference?



Thank You

Questions?