Technological Readiness

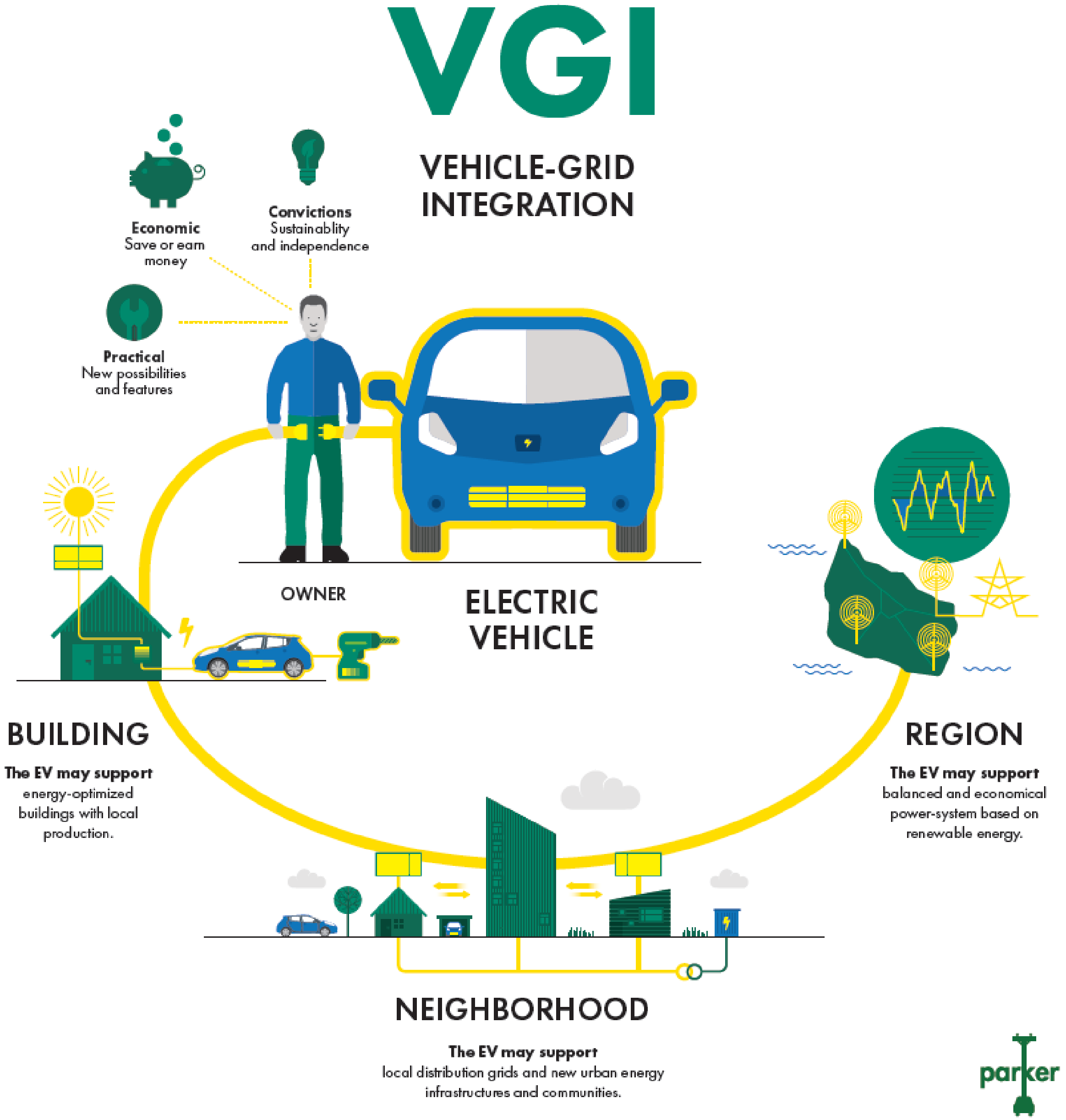
State-of-the-art technology used by PARKER

Needs towards standardization

Testing the equipment's abilities using the Parker Grid Keys Test

Thomas Meier Sørensen
Project Officer at PowerLabDK

The goal:

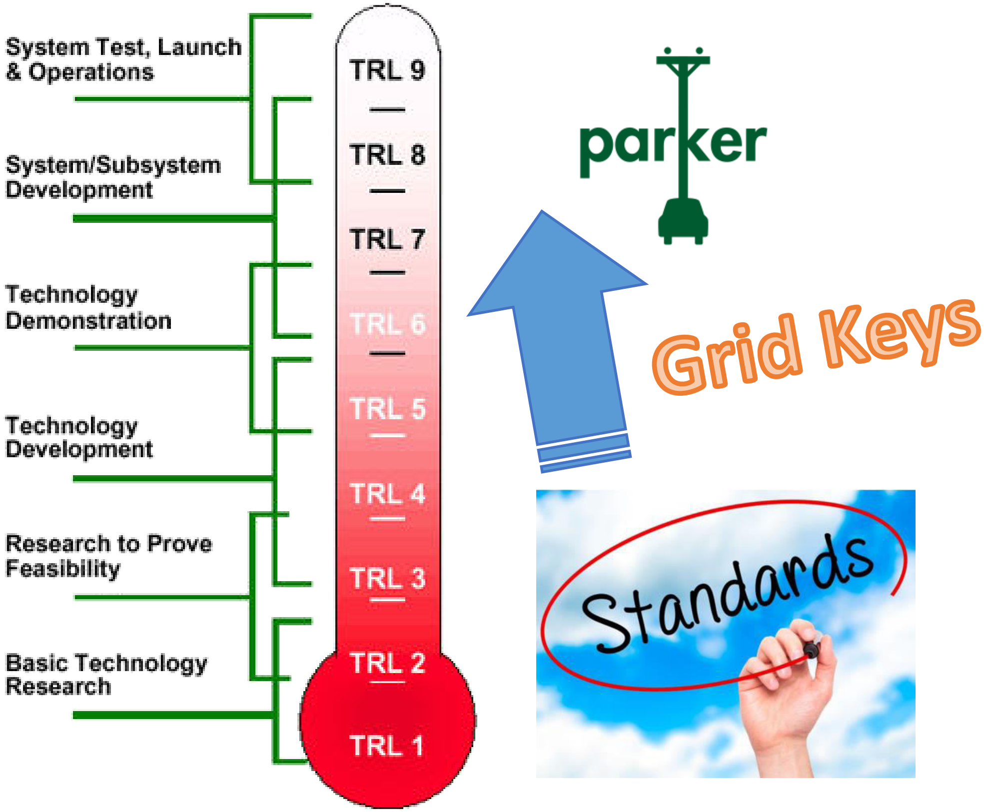


VGI = Area of research

V1G = Normal Charging
(Dumb or Smart)
(Normal or Controlled)

V2G = Bi-directional charging

The Challenge



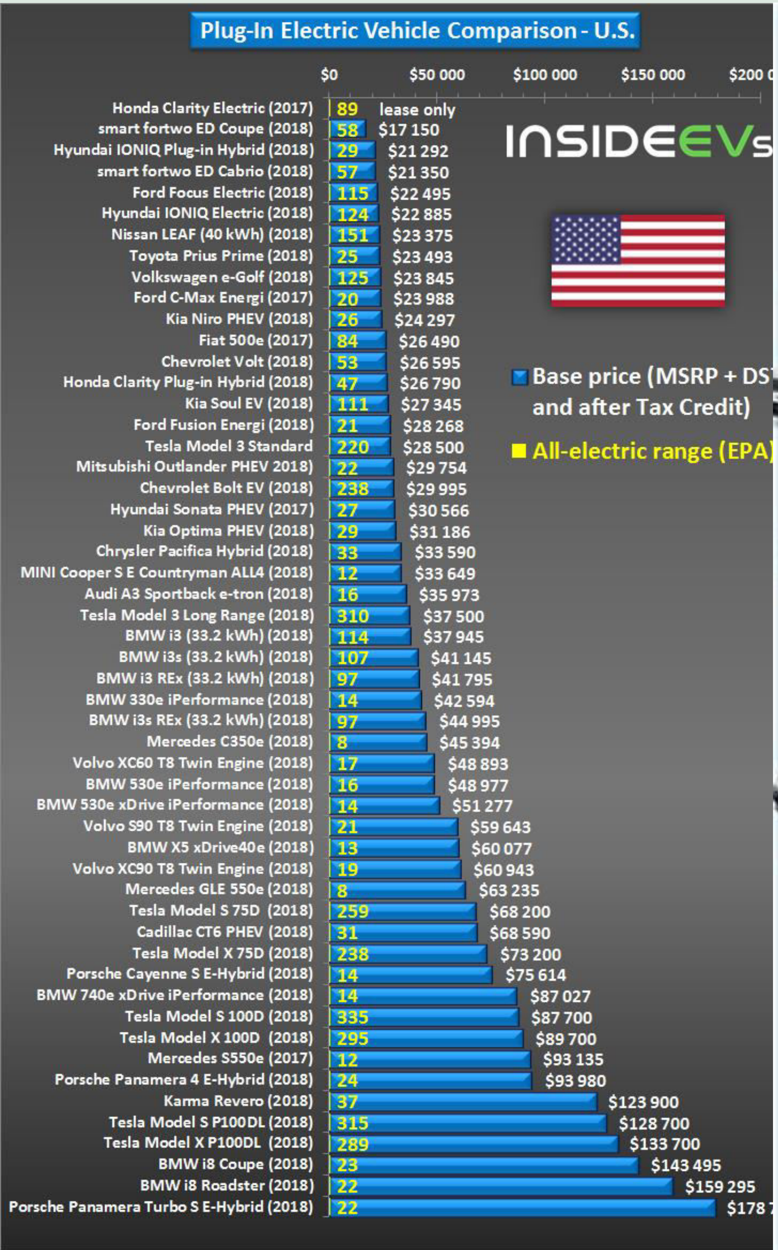
High TRL level on V2G

But - VGI is more than V2G

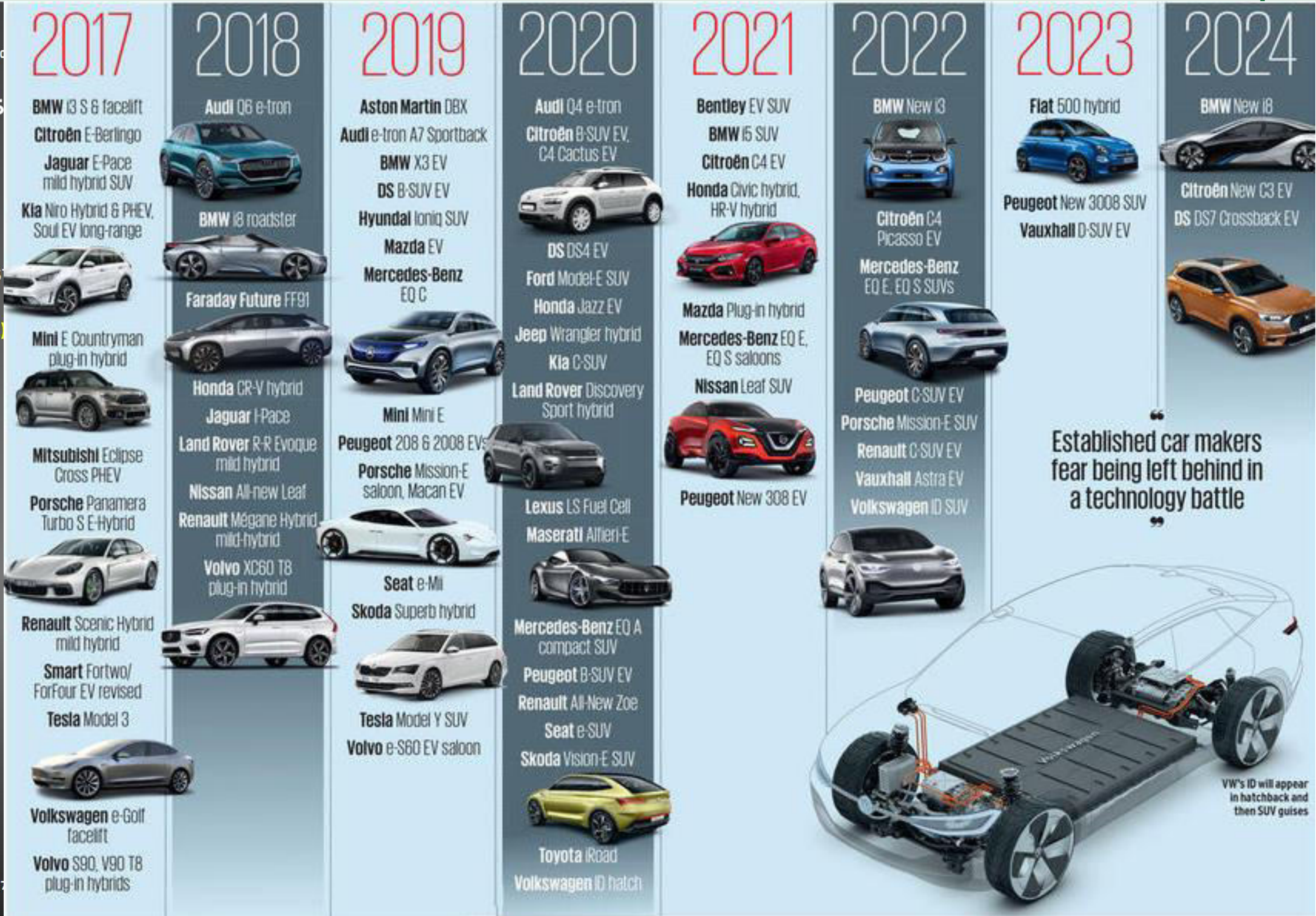
And - Standards lack essential informational objects for V2G/VGI

State-Of-The-Art (1947)

The EV's

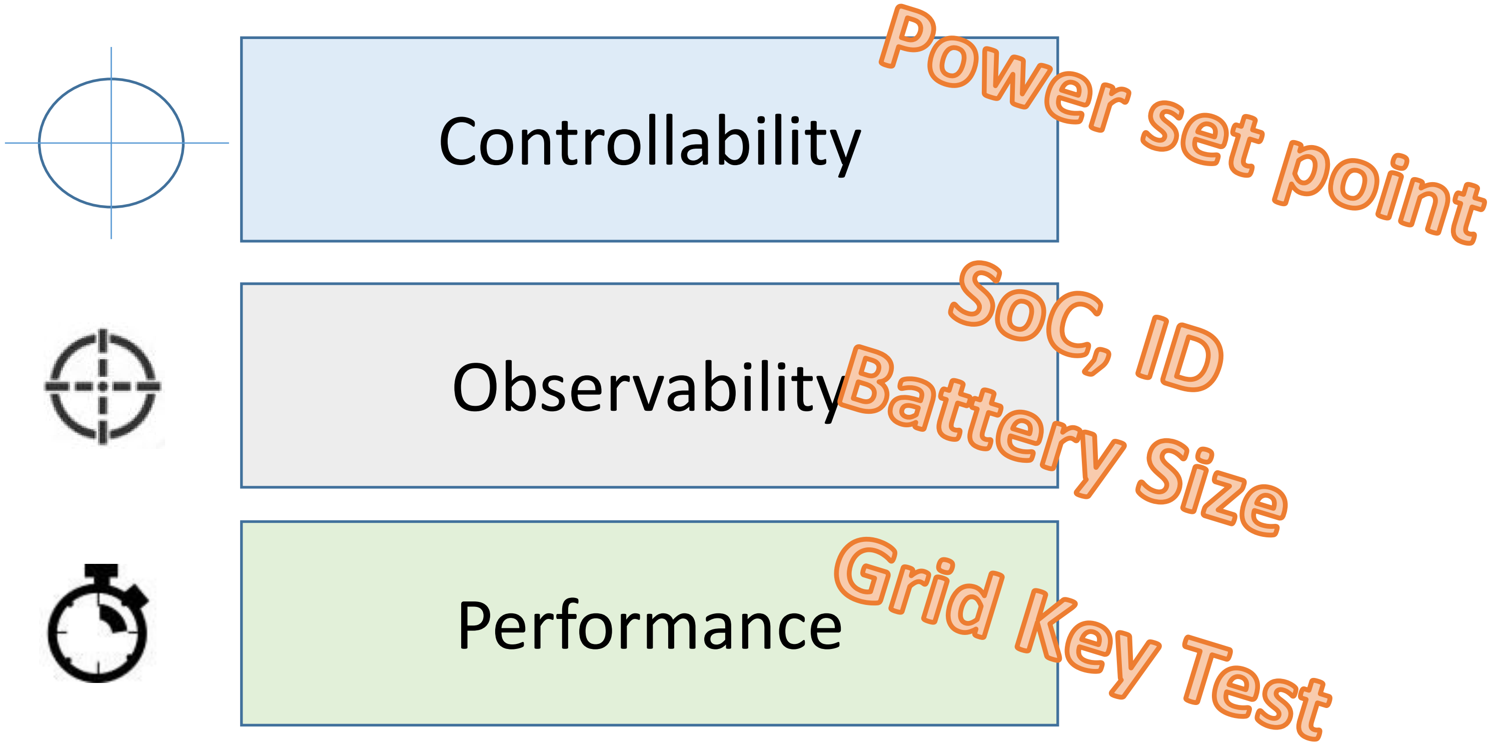


Plug-In Electric Vehicle Comparison - U.S.
$0
$50 000
$100 000
$150 000
INSIDEEVs
Base price (MSRP + DS
and after Tax Credit)
All-electric range (EPA)
Honda Clarity Electric (2017) 89 lease only
smart fortwo ED Coupe (2018) 58 $17 150
Hyundai IONIQ Plug-in Hybrid (2018) 29 $21 292
smart fortwo ED Cabrio (2018) 57 $21 350
Ford Focus Electric (2018) 115 $22 495
Hyundai IONIQ Electric (2018) 124 $22 885
Nissan LEAF (40 kWh) (2018) 151 $23 375
Toyota Prius Prime (2018) 25 $23 493
Volkswagen e-Golf (2018) 125 $23 845
Ford C-Max Energi (2017) 20 $23 988
Kia Niro PHEV (2018) 26 $24 297
Fiat 500e (2017) 84 $26 490
Chevrolet Volt (2018) 53 $26 595
Honda Clarity Plug-in Hybrid (2018) 47 $26 790
Kia Soul EV (2018) 111 $27 345
Ford Fusion Energi (2018) 21 $28 268
Tesla Model 3 Standard 220 $28 500
Mitsubishi Outlander PHEV 2018) 22 $29 754
Chevrolet Bolt EV (2018) 238 $29 995
Hyundai Sonata PHEV (2017) 27 $30 566
Kia Optima PHEV (2018) 29 $31 186
Chrysler Pacifica Hybrid (2018) 33 $33 590
MINI Cooper S E Countryman ALL4 (2018) 12 $33 649
Audi A3 Sportback e-tron (2018) 16 $35 973
Tesla Model 3 Long Range (2018) 310 $37 500
BMW i3 (33.2 kWh) (2018) 114 $37 945
BMW i3s (33.2 kWh) (2018) 107 $41 145
BMW i3 REx (33.2 kWh) (2018) 97 $41 795
BMW 330e iPerformance (2018) 14 $42 594
BMW i3s REx (33.2 kWh) (2018) 97 $44 995
Mercedes C350e (2018) 8 $45 394
Volvo XC60 T8 Twin Engine (2018) 17 $48 893
BMW 530e iPerformance (2018) 16 $48 977
BMW 530e xDrive iPerformance (2018) 14 $51 277
Volvo S90 T8 Twin Engine (2018) 21 $59 643
BMW X5 xDrive40e (2018) 13 $60 077
Volvo XC90 T8 Twin Engine (2018) 19 $60 943
Mercedes GLE 550e (2018) 8 $63 235
Tesla Model S 75D (2018) 259 $68 200
Cadillac CT6 PHEV (2018) 31 $68 590
Tesla Model X 75D (2018) 238 $73 200
Porsche Cayenne S E-Hybrid (2018) 14 $75 614
BMW 740e xDrive iPerformance (2018) 14 $87 027
Tesla Model S 100D (2018) 335 $87 700
Tesla Model X 100D (2018) 295 $89 700
Mercedes S550e (2017) 12 $93 135
Porsche Panamera 4 E-Hybrid (2018) 24 $93 980
Karma Revero (2018) 37 $123 900
Tesla Model S P100DL (2018) 315 $128 700
Tesla Model X P100DL (2018) 289 $133 700
BMW i8 Coupe (2018) 23 $143 495
BMW i8 Roadster (2018) 22 $159 295
Porsche Panamera Turbo S E-Hybrid (2018) 22



2017
BMW i3 S & facelift
Citroën E-Berlingo
Jaguar E-Pace mild hybrid SUV
Kia Niro Hybrid & PHEV, Soul EV long-range
Mini E Countryman plug-in hybrid
Mitsubishi Eclipse Cross PHEV
Porsche Panamera Turbo S E-Hybrid
Renault Scenic Hybrid mild hybrid
Smart Fortwo/ ForFour EV revised
Tesla Model 3
Volkswagen e-Golf facelift
Volvo S90, V90 T8 plug-in hybrids
2018
Audi Q6 e-tron
BMW i8 roadster
Faraday Future FF91
Honda CR-V hybrid
Jaguar I-Pace
Land Rover R-R Evoque mild hybrid
Nissan All-new Leaf
Renault Mégane Hybrid mild-hybrid
Volvo XC60 T8 plug-in hybrid
2019
Aston Martin DBX
Audi e-tron A7 Sportback
BMW X3 EV
DS B-SUV EV
Hyundai Ioniq SUV
Mazda EV
Mercedes-Benz EQ C
Mini Mini E
Peugeot 208 & 2008 EVs
Porsche Mission-E saloon, Macan EV
Seat e-Mii
Skoda Superb hybrid
Tesla Model Y SUV
Volvo e-S60 EV saloon
2020
Audi Q4 e-tron
Citroën B-SUV EV, C4 Cactus EV
DS DS4 EV
Ford Model-E SUV
Honda Jazz EV
Jeep Wrangler hybrid
Kia C-SUV
Land Rover Discovery Sport hybrid
Lexus LS Fuel Cell
Maserati Alfieri-E
Mercedes-Benz EQ A compact SUV
Peugeot B-SUV EV
Renault All-New Zoe
Seat e-SUV
Skoda Vision-E SUV
Toyota iRoad
Volkswagen ID hatch
2021
Bentley EV SUV
BMW i5 SUV
Citroën C4 EV
Honda Civic hybrid, HR-V hybrid
Mazda Plug-in hybrid
Mercedes-Benz EQ E, EQ S saloons
Nissan Leaf SUV
Peugeot New 308 EV
2022
BMW New i3
Citroën C4 Picasso EV
Mercedes-Benz EQ E, EQ S SUVs
Peugeot C-SUV EV
Porsche Mission-E SUV
Renault C-SUV EV
Vauxhall Astra EV
Volkswagen ID SUV
2023
Fiat 500 hybrid
Peugeot New 3008 SUV
Vauxhall D-SUV EV
2024
BMW New i8
Citroën New C3 EV
DS DS7 Crossback EV
"Established car makers fear being left behind in a technology battle"
VW's ID will appear in hatchback and then SUV guises

The Grid Keys

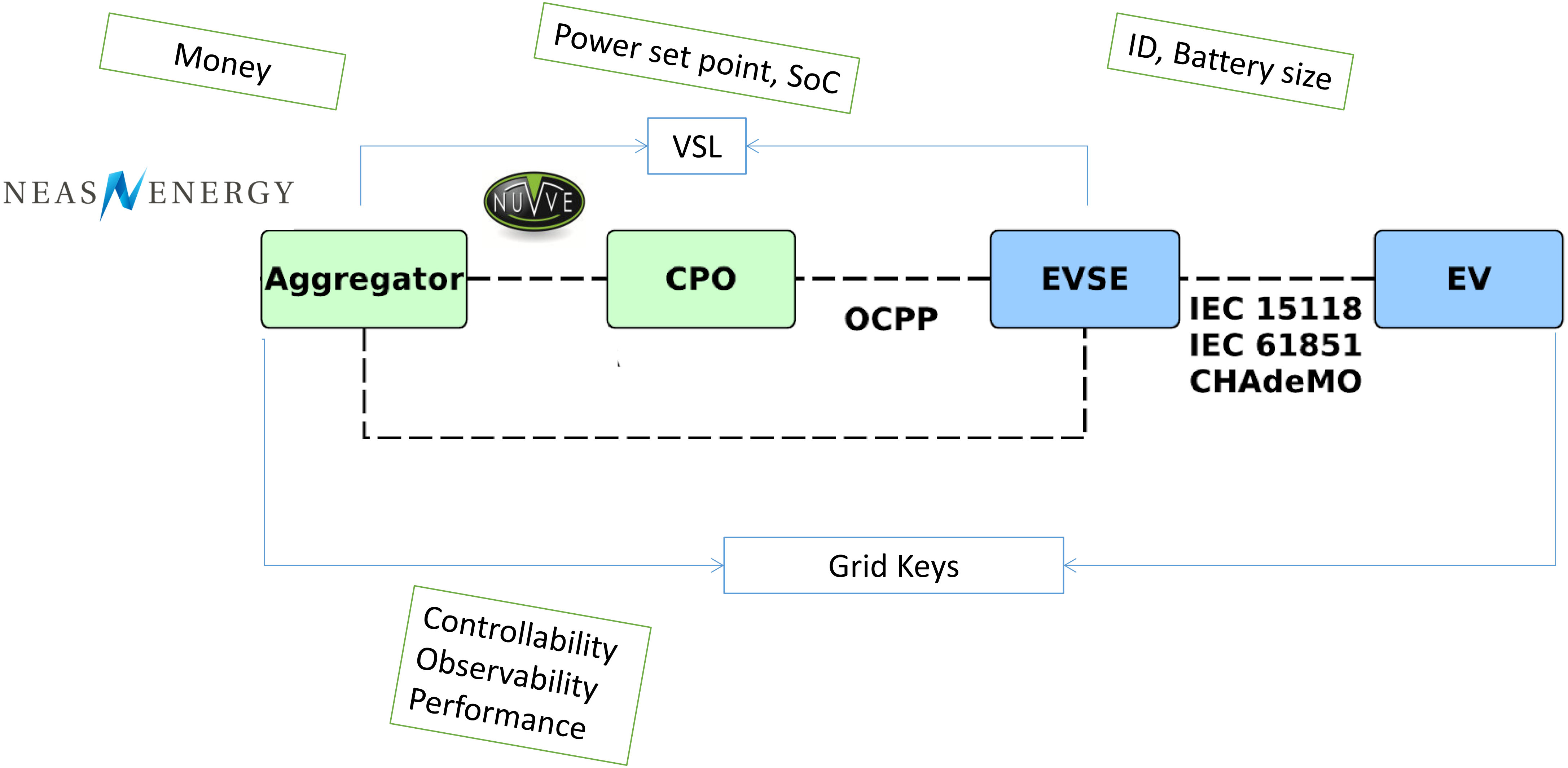


Needed for all interfaces:

- Power set point

  (P/Q pr. sec)
- SoC
- ID
- Battery Size
- Performance indicators

The Control



Money
Power set point, SoC
ID, Battery size
VSL
NEAS ENERGY
NUVVE
Aggregator
CPO
EVSE
EV
OCPP
IEC 15118
IEC 61851
CHAdeMO
Grid Keys
Controllability
Observability
Performance

The GAP (Standards)

Needed for all standards:

- Power set point

  (P/Q pr. sec)
- SoC
- ID
- Battery Size
- Performance indicators

VGI ready

Link	EV-EVSE		
Information object	**IEC 61851**	**IEC 15118**	**CHAdeMO**
Power Set point	+	+	+
Activation time	<3s	<60s	<1s
V2G	-	+	+
Reactive Power Set point	-	+	-
SoC	-	+	+
EV ID	-	+	-
Battery size	-	-	-
Vehicle status	+	+	+
(Performance indicators)	-	-	-

The Set up


NUVVE
Aggregator
DEIF
-power in control
V2G
enel
V2G
NISSAN
PSA
GROUPE
MITSUBISHI MOTORS


ENERGY SYSTEM INTEGRATION LAB - SYSLAB

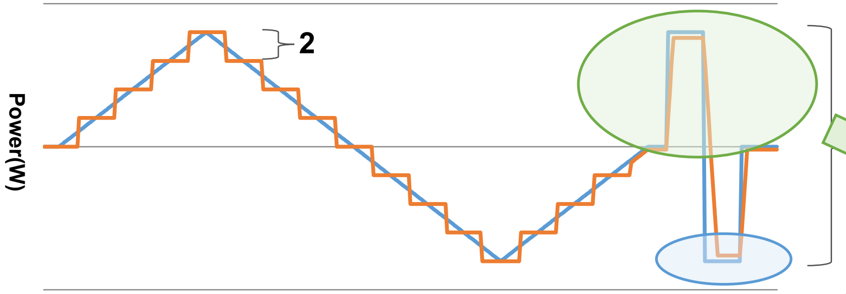

ELECTRIC LAB
enel
parker
V2G
parker


V2G
AC 65 102

The Grid Keys test (Performance)

Active power test pattern

Active power	Smooth control signal Step response	[W]

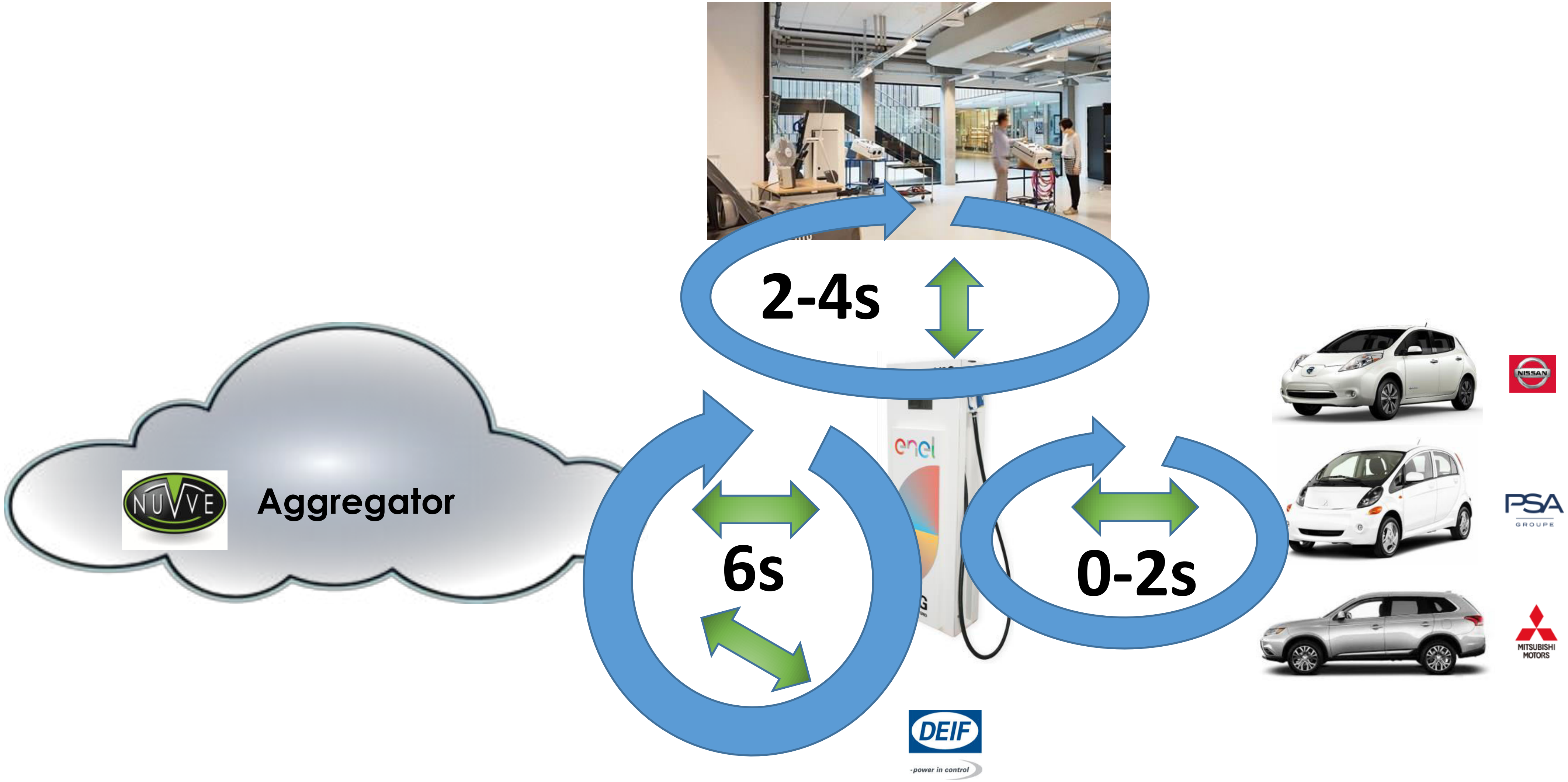


Performance evaluation

	Name	Description	Unit
1	Bi-directionality	Support of bidirectional powerflow	+/-
2	Set point granularity	Supported setpoint througout the power range	[W]
3	Activation time	Time between setpoint request and change in active power.	[s]
4	Ramping rate (Up)	Supported rate of change in power (increase)	[W/s]
5	Ramping rate (Down)	Supported rate of change in power (decrease)	[W/s]
6	Set point accuracy	Difference between required and delivered response	[W]
7	Set point precision	Variation of the delivered response	[W]

Power Electronics

The Latency



NUVVE
Aggregator
2-4s
6s
0-2s
enel
DEIF
power in control
NISSAN
PSA
GROUPE
MITSUBISHI MOTORS

The Recommendations (Performance)

Name	Description	Unit	Target (First draft)	Results EV	Results EVSE
Bi-directionality	Support of bidirectional powerflow	+/-	Yes	OK	OK
Set point granularity	Supported setpoint througout the power range	[W]	< 1 kW	~0 W	1 kW
Activation time	Time between setpoint request and change in active power.	[s]	< 10 s < 1 s < 100ms	~ 3s (AC) ~ 0-2s (DC)	6s (Parker control) 2-4s (Direct control) ~50 ms (Communication)
Ramping rate (Up)	Supported rate of change in power (increase)	[W/s]	> 10 kW/s > 1 kW/s	>10 kW/s	2 kW/s
Ramping rate (Down)	Supported rate of change in power (decrease)	[W/s]	> 10 kW/s > 1 kW/s	>10 kW/s	2 kW/s
Set point accuracy	Difference between required and delivered response	[W]	< 1 kW < 500 W	~0 W	~400 W
Set point precision	Variation of the delivered response	[W]	< 1 kW < 500 W	~0 W	~400 W

Standard

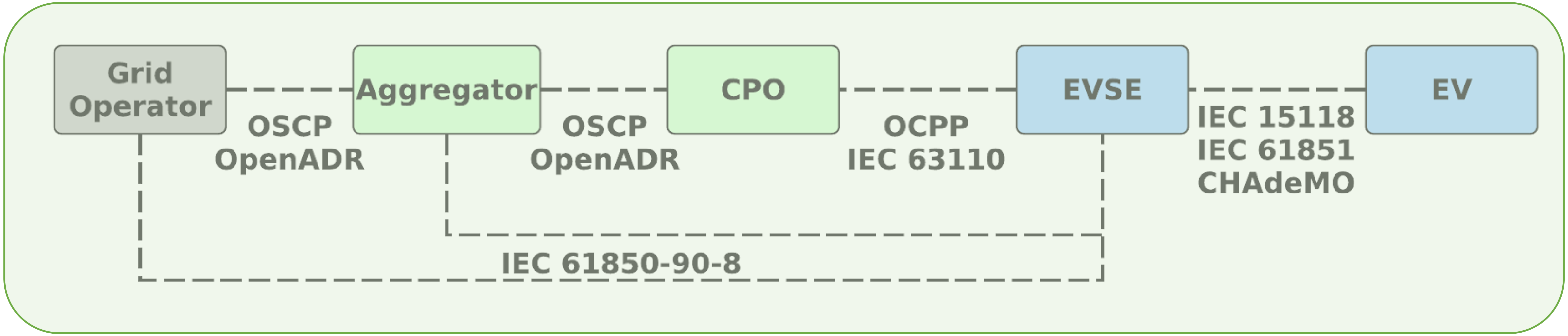
Power Electronics

The Recommendations (Standards)

Needed for all interfaces:

Power set point (P/Q pr. sec), SoC, ID, Battery Size, Performance indicators

VGI



The Summery

1. The V1G/V2G Technology works
2. EV/EVSE's with CHAdeMO 2.0 are V2G ready
3. VGI is more than simple V2G
4. The standards needs the Grid Keys Recommendations.
5. All EV's and EVSE's can be VGI ready

The End

Thank you!

Have a great summit.

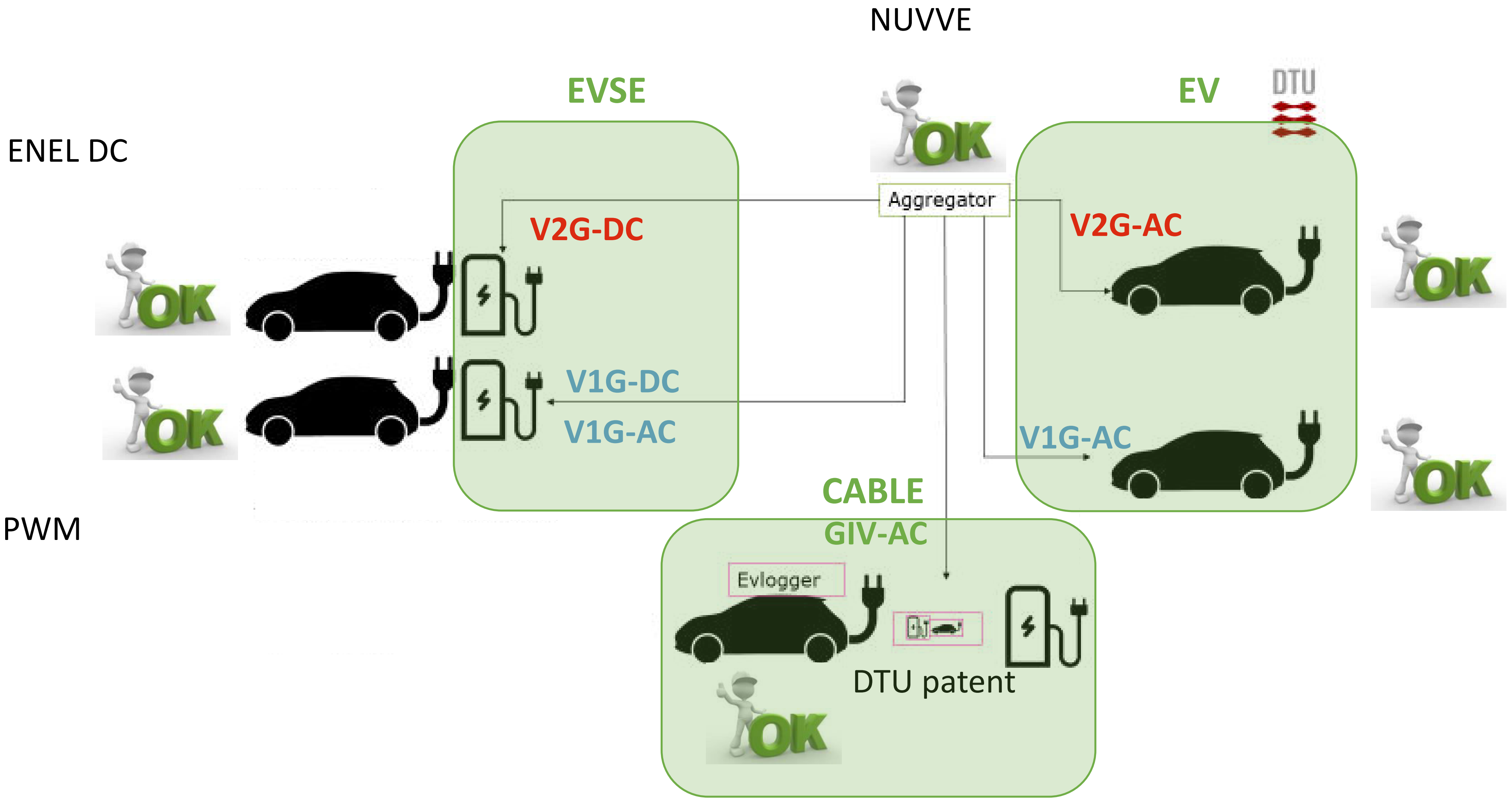
Parker Demonstration

parker

Thomas Meier Sørensen
Project Officer at PowerLabDK

PowerLab DK

The 5 VGI control options

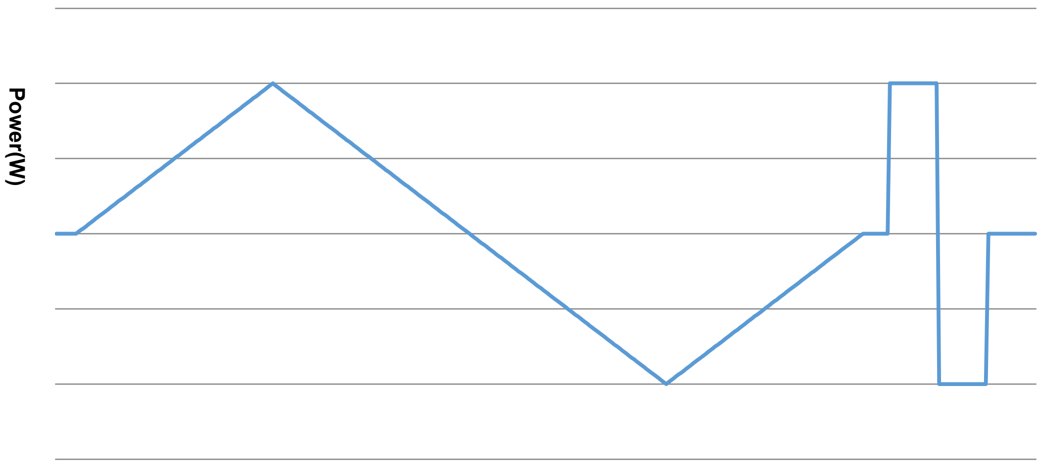


The Parker reference setup

The Grid Keys test (Performance)

Active power test pattern

Active power	Smooth control signal Step response	[W]



Performance evaluation

	Name	Description	Unit
1	Bi-directionality	Support of bidirectional powerflow	+/-
2	Set point granularity	Supported setpoint througout the power range	[W]
3	Activation time	Time between setpoint request and change in active power.	[s]
4	Ramping rate (Up)	Supported rate of change in power (increase)	[W/s]
5	Ramping rate (Down)	Supported rate of change in power (decrease)	[W/s]
6	Set point accuracy	Difference between required and delivered response	[W]
7	Set point precision	Variation of the delivered response	[W]

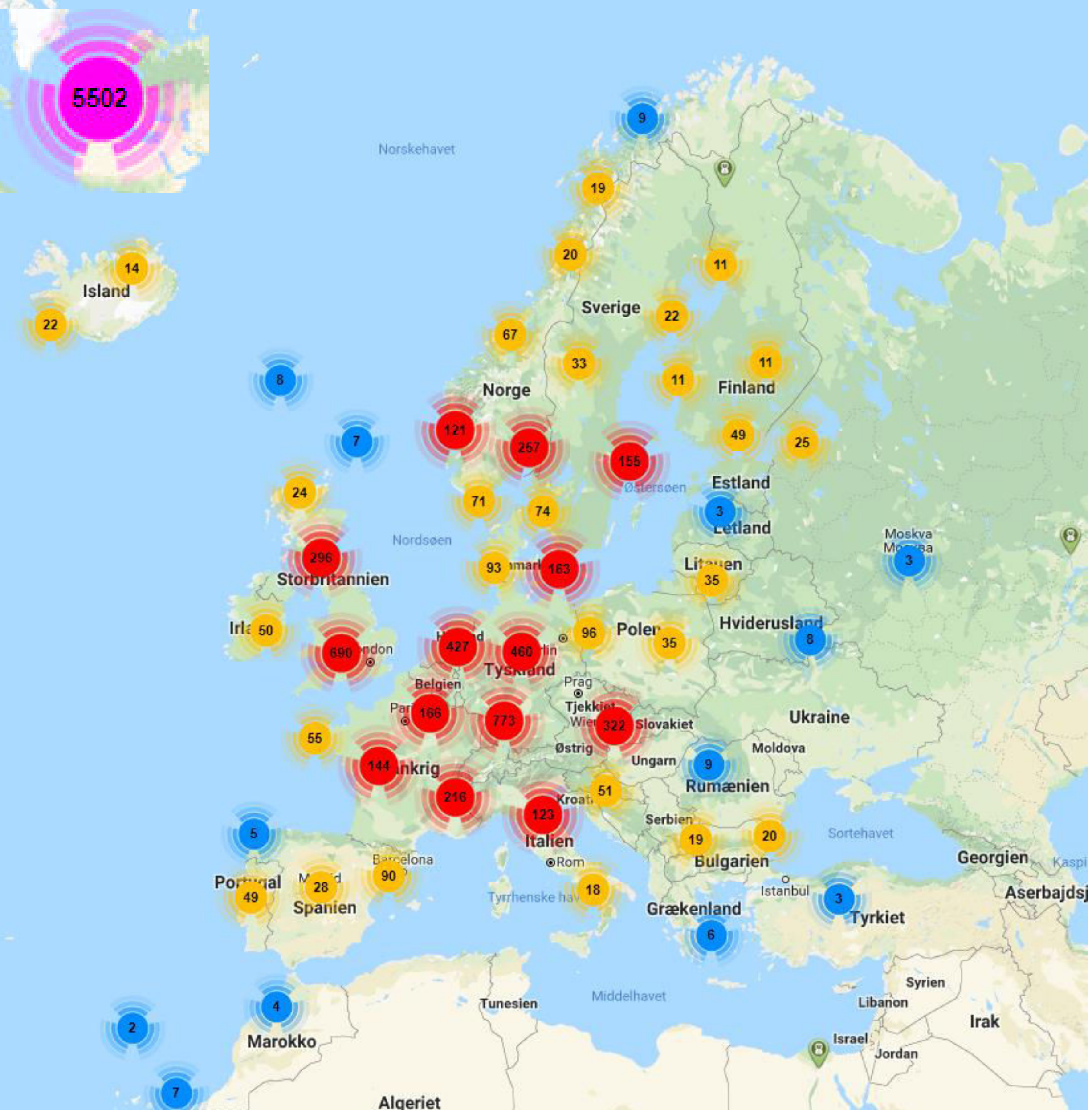
Thank you!

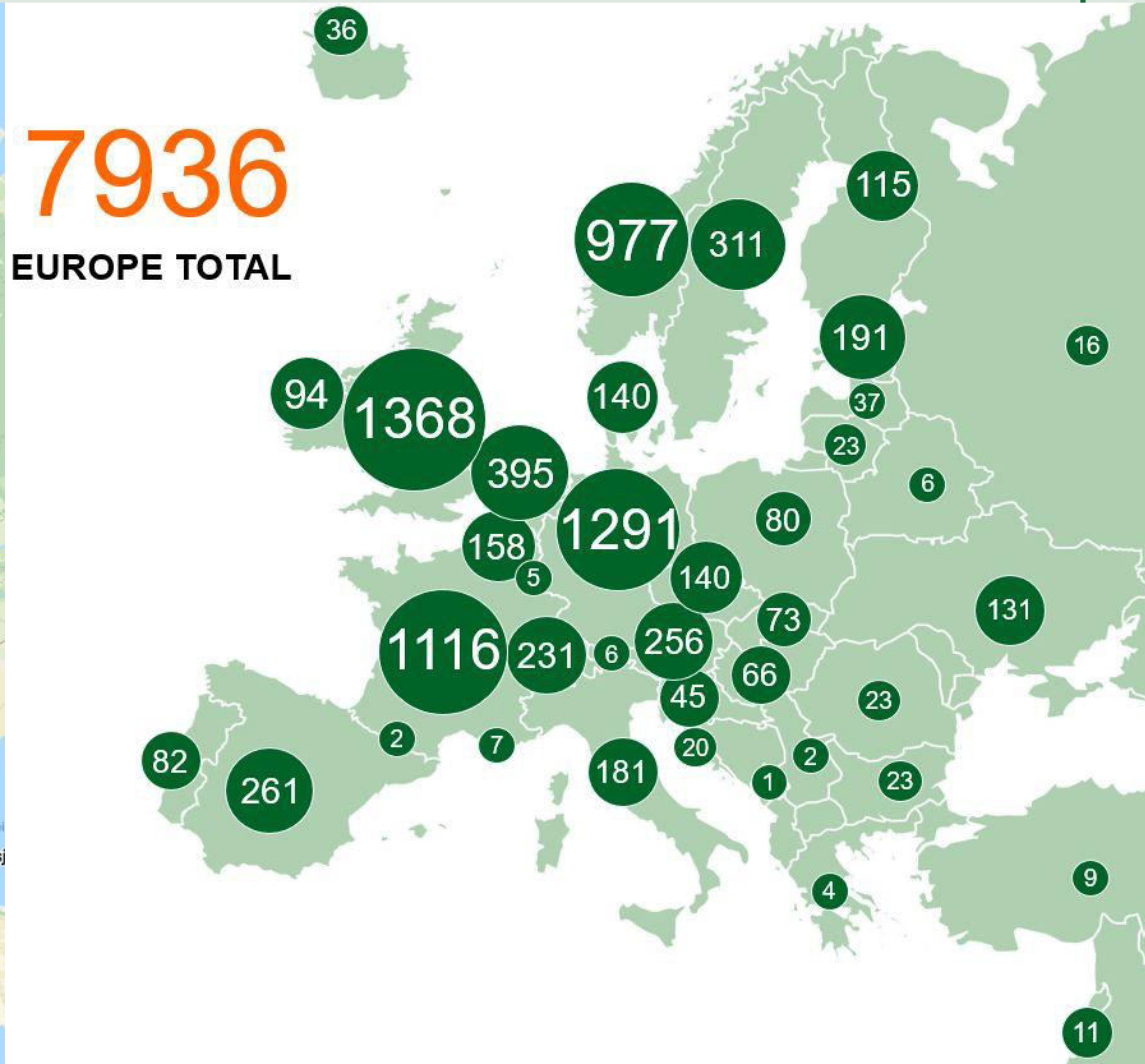
Have a great summit.

The results

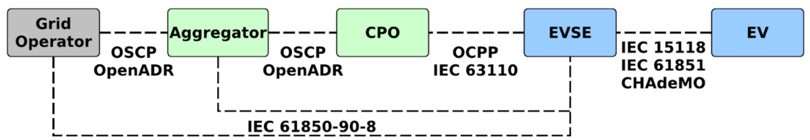
	$V1G_{AC}$	$V2G_{AC}$	DC	$V2G_{DC}$	GIV_{DC}	GIV_{AC}
	Controlled Charging	IEC61851	CHAdeMO	2.0	Grid Keys	Grid Keys
Leaf	ok		ok	ok		
Evalia	ok		ok	ok		
Ion	ok		ok	ok		
Outlander	ok		ok	ok		
Berlingo	ok		ok			
DTU-C1	ok	(ok)				
DTU AC-charger	ok	ok				(ok)
ENEL DC-charger	ok		ok	ok	(ok)	

CHAdeMO vs. CCS





The GAP – more details



Link	EV-EVSE			EVSE-CPO		CPO-Agg		EVSE-Agg
Information object	**IEC 61851**	**IEC 15118**	**CHAdeMO**	**OCPP 1.6**	**OCPP 2.0**	**OpenADR**	**OSCP**	**IEC 61850-90-8**
Active Power Control	+	+	+	+	+	+	+	+
Reactive Power Control	-	+	-	-	?	+	+	?
V2G	-	+	+	-	?	+	-	?
SOC	-	+	+	-	?	+	-	?
Activation time	<3s	<60s	<1s	-	-	-	-	-
EV ID	-	+	-	-	?	-	-	?
Vehicle status	+	+	+	+	+	-	-	?
EVSE ID	NA			+	+	+	+	+
Grid ID				-	?	?	+	+

Standards for all interfaces

ID

SoC

Battery Size

Power set point

(P/Q pr. sec)

The PARKER protocol

PARKER Protocol

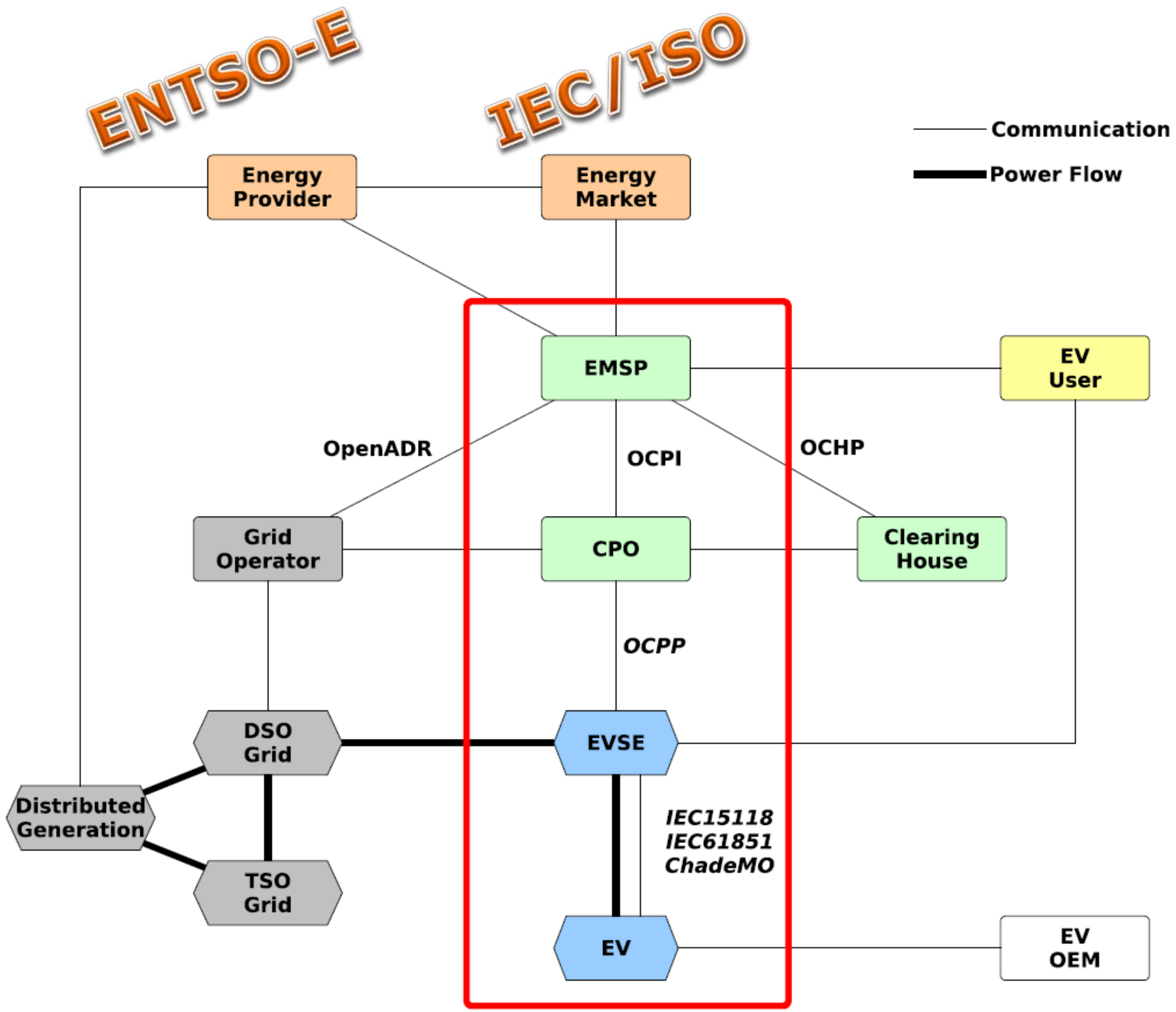
Standards for all interfaces

ID

SoC

Battery Size

Power set point (P/Q pr. sec)



The Timeline

June · **July** · **Aug** · **Sept** · **Oct**

Company announcements

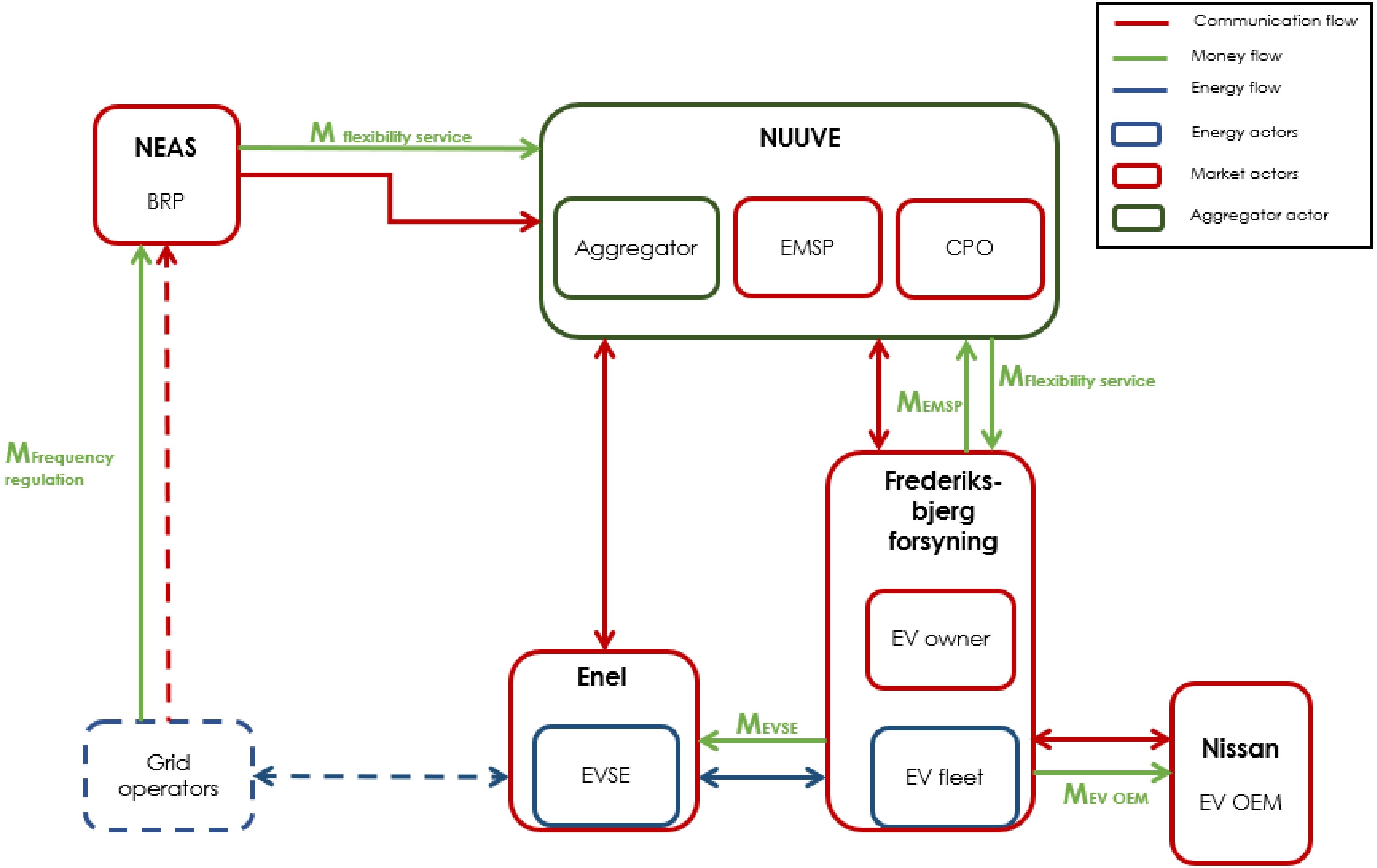
- VW: 30 new BEVs by 2025, 20-25% of sales (2016)
- BMW: EVs to be 15-25% of sales by 2025 (March 2017)
- Ford: 7 new electrified vehicles announced, $700M to upgrade factory (January 2017)
- Mercedes: $560M battery plant, $11B to bring 10 EVs by 2022, 15-25% of sales by 2025
- Volvo: All new models electrified by 2019
- Nissan: Expects 20% of EU sales be ZEV by 2022
- Tesla: Model 3 production starts
- Ford: Expects 70% of models in China to be hybrid+ by 2025
- Toyota + Mazda: Joint EV Venture
- Aston Martin: Fully electrified by ~2025
- BMW: 12 BEVs by 2025 + 13 electrified
- Mercedes: $1B refit USA plant for EV, reiterates $10B for EVs and $1B for batteries
- Jaguar: All new models electrified by 2020
- VW: $84B investment to bring 300 EVs to market by 2030
- Honda: New BEV concepts
- BYD: Expects all China sales to be EV by 2030
- dyson: $2.7 Billion in batteries and EVs
- GM: 2 new BEV models in 18 months, 20 new BEV models by 2023
- Ford: Team Edison to make BEVs, reiterates 13 new electrified vehicles by 2020, $4.5B in investments + reallocating 1/3 of combustion investment

Government actions

- **Netherlands – lower house passes motion to ban petrol vehicle sales by 2025 (March 2016)**
- **Norway – Norway discussing ban of petrol vehicles by 2025 (June 2016)**
- **Germany – passes resolution seeking to approve ZEV only by 2030 (October 2016)**
- **India – expect all electric by 2030, official policy expected in Dec**
- **China – EV mandates lobbied against**
- **Norway – update: to use a mix of incentives and fees to reach goal of no petrol vehicles sold by 2025. June 2017**
- **France – to ban petrol vehicle sales by 2040**
- **UK – to ban petrol vehicle sales by 2040**
- **Scotland – government pledges to phase our petrol vehicle sales by 2032**
- **China – "New energy vehicles" requirements published**

BEV = Battery Electric Vehicle
PEV = Plug-in Electric Vehicle
ZEV = Zero Emission Vehicle
EV or "electrified" = hybrid, plug-in hybrid, or BEV

The new ref. Arc.



PROGRAM OVERVIEW

Day one - November 21st

09.00 – 09.15	Arrival and Registration
09.15 – 10.00	Opening Session
10.00 – 11.00	Parker – Practical Experience
11.00 – 11.25	Break and VGI Exhibits
11.25 – 12.15	Parker – Business Potential
12.15 – 13.00	Lunch and VGI Exhibits
13.00 – 13.30	Parker – Technological Readiness
13.30 – 13.45	Parker - Recommendations, conclusions and next steps
13.45 - 14.15	Technological Presentation
14.15 - 14.45	Open discussion and Parker wrap-up
14.45 – 17.00	ACES - Project Overview
17.00 – 19.00	Walking tour and buffet

Day two - November 22nd

09.00 – 09.20	Opening Session
09.20 – 09.45	Keynote 1
09.45 – 11.05	V2G Worldwide Overview
11.05– 11.30	Coffee Break
11.30 – 12.50	Cutting Edge Demonstrators
12.50– 13.40	Lunch
13.40 – 15.00	OEMs on V2G
15.00 – 15.15	Coffee Break
15.15 – 15.45	Keynote 2
15.45 - 16.00	Wrap Up

- Industry
- Initiatives
- Projects

The program

12.15 – 13.00	**Lunch and VGI Exhibits**	
13.00 – 13.30	**Parker – Technological Readiness**	• State-of-the-art technology used by Parker • Needs towards standardization • Testing the equipment's abilities using the Parker test protocol **Speaker:** Thomas Meier Sørensen
13.30 – 13.45	**Parker - Recommendations, Conclusions and next steps**	• Summarized learnings of Parker • Recommendations • Next steps and actions **Speaker:** Peter Bach Andersen
13.45 - 14.15	**Technological Presentation**	• Presentation of the Parker cars and chargers • Controlling power based on frequency and marginal C02 emission **Speakers:** Thomas Meier Sørensen, Olivier Corradi
14.15 - 14.45	**Open discussion and Parker wrap-up**	Discussion directly with the speakers at three stations on the main topics: • Practical experience • Business potential • Technological readiness Wrap-up of Parker session