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Universidad del País Vasco Euskal Herriko Unibertsitatea

VITORIA-GASTEIZKO INGENIARITZA ESKOLA

ESCUELA DE INGENIERÍA DE VITORIA-GASTEIZ

Vehículos Eléctricos y su Integración en el Sistema Eléctrico

18 Abril 2024

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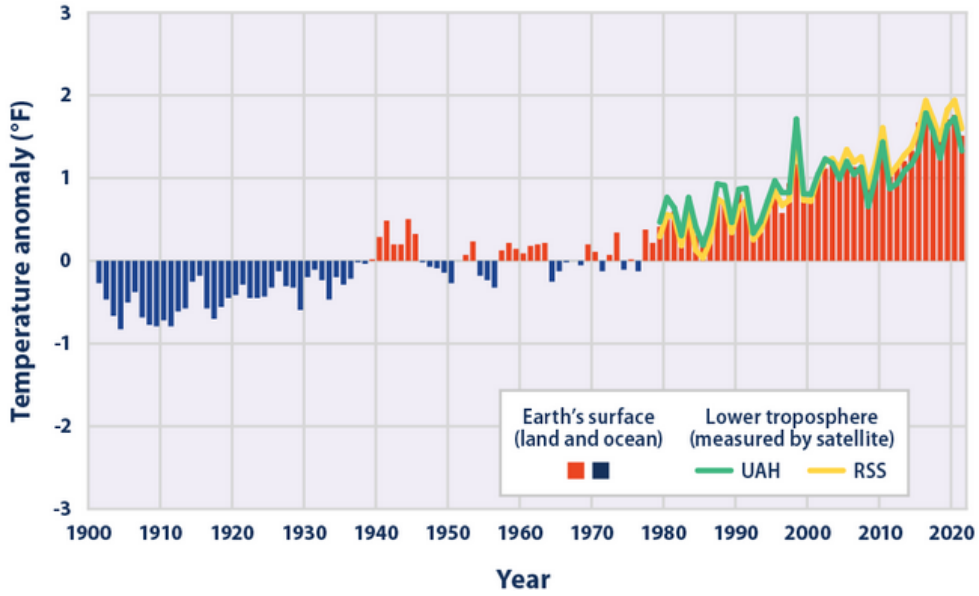
Teknologia Elektronikoa Saila

Contexto

Figure 2. Temperatures Worldwide, 1901–2021



Gases de efecto invernadero

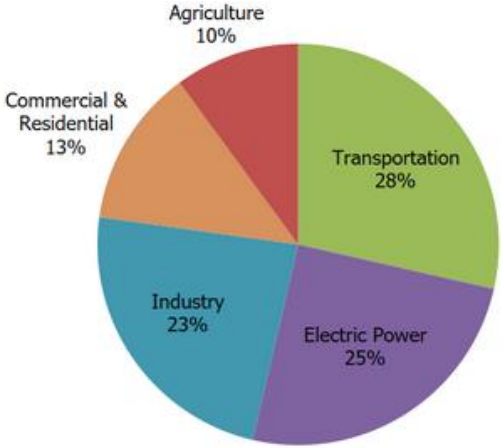
↓

Objetivo: emisión cero en 2050.

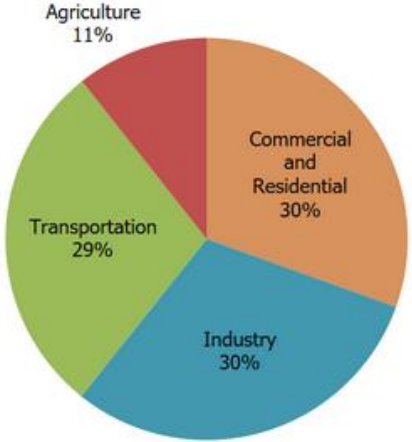
EPA – United States Environmental Protection Agency, "Climate Change Indicators: U.S. and Global Temperature", online.

Contexto

Objetivo: emisión cero en 2050 ⟹ **Electrificación del transporte.**



Total U.S. Greenhouse Gas Emissions by Economic Sector



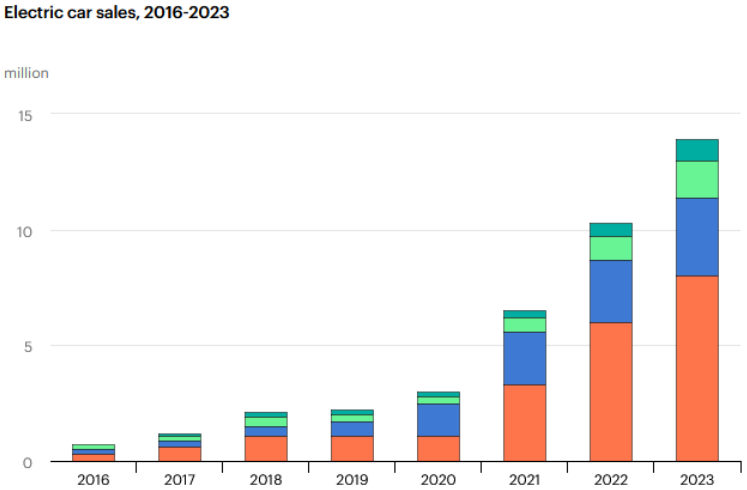
Total U.S. Greenhouse Gas Emissions by Economic Sector and Electricity End-Use

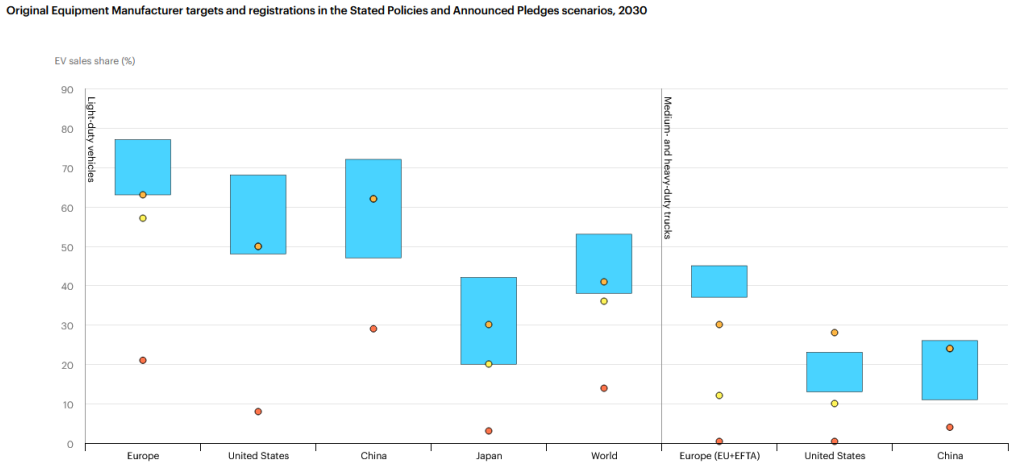
EPA – United States Environmental Protection Agency, “Sources of Greenhouse Gas Emissions”, online.

Contexto

Estado actual

Tendencia al alza en venta de VE → **Proyección a 2030 con mucho impacto.**



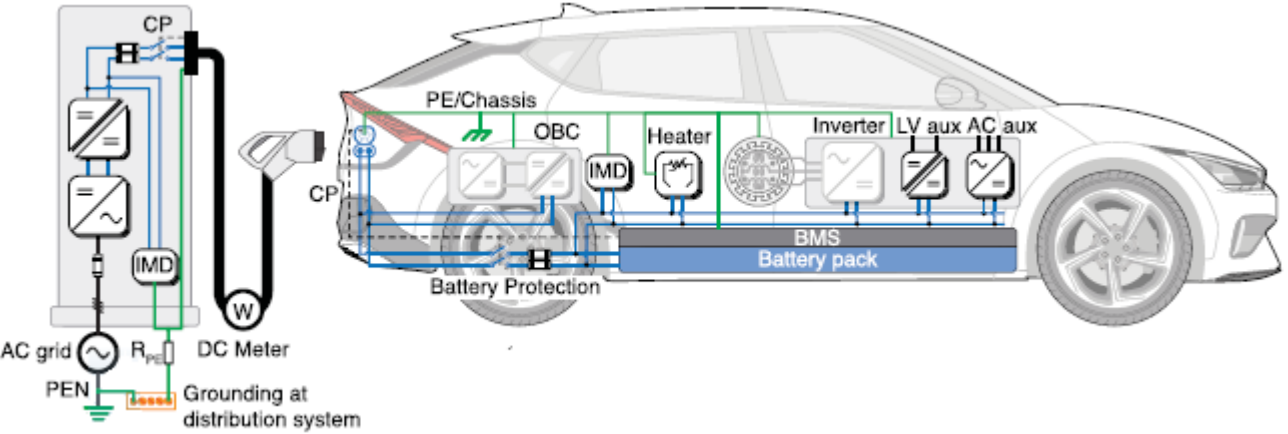


IEA – International Energy Agency, “Grid Integration of Electric Vehicles”, online.

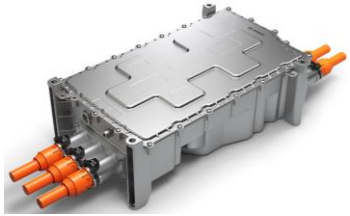
Estado actual VE

Motor(es)

Baterías



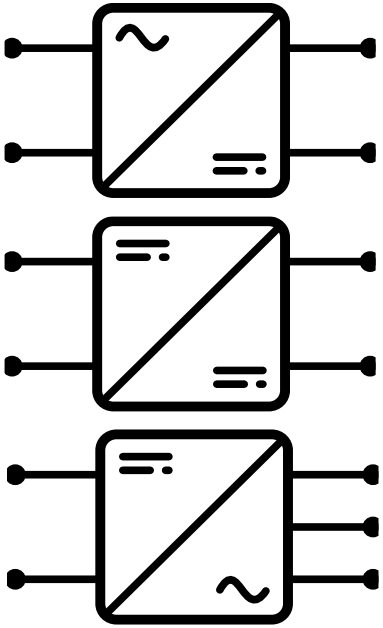
Convertidores (inversores) (cargadores)



S. Rivera et al., "Charging Infrastructure and Grid Integration for Electromobility," in Proceedings of the IEEE, vol. 111, no. 4, pp. 371-396, April 2023.

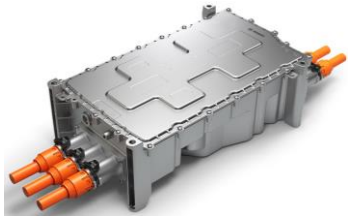
Estado actual VE

- Convertidores



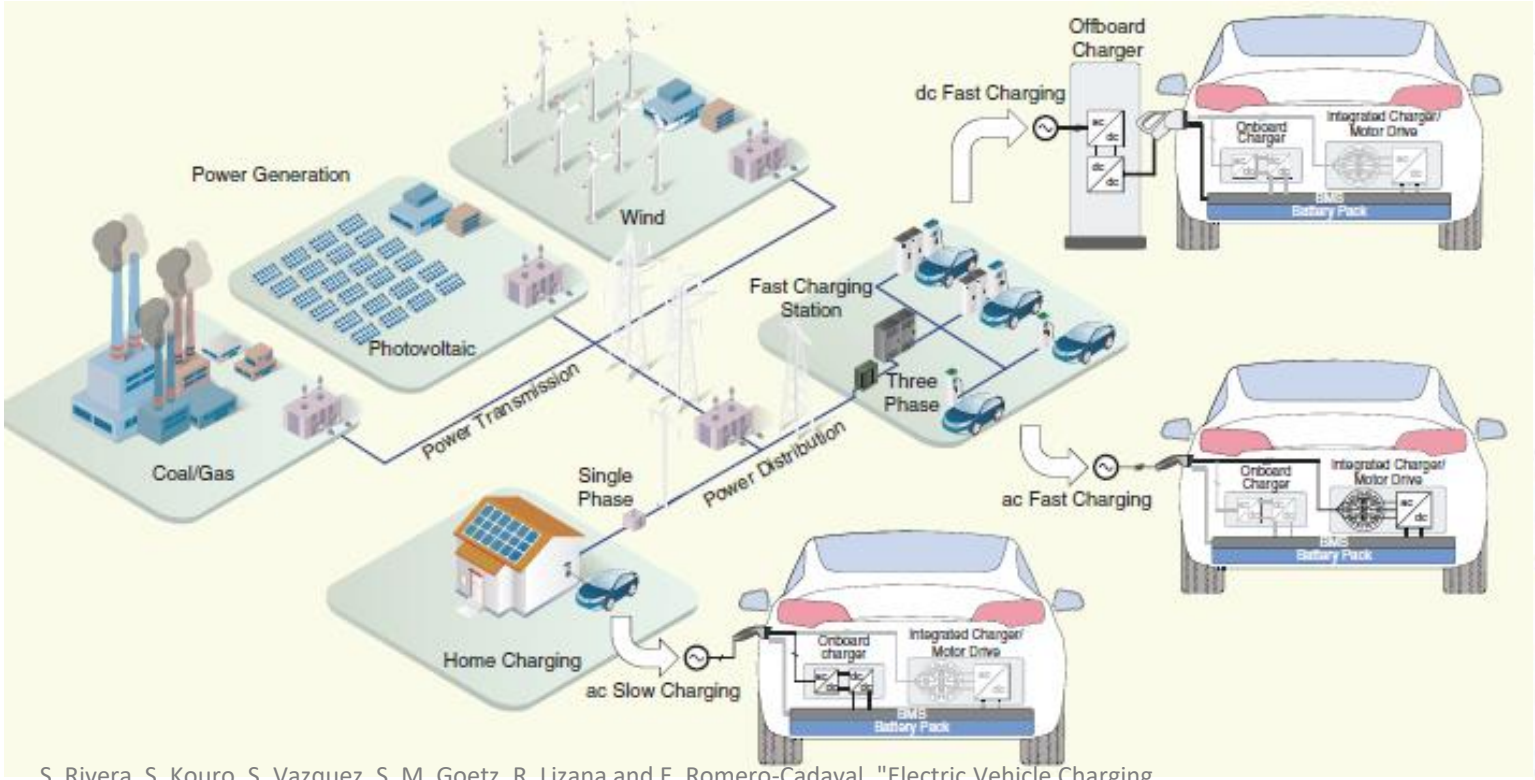
- Tensión entrada/salida
- Frecuencia entrada/salida
- DC/DC, AC/DC, DC/AC
- Mono-, tri-, poli-fásico
- Aislamiento galvánico
- Modular
- P uni/bi-direccional

Inversor(es)



Cargador(es)

Estado actual VE



DC Rápido

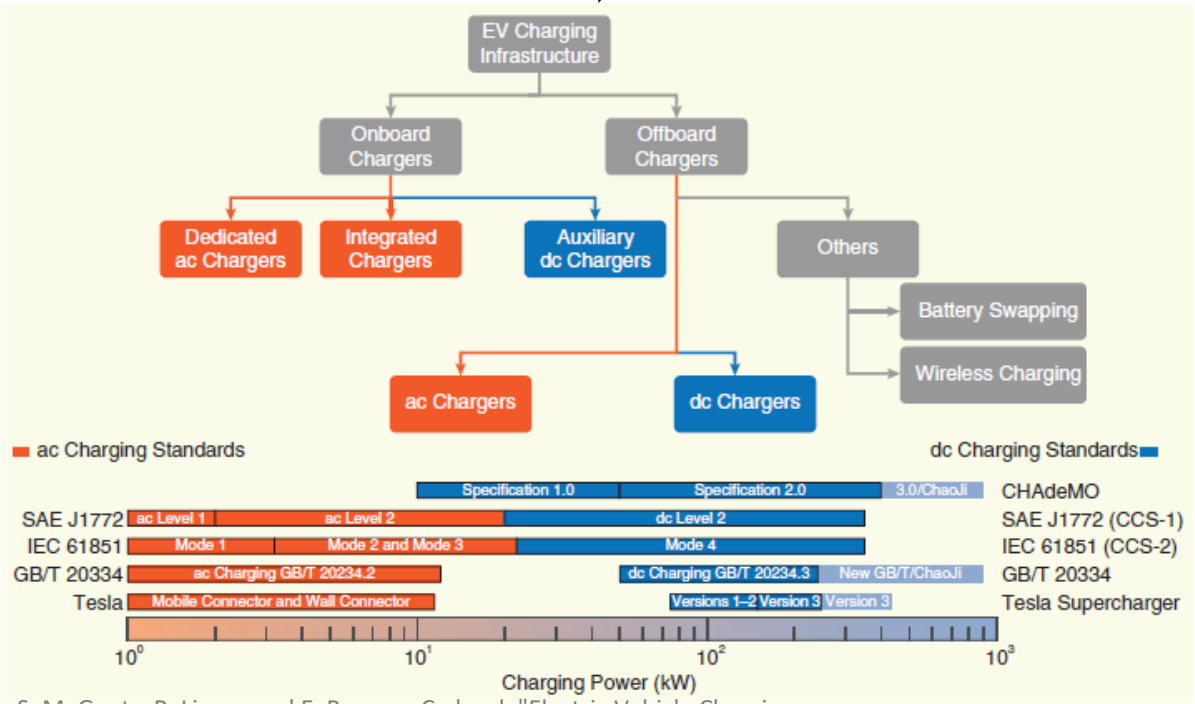
AC Rápido

AC Lento

S. Rivera, S. Kouro, S. Vazquez, S. M. Goetz, R. Lizana and E. Romero-Cadaval, "Electric Vehicle Charging Infrastructure: From Grid to Battery," in IEEE Industrial Electronics Magazine, vol. 15, no. 2, pp. 37-51, June 2021.

Estado actual VE

Cargadores de mayor potencia → **Mayor batería equivalente.**

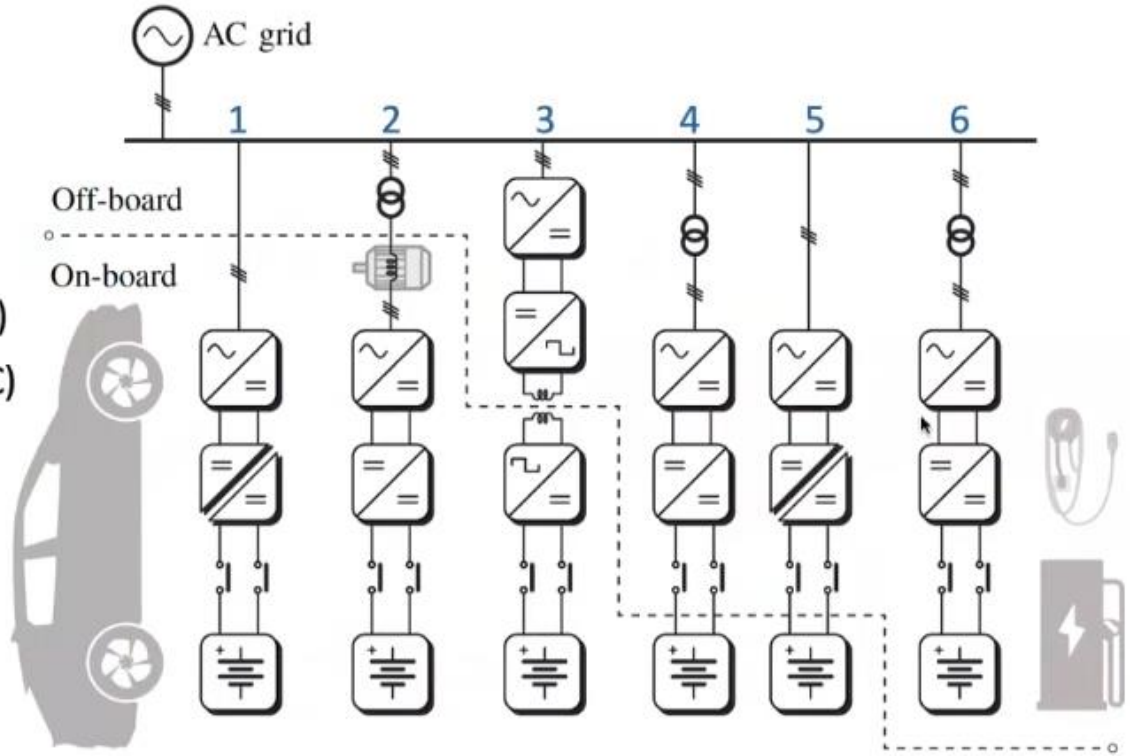


S. Rivera, S. Kouro, S. Vazquez, S. M. Goetz, R. Lizana and E. Romero-Cadaval, "Electric Vehicle Charging Infrastructure: From Grid to Battery," in IEEE Industrial Electronics Magazine, vol. 15, no. 2, pp. 37-51, June 2021.

Estado actual VE

Off-board vs. on-board

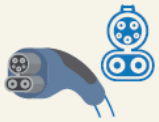
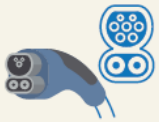
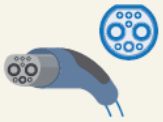
1. OBC (AC)
2. Integrated (AC)
3. Wireless
4. Off-board LF (DC)
5. Off-board HF (DC)
6. Battery swap

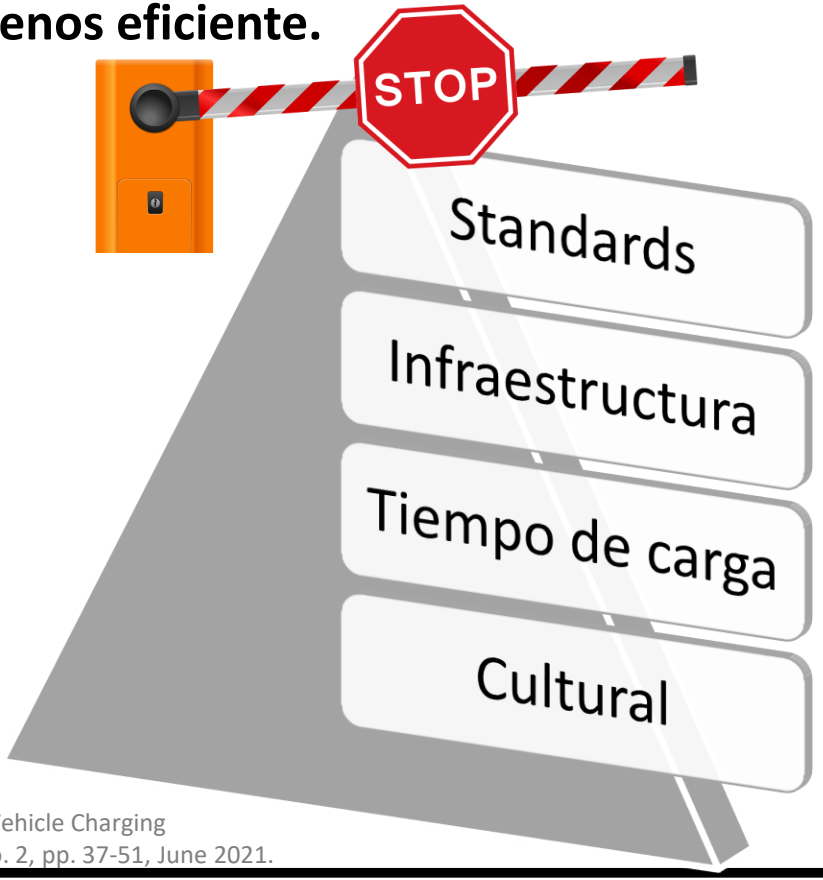


S. Kouro, “Charging Infraestructure and Grid Integration for Electromobility”, online.

Estado actual VE - Barreras

De 400V hacia 800V… → P = V · I → Más I, menos eficiente.

	CHAdeMO	CCS-1	CCS-2	GB/T	TESLA
Maximum power*	400 kW	350 kW	350 kW	237.5 kW	350 kW
Typical power†	50 kW	312 kW	350 kW	60 kW	250 kW
Output voltage	50–1,000 V	200–1,000 V	200–1,000 V	250–950 V	300–480 V
Maximum current	400 A	500 A	500 A	250–400 A	800 A
Communication	CAN	PLC	PLC	CAN	CAN
Region	Global	United States, South Korea	Europe, Australia	China, India	Global
Related standards	• IEC 61851-23/4 • IEC 62196-3 • JEVS G105-1993	• IEC 61851-23/24 • IEC 62196-3 • SAE J1772-2017	• IEC 61851-23/24 • IEC 62196-3	• GB/T 20234-3-2015 • IEC 62196-3	• IEC 62196-3
Vehicle to device	Yes	Under development	Under development	Under development	No
Plug type					
Time/100 km‡	13.73 min	4.4 min	1.96 min	11.44 min	2.74 min
Range/5 min§	36.4 km	113.54 km	254.73 km	43.67 km	181.95 km
Examples	 Delta Ultra Fast Charger: 50–550 V, 125 A (CHAdeMO); 170–1,000 V, 300 A (CCS); 150 kW maximum	 Charge Point Express Plus: 200–1,000 V, 390 A, 156 kW	 ABB Terra HP: 150–920 V, 500 A, 350 kW	 ABB Terra GB 184MVZ: 200–750 V, 300 A, 3 × 60 kW	 V3 Supercharger: 450 V, 250 kW



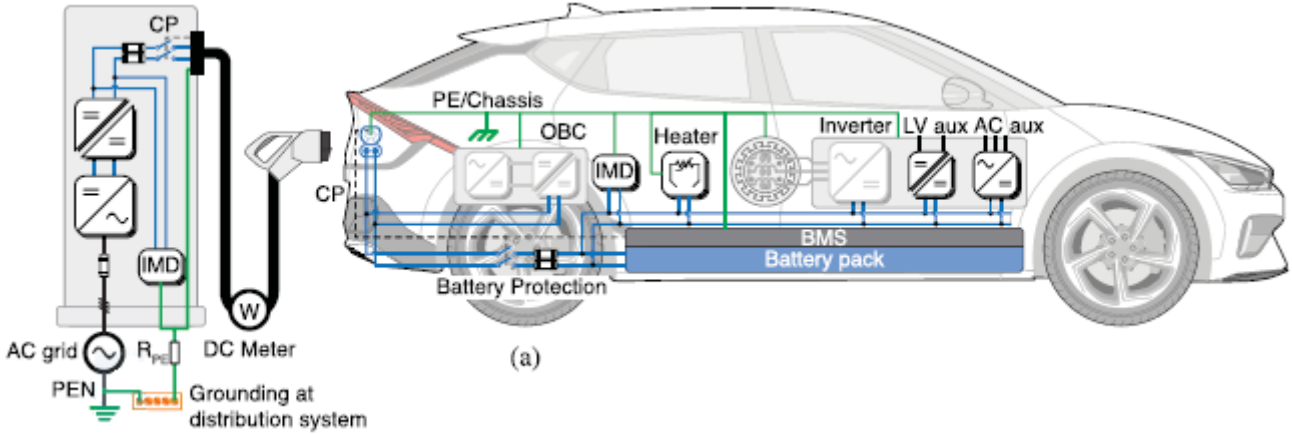
S. Rivera, S. Kouro, S. Vazquez, S. M. Goetz, R. Lizana and E. Romero-Cadaval, "Electric Vehicle Charging Infrastructure: From Grid to Battery," in IEEE Industrial Electronics Magazine, vol. 15, no. 2, pp. 37-51, June 2021.

Estado actual VE - Barreras

Oportunidades Cargadores VE

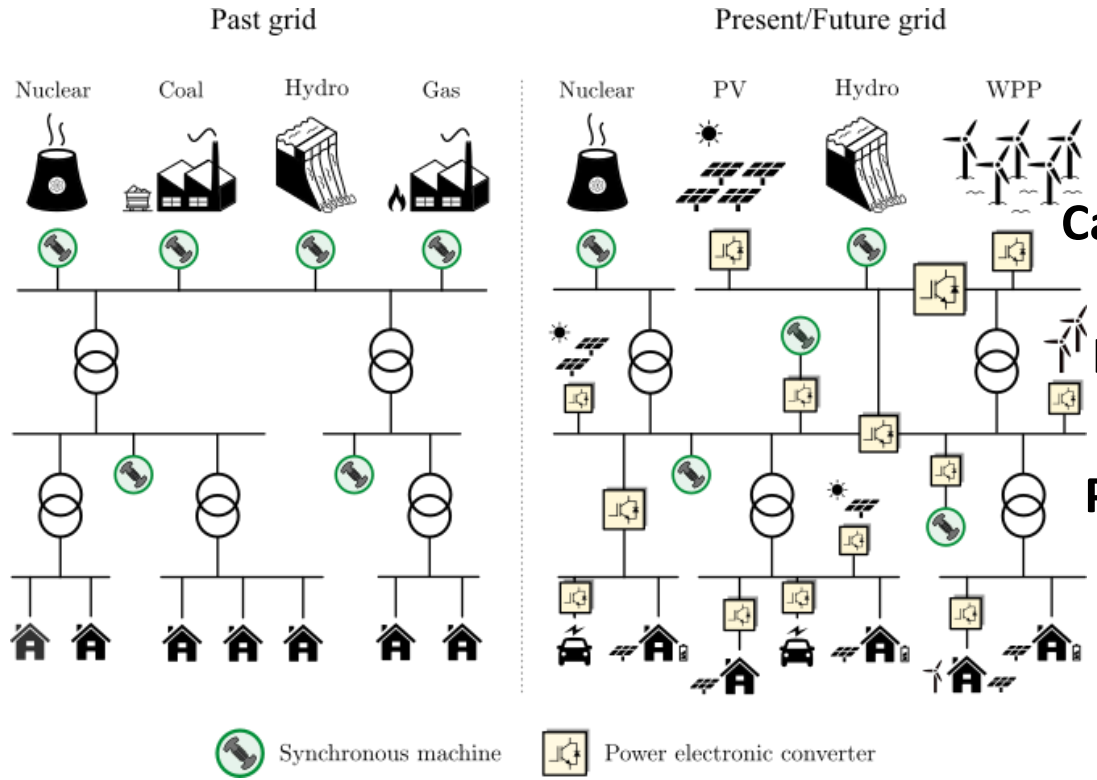
Caso más probable/simple en la actualidad… → **Carga inteligente (Smart charging)**

Potencia activa unidireccional → **V1G**



S. Rivera et al., "Charging Infrastructure and Grid Integration for Electromobility," in Proceedings of the IEEE, vol. 111, no. 4, pp. 371-396, April 2023.

Oportunidades Cargadores VE



I. Marzo, "Modular Converter Structures for STATCOM Application under Unbalanced Conditions", PhD Dissertation, Mondragon Unibertsitatea, 2022.

Cambio de paradigma en red eléctrica

↓

Integración con energías renovables

↓

Potencial para nuevas características

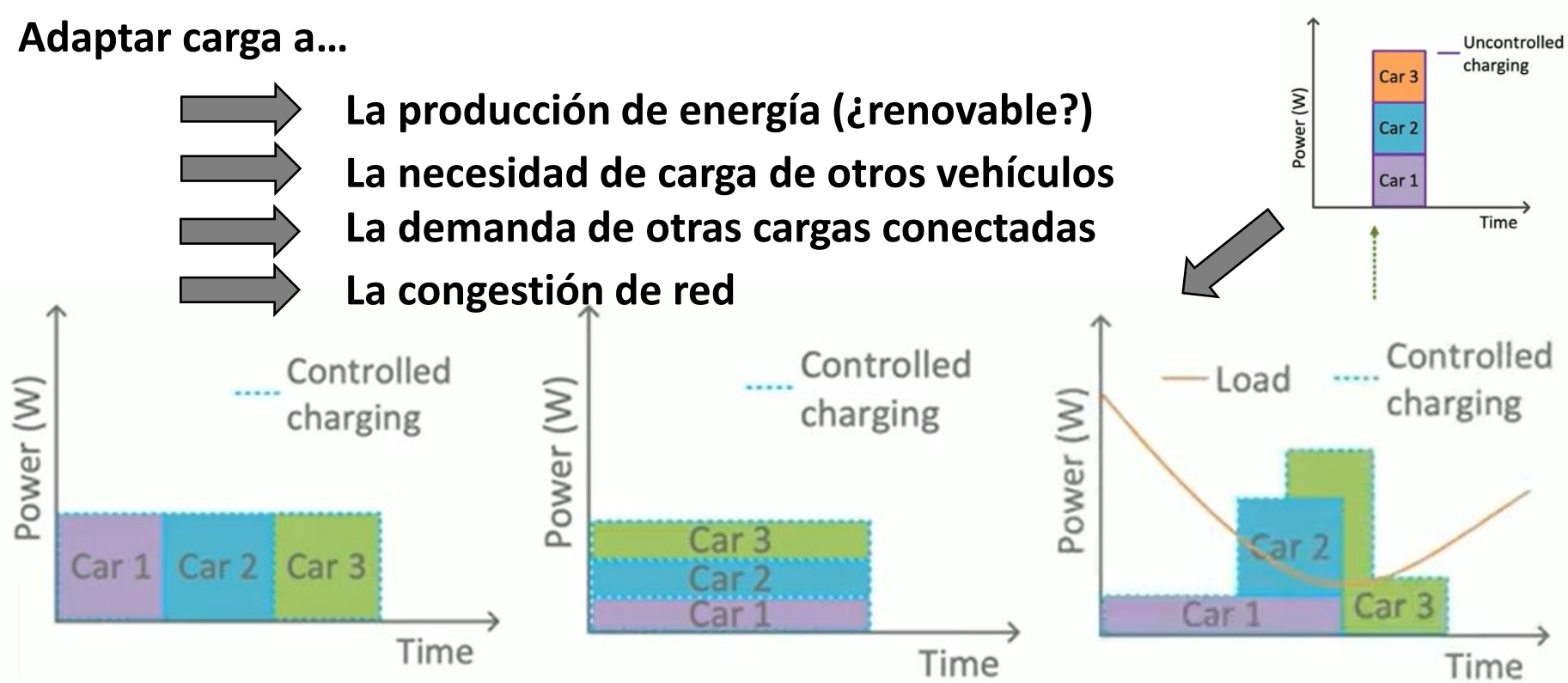
↓

Smart Charging
(¡Carga inteligente!)

Oportunidades Cargadores VE

Adaptar carga a…

- **La producción de energía (¿renovable?)**
- **La necesidad de carga de otros vehículos**
- **La demanda de otras cargas conectadas**
- **La congestión de red**



G. R. Chandra Mouli, “Smart Charging of Electric Vehicles”, online.

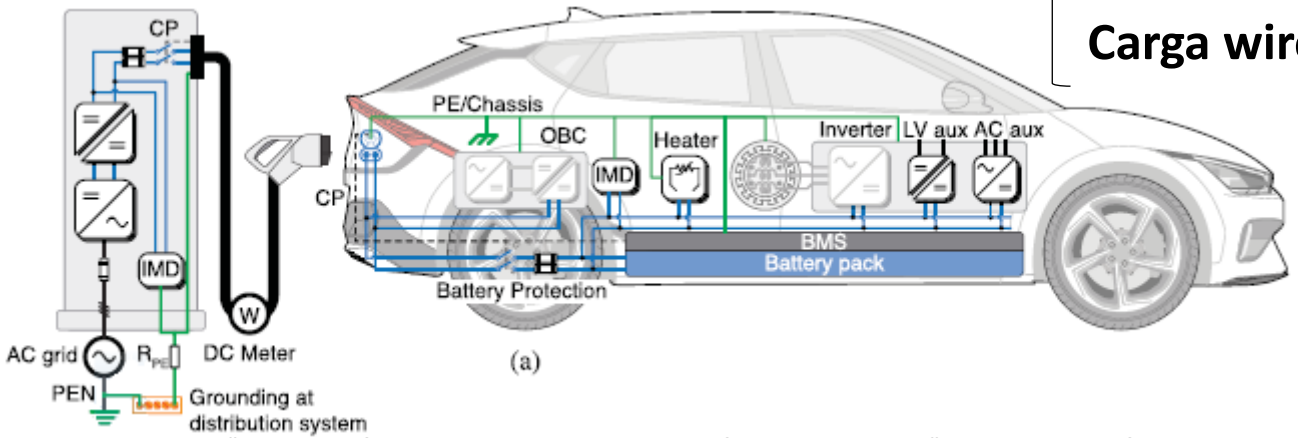
Futuro de Cargadores VE

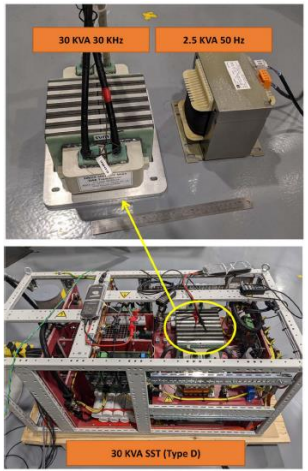
A nivel de cargador…

Potencia bidireccional ⟷

→ **V2X (V2G, V2H, V4G)**

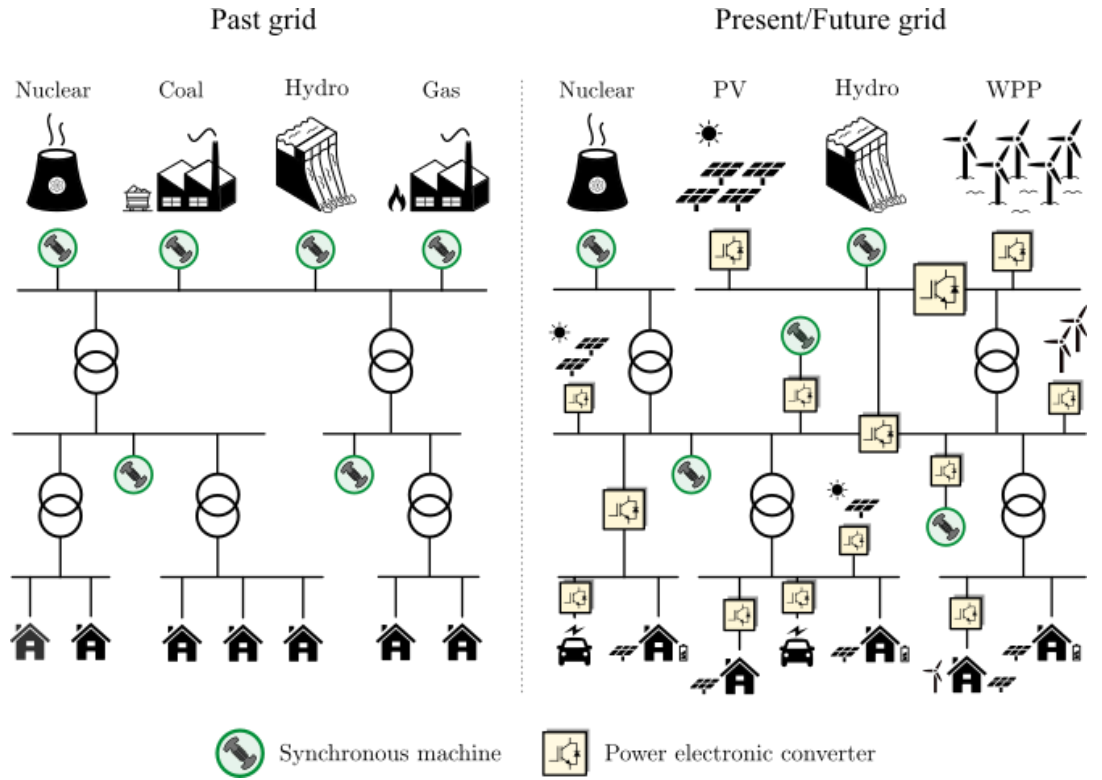
- **Siguiente escalón: Vdc = 1200 V**
- **Mayores potencias para cargas rápidas**
- **Más eficiente**
- **Semiconductores WBG**
- **Carga wireless**





S. Rivera et al., "Charging Infrastructure and Grid Integration for Electromobility," in Proceedings of the IEEE, vol. 111, no. 4, pp. 371-396, April 2023.
G. G. Farivar et al., "Grid-Connected Energy Storage Systems: State-of-the-Art and Emerging Technologies," in Proc. of the IEEE, vol. 111, no. 4, pp. 397-420, April 2023.

Futuro de Cargadores VE



I. Marzo, "Modular Converter Structures for STATCOM Application under Unbalanced Conditions", PhD Dissertation, Mondragon Unibertsitatea, 2022.

Flujo de energía bidireccional

+

Almacenamiento masivo

+

Conectividad

Funcionalidades/servicios extra!

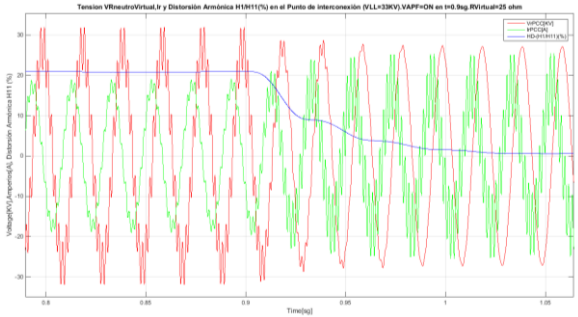
Tanto con o sin coche conectado

Futuro de Cargadores VE

Sin coche conectado

Mismos servicios que cualquier convertidor de Energías Renovables

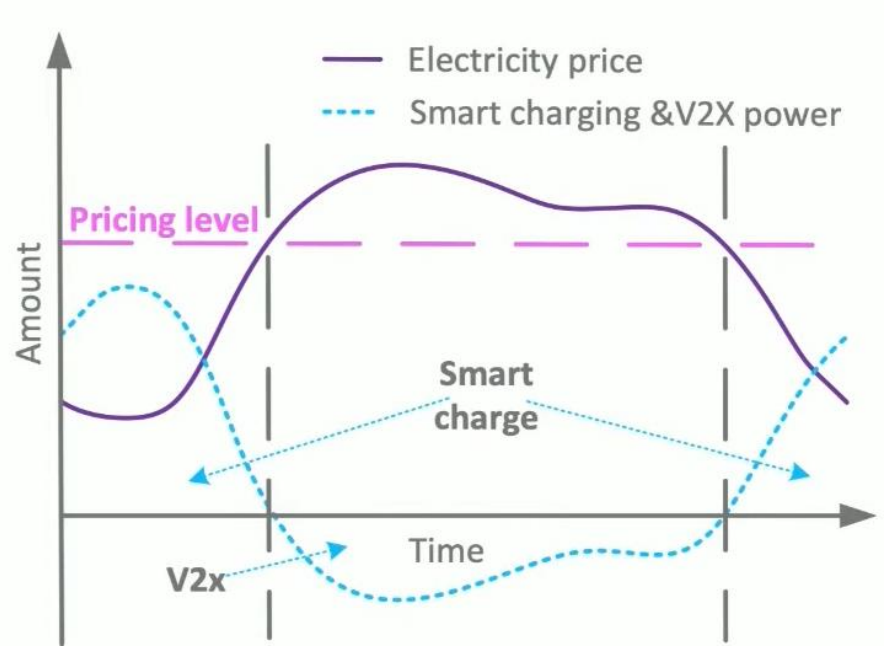
Compensación Potencia Reactiva



Filtro Armónico

Futuro de Cargadores VE

Con coche conectado



Carga basada en precio

Futuro de Cargadores VE

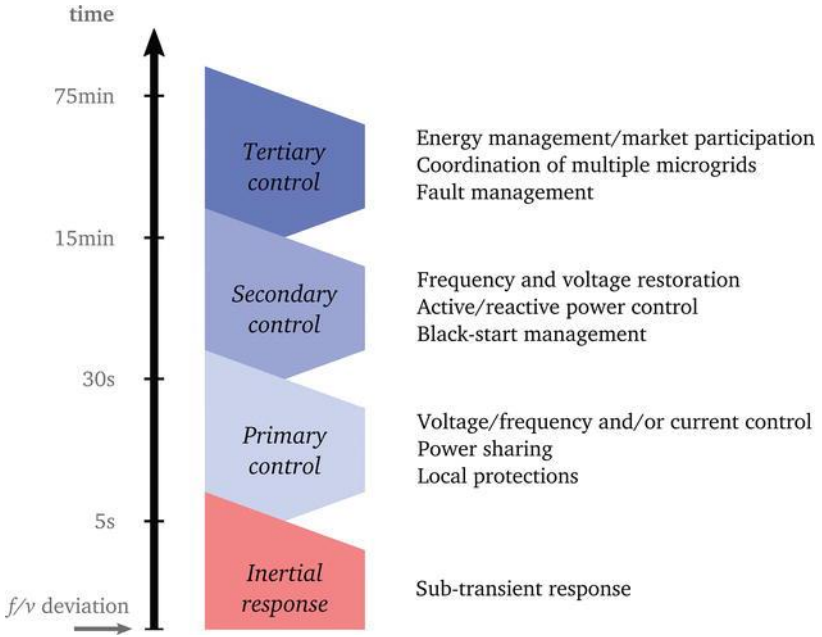
Con coche conectado

Mismos servicios que cualquier convertidor de Energías Renovables

+

Generadores

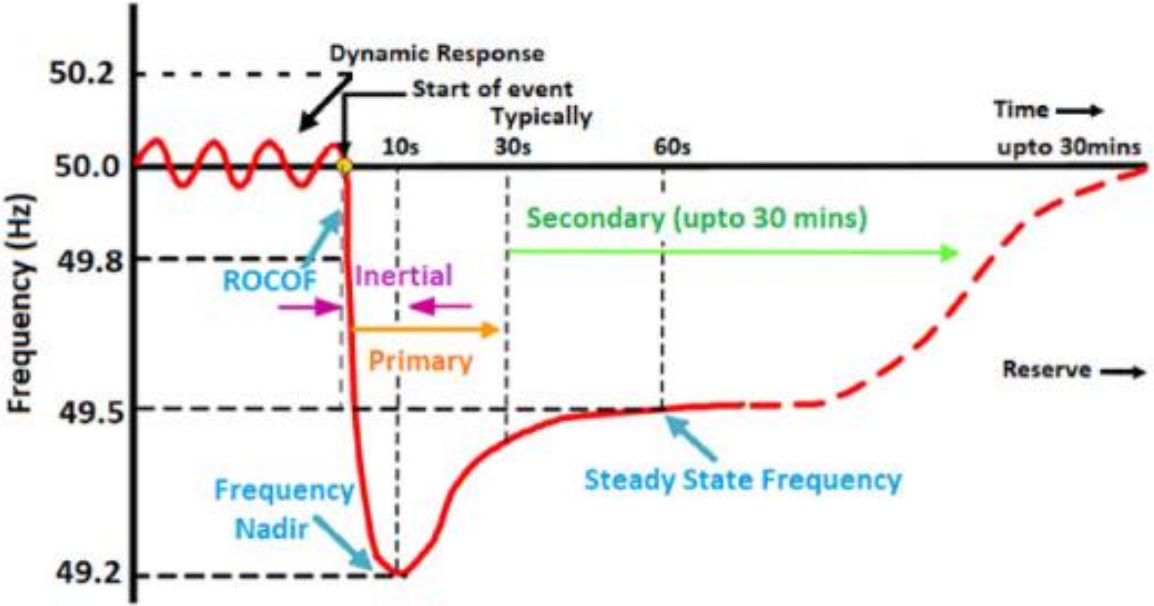
Servicios a diferentes escalas de tiempo



Unamuno, E.; Barrena, J.A, "Equivalence of Primary Control Strategies for AC and DC Microgrids", Energies 2017, 10, 91.

Futuro de Cargadores VE

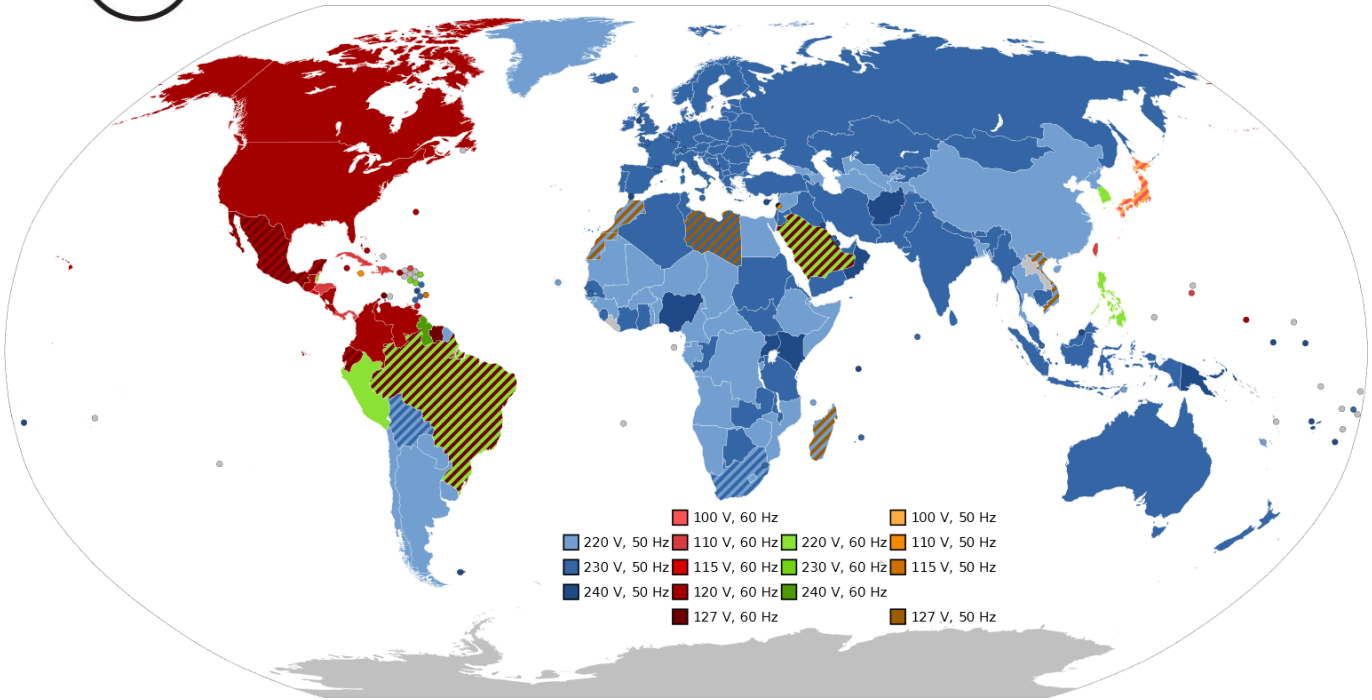
Con coche conectado



Asma Aziz, Aman Than Oo, Alex Stojcevski, “Frequency regulation capabilities in wind power plant”, Sustainable Energy Technologies and Assessments, Volume 26, 2018.

Futuro de Cargadores VE

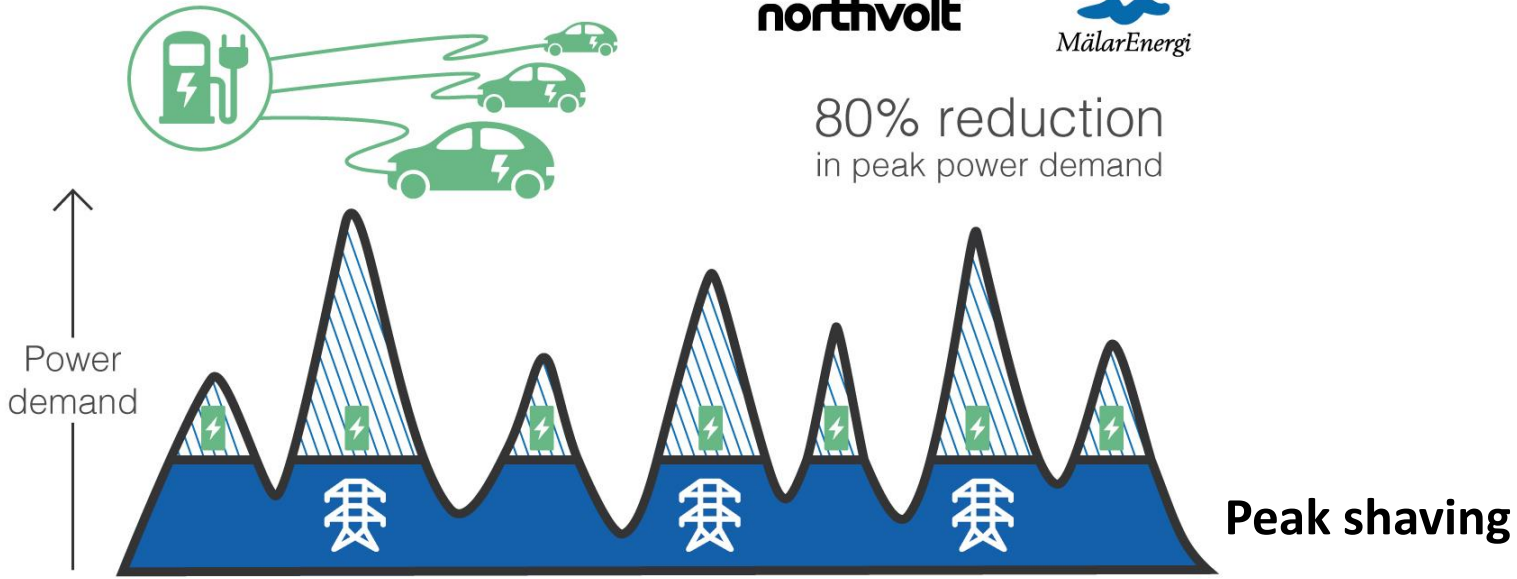
Con coche conectado



¡Modo isla!

Futuro de Cargadores VE

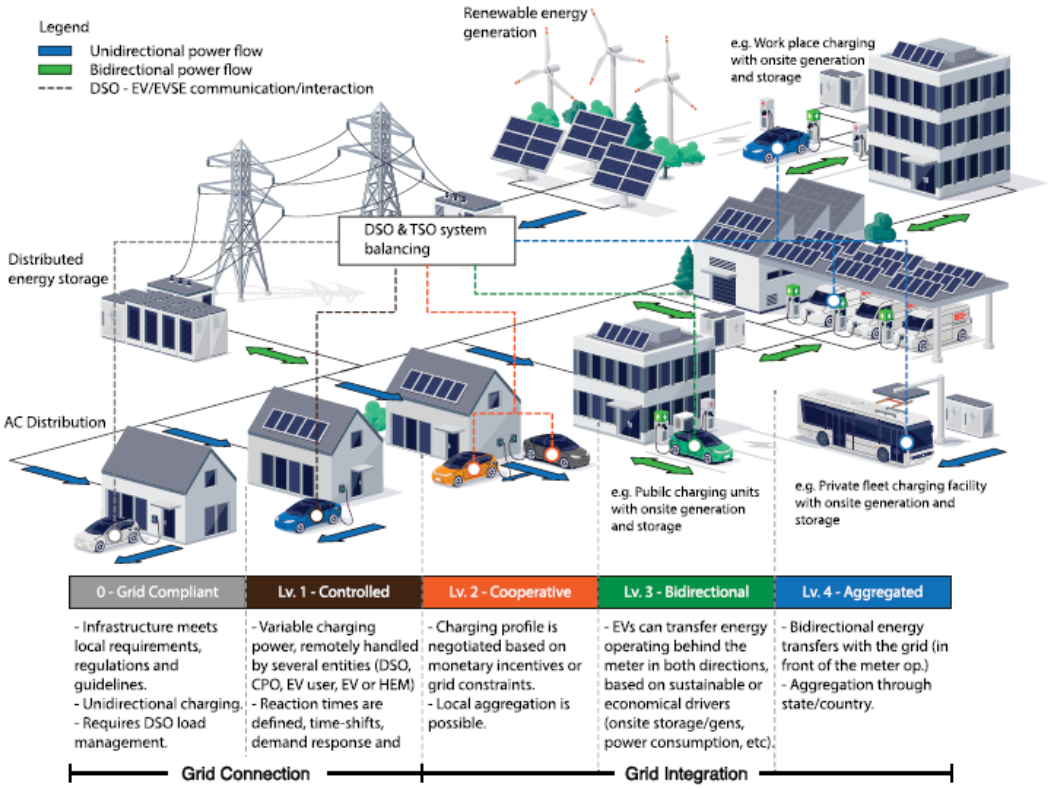
Con coche conectado



Peak shaving

Minutos/Días/Horas

Futuro de Cargadores VE



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