Electric Vehicles as Distributed Energy Resources: The Role of Advanced Bi-Directional On-Board Chargers

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ĐẠI HỌC QUỐC GIA THÀNH PHỐ HỒ CHÍ MINH

TRƯỜNG ĐẠI HỌC BÁCH KHOA

Outline

1. Clean energy needs flexibility

Solar and wind are scaling fast, but they are variable

2. EVs as distributed energy resources

Global EV growth and Viet Nam’s rapid transition

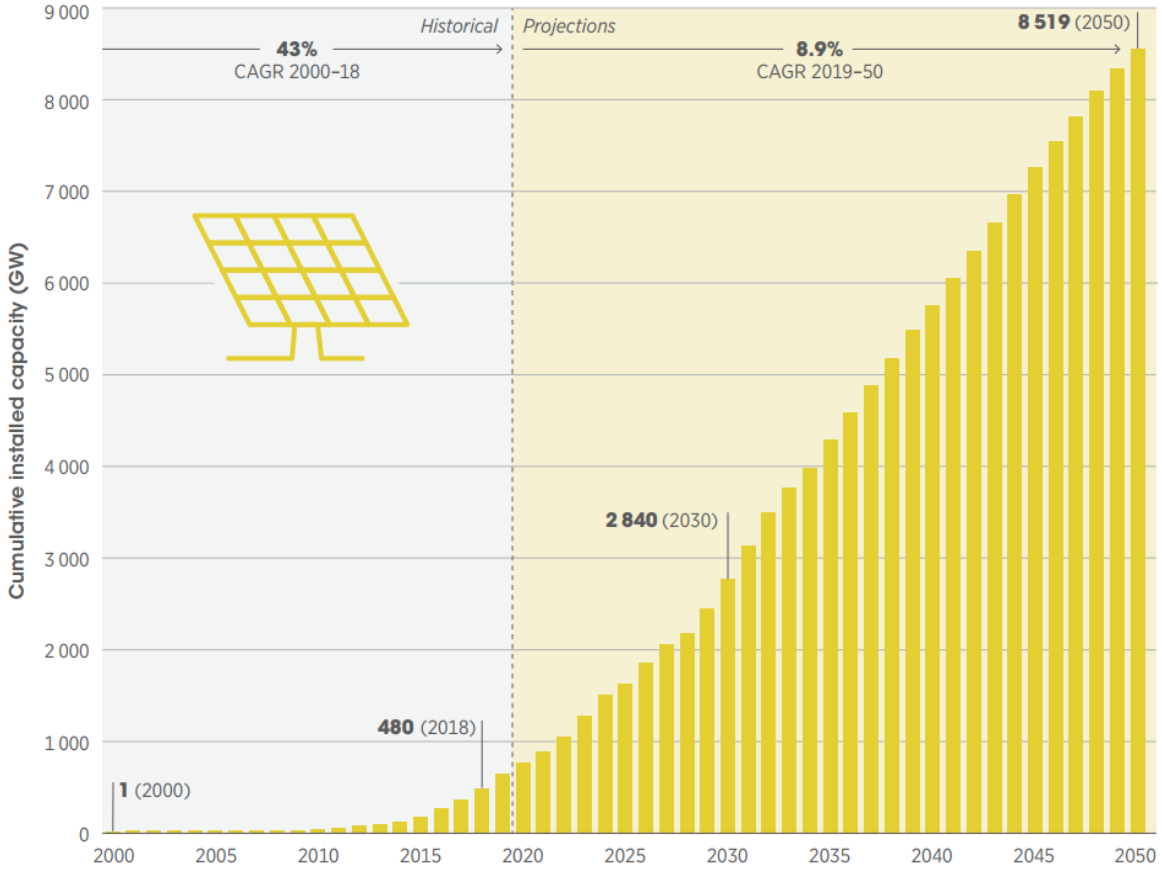
3. The bidirectional on-board charger

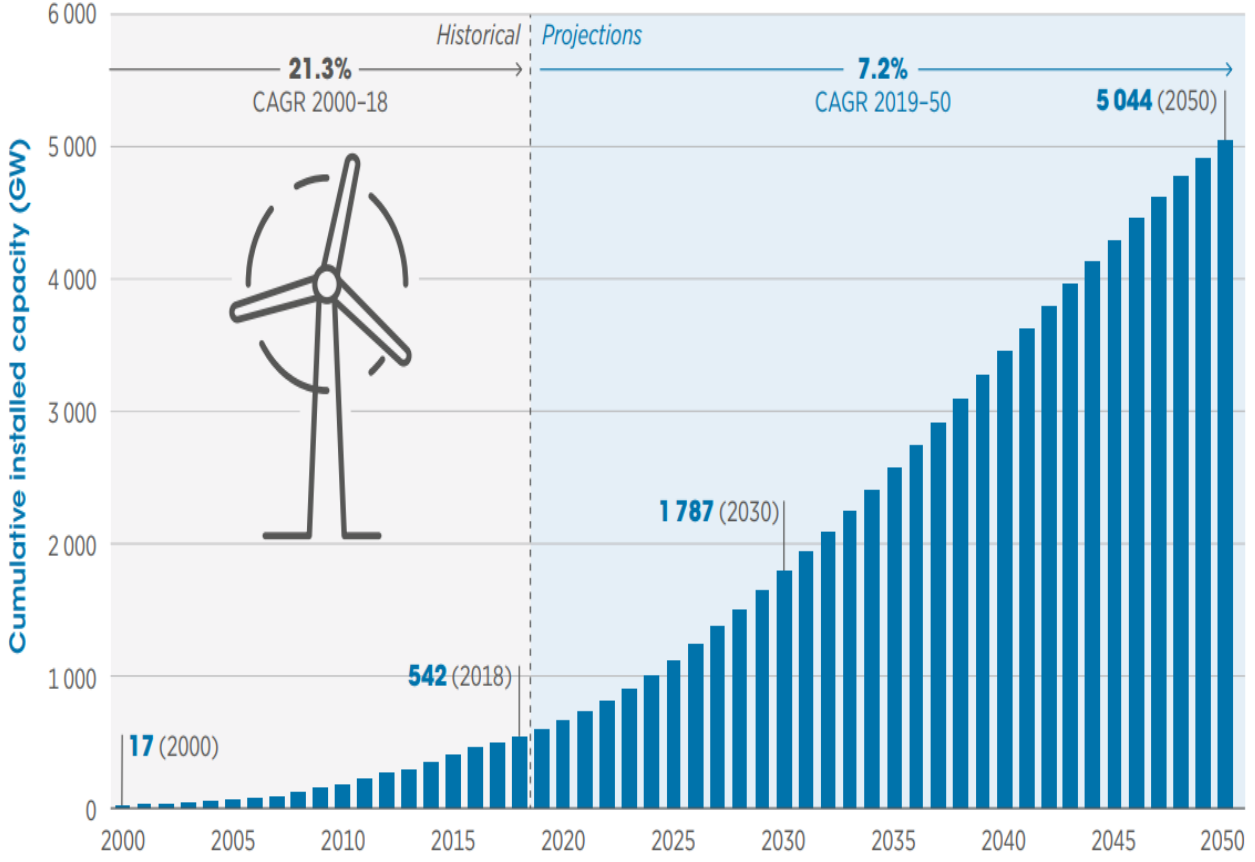
The key device that connects EVs to the grid: V2G, V2H, V2L, V2V

4. Our research: from lab to industry

Publications, prototypes and collaboration opportunities

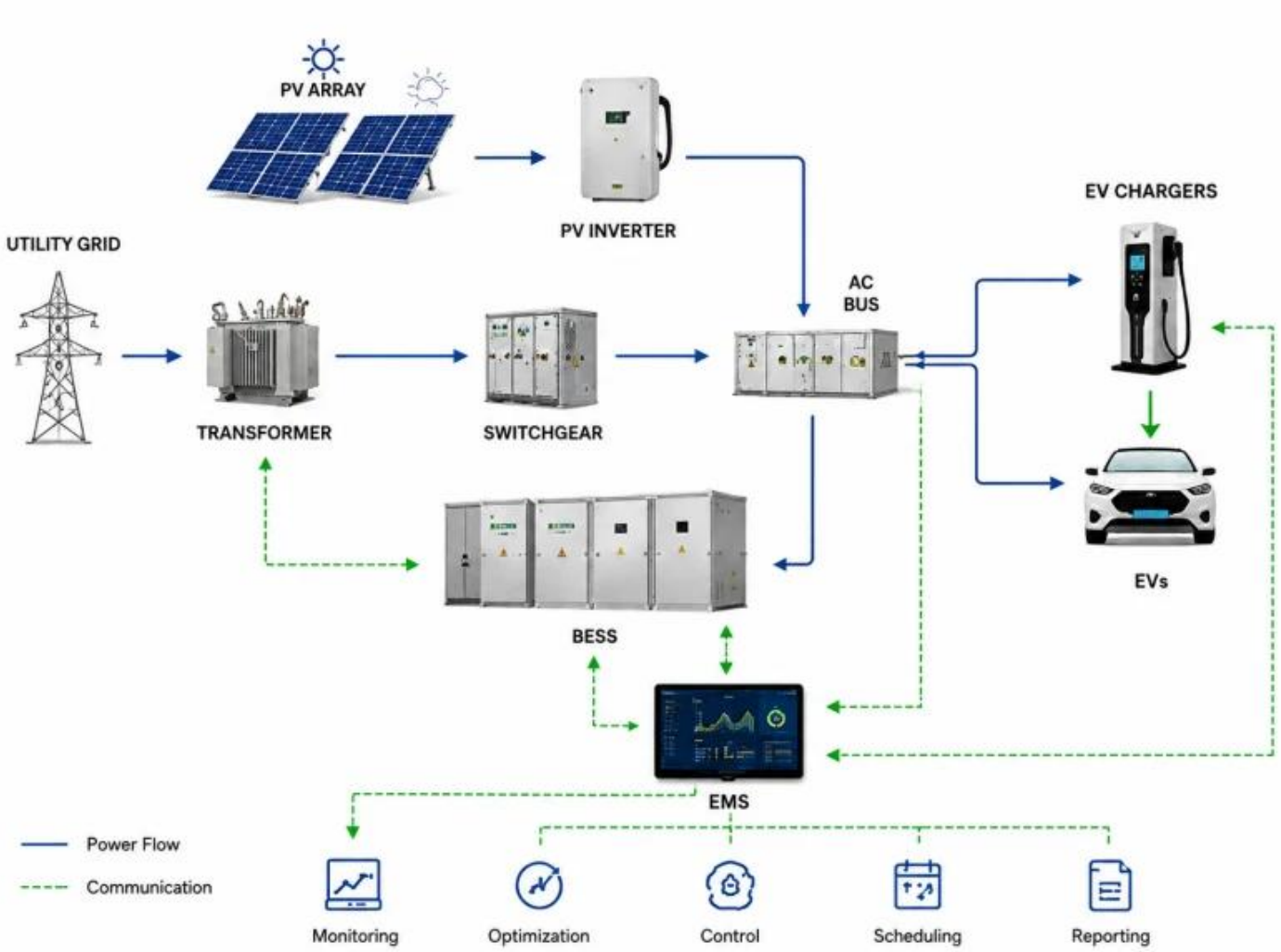
Solar and wind are scaling to terawatts





Sources: IRENA, Future of Solar Photovoltaic; IRENA, Future of Wind

EVs: mobile batteries for a clean grid



What a bidirectional EV adds

Mobile storage
Absorbs midday PV surplus instead of curtailing it

Peak shaving
Discharges at the evening peak, keeping the site under its grid cap

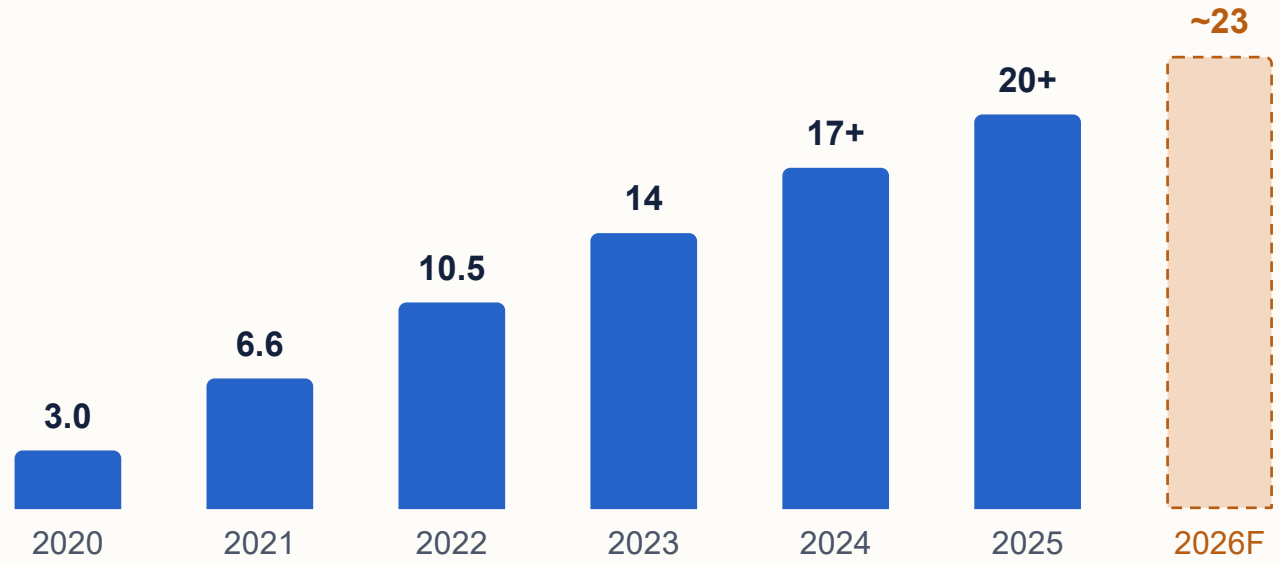
Grid support
Fast frequency and voltage support through the OBC inverter

Backup and islanding
V2H / V2B keeps critical loads on during outages

EV Market

Global electric car sales (million units)

2026 YTD (Jan–Sep): Europe +30% · N. America −24% · China −13%



20M+

EVs sold in 2025 (+20%): about 1 in 4 new cars worldwide

~30%

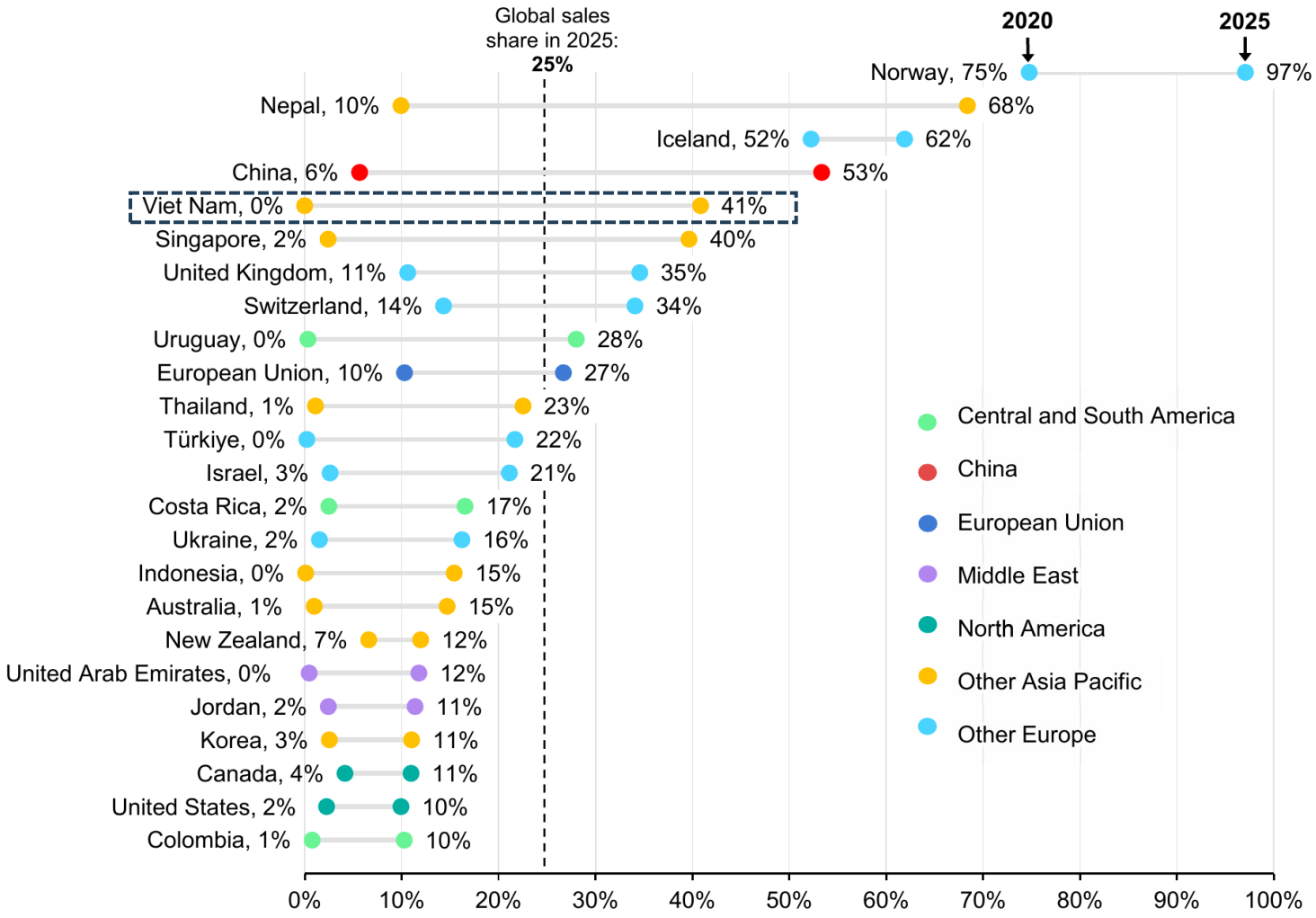
Forecast EV share of new car sales in 2026 (~23M units)

≈4.8 TWh*

of batteries in a ~80M-vehicle fleet, parked most of the day: a distributed energy resource

Sources: IEA Global EV Outlook 2026 · Benchmark Mineral Intelligence (Jan–Sep 2026) · *estimate, 60 kWh per EV

EV transitions



0% → 41%

Electric share of new car sales, 2020 → 2025

2× in 2025

Sales more than doubled: Southeast Asia's largest EV market

735,000

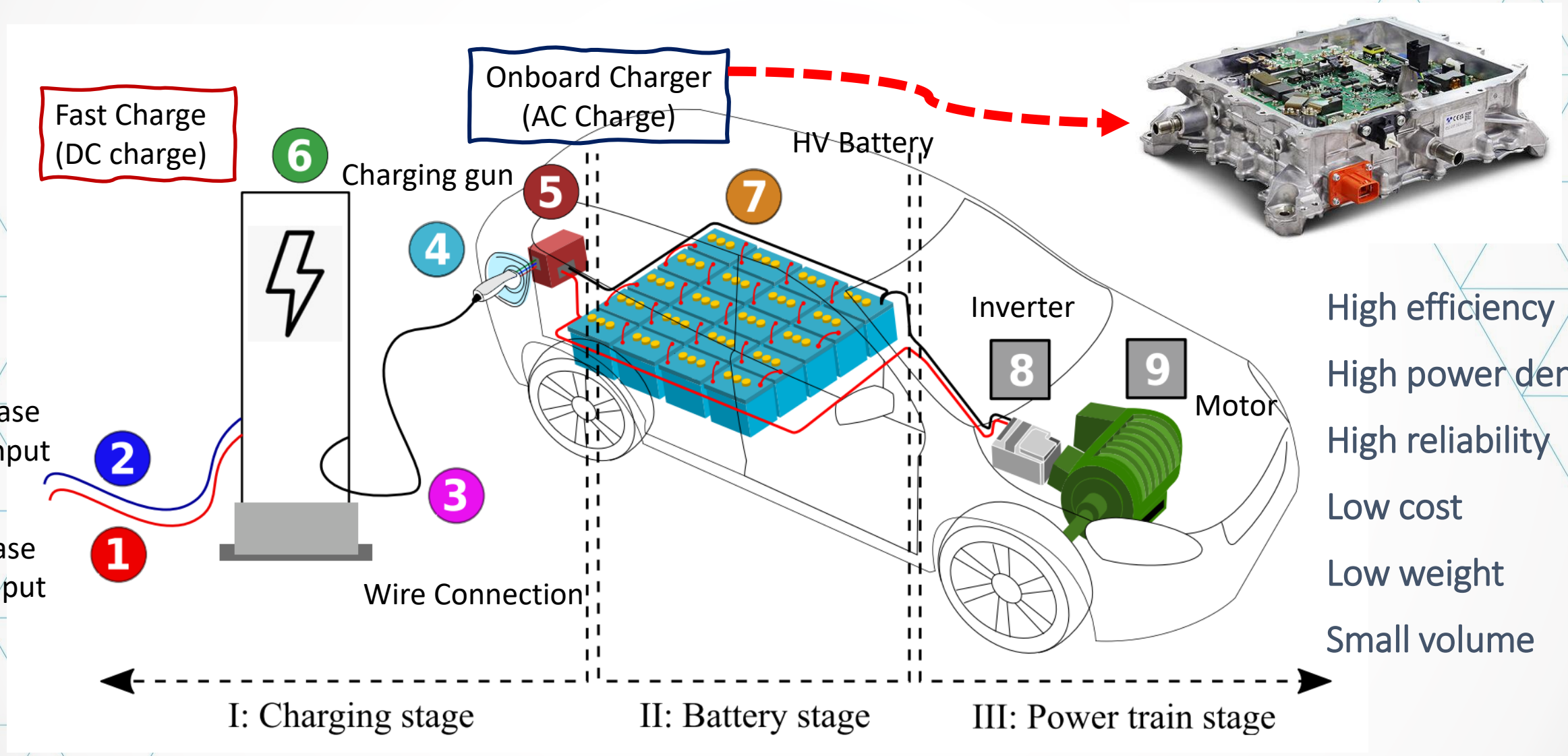
Electric two-wheelers sold in 2025, over 20% of the market

>80% by 2035

Possible EV share of new cars, the highest in Southeast Asia

Source: IEA, Global EV Outlook 2026, Figure 1.2 and Chapters 1–2 · IEA, CC BY 4.0

OBC: the EV's gateway to the grid

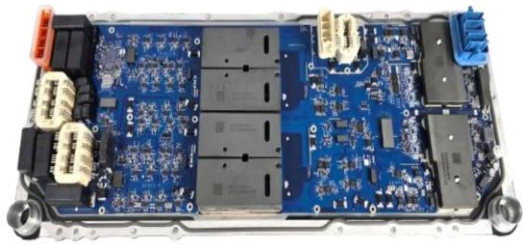


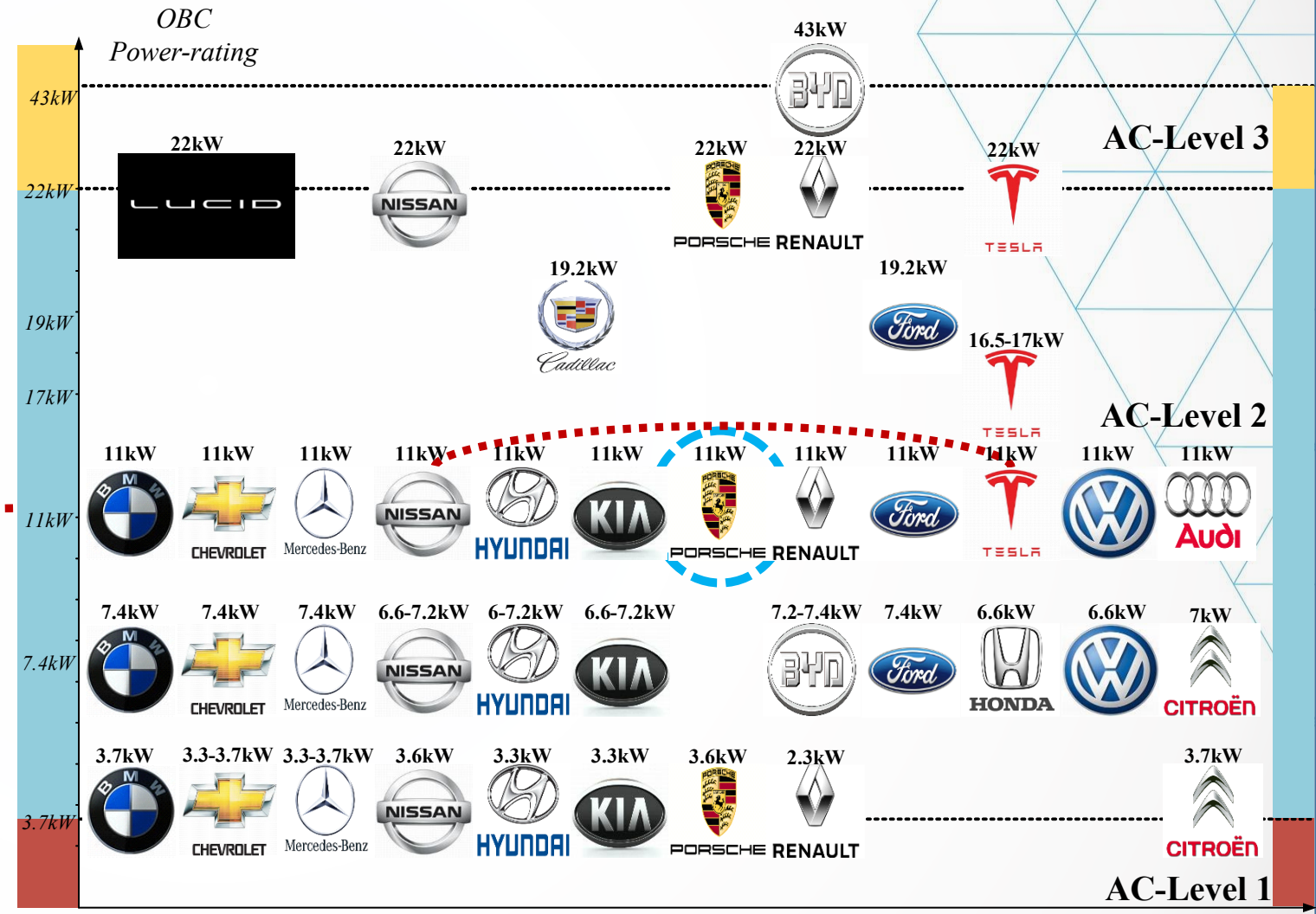
- High efficiency
- High power density
- High reliability
- Low cost
- Low weight
- Small volume

OBC power is rising: 3.7 kW → 22 kW+







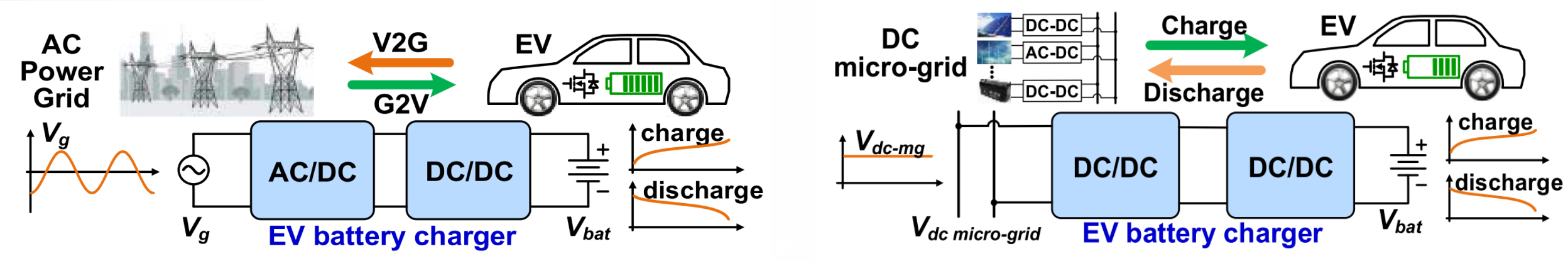


Availability of Bi-OBC in the currently EV market

Model	Year	Connector	Bidirectional
Nissan Leaf (Gen 2)	2013	CHAdeMO	V2G, V2H *
Hyundai Ioniq 5	2021	CCS/NACS	V2L (3.6 kW)
Kia EV6	2021	CCS/NACS	V2L (3.6 kW)
BYD Atto 3	2022	CCS	V2L (2.2–3.3 kW)
Ford F150 Lightning	2022	CCS/NACS	V2H, V2L (9.6 kW)
Tesla Cybertruck	2023	NACS	V2L (9.6 kW), V2H (11.5 kW)
GMC Hummer EV	2024	CCS/NACS	V2L, V2V (6 kW), V2H (9.6 kW)
Kia EV9	2024	CCS/NACS	V2L (3.6 kW), V2H
Renault 5 E-Tech	2024	CCS	V2G (11 kW), V2L
Volvo EX90	2024	CCS/NACS	V2H, V2G (11 kW), V2L
BMW iX3 (Neue Klasse)	2026	CCS/NACS	V2L (3.7 kW), V2H, V2G (11 kW)
Nissan Leaf (Gen 3)	2026	NACS/CCS	V2L (3.6 kW), V2H/V2G †

** Requires external CHAdeMO bidirectional charger. † Market-dependent / announced.*

Bidirectional charging is taking off



Source: IEEE Transactions

OBC MARKET

$9.4B → $25.5B

2024 → 2030, CAGR 18.2%. The 11–22 kW segment grows fastest (19.2% CAGR).

BIDIRECTIONAL CHARGING

$70M → $844M

2025 → 2035, CAGR 28.3%. Small today, the fastest-growing part of EV charging.

CASE: RENAULT 5

11 kW AC V2G

Bidirectional OBC; V2G in France and Germany (2024), UK (2025). AC V2G avoids a ~€8,000 DC station.

Bi–OBC Vietnam’s strategic technologies

GROUP 5

Advanced energy and materials

P18 · Batteries and BESS

P20 · Power equipment, drives

- EV battery = a mobile BESS
- Bi-OBC enables V2G, V2H, V2L
- Efficient chargers and drives
- Stores midday PV for the evening
- Backup power during outages

GROUP 6

Semiconductor chips

P23 · Specialized chips

Power semiconductors

- SiC / GaN power MOSFETs
- Gate drivers and controller MCUs
- EVs: a major power-chip market
- 800 V platforms drive SiC demand
- Chance for local chip design

GROUP 1

Digital technology

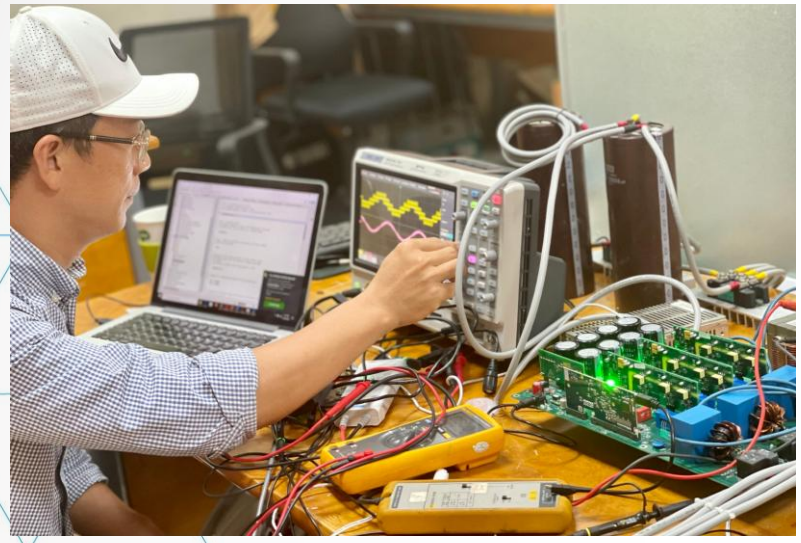
P3 · Digital twin platforms

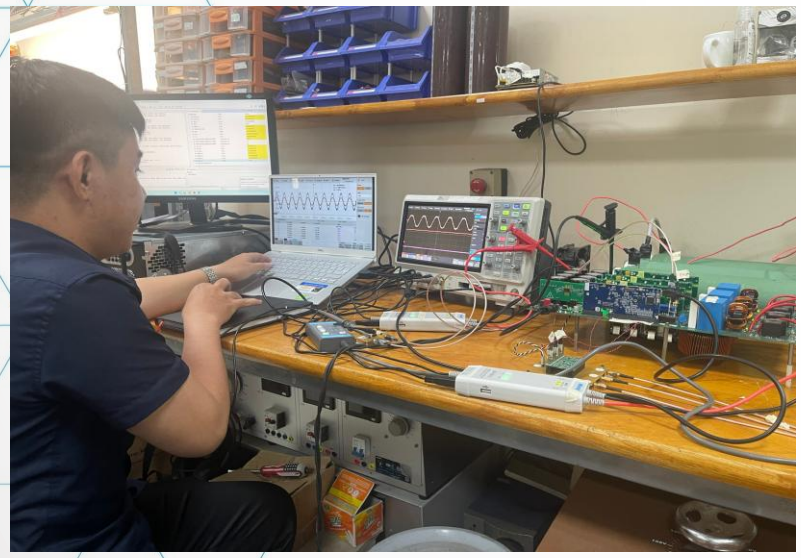
AI · IoT · big data

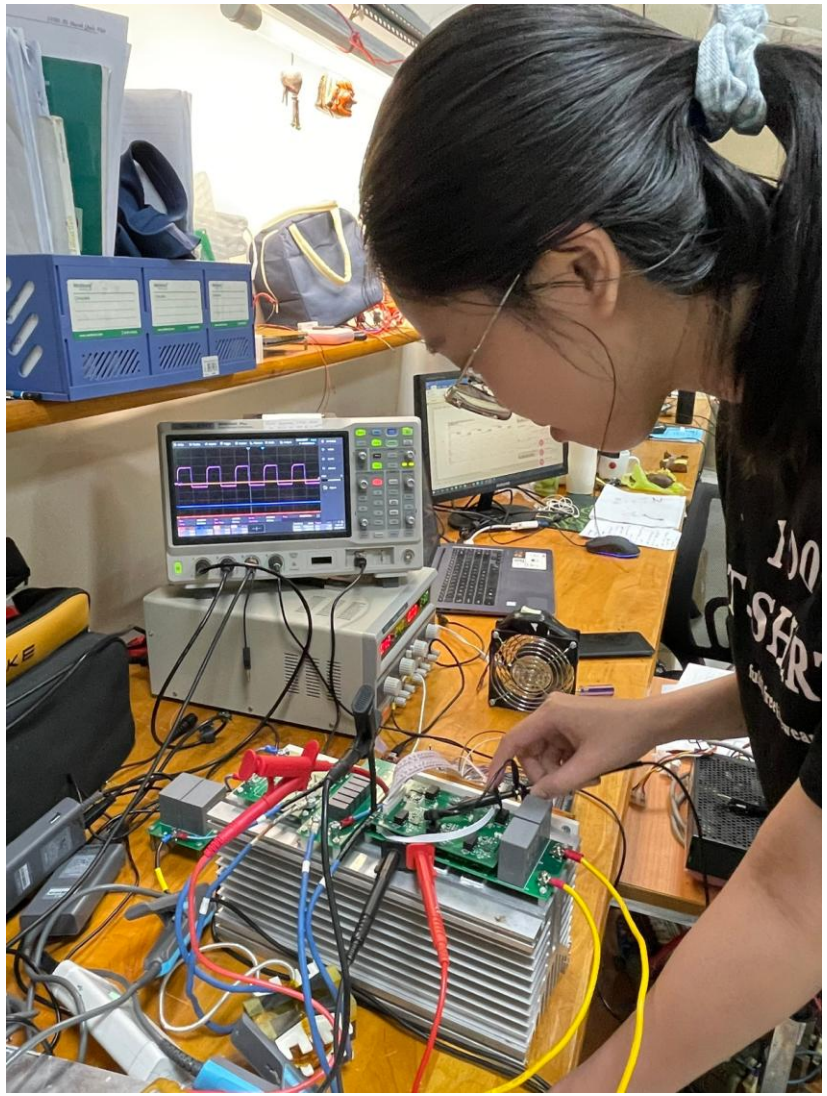
- IoT links each EV to the grid
- AI forecasts trips, PV and load
- EMS dispatches V2G fleets
- Smart charging cuts grid peaks
- Digital twin tests V2G safely

Source: Decision 21/2026/QĐ-TTg, effective 1 July 2026 (10 technology groups, 30 strategic products)

Bi–OBC from Lab to Industry

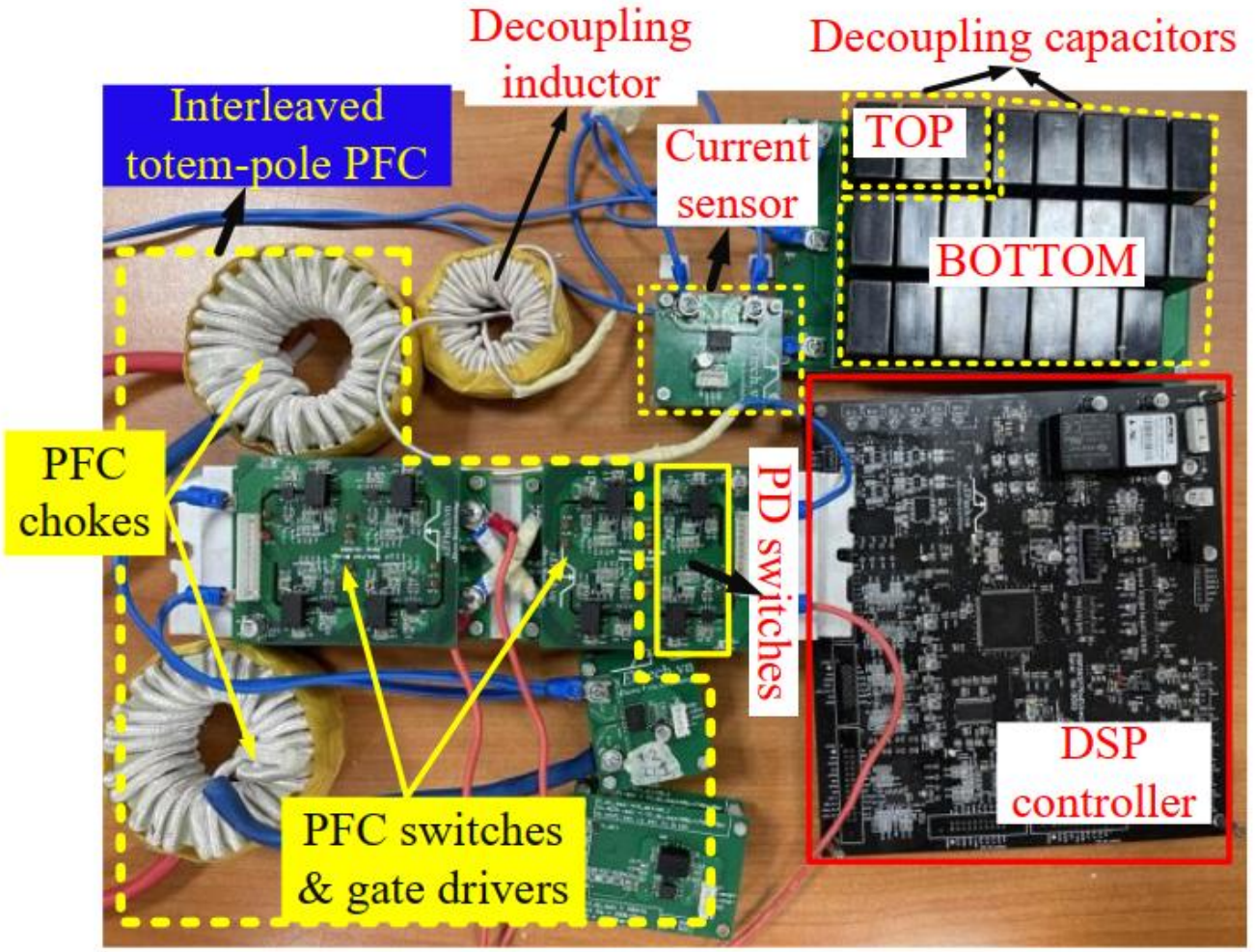


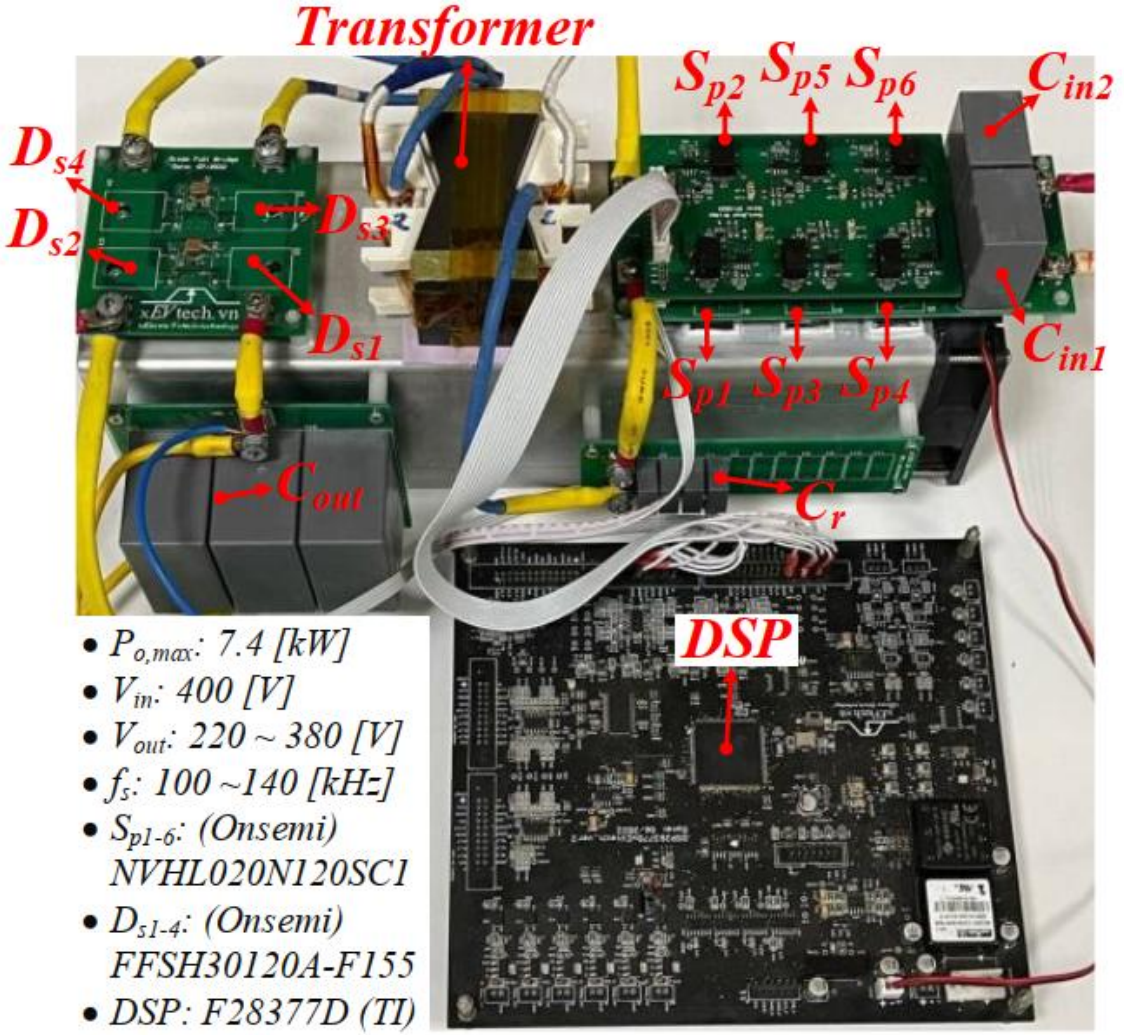






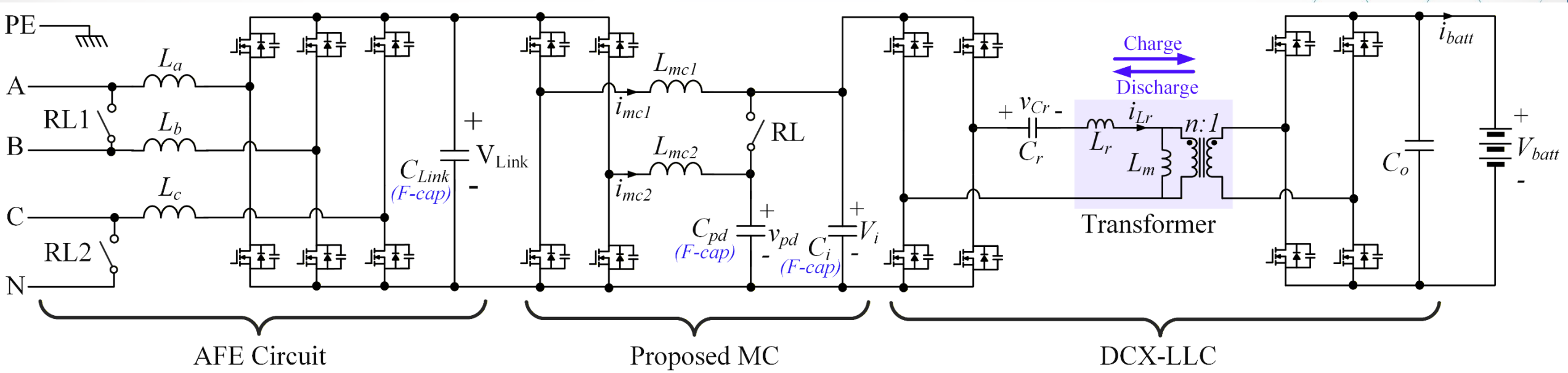
Bi–OBC from Lab to Industry

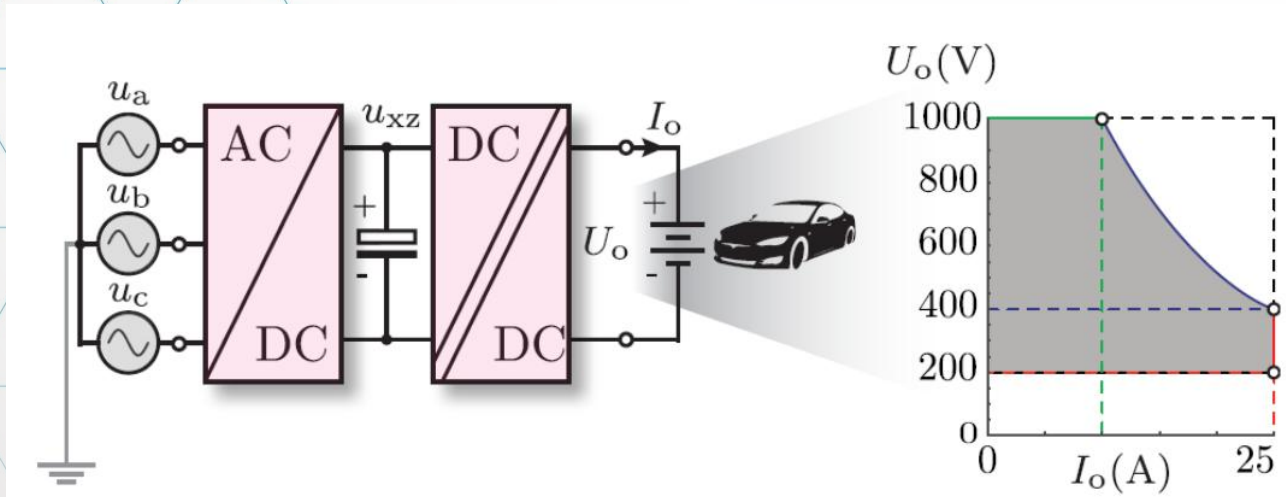


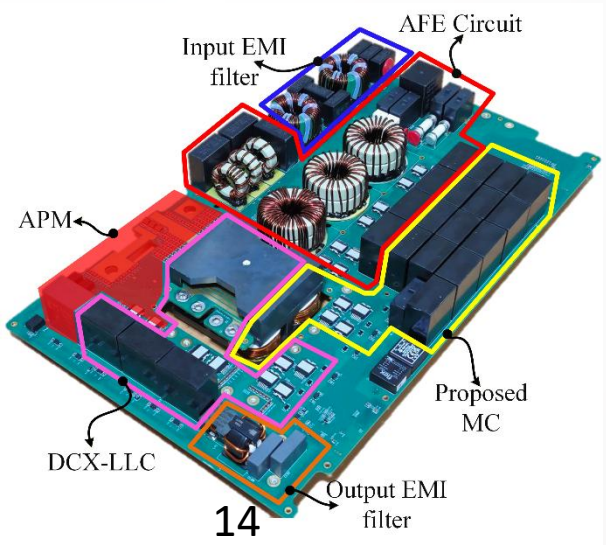


- $P_{o,max}$: 7.4 [kW]
- V_{in}: 400 [V]
- V_{out}: 220 ~ 380 [V]
- f_s: 100 ~140 [kHz]
- $S_{p1\text{-}6}$: (Onsemi) NVHL020N120SC1
- $D_{s1\text{-}4}$: (Onsemi) FFSH30120A-F155
- DSP: F28377D (TI)

Bi–OBC from Lab to Industry







Bi–OBC from Lab to Industry

Non-Ecap wide-range bidirectional OBC

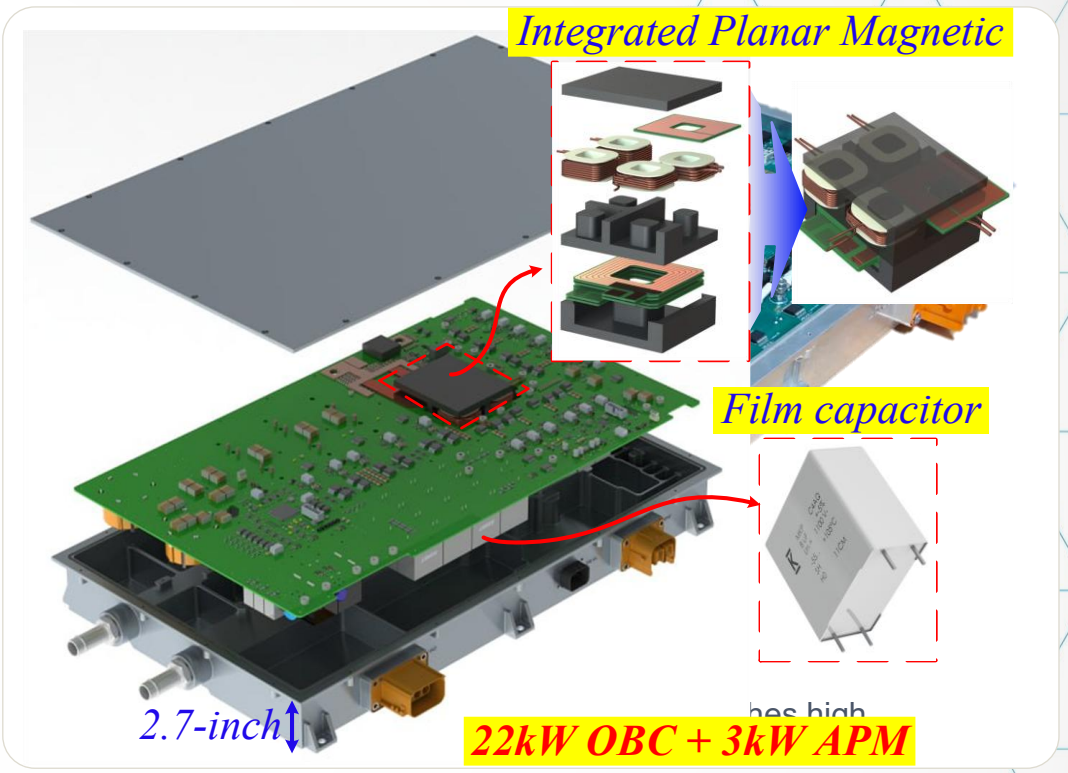
Multifunction circuit, no electrolytic capacitors · *IEEE TTE 2026*

Three-level T-type LLC, adaptive PWM

Wide battery-voltage range for the DC/DC stage · *IEEE TTE 2025*

Power decoupling for 800-V OBC

Split-capacitor design cuts DC-link capacitance · *IEEE TTE 2024*



250–850 V battery range

>95% efficiency at full load

PF = 0.99

THD < 5%

1- and 3-phase AC input

Applications

EV and e-bus chargers · V2G / V2H microgrids · BESS and DC chargers

Transfer model

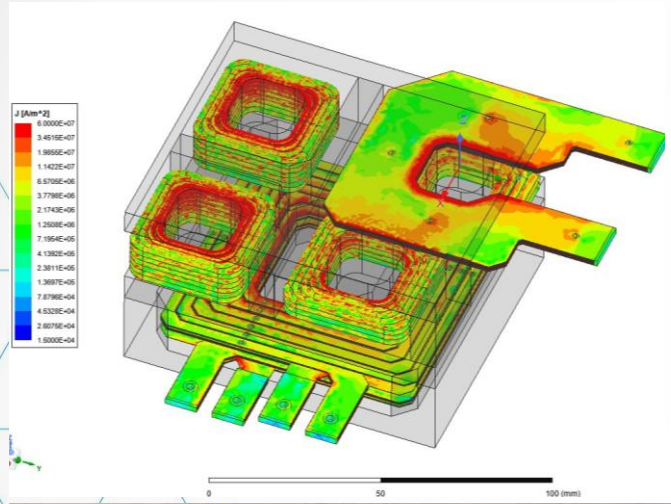
IP licensing · joint R&D and pilot builds · engineer training

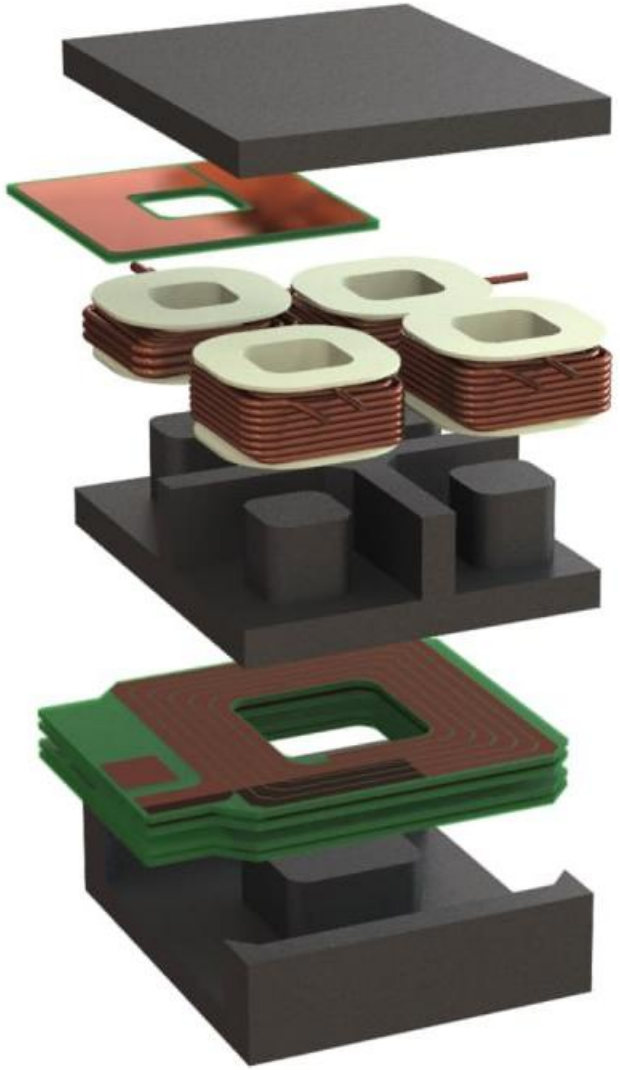
Partners we seek

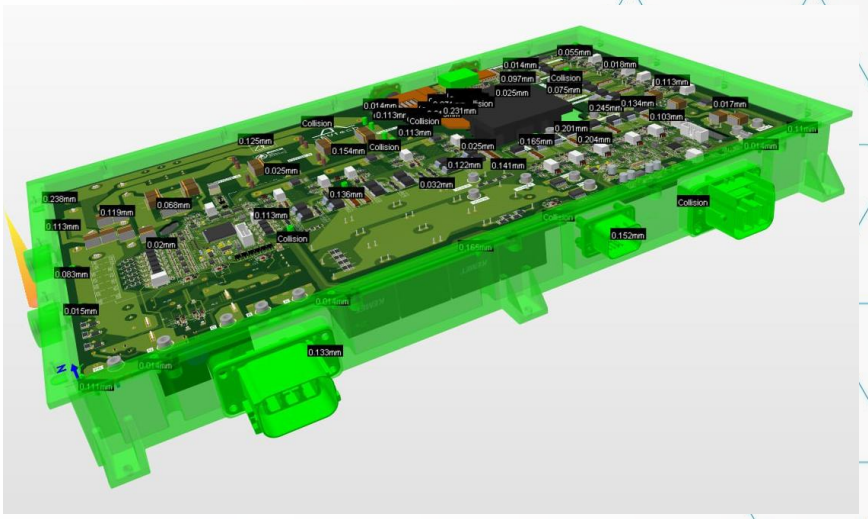
EV makers and suppliers · charger and BESS firms · SiC / GaN chip partners

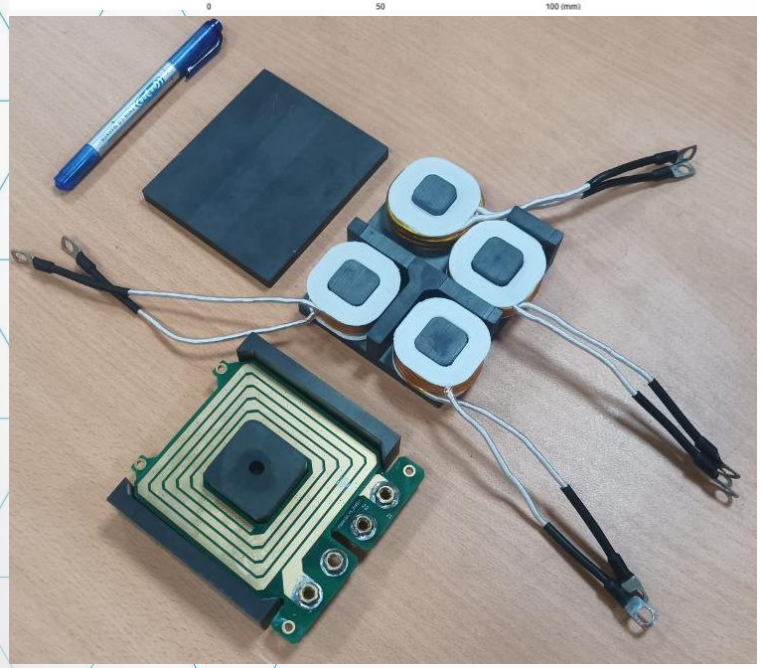
Publications: IEEE Transactions on Transportation Electrification (IF 8.5), 2024–2026

Bi–OBC from Lab to Industry



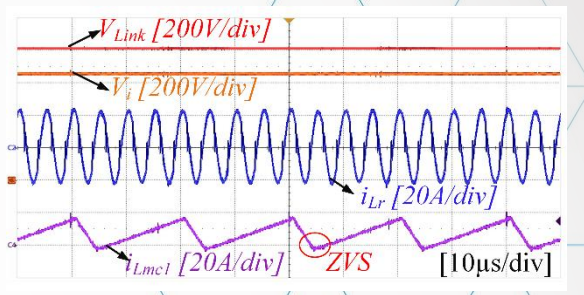




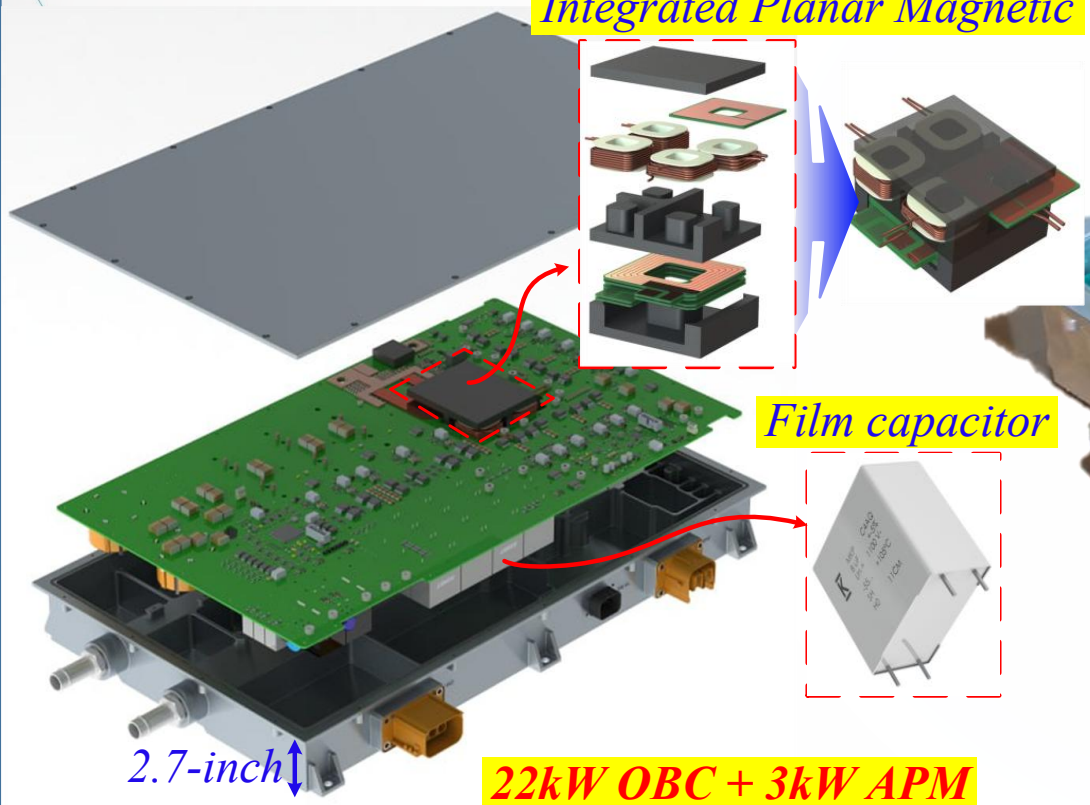




Bi–OBC from Lab to Industry



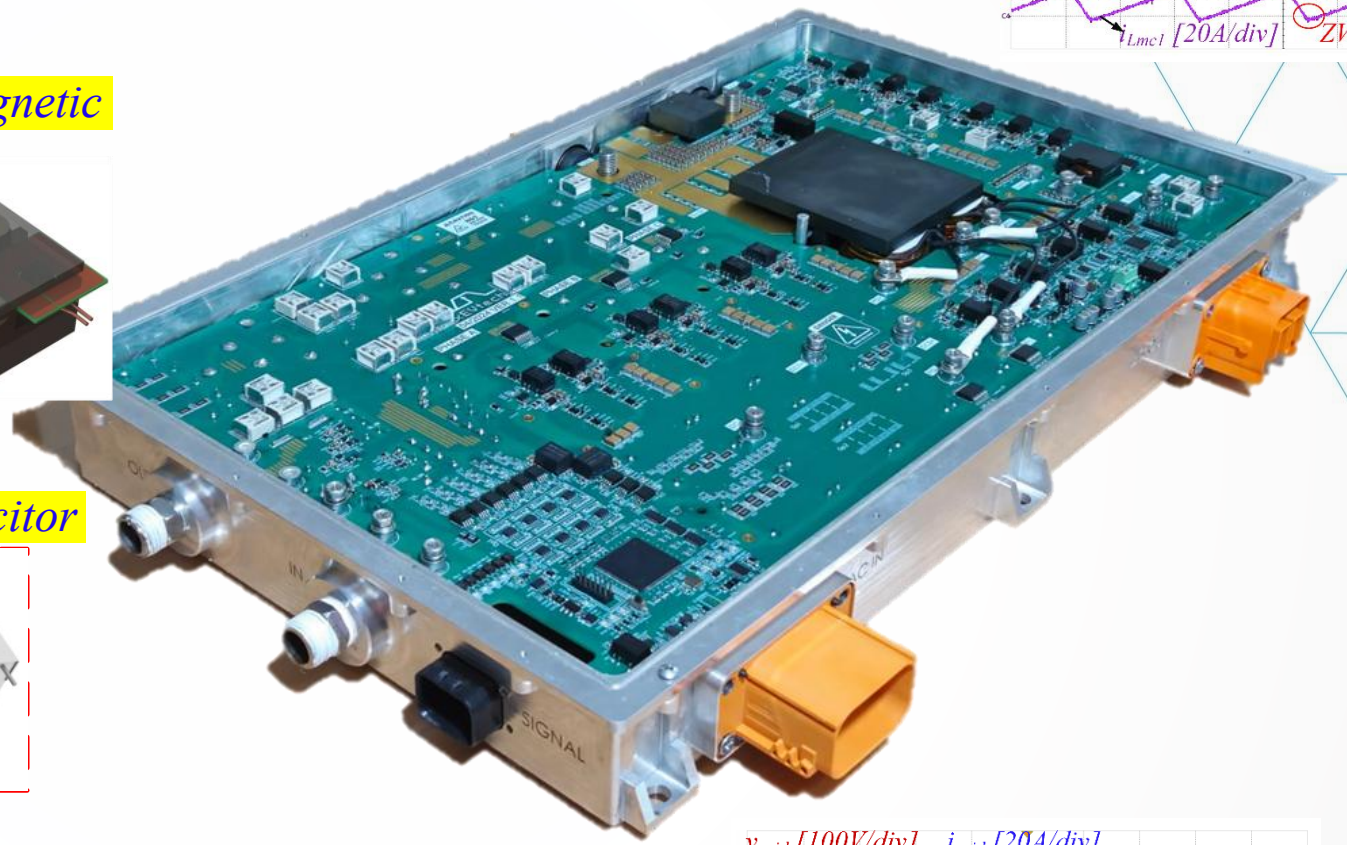
Integrated Planar Magnetic

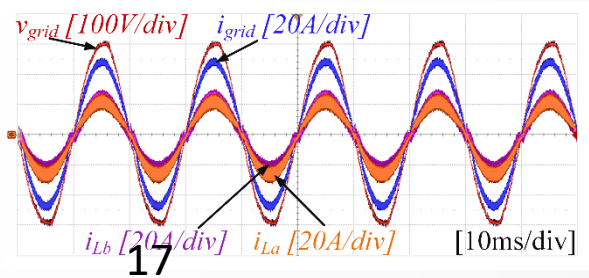


Film capacitor

2.7-inch

22kW OBC + 3kW APM





Let’s build the bidirectional future together

Industry: co-develop and pilot Bi-OBC, V2G and storage products

Research: joint projects, publications and student exchange

Agencies & investors: scale-up, technology transfer and pilot deployment in Viet Nam

Thank you!

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