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DC Fast Charger (DCFC) Infrastructure



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About Rhombus

Experts in power conversion and energy management, delivering intelligent conversion solutions to the market

Rhombus solution(s)

- Intelligent power conversion solutions for energy storage, test applications, & fast charging in the commercial / industrial segments
 - Bi-directional Inverters for Energy Storage Systems and Microgrids
 - Regenerative Test Equipment
 - Fast Charging Systems for Heavy Duty – Commercial Vehicles
- Design services in Power and control
 - Power Electronics Contract Innovation / Engineering
 - Experts in power and control
 - Leadership in Wideband solutions focused in Silicon Carbide
- Vectorstat – Mesh network site controller

Differentiation

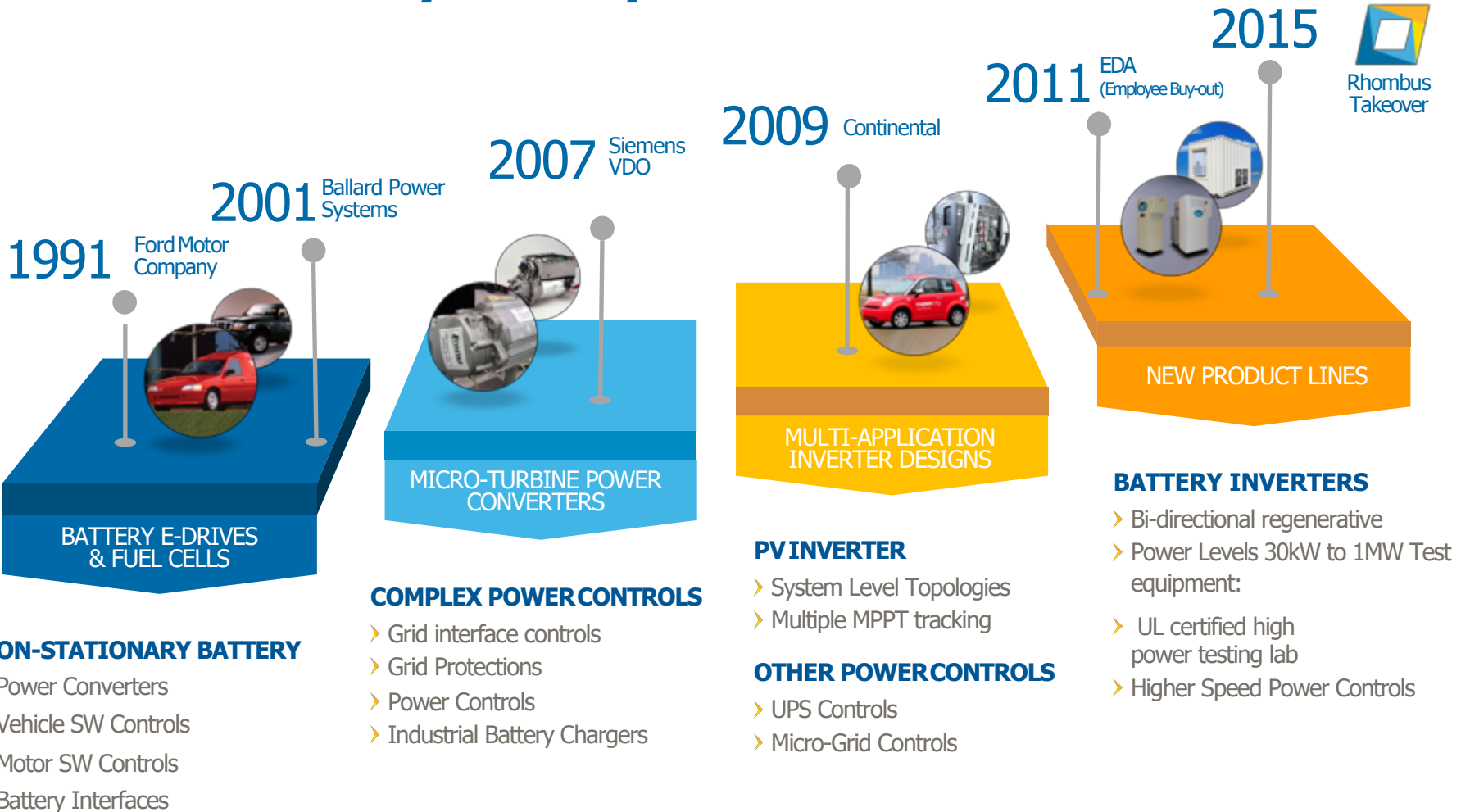
- Deliver highly robust products, semi-customized, white-labeled solutions w/ integrated software to the market.
- Made in USA

History and team

- Founded in 2012 by a group of seasoned power electronics industry veterans
- Acquired Energy Development Associates and its team with a 25-year history in developing electric vehicles and power conversion solutions



Dearborn Facility History



Shipping Inverters since 2001, Over 1000 units in the field

- Quality Example: 130 Active units, >4 M hours operation with < 18 operational events
- Nearly maintenance free

Fast DC Charger Overview

CCS1 Dispenser
Nozzle



Top or
Bottom Fed

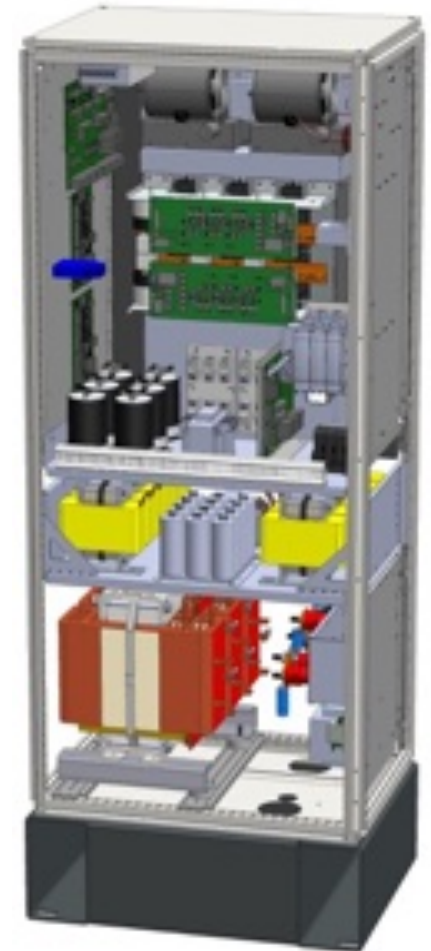


Dispenser

Top or
Bottom Fed



PCS



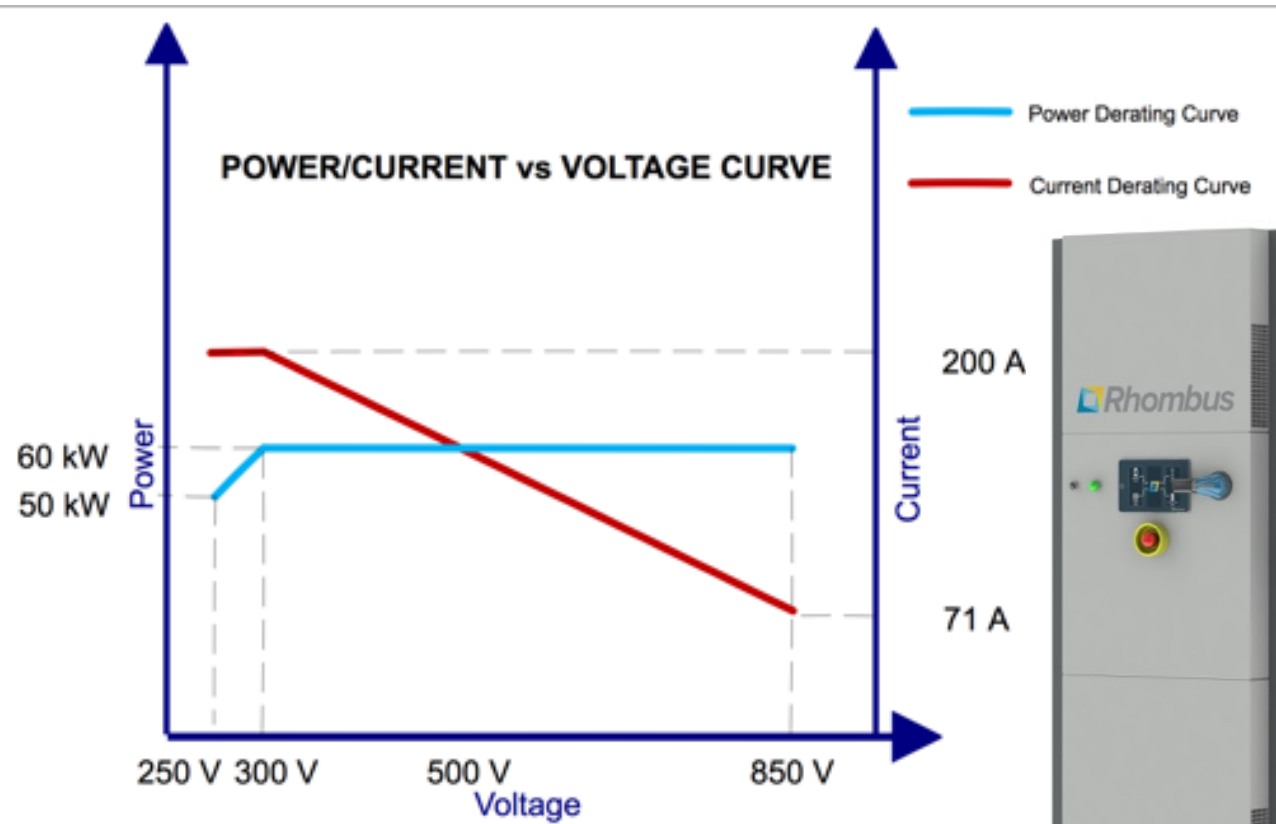
Specs

- CCS1
- ISO/IEC 15118-3
- OCPP 1.6

Certifications

- SAE J2894/1
- SAE J2894/1
- UL991/2231-1/2231-2
- IEC61851-1/61851-21/23/24
- UL9741
- NFPA 7-

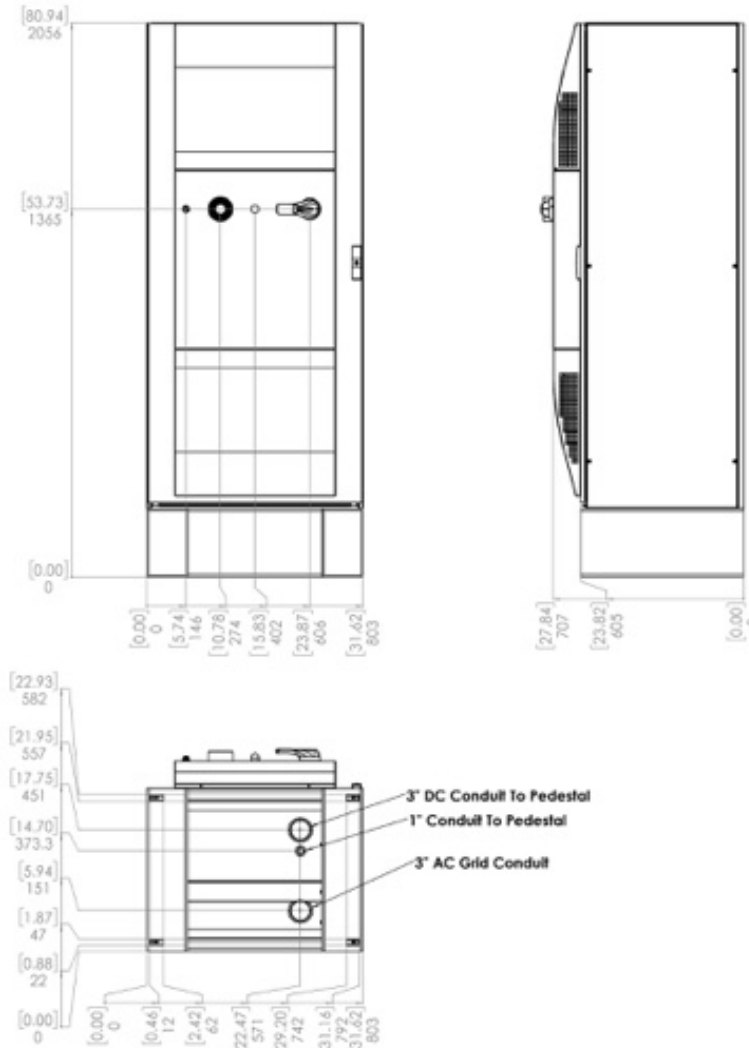
60 kW Charger



Specs

- 60 kW
- V2G (Bi-directional)
- CCS1
- ISO/IEC 15118
- OCPP 1.6
- NEMA 3R
- Dual Voltage Range
- Separate Charge Dispenser

Mechanical Overview of 60kW Charger



Charging Overview

Key Characteristics	L1	L2	L3
Power	1.4kW	3.3 – 19.2kW	25– 500kW
Cost	\$	\$\$	\$\$\$ - \$\$\$\$
Use	Home	Home/charge Station	Commercial
Type of Voltage	AC	AC	DC and DC/AC
Source Voltage	120 VAC	208 - 240 VAC	240 – 480 VAC
Charge Voltage	120 VAC	208 - 240 VAC	200 – 800 VDC 208 – 240 VAC
Connector	J1772	J1772 or CHAdeMO	J1772-Combo (CCS1) CHAdeMO
Time to Charge	Long	Medium	Fast
Size	Small/Portable	Medium/Fixed	Large/Fixed

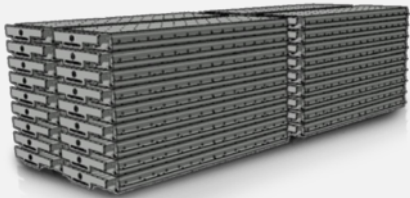
Level 3 Chargers

Key Characteristics	Uni-Dir (V1G)	Bi-Dir (V2G)
Overview		
Power	25kW-500kW	50kW-500kW
UL	UL 2202 UL2231-1 UL2231-2	UL9741 UL2231-1 UL2231-2
Cost	\$\$-\$\$\$\$	\$\$-\$\$\$\$
Use	Charging	Charging Stack Revenue Opp Emergency
Time to Charge	Medium - Fast	Medium - Fast
Electrical Characteristics		
Source Voltage	240 – 480 VAC	240 – 480 VAC
Source Current	50-1000 AAC	100-1000 AAC
Source Frequency	50/60 Hz	50/60 Hz

Level 3 Chargers

Key Characteristics	Uni-Dir (V1G)	Bi-Dir (V2G)
Physical Characteristics		
Size	Medium/Large	Medium/Large
Configuration	Stand-a-lone PCS + Dispenser	Stand-a-lone PCS + Dispenser
Cable Entry PCS/Dispenser	Top/ bottom	
Cable Exit PCS/Dispenser	Top/ bottom	
Distance to dispenser	Up to 500 ft (possibly more)	
Connector	J1772 or CHAdeMO	J1772 or CHAdeMO
Operational Temp	Depends on Mfg. / Depends on location	
Indoor/Outdoor	NEMA1/NEMA3R	NEMA1/NEMA3R
Communication		
Vehicle Communication	CHAdeMO CAN bus & ISO 15118	ISO 15118
Network Management	OCPP 1.6	OCPP 1.6
HMI (Human Machine Interface)	Plug & GO/Pay-Terminal/Ext Pin	

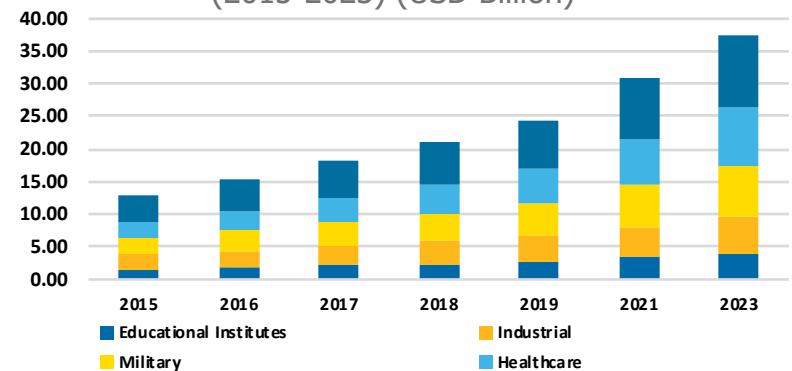
Future: Built to Order, Containerized Microgrids



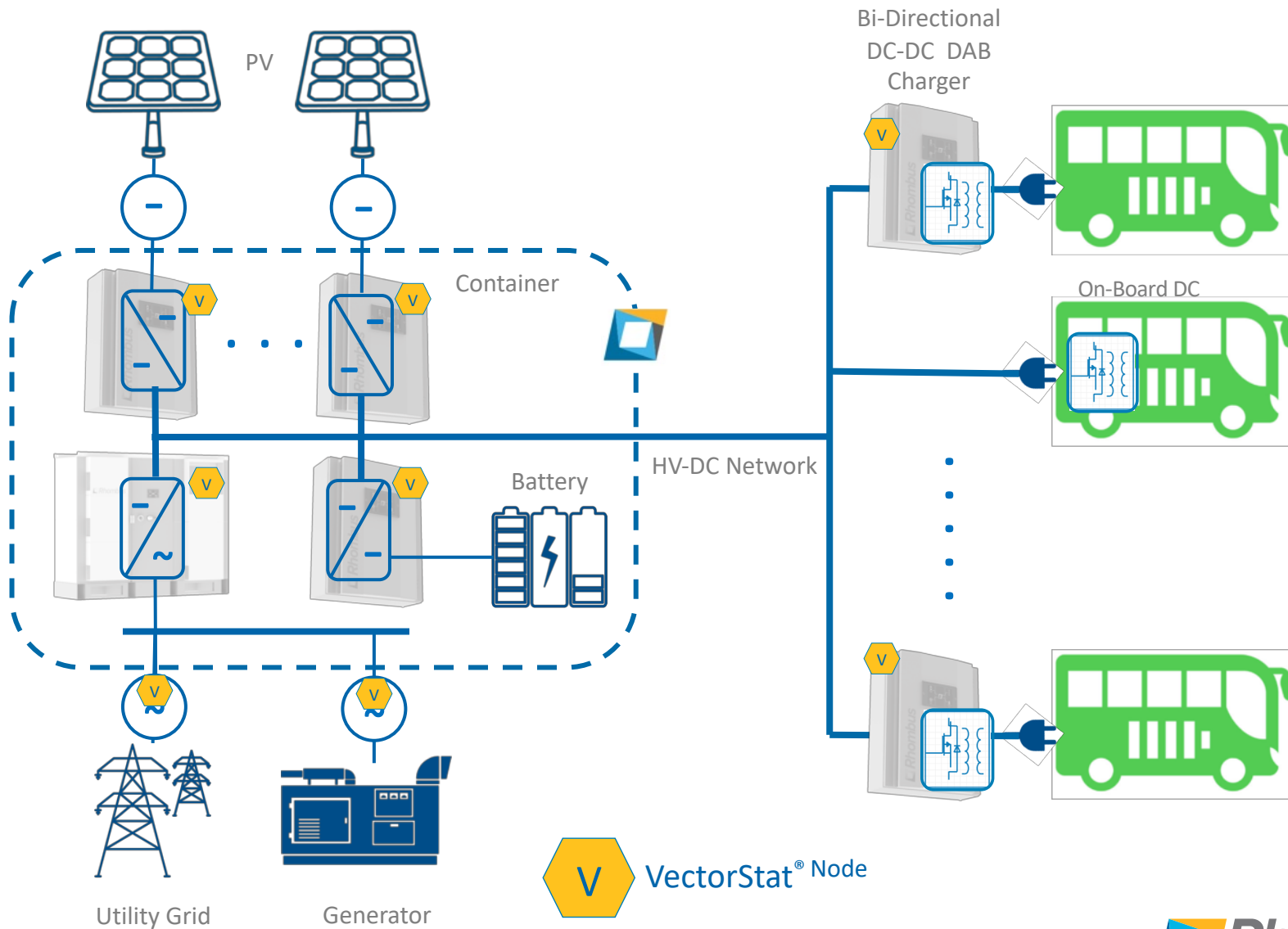
Rhombus Power Hub

- Containerizing reduces the installation cost & complexity
- Increases Site flexibility
- High Density, Batteries 2-4MWh
- High Power 500kW-1MW PCS (off grid / on grid)
- VectorStat Site Controller
- Gen-Set Connections
- PV Connections
- Multiple configurations, Factory Built & Tested
- Integrated Fire Suppression & Safety Systems

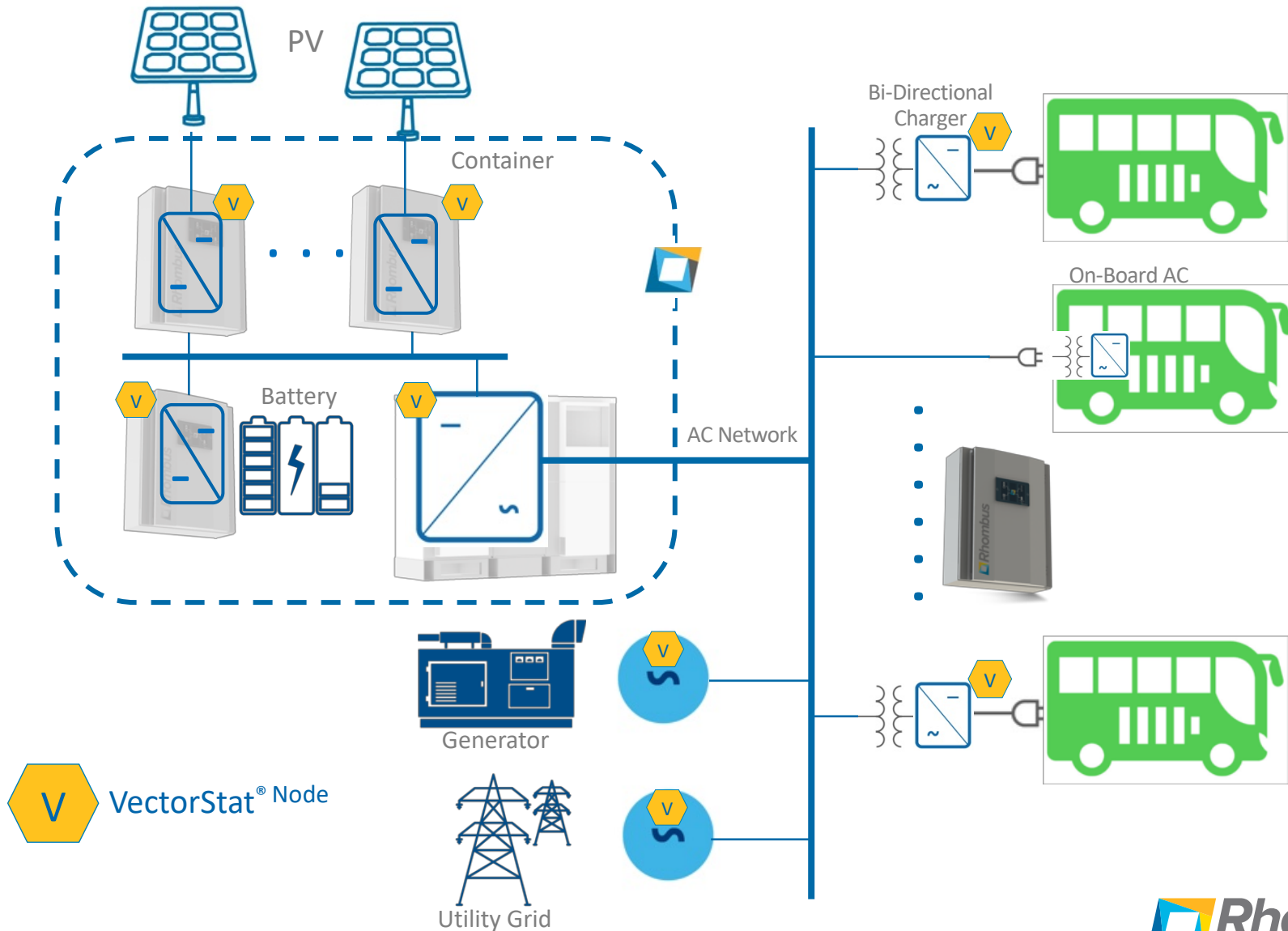
Microgrid Market, by vertical (2015-2023) (USD Billion)



Rhombus DC Power Hub

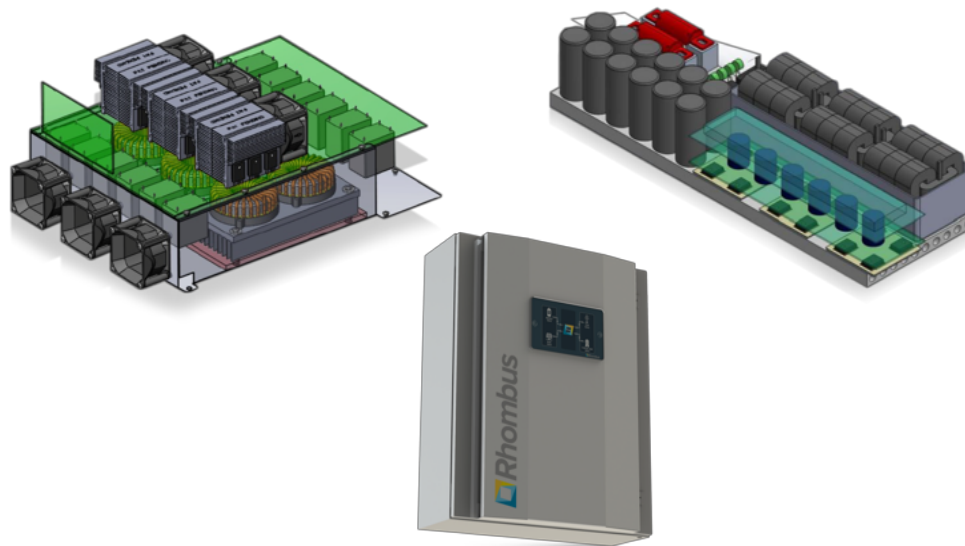


Rhombus AC Power Hub



Roadmap: Silicon Carbide (SiC); Integrated Software

- The tipping point has arrived for the \$40B Power Electronic Industry to adopt “wide-band gap” semi-conductors. The components are still 2-3X the cost of silicon but the reduction in system level cost makes products less expensive and more efficient.
- SiC-based Inverters / Converters reduces the size and switch losses by ~50%
- Rhombus has extensive experience in developing products using SiC



Silicon Carbide (SiC) Semi-Conductor Adoption

