

Power Packaging Trends in Emerging 48V Ecosystem

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Agenda

- 1 Introduction
- 2 Automotive 48V MHEV
- 3 Cloud Computing & 5G Infrastructure
- 4 Power Packaging Trends

Amkor by the Numbers



Founded in
1968



\$5.1B
Net Sales*



30,000
Employees



\$550M
CapEx*



11,000,000
Square Feet of
Manufacturing Space



Footprint in
11 countries

End Markets



Automotive



Communications



Industrial



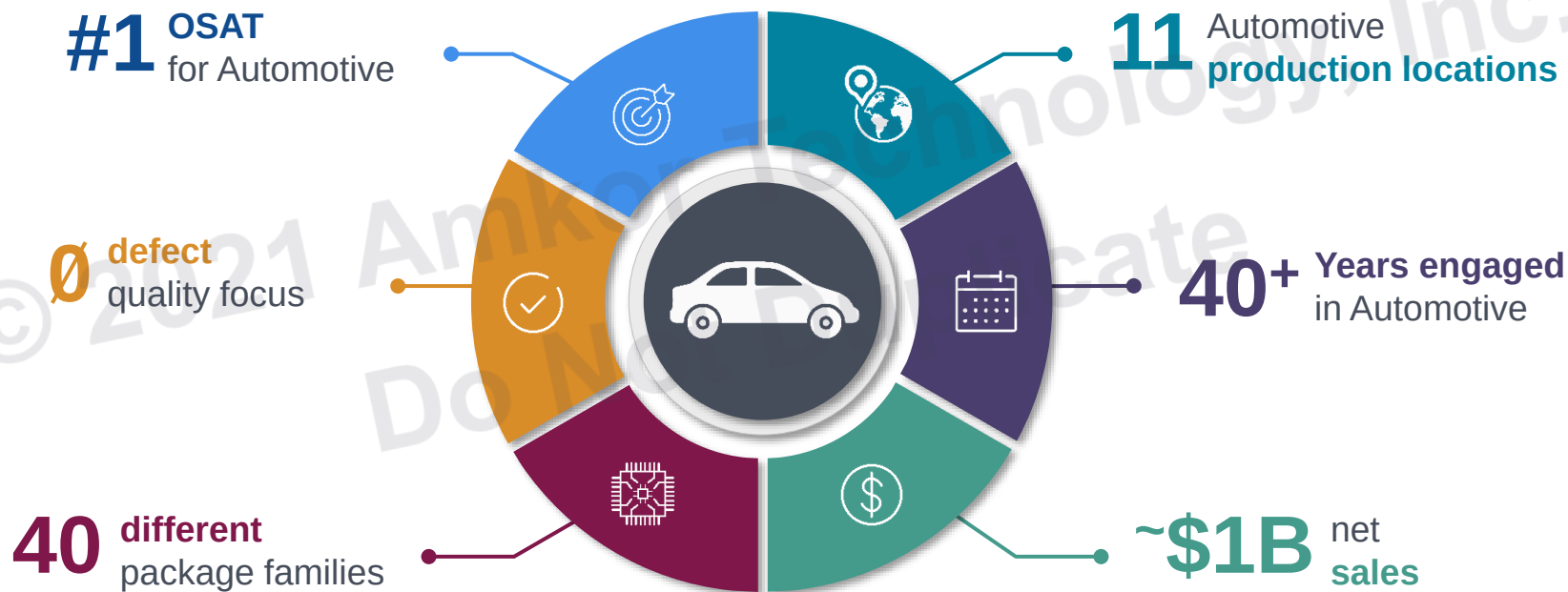
Computing



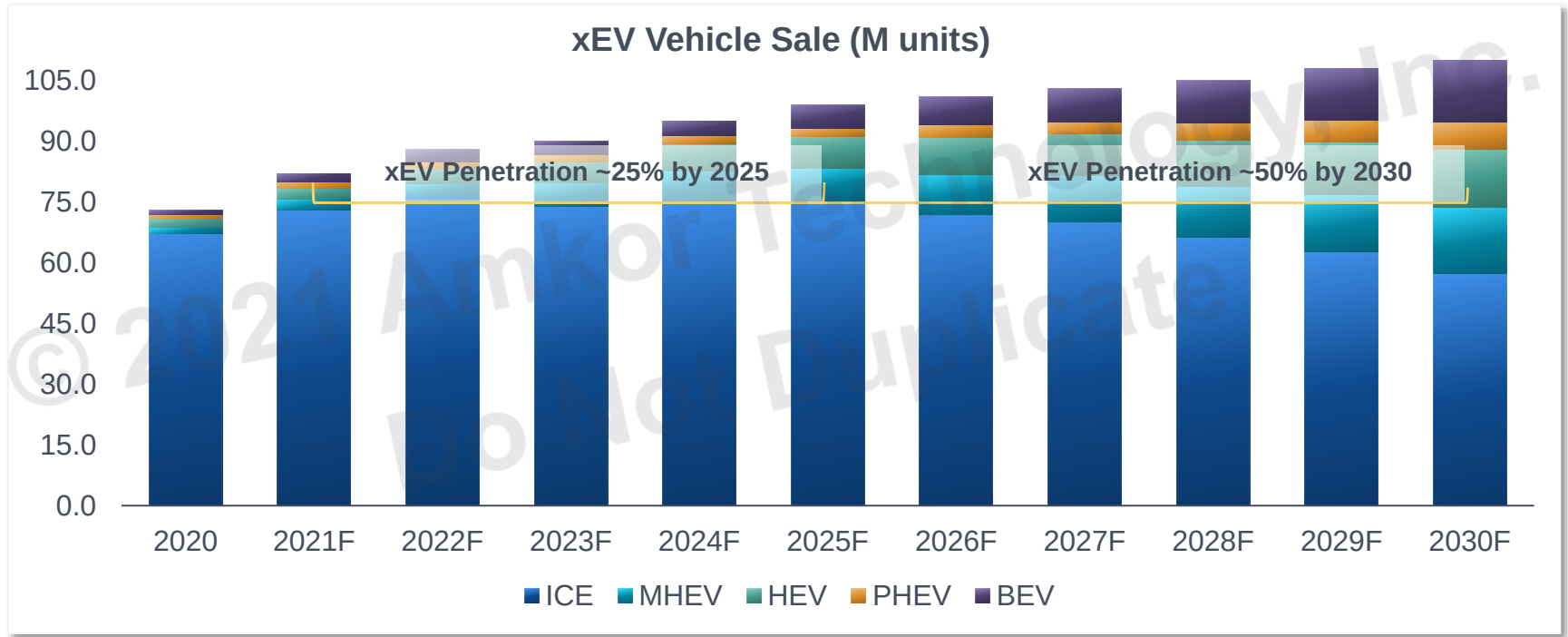
Consumer

*2020 results

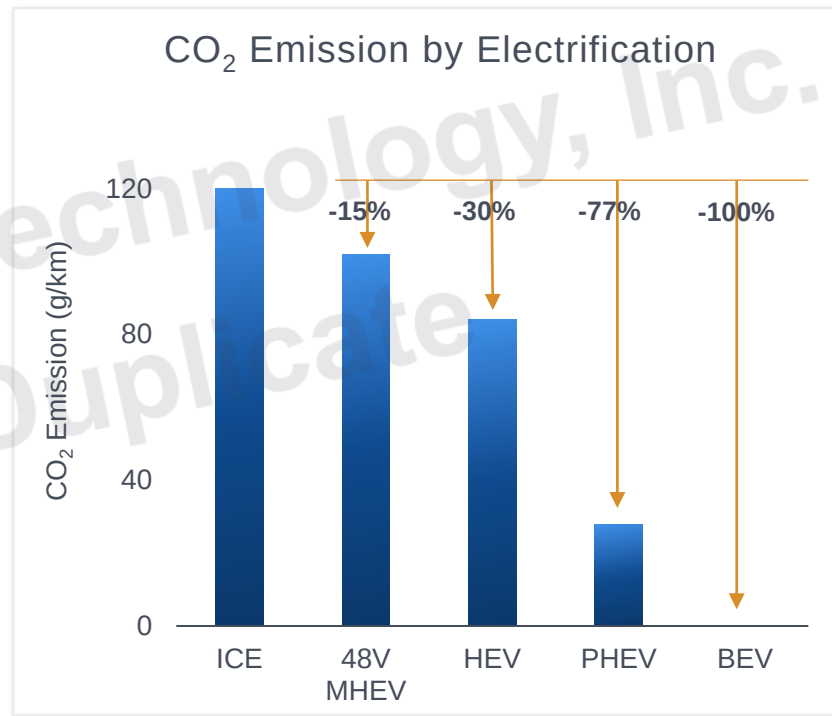
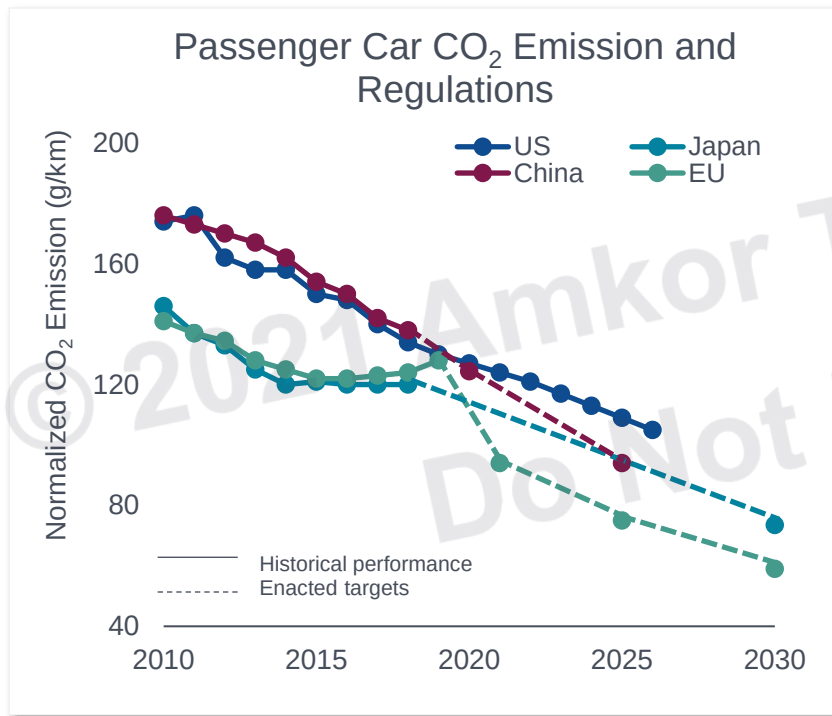
Amkor Automotive by the Numbers



xEV Trends Unchanged



Electromobility Mandates



Applications in 48V Ecosystem

Automotive Mild Hybrid Systems

- ▶ Starter – generator
- ▶ Computing loads

Belt Alternator Systems



ADAS Computations



12V

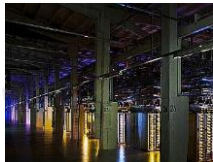


Car Battery, Data Center Servers

Cloud Computing/5G Infrastructure

- ▶ High density server racks
- ▶ 5G power supplies

Hyperscale Data Centers



5G Infrastructure



24V



Automation

Industrial Automation

- ▶ Factory automation (I4.0)
- ▶ Personal care robots

Industry 4.0



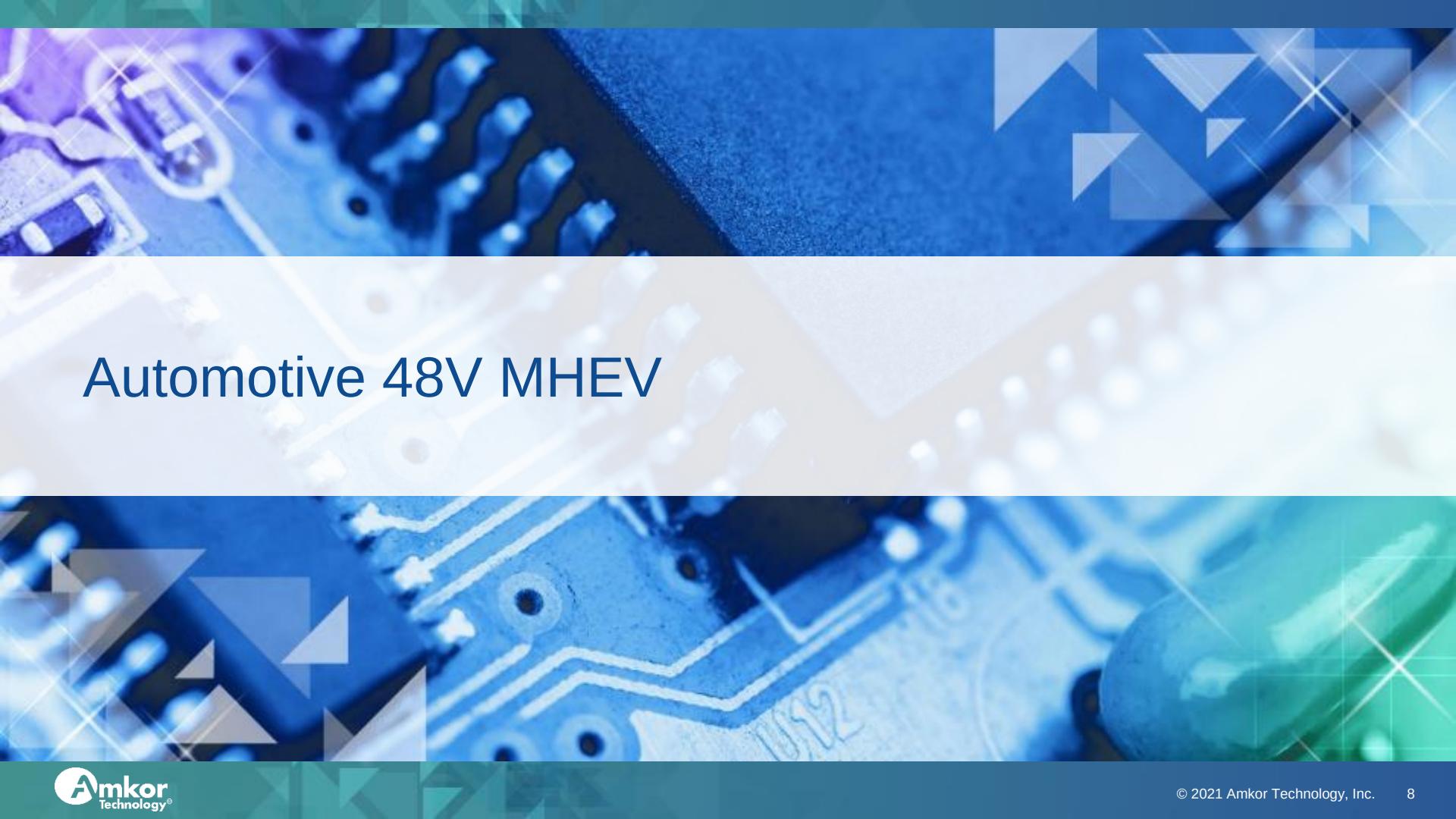
Care/Collaborative Robots



48V

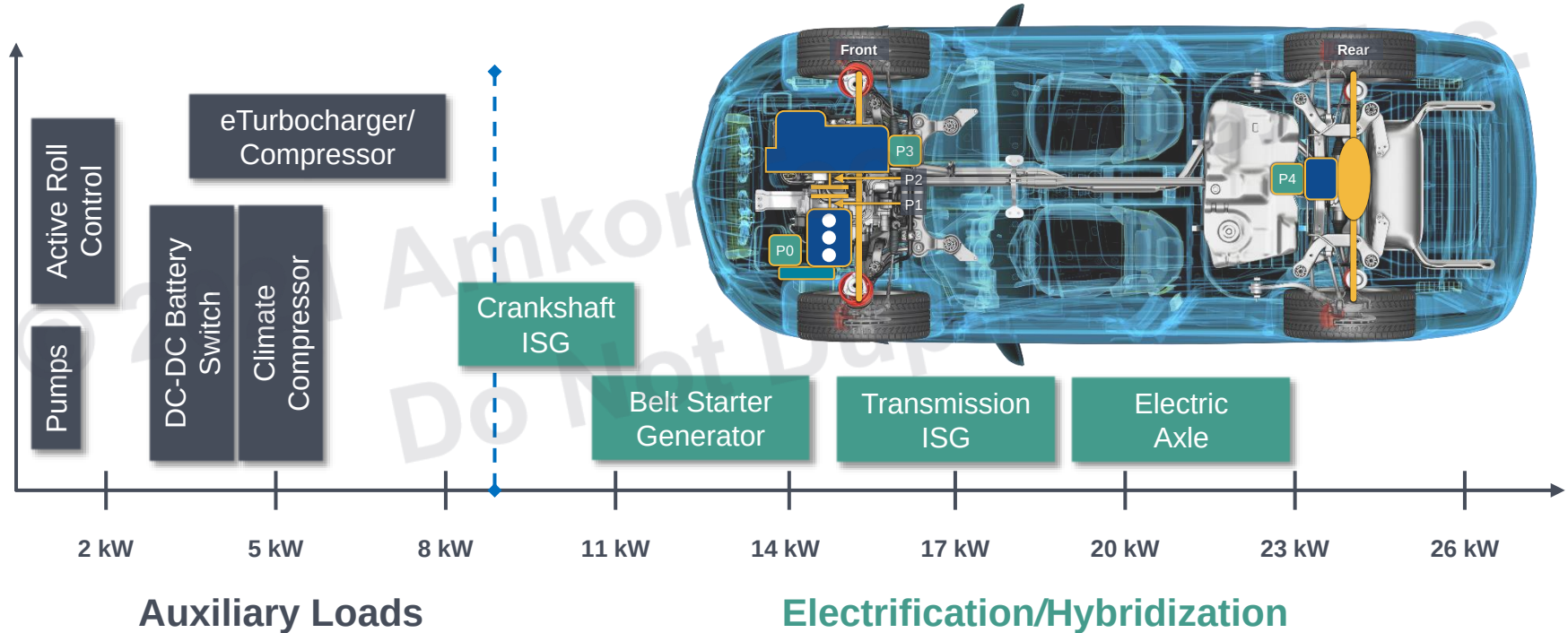


Telecom Systems



Automotive 48V MHEV

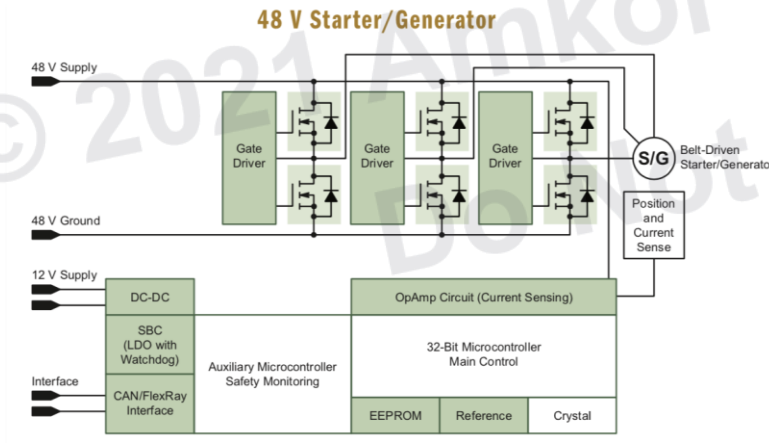
48V – Powertrain Configurations



48V Systems in Automotive

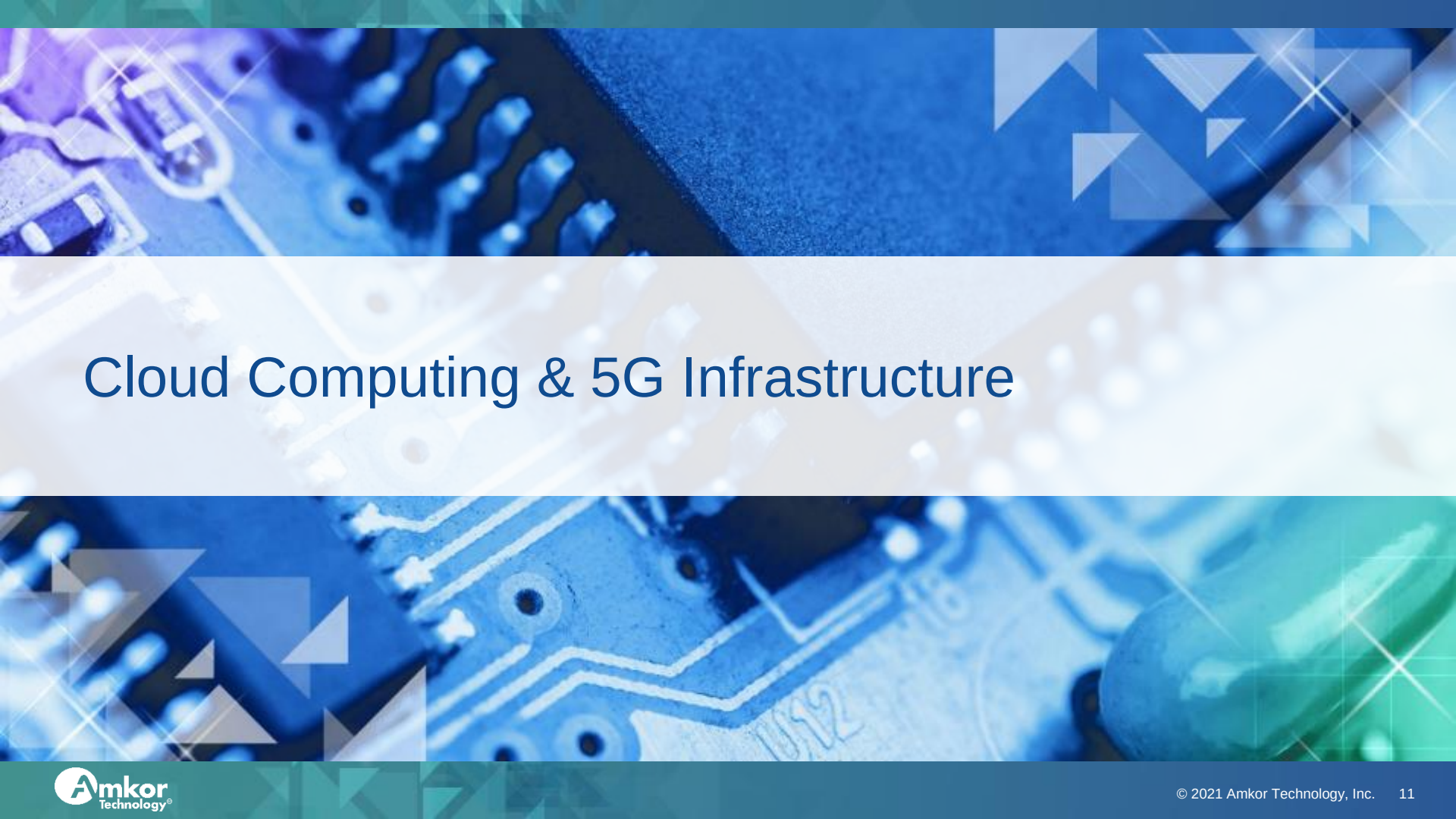
- ▶ Reduces emissions by 15%;
70% benefit at 30% cost
 - ▷ Electrification of mechanical parts
 - ▷ Hybridization

- ▶ Point-of-load for future applications
 - ▷ Connectivity
 - ▷ ADAS functions



Source: ON Semi

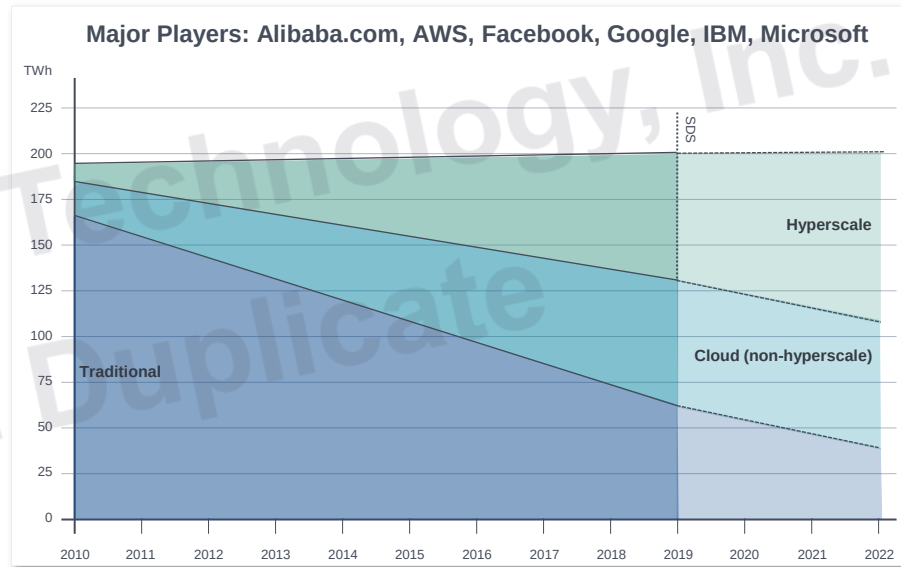
System	Function	Package					Count
Inverter	DC-AC	DPAK 	D2PAK 	PQFN 	TOLG 	TOLL 	18x/3 kW
Converter	DC-DC	PQFN 	SO8-FL 	TOLG 	TOLL 		3x/3 kW
Gate driver	Power stage control	SOIC 	DSO 				3x/3 kW
Microcontroller	Main control	TQFP 	LFBGA 				1x



Cloud Computing & 5G Infrastructure

Cloud Computing & 5G Infrastructure

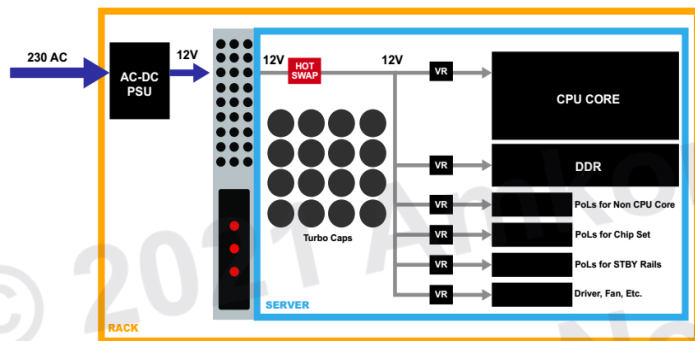
- ▶ Open Compute Project (OCP) mandates
 - ▷ Server designs
 - ▷ Rack designs
 - ▷ Energy efficient data centers
- ▶ Next wave of growth from 5G Telecom
 - ▷ 3-5x more units than 4G
 - ▷ mMIMO – large number of radios
 - ▷ Increased server content – SDR and edge computing



Source: IEA

Power Architecture

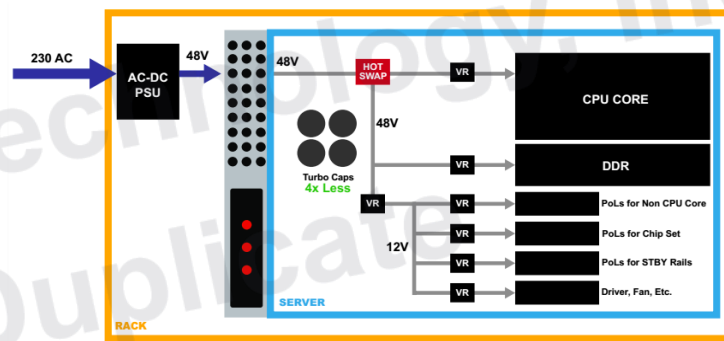
12V Server Power Delivery



Source: Wiwynn

- ▶ High power trend – HPC/GPU
- ▶ Copper loss minimization
- ▶ Connector busbar sizing

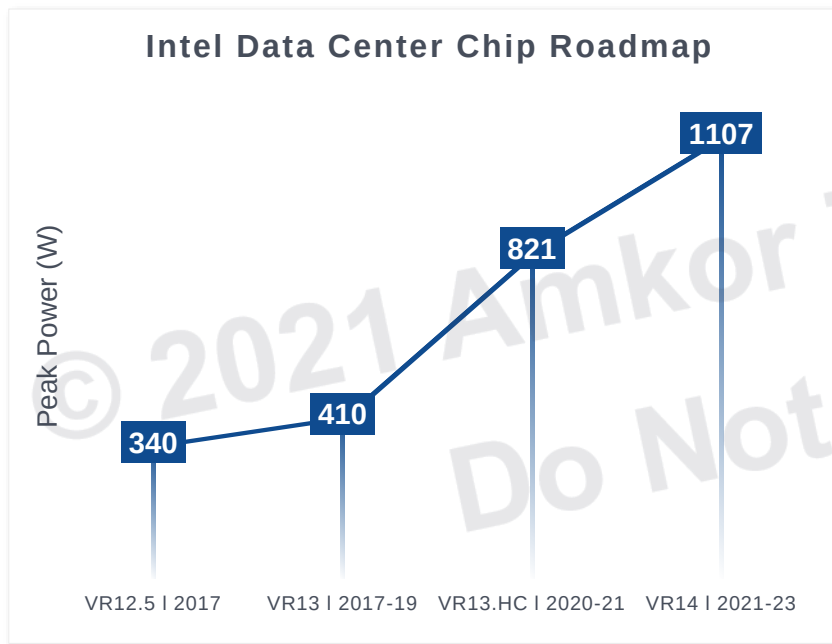
48V Server Power Delivery



Source: Wiwynn

- ▶ Support higher power
- ▶ Higher efficiency
- ▶ Cost-effective 'in rack' UPS

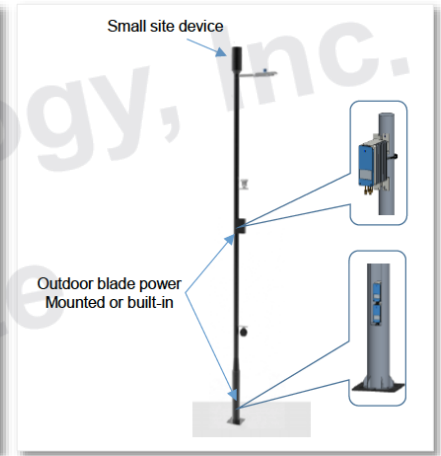
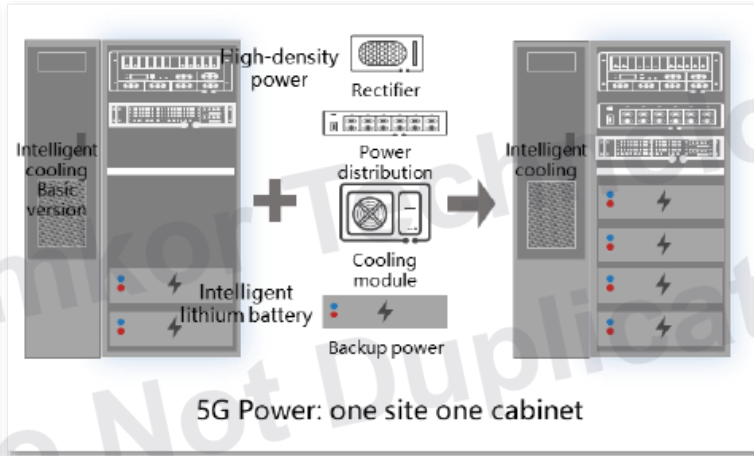
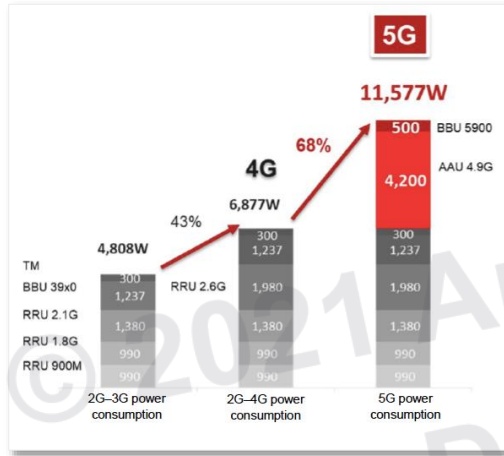
Shifting Trends in Computing



Source: Intel

- ▶ Higher power cores allows for higher rack power density
- ▶ Shifting power architectures
 - ▷ Traditional 2-stage conversion using transformer and 48V to load
 - ▷ Direct conversion from AC to 400V to 48V

5G Power Consumption



- ▶ Sites with 5 bands will consume ~11 kW
- ▶ In few years sites supporting >10 bands will consume ~23 kW

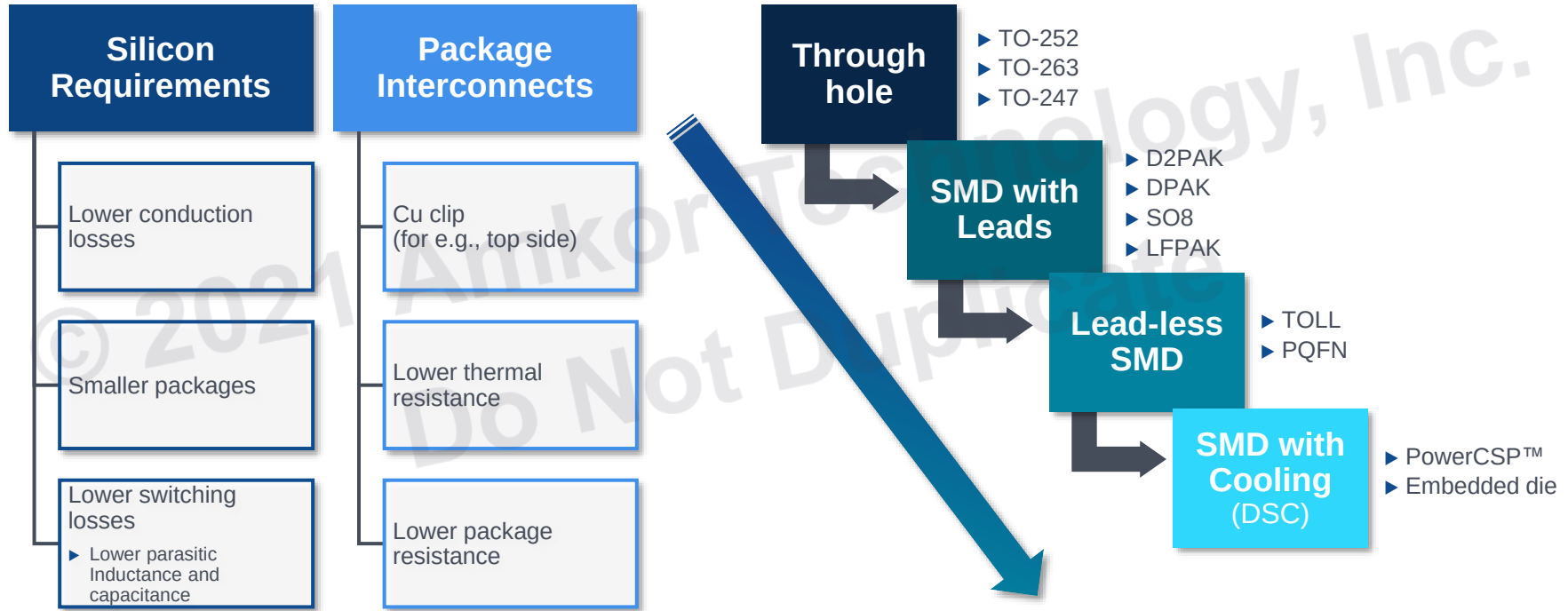
- ▶ 48V Rectifier uses 600V+ FETs & 80-150V MOSFETs
- ▶ BBU & RRU power supplies require 80-150V MOSFETs
- ▶ 4-5x FETs (RRU/AAU) as we shift from 4G to 5G

Source: Huawei Technologies 5G Power

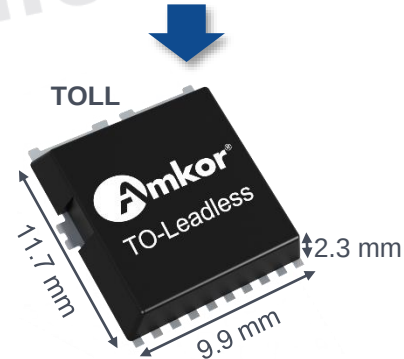
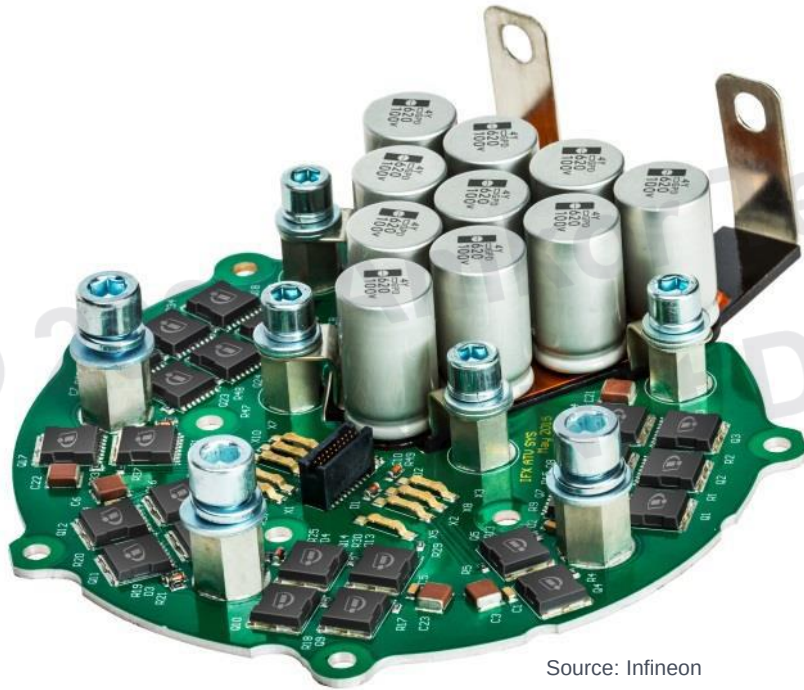


Power Packaging Trends

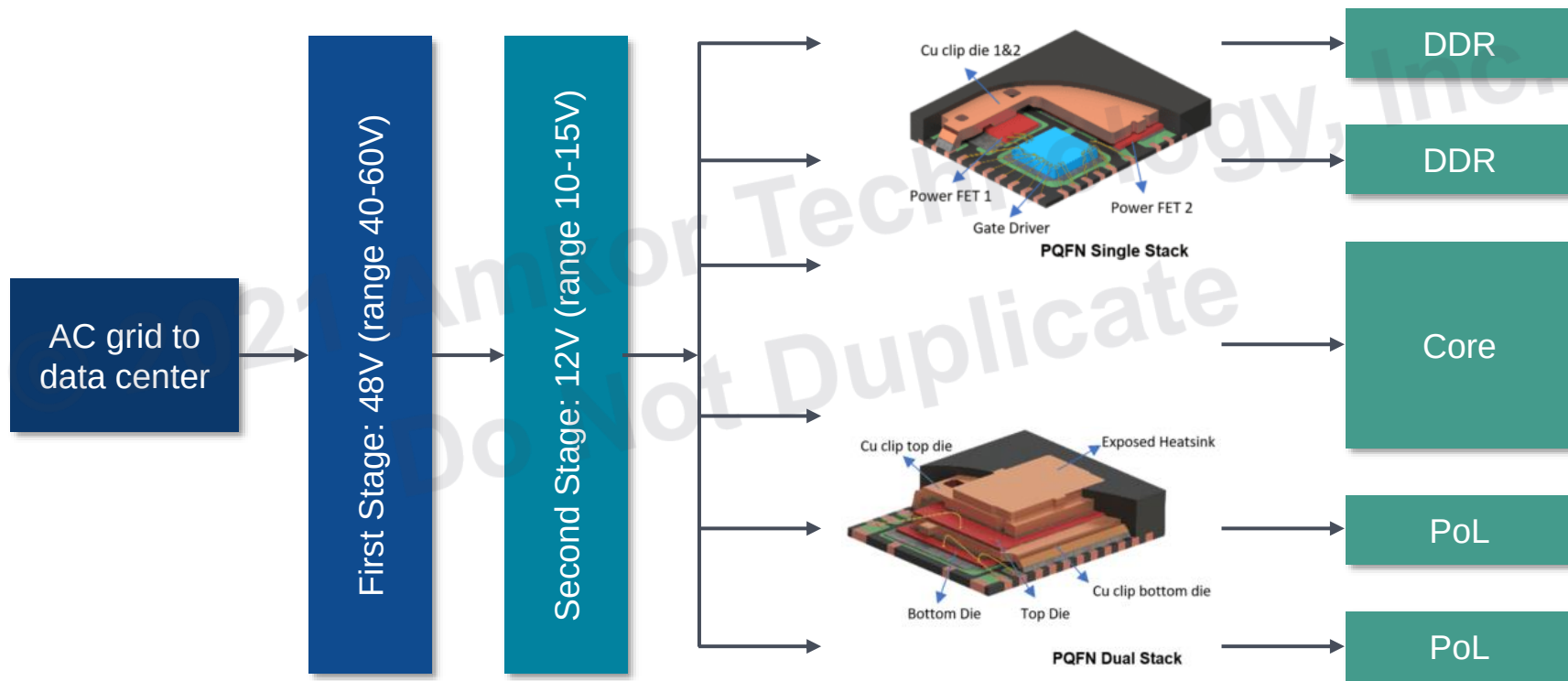
Technology Trends



48V Automotive Use Case



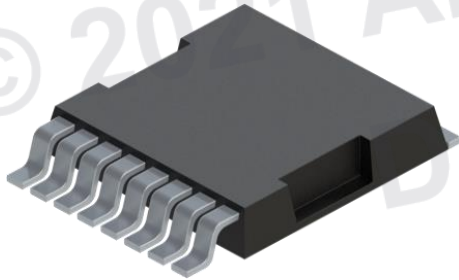
Data Center Power Delivery



Other Challenges

Temperature Cycling on Board (TCoB)

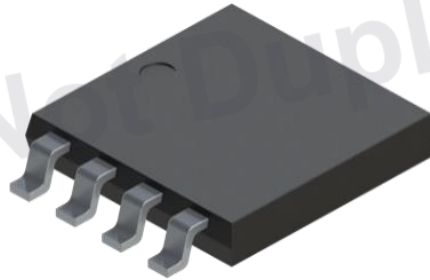
- ▶ Emerging mission profiles
- ▶ Extended reliability



TOLG

Higher Power Density (PUE)

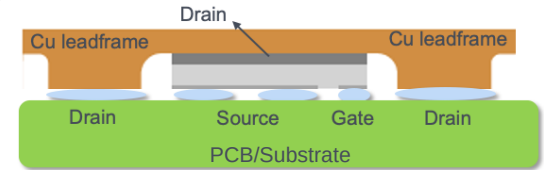
- ▶ High density server racks
- ▶ Smaller footprints



LFPAK 8 x 8 mm

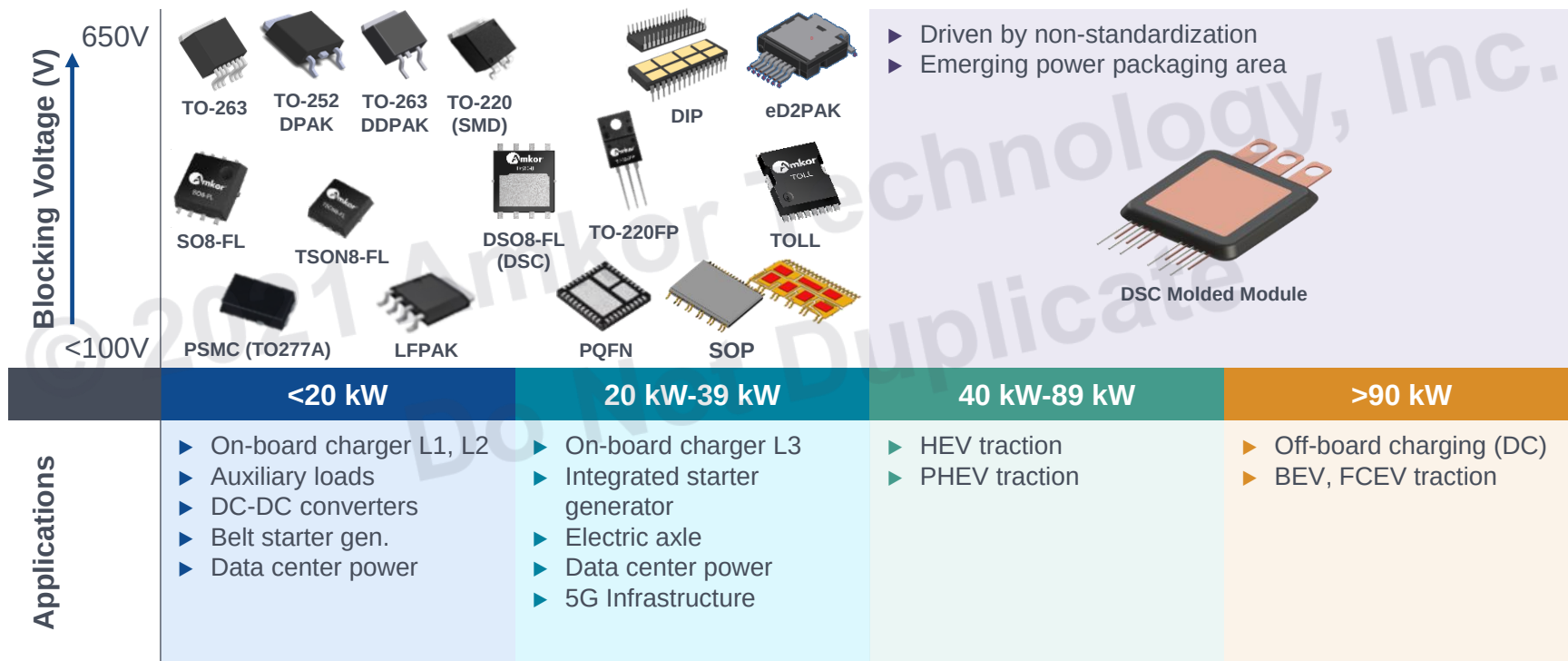
Higher Switching Frequencies (f)

- ▶ Fast transient responses
- ▶ Low parasitics, effective cooling



PowerCSP™

Power Product Mapping





Thank You

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