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ANGELTECH

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GaN is widening the applications field in power electronics

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STMicroelectronics

Energy transition

Resources are a common asset...

Reduce greenhouse gas emission

- **Transport**: automotive, space & aeronautics,
- **Industry**: pumps, motors, air-conditioning, multimodal energy approach
- **Digitalization**: massive data and « real time » calculation, data server, IA, …

➔ « Fossil » energy to be massively reduced

Optimize all usage

- **Electrical power is also scarce**
- From production to…
- Recycling & upcycling

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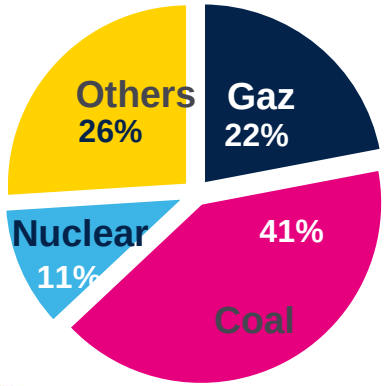
Energy saving with WBG* deployment

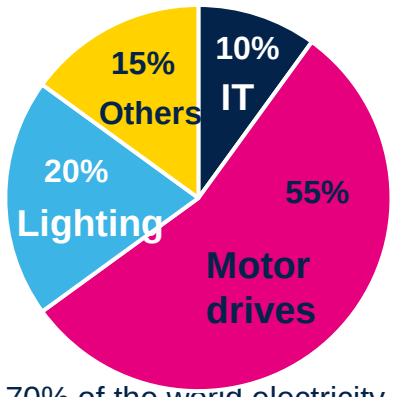
Electricity generation



World - 25000 TWh/Y (2021**)

■ Gaz ■ Coal

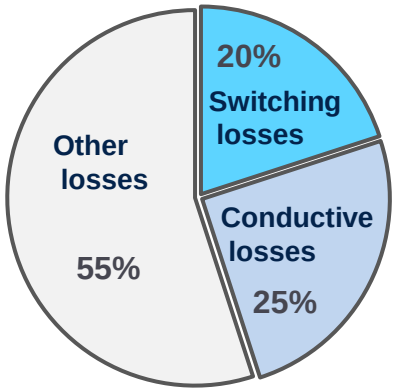
Electricity usage



70% of the world electricity is managed by power electronics

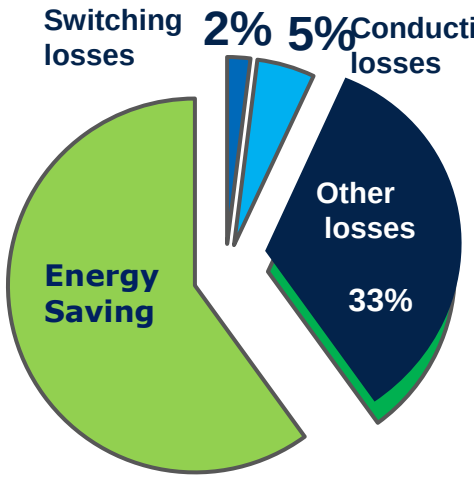
650 V

Silicon technology



Total efficiency < 85%

WBG technology



Total efficiency > 95%

* Wide bandgap
** www.iea-4e.org

3 to 7% global energy-saving estimated through deployment of WBG

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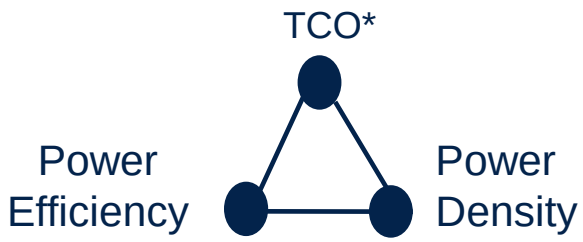
SiC and GaN semiconductors: enabling energy-efficient applications

Wide-bandgap semiconductors offer superior benefits and characteristics, thanks to:

Faster switching	Lower switching losses and higher efficiency
Higher switching frequencies	Smaller passive components
Higher operating voltages with low on-resistance	Reduced currents and lower conduction losses
Higher junction temperatures	Reduced cooling requirement
Higher power densities	Miniaturization

New paradigm with WBG



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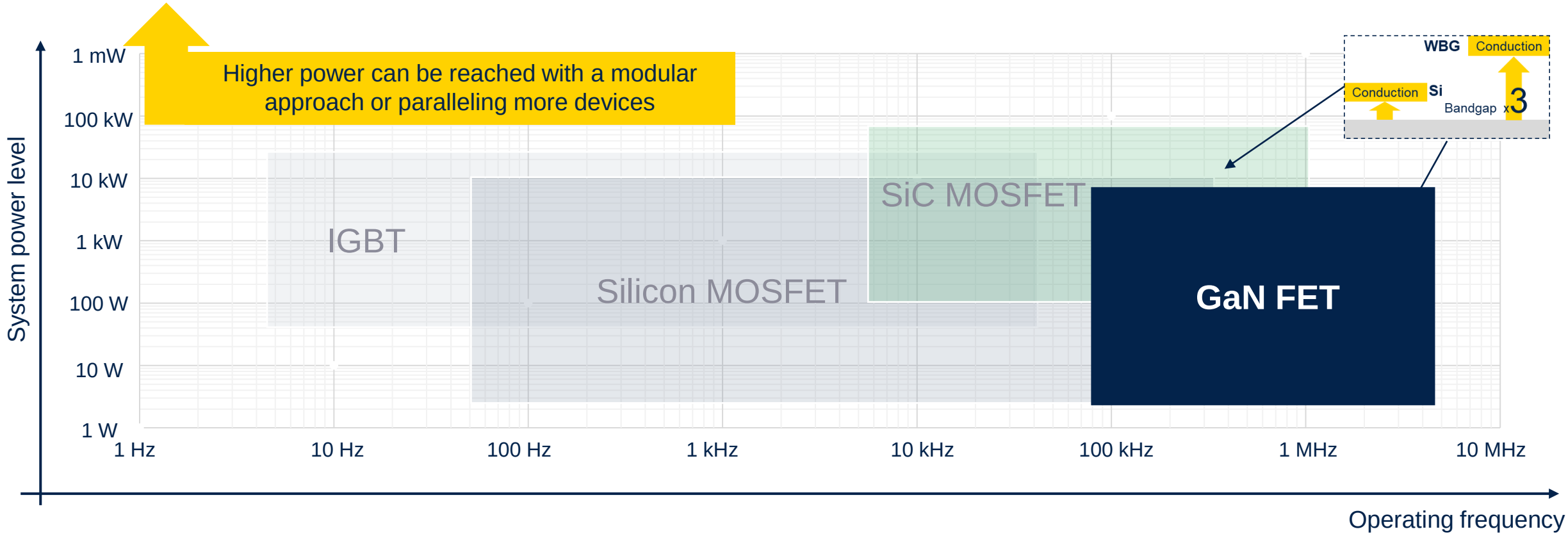
Silicon, SiC, and GaN mapping as of today

Silicon and wide bandgap materials are complementary



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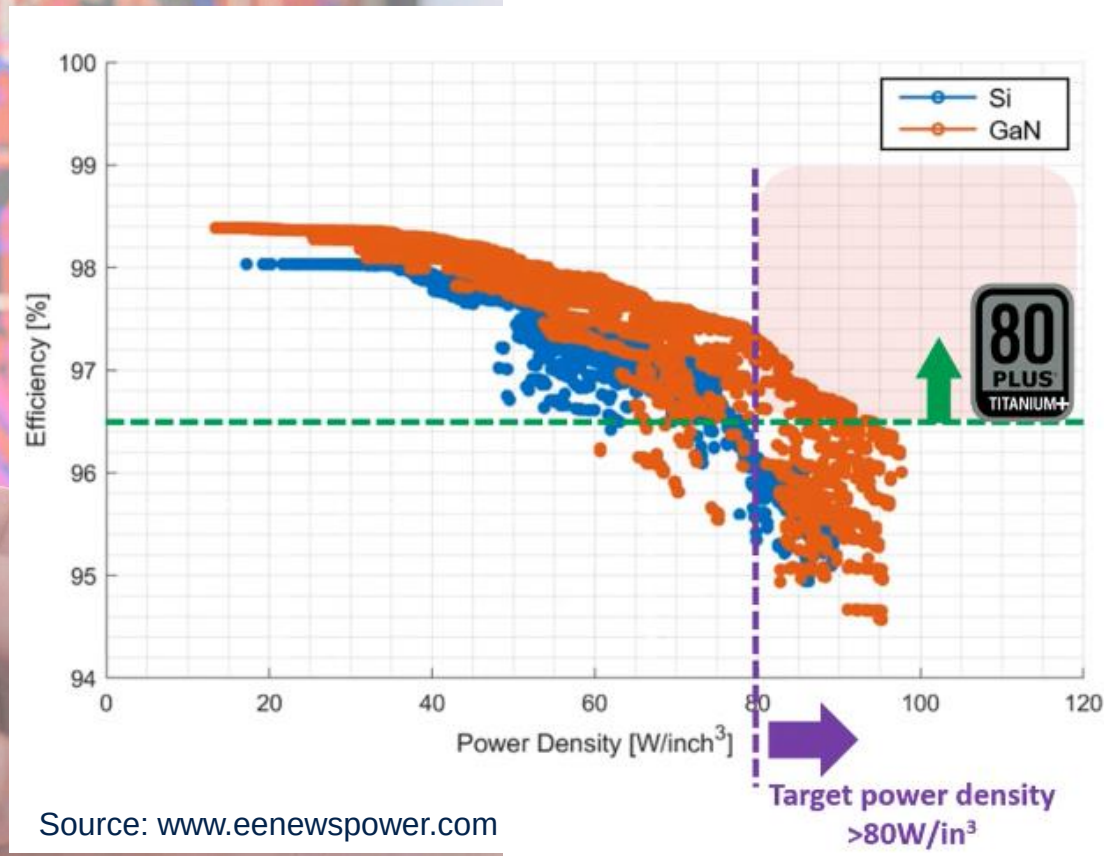
GaN can help meet growing power density needs for AI datacenters

By 2027, annual worldwide AI-related electricity consumption may rise by 85 to 134 TWh based on the projected AI server production



Source: www.eenewspower.com

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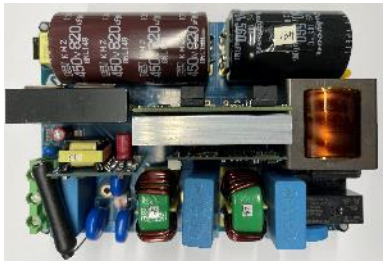
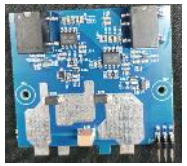
SiC/GaN boost efficiency and power density for AI server/datacenter

3 kW totem pole PFC with SiC or GaN

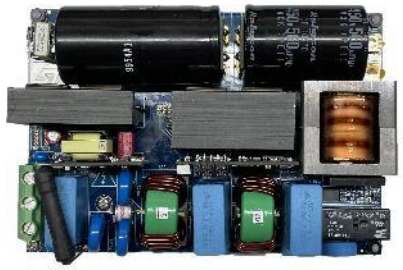
ST Power GaN to boost efficiency **(100 x 145 x 40 mm)**

GaN

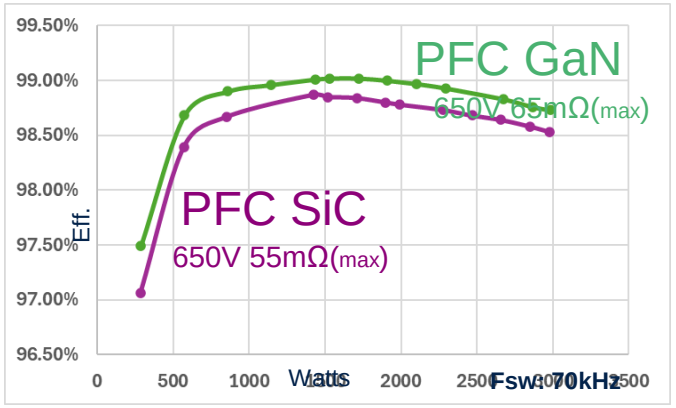




SiC MOSFET

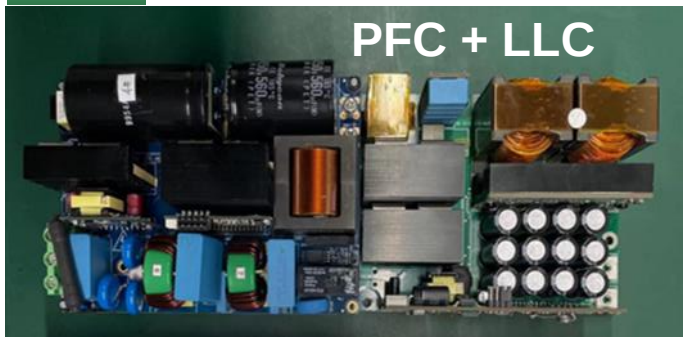


PFC	SIC MOSFET		GaN
Power density (w/inch³)	85	x1	85
Power rating	3 kW	x1	3 kW
Peak eff. at 230Vac	98.5%	+0.5%	99%



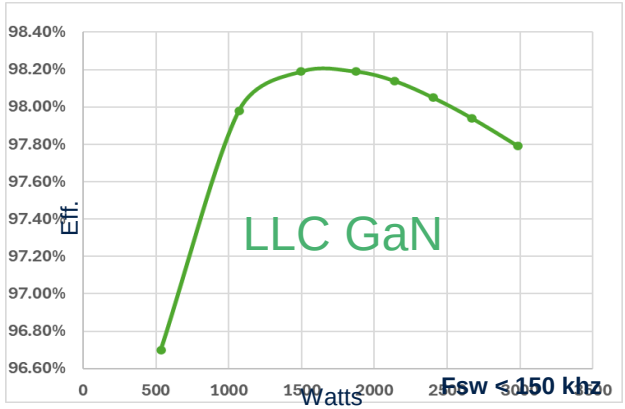
3 kW totem pole PFC + LLC with GaN

GaN



80 PLUS TITANIUM

73.5 x 265 x 40 mm



PFC+LLC	Si MOSFET		GaN
Power density (w/inch³)	45	X1.5	89
Power rating	2 kW	X1.5	3 kW
Peak eff. at 230Vac	95.28%	+1.94 %	97.22%

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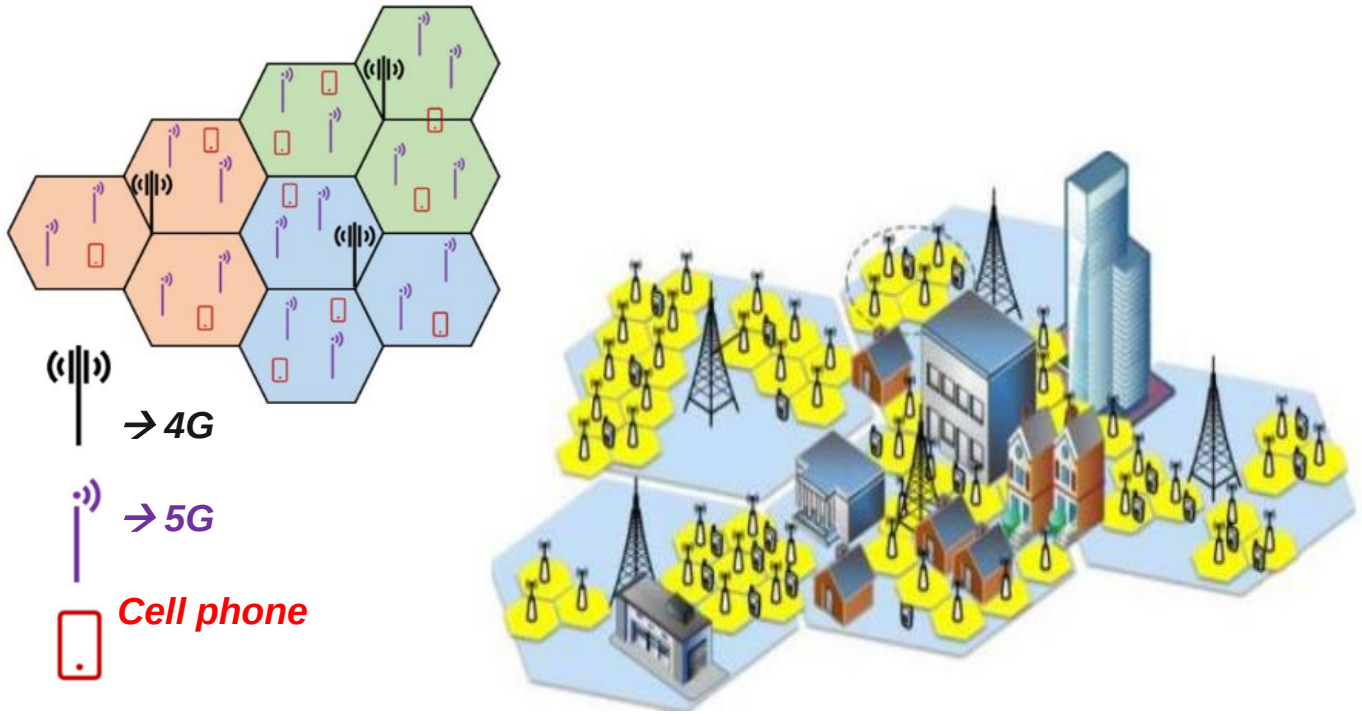
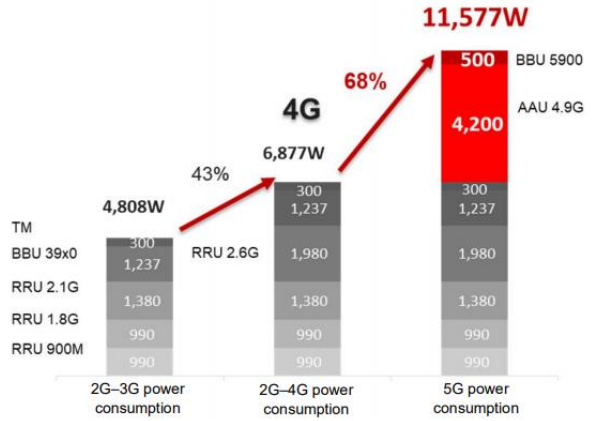
Higher system integration for 5G telecom power

Enabling higher power density and higher efficiency

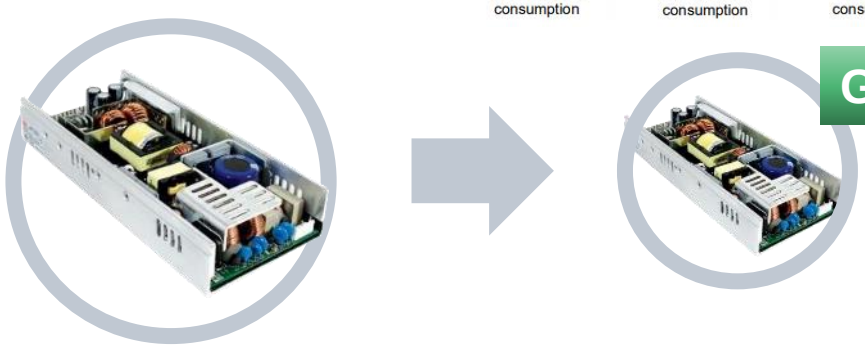
Smaller coverage due to higher frequency radio: to achieve high network speed and low latency



Higher power consumption in 5G usage: to fulfill high traffic density and connection density



Source: Huawei



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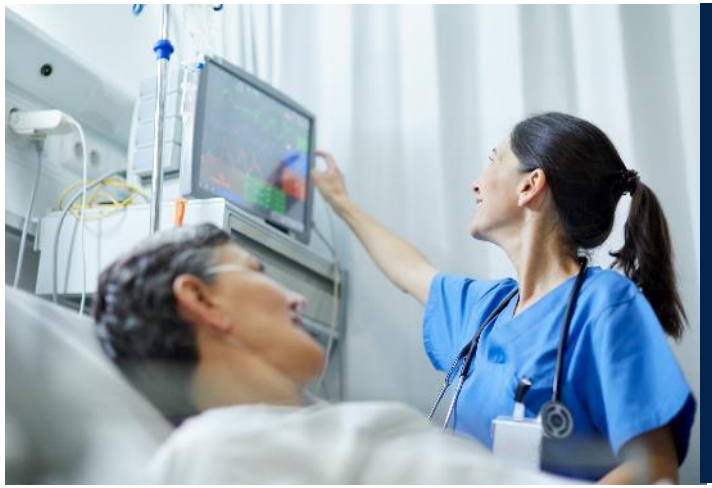
Challenges for the grid

How to optimize investment in **energy transmission** upgrades?

How to manage **peak loads that** are becoming increasingly **unpredictable**?

How to set up **new grid infrastructure** in congested areas?



How to ensure a **reliable** supply to critical functions?

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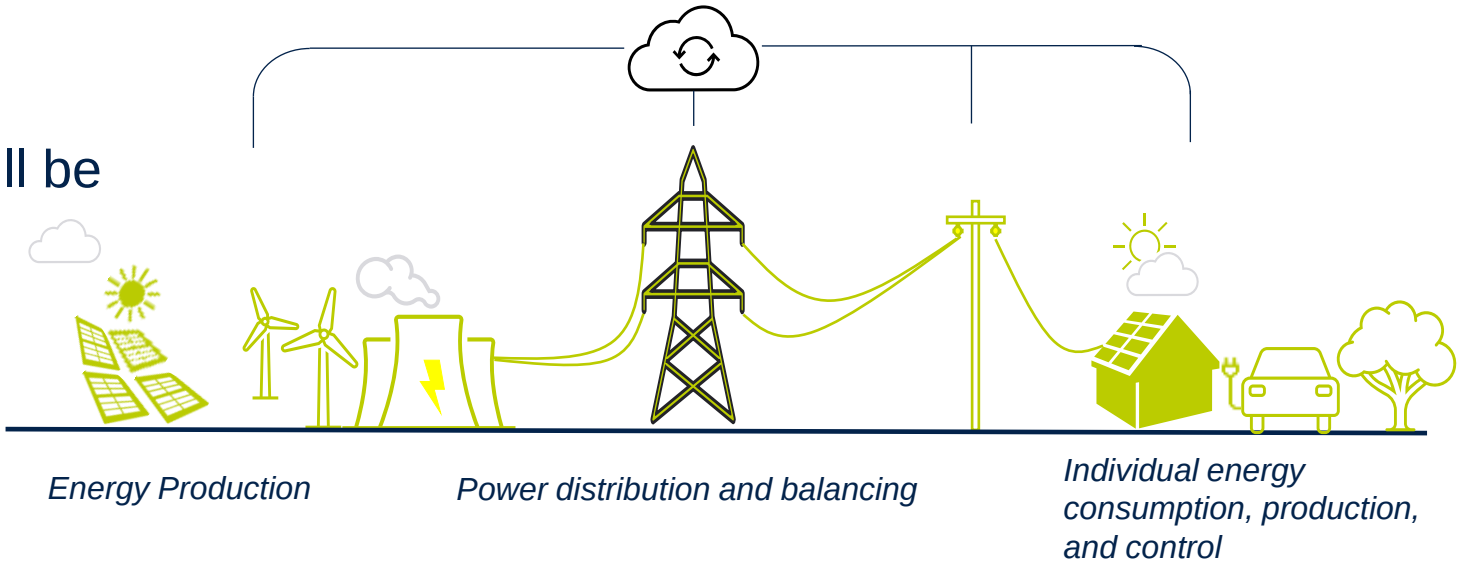
Secure & resilient power network

- Stationary energy storages: stabilize the network
- Easily deployable: EV batteries will be widely adopted
- Interconnected network from individual user / distribution / global and local production
- Immunity to cyber attack



New applications require bidirectional power flow

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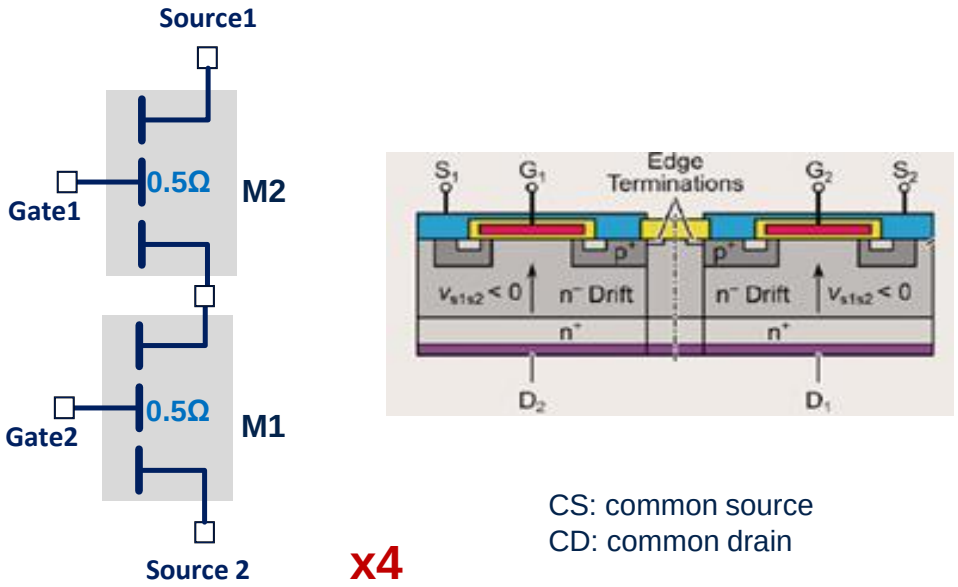
Bidirectional switch

Bidirectional switches in CS or CD configuration with two separated drift regions

Bidirectional switches in CD configuration with shared drift region

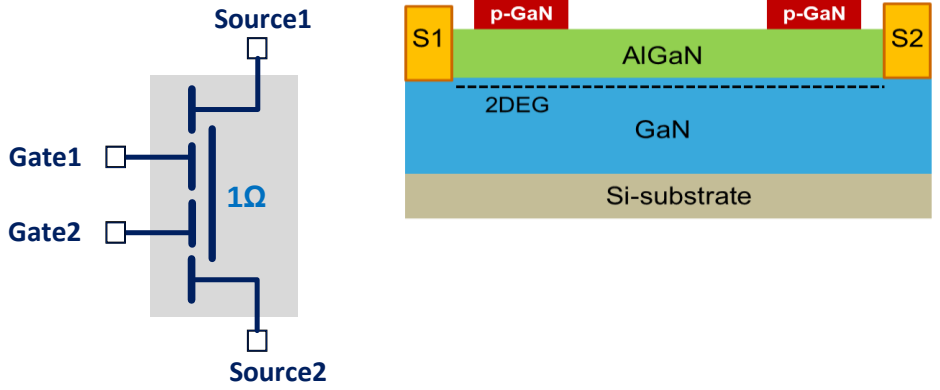
Si, IGBT, SiC



x4

CS: common source
CD: common drain

GaN



x1

Monolithic BDR switch is a key feature of GaN technology

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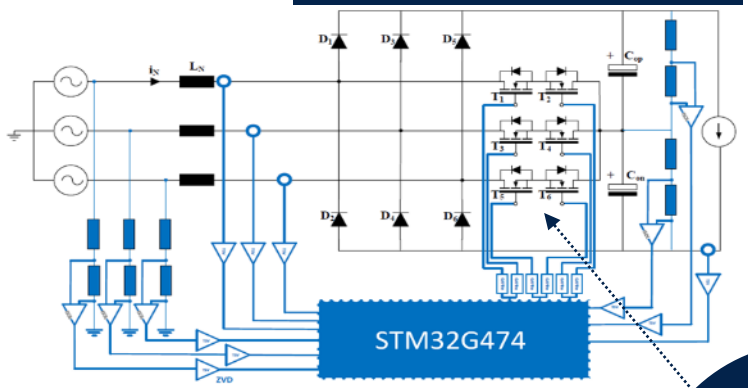
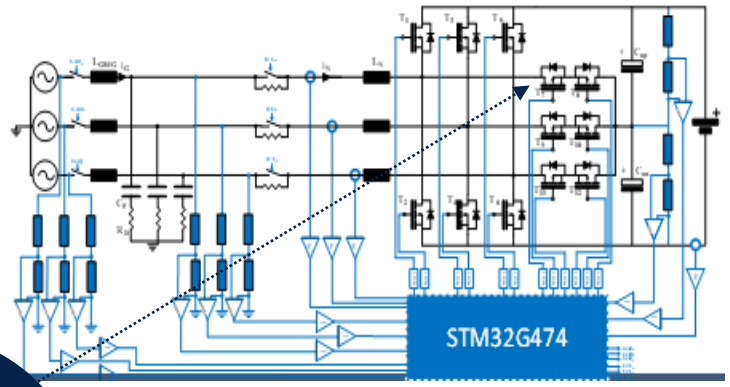
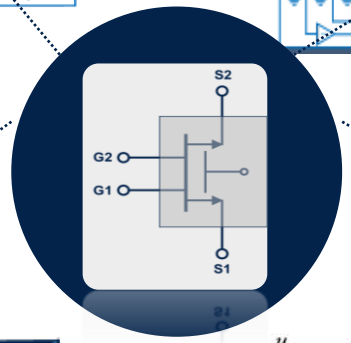
Bidirectional GaN to replace back-to-back switches

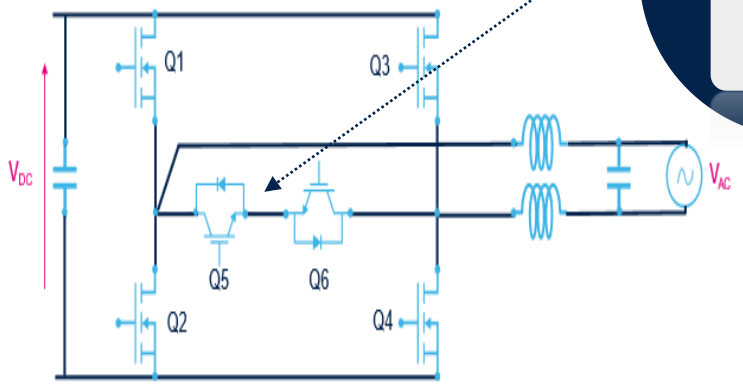
3L Vienna rectifier



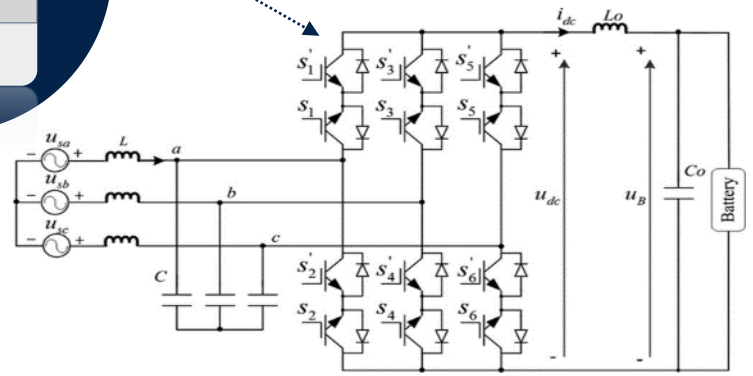
3L T-Type bidirectional PFC







HERIC inverter



AC-DC-matrix converter

- **Components reduction**
- **Higher frequency operation due to GaN**
- **Size reduction of passive components**
- **Increased power density**
- **System's cost reduction**

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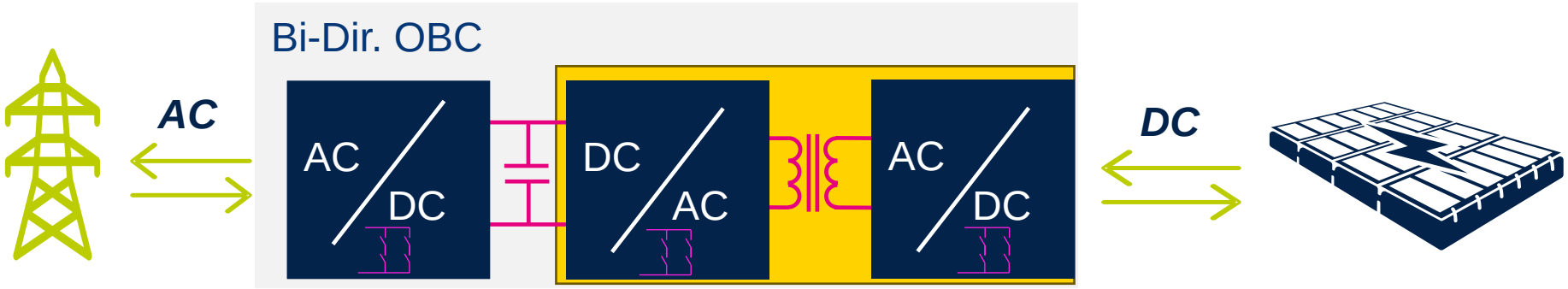
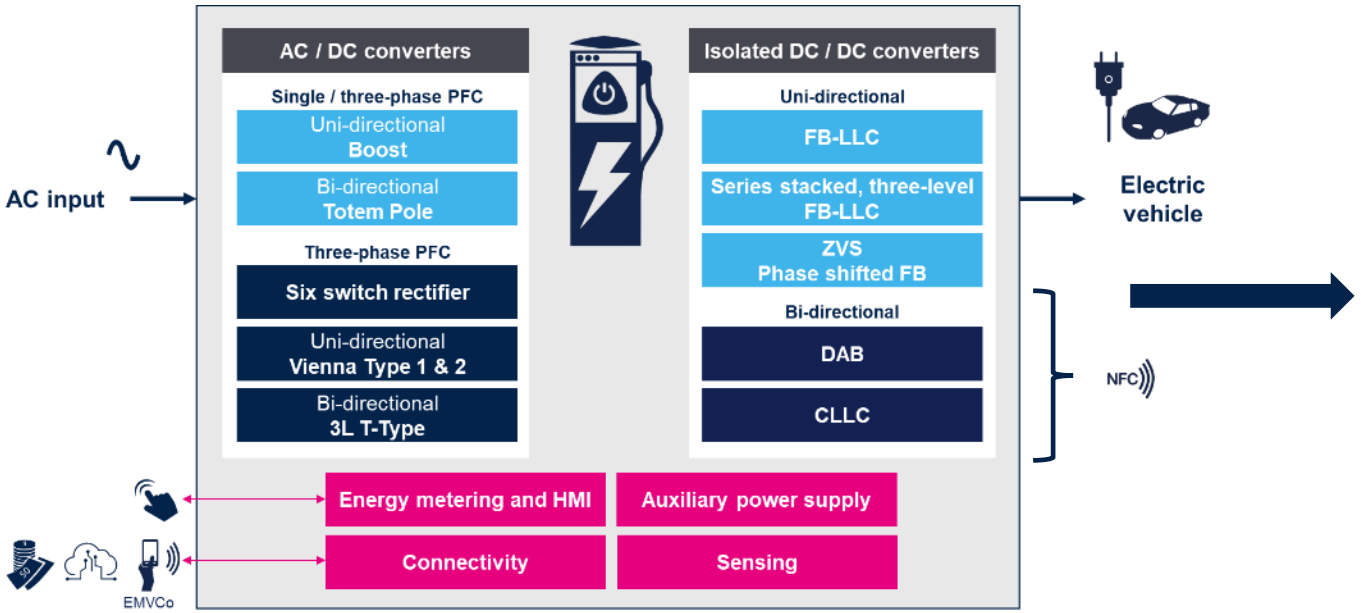
Bidirectional GaN – On-board charger





Bidirectional GaN to enable:

- Simplified system, less passive and power switch components
- Higher system robustness and reliability
- Higher power density for even more space and weight saving

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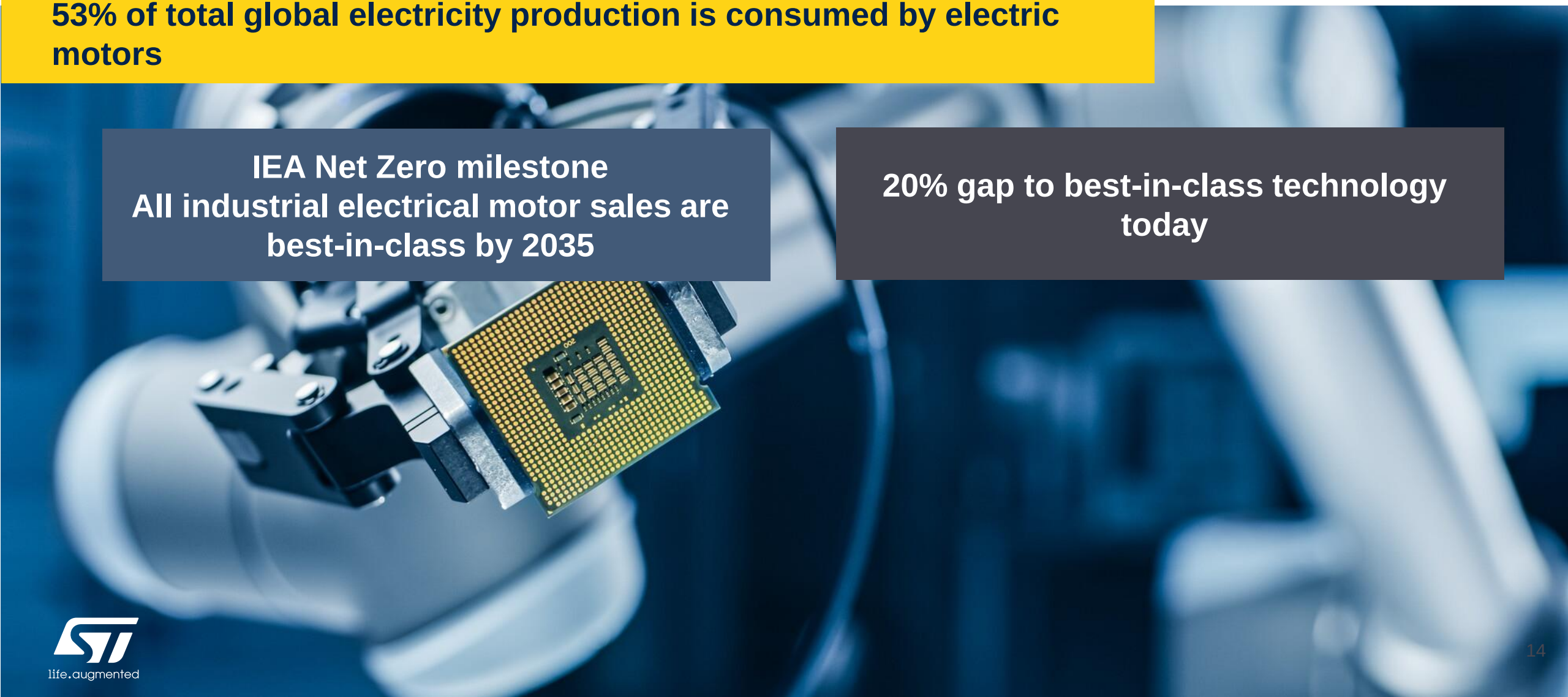
Motor control landscape

53% of total global electricity production is consumed by electric motors



IEA Net Zero milestone
All industrial electrical motor sales are best-in-class by 2035

20% gap to best-in-class technology today

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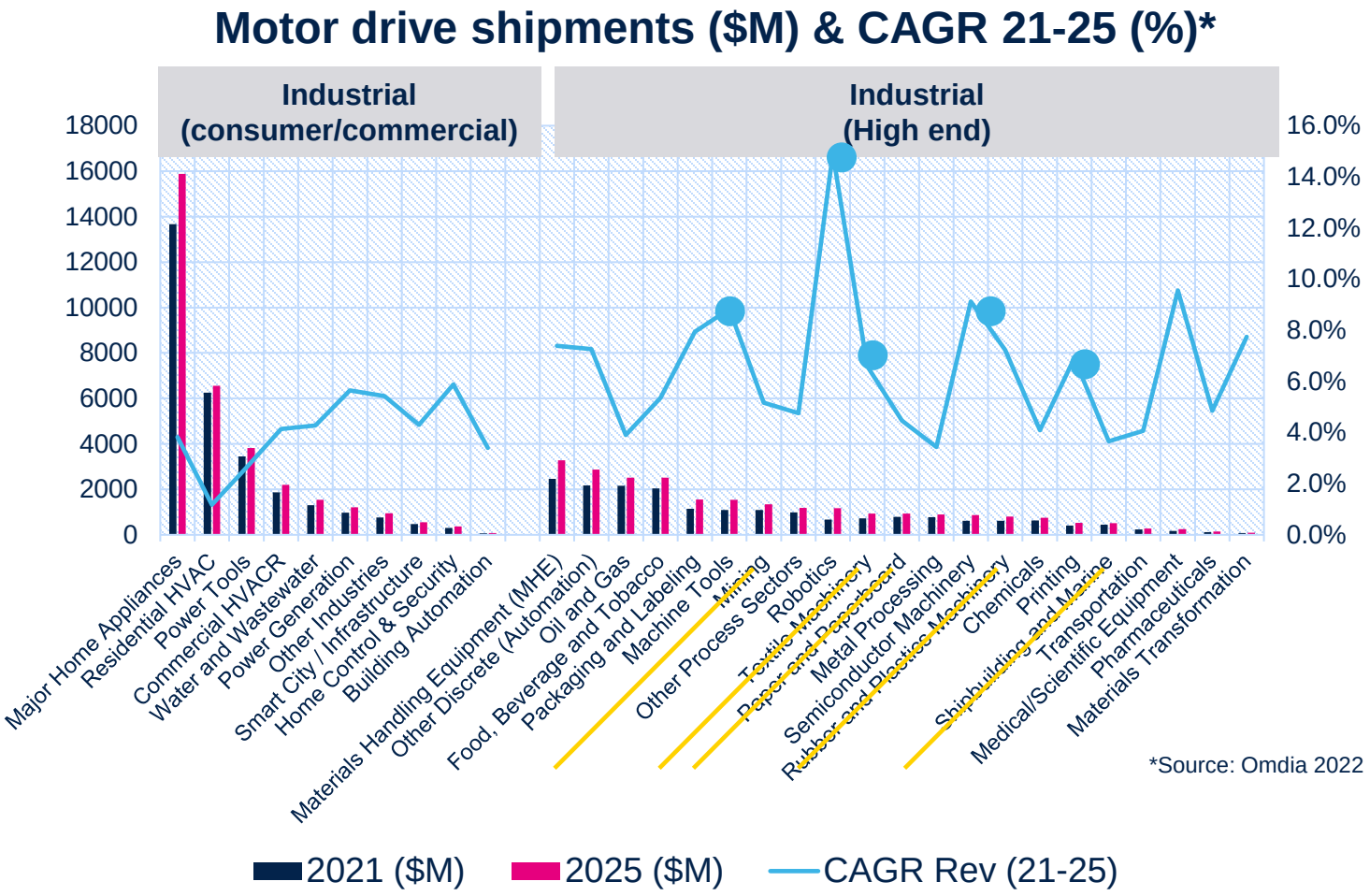
Servo drives
Top CAGR in high end industrial



*Source: Omdia 2022

Robotics CAGR 14.9%

Semiconductor machinery CAGR 9.1%

Machine tools CAGR 8.8%

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500 W high voltage motor drives based on GaN

GaN high voltage servo motor drive

Key features:

- GaN ready solution for motion control
- 10 V dV/dt both hard-on and hard-off
- Overcurrent protection integrated in the gate driver
- FOC supported
- Designed for 230 V AC mains
- HEMT GaN 650 V, 65 mΩ typ R_{DSon}

Specifications:

- 500 W+ max output power without cooling fan
- RS485 for absolute position encoder
- SPI, I²C
- Hall sensor & encoder

Applications

- **Home appliances**
- **Servo drives**
- **High speed motors & tools**
- **Miniaturized motors**

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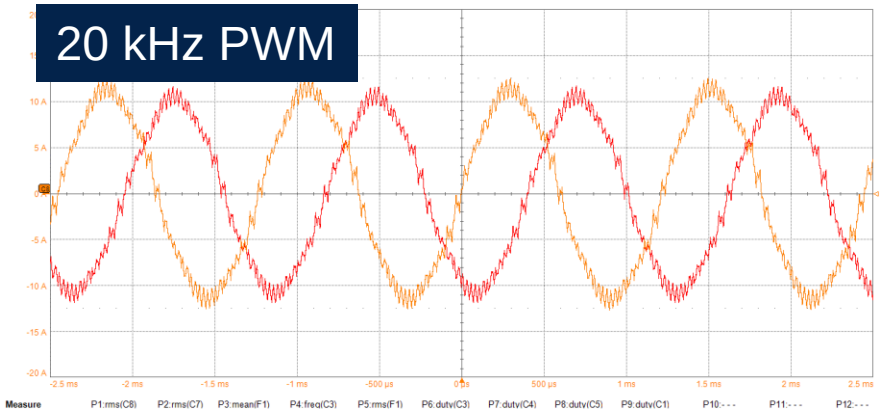
Overall efficiency improvement increasing the PWM frequency

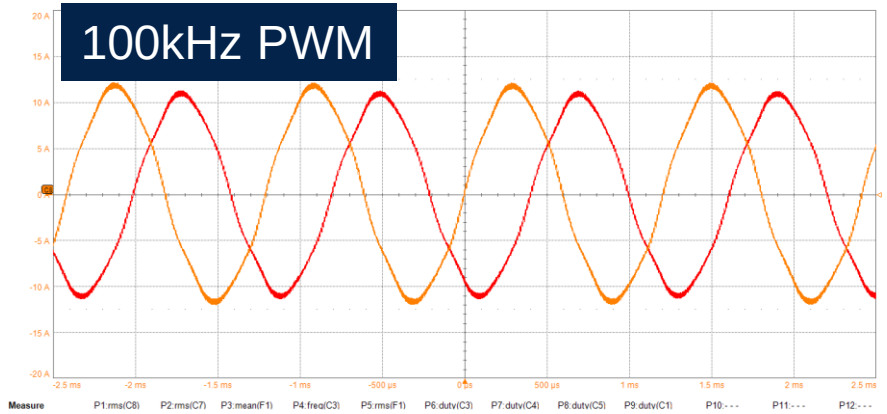
20 kHz PWM



Peaks	Frequency	Amplitude
1	750 Hz	6.5713 A
2	40.75 kHz	269.4 mA
3	39.25 kHz	248.8 mA
4	3.76 kHz	248.1 mA
5	21.50 kHz	159.0 mA
6	18.50 kHz	135.4 mA
7	122 Hz	115.7 mA
8	17.00 kHz	113.4 mA
9	23.00 kHz	102.3 mA
10	1.46 kHz	98.8 mA

Not producing active torque

100kHz PWM



Peaks	Frequency	Amplitude
1	750 Hz	6.6455 A
2	3.75 kHz	251.8 mA
3	199.24 kHz	85.2 mA
4	5.25 kHz	74.2 mA
5	98.50 kHz	44.4 mA
6	101.49 kHz	37.8 mA
7	103.00 kHz	31.1 mA
8	97.00 kHz	28.6 mA
9	196.24 kHz	11.4 mA
10	49.24 kHz	7.7 mA

	Si @20kHz	GaN @100kHz
Inverter efficiency	98.28%	98.68%
Motor efficiency		+4%
Overall efficiency		+4.12%

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COP Test for HV fridge compressor

Compressor motor:
- Phase resistance: 10 Ω
- Ls: 200 mH

Power devices	Fpwm (kHz)	Nominal speed [rpm]	Cooling capacity [W]	Input power [W]	COP	COP increased
Leading solution STD8N60DM2	5	1200	65.793	34.681	1.897	
		3000	167.208	89.78	1.862	
		4500	232.425	145.847	1.594	
New ST GaN solution SGT120R65AL	5	**1200**	66.814	34.451	1.939	+2.2%
		3000	169.875	90.313	1.881	+1.0%
		4500	233.945	146.26	1.600	+0.3%
	8	1200	66.379	34.852	1.905	+0.4%
		3000	168.538	89.869	1.875	+0.6%
		4500	233.182	146.394	1.593	0

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GaN technology adoption trends and opportunities

Penetration of existing markets

Improving value proposition

- Better figures of merits
- Lower system cost
- More system functionalities

From 15 to 240 W adapters

- Tiny USB Power Delivery
- LED lighting

2020

Expansion into « new markets »

Providing performances

- High reliability
- Robust (short circuit, overload, ...)
- Advanced packaging
- Die integration (PM, IPM)

Auto On/Off board charger

- Higher efficiency
- Lower BOM cost

PSU data Server

- Hard switching applications
- Bridgeless Totem Pole
- DC-DC LLC

2025

Substitution by alternatives

Challenging others

- High Voltage (900 - 1200 V)
- Vertical GaN
- Multicellular approach

Motor Control (Inverter)

- Fewer losses
- Less ripple torque
- Smaller filter

2030...

Our technology starts with You

Find out more at http://www.st.com

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