



Exploiting the unlimited potential of Solar energy – Trends and solutions

March, 2020



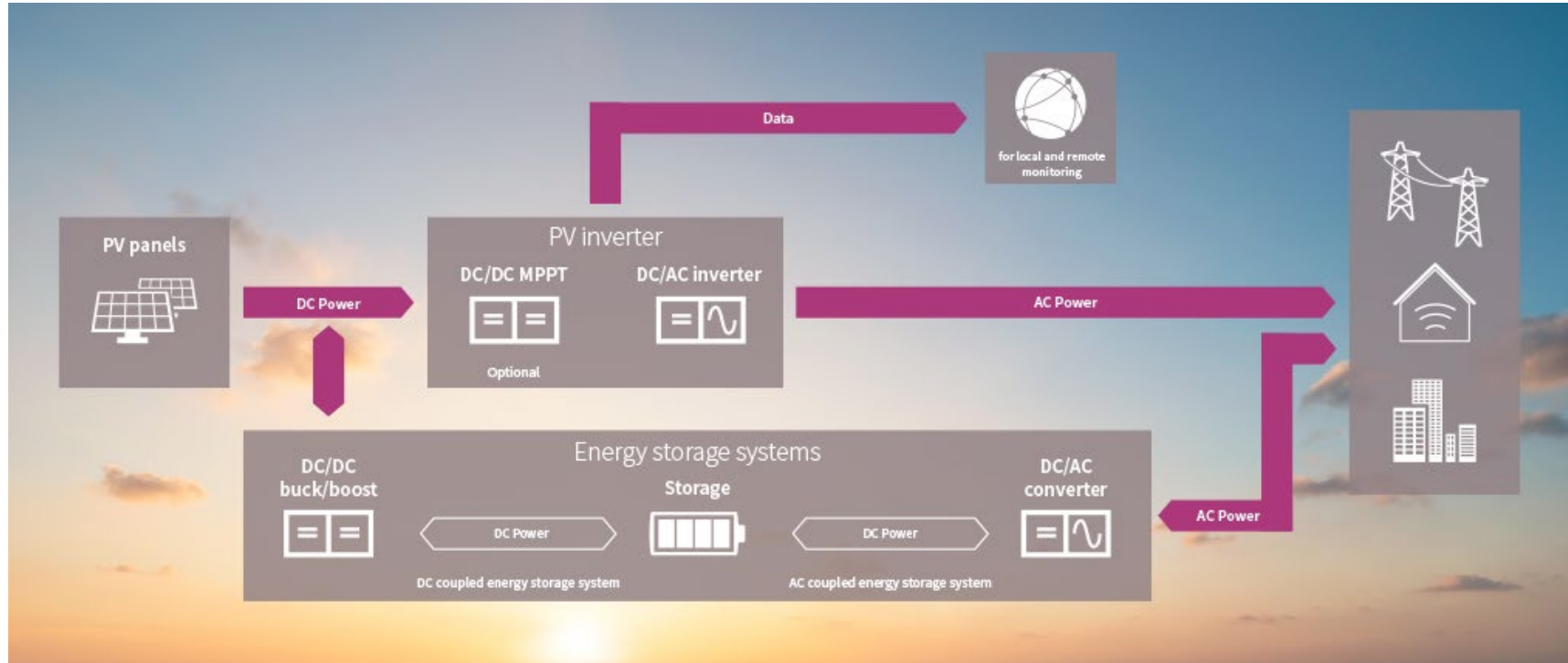
Agenda

- 1 What is PV application?
- 2 PV market and its eco-system
- 3 Topology, application trends and requirements
- 4 Solution offering
- 5 Customization process
- 6 Summary and support

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Structure of Solar power generation



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Solar market segmentation and sub applications



Residential applications

- Installed in private spaces
- **up to 10 kW** of energy



Commercial applications

- Installed in offices and factories
- **up to 5 MW** of energy



Utility scale applications

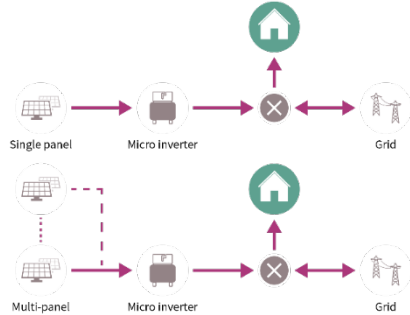
- Installed in the field
- **above 5 MW** of energy

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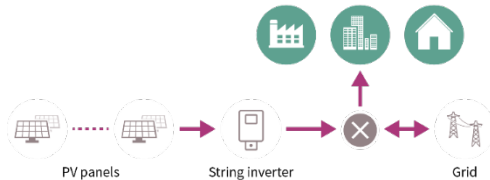
Types of solar inverter

Micro inverter



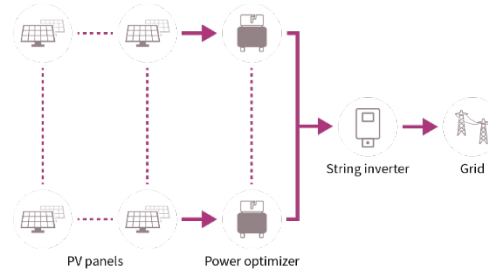
- > Power conversion on each individual panel
- > Sub application: Residential

String inverter



- > Power conversion on solar panels are connected together into strings
- > Sub application: Commercial and utility scale

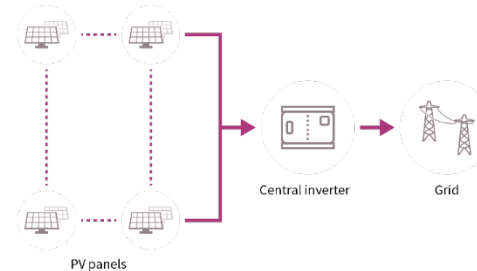
DC optimizer + multi string inverter



- > String inverter is connected with several (MPPT)¹ power optimizer at panel level or string level
- > Sub application: Residential, Small commercial

¹ MPPT – Maximum Power Point Tracking

Central inverter



- > Power conversion on multiple strings of solar panels are connected together
- > Sub application: Utility scale

Technology trends



Micro inverters

- › **Multi module:** Multiple panels attached per micro inverter
- › **Usage of compact SMD packages** (Surface-Mount-Device): SuperSO8, DirectFET™, TOLL
- › **Reduced cooling system,** heatsinks and enclosure
- › Micro inverter **producers partnering with panel manufacturers** for module level integration



String inverters

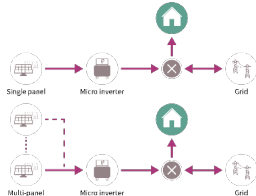
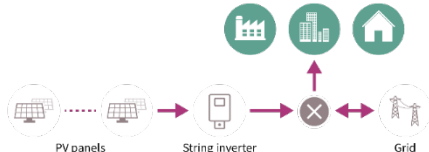
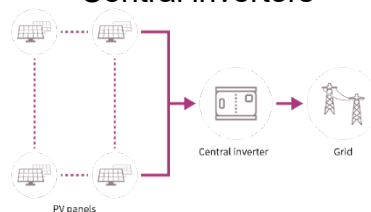
- › **Commercial installation up to 1 MW:** Applied with a 1000 V PV voltage
- › **Utility scale installation up to 20 MW:** Applied with a 1500 V PV voltage
- › **NPC1 to ANPC** → Output power independent of pf
- › **Multilevel topology in single phase inverter:** Cost, size and weight reduction through smaller magnetics & cooling



Central inverters

- › **Utility scale from 20 MW:** Applied with a 1500 V PV voltage
- › Inverter power grows from 3 MW to more than 5 MW
- › **NPC1 to NPC2** → Typ. 3 ... 4 kHz operation, NPC2 topology improves the power density, enable to use standard gate driver thanks to low stray inductance layout and reduced the cooling efforts

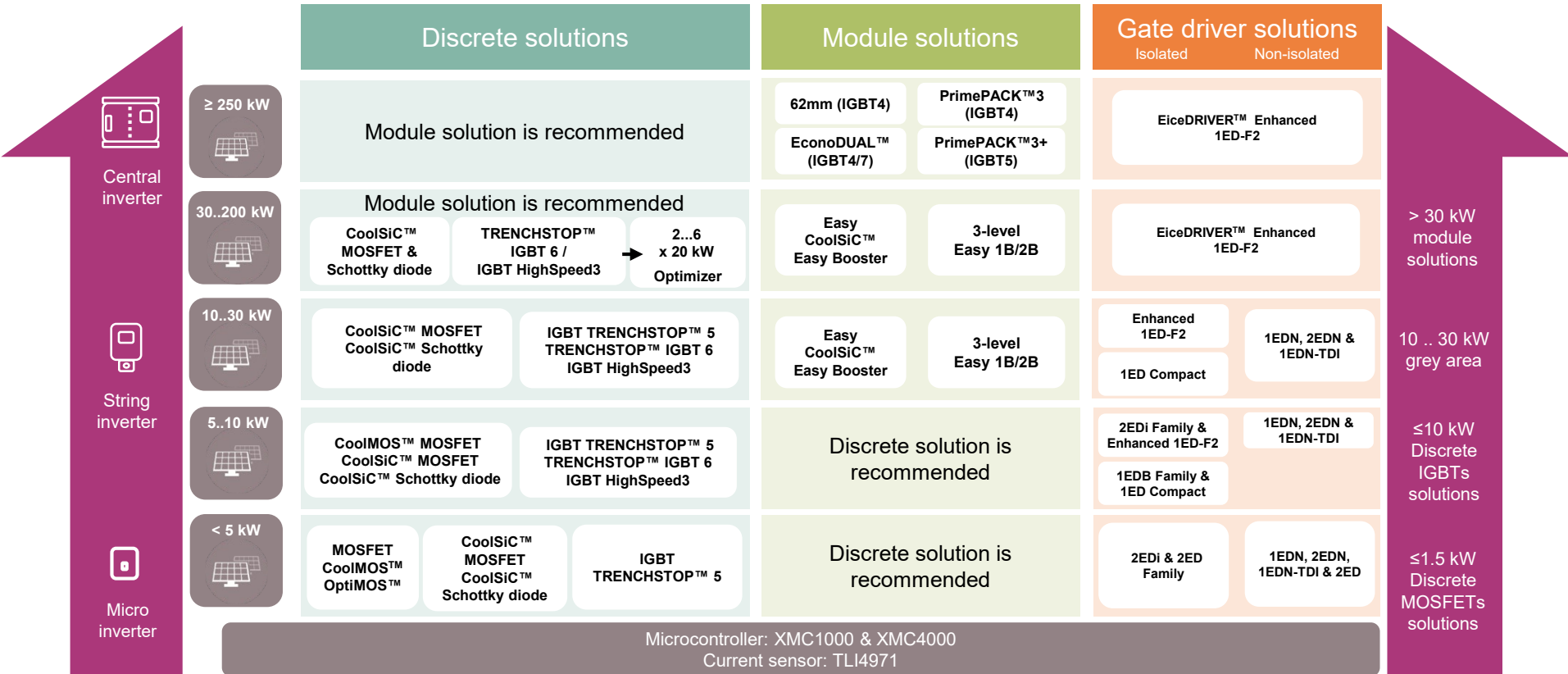
Application requirements at a glance

	 μ-Inverters	 String inverters	 Central inverters
PV array voltage	40 ... 80 V	600 V, 1000 V & 1500 V PV array	1000 V & 1500 V PV array
Power Range Switching Freq.	200 – 1500 W 40 ... 80 kHz	1 ... 200 kW 20 ... 35 kHz	600 ... 1250 kW 2 ... 4 kHz
Output voltage	110V / 230V (1Φ)	110 / 230V (1Φ) 360 ... 800V (3Φ)	320 ... 690V (3Φ)
Topology	<u>DC/DC + DC/AC Stage</u> DC-DC: LLC or Flyback DC-AC: 2-Level or Cyclo-converter	<u>DC/DC + DC/AC Stage</u> DC-DC: Single or Dual Boost 1Φ: 2-Level, H5, H6 & HERIC 3Φ: 3-Level: NPC1, NPC2 & ANPC	<u>DC/AC Stage</u> 2-Level (3Φ Full Bridge) 3-Level: NPC1, NPC2 & ANPC
Type of Installation	Residential	Residential, Commercial & Utility Scale	Big Commercial & Utility Scale
Pros and cons	- Higher flexibility & scalability / harvesting - Higher system cost	- Widely used / Up to 98% efficiency - Higher flexibility & scalability / Harvesting - Moderate system cost	- Highest efficiency up to 99% - Lower system cost - Low flexibility & scalability / Harvesting

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Infineon's power solution positioning for solar application



Micro inverter – Topology and device selection

# of PV Panels per micro inverter	Single		Multiple
Type	Full bridge	Cyclo inverter	Full bridge
Topology			
PV array voltage	$\leq 60\text{V}$		
Blocking voltage	60 – 650 V (Primary side: 60 V - 150V & Secondary side: 600 V - 650V)		
Focus product / technology	60V - 150 V OptiMOS™ 600 & 650 V CoolMOS™ or CoolGaN™ CoolSiC™ Schottky Diode EiceDRIVER™ Gate Driver for MPPT stage (2EDN7524F) EiceDRIVER™ Gate Driver for inverter stage (2EDS8x65H)		



OptiMOS™



CoolMOS™



CoolSiC™



CoolGaN™

300 W

1500 kW

Power optimizer / MPPT – Booster – Topology and device selection

Location	PV panel level		
Type	Full bridge	Single Boost	Dual Boost
Topology			
PV array voltage	$\leq 60 \text{ V}$	600 V / 1000 V	1500 V
Blocking voltage	60 – 150 V	600 V / 650 V / 1200 V	1200 V
Discrete solution	60 – 150V OptiMOS™	600 V / 650 V: CoolMOS™ & CoolSiC™ MOSFET / IGBT TRENCHSTOP™ 5 S5 / H5 + CoolSiC™ Schottky diodes 1200 V: CoolSiC™ MOSFET / IGBT HighSpeed3 H3 / TRENCHSTOP™ IGBT6 S6 + CoolSiC™ Schottky diodes	CoolSiC™ MOSFET / HighSpeed3 IGBT H3 / TRENCHSTOP™ IGBT6 S6 + CoolSiC™ Schottky diodes
Module solution	Not recommended	EasyPACK™ 1B/2B	-
Gate driver solution	EiceDRIVER™ (2EDL81xx)	EiceDriver™ 1EDN for MOSFET EiceDRIVER™ 1ED Compact for IGBT EiceDRIVER™ low side (IRS44273)	EiceDRIVER™ 1ED Compact EiceDRIVER™ low side EiceDRIVER™ Enhanced 2ED-F2



SMD

200 W



TO-220 / TO247-3 / TO247-4

10 kW



Easy 1B/2B

up to 25 kW

1-phase string inverter – Topology and device selection

Type		2-level	HERIC	H6	Multilevel
Topology					
Blocking voltage		600 V / 650 V	600 V / 650 V	600 V / 650 V	150 V
Focus product / chip technology		S1...S4: CoolSiC™ MOSFET / CoolMOS™ / IGBT TRENCHSTOP™ 5 L5 / H5	S1...S4: CoolMOS™ & CoolSiC MOSFET IGBT TRENCHSTOP™ 5 L5 / S5 S5/S6: IGBT TRENCHSTOP™ 5 L5 / S5	S1/S2: IGBT TRENCHSTOP™ 5 L5 / S5 S3...S6: CoolMOS™ / IGBT TRENCHSTOP™ 5 S5 / H5	S1...S8: OptiMOS™ / CoolGaN™ MOSFET
Gate Driver	MOSFET	2EDi Family (2EDF8275) or (2EDF9275) for SiC	2EDi Family (2EDF8275) or (2EDF9275) for SiC	2EDi Family (2EDF8275)	2EDi Family (2EDF8275)
	IGBT	EiceDRIVER™ SOI (2ED218x) / EiceDRIVER™ low side (2ED24427)	EiceDRIVER™ SOI (2ED218x) / EiceDRIVER™ 1ED Compact	EiceDRIVER™ SOI (2ED218x) / EiceDRIVER™ 1ED Compact	EiceDRIVER™ 1ED Compact / EiceDRIVER™ high side (IRS20752)



DirectFET / D2PAK / SS08 / TOLL



TO-247



TO-247-PLUS

1 kW

3 kW

6 kW

< 10 kW

3-phase string inverter – Topology and device selection

Type	2-level	3-level NPC1	3-level NPC2	3-level ANPC
Topology				
PV array voltage	1000 V	1000 V	1000 V	1500 V
Blocking Voltage	1200 V	650 V	1200 V + 650 V	950 V / 1200 V
Discrete solutions	S1/S2: CoolSiC™ MOSFET / IGBT HighSpeed3 H3 / TRENCHSTOP™ IGBT 6 S6	S1/S4: IGBT TRENCHSTOP™ 5 S5 or H5 S2/S3: IGBT TRENCHSTOP™ 5 L5 / S5 D5/D6: CoolSiC™ Schottky Diode	S1/S4: CoolSiC™ MOSFET / IGBT HighSpeed3 H3 / TRENCHSTOP™ IGBT 6 S6 S2/S3: IGBT TRENCHSTOP™ 5 L5 / S5	Not recommended
Module solutions	DUAL, Easy 1B/2B (CoolSiC™ MOSFET)	3-level, Easy 1B/2B	3-level, Easy 1B/2B	3-level, Easy 2B (CoolSiC™ or S7/L7)
Gate driver solutions	EiceDRIVER™ Enhanced (1ED-F2) / EiceDRIVER™ 1ED Compact			



Discretes

10 kW



Easy 1B

30 kW



Easy 2B

100 kW

Central inverter – Topology and module selection

Type	2-level	3-level NPC1	3-level NPC2	3-level ANPC
Topology				
PV array voltage	1000 V	1500 V	1000 V	1500 V
Module configuration	DUAL	DUAL (x3)	DUAL + Common Emitter or Common Collector	DUAL (x3)
Module Package	62mm EconoDUAL™ 3 PrimePACK™ 3 PrimePACK™ 3+	EconoDUAL™ 3 PrimePACK™ 3 PrimePACK™ 3+	62mm	EconoDUAL™ 3 PrimePACK™ 3 PrimePACK™ 3+
Gate driver	EiceDRIVER™ Enhanced (1ED-F2) / EiceDRIVER™ 1ED Compact			



62 mm



EconoDUAL™ 3



PrimePACK™ 3



PrimePACK™ 3+

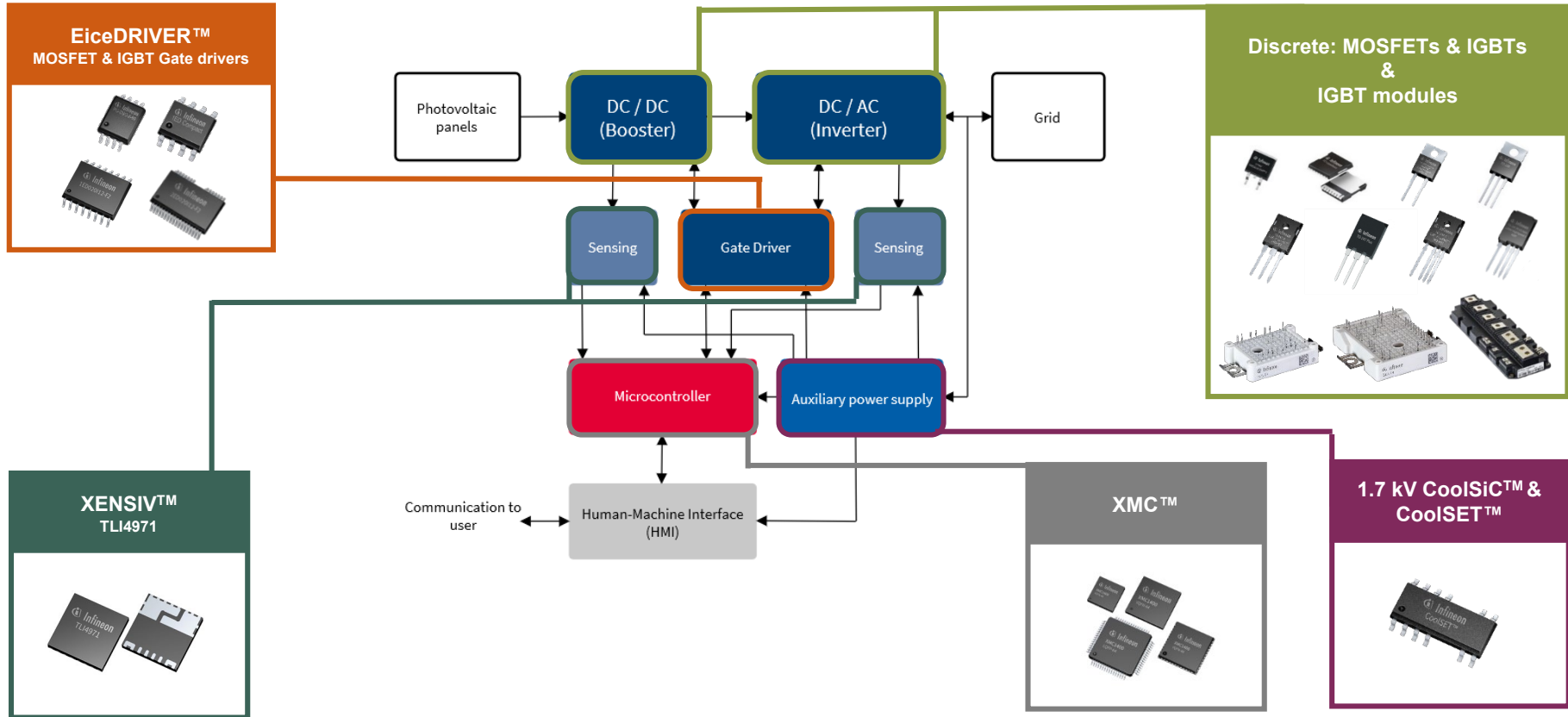
≤ 250 kW

≤ 500 kW

800 kW

≥ 1000 kW

Infineon product offerings for solar application



Benefit from optimal system solution



System expertise

Backed by our in-depth application know-how, we can reduce learning cycles and rapidly customize solutions with our proven short-flow processes. We are a partner during the whole design phase, also to support simulation (e.g. loss/junction temperature, cosmic reliability, and lifetime estimation).



Flexibility

With our broad portfolio of power semiconductors plus our expertise in leading technologies such as Silicon (Si), Silicon Carbide (SiC) and Gallium Nitride (GaN), we can customize chip technology and packaging to offer you the perfect solution for your photovoltaic inverter.



Scalability

We draw on the largest power manufacturing capabilities. We own our frontend and backend manufacturing facilities, which means we do not rely on third-party suppliers.



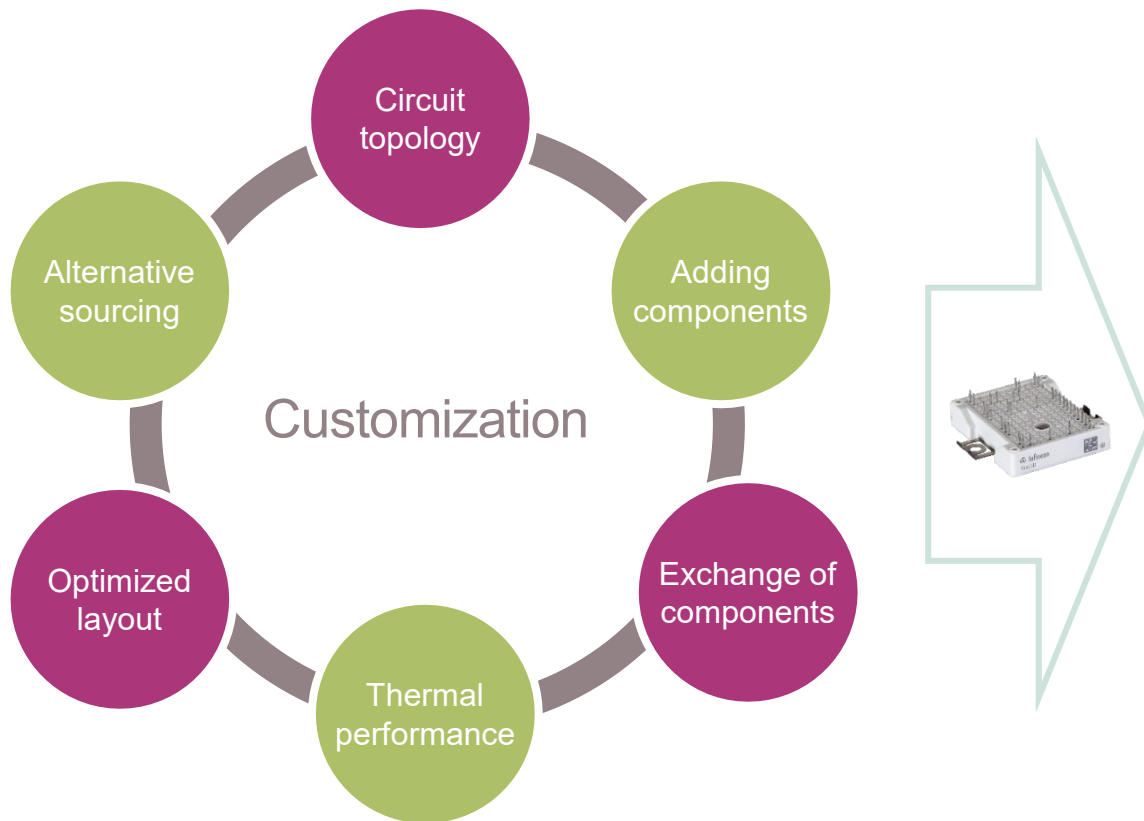
Quality

Our chips and modules are thoroughly tested to ensure they can withstand the harsh environmental conditions that photovoltaic systems are subject to. Our entire manufacturing process flow is designed to rigorous quality standards.

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Various possibilities to customize your module



Customer-specific solutions

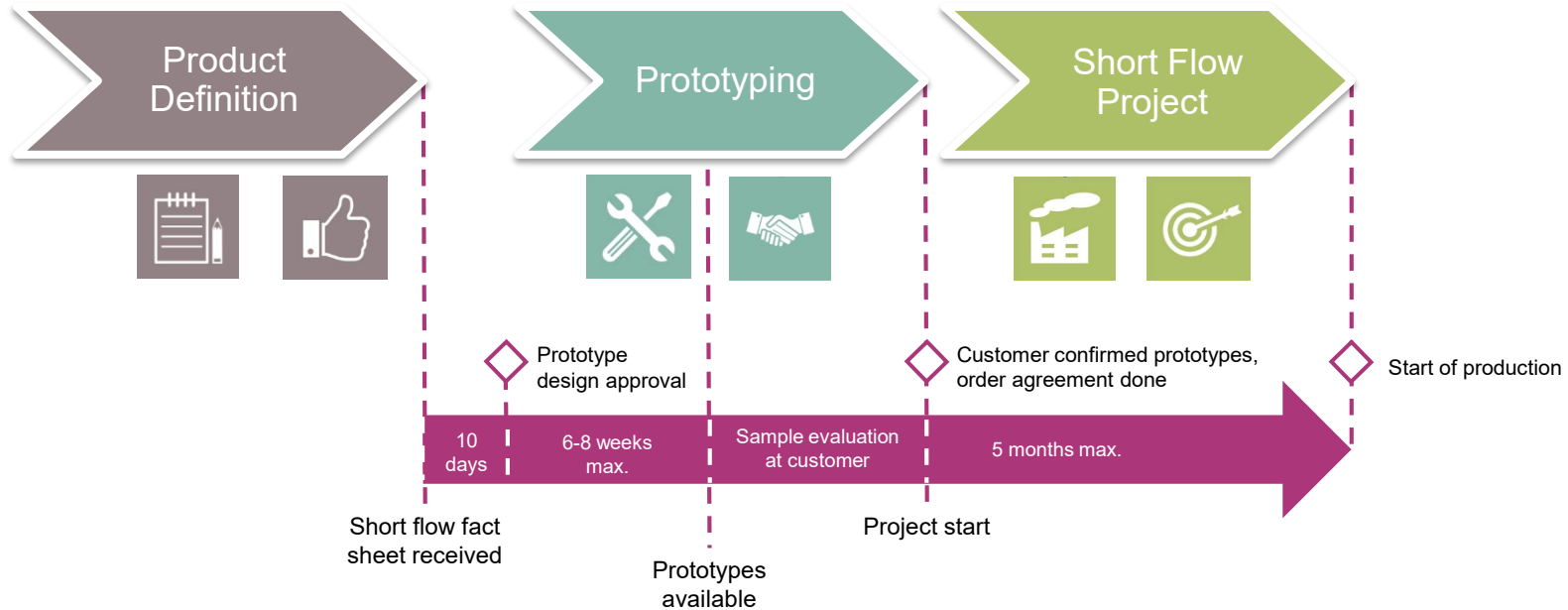


Fast sample availability



Fast ramp-up

Get your customized module in a five month timeframe



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Summary / Conclusion



The application can be categorized under three segments: Residential, commercial and utility scale



String inverter is gaining popularity in utility scale application, and covers the complete range of application



System cost and performance optimization are key driver, fast time to market and reliable delivery performance are key requirement.



Our unique system expertise and unmatched capabilities in power semiconductors make us the natural choice for every solar inverter solution.



Further support material



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- › [IGBT modules](#)
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- › [Microcontroller](#)
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Part of your life. Part of tomorrow.