APEC 2023
MARCH 19-23, 2023
ORANGE COUNTY CONVENTION CENTER | ORLANDO, FL

"GeneSiC high-speed, high-voltage SiC drives high-power innovation"

Dr. Ranbir Singh
EVP GeneSiC

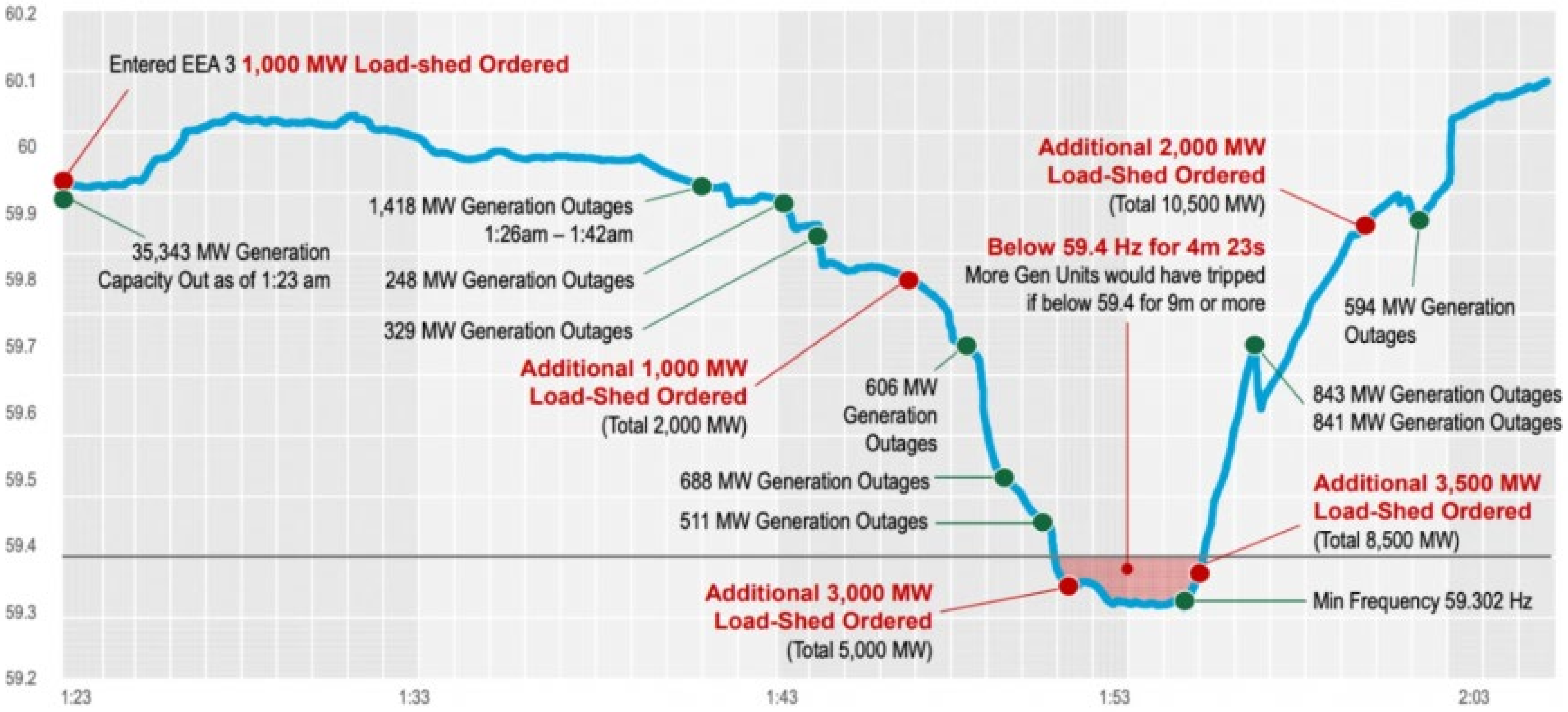
Navitas

Energy • Efficiency • Sustainability

Life Can Be Unpredictable.

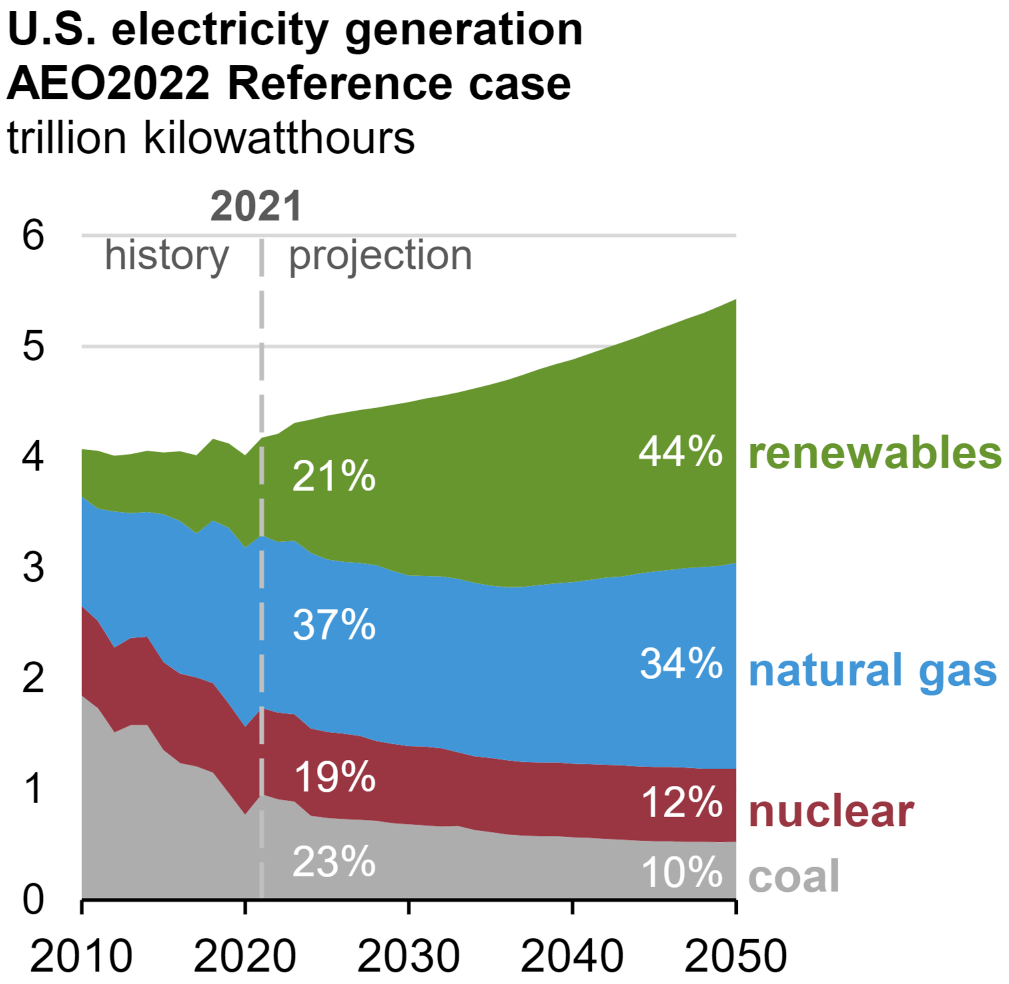
Navitas GeneSiC™

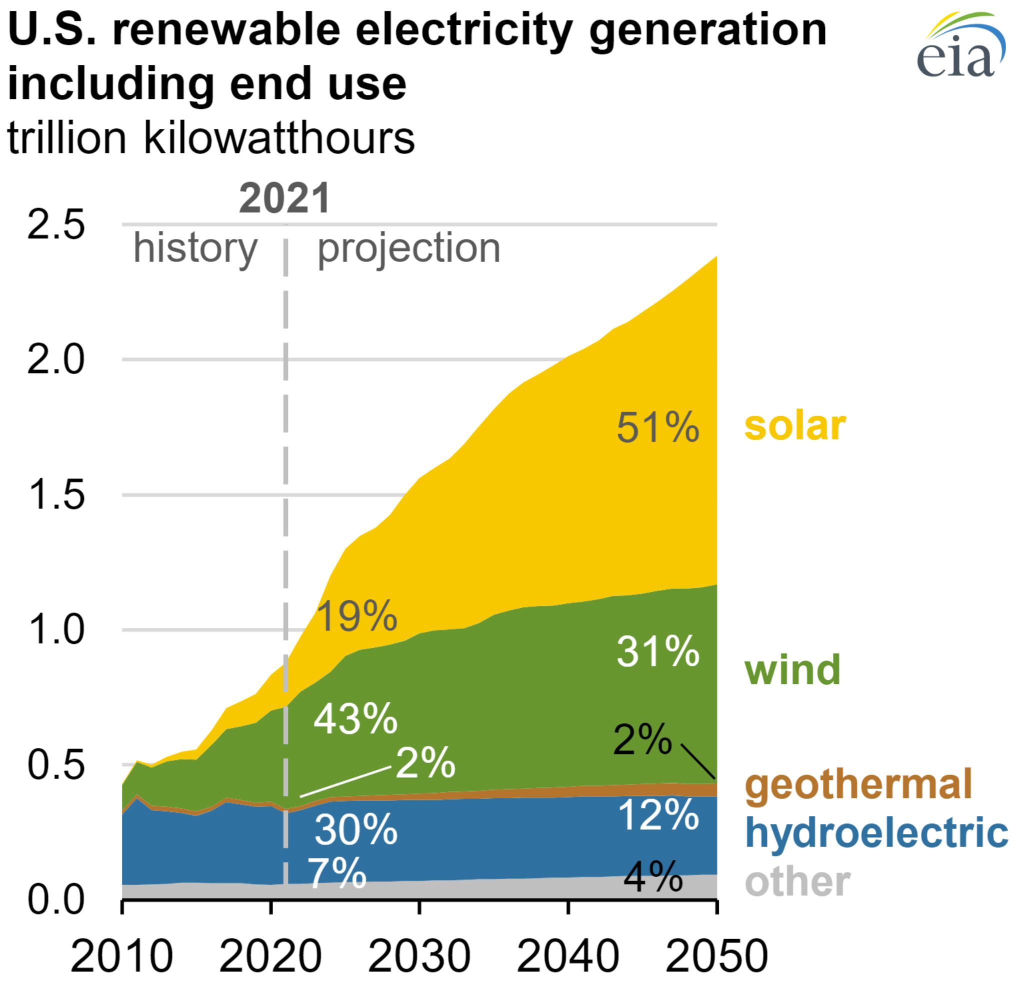
Texas Power Grid, February 21st 2021



Electric Reliability Corporation of Texas (ERCOT)
December xxx 2022, link

…and though Solar is a Growing Source of Power

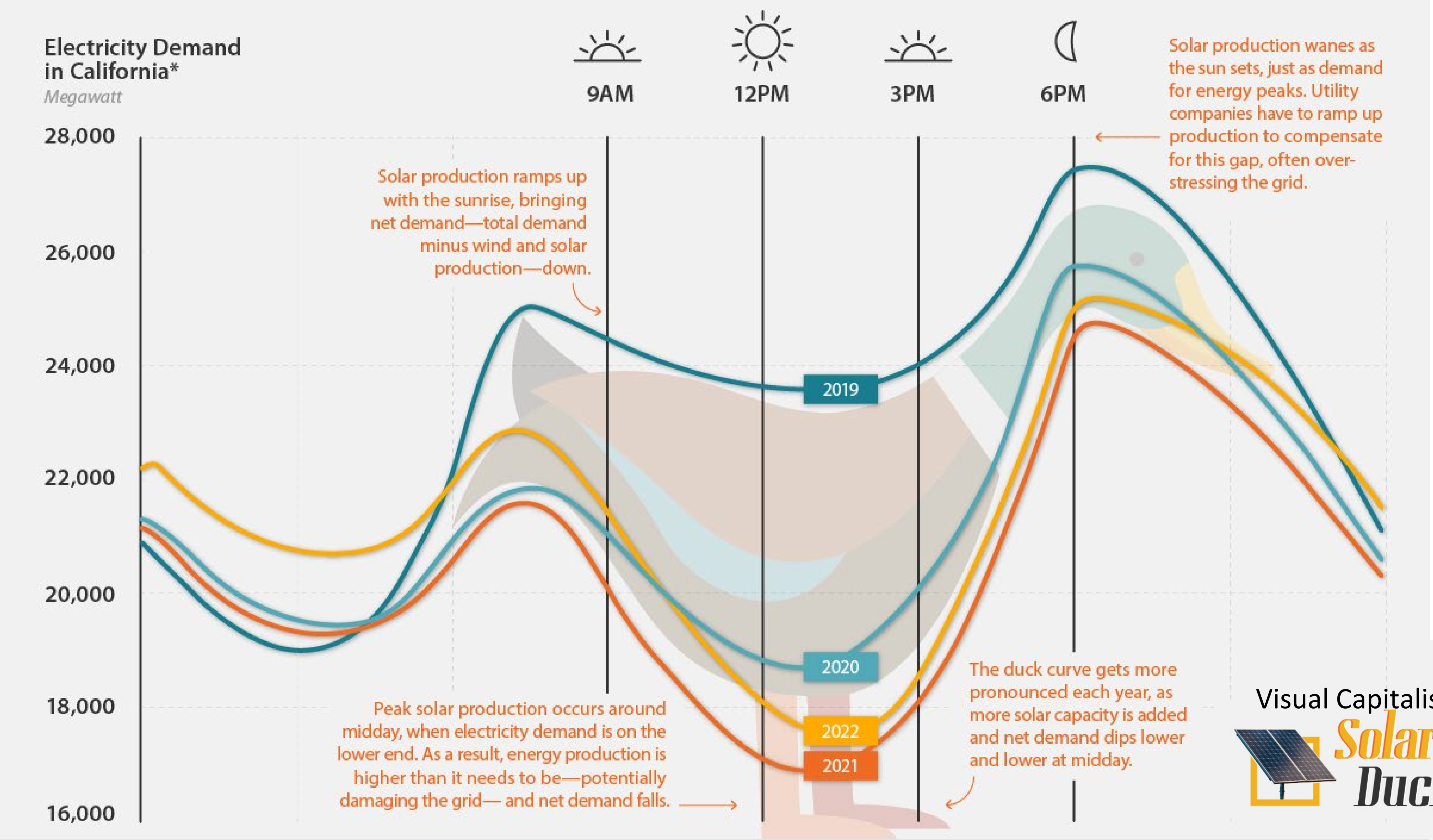




Source: U.S. Energy Information Administration, *Annual Energy Outlook 2022* (AEO2022)
Note: Biofuels are both shown separately and are included in petroleum and other liquids.

…Supply & Demand Don't Match

Navitas GeneSiC

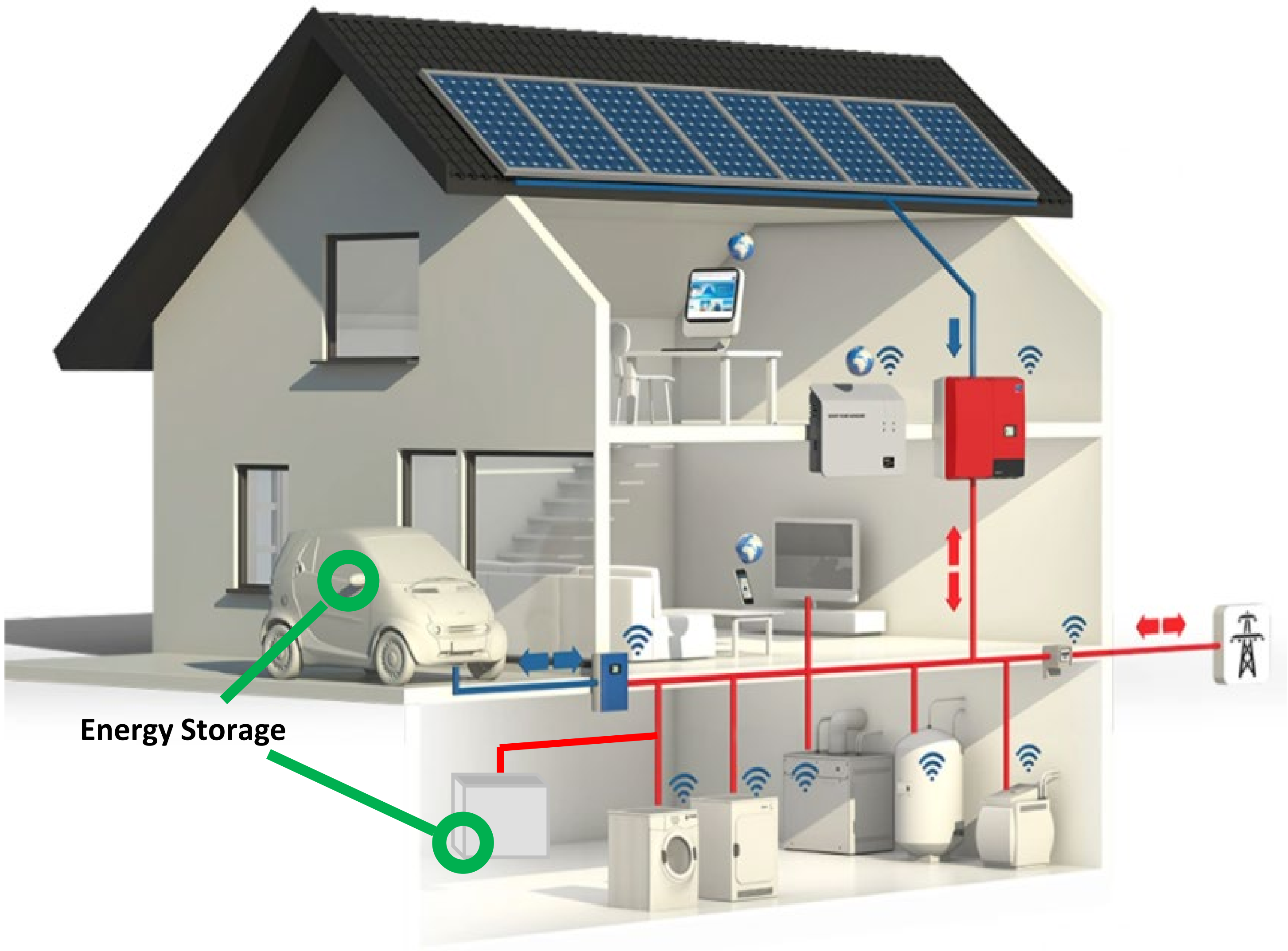


Visual Capitalist Elements

Solar Power Duck Curve

Domestic Micro-Grid with Energy Storage(s)

Navitas GeneSiC™



Battery Energy Storage System (BESS)

US storage/panel ‘attach rate’
+1.8x in 18 months

Energy storage available from

- Enphase
- Tesla
- Solaredge
- Toshiba
- GE, etc.

Bi-directional on-board chargers in:

- Nissan Leaf
- Ford F-150 Lightning
- Hyundai Ioniq 5
- Kia EV6
- Mitsubishi Outlander PHEV, etc.

GeneSiC™

Patented Trench-Assisted Planar SiC MOSFETs

Up to 6.5 kV

Largest range of SiC FETs & diodes
(650 V to 6.5 kV)

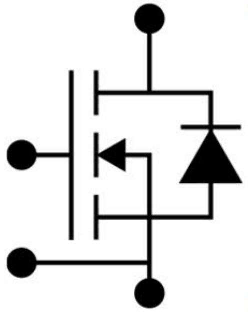
Fast Switching

Highest efficiency hard-switch, soft-switch
(Lowest E_{ON}, E_{OFF}, E_{ZVS} losses)

Cool Operation

Lowest $R_{DS(ON)}$ at high temperature
(25% lower than industry typical)

Cool. Fast. Rugged.



100%-Tested Robust Avalanche

Highest published capability to handle excess energy in fault condition

Long Short-Circuit Withstand Time

World-class survival duration in fault condition

High-Power Paralleling

Matching currents
(Stable V_{TH})

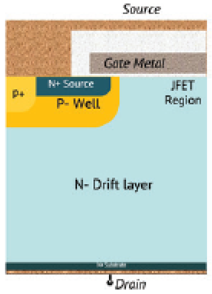
Based on Navitas testing of 1200V SiC MOSFETs vs. competitor products

SiC Strategies

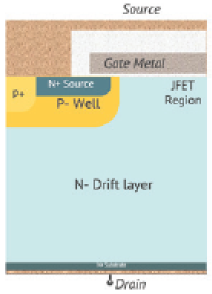
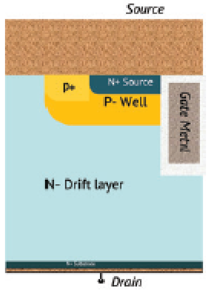
How has SiC progressed?

- *Performance*
- *Reliability*
- *Manufacturability*

The Planar Problem

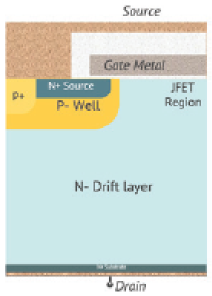
	Planar 
Manufacturability	» *Repeatable* » *High yield* » *Low cost*
Performance	» *High $R_{DS(ON)}$ / area* » *Slow switching* » *High $R_{DS(ON)}$ / Δ temp*
Reliability	» *Rugged gate oxide (stable V_{TH})*

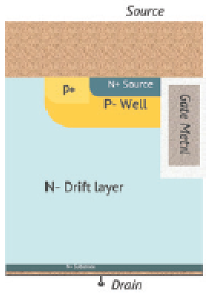
The Trouble with Trench

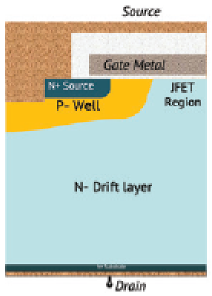
	Planar 	Trench 
Manufacturability	» Repeatable » High yield » Low cost	» Inconsistent trench etch » Lower yields » High cost
Performance	» High $R_{DS(ON)}$ / area » Slow switching » High $R_{DS(ON)}$ / Δ temp	» Lower $R_{DS(ON)}$ / area » Faster switching » High $R_{DS(ON)}$ / Δ temp
Reliability	» Rugged gate oxide (stable V_{TH})	» Failures due to non-uniform gate oxide » Lower short-circuit capability

Best of Both: Trench-Assisted Planar Gate

Navitas GeneSiC™







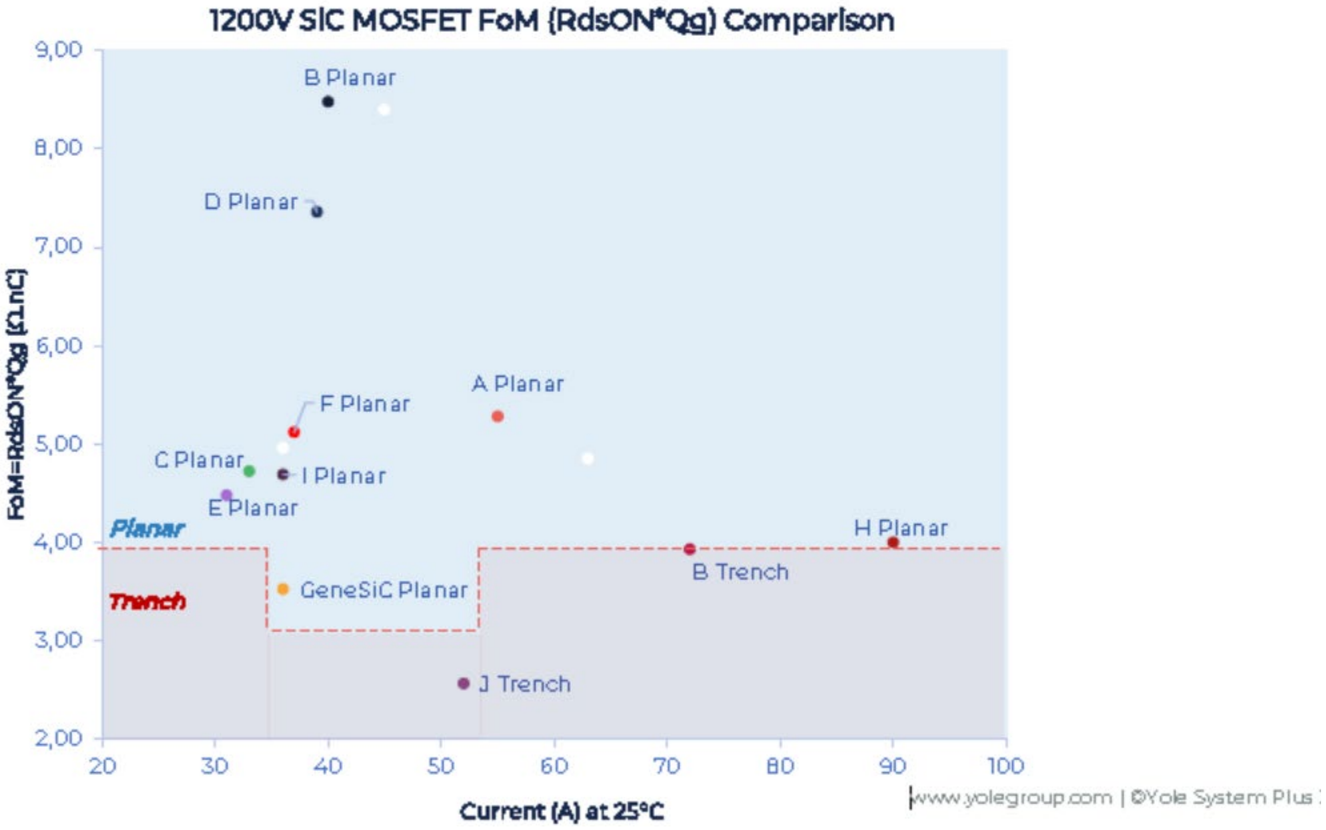
	Planar	*Trench*	*GeneSiC*
Manufacturability	» *Repeatable* » *High yield* » *Low cost*	» *Inconsistent trench etch* » *Lower yields* » *High cost*	» *Repeatable* » *High yield* » *Low cost*
Performance	» *High $R_{DS(ON)}$ / area* » *Slow switching* » *High $R_{DS(ON)}$ / Δ temp*	» *Lower $R_{DS(ON)}$ / area* » *Faster switching* » *High $R_{DS(ON)}$ / Δ temp*	» *Lower $R_{DS(ON)}$ / area* » *Fastest switching* » *Lowest $R_{DS(ON)}$ / Δ temp*
Reliability	» *Rugged gate oxide (stable V_{TH})*	» *Failures due to non-uniform gate oxide* » *Lower short-circuit capability*	» *Highest 100% tested avalanche* » *Long short-circuit withstand time* » *Rugged gate oxide (stable V_{TH})*

Yole SiC MOSFET Comparison shows GeneSiC FOM better than competitors Trench technology

Navitas GeneSiC™

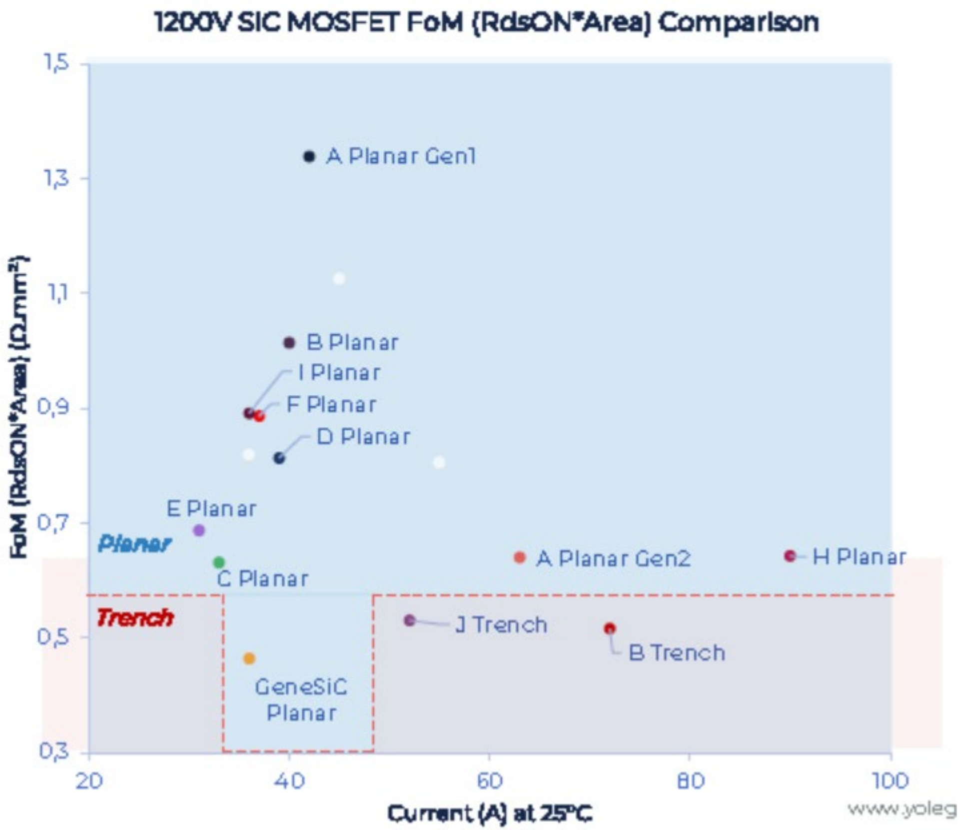
SIC TRANSISTORS PERFORMANCES - RDSON*QG FOM COMPARISON

Source: SiC Transistor Comparison , Yole SystemPlus, December 2021



SIC TRANSISTORS PERFORMANCES - RDSON*AREA FOM COMPARISON

Source: SiC Transistor Comparison , Yole SystemPlus, December 2021



Best High-Speed, High-Temp Performance

Navitas GeneSiC

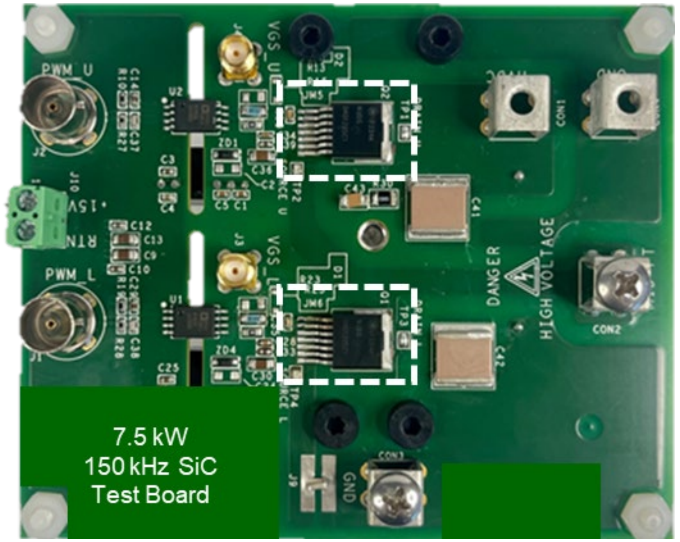
Supplier	Resistance		Energy Loss				Figure-of-Merit (*Low number is better*)	
	$R_{DS(ON)}$ @ 25°C (mΩ)	$R_{DS(ON)}$ @ 175°C (mΩ)	E_{ON} @ 25A (µJ)	E_{OFF} @ 35A (µJ)	E_{OSS} @ 800V (µJ)	E_{ZVS} E_{OFF}-E_{OSS} (µJ)	**Hard-Switching** R_{DS} @ 175°C x (E_{ON}+E_{OFF}) (Ω-µJ)	**Soft-Switching** R_{DS} @ 175°C x E_{ZVS} (Ω-µJ)
GeneSiC	40	57	600	80	34	46	**38.8**	**2.6**
#2	40	68	600	80	40	40	46.2	2.7
#3	40	80	850	390	35	355	99.2	28.4
#4	40	71	550	150	35	115	49.7	8.2
#5	45	85	520	65	29	36	49.7	3.1

Lowest power loss at high temp, high speed **=** ***Highest Efficiency, Energy Savings Small Size, Light Weight, Low System Costs!***

Reference 1,200V SiC FET, 40-45mΩ devices; GeneSiC = Trench-Assisted Planar G3R40MT12J; based on Navitas test result & competitive data sheet parameters.

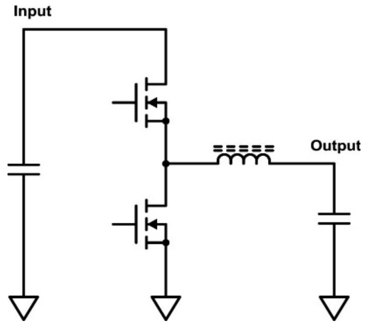
Faster, Cooler, Longer Lifetime

Navitas GeneSiC™

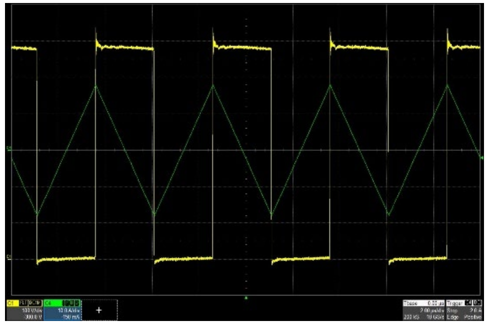


Test Board

- GeneSiC trench-assisted planar FET vs. Competitor SiC FET
  - 1,200 V, 40 mΩ, D2pak in half-bridge
  - Represents 7.5 kW DC-DC converter (e.g. data center, EV)
  - 150 kHz switching = ~10x faster than Si IGBT example
- GeneSiC: **>80% energy savings (>3,000 kWh/yr) *vs Si IGBTs***
  -25°C cooler = 3x longer life *vs other SiC*
  (reduced maintenance / repair costs)



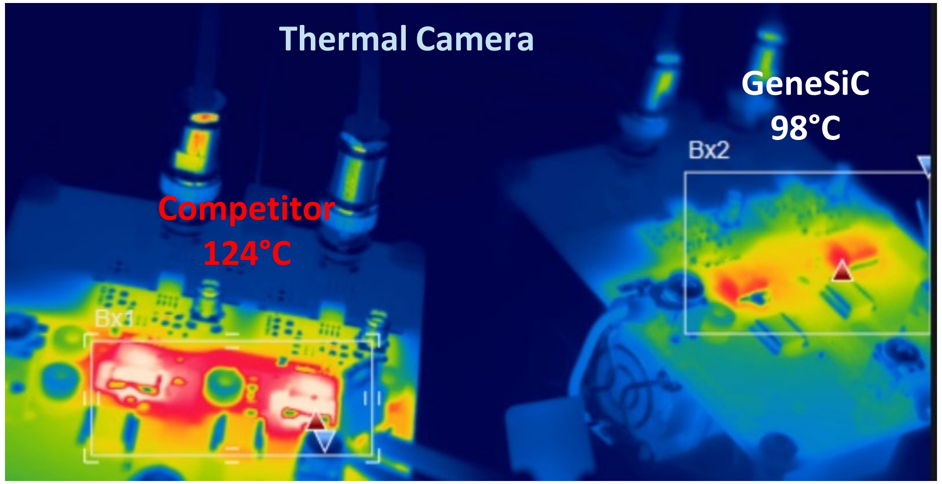
Test Circuit
(1-phase of 3-phase motor drive)



Switching Waveforms
(40 A pk-pk, 20 A turn-off}

Competitor SiC
45 W system loss

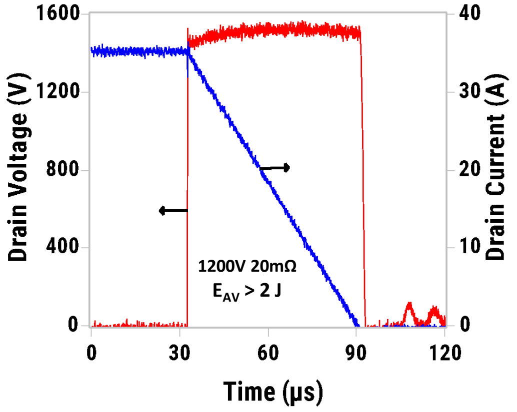
GeneSiC
40 W *system* loss
-30% *SiC* loss



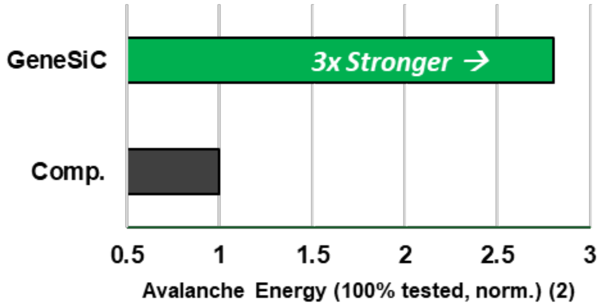
High Quality, High Reliability

100%-Tested Avalanche

Highest published capability to handle excess energy in fault condition

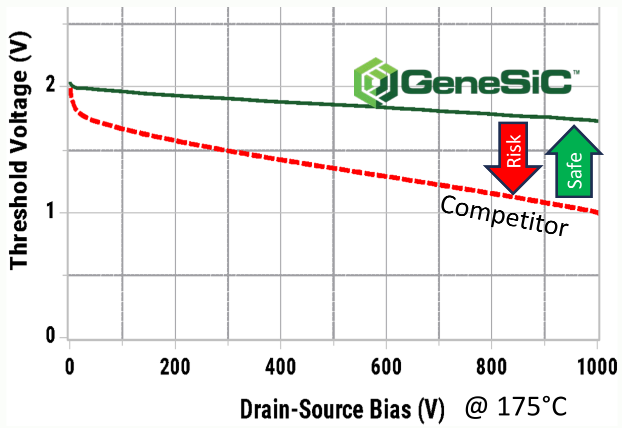


Critical in applications like motor drives to withstand unclamped inductive load (UIL) energy dump in situations like motor open-circuit (O.C.)



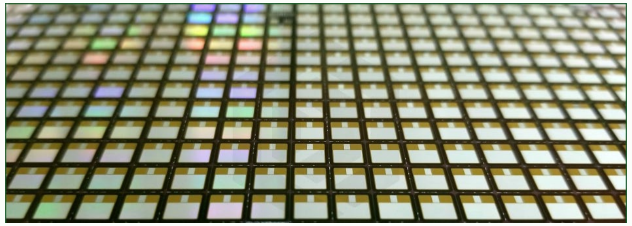
High Power Paralleling

Matching currents
(Stable V_{TH})



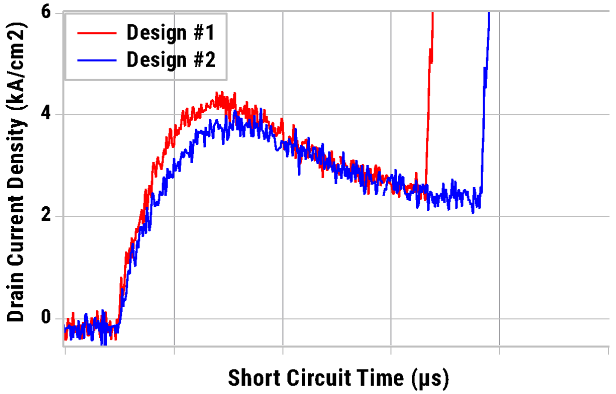
Competitor products allow threshold voltage to drop under high voltage, creating risk of turn-on error

GeneSiC packaged and bare-die FETs can be paralleled reliably for high-power applications

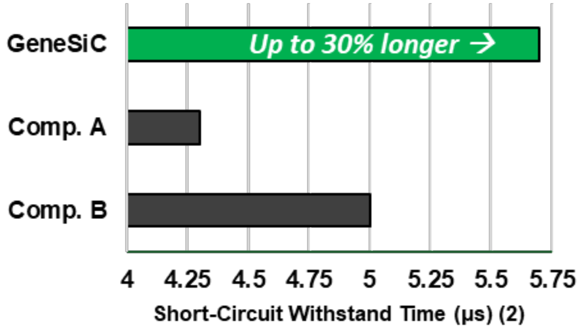


Long Short-Circuit Withstand Time

World-class survival duration in fault condition



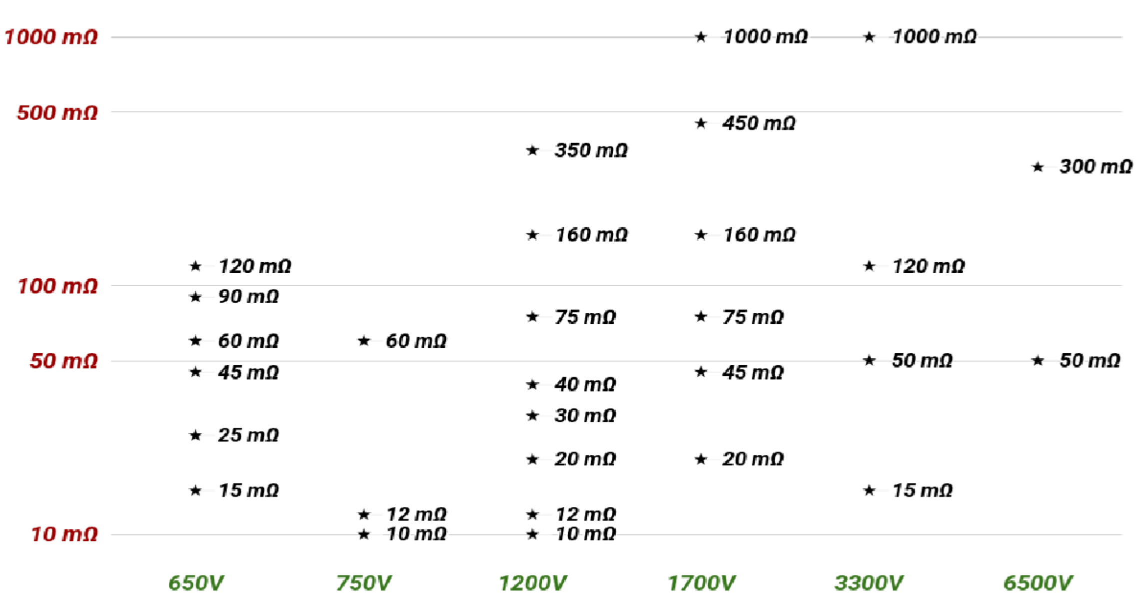
Critical to prevent failures like motor short circuit where the FET faces full voltage (V_{DD}) in ON-state.



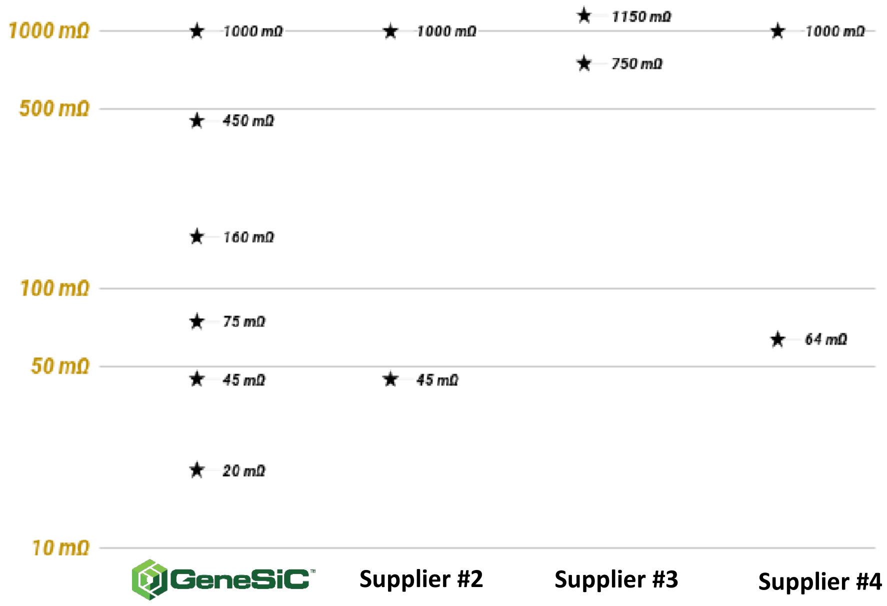
Broadest SiC FET Portfolio(1)

Navitas GeneSiC

GeneSiC 650–6,500V Trench-Assisted Planar SiC FETs



GeneSiC Most 1,700V SiC FETs

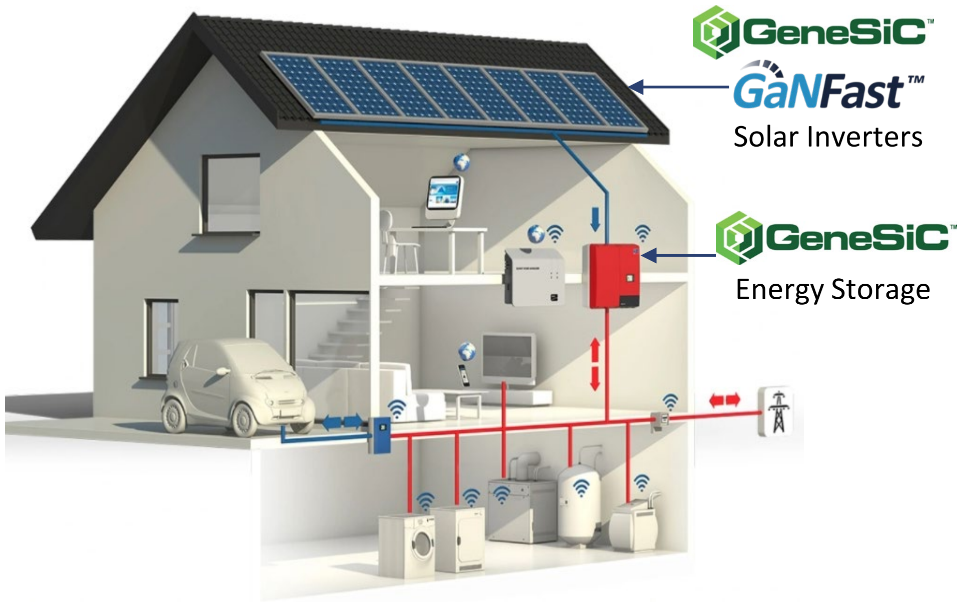


- 50+ SiC MOSFETs, array of standard packages
- Only supplier with 650V to 6,500V SiC MOSFETs
- Broadest industry offering for 1700V SiC MOSFETs

DO-214	TO-252-2	TO-263-7	TO-220-2	TO-247-2	TO-247-3	TO-247-4	SOT-227	Bare Chip

1) based on GeneSiC voltage range of production released SiC MOSFETs compared to all publicly identified voltage ranges of other SiC suppliers.

SiC in Solar & Energy Storage



25°C cooler with GeneSiC

Customers in Development, Production

Advanced Energy, Alpha power solutions, ENPHASE, solaredge, GROWATT, CHNT, GOODWE, Steca A KATEK Brand, SUNGROW Clean power for all, EXIDE TECHNOLOGIES, KACO new energy.

Market Potential (2)

- Residential Micro >$1.4B (GaN)
- Residential String >$1.0B (SiC)
- Commercial String >$1.0B (SiC)
- Energy Storage >$1.25B (SiC) *(50% attach rate)*

Total = >$4.65B

Strength & Opportunities

- Solar up 3x 2022-2027, more capacity than natural gas by 2026, coal by 2027
- Inflation Reduction Act: >$50B to solar, storage and wind
- Bus voltages rising to 1,500V – matches GeneSiC 3,300V capabilit

(1) Navitas est. 6.2 kW residential installation with silicon inverter at 97.5%, GaN at 98.5% efficiency.
(2) Market estimates for 2030, based on DNV and Navitas analysis

SiC in EV: On-Board & Roadside

Navitas GeneSiC

>$11B/year Opportunity(1)
(On-board >$10B/yr + Roadside >$1B/yr)

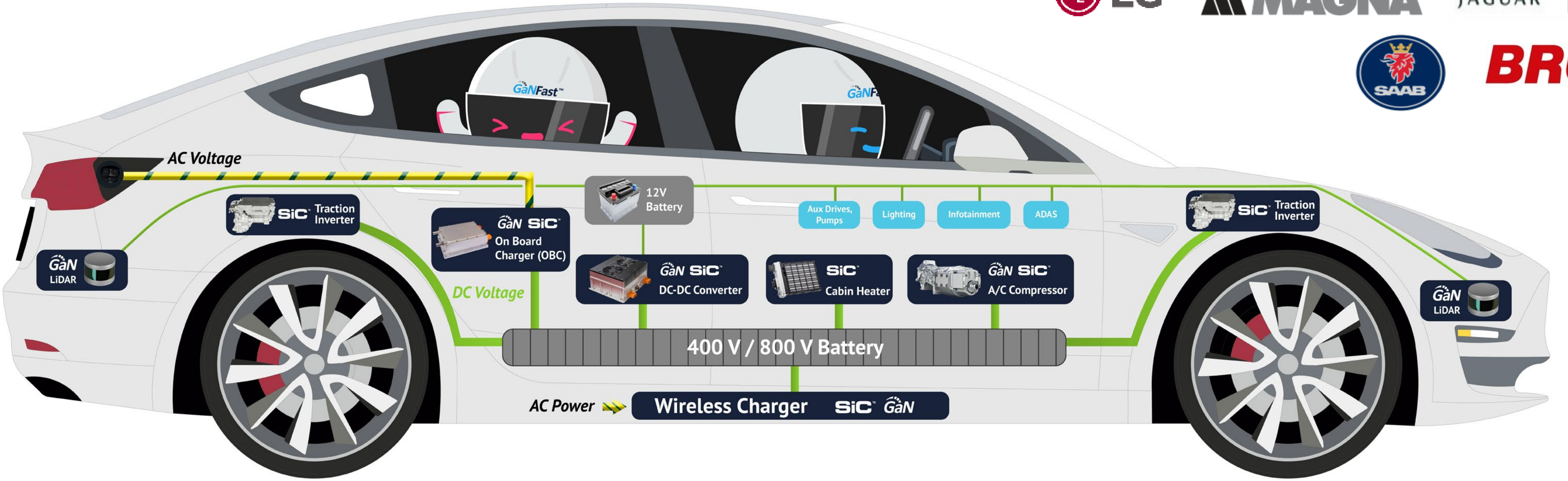
Customers in Production, Development

Mercedes AMG
BYD
INOVANCE
EVTECH 富特科技
SHINRY
GEELY
LG - MAGNA
JAGUAR
LAND ROVER
SAAB
BRUSA

Navitas EV System Design Center

- 5 platforms, for 10 customer projects, including:
- 400V, 800V and 6.6-22 kW, bi-di charger (2-in-1), bi-di + DC-DC (3-in-1)
- Increasing bus voltages play to Navitas 3,300 V strength

Navitas + Geely Joint EV Design Center



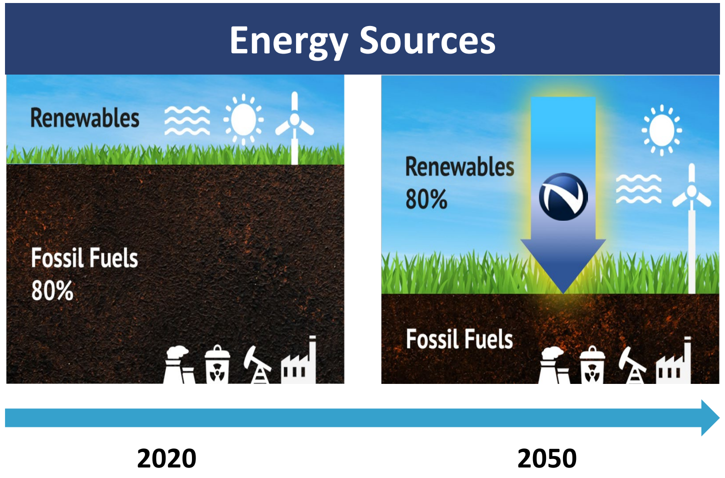
"10-80% charge in only 18 minutes!"(2)

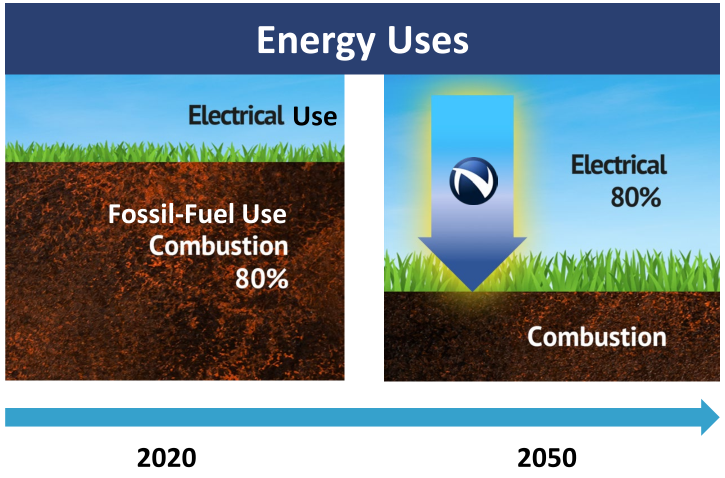
(1) Estimate 2030, 30M EV/yr, based on DNV and Navitas analysis. Note: Assumes 150 kW traction inverter, 100 kWh battery, $100/kWh battery cost and typical 230 mile range.
(2) Level 3 800V 350 kW DC charger 10-80% in 18 minutes for Genesis GV70 SUV

Mission: Electrify Our World™

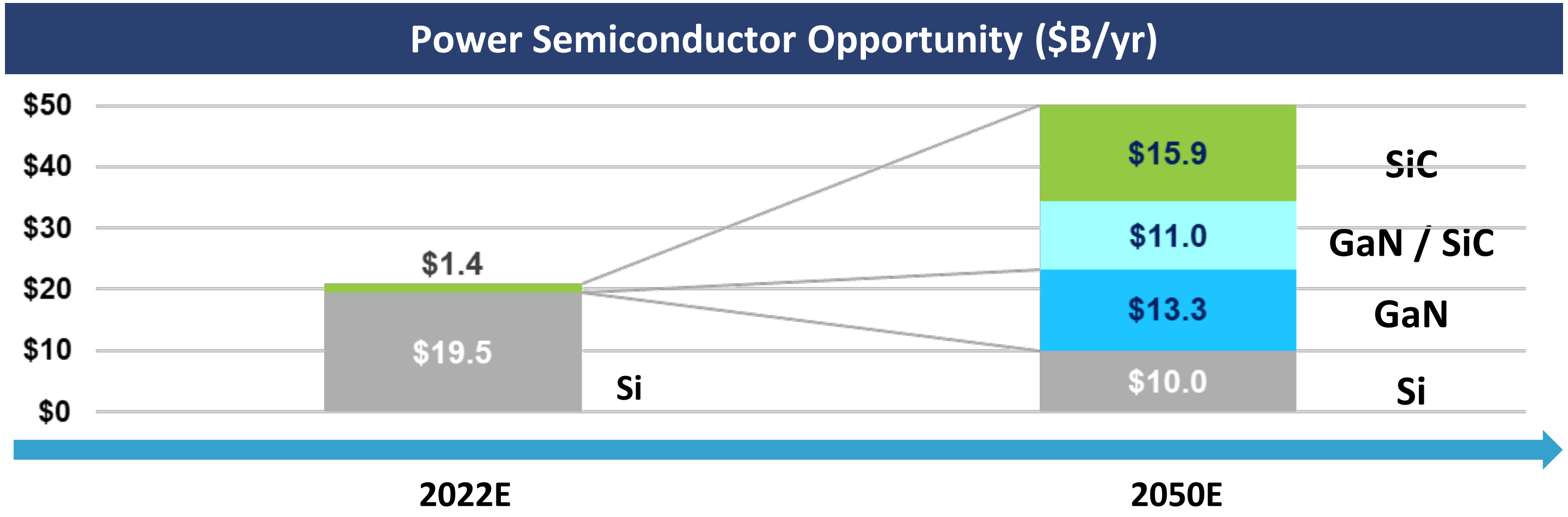
Navitas GeneSiC™

Energy sources and uses are being electrified…





…creating a $40B GaN + SiC opportunity by 2050



Fossil-fuel vs renewable ratios adapted from IRENA 2020 "Global Renewables Outlook".
Shift required to meet "Transforming Energy Scenario, 9.5 Gton target in 2050", per Paris Agreement's 1.5°C rise.
Market opportunity $ from Yole Développement, 2020 and Navitas analysis.

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