

# Electrify Our World™

How the Si to GaN/SiC Transition  
Accelerates Our Journey From Fossil Fuels



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**Guangzhou, November 2023**

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- On behalf of the Power Sources manufacturers' Association (PSMA)
- Thank you to the China Power Supply Society
- For the opportunity to present at this year's CPSSC
- We wish our long partnership to continue



- *To integrate power industry resources to profitably serve the needs of users, producers, industry stakeholders and all PSMA members.*

## Committees



Safety & Compliance



Energy Harvesting



Semiconductor



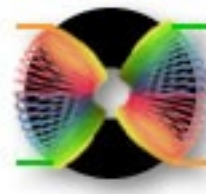
Transportation



Capacitor



Energy Management



Magnetics



Packaging & Manufacturing



Education



Energy Storage



Power Technology Roadmap



Reliability

## Conferences (Sponsor)



## (Co-sponsor)

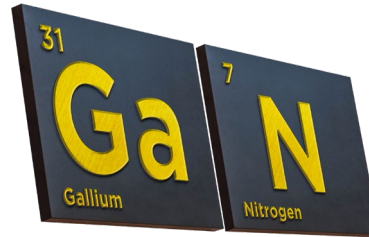


# Electrify Our World™

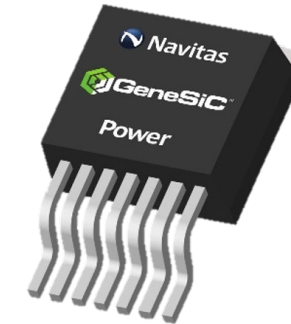
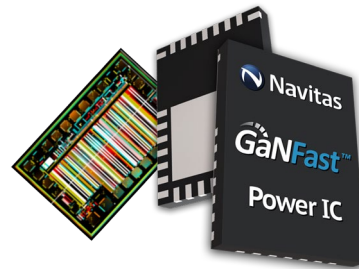
How the Si to GaN/SiC Transition  
Accelerates Our Journey From Fossil Fuels



## Technologies



## Products



## Applications



Navitas  
Efficiency to the Max  
240W SUPERVOOC CHARGE

realme

World's 1st 240 W Dual-GaN High-powered Charger  
2.34 W/cc Highest Power Density



4.6 kW

Navitas  
GeneSiC™  
Power

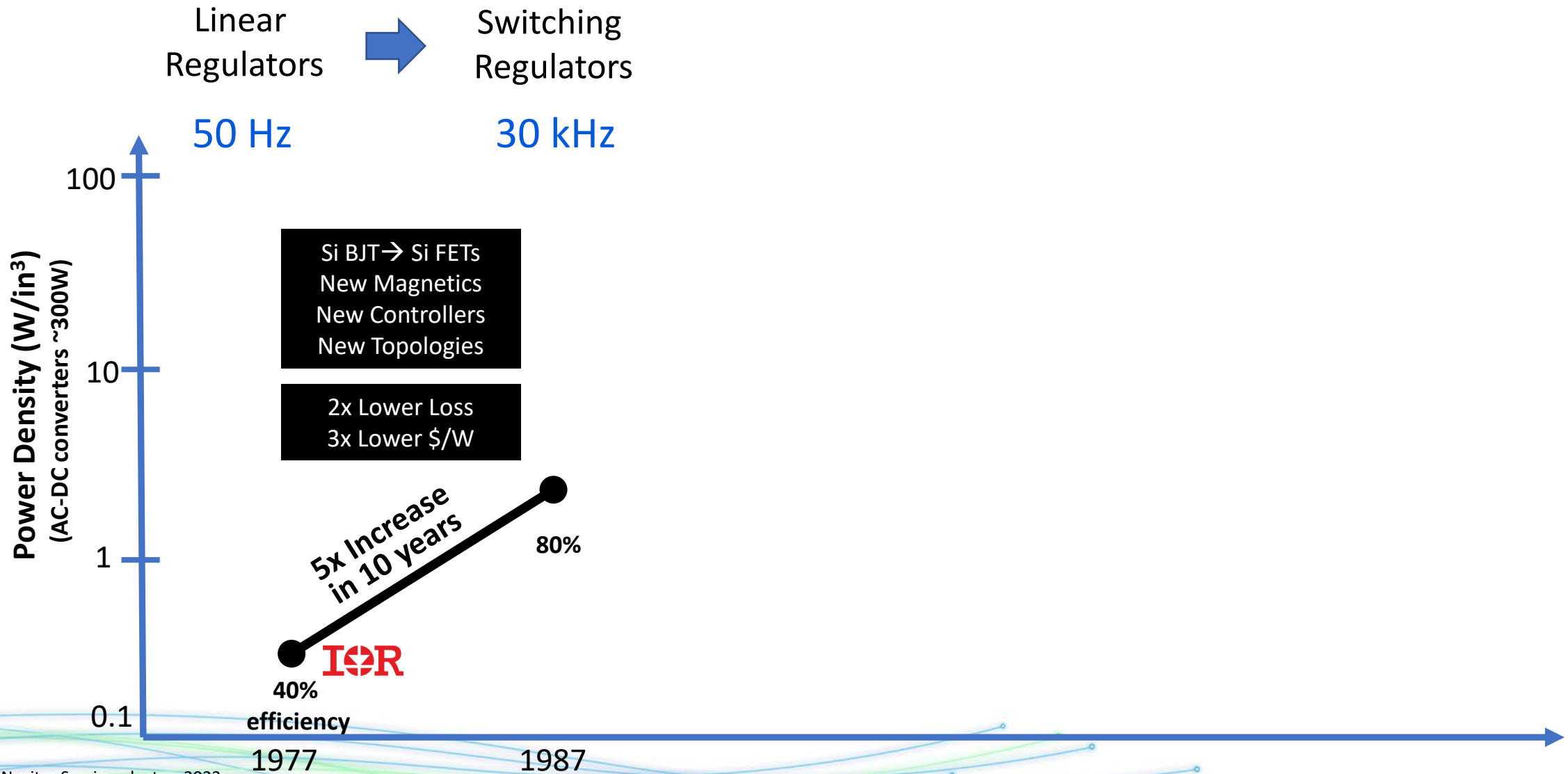
steca  
A KATEK Brand

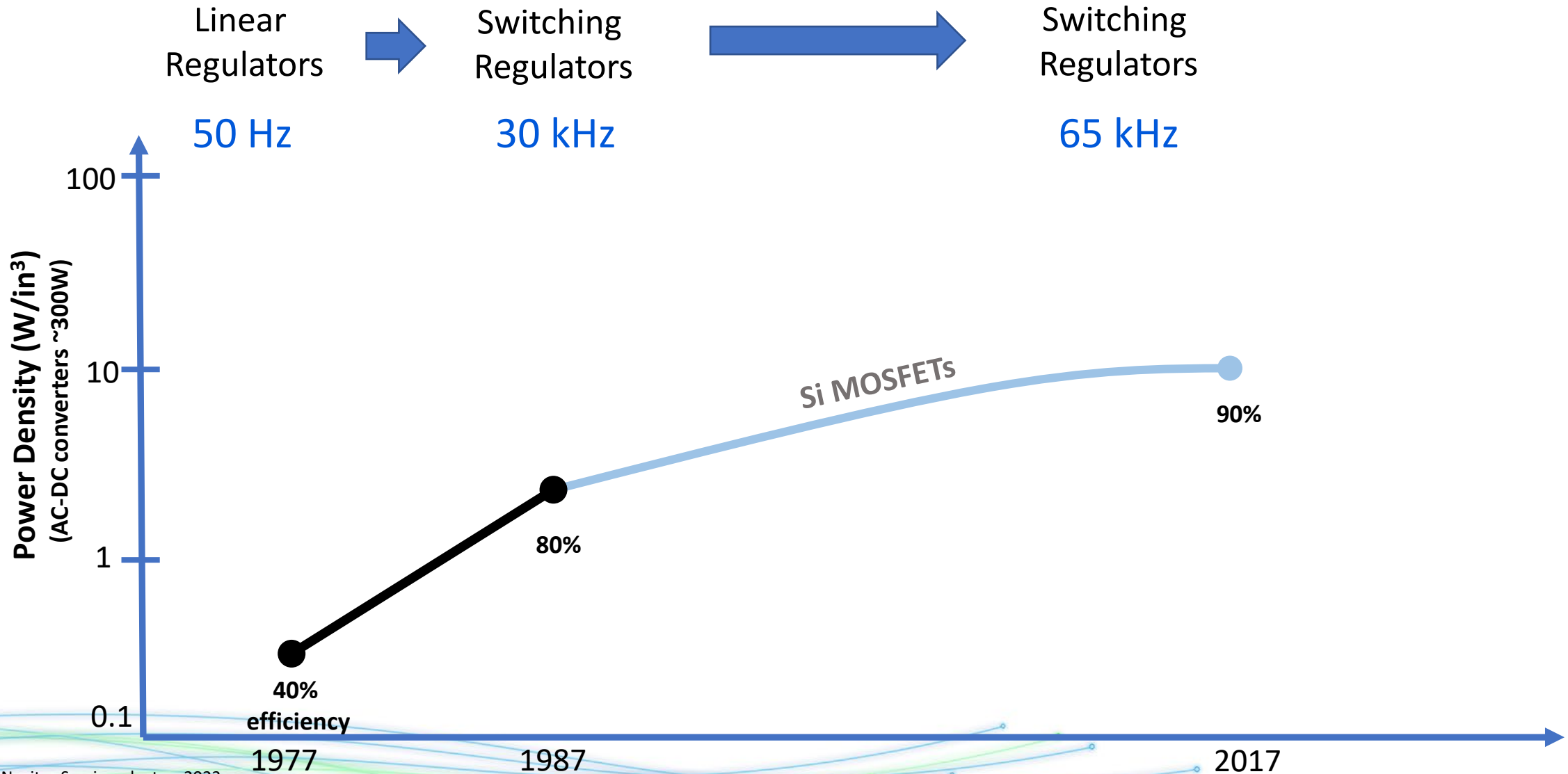


ZEEKR | VREMT

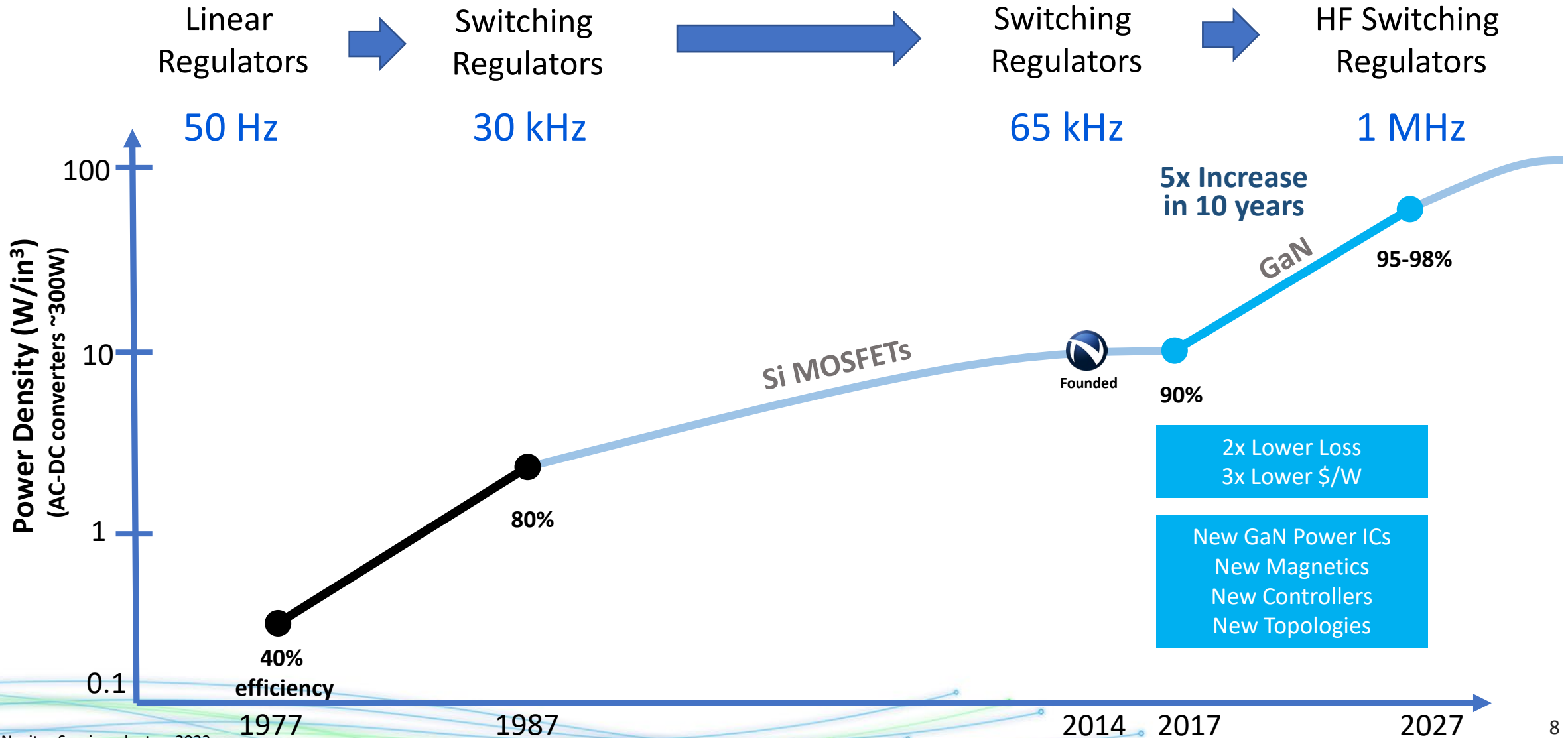
ZEEKR VREMT - Navitas Semiconductor  
Next-Generation Power Semiconductor Joint Lab

Navitas  
GaNFast™  
Power IC



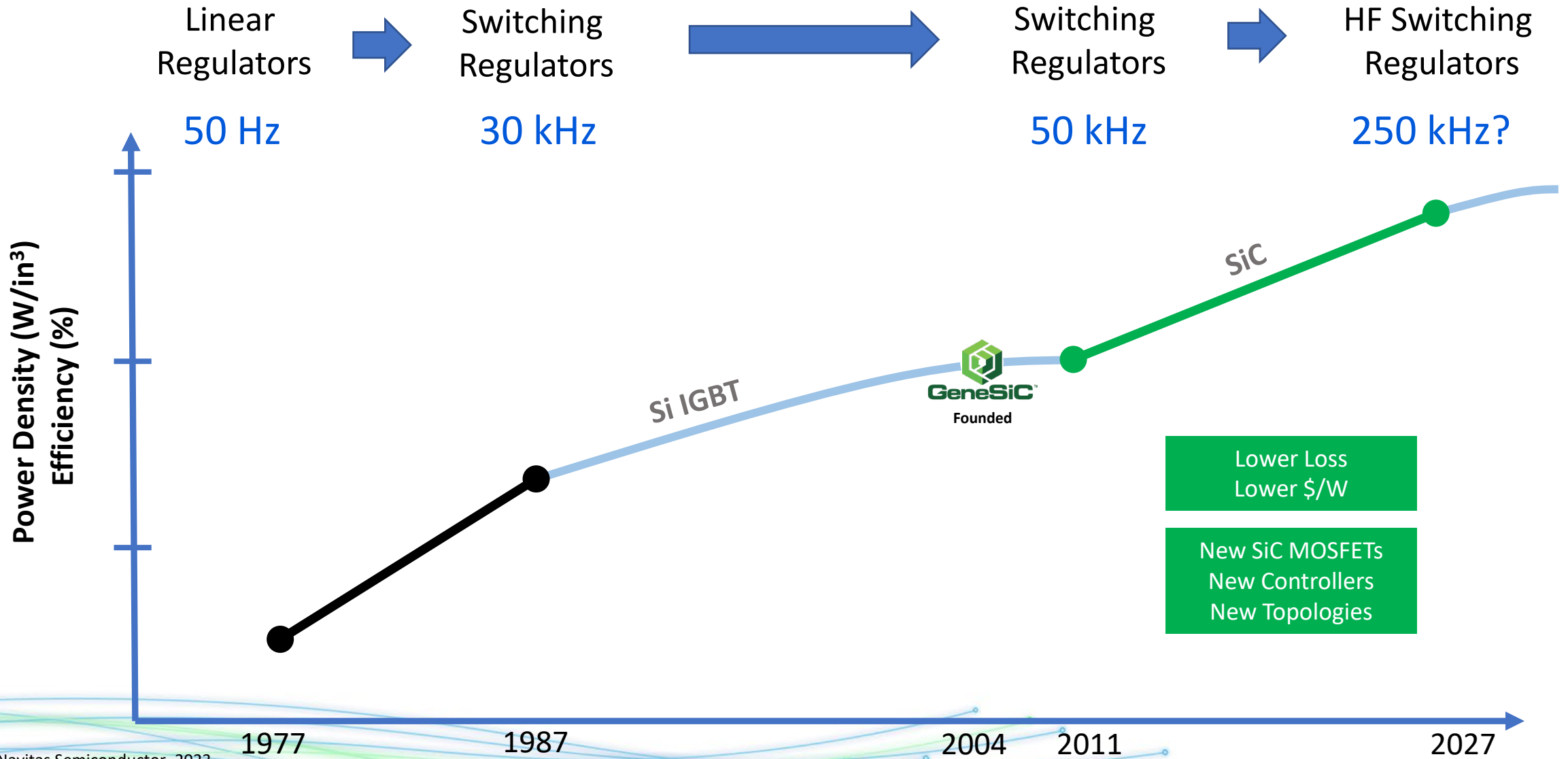


# Second Power Revolution (Si MOSFET → GaN)

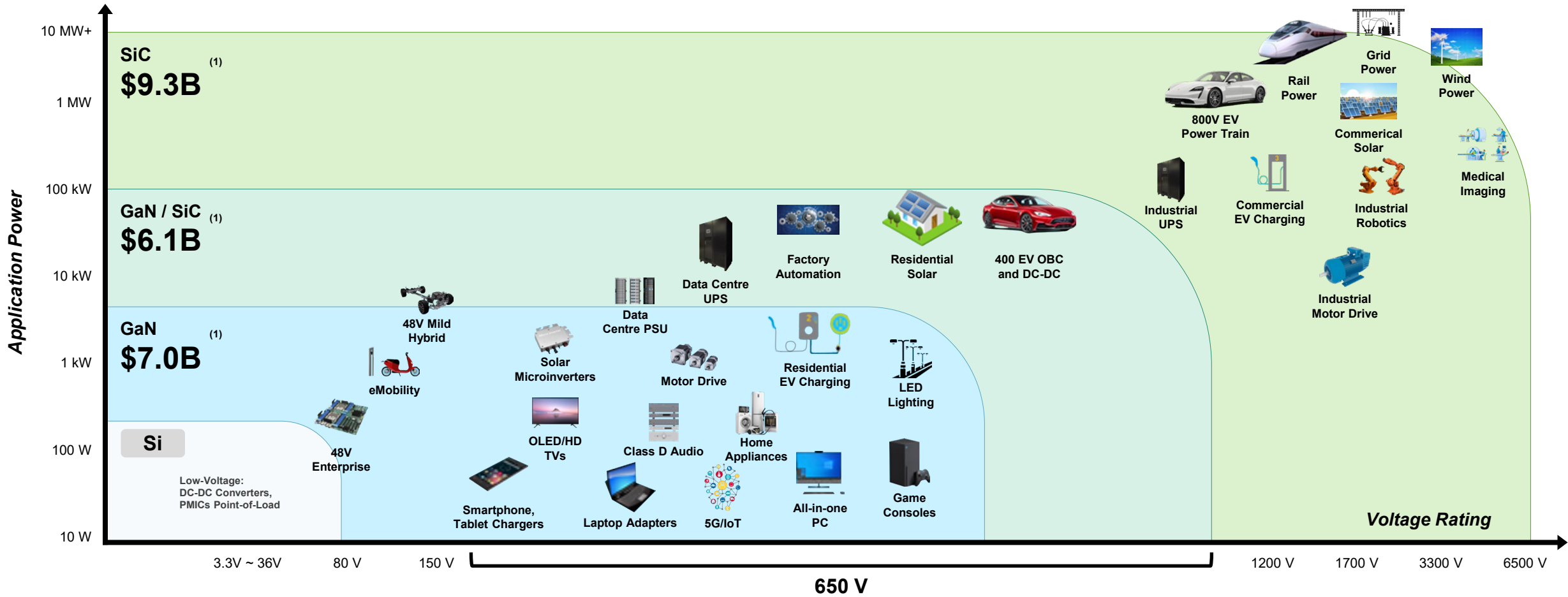




# Second Power Revolution (Si IGBTs → SiC)



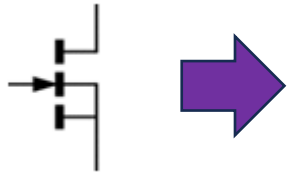
# \$22B+ 'Pure-Play' Potential Opportunity <sup>(1)</sup>



(1) Axes not to scale. Based on internal company estimates, Navitas believes that the potential market opportunity in 2026 is \$22B+ for GaN and SiC, replacing certain of the silicon market share

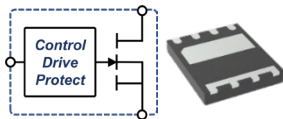
# The Revolution... in GaN

## Unprotected GaN



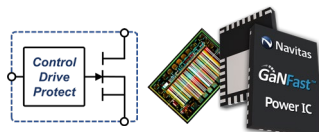
- Exposed gate
- External gate drive
- $dV/dt$  sensitivity
- Layout sensitivity
- ESD sensitivity
- Unknown reliability
- Unknown robustness

## GaNFast™ Gen1.0



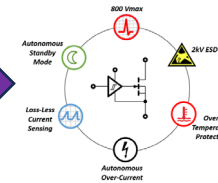
- ✓ Integrated gate drive
- ✓  $dV/dt$  immunity
- ✓ Layout insensitive
- ✓ 2KV ESD rating
- ✓ Proven reliability
- ✓ Proven robustness

## GaNFast™ Gen2.0



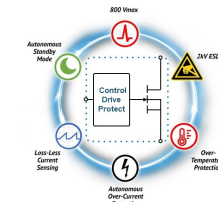
- ✓ Integrated gate drive
- ✓  $dV/dt$  immunity
- ✓ Layout insensitive
- ✓ 2KV ESD rating
- ✓ Proven reliability
- ✓ Proven robustness
- ✓ Larger cool pad&package

## GaNSense™ Gen3.0



- ✓ Autonomous standby
- ✓ Autonomous protection
- ✓ Loss-less current sensing
- ✓ High precision for current sensing
- ✓ High efficiency

## GaNSense™ Gen4.0

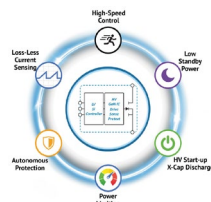


Smart  $dV/dt$  technology

- ✓ Autonomous standby
- ✓ Autonomous protection
- ✓ Loss-less current sensing
- ✓ High precision for current sensing
- ✓ High efficiency
- ✓ EMI improvement

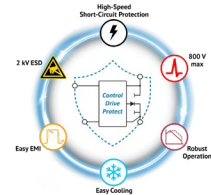
More integration  
More Features  
Easier to use  
Reduced BOM

## GaNSense™ Control Gen4.0



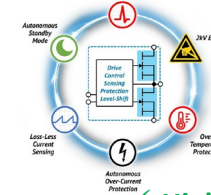
- ✓ Loss-less current sensing
- ✓ Autonomous protection
- ✓ High efficiency
- ✓ < 20mW stby power
- ✓ Multi-mode CCM/DCM + variable freq ctrl
- ✓ Fewest external components
- ✓ Smart  $dV/dt$  control easy EMI

## GaNSafe™ Gen4.0



- ✓ Autonomous standby&protection
- ✓ Thermal-enhanced with larger package
- ✓ TOLL PWM
- ✓ GaN safe
  - ✓ OTP setpoint 170C , SCP<=200ns
  - ✓  $dV/dt$  immunity , 2kv for all pin

## GaNSense Half-Bridge Gen4.0



Smart  $dV/dt$  technology

- ✓ Highest integration
  - ✓ integrated HS and LS FETs
  - ✓ Integrated level-shift isolation
  - ✓ integrated boot-strap
  - ✓ Shoot-through protection
  - ✓ Enlarged cooling pads
- ✓ Fastest switching
- ✓ Highest efficiency

## Discrete GaN Half-Bridge



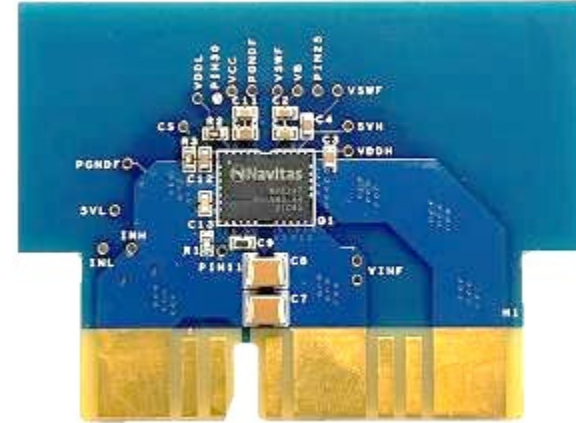
- 33 components
- 250 mm<sup>2</sup> footprint
- External HB driver HVIC
- External HV bootstrap
- 2x HV bypass diodes
- 2x external gate drives
- Exposed gates

61% fewer components

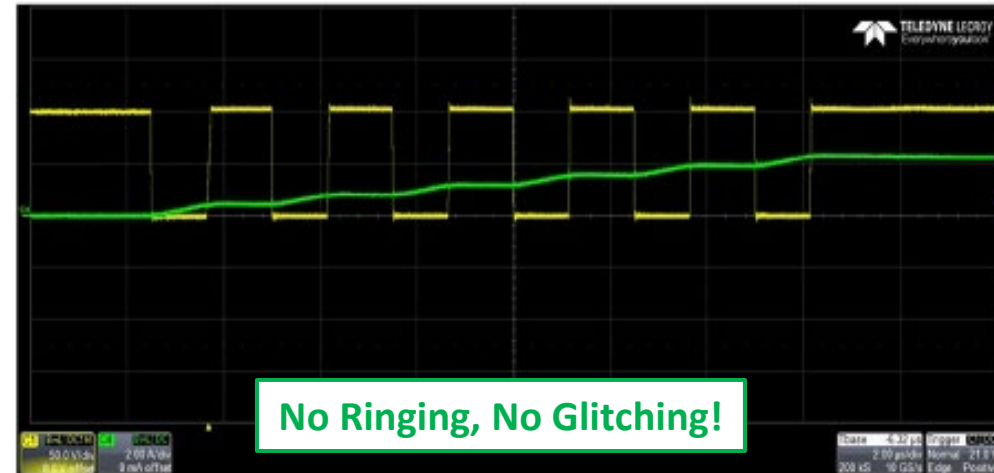
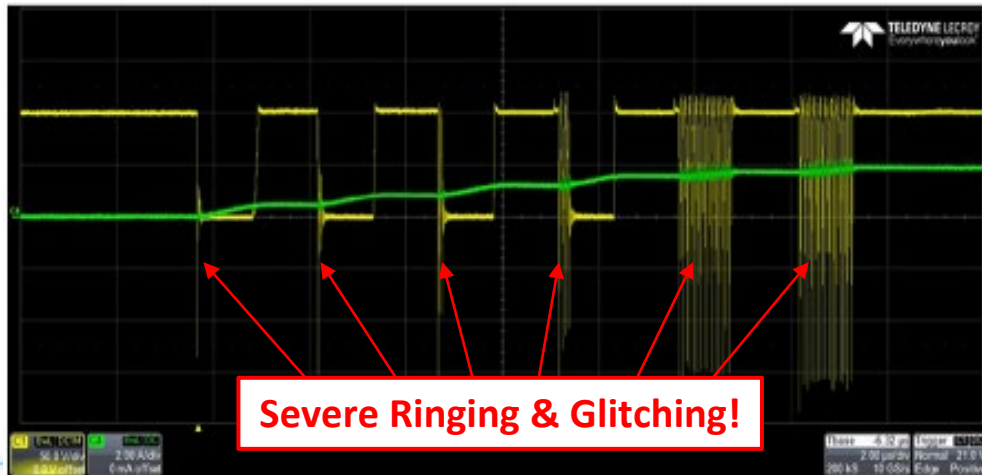
64% smaller footprint

Complete integration

## GaNSense Half-Bridge IC



- ✓ 13 components
- ✓ 90 mm<sup>2</sup> footprint
- ✓ Level shifters
- ✓ Bootstrap
- ✓ Gate drivers
- ✓ No exposed gates



**GaN MCM**  
**45W**



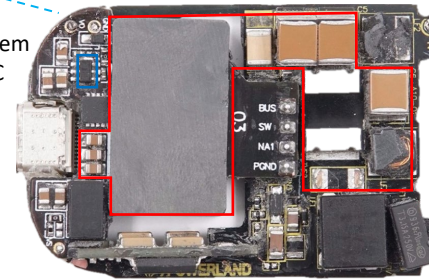
Passive Components



GaN Discrete in Multi-Chip-Module (MCM)

*Speed Shrinks Passives*

System IC



Passive Components

**GaN ICs**  
**50W**



System IC

GaN ICs

**65 kHz**  
**Bobbin Transformer (23 mm thick)**  
**Electrolytic Capacitors**  
52 x 53.1 x 30.1 mm = 83 cc Case + pins  
**0.5 W/cc**

6x Faster

3x Smaller

**400 kHz**  
**Planar Transformer (8 mm thin)**  
**No Electrolytic Caps**  
82.2 x 39.0 x 10.5 mm = 34 cc Case  
**1.5 W/cc**

(1) Samsung 45W charger (GaN MCM) vs. OPPO 50W SuperVOOC Cookie (Navitas GaN IC)

## Aftermarket Examples



## Tier 1 OEMs



260

GaN Chargers  
Mass Production<sup>(1)</sup>

150

GaN Chargers  
In Development<sup>(1)</sup>

100%

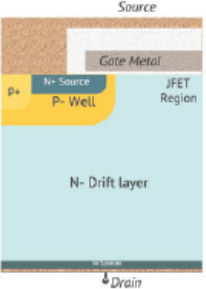
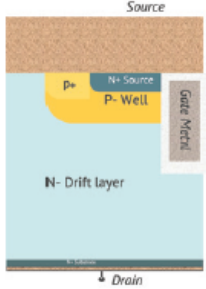
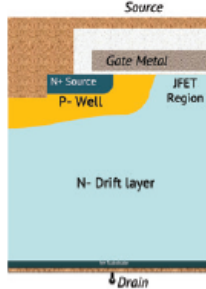
Top 5/5 Smartphone OEMs and  
Top 5/5 Notebook OEMs  
In Production with Navitas<sup>(2)</sup>

100M+

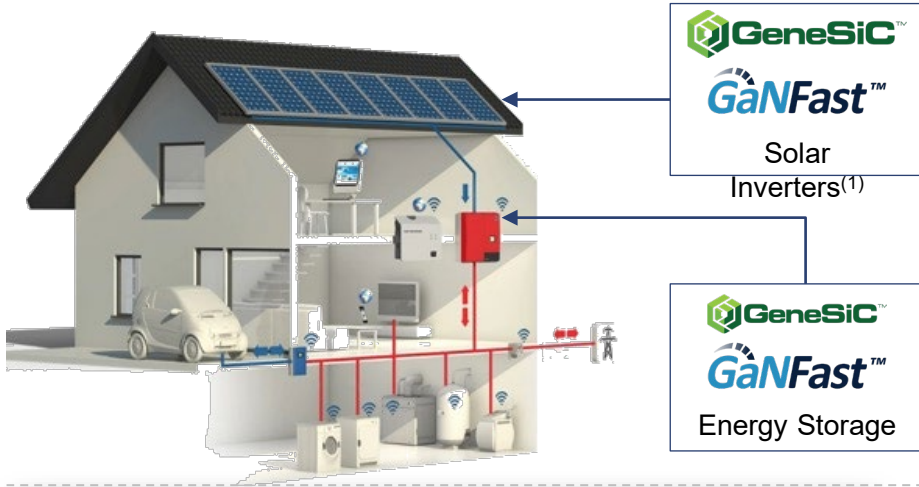
GaN ICs Shipped<sup>(3)</sup>

**Notes:**  
 1. As of 5/15/2023  
 2. Based on internal Navitas estimates of top mobile OEMs and their existing customer engagements  
 3. As of August 2023



	<p><b>Planar</b></p> 	<p><b>Trench</b></p> 	<p><b>GeneSiC</b></p> 
<b>Manufacturability</b>	<ul style="list-style-type: none"> <li>» Repeatable</li> <li>» High yield</li> <li>» Low cost</li> </ul>	<ul style="list-style-type: none"> <li>» Inconsistent trench etch</li> <li>» Lower yields</li> <li>» High cost</li> </ul>	<ul style="list-style-type: none"> <li>» Repeatable</li> <li>» High yield</li> <li>» Low cost</li> </ul>
<b>Performance</b>	<ul style="list-style-type: none"> <li>» High <math>R_{DS(ON)}</math> / area</li> <li>» Slow switching</li> <li>» High <math>R_{DS(ON)}</math> / <math>\Delta</math> temp</li> </ul>	<ul style="list-style-type: none"> <li>» Lower <math>R_{DS(ON)}</math> / area</li> <li>» Faster switching</li> <li>» High <math>R_{DS(ON)}</math> / <math>\Delta</math> temp</li> </ul>	<ul style="list-style-type: none"> <li>» Lower <math>R_{DS(ON)}</math> / area</li> <li>» Fastest switching</li> <li>» Lowest <math>R_{DS(ON)}</math> / <math>\Delta</math> temp</li> </ul>
<b>Reliability</b>	<ul style="list-style-type: none"> <li>» Rugged gate oxide (stable <math>V_{TH}</math>)</li> </ul>	<ul style="list-style-type: none"> <li>» Failures due to non-uniform gate oxide</li> <li>» Lower short-circuit capability</li> </ul>	<ul style="list-style-type: none"> <li>» Highest 100% tested avalanche</li> <li>» Long short-circuit withstand time</li> <li>» Rugged gate oxide (stable <math>V_{TH}</math>)</li> </ul>





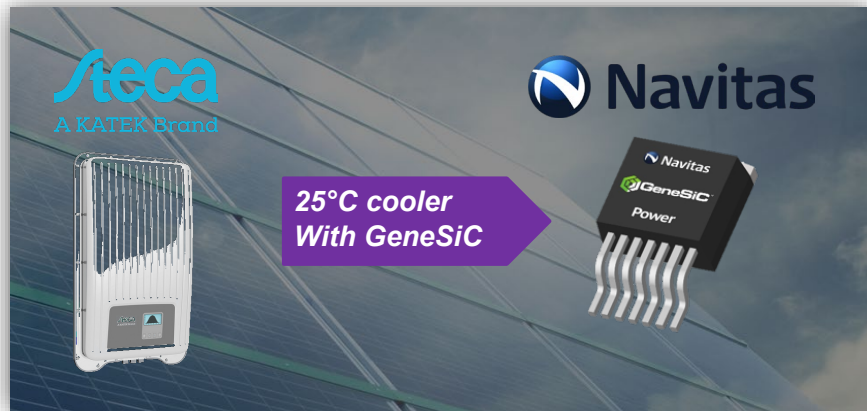
**>\$4.65B**  
Market Potential for GaN and SiC <sup>(2)</sup>

### 35 Customers in Production, Engagement<sup>(3)</sup>



### Navitas Strength & Potential Opportunities

- Solar up an estimated 3x 2022–2027, more capacity than natural gas by 2026, coal by 2027
- Inflation Reduction Act: >\$50B to solar, storage and wind <sup>(4)</sup>
- Navitas estimates that bus voltages will rise to 1,500V – matches GeneSiC 3,300V capability
- Immediate SiC revenue, GaN revenue starting from 2024



**Notes:**  
 1. Navitas est. 6.2 kW residential installation with silicon inverter at 97.5%, GaN at 98.5% efficiency  
 2. Based on internal Navitas estimates of the market potential by 2030.  
 3. Represent select potential customers Navitas is in discussions with currently. Representative logos do not indicate binding long-term agreements with any of the companies  
 4. Based on discussions with Navitas customers

## >\$11B/year Opportunity in 2030<sup>(1)</sup>

(On-board >\$9B/yr<sup>(1)</sup> + Roadside >\$1B/yr<sup>(1)</sup>)

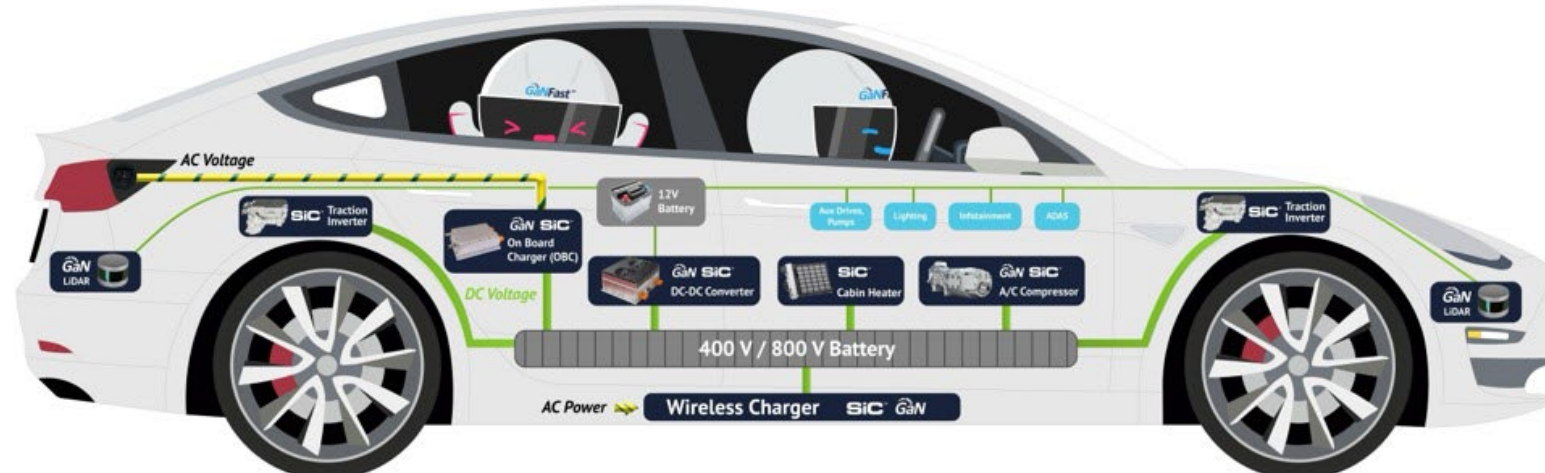
Immediate SiC revenue, GaN revenue from 2025

### Navitas EV System Design Center

- 5 platforms, for 10 pipeline opportunities<sup>(3)</sup>, including:
- 400V, 800V and 6.6–22 kW, bi-di charger (2-in-1), bi-di + DC-DC (3-in-1)

### Navitas + Geely Joint EV Design Center

## Customers in Production, Engagement<sup>(4)</sup>



**“10–80% charge in only 18 minutes!”<sup>(2)</sup>**

**Notes:**

1. Company internal 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.
  3. This reflects estimated potential future business based on interest expressed by potential customers for qualified programs, stated in terms of estimated revenue that may be realized in one or more future periods. Pipeline opportunity is not a proxy for backlog or future revenue or other measure or indicator of financial performance. Rather, Navitas uses customer pipeline as a statistical metric to indicate relative changes in future potential business across various product markets. Time horizons vary accordingly, based on product type and application.
  4. Actual business realized depends on ultimate customer selection, program share and other factors
4. Represent select potential customers Navitas is in discussions with currently. Representative logos do not indicate binding long-term agreements with any of the companies

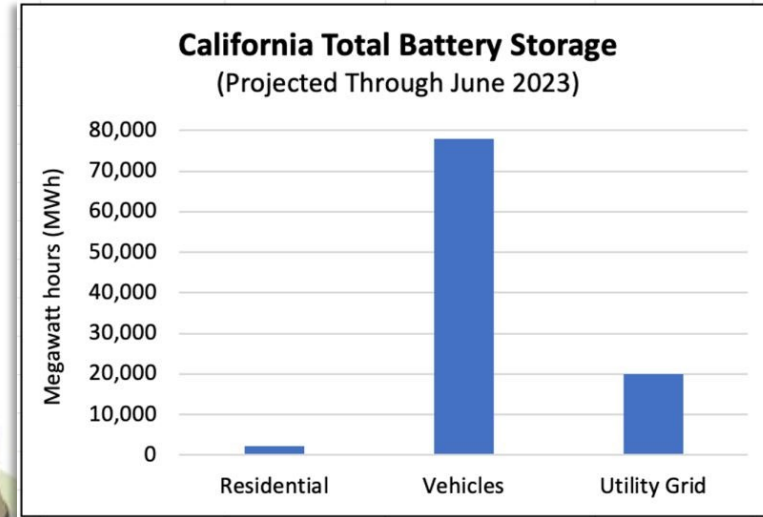
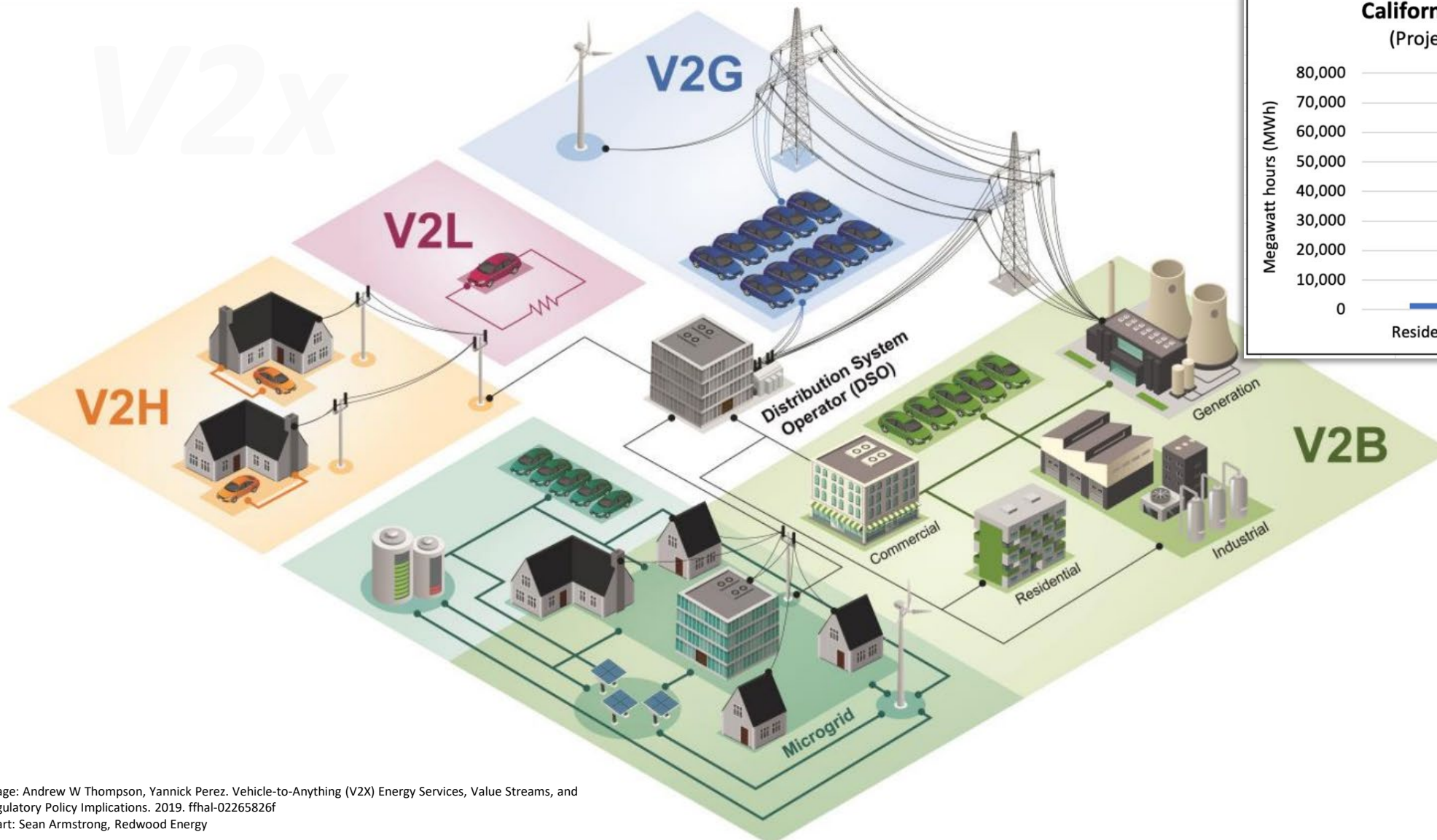


Image: Andrew W Thompson, Yannick Perez. Vehicle-to-Anything (V2X) Energy Services, Value Streams, and Regulatory Policy Implications. 2019. ffhal-02265826f  
 Chart: Sean Armstrong, Redwood Energy

Every **GaNFast™ IC**

saves

**4 kg CO<sub>2</sub>**



**4x-10x** lower component CO<sub>2</sub> footprint than silicon

**28% lower** lifetime CO<sub>2</sub> footprint for chargers / adapters

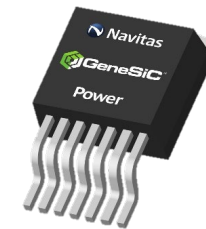
**Accelerates** transition from ICE to EV by **3 years**, saving **20%/yr** of road-sector emissions by 2050

GaN + SiC save up to **6 Gton / year** by 2050

Every **GeneSiC™ FET**

saves

**40 kg CO<sub>2</sub>**



May '22 World's first semiconductor company  
CarbonNeutral® certified



August '22 First 100,000 tons CO<sub>2</sub> saved  
(Over 200,000 as of November 2023)



October '22 Recognized for industry-leading  
sustainability reporting

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