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GEV ELECTRIFICATION
THE ENERGY-AI NEXUS

Reaping the opportunities while addressing the challenges

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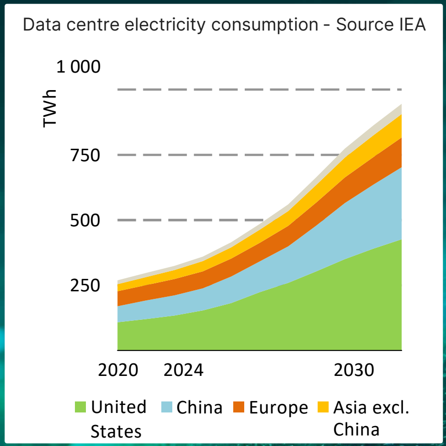
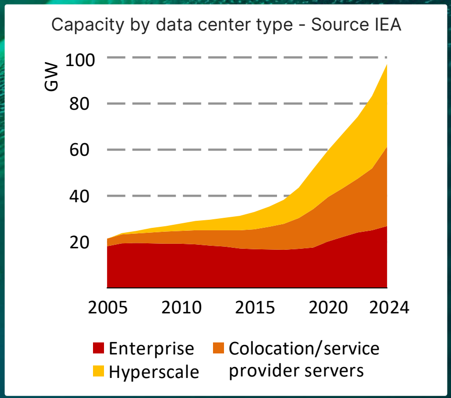
“THERE IS NO AI WITHOUT ENERGY. AT THE SAME TIME, AI COULD TRANSFORM HOW THE ENERGY INDUSTRY OPERATES.”

Source: IEA - Energy and AI

THE GROWING AI ENERGY DEMAND

- ✓ In 2024, data centers are estimated to consume approximately 415 terawatt hours (TWh) of electricity, representing about 1.5% of the world's total electricity usage. Over the past five years, this consumption has increased at an annual rate of 12%.
- ✓ Data centers require rapid grid connection, reliable power supply, fast supply chain, cost efficiencies and sustainability credentials.
- ✓ Hyperscalers are planning future data centers between 1 GW to 3 GW. Energy efficiency is key requiring new approaches such as switching from LV to MV to reduce losses and adopting new DC distribution architectures.
- ✓ AI factories drives GW scale systems with very complex loads experiencing steep ramps at very high frequency … brining new challenges in terms of quality, availability and grid supply stability.





Sources: US DOE, IEA, BofA, GEV internal analysis

HYPERSCALERS POWER NEEDS – WITH UNCERTAINTY

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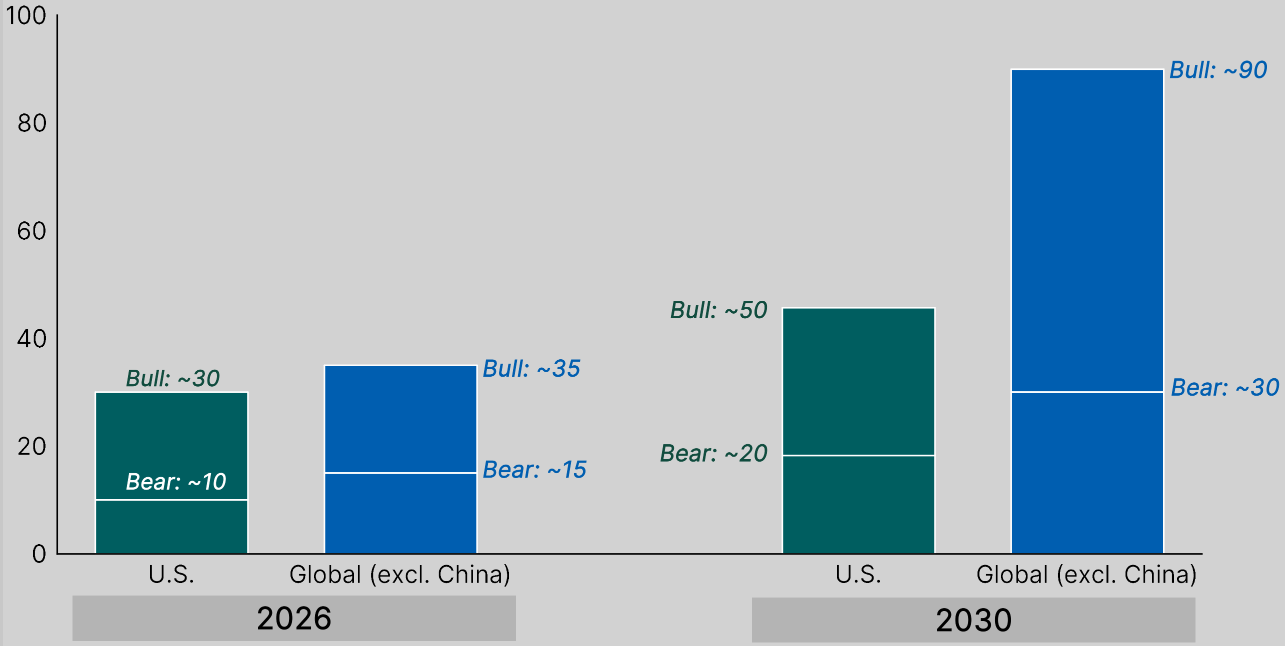
New data center primary power firm capacity required for hyperscalers est. to add 10-30 GW by ’26 / 20-50 GW by ’30 in U.S. and 15-35 GW by ’26 / 30-90 GW by ’30 Globally (excl. China)

New data center primary power firm capacity required for hyperscalers (GW)



Uncertainty around AI underlies wide 2030 range

Uncertainty is driven by:

- **Supply chain constraints** potentially delaying buildout in the near-term
- **Power efficiency gains** in GPUs and other data center infrastructure
- **How quickly the load shifts** from energy-intensive **AI model training** to comparatively energy efficient **AI inferences**
- **AI adoption levels** by end customers
- **Company response to increasing costs** of AI due to power and technology inputs
- Uncertainty around **sovereignty regulations**, which could drive rest-of-world demand

Note: GW numbers refer to total facility power and does not include backup / additional nameplate capacity needed (e.g., for wind / solar). Global refers to Global excluding China
Source: Goldman Sachs; Semianalysis, IDC; Market participant interviews

AI-DRIVEN POTENTIAL CONSTRAINTS AND CHALLENGES

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- BtM generation availability
- Long lead grid equipment
- Other supply chain constraints
- Demand estimation
- Grid capacity availability
- Interconnection queues
- Permitting challenges
- The good neighbor?

SPEED OF DEVELOPMENT IS KEY – ADVANCED GRID TO RACK SOLUTIONS ARE EMERGING

AI USE CASES FOR UTILITIES – A FEW EXAMPLES

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DEMAND

- Usage and Processes Optimization – Energy Savings
- Usage and Processes Optimization – Carbon Reductions

GENERATION

- Weather and Generation Forecasting
- Supply Chain Visibility and Optimization

GRID

- System Stability Analysis
- Vegetation Management

OPERATION

- Asset Health Monitoring
- Control Room Virtual Operator

AI-DRIVEN TECHNOLOGY ACCELERATION

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SMALL MODULAR REACTORS

Microsoft partners with **Constellation Energy** to restart the Three Mile Island reactor and invest in SMRs. **Amazon** collaborates with **X-Energy** and **Dominion Energy** on multiple SMR projects, including a $650 million data center campus and new SMR developments in Virginia and Washington. **Google** partners with **Kairos Power** to build up to seven SMRs by 2035. **Oracle** has plans to build three SMRs for future data centers.

GEOTHERMAL

Google leads with investments in enhanced geothermal projects, such as partnering with **Fervo Energy** on a pioneering geothermal plant in Nevada. **Microsoft** plans to build a geothermal plant in Kenya to supply one of its data centers and uses geothermal energy to heat and cool its expanded campus in Redmond, Washington.

NEW MATERIALS

- AI is accelerating new materials discovery for energy by using generative models and machine learning to rapidly **predict** and **design materials** with tailored properties. Tools like **DeepMind's GNoME** have identified millions of new stable crystals, vastly expanding the candidate pool for energy storage, catalysis, and clean energy technologies. **Generative AI** models can be used to suggest novel chemical structures and compositions for materials that could be used in DAC.

CASE STUDIES

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MVDC ARCHITECTURES

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Today... 6 conversion steps

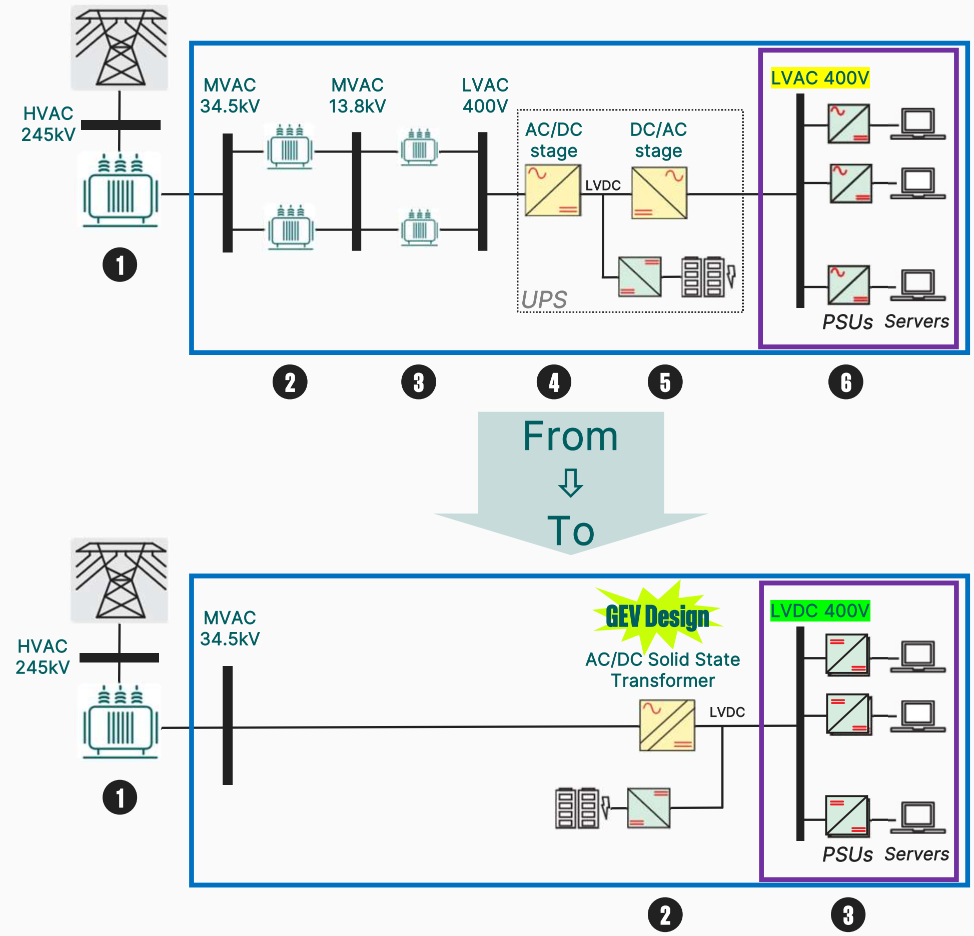
Challenges

- Support peak loads (AI) up to 80% @ GW
- Stability of the power supply network
- Modular distribution to reduce turnaround time
- Extension into urban areas beyond 100MVA

Tomorrow... 3 conversion steps

Customer Value

- Costs ↓ (capex 20% ↓, cables 60% ↓)
- Substation to rack efficiency 5% ↑
- Diversified supply chain with new magnetic materials, less copper
- Absorb AI load cycling with easier battery storage integration



MVDC ARCHITECTURES

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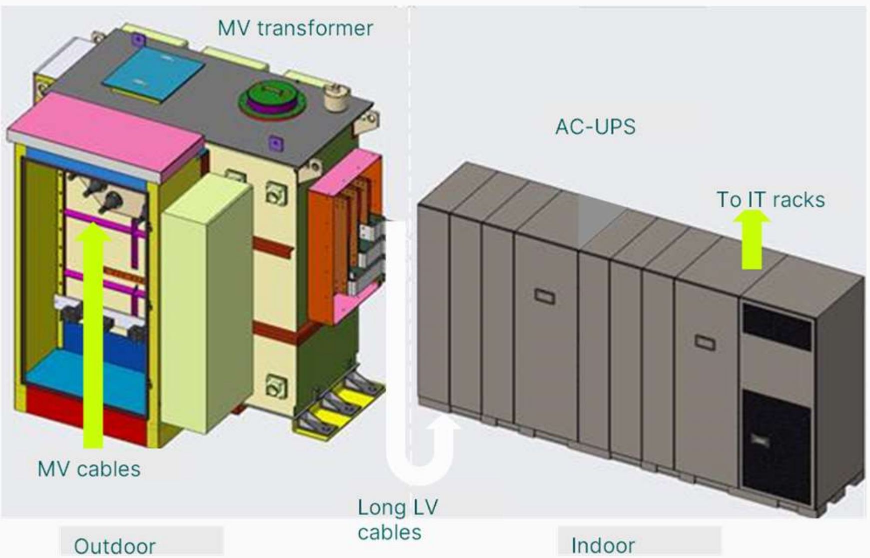
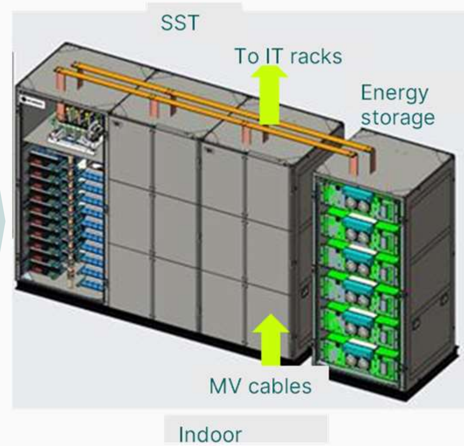
Existing MV transformer & AC UPS



SST benefits & differentiation

- Power density 3x
- Direct connection to 34.5 kVac
- High availability N+2 redundancy
- Modular & scalable design ↑5MW
- Liquid cooled ↓ HVAC, PUE 1.5↓1.3
- Grid power quality improved

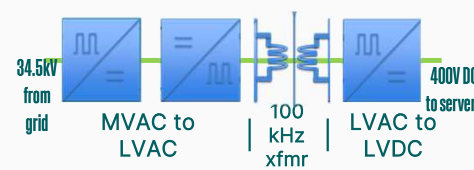
New Solid State Transformer



Program Execution

- ✓ 2019-2022: Development of power electronics building block
- ✓ 2023-2024: Solid State DC Xfmr PoC
- ❖ **2025: SST demo**
- ○ 2026: Pilot
- ○ 2027: ATQ
- ○ 2028: Scale

Core Technology



Power electronics + high frequency conversion

DISTRIBUTION INTERCONNECTION CHALLENGES

ELECTRIC VEHICLES	DER CONCENTRATION	DATACENTER GROWTH
		

3X electricity demand by 2050

217GW of added DER capacity through 2028 in the US

Processing distribution interconnection requests can take MONTHS

AI-ENHANCED POWER GRID INTERCONNECTION ANALYSIS

GOALS

Use continuous simulation to perform end-to-end energization study in 8 hours for 1 load interconnection request over 3 years of forecast scenarios.

BEYOND PLANNING TOOLS

Traditional planning tools and processes fall short of meeting these needs. Need to use more accurate operational models and operation optimization tools with GPU acceleration.

USE OF AI

ML to enable selection of representative scenarios and determine anticipated violations. GenAI to summarize expected violations, bridging solutions with sizing, and key outcomes.

Enable bridging solutions to address violations versus denying or delaying interconnection requests.

TECHNICAL CAPABILITY AND INNOVATION DRIVERS

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GridOS® DERMS

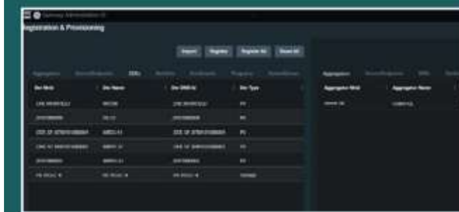
- Using DERMS Optimization for operation optimization with new bridging solutions
- Checking feasibility for automated constraint management to mitigate violations

GPU-accelerated optimization

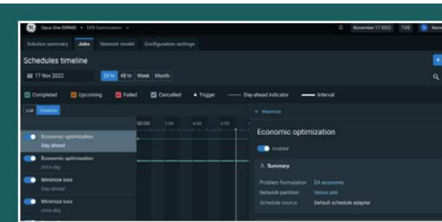
- Nvidia GPUs to accelerate large-scale optimization
- Integrating Nvidia cuDSS GPU-accelerated Direct Sparse Solver library

AI & Machine Learning

- Reliable scenario reduction based on anticipated local violations
- Robust ML to handle load and topology changes

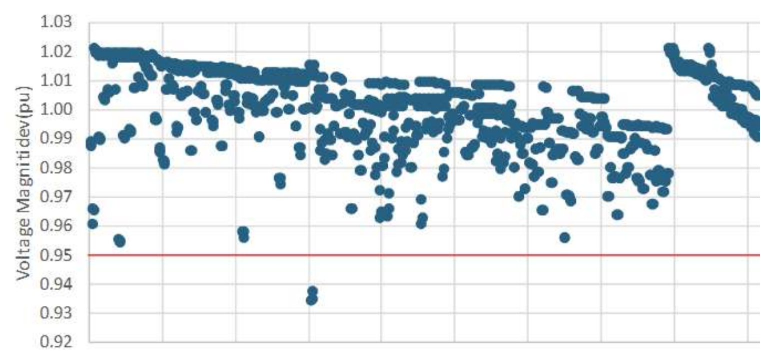


Model Manager: Maintain and ingest network and DER asset data into a model that ensures a single source of truth.



Optimization: Optimally schedule DERs based on grid constraints, economics and more. Generate safe operating limits.

NVIDIA. NVIDIA cuDSS



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