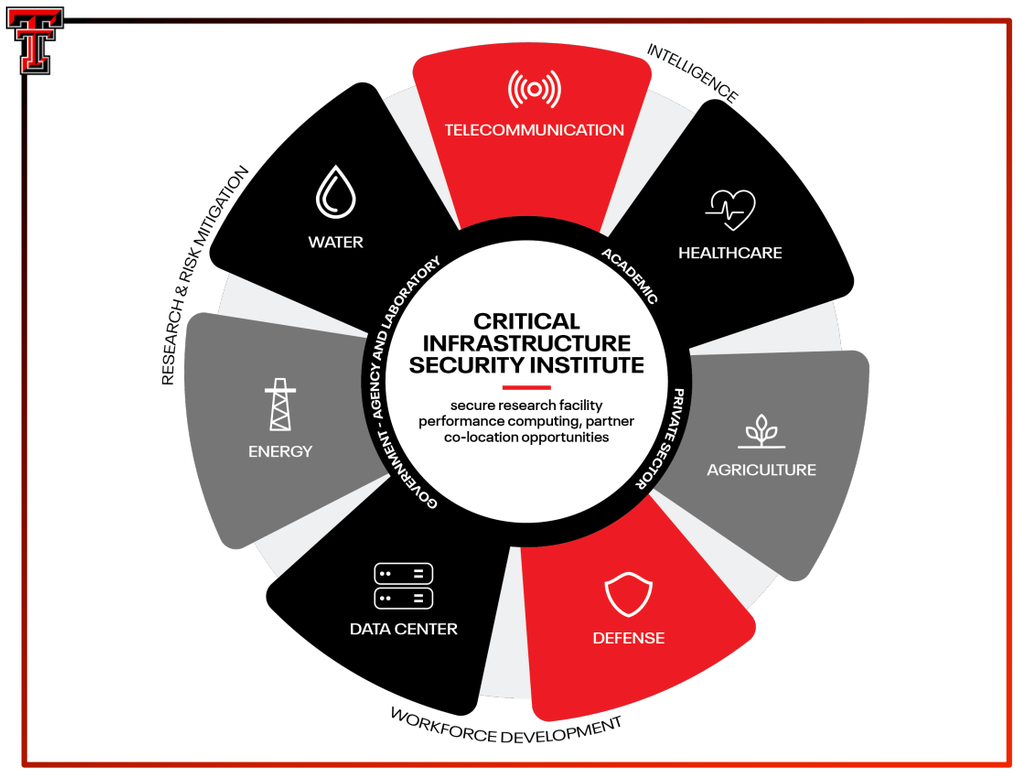
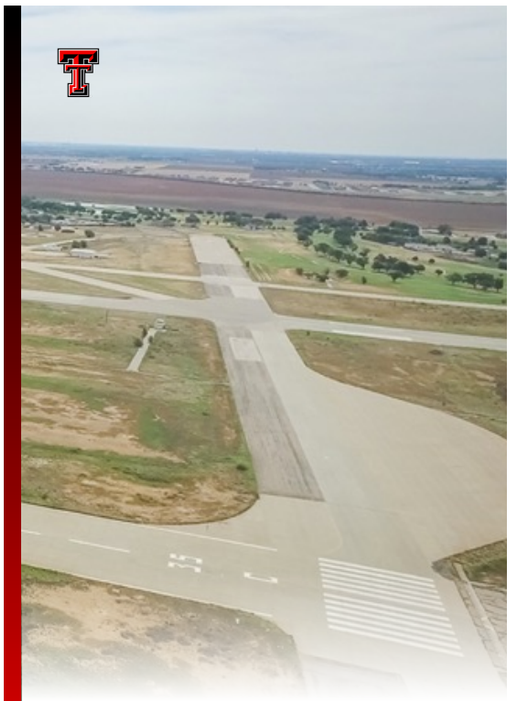
SERIES TWO I MICROGRIDS & ENERGY SYSTEMS

LUNCH & LEARN





REESE NATIONAL SECURITY COMPLEX

FORMER U.S. AIR FORCE BASE

- Located 10 miles from campus on over 2,000 acres of land with perimeter fencing and locked gates.
- Private airfield with two active runways for easy access for defense partners.
- Available real estate for new developments
- Vacant buildings for renovations
- Competitive pricing for tax incentives

Protecting Critical Infrastructure Through Energy Systems

Argenis Bilbao, Ph.D.
Director, GLEAMM

LUNCH & LEARN

GLEAMM

GLOBAL LABORATORY FOR ENERGY ASSET MANAGEMENT AND MANUFACTURING

Microgrids Introduction and Their Role in The Datacenters Age

Argenis Bilbao, Ph.D.
Senior Director
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Introduction – About Myself

- Educational Background: Electrical Engineering Ph.D. with strong Computer Engineering/IT background
- Research interest areas include:
  - Power systems
  - Cyber-Security
  - Microgrids / Microgrid controls
  - Conventional / renewable power generation
  - Artificial Intelligence (AI) / Machine Learning (ML)
  - Power electronics
  - Power semiconductor devices

Microgrids and Energy Sources

What are Microgrids?

A **microgrid** is a localized electrical power system that integrates distributed energy resources, energy storage, and electrical loads within a defined boundary. It can operate either **connected to the main utility grid** or **independently (islanded)** when the main grid is unavailable or experiencing disturbances.

- Solar photovoltaic (PV) systems
- Wind turbines
- Natural gas generators
- Diesel generators
- Combined Heat and Power (CHP) systems
- Fuel cells

Microgrid Model Advantage

- Increase power system resiliency
  - Can operate in **island mode** during natural disasters or grid failures
  - Recovers more **quickly** following hurricanes, wildfires, winter storms, or cyber incidents
  - **Reduces dependence** on long-distance transmission infrastructure
  - Supports community resilience during emergencies

- Increase power system reliability
  - Provides **continuous** power during utility outages
  - Reduces the **frequency and duration** of service interruptions
  - Maintains electricity supply to **critical** facilities such as hospitals, military installations, and emergency response centers
  - Enables **automatic** fault isolation and restoration

Texas Energy Facts

- Texas **leads the growth** of renewable energy in the United States, particularly in wind and solar power. The state has made significant investments in wind farms and solar facilities, becoming a national leader in electricity generation from these renewable sources
- Texas is the national **leader** in wind energy generation
- It **surpasses** all other states in installed capacity and electricity production
- Texas added approximately **4,374 megawatts (MW)** of battery energy storage capacity
- Wind energy accounts for a **significant** share of the state's total electricity generation (23%)
- Texas ranks among the nation's **leading states** in solar energy generation (12%)
- Solar energy capacity is expected to grow by **41 gigawatts (GW)** over the next five years
- Between **40-50% renewable penetration** level. **Up to 70%** in isolated cases

Energy Source Economics

Rank	Source	Cost ($/MWh)	
1	Utility-scale Solar PV	38–78	Lowest-cost source in sunny regions.
2	Onshore Wind	37–86	Comparable to utility-scale solar; best in high-wind areas.
3	Natural Gas Combined Cycle	48–109	Lowest-cost dispatchable fossil generation.
4	Geothermal	61–102	Highly reliable but geographically limited.
5	Coal (new plant)	71–173	Rarely economical for new construction.
6	Offshore Wind	72–140	Higher installation and maintenance costs than onshore wind.
7	Natural Gas Peaker Plant	138–262	Built for peak demand rather than continuous operation.
8	Nuclear (new construction)	141–220	Highest capital cost but provides reliable baseload generation.

Microgrids are natural companions of Datacenters!

The GLEAMM Microgrid

About GLEAMM

Mission

Bring together researchers from multiple disciplines to perform research under the energy umbrella from federal research laboratories, private industry and other research universities. GLEAMM aims to push the current state-of-the-art energy-related technologies further through scientific innovations and knowledge dissemination.

Currently funded areas in Green

Research Areas

- **Cyber-Security**
- **Smart Grids**
- **Wind energy integration**
- **Solar energy integration**
- **Energy management**
- **Grid/Microgrid controllers**
- **Artificial Intelligence (AI) / Machine Learning (ML)**
- Smart energy devices
- Electric/hybrid-electric vehicles
- Drone inspection systems
- Fuel cells
- Hydrogen production and storage
- Power electronics
- **Power semiconductor devices (wide and ultra-wide bandgap)**
- Wireless Power Transfer (WPT)

Funded areas are shown in **GREEN**

GLEAMM's Assets

Currently:
Hardware Assets

- 1 MVA Service Power Transformer
- 569 kVA Diesel Generator (and an Automatic Transfer Switch)
- 25 kVA Diesel Generator
- 350 kW Solar Plant
- 500 kW Programmable Resistive Load Bank
- 200 kW Manual Resistive Load Bank
- 187.5 kVAr Programmable Inductive Load Bank
- 380 kW Datacenter (Critical Load)
- 8 kW / 22.8 kWh UPS Battery
- 60 kW / 130 kWh battery
- 12 kVA Regenerative 4-Quadrant AC Load
- 3x Opal-RT hardware in the loop simulators
- Typhoon HIL
- RT-LAB
- 8 kW interconnected AC nanogrid with energy storage and independent solar generation
- 2.5 kW Wind turbine simulator

Software

- MATLAB/SIMULINK (All toolboxes)
- PSSE
- PSCAD
- PowerWorld
- Exata CPS
- RT-LAB
- Hypersim
- VOLTRON

Other

- 150 kW Power purchase agreement
- Access to historical weather data
- Multiple SEL PMUs / Relays
- PPA

GLEAMM's Hardware Assets



569 kVA Diesel generator



350 kW solar array



750 kW programmable loads



Battery energy storage



12 kVA
Regenerative load



Control building

GLEAMM's Hardware Assets (Cont.)



25 kVA Diesel generator



Power/Energy Monitoring





Solar/Inverters



Opal-RTs, RTDS & SEL Devices



Energy Storage



PEM Electrolyzer

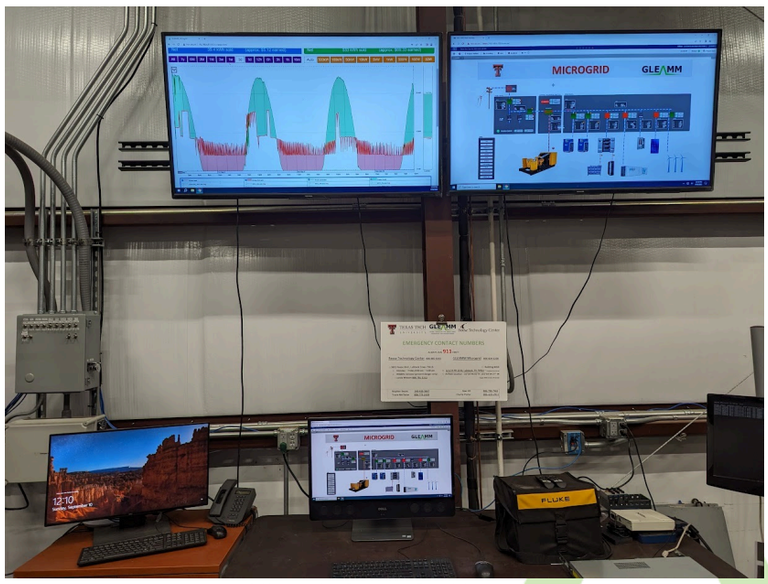
GLEAMM Control Building





Panoramic of the GLEAMM Building

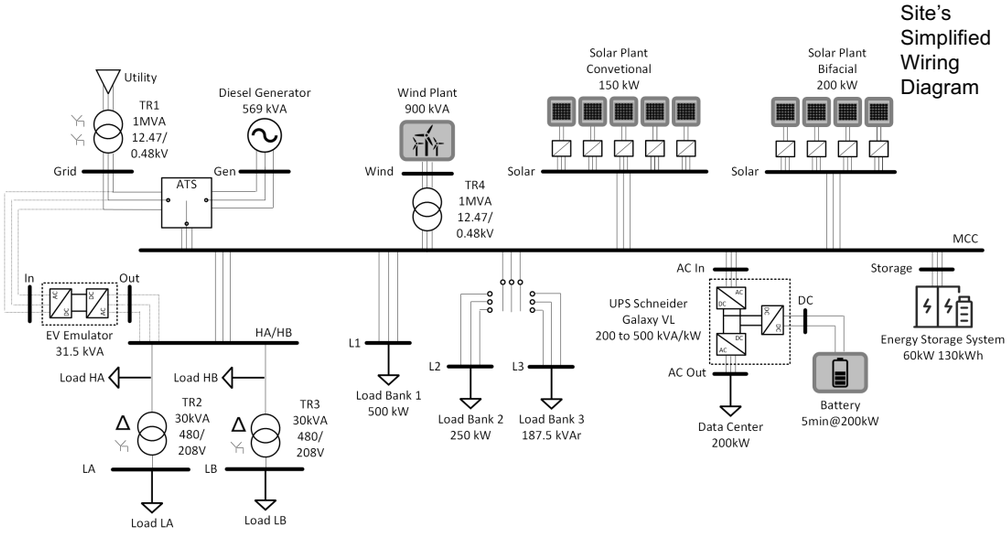
GLEAMM Control Building



Microgrid Control Dashboard

GLEAMM Control Building

Site's Simplified Wiring Diagram



GLEAMM Site



GLEAMM Location

- Located 20 miles away from campus (20-minute commute).
  - Easy access
- Decommissioned Reese Air Force Base
  - Large space to test, demonstrate and characterize large systems.
- Electrically isolated from main campus.
  - Affords us great flexibility to perform research quickly and efficiently.



Datacenters

What is a Datacenter?

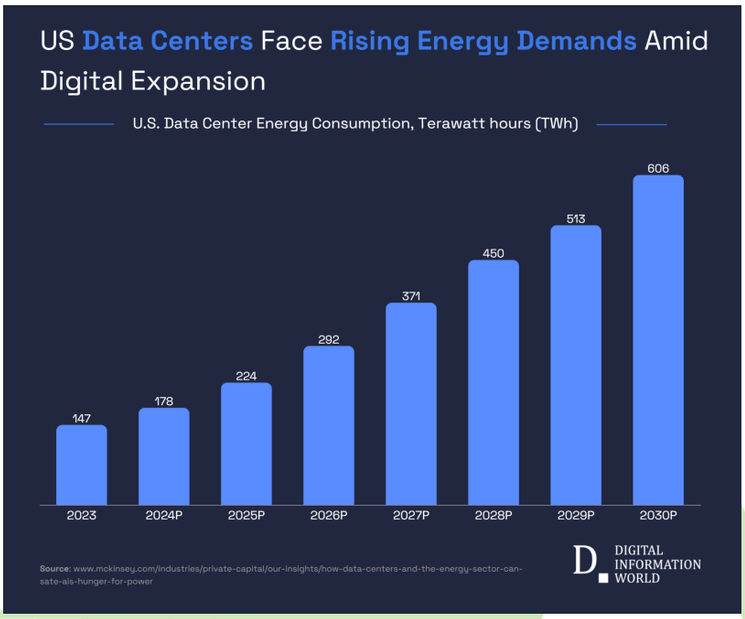
A **data center** is a facility that houses computers and networking equipment used to store, process, and deliver digital information. Think of it as a giant, highly secure "home" for the servers that power websites, apps, cloud services, and business systems.

When you:

- Open a website
- Watch a movie online
- Store photos in the cloud
- Send an email
- Use an AI chatbot

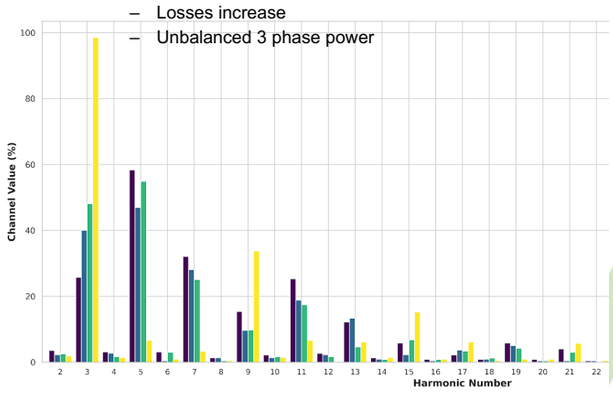
Data Center Type	Typical IT Load	Total Facility Power
Small enterprise/server room	50–500 kW	75 kW–750 kW (250 houses)
Medium enterprise	0.5–5 MW	0.75–7.5 MW (2,500 houses)
Large colocation	10–50 MW	15–75 MW (25,000 houses)
Hyperscale cloud	50–150 MW	75–225 MW (75,000 houses)
AI/HPC data center	100–500+ MW	150–700+ MW (233,333 houses)

Expected Energy Use



Draw: Not The Only Problem!

- Non-linear load due to power electronic power supplies!
  - Bad displacement and distortion power factor
  - Very high total harmonic distortion (THD)
    - Power system suffers
      - Power transformers
      - Transmission lines
      - Losses increase
      - Unbalanced 3 phase power



REPACS Project

"REmotely-managed Power Aware Computing Systems and Services"

Current Projects

- NFS REPACS!!! ($12M)
- Cyber-Security research workforce development – DoE ($2.5M)
- Workforce Development in Cyber-Security and Materials – Congressional ($9M)
- Workforce Development in Data Science – Texas Workforce Commission ($300k)
- West Texas Cyber Workforce Development Consortium (WTCWDC) – DOC ($199k)
- A Clean Energy and Rural Electric Industry Focused University Cyber- Physical Security Center – DoE ($2.5M)
- Advanced Semiconductor Power Devices – DOD ($14M)
- Workforce Development for Research in Advanced Materials and Cognitive Radar Technology – DOD ($6.4M)

REPACS Focus

- Improvements to data center and infrastructure control
- Ability to adjust workloads to match data center load conditions including the availability and cost of electrical power
- Advanced remote management capabilities and automation tools



Cluster Resources Overview

- CPU Resources
  - 110 nodes (28,160 cores) of AMD Zen4 Bergamo x86 cpus
- GPU Resources
  - 8 nodes * 4 NVIDIA H100 GPUs (2 pairs of H100NVL per node)
- Storage Resources
  - Combined Hammerspace cluster-wide storage for system and user account use (2.5 PB)

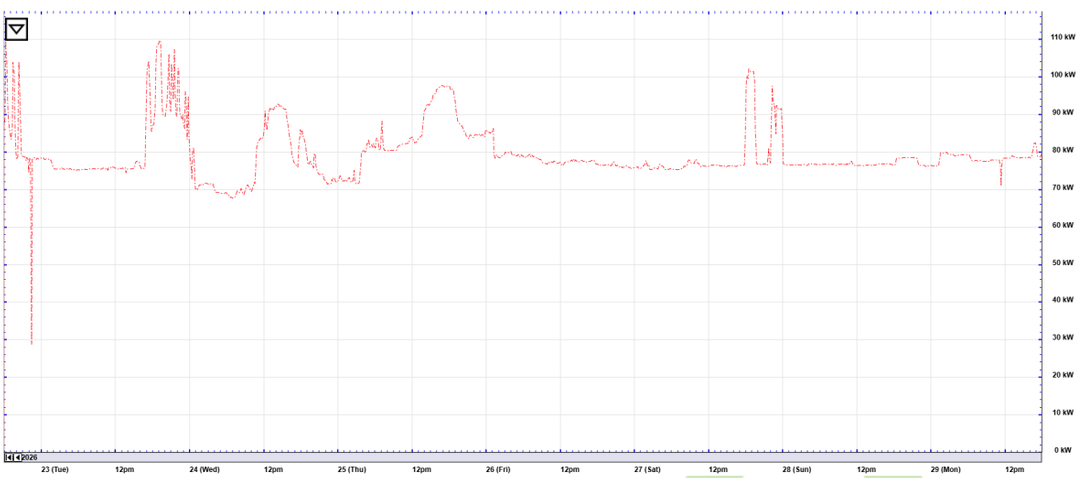


Chosen to be a good match to currently running NSF cluster resources to allow us to study actual workloads in practice

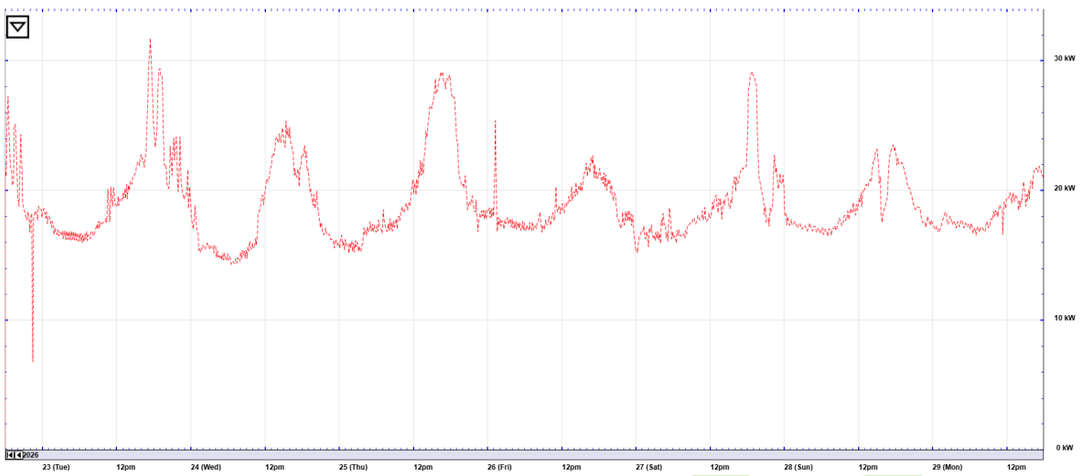
Cluster Resources Overview



Measurements: Datacenter Load



Measurements: Cooling Load



Our Solution to The Problem

- Power/Energy Awareness
  - Current transformer installation
    - All energy sources
    - All loads
      - Datacenter
        - Overall
        - At the node level
      - Datacenter cooling
      - Building (lightning, humidity control, etc.)
  - Temperature sensor installation
    - Room temperature
    - Outside temperature
- Datacenter load modulation!!
  - CPU frequency scaling
  - GPU frequency scaling
  - Control node's power states
  - Control baseboard management computer (BMC) to completely power off nodes
- AI/ML model development for job energy consumption/cost prediction
- Energy market for job scheduling!

Questions?

THANKS FOR JOINING

Protecting Critical Infrastructure Through Energy Systems

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SERIES THREE I CYBERSECURITY

COMING OCTOBER



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