Grid Modernization in New Mexico:
New technologies and research validation needed

Dr. Olga Lavrova

Dept. of Electrical and Computer Engineering | Electric Utility Management Program

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Electric Grid is going through a fundamental transition

- Many new Grid Modernization Devices are commercially available:
  - Solid State Transformers/Solid State Digital Substations
  - Storage technologies
  - Inverter-Based Resources (Voltage Source Converter/ Current Source Converter)
  - FACTs devices: SVCs, UPFCs, STATCOMs, TCRs, TSC
  - AC/DC Microgrids
- Renewables and Power Electronics are not just re-writing the rules of grid operation, but: hyperscalers and data centers are building their own grids (behind the meter, or combination, aka nested microgrids)
- AI and Data center loads act as fundamentally different loads – very "spiky", and very different frequencies than the grid is used to
- Modernized grid need to be able to continue to maintain reliability and meet adequate standards, at speeds faster than traditional grid
- Cybersecurity is a common denominator

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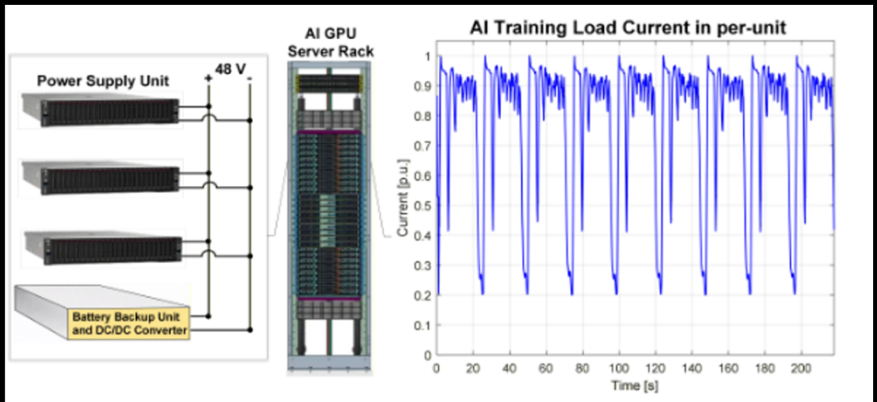
Example of datacenter load:



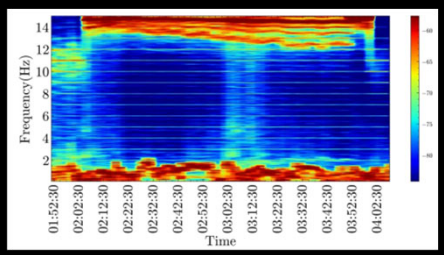
E. Choukse et al., "Power stabilization for AI training datacenters," arXiv preprint arXiv:2508.14318, 2025 [1].

Dynamic AI training is highly variable

Why Are Data Center Grid Oscillations a Growing Issue?

RESEARCH PROBLEM

- **14.7–14.8 Hz** oscillations detected in Dominion Energy's 115 kV network, sourced from a data center cluster.
- Visible as voltage flickering and lasting ~2 hours before damping.

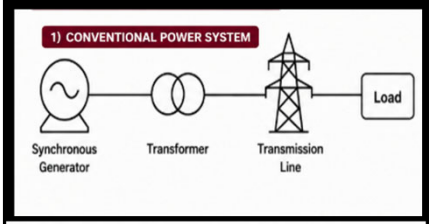


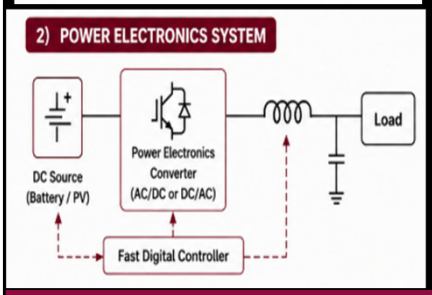
KEY FINDINGS

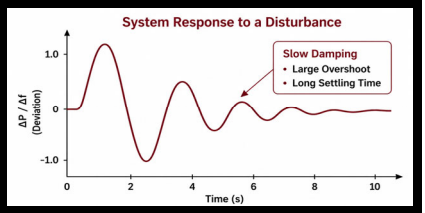
- A 10–11 Hz control mode in the data center's UPS input stage lost damping and resulted in a ~14.7 Hz limit cycle.
- STATCOM setpoint adjustment to −71 MVAR resolved the event. Confirmed by data center owner

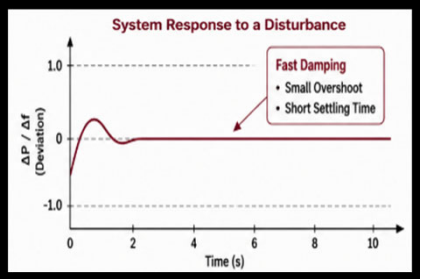
Mishra, C., Vanfretti, L., Delaree, J. Jr., Purcell, T. J., & Jones, K. D. (n.d.). *Understanding the inception of 14.7 Hz oscillations emerging from a data Center*. Sustainable Energy, Grids and Networks (SEGAN).

Grid Stability and Resiliency Advantages: Conventional Power System Vs Power Electronics System









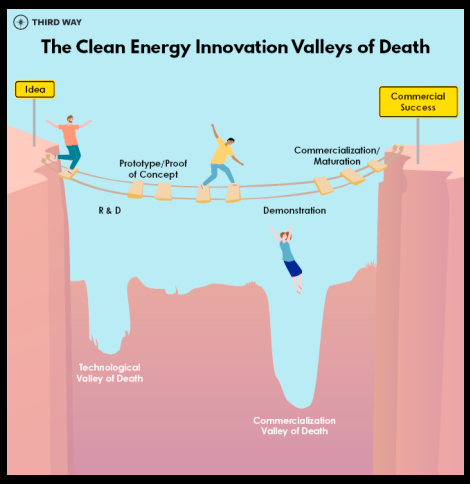
Power Electronics System provides faster damping, lower overshoot and improved system stability

How can we validate/verify these improvements in new grid environment?

- It is both impractical, not safe and would not be ethical to perform electric grid experiments on the “real grid”
- Specialized large-scale high-voltage, high-power, flexible and controllable “test grids” are needed to perform such controlled experiments
- How large is “large-scale” ?

U.S. Lacks Large-scale, High-Power, High-value Demonstration Sites

- Validation at high voltages is often lacking
- Limits technology commercialization
- Technologies are often not applicable to rural and dispersed environments (including military installations)
- Economic and regulatory structures are not aligned
- Demonstration sites need to blend tech-to-market with resiliency and ability to mitigate risk (natural disasters such as wildfires, and targeted threats, such as cyberattacks).



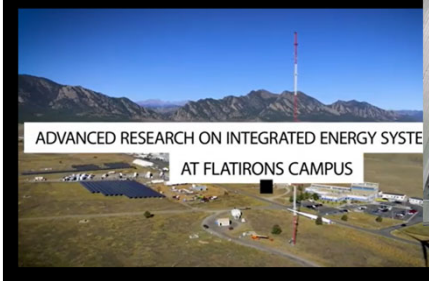
Examples of similar test sites/test beds:

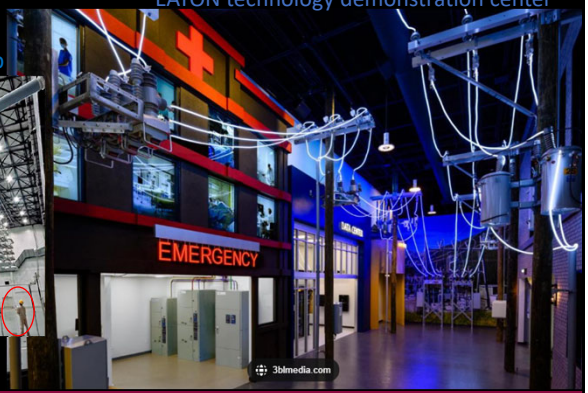
- There are very few similar large-scale high-voltage real-life testbeds, some are at National Labs, some are proprietary equipment vendor (i.e. not available to broad research and startup community)

EATON technology demonstration center

HVDC and thyristor test lab

- ARIES at Flatirons Campus, NLR





NMSU Grid Modernization Testbed: Goals and Objectives:

To develop a flexible microgrid testbed:

- For maximum flexibility to conduct research at different voltage levels and different electric grid topologies (i.e. reconfigurable) for multi-disciplinary research, and for external research (i.e. with partners)
- Controllability, monitoring and research-grade instrumentation are extremely important
- Cybersecurity component is very important
- Should allow for future expansion and to accommodate future goals (the "unknown" unknowns)
- To be a user center (i.e. for collaborations with National Labs, utilities, industrial partners, etc).

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Where we are now: Funding updates

- In 2023, Senators Ben Ray Lujan and Heinrich secured $1.6M for IDEAL to be upgraded into a microgrid and grid modernization test lab

- In 2024, NM Technology Enhancement Fund matched an additional $1.6M for these upgrades for grid modernization test lab

Majority of Funding is used for:

High Voltage Infrastructure (transformers, switchgear) for Microgrid Testbed

- In 2024, Senators Ben Ray Lujan and Heinrich secured further $1.2M towards adding the cybersecurity component to testbed

Majority of Funding is used for:

Cybersecurity Equipment for Smart Grid Testbed

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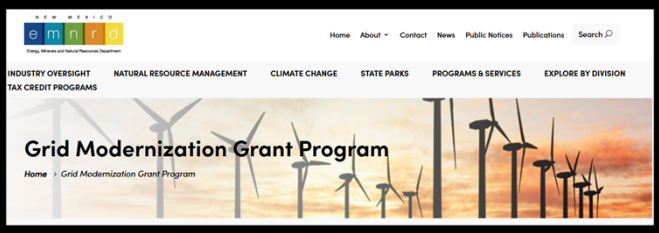
EMNRD funding for Grid Modernization Testbed!



Funding will be used to construct state-of-the art grid modernization test facility

Research Building Vision

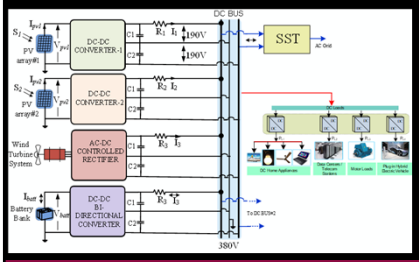
- Funding will be used for a new state of the art energy research lab facility . The goal of the project is to establish New Mexico State University as a leader in clean energy research.
- The IDEAL facility aims to accomplish the following:
  - Enhance the existing site to support the functions of the new research lab.
  - Incorporate state-of-the-art visual demonstration and grid-simulation technologies to conduct tours and demonstration events in an effort to inform the general public on emerging energy technologies and the future of energy policies.
  - Provide flexible training spaces for trade organizations to conduct training and seminars for workforce development.
  - Provide state of the art, flexible lab spaces to support STEM and outreach activities. The flexible spaces are intended to be used by multidisciplinary industry leaders in emerging electrical technologies to collaborate on research and development of efficient and sustainable energy systems.
- Provide office spaces and collaboration spaces for visiting researchers, staff, students and specialists.
- The architecture aims to incorporate multiple forms of emerging energy technologies to be used as a teaching tool for students and the general public.
- The building will be a landmark that establishes New Mexico State University's presence as a leader in energy research and will be used as a marketing tool to attract industry leaders.

NMSU Testgrid Capabilities

- **Microgrid capacity**
  - **Fully Islanded operation capability**
  - Up to 8MW available power
  - Supports diverse, reconfigurable grid research on realistic distribution system
  - Fully instrumented for research-grade data collection
- **Existing equipment**
  - 3MW PV + 4MWh Storage
  - 750kW PV
  - 20kWhr residential storage
  - 100kW Compressed Air energy storage system (CAESS)
  - 750kW hydrogen electrolyzer
- **Laboratory capabilities**
  - Approximately 1500sq ft power labs
  - Individual access for proprietary projects
  - Future: high bay
- **Power Hardware in the Loop**
  - OparlRT real-time simulator
  - 30kVA regenerative power amplifier (OpalRT)
  - 30kVA Grid Simulator (Chroma)
  - Provisioned connectivity with load bank, vehicle chargers, generator, energy storage
- **Voltage and Current capabilities**
  - 3 phase test voltages available at 23.9kV, 4.16kV, 480V, lower voltage
  - Current ratings – variable
  - CamLock equipped connection points at various transformers and switches
- **DC microgrid capabilities**
  - 380V DC grid, 30A ampacity
  - Selectable DC / AC grid-tie
  - Bipolar (+/-190V) or unipolar (380V) flexibility

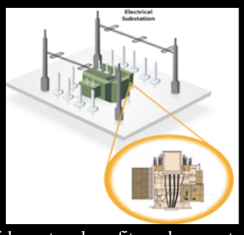
Research projects we are working on:

- Energy Storage Applications Lithium Ion and alternatives (CAESS, ZnMn oxide, others)
- AgriVoltaics
- Hydrogen and Geothermal
- And many more

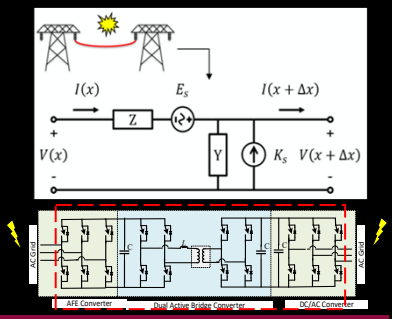


- High Voltage/High Current Power Electronics for transmission, distribution, data centers, HVDC, transportation, Solid State (Digital) Transformer substations

From DOE Roadmap: A Solid State (Digital) Power Substation (SSPS) is defined as a substation with strategic integration of high voltage power electronics for enhanced capabilities that can provide system benefits and support evolution of the grid.

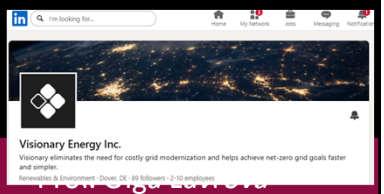


- Grid Stability and Reliability Transient analysis for high renewables penetration, extreme weather scenarios, EMP vulnerabilities



Growing innovation for NM: Working with startups:

- Nyquis
  - AI-assisted real-time electrical fault-detection
- Google Tapestry Project
  - Interested in deploying their sensor in our testbed
- Wildfire detection/grid resiliency modeling
  - Several companies working on different approaches
- Visionary Energy
  - Line-interactive storage system



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Who benefits from this testbed facility and research:

- NM Communities via technology commercialization, and electricity reliability, security and affordability
- Electric grid and electric utilities sector: NM utilities (PNM, EPE, rural electric Co-Ops) and US-wide
- Future workforce Students are getting hands-on experience on technologies of the future
- Industrial Partners renewables sector (energy storage, transformers), EV automotive and transportation sector, data centers and cybersecurity sector

- National Lab Partners NMSU's high voltage and microgrid infrastructure are unique, and some component are not present even at the Nat. Labs

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Outreach and public service:

We host a large number of visits to showcase all technologies :





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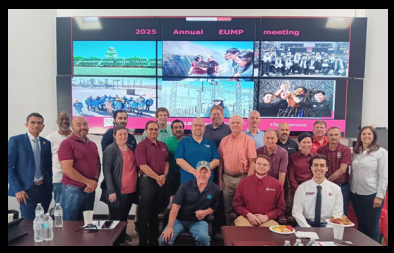
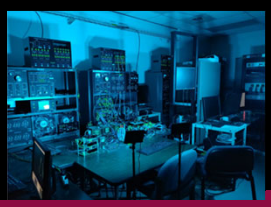
Workforce development and education

- We are preparing students for jobs of the future grid and grid technologies (i.e. storage, geothermal, power electronics, microgrids, pulsed power, electric motors and drives, charging stations, flywheels, as well as cybersecurity for the above)
- This includes working with/for NM startups and startups willing to relocate to NM
- Every graduating student is a success story ! (shows the value of higher education)





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We are just getting started !

More great projects, demonstrations education, and service to NM communities to come !

THANK YOU FOR YOUR SUPPORT !!!