

5G Green Puerto Rican Grid

ADMIRAL DAVID SIMPSON, ALI MEHRIZI-SANI,
NISHITH TRIPATHI, JEFF REED

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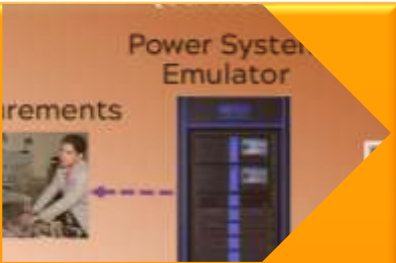
POWER AND ENERGY CENTER

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PR 5G Control for Alternative & Primary Energy Source Integration

Project Phases

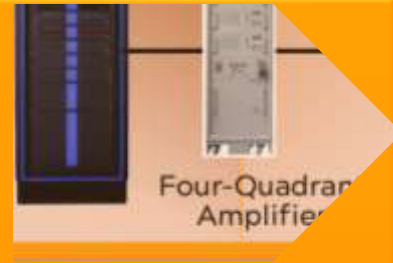
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Proof-of-Concept Testbed Development at Virginia Tech, UPR-M PR Power Assessment

- Evaluate different local renewable energy resources for inclusion in the microgrid (example resources for the testbed; not exhaustive)
- Significant research is needed in the area of wireless applications to smart grid control
- Implement 5G-based smart microgrid testbed: Integrating communication to the hierarchical control to improve resilient in the microgrid
- Integrate VT testbed microgrid with local utility's grid (VTES and/or AEP)
- UPR-M with PREPA evaluate 'as-is' & 'to-be multi-source power grids'

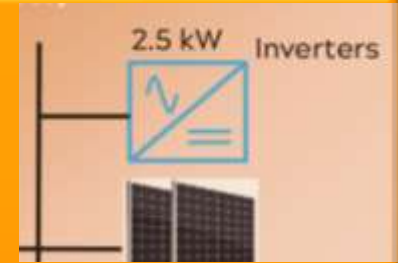
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Proof-of-Concept Testbed Development at UPR-M and Student Exchange

- VT actively helps with testbed hardware configuration and sharing software expertise
- Puerto Rico and VT students and VT researchers visit each other's university and lab
- UPR-M and PRSG Zone work with utility (PREPA and LUMA) and alternative energy companies
- VT develops template for 5G controlled alternative energy source integration into primary power distribution and control

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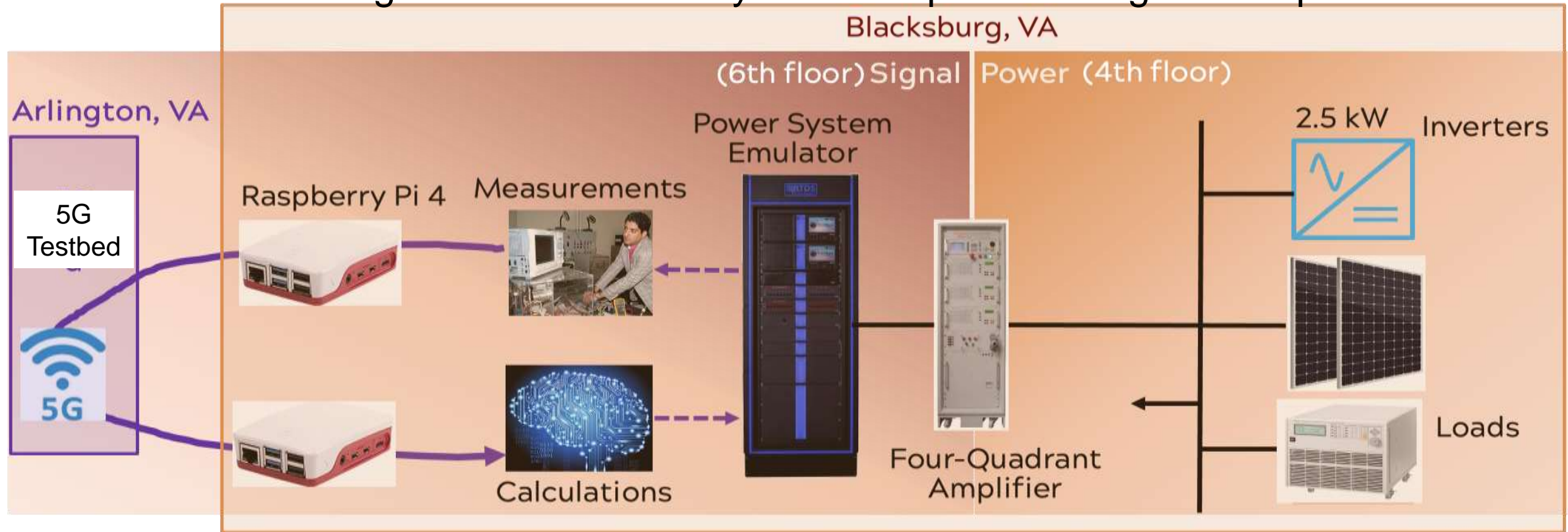
Integration of Smart Microgrids into the Traditional Grid in Four Puerto Rico Communities

- Smart Microgrid in the context of communities vulnerable to extended power outages due to climate change such as stronger and frequent hurricanes.
- VT provides business and technical consulting services.
- UPR-M provides field engineering and on-site integration support
- PREPA and alternative energy companies, and VT and UPR-M Team implements an operational solution
- VT and UPR-M develop exportable 5G control platform for alternative and primary source energy distribution
- VT and UPR-M publish final assessment and recommendations for Puerto Rico 5G control for alternative and primary energy source integration project

✓ VT/VTES, AEP and PREPA will be co-inventors of macro grid-micro grid interface solutions and would benefit from future royalties/licensing fees

1 Architecture of VT's Existing 5G Power Grid Testbed

- ✓ Build upon prior work to transform VT & UPR-M testbeds in this project to facilitate required research and guide 5G alternative energy resiliency enhancements for PR Power Grid Recovery
- ✓ VT testbed integration with VT Utility to develop PR Microgrid Pilot plan



VT 5G O-RAN Testbed to Help Puerto Rican Testbed

- ✓ We will significantly transform each testbed and connect it to the local utility network – harmonize configurations

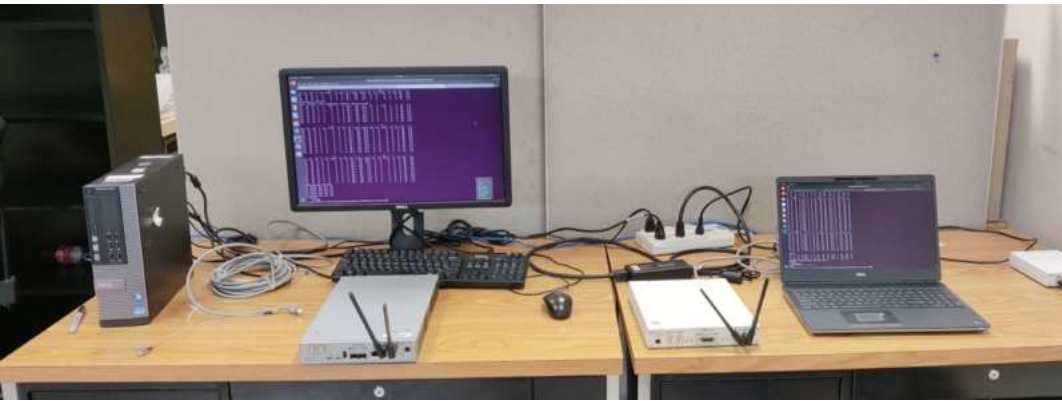


Fig. 1. In-lab 5G O-RAN Testbed at VT

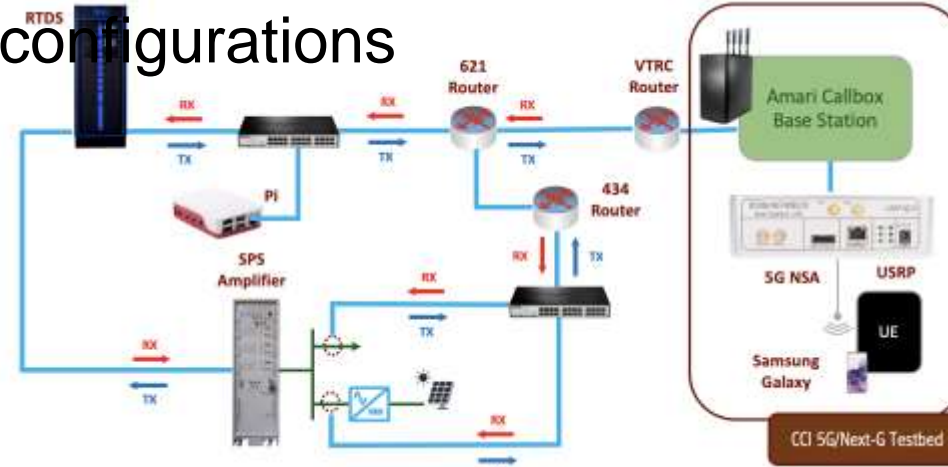


Fig. 3. VT/CCI 5G-microgrid testbed setup

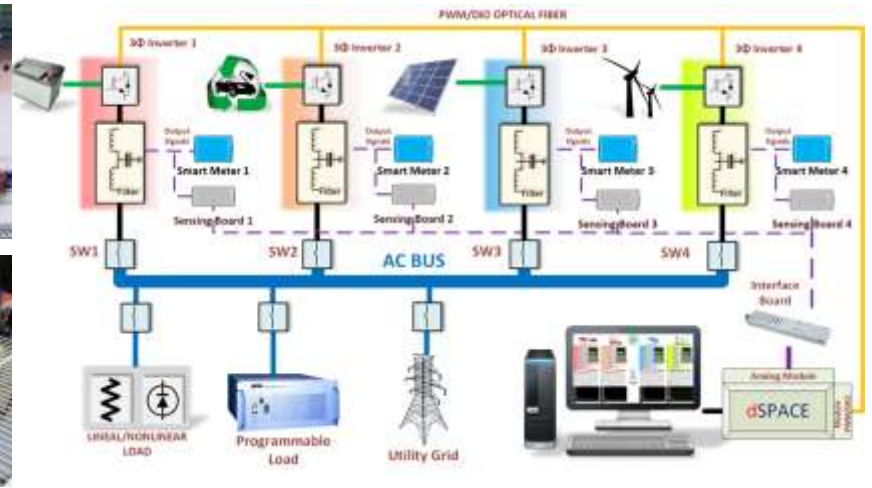
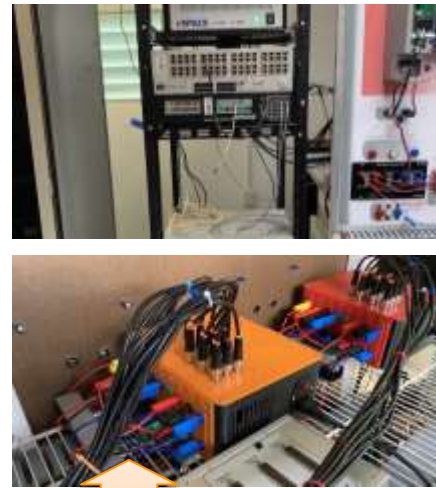


Fig. 2. VT/CCI xG Testbed. With 72 nodes, 4 MEC, and O-RAN capability, this is one of the largest university-based SDR testbed in US.



Fig. 4. VT microgrid testbed setup

Capabilities: UPRM Microgrid Laboratory



The laboratory is an NSF-MRI Instrument that is composed of an OPAL RT system (Real-time Simulator + Power Amplifier) and two 10kVA inverter-based setups, as well as four electronic DC power sources, loads, 2kW PV array on the rooftop of the building, a battery system and SCADA system. The setups can simulate different MG configurations.

Development and Validation of Models to Assess Dynamic Response of Converter-Dominated Power Systems across Multiple Spatiotemporal Scales

Computing Efficient Models of Solar PVs for Voltage Stability, Fault Analysis, Large-Signal and Small-Signal Stability Analysis

NSF CRISP Type 2: Interdependent Electric and Cloud Services for Sustainable, Reliable, and Open Smart Grids

Capabilities: UPRM Communities



Solar house consists of a showcase of sustainable living, which serves several purposes, including research, and workshop venue. It is used to receive visits from the general public for outreach and general education. It supports sustainability education and undergraduate research. UPRM Team is involved in many community initiatives related with bringing resilient energy to vulnerable communities round the island (PR)



DOE Developing socially and economically generative, resilient PV-energy systems for low- and moderate-income communities: Applications for Puerto Rico.

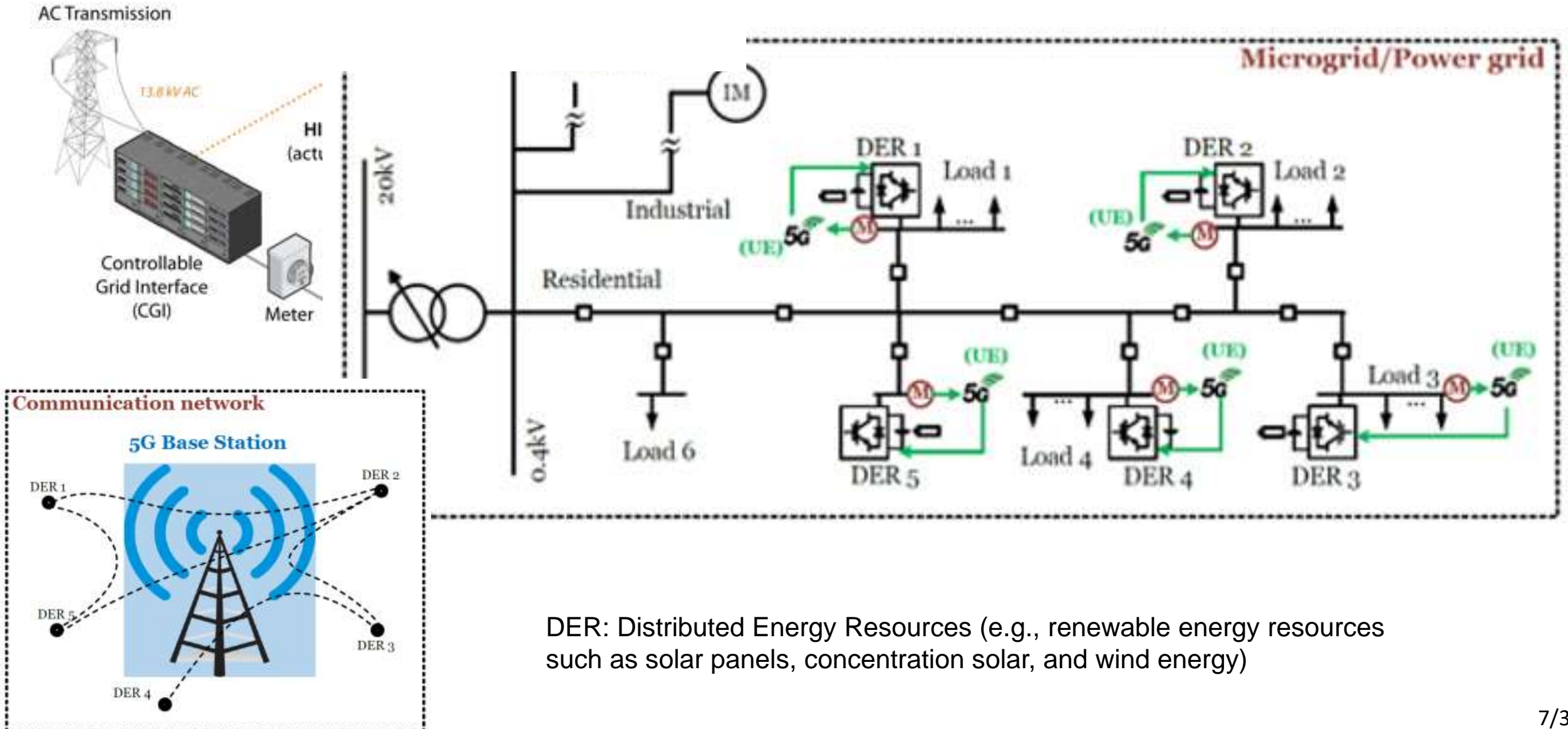


NSF Collaborative Research on Resilient Infrastructure and Sustainability Education - Undergraduate Program (RISE-UP)



Development of Representative Microgrids Test Cases and Study of Selected Operational Scenarios in the Island of Puerto Rico

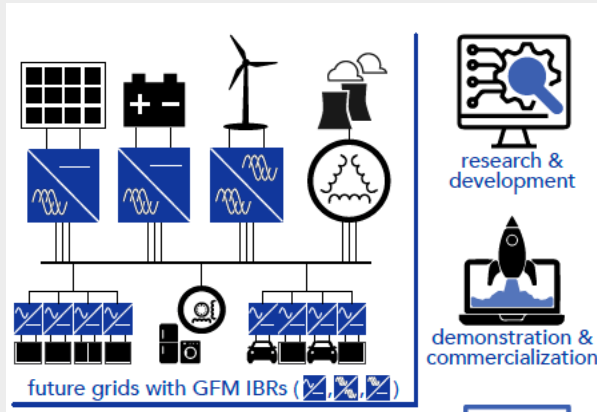
Example Microgrids in the Traditional Grid in Puerto Rico



1 Our Approach Builds Upon Prior Work on 5G and Energy...

UNIFI

\$25,000,000 total (2022)



Sponsor:

- U.S. Department of Energy

Highlights:

- **Universal Interoperability for Grid-Forming Inverters (UNIFI)** is a consortium of universities, industry stakeholders, utilities, and system operators driving advances in broad range of grid-forming technologies connected to the grid.
- **Cybersecurity**, control, and stability are among these studies. VT (Ali's research group) will make primary contributions to cybersecurity aspects.

Clean Energy Campus

\$4,500,000 total (2018)



Sponsors:

- State of Washington
- U.S. Department of Energy
- Pacific Northwest National Laboratories (PNNL)

Highlights:

- A 75 kW **solar PV system** at WSU Research Park deployed as a **ground-mounted** 45 kW portion and a 30 kW **rooftop** portion.
- It is a **grid-tied microgrid** system connected in parallel with Avista's service.
- The system had to be limited to 100 kW because of Avista's limit for **net metering**.

Microgrid Controller

\$1,200,000 total (2017)



Sponsor:

- U.S. Department of Energy

Highlights:

- Design a **microgrid** at The Navy Yard and create a 34 MW Community **Microgrid** Controller System

Other VT 5G Research Efforts: 5G microgrids for DoD, 5G smart warehouse, security of Non-Terrestrial Networks, smart traffic intersections using V2X, 5G for firefighters, Open AI Cellular (5G O-RAN testbed), 5G for train crossings, UAV geofencing for AF, 5G security with Deloitte, 5G security for defense vendors

Next Steps/Questions

- **Harmonization with UPR-M Goals for the Project**
- **What are the steps needed to get our proposal approved FEMA?**
- **Seek a meeting with FEMA before formally submitting the proposal to learn about expectations or FEMA goals**
- **Should we seek a meeting with DOE before meeting FEMA?**
- **Should we create an advisory board consisting of NREL, US Army Corps of Engineers, INL (Idaho National Lab), and PNNL (Pacific Northwest National Lab)?**
- **VT, PR5G Zone, and UPR-M (with businesses such as utilities and wireless infrastructure providers) to prepare the budget?**
- **VT and UPR-M to seek support from power utilities**
- **Funding strategies for the project and for post-project efforts**