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EPRI GRANT PROPOSAL-2

Proposal Title:	**Integration of Edge Energy Resources with Main Energy Grid**
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Submitted by

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Prototyping
Integration of Edge Energy Resources (EER) with Main Energy Grid (MEG)

1. Proposal Summary: Community-based DC microgrids, referred to as Edge Energy Resources (EER), are increasingly deployed globally to enhance energy resilience and sustainability. However, their large-scale implementation faces significant technical challenges: (i) initial synchronization with main utility grids (MEG), (ii) slip management during operation, and (iii) mitigation of distortions produced by inverter electronics. This proposal introduces a Phasor Measurement Unit Assisted Inverter (PAI) to address these challenges. The PAI continuously receives real-time data at a high resolution from a nearby Phasor Measurement Unit (PMU), capturing MEG's voltage characteristics (magnitude, frequency, and phase). This real-time reference signal allows the inverter's output AC voltage to closely mimic the MEG's AC voltage, enabling seamless initial synchronization, effective slip management, and mitigation of zero-crossing distortions.

The project aims to integrate EER with MEG using:

- **PAI Technology:** The PAI utilizes real-time data from the PMU installed in the electricity distribution system. This technology constructs real-time reference signals for the inverter output, ensuring it closely aligns with the MEG's voltage characteristics.
- **AI-Based Algorithms:** The project employs advanced AI algorithms to achieve optimal synchronization of campus microgrids with utility grids, manage slips in real-time during operation, and efficiently mitigate distortions produced by inverter electronics.

2. Benefits:

- **For Consumers:**
    - **Cost Savings:** The EER system significantly reduces utility bills by optimizing electricity consumption. The microgrid system uses advanced algorithms to determine the most efficient times to use appliances and other electrical devices, ensuring that energy is consumed when it is least expensive.
    - **Privacy Protection:** The system ensures privacy by masking energy usage patterns through intelligent algorithms. It anonymizes data to prevent third parties from inferring personal habits or routines, thereby safeguarding user privacy.
- **For Utility Companies:**
    - **Demand Reduction:** The system reduces peak power demand, contributing to more efficient energy distribution. By shifting energy consumption to off-peak times, it helps in flattening the demand curve, reducing the strain on the electrical grid during peak hours.

- **Load Diversity:** Enhances the load diversity factor, balancing energy loads across the grid. This balance ensures that no single source or region is overburdened, leading to a more stable and reliable energy supply.
- **Grid Stability:** Improves overall grid stability by predicting and managing energy consumption patterns. The predictive capabilities of the system allow utility companies to anticipate energy needs and adjust supply accordingly, minimizing the risk of blackouts or other disruptions.

- **For EV Owners:**
  - **Fast Charging Capabilities:** Provides fast charging capabilities and scheduling flexibility. This feature supports the growing demand for electric vehicles by ensuring efficient and timely charging.

3. Broader Impacts: This project will benefit utility companies, community-based DC microgrid owners, and EV owners by:

- **Resolving Integration Issues:** Facilitating the seamless integration of EER with MEG by addressing synchronization, slip management, and distortion mitigation, thus overcoming technical barriers and promoting sustainable energy practices.
- **Efficient Resource Utilization:** Integrating multiple DC resources using a single PAI instead of multiple inverters and synchronizers, streamlining operations, and reducing costs.
- **Enhanced EV Infrastructure:** Offering fast charging capabilities and scheduling flexibility for EV owners, bolstering the adoption of electric vehicles and contributing to environmental sustainability.
- **Educational Initiatives:** Developing comprehensive course modules on EER and MEG operations for AAMU students and TVA personnel. These modules will provide practical knowledge and skills in advanced energy technologies, preparing a skilled workforce for the future energy sector.

4. Project Progress: a. Student Involvement: Shanice Gray, an Electrical Engineering and Computer Science (EE&CS) student, began working on this project in September 2023. Her dedication over two semesters (Fall 2023 and Spring 2024) has been instrumental in advancing the project to 60% completion. Shanice's contributions have been pivotal, including:

- **Algorithm Development:** She has created sophisticated AI algorithms that form the backbone of the PAI system. These algorithms are capable of real-time decision-making, synchronization, slip management, and distortion mitigation.
- **System Integration:** She has integrated various ICT components to ensure seamless communication between the system's hardware and software, enabling efficient data processing and real-time action.

- **Preliminary Testing:** Shanice has conducted preliminary tests to ensure the system's reliability, efficiency, and user-friendliness. These tests are crucial for identifying potential issues and areas for improvement before full-scale implementation.

b. Presentations and Recognition:

- **February 2024:** Shanice presented the project to Tennessee Valley Authority (TVA) officials during a meeting organized by Dr. M. Dweik, Vice President of Research and Economic Development. The project received positive feedback, highlighting its potential for real-world application and its innovative approach to energy management. TVA officials noted the system's capability to address current energy challenges effectively.
- **March 2024:** Shanice showcased the project at the University-wide STEM Day. The project earned third place, with judges from the industry recognizing its innovative use of AI and ICT to address energy management challenges. This accolade underscores the project's relevance and the quality of the work done.