INDUSTRIAL SOLUTIONS LABORATORY

Company Information

Company Name	Duke Energy	**Date Submitted**	*November 28, 2023*
Project Title	Design of Generator Circuit Breaker Improvements *(DUKE_BREAKER)*	**Planned Starting Semester**	*Spring 2024*

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills.

Discipline	Number	Discipline	Number
Mechanical	3	Electrical	2
Computer		Systems	

Company and Project Overview:

Duke Energy is one of the largest electric power holding companies in the United States, providing electricity to 7.7 million retail customers in six states. We have approximately 51,000 megawatts of electric generating capacity in the Carolinas, the Midwest and Florida – and natural gas distribution services serving more than 1.6 million customers in Ohio, Kentucky, Tennessee and the Carolinas. Our commercial business owns and operates diverse power generation assets in North America, including a portfolio of renewable energy assets. We are transforming our customers' experience, modernizing our energy grid, generating cleaner energy and expanding our natural gas infrastructure to create a smarter energy future for our customers.

The McGuire Nuclear Station is located on Lake Norman in Huntersville NC. There are two pressurized water reactors on site that started operation in 1981. Station capacity is 2,386 megawatts.

Bad Creek Pumped Hydro Station is 8 miles north of Salem in Oconee County S.C. The station is 540 feet underground, and is located more than 1200 feet below Bad Creek Reservoir. The pump-turbines move

water from Lake Jocassee to Bad Creek Reservoir when demand is low and reverse flow to generate up to 1680MW when demand is high.

Duke Energy is in the process of upgrading our legacy 24KV, 300 kA interrupt air blast breakers with 31KV, 300 kA interrupt Sulfur Hexafluoride (SF6) breakers. While the new breakers have fewer operating components, some of the auxiliary indications for monitoring and trending have been less reliable. The breaker also has a new failure mode where on low gas pressure conditions the breaker will not operate. Duke is looking for alternative solutions other than what is provided by the OEM.

Project Requirements:

1. Review documentation for the new Generator Circuit Breaker (GCB), its associated components and prior documented failure modes.
2. Coordinate with Duke Energy Fleet Maintenance Services (FMS) and equipment engineer from Bad Creek Hydro for their input.
3. Design solutions to mitigate past issues.
    a. Trip coil/Close coil monitor failures.
    b. Solution to add gas to the breaker while breaker is in service.
    c. Cost/benefit analysis to add service ports to disconnect surge arrestor and 24KV potential transformer from 24KV bus with out requiring personnel to fully enter breaker. This is to mitigate complications of confined space entry in a potentially oxygen deficient environment in support of high voltage insulation integrity tests (hi pot).
    d. Infrared temperature probes failing and not communicating with data acquisition system. These are in a 130F environment and subject to air flow
    e. SF6 digital density monitors not communicating with data acquisition system.
    f. Failure of hydraulic pilot valve separating from hydraulic body
    g. Miscellaneous solutions for other issues discovered while working with FMS and Bad Creek.
4. Review expected part life based on expected operations to recommend appropriate maintenance strategies/cost benefit for testing and replacement.
5. Component requirements
    a. All components shall be off the shelf or can be fabricated in a metal shop. No custom printed circuit boards.
    b. Any software required for components shall only be from component vendor due to nuclear's cyber program . Programming logic functions inside vendor's software is acceptable.

Site Visits

In early March, Bad Creek Pumped Hydro Station is scheduled for maintenance on one of their GCB which is the same as McGuire's. Due to operating their breaker about four times daily they're due for a 15 year

overhaul every five years.

In June McGuire Nuclear Station will receive their new GCB breaker.

Expected Deliverables/Results:

- Deliverables/solutions are expected for Sections 3a-3c and 4. Deliverables are desired for sections 3d-3g, but it is recognized that due to proprietary parts a retrofit solution may not be feasible. It is expected to document the basis for solutions that are not feasible.
- Design solutions to some/all the issues mentioned above.
    - Bill of Materials
    - Drawings/Mark ups
    - Setting files
- Maintenance strategies, Life Cycle review, spare part strategies.

Disposition of Deliverables at the End of the Project:

Students are graded based on their display and presentation of their team's work product. It is mandatory that they exhibit at the Expo, so if the work product was tested at the supporter's location, it must be returned to campus for the Expo. After the expo, the team and supporter should arrange the handover of the work product to the industry supporter. This handover must be concluded within 7 days of the Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- US Citizenship required for all team members due to security requirements for nuclear power plants.
- Site visits are required to both McGuire and Bad Creek locations. Mileage will be reimbursed per course policy.

Skills

- Experience in programming data acquisition systems desired. (for example Labview or Schweitzer)

Course Work Prerequisites

- MEGR 3216 - Thermal/Fluid Design, Required for one or more members
- MEGR 3121 - Dynamics Systems I, Required for one or more members
- ECGR 3123 - Data Communications and Networking, Desired for one or more members
- ECGR 4123 - Analog and Digital Communication, Desired for one or more members


INDUSTRIAL SOLUTIONS
LABORATORY