SMART GRID CENTER
TEXAS A&M ENGINEERING EXPERIMENT STATION

Distributed Generation and Its Impact on Market and Protection

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Project Category:	Testbed demonstration
Project Domain:	Distributed generation
Project Description:	The landmark FERC Order 2222 is bound to have substantial impact on distributed generation's growth in the power systems. This project will examine the market as well as physical protection operation with proliferation of distributed generation resources in utility grids equipped with conventional time delayed overcurrent (TDOC) protection.
Expected Duration:	2 years
Funding per Year:	$40K/year
Key objective:	To investigate the implication of distributed generation in both market and physical operation for utilities and system operators. In particular, to explore the potential of AI-based adaptive protection for improved resiliency.
Expected Deliverable:	Testbed deployment, study report, as well as policy recommendations

Project Schedule

This project will include a 24-month program to explore and develop the potential to increase the reliability of power distribution grids with high renewable penetration by developing a robust reinforcement learning based protection system. The project schedule is summarized in Table 1. The detailed tasks of this project are listed as follows.

Task 1: Literature, Industry and Policy Review and Framing the Problem (M1-M6)

This task aims to investigate the state-of-the-art technology currently used in the industry as well as proposed improvements and alternatives in the existing literature. Efforts will also be put into studying the impact of Distributed Generation (DG) on protection of distribution feeders and the electricity market anticipated by the FERC 2022 order on opening up the market to distributed energy resources.

Subtask 1.1: Study the impact of increased DG capacity on protection and market (M1-M4)

Subtask 1.2: Survey and comparison of proposed methods in existing literature (M5-M6)

Deliverable 1: A literature review and results of initial studies will be delivered at the end of Month 6. The review report will include: 1) The effect of higher distributed renewable generation capacity on protection and market; 2) Performance comparison among proposed methods in existing literature.

Task 2: Protection Algorithm Design using Reinforcement Learning (M7 – M18)

This task will develop and test by simulation a reinforcement learning algorithm that can be used to train the fault detection mechanism of microprocessor protective relays.

Subtask 2.1: Develop and select a simulation platform with suitable models for power electronic based renewable energy resources (M7 – M11)

Subtask 2.2: Develop a reinforcement learning algorithm that can train relays to reliably detect and respond to faults under a union of operating states and fault parameters. In particular, we aim at identifying non-detection zones (NDZ) of the conventional TDOC, and developing an adaptive setting approach which amounts to RL in the loop using stream of real-time and historical data (M12 – M18)

Task 3: Test and Validation of Developed Algorithms (M19 – M22)

This task will validate the developed algorithm using data generated by running EMTP simulation.

Task 4: Summary Report (M23 – M24)

This task will finalize and deliver the project report and software developed including source code, binary files and user's manual.

Deliverable 2: The developed software and its manual will be delivered at the end of Month 24.

Deliverable 3: The final project report will be delivered at the end of Month 24.

Table 1 Project Schedule Summary

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Task 1																								
Task 2																								
Task 3																								
Task 4																								

References:

[1] Wu, D., Zheng, X., Kalathil, D., & Xie, L. (2019, December). Nested reinforcement learning based control for protective relays in power distribution systems. In *2019 IEEE 58th Conference on Decision and Control (CDC)*

[2] Wu, D. Kalathil, D. Begovic, M. and Xie, L. (2020), Deep Reinforcement Learning-Based Robust Protection in DER-Rich Distribution Grids, *Working Paper, to be submitted to IEEE Transactions on Power Delivery*.