SF-PPR PERFORMANCE PROGRESS REPORT NARRATIVE

For Centers of Excellence (Bucket 5)

Grant 2

April 1, 2024 thru September 30, 2024

Texas Commission on Environmental Quality (TCEQ):

Oversaw the operations of both Texas OneGulf (OG) and the Subsea Systems Institute (SSI), which included the review and acceptance of deliverables, invoices, and travel requests.

Submitted CofE Grant II Monetary Amendment on August 1, 2024, requesting additional funds and extending contract dates to February 28, 2027 for both OG and SSI. The NOA was received September 26, 2024.

Executed amendments for the following:

- OG GAD 3: extended Task 3 deliverable due date to October 31, 2024 and extended the period of performance to November 30, 2024.
- OG GAD 4: extended Tasks 1 and 2 deliverable due dates to October 31, 2024 and extended the period of performance to December 31, 2024
- OG GAD 5: adjusted the contract budget to reflect the indirect cost rate previously omitted from the original budget; this did not change the total budget amount; and change Baffin Bay location to Upper Laguna Madre.
- OG GAD 6: increased the contract budget to correct the omission of the indirect cost rate.
- OG GAD 7: increased the contract budget to correct the omission of the indirect cost rate.
- SSI GADs 8, 9, 10, and 11: extended the period of performances to February 28, 2025.

OneGulf (OG):

GAD 1 – 22150 Operations and Administration

Met the reporting requirements, continued to oversee the day-to-day operations, and administration of the Center. Continued execution of three selected projects from Notice of Funding Availability (NoFA) FY23. Drafted and submitted Grant Activity Document (GAD) 5-7 documents, including Personnel Eligibility List (PEL). Continued interviews with each Texas OneGulf Agency Council (TOAC) and Texas OneGulf Consortium Leadership (TOCL) in preparation for meeting and analysis to establish funding priorities for next Request For Proposal (RFP). Reviewed, edited, and finalized the Strategic Research and Action Plan (SRAP) for 2024. Planning for RFP FY 2025. Hosted a TOAC meeting to introduce Dr. Montagna and discuss the direction of Texas OneGulf. Reviewed, edited, and re-submitted monetary amendments documents for submission to TCEQ and Treasury. Executed non-monetary amendments for GADs 3 and 4, and monetary amendments for GADs 5-7.

GAD 3 – 40605 Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities

The team has been meeting regularly, once a month, for project updates and progress reporting among team members. Progress has been made in estimating average annualized losses (AAL) by individual properties incorporating projections of different intensity storm scenarios (2-, 5-, 10-year, 100-year, 500-years). In collaboration with the data analytics team of the Institute of

Disaster Resilient Texas (IDRT), our research team has started the development of a buyout dashboard by integrating the data generated throughout our research project.

<u>GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay</u>

Conducted a series of field deployments with the newly developed low cost observing system. Initial deployments were for method development purposes and occurred in the Brownsville ship channel immediately adjacent to the University of Texas Rio Grande Valley (UTRGV) marine facility. During these deployments, we repeatedly deployed the system at the edge of the ship channel both to understand how long it would take to deploy and recover, and to work through our methods to make deployment and recovery as efficient as possible. We also evaluated floatation and ballasting and the interaction of the system components with wind, waves, and currents and made adjustments to the system (altering attachment points, line and shackle types, and electronic mast attachment components) to improve its ability to operate in those conditions for extended periods. Once this was completed, we began a series of deployments in the Corpus Christi ship channel. We made three consecutive trips to Corpus Christi for this purpose, totaling 11 days of travel. During two of those trips, we encountered weather related to either thunderstorms or tropical storms in the Gulf of Mexico (GOM), but we were still able to get on the water and deploy the system most of the days. Overall to date, we have had six days' worth of time on the water where we deployed the system in the ship channel to collect data. We are in the process of analyzing that data now. In addition, the co-PIs held meetings to discuss the study progress, analysis of the bay model, and the sensor array configuration.

<u>GAD 5 – 44890 Advancing harmful algal bloom monitoring efforts on the Texas coast to protect human health and coastal economies.</u>

HAB reports: During the reporting period, we communicated via email to Mr. Kirk Wiles (Texas Department of State Health Services), Mr. Brad Lomax (Texas Oyster Ranch), and Dr. Steve Morton (NOAA) about lack of HAB detection in samples collected in Copano Bay on 5/1/2024, 6/26/2024 and 9/4/2024. Imaging FlowCytobot (IFCB) deployment: In this cycle, we evaluated multiple locations in the Baffin Bay and Upper Laguna for possible IFCB deployment. Based on those visits, it was determined at the time that we would be unable to deploy in Baffin Bay because of lack of pier space and/or inadequate logistics (electrical, water depth). However, a visit to the TPWD Hatchery on the Upper Laguna Madre in Flour Bluff yielded a possible deployment location. We also just heard from another landowner on Baffin Bay, who offered pier space. In the next cycle, we will visit the Baffin Bay site and make a final decision on where to deploy. As for Copano Bay, we worked with the pier owner (Brad Lomax) on site preparation logistics and were prepared to deploy the IFCB in the next cycle. However, his pier was subsequently destroyed by Hurricane Beryl in early July. In the next cycle, we will find an alternative deployment location. We have already reached out to another oyster farmer in the area who is eager to work with us. Data management/visualization: In this cycle, we worked with project collaborators at HRI to begin development of a robust image classifier and outlined a work path for IFCB data integration, interpretation (by the classifier), and subsequent dissemination via a dashboard. Development of a HAB monitoring plan: In this cycle, we developed a survey that will be sent to stakeholders to inform development of the HAB monitoring plan. We also held several planning meetings with the Texas State Aquarium and state partners for a HAB event response workshop, to be held in October.

<u>GAD 6 – 44891 Risk Communication in an Age of Misinformation: Emergency Manager and Household Perspectives Pre- and Post-Disaster</u>

- Developed and secured approval of interview protocol from Institutional Review Boards at Texas A&M University and University of North Texas.
- Hired student research assistant at University of North Texas.

- Trained graduate student researchers to conduct interviews with emergency managers in the study area.
- Contacted emergency managers in the study area for participation in an interview.
- Conducted interviews with 10 emergency managers in the study area.
- Began first draft of paper to highlight findings from the interviews.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data
- Conducted project meetings with team.
- Scheduled and conducted the first of three planned stakeholder focus groups.
- Began acquiring, cleaning, and organizing social network data, meteorological and oceanographic data, and damage and loss data for associated disaster events.
- Began development of the AI/ML module of the DIEP using the data collected, with focus on algorithms that can be used to curate data, identify irrelevant information (denoising), and perform user localization from social media sources.

Subsea Systems Institute (SSI):
GAD 1 - 22029 Operations and Administration
- Met the reporting requirements, continue to oversee the day-to-day operations, administration of the center, meetings with researchers, industry, and government.
- Held principal investigator kick-off meeting.
- Update SSI website to reflect four new projects.
- Worked on Quarterly Report #6 and submitted to TCEQ on August 26, 2024

GAD 8 – 42111 Offshore Asset Integrity Monitoring: Environmental Monitoring
TASK 1: Development of Self-Powered Distributed Sensors/Reporters for Integrated Offshore Asset and Local Environment Monitoring

- Improved non-contact multi-layers radial-arrayed rotary electrification for high performance triboelectric generator designed in March of 2024
- Measured output power of new generators. Multi-layers non-contact radial-arrayed triboelectric generator was improved by replaced PU and PTFE. Investigated the integration of this generator so that the output power can be multiplied.
- Measured output power of new generators.
- Continuously improve the performance of multi-layers non-contact radial-arrayed triboelectric generator by adjusting the angle of each Cu piece and the distance of each plate.
- Measured output power of new generators.

TASK 2: Practical Implementation of Organic Electrochemical Transistors (OECTs) for Subsea Detection

- Fabricated a second version of the sensing box. The previous version exposed a big shortcoming: the distance between the sensor and gate probe was too long, hindering the stability of the data.
- Located the sensor and gate probe at the top of the box at a closer distance.
- Added a battery group to provide the reverse voltage, reducing the number of cables needed from the outside.
- Reduced the size of the box by 20%.

- A crucial part of our research involved the development of a sensor array for detecting multiple chemicals simultaneously. We employed a Keysight U2722A instrument to gather data on the OECTs' response over time, observing significant decreases in current when exposed to oil-water mixtures. The sensing circuit was enhanced to enable bi-directional voltage output through a differential amplifier. Various solutions, including pure water, soda water, seawater, and oil-water mixtures, were tested, revealing significant current changes when large amounts of oil were present. The reusability of the sensors was also confirmed, as they continued to function after exposure to oil
- In this reporting period, some of the shortcomings of the sensor and circuit enclosure were rectified to have it able to work in underwater conditions (IP67). The Fig. 1 shows the open-view of the sensor device with a single USB cable to be connected to the host computer
- The sensor device contains the circuit which records the current data through the channel and send it over to the host computer. The finalized sensor device was tested with host computer running MATLAB to view the results in the presence of oil
- At the time of the reporting, the computation of the raw data is being done in the host computer running MATLAB. To be able to integrate this sensor device with robotic fish or any other carrier these computations has to be done on-board on the circuitry of the sensor. We are working on the embedded program to be computationally light so that the raw current data from the channel can be processed within the on-board circuit. After this done, the sensor device would be able to provide processed values over single wire interface which is more practical for interfacing with any other robot carrier, like robotic fish
- To be able to integrate the sensor with robotic fish, we are working on the robotic fish design revisions. As the sensor inherently absorbs oil onto the channel, it brings some more challenges in terms of collecting data in one single run of the robotic fish. More practical solution would be, the robotic fish has more maneuverability so it can cover maximum area in the same amount of time. This would allow us to get the better idea of highest point of the oil concentration in water
- For this purpose, the revised design of the robotic fish has active pectoral fins actuated with independent servo motor which would allow the robotic fish to have small turning radius and increase maneuverability
- Water diffusion in OECT materials including PEDOT:PSS was also investigated through experiments and modeling for stability assessment at subsea conditions

GAD 9 – 42112 Design and Development of Offshore Power Systems
TASK 1: Multi-port Energy Router using Intelligent Transformers (MERIT): Energy

The power management scheme to optimize the utilization of wind power while sustaining the offshore grid in the islanded mode, as long as possible. To supply uninterrupted and reliable power to the subsea loads, the MER must have a robust control strategy. The supervisory mechanism guarantees that each source offers accessible power by considering the load demand and ensuring a reliable electricity supply to subsea loads. This was accomplished by maintaining the desired state of charge (SOC) for the batteries. The first phase of this project focused on the 'power control algorithm' with a triple-active-bridge (TAB) converter for the integration of BESS (battery energy storage system), WTGs, and offshore grid to supply reliable power to the subsea loads. Continuing from that, a control algorithm was implemented on the best-selected architecture. The next phase of the report completed the tasks on medium-power subsea motors for oil and gas applications, termed goal 3.

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In Goal 3, an elaborative control structure was thoroughly studied. Under Task 4, this project delved into a comprehensive examination of various ML algorithms applicable to power electronic converters, drawing insights from an extensive review of existing literature. Then the ML control was implemented on a dua-active-bridge (DAB) converter, and the results were studied. In goal 5, a low voltage ride-through (LVRT), also known as fault ride-through (FRT), control algorithm is under development, with the TAB converter discussed under goal 2.

- Out of these five goals of this project, the first three (Goal -1, Goal-2 and Goal-3) were completed, and reports were delivered. Goal 4 and Goal 5 are progressing accordingly.

Work Progress under Goal 4:

- Controlling power electronic converters can be particularly challenging due to various factors, including changes in ambient temperature and parameters, communication delays, and the limitation of the absence of precisely designed transformers. Therefore, machine learning methods are becoming more and more popular in all the research field domains, including power electronics. There are several advanced machine learning methods available based on different objectives. Therefore, this section first delves into a comprehensive examination of various ML algorithms applicable to power electronic converters, drawing insights from an extensive review of existing literature. In the earlier report, we reported a few techniques for DAB converter control – a) linear regression, b) k-nearest, c) Decision trees. Now in this month, a few more techniques have been studied which are as follows.
- ML methods for DAB control
- D. Decision Trees: Decision trees can perform both classification and regression tasks. They are the fundamental building block of ensemble methods like random forests. Decision trees are simple and can easily handle both numerical and categorical data. However, when they are deeper, they become prone to overfitting. Even a small variation can lead to a completely different tree structure. Such model instability can be minimized with techniques like bagging and boosting. In this study, a regression tree was built with a depth of 11 layers and 351 leaf nodes. For TPSC DAB, training and test accuracies were observed to be 99.99% and 33.33%, respectively. The significant difference between the training and test accuracies indicates that the decision tree is overfitting. To avoid overfitting, either the number of training data points needs to be increased or variations should be introduced into the dataset.
- E. Random Forest: An ensemble method is a technique that combines the predictions of different machine learning algorithms to improve the overall model performance. Some popular ensemble learning techniques include boosting, bootstrap aggregation (bagging), and stacking. Random forest (RF) is also a type of ensemble learning because it combines a collection of decision trees, each contributing to the final prediction. RF addresses the shortcomings of individual decision trees, such as overfitting and model instability. By selecting the best trees from the collection, RF can effectively handle large and complex regression and classification problems. However, random forests are also susceptible to overfitting, and the model is typically larger and computationally more expensive compared to decision trees. In the case of TPSC-DAB, training and test accuracies were observed to be 99.87% and 33.33%, respectively. The significant difference in accuracy suggests that the ensemble random forest model, like decision trees and KNN, is overfitted. Therefore, it can be concluded that most machine learning models are prone to overfitting when dealing with smaller datasets like TPSC-DAB.

- F. Artificial Neural Network: Artificial Neural Networks (ANNs) are inspired by the networks of biological neurons. They are highly versatile, powerful, and scalable algorithms, making them well-suited for addressing large and complex tasks. There are various types of neural network architectures, including feed-forward neural networks, also known as multi-layer perceptrons (MLPs), recurrent neural networks, convolutional neural networks, and more. Research is continuously underway to develop novel neural network architectures aimed at overcoming challenges such as heavy computational requirements for model training, the increasing demand for faster model inference on low-powered edge-computing devices, and the need for model adaptability across a wide range of applications using a single model.
- In this project, a feed-forward neural network is utilized to estimate the predictor function for TPS control of a DCDC DAB converter. Initially, an ANN architecture with 5 hidden layers and a varying number of neurons in each layer was selected. The model underwent training for 200 epochs. Both the training and validation losses experienced a drastic decrease until the 8th to 10th epochs; thereafter, both losses remained relatively steady throughout the training process, with the validation loss slightly elevated. The consistent gap between the training and validation loss after the 25th epoch indicates underfitting of the model. With this architecture, the ANN achieved training and test accuracies of 17.27% and 28.77%, respectively, on the TPSC-DAB dataset. The lower accuracy of the ANN model is attributed to underfitting, leading to poorer performance compared to linear regression, especially with a smaller dataset.
- To obtain the best model, the number of hidden layers was subsequently increased, and the model's performance was analyzed. It is observed that increasing the number of hidden layers initially improves the model's performance, but after the 20th layer, the performance drastically deteriorates. Furthermore, if the model is trained with deeper hidden layers, i.e., beyond the 50th to 60th layer, the model's performance becomes more or less similar to that of shallow hidden layers. Based on this analysis, the optimal number of hidden layers for this problem was found to be 8 to 10 layers. In addition to optimizing the hidden layers, additional data points were generated using analytical methods, and the training split ratio was further increased to 90% of the entire dataset. Finally, MATLAB's Neural Network Toolbox was used to train the ANN model with the optimized number of hidden. Consequently, the ANN model with 10 hidden layers was found to achieve training and test accuracies of 99.95% and 99.99%, respectively. Subsequently, the Simulink block of the trained model was exported and implemented in the simulation.
- G. Comparative study of the models: All machine learning methods compatible with multi-output regression problem were explored for the TPS control of the dual active bridge converter. It is observed that while neural networks are popular techniques in the artificial intelligence (AI) field, they are susceptible to underfitting with fewer data points. However, despite lower training accuracy compared to other models, ANNs are more generalized and thus perform better during model inference. One of the main objectives of the study is to determine if a simple and lightweight machine learning model can be used for TPS control of the DAB converter, making it easily deployable on lower computing devices like DSPs. It is evident from the analysis that lighter models such as linear regression, KNN, and decision trees outperform ANNs during both model training and inference. Additionally, the ANN model requires significantly more time for both training and inference compared to other multi-output regression models. In

conclusion, it can be inferred that less computationally expensive ML models are best suited for the DAB-TPS control problem, particularly for deployment on lower-powered devices like DSPs.

- In the next reporting period, one of the computationally inexpensive methods will be implemented on DSP platform.

Work related to Goal 5:

- The work under this task is to build LVRT control for the TAB converter with different sources and loads connected to the grid. To supply reliable power to a critical load or to perform fault ride through control – a thorough examination of the IEEE 1547 standard was conducted earlier. In this month, a control strategy has been developed for implementation in Typhoon HIL.
- 1.2. Selection of Power flow control strategy
- Dwelling upon the architecture described in Goal-2, we consider the same TAB converter with three ports: load, source, and storage element. Port 1 hosts a load with a rated power of P1, port 2 connects to a source with a rated power of P2, and port 3 accommodates a source or sink (battery storage) with a rated power capacity of P3. It's important to note that for a given power flow of P1, P2, and P3, multiple sets of control variables are possible. An optimal internal control strategy has already been developed to ensure efficient and stable operation of the converter under steady-state conditions. However, this task extends beyond steady-state to address short or intermediate fault conditions, preventing a complete disruption of power flow from the wind or PV source.
- There are two possible fault scenarios: a) from the source/grid side, and b) from the load side. In the case of a fault from the source/grid side, an under-voltage condition may result in a power dip on the load side. This temporary power dip must be mitigated by supplying energy from the battery storage. Conversely, in an overvoltage condition, there is a risk of a power surge from the source to the load side. The storage system must immediately address this surge, as its dynamics are not fast enough to respond on its own. Therefore, the control system must ensure swift adaptation to this abrupt change. In the next month implemented control will be demonstrated.
- → To supply uninterrupted and reliable power to the subsea loads, the MER must have a robust control strategy. The supervisory mechanism guarantees that each source offers accessible power by considering the load demand and ensuring a reliable electricity supply to subsea loads. The primary objective of the power management scheme presented here is to optimize the utilization of wind power while sustaining the offshore grid in the islanded mode for as long as possible. This is accomplished by maintaining the desired state of charge (SOC) for the batteries. The first phase of this report focused on Goals 1 and 2 which concern the 'power control algorithm' with a triple-active-bridge (TAB) converter for the integration of BESS (battery energy storage system), WTGs, and offshore grid to supply reliable power to the subsea loads. Continuing from Goals 1 and 2, a control algorithm is implemented on the best-selected architecture. The next phase of the reports completed the tasks on medium-power subsea motors for oil and gas applications, termed Goal 3. In Goal 3, an elaborative control structure is thoroughly studied. Under Goal 4, a machine learning (ML) based control is implemented on a dual-active-bridge (DAB) converter, and the results are analyzed. In Goal 5, a fault ride-through (FRT) control algorithm is developed, with the TAB converter discussed under Goal 2.

- Controlling power electronic converters can be particularly challenging due to various factors, including changes in ambient temperature and parameters, communication delays, and the limitation of the absence of precisely designed transformers. Therefore, these days, machine learning methods are becoming more and more popular in all the research field domains, including power electronics. There are several advanced machine learning methods available based on different objectives. Therefore, this section first delves into a comprehensive examination of various ML algorithms applicable to power electronic converters, drawing insights from an extensive review of existing literature

- The major divisions in ML approaches can be classified as (a) Reinforcement Learning (RL) (c) Unsupervised, and (d) Supervised Learning.

- (A) Reinforcement learning - an environment-centric methodology, enabling machines and software to autonomously determine optimal behavior, thereby enhancing efficiency within a specific context. The foundation of this approach lies in penalties or rewards, intending to execute actions that minimize penalties and maximize rewards by harnessing insights derived from the environment. RL can enhance the efficiency of complex systems through operational optimization or automation using trained Artificial Intelligence models.

- (B) Semi-supervised: - operates between "with supervision" and "without supervision" learning approach, therefore it is considered as a hybrid method. The semi-supervised approach proves advantageous in real-time scenarios due to the abundance of unlabeled data and the scarcity of labeled data across diverse contexts. It excels in predictive accuracy compared to predictions solely relying on labeled data.

- (C) Unsupervised: - a data-driven process, with minimum or no human interface. It involves the analysis of datasets containing exclusively unlabeled data. This approach is extensively employed for data exploration, grouping results, identifying meaningful structures and trends, and extracting general features.

- (D) Supervised: - as a process of making a function to learn to map output from input. A function is inferred by using training example collection and training data which is labeled

- But among these various techniques Reinforcement learning stands out as superior for real-world applications. The trend of analysis can be noticed from the literature survey. Therefore, the following study has focused on reinforcement learning methods. There have been extensive applications reported for reinforcement learning from computer systems, energy-related, finance, healthcare, robotics, transportation, and education-based applications to games, and these RL methods are also categorized for these applications, few of these categories.

- However, our study focused on power electronic applications. A method involving Bayesian Regularization with artificial neural network (BR-ANN), and random forest (RF) with bootstrap aggregation technique has been proposed to model the transient and steady-state response of the power converters, respectively in [2]. Concurrently, there has been significant work done in replacing the lookup table and extending the soft-switching operation range in a DAB converter using various machine-learning algorithms. A reinforcement learning (RL) algorithm - Q learning [4] is used to optimize the phase shifts to achieve minimum current stress without violating the soft switching constraints. A discrete lookup table is later replaced by training ANN on the RL-optimized solutions. Hence, with the RL-ANN TPS control scheme, efficiency was

improved by 29.4% in low-power conditions and 7.6% under high-power conditions compared to the single phase-shift (SPS) modulation technique. Some researchers have experimented with Deep Q-learning Networks (DQN) to get the optimal phase shift angles for minimum inductor RMS current and ZVS guaranteed throughout the operation [5]. Even a more advanced RL algorithm - Deep Deterministic Policy Gradient (DDPG), has been used to solve the optimal phase shifts for TPSC of a DAB converter, to minimize the overall power losses [6]. Similarly, in [7], the authors have performed both the simulation and experimental studies on automatic TPSC, optimized for minimum power losses; and AI-based TPS modulation technique targeted to minimize the current stress [8]. Both these papers have divided their work into three stages, i.e., training optimal TPS modulated phase shifts on a neural network to replace conventional analytical methods, phase shift modulations optimization with particle swarm optimization (PSO) for improved power efficiency, and finally, real-time implementation with fuzzy inference system (FIS). The one objective of this work is to explore computationally less demanding machine learning (ML) models to replace the lookup table for optimal phase shift modulations of the DAB.

- Notably, the focus of progress in this report pertains to the DAB converter, rather than the TAB converter as previously indicated. Due to the absence of prior experience with the intricate structure of the TAB converter to be integrated with ML topology, constructing the model for training the systems posed considerable challenges. Therefore, the decision to prioritize the DAB converter over the TAB converter stems from the intention to establish the control algorithm using a simpler structure for training and comprehending the model's behavior.

- Conventional Phase Shift Control: Traditional phase shift control stands out as the fundamental and widely employed method for DAB control. It operates by maintaining the duty cycles of square waves at both ports at a constant 0.5, utilizing only phase shift as a control parameter for the circuit

- Dual Phase Shift Control: Dual-phase shift control (DPSC) emerges as a progression from the traditional control approach. Its distinguishing feature lies in the inclusion of an additional variable: control over the duty cycle of one port. This adjustment facilitates a reduction in the current passing through the bridges, particularly advantageous under lighter loads where the use of TPSC would result in inefficiencies. Consequently, DPSC serves to optimize DAB control, enhancing overall system efficiency and alleviating switch stress during lighter loads.

- Triple Phase Shift Control: Triple phase shift control represents a further advancement beyond the aforementioned control methodologies, incorporating three variables to govern power flow. Similar to DPSC, this control strategy mitigates current stress on switches compared to traditional methods. This leads to a positive impact on primary system losses, enhancing efficiency by leveraging three degrees of freedom

- The behavior of the dual active bridge converter is typically described through two main approaches: the harmonics model and the piecewise model. In this study, the harmonics model has been employed for analyzing the converter due to its straightforward nature. Utilizing the harmonics model, the analysis expands the quasi-square voltages at the outputs of H-bridges through the Fourier series. The power P transferred between ports using the fundamental voltage components is, $P = 4/(\pi^3 fL) V_1 \cos(d_1/2) V_1 \cos(d_1/2) \sin\emptyset$. Here d1 is the duty cycle of port 1, d2 is the duty cycle of port 2, and ϕ is the phase shift between the bridges, and f is the switching frequency of the converter

and L is the leakage inductance value of the converter. Therefore, the power transferred within the DAB relies on the duty cycles of the bridges and the phase shift between them. It is noteworthy that different combinations of d1, d2, and φ may yield identical power values. However, in such cases, analyzing the current flowing to the transformer winding is beneficial, as the set with the minimum peak or RMS current contributes to better efficiency in terms of conduction losses for the overall system.

- Next, a control system employing CPSC is realized with Proportional-Integral (PI) controllers, which provide phase shift φ as output and transmit it to the bridge at the output side with a fixed duty cycle. Conversely, when DPSC or TPSC is utilized, a lookup table is employed to store the values of d1, d2, and φ corresponding to predetermined power flow levels. This lookup table is generated using the power equation, iterating through each possible combination of d_1, d_2, and $φ$ while adhering to appropriate limits. Introducing a novel control approach for DAB in this study is a Neural Network (NN)-based DAB control which will be comprehensively explained in subsequent sections

- Data Preparation and Interpretation: The goal of this work is to identify a lightweight and computationally efficient Machine Learning (ML) model suitable for low-resource computing devices such as microcontrollers and Digital Signal Processors (DSPs). This allows for the implementation of online learning on board, utilizing real-time data to dynamically enhance model performance. A dataset for Triple-Phase Shift Control of a Dual Active Bridge Converter (TPSC-DAB) is generated through analytical methods outlined in equations [3]. The dataset is meticulously filtered to minimize current stress for a specific combination of modulations (φ, d1, and d2), ensuring its suitability for training purposes.

- The dataset is subsequently partitioned into training (80%), validation (10%), and test (10%) sets. For ML training, power is selected as the sole input variable, while φ, d1, and d2 are designated as multi-output variables. Given that the system constitutes a single-input multi-output (SIMO) configuration, not all machine learning methods are suitable for multi-target regression problems. Consequently, this paper focuses on training and testing various ML algorithms compatible with multi-output regression on the DAB-TPSC dataset. A comparative analysis of the performance of each model is conducted through simulation, providing insights into their effectiveness

- Linear Regression: Linear Regression stands as one of the simplest algorithms in the domain of machine learning. It offers a linear approach to modeling the scalar response of one or multiple explanatory variables. In the case of multiple inputs, it is also referred to as multi-linear regression. Despite its simplicity, Linear Regression proves effective for single-input single-output (SISO), single-input multi-output (SIMO), or multi-input multi-output (MIMO) systems. In a multi-output regression scenario, the linear regression model endeavors to correlate the input variable with each of the output variables, resulting in the final output being a composite of individual predictions. For TPSC-DAB, the observed training and test accuracies were 67.08% and 53.31%, respectively

- K-Nearest: K-Nearest Neighbors (KNN) can serve both classification and regression tasks, although it is predominantly used for classification purposes. In a regression context, the KNN algorithm utilizes feature similarity to forecast outputs for new data points. The predicted value is computed as the average of the k nearest neighbors. Choosing a smaller k enhances training accuracy but raises the risk of overfitting. Conversely, opting for a larger k results in a more generalized model, though training may

necessitate a larger dataset to avoid under-fitting. For TPSC-DAB, KNN achieved training and test accuracies of 99.36% and 33.33%, respectively. Once again, the notable disparity between training and test accuracies indicates the potential overfitting of the model

- Decision Trees: Decision trees can perform both classification and regression tasks. They are the fundamental building blocks of ensemble methods like random forests. Decision trees are simple and can easily handle both numerical and categorical data. However, when they are deeper, they become prone to overfitting. Even a small variation can lead to a completely different tree structure. Such model instability can be minimized with techniques like bagging and boosting. In this study, a regression tree was built with a depth of 11 layers and 351 leaf nodes. For TPSC DAB, training and test accuracies were observed to be 99.99% and 33.33%, respectively. The significant difference between the training and test accuracies indicates that the decision tree is overfitting. To avoid overfitting, either the number of training data points needs to be increased or variations should be introduced into the dataset

- Random Forest: An ensemble method is a technique that combines the predictions of different machine learning algorithms to improve the overall model performance. Some popular ensemble learning techniques include boosting, bootstrap aggregation (bagging), and stacking. Random forest (RF) is also a type of ensemble learning because it combines a collection of decision trees, each contributing to the final prediction. RF addresses the shortcomings of individual decision trees, such as overfitting and model instability. By selecting the best trees from the collection, RF can effectively handle large and complex regression and classification problems. However, random forests are also susceptible to overfitting, and the model is typically larger and computationally more expensive compared to decision trees. In the case of TPSC-DAB, training and test accuracies were observed to be 99.87% and 33.33%, respectively. The significant difference in accuracy suggests that the ensemble random forest model, like decision trees and KNN, is over-fitted. Therefore, it can be concluded that most machine learning models are prone to overfitting when dealing with smaller datasets like TPSC-DAB

- Artificial Neural Network: Artificial Neural Networks (ANNs) are inspired by the networks of biological neurons. They are highly versatile, powerful, and scalable algorithms, making them well-suited for addressing large and complex tasks. There are various types of neural network architectures, including feed-forward neural networks, also known as multi-layer perceptron (MLP), recurrent neural networks, convolutional neural networks, and more. Research is continuously underway to develop novel neural network architectures aimed at overcoming challenges such as heavy computational requirements for model training, the increasing demand for faster model inference on low-powered edge-computing devices, and the need for model adaptability across a wide range of applications using a single model

- In this project, a feed-forward neural network is utilized to estimate the predictor function for TPS control of a DCDC DAB converter. Initially, an ANN architecture with 5 hidden layers and a varying number of neurons in each layer was selected. The model underwent training for 200 epochs. Both the training and validation losses experienced a drastic decrease until the 8th to 10th epochs; thereafter, both losses remained relatively steady throughout the training process, with the validation loss slightly elevated. The consistent gap between the training and validation loss after the 25th epoch indicates the under-fitting of the model. With this architecture, the ANN achieved training and test accuracies of 17.27% and 28.77%, respectively, on the TPSC-DAB

dataset. The lower accuracy of the ANN model is attributed to under-fitting, leading to poorer performance compared to linear regression, especially with a smaller dataset.

- To obtain the best model, the number of hidden layers was subsequently increased, and the model's performance was analyzed. It is observed that increasing the number of hidden layers initially improves the model's performance, but after the 20th layer, the performance drastically deteriorates. Furthermore, if the model is trained with deeper hidden layers, i.e., beyond the 50th to 60th layer, the model's performance becomes more or less similar to that of shallow hidden layers. Based on this analysis, the optimal number of hidden layers for this problem was found to be 8 to 10 layers. In addition to optimizing the hidden layers, additional data points were generated using analytical methods, and the training split ratio was further increased to 90% of the entire dataset. Finally, MATLAB's Neural Network Toolbox was used to train the ANN model with the optimized number of hidden. Consequently, the ANN model with 10 hidden layers was found to achieve training and test accuracies of 99.95% and 99.99%, respectively. Subsequently, the Simulink block of the trained model was exported and implemented in the simulation

- Comparative study of the models: All machine learning methods compatible with multi-output regression problems were explored for the TPS control of the dual active bridge converter. It is observed that while neural networks are popular techniques in the artificial intelligence (AI) field, they are susceptible to under-fitting with fewer data points. However, despite lower training accuracy compared to other models, ANNs are more generalized and thus perform better during model inference. One of the main objectives of the study is to determine if a simple and lightweight machine learning model can be used for TPS control of the DAB converter, making it easily deployable on lower computing devices like DSPs. It is evident from the analysis that lighter models such as linear regression, KNN, and decision trees outperform ANNs during both model training and inference. Additionally, the ANN model requires significantly more time for both training and inference compared to other multi-output regression models. In conclusion, it can be inferred that less computationally expensive ML models are best suited for the DAB-TPS control problem, particularly for deployment on lower-powered devices like DSPs

- The dual active bridge with the parameters shown in Table I with a Neural Network method was simulated on MATLAB-Simulink. The NN controller model is trained which takes power P as input and, provides three outputs: phase shift and duty cycles for leading and lagging bridges, respectively. The closed loop also involves a PI control, this main PI controller adjusts the phase required for the required power delivery and keeps the output voltage stable. Therefore, during the dynamic operation of the converter, when the power demand is the same, β is the same but d1 and d2 are considered constant for the least reactive power component and least harmonic power circulation. Thus, the target is to achieve an active power delivery with the best input power factor. The voltage and current waveforms are being analyzed for 100kW power transfer

- First, we have trained a neural network (NN) model in Simulink. We obtained the weights obtained for a NN network from Simulink. These weights are then used to implement real-time control, such as on the PYNQ-Z2 board. Initially, the controller algorithm is tested step-by-step using a Python script in a Jupyter notebook. We have successfully implemented the control in this manner. However, the issue with the Python script is that the switching frequency for the PWM has certain limitations, preventing us from

increasing it further. Therefore, we will now implement the same control using VHDL directly on the PYNQ-Z2 board. We have tried to implement the control with the Vivado platform. The system works fine in the open loop with only a certain power output. It fails to generate exact phase shifts for different power ranges, as the output voltage is not being monitored during the open loop. To make it a closed-loop system, we need an NN that can work on the error signal for a wide range

- The work under this task is to build LVRT control for the TAB converter with different sources and loads connected to the grid. Before approaching the control, it is necessary to understand the constraints for the control action laid by IEEE-1547. Therefore, this task was initiated with a deep study of IEEE standards for LVRT. A thorough examination of the IEEE 1547 standard has been conducted. Within the scope of this project, particular attention has been devoted to understanding the control of DER systems during disturbances in area EPS.

- The IEEE 1547 standard outlines technical specifications governing the functional aspects of Distributed Energy Resource (DER) systems interfaced with the grid. It specifies the requirements for the following: 1) Reactive power capability and voltage/power control; 2) Response to abnormal conditions in area electrical power systems (EPS); 3) Maintenance of power quality; 4) Islanding; 5) Integration of DER on distribution secondary grid/area/street (grid) networks and spot networks; 6) Interoperability, information exchange, information models, and protocols; and 7) Testing and verification requirements

- The control requirements for a ride-through action and the applicability of this IEEE 1547 are also categorized according to the kVA rating of the system:

- Category A where the DER penetration in the distribution system is lower, and where the overall DER power output is not subject to frequent large variations.

- Category B covers all requirements within Category A and specifies supplemental capabilities needed to adequately integrate DERs in local Area EPSs where the aggregated DER penetration is higher or where the overall DER power output is subject to frequent large variations.

- Once the category is defined for the system to be integrated, the control action for the system has to follow the following subcategory during the abnormalities. These subcategories define the boundaries and limits for the control action during system operation.

- Abnormal operating performance
  - Category I addresses fundamental bulk power system (BPS) stability and reliability requirements achievable by current widely-used DER technologies.
  - Category II encompasses all BPS stability and reliability needs, aligning with existing reliability standards to prevent tripping during a broader array of disturbances affecting BPS stability.
  - Category III addresses both BPS stability/reliability and distribution system reliability/power quality needs, aligning with existing interconnection requirements particularly suited for environments with very high DER penetration

- Several abnormalities types are listed and discussed in IEEE 1547.- Low-voltage ride-through (LVRT), High-voltage ride-through (HVRT), Low-frequency ride-through (LFRT), High-frequency ride-through (HFRT), Rate of change of frequency (ROCOF) ride-through, and Frequency-droop (frequency-power). The major two are being

considered in the following text for the control actions toward voltage abnormality and frequency abnormality. The boundary of the control for voltage abnormalities (phase-phase/phase-neutral/phase-ground) and the parameters are also considered for the control establishment.

- The testing of the ride-through requirement has to be conducted as per the proper conditions mentioned in, and these test conditions are also noted. Therefore, the control on the integrated system must pass this test for proper implementation on the grid system. The ride-through tests shall be performed at two output power levels, high and low, and any convenient power factor greater than 0.90. Low-power tests shall be performed at any convenient power level between 25% and 50%.

- Dwelling upon the architecture described in Task 2, we consider the same TAB converter with three ports: load, source, and storage element. Port 1 hosts a load with a rated power of P1, port 2 connects to a source with a rated power of P2, and port 3 accommodates a source or sink (battery storage) with a rated power capacity of P3. It's important to note that for a given power flow of P1, P2, and P3, multiple sets of control variables are possible. An optimal internal control strategy has already been developed to ensure efficient and stable operation of the converter under steady-state conditions. However, this task extends beyond steady-state to address short or intermediate fault conditions, preventing a complete disruption of power flow from the wind or PV source. In this quarter, we developed a technique to control the power transfer under fault.

- To bring a seamless power transfer operation into action, the power transfer algorithm is explained with the flowchart in Fig. 1. At the start of each switching cycle, the fault condition is sensed. Under the no-fault condition, power transfer occurs among the load, battery, and source (PLoad <=> PBat <=> PSource) through conventional TAB converter control. If the source power is higher than the load, the excess power is stored in the battery. In the event of a short-circuit fault (SCF) on the source side, the TAB topology operation shifts back to a DAB topology for delivering power from the battery to the load, Pbat => PLoad. In the SCF on the load side, to minimize fault impact with fast dynamics, the converter operation shifts to a non-conventional Buck or Boost operation.

- Once the battery state of charge reaches a maximum of 100% or a minimum of 20%, a trip is unavoidable. Notice that in this work, the algorithm is developed for uninterrupted power supply generation. This enhancement would enable the system to maintain power supply even under extreme conditions by isolating critical loads from non-critical ones. The algorithm's adaptability ensures that power delivery is optimized based on real-time conditions, reducing the risk of power outages and enhancing system resilience. By dynamically adjusting the power flow and switching between different converter operations, the system can handle a variety of fault scenarios with minimal manual intervention. Furthermore, the power transfer algorithm is designed to be scalable, allowing for future upgrades and integration with other renewable energy sources, such as solar or wind power. This makes the system not only robust and reliable but also sustainable, contributing to a greener energy landscape.

- To verify the effectiveness of the proposed topology and corresponding control strategy, simulation is conducted in MATLAB/SIMULINK. The proposed topology is implemented in simulation with system parameters. Since the source voltage in this

simulation is higher than other voltages, the TAB operates in Buck mode under fault. To validate the performance of the proposed topology under SCFs and OCFs, three cases are presented: · Case 1: An SCF fault occurs in S31 or S32 at 20 µs before 0.1 s, and the system isolates the SCF and switches to Buck mode at 0.1 s. · Case 2: An OCF occurs in S11 at 0.2 s, and the OCF is detected after 40 µs, meanwhile S11 is replaced by S12. · Case 3: The SCF is cleared, and the system switches back to conventional mode from Buck mode at 0.3 s.

- The waveforms of the proposed TAB and conventional TAB for Case 1 are presented. When an SCF occurs on the load side, the control goal is to maintain the power level inside the TAB, ensuring that the power drawn from the source remains stable, preventing internal faults from impacting external systems. The conventional TAB converter exhibits a significant dip in the source side DC link voltage V1 during the SCF, followed by a substantial surge. This is because the transient response of the traditional TAB converter is slow, requiring an extended period to return to a steady state. The sluggish response time may exacerbate the impact of faults, leading to pronounced voltage fluctuations and potential instability in the system. This can also be demonstrated by the waveform of the battery power, which increases slowly after an SCF. In contrast, in the proposed TAB converter, the battery power can rapidly increase to the reference value through the quick transition to Buck mode after the SCF. This swift response significantly reduces voltage fluctuations in V1, ensuring a more stable and reliable operation under fault conditions. Meanwhile, the proposed TAB demonstrates superior performance in managing fault currents. It can quickly short-circuit the windings, resulting in a rapid reduction of the fault current. In contrast, the conventional TAB exhibits prolonged fault current oscillations due to the lingering effects of magnetic flux. This rapid fault current mitigation enhances the overall system stability and reduces the risk of component damage without the need for additional protection devices. The voltage and current waveforms of the proposed TAB converter in Buck mode for Case 2. Before 0.2 s, the battery absorbs power from the source in Buck mode with PWM signal controlling S11. An OCF occurs at S11 at 0.2 s. After 40 µs, the OCF is detected and S12 replaces S11 to receive the PWM signal and continue the Buck operation. During the transition, since the energy stored in the inductor is limited, the battery current reduces dramatically at the beginning of the fault and recovers within 0.4 ms after S12 starts to operate. During this period, the source DC link voltage V1 fluctuates within 5%, demonstrating that the proposed topology effectively addresses OCFs without impacting the power transfer capability.
- The operation waveforms for Case 3. Before 0.3 seconds, the system operates in Buck mode is studied. At 0.3 seconds, after the SCF in Case 1 is cleared, the system switches to the conventional TAB mode of operation. During the transition, the battery current gradually decreases to 0 A, while the load current steadily increases to 150 A. Meanwhile, the source voltage fluctuation is within a satisfactory range. It needs to be noted that fast dynamics are not required in this case since the fault has been cleared before the transition.
- Buck/Boost mode of operation only involves two bridge arms, this topology is highly tolerant to OCFs in other switches, without compromising power transfer capability during fault conditions. Simulation results demonstrate that the proposed topology and control scheme are effective, realizing a seamless transition to post-failure modes.

TASK 2: Optimal Sizing of Onsite Generation Resources for Self-Sustainable Offshore Loads

- Time Domain Simulations and stability Analysis are being performed for the proposed OHRES system. The time domain simulations are performed on MATLAB Simulink. 4 different case studies are being analyzed.
- In the first case study, seasonal variations will be analyzed. In this investigation, 4 different seasonal variations in wind and solar irradiation will be simulated to observe the resilience and reliability of the proposed OHRES.
- In the second case study, climate extremities will be analyzed. Here the impact of extreme weather conditions pertinent to offshore environment like strong winds and intense summer heat will be simulated to observe the resilience and reliability of the proposed OHRES system.
- In the third case study, load fluctuations will be analyzed. This analysis will delve into the OHRES's response to abrupt and substantial variations in load. By performing this analysis, we will gain insight into the adaptability and stability of the OHRES system.
- In the fourth case study, the OHRES response to faults and disturbances will be analyzed. Faults such as loss of a generation unit (e.g.: a wind turbine) or the loss of a Battery unit will be simulated, and the resilience of the system will be observed.
- The ultimate goal of this simulation is to validate the system's design parameters, identify possible vulnerabilities, and optimize its configuration for reliability and efficiency in offshore energy applications.
- The Simulink model currently contains a hybrid photovoltaic and wind power subsystem which models the offshore wind turbines and the photovoltaic systems. The offshore wind turbine model takes in input of the number of wind turbines and the wind speed while the FPV model takes into account the ambient temperature and the irradiance. The hybrid photovoltaic and wind power system is connected to a three-phase transformer which is connected to an infinite bus which is coupled to a load.
- Initially, some challenges were encountered within the model. Through testing and troubleshooting, we have rectified the bugs, and have a model that operates as predicted and generates accurate V-I curves. At present, our model depicts the battery as an infinite source, serving to mitigate the intermittencies stemming from renewable resources. Likewise, the load is simplistically portrayed as a constant 3-phase load. However, it's essential to acknowledge that the load dynamics on offshore oil and gas rigs differ significantly; they comprise various motor loads rather than a uniform 3-phase load. As a result, refinement of the model is intended to accurately capture these nuances in load behavior.
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- The ultimate goal of this simulation is to validate the system's design parameters, identify possible vulnerabilities, and optimize its configuration for reliability and efficiency in offshore energy applications.
- The preliminary design of the Cost Optimization for Renewable Sizing (CORS) planning model for Offshore Hybrid Renewable Energy System (OHRES) was completed and the CORS model was integrated to a Neural Network Based Battery Degradation (NNBD) model to accurately predict the usage-based degradation of the BESS system and subsequently the costs associated with it prior to this date. The CORS planning model coupled with the Neural Network Based Battery Degradation Model was developed to minimize the overall lifetime cost associated with the OHRES while at the same time ensuring a reliable power supply to the O&G platforms.
- An assumption that the weather profiles remain the same for all days of the lifetime of the microgrid was made using the CORS planning model. However, practically, this is not the case as the weather patterns change on a daily basis. To check the robustness of the system, the proposed microgrid was simulated in MATLAB under varying conditions.
- Simulations on different case studies were performed to analyze the stability of the of the proposed system.
- For the base case, a constant PQ DC load is considered. In this scenario, the power generated from the PV array and the Wind turbines are calculated to be sufficient enough to meet the load demand. The power generated by these resources after boosting and rectification is sufficiently able to supply the load. The system takes a few minutes to adjust itself before it settles to consume 65MW of power, the voltage stays constant at 520kV and current at 125A. Similarly, the battery profile takes a few minutes to adjust itself before settling. Since, the power from the renewable resources is sufficient to power the load, no power is drawn from the battery.
- The Gulf of Mexico experiences a wide range of climate extremities. One in particular being the active hurricane season. Conditions similar to the this were simulated where very little power can be generated from the FPV subsystem and almost no power from the OWT system due to extremely high windspeeds. In such a case, almost no power is available from the renewable resources and all the power will need to be met by the BESS subsystem. However, the OHRES system hasn't been designed to account for climate extremities such as an active hurricane season, hence, the OHRES system will not be able to support normal operations of the O&G rig during climate extremities.
- To implement the optimal sizing and operation model in Python, we utilized packages such as Pyomo and commercial solvers for optimization modeling and solving. To enhance user-friendliness and practical application in industry, we plan to develop a graphical user interface (GUI). Since the model is implemented in Python, developing the GUI in Python ensures a cohesive environment, reducing the complexity of transfer and integration. Python offers several packages for GUI design and implementation, catering to various needs from simple interfaces to complex, cross-platform applications.

Tkinter, the standard GUI library for Python, is widely used due to its inclusion in most Python installations, making it accessible for beginners. It is ideal for creating straightforward and moderately complex applications with its simple, easy-to-learn interface. For more advanced capabilities, PyQt provides a robust set of tools for building sophisticated, feature-rich applications that run on Windows, macOS, and Linux. PyQt's comprehensive widget set and support for multimedia and networking make it suitable for professional-grade software. Another popular option is Kivy, an open-source library designed for developing multitouch applications across multiple platforms, including mobile devices. Kivy is highly customizable and excels in creating applications with modern, touch-friendly interfaces. Similarly, wxPython is a cross-platform toolkit that enables the creation of native-looking GUIs on different operating systems. Its rich collection of widgets and adherence to native platform conventions make it a favorite among developers aiming for a consistent user experience. For those focusing on the GNOME desktop environment, PyGTK offers seamless integration with GTK, providing a wide range of widgets tailored for Linux applications. After comprehensive consideration, PyQt was chosen for this project's GUI development. Firstly, PyQt offers more complex functions compared to Tkinter, such as a comprehensive widget set, multimedia support, networking, and database integration. Secondly, our focus is on desktop devices, making PyQt more suitable than Kivy, which excels on mobile devices. Thirdly, many power system-related simulation and analysis software run on Windows, such as PSSE, PowerWorld, PSCAD, Tara, UPlan, etc. Our project will primarily focus on the Windows platform, making PyQt more suitable than PyGTK.

- We have installed the PyQt5 package, the 5th version of PyQt, in the Python environment and developed initial GUI windows for testing. In a PyQt application, everything is a widget: buttons, labels, windows, dialogs, progress bars, etc. PyQt provides various functions to create and set these widgets, including QLabel, QComboBox, QCheckBox, QRadioButton, QPushButton, QTableWidget, QLineEdit, QSlider, QProgressBar, etc. When creating these widgets, the project will likely consist of multiple widgets. In this case, we need to specify how to position them using functions such as Move, QVBoxLayout, QHBoxLayout, QFormLayout, and QGridLayout. To respond to user actions and run application functions, Qt uses a mechanism called signals to react to events such as button clicks. For example, 'widget.signal.connect(slot)' is used to connect a signal to a slot. After familiarizing ourselves with PyQt functions and mechanisms, we developed a sample window including text and buttons. We further developed another window with multiple buttons, where clicking each button opens a new window with a specific response. Following these initial testing cases, our next steps will focus on connecting each button to specific functions for running the optimal sizing and operation simulation. Each button will represent a specific scenario, and the corresponding parameters for that scenario will be delivered to the function and executed upon the user's click.
- To enable the GUI to run the optimal sizing and operation model, we updated the codes to integrate the model with the click button functionality. We also added message boxes to inform users when the solution is obtained.
- To integrate the optimal sizing and operation model with the GUI window, we updated the codes to implement the model and find the optimal solution. We organized the Pyomo model and the solving codes into a single function, 'BattDeg', which takes the

selected case as input. To run this function upon clicking a button, we used 'button.clicked.connect' to link the button click action with our custom function, 'show_msg_box', within the GUI window class. This function judge which button was clicked and runs the 'BattDeg' function with the input of the specified case (e.g., Gulf of Mexico, Alaska, California). Initially, a QMessageBox pops up to indicate the model has started running. After the 'BattDeg' function completes, another QMessageBox indicates that the process has finished.

- The GUI is further developed for case selection and parameter customization. Users can now select the desired case and set cost parameters for different types of technologies used in the simulations. The selected case and customized parameters will be displayed on the main window for users to review before running the simulation. In the main window of our user interface, we added a new section titled 'custom cost parameters and running'. We added one clicked button 'case options' and five clicked buttons for cost parameter settings of various technologies including Wave Energy Converters (WEC), Tidal Energy Converters (TEC), Offshore Wind Turbines (OWT), Floating Photovoltaics (FPV), and Battery Energy Storage Systems (BESS). After users select a case and set the costs parameters, the customized information should be displayed on the main window for review. Thus, we added labels to showcase the customized information. When the tool starts and the main window opens, these labels will initially display 'default costs setting' to indicate that no user input has been provided yet. Additionally, we included a button beneath these labels for users to run the simulation based on the displayed settings. Clicking the 'case options' button, triggers the 'select_case' function in the GUI codes. This function uses 'QInputDialog' to display a new window with a dropdown menu for selecting available cases. Once a case is selected and the window is closed, the function saves the selection and updates the main window to display the chosen case under 'case to run'. Clicking the buttons for setting cost parameters for specific technology triggers the 'show_pop_up' function in the GUI codes. This function will then display the corresponding window (PopUpWindow1-PopUpWindow5) based on the button clicked. Each 'PopUpWindow' uses 'QLineEdit' from the PyQt5 package to create text boxes for user input of cost parameters. An example of the popup window for TEC cost settings. The 'show_pop_up' function also employs a timer to iteratively check if the popup window is closed. The 'check_close' function checks the window status, and once the window is closed, it calls the 'sync_params' function to save the user-input cost parameters, update the display on the main window, and stop the timer. The updated labels after the user sets the parameters.

- We made several enhancements to the GUI design: we added our lab icon to the top left corner of each window; We adjusted the position and front of the section titles; We modified the position and size of the popup windows.

GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems
TASK 1: Robotic Fish Enabled Pipeline

- The robot fish is up and running with all its capabilities in the pipeline tracking. Time to time improvements are done based on the feedback we get in the testing.
- The robotic fish was able to track the pipeline with PID controller. To improve the performance, more detailed study in the dynamics of the robotic fish is needed. A dynamic model for the fish tail mechanism is developed which provides the forces being acted upon in each direction. The forces come out to be sinusoidal in transient behavior

- with some positive and negative offset which is mainly responsible for driving the robotic fish to move in heading direction or the lateral direction.
- 2D robotic fish simulator is developed in python. Different control strategies can be applied in the simulator to see the real behavior of the robotic fish, before testing it on the physical robot.
- The movement of the fish tail creates a shaky motion in the robotic fish head, which brings a challenge in pipeline tracking because of the shaky image from the camera. This dynamic model will help understanding the forces causing the robotic fish head vibration frequency and amplitude, which would further support in designing an algorithm to avoid those image movements from the camera.
- Due to limitations in hardware performance and device energy consumption, we adopted a strategy to simplify the pre-trained model to achieve high frames per second (fps) for real-time video processing. Three final models, designated as small0, small1, and small2, were developed as candidates. Each model comprises two components: a color enhancement module[2] and a deblurring module. While all models utilize the same color enhancement module, variations arise in the deblurring module. Specifically, small0 employs a simplified convolutional neural network (CNN) without a residual layer, small1 uses a simplified CNN with a residual layer, and small2 is a fully quantized model[1]. The performance of these models is assessed using the Peak Signal-to-Noise Ratio (PSNR), and the processing time per frame and the corresponding fps are recorded for each model.
- Although the PSNR values do not reveal significant differences, visualizing the performance will provide clearer insights. Generally, the more complex the model, the better its deblurring performance, albeit at the cost of increased processing time.
- The camera module, battery pack, and Raspberry Pi have been installed and tested, making the module ready for further testing on the target application.
- Started work on designing the testing rig for the robotic fish. Testing the forces in all rectilinear directions and moments is the first thing to be accomplished in this process. This month we developed a testing platform to record the forces using a force and torque sensor FT40 which give precise measurement with up to 1mN accuracy.
- Successful completion of robotic fish fabrication and extensive testing, confirming sufficient propulsion force even at varying depths.
- A GUI based application is developed in python, which captures the image from the onboard camera, detects pipeline, calculates and shows the heading angle vectors and angles required for the control development.
- Initial testing for the pipeline tracking is completed and preliminary results are acquired
- We have finished the development of the underwater image enhancement/motion deblur using deep neural networks.
- We have migrated the image enhancement deep neural network to the Raspberry PI 4 kit
- Comprehensive testing has been conducted and results have been gathered. A manuscript is ready to be submitted in research journal for the publication.

TASK 2: Autonomous Underwater Vehicle Navigation through Steel Scaffolding

- Submitted a paper to CASE 2024 on the magnetic camera: https://2024.ieeecase.org/call-for-papers/ "Detection and Tracking of Underwater Pipes using a Magnetic Camera
- Performed buried pipe experiments with current camera
- Prepared for pool experiments with a vertically mounted pipe and the 3D magnetometers

- Assembling TMR sensor-based camera
- Continued implementation of camera on robotic fish

GAD 11 – 42115 Offshore Energy Transition: Repurposing Gulf of Mexico Assets

TASK 1: Characterization of Deep-water GOM (Gulf of Mexico) Salt Domes and Proximal Sediments for Storage of Hydrogen and Sequestration of CO2

TASK 2: Developing Methods of Producing and Processing Marine Algae to Biocrude

- Solids extracted from autoclaved (AC) slurry were analyzed for lipid content. Lipids were extracted as fatty acid methyl esters (FAME), which were formed using transesterification. Solids were analyzed for moisture content. For transesterification, 1 g DW of solids was added to two-neck round bottom flask. Methanol (34 mL), hexane (40 mL), and 72% sulfuric acid were all added to the flask. A condenser with cooling water was added to the top of the flask to prevent solvent evaporation. The contents of the flask were heated to 90 °C for 40 min. The flask was allowed to cool to room temperature and then the contents were transferred to a separatory funnel. The flask was washed with 20 mL of DI water and then transferred to the funnel. The layers were allowed to separate and collected in different falcon tubes. The hexane layer was centrifuged to ensure proper separation at 7300 RCF for 8 min. The hexane layer was pipetted into a clean beaker and filtered through 0.2-micron filter. The filtered sample was then transferred to a clean round bottom flask for solvent evaporation using a rotary evaporator. The weight of the extracted FAMEs was recorded. Extracted FAMEs were resolubilized in 20 mL of hexane and stored in -20 °C. The percent FAME extracted from trans esterified biomass (DW) was calculated. Transesterification of solids recovered after autoclaving at solids loading 3, 5, 8, and 10% resulted in FAME yields of 22.9%, 21.8%, 21.0%, and 20.6% DW, respectively. Transesterification of canola oil resulted in a FAME yield of 97.1%.
- A mixture of FAME reference standard 461C from NuChek Prep (C8:0-C24:0) was used to prepare a 10 mg mL-1 working solution. The neat mix was added to a sterile pre-weighed 15 mL falcon tube. The weight of the neat mixture was 0.106 g. To prepare a 10 mg mL-1 working standard, 10.6 mL of hexane was added. Reference standards were prepared as per the dilutions listed in the LAP. Methyl Tri decanoate (C13:0 Me) was used as an internal standard as microalgae do not contain this FAME. A 10 mg/mL of internal standard solution was prepared by adding 57.5 μL of neat C13:0 Me solution and bringing it to a 5 mL volume with hexane. For sample preparation, 250 μL of extracted FAME, 250 μL of internal standard, and 1 mL of hexane was added to 1.5 mL amber vials. Extracted FAME and reference standards were analyzed using gas chromatography mass spectrometry (GCMS). FAME samples were analyzed using a Shimadzu equipped with a GC and MS unit. The temperature profile of the capillary column (30 m x 0.25 mm x 0.25 μm) was as follows: 80 °C for 0.5 min.; raised to 175 °C at a rate of 30 °C min-1, raised to 260 °C at 5 °C min-1 and maintained for 6 min., and raised to 280 °C at 30 °C min-1 and maintained for 1 min. The injector temperature was set to 250 °C and the injection volume was set to 1 μL by split injection mode (10:1). The total run time of the program was 34.33 min. which was automatically calculated by the software.
- Algal slurries were prepared at different solids loading (3, 5, 8, and 10%) and autoclaved for 15 min at 121°C and 15 psi. Slurries were cooled to room temperature and then centrifuged for 30 min at 10,000 rpm and 4 °C. The centrifuge conditions were set to

ensure pellets did not resolubilize while removing the hydrolysate. The hydrolysate was decanted and stored at 4 °C for further testing. The moisture content of the pellets was analyzed, and the dry weight (DW) was calculated. The pellets from 3% FH and 3, 5, and 8% AC slurries were used for biocrude production. To a high-pressure stainless-steel vessel, 1 g of biomass and 100 mL of MilliQ water were added to create a 1% slurry. The pressure vessel was placed in the reactor for hydrothermal liquefaction (HTL) at 350 °C for 1 h. The samples were quenched with water for 5 min. and left at room temperature. Next, samples were rinsed with 20 mL of dichloromethane (DCM) and transferred to a 50 mL falcon tube. Samples were vortexed for 1 min. at 3,000 rpm and then centrifuged at 2,000 g for 1 min. resulting in the formation of an aqueous phase and solid and organic phase. The contents of the falcon tube were transferred to a separating funnel and the aqueous phase was transferred to a pre-weighed vial. The solids and organic phase were filtered through a 0.45 µm glass microfiber filter using a Büchner funnel. The organic phase, comprised of DCM, was transferred to a pre-weighed vial, and evaporated to dryness under N2 for 8 h Bio-oil produced using 3, 5, and 8% AC samples had a yield of 42.6%, 51.8%, and 37.3%, respectively. The CHNS content of the isolated bio-oil was analyzed. The carbon and hydrogen content in bio-oil increased indicating high levels of lipids while nitrogen and sulfur content decreased, indicating low levels of protein compared to the carbon, hydrogen, nitrogen, sulfur, and oxygen (CHNSO) content of whole N. gaditana. This is highly advantageous as high nitrogen and sulfur content increase risk of slagging and fouling of catalyst.

TASK 3: Extending the Life of Offshore Oil and Gas Infrastructure in the Gulf of Mexico for Profitable New uses in Power and Hydrogen Generation in Preparation for the Energy Transition.

- Developed high level designs from different platform configurations for hydrogen and power export projects
- Detailed economic model nearing completion – generated preliminary results on NPV and ROI for different projects

* 2) Summarize any key accomplishments, including milestones completed for the reporting period.

TCEQ:

Submitted CofE Grant II Monetary Amendment on August 1, 2024, requesting additional funds and extending contract dates to February 28, 2027 for both OG and SSI.

Executed amendments for the following:

- OG GAD 3: extended Task 3 deliverable due date to October 31, 2024 and extended the period of performance to November 30, 2024.
- OG GAD 4: extended Task 1 and 2 deliverable due dates to October 31, 2024 and extended the period of performance to December 31, 2024
- OG GAD 5: adjusted the contract budget to reflect the indirect cost rate previously omitted from the original budget; this did not change the total budget amount; and change Baffin Bay location to Upper Laguna Madre.
- OG GAD 6: increased the contract budget to correct the omission of the indirect cost rate.

- OG GAD 7: increased the contract budget to correct the omission of the indirect cost rate.

OG:

GAD No. 1 - 22150 Operational and Administrative
- Completed award set up for GADs 5-7.
- Discussed program evaluation and metrics.
- Operations and administration team is in transition from staff turnover.
- Continued to monitor research project(s).

GAD 3 – 40605 Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities.
- Successful engagement with HGAC's data analytics and IDRT's data management teams to develop a decision support tool around property buyouts in the region.
- Develop risk assessment at the property level by incorporating floods differing in occurrence probabilities (100-year, 500-year, 10-year, 5-year, 2-year). The risk assessment creates average annualized losses (AAL) for each property and allows us to identify hotspots where the risk of flood realized in terms of property damages is high.
- Compiled disparate datasets generated as part of this research and aggregated property (individual)-)-level data at the census tract level to ensure to protect location-specific identifiable information. This data includes number and the total area of buyouts, total cost of buyouts, relocation distances (average, median, minimum, maximum), flood risk, social vulnerability indices, and hotspot indicators where both the social and flood vulnerabilities are high, AAL). Started building a buyout dashboard employing the data generated and compiled by our research team.

GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay
- Completed the key field deployments with the newly developed low cost observing system.

GAD 6 – 44891 Risk Communication in an Age of Misinformation: Emergency Manager and Household Perspectives Pre- and Post-Disaster
- Task 1 near completion - collect information form emergency management professional and media representatives about risk communication preferences and practices.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data
- Completed (and submitted via GRIIDC) deliverable of Master list of stakeholders' goals, unmet needs, backgrounds, and abilities (to inform further development of DIEP and related tools).

SSI:

GAD 1 - 22029 Operations and Administration
- The operations and administration team are fully staffed.

GAD 8 – 42111 Offshore Asset Integrity Monitoring: Environmental Monitoring
TASK 1: Development of Self-Powered Distributed Sensors/Reporters for Integrated Offshore Asset and Local Environment Monitoring

- Determined that multi-layer radial-arrayed rotary triboelectric generator can support more output
- Obtained an optimal structure that can integrate multi-layers non-contact sliding mode triboelectric generators covered by PU and PTFE separately.
- Determined that electrodes relative area of triboelectric generator is highly related to the output power. To avoid large and space occupied situation, multi-layers type is a better choice.
- Determined that PU mode doubled output voltage at the same electrodes distance, compared with air gap when the Cu angle was set by 15˚.

Task 1: Goal 1: Design of highly efficient buoyant triboelectric blinkers is 95% completed

Task 1: Goal 2: Fabrication and characterization of buoyant triboelectric blinkers is 60% completed. Designed, fabricated, and demonstrated multi-layer stacking-sliding mode triboelectric generators.

- Goal 2 is currently at 95% completion

GAD 9 – 42112 Design and Development of Offshore Power Systems
TASK 1: Multi-port Energy Router using Intelligent Transformers (MERIT): Energy

- Goals 7, 8 and 9 were completed before the end of April 2024

TASK 2: Optimal Sizing of Onsite Generation Resources for Self-Sustainable Offshore Loads

- The MATLAB Simulink Model has been generated and validation tests under the different scenarios is being performed.
- The GUI model has been generated and upgrades are being made to enhance user experience.

GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems
TASK 1: Robotic Fish Enabled Pipeline

- Successful completion of robotic fish fabrication and extensive testing, confirming sufficient propulsion force even at varying depths.
- Successfully, developed the dynamic model of the forces generated by the fish tail mechanism moving at different frequencies and different phase angles.
- Successfully, developed the dynamic model to study the robotic fish movement in water caused by the forces. Some parameters still need to be estimated with experiments. This dynamic model will help in designing better control techniques for pipeline tracking.
- We have conducted testing on the development of underwater image enhancement using deep neural networks.
- We have assembled the Raspberry PI 4 kit and streamlined the workflow for migrating the image enhancement deep neural network to the mobile unit.
- Designed and fabricated the testing rig for the force testing of the robotic fish. The tests are still to be performed.
- Robotic Fish has been tested in a swimming pool.
- HD camera is installed in the robot fish to make it able to view the pipeline and capture imagery in the water.
- A python-based Windows Application is developed to see the live performance of the pipeline tracking of the robotic fish.
- Fully checked the ROV and fixed the waterproofing issues.
- Developing vision algorithm to detect white pipelines

- Preliminary testing of the robotic fish-based pipeline tracking
- Implemented a deep learning-based object recognition model and tested it on a mobile computing platform.
- Set-up a testbed for edge computing
- Tested the edge computing on the testbed.

TASK 2: Autonomous Underwater Vehicle Navigation through Steel Scaffolding

- Sediment (sand) does not seem to impact performance of Hall-effect based camera.
- Calibration of the fluxgate sensors by subtracting the initial detection sphere has shown promise in preliminary lab testing.

GAD 11 – 42115 Offshore Energy Transition: Repurposing Gulf of Mexico Assets
TASK 2: Developing Methods of Producing and Processing Marine Algae to Biocrude

- We have successfully up-scaled N. gaditana culture to ~48 L and are identifying the conditions to flocculate. Highest yield of lipids was extracted from 3% AC. GCMS revealed that most prominent FAMEs were methyl myristoleate and methyl laurate. HTL of lipid-rich solids extracted from 5% algae slurry had a bio-oil yield of 51.8%. The carbon and hydrogen content of bio-oil increased and nitrogen and sulfur content decreased.
- Lipid extraction, GCMS analysis of FAMEs, HTL of lipid-rich solids, CHNS of bio-oil

TASK 3: Extending the Life of Offshore Oil and Gas Infrastructure in the Gulf of Mexico for Profitable New uses in Power and Hydrogen Generation in Preparation for the Energy Transition.

- Model design and Set Up completed.
- Results presented at different forums.

* 3) List any contracts awarded during the reporting period, along with the name of the contractor and its principal, the Unique Entity Identifier (UEI) of the contractor, the value of the contract, the date of award, a brief description of the services to be provided, and whether or not local preference was used in the selection of the contractor.

TCEQ:
No contracts were awarded during this reporting period.

OG:
No contracts were awarded during this reporting period.

SSI:
No contracts were awarded during this reporting period.

* 4) If the recipient or any subrecipient is authorized to make subawards, list any subawards executed during the reporting period, along with the name of the entity and its principal, the Unique Entity Identifier (UEI) of the entity, the value of the agreement, the date of award, and a brief description of the scope of work.

TCEQ:
No subawards were executed during this reporting period for TCEQ.

OG:

No subawards were executed during this reporting period for OneGulf.

SSI:

No subawards were executed during this reporting period for SSI.

SECTION B-2:

* 1) Indicate if any operational, legal, regulatory, budgetary, and/or ecological risks, and/or any public controversies, have materialized. If so, indicate what mitigation strategies have been undertaken to attenuate these risks or controversies.

TCEQ:

There were no operational, legal, regulatory, budgetary, and/or ecological risks and/or public controversies for TCEQ during this reporting period.

OG:

There were no operational, legal, regulatory, budgetary, and/or ecological risks and/or public controversies for One Gulf during this reporting period.

SSI:

There were no operational, legal, regulatory, budgetary, and/or ecological risks and/or public controversies for SSI during this reporting period.

Although Hurricane Beryl impacted the city of Houston, including the University of Houston campus, with debris, damage, and power outages, it only slowed work for a few days.

* 2) Summarize any challenges that have impeded the recipient's ability to accomplish the approved scope of work on schedule and on budget. If the scope of work is not on schedule, the recipient should propose a revised schedule and update its milestone report.

TCEQ:

Staff changes at TCEQ presented delays in moving forward with the monetary amendment request. In August 2024, the Grant Specialist III for Bucket 5 CofE II transitioned to Grant Specialist V Work Lead for Treasury-related projects. A Grant Specialist II was hired with a start date of October 1, 2024.

OG:

GAD 3 – 40605 Flood Risk and Vulnerability: Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities

- Due to staff changes in the Institute of Disaster Resilient Texas team, who were supposed to help with the dashboard, there was a delay in the building of the dashboard and in engagement and outreach to stakeholders to engage and co-produce the dashboard. Requested additional 6 months to complete deliverable 3 and close out of project.

GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay

- The delay in the initial contract and subsequent agreements did result in both a shift in the start date and schedule conflicts with other projects and among the different investigators. We were able to work through these, but it did necessitate changes in the sequencing of activities. It also necessitated changes in approach to some extent, most

specifically we opted to develop a lighter weight more compact set of observing system components that required fewer people to deploy and could be deployed from smaller vessels without lifting equipment. That helped with the personnel scheduling constraints. The tradeoff was time, we had to spend more of our time developing that system because we could use fewer off the shelf components; however, it also resulted in a system with other advantages as well. For example, we estimate that once the system components are connected and started on deck it only takes 10 minutes to deploy the array and only requires two people on deck, and recovery is the same (10 minutes, 2 people).

GAD 5 – 44890 Advancing harmful algal bloom monitoring efforts on the Texas coast to protect human health and coastal economies

- In July, the deployment site for one of our IFCBs (pier on Copano Bay) was destroyed by Hurricane Beryl. This has not delayed us (yet), and we continue to look for new locations for deployment. This may lead to delays in the next cycle if we have not identified a new location.

GAD 6 – 44891 Risk Communication in an Age of Misinformation: Emergency Manager and Household Perspectives Pre- and Post-Disaster

- There were a number of potential storms and one hurricane – Beryl – to hit the Texas coast during the reporting period. This delayed interviews with emergency management professionals who were busy making preparations for these storms. Much of the study area was impacted by Hurricane Beryl, thereby making it difficult to move forward with interviews of emergency managers.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data

- Due to new pricing plans implemented by X (formerly Twitter), we have requested and received permission to purchase access to the social media data ("Tweets") needed to complete the project. These expenses were not in the original budget because academic access to Twitter data was previously available free of charge. We remain on schedule to complete the approved scope of work.

SSI:
No challenges that have impeded the SSI's ability to accomplish the approved scope of work on schedule and on budget.

SECTION B-3:

* 1) Summarize any significant findings or events, including any data compiled, collected, or created, if applicable.

TCEQ:
TCEQ submitted its request for a monetary amendment August 1, 2024. Treasury's NOA for CofE Grant II Monetary Amendment -03 was received September 2024.

OG:
GAD 3 – 0605 Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities

- We compiled and aggregated data generated by the research team on flood risk, vulnerability assessment, buyout location and relocation, and hotspots.
- Estimated the property level average annualized risk for Harris County.

GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay

- We collected field observing data over the course of six days for differing lengths of time each day and are analyzing the results now.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data

- Data created: Master list of stakeholders' goals, unmet needs, backgrounds, and abilities. Associated significant findings: the 13 most important outcome variables for meeting stakeholder needs were identified. These are the variables that will be modeled using the DIEP system.
- Data collected: X social media posts for Hurricane Beryl (10,000 Tweet sample). Associated significant findings: Identified data cleaning and quality control needs for working with tweets for Texas hurricanes. Identified zip code as target geographic level for DIEP modeling.

SSI:

GAD 8 – 42111 Offshore Asset Integrity Monitoring: Environmental Monitoring

TASK 1: Development of Self-Powered Distributed Sensors/Reporters for Integrated Offshore Asset and Local Environment Monitoring

It is confirmed that a triboelectric generator can produce a high voltage and power many light-emitting diodes at the same time. We found that some special configurations showing better performance, such as PU and PTFE pairs.

We have validated that multi-layers triboelectric generators can be integrated and scaled to produce more power.

GAD 9 – 42112 Design and Development of Offshore Power Systems

TASK 1: Multi-port Energy Router using Intelligent Transformers (MERIT): Energy

- Numerous ML methods have been implemented to train the control model for the DAB converter, and one of them has been reported in this report.
- The boundary selection for LVRT control and the testing method for LVRT were studied by IEEE 1547. The associated control strategy was implemented.

TASK 2: Optimal Sizing of Onsite Generation Resources for Self-Sustainable Offshore Loads

GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems

TASK 1: Robotic Fish Enabled Pipeline

We have finished the pipeline tracking control. Selected the baseline method for low-light image enhancement and targeted the hardware platform for the edge computing.

TASK 2: Autonomous Underwater Vehicle Navigation through Steel Scaffolding

- We have finished pipeline tracking control.
- We have selected the baseline method for low-light image enhancement.
- We have a target hardware platform for the edge computing.

TASK 3: Innovative Research in Monitoring Subsea Connections using Percussion and Machine

GAD 11 – 42115 Offshore Energy Transition: Repurposing Gulf of Mexico Assets
TASK 3:

Space availability on typical offshore decks limits size of hydrogen export projects. Power export projects not as limited – decks can support larger power export projects.
Clean energy projects can generate sufficient cash flow to cover decommissioning costs to be incurred before and after the clean energy phase. Challenge remains in generating an acceptable ROI.

SECTION B-4:

* 1) Describe any activities to disseminate or publicize results of the activity, project, or program, including data and its repository and citations for publications resulting from this Award.

TCEQ:
TCEQ RESTORE staff periodically updated the RESTORETHETEXASCOAST.org web site, including references to Bucket 5 activities.

OG:
GAD No. 1 - 22150 Operational and Administrative
- Dr. Paul Montagna presented "Freshwater inflow to Texas bays and estuaries" at the Brazos River BBASC meeting, Conroe, TX, 11 July 2024, 21 participants. This presentation described State needs and potential research topics for the upcoming RFP.
- Dr. Paul Montagna presented "Freshwater inflow to bays" at the Texas Outdoor Writers Association annual conference, Fulton, TX, 10 May 2024, 19 participants. This presentation described the State approach to environmental flow planning.
- Dr. Paul Montagna presented "Freshwater inflow to Texas bays and estuaries" at the Trinity-San Jacinto-Galveston Bay BBASC meeting, Conroe, TX, 1 May 2024, 49 participants. This presentation described State needs and potential research topics for the upcoming RFP.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data
- Preliminary results were shared with our stakeholder partners during the focus group activities completed during the reporting period.

SSI:
GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems
TASK 1: Robotic Fish Enabled Pipeline

X. Yi and Z. Chen, "Image-based Visual Servoing Control of Underwater Vehicle for Pipeline Tracking", International Journal of Intelligent Robotics and Applications, Vol. 8, pp. 1–13, 2024.

TASK 2: Autonomous Underwater Vehicle Navigation through Steel Scaffolding

Submitted a paper on the magnetic camera mounted on the ROV for pipe tracking to CASE 2024 (https://2024.ieeecase.org/). CASE 2024 held on August 28 – September 1, 2024, in charming Puglia (or Apulia), Italy.

GAD 11 – 42115 Offshore Energy Transition: Repurposing Gulf of Mexico Assets
Task 2:

James Pierson 1, Gopi Raju Makkena 1, Sandeep Kumar 2, Vinod Kumar 3, Vivekanand Vivekanand 4, Hasan Husain 1, Muhammad Ayser 1 and Venkatesh Balan "Modeling the Production of Microalgal Biomass in Large Water Resource Recovery Facilities and Its Processing into Various Commodity Bioproducts" published in Fermentation Journal

Drashti Mojidra,1Venkatesh Balan,1Sandeep Kumar2 "Developing Methods of Producing and Processing of Marine Microalgae to Biocrude" Poster shown during Energy Research Day at The University of Houston Main Campus

Task 3:

Phase 1 results documented in two technical papers to be submitted to journals for publication; summary paper accepted for presentation at Offshore technology Conference in May 2024 Presenting results at the IPF24 Oceantic Network offshore wind conference in New Orleans in April 2024.

SECTION B-5:

* 1) Describe all efforts taken to monitor contractor and/or subrecipient performance, including site visits, during the reporting period.

TCEQ:
TCEQ monitored subrecipient performance include ongoing communication with both Centers through e-mail, phone calls and conference calls, reviewing Financial Status Reports (FSRs) and Progress Reports for accuracy, reviewing each Centers' performance by comparing FSRs and progress reports to executed grant activities, and review and acceptance of project deliverables.

OG:
GAD No. 1 - 22150 Operational and Administrative
- Held project meeting as needed or requested per PIs of GADs 3-7.
- Continued monitoring all GAD performance through reporting, travel request, and invoices.

GAD 3 – 40605 Flood Risk and Vulnerability: Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities.
- Monthly meetings with PIs to monitor the progress of the project and has written notes and video recordings of stakeholder meetings to keep track of information they provide as well as follow-up with commitments.

GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay
- There were two subawards in this contract to co-PIs at Texas A&M University (TAMU) College Station and University of Houston. We held meetings to discuss work progress and monitor performance.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data
- Weekly Zoom meetings and frequent email communications were used to monitor progress of the Texas A&M University (TAMU) subrecipient towards completion of their assigned project tasks.

SSI:

- Program Director, Research Administrator, and Industry Liaison meet monthly to monitor performance and review submitted Principal Investigator reports.
- Principal Investigators and their teams meet quarterly with the Program Director, and Industry Liaison to discuss activities, key accomplishments, challenges, and other activities of the projects.

* 2) For subawards, indicate whether the subrecipient(s) submitted an audit to the recipient, and if so, whether the recipient issued a management decision on any findings.

TCEQ:

Staff revised the process to request track audit and certification submissions so that reminders can be sent to subrecipients when these documents are due to be submitted as a deliverable by September 30 each year. No audit information was requested during this reporting period.

OG:

No single audit information was requested from Texas A&M-Corpus Christi during this reporting period.

SSI:

No single audit information was requested from the University of Houston during this reporting period.

* 3) For awards where Davis-Bacon Act provisions are applicable, indicate whether the recipient and/or subrecipient(s) received and reviewed certified weekly payroll records and/or whether the recipient or subrecipient(s) conducted labor interviews.

TCEQ:

The Davis-Bacon provisions are not applicable.

OG:

The Davis-Bacon provisions are not applicable.

SSI:

The Davis-Bacon provisions are not applicable.

* 4) Describe any other activities or relevant information not already provided.

TCEQ:

TCEQ continued to work with both Centers to develop the material needed for the CofE Grant II Monetary Amendment that the agency submitted August 1, 2024. The NOA was received by TCEQ on September 26, 2024.

OG:

There are no other activities or relevant information for OneGulf that is not already provided.

SSI:

GAD 9 -42112 Design and Development of Offshore Power Systems
Personnel Change: From January 2024, Tutan (Postdoctoral Fellow) is continuing to work on this project. Arnur and Virendra have completed their PhD degrees and are no longer working on this project.

GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems
TASK 3: Innovative Research in Monitoring Subsea Connections using Percussion and Machine

* Summarize the activities planned for the next reporting period.

TCEQ:
With the NOA for CofE Grant II Monetary Amendment -03, TCEQ is preparing Contract Amendments for OG and SSI. Upon competition, GAD Amendments will be executed, as needed. Continue to monitor active grants, including budgets, deliverables, and productivity.

OG:
GAD 1 – 22150 Operations and Administration
- Continue to monitor current research projects.
- Continue content analysis as preparation for the next RFP.
- Plan for next RFP cycle
- Upon monetary amendment of Contract award, we will then amend GADs as applicable and appropriate for no cost extensions and amend GAD 1 for a monetary amendment.
- Complete annual report for RESTORE Council as requested by TCEQ.
- Consult with TOAC, TOCL and TONE to update SRAP
- Update research priorities in SRAP.
- Continue search for hiring of Program Manager and Research Specialist.

GAD 3 – 40605 Flood Risk and Vulnerability: Evaluating the Fiscal and Social Implications of Property Buyouts in Flood-prone Communities.
- Continued development of a GIS-based decision dashboard in partnership with the research team of IDRT and local stakeholders.
- Follow-up with the Data Analytics and Research Divisions of the Harris-Galveston Area Council, with the city of El Lago, Pasadena, and Baytown communities to introduce the tool, solicit feedback, and make appropriate changes if needed.
- Develop several manuscripts to be submitted for publications, incorporating (1) hotspot analyses; (2) fiscal impacts; (3) property hedonic model; (4) flood risk modeling.

GAD 4 – 34872 An Observational Study of Ship Channel and Shallow Bay Interactions and their Influence on Sediment Transport, Mixing, and Water Quality in Corpus Christi Bay
- We are reviewing results of the field observations.
- We will evaluate whether it is beneficial to collect any additional data in the time remaining.
- Investigators will analyze and synthesize results in a final report with recommendations for future steps.

GAD 5 – 44890 Advancing harmful algal bloom monitoring efforts on the Texas coast to protect human health and coastal economies
- Select the Baffin Bay/Upper Laguna Madre IFCB deployment site and order instrument.
- Identify new Copano/Aransas Bay deployment site and finalize site preparation logistics.
- Conduct stakeholder survey and analyze results.

- Conduct analysis of water quality data in support of HAB monitoring plan.
- Participate in HAB event response workshop at Texas State Aquarium to receive additional stakeholder feedback on HAB monitoring plan.

GAD 6 – 44891 Risk Communication in an Age of Misinformation: Emergency Manager and Household Perspectives Pre- and Post-Disaster
- Continue to conduct interviews and focus groups with emergency managers to collect data on risk communication experiences, perceptions, and challenges.
- Analyze interview data to identify themes and critical issues.
- Prepare paper to present interview data findings.
- Develop the survey experiment to explore effectiveness of varied risk communication channels and messages.
- Develop survey questionnaire to explore household risk information perceptions, preferences, and needs.

GAD 7 – 44892 Towards Targeted Risk Mitigation: Community Engaged, Fast Impact Estimation of Extreme Weather using Big Social and Climate Data
- Continue acquisition, cleaning, and organizing of data sources relevant to the identified disaster impact types, including social network data, meteorological and oceanographic data, and damage and loss data for associated disaster events.
- Continue development a prototype Disaster Impact Estimation Prediction (DIEP) system (including artificial intelligence (AI) and machine learning (ML) approaches such as deep neural network (DNN)), to estimate statistics for identified disaster impact types based on social and climate data and using machine learning techniques.
- Begin developing online GUI for estimation, visualization, and communication, developed through user- centered design, prepared using standard web technologies.

SSI

GAD 1 – 22029 Operations and Administration
Continue administrative and operational work to develop Center of Excellence

Hold advisory board meeting.

GAD 8 – 42111 Offshore Asset Integrity Monitoring: Environmental Monitoring
TASK 1: Development of Self-Powered Distributed Sensors/Reporters for Integrated Offshore Asset and Local Environment Monitoring

TASK 2: Practical Implementation of Organic Electrochemical Transistors (OECTs) for Subsea Detection

GAD 9 – 42112 Design and Development of Offshore Power Systems
TASK 1: Multi-port Energy Router using Intelligent Transformers (MERIT): Energy

- Implementation of DAB converter control using the developed ML method using the HIL or simulation platform.
- Final development of LVRT control for the TAB converter, and implementation using the HIL or simulation platform

TASK 2: Optimal Sizing of Onsite Generation Resources for Self-Sustainable Offshore Loads

GAD 10 – 42113 Offshore Robotics and Automation for Safer Offshore Energy Systems
TASK 1: Robotic Fish Enabled Pipeline

TASK 2: Autonomous Underwater Vehicle Navigation through Steel Scaffolding

TASK 3: Innovative Research in Monitoring Subsea Connections using Percussion and Machine

<u>GAD 11 – 42115 Offshore Energy Transition: Repurposing Gulf of Mexico Assets</u>

TASK 1: Characterization of Deep-water GOM Salt Domes and Proximal Sediments for Storage of Hydrogen and Sequestration of CO_2

TASK 2: Developing Methods of Producing and Processing Marine Algae to Biocrude

TASK 3: Extending the Life of Offshore Oil and Gas Infrastructure in the Gulf of Mexico for Profitable New uses in Power and Hydrogen Generation in Preparation for the Energy Transition.