ALBERTA INNOVATES

CLEAN RESOURCES FINAL REPORT PACKAGE

Project proponents are required to submit a Final Report Package, consisting of a Final Public Report and a Final Financial Report. These reports are to be provided under separate cover at the conclusion of projects for review and approval by Alberta Innovates (AI) Clean Resources Division. Proponents will use the two templates that follow to report key results and outcomes achieved during the project and financial details. The information requested in the templates should be considered the minimum necessary to meet AI reporting requirements; proponents are highly encouraged to include other information that may provide additional value, including more detailed appendices. Proponents must work with the AI Project Advisor during preparation of the Final Report Package to ensure submissions are of the highest possible quality and thus reduce the time and effort necessary to address issues that may emerge through the review and approval process.

Final Public Report

The Final Public Report shall outline what the project achieved and provide conclusions and recommendations for further research inquiry or technology development, together with an overview of the performance of the project in terms of process, output, outcomes, and impact measures. The report must delineate all project knowledge and/or technology developed and must be in sufficient detail to permit readers to use or adapt the results for research and analysis purposes and to understand how conclusions were arrived at. It is incumbent upon the proponent to ensure that the Final Public Report **is free of any confidential information or intellectual property requiring protection**. The Final Public Report will be released by Alberta Innovates after the confidentiality period has expired as described in the Investment Agreement.

Final Financial Report

The Final Financial Report shall provide a complete and accurate accounting of all project expenditures and contributions over the life of the project pertaining to Alberta Innovates, the proponent, and any project partners. The Final Financial Report will not be publicly released.

ALBERTA INNOVATES

CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	**Field Demonstration of Artificial Intelligence powered Predictive Emissions Monitoring Systems (PEMSs)**
Alberta Innovates Project Number:	212201791
Submission Date:	Oct 20th 2023
Total Project Cost:	$2,268,021
Alberta Innovates Funding:	$350,000
AI Project Advisor:	Claude Ghazar

2. APPLICANT INFORMATION:

Applicant (Organization):	PTAC Petroleum Technology Alliance Canada
Address:	Suite 400, 500 5th Avenue SE, Calgary, AB, T2P 3L5
Applicant Representative Name:	Marc Godin
Title:	Director of Technology
Phone Number:	403-870-5402
Email:	mgodin@ptac.org

3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

The following partners were crucial to the project goals and the project overall:

- CRIN
- MITACS
- Alberta Machine Intelligence Institute
- VL Energy
- Suncor Energy

These partners were instrumental in successful development, deployment, reporting, and evaluation of this project.

A. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes and benefits.

RESPOND BELOW

VL Energy has developed a first-of-its-kind artificial intelligence (AI) powered Predictive Emissions Monitoring System (PEMS). Leveraging the power of cloud computing and AI methods, the PEMS dynamically analyzes the operating parameters of combustion equipment and empowers predictive models for emission monitoring. Compared to the incumbent Continuous Emissions Monitoring Systems (CEMS), PEMS significantly reduces capital and operating costs, while improving safety and mitigating environmental impacts. The commercial application of VL Energy's AI-powered PEMS at current oil and gas production sites has the potential to reduce GHG emissions by 342,780 t CO2e over the first five years. This project has realized a demonstrated, robust, approved, safe, and cost-effective method for air emission monitoring for oil sands OTSG's, gas plants, and other combustion sources. The project will also support 20 direct and 120 indirect jobs by 2030.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

Sector Introduction

The primary target market for the PEMS solution is the facilities equipped with CEMS. Specifically, when thinking of CEMS within the oil and gas industry, the end users are oil sands, natural gas processing, refineries, and petrochemicals. Continuous Emissions Monitoring Systems (CEMS) continuously sample the exhaust gas, heat it, and run collected gas through gas analyzers to measure the concentration of emission sources. These systems are expensive and unsafe and are slated for replacement by innovative solutions such as the PEMS product commercialized through this project.

A secondary market is to provide cost-effective continuous emissions monitoring methods for all oil and gas producers, instead of using generic emission factors. In order to evaluate the market for PEMS, it's important to review the current CEMS market. According to TechNavio Global CEMS Market (2015-2019) report, the total addressable market (TAM) across Canada is CAD $300 million per year. In Alberta alone, there are ~ 150 facilities equipped with ~200 CEMS units according to Alberta Environment and Parks (June 2021). The TAM for Alberta alone is ~ CAD $80 to $100 million and ~ CAD $8 million to $10 million per year because traditional CEMSs have a 7–10-year lifetime.

Knowledge and Technology Gaps

The project team validated and commercialized a cloud-based PEMS for gas emission monitoring, GHG reductions, and fuel consumption optimization.

The project addressed the following gaps:

- **Inaccuracy of predictive models:** Existing predictive models are built based on the first principle and statistical methods. This project commercialized an AI-based predictive model based on big data analytics and advanced ensemble algorithms for higher accuracy.
- **Lack of CEMSs for small combustion sources:** This project will validate the transferability of predictive models from one equipment to another. By doing so, PEMS provides cost-effective monitoring methods for small sources, such as engines, heaters, and boilers.

- **Loss of production and increase of GHG emissions**: Production loss and emission increase from venting, flaring, and/or fugitives because of equipment trips through the deployment of the well-predictive and preventative maintenance models.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Knowledge or Technology Description

The aim of the project team was to further solidify the technology behind the overall PEMS applications, progressing from a TRL of 7 to 9. The work done in this project is part of a broader project scope supported by the Clean Resources Innovation Network (CRIN). Information on the CRIN supported VL Energy project can be found here: https://www.cleanresourceinnovation.com/competitions/digital-oil-and-gas-technology-competition

The scope of this project focused on the following aspects of the PEMS technology:

- **User automation interface and cloud computing:** Creating an easy-to-use interface that showcases a variety of sensors, alarms, and overall real-time readings of emitted gases. The team also focused on creating a cloud-based system to intercept, review, analyze, and then report collected data.
- **Address sensor drifting:** Another key aspect of this project was to effectively address sensor failure and drift.

The scope above was addressed with three specific milestones that were completed from Jan 2022 to Aug 2023. The milestones were as follows:

1) Data Collection and Model Training and Testing: The project team worked towards selecting model inputs, collecting historical data, and training and assessing an initial model embedded within the PEMS unit. This milestone led to the development of a robust stacked deep learning model that is customized to the industry project partner.
2) Regulatory Collaboration: This milestone focused on guiding and establishing regulatory collaboration by initiating approvals from Alberta Environment and Parks and Albert Energy Regulator. Also included in this milestone was acquiring PEMS code for testing against existing CEMS code and creating data packages/summaries in collaboration with our industry partner.

3) Front-end and Back-end Development, Model Deployment, and Real-Time Monitoring: The last milestone was focused on access of PEMS units by project partners through an intuitive user interface supported by cloud-based data pipeline.

Overall, the project met the required scope assigned with no major changes to project objectives or milestones. The PEMS unit has been deployed and tested by industry partners and will continue to be successful in its early commercialization journey.

Performance Metrics

The were various metrics that were assigned to understand the overall progress of project milestones and their intended outcomes. The following showcases the overall success of the PEMS project:

- The project achieved the required TRL of 9
- VL Energy was successful in collaborating with industry partners and members of the clean energy ecosystem, with multiple marketing collateral and publications developed and published.
- All milestones were delivered on time and on budget
- Multiple end users for the PEMS unit will be realized due to the achievements of objectives in this project

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

Alberta Innovates funding was critical to forward two aspects of PEMS:

1) Funding was sought to automate a manual data transfer process and transition operations to cloud computing, which would significantly reduce manual involvement and streamline the data processing.
2) Funding was sought to augment the system's capability in detecting sensor drifting, a requirement for adherence to local regulations.

In order to achieve the above advancements, the team worked through three milestones in the span of 20 months, from January 2022 to August 2023.

Milestone 1: Data Collection and Model Training and Testing

The project team focused on selecting appropriate model inputs, collecting historical data, and

developing and evaluating an initial model integrated within the PEMS unit. The aim of this milestone was to create a functioning machine learning or deep learning model tailored to each unique industry partner's historical information and operational processes.

Milestone 2: Regulatory Collaboration
Milestone 2 demonstrates progress towards regulatory collaboration. The project team initiated the regulatory approval process, engaging with local regulatory bodies, and setting up a trial conforming to regional monitoring regulations. They also worked on a Quality Assurance Plan and continued to enhance the machine learning model within the PEMS unit to manage sensor drifting.

Milestone 3: Front-end and Back-end Development, Model Deployment, and Real-Time Monitoring
This milestone focused on the user-friendliness and accessibility of installed PEMS units for industry partners. VL Energy has developed APIs for smooth information flow, a cloud-based database for field data storage, a review dashboard, and a daily alert system for emission monitoring. The project team will further refine the deployed PEMS model, completing the what-if analysis, and proactive maintenance models, and eventually transition the model to the cloud for easier access by industry partners.

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project's milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

Project Results

Project results were realized by milestone and are summarized as follows:

Milestone 1: Data Collection and Model Training and Testing

- **Data Collection and Review:** Successful gathering and assessing essential equipment and system datasets, which is critical for understanding the framework needed for accurate predictive modeling of emissions.
- **Model Input Selection:** Thorough screening and selecting model inputs using statistical and machine learning techniques, ensuring the relevance and significance of the chosen parameters for the model.
- **Data Pre-processing:** Application of various data pre-processing approaches to enhance the quality and reliability of the dataset, preparing it for effective model training.

- **Model Development:** Development and evaluation of multiple machine learning and deep learning models. A hybrid model showed promising results in initial tests, indicating a step forward in achieving the desired predictive accuracy.
- **Feature Importance Evaluation:** Assessment of the importance of individual features in the model, identifying significant contributors to the model's predictive capability.
- **Upcoming Testing:** Plans were created for further testing of the developed model with new data to ensure its robustness and readiness for practical application.

Milestone 2: Regulatory Collaboration

- **Initiation of Regulatory Approval Process:** The project team embarked on securing necessary approvals. This included initiating dialogues with relevant environmental and energy regulatory bodies and preparing to commence trials in accordance with local emissions standards. Collaborative efforts between VL Energy and its industry partners were underway to compile and present requisite data packages and summaries to various stakeholders.
- **Monitoring Plans:** Engagements have been initiated with key stakeholders to kickstart the emissions monitoring program. This encompasses the consolidation of practical procedures and the assembly of an information package for submission to the regulatory bodies for their approval.
- **Quality Assurance Planning:** Work commenced alongside project stakeholders on the quality assurance program, with ongoing dialogues to align on process parameters ensuring accuracy within operational processes required for the emissions monitoring system.
- **Sensor Drift Management:** A machine learning model has been developed to tackle sensor drifting issues by detecting and rectifying anomalies or missing values in key input sensors. When a sensor operates outside the stipulated range, corrective measures are initiated based on predictive insights from the model.
- **End-user Interface Development:** An interactive user interface is being crafted to facilitate real-time monitoring of instrumental sensors and system predictions. The interface will also enable statistical analysis on sensor readings and emissions data, with automated report generation for regulatory submissions.
- **Commercial Product Refinement:** Efforts have been intensified to refine the product offering, laying a solid foundation for future commercialization pathways.

Milestone 3: Front-end and Back-end Development, Model Deployment, and Real-Time Monitoring

- **Deployment and Enhancement:** The model was transitioned to a cloud platform, with established data and CI/CD pipelines ensuring seamless data handling and model updates. Post-evaluation tests, conducted periodically, served to refine the model with insights from accurate and inaccurate predictions.

- **Routine Monitoring and Alerts:** A mechanism for daily checks was set up alongside a notification system to maintain model integrity and alert on deviations from operational parameters, ensuring a responsive approach to potential issues.
- **Sensor Management and User Interface Refinement:** Strategies for managing sensor drift were tested and refined, while user feedback drove enhancements to the interactive dashboard, improving overall user experience.
- **Maintenance and Ongoing Evaluation:** Rigorous testing and troubleshooting of the system's dashboard, alert setup, and model performance continued, leveraging a significant dataset to ensure accuracy and reliability.
- **Product Advancement:** Successful deployment in this milestone laid a solid foundation for engaging more clients, refining the commercialized product, and progressing towards patenting the product and its processes.

F. KEY LEARNINGS

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes.

RESPOND BELOW

Learnings

Learning was realized by milestone and are summarized as follows:

Milestone 1: Data Collection and Model Training and Testing

The first milestone, beginning of the project, focused on the following:

- **Understanding System Dynamics**: A thorough review of the equipment and process parameters provided foundational knowledge crucial for model development tailored to accurate emission predictions.
- **Input Selection and Data Significance**: The meticulous selection of model inputs, coupled with the collection of historical data, underscored the role of precise input selection and quality data in model development and performance.

- **Model Performance and Improvement Areas**: The exploration of various models and the subsequent performance analysis highlighted the potential of a specific hybrid model, while also identifying the importance of capturing distinct data peaks as an area for improvement.
- **Readiness for Unseen Data Testing**: The upcoming testing phase with unseen data emphasizes the importance of validating the model's robustness and generalization capabilities, preparing for real-world application.

Milestone 2: Regulatory Collaboration

This milestone was focused on regulatory collaboration as well as technical developments required for PEMS. Specifically:

- **Model Development and Accuracy**: The PEMS model was refined using a substantial dataset collected over a number of years. It underwent a training and validation process, with further validation carried out in collaboration with a partner. Improvements were noted in sensor drifting management and real-time monitoring integration.
- **Regulatory Approval Initiation**: The initiation of the regulatory approval process, along with the development of monitoring plans and a Quality Assurance Plan (QAP) began successfully. Ongoing discussions with various stakeholders occurred to understand the approval timeline and requirements, setting the stage for enhanced automation within the PEMS system and efficient addressing of future approval needs.
- **Sensor Drift Management**: Continuous testing of machine learning models for sensor drift detection was in progress during this milestone, contributing to the creation of precise alarm systems for monitoring teams. This element is vital for ensuring the PEMS model operates as required, with ongoing refinement being emphasized. This work was focused on further in milestone 3.
- **End-user Interface Automation**: A user-friendly dashboard is being developed to facilitate the review process of the PEMS platform, focusing on intuitive visualizations to aid effective decision-making by monitoring teams. This development is also aiding in conceptualizing the commercialization trajectory and further improvements for the product.

Milestone 3: Front-end and Back-end Development, Model Deployment, and Real-Time Monitoring

Key learning items in this milestone include:

- **User Interface Development**: A user interface was developed and successfully implemented for end-user interaction, facilitating easy access to key data and insights.
- **Dashboard Features**: The dashboard provides a structured view of sensor readings, alarms, real-time data monitoring over selected intervals, and pages for viewing basic sensor information, real-

time sensor readings, dynamic prediction results, and real-time prediction metrics along with assigned rules for corresponding sensors.

- **Cloud Data Pipeline Deployment**: A data pipeline, including a CI/CD pipeline and a collection of machine learning models, was successfully deployed on a cloud platform, demonstrating a streamlined process for data retrieval, processing, and real-time monitoring.
- **Sensor Drift Detection**: Machine learning models were developed and tested for detecting and correcting sensor failures and drifts. The process involved predicting future sensor readings, comparing them with actual readings, and identifying notable gaps indicative of sensor failure or drift. Effective measures were established for labeling and correcting these discrepancies, enhancing overall system reliability and accuracy.

G. OUTCOMES AND IMPACTS

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

Project Outcomes and Impacts

The PEMS technology developed due to the support of Alberta Innovates under this project report has assisted in primarily increasing the technical capacity of the solution. Overall, the system has achieved TRL 9. Other key outcomes include:

- VL Energy has successfully finished its work with Suncor and is looking to work with other industrial partners in the next 2 years.

- VL energy has successfully collaborated with PTAC and Suncor, with additional funding from CRIN. VL is also now working with Canadian Destruction Lab (CDL). CDL will accelerate PEMS adoption and investment in VL Energy.
- Publications: VL Energy is successfully completing the publication of PEMS with their industry partner for this project.
- The project team has successfully tested and deployed cloud computing and overall cloud infrastructure for the PEMS solution.
- Sensor drift has been successfully completed and tested.
- The project remained aligned with budget requirements for each milestone and has met project budget requirements.

The following list includes the variety of activities that occurred over the duration of this project:

- PTAC CRIN Innovation Showcase: VL Energy has shared its innovative PEMS product in the PTAC CRIN Innovation Showcase platform. The platform is accessible to hundreds of stakeholders in the energy network across Alberta, Canada, and North America.
- World Petroleum Congress: VL Energy has been part of multiple presentations, events, and B2B meetings during this event.
- Digital Innovation Forum: VL Energy will be presenting at the upcoming Digital Innovation Forum hosted by PTAC. This is an annual event that showcases digital-based energy sector focused solutions and problems.
- YouTube DEMO of PEMS: VL Energy is now offering a demonstration of their PEMS dashboard for other stakeholders and the public to view. Link here: https://www.youtube.com/watch?v=Lmfxj3I8n4s
- Digital Spotlight: VL Energy was a panelist in the Jan 2023 Digital Spotlight event series called “Actionable outcomes from Artificial Intelligence and Machine Learning”
- CRIN’s Project Cafe: VL Energy presented in CRIN’s project cafe to provide an update on the PEMS work that occurred in 2023.

H. BENEFITS

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

Economic

The economic benefits to Canada's energy sector through the implementation of the Project Emission Management System (PEMS) are significant. Firstly, PEMS presents a cost-effective alternative to traditional Continuous Emission Monitoring Systems (CEMS), with initial costs being around 70% of CEMS, and operating costs estimated to be 80% lower. This cost efficiency is further enhanced by integrating PEMS maintenance into existing facility maintenance programs, which requires no additional instrumentation or specialized care. Furthermore, the SaaS distribution model of PEMS alleviates the need for routine staff training on environmental reporting, a requirement in traditional CEMS.

Secondly, the project showcases the Canadian oil and gas industry's adaptability to emerging technologies, reflecting a strong commitment to enhancing environmental performance. This adaptability is likely to attract new investments as environmental, social, and governance (ESG) considerations become increasingly crucial in managing investment risks. Companies quick to adopt such innovative technologies might gain a competitive edge, particularly in a landscape where disruptive technologies are redefining traditional business models and practices across various sectors.

Lastly, the project contributes to the development of new processes and products, extending the application of acquired knowledge and advanced cloud analytics across all oil and gas production processes. This initiative promises more accurate emission quantification and monitoring, replacing outdated emission estimation methods with a verifiable and representative solution. By enabling the Industrial Internet of Things (IIoT) through cloud computing and AI, the project facilitates real-time data

processing and communication, offering facility operators valuable insights for optimizing operational efficiency, enhancing productivity, and managing industrial assets and processes more effectively. Through these advancements, the project sets the stage for significant economic benefits, improved environmental stewardship, and a competitive advantage in the evolving global energy market.

Environmental

PEMS intends to mitigate GHG emissions and enhance energy efficiency through two key strategies: firstly, refining fuel consumption efficiency through analytical methods to decrease emissions from stationary combustion, and secondly, minimizing equipment downtimes to reduce venting emissions. The vented gas, rather than being released, would be utilized as fuel, mitigating unnecessary emissions.

The solution highlights the significance of accurate emissions monitoring for effective resource allocation. It aims to replace the generic emission factors traditionally used in environmental monitoring with a more reliable and continuous monitoring tool supported by PEMS.

Additionally, PEMS is geared towards enhancing safety measures by significantly lowering fire risks associated with conventional monitoring systems, thus contributing to a safer operational environment in oil and gas facilities.

Building Innovation Capacity

By 2030, it is estimated that 20 direct jobs will be created and 120 indirect jobs. VL Energy has worked and will continue to work hand in hand with our industry partners to ensure their workforce is well-equipped and trained to work with digital solutions. The project will bring AI, cloud computing, and machine learning skills and knowledge to workers in the oil and gas industry. The project has led to a series of webinars and training sessions for various departments within the industry partners' organization, such as instrumentation, environmental, and maintenance. The day-to-day operators in oil and gas companies now understand how AI-based predictive models work, and they can successfully design their routine activities in parallel to the predictive models. All developed infrastructures, technical knowledge, and regulatory input can be utilized across oil and gas, and the larger energy ecosystem, allowing VL Energy to promote validated solutions that can be used to mentor and guide other SMEs looking to work on similar challenges.

PEMS can also be used around the world. The United States (US) and the European Union have established regulatory frameworks for PEMSs. Other regions, like the Middle East and Asia, use the US Environmental Protection Agency (EPA)'s PEMS regulatory framework. Our cloud-based product together with the SaaS distribution model will enable us to provide services locally in Canada to facilities around the world. The knowledge and export relationships developed will be further shared with SME communities in Canada.

Social

The economic benefits to Canada's energy sector through this project include the reduction of capital cost, annual operating cost as well as the increase of competitiveness. PEMS uses process instrumentation and the PEMS routine maintenance is integrated into facility's preventative maintenance programs. No extra instrumentation or care is needed. In addition, PEMS is a SaaS distribution system thus eliminating

routine training for environmental reporting staff. In contrast, traditional CEMSs need daily, weekly, monthly, semi-annually, and annual PMs on their components, such as analyzer calibration, calibration gas audits, and much more.

The project showcases Canadian oil and gas industry's capability to adopt emerging technologies and its commitment to continuously improve environmental performance. Investors are increasingly considering environment, social, and governance (ESG) issues to help manage investment risks. Under ESG ratings, companies that quickly adopt new technologies may have a competitive advantage over those that try to maintain business as usual.

Increasingly a range of disruptive technologies is:

- Being used across business sectors to disrupt traditional business models and incumbents and to create entirely new solutions, including in the areas of impact and sustainability, and
- Shaping the way that companies and investors do business and measure impact.

This project has demonstrated Canadian oil and gas industry's willingness to apply new technologies in terms of addressing underlying environmental issues, as well as measuring and monitoring the environmental impacts.

The knowledge base and skills developed from the project and from the creation of a cloud platform for advanced analytics can be used on all oil and gas production processes. Improving the accuracy in quantifying and monitoring air emissions through the implementation of AI, cloud computing and IIOT will replace the current emission estimation methods that are using generic emission factors. The proposed solution is verifiable and more representative of the facilities' emission profile.

I. RECOMMENDATIONS AND NEXT STEPS

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

Commercialization Plan

PEMS is poised to disrupt the market and usher in breakthrough technology by amalgamating AI and cloud computing for precise and cost-effective emissions monitoring. This project characterized a joint tech

demonstration and evaluation and is expected to diversify industry offerings and accelerate innovation, especially within Alberta and Canada. The cloud infrastructure pivotal to this project facilitates not only a global outreach for the proposed solution but also lays a foundation for other prospective technical advancements such as digital asset management in the oil and gas sector. Through the course of the project, a robust knowledge transfer is anticipated, enriching Canadian companies and fostering commercialization efforts. This transfer of expertise and technology is facilitated by collaborations among sizable entities within the oil and gas sector and academic institutions, mutually benefiting from shared knowledge pivotal to this project.

To gain a competitive edge globally, hastening innovation and market introduction is essential for companies operating in the AI and data analytics domain. This acceleration is achievable through strategic partnerships with stakeholders in the oil and gas industry, tech vendors, academia, and tech commercialization hubs. The project, backed by major oil producers and Alberta Innovates, showcased the successful implementation of PEMS, expediting the acceptance of AI-driven solutions and advanced data analytics applications. The project team is in active discussions for purchase of PEMS by other industrial partners.

The next two years for PEMS is focused on:

- Working on increased investment through more structured groups of advisors, initial clients, and overall government assistance
- Working on licensing secured intellectual property
- Expanding beyond the oil and gas market to industrial markets such as large boilers (larger equipment) available on municipal and public sites
- Continued long sales cycles with oil and gas clients

J. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

Over the project's duration, a plethora of activities unfolded to promote VL Energy's innovative PEMS product. These included showcasing the product on the PTAC CRIN Innovation Showcase platform, accessible to a broad spectrum of energy stakeholders across Alberta, Canada, and North America. During the World Petroleum Congress, VL Energy engaged in numerous presentations, events, and B2B interactions. They also presented at the Digital Innovation Forum hosted by PTAC, an annual event spotlighting digital solutions tailored for the energy sector. To broaden outreach, a demonstration of the PEMS dashboard has been made available on YouTube for stakeholders and the general public. VL

Energy also participated as a panelist in the January 2023 Digital Spotlight event series, focusing on tangible outcomes driven by Artificial Intelligence and Machine Learning. Furthermore, an update on the 2023 PEMS project was shared during a presentation at CRIN's Project Cafe, marking a significant stride in disseminating the advancements of the PEMS initiative.

VL Energy has a long-standing relationship with PTAC and continues to work on sharing project updates and networks with the broader energy ecosystem through publication and event streams provided by PTAC.

K. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits and next steps.

RESPOND BELOW

The project spearheaded by VL Energy aimed at the commercialization and deployment of a cloud-based Predictive Emission Management System (PEMS) as a modern, cost-effective alternative to traditional Continuous Emission Monitoring Systems (CEMS) in the oil and gas sector. This initiative primarily focused on addressing the gaps in current emission monitoring systems by utilizing AI and big data analytics to enhance predictive accuracy and provide a cost-effective solution for small combustion sources. The project was structured around three critical milestones: data collection and model training, regulatory collaboration, and system deployment alongside real-time monitoring.

Key learnings from these milestones emphasized the importance of accurate data collection, the potential of hybrid AI models, and the necessity of engaging with regulatory bodies early on to secure necessary approvals. The project successfully demonstrated the capability of PEMS in managing sensor drift, providing real-time monitoring and alerts, and offering a user-friendly interface for end-users, thereby advancing the Technology Readiness Level (TRL) to 9.

The outcomes and impacts of the project are significant. The PEMS technology has shown potential economic benefits by reducing the initial and operational costs associated with emissions monitoring. Additionally, it reflects the adaptability of the Canadian oil and gas sector to emerging technologies, which could attract new investments and potentially give companies a competitive edge in the global market. Environmentally, PEMS aims to mitigate GHG emissions and enhance energy efficiency, contributing to a safer operational environment. On a broader scale, the project has fostered innovation capacity, expected to create direct and indirect jobs, and brought a wealth of AI, cloud computing, and machine learning knowledge to the industry.

The next steps are directed towards the commercialization of PEMS, with plans to secure increased investment, license intellectual property, and expand its application beyond the oil and gas sector. There's an active pursuit to engage more industrial partners for PEMS adoption, emphasizing the

project's commitment towards not only advancing a commercial product but also fostering a conducive environment for knowledge transfer and collaborative growth within Canada's energy sector.

Throughout the project duration, a variety of activities were carried out to promote PEMS to stakeholders within Alberta, Canada, and North America, including presentations at notable events like the World Petroleum Congress and the Digital Innovation Forum, as well as a public recorded demonstration of the PEMS dashboard. These activities have significantly contributed to the project's knowledge dissemination efforts, showcasing the innovation and potential of PEMS in revolutionizing emissions monitoring in the energy sector.