Final Year Project Showcase Batch 2020
Year 2024

	Department: Petroleum Engineering Programme: Petroleum Engineering
1	**Project Title** Development of Automated Workflows and Models to Optimize Drilling Operations: A Practical Approach from Data Engineering to Data Science
2	**Project Idea** To utilize technology (Data Engineering, Big Data Analytics, AI) for effective decision-making in oil and gas drilling operations, with the goal of reducing costs and increasing safety
3	**Process** The process includes data engineering and management to process large amounts of drilling data in real time streaming, an auto rig state analyzer for classifying rig states to facilitate subsequent models and calculations, and drilling optimization, where the models are responsible for making crucial calculations to optimize drilling operations.
4	**Outcome** The key outcomes of the project include: 1. **Development of Real-Time Drilling Optimization Models**: The project successfully developed several models, including a Rig State Classification Model, MSE (Mechanical Specific Energy) Model, Bit Failure Monitoring Model, and ECD (Equivalent Circulation Density) Prediction Model, which contribute to optimizing drilling operations in real time. 2. **Automated Workflow Design**: An ETL pipeline was designed using Apache NiFi to extract, transform, and load real-time drilling data in WITSML format, enabling automated data processing for real-time analytics. 3. **Rig State Classification**: The Rig State Classification Model effectively classified rig states into Macro and Micro levels, which is important for evaluating key performance indicators (KPIs) and triggering state-specific drilling models. 4. **MSE and Bit Failure Monitoring**: The MSE model optimized drilling safety and resources, while the Bit Failure Monitoring Model, combined with MSE ratios, provided crucial insights for preventing bit failure during drilling. 5. **ECD Prediction**: An ECD model, trained using both real and synthetic data, achieved high accuracy, with an R^2 score of 96.4% for real data and 99.4% for synthetic data, making it reliable for predicting ECD in real-time operations. 6. **Drilling Optimization Model**: The model optimized drilling parameters (ROP, WOB, and MSE) to maintain safety and predicted the Rate of Penetration (ROP) required for specific drilling intervals, despite data limitations.
5	**Evidence (Theoretical Basis)** This final year dissertation focuses on optimizing drilling operations by developing an automated workflow to provide real-time insights and assist drilling professionals in decision-making. Drilling is one of the most expensive processes in the oil and gas industry, and this project aims to reduce costs and time, especially in light of fluctuating oil prices.

	With the rise of big data analytics and artificial intelligence, the project explores the use of these technologies for drilling optimization. It outlines the design and development of key models, including a Rig State Classification Model, Surface and Downhole MSE calculation models, Bit Failure Prediction Model, and Drilling Optimization Model. The data extraction, transformation, and loading (ETL) pipeline were designed using open-source tools, allowing real-time data processing and analytics through Apache Kafka and a time-series database. The workflow includes rig state classification, MSE monitoring for efficiency, bit failure prediction, and ECD (Equivalent Circulation Density) prediction. The optimization model recommends optimal drilling parameters for enhanced efficiency. The workflow and models, once validated by experts, can be implemented in real-time drilling operations centers (RTOCs).
6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities and Communities"** The project can optimize drilling operations by automating workflows and using real-time data analytics. This reduces **drilling time**, **fuel consumption**, and **equipment failures**, leading to lower operational costs. The **Bit Failure Prediction** and **MSE Models** prevent unnecessary downtime and equipment replacements, cutting costs further. The automated **ETL pipeline** streamlines data processing, reducing manual labor and errors, ultimately improving overall efficiency and significantly reducing production costs.
7	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence
a	**Attainment of any SDG** (e.g., How it is achieved and why it is necessary for the region) **1. SDG#8, Decent Work and Economic Growth** The project aims to **optimize drilling operations**, which directly impacts the efficiency of oil and gas production—a key driver of economic growth. By reducing **drilling costs and time**, the project helps improve profitability in the industry, making it more sustainable, especially in fluctuating oil markets. Additionally, automation in workflows enhances productivity and reduces the margin for error, creating **better work conditions** for drilling professionals by aiding in decision-making and improving safety. This supports sustainable economic growth while fostering innovation in workforce management. **2. SDG#9, Industry, Innovation, and Infrastructure** The project embraces **innovation in drilling technologies**, using **big data analytics, artificial intelligence**, and advanced ETL pipelines to monitor and optimize drilling operations in real-time. It contributes to the modernization of the oil and gas industry by integrating **advanced technological infrastructure** such as Apache NiFi, Kafka, and timeseries databases to improve data handling. This aligns with SDG 9 by promoting **resilient infrastructure** and fostering **innovation in industry practices**, improving efficiency and reducing operational costs. **3. SDG#12, Responsible Consumption and Production** By focusing on drilling optimization, the project indirectly supports **responsible consumption of resources** in the oil and gas industry. The **MSE and ECD models** help

	minimize waste and resource consumption by ensuring efficient drilling practices. The **Bit Failure Prediction Model** prevents unnecessary equipment use and replacement, reducing waste and promoting **sustainable resource management**. Furthermore, the automation of workflows enhances decision-making, ensuring that drilling operations are performed within optimal and safe parameters, contributing to the responsible use of resources and production processes.
b	**Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) **Carbon Reduction:** • By optimizing drilling operations through real-time insights, the project reduces the **time** and **resources** needed for each drilling project. Shorter and more efficient drilling operations lead to a **decrease in fuel consumption** of drilling rigs, generators, and related equipment, contributing to **lower carbon emissions**. • The **Bit Failure Prediction Model** prevents unnecessary equipment usage and failures, reducing the need for frequent replacements or repairs, which also lowers the energy required for manufacturing new components, further reducing the carbon footprint. **Energy Efficiency:** • The **MSE (Mechanical Specific Energy) Model** helps optimize the **energy required** to penetrate the rock formations, ensuring that energy use is kept at efficient levels without overuse of power or resources. This increases **drilling efficiency**, reducing wasted energy during operations. • The **ECD (Equivalent Circulation Density) Model** helps manage drilling fluid and pressure more effectively, reducing the energy needed to pump fluids and maintain wellbore stability. **Resource Optimization:** • By optimizing parameters such as **Rate of Penetration (ROP), Weight on Bit (WOB),** and **MSE**, the project minimizes **resource wastage**, such as excessive fuel or materials, contributing to more sustainable and environmentally friendly drilling operations.
c	**Cost Reduction of Existing Product** Reduction in per-day drilling costs is proportional to reductions in drilling time, equipment costs, failure costs, and costs due to any incidental/accidental events involving MSE and ROP parameters. The project also reduces well-planning costs by utilizing compiled past/recorded decisions. In short, the net drilling cost of the project is lowered through controlled monitoring and providing effective decision-making, optimizing operations and minimizing unexpected expenses.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) **Current Process Issues:** 1. **Inefficiencies in Drilling Operations**: Traditional drilling operations often face issues such as excessive drilling time, equipment failures, and suboptimal use of resources.

	2. **Manual Data Handling**: Current methods for data collection and analysis can be slow and error-prone, leading to delayed decision-making and increased operational costs. 3. **Lack of Real-Time Insights**: Without real-time data, adjustments to drilling parameters are reactive rather than proactive, which can lead to inefficiencies and increased costs. **Suggested Improvements:** 1. **Implement Automated Workflow**: Develop and deploy automated models for real-time monitoring and optimization, including Rig State Classification, MSE (Mechanical Specific Energy) Models, and Bit Failure Prediction Models. This improves efficiency by providing timely insights and recommendations for adjustments. 2. **Enhance Data Management**: Use an ETL pipeline to streamline data extraction, transformation, and loading. Tools like Apache NiFi can automate these processes, reducing manual handling and errors, leading to faster and more accurate data processing. 3. **Optimize Drilling Parameters**: Utilize models to optimize parameters such as Rate of Penetration (ROP), Weight on Bit (WOB), and MSE. This helps in making informed decisions to improve drilling efficiency, reduce time, and lower costs. **Benefits:** • **Cost Reduction**: Reduces operational costs by minimizing drilling time, preventing equipment failures, and optimizing resource use. • **Efficiency Improvement**: Enhances the overall drilling process by providing real-time insights and automated adjustments, leading to better performance and reduced downtime. • **Superior Product**: Results in more efficient and reliable drilling operations, contributing to higher productivity and better overall outcomes.
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market **Current Market Issues:** 1. **High Costs and Inefficiencies**: Many drilling operations face high costs and inefficiencies due to outdated methods and lack of real-time data analytics. This affects profitability and limits competitiveness in the market. 2. **Limited Technological Adoption**: The drilling industry may be slow to adopt new technologies, resulting in missed opportunities for improvement and market differentiation. 3. **Complex Decision-Making**: Traditional processes can lead to slow and reactive decision-making, impacting the ability to quickly adapt to market changes and client needs. **How the Project Expands Market Share:** 1. **Introduce Advanced Technology**: By implementing automated workflows and real-time data analytics, the project demonstrates a commitment to innovation, attracting clients who seek cutting-edge solutions for cost-effective and efficient drilling operations. 2. **Offer Cost Savings**: The optimization models developed can reduce drilling costs and improve efficiency, making the services more competitive. Lower operational costs can be passed on to clients, providing a competitive edge in the market. 3. **Enhance Decision-Making**: Real-time insights and automated recommendations improve decision-making speed and accuracy, enabling quicker adaptation to market

	demands and client requirements. This responsiveness can attract new clients and retain existing ones. **Benefits of Market Expansion:** • **Increased Competitiveness**: Offering advanced, cost-effective solutions positions the company as a leader in innovation, expanding its market share. • **Attract New Clients**: Enhanced efficiency and cost savings can attract new clients looking for modern, reliable drilling solutions. • **Client Retention**: Improved services and decision-making capabilities strengthen client relationships and foster long-term partnerships.
f	**Capture New Market** (e.g., Niche market or unaddressed segment) **Capturing New Market Segments:** **Current Market Gaps:** 1. **Niche Markets**: Client companies like OGDCL, UEPL, PPL, MOL, POL, PEL etc. 2. **Smaller Operators**: Smaller or mid-sized drilling or E&P companies might lack access to advanced technology due to high costs or complexity like Tianjin Drilling, PEL, GHPL etc **Strategies for Capturing New Market Segments:** 1. **Develop Specialized Solutions**: Tailor the technology and models for specific niches like unconventional/UBD/MPD drilling, especially in the abnormal formations addressing unique challenges and requirements of these segments. 2. **Target Emerging Markets**: Expand into developing regions by offering affordable, efficient drilling solutions that can help meet the rising demand in these areas. Local partnerships and customized solutions can enhance market entry. Currently, only few companies are active in providing these advances in Pakistan.
g	**Any Other Aspect (Please tag it like above options)**
8	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service **Industry:** Oil and Gas, Energy **Groups/Individuals:** Drilling Team/Crew/Engineers/Managers **Targeted Companies:** Oil and Gas Exploration and Production Companies such as OGDCL, UEPL, PPL, MOL, POL, PEL etc. Drilling Service Companies like SLB, Halliburton, Tianjin Drilling, CNPC, HILONG etc.

9	**Team Members** (Names along with email address	Syed Huzaifa Ahmed (syedhuzaifaahmed6@gmail.com) Aisha Khan (aishakhan6144@gmail.com) Maliha Waseem (maliha.waseem14@gmail.com) Yahya Sheikh (yahyasheikh424@gmail.com)
10	**Supervisor Name** (along with email address)	Dr. Javed Haneef (javedh@neduet.edu.pk)