

Annex : Summary Table

#	Title	Year	Authors	Research Type	Contributions	Flow Meter Type
1	First Principles and Machine Learning Virtual Flow Metering: A Literature Review	2020	Bikmukha metov, Jäschke	Literature research	<p>Comprehensive literature study of Virtual Flow Meters (VFM) and provides related domain knowledge on petroleum industry and oil well sub-system</p> <ul style="list-style-type: none"> • Types of physical flow meters • Types of virtual flow meters • Types of sensors • Review of physical flow meters • Review VFM models • Performance and economical evaluation of physical and virtual FMs <p>Highlights machine learning as a strong alternative to first principles VFM and the importance of computing uncertainty in machine learning estimates is vital for future development.</p>	NA
2	Modelling oil and gas flow rate through chokes: A critical review of extant models	2022	Agwu, Okoro, Sanni	Literature research	<p>Comprehensive literature study similar to [1].</p> <p>This research further goes on to summarise most empirical research done since 1950 in-terms of methodology, data-size, data source and independent variables.</p> <p>Provides related domain knowledge on petroleum industry and oil well sub-system similar to [1].</p>	NA
3	Virtual Multiphase Flow Meter using combination of Ensemble Learning and first principle physics based	2022	A. Ishak et al.	Quantitative research	<p>Uses ensemble learning to develop the data driven model by incorporating multiple ML models.</p> <p>Data driven model is combined with the physics model using a combiner.</p> <p>Achieves a 50% improvement in performance using the combiner compared to their stand-alone performance of physics based and ML based VFMs.</p>	Hybrid VFM
4	Virtual multiphase flow metering	2018	T. A. AL-Qu tam et	Quantitative	ML VFM based on ensemble learning.	ML VFM

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	using diverse neural network ensemble and adaptive simulated annealing		al	research		
5	A Machine Learning Approach for Virtual Flow Metering and Forecasting	2018	N. Andri anov	Quantitative research	<p>Principle Estimate future values of multiphase rates based on the previous behaviour of the system.</p> <p>Model Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN) model.</p> <p>Not only to accurately estimate the multiphase rates at current time but also to forecast the rates for a sequence of future time instants.</p>	ML VFM
6	Bayesian neural networks for virtual flow metering: An empirical study	2021	B. Grimstad et al	Quantitative research	ML based VFM, implemented on Bayesian Neural Network (BNN).	ML VFM
7	A Physics-Informed Neural Networks (PINN) oriented approach to flow metering in oil wells: an ESP lifted oil well system as a case study	2022	T. S. Franklin et al	Quantitative research	A hybrid VFM combining Physics Informed Neural Network (PINN) model and LSTM-RNN based ML model.	Hybrid VFM
8	Cloud-based virtual flow metering system powered by a hybrid physics-data approach for water production	2023	Rafael H. Nemoto	Quantitative research	<p>Their work presents a cloud-based Virtual Flow Metering (VFM) system powered by a hybrid physics-data approach to estimate the water production per well in a gas field.</p> <p>Hybrid approach, which allows accurate calculations near real-time conditions, is based on the description of the flow through the wellbore using</p>	Hybrid VFM

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monitoring in an offshore gas field				physics-based models pertaining to gas-liquid flows with high gas volume fraction. A data-driven approach is implemented to tune the flow model using well test data.	
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