November/
December 2020

SPE Review London

The official e-magazine of the Society of Petroleum Engineers' London branch

NEWS! LONDON SECTION 50-YEARS MILESTONE

Downhole data acquisition in well testing

Also in this issue:

- C-level talks: Martin Blunt
- Full cost resilient business, fields, and production
- Oil and gas leasing: Using proximity analysis and machine learning

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PLUS:

Book Review: The Ministry for the Future
SPE YP: new committee, events, updates
SPE International conference 2020

SPE International London Section

BEHIND THE SCENES LETTER FROM THE CHAIR

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ABOUT US

The Society of Petroleum Engineers (SPE) is a not-for-profit professional association whose members are engaged in energy resources, development and production. SPE is a non-profit professional society with more than 156,000 members in 154 countries, who participate in 203 sections and 383 student chapters. SPE's membership includes 72,000 student members. SPE is a key resource for technical knowledge related to the oil and gas exploration and production industry and provides services through its global events, publications, events, training courses and online resources at www.spe.org. SPE London section publishes SPE Review London, an online newsletter, 10 times a year, which is digitally sent to its 3000+ members. If you have read this issue and would like to join the SPE and receive your own copy of SPE Review London, as well as many other benefits – or you know a friend or colleague who would like to join – please visit www.spe.org for an application form.

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SPE SECTION EXCELLENCE *** AWARD *** 2020

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Share your experiences and stories online http://london.spe.org/home

Behind the Scenes: SPE Review Editorial Board

Elizaveta Poliakova, Editor in Chief

Elizaveta is a Reservoir Engineer at Trident Energy Management Limited. She has a Master's of Science in Petroleum Engineering from Imperial College London and a Bachelor's in Petroleum Engineering from the University of Leeds.

Elizaveta has been with SPE for more than five years. She was the President of SPE Imperial College Chapter and the President of SPE Leeds Chapter. Previously, she was also on the committee of SPE YP.

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Business editor and writer. Finding, explaining and sharing stories that people can understand and relate to. International experience in technology, environment, and animals as therapy.

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Justin Reynolds

Business writer focused on the energy and finance sectors. Currently writes for financial journals, has worked as communications officer for an oil & gas start-up, and features writer for The New European.

A big Thank You! to all the organisations that support the SPE London section

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Letter from the SPE London Chair

Dear SPE London members and colleagues,

Welcome to the December issue of the SPE Review.

I hope you are all remaining safe and well as the Covid19 pandemic continues to affect our daily lives. There have been several recent macro events that will impact our industry in the near term, and I'm speaking about the good news regarding the approval for use of a number of vaccines to combat the spread and impact of Covid19. We also had the US presidential election, which has confirmed a democrat victory with the consequent impacts on the shifting of climate related priorities within the US. More recently we continue to see OPEC and its partners maintain oil supply cut discipline, albeit there is a likely increase in supply from January 2021. The impact of the vaccine roll-out and supply cuts has under pinned the rise in the oil price to just below $50per barrel - a very different picture to earlier this year. Hopefully, these positive outcomes will provide the impetus for businesses to be more optimistic about future increases in investment in people and projects in the years ahead.

Staying with industry views, the President of SPE International, Dr. Tom Blasingame, had some worthwhile insights written in his JPT column. Tom has a strong desire to move the society, and therefore the membership, into the forefront of the implementation of the Energy Transition. The awareness of the implications of future Environmental, Social and Governance (ESG) behaviours is something that all members are advised to understand and embrace. In reflecting this focus, there will be additional wording in the SPE's purpose that includes 'the SPE will evolve into a low carbon future'. In Tom's words: "We are in an energy transition, and it cannot happen without us and our labour."

The offerings across our membership has been quite extensive since I last wrote to you. The jointly hosted London Finance and Investment conference titled 'Reliance and Transformation' provided a range of valuable insights into Energy Transition projects, financing and industry behaviours that will become common place throughout this decade. The section offering of evening lectures continues in what is now the common virtual environment. Thanks to Tim Lines for creating a diverse and interesting program that provided us with two talks with an AI and data management theme. The Distinguished Lecturer Dr. Shahab Mohaghegh provided insights into machine learning and its application within subsurface engineering. To complement this presentation, representatives from Palantir shared some of their ground breaking work with bp that covered data mining, developing data science applications to improve production optimisation and delivering improved production and recoveries.

Most recently the student section of Imperial College London hosted a discussion on carbon capture use and storage with input from Dr Sean Krevor, Professor Martin Blunt, and Syrie Crouch (Shell VP CCS). The overall message was that, to influence the impacts of climate change, the oil and gas industry needs to get behind CCUS technology and invest significantly in both financial capital and in developing engineering talent.

The Section continues to evolve with the changing times the industry is facing. The Net Zero committee, led by Alison Isherwood, aims to provide the membership with information, host events and promote discussion on issues around the Energy Transition, Sustainability and the impact of the drive to a Net Zero world. Alison and her team are working with our program Chair, Tim Lines, to provide a Net-Zero-themed series of evening talks during our January and February evening sessions, and I encourage you to engage with these significant events. Additionally, those that follow the section through our social media channels will have seen that the Net Zero team are providing a series of Net Zero 101's to help guide you through the maze of energy

Letter from the SPE London Chair continued

transition. The next topic is the UK's 10 point plan for a green industrial revolution - top topic for the section is the commitment to invest significantly into Carbon Capture Use and Storage.

I encourage the membership to support Alison and her team as they develop content and host events.The section is a volunteer led and industry supported organisation so it's great to get a well recognised businesses supporting the section. The section has been offered continued sponsorship from OPC, a long time supporter, and from Premier Oil. Thanks to both businesses for sticking with the section and helping us provide a diverse program to our membership.

I recognise that many members are facing uncertain times by virtue of the impacts of a global pandemic that has reduced oil demand, resulting in low oil prices and stressing the financial viability of many businesses. The increasing calls for rebalancing the energy supply base only increases this uncertainty. At this time of year, you will be seeing mail shots to renew or re-join the SPE. It is a personal decision. However, I encourage you to reaffirm your commitment, as the SPE and, therefore, its membership, are central to providing safe and efficient energy to the world. At times when your businesses are cutting costs in training and in staff, the SPE has many resources and support mechanisms that you can only access as members. I believe the annual fee is very worthwhile - it's up to you to make the most of it.

For those of you celebrating the festive season, I hope tyou enjoy it as best you can considering the circumstances we have to live within. I encourage you to follow the guidance provided so that we can get back to business as soon as possible in the new year.

I continue to look forward to sharing our 2021 SPE London journey together.

Adrian Southworth, SPE London Chair

Letter from the Editor

Dear SPE members and colleagues,

Welcome to the final publication of SPE Review London in 2020. This year happened to be a challenging ride that none of us could have foreseen. The collaboration of doctors, scientists, politicians, public servants, as well as the compassion and empathy of all throughout the pandemic, has led to progressive results against the virus. Glancing over the past year, each and every one of us contributed towards the global goal of fighting COVID, and we shall continue to do so - whether it is by adapting towards working from home, wearing masks outside or switching from the real-life gatherings to virtual ones; speaking of which, my husband and I have recently attended a virtual wedding for the first time! Take this moment to appreciate what you, your colleagues, friends, and our society as a whole have done to achieve everything that has been accomplished in the past year.

Within SPE London, a series of new initiatives took place in 2020. We introduced a new Net Zero committee, hosted our first School Talk (virtually), began the C-Level Talks series, and launched a Book Review program in SPE Review London. Moreover, to highlight a year of continuous evolution, we have been awarded the SPE Section Excellence Award!

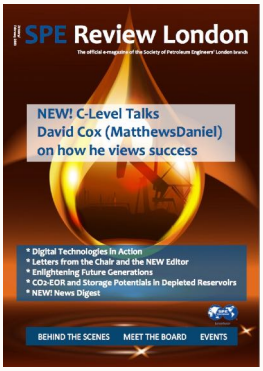
In this publication, you will find a summary of SPE International's annual event, the SPE Upstream Finance and Investments Conference, on page 07; introductions of the new committee members for SPE Young Professionals and SPE Imperial College London Chapters, on pages 28 and CCC; C-Level Talks with Professor Martin Blunt, Head of Petroleum Engineering at Imperial College London, CTO at iRock, Director of Research at Streamsim Technologies and professor at Politecnico di Milano, on page 18; a fascinating Book Review of The Ministry for the Future, on page 35; detailed overview of the Downhole Data Acquisition process in Well Testing, on page 09; a comprehensive overview of O&G Leasing, on page 20; and our second article on Energy Transition and Net Zero, on page 29.

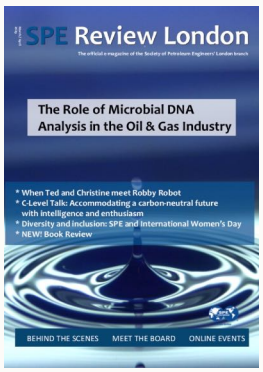
This issue also completes my first year as the Editor in Chief for the Review and I would like to thank our readers, members, the editorial board and the SPE London Board for your continuous support throughout the past year.

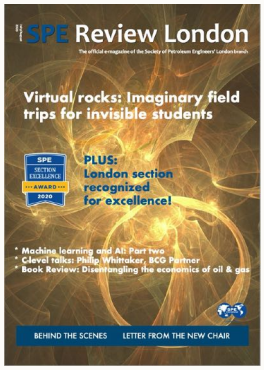
On behalf of the SPE London Review Editorial Team, I wish you a Merry Christmas and a Happy New Year!

Stay safe and take care.

Sincerely Yours,
Elizaveta Poliakova







NEWS DIGEST... NEWS DIGEST... NEWS DIGEST

Maersk Drilling's new CEO

The Board of Directors of Maersk Drilling, the Danish drilling contractor, has appointed Christine Morris as the company's new Chief Financial Officer. Christine previously undertook CFO and Treasurer positions for US public and private corporations, and has 25 years experience in the finance sector.
Learn more here **And here**

ISurvey Offshore: biggest project in North Sea

"Equipped with multi-beam echosounder (MBES), side-scan sonar (SSS) and magnetometers, our spread of equipment and personnel dealt with the full gamut of North Sea weather, while safely achieving all workscope objectives and completing this milestone project on schedule," said iSURVEY Managing Director, Andrew McMurtie.ISurvey Offshore has completed 6,300 km of the survey for the contract, which consisted of two parts contributing to Magseis Fairfield's ocean bottom node (OBN) exploration project within the Cornerstone area.
Read more here

OGUK: Prime Minister emission targets require sector deal

Earlier in December, OGUK stated that the new announcement by Prime Minister about emission targets has reinforced the necessity of a sector deal. The announcement reveals the plan of the British government to cut the UK's carbon dioxide emissions by almost 70% by 2030. This goal sets a higher rate of CO2 reduction target than any other economy.
Read more here

Asian Oil Demand boosts North Sea Crude prices

North Sea Oil prices are catching up with the other markets that have already started to benefit from the increasing interest from Asian countries.Over the past fortnight, Asian refineries, especially small independent refineries in China, that received extra government allowance to support economic recovery; have increased their demand in crude from Middle East, Russia, U.S and the North Sea.
Read more here **And here**

The London Section has been acknowledged for 50 years of furthering SPE's mission and supporting local members.

"This network that your section provides from year to year, is instrumental to member engagement and development, and helps SPE to build recognition as a unique world-class professional society.
SPE applauds your section's past and current officers and members for bringing London Section to this 50-year milestone anniversary."

Caroline Seifert, Sections and Chapters Senior Coordinator, SPE

Section excellence award

The London Section has been awarded the Section Excellence Award for 2020.

The award states:
"This prestigious award is the second highest honor a section may receive and is awarded to only 20% of eligible sections around the world.

The award is in recognition of your section's hard work and strong programs in industry engagement, operations and planning, community involvement, professional development, and innovation. We know the past year has been unique, and we thank you for continuing to fulfill SPE's mission and serve your members."

SPE International's upstream finance and investments conference, November 2020

November saw the return of SPE International's upstream finance and investment conference, a unique annual event bringing together the industry's operators and service companies with their investor community.

Usually based in London, the conference this year took place virtually on November 11 and 12, allowing speakers and delegates to join in from across the world. The organising committee did a fantastic job of delivering the conference in this new and unfamiliar format, as Alison Isherwood reports.

I was very pleased to be asked to chair this year's conference and worked with an expert committee, including London SPE's Tim Lines and Adam Borushek, to put together a full and varied programme on our chosen theme of "Resilience and Transformation". The programme did not disappoint, giving a fascinating insight into where our global industry currently sits after arguably the toughest year in its history.

The conference kicked off with a keynote speech from Steve Phimister of Shell on "Transformation in Uncertain Times", which set the tone for the rest of the conference with a message of 'being bold in ambition, practical in action and collaborative in approach'. The commitment towards Net Zero and ESG (Environment, Social, Governance) was evident across the full two days of the conference, not just from major oil companies but also smaller operators, service companies and investment companies. It was also clear this wasn't a voluntary commitment but a necessity to attract capital back to the industry and maintain our social license to operate.

A highlight of the conference was the first session on lower carbon investment, looking at the increasing focus on the carbon intensity of projects and the growing area of carbon trading including the choice between engineered and natural carbon abatement projects.

This was followed by excellent debate in the private equity and E&P session, a revisited topic from last year, including how the financial discipline of PE can help build value for the next owners of O&G assets, even in these difficult times, but how there needs to be a two-way conversation with government to facilitate this.

Day one finished with a review of 'pathfinder' investment, looking at how smaller O&G companies have fared in 2020, from both a European and North American perspective. The stark realities of this year were bought home during this session, especially from our American colleagues discussing the shape of the shale industry, but there was also some practical discussion of what needs to change and even some optimism on future oil price.

SPE International conference... continued

Day two kicked off with a global review of how covid has affected our industry and the energy transition, looking at it from a European, Asian, North American and International Energy Agency perspective. We saw various forward projections of economic recovery post-covid and the high and low carbon energy demand associated with these.

There was a sobering review of how O&G is performing financially compared to other sectors, including a buoyant renewables sector, which was shared again and again in subsequent sessions as speakers talked about different ways to tackle it.

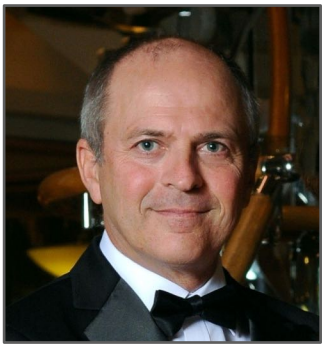
There was valuable insight into China's increasing focus on electric vehicles and high speed rail to reduce its dependency on imported oil, but little detail yet on how this fits with the country's 2060 Net Zero pledge. The session on resilient operations and supply chains focused on collaboration, consolidation and digitisation as key components in surviving through turbulent times, with optimism that there is still room to improve the efficiencies in how O&G does business in order to improve profitability.

The final panel session took a look at projects of the future, including a review of sustainability reporting and practical steps to reduce carbon footprints offshore, and a warning about the importance of maintaining investment and experienced operators in our sector to ensure ESG measures can be effectively implemented.

The conference was drawn to a close by David Chelich of TMX with an overview of the Canadian energy capital markets. This showed many of the same trends as European markets in terms of renewables outperforming O&G and gave a reminder that our industry needs to focus on profitability to survive now, rather than the historical focus on production and reserves growth.

The conference was eye-opening, and not always comfortable listening but surprisingly uplifting in terms of the unfaltering commitment to Net Zero and the belief we can transform our industry to meet this goal. I can't wait to see what next year's conference will hold in store for us!

Downhole data acquisition in well testing



Paul Nardone has over 35 years' experience in well testing and completions operations globally. He is author of Well Testing Project Management one of the few practical textbooks on well testing and has also written numerous other related articles and presented at various industry events.

Paul is a co-founder of Well Test Knowledge International (WTKI) which is a widely recognised provider of well test expertise, software, and training. He currently lives in the UK.

This article was first published in WTKI.

Abstract

If you are planning a well test to evaluate a reservoir you are essentially investing in data, specifically pressure and temperature data and how pressure responds to changes in flowrate. The purpose of this endeavor is to make informed development decisions that may involve a considerable investment of company resources. Even if your intention is to sell the development rights onwards, the information is no less valuable, since any prospective buyer will want to know as much as possible about the asset before committing to it.

A full exploration DST, in a general sense, can be separated into two physical environments, surface and downhole.This paper discusses those aspects of the well test design that address electronic downhole data acquisition.

A Little Bit of Background

How do we see into a reservoir? There are several tools available to the resource company, including seismic, drilling, logging and existing geological data from offset wells. But it is in well testing that a unique pressure signal based on the dynamic behaviour of the reservoir is acquired.
Electronic gauges measuring downhole pressure and temperature provide the means by which engineers can interpret and infer characteristic reservoir properties, including permeability-thickness, connectivity and reservoir size.

Planning

As the test objectives are being developed by the subsurface team, some of the practical questions that follow will relate to the physical design of the test.

- Do I need downhole data acquisition?
- Do I need memory or surface read out?
- What type & how many gauges do I need?
- Where should they be installed in the DST string?
- How should they be set up?
- What test programme should be followed?
- What QA/QC is needed?

We'll tackle these questions in the course of this article and to do so we also need to discuss something of the hardware involved and the different options available in terms of hardware specification and other contrasting features.

How a Recorder Gauge Works

Put simply, whenever pressure is applied to a sensor, it produces a physical deformation in the sensor. This happens in both mechanical and digital gauges. To use the example of a quartz crystal sensor, application of an electrical field causes the sensor to vibrate at a characteristic resonant frequency, which changes when pressure is applied. The frequency can be recorded as a piece of raw data, and after calibrating the change in resonant frequency to the applied pressure, the signal can be output as a pressure measurement.
Because a change in temperature also influences the sensor response to pressure, the calibration must also

Downhole data acquisition in well testing continued

compensate for temperature. When matching a particular gauge to a specific set of test objectives, we must consider gauge specification, or for the purposes of this article, gauge metrology. This includes all of those characteristics of a gauge which define its measurement capability, some of which are likely to be critical in determining which gauge to use.

- Accuracy
- Resolution
- Pressure & Temperature Range
- Repeatability
- Stability (resistance to drift)

Memory Size and battery life are also key characteristics when assessing the suitability of a gauge for a particular application.

Factors Affecting Metrology / Gauge Performance

Resolution

The resolution of a gauge is a measure of the smallest change in the parameter being measured that a gauge is capable of sensing. If the test involves an extended build-up or the search for deep boundaries in the reservoir where very small incremental changes of pressure are important, then high resolution gauges will be necessary in order to detect and show the very small changes in pressure taking place in the late time build-up. Typical resolutions quoted for gauge systems range between 0.1 and 0.001 psi. Resolution is determined not only by the sensor but also by the entire electronic assembly, since the processing section of the gauge also has a resolution, which, if lower than that of the sensor, will influence the overall resolution.

Accuracy

Is the closeness with which a measurement recorded by a gauge approaches the true value of the parameter being measured. Accuracy can be expressed as a percentage over the full scale of the gauge or as a specific value on the indicated reading. For example, a gauge might have an accuracy of 0.02% over a range of 15,000 psi, or, it might also be expressed as an accuracy of 3 psi.

Linearity

The degree to which the sensor response to changing conditions will be linear over its full range. Calibration is necessary to correct this.

Hysteresis

The deviation in sensor response between increasing and decreasing conditions (pressure & temperature). The calibration of the gauge must be performed in both directions to address hysteresis.

Drift

The gradual and uniform deviation of the gauge response in one direction over time, i.e. the gradual loss of calibration. Often quoted with values of 0.01 to 0.025% of full range over a year, however, larger deviations do occur.

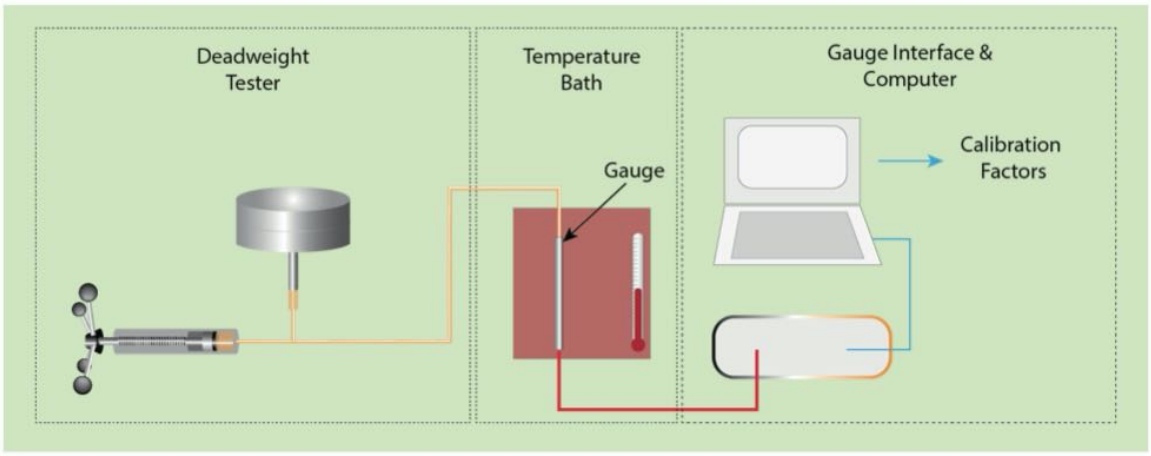
Temperature

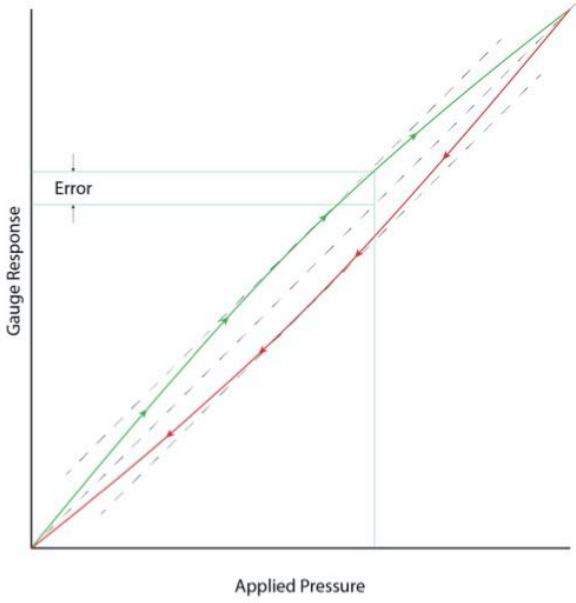
Pressure transducers are influenced by temperature, which in turn will influence the sensor response to an applied pressure, in order to correct for this the gauge is calibrated at a range of temperatures and a temperature correction is built into the processing part of the gauge.

Downhole data acquisition in well testing continued

Calibration

Various factors contribute to the general deterioration of gauge metrology with time, including the frequency of use, the exposure conditions, and the time since the previous calibration. Every gauge requires periodic calibration in which pressure and temperature from a master source are applied to the gauge, the output from the gauge is then corrected to the reference value using a calibration factor or coefficient specific to the pressure and temperature applied. Numerous such measurements are applied for both increasing and decreasing values in order to address linearity, hysteresis and all the other factors that influence the overall gauge performance.

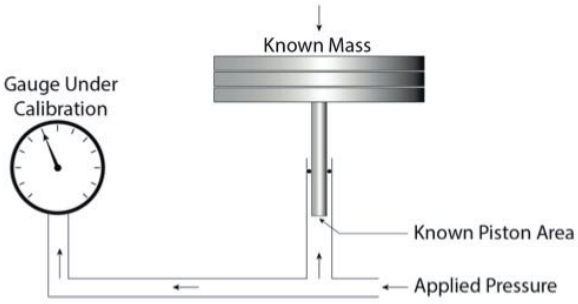




The graph illustrates the calibration process, a known pressure is applied by a master reference such as a deadweight tester. The value measured by the gauge is corrected to the true value using a calibration factor, which basically converts raw data output to the value of pressure applied. The full range of calibration factors or coefficients is generally applied to the raw data using a multi-term polynominal function.

Post Calibration

Since a gauge records raw data which is then processed internally where the calibration factors are applied, it is possible, to have it re-calibrated after the job and then apply the new calibration factors to the raw data set. This is done if the data from the gauge is suspect.



A deadweight tester works on a very simple principle, a known mass is placed on a piston that has a known area. Pressure is applied to the piston until the mass is lifted off its rest, the pressure indicated on the pressure gauge can then be verified against the pressure represented by the deadweights.

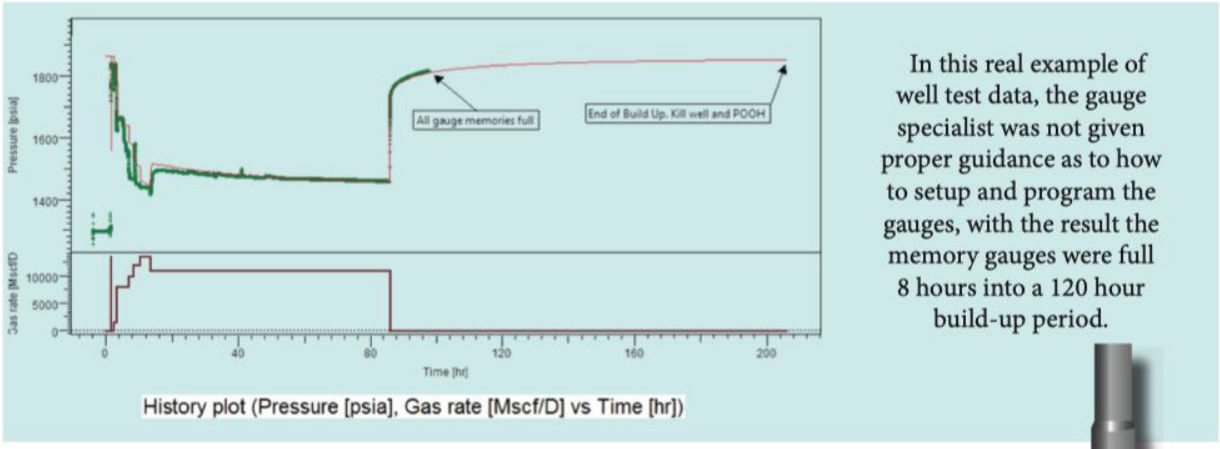
Downhole data acquisition in well testing continued

Memory Gauge Programming

When it comes to programming a memory gauge the drivers are the internal limitations of the gauge, i.e. memory and battery life, and the test objectives, how long is it and at what periods are things changing rapidly.

Clearly, during an extended build up where pressure is changing very little, there is no need to have the gauge recording data points every second. This might risk filling the gauge memory before the build-up period is complete and miss out recording valuable late time data.

A data set on a memory gauge includes a pressure and temperature measurement. If a particular gauge had the memory capacity to store 1 million data sets, then the gauge could be set to record a data set every second and the memory would be full after 11.6 days. If on the other hand the memory capacity was stated as 1 million data points, then actual capacity to record each data set, pressure and temperature, would be half a million data sets or about 6 days recording at a 1 second scan rate.



History plot (Pressure [psia], Gas rate [Mscf/D] vs Time [hr])

In this real example of well test data, the gauge specialist was not given proper guidance as to how to setup and program the gauges, with the result the memory gauges were full 8 hours into a 120 hour build-up period.

Gauge fitted inside a slot of a gauge carrier, ready to pick up and install in the DST string.

Memory gauges are generally fitted inside gauge carriers which connect directly to the DST tubing. The gauges are fitted into slots in the carrier with a porting arrangement so that the gauge sensors pick up the internal pressure.

The carrier itself will be full-bore so as not to restrict fluid passage and also to permit intervention operations.

When programming a gauge some contingency needs to be made for unplanned events,. This would be particularly relevant to a subsea well test. If the facility were to suspend operations in the middle of a test due to weather, the delay so caused might result in some of the test data being lost because the gauge memories had filled before the test programme had been completed.

Against this type of contingency some gauges incoporate safety features. For example, once the memory reaches 80% capacity, the gauge might automatically go into a long term mode and record data with less frequency, for example every 5 or 10 minutes or even longer in some instances.

Most gauges have the facility to programme a range of scanning rates, typically between 1 second and 10 minutes. The engineer might anticipate, based on the test schedule, when higher scanning rates are likely to

Downhole data acquisition in well testing continued

be required and when lower scanning rates will be acceptable. During the well unloading and drawdown sequence, pressures and temperatures will be changing rapidly. During such periods higher scan rates are needed to capture all the data, typically scan rates of one second would be used. During the latter part of the build up, conditions will change only very slowly and therefore fewer data points will be required. Scan rates might be set to every five minutes, for instance.
This could imply that it's a good idea to try to anticipate how the test will unfold and then apply scanning rates accordingly during particular time intervals. However, this is dangerous because of the unplanned events previously referred to, which can mean that the fast and slow scanning rates end up being applied to the wrong time intervals. Where memory size is adequate, the engineer might adopt a more cautious approach and implement a high scan rate for the entire test.

Extended Battery Mode

If an extended well test is required, memory extensions can be added to the gauges. This might address the memory size issue, but the battery life might still be limited. One possible solution for extended tests to set the gauge into a sleep mode, whereby it all but shuts down for a period, for example for one or more hours, to reduce battery load, then automatically wakes up to record a data set and once again return to sleep mode. By this means the battery life of the gauge can be extended.

What Does Gauge Data Look Like?

We have seen that downhole gauges record only pressure and temperature at some frequency determined by the programming of the gauge and with a degree of accuracy and resolution dependent on the characteristics of the gauge, the calibration and the environment it is operating in.
When a memory gauge is retrieved at surface, the data can be downloaded quite quickly into a format specified by the client. Usually output into ASCII (American Standard Code Information Interchange), this format is readily adapted to the different software packages that are used to analyse the data and can also readily be read by simple text readers or common platforms like Excel.
Well test reports from the wellsite can combine the downhole data with surface acquired data which also displays the sequence of events for the operation. This is very useful to those analysing the data to understand what was going on operationally when changes in the data occur. For example, simply looking at gauge data with an anomaly or feature, the engineer does not know if the anomaly is a fault with the gauge, a feature of the reservoir or related to some operation of the test. For example if the driller adjusts the annulus pressure, if a choke change occurs, if there is a hydrate plug or any of a range of other issues. Without reference to the surface acquired data it can be difficult to build a full picture of what is going on.
It is always advisable to run more than one gauge in the well. Typically three or four gauges are fitted inside a gauge carrier. Having multiple gauges provides a degree of insurance against gauge failure and also provides increased confidence in the data recovered.
Sometimes, dual gauge carriers can be run in the DST string to provide some localised gradient data and often one or more gauges are ported to measure annulus pressure rather than production bore pressure. This data can be useful for troubleshooting, or just to verify the timing of events, since many DST tools are operated by annulus pressure.

Surface Readout

The ability to acquire downhole pressure and temperature data in real time has been available for many years. However, for much of this time in order to do so required a cable inside the DST string which necessarily involves pressure control equipment. This type of operation is complex and time consuming and often can only be performed after the main test has been completed since it is undesirable to have wireline cable in the wellbore during flow periods.
New technologies have since displaced the need for wire intervention and gauge systems are available which are capable of transmitting downhole data to surface using acoustic signals through the fluid medium or electromagnetically through the casing steel.
These systems are more expensive than memory gauges but often pay dividends in terms of the value they add to the test by being able to make real time decisions based on well performance.

Downhole data acquisition in well testing continued

Real-time data is also useful for the operation of the test, for example in measuring the fluid underbalance precisely, determining valve equalization pressures, verifying downhole valve function or trouble shooting a range of issues.

Designing The Test

Since the objective of the test is the reservoir, then as much as possible we need to design the hardware setup and the procedures in such a way that non reservoir related effects such as wellbore storage, tide and the operations taking place in the surface facility do not adversely interfere with reservoir behaviour; in practice a great deal can be done to mitigate these effects.
The most important interpretation is usually based on build-up data i. e. data acquired after the well has been shut-in. It is during this period where that the behaviour of the reservoir can be studied with the minimum of external interference.
I mentioned above that data interpretation is based primarily on build-up data, but not exclusively. The production data during the test is also important and the interpretation model built around the build-up must later be matched to the production data to achieve a more refined match.

Tidal Effects

If the operation is taking place offshore, or even onshore but near the coast, then it is likely some tidal signal will be observed by the downhole gauges. Today, data interpretation software is quite sophisticated and capable of compensating to some extent the influence of tidal data, provided some knowledge of the tides during the test is available. One practical solution is to place one or two pressure gauges on the sea bed to record the tide during the test. This data can later be imported into the analysis software so that the tidal signal can be removed from the downhole data.

Depth Control

The

Time	*Choke*	*WHP*	*WHDCP*	*WHT*	*BHP*	*BHT*	*Qgas*	*Qoil*	*CGR*	*WGR*	*H2S*	*CO2*	*Gas SG*	*Oil SG*
	64 ths	*psia*	*psia*	*degC*	*psia*	*degC*	*MMSCFD*	*bopd*	*b/mmscf*	*b/mmscf*	*ppm*	*%*	*Air=1*	
hh:mm	*xx*	*xxxx.xx*	*xxx.xx*	*xxx.xx*	*xxxx.xx*	*xxx.x*	*xxx.x*	*xxx*	*xxx*	*xxx*	*xxx*	*xxx*	*x.xxx*	*x.xxx*

hh:mm Events including; opening well, shut in, choke changes, separator, chemical injection, sampling, others.

A typical well test report output

downhole gauges are some thousands of feet below surface so the hydrostatic pressure acting on the gauges due to the height of the column in the wellbore will be significant. At different times the weight of this fluid column will change. For example, as the gauge is run in hole with the pipe a gradual increase in hydrostatic will be recorded. The fluid in the wellbore may be changed after the DST string has been installed in order to introduce a static underbalance then an applied surface pressure may be applied to activate TCP perforating guns, this will appear as a large spike in pressure on the gauges, over and above the hydrostatic weight of the fluid column. Then the hydrostatic will change again as the well is unloaded and the completion fluid is replaced by reservoir fluids.
Knowing the precise depth of the gauge sensors is important in order to be able to account for all of the different hydrostatic effects seen, and since gauges will generally not be positioned directly across the reservoir, there will be some hydrostatic effects to account for between the gauges and the reservoir itself.

MD vs TVD

Measured Depth (MD), is the total depth along the well, this takes into account the fact that the well may not be straight, some horizontal wells can be some hundreds or thousands of feet in length without any change in depth. MD is therefore useful in determining things like number of pipe joints needed, or volumes of fluid needed. But is not so useful when it comes to determining pressure. True Vertical Depth TVD is the vertical depth of some point in the well to surface, drawn as a straight line, this is the depth we are concerned with when it comes to hydrostatic pressure.

Downhole data acquisition in well testing continued

Generally, a survey of the well will be performed at the end of the drilling phase. The survey, performed using gyro tools can measure orientation in three axes, so that a detailed map of the well bore can be produced this survey will output a TVD for every MD point recorded. The test engineer should consult this survey when preparing the pipe tally so that the precise depth of the gauges will be noted on the DST schematic.

Wellbore Storage

Downhole shut in tools located as low as practicable in the test string will have a significant impact on wellbore storage. Some effects will still occur between the open reservoir and the tester valve though these will generally be small and shouldn't impact data significantly.

Data Acquisition Tendering

We've discussed many of the specifications of gauges systems and how some of these would be more suited to a particular test objective than others. For example, battery life is important when it comes to extended tests. There are many gauge service providers on the market, what should we specify in the tender to attract competitive bids and to ensure the system selected is suited to our needs?

There are both commercial and practical considerations, including; reliability, gauge metrology, engineering interfaces, technical support, hardware availability and, of course, commercial terms.

Reliability is obviously very important, the test will cost a great deal of money and therefore we want to make sure that the gauges actually work. There are several things we can do in this regard, some of which can be specified in the tender documents:

- Track records including details of failure histories
- Frequency of calibration
- Individual gauge history records
- Multiple gauges available for back-up

At the Wellsite

In order to complete this discussion on downhole data acquisition, we will look at the roles of two key individuals at the wellsite: The reservoir engineer and the data acquisition specialist.

Data Acquisition Specialist

This role is a 24 hour role, that is to say, that when operations are ongoing for an extended period, there will be two personnel working on opposite shifts to provide coverage.

The data acquisition specialist(s) are responsible for receiving the data acquisition hardware at the wellsite. Specifically they will perform the following;

- Confirm full inventory of equipment received
- Perform function checks of all tools
- Ensure that gauges are calibrated and new batteries are fitted.
- Pressure test gauge carriers
- Ensure gauges are setup according to the program or as directed by the reservoir engineer
- Verify gauge sensor depth (TVD) according to running tally
- Oversee the installation of gauges and related hardware into the well
- Verify surface readout functions (if used)
- Attend gauge display monitor throughoutoperations
- Monitor data feedback and advise well test crew and reservoir engineer of status of gauges or anomalies in data
- Assist operations or troubleshooting downhole issues
- Produce regular report outputs as per client requirements.
- Oversee recovery of hardware from the well
- Download all gauge data and provide a copy to the client
- Pack all hardware for shipping
- Produce end of well report after the job

Reservoir Engineer

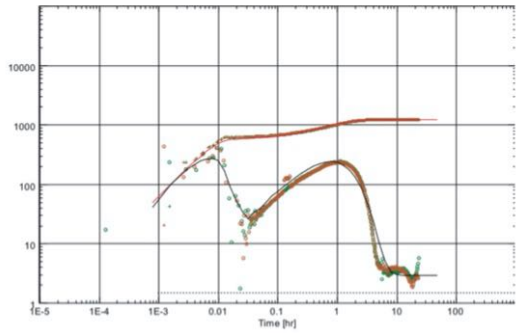
Downhole data acquisition in well testing continued

The reservoir engineer is responsible for managing the asset, i.e. the reservoir. The purpose of this role at the wellsite is to maintain a focus on the test objectives and ensure optimum data quality. Some of the specific roles of this indvidual include:

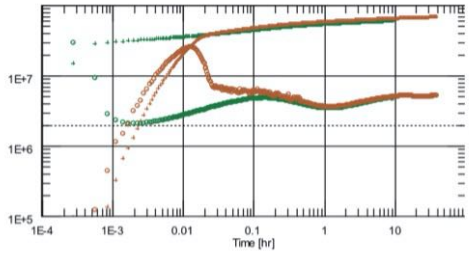
- Determining gauge programming setup
- Making decisions in relation to each phase of the test, e.g. clean up, drawdown and build up periods, duration and acceptance criteria for changing from one to the other.
- Validating the quality of the data acquired by the gauges
- Determining the distribution protocol so that data transmitted from the wellsite is controlled.

Effect of Wellbore Storage on Gauge Data

Enormous wellbore storage during a pressure fall off on a water injection well with surface shut in. The reservoir receiving the injection was under-pressured which contributes to the large WBS



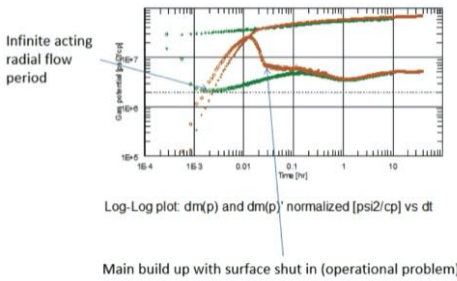
Log-Log plot: p-p@dt=0 and derivative [psi] vs dt [hr]



Comparison of the well test diagnostic plot during a DST with and without downhole shut in

Log-Log plot: dm(p) and dm(p)' normalized [psi2/cp] vs dt

Downhole vs Surface Shut In



Downhole data acquisition in well testing continued

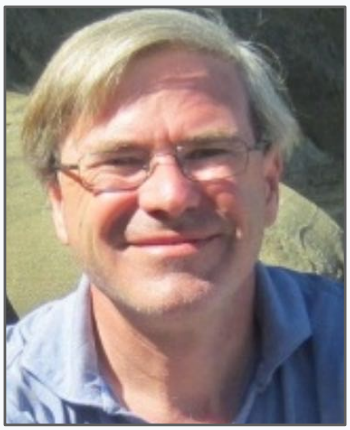
Acronyms

ASCII	American Standard Code Information Interchange
BHP	Bottom Hole Pressure
BHT	Bottom Hole Temperature
BSW	Base Sediment & Water
CGR	Condensate Gas Ratio
CO2	Carbon Dioxide
DST	Drill Stem Test
FWHP	Flowing Wellhead Pressure
FWHT	Flowing Wellhead Temperature
GOR	Gas Oil Ratio
H2s	Hydrogen Sulphide
HPHT	High Pressure High Temperature
MD	Measured Depth
MMSCFD	Million Standard Cubic Feet Per Day
Qgas	Gas flow rate
Qoil	Oil flow rate

Glossary

Accuracy:	The closeness with which a measurement approaches the true value of any parameter.
Acoustic:	A gauge system which transmits signals through a fluid medium using sound energy
Choke:	A restriction in the flowstream used to control production rates and pressures
Drift:	The tendency for a gauge measurement error to accumulate in one direction over a period of time
Hysteresis:	The difference in measurement between increasing and decreasing values for any parameter
Linearity:	The degree to which incremental changes applied to a sensor, produce a corresponding straight line output from the sensor
Metrology:	A collective term referring to all of the gauge performance measures, i.e. accuracy, resolution, range, drift, hysteresis, linearity
Resolution:	The smallest change in a parameter that can be represented as an output by the gauge
Wellbore Storage:	The activity which occurs in the wellbore above the reservoir, after shut in, which manifests itself as noise on the gauge data and masks reservoir response. Wellbore storage is often referred to as 'afterflow'

A busy, creative life engaged in doing the things you love: Recipe for a good life



Professor Martin Blunt is Chair in Petroleum Engineering at the Department of Science & Engineering at Imperial College London. In addition, he is Chief Technology Officer at iRock, Director of Research at Streamsim Technologies, and Professor at Politecnico di Milano.

Previously he was Head of Department of Earth Science and Engineering, Imperial College London from 2006 to 2011, Head of Petroleum Engineering and Rock Mechanics (PERM) Group from 1999 to 2006, and Associate Professor of Petroleum Engineering, at Stanford University, California from 1992 to 1999. He holds MA and PhD degrees in theoretical physics from Cambridge University.

Who is Martin Blunt? Tell us about yourself.

I was born in London, but spent my childhood in Sussex. I went to local schools, where my favourite subject was history. I also loved reading literature (and still do). It was only when I was 16 and learnt calculus that I decided to pursue science and maths. I noticed that I found these subjects easy, while others struggled with them. I then went to Cambridge and studied Natural Sciences, specialising in physics. I stayed on for a PhD in physics. My PhD was partially funded by BP. It was on fractals and viscous fingering. This is where I first developed my interest in fluid flow in porous media, but in my first paper I muddled up porosity and permeability, so I had a lot to learn!

Walk us through your career. How did you become Chair in Petroleum Engineering at Imperial College London?

After Cambridge I worked for BP. In 1991, I visited California for the first time and fell in love with the Bay Area. When a position was advertised at Stanford, I could not resist the opportunity. I left for the US in 1992 and was an Assistant and then Associate Professor in Petroleum Engineering. I valued every day that I was in Palo Alto: it is a wonderful place with a perfect climate, and the university had a no-nonsense aspiration to excellence.I enjoyed teaching and research, but for family reasons we wanted to return to the UK.
On one of my visits to London, Alain Gringarten, who had recently arrived as Director of the MSc in Petroleum Engineering, invited me to lunch at the Brasserie San Quentin (now sadly closed) on Brompton Road and persuaded me to apply for a position at Imperial. I started at Imperial in 1999.

You are also Chief Technology Officer at iRock, Director of Research at Streamsim Technologies, and Professor at Politecnico di Milano. How do you find balancing between teaching and working in industry?

Stanford is in the centre of Silicon Valley, the start-up capital of the world. So when, with a couple of PhD students, we developed a new streamline-based reservoir simulation technology it made sense to found a company to exploit the ideas. OK, it wasn't Google, but Streamsim has been a successful business for the last 20 years, and has given me a new insight into the commercial world. The second company, iRock Technologies that offers digital core analysis services to the oil industry, was also founded by one of my former PhD students. It is highly successful with 60 employees.

Petroleum engineering is a practical subject, so it makes sense to pursue new ideas commercially as well as scientifically. I find it invigorating to juggle my time between more theoretical and commercial interests, and am proud that my research has had an impact in the real world. Imperial College also strongly supports this type of entrepreneurial activity.

My partner is Italian and we have decided to bring up our children in Milan. So, I spend a lot of time in Italy. I am a visiting professor at Politecnico di Milano, the principal engineering-focussed university in Italy. I teach a petroleum engineering course there, and am involved in joint research on three-

Working hard and playing hard... continued

phase flow. As we have found out in lockdown, most of us can work from home, or wherever we are: I am used to working remotely, so in many ways 2020 with its Skype and Zoom meetings with colleagues and students has not been that unusual for me.

In 2011, you were awarded the Lester C. Uren Award from SPE. Tell us a more about that.

This is an award to recognise achievements in petroleum technology made before the age of 45. It is named after a professor at the university of California who introduced one of the first petroleum engineering courses in 1915 - although Imperial was slightly earlier, albeit with a Petroleum Geology course, founded in 1913 by Vincent Illing. Anyway, I was greatly honoured to be recognised by the SPE in this way. I was presented with a large plaque at a carefully-planned awards ceremony at the SPE Annual Meeting in Denver. Even though it was only September, it was snowing when we left.

Prior to becoming Associate Professor in Stanford University, you worked in BP as a Research Reservoir Engineer for 4 years. Many people choose to pursue either a career in academia or in industry, in your opinion, how different are the skills for each of the routes and what are they?

My PhD was in physics. I wanted to move into industry for two reasons. Most young physicists dream of being the next Einstein. Well, that wasn't going to happen! Secondly, I became disillusioned with the rather theoretical approach of physics at university and wanted instead to solve real-world problems. In my case the important skills have been technical – the ability to identify and tackle new problems. In industry there is more a focus on practical impact, but even at university this needs to be stressed to secure funding from industry.

Looking back to when you graduated from the University of Cambridge, what one advice would you give to your younger self? Would it be the same to those who are just about to enter O&G industry? What about those who are just about to start their degrees?

I would advise people to pursue the things they are good at and enjoy - then, like me, you can spend the rest of your life doing a job you love. Also keep your options open – when in doubt do not close off options. Always keep learning: everything I teach I learnt myself; none of it came from classes I took.

From your experience, what are the important points for O&G companies to focus on in downturn crises like the current one?

They all focus on the same thing - cutting costs and people. Instead, they should be retaining skills and continue to recruit new talent - it is easier to attract good people in a downturn that in a boom year. You need a creative mindset to come out of a crisis - instead all the companies do the same thing, and hunker down, adopting no new technology or ideas and hoping for better times. No wonder there's a problem!

What current developments of Oil & Gas Industry excite you and where do you think our Industry is going to be in a 10 years' time?

Independent oil companies face an existentialist crisis. The relentless round of cuts have left them with a depleted pool of expertise. They no longer can offer an obvious technical advantage over national oil companies, that have a much more stable workforce, and who own most of the oil and gas. Furthermore, we need seriously to address the threat of dangerous climate change. While many companies are announcing plans to be net zero by 2050, how they will do this remains vague, and comes with further pruning of an already emaciated workforce in their core subject - managing subsurface flow. The exciting prospects are exactly in this domain, using this expertise to invest and implement large-scale carbon capture storage which is essential to address the climate challenge. Furthermore, similar expertise can be brought to bear to understand geothermal energy, while the industry's track record of large infrastructure projects can be put to good use designing, implementing and powering the transition to a low carbon economy.

It takes imagination, creativity and the engagement of the best minds to change the world. The oil industry has done this in the past through delivering unparalleled prosperity to the world over the last century. The industry is at a crucial turning point - they either become innovative, value their staff and have a can-do mentality to new ideas, or they may suffer the same fate as coal companies and find themselves on the wrong side of history.

Oil and gas leasing: Using proximity analysis and machine learning to predict bid price

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Currently he is helping customers implement data marketplace web portals to democratize and extract value from data.

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Abstract

Energy companies participate in lease sale to secure the lease for wind and mineral exploration rights in offshore federally owned areas. Companies go through an intense process to analyse several data sources before making a decision to submit a competitive bid package. This is based on an economic return on investment. With the falling oil prices and capital pressures, companies must invent new ways of analysing data and leveraging technology to price the blocks as accurately as possible to optimize the spend. This paper discusses geological, geophysical, commercial and political factors that influence lease sale and presents the results of a machine learning(ML) experiment in predicting bid prices using a subset of the factors. Defining a predictive model would help companies in pricing the bid package competitively to secure the lease for mineral oil and gas resources. A combination of geographic information system (GIS) techniques and ML are used to draw a relation between input factors and the historical bid price. Predictions for pricing are drawn using random forest regression model. The model may be extendible to include additional factors and geography specific requirements. The area chosen for this study is offshore Gulf of Mexico region. The study relies on data sources available in public domain from Bureau of Ocean Energy Management (BOEM) and Energy Information Administration (EIA).

The outer continental shelf (OCS) in Gulf of Mexico of United States is a large store of natural resources that support the growing demands of oil and gas. The coastal environment is sensitive and is important for commercial, recreational and ecological reasons. The Outer Continental Shelf Lands Act was amended in 1978 to regulate the leasing activities for exploration and production of oil and gas resources and protect the marine environment. Oil and gas companies can participate in a competitive bidding process to secure a lease on a block for a primary term between 5 and 10 years. Lease blocks serve as the legal definition for offshore boundary coordinates used to define small geographic areas within an official protraction diagram (OPD) for leasing and administrative purposes. Lessees must begin exploratory drilling within the primary term to ensure continuity of the lease. Lease blocks receive a varying number of bids with different bid values. Companies that participate in bidding have their own corporate strategy to create the bid package. Several factors need to be considered in order to differentiate lease block potential in Gulf of Mexico region. Broadly we can categorize them as follows:

Geophysical / geological factors

1. Availability of high-quality seismic data. This is needed to conduct meaningful seismic interpretation to identify oil and gas reservoirs and their size and location.
2. Proximity of seafloor geohazards to the lease block. Companies are expanding oil and gas operations into deeper waters and managing risks related to geohazards is extremely important.

Offshore geohazards include several geological phenomena, such as submarine slides, shallow gas and dissociation of gas hydrates, shallow water flow, mud volcanism, and seismicity. Side scan sonar (SSS) surveys

Oil and gas leasing continued

are useful to identify the seabed hard ground, active gas seeps, seafloor debris like shipwrecks, lost fishing gear, anchor cables and drill pipe.
3. Map of subsurface salt domes. Salt domes deform rock structures so form traps for oil and gas resources. Proximity to these structures could be an important factor to consider.
4. Reservoir and water depths. Deep water reservoirs bring significant risk to the project including increased cost for exploration and production. Pricing for deep water lease blocks include water depth as a key factor.
5. Confirmed or probable oil and gas seeps. These seeps could indicate existence of a deeper reservoir. A combination of seismic interpretation and proximity to seeps could be used in developing pricing strategies for a lease block.
6. Wells and fields. Proximity to existing discoveries boosts potential for finding oil and gas resources in the lease block and could drive higher bid pricing.

Commercial factors

1. Historic price of oil. Drilling for oil is a capital-intensive operation and decrease in oil price leads to reduction in the activity. Oil price is a crucial factor in developing the pricing strategy.
2. Proximity of existing infrastructure (pipelines, platforms etc.). Construction of subsea infrastructure is a risky and capital-intensive project and companies prefer lease blocks nearer to existing infrastructure and bid higher to secure the lease.
3. Historical lease sale data including number of bids received per block. This information can provide a baseline for comparison.
4. Offset well production data. Proximity to fields with upward production trends can have a great influence on the pricing of a surrounding lease block.

Political factors

1. Timing of the upcoming lease rounds, rental and royalty payments on the lease can influence the bid pricing and strategy as availability of lease blocks with discovery potential in distant future could be greatly influenced by oil price at that time.
2. Access to lease rounds in different geographies. Gulf of Mexico region has been facing competition from other basins in the world including onshore US basins and Mexican waters. Participation from companies in this region is on a decreasing trend.
3. Geopolitical factors and government policies including moratorium established by US congress. US government policies on sanctions imposed on certain countries could affect theprice of oil by driving up demand and therefore have an impact on lease sale.

Data peparation and proximity analysis

The process of coming up with the lease bid package is kept secret by the companies and identifying comprehensive list of factors is crucial in defining the pricing strategy for a lease block. Proximity information is a key variable that need to be considered for several factors while evaluating the long-term capital expenditure and the risk of the project.

The chosen study area is US Gulf of Mexico. BOEM is responsible for leasing the blocks in this region. The bureau maintains a comprehensive set of maps, GIS data for historic and future lease sale. Data from 2005 to 2018 is obtained from BOEM for analysis. Figure 1 (overleaf) shows the area of interest with respect to US south boundary, feature layers (lease and infrastructure) considered and puts everything in a perspective from proximity point of view.

Data files are available from BOEM in multiple formats. Datasets within the scope are downloaded as flat file database (comma separated valued (CSV)) and ESRI spatial database shape file formats. Datasets available

Oil and gas leasing continued

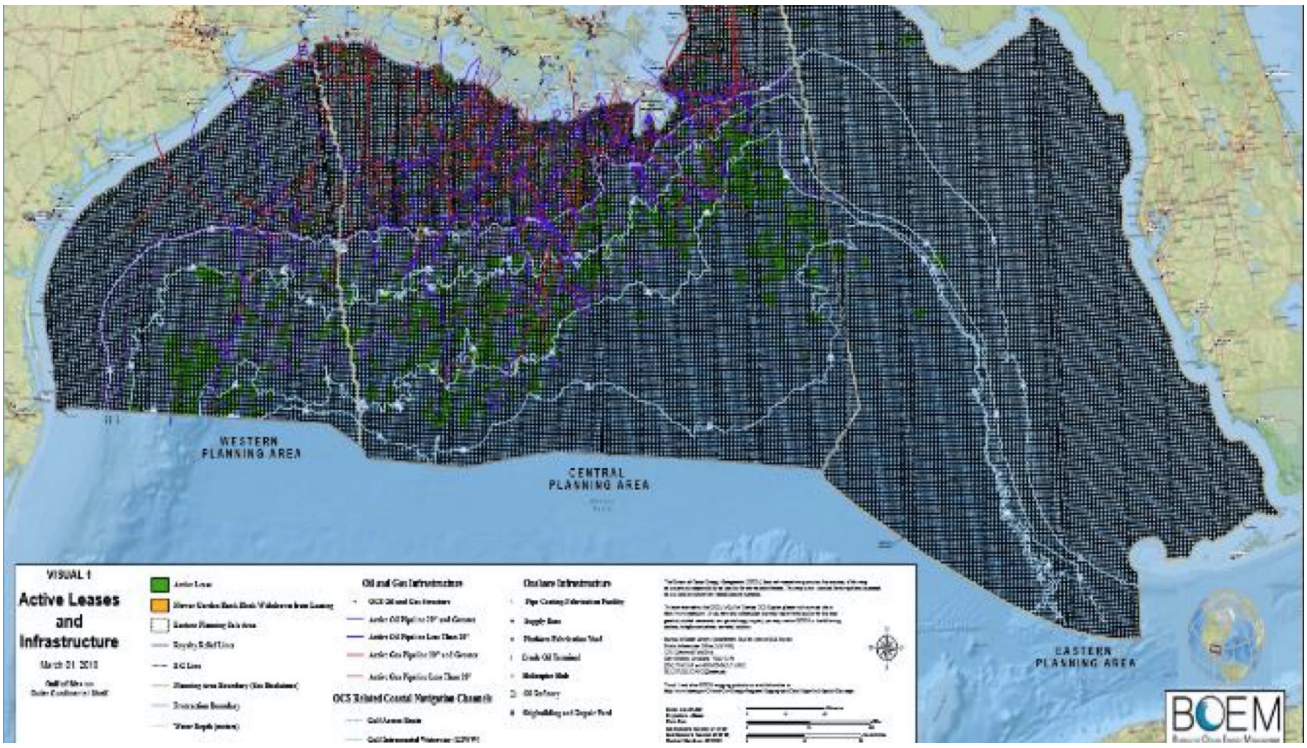

Figure 1. Gulf of Mexico - study area

from BOEM are processed in North American Datum 1927 (NAD27) coordinate system. In order to calculate distances to determine proximity, all the spatial data has been transformed to a common projection NAD27.BLM-16N US Foot unit. Bid results from 2005 to 2018 from Eastern, Central and Western GOM areas were considered for this study and analysed. It is observed that the bids received by BOEM are clustered with the maximum highest bid being $157 million and the lowest highest bid was $125. The water depth for these leases ranged between | meter to 3398 meters and the historic oil price for this time period are between $38.28 and $115.48. Data available from public domain is not ready for analysis / consumption. Data had to be prepared to create a unified dataset for machine learning. Using Safe Feature Manipulation Engine (FME) software, a tool was developed to process spatial files, CSV files and merge data into a single shape file database. FME is a software for solving data transformationchallenges across multiple formats. It is used for building and automating workflows related to extract, transform and load (ETL) operations.

The objective of proximity analysis is to find the nearest feature based on the distance and use distance as the predictor variable to establish relation with bid price (target variable). Proximity Analysis is an analytical technique used to determine the relationship between a selected point and its neighbours. GIS techniques are used to determine distances for different factors (feature variables) based on their proximity to the lease block. Distance indicates the level of influence of the factor on the lease block price. Workflow tool in FME is created to convert all the input data into a common projection, convert flat file databases to ESRI shape file format (based on coordinate information available in the input file), followed by calculation of intersection of every lease block in the study area with other layers to calculate closest feature. FME NeighborFinder transformer is used to calculate and capture closest distance as an attribute in the shape file database. The tool comprised of input datasets, readers, transformers and writers that merge data into a flat file database. Figure 2 (overleaf) shows the tool created in FME for processing the data. The output of this tool are multiple flat file databases with closest distance of every lease block to the respective feature factors shown below:

- highest bid value
- water depth

Oil and gas leasing continued

- historic oil price
- distance from nearest field
- distance from nearest pipeline
- distance from nearest confirmed oil/gas seep
- distance from nearest platform
- distance from nearest well

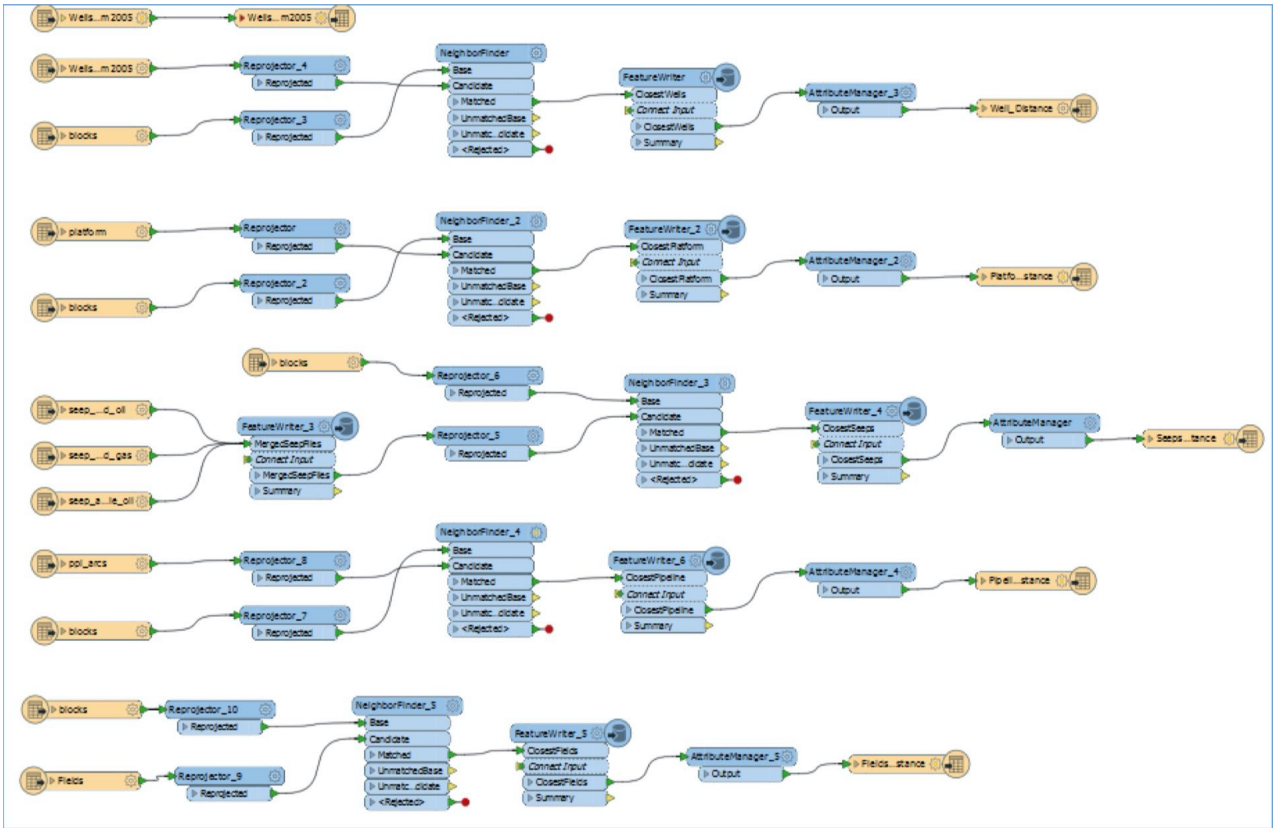

Figure 2. FME ETL workflow

All the individual flat file databases are combined into a unified dataset. This dataset serves as the input for analysis in machine learning model for training and predicting the bid values. The processed unified dataset contains 6,892 records.

ML model and regression analysis

The objective of building a machine learning model is to identify historic trends in the data and predict future lease block pricing based on training data and determine the most important factors that influence the prediction. Two regression techniques have been used in this experiment - Multiple Linear Regression and Random Forest Regression. The algorithm relies on relationships between dependent (bid value) and independent variables (factor variables). Python scripting and associated libraries can be used to build the models for training and testing the data. Python is an interpreted, object-oriented programming language for rapid application development. It is an open source tool available for all major platforms and is widely used by data scientists for solving problems using machine learning. Before building the model, the data in unified dataset is normalized so that every data point is within a range of 0 and 1. This helps in visualizing the data on a common scale and relationships between variables can be identified. The formula used for data normalization is: X(normalized) = (x — x(min)) / (x(max) — x(min)). A sample of the normalized dataset is shown in Table 1 (overleaf).

Oil and gas leasing continued

High_Bid	Water_Depth	OIL_PRICE	FIELD_dist	PIPEL_dist	SEEP_dist	PLATF_dist	WELL_dist
10620	0.0132	0.7115	0.1163	0.0101	0.2445	0	0.0229
14706	0.0486	0.8086	0.0676	0	0.0142	0.0572	0.0809
15051	0.0474	0.7336	0.1769	0.0096	0.0541	0.0132	0.0137
17111	0.8958	0.2360	0.2708	0.3623	0.3479	0.4065	0.2761

Table 1. Normalized data sample

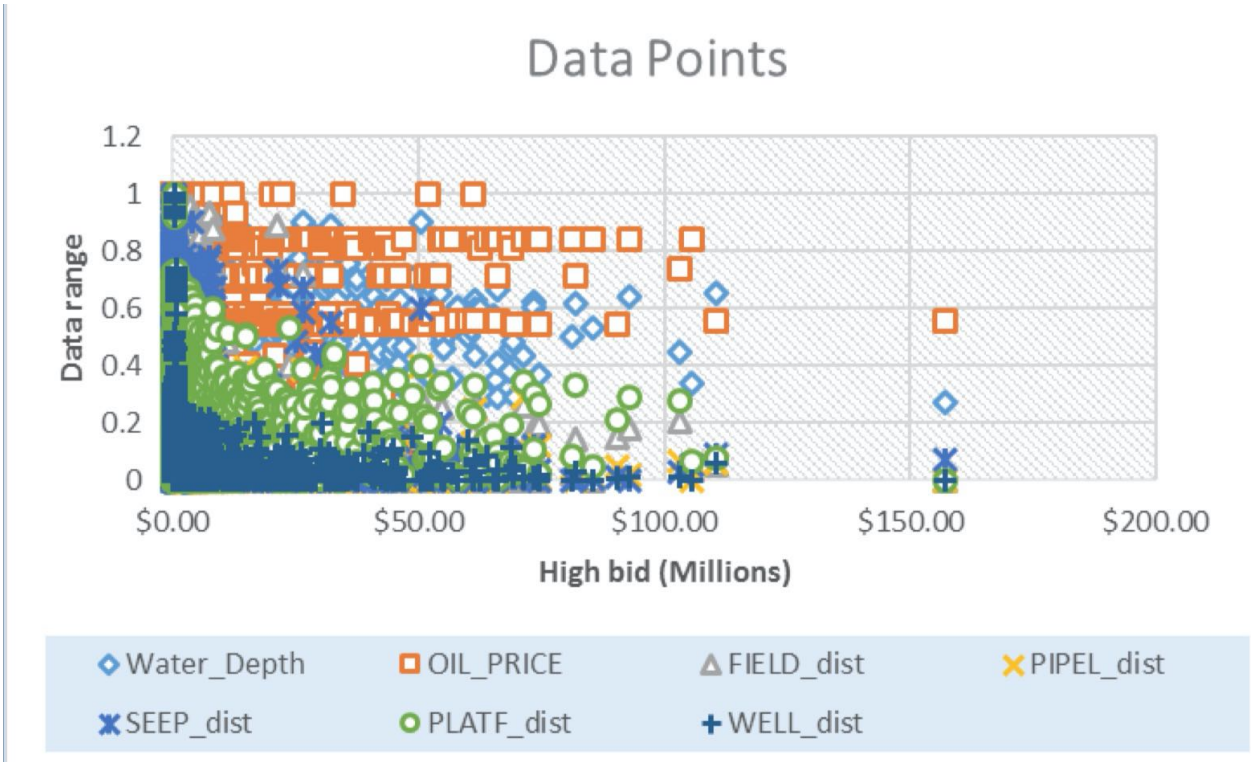

Figure 3. Normalized data plot

After normalizing the input dataset, regression models are implemented to establish relationship between dependent and independent variables. In statistical modelling, regression analysis is a set of statistical processes for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. Plotting (Figure 3) independent variables against independent variable (highest bid value) showed no linear correlation between the variables. Implementation of Multiple Linear Regression on the dataset gave poor prediction accuracy. As there is no linear correlation, two different machine learning approaches were tried using decision trees. The first approach is called Random Forest Regression, which is a supervised machine learning algorithm. The algorithm builds an ensemble of decision trees, aggregate them to arrive at a more accurate prediction. The algorithm can be used for both regression and classification purposes. In a decision tree each internal node represents a test on an attribute, each branch represents the outcome of the test and the leaf node represents the final decision taken after computing all attributes. In random forest, the decision trees are constructed independently using a different subsample of the data. Python scripts are created using Scikit-learn package. Scikit-learn is an open source machine learning library for python programming language. The package contains RandomForestRegressor object for model training and prediction. Training data is required to build the model so the algorithm can learn the data patterns based on the input variables. The input dataset is split into training and testing datasets in the ratio of 2/3:1/3 and this is a common practice in machine learning.

Oil and gas leasing continued

The second approach implemented is called Gradient Boosting Regression. It is similar to random forest regression except that it uses a particular type of ensemble method called gradient boosting. Gradient Boosting builds the model in a sequential manner. At each stage of model building, the decision tree is chosen to minimize a loss function based on the current model. Python scripts are created using eXtreme Gradient Boosting (XGBoost) Regression python package. The library implements machine learning algorithms under Gradient Boosting framework. XGB python package contains XGBRegressor object for model training and predictions. Both approaches are implemented and models are trained with input dataset to predict the bid values.

Conclusion

It is observed that for bid values higher than $1 million, the prediction accuracy decreased drastically indicating that the pattern for those bids are outliers in this model and there could be additional parameters that may have influenced the bidder to place higher bids to win the lease. All the values over $1 million have been eliminated as outliers from the computation. For model building, the study considered a sample size of 4800 records with highest minimum bid value of $10,620 and highest maximum bid values of $984,960. Figures (4, 5, 6) below summarize the results of the regression models using both approaches. Both algorithms were able to predict high bid values with 55% accuracy using input parameters such as oil price, water depth, distance to closest wells, fields, platforms, pipelines, confirmed seep locations. The mean absolute error of the predicted bid value is about $130K. Python script with multiple linear regression computed a poor prediction accuracy of 6%. Both algorithms have been tested with different values for n_estimators and max_depth parameters and there was no change in the computed prediction accuracy.

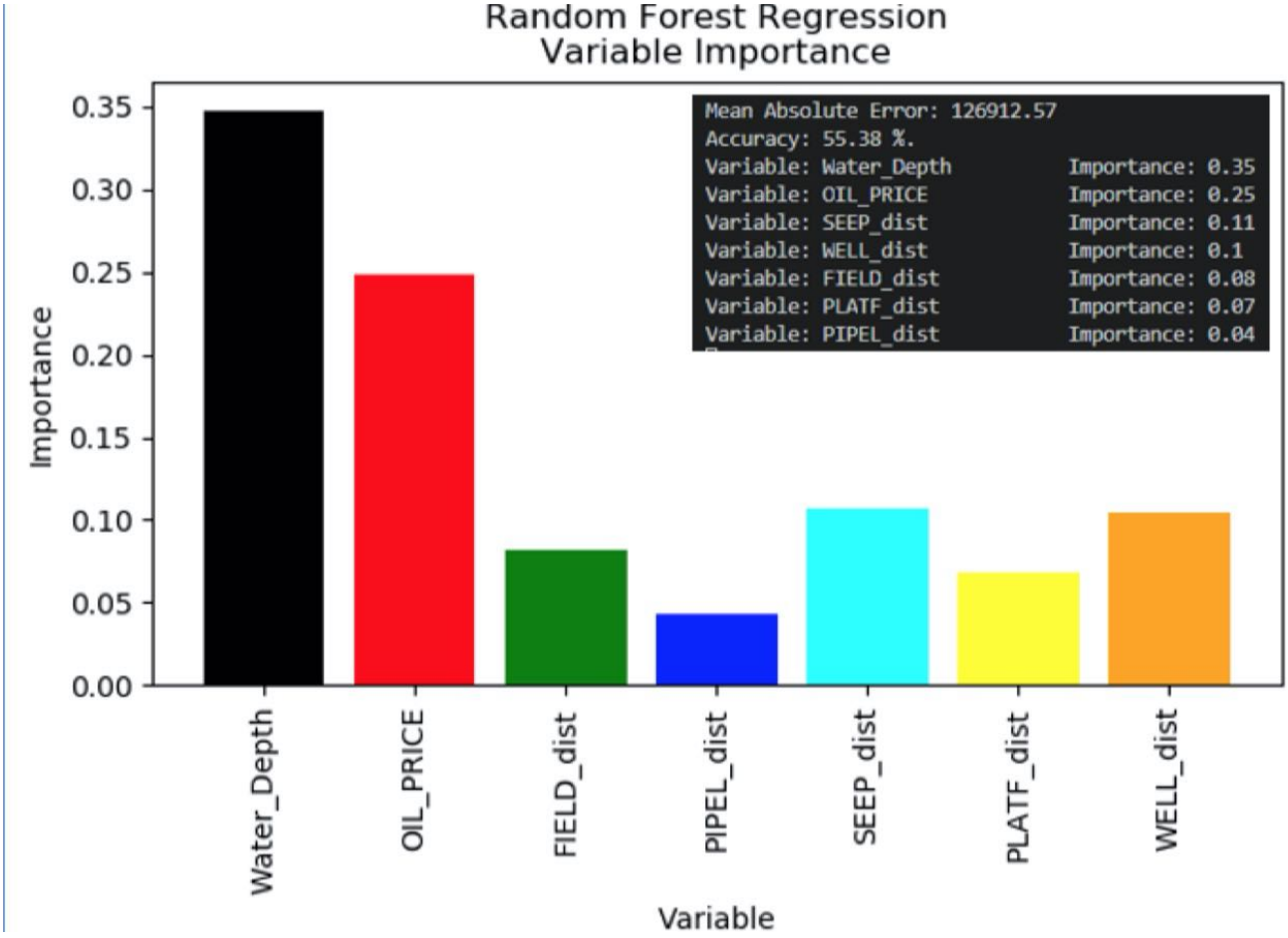

Figure 4. Random regression forest results

Oil and gas leasing continued

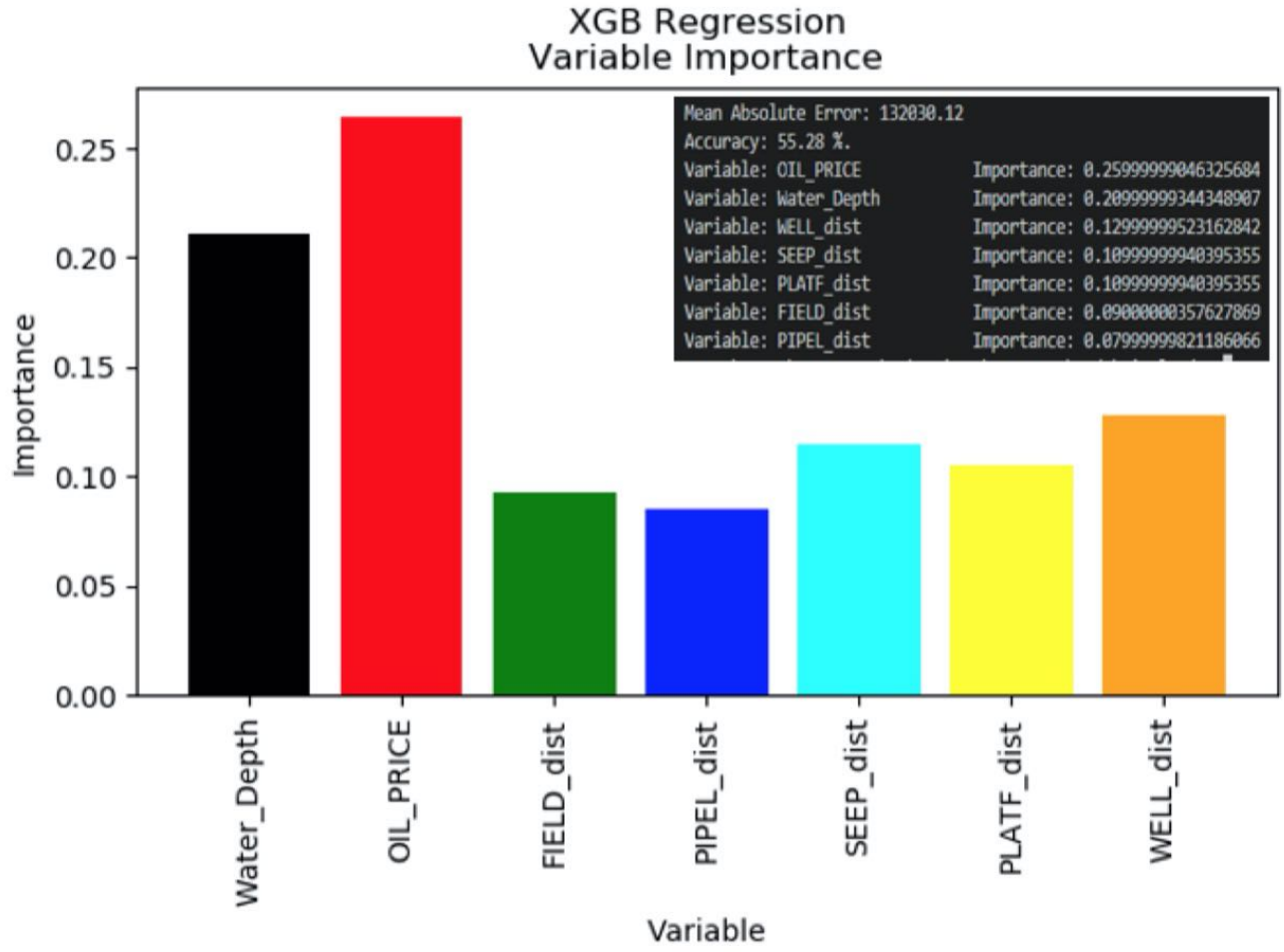

Figure 5. XGB regression results

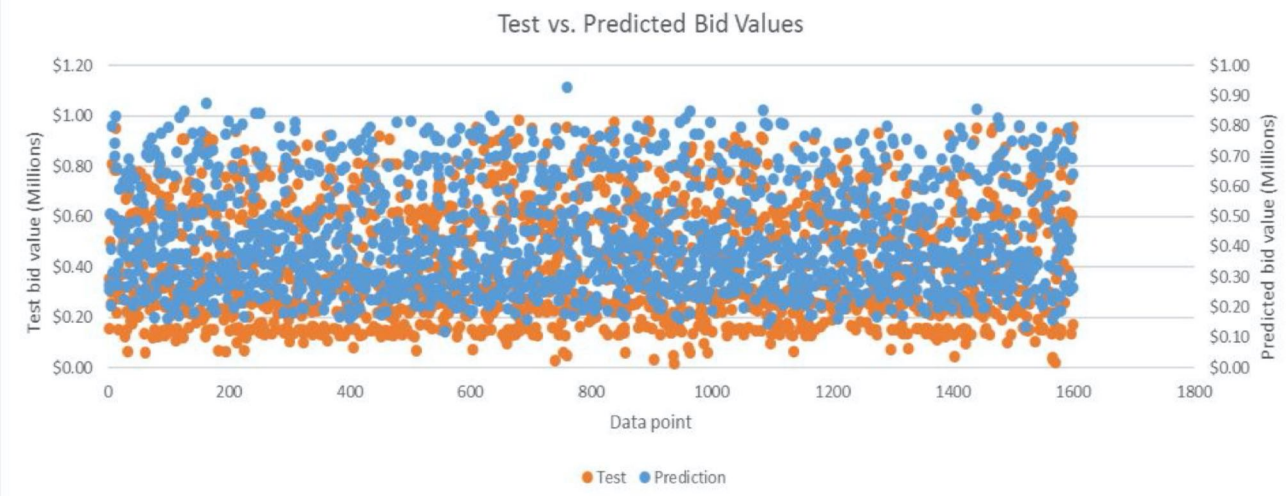

Figure 6. Testing and prediction values

The random forest algorithm was able to predict high bid values with about 55% accuracy. It is observed that water depth and oil price variables played significant role in determining the predicted bid value. As the bid values increased in the training dataset, the accuracy of predictions decreased. In this paper there is insufficient information in public domain to correlate higher bid values (considered as outliers and removed from calculations). These higher bid values from companies could be attributed to knowledge about

Oil and gas leasing continued

additional parameters such as access to high quality seismic data, confirmation of a discovery, production trends in nearby fields, proximity to geohazards, salt interpretation, field reserves estimates, well permits, rent and royalty payments, EMV calculations and other variables. Better understanding and access to this information is needed for incorporating these variables in the model and derive better predictions and these are out of scope of current research.

The study can be extended to include additional variables described above including temporal information such as discovery date for fields, wells based on spud dates etc. which has not been considered in the analysis. Evaluating other machine learning models to improve predictions is another interesting area to explore and further this study. This paper shows how a combination of GIS and machine learning techniques can help companies process the spatial data and derive useful information that can help in coming up with competitive lease bid package.

Acknowledgement

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SPE YP: new committee, events, and updates

We hope our colleagues from around the world are well and safe during these strange, but hopeful times. It has certainly been a whirlwind of a year, with a lot of uncertainty for our industry.

I am proud to introduce our new committee for the 2020/2021 academic year. We ensured that we have the right blend of experienced and young professionals as well as fresh graduates to help us plan and deliver educational and insightful initiatives over the coming year.

We have already held several events, albeit virtually due to the current climate we find ourselves in. It was important that the pandemic did not impede our ability to collaborate and share different views. Incidentally, it meant our colleagues had a lot more time on their hands to join our events from the comfort of their homes.

Every year, we strive to offer new perspectives and opportunities for our colleagues in the oil and gas industry, to learn about the new and emerging ways that our industry is evolving by the day! This can be seen from our Digitalisation and Data Management events, through to technical webinars focusing on Carbon Capture and Storage, and more traditional upstream related topics.

We also held the first of our mini-series events 'Meet the Leaders.' The aim of this series has been to expose SPE members to conversations with leaders from our industry, ranging from top-tier management executives to experienced engineers. We believe this will provide graduates and YP's the unique opportunity to learn from different experiences and go a long way in helping them decide on their future career path.

Even in our industry, I have seen first-hand how our ways of working have been forced to change and adapt, with more reliance on virtual interaction and digital modes of communication. While companies may have premises that have been vacant for close to a year now, they can take solace in the efficiency and higher productivity seen over the past few months.

On behalf of our committee, we would like to wish you all a very Merry Christmas, a Happy New Year, and see you soon! Take care of yourself and your family.

Shwan Dizayee – YP Chair, and Samad Ali – YP Vice-Chair


Shwan Dizayee


Samad Ali


Theresia Citraningtyas


Raghd Gadrbouh


Vikas Kooneti


Umair Tariq


Muhammad Usman


Natan Battisti


Laith Jaghman

Full cost resilient business, fields, and production

Welcome to the London Sections' Net Zero Committee section of the SPE Review London where we will present and discuss a range of topics associated with Energy Transition and Net Zero. We hope these articles will be informative and help readers understand some of the significant changes in the oil and gas industry.

This is the second in a series of articles for SPE Review London covering sustainability brought to you by Adrian Gregory, who is a subsurface and wells engineering consultant. Adrian will be writing future briefing articles broadly focusing on sustainability strategy, frameworks, principles, delivery and performance.

This article will mainly be covering 'ownership', 'rights', and 'obligations' - introducing the beginnings of sustainability thinking more than three hundred years ago, concentrated in the last few decades due to real issues of planetary boundaries and climate change. A journey which has introduced Corporate Governance (CG), Corporate Social Responsibility (CSR) - citizenship - and, in 2005, Environmental Social Governance (ESG) into the Sustainability 'Responsible Business' theme. Now, due to external market disrupting events, the 'Resilient Business' theme has come very much to the front and centre of Corporate Governance too. Simply considering activities from the one-dimensional lens of 'economic and commercial' preferences is now under severe threat for natural resource companies. Today, having a responsible and resilient business model is one of the key tasks of effective Corporate Governance.

'Sustainability': What does it actually mean to you, your work-space, your work-choices, your future work-opportunities?

Hopefully, the first article has started to shed more insight into this super discipline to shine light with answers to questions probably not thought critical enough to answer before responsible and resilient business practices appeared. The first article touched on sustainability strategy and integrated thinking, emblazoned with Lovelock's genius for 'top down' ecology thinking. Before we can progress to focusing on sustainability frameworks, principles, delivery and performance, we need to introduce more core elements of Sustainability. This article will concentrate on today's 'now', and the next article more on 'tomorrow'.

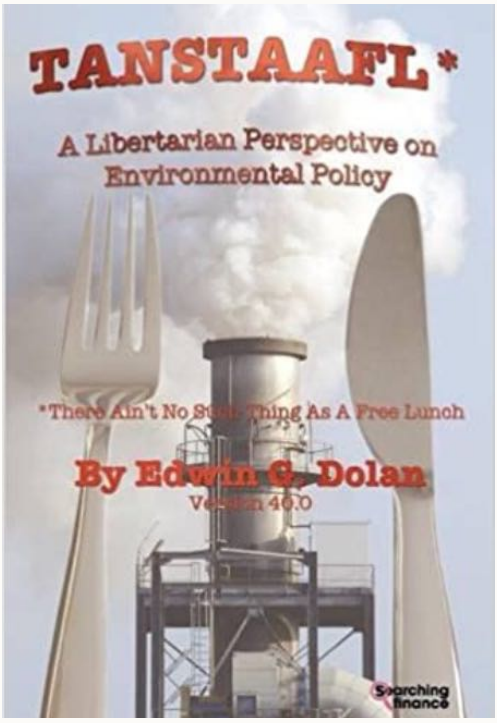
One of the core elements of strategy is 'where are we now'? Profit is very much in the now, equal to current revenues minus current costs, Profitability 101. Any economic consideration of future revenues and costs, discounted 'flows' is 'value evaluation'. Yet profit maximisation, since the 1980's, seems to have clouded or focused business objectives into a one-dimensional trajectory, tending to focus just on shareholders' benefits, often at the expense of stakeholders, local communities and even environmental considerations.

Environmental standards and regulations are dictated through governments and 'Political Governance', but, why is 'Social Capital' the domain of government and non-governmental organisations? This thinking starts to raise questions of ownership. Do shareholders really 'own' public companies - justifying this one-dimensional thinking? If you are a shareholder in Coca-Cola, can you then go to any of the global branded dispenser machines and take out 'your can' free of charge? For businesses discovering, developing, producing and stewarding natural resources, ownership has much more important questions: Who owns nature and its ecosystem services. Our Planet Oil natural resources' have taken millions or hundreds of millions of years to 'create' effective sources, seals, traps and migration pathways - so who does 'own' them?

Ownership of nature, or natural resources, was cast in print in 1689 by John Locke[1]. Locke was the first real pioneer to appear on the sustainability landscape. He used examples of acorns' and apples' ownership[2]

Full cost resilient business, fields, and production continued

(I preferred wild strawberries[2]) to illustrate the answer to this key question. The work done in 'gathering', or exploiting, common land goods - 'removing them out of that common state they were in, hath fixed my property in them'. With my example of wild strawberries, stewardship would involve, in addition to seasonal exploitation of nature, also improving the selection of the plants; cultivating them on private land not just common land; increasing the crop yield; producing associated products to sell with the strawberries; and, finally, providing a service to steward increase consumption[2]! By enhancing the value, stewardship is essential in creating a resilient natural resource business, built on best practise 'work done'.



Issues of 'work done' and 'enhancing value' leads nicely to the first real pioneer of modern day sustainability, Edwin G. Dolan. In 1971, Dolan wrote 'There ain't no such thing as a free lunch' (TANSTAAFL[3]). This book is so popular, the 40th version was published in 2011. The book has become the bedrock of natural resource economics and a must read for anyone interested in natural resource ecology. Dolan's book nicely discusses how 'everything of value' has a cost. There is an 'opportunity cost - the idea that whatever you chose to do has a cost that is measured in terms of the other things (or activities) you could have done instead with the same time and resources', work done. Particularly with non-renewable resources, full cost pricing including waste disposal, harm from pollution, and depletion of resources is the only way for industry to co-exist with society, without gaining at the expense of others. Full cost pricing is socio-efficient. The polluter must pay the full costs. Delaying full costs only makes the total costs higher - such as exampled by UK nuclear power station decommissioning since the 1990's. Anything 'free' costs twice as much in the long run, or turns out to be worthless. For greenhouse gas (GHG) emissions, the latter case is certainly not true. Free rider effects have to be overcome with GHG emissions. Ownership[4] and measurement[5] and achieving Net Zero methane and CO_2 emissions all need 'Carbon Governance', stewardship and management to abate climate change.

Ownership determined by law gives certain rights and duties over assets which may be objects, natural resources, land/real estate or intellectual property. Ownership is the basis for many other concepts that form the foundations of ancient and modern societies such as money, trade, debt, bankruptcy, the criminality of theft and private versus public property, and excludability. Ownership is the key building block in the development of the capitalist socio-economic system. Adam Smith stated that one of the sacred laws of justice was to guard a person's property and possessions.

Licensees have legally binding contractual obligations to meet the conditions of their licences. Proper maintenance of a license is key to investor confidence and the relationship with the licensing authority - both key elements for successful delivery of the MER UK strategy. In addition, where licensees pay insufficient attention to their regulatory obligations, it may have the potential to affect their social or societal license to operate. 'Stakeholder license to operate' refers to the ongoing acceptance of a company or industry's standard business practices and operating procedures by its employees and stakeholders. 'Social license to operate (SLO) also requires ongoing access to local community social capital. Some subsurface operations, such as onshore fracking, now require a 'Societal license to operate' (SL2O)[6], outside the gift of political or regulatory governance[7] - needing general public societal acceptance from society-at-large. Issues of national interest become not so clear cut under 'Political sustainability' - even questioning the commercial actionability of some operations without a SL2O. With SLO operations, the additionality of also having to cover more external rather than internal events within the Corporate Governance 'codes of practice' has to be borne in mind. Grievance policies and mechanisms have to be in-place ensuring that organizational activities are

Full cost resilient business, fields, and production continued

consciously responsible for its actions, non-action effects and their impact of these on its stakeholders and the ability for the company's continued access to Social Capital.

Because the societal link with fossil fuel emissions now affecting the natural and urban green 'commons', SLO is now more often being enforced by political governance, such as the UK Oil & Gas Authority for UKCS operations. The issues with the 'commons' were traditionally solved by using property rights and supply management. Issues of the 'polluter pays' for such emissions are expected to be addressed in the UK Energy white paper soon to be published. Climate change will be abated through carbon governance, stewardship and management. 'Carbon Governance' means effective measurement, transparent reporting and abatement of Scope 1, Scope 2 and Scope 3[8] carbon equivalent emissions through concerted collective action. Typically, carbon equivalent emissions are measured in absolute terms of MT CO_2e pa in most annual Sustainability Reports - effectively a measure of the company's associated 'carbon footprint'. If these footprints are not reduced and abated by the end of the Energy Transition, it is expected this will lead to those operators losing their SLO. It is also predicted that regions where only 'Stakeholder license to operate' is needed will, however, also start to diminish if local societal commitments and responsibilities (i.e. 'Just Transition') are not seen to being delivered where elsewhere the new green low carbon economy is now flourishing, delivering new consumer choice and carbon neutral products which actually meet their owners' Carbon Governance obligations.

Regions where SLO have been added to upstream operatorship's required competency now face a similar industry technical challenge as faced in the early 1990's. Back then it became very clear that 'simple' waterflooding offshore fields were not going to be enough to deliver the oil necessary to match increasing global demand, and replenishment of annual stock produced, plus adding additional reserve. This was met with the commercialisation of 'Improved Oil Recovery' (IOR) techniques. Now, today, accelerated 'Carbon Capture Underground Storage' (CCUS) is the only real means to deliver petroleum Scope 3 progressive emissions reductions down the Net Zero pathway - particularly for industrial hub decarbonisation. The IEA roadmap published in 2009 stated that by 2020 we would need some 300 MT CO_2e storage capacity per annum through 100 CCUS projects of scale; increasing to approximately 850 MT CO_2e pa by 2030. Hence the need to accelerate new CCUS development projects. Some say Blue Hydrogen is already booking its CCUS capacity in the projected existing trend of building new and additional CCUS social industrial hub infrastructure.

How much petroleum upstream associated CCUS capacity will get booked is very much dependent on how much 'Resilient Business, Fields and Production' can pay for their associated new capacity CCUS stock above any regional government carbon subsidies. IOR delivered and still is: Will Corporate Governance deliver petroleum carbon neutrality? Where in the world, at the scale required, will CCUS stock capacity be developed? Does petroleum need a corporate CCUS 'bank' similar to the Green Bank that was so successful in delivering UK renewable energy at scale today?

Concerns in 2020 within Corporate Governance over 'resilient business models' with 20-20 hindsight led probably to the largest improvement in Corporate Governance processes for natural resource companies since capitalism commenced. The emergence of having a board Technical Committee blew in on a hurricane this year to provide 'Technical (Project) Risk' governance. Empirical analysis supports that Technical Risk, as a rule-of-thumb, is approximately equal to the associated costs squared. Saudi Aramco[9], being the world's lowest lifting cost producer at $2.8/BOE, has a considerable Technical Risk advantage over offshore provinces, particularly deep water and the artic. It is surprising that it was in 1973 when 'Political Risk' delivered 'Technical Risk' into the global headlights, by forcing global exploration and production into high cost offshore environs, that it has taken so long for Technical Risk to be taken on board. Technical Committees are now set to grow within natural resource public companies as have the recent emergence and near full saturation of Sustainability (or ESG) Committees, now providing timely advice on associated Net Zero, Transition & Physical Climate risks & opportunities on the back of 2004 GHG Protocol[4]. This key GHG corporate accounting and reporting standard puts board governance firmly and transparently as the first step along the Net Zero

Full cost resilient business, fields, and production continued

pathway when it comes to settling corporate emission targets. In the contemporary corporation, this duty has come more to the fore with boards and board committees receiving regular and frequent reports on the risk position of the firm. Although the information presented to boards can be extremely summarized and condensed, the board's responsibility for the overall management of firm's risk, sources of risk, and judgement are now well-established.

That covers just about most of today's 'now'. More on 'tomorrow' in the next article, covering tragedies, curse and disease. No dragons, but a handfull of bewitching stones.

Article 3 in the next SPE Review London will cover both 'governance' and 'governess' - thinking about tomorrow's next and future generations, a core foundation of Sustainability - Governance and Governess, endurance of Systems and Processes.

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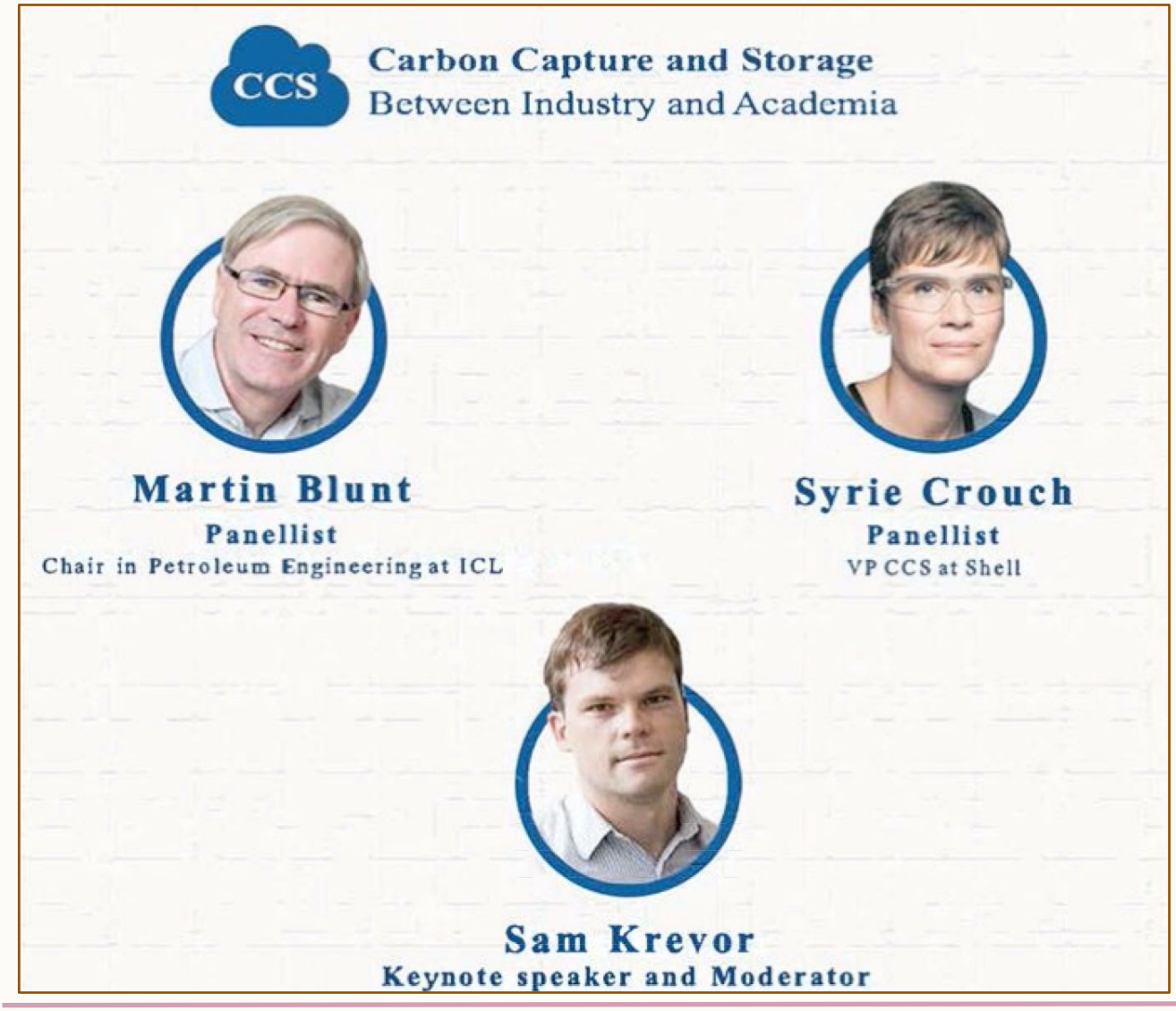
Carbon capture and storage: collaborative forum

SPE Imperial College London chapter successfully organized its first forum in collaboration with the O&G industry and the Imperial College London, in December 2020. The discussions revolved around Carbon Capture and Storage (CCS) and leading experts from the industry and academia presented their take on the technology.

On 9th December, with more than 120 participants, the forum commenced with a keynote delivered by Sam Krevor, the Senior lecturer in the Department of Earth Science and Engineering at Imperial College London. He gave an introduction to the CCS research and its contribution to the 2050 Net-Zero target. He was followed by the VP CCS at Shell, Syrie Crouch, and Professor Martin Blunt, Chair in Petroleum Engineering at Imperial College London. Syrie showcased Shell's recent work relevant to addressing CCS and energy challenges, covering a wide range of policy areas and techniques used globally. Professor Blunt provided information on the current CCS research being conducted in the academic world and the industry challenges being addressed by the research.

The second part of the event saw a vivid discussion between Martin Blunt and Syrie Crouch moderated by Sam Krevor. Various questions and ideas were addressed in this part, in which the audience actively participated.

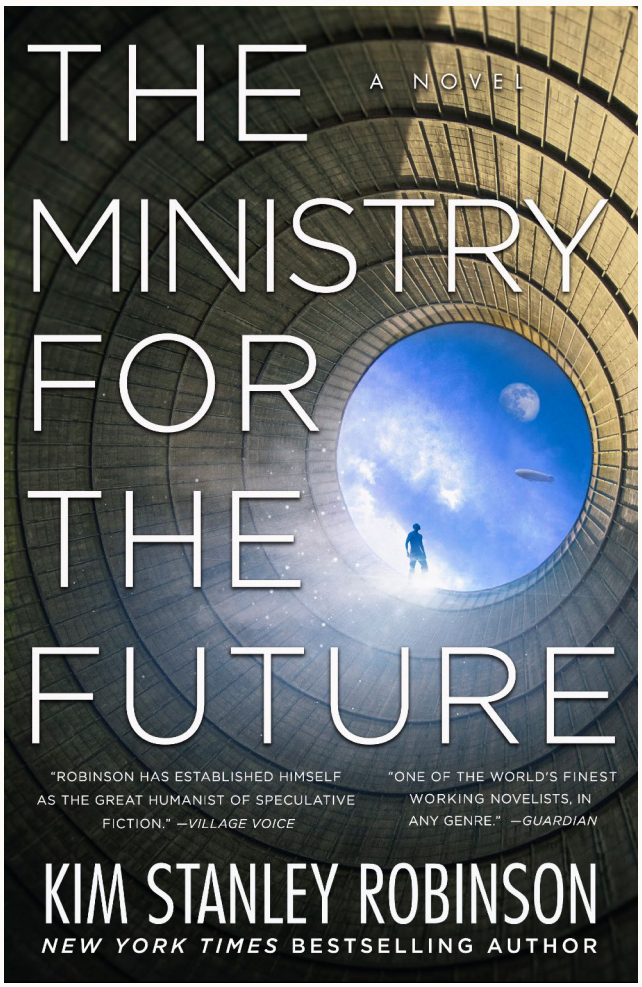
Overall, the event was well appreciated by both the participants and the speakers. SPE Imperial College London chapter hopes to continue organizing such events in the future.



Adventures in engineering

Editorial Board member Justin Reynolds reviews The Ministry for the Future by Kim Stanley Robinson, published by Orbit.

A new novel by science fiction author Kim Stanley Robinson imagines how engineers - including those from the oil and gas sector - can help pioneer solutions to the climate challenge.



A story in which engineers are the heroes sounds like an odd formula for a best-selling novel, intriguing as it may be for readers of this publication. But leading science fiction writer Kim Stanley Robinson has been writing them for decades.

Robinson's protagonists are usually everyday scientists and engineers, placed in exceptional circumstances, here on Earth or further afield, stumbling on solutions through trial and error, pooling their knowledge, and working for the greater good of the community of which they are part.

The series for which he is still perhaps best known, the Red Mars trilogy, puts engineering centre stage, exploring how the first settlers on the red planet construct a new human colony from first principles, designing not just the infrastructure that will sustain life there - its cities, transport, and mines - but also its political and economic structures.

His latest, The Ministry for the Future, scarcely qualifies as science fiction at all, the story beginning not the far future or on some distant world, but here on Earth, just five years from now. The Ministry that gives the book its title is a UN agency established to help drive through the Paris Agreement and other international climate accords. It has the usual powers - no more and no less - granted to international institutions: some capacity to finance initiatives and to exert moral pressure on governments and banks, but no hard powers to enforce.

But the Ministry's team, a close knit group of diplomats, bureaucrats,, economists, engineers and scientists, emerge as the novel's rather ordinary stars. Through persistence and pragmatism, illuminated by occasional shafts of inspiration, they find a way of unravelling the various knots of the climate crisis: fast-forwarding the energy transition, encouraging the development of green modes of transport, overseeing the mass adoption of sustainable agriculture, redesigning the financial system to direct capital towards green energy, and patching together solutions for a variety of vexing environmental crises caused by rising temperatures.

Somehow, by the end, it seems that they - and humanity - are getting somewhere. The Ministry of the Future is fiction, but in the course of more than a hundred chapters running to nearly six hundred pages, it discusses a host of climate change techniques, technologies and policies that we may - before too much longer - be using in the real world.

Antarctica: oil and gas to the rescue?

Robinson's preoccupation with technology places him firmly in the science fiction tradition. But he departs

Adventures in Engineering continued

markedly from the genre's fascination with the 'technological sublime': the sci-fi of starships, intergalactic civilisations and megastructures represented by iconic images such as the partially-constructed Death Star in the original Star Wars trilogy. Robinson is much closer to the political science fiction of the early 20th century, which sought to imagine how technology could be used for the common good: the utopian tradition of HG Wells and early Soviet sci-fi that dramatised the central role of the engineer in designing the ideal society.

The Ministry of the Future attempts to offer a blueprint for how we might use our technological resources to feel our way through the challenges of the next few decades to the light of a more sustainable world, the story following the painful emergence of a new era encompassing renewable power, regenerative agriculture, solar-powered sail and hydrogen-borne airships.

The oil and gas sector plays a central role, and as might be expected, it doesn't get easy ride. But here, the industry is seen as part of the solution to the climate challenge, not just as the problem, its expertise called upon to illuminate one of the book's central narratives: the intimidating challenge of stabilising the relentless, accelerating slide of Antarctica's glaciers into the southern oceans, threatening a rise in sea levels that would overwhelm the world's beaches, salt marshes, seaports and coastal infrastructures.

Robinson's engineers are forced to reject the most commonly suggested solution - the pumping of water back onto the Antarctic mainland as the glaciers melt. Logical as it sounds, it soon becomes clear it just can't be done. To make up for glacial erosion causing a rise in sea levels of just one centimetre it would be necessary to pump back three thousand six hundred cubic kilometres of water. As one of Robinson's scientists observes that would be 'six hundred times as much as all the oil pumped every year. … That much energy would take ten million windmills … And the water would have to be moved in pipes, and that's more pipe than has ever been made.'

They find a fix by going to the root cause of the problem: the accumulation of water below the glaciers due to meltwater running down cracks in the continent's ice. The trapped water lubricates and lifts the glaciers, detaching them from the bedrock that once fixed them in place. So they get to work pumping the water out beneath them to force them to resettle on the ocean floor, a herculean task requiring the pumping of thirty cubic kilometres of water, the equivalent of 'a clear cube of ice about four kilometres on a side and the same high, so half as tall as Everest'. But it can be done using established technologies: the ice coring systems long used by researchers to gain ice samples or drill down to subglacial lakes - and of course the drilling techniques familiar to oil companies.

And it works: a system is hacked together using drilling techniques we already know, powered somewhat bizarrely by Russian communications satellites that send power down to be picked up microwave collection stations that power pumps and heaters. It's a hack, but it's enough, for now. Flying over Antarctica, one of Robinson's narrators describes the landscape: 'Snow or ice as far as they could see. Then a cluster of black dots. Around the dots black threads, like a broken spider web. These dots and lines held civilisation suspended over the abyss.'

Carbon coins for net zero

One of the book's most important innovations is not a technology but an economic initiative. Few novels concern themselves with the intricacies of quantitative easing, but another of Robinson's principal storylines follows the Ministry's long struggle to convince the world's central banks to rewire the global financial system

Adventures in Engineering continued

to direct capital towards carbon capture, renewables and other sustainable technologies.

After ceaseless lobbying, and several shocks to global markets triggered by successive climate crises, the bankers relent and introduce a new digital currency, a carbon coin disbursed to the oil majors and petrostates on condition they move decisively towards net zero production. Coins are awarded for every tonne of carbon not burned or sequestered, and backed by hundred-year bonds with guaranteed rates of return underwritten by the banks, and supplemented by a carbon monitoring and certification industry that works much like today's bond rating agencies.

And the currency takes off. By making applications for the coin to the 'Climate Coalition of Central Banks' OPEC and the majors get the decisive financial incentive they need to wean themselves off hydrocarbons, receiving compensation in proportion to their stranded assets.

When a power struggle in Saudi Arabia leads to the fall of House of Saud, the new Arabian government commits to move away from oil to solar, and makes an immediate claim for carbon coins worth several trillion US dollars to fund the transition, a claim granted on condition that the payments are scheduled according to how fast the Arabian oil would have been produced and burned. Brazil soon follows, pledging to end its own oil sales and to protect the Amazon rainforest.

It all sounds rather technical for a novel. But it's classic Robinson: a thought experiment - conveyed through compelling narrative - sensitive to the psychology of how change actually happens. Wielding the stick with carbon taxes isn't enough. A carrot - the carbon coin - is needed as well. The prospect of reward for going carbon neutral proves the key to supercharging the transition to net zero. Through these and many other projects progress is made: carbon buildup is stabilised; the immediate fear of a big rise in sea levels is averted; the decisive shift is made from hydrocarbons to renewable forms of energy.

The possibility of progress

The Ministry for the Future offers a panoramic vision of the possibilities of engineering recalling - though in a fictional register - John Browne's cultural history of engineering: 'Make, Think Imagine: Engineering the Future of Civilisation', reviewed in this magazine's May/June 2020 edition.

Browne's book, and many others concerned with our response to the climate challenge, highlights what we need to do. Robinson explores how we can do it, trying to drag us away from the lure of indifference and despair, and make vivid the possibility of the progress we can make using the expertise and technology we already have. A sustainable world can be something more than science fiction.

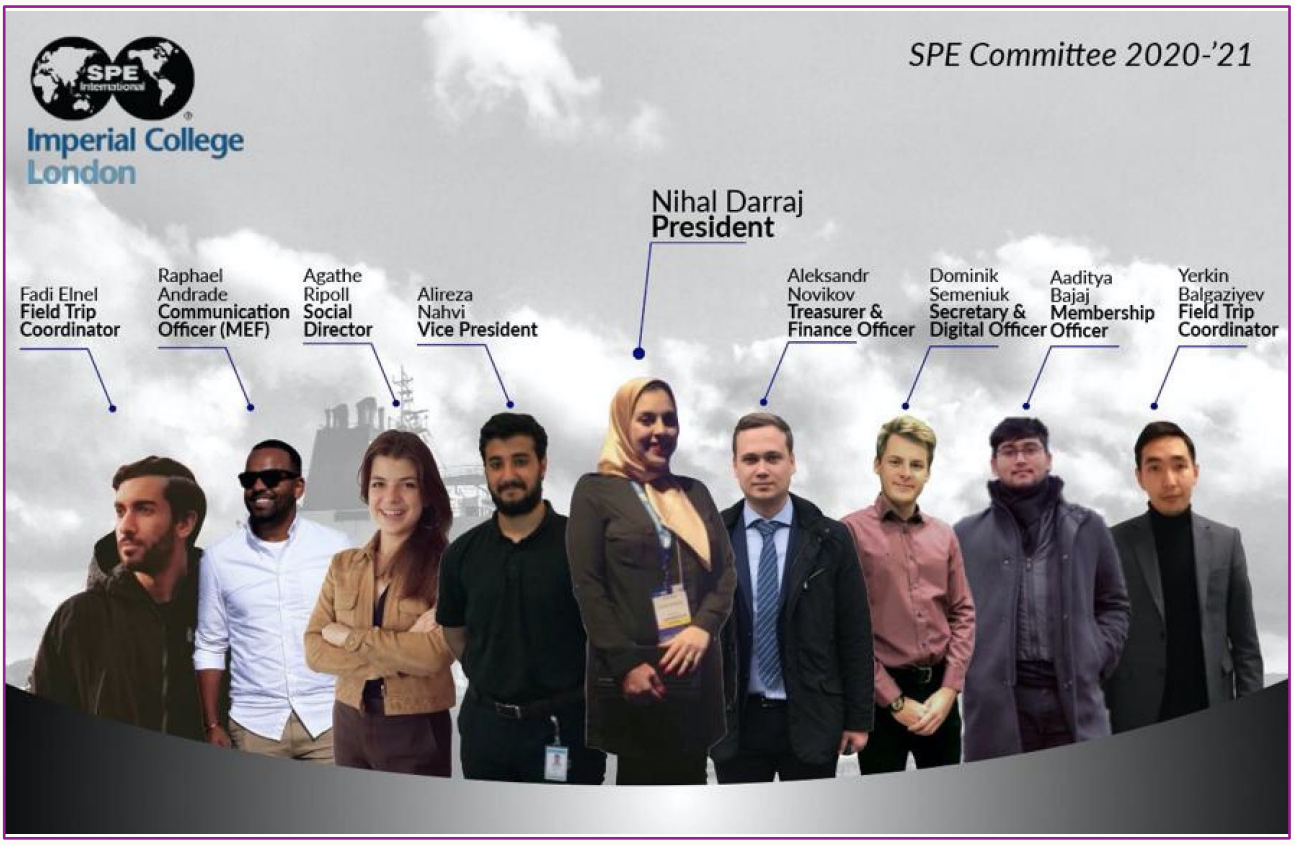
For people looking for a good story this Christmas that offers something more than escapism, and gives the field of engineering some well deserved time in the sun, The Ministry for the Future may be the ideal read.

SPE Imperial College London team

As the need for energy transition becomes ever more apparent, the Oil and Gas Industry faces a series of new challenges. This is the reason why our esteemed SPE community, from incoming students to experienced professionals, must adapt to a world of changing demands; a world where the 'new normal' is already part of our daily lives.

Established in February 1974, the SPE Student Chapter at Imperial College London has a history of turning challenges into opportunities for both graduates and young professionals. This time, our society focuses on equipping its members with knowledge that is essential for today's energy transition. Among our plans for the upcoming year we will include discussions on Machine Learning and Artificial Intelligence and its deployment to our industry; the significance of CCS projects, sustainable development, and last but not least, debates on the future of O&G. We hope this will contribute towards the prosperity of a more efficient and cleaner energy industry.

We would also like to take this opportunity to introduce our new leadership committee. This year, our members come from nine different countries: Egypt, France, India, Iran, Kazakhstan, Poland, Russia, Sweden and Switzerland. The team includes students from three different MScs programs at Imperial College London: MSc of Petroleum Engineering, MSc of Petroleum Geoscience and MSc of Metals and Energy Finance. Lastly, a special thanks to Agathe Ripoll and Aaditya Bajaj, who in times of a global pandemic still managed to bring us together digitally on the image bellow.



If you are interested in our program for this year, kindly reach out to us on spe@imperial.ac.uk. We will be in touch!

You can read more about our roles and goals for this year here:
http://www.imperial.ac.uk/earth-science/prosp-students/pg-courses/opportunities-in-london/spe/committee/

Meet the SPE London Board

SPE is a non-profit professional society with more than 156,000 members in 154 countries, who participate in 203 sections and 383 student chapters. SPE's membership includes 72,000 student members. The SPE London Section, with an average 2,000 members and seven associated student chapters, is an active section with an aim to connect, engage and promote the exchange of knowledge within the London energy community of technical and commercial professionals. The SPE London board is the governing body for the SPE London section. The different committees oversee the chapters various activities including the evening programme, various SPE events, Young Professionals, Women in Energy and associated student chapters.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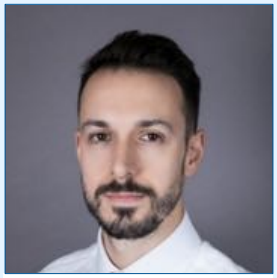
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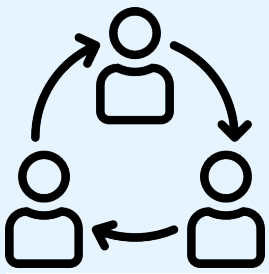
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Challenging, fun, career-boosting, educational - why not explore the great opportunities with the SPE London team?

LOVE TO ORGANISE?
Volunteer with the events section of SPE London – you'll learn lots, be valued for your ideas, and have fun!

GOT GREAT IDEAS?
How about sharing and contributing as an SPE London Board member?

YOUNG PROFESSIONAL?
Learn, explore and meet your fellow YPs at SPE London

FIND OUT MORE!
Get in touch with our Editor, Elizaveta Poliakova via LinkedIn