September/October 2020

SPE Review London

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

SPE SECTION EXCELLENCE *** AWARD *** 2020

Understanding the living planet and Gaia stewardship

* Introducing the London Net Zero Committee
* C-level talks: Olivier Decombes, AqualisBraemar
* Interaction between hydraulic and natural fractures
* Regional SPE recognition awards!

PLUS:

Reservoir Engineering Studies for CO_2 Storage
Book Review: Disentangling the economics of oil & gas
Data Democratization through a marketplace
Machine learning and AI: Part three

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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In this issue

FEATURES

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.

Josh Beinke

Graduated from University of Adelaide in 2008 with a Petroleum Engineering degree. Moved to Europe in 2016, and working as a Production/ Exploitation Engineer with Vermilion Energy.

Ffion Llwyd-Jones

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.

Mark Beleski

Experienced engineer, with deep understanding of industry practices, trends and challenges. Energy Loss Adjuster with AqualisBraemar, in London.

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

GeoScience

Imperial College London

SERICAENERGY

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Anadarko

OPC

Letter from the SPE London Chair

Dear SPE London members and colleagues,

Welcome to the November issue of the SPE Review. I hope you are all remaining safe and well as the Covid19 pandemic continues to affect our daily lives. We are going through extraordinary times with what seems to be a continuous feed of competing forecasts on the future of oil and gas demand. Since my last letter, we have had three major forecasters (BP, OPEC and IEA) giving differing views on the future of oil and gas demand and therefore the viability of our industry. From my experience in production forecasting behaviour all I can say is they will all be wrong and we will end up somewhere between what BP (pessimistic) and OPEC (optimistic) assume will be the future.

Staying with industry views, the new President of SPE International, Dr. Tom Blasingame, had some worthwhile insights written in his JPT column 'In The Storm', which I encourage you to read and think about. The most pertinent passage was the observation by an SPE member that the Oil and Gas industry had become arrogant about the future being just like the past! We can say for sure that's not going to be the case and, as a collective, we need to re assess our attitudes about our role in the future of energy supply. Tom provided a three-word phrase I think captures the mood of the industry at present where we need to survive, then revive and hopefully, in the near future, thrive.

It's always a pleasure to congratulate members' achievements, and the section has three winners of Regional SPE Recognition Awards. So, ongratulations to Zahraa Alkalby (Regional Young Member Outstanding Service Award), Dr Max Kotenev (Regional Young Member Outstanding Service Award – North Sea Region), and Babatunde Anifowose (Regional Sustainability and Stewardship in the Oil and Gas Industry, North Sea Region). The current restrictions don't permit us to congratulate these winners personally, however, please recognise their achievement if you interact with them.

The SPE year is now in full swing with the first of the monthly evening talks held in what is now the common virtual environment. Thanks to Tim Lines for creating a diverse and interesting program. Thanks to Chrysaor for sharing their thoughts on the future of the North Sea, and to CGG giving us an insight into the role geomechanics plays in understanding CO2 injection. The Young Professionals have been busy offering virtual events and it's encouraging to see their program offers a range of topics including interacting with the Senior Professionals. Great work by Shwan (YP lead) and Vincent Penasse to present the YP/SP event on Valuing Oil and Gas Assets.

The section continues to evolve with the changing times the industry is facing. The section has launched a new Net Zero committee, led by Alison Isherwood, which aims to provide the membership with information, host events and promote discussion on issues around energy transition, sustainability and the impact of the drive to a Net Zero world. 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 business to support the section. CGG has agreed to take an annual sponsorship package and offered to support an event associated with the Net Zero Committee. Thanks to Carolina Coll at CGG for providing this support.

As I finish this letter, I've just come from a Townhall meeting with the exiting SPE President Shauna Noonan, who provided some insights to the wider issues facing the SPE community, not least of which is the somewhat bleak financial status of the society. Offering a better membership proposition is one of the key topics the SPEI board is looking to deliver, along with improving its own IT backbone, getting the SPE app more visible and with greater content facilities, making sure members in transition are supported, and developing the Energy4me program. I intend to comment more fully on this call and will distribute to our membership.

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 October issue of the SPE Review! I hope you are remaining safe and well while adapting to the 'new normal' under Covid19 effects.

In this issue, we are celebrating a creation of the new committee within SPE London Board, Net Zero Committee, chaired by Alison Isherwood. SPE London Net Zero committee focuses on informing membership on ways of working towards net zero while incorporating sustainability into our initiatives. With this in mind, our October publication pays a special attention to the topic of sustainability in Oil and Gas, reviewing the book “Net Zero” by Dieter Helm with Justin Reynolds (page 29).

In addition, I would like to congratulate Maxim Kotenev with receiving the 'Regional Young Member Outstanding Service Award North Sea Region 2020'; Dr Bababtimbe Anifowose with obtaining the 'Regional Sustainability and Stewardship in the Oil and Gas Industry', and Zahraa J Alkalby with receiving the 'Regional Young Member Outstanding Service Award North Sea Region 2020;. For personal and professional stories of the winners go to page 19.

This is also the issue in which we conclude our trilogy by Cameron Snow on Machine Learning and AI in Oil & Gas (page 8); introduce you to James’s Burtonshaw work, that won the Best MSc Petroleum Engineering Thesis at Imperial College London 2020 (page 16); review 'Risk based abandonment of wells' with Wijnand van Eijndthoven (page 12) and show you a glance of 'Data Democratization through a marketplace' by Dominic Launder and Naga Suresh Gov (page 20).

Moreover, we would like to take this opportunity to thank our readers for the exciting feedback on our activities! Please share your thoughts on: spelondon@spemail.org

Finally, I would like to thank Josh Beinke, Ffion Llwyd-Jones, Justin Reynolds and Mark Beleski, our Editorial Team for their support, endless ideas and drive!

Stay safe and take care!
Elizaveta Poliakova

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

CGG's smart data solutions to win management contracts

High priority on digitalizing and increasing the values of legacy data continues to rise among the O&G clients as CGG Geoscience announced that it's Smart Data Solutions (SDS) business group won data management contract with a total backlog of approximately $10 million.
Learn more here

More resilient Oil & Gas Supply Chains with the help of technology

According to EY Oil and Gas Digital Transformation and the Workforce Survey, the downturn created a need to re-innovate business strategy in the Industry. Three main performance changes to be considered at the heart of transformation: (1) capital allocation to achieve net zero; (2) enabling data-driven decision-making capabilities and (3) better understand collaborative ecosystems.

With cost reduction as one of the main goals, digital innovation opens a door to restructure the supply chain from "traditional linear model to a networked ecosystem where any event occurring is seen by all". Managing the links between upstream operators, service companies and equipment & material manufactures is among the main complexities that this transformation carries.
Read more here

Forming largest London-listed independent O&G producer: Chrysaor and Premier Oil

The largest independent oil and gas group listed in London has just been created as the result of Chrysaor agreeing to a reverse-taking over of Premier Oil. With total ownership of at least 77% of the group, Chrysaor signed an agreement that will form a combined company producing circa 250,000 boe a day and reserves of 700m bbl.
Read more here

Subsea industry: post-energy transition future

Subsea industry that provides infrastructure and hardware enabling O&G operators to function is facing a significant challenge as oil and gas companies push for greater production at lower costs. As the world slowly turns towards cleaner energy and the current downturn is making suppliers' businesses financially untenable, subsea industry explores other options to partially apply its expertise away from oil and gas.

"While oil and gas is still the largest market for the subsea industry, diversification into other areas of underwater engineering is more important than ever," said Niel Gordon, CEO of Subsea UK. "Offshore renewables now account for almost 25% of all subsea revenues.
"The subsea industry essentially comprises everything beneath the water line and represents a massive opportunity from offshore floating wind to hydrogen and CCUS [carbon capture, usage, and storage], defence, marine science, and aquaculture."
Read more here

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.

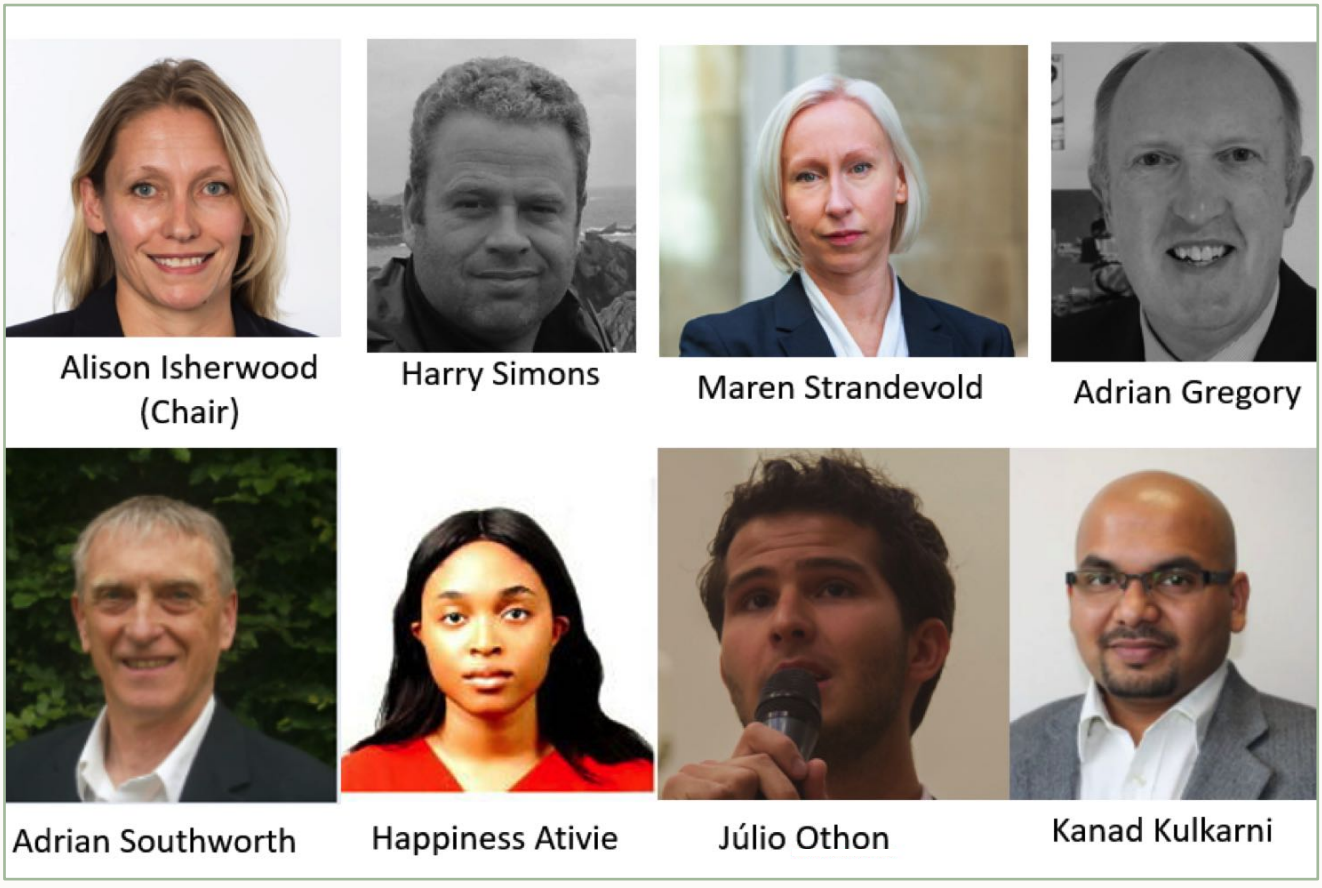
The award is in recognition of your section's hard work and strong programs in industry engagement, operations and planning, community involvement, professional development, and innovation. We know the past year has been unique, and we thank you for continuing to fulfill SPE's mission and serve your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

Introducing the London Net Zero Committee

The London Section has introduced a new committee to help integrate sustainability into the section's activities and to engage the membership on our industry's role in working towards net zero. The committee has a diverse background to bring in new ideas and knowledge and help facilitate collaboration with the wider energy network. Check out the committee's bios, as well as a wealth of useful links, on the new net zero committee webpage.

In terms of our mission, Harry Simons, committee member, sums it up well:
While we begin our journey to keep members informed and engaged on sustainability, and the steps the oil and gas industry is taking to support activities to achieve 'Net Zero', it's clear in talking to different groups of people that we're not all starting from the same position of knowledge - not everyone has the same understanding of what it means. So, part of our job is to cover the basics and the bigger picture as well as specific details relevant for the oil and gas industry.
For example, Net Zero means reducing our net emissions of greenhouse gases to zero, but it does not stand on its own. It is part of the 17 United Nations Sustainability Goals (SDGs) (Goal 13: Climate Change and Goal 7: Affordable and Clean Energy) in which the Energy Industry must play its part. It is, therefore, only part of an overall plan to address some of the world's pressing economic, social and environmental challenges. To understand how Net Zero fits in with the larger plan, the first place to look is, perhaps, the IPIECA publication 'Mapping the Oil and Gas Industry to the Sustainable Development Goals: An Atlas'. Having sight of the SDGs will make it clearer why the next 30 years will potentially be such a transitional time, not just for our own, but all industries and the people working within them.
Sustainability means: Meeting the needs of the present without compromising the ability of future generations to meet their own needs. This is a complex balancing act in which we all need to play our part.

Check out the article on page 27 *by committee member, Adrian Gregory, the first in a series of sustainability articles. Keep a watch for more articles, event announcements and opportunities to engage with the Net Zero Committee.*



Machine Learning and AI applications in Oil & Gas, Part 3

In the third of a three-part series, Cameron Snow (co-founder, Danomics), provides an overview of existing applications of machine learning and AI, and where opportunities are ready to be seized.

Now you've seen the potential of machine learning and AI in oil and gas, you've taken the steps toward becoming a data-driven organization, and you're ready to take the next steps. There are many questions you need to answer to know the next steps. Which internal projects are amenable to machine learning solutions? Is the solution off the shelf or custom? What vendor should you use? What does success mean? What should the budget be? In this third and final installment of thes series, I'll walk through a framework for evaluating these questions.

Project Selection

There is no shortage of vendors who are either willing to tell you that either (1) every project needs machine learning; (2) that there is a very narrow range of projects that need machine learning and they just happen to have a solution; or (3) that those who fall into the first two categories are just snake oil salesmen. You should be skeptical of all three. The first doesn't have any particular solution, but knows they can use it to sell you on all sorts of other products, the second has a solution and they will do anything to shoehorn you into it , and the third has a traditional product and is worried about losing market share to new technologies. So, where to start? A good candidate project will receive a 'yes' to the following questions:

1. Does the prediction need to be performed frequently?
2. Does the task/prediction require several pieces of input data?
3. Is the output of the prediction a classification, ranking, or numeric prediction?
4. Do you have adequate training data?
5. Is the ideal solution based purely on the data with few/no outside considerations?
6. Can the project be trialed or the outputs easily QC'd?
7. Will success create (enough) value for the company relative to the cost of the project?

Off-the-shelf vs. Custom Solutions

At present there are very few 'off-the-shelf' solutions ready to use out of the box, and those that are have a necessarily narrow scope. This means, in most circumstances, you will need a 'custom' solution. There are also various levels of customization, each of which will affect project costs and timelines. The following questions are worth consideration:

1. Does an off-the-shelf solution exist?
2. How complex is the project?
3. How 'unique' is this project?
4. Does the model need to be strictly proprietary?

If an off-the-shelf solution exists, the question becomes one of value add – at the given price does the solution offer the value I need? In this case, the decision to buy can be evaluated in the same way as any other software or service. If a custom solution is required a more detailed analysis will need to be undertaken. More complex problems (e.g. prediction of rare events, predictions that involve data streams on multiple scales, time frames, and with disparate data types) will likely have higher costs and longer project timeframes. Increased complexity also increases the risk of project failure. A project may be novel, but not unique with respect to the techniques used. If a 'standard' machine learning model can be adapted and tuned to your project, there may be an avenue towards keeping costs down and shortening timelines. Finally, it is worth considering if the model/solution need to be proprietary. If not, then the development cost can be split

Machine Learning and AI applications in Oil & Gas, Part 3 continued

between the early buyers and future buyers the vendor can sell the solution to.

Vendor Selection

Vendor selection is one of the most difficult questions for oil and gas companies evaluating machine learning solutions. There are pros and cons associate with all of the vendors, so when deciding on a solution the following questions are important to evaluate:

1. Does the vendor have domain expertise?
2. Does the vendor have the requisite data science capabilities?
3. Is the vendor focused on cross-selling traditional software and services?
4. Is the vendor capable of advancing models from R&D to production?
5. Has the vendor asked you to define success?

If a vendor has strong domain expertise it may enable a more hands-off approach. However, few of the traditional service companies have built out strong internal resources and may sub-contract work to specialist partner firms. Furthermore, there is a higher likelihood of a bait and switch – you start a machine learning project and end up with a traditional study. Often overlooked is the ability to truly productionize models – having the capabilities to deploy models sustainably is an additional skill set that many firms cannot deliver on. The question of defining success is one that the vendor should spend significant time on and is expanded upon below.

Defining Success

The failure to define what success is early in a project is one of the most common problems when initiating new projects. In fact, this is such a critical aspect that if a vendor has not asked you to define success they should be disqualified from selection. Success can take many forms and defining it should be carefully done, ideally before project kickoff. In defining success, the following should be considered:

1. What is the accuracy and precision of the current predictions?
2. How much effort is required in making the current predictions?
3. What is the level of accuracy and precision required to improve business outcomes?

The answers to these questions may be harder than you think. Take for example pre-drill production forecasting in a shale play. Have you documented pre-drill predictions? Can you set up blind tests and lookbacks as your knowledge of the play has improved? Let's assume your company can currently make forecasts within 30%, would improving that forecast to 25% change the decision-making process? What if it could be reduced to 10%? What if it couldn't be improved, but the process could be accelerated 100-fold? Would that be a success?

Budgeting

Unless an off-the-shelf solution is available project budgeting will be required. This is most often done on fixed price basis or time and materials basis. The former provides the client with more certainty on spending levels but may also set the stage for underperformance. It is easy to imagine the bar for success being set to low and an early model exceeding the hurdle, allowing the vendor to deliver a model that may not be fully optimized. Conversely, time and material contracts, unless closely followed, may lead to a constant stream of expensive tweaks and iterations that fail to generate material improvements.

Conclusions

When embarking on a maiden voyage down the machine learning path, it is critical that early projects be carefully screened – early failures can sour management's appetite for the technology. It is imperative that companies understand what projects are suitable for machine learning, what vendor qualities are important, and how to define success. Failure to do this is a rigorous manner sets the stage for disappointment.

Working hard and playing hard, and giving back to communities through charity and mentoring

Olivier Decombes is a Director with AqualisBraemar, based in London, UK. After graduating from the Ecole Nationale Supérieure des Industries Chimiques Nancy, France with a Chem. Eng. Degree, Olivier began a 12-year career with Schlumberger as a field engineer, working in challenging environments in Africa and Venezuela.

Olivier transitioned into the Energy Insurance market working in both claims and underwriting positions, where he developed a deep understanding of his clients and their coverage needs in the Upstream, Downstream, Midstream and Power sectors. Prior to joining AqualisBraemar, he was at Barbican Insurance Group.

Who is Olivier Decombes? Tell us about yourself.

I was born in The French Alps and am a keen skier as are most of my family members. I do enjoy a good mountain bike ride and regular running, but equally appreciate quiet relaxing time reading books, mainly on history and geopolitics. Travelling has been a passion from an early age and I was very lucky to have the opportunity to spend the majority of my professional life abroad, though sometimes in very challenging conditions.

I am a great believer of work hard, play hard. Having been fortunate enough to have the opportunities to study and develop professionally, I believe that we have a duty to give back to our communities through charity and mentoring.

I am the lucky father of an incredible daughter.

Walk us through your career. How did you become a Director at AqualisBraemar?

I started my professional career with Schlumberger as a Wireline Field Engineer, responsible for the data acquisition and interpretation for Oil & Gas wells. Within a short period, I was responsible for a crew, high-value equipment and national and international clients. The job was extremely demanding, but equally rewarding. My different field assignments gave me both a sense of freedom as entirely in charge of my own operations and of responsibility as being the sole representative of a major organization. I worked predominantly in remote and challenging locations, both Onshore and Offshore, including Angola, Namibia, Congo, Senegal, Libya, Algeria, Venezuela (yes, Venezuela was very challenging) to name a few. I had to provide top-quality services to a broad and diverse spectrum of clients, ranging from large National Oil Companies (NOCs) and Super Majors with significant technical expertise and financial backing to independent start-ups drilling a one-off exploration well which would make it or break it.

Part two of my career started in the insurance industry as an Energy underwriter. Having a deep knowledge and understanding of the operating standards and of the needs of my clients through my ‘previous professional life’ gave me a significant competitive edge after learning the basic of the Insurance world. I successfully developed strategies, built and coach underwriting teams and implemented plans for a start-up, a major energy player and a Lloyd’s syndicate.

I recently joined AqualisBraemar as Director for the Energy loss adjusting division in charge of Africa, Europe and Russia. Having been involved in the negotiation of major claims as an underwriter, the transition from underwriting to loss adjusting was natural and seamless. In my current position, my Energy field and underwriting backgrounds are essential for the fair and fast resolutions of high value and complex Energy losses.

Looking back to when you graduated from Ecole Nationale Supérieure des Industries Chimiques with a Degree in Chemical

Working hard and playing hard... continued

Engineering - did you find it difficult to start as a Field Engineer at Schlumberger?

Schlumberger had an unique and outstanding in-house training program for newly graduated engineers. The intense training period aimed at preparing us technically and psychologically for our upcoming field career in the Oil & Gas industry. The training centre I was sent to was in Medan, North Sumatra. Twelve engineers from eight different countries with very diverse backgrounds attended three months of lecturing and practical works (the facility had three wells to simulate life on a rig). Upon completion of the training program, the engineers who successfully completed the program were sent to their assigned locations around the globe. My first position was offshore Angola, which was still experiencing a civil war at the time. Operating conditions were extreme and one might consider that I was thrown at the deep end, but working in this type of environment was anything but a routine, fun and enriching. Looking back, I believe that my Chem. Eng. degree gave me a very solid base for planning tasks, organizing my work, resolving problems and thinking out of the box when necessary, which was a regular occurrence.

Throughout your career, you Worked in Africa, Latin America and London. What are the main cultural differences that you noticed?

The Oil & Gas industry was, and still is, unlike almost any other industry - a very thrilling and exciting industry in terms of exposure to a very broad spectrum of cultures and working environments. There are obvious social, cultural and professional differences when living and working across different continents but, whether you are performing a remote Coiled Tubing job in Siberia or analysing reservoir data in a slick high-tech facility in Houston, chances are high that you will be working, interacting and exchanging ideas within multinational and diverse groups of highly motivated individuals. Tight deadlines, high stakes and significant investments create environments where invariably things get done and individuals are committed to deliver results through hard work.

After a 12 years career of being a field engineer, what prompted you to change to Energy Insurance?

I had reached a stage in my professional life where I wanted new challenges, and where the professional and human experiences I gained in the field of Energy could be used to support customers through financial transactions and not only from a pure operational angle. I was very fortunate to be given the opportunity to build a team and develop and grow a profitable book of business from scratch in an insurance start-up which was appealing and exciting after working for 12 years in a listed organization of 60,000 employees. I believe that the breadth of experiences offered by the Oil Patch is truly unique and that the skills and expertise developed in the Energy arena are transferable to other industries, which is a unique value proposition for highly motivated young individuals.

In your opinion, where will the energy sector be within next 10 years?

The Energy sector as a whole rapidly became unpopular on a global scale for its detrimental impact on the environment and contribution to global warming, but a deep transformation is on-going and the sector will most probably not be recognisable in a decade. Substantial increases in solar and wind power have already helped generate 45% of Britain's electricity from green energy in the first quarter of 2020, overtaking power generation from fossil fuels. Renewable energy has been the energy source that was the most resilient during the Covid-19 lockdown and its pace of development will only accelerate in the future. Concurrently, conventional Energy players have no choice but to rethink their models and strategies to both enhance their operational efficiency and transition to lower/ zero carbon emission.

The Energy industry is already facing a shortage of talent in the renewable sector that has experienced an exponential growth of job creation between 2017 and 2020. The new generation should be thrilled by the short, medium and long term challenges required to transform the energy sector and make it sustainable. New jobs for this fast-pace transition are clearly on high demand in the green Wind, Solar, CCS and Hydrogen sectors, but equally in the conventional sector with big data technology, reservoir optimization and enhanced recoveries driving efficiency.

Risk-based abandonment of wells

After holding various roles as a geologist at Shell, Wijnand van Eijndthoven became a contract geologist at DNV GL. In this role, he worked closely with well experts from DNV GL to develop the SPA tool and contributed to the new release of RP E103. Wijnand presented the content of this article during an SPE Netherlands general meeting in The Hague on December 9th 2019.

4,000 professionals in DNV GL Oil & Gas are part of a global company of 12,000 highly qualified employees that also provides services to the Maritime, Energy Production and several other industries. DNV GL's well community, consists of more than 25 experts located worldwide, who support drilling and well organizations in developing technology, setting standards and provide technical expertise on drilling and well projects.

Introduction

Cost reduction in well abandonment receives an increasing amount of attention in the petroleum industry. It is expected that hundreds of wells have to be abandoned in the North Sea alone in the coming decade. The last years have seen an increase in abandonment activities in, for instance, the Netherlands, in line with the expected activity curve published by EBN [1]. Even though current times are highly uncertain, it appears the well plug and abandonment boom has commenced.

Abandonment costs are expected to be high with estimates of €86bn for the entire North Sea basin. The high uncertainty around the abandonment cost is well illustrated by the UK Oil & Gas Authority that estimate abandonment cost ranging from €45bn (P10) to €77bn (P90) for the UK alone [2]. Given the high estimations cost reduction is an important topic. E.g. Dutch platform for re-use and abandonment Nexstep set a 30% cost reduction goal [3].

Meanwhile the quality of plug and abandonment operations are under increasing scrutiny from society and regulators. Isolation integrity remains a key concern. Re-use of old oil and gas wells for storage or sequestration purposes is an additional reason to understand the state of old wells. The petroleum industry is challenged with mitigating a large volume and cost of P&A activities while maintaining high quality standards.

Risk based P&A

International standards advocate for a risk based approach to well integrity management. Independent verification major DNV GL applied this rationale in its recommended practise 'Risk Based Well Abandonment' (RP 103), most recent update released September 2020 [4]. Following the recommended practise is a partial solution to abandonment cost reduction and quality assurance.

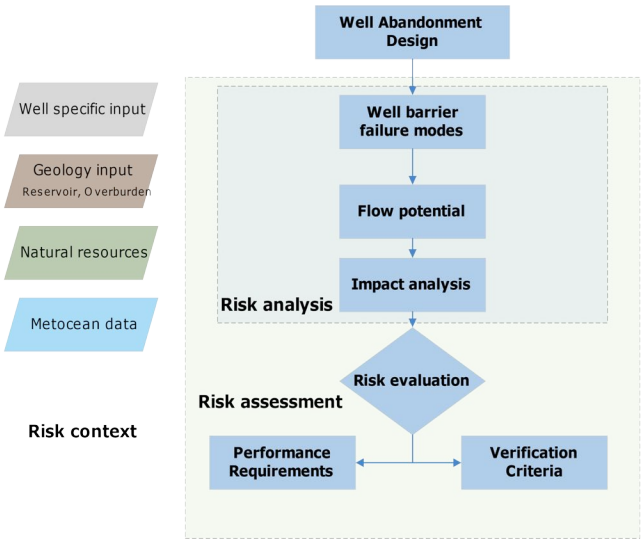


Figure 1. Elements in well abandonment risk assessment [4].

The risk based process starts with identifying all relevant risks to the abandonment project. Main topics are well specific-, geology-, and natural resources input data. Analysing well barrier failure modes and identification of formations with flow potential are requirements for all well abandonment projects. These requirements in the North Sea area are generally set by mining laws and industry regulations. In

Risk-based abandonment of wells continued

recent years industry regulations have been adapted to allow for risk based operations (e.g. NOGEPA [5] and Oil & Gas UK [6]). Analysing the impact of well barrier failure or flow potential on the success of the well abandonment is usually done in a qualitative way.
Risk Evaluation criteria are set by recommended practices, internal standards, and mining laws. In a risk evaluation of an abandonment project elements are risked against these boundaries. A project risk matrix is commonly used for this risk assessment. Subsequent detailed abandonment planning benefits from the risk evaluation by setting smart performance requirements or verification criteria.

Data Handling

Access to all well data is vital to understand the condition of the well, properly risk relevant categories, and plan a high-quality abandonment. Data on drilling, well construction, significant well life events, and current status are, amongst others, of interest to P&A planning. However, it has proven difficult to access the 1000's of legacy datafiles per well, especially if wells were drilled decades ago. E.g. It is not uncommon to encounter handwritten notes on the construction of a well. Fortunately, modern cognitive search engines are capable to retrieve hand written information from a scanned pdf or picture.
Big data, machine learning, and data analytics are currently developing at a fast pace and can be of use in risk based abandonment. Structuring the legacy data retrieved through cognitive search greatly enhances access to relevant data. Pattern recognition can reveal trends in well element quality underpinning the risk assessment. Automation of data analyses holds the potential to significantly reduce planning time while maintaining high quality levels in abandonment planning. A recent example from Norway automatically compiled time-depth curves from retrieved incident reports listed in end of well reports based on machine learning techniques. The learning gained from this example has been applied back into well design processes DNV GL's secure data solution Veracity is capable of storing, retrieving, and analysing relevant well files.

Applying the Risk Based Method

DNV GL believes executing a risk assessment in an abandonment project will be greatly helped by a Sealing Performance Assessment (SPA) tool. An SPA qualitatively risks all well elements (e.g. formation, casing, cement, shoes, packers, etc.) for their capacity to contain pressure and/or flow. Unique about a SPA tool is the ability to compare on a risk basis the sealing capacity between well and formation, as well as between wells. To achieve a high-quality risk assessment in a Sealing Performance Analysis expert data handling is essential. The risk levels used in an SPA are defined by local mining laws, company internal standards, and best practices (e.g. DNV GL RP E103 [4]). The results of an SPA form an excellent basis for abandonment classification (e.g. what well can safely be abandoned with more cost effective equipment?) and detailed design (e.g. what interventions are required on a risk basis to achieve a high quality abandonment at all levels in a well).

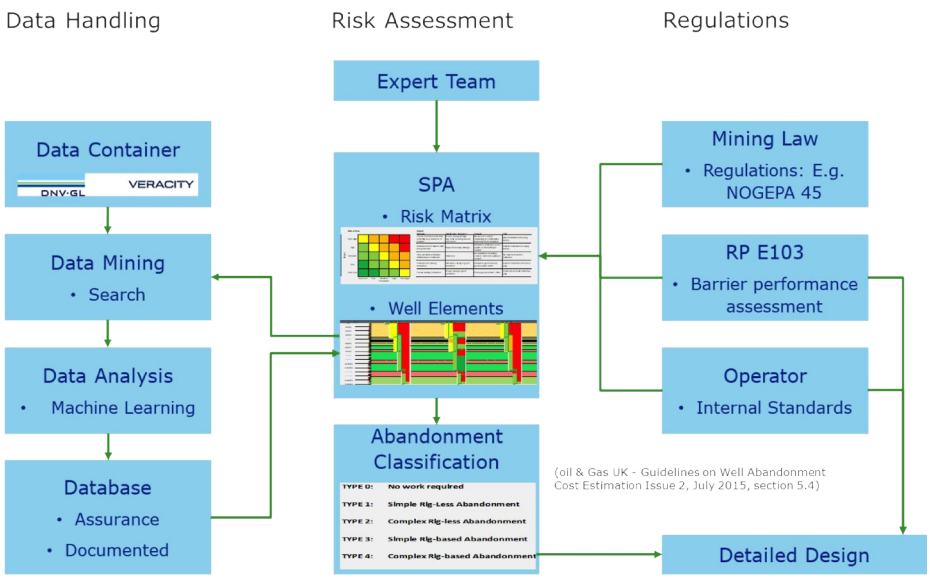


Figure 2. Workflow of an abandonment risk assessment using a SPA [7].

Risk-based abandonment of wells continued

An SPA diagram is constructed by risking all well elements against their probability of and impact on undesired flow or pressure build-up. Analysis of formations, or zones, with flow potential and sealing capacity at reservoir and overburden levels is risked in the same way. The well operations history is summarized in the annulus pressure recordings summary at the top of the well. The same assessment can be repeated for all wells in a field abandonment project without limitations. Pressure communication and cross-flow can easily be identified by an expert team, within a single well or between a complex set of wells.

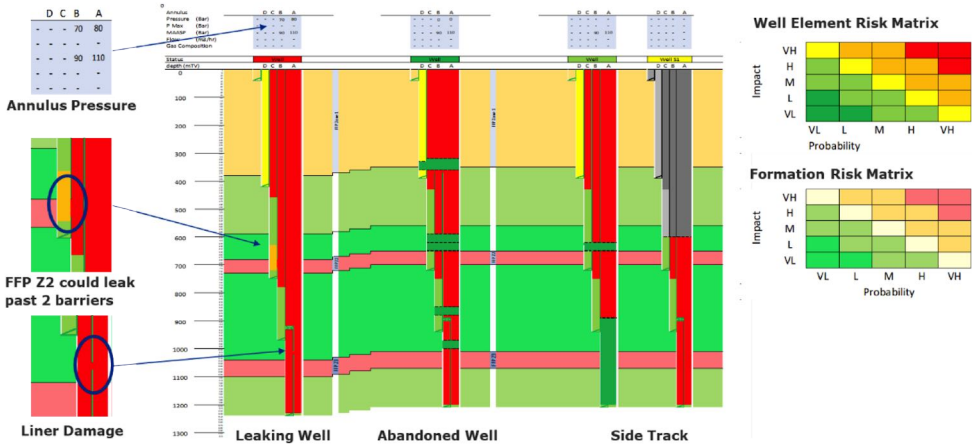


Figure 3. SPA diagram showing the risk matrices for well elements and formations, pressure development throughout well life, and identified failure modes on a risk basis [7].

The SPA diagrams can also be used as a method for verification of permanent well abandonment design, where trackability, quality of data, uncertainty in assessments and assumptions are clearly presented in the SPA. In this manner, key stakeholders grasp a quick overview and have the possibility to drill down into important details, all in one tool.

The SPA tool has proven to solve poorly understood well leakage during a complex field abandonment campaign. Leakage paths through cement and plugs were identified by an expert team, and recognized patterns reduced the remaining abandonment scope, and associated cost, significantly.

Conclusions

There is evidence the very significant abandonment effort in the North Sea has started. Cost reduction while maintaining high safety and quality standards is a major challenge. Risk based P&A can contribute to achieve this cost reduction by taking a smart and structured approach. Essential in addressing the abandonment challenges is access and digesting all data from well construction, well history and the current status. Smart data handling tools are now available to achieve this. Establishing the risk context is significantly improved by executing a Sealing Performance Assessment on a well or even field scale. Comparing well barrier performance with flow potential from the formations on a risk basis gains fast and high quality insights in the well P&A challenge at hand. Time efficiency, applying the right tools for the job, and materials reduction achieved through risk based P&A contribute significantly to cost reduction in well abandonment projects.

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YP/SP collaborative event: How to value upstream assets in the oil & gas industry

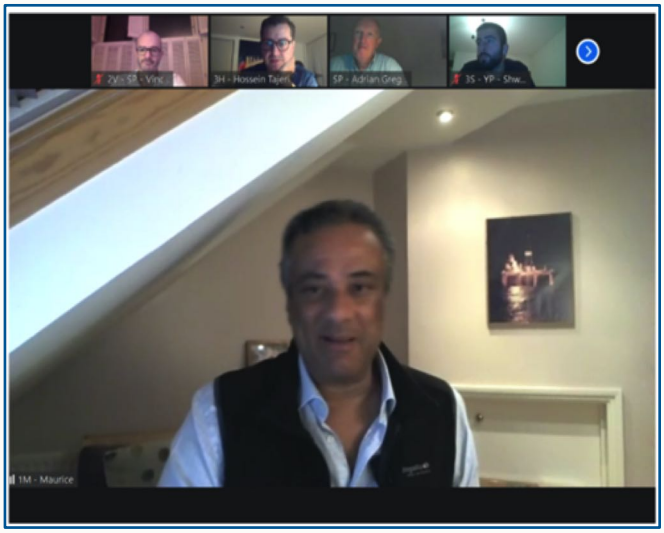
On October 6, 2020 the second in a series of YP/SP events was successfully held as a virtual collaborative event on upstream asset evaluation. The event was devised and managed by Vincent Penasse and Shwan Dizayee who share a passion for creating a knowledge-sharing environment between the younger and senior professionals within the section's membership. The event content was delivered by two distinguished speakers from industry, Hossein Tajeri and Maurice Eaton.

The aim and objectives of this type of event are to bridge the knowledge gap between Young Professionals (YP's) and Senior Professionals (SP's) and create a medium between all career stages for discussion and knowledge sharing. There was a good turnout of 30+ attendees from a range of regions, backgrounds, and industrial experience.

The event had two sections: Part 1 concentrated on sharing with the audience a range of Asset Evaluation themes, while Part 2 offered an opportunity for mixed groups of YP's and SP's to discuss the presentation material.

Part 1 of the event began with a presentation revolving around the process steps involved with Upstream Asset Evaluation. The presentation was broken down as follows:
- Deep dive into the asset lifespan, and the different key elements involved at each stage of the lifespan of the asset.
- Differences in priorities and responsibilities of the 'seller vs buyer' were explored across the asset lifespan.
- Asset evaluation methods & chances of success calculations were presented showing how the 'Internal Rate of Return' (IRR) is calculated coupled with probabilistic Monte-Carlo type evaluations.
- Corporate strategy and portfolio management of the assets along with the different parameters involved within this complex process.
- An average timeline of an example asset evaluation was presented in the form of a case study to stress the prolonged timelines of such a study due to the complexities involved.

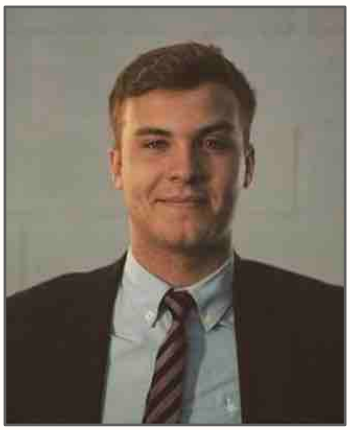
Part 2 of the event split the attendees into 6 groups via break-out rooms ensuring there was a mixture of SP/ YP representatives with coordinators to help facilitate the discussions. The purpose of this group exercise was to discuss the presentation material, highlight areas of poor understanding and share experiences. The groups provided feedback either as questions for the presenters or to share experiences and examples of best practices. This was hugely successful with some interesting questions revolving around the current industry climate, external factors, and the intricacies of the asset evaluation process.



An SPE Connect page has been set up and we are encouraging attendees and interested SPE members to continue with these discussions and further collaborate on the topic of Asset Valuation. The SPE Connect page is entitled 'Asset Valuation YP / SP event - SPE London'.

We would like to extend our thanks to our speakers, coordinators, especially Vincent and Shwan, from the SPE London and SPE YP London sections. Please provide feedback about this event and any suggestions about future YP/SP events or topics to either Vincent (Vincent.Penasse@neptuneenergy.com) or Shwan (Shwan.Dizayee@infosysconsulting.com).

Interaction between hydraulic and natural fractures, and effect on well productivity



James Burtonshaw was awarded the Energy Institute Best MSc Research Thesis Prize in Petroleum Engineering at Imperial College London in 2020. His background in geophysics led him to pursue a project involving rock physics and its applications in improving subsurface permeability and well productivity during the hydraulic fracture of naturally fractured petroleum systems.

James holds a Bachelor of Science with first-class honours in Geophysics and a Master of Science with distinction in Petroleum Engineering, both from Imperial College London. He is an Associate of the Royal School of Mines (ARSM).

James is primarily interested in applying rock physics principles to artificially engineer the type/mode of failure of the in-situ reservoir rock as to improve well productivity, EOR technologies - especially the less well studied heavy oil thermal methods, alternatives to standard HPAM in polymer EOR, and surfactant floods - and the pore-scale physics involved in the geological sequestration of supercritical carbon dioxide.

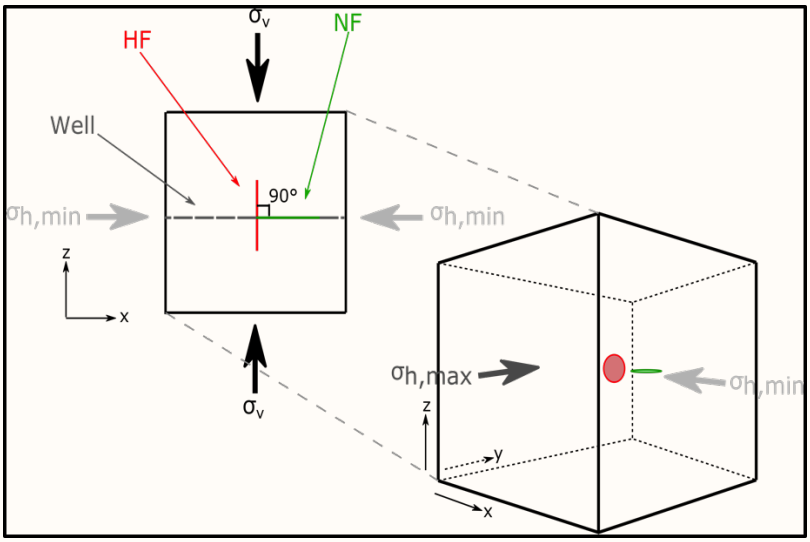


Figure 1. A not-to-scale schematic representation of the experimental setup. Note that the wellbore is removed from the 3-D schematic (right) for simplicity.

Understanding the interaction between hydraulic and pre-existing natural fractures, and how that interaction can be artificially engineered, is of vital importance in improving reservoir permeability and ultimately well productivities in unconventional petroleum systems. A three-dimensional, fully-coupled, thermo-hydro-mechanical, finite element, fracture mechanics code (Paluszny & Zimmerman, 2013; Thomas et al., 2020) was implemented to simulate stress intensity factor-based interaction effects between static hydraulic (HF) and natural fractures (NF).

A cuboidal domain – representing the rock matrix – containing 1 static hydraulic fracture, with radius 4 m, and 1 natural fracture, with radius 1 m, was constructed (*Figure 1*). The rock matrix, natural fracture and fracture geometric properties, as well as the base case treatment parameters and reservoir stress states, were assigned to be representative of the Longmaxi Shale Formation in Sichuan Basin, China. Six simulations were performed to assess the effect of fracturing fluid viscosity and injection rate on the interaction between the hydraulic and natural fracture – specifically on the balance of tensile to shear failure of the hydraulic fracture. This balance of tensile to shear failure is quantified by the tensile-to-total shear intermodal failure ratio. Higher values imply greater degrees of tensile failure of hydraulic fracture tips, relative to shear failure. Three viscosities – 0.002 Pa s (standard slickwater), 0.05 Pa s, and 1 Pa s - and three injection rates - 0.07 m3s-1, 0.15 m3s-1, and 0.23 m3s-1 - were simulated.

Interaction Between Hydraulic and Natural Fractures continued

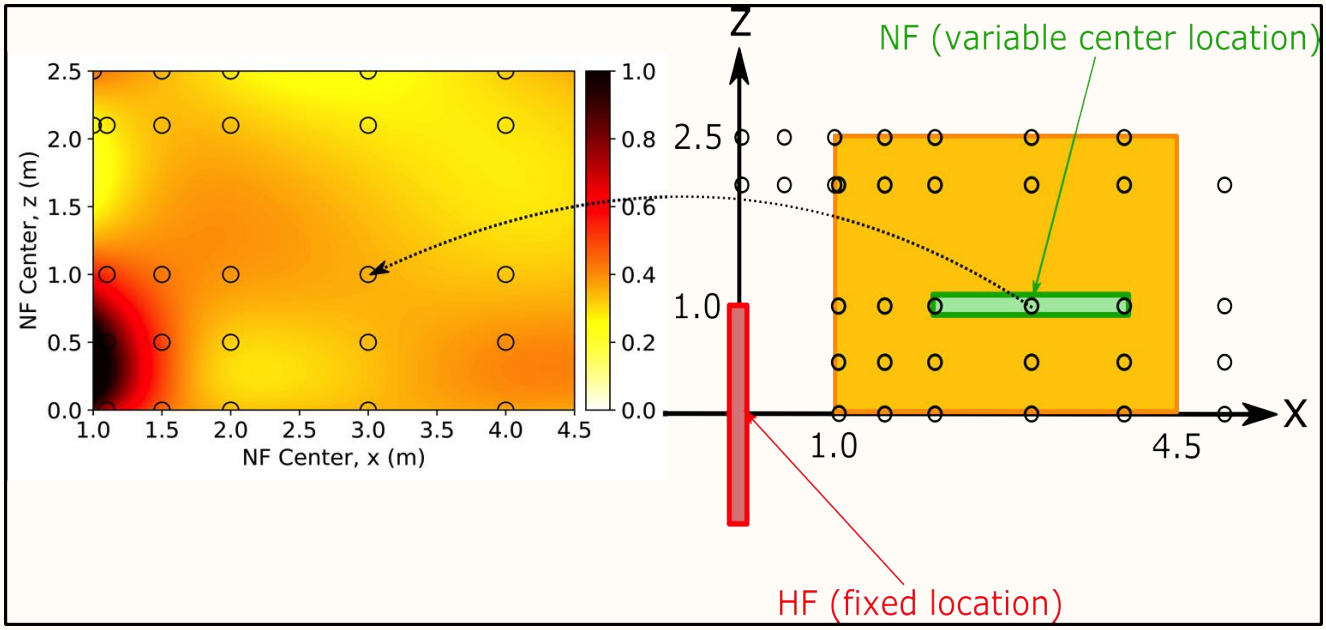


Figure 2. An example SIF interaction map for 1 m equiradii fractures (left), and a schematic of the x-z plane (right), where the orange box is the locations covered by the SIF interaction map on the left. The open black circles are the locations of true data points. The values of the interaction parameters on the HF are plotted with coordinates equal to the coordinates of the NF center in that particular simulation (dotted black arrow).

The results are plotted as stress-intensity factor (SIF) variation maps (Thomas et al., 2017), as in *Figure 2* (next page). The hydraulic fracture always remains static, whilst the natural fracture is moved through space between different simulations. on the HF is calculated for each different simulated HF-NF spacing (open black circles in Figure 2), and is plotted at the current location of the NF center. The value of in the regions between the simulated cases is then determined using a cubic interpolation.

Figure 3 (next page) shows SIF interaction maps for the three cases in which the fracturing fluid viscosity was varied. In all three cases, the regions of highest tensile failure, relative to shear failure, exist along the z = 1-2 m and z = 4 m planes. Since the HF lies in the z-plane and has radius 4 m, the high magnitude region along z =

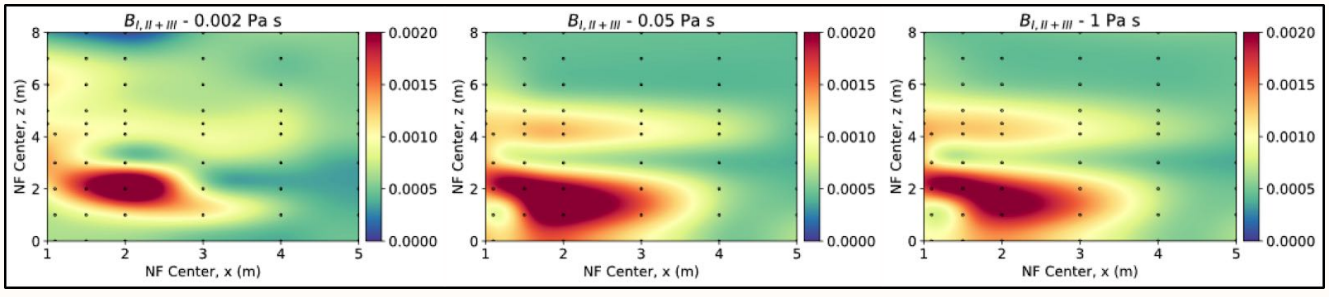


Figure 3. SIF interaction maps for the tensile-to-total shear intermodal failure ratio, , for cases with varying viscosity – 0.002 Pa s (left), 0.05 Pa s (center), and 1 Pa s (right).

1-2 m represents the horizontal plane containing the HF half-radius, and the high magnitude region along z = 4 m represents the horizontal plane containing the HF tip. As the viscosity is increased from 0.002 Pa s to 0.05 Pa s, the high magnitude regions along z = 1-2 m and z = 4 m increase in both magnitude and extent. Therefore, as the viscosity increases to 0.05 Pa s, the degree of tensile failure relative to shear failure increases. This physically translates to wider hydraulic fracture apertures and increased subsurface permeability, which ultimately increases well productivity. When the viscosity is further increased to 1 Pa s,

Interaction Between Hydraulic and Natural Fractures continued

no further increase in is observed, and as such, no further increase in the width of fracture apertures and thus, subsurface permeability, is observed. Therefore, intermediate viscosities (0.05 Pa s) optimize the degree of tensile failure and reservoir permeability. Physically this arises because as the viscosity is increased, the degree of fluid leak-off - from the fracture to the matrix - decreases. Therefore, as more fluid is retained within the fracture, the pressure within the fracture remains high, and the wider the fracture faces may be propped apart. The degree of tensile failure does not increase further as the viscosity increases above 0.05 Pa s, because at 0.05 Pa s the fracturing fluid is already sufficiently viscous that fluid leak-off becomes a negligible phenomenon. Thus, there is no additional retention of fluid within the hydraulic fracture, and as such, no additional pressure within the fracture to prop fracture faces apart.

Figure 4 (below) shows SIF interaction maps for the three cases in which injection rate was varied. Again, in all three cases, the regions of highest tensile failure, relative to shear failure, exist along the z = 1-2 m and z = 4 m planes. As injection rate is increased from 0.07 m3s-1 to 0.15 m3s-1, a small increase in the degree of tensile

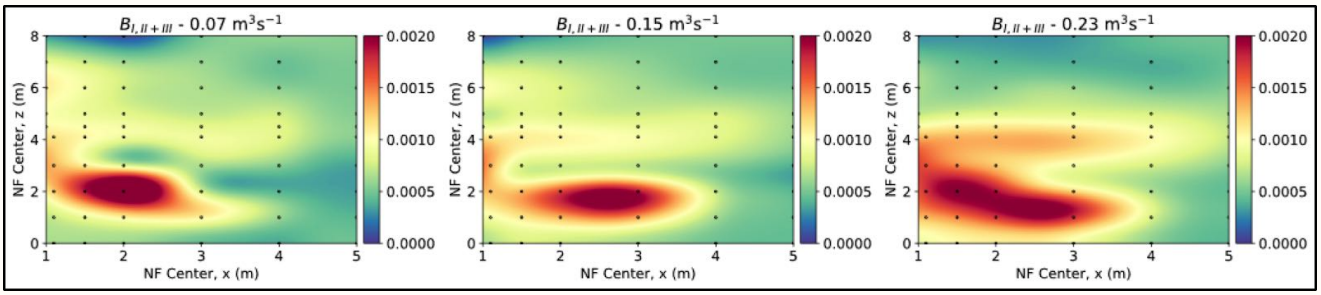


Figure 4. SIF interaction maps for the tensile-to-total shear intermodal failure ratio, , for cases with varying injection rate – 0.07 m3s-1 (left), 0.15 m3s-1 (center), and 0.23 m3s-1 (right).

to shear failure is observed; particularly along the hydraulic fracture tip (z = 4 m plane). When the injection rate is increased further to 0.23 m3s-1, the degree of tensile failure, relative to shear failure, dramatically increases. This is most clearly seen along the z = 4 m plane and by the fact that the two distinct high magnitude regions are beginning to merge along the z = 3 m plane.

It can be concluded that higher injection rates optimize the balance of tensile and shear failure to yield the highest reservoir permeability and thus, well productivities. At first, this may be surprising. Since fluid-leak off is governed by the net pressure existing between the pressure in the fracture and the matrix pressure, one might expect that more fluid leak-off occurs with the use of a higher injection rate. However, fluid leak-off is also a time-dependent phenomenon. As the net pressure is initially greater for the high injection rate case, the degree of fluid leak-off is initially high. However, this results in a rapid decrease in the pressure within the fracture, and along the fracture length, and an increase in the matrix pressure as fluid leaks-off. The result is that the net pressure is lower over the time of the simulation than for the cases using a lower injection rate. Thus, more fluid is retained in the hydraulic fracture over its entire length for the high injection rate case and hence more pressure exists to prop fracture faces apart in tension.

The paper also examines the effect of fluid viscosity and injection rate on the re-activation of natural fractures, on the initial growth of the hydraulic fracture network, and briefly on the magnitude of the shear effects which control induced earthquake generation.

Acknowledgement

This research was performed under the supervision of Dr Robin N. Thomas and Dr Adriana Paluszny of the Imperial College Rock Mechanics Research Group.

Regional SPE Recognition Awards - North Sea region

It's a real pleasure to recognise three of our outstanding members for their contributions to the Society of Petroleum Engineers.
Because of the current restrictions it is disappointing that we cannot recognise and celebrate with these outstanding members in person, so please if you interact with any of them make sure you say thanks for all your efforts and well done!

Regional Young Member Outstanding Service Awards

Dr Maxim Kotenev (Past Chair of London Section) is a senior reservoir geoscientist with Sasol. He previously worked with Rosneft and Robertson CGG. He has co-authored 15 technical papers. Max earned a BSc degree in petroleum engineering and an MSc and PhD in petroleum geoscience, and speaks four languages. He also competes in sports, enjoys volunteering, and is passionate about developing the communications side of SPE London. Max was recognised for this award due to his leadership skills within the SPE and petroleum industry: he led volunteer initiatives at local and regional levels, and has evolved within the SPE through prominent contributions in the Student chapter, Young Professionals section, SPE London Board and SPE YMEC (Young Member Engagement Committee).

Zahraa J Alkalby (2020 Chair of SPE International Women in Energy, WIN International) is a Reservoir Engineer with the French major Total. Zahraa has two MSc's covering Petroleum Engineering and Reservoir Evaluation and Management. Zahraa has been recognised for her 10 years + commitment to supporting a range of local and international SPE programs. She has also demonstrated leadership in mentoring university engineering students, including as visiting lecturer at Basra University. Zahraa has been a supporter of the SPE e-mentoring program, and is a strong advocate of SPE's gender diversity program, which encourages women to pursue technical and leadership careers. Increasing the visibility of the SPE's WiN community, currently 52 committees, which aims to empower and support women at all stages of their careers is amongst her interests. Zahraa is hoping to build relationships with other technically focused organisations to widen her influence and encourage more women to pursue careers in STEM.

Regional Sustainability and Stewardship in the Oil and Gas Industry Award

Dr Babatunde Anifowose (Board of Directors of Society of Petroleum Engineers' Sustainable Development Technical Section, and Administrative Chair) currently lectures and researches on the subject of sustainability and environmental impacts (with specific focus on energy project developments) at Coventry University. Dr Babatunde Anifowose's expertise lies in the water environmental impacts of complex projects and project performance evaluation through Environmental Impact Assessment as a planning tool for sustainable development and climate change impact mitigation. Dr Anifowose has consulted to a number of international organisations on a range of environmental projects, including for the ERBD, World Bank, Japan International Cooperation Agency and the UK Treasury. He is a member of the UK Engineering and Physical Sciences Research Council's (EPSRC) Associate Peer Review College.

Babatunde was recognised for this award as an acknowledgement of his outstanding contribution and significant accomplishments in the area of Sustainability and Stewardship. In addition, he has led the infusion of sustainability into university petroleum curriculum in several ways, including the creation of the MSc Petroleum and Environmental Technology programme for which he served as the Course Director from 2013 to 2018, acting as the expert assessor for the revised BEng/MEng Petroleum Engineering programme to include Sustainable Development at a UK university, and memberships of a number of industry education, accreditation and professionalism committees.

Data democratization through a marketplace

A point of view by Dominic Launder, Naga Suresh Govindaraju, and Nirav Krishnakant Gandhi.

Abstract

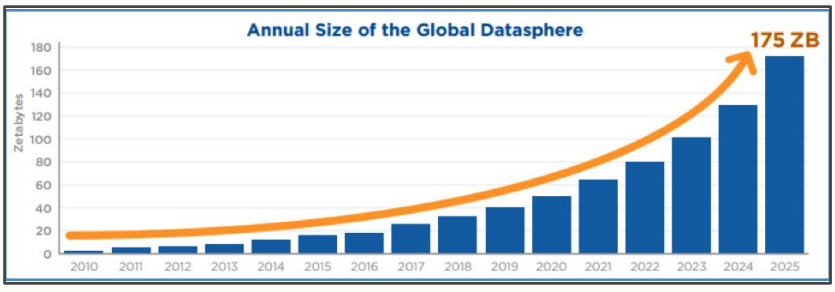
Lower oil prices over the last few years have pushed oil and gas companies to focus their efforts on improving efficiency. This effort has led to significant investments in the conventional technology, which has increased production rates. The fact is, not many operators have been able to maximize their production potential - according to the industry benchmark, a typical offshore platform runs at approximately 77% of its maximum production potential. Much of the efficiency gaps are due to operational complexities in production and processing facilities. Reducing operational complexity has now become a priority for the operators, which has made way for the Digital-First ethos.

Digital-first pushes companies to plan and deliver against data-driven decisions. Information Technology (IT) organizations, to meet the expectations, have scaled up deployment of data-centric solutions for data capture, insight generation, and pattern identification to extract greater value from the data. Data volumes are doubling every two years, which is too much for traditional data management tools and practices to absorb. As per industry sources, 40% of a data user's time is spent in data search and preparation, while nearly 20% of the time is used re-creating information assets which already exist.

The increasing pressure to make data work harder, to generate more value from it, means that successful data strategies are those which empower the users by making more data easily discoverable and critically, easily consumable. This means identifying and removing bottlenecks preventing efficient data access. Data Democratization as a concept has emerged out of this necessity and is pushing organizations to rethink how data is acquired, managed, distributed, and consumed. Data Democratization is data freedom. This kind of easy/open access is foundational to digital transformation initiatives for any organization wishing to effectively tap into the enormous data pools held captive by traditional siloed data practices and policies. This point of view discusses data marketplace as a concept to expedite data democratization across the organization where data creators and consumers collaborate, innovate, and create value.

Data challenges faced by oil and gas companies

Today, data is transforming the way we live, work, and play. Businesses and consumers are becoming increasingly dependent on digital ecosystems leading to an increasing surge in the growth of data. IDC forecasts the Global Datasphere to grow to 175 ZB by 20251. In old money, 1 ZB equals 1 Billion Terabytes. That's 175 billion external hard drives (paper weights) on your desk, and change.



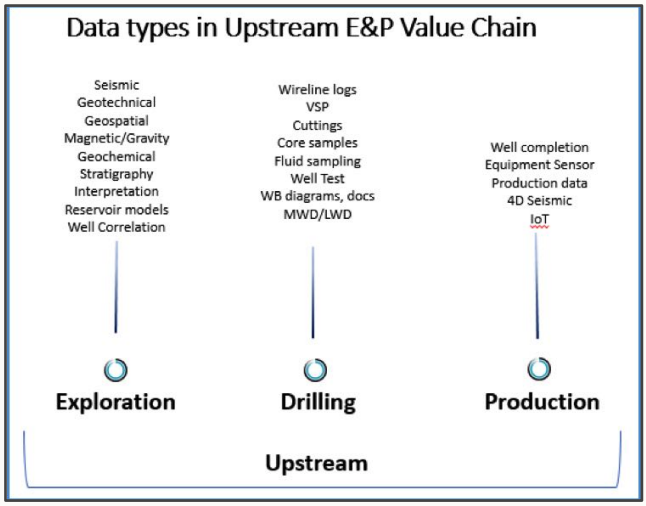
Oil and gas companies have been dealing with large datasets for a long time. Recent investments in technological innovations in the value chain have made them a very data-intensive industry needing ever more storage, performance and management. Massive data use is very expensive, therefore it is very important to consume the data for useful purposes and potentially for innovative, ground-breaking purposes to eke out as much value as possible.

Data diversity

Exploration and monitoring of the subsurface using 2D, 3D or time-lapse 3D (4D) seismic techniques generate huge volumes of data used for imaging. Drilling operations produce downhole logging and measurement data that are transmitted to the surface in real-time. Sensors and other IoT devices instantaneously stream production data from various equipment and instruments on an asset.

Data democratization through a marketplace continued

Data generated throughout the Exploration and Production (E&P) value chain are many and varied.
- Structured: SCADA/IoT systems, surface and subsurface facilities, drilling data, production data, PPM tools, asset related data, time-series data
- Semi-structured: Modeling and simulation data
- Unstructured: Well logs, drilling reports, engineering drawings, seismic images



Understanding how to organize this diversity of data with the right context has always been a big challenge for E&P organizations. It takes time and requires human interpretation resulting in increased time-to-insight. A scalable and repeatable process is needed to address these issues.

Enormous volume

At each step of the E&P value chain, more data is being generated and collected from connected devices deployed at operational and remote-site locations. The average oil rig has thousands of sensors continuously streaming data, with an average well creating 10TB data per day. The digital-first strategy will drive the installation of more remote sensors to replace human intervention in the future to improve operational safety and reduce the reliance on experienced engineers who due to several reasons are becoming a scarce resource. With the increased volume and complicated content formats, E&P organizations need technology that can support enormous storage needs with robust security combined with easy access to data.

Siloed data processing

The ability to capture and process large amounts of data is crucial for E&P organizations. There are many examples in which real-time and constant processing of data is vital - e.g. Remote site engineer wants to analyze LWD logs to predict potential drilling hazards in real-time.

Across the organization, data consumers often suffer from numerous pain points to discover and make sense of the data. International E&P organizations have complex organizational structures where operations span multiple geographies, business verticals and technical disciplines that create data silos (e.g. wells, production, regional time-series data from the field, well logs, reservoir models, seismic). There are often nuances in the data supplied by service companies that make the process of manipulating and analysing disparate, largely unconnected data more time-consuming. Access to data and knowledge is often restricted and hence is not easily shareable with other teams leading to lost opportunities and the development of poor data practices, orphaned data, duplication and re-work.

Data quality

Issues in the data quality and lineage or provenance, type of data transformation, lack of empirical integrity could lead to lack of trust in the data and therefore in the decision relying on it. Data replication creates multiple versions of the data and therefore over time, the knowledge is lost in searching for the master copy used for decision making. Knowing the master copy used for decision making often isn't enough, the thinking behind it (perhaps a report including data sources) is not typically available or referenced to that data outside the report itself. Most companies could likely not trace the series of decisions that relate an appraisal well location to the original data driving the decision to position it where it was drilled. In order to be data-driven, companies while learning from success and failure, also need to remember precisely which data drove those decisions so they can iterate, improve performance and not make the same mistake twice.
Much time goes into finding and manipulating data before any time is spent gaining insights from it. Data Scientists spend 60% of their time cleaning and organising data - leading to value erosion. The challenge is

Data democratization through a marketplace continued

amplified further by overly complex data access controls defined by hard to find data owners and so the data remains hidden away regardless of security classification.

Why data democratization is important

Data democratization changes how organizations manage data access, usability, data ownership, and data culture. It promotes removing barriers to data access and minimizing gatekeepers protecting data sitting in disparate silos. Historically an approach of 'least-access' to data has been imposed on organizations partly due to technology, information security and culture in play at the time. Democratizing and improving our knowledge of data allows everybody to search, understand, and use data so that they have the chance to perform their current work in a more performant and consistent way. It provides opportunities to seek additional value, to explore new theories, to experiment. Undirected exploration of data, serendipitous discoveries, patterns, relationships between data, processes, people - local and remote, connected and disparate have the potential to uncover huge value for an individual, a team, a business unit, a company.

Successful data democratization and presentation should enable people with little or no formal training in data science or coding to start exploring. Data democratization and improving content understanding is incredibly helpful to professional data scientists as well as citizen data scientists and developers who are learning some of the basics of data wrangling and no/low code tools. Data empowerment is when consumers have access to curated data in an environment complemented by integrated, intuitive data science, visualization, and reporting tools. Gartner's technology trends of 2020 describe the democratization of data, analytics, and technology being able to deliver citizen access. It will lead to the rise of citizen data scientists who can generate data models relying on AI to write code and automate testing. In a data-intensive industry, data democratization crucially pushes an organization towards a more data science mindset and to inspire and promote a data-driven culture.

Organizations that believe in data democratization should have a competitive advantage in leveraging their data assets, technology, and people. Combined with easy availability of the right tools and training, it allows deep domain-skilled experts from across an organization to take advantage of powerful analytical tools and techniques which have previously been siloed themselves to the realm of the professional data scientist. This could be game-changing to any business to which data is foundational.

While successful data democratization relies on making datasets accessible to more and more people, some datasets should be protected for different reasons. Defining the balance between open vs. controlled access is the key to success.

How a data marketplace provides a solution

Amazon Marketplace is where sellers bring their products to market. On similar lines, a Marketplace for data is a platform where data producers and data consumers collaborate to search and discover enterprise data assets, network with data experts and collectively enrich and improve the value of data. A Data Marketplace is an omnichannel app accessible to all stakeholders within the organization. It revolutionizes the way data is discovered and accessed. For example, a well-site engineer may want to quickly test a new hypothesis. Having the required data easily accessible in a state that is understandable (through meaningful metadata), will improve the ability to run the experiment at short notice, will encourage more experiments since they are quick and easy to do and so potentially generate new, insights to capitalize on any of these lightbulb moments. If we repeat this success across the organization, the potential upside becomes hard to overstate.

Data democratization through a marketplace continued

More than just a data catalogue

A Marketplace for data might be thought of as a window into an organization's data, a catalog of catalogs, a tunnel into multiple systems of insights. Usually, each dataset/data silo (e.g. seismic, geospatial, unstructured documents, well logs, structured System of Record (SoR)) has its own metadata catalog. These catalogs come with their specific nuances, limitations, and integration problems. Overlaying an API layer to query catalogs will improve the discovery and usability of data. A Marketplace UX should seamlessly integrate metadata and data science/visualization tools, which end-users can deploy against discovered content easily. A mature data catalog should capture data asset description, column description, data profile, quality attributes, full data lineage, business and physical models, security classification, data experts / owners, business meta data and technical meta data such as last updated date, number of records etc.

Expedites the data science and analysis journey

Mature data organizations are standing up DataOps squads to operationalize data science and bring data scientists closer to their business and data engineers. The entire process aims to reduce time-to-insight at scale. While the focus of DataOps squads is to bring in automation and monitor data for quality, the squads should define and implement strategies that enable discoverability of data and models generated. The data pipeline should automate capturing business and technical metadata of the data asset along with complete data lineage and catalog the information. In-built data quality within the data pipeline ensures only high-quality data is available for analytics. The metadata catalog helps a Marketplace application to search and surface datasets and data science models. Deploying DataOps strategies will enable data scientists and analysts to discover datasets quickly and reduce time spent searching for high-quality data.

Discover curated content with contex, metadata, and lineage

Finding the right data at the right time is a pain shared by many in an E&P organization. A solution to this problem is to improve or enrich the metadata of the data asset which a search engine could use for discovering the assets. Metadata provides information about data, including tags, descriptors and system-generated information. Metadata captures both technical and business orientated information where context is the magic word. Understanding how to use the data is very important. An 'appropriate usage' as a warning or cautionary text can help the user make sense of data. For example, making borehole trajectory decisions using outdated drilling geometry data to plan operations could lead to catastrophic failure. An engineer would benefit in this instance from metadata including a comment such as "this data should not be used for trajectory analysis". Any time data is to be used to make a decision or provide inputs to perhaps unrelated work which may impact Health, Safety, Environment (HSE) in any way, enforced safeguards need to be in place to prevent accidental or inappropriate use of data. This is where lineage, transformation history etc. become critical.

Democratizing raw data is not always a best practice. With the democratization of raw data, there is a risk of misinterpreting the content, and decisions taken based upon it could therefore be flawed. Using raw data can require advanced data science skills and owing to the paucity of metadata, deep domain expertise and understanding of the content, context, and the data structure is key. Most of the marketplace users/data consumers are looking for enriched, curated, well described data. A marketplace provisioning curated data products should yield greater value to an organization.

Completed meta data fields, including last updated date, lineage, tags and description shows that someone cares about the data and how it is discovered and used, a prerequisite for good data practice. Full lineage from a single source of truth and transparency of any transformations will empower users to make informed decisions from accurate and trusted data sources.

Promotes collaboration with peers and other SMEs

The ability to collaborate with the right people, at the right time is another benefit gained from a marketplace. Collaboration with experts contributes to organization-wide knowledge sharing and it reduces duplication of effort and analysis time and promotes outcomes that build upon shared foundations.

Data democratization through a marketplace continued

The socialization of data encourages experimentation and use-case generation. The ability to capture and share comments, tips & tricks, do's/don'ts, and lessons learned are powerful methods to leapfrog to new insights.

Most organizations are familiar with enterprise social networking (e.g. Yammer). Data communities can experiment with such communication platforms for discussing data (if the data is appropriately classified). Marketplace should integrate with social networking platforms to foster collaboration between data experts and consumers, which will cut the chase gathering information about data.

Integrate with tools for seamless connectivity with data
Tools extract value from data, so users should be able to access a variety of them for data analysis. A Marketplace aims to serve different personas with varying levels of technical capability - the user journey of a Data Scientist will likely be different from a Citizen Analyst.

Understanding the most widely used tools across the organization and integrating with marketplace helps users to find and connect data seamlessly for analysis. Data science and visualization tools are required to generate valuable insights that can be pushed back into the data ecosystem for discovery and reuse.

Key success factors

Robust search and mature data catalog - A robust and flexible search capability built upon a mature data catalog is critical to achieving user satisfaction and focused search results. To get the right dataset a data-asset should sit within structured category hierarchies and be tagged with relevant search terms from a business glossary and user tags. Different user groups use different nomenclature and terminology; therefore, the search should be broad enough to capture these ontological nuances yet be focused enough to show the most relevant results on the first page. The catalog must accommodate searching by free text, filters/facets and deliver results parsed by a relevance algorithm.

Effective change management: Most of the time, a product gets built before the market knows that they need it. Effective change management is vital for creating awareness among the intended user community. Anticipation of the potential benefits and early feedback upon release for feature development specific to various data communities is key to uptake. Working with users on real use-cases brings the product closer to them and demonstrates tangible benefits and improvement potential. Early adopters generate ideas which evolve into more ideas, therefore the sooner the users experiment with what the Marketplace provides and can appreciate the benefits, the better the outcome and the greater the return on the investment will be. There's no better champion or promoter than users to other users. Robust change management and a well-planned, consistently executed communication program both from top-down and bottom-up is crucial to the success of the Marketplace and the concept of data democratization itself.

User adoption: People like the concept of a Marketplace. They are all over the web, private and public, stores, warehouses, fulfilment brokers, academia and government organizations. Develop a brand and the perception of a one-stop-shop to find and use data. Get the big-ticket items right early on by working with active and enthusiastic data communities and that's half the battle won. More users enhance the Marketplace content further by collaboration, publishing insights back to the Marketplace. Crowdsourcing for metadata enrichment and glossary improves search quality. If users find what they want, then adoption goes up.

Re-imagined data ownership, governance: Data ownership and custodianship are the foundation of data management. Data Owners must be willing to come along on the Marketplace journey, to manage and promote their data, and to open access to it across the business. Tight access controls would result in unhappy customers. Finding the right balance between what needs to be controlled and what can be opened for general access determines the success of a marketplace. Governance mechanisms need to be defined and implemented to ensure meta data is ever-green for old and new data.

Data democratization through a marketplace continued

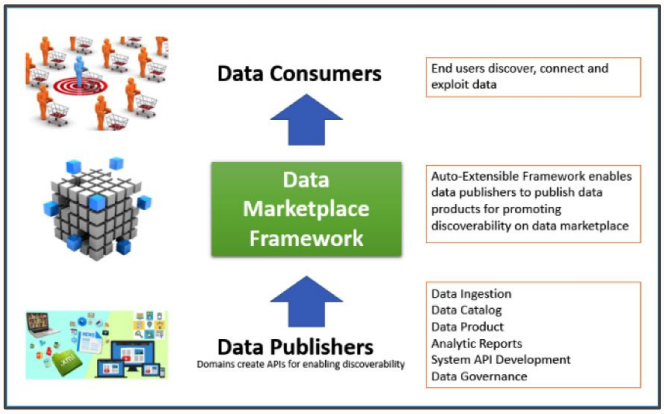
Security classification (e.g. general, confidential, secret, or public) should be defined at data source level. This rating is stored as technical metadata and will hasten any access requests for data not already available in the Marketplace. Ideally, most data should be available to discover and use across the organization. To attain an open data eco-system the principle of 'most access' is useful rather than the more traditional and still commonplace approach of 'least access' to data. With the exceptions of 'secret' data, personally identifiable information (PII), content restricted by company policy or regulation and law, all other datasets must be discoverable.

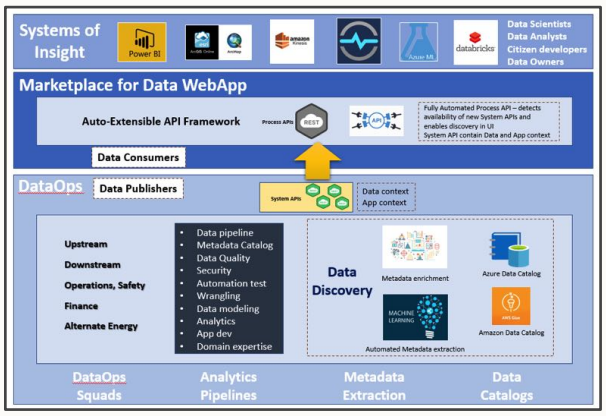
A robust security model is an essential component of data marketplace. Such models could include data licensing implementation to open the data based on a user's persona/role. Automating security via APIs is required so that users can request access to non-general access datasets.

Greater trust in the content: A guiding principle and benefit of a Marketplace is to improve trust in data which encourages usage. A Marketplace attempts to overcome trust issues by making the data journey from source transparent. That includes data lineage, any transformation, applied quality measures, curation, ownership etc. If there are quality issues or anomalies, a Marketplace can provide information with metadata and annotations to users. Conversely users themselves can highlight issues to fellow users. When people find trusted data sooner, they leapfrog over the typical search torment to work on good data with the tools provided and get to insight faster.

Simple connectivity with the right tools: After finding high quality data, the next logical step in a user journey is to easily connect to their tool of choice for performing analysis. The ability to seamlessly connect various data science and analytical tools is a critical success factor to improve the user journey. A Marketplace experience should include connecting people, data and tools without having to leave the platform. Common pain points include the need to manipulate, wrangle and otherwise prepare data with tools before analysis can begin; hence, the data Marketplace can assist by making possible data discovery, preparation and analysis in one place. Success might be the ability to find and open trusted fit-for-purpose data in a tool of the users' choice in three clicks.

Collaboration between data experts and users (contributors and consumers): Collaboration among users, data experts, or groups helps in sharing insights or improve the dataset collectively. The socialization of data





encourages data science culture and data openness. Organizations can utilize the platform itself with comments and ratings or use social networking platforms like Yammer groups to discuss datasets (non-confidential), tools, processes and even suggest feature enhancements, new data needs.

Onboarding new data sources: As E&P organizations' data maturity grows, the data variety and sources will broaden. As data from different functions and disciplines migrate to the cloud, it is important to ensure that data silos are not propagated, and the Marketplace catalog is refined. As sources turn on and off, a seamless plug & play process (figure below) is necessary to reduce technical integration efforts. A more mature

Data democratization through a marketplace continued

organization will go beyond provisioning raw source data and begin building business data models and other products that the more discerning data consumer desires. Similarly, advanced data groups and formalised data management processes compile and curate data to be published via the Marketplace creating a more valuable consumer-ready data estate.

Design considerations

- There are three facets to data Marketplace - data search, connectivity to tools and ability to push valuable insights / refined datasets back into Marketplace. The ability to connect tools with data relies on the availability of a rich set of REST APIs, a definite design consideration while building a data Marketplace. Technical limitations could prevent seamless connectivity between data found on the Marketplace and the tools.
- A Marketplace relies on a robust search algorithm that can search and pull meaningful results. Search relies on the persistence of relevant business and technical metadata. Data owners and experts play a critical role in governing metadata as part of DataOps. User adoption heavily relies on how successfully data Marketplace is helping users in finding the right data. Keeping the data catalog evergreen needs significant time committed from DataOps teams. These teams need to recognize that the catalog enables the discovery of data and should be maintained consistently and with set standards as it helps organizations realize the value that is being delivered by citizens, expert analysts, and data scientists.
- An organization readiness needs to be assessed before building a Marketplace for data. One of the key considerations is to evaluate if data owners are willing to share data with others. Inhibitions due to poor data quality or internal competition could promote reluctance to share or 'data hugging' and retaining hard to surface data silos. Changing the organizational mindset to crowd-source and collectively improve data quality is not an easy task. Data owners play a vital role, and they need to be made aware and accept their responsibilities around data democratization.

Conclusion

Economic pressures on E&P organizations are influenced by falling renewable prices, global geopolitics to growing concerns of the societal reputation of hydrocarbons. E&P organizations must look at ways to reduce costs, find operational efficiencies, and reduce net carbon. Big data will continue to grow, as will the evolving challenge. Firms must look at ways to capitalize on their data assets through technologies and process improvements, equipping employees with the right data and technologies.

As companies embark on their digital transformation towards fully becoming data-driven, points explained in this paper help understand what these players are doing and what they might consider doing to expedite data democratization to stay ahead of the competition. Re-defining data ownership, data governance, embracing DataOps principles are good initiatives, but organizations should not lose sight of the data discovery element, which is vital for successful transformation.

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Understanding the living planet and Gaia stewardship

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.

Our first feature about Sustainability is brought to you by Adrian Gregory who is a subsurface and wells engineering consultant. Adrian will make more contributions in future editions of the SPE Review London, and is excited to be part of and contribute to the new London SPE Net Zero Committee. Future briefing articles will broadly focusing on sustainability strategy, frameworks, principles, delivery and performance.

As an introduction I will be contributing to a number of articles broadly focusing on sustainability themes such as strategy, frameworks, principles, delivery and performance. These sequenced articles will all be brief, but aimed to share knowledge and create discussion.

Sustainability, what does it actually mean to you, your work-space, your work-choices, your future work-opportunities?
In my view, the value of sustainability is to understand the 'Value of Everything'. It is up to individual readers how much they adapt the content to their circumstances as every enterprise will have a different set of sustainability themes and focus areas, a differentiating strategy.

Sustainability in itself is not made up of disperse topics, but is built on collaborative and integrated thinking, a bit like our spine and central nervous system, blood and lymphatic systems that keep our bodies and minds functioning now and in the future. Behaving in a sustainable manner is core to the future success of economies, societies and to our living planet.

For those new to these concepts, think of sustainability as a core behaviour to future jobs, wellbeing and protecting our planet's boundaries.

To begin with let us focus on a sustainability strategy, which starts with thinking about, and answering to the best of our collective abilities, questions (and scenarios).
The better the questions, the better the answers, the better the sustainability strategy.

In attempting to develop a sustainability strategy there are a number of questions that you could ask. I've selected two for consideration that probe our understanding of the impact we have on the Living Planet and our sustainability behaviours.
Q1. What constitutes Life? What is a Living Planet?
Q2. How sustainable is our Living Planet in the future, say in 30 years' time, the time frame over which many governments and organisations have committed to a Net Zero Carbon emission environment?

James Lovelock[1] who is a long-standing commenter of the Living Planet theme is an author resource[2] that should be read to help explain potential answers to Q1. Lovelock proposed a 'Top Down' view on sustainability. However, with recent thinking there may be alternative ways to approach sustainability in a more integrated manner. Lovelock has embraced what is called Gaia theory - Gaia was the Greek goddess of the Earth - as a foundation to sustainability. These similar principles have been adopted by the Society of Petroleum Engineers in creating their Gaia Sustainability Program.

The SPE Gaia Sustainability Program's intent is to provide the membership with the means to co-create activities and action plans that rise to the scale of urgency of the planet's sustainability challenges - reinforcing existing efforts and introducing new.

Through the Gaia Principles to collaborate, engage, aggregate and mobilize we can secure innovation, measure what matters, listen to and communicate the opportunities of the Energy Transition and the importance of biodiversity, while having due regard for the UN Sustainability Development Goals and our collective social responsibilities.

Q2 cannot actually be answered with certainty, as it depends on humanity and on our future preferences and behaviours. Using scenarios, many of today's uncertainties can help test our strategic thinking, working practices and resilience. An example of how current and future behaviours will test resilience is how people living on low-lying coastal areas react to a sea level rise for a global 2+ oC temperature increase.

So, thinking about our industry, how resilient are your employers' assets and activities? How resilient are their fields, hubs, infrastructure? What reserves are at risk? How resilient is their production? What yields (recovery factors) and reliability efficiencies can be achieved today and in the future? What about stranded resources? How good is the stewardship of your company's natural resources? Some $50 billion USD petroleum wealth capital has been written off in 2020 so far. For corporations, Portfolio Management built on natural resource stewardship is an important feature of their business.

The role of engineering is evolving and for an insight into its future Professor Clift[4] has provided some great material.

Big engineering projects have been regularly presented in the SPE London events representing the relationship between engineering and finance. The emergence of social engineering and finance was predicted with the 'visible hand' of the marketplace driven by industrial policy, national investment and responsible investment. The introduction of the 'visible hands' when for so long humanity has relied on just the 'invisible hands' shows the greatest shift I've seen in my lifetime. Examples of this change where social engineering is being delivered is in the Carbon Capture, Usage, Storage (CCUS), and other societal projects such as the planned Humberside project and the Norwegian-sanctioned Northern Lights and Longship projects. We are now living in the Energy Transition for real with some people thinking that peak oil demand may have been in 2019[5].

I believe that there is an exciting future in which we engineers now live!

Article 2 in the next edition of the SPE Review will be covering 'ownership' and the assertion that 'there is no such thing as a free lunch': Full Cost Resilient Business, Fields and Production.

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How we can get to Net Zero

Editorial Board member Justin Reynolds reviews Net Zero: How We Stop Causing Climate Change by Dieter Helm, and published by HarperCollins.

Dieter Helm's latest manifesto for the energy transition offers a bold programme for navigating the path to a net zero economy.Reading too many climate crisis books, as your reviewer is prone to do, is not necessarily good for your mental health.

A grim opening chapter presenting the scale of the challenge before us is usually followed by a detailed blueprint for action, that one reads with a sinking feeling as its political unviability becomes apparent. Dieter Helm, an economics professor at Oxford University, is as well qualified as anyone to try squaring the circle of offering a programme both commensurate to the task at hand and sensitive to political realities. Helm's prolific publications over the past decade have covered every aspect of the energy transition. The Carbon Crunch and Burn Out considered how we might move beyond reliance on fossil fuels without indulging in wishful thinking that we have reached 'peak oil'. Natural Capital and Green and Prosperous Land suggested how the often overlooked contribution our wasteful agricultural system makes to carbon buildup might be addressed. And in 2017, he found time to oversee the government's Helm Review, a major study of how energy market pricing might be rebalanced to favour renewables.

Helm is as well known for his blunt style as his grasp of the issues, ever ready to prescribe policies that pay no regard to orthodox political boundaries. His latest book, *Net Zero: How We Stop Causing Climate Change*, draws on the full range of his expertise to present a programme for achieving the target for net zero carbon emissions by 2050 that has been adopted by the UK and other governments. It bears all of Helm's hallmarks, a cascade of proposals set out in clear, matter-of-fact prose, together with caustic observations on the failures of existing policy that, here, are somewhat more acidic than usual.

Failure past and present

Net Zero opens with a biting critique of the chronic failure of international climate change initiatives over the past 30 years. The series of UN climate conferences set in motion by the 1992 Rio de Janeiro Earth Summit - Kyoto, Copenhagen, Paris et al - have fallen woefully short of their objectives.

There have been important advances. As renewables technology has improved the cost of wind and solar has fallen. Coal is falling sharply as a proportion of the world's energy. And the climate emergency is now firmly established as a major political issue.

But fossil fuels still provide some 80 per cent of the world's energy, and as global GDP rises their absolute use will continue to rise even as their relative share of the mix falls. Nature's capacity to sequester carbon is being eroded with the clearing of the great rainforests of South America and Southeast Asia, and the draining of major wetlands such as the Congo basin. And plastic and e-waste has accumulated exponentially, polluting the oceans and turning vast tracts of developing countries into giant rubbish tips.

For Helm, climate mitigation policy has been 'looking down the wrong end of the telescope', focusing on reducing carbon-intensive production rather than the consumption that drives it. There's no way of getting round it: we quite simply have to make do with less. And he argues that the task of reducing consumption is

How we can get to Net Zero continued

a matter for national policy, not international agreements.

The climate change framework developed by successive UN conferences is - in essence - a carbon cartel forever seeking to limit global emissions by carving up emissions allowances between nations. It suffers the fundamental problem of all cartels: participants will cheat if it is in their interests to do so, catching free rides on the back of the sacrifices made by others. The hope that the great power blocs will cede their sovereignty has always been a fantasy. Helm fears it can never be 'UN First, but rather … China First, India First, Russia First and America First, as it always has been and probably always will be.'

Even the efforts made by the one region that has attempted to decarbonise, the EU, have not been selfless, or particularly effective. Most EU members have indeed pared back their own carbon-intensive production, and invested heavily in renewables. But they have also offshored their pollution. Europe is now much more reliant on energy produced in countries with less stringent carbon regulations, and much of its new green infrastructure was made overseas: most of the gleaming wind turbines and solar panels that line North Sea horizons and stretch across the plains of Germany were built by energy-intensive manufacturers in China. For all the controversy surrounding shale gas the irony is that US energy policy is arguably cleaner than Europe's: fracking has allowed the US to transition from coal to gas, and has reshored energy-intensive businesses from China and elsewhere.

The chronic failure of climate policy tempts us to fall back on the hope that technology will save us. As solar, wind and battery storage solutions improve, the argument goes, the price of renewable energy will undercut that of fossil fuels, facilitating a relatively painless transition to a new green economy.

But that rosy scenario overlooks the hard fact that fossil fuel technology is advancing every bit as rapidly. As readers of this publication well know, new seismic, drilling and machine learning processes facilitate the discovery of new hydrocarbon resources that can be extracted ever more cheaply. The cost of renewables not only has to continue to fall rapidly, but to do so considerably faster than that of fossil fuels.

Increasing political, consumer and investor pressure is being placed on western oil and gas corporations, and some have engaged on a slow process of realignment, but Helm points out that 90 per cent of fossil fuels are produced by state-owned companies in - often authoritarian - nations whose economies depend on them. 'Climate activists attack European and US politicians and company executives,' he writes. 'They don't dare take on Vladimir Putin, Xi Jinping and Mohammad bin Salman. Gluing yourself to the HQ of Shell or BP is easy: doing it in Moscow, Beijing or Riyadh is much tougher.'

Taxing consumption

So what would Helm do? His programme starts with the introduction of a carbon tax on all carbon-intensive goods and services, a levy that would make the environmental cost of producing them explicit. Crucially, it would apply not just to domestic production but to imported goods as well. If the cost of goods produced at home rises relative to imports we will simply buy from polluting countries, as the EU has done.

Setting a price on carbon allows the market rather than the state to take the strain of identifying which carbon-intensive products should wither away, and which green alternatives should flourish. A carbon tax assumes 'pervasive uncertainty about the opportunities and costs of the various options and … seeks out the

How we can get to Net Zero continued

lowest-cost options.' Governments that try to micromanage the energy transition, retiring certain industries and investing in others, leave themselves open to lobbying by vested interests.

A carbon tax would ensure 'the costs of our pollution confront us every day', making it clear to us just how dependent we have become on fossil fuels. It isn't just the obvious things: the petrol we put into cars, the flights we take, the plastic we throw away. It's also the synthetic fibres we wear, the detergents we use to clean our homes the processed food we eat, the steel and cement that make our houses and offices.
A tax on carbon consumption would offer the strongest incentive possible for a mass shift to green alternatives such as organic food, and discourage carbon-intensive luxury items. The environmental cost of travel would become especially clear. Planes and ships powered by solar, batteries and hydrogen may shimmer on our technological horizon, but for quite some time to come air and sea transport will remain highly carbon intensive. Carbon pricing would also highlight the mixed blessing of a new age of electric vehicles. Ambitions to replace the internal combustion engine with hundreds of millions of 'EVs' overlook their dependence on cobalt, lithium, nickel and other materials: the construction of an electric car is twice as energy intensive as a diesel.

The tax could be introduced by simply adding a price increment to products roughly indicative of their carbon footprint. It could be dialled up or down as governments close in on their net zero emissions target. Aware of the dangers of hammering economies with a post-Soviet Bloc style price shock, Helm suggests the tax should be introduced gradually, starting at a relatively low level with the credible expectation that it will rise over time, thereby allowing consumers and companies to prepare for price rises, rather in the way that governors of central banks provide forward guidance on the setting of interest rates. Taxes on carbon-heavy imports would be set according to estimates of carbon input by country of origin: steel from China or palm oil from Malaysia, for example, might be taxed particularly heavily.

Helm believes a carbon border tax would be consistent with WTO rules, which allow for environmental adjustments, and, indeed, that it offers strong inherent incentives against a trade war. A tax on imported goods goes to the importing country's exchequer. But if the exporting country has already set their own domestic carbon tax the import would qualify for an exemption, since the polluter is already paying. The imposition of a carbon tax on imports by one country, therefore, would encourage others to introduce their own taxes: better the money go to their own government than the importer's. As Helm puts it: 'If enough countries opt for the border tax approach then there will be a critical mass and these powerful incentives will cascade through the global economies as every trading country now has an interest in putting a domestic carbon tax in place.'

Investing in the green economy

Though Helm believes the play of market forces, filtered through a carbon tax, can pick out the winners and losers in the emergent green economy, he still envisages a critical role for the state. Only public planning and investment can deliver the infrastructure on which a net zero economy will depend. Governments should use the revenue accumulated through a carbon tax to deliver the low-carbon communications, energy and transport networks that the market will not provide of its own accord.

Helm's model is not quite that of a Green New Deal, most versions of which propose an economic stimulus package that increases both investment and consumption. He has in mind something more like a wartime economy, in which the state engineers a shift from consumption to investment. During wars states suppress consumer spending through taxation and rationing and redirect resources to military infrastructure. Governments seeking to manage the energy transition should reduce consumption to sustainable levels through a carbon tax and spend the proceeds on green infrastructure.

Under Helm's plan the state's responsibilities would include the conversion of road and rail systems for electric- and hydrogen-powered vehicles, 'smart' energy networks able to optimise power supply and

How we can get to Net Zero continued

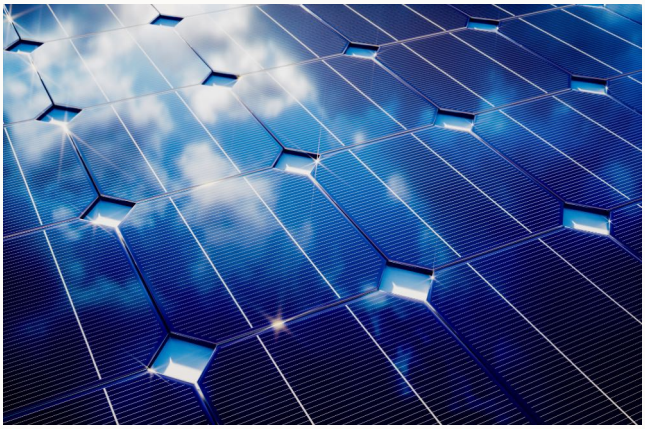
incorporate storage, and the fibre and broadband infrastructure necessary to support these and other decarbonising networks. All of this will require public investment in research and development into the next generation of renewables technology: rechargeable flow batteries, floating wind turbine platforms, solar panels able to use more of the light spectrum, green hydrogen.

And the state must also lead the development of the infrastructure necessary to drawdown and sequestrate carbon emissions: even a net zero economy will need to produce some carbon for essentials such as chemicals, plastics and backup energy supplies. This will include the building of a robust carbon capture and storage (CCS) framework, which in Britain's case might be centred in the North Sea, which already has an abundance of old wells and an extensive pipeline system.

But the greater task would be the restoration of the land's natural capacity to absorb carbon through reforestation, the recarbonisation of soils, and the regeneration of peat bogs and coastal marshes. This will require investment in new farming techniques that make full use of digitalisation, robotics and AI that would allow, for example, crops to be cultivated indoors through smart monitoring systems, cutting reliance on fertilisers that erode soil and biodiversity. For Helm the prevailing notion that polluters should offset their own emissions is hopelessly inefficient: far better to let the state coordinate a nation-wide sequestration and land regeneration programme using funds from the carbon tax.

Some questions

With Net Zero Dieter Helm gives us another provocative climate manifesto that evades ready categorisation. He is sceptical about capacity of the state to manage the fine detail of the energy transition. But the emphasis he places on the urgent need to cut consumption aligns him with concepts of degrowth more usually associated with radical ecosocialists.



Some important questions go unanswered. The harsh impact a carbon tax will have on very many consumers already struggling to make ends meet is barely mentioned. Helm is surely right to highlight our mutual responsibility for managing the demands we place on our planet. But he overstates the agency many of us have to significantly change our consumption patterns, entangled as we are in an economic machine premised on constant accumulation. And we might ask whether the carbon tax is quite as bulletproof as Helm suggests. Wouldn't the setting of the carbon price be just as vulnerable to lobbyists as the auctioning of permits or the allocation of state subsidies to favoured industries?

Helm is aware of the profound political challenge of introducing a significant tax on consumption. But he doesn't do his case any favours by presenting the prospect of reduced consumption in terms of sacrifice. 'Whether the political processes, democratic or otherwise,' he writes, 'can deliver an enlightened self-interest which involves quite a lot of pain is the issue upon which the future of our climate, and planet, depends.' Yes: but if the case for lower consumption is ever to win public acceptance it must be presented in terms of the benefits it would offer, not just its costs. There is much to be said about the advantages lifestyles less centred on consumption might offer in terms of health, increased opportunities for leisure, the convenience of remote working, and so on, as has often been noted during the current pandemic.

Like all climate transition programmes Helm's is incomplete. But this is one to take seriously, navigating an immensely complex debate with intelligence, formidable learning and due attention to what might actually be politically possible.

Reservoir Engineering Studies for CO2 Storage

Marie Ann Giddins is a Schlumberger Advisor in Reservoir Engineering, based in Abingdon Technology Center, UK, where she provides technical advice on reservoir simulation software, workflows and integrated studies.

Her areas of expertise include advanced reservoir engineering applications such as Enhanced Oil Recovery (chemical EOR, miscible injection and thermal studies), gridding and upscaling, uncertainty and optimization.

Carbon capture, utilization and storage (CCUS) projects are expected to make a significant contribution towards reducing the amount of carbon dioxide (CO_2) in the atmosphere, to help meet future emissions targets. CO_2 can be captured from natural gas production and from industrial sources such as power stations and cement factories, and new technologies are evolving, e.g. direct air capture. Captured CO_2 can be utilized for fertilizer, food production and other chemical processes, or for enhanced oil and gas recovery (EOR and EGR), or it can be sequestered in geological structures, including saline aquifers, depleted oil and gas reservoirs and deep coal beds.

Today, the total injection from worldwide CCUS projects is around 35 megatonnes (Mt)/year, with typical projects storing around 1 Mt/year. Typical scenarios propose increasing CO_2 storage to 1 – 5 gigatonnes (Gt)/ year in the near future, but success will depend on identification of suitable sites, design of injection and monitoring strategies, and effective control of costs and risks (IEA, 2019). Some longer-term projections reach around 50 Gt/year - recent studies indicate that it could be feasible to develop storage capacity to support those high rates (Krevor et al, 2020).

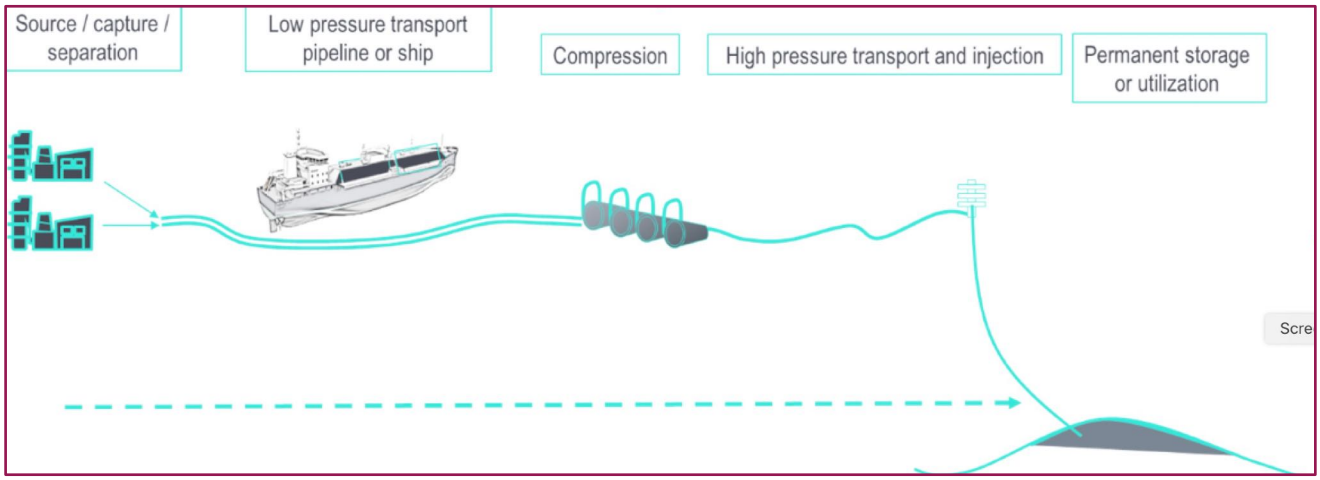
CO_2 injection: surface facilities at SACROC unit in Texas. (Schlumberger, 2016)

To achieve such ambitious goals, reservoir engineering studies are essential for selection, planning and management of storage sites (SPE, 2020). Engineers need reservoir simulation models to study CO_2 dynamic behavior over the lifetime of a storage project, to answer questions on capacity, injectivity and containment for the site. This requires specialist software features, as well as all the functionality used for dynamic simulation of oil and gas fields. This article focuses on deep saline aquifers, which have very high potential storage capacity.

The amount of CO_2 in the atmosphere increased from 280 ppm in 1,750 to 415 ppm in 2019.
1 ppm CO_2 ≈ 2.13 gigatonnes (Gt) carbon ≈ 7.8 Gt atmospheric CO2
1 tonne CO_2 ≈ 535 m3 at US standard conditions

The simulator must represent the complex physics and chemistry of CO_2 behavior. It can be a component of both hydrocarbon and aqueous phases. Above the critical point (31C, 73.8bar) pure CO_2 exists as a

Reservoir Engineering Studies for CO2 Storage continued



CO_2 capture and storage process

supercritical dense phase, with gas-like viscosity and liquid-like density. Below the critical point it can exist as gas or liquid. CO_2 is present as a non-hydrocarbon component of natural gas and oil. When injected, it can become miscible with oil at high pressures.

CO_2 solubility in the aqueous phase increases with decreasing temperature and/or with increasing pressure and decreases with increasing brine salinity. Following injection into a saline aquifer, CO_2 forms a gaseous plume that migrates in the pore space, influenced by pressure gradients, gravity and buoyancy forces. Underground, it is trapped by various mechanisms over different timescales.
- **Structural trapping**: Gaseous CO_2 can be trapped by cap rock or structural features (important in injection and post-injection phases while gas is highly mobile).
- **Residual trapping**: The gas phase is immobilized due to the effects of relative permeability and capillary pressure (important in injection and post-injection phases while gas remains mobile).
- **Solubility trapping**: CO_2 dissolves into the aqueous phase (a process which starts when CO_2 is injected into brine, but may take hundreds or thousands of years to complete).
- **Mineral trapping**: The acid formed by CO_2 dissolution reacts with the reservoir rock and mineralization occurs (a long-term process that can take many thousands of years to complete).

In a compositional reservoir simulator, the phase behavior of CO_2 in hydrocarbons can be modeled using an equation of state (EOS). For CO_2 interactions with the aqueous phase, the mutual solubility of CO_2 and H_2O can be represented by fugacity equilibrium and depends on pressure, salinity, temperature, and composition. Brine density can be corrected for dissolved salt and CO_2. The effects of halite and calcite precipitation and dissolution can be modeled using chemical reactions. Thermal simulation capabilities are needed for studies where temperature has a significant impact and changes over the lifetime of the storage system.

Injector performance is critical to achieving high injection rates as safely and economically as possible. Near-wellbore interactions between CO_2, water and salts can affect injectivity. As CO_2 is injected, H_2O in brine evaporates into the gas, resulting in “dry-out” in the region near the injection well, when residual water saturation can reduce to zero. This increases the effective permeability to CO_2 and injectivity increases. On the other hand, in high-salinity brine there is a risk of “salting-out” as H_2O evaporates. Increasing salinity leads to salt precipitation, which reduces permeability and porosity and so injectivity decreases (Hurter, 2007).

The desire to inject large volumes at low cost could be in conflict with the need to maintain the integrity of the storage site, where there is a risk that high injection rates may lead to pressures high enough to induce fracturing and possibly affect the cap rock. In a saline aquifer, the initial pressure may be relatively high, compared to the pressures found in depleted hydrocarbon reservoirs - some studies propose producing water

Reservoir Engineering Studies for CO2 Storage continued

from the aquifer before starting injection. For reservoirs at lower pressures, there may also be a risk of cooling due to Joule-Thomson effects, which can increase the risk of fractures. Integrated geomechanical studies are needed to establish safe injection rates and pressures, to meet regulatory requirements, particularly for new storage plans that go beyond the conditions that have been experienced in previous CO_2 projects.

Uncertainty is a major challenge in CO_2 storage. Subsurface characterization data are relatively limited for deep saline aquifers, which increases uncertainty, but quantification of risks is essential for storage projects, to optimize costs and satisfy regulations. Recently there have been step changes in industry capabilities for running multiple simulation realizations, using high-resolution models with evolving cloud solutions. In a typical oil or gas field, the range of possible outcomes can be adjusted over time, using data such as observed production, but in a carbon storage site, an appropriate monitoring program is needed.

Monitoring can cover CO_2 injector performance, well integrity, plume movement and leakage outside the storage site, using techniques such as downhole sensors, fluid analysis, neutron logging, seismic and electromagnetic surveys. Site-specific solutions can include construction of strategically positioned observation wells and time-lapse seismic surveys (Schlumberger, 2020). Questions to be answered in designing a monitoring and surveillance program include what parameters to monitor, where to place sensors, and when to take measurements; allowing for the need to control costs over the lifetime of the storage site. Dynamic modeling is essential to identify parameter ranges, plan measurements, perform history matching during the injection and post-injection phases, identify anomalies and update future predictions (Senel, 2012; Furre et al, 2017).

For a complete analysis of CO_2 storage, reservoir simulation must be part of multi-disciplinary workflows covering the supply chain from capture and transportation to injection in the aquifer or reservoir. Integrated asset models can include surface facilities, flow assurance and subsurface analysis. Multi-reservoir models may be required for large projects and could include CO_2 sources in oil and gas fields as well as multiple storage sites.

It is clear that experts from the oil industry will have key roles in determining the feasibility of large-scale CCUS projects and ensuring successful implementation. This opens up a new role for petrotechnical experts. Now is the time for anyone who wants to be involved, to build new understanding of CCUS, to augment their existing knowledge and skills.

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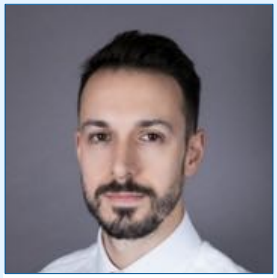
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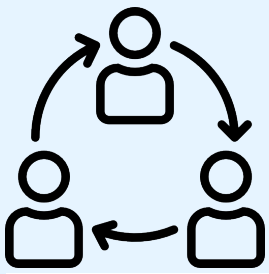
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