energy transition

Competing in a new energy landscape

A New Era for the Geoscientist

15 - 16 October 2019 | Edinburgh, United Kingdom

SUMMARY REPORT

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MESSAGE FROM THE CHAIRMAN

Chairman's reflections on the AAPG Energy Transition Forum 2019: A New Era for the Geoscientist

Max Brouwers

AAPG Forum Chairman,
VP Exploration Europe, Russia & The Caspian, Shell

This years forum provided deeper insight into what the energy transition entails and energised the attendees on the potential it holds for geoscientists. A mix of students, business professionals and academia discussed their views and a poll at the end of the event highlighted that their outlook was much more positive following the 2 days of presentations and discussions.

During the forum the consensus view on the future landscape was that:

- By 2050, the population will have risen from 7 to 10 bln, global economy more than doubled, energy demand 70% greater and food demand 45% more. The vast majority of energy scenarios project an increased electrification and diversification of energy supply sources, with oil and gas still being a material part of the mix for decades to come.
- Large energy companies have the ability (capital, technology & longer-term horizon) and increasing social responsibility to build a more sustainable future. However, for them to do so the underlying economics need to be sound, and governments will need to step-up in setting the policies to create the required regulatory and fiscal framework.
- CCS (Carbon Capture & Sequestration) is moving from a "nice to have" to a "must have" for countries such as the UK, if they want to meet their energy ambition. Next to an economic incentive, CCS requires a deep understanding of the geological challenges, for example the reliability of the seal after depressurising, drilling bore holes through it and potential geochemical reaction with CO2.
- Digitalisation continues to become more mainstream in geoscience, with Open Subsurface Data Universe (O-SDU) poised to be the new O&G platform industry standard. Having such a standardised data architecture is crucial to encourage tool & application innovation, and thereby delivering on the potential of digitalisation. This in turn will liberate data and get more value out of it by machine learning and AI.
- The increased need for energy storage given the requirements to balance an increasingly complex power grid, will further encourage exploration for rare earth minerals. Lithium exploration is in its infancy and greater demand is opening up unexpected areas for viable exploration, including right on the UK's doorstep.

Despite the vast majority of all scenarios indicating that oil and gas will be required for decades to come, there will be changes in what, how and when to explore and exploit, considering the already discovered resources and new types required. This means the role of the geoscientist will gradually change.

The projected global increase in energy demand, and the diversification of supply sources means a deep, solid understanding of geoscience core skills is still required, be it for oil & gas exploration, CCS, rare earth metal mining or geothermal energy extraction. Due to the growth in digitalisation and fusion of energy supplies, there will be a wider spectrum of roles for geoscientists, especially those who have multi-domain knowledge and maintain a learning mind-set.

More discussion is required outside our ecosystem, especially with governments and the public at large on how traditional integrated oil & gas companies are transforming into integrated energy companies, diversifying the service they provide to society and how they can be part of the solution. The discussion should not underplay the contributions made in the improvement of people's lives due to greater access to energy and be a source of investment capital required for renewable energy, whilst also acknowledging the environmental challenges of the current energy supply mix.

In particular, geoscientists need to reach out and encourage the next generation of geoscience students. This new generation deeply cares about climate change and is keen to get involved. To attract talent, universities and companies need to show how their studies & work link to their core values, and how they too can become part of the solution.

Geoscientist have unique insights on long-term processes impacting the earth, are skilled in dealing with uncertainty, collaborate with other sciences and have the ability to deal with large amounts of data. Hence, step-up, play your role and seek the dialogue in the energy transition!

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THE FUTURE OF ENERGY

What is the role of the geoscientist in delivering the future of energy? Can I realistically help and have a positive impact on the environment as a geoscientist?

Against a backdrop of increased understanding and clarity on the changing climate, and how a transition of the energy system plays a significant role in this challenge, the role of the geoscientist can feel uncertain when looking to the future. Our expert panel set the scene for what the traditional energy industry can bring to the table, from skills and cash flow to ideas and expertise, and with it the geoscientists and their unique and valuable position to unlock the subsurface – a requirement not just to optimise remaining oil & gas production, but also for the intricate task of storing captured carbon alongside complimentary clean energy sources.

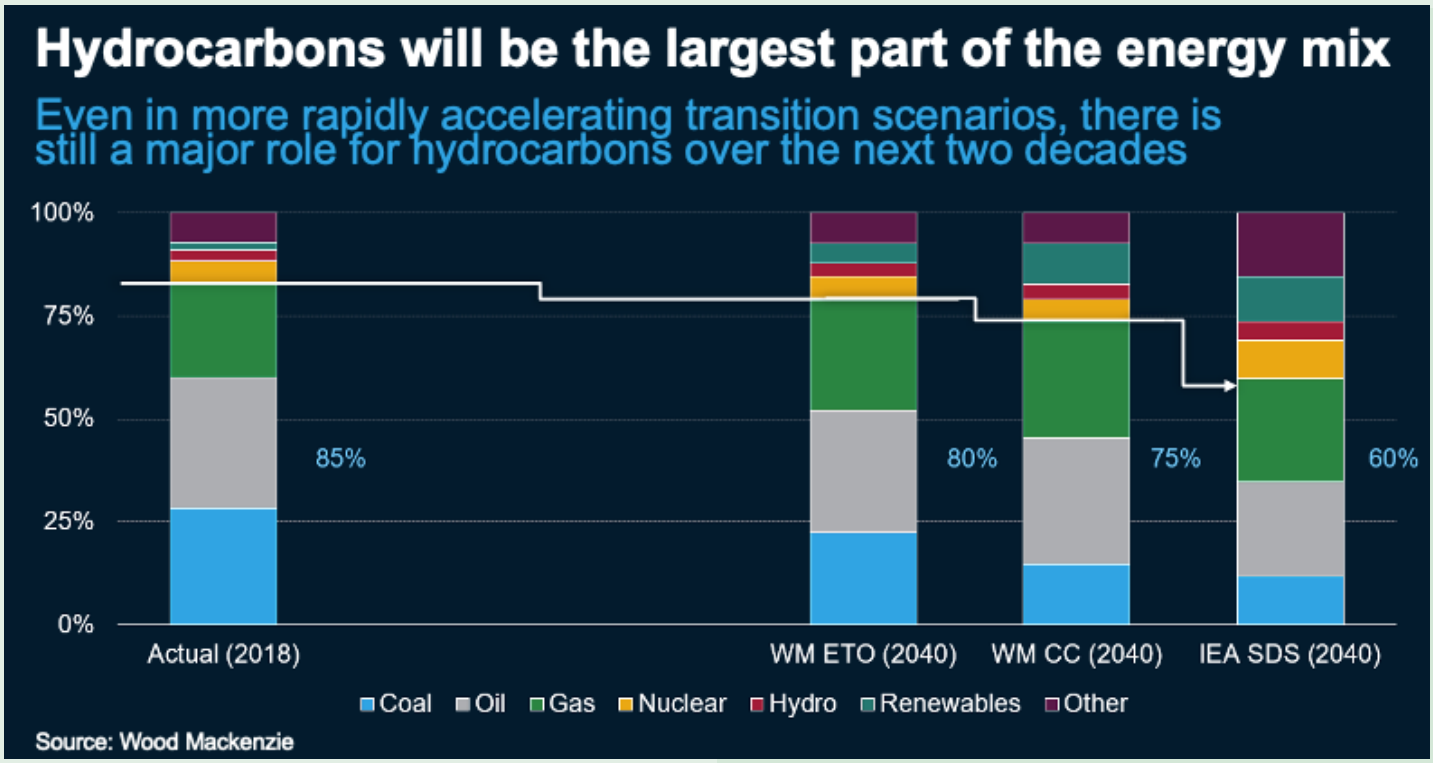
OBSERVATIONS:

- The energy industry has a proud history and a noble purpose - to supply the world with viable, adequate, economic, affordable energy without trampling on the environment or on other peoples' rights and aspirations - and its purpose today remains exactly the same.
- Throughout history the energy industry has done a phenomenal job of driving the global economy and providing relatively cheap and accessible energy.
- Given global emissions are exceeding the 2-degree Scenario – policy, technology and investment require a vast scaling up to shift incentives and behaviours to get back on track.
- As a key part of this, the energy transition is both necessary and inevitable. There have been energy transitions before; from wood to coal, coal to oil, oil to gas, and now to renewables & electrification.
- The Paris agreement cannot be achieved by technology alone, nor can it be achieved by solely looking to one sector – there is a need for alliances between companies, governments and civil society.
- To accelerate the shift to a 2-degree world, governments must incentivise low-carbon technologies – focus on decarbonisation of the industrial sector, the rise of hydrogen and Carbon Capture & Storage.
- This can be achieved by regulation from governments. A government mandated price on carbon that is high enough will force real change – all major companies have been asking for this.
- A global approach on items such as efficiency mandates on vehicles or banning CO2 emitting processes unless those emissions are captured, equals the playing field.
- Business as usual leaves us with devastating consequences including a global mean temperature increase of at least 6-degree C in the long term, rising sea levels, change in precipitation patterns such that dry parts of the world will get drier and the rainy parts getting wetter, fragile ecosystems will be put at risk, increasing occurrence of extreme weather events, ocean acidification damaging marine life and ultimately an increased risk to human lives and livelihoods. The cost of reactively adapting and responding to climate change could be huge.
- A transformation is required to enable the traditional oil & gas industry to achieve its purpose from other energy sources and also mitigate the negative impacts of both the new energy sources and the old. Economies that have viewed the energy transition as an opportunity are reaping the benefits.
- The traditional oil majors have the skills and cash flow to contribute enormously to this transformation, and geoscientists within these companies have an important and specific role to play.

"We as an industry need to be at the vanguard of how to accelerate the energy transition"
Neal Andreson, CEO, Woodmac

- Some companies are being perceived inaccurately as climate deniers, and a broader negative view of the industry is affecting the pool of talent available to the industry. There is an urgent need to demonstrate that oil & gas industry is positively contributing to the energy transition and accepting electrification. There is a need to be visible in embracing the Energy Transition.

THE FUTURE OF ENERGY



- There is a danger that the wrong choices will be made regarding energy if governments only hear one side of the argument; they may take steps of what needs to be done but toward more popular and less efficient energy policy decisions.
- A collaborative effort to work together constructively, with an open minded and cross sector approach, is needed to reach out into society to further the general understanding and appreciation of the energy sector. Dialogue should include vocal critics to engage them in development plans and proactively spread information.
- Recent trends have shown that shareholders increasingly do not want shares in a company without environmental standards – it is not solely about profit but a balance with responsibilities.
- Climate change is impacted by many factors, the Global Calculator (http://tool.globalcalculator.org/) allows testing choices we as society can make, such as an aggressive switch to renewables as well as material changes in food choices with the latter having a surprisingly big potential to impact the climate.

CONCLUSIONS:

- The role of energy throughout history has been hand in hand with economic growth. Now there is broad societal expectation of the requirement for this partnership to continue in a more sustainable manner and within the bounds of the Paris Agreement, working towards a 2-degree future.
- To accelerate the shift to a 2-degree world, governments must incentivise low-carbon technologies – focus on decarbonisation of the industrial sector, the rise of hydrogen and deployment of Carbon Capture & Storage.
- Change will not come from technology alone but from an alliance between business, governments and society. The current energy industry players have an important and valuable role to play.
- To improve the pace of change, industry needs to work collaboratively with society to help achieve the cheapest transition with the greatest positive impact, stimulated by pan-governmental policies. The energy industry needs to fix its image and act to continue to attract talent to work on the future energy solutions required today.

"Achieving the Paris targets cannot be done by one sector of society or one industry – it needs alliances between companies, governments and civil society"
Sir Mark Moody-Stuart, Chairman of Foundation for the United Nations Global Compact

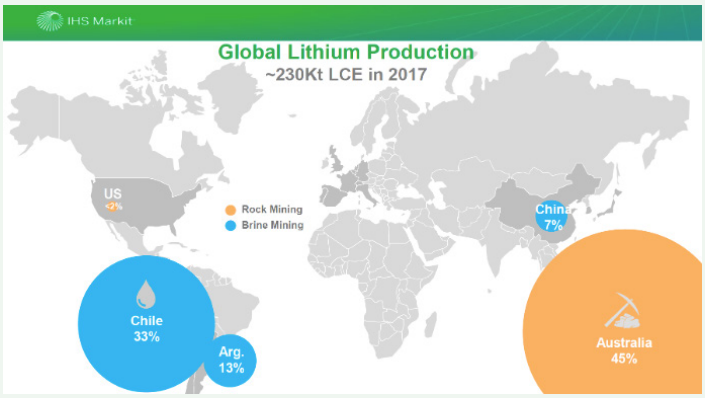
SUSTAINABILITY

Does the energy transition deliver real jobs for me as a geoscientist? How sustainable is a geoscience career?

As the world begins to shift to a carbon neutral and sustainable future, where does this leave the sustainability for geoscience careers? Beyond oil and gas exploration and production, where skills will certainly be required for decades to come, there are a number of surprising sectors in which a geoscientist could apply themselves within the energy industry.

OBSERVATIONS:

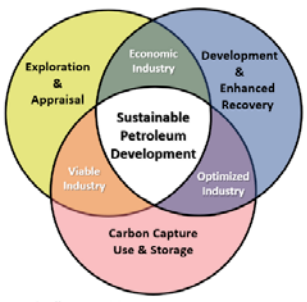
- The energy transition is part of a bigger sustainability picture involving population increase, economic growth and equality as some of the 17 partly interdependent United Nations Sustainable Development Goals (SDG). SDG number 7 specifically talks to energy – "Ensure access to affordable, reliable, sustainable and modern energy for all".
- The storage of captured carbon is increasingly important in order to mitigate climate change but progress has been too slow, for several reasons, including how it is framed and how it is perceived publicly.
- CCS deployed as a 'carbon neutral hydrocarbons' or for enhanced oil recovery does not help the industry's image. However industrial CCS for high carbon sectors that are difficult to decarbonise (such as cement and steel) is much easier to align with a renewable energy future – and a more noble cause to promote.



Source: IHS Markit

- There is a strong legal framework under the European CCS Directive to ensure the safe geological storage of carbon dioxide. The energy industry is covered by strict national and international regulations to ensure health and safety and environmental protection, and international standards for CCS are being developed by the International Organisation for Standardisation (ISO)
- The skills required in finding suitable CCS reservoirs are very closely linked to those of geoscientists currently within the oil and gas sector. Whilst the CCS industry is lagging in scale currently, the huge forecast for CCS demand in most decarbonisation scenarios means this is a viable long-term career consideration for geoscientists.
- Beyond a crucial role in CCS, geoscience underpins the exploration, development and risk management required in a host of energy centric businesses: solar, hydro, geothermal, wind, critical minerals and natural gas to liquids.

Source: United Nations



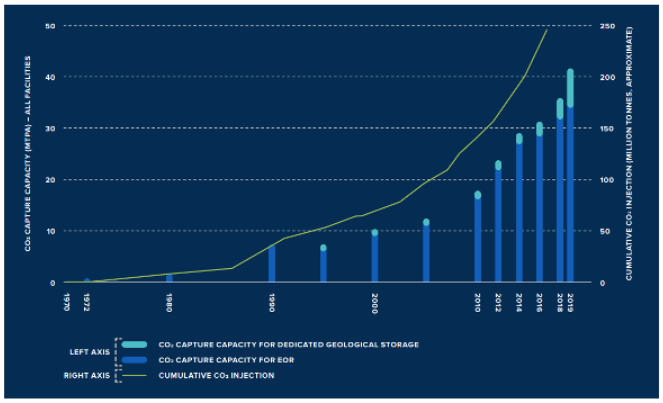
Source: ccsassociation

- Natural cross over and synergies exist between the worlds of oil & gas and those of geothermal. These can be deployed not simply for geothermal power plants but novel approaches. These include harnessing hot water co-produced by hydrocarbon wells, delayed decommissioning and repurposing of hydrocarbon wells for geothermal energy production and storage.
- Almost all future energy scenarios involve an exponential increase in battery technology. The underlying critical mineral exploration that will be required to support this resource demand will open doors for many mineral geoscientists.

SUSTAINABILITY

- One example of new ideas in old places is a lithium mining project in Cornwall. Lithium mining is in its infancy and is now a critical mineral, so new exploration and mining processing methods are required. New techniques are enabling production of this critical mineral in the UK.
- As the energy transition deepens and further opportunity arises to meet the challenge other technologies are likely to emerge. One such example is that of compressed air energy storage (CAES) in porous rocks – by injecting air into permeable strata using cheap renewable power in the summer, this can then be extracted and converted to useful power during the dark winter months to help balance out the longer term seasonal variety in renewable production.

"Cumulative contribution to climate change mitigation. By the end of 2017, more than 230 Mt of CO2 had been successfully captured and injected deep underground globally."



Source: Global CCS Institute – The Global Status of CCS 2018

CONCLUSIONS:

- The UN Sustainable Development Goals are commonly underpinned by geology. Geoscience as a pursuit and noble career is certainly sustainable. Whilst it is mostly associated with the exploration and production of oil and gas there is a wide and varied market available for geoscientists to apply their skills sets.
- For those joining or already within the oil and gas sector, perhaps looking to what the future may hold for their career paths, CCS should factor as a potential and very viable option given the expected growth in demand.
- Exploration for critical minerals will be more and more important as the electrification of a greater portion of the energy system relies upon a greater proportion of short-term storage.

"Our future is increasingly being shaped by new energies and digitalisation. As geoscientists we need to consider what changes are required to remain relevant and what opportunities this future offers"

Max Brouwers, Chairman, VP Exploration Europe, Russia & The Caspian, Shell

SURVEY RESULTS

Changing perceptions on the future for geoscientists in Energy…

In 2019 the forum focused on the impact that the energy transition will have on geoscience. But what do geoscientists themselves think about the future? How is the energy transition impacting their perceptions of career opportunities and does this vary around the world? To get a better understanding we surveyed our membership base. Here are the perceptions of geoscientists at the turn of the decade:

GLOBAL GEOSCIENTISTS – SURVEY STATS:

- 25 questions to gauge opinion on 4 topics: the future of energy, the role of the geoscientist, digitalisation, "your career"
- 601 responses globally
- Nearly even split between N America & Europe with ~16% Rest of World (RoW)
- 76% of N American respondents were experienced (>15 years in Energy Industry) compared to 50% of Europeans

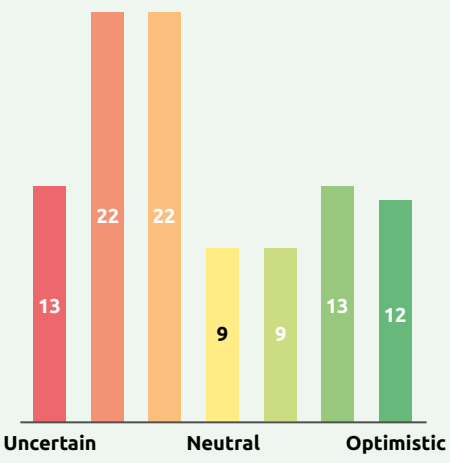
SURVEY OBSERVATIONS:

- Overall, the respondents are pessimistic about meeting the Paris Agreement 2.0°C target with 68% of geoscientists not expecting it to be met. Within this Europeans are more optimistic than North Americans, and younger respondents are more optimistic than those with more experience.
- Around 60% of the respondents said they were willing to dedicate some part of their career to meeting the 1.5°C future challenge. This was stronger within early career subgroups and whilst the experienced subgroup (>15 years) tended to agree, there was also a greater tail of those with more than 15 years industry experience which were strongly against; these responses were predominantly from within North America.
- Only approximately two-thirds indicated that they understand the role of Energy within the climate crisis.
- Regarding the natural environment, Europeans & the rest of the world (RoW) held a greater concern for the future of the environment. Less concern was held by those with longer careers.

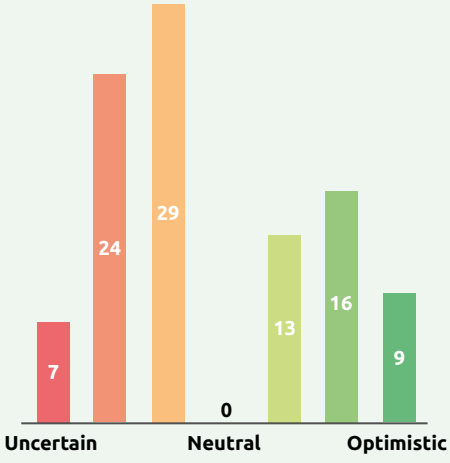
Changing perceptions on the future for geoscientists in Energy…

How do you feel about the future for geoscientists in Energy?

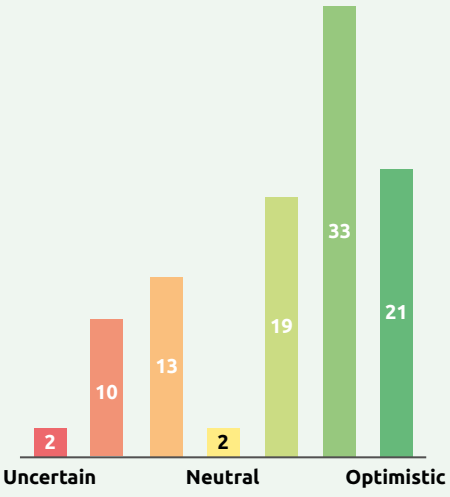
% Response of Pre-conference Geoscientists Survey (n=547)



% Response of Conference Attendees beginning of first morning

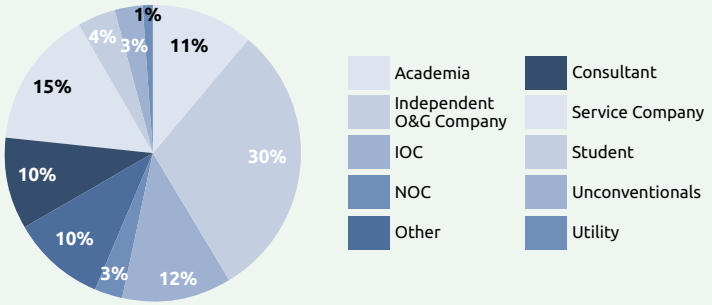


% Response of Conference Attendees end of last afternoon



SURVEY RESULTS

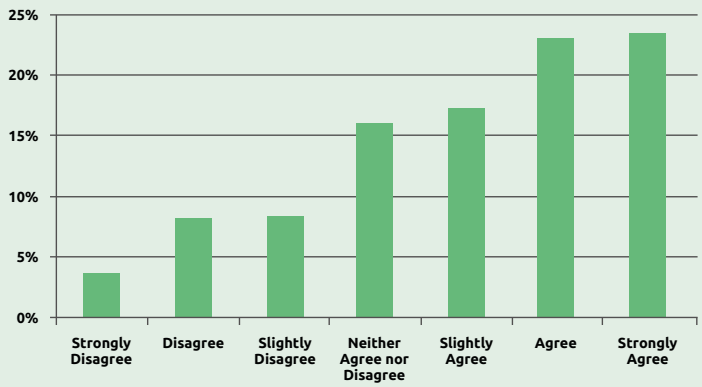
Survey Respondents breakdown



Source: AAPG Global Geoscientist survey 2019

- While 62% of respondents believe that Oil and Gas exploration can be consistent with sustainable development, only a quarter of respondents feel that their employer has a clear plan to work towards a 1.5°C future.
- The results indicate that those longer in the industry are more likely to agree that 'exploration for oil and gas is consistent with sustainable development'.
- It can be inferred that geoscientists really do love geoscience; 60% of repsondents would encourage new graduates to consider a career within the energy sector and 80% would encourage students to take up geosciences.
- This is despite the majority of respondents agreeing that geoscientists within O&G are perceived negatively by society (77% agree) with strongest belief held by those with 5-10 years' experience.

I am confident I can have a long and successful career in geoscience



Source: AAPG Global Geoscientist survey 2019

- Changing work place expectations can be seen in new recruits; less experienced geoscientists (<10 years) expect to work within different sectors of the energy industry with more uncertainty shown for those with 10-15 years experience and ambivalence for those with more.
- When considering digitalisation, 64% of respondents feel they have the skills to apply to digitalisation within the industry, however the younger respondes are more likely to try to diversify their skill sets. The more experienced geoscientists are more ambivalent about diversifying skills. Intent to diversify their skillsets is strongest for those outside of North America.
- 82% of respondents are aware of the digital tools available to them and all experience groups consider digitalisation to have a positive impact on geoscience (83% positive)
- However, of the 7% that don't believe digitalisation will have a positive impact on the future of geoscience this response mostly came from those with longer careers - none were new recruits (<5 years, 92 respondents)
- Whilst the majority of respondents (63%) are confident about a long and successful career in geoscience, those in the 5-15 years experience bracket have a greater proportion of pessimism relative to their subgroup.
- However, that sentiment is not equally held for the future of geoscience in energy:
    - 48% of all respondents are worried about job security with early career groups (<15 years experience) having a stronger tendency toward job security concerns than the experienced who are more ambivalent
- On the prospect of working in oil & gas in 10 years from now; this was a polarising question with new recruits (<5 years) more likely to state strongly for or against where as the other early career groups (5-15 years) appear more uncertain.

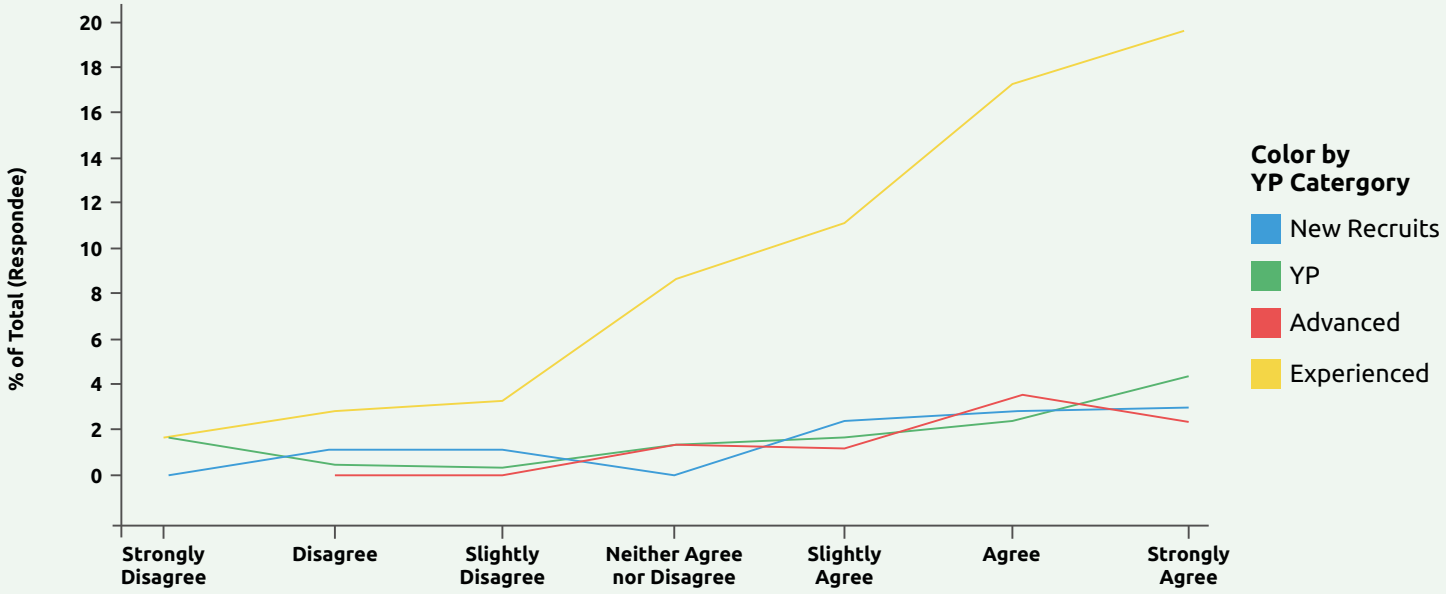
CONCLUSIONS:

Early Career Considerations

- New recruits (<5 years) have a greater proportion of skepticism toward a belief in Oil and Gas being a dominant part of the energy mix for the next 30 years.

SURVEY RESULTS

I believe geoscientists within the oil and gas sector are perceived negatively by society



- Less experienced geoscientists (<10 years) expect to work within different sectors of the energy industry.
- Survey respondents with less than 5 years experience were the only demographic to hold a more positive view regarding company loyalty as a determining career factor.

Regional variations

- Respondents are more likely to be intending to diversify their skill set outside of North America.
- Europeans are more likely to be optimistic about meeting the Paris goals.

Future Skills Supply

- Most respondents would encourage others into geoscience and energy, even though they believe they will be negatively perceived by society.
- Most respondents have confidence in a long and successful geoscience career, but half have concerns on job security and there is uncertainty across the board about the future of geoscience within the energy industry.
- There may be uncertainty for future oil & gas roles but younger geoscientists are willing to diversify their skill set and work within other sectors of the energy industry.

"We as an industry need to be at the vanguard of how to accelerate the energy transition"

Neal Andreson, CEO, Wood Mackenzie

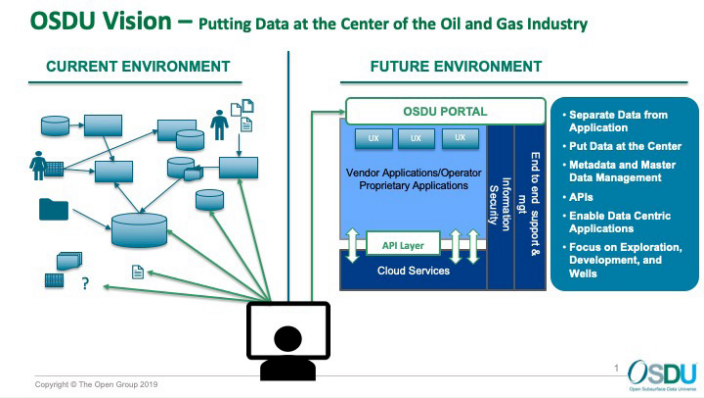
DIGITALISATION

Is digitalisation an evolution or a revolution? What is the geoscientist already doing differently?

Geoscientists have been digital for over 20 years. With all the talk of 'digitalisation' in recent years are we talking about the development of routine systems and applications currently in place or true disruption? It's time to step beyond the jargon and understand how ways of working have already changed, where they will continue to change and how to capitalize on this.

OBSERVATIONS:

- The proliferation of cheap and available computing power over the previous decades has changed how geoscientists approach their work. People entering the workforce are very aware compared to previous generations and those that follow will normalise what we today consider cutting edge.
- Today we are seeing the next step for the accessibility of this computing power through parallel developments in connectivity and bandwidth. Whereas a decade ago geoscientists were working from dedicated high-end workstations the geoscientist of the future will be working off the cloud, as some are doing today.
- Increased connectivity and the vast processing power available at offsite super computers presents both opportunity and challenges. Whilst we can do much more with our data much more quickly, we are limited with the accessibility to that data. The bottle neck has moved from the machine to the warehouse.
- To combat this, new approaches to data storage and the systems that support it will be required. A more collaborative culture, sharing of information, can be developed. Building software for closer collaboration between operators and vendors can minimise this bottle neck whilst still respecting legal ownership boundaries and agreements to protect data and IP.
- Concerns about security for data in the cloud are not warranted, the cloud is secure above and beyond anything prior. The music industry had to resolve the same issues around digital rights and entitlements, they too have complex transactions, the energy industry can learn from them.
- Historically seismic data has been stored in a high carbon footprint way, multiple companies storing the same seismic data in warehouses. Utilising the cloud reduces this footprint by removing duplication. Because power demands of the data centres are so high, increasingly now this data is stored in energy efficient areas, powered by renewable energy. With a more common approach to digital storage of data the carbon footprint is being reduced by working more remotely. Coordinating supply chains digitally drives efficiency and reduces CO2.
- One of the biggest blockers to unlocking the industry's data to the digital opportunities available is simply getting data into the system. It takes time, effort and dedication with everyone often trying to do their own independent thing. This risks creating a tiered digital transformation with familiar difficulties when crossing different geographies, different regulations, different pace of change and data residency laws.
- However, there is a mindset shift happening, a real willingness to look differently at this – across workflows and security – with real momentum growing.



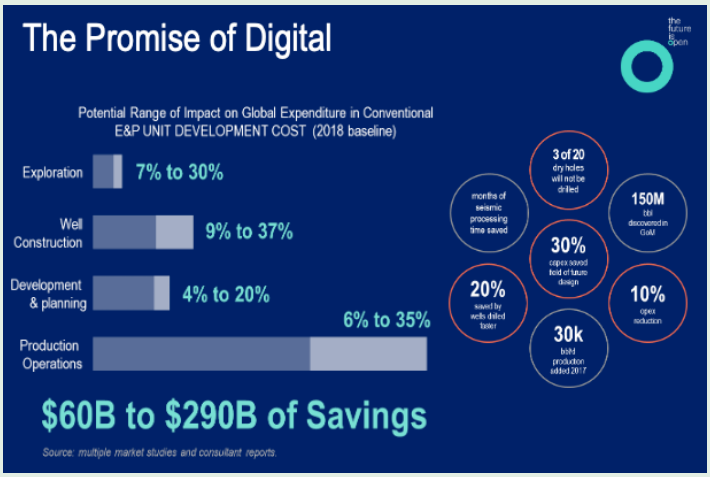
Source: Open Subsurface Data Universe

- The Open Subsurface Data Universe (OSDU) is a potential solution to these challenges, presenting a cloud based, connected, secure and accessible approach to connecting the industry's data to the potential of digitalisation workflows.
  - All subsurface and wells data in one data platform, removing the silos

DIGITALISATION

- Data is separated from applications, all data accessible to all applications
- Global oversight on what data is available, access to all meta data
- With this start-up, third parties, in-house teams and academia can develop software useable (once licensed) to all operators running OSDU, creating a much larger market

- Once the data is loaded, new technologies that harness previously inaccessible computing power, such as machine learning (ML) and artificial intelligence (AI) will enable greater flexibility and speed in workflows, allowing geoscientists to focus where they need to focus – deploying their critical subsurface understanding.
- Rapid seismic processing of massive data sets may be accessible in the coming years, allowing optimised planning, increased efficiency and reduced subsurface risk.
- Automation of data and processing will not reduce the need for skilled geoscientists, rather it may increase the ability of those experts to deploy their skills to the subsurface challenges.
- Digitalisation of the work environment is happening today and there are huge opportunities for the geoscientist of the future with unparalleled access to data, combined with the ability to work with data in new ways.



Source: Presentation by Stephen Warner

CONCLUSIONS:

- Digitalisation carries a broad meaning for the energy industry. Behind all of the jargon there is a common theme of remote access to vast computing power to unlock massive potential in workflow efficiency, optimisation and greater availability for geoscientists to apply their critical thinking skills to subsurface challenges.
- To be able to capitalise upon this opportunity the energy sector needs to de-bottle neck our old ways of working. With increased bandwidth enabling cloud-based solutions with greater reliability, there is a need to unlock the sectors data to release the potential. This requires a paradigm shift approach to data. We will need to learn from other industries that have overcome similarly complex problems.
- A collaborative approach to digital storage, rights and IP will be required from vendors and operators alike, to enable cross boundary solutions which respect legal agreements whilst minimising the current inefficient and carbon intensive physical storage solutions repeated my multiple companies.
- The solution to these problems is within our grasp in the coming years and with them will come new opportunities for the geoscientist. New skills will be required but nothing will replace fundamental core subsurface understanding and expertise.

"Think big, smart small – we all own the future so start inventing"
Arno Van Den Haak, Head Worldwide Business Development Oil & Gas at Amazon Web Services

SKILLS AND NEW WAYS OF WORKING

How do we ensure a supply of top talent pursuing geoscience career paths in the future? How do we equip graduates and staff with the skills & experiences needed to support all relevant stakeholders in the ongoing energy transition?

With change occurring in the sector at a greater and broader pace the expectation of geoscientists is evolving. A solid grounding in fundamental subsurface principles will always be a key component for geoscientists. New recruits and experienced staff alike need to complete that grounding to approach challenges raised by the energy transition and digitalisation.

OBSERVATIONS:

- The change across the energy sector is bringing a new emphasis to the skill sets required by geoscientists. From digitalisation to sustainability, the considerations when planning training and development are perhaps more varied and uncertain than they have ever been for geoscientists when thinking about their careers.
- A common observation when considering the challenges faced by the sector is the concept of data only being as good as the geoscientist analysing it. Fundamental grounding of core geological principals will always be required, and complimentary digital skills should not be prioritised in place of this.
- However recent trends have shown a marked decrease in applications to read Geology at universities. In the UK, 38% drop between 2012 and 2019. The sector is failing to attract sustainable levels of talent from graduates and this exposes the energy industry to a looming skills deficit as mature experience retires.
- Recognising the image problem the energy industry holds, particularly the hydrocarbon sector, there is a challenge to understand how we can be distinctive and relevant to all levels of the educational system – from schools through to colleges and universities but also outside of academia to the general public and broader society.

Source: Presentation by Edith Newton Wilson, AAPG EMD

- The narrative on 'why' linked to the underlying purpose of the sector is becoming more of a factor for graduates when considering a career in the industry. It is no longer sufficient to buy talent, the package on offer needs to be clear on purpose and impact – starting with the 'why' before building on the 'how' and 'what'.
- Demonstrating the role geoscientists play in the future energy mix is incredibly important, particularly in reassuring existing staff of their future employability and attracting new graduates today. From geothermal, blue hydrogen and complimentary services required for renewables, to sustainable resource exploration for critical minerals used in batteries, there is a great demand for skilled geoscientists.
- Exploration for, and understanding of, suitable long-term storage sites for carbon, hydrogen, heat and comressed air are all critically important and are roles that geoscientists can fill. Almost all future decarbonisation scenarios factor in a large CCS component, mostly deployed as the efficient way to decarbonise heavy industry (e.g. cement & steel production).

SKILLS AND NEW WAYS OF WORKING

Geoscientists joining and currently within the oil and gas sector are best positioned to transfer their skills to this challenge and should be encouraged and rewarded to do so.

- Institutions are beginning to step up to the changing expectations of graduates and programmes such as the Centre for Doctoral Training (CDT) in GeoNetZero, as an extension of the original CDT in Oil & Gas larger Doctoral Training Partnership (DTP) scheme, is one successful example of this:
    - Helping provide a greater emphasis on linkage between geoscience and its societal relevance;
    - Adding value and all-important context to the research being undertaken; that faces key Global Challenges
    - Including 20-weeks of high-quality training to enable both a skills and academic grounding;
    - Placing geoscientists at the heart of the decarbonisation debate.

CONCLUSIONS:

- There is a huge role for geoscientists and the energy industry should not resist change, we should be leading into it.
- Challenges with our public image need to be overcome such that we can attract sustainable levels of talented geoscientists.
- Geoscientists have a complimentary and diverse skill set to be proud of. Almost every Sustainable Development Goal "starts with the rock" which means someone still needs to know that rock and how to find that rock.
- To contribute to the future energy system geoscientists should consider their skill sets against an evolving digital future but keep true to their fundamental grounding in the subsurface.
- The pace and rate of change as technology becomes even more ascendant through the digital revolution will mean organisations will need to pivot significantly to continuous learning to ensure they've got sufficient skillsets in their staff.
- We need to think not only of the technical skills, but how we develop and engage and continue to reward geoscientists as they move their careers through the energy transition. That might be initially working in the front end powering the energy transition, but then transitioning themselves into the sustainable sectors that will really drive the transition to closure.

"There is a need for a call to arms and we must find the connect: the geoscientist's skills and techniques, combined with the wonderful imagery they deploy, needs to be communicated to a younger generation who have the skillsets to use this technology and these digital techniques and also have grave concerns about the planet, that must be respected. Joining these two factors into an ongoing narrative that geoscientists – geologists and geophysicists in particular – have an integral role in solving the problems and global challenges that are facing the earth is key. The younger generation want to make a difference"
John R. Underhill, Professor at Heriot Watt University

FURTHER RESOURCES

http://tool.globalcalculator.org/
www.opengroup.org/membership/forums/open-subsurface-data-universe
www.ogauthority.co.uk/data-centre/national-data-repository-ndr/
https://www.theogtc.com/newsroom/news/2020/14m-to-map-carbon-storage-potential-of-uk-offshore-areas/
www.aapg.org/divisions/emd
https://geo-net-zero.hw.ac.uk/
www.geolsoc.org.uk/Geoscientist/Archive/September-2019/Feature-1