energy transition

Competing in a new energy landscape

Geoscience in a new era

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SUMMARY REPORT

MESSAGE FROM THE CHAIRMAN

AAPG Energy Transition Forum – A New Era in Geoscience

Max Brouwers

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

As the energy industry considers lower-carbon technologies and new commercial models to carry it through the energy transition, the AAPG Forum Design Committee considered where that leaves the geoscientists that support a sustainable energy future. Ensuring the relevance of geoscience today and tomorrow presents us with several dilemmas.

We believe that this forum went some way into addressing these dilemmas. Deepening the answers lies with ongoing conversations on the future of energy, sustainability, digitalisation, talent & skills and collaboration between a broad range of technology, geoscience, renewable and oil and gas industry contributors and regulators.

During the two days of the forum, discussion focussed on certain core themes. The emerging consensus was that:

- The Energy Transition is irreversible, but will take different speeds and shapes in different geographies, given various local economic and societal pressures. In all scenarios there is still a need for oil and gas for the foreseeable future, and the demand for certain earth metals will actually materially increase.
- Geoscience skills are still needed during the Energy Transition to continue to provide the increasing amount of energy the world needs in the decades to come. This energy will come from a more diverse set of sources and many require geoscience skills (e.g. geothermal). Also, subsurface skills are required for environmental solutions, such as carbon capture and sequestration.
- Digitalization will transform the geosciences as it is such a data-rich field and that is where Artificial Intelligence (AI) and Machine Learning (ML) can have the biggest impact. Digitalization is not expected to take away geoscience roles, but will materially change the way we work.
- Geoscientists bring unique skills to the Energy Transition, given their deep experience dealing with highly complex problems and the use of big data. The geoscientist of the future needs deep 'domain knowledge' as well as being adept with digitalization.
- Geoscientists can be proud of the huge contributions they made to the progress of society over the past decades. They now need to step forward and engage with the wider society on solving the dilemmas associated with the Energy Transition.

A diverse programme committee recruited distinguished, expert speakers to address the themes of the Future of Energy, Sustainability, Digitalisation, and Skills and New Ways of Working. Sessions were structured to provide thought-provoking presentations that prepared us for interactive breakout sessions utilising a variety of facilitation styles to maximise engagement.

The following pages constitute a scribe's report of the discussions

THE ENERGY TRANSITION OVERVIEW

We are witnessing and can contribute to the deepest, most far reaching and fastest transition of humankind: this is happening because of us and produced by us. The Energy Transition is a huge responsibility but also a huge opportunity, global demand for energy continues to rise, while the fuel mix will change significantly as we try to reduce carbon emissions.

MACRO TRENDS:

- The world energy consumption rises mainly in new emerging economies. Accelerating energy demand is driven by population growth and economic development – there will be 1.8 bn more people in the world by 2040 with 75% of the population living in cities – India and China and Africa will lead energy demand growth over 2015-50, while China peaks and OECD markets decline.
- The global energy scene is in a state of flux due to both economic and societal drivers. Large scale shifts in the global energy system are happening thanks to rapid deployment and deep declines in cost of major renewable energy technologies and growing shift towards electric in energy use across the globe.
- Many countries are trying to do the right thing for their economy and populations; they are not driven by a desire to save the planet.

ECONOMIC DRIVERS UNDERPINNING THE TRANSITION:

- The hydrocarbon era is not over soon. According to a McKinsey scenario, fossil fuel use might flatten from 2035, with oil and coal in decline but gas use continuing to expand. In the next decade, liquids demand growth is fueled by chemicals and transport.
- **Coal** demand is expected to peak in next decade, there will be a rapid and intentional displacement of coal with gas. Governments must be convinced that gas is a viable and profitable alternative to coal.
- **Oil** is expected to peak in the next two decades. Its decline won't end for lack of supply – technological and economic competition for oil is coming, with a shift from oil-based transport to electricity based transport. The question is "when" rather than "if".
- **Gas** demand is foreseen to continue to grow to 2040, with the pace determined by affordability of gas relative to other fuels and technologies and policies that governments put in place. Demand growth is driven by China's policy push for gas use in power and industry as well as by competitive prices in producing regions.
- **Electrification** across key end uses – particularly in buildings and road transport – underlies an acceleration of electricity demand relative to demand for other fuels. Energy intensity is improving across regions and end-use sectors with the switches to more efficient fuels and technologies. Strong improvements in economics of electric vehicles trigger rapid uptake, for cars as well as trucks. In a disrupted case, electricity demand growth could be boosted to 2.9% per year.
- **Renewables'** cost decline accelerates further, out-competing new-built fossil capacity today and existing capacity in 5-10 years causing electricity demand to grow four times faster than all other fuels.
- **Carbon Capture and Storage (CCS)** can play a prominent role in the Energy Transition, but faces much resistance on land through the social license to operate. Political and social will is the challenge. Oil and gas companies must be seen collectively as leaders in this. This will increase their market value because of investor expectation, and also garner public approval.

> "When economics and society come together to change we will be at a tipping point for energy transition"
>
> Lucia van Geuns, Strategic Advisor Energy, The Hague Centre for Strategic Studies

> We have to understand that this transition is fraught with challenges and barriers and naysayers. In the face of this you have to be stubborn in your optimism because you know there is a better future for the world and your profession
>
> Christiana Figueres, 2010-2016 Executive Secretary of the UNFCC

SOCIETAL & GEOPOLITICAL DRIVERS UNDERPINNING THE TRANSITION:

- In a fast-changing world, key uncertainties will determine how these developments play out locally – regulatory/municipal push for electrification/decarbonisation; market models and implications of high renewables systems; nuclear and coal politics sensitivities; fossil fuel price impacts; resource and supply chain implications; consumer consciousness.
- **China's** investment is mostly in Renewable Energy: they want to create 13 million jobs and provide their population with cleaner air. China's mix changes fast – China will invest between 2017 - 2020 343 billion euros in wind, nuclear, hydro and solar to replace their coal-fired electricity generation.
- **Morocco, Chile and Mexico** are three Renewable Energy leaders – this is to satisfy the growth in energy demand, job creation, and the need for affordable energy.
- **India** has a moratorium on all new coal from 2027 with solar being cheaper than coal in India. However, currently strong growth in coal demand in India and other developing markets partially offsets declining demand in OECD countries and in China.
- **US** CO2 emissions gone down due to a surge in shale gas production, which replaces coal, however cheap US coal now exported to Asia and Europe increasing emissions there. US coal exports increased by 61% in 2017 as exports to Asia more than doubled. US monthly crude oil production exceeded 10 mbpd, highest since 1970.

OIL AND GAS INDUSTRY RESPONSE:

- To achieve a successful Energy Transition, companies and individuals must be part of the response to future challenges; they will need to find new innovative and sustainable ways to provide energy; they will need to utilise climate efficient energy production technologies and techniques and many will choose to become broader energy companies.
- Industry needs to keep identifying tipping points – e.g. Move to shared mobility is a tipping point particularly in China given the scale – if the government decides to shift to electric cars this could happen within 4-5 years and Chinese power systems are already designed to accommodate this.
- The speed of digital capabilities and pace of change will mean that companies will be able to work together in the future to produce new products by sharing data – especially datasets that are not competitive data, such as HSE. The role of the geoscientist in all of this is still hugely important: they already have experience of dealing with highly complex problems; they are used to big data.
- Digital will not take away jobs, but jobs will fundamentally change. The industry will have intelligent machines and data platforms but geoscientists will still be fundamental in creating solutions from software that provides reliable data and has increasingly reliable datasets.
- Reputation management needs to be a priority, as the low carbon world still needs some fossil fuels. The oil and gas companies who are going in this direction are beginning to make this change. However, there is an industry need for state and national oil and gas companies to adopt the same disclosures as the IOCs – lack of transparency will affect the whole industry both operationally and reputationally.
- Companies need to develop non-traditional learning methods, such as Yammer groups and apps to enable seniors to coach younger colleagues; reskilling will play a key role in ensuring that workforce is "fit for purpose".

> Geoscientists can transfer their skills – think big, think wide
>
> Lisa Rebora, Head of Sustainability and Strategy, Equinor

GEOSCIENTISTS IN THE ENERGY TRANSITION:

- Geoscientists will have a continuing role to play in gas – certainly until 2050 or 2060. But even if the move to renewables goes at an accelerated pace, geoscientists will remain very important in carbon capture scenarios and new energy solutions such as geothermal, and the development of other types of renewable projects.
- Additionally, the 2 degree economy that will exist by 2050 will create a demand for new metals and minerals – 200% increase in demand for aluminum, iron, lead and nickel; a staggering 1000% for cobalt, lithium, manganese. Challenge is that we have very little understanding of those levels of metals and minerals, and very little geological data means huge demand for skill sets.
- The mix of skills that geoscientists have is unique, particularly in managing data and solving complex problems. There will, however, be a need for more people who are multiskilled by integrating geological knowledge with that of computer science.
- There are boundless opportunities for geoscientists in geothermal development, and other low carbon energy sources, where technologies and concepts need to be developed.
- Universities need to proactively reinforce the message that petroleum geologists and petroleum engineers are still needed in the future, but may need to change the curriculum and how the profession is promoted.
- There is great confidence in the next generation: they are already hugely environmentally aware and it is important that senior professionals inject optimism and empowerment into the next generation of decision makers.

CONCLUSIONS:

- We are transitioning to towards a low-carbon world; this is good news for the planet and for humankind.
- The Energy Transition is irreversible and within this oil and gas definitely have a future for decades to come. There is a lot of uncertainty on the speed and magnitude of the change.
- There is no single story about the future of global energy: policies and/or events will determine the way forward.
- The form the Energy Transition will take place around the world will depend heavily on geography, national economic priorities, political will and public opinion.

> In face of the huge opportunities and uncertainties we face, geoscientists need a suitcase full of skills to be ready to travel – not just geographically, but cross-disciplines and across the value chain
>
> Max Brouwers, VP Exploration Europe, Russia and the Caspian, Shell

THE SUSTAINABILITY TRANSITION OVERVIEW

Will in-depth domain knowledge be enough or will the geoscientist of the future need to have hybrid competencies and a polymorphic skillset? It is conceivable they may also need to be better versed in the commercial part of the business, willing to work beyond upstream and into the extended value chain and mobile across a broader industry, from digital tech, to seismic operator, to oil & gas, to renewable and back. What impact will that have on how jobs are done, the skills necessary and the culture of organisations?

> A diverse energy mix requires diverse people - it is time for Geoscientists to position themselves in the Energy Transition dialogue

Marit Brommer, Executive Director, International Geothermal Association

OBSERVATIONS:

- Important to remember that improvements in society over past decades are due, in part, to reliable energy supply; the industry has endeavored to provide access to affordable energy to an increasing population. The industry should be proud of the fact that it not only delivers affordable energy but can also create businesses, employment and training in the countries in which it operates as well as it generating revenues for host countries.
- License to operate is underpinned by three cornerstones: security of supply, cost efficiency and producing hydrocarbon at the lowest possible CO2 intensity. Threaded through all of this are the UN Sustainable Development Goals and the terms of the paris Agreement. Key sustainability areas are carbon footprint, flaring, distance to infrastructure and development concept – geoscientists have huge role to play in these areas.
- The world as we it know is changing rapidly; 65% of today's primary school children will have a job that doesn't exist today; the rise of renewables will create new companies within the supply chain and new types of jobs. Society will demand change as younger generations are more sustainable focused and they will become the change agents in the coming decades.
- Geothermal Energy is an area where geoscientists can and will play a key role. However the technology called Engineered Geothermal Systems that aims to produce heat from sedimentary basins and granite basements is still immature. There is a need for investment in new technologies and standards, such as geothermal well designs and the definition of geothermal reserves and resources.
- The International Geothermal Association is deploying the UN Framework Classification on geothermal reserves and resources and aims to set guidelines, principles and worldwide best practices.
- Paris and Munich are two leading cities on the road to geothermal. Drilling is ongoing in Paris, and Munich aims to be about 100% geothermal by 2030. Leading countries are Iceland and Costa Rica, which achieved 99% renewable energy in 2017.
- The approach to the Energy Transition must be collaborative and the wider energy industry needs to adopt a stakeholder approach. However, progress is not fast enough to reach Paris Agreement goals and Social Development Goals. Strong need for a coherent ongoing vision – REN 21 working with International Energy

"We need to change our perception and myths and leave our comfort zones"

Rana Adib, Executive Secretary REN21

Agency; if the renewable players and efficiency players and the oil and gas players would come together it would be powerful.

- Still huge disparity in subsidy levels for fossil fuels and nuclear versus renewables; this tension is at a country level unless international policy is set.
- Renewable Energy has decentralised systems and hence not centralised investment – there is a clear trend to distributed approaches. Policy frameworks need to build in different approaches and create a level playing field for renewables and decentralised off-grid renewables

CONCLUSIONS:

- The renewable energy route and powergen are now commercially attractive, not just driven by green credentials; geoscientists have the skills to know where to look for the best resources that are most cost efficient and deliver the lowest carbon intensity. Their role is critical in managing the carbon footprint of mature fields.
- Companies need to be able to run rigorous scenarios that truly stress test the business case, the commercial case, the risk profile and the carbon footprint calculation.
- There are many skills that are transferable to renewables: opportunities exist across the energy supply chain or when working in an integrated oil company. For example, Offshore Wind projects are large complex projects that need a robust safety culture, marine operations and maintenance, technology innovation and the ability to leverage local presence and corporate capabilities. Geoscientists can transfer their skills.
- The Energy Transition poses lots of challenges and many solutions; a key enabler will be to introduce a rigorous emissions system for not just CO2 but all damage but this is heavily dependent from region to region. Specific countries and regions have very different attitudes and regulations – organisations like OGCI have huge part to play in this and in creating a standardised approach.

"When the next chapter is written, we will see the value was between people and new technology"

Ashild Larsen, CIO and Senior Vice President Corporate IT, Equinor

THE DIGITALISATION TRANSITION OVERVIEW

In a world that focuses increasingly on Artificial Intelligence and Machine Learning, where are the opportunities for applying digitalization to improving every facet of the exploration discovery and production value chain? What ambitions are there for applied digitalization, which improves ongoing businesses with the potential of areas of co-creation.

OBSERVATIONS :

- Sustained low oil prices in the oil and gas sector for the past five years has driven significant pressures in CAPEX and has driven new levels of operational efficiency invoking pressure on the knowledge agenda.
- Increased M&A activity and growing consolidation has given rise to new business models while the industry is experiencing substantial talent departure – there is a significant challenge in filling the knowledge gap.
- These disruptions drive the need for new levels of innovation and digital is very important in that context. There is a need to combine digital technologies with geological domain knowledge to enable industry goals. These need to be packaged so assets are created that are useable for everyone and link technical experts to domain experts to fully capitalize on the latest transformational technologies being brought to market. All data will be accessed from all places by anyone, so security is paramount.
- The Digital transformation will be data centric, not just traditional data but structured and unstructured data; this is where new technologies are so key, the 80% of unstructured data that has traditionally been 'dark', can now be analysed and made sense of, enabling seismic shifts in the value that can now be gleaned from this new data previously unreadable through traditional computer. Now all data can be understood, it can be personalised so you can see what is relevant to you, scalable across the E&P value chain, and automated to eliminate manual tasks.
- The four main pillars of the digital transformation are:
  - **Cloud** – data accessed through the cloud, increasing speed in processing of this data and reducing the traditional costs associated in hosting it.
  - **IOT (Internet of Things)** – there is an explosion of connectivity driving embedded devices that can now talk to each other to reduce maintenance costs and drive efficiencies.
  - **Artificial Intelligence /Cognitive Computing** – now all data can be understood by AI technologies, it can be reasoned with and can learn from the data. AI will not only assist geoscientists in their day jobs, but it will formulate hypothesis from its knowledge based to advise professionals and ultimately recommend the next best action they should take. As such, AI for the E&P community should be seen as Augmented Intelligence as opposed to

> "It's not only energy transition, we're talking about energy disruption; this disruption drives the need for new levels of innovation and creates transformational opportunities for the next generation, particularly around cognitive AI – we will be looking at a new skills demand and new levels of innovation"
>
> Luq Niazi, Global Managing Director, IBM Chemicals and Petroleum Industries

'Artificial', as it will never truly replace a human. All major processes and major industries will be transformed by AI in the next 5-10 years.

» **Block Chain** will transform how all transactions are made in the future. Providing an immutable digital ledger so that the provenance of every component of a transaction is secure.

- Combining the four main pillars allows a rapid analysis of massive volumes of divergent data, shows new pattern sequences and value and as a result innovation now takes days or weeks, not years.
- The digital transformation provides the ability to gain new insights aided through the advent of High Performance Computing which helps to discover data you never knew you had with the power to process it at scales and speed never previously imaginable. This processing power will further increase exponentially with the rise of Quantum computing which will fundamentally transform the technology industry in with unparalleled precedent.
- Knowledge across the organisation will be available to all – including people who wouldn't previously have had access to it. This helps to re-imagine the workflow and approach problems differently.
- Machine Learning (ML) will transform our way of thinking – e.g. do we need additional appraisal wells? ML will allow the E&P community to reduce decisions made using human-centric binary rule based approaches, increasing analysis accuracy and removing the need for humans to perform these activities.

CONCLUSIONS :

- Augmented Intelligence (AI) will allow interaction that will enhance the decision basis, but not replace the geoscientist. It's about helping humans become faster and smarter at the tasks they're performing. It will make them more effective by unlocking the dark data and correlating it with multiple sources and allow them to concentrate on less obvious tasks. On the other hand, AI will drive a new skills demand and new levels of innovation. It is currently anticipated that AI will in fact have a net-positive affect on jobs in the Oil and Gas sector, even if it removes the need for some of the less skilled roles.
- Seeing change in oil company profiles, especially in mature areas – private equity funded small companies need to access to the same technology as the majors. Having access to all these technologies allows smaller companies to play on a level playing field and gives them the same access as the larger companies.
- New forms of collaboration will change how Oil and Gas companies work. Need to collaborate especially with technical institutes to ensure continued development with customers to ensure solutions are appropriate and with technology organisations to ensure optimum delivery.
- Another significant change is that there will be increasing collaboration between contractors because oil companies are demanding that domain experts will collaborate with other domain experts. In the future we will look to who is able to participate in the data ecosystem – this will be an interesting transition.
- The future composition of oil and gas industry staff will still be heavily geosciences based but they will be interacting with a wider spectrum of people from different domains to accommodate the move from How? to What?
- Possibility of global collaborative E&P cloud – we are heading to a space where we can prospect in the cloud and build a database to provide all the micro services to help with full life cycle.
- We are at the dawn of a new era. The new world requires agility, flexibility and a platform to leverage these abilities and innovations. It will be digital. Cloud is the new normal. New tools: AI, ML, scalable computing, IOT and integration require a new way of working and allow the emergence of new business models driven by the integration of technologies and capabilities not imagined before.

YOUNG PROFESSIONIALS' PANEL DISCUSSION ON DIGITAL

"When people get over the idea that something that took a year, such as seismic interpretation, now takes a day or less, our processes will need to be radically changed and project plans will need to be radically altered to accommodate that. It will change the day-to-day workflow significantly"

Arno van den Haak, Head Worldwide Business Development, Oil & Gas at Amazon Web Services

The Young Professionals or Next Generation see digital in a significantly different way: "it's just there" – you need to work at getting the most out of the data we have and this needs constantly changing technologies. Digital helps work/life balance and they expect exceptional user experiences. They acknowledge the need to extract more value from data and saving time; they see it is an enabler to making workflows much faster.

They see their oil and gas company leadership embracing digital through their digital roadmaps, but companies need to overcome the challenge of translating these topics so that people do not misapply terms. They feel their leaders give them trust and space to actually pursue these roadways even if they don't quite know where it will take them. They see an increasing number of data science professionals within their companies. The service providers see digital as inherent in what they and their companies do – it is a natural profession of the day-to-day work. Those just graduating have often had AI, machine learning and programming as part of their degree course. This is important so that students learn how this can be integrated into geosciences. Online courses to learn about AI and machine learning can play an important part of a young professional's learning journey. Working in collaborative teams greatly enhances learning and skills adoption and is fundamental to knowing what is possible in this environment. They have faith that geoscientists are not going to be replaced by machines! It will still be possible to have a technical career with digital providing more time and greater efficiency. They see the opportunity to move across organisations from exploration to new technology development and digital. They are impatient, however – they know the potential and the promise, and are eager for the data ecosystems to be in place. The new graduate wants to work in a company that "takes the digital transformation in its stride, is transparent and good at communicating" both internally and to society as a whole. Five key factors for the next generation are: Speed, Change, Progress, Innovation and New Skills.

SKILLS AND NEW WAYS OF WORKING

Will in-depth domain knowledge be enough or will the geoscientist of the future need to have hybrid competencies and a polymorphic skillset? It is conceivable they may also need to be better versed in the commercial part of the business, willing to work beyond upstream and into the extended value chain and mobile across a broader industry, from digital tech, to seismic operator, to oil & gas, to renewable and back. What impact will that have on how jobs are done, the skills necessary and the culture of organisations?

> We need to be a society of problem solvers. The answers are not in the back of the book

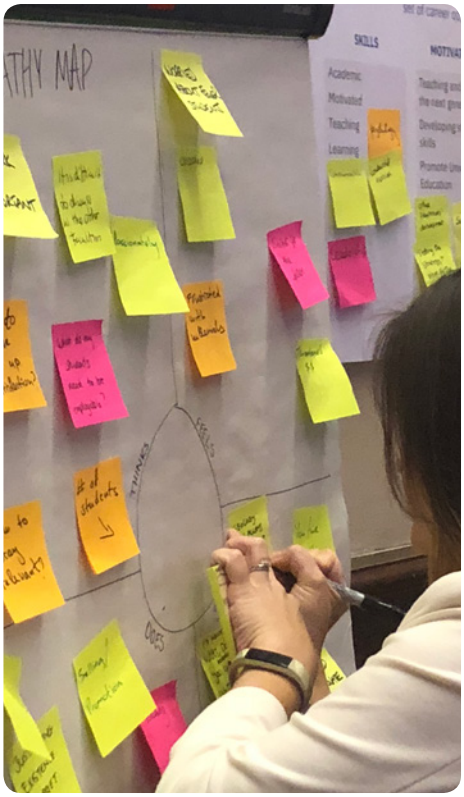
Lindy Elkins-Tanton, Director of the School of Earth and Space Exploration, Arizona State University and Leader, NASA Psyche mission

OBSERVATIONS:

- If geoscience is going to make a truly transformational effect on many of the big issues facing the world we need to educate students to be comfortable with engaging with people from maths and computing and talking about big data.
- The challenge is even broader if it will affect many of the big issues we've got to fulfil in the global roadmaps needed as set out in the 2015 Paris Agreement and the UN's Sustainable Development Goals.
- Geoscientists have much to contribute in the broader energy sphere because of way they think: they are used to dealing with complex holistic environments, good at systems thinking and without full data sets.
- As the world changes, the nature of what is required is changing and the big changes are not only technical in nature:
  - » **Societal:** The industry will need to think about its role to society even more and recognise the importance of trust, transparency and ethical aspects in meeting the expectations of broader society.
  - » **Ethical:** The choices the industry makes are increasingly more ethical, moral and aesthetic choices (over technical) and this needs to be brought into the training of being a scientist.
  - » **Sustainable:** The 21st Century geoscientist needs to be interdisciplinary, participatory

> The promise, excitement and optimism is around a new kind of energy/resources landscape of which the geologist will have to be part, and that is part of the sense of excitement that I tell people. Oil and gas has this fundamental contribution to make to sustainable development and this means that young people are entering the energy industry now at one of the most exciting transformative times of human history and if we can get that across, if we can capture that, there's going to be no shortage of people that want to come into geosciences

Ian Stewart, Professor, University of Plymouth



and recognise the different types of knowledge that exist that need to be taken into account – lay knowledge, public knowledge - contributing to sustainable development.

» **Digital:** Data science, data analytics, data visualisation and information science will need to be a greater part of the degree courses offered.

- Skillsets therefore should be around transformative science – new types of climate environments, energy environments and social contracts. This means being able to engage effectively with the social scientists, psychologists, anthropologists and those in communications and creative arts as we need a broader way to think about and to understand the public and what is they need to know about our world.

CONCLUSIONS:

- One of the things that geoscientists are good at is making decisions with incomplete data and joining the dots. This means that the skillsets geoscientists bring may not be technical.
- Graduates today think differently. They look for experiences and environments that are conducive to their own personal learning: to be exposed to new and exciting technology that allows them to use and learn different skills and gives them ability to try different things.
- We need a balance of scientists coming through who understand rock chemistries and rock physics but also who are comfortable with big data. At the same time they need to understand and engage in the economic, geographic and societal concerns.
- Graduates will be attracted to companies who engage and communicate honestly and effectively internally as well as externally about their approach to this evolution.

THANK YOU TO THE COMMITTEE AND SHADOW COMMITTEE

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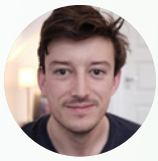

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Keep Shaping the debate during and after the conference at the '*AAPG Energy Transition Forum*' on our Linked in Group!