digital energy journal

The machine learning issue

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Machine learning may change oil and gas – but not the way we think

Accenture has just published a survey of C-suite and director level IT and business executives, saying that 76 per cent of them believe that "DARQ" – that's distributed ledger, AI, extended reality and quantum computing – will have a "transformational or extensive impact on their organisations over the next three years."

For this issue, we talked to people at the cutting edge of machine learning, in both subsurface and operations domains – and there does seem to be an argument for slow and steady improvement in machine learning, and value the industry gets from it. "Transformational" may be going too far, but you can draw your own conclusions. Machine learning is a subset of AI.

I'm not sure about the other elements of "DARQ"! Although like with machine learning, the definitions are not completely clear.

"Quantum Computing" seems to mean superfast computers using advances in materials technology at the molecular level. So relevant if you have a need for fast computers. Do we?

"Extended reality" seems to mean computer generated material seen on top of your normal view, for example if you are wearing special glasses. That's useful for people working on top of telegraph poles and other manual work where having hands free is useful. It can be a distraction if you are operating vehicles, and for many tasks the desktop computer, tablet or smart phone is still ideal.

"Distributed ledger" seems to mean a record of something in a way no single party can tamper with. This is something humans have been able to do for millennia, recording transactions on stone, or having central property registers. Bitcoin took the technology to another level but that was to meet some special use cases of a currency beyond the reach of government. My guess is the main obstacles to sharing information are commercial, not technical, in which case a better technology won't change anything.

AI is perhaps the most interesting. I interviewed the founder of perhaps the most advanced asset integrity machine learning company, who told me that he did not personally understand what "AI" meant, but "machine learning" was something he did understand. He defined it as using computers to understand the relationships between different variables based on observed data.

The oil and gas industry does have many different data variables to work with across subsurface, production and operations – and there are many efforts to better use machine learning to work with them – and we have many illustrations in this issue across seismic interpretation, well log interpretation and asset integrity management.

Our own theory of the most interesting technology is something you might not think of as a technology – better mapmaking for how all of this stuff should fit together, so it can be carefully designed to provide the right information to the right people which they need to achieve their goals. So we don't need to spend so much time updating each other with e-mails and meetings. We can also carefully design our system so it makes the most of both computer power and brain power, while simultaneously being secure, flexible and maintainable.

We'll continue our discussions about software mapmaking, machine learning, and perhaps also distributed ledger, extended reality and quantum computing, at our events during the autumn in London, KL and Stavanger. We look forward to seeing you there.

Karl Jeffery, editor
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Shearwater GeoServices 12-streamer 3D offshore seismic research vessel SW Amundsen. In summer 2019, she will be surveying the Tyra, Tyra SE and Roar Fields offshore Denmark for Total E&P Danmark, with Shearwater's multi-sensor Isometrix acquisition system.

How do we use machine learning on oil and gas subsurface and production data?

We asked Duane Dopkin, Executive Vice President of Geosciences at Emerson E&P Software, about how he sees machine learning's role in oil and gas production and subsurface data – and where it is going.

Machine learning has been used in oil and gas subsurface projects since the mid-1980s, when algorithms like "back propagation neural networks" were implemented to automate tedious tasks says Duane Dopkin, Executive Vice President Geosciences at Emerson E&P Software, (formerly Paradigm).

Duane Dopkin, Executive Vice President Geosciences at Emerson E&P Software, (formerly Paradigm).

Today there is growing interest in machine learning technology, in part stemming from activity around the "digital transformation" and the promotion of machine learning by big tech companies like Google, Amazon, Microsoft and IBM. Most of the latest wave of interest is built around more sophisticated machine learning engines which these companies are offering, he says.

There are a number of thought leaders in the oil and gas industry who have invested heavily in the promotion and evaluation of these new machine learning engines, he says.

But there is still a gap between the role and goals of machine learning as envisioned by the thought leaders and the practitioners – geoscientists and engineers who have to extract insights from subsurface and surface digital data, and have confidence in the results. "It is the role of thought leaders to push this technology out. It is the role of practitioners to put the brakes on – proceed with caution, as it takes a while to solve surface and subsurface problems with emerging technologies.

"It is an evolution, it doesn't happen overnight. The gap will be closed with time and continued refinements, not only to machine learning methods, but to preparation of the input data and careful 'crafting' of the training sets - prerequisites for a successful outcome from machine learning applications.

Many successful applications of machine learning operate on consistent and highly sampled data, like consumer data. Oil and gas digital data is more complex and the problems we are attempting to solve with machine learning are also more complex. So different methods need to be applied.

Defining machine learning

Mr Dopkin says that machine learning uses algorithms that are used to solve non-linear problems, or to put it more simply, to help us understand multi-dimensional data relationships that are difficult to ascertain using deterministic methods.

This relationship may depend on many other factors, including factors you don't know, such as the relationship between the hours you spend teaching a child math and their scores on an exam.

There are some deterministic algorithms that have been used extensively in the oil and gas industry which are very reliable and very predictable; therefore their limitations and strengths are well understood. These methods set a performance bar for machine learning methods.

"Some of the tasks we applied machine learning to in the 1980s and 1990s are pretty mature now," he says. "They are institutionalised in our workflows. Geoscientists are comfortable with those methods."

To use these algorithms, you first select which algorithm is appropriate together with your understanding of the physics of the subsurface. You prepare your input data, train the machine learning method, and then turn it loose on the problem.

Today, many learning algorithms are available as open source, making it much easier for geoscientists to try them out without having to invest heavily in them upfront. These software trials also allow geoscientists to assess the effort and cost in integrating (embedding) them into their proprietary solutions.

Deep learning

More recent developments use "deep learning", neural networks, that look for patterns in large data sets. The deep learning engines contain multiple layers, multiple nodes, and accept multiple inputs to carry out more advanced image recognition problems or transform one data type to another.

"These deep learning applications are still relatively low on the maturity curve, he says. "But they are gaining a lot of ground quickly," particularly for classifying data and image recognition. Deep learning algorithms show a great deal of progress in their application to surface and subsurface oil and gas digital data.

Machine learning lessons

Over the past 30 years in which Emerson E&P Software (Paradigm and Roxar) has been working on machine learning technology, it has learned a great deal.

It has learned that data preparation is critical, if you want machine learning to make useful predictions, data transformations, or data integrations.

It has also learned about the importance of selecting the right machine learning algorithm for the problem. The company has over 15 different machine learning 'engines' or algorithms that can be applied to solve different surface and subsurface challenges.

It can require a great deal of experimentation, with a practitioner exposing different machine learning methods to different input datasets.

It advocates the use of "physics-based models", where the model reflects in some way the physics of how the parameters actually relate.

All of these algorithms "absolutely" need domain expertise to use, he says. "You have to understand what you are doing."

Surface and subsurface data

Machine learning is more adaptable to surface recorded (engineering) data, such as production data, than to subsurface data, Mr Dopkin says. "Engineering data carries less complexity than subsurface data."

For example, machine learning can be used to forecast future production based on observed patterns in historical data. It can also be used to predict equipment behaviour. The algorithms can be run in real time (during operations), enabling them to support real-time decisions, such as when to do workovers, or strategies for optimising production.

"Machine learning is very applicable to that kind of data, looking for trends, forecasting futures and predicting failures," he says.

But in the subsurface domain, machine learning "is not as applicable right away," he says. There are many more complexities, with diverse data types, data resolutions, and data sizes".

Working out how to apply machine learning to these data sets, and understanding the limitations, takes time, he says. And the large data sets create extra challenges. "We can be talking about applying ML to tens or hundreds of terabytes of data."

In the subsurface, machine learning is typically applied to different sets of problems, including automating tedious activities such as picking first breaks, velocities, or seismic horizons as part of the seismic interpretation process. It can also be used to classify rock types or seismic facies, or to integrate seismic data with well logs.

Deep learning algorithms can now be applied to pre-stack seismic data to search for specific geologic features, such as faults, fractures, reefs, edges, channels, or karst features. "Machine learning holds a lot of promise here," he says.

Data integration

Machine learning can be used to help integrate subsurface data types together, a tricky task to do manually when the data samples different regions of the subsurface and at different resolution levels – such as cores, well logs and seismic.

Some data is sampled heavily in 3D space, like seismic data – and other data is densely sampled in a vertical domain, such as well logs. In addition, the different data types see the rock itself a bit differently.

There are many disciplines in the industry working with different types of data – for example, geophysicists with seismic data, petrophysicists with well logs, geologists with geologic models, engineers with pressure and saturation data. But it all needs to come together to enable reliable decisions about how to make safe and economic drilling decisions. In that sense, machine learning can be considered a collaboration tool, Mr Dopkin says.

Data managers

Data managers are still necessary in the world of machine learning – keeping track of where data is and what it shows.

Machine learning actually "creates a new set of data management problems," he says – storing the data about the machine learning training, so that other people can access it and apply it to their data.

There also need to be standards for how machine learning data is stored.

And since machine learning might be run on multiple data types, including seismic data, core data, well log data, and maybe engineering data, it is important to keep track of the sources of the data.

"Currently, machine learning does not simplify the data management problem; rather, it is forcing another set of data management standards and controls on digital data and applications," he says. However, machine learning holds tremendous potential to help solve many other types of data management problems.

ML in facies classification and seismic inversion

Two good applications of machine learning in the subsurface are classifying facies (rock types) and improving seismic inversion. CGG GeoSoftware's Daria Lazareva and Brian Russell explained how to do it.

Facies classification means using well log data to try to work out what rock types you have. This is the domain of petrophysicists and is an important part of the reservoir characterisation process.

Well logging tools record a range of measurements such as neutral porosity (NPHI), gamma ray (GR) and density (RHOB), along selected intervals in a well. The purpose of the logging is to try to work out what the subsurface is composed of (e.g. sand, clay and lime), identify the reservoir intervals and work out what their characteristics are.

Expressed in general terms, the machine learning technique aims to find out what kind of rock type (facies) the well log data are indicating for a certain depth range, based on its characteristic properties. On the cross-plots (2D and 3D graphs) that petrophysicists use, the well log data will form different clusters of points representing different facies.

Analysing and untangling clusters of data points is something that machine learning is well suited to. You can easily do "sub-clustering" analysis to look for additional detail and additional rock types, for example sub-dividing a rock unit into lime-rich and dolomite-rich layers, said Daria Lazareva, Technical Advisor Petrophysicist, with CGG.

She was speaking at a 'lunch and learn' session at CGG's exhibition stand at EAGE London in June.

As usual with well log analysis, there will probably be lots of clean-up or other "wrangling" to do on your data first, such as to edit well logs, do basic petrophysical analysis, do some quality control, or convert data from one format to another, or move it onto a cloud storage platform. Again, machine learning can help with some of these tasks, such as identifying bad sections of logs and making an automatic first pass at editing them.

The aim is to build an "electrofacies column", a set of well-log responses which characterise a lithologic unit, and enable it to be distinguished from, or correlated with, other lithologic units.

The facies classification can be "unsupervised", where you just let the algorithm see what it can detect, or "supervised", where it is trained by parameters described by someone who knows what to look for.

CGG GeoSoftware recommends the Python programming language to work with your data, since it is the fastest growing, with many online courses and free "open source" scripts available. There are already Python scripts to do tasks petrophysicists often want to do, or you can make your own.

With CGG GeoSoftware's PowerLog petrophysical software, you can easily work on your data with Python scripts, thanks to the open Python ecosystem that they have provided.

Examples of Python scripts you might want to use are NumPy (support for large, multi-dimensional arrays), SciPy (scientific computing), matplotlib (a plotting library), Keras (neural networks), Theano (mathematical expressions), scikit-learn (machine learning), Pandas (data manipulation), Plotly (graphing). You will probably want to run it in an "Integrated Development Environment" such as Jupyter or Spyder, Ms Lazareva said.

Ms Lazareva presented an example with a 3D cross plot covering density (RHOB), Neutron Porosity (NPHI) and Gamma Ray (GR), showing how they relate.

You can reach 80 per cent prediction accuracy, she said.

Augmenting Seismic inversion with deep learning

The second machine learning use case presented was deep neural networks guided by theory, as a tool to do seismic inversion (converting recorded seismic data into a depth-based rock property model of the subsurface).

It was presented by Brian Russell, Vice President of CGG GeoSoftware, and co-founder of Hampson-Russell.

The traditional way to predict rock properties from seismic without doing an inversion is "multi-linear regression", trying to develop relationships between the recorded well and seismic data and then predict how the subsurface should look.

Deep neural networks (DNN) can develop non-linear relationships linking the target (i.e. rock properties) with the various given seismic attributes. They have multiple layers to give them "depth". With multiple layers, a neural network can make a model of complex non-linear relationships, giving a different weighting to multiple factors as it is 'trained' for the system, until it can predict the right answer.

To use a cat image example, there is a complex nonlinear relationship between a cat and the collection of coloured pixels which make up a photograph of a cat. By understanding this relationship through a sufficient amount of training, a computer can identify if a photograph shows a cat or not, although the cat might be viewed from a different angle, or a different light, and the cat might be of a different age, weight or facial features.

DNN applications are data-driven, typically needing a large labelled data set for training – which is available for commonly used voice recognition and image classification systems, but not usually available in the oil and gas industry, where you might only have data for one or two wells to work with.

Meanwhile, the oil and gas industry also uses "theory based models", which describe how the subsurface works based on scientific principles – but don't need large amounts of training data. So how about using scientific knowledge to help make much larger data sets – and then using these larger data sets to train the neural network. This could be called "hybrid theory-guided data science".

Dr Russell illustrated this with a data example from the US Gulf Coast, aiming to predict reservoir properties with a mixture of scientific theory and data science.

The theory used in this case was known rock physics relationships for the reservoir, which were used to make a simulated set of well logs, and synthetic seismic data. This was then used to train the deep neural network. The project only used log data from one well.

CGG GeoSoftware has 500 different rock physics models available that will suit most lithologies encountered in oil and gas exploration.

One concern is "overtraining", where a model is trained so much on data from one specific well that any understanding it produces is only relevant to that one well.

Another example was illustrated with a North Sea dataset (Colwell & Kjøsnes, 2018. Data courtesy of Aker BP), where there were known reservoir properties. Three different prediction methods could be compared - multi linear regression (MLR), a standard probabilistic neural network (PNN), and a deep feed-forward network (DFFN) combining synthetic data with the machine learning.

Field A had a deep submarine fan system channel, Field B had remobilised sand injectites.

In both examples, the DFFN was slightly better than the PNN, and both were better than the MLR.

In net pay prediction, MLR under predicted, PNN over predicted, and "DFNN seems to show the best path", although there was not actually a dramatic difference among the three, he said.

The system would ideally have over 12 wells to train on, but "we can get away with 6," he said. "The more data you have in ML the better."

"So it looks promising, a neural network could, in the right conditions, replace seismic inversion as part of a hybrid theory-guided data science approach."

Reference: Colwell, T., Kjøsnes, O. [2018] Comparative Study Of Deep Feed Forward Neural Network Application For Seismic Reservoir Characterization, EAGE Machine Learning Workshop

ML on equipment – spotting failure signatures

The best way to use machine learning to improve equipment performance is by spotting a "signature" of an emerging problem, perhaps months before it actually emerges. We talked to Mike Brooks, Asset Performance Management (APM) consultant at AspenTech

One of the most useful ways that machine learning can help improve equipment reliability is if it can spot the specific 'signatures' in sensor data which indicate a problem emerging, says Mike Brooks, Asset Performance Management (APM) consultant at AspenTech.

AspenTech provides software for asset optimisation, working in the chemicals, manufacturing, oil and gas (upstream / downstream), power, engineering, and wastewater sectors. It is based in Massachusetts.

Equipment problems often follow a certain course of action, which you might be able to spot with the help of machine learning, Mr Brooks says.

One example, often referred to as the silent killer of compressors is liquid carry-over when micro water droplets travel into a compressor, causing pitting and deposits that lead to vibration and catastrophic bearing failure.

This can arise from a complex sequence of events, starting with a higher ambient temperature in summer, meaning that gas is not cooled to the desired temperature in a cooling system, so it has a higher volume and so a higher velocity through a separator, which can shear droplets from the surface. The water droplets then cause damage to the blade, or imbalances in the bearings.

All of this leaves a trail of sensor data which sophisticated machine learning algorithms can detect – seeing indications of a problem emerging months before it actually does.

So you are not just identifying a change (or 'anomaly') to a normal operating pattern, you are seeing a specific series of events identifying a failure about to occur, he says.

The same failure patterns can often be seen on similar equipment, such as pumps, and even static process equipment such as heat exchangers and boilers.

The AspenTech software takes data from (for example) 160 different sensors on a compressor, to make a continuous assessment of how close

Mike Brooks, Asset Performance Management (APM) consultant at AspenTech.

operations are to normal and to detect when specific failure patterns emerge.

By learning the signatures leading to failure rather than only detecting anomaly conditions starting to happen, Mtell provides much earlier warning of problems, which gives companies much more time to arrange maintenance work, in a safe coordinated manner including spare part deliveries.

The system is also designed to spot deteriorating process operating conditions which might impact product qualities and yields.

ARC of Boston, USA has conducted studies that have shown that 85 per cent of all equipment failures are caused by errant process conditions, rather than just wear and tear of equipment, Mr Brooks says.

Bearing this in mind, some operators of complex equipment now say they want to eliminate maintenance completely – just by establishing when they have disorderly process behaviour and adjusting accordingly to avoid the deterioration.

Other companies

Many companies have aimed to develop services which don't do anything more than spot 'anomalies', something different from normal conditions, by analysing sensor data, Mr Brooks says.

But these can just end up dumping lots of unhelpful work on company experts. For example, the software spots 10 "anomalies", an expert then needs to figure out if they are a genuine problem or not – and if so, work out what to do about them.

Also, many other equipment monitoring companies limit themselves to vibration analysis. By the time the equipment is showing high vibration it may be too late, you already have damage.

The AspenTech software, by contrast, looks for the root cause conditions manifested in small changes that happen over time.

Many companies build engineering and statistical models of "normal" operation of the equipment, so they can be compared with current operations. These models can take months to build and expect pristine data and operating conditions.

But the only time equipment normally works according to the engineering and statistical model is when it is new, Mr Brooks says. All equipment will wear and 'drift' over time, and this is normal. The AspenTech software can track slow drift in the sensor readings over time, without causing any alarm, unless it sees a signature of a fault.

Emphasise what it does

Although the AspenTech software uses machine learning, Mr Brooks would prefer the software to be recognised simply for what it can do – provide precise early warning of a problem, so you have plenty of time to fix it.

The purpose of the software can simply be described as "to make machines smart" – to tell you when they are about to break.

"We say we are [helping customers] understand the problem and providing the kit to solve the problem. We are going to stop machines breaking," he says. "We get machines that can run better, and longer and maintenance cost goes down."

And of course, machine learning technology itself does not fix the problem – you also need a work process and a methodology.

Mr Brooks also believes software should be known for what it does (help improve the reliability of the equipment), not the embedded technology alone; it's machine learning and it needs data context and domain knowledge to achieve the results.

Mr Brooks notes that in the past a lot of business intelligence and data warehousing projects failed because organisations did not know what problems they wanted to solve before proclaiming business intelligence or data warehousing as the answer.

"I see the same things happening today. Machine Learning alone cannot solve the problem. It needs guide rails to ensure it provides correct, meaningful answers. It needs domain expertise and meaningful contextual data."

In energy and manufacturing, the overall problem people want to solve is usually improving operational excellence, or achieving small improvements. For example, many firms see the deployment of digitalization, IIoT, Industry 4.0, big data and machine learning as a business initiative where what they are really trying to do is improve operational excellence and those other things are the means to do it.

In his earlier role as CEO of Mtell (a machine learning company acquired by AspenTech) Mr Brooks insisted that the software should be usable by 'Joe Normal', who may be an expert in compressors, but is not an expert in machine learning. "I wanted to do this so you don't need a data scientist," he says. "Small companies can't afford to hire their own data scientists."

Also, the software should not require anybody to change their standard work processes in order to benefit from it, Mr Brooks believes. They should be able to do it with their current skills and the way they work right now.

Rather than exposing customers to the workings of the machine learning, you just see a nice user interface. The customer never needs to see the model underneath it. "We don't talk to people about our algorithms," he says, "they do not need to know, we handle all that under the covers."

Prescriptive maintenance

Mr Brooks tries to avoid the term "predictive maintenance," saying that most companies that sell it offer no prediction at all, or just basic prediction, which makes it meaningless.

So instead, it uses the term "prescriptive maintenance," meaning a software system which identifies issues and then tells you what operational changes or maintenance tasks need to be done to solve any emerging problem. This notification can also be passed into work management and procurement systems.

Building and updating the model

The pattern identification for detecting normal and failure conditions can be made in a few hours or for very complex equipment in a few days - this is a profound change for software in this space that can take months to develop and deploy - and end users can do it themselves. The company wrote down its "best practise" for implementing the system, and it has been through four iterations so far.

Machine learning needs domain knowledgeable people to provide 'guide rails' – working out what data would be needed to feed it, which data relationships (that the machine identifies) make real world sense, Mr Brooks says.

The set-up work involves gathering data for example for the past 2-5 years, also talking to engineers, and looking at work orders (for example in ERP software) to see what maintenance was done. Then it can be possible to see patterns in the sensor data which led to failures.

The work, to conduct a test on several assets at the Saras refinery in Sardina, Italy was done in about 2 weeks. Another job on a petrotechnical plant in Southeast Asia took 2 people 3 weeks, covering 4 pieces of equipment, where the competition took months, Mr Brooks says.

The system can work on much more than rotational equipment, which is a limitation of most other similar services, he says. There is no reason why the system can't be used on more complicated equipment as long as it has access to sensor data. Consider aeroplanes. The engines may be carefully monitored by their manufacturers – but the item which fails most often is the toilet.

The technology could be applied in the shipping industry, although the company has not worked in shipping yet – but has done similar work on locomotive engines. There are big engines which fail. In this sector it might welcome a partner interested in applying and implementing the technology.

Updating the model

If the system notices that something is happening which it hasn't seen before, the next task is to classify it manually.

If it is identified as a new 'failure pattern', then it is a manual task to build an 'Agent' to look to see if it happens again. These "agents" can then be used in other similar equipment, such as your other boiler feedwater pumps.

If the change is identified as a "process change," such as the refinery taking a different type of crude oil, it is a simple task to just tell the computer, and the baseline pattern is automatically recalculated. After process changes, there may need to be recalibration in what the 'failure modes' look like.

Background

Mr. Brooks has a background in control, automation and industrial IT systems. He is a former president and CEO of a company called Mtell, which was purchased by AspenTech.

Before that he was a venture executive with the venture capital group of Chevron. He began his career as an engineer at Esso and Chevron.

Mtell was the first company to use machine learning in asset management, beginning 10 years ago Mr Brooks claims.

The CTO had worked with machine learning in neuroscience and brought forward the idea of applying the technique in the maintenance arena.

He has been involved in the "O&M Foundation", a project with a mission to connect operations and maintenance systems.

AspenTech had been a leader in developing dynamic models for complex equipment, and so the machine learning technology was complementary. It provides products for mining, energy, chemicals, food and beverage, as well as the oil and gas sector.

What you can do with satellite imagery

Today's satellite imagery, with pixels representing a square just 30cm on the ground, is being used to help map energy infrastructure, monitor vegetation around powerlines, monitor location of vehicles, monitor vessels, monitor disaster response, optimise irrigation and monitor air quality. This might give some ideas for the oil and gas industry

There have been big advances in recent years in the quality of satellite imagery – now with individual pixels as small as 30cm on the ground – and how companies are finding business value from it. We were invited to the Maxar annual "ENGAGE" conference in Barcelona in June to find out more.

The event did not focus on the oil and gas industry specifically, but included plenty of coverage from topics close to oil and gas, such as electricity, infrastructure, trading, maritime, road vehicles, mapping and tracking animals. Also the development of AI tools to better analyse imagery.

Daniel Jablonsky, President & CEO of Maxar said that the main emphasis is now on looking for ways to "take the human out of the loop" with image analysis. The images can be enormous, so too large to analyse without a computer, unless you are looking for something specific.

The costs of satellite imagery vary. If you want to "task" a satellite to collect a high resolution image of a certain point on earth on a certain time, you have to pay a fee. But Maxar also makes large amounts of high (but not the highest) resolution data available free of charge via online tools, although without functionality to download any of the images onto your own computer or software system.

Amazon and cloud AI

Amazon Web Services (AWS) sees a business opportunity with satellite data, both from storing it on its cloud services, and supporting artificial intelligence tools, said Luke Wells, Solutions Architect with Amazon Web Services.

It can offer pre-built AI algorithms for tasks such as estimating the height of an object in a satellite photo from a shadow, or finding specific objects even though the lighting levels may be different.

Customers may need to develop their own special models for their purposes, in which case they will need a lot of labelled training data and people to train the algorithms.

Amazon has developed a service called "SageMaker" to support the building, training and deployment of machine learning models at scale. It can be used together with Amazon's "Mechanical Turk" service providing access to people able to do the manual work. The software takes a subset of the raw data, sends it to people for labelling, and then use this subset of labelled data to train a machine which can then label the rest.

Electricity infrastructure

Kedar Kulkarni, CEO of AI company Hyperverge, talked about his company's project to map the power (electricity) infrastructure in Texas. The map includes power lines, solar panels, wind farms, substations and other infrastructure. It also includes estimates of the voltage carried in the various cables. It won $1m funding, working with DNV GL.

The map will be used to plan out good locations

Delegates at Maxar's ENGAGE conference on satellite imagery in June

for future solar farms, estimating where power is likely to be most needed, and minimising the amount of high voltage power cables, which can cost $2m a mile. The data covers an area of 700,000km2, including 5081 substations.

The AI needed extensive training, as not all electricity towers in Texas have the same design, and are viewed from different angles.

The company grew out of a 2014 student research group, and was interested in business applications which could make use of the massive jump in AI analysis of imagery which happened around that time. This was partly due to the use of synthetic data for training. People learned how to use a computer to simulate what an object would look like when viewed at different angles, and use these multiple images to train the AI.

The World Bank is also using satellite imagery to work out the least cost way to bring electrification to a region in a developing country, said Keith Garrett, Senior Geographer.

Cotesa, an electricity supplier, explained how it uses satellite imagery to detect where there are trees close to power lines and so a risk of damage. The images are analysed to get an estimation of the height of power line poles from the length of their shadows. The service can be much cheaper than analysing power lines by helicopter, as the task is traditionally done.

Maritime

In the maritime domain, the European Maritime Safety Agency (EMSA) uses satellite imagery for safety and security purposes, including monitoring pollution (oil spills), fisheries, customs, borders, and refugee vessels. Its customers include FRONTEX, the European Border and Coast Guard Agency.

It can provide images just 20 minutes after the image is acquired.

Satellite imagery could be used to develop a new global maritime domain awareness system, said Guy Thomas, Founder and Director of C-SIGMA LLC, and a maritime domain awareness expert with the US Department of Homeland Security. Ship locations are already tracked using radio beacons (automatic identification systems). But there are concerns about these systems broadcasting false information or being switched off, in which case vessels can be tracked by radar and satellite imaging. But the data needs to be gathered together.

Satellite data plus

There are many projects combining satellite imagery with other forms of data.

Geospatial Insight uses satellite imagery to provide risk data to traders and insurance. For example, data about how much oil is stored in different places (from monitoring length shadows made by the floating lids of storage terminals), how many cars are in car parks (to monitor number of customers of a retail competitor), how much damage has been caused by a natural disaster. For the insurance sector it can automatically generate data about a property, including its construction material, floor area and number of storeys. "AI makes the analysis scalable," said Dave Fox, CEO.

Drishtie Patel, program manager with Facebook's Maps Data Team explained how her company uses data gathered from its app on billions of phones, together with maps generated from satellite imagery, for social benefit.

In an emergency evacuation in the US, it was able to tell where people were moving from and to (from their location). It could also detect whether their phones had connectivity, and if they were being charged, so it could see where power and internet connectivity was available. It could see where people were moving. It could also see which parts of the country had less people in them than before.

Facebook has worked with Maxar to develop street maps of parts of the world which previously did not have them. A team of just 20 people mapped out every road in Thailand.

Nokia uses of satellite data to help manage the complexity of the network, said Lorenzo Minelli, Head of Global Network Planning Optimization. It tracks the quality of connectivity in 3 dimensions, so it can see how good people's cell phone coverage is if they are on the 20th floor of a tower block, compared to the ground floor. One of the company's goals is to reduce the amount of buffering involved when watching videos. It also wants to better make its capital expenditure on where it can have the most impact.

South East Asia taxi app Grab uses satellite images to build better predictive traffic models, including mapping traffic flows from the location of customers' mobile phones, said Ajay Bulusu, Director Geo with Grab.

Delegates at Maxar's ENGAGE conference on satellite imagery in June

Tata Consultancy Services uses satellite imagery to monitor when farmers are burning stubble (leftover from crop production), which can create a lot of pollution. It also has ways to integrate satellite data with other data to estimate how much crops can be grown on a certain area of land, explained Dr. Srinivasu Pappula, Chief Scientist & Global Head, Digital Farming Initiatives, Tata Consultancy Services.

cloudeo AS has a system to optimise the use of water sprinklers in agriculture, to get the maximum yield with the least water. It gathers data from soil based sensors, together with climate data (past and future rainfall) and satellite imagery. The system includes precise position data for every sprinkler nozzle. A machine learning algorithm is used to make the assessment.

Geospatial company TCarta makes an analysis of air quality in London, using 50cm pixel satellite data to identify the location of 220,000 vehicles in central London. It uses the locations to generate models of pollutants in a 20m grid.

Terrabotics is developing technology to estimate how much oil companies are flaring, based on satellite imagery mapped against the owners of wells in that location. The satellite image can only see the flare from above, and needs to infer the gas flow rate to the flare based on the radius of the flare from above and its colour. This can be a complex data management exercise.

In-Q-Tel, a not for profit venture capital firm in Virginia, ran competitions to find the best algorithm for analysing data – with $50k cash prizes, and a plan to turn the winners into open source software, said Ryan Lewis, Senior Vice President.

It included detectors for buildings and roads. "We want to think of challenges which are technically complex and tractable (easy to deal with), he said.

There was a concern that multiple companies would make great algorithms and it would be difficult deciding how to allocate the prize, but this did not happen. When the algorithms were tested, "The winning score was 0.26 out of 1," he said.

The World Wide Fund for Nature (WWF) Germany plans to build a new "PandaSat" satellite constellation with its own network of micro-tags for tracking wild animals, said Aurelie Shapiro, Senior Remote Sensing Specialist with WWF. The Existing satellite tracking and communication systems are costly, bulky, extremely expensive and so rarely launched that they are designed and planned years in advance.

DUG – HF elastic FWI on the cloud – on 250 petaflops

Geoscience company DownUnder GeoSolutions (DUG) has opened "one of the world's most powerful supercomputers," a 250 petaflop data centre in Houston, to do HF elastic FWI seismic processing

Geoscience company DownUnder GeoSolutions (DUG) has opened "one of the world's most powerful supercomputers" in Houston, to provide a cloud based seismic processing service.

DUG is based in Perth, London, Houston, and Kuala Lumpur.

The Houston machine, called "Bubba", has 250 petaflops of data compute capacity, and uses 15mW of computing power. One petaflop is one quadrillion floating point operations per second (FLOPS). A quadrillion has 15 zeros.

DUG is already working on a second data hall, with plans to start building in late 2019, which will give it a total of 650 petaflops. Further plans are in place to build to an exaflop (1000 petaflops) by 2021, perhaps eventually it will be multi-exaflop. Matt Lamont, managing director, says he can already see the demand for this.

For cooling, the computer nodes are submerged in 700 tanks filled with polyalphaolefin dielectric fluid. The facility has 13 miles of pipelines to carry the cooling fluids, and have 10 x 20 foot tall cooling towers to remove the heat.

From a geophysical perspective, the goal of the facility is to provide high frequency, elastic, full wave inversion, 6-12 months faster than competitors.

Low frequency FWI (up to 12 Hz or higher) is mainstream today as part of a traditional processing and imaging workflow. High frequency FWI is the same algorithm run to higher frequencies. The algorithm scales relative to frequency to the power of 4, becoming very compute intensive (and expensive) at high frequencies.

"Elastic" refers to the "elastic" rock parameters – velocities of the compressional and shear waves, density, and estimates of elastic rock parameters—compressional- and shear-wave velocities (Vp and Vs, respectively), density, and Thomsen's parameters which describe anisotropy.

The "full waveform" refers to the fact that it uses the entire wavefield not just primary reflections.

This includes 'multiples' (where a seismic wave bounces between two reflectors multiple times) – this is normally treated as noise. It also includes refracted energy (where the wave bends), guided waves (where seismic energy moves laterally through the water layer). The processing also covers shear waves as well as compressional waves. Because these parts of the wave are included in the inversion, no pre-processing is necessary to remove them, as usually happens.

Full-Waveform Inversion (FWI) is a process to generate high-resolution velocity models by minimizing the difference between the observed and modelled seismic waveform.

The technique creates a subsurface model from the seismic, then uses this subsurface model to create synthetic seismic (the seismic recording which would be made if the real earth exactly matched this model). Then this synthetic seismic is compared to the actual seismic, and multiple iterations run until it gets the closest match. There can be as many as 100 iterations.

High frequency, elastic, full wave inversion was just a hypothesis in 2015, but now it can be done for real, Mr Lamont says.

There are illustrations on the DUG website about how much better the seismic images can be from this technique (page https://dug.com/dug-geo/full-waveform-inversion-fwi/).

DUG has its own software called "DUG Insight," for the processing. The software also has functionality for acquisition quality control, petrophysics for geophysicists, and rock physics. This software has been written "ground up" over the past 10 years.

Of course, companies can buy their own computers to do their work. But they will probably reduce costs by using DUG's computer centre, in effect sharing computer hardware with others. Also many companies have held back from investing in their own hardware during the crash, Mr Lamont says.

DUG's computing infrastructure has already been used by Quadrant Energy and Carnarvon Petroleum for its "Dorado-1" oil discovery in Australia, announced in August 2018, Mr Lamont says. This was estimated at 171m barrels of oil (at 2C probability), the third biggest oil find off Western Australia.

To provide the seismic interpretation as fast as possible, seismic data can be streamed from vessels as soon as it is recorded. DUG is working in this way with the marine geophysical company Polarcus.

Phil Fontana, chief geophysicist at Polarcus, said that DUG could provide high quality broadband post stack time migration (PSTM) data just 4-6 weeks after the last seismic shot.

The company now plans to develop the system to run reservoir simulations and augmented learning, where the computer helps people to learn, or makes suggestions. "We're looking at partners to work with on that," Mr Lamont says.

The company is developing case studies of how it works with land 3D data, multi azimuth streamer 3D data, ocean bottom nodes and 'salty' marine.

Costs of the service

Different options are available for using the service, depending on whether you want compute power only, or data storage, software (DUG Insight) and associated services.

A committed node will cost 55 cents per node hour, for a minimum 2 year commitment. Or you can purchase on demand access for 75 cents a node hour.

A Processing and Imaging (P&I) license for a workstation is charged from $18k / year

Companies can build their own direct access to the Houston facility, so they can move data in and out faster. Already seven companies have done this.

Processing time for data covering 500 km2, 12.5 x 25m bins, will be approximately 4,500 node hours for 3D SRME (Surface-related multiple elimination), 1,000 node hours for Radon transform, 1,500 node hours for seismic regularisation (placing into a grid).

Kirchhoff PreSTM might take 1500 node hours for 250 km2, or 49,000 node hours for 8,000 km2.

Maillance – machine learning on production data

Maillance of Paris and Houston is developing machine learning algorithms to help production engineers make better decisions.

Founder and CEO Jean-Paul Dessap formerly worked in production simulation and optimisation at Schlumberger, including managing innovation programs. He left Schlumberger to start Maillance in 2017.

The company currently has pilot projects running on data from North America, Middle East and Asia, both conventional and unconventional wells, using production data together with reservoir data.

The software aims to spot patterns in data which might help answer questions like "which wells make the best workover candidates," or "where are the sweet spots in the reservoir for infill wells," he says.

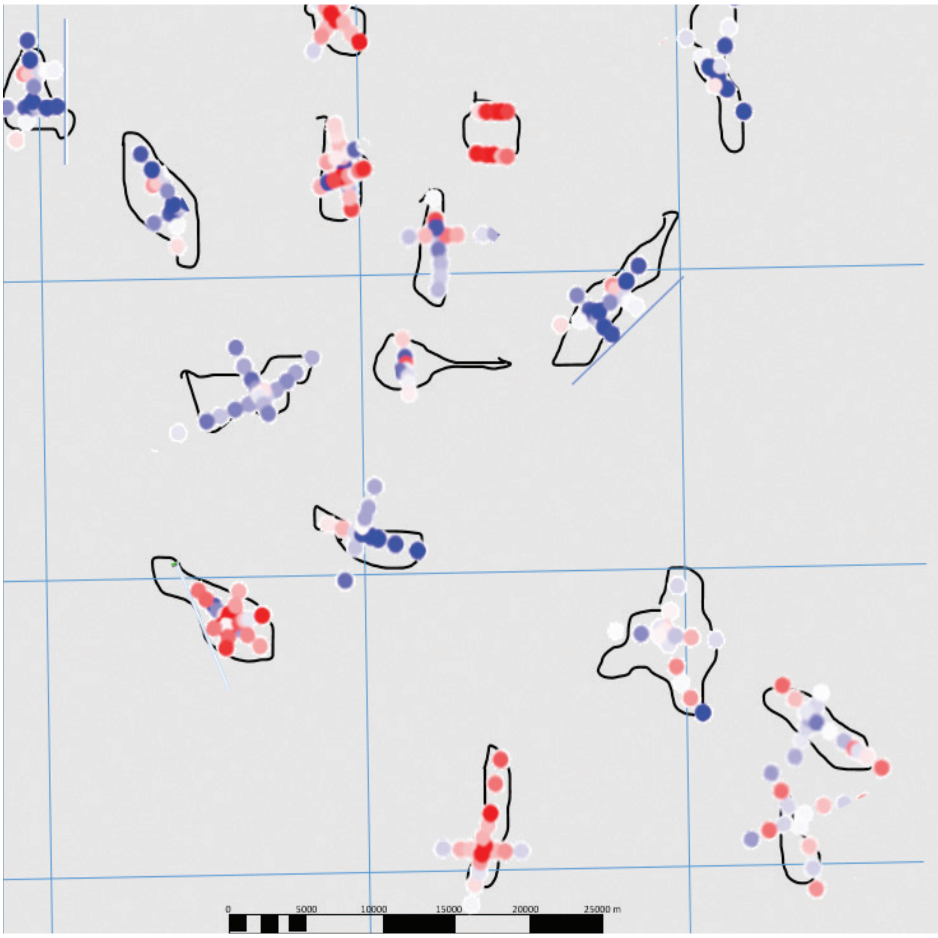
Companies normally use reservoir simulators to make such decisions. Maillance is designed to work in parallel with standard reservoir simulation, not try to replace it.

Companies may perhaps not want to execute the recommendations the AI engine makes directly, but they can see it as a source of suggestions worthy of further investigation, he says.

The machine learning tries to find a relationship between "certain features of the problem" and the target, he says.

Biodentify – DNA analysis to find oil

Biodentify of Delft, the Netherlands, is doing DNA analysis of microbes from soil and seabed samples to help find hydrocarbons



Biodentify made estimates about whether certain North Sea prospects would be prospective or dry, based on seabed samples. Red = prospective, blue = dry. Figure is realistic but anonymised

The company takes advantage of big advances in DNA profiling technology over the past years, which can analyse the DNA from any physical sample. DNA profiling is used to analyse cancer tumours, assist criminal investigations, and analyse parentage and ancestry.

The technique is used by Biodentify to analyse the microbes found in a soil or seabed sample above a suspected reservoir.

All oil and gas reservoirs leak slowly, which means that there is a slightly higher presence of hydrocarbon (gas) in the soil above reservoirs. These hydrocarbon gases can be very difficult or impossible to detect directly, because the concentrations are so low, but they do show up in the mix of microbes which you find feasting on the gas in the soil.

The effect also works in reverse – there are microbes you would normally expect, but which do not thrive in the presence of hydrocarbons.

The company uses artificial intelligence techniques to map the prospectivity according to the microbes present in the sample. This can be known as its 'DNA fingerprint'. The basic idea is that you might find a similar cluster of microbes above two adjacent hydrocarbon reservoirs.

There are hundreds of thousands of different types of microbes, not all of which have been labelled, says Mart Zijp, Head of Operations with Biodentify. So instead they can be labelled with a DNA related code.

The system usually needs a minimum of about 50 differentiating microbes which are affected by the microseep present to work, Mr Zijp says.

There are some microbes which are commonly found above a hydrocarbon filled reservoir, with the same microbe found above reservoirs which are not in the same basin, even on opposite sides of big oceans.

The seabed samples can be taken <1m depth into the seabed, with a "drop coring technique". Onshore samples are usually taken from about one foot depth. They need be no larger than "half a teaspoon" in size, he says.

The company has done a number of pilot projects, where an oil company asked it to try to find known reservoirs, by comparing the microbes above a reservoir with the microbes in other parts of the region.

The company has done 6 projects in the US, and also projects in the Dutch and Norwegian sectors of the North Sea, and Argentina's "Vaca Muerta" shale play.

The company is a spin-out from Dutch research organisation TNO in 2014. Its website is biodentify.ai.

Launch of "Open Subsurface Data Universe" forum

A group of oil company organisations have formed the "Open Subsurface Data Universe Forum", with an aim to develop a standard system for sharing subsurface data within companies.

Founding operator members include Anadarko, BP, Chevron, ConocoPhillips, Devon Energy, Equinor, ExxonMobil, Hess, Marathon Oil, Pandion Energy, PETROBRAS, Reliance Industries, Shell, Total and Woodside Energy. There are also 35 supplier members, including Amazon Google and Microsoft, Baker Hughes, Halliburton, Schlumberger, CGG, TGS Dell, Emerson E&P Software.

The forum is formed under the "Open Group," which describes itself as a "global consortium that enables the achievement of business objectives through technology standards."

Open Group is a not for profit company, with around 70 employees, around half in the US, around half in the UK, and a small number in India and China.

The subsurface data universe forum aims to develop a standard platform covering exploration, development and wells data, making it easier to access subsurface data, and easier to use software tools with it.

It should also make it easier for suppliers to develop new products on subsurface data, because the data will no longer be locked inside proprietary software. Conversely, it will make it harder for software companies to control how data within their software is used.

The forum members will not actually share any data, but will develop a standard way to store data so that it can be more easily shared, within their company and within others.

Petrotechnical workflow management company Bluware has donated its seismic data compression software "OpenVDS" to the forum.

Harald Laastad, VP and Program Lead Subsurface Analytics, Equinor said, "It is our belief that the foundation of a digital energy company is to make data available to our users at any time and place. "The OSDU Forum supports this ambition by enabling standardized access to subsurface data, separating lifecycle data management from the applications enabling innovation and creative use of subsurface data."

"We believe in putting data at the centre as an industry, and that offering a broad API-driven platform for application development is crucial to support organizations in this sector," said Johan Krebbers, GM Digital Emerging Technologies/VP IT Innovation at Shell.

The project team will start with wells data, developing a common definition for data, and a standard for metadata – how the data will be packaged, said Dr Michelle Supper, who looks after a number of Open Group workgroups including this one.

Then it will add in seismic data. It won't include interpreted data (which can be managed with Energistics' RESQML standard).

There are 15 different work groups developing the standard, including looking at security.

The first release of the standard is planned for Sept-Oct 2019.

Silixa's in-well fibre optic sensing – good for subsea and carbon capture

Silixa reports that its improved fibre optic sensing technology for wells is proving useful in subsea wells and CO2 storage wells

UK fibre optic sensing company Silixa reports that its new technology "Carina" is proving very useful in subsea wells, which may have long tie-backs to the nearest platform.

The fibre optic cables are installed permanently in wells and connected to an interrogator system at the surface. The fibre optic cable is installed at the time of completion of the well.

The interrogator sends a light pulse through the fibre, part of which gets reflected back. From the patterns in the reflection, it is possible to detect tiny changes in strain on the cable, which are caused by the effects of acoustics, vibration or pressure acting on the fibre.

The fibre optic cables are commonly used for Vertical Seismic Profiling (VSP) surveys, recording seismic signals as they propagate through the subsurface to the well.

Being permanently installed in a well, they enable repeat surveys to be made inexpensively, because you only need a seismic source, the recording equipment is already in place.

The result is a picture of how the reservoir is changing over time, such as how a reservoir is draining into a well, or how a CO2 injected plume is spreading into the reservoir.

You can also monitor caprock integrity, because the acoustic signature of any cracks in the caprock will be recorded and can be located.

Seismic recording can be much better quality when it is recorded in a well, rather than recording it on the surface, because the seismic energy has a much shorter travel distance. The signal only has to travel from the surface, down to the reflector then to the well, rather than from the surface, down to a reflector and back to the surface.

The conventional way to do seismic surveys in wells is by using geophone wireline equipment which involves lowering an array of geophones into the well temporarily on a winch.

Wireline surveys on subsea wells can cost "tens of millions of pounds", says Andy Clarke, DAS Applications Principal with Silixa. For this reason, they are rarely done.

Another alternative to VSP surveys is to have sensors installed on the seabed, using either ocean bottom cables (OBC) or nodes (OBN).

This technology can generate "amazing images" but a cost of hundreds of millions of dollars, Mr Clarke says.

One difficulty (until now) with fibre optic cables in subsea wells is that the wells are often located tens of kilometres away from the nearest platform, connected through a "subsea tieback", and there was a limitation to the length of fibre optic cable which could be used.

But Silixa has got around this problem by developing its own specially engineered fibre optic cable which enhances the backscattered light enabling much longer lengths of fibre to be interrogated. It calls this cable "Constellation". It is a key component of the "Carina" product.

Constellation provides 100 times better signal to noise ratio compared to standard fibre optic cables. It does this by being specially engineered to reflect more light back to the interrogator.

The Carina system can detect a strain of less than 1 x 10 to the power of -12. (That's a number with 11 noughts after a decimal place, then a one).

It can work with up to 20km of umbilical (cable between the well head and the surface interrogator equipment) and with wells up to 6km deep – so a total length of 26km.

Silixa says that many subsea wells have lower recovery factors than they should do, due to the difficulty of collecting data from them. This is something that subsea fibre optics should be able to help fix.

CO2 monitoring

The same technology has also been used in a number of CO2 sequestration wells, to monitor how the CO2 plume is spreading through the subsurface.

It has been used in projects in Australia, the US, Canada, Italy, Spain and Korea.

One project is the Otway experimental CO2 storage site in Australia, storing 65,000 tonnes of CO2 in 6 wells. Here the plan is to use fibre optic sensing to image the whole reservoir.

Other projects include the Battelle CO2 storage project in Michigan and the Citronelle CO2 storage project in Alabama.

The technical set-up is similar, with a permanent fibre optic installation in the well.

As well as monitoring the CO2 reservoir in the same way as you monitor an oil reservoir, you might want to listen for fractures or identify microseismic events that could indicate a compromise to the integrity of the storage medium.

The same system can also monitor the wells for leaks by listening to the sound created by the leak.

Less intrusive sources

The company's Carina system is so sensitive that it allows the use of much less intrusive seismic sources. This is important following environmental concerns about standard seismic sources.

It is experimenting with using continuous low-power seismic sources to gently shake the ground rather than using explosives or large vibroseis trucks..

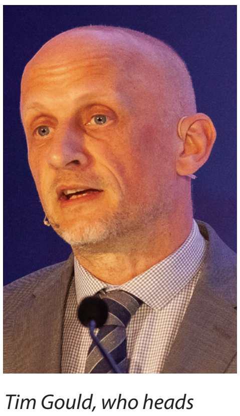
There have also been experiments using naturally occurring noise, such as sea waves or traffic noise, as a seismic source. This could completely remove the need for any seismic sources.

EAGE debate – industry in 2030

The opening session of the EAGE London event was a debate "What Will the Oil & Gas Industry Look Like in 2030 and Beyond" with senior representatives from IEA, BP and Equinor

Tim Gould, who heads analysis of energy supply at the International Energy Agency, said that 2018 saw the highest growth in energy demand so far this decade. 70 per cent of this growth in demand was met by fossil fuels, with gas having the largest growth. But "renewables are growing very strongly," he said.

A fifth of the energy demand growth is attributed to weather related factors. 2018 was a very hot year in some parts of the world, leading to sales of 175m new air conditioning units. There were also some cold snaps, pushing up heating demand. 2018 also saw the biggest ever energy related CO2 emissions.



Tim Gould, who heads analysis of energy supply at the International Energy Agency

There is a big disconnect between what is happening, and what people say should be happening, in terms of climate change. "We don't see the fundamental re-allocation in energy investment capital towards cleaner technologies that would be required to turn emissions around," he said.

There has been a reducing amount of money being put into energy overall, not because of increased energy efficiency, but because of the trends in the oil and gas business.

IEA is making projections of where oil and gas demand will go, looking at marketing developments and policies. It does not generate a projection consistent with the Paris agreement, he said.

Even in a scenario of "strenuous decarbonisation," oil and gas production in 2030 will be roughly at the same levels it is at today. A sustainable development scenario will need a lot more money into the electricity sector – but will still need substantial investment in upstream.

"The rate of decline in existing fields is far greater than a plausible rate that oil demand could fall," he said. "That's an issue we find very difficult to communicate. Understanding the implications of decline rates is one of the most important [issues] in understanding the future."

The level of project approvals for conventional oil and gas projects have fallen substantially.

"Project approvals are pretty much in line with what we think is necessary for a Paris scenario.

But the consumers have not yet got the memo. Oil consumption continues to grow at a rapid pace."

Project approvals also need to rise in natural gas sector. "The world is not investing enough in traditional elements of supply to maintain today's consumption patterns. Whichever way you look at this, we are storing risks for the future."

"The simplest way to think about decarbonisation is to electrify end use then decarbonise electricity," he said. "But what should be very clear to this audience is that this isn't going to get you where you need.

"Electricity is 20 per cent of our consumption today. If you push it very hard – electrify many sources of heat, transport – you could get that to 30 per cent by sometime in the 2030s. That leaves 70 per cent of the energy system dependent on molecules of some kind or another."

"There are parts of the energy system that in the long term will be very difficult to electrify – anything involving goods and moving people over long distances."

For cement, iron and steelmaking, and long distance travel, Mr Gould thinks it is "stretching it" to think that energy can ever be fully supplied by electricity, "even in the long term, even with a breakthrough on the battery side."

"That's where you have to start thinking about reducing emissions intensity of gases and liquids that are supplied today. Make sure you're not flaring, reduce methane emissions, think about decarbonised sources of supply – hydrogen or other hydrogen rich compounds, Biogas, biomethane or various other sources of energy.

"For the stuff you are still having difficulty with – you have to start thinking seriously about CCS [carbon capture and storage]."

Technology

In terms of technology, "we spend a lot of time thinking about the range of innovation you're going to need," he said. "Each of the large energy industrial sectors has its own challenges."

"There's enormous amount of thought going into the intersection of digitalisation and electrification, it is unclear for us how exactly that plays out."

Technology may make mobility cheaper and push up demand. They may also be "confluence of circumstance" – more people wanting to go the same place at the same time – so more use of ride sharing.

If we align autonomy, electrification and ride sharing, "you can have dramatic changes."

"If you only get two of them you might not get anything like the sort of changes. It's still not completely clear in all circumstances if digitalisation is a friend or foe of a rapid transition."

Scenarios

IEA's ideas about the future should be considered as "scenarios" not "forecasts", he said – and there are many unpredictable factors.

As an illustration of where a scenario had been wrong, he said IEA did not expect Chinese growth over 2005 to 2014 to be as strong as it was. This led to a bigger demand for coal than expected. Although China has also shown more public support for solar PV than expected.

"Back in 2008, Chinese government said, by 2020 we're going to have less than 5 GW of solar.

2020 is [nearly] upon us and China will have well over 200GW of solar."

The first time IEA did a "2 degree scenario" was 11 years ago – in 2008. "We received quite a lot of pushback, people saying, why are you doing this".

"We warned at the time that if we don't act decisively – by today we could have annual emissions around 33.7 gt of CO2. The figure we saw for 2018 was around 33.1."

"The argument at the time – if the world acts decisively we can get the peak under 31, and start to manage the decline from early 2010s. Now 10 years later we're faced with a need for a much steeper decline in CO2 emission reduction to get the same stabilisation."

BP – wide range of efforts on carbon

BP's efforts to reduce CO2 emissions range from reducing methane intensity in operations to investing in battery technology, said Angela Strank, Head of Technology and Chief Geoscientist Downstream with BP

If government policies, technology and social preferences continue to evolve as they have done in the past, BP "can see a scenario where global energy grows by a third by 2030", said Angela Strank, Head of Technology and Chief Geoscientist Downstream with BP.

Angela Strank, Head of Technology and Chief Geoscientist Downstream with BP.

This means adding another US and another China to today's energy demand.

She was speaking at the opening session of the EAGE forum in London in June 2019.

Renewables are growing at a rate faster than any fuel has in history, and could supply a third of energy by 2030. Oil and gas could supply half of all energy demand by 2030 (the rest coal / nuclear), she said.

If there is a "more rapid energy transition scenario", bringing in energy efficiency measures, energy demand might grow by a fifth rather than a third. But, "even in that scenario oil and gas is projected to make up around half of global energy demand by 2040," she said.

BP has a wide range of measures associated with reduced CO2 emissions, she said. In upstream, the company is focussing on "advantaged oil" (which needs less energy to produce) and growing its gas production. It has a target of methane intensity of 0.2 per cent, measured as gas emitted over gas produced.

In 2018, it reduced operational emissions while increasing oil and gas production 3 per cent. It has made improvements to reduce flaring, improve pump efficiency and improve supply vessel planning.

It is developing a mix of cameras and tools to detect methane emissions, even in remote places.

It formed the Oil and Gas Climate Initiative together with 12 other oil majors, and one investment it has made is in GHGSAT, which launched a satellite in 2016 to measure CO2 and methane emissions in a facility.

BP's wind power business in the US has 1 GW of capacity. It is in the solar business through its acquisition of LightSource. The renewables presence has expanded from 5 countries to 10.

It is producing methanol from sugar cane processing in Brazil, so a biofuel. It has refineries processing vegetable oils and fats. It is offering aviation fuel with conventional fuels blended with fuels from recycled cooking oil.
BP is also working on research to help make gasoline and diesel car engines more efficient – perhaps 50 per cent more efficient by 2040. One way to improve fuel economy is to find ways to reduce engine wear.

In shipping, it recently launched "some of the most efficient LNG vessels."

It is also investing in vehicle charging stations and battery technology, including a technology Storedot to charge a mobile phone in under a minute, aiming to charge a car battery in the same time it takes to fill the tank – 5-7 minutes.

It is working together with Equinor and OGCI to do a feasibility study for the UK's first "full chain" carbon capture project in Teesside, generating power from natural gas.

Ms Strank was asked about how fast she thinks battery technology may advance. "I was in China last week, every time I go to China I'm astonished about the pace of change, and the resources being put into [batteries], scientists, engineers and money," she replied.

"It may be possible for a breakthrough to come, it is difficult to predict. People are very optimistic about what's possible."

"Cost of batteries is an issue. In China they were pretty optimistic about cost parity with ICE (internal combustion engine vehicles) coming in the next few years."

Equinor – increasing pressure from investors

Investor groups are putting increasing pressure on oil company boards to do more about climate, said Jon Erik Reinhardsen, chairman of Equinor (formerly Statoil) – and we can expect behaviour to change as a result

Investors are now having significant influence on aligning oil companies with Paris agreement," said Jon Erik Reinhardsen, chairman of Equinor (formerly Statoil), speaking at the opening session of the European Association of Geophysicists and Engineers (EAGE) annual meeting in London in June 2019.

A group of investors with $33tn under management called Climate Action 100+ "has had a material impact on oil companies," he said.

Jon Erik Reinhardsen, chairman of Equinor (formerly Statoil)

Equinor sees the ground changing so much that it changed its name in summer 2018, after being Statoil for 45 years. The Statoil name "represented certainty the world needed oil and gas and Statoil provided it as safely and efficiently as possible," he said. The name change reflects the fact that this is no longer the case.

Factors weighing into the decision included that Equinor "accepts climate change is real and it will make an impact on how we do business," he said. "We support Paris agreement – we want to be part of the solution for a cleaner energy supply to the world. Under the new strategy we are becoming a broad energy company."

"We believe demand for oil and gas will eventually start flattening out – first for oil and later for gas.

That is a necessary thing to happen to meet Paris agreement goals," he said.

Equinor has ambitions to invest 15 to 20 per cent of its capital into renewable energy from 2030 (although the remainder will still be oil and gas).

Mr Reinhardsen said he sees a carbon tax as a very important measure to drive change in emissions. "From an international perspective, we don't have a legislative framework [for reducing emissions]. But we do have Paris agreement and UN sustainable development goals," he said. "Both accords have become widely accepted among societies, investors and companies as targets to [help] strive to improve climate."

Equinor sees the changes to the oil and gas industry happening on 3 major themes.

Companies will increasingly compete based on their carbon efficiency, so will look for 'low carbon' resources and energy efficient solutions. Carbon taxes "will play an important role driving this development."

There will be increased focus on how to mitigate carbon emissions, which can be from natural carbon sinks (such as forestation), CCUS, and generating hydrogen from natural gas (with CCS).

There will be increasing expectations and demands from society and investors with climate and sustainability.

Equinor's new Johannes Sverdrup development will produce 660,000 bopd at maximum production, with CO2 emissions from operations at under 1kg CO2 per barrel, a 20th of industry average. This is possible because the hydrocarbons are of high quality, and because the field will be powered by electricity generated by hydroelectric power onshore.

Mr Reinhardsen was asked how CO2 emissions could be incentivised, after we have seen the carbon tax system not really functioning properly in Europe. "I think we have to keep working on this," he said. "One of the elements that comes into play is the degree we are successful with CCS. That could create space for some of these industries."

"It is always about technology, developing new solutions."

"We should go out of this room with some pride saying we come from an [oil and gas] industry which supplies affordable energy to the world – which is stabilising the whole world these days. Even though energy prices are volatile it is better than the alternative.

The debate with environmental groups could be better. It is important for the oil and gas industry that the debate is something more than "us vs them", he said. ""We all work to solve the same problem, we may differ a bit about how to get there.

Some environmentalists believe that the right pathway is to close down everything to do with oil and gas. But even if climate is a bigger priority for you than energy supply, there is an argument that it is "better to work with the industry that has investment funds," he said. "You need some big financial muscle for this to happen."

You can watch all the EAGE sessions reported here on video at
https://www.facebook.com/EAGEglobal/videos/2389538707946354/
Or **http://bit.ly/EAGE19**

EAGE: BP, Exxon, Total, IBM, discuss new technologies

A discussion forum at EAGE "New Technologies for Geoscience and Engineering", with senior speakers from BP, ExxonMobil, PGS, Total and IBM, looked at understanding how the shale revolution happened, better ways to digitise information in people's heads, and what success looks like today, among other topics

Rebecca Wiles, Head of Upstream Technology, BP, was asked what she thought the most interesting new technology developments were. She said the company is doing much to remove laborious repetitive tasks from seismic interpretation, and finding ways to carry more uncertainty in its models.

It is keen to find ways to "carry more uncertainty" through reservoir monitoring. There is uncertainty in a lot of the data, but information about the uncertainty often gets lost.

It is moving to "intelligent completion" fibre in wells, which can be used for detecting sand, profiling flow into wells, and vertical seismic profiles. Fibre optics in wells is "going to be a game changer," she said. "We've just started understanding what we can do with it."

It has 3D control systems for all production facilities, which can be used to test what the result of any adjustments will be, before doing them for real.

"We have a concept 'connected upstream, about having a live data ecosystem. Everyone can develop (Insights) instead of holding it in people's pockets. We have a production optimisation advisor, gathering data and going to operators."

"The next step will be predictive analytics – we can intervene before problems happen," she said.

She stressed that while traditional physical understanding is still "really important" in geophysics, the company is looking for people with data skills.

BP is keen on working in "agile ways", which she defines as "giving a small team a very specific business problem, identifying any barriers impeding movement and removing them immediately."

"You can apply it to all pieces of work," she said. "We've seen four fold improvements in the pace that we're working. People are focussed on one task and very deliberate about how they are achieving it."

"It can make it more exciting for people we're bringing into the company", she said. "It flatters the hierarchy. It means a different type of leadership, more about removing barriers, focussing on what's most important."

BP has separate "technology" and "digital" organisations, she said. Sometimes technologies cross, for example autonomous underwater seismic acquisition started as a "technology" project but might be more of a "digital" one.

When asked about technologies BP has taken from other industries, Ms Wiles cited a technology originally developed for crime investigation, to make 3D models from photography. The company now uses it to make 3D models of offshore facilities in Trinidad using photography.

Another technology taken from other industries is robotic drones for inspection.

ExxonMobi

Michael Cousins, Head of Exploration, ExxonMobil, said that maybe we are missing something with all our focus on seismic.

"If I ask the audience, 'what does success look like,' most of you would say Lisa – 1 (Guyana), Zohr (Egypt), Glaucus-1 (Cyprus), Brazil subsalt," he said.

"I put to you, success comes from two things, identifying and capturing opportunities ahead of the competition, and how we make the most out of the inventory of opportunities we have."

The winners in the oil and gas industry are the companies with the lowest cost of supply, he said.

"We all gravitate to 3D seismic. It is big big big data, It is pattern rich and labour intensive. But I put it to you, by the time you get to 3D seismic, you've lost the race."

"We have access to minds of tens of thousands of geoscientists who have come before us. [The challenge is to] see the things they recognised, or saw and didn't recognise.

"With AI, data management, we can look at (millions) of documents which exist, to find the next Brazil subsalt or the next Guyana."

"Don't think of it as 3D seismic. Think about accessing minds of geoscientists who came before us."

Exxon would consider any new technology in a positive light, if it "lets individuals spend more time on things that matter," he said.

On the subject of recruiting, Mr Cousins said, ""we have absolutely no trouble recruiting the talent we need in geoscience and engineering.

"Our strength is ability to integrate different types of data. If we can hire people who can integrate different types of data we'll be successful," he said.

But "people we hire today want to be heard, they want access to the latest technology."

"We have to make the industry attractive, that's from telling our story better. That is less about technology and data. You tell people you love what you are doing and why."

Mr Cousins said he did not believe computers would ever find oil by themselves. "Oil is found in the minds of men and women. It will be the same in 20 years as it is today."

PGS

Per Arild Reksnes, EVP Operations and technology with seismic company PGS, said he has been trying to work out why AI and automation should be particularly relevant now, when it has been under development for decades.

It may be because computing power is better today, or because there has been progress in other industries.

Automation and AI could change how geoscientists work, and change the relationship between service companies and their customers. It can help people work more efficiently, bringing the seismic turnaround time down.

Although it is not clear whether the biggest priority for customers is faster seismic data or better interpretations, customers always say they want both, he said.

IBM

IBM recently did a trial to see if it could predict gas production by automatically analysing well logs, said Ulisses T. Mello, Director Research, IBM Brazil. It was expected to be "pretty hard", because it takes a lot of work to do [manually].

"But I was surprised how well we did. Gas is less sensitive to geology, much more mobile than oil."

"When you prove [analytic] techniques are successful in some way, people change their minds," he said.

In terms of cybersecurity, Mr Mello said he thought open source code could be more secure than proprietary code, citing Linux as an example. "Our experience is the more open, the more secure it is. The more people looking at the code, the higher chances of having a better piece of code."

"Critical thinking is the most important skill people have," Mr Mello said. "We have to think about how to balance technology with ability to develop critical thinking. My son went to a liberal arts school – I saw him [develop an] ability to rip apart a problem and rebuild it."

Total

François Alabert, VP Geotechnology, Total, also asserted that the company does not have any difficulty attracting the people it wants. "A lot of young and brilliant geoscientists want to join Total," he said.

"I don't like the word AI. Intelligence is human. I like "augmented intelligence," he said.

Mr Alabert sees “getting more technology into the field” as a major challenge, seeking smaller sensors, such as for temperature and resistivity, to get a much better understanding of reservoirs.

“The cheapest way to find oil is just behind pipe,” he said.

“The combination of data downhole with data processing power could be a game changer.”

How to digitise knowledge

Speakers were asked what they thought was the best way to digitise knowledge in people’s heads.

“The way you capture that data is simple, you digitise it,” asserted Exxon’s Mr Cousins. “You can draw out sentiments in documents. It is completely practical to do that.”

“You need to make analogue digital,” said PGS’s Mr Reksnes. “There’s ways to do it, but it costs a lot of time and money. So you need a good business plan. Maybe it is better thing to approach the human side and go that way.

“The issue is knowledge lifecycle management,” said IBM’s Mr Mello. “We are still in the infancy of this.”

How shale happened

Speakers shared some interesting views on how they thought the shale revolution happened.

Shale is both a concept and a technology, in thinking that a source rock can be a reservoir, said Total’s Mr Alabert.

At the time shale was developed, there was a big interest in looking for new sources of oil and gas molecules. The oil price was thought to be sustainably high and the exploration costs were increasing. This is different to today, he said.

Shale took advantage of technologies which already existed, such as horizontal wells with fractures in multiple places. Today, satellite data is being more widely used, including for surveillance of installations.

Exxon’s Mr Cousins said many people assert that shale is just ‘carpet bombing,’ [covering the ground with wells], and has nothing to do with technology. “If anyone makes an assumption technology had nothing to do with [the shale revolution], that’s flat out wrong.”

“Those who have the sweet spot will win. The best players are those who understand the use of technology to get the most out of every reservoir, including AI.”

Digital disruption

Speakers were asked how they make sure they are prepared for the next “disruption”.

BP’s Ms Wiles says that the company has a “venturing” arm, which makes investments in emerging technologies, partly as way it can understand them better. Its recent investments in the ‘cognitive’ area are Belmont Technology and Beyond Limits. “You have to have your antenna out,” she said.

PGS’s Mr Reksnes noted that people usually use the term disruption to refer to technologies like Uber, which developed a better way to order a taxi using the internet. But it is “a very simple problem,” he said. “Oil and gas is very complex. “The industry is already trying to look at every way to be more efficient. So I don’t feel we are in big risk of disruption.”

IBM’s Mr Mello said that disruption can be more about business models than technology. For example, Uber tackled an inefficiency problem in the taxi sector.

The industry has developed new business models to cope with different challenges at stages in the oil price cycle. So we saw the development of shale when the oil price was high. When the oil price was down, it developed new business models around risk sharing, such as with drilling companies taking some of the cost of a well and sharing the benefit.

Oil and gas companies could learn something from technology companies, which are reconsidering their business models all the time. “They are much more paranoid,” Mr Mello said.

EAGE discussion – the changing role of geoscientists and engineers

A “Forum Session” at EAGE in London discussed the changing roles of geoscientists, engineers, including two recent graduates working at BP and Halliburton, the CEO of CGG, a lecturer from Imperial College and an executive search consultant

A “Forum Session” at EAGE in London discussed the changing roles of geoscientists and engineers, as the energy and technology landscape changes.

Participants included with two recent graduates working at BP and Halliburton, the CEO of CGG, a professor in reservoir physics and EOR at Imperial College, and the senior client partner for energy EMEA with executive search consultancy Korn Ferry.

The cyclical nature of industry is a big challenge with attracting people, said Sophie Zurquiyah, CEO of seismic services company CGG.

CGG currently has 2100 people in its geoscience group, looking at seismic imaging, characterisation, and data management. These people are often highly qualified, with PhDs and Masters Degrees. But the workforce is 40 per cent less than it was a few years ago.

There is an “acquisition and equipment” group at CGG, people who move around the world doing seismic services, more “hard core engineering”. The multiclient group is people with more of a sales background, but still technical, she said.

The company is looking to use digital technology to find ways to work in a more efficient manner, and bring machine learning into workflows. For example, developing automated tools to clean data and make it consistent.

Usually about 5-7 per cent of staff choose to leave every year. But the company does not find it very difficult to recruit, and receives many CVs. An issue with new graduates in Europe is that people see the oil and gas industry as an “industry of the past,” she said.

One way around it is to emphasise that people can learn skills at CGG which would be useful even if they choose not to stay in the industry – and also make people feel that they are constantly learning, she said.

The industry's technical challenges are a big draw for people, she said, such as making better images from seismic below water, or handling the increasing volumes of data.

Ms Zurquiyah sees machine learning as a "sophisticated name for statistical methods." It is useful to augment more traditional ways of working, and remove biases.

Ann Muggeridge, Imperial College

Ann Muggeridge, Professor in Reservoir Physics and EOR, Imperial College, said she thinks this is "a great time to be an earth scientist / engineer," with such big challenges.

However there has been a big fall in people applying for courses on earth science. This can be partly attributed to fewer 18 year olds in the UK applying for university in general, she said.

Many graduates are concerned about climate change and single use plastics, and associate both of those with the oil and gas industry. "Maybe we should be teaching more about CCS, or other types of geology," she said.

But if that was to happen, something else would need to be removed from the course to make room, she said.

Efforts have been made to bring more digital skills into the course, so not just about colouring pens and rocks. "Our graduates will need to be aware and literate in digital tools. But before you use the tools you need to be aware of principals of earth science."

The industry could do more to emphasise its "fantastic science and engineering" to improve recruitment, she said. "But also a lot of people don't want to listen."

There were suggestions that degrees could be named differently to reflect the jobs oil companies might be looking for, such as "seismic processing." But Ms Muggeridge cautioned against this, saying that degree course titles will only attract 16-18 year olds if it is something they recognise, or which relates to their school education or career.

Iain Manson, Korn Ferry

"I don't think that I've seen industry in a disruption quite like at the moment," said Iain Manson of executive search firm Korn Ferry. "Everyone's talking about 'energy transition, there's environmental pressures, new strategies and business models, changing geopolitics, new technologies – AI / big data. Disruption is here to stay."

"We've done a lot of research into what leaders (need to do). They need to drive, give purpose, and energise people. Millennials are looking for that sense of purpose," he said.

An obstacle to recruitment is the perception that oil and gas is a 20th century industry, he said.

Also today's students are "much less interested in things that we [an older generation] were interested in," he said, such as a job for life.

"We have to position the industry as having a laudable purpose," he said. Also presenting itself as the 'energy industry' not oil and gas would help. Also emphasising that 20-30 per cent of oil production is used for petrochemicals.

Naphtali Latter

One of the biggest barriers to digitalisation is our "organisational culture" of people not wanting to be seen failing, said Naphtali Latter, an account manager, with Halliburton, who graduated with a Bachelor of Science in 2010.

"A lot of companies are hallucinating when it comes to digital transformation. What results have you actually seen?" she asked.

One barrier is "education of senior management in digital," she said. "I've been to digitalisation workshops with senior managers and their digital teams. These guys don't know 100 per cent what everyone is talking about. If you're going to make such a large change in an organisation it has to come from the top. [But] At the top there isn't a fundamental understanding of what's going on."

I went to a conference on the future of digitalisation in the North Sea in Edinburgh. I was extremely underwhelmed. The closest thing was "let's plan a well in a day" from Aker BP. A bolder aim could be, "let's process a seismic project in a week," she suggested.

Also, "I don't feel the appetite for change is genuine," she said. "

Millennials can be attracted to an industry which has buzzwords like disruption and innovation, she said. "We want the chance to change."

James Hamilton-Wright

James Hamilton-Wright, a geoscientist at BP who graduated from Imperial College with a Masters in 2016, said that he thought new roles and training programs need to be created in oil companies to help work with the new data being created. For example, BP has a graduate scheme on subsurface information management.

The oil and gas industry might recruit more easily if it appealed to people who are looking for a challenging career, saying they can be part of solving the hardest questions.

Layoffs a deterrent?

Speakers were asked whether the layoffs in the oil and gas industry over past years are deterring people.

Imperial's Ms Muggeridge said that students were often not aware of these sorts of issues when considering options at 17 years old. But their parents are aware and are guiding them.

She saw a phase lag of about 18 months between when the oil crash happened and when she saw a reduced intake of students.

CGG's Sophie Zurquiyah thought that a bigger issue was a perception that the industry has a corruption problem.

Do we need degrees?

Ms Latter questioned whether people need to take three year degree courses. Only one module of her course was directly relevant to her future job, in seismic processing.

Imperial's Ms Muggeridge said it was more of a culture in the UK that everybody should leave school at 18 and get a degree. Alternatives could be explored, such as a foundational training before your first job, and additional training as needed after that. But also bear in mind it makes it much easier financially for the university to have student for three years continuously, rather than in shorter bursts.

Mr Hamilton-Wright agreed it is a "deep-rooted thing" in schools to go to university and get a job. Some people get very disappointed when it does not turn out for them, with a Masters' degree and still unemployed.