SPE Review London

SPE London Section

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

Making a difference: women in energy

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C-Level talks: Peter Clutterbuck

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Failing in the virtual world is not expensive – get your Digital Twin implementation right!

SPE SECTION EXCELLENCE AWARD ★★★ 2020

50 YEARS

LETTER FROM THE CHAIR   LETTER FROM THE EDITOR

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ABOUT US

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

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In this issue

SPE SECTION EXCELLENCE *** AWARD *** 2020

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Behind the Scenes: SPE Review Editorial Board

Elizaveta Poliakova, Editor in Chief

Elizaveta is a Reservoir Engineer at Trident Energy. She has an M.Sc in Petroleum Engineering from Imperial College London and a B.S. in Petroleum Engineering from the University of Leeds. Elizaveta has been with SPE for more than five years. She was the President of SPE Imperial College Chapter and the President of SPE Leeds Chapter. Previously, she was also on the committee of SPE YP.

Josh Beinke

Graduated from University of Adelaide in 2008 with a Petroleum Engineering degree. After several years with Chevron moved to Europe in 2016, now working as an Exploitation Engineer with Vermilion Energy.

Ffion Llwyd-Jones

Business editor and writer. Extensive experience in writing and editing (digital and print). International experience in technology, health, and the environment.

Mark Beleski

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

Shalom Amakhabi, Editorial volunteer

MSc Petroleum Engineering student (Imperial College London); BEng in Petroleum and Gas Engineering from Nile University of Nigeria. SPE member 5+ years, and membership chairperson for the SPE Nile University of Nigeria student Chapter.

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

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GeoScience

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Imperial College London

Letter from the SPE London Chair

Dear SPE London Members and colleagues,

As a section, we continue to deliver high-quality technical content to share best practices across our industry. We received your strong feedback that the best format for you to access technical presentations is online and we continue to hold our meetings through Zoom with strong attendance. However, the missing networking aspect of SPE could lead to new connections, initiatives and friendships. The new 'Energy on Draft' social event that we organised in cooperation with PESGB and AAPG is an answer to that. I am very happy to see us introducing back in-person events, as I had moved to London just before Covid and have not had a chance to attend many since then – I believe many members might be in a similar situation. I would like to thank our board member Percy Obeahon for coordinating and spearheading this event.

The section continues to thrive thanks to the support of our Sponsors. I would like to thank the Sponsorship Chair Adrian Southworth and all the ever-growing list of sponsoring companies: Harbour Energy, GeoScience, Neptune Energy, OPC, ERCE, Serica Energy, CNOOC, RPS , CGG, and Imperial College London. This support would allow us to sustain our activities and grow in scope as we come back to more in-person events. I am particularly glad to see the financial support combined with volunteers joining the board, which allows us to build lasting relationships and brings fresh ideas.

Finally, the Section runs through the dedication and the efforts of volunteers. SPE runs on annual sessions ending each year on 30th of June. We will be electing a new board and looking for new volunteers to fill the positions on the board and within the subcommittees. I would like to thank all the hard work the current board members and volunteers have put in to make this year a success. Please get in touch with us if you would like to get involved.

Our Section is dedicated to providing value to the membership! Thank you for attending our events and please feel free to share with us your thoughts post events or through social interactions. As volunteers, our focus is to bring value to our fellow members.

Kind Regards,
Adam Zalewski, SPE London Section Chair
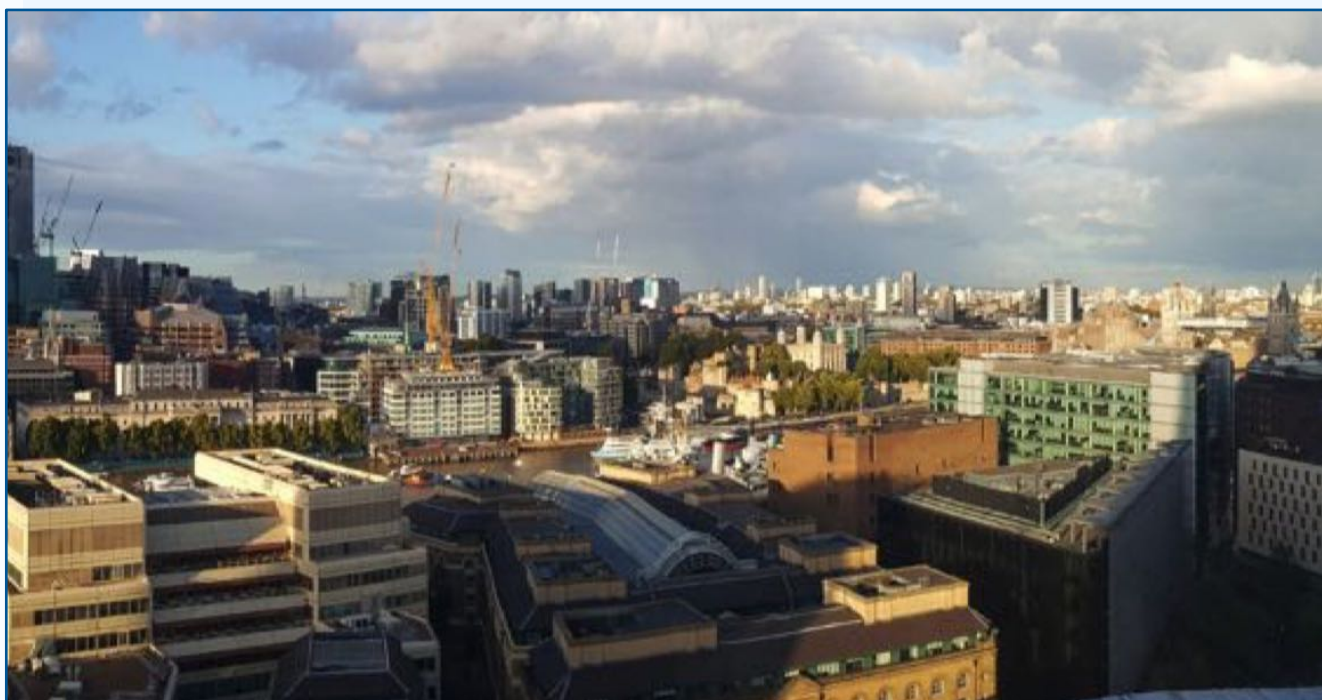
Letter from the Editor

Dear SPE Readers and Colleagues,

Happy Easter! Welcome to the second edition of SPE Review London in 2022. We hope you enjoyed 'Energy on Draft' event in collaboration with AAPG and PESGB on the 28th of April! We also hope very much that you enjoyed our Evening Talks on the 26th of April and 31st of March chaired by Tim Lined. As well as the two events by SPE YP London (How to build and market yourself for the future & Hydrogen: opportunities and challenged) and the event by SPE London Net Zero Gaia: Social License to operate.

In this publication, **C-Level Talks** features Peter Clutterbuck, who was CEO of Orca Exploration, managing the Songo Songo field in Tanzania. Previously, he was VP Operations for TSX listed PanOcean Energy. Please refer to **page 7** for the full Talk.

On **page 17**, you will find an article about '**Getting your Digital Twin right**' by Balasubramanian Chandrasekaran, Dhiraj Rane, Gautam Saha, and Prem Paramasivam.

SPE Imperial College London hosted a panel event to celebrate International Female day '**Making a Difference: Women Leaders in Energy Industry**', featuring Kathryn Dawson, Chief Development Geoscience and Principal Development, Tullow Oil; Norbashinatun Salmi, Head of Field Cluster 2, Petroleum Engineering Department, PETRONAS Carigali; and Professor Ann Muggeridge, Chair in Subsurface Physics, Department of Earth Sciences , Imperial College London. Read more on **page 9**.

On **page 11**, Martin Blunt, Professor of Flow in Porous Media at Imperial College London and Director of the new MSc introduces the **new MSc Courses: Geo-Energy with Machine Learning and Data Science (GEMS)**. These courses will be taught from September 2022 in place of MSc Petroleum Geoscience and MSc Petroleum Engineering.

On **page 14**, we continue to share **SPE London Net Zero 101 series** answering the question: What is a 'Just Transition' and why should O&G workers care? by Alison Isherwood.

Last but not least, on **page 25**, Adrian Gregory covers '**Continual innovation and entrepreneurialism**' in the SPE London Sustainability series.

I would like to thank our Editorial Team for their continuous flow of energy and ideas of how to make every publication of SPE London Review better!

Sincerely Yours,
Elizaveta Poliakova

Click here to access past issues of the SPE Review London!
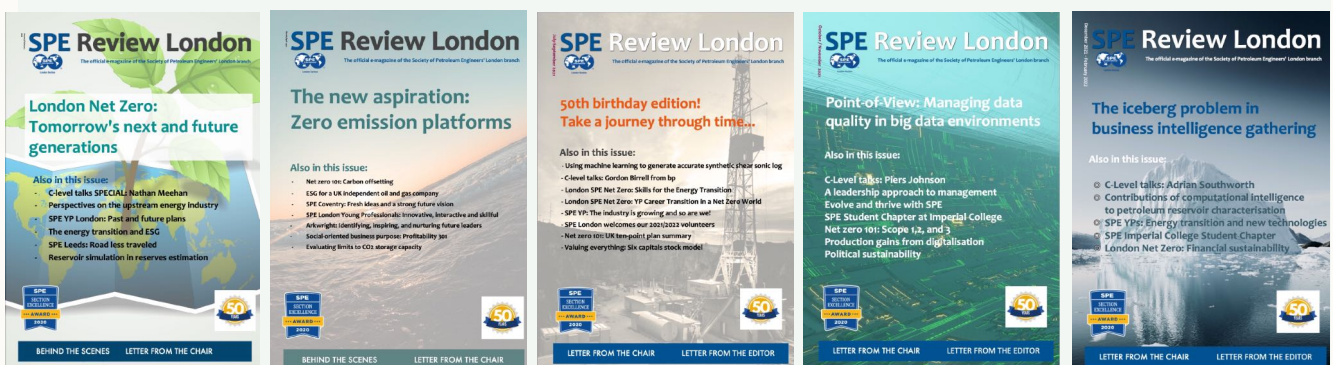
NEWS DIGEST... NEWS DIGEST... NEWS DIGEST

Finder times entry into the North Sea to increase its leverage

An agreement between Talon Energy and Australia-based Finder Energy means the latter has acquired a 100 per cent interest in Seaward Production Licence P2527 in the Outer Moray Firth. Finder said the agreement is conditional on getting the usual regulatory approvals.
Read more

BP pushes ahead with plans for the redevelopment of Skua field

Following its plans to develop the North Sea oil and gas field, BP has submitted its Murlach project environmental statement to the energy regulator. Installation and drilling operations of the subsea facility could begin in 2024, with the first oil expected in 2025.
If approved, the project has an estimated production life of 11 years, with an approximated peak daily production of 17m cubic feet of gas and 20,000 barrels of oil.
Read more

British Geological Society to advise on shale extraction evidence

In April, the UK government commissioned the British Geological Survey to advise on the latest scientific evidence around shale gas extraction. Activity in England was paused in 2019 following a North Sea Transition Authority report, with any further development or exploration needing to meet rigorous environmental and safety protections.
A report is expected before July 2022.
**Read more**

Phase 1 investigation completed into merger

February saw the start of the Competition and Markets Authority's (CMA) investigation into the merger between Noble and Maersk Drilling.
Results from the initial Phase 2 found the deal raises competition concerns in the supply of jack-up rigs for offshore drilling in the area comprising the UK, Denmark and the Netherlands (North-West Europe).
Read more

Keeping energy flowing in the next decade

The British Energy Security Strategy report was published earlier this month (April), with a key takeaway identified as the backing by Whitehall to keep energy flow secure into the next decade, supporting UK upstream oil and gas. various elements include the announcement of new oil and gas licences, research funding for low-carbon hydrogen fuels, and a remit for new nuclear reactors to deliver additional baseload power.
Read more
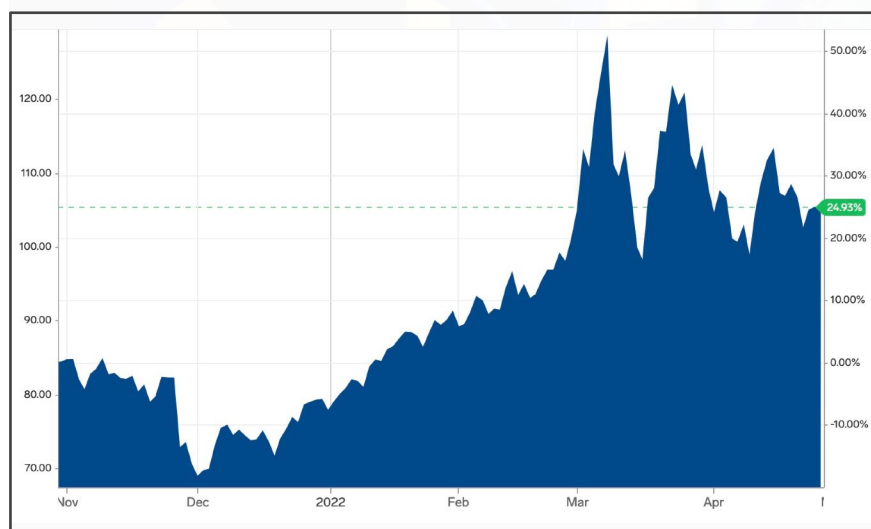
Oil (Brent) 105.04 -0.11 (-0.10%) – 28/04/2022 (**Credit: Market Insider**)

Catching the wave: new regions and technologies

Peter was CEO of Orca Exploration, managing the Songo Songo field in Tanzania, supplying 90mmscf for 400MW power and industry. Previously, he was VP Operations for TSX-listed PanOcean Energy, producing 20,000bopd onshore and offshore operations in Gabon. He was responsible for the discovery and initial development of the Rubiales Field in Colombia. He had a 15-year career in operations management positions with the BP group in Abu Dhabi (Bab and Bu Hasa), North Sea (Forties, Ninian, Magnus, Andrew, Buchan), and Alaska (Prudhoe Bay and Kuparuk). He served on the Board of the Society of Petroleum Engineers in London. He has a degree in Engineering from Cambridge University.

Who is Peter Clutterbuck? Tell us about yourself.

I was brought up in a military family, and we had 21 homes in 20 years. The Army used to move families around by troopship, and one of my first memories, when six years old, was en-route to Malaya, where my father was fighting as a Royal Engineer against the Communist terrorists in the jungle.

We were hit by a fierce North Atlantic winter storm, with waves higher than the ship, about 50 feet. The waves broke into the upper deck, causing a lot of damage. We reached the magical Orient after many refuelling stops, six weeks later. I loved the adventure of all this, which influenced me to join the oil and gas industry, which has similar challenges: getting the community onside, managing logistics in a hostile world, and using the newest technology to tackle seemingly insurmountable problems.

While completing an Engineering Degree at Cambridge University, I looked for challenging jobs and found seven. The one I liked the best was with the Iraq Petroleum Company, operating immense reserves of Middle East oil. I saw a photograph of a geologist with a map on his Land Rover bonnet, surveying a sea of huge sand dunes. This was what I wanted to do.

At the interview, I was warned that living conditions in a bachelor camp were rough and asked what my main sport was. I explained that it was offshore sailing in a wooden dinghy. "Good" replied the interviewer. "If you had said 'playing the cello', you would not have got the job. You will be posted to Abu Dhabi."

Soon I was in the huge dunes of the Rub-al-Khali, the Empty Quarter of Arabia, where we were discovering new supergiant oilfields every year, some as big as 14 billion barrels of reserves.

I got an idea of how powerful the energy was from oil and gas. An unmanned production station had shut down, and two of us were sent out to restart it. It was hissing poisonous gases from 3000 psi wells with high levels of hydrogen sulphide. The maximum safe pressure of the vessels in the plant was 250 psi. Then the safety shutdown system failed, and oil roared through as the plant thundered, and gas screamed out of control. There was a loud bang and a tremendous shuddering. The plant pressure rose above 250 psi, then 300 psi, then 400 psi, then 500 psi. The oil was escaping in a roaring fireball going up hundreds of feet into the sky. We both turned the big valves manually and shut off the well pressure on borrowed time, exhausted. We had been very lucky. Later, I was to become a drilling engineer and run a nine rig drilling programme, completing over 100 wells per year.

I was keen to work in the North Sea, where oil had been discovered. This was a tremendous opportunity, using new technology. There was an Arab embargo, which caused a three-fold increase in oil price, and set off a global push to diversify oil production away from unstable countries. BP had lost its core business in Iran, Libya and Iraq. Now, all eyes were on the North Sea, including the Government, which was relying on this to bail it out of a financial crisis. We were setting new records for water depth, and 100-year storms were happening regularly. I was initially managing BP's floating rig well appraisal operations, then I was assigned to Forties to commission the oil production and NGL facilities. This included climbing a 230-foot ladder, sometimes iced over, often in fierce gales, to work on the flare. The Forties Alpha platform was the first to produce oil in the UK North Sea. These platforms were the biggest ever constructed. It was magical to be part of this, pushing the envelope.

Catching the wave: new regions and technologies... continued

BP then posted me to the Arctic North Slope of Alaska, with offices in San Francisco. Our mission was to sell all our US assets, but we soon realised that they were greatly undervalued. We managed to convince the BP Board to reverse this strategy, allowing us to start up the Kuparuk oilfield and operate the bulk of the 13-billion-barrel Prudhoe Bay oilfield. I was responsible for a $1.2 billion annual budget, drilling 120 wells per year, with 13 rigs, then the world's most expensive oilfield development.

After BP, most of my work was as CEO managing smaller independents, where the challenge was always to perform miracles for shareholders on tiny budgets. One of the more memorable was to drill for shale oil and gas in Poland's Baltic Basin, in partnership with ConocoPhillips. We were ahead of the land rush, and drilled some great horizontal wells with multi-stage hydraulic fracture completions, but could'nt achieve commercial rates, despite being the best shale wells in Europe. Someone may crack the code and take the prize on this huge gas volume, which will reduce dependence on Russian gas

You have worked in many different countries and managed projects all around the world. How did Oil & Gas differ across the globe? What were the main challenges?

The most exciting ones were the pioneering ones, being a first mover. The main challenges were mostly downhole problems in drilling and testing wells, also harsh environments. One of my happiest jobs was managing the start-up and operation of the Songo Songo field offshore Tanzania, delivering natural gas to five power stations and 36 industries: the first and biggest in East Africa. We had a world-class reservoir, cooperative government and happy shareholders.

You have worked as a managing director for operators and service companies. How did your experience differ from one to another?

I have generally worked for oil and gas companies, usually as an operator. The pressure was intense, to deliver.

I have not done well as a non-operator, being frustrated by differences of view with the operator.

You have founded and managed multiple companies. What was it like to found an oil and gas company?

Start-ups are always challenging.

My most memorable one was to drill in Colombia's Llanos basin under guerrilla control and make a large heavy oil discovery.

Another was to work in Arctic Russia as the Soviet Union collapsed. We worked over 130 oil wells and set up a new working culture to replace the failed Soviet system. It was hard work, at minus 50 deg C, but we were in Russia at a good time.

What technology developments did you find most impressive over your career? And which do you think awaits in the future?

Three stand out: seismic processing and interpretation, deepwater offshore operations, and multistage hydraulic fracturing.

Future big discoveries will be mostly in deep water. Onshore technology will increasingly focus on well deliverability and social benefits.

Tell us more about your career transition from Oil&Gas to the Geothermal industry.

Geothermal is underutilised, because of subsurface risk, high capex, and disappointing economics. These will steadily improve, especially as oil and gas professionals migrate over. The potential is huge, and the prize is attractive: zero emissions and 24/7 energy delivery, making it competitive with oil, gas, wind and solar.

What advice can you give to university graduates who want to join the Industry?

Get involved with renewable energy, as this will likely need more professionals as these sectors grow. Most oil and gas disciplines will be needed, including subsurface expertise for things like geothermal and CCUS. However, oil and gas will produce at least half of the energy mix for several decades, requiring substantial development to offset natural decline. The next few years will also be busy, to replace Russian exports, with an ongoing likely high oil price.

Making a difference: women leaders in energy

International Women's Day (IWD) is an annual global celebration to reflect and recognize the social, economic, cultural and political achievements of women. The theme of IWD 2022 is 'Break the Bias', a call for a more diverse, equitable and inclusive society.

To commemorate women in the energy industry, SPE Imperial College student chapter organized a forum with three women leaders who have been a part of the energy sector for at least 20 years to create more awareness on the diversity and inclusivity agenda, and allow students to interact with the speakers as they prepare to embark on their professional lives in the future.

The event was participated by around 20 students and brought together perspectives of women in both industry and academia to share their experiences and wisdom in making a difference with their passion.

The key speakers included :

Kathryn Dawson, Chief Development Geoscience and Principal Development, Tullow Oil.
Kathryn is an experienced industry development geophysicist. Following a BSc in Geophysicist the University of Leicester in England and Masters in Geophysics at the University of Durham, she entered the industry in 1990 joining Amoco UK Exploration Company, a subsidiary of Amoco Corp. At the BP Amoco merger, she chose to take a diversion from the oil industry and joined the British Royal Navy as an officer responsible for training in the mechanical engineering branch. Her interest in matters geophysical drew her back to the oil and gas industry, and she joined Tullow Oil in 2005.

Norbashinatun Salmi, Head of Field Cluster 2, Petroleum Engineering Department, PETRONAS Carigali.
Norbashinatun obtained her BSc in Chemical Engineering from University of Manchester in 2002 and embarked on her career as a Production Technologist in PETRONAS. She was required to perform both technical studies in the office and to be in the field either offshore or at the warehouses and fabrication yards. She has held various leadership roles across the upstream sector which includes field development, production surveillance, techno-commercial evaluation and business portfolio management. Currently, she is also in her final year of the MEng. Renewable Energy Engineering from a 2-year part-time programme.

Professor Ann Muggeridge, Chair in Subsurface Physics, Department of Earth Sciences, Imperial College London.
Professor Muggeridge obtained her BSc in Physics in Imperial College and her PhD in Atmospheric in University of Oxford. She was a research reservoir engineer in BP prior to joining academia in Imperial College London in 1995. Professor Muggeridge held various roles in the Department of Earth Sciences and Engineering and is currently the Chair in Subsurface Physics. Her most recent measure of esteem is her role as Chair of Scientific Advisory Committee for Norwegian IOR Centre.

During the session, participants had an opportunity to listen to various aspects of the invited speakers' experiences including their advice on managing a career in the sector.

A discussion on gender equity was among the questions shared by the participants to the speakers and was addressed during the session.

Making a Difference: Women Leaders in Energy ... continued

Key excerpts shared by the speakers:

What do you find most rewarding in your career?

Kathryn: I find so many elements rewarding, I have always liked solving problems and I think that's what drawn most of us to science, those technical challenges and solutions. If there is one thing I find rewarding, it would be, when there is injustice or improvement needed, and through my role, I could help fix. As one rise through leadership, they will have more influence and could contribute in helping and making a difference in someone's career.

Norbashinatun: In the earlier days of my career, I used to find it extremely rewarding to be able to comprehend and solve difficult technical tasks, implementing new technologies and increasing projects and business values. Now, as part of the management team, I find it even more rewarding to be able to support, facilitate and be part of the growth of my subordinates particularly the younger engineers.

Professor Muggeridge: The most rewarding aspect of being part of academic is the diversity of the job we do. Being in an applied area, trying to understand how it works and collaborating with industry to provide insights and changing how things work. Its been a rewarding experience to be able to work with the Norwegian Petroleum Directorate on the EOR in North Sea and with BP in specific research areas and the joy of having met many students over many years and seeing them progress.

What do you find most challenging in your role?

Kathryn: I would say managing egos have been one of the more challenging part of my role. Often times, we associate the ego with something negative but the ego is a sense of self, its something we bring with us in meetings and engagements. In the realm of finding technical solutions, we always want to find the best solutions and we may bring our personal egos in the discussion. Managing that in a team can be rather challenging in certain ways.

Norbashinatun: The biggest challenge for me would be when I have conflicting urgency in both family and work. I find it extremely difficult to have to prioritize when its both urgent. Through the years I have been able to improve my ways and ensure my team are provided with the right support should I need to attend to my children or family matters prior to responding an urgent work related matter.

Professor Muggeridge: The biggest challenge as a leader or being in a more senior position in an organisation is keeping all the different activities you are involved in, making sure nothing gets forgotten, whether its talking to my personal tutees, making sure the research is progressing, dealing with the training courses the college wants me to undertake. Its making sure you can do everything and still have time off in the evening.

What the one piece of advice you would give to a younger version of yourself?

Kathryn: I believe there is no perfect course through life and I am happy with some of the mistakes I made. Looking back, what I would probably advice is to not be afraid of making mistakes and embrace in making mistakes, learn from them and push the boundaries of what you know.

Norbashinatun: Looking back, I now realize that leadership is really how you make others feel, and how you could offer and provide them a better quality of life. At the same time, the main advice I would give to a younger version of myself is to not be afraid to challenge the status quo and to speak up and reach out so that you can bring the best out of what you do.

Professor Muggeridge: Reflecting on how I felt when my children were little, there will be a point where you will be trying to hold the job together. I kept on working even though it could get tough at that time. It eventually paid dividends in the end despite having the guilt of having to farm the children out or not being able to pick them up from school, something a lot of women experience. My advice to the younger version of myself would definitely be to absolutely keep on going and pursuing your career and interests. It gets tough at time but it's absolutely worth it having something that belongs to you.

New MSc at Imperial College London: Geo-Energy with Machine Learning and Data Science (GEMS)

Martin Blunt, Professor of Flow in Porous Media at Imperial and Director of the new MSc, explains the reasoning behind the creation of the new programme, together with an overview of the GEMS MSc, and the three groups of students that may benefit most.

Imperial College London has a proud tradition of petroleum-related teaching and research dating back to 1913: you can see 'Oil Technology' engraved in stone at the entrance to the Royal School of Mines. Since the 1970s, Imperial College has taught two MSc programmes in petroleum-related subjects: an MSc in Petroleum Geoscience and an MSc in Petroleum Engineering. The current Petroleum Engineering MSc was last redesigned in 1996.

Last year, however, after a long period of reflection in lockdown, the petroleum-related teaching staff at Imperial agreed that the two petroleum-related MSc programmes should be replaced by a new programme, fit for educating the next generation of subsurface geoscientists and engineers. The final decision to launch the new course was made after wide consultation with staff, students, alumni and our colleagues in industry.

This new course, Geo-Energy with Machine Learning and Data Science (known by the more manageable acronym GEMS) will admit its first students in October 2022 and is currently accepting applicants: for more details and information on how to apply, please go to:
https://www.imperial.ac.uk/earth-science/prosp-students/pg-courses/geo-energy-machine-learning/

New MSc at Imperial College London ... continued

The reasons behind this major change in the direction of our teaching, which will also be reflected in how we redirect our research efforts, are as follows:

◎ The hydrocarbon industry is undergoing a period of radical change to meet the challenge of being consistent with net zero emissions by 2050 to address the threat of dangerous climate change – the so-called Energy Transition. Our current MSc programmes, which are focussed on traditional hydrocarbon exploration and production, are not explicitly aligned with the College's stated position on sustainable development and climate change targets – see **www.imperial.ac.uk/about/leadership-and-strategy/college-endowment/policy-working-group/**

◎ The fundamental skills taught in our current petroleum MSc programmes are useful in other fields related to sustainable energy and the climate crisis, namely geothermal energy and carbon dioxide, hydrogen and thermal energy storage. This is not reflected in the current programme content.

◎ The current curricula do not develop skills in programming, machine learning, and data science, which are increasingly in demand from employers, including in roles associated with the oil industry.

◎ Applications for our petroleum MSc programmes decreased three to four-fold in 2021 compared to 2020, which itself was a bad year thanks to low oil prices. While much of this could be due to the pandemic, it is felt that applications are likely to remain at a level that continuation of the programmes would be impossible to justify.
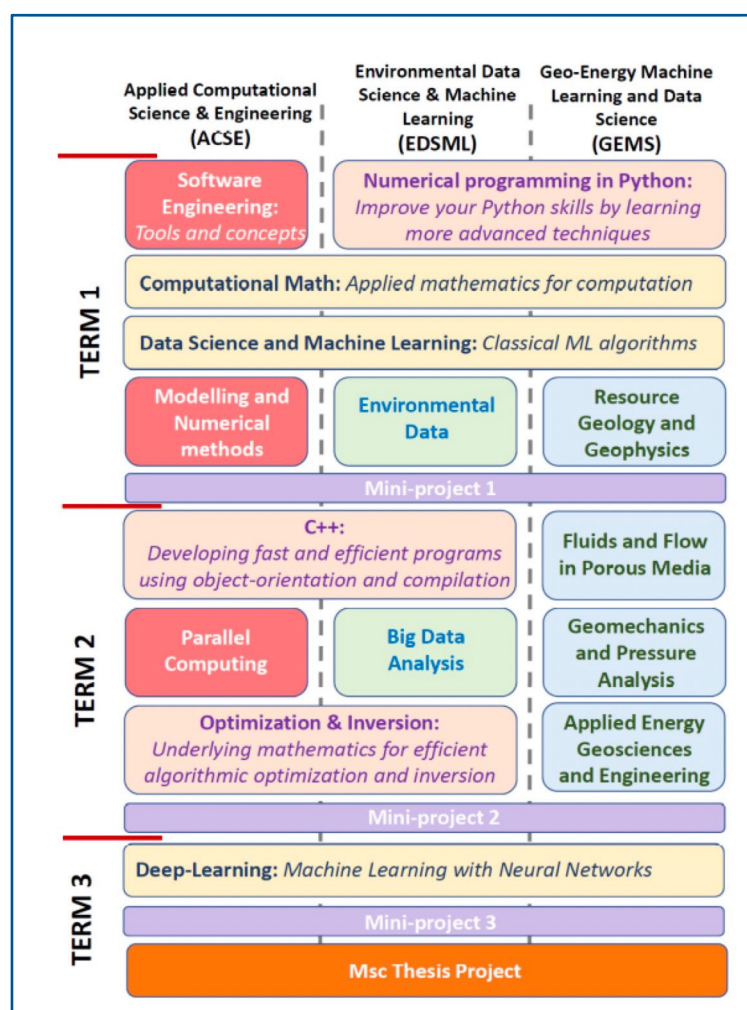
Brief course overview

If you are potentially interested in this course, or know someone who is, here is a brief overview of what the GEMS MSc will cover. Lectures will all be held in the Royal School of Mines in recently refurbished facilities: all students will have their own dedicated laptop.

The overall curriculum is outlined in the figure (left) and is integrated with our existing programmes ACSE (Applied Computational Science and Engineering) and EDSML (Environmental Data Science and Machine Learning).

We aim to have 50% women students and offer scholarships to widen participation in our courses.

The course covers subsurface geoscience and engineering with application to carbon dioxide storage, hydrogen storage, water management, hydrocarbon recovery, geothermal energy and other subsurface processes.

The course provides the knowledge essential for developing a sustainable energy economy and tackling the climate crisis. The unique

New MSc at Imperial College London ... continued

feature of the programme is the development and application of skills in data science and machine learning. An emphasis is placed on developing and applying numerical, analytical and computational concepts. The programme is intended to educate geoscientists and engineers to acquire advanced computational, data science, machine learning, and numerical skills relevant to working on various aspects of the energy transition.

Some prior coding experience is a requirement of the course, but students are not expected to be expert, and self-taught students are welcome: there will be a mandatory pre-sessional training course in programming in Python.

We will provide support throughout the course to help students with coding, through the provision of online resources, and dedicated study space and teaching assistants.

The course also covers data science, numerical methods, and machine learning. Throughout the programme, these concepts will be applied to problems in subsurface geoscience and engineering, including geological data collection and analysis, fluid flow in porous media, geomechanics, and targeted analysis of topics relevant to the energy transition. For the summer research project, there will be the opportunity to take up optional placements in industry.

The programme is aimed at three groups of students
 – Students with strong methodological backgrounds in mathematics or physical sciences who wish to move to, or specialise in, an applied field with an emphasis on subsurface geoscience and engineering

 – Students with a more applied background in geoscience and engineering, wishing to learn about data science and machine learning (the underlying theory/algorithms and how to implement/use them in code) and how these can be used as modern data-driven problem-solving and analysis tools

 – Students with a background in computer science wishing to expand their knowledge of applied data science, machine learning and associated computational and observational techniques in the context of subsurface energy and storage, and to gain experience in the ways in which these can be used to solve large-scale subsurface geoscience and engineering problems.

The programme consists of taught modules and project work delivered over the first two terms of the academic year, followed by a research project. There are no exams – all assessment is based on coursework completed during term time.

Based on previous cohorts of students, approximately one third go on to further study either another MSc programme or a PhD. The other two-thirds work mainly in industry. The principal employers of graduates from this programme will be the large data and computer companies, consultancies offering services to the energy industry and working on natural geo-hazards, and the energy industry itself, including oil and gas, as well as renewables. In particular, there will also be opportunity to engage with potential employers in the energy industry outside the current oil and gas industry.

What is a 'Just Transition' and why should oil and gas workers care?

A 2020 survey of 1,546 UK O&G workers found that 91% of respondents had not heard of the term Just Transition despite being at the heart of its intentions. Therefore, I decided it was a worthy addition to our Net Zero 101 series!

This article is authored by Alison Isherwood, Net Zero Committee Chair at SPE London.

The concept of a JustTransition emerged in North America in the 1970's when trade unions fought to protect workers' rights while acknowledging the need for more stringent environmental regulation. If chemical plants or coal mines had to close then the workers and their communities needed support. It was a coming together of labour and environmental activism.

Earth Day Protesters 1970's

However, the term has only been used more widely since 2015 when it was included in the Paris Agreement[2] and the International Labour Organisation (ILO) published global *JustTransition* guidelines[3] to support governments in developing policy that 'anticipates impact on employment' and provides 'adequate opportunity for skills development and social dialogue'. This captures two fundamental elements of a *JustTransition*, long-term skills and employment planning and giving workers a voice. It also suggests that governments hold the ultimate responsibility for ensuring a *Just Transition*.
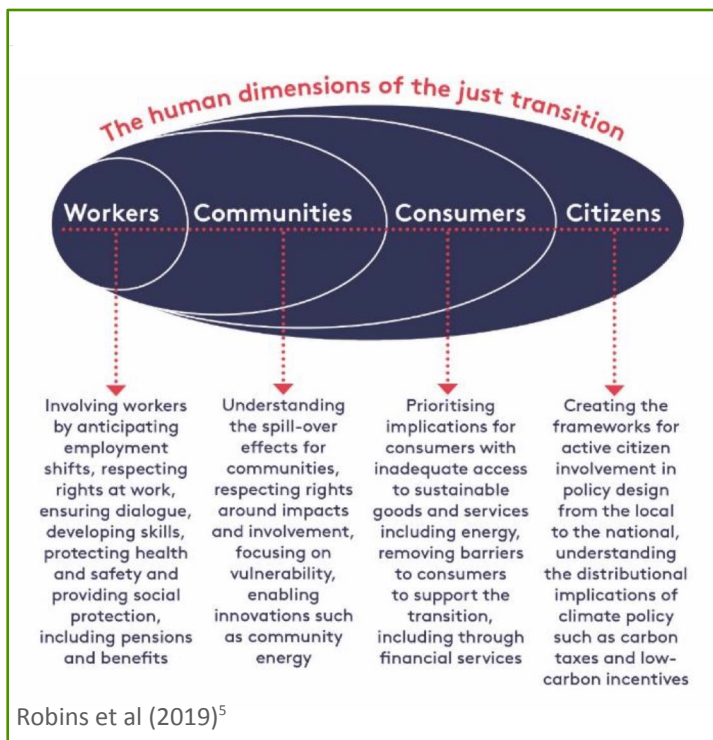
The 2019 EU Green Deal (obviously no longer applicable in the UK) proposes providing '...tailored financial and practical support…' for workers moving away from hydrocarbon based industries, and includes a *Just Transition Mechanism*[4] to ensure they 'leave no-one behind'. This is a poignant phrase that I think sums up *Just Transition* rather nicely. Some take the definition of *Just Transition* far beyond the protection of fossil fuel workers, extending it to the cascading human impact of climate response across society[5] or viewing energy transition as an opportunity to fundamentally change our economic system and reduce inequalities[6]. However if we focus, for now, on fossil fuel workers what does 'protecting' them mean? To me it is about much more than financial compensation, it is about empowering and preparing workers to play their role in the future of energy and helping them maintain their sense of purpose through the energy transition. It is about ensuring that there is focus on the human aspect of the transition in order to get buy-in for the transition across all parts of society, as without that it will not happen with the urgency required. The recent UK climate assembly[7] was one attempt at this but received limited publicity.

So what is being done in the UK to ensure a just transition for O&G workers?

I am pleased to say that a lot of foundations have been laid over the last year, but Scotland is ahead of the rest of the UK. The Scottish government formed the Just Transition Commission (JTC) in early 2019 to decide how the ILO guidelines should be implemented in Scotland with a final report due Jan 2018. In late 2020, Scotland also announced a £25 million National Transition Training fund9 and plans for establishing a Green Job Skills Hub through Skills Development Scotland (SDS)10. Skills is a devolved issue and the comparable UK-

What is a 'Just Transition' and why should oil and gas workers care? ... continued

The human dimensions of the just transition

Robins et al (2019)[5]

Source: Adapted from Robins et al. (2018b)

wide skills commission, UKCES, closed in 2017. While the UK government does not use the phrase *Just Transition*, in November 2020 it announced the launch of a *Green Jobs Taskforce* which states as one of its main aims to 'support workers in high carbon transitioning sectors to retrain in new green technologies'[11]. Hopefully, this taskforce can play a similar role to Scotland's SDS and JTC for the wider UK O&G workforce. This is important, given that more than 60% of UK O&G workers reside outside Scotland[12].

No UK-wide funding for skills development has yet been announced. However, the recent UK government Energy White paper suggested that a North Sea Transition Deal will be agreed in the first half of 2021 to ensure we 'retain existing skills and capabilities in the O&G sector to give the UK first move advantage in emerging low-carbon sectors'[13].

While governments may hold the ultimate responsibility for a *Just Transition*, proactive action at business and worker level, including through professional societies such as SPE, can help optimise and guide the direction of that transition, especially in the area of upskilling. One promising initiative is being led by OPITO, the not-for-profit energy industry skills body. In late 2019 OPITO formed the Energy Skills Alliance (ESA), with representatives from O&G, nuclear and renewables, government bodies and trade unions, to 'help create an integrated skills strategy for a net zero UK energy industry'[14].

This work is ongoing, with no official workplan, timeline or results published to date but I linked into those involved in this initiative through my University studies. I hope over the coming months we will be able to share more information with our membership on how we can ensure subsurface professionals get the practical support they need for a *Just Transition* through the ESA or other initiatives.

Just Transition & The Sustainable Development Goals

My personal opinion is that the use of the phrase *Just Transition*, and the dialogue and activity surrounding it, can play an important role in achieving a balance between the social, economic and environmental elements of sustainability as we strive for net zero.

What is a 'Just Transition' and why should oil and gas workers care? ... continued

Many people are now strongly focused on reducing greenhouse gas emissions, and rightly so, but *climate action* (*goal 13*) is just one of 17 Sustainable Development Goals (SDGs). These 17 goals cover a wide spectrum of interconnected environmental, social and economic targets, including *decent work and economic growth* (*goal 8*) and providing *affordable and clean energy* (*goal 7*).

As energy professionals I believe we all have a responsibility to help others understand the interplay of these SDGs goals, including the continued role of O&G, at the same time as proactively working to secure our own Just Transition. My priority goal as Net Zero Committee Chair at London SPE is to help facilitate this process.
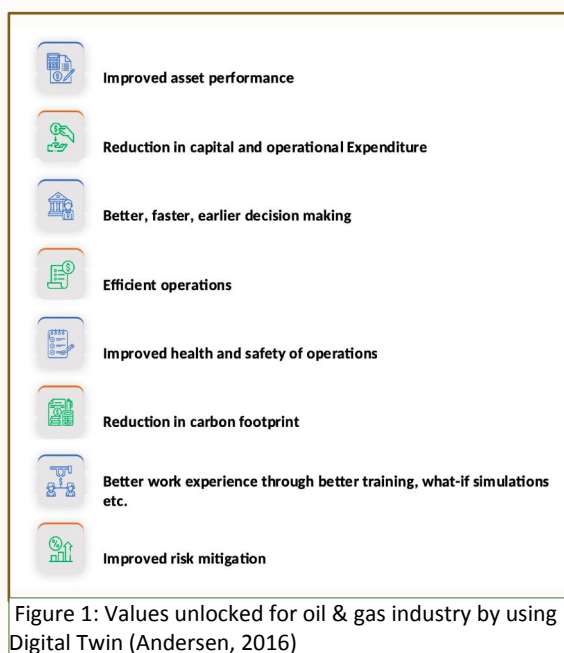

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Failing in the virtual world is not expensive – get your Digital Twin implementation right!

This article is co-authored by Balasubramanian Chandrasekaran (Senior Principal with Infosys Consulting), and Dhiraj Rane, Gautam Saha, and Prem Paramasivam (Senior Consultants with Infosys Consulting).

Covid-19 has been a watershed moment for many asset-heavy firms, and the oil and gas industry is among the worst hit. Companies are not only grappling with volatile crude prices due to rapidly changing supply and demand scenarios, but also must reinvent themselves rapidly as the world embraces a reduction in carbon footprint. Operating under such conditions, oil and gas companies are forced to be innovative and transform themselves to be sustainable for the future.

Figure 1: Values unlocked for oil & gas industry by using Digital Twin (Andersen, 2016)

- Improved asset performance
- Reduction in capital and operational Expenditure
- Better, faster, earlier decision making
- Efficient operations
- Improved health and safety of operations
- Reduction in carbon footprint
- Better work experience through better training, what-if simulations etc.
- Improved risk mitigation

The adoption of digital technologies is at the heart of this transformation. Digital twin is one such technology that looks promising. Digital twins are virtual representations of physical assets throughout an asset life cycle. As per Gartner's[1] top 10 oil and gas trends 2021, digital twins will deliver business value through increased integration of internal systems, human activity, and external ecosystem.

As per a pre-Covid forecast, the global market for digital twin was expected to grow 38% annually to reach $16 Billion by 2023 and $25 B by 2025[2,3].

However, following the advent of Covid, the digital twin market is now expected to grow at a CAGR of 58% from $3.1 billion in 2020 to $48.2 billion by 2026[4] Digital twins can also unlock additional benefits of $1.3 trillion of economic value and 7.5 Gt CO_2 emission reduction between 2021 to 2030[5].

Digital Twin - Challenges

While digital twin technology offers great potential to transform business and operations, oil and gas companies are facing challenges in adopting it on a broader scale. According to a 2018 survey by Tech Pro Research, 70% of the digital transformation[6]) initiatives will not reach their stated goals, and the statistics won't be too different for digital twin implementation. Why does a successful digital twin implementation pose a challenge?

Many global organizations fail to achieve the full potential of the technology for reasons illustrated below:

Looking at Digital Twin as a technology problem rather than a business problem
Since there are so many digital twin technologies in the market, organizations end up looking at this problem as a choice of technology. Organizations must realize that digital twin technologies have different capabilities and maturity levels across what they can and cannot provide. The selection of digital twin use cases should be guided by the organization's business strategy and requirements and not based on what technology can do.

Adoption Challenges
Digital twin technologies bring tectonic shifts to the way businesses operate, and organizations may not be ready to adopt the changes. These manifest due to the following reasons:
 – Lack of awareness
Digital twin is an evolving technology, and if the leadership and operational teams are not fully aware of what it is or what it can do, then they either fail to invest time/money into it, or they lack the necessary conviction,

Failing in the virtual world is not expensive... continued

which leads to downstream issues. The lack of awareness leads to uncertainty and unrealistic expectation of outcomes.

 – **Stakeholder alignment is hard**
Because of the way digital twin technologies affect different areas of the company; all the stakeholders need to be completely aligned for it to be successful. Achieving stakeholder alignment is easier said than done.

 – **Lack of cross-organizational synergy**
In large organizations, it is quite common for departments and functions to continue to operate in silos, with their respective department goals in focus. The lack of synergies will lead to reduced value derived from the implementation of digital twin.

Going big
To deliver quick and significant impact, organizations sometimes take up ambitious and complex use cases with several million dollars' worth of budget. Thus, these uncertainties in selecting the use cases can pose the following challenges:
– Risks of program failure,
– Lack of losing the top management interest if outcomes are not shown quickly,
– Producing interim solutions which may not directly link to a business value but only act as building blocks
Thereby, those use cases would not be able to prove value within a financial cycle.

Building solutions that cannot scale or sustain Implementing proof of concept solutions that cannot be scaled or sustained is not enough. To stand the test of time, the solutions must be built with an intention to scale and sustain

Not setting up the right data foundations
For a digital twin technology to work well, it has to have the necessary foundations in data. If these foundations are weak, the digital twin technologies will yield less value over time and/or lose the interest of the stakeholders. The article[7] on the iceberg problem with data and business intelligence gathering explains this issue.

Not giving sufficient importance to security requirements
According to Gartner's estimation, 75% of the digital twins for IoT-connected OEM products will utilize at least five different kinds of integration endpoints by 2023. These numerous endpoints would generate huge volumes of data and potential access points for security vulnerabilities. Hence, the organizations should identify these endpoints and the possible security vulnerabilities to implement required security protocols for avoiding any risks on the digital twin model[8].

Addressing these challenges
Digital twin applications may have their set of challenges, and the solutions are still evolving. As the adoption of digital twin increases across industries, companies should focus on adopting the Digital Twin in a phased manner by implementing quick wins to ensure early commercial value and build on it to expand the use cases by achieving ROI in the long run.

Building the Digital Twin Roadmap
It is a daunting and unsolved problem to identify which use cases to go after, which technology to choose, and the approach to take. There are costs involved in terms of people, time, and efforts to build the digital twin model along with investment in infrastructure. It is crucial to be able to show the value of this investment through returns in business value on a sustainable basis.

Organizations can use the Desirability, Feasibility and Viability framework to solve this dilemma[9]). Figure 2 (next page) explains the approach that helps the decision-makers to align the digital twin use cases against the actual business value. Considering the complexity of implementing digital twin, this methodology will help decision-makers to identify how to implement digital twin technologies in their firm.

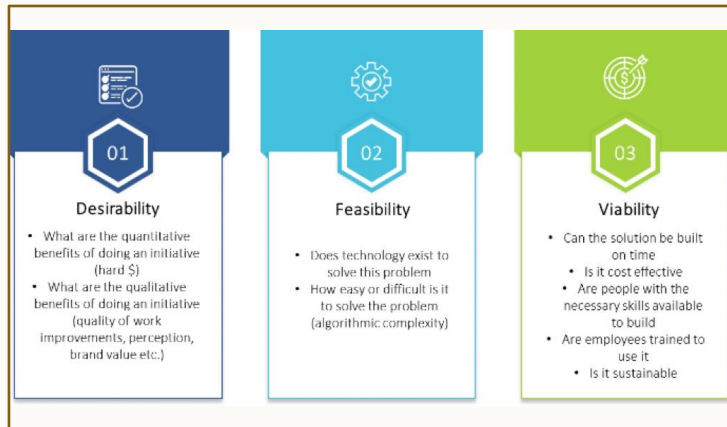# Failing in the virtual world is not expensive... continued

Figure 2: Questions for DFV workshop

Further, it also enables the business to arrive at the right KPIs and predict the ROI from implementation.

The chart in Figure 3 (below, left) lays out the outputs of the DFV analysis whereby the X-axis represents the feasibility, the Y-axis is the value, and the size of the bubble is the Use Cases which indicates the viability (larger the bubble the better the viability).

Each digital twin use case is assessed for its DFV (Desirability, Feasibility, and Viability). Laying these use cases in this manner clearly provides

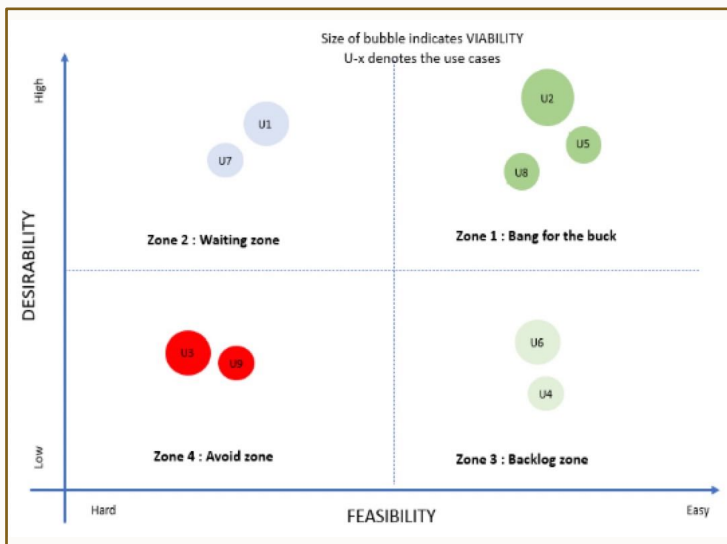a roadmap of which use cases to go after and why as below:

Figure 3: DFV 2x2 Categorization matrix

Zone 1 - Bang the Buck zone: The top right quadrant with larger bubble sizes of use case are the easy low hanging fruits, i.e. they have a lot of business value and are relatively easier to implement in a cost-effective, sustainable manner.

Zone 2 - Waiting zone is the intersection of hard implementation but high value for the business use cases. This denotes the maturity of technology and to wait further by substantially supporting through detailed market research as and when available for the use cases in this quadrant. Ideally, with the Pareto (80-20) principle, a big chunk of business value usually is realized within Zones 1 and 2, and a conscious choice to stop here could be taken.

Zone 3 - Backlog zone as this brings a low business value but easy to implement use cases. These could be done once the Zone 1 items are finished and there are no Zone 2 items to pick up meantime.

Zone 4 - Avoid zone, which is the intersection of Hard to do items and low value for business, and hence suggested to avoid picking these use cases.

Getting Stakeholder Alignment and Spreading Awareness

Leaders deciding to adopt digital twins need to chalk out their business goals and work on the adoption strategy and roadmap in the initial phase. But before this, to have a quicker turnaround time in the initial strategy phase, it is important to work on the following steps as shown in Figure 4 (next page):

1: For a start, identify the stakeholders and map them according to the above Interest-Influence Matrix for stakeholder analysis (Figure 4).

2: Start educational mailers and webinars on digital twin, the business impact, and its prevalent applications across the organization.

3: Form or utilize the Centre of Excellence to lead and work on the pilot, to have a common vision and exposure across the units in the organization.

4: Start portraying digital twin success stories to the Leadership and secure an early buy-in from the 'High power – High Interest' stakeholder group.

5: The stakeholders having high influence need to be brought on board for the strategy, funding, and approvals.

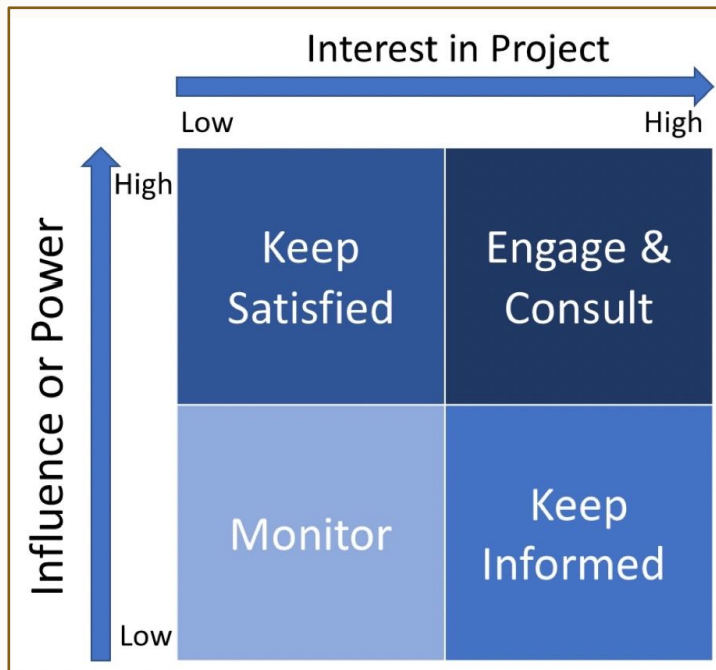# Failing in the virtual world is not expensive... continued

Figure 4: Stakeholder alignment and spreading awareness

6: The stakeholders carrying high interest in the project can help in digital twin awareness campaigns.

For spreading awareness and initiate preparedness for the digital twin program, it is also important to:
1: Start identifying and creating the right mix of focused talent with domain as well as technical expertise.
2: Initiate parallel market research and vendor discussions for probable solution implementation.
3: Conduct Design Thinking workshops to choose and align use cases with the organization's vision, strategy and business goals.

Adoption of Digital Twin

For successful implementation and adoption of digital twin technology and harnessing the technology to derive maximum potential, the pilot use cases need to be scaled across the vertical or the organization. Figure 5 (below) explains the 4E framework suggested for the adoption of change management.
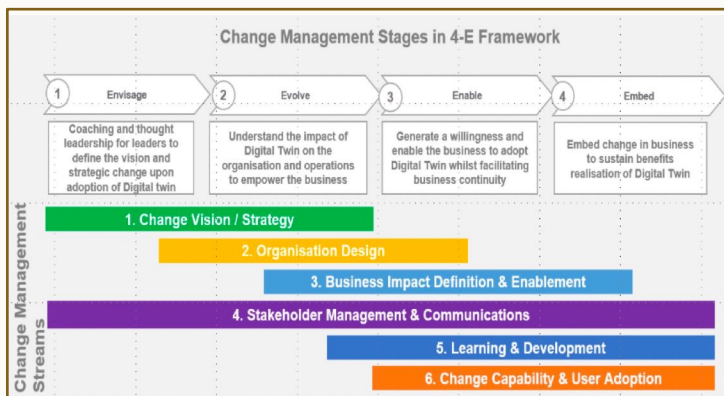

Figure 5: 4E framework for change management approach

A: The scaling of digital twin needs to progress in a phased approach from a POC to an operational digital twin. Agile or SAFe methodology can be effectively used to identify and complete milestones, and validate the outputs periodically.
B: The choice of technology is important while building your digital twin. It is recommended to choose technologies that support scaling, give the necessary performance, and platforms to scale efficiently.
C: Scaling calls for organization-wide changes such as ways of working, hierarchy, functional reporting, technology architecture, systems and processes, compensation, HR policy, Training, etc.,
D: Apart from managing the aspect of change management, it is also important to set good Master Data Management and Data Governance in place. These activities can be done by establishing data discipline centers and assigning the responsibilities such that data standards and governance is maintained within the organization
E: Scaling can happen successfully only with a proper deployment process (of the twin to various assets). It is important to set this in place before scaling to multiple assets.
F: The digital twin should account for scalability by design. It shouldn't be built with very niche requirements to meet the needs of a particular asset.
G: When a digital twin solution is launched, the organization must perform sufficient due diligence to ensure the digital twin can function in a multi-asset model instead of using a single asset.

Delivering solutions incrementally

Instead of delivering very large-scale solutions, organizations should drive small-scale tangible business cases and scale them across assets. This approach is very de-risked while simultaneously helping to fail fast if an

Failing in the virtual world is not expensive... continued

option doesn't work. This way, the organization can rapidly change course and work toward a different solution with a much lower technical debt.

Scale the Digital Twin Right

Today, there are multiple frameworks to implement a digital twin solution like the 3-layer framework or the 4-layer framework[10,11]. However, these frameworks emphasize integrating the static and dynamic forms of data. But with the developments of new technologies, it is vital to create an enhanced multilayer framework for digital twin. We suggest a 6-layer framework that converges physical and virtual layers by developing an interactive environment combined with intelligence and security. Adopting the 6-layer framework will help organizations gain real-time insights and have a robust and sustainable solution.

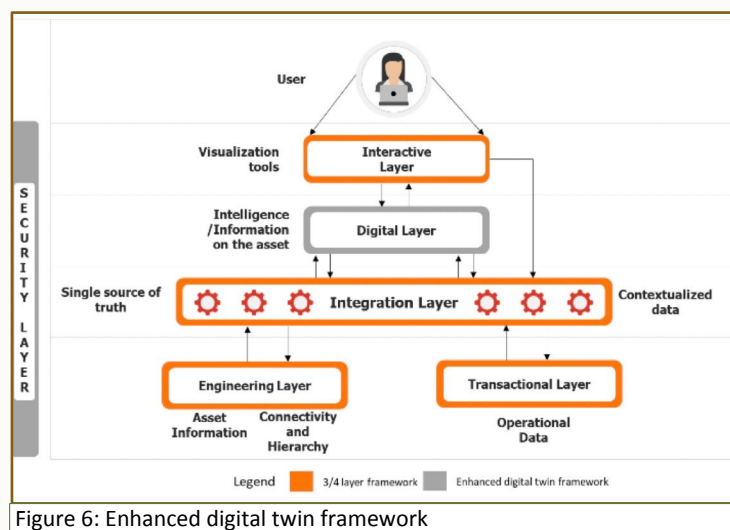These are the 6-layers from our Enhanced Digital Twin Framework:

Figure 6: Enhanced digital twin framework

Engineering Layer
This is a static layer and consists of asset information, data glossary and static information for the components involved in our use case, classified as Structured data. It will also consist of designs, drawings, blueprints, etc., classified into Unstructured data.

Transactional Layer
This layer captures dynamic and real-time data from various operational data sources such as ERP systems, SAP systems, Procurement software, Logistics applications, Project life-cycle management (PLM) applications, IoT sensors monitoring physical assets, and daily transactions data sources such as databases.

Integration Layer
The Integration layer is the layer that marries the static data, whether structured or unstructured (Engineering Layer), with the dynamic and transactional data (Transactional Layer) through contextualization. It depicts the working data model of the components or assets identified for the use cases by creating a single source of information.The above three layers are present in multiple digital twin frameworks.
The 4th layer in some 4-layer frameworks is the interactive layer.

Interactive Layer
The Interactive layer, including the visualization component, is the most vital part of the digital twin. It allows the operator/end-user to experience the digital twin as if they are experiencing the working model in real life. The user can interact with the digital twin in multiple ways:
– Access the 2D/3D models using an Interactive interface to interact and control the operating assets,
– Use AI-ML and analytical platforms to forecast operational maintenance insights along with real-time simulations for decision making, and
– Use AR/VR/MR technologies to have an immersive experience with a scaled 3D model, have a complete 360-degree field view, and an in-person experience.

We have enhanced the existing frameworks with the following layers:
Digital Layer – The digital layer consumes the ready-to-use information from the Integration layer with added intelligence using Industry 4.0 technologies like Machine Learning, Deep Learning, and Artificial Intelligence. This integration helps bring a decision framework to identify the current behavior patterns and predict the futuristic patterns.
Security Layer – A digital twin is mostly stitched with multiple applications, databases, and systems coming together on the same platform. So, security should be set up at the periphery of the platform, hosting the entire solution or at individual layers or both places. This security enhancement will help mitigate the threat of

Failing in the virtual world is not expensive... continued

cyber-attacks, internal and external fraud, data breaches, and other issues that threaten the system's integrity and erode trust in the data it produces and consumes.

We suggest implementing Feedback Loops in the Enhanced Digital Twin Framework along with the above six layers, which paves a path for continuous integration and sustainability.

Feedback Loops – These loops (indicated by the two-way arrows in Exhibit 6) enable bidirectional information movement in the twin. Using a feedback loop will enable the digital twin model to allow users to feed information back into the same model to help derive matured and optimized insights in the future, making the digital twin model 'Sustainable' in a true sense.

Effective Data Management

Digital twins thrive on data fetched from disparate sources in non-uniform formats. Building the digital twin model requires effective data management for a consistent data flow throughout the twin. It includes:

– Enabling connected systems to fetch the data from its historical or real-time sources

– Store data appropriately. A Data Lake suits large unstructured data while a warehouse suits structured data. Depending on your needs, an appropriate decision is to be taken.

– Ensure data standardization

– Have an end-to-end data mapping process in place to avoid unnecessary data flowing and persisting through the digital twin

– Ensure user-specific Data Governance policies in the program

Enhanced Security

The integrated data, analytical data, and visual data should be completely secured from any possible breaches, internal or external, frauds or cyber security attacks. This can be done by enforcing multiple security policies. The policy enforcement should be based on the type of data and the audience of consumption.

Security for digital twin can be implemented by following methods:

– Maintain Role-Based Access Control lists with Active Directory for appropriate authentication and authorization,

– Continuously refresh Access Control lists for maintaining appropriate audience

– Allow creation of Private Links to access integrated applications using the private endpoints over the Private Virtual Network (VNET)

– Encrypt the data at rest and in-transit using encryption keys

– Implement cybersecurity protocols and policies to safeguard the digital twin model and data from hackers

Conclusion

Building a digital ecosystem using digital twins will enable industries to improve their bottom-line, have better decision-making power, and at the same time, protect the environment by reducing carbon footprint significantly. Also, the best part of digital twin application for industries is to know about failures in the virtual world, and not execute them in real-life thereby emphasizing the topic: 'Failing in the virtual world is not expensive'.

Therefore, leaders across multiple sectors are coming forward to adopt the digital twin across various companies. However, with the business challenges they face throughout their journey, many are not sure how to proceed with the implementation of the twins.

Our suggestions in this point of view hopefully help them to address these challenges effectively and move forward. As the digital twin market continues to mature, industries such as oil&gas, utilities, manufacturing, pharmaceuticals, and retail are bound to witness a higher digital twin adoption rate. More standards and open-source integrations entering the market would assist the industries in building and consuming the digital twins. Organizations should not miss out on opportunities to implement this technology and reap the continuous benefits from these sustainable models.

Failing in the virtual world is not expensive... continued

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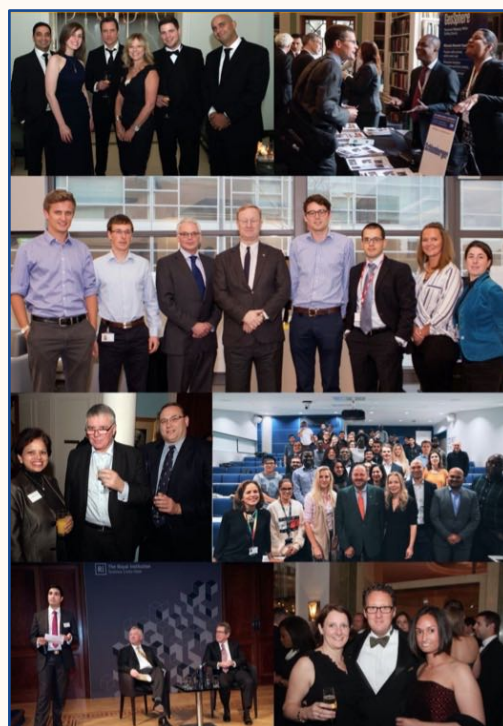
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Welcome to the London Section's Net Zero Committee section of SPE Review London where we will be presenting and discussing a range of topics associated with Energy Transition and Net Zero. We hope they will be informative and help readers understand some of the significant changes in the oil and gas industry.

This is the ninth in a series of articles covering Sustainability, written by Adrian Gregory who is a subsurface and wells engineering consultant.

Adrian is excited to be part of and contribute to the London SPE Net Zero Committee and will be writing future briefing articles broadly focusing on sustainability strategy, frameworks, principles, delivery and performance.

This article will cover Continual Innovation & Entrepreneurialism - Sustainability Performance; Value, Impacts & Effects. Sustainability has dimensions & perspectives, interconnectedness of composites, compounds and elements which have enduring complexity, requiring Integrated Thinking & Systemic Thinking. Continual Innovation & Entrepreneurialism builds the capacity to manufacture produce deliver the future. 'Understanding' 'Being Understood' 'Whisperers Influencers Paradigms Principles' 'Happiness' 'Healthiness' 'Scape Scale Scope Spark Speed' 'Silver Gold Platinum Bullets' and 'Participation' 'Motives Motivation Engagement Progression' will be covered. With 'guest appearance' from Goddess Nigella – the 'spark' to launch a million entrepreneur-'ships'.

For those readers who want a 22-seconds outtake

"Sustainability Perspectives of Technical Political Financial create the Global Sustainability Pillars of Opportunities from the 'Custody Chain'. The challenge of these opportunities reside and are delivered within Dynamic Circularity, Continual Innovation, Entrepreneurialism, and 'Liberalism vs Authoritarianism' Patronage-Market Forces.

This Article focuses mainly on Continual Innovation and Entrepreneurialism; 'creating and developing'. The key composites of Engineering Sustainability are Resource Based, Ecosystem Based & Value Based. Engineering Sustainability builds from re-investing Capitals Stock providing the Sources & Resources with activities requiring economic social environmental Stewardship and 'ultimate' Means through Succession Conservation Partnerships to deliver the 'ultimate' End. Performance is embedded through Participation & Motives Motivation Engagement Progression (5 Principals).

Ownership & Leadership help optimise the productive use and reinvestment of the Capitals Stock (Inclusive Capitalism). Natural Succession & Technical Succession are needed to be combined to deliver "True Sustainability; 'the well' that keeps on giving". This requires the whole Custody Chain to perform delivering the Total Value Chain of Governance Value & Governess Value; Total Intrinsic Value. Globally, this creates 'The Sustainability Economy'. This requires proficient Citizenship (Business Agency as a 'Stakeholder in Society'), Custodianship tracking all component 'footprints' linking 'Manufacture Production Delivery to Consumption', the Custody Chain, without polluting, emitting, wasting, depleting (or exhausting) or losing the productive Resources; and Guardianship tracking all 'footsteps' so planetary systems endure, through protecting, supporting Life; Urban & Natural.

Humanity must keep 'creating & developing' to endure so Performance is key, embedded by 5 Principals. Engineering Sustainability means Sustainability Performance must have two composites: Material Performance & Proficiency Performance. Sustainability Performance needs to be measured in terms of Value, Impacts & Effects. Material Performance & Proficiency Performance both matter in terms that the former addresses material FootPrints, the latter addresses proficiency of the associated FootSteps. Sustainability Performance has to measure, track, respond to Pollution Emissions Waste Depletion Loss; Reduction is the ultimate pathway. Mastery of Proficiency is the 'ultimate' Means to achieve the 'ultimate' End; Doing Right".

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The 'Sustainability Perspectives', **Technical Political Financial**, create the **Sustainability Pillars of Opportunities** from the 'Whole Chain'; **Governance Governess Worthiness**. The challenge of these opportunities reside and are delivered within **Dynamic Circularity** (**Article 5** – assimilating **Intrinsic Value**), **Continual Innovation**, **Entrepreneurialism**, and '**Liberalism vs Authoritarianism**' **Patronage-Market Forces**. This article will focus mainly on Continual Innovation and Entrepreneurialism; 'creating and developing'.

Figure 1, illustrates the key composites of **Engineering Sustainability**: Resource Based, Ecosystem Based & Value Based. Engineering Sustainability builds from re-investing Value Based **Capitals Stock** (**Article 6**) providing the Sources & Resources. Resource Based activities requires economic social environmental **Stewardship** and Ecosystem Based 'ultimate' **Means** through **Succession Conservation Partnerships** to deliver the 'ultimate' **End**. Stewardship ensures **Ownership & Leadership** to help optimise the productive use and reinvestment of the **Capitals Stock** (Inclusive Capitalism). **Natural Succession** & **Technical Succession** is needed to be combined to deliver **True Sustainability**; 'the well' that keeps on giving, to be discussed next in the last Article of this Series. This requires the **Whole Chain** to perform, enacting **Worthiness**, delivering the **Total Value Chain** of **Governance Value** & **Governess Value**; Total Intrinsic Value. Globally, this creates 'The Sustainability Economy' (Figure 2); **Global Sustainability**.
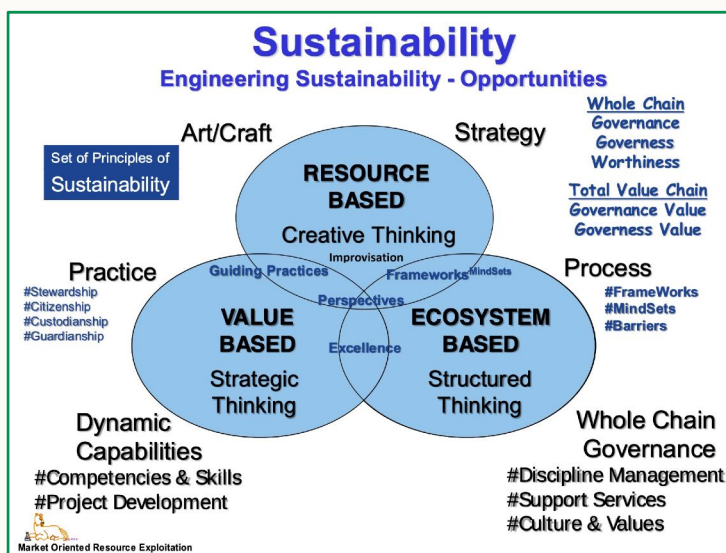

Figure 1: Engineering sustainability – the opportunities

Figure 2: The sustainability economy

For **Global Sustainability**, the **Whole Chain** must perform requiring proficient **Citizenship** (Business as a 'Stakeholder in Society') "everyone with the capacity to realise their needs, if they so desire"; **Custodianship** (**Custody Chain** tracking all component 'footprints' linking 'Manufacture Production Delivery to Consumption') "that satisfies present consumption without compromising future options" without polluting, emitting, wasting, depleting (or exhausting) or losing the productive Resources at our disposal; and **Guardianship** (Government protecting 'Natural Resources', particularly 'Nature Stock'; tracking all 'footsteps') of planetary systems "enduring, remaining productive & regenerative to support Life".

Natural Regeneration is to replace 'natural loss'. **Technical Urban Regeneration** being "leaving the 'working landscape' in a better state than the previous generation"; **Doing Better**. So Humanity must keep 'creating & developing' to endure so Performance is key, embedded through *Participation & Motives Motivation Engagement Progression* (5 Principals). That's Our Life's work. **Social Development**[1] defined as 'an evolutionary process in which the Human Capacity increases in terms of initiating New Structures, adapting to continuous change, and striving purposefully and creatively to attain new goals' (Peet 1999).

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The Natural World recycles their 'waste' its natural processes produce. The Urban World does not! Natural 'species' boundaries are a tiny percent of their World; unlike the technical 'species' production boundaries -- globally polluting, emitting, wasting, depleting, losing productive Resources. Engineering Sustainability means **Sustainability Performance** must have two composites: **Material Performance** & **Proficiency Performance**. **Sustainability Performance** needs to be measured in terms of **Value, Impacts & Effects**. **Material Performance** & **Proficiency Performance** both matter in terms that the former addresses material **FootPrints**, the latter addresses proficiency of the associated **FootSteps**. **Sustainability Performance** has to measure, track, respond to **Pollution Emissions Waste Depletion Loss**. **Mastery of Proficiency** is the 'ultimate' Means to achieve the 'ultimate' End; **Doing Right**. Proficiency is linked to a sense of 'Happiness'.

For 'Great Organisations of Sustainability', **Proficiency of Performance** is not 'manufacturing producing delivering' at the expense of others, therefore needing 'mastery' of **Worthiness** for all **Material** activities. **Pollution Emissions Waste Depletion Loss** Performance cannot be fragmented – **Reduction** is the ultimate 'pathway'.

In this dynamic **Sustainability Economy** (**Figure 2**) – the heart of the 'flows' must be in holistic synergy, **Recycled** continually using the **Circular Economy**[2] (**Article 3**) -- just one of the key tools in the **Sustainability Tool Box**. The **Circular Economy** primarily matters for **Pollution Reduction**; **Pollution Prevention** and **Reducing Emissions** (Product & Resource Footprints) helping to drive **Design** and incorporation of **Eco-Efficiency** into the Whole Chain through the associated 'chain of custody' (**Custodianship**) -- tracking all components **FootPrints** considering **Life Cycles & Design** and **Re-Purposing** Grey Utility to Blue Utility or Green Utility; **Conservation**. Proficient use of **Storage** is another key Sustainability 'tool', minimising consequential additional pollution and emissions post Storage 'modus operandi'. The Proficiency of **The Performance Economy** will be discussed later in this Article embedded in 'Participation' & 'Motives Motivation Engagement Progression' five **Principals**.

Wholeness for a company is best made up of **Creative Activities** to **'**manufacture produce deliver**'** **Better Development** plus (a) **Optimised Reduction** built from the **Sustainability Economy** respecting the full **Life Cycle Assessment** (**LCA**) **framework** -- not a Linear Economy ('Take-Make-Waste'); (b) **Purpose Fit** reflecting 'Means vs Ends' (Technical Sustainability vs True Sustainability); and (c) **Group Motivation** and **Group Share & Partnerships** building additional **Technical Excellence & Functional Excellence**; 'engineering the future' **[Figure 1, Article 8]**.

Some (up till now) enduring companies have some 50 years of regulatory pressure, admittedly 'splashed' with elements of **Regulatory Capture**, to reduce their Technical Environmental Impacts and 'costs' borne by Urban World and the Natural World. Embracing, reducing their Technical Social Impacts too is a relative new 'conduct & custom' even though practices of **Citizenship** is not new, just poorly 'enforced' by Government. **Transactional Costs** are increasing again post 'electronic digitisation'. The **Natural World** has not seen Government represent 'their' interests by any measure of comparison to our **Urban World**, with Governments hiding behind the 'ideology' of Sustainable Development, a 'Social Structure' for actually **Social Development**[1], with 'splashes' of bottom-line 'Natural Development'. This 'structure' therefore having well documented[1] 'Defects', 'Deficiencies', even 'Dereliction'; multiple 'D's if their 'documented' trail was to be marked by **Societal Scrutiny**.

In fact, historically many think **Nature** is just a free **Public Good**, or free service for **Exploitation** (**Article 10**). However, Sustainability **Progression** has been made with more progressive companies not just offering the Government regulated 'minimum' but some are now moving to actually internalise more and more of the **Externality Costs** they once imposed upon **Society**, and at the dereliction of **Nature Stock** 'depletion & loss'. Enterprise **Sustainability Business Excellence** is finally being nurtured.

Sustainability Excellence progression focuses currently on four keystones: **Full Costs**, **Values**, **Interests** and **Responsibility**. **Respondibility** (**Article 7**) has yet to be added; the fifth keystone. Internalising *Full Costs*

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(Socio-Efficiency) do decrease current **Profits** but lead ultimately to additional **Sustainability Value**, particularly when crafts can be 'downscaled' and packaged up for local communities to service; increasing local community Quality-of-Life (-Styles); reducing local 'urgent' need to transfer **Wealth** instead. **Sustainability** *Values* (**& Behaviours**), borne from **Sustainability Principles**, to 'nurture create develop' the more 'mainstreaming' of **Integrated Thinking** (TBL), **Systemic Thinking**, **Sustainability Practices**, Better Metrics and Accounting, through principal *Participation*, of **Material Performance** (through Annual Financial & Sustainability Reporting); 'Moving Minds' by having dialogue on **Proficiency Performance** (principals *Motives Motivation Engagement Progression*); **Paradigms**; **Principles**. *Interests* of Shareholders Society Environment should be reflected positively through **Business Governance** & **Corporate Governance**, delivering clarity for a representative **Social Oriented Business Purpose**, through *Participation*. *Responsibility* for the Urban World in parity with the Natural World, **Governance of Responsibility (Guardianship – Phase I)**, has yet to be developed by Government protecting, or then Enterprise respecting, requiring the limits of **Valuing Everything** to be achieved with credibility, particularly for the **Living Commons** and **Eco-System Services** (**Nature Stock**). This is coming more and more in-focus as **Integrated Thinking** & **Systemic Thinking** develops & progresses.

Respondibility, particularly for the Urban World living on the **Tragedy of the Front-Line** of Climate Change and the Natural World living with increasing mainstream **Tragedy of Depletion & Loss**, needing embryonic **Governance of Respondibility (Guardianship – Phase II)** not even discussed for **International Waters** that 'comprise nearly two-thirds' of **Planet Ocean**. Where are the **Ocean Guardians** in Government? Not enough Government **SpaceTime** for "Protecting Planet before Profit". What about protecting the **Space** above the **Global Cover**? Thinking outside-the-box (**Articles 7 & 8**). **Forest Guardians** are only going to save their Forests! Oceans need protecting from the **Tragedy of Pollution Emissions Depletion Loss**, as well as wasted opportunities. 'Responding through Loss' is fragmentation; Poor Governance.

The five cornerstones of **Sustainability Business Excellence** being (1) Eco-Efficiency; (2) Quality Management, reflected through Value Maximisation; (3) Social Oriented Business Purpose, particularly necessary in regulated activities having a Social License to Operate (SLO), or Societal License to Operate (SL$_2$O); (4) Market Advantage, where Cost of Capital is reflected 'flourishingly' with ESG metrics, but, more importantly access to **Best Talent** due to candidates full engagement with the associated **Business Purpose**, back by Sustainability **Progression**; and 5) **Sustained Value**, sustained through **Value Creation** & **Wealth Creation**.

What Matters Now?

Better Practices needed to be developed at planetary scale which does not come cheap and is not simply a matter of **Technology Transfer**. The **Limitation** of the **Present State of Technology** particularly in Emerging Economies is more complex (Technical, Economical, Environmental, Political, Societal [TEEPS] **Sustainability Contextual Framework**). **Technical Limits** based on **Competence** matters reflective over **SpaceTime** through **Proficiency**, **Proficiency of Performance**; as well as **Physical Limits** & **Environmental Limits**.

Wholeness matters (**Article 8**) if needing to 'connect' with the Impacts & Effects of our Activities, Actions and Non-Actions in order to advance; **Doing Better**. Fragmentation is not Sustainability. Only understanding the 'system' by contemplating the 'whole' can deliver full **Systems Thinking** achieving excellence in **Product Stewardship** and **Resource Stewardship**. 'Our mind' can see how we are connected to 'reality', not separate. Developing **Capacity** to create the results truly desired requires new and expansive 'patterns of thinking' where **Group Motivation** is set free [**Figure 1, Article 8**]. 'Shift-in-mind' requires proficient **Adaptive Learning** & **Generative Learning**; plus **Adoptive Learning** adding the guiding Sustainability Practices; **Additionality**.

With 'Great Organisations', what you "do not see is the way all the parts work together. I do not believe 'great organizations' have ever been built by trying to emulate another, any more than individual greatness is achieved by trying to copy another 'great person'."[3] Often it takes working for many of these **Great**

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Organisations before it is obvious how different they really are as a 'whole'. So even Great Organisations can do better through **FeedBack Learning Progression** ('FLP'). The best have a certain 'quality of performance', **Richness** in competencies & skills – discipline led specialisms & generalists; pan & cross, multi-skilled.

Responsible Business must "do business in a manner that obeys the law, produces safe and cost-effective products and services, creates jobs and wealth, supports training and technology cooperation and reflects international standards and values in areas such as the environment, ethics, labour and human rights." This requires **Conduct & Custom,** acting with due regard (**Citizenship**). Values are often misaligned making them a poor 'map' to follow in business & commerce when advancing to a 'new horizon', hence the need for Adaptive Learning of the set of **Sustainability Principles** (**Article 8**); best introduced through *gap analysis*.

Technical Sustainability delivery of the 'means' through **Content**, must build from enterprise's **Research & Experimentation**, **Knowledgeable Practices & Mindsets**, **Processes**, **Frameworks & Systems** - through **Continual Innovation**. Paramount now too is **Entrepreneurship** creating **Value** from the New Opportunities and New Utility, creating New Enterprise -- overcoming **Risk** beyond normal, current activities and progressing at pace. **Business Sustainability** now is the best place for Continual Innovation & Entrepreneurialism to reside. **Freedom** to experiment and to carry out experimentation, but, evaluated using objective criteria and 'economic social environmental' metrics. Hence best results typically are borne through enterprise particularly at pace, not through governmental research or pure academia.

Sustainability Context has now been outlined in **Articles 1-8**. This Article helps to set the **Scape** for 'how' to get to the destination "Sustainability" (**Scape Scale Scope Spark Speed**). The last 350 years of the industrial revolution has now created amazing examples of successful **Enterprise** "Profitability"; the **Great Organisations of Unsustainability**. These companies enjoying the 'fruits' of their 'labours' input - creating massive **Wealth** for the 'owners' and 'The Board', and for that **Wealth** reuse to reinvest elsewhere; and from their Human Capital work-done benefits fuelling the Government 'coffers' to expense on their 'tribes', prolonging democratic 'power' for longer; **Carbon Entanglement**.

"Profitability" is 'performance' measured over a limited time frame; for **Enterprise** this is effectively yearly as a 'financial' period; for Governments effectively around '5 yearly' electorally. The economic concept of **Economic Rent** has now significant importance as a longer term 'performance' measure when thinking about 'use' in 'The Market' and Capitalism's reinvestment of **Manufactured Capital**; just one of the six **Capitals Stock** (**Article 6**). **Excessive Economic Rent** for those periods in time is a clear sign of significant economic 'success' measure. The more periods of 'excess' encountered, the more obvious that certain sectors 'enjoy' & 'endure' significant success & failures - **Riskiness**. So to now is understanding a 'species' or sector's long term 'endurance' – its **Healthiness** needed along with its **Worthiness** (**Article 8**). Judge of **Perspectives** being a good associated sense of **Healthiness**.

Resource Based companies, over the last 350 years of **Unsustainability** have now clearly been the champions of **Prosperity** through "Profitability"; …so far! 'Why' firms desire to get to "Sustainability" through the 'Triple Bottom Line' is now obvious to all those that 'look up'. Mastery of Sustainability takes 'Space' & 'Time' to build the 'capacity to endure'; **SpaceTime**. **Proficiency** can be thought of enduring **Work Done per 'unit' SpaceTime**.

Profitability is one dimensional as discussed in **Article 4** (**Table 1**). **Sustainability** is three dimensional (Economic Social Environmental) and **Global Sustainability** is four dimensional (Economy Society Environment Governance). **Sustainability** also has **Perspectives** (**Technical Financial Political**); **Healthiness**. Proficiency; **Happiness**.

"Profitability" is simple to gauge - "what profits were generated in the period?" "Profit or Loss?" "Sustainability" is complex, so complex it is simple (but not simpler) "how healthy is the enterprise in the long term?" "Enduring or Not?"; **Healthiness**. When companies make **Excessive Economic Rent** and burn like

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'stars' it is a hard choice to make now: **"Profitability" vs "Sustainability"?**

"Profitability" through its *complicatedness*, can be made 'mechanistic'; 'command' & 'control' enforced. "Sustainability" through its *complexity*[(4)], needing **Continual Innovation & Entrepreneurialism** - the future pathway now being not certain; having 'Limits of Certainty'. However, these 'limits' deliver to 'Bold Governance' the 'new futures' - surprisingly, unexpected and astonishingly. Expectations of control now make no sense in emergent and complex 'worlds' of systems. Optimised vs Optimal outcomes. Motivation vs Mundane labouring. Fit vs Undefined 'Whying' (Purpose).

The **Practices**, **Mindsets**, **Excellence** of **Great Organisations of Sustainability** now matter to becoming the Enterprise 'successes' of the Next Generation; 'The Future'. These 'New Successes' are unlikely to be created by 'Grande (Enterprise) Strategy', 'top down'. More likely to be driven 'bottom up', **Sustainability Value** being discipline led – free-flowing 'Means' to achieve 'Ends'; delivering ultimate **Means** to achieve the ultimate **End**. **Zero Pollution Emissions Waste Depletion Loss**. The main difference now between Great Organisations of **Unsustainability** and the future **Sustainability**, being their 'Proficiency of Performance' of **Pollution Emissions Waste Depletion Loss Reduction**; the **Means**. Both **Material Performance** & **Proficiency Performance** now matter.

The Future

Great Organisations of Sustainability will be well practiced in **Dialogue** around **Paradigms**, then **Engagement**. Catalysed through **Partnerships** so breakthroughs enable 'winners-takes-all' based on **Total Value Chains** (**Governance Value** & **Governess Value**). Their 'modus operandi' reflects the **Principles of Sustainability** (**Article 8**) to ensure that their activities and investments today do not limit the range of economic, social, and environmental options open to future generations.

The new industrial 'climate' will be of multiple Perspectives, Values, Co-Evolution and Unintended Consequences through Experimentation; **Being Bold**. The **Motivations** & **Perspectives** of companies will make it obvious whether Enterprise 'pathways' being followed are towards destination "Sustainability" and not simply one dimensional "Profitability". **Guiding Practices** (based on Principles), **Frameworks** (based on Mindsets) and **Excellence** (based on interconnectedness) are all compounds of composites for **Great Organisations of Sustainability**; **Purpose Fit**, **Optimised 'Enactment'**, **Group Motivation [Figure 1, Article 8]**.

Sustainability will be about the **Prosperity of People & Planet** (**3Ps**), **Ecosystem** (Socio-Environmental); **Wholeness** (Activities, Actions, Non-Actions) and **Totality** (Value). Not about individual species or organism; tolerating depletion & loss for one dimensional **Social Development**; an Urban World with lack of equity, diversity, interconnections, relationships, patterns, and context; systemic problems and crises of perception; **Defects Deficiencies Dereliction**.

'The Future' will needs radical shifts in our Values, Perspectives and Thinking; **Interconnectedness Variation Chance Randomness** is actually our Human World (**Our Urban World**). It is not 'mechanistic'. Be wary that 'everything can be tested and evidenced', 'what causes what', 'what is coming next'. Less **Planning** and more **Experiments & Experimentation**; **Regenerative Learning**. Live with 'Limits to Knowledge' so experience, competencies & skills matters. **Proficiency Performance** can only develop with time, mattering more than **Material Performance** - the only 'wod' currently being waved to external 'viewers' of Annual Reports; Financial & Sustainability Reports.

Sustainability Performance is not about the measurements, but, moving the **Dynamic Materiality** on towards the 'destination'. The **Sustainability Context** of the **Decisions** matter - moving to a better 'place'. **Proficiency** is about **Systems Thinking** & **Interconnectedness**, alignments & time scale; about getting **Principles** & **Purpose** correct to attract the right competencies & skills. Who makes the **Decision** which **Performance Metrics** are to be used? *Participation*. **Conduct & Custom** - acting with due regard, will matter in 'The Future'. Poor Governance will create lower returns as **Motives & Motivation** are 'lights' that illuminate the shadowy

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edges and the 'darkness'. Engagement vs Divestment? **Responsible Behaviour** matters more than perfect **Disclosure**.

Perspectives, based on **Sustainability Context**, will help to judge on **Healthiness**; long term performance. **Performance** based on hitting the desired **Targets**; **Standards of Performance**. **Value** analysis based on 'certain' **Impacts & Effects** being *achieved* through **Activities, Actions**; with **Non-Actions** on-trend. So these Impacts & Effects - determine Performance too, not just **Profitability**. **Performance Management Systems** [PMS] will matter; **Competence Assurance Management Systems** [CAMS] playing a part too in 'The Future'.

The need for **Competent Data** (precise & accurate data) depending on which **Performance Measure** is being considered; **Backward Data**, **Current Data**, **Forward Data**. **Data**, particularly **Intrinsic Data**, needs **Capture Storage Processing Harvesting**. Internal & external 'performance' measures will matter in 'The Future'. **Lack of Clarity** will be just as bad as **Lack of Transparency**, effecting Reputation Capital of **Enterprise** and **Government**. 'Value everything' will be mainstream, Our Urban World & Natural World; **Our Living Planet** (**Article 10**).

Planet before Profit, but, with People; 'Living with Prosperity', 'creating and developing'. WE have the **Means** now, just desire the **Ultimate Means**. 'Whisperers Influencers Paradigms Principles' now need more consideration.

Touching Minds – Changing Habits

Engineering the Future (**Article 8**) needs the ability to 'touch minds' and 'change habits', to 'shift-in-mind'[3] to innovate from the 'Horizon of the Present'; guiding to the 'Horizon of the Future', when often current **Values** are misaligned, a poor 'map' to navigate-by; **Human Endeavours**. "Whispering" is a specialist competence, skill often needed to best achieve this **Paradigm Shift**[5] to the next **Horizon**. **Whisperer** is a person who is unusually skilled, most of the time at 'calmly' guiding, influencing, 'managing' direction of others; a spirit, understanding of the natural instinct, with the ability to plant 'seeds' on 'welcoming' domains. 'Seeds' cast on 'hard' ground rarely germinate.

Best guiding the **Sustainability** Activities Actions Non-Action are the **Whisperers**. This was how Improved Oil Recovery (**IOR**) achieved adding some 8.6 Billion BO in the UKCS from 1992. Instead of 'Peer Reviewing' operators work from 1992-1996, Winfrith technical specialists (resourced from the UK DTI IOR Programme) gave their IOR studies to guide Reservoir Engineers in operator companies. Key inputs and functional simulation functionality **Technical Guidance** was provided - such as how best to achieve Gas Injection & Polymer Injection options to improve recovery -- getting the best outcomes from dynamic (subsurface) reservoir simulations; predictions of **Shifting Paradigms** over 'base-line' Waterflooding.

For instance for Gas Injection, if operators used 'Stones1' correlation not 'Stones2' - uneconomic dynamic simulation predictions would result and the operator 'asset management' would lose confidence. Obviously, the technical understanding for the preference of 'Stones2' vs 'Stones1' was provided too, before these models (**Paradigms**) could be history matched with actual reservoir 'performance' data. With Polymer dynamic simulation models and use of Horizontal Wells, specialist **Knowhow** had to be 'whispered' too; along with Late Field Reservoir Depressurisation, Polymer Gels well treatments, Horizontal Water Injectors and Thermal Fracturing benefits; the 'tips of icebergs' that sliced open the 'minds' of giants'; 'lighting up the shadows' cast by simple Waterflooding Vertical Wells.

Benefits of using Horizontal Wells bloomed post 1992 with operators then submitting plans using 'Designer' wells and complex Multilaterals; praised then by Government at **Conferences of (IOR) Communities**; fueling the 'desire' for more; **Sustainability Desire** – improved recovery, extended field life, delayed abandonment; job security! A lot of near field additional production was achieved by using Extended Reach Drilling - some up to twenty kilometers from existing facilities. Space 'developing' at its best. Some new techniques like Underbalanced Drilling were applied, but, did not scale.

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Whispering successes & failures was a key part of the UK DTI IOR Programme from 1992-1996; a National Programme. Whispering spread to many other UK Government National Research Programmes; **Catapults**. **Whispering** is **Value for Money**, something lost in Business Commerce governed by **Net Present Value** ('NPV'), not **Valuing** Sunk Costs; **Conservation [Governess]**.

Whispering is both physical and spiritual - conservation at its best. **Physical** because Whisperers get unique access to 'giants' and 'big beasts' of industry; more than pure Enterprise. **Spiritual** because these giants' human side take you deep into their own 'psychic' processes and thinking; their associated 'souls and minds', their natural instincts, which most likely too were not being opened within these giants' gaze of the Corporate revolving 'eye'. **Human Behaviour** has to change to 'shift-in-mind'. **Moving Minds** cannot be understated, the ultimate means of effective **Whispering** when technical conversations become a 'breeze'; the **Structural Barriers** (**Article 6**) removed of self-imposed 'limits & limitations' which impedes new understanding; overcoming management's call to "stay on message", 'this is business'; **Lose-Lose**.

Whispering is technical **Win-Win**[5]. That guiding 'seed' is then cast onto 'welcoming ground', delivering later an 'oak' for all to view. This 'spirit'ual side then infests the associated **Whisperers** to guide more and deeper, spreading guiding 'seeds' widely in shadows from revolving 'eyes' and now additional 'ears'; fueling the **Process of Advancement**; **Innovation** leading to **Continual Innovation**. **Changing Habits** simply by **Touching Minds** where often **Corporate Values** are misaligned; **Profitability vs Sustainability**; Waterflood methodology vs IOR Techniques based on the **Principle of Improved Recovery**. All launch **New Techniques** as **Practices** advance. 'Proficiency Performance' being the fundamental benefit if asked "Why?". Advance, Improve, Enhance; 'creating & developing'.

Measuring Performance, the data & information is just about fulfilling **Metrics & Analysis** to gain **Understanding** – often only **Material** to **Investment Governance** (**Article 8 – ESG**). *Participation* needs to be embedded. **Proficiency** is about competencies & skills needed to **Move Minds** to the 'Horizon of the Future'; **Changing Habits** of **Society Government Enterprise Academia**. **Dynamic Materiality**. Is the Corporation **Purpose Fit** to meet that move from 'Current to Future' **Performance**? 'Being Understood' requires **Proficiency & Mastery**; the latter being **Demonstrated** and **Audited**.

Wishful Thinking & **Fragmentation** does not 'cut' with present Society' **Needs,** particularly with **Societal Scrutiny**. **Being Understood**, changes **Values & Behaviours; Habits** advanced through **Proficiency**; **Doing Right**. **Natural Instincts** prevail given majority influences; **Structural Barriers** breached. 'The Future' lies in the **Great Organisations of Sustainability** not the current **Great Organisations of Unsustainability**. **Proficiency** of **Doing Right** is the 'New Efficiency'; along with **Doing Things Right** & **Doing the Right Things** (**Articles 4, 5 & 7**) and **Why-What-How-With-Marked** by **Societal Scrutiny (Articles 5 & 7)**.

Motives, Motivation & Engagement by 'equals' goes so much further than top down giants' **Participation** with Government, focus just on **Material**. **Government protect** - conservation of National Industry is paramount to National Policy and National Interest; what is **Material**. Importance of National Security being fleeting when **Wishful Thinking** gets too much 'air-time'; Proficiency lost. **Whispering** is 'Value for Money', the main domain of **Government** – but needs effective political champions. The technical political financial 'guiding hands' of the marketplace; **Social Science Engineering Technology** (**Article 1**), Whispering to the 'invisible hands' of Enterprise, through 'giants' - aiding entrepreneurial activities, breeding New Enterprises, Activities, Actions and Non-Actions.

Lack of Whispering breeds sector **Stagnation** as was evident in 1992, situated then on that resulting downward trending UKCS waterflooded production of crude oil from vertical well stock with associated lack of diversity of specialist techniques; later to be borne from casting the UK IOR Programme as *applied*; not *pure* under previous efforts. **Pure** is for the domain of **Academia** in particular **Blue Sky** research; Institutions with benevolent funds. **Applied** achieves most through market oriented **Consultancy** ("Whispering" elements or composites) from **Pure**. **Applied** understanding, fueling **New Pure**. **Wholeness** from composites of **Society**

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Government Enterprise Academia domains.

Experimentation and Demonstration of **Understanding** is key, but, **Being Understood** is protecting; conservation through **Succession & Stewardship**; service & stewards. **Proficiency of Performance**, often **Being Understood** only by **Standards of Performance** (**Pollution Emissions Waste Depletion Loss**). **Sustainability 'Horizon of the Future'** is poorly guided by **Understanding** from **Measuring Performance** only cast from 'light' currently from the **Unsustainability 'Horizon of the Present'**. Until **Society Government Enterprise Academia** is moving along that **'Horizon of the Future'**, most **Material Performance** reported will be misaligned however well measured. **Touching Minds**, **Changing Habits** by 'shift-in-mind' matters.

We cannot underestimate the importance of Continual Innovation & Entrepreneurialism, 'creating & developing'. As now famously remarked, "The Tragedy of the Horizon" has to be 'understood' but "The Tragedy of Outcomes", is not addressed through **Wishful Thinking**, it requires in addition the 'understanding' of **Government Enterprise Academia**, through Governance Value; requiring activities and actions to be **Purpose-Full** & **Meaning-Full**. Only **Proficiency of Performance** can test for 'Purpose-Fitness'; **Sustainability Performance** Intrinsic Data (Value Based); the importance of 'content' to 'insight' - gaining **Understanding**, **Being Understood**. We now need 'shift-in-mind' to **Proficiency Performance**, needing Leaders & Leadership. **Material** alone is fragmentation, without **Proficiency**.

Leader Leadership

Leader Leadership (**Article 8**) is the ability to inspire and move people towards a distinction [**Sustainability**] through being an **Influencer** [**Stewardship**] building from **Succession**, natural or technical. **Leaders** are pioneers[6] – "people who are willing to step out into the unknown"; **Leadership** is the relationship between **Leaders** and **Followers** -- motivating and inspiring; moving minds, changing habits.

Look "beyond the horizon of the present"[6]. **Leader Leadership** attracts a tribe of 'followers' with energy, catalogues of courageous acts 'against the current horizon', and with novel self-belief; **Character**. 'Doers' who have not been subordinated to 'The Past', who through self-determination look continually for answers; sometimes failing. A **Kinship** affinity.

Fellowship forms around **Change Agents**, focused on the **MarketSpace**. **Doing Better** forges the change to 'The Future', originating from **HandPrints** cast onto the MarketSpace; a 'wall' of endeavours waiting to be connected through **Succession;** Opportunities in **BluePrints**.

Followership is a more recent addition, where **Purpose & Strategy** has been interwoven into the 'Fabric' of the Enterprise such that the associated **Human Capital & Reputational Capital** has **Leadership** of the business 'Why' and 'Direction' of travel. **Followership** thereby helps individual Leaders to grow through their Leadership Behaviour, along that 'horizon' cast by **Purpose & Strategy**. **Followership** is hard to achieve in practice, but, is the only internal option if that Enterprise lacks Senior 'Leaders and Leadership'; usually where 'blind rot' has accumulated and certainly where external Mindsets are deemed unwarranted; Poor Governance.

The need to '**Understand (the) Doing**', the quest, happens before the '**Being Understood**' can happen[5]. **Content** builds **Context** and the **Insight** needed. 'Productive Tribes' create the **Content**; the 'New Covenant of The Future'. **Unsustainability** was enacted through **Exploitation**, being only Economic **Market Oriented** not Social (Organisational) **Nexus Oriented** nor Environmental **Nature Oriented** – which lasted nearly 350 years; the **Great Organisations of Unsustainability**.

Great Organisation of Sustainability will be 'future fit'; enduring through **Stewardship** and globally through **Citizenship**, **Custodianship** and **Guardianship**. These **Guiding Practices** will require a 'recipe book', being tailored to each 'species' aiding **Adoptive Learning**, replacing outdated pure **Exploitation** practices.

Sustainability Content goes back many hundreds, or thousands of years of history and roots. **Sustained**

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Value, the Golden Goose – laying Golden Eggs ascribed to Aesop around 600 BC (**Article 8**). **Principles**[5] of Scape are **Natural Laws**, 'lighthouses'. **Stewardship** cast back in 1973, 'Ultimate Means to Ultimate End' (**Article 8**); Service and Stewards. Like Knights Templar. 'Hidden by Shadows' - present, but now 'unearthed' by the quest-full few enduring to be **Purpose-Full** & **Meaning-Full**.

Management may be 'cool, aloof and analytical - separating emotion from work'[6]; dimension of control - control of resource sapping the necessary 'excel' from the **Activities** and **Actions**; often causing **Non-Action**. **Excellence** matters when **Specifications** are the cause and driver of change (**Article 8**); **Changing Specifications** and **Changing Boundaries** - limits and limitations.

Leader Leadership embrace 'inspiration, passion, elation, intensity, challenge, caring, kindness, love'[6]; **Complexity**. Protecting the development of new; focused Motivation & Enthusiasm. **Being Understood**, having **Purpose** and **Enactment**, clear to all. 'Recipes' which can be adapted to all 'habits'[5]. **Adaptive Learning**, **Adoptive Learning**, **Regenerative Learning**. Enabling is the 'key' to the 'Future Horizon'.

Sustainability is advancement; **Doing Better**. **Invention** is the discovery of 'New' or a novel scientific or technical 'Idea'. An **Invention** only needs the 'Idea' to be proven as workable. Only a few Inventions leads to Innovations because not all of them are economically feasible. **Innovation** is the introduction of a new or improved approach to a known process or product – achieving an incremental improvement. **Invention** takes much longer and often needs a massive 'spark', failure being endemic. Invention is famously referred to as "1% Inspiration, 99% Perspiration". Less famously, **Innovation** is "10% Inspiration, 90% Perspiration". But **Invention** does have **Ownership** rights (**Manufactured Capital**, **Financial Capital**, occasionally **Natural Capital**); **Intellectual Property Rights** often leading to filing of **Patents**. Some Research Organisations in the seventies & eighties used to collect **Patents** like stamps! Both now have been seen as poor investments apart from 'real novelties'; a rare 'beast', a novel mistake!

Innovation is hard to secure Intellectual Property Rights ('IPR') which actually 'fuels' the societal 'fire-of-progress' with great 'new or improved' approaches typically going 'viral' within 'days'. The problem of 'Innovation Ownership' is that by being often discipline-led, the fact that someone has achieved 'new or improved' means others with similar **Specialisms** or **Generalisms** – through 'trial and error', will discover that **Means** for themselves. The fact of 'discovery' is not 'unique' when the 'pathway' to that 'discovery' is open to all equally skilled. The **Value** was in knowing it was solvable, which has 'fleeting' **Ownership**, once everyone knows! With Innovation gained using **Intrinsic Data**, Ownership can be more protected but still relatively 'fleeting' – Consultancies surviving on **Continual Innovation**, by discovery after discovery built from **Intrinsic Data**, incorporated into their **Tools of Trade**. **Disruptive Innovation** can wipe out whole rafts of business Asset 'species' in real time, not semi-geologic time.

To **Paradigm Shift**[5], the 'process of Innovation' needs to be first 'understand-ed' ('Project Understand') and then interconnected into the 'fabric' of all **Great Organisations of Sustainability**; 'Project Understood'. The biggest **Paradigm Shift** in the history of the **Industrial Revolution** will be to move from **Unsustainability** to **Sustainability**. The conquering of **Pollution Emissions Waste Depletion Loss**.

Innovation is typically linked to the creative activities of 'Process' [**Article 8**, **Figure 1**]. Mindsets, Frameworks, overcoming Barriers all linked strongly to Innovation; **Creative Thinking** & **Motivation**. **Invention** is in the 'shed'; **Innovation** is in the 'head'; **Continual Innovation**, more 'heads the better'. **Sustainability** is about securing 'opportunity after opportunity'; an enduring process built through the interconnectedness of **Group Motivation**, **Optimised 'Enactment'** and being **Purpose Fit**.

The **Innovation Process**, in the future, will need to be Technically managed, the **T-manager** role; part Specialist, Leader, and Maverick – a very rare 'beast' replacing the redundant Patent 'stamp' collector manager (**P-manager** role). **Group Teams** being the early adopters creates Delivery managers, the **D-manager** role, most likely through **Ecosystem Organisations**; **Partnerships** (Ecosystem Based). In the future, if firms

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want access to **Patented Invention**, simply partnering through **Ecosystem Organisations** will deliver at pace (**Speed**). **Great Organisations of Sustainability** will be built mainly from being **Resource-Based** & **Ecosystem-Based** (**Figure 1**); then having **Resiliency** through **Diversity of Partnerships**. **Innovation Process** & **Innovation Management** are now becoming 'core' to **Sustainability Delivery**.

Being Innovative, to 'innovate', is the ability to understand the problem, adapt to the challenge and deliver appropriate solutions quickly; minimising consequential outcomes. **Novelty** is something new, fresh, interesting or unusual; an **Innovation**. **Novel Investment** was discussed in **Article 3** being comprehensively discussed by Tim Jackson, delivering "hope for our children". **Novelty** and **Novel Investments** forms the central core to the Natural Resource Ecology **ESP model** (**Environmental Societal Prosperity**) a major breakthrough before applying it to Integrated Thinking and Systemic Thinking of **Sustainability**. **ESG** means **Familiarity** is assured leading to more **Novel Investments**.

During 'Project Understand', **Kinship** is important as touchpoints 'spark' the future (enter 'guest appearance', **Goddess Nigella**). Shadows flicker and jigsaw shapes connect; content builds. Capture can be fleeting so time has to be a free resource to 'excel'. The cost of 'The Future' has to be borne; speculation leads to accumulation. With 'Project Understood', attraction to 'New' creates more 'sparks' and conservation is achieved; a **New Covenant** in-place; protected by the custody of **Stewards**, and **Guardians**. Additional **Covenants** build credibility that the 'shift' to 'The Future' has commenced. **Society** decide, **Government** protect, **Business** respect, **Academia** creates. **Conservation** is key because the New Horizon has Succession; **BluePrints** bridging across the 'horizon of the present', like a 'river' which needs traversing to get to 'The Future'.

Leader implies 'on top' but all Great Organisations have two 'ladders'; **Technical-ship** and **Management-ship**. **Technical Succession** comes from the former, though Champion managers, the **C-manager** role, from the latter, always catalyse progression; **Internal Influencers**. **C-managers** have been around now for over twenty years. In firms where they are not present, then **New Enterprise** results with **Knowhow** transported with the 'New' to the New; **Entrepreneurship**. The **Technical Ladder** is multi-dimensional, 'diversity of thoughts', cross & multidisciplinary working; Technical Succession **HandPrints** & **BluePrints** deliver both 'Stock structures' and 'Flow conduits' to future success.

Traditional Resource manager, the **R-manager** role, is one dimensional so when the 'Paradigm Shifts'[5], being 'on top' flips to the 'cavernous bottom', reality; last decisions, lasting the longest. Board 'blind rot' is hard to quell without **External Influencers**. **R-managers** have also been around for as long as **C-managers**, but, they have not fared well being the first to suffer in the Energy Transition since post 2014. **Principles** are like lighthouses with permanent value[5]; keeping the 'ship' from a rocky end. Simply tempting a fateful end can happen when misaligning the 'map' through poor **Understanding**, **Values**, **Governance** and **Paradigms** detached from **Principles**, the **Natural Laws** governing human effectiveness, **Human Conduct**. 'Management Top' of **Unsustainability** is the 'New Bottom' of **Sustainability**. The **Paradigm Shift** is real, ask the **R-manager**. **R-managers** who have 'bottomed' seem so far to attain new success in the 'craft' sectors; away from the 'mainstream' flow of the Current Horizon.

Internal Entrepreneurial managers, the **E-manager** role, however, is battle hardened now, 'ship' jumping well practiced; being Good Citizens additionally help **E-managers**, well aware of 'Society deciding'. Academic Institutions funded through initial benevolent funds have high demand for **E-managers** because **Pure** & **Blue Sky** more often than would be thought likely – manufacture produce deliver **Novelty**, which is then spun-off to **Wealth** so the **Economic Rents** can be re-invested to benefit 'institutional nepotism'; **Institutional Capitalism**.

The new breed of 'Ecosystem Organisation' managers, the **EO-manager** role have 'regeneration' on their side. 'Optimised Technical Diversity of Supply' delivering better horizontal and vertical 'conduct & service' offerings; through multiple partnering entities. This is symbiotic with inherent strength from many Asset

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'Species' Classes (**Article 8**), 'entanglement of the many' in Value Chain **Ecosystem Organisations**; a 'model twin of Nature'. **Nature** is borne with this inherent strength of 'entanglement of diversity'. **Diversity of Proficiency** matters, natural and technical delivering more **Mutual Benefit** or **Mutual Dependence**. **Natural Succession** and **Technical Succession** being both enduring; more important for **Advancement** now that we have the 'means (dimensions)' of **Stewardship** and the embryonic 'perspectives' of **Sustainability**; embryonic **Means** heading towards the **Ultimate Means**.

<u>Entrepreneurialism</u>

Entrepreneurialism is key as New Utility is need at global scale, both **Blue Utility** & **Green Utility** (**Article 7**); 'creating and developing' of new economic **Enterprise** and ventures through **Partnerships**.

Social Development is also needed in the understanding of **Making Decisions** without Full Knowledge, the existence of Additional Costs, particularly **Transactional Costs**, and in the Acquisition and Communication of Information, Concepts and Opinions needed to advance **Social Acceptance**; the bounds on individual & collective **Rationality**[7]; and the role of the **Entrepreneur**.

Market Inertia is currently causing lack of progression to the Better Utility needed as exampled by **Natural Gas**. **Natural Gas** has always been a very efficient energy source, though obviously needs **Carbon Removal** to survive the **Energy Transition**; producing typically around 490g CO_2/kWh [Natural Gas Energy Density around 35 MJ/m3]. **Coal** on the other hand has always been a 'dirty' energy source producing typically around 820g CO_2/kWh [good quality bituminous Coal Energy Density around 22-25 MJ/m^3]. So if all the Coal sourced Power Stations were repurposed to using Natural Gas by 2030 this would broadly half the associated emissions from current Coal Power Stations. There is globally enough **Stranded Resources** of Natural Gas, **Speculative Resource** & **Contingent Resource**, to replace Coal use in the Power Sector; driving then forward the need for Natural Gas Carbon Removal in that Power Sector post 2030; delivering further Emissions Reduction from 2030; PLUS 'creating and developing' Subsurface Storage Utility close 'at hand' or further New Infrastructure to transport to existing 'hands'.

However, complexity 'blinds' **Decision Making**. Carbon Removal from Natural Gas Power Stations is the most expensive technology currently, more expensive than Coal Power Carbon Capture technology. Stranded Resources of Natural Gas means new structures, particularly pipelines will have to be scoped, designed, constructed, commissioned 'perpetuating' the age of Fossil Fuels. **Liquefied Natural Gas** (LNGs) [50-150 KgCO$_2$e/BOE (Scope 1&2)] tend to have twice the **Carbon Intensity** than Natural Gas resources developed by pipelines [5-22 KgCO$_2$e/BOE (Scope 1&2) UKCS].

Hydrogen, many Governments' post Transition Energy fuel of choice (eg Japan, parts of the UK) to replace Natural Gas or Petroleum Liquid products, has a GWP(20) of 33 compared to Methane GWP(20) of 56-96. **Global Warming Potential** (GWP) is the heat absorbed by any greenhouse gas (GHG) in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of Carbon Dioxide (CO_2). GWP is 1 for CO_2. Hydrogen is a **Feedstock**, requiring energy to create the **Resource Stock** needed. Grey Hydrogen is not a Natural Resource from the **Hidden Commons**, unlike Natural Gas, which is in the 'name'. Currently **Grey Hydrogen** creates/produces around 10 tonnes of CO_2 per tonne of Hydrogen, from Coal and Natural Gas sources. Globally around 75 million tonnes of Grey Hydrogen are created as **Feedstock** per year. **Green Hydrogen** was typically around 4 times the Market Price of **Grey Hydrogen** in 2021. However, **Hydrogen Leakage** is significantly greater than associated Methane, around 2.8% from current above ground storage facilities and Hydrogen will need new infrastructure at scale, increasing **Material FootPrints**. Methane infrastructure is predominantly present today, apart from new pipelines connecting Stranded Natural Resources. So Hydrogen 'creating & developing' by some Government 'design' has major issues of **Proficiency FootSteps** towards further **Climate Changing Emissions**. Some 'experts' estimate current total 'Grey' Hydrogen emissions are very similar to total 'Aviation' emissions. Something for **Societal Scrutiny** to

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investigate!

The current lack of **UK National Storage** at scale for Natural Gas is another good example of 'stern' Economics – one dimensional Activities, Actions, Non-Actions without **Valuing Everything**; eg **Security of Supply** 'what's Material?' What about **Proficiency**?

Conduct & Custom is very much part of **Citizenship**, delivered through **Corporate Governance**, along with Management and Employees **Service & Stewarding**. **Ethical Morals** (Conduct & Custom) and **Valuing Natural Resources** (Governess Value) is very poorly reflected on most Economics Degrees, globally. Yet Milton Friedman, September 13, 1970, famously stated that **Business Enterprise** should "make as much money as possible while conforming to the basic rules of **Society**, both those *embodied in law* and those *embodied in ethical custom*" [**Principle of Profit Primacy**]; **Citizenship.**

Business Organisation (Enterprise) will be considered a good 'Citizen of Society' if it operates socially and ethically; with due regard to Safety & Wellbeing, Community and Environmental Stewardship; **Conduct & Service**. Enduring **Business Models** makes 'Security of Supply' a Sustainability 'compound entity'; **Government & Business**.

The lack of Competence (**Bounded Rationality**)[7] without **Full Knowledge**, exasperated by **Wishful Thinking**, typically means **Decision Making** is based on **Incomplete Knowledge**, resulting in **Uncertainty** & **Complexity** typically in 'systematic' situations (ie Sustainability - Systems Thinking). **Figure 3** illustrates the Market 'Structure Conduct Transactional' impacts and effects which this creates and helps to develop, such as **Entrepreneurialism** through **Opportunism;** and **Societal Scrutiny**. **Governance Guidelines** are expertly covered by Scott Randall[8] (2008) being **Criticality Consistency Accuracy Transparency Competence**. His book being a 'must' read for anyone interested in **Business Governance**.

Figure 3: Transactional composites – enterprise conduct and service
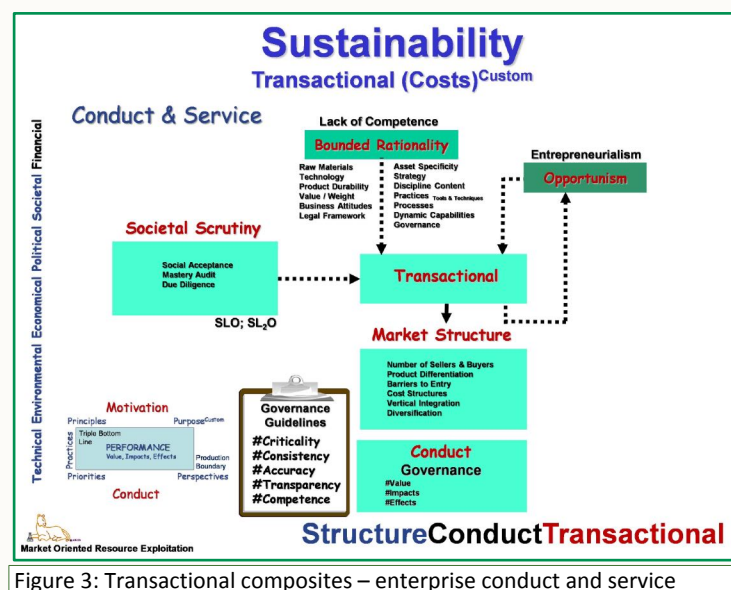
"An entrepreneur is nothing if not an opportunist"[7]. **Opportunism** is the 'Practice' of 'taking advantage of opportunities'; being 'entrepreneurialistic'. Opportunism is a motivational attribute, an important composite of **Entrepreneurship**. **Good Practice** is important to ensure **Good Motivations** are followed; any Current Knowledge and Current Knowhow having good regard for 'Principles of Good Faith' limiting potential conflicts of interest. **Arising Knowhow**, in particular, is owned by the Entrepreneur or New Venture owners. A clear distinction.

Asset Specificity, is how readily the 'Asset' (ie 'resource' - 'thing' of value'; asset, specialist, knowhow) can be adapted for other purposes.

Low Specificity being flexible; generic. *High Specificity* being specialised; specific. Knowhow and specific on-the-job training being **Human Specificity**. Equipment specifically designed to produce a Product or Resources being **Physical Specificity**. **Site Specificity** being separable stages of Manufacture Production Delivery which if located in close proximity will reduce transportation and other costs; 'creating & developing' **Opportunism**.

When **Bounded Rationality** & **Opportunism** co-exist such as in early stages of 'creating and developing' of new commercial Enterprise and Ventures, such 'uncertainty, small numbers of exchanged relationships or asset specificity – market exchange problems occur and efficiency considerations will favour alternative organisational forms.' **Bounded Rationality** & **Opportunism** are particularly important to **Business**

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Sustainability. Firm's should be organised and behave depending on Human, Social & Environmental attributes – trustworthiness, morality - ethics; operating in good faith. Innovation within a 'framework of Values', based on **Value**, would signal if the firm's creation activities are linked to the firm having a **Social Oriented Business Purpose**. Organisational & Behavioural issues are therefore just as important as Manufacturing Production Delivery 'efficiencies'; **Proficiency** being the 'new efficiencies' through **Doing Better**.

Having **Full Knowledge**, present & future, would leave no scope for **Entrepreneurship**, and organisational features would not matter if there was no difficulties in predicting future prices & demand, and writing long term contracts. Existence of **Asymmetric Knowledge** and its impact on the behaviour of individuals as 'agents' or 'principals', not having a conflict of interest, creating a view that firms are 'nexus of contracts' implied through activities and action; an **Agency**. Increased **Risk** through transitions, means specifications have to change – 'Excellence of Competence' being the main guiding 'light' to pursue along with **Motivation**. Change & change again, means challenges after challenges.

Entrepreneurialism centers or focuses where **change** and **disruption** (Technical, Political, Financial) 'Perspectives' can lead to significant new opportunities not yet fully identified, captured or have reached Full Market penetration (R&5Ds) – needing the right **scape**, needing **scale** up to reach full **scope**, where a **spark** is likely, or **speed** can be delivered through existing Value Chains; **Governance Value & Governess Vaue - Scape Scale Scope Spark Speed**.

Typically, Entrepreneurialism focuses where **Asymmetric Information** exists. *Technically* in areas such as intangible Intellectual Property (Brands & Reputational Capital), specialist competencies & skills (Human Capital), patents, concepts & 'concept products', experience, insight, wisdom & knowhow. *Politically* in areas such as regulation space such as bestowed in Natural Resource license pseudo-markets, markets with imperfect competition and externalities, government contracting space, limited regulation space – space protected by limited disclosure & transparency. *Financially* in areas such as contractual market and transaction space, commerce limiting disclosure & transparency. Typically what is in the 'public domain' may be very interesting and informative, but, **Asymmetric Knowhow** and **Asymmetric Project** delivery-ability to execute and scale-up projects – on time and under budget is a valuable 'trade' **Competence** at the core of **Business Sustainability**, delivering Full Value. New entrants often make mistakes in even mature 'species' disciplines as typically the **Asymmetric Information** exists between disciplines, core to Gaia's top-down thinking which did not match with bottom-up experts at conception; delivering **Integrated Thinking**.

The scope and global market scale makes **Entrepreneurialism** launch millions of entrepreneur-'ship's per year. However, the one in each million that goes on to achieve Full Market penetration does require **Goddess Nigella** – the often magical 'spark' that delivers 'lift-off' to the New Market 'space' destined for entrepreneurial exploration to exploitation, and now involving 'Stewardship Systems' over 'Fragmentation'. Human Capital, Social Capital and Financial Capital building new Reputational Capital & Manufactured Capital, often, unfortunately transferring Natural Capital to these other 5 Capitals Stock.

Sustainable Entrepreneurship will be about ensuring the **Planetary Stock Balance** is taken into account under **Primacy 401 (Article 6**). It is hard to see how going forwards, Full Market adoption of new materials, products, resources, energy, power can occur without passing the **Stock-of-Life** Societal Scrutiny Guide-Price or equivalent 'bench-marking' Technical Assurance. Elements of **Regeneration** will be key, natural & technical, increasing over time to become critical, unless, major technological breakthroughs can be 'sparked' and nurtured into Life by **Goddess Nigella**; **Disruptive Innovation**, "unexpected solutions rarely emerge from industrial applied research and that is a shame because this is where the 'next big thing' is hidden."[9]

Disruptive Innovation means firms & corporations need transformative change of their **Business Model**. This might even need to happen continually depending on non-linear changes in **Consumption**. This needs a **six prong focus**:

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1: **Adaptation of Organisation:** Re-Architect of Purpose & Mission – becoming more *Social Oriented* plus clarity of 'Vision', linked to **Strategy** to help overcome internal **Structural Barriers; Re-Framing** to 'refocus' 'reengage' **Means**, **Thinking** (Integrated & Systemic), **Mindset** (view point eg choices [eg **Source** of Resource]), **Better Behaviour & Values** (based on Value, Impacts & Effects) based on **Sustainability Principles**

2: **Living Systems** – Natural Regeneration & Technical Regeneration (Ecosystem Organisations)

3: **Fragmented Wholes** – Operations & Projects looked at through lens focused on **Composites & Compounds**, even **Elements**

4: **New Learning** – Unknown Unknowns, through Discovery & Intrinsic Data

5: **Radical Innovation**[9] – introduction of a transformative Business Model that seeks to completely 'demolish' and 'replace' an existing **Industry** or create a whole **New Industry** by taking an existing System, Design or Invention and turns it into something **New**

6: **Human Capital** motivated to 'drift-off' into **Entrepreneurialism** through **Learning Organisation** Thinking; creating New Enterprise organisations, internal or external to the host **Business Model**. This is very much a part of today's 'business dynamism', just with more urgency as existing Business Models fail to deliver as much Value due to condensing and maturing Life Cycle economic Market Price erosion -- hence why **Continual Improvement** has proved invaluable over the last thirty years. **Capacity** matters aiding endurance.

Continual Innovation

Continual Innovation, builds very nicely out of the **Learning Organisation** Thinking, particularly well expressed in Peter Senge's book "the Fifth Discipline"[3], first published in 1990. The **Learning Organisation** being defined as 'desiring to continually expand its **Capacity** to create its future – survival not being enough, but, needing Adaptive Learning & Generative Learning competencies & skills'; individual & organisational. Senge's fifth discipline was 'Systems Thinking', **Systemic Orientation**, fusing five 'composites' into a coherent body of theory and practice; an 'ensemble' – not simply learning by 'schooling' influences but also cognitive (thinking, understanding, learning, remembering), socio-cultural, working as an influencing 'whole' to deliver shared co-benefits. For Sustainability – this is synonymous to **Stewardship**; **Doing Right for The Whole**.

Senge introduces the concept of **Metanoia**, a 'shift-of-mind'[3] or movement of the mind typically linked to having worked as part of a great **Team**; with 'meaningful' experiences. Team working being the building blocks of **Group** organisational working & endeavours. Senge's ensemble creates a 'species', 'kind' which is unique to the business **Purpose** of each organisation (**Article 4**), anchored in the present but focused on the future; individual **Innovation** or organisational **Continual Innovation**.

Senge's five ensemble[3] composites being (1) **Systems Thinking** – a 'conceptual framework' making the *full* patterns clearer; (2) **Mastery** – to realise 'outcomes that matter', personal special 'level of proficiency' – **Specialisms**, built on complex lifetime learning through completing 'work-done'; (3) **Mental Models** aiding understanding, activities & actions based on 'known' **Content** but creating a 'sense' of the 'unknown' to guide Risk Assessments & Risk Management – creating Contingency Planning and gathering new scientific evidence and engineering insights; (4) **Shared Vision** – seeking to create through vision, mission, goals & values – built from a 'Common Identity' galvanised through 'recipe' **Set of Principles & Guiding Practices**; and (5) **Team Learning** – built on collaboration, cross disciplinary Specialisms 'working', focused on 'creating & developing', Performance & Delivery, having capacities for co-ordinated activities & actions, gaining collective insights from different **Disciplines**. For Sustainability again the 4th element – this is synonymous to the importance of **Sustainability Principles** and the foundation four core guiding **Sustainability Practices**: Stewardship Citizenship Custodianship Guardianship.

To achieve **Sustainability** and get to the New Utility, new **Innovation** is needed overcoming both the 'friction', 'resistance' attracted to the better new 'concepts & ideas' content – as well as material 'energy' often through personal sacrifices needed to 'fuel' -- projecting the innovation 'forward'[10]. Often Innovation Resourcing, the 'new content' & 'energy' provision, is linked to the saying "you have to speculate to accumulate". The **Human Element**[10] linked to four 'frictions & forces': **Inertia**, **Effort**, **Emotion** and **Reactance**.

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Market Inertia as already discussed in the last section (with the 'future' use of Natural Gas) is linked to **Complexity** – status quo, vested interests, wishful thinking, lack of competence (understanding), issues related to being understood. **Effort** linked to 'cost' of implementation, real & perceived. **Emotion** concerning audience reaction to 'views' on the **Horizons**; advocates, activists, anarchists, adversaries. **Reactants**, based on how 'innovation' is 'creating & developing' change, **Paradigm Shifts**. These are why **Entrepreneurialism** and **Continual Innovation** go hand-in-hand. Organisation matters to overcome 'frictions & forces' by **MEANS** being 'collectively owned'. **Societal Innovation** is also important where 'Values' need to be based on 'Value' and Behavioural Change must happen if the move to the New Utility is to achieve **Global Sustainability**. Complex topics of Social Consumption; Global Population vs Planetary Resources; Conservation may only be tackled effectively in the future by **Citizens Agency**, currently in embryonic development itself.

Innovation, to have 'the dream' has been likened to having to cross 'the stream', building a 'bridge' from 'the now' to 'the future'. To get to **True Sustainability** very much follows this concept, creating the New Utility, built from **Succession** & **Stewardship**. **Stewardship**, "doing right for the whole", systemic, achieving **Total Value** (the sum of **Governance Value** and **Governess Value**) – developing, delivered through engineering, guided by the science. **Conservation** of the current – building the 'bridge' *from firm ground*; and **Change**, achieving the 'new', building the 'bridge' *to the destination*.

Being 'Good Stewards for the Resource' conserving for **Sustainability** should be just as important as being 'Good Stewards of the Sustainability Vision & Sustainability Mission'; how to cross 'the stream' -- needing a level of **Certainty** and **Commitment**. The degree of Certainty needed has to come from **Technical Succession**; **BluePrints** built from **HandPrints**. **BluePrints** being anchored in the recent past & present; giving 'the bridge' 'familiarity' with existing 'Designs', 'stability through Proficiency', while crossing 'the stream'.

Also needed to achieve the **Innovation** required, are **Leaders who Serve** (**Leader Leadership**), people who can actually deliver through their work and work done; **Stewardship**. **Ownership** of Natural Resources was cast in print in 1689 by John Locke[11]. Locke was the first real pioneer to appear on the **Sustainability Landscape**. The **work done** in 'gathering', or exploiting, common land goods – 'removing them out of that common state they were in, hath fixed my property in them'. **Stewardship** is often involved due to the seasonal exploitation of Nature, also improving the selection of the plants; cultivating them on private land not just common land; increasing the crop yield; producing associated products to sell with these goods; and finally providing a 'service to steward' increase consumption. By enhancing the **Value**, Stewardship is essential in creating a resilient Natural Resource business – built on Best Practice 'work done'.

Edwin Dolan, in 1971, published TANSTAAFL[12]: 'There Ain't No Such Thing As A Free Lunch'. This book has become the bedrock of Natural Resource economics and a must read for anyone interested in **Natural Resource Ecology**. Dolan's book nicely discusses how 'everything of value', has a cost. There is an '**opportunity cost** – the idea that whatever you chose to do has a cost that is measured in terms of the other things (or activities) you could have done instead with the same time and resources', enduring 'work done'. Particularly with Non-Renewable Resources, **Full Cost** pricing including waste disposal, harm from pollution & emissions, and depletion of resources is the only way for industry to co-exist with **Society**, without gaining at the expense of others. **Full Cost** pricing is socio-efficient. The polluter must pay the Full Costs. For greenhouse gas ('GHG') emissions, the free rider effects have to be overcome so Scope 3 Emissions have to be part of the **Custody Chain**, linking 'Manufacture Production Delivery' with 'Consumption'. **Total Emissions** matter.

Considering **Wholeness** vs **Fragmentation** will create a lot of future **Innovation**.
"From a very early age, we are taught to break apart problems, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay a hidden, enormous price. We can no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole. When we then try to "see the big picture," we try to reassemble the fragments in our minds, to list and organize all the pieces. ...Thus, after a while we give up trying to see the whole altogether."[3]

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The challenge of building organisational **Abilities**, **Capabilities** and understanding the **Capacities** to continually adapt to changing realities, clearly depends on new ways of thinking, operating and motivating; as well as the needs now to **Doing Better**; **Better Practices**, **Better Development**, **Better Government**, **Better Capitalism** and **Better Consumption** (**Figure 2**).

During the Grey Utility (**Article 7**), 'silver' bullets were seen as the innovation pathways. Now **Continual Innovation** delivers **Silver Gold Platinum Bullets**; respectively being Grey Utility, Blue (Better) Utility, and Green (New) Utility at **Scape** (Developed, Emerging, Surviving Economies [**Article 7**]), **Scale**, **Scope**, **Speed** (Pace - Prototype, Demonstration, Deployed, Full Deployed - Technology). **Continual Innovation** delivers the **Current Utility**, **Better Utility**, and **New Utility**.

As **Article 7** discussed for **Global Sustainability**, the move to the Better Utility, those **BluePrints** have already been created by the **HandPrints** of the industrial revolution since 1575, built through **Technical Succession**. The Blue Utility just needs the **Spark** from **Goddess Nigella** -- sparking the necessary Better Utility; particularly at **Scope**. Then on at pace, speeding to the New Utility; at **Scale** -- transforming through systemic **Re-Architecture**, systemic **Restoration** but more importantly systemic **Regeneration**, natural & technical. **Natural Regeneration** is to replace 'natural loss'. **Technical Urban Regeneration** being "leaving the 'working landscape' in a better state than the previous generation"; **Doing Better**. To move from Grey-to-Blue-to-Green will take more Global Partnerships, need more Global Finance & Global Funding Networks but has considerable less **Risk** which is how Engineers 'build to get across streams'.

The Apollo Space Mission did not get to the moon on Apollo 1 but Apollo 11. Apollo 11 was engineered using three spacecrafts to achieve its mission: the Command Module Columbia, a Service Module and the Lunar Module Eagle. To developed New Utility – the **Green Utility** will need lots of prototypes – failures will be high, successes few; we know that as otherwise the Urban World would be as sustainable as the Natural World (**Article 7**).

The technical 'Bullet' - needs **Design** with **Work Done** to hit **The Target** (The Market); with the desired precision or accuracy. The 'Bullet' needs 'fuel' to get to 'The Target' and an organisation, built on **Entrepreneurialism**, to overcome the 'actors & factors', 'frictions & forces' on route to still hit 'The Target'. **Proficiency Performance** of organisations, will be based on actually *achieving* the desired precision or accuracy; within set time frames; **Climate Tipping Points** are on the **Current Horizon**.

To achieve Innovation & Entrepreneurialism needs that '**Spark**'; a moment of inspiration, ingenuity, insight, wisdom, creativity - a 'coming together' guided by the 'hand' of **Goddess Nigella**. A technical 'happening'. This might take 100 prototypes, or just a couple - but it happens. Then the hard work starts with earnest. Not all breakthroughs change the **Scape**, most never reach full **Scale**. **Scope** is certainly improved, advanced; pace and clarity improved, often resulting in a 'step-wise' increase in outcomes. Shifting of 'Current Horizon' Paradigms to 'Future Horizon' Paradigms will be achieved over **SpaceTime**. The 5Ss of Sustainability: **Scape Scale Scope Speed Spark** guided by the **Science of Sustainability – Technical Social Environmental** (**Article 6**); Innovation & Entrepreneurialism sparked by **Goddess Nigella** built on Research & Development; building of prototypes leading to Demonstrations, Dissemination, Design; on to Deployment (R&5Ds) (**Article 4**) before achieving commercial Full Deployment.

Climate 'happenings' caused through **Global Emissions** are now 'sparking' a different change – **Citizens Agency**[13]. Water Pollution through **Global Pollution** will 'spark' changes when the **Evidence** has been scientifically captured from the **Deep Oceans**; soon one hopes. **Hope**, unfortunately, is not enough to change the 'Perspective' of **Political Sustainability**, which is built on 'limitation' driven by **Tragedy** (**Article 7**); Tragedy of the Commons, Tragedy of the Horizon, Tragedy of Outcomes. **Tragedy of the Front-Line** is at least 'sparking' now the **Political Mindset**. Putting 'Profit before Planet' is not politically enduring. **Government** protect.

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Environmental 'sparking' through **Nature & Climate** is just as powerful as 'sparking' through **Market Forces**, catalysed through 'sparking' caused by **Social Organisation**, a 'Nexus of Citizen Consumers'; **Citizens** & **Capitalist Society**. **Liberalism**.

Patronage & Market Forces: Liberalism vs Authoritarianism[13]
Social Citizenship has historical legacy with authoritarian roots, much longer than **Business Citizenship**, only some 50+ years cast in **Liberalism** (**Article 7**). Building from after the First World War till the 1940's, the Market **Supply Chain** became an obvious nexus for improvement as **Globalisation** expanded, built from the succession of **Imperialism** from the Victorian Age. **Patronage** particularly evident from mobilisation & delivery for **Wars, Campaigns & Kings** moved to towards liberating **Social Consumption**. **Consumers** before then, had been very much the "Subjects of The King"[13] for thousands of years governed by Market **Authoritarianism**. Supply Chains improved such that by the 1960's it became obvious the 'Consumer is King'.

In the 1980's the **Value Chain** (Porter[14], 1985), **Integral Thinking** resulted in 'Vertical' as well as 'Horizontal' complex 'Chains' resulting in these 'entangled' companies focusing on 'Profit is King' – outsourcing the rest; cutting costs as revenues are being maximised through 'marketing' consumption – delivering global **Value Chains**; 'specialist entities' connected in a nexus of 'complex contracts'.

Global Population doubling increased **Economic Growth** through Labour Markets opportunities; global 'mega' containerisation with cheap energy supply particularly Coal in the Far East and Natural Gas in North America resulted in year-on-year outsourcing of Developed Countries non-advantaged 'Shires & Provinces' work-scope to global scapes where deemed Market advantaged **Scale Scope Spark Speed** was focused on **Cost Advantaged**, often 'bottomed' however in terms of Product Quality, Product Stewardship, Resource Stewardship, Environmental Stewardship or Human Rights but maintaining 'Consumer is King' and 'Profit is King' through Government deregulation and pursuit of Free Trade; **Consumption as King** driving Manufacture Production Delivery.

In 2004, the Greenhouse Gas (GHG) Protocol[15] and 2005 acceptance of ESG Investment Governance should have heralded in the introduction of the 'Custody Chain' Custodianship; linking 'Manufacture Production Delivery' to 'Consumption'. It has however due to Government putting 'Profits before Planet' and Corporate Governance 'greenwashing', that 'Accountifactual is King' has been considerably delayed. Total Impacts and Total Effects from the 'shires' to 'regions' to 'nations', globalised to 'Planet scale' only became 'the future' Horizon' in 2020. The paradigm of "Chain Fragmentation" is over; shifting to the "Wholeness Chain"; accountifactual **Custody Chain**. In 2021, **Developed Countries** Governments agreed at COP26 that heading to **Net Zero** was now mainstreamed at least on 'scope'; some enacted through National Laws.

Spillovers are now **Accountifactual**; part of the Custody Chain; **Relevance** & **Transparency** matters. 1970's **Sustainable Development** ideology was linked to Relevance, Ownership, Morals, Ethics, Equity, Justice, Realignment of and Redistribution of Opportunities & Wealth; a thick 'soup'. **Global Sustainability** has high demands on Relevance, Ownership, Equity and Principles (Inclusiveness; Governance, Governess, Worthiness; Social Need); the **Global Quadruple Bottom Line** (GQBL) enduring through the **Global Economy Society Environment & Political Governance**.

'Manage only what your Measure' unfortunately is **Fragmentation**. Being **Respondible** means 'Management by Authority' is not enough operating and delivering with **Limits & Limitations**. Micro-management needs to end. The need and desire is to **ReFrame & ReArchitect** -- instigating **Leader Leadership** to ensure enduring **Resilience**; moving across different economies. **Freedom** to 'Act with Scrutiny' and focus on 'Delivery & Proficiency Performance' (Goal Optimised) is important enough to demand change to hopefully ensure **Resilience** is to be endured in many commerce sectors.

Developed Economies do have a head start but the importance in **Civil Society** must not be taken for granted. The **Capitalist Society** has goals too needing **Doing Good** and the desire of **Doing Right**. The role of Business in

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Society is an ancient matter which up until now there has been no agreement which settles this matter; this situation has not been conclusively determined and may never be if Humanity continues to 'take' the future. **Sustainability Reports** and **ESG Reporting** need to build a broader narrative; **Content** based on **Material Performance** and **Proficiency Performance**. It is important in any assessment or analysis that the **VUCAR** framework is given respect by Business; **Vulnerable Uncertain Complex Ambiguous Radical**.

Liberalism through the **Capitalist Society** is now increasing **Citizens Agency**[13] seen by increasing *Participation*, caused by lack of **Good Political Governance** on Nature & Climate (**Pollution Emissions Waste Depletion Loss**). **Social Citizenship** and growing **Business Citizenship** clamour for **Prosperity of People & Planet (Climate, Nature)**; **Our Living Planet** is increasing, ratcheting up through the 'happenings' all around Humanity, post 1.0 DegC temperature rise – not the 1.5 DegC as offered by **Authoritarianism**.

Authoritarianism vs Liberalism has been a battle of **MindSets** for Centuries. Skirmishes & Battles between these two great **Patronage & Market Powers** have started to flare-up again. "Consumption as King" no longer 'cuts the mustard' or 'butters the toast'. The 2020's will mean 'Accountifacual is King' guided by **Citizens Agency**; **Societal Scrutiny**. Prosperity from **Consumption** but through 'Proficiency of Manufacture Production Delivery Consumption', through **Ecosystem Organisations** in tune with Economic Social Environmental **Stewardship**.

'Accountifactual is King' because the roving 'eye' of **Authoritarianism** has failed to protect **Consumer Choice**. The human choice to be "Unsustainable or Sustainable". **Individual Autonomy & Free Choice** has deep roots in **Liberalism**. Authoritarian, **Poor Political Governance** beware; Demand & Supply matters as well as **Doing Right** – **Valuing Everything**. Old 'stern' economists beware.

The solution seems obvious to some – invite Engineering back to the table as in the '1886' era, achieving Sustainability in an "engineering context"; achieving 'enduring' systems & processes, guided by the science. "Stop treating Nature as Our Toilet" by installing an enduring system, *purpose-full*; plus *meaning-full* "reduction of pollution emissions waste depletion loss". By 2030's 'Reduction will be King'. **Citizens Agency** is driven by 'ideas of truth' – 'stern' economists were one dimensional, 'diversity of thought' matters particularly when so much of Government & Humanity is still fixated on the **Current Horizon**. The Club of Rome was many dimensional but still fragmented without Engineers presence at their 1970's 'tribe' meetings. **Social Development** is one dimensional, focusing only on *Human Capacity and associated New Structures*. What about the Natural World's strength of Natural Regeneration.

Usually the news is that each time from 'flaws of systems & processes' enhancements are 'learnt', but, from 'this time' these 'reforms used' from **Technical Succession** will not make it safer. **Natural Succession** cannot be ignored by Government Non-Action 'protect'. Nature & Climate are LINKED! Both **Technical Succession** and **Natural Succession** need engineering. Bad **COP** (**Article 7**), will not solve anything **Material** without proficient solutions to both Climate & Nature; **Advancement of FootSteps** – Global Sustainability matters. Society Government Enterprise Academia start by the 'Ultimate Means' [**Stewardship**]: *Participation; Motives Motivation Engagement*; and track *Progression* through both *Material Performance* & *Proficiency Performance*.

Engineering the Future – Proficiency 'The Performance Economy'

Engineering the Future, we need **Responsibility** as well as **Respondibility** (**Article 7**). **Governance of Responsibility (Guardianship – Phase I)** requiring the limits of **Valuing Everything** to be achieved with credibility, particularly for the **Living Commons** and **Eco-System Services** (**Nature Stock**). **Governance of Respondibility (Guardianship – Phase II)** is important for **Our Urban World** living on the **Tragedy of the Front-Line** of Climate Change and the Natural World living with increasing mainstream **Tragedy of Depletion & Loss**. **International Waters** that 'comprise nearly two-thirds' of **Planet Ocean** and protecting the **Space**, above the **Global Cover**, need **Global Governance Systems**. Thinking outside-the-box (**Articles 7 & 8**).

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'Material Performance' **FootPrints** & 'Proficiency Performance' **FootSteps** mean that **Participation Motives Motivation Engagement Progression** matter. The **FootPrints** left behind are dictated by the Tools & Mechanisms how humanities **FootSteps** are made. Even stepping on stone, those stones wear – **FootSteps** 'erode' with space & time, often before **FootPrints** become obvious. **Dimensions** & **Perspectives** matter: **Technical Sustainability**, **Political Sustainability**, **Financial Sustainability** [Diversity of Thoughts; Healthiness]. Current **Values** are miss aligned – we need the **Set of Sustainability Principles** & **Guiding Sustainability Practices** to 'light' up the 'shadows' under smoky skies: **Stewardship** (Ultimate Means), **Custodianship** (Custody Chain; Zero Harm; Zero Trace), **Citizenship** (of Society & of Business); **Guardianship** (Governance of Our Living Planet); and finally but not least, **Wholeness**: Governance Value, Governess Value, Worthiness (Opportunity Costs).

Stewardship provides the 'Ultimate Means' – full of Paradigms [Minds & Models], Principles, Practices, Priorities [Strategy], Purpose, Perspectives, Proficiency [Ability, Capability, Capacity: MindSets & Frameworks; Art & Craft]; ultimately Performance [Material & Proficiency] matters from wrong-to-poor-to-good, excel to Excellence.

To instigate **Engineering the Future**, building the 'bridge to the future' has to follow the **Ultimate Pathway** (**Figure 2**), the **Reduction** tasked at every **'Step'**:
1: Source, Secure & Survey the Scape [Resource]
2: Set & Test the Foundations [Explore & Appraise]
3: Develop [Select, Define, Design; Procure & Construct; Commission]
4: Produce without Harm or Trace ['The Use']
5: Recycle during 'The Use' (**Figure 2**)
6: Storage & Repurpose during 'The End'
7: Rehabilitate, Rewild, Restore, Regenerate 'The New'.

Performance – Value, Impacts & Effects
Performance matters - hitting the desired Target. Value analysis is based on 'certain' **Impacts & Effects** being achieved; through **Activities, Actions & Non-Actions**. So these Impacts & Effects - determine Performance. **Performance Management Systems** matter. They need precise & accurate data depending which **Performance Measure** being considered. Internal & external measures matter too. **Lack of Clarity** is just as bad as **Lack of Transparency**. **Reputation** matters.

In transitions, the Target which **Performance** is measured, is moving hence **Dynamic Materialism** matters. The moving 'boundary conditions' become such that there gets to a point in 'space' or 'time' when **Transformation** becomes the **Desire**. As with Economics based on **Pure Opinion**, 'missing' Behaviour matters – time will tell how important those 'gap' will actually be. Our technical-economic evolution (**Techno-economic**), unlike all other species, is very much 'in the mind' until it effects social & environmental Dimensions too; as we have now achieved!

In 1992, Stead & Stead suggested we were rapidly reaching a crossroads (**Article 3**). Jackson, twenty years later explains 'at that crossroads' why **Sustainability** is so important, very much like Darwin pointing out the step change in thinking in 1859. **Scale** is driven by **Human Population**, which has no thought of slowing; spread across the Developed Economy, Emerging Economy and Surviving Economy. **Global Population** consequences are driving **Triple Bottom Line** 'happenings' – creating tensions between 'species' and the Planet. Perfect for **Citizen Agency** to attempt solutions along with **Consumption** and **Conservation**.

Future growth is now at risk, some saying we are or even have reached the natural 'limits' of our finite Planet. 'Prosperity without growth' was Jackson's supporting 'actors' contribution. What is certain is that **Performance** on Reducing Pollution and Reducing Emissions matters and simply reducing **Carbon Intensity** is not sufficient with our current **Scale** of **Carbon Footprints** and cumulative industrial, agricultural & societal

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Scape threatening Pollution & Emissions.

The 'Physical Part of Performance', the **Material Performance** addresses the **Material FootPrints**. Relevant and reliable Data & Information is needed to fulfil Metrics & Analysis - Material to Investment Governance; *Participation* key. Focus on 'footprints' and 'cumulative pollution & emissions', as Jackson pointed out (**Article 5**) but which is still contested or disregarded by many today. Legacy **Liability Risk** is reaching a tipping point – the *elephant in the room* driving **Investment Governance** and **Responsible Investment.**

The **Proficiency** of **The Performance Economy** (**Figure 4**); **Doing Right** is more the 'spiritual' part of **Performance**. **Dynamic Materiality** of **Motives Motivation Engagement Progression** principals. To respect what **Society** decide and **Government** protect. These 'principals' must transparently enlighten how **Business** is respecting **Government** National Goals set to protect Economic Social Environmental interests (Society, Nature, Climate) as well as 'Social Needs of Inclusion & Social Decisions' (Global Sustainability).

Motives must explain with clarity & transparency 'What' each Enterprise is trying to achieve; and 'Why'. **Motivation** must explain with clarity & transparency the 'Driving Force' behind 'Why' needs to be achieved. **Engagement** must explain with clarity & transparency 'How' goals are being achieved, 'With' milestones & sub-targets. **Progression** is about 'Today' presenting clear & transparent 'Past, Present & Forward' Data and 'Why' this data is 'Intrinsic Data'.

'Take-Make-Use-Dispose' has 'engineering' with 'Sustain' 'Ability' built into the **Custody Chain** and **The Sustainability Economy** (**Figure 2**) through **Proficiency** of **The Performance Economy**. 'Taking' Sources & Resources, 'Making' Products need to reflect **Best Practice** economic social environmental **Stewardship** of both **Resource & Product**. 'Use' of Product and End-of-Life must start in unison. Delivery, commissioning and **Sustained Use** creating 'Pollution Emissions Waste Depletion Loss' needing to be addressed depending on **Material Impacts & Effects**. **Proficiency** must develop particularly with **Recycling** through **The Circular Economy**. **Carbon Reduction** proficiency through **Design** ('Waste' Prevention), **Flows** (Circular Carbon Economy) and **Stock** (Carbon Governance). **Design** comes naturally to engineers. Bespoke design and 'design for prevention'[16] contributing much in the future, helping to reach **True Sustainability**. The **Circular Carbon Economy**[17] ('CCE'). **CCE** is more about **Resource Flows**. **Replace** (eg creating blue hydrogen) and **Redefine** (eg creating carbon neutral products) have been added to **CCE** making this fully complement the carbon 'flows' in Carbon Ecosystems. **Carbon Governance and Carbon Budgets** is more about **Resource Stock**: Repair, Renew, Regenerate, Rehabilitate, Remanufacture/Refurbish, Repurpose.

Figure 4: Proficiency – the performance economy: carbon governance; design; circular carbon economy (CCE)
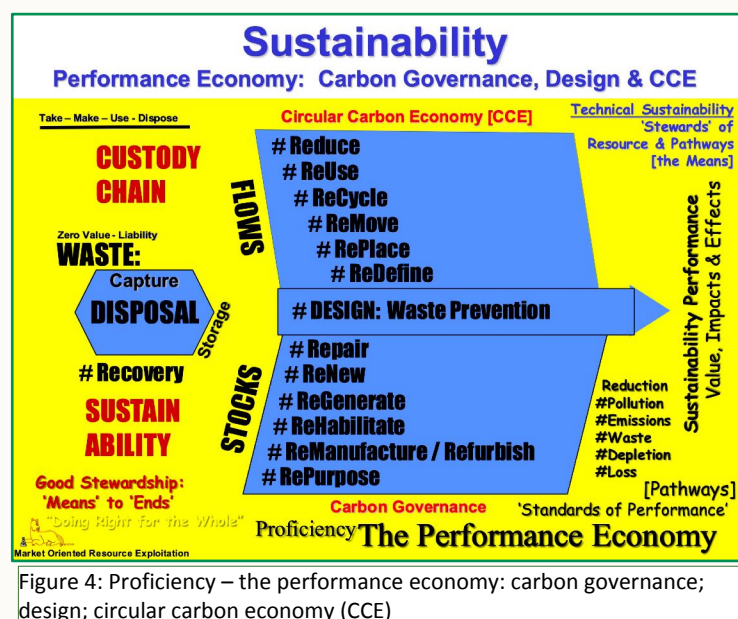
Finally **Disposal**, post optimise **Recycling**. Only **Zero Value Liability** 'Waste', Energy & Material should be disposed – but 'Stored' for potential recovery allowing **Future Use**. Like storing 'Acorn' for future 'Oaks'. Future 'creating & developing' have no realistic boundaries.

As **Figure 3** depict **Business Agency** proficiency revolves around **Motivation & Conduct**. Business Agency should be a 'Stakeholder in Society'. Take-Make-Use-Dispose optimisation depends on Business Agency being Responsible & Respondible. So, by example, if **Priorities** change, Practices Perspectives, Performance, even Principles & Purpose must change to, if **Value Impacts Effects** are to be addressed.

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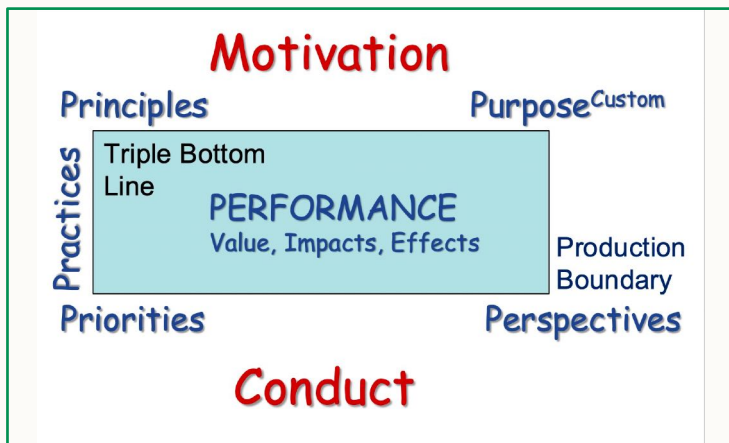
Carbon Removal – Carbon Reduction [Technical Regeneration of Global Cover] Without the challenge of **Net Zero** being met – **Total Carbon** in the atmosphere will keep on increasing, driving up global temperatures. Currently our **Unsustainability** means **Doing Better** in order to achieve 'the ends', **Sustainability**. Better Practices, Better Development, Better Governance, Better Capitalism, Better Consumption is paramount needing **Continual Innovation & Entrepreneurialism**.

Ultimately **Carbon Removal** from Industry Agriculture Energy needs to be achieved as 'conservation' of some composites of current **Capitals Stock** seems inevitable today when considering the remaining **Carbon Budgets** and associated **Time Frames** before **Climate Tipping Points** make non-linear Impacts & Effects on Prosperity People Planet. Where ultimately **Carbon Removal** needs to reduce the cumulative 'Carbon' such that Global CO_2 concentrations are back below at least 'science guided' 350ppm, Net Zero has to be achieved first as otherwise cumulative 'Carbon' will simply keep increasing.

In 1971, the time of Dolan and Limits to Growth – our modern day origins of Sustainability and Sustainable Development thinking, had 58% **Planet Wilderness** and 326 ppm respectively. How can the **Urban World** be considered Sustainable without honouring humanities pledges back in the 1970's to "not limit the range of economic, social, and environmental options open to future generations" by not honouring those modern day origins of Carbon, as The Benchmark? 326 ppm or 350 ppm seem good targets for **Carbon Reduction**, 'engineering the future' though 365 ppm would be a number all Humanity could at least remember if **Citizens Agency** 'spreads-the-number'. **Business Agency** must then respect as a 'Stakeholder in Society'.

'Best' Bakers Dozen 'Opinions' – The Beginning for Better Options?

Human Nature means we repeat the same mistakes, over & over again. But at least we have identified the problem **Our Urban World** has to 'create and develop' to replace **Loss**, unlike the **Natural World** which uses **Natural Regeneration** to replace its **Loss**. 'Creating & Developing' 'Manufacture Production Delivery' Technical Political Financial **Means** and 'Consumer Values & Behaviours' currently result in global 'Pollution Emissions Waste Depletion Loss'; now at near Environmental & Social non-linear **Tipping Points**. Humanity is close to 'Two Minutes to Midnight'.

Engineering the Future, we need to focus on the equivalent '2 minutes past midnight'. To take a step back is necessary before taking a step forward. Humanity is good at challenge, scale and resilience. In the last fifty years, we have consumed 1 trillion barrels of crude oil and felled some 4 trillion trees. Getting through Covid has made everyone more resilient. It's now time to *restore* back to how it was. Luckily, Humanity is informed and we have **BluePrints** so as with **SpaceTime**, we can go 'forward' back to where we need to be.

Good Governance plus a deepening role, influences and effects of **Citizens** needed along with **Societal Scrutiny** – making 'Best Judgements' on **Worthiness** of Enterprise's Activities, Actions and Non-Actions **Current Horizons** and the Better Utility and New Utility of **Future Horizons** as the **Paradigm Shifts**.

Hindsight now gives us the **Means** to not repeat the same Impacts & Effects going forward; **Progression**. The good thing about **Sustainability**, we all 'know' what we should be doing! Destruction of **Nature Stock**, Depletion of scare **Natural Resources**, Polluting & Emitting into our Air, Water and Scapes which **Social Organisational Nexus** and the **Natural World** need for Life can only continue to cause **Loss of Biodiversity & Habitats** – potentially all our coral seas. This makes little sense to an apex predator. Food, Health, Clean

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Water are **now** securities not guaranteed – in mega cities you cannot simply go foraging in the 'woods' for sustenance. **Human Nature** needs reforming. Manufacturing Producing Delivering at global scale matters – there are 'limits & limitations'. There are much better alternatives to coal sourced Power Supply – just because we have some 350+ years of associated Resource supply does not necessitate using it all today and for tomorrow's Generation.

The **Current Horizon** will be increasingly bumpy, up and down, winding, often meandering – with limitations, such as caused by Political Policies, 'event' consequences, frustrations of collaborative action, but increasing **Desire**. Foraging without a 'manual' means **Engineering the Future** will naturally rely on **Succession & Stewardship**. We all 'know' what we should be doing. **Nature Stock**, is an amazing 'store'; take an 'acorn' and you can produce an 'oak' that lasts hundreds of years – an enduring regenerative 'capital' & 'yield' stock. Even though many 'oaks' are now being lost through **Climate Change**, particularly in the UK.

One area of R&5Ds is obtaining Quality Data, ensuring **Accuracy** through 'tools-of-trade'. **New Data** and **New Learning**, infilling the gaps & more theory to guide improved practice and to advance practice. Historical performance Intrinsic Data is only as valuable as the accuracy of the measurement & subsequent analysis. Governance & Management matters. **Carbon Governance** is organisational and based on **Stock**, **Carbon Management** is activities-led and based on **Flows**.

The future will tell us which **Limits** need to be re-engineered, guided by the **Science of Sustainability – Technical Social Environmental**. The Science of Sustainability ('SoS') guides on Environmental Limits and the Tragedy of the Horizon. There is also **Tragedy of Ignore-ance** – by not 'minding the gaps' between disciplines and engineering deficiencies. Sustainability builds from the tapestry of current Economic Social Environmental **Dimensions** based on **OPTIONS**, ensuring Activities Actions Non-Actions today do not limit *options* open to Future Generations; hence increasing the importance of **Governess** of **Nature Stock**, by example. **LIMITS** which matter, are Natural Capital (Resource & Resources), Nature (Biodiversity, Habitats, Ecosystem services), Transition to New Capitals Stock, Valuing Everything, and Our Values – Behaviours. Note these today are all deemed 'limits' under the **Tragedy of Order**; as the future Dimensions will be less ordered in **SpaceTime** if we look back in **Time** -- the past being more ordered.

<u>**Working Landscapes**</u>
Opinions 'Collectively Owned' – 'Means' to Doing Better

1.   **Phase out Coal use in the Power Sector, 2030 in Developed Economies, 2035 in Developing Economies; Phase Down in Surviving Economies by 2045 through Mass Technology Markets by Solar means.**

2.   **Create Pristine International Waters (IW). Charge for access to IW - Invest funds in Global Sustainability Projects. 'Clean Technology' Shipping from 2030 in IW. Ban Fishing in IW from 2024 for 5 years to observe how much additional Carbon can be captured/removed through Deep Oceans Natural Regeneration. Fishing should only be allowed in National Waters - regulated by Nation States. IW fish being fished in National Waters – delaying fish caught spawned from IW. Based on emerging Scientific Evidence, respond accordingly.**

3.   **Charge for access to Space - Invest funds in Global Sustainability Losses & Damages from Climate Change.**

4.   **Reduce use of Liquefied Natural Gas (LNG). Build the necessary pipeline to connect up Stranded Natural Gas Resources by 2026 at the latest. Ensure all Natural Gas pipelines can be Re-Purposed to potential future Hydrogen Use.**

5.   **Build Natural Gas Power Plants with Carbon Capture in every country that uses Natural Gas; mandatory post 2030. Proficiency of Capture matched by Proficiency of regional Carbon Storage or**

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associated Export capacity.

6.   Domestic Natural Gas supply must have Clean Hydrogen spiked in, in increasing volumes from 2030. Up to 20% Hydrogen needs to be spiked by 2040.

7.   National Natural Gas Storage capacity must be large enough to secure minimal Natural Gas prices in warm weather months. This Capacity must bake in volumes used for Blue Hydrogen National volumes as well as for National demand from Energy & Domestic use.

8.   Ensure Crude Oil Markets and Electric Car Markets are efficient, not led by Geo-Politics post 2030.

9.   Educate that Methane is too valuable to waste, particularly associated with Land Fill waste sites; Wells & Mines. Monitor and publish quarterly Methane emissions, by day and month, in every Nation by 2025.

10.   Grey Hydrogen feedstocks to be replaced by Blue or Green Hydrogen by 2030. 20% reduction in Grey Hydrogen by 2025.

11.   Set up National Governance Office, responsible to the Cabinet. This Office will issues the Annual National Sustainability Reports, as demanded now for large Companies & Corporations. This Government Sustainability Report should have four sections: Citizenship (Values & Behaviours): Stewardship (Resources & Products); Custodianship (Sources & Boundaries); Guardianship (Wilderness & Nature Stock).

Sources of (1) National Waste - Pollution & Emissions; (2) top 100 sources by CO2eq; (3) Sewage in Discharge, Solid Plastics, Microplastics in Solution measured in all Estuaries, Coastal Waters, at National Boundaries particularly regions entering International Waters.

12.   International Waters ['Blue Planet'] Governance - Annual Ecosystem Financial Report (FR) & Sustainability Report (SR); once understood do similar having 'Space & Global Cover' Ecosystem FR & SR.

13.   Consumer Labelling - Customers & Consumers provided with economic social environmental 'Guide-Rails' at point of Purchase.

Crossing 'The Stream'

The four **Core Practices of Sustainability** being the **Means** to achieve **True Sustainability**, 'the well' that keeps on giving -- through Natural Succession & Technical Succession, Continual Innovation & 'spark' of Entrepreneurialism; Goddess Gaia & Goddess Nigella! combined, the discussion for the next Article.

"To have the dream – we have to cross the stream, we can take (or make) the future (Abba, 1979); and deliver through more engineering, guided by the science" (**Article 3**). 'Taking' is classical **Social Development** (& Economic Growth) where few benefit at the expense of the many, particularly living off the Natural Environment in the Wilderness, and those not desiring living off the Technical Environment in the Urban World which Humanity has built this side of 'The Stream', continuously impinging on Our Living Planet's **Commons & Global Cover**.

'Making' is clearly 'creating & developing', considering the **Technical Sustainability** perspective of **Wholeness**. **Succession** helps to guide the understanding which different 'elements or building blocks' (**Composites**) are to be conserved and which utility full **BluePrints**, where **Continual Innovation & Entrepreneurialism** are needed to 'bridge' across 'the stream'; 'engineering the future' (**Article 8**) guided by the 'Engineering Approach'[18].

Conversation is a critical part of **Wholeness** activities; embracing **Totality**, not Fragmentation. **Transformation through Conservation** takes a lot of dialogue & integrated models (**Paradigms**) and modelling

Continual innovation and entrepreneurialism... continued

(**Shifting Paradigms**). **Stewardship**, enabling **Ownership** and **Leader Leadership** to deliver Service & Stewards. 'Building' needs **Technical Mastery** (Proficiency), **Material** and having a group **Shared Vision** through **Partnerships**; all needing to have the 'collectively owned' **Means** to build 'The Bridge'.

This 'Bridge', our **Capacity** within the **Sustainability Context** is now 'The Practical Necessity' to link 'Manufacture Production Delivery' to 'Consumption' (**Custodianship**), through the **Custody Chain**, due to the 'Limits & Limitation' **Prosperity** is now 'happening' through global **Pollution Emissions Waste Depletion Loss**. **Sustainable Prosperity** is threatened, millions living on the **Tragedy of the Front-Line** already.

Business Sustainability, through Technical Political Financial **Ownership & Leader Leadership** is a critical 'Stakeholder in Society'. The **Natural World** (**Nature**) has been made the other critical 'Stakeholder in Society' through **Government** putting 'Profit before Planet', surreptitiously orchestrating global **Natural Depletion & Natural Loss** primarily through **Non-Action**, by not protecting **Wilderness** such as **International Waters** and now **Space**, above Global Cover. The **Natural World** lacks 'capacity' for Natural **Ownership & Leader Leadership** so relies on the same **Government** 'Governance Systems' to put now 'Planet before Profit'. **Guardianship** protects **Conservation**, natural & technical, ensuring 'maximum' **Regeneration**; 'the well' that keeps on giving.

Sustainability is a 'destination', it could just mean future **Enterprise** will be a liberating activity; **Global Sustainability** a universal liberating activity. We will not know until 'The Bridge' is engineered and built. Life is uncertain, but currently **Authoritarianism** forces are a poor substitute for **Liberalism** forces. Creating & Developing (**Technical Sustainability**), Protecting (**Political Sustainability**) and Investing (**Financial Sustainability**) in **'Markets & Inclusive Capitalism'** and **'The Commons & Global Cover'** could be humanities best Activities, Actions and Non-Actions yet!

There are **Limits of Certainty**, downsides happen more often than you would think. However, WE do know now the **Great Organisations of Sustainability** are on the other side of 'The Stream'; they certainly are not THIS SIDE. We have not found them after more than 350 industrious years, some might say since 'Our Creation' millions of years ago. Our **END** of the beginning has started, 'two minutes before midnight' (**Articles 3, 6**). WE must start 'building' with **MEANS** 'collectively owned' focusing **Material Performance** & **Proficiency Performance** through **Participation, Motives Motivation Engagement Progression**, five principals; **Reduction of Pollution Emissions Waste Depletion Loss**. Value, Impacts & Effects matter. Planet before Profit, but, with People; 'Living with Prosperity' 'creating and developing'.

Article 10, the last in the current series of Articles in the next SPE Review will cover Our Living Planet, Natural World and Our Urban World – The End of the Beginning.

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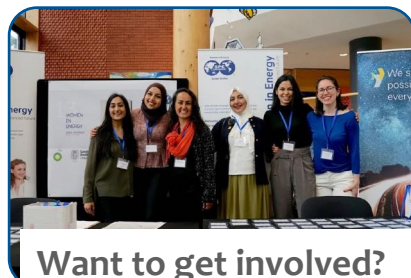# Fun, career-boosting and educational opportunities with the SPE London team

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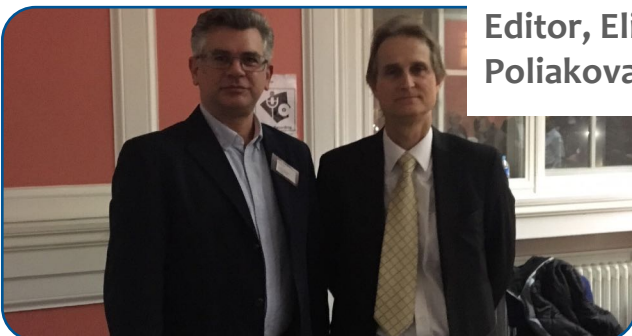How about sharing and contributing as an SPE London Board member?

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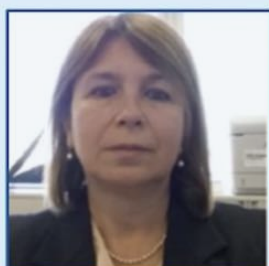
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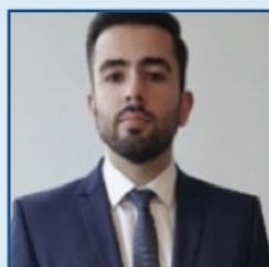Alain Gringarten

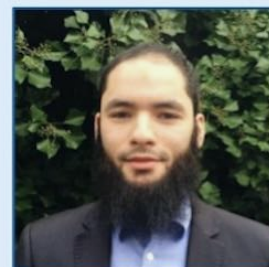Comunications Chair
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