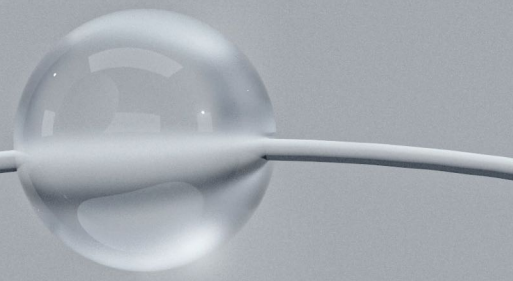
May-June 2022

SPE Review London

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

London Section

Are we over-selling hydrogen in the UK?



Also in this issue:

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Carbon Intensity: Russell Julier discusses three common expressions

Energy on Draft: what a success!

Our Living Planet, the Natural World and Our Urban World – The End of the Beginning

SPE SECTION EXCELLENCE *** AWARD *** 2020

50 YEARS

JOINT LETTER FROM THE CHAIRS

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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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SPE SECTION EXCELLENCE *** AWARD *** 2020

In this issue

FEATURES

Photo by MIlad Fakurian

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.

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A joint letter from the past Chair and the incoming SPE London Chair

Dear SPE London Members and colleagues,

It was an absolute pleasure to serve as a Chairperson over the last 12 months. It was an interesting and rewarding experience as we have manoeuvred as a section through the Covid restrictions and slowly started to mix online events with in-person networking. I am really proud of the work that the section has put in and the achievements we have had. I am sure that the Section will continue great work under the leadership of Elizaveta Poliakova, who has been supporting me as Chair Elect. I will let her take the stage and introduce the new direction for the SPE London Section.

It´s an honour to start serving SPE London Chapter as the new Chairperson. My name is Elizaveta, and I am a Reservoir Engineer with Trident Energy. I have been with SPE since 2015, when I started as a part of SPE Leeds Student Chapter Committee. I then moved to become President for SPE Imperial student chapter, as well as a part of SPE YP London Section. For the past 2.5 years, I was the Chief Editor of SPE London Review.

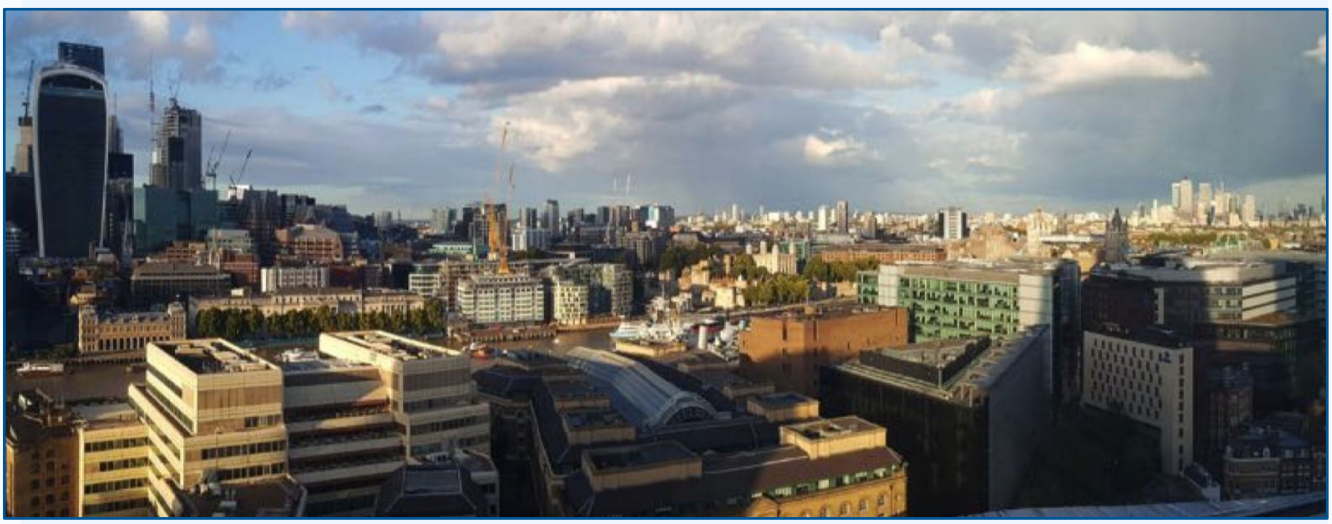
I would like to thank Adam for the outstanding work on Chairing SPE London last year. In 2021/2022 our calendar of events achieved a golden middle between face-to-face and online activities. For 2022/2023 we will continue to drive our Society forward. For me and our Board, the attention is set on increasing the value you receive by being a member of SPE London – and with this, feed our membership growth.

Another priority is set on supporting Student Chapters; especially the universities undergoing a transition in energy-related degrees. I look forward to strengthening communications and workshops with Oil & Gas students.

Lastly, this past year has seen great effort in creating networking opportunities with partner societies, such as AAPG and EAGE. I am aiming to ensure our members continue benefiting from live events and technical talks across energy-relates societies and SPE Chapters!

We hope you enjoy this read. Have a lovely August break!

Sincerely yours,
Adam and Elizaveta



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

'Re-fracs': A Cheap technique to boost U.S. shale oil output

With reluctance to invest in more output in the oil industry, experts have proposed that a re-frac can be 40% cheaper than a new well. The re-frac will serve as a booster shot for oil producers as a quick way to boost output for smaller investment than a new well.

Shale oil producers look to take advantage of $100 a barrel of crude without making big investments in new wells and fields. There is a broader application of this technique as technology improves and companies try to be prudent.

Read more

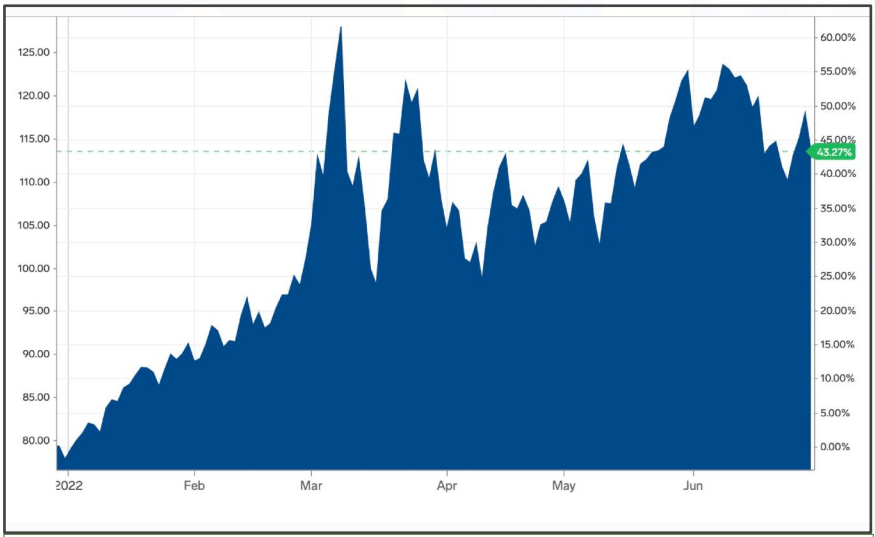
Planned European pipeline to CO_2 storage sites

Belgium's Fluxys and Norway's Equinor plan to transport CO_2 captured on the European continent for storage underneath the North Sea via a 1,000-km (620-mile) pipeline, according to a joint statement.

The infrastructure project could be operational by 2030 and would help reduce emissions of climate-warming gases in NW Europe.

Equinor is an oil&gas producer developing CCS deposits offshore Norway for commercial use, while Fluxys is a gas-pipeline operator.

Read more



Oil (Brent) 113.41 -4.7 (-3.98%) – 29/06/2022 (**Credit: Market Insider**)

Orcadian Energy submits low-emission pilot oilfield FDP

Orcadian Energy has submitted a draft of a low-emission pilot oilfield field development plan to the North Sea Transition Authority (NSTA).

The company's proposed low-emissions FDP for its pilot is based on an FPSO with 34 wells to be drilled by a jack-up rig through a pair of wellhead platforms to powered by a floating wind turbine. The proposed emissions per barrel produced are expected to be an eighth of the 2020 North Sea average and less than half of the lowest emitting oil facility currently operating in UKCS.

The oilfield is in North Sea licence P2244 Block 21/27a where Orcadian is the operator with 100 per cent interest.

Read more

Canadian assets sold for $1.5 billion

Imperial Oil and Exxon Mobil Corp are to sell their Canadian-based Montney and Duvernay assets to Whitecap Resources Inc for C$1.9 billion ($1.48 billion).

Read more

Understanding the complexities of the challenges

Alison Isherwood is an independent reservoir engineering consultant who has previously worked for Shell, Hess and Ophir and has worked in the USA, Asia and the UK. She has significant experience in field development, production optimisation, M&A and reserves auditing.

Alison is currently completing a post-grad course in Sustainable Business at Cambridge University. She also leads the London SPE Net Zero Committee, helping members understand their role in the energy system of the future, both in terms of achieving net-zero and integrating sustainable practices.

What attracted you to chemical engineering at university?

I really loved english and art as well as science and maths at school so I actually thought about going in many different directions. However, I always wanted to do something useful for society and I think problem solving as an engineer fitted my strengths as well as that desire. I remember deciding I wanted to try and help solve the world's energy crisis when I was in 6th form (we definitely thought we were running out of oil in the early 1990's!), and I suppose in a funny way I am still trying to do that. I also took part in the Engineering Education Scheme (EES) in 6th Form, run by the Engineering Development Trust, who are still running similar programmes today. As part of the EES I did an industry-based project and visited different university engineering departments. That really helped me make an informed decision about chemical engineering.

How do the challenges in the 'green' sector compare to the ones in oil and gas?

First of all, I want to say I have a vision of an integrated energy industry and I don't really like to make that 'green' distinction between types of energy, because I think it's so much more complex than that when you consider social as well as environmental impacts. In fact, building that 'energy literacy' across wider society is one of the challenges for all of us. Right now, we still need all forms of energy, and we need the talented people working across the whole energy industry to come together to help decarbonise that energy. In my current 'portfolio' career I am pleased to say that I still do plenty of oil and gas work alongside my other sustainability and geothermal projects. I don't think anyone should feel ashamed to say that. In fact, I believe working in oil and gas is where you can actually make the most difference (and let's face it, its wonderfully challenging and interesting, too).

The main challenges in renewable energy and CCS are financial. Renewables are inherently less energy dense than fossil fuels, so there is also this huge infrastructure and land-use challenge when you think about the sheer scale-up required. There is a lot of talk about wind and solar being cheaper than oil and gas now but we all know that they are intermittent and the energy-storage part is challenging. Plus, the potential returns on renewables are generally a lot lower than oil and gas, certainly in geothermal.

However, that lower, but more stable, return can be attractive and certainly more sustainable in the long term, it is just likely to attract a different type of investor to oil and gas. That's why, I think, that every oil and gas company is not diversifying as fast as some would like to see. CCS is clearly even more challenging as it is reliant on carbon pricing, as there is no actual product, but there are many dedicated people trying to make the business model work.

Of course, the human race created our market-driven economy so, ultimately, we can collectively decide to change it if there is the political will. I've concluded that the only way to change behaviour – either that of the business world or individuals – is through government policy that steers that directional change. You have to make it easier to change than stay the same.

The other challenge is that there are just not that many jobs out there now in things like geothermal and CCS, because of the financial challenges, and those renewables/sustainability jobs that are out there may well pay less than the oil and gas job.

Understanding the complexities of the challenges... continued

Why did you decide to u-turn your career and diverge towards energy transition?

As my last answer suggests, I don't see it as a u-turn, it's more of an evolution and a change in mindset in how I use my skillset.

I only started seriously reading up on sustainability in 2019. I chaired a session on sustainability at the 2019 SPE Upstream Finance and Investment conference. After that, I was hooked. I desperately wanted to better understand the complexity of the challenges we face as a society, not just in terms of providing energy, but all the interlinking social, economic and environmental issues. I hoped it would illuminate a path forward in terms of how I could contribute better. That drove me to enrol in the Cambridge Institute of Sustainable Development Post-Graduate Certificate in Sustainable Business.

The course is very broad in terms of subject matter, in both understanding the problems and devising solutions, and attracts students from all over the world and across all industries, including retail, tourism, construction, finance. That gave me the foundation of broader understanding that I needed.

The biggest take away from the course for me was the concept of 'Business with purpose', the idea that a business doesn't need to just be about profits. This is something that I had always felt at odds with throughout my career and which, if I am honest, had gradually been eroding my ambition to drive my career forward. As I said in my first answer, I have always wanted to do something useful for society, and the concept of business with purpose is what really drove me to change direction and strive for that purpose within the work I do.

What advice would you give to your younger self when you started as an Asset Reservoir Engineer with Shell in Aberdeen?

Earlier in my career, I was often told that I cared too much, tried too hard, wore my heart on my sleeve and needed more gravitas. I realise a lot of that advice came from a good place but I also think some of it had a gender aspect to it with people trying to fit me into a certain profile. I think the benefits of authentic leadership, emotional intelligence and diversity are now being better recognised. Overall, on that front, I would say "Continue being yourself Alison, but do try and keep things in perspective and don't sweat the stuff you can't control".

The other advice I would probably give my younger stuff is to be a bit more demanding, make sure you think about what you want out of your career. Demand support for your development in return for all your hard work – for example an opportunity for a special assignment or attending a conference. That was some advice I was given early in my career that I should have followed more, but I do think graduates today appreciate the need to drive their own career development better than I did.

How was your transition from chemical to reservoir engineering? How does it compare to your transition from oil and gas to the geothermal industries?

Moving from chemical engineering to reservoir engineering was actually harder than I thought it would be, because of the subsurface uncertainty. Working in a world 1000s of feet below ground that you can't see is quite a mindset change from designing chemical reactors and distillation columns!

It took me at least six months to get any kind of concept of geological variability and the impact on fluid flow through it. After I did a beginners course in geophysics and understood the inherent uncertainty within seismic I found it even harder to get my head around things! At the same time, it is fascinating, I love the way every reservoir is unique and I strongly encourage all reservoir engineering to make the team's geologist their best friend if they want to become a better reservoir engineer.

Oil and gas to geothermal is a much simpler jump, especially if you have originally come from chemical engineering so have plenty of heat flow analysis under your belt. Heat flow analysis is very similar to fluid flow, for example in a conduction-only system you are looking at temperature drawdowns in the same way you look at pressure drawdowns in an oil and gas reservoir, that temperature delta is what drives your flow of heat.

Understanding the complexities of the challenges... continued

I now also do greenhouse gas accounting work as part of my consulting role. I was surprised at how much cross-over there is, as all my reserves auditing experience has come in handy, my greenhouse gas training made a particular point about the need to maintain 'professional scepticism', which describes the role of a reserves auditor perfectly! Plus many of the same uncertainties exist in estimating emissions as they do for production forecasting, and a technical engineering background is really beneficial.

What guidance do you give young graduates through your mentoring and volunteer work?

Some of the same advice I have already mentioned, around maintaining perspective, especially around things you can't control, while at the same time driving your own career development in terms of pushing for those important opportunities.

Another one is always asking for help, don't waste time struggling on your own. In almost any technical role it is about teamwork, everyone has different strengths and experience and to do your best work you need to draw on all that other knowledge. As part of that I always advise them not to be afraid to admit when you find you have made an error, we have all done it, it's no big deal and you build important trust with your team when you communicate that.

One other point I make is around prioritising what needs to be done, making sure you tackle the most important stuff that has the biggest impact first. I found I only really developed my prioritising skills after I had to juggle a young family with my career, but I try and encourage my mentees to work on that a bit earlier in their career to minimise stress and keep a healthier work life balance.

EVENT: Energy on Draft

Energy on Draft: what a success!

'Energy on Draft'

At the end of April, the first Energy on Draft event took place at the Horniman at Hayes near London Bridge. The first event of its kind, Energy on Draft was a joint social networking event organised by SPE London with the YP London chapters of the PESGB and AAPG.

The event was a great success, allowing Energy and Geoscience professionals to gather in person. Members young and old reunited and many new connections were forged.

We look forward to seeing you at our next 'Energy on Draft' event coming in July.

Are we over-selling hydrogen in the UK?

Tom Baxter is a chemical engineer with 40 years working in the oil and gas industry. Tom graduated from Strathclyde University in 1975 with a B.Sc. in chemical engineering (first-class honours) and is a Fellow of the IChemE. He has worked with ICI Petrochemicals, Ciba-Geigy, British National Oil Corporation (BNOC), Altra Consultants, and Genesis. Since 2003, Tom has been visiting Professor of Chemical Engineering at Strathclyde University. He is currently a chemical engineering consultant providing energy and greenhouse-gas-reduction expertise. Area of hydrogen expertise: Hydrogen production, domestic heating, blending hydrogen with natural gas.

Introduction

My thinking is largely based on the European Union's 'Powering a climate-neutral economy: An EU Strategy for Energy System Integration'.

The key tenets are:
1: A more 'circular' energy system, with energy efficiency at its core.
2: A greater direct electrification of end-use sectors (heat pumps for space heating or low-temperature industrial processes, electric vehicles for transport, or electric furnaces in certain industries).
3: Use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible.

As mandated by the UK Government, a 40% GHG emissions reduction is needed by 2030. So, we clearly need material action this decade. The media is awash with the benefits of hydrogen and a large number of organisations are touting hydrogen as key to delivering net zero. While I believe hydrogen has an important role within delivering net zero, hydrogen should be used wisely.

This article will question whether the use of hydrogen in many proposed sectors is a wise choice.

The case for hydrogen

Hydrogen has, on the face of it, much appeal. Reported benefits are:
– It combusts to water (and NOx).
– It is the most common element in the universe.
– Hydrogen can be delivered via the existing natural gas infrastructure
– It can be stored for use when renewable wind and solar is limited, thus acting as a buffer for daily and seasonal weather power demand variations.

It also ticks the ESG box for investors. There seems little not to like about hydrogen, but when the claims are researched and compared with other heat and power vectors they begin to seriously unravel.

Hydrogen Production

First, let's understand how hydrogen is produced.

It is important to recognise that hydrogen, unlike natural gas, does not exist in nature – it has to be manufactured. Today, grey/brown/black hydrogen is made primarily from fossil fuel reforming. The reforming process requires a significant amount of heat and power to convert fossil fuel into hydrogen and CO_2. Approximately 9-11 tonnes of CO_2 is vented per tonne of synthesized hydrogen.

Clearly, current reforming practices are unacceptable in a net zero future. To abate CO_2 production, a carbon capture and storage system (CCS) is required and this makes the so-called blue, low-carbon hydrogen.

Are we over-selling hydrogen in the UK?... continued

A much-touted alternative to reforming is electrolysis – here water is cleaved into its constituent parts, hydrogen and oxygen. The cleaving process needs electrical power and if the electrical energy comes from renewables then electrolysis delivers green, carbon-free hydrogen.

All future hydrogen-based energy plans I have reviewed involve the application of electrolysis. However, electrolysis costs much more than reforming, so fossil hydrogen with CCS will be the main route for hydrogen until electrolysis becomes cost competitive. That could be a decade or more according to the EU.

Hence, at scale hydrogen provision will initially be blue. To manufacture blue hydrogen requires around 30% more fossil gas to produce a kWh of heat. That means the use of more fossil gas.

When the UK is seeking energy security, blue hydrogen is an unwise option in my opinion. That 30% more fossil gas means the gas suppliers are working harder with increased methane, CO_2, NOx, SOx and particulate emissions across the supply chain. GHG potent methane being a particular concern.

It is abundantly clear that hydrogen will cost the user more per kWh than the natural it is derived from. From a domestic viewpoint, that means energy prices will rise if blue hydrogen is used for domestic heat. When there are a large number of households in fuel poverty, blue hydrogen will result in more families being in fuel poverty.

I can't see the justification for blue hydrogen for domestic heat. It is also of note that the German Government has disavowed blue hydrogen.

Current Hydrogen Production GHG Footprint

Hydrogen is a key chemical precursor for non-fuel industrial applications – ammonia, methanol, oil conditioning.

As previously stated, current hydrogen production is GHG emitting – it is a higher emitter than international aviation or international shipping.

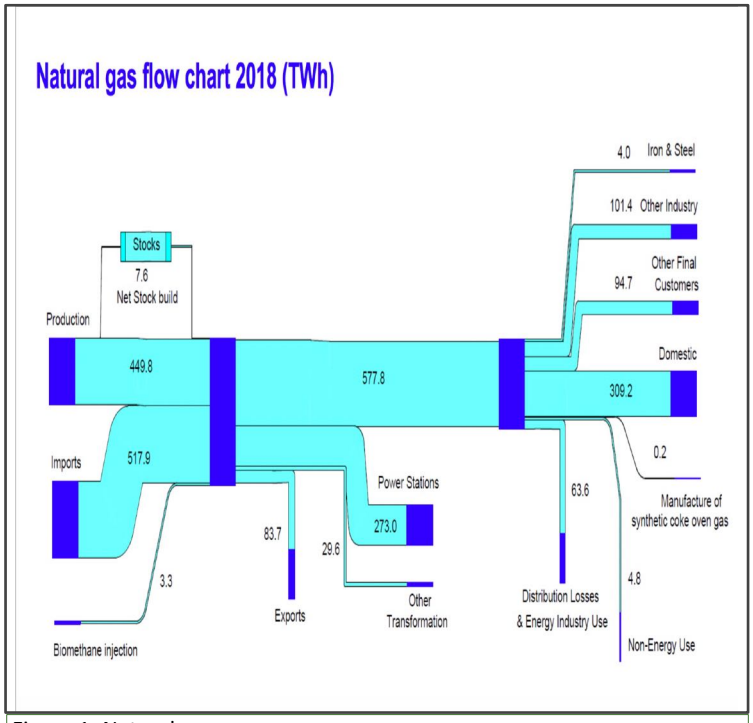


Figure 1: Natural gas users

To my way of thinking, before we look to use hydrogen for fuel or mechanical work, current grey/black/brown has to be tackled as a matter of priority.

Tackling current hydrogen production first is a feature overlooked by many strategies.

Hydrogen for Heat

The UK Government's DUKES (Digest of UK Energy Statistics) database shows the UK's natural gas users – these would be the candidates for a natural gas to hydrogen change out.

In *Figure 1 (left)*, the left-hand side of the chart shows the natural gas sources – production from the UK's gas fields and gas imports. The right-hand side shows the gas users.

Are we over-selling hydrogen in the UK?... continued

It can be seen that the four largest gas users are first the Domestic Household, then Power Generation, followed by Other Industry and then Other Customers. A little bit of number crunching shows that the domestic household uses 40% of the consumed natural gas. Not only that, a large portion of the natural gas used for electrical power generation is used by household electrical demand, hence households are the UK's largest consumer of heat and power. Therefore, if we approach the domestic household from an energy efficiency standpoint, making households carbon neutral should be a key aim.

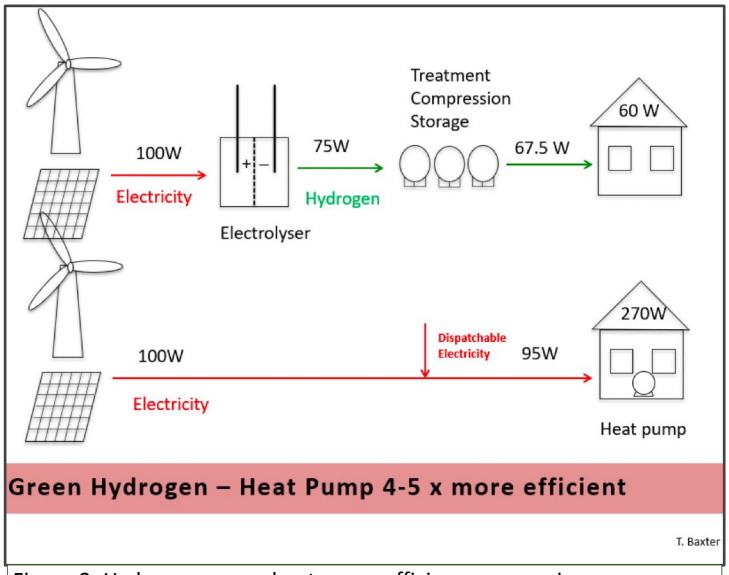


Figure 2: Hydrogen versus heat pump efficiency comparison.

With the mantra 'energy first', building insulation should be a key priority for government – it is net-zero pathway independent. It is technology ready and can be deployed now.

With respect to heat, households are where electrification trumps hydrogen. A heat pump requires around 20% of the energy of hydrogen for heat. See *figure 2* (*left*).

But, how can families in fuel poverty afford £10,000 – 15,000 for a heat pump?

This is where we look to government to introduce progressive taxation, grants and change the tariff to provision of heat. Here the householder pays for the capital and operating cost of the heat pump in the tariff.

Hydrogen Domestic Safety

There is also the issue of hydrogen safety in a domestic setting. It is interesting to see how the Control of Major Accident Hazards view hydrogen. Here are the storage quantities that are thresholds for permitting: Hydrogen – 5 tonnes; Natural gas – 50 tonnes; Acetylene – 5 tonnes; Methanol – 500 tonnes

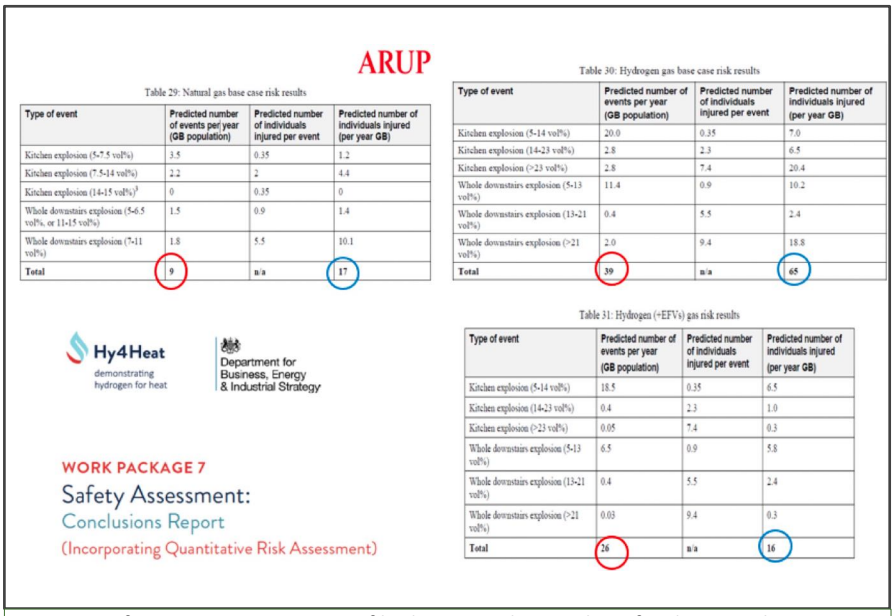


Figure 3: Safety metric comparison of hydrogen and natural gas for domestic heat.

As can be seen, because of its explosive and flammability properties, hydrogen is much less safe than natural gas. It is also much more prone to leak.

Domestic hydrogen safety has been studied in the UK Government's Hy4Heat programme. The aim of the hydrogen safety work package was to demonstrate hydrogen to be as safe as natural gas. The results of the Hy4Heat Quantified Risk Assessment are shown in *figure 3* (*left*).

Are we over-selling hydrogen in the UK?... continued

Tables 29 and 30 compare the results of hydrogen with natural gas . The results show that the risk (probability x consequence) of an injury is four times higher with hydrogen.

Clearly, that does not meet the Government aim of equivalent risk.

To bring the hydrogen risk to the same level as natural gas, two, in-series, excess-flow valves (EFVs) are installed. If a hydrogen leak occurs in a household, the EFVs are there to reduce the size of the leak so the consequence of a fire and/or explosion will be reduced.

Table 31 shows the results with two EFVs. Because of the reduced consequence the overall risk is now the same, but the frequency of fires/explosions remains three times that of natural gas. That does not seem like an acceptable risk basis from my viewpoint. It is a bit like buying a car where the salesman tells you it will crash more often, but the safety features mean you will be just as safe.

Power Generation

The next largest UK gas consumer is electricity generation. Reducing gas consumption and GHG footprint here is clearly a role for energy efficiency and renewables – consume less power and generate electricity from carbon free sources and renewables – wind, solar, hydro, bio-fuels, nuclear, tidal and geothermal. There is also the option of importing low carbon electricity using interconnectors.

Dispatchable Energy

An argument used by hydrogen proponents is that hydrogen is the only energy vector that can be stored in sufficient quantities to cover for renewable intermittency. What do we do when the wind doesn't shine or the wind doesn't blow?

Hydrogen proponents like the UK Hydrogen and Fuel Cell Association say we can use surplus renewables, particularly wind in the UK, to make hydrogen and store it for times when renewable supply is weather curtailed. There are, though, other means for storing energy – batteries, thermal, bio-fuels, hydrogen derivatives, pumped hydro, compressed gas, graviticity.

The Integrated Energy Model

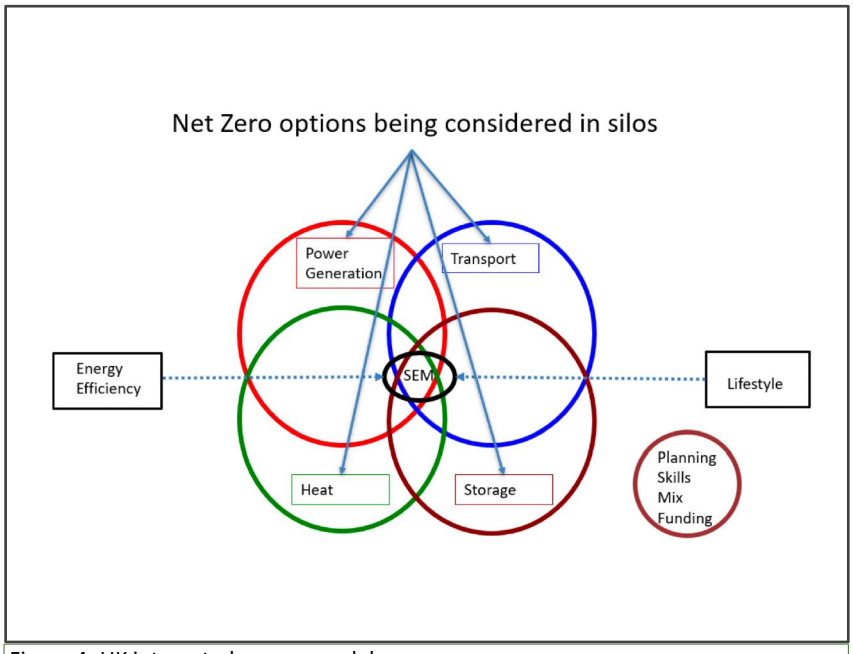


Figure 4: UK integrated energy model.

To understand and optimise potential net zero pathways it is misleading to look at a sector on its own. For example, if we insulate and electrify households the efficiency gains offered means that we need to store less energy. It also means that the energy suppliers are providing less energy.

Sector-based analysis without a holistic based overview of the sector impacts on other sectors will therefore lead to flawed conclusions. The UK needs a statistically and risked based integrated energy model as illustrated in *figure 4* (left).

Are we over-selling hydrogen in the UK?... continued

This model (digital twin) would allow net-zero pathways to be holistically tested and compared to facilitate the identification of an optimal pathway.

To my knowledge, such a model does not exist and policy and strategy seem to be based upon assertion rather than quantified evidence.

Other Industry

The next largest natural gas user is Other Industry. Main consumers in this sector are the refining and chemical industry, food and drinks, mechanical engineering (car manufacture etc.) and mineral products.

To reduce gas usage in industry, energy efficiency, electric heating and heat recovery are key. This will reduce the need for gas, but there are some industrial processes that will be difficult to electrify. Here hydrogen will have a role in hard to abate sectors such as steel production.

Other Final Customers

Other Final Customers involve mainly heat for public administration buildings and commercial office blocks. The discussion around net-zero for households applies here, too.

The upshot of the aforementioned options for decarbonising industry and domestic users means the case for hydrogen looks very weak in my opinion.

By embracing the EU strategy of energy efficiency and electrification, I can't see a compelling case for hydrogen replacing natural gas for heat and power in many sectors. Energy efficiency and electrification are superior long-term, cost effective options for delivering net zero.

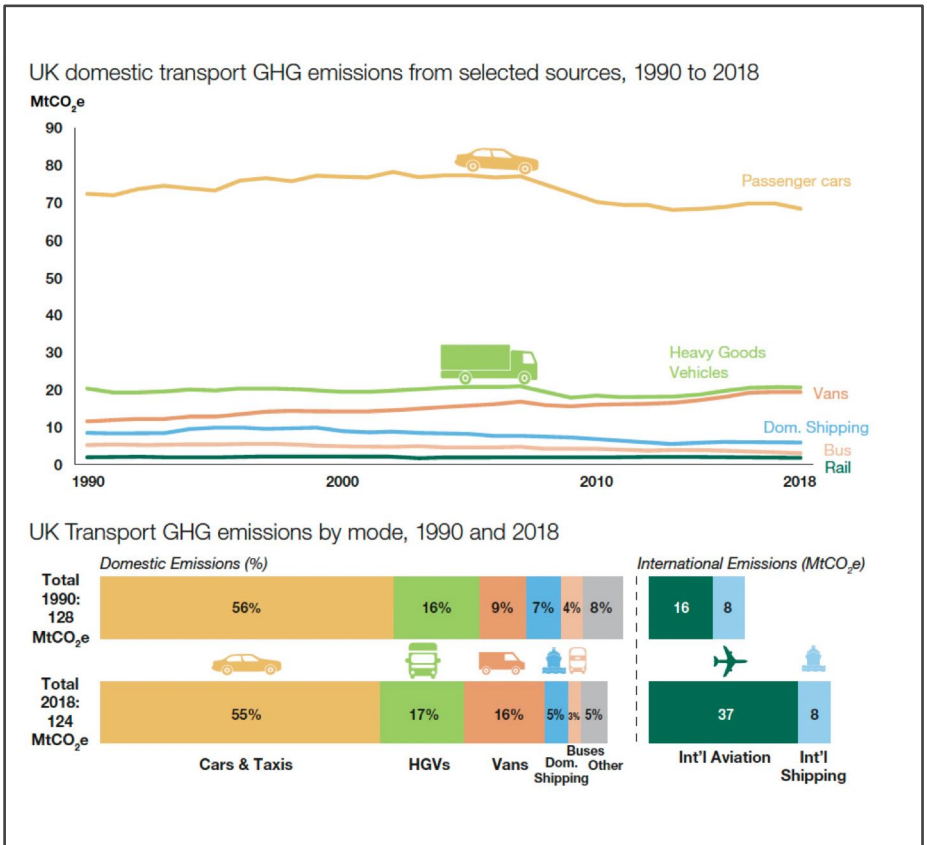


Figure 5: Transport emissions.

Electrification allied with energy efficiency measures, such as household insulation, are ready now and needed to deliver the UK's 40% GHG reduction targets. If the UK has any chance of achieving its 2030 GHG reduction targets, hydrogen is not the solution as it is expensive, inefficient and can not be rolled at scale in the mid term.

Surface Transport

Turning attention to UK transport, it is the largest single sector of GHG emissions. The UK Department of Transport report 'Decarbonising Transport – setting the challenge' provides the following *figure 5* (*left*).

Are we over-selling hydrogen in the UK?... continued

The importance of decarbonising the passenger car is obvious. The battery electric vehicle (BEV) is the EU's preferred option and most transport energy commentators are in agreement. There is little place for the inefficient hydrogen fuel cell electric vehicle.

Hydrogen is touted as an option for long distance heavy haulage and shipping where battery size is said to be limiting. Battery densities continue to improve and the justification for hydrogen for heavy haulage is weakening. Indeed Scania, Europe's largest truck manufacturer, has scaled back its hydrogen truck in favour of electrification.

The upshot is: hydrogen can offer solutions for the hard-to-abate parts of industry and the transport system. For the largest part of the power-use side, electrification and energy efficiency look far more attractive.

Hydrogen is good for big business

My findings are out of step with the Hydrogen Economy being touted by many as key to net zero in the UK. Why might that be?

Perhaps the answer lies in the interests of big business. The UK All Parties Parliamentary Group (APPG) of MP's and business organisations recently produced 'How the UK's hydrogen sector can help support the UK's economic recovery'.

Considering the report's sponsors it is not surprising that hydrogen is viewed very favourably.

The sponsors are businesses that have a vested interest in promoting hydrogen. Domestic gas boiler providers, gas network operators and fossil fuel producers who know that for the foreseeable future, hydrogen will be fossil derived.

I frequently return to the point – is the vested interest of business best for UK consumers?

Conclusions

My research on the energy landscape and hydrogen's role has taken me to the following conclusions:

1: Analysing energy options in silos leads to unbalanced, non-optimal conclusions.

2: What is good for hydrogen big business is not good for the consumer.

3: Blue hydrogen has little part to play in a net-zero future.

4: The UK's immediate focus should be on the high GHG sectors – passenger car/vans, domestic heating and insulation, grid upgrades, demand management/smart grid, renewable power generation.

5: Now is not hydrogen.

6: The case for hydrogen is evidence weak in many applications.

Carbon intensity

Carbon intensity is key performance indicator that is frequently used to compare the amount of CO2 emitted due to a given activity and provides a basis for comparison between alternatives. It is typically expressed with respect to grams of CO2 emitted per kWh of electricity produced or consumed, per unit of heat (MJ) created, per km travelled, or economic value ($GDP) realised. Three common expressions of carbon intensity are discussed.

This article is authored by **Russell Julier**.

Carbon Intensity of Oil and Gas Production

Carbon Intensity associated with the upstream production of oil and gas is defined as the amount of carbon dioxide (grams of CO_2) emitted with respect to the energy of the hydrocarbons produced (MJ). It thus refers only to those emission arising from upstream production operations only (Scope 1 and 2 emissions) and does not include those emissions that arise from the combustion of the products themselves (Scope 3 emissions) (Ranganathan et al., 2004).

(Masnadi et al., 2018) provides a useful comparative study of the carbon intensities of upstream oil production across the world (*Figure 1, below*). The analysis shows the large differences between high carbon

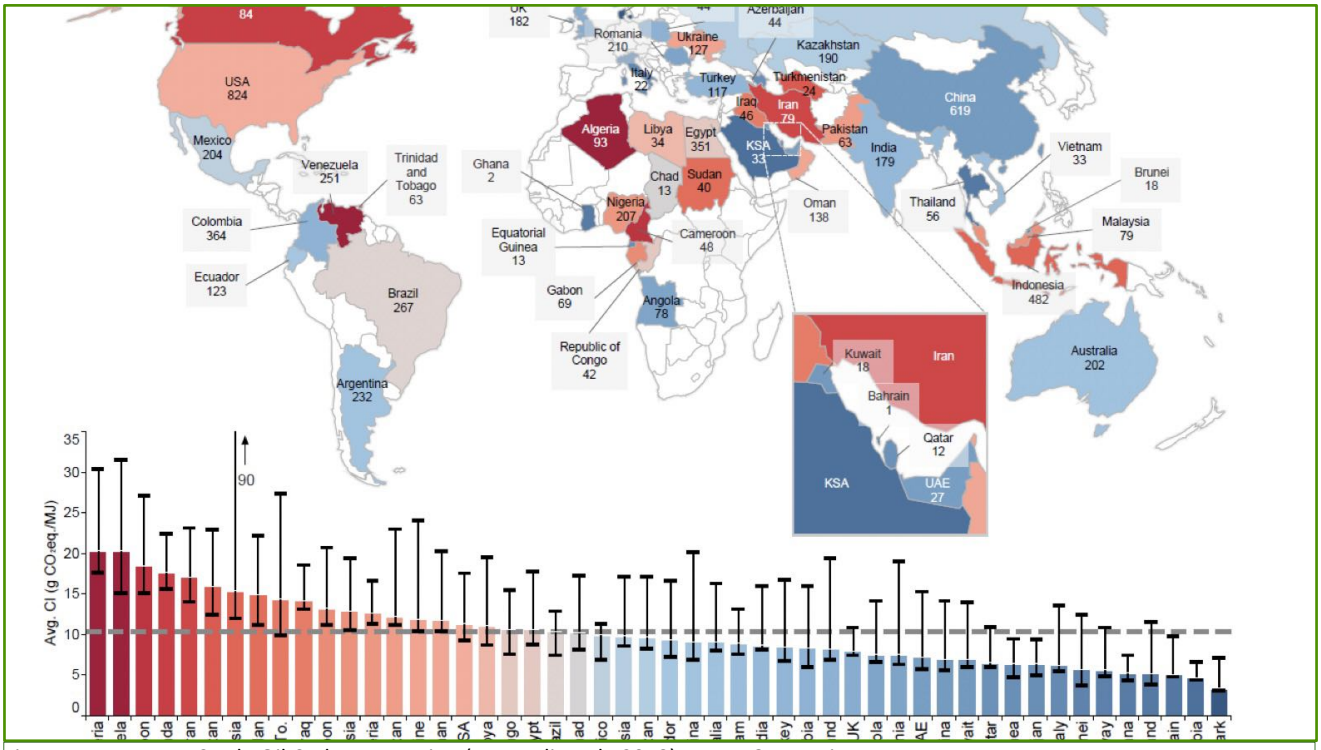


Figure 1: Upstream Crude Oil Carbon Intensity. (Masnadi et al., 2018) Power Generation

intensity crudes, typified by increased complexity, heavy oil production, use of extensive flaring and venting and those with the lower carbon intensities with lighter crude types and tighter environmental regulations. The authors highlight the significant carbon dioxide emission savings possible from technology innovation such as remote sensing, use of low carbon energy sources such as solar-powered steam generators as well as initiatives such as the World Bank's Global Gas Flaring Reduction Partnership.

Such activities will be essential to minimise future emissions and for the industry to retain its social licence to operate during the energy transition.

Carbon Intensity for power generation is commonly defined as the amount of carbon dioxide (grams of CO_2) emitted with respect to the energy created (expressed in Kilowatt-hours) and is used to compare the CO_2 emissions from alternative power generation sources.

Carbon Intensity... continued

The calculation can be completed either on a life cycle basis, which considers of the operational and embodied carbon dioxide emitted from a power source arising from its construction, operation and decommission or by considering the CO_2 arising from operational activities only.

The life cycle basis is more difficult to calculate but is useful for comparing the CO_2 emissions arising from fossil fuel and renewable sources and aids future investment decision making while the operational carbon dioxide intensity is more appropriate for day-to-day optimisation and forecasting.

(Edenhofer et al., 2012) presents a useful plot (*Figure 2, below*) of the life cycle of carbon intensity in g CO_2 per kWh from a range of different electrical generation technologies.

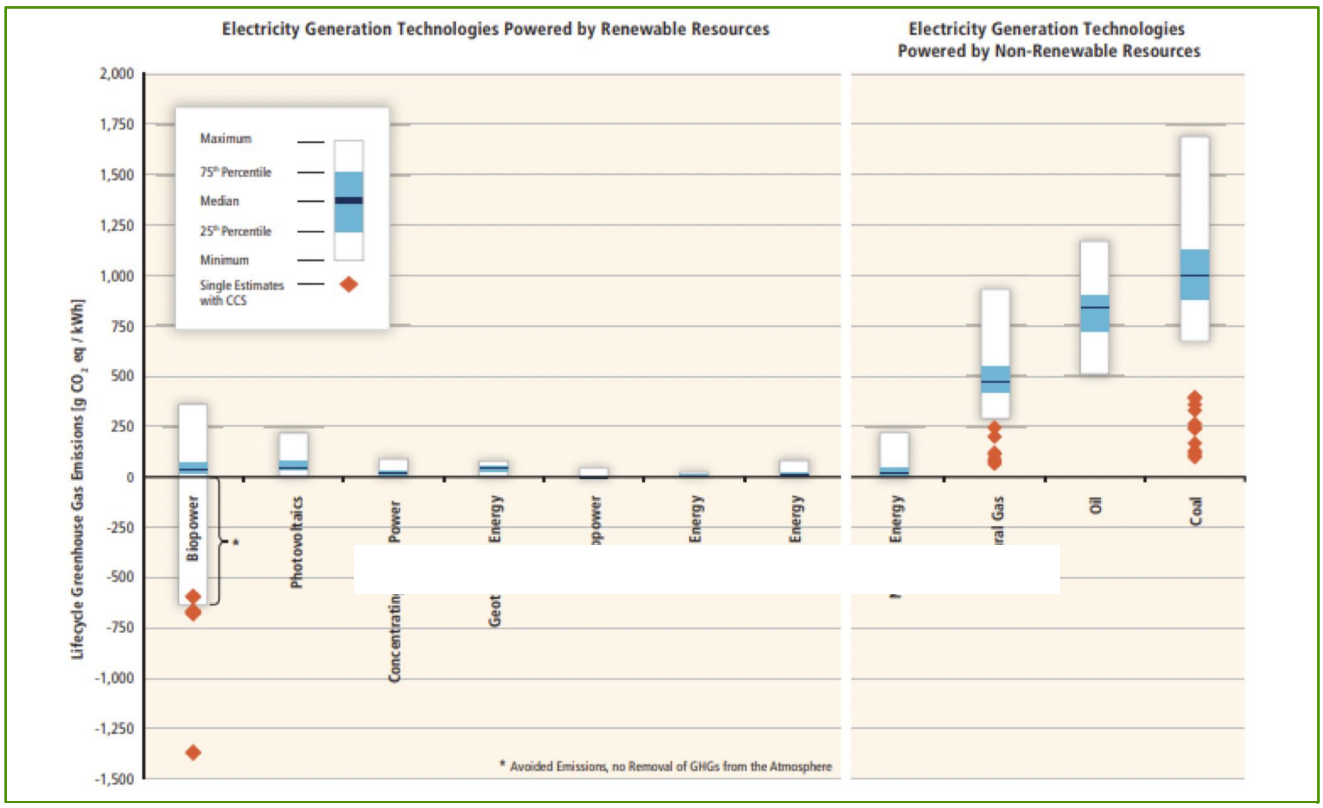


Figure 2: Estimates of lifecycle g CO2 eq./ kWh (Edenhofer et al., 2012)

Renewable sources of electricity generation have small but nonzero carbon intensities arising from the emission associated with their construction. Fossil fuel-based electricity generation sources have orders of magnitude higher carbon intensities that can be offset using Carbon Capture Usage and Storage technologies.

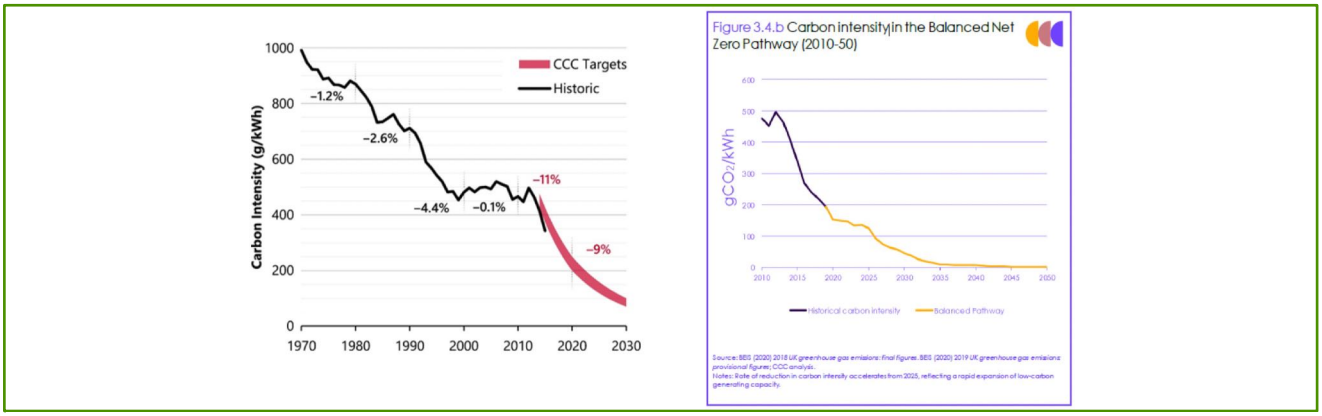


Figure 3: Historic and Forecast Carbon Intensity (Balanced Net Zero Pathway – 6th Carbon Budget Report) (Staffell, 2017),(Committee on Climate Change, 2020)

Carbon Intensity... continued

generation arising from the withdrawal of coal-fired power stations and increase in the use of renewables in the UK's electrical system. Figure 3 presents the historic and forecast fall in carbon intensity for power generation.

The significant reduction in Carbon Intensity observed from 1970 to 1980s was a result in the rise in the proportion of nuclear and in the 1990's by the 'dash for gas'. The recent reductions are due to the rise in renewables.

The 6th Carbon Budget Report shows how this decarbonisation journey is forecast to continue in the 2020s and 2030s with the continued rollout of low-cost renewables and the development of Carbon Capture and Storage, as well as increased demand-side flexibility that will allow near zero CO_2 intensity to be achieved by 2035.

Economic Efficiency

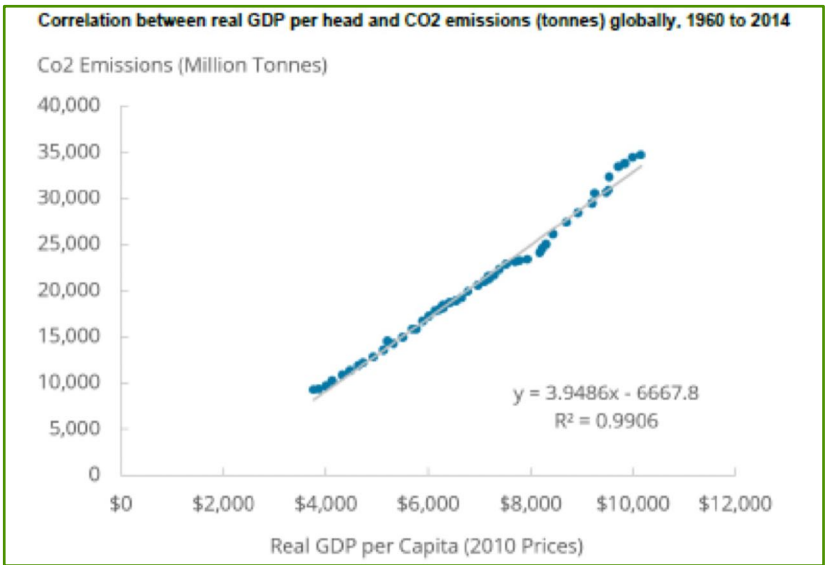


Figure 4: World GDP per head and CO2 Emissions (Office of National Statistics, 2019)

Carbon Intensity is also used as a measure of the carbon efficiency of an economy when expressed as grams per CO2 per $ GDP. The relationship between economic growth and rising energy use has long been established and remains a strong effect (Figure 4).

The decoupling of carbon emissions from economic growth is therefore an essential requirement to achieve net zero if we are to maintain economic growth along with declining CO2 emissions and some economies across the world have been showing declining carbon intensity with respect to GDP.

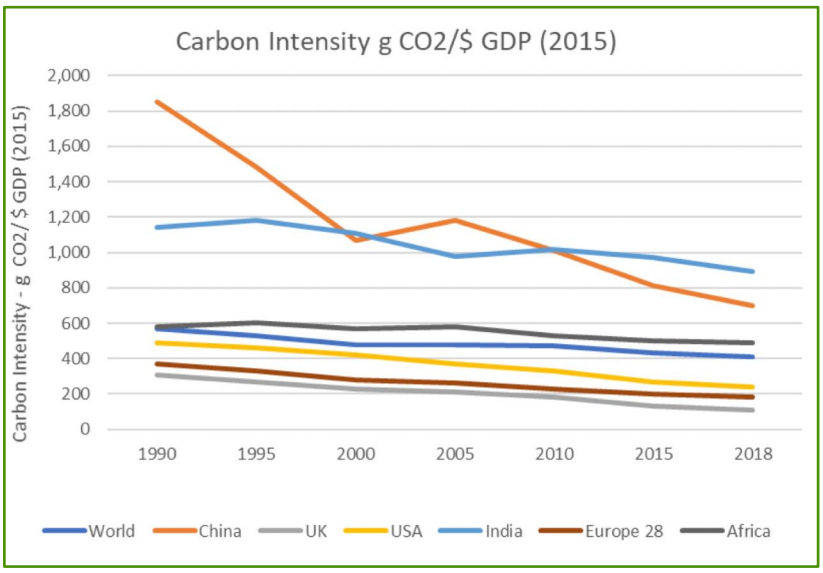


Figure 5: Selected Country Carbon Intensities, g CO2/ $GDP (2015) (International Energy Agency, 2021))

Significant reductions in carbon intensity have been observed from China but these are still high when compared to Europe and the USA.

Within the UK, the decline in CO_2 emissions has been driven predominately by the improvement in carbon intensity from power generation but also through improvements in energy efficiency achieved in transport and manufacturing. There have also been more structural changes that have seen a relative decline in the UK's manufacturing sector and a rise in the less carbon intensive service sectors

However, this is only part of the story, the UK's 2008 Climate Change Act only requires that the UK's territorial

Carbon Intensity... continued

CO2 emissions be reduced, and this does not include those emissions that arise from outsourced manufacturing activities that provide goods and services that are consumed in the UK.

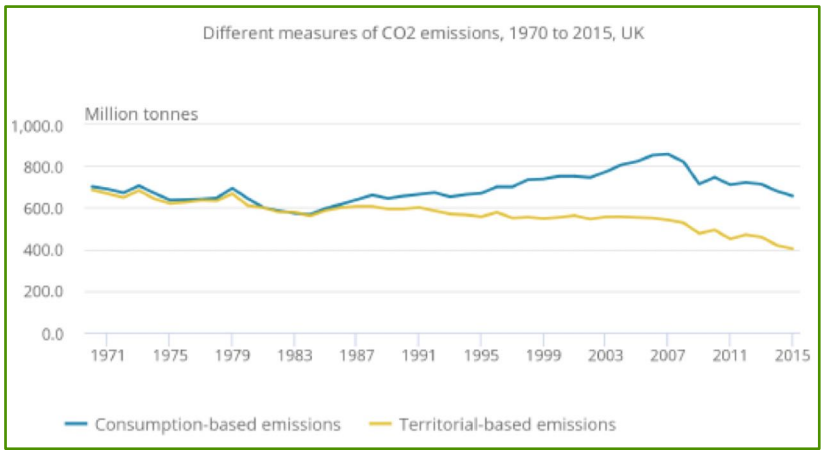


Figure 6:UK's Territorial and Consumption based emissions history (Syed, 2019).

Once these consumption emissions are included, the total UK CO2 emissions showed an increasing trend from the 1980's and have declined only from 2007 (*Figure 6, below*). Consideration of these consumption emissions is one of the key messages of the 6th Carbon Budget which recommended that the UK should also "involve actions to track and reduce its overseas footprint" (Committee on Climate Change, 2020).

Clearly, there is still much to be done to tackle high carbon intensities, by industry and society, both in the UK and Abroad.

For the oil and gas industry, activities to reduce scope 1 and 2 emissions are an essential first step to enable retention of its licence to operate, for society, recognition that emissions occur not only territorially from energy generation sources but are also a consequence of our consumption patterns and reducing these emissions may be the hardest of all.

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Our Living Planet, the Natural World & Our Urban World – The End of the Beginning

Welcome to the London Sections' Net Zero Committee section of the SPE Review where we present and discuss a range of topics associated with Energy Transition and Net Zero. We hope these will be informative and help readers understand some of the significant changes in the oil and gas industry.
This is the tenth and last in a series of articles for the SPE Review covering Sustainability brought to you by **Adrian Gregory** who is a subsurface and wells engineering consultant.

This article covers Our Living Planet, the Natural World & Our Urban World – 'the end of the beginning'. Sustainability has dimensions & perspectives, interconnectedness of composites, compounds and elements which have enduring complexity, requiring Integrated Thinking & Systemic Thinking. Resources, Ecosystems and Value matter for Business Sustainability. Continual Innovation & Entrepreneurialism builds the Capacity to Manufacture Produce Deliver the future which now is linked to sustainable Consumption, Recycle & Storage; the Custody Chain of the Sustainability Economy. Sustained Capacity having the Power, Means (Material & Proficiency) and Resource to 'Perform & Withstand' the pathways to the Future Horizon. 'Awareness' 'Relevance Reliance Resilience' 'Dishing' 'Ecowashing Swashing Greenwashing' and 'FootSteps FootPrints FootFalls' will be covered under the specific Article theme "Planet before Profit, Valuing Everything".

For readers who want a 22-seconds outtake:
Engineering Sustainability will deliver Sustained Value, Sustained Capacity and Sustained Conservation. Sustainability Progression requires the composites of 'Relevance Reliance Resilience'. Our Living Planet, the Natural World & Our Urban World, is at 'the end of the beginning' needing now Technical Succession & Natural Succession to deliver the means to move to the Future Horizon. 'Dishing' & 'Washing' are consequences of the lack of full Awareness & Desire needed to achieve 'transitional' transformation Re-Balancing, Re-Architecting & Re-Framing of Sectors; some Species burning like 'Stars', initially. Cost of Capital is a good 'guiderail' for future Material & Proficiency 'contribution' towards sustainable Consumption, Recycle & Storage; delivering Enterprise Value & Sustainability Value. The Custody Chain is now mainstream associated with 'Source to Resource to Product to Consumption, Recycle & Storage'; Sustainability Economy from Source-to-Storage. Sustainable Institutions have Enterprise Value & Sustainability Value. Sustainability is the 'capacity to endure' over spacetime through economic, social and environmental means and resource ensuring that our activities and actions today, do not limit the range of economic, social and environmental options open to future generations. To achieve Sustained Capacity requires Building Capacity, taking "Two FootSteps – one for Mankind; one for Wildkind"; Parity. The TBL framework, proposed in 1997, has moved from 'Bottom-Line Outcomes' to addressing 'How to Do Right, Do Good, Do Well?' through service & stewards; 'Economic Social Environmental' Stewardship must deliver the desire for "Sustainability over Profitability". Our Living Planet now needs 'Planet before Profit, Valuing Everything' as WE are at the 'end of the beginning'. Human Nature needs reforming; Human Endeavour 'creating & developing' needs Human Behaviour to have an attitude perspective change, to change in attitude through adaptation, even exaptation; Adaptability. Measuring our FootFalls as we cross boundaries into the Wildernesses now matters as human-induced Climate Change solved by Technical Means & Resource are not enough to Regenerate Ecosystems; WE also need Natural Means & Nature Stock with the Natural Sustained Capacity of Regeneration -- 'the well' that keeps on giving… to get to the Future Horizon; True Sustainability. Natural Living Resource Conservation – the new perspective of Natural Sustainability, adding potentially a new 'Natural Economy', matters as much to Our Living Planet as Technical Reduction of 'Pollution Emissions Waste Depletion Loss' if WE are to move to the Future Horizon – creating the Great Organisations of Sustainability."

Our living planet... continued

The previous nine Articles have introduced Integrated Thinking & Systemic Thinking ('Thinking') ending with the Desire that Humanity must put 'Planet before Profit'; with People living with Prosperity, 'creating and developing'. Creation & Exploitation being tradition business 'Yin & Yang', which through the addition of Stewardship can now deliver Business Sustainability. Sustainability requires a competent level of Awareness; dependent on Dimensions & Perspectives Context & Wholeness Understanding. The final focus of this last Article is that this means Humanity, to endure, WE must Value everything we have – Our Living Planet's Capacity & Resource; Totality. 'WE' being 'collectively' and to the Mutual Benefit of all 'Humankind' & 'Wildkind'; all Living Resource -- Our Urban World & Natural World; Our Living Planet.

Many think Nature, particularly Nature Stock, is just a free Public Good, or free 'flowing' service for Exploitation. However, Sustainability Progression has been made by 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 the Environment; particularly Nature Stock 'depletion & loss'. Enterprise Sustainability Business Excellence is finally being nurtured. Global Sustainability, through proficient Stewardship, 'test' is to advance and deliver more Sustained Value, Sustained Capacity & Sustained Conservation. Enterprise 'marked' by achieving Economic Social Environmental (Triple) Bottom Line 'Outcomes Outputs Outtakes', built from Doing Right, Doing Good, Doing Well (Article 7). Globally 'marked' by the presence of Inclusive Capitalism and the rising Base of the Pyramid.

Figure 1: Sustainability Progression – Relevance, Reliance and Resilience

Desire is the 'firm' foundation to put Planet before Profit. This is primarily ensured through Political Sustainability perspectives having proficient Awareness to ensure Worthiness through Valuing Everything and to protect all material Living Resource; Planet Profit Value. Wishful Thinking is not a 'firm' foundation to move from the Current Horizon to the Future Horizon. Engineering Sustainability requires BluePrints, Means, Resource and sufficient Desire. Sustained Capacity is only achieved having the Power Means Resource. Means being Material & Proficiency. This level of proficient Awareness effects Decision Making & Financing, particularly Novel Investments; mastering the 'Ultimate Means' of Technical Competence; Proficiency.

Cost of Capital is a good 'guiderail' to guide the associated societal Relevance for future Material & Proficiency 'contribution' towards sustainable Consumption, Recycle & Storage; delivering Enterprise Value & Sustainability Value. The Custody Chain is now mainstream – endeavouring to account 'total' Pollution Emissions Waste Depletion Loss ('PEWDL') associated with 'Source to Resource to Product to Consumption, Recycle & Storage'; the Sustainability Economy [Figure 2, Article 9] from Source-to-Storage. Reliance is based on 'Supply of Resources', the Future Flow over spacetime – so purposeful meaningful mindful Forward Data must be 'Accountifactual', demonstrating the desired Reduction of PEWDL towards Milestones & 'end' Goals or otherwise Resilience will be continuously questioned, affecting Capitals Stock – leading to associated 'Dishing' of industrious Sectors & Species. Hence Sustainability Progression requires the composites of Relevance Reliance Resilience (Figure 1).

Resilience has to date been addressed very much through Fragmentation, not Wholeness. Without future Resource or Product Relevance through assured future Consumption, Recycle & Storage; future Resilience cannot be achieved ending with Resource staying as Stock (Stranded Assets), and future Products not actually

Our living planet... continued

'Manufactured Produced Delivered'. Without future Reliance on deliverable future Flows, uncertainty creates Risk increasing the associated cost of Capitals Stock; Cost of Capital increasing in certain Sectors.

'Creating & Developing for Progression' also means the 'Advancement of Conservation'; Sustained Conservation and not destruction of the Natural World nor being viewed as an obstruction to Our Urban World. Conservation is in the mainstream of Sustainability Progression; Natural Living Resource Conservation being very much part of Natural Capital (Capitals Stock, Article 6) and Natural Sustained Capacity (Flows – Perform & Withstand). Sustainability Progression means that 'noticeable' or 'measurable' advancements must be made moving towards set Milestones and 'end' Goals; meeting Objectives.

The Challenge of Resiliency for any Corporation today is that 'Accountifactual is King' within the Custody Chain, from Source-to-Storage. Accounting for Total 'Pollution Emission Waste Depletion Loss' is embryonic 'systemically to be held to account' – creating uncertainty when considering verification of Data Disclosure. Progression has the additional challenges in 'The MarketPlace' of the Dominant Supplier in some Sectors or Provinces. Dependency, such as through Energy Provision can be limited to local or regional Sources. Dominance, of some Sectors can occur by major 'Manufacture Production Delivery' Corporations, some with National Sovereign 'association' taking strategic positions to create future Global Supply. Recycle and 'end' Storage being very much aspirational in Developed Economies.

Resilience is often thought of as part of the Capacity for particularly Sustainable Institutions to withstand perturbations and extreme Economic Social Environmental Challenges but still remain functioning and even emerging through Re-Architecture, New Creativity and 'Purpose through Re-Framing'. Re-Balancing & Re-Architecting of Sectors is all part of staying resilient through 'transitional' transformation. Moving from Great Organisations of Unsustainability to the Future Horizon of Great Organisations of Sustainability will be no different.

Visibility of what companies are actually doing is key to staying onside with local Communities & Society-at-large. This is also driving the Desire for more regenerative Means particularly related to Stock-of-Life sourcing Resource and yielding Resources and Products. Visibility of how people live their lives and how this may change is also key; particularly in reforming Human Nature. Enterprise will need to consider 'wider choices' if they want to maximise access to Environs Capitals beyond the factory area or 'production boundary' (Article 6). The new generation will have a very different viewpoint on the future Relevance of existing legacy 'stock', its Resources and associated Products, its associated practices, impacts & effects; Resource Relevance.

Usually the news is that each time from 'flaws of systems & processes' enhancements are 'learnt', but, from this time these 'reforms used' from Technical Means will not make it safer. Natural Means cannot be ignored by Government (Non-Action) protect. Nature & Climate are linked. Both Technical Development and Natural Development need engineering. Advancement of FootSteps require Proficiency of the Future Horizon, so Global Sustainability matters. Society Government Enterprise Academia must start by the 'Ultimate Means' [Stewardship]: Participation; Motives Motivation Engagement and to track Progression through both Material Performance & Proficiency Performance.

Techno-Optimism (Figure 1), the wishful 'hope' of delivering unproven Technical Sustainability in the future being a good example of the need to have Proficiency Performance, mastered before 'counting chickens', embedding them into Forward Data. Standards of Performance are starting to be addresses, some newly characterised under 'HallMarks'. Technical Sustainability advances daily in some Sectors; the important question of Progression being is that at an 'acceptable pace'? 'Acceptable pace' needs suitable Desire and sufficient Power.

Transition Risk (Figure 1) based on the perspectives of Sustainability Progression revolves around three key composites Value Profit Planet. Value around Technical 'Proficiency & Material' linked to Complexity & Systems. Profit around Financial 'Commercial & Economic' Activities & Actions linked to Numbers & Accounts. Planet around Political 'Policy, Regulation, Legality' linked to Impacts & Effects. Legacy Liability Risk is reaching

Our living planet... continued

a tipping point – the elephant in the room driving Investment Governance and Responsible Investment; ESG frameworks.

'Dishing' of specific Industrial Agricultural Energy Sectors & Species without 'full' Awareness through any 'transitional' transformation is not helpful, but, is too easy to do today with so much of Opinions driven through Disparate Association and Fragmentation. Governance Governess Worthiness matters; Wholeness (Article 7). As discussed in Article 9, Proficiency Performance & Material Performance means the Performance Composite of the 5 principals: Participation & Motives Motivation Engagement Progression needs to be reported with clarity & transparency -- in particular for Global ESG frameworks. The 'notion' or theme of 'Environmental Sustainability' being especially associated around the current lack of 'fully' proficient Awareness which raises the likelihood of resulting 'Ecowashing'.

Lack of 'full' Desire needed to achieve 'transitional' transformation (Re-Balancing Re-Architecting Re-Framing) of certain Sectors means that some associated Species create fragmented Annual 'Financial & Sustainability' Reports and external Outtakes. The resulting 'Ecowashing Swashing Greenwashing' being the most likely ESG Outcomes through Poor Governance; typically not grasping the urgency of the Capitalist Society with Citizens Agency & Business Agency, to move from the Current Horizon to the Future Horizon – 'Sustainability over Profitability'. Competence is not enough when 'transitional' transformation requires Proficiency.

'Ecowashing Swashing Greenwashing' needs attempted 'definitions'; to associate better characterisation and hence improve Awareness through assessment. All three ESG Outcomes being associated, linked typically to Transnational Reporting; Global Sustainability attributes linked to Outputs Outcomes OutTakes. Eco-washing or Ecological (or Environmental) 'Washing' – being linked to lack of clarity & transparency of 'Non-Action', or poor response outside the 'Production Boundary' [Custody Chain]. S-washing – to lack of clarity & transparency from 'Swaggering', making claims which subsequently are found to lack scientific or social foundation; particularly related to the actual costs borne by Society. Green-washing – to lack of clarity & transparency of 'Behaviour or Activities' that make People believe that an Enterprise's Governance is 'Respecting the Protection' of the Economy Society Environment - more than it really is 'doing'; particularly advancement of new Green Utility. Characterisation of Green-washing is more advance, with two broad 'categories':

Type 1: Overpromising on claims of Return, Risk or Impact when that is not justified by 'Evidence' or 'Knowledge'

Type 2: Inflated claims on what an organisation is actually doing on Responsible Investments ("Greening").

Dishing of specific Industrial Agricultural Energy Sectors & Species is too easy to do during early Transition Space. Awareness driven by 'ideas of truth' (Article 9) and Association with Peer Groupings often without Context or deep Understanding can result in Dishing. Technical Knowledge (Content), particularly New (Technical) Knowledge, has to be tested to ensure our experiences are not biasing through our beliefs or 'mind-image', obscuring reality; Truth (Article 9). Fragmentation is a means of living with differences. Fragmentation demonstrates the heterogeneity of Wholeness. Sustainability being a 'super discipline' requiring Integrated Thinking and Systemic Thinking. Science is based on Evidence; Engineering is based on discipline-led structured & systemic Applied STEM; and Economics can be based on Pure Opinion – often a belief. Gaps ('Unknowns') will always be there in our mind's Understanding and our Response.

Petro-dishing of the Petroleum Sector activities will be mainly linked to associated Carbon Emissions (particularly legacy contributing to the Carbon Budget), Flaring, Venting, Losses; Ecological Impacts & Effects -- driven by poor response, poor practices or poor processes such as Decision Making. Inevitably these are going to attract elements of Dishing by Individuals & Peer Groupings wanting 'Sustainability over Profitability'. All Industrial Agricultural Energy Sectors are however currently unsustainable – needing their associated

Our living planet... continued

Reduction of PEWDL. For Oil & Gas, in the foreseeable future – this will led to Re-Balancing of the Petroleum Sector through the Energy Transition. Many New Opportunities lie ahead to be resourced by Transition-Led new Capitals Stock (Article 6) guided by proficient Economic Stewardship on the quest for Sustained Value.

Enterprises having a Social Oriented Business Purpose have the full Awareness that Business Sustainability is more than just Profitability, but, striving for branding, strategy and all activities and actions to have Sustainability, engineered and built from Stewardship & Succession; Economic Stewardship, Social Stewardship, Environmental Stewardship delivering Sustained Value, Sustained Capacity and Sustained Conservation.

Complexity of delivering Prosperity of People & Planet (3Ps) requires clear Thinking, not Wishful Thinking; Wholeness, not Fragmentation, leading to Balancing, not Trade-Outs between Totality (Composites Compounds Elements). The Energy Transition is about Re-Balancing, so by example, Petro-dishing is not productive when targeted at current Petroleum Products. The Petroleum Species have to innovate just as much as other Industrial Agricultural Energy Species. Trade-Outs, such as Coal use in the Power Sector have to be made with 'full' Desire, having full Awareness that the loss of that associated sustainable Capacity will have to be proficiently replaced through Doing Right as Energy Security (ie Regional Capacity) is very much part of Sustainability; but not Profitability. Profit often profligates from having a lack of 'Security'; in addition to Transition Risk. Ethics, reflecting competent Conduct & Custom (Article 9), becomes more challenging to apply consistently linked to respect, when protect is weakly Government regulated or absent from the current agenda.

Sustainability is the 'capacity to endure'; Performing & Withstanding. Profit before Planet is unsustainable, creating long-term changes in Climate & Nature (Biodiversity & Habitat Loss); some changes are deemed irreversible now. The IPCC WGII Report published in February 2022[1] mentioned the word 'irreversible' 107 times; affecting Human Ecosystems & Natural Ecosystems and how to best reduce these adverse consequences for the current and future generations. In the context of Climate Change, Risk can arise from the dynamic interactions among climate-related Hazards, the Exposure and Vulnerability of affected Human Systems and Natural Systems. The Risk that can be introduced by Human Responses (Respondibility) to Climate Change was a new aspect considered in this report, when compared to previous.

> "Human-induced climate change[1], including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability. Some development and adaptation efforts have reduced vulnerability. Across sectors and regions the most vulnerable people and systems are observed to be disproportionately affected. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt. [high confidence]
>
> …Climate change has caused substantial damages, and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems [high confidence]. The extent and magnitude of climate change impacts are larger than estimated in previous assessments [high confidence]. Widespread deterioration of ecosystem structure and function, resilience and natural adaptive capacity, as well as shifts in seasonal timing have occurred due to climate change [high confidence], with adverse socioeconomic consequences [high confidence]."

The Energy Transition in particular needs Security of Assurances, not aspirations to meet Net Zero Goals set without 'firm' foundations. With such long term aspirations set without clear and transparent Ultimate Means show the necessary Awareness & Desire is not front & centre in the Political Arena, leading to associated Enterprise lack of corresponding respect. Best Opinion on this Net Zero lack of Proficiency is that today's 80% Molecules vs 20% Electrons 'Energy Supply' needs to be transitioned to >50% Electrons by 2050. "How?" is the question that only is answered today by resulting to Techno-Optimism (Figure 1) – hence Reliance 'scores' badly; effecting Resilience in too many Sectors & Species.

Our living planet... continued

To stop catastrophic Climate & Natural World impacts & effects – this must be achieved without major impacts & effects on Inclusive Capitalism which must ultimately finance the estimated $100 – $150 Trillion (Article 7) investment needed between now and 2050. So having Security of Assurances around 'How' needs Societal Scrutiny which can only happen based on fully deployed Proficiency which means many Milestones along the Energy Transition pathways towards Net Zero must be considered. A step-by-step approach is the only way to engineer 'Sustainability'. Risks are not always additive, many are multiplicative -- particularly taking the Back-End Loading strategy (Article 4) affecting a Carbon Budget with Unknowns. The bigger picture being not only Consumption, without effective Recycle & Storage, is effecting the Planet Climate & the Natural World – but primary Natural Phenomena (eg Volcanic activity) can result on the deemed time frame to Net Zero, as well as the increasing threat of supplemental Climate Tipping Points; both of which are very uncertain and are not modelled even with precision 'cause & effect' to Withstand as well as human-induced 'cause & effect'.

Business Sustainability Performance needs clear and transparent Motives Motivation Engagement Progression; with the longer term interests of Directors, Shareholders & Stakeholders re-balancing their company's 'Manufacture Production Delivery' with sustainable 'Consumption, Recycle & Storage' by Society; the Custody Chain reducing Pollution Emissions Waste Depletion Loss (Article 9). Participation of Stakeholders is particularly important when setting relevant Metrics for Material Performance. This takes time and Desire too.

As well as Human Endeavours changing & adapting, so too does Human Nature & Human Behaviour, adapting and reforming. Human Nature needs reform as demonstrated by the dominance of Our Urban World over the demising Natural World; the 'Disappearing Planet'. When Human Population increases, so too should the Natural Ecosystem Services be increased – not decreased by Humanity. This calls for actual reform of Human Nature now we are living with both physical and environments Limits (Article 6). Human Nature needs 'physical' boundaries imposed and quickly, particularly where there are no Free Rider Effects (International Waters & In-Space). In fact for Natural Resources, any Wilderness should have associated physical limits on all Humanity; particularly entry points – subject to 'entry tolls' plus any additional 'fees' based on commercial intentions plus the associated extent of evidence of 'non-zero harm & trace' criteria. Adaptation & Mitigation, Depletion & Loss and raising the Base of the Pyramid (Article 7) all have to be funded; increasing total funds annually in-line with increasing global CO_2 atmospheric concentration is the challenge which can only be met now by Outside-the-Box Thinking. It is time to settle in International Law, the Natural Ownership of Wildernesses. It would create a new Natural Economy and push Natural Sustainability to mainstream Thinking.

Our Human Footsteps matter – providing the Ring of Protection ('RoP') to Our Living Planet's Commons & Global Cover [Sustainability Economy, Figure 2, Article 9]. But our Human Footfalls can be tracked very effectively now through our electronic data 'print' - providing the Line of Respect to Our Living Planet's Nature Stock. This Line of Respect ('LoR') being 'bi-directional', so more than a shield, an umbrella or a 'boundary' wall and does not have to be physical. Humanity should respect the 'Needs' of both sides, Our Urban World & Natural World. 'Conflict' has to become secondary, with the Needs of both sides considered in Parity; Global Sustainability. Humanity needs to have due regard of its own FootFalls respecting the Natural World's Boundaries thereby protecting the Nature Stock from OUR Traces & Harms [Social Guardianship]. Sustained Conservation matters with Environmental Stewardship still grasping at Re-Wilding while the Disappearing Planet increases by the moment, needing to Recover based on Priorities.

The benefit of the Natural World is that "What WE can Conserve – WE can Harvest at a Sustainable Yield". Natural Sustainability perspective may be in the 'shadows' today, it just needs new Global Governance Systems to become mainstream. Watch this Space.

Only Sustained Conservation of the Natural World & Nature Stock can hope to deliver a Pristine Natural Environment, but, that requires material reduction in Pollution Emissions Waste Depletion Loss in the Natural

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World, as well as Our Urban World. Sustained Value (Article 8), through organisational enterprise's Decision Making, in a manner that reflects the core set of Principles of Sustainability (Article 8), ensures that these activities and investments today, 'Creating & Developing', do not limit the range of economic, social, and environmental options open to future generations. The importance of Sustained Value was highlighted sufficiently in Article 8. Sustained Capacity & Sustained Conservation is the address of this last Article.

To change Human Nature will need mechanisms conditioning individual Human Behaviour and creating 'Values' based on 'Value', but, not losing individual autonomy & free choice. Measuring our FootFalls as we cross boundaries into the Wilderness-scapes now matters as Humanity has used up its time to solve Emissions causing Human-induced Climate Change[1] by Technical Development alone. Natural Development is now just as important -- 'the well' that keeps on giving; hence the need to Value everything to achieve Planet before Profit with Why-What-How-With-Marked by Societal Scrutiny (Articles 5, 7). Use of Technical Means & Natural Means is one key differentiator for 'Sustainability over Profitability'.

Companies Business Guardianship need to have due regard of their own FootPrints and respect the Planet's (societal & environmental) Boundaries; and protect Natural Wilderness-scapes from their own FootSteps, affecting The Commons & Global Cover; the Ring of Protection (Sustainability Economy). Humanity's Social Guardianship needs to have due regard of its own FootFalls respecting the Natural World's Boundaries thereby protecting the Nature Stock from OUR Traces & Harms. Tracking societal Footfalls is one simple way to raise Awareness; Line of Respect to Our Living Planet's Nature Stock.

So FootSteps FootPrints FootFalls matter being Outcomes Outputs Outtakes linked to Consumption, Capacity 'flows of Value' and Capitals Stock 'composites'. They are actually Sustainability 'Compounds': (1) FootSteps are Technical 'steps' impacting/ effecting the balancing between Consumption & Capacity; (2) FootFalls are People 'steps' impacting/effecting the balancing between Consumption & Capitals Stock; and (3) FootPrints are (Our Living) Planet 'steps' impacting/effecting the balancing between Capacity & Capitals Stock. FootPrints that matter are not just Industry Agriculture Energy impacting/effecting Sustainable Prosperity but are also from Primary Natural Phenomena (eg Volcanic activity) as well as the increasing threat of Vulnerability from human-induced Climate Supplemental Tipping Points. OUR Capacity & Capitals Stock at the 'end of the beginning' of Our Living Planet has never been so precarious in the history of Humankind. Increasing Human Population increases FootFalls needing more societal respect to the Natural World – getting to the Future Horizon will require Outside-the-Box Thinking too (Articles 7, 8). Global Sustainability will only be achieved if Capitalism becomes inclusive, 'performing & withstanding' to all, Inclusive Capitalism; Developed Economies and Emerging Economies through Better Development.

Covid was a wake-up call to how fragile Humanity actually is when disease effects everyone, globally. The Environmental Challenges from Climate Change and Biodiversity & Habitat Depletion Loss will be faced by all of Society, civil or not. All three will be eclipsed by the fourth Great Challenge, Polluted Water; particularly Oceans (International Waters) and Seas as so much food today is delivered through their Natural Ecosystem System Services. Oceans play a critical role in the stability of our Climate. 'Scientists estimate 50-80% of the oxygen production on Earth comes from the ocean. The majority of this production is from oceanic plankton… Prochlorococcus, is the smallest photosynthetic organism on Earth. But this little bacteria produces up to 20% of the oxygen in our entire Biosphere. That's a higher percentage than all of the tropical rainforests on land combined.'[2] People Climate Nature; Doing Right, Doing Good, Doing Well (Article 7).

So the other elephant in the room is that Our Urban World needs to Work with Nature. Oceans matter, we know that now – science is however too far behind on this Evidence to guide forcefully enough. Humanity needs to act now based on Best Judgement & Common Sense. This 'elephant', Nature was for the first time cast transparently in the catalogue for reference at COP26 (Article 7). Our Living Planet, the Natural World & Our Urban World is finally cast together at 'the end of the beginning'. Technical Political Financial Perspectives have taken too long to agree – Our Future is now dependent too on the Natural World. So Technical Political Financial Natural Perspectives. To endure as we do today, and hopefully as we did

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yesterday, now requires 'full' proficient Awareness of Our Living Planet; Totality delivered through Wholeness, engineering Sustainability through Our Urban World & the Natural World – building enduring Capacity.

Lovelock, in 1979 highlighted how poorly Humanity understood Nature, "everything in Our Living Planet is interconnected". Scientists are still working on the Planetary Evidence. Be wary of 'Doughnut Economics' if built on unsure bedrock. The Natural World's complexity had kept our Climate stable until the Industrial Revolution started. Science, today, is still catching up as so many of the Oceans are below 3000m water depth. Tragedy of the Front-Line is at least 'sparking' now the Political Mindset. Putting 'Planet before Profit' is not politically enduring without strong global Desire. Government protection needs action before final scientific evidence. Humanity has to learn at pace, Valuing Everything particularly Nature Stock; Valuing Nature & the Natural World.

Critical 'Stakeholder in Society' are now Business & the Natural World. Government primarily through Non-Action has not protected Wilderness-scapes such as International Waters and now In-Space, above Global Cover. The Business & the Natural World both now lacks Sustainability Capacity on the Current Horizon. Guardianship needs prominence now to protect Conservation, Natural & Technical, ensuring 'maximum' Regeneration to Regenerate Ecosystems; 'the wells' that keeps on giving. Global Governance Systems are needed to protect International Waters, some two-thirds of Planet Ocean and to start then protecting the In-Space, above the Global Cover; thinking Outside-the-Box (Articles 7, 8).

With Opinions such as new solutions from Capitalist Means, such as charging Entry Tolls will create an immediate Social Wealth at the Base of the Pyramid to local indigenous communities on the Planet's 'Boundary to the Natural World'. Nature is not a Public Good. Non-excludable Common Goods such as Nature & Natural Ecosystem Services can be made through Inclusive Capitalism to have their 'stock' less non-excludable through reducing 'rights-of-passage' through their 'scapes'. To change Human Nature will need mechanisms conditioning Individual Behaviour & Group Behaviour -- creating 'Values based on Value', but, not losing Individual Autonomy & Free Choice.

Respondibility, particularly for the 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, needing embryonic Governance of Respondibility (Guardianship – Phase II). 'Responding through Loss' is fragmentation; Poor Governance (Article 9).

Government must protect 'Our Living Planet', Our Urban World & the Natural World, through Good Governance, Policy, Regulations, Standards, Education, providing incentives to change Human Behaviour through increased Awareness; tilting the 'playing field'. Provision of choice – ensuring meaningful 'light' on diversity, creating 'colour' in delivery. With increased Human Population – corresponding restoration of Natural Ecosystem Services must be demonstrable as well as Conservation of existing Nature Stock; renewing Natural Resources and maximising the regenerative nature of the Natural World, particularly the Oceans; the Blue Planet of Nature Stock. Government putting 'Profit before Planet' only create tensions between remaining 'species' and the Planet. Valuing Everything is not optional any more due to Limits & Limitations. Under Sustainability, Governments' protect, WE need Global Governance Systems now for the Natural World!

Future Value, particularly Governess Value has been poorly Understood – Sustainability is only achieved by 'not limiting the range of economic, social, and environmental options open to future generations'. Analysing the Worthiness of 'Current Horizon' activities is key, as the choice of what is to be conserved is important as we attempt to move to the Future Horizon. Succession helps to guide that Understanding, providing Means through BluePrints. What different 'elements or building blocks' (Composites) are to be conserved and which 'utility' full BluePrints are needed to 'bridge' across 'the stream'; 'engineering the future' (Article 8) is very complex; not a simple Plan.

Society ultimately must Decide whether Our Living Planet is to be sustainable; hard decisions will have to be

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made now and ever increasing into the future until the 'Ultimate Means' to achieve Sustainability have Proficiency. Competence is not enough any longer with the 'Levels of Proficiency' dictated by levels of Limits & Limitations encountered. 'Current Horizon' BluePrints, Material & Capacity must deliver the Future Horizon New Utility & Sustainability Performance; Sustainable Prosperity (Figure 2).

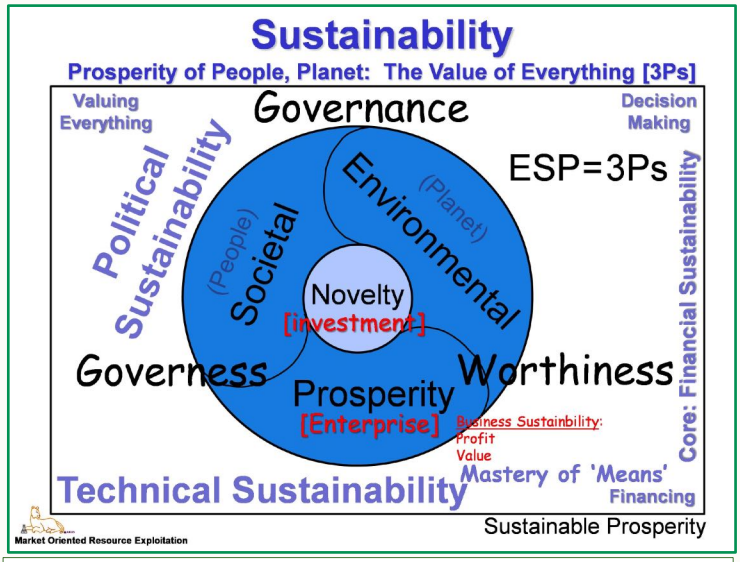

Figure 2: Sustainability – Perspectives of Technical Sustainability (Proficiency), Political Sustainability & Financial Sustainability with Cornerstones of: Technical Competence (Proficiency), Valuing Everything, Decision Making, Financing

The Energy Trilemma of 'cleaner reliable affordable' Energy is about 'Manufacture Production Delivering to Consumers, Recycle & Storage' [Custody Chain] linked to three 'compounds':

(1) 'Sustainability' [Perspectives of Stock Resource; Cleaner-Reliable

(2) 'Security of Supply' [Flows; Reliable-Cleaner]

(3) 'Affordability' [Stewardship; Cleaner-Affordable].

Hence ,long-term Sustained Capacity (Performing & Withstanding) is key. Sustained Capacity having the Power Means (Material & Proficiency) Resource to Perform & Withstand increasingly along the 'pathways' to the Future Horizon. Engineering these pathways – staying the 'course' requires Proficiency (Specialist Skills) & Competence (Generalist Skills); 'Mastery of the Means' of Technical Sustainability. Article 9 presented Sustainability Performance linked to Material Performance & Proficiency Performance; Value Impacts Effects. Figure 2 shows 'Prosperity of the Enterprise' linked to Business Sustainability; Profit & Value.

As Humanity is now close in Spacetime (Article 9) to the end of the Great Organisations of Unsustainability and if WE build new Sustainability Capacity through advancements of current Enterprise Capacity – moving from Grey Utility to Blue Utility and on at speed to Green Utility; the Great Organisations of Sustainability will begin to emerge. There are Limits of Certainty, downsides happen more often than you would think. Our END of the beginning has started, 'two minutes before midnight' (Articles 3, 6). To 'get' to these Great Organisations of Sustainability, 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. 'Planet before Profit, Valuing Everything'. WE have the Means now to start particularly Valuing Everything, just desire then the Ultimate Means of New Utility yet to be demonstrate as Proficient, to reach the Future Horizon.

The Natural World, through Nature, regenerates to replace its Losses. Humanity uses 'Creating and Developing'; OUR 'seventh senses' through MindSight[3] by reflecting on 'Our Experiences'. MindSight is synonymous with "Project Understood" (Article 9) of Continual Innovation. This is only best after "Project Understand", the use of 'Perceiving' [Perceiveship]; OUR 'sixth senses'. Human Behaviour [MindSight][3], being MindFull (along with PurposeFull & MeaningFull (Article 9)) is deemed best by Dr Siegel when:

(1) "WE accept it" – that the Paradigm Shift is desired ("Move from Unsustainability to Sustainability")

(2) "Let go of the Current Horizon" [Polluting Emitting Wasting Depleting Losses]

(3) "Transform to the Future Horizon"; Creating & Developing [Technical Sustainability], Protecting [Political Sustainability] and Investing [Financial Sustainability] in 'Markets & Inclusive Capitalism' and 'The Commons & Global Cover'.

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The Structural Barriers (Article 6) of self-imposed 'Limits & Limitations' that impede New Understanding fall away when "WE accept it", having the collective Desire to move to the Future Horizon of Sustainability. That now will take Parity, the state or 'condition' of equal status between Our Urban World & the Natural World.

"He that seeketh victory over his 'nature', let him not set himself too great nor too small tasks; for the first will make him dejected by often failings; and the second will make him a small proceeder, though by often prevailings."

Working with Nature is now preferred – not seeking "Victory over Nature". Natural Means & Technical Means are now both needed to be combined to deliver the means to move to the Future Horizon, True Sustainability; 'the wells' that keeps on giving [Regeneration & to Regenerate Ecosystems]. To achieve Sustained Capacity requires Building Capacity, taking "Two FootSteps – one for Mankind; one for Wildkind"; Technical & Natural; in Space & Time. Global Sustainability must 'Create & Develop' Social Development and Natural Development, overcoming the current 'Defects', 'Deficiencies', 'Dereliction' if marked by Societal Scrutiny.

The Current Horizon will be increasingly bumpy, up and down, winding, often meandering – with Limits & Limitations, such as caused by Political Policies, 'event' consequences, frustrations of collaborative action; but increasing Desire. Foraging without a 'manual' means Engineering the Future (Articles 8, 9) will naturally rely on Succession & Stewardship.

This last Article in this Series on Sustainability will now attempt to summarise the 'Current Narrative of "Sustainability", today and tomorrow'; 'Sustained Capacity - VRIN Proficiency Test'; 'Sustained Conservation - Responsibility Respondibility Adaptability'; and 'Future Sustainability - Our Living Planet'; 'pulsating the mind' with intermittent Moments of Truth.

Moments of Truth (1) & (2)

(1) WE have left it too late to get to Global Sustainability by Technical Means alone. WE had the embryonic Means around 2004 – 2005 but lacked the Governance (Political & Corporate) & Societal Desire. Profit before Planet – "Consumption as King" has lasted some twenty years too long; Profitability. WE are now moving from "Consumption as King" to "Accountifactual is King" (Custody Chain). When the 'Ultimate' Means (Blue Utility & Green Utility) have been engineered, we will be living with "Reduction is King". Scientific Understanding had been 'built' (Project Understand; Content) around 20 years ago BUT 'Project Understood' did not gain momentum till around December 2018[5]. Project Understand of the Natural World's Wilderness-scapes, such as Planet Ocean is still ongoing; as pointed out 'we know more of deep space, than our deep oceans'.

(2) 'Happenings' today are because of changes to Nature & Climate. Pollution Emissions Waste Depletion Loss. Systemic Thinking is needed to get to destination Global Sustainability. Fragmentation and Wishful Thinking only really address one today: Social Development (Article 9).

Current Narrative of "Sustainability", today and tomorrow

Sustainability, today, is based now on a set of Sustainability Principles (Article 8), Dimensions & Perspectives and guiding Sustainability Practices; Stewardship Citizenship Custodianship Guardianship. Integrated Thinking of economic, social and environmental Means (& Resource) should ensure that our activities and actions today, do not limit the range of economic, social and environmental options open to future generations. The

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Means being Material & Proficiency. Sustainability Performance is therefore critical to ensure that our 'Activities & Actions' are enduring and not limiting OUR 'Future Options'.

Sustainability Reporting most often today is not clear 'How' associated material Activities & Action will be changed to respect Future Options; presenting clear and 'PurposeFull MeaningFull MindFull' context, content & milestones. The Custody Chain [Custodianship] linking 'Manufacture Production Delivery' (Resource-to-Product) to 'Consumption, Recycle & Storage' with Material Performance & Proficiency Performance. Today the Custody Chain reported is fragmented typically focusing only on Scope 1 & 2 Emissions; not Source-to-Storage. Metrics & Measurements reported are typically taken from ESG framework assessments which have their own issues such as lack of 3rd Party Technical Assurance, even Quality Assurance. Often 'The Data' presented is based on estimates without 'precision of actuality'. Global Standards still need to be demonstrated per Sector & Species.

Tomorrow will be different!... For Sustainability, the Proficiency Performance of Activities & Action vis-a-vie Future Options matter as well as Present (Current & Backward) & Forward Material Performance data. Sustainability Reporting must reflect the composites Value Impact Effects and to reflect Capacity, hopefully Sustained Capacity, full of 'Responsibility Respondibility Adaptability' (Article 7). Corporate Damages & Losses are starting to become material; Climate & Nature. If Natural Sustainability mainstreams linking the Natural World to Our Urban World, 'Conserve-to-Harvest' reporting linked to Sustainable Yield must emerge; embryonic Future Horizon 'pathways'.

Today, Business Organisation's Values are often too much based on the Current Horizon, so poorly aligned to the Future Horizon. Having a Social Oriented Business Purpose matters, embedding a clear set of Principles and guiding Practices; being fully aware that Business Sustainability is more than just Profitability and not 'Manufacture Production Delivery' at the expense of others; Society & Environment [Global Sustainability].

Tomorrow, Business Organisation's Sustainability Performance therefore must include the 5 Sustainability Principals (Article 9): Participation, Motives Motivation Engagement Progression driving towards achieving the 'Ultimate' Means to 'Ultimate' End; True Sustainability – 'the destination' on the Future Horizon, not the Current Horizon. The Means & Resource (particularly Source-to-Storage) have to be demonstrated to be proficient to move organisations towards the Future Horizon; respecting Future Options. Without embedding Sustainability Principles today, Great Organisations of Sustainability will not be delivered tomorrow. If Profitability is about Trade-Offs; Sustainability is about 'Creating & Developing', Building Capacity; Planet before Profit, Valuing Everything.

A Sustainable Urban World needs to have Global Sustainability through Markets & Inclusive Capitalism. To get to the Future Horizon, WE need Systemic Thinking to understand Wholeness and not to fragment ensuring that our 'activities and actions' today do not limit our range of options today and tomorrow, protecting The Commons & Global Cover; Global Sustainability.

The current Sustainability Narrative is that 'Footsteps' create 'Footprints'. Therefore 'Proficiency of Footsteps' & Material will dictate Humanity's ability, capability and capacity to get to 'the destination' & 'How' long it will take to get there; using both OUR sixth senses ('Perceiving') & seventh senses ('Creating & Developing'). Proficiency has to be mastered at the increasing level required, as well as the Desire and 'means' to move from the Current Horizon to the Future Horizon; reducing Pollution Emissions Waste Depletion Loss. For Business Sustainability, 'Conduct Custom Goods Services' matter (Article 9), particularly Corporate Governance with transnational oversight.

Tracking Humanity 'Footfalls' are necessary now due to increasing Human Population effecting Sustainability Capacity. New Outside-the-Box Thinking will be required as Global Sustainability will only be achieved if Capitalism becomes inclusive, 'performing & withstanding' to all; Inclusive Capitalism. Protecting Our Living Planet means that Our Urban World needs to Work with Nature; Technical Means & Natural Means are both now needed to deliver the Ultimate Means.

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The Triple Bottom Line ('TBL') framework: Economic Social Environmental ('Dimensions') accredited to the genius Integrated Thinking of John Elkington[4] was published in 1997. The TBL framework was cast to help evaluate Corporate Performance in a broader perspective, creating greater 'business value'; Enterprise Value & Sustainability Value. Unfortunately, without Proficiency, Means or the Desire to enact this broader perspective, the TBL framework, has predominantly improved Enterprise Value (through Profitability) NOT Sustainability (Value). Improved Profitability since 1997 has been at the furthering expense of People & Planet creating many Great Organisations of Unsustainability; accelerating 'happenings' not mitigating them.

This is because Economic Social Environmental TBL dimensions were actually focused on 'Outcomes'; 'bottom line' Outcomes. Today, Sustainability Performance is predominantly focused on Material Performance, fragmented; Proficiency Performance excluded and needing the 5 Principals (Article 9) to be urgently included in any Sustainability Reporting or ESG framework assessment.

Today, the TBL framework implementation typically excludes 'intrinsic practices' at 'ideas conception' because Sustainability is not considered as the 'overarching umbrella' encompassing ALL Activities & Actions. It is through these 'intrinsic practices', Succession, both Technical & Natural, Blueprints can then have a more prominent part in the Future Options rather than 'elephant leaping' to 'New Utility of Wishful Thinking'. It is primarily through Technical Sustainability (Principles, Strategy, Priorities, Practices & Frameworks; Delivery and Performance; Dynamic Materiality) that business Stock & Flows need to be critically aligned with the current Enterprise Value (E_V). Total Value means Technical Sustainability has to be the DNA core of the Total Value 'umbrella' of the whole enterprise; Sustainability, Stewardship and Succession (Article 8).

Inclusion of Sustainability Practices such as Stewardship - services & stewards, than would ensure Integrated Thinking to be included while 'Creating & Developing' integral pathways resulting in 'Sustainability over Profitability'; "Planet before Profit, Valuing Everything"; Planet Profit Value. Sustainability Wholeness (Figure 3) is critical to ensure Dimensions, Perspectives, Global Sustainability & Sustainability Practices create enduring and sustainable TBL outcomes through Engineering Sustainability and Building Capacity; Performing & Withstanding.

Systems Thinking is about understanding 'The System'; contemplating 'The Whole' not any individual or fragmented 'elements' being just part of the total 'pattern'; Tapestry. Conceptual Frameworks, like TEEPS (Articles 7, 8) and 'Toolbox' Better Practices can only increase in relevance to the Future Horizon, and 'How' to get there; Engineering Sustainability. 'Human Endeavours are Systems too; fabric of interrelated Dimensions, Activities & Actions' built from "Disciplines". Within Disciplines, 'Seeds' cast tend to fall onto more Welcoming Ground; Nurtured to produce 'Great Oaks' over spacetime. A benefit of Systems Thinking; The Whole is more important than the 'sum of the parts'. Whether these 'endeavours' are enduring and bear more 'Seeds' depends on Perspectives; Technical Political Financial Natural. Human Endeavours become reflected in Business Organisation through Continual Innovation & Entrepreneurialism (Article 9).

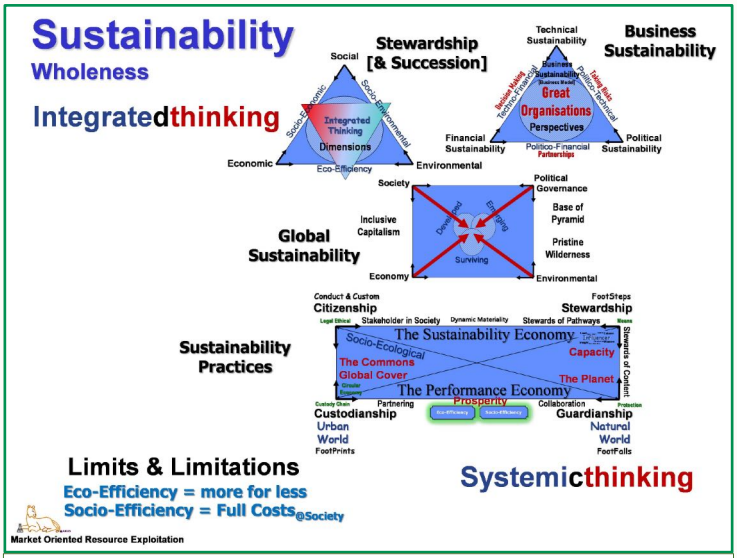

Figure 3: Sustainability Wholeness – Stewardship (& Succession) [Dimensions]; Technical Sustainability, Political Sustainability & Financial Sustainability [Perspectives; Business Sustainability]; Global Sustainability & Sustainability Practices

Systems have Means & Resource, hence why Systemic Thinking is such a core part of Sustainability Thinking. A Social Organisation System is often thought of as a Nexus; "everyone with the capacity to realise their needs, if they so desire". An Economic

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Organisation of 'Manufacture Production Delivery' system being an inclusive Market; "that satisfies present consumption without compromising future options". An Environmental Organisation providing Natural Ecosystem Services system (from Nature Stock) being Nature; "enduring, remaining productive & regenerative to support Life".

Today's Economic Social Environmental TBL 'Dimensions' also make up a rich Fabric Materiality (Article 6); a Tapestry from which going forward is improved and enduring so that Sustainability attainment 'performance' can be also 'marked'; through Standards of Performance. Managing without Factual Measurements and resulting to 'Manage only what your Measure' unfortunately is Fragmentation, not Sustainability hence Participation with Stakeholders is key to ensuring the Metrics and associated Goals are not based on aspiration, but, are actually Material. The TBL Tapestry should consistently illustrate that there is Balance between each 'Dimension', NOT a Trade-off by-any means. Everything has to be valued; Valuing Everything. Annual Sustainability Reports and ESG Reporting which just focus on Impacts & Effects miss the Value Composites gained through Valuing Everything.

Recently these TBL 'Economic Social Environmental' Dimensions have now been recast as Economic Stewardship, Social Stewardship and Environmental Stewardship. Simply replacing 'Means' by 'Stewardship':

> Environmental Stewardship has been around for years now; with the ultimate desire for Sustained Conservation [Natural World & Nature Stock].
>
> Social Stewardship has been given prominence through enacting 'Social License to Operate' (SLO) through Regulatory Policy; with the ultimate desire for Sustained Performance (particularly through Progression, 'Creating & Developing') and Capacity Building; Sustained Capacity. Progression having composites of 'Resilience Relevance Reliance'. Progression takes Perseverance too! Social Stewardship supports having a 'Social Oriented Business Purpose' (SOBP).
>
> Economic Stewardship is the 'laggard'; with the ultimate desire for Sustained Proficiency (Spacetime) & Value; Sustained Value (Article 8). Mastering Economic Stewardship is gained through Proficient Decision Making & Financing. Making ('Whole') Decisions requires Valuing Everything, Economic Competence based on Long Term 'Limits & Limitations'; Risk Reward Effort. Economic Proficiency is needed where Market Value of companies has a linked correlation with their Social Behaviour and Environmental Impact. Efforts can be better expended in educating Governance & Management on Balancing Economic Social Environmental ramifications of their Activities, Actions and Non-Actions. To have Proficiency Mastery of Economic Stewardship requires the Ability, Capability, Capacity to 'Value Everything', Governance Value & Governess Value as well as Worthiness Mastery, taking the better 'pathways' towards the Future Horizon; embrace Wholeness, today and tomorrow.

John Elkington[4] classical definition of Sustainability has stood the test of time since 1997. 'His' Sustainability had the 'principle' of ensuring that our actions today, do not limit options open to future generations. WE now have a 'set of Principles' to consider plus 'guiding Practices'. What has also advanced is the 'Thinking of How' to get to 'The Destination' and the importance of Capacity – Performing & Withstanding the 'pathways' to the Future Horizon; now becoming all too real. 'Thinking of How' has been advanced to addressing 'How to Do Right, Do Good, Do Well' through service & stewards; Economic Social Environmental Stewardship with Enterprise Doing Right, People Doing Good, Nature & Climate Doing Well (Article 7).

This means, as a small Progression, today's "Definition of Sustainability" can be advanced to:

> Sustainability is the 'capacity to endure' over spacetime through economic, social and environmental means (and resource) ensuring that our (activities and) actions today, do not limit the range of economic, social and environmental options open to future generations.

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The degree to which tomorrow is 'shaped' very much depends on How Proficient the Great Organisations of Sustainability will be. The Great Organisations of Unsustainability have taken a tremendous amount of Risk Reward Effort to get to their 'current destination'; with many failures and a few remarkable successes. Building Capacity, sustained or unsustained, takes Succession & Stewardship; and Perseverance blessed with Serendipity.

Humanity's proficiency to Value Nature Stock and Working with Nature has to start tomorrow too. Sustained Conservation is not an option. Very difficult Political Decisions to protect will have to be made; particularly depletion of fisheries and global polluted water 'sources', entering International Waters whose natural Ownership should be the Natural World – not Our Urban World. Unrestricted In-Space Resource use will then have to be met head-on. Natural Means & Technical Means are now both needed to be combined to deliver True Sustainability; 'the wells' that keeps on giving. "Two FootSteps – one for Mankind; one for Wildkind"; Technical & Natural; in Space & Time; Parity.

Global Sustainability must 'Create & Develop' Social Development and Natural Development, in Parity, overcoming the current 'Defects', 'Deficiencies', 'Dereliction' if marked by Societal Scrutiny.

Sustained Capacity – VRIN Proficiency 'Test'
[Social Stewardship]

Capacity is difficult to 'Create & Develop' – particularly Proficient Capacity or 'New Utility on the Future Horizon', which is more demanding on Resources than just Competent Capacity or 'Present Utility on the Current Horizon'. Some Capacity's Added Value can quickly be eroded, if considered a Competitive Advantage based on Value, because of rapid technological changes and technological evolution; driving the Competitive Forces, in Industries and Markets [Riad Shams, 2016[6]]. Building Capacity is desired to improve Performance and advancement through Sustainability Progression; achieving successful sustainable Outcomes (Enterprise Value & Sustainability Value -- 'creating & developing').

"For the firm, Resource(s) and Product(s) are two sides of the same coin. Most Products require the services of several Resources and most Resources can be used in several Products [Market]. …By a Resource is meant anything which could be thought of as a strength or weakness of a given firm."

[Birger Wernerfelt, 1984[7]].

Typically Resources thought of 'as a strength' (or weakness) for a Firm, owned or controlled by the Firm, can be:

(1) Assets

(2) Capabilities

(3) Organisational Processes

(4) Attributes [quality or feature; characteristic, inherent part (eg brand)]

(5) Information

(6) Knowledge.

For Capacity to be Valued it needs to be Understood in terms of Ability [Manufacture Produce Delivery; Recycle & Storage]; Current 'Store'; Current Stock; New Projects [Contingent Ability]; Role & Competence (/ Proficiency). Ensuring 'Performing & Withstanding'.

Sustained Capacity is achieved through Sustained Performance (particularly through Progression, 'Creating & Developing') and Capacity Building. Hence concepts of Sustained Capacity & Sustained Competitive Advantage

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are very closely 'linked' – often with 'entanglement' type Sectors & Species, such as Petroleum.

In a Resource-Based organisational setting, 'Value Rareness Inimitability Non-Substitutability' is considered the key Proficiency Framework 'Test', VRIN, where any new Sustained Competitive Advantage (through Engineered Sustainability 'Creation and Exploitation'; Stewardship) should be tested against [Jay Barney, 1991 [8]]. Sometimes, other articled authors merge the Non-Substitutability composite in with the Inimitability composite when 'Organisational' Dynamic Capabilities are specifically more important than Resource Based Assets, resulting in the Proficiency VRIO 'Test'; particularly Decision Making & Financing Sustained Capacity (Figure 2).

Dynamic Capabilities (Article 8) are defined as the firm's ability to integrate, build, and reconfigure internal and external competencies (& skills) and competency (roles & responsibilities) to address rapidly changing environments; a composite of Competence. However, because of the commonalities and substitutability features[8], these Dynamic Capabilities and the subsequent Competitive Advantage does not gift them to have enduring Material & Competence/Proficiency; ie Sustained Capacity. Exceptional circumstances being unique organisational 'entanglement' or Continual Innovation based on overall learning experience; more than the Competitive Market evolution by associated competitors.

Linking Dynamic Capabilities into New Capacity 'Creating & Development' tied to uniqueness of associated Resource (eg specific Petroleum Province) creates more enduring Inimitability & Non-Substitutability 'competencies and competency' by reducing the Resources' and the consequent Dynamic Capabilities commonalities and substitutability features. Companies without Sustained Capacity can still form Partnerships, particularly in Industrial Hub settings, to overcome these types of Sustainability Limitations (Article 7).

Birger Wernerfelt[7] pioneering paper on the importance of having 'A Resource-Based View of the Firm' specifically covered the benefits of Mergers & Acquisitions ('M&A') – strengthening the Sustained Capacity (& Sustained Competitive Advantage) by exercising 'Value creating Strategy' through M&A of Resource Bundles; 'Supplementary Resource & Complementary Resource' Bundles. Related Supplementary getting "more of those resources you already have". Related Complementary getting "resources which combine effectively with those you already have". Other "Value" Acquisition Strategies are more Product-Oriented and tend to focus on the Firm's ability to enter and 'dominate' Attractive Markets.

M&A purchase of Resource Bundles, in this Capacity perspective, provides the chance of maximising Market Imperfection and perhaps getting a 'cheaper buy' being greatest if one tried to build on one's most unusual Resource or Resource Position[7].

"Doing so should make it possible to get into buying situations with relatively little competition, but also with relatively few targets. Although, in theory, it would be best to be the sole suitable buyer of a lot of identical targets, even a bilateral monopoly situation would be better than a game with several identical 'buyers and sellers'. Especially since the latter situation will most likely lead one into heavier competition in the race to build resource position barriers after the acquisitions have taken place."[7]

Sources of Sustained Capacity are complex, often systemic, often not fully Understood. Where Bounded Rationality & Opportunism co-exist this will favour alternative organisational forms (Article 9); Entrepreneurialism. Bounded Rationality & Opportunism are particularly important to Business Sustainability; Systemic Thinking around Planet Profit Value. Firm's should be organised and behave depending on Human, Social & Environmental attributes – trustworthiness, morality – ethics. Organisational & Behavioural issues are therefore just as important as traditional Manufacturing Production Delivery 'efficiencies'; Proficiency being the 'new efficiencies' through Doing Right & Doing Better.

Engineered Sustained Capacity building needs to focus on Branding & Strategy, particular Sustainability Strategy; also to focus on Interconnectedness & Interrelationships with Stakeholders & Consumers – creating

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& developing Mutual Benefits; hence the new opportunities the Custody Chain (Article 9) offers linking 'Manufacture Production Delivery to Consumption, Recycling & Storage'; Custodianship building Proficiency through understanding Dynamic Materiality.

Sustained Capacity is having demonstrated Power & Proficiency to Perform or Withstand; Totality.

Sustained Conservation - Responsibility Respondibility Adaptability
[Environmental Stewardship]

The four guiding Core Practices of Sustainability need Proficiency Mastery, Material Power-to-Do and Perceiveship ("Our Sixth Sense") to achieve True Sustainability, through Natural Development & Technical Development, Continual Innovation & 'spark' of Entrepreneurialism; Goddess Gaia & Goddess Nigella combined. Global Population consequences are driving Triple Bottom Line outcomes, 'happenings' – creating tensions between Species and the Planet. This is perfect for Citizens Agency to attempt solutions along with Consumption Conservation Adaptation. Social Citizenship and growing Business Citizenship clamour for Prosperity of People & Planet (Climate, Nature); Our Living Planet brings Responsibility and now Respondibility and those millions living on the 'Tragedy of the Front-Line', Adaptability.

Environmental Stewardship has been increasing in importance now for many years, typically embedded into Citizenship by Corporations. Sustained Conservation Proficiency is definitely on the Future Horizon. For the Natural World, the Natural Means of Conserve leads to sustained Yield, Harvest for Our Urban World; 'entanglement' and Bundled Natural Resources of Mutual Benefits.

Governance of Responsibility (Guardianship – Phase I) requires 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 (Article 9).

Conservation; Adaptation & Regenerative Learning

"Earth is the only place we know of in the Universe that can support Human life. Yet Human activities are progressively making the planet less fit to live on."[9]

Robert Allen wrote his seminal book "How to save the World – Strategy for World Conservation"[9] in 1980. These words then, as with the 1970's 'aliens' from out-of-space which still have not shown up (Article 3), means Humanity alone must act to secure OUR Future; Our Living Planet. WE must choose what is to be conserved; Doing Right, and what needs to be advanced; Doing Better - Practices Development Governance Capitalism Consumption (Our Urban World); Conservation (Natural World). WE can only survive as we did yesterday (without Limits & Limitations) in the Future through Proficiency. Competence does not have enough Sustained Capacity building – neglecting the essence of the Natural World by example; Natural Ownership.

Usufruct is an ancient "limited real right found in civil-law and mixed jurisdictions that unites the two property interests of 'usus' and 'fructus'. Usus (use) is the right to use or enjoy a thing 'possessed', directly and without altering it. Fructus (fruit, in a figurative sense) is the right to derive 'profit' from a thing 'possessed': for instance, by selling crops, leasing immovables or annexed movables, taxing for entry, etc. A Usufruct is either granted in severalty or held in Common Ownership, as long as the property is not damaged or destroyed." Our Social Development paradigm is the advancement of Human Living Standards without jeopardising Value or the Planet's Ecosystems by causing Impacts & Effects such as Deforestation, 'De-fishation', Polluted Water and Poor Air Quality that results in consequences to the Urban World & the Natural World, with the harm or even loss of Species. So Usufruct in action! Unfortunately, WE have "damaged & destroyed" increasingly the

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Natural World, eg the Disappearing Planet. The Law needs to change in the Line of Respect, Parity – respecting two equal Worlds. The right to enjoy the use and advantages of the Natural World short of the destruction or waste of its Nature Stock MUST STOP. Conservation matters too much now, needing to Recover based on Priorities. The benefit of the Natural World is that "What WE can Conserve – WE can Harvest at a Sustainable Yield" to the Mutual Benefit of Our Urban World.

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

This 'Bridge', our Capacity within the Sustainability Context is now 'The Practical Necessity' to link 'Manufacture Production Delivery' to 'Consumption, Recycle & Storage' [Custodianship], through the Custody Chain, due to the 'Limits & Limitations' 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-scapes such as International Waters and now In-Space, above our Global Cover. This means the composites that now matter are Technical Political Financial Natural.

The Natural World lacks 'capacity' to enforce its Natural Ownership & Leader Leadership so relies on the same 'Urban' Government 'Governance Systems' to put now 'Planet before Profit', on their behalf. Humanity cannot keep denying them of their Natural Ownership of Wildernesses being outside of the boundaries of National Sovereign States & Nations. Guardianship protects Conservation, Natural & Technical, ensuring 'maximum' Regeneration and to Regenerate Ecosystems; 'the wells' that keeps on giving.

During 'Project Understand', Kinship is important as touchpoints 'spark' the future (Goddess Nigella, Article 9). 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 is in-place; protected by the custody of Stewards, and Guardians. Additional Covenants, through conservation, build credibility that the 'shift' to 'The Future' has commenced. Society decides, Government protects, Business respects, Academia creates. Conservation is key because the Future Horizon has Succession built from the Current Horizon; BluePrints bridging across the 'horizon of the present', like a 'river' which needs traversing to get to 'The Future'.

'The Future' will need 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; Adaptation Learning & Regenerative Learning. Continual Innovation, builds very nicely out of the Learning Organisation thinking, being defined as 'desiring to continually expand organisational Capacity, through Development, to create its future'. The test of achieving Sustainability Progression towards the True Sustainability 'destination', is whether Sustained Value is created, catalysed through Responsible Investment. This means that Adaptive Learning & Regenerative Learning, building new competencies & skills, individual & organisational, are a key part of delivering Systemic Thinking (Article 7).

Adaptability

'Adaptation is defined[1], in Human Systems, as the process of adjustment to actual or expected climate and its

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effects in order to moderate Harm or take advantage of beneficial opportunities. In Natural Systems, Adaptation is the process of adjustment to actual climate and its effects; Human Intervention may facilitate this. Adaptation Limits are the point at which an actor's objectives (or System needs) cannot be secured from intolerable Risks through adaptive actions.'

"Complex Systems, at least in Our Living Planet, are made up of unique Individuals, in qualities and character -- that interact in multiple ways. The Elements themselves can Change Learn Adapt. Connection can change, loosen, reform, and the Boundaries of the System can shift over times; tangible things interacting where Boundaries are where something ends and something else begins. In the Real World, this concrete view is an approximation. Adaptability and Resilience require 'Diversity Variation Fluctuations'; needing degrees of freedom to operate – pathways to achieve or allow new self-organisation to happen. Hence 'degrees of difference' is one aspect of Resilience which needs to exist. Ecosystems need to be resilient to fluctuations, shifts in Boundaries and Connectedness. Individual or Agent, the ability to survive until a 'window' opens once a 'door' has shut. The need to experiment, to test Our Judgements, helps to validate individual ability to withstand certain Known-Unknowns. The real test is to encounter Unknown-Unknowns; and to Perform & Withstand."

With Adaptability, Exaptation is also key, being the 'process' by which features acquire functions for which they were not originally adapted or selected to perform. Exaptation therefore strengthens our Adaptability. Maladaptation is poor or inadequate Adaptation[(1)]. 'Adaptation is maladaptive if actions end up contributing to Climate Change. Maladaptation refers to actions that may lead to increased Risk of adverse climate-related Outcomes, including via increased Green House Gas Emissions, increased or shifted Vulnerability to Climate Change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, Maladaptation is an unintended consequence.'

'Resilience[(1)] is defined as the Capacity of Social, Economic and Ecosystems to cope with a Hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure as well as biodiversity in the case of Ecosystems while also maintaining the Capacity for Adaptation; Learning and Transformation. Resilience is a positive attribute when it maintains such a Capacity for Adaptation Learning Transformation.'

'Justice[(1)] is concerned with setting out the moral or legal principles of Fairness and Equity in the way people are treated, often based on the Ethics and Values of Society. Social Justice comprises just or fair relations within Society that seek to address the distribution of Wealth, access to Resources, opportunity and support according to principles of Justice and Fairness. Climate Justice comprises Justice that links Development and Human Rights to achieve a rights-based approach to addressing Climate Change.'

'Vulnerability is widely understood to differ within Communities and across Societies, Regions and Countries, also changing through time. Adaptation plays a key role in reducing Exposure and Vulnerability to climate change. Adaptation in Ecological Systems includes autonomous adjustments through Ecological and Evolutionary processes. In Human Systems, Adaptation can be anticipatory or reactive, as well as incremental and/ or transformational.'

The IPCC report[(1)] recognises the value of diverse forms of Knowledge such as scientific, as well as Indigenous Knowledge and Local Knowledge in understanding and evaluating climate Adaptation processes and actions to reduce Risks from human-induced Climate Change.

Ecosystem Health was used[(1)] to describe the condition of an Ecosystem, by analogy with Human Health. No universally accepted benchmark exists today for a healthy Ecosystem. Rather, the apparent health status of an Ecosystem is judged on the Ecosystem's Resilience to change, with details depending upon which metrics (such as Species Richness and Abundance) are employed in judging it and which societal aspirations are

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driving the respective assessment. Judge of Perspectives being a good associated sense of Healthiness (Article 9). Planetary Health[1] being a concept based on the understanding that Human Health and Human Population depend on Ecosystem Health and the 'wise (Environmental) Stewardship of Ecosystems'[1].

As well as Human Endeavours changing & adapting, so too does Human Nature & Human Behaviour, adapting and reforming. Human Nature needs reform as demonstrated by the dominance of Our Urban World over the demising Natural World; the 'Disappearing Planet'.

Natural Sustainability – Perspective of Living Resource Conservation[9]

Human Nature needs reform and Human Behaviour a change in attitude if Humanity is to halt Harming and leaving Traces in Our Urban World and the demising Natural World; the Disappearing Planet.

The Disappearing Planet is losing Green Commons quality of soil, deforestation, Living Commons wildlife and wilderness (Nature Stock) while facing increased desertification, destruction of coral reefs, urbanisation, floods, fires, over-fishing (of the Blue Planet) and species extinction from all Commons; all at increasing pace. Working with Nature has never been so important – for so many. Living Resource Conservation needs Parity between Our Urban World and the Natural World. Natural Development is now as important at Technical Development; Parity.

A New Humility is desired, "born of the realization that even man's most astonishing achievements cannot offset his disastrous devastation of the earth, its plants and its animals …We must recognize that we are a part of nature and must resolve that all our actions take this into account."[9]; Valuing Everything. 'Performing & Withstanding' has never been so important some 40 years later. Our own Species needs Human Nature reform and Human Behaviour having an attitude perspective change.

Living Resource Conservation, Natural & Urban, is no longer "peripheral to Mankind's continuing quest for Social and Economic Welfare"; Environmental Welfare is now front and centre too. Human Needs and improvements of Quality of Human Life depend on Conservation as much as Conservation depends equally on Human 'Creation & Development'; Parity between "Humankind" and "Wildkind" FootSteps.

Allowing Our Living Planet to be a much less fruitful and promising place for all Living Systems, all witnessing decline since they were born through Environmental Destruction and an increasing suffocation of Our Biosphere with unabated Emissions; is not good Environmental Welfare. This thin covering that Sustains Life is unique literally anywhere! Our Living Planet has unique Productive & Regenerative Capacity – but is not Valued by most economists who also don't Value enterprise ethical Custom; both issues fanning "Profitability over Sustainability". No wonder Humanity in the 1970-80's worried about 'aliens' from out-of-space, as their 'aliens' were more intelligent than most economists – the 'aliens' would 'Value Biospheres' highly because they would then exist.

To use Natural Succession, Natural Processes & Nature Stock in Wilderness-scapes for the 'Natural Benefit' of Our Urban World just takes concerted action; "Global Political Governance over Wildernesses". 'Conversations delivering Global Conservation' overcoming Non-Action - embodied into International Law ethical custom of Natural Living Resources. "Thy shall not Harm or leave Traces into the Wildernesses – the Natural World owns its Nature Stock outside National Sovereignty Physical Boundaries". Job done. Frontier deep 'space' should be globally governed by "Humankind" protected & respected, for "Wildkind". Let Wilderness-scapes Recover, undergo Remediation Restoration Rewilding and Regeneration commencing to Our Mutual Benefit; Natural & Urban.

Citizens of all Nations have been 'touched' by global energy interdependence, as well as war, poverty, epidemics, inflation and unemployment; why not now the Interdependence of Nature? Ecological links to Economic Social Environmental Stewardship. Inconvenience, but when Valued, a cost well borne out of the Profitability of Transnational Corporations operating outside of individual National Sovereignty domains. 'Management' would be needed to reduce the new exposure of 'violence' and 'inappropriate activities'; a 'straw' that most of these

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interdependent Activities attract when Regulation through Law is first bestowed; to protect.

Local effects like Polluted Water entering Our Living Planet's Wilderness-scapes will have to be monitored, and National Fines imposed; as National Taxation 'coffers' are greater where economics has been traded-off against Social-Environmental Dimensions. The 'Ability to Conserve' Wilderness-scapes creates the 'Ability to Harvest'; increased Natural Ecosystem Services & Natural 'Crops'. Introducing Outside-the-Box solutions (Articles 7, 8) will mean the Natural World will be distributing more than just Natural Flows – new Financial Funds to re-invest; Natural Capitalism built from Natural Economy.

Time is of the essence, as the Biosphere Capacity to regenerate reduces, from Human Activity; as Human Population increases so choices will be harder and the room for manoeuvre reduced. Making Future Life more expensive for the few and impossible for the poor, is a good reason to start now; helping to level-up Developed Economies and Emerging Economies. Climate effects will be experienced more sharply and more extensively. More Awareness will help with Our Adaptability becoming wiser as well as clever; proficiency tested through 'happenings'; Withstanding.

Sustained Conservation is the Conduct of individuals or the enterprise necessary through their 'Activities Actions Non-Actions', so that Humanity can have some of "our cake" and "eat it" from Natural Means (Succession & Processes) & Nature Stock. The 'Preservation of Nature Resource, despite Use'. This was the term first used to describe 'sustainability' by Hans Carl von Carlowitz in 1713. Carlowitz suggested "nachhaltende nutzung" (Sustainable Use) of Forest Resources, which implied maintaining a 'balance' between 'harvesting old trees' and 'sustainable development' – historical roots ensuring that there were enough young trees to replace them. Enterprise Value & Sustainability Value in appropriate Balance; Sustained Value, Sustained Capacity and Sustained Conservation – Engineering Sustainability.

For Natural Living Resource this means doing four things[9] in the new perspective of Natural Sustainability, potentially 'creating & developing' a new significant scale Natural Economy:

(1) Preserving essential Ecological Processes & Living Systems

(2) Preserving Genetic Diversity

(3) Utilising Natural Means (Succession & Processes) to Build Capacity

(4) Utilising Species & Ecosystems Sustainably.

Preservation is a vital form of Insurance & Investment. Depletion & Loss are effectively non-recoverable unless novel solutions can be progressed. Cycling oxygen and carbon, nutrients, cleaning of air and water requires maintenance and flourishing Natural Ecosystems – systems of plants, animals, micro-organisms habitats in soil, forests, estuaries, seas and oceans. There is a great deal to Sustain (Conserve) and need to Build Capacity advancing 'Performing and Withstanding' in many Habitats. Utilisation of Utility depends on societal dependence on the Resource in question. The greater the diversity and flexibility of any Technical Political Financial (Natural?) Economy, the less the need to utilise certain Resources as sustainably.

Rural communities have direct and immediate dependence on Nature Stock. Modifying their Environment to escape the trap of poverty, irresponsibility, ignorance, greed makes Inside-the-Box solutions unlikely, if not impossible to implement successfully. Social Development is now interdependent with Natural Development. To Conserve the Natural Living Resource, Human 'survival and well-being' must be incorporated through Mutual Benefit into all Natural Living 'Wilderness-scapes'. Human Awareness, Human Understanding and the Human Role (Competency); Human Endeavour must be reoriented to embrace Parity between both Worlds that make up Our Living Planet; Our Urban World & the Natural World.

The current Thinking within Our Urban World's Technical Means, is that 'Regeneration' is about leaving the Urban & Rural 'working landscapes' in a better state than the previous generation. Natural Means offer Natural Regeneration in the Natural World with substantial potential for Wilderness-scapes Recover

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Remediation Restoration Rewilding commencing for Our Mutual Benefit through new Global Governance Systems.

Environmental Stewardship is more than being good 'Watchers' of Nature, it requires Working with Nature, protecting it by Valuing Everything, demonstrated through Worthiness. Natural Succession is not like Technical Succession. Regeneration Rewilding Restoration Remediation Recover Redefined takes Natural Means; time to respond. So Human Endeavours to achieve 'Deep Conservation' will have to prioritise in the medium term, such as oceans within International Waters, prioritising associated clean-up of Polluted Waters & Wastes entering such once pristine Wildernesses.

Education raising Awareness to identify local obstacles, Content raising Understanding to identify the priority requirements, and having dedicated Guardians to ensure Decision Making & Financing is commensurate to overcome the obstacles and to fund the priorities are good means to raise Local Communities & Regional Social Groups engagement, reducing Conflicts and advancing Cooperation; Changing Behaviours – having an attitude perspective change. Participation driven through 'Acting Local' with Global Governance Systems protect frameworks in-place spreading Mutual Benefits when Engagement has achieved Proficiency; 'Mastery through Competence' with demonstrated Reduction of PEWDL and flourishing Wilderness-scapes.

Sufficient Natural Content, in order to Prioritise, is needed to satisfy the three criteria for deciding priorities[9] to 'rank' which Natural Living Resource to endeavour to Recover: 'Significance Urgency Irreversibility'. Significance based on how important is the requirement; Urgency based on the rate how a significant problem will become worse; and Irreversibility gives the highest priority to prevent further irreversible damage to Natural Living Resources. Natural Priority through Comparable Advantage, "evil" vs "more evil" ("bad" vs "worst") being significantly different from Commercial Priority Decision Making through Comparative Advantage (Article 4). Natural Sustainability perspectives are different, though embryonic.

Future Sustainability – Our Living Planet
[One Step for Humankind, One Step for Wildkind]

Our Living Planet needs to takes "two FootSteps – one for Mankind; one for Wildkind"; Technical & Natural, 'Humanity working with Nature'; Parity. 'Mankind' might be fixated on 'his' Technical Means; but Natural Means will be needed too – "Goddess Gaia of the Wildernesses". Goddess Nigella can spark Continual Innovation; 'Creating & Developing' Entrepreneurialism. Both, however, supporting Governess, the Current & Next Generation; so more 'Humankind' FootSteps.

The 'predicted' scenario in Article 1 of Bournemouth having future temperatures similar to Barcelona in the 1960's and seeing Sandbanks & The Peninsula cast back to the 'Below the Sea' may be just 'Moments of Truth' based on current 'Standards of Performance' of human-induced Climate Change. Though Predictions rarely come true - Moments of Truth may to be just lost in time, or actual precision in 'happenings'; Outcomes. Casting from 'The Shadows' - the edges of Progression, Truth is hard to find firm evidence with such a long road ahead. Diversity of Proficiency matters, Natural Means and Technical Means delivering more Mutual Benefit or Mutual Dependence.

Technical Development is not sufficient to save Our Urban World from the forces limiting Our Future presence on this Planet. Just "look-up". Natural Development, from the Natural World, from its Wilderness-scapes is needed too. Resource versus Utilisation, is a tapestry best serviced & stewarded through Technical Means AND Natural Means. As found back in the 1800's Sustained Yield (Nachhaltigkeit, or 'Lastingness') from the 'forests' was important. Sustained Yield from the soil, land, estuaries, seas, oceans and in-space are now important -- our 'hope in hell' of achieving a Sustainable Future.

Global Sustainability is needed as not all of Humanity has the same Social Development opportunities, only exacerbated by an ever blooming Human Population. Those living today on the Tragedy of Front-Line need

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their Living Standards re-addressed. Regeneration in Natural World has a purpose – it is to replace the Natural Losses. Natural Regeneration is not for uncontrolled Growth, beyond the Natural Capacity and Natural Ecosystems Services; with Natural Development, a qualitative change of Nature Stock. Our Urban World Technical Means, 'Regenerative' (Technical Regeneration) is about leaving the 'working landscape' in a better state than the previous generation; more an aspiration full of Techno-Optimism.

Putting the Planet before Societal Prosperity is something Political Sustainability is now having to grasp as societal Awareness and Understanding builds from their shadows of Poor Political Governance competence. Citizens Agency is building. Citizen Assemblies being a good place to start addressing how Humanity re-addresses Human Population 'Growth'. Quality Full Education and Means are then needed. Followed by Local Community awareness. Regional and National Political Policy in the years to come, once Citizens Agency has built credibility. "Citizens decide, Government protects, Business respects, Academia creates".

The 'Covid Pandemic' has been an entrée, a 'taster' of further Human Population 'Growth' towards the 'main course'. The Natural Regenerative Limit of the Our Living Planet is approximately that of the Human Population around the 'time' of 365 ppm CO_2 in the atmosphere. Spacetime will, through Technical Means & Natural Means, point towards hopefully a grosser Human Population but Proficiency of our current Footsteps – Our Urban World is currently still on route towards continual Unsustainability. Nature & Climate is degrading too fast, 'look up' towards Our Nexus & the Natural Ecosystem.

Global Sustainability is more than just Economic Stewardship, it is about Ecology too; Social Stewardship and Environment Stewardship is not just for the betterment of People but for the Planet's Natural World too. Material Performance is needed, assessing and tracing Economic, Social and Environmental Impacts & Effects; Our FootPrints. Proficiency of Performance is also needed to ensure endurance towards the 'Ultimate Means' to achieve the 'Ultimate End'; True Sustainability, the next generation destination; Our FootSteps matter.

Can the Urban World & the Natural World Co-Exist? Human Development is defined as 'an evolutionary process in which the Human Capacity increases in terms of initiating new structures, coping with problems, adapting to continuous change, and striving purposefully and creatively to attain new goals'. A multi-dimensional process. Traditional societies are entangled by Norms, Beliefs and Values, which are hampering their Development. Therefore Sustainable Development is about Human Development – not Natural Development nor Nature Capacity (Stock) building. Therefore it does not seem surprising that Humanity advances at the Natural World's expense. So Sustainable Development is not Global Sustainability at all. Sustainable Development without the Natural World Ownership is 'One Directional' -- increasing Pollution, Emissions, Depletion of abundant Natural Resources, Waste and Loss of Biodiversity.

Once WE have sufficient Desire to move from the 'Current Horizon of Unsustainability' to the 'Future Horizon of Sustainability'; our (activities and) actions today, should not limit (opinions and) options open to future generations.

"The future is not written in stone, nor do we need to stand by helplessly as it unfolds. We all just have to think a little bit harder, and a little more creatively, to see opportunity."

Ultimately WE need to protect The Commons & Global Cover and The Markets & Capitalism; developing Inclusive Capitalism and delivering Social Needs; Society decide Government protect Business respect Academia create.

Foraging without a 'manual' means Engineering the Future will naturally rely on Succession & Stewardship. The new Post-Normal 'World' of 'Facts uncertain', 'Values in dispute', 'Stakes high', 'Decisions urgent' means Principles are the 'lighthouses' - where misaligned Values are poor 'maps' to follow, being 'in dispute' on the Current Horizon [Jerome Ravetz, Silvio Funtowicz (1990's) Post Normal World]. WE now have the set of Sustainability Principles.

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WE now have guiding Sustainability Practices and are trying to address the Custody Chain; 'Source to Storage'. WE should have a Social Oriented Business Purpose if operating under a Social License to Operate (SLO). WE lack the 'Ultimate Means to achieve the Ultimate End'; but have BluePrints cast from Succession. Stewardship is maturing – just lacking competence in Economic Stewardship, with Decision Making needing to embrace Valuing Everything cast under the roving 'eye' of Worthiness; Technical & Natural Intrinsic Resources. Sustainability is working with Perspectives; being a good judge needs just Common Sense. Priorities, enhancing Business Model for future Resiliency, need careful thought and strategy as 'Stakes are high' and 'Decisions urgent'. Proficiency of Performance are demonstrated by transparency of Motives, Motivation, Engagement and Progression; Group Motivation being a good sense of group Happiness – an internal 'spirit' driving Continual Innovation & Entrepreneurialism. Material Performance is only a Milestone; 'current tasks' for achieving Period Performance Understanding. Being Understood is the 'grail' to achieve hope that the 'Ultimate End' can be achieved in time; True Sustainability.

Engineering the Future: Recipe Book on Engineering Sustainability

This Series of 10 Sustainability Articles provide insights for Engineering the Future – a Recipe Book for 'Engineering Sustainability'. Those 'Recipes' per Article 'Sustainability Theme' have hopefully enlightened – highlighting 'shadowy' and 'mainstream' Sustainability Content particularly around Value Profit Planet – the big Transition Risks. Thoughts of Prosperity Healthiness Happiness which are so much more than just transitioning 'Self', 'Sector' or 'Species' -- where so much work-time is expensed in work-space, work-choices, and enduring to achieve future work-opportunities (Article 1). To engineer Building Capacity takes purpose-full, meaning-full mind-full 'Means towards Ends'. These 7 'memories' of Sustainability 'Contextual Content' will enable your 'recipes' to flourish too:

Sustainability Contextual Content {Recipe Book}

1. Sustainability is cast based on a Set of Principles and Guiding Practices [Stewardship (Ultimate Means to End), Citizenship (Conduct & Custom), Custodianship (Custody Chain), Guardianship (Protecting & Respecting)].

   Sustainability is made up of many 'Ps':

   Paradigms [Mental Models]
   Principles
   Practices [Stewardship, Citizenship, Custodianship, Guardianship]
   Priorities [Strategy]
   Purpose
   Perspectives [Technical, Political, Financial, (Natural)]
   Proficiency [Ability, Capability, Capacity]
   Performance [Material & Proficiency]

2. FootPrints FootSteps FootFalls matter – they are actually Sustainability 'Compounds'. FootSteps are Technical 'steps' impacting/effecting the balancing between Consumption & Capacity. FootFalls are People 'steps' impacting/effecting the balancing between Consumption & Capitals Stock. FootPrints are (Our Living) Planet 'steps' impacting/effecting the balancing between Capacity & Capitals Stock. FootPrints that matter are not just Industry Agriculture Energy impacting/effecting Sustainable Prosperity but are also from Primary Natural Phenomena (eg Volcanic activity) as well as the increasing threat of Vulnerability from human-induced Climate Supplemental Tipping Points. OUR Capacity & Capitals Stock at the 'end of the beginning' of Our Living Planet have never been so precarious in the history of Humankind.

3. Dimensions matter: Economic Stewardship (Sustained Value linked to Decision Making & Financing), Social Stewardship (Sustained Capacity linked to Performing & Withstanding), Environmental Stewardship (Sustained Conservation linked to the Urban World's Custody Chain 'Source to Storage'

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and the Natural World's 'Conserve to Harvest')

4. Perspectives matter: Technical Sustainability, Political Sustainability, Financial Sustainability; and now Natural Sustainability needing new Global Governance Systems to enter mainstream 'Sustainability'

5. Participation, Motives Motivation Engagement Progression will clarify and add transparency to Material Performance & Proficiency Performance

6. Need Respondibility as well as Responsibility & Adaptability – Working with Nature. The Performance Economy is made up of many 'Rs':

   Flows: Reduce, ReUse, ReCycle, ReMove, RePlace, ReDefine
   Stocks: Repair, ReNew, ReGenerate, ReHabilitate, ReManufacture / Refurbish, RePurpose
   Storage: Recovery
   Nature Stocks: ReGeneration, ReWilding, ReStoration, ReMediation, Recover, ReDefined

7. Wholeness matters: Governance (Enterprise Value to Full Value), Governess (Existence Value & Future Value; Speculative Resources & Prospective Resources); Worthiness (Opportunity Costs).

Moments of Truth (3) to (6)

(3) What "WE can Conserve – WE can Harvest" at a Sustainable Yield. Natural Sustainability is in the 'shadows' today, just needing Global Governance Systems to become mainstream.

(4) Custody Chain has 3 main touchstone Activities build from cornerstones of Proficiency, Valuing Everything, Decision Making, Financing (Figure 2):

a. Resource-to-Product

b. Consume-to-Recycle & Storage

c. Conserve-to-Harvest

(5) The big question being "Sustainability, why not?" There seems main reasons why 'Sustainability', 'coined' back in the early 1970's has fluttered, stuttered but still endured:

a. 'Features' are not Valued, therefore it has not helped Sustainable Development? being "a question" (Article 5). 'Sustainability' is a Value, "Sustainability Value" therefore is more than a 'Feature'. Those who have Understood this have caused 'Sustainability' to endure.

b. 'Disparate' & 'Fragmented' activities and actions form no or limited basis for comparison, nor cooperation. Lacking the context of 'The Resource' as the starting point, focusing on 'Exploitation & Extraction' – not Stewardship of those Resources from Source-to-Storage, through servicing & being good stewards, into the future and for the benefits of the current, next and future generation; has proved limiting.

c. 'Wishful Thinking', not practicing 'Integrated Thinking' & 'Systemic Thinking', has too long treated Our (Complex) Living Planet as linear or process, even circular processes, rather than Complex Systems with Dependencies and Interdependencies [Economies: Technical Political Financial Natural]. Too long has 'near enough' been deemed just 'good enough' Business or Governance – Local Community, Regional, Nationally and Globally. With the rise of Capitalist Society – Thinking is needed to

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achieve 'Wider Choices' in Decision Making, addressing Worthiness "Opportunity Costs" – Creating & Developing; New Possibilities; Consumption, Recycle & Storage; Conserving & Harvesting at Sustainable Yields.

d. 'Current Costs', not 'Full Costs'; 'working at the expense of others' has been driven by deemed "Good" (Business) Practice such as 'delivering at speed', 'just-in-time' manufacturing, 'lean' operations -- where Human Capital is provided at a fraction of the 'Total Costs'. Societal Scrutiny needs to be the roving 'eye' within Business Enterprise for 'Total Costs'. What WE do today Effects, Impacts the Future; such as the Regeneration Capacity of same core elements of Natural Capital – Nature Stock. Renewal – ReNew is not the same as ReGenerative - ReGeneration. 'Full Costs' to 'Total Cost' acceptance is a function of Societal Scrutiny. So the ability to present the benefits of current and future projects and activities externally is growing in both urgency and importance. Citizen Investors (Article 5) want to know what Business is "up to and how sustainable? -- their operations are".

e. 'Market Value' vs 'Total Value', for nearly forty '+' years, Subsurface Reservoir Engineers have been working in 'Sustainability' without realising it! WE have always thought of the Total Resource (HIIP) which we then use by applying appropriate Recovery Factors (%) to evaluate Current Recovery, guided by dynamic reservoir models to evaluate Ultimate Recovery, deemed 'full' economic recovery of Reserves. This is the same as Enterprise (Current Market) Value; Governance Value or Full (Market) Value; with Governess Value added on resulting in Total Value (Articles 4, 6, 8).

f. Lastly, 'Sustainable Development?' for endurance needs Governess as well as Governance; Integrated Thinking. A large proportion of Humanity is not in 'The Market' so not a part of Governance Value. They live, do work, have "Effect & Impact"; and often flourish within Governess Value. By miss-focusing on just 'The Market' Activities, Actions and Non-Action, is excluding where the Sustainability 'Umbrella Value' is definitely as much a part of the Total Intrinsic Value; the sum of Governance Value & Governess Values. Resource Enterprises need to keep the Citizen Investor and Market Investor full appraised of Speculative Resources (Existence Value) and Speculative Prospective and Prospective Resources (Future Value).

(6) "This is not a drill". The Climate & Nature 'Clock' is ticking… It is a 'Practical Necessity' for **Our Urban World** to link 'Manufacture Production Delivery' to 'Consumption, Recycle & Storage' [Custodianship], through the **Custody Chain**; and to Business to Respect the **Ring of Protection** and Society to honour the **Line of Respect** [Guardianship] for the **Natural World**; embryonic **Natural Sustainability** for **Our Living Planet**.

Sustainability is very much about 'P's and 'R's. **Proficiency & Resource** being a simple example from this Article. The **Age of Stone** & the **Age of Petroleum** being great periods of Humanity's **Creation & Exploitation** of **Our Living Planet**. The many few who have actually worked the latter know 'Our Age' could actually be technically penned as the **Age of Rock Porosity**, even the specialist tribes of Subsurface Engineers, who understand Resource **Stock & Flows**, actually technically penning it the **Age of Rock Permeability**; the **Hidden Commons** technically dominated by the **Permeability World** (penning as a true Specialist Engineer!). So these two great Ages were really about 'Creating & Developing' **Surface Rock Solids** & **Subsurface Rock Material Flows**; **Stock & Material Resources of Rocks**.

How to move from the **Great Organisations of Unsustainability** to the **Great Organisational of Sustainability** being the 'New Puzzle'; **Doing Right**, **Doing Good**, **Going Well**. The next main 'Recipe' Book. **Succession & Stewardship** will engineer the Future Horizon - the **Age of Sustainability**, which today at the 'end of the beginning' has demonstrated presence by the 's' of 'P' & 'R'; more than just pluralisation. **Blue Utility** will get **Our Living Planet** off the Current Horizon. Only then, will WE see the possibilities of the Future Horizon.

For those not used to **Creation**, the **Working Landscape of 'Exploration & Appraisal'** is very well practiced through the **Ages of Permeable Rocks** as is 'Competent' **Exploitation** and now the embryonic 'Proficient' **Stewardship**. This is not a leap of faith, but, simply continued steps along the same *spacetime* pathways.

The 'key' lies in stewarding & servicing **Wholeness**, tested through **Worthiness** which needs **Proficiency**, as **Fragmentation** only delivers the Current Horizon. **FootPrints FootSteps FootFalls** will all play their role – 'Recipes' matter. OUR activities & actions will continually add **Governance Value & Governess Value** when WE reach **True Sustainability** only then will "WE not limit the range of stewardship *options* open to future generations -- in the quest for Sustainability".

The Future Horizon is Complex, so lots of **Change & Opportunities** to build sustainable organisations; some will be 'greater' than others. My Grandfather worked 'life-long' for Mobil, whereas my 'life-journey' was working for Aramco, Exxon (Esso Petroleum), Shell, bp, ARCO, Phillips, ConocoPhillips, Nexen, CNRL, Kerr McGee, BG, Centrica, GdF, RWE, Addax, DONG, to lowly Taylor Woodrow Energy (plus the UK Government, Universities, an Investment Bank & the EU!).

All Petro-organisations having or had **Unsustained Capacity** except Aramco which has **Sustained Capacity** as long as Petroleum stays **Relevance** for the next 150 years, due to its unique **Working Landscape** of **Natural Resource**. The remaining rest will have to re-balance, re-architect, re-frame or 'burn like stars'. 'Creating & Developing' as witnessed over the last forty years, introduced lots of **Change & Opportunities** (EOR to IOR having my **HandPrints**) so nothing 'new' except now the transformation of the horizon at 'dawn'; at the dawn of the **Age of Sustainability** at the 'end of the beginning' of **Our Living Planet**.

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