ENERGY COLLAPSE

Understand why we are facing the greatest economic collapse in human history and how to survive it.

With over 600 predictions for the future of society, politics, economics, business and technology, our latest (2024) analysis gives you a complete understanding of the role energy has played in our past, our present and how it will affect all our futures.

2024 EDITION

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ABOUT

My name is Ken Ticehurst, I am an analyst and I'm obsessed with how the global economy works and what are the fundamental reasons we have become so civilised and technologically advanced, I have a background in Industrial Design and data analytics, along with a passion for the history of economics, technology and energy.

I have for over a decade been modelling financial assets and designing algorithms for traders and investors based on data, during this time I began to look at the effects of energy on the markets, the global economy and how crucial a role it plays in our technological civilisation.

I have been watching this energy crisis unfold for years, the Shale boom that is now faltering has given me more time to research the implications of how the world will look and behave in the future, who wins and who loses, how will we spend our time what sort of jobs and businesses are there.

My research has culminated in this book, which is intended to make the reader understand the civilisation they are living in, to view it through a different lens, to be able to understand the crucial role of energy in our progress as a civilisation. To also understand the huge changes that are coming to all of us over the next decades.

Our readers will be able to make better decisions and plans, navigate their way towards a different future than many are expecting. Most citizens feel this change already, costs are rising, living standards continue to decline, politics is becoming more unpredictable, the world is in increasing conflict, technology is bringing new challenges.

Change brings winners and losers, the only way to succeed is to embrace it and adapt to it, because it's coming whether we like it or not.

INTRODUCTION

Change is already here, the economic crisis of 2008 was as a result of the peak in conventional non-OPEC oil production in 2007, economic demand was boosted after 9/11 by lower interest rates but oil production was faltering and the price of oil rocketed causing a collapse in demand and in economic activity resulting in a rise in debt defaults triggering a financial crisis.

Oil then stayed above $100 dollars as demand began to return, but the global economy wallowed under the high price of oil, until non-conventional shale oil production in the US took off and the oil priced dropped sufficiently for economic activity to increase.

Fracking shale oil is not a triumph of ingenuity, although it is clever, it's a desperate attempt to extract less and less dense (useful) energy because we have used all the decent cheap deposits already. The problem is the once and done shale oil boom that got us out of the last hole is coming to an end, which means any attempt to increase demand will lead to sharply rising prices.

Today we are close to the peak in the Permian Basin the last great US Shale oil deposit and this means that global oil production conventional and non-conventional is going to begin its terminal decline over the next few years, to understand what this means, it's worth understanding the role energy plays in our civilisation.

We live in an age of outstanding prosperity, technology and enlightenment, we are at the peak of the greatest civilisation humanity has ever created.

We have today a fundamental belief in humanities continuous linear progress towards greater enlightenment and the belief that technology and pragmatism will solve all crises. The rate of technological progress for those alive today has been exponential, for those born one hundred years ago our progress has been nothing short of unprecedented.

From the telephone, television, the mass transport of the automobile, the jet engine, nuclear power, computers, rockets, space travel, the internet, artificial intelligence.

Not only do we have these landmark technologies, we have mass manufacturing continually reducing the cost of technology for the consumer, mass shipping through containerisation again reducing costs giving us the ability to continuously produce and move products faster and cheaper almost year on year.

We have also become better at extracting minerals and resources from the ground and manipulating these products to create more and more advanced materials with so many applications that enhance our lives, from plastics, to liquid fuels, semiconductors, carbon fibre and high tensile steel.

Advancements in agriculture, medicines, surgery, sanitation, an abundance of food, have all greatly reduced diseases, illness and famines. Life expectancy has increased hugely.

The global population has grown dramatically, whilst at the same time the birth rate has fallen across much of the world as populations have become wealthier and more secure.

The diesel engine, is today the backbone of global distribution systems, powering ships, trains, lorries. It powers the resources sector with excavators, trucks and a host of other mining equipment.

The jet engine has brought global mass transportation allowing the spread of people, ideas and technology that has driven the globalised world we live in today. The ability for an individual to be able to travel anywhere within in a matter of a day has driven the outsourcing of technology and manufacturing to developing nations.

The computer and the internet have transformed the ability of humanity to spread ideas, both good and bad, autocratic and democratic regimes, have become threatened by the ability to mass organise and disseminate ideology.

However, all of these advancements sit on the shoulder of fossil fuels, from the coal age of the Industrial revolution to the oil age we are in today, the power of our civilisation comes from our ability to harness external energy.

Deisel from crude oil stands at the pinnacle of our industrialised society, with its inevitable decline in production we will have to face the consequences, we can mitigate and conserve but as we will see later in this book the move towards green energy is in itself a fundamental and unprecedented move away from the increasing energy density we have always sought.

Without a constant supply of cheap energy our economic system falters debts become un payable as the economy contracts, 2008 was the start, there will be more contractions. The energy and resources required to transition to renewables and maintain our current lifestyles are just not there in sufficient quantities.

The resources sector - metals and minerals are also facing extraction limits of their own, renewables will require considerable amounts of metals and fossil fuel energy in their production to capture less dense less dependable wind and solar energy.

Politically we are living in an age of extreme technological and scientific complexity, but our politicians have almost no technical background, our ship is rudderless and headed for the rocks. We are too late for a strategic approach to the coming crises, that time has long since passed. We will react politically to events as they unfold always in a sense of crisis with no real understanding of the causes until it is too late.

Today we need to prepare for a different future, a future not of constant growth or abundance but one of less complexity a simplification of our economic and social structure.

In this book we aim to give you the tools and information you need to make the changes that will inevitably be forced on you in the future. We aren’t facing a dystopian world, but it will be different, our politics will probably make things worse and our financial system is not equipped to deal with the changes we have ahead.

PEAK OIL

The concept of peak oil was developed and modelled by M King Hubbard he correctly predicted the decline of US conventional oil in the 1970 as far back as the 1950's. He didn't predict the increase in production in non-conventional oil in the 2000s.

Today all the cheap energy is gone, there is still plenty of energy left but it's not as easy and cheap to extract as that which got us to this point. Every year that passes this fact will continue to drag on our economies and lives and every year it will become more and more obvious.

The remaining energy is less dense, less accessible more expensive to extract and refine. Much of it exists in politically unstable regions of the world that are about to have their own population and energy consumption booms. This will reduce the global exports of available dense energy.

We have we have already begun the energy decline; we have exploited the best, most accessible, most abundant energy deposits.

The peak of oil discoveries was in the 1960's since then discoveries have trickled to a fraction of those finds. Conventional oil production has already peaked and non-conventional is more than likely about to peak.

Today we consume more than four times the oil we discover every year. We peaked in global conventional oil production in 2016, even if OPEC increased its production to its theoretical if unlikely maximum capacity, we would not be able to regain this peak output.

Between 2016 and 2023 US non-conventional shale production accounted for 85% of non-OPEC supply growth, the Bakken and Eagle Ford shale fields peaked in 2015 leaving the Permian Basin as the single source of oil supply growth globally, with all conventional oil supply contracting the world needs the Permian Basin to continue to increase its output.

Global oil demand shows no sign of abating, continuing demand and limiting supply lead OECD countries to release supplies from their strategic reserves after the Russia Ukraine conflict saw sharp price rises, this is unsustainable in the long term and most of these reserves may never be replenished.

From now on just six counties in West Texas must meet all global oil demand growth

The Permian Basin is depleting faster than many of us thought, and it is likely that this year 2024 it will begin its decline in output, this is potentially a dramatic event in the oil age and it will more than likely create an event similar to 2008 financial crisis, within a few years

Productivity per well is already peaking in the Permian Basin, in order for the entire basin to continue to grow its output, more wells are needed, this is the first sign of exhaustion of a field, it means the best wells have been exhausted, basin wide output decline is more than likely to follow reasonably quickly.

This is high grading whereby tier 1 assets are drilled before tier 2 assets, it is likely that the Permian Basin has had most of its best wells depleted and only the less good wells remain if this is so and it seems most likely then a rapid decline in output remains a distinct possibility, this could begin to occur in the next 12 months

If we are correct the Shale growth phenomena is behind us and global peak oil production is here, with no growing fields in either conventional or non-conventional OPEC or non-OPEC left we must face the beginning of the end of the oil age.

IMPLICATIONS

As we will reference throughout this book, the result of peak oil will not be pretty for most, lower standard of living, less economic activity and less wealth and consumption.

The way we do things will change the way we think and our day-to-day activities will also be altered, but these changes will come over time not all at once. A series of economic shocks, 2008 was the first energy shock, will alter our economies, we will have periods of calm, some mini booms and then periods of economic disruption.

Our energy needs will be more and more dictated by the Middle East and Russia, our political system is not equipped to deal with the end of the age of abundance, our economic and financial system will need to deleverage, huge piles of debt will unpayable as the size of the economy begins to shrink.

Social and political disruption will intensify as we alter our expectations about the future, the way we do things will change and many of the old complex systems will eventually fail, the end of globailsation, the decline of the multinational and the renaissance of the small business will bring enormous opportunities as well.

Change is always difficult for some and brings opportunities for others, the implications of peak oil means that adapting to change is the only solution to facing the inevitable consequences of the end of cheap oil.

There is still plenty of oil left but its just not as good or as cheap to produce, as we face oil shocks and high prices these deposits will be exploited but the overall trajectory is down, more energy will be required to extract what is left, leaving less to be available for demand.

Our job now is to grasp the situation, to understand the complex nature of our relationship with energy now and in the past and then to model the future looking at the most likely scenarios for how we react economically, technologically and as producers and consumers to this crisis.

THE DEBT BUBBLE

The era of abundant low-cost energy has applied positive leverage to the discretionary side of our economies asset prices, consumption and production etc. Cheap energy has driven prosperity higher at the same time as holding down the cost of necessities such as food and water.

This has created large surpluses especially in industrialised economies which has aided the process of financialisaton and mass consumption. We have though an enormous problem in the global economy huge levels of debt are not compatible with a declining economy.

A wave of defaults must occur either by outright defaults or by inflation, most Sovereign nations will face a debt crisis as receipts from economic activity decline and spending on welfare increases, large corporations, local governments and businesses and private individuals with excessive leverage and a decline in income.

Our financial system is designed for growth, debt is a claim on future economic activity and interest on growing future economic activity, for debt to increase and be serviced and repaid benign conditions must be met with an ever-expanding economy.

The only way to make the value of debt worthless is to make the currency it is monetised in worth even less, inflation is always the preferred method at least to begin with.

it is likely that as we pass peak and assuming demand is still robust then we will have a price spike leading to inflation and an economic slowdown.

The decline in output will start slowly and accelerate over the rest of this decade, we have at least until 2025/26 before this is front and centre of all our minds, for now it will go unnoticed. So precarious is the financial system with elevated levels of debt and normalised interest rates that it is hard to know if we get an oil spike over the next year to kill demand or if demand will be destroyed by a financial crisis first.

The debt crisis of 2008 has been dealt with by even more debt and low interest rates encouraged it. this was in small part as a result of the Sale boom driving the oil price well below $100 where it had been for some time and was acting as an anchor on the global economy, this lead to the growth spurt in the global economy particularly asset prices up until recently.

The opening of the rest of the world and then later China after Covid caused a surge in demand for energy, added to that the Russia Ukraine conflict caused a sharp rise in the price of oil and Natural Gas, this has concentrated minds in Governments around energy security, but much of this is too late.

The prices of oil and natural gas will continue to become even more volatile and this will mirror much of our economic conditions, the threat to all of us is how the financial economy copes with the stresses of deleveraging ither by defaults or by inflation, our businesses, jobs and investments will be affected by this dynamic as it plays out over the next decades.

This book will help you now to be ready for the future.

THE FUTURE

We attempt to create for you the reader a broad-brush approach to the future, how we behave, what we consume how we organise our lives in the age of peak oil, we believe that because of the crucial role that oil plays in our modern technological society that a decline in output will have serious implications for our futures.

The future is not linear we have for too long believed in finite growth but it is not possible, so the question is what does the world look like in the future what sort of businesses will do well, what are the careers that will be thriving, how do we embrace post consumption.

We hope that at the end of this book you have a deeper understanding of the past the present and the future, and instead of being a victim of circumstance you can begin to see ways of adapting to the future.

Our frameworks for survival, explain in detail many ways in which there are opportunities to adapt and create new businesses or adapt your skills and increase your use to society. Some things we are good at now won't be useful in the future.

The trick with change is to anticipate it, understand it and to be able to adapt quickly when it comes, this book will help you do just that.

SIGN POSTS

We have already begun the decline the financial crisis of 2008 was as a result of peak non OPEC oil production, since then we have begun to change, things have never been the same since then, for a start the volatility in the price of oil has increased considerably.

So in order for a society to adapt over time to a significant change in its economic output we should begin to see changes already and we believe there is already plenty of evidence that a systemic change is underway all of which will be discussed in much greater detail in the chapters ahead.

Along the way there are many and varied sign posts to show you how society is beginning to fracture from behaviours to the built environment.

- Prices for essential goods begin to rise and rarely fall back.
- Deeper and more frequent economic shocks, bouts of inflation, each one worse than the one before.
- Energy prices become more and more volatile.
- Increasing geo political tensions specially around resource countries like the Middle East and Russia.
- Road infrastructure begins to decline, maintenance becomes an increasing burden.
- Less and less cars on the road, this is already happening with new car sales in the west and much of the world including China declining.
- Over time more and more cars will break and their owners will be unable to repair them either due to cost or getting spare parts. As the fleet gets older the reliability decreases.
- Large corporations begin to fail, economies of scale fail in a declining economy.
- Supermarket shelves become more sparse as stocks deplete either financial or physical.
- The roll out of larger supermarkets and chains grinds to a halt.
- Companies especially energy companies start to devour their competition as the only way to increase reserves.
- Hedges lawns and municipal spaces stop being cared for trees begin to obstruct highways and foot paths power grids are disrupted as overhead cables are broken by green growth.
- Intergenerational living makes a comeback as the costs of sparse living hit home. Fuel energy and food bills become unaffordable along with rent.
- Children increasingly don’t leave home as they move through their twenties and into their thirties.
- Further education applications begin to decline as it becomes obvious less higher forms of education are required in a less complex economy.
- Gold makes a come back as a store of value for investors.
- Construction and infrastructure projects get shelved.
- More high street shops are boarded up especially non essentials.
- Political instability increases, Trump, Brexit and an increase in nationalism.
- Debt defaults start to occur

FRAMEWORKS FOR SURVIVAL

In the following chapters we have many predictions for the future and we set out not only the history of our rise to a complex civilisation but the science and physics of our current predicament

Not only is this a self-help book but it is also a book that should demonstrate the huge predicament we are facing as a society, it's a history and science book along with current affairs.

But it is important to concentrate on some of the ways in which being forewarned is forearmed.

We attempt to create a framework for surviving and thriving in a post abundant world, we hope to convince you that energy is the key to every part of our current complexity and our technological progress.

We hope you will realise that without sufficient energy technological progress cannot continue.

So, we must create a framework for living in a reversing decomplexifying world a world post consumption post growth sounds like a nightmare and to many it will be but it can also bring a profound change in how we deal with each other.

It doesn't have to be all bad or a dystopian nightmare it's up to us how we deal with it. The irony is that many of the aspects of this decline will be manageable for most individuals but bad for the collective economy.

We can all travel less, eat less, consume less, own less without too much trouble but for the economy as a collective it could be a disaster. Surviving and thriving means being necessary useful and adaptable.

As the economy collapses back in on itself you will become more important to your friends and society if you have skills energy and the optimism to be able to overcome adversity.

HIERARCHY OF NEEDS

Food, water, sanitation, energy, heat, and shelter are the basic bottom of the pyramid of needs, everything afterwards is discretionary. This is important to keep in mind that you must be working towards securing these necessities and also ensuring that your income is based around these basic necessities rather than in a more discretionary sector of the economy.

Today the internet is a new addition to our hierarchy of needs, it is a pathway towards a new low consumption economy, digital information and entertainment kept most sane during the lockdowns it is likely that maintaining an internet in most industrialised societies is a necessity for continued economic activity. Pre internet might as well be the stone age now for us.

DISCRETIONARY

The discretionary sector of the economy will shrink considerably, and will probably alter in its composition, we will spend less on our houses, less on cars, we will spend more on clothes but have less of them, we may end up eating out at more affordable restaurants.

CONSUMPTION

Being superfluous or discretionary, profligate and high maintenance is likely to be an even worse trait in the future than it probably is already. Notwithstanding that as people become poorer, they are more likely to become more antagonistic towards the wealthy and those that flaunt it.

Being happy with less will be a key to surviving the phycological trauma of watching an economic system that for so long promised so much slowly decline and fail to meet the expectations it had promised.

It is always easier to make an informed decision to change one's behaviour and outlook than have it forced upon you, it's better to make a conscious decision to change than have it forced upon you, time allows you to

The age of abundance is over and so it is important to you that you can adapt a frugal mindset and train yourself to live with only the things you actually need.

Having frugalism forced upon you means you are unprepared and you don't understand what is necessary and what is superfluous.

It is better to learn and adapt with a decent enough timeframe, it gives you time to make mistakes and experiment with the many aspects of food, shelter and services.

FINANCIAL STRESS TEST

To assume that your economic circumstances will always be benign is the road to ruin, you must constantly manage your finances and assume the worst outcome is just around the corner.

After many bailouts over the last few years there will come a point when the state will be unable to bail everyone out, it is the inevitable outcome of constant deficits that eventually it will fail.

Income, expenses and savings how long can you maintain your own deficit?

Savings have been a thing of the past especially with low interest rates, and we wouldn't recommend saving in a paper currency.

FITNESS

As we head over the energy cliff, we will see a shift away from capital and money back to labour. The energy embodied in fossil fuels cannot be replicated with renewables and so our economic system will need to contract.

Many of the things we take for granted will be unobtainable in the future basic skills will require more physical labour and so it is essential to be able to do a hard day's work in return for food and energy.

Fortunately, the bar is set pretty low at the moment the physical fitness of the majority of our citizens is abominable especially in the developed world and so anything you can do to get ahead of the majority will be to you advantage.

Lift weights and increase your cardio work as soon as you can join a gym, they are pretty cheap these days. Not only will you increase your strength and stamina but also your mental health.

It is difficult to comprehend a collapse in the economic circumstances of your friend's society and families but it is inevitable and so you need to enhance your mental health.

Exercise is an excellent way to overcome mental health problems and give you a sense that you are enhancing your ability to process and overcome the future.

Do weights much of the difficult things require strength first and stamina second carrying food energy or water over distances requires strength first.

Cardio work is important but strength tops it in most circumstances.

DIET

The first thing you need to do is learn to cook from basis ingredients learn to make and use stocks learn your spices and your herbs they can turn boring food into super tasty food.

Eat clean avoid all processed foods not only are they expensive they are full of rubbish that shouldn't be going near your gut.

As we descend over the energy cliff many of these processed foods will become unavailable as complex factories become unviable and start to fail due to difficulties sourcing energy and parts to run the processing facilities.

An ability to make great tasting food from simple ingredients is a survival skill at the very top of the hierarchy of needs.

Being able to feed yourself, your friends, family and community is a super power in an energy deficient world. Communal cooking saves energy compared to solitary cooking.

A diet that is largely plant based will become the norm within a few decades if not sooner partly as a consequence of energy issues but largely as governments tax farmed animal products.

The transition to plant based is not easy it requires a fundamental understanding of many ingredients plants herbs and spices traditional experienced chefs struggle with this transition so you will need much more time than you realise.

As much as you may love meat it will become more unaffordable and so you need to start the transition early.

Beans, pulses fruit and vegetables can be turned into healthy tasty meals but it requires skill and expertise you need to gain this knowledge quickly.

If you wait until you are forced to change you will have a miserable experience it is better to make the change slowly and without the pressures of feeding your family with a set of ingredients you are unfamiliar with.

SKILLS

Have a skill or skills that are transferable especially in growing or cooking food. As the cost of food and energy explode so being able to make something out of nothing will become invaluable.

Mending fixing machines and shelter is a top skill to have. Try to learn to use simple hand tools and a bit of muscle rather than relying on power tools for everything.

As we head over the energy cliff energy will aften be unreliable so an ability to crry out your work or skill absent of energy will be invaluable.

Think of the great boats and building that were built before the industrial revolution most of these skills have been lost but can be recovered with some application and some grit.

GOLD

The prime means of saving is in gold which has been money for thousands of years, it cannot be printed by central banks in fact it's the only real asset that every central bank has in their vaults.

Before paper money gold along with silver was money. Once we headed up the energy density ladder and economic activity kept growing gold became obsolete as a medium of exchange.

Oil became the ultimate store of value and paper currencies were able to expand at a similar rate to the new fossil fuel powered economy, that allowed money to change from being a store of value to a medium of exchange it in effect it became a medium of exchange.

You must have a minimum of six months of savings in a variety of assets with some cash and precious metals.

DIAMONDS

HOARDING

Next hoarding of alcohol, nicotine, medicine, anything associated with addiction or lifesaving goods. Shares in companies providing these services will allow a greater absorption of money and require less physical hoarding

Seeds, along with food are also a good way of maintaining purchasing power by owning goods with value or utility.

Woods and wood, coal or gas supplies are also highly desirable and provide utility.

Base metals, copper, steel and goods that will be used on the other side of the economic crisis.

Rarity is always a better bet than paper money which can be created at will, art and real estate will still lose value in real terms but will still go up in value relative to paper money.

Technology, spare parts mother boards, processors car parts are all better than cash during a currency collapse.

Long dated foods especially with high calories, tinned meats, high sugar content and low moisture

Nappies sanitary pads, soaps, shampoos etc. Non-perishable goods.

SOCIETY

Relying not on wealth but on community is not all bad and many of the dystopian versions do not have to happen the world could be a nicer place if we want

The rise of the energy dense coal and oil ages brought many profound changes not least was the disintegration of the family unit. Transportation allowed mass migration and opportunity for travel and living abroad all of which have had positive effects but it has reduced the importance of the family unit for good or bad.

This will change as energy becomes increasingly scarce and opportunity diminishes so families may well stay closer together and be less inclined to operate across many countries and continents.

Immigration will become less desirable for energy poor countries and hostility will grow between natives and economic migrants all struggling to share diminishing resources.

Households will become more dense again as costs of essentials rise so sharing will become more acceptable and economically more practical.

Greater complexity has brought more financialisation which has allowed for many in the west to be comfortable and rich in financial claims such as assets bonds pensions and savings.

Put simply if you have money you don't have to be nice to people you just pay them to get them to do what you want. But when those claims are no longer worth the paper, they written on then the nature of wealth changes

In energy deficient societies being nice is a prerequisite skill to survival if you have no wealth then you need to cooperate with your friends' neighbours and family to survive. They need to like you to help you or at least you need a skill they deem necessary and important to their own survival.

Society will have to change and reverse many of its modern tendencies for individualism which are a consequence of energy intensity and the complexity it brings.

The family home will become more intergenerational this trend has been developing for some time already but has more to do with the financialisation and hording of shelter for profit than the increasing cost of heating the property.

TRANSPORTATION

The demise of the car as a mass mode of transit is also part of the move away from individualism that to has already begun, this trend is also underway in most of the world as demand for new cars peaked a few years ago.

For those who have experience of living in an energy starved society the bus coach, mini bus and the taxi are dominant means of transportation often the mini bus.

The other aspect to note is the degradation of the road infrastructure system roads require constant and costly maintenance and over time if not looked after can very quickly fall into disrepair.

This then starts to degrade the fleet of motor vehicles punctures and shock absorbers are the first casualties. So even though the number of vehicles on the roads drop there is still plenty of repair work that needs to be undertaken.

Poorly maintained roads can increase fuel consumption in many instances. The greatest problems come with motorways or high-speed long-distance sections that become dangerous if poorly maintained. So, unless well maintained they cease to be of any use and will be the first casualties of a declining road network.

Railways will be maintained as they are generally a city centre to city centre infrastructure and supersede the car. Like peeling back an onion the older the technology the more resilient it is likely to be. The railway system in the developed economies goes back pre-oil age and so will survive.

Airports will dwindle in size and importance as the number of journeys remorselessly declines. Aviation will become exclusive and probably more dangerous as declining investment in design and maintenance leads to older and older fleets of aircraft running.

Investment in energy intensive infrastructure is likely to be a recurring theme aviation is at the forefront of this decline in safety critical infrastructure investment not least because much aviation is frivolous and lies outside of the non-discretionary sector

RELOCATION

Not all cities and regions are created equal, it is likely that the Northern Hemisphere cities will be seen as more desirable in terms of law and order and resilience to extreme weather events, proximity to energy and commodities are also important in factoring in the safest most resilient regions or cities.

NECESSITIES FOOD

It will surprise many but energy density inside the home has led to much more food consumption within our homes than in the past. Big domestic expensive kitchens are a relatively new phenomenon requiring lots of energy to operate and maintain.

Modern domestic kitchens are capital intensive infrastructure and as such we tend to use them more than less energy dense societies who tend to cook and eat regular meals in a more collective setting.

Energy scarcity actually makes restaurants and cafes more efficient places for the collective process of making food not only the sharing of energy bills but the infrastructure costs are spread over so may more households than just the one.

Ironically over the last few decades as the cost of food has plummeted in developed nations the restaurant industry has had to impart considerably more labour and complexity into each dish to justify its prices.

As the cost of food rises there will be less need for such inputs. The rock star chef will give way to far more simple restaurants but whose meals represent a greater share of the consumers take home pay.

Put simply as the cost of food rises so its complexity will have to decline or it will be completely unaffordable. As the cost of food rises as a share of the customers pay so the restaurants need less customers to survive and or less margin per customer to make a profit.

WHITE GOODS

Fridges, freezers washing machines, tumble dryers will decline in demand and also face the decline in economies of scale, overtime laundrettes will make a comeback as they are able to offer economies of scale and have an economic incentive to pay the upfront capital costs required to run an industrial process.

Collective laundrettes will make a comeback as they will have economies of scale and as energy consumes a larger share of take-home pay, they will be able to make significant savings.

BUSINESS

Needs over wants has to be the goal for most if not all aspiring business owners as discussed above food represents a need and once the basic understanding of the maths is undertaken there is plenty of scope for business to adapt and to thrive.

Discretionary businesses will not disappear just as the wealthy wont all disappear, so there are still opportunities for indulgence but there will be considerably less. Think faberge eggs the super-rich will still demand exclusivity and will continue to be patrons for the most talented of individuals.

The outward display of wealth will decline own a supercar by all means but be very discrete about where you drive it. The same with expensive watches – over time this will end the desire for these products as the whole point of having them is so others can see you have them.

We may see the re-emergence of super expensive furniture hidden away from all but guests think Faberge and Chippendale not Ferrari and Rolex. Think expensive toys at home and not on display.

COMPONENTS

Repairs and spares will be a boom for business as less gets thrown away and replaced make do and mend.

Rapid prototyping and one-off parts construction could make a comeback essentially an artisanal approach to certain components.

As the effects of decomplexification and diminishing scales of production become better understood hoarding of components is likely to be a good investment.

CLOTHING

Fashion will decline fast fashion will cease to exist most clothing over time will be darker as it stains less and can be left longer between washes. Washing clothing is an energy intensive process light and white clothing will become the preserve of the wealthy and for special occasions for the rest.

Lower volumes and higher relative prices allow for more artisanal and local manufacturing of garments seamstress and garment manufacturing skills will be a key competence again in each country.

Clothing will become more expensive and as volumes fall and consumers begin to buy less the quality will likely improve.

Large retailers will start to close and smaller retailers will re-emerge possibly specialist in one area say jeans or shirts rather than the whole wardrobe. As mega factories cease and more artisanal local suppliers emerge this will hamper the business models of large corporations.

Department stores may make a comeback but with a distinctly more local flavour

Bulk shipping of fabric is more efficient than bulk shipping of clothing so represents the least energy intensive means of moving textiles globally. Higher garments costs mean higher wages for local skilled producers

Clothing repair skills will increase being able to use or owning a sewing machine will be a good investment. Over time more and more people will be able to repair their own clothes or adapt garments.

WATER

As scarcity has been a problem in many parts of the world even during the energy ascent it will continue to be a problem for billions.

For much of the developed world this service will be nationalised and rationed infrastructure spending will be a key component of the service.

For those economies with extensive infrastructure rationing will be enforced where the infrastructure is in disrepair throughout the use of stand pipes.

The state will nationalise all utilities as we become less energy intensive. Water thirsty businesses will look to private contractors to fulfil supply when there are infrastructure failures.

De centralised water storage and distribution systems will be known as water hoards but will provide a vital function mainly for water intensive businesses.

COMMUNICATIONS

The mobile 5g networks and fibre optic networks will be nationalised in most countries over the coming decades so vital has it become that it now ranks only behind food energy and water

The systemic nature of modern communications means they are even vital for the more noble services food water energy in terms of logistics etc.

Laptop, mobile phone chips servers all it infrastructure and consumables will be horded and will be far more intensively recycled and repaired.

Manufacturers will be faced with declining economies of scale and will likely have to either reduce the complexity of their technology or and increase the longevity of the products they manufacture.

The internet of things is never likely to be a thing for most of us because the rise of things is a consequence of energy density availability and generating surpluses. Things are going to get more expensive

ELECTRICITY

As we move forwards, we are going to see intermittency and blackouts accelerate it will become more normal than we would want. It is a feature of low energy density economies but it is survivable.

Backup power generation using diesel will be for the well organised and well-funded for the rest of us we will have to adapt to non-functioning payment systems just at the point where they have become and endemic and critical part of business transactions.

Lower energy dense countries cope with blackouts because they still use paper money and coins for payment developed economies with digital systems will be more at risk from blackouts than these less advanced economies.

FARMING

We will see peak farming in the next decade as livestock husbandry begins to decline, arable crops will be eaten at source by humans and not diverted inefficiently to livestock as is the case now.

This will lead to volatility in the meat markets large culls push supply above demand suppressing prices and then supply falls below demand and prices accelerate again.

Refrigeration systems are no longer needed in such quantities land becomes un grazed and the countryside and agricultural belts begin to change across the globe.

Rewilding will occur as acre after acre falls fallow and there is no need for the land to be productive and maintaining it becomes too expensive.

Politicians are already in the process of pushing this change in the face of climate change but in reality, the decline in energy density will hasten this process.

Backyard farming will replace large scale agriculture in as much as allotment style fruit and veg agriculture will replace the lawn mower and manicured garden over time.

We are likely to see domestic gardens turned over to some form of food farming horticulture will give way to agriculture.

Grains will be the sole preserve of industrial agriculture in the future.

REAL ESTATE

As surpluses grew and economies became financialised assets such as real estate rose in a corelation with the fall of non-discretionary such as energy and food.

A greater surplus was re lent by banks to citizens to outbid each other on real estate as prices rose hording began further restricting the supply.

This dynamic will play out in the non-discretionary – essentials markets as they too rise in value.

As the costs of building products fell so the value of land rose.

Once an economy is unable to produce a surplus then eventually the financial system begins to fail especially if it is heavily indebted asset prices are no longer buoyed by increasing levels of credit and debt.

Debtors struggling to pay for the cost of essentials begin to default on their financial liabilities rather than go hungry as asset prices fall it is a double-edged sword as the ability to be able to buy a house falls within the reach of many more citizens but the ability to service the running costs - heating, electricity water services and food become a greater burden.

Overtime the housing stock begins to deteriorate as multi-generational occupation reduces demand and real estate starts becoming a liability to own rather than an asset. Maintenance costs become more difficult to service.

Large houses become the preserve of only the super-rich small houses become more in demand. Larger houses get partitioned in to smaller more efficient dwellings.

Large cities fare worse in the energy collapse, downsizing reduces demand for rental properties and larger properties, the countryside becomes more attractive but transportation issues limit its economic potential to those who have access to land to cultivate.

Many landlords are affected as tenants walk without paying up, rentals tend to lose purchasing power relative to other stuff like food.

Taxes can increase on second homes and on landlords as governments seek higher income streams. The winners in the previous boom are losers in the economic crisis that follows.

HIGH STREETS

A slow demise in the corporate high street and an increase in independent retailers offering less generic more specific products, food, clothing being the two most prominent.

Food outlets become less generic and are owned by locals sourced more locally higher prices for food means lower turnover required for profitability and hence more outlets.

MEDICINE & HEALTHCARE

Already struggling services will be stretched even further but conversely many diet and lifestyle related illnesses will begin to disappear as the costs of calories and the ability to become obese fall away from all but the richest.

Diagnostic machinery and technology and the potential for genetic technology may also arrive in time to negate much of the negative effects of a decline in energy density and availability.

JOBS AND CAREERS

A decline in the discretionary sector will affect many types of jobs and careers as consumers are forced to choose how they spend their money vast swathes of economies will decline but conversely there will be more economic activity in the non-discretionary sector.

As diseconomies of scale kick in less products need to be manufactured or sold to make ends meet less profit will flow to shareholders and more will stay with the workers at the coal face. Less layers of management and bureaucracy will exist.

Profits will stay within communities rather than move towards centralised corporations' economic activity will be more vibrant at a local level and more catastrophic at a corporate and macro level.

Shareholders and bureaucrats will be the hardest hits as diseconomies of scale alter the jobs market. Entrepreneurship will be reinvigorated at the expense of corporate capital.

SKILLS

As we climbed the energy density ladder complexity increased the variety of potential jobs available this will go into reverse

Skills that meet the hierarchy of needs will be in demand. Labour will be more valued than management or intellect-based jobs the geek suffers.

The ability to do hard work or have practical skills such as mechanical or it repair will be in demand.

Exercise

Being fit, get fit keep in shape and be able to compete for physical work from growing food to construction.

600 PREDICTIONS

Plenty of the predictions in this book will be wrong but many will be right, all are possible and some very likely. There are conflicting predictions for which i make no apology.

For many predictions there are realistic opportunities for businesses and investors to capitalise from technological, social, economic or political changes.

This book is intended to make the reader think about big things and not the small things that litter our everyday lives, careers and businesses.

If this book makes you think about the world differently and helps you make better decisions then it will have achieved its goal.

There is no time scale given for any predictions. Nor are they in chronological order. Nor is any preference given to any particular prediction or outcome.

Many of the events forecast here have already started but remain unnoticed by the majority of citizens. It is only as trends strengthen and become pervasive that the vast majority notice something has changed.

Each prediction should be taken on its own merit rather than as part of a grand overall vision. Many of the events forecast here will occur but the order these events take place is beyond the scope of this book.

K Ticehurst

Author

1. There will be a slow grinding decline in the availability of fossil fuels and many other commodities. The energy costs of extracting these resources increases as their density declines. This will weigh more and more heavily on advanced economies. The discoveries of new energy and mineral deposits has been decreasing for decades. The depleted output from mines will become more valuable over time, mining shares are likely to experience increasing volatility.

2. A commodity super cycle will dominate the next few decades. Depleted resources mean one by one the supply of energy and minerals such as oil, indium, platinum rare earth minerals will be from less dense less predictable sources.

3. Economies used to cheap constant supplies of energy and materials will begin to stagnate and wealth and economic activity go into reverse. For many minerals the ore hardness is increasing meaning they are found in harder rocks requiring far greater energy to extract and process. This trend has been and will continue to accelerate this century. Gold miners can act as both an inflation hedge and resource depletion hedge. The jurisdiction of the miner is as important as the quality of gold in the ground.

4. The ore grades of mines and wells will continue to decline precipitously over the coming decades. Technological developments can mitigate this phenomenon for a period but even technology will be unable to make progress in the not-too-distant future. We will need to find more deposits, explorers and miners will require more investment. Technological improvements tend to speed up extraction, rather than increase overall quantity extracted.

5. Eroei (energy returned on energy instead) for oil continues to decline, this means an accelerating cost of extracting energy, and at the same time a need for even more energy to extract metals and minerals.

6. Higher energy prices will be the prime catalyst for persistent inflation, it will drive labour costs higher in much the same way as cheap energy drove them lower.

7. As wealthy economies attempt to transition from fossil fuels to renewables and maintain growth and a high standard of living and consumption, they will spark a sharp rise in the demand of fossil fuel energy itself.

8. It will become increasingly apparent that transitioning to renewables will itself require a huge increase in the volume of scarce resources and an enormous increase in demand for fossil fuels to manufacture these green technologies

9. The dash to renewables is hampered by a shortage of rare earth minerals from China, and bottlenecks in many resources global mineral exploration will need to intensify.

10. An explosion in rigs and in exploration. Recycling technologies for rare earth minerals big business. The oceans will be used as a major source in the coming decades as we attempt to reduce our dependency on the Chinese.

11. This additional demand to an already tight energy market will drive commodity prices higher. Further exacerbating the cost of essentials for citizens reducing the demand for discretionary spending and further reducing the size of the economy - stagflation.

12. Periodic spikes in energy prices will bring economic contractions shortly afterwards. As commodity prices rise exploration companies will become attractive speculative plays.

13. As the energy density of fossil fuels declines so the productivity of some forms of agriculture declines. Less pesticides and fertilisers available at much higher prices reduces the output of crops at the same time as the inputs are rising steeply.

14. Pesticides have prevented agricultural calamities like the Irish potato famine from happening over the last century, but they represent a blunt tool as they target both unhelpful and useful insects. The insect genocide will have a profound effect on the entire food chain over the coming decades.

15. Vital phosphate production from Morocco could be disrupted if a sustained Arab spring evolves in its youthful population. A large part of the world's phosphate lies within the western Sahara conflict zone.

16. Global synthetic fertilizer (nitrogen, phosphate and potash) and natural gas markets become more volatile over time putting tremendous pressure on global agricultural output. You need natural gas to produce ammonia and you need energy from fossil fuels to mine for phosphate. You need ammonia and phosphate to make fertilizer. You need fertilizer to grow food at scale. You need food to keep the peace.

17. The recycling of minerals from our technology (e-waste) will grow rapidly over the coming decades. Sewage will become a major source of minerals recycling and water extraction. Water management becomes a key technology in most economies large scale infrastructure

18. E-waste is recycled using green chemistry microbes iron, copper, aluminum and gold are extracted. Landfills become economically viable sources of mineral extraction.

19. Some countries and regions will benefit greatly from resource entropy as their deposits grow in value and utility. Low density populations with large mineral deposits, Canada, Australia, Kazakhstan, south Africa.

20. Politics is dead but most people don't realise it until it is too late. Modern political theory was borne from the move away from land at the start of the industrial revolution, as we exploited more dense forms of energy. Factory work, overcrowded cities, pollution, created unions and labour movements. Vast populations involved in industrial labour. Modern technology makes these political arguments redundant.

21. Western democracies begin to fail politically and economically, decades of excessive benevolence has helped create bloated private and public oligarchies. Governments have become such a large share of the economy that corporate control of government spending is more lucrative than competing in a free market.

22. Corruption continues to grow as government deficits increase, as the states' share of the economy increases politicians and civil servants fall prey to increasing temptation from large financial entities.

23. Laws become increasingly controlled by the interests of large corporations or government agencies. Central banks print more money and most of it ends up in the hands of a small minority, including law makers.

24. Politicians become hostage to events, like two sides fighting over the steering wheel on a fast-moving train but refusing to use the brakes. Both sides making promises to voters they cannot keep. Politics will make our problems worse not better.

25. Western - especially European politics will become increasingly divisive between working class somewhere vs the mobile educated global anywhere. The main division will center around the need for immigration to keep populations rising to fund welfare, social care, past debts and the infrastructure required by a developed nation. Those able to control labour especially skilled will have considerable power again.

26. As nationalism grows in politics multinational corporations move from a more conservative political bias towards the political left in an unnatural alliance with globalist internationalist ideology.

27. The ideology of international socialism becomes a perfect fit for multinational corporations who thrive on less borders increased freedom of movement. Greater concentrations of political power make economic sense for large multinationals seeking to lobby for law and tax exemptions.

28. The pandemic has begun a shift away from commuting and city centre office work. Less physical and social contact means less groupthink, less political and economic concentration in the centre.

29. More workers live further away from cities and visit them less, spending more time in the regions. The collective dynamic begun during the industrial revolution may reverse.

30. Cities have and will always be cultural and political melting pots the driving centres of political activism but this force will decline over time.

31. Politicians will prove themselves to be inept at understanding the complex subject of energy and its role in economic development and technology. They will mishandle the decline of energy density and will run deficits far in excess of the size of the economy which will continually add to inflation.

32. Politicians will come to understand that technology is a result of energy density and availability and that energy and technology are not the same. They will over spend on technological fixes that will continue to fail but will be very lucrative for those with supposed technological fixes.

33. Businesses that manage their energy usage and supply efficiently and install redundancies, alternatives and efficient storage will be able to profit at their competitors' expense from the disruption. Being able to switch energy inputs at relatively quick notice will be an advantage

34. Governments will pivot towards resilience and self-sufficiency rather than towards expansionism and globalisation. Culture wars and identity politics will fade as populations become more entrenched in nationalism.

35. As labour becomes dominant over capital there is push back in cultural areas such as feminism the re-emergence of manual labour as energy becomes scarce sees the re-emergence of a male dominated society.

36. The age of the geek ends as technology goes into reverse

37. Socialism will suffer great setbacks as national identity becomes more entrenched. Globalisation and the spread of universal political ideology will fall out of favour. As travel and global ideologies begin to fade.

38. Governments begin to concentrate on providing and securing necessities rather than pursuing more idealistic political policies. Governments fall or survive on their ability to provide basics of food, water, sanitation, energy and shelter.

39. The nature of politics changes as out go the political ideologies of the twentieth century and in comes production, supply chains, science, technology and engineering. Expansion gives way to efficiency doing the essentials with less energy potential

40. Governments that fail to embrace change become increasingly authoritarian they begin to nationalise more and more infrastructure in a vain attempt to control their economies. This will happen mainly with energy and production infrastructure water and transport.

41. Western politics will become increasingly divided between left and conservative, between Christians and libertarians. Between women's rights and LGBT, between LGBT and religious structures.

42. Culture wars will continue to consume many but, in the end will fade as food and energy prices become a real political flashpoint and focus politicians away from creating ideological divisions to providing basics.

43. The politics of dealing with climate change, the lag between doing the right thing to reduce emissions and getting results through declining co2 emissions becomes increasingly problematic. Making meaningful sacrifices today for unquantifiable results in the future is a hard sell at the best of times - especially when it comes to climate change.

44. It will become more and more obvious that the green growth and agenda is a cover for the real threat of declining energy density and energy poverty that will become a far greater threat to humanity.

45. Declining energy density will mean less growth, higher prices, declining living standards along with less emissions. Climate change may not be a priority for politicians in these circumstances.

46. The entire green agenda will become less and less important as energy poverty begins to overwhelm the middle classes.

47. Inequality will decline as the rich lose the most; however relative poverty will increase as the poorest are hardest hit by the effects of declining energy density.

48. Politicians will increase welfare and subsidies, price controls, rent controls as the effects of declining energy density become apparent.

49. The rich will lose the most but the poorest will feel the most affected. Governments will be forced to tax the wealthiest by ever increasing amounts as economic activity declines. The winners of the age of energy density will have to pay the biggest price in the future

50. Political debate will continue to be divisive as advertising algo driven social media continue to deliver biased unchallenging content designed to deliver the consumer a happy unchallenged echo chamber.

51. Politicians will attempt to control social media giants by breaking up ownership but will be powerless to prevent individual platforms. Any attempt to control content will be a free speech issue.

52. Legislation will evolve focusing on requiring increased data transparency of all social media. Huge data sets will become available for the whole of society to mine.

53. The internet and social media are doing for the political establishment what the printing press did for the catholic church. Weaken and fracture it by presenting an alternative reality to that presented by the establishment.

54. Social media will decline in use this century and become more fragmented new specialist subject or ideology platforms will emerge

55. This modern transformation of the way information and ideas are disseminated will increasingly undermine western political institutions but may find radically different ways of conducting government.

56. Arab spring will become western spring. Just like Martin Luther an intellectual will emerge able to provide a new narrative that usurps modern political theory. Energy and commodity security will become a significant element of future social media and political discourse.

57. Ideology may well switch towards a frugal minimalist cultural revolution where wealth and consumption become a target of ridicule and persecution.

58. Technology will create news ways of conducting political debate and decision making. In the future. Democracy will be served by a system of referendums with politicians largely replaced by technocrats and specialists.

59. Energy, data and technology experts will replace economists and politicians as the drivers of production and consumption.

60. The will of the people will be expressed more often and in more detail by technology. Politicians will be like lawyers making arguments to the voters but the ultimate policy will be dictated by mass electronic voting.

61. Power will shift from political parties to powerful individuals with technological solutions to physical engineering and scientific problems.

62. The balance of power that existed after the second world war is over, demographics, energy, climate change, nationalism, miniature chaotic warfare all add to the complexity of geopolitics.

63. The United States will still be the global superpower but will be less willing to act as a global policeman. China and Russia will exploit this to expand their own ambitions.

64. As we in the west attempt to transition away from oil, coal and natural gas expect the producers to sell more of their energy to China and India and keep more for their own domestic consumption.

65. The middle east will pivot eastwards to where the growth will be for decades to come. They will slowly abandon the west on economic grounds but also with an historical background of imperialism.

66. China and India will not decarbonise in the coming decades they will continue to benefit from fossil fuels especially coal to grow economically.

67. Unless and until a viable economic alternative can be found or climate change becomes intolerable. Fossil fuels will remain a key energy source for the coming decades.

68. Australia will maintain economic leverage over China especially as coking and thermal coal supplies tighten globally, it will be aided in its hegemony by the us and the UK.

69. Australia's' deposits of uranium are also of strategic importance. China will eventually move away from coal to nuclear.

70. Australia will still export coal but will pivot heavily towards solar it will become a net exporter of hydrogen energy and uranium in the coming decades.

71. Hydrogen created from renewables using sea water will greatly enhance the ability to store and transport renewable energy from more extreme regions to where it is needed.

72. Norway, Germany, UK, Saudi Arabia, north Africa and the us will become major producers, users and in some cases like Norway potentially large exporters of hydrogen.

73. Western countries especially the EU will embark on a trade war with China and India, trade with these two countries will be declared dirty and taxed heavily at import the failure of China and India to decarbonise and stop burning coal will have implications.

74. Carbon taxes will be a major tool for nationalisIng production and protecting jobs. This will further boost domestic production of manufactured goods in western industrialised economies and strain global trade.

75. These policies will further increase inflation within the EU especially.

76. The west will fall behind Asia in terms of economic growth as the costs of decarbonising weigh on their economies. But in the medium and long term will gain another technological advantage over developing nations if the net zero transition is successful. This would likely be with a large nuclear program.

77. The decline in trade between the west and OPEC energy producers like Saudi Arabia, Iraq, Iran will make them more independent. But this will make the region more unstable and in the end are likely to become an unreliable or nonexistent exporters.

78. Energy exports will involve oil for food, manufactured goods or technology rather than debt. Currencies will cease to be accepted by many commodity exporters precious metals are likely to re emerge as a form of sound money.

79. India's sphere of economic influence will grow considerably, it will dominate the Indian ocean but will come into conflict with neighbours. China to a lesser extent but the Islamic world to a greater extent.

80. The political imperative of India is to be able to access gulf state energy for decades to come and in return provide goods and labour. India will need to compete with western developed nations for high quality energy

81. India will be able to control access to the pacific and access to the gulf of Arabia, thereby controlling the flow of energy from Arabia to south east Asia and especially China.

82. India will erect a defensive position on the Andaman islands and be able to control the straits of Malacca and the gateway from the pacific to the Indian ocean. This is a key card in India's' plan to counter Chinas' dominance in the Himalayas.

83. India will become a keystone for either the west or the east, it will likely choose the east and will be vital in securing energy flows through the Indian ocean and holds a key card to bargain with China.

84. India will industrialise, because of its proximity to middle east energy and its' sheer population size and economic potential. It will become a larger consumer of nearby gulf energy.

85. China will play a role in this development as it becomes more middle class and wealthier it will export its inflation by outsourcing to India, Pakistan and Bangladesh as the west did before.

86. Turkey will become a dominant power in the middle east and perhaps the entire Islamic world. It currently dominates its' Muslim neighbours both economically technologically and militarily.

87. Turkey possesses an abundance of water as the source for the Euphrates and Tigris rivers in Anatolia. It holds strategic power over Iraq and will wish to benefit from its' energy deposits.

88. Turkey will not join the EU. Its ambitions will point towards the south, the black sea and the Turkic regions of central Asia.

89. The Ukraine war will drag on as Russia slowly landlocks Ukraine, energy is a strategic factor in all conflicts those with it will always succeed over those that do not have it.

90. Turkey and Russia will continue to clash over the black sea and across central Asia as proxy Russian and Turkic conflicts escalate.

91. Much of Russia's oil exports could be halted if turkey halts trade through the Bospherous straights. A turkey Russia conflict could force energy prices much higher.

92. However more likely that turkey Russia and the gulf states form a block as the economic woes of Europe deepen and its economic power wanes.

93. Morocco will be the world's dominant supplier of phosphate a vital component of food productivity. Coupled with an expansion of solar and wind energy and an Atlantic coastline it is likely to have a relatively prosperous future.

94. Fergana valley in central Asia will become a major proxy conflict zone between Russia, turkey, Islam and China.

95. Russia will partly dissolve to the east; it will fall under the influence of China and its wholescale migration into Russian territory and to the south it will struggle with the Islamic world.

96. Europe will try to choose Russia over turkey as its long-term strategic ally – energy. This would isolate turkey and much of the Islamic world propelling it towards a more unified future.

97. Turkeys strategic hold over seaborne trade into central Europe needs to be negated a new canal and infrastructure will be built to bypass the bospherous straights and the black sea.

98. Conflict will be virtual, micro and anonymous. No single nation or entity has sufficient access to the levels of energy and resources required to wage a global campaign of invasion and conquest similar to the more energy dense period of the early twentieth century.

99. There will still be conflict but much of it will be by proxy, framed as terrorism it will be cyber, digital and political or miniature, autonomous, anonymous drones.

100. Fossil fuel producing nations like Russia, Iran, Iraq, Venezuela, Saudi Arabia, Nigeria will all reduce exports and an increasing share will be used to pacify their own populations.

101. Reducing the cost of essentials for domestic political gain will become more important for energy producers than exporting to developed countries facing economic and debt crises.

102. Tensions between Shia and Sunni will grow in the oil rich regions of the gulf. A lack of exports reduces Saudi Arabia's influence abroad and begins to destroy its finances. Turkey backed by Egypt may take political, economic and military control of the Arabian Peninsula.

103. Globalisation will go into reverse as energy export markets decline and geopolitical tensions grow. Global transport routes will be less dependable in the future.

104. It is likely that the size of the global merchant fleet will begin to decline. Companies develop smaller container ships more capable of navigating more sea routes - smaller ports. The end of the mega container and mega port. Old ports once abandoned will re emerge as viable centres for trade

105. Manufacturing especially critical components will be on shored in most developed economies over the next few decades. Supply chain issues especially with China make this strategy more attractive. Infrastructure spending and skills training.

106. The economic efficiencies of globalisation will go in to reverse as countries duplicate efforts in manufacturing and technology to maintain independence and security. This will increase the global demand for resources and infrastructure.

107. Post industrial economies will re industrialize but mainly with robots and smart factories, they will only replace some of the offshored jobs with domestic labour.

108. Micro factories may rival the old mega factory as production comes closer to consumption and new materials and fabrication techniques make this possible. Automation and robotics.

109. Costs of goods will increase for advanced economies as increased domestic manufacturing will be required to meet higher environmental and employment standards than the previous offshore model.

110. Re industrialisation will lead to lower profits for many corporations habitually used to products produced by low wage and low environmental standards suppliers.

111. The United States will increasingly isolate itself from the global arena through a mix of internal energy production leading to greater energy independence and internal political priorities. The us taxpayer should benefit from spending being diverted to domestic infrastructure. Roads, railways, nuclear, geothermal.

112. Global populations will migrate north as the climate warms, the economic temperate zone will move north. The temperate climate has allowed economic prosperity to condense in this region.

113. Most of the worlds' great capitals lie at the centre of the economic temperate zone between the arctic polar circle and the tropic of cancer. Economic activity will move northwards; St Petersburg, Stockholm, Edinburgh, Vancouver.

114. Russia will have a passage through the arctic ocean and establish a new arctic port and city if the pack ice melts and global warming becomes a reality.

115. Most of the worlds' young and growing populations lie outside the economic temperate zone below the tropic of cancer. Rising temperatures will negatively impact these economies as agricultural output and access to water decline.

116. As the climate warms China, north Africa the us and central Asia slip out of the economic temperate zone. India, south and southeast Asia fall further in to the intemperate hot zone.

117. China will continue to outpace the us and as its' citizens incomes rise so its share of global consumption will rise significantly. However, it will not become a global super power. As its population will begin to decline during this century.

118. As its wealth improves and birth rates declines even more. China will import and consume higher end goods as its middle classes expand. Its infrastructure spending will decline.

119. India will become a global power in the future as its population outpaces China and its wealth and technology increases. It will develop by burning its domestic coal supply and imports from Australia.

120. India will need to spend on its infrastructure over the coming decades the question is will its technology come from the east or the west.

121. Much of the growth of the Indian population will be young Muslims, this will lead to political instability within India. The level of political stability will dictate India's growth trajectory and potentially that of much of south Asia.

122. Countries like Mexico, Philippines and Indonesia will see their economies grow relatively to the west as their baby boom generations become active in the economy and they attempt to raise their standard of living.

123. Indonesia will become a major industrial manufacturing centre as China exports its manufacturing capacity. Low labour costs will make it attractive. Oil and an abundance of geothermal potential will power this development.

124. The current demographic youth bulges of Pakistan, middle east and north Africa point to relative increases in GDP this century. A youthful population means political instability in the short term. These surges in population will demand technology and access to fossil fuels.

125. As with all developing nations much of this relative increase will be through increases in fossil fuel use especially coal

126. Russia with a declining population will continue to be a major energy exporter of key importance. Expect Russian energy and resources to continue to be a key part of the global economy.

127. The growth in the populations of Pakistan, India, Bangladesh, Egypt, Sudan, Ethiopia etc. Will strain the water systems - shortages will lead to political instability and food shortages.

128. Ethiopia will become a key player as the source of water for Egypt and the Sudan. Likewise, Himalayan hegemony will involve India, Pakistan and China.

129. Developed economies will see increasing population decline driven by declining birth rates, declining life expectancy amongst generation x due to poor diets and lifestyles and the boomers passing.

130. A talent and wealth drain towards Asia, the middle east, especially India. Economic growth will decline in developed economies and stay low for decades.

131. During the thirties the baby boom generation will decline in Europe and north America. Reducing social care burdens and redistributing their wealth to their offspring. A new generation of consumers will spend on starting families and buying homes.

132. By 2030 over 50% of the us will be obese, Europe will not be far behind. Europe will struggle to maintain a stable population as life expectancy declines amongst this cohort.

133. Declining populations are a toxic mix for governments biosciences will become an economic necessity to reverse these declines, longevity would be a huge economic boost to an ageing society.

134. Younger generations take action and become much healthier than their parents. Obesity begins to decline as these generations are influenced more and more by social media and sport star plant-based athletes.

135. Ageing populations and worsening health outcomes in developed nations will cause economic stagnation as a diminishing workforce will find it increasingly difficult to meet the burdens of past debt, current social care, health costs and infrastructure burden.

136. The value of labour will increase relative to the value of other assets. This promotes a redistribution of wealth from older less mobile to younger more physically active.

137. South Asia, south and central America will boom for several decades as their population grows, becomes wealthier and consumes more of its own production.

138. Russia and Japan will see their populations decline but Japan will fare far worse. Automation and robotics will become even more necessary, expect Japanese robotics and technology to continue to be at the forefront of solving these problems.

139. Russia will continue to run a large trade surplus and increase its influence globally. Russia will be too important to ignore. But its population will continue to shrink.

140. Russian oil and gas reserves will give it enormous leverage in the future, it will look to reverse its' population decline.

141. An ageing Japanese population, lack of immigration and energy deficit will necessitate technological developments in the field of energy conservation, storage and harvesting to surge in Japan.

142. Nuclear and geothermal are likely to be the main sources of domestic energy for Japan along with hydrogen from renewables will be imported from Australia.

143. Tensions between India and China will increase over the next few decades until and if the power of Islam becomes a threat to both countries. In such a case this threat will bring both countries to a common purpose.

144. The main barrier to a full India China conflict is the Himalayas. In reality the range is so huge it acts as a virtually impenetrable barrier.

145. The proximity of Islam to India and to a lesser extent China makes this potential joint threat a source of long-term unity. If Islam was to become a unified force with internationalist ambitions. Indonesia is a key Islamic state it guards Asia's route to the middle east. Protracted instability would threaten global trade.

146. China will annex Taiwan; the west will be unable to interfere as it will be unwilling to confront China directly. Russia will do the same with Ukraine the west will be too weak to defend these countries. Slow grinding economic annexation, political manipulation, followed by either a quick hot war or a takeover of a country that capitulates.

147. Latin America and especially Mexico will become increasingly important in us politics, waves of Hispanic migrants will increasingly see its loyalty with west coast Hispanic catholic culture and language rather than the Anglo-Saxon protestant east.

148. Mexico will struggle to remain a single entity, its' capital so far from an economically stronger and continually more independent north. It may well fragment the us will subsidise Mexico more and more to prevent this from happening.

149. The United States will become increasingly politically divided between a burgeoning Hispanic catholic west coast and a more Anglo Saxon, protestant east coast. Continuing droughts in the southern states and Mexico will affect the political and economic balance in the region.

150. Us population migration north will intensify. Technological advances in water purification and management, renewables, geothermal, energy storage will be implemented here, before many parts of the world.

151. This changing us demographic and political dynamic will lead to a greater focus on domestic affairs, coupled with a declining appetite for external energy and less motivation to police the world will see an increasing political need to put the us first.

152. This will reduce us technological advancement long term but boosting the us economy as spending is concentrated domestically. To much us spending has focused on overseas hegemony.

153. The United States will remain a singular entity and will continue to be a super power for the remainder of this century. Its democratic values, language, culture, geography, geology and technological superiority will keep it at the forefront of global hegemony.

154. Regardless of the state of global paper currencies the us dollar will remain the cleanest shirt in the laundry basket.

155. Europe will struggle, declining birth rates, few natural resources, waves of immigration and a withdrawing us could see it more vulnerable to political instability and more isolationist ideology.

156. Europe will become more and more dependent on Russia for its energy especially as it adds more renewable capacity to its grids.

157. The eu will struggle to maintain cohesion the European court will be disbanded or ignored. Member states will one by one ignore the commission. Eventually freedom of movement will disintegrate.

158. Eu borders will be erected at the edge and the commission will become more right-wing, isolationist and anti-immigration.

159. Islam will become a more cohesive force overtime and a greater threat to southern Europe. The Balkans will become a conflict zone between proxies.

160. Exporting goods and services to Islamic nations will grow dramatically as their populations and economic power grow.

161. Friction will increase across the southern fringes of the Sahara as Islam and Christianity battle for hegemony. Ethiopia and Nigeria will be the two hot spots in this conflict. Both with large mixed religious populations. Conflict across this region will intensify and reduce economic potential.

162. As Europe declines it will be faced with waves of immigration mainly from Islamic countries, migration of sub-Saharan Christian Africans' may well cease as the journey through Islamic territory may become too dangerous.

163. Southern Europe may become increasingly more Islamic and tensions will grow, along with a rise in Islamic cohesion, will increase nationalism in Europe and a change towards European retrenchment rather than expansionism.

164. Advances in bio technology will prolong lifespans stem cell therapy is looking to achieve longevity escape velocity. Limited rejuvenation may also be possible within a few decades. These technologies will fundamentally alter global demographics, financial cycles, investment horizons and the global economy.

165. This technology will become cheap and endemic. The costs to governments and economies of ageing are high in loss of economic activity and rising healthcare costs. Understanding the role of demographics in economic demand and politics will be increasingly important.

166. Societies with access to longevity bioscience will be subject to profound consequences a collapse in the birth rate, children will be rare, schools will close. A collapse in pharmaceutical demand, medical demand, a huge increase in the productivity capacity of the participants in the economy along with a huge decline in liabilities.

167. A complete crash in the pensions industries as actuarial models would not be able to compute this new reality. Legal battles between pensioners taking these drugs and the pension companies forced to pay the pensions of ever longer living pensioners.

168. The nature of money will change over the coming decades, it will begin to return back to a store of value as it has for most of history. As we exploited more and more energy precious metals or other stores of value were unable to keep pace with the explosion in economic activity.

169. The paper monetary system we have today is the perfect system to ruthlessly exploit resources. Credit brings consumption from the future (saving first) to the present it speeds up an economy by creating consumption. Provided the economy keeps expanding this isn't a problem.

170. Money, which changed in the twentieth century from a store of value gold, to a means of exchange fiat, will return to a store of value.

171. As we exploited more energy and gained more complexity the need for a means of exchange increased dramatically. The energy exporters became happy to swap their energy for a means of exchange not a store of value. The economic value debtors (us, Europe) could add to their energy via technology was a fair exchange at the time.

172. Energy will be recognised as the ultimate store of value those that have it will demand payment in an alternative store of value rather than a means of exchange - debt. Whether this be gold commodities, technology or finished goods. Global bartering between consumer and producing economies.

173. Until the value of debt is destroyed by inflation governments cannot return to sound money and balanced budgets. Until the purchasing power and economic influence of government deficits is reduced to virtually zero then debt will continue to act as a drag on global economies.

174. The green new deal will be an investment boom for the financial industry, huge investment flows from governments in to renewables will be a profitable source of income.

175. Businesses and investors will use the green new deal as a way of monetising climate change through a huge infrastructure and manufacturing boom financed by tax payers.

176. The global financial industry will shrink as a share of global GDP over the coming decades. It will be more noticeable in the west. Declining energy density and availability will reduce the value of debt in the economy and the role of financial capital.

177. Retail banking systems will be controlled by national governments and central banks issuing digital currencies.

178. The financial industry will enter a period of volatility as many financial asset bubbles burst. Declining energy density and a declining ability of many economies to generate surpluses will doom them to a sustained economic contraction.

179. Insufficient wealth available to repay debt will over time force interest rates much higher to compensate for increased risk of default. Cascading defaults will cause shockwaves through global economies.

180. The role of investment advisor will be taken by ai systems sifting through ever increasing amounts of data. Roboinvestment systems will compete for investors. The amount of data available today and in the future will be so huge that only machine learning can determine significance.

181. Crypto currencies will be recognised not as money but as a digital commodity. The volatility of bitcoin renders it an ineffective means of exchange. Its limited availability makes it no better than a monetary metals or copper or oil.

182. Faced with high emissions from mining and no direct utility like oil or copper bitcoin will remain a niche anomaly which benefits early hoarders and adopters and not those swapping labour or physical goods for it.

183. Bitcoin and other crypto currencies will never be global universal payment systems, bitcoin as a decentralised anonymous payment system does not sit well within the financial and political ambitions of most central banks and governments.

184. States will demonise bitcoin it allows hackers and ransomware to be paid anonymously. Whilst the intentions of many using and developing crypto currencies are good its ultimate aim is to disrupt banks.

185. That is not allowed by central banks and governments, China and Switzerland will be followed by many more countries banning crypto.

186. All fiat currencies will eventually move to CBDC (central bank digital currency) the problem authorities have with their currencies is the lack of data they are able to mine. This reduces the levels of potential taxation and increases the cost of investigating tax fraud. Digital payment systems allow the issuer to track payments, gathering data on each transaction within the payment system a technology governments and central banks will want to exploit.

187. Fintech payment systems built on the blockchain will continue to grow until there are only a few major players mainly owned by the banks, the data collected through these transactions is currently the best real time transactional data we have.

188. However, when central banks create their own digital currencies (CBDC), this data will be less significant compared to central bank data.

189. The future of money that will be decreed by states is a central bank issued digital currency (CBDC) every transaction can be audited, tracked and analysed. Each national central bank will issue their own digital currency so as to have total control of the transaction data in the nation's economy.

190. This data flow will transform the power of central banks and governments, they will own the data on all transactions within their economy, real time taxation, real time central bank intervention, anti-corruption power.

191. The data these digital currencies accumulate will be the subject of access and privacy arguments free of restrictions this meta data will be a goldmine for the financial and business community.

192. In a financial system with a CBDC commercial banks and the banking system will continue to issue loans and take deposits as they always have. But they will be in the form of digital currencies.

193. The central bank will control the blockchain and the data in its entirety. A switch to a digital currency will be done so as to protect the interests of the banking system.

194. The blockchain will not be as widely adopted as many believe but it will most likely be used in financial and energy transactions in a networked financial and energy grid. The blockchain decentralises databases creating a tamper proof way of recording and storing data, value, ownership, contracts etc. Proof of work authentication slows down transaction speeds and increases energy consumption per transaction. Governments and central banks will be the main beneficiaries of blockchain, and digital currencies.

195. Defi (decentralised finance) blockchain technology hack proof smart contracts. Will provide extremely useful solutions to a limited number of problems. Networked efficiencies especially in smart grids with energy trading, futures contracts, credit markets.

196. As we come down the energy density ladder many assets bid up during the expansionary phase of increasing growth, energy consumption and debt will face secular declines.

197. Real estate, art, bonds and many stocks. Assets reliant on yields will lose purchasing power relative to commodities especially energy. Assets reliant on discretionary spending will also decline in value.

198. Vast surpluses of wealth built up will be destroyed by stealth as the purchasing power of currencies declines. Assets will rise in nominal terms but will fall relative to the cost of necessities.

199. As the costs of necessities rise sharply and discretionary spending collapses. The commitments of welfare, pensions and other financial liabilities is reduced relative to the size of the economy.

200. The next tech crash will see the second wave of disruptive internet tech companies reach maturity Apple Google Amazon Facebook etc. Much of the overvaluation of their stocks will disappear as they reach maturity and penetration.

201. These widely adopted industries will provide better returns through dividends after they are revalued. The darling stocks of today become the boring cash cows of the future. Think railway mania, first tech. Bubble (Cisco Systems etc.)

202. The next tech bubble will be in biosciences, ai, energy transformation and storage, new materials, but it won't be the next bubble. The next bubble will be in commodities this will destroy the debt and tech bubble, only after that will come the next tech bubble.

203. Real estate will decline as a share of wealth in most advanced economies as growth disappears real estate declines in value and its maintenance becomes a greater liability and cost in an energy limited environment.

204. Remote land previously of little value will rise relative to cities, advances in renewable energy generation, energy storage density and the space required to harvest less dense energy will alter the economic balance of land use.

205. Politicians introduce rent and price controls to alleviate the burdens of inflation. High energy costs and high food costs leave little surplus for high shelter costs. Real estate shrinks as a share of economies.

206. Surpluses created by cheap energy and food disappear these surpluses created the credit bubbles that allowed housing to be bid higher and higher. The price of shelter is irrelevant to its utility, the price may change but it still provides a basic human need.

207. Politicians will target landlords with taxes and regulation, shelter will be viewed more as a human right than a financial asset.

208. As energy density declines, we begin to re-invent our housing, much of the open plan living we have built has increased the running cots of our homes.

209. Less energy and higher prices will lead to smaller rooms and dwellings become more efficient and more desirable. Mansions become less desirable in high energy cost environments. The micro home becomes the next housng trend big open plan spaces fall out of favour.

210. Advances in internet communication by satellite to remote areas has increased penetration of mobile networks, renewables technologies, reduces much of the economic benefits of cities and revalues land.

211. The value of land has traditionally been enhanced by its access to infrastructure road, rail etc., but with developments in digital connectivity and off grid renewable living remoteness is no longer an impediment to economic activity.

212. The Philippines and Indonesia may represent one of the last property booms, island nations with solar and geothermal potential would be attractive locations for technological migrants.

213. The geographic isolation of islands reduces the cost of security and amplifies the efficiency of water born trade, coupled with relatively dense geothermal energy availability makes these Indonesia and the Philippines attractive to technological settlers.

214. Politicians target real estate winners as their finances deteriorate. Higher property taxes hurt the wealthy and middle class. Cities are subject to larger taxes as infrastructure costs; roads, lighting, transport weigh heavily on a declining population and economic intensity.

215. Post covid mega cities never recover their pre-eminence, remote working reduces city centre activities and pushes this activity out to the suburbs and regions.

216. Only port cities continue to do well as de globalisation reduces boat sizes so older ports are reinvigorated. Ocean energy harvesting will also bring trade to many ports as energy terminals and distribution hubs.

217. Inflation will become pervasive, as we climbed up the energy density ladder and grew wealthier, we began to divert surpluses in paper currencies in to art and collectibles, a natural reaction to swap a currency that is consistently losing value through inflation for a unique and rare object. These assets bubbles were the obvious results of deficits and excessive money printing, but with declining energy density surpluses disappear and asset prices fall.

218. Bonds will collapse in value over time, central banks will continue to purchase them and attempt to maintain low rates allowing governments to fund their deficits.

219. The return of money will become more important than the return on money as economies shrink interest payments are more difficult to extract, defaults rise and interest rates need to compensate for higher levels of risk.

220. Wines, classic cars other collectibles requiring high cost of carry (registered storage or maintenance) will decline in relative value. Art may well fare better especially pre-modern-with genuine rarity, uniqueness and historical significance.

221. Non-fungible tokens (NFT) will continue to boom and bust as their younger early adopters move up the income scale. They are an investment class recognised more by younger generations as wealth cascades downwards these digital investments may grow.

222. Governments will continue to run deficits and they will get larger in nominal terms, but as the purchasing power of their currencies declines, the effectiveness of these deficits will reduce.

223. Central banks will attempt keep interest rates low by continuing quantative easing. Government deficits will be financed by central banks. They will reduce the value of debt in relation to energy, commodities, goods and services by inflation. Whilst at the same time keeping the cost of servicing debt as affordable as possible for as long as possible.

224. However there will come a point when they lose control and inflation becomes ruinous Japan could be the first industrialised economy to either let its' currency collapse inflate away its debts or raise rates and see its economy implode as its gigantic debt burden destroys economic activity.

225. If debt is a claim on future growth (energy) then as the economy shrinks through a lack of energy it makes debt harder to service and repay in real terms a shortage of money will be met by more money creation.

226. Government tax takes will decline as they move away from fossil fuels, creating even greater deficits. Most green energy will need to be subsidised, but as it becomes a larger share of the economy it will impair government finances. The taxation on fossil fuels will have to be found from another part of the economy.

227. Central banks globally will trash their currencies in coordinated attempts to reduce the value of debts relative to all other goods. Central banks only real tool is to print money to create demand and prop up debt markets and by extension asset prices with low interest rates.

228. As we went up the energy density ladder creating more debt worked as there was always enough future energy density available to meet demand by expanding the economy.

229. On the way down the energy density ladder central banks trying to create demand will just lead to more and more inflation as there will not be sufficient energy density to fulfil the demand.

230. The next global economic events will be all be global inflation events, in this century we have had two global deleveraging panics, we are now a globally interconnected economy, only low energy intensity economies have escaped these events.

231. Until recently government deficits had a marginal effect on prices and inflation so this new money maintained its purchasing power to the benefit of the state. But conversely the overall value of the debt also maintained its purchasing power.

232. At some point government deficits begin to affect real prices like commodities and wages then inflation becomes persistent, a wage price spiral begins. Then the currency and the deficits will lose purchasing power as prices increase faster than spending.

233. Governments lose control off inflation and have a choice to balance the books or increase deficits to pacify voters through price controls and subsidies. Deficits will have to increase to keep pace.

234. Central banks will continue to ban recessions, so excessive are the levels of debt that deleveraging is unthinkable for them. Like a forest never allowed to burn, eventually the level of built-up deadwood becomes so large that a fire ignites that is impossible to put out.

235. So intense is the blaze that the entire forest is destroyed. Recessions rejuvenate economies like forests, clearing the way for fresh growth. Until the value of debt and government liabilities is a fraction of the size of the economy, will a true recession be allowed. Central banks policies prevent recessions allowing bad businesses to survive, increasing the deadwood (piles of bad debt) and preventing new growth and rejuvenation.

236. currencies will decline as governments become increasingly unable to manage their finances and central banks print ever larger quantities of money. As rates rise energy will become more expensive further depressing the growth of these economies.

237. The cost of essentials will rise. This will be the catalyst for many new energy production, storage and distribution technologies to become economically viable.

238. The currencies of western developed economies will lose significant purchasing power, their economies will experience bouts of inflation, economic crises followed by periods of stability. It will feel like a slow decline with intermittent crises.

239. Currencies like the New Zealand Australian and Canadian dollars will fare better as their commodity exports gain in purchasing power.

240. As the cost of meat and dairy soars and consumption falls the inefficient calory conversion of fossil fuels to plant energy to meat energy makes the cost of meat uneconomical for many producers and consumers.

241. Carbon taxes, droughts will also impact this sector, meat becomes a luxury commodity, animal farming becomes niche high-end business. The value and profitability of meat per kilo rises.

242. As the essentials of food energy and materials become more expensive, the consumption of discretionary goods collapses, online and offline retail collapses. Brands begin to disappear and choices become fewer and fewer. Defensive investments

243. New cars and holidays once a right of many in developed nations become a rarity for most of the middle classes. Global tourism declines, real estate prices fall. The price of aviation increases and becomes a luxury only affordable by the rich. Consumer non-cyclical investments.

244. Second hand goods like cars hold their value better as less new inventory enters the market, the embedded value of the energy metals and components rises – scrap values rise. Metals start being stolen.

245. Global holiday destinations particularly more remote ones begin to collapse economically, Thailand is particularly hard hit. Across the Mediterranean, the Caribbean, south east Asia many coastal economies see serious declines in wealth and income as the tourism industry declines sharply.

246. Cities like Barcelona, Paris, London, Sydney, Toronto will see collapses in real estate prices.

247. regional and micro governments begin to default on their debts, this will begin a cascading default of debt that will begin to affect much larger economies, these micronations will default on their debts through inflation.

248. Dollar denominated debts begin to default and a dollar squeeze is met by more printing from the federal reserve.

249. As western economies decline governments deficits will soar, tax receipts will decline just as govt liabilities increase, healthcare, debt servicing, social care. Ai and robotics will become more important in the care and monitoring of patients.

250. Inflation will rise amongst all economies; labour rises as a share of the economy. The rise of intermittent renewables in energy networks will cause disruptions in industrial output and add costs to inputs. Much higher input costs will see more labour go into food production as it becomes a larger share of the economy.

251. China will attempt to transform its economy from one focused on industrial production and exports to one beginning a large and sustained move towards more internal consumption of its own goods as demand from abroad declines.

252. China will continue to increase its wealth; development will be focused more on consumption with a greater focus on leisure it will peak in industrial capacity.

253. The circular economy of recycling and carbon taxes will push up costs and will mitigate some of the effects of resource entropy. Carbon taxes will be unpopular but will help to nudge behaviour.

254. The economic stimulus of government debt continual freshly created money, diminishing resources, declining energy exports and the energy intensity required for the green new deal will overwhelm most initiatives. Inflation protection required as a result of central bank policies.

255. The Chinese yuan will float against all currencies as it becomes a consumerist society its currency will rise increasing the purchasing power of its citizens. Western producers will become competitive and Chinese exports less attractive.

256. As the yuan increases in value expect manufacturing to move towards India across Asia and Africa. Non-critical manufacturing labour intensive textiles, homeware, shoes, and discretionary goods real estate investments in these regions will do well as economic activity increases.

257. De industrialisation will begin to reverse the trend of western economies substituting productive well paid domestic jobs for cheaper imports and credit expansion to fill the economic activity gap. Factories and infrastructure will need to be designed, planned and built. This will be in critical defense, energy, food and technology industries.

258. Globally central bank currencies will begin to decline but not against each other as happened in the past when economies were less interconnected and pursued different economic paths. Instead, they will all depreciate against commodities and energy. Inflation protection.

259. The financial liabilities, debts and obligations built up in the post war period of energy density are so enormous they can only be inflated away against the resources and energy they make claim against. As energy density declines and with-it economic expansion so the ability of the economy to repay the debt in real terms declines.

260. During this transition period there will be turbulence, disruption, political, economic and social change. The greater the liabilities and the scarcity of the resources they make a claim against the harder the re adjustment will need to be.

261. Low energy density businesses with little financial claims will fare much better in this transition. Net zero businesses, businesses that can provide consumer experiences rather than the consumption of physical goods.

262. The developing world will begin to consume more of its own production. Financial capital moves in to these regions to increase internal consumption. Credit. Markets become larger and more liquid.

263. These growing populations become large consumers of electronics household goods and automobiles. India, Asia and the middle east can expect to see large increases in living standards and consumption.

264. Financial capital will move to Africa, Asia and south Asia in particular as western economies stagnate, their populations ageing and their consumption declining in comparison to faster growing regions. Banking and financial services will benefit from exporting their expertise abroad.

265. The Asian economies will move from mainly producers to also becoming larger consumers as their interest rates fall and their purchasing power increases making them less competitive but giving them greater financial muscle. Prices for finished goods will rise globally as supply fails to meet demand.

266. Capital will accelerate its flight from the developed world as its fiscal, demographic and political conditions deteriorate. Only large-scale immigration can boost developed economies, but that will bring political tensions.

267. Developed nations governments will choose greater limits to immigration, with increased nationalism and protection of domestic voters. Skilled manual workers will see large increases in their standard of living.

268. As Africa and the middle east develop, waves of emigration towards the west may subside. As their fast-growing populations boost economic activity attract capital and boost domestic living standards.

269. Expect parts of Africa to go through a development phase with increases in infrastructure and real estate development. Africa with a young and growing population will see an explosion in its population, consumption and economic activity.

270. Foreign capital will finance economic growth in production, consumption and infrastructure. Sub-Saharan Africa's main reasons for a lack of development is its geographic and geologic constraints and not its political governance although that is a consequence of its inability to trade profitably with the world creating isolation throughout of much of the continent.

271. Businesses that provide the things we need will fare better than businesses providing things we want. Abundant energy allows us to satisfy more wants. Energy scarcity reduces the ability of an economy to produce a surplus with which to consume more of what we want.

272. Surpluses that consumers have may well be directed towards experiences rather than the consumption of physical discretionary goods. Less retail shops more social, cafes, food, tech games simulators.

273. The restaurant and food industries will change dramatically. High value fine casual dining restaurant hotel industry requires low food costs. High labour costs are required to create complex menus. High food costs destroy this model and reduces the complexity of the restaurant industry.

274. Menus become simpler and as food becomes a higher proportion of incomes so restaurants need less customers and less margin to make a profit. Eating out becomes better value smart businesses adapt but complex menus become too expensive for all but the rich.

275. Business divides and becomes more political, internationalist multi-national corporations, banking, media align with left internationalist middle-class professionals mainly city dwellers. Energy density drove the rise of the socialism and globalisation, the rise of the multi-national corporations. The move from farms to factories to exploit energy drove the founding of labour movements, unions, socialism and the rise of corporations.

276. Nationalism thrives among smaller more national boundary businesses. Those businesses and voters who do not benefit directly from freedom of movement and capital.

277. As we come down the energy density ladder, internationalism, globalisation and multi nationalism will all decline.

278. As governments continue to run larger deficits, they control ever larger parts of the economy, distorting it and many of the businesses that benefit from this spending.

279. Businesses and entities most reliant on government deficits for their economic activity will be the ones that fail most spectacularly as the purchasing power of the currency and the state declines.

280. Business as usual is dead, technology and energy density will transform businesses over the coming years. Businesses will have to cope with declining disposable incomes higher input costs for commodities, labour shortages and increased wages. Smaller businesses are likely to outpace larger businesses.

281. Corporations reliant on the west for military hegemony especially naval to keep sea lanes open and infrastructure safe will struggle as supply chains become fragmented and resources increasingly scarce. Their business models will be disrupted and doing business will become more costly.

282. Holding and storing stock and inventory will become more necessary larger corporations will need to re-engineer their business models. Outsourced warehousing and logistics will increase.

283. Many large businesses will go bankrupt or shrink dramatically, as some of these business models fail, they will be replaced by smaller more nimble, local companies.

284. As volume declines so the price of goods rises especially essentials less volume means smaller entities can enter the market and make a profit. Think needs not wants businesses

285. As consumption falls many industries will lose critical mass entire industries will go from sophisticated high-volume markets to disrupted low volume, niche less dependable industries.

286. Components for some technologies will become harder and harder to source entire industries may be uneconomical especially in the field of discretionary spending. This will lead to a decomplexity spiral as many layers of supply chains, specialisation and technologies are surplus to requirements.

287. Smaller technological companies will become low volume niche suppliers of components for critical infrastructure, many critical components in our systems will become substantially more expensive.

288. Investing in semiconductors the brains of technology is like selling shovels to miners in the goldrush, more dependable an income than the riskier fruits of the potential economic gain from the output from the shovel.

289. Out of town retail shrinks considerably even supermarkets are subject to the decline in economic activity. Less choice and complexity, it leaves empty shelves and renders large floor spaces and out of town super stores unviable.

290. The high street and town centre sees a revival of smaller independent retailers with less complex supply chains and the ability to stock pile and source goods independent of a central control. Greater flexibility of decision making and risk-taking will be needed in a less dependable world.

291. Food and beverage businesses will dominate high streets. The hospitality trade will adapt to labour shortages by buying in more pre-prepared foods or using ghost kitchens. Menus will become simpler, rising food costs will be good for food producers and retailers.

292. Hotels will adapt to reductions in tourism by becoming lodging houses reducing the need for more housing. Longer stay tenants will board and receive meals. The decline in global tourism and especially business travel will reduce real estate prices and accommodation pressures in most cities.

293. Goods will continue to move across the globe, but will be less dependable, shortages of goods will appear at different times. This will require more capital to be held in the storage of physical goods than in infrastructure or financial investments and claims on the future. Expect the financial industry to shrink as a share of global GDP

294. In the west capital will be better invested in production of necessities than in assets like govt debt or real estate that depend upon surpluses and financial claims for their values. Technology especially energy and biosciences will be major economic drivers,

295. Supply chains will be re-engineered to reduce complexity, investment in storage and security of storage will be required. Logistics will increasingly use ai and networking to increase efficiencies.

296. Capital will move toward the delivery and supply of essentials food, water and energy rather than in discretionary goods. These industries will become a large part of economic activity as discretionary goods plummet as a share. Utilities will be attractive investments.

297. The nature of work will change in the west advertising and marketing the legal profession accountancy along with professional services and finance will all see secular declines in their industries.

298. As layers of complexity and economic activity are destroyed by ai and energy deficits so the demand for many professions will decline. These services will be required in other parts of the global economy especially the middle east and India.

299. The division of labour will go into reverse as declining energy density drives less economic expansion and less complexity. Specialisation becomes less useful as ai systems undertake more tasks, the middle-class declines considerably.

300. The arts and culture will decline in economic significance in western economies but will remain a universal good for societies. It will be demonetised.

301. Agile humans will be the main winners this century. Agile humans will be the dominant economic force. The share of wealth will move rapidly from old to young and from intellectual and capital to labour.

302. In an energy starved society think gladiators, sports stars, super chefs, special forces. These skills will define the middle classes. High skilled agile. Think engineering and construction skills.

303. White collar workers to feel the disruption from technology that blue collar workers have been experiencing for decades. Middle class consumption to decline - brands, hospitality and travel to suffer.

304. Middle class repetitive cognitive jobs will be replaced by ai systems and algorithms the cost of replacing these jobs will be less than replacing repetitive manual jobs requiring hardware (robotics) as well as software. This change will be faster and more disruptive than many expect. Investment in a myriad of small startups will grow rapidly.

305. Lawyers, bankers, accountants, healthcare consultants and other professions will all see the power of ai and algorithms disrupt their industries. Powerful technology companies will influence governments to decomplexify statutes and reduce regulation to allow simpler faster more efficient ai systems to evolve.

306. Demographic and cultural changes to developed economies means there will be a shortage of skilled manual labour making modern infrastructure more expensive to maintain. Robotics and especially exoskeletons will reduce some of the physical burdens in construction and keep older workers in the industry for longer.

307. Once it becomes increasingly difficult to maintain complex existing infrastructure, it will become almost impossible to develop any new infrastructure. Buildings won't be demolished; the embedded energy will be repurposed. Large scale projects will give way to repurposing and upgrading existing infrastructure.

308. Collaborative robots easily retrained at low cost will be used in far more areas especially low production volume repetitive manipulative tasks. Humans in many cases will work alongside robots training and guiding them.

309. telepresence will allow humans to operate robots in dangerous environments using vr and haptic feedback combined with ai all the risk will be transferred to the robots.

310. Post covid cities fail to regain their previous levels of economic activity, a large surplus of offices is turned in to domestic living space.

311. Many hotels switch to long term residential rental contracts. Railways and underground transportation systems are underutilised but still need to be paid for. Rents collapse as residential capacity increases beyond demand.

312. Footfall from commuters and tourism declines, pollution and noise levels also decline, the quality of living improves as the intensity of economic activity declines.

313. Cities continue to be economically and energy efficient machines for living in. High density allows an efficient concentration of services, infrastructure and culture.

314. Rural living will become more expensive in terms of transportation costs. But as food and energy costs rise and micro energy generation and storage costs and density improve, space will become more economically more valuable than the efficiency gains of dense cities.

315. Many coastal cities will abandon expensive sub surface transportation because of flooding. They will rely on integrated above ground autonomous transport systems buses trams and taxis etc.

316. Significant public money will be spent on re greening cities. Reducing road networks, de hardening the urban landscape. Especially with flood control in mind and increasing urban agriculture.

317. Without inward migration many developed economies will struggle to maintain their infrastructure over time. The costs of standing still will rise substantially. Engineering and construction skills will be scarce and highly valued.

318. The costs of energy intensive concrete and steel will rise making large scale construction projects more and more unviable. Construction will focus on smaller buildings requiring less energy intensity. Prefabrication will become the dominant form of construction.

319. Skills, labour and capital will be occupied more by maintenance tasks than by new development. As capital moves towards economies with growing populations and economies so these skills will drain away from ageing developed economies, further exacerbating skills shortages.

320. The push towards lower density sources of energy will have a profound effect over time on population distribution and infrastructure. As we moved up the energy density ladder cities made sense, centres of industrial and commercial activity huddled together burning energy in larger and more efficient power stations.

321. Cities and the need for infrastructure will decline as we move outwards seeking less dense forms of energy. Wind, solar and geothermal. They will continue as centres for government, law and culture, but will never achieve the levels of economic dominance during the peak in energy density.

322. Our economic system which transforms low-entropy materials and energy into high-entropy waste will meet the laws of thermodynamics even more noticeably over the coming decades. Exergy the potential amount of energy available to do useful work is declining, this will accelerate over the next decades. An economic shift that has already started will slow global production especially in advanced economies.

323. Fossil fuels will still power the global economy well in to this century. Liquid and chemical technology will end up being a longer-term solution to the storage of intermittent renewable energy and for many forms of transportation. Investments in non-battery liquid chemical energy storage systems could be big winners.

324. We will fail to cut global co2 emissions in half by 2030, it is likely we will be producing more emissions by 2030 not less.

325. Natural gas will be the final transition fossil fuel and will still be widely used in the middle of this century. High energy density methane will be used for electrical generation and for chemicals and materials developments until such time as alternatives are discovered.

326. The complexity of our economic dissipative energy system and the misunderstanding of the energy density and intermittency of renewables will cause the global economy to continually stall.

327. A lack of investment in fossil fuels brought about by a surge in renewables investment will cause constant energy spikes in fossil fuels bringing larger disruption than expected to energy dense economies.

328. Intermittent low-energy density renewables will require significant materials, manufacturing, land use and redundancies to be a viable contributor to a constant electrical energy supply. These costs will add a significant financial burden for economies.

329. Over time energy efficiency will become an economic necessity because of scarcity. Reengineering much of the urban environment will become economically essential creating a construction boom in insulation and passive houses.

330. Youth bulges in developing nations will bring political instability especially in the middle east disrupting global energy flows. We will see huge increases in domestic consumption in these oil rich economies.

331. An energy crisis in the middle east would see fracking increase amongst industrialised nations bringing them in direct conflict with environmental ambitions.

332. Hydraulic fracturing (fracking) will be used to produce tight oils (LTO) and shale gas across the globe but this supply will be expensive and dirty. This is the consequence of tapping continually less energy dense sources.

333. The water intensity of fracking makes producing it in water stressed areas problematic. Russia and South America have large deposits within non-drought areas expect a large energy investment boom in alternative oil and gas sources as prices rise.

334. As we transition away from energy dense fossil fuels, we have only one technology that can keep us heading up the energy density ladder. Uranium yellow cake has seventy thousand times more energy per kilo than natural gas.

335. Traditional nuclear fission as opposed to fusion will dominate in the short term. China India and Russia will expand their capabilities. Australia and Kazakhstan hold some of the largest deposits.

336. Nuclear energy will see an explosion in demand as more advanced economies experience energy disruptions transitioning to renewables. European countries that have abandoned nuclear will fall behind those that embrace the high levels of energy density that nuclear offers. The time taken to construct a nuclear power plant means countries that fall behind could do so for decades.

337. It will become more and more obvious that nuclear energy regardless of its' chequered history is seen as the natural driver for humanity to maintain our economic system of continually exploiting ever denser stores of energy density. Countries that understand this first will have a lasting economic advantage over those that won't or can't transition to higher levels of energy density.

338. Small modular nuclear reactors (SMR) will become a significant part of energy production for some nations, base loads will eventually be powered by fusion reactors and will allow for a greater penetration of renewables in a modern electrical grid system. Safe clean abundant energy sourced from deuterium found in sea water tritium confined fusion (mcf)

339. Liquid-fluoride thorium fission will become economic, abundant thorium derived from soil. Cooled by liquid salt. Much safer, cleaner with a more abundant fuel source. China and India have some of the largest thorium deposits in the world.

340. Nuclear reactors and renewables will also generate hydrogen used in transportation; nuclear fusion, solar and liquid fuels are the key energy components most likely to win in the future.

341. Mega grid scale wind power will be restricted to a few areas of the globe. Where wind speeds are high and constant. Less hospitable less population dense areas like Greenland and the Antarctic will be energy harvesting regions distributing energy by liquid fuels or by hvdc electric cables.

342. Solid state wind power (ewicon) (swet) may have some benefits in the future but wind is likely to gain a footing at the smaller scale, vortex induced vibrations vortex shredding, savonius turbines.

343. Floating offshore wind turbines - higher more constant winds give increased energy density. Energy sourced from the oceans will increasingly be part of the energy mix. Autonomous harvesting.

344. Tidal power has been used for hundreds of years to grind grain, and will be part of the future energy mix, dependable renewable and relatively dense source of energy. Tidal barrages are expensive and environmentally contentious.

345. Tidal fences, turbines and kites offer less costly solutions in the future. Tidal offers energy density and predictability so often missing from renewables. Floating mobile power stations with turbine blades seem to provide the most cost-effective solutions. Figure of eight kites are increasing in installed capacity and efficiency.

346. Solar will become the dominant global renewable energy source, the amount of sunlight (solar energy) that hits earth in ninety minutes is about the same as the energy consumption of entire planet for a year. Silicon is currently used but perovskite combined with silicone may be a significant advancement in the next decade. As the energy density of solar increases, it will become more useful.

347. The surface area required for pv will become less of an issue in the future. Currently pv panels are not sufficiently energy dense and require considerable land area. The energy density of panels will continue to improve

348. Agrivoltaics (apv) mixing agriculture and photo voltaics will increasingly mitigate pv effects on land use. Shading from panels aids many plants and in return helps cool the panels.

349. Solar regions experience economic growth, south Africa, Namibia, north Africa, the middle east and notably Australia as they produce and export ever more efficient energy stored as hydrogen.

350. Saudis and middle east will transition to solar they will restrict oil exports as their population grows and consumes more energy domestically. High global oil prices will fund their transition. The renewable energies boom mainly solar will be greatest in the middle east and the United States.

351. Nano coating technology will make solar panels less susceptible to dust and wear increasing efficiency and reducing costs. Buildings will increasingly incorporate solar glass and be able to generate electricity

352. Synthetic leaves will make energy form carbon dioxide, artificial photosynthesis from water and carbon dioxide produces synthetic fuels. (synthesis gas). Which is currently produced in large quantities by the petrochemical industry from fossil fuels and is used in used in hydrogen production, fertilisers, methanol. This will be a revolutionary carbon negative source of energy dense fuels useful in materials, petrochemicals, transport fuels.
353. There will be a geothermal energy boom. The geothermal energy potential in the upper 10 km of earths' crust contains fifty thousand times more energy than all fossil fuels worldwide. Enough to power our global civilisation for millions of years.

354. Geothermal technology will increase exponentially in the decades ahead. Every km down sees an increase of 35 degrees centigrade, tapping this abundant source of energy will be key to our future prosperity.

355. Geothermal technology will develop well beyond traditional geologically active areas as the fist wave of adopters pushes the technology forwards and reduces costs.

356. The high temperature gradient between the surface and 10 km below means a source of reliable potential energy too large to ignore. Drilling technology largely developed for the fossil fuel industry will be advanced for geothermal energy.

357. Harder rock formations and deeper boreholes will require non-conventional drilling techniques to save energy and costs, thermal laser, mechanical and hydraulic drilling. Automated drilling rigs faster deeper and cheaper holes need to be dug.

358. Geothermal will be used in many parts of the world for domestic heating and cooling but also in the use of agriculture especially in northern climates. Huge warehouses will grow food all year round kept warm from geothermal heat and electrical power driving led lighting allowing year-round agricultural productivity. Investments in non-traditional agriculture using geothermal

359. Enhanced geothermal systems (egs) use fracturing of hot rocks by injecting fluids under pressure this increases the area over which heat exchange with the rock can occur. Additional boreholes are sunk to exchange the heat and energy. Contentious but efficient cost-effective at lower temperatures and requiring shallower drilling. This will be utilised in more remote areas.

360. Greenland and Iceland become critical to the entire internet as geothermal energy density, wind energy and a cold climate make them ideal as the world's most efficient server farm it powers much of the internet. We will be constantly looking for temperature gradients, areas where heat and cold come in to contact.

361. The oceans become recognised as high-density renewable energy locations; offshore energy harvesting creates abundant green energy.

362. Ocean thermal energy conversion (otec) exploit the potential energy in the temperature gradient from the surface to the bottom this allows the transformation to useful energy. Combined with kinetic energy from waves and floating wind turbine technology the oceans fill with new generation energy platforms.

363. The island nations of Iceland, Philippines, Indonesia, Japan and New Zealand will become increasingly dependent on geothermal power this will boost their long-term energy independence.

364. The us becomes the world's first solar to hydrogen super power it harnesses the sun to make liquid fuels to power domestic transportation and aviation along with nuclear and geothermal.

365. A geothermal drilling boom (Oregon and Idaho) the us will have cheaper energy than many other economies.

366. The transition to intermittent renewable energy and the weaning of advanced economies from fossil fuels will prove to be disruptive and expensive mainly due to energy storage issues.

367. Fossil fuels gave us convenience and energy density, renewables give us neither, so in order to replicate the utility of fossil fuels with renewables cheap dense energy storage systems are vital.

368. Backup energy storage systems for homes and businesses will experience dramatic growth in demand as renewables intermittency disrupts energy systems. Hydrogen and redox flow batteries, lithium-ion packs.

369. Energy storage will be part of the next great investment bubble, from lithium battery technologies to, hydrogen, liquid air.

370. the technological development of new energy storage systems will be essential as we attempt to transition. Levelised cost of storage (lcos) is an essential measure of battery technology but just as important is what the energy characteristics of each battery systems are.

371. Electrical grids need both instantaneous short-term production to cope with surges and more stable stores able to store renewable energy when it is not required immediately with longer storage and supply duration for times when renewables do not meet demand.

372. Large scale utility lithium-ion battery storage systems will be limited to the important job of short-term frequency generation as they offer a high (lcos) but effective instantaneous grid stabilisation. But will not be sufficient for longer duration base loads in a grid with a large percentage of renewables.

373. Lithium-ion batteries will be mainly for short term instantaneous high energy density grid modulation and small-scale portable power.

374. Nano diamond battery technology encases spent nuclear fuel from fission reactors and encases it in artificial diamond. Turning beta decay (radiation) into electricity. Micro scale batteries lasting thousands of years will be used in space, sensors, detection.

375. Nano diamond encasement will increase the viability of nuclear this potentially eliminates the problem of toxic waste and enhances its long-term energy efficiency.

376. Chemical flow batteries iron flow, will provide better grid scale storage. Rust (iron-air), zinc air or aluminum air batteries are longer duration (100 hour), grid scale battery solutions. Using cheaper more abundant materials.

377. Currently aluminum air batteries could well have a sufficiently high energy density potential to be a possibility in ev. They are being subsidised in India which has large reserves of aluminum and significant smelting capacity.

378. Cost-effective grid scale liquid air storage (cryogenic battery) storage essentially a compressed air system where excess renewable energy is stored using cooled air to seven hundred times less volume. When the grid requires it reheat it and extract the energy from the expanding material.

379. Low technology expandable and with potentially high energy efficiency. Currently this represents the best scalable, cost-effective renewables energy storage system it holds grid scale power delivery in the three-to-twenty-four-hour duration ideal to transform renewables in to a base load supplier and reduce curtailment.

380. Liquid metal batteries will offer high energy density, frequent cycling, long life and high efficiency and deep cycling.

381. Solid state batteries will provide a far more elegant solution than current ev batteries. Superior energy density and charging rates will transform the entire battery market but also fundamentally alter the ev market in terms of range and practicality.

382. Current lithium-ion batteries have a highly flammable liquid electrolyte inside them that can be explosive. Solid state batteries using super ionic conductors would be more stable and far more useful.

383. Beyond lithium comes sodium and potentially magnesium as potential a much more abundant material with lower energy density and a better cycle life.

384. Supercapacitor batteries built with graphene carbon nanotubes are multiplying the energy density of previous supercapacitors. Fast charging and bigger punch, will be used to prolong the lifespan of lithium-ion batteries and then solid-state batteries in the future.

385. Hydrogen will be stored in solid form solid-state hydrogen storage light activated energy storage (laes) using shape memory alloys will be a key part of the hydrogen economy. Storage is the key drawback for hydrogen this technology offers a safe potentially cost-effective solution for the storage and transportation of hydrogen.

386. Energy creation and storage will be enhanced by smart distribution of interconnected storage and generation technologies. Balancing between demand and supply will be critical in ensuring greater efficiency and stability of smart grids with intermittent renewables playing a large role.

387. Ai (artificial intelligence) will be responsible for running many smart grids of interconnected and varied energy sources. Making decisions on the supply and allocation of energy will make it a critical component of our energy system.

388. Autonomous ai electric vehicles fleets will act as energy stores charging and discharging as part of the interconnected grid system. Adding to a smart grid and helping balance loads. The price of transportation will be in part a consequence of the cost of electricity used during the journey. Peak demand will be more expensive.

389. Superconductivity is the holy grail of electrical energy transportation and transmission, copper, gold and silver are all electrically conductive but have different levels of electrical resistance. Energy created is lost in transmission through power lines or inside a computer through the heat generated by the electrical resistance of the materials we use today – copper mainly because it is cheap. Super conductive materials behave differently at the quantum level, they have no electrical resistance.

390. Smart grids will allow users and producers to trade energy, energy storage companies will buy energy when supply outstrips demand and sell it back when the opposite is true. Intermittent low density energy harvesting will require an entire energy storage industry. Energy storage may become a legitimate living for many businesses and entrepreneurs. Combining bespoke energy storage systems with cutting edge trading systems.

391. Coming down the energy density ladder smart grids will allow a more efficient use of renewables. But the true backbone of any electrical grid, smart or dumb is the storage of energy and the ability for it to do work when it is required.

392. Large scale nuclear will reduce much of the necessity for smart grids but for many economies around the world access to nuclear energy technology is unlikely. Countries that commit to a substantial nuclear energy programme will experience substantially better levels of economic growth than those that rely on renewables. Development times for nuclear can be as long as a decade so any quick move in to nuclear is impossible at present.

393. Much scientific development will become increasingly harder to finance and justify. As the complexity of our technology grows. Each scientific advancement will require greater capital and risk but will in aggregate offer less benefit. Medicine specifically biosciences will buck this trend for the next few decades.

394. However due to our reliance on fossil fuels and their unique ability to store dense energy we are at the beginning of an energy creation and storage technology wave that will be increasingly forced on us.

395. The complexity of our technology requires near perfect supply chains, continuous threats and disruption will have exponentially larger negative effects on developed nations. High levels of complexity in an economy or business become a negative drain when energy density is low and declining.

396. artificial intelligence will not reach any level of self-awareness to be a threat to humanity this century. Instead, ai will become a threat to professionals and experts in narrow fields of technology. Ai will accelerate the division of labour but, for the first time it won't be human labour.

397. The threat from ai comes in its applications and the systemic nature of the systems it is used to control and our reliance on its' output. It will be blamed for systemic errors most likely in the financial world mis pricing risk. Competing algorithms will lead to volatility and mistrust within these financial systems.

398. The owners of this technology will be unable to explain the outputs these systems make, because they themselves do not understand the logic and complexity of their systems learning and decision making.

399. The logical decisions made by ai systems will bring great benefits but potentially catastrophic moments as these systems make unexpected decisions that their owners cannot understand, explain or justify.

400. Quantum computing will allow millions of simultaneous computations solving complex problems almost unsolvable with classical computers. Cryptography, protein modelling, materials combinations. As our technology moves towards the atomic scale, so the complexity increases much greater levels of computational power will be required.

401. Ai machine learning and algorithms will be widespread but will be fragmented across thousands of unconnected systems developed independently to achieve specific tasks in a wide variety of industries and businesses for a multitude of purposes.

402. Data like energy exists all around us but needs extracting and refining to make it useful. The same is true for information, the creation of useful training data for machine learning is the single biggest cost and barrier to faster adaption and lower prices.

403. Data collection and training will be the key resources required for ai systems to work effectively the training must be free of biases, programmers will be replaced by rationalists.

404. Ai (machine learning) will advance the speed and cost of designing personalised drugs, vaccines synthetic biology, it uses huge datasets to find patterns a human would be unable to find. Ai in object recognition scans humans for medical and security identification from voice facial to biometric authentication, no keys no cards will be required in the future.

405. Ai will continue to make great strides in the identification of new diseases and pandemics. But with that comes the ability to over identify

406. Ai scans ariel satellite images for crime, waste, planning, traffic, water, conservation, agriculture forestry and many state functions. Its ability to monitor changes in environments through image recognition aids governments in controlling development within their borders.

407. Ai deep fake technology will become endemic it will enhance division and increase confusion as it gets better. But will conversely give recognised media outlets more authority as they are able to verify footage. Accredited media will become the only “reliable” source which in itself will cause further division.

408. Networked cloud ai will be added to all products to make them more intelligent just as electricity was added in the past. Much of it will be a gimmick but it will transform construction and manufacturing as this accumulated experience of tasks creates better autonomous machines.

409. Intuitive ai will be able to accelerate the design process in many creative industries, engineering, architecture, materials, automotive will see a new generation of designs. Lightweight, strong using less materials more organic and more representative of natural forms.

410. This level of ai complexity will supersede human ability to design structural components at first and later even aesthetic forms.

411. Nlp ai (natural language processing) will be a key backbone in many industries, from interacting with humans in service industries to sifting through large data sets for science and technology industries. Financial services, researchers, science will use nlp to sift through large amounts of information.

412. Nlp will be used as a diagnostic tool for health and wellbeing. Image and voice detection will be capable of diagnosing, mental states, this technology may be used in the criminal justice system but not without substantial opposition.

413. Connected device technology will plateau as development moves from increasing performance to the materials and elements used to manufacture this technology. Investments in material technology research companies will focus on developing applications for abundant materials.

414. A scarcity of minerals used in these devices threatens the long-term development of our technological society, more common and abundant materials will need to be harnessed in our technology. Rare earth mineral miners and explorers outside China and in friendly jurisdictions should be good investments.

415. Machine learning will be responsible for significant materials breakthroughs in the coming decades. Materials technology lies at the heart of our advanced civilisation. Almost all our modern materials require the energy density of fossil fuels either in the transformation process or as the raw material. The production of basic materials will be unable to meet demand.

416. The pace of new material development will be exponential over the next few decades. Materials discovery has been by the practice of trial and error. This hasn't changed for centuries and is generally limited to tiny alterations to existing known materials and compounds. We have thousands of types of steel for example. But in order to test the vast amount of other possible material compounds machine learning must be deployed.

417. A huge number of materials will need to be re-engineered away from fossil fuels most notably plastics that have many applications critical to our way of life and as yet with no available substitute material. Plastics are created from energy dense hydrocarbons (fossil fuels), it takes little energy to transform a high energy dense hydrocarbon (natural gas) to a lower density plastic. Energy is released in this process. However, our intention in the future is to take lower energy dense materials corn or plant material for example and make them stronger and more useful by adding energy to the process. This now requires an energy input at the transformation process rather releasing energy.

418. Materials informatics will be at the heart of a green materials revolution a quantum leap in our advancement. This technology is at the start of a significant investment bo0m. Advances in battery technologies and solar to name but a few key areas where this technology.

419. The application of machine learning will allow us to sift through the billions of possible materials and chemical compounds and alloys that could create materials to help in getting to net zero.

420. Graphene ten times stronger than steel will be used in more products. From electronics, solar cells, batteries, ultracapacitors, desalination, display screens. Silicene may well be a more affordable replacement than graphene.

421. Large scale construction projects will become scarcer. Carbon capture concrete may reduce the environmental impact of concrete production but does not reduce its energy intensity.

422. Bamboo composite becomes a widely used building material in the future sand is becoming scarce and the energy costs of concrete are large. Smart materials like shape memory metals and plastics can alter our infrastructure our homes furniture

423. Nanotechnology allows for the tailoring of material properties at an extremely small scale, making, stronger, lighter, more reactive and electrically conductive materials. Take carbon dioxide and nitrogen from the atmosphere and convert it into plastics or fuels. Nanosheets can harvest electrical energy from small motion.

424. Nanotechnology will be digested and monitor all the functions of the human body. Human excrement will be invaluable as a medical diagnostic tool, the ability to detect diseases and cancers years before other techniques through faeces means a huge leap in disease diagnosis. Nano diagnostics will monitor the gut microbiome detecting early signs of cancer, diseases and viruses.

425. Nanotechnologies like metal organic frameworks (mof) are nanoparticles used for filtration, lithium and fresh water both from sea water will be made more cost effective with this filtration technology, saving lives and increasing the supply of lithium.

426. Carbon nanotubes low weight, high tensile strength, high thermal and electrical conductivity. Semiconductor properties and chemical stability are all properties of this technology that can be exploited. Increased battery, solar panel and electrical conductivity all promise large increases in renewable energy and ev market.

427. Steel will be a key commodity to reaching net zero vital in the renewables sector. Iron and steel currently first in co2 emissions and second in energy use high energy use and carbon from high emissions coke (superheated coal in the absence of oxygen). Most recycled material, new steel production from iron takes eight times more energy than recycled steel.

428. Green steel making involves hydrogen used instead of coke in a blast furnace with water not co2 as the by product. Lime and carbon are then added to this sponge iron in an electric arc furnace to produce greener steel substantially lower emissions.

429. 3d printing harnessed with ai design software will be capable of producing intricate and organic physical structures super lightweight and super strong saving weight and materials. Its cost effectiveness will grow relative to the intricacy of the objects it builds.

430. New ai designed structures will be too complex for traditional manufacturing techniques, cars, aero planes, space, buildings.

431. 3d printing will be used in medical fields for regrowing damaged organs, using stem cells to regenerate tissues.

432. 3d printing (additive printing) will become mainstream when it is able to print bespoke clothing, footwear or furniture at cost effective prices. Until this point it will remain in the engineering, manufacturing and bioscience sector, where it will become more pervasive and more useful.

433. The price of everyday chemicals will rise affecting the price of many goods. High energy density methane is used for chemical production. Chemistry is abundant in our societies, from food, clothing, medicines, pesticides, technology, energy production and storage.

434. The chemical industry is the largest industrial consumer of energy and a significant polluter. Increases in the costs of chemical products will affect every part of our lives. A shortage of chemical products halts large parts of the industrial economy.

435. The chemical industry also affects the world around us, chemical products run off to form algal blooms and ocean dead zones. A drastic reduction in the global chemical industry would significantly improve our environment over time. Water and carbon dioxide are being developed as non-toxic solvents.

436. Chemistry needs to develop safer products for human health and the natural environment derived from less dense source of energy. Green chemicals will bring together electrolysis and fermentation (technical photosynthesis) using renewable energy. Turning carbon dioxide into carbon monoxide (electrolysis) and then feeding carbon monoxide to bacteria (fermentation).

437. Biosciences will be a large part of the next tech bubble. The economic potential to governments and citizens is enormous in an age of energy density. Biosciences may come to our rescue. From green fuels to gene editing this technology may enhance our lives will little to no energy intensity.

438. Only 5% of monogenic diseases have an available treatment today crispr cas-9 will allow inexpensive dna editing tool to correct delete inactivate or repair mutated genes this technology will be able to eventually cure nearly all these genetic diseases. This discovery led to a technique to genetically cut and paste the dna of all life forms

439. Genetic sequencing, enhanced manufacturing and logistics will allow for faster vaccine design, production and distribution. Lockdowns will be shorter and more targeted bring less disruption to the global economy.

440. Many genetic illnesses will be curable with gene editing technology. But more people will die from their own lifestyles than will be saved by new technologies.

441. Being more than your genome the epigenome controls gene activation the transcriptome dims or brightens the gene new drugs will allow to more accurately targeted diseases.

442. Bio terrorism will become a credible threat requiring enhanced biosecurity technology. This will necessitate an increase in personal and public bio protection from sensors to breathing apparatus. There estimated to be over a million viruses yet discovered in nature they can be manipulated using inexpensive crispr cas9 technology.

443. These new biotechnologies will allow humans to cure and then prevent illnesses human engineering will see life expectancy in aggregate increase over the longer term.

444. Over the coming decades the race will be on to produce therapies for thousands of genetic diseases. Human enhancement will become commonplace. It will help provide mobility to those without, but it will also lead to superhumans.

445. Biohacking using crisper cas-9, will proliferate, new species of domesticated animals will be created genetic modification of plants has been carried out for thousands of years and the same is true for livestock. Domestication is a deliberate modification in the genetic properties by selective breeding for traits (dna) that are preferred. But this technology took many generations to evolve and produce the species we have today.

446. Today we have the ability to introduce traits from other species that in essence is the disruptive element of new technology, combined with the speed of change.

447. Biohacking will flourish in non-conventional jurisdictions as eu and us will legislate to proscribe some activities mostly associated with human engineering. The economic damage to conventional medicine and pharmaceutical companies' business models will be enormous.

448. Russia, China and many less regulated jurisdictions may lead the way in genetics over the coming decades. Currently the uk looks set to break from north america and the eu in this regard if it doesn't regulate this technology, it will be the world leader.

449. The rise of autonomous anonymous drones will alter the global balance of power as warfare becomes smaller more intelligent and proliferated, large naval fleets will become vulnerable and undefendable.

450. The end of big military and of the safety of oceans and the dependability of merchant shipping on superpowers will have significant effects on globalisation.

451. The end of global hard power projected through large military infrastructure and the beginning of miniature disruptive anonymous warfare. The decline of globalisation and safe maritime transportation.

452. Defense industries to struggle to gain funding for large scale complex projects. Defense will concentrate on smaller scale individualistic division of labour specialist weaponry develop by smaller scale lower cost contractors.

453. Lethal autonomous weapons systems like ai drones will become increasingly dangerous especially in the oceans. Large vessels will become expensive targets for swarming, fast, autonomous and anonymous intelligent surface and sub surface drones.

454. From supercavitating torpedoes, hypersonic terminal packages, drones to ballistic missiles there are today a host of technologies that can make a blue water fleet vulnerable to attack.

455. Loitering munitions kamikaze drones, swarming ai drone s will overwhelm air defense systems by sheer mass of attack swarming drones can only be countered by the same. Humans will be incapable of dealing with the speed and technology.

456. A new arms race as all countries adopts this technology. Complex autonomous systems will react to each other escalating conflicts. Aerospace and defence industries.

457. Unable to secure its own infrastructure large modern warfare systems most notably blue ocean navies become ineffective, a costly liability. Under these circumstances political will to be the world's policeman will fade and the us will prioritise its domestic interests and substantially withdraw from the global stage.

458. Without the dominance of any single naval power, shipping and trade becomes less secure and more expensive in certain parts of the world. Especially south east Asia. China and India will vie for political and economic dominance in this region.

459. An inability for any single power to have hegemony over the oceans substantially reduces the chances for major conflict. Invasions require armadas but armadas can be destroyed for a relatively small financial outlay.

460. Weapons become smaller and more intelligent; drones will have the capacity to destroy hard power infrastructure globally. Countries and regions will become more nationalistic as global hard power fades regions and infrastructure will become harder to defend and less decisive for global superpowers like the us.

461. Governments will prioritise spending for energy and food security technology and infrastructure and defense rather than hegemony.

462. Automated subsea drones can cut communication cables rendering the internet potentially unusable for a relatively inexpensive cost. Anti-satellite technology will proliferate over the coming decades from lasers to guided missiles threatening global communications through an exponential increase in space debris.

463. Rogue actors can debilitate satellites for a relatively low cost. Drone satellites capable of targeting other satellites and disrupting communications systems. Satellites will need to become more complex, autonomous or cheaper and more throwaway to avoid these threats. Smaller cheaper satellites will proliferate to counter this threat.

464. Entanglement of nuclear and conventional military defense detection and increasing ip operating systems and networking will leave western industrial nations open to increased cyber-attacks of critical defense systems.

465. Low level cyber wars will be constant theme throughout this century both in industry, defense and at the state level constantly attacking networks.

466. The volume of cyber-attacks globally will increase exponentially over the coming decades. Every day millions of cyber-attacks occur, from data breaches to malicious malware attacks designed to extort money or to destabilise and disrupt companies or countries.

467. Disinformation or information manipulation will increase exponentially over the coming decades. It will increase paranoia and distrust amongst populations leading to friction and division.

468. Political discourse will become more divided. Disinformation will be used by states corporations, political movements and individuals in equal measure.

469. Disinformation will be used by rogue actors to cause banking crises, panic buying, stock market and commodity volatility. Halting banking services transactions, payment systems and atms. The damage to governments, financial entities and businesses are enormous and growing.

470. The low barrier to entry and an exponential growth in our technological complexity makes this disinformation amplification an escalating threat. It will increase volatility in our financial system.

471. More and more data will be stolen or intercepted. This “man in the middle” intercept and eavesdropping represents one of the biggest gaps in internet security hacking the internet’s infrastructure.

472. Border gateway protocol (bgp) allows data packets to be sent and received around the world by the 4 billion internet users. These date packets are controlled by some eighty thousand autonomous routers. The bgp designed for efficiency and not security.

473. A global cyber-attack will be as devastating to the global economy as covid was. Data loss and disruptions in connectivity will cause systemic disruption to global trade and supply chains. We will learn to manage breaches more effectively.

474. Taking a leaf from natural viruses it is impossible to prevent them from existing but creating diagnostics tools and antiviral code. Better data hygiene fewer duplicate data and data ranking for sensitivity.

475. As ai becomes cheaper to develop it will be a threat by the second wave adopters in the field of cybersecurity. Ai will be increasingly weaponised by malicious actors, its ability to scale at speed makes it dangerous.

476. Ai can be trained to find weak targets, its effective at mass phishing, personal data collection and collation. It can be trained to create effective clickbait at a far faster rate than a human being.

477. Ai allows mass continuous automated constantly developing attacks, it is a cost effective highly effective development framework for hackers.

478. As the world becomes more digital and the number of connections increases so the opportunities for cyber pandemics will also increase. The speed and intensity of malware, botnets and ransomware attacks will increase creating larger economic damage.

479. Smart grids and autonomous networked fleets will need to spend significant amounts of effort in counteracting this threat. Anonymous crypto currencies have facilitated much of the economic cybercrime but state, political and other non-economic actors are likely to be the biggest threat.

480. Current encryption will become obsolete with the quantum computers. The faster computers become the better the encryption everybody needs. The faster a computer the greater the speed it can deploy to overcome encryption.

481. The more data we place on networks the more encryption we need. All these increasing calculations require increasing amounts of energy. Over time doing the same thing will become more complex and take more energy.

482. English will become the dominant language of science, education & business on the planet. Many national languages will slowly fade over the century.

483. English will be the main language of further education in much of Europe and across the world. Businesses able to help teach english reading writing and pronunciation efficiently and at scale.

484. The education sector will be hugely impacted by ai (edtech) software over the coming decades, much of the educational sector will be displaced.

485. This will level the global playing field for knowledge and access to technology and will see an explosion in development amongst poorer nations it will level the global intellectual and technological playing field.

486. Ai will create individualised learning allowing students to move through a curriculum on ability rather than age. Stem subjects will become much more accessible.

487. learning will be more informal schools will become social centres rather than purely educational. Virtual reality can be used to create virtual labs and experiments enabling foundation of science to be taught quickly and cheaply.

488. China and Japan especially will be held back by their alphabets, the latin alphabet is a far more efficient system of communication than pictoral writing systems. Their share of the global digital and scientific economy will be smaller in comparison to their shares of industrial activity.

489. Translation technology can help bridge the gap this market must grow rapidly in these countries. But is no substitute for near native levels of english language skills.

490. English is the single biggest language of science and technology economies whose native alphabet is latin and have significant english reading and writing levels will prosper in the digital and science arenas.

491. Britain and the us will remain an attractive economy, a high level of scientific expertise, strong communications, democratic values and language density that it will allow them to continue to remain a technological superpower per head of population.

492. India will be able to grow substantially because of the penetration of the english language and the latin alphabet. A populous nation still tied to the british commonwealth.

493. The internet will continue to make life better. The spiraling cost of energy, travel and essentials will be offset with an ever-increasing stream of information and content for consumers at constantly declining prices.

494. More of consumers incomes will go on digital rather than physical goods, entertainment films, tv and sport.

495. The internet will be in reach of virtually all humanity through satellites or high-altitude solar powered drones. Low earth orbit satellites reduce the latency by reducing the distance.

496. This will alter the economic intensity of previously remote regions; better digital connectivity will increase the economic potential of remoteness.

497. Technology will continue to reduce the costs of producing digital entertainment. More entertainment at a lower cost. Technology companies will use ai to generate film sets, actors' sequences and whole films.

498. New entertainment companies will grow from nothing. Gaming will continue to grow as a share of disposable income.

499. Esports will continue to grow, football (soccer) will continue to be the dominant global sport. Esports will still continue to pull in huge audiences and will eventually become mainstream.

500. New forms of digital streaming will allow top European clubs to increase their revenue models. Expect the first billionaire sports person to be a European footballer.

501. Cricket will become a large value sport as the populations of India, pakistan and bangladesh become wealthier and spend more of their income watching this sport.

502. Consumption will become increasingly digital and less physical, the chaotic changes seen in media content delivery and consumption over the last few decades will continue. Western sport, film, tv will continue to dominate most global culture and maintain anglo saxon soft power for decades to come.

503. Transportation will decline as a share of global gdp, energy costs, geopolitics and technological advances will see the decline of the personal automobile and the rise of networked autonomous transport systems.

504. Growing populations in energy exporters will see demand for large increases in internal consumption of energy. Huge decreases in energy exports will limit availability for energy import economies.

505. Network technologies ai fleets autonomous uber cars will become a necessity to introduce massive transport efficiencies across all cities and reduce the energy density of transportation use and infrastructure.

506. Ai autonomous fleet learning will advance the ability of self-drive cars to navigate cities. The network effect will be particularly useful in transportation once one vehicle has successfully navigated a section of road all vehicles will have the same knowledge.

507. It will dramatically reduce the speed and costs of implementing and running ai it will accelerate its adoption. This will dramatically reduce the number of vehicles on our roads and the size of the automobile industry.

508. City dwellers will need less and less private transport, ai transportation will become cheaper, more frequent and pervasive. Networked autonomous ai transport systems will bring huge economic benefits to cities across the world.

509. Ai lorries will become ubiquitous on intercity regional transport systems. Ev and hydrogen powered vehicles the us and australia may for example have more hydrogen in their fleets and Europe more ev.

510. In time human driving will be almost completely banned in cities. Large fleets of networked ai taxis, buses, trams and trucks move goods and people. The efficiency and energy savings are so huge this will become a necessity not a luxury.

511. If aviation electrifies it comes in to conflict with other energy users. As we fall down the energy density ladder energy scarcity means prioritising energy use on needs rather than wants.

512. Mass electrification is a problem as so many more new demands are being made on electrical grids, electric vehicles, homes, businesses and industry will all take preference in a renewables-based grid. Needs vs wants.

513. Aviation has a chance of electrifying, superconducting electric motors a third smaller than current electric motors boost power to weight ratios, increased battery density will all bring electrification closer. But although electrical aviation will become possible it will be limited by our ability to produce sufficient electrical energy.

514. Aviation will continue to use fossil fuels even when electrification becomes viable. Its energy demand will add excessive electrical demand to the grid. Electric aviation will not take off until a large roll out of nuclear power offers a large base load of electrical energy.

515. Crossing the globe will get quicker again for some - mainly across water. Hypersonic aviation scramjet shockwaves low boom supersonic flight, will be a new dawn in faster travel for the wealthy.

516. Subterranean hyperloop transportation will become viable, autonomous excavators and fabrication systems would reduce the infrastructure and labour costs. Subsurface means no expensive planning and land ownership disputes. This would apply to more densely populated countries

517. Wind power will be harnessed to increase the fuel efficiency of shipping, wing sails, rotor sails and flettner rotors will all help to reduce the emissions and energy intensity of sea born transportation.

518. Shipping has been able to save cost by slow running its' diesel fleets and may have to slow down even more. Offshore energy generation may allow green liquid fuels generated at sea to be used at sea.

519. Autonomous shipping will bring cost benefits to ship owners. Less safety requirements for container vessels will see a host of new entrants of varying size and speed. Without human crews' economies of scale and time change.

520. Shipping will remain the most important and efficient transportation system for goods even in a deglobalising economy. Oil and gas transports will be the last commercial vessels to become entirely autonomous.

521. Agriculture will become a larger share of industrialised nations' economies. Technological research a key part of national security.

522. Agricultural bioscience, genetics, crispr cas-9 will speed up the age-old process of genetic mutation. Agricultural monitoring, better drought resistance higher productivity more resistant to pathogens. Crispr adds no foreign dna whereas gmo's do.

523. Agricultural infrastructure and skills will all become larger shares of our economy. Low energy storage of food surpluses will be as important as the energy storage revolution we are going through.

524. Extreme weather from floods to water shortages and depleted supplies of pesticides and fertilizers. More expensive energy inputs will reduce the productivity of vital crops especially in water stressed areas driving up food costs.

525. As water scarcity increases the global food export market will decline as the dependency of agriculture on water becomes more critical. Agricultural exports are essentially a water export and will slow to a trickle in many parts of the globe.

526. Food prices will continue to rise as 50% of all the human calories come directly or indirectly from rice corn (maize) and wheat. Most of which is grown in areas already under rising water stress.

527. Crop yields will fall, prices will rise. Giffen goods; will see a collapse in disposable income drive a greater consumption of basic food stuffs and a collapse in demand for higher value foods. Higher value specialty foods collapse and basic food types explode in demand.

528. We will grow far more of our food in urban settings, cities will become considerably more agriculturally productive in the future. A whole science of urban farming will develop using a combination of genetics, ai, natural and synthetic light.

529. Aquaponics aeroponics and other technologies will grow as food prices rise these forms of agriculture will become more competitive. Further developments will increase the productivity of cities.

530. Coastal populations like Japan, heavily reliant on fish for their diets will become increasingly threatened by a lack of fish stocks and the external political pressure to alter their diets and preserve what is left.

531. Approximately 3 billion people rely on fish stocks for their primary source of protein. A rapid depletion of supply will place a severe strain on their food supply and drive the demand for substitutes.

532. Japan and Asia will become a hub for alternative food technologies over the coming decades. Plant based fish substitutes will be a multibillion-dollar industry, with so many species there is ample opportunity for a whole industry of small companies.

533. The marine capture industry (fishing) will collapse, total global capture hasn't increased since the 1980's in spite of increased technology, further offshore, smaller fish and less desirable species.

534. As on land the energy density of fish a key resource is declining and the energy required to harvest it is increasing. It is likely that a collapse will be fast. Aquaculture will become a key supplier of fish protein.

535. Certain species of fish become too scarce and too expensive to farm; oily fish that needs to be fed fish have a negative fish in fish out ratio. They need to be fed more fish protein then they actually create. Pollution from waste and un digested feed causes oxygen depletion.

536. Overcrowding in fish farms causes diseases which are transferred to wild populations. It is more likely that only a limited number of fish can be farmed commercially with a positive energy return on energy invested (eroi).

537. As the environmental, welfare and health implications of a meat and dairy western diet become better known so plant-based diets will become more widespread.

538. Large multi-national food companies will sell their meat and dairy businesses. Online meat and dairy with home delivery will develop as meat becomes a luxury product. Supermarkets will become green non-meat and dairy vegan.

539. The traditional meat and dairy industry will decline sharply as lab-based meats and plant-based substitutes become better and substantially cheaper than meat and dairy itself.

540. Social attitudes towards meat and dairy industry will harden and it will become less and less socially and politically acceptable. To subsidise these industries. Animal welfare rules and regulations will increasingly tighten amongst developed nations.

541. Increased environmental and welfare standards this will affect economies like brasil, argentina and australia but it will hugely reduce the need for deforestation. This change will reduce the global timber supply in the short-term.

542. The rainforests will stop shrinking and will begin to grow again as the demand for feed crops will reduce dramatically as every calory reduced in livestock production means a nearly ten-fold reduction in plant calories required. That means far less land is required for a plant-based diet.

543. Crops no longer being used for animal feed will be turned into bio fuels but over time this will become economically unviable as the fossil fuel inputs fertislisers and pesticides become more expensive.

544. Insects will become an increasing part of diets across the globe. Its vastly more efficient means of producing protein than meat and dairy will become more noticeable as its price falls.

545. Brands especially food will soon have a good business case for divesting themselves of polluting environmentally damaging products like meat and dairy and pushing us towards a plant-based diet.

546. Plant food will be better for business, foodstuffs made from animal products for example require far more complex supply chains and environmental standards because of the bacterial properties of animal products. Plant based foods on the other hand have far less stringent requirements and costs.

547. Food will be a larger share of household budgets in developed economies than in the last forty years. Discretionary spending will be hurt. However, as food becomes more expensive so many western dietary and lifestyle illnesses become less common. Obesity plateaus and begins to decline.

548. As food prices rise so political instability rises in Asia and the middle east. Young populations needing access to food and jobs will be hardest hit.

549. Rising food and energy costs relative to income becomes economically intolerable. Arab springs become more commonplace as governments fail to provide sufficient food for their populations.

550. The obesity epidemic in wealthier societies will begin to peak as higher prices for food calories, carbon taxes on meat and dairy, an increase in knowledge and data will lead to an improvement in diets. Cheap food calories will become a distant memory and only the truly wealthy will be able to afford to become obese.

551. The need for expensive healthcare will decline as the implications of western diets become more understood by politicians as its effect on domestic life expectancy become more obvious.

552. The scientific understanding of the effects of food on our health and the financial implications for governments will be too large to ignore. Businesses able to prevent illness through health and wellbeing will be the net beneficiaries of public health drives and the associated spending.

553. The funding of healthcare will change. Insurance premiums will be dependent on adherence to ai systems monitoring and scanning patients for evidence of improved health conditions due to lifestyle changes.

554. Gut biome sensing will detect diet, being unhealthy will be costly and the non-adherence to prescribed changes will be penalised.

555. A pill for every ill based health system will be increasingly seen as financially gaining from suppressing the symptoms of illnesses that could be cured by diet and lifestyle.

556. The death toll from the side effects of excessive pill prescription will become a national disgrace in many western health systems. Governments will look to spend considerably more on prevention through health and lifestyle initiatives.

557. Medicine and biology will lead technological discovery, medicine has lagged physics and engineering for millennia and has much more catching up to do.

558. However, the nature of medicine will change dramatically. These sectors are likely to see large bubbles in investment in the coming decades, larger than the silicon valley bubbles.

559. Medicine will change from using an indiscriminatory sledgehammer to alleviate symptoms to a more targeted approach aimed at cures for illness.

560. We will enter the post antibiotic era where routine infections become deadly again and surgery becomes perilous. This could begin to reduce the life expectancy of those requiring surgery or suffering from wounds. The over use of antibiotics leads to a dramatic reduction in its effectiveness.

561. Nano composites will be used to create surgical devices that repel bacteria this will reduce the need for antibiotics but not eliminate it.

562. The therapeutic use of bacteriophages to treat pathogenic bacterial infections becomes widespread throughout the west. There are more phages (virus) on earth than all other species combined including bacteria, they only kill bacteria. There are millions of types of phages.

563. Phages will be used to overcome our resistance to antibiotics. A much more targeted approach to infection control. Phages have been used in conjunction with antibiotics; as bacteria mutates to defend itself to a phage it becomes immune to antibiotics. Country of georgia becomes the epicentre in the fight against bacterial infection.

564. The world will continue to be hit by pandemics, either born from nature or by the use of gene editing technology. As crispr cas9 becomes cheaper it will be possible to mutate viruses by much smaller groups of individuals.

565. As the global population has grown the incidents of pandemics has increased and will continue to do so. Technological advances made during covid will lessen their impact on societies and economies.

566. Technology will be better at identifying viral outbreaks, isolation will become less damaging to economies and death rates will be lower. However, coronavirus was a relatively mild virus and there exists the possibility of a far more deadly pandemic.

567. A virus with a mortality rate twenty times that of coronavirus is possible and would be devastating to the global economy, the lessons we have learned from covid would provide little mitigation, if this event took place with the value of debt high as a percentage of gdp, then central banks would be unable to prevent a deflationary collapse.

568. If a far more deadly pandemic occurred after the effects of inflation on the value of debt, then it would be a less devastating event economically as any debt deleveraging would be less significant.

569. The first and most obvious impacts of climate change may be in the drop in the production of staple crops such as corn (maize), soybeans and rice. Although more co2 positively impacts photosynthesis and water retention in plants, it has an opposite effect on nutritional content. This is more noticeable in wheat than in corn.

570. Water cycles will continue to intensify globally as temperatures rise and the climate becomes less benign. We will see droughts and floods become more common and severe. The insurance industry will become unrecognisable under these circumstances.

571. A grand solar minimum may interrupt our climate predictions as solar activity wanes this could have negative effects on global food production, weather and temperatures.

572. Increasing water scarcity as a result of climate change, rising populations and a fast-growing global middle class eating more protein will be a major cause of global insecurity.

573. Water scarcity will increase the technology of reverse osmosis desalination plants used in Saudi Arabia and solar energy to create steam combined with harvesting the minerals from sea water. Solar hydropanels distil humid air, carbon nano materials greatly increase filtration efficiency.

574. Many major rivers globally will become less navigable during the summer and more prone to flooding in the winter. These arteries the rhine, danube, yellow river, mississippi, indus river all make more landlocked regions economically viable. Many of the regions will have to rely on smaller boats to navigate shallower rivers.

575. Aviation will be increasingly grounded by heatwaves especially higher altitude regions as heat reduces lift and performance too hot too dry too little air pressure means plains unable to use runways. Night time flying will be required but will conflict with residents.

576. The effects of climate change will probably not be as catastrophic as some are predicting, but will still be significant in the short term. This will lead to cynicism as the apocalyptic outcomes fail to materialise. However, there will still be severely negative effects but only for a minority.

577. The costs of decarbonizing and transitioning away from fossil fuels will become a major economic drag for economies. Substantially more investment will be required than is currently understood by politicians.

578. A biophysical tipping point is possible but is unlikely - however, a warming planet will bring more frequent severe stress events many of the world's cities will be impacted by floods and heatwaves. Over the decades some cities will become harder and harder to defend.

579. Depending on geography some megacities may begin to decline in size. As the cost of mitigation become too great. At danger cities include sao paolo, delhi, guangzhou, mexico city, rio de janeiro, mumbai, manila, cairo, jakarta, dhaka

580. Other cities will become safe havens and will boom over the next decades, but that in itself might make these cities become less resilient in the future. Climate resilient cities buffalo cincinnati, wellington, copenhagen, stockholm toronto, vancouver, calgary, chicago, pittsburgh, boston, zurich, washington d.c., atlanta.

581. Resilient countries will see waves of migrants heading towards their borders. Us, canada Switzerland, Denmark, Norway, Finland, UK, Netherlands, Japan, Sweden.

582. Each of these extreme climatic events whilst severe will be short lived and will not be decisive events to compel societies to abandon fossil fuels unless and until the negative financial implications of such a move are limited or nonexistent.

583. Environmental activism will become increasingly more violent and radical in western economies. Energy and communications infrastructure will be continually targeted, this will result in ever increasing serious economic disruption and costs.

584. The positive effects of a warming climate will become more obvious, increased plant growth, more forestry and increased agricultural output especially in the northern hemisphere will all be consequences of higher levels of carbon dioxide and a warmer climate.

585. Northern hemisphere economies will experience a growth in new agricultural products such as wine and fruits not previously grown.

586. Relatively inexpensive solutions will mitigate many of the negative effects of climate change, acute sea level rise will affect only a minority of the global population small island states will be dramatically affected.

587. Billions of dollars of mitigation funds will flow in to climate impacted economies. They will experience huge investment bubbles.

588. The most drastic effects of climate change will be in the oceans where already depleted fish stocks will be under pressure from warming oceans, agricultural and human run off and retreating coral reefs.

589. The global fishing industry will collapse faster than most expect. This will affect poorer coastal populations forced to buy fish protein from farmed sources.

590. In the twenty thirties rising sea levels will become more significant the moon wobble cycle of 18.6 years either suppresses daily ocean tides or amplifies them. First observed and recorded in 1728, what's making this more significant is the accumulated and accelerating rise in sea levels caused by a warming atmosphere and ocean.

591. It will become increasingly apparent that the political promises of net zero will be economically unachievable without a serious reduction in living standards. Net zero skepticism will become mainstream, climate resilience will become a key spending area for national governments. Growth in businesses able to offer smart solutions to mitigating the worst effects.

592. At the same time the costs of decarbonizing will weigh heavily on ordinary tax payers and consumers - a backlash against environmental campaign groups and ther tactics will see political movements adopt an effective and popular climate mitigation agenda. A re-engineering of infrastructure flood protection, sea wall defenses will see dramatic growth.

593. A climate mitigation agenda rather may well be very popular at points during our transition and could even result in some major western economies reversing many green policies in favour of more instant policies of maintaining or not degrading living standards by reducing environmental burdens and promoting an increase in the use of fossil fuels.

594. Fossil fuel use will still be a dominant feature for decades to come like an old motor this infrastructure will require constant maintenance for decades to come.

595. As the global climate warms this century Russia and Canada will be a major beneficiary. As their climate begins to fall within the long-term economic temperature zone 11-15 degrees Celsius, waves of migration from China and Asia however will bring about regional conflict. Europe and America will suffer Canada will become a net beneficiary from us immigration.

596. Japan and the United Kingdom will remain prosperous island states. There are three geographic states for nations; island, coastal and landlocked. Island states will by and large prosper, water transport is the most efficient, islanders are generally the best at water transportation.

597. The US, India, China and other coastal states with good navigable waterways will always have a key advantage. However, as droughts in the summer and intense flooding in the winter take their toll these economically important waterways may become less navigable, pushing up costs for transportation.

598. Landlocked regions will remain significantly undeveloped. Central Africa and central Asia will never be fully exploited for their minerals. Declining energy density makes undeveloped hard to get to regions even less likely to be exploited.

599. The resources we have been unable to exploit up to this point will have too low an EROI to be worth exploiting in most cases.

600. Sub-Saharan Africa will still lag the world in economic activity in the future because its geography is not ideal for intense economic growth. A lack of navigable waterways and ports due to shallow waters and fast running rivers hinders its ability to be a genuine sea faring continent.

601. Transportation costs are high and fresh water and minerals whilst abundant are mostly in remote regions. Reducing economic potential to a few key areas.

602. Indonesia and the Philippines will use their geologic resources to enhance their island advantage they become large economic centres in the future. Geothermal temperature gradients allow the exploitation of geothermal heat this energy potential will allow new economies to grow, new regions to expand.

603. Open expanses of land and sea will be able to be harvested high predictable wind speeds, wave motion, thermal gradients, tidal motion, solar energy will become new areas of energy density.

604. Coastal communities once reliant on fishing for their livelihoods will become small scale energy harvesters, more and more energy harvesting systems will be deployed in the oceans of varying sizes.

605. As solar power becomes more effective and energy storage becomes more efficient expect a move to solar dense regions to farm solar energy.

606. The current technology being developed to establish a self-sustaining space colony could be suitable with efficient solar for living in inhospitable regions on earth. Technological small scale desert farming and civilisation could become a realistic possibility.

607. Greenland and Iceland supply northern Europe with renewable electricity through HVDC and in the future super conductive underground power cables. Morocco and north Africa supplies solar and wind power to the UK and other European countries.

608. Many remote locations become more habitable with more permanent technological settlers, advances in space habitation; energy generation, storage, low orbit satellite communications, allow civilisation to re spread across the globe, this will likely occur sometime after tourism has collapsed.

609. The green new deal promoted by politicians is called in to question, the promise of lots of well-paid jobs in green energy is not a benefit, it is an indicator of the high costs and effort required to create useful energy from low density sources.

610. Within this century mankind will begin to mine other planets and bodies for rare minerals and energy. The moon will be permanently manned and some forms of polluting manufacturing or experimentation will be conducted on its surface.

611. The moon will be used to provide solar energy generation for space exploration by converting water found on its surface into hydrogen rocket fuel. The moon itself will be mined for minerals. Low gravity will provide an excellent jump off point for mars and space mining and exploration.

612. We will become an inter stellar species.

SUMMARY

613.

CIVILISATION AND ENERGY

So as we enter the age of decline in energy production its worth understanding the crucial role that energy has played in humanities rise from hunter gatherer to this technological age we live in today.

As our hunter gatherer ancestors spread across the globe, they discovered new lands that gave huge abundance to the early settlers, there were probably significant surpluses at first.

About ten thousand years ago humanity started to settle and began to farm, this switch to agriculture was most likely because it generated a surplus and standard of living above that of being a hunter gatherer.

The transformation of natural resources through the use of energy saw the technological development of the metal ages, the advancement of society and surpluses that translated in to early civilisations with the ability to create structures that are still visible today.

The domestication of the natural resources of livestock to create high density energy foods such as milk and cheese has allowed surpluses and the ability to store a surplus for when it is needed.

Genghis khan conquered the western world because the Mongols were able to harness the power of horses for warfare, transport and calories from their milk, they had technology and resources far above those of their neighbours.

The Egyptians harnessed the natural resources of the Nile to build one of the great early civilisations, the geographical abundance of the Nile delta was a magnet for technology, civilisation and enlightenment.

The great structures of previous empires we admire so much today are in most cases the product of the external energy surplus supplied by slavery or by surpluses generated through conquest.

The Euphrates, Tigris, Nile and Indus rivers have all been the centres of early civilisations because their geography gave them fresh water, fertile soils packed with minerals washed downstream from higher altitudes enabling early farming and fishing, generating a surplus allowing the construction of infrastructure and the first towns and cities.

The Minoans of Crete, like many island and coastal maritime empires to come were at the centre of trade across the Mediterranean. Moving goods by water remains today the most efficient means of transport as it was back then, this has always given coastal states an economic advantage over land locked territories and will likely increase in time.

The trade in goods and commodities across the Mediterranean during the bronze age, was also accompanied by an exchange in ideas and culture and a huge increase in enlightenment, technology and philosophy, the interruption of this trade saw a complete collapse in these civilisations across the region.

The Romans perfected the industrialisation of mining and manufacturing So intensifying their use of energy and resources to build an advanced civilisation that has left its mark in ice cores in Greenland showing a surge in man-made pollution not seen before seen before and not seen for another 500 years after its collapse.

The Vikings harnessed the wind by advancing the technology of boat building and navigation to make journeys so far ahead of their time that they are still underestimated today. They reached America by crossing the Atlantic in voyages at the forefront of technology, they had been building fishing boats to catch cod in the north Atlantic, and increasing their ability to navigate such heavy home seas gave them a technological advantage.

As the technology of boats increases and oceans become navigable power moves from Mediterranean empires to the Atlantic empires, the Spanish, Portuguese, French, British and Dutch all compete for trade and dominance through marine technology.

The ability of these nations to navigate oceans gave them an economic advantage over the old Mediterranean regions of classical antiquity, from north Africa, eastern Mediterranean, Greece and Italy never again create a dominant civilisation.

The equine nomads from the Eurasian steppes skilled in horse breeding, have over thousands of years transformed a small animal incapable of carrying a rider in to a cavalry horse capable of carrying an armoured warrior.

Advancements in saddles, stirrups and bits along with a superior skill in horsemanship allows these technologically advanced waves of invaders pushing across western Europe overcoming settled agricultural economies.

The transformation of the horse into a weapon of destruction and the ownership of this technology altered the balance of power in much of Europe, old roman tactics of slow-moving disciplined infantry relying on logistics and supply lines was swept away by fast moving mobile cavalry.

It was not until the invention of muskets and canon that the balance of power moves away from this equine technology back towards a structured logistical infantry and state.

The United States used their huge energy and mineral resources to defeat the resource deficient Japanese and nazis during the second world war. The axis powers of Germany, Italy and Japan, fearing an inability to access sufficient resources attempt to capture oil fields in the caucuses, south east Asia and in north Africa the Suez Canal to gain access to middle east oil.

All of these civilisations and the many others there have been are a consequence of the advancement of technology over their neighbours and the ability to harness energy and natural resources to create a surplus that allows art, culture, politics and enlightenment to flourish.

These empires were not a consequence of the ability of one individual to inspire nor because of some superiority of culture or race. They were the consequence of the geography, geology, energy and resources available with which the inhabitants are either able to survive or thrive.

The opportunities for groups of people to expand and build empires and great civilisations is one that is rarely if ever turned down.

A technological, environmental and geographic advantage will be exploited by members of the society to increase the wealth of all of the society.

But all of these empires were supplanted by others, the wealth and power of the Greeks fell away and the Romans became the dominant force in the region creating one of the most iconic empires in human history.

This book studies the rise and fall of western empires and is by intention relatively limited to the Atlantic, Mediterranean, middle east, and western Asia. There have been countless great civilisations in the east of equal and at some instances highly significant but will be for further enquiry in the future.

All of these examples and many more are the direct consequence of the transformation of natural resources through the use of energy to create tools and machines to create an economic surplus or a strategic advantage over their neighbours,

ENERGY AND TECHNOLOGY

Energy is the real source of economic wealth, prosperity and civilisation – technology is the process by which we harness and transform it and money and currency are merely a means of accounting for it. The horse is energy and the harness is technology, we need the harness for as long as we have the horse, no energy no technology.

Throughout history humanity has been able to overcome obstacles and to develop new technology through the release of energy by burning it and transforming natural resources to build ever more complex products, economies and societies.

Since harnessing fire, mankind has used more and more exogenous energy, that is external energy not consumed as food and transformed through physical labour. After open fires came kilns for pottery, external energy (wood) heated to a high temperature to transform the material properties of clay through the application of heat energy to create an early technology still vital today.

Kiln technology allowed us to enter the metal ages. By transforming wood to more energy dense charcoal, the next step on the energy density ladder was taken.

Wood transformed to charcoal creates higher temperatures, higher temperatures allowed more materials like metals to be transformed. Charcoal gave way to coal - another step up the energy density ladder.

Coal became the energy of choice once we had significantly deforested much of Europe to build ships and became short on material to create charcoal it forced a move up the energy density ladder. Technology followed the energy source and opened up new avenues to exploit.

In spite of the importance of coal itself it was a fraction of the cost of the steam engines it ran as with oil today the cost of the combustion engine far outweighs the cost of diesel or petrol.

In essence the cost of the energy input is a tiny fraction of the profit it returns and as such this is the reason it is overlooked in favour of the harness. The energy input must be fraction of the total cost to allow the technology to be created and a surplus to be made to compensate for the effort required

The problems come as the cost of the energy input begins to rise inexorably as its scarcity becomes a monetary drain sucking away the surplus

Metal gave us better ploughs and tools to shape our world more efficiently. It gave us nails to make more complex and stronger structures like boats that could cross greater distances. It gave us better saws to cut down larger trees and sped up our ability to consume our early primitive biomass energy sources

An early yet un relenting example of the progress traps, we set for ourselves and the nature of our current situation where we exploited our natural resources to the point where in the past, we were forced to make a move up the energy density ladder but today that option is increasingly limited.

The transition to agriculture was the stockpiling of food energy and increasing the efficiency of production. Domesticated livestock represents a store of energy for work (labour) or consumption (calories).

A field of wheat represents a denser store of food energy close at hand rather than previously foraging for less dense and less predictable supplies of calories.

The harnessing of livestock and in particular the horse shifted the power of whole civilisations. The transformation of the horse from a small animal capable of pulling a chariot to one capable of

carrying full armour was a deliberate and sustained effort to transform the energy density of an animal and the work it could do.

The transformation of all livestock to more docile larger and more energy dense breeds allowed larger fields to be ploughed, goods to be carried further afield and represented more efficient stores of food calories.

Virtually the entire history of human civilisation is built on the harnessing of one particular source of exogenous energy. Human slavery has existed as an economic necessity for nearly every civilisation throughout history, until the arrival of “the ghost slave” oil.

Civilisations such as the Greeks prospered economically through the extensive use of slavery to allow their owners to live more energy dense and better existences than they could provide through their own physical labour.

The advancement of boat design and in particular sails allowed the efficient harnessing of wind energy to make circumnavigation of the world possible and began the centuries of globalisation that followed.

Sea transportation and trading became the most energy efficient means of transporting ever larger quantities of goods from across the globe. Harnessing wind power became the single most important technology for all would be empires until coal fired ships arrived.

These are the early steps in our continual attempts to exploit energy in more and more dense forms. From the first fire pits we have steadily moved up the energy density ladder.

From wood to charcoal which allowed hotter fires and better metalworking. To coal, oil and natural gas, we have always gone in one direction up the energy density ladder. Exploiting more and more dense forms of energy.

The coal age gave way to the oil age and a new industrial revolution, first powered by coal and then by oil. Coal gave us the steam engine and the telegraph, oil gave us the internal combustion engine, electricity, pharmaceuticals, petrochemicals, radio, film and records, aviation and computers.

Whilst many talk of another industrial revolution today the truth is that much of what we call technology has been with us for some time most of the productivity gains from the internet and computers are long gone.

Most internet technology centres around entertainment, much of our day-to-day stuff was invented decades ago tv, phones, cars, aeroplanes we have gone through a miniaturisation and efficiency phase but without a newer and more dense source of energy there will not be a new industrial revolution.

We will merely enhance the technology we have had for some time additions such as ai not as significant as the invention of the telegraph, the steam engine or the internal combustion engine and as such we are wallowing at the end of the oil powered second industrial revolution with little to no technological growth left.

JEAVONS PARADOX

As we begin to decline in oil production we will look for technological solutions, the most likely is that we can offset the decline with efficiency measures,

Jeavons' Paradox, also known as the Jevons' Paradox or the Jevons' Effect, is an economic theory that suggests that improvements in energy efficiency may paradoxically lead to increased overall energy consumption.

The paradox is named after the English economist William Stanley Jevons, who first described this phenomenon in the 19th century. Jevons observed that as improvements were made in the efficiency of coal-powered steam engines during the Industrial Revolution, the overall consumption of coal increased instead of decreasing as one might expect. This counterintuitive outcome occurred because the increased efficiency reduced the cost of using coal, leading to increased demand and wider usage.

The underlying mechanism of Jevons' Paradox can be explained through the concept of rebound effect or backfire effect. When the efficiency of a particular energy resource or technology improves, it becomes cheaper to use, making it more attractive and accessible to consumers. As a result, the overall consumption of that resource or technology increases, offsetting the gains achieved through improved efficiency.

Jeavons' Paradox can be observed in various sectors and contexts, including energy-efficient appliances, transportation, and industrial processes. For example, as cars become more fuel-efficient, people may choose to drive more or switch from public transportation to private vehicles, leading to increased fuel consumption.

The paradox highlights the complex relationship between energy efficiency, technology, and human behavior. While improving energy efficiency is crucial for reducing resource consumption and environmental impact, Jeavons' Paradox suggests that it alone may not be sufficient to achieve significant reductions in overall energy use. To effectively address energy consumption, a comprehensive approach that combines efficiency measures with conservation efforts and behavioral changes is often necessary.

Certainly! Here are five examples of the Jeavons' Paradox in action:

1. Energy-efficient light bulbs: The shift from traditional incandescent light bulbs to more energy-efficient options, such as compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs), has led to reduced energy consumption per bulb. However, the lower operating costs and longer lifespan of these energy-efficient bulbs have made lighting more affordable, encouraging people to use more lights or keep them on for longer periods, ultimately increasing overall energy consumption.

2. Fuel-efficient vehicles: Improvements in vehicle fuel efficiency have been a key goal in the automotive industry. However, as cars become more fuel-efficient, the cost per mile driven decreases, making driving more affordable. This affordability, coupled with increased accessibility, may result in people driving more frequently or taking longer trips, offsetting the energy savings achieved through improved efficiency.

3. Digitalization and electronic devices: The advancement of digital technology has made electronic devices more energy-efficient over time. However, the widespread adoption of devices like smartphones, laptops, and tablets, along with the increasing functionality and usage patterns, has led to a substantial increase in overall energy consumption related to charging, data centers, and network infrastructure.

4. Industrial processes: Energy efficiency improvements in industrial sectors, such as manufacturing, have often led to increased production levels rather than reductions in energy usage. As businesses can produce goods at lower energy costs, they may expand their operations, increase output, or introduce new products, ultimately driving up overall energy consumption.

5. Home insulation and heating systems: Enhancing insulation and employing more efficient heating systems in buildings can lead to reduced energy consumption for heating purposes. However, the cost savings associated with lower energy bills may encourage people to maintain higher indoor temperatures or expand the heated area, thereby partially or completely offsetting the energy savings achieved through efficiency improvements.

These examples illustrate how the Jeavons' Paradox manifests across various domains, highlighting the need for a comprehensive approach to energy conservation that goes beyond efficiency improvements alone.

THERMODYNAMICS

The first law of thermodynamics – the conservation of energy states that energy can neither be created or destroyed but only transformed.

Sunlight energy is our major source it is either current or stored. Current sunlight supplies the energy required for photosynthesis in agriculture and inputs for solar panels - it is diffuse and not very dense. However, stored solar energy when in the form of fossil fuels, provides a level of density that has enormous utility to society.

The second law of thermodynamics states that in a closed system entropy will always increase. That is order will always give way to disorder pockets of energy density will over time disappear.

Entropy is a concept that originates from thermodynamics, the branch of physics that deals with the relationships and conversions between different forms of energy. In the context of energy and fossil fuels, understanding entropy is crucial to grasp the implications of energy transformations and the limitations of certain processes.

Entropy is a measure of the amount of disorder or randomness in a system. It is a concept that helps us understand the direction in which processes naturally tend to move. Energy tends to disperse or spread out over time. Entropy is associated with the dispersal of energy in a system. High entropy corresponds to a more disordered and less useful form of energy, while low entropy corresponds to a more ordered and useful form of energy.

Fossil fuels (like coal, oil, and natural gas) contain stored energy in a relatively concentrated and ordered form. When these fuels are burned to produce energy, they undergo combustion reactions that release the stored energy. The process of burning fossil fuels increases the entropy of the system. The concentrated chemical energy in the fossil fuels is transformed into heat energy, which tends to disperse and spread out, increasing the overall entropy of the surroundings.

Our modern standard of living is highly dependent on the availability of abundant and concentrated energy sources, such as fossil fuels. These fuels have high energy density, making them efficient for powering various applications, from transportation to electricity generation.

As we extract and utilize fossil fuels, we contribute to an increase in entropy in the environment. This increase in entropy is linked to the irreversible transformations of energy from a more ordered state to a more disordered state.

The concept of entropy helps us understand the natural tendency of energy to disperse and become more disordered. Fossil fuels, while providing concentrated and ordered energy, contribute to increased entropy in the environment through combustion processes. Balancing our modern standard of living with sustainability requires exploring and adopting energy sources and technologies that minimize the environmental impact and increase overall efficiency.

All physical systems, including human-made structures and technologies, are subject to natural degradation and decay over time. This is a manifestation of the second law of thermodynamics, which states that the entropy of an isolated system tends to increase over time.

The forces of entropy lead to wear and tear, making maintenance and preservation critical for the longevity of infrastructure and technologies.Energy tends to disperse and spread out. Fossil fuels, which have played a central role in powering the industrial revolution and modern civilization, release energy through combustion but also contribute to increased entropy in the form of dispersed heat.

Human civilization has continually advanced through technological innovation. Technologies are developed to overcome challenges posed by natural forces of entropy, whether in the form of

materials science to create more durable structures or in the development of energy-efficient technologies.

Regular maintenance and repair of infrastructure are essential to counteract the forces of decay and wear. This includes repairing roads, bridges, buildings, and other critical components of the built environment.

In essence, the forces of entropy pose challenges to the sustainability and longevity of human civilization, but through scientific understanding, technological innovation, and responsible stewardship, we have developed strategies to overcome and mitigate these challenges. The ongoing pursuit of knowledge and advancement in science and technology remains essential for addressing the complex interplay between entropy and the progress of human civilization.

The increase in entropy can have several effects on technological civilizations. Entropy, in the context of thermodynamics, is a measure of disorder or randomness in a system. As technological civilizations progress, they interact with their environment, and the processes they engage in can contribute to the overall increase in entropy. Here are some effects of increasing entropy on technological civilizations:

As technological civilizations extract and utilize resources for energy and manufacturing, the processes involved often contribute to an increase in entropy. This can lead to the depletion of finite resources, especially if extraction and consumption are not managed sustainably.

Many technological processes release waste products and by-products into the environment, contributing to pollution and environmental degradation. The disposal of industrial waste, emissions from combustion processes, and the use of certain materials can increase entropy in the environment, impacting ecosystems and biodiversity.

The generation of energy, particularly through the combustion of fossil fuels, increases entropy by dispersing energy in the form of heat. While this is a natural consequence of thermodynamics, it poses challenges for sustainability and environmental health. Transitioning to cleaner and more efficient energy sources can mitigate some of these effects.

The second law of thermodynamics implies that over time, all physical systems tend to move towards a state of greater disorder. This includes the decay of infrastructure and technologies. Without proper maintenance and investment in upgrades, the efficiency of infrastructure can decline, leading to increased energy consumption and environmental impact.

The consequences of increasing entropy, such as resource depletion and environmental degradation, can have economic and social ramifications. Technological civilizations need to find ways to balance economic development with sustainable practices to ensure long-term stability and well-being.

Increasing awareness of the impact of entropy on various aspects of civilization has led to a continuous search for more efficient technologies. This includes innovations in energy production, materials science, and waste management that aim to minimize the negative effects associated with increasing entropy.

In summary, the effects of increasing entropy on technological civilizations are multifaceted. While technological progress inherently contributes to entropy, civilizations can mitigate these effects through responsible and sustainable practices. The ongoing challenge is to strike a balance between advancing technology and minimizing the environmental and societal consequences associated with the inevitable increase in disorder and randomness in natural systems.

We as a civilization have increased the natural rate of entropy on our planet, we have been exploiting our fossil fuel deposits burning the best deposits and transforming them in to goods and services we consume.

These low entropy resources were a onetime gift to humanity and we have raced through them at an ever-increasing rate, entropy can never decrease so we cannot go back in time we have lost the useful energy and what we have left is less useful.

Because entropy is a natural force then disorder is the natural state - the entire progress of civilistion is a battle to over some the relentless force of nature and entropy, beating back entropy requires energy so energy is the essence of civilisation.

The standard of living we enjoy today is directly related to the amount of order we can impose on our environments it is therefore directly related to the amount of useful energy we have access to.

THE ENERGY DENSITY LADDER

Modern society is awash with stuff, we are a carbon-based species. Carbon forms the foundation of our bodies and the external world we experience. Almost everything we touch is carbon-based.

Not only is our stuff mostly based on carbon, but the energy required to manipulate materials – to make stuff – comes predominately from hydrocarbon-based feedstocks as well. For example, we can't make steel without the energy inputs from fossil fuels.

Since energy is the basis of civilisation, mastering the chemistry of hydrocarbons and harnessing the energy of fossil fuels is key to the modern economy. When transforming materials, it is easier to start with a source that has higher embedded energy than the products you intend to make.

Ideally falling down the energy density ladder going from one chemical compound to another releasing energy. Whereas going in the opposite direction requires putting energy in (like climbing the ladder).

At the top rung of our hydrocarbon ladder sits methane (natural gas) it has the most embedded energy. When you burn methane fully it gives off an enormous amount of useful energy.

Take polyethylene, which is the highest volume production plastic in the world. Industrially, polyethylene is made by sliding down the ladder: ethane is converted to ethylene, which is then polymerized.

The next rung down from methane sits oil, an easily transported liquid at room temperature and pressure but with less embodied energy than natural gas. Oil serves many purposes for which methane is unsuitable. However, you must burn more oil to get the same amount of useful energy

Further down the ladder is coal. Coal is even more oxidized than oil, sitting closer to the ground. It is also quite dirty, filled with nasty impurities. But coal is cheap and is a solid easy to transport and burn.

At the bottom is wood (biomass), like all plant stuff it is the product of photosynthesis (so are coal and oil, of course, but wood just died more recently).

In a highly inefficient process, nature starts with co2 and begins to climb the ladder using sunshine as the fuel. This process takes millions of years and cannot be replicated by technology only by time and geologic pressure the fossil fuels we burn today are a once in a lifetime gift.

When we use hydrocarbons as a source of energy, we want to be at the highest rung possible. This is, in fact, how societies evolve. Wood burning gives way to coal, which eventually gives way to oil and then natural gas.

As societies become more sophisticated; they can exploit more energy dense hydrocarbons to create cleaner environments. Natural gas is the cleanest burning carbon-based fuel. You can use it directly in your kitchen with minimal ventilation for a reason.

The move away from burning biomass and coal in the home has helped reduce millions of deaths from respiratory disease across the globe

Almost all synthetic materials in modern life start near the top of the ladder and are engineered downward in a controlled burn. Energy is released not added to the process

Ethane is close to natural gas on our ladder, while polyethylene has virtually the same inherent energy as oil. To make polyethylene is to descend down the ladder.

In theory polyethylene could be made from corn, but that involves climbing the ladder with big steps. Corn is made from co2 and solar energy on it is a biomass so is at the bottom of the ladder.

To make polyethylene from corn, you first need to produce corn ethanol, ethanol is higher up the ladder than corn, similar to coal, but much lower than polyethylene. Jumping yet another full rung, while possible, simply doesn't make economic sense, even with substantial government support.

Simply put every time we try to recreate higher energy dense materials with lower dense energy and materials we are going against the fundamental physics of energy.

Many of our solutions such as renewables or bio fuels require us to either move up the energy density ladder in chemical terms or down the ladder in terms of energy input this goes against all of our previous behaviour as we have developed the society we live in today.

EROI ENERGY GAIN

External energy is never entirely free it takes energy to get energy, from the energy used in gathering sticks to build a simple fire through to modern day exploration, drilling, pumping and refining oil it always has a cost - the amount of useful energy left after taking in to account the energy expended getting it.

The first oil wells in the us produced one hundred barrels for the cost of one barrel of energy used, oil was high quality, energy dense and easily accessible, today we are using tar sands from Canada, low density, and low quality, requiring extensive processing and for every two or three barrels of useful energy produced one barrel needs to be used.

At the same time the low hanging fruit of global fossils fuels had been used and explorers had to start looking at energy deposits harder and much more expensive to produce a profit from, often needing more refining, environmental regulation pushed costs up along with changes in politics in some producing countries and regions making investment riskier.

Today when we discuss fossil fuels it is generally within the context of climate change and carbon dioxide emissions, the general assumption is that we have more than enough supply of fossil fuels and plenty of demand to keep on our upward trajectory of carbon dioxide emissions. However today the world is in a vastly different place to that of much of the upward curve.

WHERE IS OIL FOUND AND WHO CONTROLS IT

WHAT'S SO SPECIAL ABOUT OIL?

Oil is the most special of all the fossil fuels its at the fulcrum of the fossil fuel age, its more energy dens than coal, but its easier and safer to transport than its more energy dense relative methane. It easily produces kerosene, petrol and diesel amongst many other products.

But without oil, there are no diesel engines and without a diesel engine not much gets moved anywhere, from trucks and vans to oil tanker, mining vehicles, and railway cargo the diesel engine is at the heart of our global freight system.

Without oil we can't mine for resources, transport raw materials and finished goods, without aviation fuel refined from crude oil we cant fly planes and connect the whole world.

Over the last century, oil has played a pivotal role in shaping the development of civilization, driving technological advancements, and influencing living standards. Its significance is particularly pronounced in the exploitation of other natural resources. Here are key aspects of how oil has impacted these areas:

Internal Combustion Engine: The widespread adoption of the internal combustion engine fueled by oil revolutionized transportation. This led to the mass production of automobiles, airplanes, ships, and trains, significantly reducing travel times and expanding economic activities.

Energy Source: Oil became a primary energy source for industrial processes, providing power for machinery, factories, and electricity generation. This energy density and versatility propelled industrialization and economic growth in the 20th century.

Petrochemicals: Oil is a crucial feedstock for the production of petrochemicals, which are used in the manufacturing of various products, including plastics, synthetic materials, and chemicals. This has driven innovations in industries ranging from packaging to electronics.

Mechanization: Oil-powered machinery, such as tractors and other farm equipment, transformed agriculture. This led to increased productivity, reduced labor requirements, and the ability to produce food on a larger scale, contributing to the so-called Green Revolution.

Strategic Resource: The control and access to oil resources have been central to geopolitical dynamics, influencing international relations and conflicts. Nations with abundant oil reserves often hold significant economic and political influence.

Affordable Energy: The availability of affordable energy from oil has contributed to an improved standard of living. It has made energy-intensive activities, such as heating homes, powering appliances, and lighting, accessible to a larger population.

Urban Expansion: The availability of oil-powered transportation facilitated urbanization by making daily commutes and transportation of goods more efficient.

Infrastructure: Oil played a crucial role in the construction and maintenance of infrastructure, including roads, highways, and airports.

Water and Mining: The extraction and processing of other natural resources, such as water and minerals, often rely on oil-powered machinery. Oil is used in mining operations, providing energy for extraction and transportation.

In summary, over the last century, oil has been a cornerstone of civilization's progress, providing energy for transportation, industry, and technology. Its role in the exploitation of other natural resources is pivotal, influencing the way we extract, process, and utilize various resources. As

societies navigate the challenges posed by environmental concerns and seek sustainable alternatives, the role of oil in shaping the future of civilization continues to evolve.

WHATS IN A BARREL OF OIL?

A barrel of crude oil is a unit of volume used in the oil industry. The standard size of a barrel is 42 U.S. gallons or approximately 159 liters. This unit of measurement dates back to the 19th century when oil was transported and stored in wooden barrels.

Crude oil is a mixture of hydrocarbons—compounds composed of hydrogen and carbon atoms—along with various impurities such as sulfur, nitrogen, and trace metals. The composition of crude oil can vary significantly depending on its source, and this variation is a key factor in determining the quality and energy content of the oil.

The energy content of a barrel of crude oil is typically measured in terms of its calorific value, which is expressed in British Thermal Units (BTUs) or gigajoules. The calorific value represents the amount of energy released when a specific quantity of the substance is burned.

On average, a barrel of crude oil contains about 5.8 million BTUs of energy. The energy content can vary based on the specific gravity and composition of the crude oil. Lighter, sweeter crude oils with lower sulfur content generally have a higher energy content than heavier, sour crude oils.

Not all barrels of oil are the same in terms of energy equivalence. Crude oil is classified into different types based on its characteristics, and these types can have varying energy contents. Two primary characteristics used for classification are:

Sweet crude oil has a low sulfur content, making it less environmentally polluting and easier to refine. It generally has a higher energy content.

Sour crude oil has a higher sulfur content, which can complicate refining processes and result in higher environmental emissions.

Light crude oil has a lower density and viscosity, making it flow more easily. It is often easier to refine and contains a higher proportion of lighter hydrocarbons, which have a higher energy content.

Heavy crude oil is more viscous and may contain a higher proportion of heavier hydrocarbons, which can have a lower energy content.

As a general rule, light and sweet crude oils are considered more desirable due to their higher energy content and ease of refining. Heavy and sour crude oils may require more complex and energy-intensive refining processes, and their products may have lower energy yields.

In summary, while all barrels of oil have energy stored in them, the energy equivalence can vary based on the type and quality of the crude oil. The specific characteristics of the oil, such as its sulfur content, density, and composition, influence both its market value and its energy content. Light, sweet crude oils are generally preferred for their higher energy content and easier refining processes.

The refining of crude oil is a complex process that involves separating the various components of crude oil based on their physical and chemical properties. This process, commonly known as oil refining or petroleum refining, takes place in a refinery and results in a wide range of products with different uses. Here is an overview of the refining process and the breakdown of products obtained from a single barrel of crude oil:

Crude oil is first heated in a distillation column, a tall vertical tower with multiple trays. As the oil is heated, it vaporizes, and the vapors rise through the column.

The different components of crude oil have different boiling points, and they condense at various heights in the column. The heavier components condense lower in the column, while lighter components condense higher.

The fractions obtained from the distillation column include gases, naphtha, kerosene, diesel, and heavier components, each fraction is sent to specific units for further processing, Various conversion processes are employed to modify the molecular structure of certain fractions to enhance their properties.

Common conversion processes include: Cracking: Breaking down large hydrocarbons into smaller, more valuable ones, Hydrocracking: Using hydrogen to break down large hydrocarbons, improving the yield of lighter, more valuable products.

Fractions are often subjected to treatments to remove impurities. For example: Hydrotreating: Hydrogen is used to remove sulfur and nitrogen impurities. Catalytic reforming: Improves the octane rating of gasoline by rearranging hydrocarbons.

Refined products may be blended to achieve specific properties, such as the octane rating in gasoline, the specific breakdown of products from a barrel of crude oil can vary based on the type of crude and the refining process,

but a typical breakdown might look like this: Gases (about 10-20%), Methane, ethane, propane, butane, and hydrogen, Used for heating, cooking, and as feedstock for the petrochemical industry. Naphtha (15-25%) Light liquid hydrocarbons. Used as a feedstock for the production of gasoline, as well as in the petrochemical industry. Kerosene (10-20%):Used for jet fuel, heating, and as a feedstock for the production of diesel. Diesel (20-40%): Used as fuel for diesel engines in transportation and industry. Gas Oil (10-25%): Heavier distillates, used for lubricants, industrial fuels, and as a feedstock for further processing. Residuum (5-15%): Heaviest and thickest fraction, used for asphalt, lubricating oils, and as a feedstock for further processing.

In addition to the main fractions mentioned, refineries produce various by-products and specialty products, including lubricants, waxes, and petrochemical feedstocks.

It's important to note that these percentages are approximate, and the actual breakdown can vary depending on the crude oil source and the specific refining processes employed. Modern refineries are highly sophisticated, and their configurations can be adjusted to optimize the production of specific products based on market demand and economic considerations.

THE ENERGY STORAGE PROBLEM

The problem facing us is not necessarily energy creation, solar panels are becoming cheaper and more efficient.

Energy storage is the fundamental issue facing the modern grid, technically renewables can replace all or a substantial proportion of fossil fuel use, but they do not replicate the unique storage properties of fossil fuels.

A pile of coal or a tank of natural gas next to a power station acts as a battery a store of energy, stockpiles can be increased and a calculated amount of energy can be transformed into electricity for homes, factories, shops, hospitals, railways and in the future electric cars.

In order to transition to electric cars and reduce fossil fuel use not only will we have to dramatically increase the amount of energy we create, but also a radical change in storage technology. Fossil fuels are the pre-created store of high energy density easily distributed and stockpiled; renewables will need to be able to replicate the characteristics.

Intermittent renewal energy generation can only be mitigated by technological developments in the transformation of green electrical energy in to a stable store of potential energy that can be re transformed back to electrical energy and then distributed and made use of on demand.

Batteries are essential for mobile technologies, from mobile phones to electric vehicles, but in order to be able to generate the electricity for the grid to charge these batteries on demand as we are used to, we need to be able to transform stored potential energy in to electrical energy.

Storing all the uk energy needs for say seven days in a battery system is technically possible but the physical size of any system using current technology would be too large and require too many resources to create. Any advances in the efficiency of batteries would reduce the hurdles but at the same time will likely increase the demand for electrical energy.

If batteries were to become ten times more efficient then it may be possible to power aviation through electrical renewables, this would put a further strain on the electrical grid and on renewables and would require even greater levels of back up storage.

Batteries themselves become obsolete and would require replacement at an enormous expense on a regular basis, they require rare minerals in short supply and the recycling of batteries is difficult and the waste is dirty.

The intermittent nature of renewables requires a backup store of energy the only real solution is to turn electrical renewable energy into a liquid fuel. Easily stored within our current energy infrastructure.

The advantages of storing renewable energy in liquid form is a higher level of energy density, less need for expensive batteries and a means of storing green energy that replicates many of the features of fossil fuels, particularly oil and gas.

Unlike batteries the efficiency gains of storing energy by conversion to liquid fuel can be at the production stage, the actual store of energy remains the same. The costs of upgrading production processes to increase the efficiency of producing liquid fuels is far less than manufacturing new batteries to replace an outdated battery storage system.

The technology already exists and whilst its efficiency needs to be greatly enhanced it can only happen if the same political will to set targets is applied to creating a feasible plan to meet these targets. The fundamental driving force behind a technologically advanced economy is its ability to

dissipate external energy on demand, a failure to be able to do so for any length of time would see a catastrophic decline in economic activity and living standards.

ENERGY , MONEY & CREDIT

Money is a claim on future economic growth, economic growth requires energy and so money is essentially a claim on future energy, we save money to buy things and hope that there is sufficient energy in the future to make that product or supply that service.

To understand how energy influences money and how its loss will cause financial crises we need to understand a bit about money, credit and energy, the history of financialization and the implications of a an economy based on debt with decling energy inputs.

Money a medium of exchange, a store of value that allows us to operate a more sophisticated economy than that based on barter.

Money in its various forms allows trade to flourish, it separates the producer from having to trade directly with the consumer. Money needs to be widely accepted, the participant who accepts money for goods or services has to have faith that they are able to exchange it at some time in the future for a different good or service at reasonable value.

Credit is an exchange of money or goods for a promise to repay at a later date and with agreed terms. Often these terms involve the repayment of the loan plus interest, this represents the risk of the lender taking on the debt and the opportunity lost by lending the money to this venture and not another.

Neither money nor credit are anything new, they have been used for thousands of years from commodity money, precious metals coins to futures contracts used by Sumerians thousands of years ago. For most of early history money was mainly in the form of commodity money, this is money whose value is derived from the commodity from which it is made.

Commodities used as money in the past include, gold, silver, copper, bronze, iron, grains, livestock, peppercorns, shells. More recently tobacco and alcohol have been used, all of these commodities have an intrinsic value, regardless of whether an economic participant is directly in need of a particular commodity they are willing to accept it as payment for goods or service knowing it has an intrinsic value.

These commodities generally have a degree of longevity, ease of storage and transportation, over time precious metals became the preferred commodity money, other commodities were subject to consumption and supply issues, whereas precious metals were stored as value rather than consumed as with base metals, grains, cigarettes and alcohol.

Gold and silver coins represented a store of energy, value, rarity and fungible but most of all universality of acceptance desire but also of recognition. The rarity of these metals and the universal use of them to display wealth made an ideal money in a world with little external energy dissipation.

Credit is likely to have been used as far back as early mankind even before the move to an agrarian economy, small groups accepted goods and services from each other in return for reciprocity at a later date and these groupings had deep connections and shared histories and interdependence making faith of repayment logical.

Barter would have been more likely between societies with little mutual trust, barter is the immediate payment for a good or service. Money lending is likely to have taken place throughout the bronze age, often this involved the state or monarch lending out some of its wealth including grains, with repayment occurring after harvest.

Trade during the bronze age was widespread throughout much of the Mediterranean, the movement of goods, people and wealth required commodity money often in the form of precious metal coins with a stamp or mark of the ruler or issuer. But they also used a form of representative

money commodities could be stored at a warehouse or sovereign depository and a receipt issued which could be widely exchanged for other goods and services, the tablet could later be exchanged at the warehouse by a different economic participant.

The earliest known banking dates back to the Greeks banks are formed which take deposits, lend and change money. The disparate city states acted as separate economic units for much of the time, citizens relied on trade, the line between banking, finance and trading had always been blurred but with the Greeks the idea of private capital grew.

The city states had a political system which allowed the creation of citizenship, private wealth was allowed and was used to finance private trade. This is the birth of capitalism in its most basic form, only male landowners had a franchise and thus only they were deemed citizens. Up to half of the population in some of these city states were slaves and had no entitlement.

The romans had a sophisticated financial system but it was mainly based on imperial powers, private capital and wealth was subordinate to the state. Wealth was made by the expansion and conquest of neighbours, huge wealth was taken from the Greeks, Egypt, Gaul and Britain, gold commodities, art and slaves all financed the expansion.

Precious metal coins were minted with the mark of each ruler, as the roman empire began to collapse its finances began to deteriorate, it had increased its military spending considerably, it had paid off Germanic tribes to sue for peace, handed over lands to migrating tribes and began to lose control over the taxation of regions as its ability to maintain security waned.

The expansionist economics of the roman empire had created a huge state with high bureaucracy and a large military, but once it failed to continue to expand the revenue dried up exposing the true costs of the empire, the burden of cost began to fall within the economy and mainly on agricultural production.

Revenues fell and costs were paid with debased coins issued by the emperors, silver coins continued to have less and less silver, inflation became rampant as money became worth less and less, taxes continued to rise, economic activity decline and the empire slowly collapsed.

The capital out flows from western Europe continued in to the Middle Ages, trade in spices, silk and other goods from Asia were flowing through the silk road, by both land and partly by sea. These goods were paid for with precious metals from European gold and silver mines.

The crusades opened contact between the Muslim world and western Europe it began the growth of city states such as Venice who benefited from the trade in slaves to Africa, the crusades and spices and silks from the east via Alexandria in Egypt and through trade in the black sea with the silk road.

The trade in the Mediterranean saw the growth of other city states such as genoa and the rise of banking and finance to facilitate trade, but also to finance wars.

The merchants in these cities held considerable political and economic power, this saw the renewal of private banking used by the Greek city states. These banking families financed sovereigns in the 14th century the Bardi family lent Edward iii of England 900,000 gold florins to finance his fight with the French when he defaulted on the loan a number of banks failed.

The flow of precious metals out of Europe and the exhaustion of many of its mines saw a scarcity of gold and silver in the middle of the 15th century. Economic activity declined and as money became scarce it was horded, the value of other goods and commodities deflated against the value of money. This is one of the earliest documented monetary deflations, economic activity declined as producing or trading goods became less profitable than just holding money.

The monetary deflation was solved by increased mine production and by the 16th century vast inflows of precious metals from the new colonies in the Americas.

Huge quantities of gold and silver arrived in Europe via the Iberian Peninsula. This vast influx of precious metals caused a monetary inflation in Spain and other parts of Europe, precious metals mining in Europe had recovered from the previous deflation and populations were expanding after the previous plagues.

The Spanish responded to this drop in the value of money by attempting to reduce or control the supply of goods and commodities, economic participants held goods and commodities in preference to holding a constantly devaluing money.

This caused a disruption in production and economic activity with ensuing famines and economic hardship. Disastrous economic policies combined with the huge costs of constant military conflict, a failing economy saw Spain default on its sovereign debt four times in the 16th century causing the failure of the German banking system which had financed the Spanish empire.

Private banking now financed trade, wars and empires, the economic power of these city states transformed into banking dynasties that would finance global trade and the many wars to come. As the marine technology of Europeans increased, empires began to grow and circumnavigate the world. Trade began to flourish goods were moving across the globe but now by sea where far larger cargoes could be moved harnessing the wind and technology.

As trade began to go global so the foundations of the modern banking industry took place in Europe, as the gaps between the producer and the consumer grew and the sheer volumes grew financial institutions were able to act as a central point of trade and as frontiers expanded so did banks smoothing global trade.

The increase in finance as the power behind trade and empires saw the private capital of merchants become more dominant than the sovereigns themselves, the increasing complexity of economies through the harnessing of technology and trade increased the role and power of private capital. Stock markets arose and capital could be raised for a wide variety of ventures.

In the 17th century the Dutch introduced financial innovations, whilst the previous Italian city states had traded sovereign debts the Dutch created a full capital market for debts. The Dutch east India company became the first company to issue shares and bonds to the general public this accumulation of capital ensured the growth along with the British east India company of one of the earliest global corporations.

As the industrial revolution began the need for money changed further, being less a store of value and a physical manifestation of effort and energy, it became more of a medium of exchange.

The increasing amount of and ability to exploit external energy and resources was driving a huge increase in the manufacture and consumption of goods.

The world awash with energy, products and goods in abundance finds less and less of a need for money as a store of value, a medium of exchange is all that is required when there is so much abundance of new technology to consume.

The Germans financed the first world war through debt rather than by raising taxation, after their defeat they were saddled with huge debts, the treaty of Versailles left them with even larger debts by way of reparations. The debts needed to be paid in foreign currency so the German central bank printed huge quantities of marks to exchange for foreign currency.

The mark began to depreciate rapidly a loaf of bread went from 160 marks to 200 billion within a year, this was a hyperinflation of a paper money.

The mark was merely a fiat money, it was issued by a central bank and was accepted as a medium of exchange because the state demanded payment of taxes in this medium.

The mark had been convertible to gold prior to the first world war but its convertibility had been removed it no longer represented a physical asset.

The central bank was now able to create as much money as it wished, faced with crippling debts it embarked on a huge devaluation of its currency, its debts in foreign currency terms became more crippling and eventually the German government of the time known as the Weimar republic defaulted.

The economic and political turbulence that began with the accumulation of debts from the first world war resulted in the rise of Nazism and set the seeds for the second world war.

The end of the second world war saw the resumption of global trade the us dollar became the de facto global currency after the Bretton woods agreement, it remained redeemable for gold until the early 1970s when it came off the gold standard and its value was no longer fixed to a fixed quantity of gold.

From this point on global currencies became fiat currencies, their value was determined by the market, one paper note only became redeemable for another one its purchasing power was determined by the faith a market had in the economy, governance and the supply relative to demand of a currency.

Global currencies began to be traded and as markets deepened and became more powerful so the purchasing and economic power of any nation could be manipulated by large flows of capital in to or out of its economy.

The collapse of the Soviet Union saw the pre-eminence of the free-market capitalist system, the inherent advantage of private capital markets in allowing price discovery to determine where investment and speculation should take place was far more efficient than a centrally controlled system where allocation of capital and investments were based on political rather than economic metrics.

Since the collapse of the Soviet Union the global economy and technology have expanded rapidly, much of this has been through the use of credit. With external energy in abundance and ever-increasing technological ways to exploit it the suppliers of energy have accepted debt in exchange for their commodities.

The creation of money is not as most understand, money is created by banks when a loan is taken out it is called fractional reserve banking as long as people are willing to take on debt then consumption can be brought from the future to the present.

Global debt has grown substantially as unbacked currencies driven by the banking system have hugely increased the supply of money and demand with the global economic system.

All advanced economies rely on external energy to power their economies and advance technology, major suppliers of energy have always been willing to accept debt from these advanced economies in payment for their energy exports.

From the moment the dollar left the gold standard resource exporters like Saudi Arabia had little choice but to accept unbacked dollars, an inability for these countries to exploit these resources themselves due to a technology deficit.

The only way for these exporters to benefit from their resources was to sell it to the advanced economies in return for a claim on the resulting economic output.

The bringing demand forward from the future to the present by relieving a consumer from the burden of having to save first before consuming a product has allowed huge leaps in demand for technology.

For much of history debt has been used for productive purposes to create a surplus from the purpose for which the debt is used to generate a living and meet the terms of the loan.

Increasingly debt has been used for purposes other than productive assets, as the developed world increasingly turned towards consumerism a whole new debt bubble has financed the purchase sale distribution and manufacture transport and mining of energy and natural resources to create these products.

Much of this demand is discretionary, price sensitive and relies on a surplus elsewhere to finance it say a job. The demand ultimately relies on constant growth in a finite world

Today we have already faced a global financial crisis which was the result of too much debt, our response has been to double down and add on yet more debt.

We have financial and monetary system designed for constant growth, we constantly borrow form the future to finance today, and we make assumptions about the future based on the past. Politics, economics and finance all disregard our finite limits and ignore the role of energy in our economic system.

Any reductions in either supply or demand of energy and thus slowdown in growth would see an increase in default rates amongst consumers, retailers and producers of non-discretionary goods, a reduction in mining, processing, and transportation.

Money being used and circulated less would attain greater value over discretionary goods and would slowly if allowed become a store of value, it is likely that central banks faced with this outcome would simply print more money but it may not be effective.

The next financial crisis will be as a direct result of a drop in economic output caused by a spike in its price as output begins to fall way below demand, this will be the next economic shock, we are already seeing gold begin to break free in most global currencies.

As we have already noted the huge size of global debts must be defaulted on either by inflation or by outright nonpayment, it is more than likely that the future stores of value will be commodities as they were before, most notably gold, and perhaps silver will return as a monetary metal as it had been in the past.

MATERIALS PEAK

The story of human civilisations use of exogenous energy is always about adding more dense forms of energy to existing sources. We still use as much biomass as two hundred years ago, we just added coal, then oil and then gas - always denser.

But the perceived wisdom today is that we will add less dense energy sources - renewables and subtract more dense energy sources – fossil fuels. This goes against the entire history of human technological progress

Worries over emissions, pollution and climate change have put us on a path towards net zero and most likely a severe decline in living standards especially amongst economies with high levels of energy intensity.

A herculean effort to build a new energy system will require enormous quantities of energy and minerals to build the solar panels, wind turbines and energy storage systems. This demand will overwhelm both energy and commodity supply and push costs up threatening to destabilise the entire global economy.

Innovation will continue, but even in an age obsessed with technology, the scope for progress is limited by the laws of physics. Renewables, too, have their technical efficiency limitations.

One of these is the Shockley-Queisser limit which determines the maximum potential efficiency of solar panels. Another is Betz's law, which does the same for wind turbines. Technological development is already close to these theoretical limits.

Any dramatic expansion in renewables capacity will make huge demands on material resources, including steel, concrete, copper, cobalt and lithium. Even if these resources exist in the quantities required, they can only be made available through the use of fossil fuels energy from oil, gas and coal.

But we cannot assume that the true costs of renewables will ever fall to levels low enough to replicate the economic value of fossil fuels.

An increase in sustainability is a perfectly rational goal for humanity to strive for. But "sustainable growth" is almost impossible especially from these lofty levels of fossil fuel energy intensity. We can have a green economy without fossil fuels but the energy density will be so much smaller that the econ0my itself can only be a fraction of the current fossil fuel economy.

Besides the production of energy itself, lies all the other useful materials we exploit, from base and precious metals to rare earth minerals - all of which are required in huge quantities just to maintain our current standard of living.

All these deposits are themselves subject to depletion, our economic system has become so good at creating demand and then supply through increasing debt and bringing consumption from the future to the present.

Ore grades for many of our important minerals are declining, newer sources come from bedrock more difficult to extract and process, requiring more energy and more cost.

Environmental standards increase costs as do the increasingly inaccessible locations, the geography and geology of deposits is becoming a financial drag. The jurisdictions of many regions with useable deposits are often questionable leading to increase risk and intermittency of supply.

All these factors lead to a slow and lumpy decline in mineral supplies with intermittent price spikes followed by short lived increases in supply.

DEBT AND ENERGY

The more exogenous energy a civilisation requires the more complexity there is. The move from hunter gatherer to farmer required planning infrastructure and the spread of skills, tools and information required ever greater leaps in complexity.

From shelter to ploughs, selective breeding, harvesting, planting, herding, the division of labour began where specialisation began, farmers, herders, merchants, builders all specialised and added to complexity.

All these skills lead to the formation of the first urban settlements and the creation of money as a means of exchange and writing as a store of information.

This is the complexity trap we create for ourselves and have done throughout history we create systems that eventually fail we always have and we always will

The social development and complexity of a high energy intense economy are enormous any significant deficit of energy will lead to a rapid decomplexify spiral turning back decades of progress reversing the division of labour and destroying layers of middle-class professional employment opportunities.

But the economic implications of this energy density decline are unseen by most because the link between energy density and debt is little understood.

Debt is a claim on future economic activity, all modern economic activity requires increasing amounts of cheaper energy. Debt is a claim on future supplies of ever cheaper energy.

Simply put at some point economic activity will cease to grow and we will enter a terminal decline large amounts of debt will become unpayable and the interest on any new debt will have to reflect the uncertainty of a secular decline in economic activity.

Asset prices, currencies, money, debt and labour will all be repriced to represent this new reality.

It maybe that we have already passed the introduction to this calamity and are now near the catastrophic collapse stage. We have been deluding ourselves that we can continue to rely on ‘infinite growth on a finite planet’ for many decades now in spite of the numerous warning signs.

We’ve been able to create artificial “growth” by pouring vast quantities of cheap credit – and, latterly, cheap money as well – into the system.

We must decide how these ends whether by way of a currency collapse through inflation or a deflationary bust through a dramatic drop in economic activity and asset prices. Either way we will all be poorer at the end of the readjustment.

However, most of the essentials – including water, food, heating, infrastructure and transportation are highly energy-intensive, meaning that the costs of necessities will continue to rise, massively reducing surpluses and cratering the discretionary sector of the economy.

This means that the demand for discretionary goods and services - needs not wants will contract dramatically putting at risk potentially millions of livelihoods especially in advanced economies

Current economic thinking still believes there is no material shortage that cannot be overcome by using financial demand to increase supply through an increase in prices. The truth is that no amount of demand, and no increase in price, can produce anything that does not exist in nature.

Nor can technological innovation overcome the laws of physics in general, or the laws of thermodynamics in particular.

As we have moved up the energy density ladder, we have been able to add layers of complexity, the horse, the sailboat, the steam train, the automobile, the aeroplane, space, internet and so on.

These steps have always been up the energy density ladder not down it. But as we reach peak cheap energy our complex system begins to feel the effects of entropy the longer a system has been in place the more it starts to decay the second law of thermodynamics entropy exerts a greater and greater force.

The more we persist in adding new layers of complexity the greater the cost of entropy and maintaining order in systems that are prone to decay roads, bridges, ports, shipping, energy infrastructure, electrical grids all require more and more maintenance.

Catabolic collapse we tend to create an excess of complexity such that eventually its maintenance becomes too large a burden on society

Of course, this phenomenon exists not just in the real economy but also in the energy infrastructure itself. As this complex infrastructure begins to decline as the inputs themselves also begin to decline investors become unwilling to spend more on capital expenditure and failure rates increase.

Infrastructure owners and shareholders are likely to want to squeeze every last cent out of their assets and so will run their equipment hot and to the point of exhaustion.

As demand dwindles so suppliers exit the industry spares become harder to source and more parts of the fossil fuel industry begin to fail. This leads to a continual decline in output that may exceed the initial declines in inputs. The system itself reaches a point of catastrophic failure.

It is with this backdrop in mind that we look to the future, there is an abundance of energy available in the universe and on this planet, but much of it doesn't have the levels of density we have been used to.

The greatest threat to our ability to overcome our energy density problem is not our technology, it is our financial and political systems, they have been forged in an era of rising energy density, where the energy required to expand the economy was always increasing in supply and generally falling in price.

But at the start of this century as we reached peak conventional oil production, banks and governments were busy expanding consumption with easy credit, but when oil production failed to keep up with this demand the price of oil sky rocketed and the first energy crisis began.

High energy prices always precede recessions and 2008 was no different. From this point on the price of oil on global markets has become far more volatile.

But instead of recognising the problem central banks and governments solved a debt crisis by hugely increasing deficits, supressing the costs of debt and pumping up an even greater debt bubble than before. Bringing demand from the future to the present and creating ever increasing claims on future growth reliant on cheaper energy that simply cannot exist.

We have been fighting the physics of declining energy density for over a decade, us shale has been the once and done energy gap filler in the global economy until recently.

Shale oil costs more than previous sources of energy it is less dense not very profitable and takes a lot more energy than conventional oil fields. Wells deplete quickly and drilling can often be hit or miss. Requiring greater risk and capital expenditure for a limited return

(ECOE) energy cost of energy extracted refers to the proportion of accessed energy which is consumed in the extraction process, and is not, therefore, available for any other economic purpose than that of securing the energy in the first place.

Largely because of the depletion of all the low hanging fruits, the ECOEs of oil, natural gas and coal have been rising relentlessly, pushing overall trend ECOE to ever higher levels.

This begins to weigh ever more heavily on surpluses and reduces prosperity, because prosperity is a function of the surplus energy available to the economy. As the costs of extraction rise, surplus energy availability is reduced and economic activity contracts.

As the costs of energy soars and begins to dominate the whole economy its purpose a s a driver of growth ends and its sole reason for existence is to maintain any standard of living above that of a third world country. The whole point of a complex energy system is to create a surplus

Simply put we frack because we haven't got anything better to exploit for oil and gas, we are someway in to this phenomenon but as yet central banks and governments still act as though we are rising up the energy density ladder.

Energy choices being made today by governments will affect their citizens for decades to come and many them make little sense the abandonment of nuclear and headlong rush to renewables, with little plan is risky at best.

We have a choice moving forwards, to continue our move up the energy density ladder by moving to nuclear seventy thousand times more energy dense than natural gas.

Or we can take the route that many developed nations are moving towards - renewables technology to extract less dense forms of energy and all the costs and complications such a move would entail.

Electorates are not being given a true picture of the choices that lie ahead of them, it is not a conspiracy, it is much worse. It is a complete lack of understanding of the role of energy in our economic, political and social structures.

This is about how the laws of physics meet the laws of economics and politics and how we survive and thrive. We assume that politicians continue the growth at all costs philosophy. The continued rapid consumption of the remaining useful energy for the sake of short-term electoral success and they take us to the point where we collapse involuntarily rather than a controlled descent.

We may well be at this point already we had a chance in 2008 when the first energy spike hit us, to change course to reduce consumption and recognise the predicament, we face but we chose to ignore the real reasons we are where we are and continue headlong over the energy cliff and into oblivion.

We have tried to counter an energy deficit with increases in spending which simply means an increase in financial liabilities at the very point it is becoming apparent that there is less energy available from which to create economic activity and to derive a surplus with which to settle these claims on the future.

Simply put less energy reduces the ability of an economy to settle any claims on future growth and economic activity.

HISTORY OF ENERGY

The advancement of humanity and its' dominance over all other creatures on earth is its' ability to harness and dissipate exogenous (external) energy. Virtually all other animals all of the time only exploit their own personal physical energy (labour) through the consumption of food.

Civilisation depends on an ability to create a surplus with which to build structure and order.

A collection of human beings by their own physical labour can provide an adequate standard of living with enough skill and effort.

But in order to live the modern lives we live today where a fraction of the population is involved in the basic provisions of energy, food water and shelter we must have a continuous supply of external energy with virtually no interruption.

The addition of external energy and the reduction in the necessity of physical labour reduces the effort required for a society to provide its' basic sustenance. Machinery replaces age old skills; technology is the replacement of skills through the use of external energy.

From the time mankind has been able to harness exogenous energy through fire to overcome our own physical limits of labour, our development has been solely down to our ability to find, transform and dissipate ever larger quantities of external energy and natural resources.

Our ancestors dissipated the stored energy of wood through fire to keep warm, cook food, make pottery and forge metals.

Horses, livestock and slaves to forge empires, the energy of the wind to circumnavigate the world using sail boats, coal to power the industrial revolution and railways through the steam engine.

Oil was transformed in to petrol, diesel and kerosene and through the internal combustion engine, cars, trucks, container ships and the aeroplane changed the nature of our societies.

Electricity was the transformation of fossil fuels into a different form of energy capable of being controlled distributed, leading to the lightbulb, fridge, freezer, tv, the computer and internet age.

Globalisation is only possible through the exploitation of external energy to move and transport people and goods, the faster the transportation the more globalised we become.

Our political and social structures are born from the industrial revolution the age where we began the surge in external energy use.

Solar energy

For much of history solar energy has been the main external energy source for the development of the natural environment, photosynthesis allows the transformation of solar energy in to vegetable matter providing energy for the creation and development of the many species we have today.

The transformation from hunter gatherer to agrarian society was a deliberate attempt to increase the productivity of photosynthesis by increasing the density of edible desirable plants and locating them more efficiently closer to the point of consumption.

Controlling the location of large sources of protein was another increase in the productivity of solar energy, domesticated animals can be grazed in economically more productive spaces.

The increase in the ability of early farmers to productively grow crops and the domestication of livestock was the intensification of solar energy to increase productivity and generate a surplus.

Solar energy has always been the most fundamental external energy source on earth, we tend to take it for granted today, but throughout history changes in the amount of solar energy available have had substantial effect on the output and viability of a society.

From the end of the last ice age and the start of warmer temperatures agriculture became more viable across the globe and independently, different regions of the world adapt to this new technology.

Sudden and prolonged changes in the amount of solar energy available have fortunately been limited but have led to famine, volcanic eruptions have been responsible for dips in solar intensity that have reduced output for a number of years.

Biomass

Prior to the industrial revolution our past history of exogenous energy use was far more limited, the first use of fire by mankind transformed our diet and helped in our evolution.

Around 25,000 BC the first high temperature wood fired kilns are developed for firing clay to transform it into pottery.

This one of the earliest examples of the design of a method to deliberately create an increase in energy intensity to alter the properties of a mineral to create a product.

This is probably the true start of the intensive exploitation of exogenous energy that dominates our modern world, charcoal is developed to increase the useful energy in biomass by removing the moisture it can heat kilns to higher temperatures.

Our use of biomass today is still roughly similar in quantity to that used at the start of the industrial revolution our economic intensity has increased not by stopping using biomass but by adding more energy dense energy sources.

Domestication

The domestication of animals served as a source of exogenous energy, the domestication of the dog over 130,000 years ago gave mankind an advantage, dogs have the ability to guard defend and help with hunting increasing the efficiency of hunter gatherers and then settled farmers.

The domestication of sheep, goats and pigs reduced the need to expend energy hunting and increased the amount of protein stored and available for consumption.

The domestication of the horse also increased the speed and range of travel available to those with both the skill and access to equine technology. Beasts of burden such as horses, donkeys and oxen were bred over time to perform various functions from pulling ploughs to chariots, wagons and later carrying riders.

A human has one twentieth the work energy of a horse, the ownership of a domesticated animal gave a considerable advantage especially to early adopters.

Societies with access to equine technology had access to significant external energy and increased the energy intensiveness of their economy, land could be cultivated by domesticated animals and used more intensively and greater surpluses could be created.

The technology of domestication through selective breeding created animals with divisions of labour, oxen pulled, ploughs, horses carried riders and pulled carts and donkeys carried packs over rough ground, camels traversed arid regions.

Slavery

Civilisations throughout history have used slavery as a significant source of external energy, as long as mankind has been fighting over land and resources, they have been enslaving their opponents to harness their energy for their own purposes.

From palaces to temples, mines, roads and agriculture slavery has been an endemic part of the infrastructure of all the great cultures and civilisations we so admire today.

The surpluses from slavery enabled the Greeks to have the time to enquire and investigate philosophy, as much as half of the population of some ancient Greek city states were slaves and at least a quarter of the roman empire.

Enslavement for economic gain has been universally used throughout history to allow one society to live a higher standard of living than they could with just their own labour.

Slavery in the southern states of America conflicted with the industrialisation of the northern states as the age of slave empires gave way to the hydrocarbon empire.

The cotton plantations of the south required manual labour and represented the old empires based on slavery and exploitation of conquered peoples but the factories of the north were part of the industrial revolution where technology and the intensity of hydrocarbon use are the engines of growth.

Wind

The earliest civilisations were centred on river deltas where soils rich in minerals were replenished by freshwater rivers, agriculture in these regions flourished access to the sea and a need to navigate rivers ensured these societies were at the forefront of boat design, and seamanship.

An abundance of fish both fresh and salt water gave further incentive to harness the seas and river for transportation, resources and trade.

Fishing had until the steam powered boat always been at the forefront of advances in boat design, initially boats were powered by human labour and allowed the transportation of bulky goods to be much more efficient than by land.

Over time sails were introduced although at first relatively inefficient at harnessing wind energy.

Coastal trade and trans Mediterranean trade flourished throughout the bronze age, but technology was relatively limited at the time right through to the fall of the roman empire, oceans were not navigable by the classical empires.

Advances in sail design, hulls and rigging allow greater distances to be travelled, the harnessing of wind energy creates the greatest empires humanity has seen from the discovery of the new worlds to the circumnavigation of the globe.

Just as mankind had been developing kilns to harness more of the energy from coal and charcoal, so boat builders and sail designers were trying to capture as much energy as possible, a theme that would last until the start of coal powered vessels.

As the iron age spread to northern Europe it reached societies such as the vikings who had been trading across the Baltic Sea and Scandinavia for millennia, building better stronger boast to navigate more hostile North Sea, Baltics and Atlantic.

The introduction of iron allowed a leap in the technology of hull design and rigging, throughout the time of the roman empire these societies remained free from the influence of the roman empire and upon its collapse started to fill the void.

Trans-Atlantic journeys were made by the vikings nearly 500 years before Columbus, marine development spread across the western Atlantic states, and by the 15th century the age of discovery began global trade would be powered by the wind for the next 500 hundred years.

Advances in marine technology allowed sailors to capture more and more wind energy to propel bigger loads at higher speeds.

The arrival of metal hulls, steam power and then diesel engines ended the reliance on wind for global trade, journey times dropped greater distances could be travelled. The energy density of coal and then oil transformed the range and speed of shipping both civil and military.

Wind power today is ubiquitous with huge turbines, as we dash for net zero but in essence we are reaching for a problem that bedevilled all sailors before fossil fuel powered vessels, intermittency or the dreaded doldrums.

Wind is unreliable low density form of energy and as soon as the great navies could convert their fleets to coal and then oil they did, from that point on oil became a geopolitical resource that resulted in numerous wars, to secure enough supply to maintain a modern fleet.

Coal

It wasn't until the iron age that the use of high-density external energy to transform one element into another truly began to spread throughout the globe, this is the beginning of the advancement of a global technology boom.

Whilst the bronze age was limited by the availability of tin a rare metal found in limited locations and vital to the bronze making process, iron ore was much more abundant.

Bronze and then iron need to be heated to a higher temperature than pottery, charcoal and then coal was used, allowing for higher temperatures.

This transformation of kilns during the metal ages demonstrates the role of technology in humanities continual search for deposits of ever higher levels of energy density to be able to transform more resources and minerals into more and more products and materials.

Coal is a fossil fuel, formed over millions of years from organic matter it is mainly made of carbon and has a higher energy density than wood, it is today the largest anthropogenic source of carbon dioxide.

The first known use of coal dates back to about the 4th century by in Greece and is described as being used for metalworking, but has most likely been used sporadically for thousands of years where it has appeared on the surface and where societies have understood its' properties.

Coal is found in different forms from brown coal with a low energy density to much darker coal with less impurities and much higher density. It is found in seams which are often exposed at the surface but can run deep below the surface.

Early use of a coal seam means easy extraction at the surface, over time the coal not yet mined is deeper and more difficult to extract, requiring more energy, technology and money.

Coal had been used since at least Greek times in iron making the higher energy density allowed higher temperatures to be achieved, the romans had developed the first great industrial empire. Their economy was built on a level of energy intensiveness far above those of civilisations that came before them, they were the first society whose growth was accompanied by a considerable increase in their emissions.

The romans mined Britain and across its' empire for a range of resources, coal at this time was more than likely on the surface and required little technology or effort, it was used in metallurgy and

domestically. After the fall of the western empire economic activity slowed down considerably across Europe and the Mediterranean.

Coal continues to be used throughout the Middle Ages but most mining is small scale and much of the coal used is surface coal easy to extract, a thriving sea trade along the east coast of Britain brought coal to London from northern Britain.

In the 13th century the use of sea coal was banned in parts of England due excessive pollution, metalworkers in London were forced to revert back to charcoal.

Coal had been traded across Britain for hundreds of years before the industrial revolution, mainly for heating and metalworking.

However, it is the start of the industrial revolution that the use of coal for mechanical advantage becomes possible.

The invention of the steam engine allows coal to be used to power mechanical devices, pumps prevent times from being flooded, looms to produce cloth, and engines to power railways and boats.

In the 16th century the demand for charcoal for metal working and wood to build ships for the royal navy was so large that Britain was running out of wood, imports from the Baltic and north america bridged the gap for boat building, but for metal working coal was the only solution.

Mining intensified during this time and it is probably at about this time that coal begins to be seen as a strategic resource with considerable potential.

It wasn't until the introduction of the steam powered pump that deeper coal mining was possible, the invention of the steam engine and pump powered by coal transformed the fortunes of the industry.

With this new technology coal deposits across the world could be exploited with much more ease, deeper shafts could be sunk and air could be pumped in and water pumped out.

The industrial revolution saw the emergence of coal as a resource capable of powering a new level of technology, Britain at that time had extensive coal reserves.

Steam power was used in manufacturing for locomotives and then for steam ships. Global deposits of coal began to be exploited as coal fired ships needed refuelling on long voyages.

Britain with an abundance of natural resources powers ahead with the industrial revolution built on exploitation of abundant high-quality coal.

Coal powered the first electrical grids, this transformation of hydrocarbon energy into electrical energy allowed the first consumption of energy where at the point of use none of the pollution occurred.

Until this point wood, charcoal and coal had been burned in the home, whale oil, oil, candles and kerosene were used for lighting all required the direct burning of fuels and the subsequent pollutants being in the home.

Electricity allowed lighting and the introduction of telephones, domestic appliances to enter the home and workplace. This increase in the energy intensity of modern households enabled the creation of a vast array of electrical devices from washing machines, fridges. It wasn't until the 1960s that oil surpassed coal as the predominant global hydrocarbon.

Oil

One barrel of oil holds the energy equivalent of eleven years of human labour.

Oil is a fossil fuel it consists of naturally occurring hydrocarbons, the name covers both the raw crude oil and the processed products refined from crude oil. In its crudest form it is a dark brown or black liquid, it is found within certain geological formations and is mined generally by drilling.

It is refined into a range of products by a technique known as fractional distillation. Depending upon the temperature achieved it can be distilled in to gasoline, plastics, synthetic textiles, drugs, cosmetics, kerosene, diesel, heating oil and bitumen.

The properties of such a high-density energy resource are the foundations for the growth of the 21st century.

Petroleum is a naturally occurring substance that can be found close to the surface as well as much deeper underground, it has been used for thousands of years.

It is believed that the construction of Babylonian roads used asphalt derived from oil in about 2,000 by, tablets indicate that the Persians used crude oil for lighting and medicinal use.

Oil fields around Baku and Azerbaijan were first discovered in the 9th century they were later described by Marco Polo as being extensive.

Crude oil was often distilled by Arab chemists in the Middle Ages, the streets of Baghdad were believed to have been paved with tar, a naturally occurring form of crude oil. These chemists were able to refine crude oil to make much more flammable liquids.

The flammable properties of oil were discovered by the Arabs but became known to Europe through Islamic Spain. Petroleum has been known within Europe from as early as the 16th century.

The creation of paraffin wax from coal created a cheaper cleaner and better alternative for lighting and is undoubtedly a reason for the end of commercial whaling industry as whale oil was a common source foe lighting, the invention of paraffin has probably saved the whale from over exploitation and probably extinction.

In the 19th century oil starts to be found and exploited in increasing quantities. Chemists were able to distil petroleum into lubricants and paraffin, these were from easily accessible surface deposits of crude oil.

The first modern oil well was believed to have been in Pennsylvania in north America, oil was extracted by way of a drill and represents the method by which this new energy source would be extracted across the globe, from the middle of the 19th century onwards the extraction and refinement of oil was constantly being improved, the first refinery is opened in the 1850's and kerosene is invented.

Whilst wells were drilled in Europe throughout this period, they were relatively small in comparison to the United States who were on the verge of discoveries that would propel them towards being a global superpower.

J d Rockefeller created standard oil which would become one of the largest oil companies on the planet, in the early twentieth century it was deemed to be a monopoly and was broken up in to smaller companies such as ExxonMobil and Chevron companies that are still in operation today.

During the 1920s and 30s extensive deposits of oil were found in Venezuela who become the second largest oil exporter, In the Middle East large deposits are found in Iran, Iraq and Saudi Arabia western oil companies exploit these resources as much of the middle east is controlled by European powers.

After the second world war the United States signs an agreement with the Saudi Arabia guaranteeing its security in return for access to its extensive and high-quality oil fields by its oil companies. Saudi Arabia became the largest oil exporter on the planet.

1960s oil becomes primary source of energy on the planet overtaking coal, OPEC is formed and the USSR begins to exploit its newly discovered oil reserves in western Siberia.

In 1972 US oil production peaked and began to decline and begins importing oil, the significance of the middle east as an engine for world growth grew.

The price of oil escalated considerably in the early 70s as an oil embargo by OPEC members drove the price up causing the first oil crisis significantly impacting the economies of industrialised nations. From this point on many economists realise the importance of cheap oil to the growth of the global economy.

The higher oil price forces investment in alternatives such as nuclear and hydroelectric, western technologically advanced oil companies are able to look further afield for new deposits. The USSR becomes the largest oil exporter in the world, the US exploits new deposits in Alaska, new deposits are found in the North Sea and the Gulf of Mexico.

In 1979 the Iranian revolution sees oil production plummet and a new oil crisis begins a war between Iraq and Iran that lasts for eight years, OPEC production falls and western oil companies become the dominant producer of oil again.

Throughout the 90s the price of oil remains low as new streams are exploited in the North Sea in Africa, the Gulf of Mexico, Russia increases its efficiency post-Soviet Union collapse, Saudi Arabia with access to the cheapest reserves increases output to weaken its neighbours economically.

These low prices dramatically increase demand for oil and in the early part of the 21st century the invasion of Iraq caused output to fall and saw the price of oil climb. The third oil crisis ushered in the global financial crisis.

Higher energy costs in a technological society predicated on consuming ever increasing quantities of energy are a disaster, many activities once profitable became uneconomical, debts started to be defaulted on and it took unconventional measures by central banks globally to halt a systemic financial collapse.

As the oil price recovered it became economically profitable to refine unconventional sources of oil such as shale oil and fracking. While shale is abundant it produces less energy than conventional oil and requires more refining and produces more emissions than higher grade crude.

Through the exploitation of unconventional sources, the US is able to increase its production, but shale oil is less energy dense it requires far more energy to extract a barrel of oil than Saudi oil and any sustained drop in the price would make this energy source uneconomical.

However, any sustained rise would now be countered by increased production of these unconventional resources.

The last hundred years have seen the age of transport through the technological transformation of oil in to liquid fuels such as gasoline, diesel and kerosene. The motor car powered by the internal combustion engine, the diesel engine powering ships and lorries, the aeroplane initially powered by internal combustion engine is then able to go truly global with the introduction of the jet engine.

This high-speed transportation has changed the very nature of communities and families, our ability to travel often means we are able to live further apart than our ancestors, today our communities have more people from further away than at any time in history. This globalising effect on people,

goods and services has had a profound effect on our politics, cities, societies, families and relationships.

Natural gas

Natural gas (methane) is a fossil fuel with higher energy density than coal or oil some seeps to surface others are trapped in shale and clay

In traditional oil wells like those in Pennsylvania gas is a by-product burned off at well head, it was initially used as lighting transported through lead pipe

Bunsen mixed air and gas and its showed versatility for cooking and heating after the 1890s electrification ended the demand for gas as a fuel for lighting.

Transportation and storage of natural gas was difficult up until WW2 when metal welding and pressurised vessel technology improved.

After WW2 in the 50's pipelines laid throughout the US and gas become more viable as a fuel for heating, cooking and in industrial processes particularly in the petrochemicals industry for plastics and other materials.

Horizontal drilling techniques and hydraulic fracturing of shale deposits technology was first used in the fifties and sixties but couldn't compete with conventional deposits of natural gas.

The natural gas global market has altered considerably in the last decade pipelines have given way to liquified natural gas (LNG) shipped across the world.

The old pipeline system required infrastructure and fixed contracts between supplier and consumer. The new LNG system opened gas prices to the global markets and created a huge change in the volatility of prices as consumers became reliant on global spot prices rather than fixed long-term contracts.

Nuclear

The electron is first discovered in the 1890s, Einstein first understood that energy and mass are related all mass contains energy e =mc2. If mass disappeared it would be replaced by energy.

The neutron is first discovered in 1930s, Enrico Fermi discovered the properties of uranium, the first atomic bombs end the second world war.

Nuclear energy is seen as the future in the 1950s but a series of accidents from Chernobyl to Fukushima have dented its appeal and environmental pressures have dented its appeal and popularity.

But the energy density of nuclear is far superior to that of oil or natural gas its implementation in the advanced naval vessels over the last few decades has proved its ability to perform with a high degree of safety.

A new breed of smaller reactors may well be the future in a mixed energy grid.

Studies have shown the superiority of nuclear as a clean energy source requiring far less land and resources than renewables, emitting less co2 and harming less of the population than biomass and fossil fuels do with their air pollution.

A constant uninterrupted supply of clean energy from an energy dense material far higher up the energy ladder than methane.

HISTORY OF TECHNOLOGY

From the first stone tools onwards humanity has always risen above other species through the use of technology, a blade was fashioned from stone or bone using human effort (labour) but the tool once transformed reduced the human energy required to hunt, skin and butcher the carcas.

Over two million years ago our ancestors began using simple tools, from stones to break open shells or sticks for protection, over millennia through a process of experimenting and enhancing skills of crafting tools were enhanced.

Over the last few hundred thousand years man has gone from harnessing fire to cook food, make pottery and then metals, right through to the industrial revolution up to the present, every advance is a recombination of previous technology.

Technology today is the result of this journey where no single product stands in isolation from everything that has gone before. Technology is not a list of great inventions it is a story spanning hundreds of thousands of years of slow incremental growth, where civilisations race ahead of others and then fall behind.

The earliest known pottery dates back to at least 25,000 bc a ceramic figurine from the czech republic, pottery appears in china in 18,000bc, the far east in 14,000 bc and in japan in 10,000 bc.

The first pottery was simple earthenware fired at low temperatures more than likely in basic pit fires at temperatures as low as 600 c. It was porous and unglazed, fairly limited but of sufficient utility that its production persists and there is a continuous growth in the technology of pottery.

Pottery grew around deposits of clay in different parts of europe, asia and china, the technology of pottery was the first time humanity had used external energy to transform the material properties of a mineral. It required a level of technical understanding and over time the development of kilns to create ever higher temperatures to achieve better quality pottery.

The process of domesticating animals requires a sustained alteration in the behaviour of an animal to ensure it is more useful to the owner, it should not be confused with training which is a behavioural modification, and domestication involves the permanent genetic change through the conscious selective breeding by humans to select based on desired traits. There is a genetic difference between domestic and wild populations.

The dog was the first vertebrate to be domesticated and was established across eurasia over 100,000 years ago, the cow and pig in about 13,000 bc, sheep about 10,000 bc, cattle modern day by 8,000 bc. Cows were used as draught animals in 4,000 bc in the middle east helping to plough fields and provide milk, this process of domestication increased the specialisation and the complexity of these economies as specialist skills were required.

The horse was domesticated on the eurasian steppes by around 4,000 bc from the original small animals incapable of carrying a rider but being able to pull a chariot through to the largest of horses capable of carrying a fully armed knight mankind has selectively bread the horse,

The development of cavalry techniques originates from the eurasian steppes the origination of the domesticated horse the home of the eurasian equine nomads. This region develops larger horse through selective breeding, the bit, saddle, and stirrup and have a much higher density of horsepower than their neighbours. They are expert horsemen with an economy based on the breeding, trading and use of horses

By about 600 bc in the iranian steppes a breed of horse appears large enough to carry an armoured soldier, the catephract, a heavily armoured cavalry man with a heavily armoured horse, this begins the age of the dominance of cavalry on the battlefield for nearly two thousand years.

This technological advantage is a combination of an environment and geography beneficial to horses and the technological development of selective breeding, domestication and horsemanship by the nomads in the region. These equine eurasian nomads conquer china and send waves of migrants across eurasia, from the early settlers who bring proto languages and pottery to the goths, turks, huns all the way through to the mongols.

Over time this equine technology permeated europe and helped lead to the collapse of western roman empire unable to expand and unable to compete with tribes of fast-moving cavalry able to outflank roman legions. An empire largely based on a sedentary agrarian lifestyle with settled communities and a complex economy of trade and industry has difficulty dealing with this new threat

Whilst the spread of metal working technology was relatively quick, the transference of horses was slower, cavalry was mainly comprised of gelding, castrated male horses unable to breed if captured. Breeding pairs were expensive and hard to come by and so the spread was slow.

Domestication and selective breeding is a slow process of trial and error and whilst it has brought many benefits it has also brought negatives, domesticated cattle have given humanity measles and tuberculosis, pigs and ducks have given humans influenza and horses rhinovirus.

Agriculture is the process of cultivating plants and livestock for human consumption. The rise of agriculture is more than likely a consequence of an ability to create a surplus in excess of that of a hunter gatherer. The move towards an agrarian economy is believed to have occurred around the fertile crescent stretching from the nile delta to the euphrates river.

In about 11,000 bc global temperatures begin to rise as the last glacial maximum ended and the holocene begins, it is more than likely that this change in temperature allows farming to create a meaningful surplus.

Plant domestication began in the middle east in about 10,000 bc, wild wheat seeds don't stay on the stem when ripe, but fall to the ground making harvesting impossible, but a random genetic mutation left the seed on the stem when ripe making harvesting possible, this mutation created a this preferential seed for this crop by humans allowed its dominance.

Around 10,000 bc hunter gatherers began to farm, this change from hunter gatherer to farmer created social and economic changes and in about 8,000 bc settled villages appear around the tigris and euphrates rivers, agriculture requires more planning and communication between groups of people and possibly greater cohesion in order to protect crops and infrastructure.

It is also thought possible that the move towards agriculture is more a consequence of the efficiency of hunter gatherers. It is possible that they hunted larger species to extinction and hunter gathering became less productive as a consequence. The creation of stone tools, spears and blades had led to a progress trap whereby technological progress had altered the environment to the detriment of the inhabitants, this may have been the first instance of a phenomenon that still exists today.

The earliest dyed flax dates back to 34,000 bc, the first indications of the weaving of textiles date back to 25,000 bc in what is now the czech republic. By about 7,000 bc woven hemp cloth is being made in turkey, by the bronze age the egyptians are weaving cloth from flax, from 2,000 bc wool is being weaved in other regions.

The domestication, cultivation and transformation of plants into a complex material is another technological leap and leads to further economic complexity through the division of labour into a variety of skills needed to create the finished product.

It necessitated the growth of settlements and towns, roads and sewers were first built. The increase in complexity saw the emergence of a stratified society, the beginnings of mathematics, writing, politics and economics.

The bronze age was an era of great civilisations the mycenaean's, minoans, egyptians they flourished with bronze axes and ploughs helping intensify agricultural production, saws and chisels to create stone buildings, nails to build bigger boats. Bronze itself an alloy of copper and tin which was only available from a handful of mines across europe and western asia.

The technological advance of metallurgy necessitated mining, trading of commodities across regions and sophisticated furnaces to create high temperatures. It also required the dissipation of larger and larger amounts of external energy throughout the entire process, most of this was from charcoal and required the clearance of forests.

This created another progress trap, the efficiency of metal tools lead to a greater demand for this new technology which in turn lead to increased production and in turn greater deforestation soil erosion and eventually to exhaustion of natural resources.

The bronze age collapse coincided with the growing technology of iron production, tin at times was scarce and expensive, leaving to limited access and limited adoption. Iron ore was much more abundant, the technology of producing iron spread more rapidly, weapons could be cast and forged by populations that were previously unable to access bronze.

The collapse of many of the bronze age civilisations was probably as a result of a degrading of these environments causing a drop in energy and food available to support the inhabitants, but also as a result of losing the technological advantage they had held for so long. Iron had the material properties to create superior armour, armoured cavalry and mass-produced swords. It transformed the ability of new metallic economies to wage wars of conquest unimaginable before iron.

Iron was at the centre of the rise of the great industrial warrior empire of rome with its technological advancement and its ability to mass produce steel to forge an advanced machine of conquest. From the beginning of the metal age right through to the invention of the rifle the sword and armour dominated the battlefield.

The romans exploited every region they conquered, from huge gold mines in spain to tin and gold mines in britain. Not only were they highly efficient surface miners but they were also able to follow ores deep underground, they perfected the use of water wheels to help remove water from these deeper mines powered most likely by slaves they were able to prevent flooding and make mines more productive.

The romans were the first industrial empire their output of resources and their intensified use of energy was so much larger than previous civilisations that ice cores from greenland show a significant rise in pollution during its existence.

Iron ore was extensively mined from the rio tinto river in southern spain and was a key resource in its ability to create iron. From this point on the ownership and productivity of mines would be as strategic imperative of any civilisation wishing to grow or survive

The first boats are likely to have been small canoes possibly dug out from a tree. It is estimated that humans reached australasia by sea over 40,000 years ago, this would likely have been by some basic canoe and probably some form of paddle. Some historians theorise that homo sapiens left africa by boat rather than by lands, but it is likely to have been both.

Fishing would have represented the first real demand for better boats the dugout canoe evolved during the stone age into a lightweight canoe with a simple wooden hull and animal skins, this would have represented a rudimentary way of sea fishing and coastal migration.

The egyptians were the most sophisticated boat builders and designers of the bronze age, this water based civilisation used boats to trade along the nile and close to the shore of the southern mediterranean. By about 4,000 bc the egyptians are building larger and larger longboats powered by oars, by 3,000 bc boats are made from wooden planks tied together or with wooden nails. The arrival of the bronze age gives boat builders metal saws, axes and chisels greatly enhancing their ability to transform wood.

The egyptians invent the square cotton sail which although not very efficient at first adds to the human power of oars, the square sail is not good at sailing into the wind and limits the amount of wind energy that can be harnessed. Through classical antiquity the romans and greeks use similar boats, naval warfare involves mainly long boats powered by oar and sail ramming each other and then reverting to hand to hand combat.

In northern europe a new and more sophisticated form of naval architecture is evolving and even before the roman empire , vikings are crossing the baltic sea in long boats. The longboat is thought to have originated in the baltic in about 400 bc. These scandinavians have compartmentalised the hull adding stiffness and enabling larger stronger boats to be built, they add metal in to the design increasing strength and size of the boats. These long ships are made from overlapped wooden planks known as a clinkers.

The long ship was lightweight strong and durable with a shallow draft able to make a beach landing, the crew was able to lift the boat out of the water and carry it overland.

The viking make incredible journeys through the river systems of europe and even make it as far as the black sea, by a combination of navigating rivers and hauling their boats overland.

The long ship and the vikings reach a peak in about 900 ad as they sack many western european settlements by navigating up rivers. The viking are the first europeans to reach north america in 999 ad.

In the 10th century the cog fist appears in northern europe and is a transformation of the boat from a weapon to that of the transportation of goods, still using the clinker technique and with a single mast and square sail these boast were rounder and could carry up to 200 tons of goods.

By the 14th century the portuguese have begun to develop the caravel a sturdier frame with the wooden boards on the hull butting against each other, this construction technique allowed for larger stronger vessels to be built. Navigating and fishing in the atlantic had forced fisherman to adapt both northern european design and those from the mediterranean to meet the challenges of far rougher seas.

The caravel was capable of having up to three masts including triangular lateen sails allowing it to tack and sail more in to the wind than the square sail. The lateen sail possibly originates from the persians in possibly the 3rd century ad and later by the arabs as they traded in the indian ocean.

Wherever it originated it is its amalgamation with a modern hull, a square sail that alters the trajectory of european history. The portuguese now had a lighter faster, stronger boat capable of crossing oceans, holding cargo and sailing more efficiently in to the wind, it was highly manoeuvrable allowing it to get close to the shore and navigate rivers and estuaries and with a big square sail could cover vast distances across the ocean.

The discoveries of the new world heralds the start of new global trade, supremacy of the oceans becomes far more important than supremacy of the mediterranean. Spices can now be directly imported to europe via sea rather than through expensive, slow and dangerous overland routes.

Diseases spread from europeans to the americas wiping out huge populations, new varieties of plants arrive in europe and domesticated cattle arrive in the americas for the first time.

As boats became larger and trade more extensive more and more timber was required and europe entered the same progress trap their ancestors had endured. By the 15th century europe was running short on timber. Wood was already being extensively used to create charcoal for metal working, houses, boats and wagons all required timber. It is likely that an inability to access sufficient cheap timber would be a partial cause of the demise of the spanish and portuguese empires.

With the advent of coal power, metal hulls and then diesel power the nature of seafaring changed, boats could travel further between stops many ports and regions lost their relevance.

Containerisation reduced the labour and cost of transportation, boats got bigger and could only dock at a few ports, the nature of global trade changed and many of the ancient routes and ports used for thousands of years became irrelevant within a few decades.

The industrial revolution was a technological transformation of coal energy to steam energy and then dissipation through machines to make goods cheaper and faster and then through other machines to transport them faster and farther.

Extracting minerals is to become one of the key skills of an industrialised society. The coal energy that fired the industrial revolution was from pits in wales and the north of england these vast amounts of energy were ready to be harnessed for millennia but needed an array of technology to be able to transform this energy in to work that was of use.

The steam engine was made from metals using techniques refined over thousands of years from the beginning of the bronze age onwards, but it needed a society with enough wealth and surplus to be able to experiment and find ways of solving advanced technological problems using the unique energy density available in coal.

The flooding of mines had always been a problem, especially as so many cornish tin mines were below the sea floor, flooded mines cost money and the demand for tin was so high that a solution would be worth a considerable fortune, so technology itself creates demand for more technology to solve the problems that technology itself creates.

The application of the steam engine for both pumping sea water out of tin mines and the first railway are all examples of the ingenious exploitation of the resources a civilisation has at its disposal, if it is able to transform these resources faster than their neighbours then they will be able to expand at the expense of their neighbours.

Transformation of coal in to electricity, created a demand for electrification, tvs, fridges, computers, the internet. The transformation of crude oil into higher octane fuels gave us motor cars, diesel containers and the jet aeroplane.

Most of the advancement in technology since the industrial revolution has involved reducing human labour and effort by increasing the dissipation of existing external energy. New ways of dissipating energy; the jet plane for example have increased demand for energy through massive increases in travel and tourism.

But with the arrival of the train, car and global aviation the geographical advantage began to change, the sea was no longer such an advantage, geography was circumvented and the access to new forms of energy from fossil fuels changed the course of civilisation and technology.

Technology for most of the twentieth century was involved in the physical movement of people, resources and goods by means of energy dissipation, trains, automobiles, super tankers, mining and manufacturing and consumerism.

The nature and type of empire changed from the dominance of the maritime empires which had lasted since the bronze age to industrialised empires based on the ability to source energy, raw materials and transform them into machines of war.

But since the dawn of the computer and latterly the internet we have begun to fashion a new age. Today we are in the information and entertainment age, we are moving towards a virtual world where more of our experiences are via a screen.

Humanity has built a tool with a billion uses – the smart phone. Technology today has begun to split in to two parts the virtual and the real worlds.

The virtual world delivers news, information, entertainment, experiences it is shaping the way we bank buy things sell things and the way we communicate.

Today a smart phone replaces so many other devices and products, a calculator, torch, watch, recorder, timer, newspaper, book, music player, video player amongst many other things.

The more code can replace physical objects with applications the more we become dependent on code and the cheaper technology becomes, companies once household names like, casio, texas, instruments and kodak are replaced by free applications on a smart phone.

Physical music, books, newspapers and magazines are all disappearing, the manufacturing of these products becomes obsolete but the creativity and ingenuity to create this disruption is the same as that which created the bronze age or the industrial revolution.

New technologies seek to threaten the livelihoods of many as it always has in the past. Today artificial intelligence is the threat that many fear the most, a technology that can learn from data and already produce some remarkable results will undoubtedly get better of the coming years.

The advancement in computer technology and its dissemination across the globe has seen the growth in the power of code. An individual with a limited amount of computing power can create technology that can be used for both good and bad. The power of code has no geographical boundaries nor does it rely on the transformation of a natural resource or any industrial process for its advancement by an individual.

Technology has the ability to enhance our lives and drive the advancement of civilisation but it also has a dark side, most technology can be used for good and bad and the past is full of examples where advancement soon gives way to periods of chaos as the distribution of power is altered by technology.

The general thinking today is that we are a technological society that we solve problems through intellect and ingenuity alone and that nothing is beyond our technological grasp, but in reality our solution has always been the dissipation of more energy to solve a problem. Whilst technology may be driving the global economy it is powered by energy.

Technology is the result of having an abundance of energy and resources, with which to experiment and transform, the history of technology is one of taking advantage of what is available and living with the consequences. The ascent of mankind is not a tale of human ingenuity overcoming the limits of nature but one of exploitation of nature itself.

The technology that is available to us is a product of the ingenuity we are able to apply to the natural resources we have available within the laws of physics.

Humanity has always triumphed over adversity through the use of intellect and technology, the west for centuries has used its technological advantage to exploit much of the rest of the globe, the spanish, portuguese, and british empires all show how powerful technology can be.

But the geography and the geology of a nation or region can have an extreme effect on the technological progress. It is no coincidence that many of the greatest empires were water born, from the minoans, egyptians, greeks, romans, vikings, dutch, portuguese, spanish and british empires, were all masters at marine trade at one time or another.

Parts of the world landlocked have at times produced empires such as the mongols but they are relatively few and far between and their technological advantage of horsemanship and diet is soon dissipated and spread throughout other regions. Empires or regions only survive if they are based on a technology that is either geologic or geographical.

GLOBALISATION

Humanity has been globalising for over 60,000 years, spreading out across the planet over time after leaving africa, spreading across the eurasian landmass and along its coasts, crossing a land bridge in to the americas during the last ice age and then finally populating the southern tip of south america.

Globalisation has never been a linear phenomenon, regions have at times been heavily integrated through trade and then at other times for reasons from conflicts to changes in environment or ideology have seen almost no trade for hundreds of years.

Trade and enterprise have been the foundations of globalisation for millennia but in its earliest form it was a slow exchange of goods and ideas from region to region limited by geography. Whereas today the range and speed of transport for both goods and people removes the geographic constraints that our ancestors faced.

About 10,000 bc the neolithic age began societies began to change from hunter gatherers to farmers. The economic management of land and resources through labour was becoming more efficient than hunter gathering and greater surpluses were created. The move from hunter gatherer to a settled agricultural society occurred independently in different regions across the world at different times.

Ownership of land and its technological mastery through selective breeding of plants and animals became the engine of growth, most trade was conducted locally at first the trade of goods and ideas was generally limited to geographical regions. The adoption of agriculture saw the beginnings of writing and settled towns and villages centred around coats and river deltas.

The growth of trade and globalisation needs both a motive and a means, the latter was initially by walking and rudimentary boats moving up rivers and along coasts. The motive for trade was relatively limited, a basic agrarian economy with little surplus or products to exchange.

The development of pottery and its transference from the eurasian steppes to western europe came through waves of migrations of eurasian equine nomads. Waves of migrations have been a key part of the dissemination of culture and technology, but these waves have also often been to the detriment of those who have been overcome. ,

The increase in technology and the transformation of minerals and ores into products of utility and value began one of the first economic trading cultures. The beginning of the bronze age saw the start of trade across europe as tin from cornwall and afghanistan found its way around the mediterranean a trade requiring, knowledge, technology and cooperation.

The alloying of copper and tin to create bronze revolutionised not only the quality of tools to aid agriculture, axes to cut down trees more efficiently, saws and chisels to carve stone to build bigger buildings.

The economic benefit of bronze created the motive for trade to flourish and the technological benefit aided an explosion in the means to transport larger loads in better boats.

Copper from cyprus was widely traded across the mediterranean and alloyed with tin from cornwall, afghanistan, the iberian peninsula and northern france. The bronze age in the mediterranean was a vibrant trading community of independent cultures all cooperating through mutual economic benefit.

the late bronze age collapse saw a complete halt in this trade and cooperation, it is a matter of debate as to the cause but famine, disease, conflict, climatic changes, and tectonic movements all played a part.

The collapse in these civilisations at the same time highlights the weakness of interconnected trading systems, the more complex technology becomes and the wider the trade of resources required to maintain a standard of living the more vulnerable a society becomes to disruptions in this system.

The arrival of the iron age altered the economic balance, the decline in importance of bronze and tin had a detrimental effect on the trade routes, economies and relations of the bronze age civilisations.

The abundance of iron ore in comparison to copper and especially tin greatly increased the supply of this new metal, power and trade shifted towards civilisations with access to iron and energy deposits.

The increase in the goods available, their superiority, lead to an increase in trade and the increase in trade lead to more manufacturing and technology. A demand for metal goods drove a search for more resources and an increase in trade from further afield. An early form of steel from india was known and used by alexander the great.

The roman empire at its zenith was built on the conquest and exploitation of natural resources unlike the previous bronze age which unified the mediterranean through trade, the romans created a trading block through the use of force.

Rome traded mainly within its own borders, mines in iberia, germany, britain, brittany, olive oil from spain and wine from around the region were all freely traded within this economic block.

Trade had long been established across the eurasian steppes by nomadic horse tribes having contact with both china in the east and persia in the west, this trade became the basis of the silk road which would stretch from the korean peninsula to modern day istanbul.

The romans first saw silk from china in 55 bc, it could have taken up to six months to cover the whole silk route passing through numerous civilisations and economies all extracting taxes and levies.

Marco polo travelled along the silk road reaching china in xxxxx trade between the east and west had been along this route for millennia but was slow, fraught with danger, expensive and required considerable energy.

But by this time the overland routes were being superseded by increases in marine technology allowing bulkier goods to be carried more efficiently over longer distances.

The exchange of knowledge and technology is as important to globalisation as goods and resources theselves.

The islamic golden age from the xx century for the next xx years was such a period a unified language and access to both historical knowledge from the greeks and from their geographical neighbours to the east.

The dissemination and exchange of ideas was more easily accomplished by having a unified language. Europeans received advanced knowledge of medicines, science mathematics through contact with the islamic occupiers of the iberian peninsula. Advances in mathematical knowledge from india arrives through intermediary societies and cultures over time and by land.

Over time humanity came to master the seas and trade flourished throughout the mediterranean during the bronze age. The Phoenicians may well have sailed around africa in 500 bc, but most epic voyages at this time were across narrow seas and around continents. Ocean travel was out of reach of older civilisations, trade was along coasts from port to port and overland all incurred costs and took time to move goods.

The vikings a thousand years ago were able to undertake epic journeys of discovery using advanced boat building techniques and enhanced sails and rigging to be able to efficiently harness the energy of the wind. They were the first civilisations to sail across an ocean and reach a new continent when they landed in north america just before 1,000 ad. This began the start of the next phase of globalisation, transoceanic trade.

At the end of the 15th century christopher columbus discovers the americas, within 30 years the globe had been circumnavigated and the great sea fairing empires of the spanish and portuguese were formed.

This was the real start of the globalisation trend we see today. This dynamic change in technology, allowed trade to flourish by boat, it became more profitable and efficient to trade by ocean than overland, the silk road and the mediterranean lost their economic dominance that had lasted for thousands of years, trade and economic power shifted to the atlantic powers.

Subsequent empires from the spanish and portuguese, through to the dutch french and british had dominated global trade, this trade had generally been one way gold and silver were plundered by the spanish and portuguese and new commodities arrived in europe potatoes, tobacco, rice.

Spices could be brought in larger quantities from asia by sea and became more widely used. Domesticated animals were introduced to south america and became the basis for the south american beef trade.

Australasia was finally discovered, mapped and colonised every populated continent was now interconnected and the start of true globalisation.

Cotton well known during the middle ages, had been imported from india since the roman empire becomes more in demand as sea routes to india open up, ships are able to carry heavier loads at a considerably lower cost that there is an increase in the imports of indian cotton fabric into britain and europe.

The colonisation of india by the british and the industrial revolution changed the textile industry and the trade in cotton. India had been both the grower of raw cotton and the source of manufactured cotton fabric for millennia. Handmade indian textiles were well known from europe to china, but the british had invested in technology and powered by water could produce fabric at a cheaper cost.

Cotton textiles were produced at mills in northern england powered by water in the 18th century but soon steam power would dominate, with vast amounts of coal available britain could produce huge amounts of textiles.

This change in technology saw a shift in globalisation from a trade in finished goods to a trade in raw materials with technologically advanced and external energy rich economies transforming these raw materials in to finished goods.

As trade grows in distance through increases in the technology and efficiency of moving goods, it has necessitated a rise in financing, from babylonia in the xxx bc futures contract through to our modern financial system the ability and speed of transportation lies at the heart of our modern lives.

The origins of modern finance are born in the trade routes of the mediterranean, the greeks used banking and the lending of money

The british east india company and the dutch exploit their respective colonies through the raising of private capital, previously empires had exploited their territories through the state and the crown. This marks the start of private global corporations and the use of private capital to drive global trade instead of monarchs and empires.

Merchant banking flourishes as trade grows, from the city states of venice and florence through to the rothschild's and later british banks. The bank of england is formed to finance the royal navy at the end of the 17th century

The electrical telegraph had been in use since the 1840s it had moved from a communications system for railways in to a more widespread communications system, marconi made the first transatlantic radio transmission. The birth of radio gave the first mass instant communication system. News and culture could be broadcast to anyone with a receiver it enables shipping and transportation.

The telephone advances the ability to communicate instantly across the globe the first trans-atlantic phone call is made in 1927, the growth in telephones allows the growth of global corporations to be able to seamlessly communicate across continents. Where once the dissemination of information was at the same speed as those of goods and people it then became instantaneous, from this point onwards the transference of goods and people is always trying to catch up with the transference of information and knowledge.

In the past the transfer of goods often moved from region to region relatively quickly and the transfer of knowledge required translation and a slow absorption. The growth of telecommunications allows information ideas and technology to begin to become more widespread.

The size and reach of british colonisation left an important legacy on the globe the dominance of the english language the dissemination of ideas and technology is done more easily in a unified single language, the global dominance of first britain and then subsequently the united states during the introduction of the ages of transportation and communication.

Just as the islamic world had unified its language and advanced knowledge during the middle ages so the adoption of english as the lingua franco of global technology, science, arts and literature so globalisation has been enhanced through this adoption.

Great canals were built the suez canal linked the indian ocean to the mediterranean the panama canal connected the pacific to the caribbean and atlantic, dramatically reducing travelling times distances and costs. Sailing ships were replaced by coal and then diesel engines, metal hulls replaced wood and the size of vessels increased substantially.

Containerisation made shipping more efficient, previously the unloading of ships required a large amount of physical labour, just as shipping had transformed from a physically demanding sailing ship to an external energy dissipater so the slow, laborious and expensive process of loading and unloading cargo entered the modern age.

Containerisation had its origins in the coal pits of the industrial revolution, coal was transported in wooden containers on board specially designed railways. Until the 1950s most developments in containers were restricted to handling bulk goods on railways.

The first specifically designed container ships appeared in the 1950s within a decade global standards are introduced to allow containers to be used on sea land and rail. As ships and the amount of goods arriving gets larger, many historical ports unable to cope with larger vessels fade many jobs are lost as physical labour is replaced by machinery.

The cost of loading and unloading falls dramatically, huge ships can now dependably cross oceans with small crews no longer dependent on the wind or tides. The distribution of goods across oceans that began with wind energy was now exclusively powered by fossil fuels. More and more goods were extracted in one place, transformed in another and consumed elsewhere. Containerisation made shipping more efficient, previously.

The rise of the jet age was a profound change in the globalisation story instead of speeding up the transfer of goods it became the transfer of people, ideas, culture and technology. Civil aviation had been developed in the 1930s but it is not until the development of the civil jet airliner in the 1950s that the jet age begins. By the 1970s the boeing 747 is introduced and becomes the benchmark for long distance air travel. Improvements in composites, aerodynamic and engines have reduced the cost of air travel and the increased the volume of people able to move across the world.

The speed of movement allowed merchants to visit suppliers, factories to be relocated to cheaper regions

Globalisation is the main driver in the world economy today, travel, tourism and consumerism all depend on the transfer of goods, resources and people at a required rate and price to justify demand. This has led to the creation of huge amounts of infrastructure from factories, ports, airports motorways, railways, retail parks, supermarkets.

Much of this infrastructure is specifically in expectation that sufficient external energy is available in the future to allow these activities to take place with a sufficient volume to make it profitable enough to continue solvently. It is also the case that much of this infrastructure is expensive and technically demanding to maintain.

This expansion in activity has been financed by debt, most consumer nations are experiencing high levels of debt at household, corporate and sovereign levels. This propensity towards insolvency lies at odds with the huge levels of infrastructure associated with this form of discretionary spending.

Globalisation and the transportation of humans will be the first casualty of any prolonged external energy deficit, a drop in the volume of humans moving across the globe will have fundamental changes in the economies of many countries often those of developing nations.

Transport infrastructure will either be closed or over time a lack of investment will lead to issues with safety and reliability.

POPULATION

The global population has grown steadily since the end of the last ice age, the transformation of humankind from hunter gatherers to sedentary farmers is what historians call the neolithic period. External energy was limited and technology was primitive, most work was done by human labour, disease was widespread life expectancy was low and infant mortality was high.

The transformation to an agricultural economy initially limited diets from what could be found to what could be grown. This change did not have an immediate effect on population growth. Families were large to compensate for a high mortality rate and to ensure a pension of labour for their old age, with no welfare state parents had to rely on their children in their old age.

Travel was non-existent and so families stayed together forming strong interdependent economic units. Violence and slavery were ways to control land and the labour of another human being, essentially making them an external energy source for the slave owner. In a world of mainly physical labour the strong dominated through the threat of violence.

The bronze age saw the beginnings of great civilisations across asia and western europe, better tools aided the productivity of farmers, domestication of animals for food and for labour increased the surplus from farming and the global population grew steadily.

The end of the bronze age sees the collapse of the early civilisations of minoa, mycenae and egypt, it is thought at this time a wave of superior weaponry from northern italy and the iberian peninsula altered the balance of power in the region. These ordered technological civilisations were possibly overwhelmed by a proliferation of weaponry as cheaper better steel became more freely available.

During this period it is believed that the global population continued to rise quickly until about 600 bc at this point it stagnates this coincides with the growth over the next few centuries of first the macedonians and then the roman empire. The growth of the roman empire is marked by aggression and most likely genocide as the first industrial empire begins to grow.

The mass production of weaponry and the sheer scale of conquests saw the ethnic cleansing of many regions, the sacking of carthage, conquest of gaul and the constant persecution of the jews. The romans economy relied on the subjugation of conquered peoples through slavery, a roman citizen could wield complete power over their salves.

During this time the development of the horse as a weapon of conquest by advances breeding larger horses and in armour from asia saw the start of centuries of conquest in asia and eastern europe, culminating in the conquests by genghis khan in 12xx. However even by this late stage much of europe had fortified itself from the effects of cavalry and military tactics had begun to evolve to negate the devastating effect of heavy mobile cavalry.

The greeks and romans both suffered from sub replacement fertility, the ruling classes of both these civilisations grew wealthy, childbirth fell. This phenomenon may well have been a major cause of the collapse of the hellenistic world. During the 3rd century bc the roman empire nearly collapsed barbarian invasions, migrations and civil wars and plagues.

After the collapse of the western roman empire, although the global population remained relatively stable, the onset of the middle ages sees a chaotic post empire with decentralisation and the implosion of many of the economic systems of rome. There is mass migration, refugees, warlords a severe breakdown in trade.

The first pandemic began in 541 ad the plague of justinian swept through the byzantine and sassanian empires, it probably arrived in constantinople via rats on board merchant ships possibly

from alexandria in egypt. It is thought that up to half the population of europe died as a result of this plague. The plague resurfaced numerous times over the next two hundred years.

The early middle ages saw population levels well below the roman peak, urbanisation was limited, and settlements were small with areas abandoned and lawless. Trade was limited, agriculture was the main occupation. The previous complexity of the roman empire had given way to a simpler economy but the culture of rome remained.

The global population begins to accelerate from about 1,000 bc, increases in technology from water mills powering sawmills, windmills powering wells and improved agricultural output using better methods of crop rotation. Technology, trade and knowledge began to flow from the islamic world.

As the middle ages came to an end a series of misfortunes befell europe, firstly the great famine began in 1315, heavy and prolonged rains in europe caused crop failures, as much as 25% of the population of some towns die over the next two years. The plague arrives from china in 1347 most likely via the mongols and the silk road and possibly through genoese merchant ships, over the next few years up to 50% of europe's population dies as a result.

By 1450 the population of europe is considerably lower than 150 years earlier, a lower supply of labour caused wages to rise more land was available for economic participants plagues continue sporadically throughout europe right up until the start of the 18th century.

The global population continues to grow throughout the spanish conquests and the start of the british empire, the rate remains relatively similar until the industrial revolution is underway. With the advent of global trade brought about by the discovery of the new world, diets gradually became better and more varied based on a wider range of choices, sugar, potatoes, fruits and spices, populations began living healthier longer lives relative to the early middle ages.

The conquests of the americas have a catastrophic effect on the populations of the aztecs, incas and mesoamericans, europeans bring infectious diseases such as smallpox and measles. Some of these indigenous populations decline by as much as 90%.

Advances in the knowledge of infectious diseases and contamination of water by sewerage had been known as far back as the minoans who built the earliest sewerage systems, but it is not until the victorian age that a concerted effort to control waste and reduce contamination is made.

The industrial revolution that has so transformed our lives begins in the 18th century, some historians argue that the invention of the printing press some 300 years earlier is the real start of the industrialisation of the world. Others argue that the invention of the steam engine to power machines rather say the water mill was the driving force, this was a huge increase in the energy intensity of the british economy and sets apart from all other economies.

The british isles abundant in resources and with a geographical advantage was fertile ground for a technological leap. Abundant coal and other minerals combined with a thriving maritime trade, overseas colonies and wealth became the epicentre for the transformation of natural resources in to goods by way of dissipating external energy.

Whilst many argue that the industrial revolution is a consequence of the british political system and the general ingenuity pf the population it more likely that it was as a result of benign geography and geology. The dutch had many of the same maritime, political and financial advantages as the british but due to a lack of resources was simply unable to enter the industrial age. A lack of the natural resources and external energy prevented a sophisticated and wealthy economy from entering a new technological age.

The industrial revolution along with a vast maritime empire catapulted britain in to a global superpower, but there is little evidence that it transformed the live of its citizens for the better. The

largescale movements of workers from agriculture to the growing urban industrial centres more than likely saw a worsening of diets, increased contact with harmful industrial pollutants and a concentration of diseases born by inadequate treatment of sewage in densely populated centres.

It wasn't until the mid 19th century that the victorians embarked on a nationwide system of sewers. The use of sewers goes back thousands of years sewers were built using brick in the indus valley modern day pakistan and india as far back as 2,000 bc.

The civilisations of greece, egypt, mesopotamia all used sewers to some extent, the romans constructed much larger systems still used today in parts of europe. After the fall of the western roman empire much of the roman infrastructure was not added to and over time began to fall in to disrepair.

Even during the age of enlightenment there was little if any development in the safe treatment of effluent and the prevention of infectious diseases, populations continue to grow towns and cities grow bigger and the problem gets worse. As britain industrialised and the urban population increased dramatically, diseases such as cholera and typhoid were able to spread amongst densely populated towns and cities.

The construction of victorian sewers would not have been possible without the humble brick, sewers had been built using bricks for thousands of years, but it is only the industrialisation of the brick making process that allows the victorians to mass produce them. Brick making machines were able to produce 25,000 bricks per day by the middle of the 19th century, life expectancy in liverpool was as low as xx before the first sewer system is built within a couple of decades it had doubled

These advances in sanitation and disease control were all only possible because of the availability of vast amounts of external energy and the technology to transform it. By the end of the 19th century oil was being used to power the first internal combustion engines, the advancement in pharmaceuticals and petrochemicals was as a result of a desire to exploit the properties and energy density of first coal and then oil.

From the first antibiotics derived from tar sands to disinfectants our ability to operate on the human body successfully has had a transformation in the treatment of disease, illness and injury all adding to the increases in life expectancy seen in industrialised economies throughout the west in the twentieth century.

The huge increase in the amount and density of external energy available in the oil age allowed the transformation of resources to create medicines to treat illness and chemicals to kill bacteria, drugs to prevent infection, the x-ray and then scanners to detect illnesses have all hugely increased the life expectancy of the citizens of energy dense economies.

As these advances have continued the global population has surged throughout the twentieth century, the main driver of this is that people are living longer. Infant mortality has increased across the globe instead of dying young people are surviving and having children of their own.

People are living far longer and as a result of this probability are choosing to have less children, as the global population has been expanding the size of the average family has been falling, less children being born to each family but living substantially longer lives.

Today western industrialised populations are relatively stagnant, the birth rate in some parts of europe is below two per woman, but for the increase in life expectancy which creates a reduction in the mortality rate for a period of time and increases in immigration these populations would be in outright decline.

As it is these populations begin to age and their economies begin to alter, they begin to shift in the demands they require, generally moving from one of consumption and high activity investing to one

of lower activity and the divesting of assets to pay for care. Over time the mortality rate will rise as the elderly begin to die and unless immigration boosts the population they will decline.

Meanwhile across asia the effects of globalisation have seen a dramatic drop in the birth rate wealthier aspirational middle classes grow, they can expect a higher life expectancy than their ancestors and chose to have less children. Japan is facing the burden of an increasingly ageing population and with minimal inward migration in the twentieth century could be the first industrialised nation to face outright population decline.

Africa is very much the exception to the current global trend many of its economies are low energy density economies, infant mortality is high, poor infrastructure and access to energy and technology limits life expectancy as a result the birth is substantially higher. The average age in africa is also substantially lower than most industrialised nations, during the next few decades these young populations will themselves have children.

If this explosion in children is accompanied by a reduction in the infant mortality rate and an increase in life expectancy then africa would become the most populous nation on the globe by 2100, this relies on a constantly increasing energy intensity and technology on the continent of africa.

As in the past the future course of the global population as well as regional populations comes doen to a technological ability to harness and adapt natural resources through the use of energy to enhance our lives and increase our longevity.

SCIENCE & MEDICINE

The beginnings of what can be considered science date back to the earliest writing systems, before this period technology was driven by the practical execution of skills through experimentation, whether this was agriculture or metallurgy. The transfer of knowledge was direct and practical and probably made the transfer of technology slow.

The earliest known writing systems date back to the 4th millennium bc, the sumerians and the egyptians had hieroglyphic symbol based systems, writing systems such as these have developed independently in civilisations from china to central america.

These post hunter gatherer agricultural civilisations need to plan crop planting, organise boundaries, trade and organise the affairs of a more structured settled community.

This creation of a written language during the bronze age began the earliest form of scientific enquiry in and around babylon, the ability to preserve ideas and to exchange information and knowledge through writing was an information revolution. Information previously was passed by word of mouth and was prone to human error, technology and knowledge passed slowly and inaccurately through society and humanity.

Prehistoric medicine was based around herbalism the use of plants still in use today, the first known dentistry was in 7,000 bc in baluchistan modern day pakistan and iran using a flint tipped drill and bow string. In france in about 5,000 bc skulls are being drilled to relieve pressure from the skull, at the same time amputations may have been taking place.

Early medical practitioners used a mixture of herbal medicines and shamanism, the earliest medical prescription appears in sumerian ur around the euphrates from about 2,000 bc.

In about 1,000 bc the babylonians and egyptians are introducing diagnosis, prognosis examination this is a logical approach to the observation and recording of illnesses and remedies.

The first medical text is sumerian in origin dating back to about 2,000 bc, this region produces further advances in astrology and medicine, equally the egyptians during this period made significant advances in mathematics, astronomy and medicine both cultures using a pictorial based alphabet. 1600 bc in egypt textbooks on surgery are being written. The egyptians develop geometry to enable the surveying of land and the construction of buildings.

In babylonia knowledge of the chemical properties of sand, clay, metals, bitumen and other minerals becomes widespread along with increases in manufacturing technology.

Astronomy and mathematics is developed to calculate the changing length of daylight throughout the year and to be able to predict the appearance and disappearance of the moon and stars.

The first modern alphabet dates back to the semitic language in about the 2nd millennium bc, however it was in about 800 bc that the first truly modern alphabet containing both the consonants of the semitic systems and the introduction of vowels developed by the greeks and influenced by the phoenicians before them.

This modern alphabet and writing system is the catalyst for the increase of and dissemination of knowledge and the pursuit of theory.

The greeks furthered the enquiry in to the theoretical principles of mathematics and science begun as far back as the babylonians, but with the ability to store and accurately disseminate information they were able to build the first knowledge based information society.

The geographical advantage of the aegean islands combined with a level of sophistication inherited from the bronze age civilisations of the minoans and mycenae and a modern alphabet and writing system all came together to create the first great mediterranean maritime iron age civilisation. Once rome had conquered greece, the flow of intellectual enquiry was slowed as the romans became the first industrialised empire the world had ever seen.

In ancient greece 800 bc basic medicine is being used to heal wounds successfully, hippocrates in around 400 bc makes huge advances in the understanding of diseases and writes many works that remain the basis of medicine up to the modern day.

In alexandria in hellenistic egypt medical schools are centres of surgical advancement, euclid introduces mathematical concepts of definition, axiom, theorem and proof still a foundation of mathematics today. Plato and aristotle develop ideas of natural philosophy, deductive reasoning and empiricism, they lay the foundations for scientific enquiry still used today.

The greeks are the driving force in medicine, science and mathematics even after the roman conquests with pharmacology and botany used as medicine, great advances in anatomy are made, however, dissection of the human body is banned limiting increased understanding. The romans invent surgical instruments scalpels, needles, forceps, and increase the knowledge of human anatomy through advancements in surgical techniques.

The romans less concerned with theoretical maths and science, were the great engineers and early industrialists more concerned with the practical application of technology to create systems designed to increase the power of the republic and later the empire. They used mathematics from the greeks to survey roads, build bridges, aqueducts and many other infrastructure products.

After the fall of the western roman empire medical knowledge is maintained by the eastern empire of byzantium whilst in the west knowledge and practice declines.

Constantinople modern day istanbul the capital of the byzantine empire becomes the centre of medical knowledge, civilian hospitals may well have been developed during this time

The fall of the western roman empire saw a reduction in economic activity, trade and scientific endeavour in western europe, the intellectual knowledge from the greeks was inherited by the byzantine empire but was also adopted by the islamic world.

However a new influence was advancing the mathematical and scientific knowledge of humanity, the indus valley in what is now north west india and pakistan had been a significant civilisation just had been those around the euphrates and the nile delta.

The advancement of this indus valley civilisation was the creation of the indo arabic numeral system with a positional decimal system in about 600 ad, this is the system almost universally used today and a distinct advantage in calculation and advancement in technology compared to the roman system. Trigonometric functions are introduced, algorithm and algebra along with further developments in astronomy.

This numerical system was adopted in the muslim world by 900 ad and adapted to arabic numerals with the addition of the decimal point, along with the legacy of greeks science prospered during the islamic golden age. The islamic world benefited from a unified language access to greek texts from the byzantine empire and access to advances in science from the indus valley.

Islamic scholars are thought to have been the founders of the science of chemistry, advances are made in mathematics, astrology and medicine.

Western europe continued to use the inferior roman numeral system, however by the time of the crusades scientific knowledge from india, the muslim world and the classical greeks was beginning to flow back to the western world.

The translation of greek and muslim scientific texts in to latin saw an explosion in the advancement of science and understanding, the new numerical system made mathematics, technology, trade easier. As this new numerical system is adapted in western europe and the mediterranean, it combines the superior mathematics of the indo-arabic numeral system with the trade of the mediterranean and begins what becomes the modern global financial system.

The 12th century in europe saw the establishment of universities, the re adoption of classical science and philosophy and the adoption of advances made by arabs and indians in science, mathematics and medicine. The fall of constantinople, the capture of sicily by the normans and the al andalus caliphate in spain all help to spread knowledge, translations of scientific texts into latin and soon european universities become the preeminent centres in the translation and study of classical and islamic knowledge.

It is not until the 13th century in europe that human bodies are dissected creating a full knowledge of human anatomy. The spread of medical knowledge through much of the middle ages in western europe was through the use of latin and the control of the catholic church, convents and monasteries were centres of healthcare and nursing rather than the advancement of science.

From the adoption of modern numbers in western europe the business of trade and banking became easier, the previous roman numbers although enhanced since the fall of the western empire were unsuitable for the creation of the modern science and banking. The creation of a financial system was as a result of both an increase in mathematical knowledge and in the new numeric system.

During the high middle ages the field of medicine saw constant increases in the understanding of anatomy, biology, herbal medicine was influential and still provide the basis for some modern drugs. The invention of the mechanical printing press begins a new information revolution – the printed book would dominate the dissemination of scientific information.

In the 16th century the scientific revolution begins in europe, notable scientists such a copernicus, galileo galilei, pascal, kepler and haley make advances in the scientific method through experimentation and reasoning during this period. Quinine and opium are two of a very few effective drugs available.

Bacteria is discovered using an early microscope, isaac newton develops physics, mathematics, optics and theories of gravity, early telescopes are developed. Hospitals became more widespread vaccines are understood and introduced. The behaviour of electricity and magnetism are studied leading to maxwell's equations and the foundation of our electrical world.

In the 1880s german dye manufacturers are able to purify individual organic compounds from tar and other minerals, the energy density, adaptability and abundance of oil would create the petrochemicals industry that would give us liquid fuels, plastics, chemicals, pharmaceuticals and a host of other products. Scientists become able to synthesize hundreds of organic compounds.

By the 1890s adrenaline and steroids are extracted from adrenal glands the observation of chemical signalling leads to the developments of drugs based on adrenal extracts.

It is not until the 19th century that the modern age of medicine begins anaesthesia, antiseptics advances in bacteriology and virology lead to a greater understanding of the spread of germs and diseases this leads to the introduction of sewers and a reduction in infectious waterborne diseases, surgeons understand the need for cleanliness.

Statistical methods are used to understand the spread of disease and infection especially in light of the crimea and us civil war where more soldiers died of infection than from their wounds.

The start of the 20th century the discovery of penicillin, the two world wars have a profound effect on the treatment and understanding of wounds and infections.

The second world war saw the industrialisation of pharmaceuticals as the huge numbers of combatants and wounded required the british and us drug manufacturers to industrialise the pharmaceuticals industry.

After the second world war modern surgery techniques allow transplants, for hearts, kidneys and livers. The arrival of anti-biotics at the start of the twentieth century transformed the ability of a surgeon to perform advanced operations and prevent infection. By the end of the twentieth the human genome has been mapped.

The twentieth century sees a revolution on physics, newton's theories are seen to be not correct in all circumstances, einstein, plank and bohr all contribute to new quantum theories even einstein general theory of relativity is disproved by this new knowledge. Dna is isolated in the 1950s

Quantum mechanics is born, nuclear fission is discovered in what historians call the age of big science, the first cyclotron developed in the 1920s marks the start of larger and more complex technology being created to solve the next problem. Science becomes a victim of marginal returns

Ai

Semi conductors

The domination of western science that began with the translations of muslim texts and the adoption of the indo-arabic numeral system flourished through the great maritime empires and made a successful leap in to the fossil fuel age began by the industrial revolution but supercharged by the oil age.

ART & CULTURE

Art and culture are as old as civilisation itself, the earliest known homo sapiens carving is in southern africa and date from over 70,000 bc, cave paintings in northern spain have been dated back to over 35,000 bc. These primitive markings were by hunter gatherers who were able to create enough surplus from their daily lives to have the leisure time to experiment with tools to create paints or dies and then observe nature and create art.

The earliest musical instruments also date back some 35,000 bc, these first known pieces of art and culture are one of the earliest indicators of a society comfortably able to create a surplus and enjoy a relatively high standard of living for the period,

Clearly there was an abundance of food, water, energy and shelter that daily life was not a constant struggle to just survive. There was clearly enough time to be civilised and engage in a cultural activity.

The earliest known carved figure is that of a lion man carved from mammoth bone around 235,999 bc this piece would have required skilfully made tools, and many hundreds of hours of painstaking carving by an individual with a high level of skill and experience. This again indicates a society with an advanced level of technology and surplus with which to have the time to create such art.

It is unclear what the purpose of this carving was for, whether it was for trading, worship or just for the hell of it and it probably doesn't matter as much as what it says about the society and economy of its creator.

The neolithic period saw the transformation of society from that of the hunter gatherers able to carve and paint in to an agrarian society, domesticating animals clearing forests, irrigating and farming the land.

The development of modern languages in europe comes during the period 4,000 bc – 1,000 bc where waves of migrants arrive from the eurasian steppes around the black eas and caspian sea, these early migrants arrive from an area that will continue to shape the civilisation and culture of europe up until the middle ages.

The generally accepted theory is that nearly all the modern languages of europe are thought to be derived from the settlers of the pontic caspian steppe before and during the bronze age, these steppes are more than likely the birthplace of the modern horse and continue to be the source of waves of horse born invaders from the huns to the mongols in the 13th century.

It is unclear what was spoken before these settlers arrived, but the consensus is that these waves are the source for languages from sanskrit in asia to french, german, latin, spanish, english, armenian, slavic and many more languages.

Around 3,000 bc the first writing is found in the early cities of ur around the euphrates the move to agriculture, irrigation engineering and fixed settlements had necessitated a growth in the communication of humanity, this technological change induced another leap in civilisation.

The bronze age brought great progress technologically and the birth of new civilisations, the minoans spread their culture across the aegean from their centre in crete heralding europe's first great civilisation.

The island of crete was at the time a geographic, geologic treasure trove waiting to be exploited. Crete lies in the heart of the eastern mediterranean, its strategic importance lies at the heart of its flourishing trade, technology and culture.

The first signs of neolithic settlement in crete date back to about 7,000 bc, the bronze age arrives at about 3,200 bc, the minoan civilisation becomes prominent in about 2,700 bc. The bronze age arrived early in crete giving its inhabitants a technological advantage, this probably as a result of its geography giving it access to trade and the inevitable transfer technological knowledge.

The minoans were a mercantile society with trade links around the mediterranean and as far as the iberian peninsula, it contained many natural harbours making it an ideal island for a truly great maritime empire. The surplus generated allowed the creation of great works of art using raw materials from across the ancient world.

The minoan civilisation collapsed in about 1,100 bc to be replaced in europe by the mycenaean empire who had been heavily influenced by the minoans themselves. There are various theories about the collapse of minoan culture from volcanic eruptions to tidal waves, all of which played a part, there is evidence that they were weakened by deforestation which lead to a collapse in industry, technology and in diet. It is also likely that as the technology of boats and sailing changed they were able to undertake longer voyages and trading routes altered, reducing the strategic advantage of crete.

It is also possible that the island of crete simply did not support the energy intensity of the iron age that was developing on the mainland.

The mycenaean, greek and roman civilisations all developed after the early development of iron, these new civilisations based on the mainland of europe but with extensive strategic coastlines were all able to cope with the energy density of iron production.

All of these civilisations in turn flourished technologically, financially and culturally through extensive trade around the mediterranean, the byzantines and then the ottomans kept the eastern mediterranean enlightened whilst the west fell in to decline after the collapse of the roman empire in xxxxxx.

It is difficult to answer why the roman empire collapsed some historians see it as inevitable, others as a result of its adoption of christianity, the differences between the old hellenic culture of the greek eastern half and the latin christian western half.

There are many reasons but it could be that after centuries of conquest, deforestation, mining and agriculture the geologic and environment that created the empire was exhausted, its failure to continue to expand meant a cap on the natural resources it had to command.

The collapse of the western roman empire also coincides with a growing threat from the eurasian steppes that had been the source of the latin and greek languages and cultures over a thousand years before, by its end the western empire was threatened by the huns most likely descended from tribes that had migrated from the caspian sea, these nomadic horse people had more than likely domesticated the horse.

In around 3,500 bc the horse is thought to have been domesticated by eurasian nomads, they are believed to have invented, the chariot, wagon, cavalry, horse archers, the bit, bridle and stirrup. Their culture was centred on horse breeding, riding and trading across the vast eurasian steppes north of the caspian sea.

By about 8th century bc these people formed a loose state called scythia mainly speaking languages later associated with iran and the persian empire. The original horse was small and unsuitable for riding or ridden warfare, they were originally used to pull chariots, and whilst suitable for certain locations were generally not effective on any rough ground. As early as 500 bc a breed of large horses had emerged from persia south of the eurasian steppes but they were rare and expensive.

For most of the roman empire the main military emphasis was on highly disciplined well-armed and armoured soldiers, with excellent road and transport system and logistics. Whilst there was always horse mounted soldiers or cavalry it was more about prestige than weapon of war, cavalry was often used for scouting and skirmishing rather than the heavy cavalry that was to come.

Towards the end of the roman empire cavalry played a more important role, the romans had been constantly fighting the persians who had larger horses a longer history with horses and a closer tie with the eurasian steppes where the nomadic horse riders lived.

These waves of equestrian steppe nomads had been coming since the 4th millennium bc bringing language and horses but were now bringing a new type of warfare, highly mobile heavy cavalry that was no match for roman infantry. By the time of the goths and huns the roman agrarian economy was no match for a mobile heavy cavalry, the roman infantry were powerless against this new mobility.

The civilisation that was the roman empire and its previous forms was all but destroyed by a culture with neither the level of sophistication, technology or culture that the greeks and romans had forged, but what the invaders had was exogenous energy, the technological development of horse breeding and domestication had taken thousands of years to produce the big heavy horses we think of when we imagine chivalric knights of the crusades and normans.

For virtually all of the classical period from the egyptians, minoans to the fall of the western roman empire the centre of trade and power was fixed to the mediterranean and trade by boat, all of the great civilisations had been centred around the waterways of europe and asia. From the beginning of the equine age the balance of power shifts to these invaders.

The collapse of the roman empire ends the classical era and begins the early middle ages, this period is one of collapse of centralised systems and the rise great migrations of peoples from germanic tribes and eurasian nomads in to the void left by rome.

It is the era of muslim conquests of what was byzantine persia, egypt and north africa by the umayyad dynasty, the rise of the emergence of christianity across europe, the frankish empire and the vikings. This fragmentation of europe led to the creation of many independent states from the viking settlers in normandy who become the normans to the city states of florence genoa, venice.

As the nature of cavalry warfare altered fortification, larger castles and city walls were created, borders were no longer defensible to heavy mobile cavalry but settlements where. The norman knights the very epitome of the equine warrior became some of the greatest castle builders of the middle ages.

These maritime city states began to flourish around the start of the high middle ages 1000 ad, they were well defended ports strategically located, the threat from land invasion had been negated by the fortification and the weapon of siege was not effective to ports unless it was land based and sea based.

Maritime powers such as venice had long traded with the muslims in north africa and middle east and what remained of the eastern roman byzantine empire at constantinople. It prospered greatly when the norman conquests began and by the sacking of constantinople in the fourth crusade it became a wealthy independent state with newly acquired lands and the plunder from the byzantine empire.

The venetians, over time these city states came to dominate trade and much of the mediterranean fell under their sphere of influence. Throughout this period these powers battled each other and the ottoman fleet.

Art and culture flourished with the increase in trade and influence of the city states of the mediterranean genoa and venice were the two dominant trading routes for the eastern and western halves of the mediterranean.

They flourish with the wealth of trade and the increased sophistication of finance and banking, great works of art were commissioned and the science of art is expanded as pigment and minerals needed to create different colours become more freely available from further afield as trade routes grew.

The study of maths, technology and especially of navigation is changing the culture of the west, the reach of these city states stretches from north africa, the iberian peninsula and all the way to the black sea. By the 13th century explorers like marco polo were able to reach as far as china along the silk road where he is believed to have met kublai khan, these journeys transferred knowledge and technology from the east to the west.

The growth of science coincides with the growth of trade and ideas from the east, mathematics, medicine, astronomy. Eventually vasco da gama finds a sea route to asia and christopher columbus from genoa discovers the new world, the ottoman empire takes constantinople and venice loses much of its geographic importance along with the other city states.

The art and cultural importance of the mediterranean once destroyed by the technological change of the equine eurasian nomad is about to change once more and the strategic geographical and cultural importance of the mediterranean would never be quite the same.

In about 1450 gutenberg invents the first mechanical printing press utilising the printing block that had been in existence for a thousand years in china. The printing revolution transforms the political and religious landscape of europe printed translations of the bible become far more accessible to the people and undermine the pre-eminence of the catholic church to interpret the bible, within decades europe is bitterly divided between protestants and catholics and embark on centuries of religious conflict.

By the end of the 15th century columbus a venetian merchant financed by the catholic king and queen of spain has discovered the americas, the spanish christians have finally taken grenada defeating the moors and restoring christianity to western europe. From this time on the christian culture of western europe begins its inexorable domination of the new worlds, in tandem with the technological advantage of the new maritime powers of spain, portugal and then later the british empire.

Spain becomes the first trans-oceanic empire and spreads christianity across to south and central america vasco da gama finds the first sea route to india for the portuguese who colonise the americas and india.

By the time the spanish armada is defeated the balance of power shifts to the northern atlantic as the british empire dominates not only the seas but also begins to assert its technological advantage. The spanish empire becomes a large centralised beaurocratic system running many colonies from the centre, it is constantly under attack from privateers what the spanish would term pirates and many of them were british, unlike the spanish navy these were smaller lighter faster ships crewed by better more motivated sailors making a living by seizing spanish galleons loaded with gold, silver and other commodities from the new world.

British ships were reputedly able to fire twice as many rounds as a spanish ship, many of the british ships were manned and captained by privateers.

What mad the british so great?

But culturally the english language. The colonisation of north america by english speakers sets the course for the next few hundred years as the domination of english language and christian culture.

The advancement of the industrial revolution gives first britain and the united states a huge technological advantage.

By the 20th century the english speaking culture begins to dominate art culture trade.

Environment

The development of humanity is the development of our ability to access and exploit resources from our environment. At the end of the last ice age at about xxxxx bc global temperatures began to rise within a few thousand years temperature plateaued and remained similar to today's climate.

in about 10,000 bc we began the move from hunter gatherers to farmers, it is likely that this change in our environment had a large role to play in this stepping stone towards civilisation. Our technological mastery and the climate made it such that we were able to be more efficient by growing food rather than hunting and gathering.

We were able to create a surplus and reduce the amount of energy it took us to feed ourselves over our previous lifestyle. We began to mould the environment to suit our purpose, mainly at this stage through the use of labour. We changed from a society taking what was available to one planning and controlling our sources of food.

The global population grew slowly at first, farming was safer and more dependable than hunting and gathering, and although for a period of time it limited diets and more than likely began the sedentary lifestyles and modern illnesses we have today it created a surplus.

At that time energy dissipation was low but the environment was already changing, the need for agricultural land meant large scale clearance of forests and a reduction in biodiversity. Fires and kilns for pottery were from wood an abundant and renewable energy.

Forests were cleared during the mesolithic period mainly for early forms of agriculture such as the grazing and containment of livestock, this clearance was mainly by way of burning the trees, this practice continued during neolithic times and has carried on ever since, there is evidence of deforestation amongst many ancient civilisations including the minoans during the bronze age.

From about 3,300 bc the bronze age was underway, the transformation of raw materials into metal was the start of a technology we are still completely reliant on today.it brought more technology and more products, larger boats could be constructed, chariots and carts all needing more wood.

From about 1,200 bc the iron age began, the production of iron requires higher temperatures than those for pottery and bronze and requires more technological progress, wood was transformed in to charcoal to create these higher temperatures.

Iron was more abundant than bronze and so could be produced at a lower price in larger quantities. The iron age is the concerted effort to find better, cheaper ways of doing things using more energy to transform different resources to create more sophisticated products at greater economies of scale.

The introduction of iron lead to an explosion in the products society could make from boats to chariots, carts, armour, swords. The more products could be made the greater the demand and the more trees were cut down and the more intense the mining.

Humanity has many times had to deal with the consequences of its own technological progress and time and again this voracious appetite to transform the environment lead to multiple progress traps, a society would arise in an area rich in resources such as wood it would settle use the resources

deplete them and then it would collapse, abandoning the settlements it had created because the resources it had been built on had all been wiped out and it became uneconomic to sustain its presence.

The economic viability and reason for a civilisation to be in a particular area was and always will be dependent on its ability to access energy and raw materials within its immediate vicinity, if the resources are exhausted there is very often no economic reason for the civilisation to exist and so it collapses.

The roman empire was built through the use of iron not only did it master the making of iron products and weapons, but also mining, agriculture and the seas. But none of these accomplishments would have been possible without the geology, geography and technological advantage rome had.

An extensive coastline and expertise in sailing, significant trade and exchange of ideas and technology, and an abundance of iron ore within its sphere of influence. The romans became masters of mining and one mine lxxxxxxxx had over 20,000 slaves working in it during the xxxxxxx.

Throughout the metal ages and right through to the middle ages the dominant sources of energy in the global economy, were still human labour, horses, livestock, wood and wind. However the technological progress of humanity was also having a detrimental effect on the environment and on localised society,

the intensification of agriculture changed the local environment and had a detrimental effect on many early societies, land once cleared of trees and intensively altered for agriculture was prone to flooding and soil erosion. There are many examples of ports being abandoned across what is now modern day turkey because the soil erosion was so extensive it lead to severe depletion of the soil which lead to the silting up of ports and estuaries as the soil was swept downstream.

Even during the height of the great marine empires the mix of energy use remained fairly similar. The increases in emissions were mainly as result of the dissipation of renewable sources. However the extensive use of wood to create bigger ships, combined with deforestation for agriculture and the use of wood to make charcoal for iron production was beginning to have a major effect on many economies.

Between 1100 and 1500 ad there was a significant deforestation in western europe, a growing population and an insatiable demand for more and bigger boats, more charcoal to forge more metal products meant that from 1,500 ad onwards the british isles were deforested that its navy had to be built using imported wood form the baltics and the new colonies of north america.

Such was the deforestation during this time in britain that the local population used to eating a rich diet of game from the forests saw a collapse in their diet and health. Europe by the 1,500s was on the precipice of a nutritional and fuel disaster, it was only saved by introduction of new foods from the new world such as potatoes, corn and the burning of coal as a substitute for wood.

One of the earliest accounts of man-made air born pollution and smog was the banning of the burning of sea coal by king edward 1 in 1272, coal was so abundant that it could be collected for free off some english shores, however the pollution levels were so bad.

The start of the industrial revolution was the beginning of humanities intense exploitation of the environment. The ability to find extract transform and dissipate external energy lies at the heart of so much we take for granted in our lives today, however it is no more than a continuation of the journey began when pottery was first fired in a kiln or the first bronze axe was made.

The difference this time was instead of using less dense forms of energy such as wood, charcoal or peat, we began using much more energy dense coal. Coal was not a new product but until the

invention of the steam engine its practical uses were limited and the expense of mining it was not economically viable.

One the steam engine was able to demonstrate its ability to harness this external energy density and transform it in to work that was of benefit to society the economic case for mining coal was made. From that moment on mankind has been hooked on fossil fuels and each generation has lived a more polluting life than the previous generation.

The introduction of the coal powered steam engine lead to the railways, steam boats, mass manufacturing as they drove the new machines. Steam trains were still being used commercially in the uk in to the first half of the twentieth century, ships powered by coal were able to cross the atlantic in the 19th century.

The industrial revolution was the technological advancement that also gave us the environmental pollution we know today, in 1858 london suffered the great stink, the cocktail of human effluent and environmental waste polluted the thames and lead to the first modern sewerage system. In the following decades more and more environmental legislation was introduced in europe and in 1881 in chicago clean air legislation was introduced.

Pollution was from human waste, industrial waste and the waste from tens of thousands of horse in our cities, the streets were covered in horse manure and urine, the arrival of the automobile was seen as a positive as its replacement of the horse helped to clean the streets.

Whilst coal was energy dense compared to wood its replacement - refined oil as diesel and petrol was another leap in man's ability to transform and dissipate even denser fossil fuels. By the 1940s the automobile was creating severe airborne pollution in most industrialised cities. The great smog of 1952 in london saw the deaths of some 4,000 people directly related to this fossil fuel pollution, eventually in 1956 the clean air act was introduced.

Overtime as industrialised nations began to be affected by the emissions this intense energy dissipation was producing more environmental rules were introduced manufacturing became more expensive. Globalisation made it easier to transfer production to cheaper countries with lower environmental standards.

Developing nations became the workshops of the world and encountered the pollution advanced nations had previously experienced. The advanced nations having transferred the production abroad imported these goods but failed to take account of the energy and pollution embedded in these imports.

We have built a society, technology, economy, politics and psychology based on the dissipation of external energy and the consumption of natural resources. This is the process that has been going on since the first pottery kilns during the mesolithic period. We are happy that our localised environment is not tainted by the production of the products we consume. We create demand for products but have them manufactured in countries with lower environmental standards than our own.

POLITICS

Division of knowledge

Confirmation bias

Uncertainty principle

Wealth effect

Collapse weimar, soviet union

Politics has always existed, citizens have always had a view as to how they should be governed even when they were living in a feudal system. Monarchies, dictatorships and any organisation into a state is a political institution as they all rely on acceptance by at least part of society, whether landowners, military or the electorate.

From the formation of the early bronze age civilisations, where boundaries and frontiers have been formed politics has been involved in the formation and administration of these organised groups. The move from hunter gatherer to sedentary agrarian society based on specific land to which labour has been used to prepare and cultivate, the value of a collective community grew.

The division of labour, through the specialisation of skills from farming, selective breeding, metal work, administration, to trade necessitated a system of order and planning. The protection of infrastructure and land rights increased the necessity for political debate and the subsequent laws necessary to allow a new social structure to form.

The city state of athens is probably the birthplace of democracy itself, from around the 6th century bc male citizens, mainly landowners were given a say the politics and organisation of the state. Whilst offering a limited franchise it marks the start of a form of collective organisation that represents more of the will of its citizens.

The greek states reliant on trade with each other and with other regions of the mediterranean, developed sophisticated trade links and financial systems. The more sophisticated an economy the more need there is for an organised political system.

There were over one hundred greek city states, they all enjoyed a certain autonomy, this in many ways is a consequence of the geography of the region, a mountainous mainland with isolated valleys and numerous island states, whilst the greeks shared a unified, language, religion and culture these states valued their autonomy but tended to coalesce into larger groupings.

Throughout most of the greek civilisation there was permanent conflict between the more powerful city states and their alliances, however throughout this entire period the need for trade between different regions. The civilisation of greece represented a multitude of defensible mountainous regions and islands, the effort and energy required to unify this whole region militarily was virtually impossible.

Relatively speaking the greeks have few resources of their own, but are by the nature of their geography a maritime economy technologically more advanced than their neighbours, trade, politics, economics and finance powers much of the advances in greek culture.

This political system lasted in varying forms until the greeks became under the control of rome. The ideas and institutions created by these city states would live long after their physical collapse and still influence modern political thought.

The roman republic was not a democracy but an oligarchy, power and land was distributed amongst elite families, rome operated an entirely different economic and political system to the greeks.

Wealth was not accumulated by mutual trade between autonomous regions but by the forceful acquisition of land and resources by military conquest.

The first known parliament is formed in iceland in the 10th century ad

After a long interruption in trade from the decline of the western roman empire the city states of venice, florence and genoa profit from the increase in trade in the mediterranean from the 11th century, the increase in spices traded along the silk road through to the black sea where venetian merchants had access to asia through the bosporus straights and contact with the muslim world.

The rise of a wealthy merchant class skilled in the art of financing, trading, navigation, logistics and warfare rather than just the ownership of land calls for a political system that represents the merchant class rather than the old greek and roman systems of land ownership. The rise of trade banking, finance facilitates a need for greater representation for the oligarchs within the political system.

As the waves of european empires expanded by exploiting the energy of wind through more advanced marine technology and navigation. The lands they discovered and thus resources available to exploit dramatically grew for those with the skills required.

Power moved away from absolute rulers to the merchants and bankers, the domestic landowner's power and those of absolute rulers declined as they began to control less and less of the new economy. Wealth and power spread to a new breed of merchants able to exploit these new resources through trade.

Under a feudal system based on the exploitation of labour with virtually no access to external energy, land ownership and control of it is the source of nearly all wealth. Empires for millennia grew through the conquest of lands and the enslavement of its people. The most powerful have always had access to external energy through the use of slaves

The industrial revolution saw wealth and power continue to move away from these old power structures, as the amount of energy and the technological increase in the ability to transform resources increased so the economic and political power flowed down from the top.

More and more economic participants moved away from the land where economic activity used to dominate and into cities where energy was concentrated they worked collectively in factories instead of being isolated on farms. As workers concentrated and become consumers, they also became greater participants in the outcome of the economy so they demanded more political power.

Politics became a mass participation event as the economy moved from one based on labour to one based on the dissipation of external energy. Power moved from landowners to those able to exploit energy and natural resources whether through technology or the skills of trade. As more economies exploited these resources the individuals within them became richer and given more access to goods became consumers and participants in the economy.

Eventually as this process continued power flowed to all economic participants, democracy was a result of the change in social and political power brought about by a huge increase in the abundance of and ability to transform and dissipate external energy.

Political parties were formed as a consequence of the industrial revolution and the start of the consumer society, collectivisation of workers was a response to the intensity of energy available. Citizens moved away from being peasants to being consumers of the abundant products that advancing economies were making.

The social change and urbanisation of the industrial revolution saw writers such as marx and engels question the commoditisation of human labour through private capital and the ownership of the means of production. As this social upheaval accelerated political and economic arguments over the ownership of property intensified the disagreement first discussed between the greek philosophers became economic and political ideologies of the left and the right.

The ideas of collectivism had been maintained during the middle ages by sections of the christian church, small monastic groups and religious orders had practiced collectivism through the sharing of land and property. In the 16th century thomas more wrote about a utopian society based on common ownership, criticism of private ownership continued during the age of enlightenment right through to the writing of marx and engels.

The rise of extreme political movements from the left and the right during the twentieth century coincided with the huge social, political and democratic changes brought about by a substantial increase in the energy intensity of the global economy. The privations of the first world war helped bring about the bolshevik revolution in russia and political turmoil in germany and other parts of europe.

The sheer volume of human labour used and lost in this war to protect the interests of warring empires run by dynastic families could not be ignored. The technology of the machine gun rendered the previous military tactics of cavalry and classical infantry battles redundant, trench warfare and head on infantry attacks were a disaster in the face of machine guns and constant artillery bombardment.

The first world war was essentially a continuation of the failure of politics to grasp changes in technology and society, the world was changing but generals were fighting battles of the past and leaders were still playing at games of empire. Just as the industrial revolution had brought social deprivation as well as greater collective power to workers so this war had brought huge costs to the combatants of all sides and greater collective power as a result.

The push towards a greater political say by these combatants drove the revolution in russia and greater democracy in britain and europe. Russia essentially a feudal state had no political system to enhance democracy as happened in britain and as a result it could only depose its czars through violence and extreme ideology.

The russian state had largely remained a feudal system, whilst much of europe was experiencing change economically and politically through industrialisation, russia remained unchanged despite some attempts to bring about change. Russian troops on the eastern front in world war one became disillusioned and radicalised making huge sacrifices whilst having no say.

At home as industrial production was diverted towards the war effort, women joined the workplace and virtually the entire society and economy became part of the military effort, shortages in basic commodities. The collectivised power of industrial workers and soldiers to maintain the state or prevent it from functioning through strikes was the legacy of this war and of the rise of industrialisation.

The rise of marxism across europe heralds a growth in fascism especially in italy, a fear of a marxist revolution in italy heralds an opposing ideology and sets the political seeds of the next war. By the 1920s europe had two radically opposing political ideologies the left and the right had extended the political spectrum.

The first world war advanced the technology of warfare from tanks, aeroplanes to warships all requiring technology and oil. From the moment the first world war ended, the rush for access to oil as a means for economic and military security began. It became obvious that the future would be dominated by access to oil and the technology of dissipating its energy.

The aggressive securing of resources especially oil that lay at the heart of the second world war was a consequence of the extreme political ideologies that had developed in europe. The fundamental nature of marxism and the threat posed by the soviet state in russia to many parts of europe created a determination by the opponents of marxism to seize resources needed to oppose this ideology and achieve their own imperialistic ambitions.

The internationalist nature of communism was at odds with the nationalism and imperialism of germany, spain, italy and japan. The second world war ended after a concerted industrial effort by the united states and the soviet union, the vast resources available to these two overwhelmed the ambitions of the fascistic energy deficient axis powers.

The end of the second world war saw the two dominant political systems of free market democracies pitted against authoritarian marxism, proxy wars were fought from vietnam, angola and south and central america, fascism had survived in europe with franco in spain, but as marxism spread through central and south america and other parts of the globe so fascistic military regimes were formed to counter this threat. Proxy regimes from both sides fought for control of countries across the globe appalling acts of state sponsored violence were committed and millions were disappeared.

The collapse of the soviet union ended much of the extremism in global politics that had existed since the first world war. The collectivist political and economic model had been unable to compete with democratic economies with private ownership and free markets providing price signals able to guide investment more accurately than central planning.

Free market financialised economies now unchallenged politically began to aggressively expand the globalised system, production was moved to cheaper parts of the globe and consumerism became a predominant part of advanced economies. Consumerism in a world of plenty gave voters expectations about how they would live their lives and the expansion in the size of the state reinforced the notion of a safety net of ever expanding growth and standard of living.

The rise in economic power of china and its competing political system in the last decades has begun to see the global balance of power begin to shift. The old political structures of the post war peace are becoming strained as former developing countries are now integral parts of the global economy often with reserves of important commodities. China, russia, brazil, iran amongst other nations are rejecting free market democracy in favour of more nationalistic authoritarian politics.

Democracy began to have its own problems as the nature of power changed from centuries of authoritarian rule where only a few were needed to be satisfied to give their consent to one where a significant proportion of economic participants, where required to give their consent.

Democracy today has become a popularity contest and politics has become a contest for delivering promises that can never ultimately be achieved. The route to political power requires popularity and that is only possible with the promise of constant growth. Political parties have today become machines for gaining power within a predefined system.

Voters and politicians now demand a linear constant rate of growth, they all expect the economy to continuously expand in part because they overestimate the power of politicians to deliver and they misunderstand the role our physical environment plays in the ability to be enlightened and civilised.

Democracy is a far more fragile concept than most assume, take away the external energy from a society and watch its political structure implode and its democracy be replaced by anarchy or despotism.

LAW

Complexity trap

The creation of laws and their enforcement lies at the heart of an ordered society, the origination of laws whether by democratic consent or by force determines the power a citizen has within a legal system. The role of enforcement and compliance of laws is of equal importance the more laws there are the more enforcement and compliance is required and the greater the chance of criminality being inadvertently or deliberately increased.

The nature of laws is also important are they created to protect the individual from the state or the state from the individual or do they protect powerful elements within society from the rest of society. The motive of all laws should be studied as much as their interpretation.

The rule of law is not in itself an inadequate expression of what it means to be civilised, at many points in the past and even today there are distinctions to be made between the law and morality, what the law compels and individual to do and what the moral course of action should be for that individual defines the civility of a society.

The first civil code or law dates back to ancient egypt in about 3,000 bc it was based on philosophical concepts of truth, balance, order, morality and justice. Sumerians and babylonians developed codes of law in the 2nd millennium bc but these were by way of fiat passed down by a sovereign. The greeks developed ideas concerning the procedure of law how to administer justice, rather than substantive law which is concerned with what is and isn't legal.

One of the earliest written greek law code is the draconian constitution, tired of the elites interpreting athenian oral law and having superior access to legal knowledge, citizens commissioned a written law code and constitution available for all to read. This constitution introduced ideas of intentional and unintentional homicide.

Courts were administered by citizens and often ordinary citizens made legal judgements against the elites. However this is still a society with as much as half the population of some cities were slaves and had no right to citizenship. Access to law and democracy was only for citizens, the idea of citizenship grew as the power of trade allowed the accumulation of private capital and with it greater representation.

Roman laws were heavily influenced by the greeks, the foundation of this law begins with the law of twelve tables in the 5th century bc during the roman republic. Once again access to unwritten laws whose interpretation was limited to the wealthy and powerful. The new code covered areas from property rights, procedure, inheritance, guardianship, acquisition and possession. It codified principles of social protection, civil rights, justice, equality and punishment for free roman citizens of the republic.

The influence of the twelve tables permeates the roman civilisation for the next 1,000 years, it lives on for the next thousand years through the byzantine empire and its effects still lie at the heart of western laws today. The idea of common law comes from these tables.

Lay persons were asked to adjudicate, there was no legal profession and no precedent was recorded case law was irrelevant and each ruling was derived from the original law and not further interpretations, this system mirrors civil law today where a judge's ruling has no theoretical bearing on future cases.

The codex theodosianus developed in the 5th century helped to consolidate over 100 years of roman law which had by that time become unmanageable. It was the first major codification and

consolidation since the twelve tables and its influence would last long after the end of the roman empire.

In the 6th century ad after the collapse of the western roman empire the byzantine emperor justinian codified and consolidated roman laws until they were one twentieth of the amount of the original texts, they were known as the corpus juris civilis, originally written in latin they were later translated in to greek the language of the majority of citizens of the eastern empire. These laws would form the basis of the byzantine empire for a thousand years until its final collapse at the hands of the ottoman turks.

During the middle ages the western areas of the roman empire used the theodosian code to govern natives, but also used germanic customary law for the germanic new comers. Germanic law relied more on compensation than punishment, laws during this time were applied by ethnicity. After the splintering of charlemagne's kingdom the feudalism of europe reduced the importance of law as power and order was derived by force rather than by way of consent. Nation states did not exist and laws became customary based on local case law.

The pillaging of the byzantine by the crusaders introduced many legal texts including the justinian code to western europe. European scholars resurrected many roman principles and used them to create modern civil law. Norman legal concepts brought to britain by the norman invasion included the idea of precedence, powerful judges were able to create precedence and this became the basis for common law, as opposed to civil law.

In 1166 at the assize of clarendon king henry ii of england introduced trial by jury in common law using the law of evidence, where enquiry was made under oath by freemen, laymen or knights. The serfs who lived under this feudal system had little rights, however the jurisdiction of the courts over the church was a source of tension

The signing of magna carta in 1215 is often cited as the foundation of citizens' rights but that excludes the previous advances in a right to trial and the main purpose of magna carta concerned the relationship between the barons, the church and the crown with its courts. Little in magna carta increased the rights of common citizens.

The cannon law of the catholic church was based on the principles of roman law and of the justinian code, as the catholic church grew in power and size it created its own system of laws and legal principles. Made and enforced by the catholic hierarchy it was the first modern western legal system and is the basis of modern european law, through ecclesiastical courts cannon law was interpreted using the procedure of inquisition.

The legal system helps to separate the powers of the state, from the end of absolute monarchs their powers have been dissolved into the judiciary, the head of state, the legislature, the executive and society itself through elections.

The judiciary is a collection of judges whose job is to mediate between parties and determine an outcome. In most systems judges may only interpret the constitution or laws, but in common law countries judges may create new laws by precedence. In countries such as the uk the tradition of parliamentary sovereignty means an unelected judiciary may not overturn a law made by an elected parliament.

The legislature is generally comprised of directly elected individuals and generally bi cameral they have two separate legislating bodies an upper and lower house, a few countries have unicameral system with one legislative house. Generally legislation is passed by a majority of members but in systems with a constitution a special majority may be required to make changes harder.

The executive is the centre of political authority of the state, it is comprised of members of the legislature and they have obtained its authority to be able to govern. The head of the executive is often called the prime minister.

In a presidential system the president is the democratically elected head of state and as in the us they can appoint their own executive, in the united kingdom the head of state is the unelected monarch but their powers are limited and separate from the executive.

Part of the role of the executive is to maintain order through the police and military, many argue that this is the monopoly on the legitimate use of force but it is an important aspect of legislation and the authority of the executive. The bureaucracy or civil service is another aspect of the executive as they are required to carry out the will of the executive.

Europeans adopted the principle of codified civil law with courts acting as prosecutors whereas the english adopted common law where judges could create precedence and influence further judgements and the courts acted as arbiters between the litigants rather than as prosecutor.

These two european systems have become the basis for most of the world's legal systems, the majority of the world has adopted the codified civil law and common law has been adopted by former colonies of the british empire. Today the european union has converged the two systems to some extent. European law is codified in treaties, but is developed through precedent set by the european court of justice.

International law increased after the second world war with the geneva conventions and the creation of international bodies such as the united nations, world trade organisation and international monetary fund. However these institutions whilst having political will have no method of enforcement.

The advent of greater democracy in the 20th century has had a perverse set of unintended consequences, whereas under absolute monarchs citizens complained of an excess of rules and laws as was the case with the american war of independence, today our elected representatives create huge amounts of laws. The more society has access to democracy the more it is subjected to greater rules and the enforcement that comes with it.

The democratic process has created a political a system that makes laws on a preferential basis that is politicians go to the polls promising laws that will benefit the section of society they need to gain a majority. As politics becomes more divisive so laws follow suit and the need for enforcement grows commensurate with the sheer weight of rules.

Political parties use the powers of the legislature through promises to use it to the advantage of some to gain control of the executive. The politicising of the powers derived from monarchs has created a legal system where control of the legislature is by way of promises to some and not others, it creates adversarial legislation, based not on sound principles of reasoning and consensus but on friction and animosity.

Tacitus in roman times argued that the more a state legislates the more corrupt it was, laws were generally made by the powerful to protect their interests at the expense of others. Confucius argued that a benign state should be able to govern by way of setting an example and behaving well rather than through excessive laws.

Western legal and political systems will have to reassess the motivation for legislation and the political process used to create it or change it. When the executive is formed it has two roles to govern and to legislate. Governing involves day to day administration, creating positive outcomes for citizens by way of effective management, decision making and other skills involved in successful governance.

However it seems more as though elected politicians prefer the role of legislature, in most parliamentary systems only a fraction of the members are actually involved in the executive. It is far easier for a government to change and make rules than ensure the effective management of the executive. A promise to change rules preferentially at an election is far easier to fulfil than say a change in economic circumstance, say higher growth or lower unemployment.

PROGRESS, TRAPS

Throughout history we have tended to repeat the same mistakes again. The same phenomena appear in small scales and larger scales

Linear thinking

This is the process of expecting the present to be just like the past and that this straight line of progress can continue indefinitely. Linear thinking assumes that the rest of the energy available to us can and will be extracted and consumed, thus also assumes that it will be at a price that consumers are able to pay and is at a satisfactory price for the producer and its constantly rising exploration and extraction costs to profit from, this is an unlikely outcome for our future.

Our economies are essentially a dissipative structure subject to the laws of energy and physics, we expect permanent growth but we live within a finite system, most of our lives are involved in the transformation of energy of one form or another into heat, light, sound, or work done, so any change in the supply or cost can have a huge effect on our futures.

We have used about half of all known available oil, what is left to find is harder and more expensive to extract, producers with low extraction costs have high social and political costs, new production involves high levels of investment and a higher price, trying sell an increasingly costly product to a customer that struggles firstly to pay for it and secondly justify its consumption when much of its use is for what we want rather than what we need.

Previous oil shocks have resulted in increases in exploration and production and efficiencies of consumption, but these increases in production of unconventional oil come at a cost, environmentally they are far dirtier than conventional oil and economically they result in lower growth, more of the resources of the economy is wasted on extraction

Energy economy

We have built our economies solely to dissipate existing external energy at an ever-increasing rate and to use as little labour as possible. Great wealth and empires in the past were built on the exploitation of human energy through slavery, today most of the world has access to the ghost slave in our lives, external energy. We live a standard of life today so far above those of the most privileged from centuries past.

For much of this energy boom the output of energy use was productive, houses, factories, roads, railways, canals, sewers, medicines, hospitals and technology. These investments lead to efficiencies profits and repayment of debts incurred, however over the last thirty years or so in western economies and latterly more globally fossil fuel use has been financed by debt and the use has been less and less for productive purposes.

Western economies became addicted to the energy from producers technologically unable to extract and exploit it themselves. Producers faced with a glut of energy ramped up supply and accepted debt in return from technically advanced economies capable of exploiting this energy to create products and benefit to society,

Energy was swapped for technology and the advancement in living standards brought about by this huge glut. Producers became wealthy, built large governments and costs to their societies, they also began using more of their production themselves as they got richer and began to sell a smaller share to advanced economies.

Over time though advanced economies deindustrialised and used more energy for unproductive purposes such as travel and consumption, financed by ever increasing debt, more and more capital

flowed into manufacturing cheaper goods in cheaper countries like China or for transportation to provide cheaper costs for services such as travel and tourism.

Consumers in advanced post-industrial consumer economies saddled with debt became more susceptible to price rises at the same time as producers and explorers saw their costs rise and hence their breakeven price was rising. Any sustained rise in the price of crude oil soon saw dissipative economies move in to recession or at least growth and demand begin to fall.

Hierarchy of needs

So, it is likely that a great deal of global energy dissipation is inelastic that is it is not a necessity rather that if finances become tight due to increasing levels of debt in unproductive consumptive economies, travel, holidays, new cars and manufactured goods are surplus to food, shelter, water and heat.

As the costs of basics rise so surpluses are depleted or become non-existent, discretionary spending declines

Energy deficit

In any society a depletion of external energy can only have a detrimental effect on its ability to sustain itself at its previous level. History has many examples of collapses most of which are for a variety of reasons.

Deforestation was essential to clear land for agriculture but as technology advanced and timber became more valuable especially when near a mineral deposit, so its scarcity became a major economic disadvantage, aside from aspects of soil degradation and other environmental damage a lack of timber meant mines becoming unproductive output falling and towns and villages collapsing.

Both the Spanish and British at times during their empires had periods where timber became so scarce and expensive that equipping a navy became almost prohibitive and it may in part a reason for the collapse of the Spanish and its debt defaults.

Dependency trap

As societies become more complex more citizens become more dependent on a greater number of members of their society, trade with other states increases this level of complexity even further, as has been said friends can become enemies and enemies can become friends,

For whatever the many reasons for the bronze age collapse when it came it was quick and brutal, within a lifetime the Mediterranean had gone from sophisticated cultured vibrant economy to complete collapse anarchy with virtually no economic output and no technology

The location of energy reserves is a key factor in its continued supply, many of the major oil fields of north America or the North Sea are in decline and deposits are in economically and politically unstable parts of the world such as the middle east, Russia, Iran, Venezuela, and Nigeria. Conflict in any of these regions could restrict the flow of oil on to markets and any steep drop in supply could push prices to a level that stalls the global economy.

Just as the interdependent states at the end of the bronze age, sophisticated trade lasted hundreds of years with exchanges of art, commodities knowledge, today we live in a similarly complex trading system with huge economic interdependences.

But this interdependence which had lasted for hundreds of years in the bronze age had brought one of the early examples of complex societies and the first examples of a complex collapse where within fifty years societies had either ceased to exist or had barely been able to hang on.

THE GREEN ENERGY LOBBY

There are questions that need to be asked about the true intentions of the environmental lobby that exists today.

For as we have and will continue to establish there are legitimate questions to be asked about the direction, we are taking with our energy policies especially in the west.

There is no doubt an acceptance and rightly so that climate change exists for we have enough evidence of this fact not from an alarmist point of view but because we know that nature is not linear and so the climate can never be unchanging it must by definition change.

Global warming was the old description but that was slowly and quietly dropped from the environmental lexicon.

But the levels of carbon dioxide in our atmosphere and their effects on a changing climate are far more difficult to substantiate for one simple reason – complexity.

Our climate is such a complex system that it is impossible to be able to predict with much certainty the effects of a rise in co2 with an increase in temperature. We can hazard a guess but in all reality that is all it is just an educated guess.

Climate modelling is still a youthful scientific endeavour because quite simply predicting events that take millennia can only be improved over millennia. Predictions made today for the end of the century can only be verified and tweaked at the end of the century which is a large lag in the feedback loop of a complex predictive system.

But at the heart of this predictive model lies data and here we have a problem because if matter on this planet is finite then the inputs to the model must also be finite and they are not.

The models assume a constant supply of hydrocarbons to the point that we have sufficient to kill ourselves come what may.

This is an absurdity to not factor in the potential for a decline in the material at the heart of the model.

Then there are the motives of the scientific community which through history has relied on two emotions to receive funding gratitude and fear after the second world war the scientific inventions of radar, atomic bombs and penicillin helped shape the allied victory.

Science especially in the us received huge funding from a grateful nation in the aftermath of the war, but later the cold war brought fear sputnik brought a fear that the soviets were technologically overtaking the us and funding poured in.

Fear tends to be a more effective emotion than gratitude when it comes to maintaining funding, but there remains a constant need by the scientific community to maintain the fear and maintain the funding.

Because climate science is such a small and weak field it is open to interpretation, politicisation and over estimation. It can become entangled in powerful interest groups like the environmental movements.

As funding increases and larger bureaucracies are created around sciences like climatology so an institutional groupthink begins to develop where any attempts at critical analysis are dissuaded.

Scientific consensus becomes a monetary imperative as Upton Sinclair said “it is difficult to get a man to understand something when his salary depends upon his not understanding it.”

So, the problem with the climate change narrative is it presents with a problem difficult to fully define and of consequence sometime in the future. It raises an alarm about a potential catastrophe that is not entirely quantifiable at a date that is not entirely determined.

The coincidence with this message coming at the point where we are beginning to run out of fossil fuels is difficult to ignore.

One could make an argument that a much more quantifiable catastrophe running out of dense useful energy is being hidden by a climate change narrative.

It's like trying to persuade a junkie to give up heroin by telling them how bad it is and it's going to kill them in the future because it is easier than telling them they are about to run out today and will have to begin cold turkey.

Telling a junkie, they are running out will cause a panic that may be difficult to control.

The finite narrative of global governments announcing the fossil fuel era is coming to an end would destroy all financial markets in months not the years that we expect in this book.

The push towards a green utopia as we have highlighted is not scalable for the whole planet to continue the level of prosperity we enjoy today.

Renewables are a technology that fits in with an economy running at a fraction of the energy intensity of today's economic system.

There is no question that our energy intense economic system is doing immense harm to the wildlife on this planet which represents only about 3% of life on this planet. The other 97% is humans and their livestock a catastrophic decline in the natural non-human biomass and natural environment is unsustainable.

There is ample reason to believe that the current levels of population and their food and economic systems are unsustainable and incompatible with a high level of bio diversity.

The question is can we move in an orderly fashion to a new level of economic intensity that protects the lives of both the human population and allows an increase in biodiversity to a sustainable level.

The answer must be that with our current economic and political system this is entirely unlikely as it would require an electorate to grow up and vote not for its best interest but for higher purpose and the truth is no party would offer such a choice and if they did no electorate would vote for it.

The green environmental movement has been described as like a watermelon green on the outside and red on the inside which means a thin skin of environmentalism covers a deeply Marxist anti-capitalist movement below.

Now there are two ways to view socialism one is community-based philosophy where individuals work collectively to protect the vulnerable and reduce inequality and suffering the second is a globalist ideology that seeks to destroy boundaries and destroy nationalist tendencies.

Fossil fuels have destroyed the community-based philosophy and promoted the globalist ideology. The ability to travel and move destroys communities and allows ideologies to move across borders.

A collapse in energy ends the globalist ideology of socialism and reinvigorates the community where travel is restricted and where you are born, is more than likely where you will die where multi generations share the same household.

The irony is that a globalist environmental lobby is advocating an energy system and pushing a climate change narrative that will destroy its very existence and replace it with a community-based system sure to reinvigorate nationalist tendencies.

For it is likely that nations threatened with a lack of energy will be unlikely to welcome new immigrants fully intent on using the resources that are already so scarce.

Which begs the question are modern environmentalist so naïve as to wish to dismantle their society's ability to sustain a certain level of economic intensity and at the same time welcome more mouths to feed and house thus compounding the misery?

Do they so misunderstand the physics of energy and the workings of a modern economy that they could be educated to this folly?

Or are they actively trying to destroy an entire economic system on purpose?

Either way they remain a potent mouthpiece for a catastrophic outcome with a diminishing chance of actually happening because we are likely to have a disorderly decline in economic intensity before any potential consequences of co2 emissions make a noticeable difference to our climate.

The effects of a disorderly decline in fossil fuels will become very visible to those that are looking with eyes wide open for everyone else it will be confusing and will look like another economic crisis.

The global warming transition agenda allows politicians to attempt a futile attempt to build up a green economy and continue believing we can carry on as normal but the truth is the greens will get some of what they want an economic implosion but a rise in nationalism as the globalist ideology ends without the energy required to dismantle borders.

But who pulls the strings and who thrives? One wonders whether a technology push as we are experiencing today is laying a groundwork for life after a catastrophe.

A catastrophic decline in economic activity could be created by a credible player announcing a decline in output the ensuing collapse would destroy lives and livelihoods of billions very quickly.

The green technology would be sufficient for the surviving elite to enjoy a decent post energy collapse lifestyle.

The wilful inability of our political and educated classes to understand energy is alarming to those that do grasp it to any meaningful level.

Their willingness to pour trillions of dollars' worth of capital into a technology with limited ability to replicate fossil fuels and their wilful ignorance of the availability of fossil fuels is astounding.

The problem with the climate change narrative is that as we go from energy crisis to energy crisis yet still mistake it for a financial crisis, we tend to dismiss going green when we are faced with rising bills and a cost-of-living crisis governments also exacerbate the problem by continuing to subsidise high energy prices rather than attempting to reduce demand.

Keeping general demand high and subsiding renewables just takes us to the energy cliff even faster and creates an even harder landing which seems to be the preferred outcome for those who really control the narrative.

Now this book is not the place for conspiracy theories and in the end, it doesn't matter what the motives of others are as long as you are prepared but it is food for thought that such a glaringly obvious set of circumstances is being so wilfully ignored by those who are elected to protect us.

There is the continuing narrative that continuous fossil fuel use is causing climate change and that this is having a catastrophic effect on humanity but the truth is that deaths related to climate change have been falling for a hundred years or more. More people die from the cold than from any excess heat.

Fossil fuels didn’t make a safe place more dangerous they made a dangerous place safer, our ability to master our climate has far outpaced any negative effects of co2 emissions and increasing fossil fuel use.

Fossil fuels allow us to control our built environment irrigation increased crop yields etc. Medicines, anti bacterials, sewerage all help to control disease and keep us from death for longer.