Rethinking the Future…

A Guide to Understanding Liquid Fuels Challenges and Moving Towards Stronger More Resilient Communities

Rethink Consulting

Changing the Way We See the World…

Rethinking the Future…

A Guide to Understanding Liquid Fuels Challenges and Moving Towards Stronger More Resilient Communities

By: Andrew Martin

Rethink Consulting

Changing the way we see the world…

Table of Contents

Introduction

Resilience has fast become a new buzzword with civic organisations, think tanks, communities and corporations addressing potential risks. A system is said to be resilient, if it has the capacity to defend against, adapt to and repair itself after disturbances. This paper explores one of the lesser known challenges which are currently, and will, increasingly impact communities, businesses and organisations over the coming years. While there has been much debate and public discourse around climate change, there has been relatively minimal public discussion and understanding of the challenges of resource depletion. Resource depletion or more specifically, the 'peaking of oil' will have far reaching and unpredictable consequences for society in the coming years. Peak Oil is the theoretical date where global oil production starts on a relentless decline into the future.

The oil depletion story is important to understand as it will have wide ranging and imminent consequences. The significance of this geological story will most probably unfold through financial and or economic crisis. The converging crises (environmental/climate), social and financial are inextricably linked. The longer governments, local and regional councils and communities ignore such matters, the harder it will be to mitigate and manage a soft landing.

Crude oil and its benefits cut across every aspect of business, community, government and society in general. Oil is the invisible hand which supports, facilitates and drives global growth and economies. It is embedded into almost every aspect of our lives and our current economic system. It has shaped modern society, from the way we get around, to what we eat and to where we live. Crude oil is the lifeblood of the global economy.

The following paper explores some of the research, analysis and commentary many leading figures in the world of energy, economy and finance have articulated. From our understanding and analysis of the current paradigm in the fields of commerce, conservation and economy, energy is clearly the most crucial of all inputs. It is therefore important to understand the role liquid fuel (crude oil), plays in modern economies. Only by understanding the potential risks can we better manage and move toward a resilient future.

Whether it is natural disasters, economic instability, resource constraints or unpredictable and damaging climatic events, the need for local resilience is becoming increasingly apparent today. We have moved from a relatively localised economy to a largely global economy. Supply chain disruptions and geopolitical events make this system interdependent and highly vulnerable. Rethink Consulting

Understanding the Power of Crude Oil

"Peak oil will necessitate many changes in society. It is difficult to imagine how we can continue a transportation-intensive culture without this key resource. Similarly, most of industrial agriculture relies on fossil fuel inputs. Indeed, oil is a feedstock of a truly massive array of products. And economic growth, entailing ever-greater throughput of materials and increasing consumption, has depended on expanding energy availability."

A Vision Plan for the City of Buenaventura, California.

Kiwi Oil Consumption

According to the 2015 BP Statistical Report New Zealand uses 154,000 barrels of oil equivalents per day. This equates to 12.5 barrels of oil per person (per annum), or approximately 2000 liters per person. This figure doesn't include the embedded energy in imported products and food items.

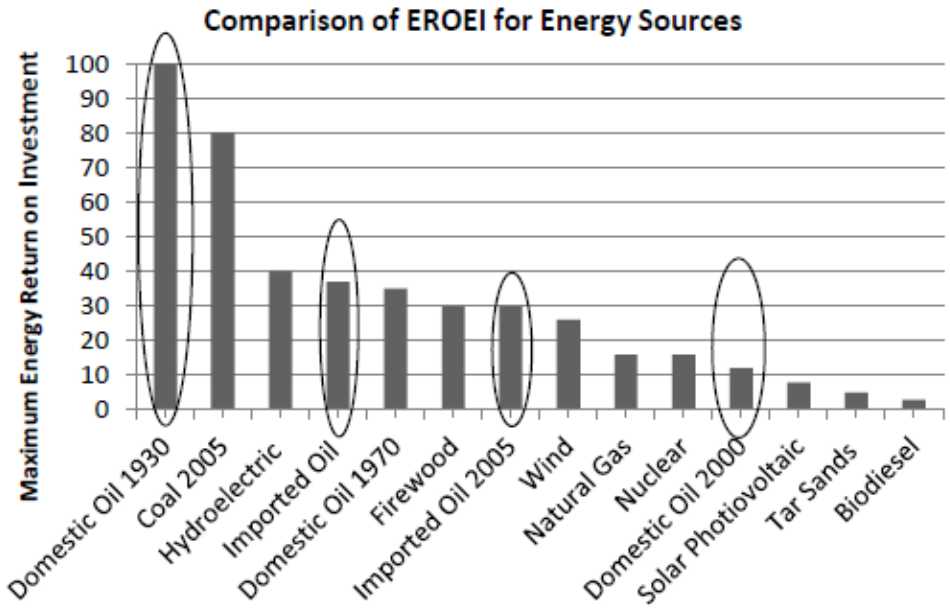
Crude Oil Facts

- A barrel of crude oil is 42 U.S. gallons equates to **158.9873 litres**.
- As a rough guide, one barrel of crude oil has the ability to do around **10 years of human labour** based on a 40 hour work week.
- Due to its high energy density, ability to be easily transported and relative abundance, oil has been the world's **most dominant source of energy during the 20th century.**
- **Over 90% of all transport fuels** are derived from crude oil.
- In industrialised countries today such as New Zealand, it takes between **seven to ten calories of fossil energy to produce one calorie of food.**
- There are **over 6,000 items** that we use each day made from petroleum by-products.
- **Global daily oil consumption is around 97 million barrels per day (mb/d)**
- **There are over 4.7 million registered vehicles (trucks, private cars, motorcycles, tractors, buses, caravans etc.) in New Zealand, all of which use some form of crude oil.**

Energy Returned on Energy Invested (EROEI)

Cheap oil has helped grow the global economy, especially in OECD and Western nations. **The ten plus years of work one barrel of oil provides has allowed society to partake in many discretionary activities. Before we can make informed decisions about the future we must understand Energy Returned on Energy Invested (EROEI). Energy Returned on Energy Invested (EROEI) is the ratio of the amount of usable energy delivered from a particular energy resource to the amount of energy used to obtain that energy resource.**

Understanding (EROEI) is crucial in our ability to fully comprehend how our economies and society at large function. Understanding EROEI allows us to make more informed decisions about the future. At this point in time, most current economic models do not factor in and account for EROEI. If we have a 1:1 ratio of energy return on energy invested then it is very difficult to have an economy as we do now. Hence, it is important in helping us plan for the future. The higher the EROEI, the more things can be done within an economic and social system. An abundant source of energy with a high return (100:1), gives us a surplus of energy, allowing us to engage in diverse activities and pursuits outside the realm of survival and maintenance of critical services.



Source: Heinberg, The End of Growth, et al Charles Hall. 2010

The above graphic illustrates the returns each energy source receives back from the initial unit of energy invested. In other words, domestic oil (U.S.) in 1930 shows for every barrel of oil used in extraction there would be a return of one hundred barrels of oil. If you invested $1 to extract oil you would receive $100 back. The interesting point to note in this graph is how significantly oil has declined in terms of its EROEI. **The EROEI has declined from 100:1 in the 1930's, to around 12:1 in 2000. Charles Hall an energy specialist and distinguished professor at the State University of New York, suggests, EROEI is a crucial component for such assessments because it indicates whether a fuel is a net energy gainer or loser (and to what extent). EROEI studies for most energy resources show a decline, indicating that depletion has been more important than technological improvements over time." [1]**

[1] Charles A. Hall, *Energy Return on Energy Invested*, Post Carbon Institute. 2013.

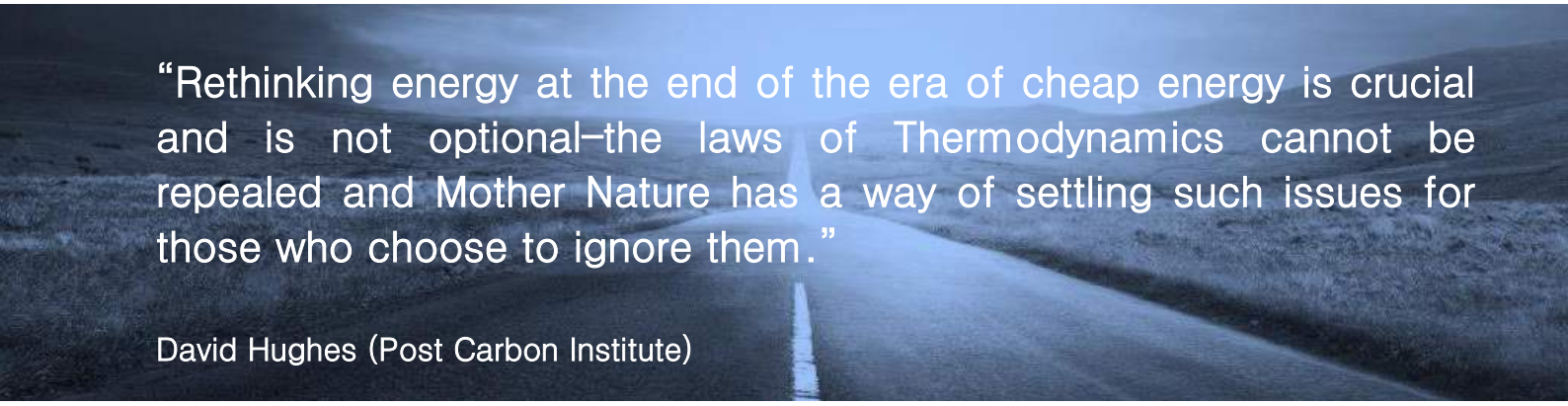
James D. Hamilton, from the University of California, department of economics, has completed research into the impact oil has on economies. His research illustrates how all but one of the recessions since World War II was preceded by a rise in the price of crude oil. Another paper (Ayres and Warr 2009) examined the interconnectedness and implications of energy and economy. The authors explored the question: "*whether energy consumption causes economic growth or whether it is simply a consequence of the level of economic activity*?" and found the former. That is useful energy, in the form of work is necessary for economic growth and that with declining fossil fuel supplies the only alternative available will be improving energy efficiency.[2]

"Many governments now are more and more aware that at least the day of cheap and easy oil is over... [however] I'm not very optimistic about governments being aware of the difficulties we may face in the oil supply,"

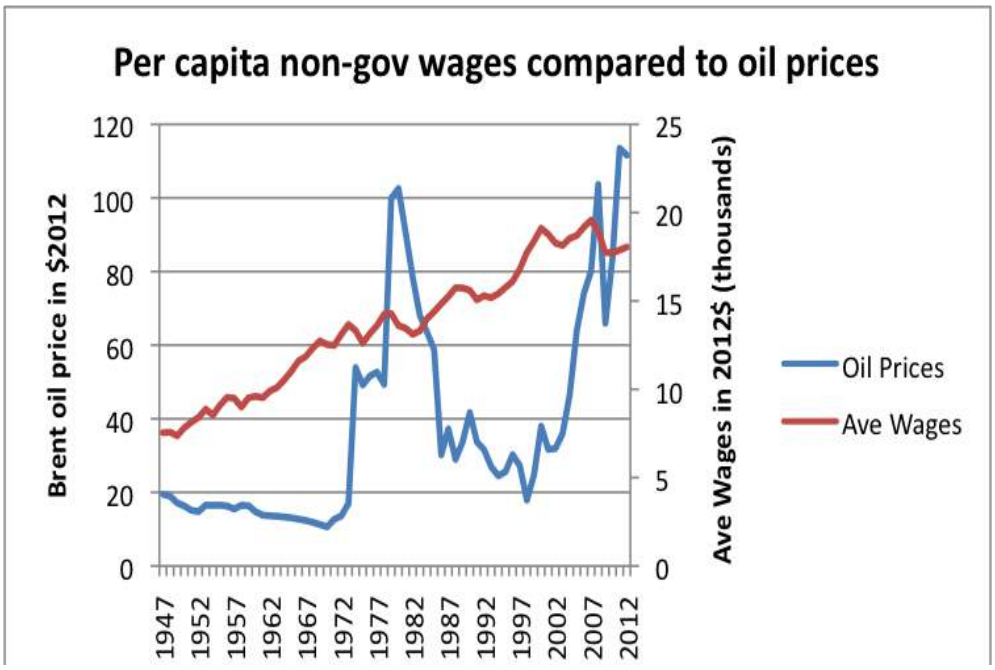
Fatih Birol
(Chief Economist International Energy Agency)

Our current society is enormously reliant on abundant cheap energy which provides everything for modern life. Housing, transportation, agriculture to schools and medical facilities, all need a constant and ongoing supply of cheap energy. It is the surplus energy outside that used to maintain services and infrastructure which has allowed economies to grow. It is important to understand that money and debt does not create energy. Debt and money are simply a claim on future energy.

Many mainstream analysts and commentators are blaming the current global economic slump on a raft of factors, everything from China to the Federal Reserve Bank to commodity prices. Yet oil has largely been overlooked as one of the underlying factors in helping contribute to this overall economic weakness gripping global growth and economies. It is important to remember just how much debt has been taken on over recent years. High debt levels will ultimately impact consumer, corporate and government spending over the coming decades. With this in mind, it is important to understand that oil demand is relatively inelastic in nature. That is, consumers cannot quickly find alternatives to oil in sufficient quantities that allow them to carry on as usual if the oil price rises or supply is interrupted. Consumers have little alternative but to keep consuming. This forces consumers to cut back on other expenditure.



While many economists would argue innovation has been responsible for productivity gains, those in the energy sector would argue, cheap energy has enabled Western economies to grow exponentially over recent decades. This fundamental shift has facilitated the overall level of output per worker to increase. This surplus energy return, enabled wages to rise rapidly (predominately during the 60's 70's and 80's) which helped facilitate the expansion of consumer demand. Studies have shown that economic output is highly correlated with increased energy consumption.



Source: Based on BP World Energy 2015 data, Gail Tvberg, OurFinitePlanet.com

The above graphic shows the correlation between oil prices and average wages. Most of the robust growth in Western economies occurred in the 1950's, 60's, 70's and 80's when oil prices were significantly cheaper. In September 2007 the price of crude stood at approximately $80 a barrel where it continued to increase to $95 in February 2008. After this point the price rose to $105 a barrel where it proceeded to increase in price until July 2008 where it reached the $130 range and peaked at $147 in July 2008, just months before the GFC unfolded. It is important to understand, energy is the economy—the global economy is predicated on low energy costs. Oil is the 'invisible hand' which regulates and lubricates the global economic system.

Understanding Resource Depletion and Peak Oil

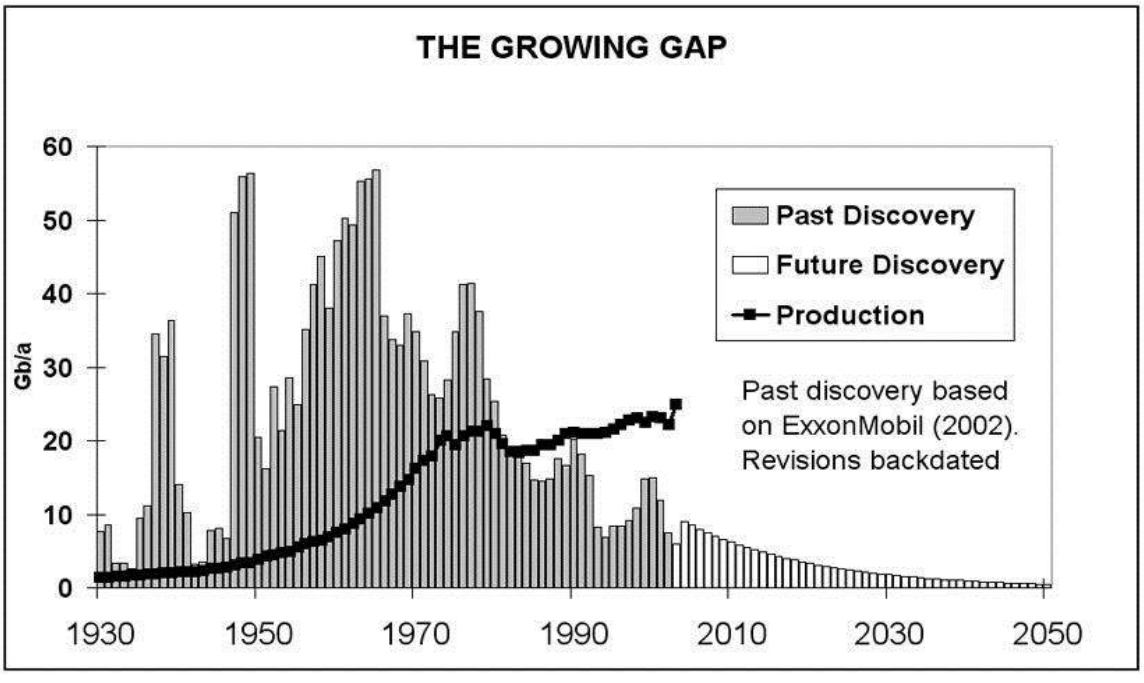
"In the longer run, unless we take serious steps to prepare for the day that we can no longer increase production of conventional oil, we are faced with the possibility of a major economic shock—and the political unrest that would ensue."

Dr. James Schlesinger - former US Energy Secretary

The term 'peak oil' refers to the maximum level of oil production. In 1956, the American geophysicist by the name Marion King Hubbert, employed by Shell oil, sent shock waves through the geological and political community when he announces his theory of 'peak oil.' Also known as the 'Hubbert Peak' or 'Hubbert Curve' theory, he outlined how a typical geological formation which contained oil, eventually reaches a maximum rate of petroleum extraction before it tails off and enters terminal decline.

Once exploited and drilled for a number of years, each oil field will follow the trend of a bell-shaped curve. This curve explains how production initially rises when first discovered, reaches a peak or point of maximum extraction, before entering on a downward trajectory. Initially used to explain individual production profiles of oil fields the theory can be used across multiple fields to help determine the overall production capacity of global production.

Peak oil does not denote the end of oil, rather the end of relatively cheap oil and high net energy oil. We are moving from an era of high-net energy oil to an era of low net energy oil. Extraction costs have increased exponentially. It now takes more energy and capital to get a barrel of oil from the ground either from tar sands, deep water or fracking.



Source: Association for the Study of Peak Oil

The above graph illustrates the challenge ahead. There is a growing gap between past discoveries and present and future discoveries of oil. Most of the major discoveries occurred between the 1950's and 1960's. Nearly all of these discoveries came from conventional oil fields in the Middle East. Data from IHS, a leading provider of information and analysis used by business and government, suggests, 2014 saw oil and gas discoveries drop to their lowest level in at least two decades. 2014 heralded the fourth year in a row of sustained declines of discoveries, making it the longest sustained decline since 1950.

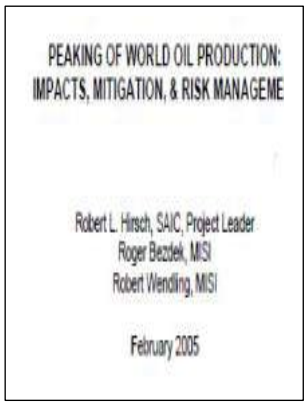
Evidence Based Research into Peak Oil

"The challenge of oil peaking deserves immediate, serious attention, if risks are to be fully understood and mitigation begun on a timely basis. Oil peaking will create a severe liquid fuels problem for the transportation sector, not an 'energy crisis' in the usual sense that term has been used. Peaking will result in dramatically higher oil prices, which will cause protracted economic hardship in the United States and the world. Mitigation will require a minimum of a decade of intense, expensive effort, because the scale of liquid fuels mitigation is inherently extremely large."

Robert Hirsch

Lead Author - Peaking of World Oil Production: Impacts, Mitigation, & Risk Management. Commissioned by the US Department of Energy

There has been significant evidence based research and analysis undertaken by government bodies, independent analysts and oil and gas companies into the potential resource constraints moving forward. A number of these papers are detailed below.



US Department of Energy 2005 – Peaking of World Oil Production: Impacts, Mitigation, & Risk Management

The report outlined the challenge of oil peaking. Robert Hirsch and his team analysed all the possible scenarios and alternatives to transitioning away from petroleum based liquid fuels to alternative options such as Gas-To-Liquids (GTL), biomass, hydrogen and electrification of vehicle fleets. **The report found that none of these would make a significant difference to the overall transition due to feasibility in the short to medium term.** A combination of cost constraints, market penetration, infrastructure requirements and economic viability would limit any significant uptake and penetration of these technologies.

UK Energy Research Centre – 2009

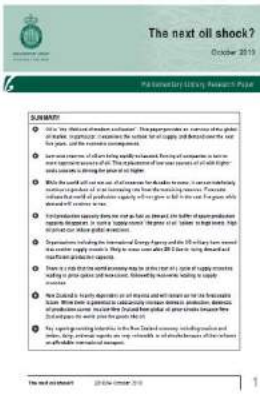
Consistent with other reports the UK research suggests decline rates are on an upward trend. **As a result, more than two thirds of current crude oil production capacity may need to be replaced by 2030, simply to prevent production from falling.** At best, this is likely to prove extremely challenging. In summary the report suggests:

"The risks presented by global oil depletion deserve much more serious attention by the research and policy communities. Much of the existing research focuses upon the economic and political threats to oil supply security and fails to either assess or to effectively integrate the risks presented by physical depletion. This has meant that the probability and consequences of different outcomes has not been adequately assessed. **On the basis of current evidence the report suggests that a peak of conventional oil production before 2030 appears likely and there is a significant risk of a peak before 2020. Given the lead times required to both develop substitute fuels and improve energy efficiency, this risk needs to be given serious consideration."**

Government Research into Peak Oil

The Australian Bureau of Infrastructure, Transport and Regional Economics (BITRE) Report, 2009.

The 474 page document, by the Department of Infrastructure, Transport, Regional Development and Local Government, in Canberra, details oil producing regions. It tables production capabilities, opportunities and threats for the global economy. **The report is lucid in outlining, "when an aggregation is done across the globe, it is predicted that world production of conventional oil is currently past its highest point (conventional oil is oil pumped from wells on land or in water less than 500 metres deep). A predicted shallow decline in the short run should give way to a steeper decline after 2016." With other non-conventional production growing in the short term, the longer outlook "suggests after 2017 global oil production will enter a new phase or 'drop-off.'** The outlook under a base case scenario is for a long decline in oil production to begin in 2017, which will stretch to the end of the century and beyond." **The report suggests that at "some point beyond 2017" there must be some effort to replace oil as and energy source.**



'The Next Oil Shock', New Zealand Parliament Research Paper, Oct 2010.

This paper provided an overview of the global oil market. In particular, it examined the outlook for oil supply and demand over the next five years, and the economic consequences. It outlined how low-cost reserves of oil are being rapidly exhausted, forcing oil companies to turn to more expensive sources of oil. This replacement of low-cost sources of oil with higher costs sources is driving the price of oil higher.

The paper outlines how New Zealand is heavily dependent on oil imports and will remain so for the foreseeable future. While there is potential to substantially increase domestic production, domestic oil production cannot insulate New Zealand from global oil price shocks because New Zealand pays the world price for goods like oil. It also highlighted there is a risk that the world economy may be at the start of a cycle of supply crunches leading to price spikes and recessions, followed by recoveries leading to supply crunches.

"Most economists are not too concerned about 'peak oil' (if they think about it at all) because they believe that markets will generate substitutes from which markets will choose. But today's markets often give very misleading signals about the potential of various fuels. The boom and bust of ethanol is an obvious example."

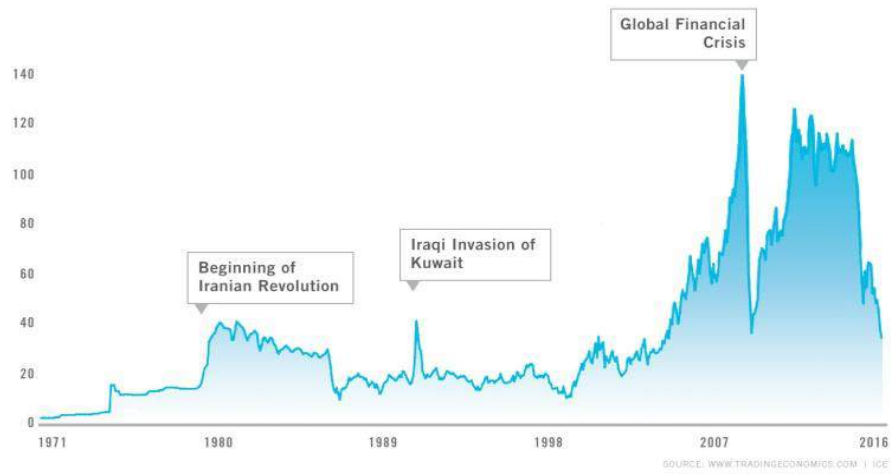
Charles A. Hall

A Financial Crisis

"The biggest take-away about the U.S. shale boom for other countries is that prices have to be high and stay high for the plays to work. Another important message is that drilling can never stop once it begins because decline rates are high."

Arthur Berman (Labyrinth Consulting Services)

To understand the interconnectedness and impact oil plays in lives, and how it influences financial markets, economies and our everyday lives, it is worth going back to 2008, prior to the Global Financial Crisis (GFC**). The below graphic illustrates how oil spiked at $147.30 in July 2008. Leading up to the subprime crisis oil prices were stubbornly high at over $100 a barrel from February 2008. Many analysts suggest the continual high price of oil leading up to the GFC, combined with increased interest rates and dubious lending practices, helped contribute to the subprime crisis.** While the root of the subprime crisis was laid decades earlier through the deregulation of the financial services sector, it was the combination of these abovementioned factors which many believe helped ignite the subprime fire.



In September 2007 the price of crude stood at approximately $80 a barrel where it continued to increase to $95 in February 2008. After this point the price rose to $105 a barrel where it proceeded to increase in price until July 2008 where it reached the $130 range, peaking at $147.

The GFC caused a collapse in the demand for oil and the price fell to around $39 in February 2009. At this point prices started to increase as demand started to rise again. By late 2009 (October), the price was consistently above $75 per barrel. By February 2011 prices ranged between $90- $120, lingering in this range for around three and a half years. During this time the oil and gas industry was busily drilling and expanding production in shale oil fields throughout the US and Canada. The increasing and persistent price of oil over this three and a half year period has never been seen before.

The stubbornly high oil prices acted as a hand brake for the global economy. In an effort to restart the global economy central banks embarked on numerous economic stimulus packages, bailouts, quantitative easing and cut interest rates to record lows. These measures could not compensate for these persistent high oil prices. Easy lending practices and cheap credit ignited another bubble of epic proportions, the US shale gas and fracking revolution. In light of cheap credit and record low interest rates, North American oil and gas producers went on a monumental spending, drilling and fracking spree.

Understanding the Difference between Conventional and Unconventional Oil

Conventional Oil

Conventional oil is a category of oil that includes, crude oil and natural gas liquids and condensate liquids, which are extracted from natural gas production. Conventional oil is typically associated with oil fields similar to what was discovered in Texas in the late 1800's and later in the Middle East which went on to become the world's largest producer.

The (International Energy Agency) IEA conducted a field by field analysis of 800 of the world's largest oil fields and suggests the depletion rates are very high (6.8% per annum). Any attempt to offset the relentless decline will be difficult, to the point that three to four more Saudi Arabian sized fields will need to be discovered to offset declines. Saudi Arabia is the largest and most prolific oil producers delivering over 10 million barrels of oil each and every day to the global market.

Unconventional Oil

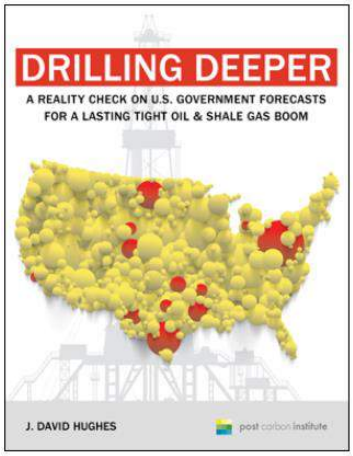
Unconventional oil consists of a wider variety of liquid sources including, tar sands, extra heavy oil, gas to liquids and other liquids. Oil shales, oil sands, coal- based liquid supplies, biomass-based liquid supplies, gas to liquids (GTL) arising from chemical processing of gas are generally accepted as "unconventional resources".

Oil and gas companies across the globe are investing in unconventional oil sources due to the increasing scarcity of conventional oil reserves. 'Peak Oil' represents a transition away from conventional petroleum, to unconventional liquid fuels. As conventional oil resources decline, more expensive unconventional resources have been developed to help stem any depletion of conventional resources.

The combination of high oil prices and low interest rates created the perfect environment for investors and oil producers to increase production significantly throughout North America. Output increased in the US from around 5 Million barrels per day (mb/d) in 2007 to around 9.5 (mb/d) in May 2015. Hence, while the fundamentals of these abovementioned reports have not changed, the peak oil issue has been placed on the back burner at least in the short term.

Drilling Deeper – A Reality Check

During the past few years, the increasing production trend of shale oil and gas in the US has generated a wave of optimism propagated by the media. Even President Obama was touting America was entering a new era of 'energy independence'. However, not everyone has joined the chorus and several commentators have predicted that the trend would be short lived. Some have flatly stated that the effort in gas production in the US is simply a financial bubble, destined to deflate soon and have significant economic ramifications through the financial markets.



Drilling Deeper Report 2013

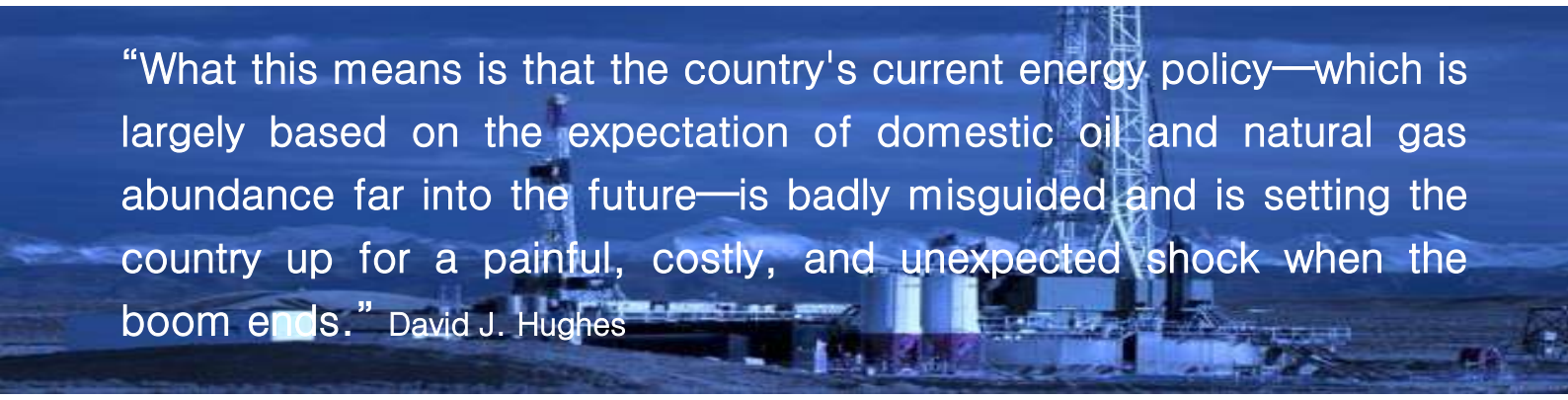
David Hughes, a geoscientist with forty years in the energy sector under his belt, including 32 years with the Geological Survey authored *Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?* in 2013. The research took a detailed look at the prospects for various unconventional fuels to provide energy abundance for the United States in the 21st century.

The report aimed to gauge the likely future of U.S. tight oil and shale gas production based on an in-depth assessment of actual well production data from the major shale plays.

A detailed analysis of well production data from these plays resulted in these key findings:

- ***Tight oil production from major plays will peak before 2020.*** Barring major new discoveries on the scale of the Bakken or Eagle Ford, production will be far below EIA's forecast by 2040.
- ***Shale gas production from the top seven plays will likely peak before 2020***. Barring major new discoveries on the scale of the Marcellus, production will be far below EIA's forecast by 2040.
- ***The 3-year average well decline rates*** in the seven plays analysed for this report (which collectively provide 89% of current U.S. tight oil production) ***range from 60% to 91%.***

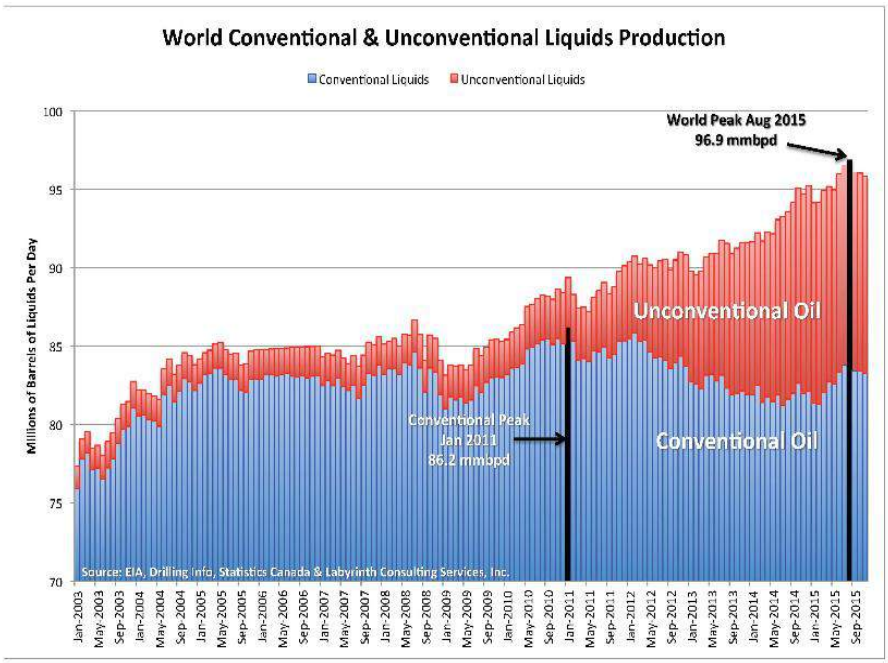
In essence, the hype that America would be 'energy independent' and millions of jobs would be created was not true. Apart from the significant decline rates observed, the report found that 98% of the 'Energy Information Administration's' (EIA), the principal agency responsible for collecting, analyzing, and disseminating energy information, projected production from seven of the largest plays were 'high' or 'very optimistic'. The basis for EIA forecasts were based on *false premises* such as: high-quality shale plays are ubiquitous, there will be always be new discoveries and production, technological advances can overcome steep decline rates and large estimated resources underground imply high and durable rates of extraction over decades. The 'Drilling Deeper' report showed that actual production data from the past decade of shale gas and tight oil drilling clearly do not support these assumptions.



Financial Challenges Ahead

A combination of record low interest rates, cheap credit and investment hype surrounding the potential of the 'shale revolution' led to over investment in the oil and gas sector across North America. The significant amount of debt taken on by the oil and gas sector, when the price of oil was high, is now impacting company balance sheets. Since the price of oil collapsed, (from over $100 to around $30) many oil and gas companies now find themselves having to continue to supply oil (at below what it costs to extract the resources) in an effort to facilitate cash flow and support debt obligations. **This has led to a glut in global oil inventories**.

The below chart shows clearly what has happened in recent years. Conventional oil has remained flat to declining while unconventional (fracking, shale oil and gas, tar sands and deep water) has risen dramatically to offset the decline of conventional oil. Many analysts suggest we have reached the peak in global oil production (both conventional and unconventional).



Source: Labyrinth Consulting and Arthur Berman

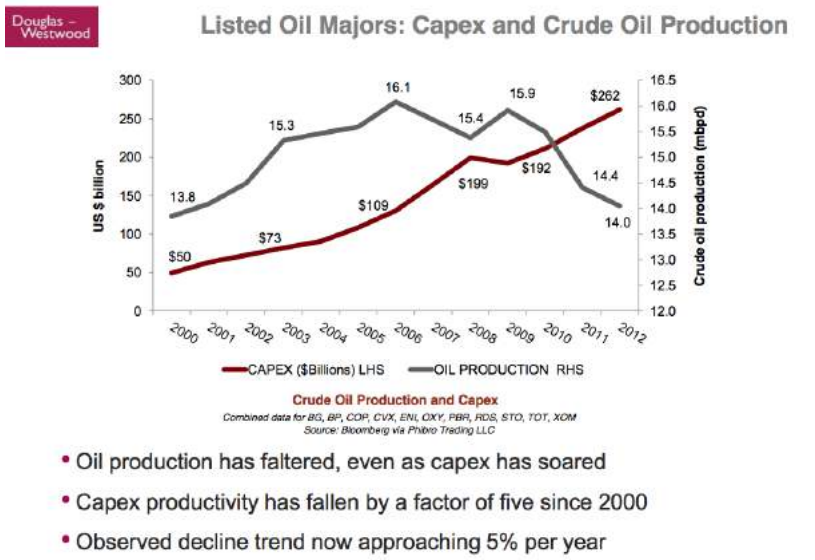
Oil is different to other commodities in that the current slump in the price of oil will not see an immediate slowing in production. The slump in oil price will affect future production as investment and exploration in new fields is pulled, cut back and divested.

The financial services giant, Deloitte predicted that over 35 percent of independent oil companies worldwide are likely to declare bankruptcy in 2016, potentially followed by a further 30 in 2017.

Many large oil and gas companies are cutting costs to improve liquidity and balance sheets. Big names such as, Shell, BP, Total SA, Chevron and Exxon have all been shedding hundreds of thousands of staff, slashing spending and cutting back on investments and developments. This is likely to have serious implications in the coming years.

The Era of Cheap Oil Has Ended

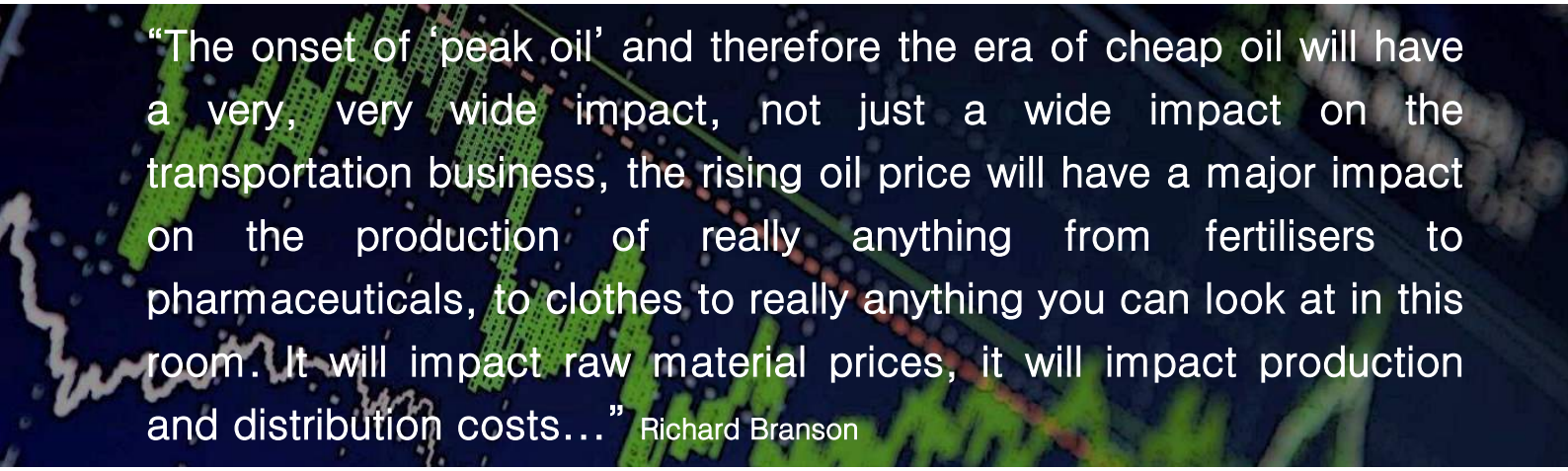
The long-term impact lower capital investment is having on the big oil companies' was evident in BP's failure to replace all the oil it pumped this year with new reserves.[3] With major oil companies finding their profit margins squeezed combined with efforts to sell assets in order to have funds to pay their dividends we are likely seeing the global peak in oil production.



The corresponding chart from 'Douglas-Westwood', an independent, leading provider of market research illustrates the predicament. The oil and gas industry has reached a point of 'diminishing returns'. The exponential increase in capital spending is seeing ever declining yields in oil production. With huge amounts of capital being poured to sustain declining production any reduction in capex will flow through to a potentially serious decline in supply at some point.

Why is this Significant?

As capital expenditure declines depletion rates will increase. Inevitably investor appetite for further investment in the oil and gas sector declines, creating a shortfall of resource to market. This will create the situation for a significant drop in oil production which could be highly disruptive to economies. It is worth remembering that many of these exploration, drilling and mining operations take years if not decades to restart once investment starts to flow again. We are facing a geophysical crisis in the availability of cheap oil. In this context 'cheap' here does not refer simply to the market price of oil, but the total cost of production. More specifically, it refers to the value of energy. **The decline in EROEI has meant that an increasing amount of the energy extracted has to be diverted back into getting new energy out, leaving less for other social investments and economic activities.**[4]

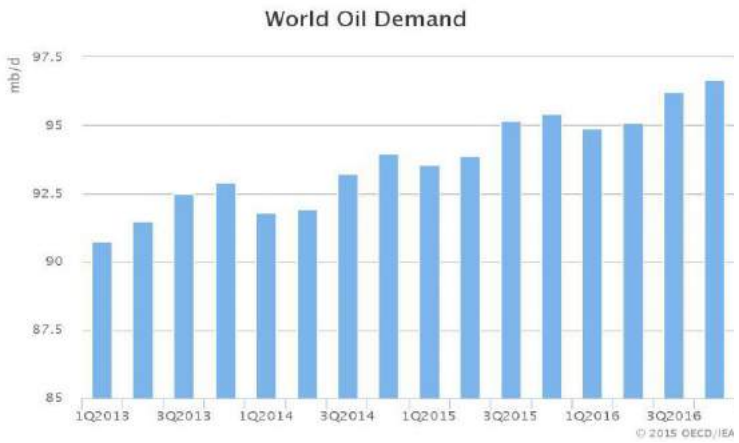


[3] http://www.marketwatch.com/story/oil-glut-drains-exxon-bp-earnings-2016-02-02
[4] Nafeez Ahmed, 'We Could Be Witnessing the Death of the Fossil Fuel Industry—Will It Take the Rest of the Economy Down With It?' Resilience, 26 April 2016.

What About the Alternatives?

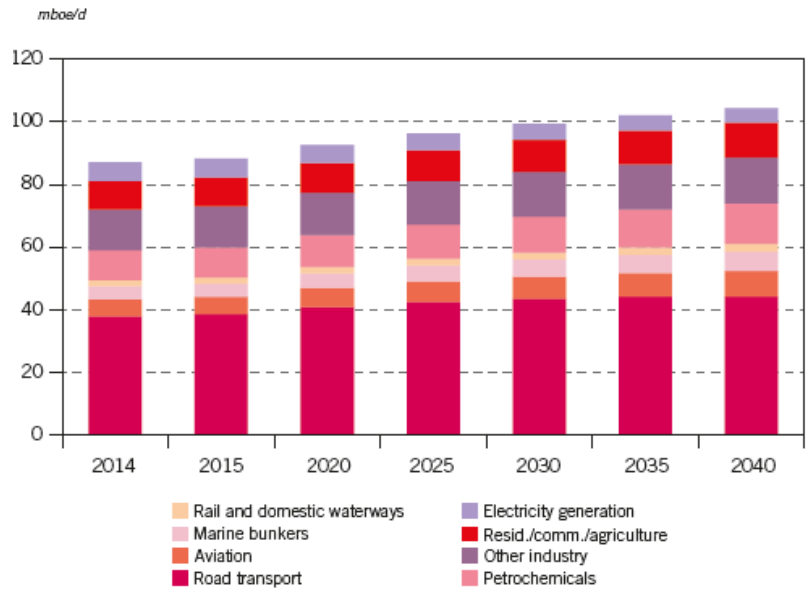
"Surveying the available alternative energy sources for criteria such as energy density, environmental impacts, reliance on depleting raw materials, intermittency versus constancy of supply, and the percentage of energy returned on the energy invested in energy production, none currently appears capable of perpetuating this kind of society." Richard Heinberg

Many suggest advances in technology and improvements in the efficiency of oil consumption will limit the impacts of peak oil. **Before we can make any predictions about the future we must understand the present. It is important to note the energy density and transportability of liquid petroleum.** While there has been some decline in oil consumption in some countries, due to efficiencies and lack of demand due to economic weakness, the overall global consumption trend for crude has been increasing. With China and India using more oil, consumption has risen from around 85 million barrels per day (mb/d) in 2006 to over 95 mb/d in 2015.



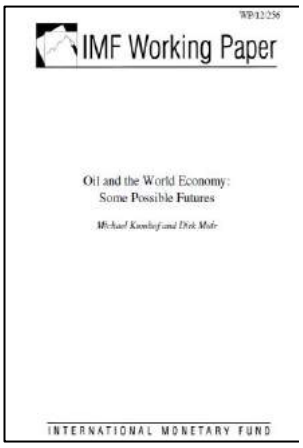
The corresponding graph from the International Energy Agency (IEA) illustrates the growth in global oil demand over recent years. While growth in oil demand for 2016 has declined marginally from 2015, the demand for oil is estimated to increase by 1.2 mb/d in 2016. Chart source: International Energy Agency, Oil Market report Feb 2016.

Oil Demand by Sector



The (Oil Demand by Sector) chart from the OPEC 2015 World Oil Outlook, illustrates the breakdown of uses for petroleum products. **While road transport makes up a good percentage (40% approx) of oil demand, it is important to note the significant reliance of many other industries crude oil supplies. It is easy to forget just how embedded oil is within modern society.** Aviation, marine fuels, petrochemicals, heavy industry, agriculture and electricity generation rely on this feedstock to support, facilitate and enable the global economy to function smoothly.

Rethinking the Future



The biggest challenge facing the transition to a low carbon, less energy intensive future is the understanding and relationship between energy return on energy invested (EROEI). How this impacts the uptake and ability to develop new technologies and the impact energy has on economies is crucial to making informed decisions about the future.

In 2012, the International Monetary Fund (IMF) commissioned a paper into economic modelling and scenario planning into the peaking of oil. The paper by Michael Kumhof and Dirk Muir, two IMF economists attempted to gain a better understanding of the likely impacts a tightening of oil supply might bring. The paper found there is a high correlation between the price of oil and economic activity. After examining all the available alternatives the study concluded*:*

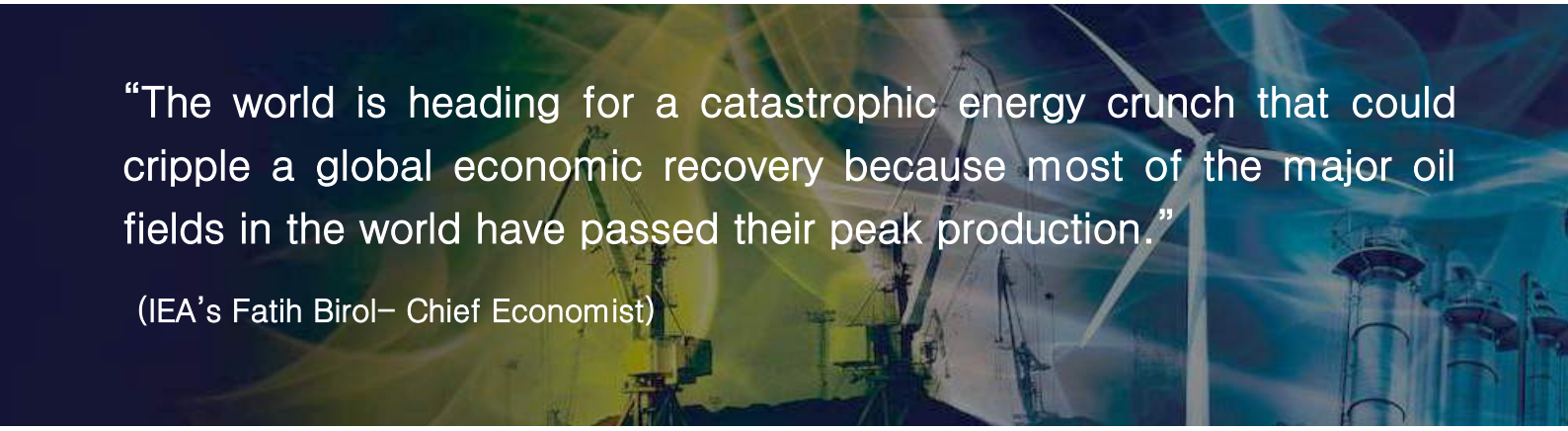
- **the properties of oil, or more generally liquid fuels (in petroleum), are far superior to any of the current alternatives. In some cases a transition towards a transportation infrastructure based on electricity, natural gas and/or liquid fuels derived from non-oil sources may be possible by retrofitting existing equipment or building differently configured new equipment. But a large-scale transition would be enormously expensive in terms of dollars, in terms of energy, and most importantly in terms of time - the transition would require several decades.**

Supply Chain Dependency (Days) for Consumer Goods

DAYS' SUPPLY	1	2	3	4	5	6	7	8	9
Chilled/frozen goods	✓	✓	✓	✓	✓	✓	✓		
Dry goods	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hospital pharmacy supplies	✓	✓	✓						
Retail pharmacy supplies	✓	✓	✓	✓	✓	✓	✓		
Petrol stations	✓	✓	✓						

Source: NRMA Motoring Services, Australian Liquid Fuel Security, 2014.

The corresponding graphic taken from the 2014 NRMA report into Australian Liquid Fuel Security, by Graham Blight, Director of the NRMA, highlights the vulnerability of supply chains when it comes to liquid fuels. While each country has varying degrees of liquid fuels production and storage capacity, the figures produced by the NRMA highlight the interconnectedness of global markets and reliance on complex supply chains indicative of most Western countries.



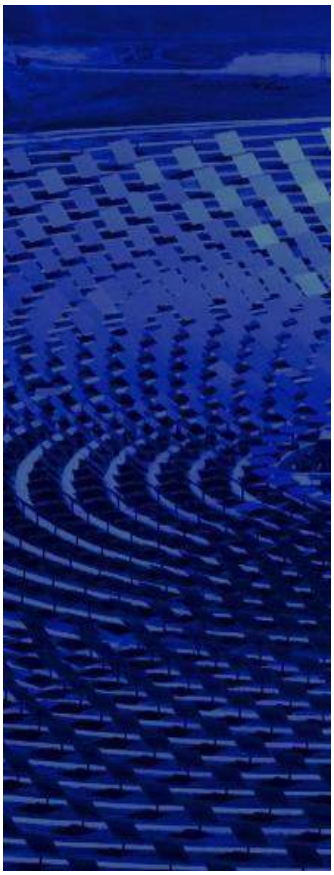
Embedded Complexity

"Peak oil will necessitate many changes in society. It is difficult to imagine how we can continue a transportation-intensive culture without this key resource. Similarly, most of industrial agriculture relies on fossil fuel inputs. Indeed, oil is a feedstock of a truly massive array of products. And economic growth, entailing ever-greater throughput of materials and increasing consumption, has depended on expanding energy availability."

Energy Descent and Community Resilience Report of the Bloomington (USA) Peak Oil Task Force

It is important to understand, we are not running out of oil as such, we are running out of 'Cheap Oil'. Cheap Oil has funded the growth in modern societies...the EROEI has given us a surplus to do many discretionary things, like air travel, build vast infrastructures and exploit natural resources, fisheries, forestry, soils etc. at a much faster rate. While there will be some niche markets it is rare to find any government reports, industry experts and energy specialists who suggest there are presently any cost effective and scalable alternatives to the liquid fuels challenge.

The complexity and highly embedded nature of petroleum across all transport classes will take decades and vast amounts of resources and capital to reconfigure transport and economic systems. Alternative energy systems, such as wind, solar and fuel cell technology, all use vast amounts of energy and resources to manufacture. The complex supply chains needed to extract resources, process, manufacture, maintain and transport these alternatives technologies is only possible with the use of fossil fuels and petroleum. While we need to reduce fossil fuel consumption as a society, we have to understand and be realistic about what 'renewables' can do.

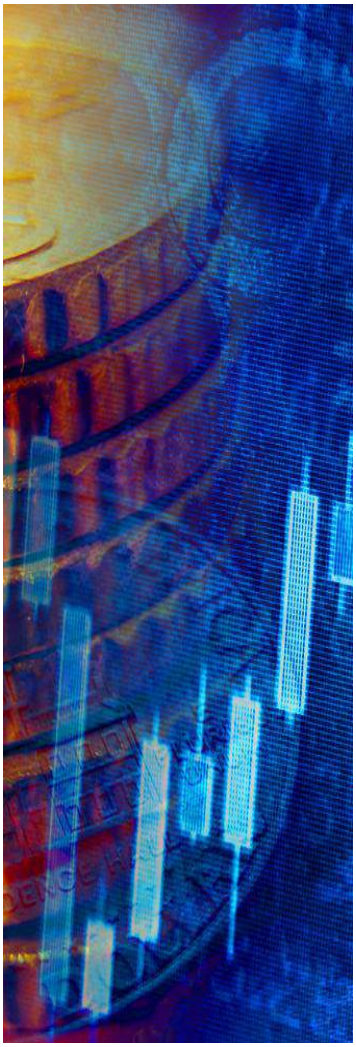


There are many factors at play which need to be considered when making decisions around building resilience and developing alternative solutions. **The economics of development and deployment, price and net energy return to society, must all be considered when making decisions about the future**. A recent example of a study of the Spanish and German renewable sector highlights the challenges. The research by Prieto and Hall, examined government data from Spain, the sunniest European country, with accurate measures of generated energy from over 50,000 installations using several years of real-life data from optimized, efficient, multi-megawatt and well-oriented facilities. These large installations are far less expensive and more efficient than rooftop solar-PV. The study found:

"the EROI of solar photovoltaic is only 2.45, very low despite Spain's ideal sunny climate. Germany's EROI is (1.6 to 2), due to less sunlight and less efficient rooftop installations"

A further study by Ferrucio Ferroni and Robert J. Hopkirk conclude: *"The result of rigorously calculating the "extended ERoEI" for regions of moderate insolation levels as experienced in Switzerland and Germany proves to be very revealing. It indicates that, at least at today's state of development, the PV technology cannot offer an energy source but a NET ENERGY LOSS, less than 1 [0.85]."*

Embedded Complexity



We cannot look at energy in isolation; debt, energy and the economy are highly correlated. Since the GFC all major economies have significantly higher levels of borrowing relative to GDP than they did in 2007. Instead of reducing indebtedness, or deleveraging, global debt since 2007 has grown by $57 trillion, raising the global ratio of debt to GDP by 17 percentage points.[5]

As the cost in terms of extraction of resources has increased, so too has the growth in debt. As the 'low hanging' easy to get resources have been exploited, the difficult harder to access resources have required increasing amounts of capital to extract resources. It is therefore important to understand that money and debt does not create energy. Money and debt simply facilitates the extraction process. The recent debt bubble has simply brought forward future production. It is not a long term solution to the broader economic challenges ahead.

Apart from artificially increasing asset prices, bringing forward production of resources and capital goods, stimulating the economy (at least in the short term) and adding to the overall GDP, excessive debt has helped heighten the extraction of resources. Expanding debt has provided a temporary and false valuation of the benefit of energy products. The energy profit from using an energy resource begins to decline and the energy profit from oil is no longer sufficient to allow the economy to grow as in the past. Hence, without continued growth in energy resources, it becomes much harder to repay debt with interest.[6]

If we have declining energy profits (declining EROEI) economies cannot grow as they have been over the last several decades. This stifles wage growth and corporate profits (both of which we are witnessing presently). Debt gets much harder to pay back, businesses cut back on borrowing, because they see fewer profitable opportunities for investment. Individuals also cut back on borrowing, because with their lower wages, it becomes more difficult to buy a house or car.[7] This makes it very difficult to fund and invest in new technologies and alternatives. Combined with already high debt, the relatively inelastic nature of oil as an energy source creates a demand side reduction in consumer expenditure.

"I am saddened that it is politically inconvenient to acknowledge what everyone knows: the Iraq war is largely about oil"

Alan Greenspan (ex Federal Reserve Bank)

[5] Richard Dobbs, Susan Lund, Jonathan Woetzel, and Mina Mutafchieva, Debt and (not much) deleveraging, McKinsey and Company, 2015.
[6] Gail Tverberg, Debt: The Key Factor Connecting Energy and the Economy, Resilience, 2016.
[7] Ibid

What Does All this Mean?

Whether it is a natural disaster, economic instability, resource constraints or unpredictable and damaging climatic events, the need for local resilience is increasingly relevant today. We have moved from a relatively localised economy to a largely global economy. Supply chain disruptions and geopolitical incidence make this system highly interdependent and vulnerable. It is important to be prepared and plan ahead for future scenarios. **We have built highly complex societies with cheap fossil energy.** We must understand **our current global economy and society is underscored by cheap energy. While alternatives will provide some solutions, they are not a cure all for the energy demands our current society requires.**

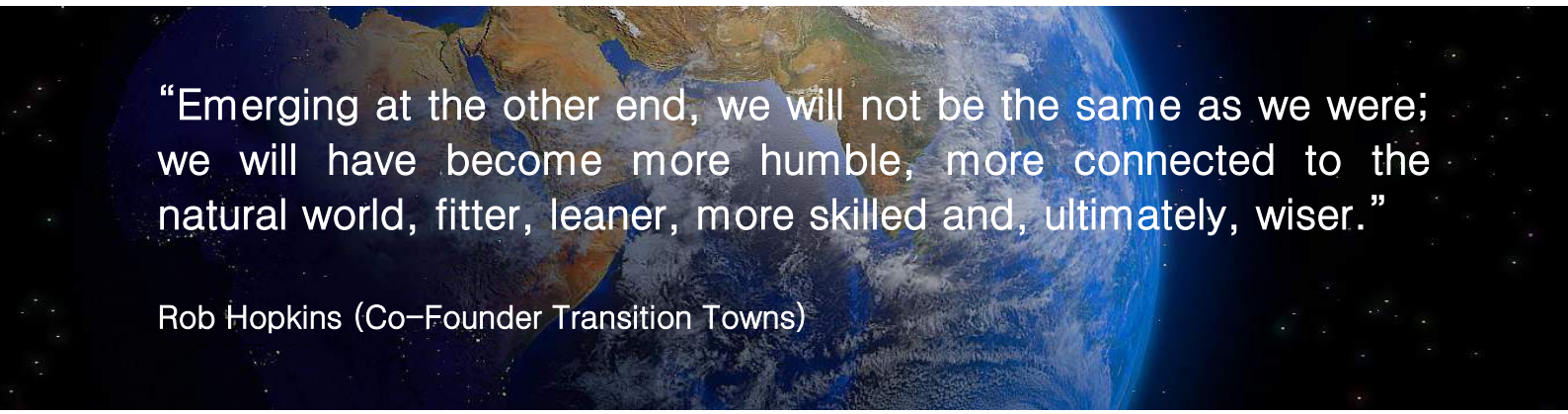
Building Resilience

The peaking of conventional oil production is a strategic, economic, social and environmental risk of epic proportions. Crude oil drives industry, transport, the agriculture sector, tourism and has significant social implications. Yet little has been done nationally or regionally in spite of the overwhelming evidence to suggest we have reached the peak of conventional production and are in or nearing the peak of global oil production.

The global economy is already experiencing 'diminishing returns' as the cost of resource extraction has been increasing over recent years. Due to the financial crisis and increasing cost of resources most economies currently face significant economic headwinds. Any shift to alternatives (such as electric vehicles) will be constrained by price, availability and economics. Studies have shown that when recessionary conditions prevail discretionary spending declines significantly with automobiles being the hardest hit.

Understanding limitations, constraints and feedback loops helps in being able to prepare and weather any potential threats or disruptions to systems. Rethinking and adaptively reengineering solutions must be of utmost importance if communities are to transition to a more resilient model. **A strategic based approach is needed as opposed to short term band aid approaches to problems and wishful thinking.**

What Kind of Future do we want?



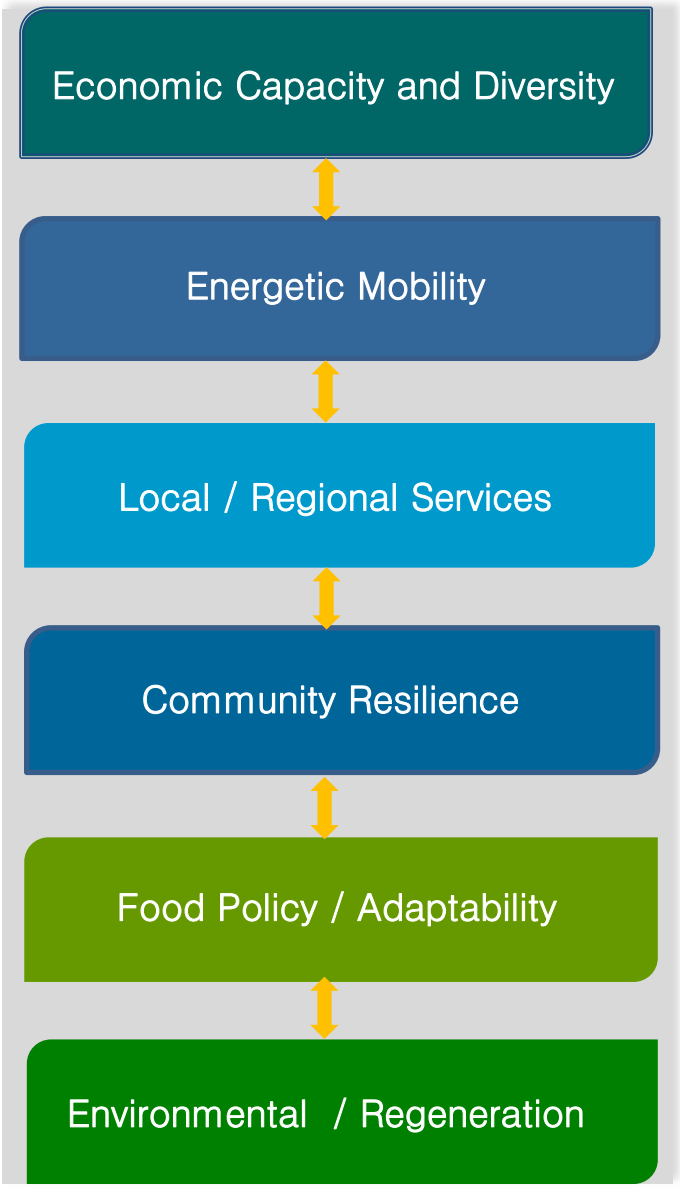
We are living through interesting, uncertain and challenging times. This period of transition will present challenges and opportunities for individuals, society and communities. While the problems are daunting there are solutions. **We already have the tools, resources and collective knowledge to facilitate significant change and redesign how we live. There are many inspiring people and groups already working towards a more prosperous future.**

If we choose to embrace the challenges head on we will be rewarded with opportunity and prosperity beyond what we could ever imagine. There are no guarantees, but can we afford to do nothing? That's why we have developed the Martin Resilience Assessment (MRA). **This unique resource takes a strategic approach to the challenges. It provides an integrated and holistic approach to the energetic, economic and environmental issues we face. Our skill set and methodology helps communities shift the paradigm, exploring opportunities which will eventually lead to more connected and resilient abundance.**

Before we can take positive steps towards a brighter more resilient future we must ask a number of questions and challenge our current assumptions. To truly change and develop we must ask ourselves:

- What kind of future do we want?
- Are our assumptions about the future based on reality?
- What is holding us back from making positive change?
- Are resources being adequately allocated?
- Is there a systems thinking approach to what we do?
- What is our ability to share information, tools, skills and resources?
- How do we reinvigorate local economies with new enterprises that are socially, environmentally and economically responsible?
- How do we inspire, support and connect local communities?
- What is the adaptive capacity of our area, region or business?
- How engaged is our local community?
- What is possible? What are the alternatives?

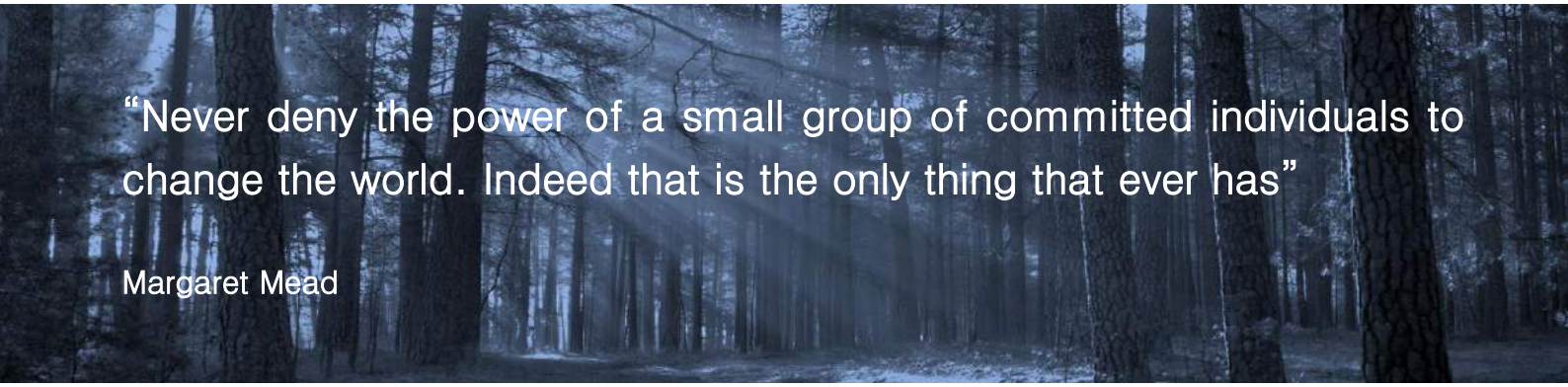
The Martin Resilience Index (MRI)



The Martin Resilience Index (MRI) is part of the broader Martin Resilience Assessment (MRA) which assesses and ranks specific segments of communities, areas or regions. This index uses quantitative data to highlight vulnerable sectors, enabling strategic initiatives to be developed. The MRI is the most comprehensive index of its kind, designed to build robust and more resilient towns, cities and communities. Assessments can be tailored for broad ranging to specific areas of interest (modules) which can be integrated into the community over time, depending upon an area/regions needs and fiscal requirements. The MRI and MRA provide a blueprint for delivering value and meaningful outcomes to your community. It is an insurance policy for your communities' future.

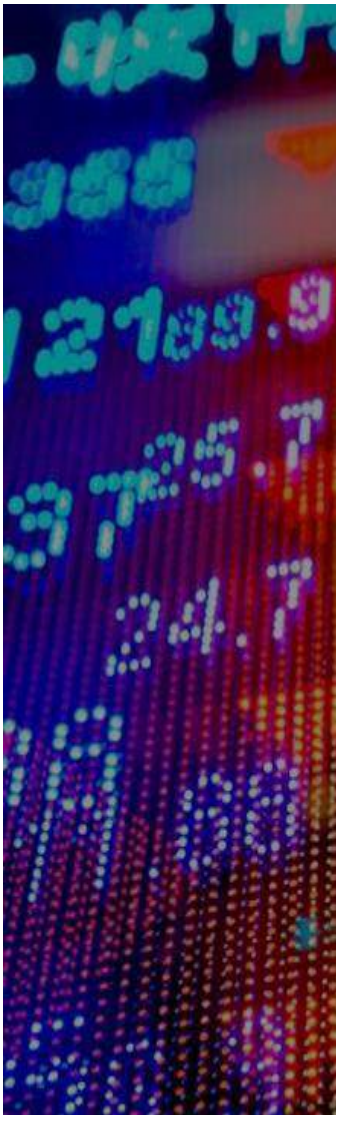
"In a time of drastic change it is the learners who inherit the future. The learned usually find themselves equipped to live in a world that no longer exists." Eric Hoffer

Building Resilience



A system is said to be resilient, if it has the capacity to defend against, adapt to and repair itself after disturbances. Like natural systems our current societal structure is interconnected yet fragile. Therefore it is natural to develop understand and accept feedback from systems in an effort to foster resilience. Understanding limitations, constraints and feedback loops helps in being able to prepare and weather any potential threats or disruptions to systems.

What is a Martin Resilience Assessment (MRA)?



BASELINE ANALYSIS determines the current capabilities, assets and or liabilities inherent in a system, organisation or business.

IDENTIFICATION of VULNERABILITIES and potential risks to each resource or asset class in conducted.

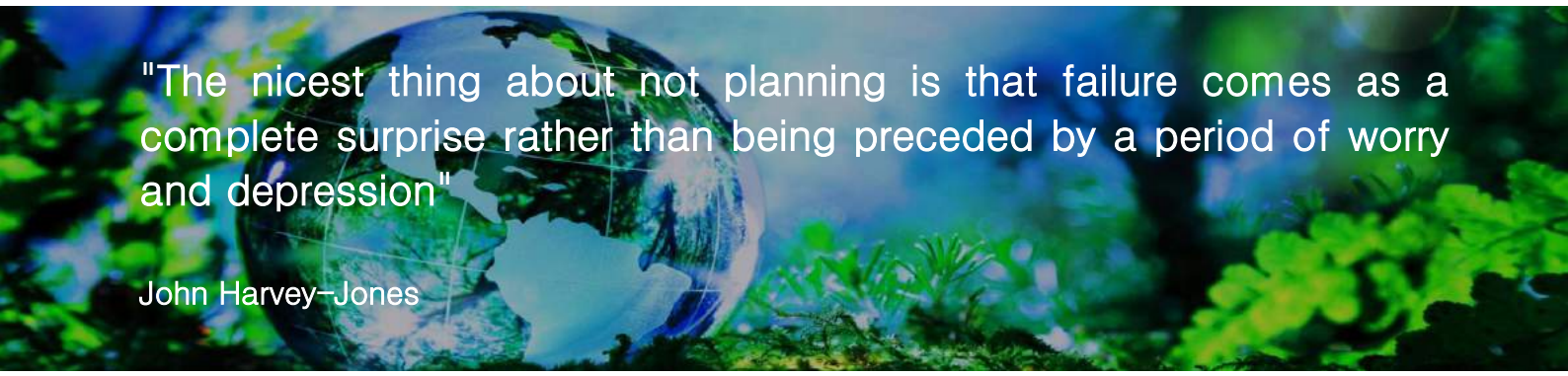
ASSIGN QUANTIFIABLE VALUES and ratings for resources or activities.

RETHINK current STRATEGY by highlighting gaps. Develop models for future scenarios.

MITIGATE and or ELIMINATE the most serious vulnerabilities.

DEVELOP Real World Cost effective recommendations and solutions to move toward resiliency.

A Whole Systems Approach to Resilience



It is now widely accepted that recent human activity of burning fossil fuels and widespread land clearance has altered the Earth's biosphere. A combination of these activities is contributing to unstable and unpredictable climate events. The climate crisis and resource depletion are inextricably linked. By solving the resource issues we can effectively mitigate environmental concerns. Hence, Rethink Consulting takes a holistic approach to solving many of the challenges we face.

Only by understanding our current circumstances can we move toward realistic solutions. While it is easy to be optimistic and come up with solutions to these challenges, we must also work within the limits of reality. We have developed a highly energy intensive economy and society; everything from food production to transport depends on interrelated energy intensive inputs for its survival. Trying to maintain our current systems by replacing fossil fuels which took millions of years to make is going to be challenging. Hence, why a strategic well thought out approach is needed.

A whole systems approach is needed to navigate the challenges ahead. We use evidence based research to develop real world solutions tailored to specific organisations or regions. We use in-house analytical tools which take into account economic, environmental and community concerns. Our detailed mapping provides our clients with a clear understanding of the capabilities and opportunities for future proofing. Our goal is to work collaboratively with stakeholders and other interested parties to formulate strategy and work through potential scenarios, risk and opportunities.

Community Benefits of Resilience Assessments

Increased Community Resilience - Builds long term capacity - Engages Community - Builds long term health outcomes – Facilitates Job Creation – **Empowers people to make positive change** - Explores Alliances - Facilitates Collaboration - **BUILDS COMMUNITY NETWORKS** - Helps develop meaningful community initiatives - Delivers measurable outcomes.....

Organisational Benefits of Resilience Assessment

Highlights Vulnerable Business Units - **HELPS DEVELOP SUSTAINABLE POLICY** - Ensures Resources are Utilised Effectively – minimises exposure to supply constraints - **Maximises ROI** - Builds a Network Resilience Map - **Identifies Opportunities** – *Helps Guide Short, Medium and Long Term Policy* - **Identifies Potential Alliances** – Reduces Costs Structures – **Builds Financial Resilience** - Reduces Environmental Footprint

Rethink Consulting can help with the abovementioned areas. We conduct resilience assessments for businesses, communities, organisations and local government to help manage risk. **Through extensive research, modelling and planning we develop collaborative real world outcomes and solutions for our clients. Our in-house resilience assessment tools (Martin Resilience Assessment - MRA) developed over many years, ensures vulnerabilities are adequately identified and addressed.** We work collaboratively and creatively with stakeholders in developing real world strategic outcomes tailored to the organisation. **Our mission is simple: we want to facilitate building more resilient and robust communities to thrive in a changing world…**

"We like to think of ourselves as rational creatures. We watch our backs, weigh the odds, pack an umbrella. But both neuroscience and social science suggest that we are more optimistic than realistic."

Tali Sharot

Rethink Consulting

Andrew Martin

B.Bus / Dip Financial Services (Securities Institute of Australia)

Andrew is an independent analyst, thinker, author and Director of Rethink Consulting. Prior to establishing his consulting business, Andrew worked with many of the world's leading investors, analysts and traders in the financial markets throughout Australasia and North America. Andrew is the architect and developer of the MRI and MRA tools which help build resilience. His extensive network of passionate, highly skilled people, make Rethink Consulting the ultimate partner.

Phone: + 61 022 312 3037 **Email:** andrew@rethinkenterprises.co.nz

Integrated Martin Resilience Index and Vulnerability Assessment