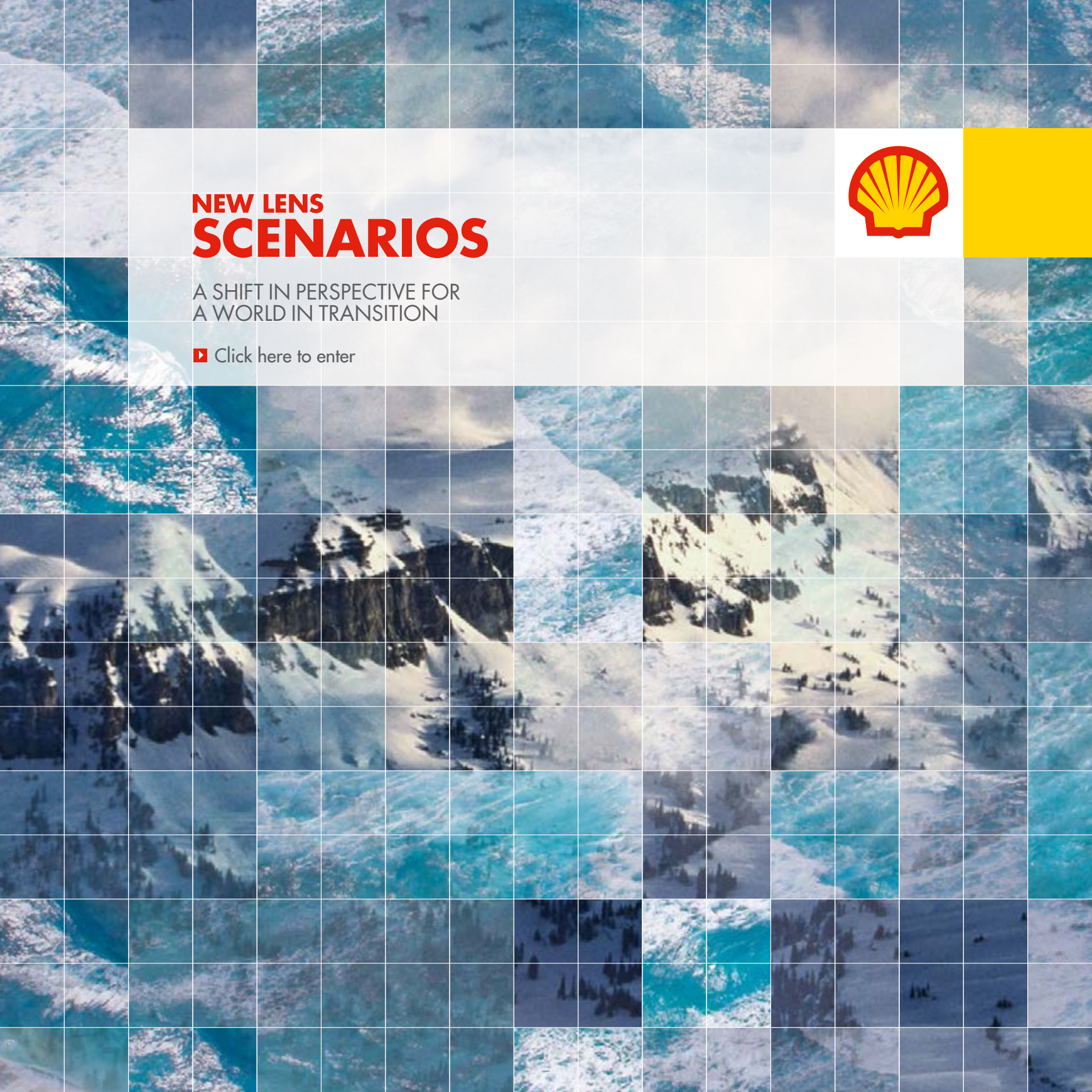

NEW LENS SCENARIOS

A SHIFT IN PERSPECTIVE FOR
A WORLD IN TRANSITION

Click here to enter

The *New Lens Scenarios* are part of an ongoing process used in Shell for 40 years to challenge executives' perspectives on the future business environment.

We base them on plausible assumptions and quantification, and they are designed to stretch management to consider even events that may be only remotely possible.

Scenarios, therefore, are not intended to be predictions of likely future events or outcomes and investors should not rely on them when making an investment decision with regard to Royal Dutch Shell plc securities.

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In an era of volatile transitions, it's unrealistic to propose a single lens through which to view the world of tomorrow. In all core factors, from networks of power and the pace of change to the policy agenda and resource landscape, it is perspective that shapes perception.

Our set of new lenses offers that perspective, enabling us to explore two future worlds and bring into sharper focus the possible outcomes of today's choices.

MOUNTAINS

This is the world with status quo power locked in and held tightly by the currently influential. Stability is the highest prize: those at the top align their interests to unlock resources steadily and cautiously, not solely dictated by immediate market forces. The resulting rigidity within the system dampens economic dynamism and stifles social mobility.

OCEANS

Influence stretches far and wide in the world of *Oceans*. Power is devolved, competing interests are accommodated and compromise is king. Economic productivity surges on a huge wave of reforms, yet social cohesion is sometimes eroded and politics destabilised. This causes much secondary policy development to stagnate, giving immediate market forces greater prominence.

FOREWORD

SHAPING A VISION OF THE FUTURE FOR FORTY YEARS

Recently, we celebrated the 40th anniversary of Shell's scenario planning practice. As we reflect on these decades of scenario work and remember the many talented individuals who have been involved over the years, we're struck by the way the scenarios influence such a remarkable range of issues, debates, and business decisions

Looking back, we see many similarities between the business environment of the early 1970s and now – for example, volatility in the global economy and certain political systems. Other features are new in that they highlight complex challenges across whole resource systems that will strain the creative sinews of organisations like ours as we move forward.

In 2011 for example, I asked our strategy team to start looking at the nexus of water, energy, and food – what we call the Stress Nexus. I believe that success for Shell – and for society more widely – lies in working better, together. As businesses we are accustomed to serving people by building effective commercial collaboration, which drives innovation and business efficiency and positively impacts profits. But what we need to do better – and fast – is improve our collaboration with other companies, with whole sectors of the economy, and with government and civil society in different geographies across the globe. Only then will we be able to take better advantage of the efficiencies that can be achieved by collaborating at a system level.

As these *New Lens Scenarios* note, by 2030 we expect demand for critical resources like water, energy, and food to have risen by 40%-50%. To meet those needs without significant environmental detriment, business as usual will not be an option – we require business unusual. Soon we will begin sharing more of our plans to strengthen partnerships and continue our active role in transforming the energy system.

These new scenarios explore complexity and ask searching questions about how we create a more reflective, responsive, and resilient business. Sharing them and driving a debate around the issues they consider are an important part of that process. I trust the supplements we will publish periodically over the next couple of years will also take this forward.

I hope you find this content thought-provoking, and I take this opportunity to encourage you to continue being part of the scenario discussion as so many have over the past 40 years. ■

PETER VOSER
CEO, Royal Dutch Shell plc,
March 2013

INTRODUCTION
THE POWER OF SCENARIOS

We are all faced with choices that produce consequences for years – and even decades – into the future. Whether we are developing new opportunities or anticipating significant threats, we base decisions on our perspectives of the future. So there is huge value in developing as rich an understanding as possible of the drivers, trends, uncertainties, choices, and cycles that will shape that unknowable future, and that may look very different through the eyes of different actors.

The future is neither completely predictable nor completely random. Any meaningful exploration of possible future landscapes inevitably highlights alternative features or patterns. For over four decades now, Shell has developed and applied contrasting scenarios to help us consider the future more extensively and deepen our strategic thinking. We have also shared summaries of that work externally whenever we have sensed that it will make a contribution to better public dialogue about the collective challenges and choices we face.

These scenarios provide quantified insights and a language for Shell's executives to apply when grappling with increasingly unfamiliar and challenging conditions. They aim to be thought-provoking yet plausible, highlighting matters already in the foreground and also, crucially, background developments that should be brought to the fore. Used effectively, these alternative outlooks can help organisations address difficult issues that need to be explored collaboratively even though there may be deeply divided opinions about them.

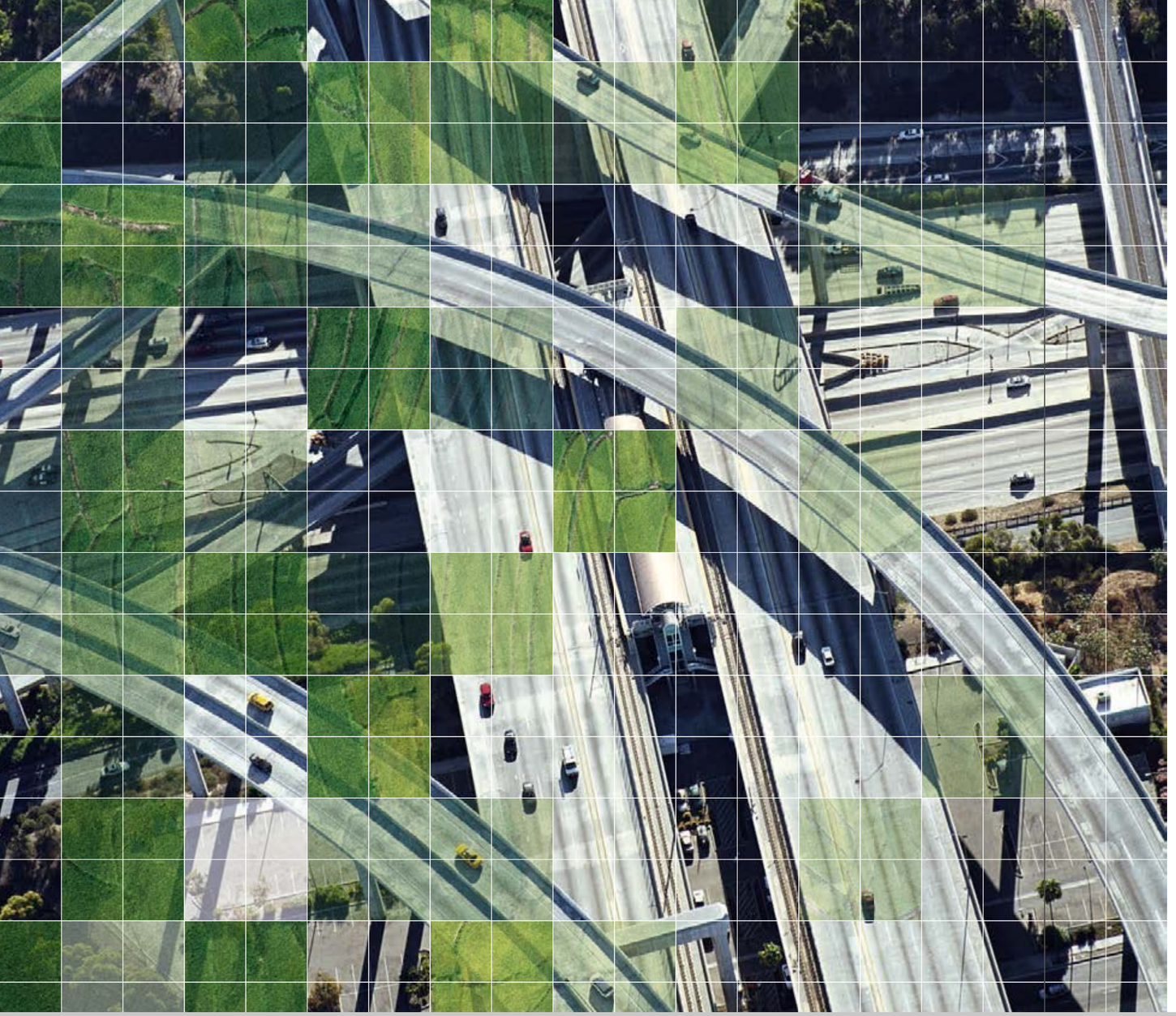
Such an approach also helps equip decision-makers with a deeper awareness of the very different perspectives others may have, the need to engage with these perspectives effectively, and the significance to their own future of the choices made by others. In that sense, scenarios are deeply relational as they focus on people and their behaviour, and not only on seemingly impersonal economic, political, and social forces.

So there we have something of the scenario alchemy as we experience it in Shell – an amalgam of a strategic thinking process, a mode of analysis, a social process of engagement and influence, and, at its most powerful, an enabler of individual and group exploration and discovery.

In that regard, the words of former US Secretary of Defence Donald Rumsfeld are relevant in that at least one of the functions of scenario work is to bring people together to explore areas in a way that may reveal 'unknown unknowns'. This exploration is not primarily intended to produce attractive booklets or reports, nice though those can be. It is most importantly about helping people take a journey that guides them into better choices based on richer considerations of the world around them.

This journey can be difficult. As the philosopher Schopenhauer pointed out, new truths are first ignored or ridiculed, then vehemently opposed, and then, ultimately, taken to be self-evident. At different points specific scenarios may be considered irrelevant, foolish, irritating, or even unnecessary. Nevertheless, experience in Shell has demonstrated the value to our company of taking this journey. ■

JEREMY BENTHAM
Vice President Business Environment
Head of Shell Scenarios



NEW LENSES FOR A NEW ERA

Previously published Shell Scenario work has highlighted our entry into an era of volatility and of multiple transitions – economically, politically, socially, and within the energy and environmental systems:

- Intensified economic cycles as the conditions have changed that underpinned the period from the mid-1980s to the mid-2000s, referred to as the 'great moderation' in the advanced industrial economies.
- Heightened political and social instability, stimulated in part by economic volatility.
- Tensions in the international order, as multilateral institutions struggle to adjust to shifts in economic power, and other arrangements proliferate.
- Significant demographic transitions, involving ageing populations in some places, youth bulges in others, and relentless urbanisation in both fast-emerging and less-developed economies.
- Surging energy demands driven by growing populations and prosperity, with new energy supplies emerging while others struggle to keep pace, and greenhouse gas emissions increasing, particularly from growth in coal consumption.
- The deployment of technological advances enabling rapid growth in resources plays such as shale gas and liquid-rich shales in, for example, North America, with ripples across the globe, but uncertain prospects elsewhere. The technology for utilising renewable resources, such as solar photovoltaic, also advances, with rapidly growing supply from a small but established base.
- Better defined and significantly challenged ecological boundaries, including pressures arising from the water-energy-food Stress Nexus, as each component experiences supply/demand tightness. Because of their linkages, these components feed off each other and accelerate the combined growth in stress.

Inevitably, given these developments, any plausible outlooks will be messy and patchy. Nevertheless, we have found that a number of new lenses can help us view familiar landscapes from fresh angles so that we can focus and clarify possible futures.

Paradox and Pathway lenses help us zoom in on trends and drivers in detail, while our Panoramic scenarios highlight broader patterns in possible future landscapes.

"IF WE WANT THINGS TO STAY AS THEY ARE, THINGS WILL HAVE TO CHANGE"

GIUSEPPE TOMASI DI LAMPEDUSA
The Leopard

PARADOXES

LOOKING THROUGH THE LENSES OF THREE PARADOXES HELPS TO HIGHLIGHT KEY FEATURES OF THE EMERGING LANDSCAPE.

THE PROSPERITY PARADOX

Economic development is raising living standards for hundreds of millions of people. But it also imposes environmental, resource, financial, political, and social stresses that can undermine some of the benefits of prosperity. Private gains can flourish while public costs mount, and greater comforts today can lead to greater risks tomorrow. Globalisation has tended to reduce income inequality between nations yet increase inequalities within them. Increasing efficiency can stimulate increases in consumption. Beyond a point, increasing prosperity does not raise subjective well-being, which can even decline. For example, the more people prosper or see others prosper, the greater their desires and expectations for themselves and for their children – and the greater their possible discontent.

THE CONNECTIVITY PARADOX

Growing global connectivity stimulates creativity but also puts intellectual property at risk. Connectivity facilitates individual expression and empowerment, but also encourages herd behaviour and amplifies swings in confidence and demand. The burgeoning availability of information has the capacity to bring insight and transparency, but data overload is equally likely to generate confusion and obscurity.

In many ways, the Connectivity Paradox drives the other two paradoxes. The deployment of information and communications technology has been a driver of economic globalisation, extending and deepening trade, financial, and research links, spreading prosperity, and generating leadership challenges. Economic, political, and social volatility may have always been with us, but this unprecedented degree of connectivity is contributing to unusual intensity in part because growth in connectivity empowers individual players. A poor street vendor can spark the toppling of governments across the Middle East, for example. A lone hacker can disrupt the functioning of large business and government enterprises. Under the banner of 'Anonymous', small numbers of 'hacktivists' can cause millions of dollars of losses to companies. A Scottish church choir singer can become a star overnight after her audition video for a TV show goes viral, and her album can become the number one best-selling album in charts around the globe.

THE LEADERSHIP PARADOX

Addressing global stresses requires co-ordination among increasing constituencies of decision-makers. But the more diverse the groups that are involved, the more that vested interests tend to block progress. An often-cited African proverb suggests that to go fast, go alone – but to go far, go together. Grappling with growing stresses requires that we go fast and far – implying a paradoxical need to go alone and together. Fresh forms of collaboration are required that cut across familiar national, public–private, and industry-sector boundaries, but there are no strong models for such collaborations, and they are immensely difficult to get off the ground because different parties remain focused on their individual foreground issues and responsibilities.

Profound policy dilemmas face the leaders of all nations. Governments, by their nature, are slower to act than the speed of contemporary life often requires. Electoral mandates generally trump management of long-term, complicated, or unpopular issues. The larger and more technical the problems facing society, the less likely it is that governments alone can solve them without help from business and other sectors. In advanced democracies, the more capacity people have to band together in special interest groups to influence government, the harder it is for government to work primarily for the common good. In many parts of the world, the more new media technology empowers citizens, the more it also empowers governments to monitor those citizens.

Globalisation itself raises a paradox for government leaders: the greater the forces of globalisation, the less the autonomous power of national governments. Similarly, leaders face a paradox that arises from human nature itself, except in times of immediate danger: the greater the need for communal, long-term solutions, the less the appetite for individual, short-term sacrifices. ■

THE RESOURCE STRESS NEXUS

By 2030, the world will need between 40% and 50% more water, food and energy, according to UN and Shell analysis. Interdependence among these resources – the Stress Nexus – also increases volatility: more energy requires more water; more food and water require more energy. Climate change could lead to extreme weather conditions, such as lengthy droughts and torrential flooding that would impact agriculture and livelihoods. Water shortages could intensify social and political instability, provoke conflicts, and cause irreparable environmental damage.

THE PROSPERITY PARADOX

With growing food demand the resource footprint (land, water, energy) of food can increase significantly as proteins take over from carbohydrates in diets.

THE LEADERSHIP PARADOX

Governments must develop policies in all areas of the Stress Nexus even without a full understanding of the interdependencies and possible unintended consequences. 'Food versus fuel' suggests that all food and fuel are equal, and that there is a direct trade-off – but the issues are more complex, and stakeholder interests frame the debates.

THE CONNECTIVITY PARADOX

Most countries are not fully self-sufficient in the interconnected Stress Nexus of food, energy, and water. What are the trade-offs between national food and energy security? How will global commodity markets impact national resource security when volatility increases?

In addition to presenting challenges, however, the resource Stress Nexus also presents opportunities. What new collaborations could be developed, even among currently unlikely partners?

PATHWAYS

ROOM TO MANOEUVRE

Financial, social, political or technological capital encourage early action and result in effective change/reform.

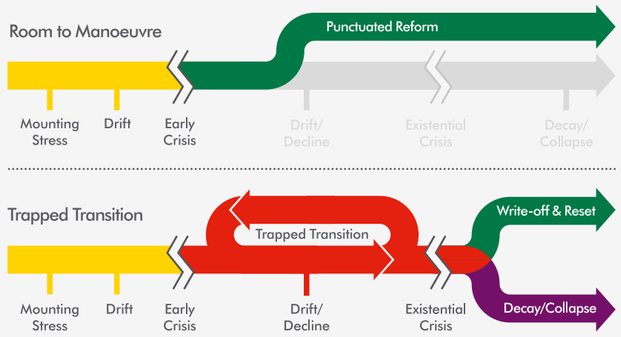
TRAPPED TRANSITION

Financial, social, political or technological capacity prove inadequate to withstand stresses. Behavioural responses delay change, causing conditions to worsen until ultimately a reset is forced or a collapse occurs.

The tensions inherent in the three paradoxes fuel the current era of transitions. Countries around the world face challenges to their economic models, political regimes and social arrangements. The US is dealing with a long-term decline in relative global power, and presently with a disappointingly slow recovery from a deep recession and a deadlocked political system. China and the other large emerging economies, which appeared resilient in 2008, are now grappling with an additional range of uncertainties in their search for stability and continued growth.

When stresses rise, and a crisis emerges, some actors exhibit relevant forms of resilience that enable them to adapt and reform. Others, however, struggle until the crisis escalates to a level that enforces either dramatic and painful restructuring or collapse. In exploring previous eras of transition and transformation, we found that two archetypal Pathway lenses help bring clarity and insights. We call these 'Room to Manoeuvre' and 'Trapped Transition'.

THE PATHWAY LENSES



To take some recent examples:

- Despite being seriously buffeted by the turbulence that the global financial crisis created, economies such as India, China, and Brazil have proved to be resilient, at least in the immediate aftermath of that crisis. In their different ways, they had the financial, social, political, or resource 'capital' to respond and reform, following a Room to Manoeuvre pathway.

- The European Union proved not to have this level of resilience, and has been following a Trapped Transition pathway in which the 'can' keeps being 'kicked down the road' while leaders struggle to create some political and social breathing space. So there is continuing drift, punctuated by a series of mini-crises, which will eventually culminate in either a reset involving the writing off of significant financial and political capital (through pooling sovereignty, for example) or the Euro unravelling.

Of course, not all countries or actors will follow one single Trapped Transition or Room to Manoeuvre pathway, nor will they be on one pathway across all challenges all the time. Indeed, what looks like room to manoeuvre to some actors will simultaneously feel like being trapped to others – think of the different perspectives of a cat and a mouse locked in a room together. Nevertheless, the Pathway lenses highlight patterns recurring throughout the broader panorama.

Countries, businesses, and even individuals face divergent paths. Will they respond to the challenges they face through adaptation and reform, following a Room to Manoeuvre pathway? Or will change be postponed, leading to a Trapped Transition, until there is either a fundamental reset or a collapse?

TRANSITION DYNAMICS

From a systems perspective, transitions occur when gaps emerge between actual and desired conditions. These gaps produce anxiety or dissatisfaction, which stimulates the development of new or upgraded approaches, which are then executed, thus closing the gap.

However, there are many time delays in this process, and many inhibitors. For example, anxiety is as likely to promote denial or paralysis as it is to encourage new approaches. Without social, intellectual, and political capital, it is difficult to overcome vested interests in order to develop and implement new approaches. Other key inhibitors include institutional inadequacy, inequality, and insecurity.

With all these system-wide inhibitors, if transition is going to progress, system-wide facilitators need to be in place – quick wins, for example, to overcome paralysis or the development of sufficient social and political capital to overcome vested interests.

The dynamic balance of inhibitors and facilitators shapes transitions, a balance that differs from actor to actor and transition to transition. If the balance favours the inhibitors, the transition becomes trapped – but sufficient facilitators create room to manoeuvre. ■

A NEW LENS ON CITIES

By 2050, around three quarters of the population is expected to be living in cities. The greatest growth in urban population over this period will be in China, India, Nigeria and the US. The most dramatic growth will come in thousands of smaller towns that will rapidly develop into cities.

Much of the infrastructure for these new cities has yet to be designed. Booz & Company (in a study for the World Wildlife Fund) estimates that the total investment in urban infrastructure and operations in the next three decades will exceed a staggering $350 trillion. The largest share of this will be in the emerging markets. Financing these investment needs will be a major challenge and will require significant innovations in global finance. If these needs can be met, it would constitute a major source of aggregate demand for the world economy for a long time to come.

Today, cities use 66% of the world's total energy – and in the next 30 years this figure could increase to nearly 80%. City development in the past has been driven by assumptions that energy would be available at a relatively low price. The lack of a perceived need to secure energy supply and to develop planning policies has led to urban sprawl and energy inefficiency.

THE PROSPERITY PARADOX

If healthy cities with abundant resources grow organically, they tend to sprawl, leading to deep energy inefficiency. Poorer and more crowded cities run the same risk. If they, too, follow the organic path, which is economically more efficient in the short term, they run the risk of locking in deep infrastructure inefficiency.

THE LEADERSHIP PARADOX

If municipal leaders assume that the problems are too hard to solve and the solutions too unpopular to execute, stresses in cities will be ignored until liveability is threatened. The gulf between political and infrastructure time horizons is very hard to bridge, yet bridging it is necessary for healthy development.

THE CONNECTIVITY PARADOX

All aspects of society must work together to solve the problem of cities' growth: government has to offer better incentives and sanctions for smart growth; society must be encouraged to moderate demand for goods in favour of infrastructure for the whole; and business must offer smarter and more integrated infrastructure, housing, and traffic solutions. To prosper, all groups must operate in a co-ordinated way, yet this dance is very hard to master.

ROOM TO MANOEUVRE

- Visionary leadership coalitions shape growth
- Authorities foresee stresses and implement integrated land, transport, energy, water, and waste planning
- Structural energy-effective solutions, including compact city development and public transport
- Knowledge shared and valued

TRAPPED TRANSITION

- Market forces alone dictate growth
- Authorities assume problems are too hard to tackle, and solutions too unpopular to implement
- Stresses ignored until city liveability is threatened and infrastructure is difficult to re-engineer
- Ad hoc, individual solutions

CITY GROWTH VIRTUOUS CYCLE

- **Ongoing development of commercial advantages**
- **Advantage may be:**
  - Trade hub
  - Cluster of expertise
  - Special economic zone
- **Companies invest to capitalise on advantages:**
  - Expanding production
  - More efficient technology
  - New products – Service industries
- **Government invests in infrastructure, enabling more efficient business operations and improving amenity**
  - Transport – Services – Amenities
  - Communications – Education
- **Jobs and wealth opportunities attract labour from outside the city – increasing labour pool and size of home market**
- **Increasing education and up-skilling build talent and entrepreneurialism**

PANORAMAS
NEW LENS SCENARIOS

As we move into a more fluid geopolitical environment, with much greater political uncertainty, we face the possibility of an increasingly confrontational world.

Four key features of the transitional geopolitical landscape stand out for the next 10 to 20 years.

THE US–CHINA RELATIONSHIP
The US will remain pre-eminent, but it will have to accept a more plural world. It will need to negotiate outcomes with other powers that have different values and objectives. In other words, the US must learn to 'enable change' rather than act unilaterally. On its own, it will no longer be willing or able to provide the global public goods on which the international order depends. A leadership vacuum could emerge if no one else is prepared to take a lead, or if the US itself is not prepared to allow others to step in on an equivalent footing.

As the growing economic powerhouse, China is uncomfortable taking on a broader global role, and continues to define its interests in specific and narrow national terms, the underlying structural differences between the US and China have shown up most significantly over trade, the exchange rate between them, and the economic imbalances that have built up over time. However, geopolitical competition is increasing between them for influence in the Asia-Pacific region, even as Japan continues to exercise substantial influence through its technology, investment, and significant foreign assistance efforts. With the capabilities of the US stretched, and with China running the risk of over-extending itself through over-confidence in its pursuit of regional interests, will one have a more decisive influence? Or will they find a way to work together in areas of mutual interest?

THE EASTERN SHIFT IN THE NEW INTERNATIONAL SYSTEM
The second key feature is the nature of the international system that the new rising powers, such as China and India, wish to see. China has always depicted its international objectives in benign terms as 'peaceful rise', and points out that under its traditional imperial tributary system, it has never sought to interfere in the internal affairs of other states. However, the tributary system was not a world of equal sovereign states but centred on China as the pre-eminent state. All other states owed allegiance, paid tribute, and shaped their policies in a way that maintained good relations with China.

Such a system does not easily translate into today's geopolitical order. Shifting into a Chinese sphere of influence is not an attractive option for many states. There is potentially a tale of two Asias. Asia may continue as the most dynamic region of the global economy; but it could turn instead into the most volatile, conflict-prone region of the global order.

"THE COUNTRY THAT DISPLAYS MORE HUMANE AUTHORITY WILL WIN"

YAN XUETONG
Professor of political science at Tsinghua University

THUCYDIDES' TRAP

Graham Allison, Professor at the John F. Kennedy School of Government at Harvard, argues that the defining question about global order in the decades ahead will be, can China and the United States escape Thucydides' trap? The historian's metaphor alludes to the dangers two parties face when a rising power rivals a ruling power. Most challenges of this nature have ended in conflict. Peaceful resolutions have required the governments and peoples of both powers to make huge adjustments.

The dramatic rise of Athens in classical times shocked Sparta, the established land power. Fear produced competition, confrontation, and eventually conflict. After 30 years, both states were destroyed. Thucydides wrote, 'It was the rise of Athens and the fear that this inspired in Sparta that made war inevitable.' Allison notes the parallel today, with China's rise provoking discomfiture and fear in the US.

US–CHINA COMPETITION

"…Competition between the United States and China is inevitable. Leaders of both countries assert optimistically that the competition can be managed without clashes that threaten the global order. Most academic analysts are not so sanguine… And given the differences between the Chinese and American political systems, pessimists might believe that there is an even higher likelihood of war… [But] morality can play a key role in shaping international competition between political powers – and separating the winners from the losers… It is the battle for people's hearts and minds that will determine who eventually prevails. And, as China's ancient philosophers predicted, the country that displays more humane authority will win."

YAN XUETONG
Professor of political science at Tsinghua University
'How China Can Defeat America,' New York Times, 2011

RUGGED TERRAIN FOR INTERNATIONAL INSTITUTIONS

The third key feature of the new geopolitical landscape is the increasing inadequacy of existing international institutions to deal with global problems such as trade protection, climate change, and nuclear disarmament. The elevation of the 'Group of 20' (G20) to the heads of government level, including both major developed and developing countries, was a response to the ongoing global financial crisis. It is more representative of where real global power lies, compared to the more exclusive 'Group of Eight' (G8), which excludes two of the eight largest economies, China and Brazil. However, the G20's transparency and accountability have been questioned, and it has yet to evolve as an enduring institution in any meaningful way.

IMF and World Bank interventions have had a mixed record, and their institutional governance remains anchored in a previous era of economic pre-eminence. Nevertheless, at a technocratic level, many forms of international co-operation or co-ordination are still being maintained and even incrementally extended.

"MUCH OF HUMAN HISTORY HAS CONSISTED OF UNEQUAL CONFLICTS BETWEEN THE HAVES AND THE HAVE-NOTS."

JARED DIAMOND
Guns, Germs, and Steel: The Fates of Human Societies

SQUEEZED GROWTH AND ZERO-SUM PERCEPTIONS

The fourth key feature of the transitional geopolitical landscape is that in dealing with the financial crisis, developed countries have not felt it necessary to offer any radically different alternatives to the liberal capitalist model that was the global exemplar prior to 2008. On the one hand, there could be a significant return of the state in shaping and steering domestic economic and social policy. On the other hand, a period of recession, or an extended phase of below-average growth, squeezes the room to manoeuvre of governments. There is no growth dividend to distribute, and politics becomes focused on sharing out the burden of adjustment. The key political question then is – who gains and who loses when growth is squeezed and the smaller pie is divided? This question becomes highly charged in an era of declining trust in government, possibly leading to turbulent political transitions with dangerously uncertain outcomes.

All countries that are integrated into the global economy, whether developing or developed, eventually require growth to maintain political legitimacy and social stability. The danger is that an increase in insecurity could lead to new fundamentalist ideologies, feeding off a populist search for scapegoats. The break point in developed countries may come not with the poor, whether working or unemployed, but with a middle class under pressure from growing global competition and facing declining living standards. It was the breaking of the middle class in post-1918 Germany that created fertile ground for political extremism. The rising demands of the new middle class in emerging countries like China, India, and Brazil place different, but perhaps equally explosive, pressures on their respective governments.

Whatever happens in the debate over rival governance models – the Beijing Consensus versus the Washington Consensus – political progress may eventually be characterised as a movement towards political structures that enable more negotiation between contending interests, rather than the imposition of one interest over others.

THE STRUCTURE OF THE GLOBAL ECONOMY

Elite regimes have traditionally derived their legitimacy through the provision of stability and justice for the majority of the populace. Over the last century the bargain has become more complicated as the pursuit of economic growth has come to be seen as a critical attribute of a modern state.

The political evolution of the liberal democracies of the OECD over the last century can be seen as a fitful, but ultimately successful, journey to address the tensions between economic growth, distribution, and social order at the national level. These democracies unwound the legacy of colonialism and total war, which disfigured inter-state relations between 1850 and 1950. At the national level this journey included a radical widening of political participation to include women and minority groups.

In the Anglo-Saxon world this journey tended to be evolutionary rather than revolutionary, with notable exceptions – the civil war in the US among them. At crucial moments reforms were led by patricians in order to ward off existential challenges.

Theodore Roosevelt responded to the excesses of the Gilded Age and Franklin D. Roosevelt to the corruption scandals of the Harding/Coolidge era and the ineffectiveness of Herbert Hoover in dealing with the Great Depression. The case of Western Europe is more complicated because of relatively recent national integration of Italy, Germany, and Spain and the territorial impact of two great wars, as well as episodes of fascism.

These richer economies evolved over a period when their per capita income levels were not all that different from some of the wealthier emerging markets today. Parallels with current emerging markets and developing countries are, however, difficult to see because any such parallels are distorted by the impact of colonial history. In some cases, what used to take around a century now seems to take just a generation (see table below).

HISTORICAL TRAJECTORIES EMERGING ECONOMIES COMPARED TO DEVELOPED COUNTRIES

	Year	Per Capita GDP*	Years in which comparable levels were reached			
			US	Germany	Japan	UK
China	1985	1,519	1840	1856	1916	1820
	2008	6,725	1940	1958	1967	1940
India	1985	1,079	1820	1820	1894	1820
	2008	2,975	1880	1900	1957	1865
South Korea	1985	5,670	1925	1955	1965	1935
	2008	19,614	1986	2006	1994	2000

*1990 International Geary-Khamis dollars
Data adapted from Angus Maddison, University of Groningen

There are also rumbles of discontent about globalisation, which some have begun to regard as a zero-sum game, despite long-term trends in global development and technology diffusion. Geopolitics, too, is playing out in zero-sum terms, with rising powers gaining at the expense of established powers. This mentality is partly responsible for the lack of effective international action to deal with climate change and shapes the competition for resources, driven by concerns over resource insecurity.

As many have argued, globalisation will survive, although it may slow, but it has no inherent tendency to promote either the free market or liberal democracy. Indeed, globalisation is commonly seen not only as harming workers, but also as eviscerating the middle classes of the developed world, as labour in the developing world raises its skills and moves further up the technology ladder.

Capitalism and the consequences of the global market economy are beginning to collide with nationalism, increasing tensions as we come up against resource and environmental limits. The next phase of globalisation promises to be as turbulent as anything we have seen in the past century.

Future geopolitical frameworks will, inevitably, have a more critical appreciation of markets in generating wealth as well as in provoking inequality and instability. Where the next consensus around states and markets will land will be a key defining argument for international politics in the 21st century, and will set the terms for how globalisation will be realised. There is still no alternative to globalisation, but it is becoming a more complex and variegated force, with negative and positive impacts, and whose future direction is uncertain.

WHERE THE NEXT CONSENSUS AROUND STATES AND MARKETS WILL LAND WILL BE A KEY DEFINING ARGUMENT FOR INTERNATIONAL POLITICS IN THE 21ST CENTURY, AND WILL SET THE TERMS FOR HOW GLOBALISATION WILL BE REALISED.

GLOBAL INCOME DISTRIBUTION

Compared to the recent past, how will the economic power of the most privileged and broader populace develop?

Branko Milanovic, 'Global income inequality by the numbers: in history and now', November 2012

MOUNTAINS AND OCEANS

Recurring patterns emerge from these details, revolving around the distribution of power and natural resource availability, and the influence these have on policy, people, markets, and growth.

The world in the future will be defined by how people and governments meet the challenges posed by institutions, inequality, and insecurity in relation to the paradoxes of prosperity, leadership, and connectivity.

- Which paradoxes will become more acute?
- Which will be resolved?
- Which industries, businesses, nations, and groups of people will have room to manoeuvre?
- Which will be trapped?
- How will the capabilities of capital, collaboration, and creativity develop?
- How will power and influence be distributed?

These scenarios are designed to provide new lenses through which to explore these issues – or, as we explore these contrasting worlds, two panoramas: high *Mountains* where the benefits of an elevated position are exercised and protected, and those who are currently influential hold on to power; and wide *Oceans* with rising tides, strong currents, and a volatile churn of actors and events with an irregular accommodation of competing interests.

These panoramas have distinctive social, economic, and political features that can be discerned over the next 20 years or so, with consequences for energy developments over half a century. Together these shape ecological outlooks beyond 2100. They form the *New Lens Scenarios* for the 21st century. ■

MOUNTAINS
A VIEW FROM THE TOP

Mountains is a world in which those occupying commanding advantage (at the top) generally work to create stability in ways that promote the persistence of the status quo. There is a steady, self-reinforcing, lock-in of incumbent power and institutions. This lock-in constrains the economic potential of some sectors of society, but enables established sectors aligned with market forces to unlock resources that require significant capital and new technology. As for the less fortunate, the thinness of social safety nets is not completely offset by the growth in philanthropy, characterised by an eruption of foundations endowed by increasing numbers of billionaires.

Latent opposition to the power of political, business and social elites is minimised through a combination of incentives and sanctions, and social mobility continues to decline. But supply-side investments are stimulated. Even with new investments, however, the absence of major structural and financial adjustments in developed countries begins to slow GDP and discourage trade. Some fast-emerging economies fall into the 'middle-income trap', where growth plateaus and stagnates after a significant proportion of the population reaches middle-income levels, largely because institutions cannot adapt to a more complex economy.

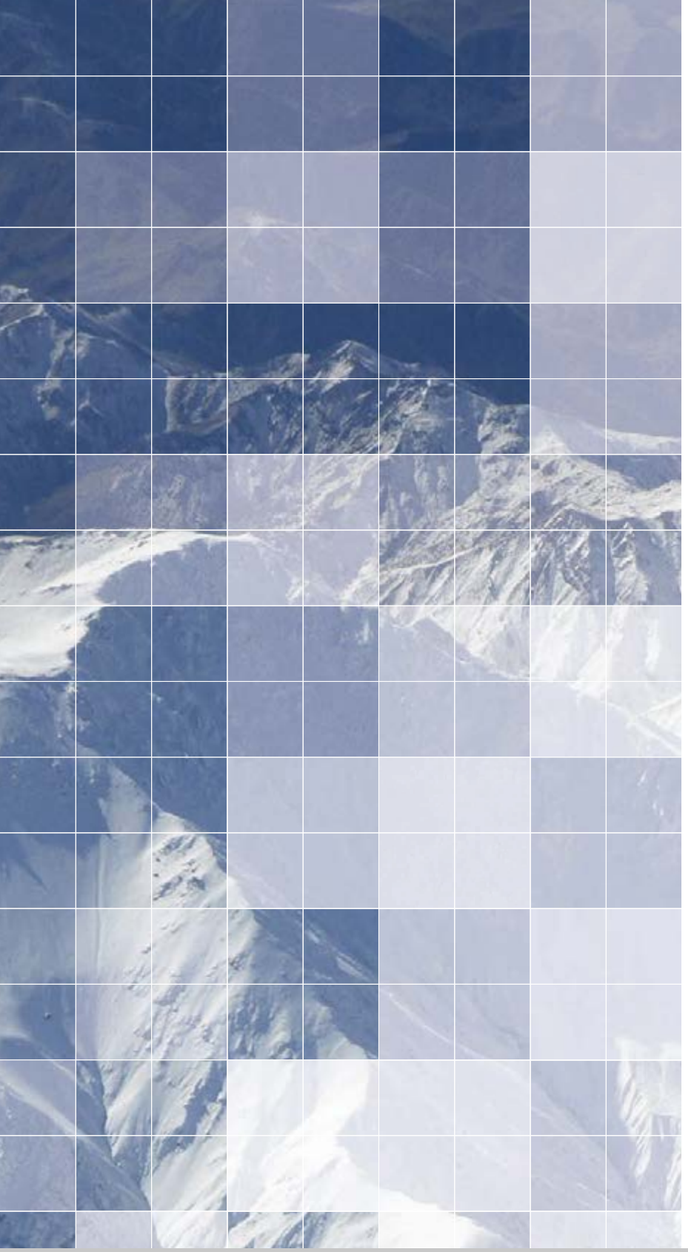
This moderation of economic growth, however, alleviates some pressure for energy demand. Demand growth is slowed even further as progress is made with supply-side energy policies, such as the encouragement of compact city development.

Tight/shale gas and Coal Bed Methane (CBM) enjoy widespread success and grow to form a new 'gas backbone' to the global energy system. With slowing growth in demand for liquid fuels, oil prices remain moderate, and overall production growth limited.

Sluggish economic growth in the early period, the relative displacement of coal by gas over the longer term, and supply-side incentives for deploying carbon capture and storage (CCS) technology and renewable energy, all contribute to a moderation in greenhouse gas emissions. Nevertheless, the global average temperature rise overshoots the current 2°C goal. ■

MOUNTAINS AT A GLANCE

- Advantage creates advantage – influence remains concentrated in the hands of the currently powerful.
- Rigid power structures and institutions hamper economic development.
- With fewer power-brokers, positive advances in secondary policy areas are feasible – e.g. compact urban development, energy and environmental stress.
- Positive resource expectations are realised and, with supportive policy frameworks in place, natural gas becomes a backbone of the global energy system.
- Increasing CO_2 and environmental stresses are moderated by slower overall growth; the substitution of coal for natural gas, and the success of carbon capture and storage technologies.



PROSPERITY

The prolonging of status quo institutional arrangements that favour the "already privileged" dampens economic dynamism over the longer term. As the rich get richer and the poor stay relatively poor, the educationally rich and their children monopolise the best schools and universities, developing and perpetuating a class system, even in countries that had not previously inherited one. Inequality indices continue their rise to a high level within many societies.

North America is affected by continuing political polarisation around fiscal arrangements and the role of government, but underlying strengths continue to shine through despite government gridlock and occasional social protests. Because of continuing sovereignty arguments, the Eurozone crisis is not resolved effectively and a prolonged period of stagnation results.

Nevertheless, there are some very visible success stories at the entrepreneurial, business, and even national levels, when high investment levels and creativity can be combined with relatively low labour costs without creating excessive discontent. These successes are particularly noticeable in a number of poor emerging economies in Africa that are ultimately able to shake off the worst excesses of cronyism and corruption.

CONNECTIVITY

Digital and financial connectivity continue to deepen in the world of *Mountains*, but firewalls and commercial private areas are also increasingly common. Using security and economic arguments, governments exercise more control over the web, leading to its 'Balkanisation' at regional and national levels. As different webs develop, national and privileged perspectives begin to be locked in. Young people attempt to rebel from time to time, leading to a world in which protest is aimed at freedom of information as well as social justice. Globalisation loses vigour, apart from where new common interests arise that fit within existing forms – for example, outsourcing labour and services to inexpensive economies.

LEADERSHIP

Leaders in *Mountains* come from a predictable sector of wealth, opportunity, expectation, connection, ideology, incumbency, and enculturation. There are a few routes for those at the bottom to rise to positions of advantage, but these pathways involve celebrated achievement in business, education, the arts, or popular culture that generally reinforce the prevailing popular ideology.

The rise of exceptional individuals serves to reinforce the idea that people are predominantly masters of their own fate. A vigorous blend of *noblesse oblige* and philanthropy addresses some of the stresses arising from the prolongation of the status quo, so that rumbles of discontent remain buried deep within societies. Because leaders address relatively limited constituencies and interests, occasional shifts in policy can be fast but tend not to be far-reaching.

The concentration of power at the top means that responses to short-term challenges are quick and decisive – but sometimes at the expense of long-term investment in public prosperity. The leadership focus remains on sustaining stability by extending and defending the status quo and responding to restlessness among the broader populace by promoting the wisdom of such moves. The public good is served when interests align, for example in energy policy, where supply security and CCS technologies are deemed essential for maintaining 'our way of life'. ■

THE NEW GILDED AGE

The last quarter of the 19th century in the United States was characterised by a sheen of glitter covering growing social and economic inequality, the building of vast fortunes through amoral, and sometimes illegal, practices, and a corruption of the political process by narrow vested interests – a period Mark Twain called 'The Gilded Age'.

There are two aspects to the rising inequality of the New Gilded Age: a skills gap between those with college degrees and those without; and a huge growth in income share for the top 1% – or really 0.1%. This new elite, much like their 19th century counterparts, built fortunes as the constraints imposed by government began to recede. The New Gilded Age is manifested in continued high levels of income and wealth inequality, despite the financial market collapse of 2008, and ongoing economic stagnation. The question is whether this will generate reformist impulses in government, as it did in the first Gilded Age.

While government policy is important, it may be that globalisation and technological advance limit the room to manoeuvre for government policy. There are crucial differences in today's globalised economies from the circumstances that saw an end to the earlier Gilded Age. This suggests that while policy will be critical, it will not be enough. The solutions to resolving the problems of the New Gilded Age will have to be radically different from the old.

THE GEOPOLITICAL SHIFT FROM WEST TO EAST

In the years ahead, the geopolitical system is under strain from a combination of two transformations. At the same time that the developed countries of the international system are undergoing a transformative economic crisis, geopolitical and economic power continues to shift from West to East, with profound consequences. Rising powers assert their interests against established powers, in part because the authority of the latter has been damaged by the crisis that has hit them. But even with this shift, Asia is the most volatile, conflict-prone region of the global order in *Mountains*.

COERCION AND RESPONSIBILITY

Globalisation in the world of *Mountains* concentrates power not only in national economies, but in the more privileged in each country. Together, these form an uneasy, but recognisable, transnational cosmopolitan elite. Multinational companies and their leaders are also seen as part of this global group. Even though they have many similar interests and issues to deal with, they also have different sources of power, wealth, and legitimacy, and these differences often lead to clashes relating to international law and competing national interests.

Like their predecessors throughout history, *Mountains* elites use a mixture of coercion and co-option to maintain power. The more enduring and successful find mechanisms for infusing fresh talent into their ranks to guard against stagnation while safeguarding their own interests.

Meanwhile, eroding national boundaries begin to influence national politics. Resistance to globalisation arises from social movements at a popular level, coming together in networks to mobilise and coordinate direct action. Democracy and populist power sometimes work against global markets, with social media serving to support local concerns.

In the face of these dilemmas, the currently advantaged seek to strengthen their hand against the political threat of corrosive globalisation by asserting the power of national or regional interest against global markets. So the drive to globalised markets – which has actually benefited the majority of the privileged – begins to be moderated by a degree of state control of markets and at least symbolic protectionism. In this way, states act as a bulwark against global market-driven insecurity both for the advantaged and for their less privileged countrymen. No matter which side is pulling the strongest in the ongoing tug of war between markets and states, the privileged manage to protect their interests.

There is a coercive flavour to *Mountains*, but this is a coercion that is sanctioned by law and justified by the need to defend stability. In countries across the world, as societies become richer, the tolerance for injustice and arbitrary action diminishes, and the drive for compliance increases – an effect that is magnified through the rise of social media. Strong and forceful states wield their power in the domestic political sphere with a proliferation of regulatory agencies, changing the balance between public and private sectors.

Revitalised states are the cornerstone of the international system in *Mountains*. While governance of the international system is driven by its more powerful members, the problem lies in getting agreement among them, in particular, securing co-operation between the United States and China. As seen in the run up to the First World War, the question in the air throughout the 2020s and 2030s is whether great powers will choose to exercise power responsibly, or risk destroying global order through an inability to foresee the consequences of their actions.

NEW 'OLD RULES' FOR THE GLOBAL GAME

In *Mountains*, the US first attempts to use its power to set the rules of the game for the international system, in accordance with its values and the promotion of American business interests. But while the US is unchallenged militarily, it no longer has the dominance over global markets that it once enjoyed. Power is more dispersed within the global economy so demands in relation to trade or financial regulation are increasingly challenged, and often effectively so.

As the global balance of power shifts, the US resists giving up its leadership role, leading to an unremitting background fear of conflict. The struggle for power continues with coercive diplomacy, blockades, and the potential for violent conflicts around territorial waters, resembling the proxy wars of the Cold War era.

China, motivated by growing nationalist sentiment, seeks a proprietary interest over East Asia, resulting in a tense stand-off, with the US acting as a guarantor of the regional status quo.

Both the US and China seek advantage over the other, if only to defend their respective interests. But defence often requires the threat of offence. The presence of nuclear weapons keeps more general war at bay, but this is a tense, difficult, and dangerous period for the global system.

The international system of *Mountains* is characterised by ad hoc coalitions against one or other leading power, creating bitter disputes. Old relationships are stretched. The US and Europe find themselves drifting apart on security issues in an atmosphere of mutual non-comprehension. The old established multilateral institutions and global agreements are also much weaker. As these institutions continue to posture and engage in symbolic gestures, rather than to take a clear lead, they succeed only in demonstrating their irrelevance to the realpolitik power play that drives the international system.

RESET TO A PRAGMATIC WORLD OF MUTUAL INTERESTS

In the decade of the 2020s, there is a growing recognition of mutual interests between the US and China, leading to a de facto Group of Two or G2 managing the global system. This is not a relationship between two allies, but a marriage of convenience forged by realpolitik calculations. Each is dealing with domestic economic issues, and hence political issues, that are influenced by the other. The confrontational world of the previous period gives way to an adaptive (but not friendly) world, where states retain 'sharp elbows' in dealing with others. The US and China share interests, but they do not share values, and they remain rivals. The struggle for power continues. The multilateral institutions of old do not make a comeback. This G2 leadership model, with its intense inward focus on back-and-forth tensions between the US and China, tends to leave other powers, especially the Europeans, in a secondary position.

By the 2030s, as other states develop, the international order becomes more variegated. Rising regional hegemons including India, Turkey, South Africa, and Brazil use their growing influence to shape their respective regional agenda. Like China before them, the foreign policies of these countries mature, creating more constituencies for a new world order, especially to deal with the growing concerns related to climate change, resource stresses, and ageing populations. Some fear the possibility of a number of major states becoming failed states if their governments cannot rise to the challenge of establishing order within their national boundaries, as the challenges to their authority mount.

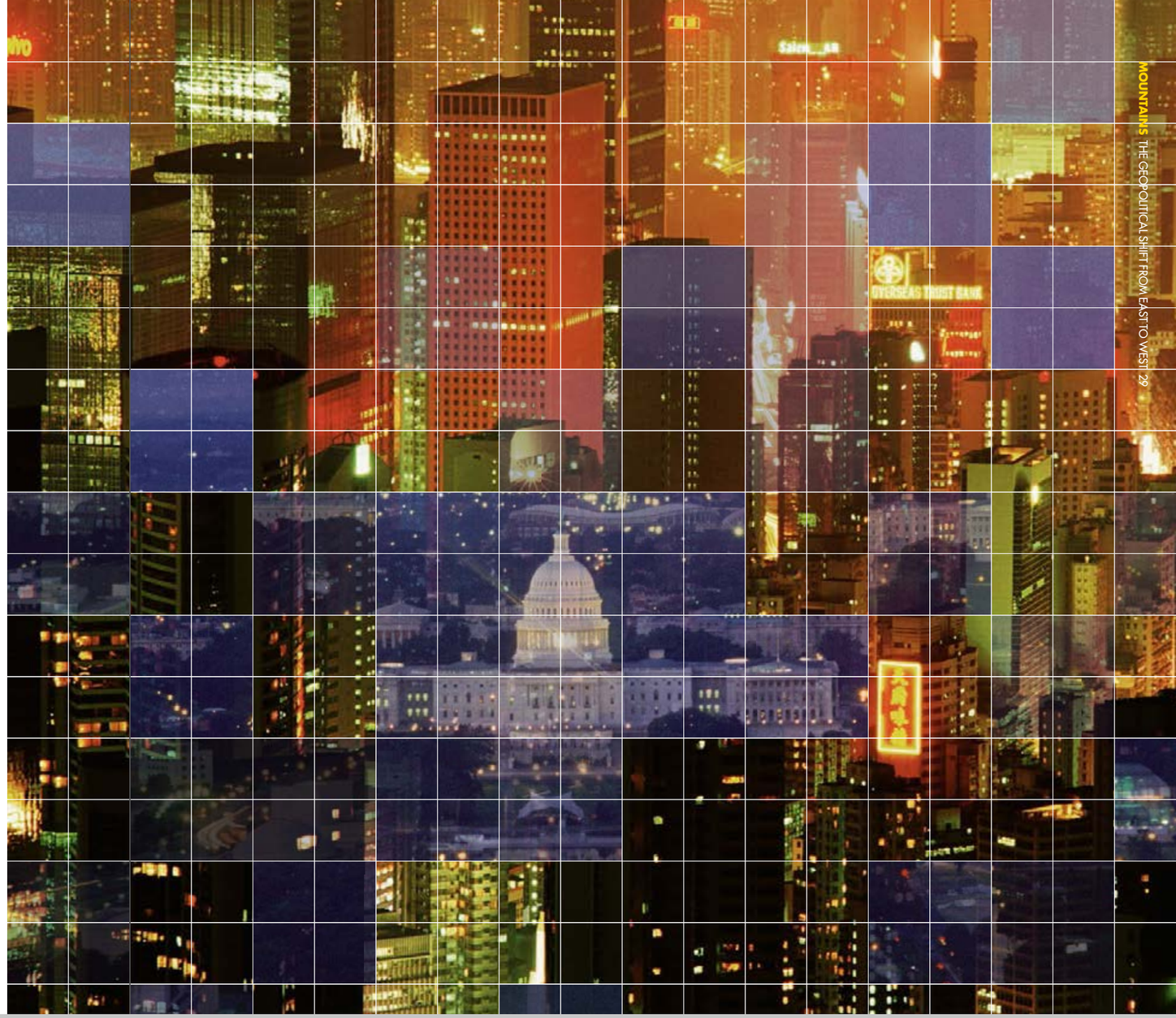
Meanwhile, ruling elites begin to recognise that new forms of international co-operation are required to deal with these challenges. Countries will simply have to learn to live with each other if they are to avoid the sort of competitive scramble that leads to mutual harm. Over time, a 21st century global 'Concert of the Great' develops, spawned by shared pragmatic self-interest.

Like the Concert of Europe (1815–1914), relationships are driven by governing coalitions of elites within a core group of great powers that includes not only the US and China, but also India, the EU, and a few select others. Unlike its predecessor, the 21st century Concert of the Great has to address a wider range of challenges to global security arising not just from the rivalry for power amongst its members, but also from financial, environmental, food, water, and other resource stresses.

Mountains remains a world of shared security concerns and arrangements to deal with them, but not of universally shared values. The challenge for the 21st century Concert of the Great is to remain flexible as conditions and national calculations swiftly change. Even more than in the past, there is no permanence in either the environment that states face or in the framework necessary to deal with this environment. Over time, the coalitions, agreements, and arrangements that underpin the 21st century Concert of the Great gradually solidify as they institutionalise and gain both depth and scope. People around the world begin to take the Concert for granted, just as they did its 19th century predecessor in the years leading up to 1914. ■

"GLOBALISATION MAKES THE WORLD SMALLER. IT MAY ALSO MAKE IT – OR SECTIONS OF IT – RICHER. IT DOES NOT MAKE IT MORE PEACEFUL, OR MORE LIBERAL. LEAST OF ALL DOES IT MAKE IT FLAT."

JOHN GRAY
The World Is Round



ECONOMIC PATHWAYS UP AND DOWN

Despite tensions among nation-states, the cosmopolitan and footloose transnational elites produced by globalisation increase in prominence as wealth and influence rise. These increasingly shape the terms of discourse and define values and norms, for better or worse. At the national level, they are increasingly influential in shaping policy, but less concerned than their patrician forebears in maintaining social cohesion, despite rhetoric to the contrary.

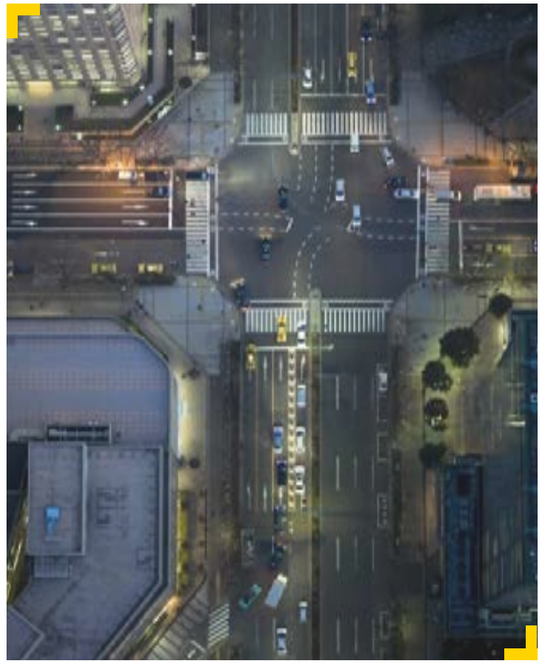
In the US, for example, income and wealth inequality continue to increase, with stagnating middle-class earnings, reduced social mobility, and an allegedly meritocratic higher education system, generously supported by tax exemptions, whose main beneficiaries are the children of the successful. Superimposed on this class divide is an increasingly serious intergenerational divide, as commitments to the elderly via entitlement programmes crowd out discretionary expenditures that could rebuild economic and social infrastructure. Similarly, in Europe an ageing population and commitments to high levels of entitlement, which are frequently underfunded, create a mixture of social and political strains that deflect attention from the core structural economic issues facing the region.

Highly directed economies also find it difficult to evolve in a supple and organic way because of the powerful alliances, enterprises, and constituencies created in earlier stages of development. By 2030, for both advanced economies and the emerging markets, oligarchic control has discouraged growth that would otherwise have been possible.

In the industrialised world the traditional link between economic growth and rising well-paid full-time employment is gradually broken. This leads to increased insecurity and a growing 'casualisation' of labour. The use of 3D printing, together with still-rising levels of Internet and communications technology use, means that labour becomes relatively less central to production. Returns to capital remain favoured, while governments raise barriers to protect jobs in their own economies. This protectionism leads to increased friction between countries.

Protectionist pressures arise, driven not only by the need to protect the internal labour market, but also by the desire to safeguard vested interests. States seek to engage opportunistically with global markets, rather than opening up to globalisation on a wholesale basis.

Despite considerable rhetoric to the contrary, the advanced economies do not succeed in fundamentally restructuring their financial systems in a way that supports grassroots innovation or small and medium enterprises. However, there is little appetite to expose the political system to the near-existential threat posed by another Great Recession. More burdensome financial regulation proves to be a tax on financial intermediation as well as an effective barrier to entry. National regulators take an increasingly sceptical view of the cross-border activities of foreign financial institutions, insisting that capital be maintained locally rather than at head offices.



At the global level there is relatively little change in the essentials of the global monetary order: the dollar remains the principal reserve currency, and the US retains its dominance of the IMF and the World Bank, partly because its main rival, China, is too busy dealing with internal tensions to risk a significant shake-up of its own financial system that could result from a more prominent regional role.

Overall, in the 2020s and 2030s, various forms of 'grit' impede the workings of the global economic system. Global economic development disappoints as advanced economies remain, or become, sclerotic, and several previously fast-emerging economies slip into various forms of the middle-income trap. Annual global GDP growth in this period averages under 2%. ■

LESSONS FROM OTTO VON BISMARCK AND SIMON COWELL

ROOM TO MANOEUVRE

Governing elites can create room to manoeuvre by adopting programmes that deflect opposition yet support their regime's underlying structure.

Germany became the first nation in the world to adopt a social insurance programme in 1889, designed by Chancellor Otto von Bismarck. He was motivated to introduce social insurance to promote the well-being of workers, keep the German economy operating at maximum efficiency, and stave off calls for more radical socialist alternatives.

More recently, national lotteries and the proliferation of TV reality entertainment provide well-publicised routes for a very small minority of individuals to become financially or socially privileged, creating an exaggerated impression of social mobility.

THE MIDDLE INCOME TRAP

Poor countries tend to grow faster than rich ones from a low relative base, due to untapped potential and because imitation is easier than invention. But that does not mean that every poor country catches up. Most countries that were middle-income in 1960, in terms of income per person, remain so 50 years later. Only 13 countries have escaped the trap and transitioned to high-income economies in this period, including South Korea and Singapore as notable examples.

As economies become more complicated, centralised control is less able to perform the co-ordination function. Beyond a modest level of activity, waves of structural economic and financial reform are required to maintain the vigour of economic growth.

INEQUALITY, ECONOMISTS, AND GROWTH

PROSPERITY

Some economists and policymakers argue that a low tax burden ought to stimulate personal effort and corporate investment while rising income inequality and a high share of profits add to the pool of domestic savings. Recent experience, however, suggests that these advantages are substantially offset by weak consumption demand resulting from stagnant earnings and fiscal stress.

In the past, economists generally regarded inequality as a necessary precondition for economic dynamism. But this thinking is now being challenged. In a recent study on inequality, Jonathan D. Ostry and Andrew G. Berg of the International Monetary Fund have concluded that the concentration of income in the hands of the rich might mean not just a more unequal society, but also less stable economic expansions and sluggish growth.

Inequality appears to have a stronger effect on growth than other factors, including foreign investment, openness to trade, exchange rate competitiveness, and the strength of political institutions. An increasing number of economists have begun to coalesce around this view, warning also of the dangers of deregulation.

For the big emerging markets, some argue that centrally directed development orchestrated by a political and bureaucratic elite can more easily solve the problems of co-ordination in a supply-constrained economy. It is certainly true that economies as diverse as the Soviet Union, Japan, South Korea, Singapore, Taiwan, and China have all enjoyed considerable success in achieving impressive industrial development under central direction for a significant period of time. By contrast, India is often pointed to as a society that has allowed premature democratisation to get in the way of growth.

The arguments, however, are subtler than this formulation would suggest. For most of these countries, fast growth was an important factor in political legitimacy in the early stages of development. It is perhaps also true that the early phase of development under autocracy was more wasteful of human and natural resources than it might have been under democracy – not an insignificant matter for a poor country.

"INCREASING INEQUALITY MEANS A WEAKER ECONOMY, WHICH MEANS INCREASING INEQUALITY, WHICH MEANS A WEAKER ECONOMY. THAT ECONOMIC INEQUALITY FEEDS INTO THE POLITICAL ECONOMY, SO THE ABILITY TO STABILISE THE ECONOMY GETS WEAKER."

JOSEPH E STIGLITZ
Nobel Prize-winning Economist

ENERGY AND THE ASCENT OF GAS

The sluggish pace of global economic growth takes some pressure off energy demand. In addition, supply-side energy policies help unlock resources, and optimistic projections for recoverable resources prove to be correct.

Tight/shale gas and CBM enjoy widespread success and grow to form a 'gas backbone' to the global energy system. Strategic urban planning promotes more compact city development and promotes transport electrification. Hydrogen infrastructure is developed for energy storage and transportation from intermittent or remote renewables in the longer term.

Demand for liquid fuels is tempered, and oil prices remain moderate on average. Natural gas prices converge globally at lower levels as a result of low-cost resource plays, such as shale gas, emerging worldwide. Moderate energy prices lead to high-cost resources being left in the ground, which puts pressure on some resource holders that are highly dependent on energy revenues.

Partial displacement of coal by gas and the incentivisation of CCS all contribute to greenhouse gas emissions reducing rapidly after 2030. Nevertheless, emissions exceed the trajectory required for a 2°C pathway.

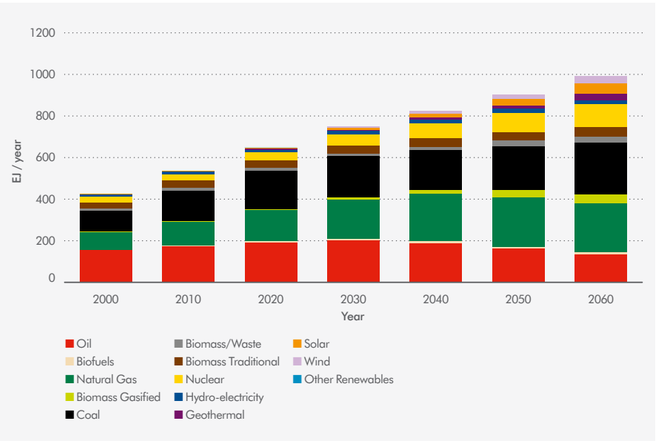
THE SLIPPING PACE OF DEMAND

With continued economic slowdown in some regions, and disappointments in growth and trade becoming more widely spread, the global financial turbulence of the early 21st century initiates a prolonged period in which the pace of energy demand growth is moderated.

In the 2020s and 2030s, some of the previously fast-emerging economies struggle with overcoming the political and social barriers to implementing waves of structural industrial and financial changes that can sustain an elevated pace of economic development. Despite global population growth, this softens the pace of demand acceleration for resources.

Before the middle of the century, however, a number of large economies emerge from the middle-income doldrums, and global economic growth begins to trend higher again. Nevertheless, because of the long-term impact of earlier measures, such as compact urban development and electrification, this economic growth does not translate into energy demand surges, particularly given the proportion of development occurring in the less energy-intensive service sector by then. This divergence marks the break in a hitherto strong correlation between economic and energy demand growth.

TOTAL PRIMARY ENERGY BY SOURCE



THE HYDROGEN PHOENIX IN MOUNTAINS

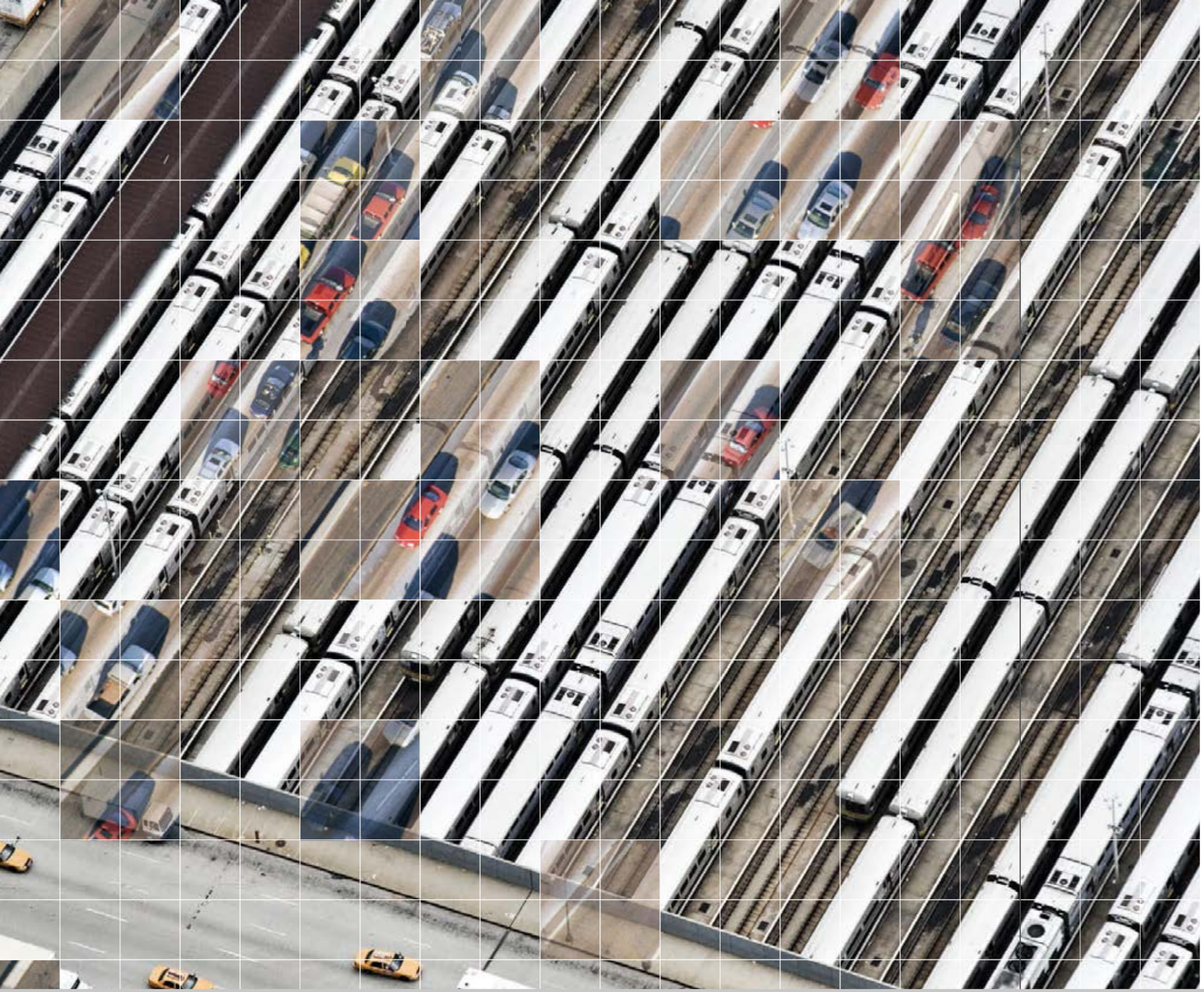
The 1990s' hype about hydrogen as a transport fuel had become quieter by the mid-2000s. Meanwhile, hydrogen has continued to play a little-noticed but substantial role as an industrial feedstock, for example, in ammonia production and oil refining. World production of hydrogen today has an energy content equivalent to 2% of total energy demand, or just over 10% of world electricity production. In *Mountains*, hydrogen is finally brought into the mainstream energy mix when forces from different sectors combine in a virtuous circle.

Electricity companies find it increasingly difficult to balance base load and intermittent sources of generation, and hopes fade that smart grids will be able to meet the sheer scale of the challenge to balance the system on their own. Scares over brownouts start to increase, and attention to hydrogen-based energy storage redoubles as building power stations that are idle most of the time proves expensive and difficult to sustain. Independently, public interest in next-generation fuel-cell vehicles grows. Top Gear™ decides for its 40th anniversary edition in 2017 to celebrate a widening range of 'reassuringly expensive' high-performance hydrogen fuel cell vehicles now in reach for wealthier consumers in both the West and the rapidly rising economies of Asia.

Building on earlier small-scale collaborative programmes, an alliance of car companies, energy companies, and hydrogen industry suppliers formed in 2020 secures support and incentives in several countries for substantial programmes to build hydrogen infrastructure. Policymakers recognise the pressing need to secure stable and affordable electricity supplies and to reduce emissions from urban transport. The prospect of a more flexible, efficient, and clean energy system from integrating fossil fuel use with carbon dioxide capture is also attractive.

Complementing on-site production in areas of heavy industry, which encourages economies of scale, local and then regional grids develop. Hydrogen production, primarily from gas, increasingly becomes integrated with the electricity system. Whilst some hydrogen use remains hidden as energy storage at power stations for times of low demand, its end-use as a direct energy carrier becomes obvious in society in transport and distributed power generation. By 2060, transport uses of hydrogen overtake industrial demand, with passenger cars being the primary force that stimulates uptake. Freight road transport follows later.

By the end of the century, it is possible that hydrogen has risen, phoenix-like, from its position at the beginning.



A CHANGING TRANSPORTATION INFRASTRUCTURE

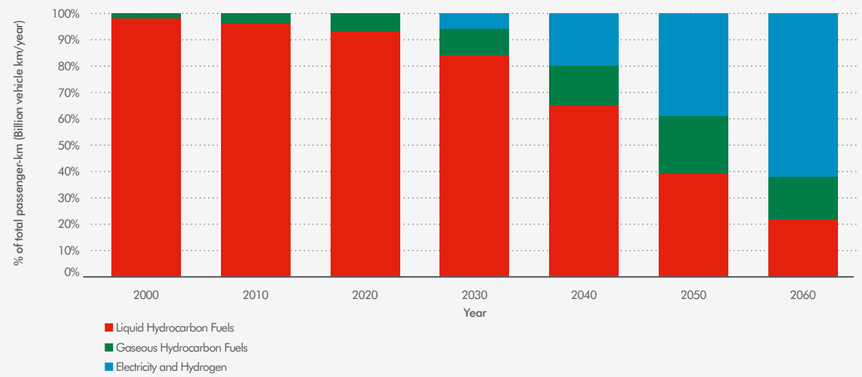
In energy-importing countries with large urbanising populations, like China and India, government policies offer incentives for compact-city development, and large businesses help plan, finance, and execute major projects. Developing efficient liveable cities is seen as a means of moderating potential social unrest, which often concentrates within urban centres. Widespread development of more compact cities offers savings on average of 2,000 vehicle-km per person per year from car use, compared to low-density development common in many parts of the world today. The reduction arises from shorter average journeys as well as a shift to public transport and two-wheelers. Furthermore, policies for compact cities go hand in hand with measures to impose vehicle fuel economy standards – an imposition made easier because the inhabitants of these cities tend to use smaller or hybrid vehicles or purchase electric vehicles (both battery electric and hydrogen). Tailpipe emission standards, anti-pollution measures, fuel taxes, and embedded CO_2 footprint taxes on imports also play a role in driving efficiencies.

In many emerging economies, natural gas (CNG)-fuelled vehicles enter the fleet in increasing numbers. Natural gas (LNG) trucks make early inroads into the market, followed by electrification for some local delivery vans. Compact urban designs facilitate this transition via 'hub and spoke' haulage centres.

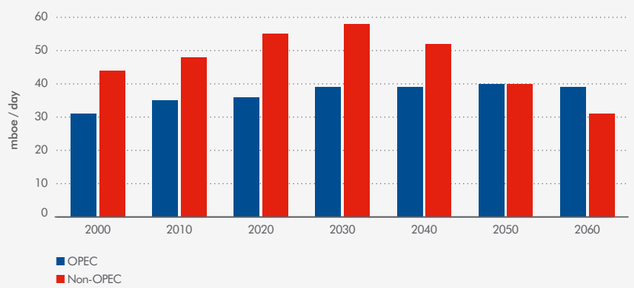
Entirely removing oil from road transport worldwide is a truly colossal undertaking. With reduced growth of travel demand, increased vehicle efficiency, and natural gas, electricity and hydrogen increasingly in use, liquid fuels for passenger road transport decline after a global peak in 2035.

By 2070, the passenger road market could be nearly oil-free and towards the end of the century an extensive hydrogen infrastructure rollout displaces oil demand for long haul and heavy loads. By this time, electricity and hydrogen may dominate, and affordable, plug-in, hybrid hydrogen vehicles offer the ultimate in flexibility and efficiency.

PASSENGER TRANSPORT ROAD BY CARRIER



OIL, CONDENSATE AND NGL PRODUCTION



THE GAS BACKBONE

The story of energy in *Mountains* is the story of the rise of natural gas. In the first decade of the 21st century, exploration success and technology advances have more than doubled the recoverable gas resource base. Tight/shale gas and CBM are the dominant factors in gas resource growth, as a combination of drilling and fracturing technologies have unleashed production.

The development of new resources worldwide is increasingly successful, enabling both supply and demand to grow extensively. This growth is supported by supply-side policy incentives common in a *Mountains* world.

Although there is some uncertainty about the amount of remaining undiscovered gas, tight/shale gas production becomes an increasingly significant portion of the global gas mix, and growth is sustained beyond the middle of the century. For the even longer term, supply-side encouragement of research, development, and deployment at scale enables methane hydrates to be developed. These resources further extend gas supply growth towards the end of the 21st century.

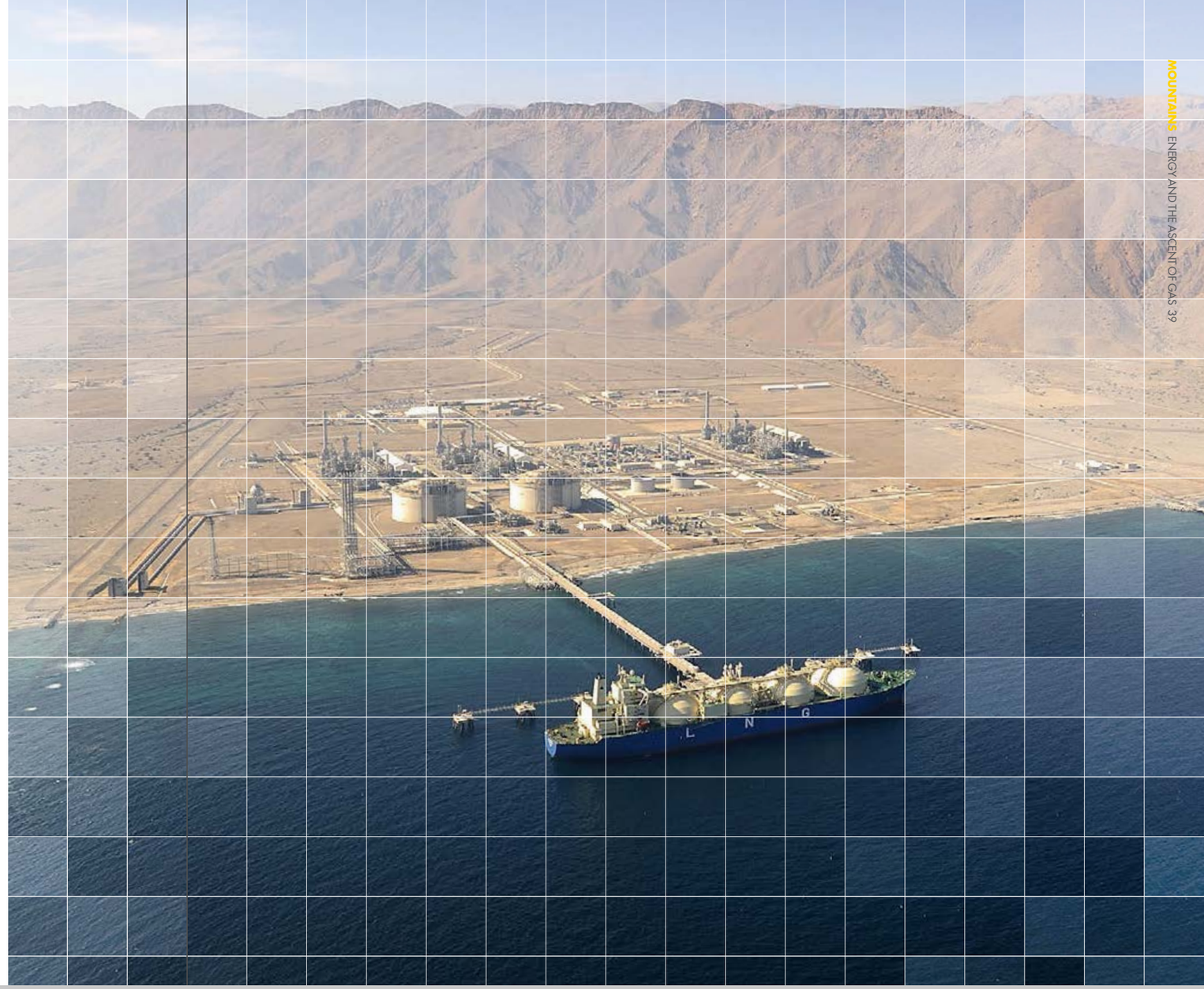
The eight countries that accounted for 60% of global gas production in 2012 continue to increase their share for the next three decades. However, the emergence of new resources creates a new world order of gas producers.

The previously anticipated decline of North American gas production is reversed and China joins the top tier of producers, allowing both of these major energy consumers to reduce their demand for coal and ultimately oil.

Relatively weak global economic growth and the abundance of gas means periods of downward price pressure for producers of all primary energies, and many of them find it challenging to secure desired economic returns. To some extent this is a self-balancing phenomenon, as reduced investment tightens supply once again.

In the oil world, moderate prices put pressure on technically difficult and expensive frontier projects more common outside OPEC. Major resource holder (MRH) countries begin to suffer diminished incomes, and social unrest grows.

While there are responses to popular demands for political reform in some countries, oil prices that are moderate, on average, perpetuate instability and constrict supply. The resulting periodic price spikes strengthen the focus on policies elsewhere to reduce dependence on imports, justified domestically by being 'good for everyone'. However, the intense pressures within OPEC and the need to incorporate growing production from Iraq also result in periodic over-production against quota and periods of price depression.



NEW RESOURCES PLAYS

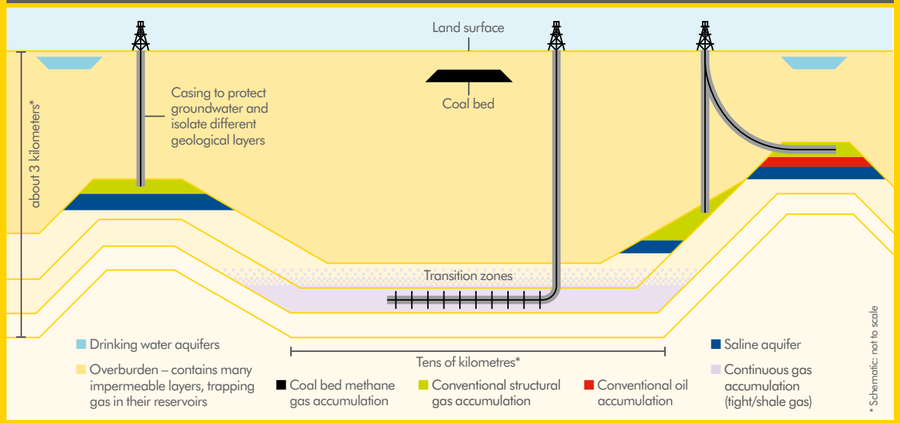
Resources such as tight/shale gas, Coal Bed Methane (CBM) and Liquid Rich Shales (also known as Light Tight Oil) are hydrocarbons that are trapped in largely impermeable rock formations deep underground. This makes them practically immobile and difficult to recover with traditional forms of oil and gas extraction. The rocks containing these resources are very tight sandstones or carbonates, shales, and coals. Production is generally only possible when the rock they are held in is fractured under hydraulic pressure – a process known as 'fracking'.

Tight/shale gas and CBM already form over 15% of global gas production and have the potential to rise to around 40% over time. The total resource base is estimated to be equivalent to about 100 years of current global gas consumption. Liquid rich shale resources are less certain. Currently they account for just 1% of total global oil production and this is expected to build to 5–10% at most. Recent estimates of the global resource base are equivalent to 15 years of current oil consumption.

Sourcing water for fracking may be an issue in areas where water is scarce. Some are concerned that fracking can cause gas to permeate into shallow water aquifers, even though the vertical separation between underground gas and water is typically thousands of metres. In a number of isolated cases, fracking of wells has been associated with small seismic events. Transporting the large quantities of equipment required to develop these oil and gas resources has also caused stresses.

Public and political acceptance of fracking varies from country to country. North America has been most accepting so far, largely because mineral rights belong to individuals, who are free to profit from leasing them. Bans are in place in a number of countries, including France, which is thought to have some of the highest potential in the European Union.

TIGHT/SHALE GAS AND CBM



In this world of geopolitical tension, the US remains the most active guarantor of global public goods, including regional peace, and remains actively engaged in Middle East diplomacy.

The abundance of gas and moderate overall energy demand lead to a plateau in oil consumption in the 2030s and a subsequent decline over the following decades.

Abundant gas also opens the route to the electrification of transport and enables newly built hydrogen infrastructure to provide storage and transport for longer-term and intermittent renewable energy. New gas grids are built fit for transition later to hydrogen – only a small cost premium is required. A hydrogen infrastructure accommodates subsequent fuel cell vehicle uptake. Shipping and road freight haulage begin to shift to natural gas in the form of LNG. In time, the downstream industry see a steady transition away from liquid fuels.

The structure of gas demand changes throughout the century. Historically, its use has been oriented towards heating, especially in temperate latitudes. In *Mountains*, gas moves out of some sectors, such as building heating, over several decades. Later, it may also begin to move out of electricity generation. Simultaneously, new markets emerge, especially for road freight and shipping, as well as petrochemicals. The chemicals market flourishes, in part because of the development of methane chemistry allowing the conversion of natural gas to chemicals.

In the 2030s, natural gas becomes the largest global primary energy source, ending a 70-year reign for oil. Before that, coal's reign as the number one global energy source had lasted around 50 years (circa 1910–1960), taking over from traditional sources of biomass like wood, peat, dung, and agricultural waste. ■

THE SHALE REVOLUTION

Hydraulic fracturing or 'fracking' has the potential to unlock huge volumes of oil and gas – more than has been consumed by the world to date and almost half of the future expected recovery of conventional oil and gas combined. In North America, the gas industry has been turned around. Facing the end of natural gas self-sufficiency in 2008, prices had soared to $12/MMBtu. Today production is up 10%, and the gas price is below $4/MMBtu. The continent faces a long future of energy supply growth with continuing low natural gas prices. Planned LNG import capacity in the US has been mothballed and the blueprints for export terminals are beginning to take their place.

As a low-priced fuel and feedstock, gas and natural gas liquids have the potential to revitalise US heavy industry and to open up new markets in transportation. Peak oil theories have been abandoned as the US enters a new age of production growth, eyeing the possibility of energy self-sufficiency by 2030.

The US has led the world in developing technology in this field and in reaping the benefits of its deployment. Traditional suppliers of oil to the US are diverting cargoes to new markets, and American coal is now exported into Europe as gas becomes the preferred fuel in US power generation.

CAN THE TECHNOLOGY REVOLUTION GO GLOBAL?

Even with technical, social, and environmental challenges to overcome, exploratory drilling is progressing across the world, and successful oil and gas wells have already been drilled in countries such as Argentina. Some reports suggest China may have more shale gas than the US, and wells are being drilled to investigate the potential as this fast-growing economy looks for alternatives to coal. Tight/shale gas has the potential to change the world order in energy.

Concerns have been raised that abundant gas could hinder the advance of the renewable sector, but gas can also act as a backbone fuel as the renewable industry develops and intermittent supply becomes an increasing challenge. Beyond displacing coal to reduce CO_2 emissions, it can serve as a low-carbon destination fuel in conjunction with carbon-capture technology, providing back-up flexibility for an increasing share of renewables.

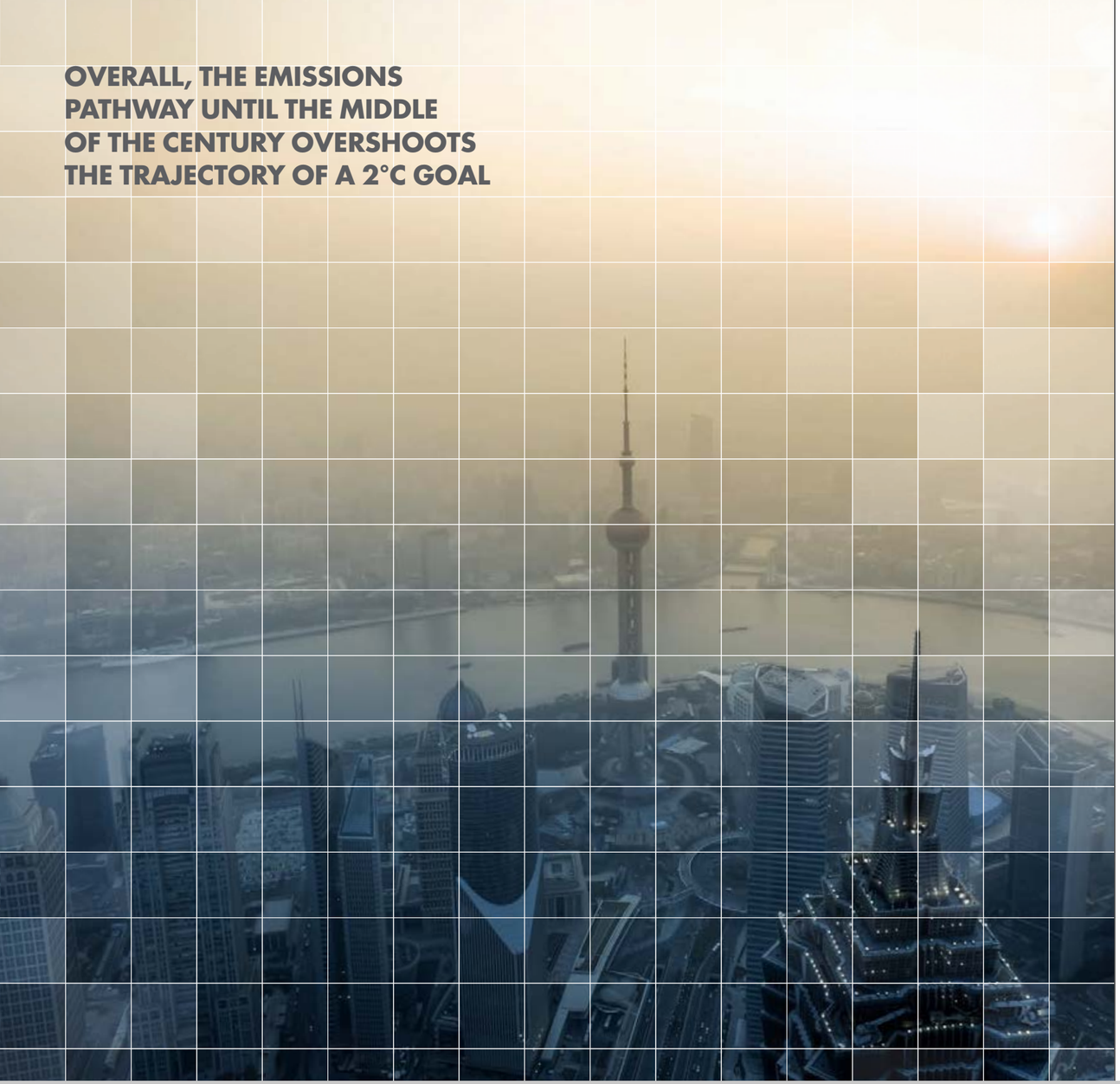
But the growth of resources plays such as shale gas and liquid-rich shales is by no means certain. New technologies, skills, and policies need to be transferred and developed to grow the potential into production.

Development must be done in a demonstrably responsible way to gain public acceptance. The future may be uncertain, but new resources plays have the potential to shape it.

METHANE HYDRATES

A methane hydrate consists of methane gas trapped in ice-like structures of water molecules by a combination of low temperature and high pressure. These hydrates are found abundantly in oceans and also in the permafrost regions of the Arctic in a range of sediments. Extraction methods are in the early trial stages, with the US (Alaska) and Japan taking the lead. Production from easier sources (the Arctic and marine sands) is not expected to start until the middle of the 21st century.

In-place volume estimates vary enormously, with a current technical recoverable range of zero to more than 100 times current annual global gas production.



OVERALL, THE EMISSIONS PATHWAY UNTIL THE MIDDLE OF THE CENTURY OVERSHOOTS THE TRAJECTORY OF A 2°C GOAL

CLOUDY SKIES

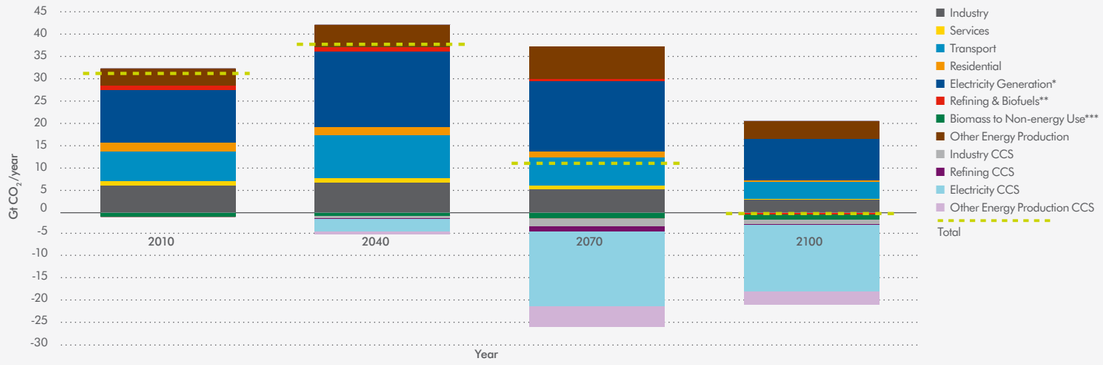
Emissions from hydrocarbon energy use continue to grow through the 2020s, although the moderated pace of economic development has an impact on their trajectory. Of greater significance is the relative displacement of coal by gas in the industrial and power generation sectors. A carbon-neutral electricity sector becomes increasingly feasible as nuclear and biomass contributions grow overall, and the application of CCS technology becomes embedded over the subsequent decades. This process is promoted by a policy mandate in which costs are passed on to consumers. Electricity prices begin to reflect an implicit price for emissions, while explicit carbon dioxide pricing remains patchy and at a low level overall.

Building on plans already in place, the early initiatives taken on CCS blossom and reach over 30% capture of CO_2 emissions from energy by 2050, and 70% by around 2075. This success enables coal to be reintroduced later when the next wave of emerging economies cause demand to surge once again. CCS is also applied to power generation from biomass. The production of second-generation biofuels contributes 'negative emissions' into the system and begins the process of actually reducing the concentration of greenhouse gases in the atmosphere.

Electricity generation becomes effectively zero-CO_2 by 2060. By 2090, these carbon sinks offset the remaining impact of the difficult to decarbonise transport and industrial sectors.

Overall, the cumulative emissions situation by the middle of the century means an overshoot of the 2°C goal, but the expanded use of CCS as a carbon sink later in the period provides a critical component to a potential pathway for managing net global emissions. ■

CO_2 BY POINT OF EMISSION



* Includes Biomass to Electricity which is, in combination with CCS, a 'carbon sink'.
** Includes Biofuels, treated as 'carbon credit'. Emissions from liquids counted in Transport.
*** Commercial biomass, not competing with the food chain.

OCEANS
A VIEW OF THE HORIZON

Oceans is a world in which competing interests and the diffusion of influence are met with a rising tide of accommodation. This trajectory is driven by a growing global population with increasing economic empowerment, and a growing recognition by the currently advantaged that their continued success requires compromise. Steady reform of economic and financial structures keeps pace with the development of fast-emerging nations and progressively unlocks the productivity of broader sectors in society. But volatility and multiple constituencies impede policy developments in other areas, so tight resources are unlocked primarily by market forces.

At first, economic pressures strain social cohesion, forcing changes in economic and political structures. Reforms raise aspirations and, when they are successful, also raise expectations for further shifts in welfare, social structures, and significant international institutions. Aspirations rise and expectations of continued improvements in quality of life become locked in. Globalisation strengthens; developing countries sustain their catch-up growth trajectories; and the key fast-emerging economies move to more balanced growth.

Gradually increasing stresses around food, water, energy and other resources become a new focus for social and political tension. Political churn and the growth in empowered constituencies now hamper policy development, and resource scarcity is addressed almost completely through market forces acting within old policy frameworks that price externalities inadequately.

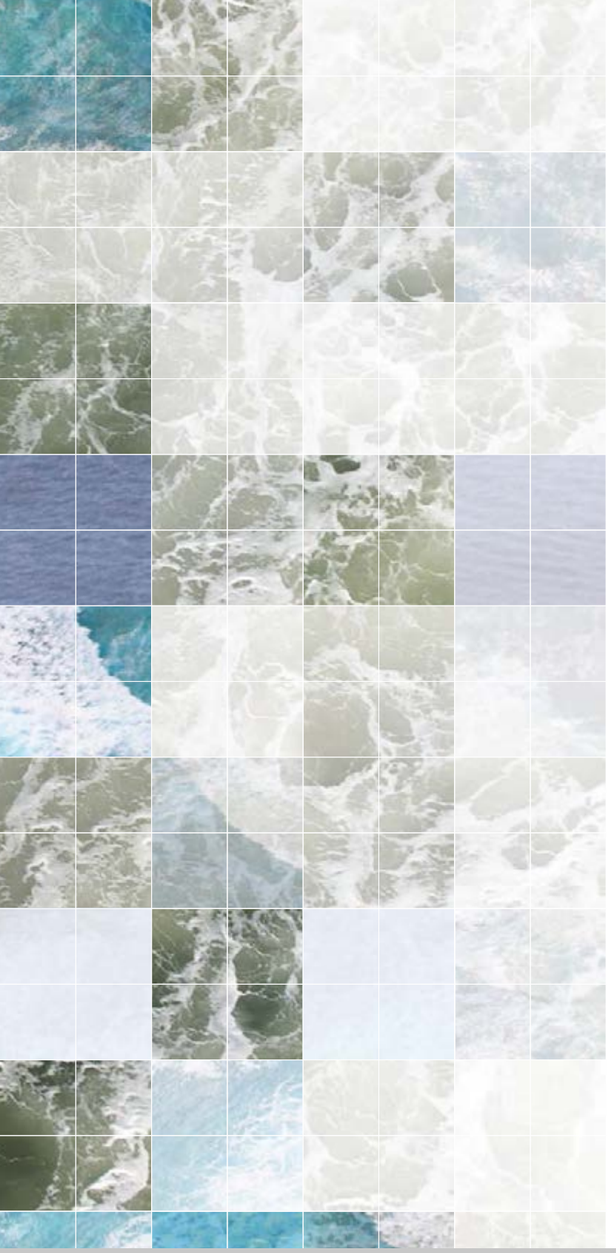
With emerging economies continuing to surge and boost energy demand, and without effective policy mechanisms in place, demand begins to squeeze supply. The noose is tightened further when tight/shale gas and CBM production do not meet initial expectations, with relatively limited success outside North America – partly because of patchy policy support and partly because of geological and technological disappointments.

Growth in oil production from a few major resource holders is also initially constrained in *Oceans* as leadership transitions take their toll. But investment ultimately picks up once stability is restored. Periods of high oil prices unlock new resources and technology options and a long oil game ensues.

With gas volume growth more modest than anticipated, coal maintains a strong role in heat and power generation. Resource stresses become severe, and high prices plus crises eventually stimulate strong demand-side investment in utilisation efficiency. These measures are not sufficient to address environmental concerns, as greenhouse gas emissions follow a pathway towards a high degree of climate change and the need for significant adaptation. ■

OCEANS AT A GLANCE

- New or competing economic and political interests are accommodated intermittently.
- Reform unleashes new economic productivity and increases aspirations for further reform.
- Empowered constituencies with new vested interests hinder secondary policy progress until resource stresses become acute e.g. urban growth sprawls, carbon capture and storage is delayed.
- Rising prices unlock more expensive energy resources and drive end-user efficiency.
- Liquid fuels and coal continue to play a leading role in the energy mix until solar overtakes in the latter part of the century. Natural gas grows but undershoots high expectations due to inadequate policy frameworks and resource disappointments.
- Greenhouse gas emissions peak and remain high for a prolonged period until reduced by the combination of biomass, CCS, and solar.



PROSPERITY

Institutional reforms are initiated or accelerated in political, fiscal, legal, and financial systems through a combination of responses to the growing frustrations of the middle classes and the foresightedness of the currently influential. In nations where there is insufficient compensation for the relative shifts in privilege, abrupt or even violent transitions occur. They destroy capital and discourage investment. Generally, the major fast-emerging economies learn from bad examples and take steps to avoid these problems, and are able to conduct reforms and reset political norms without collapse.

The strength of the developing economies stimulates the advanced economies. Eurozone reforms (involving a reduction in national sovereignty) help to create something of a European renaissance. The US economy is stable but relatively constrained by fierce political polarisation around the role of government.

CONNECTIVITY

In *Oceans*, leaders focus on nation-state issues, in part because institutional reforms are generally concentrated at the national level. A combination of localism and internationalism also develops, catalysed by the power of the digital world to focus both on local audiences and on issues diffused globally. Different affiliations emerge that are consistent with a 'shared fate' ideology, so that even with a focus on national issues, protectionism does not feature as strongly as it otherwise might.

The web spreads, deepens, and remains open. While this openness supports creativity and variety, it also enables a lock-in of perspectives when people choose to explore only what they are familiar with and associate only with 'people like us'. This narrowness of focus is enabled by search engine technology and other users of big data that reflect back to individuals what they have already expressed a preference for. So, even though new coalitions emerge that drive new agendas, there are also a growing number of isolated, excluded, or neglected groups.

Connectivity increases the capacity to improve scientific, business, financial, and supply-chain co-ordination but also increases the capacity to transmit sometimes irrational swings in opinion and diminish trust in institutions around the globe, adding to the volatility of *Oceans*.

LEADERSHIP

In *Oceans*, there is a broadening of leadership participation beyond powerful incumbents. Leaders begin to emerge from the middle classes to represent wider interests, which creates forms of social cohesion that better avoid capture by narrow interests.

Some members of the currently privileged recognise the practical and moral significance of investing more in social justice, recognising as well that national resilience generally requires resilience across multiple sectors of society. There is a shift in popular ideology towards highlighting 'intertwined fates', often promoted by scientific and business leaders more accustomed to competitive then collaborative relationships, and amplified by influential faith communities.

The Leadership Paradox sees slow movement at first as fresh political positions are created, but this eventually leads to a number of deep and far-reaching reforms. Over time, however, these reforms actually result in new vested interests that tend to paralyse further reform. Nevertheless, local and national public goods receive a boost for a prolonged period, and even some global public goods are attended to when new political attention permits. ■

A VARIETY OF SHORES

The beginnings of reform heighten aspirations by people for more, and a new – more vocal – politics gathers momentum. Politics – the debate between alternative policies and the settlement of conflicts of interest – overflows beyond agendas set by government. It is driven by the awakening of an increasingly vigorous civil society to challenge government and seek solutions to problems that lie outside public control. In *Oceans*, to appear too closely allied to one side more than another, (whether business or political interest), is to risk losing influence amongst emerging leaders.

- The debate on education takes place between parents from different backgrounds who wish for the best possible outcomes for their own children and increasing numbers of non-parents who resent the emphasis of its provision at the expense of other services.
- The debate on climate change takes place between the older generation that has presided over the problem and a younger one that aspires to find solutions and reverse its potential impacts.
- Financial elites are challenged on the streets of London and New York.
- Autocratic regimes are challenged by IT-empowered 'netizen' communities.

THE RISE OF 'NETIZENS'

In an increasingly networked world, people power drives politics to set the terms within which markets operate and to bend the state to their will. The focus falls on individual and collective rights, which are upheld against the state, rather than on the individual's responsibilities towards the state. Reversing John F. Kennedy's famous challenge in his Presidential inauguration address, people ask what their country can – and should – do for them, rather than what they can do for their country.

Non-governmental organisations (NGOs) are revitalised, although mainly those that extend their focus beyond isolated issues and embrace a systemic, far-reaching approach. In contrast, public scepticism about the honesty and effectiveness of politicians and their attendant bureaucracies is widespread. Big business falls into the same category of distrust. Suspected of being locked into an incestuous relationship with government, it is often seen as 'politicised'. In the unrelenting glare of public perception, companies and governments stand or fall by their reputation, whether justified or not.

Information technology emerges as a powerful social force and provider of alternative interfaces to governments and around which collective identities coalesce. This development challenges national governments which seek, ultimately ineffectively, to control these networks. The information revolution raises expectations and demands, fuelling the drive for improvement while inflaming resentment against established structures of social control seen to be holding people back. These populist forces well up in *Oceans*. They generate new ideas and new pressures, but sometimes promulgate narrow and selfish views.

TARA AND TINA

Globalisation continues but the nature of globalisation – or at least our normative understanding of it – changes. In the 1990s, it was dominated by the hegemony of the US and by the Washington Consensus: a liberal, free market-based approach to running national economies. In other words, globalisation was equated with following an American economic model.

By its very nature, globalisation decentralises influence and diffuses power: as many countries grow by grabbing the reins of globalisation, they stamp their own cultural, social, economic, and political marks onto whatever globalisation promotes. The Washington Consensus begins to be matched in influence by the Beijing Consensus, which advocates an alternative, more state-centric economic and authoritarian political approach. In reality, various models of governance with differing levels of state involvement are in play.

By 2025, the imprint of the US has weakened to such an extent that TINA – 'There Is No Alternative' to the advance of globalisation, liberalisation and technology – has been superseded by TARA – 'There Are Real Alternatives'. This is not a decline in globalisation, liberalisation, and technology per se, but rather a dynamic process in which other states catch up and reap the benefits to an open international order by making up their own rules for how to deal with it. TARA results in a decline in the relative power of the US, which nevertheless continues to set the global productivity and technological frontier.

'Soft power' – the power to attract others and shape other people's thinking through the compelling nature of one's own values and example – is no longer an American monopoly. Other countries and causes provide alternative compelling political and economic models, and assert influence of one kind or another through the soft power that each of them is able to deploy.

"WHAT STRIKES ONE MOST FORCEFULLY IS THE ACCELERATION, THE RUNAWAY PROGRESSION OF CHANGE – OR TO PUT IT ANOTHER WAY, THE COLLAPSING OF TIME. FROM THE FIRST CHIPPED STONE TO THE FIRST SMELTED IRON TOOK NEARLY 3 MILLION YEARS; FROM THE FIRST IRON TO THE HYDROGEN BOMB TOOK ONLY 3,000."

RONALD WRIGHT
A Short History of Progress

Globalised modernity is no longer equated with the model of the US, but, like an ocean touching many different shores, is associated with Asian developmental paths as well as trajectories based on the strong European social democratic tradition. This diverse polymorphic globalisation is expressed through strengthened supranational regional identities in different parts of the world.

THE RISE OF 'MINILATERALISM'

The problems that the global order faces in *Oceans* arise from its increasing complexity and the proliferation of international and transnational transactions. These require co-ordination which existing global institutions find increasingly difficult to manage.

In contrast to large-scale, multilateral approaches of the past, 'minilateralism' – what some have defined as the smallest possible number of countries needed to ensure the largest possible impact – proved to be more effective. Minilateralism enables the speed and flexibility to begin to deal with the deep complexity of global problems. Over time the core group expands to include other parties, becoming universally diffused and extending their legitimacy. In the next two decades minilateral solutions proliferate, keeping globalisation on track.

Forces shaping globalisation come from many diverse sources, leading to volatility and destabilisation as old state structures weaken. The increasing concentration of wealth, often among ethnically defined minorities, leads to confrontations with majority communities among whom they live. This is particularly pronounced in geographies with large populations of young people.

The results are explosive collisions between democracy and populist power on the one hand, and markets (and minorities that are seen to be the beneficiaries of them) on the other. Like the backlash against wealthy minorities, antagonism is directed against a US still perceived as all-powerful. In the cross-cutting currents of *Oceans*, the globalisation of free market democracy engenders destructive and violent reactions that punctuate the course of globalisation and make for a period of volatile transitions as well as economic growth.

The patchwork globalisation of *Oceans* does not necessarily create contradiction. Sometimes the forces work together in a form of synchronicity that recognises shared interests in an open, stable global order. The fluidity of *Oceans* creates room to manoeuvre for contending forces to align and find resolutions that can generate positive-sum outcomes.

Nevertheless, tensions remain – in part because governments are pressed to meet people's rising expectations and demand for social welfare and the provision of public services. Alongside the swift and fluid currents that generate opportunities and expand social mobility, *Oceans* continues to induce turbulent stresses and shocks.

The coming decade is characterised by a delicate balancing act. In the domestic sphere, a restive civil society no longer wishes to be constrained by the state; but it still looks to the state to provide the security and the services which form the essential basis for markets to operate effectively. In the international system, sovereignty is constrained in a world of globalised markets and assertive civil societies.

In this world of revitalised globalisation, states still assert sovereignty. Many resist attempts to impose legal and ethical rules on 'universal' issues such as human rights and sometimes find that their traditional values conflict with their global obligations.

THE NEW MANDARINS

By 2030, the world order is held together by global, nationally disembodied, economic relationships. There is a drive to open national borders, underpinned by a belief in market efficiency, which is constrained in turn by concerns over social cohesion and the downside effects of global markets. These are mitigated to some degree by economic growth, keeping discontent in check, as developing countries close the gap with developed countries, which also achieve further growth.

Rules are difficult to enforce globally and even harder to agree on. This is a long-standing problem in an *Oceans* world, mitigated somewhat by minilateral initiatives.

As *Oceans* progresses deeper into the century, a new geopolitics begins to emerge from collaborations between countries that construct appropriate 'architectures' to regulate global flows. These are built on technocratic linkages between international and national bureaucracies. It is neither meetings of government ministers, nor for that matter meetings of global non-governmental organisations, that define the international system. Rather, it is transnational networks of practical technocratic co-operation that drive progress. These networks link bureaucracies that have few shared values, and do not see the need for them. Nor are they prepared to sign up to any universal political or economic template.

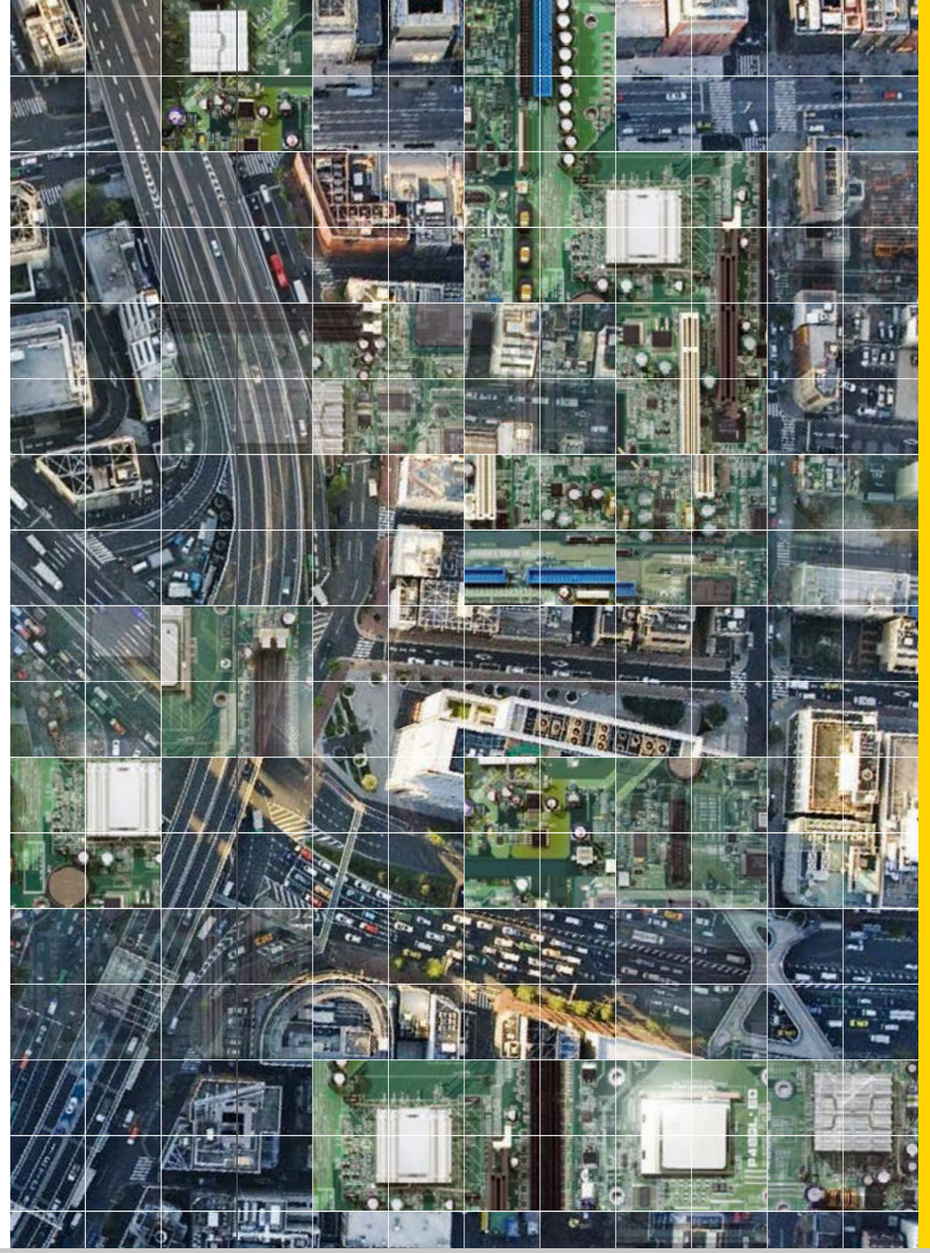
The New Mandarins suffer from a lack of global democratic accountability, but at the same time there is no one global authority to enforce their diktats on others. The ethos may be summed up as 'dull, but important – and it works'.

Moving further into a world of increasingly finite resources and growing environmental stresses, stronger countries are typically not the large ones, but the more nimble, medium-size players that are economically efficient and that have embraced radical pathways to economic sustainability. They include Japan, led by a generation of youth who recognise that less can be more, as well as South Korea, Norway, and a revived European Union that gives its member states the room to manoeuvre.

Larger countries are challenged to decentralise and innovate in order to pursue sustainable growth. By the 2030s, the US has managed to refresh and revitalise its traditional innovative strengths. China too has reformed its governance model, creating a 'new China' with the space for innovative vigour, driven by a dynamic entrepreneurial wave.

Civil societies are empowered by technology as never before. But the influence of civil society on global structures is mixed. Social organisations use new forms of communication and media to advance their agendas and to increase their influence over global issues. These agendas range from the liberal and democratic to the narrowly intolerant and even criminal. Like their counterparts today, global media networks disseminate information, global views, and parochial intolerance with equal vigour.

Even so, at the heart of the *Oceans* story are communities defined by geography, interests, or capabilities. They form the base of the whole geopolitical structure. It is their decisions and their ability to collaborate and to engage globally that determine the fate of this global edifice. ■



A NEW WORLD ORDER

"A new world order formed by horizontal and vertical government networks could create a genuine global rule of law without centralised global institutions and could engage, socialise, support, and constrain government officials of every type in every nation. In this future, we could see disaggregated government institutions – the members of government networks – as actual bearers of a measure of sovereignty, strengthening them still further, but also subjecting them to specific legal obligations … It would be a world order created by, and composed of, disaggregated state institutions, allowing nation-states to evolve in ways that keep up with changes in the private sector and that expand state power. It would be an effective world order, in the sense of being able to translate paper principles into individual and organisational action. To be truly effective, however, it would also have to be a just world order, as inclusive, respectful, tolerant, and equal as possible."

PROFESSOR ANNE-MARIE SLAUGHTER
Princeton University
A New World Order, 2004

ECONOMIC SWELLS AND TROUGHS

TRANSFERRING THE WEALTH OF SUCCESS

The Scandinavian countries are often the most successful in reconciling their social and fiscal models with the increased levels of globalisation of the *Oceans* world. Even so, equality remains as much an elite-driven process as it is a reflection of upheavals from below. In this world, the largest economies are relatively poor, and additions to the global labour force come principally from south Asia and sub-Saharan Africa.

In advanced economies, success remains distinguished by the system of education. This is underpinned by equality of access to the highest-quality education, effective mechanisms for lifetime learning, and a high minimum standard of education for all residents. Successful countries manage to overcome formidable political challenges inherent in shifting resources like financial and medical security, from the swelling population of the old to the young. It is a difficult shift, even in a closed economy, but especially in a globalised world.

Room to manoeuvre is accomplished through a complex mix of decentralisation and fiscal transfers. Medium-sized open economies find it easier to adapt to these challenges than the large continental economies, with G20 nations ending up at the rear rather than in the vanguard of social innovation.

After a rocky transition, societies that can meet these challenges and provide productive, competitive employment for their labour force are rewarded with faster growth.

EMERGING MARKETS: NEGOTIATING THE 'MIDDLE INCOME TRAP'

In *Oceans*, the emerging markets that shift to more inclusive social organisations enjoy a growth dividend that allows them to avoid the 'middle-income trap'. They sustain their evolution towards advanced economic status in large part because they have so far to go, whether in catching up with technology or in urbanisation. Some of the sustainable growth happens because of favourable demographics. A defining feature of *Oceans* is the success of India and China in moving to an empowering, inclusive economic system as they become richer. In this scenario, Asia continues as the most dynamic region of the global economy.

As the large, relatively poor economies of Asia hit their stride domestically and in terms of regional security, an urbanisation-driven boom in infrastructure investment develops. This boom includes family dwellings and is comparable to the infrastructure growth in the US, Western Europe, and Japan in the 1950s and 1960s.

While a significant part of this boom is publicly funded, financial intermediation plays an important role, including cross-border investment through equities and bonds. In order to safeguard against the problem of herd behaviour and sudden stops in capital flows, a BRICs infrastructure bank is created, as well as other new mechanisms of credit enhancement. New lenders provide competition to the US and European international financial institutions, and by mid-century, New York and London share their market primacy with Singapore, Shanghai, and Mumbai.

To accommodate resource transfer from abroad, many Asian emerging markets accept moderate deficits and appreciation in their currency exchange rates. The rise in the value of their currencies exerts a pressure on employment growth, which is still heavily dependent on exports.

DISTURBING THE MONOPOLY OF THE ELITE

In sub-Saharan Africa and many south and south-east Asian countries, pressures from rural and religious dissatisfaction disturb the monopoly of the elite. A number of countries, Ghana for example, make steady progress. For others, improvements in governance and infrastructure either do not survive or do not yield any improvement in economic outcomes.

While *Oceans* is a world in which emerging markets grow and prosper, the volatility inherent in rapid transitions creates uncertainty, especially for established investors with a lot to lose. ■

A MILLION MUTINIES

LEADERSHIP

V.S. Naipaul's perceptive 1990 review of Indian society, *A Million Mutinies Now*, argued that after millennia of a suffocating social hierarchy legitimised by the caste system, the combination of independence, affluence, and democracy was triggering a widespread questioning of traditional order and authority – a *million mutinies*. As a novelist and diarist, Naipaul was primarily concerned with the human and political implications of these upheavals. His thesis also carries important economic implications for the unleashing of entrepreneurialism and human productivity, and these implications, at least in the case of India, have become clearer since his work was published.

"GREAT EMANCIPATORY GAINS FOR HUMAN FREEDOM HAVE NOT BEEN THE RESULT OF ORDERLY INSTITUTION PROCEDURES BUT OF DISORDERLY, UNPREDICTABLE, SPONTANEOUS ACTION CRACKING OPEN THE SOCIAL ORDER FROM BELOW"

JAMES C. SCOTT
Two Cheers for Anarchism

TWO GILDED AGES

PROSPERITY

There are different, but intertwined Gilded Ages taking place simultaneously around the world. On the one hand, there is the New Gilded Age of the US and much of the English-speaking developed world; on the other there is a first Gilded Age for emerging countries in the modern era. The latter are taking advantage of the opportunities opened up by globalisation, industrialisation, and urbanisation as the West did in the 19th century, but with more advanced technology and a much more interconnected global economy.

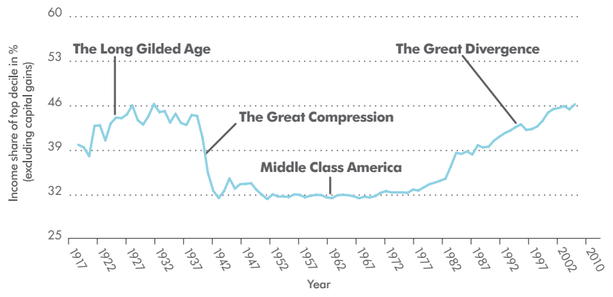
The privileged in the emerging countries benefit most, but this Gilded Age for the developing world is also lifting a large swathe of the population out of poverty into a new middle class. Elites in both developed and developing countries now interconnect, both reaping profits from the urbanising and industrialising workers of the developing world. It is the workers of both worlds, as they move up the economic ladder, who are most squeezed. The digital economy, meanwhile, which was meant to replace the industrial economy of the West, generates fewer and fewer jobs.

The collision of these two gilded ages is creating intense political and social pressures. Change is always disruptive, and the gains from this shift are unequally distributed. There may well be a reset coming in the Gilded Age of the developing world. Early signals of this are appearing in widening income and social inequalities and the increasing anger and outrage of the new middle classes. They perceive abuses of power and corruption by their governing and business elites, who come together in crony capitalist relationships. We can expect convulsive change before any point of reset is reached.

WILL THERE BE LESSONS FROM HISTORY?

The original US Gilded Age led to the 'Progressive Era', marked by the presidency of Theodore Roosevelt from 1901, after public opinion, concerned about the exploitation and abuses of the time, began to push back against its excesses. A more activist government addressed the interests of small business, farmers, and labour movements, seeking to clean up the political process and curb abuses by breaking up large businesses and monopolies. The work of journalists and activists such as Ida Tarbell was seminal to this movement. But it was not until President Wilson's introduction of estate and income taxes and his reforms against trusts, followed by Franklin D. Roosevelt's New Deal, that income inequality began to be compressed. The New Deal effectively ended the Gilded Age and gave rise to a society of broadly shared prosperity and a period of stable growth that continued until Reagan's era in the 1980s, when social and economic divides began to widen again.

THE US GILDED AGE AND BEYOND



Source: Thomas Piketty and Emmanuel Saez, amended Paul Krugman

THE WIDE WAVES OF ENERGY DEMAND

While emerging economies continue to surge and energy demand grows, the resulting supply/demand tightness is further constricted by lagging energy policies.

Outside North America, tight/shale gas and CBM have limited success due to a combination of policy, geological and technological disappointments.

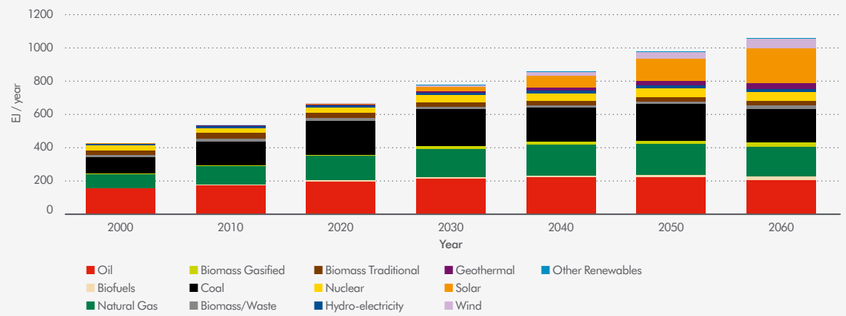
As leadership transitions take their toll on investment, oil production from some Major Resource Holders is also initially constrained. Hence *Oceans* is a particularly high oil and gas price world. This economic reality leads to the unlocking of new resources and technological opportunities, invoking both a 'long oil game' and the rise of solar power to global significance.

Because global natural gas production growth is more modest than anticipated, prices, which remain regionalised, are strong in regions of relative scarcity. Resource stresses become severe. High prices and periodic crises stimulate strong demand-side attention to increase utilisation efficiency. Nevertheless, with strong energy growth and delayed attention to CCS, greenhouse gas emissions follow a pathway worryingly much higher than the 2°C goal, which in turn further increases the focus on adaptation to the effects of climate change.

CHURNING DEMANDS AND CONSTITUENCIES

The global financial turbulence of the early 21st century introduces a prolonged period of structural economic and political reform, or even more dramatic resets where tensions are not resolved. These developments underpin the recovery of global economic growth, and hence the strong re-emergence of underlying energy demand. Population growth plays a role, but much more significant is the continuing, sometimes turbulent, development of most of the currently fast-emerging economies through the 2020s and 2030s. Development in these countries is followed by subsequent development waves of today's poorer economies. The rising tide lifts all boats, however unevenly.

TOTAL PRIMARY ENERGY BY SOURCE



SUSTAINABLE CONSUMPTION

In today's world of 7 billion people, inequalities of income and energy consumption are stark. Hans Rosling highlighted this gap, pointing out that 2 billion people live under the poverty line of $2 a day. The remaining 5 billion people divide into three groups:

- Three billion live with less than $40 a day, which allows basic electricity consumption in their homes – a light bulb and maybe a stove.
- One billion live with less than $80 a day – enough to run a washing machine.
- One billion have comparable lives to the developed world and are able, for example, to afford to fly on holiday.

Paradoxically, those empowered by economic and financial policy reforms are responsible for delays in energy reforms. The combination of delayed energy policy responses, rising demand, and a number of supply disappointments leads to high and rising real energy prices.

The shift in global energy demand is dramatic. In 2000, OECD member countries comprised 55% of world energy demand. However, with China's rise, the OECD's share was down to 45% by 2010. The shift from West to East continues in *Oceans*, and the OECD's share falls to around 33% in 2030, with significant impacts on trade flows of energy around the world.

Through deep-seated structural reforms, fast-growing emerging economies succeed in making an early transition from heavy into light industry. They build a larger service sector economy, in keeping with an emerging pattern of de-materialisation throughout the world. Pressure on resources generates prices and economic incentives for efficiency, recycling, and reuse. Heavy industry recycles steel and aluminium, many houses use heat pumps, and appliances become dramatically more efficient.

By the end of the century, one-third of chemical feedstocks may come from recycling and reuse, and the overall efficiency of the global heavy industry sector increases by 80%.

There are substantial efficiency gains in buildings, as the percentage of passive houses and heavily retrofitted homes within the overall stock increases. With a high fuel-price environment, the economic value of capital-intensive energy improvements is high. Residential energy efficiency improves by 60% on average by 2060 and possibly 90% by 2100.

Even in many poorer countries, higher personal incomes still allow a straight switch to photovoltaic solar energy (solar PV) in the residential sector at the expense of traditional biomass. The sheer quantity of localised generation technologies and the improved efficiency of electrical appliances leads to large-scale electrification.

Outside North America, with resources eventually disappointing and policy support patchy, new resource plays enjoy only limited success. The global road passenger market struggles for alternatives to liquid fuels like natural gas and electric or hydrogen vehicles. Alternatives do not make significant inroads over the next two decades, in part because of impressive technological advances with internal combustion engines that keep gasoline and diesel-fuelled cars ahead of the pack.

"…SIX OF THE THIRTY-ONE PROVINCES, MUNICIPALITIES AND REGIONS OF MAINLAND CHINA WOULD RANK AMONG THE WORLD'S THIRTY-TWO LARGEST NATIONS IN TERMS OF PURCHASING POWER. SHANGHAI IS ON A PAR WITH SAUDI ARABIA."

JONATHAN FENBY
Tiger Head, Snake Tails, 2012

Car manufacturers compete over advanced combustion engine technologies, and further efficiency gains for gasoline and diesel vehicles follow on from widespread adoption of hybrid technologies. Smaller batteries for hybrid vehicles (as opposed to the larger batteries needed for plug-in vehicles) prove more affordable to new car buyers concerned with high fuel prices. High prices and ageing populations in many countries lead to some downsizing of vehicles. Advances in materials science and petrochemicals provide spin-offs for lighter vehicles. The fight back of gasoline and diesel vehicles against substitutes succeeds despite higher oil prices, as the cost per kilometre remains affordable.

Over the longer term, higher oil prices provide support for more expensive oil resources to be developed and for biofuels to break through at scale. By mid-century, liquid fuels are still delivering 70% of road passenger-kilometres.

Oil demand grows through the 2020s and 2030s before reaching a long plateau in the 2040s. Strong growth in biofuels means that total liquid fuels continue to grow until 2060, giving rise to the long oil (and liquid fuels) game. By the end of the century, however, biofuels meet about two-thirds of all transport demand for liquid fuels, and oil is mostly used as a petrochemical feedstock, where its value tends to be highest of all.

BIOMASS IN OCEANS: THE FARMING OF ENERGY

Biomass, like hydrogen, plays a linchpin role in the long-term future of lower carbon energy systems. In the *Oceans* scenario, economic incentives align with consumer and business preferences to build biomass into one of the most valued energy-related options, first in transport, and later as a feedstock for manufacturing plastics.

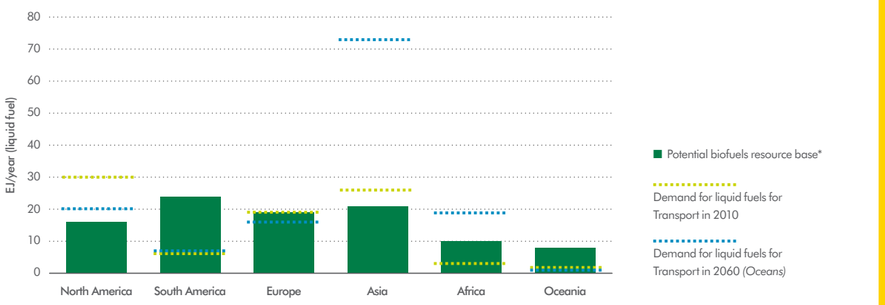
High oil prices in *Oceans* not only stimulate production of more difficult oil supplies, they also provide incentives for biofuels producers. First-generation biofuels grow steadily, reaching a peak at just over 4 million boe/d in 2050. As more stringent sustainability criteria are applied, crop types and locations around the world shift, mostly to more tropical production of sugar cane ethanol. But it is with the development of second-generation biofuels (derived from the non-food/waste crop) that production takes off. These biofuels start commercial production in the 2020s, and by 2050 production globally is catching up with the first-generation biofuels.

Even though handling biomass as a feedstock is much more difficult than dealing with oil and gas, bioplastics gain widespread consumer acceptance and also emerge at commercial scale due to surging demand for materials. By 2060, almost 10% of all petrochemical materials are derived from biomass, potentially rising to 25% by the end of the century.

In developing countries, electrification adds some further support to commercialising biomass. The growing success of solar PV enables householders to jump straight from using traditional energy sources (agricultural waste, wood, peat, dung) to using electricity in the home, even for much cooking. The weakening demand for traditional biomass leads a number of local communities to develop biomass on a more commercial basis. By the end of the century, traditional biomass use for energy has largely disappeared.

While limitations to the resource base eventually constrain the contribution of biomass in the very long run, its place is still substantial, with different forms of biomass supplying nearly one-fifth of total primary energy at the end of the century. By that time, biofuels also provide two-thirds of all transport requirements for liquid fuels. Carbon capture via bioplastics and the integration of biofuels production with CCS eventually offset all remaining fossil energy CO_2 emissions in the world energy system.

BIOFUELS POTENTIAL COMPARED TO LIQUID TRANSPORT FUEL DEMAND



* Resource base maximised for 2nd generation production
Source: Ecofys study for Shell

LONG LIQUIDS AND THE RISE OF SOLAR

Energy in *Oceans* continues on its recent path, with a combination of exploration success and technology advances, supported by increasing oil prices.

The improved capability to drill in ever harsher environments enables access to deeper water and the Arctic; enhanced oil recovery techniques become increasingly viable; fracking and drilling technologies allow the development of light tight oil and liquid-rich shales in those rock formations that prove to be attractive. The high oil price environment and increased technical capability to produce extra-heavy oil in places like Canada, Venezuela, Russia, and Kazakhstan unlock the potential for these resources.

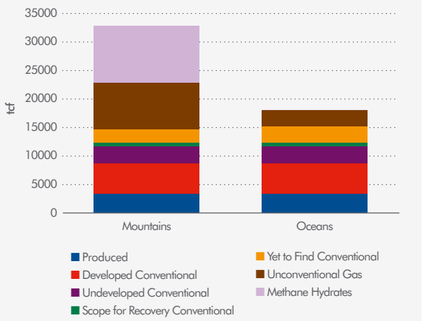
In *Oceans*, the countries that produced more than 75% of current global oil production in 2012 find their share increasing even further. OPEC countries hold the majority of low-cost growth potential, and increase recovery further with more expensive technology. However, such developments are initially limited by geopolitical instability and a resulting underinvestment in most OPEC countries.

In time, OPEC's spare capacity buffer is eroded, and markets adapt to higher price volatility and new commercial and strategic stock management. In the longer term, sufficient stability returns to OPEC for investment to pick up, but the stretch to meet strong demand growth keeps prices high, enabling the development of the higher-cost conventional and resources plays outside OPEC.

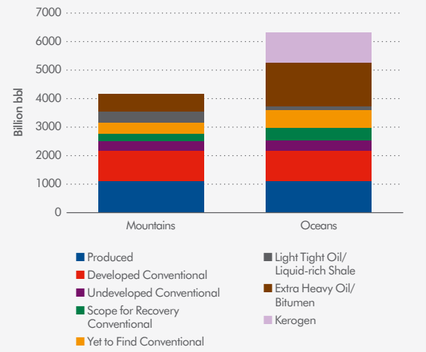
By the 2030s, the US has seen a steady decrease in imports in overall oil volumes, partly because of the increase of supply and partly because of fuel efficiency standards. Rising prices have helped moderate demand. There are, however, significant misalignments between the growing significance of liquid rich shales and the configuration of refineries and pipeline systems, so that imports and exports of refined products or crude oil are still required. Price shocks still transmit to North America, and there remains a national interest in the stability of the global energy system for wider foreign policy reasons.

The production of natural gas continues to grow, building on developments in North America. However, the great expectations so many held for the development of tight/shale gas and CBM globally are not fully met as developments prove too difficult or economically recoverable volumes too low.

GAS RESOURCE BASE



OIL RESOURCE BASE



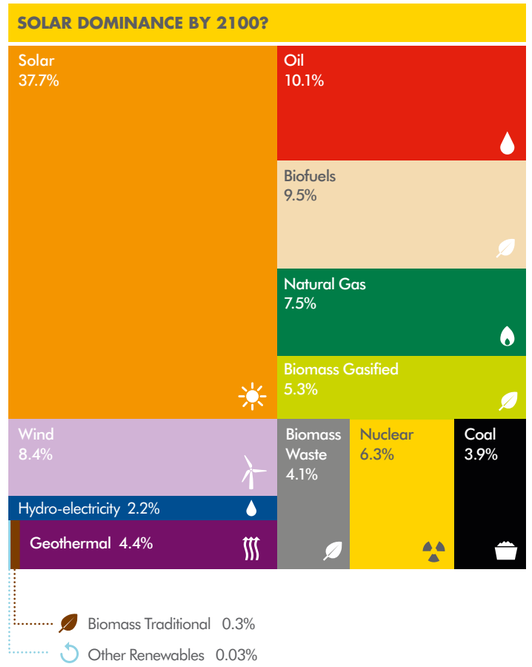
Despite its environmental impact, coal remains the most economic energy-security backstop for power generation, at least until mid-century. From that time, the increasing incidence of extreme weather events leads to sufficient international agreement on climate policy to drive significant investments in CCS and to put the brakes on coal. With the advance of CCS, global growth in coal demand returns again by 2050, as newly developing countries enter their most energy-intensive phase of development. In the absence of supportive policy regimes, nuclear power struggles to grow in most countries.

Rising prices and demand promote continuing strong growth in renewable energy. Biofuels become increasingly significant in sectors like mobility where there is a continuing reliance on liquid fuels because of the lack of credible alternatives. In other sectors, renewable resources that need large-scale or popular consent – such as wind farms and geothermal energy schemes – continue to face opposition.

These conditions favour distributed solar PV becoming a leading source of primary energy in the global economy. From its position today as the 13th largest energy source worldwide, it grows rapidly, reaching fourth place behind oil, gas, and coal by 2040, and continuing to the number one position in 2100. The sun rises to create solar energy dominance in the global system.

The rise of solar is due, in part, to public pressure that leads governments to prioritise it in the electricity 'merit order'. Grid integration is accommodated by more variable running of other forms of electricity generation through the day – notably hydro-electricity, where it is available, but otherwise gas, coal, and biomass. As the scale builds, regulators are forced to pass on these higher grid-balancing costs to power consumers. In turn, this encourages end-users to develop local solutions to even out their daily energy supply and demand. While some focus on batteries and others start to store energy as hot water, certain household appliances, like fridges and washing machines, provide the capability to link with a household solar PV supply.

SOLAR DOMINANCE BY 2100?



Small communities build co-operative solar networks, providing further balance in supply and demand patterns.

Balancing the grid over the day is one thing. Balancing it over the seasons is altogether more challenging for solar PV. At the temperate latitudes of many OECD countries, 80% of solar PV electricity is generated in the summer months. Local electrolysis and storage of hydrogen becomes a key part of the solution, particularly when combined with its industrial use. Given the difficulty of high-level international policy co-ordination, this proves more practical than plans put forward for continental scale electricity grids.

So while richer nations are earlier adopters of solar PV, it is in many of the emerging countries, that it thrives

in the long run. By 2060, close to 40% of electricity is generated from solar PV, both within and outside OECD. The figure outside OECD may continue to rise to 60% by the end of the century, and this phenomenal breakthrough is part of a growth in global electricity generation level to seven times the level of 2012.

STORMY SKIES

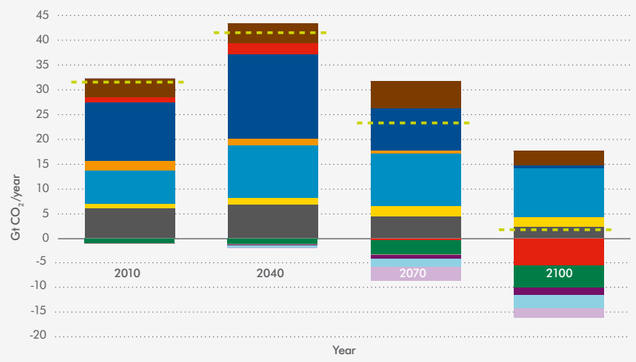
Global economic growth, the continued importance of coal in power generation, and oil in transport accompany the continuing growth in greenhouse gas emissions in *Oceans*. Offset by efficiencies and renewable energy, greenhouse gases reach a plateau where they remain from the 2030s to the 2050s. By this time, the elevated levels of CO_2 in the atmosphere are clearly shown to be linked with the observed increase in extreme climate events. These ultimately drive policy changes and the deployment of technologies that have been on the back burner, and complement sporadic efforts to price emissions.

While there is little widespread deployment of CCS early in the century, CO_2 mitigation is added to the urgent list from 2060 to complement adaptation to climate change effects. CCS grows from 5% of emissions from energy captured in 2050 to 25% by 2075. By the end of the century almost all emissions could be captured, or offset.

Having begun in advanced economies, the impact of CCS very quickly increases in fast-emerging economies. After 2050, it is implemented relatively early in the economic and industrial development phase of newly developing economies, primarily to mitigate emissions in power generation and refining.

The application of CCS to biomass and biofuel power plants becomes the first contribution to reducing overall concentrations of carbon dioxide in the atmosphere. The electricity generation sector becomes carbon-neutral in the 2090s. In the 2070s, however, carbon offsets begin to compensate for continuing emissions from the transport and industrial sectors, which are more difficult to decarbonise. ■

CO_2 BY POINT OF EMISSION



* Includes Biomass to Electricity which is, in combination with CCS, a 'carbon sink'.
** Includes Biofuels, treated as 'carbon credit'. Emissions from liquids counted in Transport.
*** Commercial biomass, not competing with the food chain.

IS 100% RENEWABLE ENERGY POSSIBLE?

One of the most popular questions in debates about the transformation of the energy system is: when will we achieve an energy system based on 100% renewable resources?

In the *New Lens Scenarios*, renewables reach a 30–40% share of total energy by 2060 in *Mountains* and *Oceans*, reaching perhaps 60–70% saturation if the time horizon is extended still further. Some may be disappointed with this figure, but there are good reasons why we will do well to reach even this level.

The first challenge is the geographical location of the renewables resource base, which is often a long way from centres of energy demand. Where there may be large solar resources (for example, the desert), they are often a long way from population hubs, which may also be in different countries or continents. Where co-location is possible, there are other issues too. The massive tracts of land required for wind, solar PV, and other renewables may constrain deployment, with social acceptability of land use a potential issue at high penetration levels. The deployment of these technologies poses particular problems in India and Nigeria, for example, which between them will comprise nearly a quarter of the world's population at the end of the century (on UN mid-range projections) but have only 3% of the world's practically available land.

The second challenge is sector saturation. Modern renewable energy resources primarily generate electricity, but in 2010, electricity made up only 18% of total energy demand. There is a limit to how much electricity can be forced into other sectors. Chemicals require hydrocarbon feedstock, transport (particularly aviation) needs hydrocarbon fuels, and steel manufacturing requires a carbon input.

Eventually, we may see a lot more hydrogen in transportation. But at first that hydrogen will come from coal or gas. Making hydrogen from renewables using electrolysis is currently expensive and thermodynamically inefficient.

The third challenge is cost-competitive storage and transport of energy over distances. For renewables to make a significant contribution to our energy system, some form of storage is needed for the times when supply cannot meet demand, and vice versa. While huge sums are being spent on research already, generation technologies are stealing a march on storage technologies. Storage needs to catch up or it may limit the speed of deployment of renewable generation technology.

Some say that inter-continental supergrids and huge sub-sea cables offer solutions to a number of these problems. Others point to hydrogen, not just as a storage medium, but also as a transportable source of energy in a liquid form. While these solutions are technologically possible, they are all huge cross-border, multi-billion dollar projects. It will take an extraordinary level of international co-operation and vast financial investment to take these steps towards the decarbonisation of our energy system.

Optimism for a completely renewable future needs to be tempered by an appreciation of the significant technological, geographical, and market practicalities, let alone the political and societal challenge required. Yet if the optimism is directed towards a zero-emission energy system, including the successful deployment of CCS and biomass combinations, then that appears a distinctly more feasible option than a 100% renewable energy system.

REFLECTIONS ON DEVELOPMENT AND SUSTAINABILITY

The *New Lens Scenarios* describe plausible developments in the socio-political-economic spheres and then push to explore longer-term energy and related boundaries.

These boundaries reflect possible consequences of each scenario but are not mechanistically linked to them. For example, if the relevant choices are made, it is possible for the robust global economic picture in *Oceans* to be accompanied by some of the energy developments currently ascribed to *Mountains*. This would provide some relief to the more extreme energy and environmental stresses to be found at the outer boundary of the *Oceans* story. It is also possible for the more optimistic assumptions about global tight/shale gas and CBM resources found in *Mountains* to be true in either scenario.

Over the century, cumulative CO_2 emissions are nearly 25% higher in *Oceans* than in *Mountains*, raising severe concerns about ongoing climate turbulence and highlighting the need for directing attention and resources to adaptation. It is, of course, very sobering to consider this 'tight' *Oceans* boundary – but it is also important to recognise that even the 'loose' *Mountains* boundary represents a significant challenge to long-term environmental sustainability. The build-up of greenhouse gases in the atmosphere still exceeds current targets for limiting atmospheric temperature increases to 2°C. This is the case even with lower economic trajectories, rapid displacement of coal by gas, advances in energy-efficient compact urban development, and accelerated deployment of CCS and other technologies.

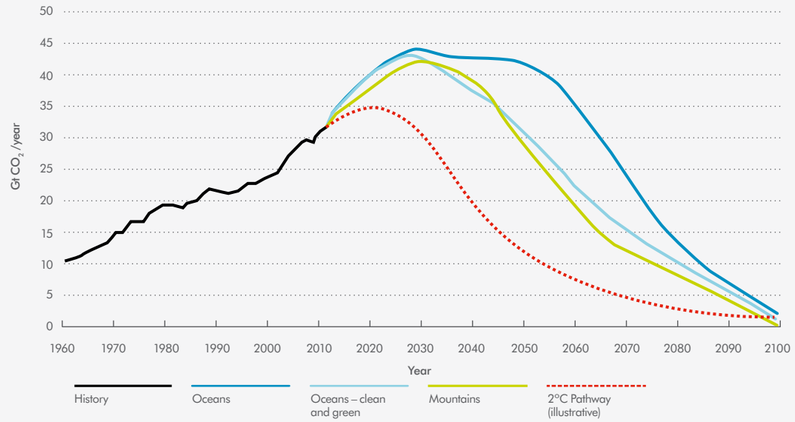
These challenging conclusions highlight the significance not only of the scenarios themselves, but also of the wider dialogue they must contribute to and the choices made as a result.

Economic growth is generally positive in itself, even though it naturally increases pressure on resources. That is a core feature of the Prosperity Paradox. If only sluggish or reactive policy responses are offered in the energy arena, then the trajectory towards the boundary described in *Oceans* will result. It will place severe stress on resource economics and the environment, not just in CO_2 terms but also for fresh water and food resources.

If unsustainable outcomes are to be avoided, the key lesson is the need to accelerate proactive and integrated policy implementation – and emphatically not to argue that poor economic outcomes for the developing world would constrain greenhouse gas emissions. In fact, vibrant economies may well be a necessary catalyst for smart resource policies because environmental concerns tend to fall down the agenda when economies are sluggish.

An impression of the impact of accelerated and co-ordinated policy can be gleaned from the CO_2 Emissions chart. This illustrates a sensitivity analysis in which the *Oceans* global economic trajectory is combined with the resource and supply-side developments explored in *Mountains* and earlier implementation of the utilisation efficiency responses highlighted in *Oceans* (*Oceans – clean and green*). While still not ideal from an emissions perspective, the positive impact is substantial – an encouraging outcome.

GLOBAL ENERGY-RELATED CO_2 EMISSIONS



In this sensitivity, growing demand is initially met by rising fossil fuel supply and the deployment of CCS. By the 2030s, more and more renewable energy sources enter the economic mix at scale, at first to meet incremental demand, but increasingly to substitute for coal and oil. The energy intensity of economic development trends downward as a result of improved urban planning and efficiency gains in energy utilisation.

Together, these developments lead to an energy system built on efficient structures and applications, gas, coal with CCS, and renewable resources. Made up of abundant resources, this system caters to demand, keeps prices affordable, and ultimately reduces its impact on the environment.

One conclusion that can be drawn from the *New Lens Scenarios* is that substantive change will not come about by itself – as a result of pricing signals or policy responses delayed until crises become apparent. A positive outcome requires a series of proactive, far-sighted, and co-ordinated national and international policy developments that, to date, seem beyond the bounds of plausibility.

Once the worst of the current financial crisis has passed, the stark prospect of such negative outcomes for all players should stimulate renewed attention. If these issues are not addressed, the tight boundary described in *Oceans* will begin to become a reality. If, however, the climate consequences accepted by the majority of the scientific community are correct, the boundary described here becomes increasingly unlikely. In other words, the high emissions associated with *Oceans* could eventually lead to a level of climate turbulence that severely damages the economy, dramatically lowers energy demand, and reduces emissions albeit by a negative route.

This work illustrates a hypothetical trajectory for greenhouse gas emissions, with potential disruptions resulting from climatic turbulence that will have an increasingly severe impact on global economic, social, and political conditions. Given uncertainties around potential developments in the longer term, it is not fruitful to build such dramatic feedback loops directly into the core scenarios. Instead we want to be clear about where the trajectories are heading and to support a better-informed dialogue about the potential consequences.

THE STRESS NEXUS: WATER-ENERGY LINKS

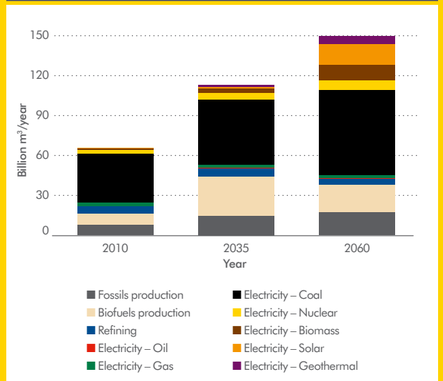
Agriculture accounts for about 70% of global fresh water use, so to explore better water practice through scenarios, it would be necessary to focus on the agricultural sector. Nevertheless, energy providers are among the largest industrial consumers of fresh water.

Water is used primarily for power generation, but it is also needed for drilling, flooding wells, refining crude, and producing biofuels. The International Water Management Institute (IWMI) estimates that the US energy industry alone accounts for 40% of all fresh water withdrawal.

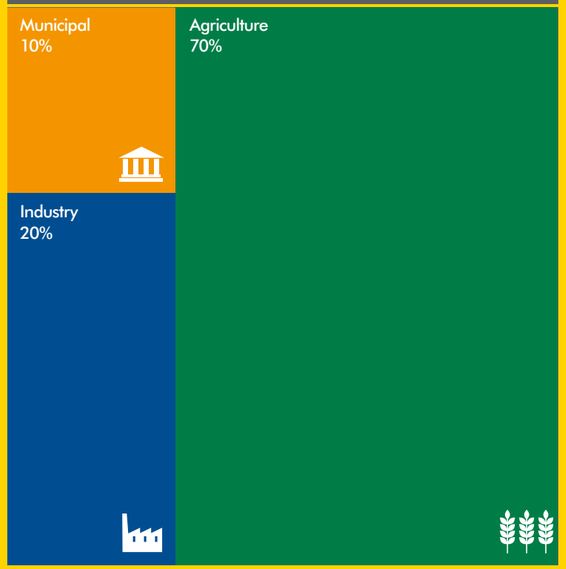
Conversely, energy is required for the supply, purification, distribution, and treatment of water and waste water. CSIS (in their report 'Clear Gold'), state that in some Middle Eastern countries, the energy to desalinate water accounts for 65% of domestic oil use. In the US, 75% of the cost of water comes from energy, and 4% of all power generation goes to water transport and treatment, according to the US Department of Energy.

Looking ahead, our detailed modelling of energy and its links to water indicate that fresh water consumption by the industry more than doubles from now to 2060. This is the case in both *Mountains* and *Oceans*, though the composition is slightly different. The main factors are the growth in coal-fired power generation, although other forms of power generation also play a role. So do biofuels production and the increasing water-intensity of oil and gas production. Fresh water withdrawals, however, actually level off as early as the current decade because of moves to more water-efficient power – for example, the phasing out of once-through cooling.

FRESH WATER CONSUMPTION (MOUNTAINS)



GLOBAL FRESH WATER WITHDRAWAL PER SECTOR



THE WORLD WILL NEED BETWEEN 40% AND 50% MORE WATER, ENERGY, AND FOOD BY 2030

DRAMATIC POSSIBILITIES: URBANISATION

In the 2020s, a series of unusually violent storms leads to sea level surges in Asia, wreaking massive flood damage on major coastal cities. Governments respond by hurriedly building dykes, new storm deflection barriers, and new energy infrastructure, especially wind and solar parks. But a decade later, another series of unusual floods destroy these deflection barriers and infrastructure.

The rich have provided generators and other energy survival mechanisms for themselves, but the poor demand that the government finds a culprit to pay for this round of repairs. In addition, rich and poor alike insist that something be done about the 'root cause' – namely, to reduce CO_2 emissions dramatically within a generation.

In response to this social consensus, fossil fuels are taxed heavily upstream to pay for infrastructure adaptations required by the new climate realities. Eventually, these costs are passed on to the end-consumers, but in the beginning they catch the fossil industry completely off-guard.

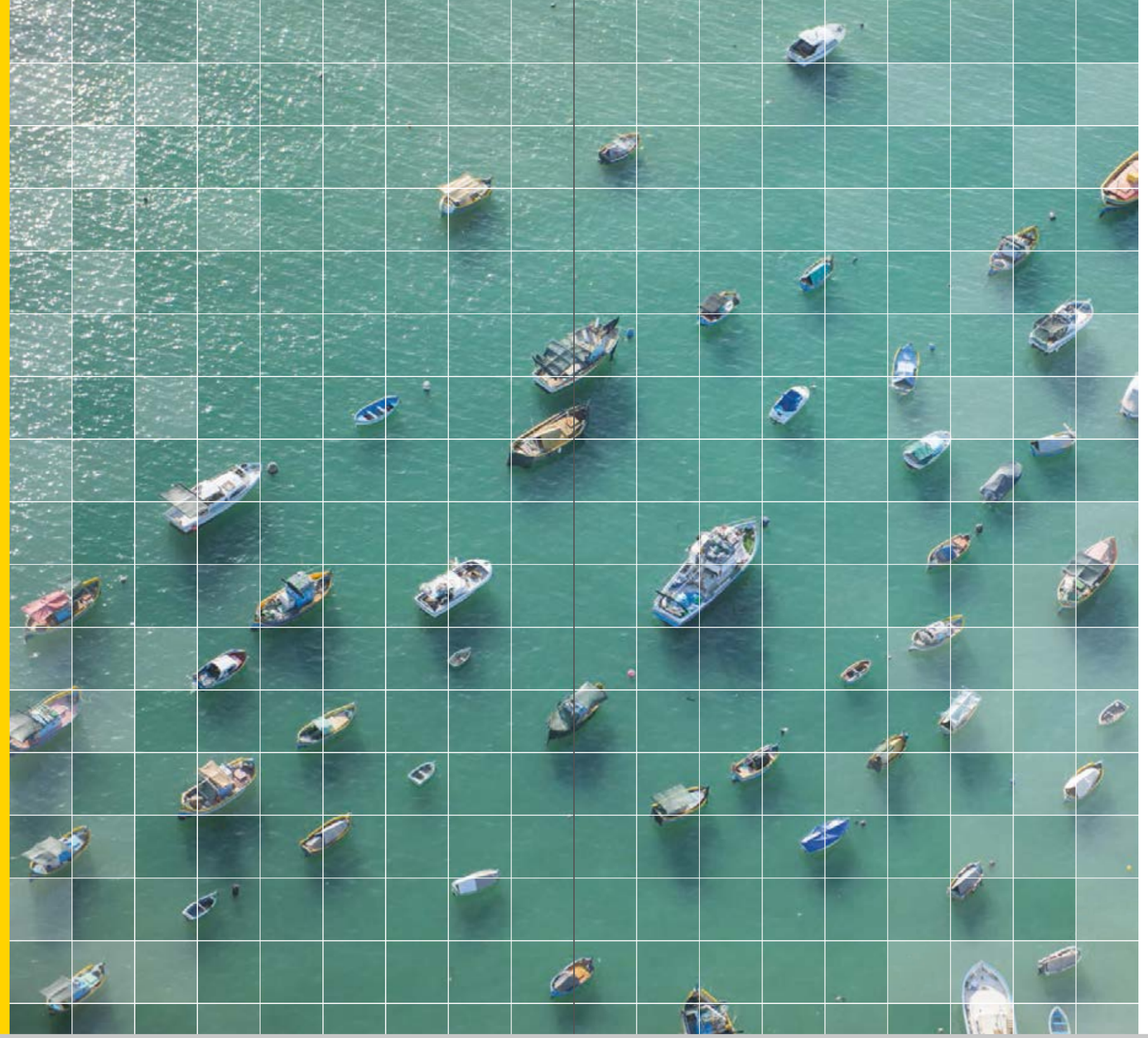
In this new world, gas is preferred above coal, and biofuels are mandated into the fuel mix at a dizzyingly accelerated pace. By the late 2030s, the deployment of CCS is accelerating as well. Regulation for 'appropriate' energy end-use emerges. This includes mandates for building in resilience such as zero-emission housing, integrated solar PV, or wind power and mini-combined heat and power (CHP). Transport demand is reduced by redesigning cities into more compact forms with logistics hubs, giving preference to low-carbon solutions (electrified public transport). These limit the opportunity for car use.

DRAMATIC POSSIBILITIES: FOOD AND WATER

Beginning in the 2020s, a prolonged drought in the US, with excessive rain and flooding in other parts of the world, severely diminishes food production for the next 20 years. Multinational corporations, which own most of the US farmland, begin selling it off in order to go into other, more predictable, business ventures. For poorer farmers in developing countries, the prices of maize, rice, and wheat shoot up.

Extreme weather events affect farms, infrastructure, and global supply lines, and sea-level rise brings saline damage to the Mekong and Ganges. Ocean acidification proves to be just as significant in harming the food chain. Corals, calcareous phytoplankton, mussels, snails, sea urchins, and other marine organisms become unable to construct their calcium carbonate shells or skeletons. Along with changes in sea temperature, their progressive disappearance stresses marine ecosystems to the point where there is large-scale species migration, even collapse.

There are mass migrations of populations that depend on all these sources of food. Governments in many countries respond with irrigation projects and flood protection, where possible, but also by forcible relocation, which proves to be very unpopular. In addition, CO_2 emissions are heavily taxed. China starts taking a lead in CCS by cleaning up its coal power generation, bringing coal back as a formidable competitor to gas in the longer term. Biofuels and other biomass-to-energy forms are reduced, as priority is given to food production.



The current debate on the future of energy is marked by a huge gulf. There are those who project what they understand to be plausible given current realities, the nature of human behaviour, and the range of economic and technical possibilities. Others set an ambition for an outcome that they would like to happen, then demonstrate mathematical feasibility in order to provide encouragement.

From a resilience perspective, the problem with the first approach is that all plausible outcomes appear ecologically unsustainable over the long term and hence becomes economically unsustainable. The second assumes a seismic shift in humanity's attitudes and lower energy consumption starting from today. In addition, the debate on climate change has been heavily contaminated by polarised and politicised ideologies spilling over from historical tensions.

Using some of the language introduced in this book, global climate policy developments are currently buried in a Trapped Transition. The situation is one of drift, with only small advances taking place while the hard choices are postponed, often for years. This delay is enabled by the long timescales that underpin global ecological shifts. But the archetypal pathway suggests that the longer the period of drift, the greater the required reset and associated write-off of financial, political, and social capital will be.

Are we morally prepared to leave the next generation to deal with this? If steps are taken sooner rather than later, will we accept the potential for economic damage and frustrations from policy mistakes and free riders? Are we ready now to explore step-wise policy implementations that unleash the power of the commercial engine to deliver global public goods in the course of serving localised private needs? ■

CONCLUDING REMARKS

Living in a complicated and connected world, we hope these scenarios contribute to dialogue about the types of choices and collaborations we can all make to realise a greater balance of positive consequences from our actions. In a more detailed way, these diagnostic frameworks and scenario panoramas are already being used in Shell to help us think through our own choices as a business and shaper of the future energy system.

They are helping us recognise how developments are connected, how feedback loops modify initial directions, and how currents in one direction build up counter-currents so that cycles become inevitable.

The sluggishness of policy reforms described at the outset of *Mountains* creates social tensions that will eventually find some form of political expression, leading to change. The reforms described at the outset of *Oceans* create broader constituencies with new vested interests that can stifle further reforms. Supply/demand tightness or looseness stimulates market prices and responses that shift the balance of supply and demand. In that sense, one scenario contains the seeds of the other, and vice versa. This feature may be more familiar to those readers with a traditional Eastern perspective while the linear quantified features of the scenarios may be more noticeable to eyes educated in Western thought-patterns. Of course, in a connected world, we are learning the importance of using both lenses.

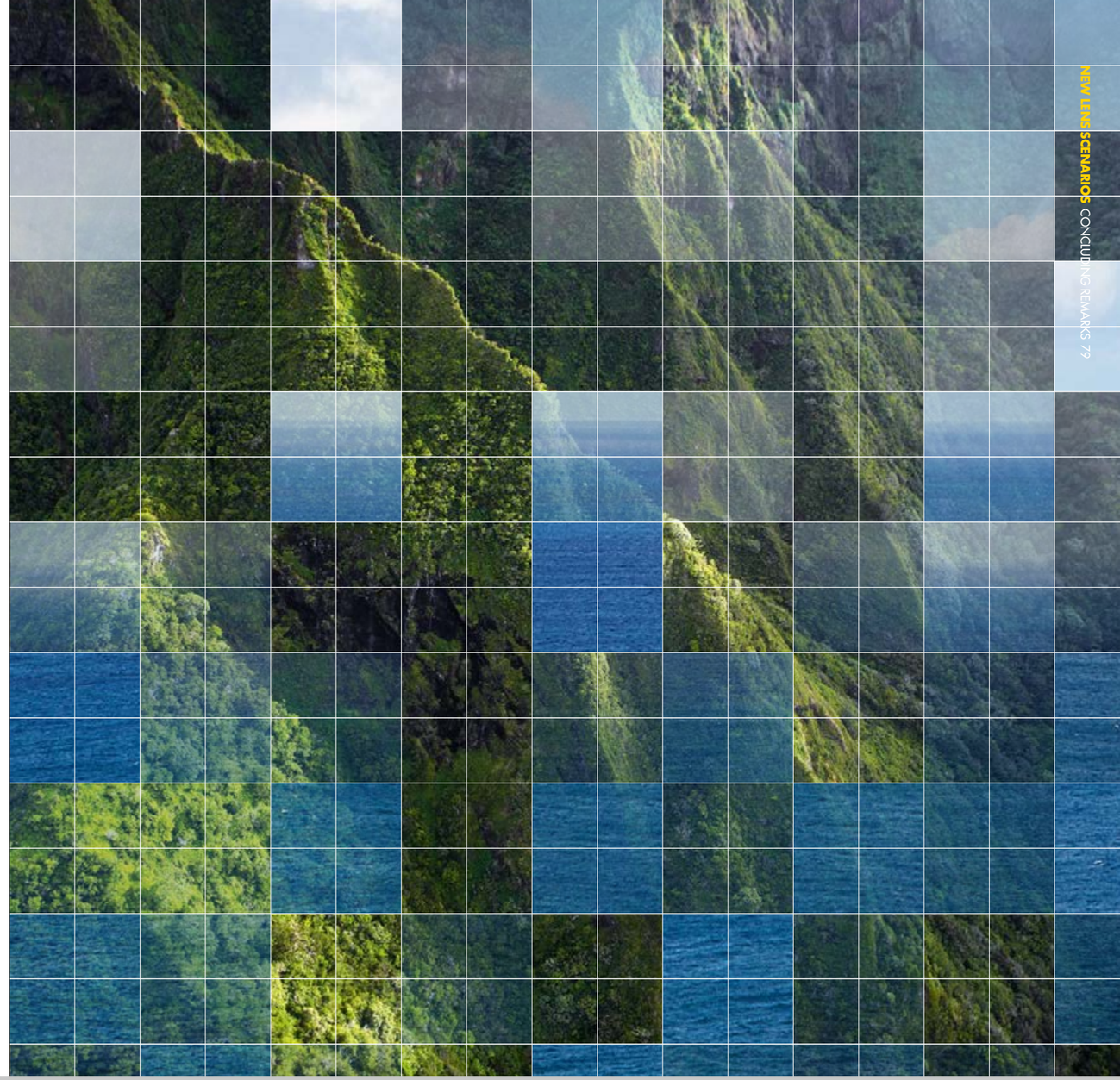
This is not an argument for assuming the future reality will be an 'average' of *Mountains* and *Oceans*. It is recognition that whichever way we look we will see both *Mountains* and *Oceans*, just as we will see the paradoxes of prosperity, leadership, and connectivity, and both Trapped Transition and Room to Manoeuvre pathways.

An aim of the scenario approach in strategic planning is to develop leaders who are better at seeing patterns of behaviour that may differ from a conventional view of the world. They also help us recognise there may be a breadth of possible outcomes to events that cannot be fully controlled, nor ignored, but may be influenced.

The wisdom of our choices, individually and collectively, is key. There are both positive and troubling features captured in both scenarios – with the distinction depending often on our own point of view. The more clearly we see the complex dynamics of tomorrow's world, the better we might navigate a path through the turbulence to calmer waters and higher peaks, making wiser choices on the journey and fostering deeper partnerships.

We hope you are as passionate about encouraging this as we are, and that the *New Lens Scenarios* we have introduced will help us all improve our vision of the future.

THE SHELL SCENARIO TEAM
March 2013



APPENDICES:
SCENARIO COMPARISONS AND CHALLENGES – EXAMPLES

AREA	DRIVERS	MOUNTAINS	OCEANS
PERSISTENT PATTERNS	Legacy positions and human behaviour	Locking-in of incumbent power, institutions and rigidities	Ratcheting expectations and accommodation of competing interests
	Counter-currents	Limited number of empowered parties facilitates some developments	Higher number of empowered parties delays some reforms
PARADOXES	**PROSPERITY**	Increasing stratification and concentration	Increasingly distributed and pervasive
	LEADERSHIP	Enduring positions of privilege and institutional arrangements	Growing base of competing constituencies and representation
	CONNECTIVITY	Globalisation loses some vigour Balkanisation of the web	Turbulent globalisation Open web development
PATHWAYS	**ROOM TO MANOEUVRE**	Currently influential economic and power structures. Policy areas that do not directly threaten status quo priorities	Middle income groups and emerging structures Core economic and financial policy reforms and growth
	TRAPPED TRANSITIONS	Economic reform difficulties bring middle-income trap for some economies Political and social stresses	New vested interests delay reforms outside priority areas Emissions and climate stresses
OTHER FEATURES	Creativity	Individual achievement in arts, technology and entrepreneurship	Political and business-model innovation
	Preservation	'Our way of life'	Reducing inefficiency Social justice
	Relationships	National and elite affiliations	Affiliations among 'silent majorities'
	Popular ideologies	Master of own fate Individual excellence and rewards People get what they deserve	Intertwined and shared fates Solidarity Systems get what they deserve

AREA	DRIVERS	MOUNTAINS	OCEANS
ENERGY DEMAND	Choice	Mandates	Markets
	Prices	Externalities implicitly included Moderate price world	Higher price world Externalities explicitly included
	Efficiency technology	Product standards	Market driven
	Efficiency behaviour	Designed-in	Price sensitive
	Economics	Initially lower than trend	Following trend
ENERGY RESOURCES	Oil	Losing ground	Long liquid fuels game
	Gas	Global success shale gas	Faltering shale gas outside N America
	Coal	Clean coal	Resilient coal
	Nuclear	Renaissance	Public opposition
	Electric renewables	Struggles on costs	Solar PV backbone
	Biomass	To electricity	To transport and (later) materials uses
ENERGY TECHNOLOGY	Innovation	Governed by intellectual property rights	Open innovation
	Implementation	Big-scale supply focused	Local responses (supply and efficiency)
	Transport	Gas and electrification Shorter urban journeys	More efficient gasoline and diesel transport
	Electricity	Centralised & CCS, integrated with hydrogen	More distributed, management of intermittency
ENVIRONMENT	Land use	Compact cities	Energy versus food debate
	Local pollution	Regulated standards designed in	Local preventive solutions
	Climate/Biodiversity	Protected areas & reforestation	Genetically Modified technology, local restoration
	Adaptation	Defences	Migration

SUMMARY QUANTIFICATION TABLES
MOUNTAINS VS OCEANS

MOUNTAINS TOTAL PRIMARY ENERGY – BY SOURCE

	Primary energy demand (EJ/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Oil	52.0	98.0	130.3	135.7	153.3	173.1	190.2	199.6	188.7	160.5	132.4
Biofuels	0.0	0.0	0.1	0.3	0.5	2.5	6.6	8.6	10.0	10.2	13.5
Natural Gas	18.9	35.3	51.6	70.2	87.3	114.8	149.7	188.8	226.2	237.7	234.8
Biomass Gasified	0.0	0.0	0.0	0.0	0.2	1.3	5.4	11.5	18.2	33.9	41.7
Coal	52.2	61.6	75.9	94.2	100.1	146.2	184.8	199.0	191.4	211.8	247.0
Biomass/Waste Solids	6.6	7.7	9.8	11.6	13.3	17.1	14.0	10.5	16.3	26.3	31.9
Biomass Traditional	14.9	18.0	21.5	26.0	29.3	33.2	35.1	37.6	39.9	42.0	45.9
Nuclear	0.0	0.9	7.8	22.0	28.3	30.1	37.5	55.6	74.6	91.9	107.5
Hydro-electricity	2.6	4.2	6.2	7.8	9.5	12.4	13.2	14.7	16.7	18.7	20.7
Geothermal	0.1	0.2	0.5	1.4	2.1	2.4	4.0	6.1	9.4	14.7	30.8
Solar	0.0	0.0	0.0	0.1	0.2	0.8	3.6	11.3	19.5	32.1	51.3
Wind	0.0	0.0	0.0	0.0	0.1	1.2	3.0	5.2	11.5	21.8	34.3
Other Renewables	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	**147**	**226**	**304**	**369**	**424**	**535**	**647**	**749**	**822**	**902**	**992**

MOUNTAINS TOTAL FINAL CONSUMPTION – BY SECTOR

	Energy consumption (EJ/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Heavy Industry	16.0	28.2	36.4	36.4	43.5	56.8	71.0	77.5	76.2	76.5	80.6
Agriculture & Other Industry	29.8	41.2	51.7	57.1	45.5	56.9	69.5	76.0	74.5	73.8	73.8
Services	6.1	12.7	16.9	19.2	23.6	30.0	36.6	43.3	52.1	59.7	68.2
Passenger Transport – Ship	0.2	0.2	0.3	0.5	0.6	0.7	0.9	1.0	1.0	1.0	1.0
Passenger Transport – Rail	1.3	0.7	0.7	0.9	0.6	0.7	1.0	1.2	1.3	1.4	1.5
Passenger Transport – Road	9.1	16.9	25.1	31.9	39.5	48.5	56.1	64.0	68.9	62.7	50.4
Passenger Transport – Air	2.3	3.7	4.8	6.2	7.5	8.4	9.9	11.2	12.1	14.0	15.7
Freight Transport – Ship	5.4	5.6	5.7	5.9	7.7	9.8	12.1	13.5	13.8	14.0	14.2
Freight Transport – Rail	2.7	2.6	2.5	1.6	1.3	1.5	1.6	1.7	1.6	1.5	1.4
Freight Transport – Road	4.1	7.2	11.4	15.2	20.4	25.1	29.8	36.2	42.6	48.1	53.0
Freight Transport – Air	0.5	0.9	1.0	1.5	2.0	2.1	2.6	3.3	4.0	5.0	6.2
Residential – Heating & Cooking	30.0	40.6	49.4	58.1	67.2	74.1	77.0	80.4	82.8	84.3	87.7
Residential – Lighting & Appliances	0.9	2.1	4.0	6.0	8.8	12.8	16.8	21.9	25.7	27.7	28.8
Non-Energy Use	3.7	9.4	14.8	20.0	25.8	33.4	45.7	58.6	69.2	79.9	91.3
Total	**112**	**172**	**225**	**260**	**294**	**361**	**430**	**490**	**526**	**550**	**574**

*All totals are rounded to the nearest whole number

OCEANS TOTAL PRIMARY ENERGY – BY SOURCE

	Primary energy demand (EJ/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Oil	52.0	98.0	130.3	135.7	153.3	173.1	196.4	214.0	221.8	220.7	201.4
Biofuels	0.0	0.0	0.1	0.3	0.5	2.5	4.6	5.5	7.2	14.2	25.9
Natural Gas	18.9	35.3	51.6	70.2	87.3	114.8	147.9	169.2	187.3	185.6	175.4
Biomass Gasified	0.0	0.0	0.0	0.0	0.2	1.3	7.8	19.8	20.4	22.1	26.8
Coal	52.2	61.6	75.9	94.2	100.1	146.2	202.7	222.3	201.7	218.6	204.2
Biomass/Waste Solids	6.6	7.7	9.8	11.6	13.3	17.1	18.7	14.1	15.5	17.7	21.4
Biomass Traditional	14.9	18.0	21.5	26.0	29.3	33.2	28.9	26.9	24.2	24.3	22.5
Nuclear	0.0	0.9	7.8	22.0	28.3	30.1	33.3	42.1	47.2	52.4	54.7
Hydro-electricity	2.6	4.2	6.2	7.8	9.5	12.4	13.5	14.8	16.8	18.7	20.6
Geothermal	0.1	0.2	0.5	1.4	2.1	2.4	5.1	9.7	18.9	26.4	34.1
Solar	0.0	0.0	0.0	0.1	0.2	0.8	4.4	25.2	70.1	132.6	209.6
Wind	0.0	0.0	0.0	0.0	0.1	1.2	4.7	13.2	24.7	42.4	59.3
Other Renewables	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Total	**147**	**226**	**304**	**369**	**424**	**535**	**668**	**777**	**856**	**976**	**1056**

OCEANS TOTAL FINAL CONSUMPTION – BY SECTOR

	Energy consumption (EJ/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Heavy Industry	16.0	28.2	36.4	36.4	43.5	56.8	74.3	76.7	80.0	90.0	92.5
Agriculture & Other Industry	29.8	41.2	51.7	57.1	45.5	56.9	69.1	76.8	81.0	85.4	89.0
Services	6.1	12.7	16.9	19.2	23.6	30.0	41.4	54.2	63.8	80.7	98.4
Passenger Transport – Ship	0.2	0.2	0.3	0.5	0.6	0.7	0.9	1.1	1.1	1.1	1.0
Passenger Transport – Rail	1.3	0.7	0.7	0.9	0.6	0.7	1.0	1.2	1.4	1.7	2.0
Passenger Transport – Road	9.1	16.9	25.1	31.9	39.5	48.5	56.8	62.2	65.4	67.7	66.2
Passenger Transport – Air	2.3	3.7	4.8	6.2	7.5	8.4	10.2	13.0	16.9	21.5	24.8
Freight Transport – Ship	5.4	5.6	5.7	5.9	7.7	9.8	12.3	13.7	15.1	16.9	17.9
Freight Transport – Rail	2.7	2.6	2.5	1.6	1.3	1.5	1.8	2.0	2.1	2.2	2.4
Freight Transport – Road	4.1	7.2	11.4	15.2	20.4	25.1	31.3	40.3	49.9	59.2	66.1
Freight Transport – Air	0.5	0.9	1.0	1.5	2.0	2.1	2.6	3.5	4.4	5.7	6.9
Residential – Heating & Cooking	30.0	40.6	49.4	58.1	67.2	74.1	72.5	73.1	70.7	73.8	76.6
Residential – Lighting & Appliances	0.9	2.1	4.0	6.0	8.8	12.8	18.3	22.4	25.5	27.6	27.2
Non-Energy Use	3.7	9.4	14.8	20.0	25.8	33.4	44.8	56.3	66.8	79.6	91.6
Total	**112**	**172**	**225**	**260**	**294**	**361**	**438**	**496**	**544**	**613**	**663**

MOUNTAINS TOTAL PRIMARY ENERGY – BY REGION

Primary energy demand (EJ/year)

Year	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060
USA & Canada	46.0	71.0	83.9	89.6	106.9	105.0	107.0	106.7	112.0	123.2	130.2
EU	31.5	53.2	65.8	69.7	72.4	74.2	71.8	71.2	73.2	80.5	88.0
Other Europe	22.4	30.1	44.9	58.2	40.6	46.4	51.3	58.6	63.7	64.9	66.7
OECD Asia & Oceania	5.1	13.9	19.6	26.9	35.6	38.0	39.2	37.9	37.5	39.3	41.1
China	10.5	15.6	25.2	36.5	49.5	101.3	152.0	193.4	213.8	211.3	199.8
India	4.9	6.4	8.6	13.3	19.2	29.1	49.4	70.7	76.1	99.1	138.7
Other Asia & Oceania	8.6	11.3	17.9	24.2	30.8	43.0	55.7	68.3	77.4	87.2	102.1
Latin America & Caribbean	7.1	9.8	16.3	19.8	25.4	33.6	41.3	49.6	63.9	78.2	88.7
Middle East & North Africa	1.6	3.0	7.5	13.5	21.2	34.8	43.3	49.4	53.6	57.8	66.2
Sub-Saharan Africa	5.3	6.9	9.5	12.7	16.0	21.3	25.8	30.9	38.9	47.7	57.6
International Marine Bunkers	4.5	4.5	4.6	4.8	6.4	8.4	10.4	11.8	12.1	12.4	12.8
Total	**147**	**226**	**304**	**369**	**424**	**535**	**647**	**749**	**822**	**902**	**992**

MOUNTAINS TOTAL FINAL CONSUMPTION ELECTRICITY – BY SOURCE

Energy consumption (EJ/year)

Year	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060
Oil	0.8	2.9	5.0	4.1	3.6	3.0	2.6	1.8	1.1	0.6	0.4
Biofuels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.9	1.9	2.9	5.0	8.2	14.4	20.0	25.7	26.8	21.5	18.9
Biomass Gasified	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.3	3.4	7.7	9.1
Coal	3.8	6.1	9.3	13.0	17.8	26.2	34.9	39.0	39.0	41.8	46.4
Biomass/Waste Solids	0.1	0.1	0.1	0.4	0.5	1.0	1.3	1.5	3.2	5.7	6.6
Nuclear	0.0	0.2	2.1	5.9	7.7	8.3	10.4	15.5	20.9	25.8	29.3
Hydro-electricity	2.2	3.5	5.1	6.3	7.6	10.2	10.9	12.1	13.9	15.7	17.4
Geothermal	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.5	0.9	1.4	3.0
Solar	0.0	0.0	0.0	0.0	0.0	0.1	1.6	7.2	13.2	19.9	29.7
Wind	0.0	0.0	0.0	0.0	0.1	1.1	2.5	4.0	8.2	15.1	22.6
Other Renewables	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	**8**	**15**	**25**	**35**	**46**	**65**	**85**	**109**	**131**	**155**	**184**

*All totals are rounded to the nearest whole number

OCEANS TOTAL PRIMARY ENERGY – BY REGION

Primary energy demand (EJ/year)

Year	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060
USA & Canada	46.0	71.0	83.9	89.6	106.9	105.0	104.6	100.1	98.4	97.6	97.9
EU	31.5	53.2	65.8	69.7	72.4	74.2	69.8	68.8	68.1	69.5	70.1
Other Europe	22.4	30.1	44.9	58.2	40.6	46.4	56.9	63.3	63.9	62.5	61.0
OECD Asia & Oceania	5.1	13.9	19.6	26.9	35.6	38.0	38.3	36.1	34.7	34.1	34.0
China	10.5	15.6	25.2	36.5	49.5	101.3	159.5	198.4	190.9	176.5	162.6
India	4.9	6.4	8.6	13.3	19.2	29.1	51.9	80.3	111.1	142.9	156.3
Other Asia & Oceania	8.6	11.3	17.9	24.2	30.8	43.0	55.2	71.9	94.4	133.2	158.2
Latin America & Caribbean	7.1	9.8	16.3	19.8	25.4	33.6	51.9	63.5	73.9	84.1	87.8
Middle East & North Africa	1.6	3.0	7.5	13.5	21.2	34.8	42.3	45.2	51.2	67.7	83.2
Sub-Saharan Africa	5.3	6.9	9.5	12.7	16.0	21.3	26.8	37.5	56.2	92.5	128.5
International Marine Bunkers	4.5	4.5	4.6	4.8	6.4	8.4	10.6	11.8	13.2	15.2	16.4
Total	**147**	**226**	**304**	**369**	**424**	**535**	**668**	**777**	**856**	**976**	**1056**

OCEANS TOTAL FINAL CONSUMPTION ELECTRICITY – BY SOURCE

Energy consumption (EJ/year)

Year	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060
Oil	0.8	2.9	5.0	4.1	3.6	3.0	1.7	0.8	0.3	0.0	0.0
Biofuels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.9	1.9	2.9	5.0	8.2	14.4	21.8	27.1	30.8	27.0	17.9
Biomass Gasified	0.0	0.0	0.0	0.0	0.0	0.0	1.2	3.8	3.7	3.3	2.9
Coal	3.8	6.1	9.3	13.0	17.8	26.2	37.7	41.9	36.9	44.0	41.8
Biomass/Waste Solids	0.1	0.1	0.1	0.4	0.5	1.0	2.9	2.7	2.8	2.8	2.7
Nuclear	0.0	0.2	2.1	5.9	7.7	8.3	9.3	12.0	13.7	15.3	16.1
Hydro-electricity	2.2	3.5	5.1	6.3	7.6	10.2	11.1	12.4	14.3	16.2	17.9
Geothermal	0.0	0.0	0.0	0.1	0.2	0.2	0.5	0.8	1.2	0.8	0.6
Solar	0.0	0.0	0.0	0.0	0.0	0.1	1.9	14.2	41.1	74.7	112.0
Wind	0.0	0.0	0.0	0.0	0.1	1.1	3.5	8.3	14.5	24.1	33.0
Other Renewables	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Total	**8**	**15**	**25**	**35**	**46**	**65**	**92**	**124**	**159**	**208**	**245**

MOUNTAINS NET CO_2 EMISSIONS – BY POINT OF EMISSION

	Net emissions (Gt CO_2/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Heavy Industry	1.07	1.79	2.12	2.09	2.43	3.16	3.70	3.72	3.20	2.62	2.05
Agriculture & Other Industry	2.07	2.66	3.34	2.87	2.40	2.91	3.58	3.69	3.15	2.64	2.23
Services	0.42	0.78	0.91	0.81	0.77	0.89	0.99	0.94	0.91	0.84	0.76
Passenger Transport – Ship	0.02	0.02	0.02	0.04	0.04	0.05	0.07	0.07	0.07	0.07	0.07
Passenger Transport – Rail	0.11	0.05	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.01	0.01
Passenger Transport – Road	0.64	1.20	1.78	2.26	2.79	3.41	3.92	4.36	4.37	3.43	2.15
Passenger Transport – Air	0.16	0.27	0.34	0.44	0.53	0.59	0.70	0.79	0.86	0.95	1.02
Freight Transport – Ship	0.39	0.39	0.41	0.42	0.55	0.69	0.86	0.96	0.97	0.98	0.98
Freight Transport – Rail	0.23	0.20	0.18	0.12	0.08	0.08	0.09	0.10	0.09	0.07	0.06
Freight Transport – Road	0.29	0.51	0.81	1.08	1.45	1.78	2.11	2.55	2.90	2.99	2.85
Freight Transport – Air	0.03	0.06	0.07	0.10	0.14	0.15	0.19	0.23	0.28	0.35	0.44
Residential – Heating & Cooking	1.09	1.47	1.57	1.84	1.81	1.88	1.90	1.87	1.81	1.69	1.55
Solid Fuels Production	1.00	0.91	0.91	0.91	0.84	1.53	1.56	1.54	1.35	1.23	1.16
Liquid Fuels Production	0.41	0.74	0.92	1.07	1.01	1.05	0.99	1.00	0.84	0.47	-0.22
Gaseous Fuels Production	0.30	0.49	0.60	0.73	0.96	1.26	1.72	2.10	2.26	2.03	1.27
Electricity Generation	1.89	3.25	4.94	6.46	8.35	11.76	15.13	16.67	14.09	7.18	0.89
Hydrogen Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.30	0.58
Heat Generation	0.18	0.38	0.69	1.24	0.97	1.08	0.94	0.79	0.64	0.45	0.32
Biomass-Commercial to Non-Energy Use	-0.10	-0.16	-0.19	-0.73	-0.85	-0.99	-0.87	-0.75	-0.74	-0.78	-0.98
Total	**10**	**15**	**19**	**22**	**24**	**31**	**38**	**41**	**37**	**28**	**17**

MOUNTAINS FRESH WATER CONSUMPTION FOR ENERGY

	Water consumption (billion m^3/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Fossils Production	1.2	1.5	3.1	4.1	5.1	7.6	10.4	13.8	15.9	16.1	17.2
Biofuels Production	0.0	0.0	0.6	1.2	1.6	8.4	21.4	27.6	28.3	23.6	21.0
Refining	1.7	3.2	4.1	4.4	5.0	5.7	6.2	6.6	6.3	5.3	4.3
Electricity – Oil	0.2	0.7	1.4	1.1	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Electricity – Gas	0.9	1.4	1.6	2.2	2.0	2.5	2.1	2.6	2.8	2.5	2.6
Electricity – Coal	7.6	11.2	17.0	23.7	29.7	36.6	46.4	50.4	48.6	54.5	64.0
Electricity – Nuclear	0.0	0.1	1.0	2.6	3.1	3.2	3.3	4.3	5.2	6.1	6.8
Electricity – Biomass	0.1	0.1	0.1	0.7	0.6	1.0	1.5	2.3	5.1	10.2	12.2
Electricity – Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	2.4	6.8	15.4
Electricity – Geothermal	0.0	0.0	0.1	0.3	0.4	0.5	0.7	1.1	1.8	2.9	6.2
Total	**12**	**18**	**29**	**40**	**48**	**66**	**93**	**110**	**116**	**128**	**150**

*All totals are rounded to the nearest whole number

OCEANS NET CO_2 EMISSIONS – BY POINT OF EMISSION

	Net emissions (Gt CO_2/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Heavy Industry	1.07	1.79	2.12	2.09	2.43	3.16	4.23	4.08	3.53	2.99	2.33
Agriculture & Other Industry	2.07	2.66	3.34	2.87	2.40	2.91	3.36	3.39	3.19	3.02	2.90
Services	0.42	0.78	0.91	0.81	0.77	0.89	1.12	1.27	1.43	1.77	2.27
Passenger Transport – Ship	0.02	0.02	0.02	0.04	0.04	0.05	0.07	0.08	0.08	0.08	0.07
Passenger Transport – Rail	0.11	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00
Passenger Transport – Road	0.64	1.20	1.78	2.26	2.79	3.41	3.98	4.29	4.35	4.18	3.74
Passenger Transport – Air	0.16	0.27	0.34	0.44	0.53	0.59	0.73	0.92	1.20	1.51	1.73
Freight Transport – Ship	0.39	0.39	0.41	0.42	0.55	0.69	0.87	0.97	1.06	1.19	1.25
Freight Transport – Rail	0.23	0.20	0.18	0.12	0.08	0.08	0.10	0.11	0.09	0.07	0.05
Freight Transport – Road	0.29	0.51	0.81	1.08	1.45	1.78	2.21	2.84	3.49	3.99	4.09
Freight Transport – Air	0.03	0.06	0.07	0.10	0.14	0.15	0.18	0.25	0.31	0.40	0.48
Residential – Heating & Cooking	1.09	1.47	1.57	1.84	1.81	1.88	1.92	1.70	1.29	0.95	0.76
Solid Fuels Production	1.00	0.91	0.91	0.91	0.84	1.53	1.77	1.66	1.39	1.24	1.06
Liquid Fuels Production	0.41	0.74	0.92	1.07	1.01	1.05	1.26	1.77	2.12	1.58	0.53
Gaseous Fuels Production	0.30	0.49	0.60	0.73	0.96	1.26	1.59	1.68	1.58	1.44	1.27
Electricity Generation	1.89	3.25	4.94	6.46	8.35	11.76	16.19	17.99	16.58	16.87	13.75
Hydrogen Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.09	0.23
Heat Generation	0.18	0.38	0.69	1.24	0.97	1.08	1.02	0.89	0.74	0.63	0.57
Biomass-Commercial to Non-Energy Use	-0.10	-0.16	-0.19	-0.73	-0.85	-0.99	-0.95	-1.01	-1.15	-1.50	-2.25
Total	**10**	**15**	**19**	**22**	**24**	**31**	**40**	**43**	**41**	**40**	**35**

OCEANS FRESH WATER CONSUMPTION FOR ENERGY

	Water consumption (billion m^3/year)										
Year	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Fossils Production	1.2	1.5	3.1	4.1	5.1	7.6	10.6	14.3	17.7	19.5	21.6
Biofuels Production	0.0	0.0	0.6	1.2	1.6	8.4	14.3	17.8	22.0	32.3	39.5
Refining	1.7	3.2	4.1	4.4	5.0	5.7	6.7	8.3	9.6	9.6	8.9
Electricity – Oil	0.2	0.7	1.4	1.1	0.6	0.4	0.2	0.1	0.0	0.0	0.0
Electricity – Gas	0.9	1.4	1.6	2.2	2.0	2.5	2.3	2.7	3.2	2.7	1.7
Electricity – Coal	7.6	11.2	17.0	23.7	29.7	36.6	51.1	58.3	50.6	52.2	46.2
Electricity – Nuclear	0.0	0.1	1.0	2.6	3.1	3.2	3.1	3.4	3.5	3.5	3.5
Electricity – Biomass	0.1	0.1	0.1	0.7	0.6	1.0	2.5	3.7	3.8	3.6	3.4
Electricity – Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.0	9.1	21.7	41.8
Electricity – Geothermal	0.0	0.0	0.1	0.3	0.4	0.5	0.9	1.6	2.5	1.6	1.3
Total	**12**	**18**	**29**	**40**	**48**	**66**	**92**	**113**	**122**	**147**	**168**

GLOSSARY

3D PRINTING

Relatively fast and low-cost manufacturing technology where a three-dimensional object is created from layers of raw material which form a precise replica of the original.

BRICS

Brazil, Russia, India, and China (sometime BRICs – also including Indonesia) – rapidly emerging economies.

CCS (CARBON CAPTURE AND STORAGE)

Technologies which can be used to collect carbon dioxide (CO_2) and place it in long-term underground storage.

CHP

Combined heat and power

ENHANCED OIL RECOVERY

A technique for increasing the amount of oil that can be extracted from a reservoir (oil field) using thermal or chemical methods or miscible gas injection.

FRACKING (HYDRAULIC FRACTURING)

A process in which water mixed with sand and chemicals is injected underground at high pressure to create cracks in sub-surface rock to enable trapped gas to flow.

G20 (GROUP OF TWENTY)

A forum established in 1999 for international co-operation on issues on the global economic and financial agenda, consisting of representatives of 19 major countries and the European Union.

G8 (GROUP OF EIGHT)

A forum established in 1975 for the governments of eight of the world's largest economies, who meet annually to discuss global issues. Members are France, Germany, Italy, Japan, United Kingdom, United States, Canada, Russia and a representative from the European Union.

GDP (GROSS DOMESTIC PRODUCT)

A measure of the annual economic activity of a nation. The sum of value added by producers in the economy plus any taxes and minus any subsidies.

LIQUID-RICH SHALES/LIGHT TIGHT OIL (LTO)

A low-viscosity crude oil or condensate contained in rock formations of low permeability.

LNG (LIQUEFIED NATURAL GAS)

Gas (chiefly methane) chilled to a liquid for transportation and then heated to return to gas for use in power generation and domestic energy supply.

MRH

Major resource holder – a nation with significant sovereign resources e.g. oil, gas, coal, metals and minerals.

NGO (NON-GOVERNMENTAL ORGANISATION)

Any non-profit or voluntary citizens group which is organised on a local, national or international level.

OECD (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT)

A 30-country organisation of mostly Western, industrialised nations formed in 1961 to help member countries achieve sustainable economic growth and employment and raise their standard of living.

OPEC (ORGANISATION OF PETROLEUM-EXPORTING COUNTRIES)

An organisation formed in 1961 to administer a common policy for the sale of petroleum. Its current members are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

SOLAR PV (PHOTOVOLTAIC)

A technology which uses a solar panel to produce free electrons when exposed to light, resulting in the production of an electric current.

STRESS NEXUS

The inter-relationship between energy, water, and food systems.

TIGHT/SHALE GAS AND COAL BED METHANE (CBM)

Sources of gas trapped underground by very low permeability rocks, such as coal, sandstone, and shale. The gas is typically extracted by hydraulic fracturing through horizontal wells.

ABBREVIATIONS ENERGY

boe = barrel of oil equivalent
CO_2 = carbon dioxide
Gt = gigatonne
kWh = kilowatt hour
mbd = million barrels per day
ppm = parts per million by volume
t = metric tonne
tcf= trillion cubic feet

INTERNATIONAL SYSTEM (SI) OF UNITS:

MJ = megajoule = 10^6 joules
GJ = gigajoule = 10^9 joules
TJ = terajoule = 10^{12} joules
EJ = exajoule = 10^{18} joules

CONVERSION BETWEEN UNITS:

1 boe = 5.63 GJ*
1 mbd = 2.05 EJ/year
1 million cubic metre natural gas = 34 450 GJ*
1 million tonne natural gas = 46 100 TJ*
1 tonne coal = 25 GJ*
1 tonne primary biomass = 12 GJ*
1 kWh = 3.6 MJ

**This is a typical average but the energy content of a particular carrier may vary.*

DISCLAIMER

This scenarios book contains forward-looking statements that may affect Shell's financial condition, results of operations, and businesses of Royal Dutch Shell.

All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements.

Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections, and assumptions. These forward-looking statements are identified by their use of terms and phrases such as ''anticipate'', ''believe'', ''could'', ''estimate'', ''expect'', ''goals'', ''intend'', ''may'', ''objectives'', ''outlook'', ''plan'', ''probably'', ''project'', ''risks'', ''seek'', ''should'', ''target'', ''will'', and similar terms and phrases.

There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this scenarios book, including (without limitation):

(a) price fluctuations in crude oil and natural gas;
(b) changes in demand for Shell's products;
(c) currency fluctuations;
(d) drilling and production results;
(e) reserves estimates;
(f) loss of market share and industry competition;
(g) environmental and physical risks;
(h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions;
(i) the risk of doing business in developing countries and countries subject to international sanctions;
(j) legislative, fiscal, and regulatory developments including regulatory measures addressing climate change;
(k) economic and financial market conditions in various countries and regions;
(l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects, and delays in the reimbursement for shared costs; and
(m) changes in trading conditions.

All forward-looking statements contained in this scenarios book are expressly qualified in their entirety by the cautionary statements contained or referred to in this section.

Readers should not place undue reliance on forward-looking statements.

Additional factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended December 31, 2011 which is available at www.shell.com/investor and www.sec.gov.

These factors also should be considered by the reader. Each forward-looking statement speaks only as of the date of this scenarios book, March 2013. Neither Royal Dutch Shell nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information.

In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this scenarios book.

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Other Shell Scenario material can be found at shell.com/scenarios.

DATA SOURCES

The principal data sources used in the development of Shell's scenario analyses and charts in this book, besides those already mentioned, are:

- IEA World Energy Statistics and Balances 2012 © OECD/IEA 2012, as modified by Shell International
- UN population division
- EIA
- Booz & Company
- International Water Management Institute (IWMI)
- Center for Strategic and International Studies (CSIS)
- The World Bank

MOUNTAINS TIMELINE

ENERGY CHANGES

Coal becomes number one energy source
Hydrogen vehicles roll out commercially
World CCS capacity 20 GW
World CO_2 emissions hit 40 Gt/year
World electricity from natural gas reaches 2000 GW, 40% above 2012's level
10% of all passenger road km in Japan from electricity or fuel cells
China has 180GW nuclear installed
Natural gas number one energy source, first ever to reach 200 EJ/y
CCS worldwide capturing 1 Gt CO_2/y
World aeroplane fleet efficiency up 50% from 2012
Non-fossil sources comprise 30% of world primary energy
CCS worldwide capturing 10 Gt CO_2/y
World nuclear capacity reaches 1200 GW
World average car fleet average (on road) 35 mile/US gal (up 45% from 2010)
Electricity decarbonised
World energy demand reaches 1000 EJ/y
India becomes world's number one gas consumer
Liquid fuels eliminated from passenger road vehicles
World road passenger-km saturates at three times 2012's level
10% of world electricity from biomass
World CO_2 emissions are net zero

SOCIO/ECONOMIC/POLITICAL CHANGES

SOCIAL AND POLITICAL PRESSURES ENCOURAGE LOCK-IN OF INCUMBENT INTERESTS
FINANCIAL AND ECONOMIC REFORMS PROVE INSUFFICIENT TO SUSTAIN HIGH GROWTH RATES
ALIGNMENTS AMONG THE INFLUENTIAL FACILITATE SELECTIVE POLICY DEPLOYMENT
TIGHT/SHALE GAS AND CBM DEVELOPMENT REPEATS NORTH AMERICA'S EXPERIENCE WORLDWIDE
INTERNATIONAL RELATIONS DOMINATED BY US AND CHINA
LIQUID FUELS FOR PASSENGER ROAD TRANSPORT PEAKS AT GLOBAL LEVEL
GAS BECOMES THE ENERGY SYSTEM'S BACKBONE (NATURAL GAS WITH INCREASING BIOGAS)
A NUMBER OF LARGE ECONOMIES EMERGE FROM THE MIDDLE-INCOME TRAP AND GLOBAL GROWTH TRENDS HIGHER AGAIN

WORLD POPULATION REACHES 8 BILLION
50% OF AFRICA URBANISED
80% OF EUROPE URBANISED
WORLD POPULATION REACHES 9 BILLION
TOTAL POPULATION IN ASIA STARTS DECLINING

2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

50% OF ASIA URBANISED
TOTAL POPULATION IN EUROPE STARTS DECLINING
ELDERLY ARE OVER 15% OF WORLD POPULATION

FAST-EMERGING ECONOMIES IMPLEMENT ECONOMIC REFORMS THAT PROVE EFFECTIVE
CHINA GDP REACHES 20,000 USD/CAP (PPP)
INDIA GDP REACHES 10,000 USD/CAP
SOCIAL AND POLITICAL PRESSURES STIMULATE REFORMS OR RADICAL REGIME CHANGE
TIGHT/SHALE GAS AND CBM ENJOY LIMITED SUCCESS OUTSIDE NORTH AMERICA
TECHNOLOGY DEVELOPMENT STIMULATED BY PRICE, BUT SECONDARY POLICY LAG
LONG PLATEAU OF OIL PRODUCTION/CONSUMPTION
AFRICA OVERTAKES EUROPE AND NORTH AMERICA AS SECOND LARGEST ENERGY-CONSUMING CONTINENT (AFTER ASIA)

ENERGY CHANGES

World wind capacity = 400GW
Car fleet in China = 114 million vehicles
World solar PV capacity = 500 GW
World CO_2 emissions hit 40 Gt/year
China overtakes USA as number one oil consumer
Oil production hits 100 mbd
USA car fleet average (on road) 30 mile/US gal (up 45% from 2010)
EU car fleet average (on road) 50 mile/US gal (up 45% from 2010)
World solar PV capacity = 1800 GW
Renewable sources comprise 20% of world primary energy
Electricity reaches 30% of final energy demand
Car fleet in India reaches 500 million vehicles
World energy demand reaches 1000 EJ/y
World solar PV capacity = 20000 GW
World road passenger-km reaches three times 2012's level
India largest energy consumer
World average heating efficiency of buildings doubled compared to 2012
Solar PV number 1 energy source
World final energy demand peaks
Electricity reaches 40% of final energy demand
World average heavy industry energy efficiency doubled compared to 2012
World air travel demand (at 22 trillion passenger-km) reaches 5 times 2012's level
Electricity decarbonised
World CO_2 emissions down to 2 Gt/year
World average car fleet average (on road) 70 mile/US gal (nearly three times 2010's level)

OCEANS TIMELINE