GLTE BRIEFING

Global Leadership & Technology Exchange

A working vision of the low-carbon economy

Inspired by GLTE London
6–7 April 2011

xyntéo

"We need to do a better job of talking about where we are going. This isn't so much a matter of climate science. It's a matter of leadership and vision – leaders need to draw on their visionary capabilities to paint an attractive, tangible view of our collective goal: the low-carbon economy."

Dr Osvald M. Bjelland, Chairman and CEO, Xyntéo

The Global Leadership & Technology Exchange was founded by international strategic advisory firm Xyntéo. Xyntéo runs the exchange programme and facilitates low-carbon collaborations among the partners. Xyntéo alone is responsible for this document and any errors it contains.

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Registered in England number: 5314641. VAT registration number: 857 5824 79

Designed and typeset by Soapbox, www.soapbox.co.uk

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A Working Vision of the Low-Carbon Economy

Inspired by the London Global Leadership & Technology Exchange, 6–7 April 2011

About the Global Leadership & Technology Exchange

The Global Leadership & Technology Exchange (GLTE), founded by international strategic advisory firm Xyntéo, aims to provide senior business leaders with the knowledge, networks and tools they need to exploit the opportunities generated by the shift to a low-carbon economy.

At the heart of GLTE is a belief in the unique power of collaboration – across value chains, across borders – to equip business leaders to achieve low-carbon growth. For many companies, carbon is "elsewhere" – that is, it originates not from within their own four walls but from somewhere else along the value chain. Only collaboration can root out these inefficiencies to capture value.

Also, carbon is so tightly wound into economic and commercial activity that extricating it calls for the pooling of resources and ingenuity on a massive scale. Our partners work together strategically and practically to develop innovative collaborative solutions that are beyond the scope, scale or capabilities of any one organisation.

GLTE partners span three continents and a range of sectors and industries, from oil and gas, energy and utilities to transportation, finance, risk management, consumer goods and information technology. Current GLTE partners are: Det Norske Veritas, Deutsche Bank, Electric Power Research Institute, Ericsson, Gazprom, Hess Corporation, PG&E Corporation, Siemens, Shell, Statoil, Subsea 7, Tata Consultancy Services, Tata Sons, Unilever and Wilh. Wilhelmsen.

About the London exchange

Twice a year the companies that make up the Global Leadership & Technology Exchange meet to share knowledge of low-carbon innovation and explore collaborative opportunities to pursue low-carbon growth. On 6-7 April 2011, senior representatives of GLTE partners and other leading businesses, scientists and regulators convened in London. Tata Consultancy Services served as the exchange's host.

Taking its cue from the Industrial Revolution, the London programme deliberated the next great turning-point for humanity – the transition to the low-carbon economy. In the opening session, we sought to build clarity around our common destination by asking ourselves what it would actually be like to live and do business in the low-carbon economy. The working sessions that followed evaluated some of the main bridges we need to cross in order to create a new kind of economic growth. What new systems, behaviours and technologies need to be developed across energy, infrastructure, mobility and production and consumption? How could "enablers" like ICT, finance and regulation accelerate these changes? And what about leadership? How do leaders from business and politics need to change in order to mobilise progress?

Global Leadership & Technology Exchange

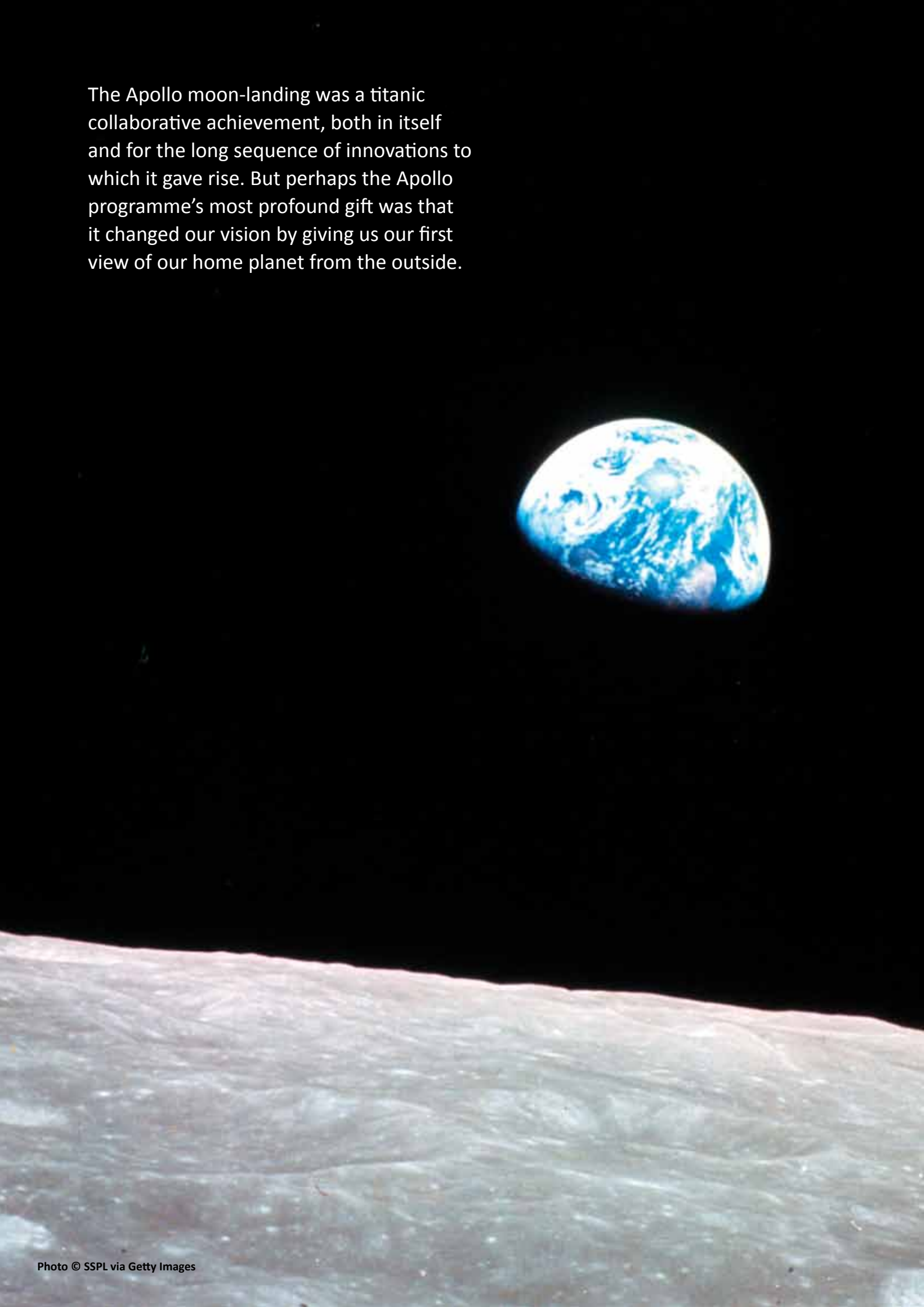
The GLTE partnership

GLTE partners span three continents and a range of sectors and industries, from oil and gas, energy and utilities to transportation, finance, risk management, consumer goods and information technology.

Collaborating under the GLTE umbrella

GLTE partners conduct low-carbon collaborations both with each other and with other organisations. At present ABB, FMC Technologies, Nexans, SKF, Telenor and Wilhelmsen Maritime Services are all involved in collaborative projects under the wider GLTE umbrella.

The Apollo moon-landing was a titanic collaborative achievement, both in itself and for the long sequence of innovations to which it gave rise. But perhaps the Apollo programme's most profound gift was that it changed our vision by giving us our first view of our home planet from the outside.



A Working Vision of the Low-Carbon Economy

Global average temperatures to increase by no more than 2˚C over pre-industrial levels. Concentrations of greenhouse gases to stay under 450 parts per million. Global emissions of 2050 to be 50% lower than global emissions in 1990.

> "We have an opportunity today at the GLTE meeting in London to offer the solutions and the clarity of vision that the world needs. We must have two things to offer. Firstly, we must have the vision to make long-term investments and plot our way through them. Secondly, we must play a determined role in shaping behaviour – be it by influencing stakeholders, suppliers or end-consumers to become a part of a low-carbon world. This is indeed the best time to lead."
>
> **N. Chandrasekaran, Managing Director and CEO, Tata Consultancy Services**

If you were to ask for an outline of the low-carbon economy, chances are that you would receive one or more of the three above points as an answer. But none paints a particularly vivid picture: each is limited in its own way – the first by its contextual poverty, the second by its scientific remoteness, the third by its diplomatic generality.

Lessons from the past

History has shown us that it is the simplest, hardest visions that stand the best chance of mobilising the energy and resources needed to get a big job done. Take the first moon landing. In 1962, the US, rattled by the fact the Soviet Union had beat them into space, was searching for a way to wrest back the upper hand. Told that the US had a shot at putting a man on the moon before the competition, the Kennedy administration settled on this. But how could the government light a fire under all the people needed to achieve such a vaulting goal?

N. Chandrasekaran, Tata Consultancy Services

The NASA chief wanted the US to shoot for "pre-eminence in space". But Kennedy argued for something more straightforward: he wanted to put a man on the moon and bring him back safely within that decade. Unambiguous, inspiring and, it turns out, effective. In 1969, the Apollo programme transported three men to the moon, set them down on the surface and returned them to earth.

Building a low-carbon economy is arguably even more ambitious than planting human feet on lunar soil in the 1960s. If we are to succeed in rewiring the way our economies

Mr Chandrasekaran's keynote speech can be downloaded at xynteo.com

and businesses grow, we need detail of the destination – colour and shade, sound, taste, touch and smell. We need to anticipate what it will actually *feel* like to work, play, live and do business in the new economy. When the proposed future becomes a concrete, compelling, attainable goal, the requisite energies and efforts are more likely to fall into line.

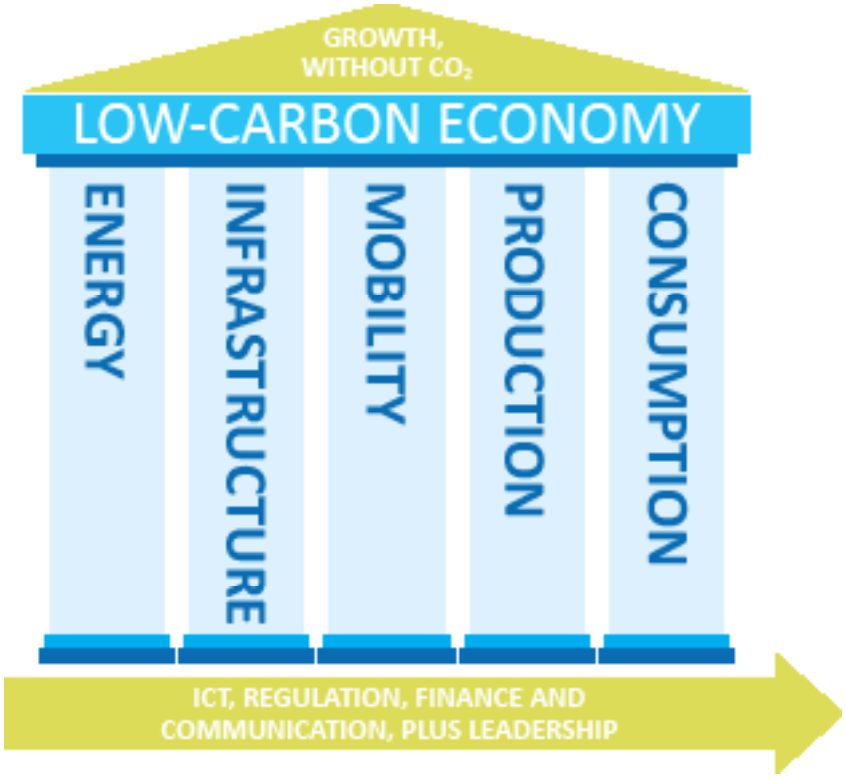
This paper's ambitions

This paper ventures to fill in some of this detail. But it marks just a modest start, presenting only a broad-brush picture of the new systems, behaviours and technologies that *could* underpin the low-carbon economy. No attempt is made to get the implied carbon savings to "add up" to the going global reduction targets. But we hope nonetheless that this initial sketch will add value by prompting more rigorous thinking within the Global Leadership & Technology Exchange about a low-carbon future and why it could make good commercial sense to embrace the transition.

Drawing on the insightful presentations and challenging discussions that took place at the GLTE meeting in London in April 2011, this paper speculates that the low-carbon future will be built up around five pillars – energy, infrastructure, mobility, production and consumption. These new systems, linked as they are, need to be built together; erect one in isolation and the house could fall down.

After sketching out what each pillar could look like, the paper evaluates the role of some "enablers" – catalyst factors like ICT, finance, regulation and communication on which progress across each pillar fundamentally depends. We finish with some highlights from the closing session of the GLTE meeting, which focused on the role of leadership in the low-carbon economy.

The low-carbon economy will be underpinned by a new kind of growth, decoupled from emissions of greenhouse gases. Making this break depends on new systems, behaviours and technologies across five "pillars": energy, infrastructure, mobility, production and consumption.



Benefits of the low-carbon economy

Thanks to Nicholas Stern and others, we are aware that the costs of action on climate change are likely to be lower than the potential costs of inaction.[a] But what about the actual benefits of living in a low-carbon economy? Here are three.

Economy

The economy could be the big winner – above and beyond the cost savings generated from avoiding the worst of the possible consequences of climate change. The gains were highlighted in a recent study on the EU, which concluded that raising its 2020 greenhouse gas reduction target from 20% to 30% could, by 2020:

- create up to 6 million additional jobs Europe-wide, reducing unemployment by over 2%
- boost investment in Europe from 18% to up to 22% of GDP
- increase Europe's GDP by an additional 6% (or $842 billion)[b]

Health

The low-carbon economy would mean less pollution and vastly better public health.

- People could live longer, with at least 750 million life-years being saved against the business-as-usual outlook, the vast majority of them in China and India.[c]
- Countries would be able to pocket the money that would have otherwise had to be spent on dealing with pollution. In 2005, the external costs of pollution in China – from health expenditure to losses in labour and land productivity – amounted to 3.8% of GDP.[d]

Energy security

The low-carbon economy's energy mix would need to be a diverse one, drawing on renewable energies – predominantly wind, solar, hydro and biofuels – as well as natural gas, other CCS-backed fossil fuels and nuclear. This diversity could lessen vulnerability to price hikes and geopolitical turmoil.[e]

a Ross Garnaut, (2008), *Garnaut Climate Change Review:* www.garnautreview.org.au/2008-review.html and Lord Nicholas Stern (2006), Stern Review on the Economics of Climate Change: Executive Summary, p. 1: //webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf

b Carlo Jaeger, et al. (2011), *A New Growth Path for Europe: Synthesis Report,* p. 9: www.european-climate-forum.net/fileadmin/ecf-documents/Press/A_New_Growth_Path_for_Europe__Synthesis_Report.pdf

c International Energy Agency, *World Energy Outlook 2010,* IEA/OCED, Paris, p. 406

d World Bank (2007), "Cost of Pollution in China: Economic Estimates of Physical Damages", Working Paper, World Bank, Report No. 39236, Washington DC: http://go.Worldbank.org/7LM8L9FAV0

e IEA, *World Energy Outlook 2010,* IEA/OCED, Paris, p. 443

One in five people, the bulk of them in rural areas, do not have access to electricity. In the low-carbon future, power generation is likely to be less centralised. Not only could this reduce carbon emissions; it could also widen energy access. Here a technician installs a solar-powered television unit in the village of Foule in Niger.

Energy

In the low-carbon economy, energy will be clean, owing to highly efficient usage patterns and a mix of sources more weighted to renewables. It will be affordable, as we use less of it overall and the costs of renewables decrease. And it will be secure, spread out across a more diverse mix of sources.

> "To win the carbon war, we must remember how important it is to incentivise alternative energies. That is very clear. But it is also clear that nothing is more important than attacking energy efficiency where the potential is significant."
>
> **Carl-Henric Svanberg, Chairman, BP**

Powering the economy

Energy is the oxygen of human enterprise, affecting every part of our lives. We need it at the flick of a switch or the turn of a key. From the heating, cooling, lighting and cooking facilities in our homes, to communication, transport and industrial processes, every aspect of modern life depends on instantaneous and continuous energy. Without energy, there would be no economic growth.

It is no accident that the Industrial Revolution was, at its core, a revolution in energy technology – a great leap forward in the way in which energy was procured and in the efficiency with which it was used. It was around this time that we found out how to exploit coal to effect, replacing the water wheel with the steam engine, in so doing accelerating the speed with which we could produce goods and transport them to ever more distant markets.


Carl-Henric Svanberg, BP

Since then, we have become steadily more adept at finding fossil fuels and using them. Today fossil fuels are woven into the very fabric of the economy: in 2008, over 80% of global primary energy demand was met by oil, gas and coal.[1] But the relationship appears to be on the rocks. Cheap for so long, the most dominant fossil fuel – oil – is becoming increasingly expensive. The recent turbulence in northern Africa and the Middle East calls into question the political and economic wisdom of relying so heavily on a single resource for our energy needs.

In more well-off countries, the cost of this dependence is being reflected in electricity bills and at the petrol pump; in developing countries, we read the effects in the 1.4

1 IEA (2010), "World Energy Outlook 2010", IEA/OECD, Paris, p. 80.

billion people (over 20% of the global population) who still lack access to electricity. And, as we all know now, our overuse of fossil fuels is imperiling the stability of the climate, on which not just our prosperity but also our existence ultimately depends.

Please, mind the gap

If things stay as they are, we could soon see the emergence of a precipitous gap between energy demand and supply. Driven by rampant growth in emerging economies, global demand could by 2050 be triple the size of 2000 levels, outpacing the ordinary rate of supply growth and leaving a deficit of around 400 exajoules (EJ) per year – the size of the whole industry in 2000.[2] This potential shortfall of energy, dubbed by Shell as the "zone of uncertainty",[3] will have to be bridged by some combination of "extraordinary demand moderation and extraordinary production acceleration".

From the weaknesses of our current energy system, we can glean the ideal features of the future model. The low-carbon economy's energy system will need to meet the three, ostensibly competing criteria pinpointed in the so-called "energy trilemma"[4]: the new energy system needs to be *reliable*; it needs to be *affordable*; and it needs to be *clean*. This goes for both our sources of energy and the way in which energy is delivered and consumed.

"By 2050 energy demand could be triple 2000 levels. Even after energy efficiency measures are factored in, the projected shortfall remains enormous: 400 exajoules – the equivalent of total primary energy production at the beginning of this century."

Harry Brekelmans, Executive Vice President for Strategy, Royal Dutch Shell

The forecast: morning efficiency gains, followed by plenty of wind and sun, and ending with late afternoon electrification.

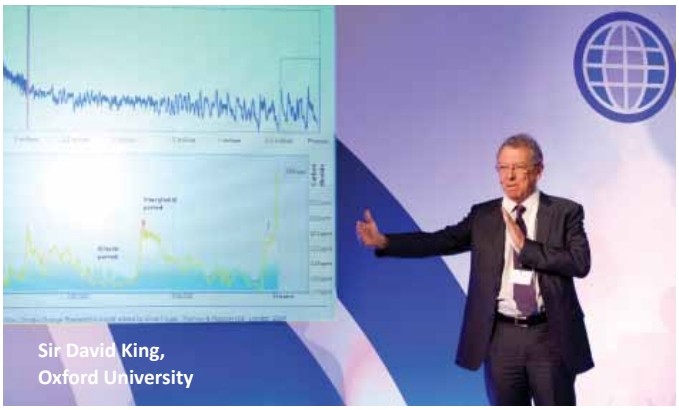
The path to a low-carbon economy will twist and turn according to which of the three strands of the energy trilemma are being pulled the hardest. However, a combination of energy efficiency, alternative energies and electrification should help us reach our destination, achieving an energy system that strikes the right balance across sustainability, affordability and security.

The rising cost of fossil fuels will hasten the journey. Subsidies for fossil fuels, which in 2009 amounted worldwide to $312 billion,[5] look set to be phased out – at least G20 leaders have announced their intention to do so.[6] According to the International Energy Agency (IEA), a complete elimination of fossil fuel subsidies would reduce carbon dioxide emissions by 5.8% by 2020,[7] amounting to a significant share of the abatement needed by that time to limit the global temperature increase to 2˚C. Also, more and more governments could move to put a price on carbon, whether that be through an emissions trading scheme or a carbon tax. Finally, fossil fuels are, by their very nature, non-renewable, meaning there are limited amounts for us to exploit. While natural gas and coal reserves continue to be plentiful, discoveries of new conventional oil reserves are becoming rarer.[8]

Harry Brekelmans, Royal Dutch Shell

2 Shell (2011), "Shell Energy Scenarios to 2050": www-static.shell.com/static/aboutshell/downloads/aboutshell/signals_signposts.pdf
3 Shell (2011), "Shell Energy Scenarios to 2050": www-static.shell.com/static/aboutshell/downloads/aboutshell/signals_signposts.pdf
4 E.ON, "Energy Trilemma: An impossible triangle?": www.eonenergy.com/In-Business/Sustainable-Energy/Sustainable+Energy/energy-trilemma.htm
5 IEA (2010), "World Energy Outlook 2010", IEA/OECD, Paris, p. 569
6 OECD, "Fossil Fuel Subsidies": www.oecd.org/document/57/0,3746,en_2649_33713_45233017_1_1_1_1,00.html
7 IEA (2010), "World Energy Outlook 2010", IEA/OECD, Paris, p. 569
8 Nick Owen, Oliver Inderwildi and David King (2010), "The status of conventional world oil reserves – Hype or cause for concern?", *Energy Policy*, Vol. 38, p. 4746.

Save energy, save money


Sir David King, Oxford University

The rise in the price of energy would stimulate radically higher energy efficiency, the low-hanging fruit along the road to a low-carbon economy. Though we use energy 60% more efficiently than we did 30 years ago,[9] the untapped potential remains significant. The US economy, to take one example, could reduce annual non-transportation energy consumption by roughly 23% by 2020, eliminating more than $1.2 trillion in wasted energy – well beyond the $520 billion in upfront investment that McKinsey & Company estimates would be required to drive the needed energy efficiency measures, including improved building insulation, LED lighting and waste heat recovery. The reduction in energy use would also cut annual greenhouse gases by 1.1 gigatonnes – the equivalent of taking the entire US fleet of passenger vehicles and light trucks right off the road.[10]

"We've got enough coal in the ground that if we burn it all, we've got a good chance of taking the Earth back to its state of 50 million years ago, when it was so warm that there was no ice left on the planet, and sea levels were 120 metres higher than they are today. The only difference is that we're now doing it far more quickly than it has happened by natural means in the past."

Sir David King, Director, Smith School of Enterprise & the Environment, Oxford University and former Chief Scientific Advisor to the UK Government

Renewables take over

The energy mix of the low-carbon economy will be weighted towards renewables. Although it is early days, momentum is already strong: in 2008-09, renewables made up 140 gigawatts (GW) of added electricity generating capacity, out of a world total of 300 GW.[11] Higher and higher fossil fuel prices, along with subsides to help establish renewables, will lend strength to the shift. According to the most optimistic scenario in a recent IPCC study on renewable energy, renewables could supply up to nearly 80% of the world's primary energy requirements by 2050, from today's base of 13%.[12] And the IEA says that biofuels could by 2050 provide 27% of total transport fuel and contribute in particular to the replacement of diesel, kerosene and jet fuel, avoiding around 2.1 gigatonnes of carbon dioxide emissions per year when produced sustainably.[13]

To move from the fringe of today's energy mix into the mainstream of the low-carbon economy, renewables will need to achieve industry-wide grid parity with fossil fuel energy technologies. Though renewables are competitive in some markets, the levelised cost of many renewable energy technologies is, for the time being, higher than market energy prices. Deutsche Bank estimates that onshore wind will likely be the first to achieve widespread grid parity with coal and gas, assuming a carbon price of €40 per tonne and an oil cost of $125 per barrel.[14] According to a recent survey by PricewaterhouseCoopers, nearly 60% of governments believe that offshore wind will become economical, without support from subsidies, within 15 years.[15] The IEA

9 World Energy Council, "Global Energy Efficiency Indicators – Key Indicators", updated 12 August 2010: www.worldenergy.org/documents/world.pdf

10 McKinsey & Company (2009), "Unlocking Energy Efficiency in the US Economy": www.mckinsey.com/en/Client_Service/Electric_Power_and_Natural_Gas/Latest_thinking/~/media/McKinsey/dotcom/client_service/EPNG/PDFs/Unlocking%20energy%20efficiency/US_energy_efficiency_exc_summary.ashx

11 IPCC, "2011: Summary for Policymakers – IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation", 9 May 2011, p. 6: www.unep.org/pdf/SRREN_FD_SPM_approved_plenary_v_03_final.pdf

12 IPCC, "2011: Summary for Policymakers – IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation", 9 May 2011, www.unep.org/pdf/SRREN_FD_SPM_approved_plenary_v_03_final.pdf, p. 18. This scenario assumes an increase in fossil fuel costs, a price for carbon from 2010 onwards and a limit on worldwide CO2 emissions to a level of 3.7 gigatonnes of CO2 per year by 2050. To accelerate the market penetration of renewable energies, various additional measures have been assumed, such as a speedier introduction of electric vehicles combined with the implementation of effective communications systems and technologies, smart meters and faster expansion of super grids.

13 IEA, "Technology Roadmap: Biofuels for transport", OECD/IEA, Paris, p. 5, www.iea.org/papers/2011/biofuels_roadmap.pdf

14 Using long-term oil-indexation contract pricing for gas, and coal at $100 per tonne. See presentation slides by Mark Lewis, Managing Director, Commodities Research, Deutsche Bank, "Re-thinking Energy Subsidies", GLTE London, April 2011: http://xynteo.com/uploads/glte_london_mark_lewis.pdf

15 PwC, "Offshore proof: Turning wind power promise into performance", May 2011: www.pwc.com/en_GX/gx/utilities/publications/assets/offshore-windpower-turning-promise-into-performance.pdf


Mark Lewis, Deutsche Bank

projects that most biofuels could be competitive with fossil fuels by 2030.[16]

How will renewable energies help solve our energy trilemma? Between 2010 and 2050, renewable energies could shave 220-560 billion tonnes of carbon dioxide off the 1.53 trillion tonnes of cumulative business-as-usual emissions forecast for that period.[17] So the criterion for lower carbon impacts would be met. Renewables should become relatively more affordable as the technologies mature and the cost curves for fossil fuels go up – in response to the removal of renewable subsidies, the implementation of a carbon price and, in the case of oil, dwindling supplies. The knock-on cost savings of clean energy would also be reflected in a lower public health bill and the elimination of running fuel costs. As for the security consideration, renewables – wind, solar, biomass and hydro – tend to be more widely distributed than fossil fuels, making them potentially less vulnerable to regional instability.

"Do you apply subsidies to industries that are being born and need support to grow more quickly? Or do you apply them to industries that are on their way out, and you're merely helping them to have a longer life? The reality is that the cost curves for renewables are falling very quickly, whereas the cost curves for fossil fuels are going up."

Mark Lewis, Managing Director, Commodities Research, Deutsche Bank

Total worldwide installed clean energy capacity by technology (as of 2010)

Wind	193 GW
Small hydro	80 GW
Biomass and waste-to-energy	65 GW
Solar	43 GW
Geothermal	7 GW
Marine	0.27 GW
TOTAL	**388.27 GW**

Source: Pew Charitable Trusts (2010) "Who is winning the clean energy race?", www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf

Nuclear energy – sunrise or sunset?

The Fukushima accident has rightly prompted reflection over the safety credentials of nuclear energy. Some governments – including Germany, Japan, Italy and Switzerland – have reassessed their use of atomic power. However, it is vital that responses are measured and proportionate – that the baby is not thrown out with the bath water. After all, accidents stemming from coal mining result in thousands of fatalities every year, receiving little media attention.[18] Given its slim carbon profile, and the growing global demand for energy, it is hard to see a future without nuclear power.[19] However, shoring up public acceptance will be crucial. Governments will need to manage nuclear power's challenges, including not only safety, but also security and waste disposal, to win the public over.

16 IEA, "Technology Roadmap: Biofuels for transport", IEA/OECD, Paris, p. 5: www.iea.org/papers/2011/biofuels_roadmap.pdf
17 IPCC, "2011: Summary for Policymakers – IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation", 9 May 2011, p. 20: www.unep.org/pdf/SRREN_FD_SPM_approved_plenary_v_03_final.pdf
18 Asia Development Bank (2006), "People's Republic of China: Poverty Reduction in Coal Mine Areas", p. 32: www.adb.org/Documents/Reports/Consultant/37616-PRC/37616-PRC-TACR.pdf
19 See, for instance, David King (March 2011), "A low carbon nuclear future", Smith School of Enterprise and the Environment, Oxford University, www.smithschool.ox.ac.uk/nuclearreport2011/nuclearreport.html

Fossil fuels: down but not out

The low-carbon economy does not necessarily spell the end of fossil fuels. Natural gas, the cleanest member of the fossil fuel family, is undergoing a renaissance. When used for power generation, it emits 20% less carbon dioxide than oil and around half as much as coal per kilowatt-hour.[20] And as a cost-effective, operationally flexible base-load generation technology, natural gas could have a vital role to play in helping the renewables industry overcome its Achilles' Heel: intermittency.

The widespread development and deployment of carbon capture and storage (CCS) technologies could further extend the fossil fuel story.[21] The IEA projects that CCS could absorb 10% of carbon dioxide emissions per year by 2030.[22] This is a tall order, given that CCS technology is still immature and expensive, and that the public needs to be convinced about the viability of the storage technology.

Electrifying our environment

Once renewables have achieved widespread parity with fossil fuels, electricity could assume much greater importance. Electrification could in particular play a critical role in transportation, particularly around the city, where small plug-in electric vehicles and buses will likely dominate the roads. The IEA projects that by 2035 about 70% of all cars sold worldwide will be advanced vehicles (ie, electric cars, plug-in hybrids and hybrids).[23]

The electrification of transport would also benefit utilities, which face a persistent challenge in balancing supply with real-time demand. Plug-in vehicle owners would buy power when it was cheap and sell when it was expensive, thereby helping to stabilise the smart grids of tomorrow.[24] Siemens estimates that 200,000 electric cars connected to the grid could make 8 GW of power available very quickly – more than what is currently required in Germany to meet peak surges.[25]

New technologies and behaviours will change the way we heat, cool and power our homes and buildings. Today in the US only 32% of energy generated from centralised power sources actually gets delivered to users.[26] In the low-carbon future, this inefficiency would be challenged by turning houses into mini-power plants, capable of not only consuming energy but also producing it. Using a combination of combined heat and power technology, roof-top solar photovoltaic panels and energy from waste, homeowners could sell energy to the grid and make a profit.[27]

> "Gas is the perfect energy source to resolve the intermittency of renewables. You could say that there is a kind of love story between gas and renewables."
>
> **Hege Norheim, Senior Vice President, Statoil**

> "Natural gas is stable, clean and reliable. Even more, it balances economy with ecology."
>
> **Paul van Gelder, Chairman and CEO, Nederlandse Gasunie**

20 The following averages for energy content and CO2 content per kilo were used: coal 24MJ/kg and 2.93 kg CO2/kg (based on 80% carbon content); oil 42.3 MJ/kg and 3.17 kg CO2/kg; natural gas 47.18 MJ/kg and 2.80 kg CO2/kg

21 International Energy Agency (2010), "World Energy Outlook 2010", OECD/IEA, Paris, p. 423.

22 International Energy Agency (2009), "World Energy Outlook 2009", OECD/IEA, Paris, p. 411.

23 IEA (2010), World Energy Outlook 2010, OECD/IEA, Paris, p. 431

24 Siemens (2010), "105 years of electromobility in Berlin", www.siemens.com/press//pool/de/pressemitteilungen/2010/corporate_communication/AXX20100458e.pdf

25 Siemens (2009), "Pictures of the Future – Spring 2009", available at: www.siemens.com/innovation/en/news_events/innovationnews/innovationnews_articles/2009/e_21_ino_0910_1.htm

26 Lawrence Livermore National Laboratory (2009), "Estimated US Energy Use in 2009": https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2009/LLNL_US_Energy_Flow_2009.png

27 Peter Head (2008), "Entering the ecological age: the engineer's role", The Brunel Lecture, p. 20, www.arup.com/~/media/Files/PDF/Publications/Research_and_whitepapers/Ecological_Age/EngineersRole.ashx

Jeremy Bentham,
Royal Dutch Shell

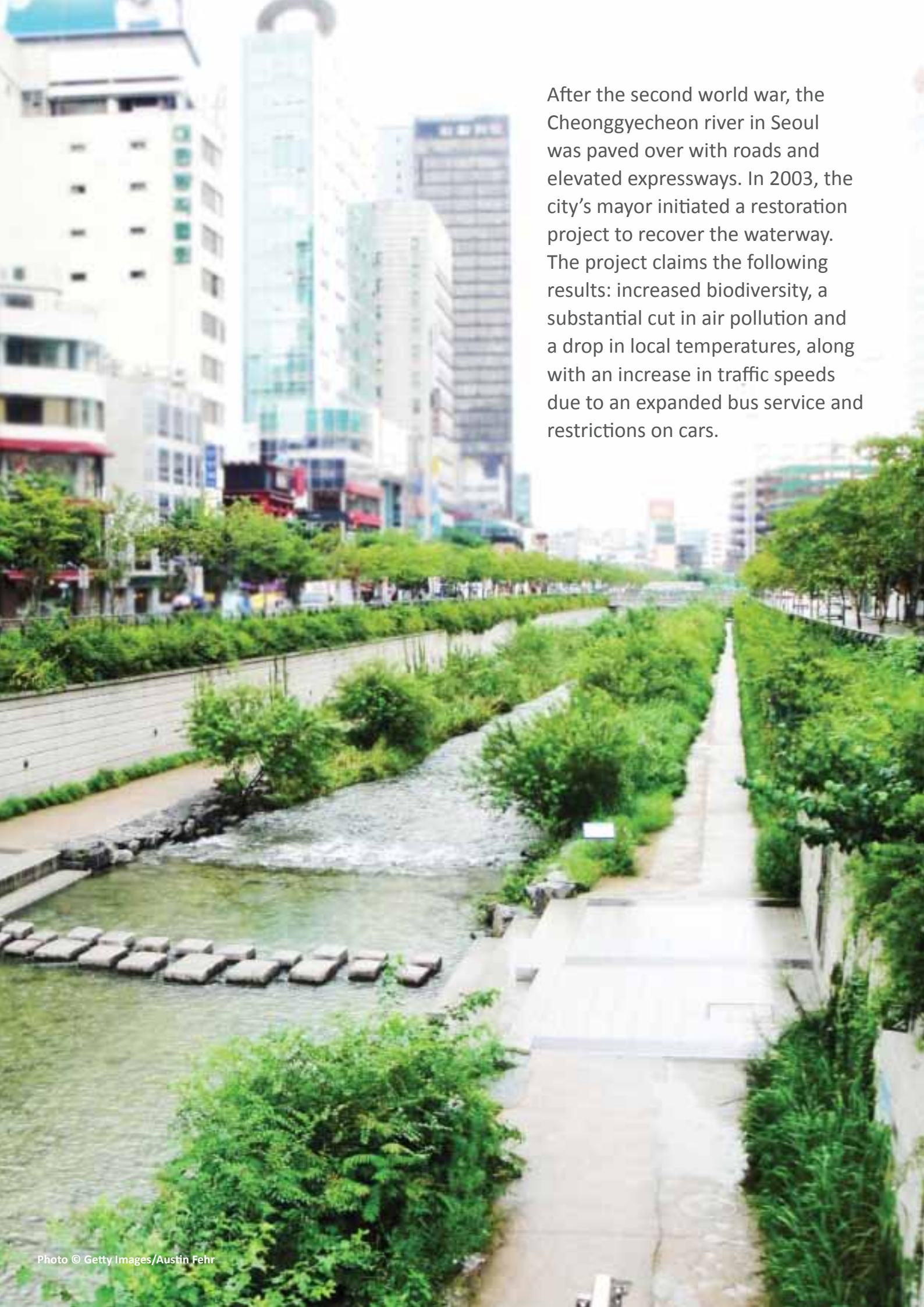
From energy to infrastructure

In the low-carbon economy, the energy mix will be more weighted towards renewable energy, though fossil fuels, backed up by CCS, could continue to play a significant role. Among the fossil fuels, natural gas's star looks the brightest as a balancing technology for renewables in power generation. The low-carbon economy will also demand a wholesale recalibration of the way in which we use energy. Renewables-based electricity, applied to everything from public transportation to cooking, is a core feature of this future.

Of the five pillars of the low-carbon future which form the subject of this paper, energy is central. The next section will evaluate how our infrastructure will need to evolve if it is to support both the new energy system we have just discussed, and the economic behaviour that will need to underpin the low-carbon future.

"We have already entered an era of volatile transitions. Emerging nations like China and India are going through materially intensive development, and a tighter market will continue to put pressure on prices and generate volatility. Improvements in policy-making and strong gains in productivity have helped economies to grow without inflation in the last two decades. But we do not believe the moderating effect of this combination of good policies, good practices, and good luck will continue into the future."

Jeremy Bentham, Vice President, Global Business Environment, Royal Dutch Shell



After the second world war, the Cheonggyecheon river in Seoul was paved over with roads and elevated expressways. In 2003, the city's mayor initiated a restoration project to recover the waterway. The project claims the following results: increased biodiversity, a substantial cut in air pollution and a drop in local temperatures, along with an increase in traffic speeds due to an expanded bus service and restrictions on cars.

Infrastructure

In the low-carbon economy we will use space differently, reducing both unnecessary travel time and wasteful practices. Our cities will be bigger; yet with fewer highways and more trees, their inhabitants will enjoy cleaner air, less heat stress and reduced noise pollution.

"We shape our dwellings, and then afterwards our dwellings shape our lives."

Former British Prime Minister Sir Winston Churchill, 1960

Infrastructure – unlocking new economic behaviour

Infrastructure can be thought of as society's physical building blocks – its roads, bridges and ports, its electrical grids, its telecommunications towers – all the systems and structures that support economic growth by increasing the productivity of labour and capital.[28] Just as the railways of the Industrial Revolution rewired 19th century economic behaviour, so too will the infrastructure ushered in by the low-carbon revolution reprogram the way we move our goods and live our lives.

Michael Treschow, Unilever

Bricks and mortar … and carbon

We have not yet, to borrow Churchill's imagery, "shaped our dwellings" in a way that supports the new economic behaviours needed to change gears – to shift from high-carbon growth to low-carbon growth. Building and operating infrastructure has traditionally been carbon intensive; power generation, transport and urban development have particularly deep carbon footprints. It is estimated that continuing current approaches towards urban infrastructure would, over the next three decades alone, generate nearly ten times the carbon dioxide emitted worldwide in 2005.[29]

Cities, the main focus of infrastructure investment, are estimated to account for more than half of global greenhouse gas emissions and for about two-thirds of global energy use.[30] And this contribution is set to grow, with more and more people moving to the cities to pursue a better quality of life. The UN projects that 70% of the global population in 2050 will be living in cities, up from a little over 50%

"It's not only companies that compete in today's world. It is actually regions and countries as well. And in that sense, infrastructure is the key word. I'm a true believer that infrastructure almost always pays off, because companies will not go to places with poor infrastructure."

Michael Treschow, Chairman, Unilever

28 New Zealand Ministry of Economic Development, "Why is Infrastructure Important?", www.med.govt.nz/templates/MultipageDocumentPage____9212.aspx

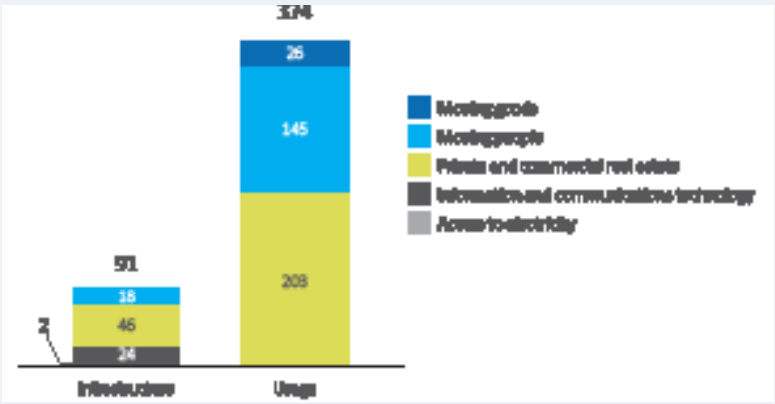
29 World Wildlife Fund (Booz & Company) (2010), "Reinventing the City", p. 2, www.wwf.se/source.php/1285816/Reinventing%20the%20City_FINAL_WWF-rapport_2010.pdf; and World Resources Institute (2009), World Greenhouse Gas Emissions 2005", 2 July 2009, www.wri.org/publication/world-greenhouse-gas-emissions-in-2005

30 UN-HABITAT (2005), *Climate Change: The Role of Cities*. www.unhabitat.org/pmss/getElectronicVersion.aspx?nr=2226&alt=1

today.[31] Our ability to harness the strengths of our cities – their high levels of knowledge and investment – will be fundamental to transforming our urban centres from a climate problem to a low-carbon solution.

Cumulative urban emissions (2010-2040)

(worldwide, in gigatons of CO_2)



Source: World Wildlife Fund (2010), *Reinventing the City: Three Requisites for Greening Urban Infrastructures*, p. 2: http://www.booz.com/media/uploads/WWF_Low_Carbon_Cities.pdf

"The way that cities develop is clearly having a big impact on energy use. In the US the average person uses three times as much energy for transport as the average European. This is not just because of energy efficiency, but also because they drive twice as far in the US, largely owing to the fact that cities there have developed in a particular way."

Jeremy Bentham, Vice President, Global Business Environment, Royal Dutch Shell

Living well with scarcity

The infrastructure of the low-carbon economy will need to be designed and constructed to thrive in a future characterised by intensified scarcity – not only of climate, but also of food, water, energy, raw materials and space. All of these resources will come under pressure from a growing global population intent on improving its standard of living.

By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under water stress conditions.[32] Already today, one in seven people around the world do not get enough food to be healthy and lead active lives.[33] By threatening crop yields, climate change could exacerbate these numbers.[34] And the IEA predicts that in 2030, without additional dedicated policies, there will still be 1.2 billion people in the world that lack access to electricity, some 85% of them in rural areas.[35]

Infrastructure can help to stem these trends through the repair or replacement of leaking pipes, ensuring all the water reaches those who need it; through the construction of roads, warehouses and irrigation systems to maximise food production and ensure that produce is delivered fresh; and through the extension or decentralisation of grids, to give rural areas access to energy.

31 UN (2007), "World Urbanisation prospects", www.un.org/esa/population/publications/wup2007/2007WUP_Highlights_web.pdf
32 FAO, "Hot issues: Water scarcity", www.fao.org/nr/water/issues/scarcity.html. According to the Falkenmark Water Stress Indicator, a country or region is said to experience "water stress" when annual water supplies drop below 1,700 cubic metres per person per year. At levels between 1,700 and 1,000 cubic metres per person per year, periodic or limited water shortages can be expected. When water supplies drop below 1,000 cubic meters per person per year, the country faces "water scarcity". See IPCC, *Third Assessment Report: Climate Change 2001*, Chapter 4.5.2, www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/180.htm
33 World Food Programme (2011), "World Hunger", www.wfp.org/hunger
34 World Food Programme (2011), "What causes hunger?", www.wfp.org/hunger/causes
35 IEA (2010), World Energy Outlook 2010, IEA/OECD, Paris, p. 237


Peter Head, Arup

"No big roads in cities! Seoul has been one of the first to recognise the economics of wasted land associated with major highways. A heavily congested major highway running through the centre of the city was removed to improve the city's economic performance and air quality. It was replaced by a river, so people can now walk and cycle to their jobs. Labour costs have gone down. Businesses are more vibrant. This is the transition to the ecological age."

Peter Head, Director and Chairman, Global Planning, Arup

Industrial symbiosis: waste = raw material

Kalundborg, a Danish town about 100 kilometres from Copenhagen, is host to the world's most well-known example of industrial symbiosis, in which companies exploit each other's residual or by-products on a commercial basis.

Excess steam from Asnæs Power Station, Denmark's largest power station, is exported to Kalundborg's combined district heat and power supply as well as to symbiosis partners Statoil, Novozymes and Novo Nordisk. These companies use the steam as a heat source before exporting it back to Asnæs as condensed steam for cooling the plant. This saves about 240,000 tonnes of carbon dioxide per year. The waste products from insulin production at Novo Nordisk are turned into pig food and landfill gas; the incineration of waste is used to make electricity; and solid biomass from making enzymes is turned into fertiliser.

Participating companies are protecting both the environment and their bottom lines. From the initiative's start in the 1960s until 1998, the initiative led to savings of $160 million.

Source: "Kalundborg: Industrial Symbiosis – Waste makes resource", Sustainable Cities, Danish Architecture Centre 2008, http://sustainablecities.dk/en/city-projects/cases/kalundborg-industrial-symbiosis-waste-makes-resource

Location, location, location

Planners in the low-carbon economy will likely encourage a move away from using land for a single purpose, such as simply living or working. Instead we will use land for a mix of purposes, so that people can live, work, learn, shop and play in much closer proximity.[36] Instead of being stuck in a traffic jam on the way back from the office in the commercial part of town, you would be able to cycle or walk home, allowing plenty of time to spend with the kids before they go to bed.

Optimising how we use space will change the way we produce goods and services. Manufacturers could be clustered according to "industrial symbiosis" principles – the sharing of services, utilities and by-product resources among industrial actors in order to reduce costs and add value, while dramatically reducing negative environmental

36 Karlson Hargroves and Michael Smith (2006), *The Natural Advantage of Nations*, Earthscan, London, p. 382.

Ashish Bhatt, Xyntéo

impacts.[37] In short, one company's waste becomes another's raw materials.

Living and working in closer quarters does not mean the creation of crowded concrete jungles. On the contrary, resource-smart urban areas could be much more pleasant places than today's cities. An increase in vegetation would improve water management, slow water run-off and improve air quality – the latter also receiving a tonic from infrastructure consolidating the shift away from highly-polluting personal vehicles to fast, comfortable and clean public transport. Green roofs, urban parks and street-side tree-planting would reduce the so-called heat island effect. Under this phenomenon, evening temperatures in urban areas with little green space and little surrounding water bodies can be two or three degrees higher than temperatures in rural areas, leading to heat stress and increased water evaporation.[38]

> "In the 64 years since independence, India's cities have boomed. In the last 40 years India's urban population rose by 230 million; the next 250 million could be with us in half that time. Faced with such rapid population growth, India's cities are the crucible in which we will forge our efforts to redefine our urban landscapes through the creation of low-carbon infrastructure."
>
> **Ashish Bhatt, Managing Director for Infrastructure and the India Infrastructure Partnership, Xyntéo**

We could turn the rural-urban divide on its head by using hydroponics and nutrients recovered from the waste stream to grow food in cities. A proportion of food could even be grown commercially by supermarkets within their existing facilities in towns and cities, reducing distribution needs.[39] To save water (and money), we would fit water capture and grey water recycling systems into our homes. It is estimated that these measures can already cut household potable water consumption by 30%.[40]

Not only do we need to recreate the places in which we live and work; we also need to redesign the structures that connect them. Major freeways actually have no place in urban areas: by promoting the one-way growth of personal vehicle use, they can choke commerce by wasting time, energy and labour in traffic. Removing freeway infrastructure would also free up land for more productive purposes and reduce maintenance costs, thereby releasing funding for more efficient public transport.

Not every city needs its own airport: in the low-carbon economy, new airports would be at least 600 kilometres apart – the threshold distance at which passengers tend to choose aviation over high-speed rail.[41] Ports would become meccas of energy efficiency – onsite renewable power generation would heat, cool and light state-of-the-art buildings and drive electric trucks, while enabling visiting ships to switch off their fuel-powered engines, reducing damage to local air and water resources.[42]

37 Abhishek Agarwal and Peter Strachan (2008). "Is Industrial Symbiosis only a Concept for Developed Countries?" *The Journal for Waste & Resource Management Professionals, The Chartered Institution of Wastes Management*, p. 42: http://abhibiz.co.uk/doc/CIWM_March_42-43.pdf. See for instance "Kalundborg: Industrial Symbiosis - Waste makes resource", Sustainable Cities, Danish Architecture Centre, 2008, http://sustainablecities.dk/en/city-projects/cases/kalundborgindustrial - symbiosis-waste-makes-resource

38 See US Environment Protection Agency, "Reducing Urban Heat Environments", www.epa.gov/heatisland/resources/pdf/TreesandVegCompendium.pdf

39 Peter Head (2008), "Entering the ecological age: the engineer's role", The Brunel Lecture, p. 65, www.arup.com/~/media/Files/PDF/Publications/Research_and_whitepapers/Ecological_Age/EngineersRole.ashx

40 Arup Integrated Urbanism, Chongming Dongtan Eco-City China (2007), www.arup.com/_assets/_download/8CFDEE1A-CC3E-EA1A-25FD80B2315B50FD.pdf

41 OECD (2008), "The Economic Effects of High-Speed Rail Investment: Discussion Paper", OECD/ITF, Spain, available at: www.internationaltransportforum.org/jtrc/discussionpapers/DP200816.pdf

42 See, for instance, presentation slides by Paul Allen, Senior Vice President, Constellation Energy, at GLTE London, 7 April 2011, www.xynteo.com/uploads/glte_london_paul_allen.pdf

Masdar City: the first city of the low-carbon economy?

UAE's Masdar City, 17 kilometres from downtown Abu Dhabi, aims to be one of the most sustainable cities in the world.

Here are some its core low-carbon features:

- The axis of the street grid provides maximum shading at the street level throughout the day, minimising thermal gain on building walls and facilitating the flow of cooling breezes.
- There are no separate zones: the city's university, its business buildings and its entertainment and leisure facilities are all embedded in the heart of the community.
- The city's low-rise, high-density design results in lower energy use by transportation (both between and within buildings) and reduces heating/cooling loads.
- As a pedestrian city, Masdar's buildings are situated close to one another, providing better shading and a cooler street environment.
- Electric buses serve as the backbone of the city's clean public transportation system.

Source: Madsar City, "Exploring Madsar City", www.madsarcity.ae/digitalbrochure/en/ExploringMadsarCity

"Eighty percent of the India of 2030 is yet to be built"

N. Chandrasekaran, CEO and Managing Director, Tata Consultancy Services

"Inadequate infrastructure is known to increase production costs and impact the productivity of the nation's most dynamic sectors."

Bakul Patel, Director, Infrastructure Development Finance Company AMC and former Sheriff of Mumbai

Built to last, so build it right

Bakul Patel, Infrastructure Development Finance Company AMC

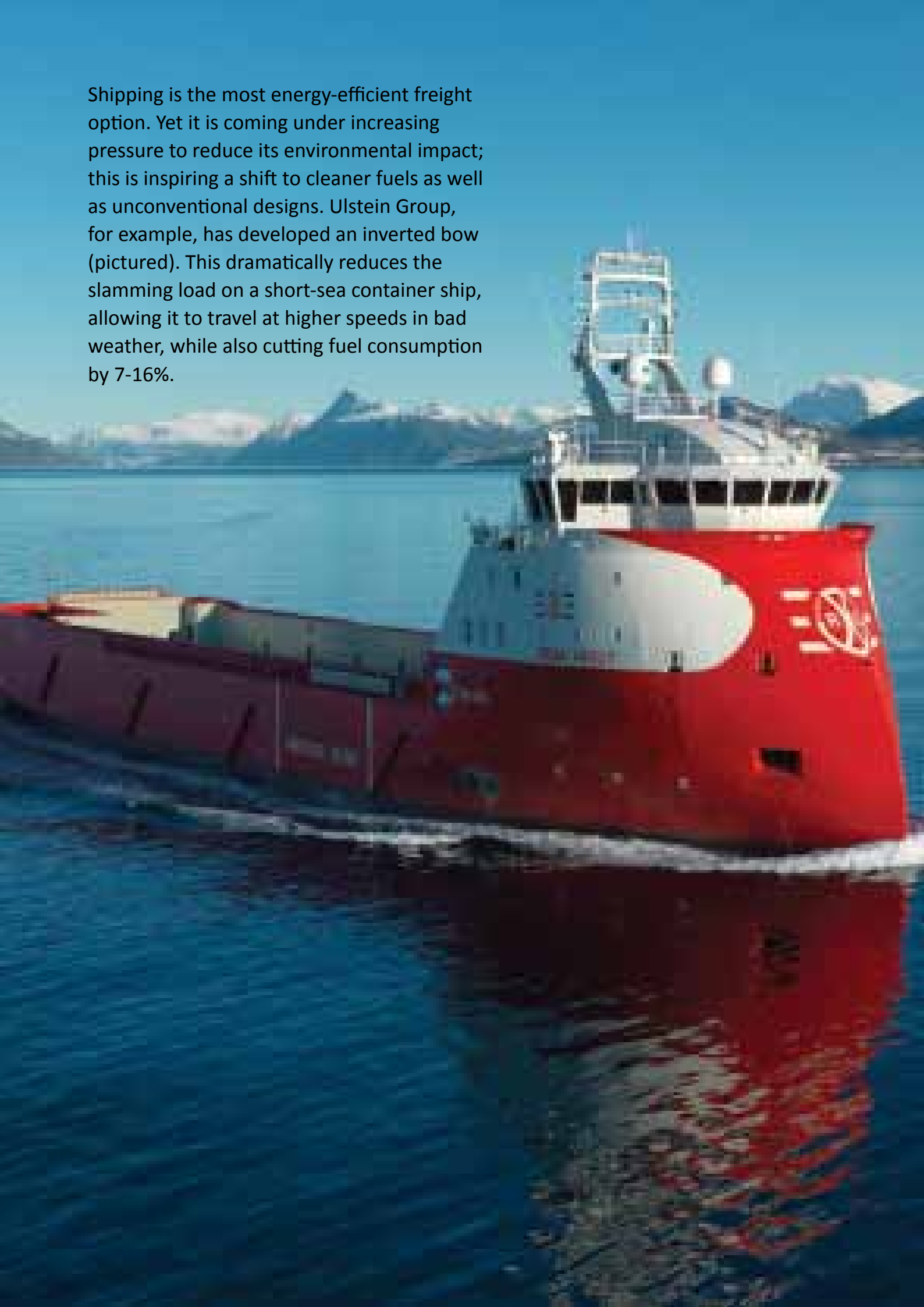
Picturing the role of infrastructure in the low-carbon economy highlights the extent to which our economies are products of our mindsets. From our mindsets and values we design our infrastructure, which in turn dictates our behaviour and keeps it wedded tightly to the perceptions that originally inspired the infrastructure. We need to rethink everything. For example: forget mines as you know them. In the low-carbon economy, the largest copper deposits in the world could be mined from the old buildings, bridges and tunnels of aging New York and Tokyo.[43]

Infrastructure typically has a long life span; it shapes economic behaviour across not just years or even decades but generations. If we continue to build infrastructure that is dependent on high-carbon inputs, then we effectively write carbon dependency into the DNA of our long-term development. In emerging economies like China and India, where infrastructure is still relatively immature, there exists a golden opportunity to break that cycle and construct infrastructure which is built to last in the low-carbon economy.

Given the carbon intensity of the transportation sector, the move to the low-carbon economy will need to see in new transportation infrastructure capable of shrinking the sector's carbon footprint while keeping society mobile. How to address these twin challenges is the subject of the next section.

43 Peter Head (2008), "Entering the ecological age: the engineer's role", The Brunel Lecture, p. 36, www.arup.com/~/media/Files/PDF/Publications/Research_and_whitepapers/Ecological_Age/EngineersRole.ashx

Shipping is the most energy-efficient freight option. Yet it is coming under increasing pressure to reduce its environmental impact; this is inspiring a shift to cleaner fuels as well as unconventional designs. Ulstein Group, for example, has developed an inverted bow (pictured). This dramatically reduces the slamming load on a short-sea container ship, allowing it to travel at higher speeds in bad weather, while also cutting fuel consumption by 7-16%.



Mobility

In the low-carbon economy, driving your car will be as carbon-efficient as walking. But fewer will own cars: car-sharing and public transportation will be the preferred methods for getting around. ICT will transform logistics: sophisticated information systems will make sure loads are full, routes are efficient and the most appropriate modes are used.

"The most efficient way to reduce emissions from shipping, beyond changing the design, is a fuel switch to LNG, together with reducing the speed. Why does oil have to travel at 15.5 knots when it could travel at 12 knots, cutting emissions in half? It would still travel first class – these are excellent ships!"

Henrik Madsen, CEO, Det Norske Veritas

The wheels on the economy go round and round

If energy is the oxygen of the global economy and infrastructure the skeleton, transportation is its lifeblood. Without it, supply would never be connected with demand; well-made goods with no buyer generate no value.


Henrik Madsen, Det Norske Veritas

Transportation's centrality to economic activity became starkly evident during the Industrial Revolution. From the exploitation of canals to the advent of the steam-powered locomotive, advances during this period unleashed unprecedented growth in trade, enabling manufacturers to get their goods to much more remote markets with much greater speed.

Since then the evolution of transportation has continued apace. Today, most of us take fast transportation for granted: it gets employees to work, shoppers to the stores and citizens to the doctor's office, the restaurant and the gym. We see nothing remarkable in visiting our local supermarket to buy bananas from Brazil, mangos from Africa and lamb from New Zealand, or in enjoying Paris one day and Hong Kong the next.

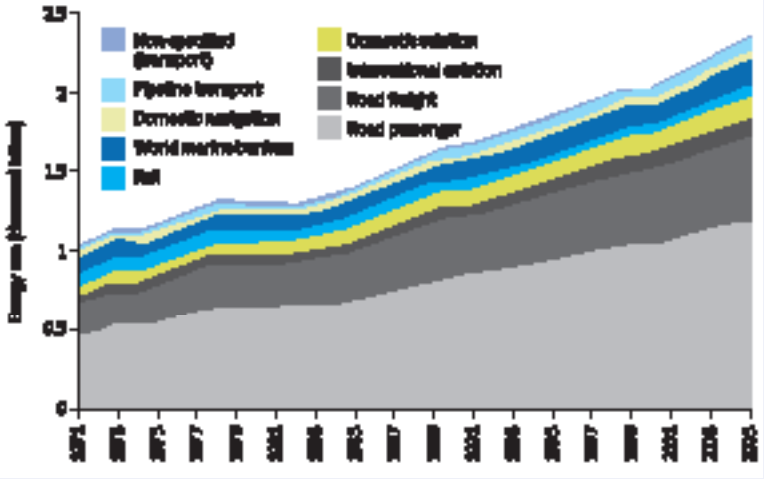
It giveth, and it taketh away

Virtually all the energy used by the transportation sector – 95% to be exact – is oil-based.[44] Diesel makes up 31% of transport's energy use and gasoline 47%. The result is that transport is a veritable carbon junkie, accounting for roughly 15% of global greenhouse gas emissions.[45] Of this, 73% derive from road transport.

44 Kahn Ribeiro et al. (2007), "Transport and its infrastructure", in "Climate Change 2007: Mitigation", contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, Cambridge University Press, p6

45 International Transport Forum (2010), "Reducing transport GHG emissions – trends and data 2010", www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdf

World transport energy use



Source: IEA (2009), Transport, Energy and CO_2: Moving towards sustainability, p. 45: www.iea.org/textbase/nppdf/free/2009/transport2009.pdf

The US sits unrivalled atop the gasoline consumption throne, consuming more than the next 20 countries combined.[46] To highlight the US's thirst for oil and the need to avoid it being replicated elsewhere, let us assume for a moment that China matched the US in terms of car ownership and oil consumption per person. To meet this demand, roughly 850 million more cars would have to hit the streets; world oil output would have to double, and global emissions from transportation would follow suit.[47] Clearly, the likes of China need to find new ways of keeping citizens mobile and connected.

Freight transport is typically more energy efficient than personal transport. However, this record is being challenged by demand for "just-in-time" shipments, causing a shift to more air and road freight at the expense of rail and inland waterway transport. Freight transport now represents 35% of total energy consumption in the transport sector. One study predicts that freight trucks will be one of the main drivers of the projected doubling of transport energy use by 2050.[48]

Innovation – taking us back to the future?

The efficiency of transportation technology has progressed leaps and bounds over the last century. But the transportation industry will need to travel much farther to stay competitive in a future where carbon will be as decisive a factor as time, convenience, comfort and cost. To get there, innovation in transportation infrastructure will be a key engine – we need to "rewire" the way in which we move goods and people around. The difference between North American and European infrastructural planning is illustrative: long distances between residential areas and urban centres give North American consumers average carbon profiles twice as large as European counterparts.[49]

46 Lester R. Brown (2009), "Plan B 4.0 mobilizing to save civilization", Earth Policy Institute (New York/London: W.W.Norton & Company, 2009), p. 96
47 Karlson "Charlie" Hargroves and Michael H. Smith, ed. (2010), "The natural advantage of nations", the Natural Edge project (London: Earthscan, 2010), p. 371
48 Kahn Ribeiro et al. (2007), "Transport and its infrastructure", in "Climate Change 2007: Mitigation", contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, Cambridge University Press, p. 9
49 World Resources Institute (2005), "Navigating the Numbers: Greenhouse Gas Data and International Climate Policy", December 2005, p. 22, available at: http://pdf.wri.org/navigating_numbers.pdf

Infrastructural innovation will have to be accompanied by advances in technology, from the development of lighter-weight materials and ultra-efficient engines, to hybrid options, hydrogen- and biofuel-powered cars and fully electric vehicles. We are also likely to see the displacement of carbon-intensive transport with more efficient modes; in some countries high-speed rail, for example, is already competing with air travel as a connector of cities less than 600 kilometers apart.[50] The IEA predicts that greater take-up of more efficient transport forms, along with progress in fuel and vehicle technology, could by 2050 cut carbon dioxide emissions by 40% below 2005 levels.[51]

Start your (electric) engines

In the low-carbon future, small cars, which operate mostly in cities, are likely to be electric or plug-in hybrids. Either way, driving your car in the low-carbon economy would need to be as carbon-efficient as walking (estimated to produce 60 grams of carbon dioxide per kilometre), and almost as efficient as cycling (30 grams of carbon dioxide per kilometre).[52] Given that new cars today in the UK produce roughly 150 grams per kilometre, there is still a considerable way to go.

With their heavier loads and typically longer driving distances, most trucks will probably need to stay powered by liquified fuel – in which case either natural gas or biofuels would provide the most realistic lower-carbon options. Technological improvements – for instance, more efficient engines, lighter materials, improved aerodynamics and better tyres – could make new trucks 30-40% more efficient by 2030.[53]

Tony Harper, Jaguar Land Rover

"By 2040, our cars need to be more efficient per kilometre than walking."

Tony Harper, Head of Research & Advanced Systems Engineering, Jaguar Land Rover

Hoist the sail

Shipping and global trade are tightly linked; so ships will continue to play a starring role in the future of transport, not least given their well-established relative energy efficiency. Per tonne of payload per kilometre, shipping on average emits less than any other freight transport option: at 2-60 grams per tonne-kilometre (g/t-km),

50 OECD (2008), "The Economic Effects of High-Speed Rail Investment: Discussion Paper", OECD/ITF, Spain, www.internationaltransportforum.org/jtrc/discussionpapers/DP200816.pdf

51 IEA (2009), *Transport, Energy and CO2: Moving towards sustainability*, IEA/OECD, Paris, p. 29, www.iea.org/Textbase/npsum/transport2009SUM.pdf

52 Tony Harper, Head of Research and Advanced Engineering, Jaguar Landrover, "The future for low-carbon cars" (presentation at GLTE London, 7 April 2011), available at: http://xynteo.com/uploads/glte_london_tony_harper.pdf.

53 IEA (2009), *Transport, Energy and CO2: Moving towards sustainability*, IEA/OECD, Paris, p. 37, www.iea.org/Textbase/npsum/transport2009SUM.pdf

"High speed railways are economic development projects. They are not return-on-capital projects."

Peter Head, Director and Chairman, Global Planning, Arup

average carbon dioxide emissions from shipping come in lower than rail (10-119 g/t-km), trucking (80-181 g/t-km) and aviation (435-1,800 g/t-km).[54]

Yet this record is no reason for complacency; international shipping, a growing source of emissions, is coming under increasing pressure to reduce its environmental impacts. In the low-carbon economy, ships would use cleaner fuels, such as liquified natural gas (LNG),[55] and unconventional designs – for example, inverted bows and ballast-free hulls to cut fuel consumption and kites to harness wind power.[56] Capacities would also be more fully exploited, owing to ICT optimisation tools. The average size of ships could rise, making shipping more efficient per tonne-kilometre moved.[57] Operational changes could also yield important efficiencies: ships could travel at lower, more stable speeds instead of rushing to port only to idle while waiting to dock.[58]

Fly like an airship?

Aviation could be much more efficient in the low-carbon economy. While today it has one of the fastest growing emissions as a sector,[59] the industry has a record of steadily improving its energy efficiency; over the last four decades, it has become 70% more fuel efficient.[60] In decades to come, new technology could enable planes to be fuelled by alternatives energies, including second-generation biofuels, fuel cells and possibly solar power.[61] Better air traffic management systems could reduce unnecessary cruising, thereby reducing energy consumption by 5-10%.[62] The estimated overall potential is that aircraft could be nearly twice as efficient in 2050.[63]

In the low-carbon economy, holiday makers could make up the bulk of aircraft passengers as business travel became less necessary, displaced by high-quality virtual communications. Some have even speculated that the implied reduced need for speed could lead to the renaissance of airships. UK think tank Forum for the Future argues that, though airships would take longer to arrive at their destination, they would provide a decidedly more pleasurable travelling experience.[64]

Airships or not, low-carbon mobility is likely to contain some surprises: we could see a return to the past. Just like the first cars, tomorrow's cars could be powered by electricity. And just like the first boats, tomorrow's ships could rely on the wind.

54 Norwegian Shipowners' Association and Xyntéo (2010), "Leadership through Rough Seas: Piloting shipping to low-carbon growth", http://xynteo.com/uploads/LeadershipThroughRoughSeas.pdf
55 DNV press release (2010), "A major step towards the new environmental era for tanker shipping", 6 December 2010, www.dnv.no/presse/pressemeldinger/2010/Amajorsteptowardsthenewenvironmentalerafortankershipping.asp
56 Wallenius Wilhelmsen Logistics, "2010 Orcelle Grant", www.2wglobal.com/www/environment/esr2010/Environmental_Value/OrcelleGrants/index.jsp
57 IEA (2009), Transport, Energy and CO2: Moving towards sustainability, IEA/OECD, Paris, p. 39, www.iea.org/Textbase/npsum/transport2009SUM.pdf
58 NSA and Xyntéo "Leadership through rough seas – piloting shipping to low-carbon growth" (2010), Xyntéo, http://xynteo.com/uploads/LeadershipThroughRoughSeas.pdf
59 International Civil Aviation Organisation, "Climate Change", http://www.icao.int/icao/en/Env2010/ClimateChange.htm
60 AeroSpace and Defence Industries Association of Europe, "European Aerospace: solutions for a low carbon future", www.asd-europe.org/site/fileadmin/aeroweek/ASD_AW_Environment.pdf
61 Giovanni Bisignani, "Aviation and global warming", *New York Times*, 20 September 2007, www.nytimes.com/2007/09/20/opinion/20iht-edbisi.1.7583290.html
62 IEA (2009), *Transport, Energy and CO_2: Moving towards sustainability*, IEA/OECD, Paris, p. 38, www.iea.org/Textbase/npsum/transport2009SUM.pdf
63 IEA (2009), *Transport, Energy and CO_2: Moving towards sustainability*, IEA/OECD, Paris, p. 38, www.iea.org/Textbase/npsum/transport2009SUM.pdf
64 Forum for the Future, "Airstream", www.forumforthefuture.org/project/sustainable-shipping-initiative/overview

Different times call for different measures

New business and consumption models would underpin and accompany all of these changes. Car sharing, for example, would enable people to hire vehicles when they need them, as opposed to buying them outright.[65] Each car club vehicle replaces, on average, 20 privately owned cars.[66] And car club vehicles tend to be newer and more fuel efficient, with average carbon dioxide emissions coming in at 64% of the emissions of the private vehicles they replace.[67]

An increase in car sharing would mean car manufacturers would need to transform their business models. Car owners would be fewer but larger, and the cars themselves would be used more often, potentially leading to a significant increase in income streams from spare parts and maintenance. Spare parts already make up a healthy 10% of major car manufacturers' sales revenue, with plenty of room to grow.[68]

The transportation sector of the future will also be more collaborative. In logistics such a shift could open up significant opportunities. UK company Shiply.com operates an online marketplace in which hauliers with spare capacity can bid for the business of customers looking for cheaper ways to move goods. By connecting transportation providers, Shiply enables them to share information about vehicle space. Shiply reports savings of approximately 6.1 million kilometres and 1.1 million litres of fuel over 16 months.[69]

Governments, too, would need to think and act differently. Public investment in rail, metro, bus and tram and in better information systems, motivated by increases in urban density, would enable more journeys to be taken by efficient public transport. Urban electric metro systems are already seven times more energy efficient than a car with an average of 1.5 occupants,[70] in addition to being considerably faster in dense urban environments.

> "Mobility is often invisible to the consumer. Take the production of a car: iron ore is dug out of the ground in Australia and sent by rail to a port, from where it gets shipped to China. It's then offloaded and sent by truck to a factory, where it's turned into a steel panel. It's then put back on the truck and sent back to the port, where it's shipped abroad for the car's assembly. After being trucked to another port, the finished car is shipped to the US. All of this before it even reaches the dealer. This has not only a big cost impact, but also a substantial carbon impact, which is often unseen."
>
> **Steve Cadden, Managing Director for Mobility, Xyntéo**

Keep moving


Steve Cadden, Xyntéo

The health of our businesses and economies depends on mobility – our ability to move people and goods around at low cost. In any future, including the low-carbon future, we will need to remain mobile. The question is, how can we do it better?

Part of the answer is: with fewer but cleaner cars; more convenient, faster public transportation; bigger, slower ships fuelled by clean energy; and more collaborative, more ICT-savvy transport business models. All of this would need to be supported by an overhaul of our infrastructure and – given transportation's role in keeping the production-consumption machine running – by a recalibration of the prevailing supply chain model, which we address in the next section.

65 See, for example, the recent launch of DriveNow, a joint venture between Sixt and BMW, www.bmwblog.com/2011/03/21/bmw-and-sixt-establish-drivenow-joint-venture-for-premium-car-sharing/

66 Carplus, *Annual Survey of Car Clubs 2009/10*, p.1, www.carplus.org.uk/wordpress/wp-content/uploads/2010/05/Annual-Survery-Report-2009-10.pdf

67 UK Department of Business Innovation and Skills, *Business Action to Influence Consumer Demand for Low-Carbon Goods and Services*, p. 79, www.bis.gov.uk/assets/biscore/business-sectors/docs/b/10-1100d-business-action-to-influence-consumer-demand-case-studies.pdf

68 See, for example, the sales figures in Volkswagen Group's 2010 Annual Report, http://annualreport2010.volkswagenag.com/servicepages/search.php?q=genuine+parts&pageID=34438&cat=b

69 Shiply (2011): www.shiply.com/eco-friendly-transport.php

70 Newman, Peter and Jeff Kenworthy, *Greening Urban Transportation: State of the World 2007*, Worldwatch Institute (Eds.) New York, W.W. Norton & Company, (2007).

Nature can teach us a lot about better production. Oxpeckers, for instance, perch on the back of large mammals, removing ticks and parasites from their hides. The oxpecker gets fed, while the mammal gets protection from disease. Exploiting comparable synergies across production systems would enable businesses to recapture the value contained in waste, saving carbon and money.

Photo © Getty Images/Seth Resnick

Production

By transforming the supply chain from line to loop, the low-carbon economy will spell the end of waste. Instead of being buried in landfill or vented into the atmosphere, all outputs will be fed back into the production cycle for reuse.

I create, therefore I am

The production of goods has always been a part of human existence. We began by forging our own tools, stitching our own clothes and feeding from our own farms. Then we understood that our goods were valued by others, so we began to trade them. Over time, we expanded our knowledge and honed our skills, allowing us to speed up our techniques and increase outputs. In some periods – the Industrial Revolution, for instance – this process of innovation sprinted forward, spurring great leaps in productivity.

Manufacturing has been the key to the economic development of a range of countries. Over the last 30 years, developing countries – particularly in Asia and Latin America – have used manufacturing to climb higher in the global economic order, abetted by the trade liberalisation and market reforms of the 1980s.[71]

"By footprinting every single product, we can go very specifically after the carbon hotspots, which most of the time are inefficiencies in our supply chain, and take the carbon out."

Ruth Girardet, Corporate Responsibility & Community Director, Tesco

Haste makes waste

The main problem with today's production system is waste: waste of material and waste of energy. The linear, one-way model of most manufacturing chains means that we use large amounts of energy to extract raw materials at one end, and generate large amounts of material waste right through the chain to the other end, where you and I are usually left to dispose of what remains.

And therein lies the irony – while we are referred to as consumers, we actually consume very little.[72] One-third of all food produced for human consumption is either lost through inefficiencies in production or thrown out. And most other goods are designed to be pitched into the trash after short life-spans; from hair

71 Gordon H. Hanson, Raymond Robertson (2007), "China and the Manufacturing Exports of Other Developing Countries", University of California San Diego, National Bureau of Economic Research and Macalester College, July 2007, www.nber.org/books_in_progress/china07/cwt07/hanson.pdf

72 William McDonough and Michael Braungart (2002), "Cradle to Grave: Remaking the Way We Make Things" (New York: North Point Press, 2002), p. 27

"We can make a lot of mistakes if we only think of the manufacturing of materials. We need to look at the whole chain, cradle-to-grave."

Dr Luis Farias, Senior Vice President, Energy & Sustainability, Cemex

dryers to mobile phone chargers, it is usually cheaper to buy a new version than get the original repaired.

Material waste is not just the stuff we throw away once the product "dies". According to one estimate, more than 90% of materials extracted to make durable goods in the US become waste almost immediately.[73] At a typical copper mine, for instance, 125 tonnes of ore are extracted to produce just one tonne of copper.[74]

Energy is another valuable resource we squander rampantly. Some is always dissipated as waste heat when fuels are burned, but inefficient technology and design are the main culprits. In the US, it is estimated that 56% of all energy is wasted, while just over 30% of power generated from centralised power sources is actually delivered to American users – the rest lost as heat during generation and leached out during transmission.[75] India's power network is even more inefficient: 32% of generated electricity is wasted during transmission alone.[76]

Dr Luis Farias, Cemex

The inefficient use of energy and the waste of material are linked; recycling material can therefore tackle both forms of waste. Steel made from recycled scrap, for example, requires just 26% as much energy as that made from iron ore. Recycled plastic uses only 20% the energy needed to produce plastic from scratch. In the case of aluminium, the figure is just 4%.[77] In fact, if the 42% of all aluminium beverage cans currently being sent to landfill in the US each year were instead recycled and re-used, the energy saved could power 700,000 homes.[78] That is because, per kilogram of metal, using recycled aluminium to produce new cans saves 14 kilowatt-hours of energy, 6 kilograms of bauxite and 4 kilograms of chemicals.[79]

Given this lavish inefficiency, we are fortunate that aluminum, iron and copper are abundantly available and easily accessible. But not so for many other metals and minerals.[80] China, for example, currently accounts for 93% of global production of so-called rare-earth elements – vital inputs for a wide range of military applications as well as green energy technologies. For two rare-earth elements in particular – dysprosium and terbium – China is effectively the sole producer.[81] A recent dispute between China and Japan, a world leader in advanced technology production and therefore highly dependent on such metals, shows that the stakes are high and climbing.[82]

73 William McDonough and Michael Braungart (2002), "Cradle to Grave: Remaking the Way We Make Things" (New York: North Point Press, 2002), p. 27
74 United Nations Environment Programme/GRID-Arendal, (2004) "How long does it take for some commonly used products to biodegrade?", Vital Waste Graphics, p1, http://maps.grida.no/go/graphic/how-long-does-it-take-for-some-commonly-used-products-to-biodegrade
75 Lawrence Livermore National Laboratory (2009), "Estimated US Energy Use in 2009", https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2009/LLNL_US_Energy_Flow_2009.png
76 The Climate Group (2008), *Smart 2020: Enabling the low carbon economy in the information age*, London 2008, p. 47
77 Lester R. Brown, "Plan B 4.0 mobilizing to save civilization", Earth Policy Institute (New York/London: W.W.Norton & Company, 2009), p97
78 The Aluminium Association, "Aluminum Industry Statistics" (2010), www.aluminum.org/Content/NavigationMenu/NewsStatistics/StatisticsReports/UsedBeverageCanRecyclingRate/UBC_Recycling_Rate_2009.pdf
79 Producing new cans using recycled aluminium saves 14 kWh, 6 kg bauxite and 4 kg chemicals for every kilogram of metal. Source: "Metals - aluminium and steel recycling", Waste Online, http://dl.dropbox.com/u/21130258/resources/informationsheets/metals.htm
80 Huib Wouters, Derk Bol (2009), "Material Scarcity", Materials Innovation Institute Netherlands, November 2009, www.m2i.nl/images/stories/m2i%20material_scarcity%20report.pdf
81 Bradsher Keith, "China Tightens Grip on Rare Metals", *New York Times*, 31 August 2009, www.nytimes.com/2009/09/01/business/global/01minerals.html
82 Bradsher Keith, "Amid Tension, China Blocks Crucial Exports to Japan", *New York Times*, 23 September 2010, www.nytimes.com/2010/09/24/business/global/24rare.html

Business often knows where energy and materials are being wasted, but takes no action since incentives are too weak. Yet due to the complexity of today's value chains, waste and associated emissions are also often unknown – out of sight, out of mind. Information technology, complemented by the adoption of a life-cycle approach to material flows, can improve business's visibility over value chains.

Of course, managing waste has an environmental impact itself. Emissions released through waste treatment and disposal contributed an estimated 3-5% of the world's greenhouse gas emissions in 2005.[83] That said, the efficiency benefits of waste prevention and recovery cut across all other parts of the economy, far out-weighing the relatively minor carbon contribution from the waste sector.


Mike Barry, Marks & Spencer

One man's waste is another's treasure

In the low-carbon economy, there should be zero net waste. Manufacturing would adopt a closed-loop system, in which all outputs are fed back into the production process. This could mean three significant changes.

Firstly, a revolution in design. In the low-carbon economy, products would be designed to last, to support efficient use, to be recycled and to draw on easily recoverable raw materials instead of virgin resources. This could entail manufacturing the way nature does: "biomimicry". A multidisciplinary scientific approach that imitates nature's designs and processes to make products more sustainable, biomimicry relies on reverse supply chain principles, where products are re-captured, then re-used or recycled, just as in nature.[84]

Secondly, a new ICT revolution in supply chain management. Harnessing IT could yield "20/20 vision" of the value chain, allowing business to identify material and energy waste hotspots and combat them through better demand forecasting and tighter inventory and asset management.

Thirdly, a revolution in industrial planning, rooted in a new appreciation of the importance of location. Once again, nature has figured this one out before us – bees stay close to the flowers, so enabling the well-being of both parties; oxpeckers and elephants live in tight proximity, the former deriving nourishment by removing ticks from the hides of the latter. Businesses and industries, too, can generate more value simply by being more judicious in their choice of location – by siting themselves next to actors with waste streams they can exploit or resources they can share to mutual gain.[85]

Sustainable product design, more transparent supply chains, a reorganisation of industrial planning – all of these innovations will depend on unprecedented levels of collaboration among value chain actors.[86]

> "Production is a huge challenge. Consumption will be an even bigger challenge. And then comes a third challenge – and this is where we move to true sustainability – and that's how we link the production system and the consumption system together. Because as much as we're trying to improve production and then consumption, thereby softening the rough edges of our existing business model, it's still the same unsustainable economy that we live in."
>
> **Mike Barry, Head of Sustainable Business, Marks & Spencer**

83 United Nations Environment Programme (2010), "Waste and Climate change, Global Trends and Strategy Framework", www.unep.or.jp/Ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf
84 Janine M. Benuys (2002), "Biomimicry – innovation inspired by nature" (New York: Harper Perennial, 2002), p2-3
85 See for instance "Kalundborg: Industrial Symbiosis - Waste makes resource", Sustainable Cities, Danish Architecutre Centre, 2008, http://sustainablecities.dk/en/city-projects/cases/kalundborg-industrial-symbiosis-waste-makes-resource
86 Tata Consultancy Services and Xyntéo (2011), "Low-carbon, high growth – the 21st century supply chain model", p. 7

"In the low-carbon economy there will be no more waste. By that, I mean that all material and energy will have a value. And so we will be dealing not with waste, but with valued resources that we will want to make the most of."

Hege Norheim, Senior Vice President, Statoil

"If you went to a Walmart in the US 20-30 years ago, most products were made in America, or in a country nearby. Over the last 30 years this has changed, and cost has been the defining strategy of this transition. Today things are starting to change once again, because of price variations, because of flexibility requirements, because of response requirements. Once again supply chains are moving closer to consumption points, as well as having some farther away."

Dr Syama Sunkara, Global Head, Supply Chain Practice, Tata Consultancy Services

Biomimicry: learning from Mother Nature

Biomimicry is a discipline that studies nature's best ideas and then imitates them to solve human problems. After 3.8 billion years of research and development, animals, plants and microbes have discovered what works. Applying these innovations in industry could form a cornerstone of the low-carbon economy. Here are just a few examples of biomimicry already making it to market:

Learning from termites – how to create sustainable buildings
The Eastgate Building, an office complex in Harare, Zimbabwe, has an air conditioning system modelled on the self-cooling mounds of termites. Through their extraordinary design, termite mounds manage to maintain inside temperatures to within 1°C, day and night, while outside temperatures swing from 3°C to 42°C. Eastgate uses 90% less energy for ventilation than conventional buildings its size, and has already saved the building owners over $3.5 million in air conditioning costs.[a]

Learning from humpback whales – how to create efficient wind power
Humpback whales measure up to 16 metres in length and weigh around 36,000 kilograms. But for such huge animals, they are surprisingly dexterous. In 2004, scientists discovered that the bumps at the front edge of a whale fin greatly increase its efficiency, reducing drag by 32% and increasing lift by 8%. Companies are borrowing the concept to create wind turbine blades that boost the amount of energy created. Companies are also applying the idea to fans, airplane wings and propellers.[b]

a Biomimicry Institute, "Learning from Termites How to Create Sustainable Buildings": www.biomimicryinstitute.org/case-studies/case-studies/architecture.html
b Biomimicry Institute, "Learning from Humpback Whales How to Create Efficient Wind Power": www.biomimicryinstitute.org/case-studies/case-studies/energy.html


Des Bell, Senior Vice President, Shared Services and Chief Procurement Officer, Pacific Gas and Electric Company

Dr Syama Sunkara, Tata Consultancy Services

Consumption – the other side of the coin

In the low-carbon economy the end of waste will mean that the predominant supply chain will be characterised by a closed-loop system, not a set of linear processes. Our production system will need to contend also with a sea-change in consumption behaviour, in which the consumer's affair with "stuff" is superseded by an emphasis on the service provided by a good.

The next section speculates in more detail how consumption would need to evolve in order to support the major shifts needed across the energy, infrastructure, mobility and production pillars of the low-carbon economy.

A Zipcar is driven past the Houses of Parliament in London. Zipcar, a leading car-sharing company, reports that each of its cars takes at least 15 personally-owned vehicles off the road. Car-sharing represents a low-carbon business model built around the idea of delivering to the customer what they really want – an efficient service.

Consumption

In the low-carbon economy, consumption will follow our resource base, not outpace it. This will require a new breed of business model and a reprogramming of consumer values, moving preferences away from goods towards services.

Consumption – the economy's *raison d'etre*


Chen Jinen, China Energy Conservation & Environmental Protection Group

Consumption endows the economy with appetite – a hungry market for all the goods and services generated by the world's businesses. This connection was demonstrated during the Industrial Revolution, when efficiencies in assembly lines led to increased production of goods at ever lower prices, making them available to a much larger share of the population.

Today, roughly 60% of the world's GDP is related to consumer spending on goods and services.[87] Much of this ground has been gained over the last five decades, with consumer spending increasing six-fold since 1960. While some of this is the product of population growth, it does not explain it all: consumption expenditure per person nearly tripled over the same period.[88] Not only are people becoming more numerous; they are also, overall, getting richer. As development pulls people up the economic ladder, they buy more expensive foods, larger homes and holidays in more remote locations.

> "Personally I believe that the low-carbon economy is not only an economic development mode, but also a lifestyle and an attitude toward life. Five thousand years of Chinese traditional culture has always embodied the Chinese nation's pursuit of a low-carbon lifestyle."
>
> **Chen Jinen, Vice Chairman, China Energy Conservation & Environmental Protection Group**

Keeping up with the Joneses

While consumption is a vital ingredient of economic growth, it needs to be conducted in balance with the available store of resources. In the industrialised world we are consuming well beyond our means. According to the World Wildlife Fund, we would need three planets if every person consumed as much as the average Briton, or five planets if the average North American was to set the global standard.[89]

87 World Business Council for Sustainable Development, "Sustainable Consumption Facts & Trends" (2010), www.wbcsd.org/DocRoot/I9Xwhv7X5V8cDIHbHC3G/WBCSD_Sustainable_Consumption_web.pdf
88 WorldWatch Institute, "State of the World 2010: transforming cultures – from consumerism to sustainability" (2010), (New York/London: W.W. Norton & Company, 2010), p3
89 World Wildlife Foundation, "One Planet Living", http://wwf.panda.org/what_we_do/how_we_work/conservation/one_planet_living/

While overconsumption has up until now been regarded a "Western" affliction, the syndrome seems to be leaking over to developing and emerging economies, riding the wave of globalisation.[90] A global middle class is materialising, featuring common, unsustainable consumption patterns.[91] The red thread is the phenomenon often referred to as "consumerism" – that is, the search for meaning and contentment through the purchase of goods and services in ever greater amounts.[92]

The question is whether this zeal for consumption is actually improving the quality of our lives. Some governments seem to think not. Prompted by work commissioned by France and conducted by Nobel laureates Joe Stiglitz and Amartya Sen, the UK government is among those rethinking the traditional emphasis on per capita GDP as a defining benchmark for public policy.[93] With wider take-up, this reappraisal could signal a new approach to economic success in which growth is evaluated against not just quantity, but also quality. Growth that systematically demolishes our resource base could be discarded and replaced by a more intelligent model that treats our environment as the strategic yet finite asset it is.[94]

We are against the clock. Over the past 50 years we have consumed more goods and services than in all previous generations put together.[95] Since 1980, we have consumed one-third of the planet's resources – forests, fish, natural minerals, metals and other raw materials. Even if consumption is slowly de-coupled from economic growth through efficiency gains, the absolute level of consumption will likely be pulled upwards by a growing population.[96]

Rent before you buy

Reining in the speed of resource depletion calls for the emergence of a new set of consumer values and preferences. The principal change would be the demise of the desire for "stuff" and the birth of a new concern with function: lumens of light, not light bulbs; no CDs, just music; movies instead of DVDs.

In the low-carbon economy, we will value the services provided by physical products and not the physical products per se. Buying a product outright would mean paying not only for the time it was being used, but also for the time it sat in your garage collecting dust and for its repair, re-entry into the production cycle or eventual disposal. Paying instead for just the service would allow us to forgo these extra costs.

With the right incentives in place, this move from stuff to services could lead to new, service-based business models, in which companies retain ownership of the goods while consumption is "leased out" to multiple customers. The model could make it possible to meet customer demands for low costs, while carbon-minimising product features – longer shelf-life, ease of disassembly and sustainable material choices – would be championed by retailers as a means of maximising revenue.

90 World Business Council for Sustainable Development, "Sustainable Consumption Facts & Trends" (2010), www.wbcsd.org/DocRoot/I9Xwhv7X5V8cDIHbHC3G/WBCSD_Sustainable_Consumption_web.pdf
91 UNEP, "Sustainable lifestyles and education for sustainable consumption", The Marrakech process, UNEP and UN, p. 2, http://esa.un.org/marrakechprocess/pdf/Issues_Sus_Lifestyles.pdf
92 WorldWatch Institute (2010), "State of the World 2010: transforming cultures – from consumerism to sustainability", (New York/London: W.W. Norton & Company, 2010), p. 3
93 Number10.gov.uk, "Britain's wellbeing to be measured", 25 November 2010, www.number10.gov.uk/news/latest-news/2010/11/britain%E2%80%99s-wellbeing-to-be-measured-57578
94 WorldWatch Institute (2010), "State of the World 2010: transforming cultures – from consumerism to sustainability", (New York/London: W.W. Norton & Company, 2010), p. 9
95 Rachel Botsman and Roo Rogers (2010), "What's mine is yours – the rise of collaborative consumption" (New York: HarperCollins, 2010), p. 5
96 World Resources Institute (2005), "Ecosystems and human well-being", Millennium Ecosystems Assessment, (Washington DC: Island Press, 2005), www.maweb.org/documents/document.356.aspx.pdf

Different business models: making more, using less

Instead of selling customers a product, provide them that service directly – when and how they want it.

Ten million buildings in metropolitan France are heated in this way. Instead of selling the households raw energy in the form of oil, gas or electricity – none of which the customer actually wants – companies undertake to keep a client's floor space within a certain temperature range at a certain cost. How it is done is up to the companies. They can convert the furnace to gas, make the heating system more efficient, or even insulate the building. They are paid for the function – the warmth – not for how they did it or what energy they used to do it. The higher the efficiency, the bigger the profits.

Another example is DuPont's industrial paints business, which switched from selling paint by volume to selling the service of painting cars. DuPont is paid based on the number of cars painted, not the quantity of paint used. This creates incentive to improve both painting methods and paints. The result is that less paint is needed for each each car, lowering both the car's cost and its environmental footprint.

"On the whole, you find wealth much more in use than in ownership."

Aristotle

This goods-to-services shift could be complemented by the emergence of "collaborative consumption".[97] Instead of buying products, consumers would share, barter, lend, rent, gift and swap products among themselves. This could include anything from sharing cars and holiday homes to lending sporting equipment and trading house utensils and tools. ICT would play a pivotal role by enabling consumers to procure the exact service needed for solely the amount of time needed.[98]

A service-based model could open up far-reaching changes in consumption patterns. The way we shop for food, for instance: the next step for online shopping could be the delivery of items at an agreed time of the day to a password-protected post box outside our homes. This would allow businesses to reduce local depots and optimise distribution. And consumers could spend less time shopping for basics; supermarkets and shops could instead function as showrooms, where people tried out different specialty products before placing orders.[99]

Regulation will play a decisive role in initiating and cementing new consumer behaviours. Carbon allowance schemes, for example, which currently exist at the industry level, could trickle down to individuals.[100] Under this framework, if we overstepped our individual carbon quotas, we could buy from others in the market. A system like this would demand high-calibre information on the carbon profile of the products and services we purchased. Again, ICT would be a critical tool for helping businesses collect, maintain and distribute this data to customers.

97 Rachel Botsman and Roo Rogers (2010), "What's mine is yours – the rise of collaborative consumption" (New York: HarperCollins, 2010), cover
98 Lisa Gansky (2010), "the mesh – why the future of business is sharing" (New York: Portfolio Penguin, 2010), cover
99 Forum for the Future, "Internet shopping", www.forumforthefuture.org/project/sustainable-consumption/overview
100 See for example Tina Fawcett et al. (2007), "Trialling personal carbon allowances", the Environmental Change Institute at Oxford, December 2007

Personal carbon allowances: it all started on an island

Australia's Southern Cross University is leading a project to test the world's first personal carbon trading programme.[a] The three-year project, which commenced in early 2011, is being conducted on Norfolk Island, a small island 1,700 kilometres off the Australian mainland.

The island is ideally suited for the initiative. With an isolated, small population (fewer than 2,150 inhabitants) living a similar lifestyle to people on mainland Australia, it is also self-contained, allowing researchers to measure everything that goes in and out.

It works like this. Everyone on Norfolk Island receives a "carbon card"; much like a debit card, this comes charged with free carbon units. Every time the user pays for petrol or power – and, from the second year, food – a number of units are deducted.

At the end of a set time period, if the user has carbon units to spare, she or he can cash them in at the bank. On the other hand, if use exceeds the free allowance, the user needs to buy more units. Over time, as lower carbon emissions targets are set, inhabitants will receive fewer free allowances.

The island's annual influx of 30,000 tourists is also being included. Upon arrival, visitors receive a carbon card with a certain number of units, depending on the length of their stay.

a "Norfolk Island to trial world first Personal Carbon Trading program", Southern Cross University, 27 October 2010: www.scu.edu.au/news/media.php?item_id=1641&action=show_item&type=M

Production and consumption – two sides of the same coin

Stripping carbon out of our production system depends on the reworking of our consumption model. If consumers do not see the value in low-carbon lifestyles, businesses will not be motivated to build new supply chains. Similarly, if businesses do not pursue new offerings, consumers will have no opportunity to pursue carbon-efficient ways of living.

The transformation of our production-consumption paradigm is a tall order. Both this set of changes, and those that need to happen in the energy, infrastructure and mobility pillars, depends on catalytic help from a cluster of cross-cutting "enablers" – ICT, regulation, finance and communication – as well as an entirely new of breed of leadership. These are dealt with in the coming pages.

With as much as 2% of annual global GDP required in investment in order to avoid the worst effects of climate change, Wall Street and its equivalents across the globe have a key role to play, together with governments, in enabling the transition to a low-carbon economy.

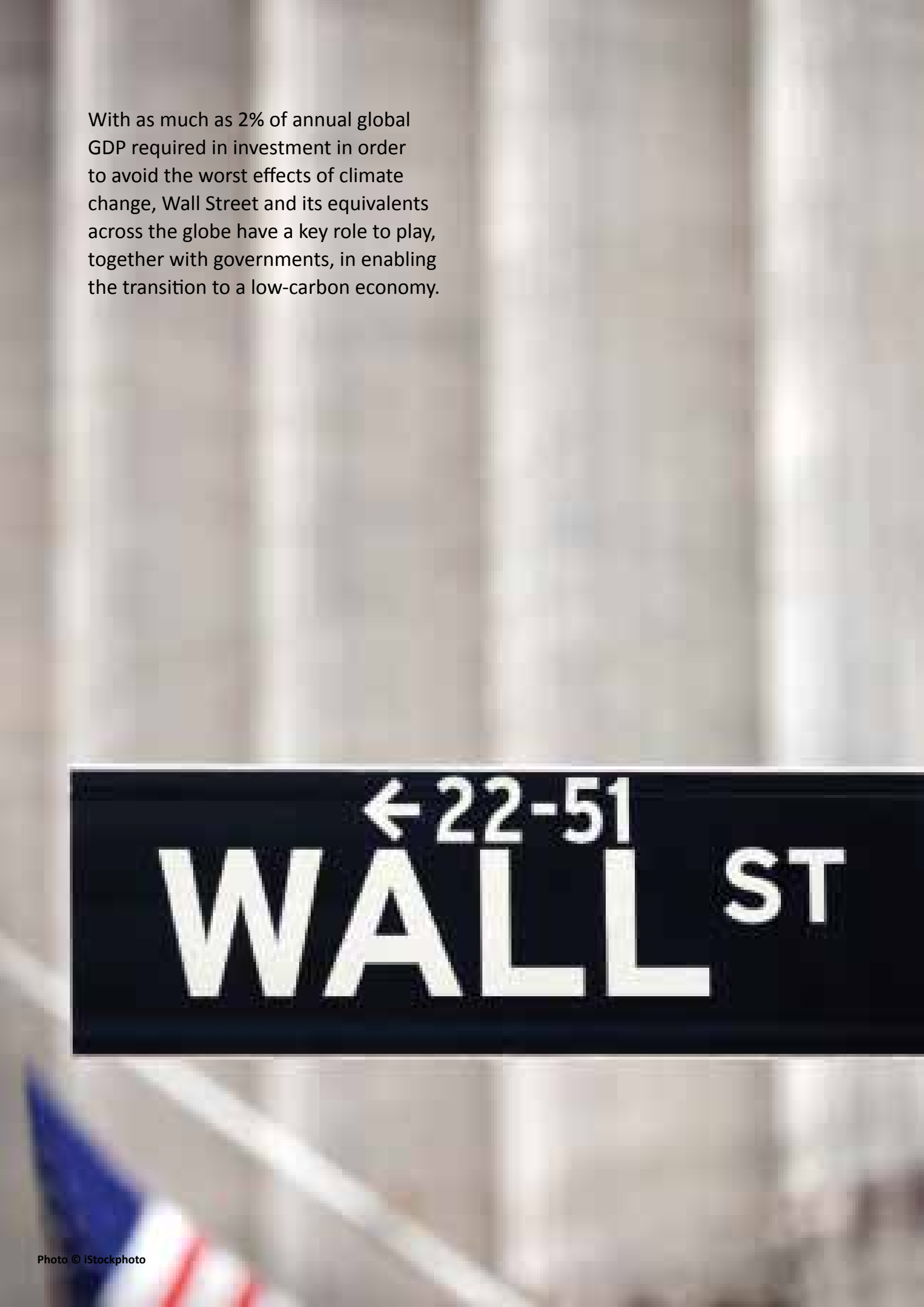


Photo © iStockphoto

Enablers

The low-carbon economy will be based on new systems, behaviours and technologies in energy, infrastructure, mobility, production and consumption. "Enablers" like ICT, regulation, finance and communication can help accelerate and consolidate our progress.

ICT: helping us to see our energy

In the late 19th century the telephone supplanted the telegraph (thought of then as the "nervous system of commerce") and imposed massive changes on business, speeding up financial transactions and tightening relationships with both customers and supply chain partners. ICT has since then continued to redefine commerce by challenging prevailing business models and unlocking doors to new ones. In so doing it has increased productivity and economic growth in developed and developing countries alike.

ICT will be a key catalyst of the changes needed to create a low-carbon economy. One of ICT's contributions could be to make our lives more virtual, allowing us to cut back on carbon-intensive activities – from daily car runs to the shops to overseas business trips. But ICT's greatest contribution is likely to be as an enabler of radically higher energy efficiency across industries and sectors.[101]

> "It is vital that government play its full part in supporting businesses as they rise to the challenge of technological development and investment in a sector which is going to grow as part of economic activity globally."
>
> **Lord Green of Hurstpierpoint, UK Minister of State for Trade & Investment**

Consumers and businesses cannot manage what they cannot measure. ICT fills this gap by enabling us to "see" our energy and emissions. By harvesting carbon data from operations and supply chains, we can identify hotspots, minimise inefficiencies and transform the way we operate throughout our value chains.[102]

Lord Green of Hurstpierpoint, UK Department for Trade & Investment

Carbon-intensive sectors such as the transportation, building and power industries all stand to gain from ICT-driven energy efficiency. More intelligent motor systems to drive down industrial emissions; leaner, more agile logistics; houses and offices built to deliver consistently high energy performance; and smart grids featuring decentralised power generation and two-way communication between producer and consumer –

101 Richard Youngman (2010), "ICT Solutions for Energy Efficiency", World Bank, p. 4, http://siteresources.worldbank.org/INFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/ICTSolutionsEnergyEfficiency_FinalJune30.pdf
102 Richard Youngman (2010), "ICT Solutions for Energy Efficiency", World Bank, p. 41, http://siteresources.worldbank.org/INFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/ICTSolutionsEnergyEfficiency_FinalJune30.pdf


Trevor Hutchings, UK Department of Energy & Climate Change

through innovations such as these ICT could, by one count, shave 15% off the world's business-as-usual carbon dioxide emissions in 2020[103] and yield efficiency savings equivalent to approximately €600 billion.[104]

ICT has a particularly powerful role to play in enabling the emergence of a new production-consumption system. On the production side, ICT will be an indispensable tool for collecting life-cycle information about products' carbon signatures, required intelligence for shrinking the environmental footprints of goods and services. By improving demand forecasting and inventory and asset management, ICT will help eliminate product waste. Better information exchange among supply chain actors can improve the capacity utilisation of delivery vehicles and their fuel use. ICT will also be key to the collaboration needed to create closed-loop supply chains featuring secure resource bases and low waste flows.

Consumption in the low-carbon economy will be tightly intertwined with ICT. Consumers will increasingly expect precise and varied information on the carbon profile of the goods they choose. The probable rise in "collaborative consumption" will similarly depend on ICT for the required consumer-to-consumer connections.

"Government intervention is often most effective where it is seeking to address a true and genuine market failure or barrier, or where the market is too slow to adapt."

Trevor Hutchings, Head, Low-Carbon Economy, UK Department of Energy & Climate Change

"If you think about the objectives of most sovereign wealth funds around the world, which are there to provide income for future generations, [clean energy] is the kind of investment they should be interested in. If you think about pension funds, which have long-term liabilities to match with long-term income streams, it is the kind of investment they should be interested in."

Lord Green of Hurstpierpoint UK Minister of State for Trade & Investment

Regulation: friend, not foe

Regulation is often seen as the enemy of business. Crippling taxes, time-killing paperwork and the like tie businesses down and distort markets with unnecessary inefficiencies.

That said, the market is not infallible: left entirely to its own devices, it too can misallocate resources and cause inefficiencies and losses. So it is with climate change, famously described by Lord Stern as "the greatest and widest-ranging market failure ever seen".[105]

How soon we arrive at the low-carbon economy will depend to a great extent on the form that regulation takes in the coming decades. Government has at its disposal a range of policy instruments, including taxes, subsidies, feed-in tariffs and tradable permits, to encourage the market to embrace high-efficiency technologies and practices. Putting a price on carbon through one or more of these instruments is thought to be the most efficient way to encourage the necessary transition.[106]

Decades-old regulation in California provides an example of innovative low-carbon government intervention. Conventional utilities earn revenue based on the amount of energy sold – the more you sell, the better. But under California's decoupling policy, which has been in place since 1982 and adopted by 12 other US states, utility revenue is severed from sales. This means that less energy use is

103 The Climate Group (2008), *Smart 2020: Enabling the low carbon economy in the information age*, London 2008, p. 29.
104 The Climate Group (2008), *Smart 2020: Enabling the low carbon economy in the information age*, London 2008, p. 29.
105 Lord Nicholas Stern (2006), Stern Review on the economics of climate change: Executive Summary, p. 1, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf
106 See, for example, the UK Treasury (www.hm-treasury.gov.uk/d/foi_gore_2.pdf), and the Australian Treasury (www.treasury.gov.au/documents/1999/PDF/110301_Carbon_Price_Talking_Points.pdf).

rewarded rather than punished. As a result, California's per capita energy use has remained relatively flat for the past 30 years; in 2008, per capita energy use in the state was half that of the rest of the US.[107]

Finance: know your risks and explore your opportunities

The Stern Review argued that 1% of global GDP per annum was required in investment in order to avoid the worst effects of climate change.[108] Professor Stern later increased the estimate to 2% of GDP to account for faster-than-expected climate change.[109]

So far the clean energy sector is leading the charge in low-carbon investment flows, increasing by 30% from 2009 to achieve $243 billion in 2010.[110] From a country perspective, China is rapidly emerging as the world's clean energy superpower, thanks to its growing financial muscle and forthright policy directives. In 2009, it topped the world chart, with $39.1 billion invested. In 2010, investment in China's clean energy sector increased to a record $54.4 billion, equal to worldwide investments in 2004.[111]

Odd-Even Bustnes, Xyntéo

"Building low-carbon infrastructure is a long-term opportunity, so let's take a long-term IT approach. Get the visibility clear, get the optimisation and collaboration going, and then let's talk transformative solutions."

Odd-Even Bustnes, Senior Advisor, Xyntéo

The UN forecasts that global renewables investments will total $1.36-$5.1 trillion for the decade to 2020 and $1.49-$7.18 trillion over the period 2012-30.[112] Real costs would be lower, however, due to factors including savings on other energies.

While governments have and will continue to play their part in this, Wall Street and its equivalents across the globe have an important role in enabling the low-carbon economy. The recent emergence of sustainability indices in various stock exchanges around the world, including the Dow Jones Sustainability Index,[113] is helping prospective investors assess the risks and opportunities of listed companies.

Pension funds and sovereign wealth funds can also accelerate our progress. With an estimated $30 trillion of global investor wealth,[114] such funds should manage the risks and maximise the opportunities associated with climate change in order to look after the long-term interests of their members. They could, for example, invest in and/or ensure companies have strategies in place to manage climate risks and take advantage of emerging clean technology and carbon markets.

107 FYPower, "California's Decoupling Policy", www.fypower.org/pdf/Decoupling.pdf
108 Lord Nicholas Stern (2006), Stern Review on the economics of climate change: Executive Summary, p. 1, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf
109 Jowit Juliette and Wintour Patrick (26 June 2008), "Cost of tackling global climate change has doubled, warns Stern", *The Guardian*, www.guardian.co.uk/environment/2008/jun/26/climatechange.scienceofclimatechange.
110 The Pew Charitable Trusts (2010), *Who's Winning the Clean Energy Race?*, 2010, p. 2, www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf
111 The Pew Charitable Trusts (2010), *Who's Winning the Clean Energy Race?,* 2010, p. 13, www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf
112 IPCC, "2011: Summary for Policymakers – IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation", 9 May 2011, p. 6, available at: http://www.unep.org/pdf/SRREN_FD_SPM_approved_plenary_v_03_final.pdf
113 Dow Jones Sustainability Index, www.sustainability-index.com/
114 Pension funds are estimated to amount to $26 trillion (see Global Pension Asset Study 2011 at www.towerswatson.com/assets/pdf/3761/Global-Pensions-Asset-Study-2011.pdf) and sovereign wealth funds $4 trillion (see Preqin study at http://www.pionline.com/article/20110308/REG/303089998)

"The role of ICT is absolutely fundamental in providing the visibility and therefore the understanding of the carbon price impacts on a particular supply chain or a line of products or services. As an enabler, ICT has made a very strong case for itself."

Tom Delay, CEO, Carbon Trust

"I am excited about the business opportunities that IT presents in being a great enabler of the low-carbon revolution."

Lakshminarasimhan Srinivasan, Head, Eco-Sustainability Services, Tata Consultancy Services

Communication: the missing link between fact and fiction

Scientists tell us with 90% certainty that humans are changing the climate.[115] Economists tell us that, unless we act, climate change will drain global GDP by 5% each year.[116]

Despite these warnings, a significant number of people in major economies still question the need to act. Only a quarter of Britons, for example, are said to be concerned about climate change,[117] with similar sentiments expressed in other developed economies, including the US.[118] These are not just voters, but shareholders and customers as well.

There is clearly a disconnect between the reality of climate science and public perception. The reasons for this vary, but could include the fact most are yet to "feel" the direct impacts of climate change. This, combined with last year's exceptionally cold European winter, which goes against the imagery generated by the term "global warming", may explain the phenomenon in the UK.[119]

Furthermore, given the complexity of the science and the technologies required to combat climate change, the average person has no option but to trust the experts – scientists, politicians and business leaders. However, the debate has in many countries become polarised, leading to mixed messages and accusations of self-interest. In essence, many have lost trust in those that we should trust.[120]

Tom Delay, Carbon Trust

Lakshminarasimhan Srinivasan, Tata Consultancy Services

115 IPCC (2007), Fourth Assessment Report: Summary for Policymakers, www.ipcc.ch/publications_and_data/ar4/syr/en/spms2.html

116 Lord Nicholas Stern (2006), Stern Review on the economics of climate change: Executive Summary, p. 1, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf and Garnaut R (2008), *Garnaut Climate Change Review*, www.garnautreview.org.au/2008-review.html

117 William McLennan (18 April 2011), "Only a quarter of Britons concerned with climate change", The Ecologist, www.theecologist.org/News/news_analysis/849698/only_a_quarter_of_uk_population_concerned_about_climate_change.html

118 Gallup (2011), "In U.S., Concern About Global Warming Stable at Lower Levels", 14 March 2011, www.gallup.com/poll/146606/concerns-global-warming-stable-lower-levels.aspx

119 William McLennan (18 April 2011), "Only a quarter of Britons concerned with climate change", The Ecologist, www.theecologist.org/News/news_analysis/849698/only_a_quarter_of_uk_population_concerned_about_climate_change.html

120 Shell (2011), "Shell Energy Scenarios to 2050", p. 38, www.shell.com/home/content/media/news_and_media_releases/2011/scenarios_signals_signposts_14022011.html

To ensure that politicians and business leaders are backed by a public and shareholders that understand the need for systemic change and large-scale investments, we need to be better at communicating the reasons why. We need to demonstrate how climate change will affect everyday life. Instead of painting a picture of doom and gloom, which only disengages people, we should also highlight the potential benefits of a low-carbon economy, including healthy GDP, lower unemployment, improved health and increased energy security.

> "The concept of subsidies for renewables is so badly misunderstood in the mainstream media. So it is absolutely vital that we re-couch the terms of the debate. For example, a price on carbon is not a tax, but the elimination of a subsidy."
>
> **Mark Lewis, Managing Director, Commodities Research, Deutsche Bank**

Business leaders are front and centre in the transition to a low-carbon economy. The closing panel at the GLTE in London featured these leaders: Justin King, Chief Executive, Sainsbury's; Caio Koch-Weser, Vice Chairman, Deutsche Bank Group; Subramanian Ramadorai, Vice Chairman, TCS; Carl-Henric Svanberg, Chairman, BP; and Michael Treschow, Chairman, Unilever.

Leadership

Decoupling economic growth from emissions of carbon dioxide will be a test of leadership. And the low-carbon economy itself will place entirely new demands on leaders in business, government and wider society. At the Global Leadership & Technology Exchange in London, a panel of leaders debated these demands. Here are some highlights.

Caio Koch-Weser, Co-Chairman, GLTE Low-Carbon Leadership Board

There is a new dynamic at play where the business community, and perhaps sometimes local governments, is prompting national political action and not the other way around.

Caio Koch-Weser, Vice Chairman, Deutsche Bank Group

Look up and look wide

We as leaders need to lift our eyes beyond the present to understand what the future holds. I found this to be highly applicable during my time in the telecommunications industry as the CEO of Ericsson. But it's even more important in the energy industry, where lead-times for projects can be very long, lasting over many decades. You have to be very confident in these projects before you invest. This may not be an industry of speed, but it is certainly an industry of scale.

Carl-Henric Svanberg, Chairman, BP

Think about it

Imagine that our cities had clever transportation systems in place, ready as urbanisation picked up speed. Imagine how much easier things would be. Think about what could have been, had we had modern broadband infrastructure wherever we are. We would be facing completely different possibilities in dealing with healthcare and education, in streamlining transport, in giving rural areas easy access to the economy. Just think about what those possibilities would actually be.

Michael Treschow, Chairman, Unilever

We need to understand the path we are on and where it is likely to lead. Only then can we understand the nature of action that is needed to change course.

Carl-Henric Svanberg, Chairman, BP

Collaboration is not a cliché

Leadership must mean partnership – between the public and private sectors, between business and academia, between innovators and investors. This might sound like a cliché, but when partnerships work, they are truly powerful. In countries where governments and industries have come together, we have seen that they have delivered real advances in clean energy.

Carl-Henric Svanberg, Chairman, BP

We leaders need to work more collaboratively across sectors, because there are issues that we cannot fix ourselves. When it comes to deforestation, when it comes to sustainable agriculture, when it comes to food security – no one alone can fix this. We need to do that together – across sectors and companies. Of course, this is tricky because we business leaders are trained to fix things ourselves, and now we have to reach out more, to governments and also to more atypical bedfellows like NGOs. This means a completely new form of leadership.

Michael Treschow, Chairman, Unilever

Collaboration versus competition

You can be part of a coalition, you can develop the vision, you can engage with the European Commission on a super grid and on cross-border feed-in tariffs and still compete very fiercely when it comes to individual projects. You can collaborate and compete at the same time.

Caio Koch-Weser, Vice Chairman, Deutsche Bank Group

It´s important to make sure that we keep untethered the power of competition, because there is nothing quite like competitive advantage to cause other members of an industry to swiftly follow.

Justin King, Chief Executive, Sainsbury's

Changing behaviour

Our approach is to provide the opportunity and the incentive for our customers to make choices for themselves. An obvious example to choose would be plastic bags. We do not believe in taxing or banning them. We think that, apart from anything else, this leads to behaviour which is almost always less sustainable than the plastic bag that's been replaced. And we think that all consumer behaviour is better and more lasting if it's brought about by positive engagement with an issue.

Justin King, Chief Executive, Sainsbury's

When one state says they are going to be the number one in terms of renewable energy, some of the others on stage automatically want to learn and collaborate.

Subramanian Ramadorai, Vice Chairman, TCS

It doesn´t help if we only work miracles in our factories; if we develop a washing powder that needs less water, we need to figure out how we change behaviour.

Michael Treschow, Chairman, Unilever

Executing the job

A decade or so ago the challenge was to acknowledge the need for change; today the challenge is about execution – about investing, innovating and inspiring. Invest where low-carbon energy is competitive, innovate where it´s not and inspire people to make a difference.

We need to invest in the most commercial forms of low-carbon energy, such as sustainable biofuels and wind. We need to focus our innovation in areas where we have the ability to commercialise low-carbon energy. And we need to inspire our people to step up to the massive efficiency challenge.

Carl-Henric Svanberg, Chairman, BP

India is growing at 8.5% a year. We can take this to 10%. But then we have to create the necessary skills to support this growth – in energy, retail, agriculture, tourism, infrastructure, construction and so on. Any one of these sectors is going to consume an enormous amount of resources. So resource efficiency needs to be built into the capabilities of the young professionals.

Subramanian Ramadorai, Vice Chairman, TCS

A new context

The climate change policy landscape has shifted fundamentally over the last 18 months – basically since Copenhagen. We see a shift from an assumption that there will be a global, legally binding agreement to a bottom-up approach where individual countries go ahead and businesses go ahead. We are moving away from the expectation that the developed world will take the lead to the realisation that perhaps the most vigorous action is now coming from some of the larger emerging markets. We are also moving away from a tendency to apportion the cost of reducing CO_2 to an increasing tendency to see the opportunity of green growth.

Caio Koch-Weser, Vice Chairman, Deutsche Bank Group

The government record

Just as we as voters and businesses get the government that we deserve, consumers get the businesses that they vote for with their ballot papers).

Justin King, Chief Executive, Sainsbury's

We need leaders who can bring themselves behind the questions and move us forward before we are fully ready.

Dr Osvald M. Bjelland, Chairman and CEO, Xyntéo

The task at hand

Leaders in this new economy need to lead transformation. This isn't about incremental change; it´s about transformative change.

Michael Treschow, Chairman, Unilever

It has taken us 200 years to bring the standards of living that we have today to a billion people in the Western world. Now we are talking of moving several billion people the same distance in only 30-40 years.

Carl-Henric Svanberg, Chairman, BP

Brave words

We don´t think businesses should be frightened of unilaterally taking decisions on sustainability issues.

Justin King, Chief Executive, Sainsbury's

We leaders need to understand clearly how sustainability drives and impacts our business and make sure that climate change issues are integrated into our core business. But it's also important that we have strong ambitions.

We at Unilever have an ambition to double our business while reducing our absolute impact on the environment. And that is not only a nice vision: it has a lot of KPIs in it, and a lot of actions.

Michael Treschow, Chairman, Unilever

Shareholders

We must understand that investors are seeking to maximise shareholder return. But they are not only short-sighted; they also look to the longer term. So as well as contributing to the world's energy needs today we must invest wisely in the sources of energy for tomorrow.

Carl-Henric Svanberg, Chairman, BP

We need to run the company with a long-term perspective while understanding at the same time that there are short-term pressures.

Michael Treschow, Chairman, Unilever

Opportunity is knocking

India and China have a golden opportunity to start from the ground level and transform through industry-to-industry collaborations, industry-to-government collaborations and government-to government collaborations.

Subramanian Ramadorai, Vice Chairman, TCS

I am always very optimistic where there are problems with technological solutions – because this means that sooner or later we will fix the problem. History proves that.

Michael Treschow, Chairman, Unilever

High stakes

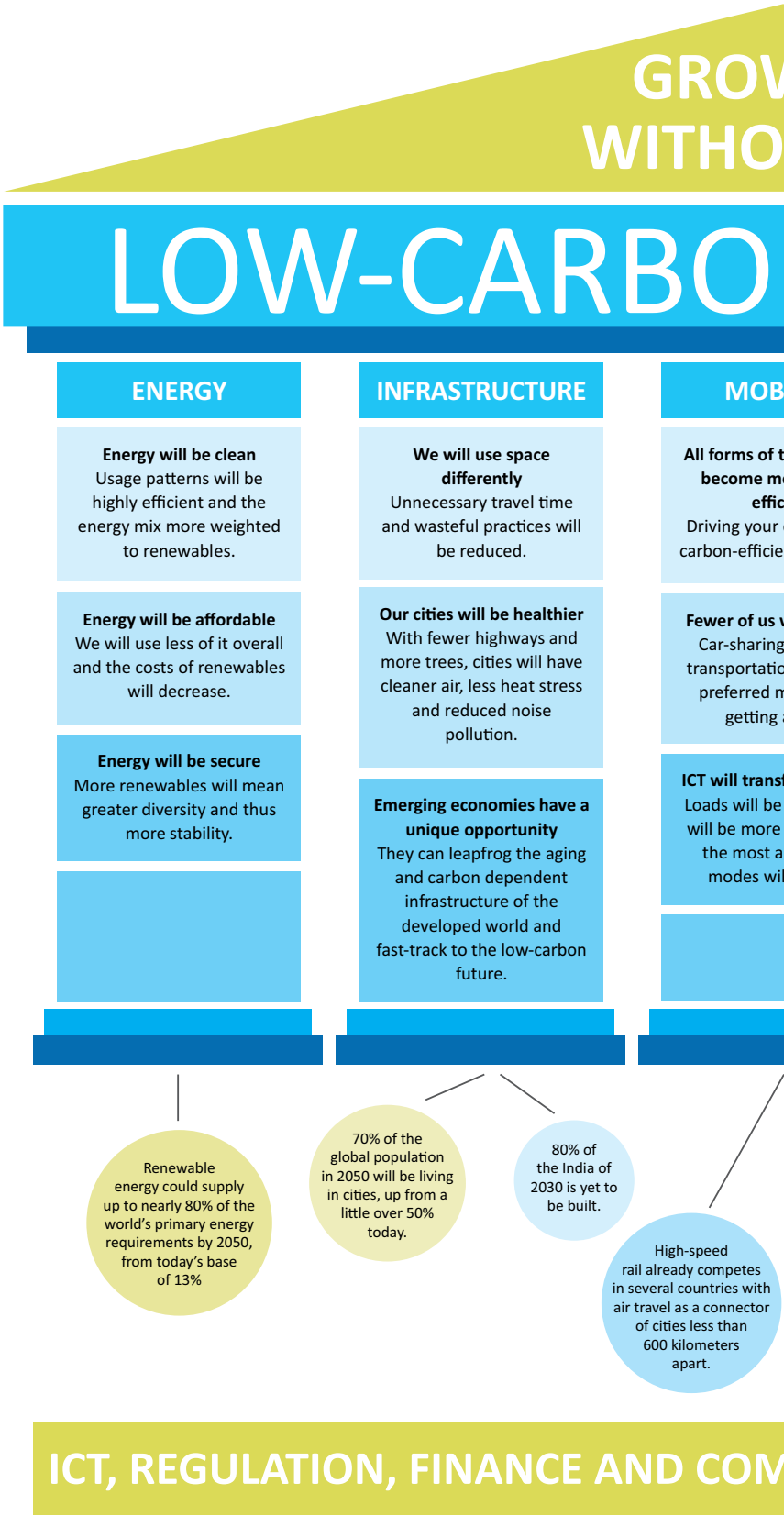
BP's scenario planning assumes that countries will, according to our base case, continue to make progress on climate change. However CO_2 will not have peaked when we reach 2030. This is not a projection; it is not a proposition. This is just a dispassionate view of what we think is most likely to happen. It is not what we want to happen. In fact it is rather a wake-up call.

Carl-Henric Svanberg, Chairman, BP

What next for GLTE?

I think GLTE has to move even more in the direction of not just discussing the what, but very intensely the how. I look forward to being part of that.

Caio Koch-Weser, Vice Chairman, Deutsche Bank Group


GROV
WITHO
LOW-CARBO
ENERGY
Energy will be clean
Usage patterns will be highly efficient and the energy mix more weighted to renewables.
Energy will be affordable
We will use less of it overall and the costs of renewables will decrease.
Energy will be secure
More renewables will mean greater diversity and thus more stability.
INFRASTRUCTURE
We will use space differently
Unnecessary travel time and wasteful practices will be reduced.
Our cities will be healthier
With fewer highways and more trees, cities will have cleaner air, less heat stress and reduced noise pollution.
Emerging economies have a unique opportunity
They can leapfrog the aging and carbon dependent infrastructure of the developed world and fast-track to the low-carbon future.
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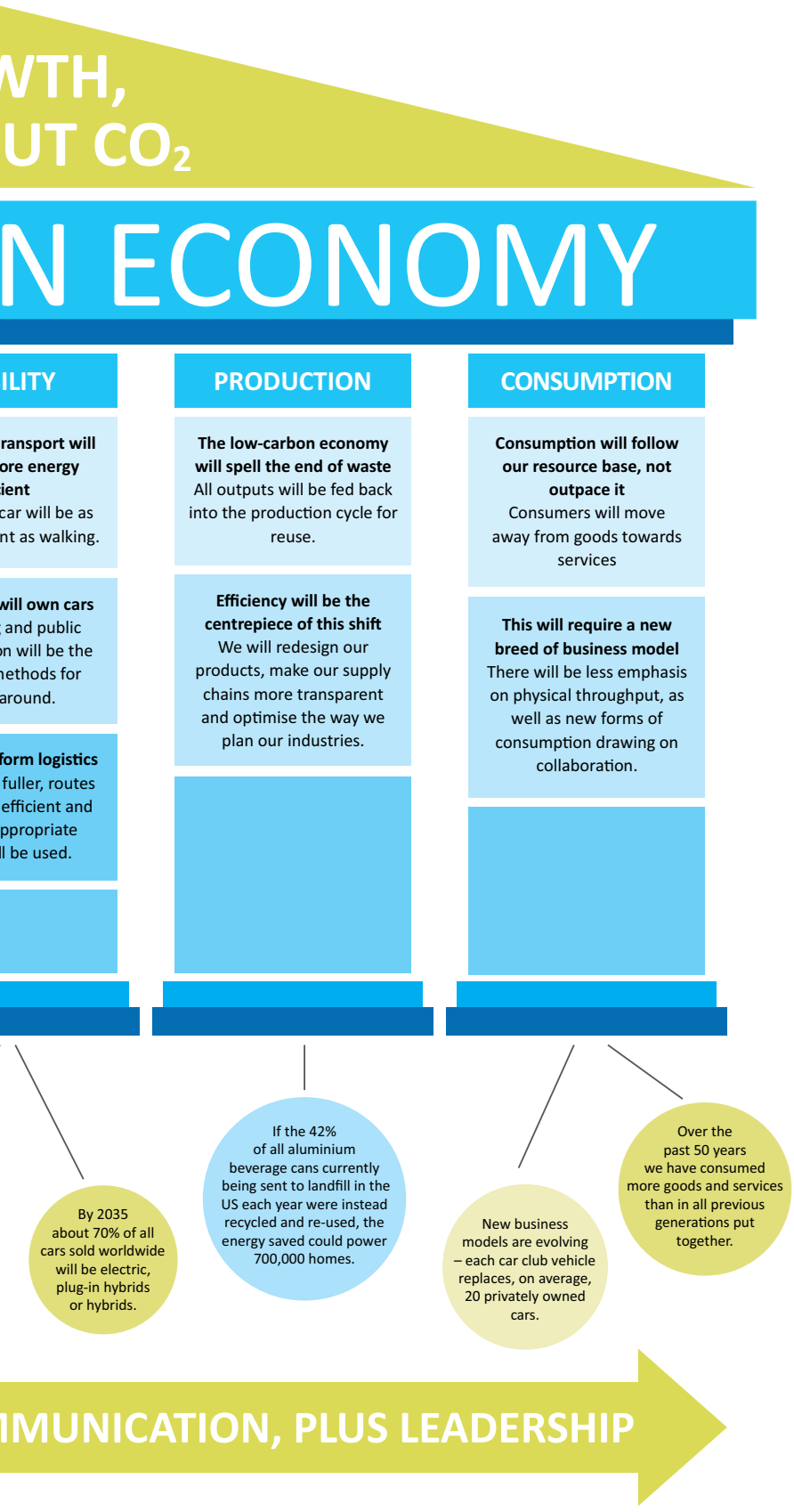
Renewable energy could supply up to nearly 80% of the world's primary energy requirements by 2050, from today's base of 13%
70% of the global population in 2050 will be living in cities, up from a little over 50% today.
80% of the India of 2030 is yet to be built.
High-speed rail already competes in several countries with air travel as a connector of cities less than 600 kilometers apart.
ICT, REGULATION, FINANCE AND COM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PRODUCTION
The low-carbon economy will spell the end of waste
All outputs will be fed back into the production cycle for reuse.
Efficiency will be the centrepiece of this shift
We will redesign our products, make our supply chains more transparent and optimise the way we plan our industries.
CONSUMPTION
Consumption will follow our resource base, not outpace it
Consumers will move away from goods towards services
This will require a new breed of business model
There will be less emphasis on physical throughput, as well as new forms of consumption drawing on collaboration.
By 2035 about 70% of all cars sold worldwide will be electric, plug-in hybrids or hybrids.
If the 42% of all aluminium beverage cans currently being sent to landfill in the US each year were instead recycled and re-used, the energy saved could power 700,000 homes.
New business models are evolving – each car club vehicle replaces, on average, 20 privately owned cars.
Over the past 50 years we have consumed more goods and services than in all previous generations put together.
IMUNICATION, PLUS LEADERSHIP

Your ideas please!

This document attempts to start sketching out a vision of the low-carbon economy. What's missing? Send any thoughts to glte@xynteo.com.