

Guessing Our Future

Signposts to 2050

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Dedication

This book is dedicated to the youth of today whose future has been blighted by the violence and short-sighted, selfish greed of my generation.

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Introduction:

This year my oldest grandchild turned seven. What will the world be like when she turns twenty or two hundred and twenty? I don't have the answer. I'm not sure anyone does. We can only hazard guesses based on the information available to us.

Each and every day we are bombarded with new data – text messages, E-mails, tweets, Facebook posts, twenty four hour a day TV channels and more. And then there are the websites we visit and the books and newspapers we read. The list of sources and the data they contain is endless. In addition, there is also all that information we never see because it is in a foreign language or an unfamiliar script; the English language media we use every day give prominence to happenings in America and Britain, but we also need to know what is happening in obscure corners of the globe.

For many years now I have made it my task to try to collect the hidden pointers to our future that are buried in this mass of data. Jigsaw puzzle lover that I am, I've then tried to piece together my picture of what the future might look like. That's what this book is all about. It's also a book that's full of facts and numbers I've collected along the way, something for which I don't apologize; we need those numbers to place matters in perspective and make informed decisions.

In the course of my researches I have read many excellent books and papers on numerous topics. Generally I find they have three flaws. Firstly they are all too often written by someone in North America or the United Kingdom based on what he (strangely, few of these books seem to be written by women) sees in his immediate vicinity; his local observations are then extrapolated to the rest of the world. Then too, it's as though they are written in a silo with next to no mention of topics covered in parallel silos even though they interrelate. Finally, books written by journalists tend to be padded out with folksy anecdotes rather than homing in on the key facts, a habit no doubt honed in writing entertaining newspaper articles. I have tried to avoid these pitfalls.

Also all too few of the writers have firsthand experience of living in the developing world cheek by jowl with the majority of mankind. They don't have unemployed neighbours living in shacks who survive on less than US\$ 5 per day. The land in their countries is mostly privately rather than communally owned and there are no tensions between traditional governance and modern constitutions. Their roadsides aren't littered and their streams clogged with plastic waste, while hawkers and beggars don't throng every traffic intersection. Tens of thousands of their homes aren't lacking in electricity, running water and water borne sewage. Children don't have to walk miles to overcrowded schools. That's just the start. The list of differences between their orderly world and that inhabited by the great majority of the world's population goes on and on.

As I've collated my bits and pieces of information, so I have identified nine major trends that are sweeping the globe. The population of the world is growing and growing older. Climate change and environmental degradation could lead to the death and displacement of millions each year. Migration and urbanisation continue unabated as people seek greener pastures. Low cost renewable energy is leading to the death of oil, gas and coal. Information is power and mass data storage and mining is empowering a handful of companies and countries. Automation is leading to increased unemployment while automated electric vehicles are taking to the roads, railways and airspace. The gap between rich and poor continues to widen. Finally, globalisation in all its forms continues apace.

Each of these trends reminds me of an elephant making its way across the plain, effortlessly swatting bushes and trees aside as it wanders or of a swarm of locusts munching across the landscape, oblivious to the humans and habitations in its path. We can see them coming from a long way off but there's little we can do to head them off. Instead we have to adapt as best we can. I have included a

chapter suggesting ways countries, companies and individuals can identify the opportunities and challenges arising out of these trends and prepare accordingly.

Many forecasts today take what has happened in the past and simply extrapolate that data into the future as a smooth trend line. I worry that we might be about to experience radical changes that deviate significantly from the past and take place faster than we expect. We need to be ready for any sudden up or down swings.

That said, the economist Branko Milanovic, as an aside in one of his books on inequality, described how he had tried to read all the major economic forecasts made during the second half of the twentieth century and found every one of them completely wrong. Based on that analysis, my guesses about the future will also be wrong but at least you will know the facts and opinions I have used in my analysis and can draw your own, maybe different, conclusions. Most of my sources are listed in the extensive References section.

Finally, as a case study, I have included a blueprint for how South Africa might prepare for this uncertain future. South Africa, poised on the cusp between the developed and the developing worlds, contains a fascinating mixture of rich and poor, modern and traditional, people speaking many languages and worshipping many gods. Also that's where my family live. Hopefully, as you read on, you can use this blueprint to mentally prepare a similar blueprint for your own country or company.

When I started out, my plan was to find a publisher who would create a paper book that could be sold in a bookstore. It might even have made me famous and earned me millions. But that's not what I want and not what will help the young people for whom the future holds many more years of living than me. Instead I want people to find the real facts, to think hard, to debate intelligently and, most of all, to act decisively, together.

There's another reason why an electronic book appeals. To go the paper route I would have to freeze my text and then wait months for a publisher to bite and start the presses rolling. In the meantime more information will have come to hand making my original script out of date.

So this is going to be an electronic publication. I am going to start by sending it to ten or so of my most thoughtful friends, asking them, if they like what I have written, to send it on to ten more thoughtful friends who will do likewise. That way, in the space of a couple of weeks it could reach millions instead of just the hundreds who might see it in a bookshop. And every few weeks I could publish a new edition and post it on my website <http://www.musings.world>.

My forecast is not the final answer. I am sure you are going to have constructive criticisms and better ideas than me. I invite you to use the blog on <http://www.musings.world> to share these with the rest of us.

Good reading and inspirational thinking!

Brian Paxton

November 2017

Population Change

The first global trend I identified is population change. Every time I visit a shopping mall or pass through a major airport I am struck by the crowds of people. Where do they all live? Where does the food come from to feed them all? How do the garbage and sewage systems cope? How many more people can the planet really support?

Certainly global overcrowding is the elephant in the room that seldom gets a mention for fear we again see one child policies or final solutions. However it's one of the biggest challenges faced by mankind today.

The population of the world continues to grow, as does the average standard of living, with the combination increasing demand for food, water, energy, waste disposal and transport and other infrastructure, all of which place increasing pressure on the environment.

According to the UN Population Division, in July 2017 the world population reached 7.6 billion, one billion more people than 2003 and two billion more than 1990. Put another way that's more than fifteen billion meals prepared and three million tonnes of sewage produced around the world each and every day!

Some 60% of the global population lives in Asia where China and India, with about 1.3 billion people each, are the world's most populous countries. This is the same as the population of Africa, home to 17% of humanity.

The UN predicts the world population could grow to eleven billion by 2100. However other experts believe the world population will only increase to around 9 billion late this century and could then start to fall as the impact of lower fertility outweighs increasing life expectancy. More than half of the growth between 2017 and 2050 is expected to be in Africa.

While the overall population is growing, global fertility has dropped from more than 5 children per woman in the early 1960s to below 2.5 today, almost low enough that the population is not replacing itself, something that is already happening in some countries. As a result, there will probably never be more young people on the planet than there are today. This dramatic decline in global fertility has led to a decrease in the population growth rate from 1.52% per year in 1990 - 1995 to 1.15% in 2010 - 2015. On the other hand, mortality of children under 5 years of age has fallen from 43% in 1800 to just 4.3% today, so many more children are moving through to adulthood.

The number of older people is also growing. Average global longevity has increased to a 2015 average of 70 years. Advances in medical science mean people could well live even longer. In most countries life expectancy is increasing, leading to larger populations of retirees who require pension and health benefits to last longer. In the last 20 years the population of persons aged 60 years or over has increased by 56% from 490 million in 1990 to 765 million in 2010. During this time, the increase in the population of older persons in developing countries was more than twice that of developed countries. Projections are that more than 20% of the global population will be age 60 and above by 2050 and the number of older persons will already have surpassed the number of children by 2047. Those are worrying numbers when you consider that many pension plans are predicated on working young people funding the pension withdrawals of the elderly.

In the short term the wealthy countries of Europe, Asia and the Americas face rapid population ageing, extremely low old age support ratios and possibly declining populations. This has a number of ramifications. Firstly, in the medium to long term are pension funds able to afford to continue paying pensions when the younger working membership is getting smaller and, possibly, resentful at having

to fund indolent retirement lifestyles? Secondly, are there still enough workers to provide all the goods and services, including care for the aged, needed by the population? Migration or increased productivity might go some way to solve this second problem. Or the mandatory retirement age could be raised, a prospect actively opposed by trade unions. Finally fewer children in the population means that educational facilities can be closed or teacher pupil ratios increased.

Looking at the problem from a slightly different angle, according to United Nations data, the working age population (defined as the population ages 15 to 64) in industrial countries peaked in 2011 at 388 million people and is expected to decline by roughly 30 million people by 2030. In Japan, the working-age population peaked in 1995 and in Germany in 1998. Maybe that's one of the reasons Germany welcomed so many Middle Eastern refugees?

One result is that the aged are being drawn back into the workforce. In the Eurozone, the labour force participation rate for those aged 65 to 69 rose from 7% in 2005 to 10% in 2015, while average participation rates for the old have also increased in Japan and the USA. In the United Kingdom the number of people over 65 still working has doubled in twenty years according to the Department for Work and Pensions and is now 10% of the workforce.

Meanwhile Africa and some countries in Asia prepare for the largest cohort of young people the world has ever seen. The forty nine poorest countries, particularly in sub-Saharan Africa, continue to face high fertility offset to some extent by premature mortality.

The global health care sector is also under pressure to provide more cost-effective solutions. With 80% of deaths from cancer, heart disease and other chronic diseases now taking place in low and middle income countries, demand for low cost medicines in developing countries is leading to conflicts with first world pharmaceutical companies determined to protect their intellectual property and profits.

At this point it's useful to understand some of the reasons why people are dying. World deaths from cigarette smoking, for instance, amount to around 5 million a year, while 17 million deaths are attributable to the side effects of obesity such as diabetes, heart disease and even some cancers. In Africa obesity is rising as the locals flock to first world fast food outlets marketed on North American sourced TV channels. Sugar has also been shown to directly cause diabetes and heart disease, even in someone with normal weight, and sugary soft drinks are estimated to kill 184,000 adults every year. In 2015 33,000 Americans died of opioid overdoses and the numbers for 2016 are expected to be much higher making it the major cause of death for people under 50 years of age in that country. At the same time, the widespread prescription of antibiotics, often unnecessarily, and the use of antibiotics in animal foodstuffs are reducing man's immunity to superbugs.

According to the Commission on Pollution and Health, published in the Lancet in October 2017, pollution kills more than nine million people prematurely, 16% of all global deaths, every year. In fact the paper pointed out that exposures to contaminated air, water and soil kill more people than a high-sodium diet, obesity, alcohol, road accidents, or child and maternal malnutrition. This is also nearly 15 times as many deaths as war and all forms of violence combined.

All these forecasts are based on looking at past trends continuing smoothly into the future. But what if a black swan event occurred that completely upsets the pattern? HIV-Aids, for instance, in a short space of time reduced South Africa's average longevity to 55 years, one of the lowest on the planet and 20% below the global average. Now we have the Zika virus affecting pregnant women in Latin America; to date there is no real evidence that Zika babies have shorter lives or that the Zika virus can lead to deaths but these too are possibilities. With Pope Francis seeming to condone contraception we could see birth rates plunging not just in the Americas but throughout the Roman Catholic world.

On a more positive note, driverless cars have now driven many hundred thousand kilometres with very few accidents. In a few years time we could all be driving around in similar vehicles that are virtually accident free, more or less eliminating the one and a quarter million deaths that occur in traffic accidents around the world each year. I don't have a statistic for the number of people who die in mining and factory accidents each year, but they too could be drastically reduced with robot technology.

Back in the medical field, unravelling the mysteries of DNA using the new CRISPR/Cas9 system could soon lead to much more effective designer treatments of cancer and other diseases, to say nothing of providing an elixir of youth to the aged. Geneticists are testing xenotransplants where animal material is modified for human insertion. The campaign to eradicate malaria by modifying mosquito DNA lends itself to deployment in countries that are home to the Zika-carrying mosquitoes; the additional resources could lead to both diseases, and the related deaths, being eradicated. On the other hand, recurrence of the flu pandemic of 1917, traces of which have been found in newly melted Arctic permafrost along with anthrax spores, or the so-called black death could see swathes of the population wiped out (as I write this Madagascar has reported more than 100 cases of the plague and the disease has spread to the Seychelles and could potentially move to the African continent).

Macho maverick presidents could lead to another major conflict, though much of it might be conducted war game-wise on computer screens far from the battlefield allowing the downward trend of annual war fatalities to continue.

Climate change scientists warn that warmer weather will lead to more deaths. A heat wave in France in 2003, for instance, led to a spike of deaths of people whose bodies were unable to cope with the high temperatures. People regularly die in storms and wildfires but I have no numbers to determine whether fatalities are increasing or not as ever stronger storms blow up and forest fires run amok. Tropical diseases, including Zika, malaria and yellow fever, could start creeping out of the equatorial regions. Looking at the issue from a different perspective, researchers suggest climate change may have contributed to the suicides of nearly 60,000 Indian farmers and farm workers over the past three decades. Finally, a couple of people in Texas cleaning up after Hurricane Harvey were attacked by a deadly flesh eating bacteria which might discourage volunteers cleaning up after future disasters!

However, after all these facts and figures, the bottom line is that the global population is going to continue to grow and to grow older, placing increasing pressure on the earth's resources. Every country is going to be affected differently and so needs to plan accordingly.

Climate Change and Environmental Degradation

Climate change is hotting up, literally and figuratively, and is likely to cause millions of deaths and relocations each year, as well as a degraded lifestyle for many. I regularly shudder at the thought of my grandchildren slowly broiling, like the proverbial frog in a bucket of water being heated over a fire, but this seems increasingly likely as political leaders in hock to the carbon lobby refuse to take real action.

Climate change is also a topic on which much has been written and in the narrative below I have selected extracts from reports by a range of experts so you can understand the full extent of the tragedy that is unfolding.

The world has warmed by about 0.9°C over the last 150 years with the pace of warming increasing in recent decades. The rapid rise of global temperature that began about 1975 continues at a mean rate of about 0.18°C per decade. The media everywhere regularly report temperatures continuing to reach record levels month after month and year after year.

As a direct result, all the oceans are warming; polar ice caps and glaciers are melting, with a cruise ship visiting Canada's far north for the first time and a tanker sailing from Norway to South Korea via the Arctic this past northern summer; sea levels are rising and shorelines are eroding; levels of water vapour in the atmosphere have risen; storms are fiercer as a result of warming oceans and once in a thousand year floods have engulfed parts of every continent; ever fiercer forest fires are blamed on global warming; coral reefs are dying; and droughts are lasting longer. There is evidence of natural species starting to migrate uphill or towards the nearest pole and of increased desertification. In the United Kingdom birdlife has diminished significantly due to climate change and destruction of habitat while in Germany the insect population has dropped by more than 70% in 30 years. Extinction is predicted for one sixth of the species on earth. Each of those statements on their own should be cause for concern; together they pose a giant challenge to humankind.

Experts, in the face of aggressive disinformation campaigns by sceptics and beneficiaries from the carbon economy, warn that world temperatures could rise significantly during the 21st century, leading to climate changes everywhere, unless governments, companies and individuals take corrective action soon. Populations everywhere seem to be split into those deeply concerned by climate change (many of whom at the same time feel quite helpless); the compromised ostriches with their heads in the ground who want to fund more coal and oil projects; and a large group who are too concerned with other issues to worry. There is also disagreement between developed nations, with a history of pollution driven industrialisation, and developing nations, industrialising to improve standards of living, on the appropriate action to take.

Despite these differences, the 2015 Paris climate accord, signed by the leaders of 196 countries, excluding only the United States, commits each country to take action to hold the average global temperature to well below 2°C above pre-industrial levels. Ideally the temperature increase should be limited to below 1.5°C even though new research suggests there is just a 1% chance that temperatures will rise by less than 1.5°C as political leaders procrastinate and prevaricate instead of acting on their pledges.

High levels of greenhouse gases in the atmosphere are the major cause of global warming. The main sources of these, of course, are coal and gas fired power stations, diesel and gasoline powered vehicles, cement works, petrochemical plants and the smoke from fires. But they aren't the only culprits. An article in Pulse of Fashion magazine, for instance, revealed that the fashion industry not only consumes huge amounts of water but also generates the same volume of CO₂ each year as 230 million cars!

In August 2017, the American government's comprehensive annual *National Climate Assessment* recorded that global carbon dioxide levels in the atmosphere exceeded 400 ppm for the first time in more than 800,000 years. Global averaged land and sea temperatures in 2016 were higher than the record temperatures of 2015. The mean sea level also reached a record high as did lake temperatures. The Eastern and Western Pacific and North Atlantic basins all recorded above average major storm activity while the Australian basin recorded none. Arctic land temperatures were 2°C above recent averages and 3.5°C up on 1900. The above-average surface air temperature anomalies for 2016 in Africa included the second-highest annual mean (of a 66-year record) in South Africa and persistent summer heat waves in the north of the continent.

A recent World Meteorological Organization (WMO) *Greenhouse Gas Bulletin* shows that during a strong El Nino event, such as that which started in 2015, atmospheric CO₂ levels rise as the earth is less able to absorb them. The latest analysis of observations from the WMO Global Atmosphere Watch Programme shows that globally averaged surface mole fractions calculated from this in situ network for the main greenhouse gases carbon dioxide, methane and nitrous oxide reached new highs in 2015, with values, respectively, of 144%, 256% and 121% of pre-industrial (before 1750) levels. In 2016, concentrations of carbon dioxide in the atmosphere surged at a record-breaking speed and reached 403.3 parts per million, up from 400.00 ppm in 2015; atmospheric CO₂ levels have now reached a level last seen three million years ago when global temperatures were 2 to 3.5°C higher than today and the sea level was up to 20 metres higher than now.

For generations we have delighted stories of how intrepid adventurers risked their lives in treks to the North and South poles. Museums have exhibits extolling the trials of Scott, Admunsen and other polar explorers as they fought through blizzards and snow drifts to reach their goal and plant a flag at the poles. Soon the opportunities for such frozen adventuring could be over. Another 2017 US government report records that the Arctic is warming at a rate approximately twice the global average. If it continues to warm at the same rate, Septembers will be nearly ice-free in the Arctic Ocean sometime between now and the 2040s.

Our days of skiing, skating and sledging in the great outdoors could also be coming to an end. Research by the University of Neuchâtel along with the Federal institute for research on forests, snow and the countryside (WSL) and the Institute for the study of snow and avalanches (SLF) found that Switzerland has nearly 40 fewer snow days a season than it did in the 1970s. Overall, snow arrived 12 days later and disappeared 25 days earlier in 2015 than in 1970. The maximum snow depth also reduced by 25% over the years and the day on which this maximum is achieved arrives 28 days earlier now than 45 years ago. In Norway, the cross country skiing season has been reduced from four winter months to two.

A paper in *Science Advances* titled *Geodetic measurements reveal similarities between post-Last Glacial Maximum and present-day mass loss from the Greenland ice sheet* calculates that melting of the Greenland ice sheet has taken place faster than previously measured because the land mass is rising as the weight of the ice reduces. A September 2017 article in *Nature* concluded that as a glacier or ice sheet loses mass in melting, the gravitational pull it exerts on nearby ocean water weakens and the adjacent sea level falls causes rising sea levels elsewhere. At the same time, the land rises up because the ice is no longer weighing it down, which causes a further weakening of the gravitational pull.

The global mean sea level has risen by about 21 centimetres since 1880, with about 7 centimetres taking place since 1990. That doesn't seem much when you regularly visit your favourite beach. However, annual occurrences of daily tidal flooding have increased 5 to 10 fold since the 1960s in several U.S. coastal cities. According to an October 2017 research report from the University of Melbourne, coastal cities around the world could experience a 1.3 metre rise of sea levels by 2100 unless coal generated electricity is eliminated by 2050. At the same time, oxygen levels in the oceans are dropping and dissolved carbon dioxide levels are rising gradually changing the marine environment. The Guardian has produced a series of maps showing the impact of rising sea levels in

several cities around the world; the map of Miami, for instance, shows much of Florida underwater. So far no one seems to have noticed that as sea levels rise, so the height of mountains above sea level reduces.

In my opening paragraph I expressed my fears about my grandchildren boiling to death later this century. Already a third of the world faces deadly heat waves as result of climate change. A study shows the health risks from heat have climbed steadily since 1980 and the number of people in danger will grow to 48% of the global population by 2100 even if emissions are drastically reduced. Europe's record-breaking 2003 heat wave resulted in more than 20,000 heat-related deaths, mainly of old and vulnerable people, including 15,000 in France, where temporary mortuaries were set up in refrigerated trucks. Siberian melting of permafrost and methane leaking is a huge unknown and could be catastrophic. These could all be ominous harbingers of the world our grandchildren will inhabit.

Scientists have concluded that the severe heat experienced in England, France, Belgium, the Netherlands and Switzerland in June and July 2017 was also made significantly more likely by global warming. Climate change made the intensity and frequency of such extreme heat at least twice as likely in Belgium, at least four times as likely in France, Switzerland, the Netherlands and central England and at least 10 times as likely in Portugal and Spain, according to a new analysis by scientists with World Weather Attribution and scientific partners in England, France and Switzerland.

Extreme heatwaves that kill even healthy people within hours will strike parts of the Indian subcontinent unless global carbon emissions are cut sharply and soon, according to more new research. In addition three quarters of India's 1.7 billion population will be exposed to a level of humid heat above which the human body cannot cool itself by sweating. Amitav Ghosh, describing climate change as the great derangement, predicts 125 million people in India and Bangladesh could be displaced by rising sea levels as well as 10% of Vietnamese; 24% of Indian arable land will become desert; and melting Himalayan glaciers will cause water shortages for the 47% of the world's population who depend on them.

Such risks have been underscored by a separate study that shows unabated climate change will cause around 60,000 deaths globally in 2030 and 260,000 deaths by 2100. The study, by the University of North Carolina, found that rising temperatures will exacerbate air pollutants that will particularly threaten those with existing respiratory conditions.

Ironically, in a case of poetic justice some of the world's leading carbon fuel producers could end up being the biggest victims of climate change. This year Houston was hammered by Hurricane Harvey while the Middle East, which for decades has produced the bulk of the world's oil and gas, is forecast to regularly experience temperatures above 40°C. Australia is experiencing record high temperatures yet persists in exporting coal and natural gas, while depending largely on coal fired power stations.

The Australian Bureau of Meteorology and CSIRO released their 2016 *State of the Climate Report*. This recorded that Australia's climate has warmed in both mean surface air temperature and surrounding sea surface temperature by around 1°C since 1910. The duration, frequency and intensity of extreme heat events have increased across large parts of Australia. Since 1970 May to July rainfall has reduced by around 19% in the southwest of Australia and increased across parts of northern Australia. There has been a decline of around 11% since the mid-1990s in the April to October growing season rainfall in the continental southeast. Oceans around Australia have warmed and ocean acidity levels have increased. Sea levels have risen around Australia.

Sydney and Melbourne regularly feature in the list of the world's most liveable cities. Now research led by the Australian National University in Canberra predicts that even if global temperature rises are kept below 2°C, summer heat waves in these cities could reach temperatures of 50°C by 2040. That date is not all that far away and surviving temperatures that high is not my idea of good living. It brings a whole new meaning to an "Ashes" test cricket series!

Over the past couple of years our newspapers and televisions have brought us vivid pictures of wildfires burning out of control leaving devastation in their wake. Thus British Columbia, Alberta, Montana and California all experienced major fires resulting in a pall of smoke hanging over Vancouver and other residential areas for weeks on end. In a recent *Proceedings of the National Academy of Sciences*, scientists from the University of Idaho and Columbia University calculated how much of the increased scope and intensity of Western wildfires can be attributed to human-caused climate change and its effects. Since 1979, climate change is responsible for more than half of the dryness of Western forests and the increased length of the fire season. Since 1984, those factors have enlarged the cumulative forest fire area by 16,000 square miles, about the size of Massachusetts and Connecticut combined. The pattern of longer fire seasons and more burned acres of forest is likely to continue as long as there is enough fuel to burn, but that there will come a point, probably in the middle of the century, when there are not enough trees left to sustain wildfires. By 2050, according to the U.S. Forest Service, wildfires will be twice as destructive as they are today; in some places, the area burned could expand fivefold.

North America is not the only continent to experience forest fires. Peatland fires in Indonesia in 1997, which covered the whole region is dense smoke, added to the global CO₂ release by up to 40%. Rain forests like the Amazon, which in 2010 suffered its second once in a hundred years drought in the space of five years, could dry out enough to become vulnerable to these kinds of devastating, rolling forest fires. During 2017 deadly fires also swept Portugal, Spain and the south of France.

Moving from land to sea, the comprehensive 2016 IUCN report *Explaining Ocean Warming* warns that Ocean warming may well turn out to be the greatest hidden challenge of our generation. In the ocean, 2015 was analysed to have been the warmest year within the 136 year records of extended reconstructed sea surface temperature and the fourth such record-breaking year since 2005. An analysis undertaken by the Grantham Research Institute on Climate Change in 2015 concluded that if the same amount of heat that has gone into the top 2000 metres of the ocean between 1955 and 2010 had gone into the lower 10 kilometres of the atmosphere, then the Earth would have seen a warming of 36°C. By factoring in the ocean, as this report shows, the perspective is fundamentally altered.

Back on land, an article in *Science Magazine* *Climate change: The 2015 Paris Agreement thresholds and Mediterranean basin ecosystems* forecasts that even if emissions are held to the level of pledges put forward ahead of the Paris agreement, southern Europe, particularly Spain and Sicily, would experience a “substantial” expansion of deserts.

Pictures of hurricanes touching down have kept us glued to our screens for months this year. Another Proceeding’s study shows that the frequency of Hurricane Sandy-like extreme flood events has increased significantly over the past two centuries and is very likely to increase more sharply over the 21st century, due to the compound effects of sea level rise and storm climatology change. During August and September 2017, the Caribbean, Texas and Florida were devastated by three major hurricanes, Harvey, Irma, the strongest storm ever recorded, and Maria. Lloyds Insurance estimates that the damaged caused by the three storms could be from US\$ 90 billion to US\$ 165 billion. Scientists attribute the strength of these storms to the increased temperatures in the Atlantic Ocean where they were spawned. In fact, this is the first year since 1893 that ten or more major North Atlantic storms have struck and the hurricane season is not yet over. In response, the Washington Post published an article showing the possible impact of 500 year storms on major US cities based on experiences over the last two decades; huge areas could be inundated.

America’s Government Accountability Office published a report in October 2017 calculating that extreme weather events over the past decade cost the federal government US\$ 350 billion. The report predicted that rising temperatures could cause losses in labour productivity of as much as US\$

150 billion a year by 2099, while changes in some crop yields could cost as much as US\$ 53 billion per annum. The Southwest will suffer more costly wildfires, the Southeast will see more heat-related deaths and the Northwest must prepare for diminished shellfish harvests.

It's not just the Atlantic that is experiencing freak weather and floods. In August 2017 huge swathes of India, Nepal and Bangladesh were inundated with monsoon rains which killed 1,200 people and displaced forty million more; that's a lot of people needing temporary shelter and feeding. A paper in *Nature Geoscience* titled *Intensification of landfalling typhoons over the northwest Pacific since the late 1970s* show that, over the past 37 years, typhoons that strike East and Southeast Asia have intensified by 12 to 15%, with the proportion of storms of categories 4 and 5 having doubled or even tripled. In contrast, typhoons that stay over the open ocean have experienced only modest changes. The increased intensity of landfalling typhoons is tied to locally enhanced ocean surface warming on the rim of East and Southeast Asia. The projected ocean surface warming pattern under increasing greenhouse gas forcing suggests that typhoons striking eastern mainland China, Taiwan, Korea and Japan will intensify further.

While some parts of the world will be wetter, other places will be much, much drier. Another paper in *Science Advances* titled *Relative impacts of mitigation, temperature, and precipitation on 21st-century megadrought risk in the American Southwest* predicts that there is a high probability that during the 21st century the American states of California, Nevada, New Mexico, Colorado and Utah could experience a megadrought lasting as long as 35 years. Already wine producing countries in Europe are starting to mutter about climate change drastically reducing yields.

Climate change and environmental degradation are closely linked. According to the Commission on Pollution and Health, published in the *Lancet* in October 2017, pollution kills more than nine million people and costs the equivalent of 6.2% of global economic output every year. Toxic air, water, soils and workplaces cause diseases leading to one sixth of world deaths and triple those from Aids, malaria and tuberculosis combined. The vast majority of the pollution deaths occur in poorer nations. Modern pollution deaths are rising fast while traditional pollution deaths such as from contaminated water and wood cooking fires are falling. Air pollution was the biggest killer, leading to heart disease, stroke, lung cancer and other illnesses. Outdoor air pollution caused 4.5 million deaths a year, while indoor air pollution, from wood and dung stoves, caused 2.9 million deaths. The next biggest killer was water pollution causing 1.8 million deaths mainly by way of gastrointestinal diseases and parasitic infections. Nearly 92% of pollution-related deaths occur in low-income and middle-income countries. Workplace pollution causes 800,000 deaths and lead pollution 500,000 deaths a year. In the United States, one of the top modern polluters, investment in pollution control has provided a return of US\$ 200 billion each year since 1980.

In 2013, melting Arctic ice changed Asian weather patterns, depriving industrial China of the natural ventilation systems it had come to depend on. The result was an unbreathable smog, which blanketed much of the country's north and was responsible for a third of all deaths in the country. One and a half million Chinese already die each year from a pollutant called PM2.5 composed of particulate matter 2.5 microns and smaller. In November 2017 cities in India and Pakistan, including New Delhi, were shrouded in thick smog that doctors warned was dangerous to the health of people living there.

A July 2017 article in *New York* magazine concluded that more than 10,000 people die each day from the small particles emitted from fossil-fuel burning; each year, 339,000 people die just from wildfire smoke, in part because climate change has extended the forest-fire season (in the U.S., it's increased by 78 days since 1970). During the summer of 2017, the City of London issued several warnings about the health effects of high pollution levels, urging people at risk to refrain from exercising. No wonder people are starting to wear protective masks when they venture out on their daily business.

An OECD working paper, *the cost of air pollution in Africa*, calculates that the death toll from air pollution in Africa has increased significantly from 1990 to 2013 in tandem with the uninterrupted growth in the size of the urban population of Africa. Premature deaths from air pollution now exceed those caused by unsafe water and sanitation. Unfortunately, the pressures of environmental regulation in developed countries could lead to the relocation of energy-intensive, polluting industries, such as smelting and pulp and paper production, to developing nations with fewer safeguards, exacerbating the air quality problem further.

A study of the oceans published in the journal *Science* calculated that up to 12.7 million tonnes of plastic waste is washed into the ocean each year. The highest contributor to plastic marine debris was China, at 1.32 to 3.52 million tonnes a year, followed by the Philippines, Vietnam and Sri Lanka. In a separate study of tap water samples from more than a dozen nations, 83% of the samples were contaminated with plastic fibres. The US had the highest contamination rate, at 94%, followed by Lebanon and India. European nations had the lowest contamination rate but this was still 72%. These two bodies of research on pollution by plastics suggest people are eating microplastics via contaminated seafood and imbibing it when they drink. It makes one think twice about putting something in one's mouth!

As I stated at the outset of this chapter, it's the young people of today who are going to reap the climate change and environmental degradation whirlwinds, not us grandparents who caused the problem in the first place. A multinational study launched to support a legal case brought by a group of young people against the US government entitled *Young People's Burden: Requirement of Negative CO2 Emissions* predicts that if rapid phasedown of fossil fuel emissions begins soon, most of the necessary CO2 extraction can take place via improved agricultural and forestry practices, including reforestation and steps to improve soil fertility and increase its carbon content. In this case, the magnitude and duration of global temperature excursion above the natural range of the current interglacial could be limited and irreversible climate impacts could be minimized. However, continued high fossil fuel emissions by the current generation would place a burden on young people to undertake massive technological CO2 extraction if they are to limit climate change and imply minimal estimated costs of 104 to 570 trillion dollars this century, with large risks and uncertain feasibility.

After this long litany of misery there is some good news, but not much. Carbon dioxide emissions in 2016 were lower than those in 2015 mostly thanks to action by the Chinese government. Renewable energy generation is now cost competitive with carbon. Electric vehicles are starting to roll off the assembly lines and several countries have set a date for the end of sales of gasoline and diesel powered vehicles. China and Northern Europe are leading the way on renewable energy and electric vehicles. Meanwhile scientists believe higher CO2 levels encourage some limited plant growth, which could help feed a growing population; that's about the only benefit of global warming that's been cited.

Climate change is going to continue to cause widespread death and destruction and countries need to also prepare for the impact of increased temperatures and rising sea levels. In the Netherlands, for instance, protective sand dunes are being built along the coast while Lloyds forecasts that insurance premiums in the USA are going to rise significantly as a result of the 2017 hurricanes. In 2015 BHP published a report showing how the company would fare under different scenarios for climate change. These are just some of the examples of preparations for a very different future.

Climate change is not a problem that can be solved by individuals doing the green thing. It needs whole countries and continents taking decisive, proactive action both to slow climate change and to cope with its side effects. However, at the end of the day I continue to be amazed that supposedly well educated world leaders are not as concerned as I am about the fate of their grandchildren and of the people who elected them. In days of yore I might have told them to roast in hell, but they might not have to wait that long.

Food and Water

Growing enough food for the future might not be one of my nine global forces, but it certainly is an essential. Each time I see a stadium full of people or visit a crowded market with all manner of foods from around the world on sale, I marvel at the complex logistics required to feed all those people with such a wide choice of food stuffs.

Though food supplies have more than kept pace with rising population levels in the past, a combination of biofuels, more people, rising standards of living and climate change, including floods and drought, are stressing agricultural production and leading to significant increases in food prices, which have more than doubled since 2004. With food already representing 10 to 20% of developed consumer spending but 65% of developing nation consumer spending, this impacts most on the world's poor. To make matters worse, some 30% of food is lost before it even reaches consumers, who bin another significant percentage.

Despite ethical concerns, genetically modified plants, animals and fish will make up an increasing part of the food chain. Scientists forecast that there could be no commercial fishing by 2048 as present levels of fishing would cause stocks to decline to less than 10% of maximum catches recorded; already 50% of seafood is farmed. There are also forecasts that before too long the volume of plastic debris in the oceans will outweigh the sea life living there and ocean derived salt supplies are often tainted with plastic microparticles.

Economists have battled to produce a simple summary of world trade in food. By reducing the trade to flows of calories Paul McMahon in *Feeding Frenzy* was able to identify the major producers and consumers of food. As one would expect, the USA, Canada, Australia, New Zealand and some EU countries are the traditional exporters who have been joined by major players in South America and Asia. As middle class lifestyles take off, so China and South East Asian countries have become major importers.

McMahon identifies Sub-Saharan Africa as a potential future breadbasket for the world. However, the continent also features strongly in his chapter on land grabs, mostly Arab and Asian countries buying into countries such as Sudan, Ethiopia, Madagascar and Mozambique, pushing the peasants off the land to make way for large scale developments he believes are unsustainable. He emphasises that China is not part of these land grabs though it is acquiring land holdings elsewhere.

While many observers are pessimistic that food production can keep pace with population growth, McMahon is much more optimistic. In his final chapter he outlines how we need to help small farmers in developing countries, behave ecologically correctly, reform financial markets and adapt to higher prices which will keep producers in business. Applying modern agrobusiness methods in Africa and Asia will simply drive subsistence farmers off the land.

His recommendations for Africa differ somewhat with those contained in a 2017 report by Ghana's African Centre for Economic Transformation which proposes that African farmers embrace modern technology, such as drones and satellites, and change land tenure systems. According to the report, most African farmers are smallholders whose average age is rising as young people flock to the cities. In early 2016 the World Bank also published a report on African agriculture with particular emphasis on debunking myths about the sector. Unfortunately climate change gets very little mention in these reports.

National Geographic Magazine carried an article on how Wageningen University & Research is improving agricultural output in the densely populated Netherlands which is also the world's second

largest food exporter by value. Dutch farmers are using driverless tractors and drones that can conduct detailed monitoring of individual plants in a field in order to significantly improve crop yields. They have reduced dependence on water for key crops by as much as 90%. They have almost completely eliminated the use of chemical pesticides on plants in greenhouses while Dutch poultry and livestock producers have cut their use of antibiotics by as much as 60% since 2009. There are many lessons from their experiments that can be applied in the world of small farmers subsisting in drought stricken areas so they produce food surpluses to generate incomes.

Turning to water, I grew up in South Africa's rural Eastern Cape region where droughts were accepted as normal. Like many families, ours adopted devices like a brick in the toilet cistern to reduce flushing and a shallow Saturday bath used by all the family members. Even so we were the lucky ones; we didn't have to share a communal tap with the neighbours or, worse still, walk half a kilometre to draw buckets of water from a polluted stream, as millions still do today. When I was a teenager, my father would take us out some weekends to view progress on the building of a dam which served the town through wet times and dry. Today I live in Cape Town where dams are at record lows after two years of below average rainfall and there are warnings there will not be enough water to supply the city's growing population into next winter's rainy season, if it comes at all.

According to the UNDP we are not alone and 40% of the world's population will suffer water shortages by 2050. Around the world, drier regions are going to have to focus on minimising water usage by, for example, replacing crop spraying with drip irrigation, and installing desalination plants which only need 2 kWh of cheap renewable energy per kilolitre. As an example, an Italian company has developed the OffGridBox container which can supply 16 kilowatt-hours of clean solar energy each day, plus 24,000 litres of filtered and sterilized drinking water, to remote locations, enough to provide for a village of about 300 people.

Feeding and watering a growing population in the face of climate change is going to be one of the major challenges faced not just by our children and grandchildren but also by our own generation.

People Movement

I had written the first draft of this chapter on my third global trend - migration, urbanisation and tourism - before I realised that I was writing about myself as well as millions more around the globe including many of the readers of this book. Like so many, I grew up in a small rural town where farming was the main occupation and there really wasn't much else to excite a young adult. No sooner had I finished high school than I moved to the city with all its opportunities and attractions. As the years went by I was fortunate to live as a migrant in some of the world's premier cities. Although I have lived in the same city for the last twenty five years, I regularly venture abroad as a tourist to experience new places and people.

This desire to move is not a new phenomenon. Right from when early mankind first emerged in Africa, we have been on the move, forever seeking greener pastures. The two big movements today are the migration of people from one country or region to another and of rural folk to the cities. The big driver for both types of movement is dissatisfaction with life in one place contrasted to a possibly better life in another. To give you some idea about the size of the issue, today some 244 million people, 3.3% of the world's population, live outside their country of birth.

Migration

Africa is the source of a large percentage of the world's migrants. The populations of the countries of West and East Africa are amongst the fastest growing on the globe leading to intense competition for resources. The area around the Sahara is already experiencing the depredations of climate change – higher temperatures, lower rainfall, less forage for flocks and herds and increased desertification. The tussle for political power over the diminishing resources has intensified, leading to uncertainty for those caught up in coups and repressive regimes. As a result there is a flood of refugees heading north to Europe or south to South Africa. The Middle East, beset by wars and climate change, is another major source of the endless stream of refugees flowing into Europe, while the movement of Rohingya refugees from Myanmar to Bangladesh features daily in the news.

Then there are the temporary workers propping up economies everywhere – Mexicans cleaning in California and Philipinos polishing Arab mansions, Pakistanis toiling and dying in the midday construction heat of Dubai or Qatar, and South Africans caring for Europe's elderly. Although they need this help desperately, the host nations make sure the workers are simply temporary sojourners with no claim to permanent residence rights or, heaven forbid, the right to vote in countries where they might even constitute the majority.

To an outsider Britain's anti immigrant Brexit policy makes no sense. Foreigners clean the toilets of Heathrow Airport and sweep London's streets. Pause for a few minutes next to any of the city's building sites and you will hear foreign languages spoken. Every coffee shop and restaurant in the capital seems to be staffed by cheerful young Europeans learning English. Scottish workers aren't interested in harvesting fruit grown by local farmers, especially at wages Ukrainians and Romanians jump at, and there are reports of food rotting in the fields as Eastern Europeans stay away. I'm not sure anyone has thought through who will do these menial jobs when the immigrants return home.

But it's not just those at the bottom of the human pyramid who are leaving their ancestral homes and moving abroad. Those with tertiary education and first world skills are also moving to places where their skills can command commensurate remuneration and recognition. The USA, Canada and Australia abound with Asians whose children are now the star academic achievers. Silicon Valley is stimulated by foreigners and many of America's Nobel Prize winners started life in another country. Elon Musk, leading the world's charge into renewable energy and electric cars, grew up in South Africa, but is now resident in the USA.

One migration issue that seldom gets mentioned is that of host countries reimbursing taxpayers in the home country for educating the professionals they poach. The points based immigration systems used by Canada and Australia, for instance, emphasise educational qualifications, while the Nuffield Trust calculates that 30% of English doctors and 15% of nurses trained outside the country. More than 2,000 of Uganda's top doctors and nurses have recently been recruited to work in Libya and other Middle Eastern countries, potentially crippling medical services in the country. Training all those professionals was expensive, particularly for countries with limited education budgets.

Those at the very top of the wealth pyramid are the ones who seem to move with the least effort – Russian moguls buying up property in London, Arab princes commandeering beaches in the south of France, the children of African kleptocrats partying in New York or billionaire hedge fund managers holing up on New Zealand wine farms far from potential nuclear explosions. Moving along with them are the world's best paid sportsmen who acquire foreign residence rights without raising a sweat; today, for instance, most of England's top football teams are owned and manned by foreigners and often play home games in foreign countries.

Now a new set of political leaders in North America and Europe, like King Canute of old, is attempting to turn off the migration tide. Visa regulations have been tightened and the immigration authorities have become more vigilant. The powers that be pay scant notion to the idea of improving matters at the migration source so that a life abroad has fewer attractions. Instead they support the bombing raids that destroy the infrastructure and livelihoods of people already battling climate change in the Middle East or the Horn of Africa.

Overseas students at Oxbridge and the Ivy League, as well as less familiar educational establishments, face new admission hurdles and higher fees. No longer are they welcome to stay on and put their new gained knowledge into practice after they graduate. Then too, tightened visa restrictions on academics and business people are making it difficult to arrange truly representative international conferences where people from all corners of the globe can meet and exchange information and ideas.

Immigration policy, especially in countries with declining populations and growing numbers of retirees, seems to be aimed at the short term with no consideration for the longer term. Japan, which has one of the world's strictest immigration regimes, is already finding there are not enough younger people to man the economy and care for the elderly. Automation is certainly going to help the situation but not everyone wants to be tended by a robot.

News headlines about migration seem to always focus on migrants entering America, Europe or Australia but other countries of the world are also coping with an influx of migrants and refugees. South Africa, for instance, is home to more than two million people from other African countries.

Urbanisation

The move from rural poverty to the distant city lights is the other migration that has been going on for centuries. More than half the human population had become urban by 2008 and cities and towns are now growing at an estimated 1.3 million persons per week. In many countries the newcomers end up in the slums along with impoverished migrants and those who have dropped out of the economic race. Living conditions in the shanty towns are primitive and chaotic. At the same time every new migrant places an additional burden on the urban infrastructure and the environment.

Edward Glaeser's *Triumph of the City* highlights some of the issues affecting urbanisation. Admittedly it has a strong American bias with Rio and Bangalore getting passing reference and Europe a bit

more, but it is instructive. He reckons Detroit failed because the blue collar workers retrenched by the automobile industry didn't have the skills to reinvent themselves as entrepreneurs. An artist's impression in the New York Times recently showed several new residential skyscrapers underway; Glaeser attributes that city's success to entrepreneurial ideas spawned in the bustling streets and coffee shops and to the ongoing availability of affordable, energy-efficient housing making best use of limited land area.

In the San Francisco Bay area, a combination of building restrictions and highly paid Silicon Valley employees is putting housing out of the price range of many, specially the low-paid retail and service staff who are pushed to the fringes. The same is happening in London, Paris, Sydney and many other first world cities.

Glaeser recommends that cities with limited land and a fast growing migrant population should build upwards rather than going low rise outwards. While Houston's leafy suburbs might seem green, the energy required for heating, cooling and cars there far outstrips that of an apartment in a city high rise building.

With these examples in mind, I turned my eyes to the housing examples around me – as you might also like to do as you plan your ideal living conditions. My son and his family live in a rural community of about sixty healthcare and educational professions. Young families there live in two-bedroomed homes just a couple of minutes walk from work. Children wander freely and safely from house to house. While they are a real community, where I live there is none. Although plots are being subdivided, bringing people physically closer, most houses have high walls from which their occupants emerge in sleek automobiles from time to time. At the other end of the scale, on the road from the airport, the city of Cape Town is no longer building one or two room shoe box houses to replace the migrant shacks; they are building two storey terrace rows. With land so scarce they do need to go higher.

As a pensioner, I would ideally like to live in a thriving community of old and young; in traditional communities grandparents live with their children and grandchildren, but in developed countries seniors are shunted away in retirement homes and villages far from the stimulation of youth.

Tourism

Actually there is a third important movement of people taking place – tourism. The UN World Tourism Association records that in less than two decades, world travel doubled from 536 million trips abroad in 1995 to one billion in 2012. While the Cold War closed off much of the world to tourism, that figure was only 25 million. Today travel and tourism is a US\$ 8 trillion a year industry. It is also the world's largest employer and one in every eleven people works in tourism and travel.

One of the reasons for the rise in tourism is the increasing number of retirees earning pensions large enough to allow them to travel internationally. However, not all tourists are welcomed and 2017 has seen protests from residents of several European tourism hotspots as their towns and cities are overwhelmed by outsiders. Amsterdam has banned the opening of new tourist focused shops.

Africa enjoyed less than 5% of the world's 1.25 billion tourists in 2016 with South Africa alone entertaining 8.9 million tourist arrivals in 2015. African tourism is forecast to grow at a compound 6% over the next twenty years. A recent Boeing commercial outlook estimates that Africa will need 20,000 new pilots, 24,000 aircraft technicians and 26,000 more cabin crew by 2035.

Of course carbon taxes on airlines and cruise shipping could dampen the tourism boom, especially for countries like South Africa or New Zealand that are a long flight or voyage from anywhere. On the

other hand the advent of solar or battery powered aircraft could significantly reduce the costs of flights to far flung places.

These three people movements - migration, urbanisation and tourism - provide both challenges and opportunities to countries everywhere.

Low Cost Renewable Energy

The advent of low cost, renewable energy powered by the sun and the wind is the fourth global trend that I have identified. Unlike the previous global trends I have discussed, it is a very positive development for mankind, heralding a potentially significant reduction in the emissions causing climate change and respiratory health problems in addition to delivering a quantum reduction in the cost of electricity. The renewable sector could also be a significant source of new jobs.

The past five years have seen huge technology leaps together with major reductions in the price of wind and solar generation. Electricity from renewable energy sources is now significantly cheaper than coal, gas, nuclear or diesel. In fact, experts have warned that the price of solar could drop so much that almost all coal mining companies could be out of business by 2025.

Batteries are also getting both more powerful and much cheaper, allowing electricity to be stored for when the wind doesn't blow and the sun doesn't shine. One result is that the purchase price and running costs of battery powered electric vehicles are dropping sharply.

The solar power referred to in the narrative that follows is purely photovoltaic (PV) where solar power systems convert sunlight directly into electricity. The numbers do not include the millions of solar hot water systems installed worldwide which will have dampened electricity demand.

World Energy Overview

The annual *BP Statistical Review of World Energy* provides one of the most comprehensive sources of information on the world energy sector. The *June 2017 Review* records that, although primary energy consumption in North America and Europe has dropped marginally during the past decade, overall there was an average world increase of 1.8% per annum. Of course this is not a bad thing if the increase was as a result of renewable energy. However, although renewable energy generation increased more than 40% in 2016 versus 2015, energy from each of oil, gas and coal also increased slightly. Consumption of nuclear power has remained more or less constant for several years, while hydro electricity consumption increased 2.8% just in 2016.

The growth rate of renewable energy has averaged an impressive compound 16% per annum over the past decade. As a result, world renewable energy consumption in 2016 was equivalent to 70% of nuclear energy generation or 45% of hydro energy consumption. Solar energy usage has grown by an average 50.7% per year in the past decade, albeit off a small base, while wind power grew at a compound 23% over the same period. It's not clear if BP has just counted the large scale commercial solar power generators or also included the small domestic installations; in Australia, for instance, despite the government's strong bias towards coal, more than 25% of homes there now have solar panels installed. Bangladesh, with 4 million PV units installed, has the largest solar home system market funded mainly using microcredit schemes.

Since 2013 the world has been adding more electricity-generating capacity from wind and solar than from coal, natural gas, and oil combined. According to Bloomberg New Energy Finance, another excellent source of information on the energy sector, solar panel installations are showing around 50% growth each year, while energy reducing LED light-bulb sales are soaring by about 140% per annum.

In September 2017, European energy consulting company DNV GL published its *Energy Transition Outlook* which predicts renewables will make up 44% of primary energy supply and 85% of electricity supply by 2050. They predict that energy efficiency will improve faster than global economic growth

due to the rapid electrification of the world's energy system leading to a plateau in energy demand from 2030. Gas supply will peak in 2035 but will still be the biggest single source of energy in 2050. Oil consumption will flatten between 2020 and 2028 before falling significantly. Coal consumption has already peaked.

Solar PV and wind costs are forecast to decrease by 18% and 16% respectively per the doubling of capacity. Electric vehicles are predicted to achieve cost parity with internal combustion vehicles in 2022 and, by 2033, half of new light vehicle sales globally will be electric.

Nuclear Power

The future of nuclear energy is uncertain after the Japanese Fukushima disaster and major new build project budget overruns. Nuclear plants are being decommissioned in Europe and the USA and the new builds in the United Kingdom, France and Finland are billions over budget and years behind schedule. Every major nuclear power plant construction company is in dire financial straits with Toshiba-owned Westinghouse poised to file for bankruptcy.

In the USA, a dozen nuclear plants are being retired because they can no longer compete costwise with wind, solar and gas. In August 2017, the V.C. Summer nuclear project in South Carolina was cancelled after \$US 9 billion had already been spent and after it became clear that the original \$US 11.5 billion estimate for the whole project would more than double to at least \$US 25 billion. Duke Energy Florida cancelled its Levy Nuclear Project; instead Duke will invest US\$ 6 billion in solar energy, smart meters, and grid modernization as well as electric vehicle charging stations and a battery storage pilot program. However, Georgia is planning two nuclear plants though this decision is not final. The Vogtle nuclear reactor project in Georgia is also expected to be cancelled because of rising costs. There are moves to end federal bailouts for existing nuclear plants that could cost more than \$US 275 billion but these might be cancelled by the new administration. Another issue facing American utilities is that facilities for storing nuclear waste have almost reached capacity.

The Hinkley Point nuclear project in the United Kingdom is running more than US\$ 2 billion over budget after just the first year of a planned 10-year construction period. The Independent newspaper reported that government figures now show the total bill to households could total £ 50 billion, more than eight times greater than the National Audit Office's initial 2013 estimate that a public investment of £6 billion would be required.

Next generation reactor projects in France and Finland are also billions over budget and years behind schedule. France is also now faced with a massive bill to maintain its ageing reactors. A recent study suggested the country would find it cheaper to scrap the whole nuclear project and invest in wind and solar instead. South Korea's new president wants his country to abandon nuclear power because of its costs and risks and Japanese politicians are promising to do likewise.

Canada's Terrestrial Energy completed the initial phase of an approval for its fourth generation molten salt reactor by the Canadian Nuclear Safety Commission. Full approval could take ten years and construction of the first commercial plant another decade. It remains to be seen whether this new technology will ever be implemented..

Small nuclear reactors are used to power submarines and ships. However they are not seen to be commercially viable.

South Africa's Department of Energy spent R 80 million on nuclear energy consultants who will probably have provided a similar picture of the state of the world nuclear industry.

Coal

The *BP Statistical Review of World Energy June 2017* records that 2016 world coal production was 7.5 billion tonnes, down 6.5% on 2015. The biggest producers were China, which produced 45.7% of the total, the USA, India, Australia, Indonesia and Russia.

The International Energy Agency (IEA) is another valuable source of world energy data. Their August 2017 *World Energy Balances Report* highlighted that coal production in China in 2016 fell by around 320 million tonnes or 9%, a fall equal to more than the total production from South Africa, the world's fifth largest coal exporter. Coal production also fell elsewhere, including the USA and Australia, leading to global output falling by 458 million tonnes. Globally, despite an increase in India, coal consumption in 2016 fell by around 2% in energy terms. The move away from coal generation is most clear within the OECD, where electricity generation from gas in 2016 was virtually equal to coal generation for the first time ever.

According to a report on the world coal construction industry compiled by Greenpeace, the Sierra Club and Coalswarm, in 2016 pre-construction activity fell by 48%, construction starts by 62% and ongoing construction by 19%. According to another source, in 2015 the Chinese government cancelled more than 200 coal fired power station projects and announced plans to reduce thermal coal output by 280 million tonnes in 2016 as part of a total reduction of 500 million tonnes. A Bloomberg New Energy Finance report calculates that China has US\$ 237 billion of potential stranded coal fired power station assets because of a massive over-build. In September 2016 the government cancelled fifteen coal power projects, totalling 12.4 GW. In January 2017 a further 103 coal power plant construction projects totalling 114GW were cancelled or delayed until after 2020. There were further cancellations in September 2017.

Elsewhere in the world coal fired power stations are in decline. Already heavily-indebted coal plant operators in India are seeking central government financial assistance to help retro-fit their coal plants in response to a government crackdown on air pollution. The total cost of the required technical updates has been estimated at US\$ 38 billion. May 2016 was the first month since 1882, when the first British power station was built, that the United Kingdom had a period when no electricity was being produced from coal.

A report by two IMF economists published in *World Development* estimates that direct and indirect subsidies to the fossil fuel industry increased from US\$ 4.9 trillion in 2013 to US\$ 5.3 trillion in 2015, equivalent to 6.5% of global GDP. China was the biggest subsidiser, followed by the USA, Russia, the European Union and India. Eliminating subsidies would have reduced global carbon emissions in 2013 by 21% and fossil fuel air pollution deaths by 55%.

The US government has announced plans to subsidise new nuclear and coal fired power stations. The net result is that 2.4 million clean energy jobs will be at risk and the USA will end up at a significant competitive disadvantage compared to low energy cost regions such as China and Europe where renewable electricity could cost half the US price.

As I mentioned in my opening paragraph, experts have warned that the price of solar could drop so much that almost all coal mining companies could be out of business by 2025. Worldwide the coal mining industry employs about seven million people. These employees will need to be retrained in the skills needed for the renewable age or deployed to rehabilitate the environmental damage caused by the coal mining. Governments will need to provide a safety net for those made redundant as coal mines close.

Renewable Energy

Renewable energy, particularly wind and solar, in addition to being cheaper to install than coal, gas or nuclear, has very low operating costs as there is no requirement to pay for fuel – sun and wind are free.

The IEA *World Energy Balances Report* also recorded that “alongside the growth in gas generation, 2016 also saw the continued increase of renewable generation across the OECD and in countries like China. In the OECD, renewables generation grew by 3.8% to account for 23.8% of all electricity generated, its highest share to date. The growth was largely driven by wind and solar photovoltaic (PV), which saw annual average growth rates of 21% and 43% between 2000 and 2016.”

Worldwide, some 73 GW of new solar PV capacity was installed in 2016, 50% up on 2015 with China providing half the additional capacity. Wind energy came in second place (55 GW), with coal relegated to third (52 GW), followed by gas (37 GW) and hydro (28 GW). Together, PV and wind represented only 5.5% of current energy generation capacity at the end of 2016, but they constituted almost half of all net new generation capacity installed worldwide during 2016.

According to Bloomberg New Energy Finance total new clean energy investment in non-OECD countries fell by \$40.2 billion to \$111.4 billion in 2016 from \$151.6 billion in 2015. While China accounted for three quarters of the decline, new clean energy investment in all other non-OECD countries also fell 25% from 2015 levels.

An October 2017 update from the IEA predicted that China, India and the USA will account for two thirds of renewable energy growth over the next five years. Renewable capacity is forecast to grow by a further 1,000 GW by 2022, equivalent to 50% of current coal generation capacity. At that stage renewable will account for 30% of world power generation, up from 24% in 2016.

The REN21 *Renewables 2017 Global Status Report* recorded that “renewable energy construction reached record levels in 2016, with 161 GW added, increasing the global total by almost 9% relative to 2015. Solar PV was the star performer in 2016, accounting for around 47% of the total additions, followed by wind power at 34% and hydropower at 15.5%. For the fifth consecutive year, investment in new renewable power capacity (including all hydropower) was roughly double the investment in fossil fuel generating capacity, reaching US\$ 249.8 billion. The world now adds more renewable power capacity annually than it adds in net new capacity from all fossil fuels combined.

“The cost of electricity from solar PV and wind is rapidly falling. Record-breaking tenders for solar PV occurred in Argentina, Chile, India, Jordan, Saudi Arabia and the United Arab Emirates, with bids in some markets below US\$ 0.03 per kilowatt-hour (kWh). Parallel developments in the wind power sector saw record low bids in several countries, including Chile, India, Mexico and Morocco. Record lows in offshore wind power tenders in Denmark and the Netherlands brought Europe’s industry closer to its goal to produce offshore wind power more cheaply than coal by 2025.

“A paradigm shift is under way in the developing world, where billions of people still live without access to electricity and/or clean cooking facilities. The cumbersome process of providing electricity access through grid extension alone is becoming obsolete as new business models and technologies enable the development of off-grid markets. Markets for both mini-grids and stand-alone systems are evolving rapidly.

“Pay-As-You-Go (PAYG) business models, supported by mobile technology (for example, the use of mobile phones for bill paying), are exploding. In 2012, investments in PAYG solar companies amounted to only US\$ 3 million; by 2016 that figure had risen to US\$ 223 million (up from US\$ 158

million just one year before). This trend started in East Africa and is quickly spreading to West Africa, as well as to South Asia. The mini-grid market now exceeds US\$ 200 billion annually. In 2016, more than 23 MW of solar PV and wind power based mini-grid projects were announced.

“The myth that fossil and nuclear power are needed to provide “baseload” electricity supply when the sun isn’t shining or the wind isn’t blowing has been shown to be false. In 2016, Denmark and Germany successfully managed peaks of 140% and 86.3%, respectively, of electricity generation from renewable sources, and in several countries (Portugal, Ireland and Cyprus, for example), achieving annual shares of 20-30% electricity from variable renewables without additional storage is becoming feasible. The key lesson for integrating large shares of variable renewable generation is to ensure maximum flexibility in the power system.”

Spreading wind and solar facilities over wide areas allows access to a wide range of different weather and also helps to smooth out peaks in users’ demand. Storage can also help match up energy generation with demand patterns.

The Citi GPS report *Energy Darwinism II* estimated that the use of renewable energy in the power sector under Citi’s ‘Action’ scenario would increase from 6% in 2012 to 34% by 2040 which will create new jobs in this sector.

Electricity utilities with an existing investment in coal or gas fired plants have a natural reluctance to invest in renewable energy. As a result, where this occurs customers are reacting to high electricity prices by installing their own stand alone solar systems. In Queensland, Australia, more than 50% of homes now have solar PV panels while in Nevada the local electricity utility sued a resort that went offline for loss of revenues.

Mark Jacobson, of the Stanford School of Earth, Energy, and Environmental Sciences, and 26 of his colleagues have compiled a report that shows how 139 countries, including South Africa, could transition to 100% renewable energy by 2050 without throwing millions of people out of work.

South Africa and Australia have several energy related features in common. Their climates are similar, with both having regions of low rainfall and high temperatures; coal is a major export of both countries as well as the major source of electrical power; and both have governments that are conservative on energy policy and closely aligned with the coal mining industry.

According to RenewEconomy, in Australia solar and wind comprise practically all new generation capacity. Solar PV capacity is set to reach 12 GW by 2020. Wind and solar PV are being installed at a combined rate of about 3GW per year, driven largely by the federal government’s Renewable Energy Target. If this rate is maintained, then by 2030 more than half of Australian electricity will come from renewable energy. If Australia were to double the current combined PV and wind installation rate to 6GW per year, it would reach 100% renewable electricity in about 2033. The price of large-scale wind and PV in 2016 was A\$ 65-78 per MWh, well below the current wholesale price of electricity in the National Electricity Market. Prices are likely to drop below A\$ 50 per MWh within a few years. Some solar installations are being built alongside defunct coal fired power stations so they can use the existing transmission infrastructure.

The renewable energy sector is already a major employer worldwide. According to the IEA, global renewable energy jobs, excluding those in large hydropower, reached an estimated 7.7 million globally in 2014, which is an 18% increase from the previous year, with the majority of the jobs found in China. In the USA, there are currently 2.1 million people working in the solar, wind and geothermal sectors. This number is estimated to increase to 2.8 million by 2022. Clean Edge estimates clean energy accounts for 2.4 million jobs in the USA alone. The American solar industry created 51,000

new jobs in 2016 and now employs 260,000 people. Britain's renewable energy sector employs 234,000 people.

A 2017 report by Dev Millstein, Ryan Wiser, Mark Bolinger and Galen Barbose entitled *The climate and air-quality benefits of wind and solar power in the United States* found cumulative wind and solar air-quality benefits of US\$ 29.7–112.8 billion mostly from 3,000 to 12,700 avoided premature mortalities, and cumulative climate benefits of US\$ 5.3–106.8 billion.

Advanced Energy Economy believes smart energy, including advanced metering and grid improvements, is a US\$ 200 billion American market.

Green investment funds are providing finance for many renewable energy projects. However, local communities rather than funds own 50% of German and 85% of Danish renewable energy facilities.

Wind Energy

The *BP Statistical Review of World Energy June 2017* records that world wind energy consumption in 2016 was 959 terawatt-hours, up 15.6% on 2015. The countries with the largest wind power consumption were China and the USA, followed at quite a distance by Germany, Spain, India and the United Kingdom.

According to the American Wind Energy Association (AWEA), the U.S. wind industry invested more than US\$ 13.8 billion in projects in 2016. As a result of increased investment, AWEA expects wind-related employment will grow across all 50 states, reaching 248,000 jobs by 2020. Currently all American windfarms are on shore with Delaware and California among the states looking at amending legislation to allow offshore windfarms.

The United Kingdom has the world's largest offshore wind capacity. In September 2017 the United Kingdom government released the results of its latest offshore wind power auction in which costs dropped below £ 58 per MWh, a drop of 50% in just two years. By comparison the Hinckley Point C nuclear plant will cost £ 92 per MWh and the Sizewell C nuclear plant £ 89 per MWh. New wind capacity will also come into operation two years before Hinckley.

In June 2016 nuclear (20%), wind and solar produced more United Kingdom electricity than gas and coal. Wind produced enough power to meet, on average, the electrical needs of 124% of all Scottish homes between January and June 2017. Wind Europe recorded that on a single day in September 2017 wind power accounted for 19.6% of the total electricity demand in Europe including 83% of Danish, 54% of Irish and 42% of German demand.

In October 2017 oil company Statoil started production from Hywind Scotland, the first floating wind farm in the world. The unit includes a one MWh lithium ion battery storage facility. Australia's Kennedy Energy Park, being developed by Tesla and Vestas, combines wind, solar and storage technologies.

Solar Energy

There are three basic types of solar energy system: photovoltaic (PV), concentrated solar power (CSP) and solar hot water systems, which use the heat of the sun to directly or indirectly heat water.

As their name would suggest, PV systems convert light into electricity; interestingly, the higher the temperature, the worse the performance of a PV panel or cell. Solar PV systems are completely scalable from a tablet sized unit that can charge phones and laptops to a solar array stretching over

several hectares that can power a whole town. Solar cells themselves have become cheap and now most of the cost is due to the related equipment and the installation process.

In contrast to silicon solar panels, which currently dominate the market at 15% to 20% efficiency, concentrating photovoltaics (CPV) focus sunlight onto smaller, but much more efficient solar cells to enable overall efficiencies of 35% to 40%. Current CPV systems are large and have to rotate to track the sun during the day. A CPV system with embedded microtracking can produce over 50% more energy per day than standard silicon solar cells in a head-to-head competition.

CSP systems are large scale utility plants which use mirrors or lenses to concentrate the heat of the sun onto a receiver at the top of a tower containing molten salt or some other heat transfer medium which stores the energy until it needs to be converted into electrical power.

All three systems work better at the equator compared to the poles because the rays of the sun have less atmosphere to penetrate. Clouds and pollution impair the performance of all systems no matter where they are located.

The *BP Statistical Review of World Energy June 2017* records that world solar energy consumption in 2016 was 333 terawatt-hours, up nearly 30% on 2015. The biggest solar power consumers were China, the USA, Japan, Germany and Italy.

The U.S. Department of Energy's National Renewable Energy Laboratories published a report entitled *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017* which calculated that PV prices dropped 30% in one year for utility-scale solar, to an average price of US\$ 1.03 per watt-DC for fixed-tilt systems and US\$ 1.11 per watt for systems with tracking.

According to Renewable Energy World, as of the end of 2016, worldwide installed solar power capacity reaching approximately 303,000 MW with China, at 78,000 MW accounted for 25.7% of the total. By mid-year 2017 the Chinese had exceeded 100,000 MW in installed solar power capacity, a milestone that was achieved a full four years earlier than the Chinese had originally estimated in the *13th Five Year Program for Solar Power Development*. The Chinese press reported that in June, 2017 alone 13,500 MW of additional solar capacity was installed.

In 2016, installed solar made up 39% of all new electric generating capacity in the USA, topping all other technologies for the first time. The U.S. market is expected to reach two million installations in 2017 and four million by 2022. Tesla has introduced solar roof tiles which double as roofing and power generators. In Missouri the local utility is rewarding west facing solar panel installations as they produce electricity in the late afternoon, the time of peak consumption. New housing estates in Miami and elsewhere in the USA are now required to be energy neutral with all homes having solar panels. Of course, if the US government proceeds with the Section 201 tariffs on solar imports, then the US solar industry could be seriously hamstrung by the higher costs and shed jobs.

Peru, Dubai, Saudi Arabia and Texas each have large scale solar projects underway that can produce electricity for less than six US cents per kWh of solar energy produced. In September 2017 Saudi Arabia received offers from Masdar and EDF to provide 300 MW PV at a cost of 1.79 US cents per kWh, lowering the previous best price of 2.42 cents per kWh achieved in an Abu Dhabi tender. RenewEconomy reports that in November 2017 the latest energy auction in Chile set a new record low for solar PV, with one bid 2.148 cents / kWh. TuNur Ltd. recently applied for authorization to build a 4.5 GW solar power export project in the Sahara Desert that would supply the European market with electricity.

South Africa is a world leader in implementing CPV with the 100 MW KaXu Solar One, 50 MW Bokpoort and 50 MW Khi Solar One concentrated solar thermal power stations operational and four more in the pipeline.

The Aurora solar project in Australia, which begins construction in February 2018 with completion expected in 2020, comprises a field of billboard-sized computer-controlled mirrors which follow the sun and reflect sunlight onto a target at the top of a 227 metre tower, where the equivalent of 1,200 suns heats up a molten salt which then passes through a heat exchanger to create steam. Western Australia is considering building 3 GW solar farms in Western Australia's Pilbara and Kimberley regions and selling their output to Indonesia via submarine cables.

In September 2017, the Indian government launched a US\$ 2.5 billion project to provide solar and battery storage together with LED lights, a DC fan and a DC power plug to households without power in rural and remote towns and villages, as a part of electrifying all Indian households by the end of 2018. Currently the homes of 300 million Indians are not connected to the grid.

According to the IEA, the number of Africans without access to electricity increased from 585 million people in 2009 to 632 million in 2014. Research showed only 1% of the US\$ 19.4 billion a year funding provided under the United Nations' Sustainable Energy for All program was being invested in off grid solutions. Just as cell phones allowed tens of millions of Africans to communicate without copper cables, so cheap solar panels could provide people across Asia and Africa with access to electric lighting and smokeless cooking without the need for expensive grid connections.

Energy Storage

By 2026, it's expected that 2.1 GW of hybrid energy storage, such as a combination of batteries and ultracapacitors, will be deployed globally. Tesla is building a major lithium-ion battery manufacturing plant in Nevada and Germany has announced plans to build a similar facility. Tesla is also installing what could be the world's largest battery in South Australia.

Currently the main focus is on lithium ion batteries using lithium sourced from Australia, Chile, Argentina, China, Zimbabwe and Namibia. Lithium-ion prices have halved since 2014. However researchers are looking to bring fuel cells and vanadium based battery technology to commercial production. Russia's Pala Investments Ltd. predicts battery demand for vanadium will grow 10 fold from 2015 to 2025. Russia, China and South Africa are the biggest sources of vanadium. GM and Toyota are experimenting with solid-state batteries that could be lighter, cheaper and longer lasting than lithium ion batteries.

California-based Ice Energy has developed technology which works alongside air conditioning units by freezing water at off-peak periods, or when excess solar or wind power is available, and using the "ice battery" to provide power-free cooling during on-peak periods.

Conclusion

Renewable energy, our fourth global trend, should be the basis of much cheaper electricity for all, a significant contribution to climate change amelioration, the creation of thousands of new jobs and a huge boost to the health of those residing near coal fired power stations. It's difficult to understand why it is not happening faster!

Mass Data Storage and Mining

Knowledge is power, as the old adage goes. A combination of low cost electronic devices, the Internet and powerful computer and data storage facilities has provided the platform for the collection and analysis of unprecedented volumes of data which are owned by a handful of very powerful companies and governments.

America's Digital Colonisation of the World

When we were at school we learned how intrepid sailors, soldiers and settlers ventured forth to conquer and settle foreign lands. The local natives they dispossessed by force of arms and germs never understood that their experience was just one small incident in Europe's colonisation of the world. Just as today most of us are unaware of America's digital colonisation of our world.

I suppose it all started about fifty years ago as the American credit card companies – Visa, Mastercard, American Express and Diners – fanned out across the globe. Between them they have signed up billions of merchants and consumers. In recent years Paypal, another American company, has joined the payment fray. While it's hard to get current, accurate information on credit and debit card usage, there are more than one hundred billion card transactions a year worldwide worth well over three trillion dollars. That's a lot of money – and a lot of valuable data on vendors, customers and their interactions being collected along the way.

Back in the late 1980's there was a Goliath and David encounter between IBM and Microsoft as to whose operating system would be used in personal computers. We all know that Bill Gates and his merry men slew the giant. Today various versions of Windows are installed on more than 90% of the 1.5 billion PCs in operation. I'm not sure how stringent Microsoft has been in collecting information on the ownership of all these PCs, but most connect to the Internet anyway and regularly feed back their status – and what else? – to home base in Redmond.

In the beginning it looked like the cell phone industry was going to be a non-American dominated event. Nokia and Erickson in Europe took a large chunk of the original cell phone market, while Canada's Blackberry pioneered smart phones. Today Asian manufactured phones predominate. However under each touch screen, the operating system is invariably supplied by either Google or Apple.

The Alexa website lists the world's most used websites. The top ten are dominated by American companies with a handful of Chinese websites interspersed. Top of the list Google now processes – and stores - over *40,000 search* queries every second on average, which translates to over *3.5 billion searches* per day worldwide. As of the fourth quarter of 2015, Facebook had *1.59 billion* monthly active users who had logged in to Facebook during the previous thirty days. According to recent industry figures, Amazon is the leading e-retailer in the United States with more than US\$ 107 billion in 2015 net sales via more than 304 million active customer accounts worldwide.

In the empires of old the colonies sent back jewels and spices, food and raw materials to merchants in the motherlands who grew rich and fat on the proceeds. Today it's data in huge quantities that is being shipped back. Data mining techniques allow today's empire builders to know more about the world's personal and business trivia than even the colonies themselves. Already Google and Facebook are using it to corner the growing online advertising market. And it was just a few years back that the credit card companies stopped Russian retail activity in its tracks during the Ukraine stand-off. What next?

Already computers are able to know your every movement; most of your conversations and written message exchanges; the state of your health minute by minute; every purchase and payment you make; every web site you visit; and a whole lot more – including the passwords you use so secretly. Microsoft is pillaging the Skype user files, while Facebook is merging the details of WhatsApp's 200 million users with its own. Amazon is monitoring shoppers' every move in its physical stores and, soon, the homes to which its drones deliver, and plans to use the data to sell more and at better prices – for Amazon of course.

A Guardian journalist asked Tinder, the dating website, to provide details of all the information it had collected on her; the download contained more than 800 pages of information. Before last year's American presidential election Cambridge Analytica, a data consulting company, was able to tap all manner of online databases to create a directory of American voters with an average of 5,000 pieces of information on each.

In May 2014 journalists reported that the America's National Security Agency (NSA) was recording and storing every single cell phone conversation that took place in the Bahamas. They speculated that this was just the tip of the iceberg of the worldwide monitoring undertaken by the NSA.

Because of the Internet, much of the data is distributed globally. To date the owners of these big databases of personal information have only used the contents to target advertising more precisely and, by the likes of Amazon and Uber, to monitor the second by second movements and performance of employees and agents as a first step to automating jobs. Down the line we can expect new medical, financial and other products tailored specifically to our needs, as well as greater surveillance by governments and management.

When it comes to personal monitoring, most of us are like lambs to the slaughter. We post every trivial detail of our personal lives on Facebook; we use Hotmail and Gmail to communicate; our kids are endlessly texting with their friends; fitness fanatics indulge in the latest medical jewellery; out of necessity we take jobs in the new economy; we smarten our homes with Internet and Bluetooth connected gadgets; and every day new surveillance cameras are erected all around us. In the USA it's probably gone further than anywhere else now that Congress has given Internet service providers permission to sell Americans' browser and app usage history.

Incidentally, it's not just in America where this mass personal data gathering is taking place. According to McKinsey Global Institute, China is responsible for 40% of global e-commerce transactions. Major Chinese ecommerce portals are required to share their data with the central government, including The People's Bank of China which shares this information with fifty other banks.

Privacy International has obtained previously unseen government documents that reveal British spy agency GCHQ collects social media information on potentially millions of people by gaining access to private companies' databases. The Investigatory Powers Commissioner, which is charged with monitoring this surveillance, was kept in the dark as the agency shared massive databases with foreign governments, law enforcement and industry, potentially for decades.

Medical Data Mining

For practically all of my adult life I have been a member of a medical aid scheme. In the beginning our relationship was simple: each month I would send them a cheque to cover my membership. As and when I incurred medical expenses, I would submit my receipts and they, in return, would send a cheque of reimbursement. No doubt they kept a record of each member's claims so that each year end they could adjust their fees accordingly – just standard cost accounting really.

As time went by our relationship became more sophisticated. My membership fee was deducted from my salary by my employer and my monthly tax payment adjusted automatically. My claims were submitted by E-mail and the refunds were paid directly into my bank account. So far so modern.

Somewhere along the line - and not really noticed by us members - hospitals, doctors and pharmacies started being required to record a standard code against each item on their invoices as well as provide details of all medication in a standard format. All this information was fed into a vast databank.

But it didn't stop there. The scheme entered into agreements with the major supermarket chains so that members participating in a so-called healthy food program would have the full details of all their supermarket purchases siphoned back into the databank. Members who opted into this scheme were rewarded with a monthly healthy food dividend paid directly into their bank accounts. So now the scheme not only knew about my medical ailments and medication, but also how many bunches of bananas or tubs of yoghurt, as well as the brand, I bought. They also knew about all my other supermarket purchases from toilet paper and household cleaners to stationery, crockery and lawn fertiliser. If they were really clever they could even have noted my supermarket absences as signs of travelling outside the country.

The healthy food program then became just one part of a healthy living program where members were encouraged to exercise and undergo regular health checks. Subsidised gym membership was offered – and monitored. Participating members were rewarded with discounted airfares and other nice perks. Once personal health monitors were added to smart phones and wearables, you could achieve even further rewards by feeding back your daily exercise regime. So each time my adult children go running, it knows where they ran, how fast they ran and, depending on the sophistication of the device, their heart rate, blood pressure and a whole host of other things we never even knew ourselves in the old days of just taking the dog for a stroll.

My guess is that the next item in their healthy lifestyle plan is going to be an offer to decipher my DNA for a few bucks, something most people will be unable to resist. We all want to know if we are descended from Genghis Khan or Alexander the Great or even Helen of Troy. Now Craig Venter's Human Longevity Company over in California claims it can create a photorealistic picture of your face just from your DNA.

Now, the big question is, what is the medical aid scheme doing with all this data they have purchased for a song? So far, they don't seem to have passed it onto greedy marketers keen to flog me all manner of things in a targeted way. Or maybe they have and the marketers have just got cleverer at covering their tracks. I also hope and pray they haven't willy nilly passed my data onto the pharmaceutical companies in exchange for a fat fee.

In the medical academic world, researchers come up with a hypothesis, design a research program and then go out and collect and analyse data. It's a process that could take months or even years. However for the medical aid scheme to conduct similar research all they need is a clever algorithm writer who can code a program to mine their ever growing databank of millions upon millions of records and come up with an answer in days – or possibly just in minutes if they're really smart.

It won't be long before a super algorithm writer decides to throw hypotheses out of the window and write an artificial intelligent supermining program that will sift out all key relationships. Some, like older people being more likely to have Alzheimers disease than young people, will be obvious. But they might find that people who buy brand A of soap and have a certain strand of DNA are less likely to incur skin cancer or that purchasers of brand B of household cleaner are more likely to be asthma

sufferers or that people in small villages who eat raisins live longer – the sky is the limit on what they could deduce – and all at the click of a mouse!

My medical aid scheme is just one example of a company to whom I have unwittingly donated my personal information without fully thinking through the implications. How many more are out there watching my every move. As my near namesake Brian Patten writes in the final line of his lovely poem *Little Johnny's Confessions*, “the sniffer dogs will hunt me down – they have my lollipops!”

Financial Transactions

The investment community was an early adopter of the Internet. Newspapers and stock exchanges published the previous day's closing prices on their websites. Stockbrokers set up websites so their clients could buy and sell stocks and bonds at the click of a mouse.

However the real electronic action took place in the trading rooms where screens provided by the likes of Bloomberg and Thomson Reuters bombarded the traders with prices and indices, news releases, trade statistics and company results. Soon a new IT expert, the quant, stepped in to automate the collection and analysis of the huge volumes of data. It wasn't long before some of the trades started to be automated using fractions-of-a-second old information from exchanges. Clever software automatically created news releases to be read by human eyes, while more sophisticated software can read and extract meaning from text messages at speeds way faster than humans can absorb the written word.

The amount of raw financial data that has been collected by the various financial institutions is awesome and so too is some of the software that analyses it. However even the quants admit they have just scratched the surface. JPMorgan, for instance, is starting to use machine learning to perform trades in its American and Asian operations. Instead of using rules developed by humans, the system has been designed to learn what and when to buy and sell from analysing billions of past transactions that were or were not successful. European trials showed that it generated more profit than human traders.

And even that's not the end. There's all that juicy data stored publicly on the Internet just waiting to be trawled. Then there are all the private databases held by everyone from Facebook to the credit card companies and from cell phone operators to private security companies. Those clever algorithm writers must be smacking their lips at the challenge of merging and mining it all.

Internet of Things

Every day we read about new devices that can collect and transmit data. The United Kingdom is reputed to have more surveillance cameras per person than any country in the world; simple technology allows them to recognize car number plates while more sophisticated software can compare faces against those stored in a database and recognize people. China has already used face recognition technology to spot criminals going about their daily non criminal business in full view of cameras. Copenhagen is introducing a system to link together all of the city's infrastructure from parking meters and traffic lights to electricity meters and lights in public buildings.

Systems for use in the home abound, from automated vacuum cleaners that feed back details of what happens in a household to fridges linked to automatic grocery ordering systems. At a meeting of hackers last year, one geek, aged just eleven years, demonstrated how he could hack a popular teddy bear and use the computer inside the toy to listen in on nearby conversations. German regulators have warned about kids' watches that can snoop on what's happening in the classroom. Smart electricity networks managing the renewable energy sources connected to a power grid, can also capture second by second of what plug in devices you are switching on and off.

Apple, Google and Amazon are in a tight contest to see who can control the household electronic space. Increasingly their control units can watch through more video cameras and switch ever more switches on and off at the press of a series of buttons on a cell phone which have replaced individual binary switches. Now it's the electronic lock on the front door that has them all excited. Amazon might be the leader with plans to allow drivers of delivery vehicles to open customer front doors and deliver items ordered from Amazon, all the time watched by cameras to ensure no mischief takes place.

If that's not scary enough, Google is now proposing to create a city of the future on the Toronto waterfront. Here every person and every thing will be monitored every second of the day. The Google presentation on the project is replete with cheery photographs of people living and working and playing. However I wouldn't like to be doing any of those things knowing Big Brother will be watching. George Orwell and Franz Kafka will be turning in their respective graves!

Cisco estimates 500 billion devices will be connected by 2030, up from 13 billion in 2013. Increasing digital connectivity is fuelling a data boom, with data volume estimated to be doubling every 18 months, and computers are certainly far better able to handle this volume than people.

All of these devices are feeding back the data they collect to centralised databases. In many cases I don't think the owners of these databases have even started to think about the myriad of insights that could be generated using complex algorithms, deep-learning neural networks and artificial intelligence to trawl through the data. Then there are all the security issues with hackers sniffing out opportunities to install malware, ransomware and even something worse.

Issues Associated with Mass Data Mining

There are several important issues associated with mass data collection and mining that we need to bear in mind as we switch on our computers and add yet more personal data to the mix.

The first issue is the ownership of the data. We like to think that our own personal data belongs to us; it doesn't. We don't even know the full extent of how our data is held by others, let alone even the first step to getting it erased from the global databank. The reality is that the data is owned by the companies and governments who own the storage facilities. By and large these are governments or large American and Chinese companies owned by incredibly wealthy shareholders; they are the ones who will ultimately benefit from the results of any data mining, whether it be by their own organisation or by customers to whom they sell access.

This brings us on to concentration of ownership. Apple, Google, Microsoft, Amazon and Facebook, five of the six largest listed American companies with a total market capitalisation of US\$ 3 trillion, all reported large revenue rises in October 2017. The major shareholders of these five companies are some of the richest people on the planet. When a potential competitor appears on the scene, it is immediately snapped up for a billion or two, like a gecko on the wall flicking out its tongue in a flash to catch passing mosquitoes. The power of these companies is such that it is doubtful if the competition authorities anywhere can keep them in check.

Another issue is who pays tax in what jurisdiction. In the early days of the Internet when we ran Internet strategy workshops for companies, we posed the theoretical problem of the Australian business person visiting Japan who went online and used their credit card from an American bank to order a book from a British company using a French website. The book was delivered by an Indian courier from a warehouse in Seoul to the hotel in Lima where the Australian would be visiting a few days later. Where would sales tax be paid on the transaction? If there was a problem with the transaction, under what laws would resolution take place?

Similar issues apply here. A valuable asset in the form of data moves between countries with next to no consideration being paid. For example many companies around the world advertise on Google and Facebook and the costs appear in the local company's accounts. Likewise many companies flight adverts served by Google's AdSense and Doubleclick on their websites, with the income reflected in their accounts. However it's not entirely clear where in the world the counterpart of each of these transactions takes place.

To make matters more complicated, the American Supreme Court has now agreed to decide whether technology firms with American operations have to retrieve electronic information stored abroad if American authorities demand it under U.S. law. If the justices do give their blessing, it will be interesting to see the response from other countries. Will they be able to demand access to data stored in the USA? Or will they seek means to block multinational companies from distributing data internationally, which is what cloud computing is all about?

The final issue is security. As the hacked teddy bear example shows, hackers and snoopers are able to access our electronic devices and the information that flows from them. They can divert the information, corrupt the information or simply embed malware in the device's software. This can obviously compromise the integrity of the databanks. Fortunately this has been recognized by the data storage owners who are able to run algorithmic software to identify data inconsistencies.

Conclusion

Mass data storage and mining is the fifth global trend, the ramifications of which should trouble us all.

Automation-based Unemployment

Nowadays I often come across teams of labourers with picks and shovels laying fibre optic cables; a mechanised trench digger could do the job of the whole team in a fraction of the time. The problem is that the low statutory minimum wage probably paid to the workers makes the capital and working cost of the digger prohibitive. Of course, raise the minimum wage and the economics could alter in favour of automation. Similarly, if the cost of a digger came down, then the labourers would again lose their jobs. In both cases the loss of the labourer jobs would be offset to a very limited extent by the higher paying jobs associated with manufacturing, selling, operating, fuelling and maintaining the digger.

This simple example encapsulates the history of the industrial revolution from even before the Luddite textile workers took up arms against the mill owners. As new technologies for the farm, the factory and the office were invented and implemented, so they displaced the people doing the jobs. Fortunately at the same time demand for goods and services increased providing new job opportunities for the displaced workers. However, maybe we have now reached the stage where all the products and services required by man can be produced by an ever decreasing workforce using more and more computer based tools.

For just over fifty years computers have allowed companies and governments to cut costs while enabling the delivery of new products and services. Invariably the cost cuts involved reducing staff, with the savings passed on to customers, shareholders and taxpayers. At the same time technology allowed organisations to offer services that would have been impossible or prohibitively expensive to deliver manually.

Over that half century computers have got smaller, much more powerful and much, much cheaper. The old IBM 360 computers of 1965 filled a huge air conditioned room and only organisations with deep pockets could afford them. Today there are many more computer chips than people on the planet, many of them smaller than a matchbox and costing just a few dollars. The much reduced prices of hardware and enabling software make automation an increasingly attractive investment, while the quickening pace of change could speed job losses.

Although most companies justify their investments on the basis of forecast cost savings, including manpower reductions, in practice they are notoriously poor at harvesting the benefits they forecast by reorganising and changing job descriptions and skills requirements. Often it is only when a recession bites that they are compelled to trim their operations to stay in business. Then, when there is an upturn in the economy, they find they can expand output without increasing staff.

One of the reasons is that it tends to be individual tasks rather than whole jobs that are automated. About ten years ago it became fashionable for companies to hire expensive business process analysis consultants who would use a mysterious methodology and a model to analyse the internal operations of companies and then recommend a redesign of roles, responsibilities and hierarchy so that the remaining manual tasks were logically reallocated to the staff that remained. I'm not convinced the savings justified the high consultancy fees.

More than seventy years ago British economist John Maynard Keynes expressed concerns about the impact of automation on unemployment levels. He advocated the introduction of a basic income grant and predicted that within a few years people would be working fifteen hour working weeks. Well, that hasn't happened. Nowadays people typically work a thirty five or forty hour week and unemployment in most countries is below 10%.

That said, the International Labour Organization, which keeps a close eye on these things, calculated that global unemployment rose by about 2.3 million people in 2016 to 199.4 million and that at least 1.1 million more will be added to the global count in 2017, taking joblessness to more than 200 million for the first time on record. Of course the world's population would also have risen over those two years and straitened circumstances will have prevented many older workers from retiring and being replaced in the workforce by younger workers.

Now, once again as in Keynes' days, economists are predicting that advances in ever cheaper computer hardware and software could lead to people being displaced much faster than new jobs are created. It won't just be unskilled workers who will be displaced; robots will take over factories, driverless vehicles will transport goods and passengers and artificial intelligence will perform thinking tasks better than professionals with post graduate qualifications.

The World Bank delved into this and calculated that 57% of OECD jobs are susceptible to automation, rising to 67% in South Africa, 69% in India and 77% in China. The reason why developing countries are more susceptible to automation relative to high-income countries is that while many jobs there are automatable, automating them is not yet economically feasible due to the abundance of cheap labour. However, a combination of rapid wage gains and aging populations in large manufacturing-producing countries, especially China, is accelerating demand for automation. Similarly, projects conceived in highly developed environments for less developed places have often failed in the past without sufficient attention to local contexts. This could change as companies develop a better understanding of local automation opportunities.

There's a second problem hidden in all the statistics; the gains from all the automation seem to be going to the management and shareholders of companies and not to the workers not retrenched. In *World without work*, an article in Atlantic Magazine by Derek Thompson, he claims the share of American economic output that's paid out in wages fell steadily in the 1980s, reversed some of its losses in the 1990s, and then continued falling after 2000, accelerating during the Great Recession. It now stands at its lowest level since the government started keeping track in the mid twentieth century. Loukas Karabarounis and Brent Neiman estimated that almost half of the decline is the result of companies replacing workers with computers and software, while other researchers point to many retrenched workers having to take lower paying jobs, often in the hospitality sector.

On the positive side, several forecasts suggest future job opportunities will be created in the information technology, industrial engineering, hospitality and renewable energy sectors. The health sector, too, is predicted to create a large number of job openings.

In the sections that follow I examine some of the technologies which are creating unemployment; describe some expert predictions for the future; and consider some of the consequences. This narrative is informed by the research undertaken by many institutions around the world, as well as my own fifty years' experience in the IT and Internet industries.

Computers and Telecommunications

Back in the early 1960's IBM was the first company to produce a commercial computer. Their 360 and later 370 mainframe models were huge machines that could occupy the whole floor of an office block and required specialised power supply systems and air conditioning units. Large companies which could afford the beasts started by using them to automate accounting and payroll functions. Clerical jobs were lost but at the same time a whole new department, Data Processing, was created in each company complete with managers, systems analysts, programmers, punch card operators and computer operators.

At the same time IBM created a worldwide organisation staffed with salespeople, systems programmers, administrative staff and yet more managers. Before too long the likes of Amdahl, ICL, Fujitsu and Hitachi had entered the mainframe computer market and set up their global networks in competition with IBM. New companies sprang up everywhere providing specialised computer room design services. Although I have never read any numbers, I suspect that by the end of it all there were no net job losses while all of the new jobs paid more than the clerical jobs displaced. The big benefit for companies was that clerical functions were performed faster and more accurately; management now had better and more timely information on which to base decisions.

The early 1970's saw the advent of the minicomputer, a smaller, less expensive machine which did not require the specialised environment demanded by a mainframe computer. As these were deployed we did start to see jobs being lost. Wang and other companies produced dedicated word processing systems which displaced typists; Honeywell, Yokogawa and Siemens led the way with computer based process control systems in oil refineries and factories that enabled smoother operation from a central control room with just a few operators; CAD systems from a range of vendors allowed engineering and architectural practices to produce designs faster, more flexibly and with fewer draftsmen; and smaller companies could now use minicomputers to automate accounting and other functions.

A popular business school case study in the 1980's concerned American Hospital Supplies (AHS) which was one of the first companies to place computer terminals on the premises of their customers so they could enter orders directly without the involvement of AHS's own order taking staff. This gave AHS a competitive advantage because, while the hospitals were happy to use the terminal of a single supplier, they weren't prepared to have a bank of terminals, one for each of their suppliers. As a result AHS not only achieved preferred supplier status but was also able to arrange for products from other vendors to be ordered using their terminals and so earn an additional commission in the process.

However there was a second benefit from the AHS terminals which wasn't highlighted at the time. Whereas before hospitals had mailed or faxed their orders to AHS for entry into their computer systems by AHS order entry clerks, now this role was being outsourced to the customers whose clerks found themselves entering orders into the hospital computer system as well as into the AHS system. So while AHS needed fewer clerical staff, the hospitals needed more. In addition, the hospital staff now had responsibility for the accuracy of the orders placed and the number of queries dropped off. This instance of using terminals to transfer the cost of the order entry function to the customer is one that has grown with the years and proliferated with online ordering and payment through websites.

About the same time banks started to introduce automatic teller machines (ATMs) which, as their name suggests, were specialised terminals which cut the need for bank staff while providing clients with a round the clock banking service. ATMs adopted the same AHS approach of making the customer – unpaid this time - responsible for the data entry. No longer did customers have to visit the branch, fill in forms and stand in a queue to withdraw or deposit money or conduct routine account queries, so they had no grumbles about taking on the task. Of course the bank did now have to employ programmers to run the systems and security guards to transfer money to the ATMs but there was almost certainly a net staff reduction. Today's online banking systems are a continuation of the process of transferring tasks to unpaid customers who don't count in regular employment and GDP statistics.

We like to think that electronic mail and the Internet arrived at the same time. They didn't. IBM with its PROFS system pioneered email within companies. The concept was that instant electronic messages would replace carefully dictated and typed memos, doing away with the need for secretaries and messengers. It probably did. However, keyboard skills were limited and soon every message was

being copied or blind copied to a dozen people who were never on the mailing list for the original paper memo. Today, company employees are overwhelmed by emails, most of which simply distract them from their core functions. As a result they either work overtime to catch up or the company is forced to take on more staff to do real work.

The late 1980's was also the time when smart people woke up to the fact that the systems used in companies were more or less the same from company to company and across industry sectors. Now, instead of hiring a horde of programmers to write bespoke computer code, companies could turn to the likes of SAP or Oracle to buy suites of software to take orders, manage debtors, control inventories, pay creditors and a host of other tasks. The only trouble is that these packages were generalised and not tailored to the specific needs of companies so a lot of time and trouble was involved in implementing these packages and then supporting them once they were live. Again, it's not clear if packaged software really led to significant job losses.

This was also the time when the personal computer first landed on company desks along with software for spreadsheets, word processing and fancy presentations to stun audiences. The PCs were hooked into the company's computer network and also functioned as terminals to access accounting systems and E-mail. While the PC certainly improved decision making, I am not convinced that it led to net job losses in the greater scheme of things.

With the advent of improved international telecommunications services in the 1990's, the AHS model was carried further as companies relocated tasks from the high wage, developed countries to staff or contractors in India, the Philippines and other Asian and African countries. In these cases there was certainly a reduction in costs because of the much lower wages in Asia and Africa, but not necessarily a reduction in manpower other than in the higher wage developed nations. Once again it was the shareholders and management who benefited at the expense of their ex-employees.

In addition to bolstering their own online presences, retail competitors are reacting to the online retailers by cutting costs and staff, including through the introduction of self service checkouts. In reality there's nothing automated about the checkout facilities at all, it's just that the unpaid customers are doing the checking out instead of paid cashiers. I'm not friends with any checkout cashiers even though they give me a friendly hello and a smile before they start spinning my purchases past their scanning machines. However, I'm not sure I'd like their jobs either, sitting or standing all day monotonously waving items from right to left then processing the payment before starting with the next customer. They must have mixed feelings about being retrenched.

According to the census records there are four million cashiers in each of America and Europe whose jobs are at risk. Like the truck drivers, whose jobs are also at risk from driverless vehicles, they don't need tertiary qualifications; a high school leaving certificate more than suffices. Three years ago Walmart, the world's biggest retailer, switched to smaller-format stores as its superstores started losing trade. Early in 2017 the company announced that some 18,000 people out of a global workforce of 2.3 million employees had been laid off. In the United Kingdom, Tesco this year cut 1,200 staff jobs in its head office and 1,100 jobs in its call centre in addition to reducing the numbers of staff in its stores. These are just the job losses that have cropped up in the media.

The same thing is happening in airports where staff numbers have been reduced as travellers check in, print boarding passes and baggage tags and then deliver their suitcases to a conveyor belt. These last two applications – and many others - are made possible by an unassuming but ubiquitous piece of technology, the bar code and its associated reader. Bar codes not only route passenger luggage to the right flight or identify what is being bought but are now used on everything from theatre tickets to international logistics to smooth the flow of people and goods.

Cell Phones

The cell phone arrived in the early 1990's. At first glance it improved productivity as employees, especially those on the road making sales visits or deliveries, were able to communicate by phone or SMS while on the move. No longer did they have to keep an eye open for a convenient public call box. But cell phones aren't just phones – they are also alarm clocks, calculators, torches, cameras, microcomputers with browsers and a whole lot more. Soon they were making a dent in the business of everyone from Swiss watch makers to Japanese camera manufacturers, all of whom had to cut staff.

Obviously they were also a direct threat to the regular telephone companies; no wonder the number of landlines available to a global population of nearly seven billion people peaked at 1.3 billion in 2008 while a United Nations study calculates that more than six billion people now have cellphones, more than have access to a toilet. At the same time the cell phone companies had to build physical networks, appoint sales staff and operate call centres so once again it's moot as to how many jobs have been displaced by cell-phones.

In the beginning cell phones were just used to make calls and send text messages. Nonetheless, these simple features started to be used in the developing world to send SMS reminders to rural patients or provide information and advice to peasant farmers or distant teachers. Banks used them to warn customers when their bank accounts were being accessed and advertisers started to use them to spam potential consumers. In rural India poor farmers benefit from digitally enabled agricultural extension services from Digital Green, an NGO that trains farmers using locally produced how-to videos delivered on smart phones. That's just the tip of the iceberg when it comes to cell phone applications.

Then cell phone companies came up with the brilliant idea of using cell phones as mobile wallets that could be used to make payments and transfer funds between subscribers without the involvement of banks. Already in Kenya more payments are made using cell phones than by credit card using the locally developed M-Pesa payment system which bypasses the formal banking sector. There the cost of sending remittances dropped by up to 90% after the introduction of M-Pesa and among the 53% of adults who reported having sent remittances in the past year, 90% did so using a mobile phone. Google has launched a digital payment app for India, called Tez, which lets users link a phone to their bank account to pay in stores and online. In the USA Apple and Walmart are conducting cell phone wallet warfare. There's no doubt all these applications must be having an impact on banks and the number of staff they employ.

Once smartphones emerged which provided access to the Internet among other fancy new features, new cell phone applications took off. By the end of 2015, there were 226 million smart phones in operation just in Africa with numbers forecast to increase to 720 million by the end of 2020. The cheapest smart phones already only cost US\$ 10 in Africa and Asia so it's not surprising that experts forecast that by 2020, just a couple of years away, four billion people around the world will own a smart phone. The GSM Association does however caution that 1.1 billion people still live in areas with little or no cell-phone coverage.

Smart phones really only came into their own when they were used in conjunction with other technologies that have become available during the past twenty years.

Global Positioning System (GPS)

GPS, which uses satellites and telecommunications to identify the locations of people and things, is another technology that is underrated yet widely used. In North America and Australia, for instance,

farmers have pioneered using GPS systems to steer driverless tractors as they plough or reap huge fields without the need to stop for refreshment, comfort or sleep breaks. In 1870, almost 50% of American employees worked in agriculture, supplying the country's food; today agriculture employs less than 2% of the population and American food production exceeds domestic demand; GPS has driven the numbers even further down.

The security and logistics industries use GPS to track the movement of trucks and cars, ships and containers of goods. In itself, this has not led to significant job losses. However it improves logistics planning and can expedite the bureaucratic processes involved in dispatching and receiving goods.

However, where GPS comes into its own is where it is married with the Internet and cellphones. Google and Michelin were amongst the first to provide digital maps showing not just roads and railway lines, but also buildings and other features of the landscape. Today just about everything has its GPS coordinates nailed down somewhere in the cloud. Drivers everywhere are using the likes of Google Maps, Tom Tom and Waze to navigate optimally through unfamiliar streets with tinny voices telling you whether to turn right or left in a dozen different languages.

Many other Internet applications build on this foundation. Uber, Lyft and other transport systems have cut the cost and improved the convenience of moving people and goods from one place to another more efficiently than a traditional taxi and maybe even the public transport network. The result might not be a change in employment numbers, but the new gig drivers compete with each other to earn the lowest fare for the ride.

Airbnb and similar services are efficient in putting travellers in direct contact with renters of accommodation in the most convenient location. Many landlords service the rooms, apartments and houses themselves rather than employing cleaning staff. As a result in many cities hotels are experiencing a drop in custom, while city residents are up in arms about the lack of accommodation for long term rentals. This is a particular problem for the part timers in the gig economy, service employees, the unemployed and those retrenched, all of whom often have insufficient resources to live in the big city communities they wish to serve.

Internet

The Internet, which we all take for granted today, has really only been widely available for less than twenty five years. In that short time it has disrupted whole industries and ways of life, in the process causing huge numbers of job losses in traditional businesses, while providing the catalyst for the spawning of a host of new entrepreneurial ventures.

The first Internet application to really take off was electronic mail. In the matter of a few years email made secretaries, word processing, telex and fax operators, messengers, mailrooms and many post office staff redundant as principals communicated directly with each other without any intermediaries. However, as the volume of E-mail, often between individuals with poor typing skills, has increased so it consumes more and more employee time. The vast number of spam messages arriving along with unnecessary copies of mail from colleagues has made the situation even worse.

After some initial suspicion on the part of company management, websites also took off creating in the process new professions such as website developers and optimisers. Alas, these new jobs are now fast disappearing as companies use products like Wordpress and Weebly, which allow near web novices to create sophisticated websites.

Search engines are what really gave the Internet a liftoff, allowing users to find the information they needed swiftly, accurately – and free. Rather than retaining consultants or buying research reports,

companies starting using their own staff, often with limited research experience, to search the web and produce competitor analyses and country and industry sector reports. Unfortunately there's not much evidence out there of mistaken decisions made by executives relying on these dubious reports but that could be due to embarrassment rather than anything else. However it certainly made a dent in the professional research and publishing arena.

Newspapers faced a different problem as they went online. On the one hand Google and Facebook now gobble up more than 75% of the advertising revenues that traditionally went to the newspapers and magazines, while on the other hand Internet users increasingly go online for their latest free news fix. Millions now rely on Facebook and Google for news even though neither employs real, live journalists. When newspaper publishers implemented paywalls, readers simply went elsewhere for their news. Young people, particularly, no longer take out subscriptions to paper publications but rely on online news and messaging systems. Another problem is that, though online advertising delivered by the likes of Google's AdSense can be targeted very precisely, advertisers were not prepared to pay anything near the same for online advertising as they did for newspapers and, especially, TV. Ad agencies are also taking a beating as companies go online and place their own adverts on websites using AdSense without needing the creative genius of the agencies.

Newspapers responded by cutting costs and staff, as well as the size of their paper publications. In 2002, over 700,000 Americans worked in the newspaper, book and directory publishing business. With the rise of the Internet, employment in this sector of the economy had dropped to just 450,000 by 2012. The US Labor Department expects further job losses and paper publishing is predicted to employ just under 350,000 people by 2022. Meanwhile Google has digitised millions of books and made them available online.

People with the words "agent" or "broker" in their titles were early casualties of the Internet. The number of US travel agents has more than halved since 1990. Travellers were able to book flights and accommodation online, investors could buy and sell stocks and bonds without involving a stock broker, sellers could sell real estate directly to buyers without an agent and those at risk could shop around for insurance. Before too long websites like TripAdvisor, Expedia and Kayak popped up, taking the whole travel booking process to a new level of ease by shopping around behind the scenes for the best flight and hotel deals. Now the hotel groups are trying to fight back by only selling rooms through their own websites. Job websites such as LinkedIn allow employers and potential employees to meet online cutting out human resource consultants while yet other websites allow properties to be sold without the assistance of realtors.

The AHS model transferred nicely to the Internet. Internet shopping took off as consumers learned how to use second generation websites where they could enter orders and make online payments. As a result, physical malls are starting to fall out of fashion as companies replace physical stores with warehouses. Jobs lost in stores and malls are increasingly being replaced by jobs associated with picking and delivering the goods ordered by consumers. The airlines took the online purchasing process a stage further allowing passengers to not only book flights through the web but also check in and print their own boarding passes before coming to the airport.

Across in China, Alibaba allows companies to create virtual stores in a vast virtual mall. Amazon, with only 34,400 staff but planning to take on another 100,000 by end 2018, is now one of America's biggest companies as it expands from selling books and music to delivering fresh food and producing its own movies. Niche or copycat retail websites have sprung up around the world. In South Africa, for instance, Takealot and Loot lead the way, while companies like Netflorist have commandeered specialist markets. Everywhere bricks and mortar malls and stores are seeing closures and a drop in traffic as consumers go online to hunt for bargains, with the added convenience of speedy delivery. I

regularly find myself shaking my head as I pass yet another giant mall under construction; don't those investors know what's coming?

It's not just malls that are under attack; office buildings are in the sights of the telecommuters who avoid the rush hour by working from home. It's a habit that hasn't caught on as it should, mostly because managers are so used to seeing employees clocking in and out that they've forgotten that the important thing is to monitor what their staff produce. However as the gig economy takes hold and companies outsource discreet tasks, rather than whole jobs, to individual specialists the end result should be fewer commuters and smaller offices. If the commuting time savings are shared between employers and employees, then obviously employers will need fewer staff – and rental office space.

Banks have been early and eager adopters of digital technologies, but many of the major innovations, such as online payments, mobile money, and digital currencies, have come from nonbank institutions, with some innovations originating in developing countries, where they overcame shortcomings in traditional financial systems. South Africa's banks were early adopters of the Internet. All the consumer banks allow clients to log on securely, manage their accounts and make payments. As with the ATM, they are able to provide 24 hour banking services with a fraction of the staff. To put some numbers on the impact, in 2016 British banks closed 583 branches and in 2017 they plan to close 762 more. More than 10,000 American bank branches have been closed since the 2008 financial crisis. Now a second generation of Internet banking groups with neither people-staffed branches nor ATMs is starting to emerge, offering services at lower costs and with better interest rates than the staid traditionalists.

Skype and other videoconferencing applications not only allow grandparents to develop relationships with grandchildren living in distant climes, they also provide the means for business partners, often located in three or more locales at the same time, to communicate effectively without the need to travel for face to face meetings. As governments start to implement carbon taxes on the airline and automotive industries, so the justification for leaving the office for meetings will decline further. Time previously wasted travelling or sitting in airport lounges can now be spent on productive tasks; how many companies have calculated how many staff they could cut using Skype? And how much confidential company information has been inadvertently leaked through overheard cell phone conversations in crowded travel facilities?

Internet communities called "crowds" are now forming to jointly provide funding, solve problems or find someone to perform an errand or a task in yet another variation of the AHS theme. These are now being used by everyone from entrepreneurs seeking finance to companies wanting service providers or just someone needing a friendly dogsitter. They are playing an increasingly important role in the gig economy. In one country the crowd, unpaid as ever, was used to identify ghost civil servants by checking a list of supposed employees on the government website while Stall Catcher is using crowd game playing to assist with Alzheimer's research.

Apart from the growing legion of people delivering goods ordered online or installing cables, are there any other corners of the Internet that might be job creators rather than destroyers? The film industry might be one as video streaming takes on television and the movie theatres. Today we have Netflix and Amazon developing their own content to compete with that of Disney.

So far I have not mentioned Facebook, Twitter, Instagram, Snapchat, Spotify or any of the other popular social media platforms since I have no evidence they assist in making operations less manpower intensive. In fact, apart from providing marketing channels of dubious provenance, their role has been more one of distracting employees from the task in hand. As unemployment ramps up everywhere, though, the social media, along with the likes of YouTube, Netflix and Amazon, will provide a valuable service distracting the indigent from their plight.

I have also refrained from mentioning virtual reality, digital currencies and blockchain technologies. Radical though they might be, it's not clear what impact they are likely to have on the employment position.

3D Printing

3D Printing, where a specialised printer is able to create metal, plastic and other objects directly from design drawings, is also starting to emerge from the shadows. Already companies are using the technology for a wide range of applications. Transport related companies can print aircraft or automobile spare parts on demand rather than keep them in stock, while major footwear companies allow customers to 3D scan their feet and use the printer to make a perfectly fitting shoe. The Robot Bike Company is using 3D printing to build mountain bikes specifically tailored to individual riders.

Meanwhile doctors are using 3D printing to create artificial limbs or make images of internal organs that need to be operated on while Nature Communications reports that a group at Columbia University have used 3D printing to make artificial muscles fifteen times as powerful as human muscle that could potentially be used in robots. In Holland a concrete bridge for use by cyclists has been 3D printed and in China, they have gone much bigger and 3D-printed a complete 6-storey office building. On the same day as the mass shooting in Las Vegas, someone posted instructions on the Internet on how to use 3D printing to make a rifle. These examples are just the tip of the iceberg; the number of examples of 3D printing is endless.

The price of the cheapest 3D printer has already dropped from US\$18,000 to US\$ 400 within 10 years, while in the same period becoming 100 times faster. By 2027, it's predicted that 10% of everything being produced will be 3D-printed. Bosch Rexroth, the drive and control unit of the private German electronics group, projects that in five to 10 years up to 40% of the manufacturing equipment it uses could be printed instead of purchased. In every case the printer is performing tasks that were previously performed by skilled craftsmen.

A number of consultants have published their forecasts for 3D printing. Gartner, for instance, predicts that the number of 3D printers produced globally will increase from 0.22 million in 2015 to 6.7 million in 2020, a huge increase in a very short space of time. Another consultancy, Smithers Pira, estimates that the size of the 3D Printing market will grow from US\$ 5.9 billion in 2015 to US\$ 49.1 billion in 2025 while McKinsey Global Institute research suggests that 3D printing could have an impact of up to US \$ 550 billion a year by 2025.

Looking at the future from a different perspective, EY forecasts that the biggest potential uses of 3D printing are likely to be in the automotive, medical, aerospace and defence, and mechanical and plant engineering sectors so this is where the job losses are most likely to take place. According to yet another specialised research group, Sculpteo, Germany is the biggest user of 3D printers.

By the end of 2017, new smart phones are expected to have 3D scanning possibilities. This will allow users to simply take 3D photographs of an object in order to create the blueprint for a 3D printer to recreate the object. With the prices of 3D printers dropping to levels consumers can afford, home 3D printing could take off as a new hobby.

Citibank clients surveyed believe automation and the developments in 3D printing will encourage companies to move their manufacturing closer to home. North America is seen as having the most to gain from this trend, while China and other previously low cost manufacturing countries have the most to lose. Eventually 3D printing could just be another variant of the AHS example as customers take on

the manufacturing process using their own 3D printers which are simply sophisticated terminals linked to the computers of the owners of the designs.

Unfortunately none of these studies estimates how many jobs are going to be shed as companies and consumers alike start using 3D printers. However, if the Gartner numbers are to be believed, millions of jobs could be lost worldwide. All in all, the big losers are going to be the fitters and turners who manned the lathes and those involved in making metal and plastic objects – and even building houses!

Robotics

Robots are machines that perform physical human work, day in and day out, around the clock and with no need for a break. They don't take vacations and they can't become union members. They can also perform a wide range of tasks - clean floors, mine a coal seam, defuse bombs, drive tanks and a whole lot more. Search the Internet and you'll find any number of stories about how robots are replacing or working alongside human beings.

Technological advances have increased the scope and usability of robotics, not only making robots smarter, safer and more applicable across a broader range of processes, but also delivering more consistent and better product quality. Meanwhile, of course, human capabilities have not improved.

It's in the area of manufacturing that robots have really taken off. The website of the International Federation of Robotics provides extensive details of the deployment of robots. The number of industrial robots in operation at the end of 2015 was about 1.6 million units. Global sales of industrial robots in 2016 were 294,312 units, 16% up on 2015. The world market in 2016 was worth US\$ 13.1 billion or an estimated US\$ 40 billion including software, peripherals and systems engineering. Sales to the electrical and electronics industry alone jumped 41% to 91,300 units. These are all very big numbers for something that is still in its infancy.

Traditionally the automotive industry has been at the forefront of using robots to make cars and trucks. Another report estimated vehicle factories deployed about 38% of existing industrial robots in 2015. Between 2010 and 2015, robot sales to the automotive industry increased by 20% on average per year but only rose 6% to 103,300 units in 2016 as demand was sated.

Chinese manufacturers bought 66,000 of the 240,000 robots sold globally in 2015 and China now has 36 robots per 10,000 manufacturing workers. This is even though wages there are lower than in the other big manufacturing economies making them more difficult to justify. By comparison, Germany has more than 300, Japan 314 and South Korea 478 robots per 10,000 workers. An August 2017 paper from the Brookings Institute showed that most US robots are installed in the rustbelt Midwest industrial area just south of the Great Lakes with one community boasting more than 15,000 robots in total and another more than 200 robots per 10,000 workers. More than half of America's 233,305 industrial robots are burning welds, painting cars, assembling products, handling materials, or packaging things. Detroit alone has 15,000 robots, 85 per 10,000 workers. In many areas the number of robots has grown by more than 20% per year since 2010.

It's not just in factories that robots are displacing humans. Last year I visited a Scottish dairy farm where, in the morning and the evening, the cows, unaided, made their way into the barn, entered a stall and allowed themselves to be milked by a machine; meanwhile the farmer was cosily ensconced in his study, watching the process on video out of the corner of his eye. In Japan, some hotels already use robots for check-in and to guide guests to their rooms; these robotic receptionists can also speak different languages depending on the preferences of the guest. Robotic floor cleaners now routinely clean the floors of homes, hotels, warehouses, barns and factories.

Amazon continues to take retail market share, at the same time automating the processes within the giant warehouses that it has established worldwide. In 2012 Amazon acquired *Kiva Systems*, now *Amazon Robotics*, and by August 2017 employed some 80,000 Kiva robots in its fulfilment centres, up from 1,400 at the end of 2013. In total it is estimated that in 2015 over 780,000 people in the US were employed in warehousing and storage centres; as companies copy Amazon, many of their jobs could be at risk.

The global market for robotics is growing far faster than expected and is projected to reach US\$ 87 billion by 2025, according to a June 2017 report by The Boston Consulting Group. The price of industrial robots and associated software will drop by 20% per year while performance will increase 5%. From 2014 to 2015, private investment in the robotics space tripled as a result of falling prices, rapidly advancing capabilities, and components usable in a far wider range of industries and applications than many observers had originally envisioned.

The number of companies producing robots continues to grow. Since 2012, 40% of new robotics companies have emerged in the consumer sector, outpacing growth in the military, commercial, and industrial sectors. The military sector has accounted for 26% of new robotics companies, the commercial sector 24%, and the industrial sector just 10%.

Robot installations are forecast to increase by at least 18% in 2017 and by at least 15% annually between 2018 and 2020. Medium term drivers of demand are seen to be the industrial internet that links real-life factories with virtual reality, collaborative robots that can work alongside humans, and machine learning and artificial intelligence.

In 2016, the World Economic Forum released a report warning that the rise of robots will lead to a net loss of over 5 million jobs in 15 major developed and emerging economies by 2020. More than 10 million United Kingdom workers are at high risk of being replaced by robots within 15 years as the automation of routine tasks gathers pace. As the cost of robots, artificial intelligence (AI) and other automation decrease over time, so other area of work are going to become vulnerable to automation. Additional research by Citibank and the Oxford Martin School titled *Technology at work: V2.0*, concluded that payback periods for some industrial robots would reduce to 1.2 and 2.6 years in China and Thailand respectively as early as 2017, an ominous sign for South Africa, Vietnam, Morocco and other countries with relatively cheap labour.

The Brookings Institute report predicted that automation would boost productivity and create fresh job opportunities, but it said action was needed to prevent the widening of inequality that would result from robots increasingly being used for low-skill tasks with more highly paid graduate industrial engineers managing groups of robots.

Expert Systems and Artificial Intelligence (AI)

Robots are designed to perform physical tasks; expert systems and AI applications are designed to take on mental tasks. Expert systems use rules developed by humans while AI systems develop their own rules as they learn from examples and from experience. In due course we will see the rise of intelligent robots which combine the strengths of AI and robots. In my previous chapter on massive data storage, I cited some examples of how AI is being used to swiftly comb massive databases and reach conclusions. Here are some other examples.

More than ten years ago one of the big accounting firms targeted smaller enterprises in the USA offering to answer all their tax queries for a small fee. The consultants taking the calls recorded all the queries in a database. In due course the clients found themselves communicating with an expert

system, which had analysed all the queries, rather than the consultants. Banks and other financial institutions have adopted a similar approach with their call centres.

Chatbots which can conduct human like conversations have been implemented in call centres for several years. Now, as their speech recognition capabilities have improved, so they have started being used in everything from medical diagnosis to conducting educational tutorials. Pundits predict that in due course they could be used in counselling and comforting as they take on more caring human characteristics. Juniper Research estimates that worldwide savings from using AI based chatbots will increase from US\$ 2.8 million in 2017 to \$3.6 billion in 2022, with China being the largest user.

Back in the hard world of business, the big four accounting firms are investing heavily in AI to undertake audits, forensic investigations and deals. Instead of simply examining samples of transactions as human auditors do today in audits, an AI auditor would be able to consider every single transaction in the client's accounting system and bank statements in a matter of minutes and spit out a report showing irregular, money laundering, fraudulent and other suspicious transactions. Highly precise audits of large companies will now take days instead of weeks, involve just a couple of auditors and, hopefully, cost a fraction of the fee. And what will be the impact on small accounting practices who can't afford to invest in AI?

Accountants and auditors aren't the only professionals under threat from AI. Ross Intelligence reported that with IBM Watson, an AI package, you can get basic legal advice within seconds, with 90% accuracy compared with 70% accuracy when done by humans. In other professions, Watson already helps nurses diagnose cancer four times more accurately than human nurses while Fukoku Mutual Life Insurance is making 34 risk assessors redundant and replacing them with IBM's Watson Explorer AI.

There are numerous other areas where AI will be implemented. Computers now write simple sport and financial stories but as technology improves, AI will write more complex stories. Because of the huge body of translated text that is now available on the Internet, language translation software is able to pore over what is there in order to provide ever improved translations. Citibank and the Oxford Martin School titled *Technology at work: V2.0* report predicts algorithms that can recommend savings and investment products to someone in the same way a financial advisor would.

Work Fusion has designed software to automate non-routine office tasks. The software essentially slices the job into smaller tasks, automates the routine ones and uses crowdsourcing to find freelancers to perform the non-routine work. As the software monitors the workers it learns from them, meaning that over time it can automate more of the non-routine tasks. Thus the freelance workers train the system to replace them.

AI image recognition software has improved from a 26% error rate in 2011 to 3.5% in 2015, better than a human with a 5% error rate. Facebook has pattern recognition software that can recognize faces better than humans and new smart phones now deploy AI based facial recognition software. As a result image recognition is now starting to be deployed as part of security systems. Germany, for instance, is trialling using face recognition software in cameras installed in railway stations.

Software from China's Face++ is being used for identity purposes when transferring money through Alipay, a mobile payment app used by more than 120 million people in China, while Didi, China's dominant ride-hailing company, uses the Face++ software to let passengers confirm that the person behind the wheel is a legitimate driver. Chinese search engine Baidu is developing a system that lets people pick up rail and other tickets by showing their face. According to research from Italy's

University of Bari, similar AI-based pattern recognition systems can identify Alzheimers in brain scans ten years before symptoms show.

An analysis by pwc found that 30% of jobs in Britain were potentially under threat from breakthroughs in AI and in some sectors half the jobs could go. Some 2.25 million jobs were at high risk in wholesale and retailing, 1.2 million in manufacturing, 1.1 million in administrative and support services and 950,000 in transport and storage. Education and health and social care were the two sectors seen as least threatened by robots and AI because of the high proportion of tasks seen as hard to automate.

The biggest impact would be on workers who had left school with GCSEs or lower. Because women tend to work in sectors that require a higher level of education and social skills, pwc said they would be less in jeopardy of losing their jobs than men, who were more likely to work in sectors such as manufacturing and transportation; 35% of male jobs were identified as being at high risk against 26% of female jobs.

While the USA is probably the current leader in AI research, China has announced plans to create an AI industry worth US\$ 150 billion and make China the global leader by 2030, by which stage computers could become more intelligent than humans.

Impact on Jobs

Every week more companies report job cuts. The banks are cutting tens of thousands, IBM announced forty nine thousand and Caterpillar ten thousand more. No doubt the big accounting practices will respond to the huge lawsuits they face by further automating the audit process and reducing the numbers of audit clerks they need. And so it goes, relentlessly, with production and profits rising even as the number of people employed reduces.

Andrew McAfee, Erik Brynjolfsson, Martin Ford and others have published a range of books and articles predicting that the next two decades will see as many as 70% of today's jobs being done by intelligent robots of one form or another. Some of those analyses, which unfortunately focus on America and Europe mostly, are summarised here to give you a flavour for the extent of the job carnage we might expect around the world.

It's useful to start by looking back in time to what has been happening in America in recent years. Since 2000, the number of American manufacturing jobs has fallen by almost 5 million, or about 30%. For instance America produces as much steel as it ever has, but with 75% fewer workers. A study from Indiana's Ball State University estimates 88% of lost American factory jobs disappeared because of automation, not trade agreements. In 1964, America's most valuable company, AT&T, was worth US\$ 267 billion in today's dollars and employed 758,611 people; today another technology company, Google, is worth US\$ 370 billion but has only about 55,000 employees.

The share of working age Americans who are actually working has been declining since 2000. Among men, the decline began even earlier: The percentage of working age men who are neither working nor looking for work has doubled since the late 1970s, and has increased as much throughout the recovery as it did during the Great Recession itself. About one in six working age American men today are either unemployed or out of the workforce altogether. For some reason this statistic does not show up in the monthly unemployment numbers published by the government.

Since 2007, 140,000 traditional retail jobs have vanished in America, while electronic retail created 126,000. However, the Progressive Policy Institute claims that including the fulfilment centre jobs created by electronic commerce boosts that figure to 400,000, far outweighing the losses. The jobs

also pay 31% more than conventional retail. This is the only positive sign coming out of the studies I have read. This contentious area clearly needs more research.

Turning to the present, OECD researchers make the important emphasis that automation targets tasks rather than occupations, which are particular combinations of tasks. Many occupations are likely to change as some of their associated tasks become automatable. Less educated workers are more likely to be replaced by automation than highly educated ones, with 44% of American workers with less than a high school degree holding jobs made up of highly-automatable tasks while 1% of people with a bachelor's degree or higher hold such a job. This implies a large decline in demand for lower-skilled workers and little decline in demand for higher-skilled workers. However this is contradicted by a statement that a talent mismatch already exists in many countries, with many well-educated workers taking employment in lower-skilled jobs; perhaps this points to an over abundance of university graduates being produced with no prospect of finding jobs commensurate with their education levels?

CSIRO's analysis of the Australian job market used a particularly comprehensive methodology. Their Data61 report describes how consultants AlphaBeta analysed how Australians spent a total of 20 billion work hours each year, assigning each of those hours to one of more than 2,000 different work tasks and then asking how a worker's time on tasks could change over the next 15 years. Of Australia's twelve million workers, about one third, including construction workers and machine operators, spend an average 70% of their time on automatable tasks. The tasks most likely to be automated are typically the most dangerous, least enjoyable and often lowest paid. Giving them to robots or AI could lead to an 11% fall in workplace injuries, a 20% rise in wages for workers who are redeployed to non-automatable tasks, and an increase in job satisfaction for 62% of low-skill workers as they focus on more creative and interpersonal activities. Over the last 25 years, one in 10 unskilled Australian men who lost their job never worked again. Today, 40% of unskilled men don't participate in the labour market. These figures have found an echo elsewhere in the world.

A study by researchers at Oxford University and Deloitte predicts that 95% of accountant jobs are likely to be automated by 2020. In Australia that's 183,900 accountants that could disappear. All in all, the Committee for Economic Development of Australia predicts that five million Australian jobs which exist today are likely to disappear before 2025.

It's not just in developed countries like Australia where professional jobs are at risk. From Bangalore, Snigha Poonan reported in the Financial Times that 200,000 Indian IT jobs are expected to disappear each year to 2020. This was echoed by IT sector researchers HfS Research who predicted losses of 480,000 IT jobs in India by 2021. Indian business newspaper *Mint* estimated that the country's top seven IT companies will retrench nearly 60,000 employees this year. One of them, Infosys, reported that 11,000 of its 200,000 employees had been "released" from repetitive tasks by automation.

In 2013, Oxford University researchers forecast that machines might be able to perform half of all US jobs in the next two decades. The most-common occupations in the United States are retail salesperson, cashier, food and beverage server and office clerk. Together, these four jobs employ 15.4 million people or nearly 10% of the labour force. Each is highly susceptible to automation.

Returning to the research by Citibank and the Oxford Martin School titled *Technology at work: V2.0*, their analysis concluded that 35% of jobs in the United Kingdom are at risk of being replaced by automation, 47% of US jobs are at risk, and across the OECD as a whole an average of 57% of jobs are at risk. In China, the risk of automation is as high as 77%. Most of the jobs at risk are low-skilled service jobs like call centres or in manufacturing industries but increasingly skilled jobs are at risk of being replaced.

Carl Frey and Michael Osborne in their research also predicted 47% of US jobs could be at risk from automation. Some 83% of jobs paying less than \$20 per hour would come under pressure from automation, as compared to 31% of jobs making between \$20 and \$40 per hour and only 4% of jobs making above \$40 per hour. The Boston Consulting Group estimates that a quarter of jobs will be replaced by smart software or robots by 2025 while the Bank of America Merrill Lynch predicts 47% of American jobs could be automated by as soon as 2020, just three years away. Looking at the problem from a different angle, October 2017 research from MIT's Media Lab predicts which American cities are most likely to be impacted by new technologies; on the whole large cities will fare better than small.

Back across the Atlantic, Britain's Local Government Association predicts that by 2022 the United Kingdom will see 9.2 million low-skilled people chasing a mere 3.7 million low-skilled jobs. The British Retail Consortium, whose members employ three million workers, a sixth of the British workforce, predicts that 900,000 of them will be made redundant in the next decade, with smaller businesses and those in poorer areas worst affected.

I'm not a great fan of research that is conducted by surveying what people think rather than analysing the numbers. Nonetheless, a YouGov poll for the Royal Society of the Arts predicted a 15% loss of British jobs by 2027 with most losses taking place in finance, manufacturing and transportation. Education and healthcare were least likely to be affected. This is an indication of what company management expects if nothing else.

One result of the automation taking place is the creation of the "gig" economy where individual tasks are outsourced to freelancers or part time contractors who endure a precarious existence and whose work often doesn't reflect in official employment statistics. Currently 53 million Americans work as freelancers, approximately 34% of the workforce. Of these freelancers, 40% are independent contractors, 27% are moonlighters and 18% are people with multiple sources of income. More people are pursuing higher education, but the real wages of recent college graduates have fallen by 7.7% since 2000. In the United Kingdom there has also been a sharp increase in self-employment, accounting for two-thirds of the job growth since 2008. Self-employed individuals now account for one in seven of the British workforce.

It's not clear if governments anywhere are prepared for the huge wave of redundancies that could sweep the globe over the next decade. Research by Politico shows people and companies in Northern Europe are, on average, better prepared and enjoy greater access to online services than their Southern counterparts, according to reams of statistics from the EU, national government agencies and a long list of public policy think tanks. In the United States the government is looking to cut rather than extend support programs.

These dire forecasts all relate to computers taking the place of people in the workplace. They don't consider the secondary effects of people being retrenched. Without salaries and wages, the retrenched workers will not be able to afford their previous lifestyles. As a result the retail sector is going to be severely hit along with the manufacturers of consumer products.

Medicine

Along with the technology, renewable energy and travel and hospitality sectors, health is an industry where jobs are expected to grow in the years ahead despite the examples of medical automation I have already listed. Factors driving this growth include growing populations; increasing life expectancy; more chronic conditions; improvements in medicine and technology; and more people getting health care insurance.

According to the World Health Organization there is currently a global health workforce shortage estimated at 7.2 million professionals, forecast to increase to 12.9 million people by 2035. In the EU it is estimated that the health care sector accounts for about 17 million of all jobs and is predicted to continue growing with an estimate of 8 million new openings between 2010 and 2020. The health systems in most EU Member States are also coming under pressure as a result of people living longer, while its health workforce itself is aging. The European Commission projects a shortage of around one million health professionals in the EU in 2020 (590,000 nurses, 230,000 medical doctors and 150,000 dentists, pharmacists and physiotherapists), if no measures are taken to encourage people to work in this sector.

A report from the US presidency states that the American health sector is expected to add more than 4 million new jobs between 2012 and 2022. Health care job openings in the US increased by 23% from September 2014 to September 2015, reaching 852,200 job openings. It is predicted that there will be a shortage of at least 124,000 physicians and 500,000 nurses by 2025. Meanwhile the British National Health Service is reported to be losing 400 GPs per month for one reason and another.

Technology is going to play a key role in filling the skills gap and cutting the cost of healthcare. IBM's Watson computer now provides automated chronic care and cancer treatment diagnostics, drawing upon reams of data that a doctor would not be able to process, including information from more than 1.5 million American patient records and clinical trials, as well as two million pages of text from medical journals.

Juniper Research interviewed key players in the medical sector and prepared a report entitled *Digital Health: Vendor Analysis, Emerging Technologies & Market Forecasts 2017-2022* which forecast widespread use of AI in the medical industry including widespread use of chatbots and computer aided diagnostic (CAD) systems which could process more than 28 million scans a year by 2022.

Surgical robots have become significantly more flexible and with a greater range of motion now perform more operations. Furthermore they can often be operated remotely with the surgeon distant from the operating theatre. Commercial service robots are now able to perform more complex tasks in elderly care, food preparation, and cleaning. In addition cellphone accessories allow continual health monitoring.

In the developing world it has been found that regular SMS communication can induce positive behaviour changes in expectant mothers by providing information on neonatal health. It can also ensure out patients take their medication. These are examples of technology performing tasks too expensive to deliver manually.

Education

Automation provides three major challenges for the education sector: providing the high level skills needed in the new automated economy; retraining those who lose their jobs; and providing appropriate education for young people who will never work.

The challenge to provide decent work to young people is a concern for both industrialised and developing countries. Of the estimated 197 million unemployed people worldwide in 2012, nearly 40% were between 15 and 24 years of age. The global economy would need to create 600 million productive jobs over the next decade in order to absorb the current unemployment levels and to provide employment opportunities to the 40 million labour market entrants each year. That's a very tall order.

Paradoxically while the world's workforce is growing apace, education systems are failing to provide enough skilled professionals, artisans and managers to meet demand, particularly for the IT, mining, energy, construction and education sectors. McKinsey estimate that by 2020, there will likely be a shortage globally of forty million highly skilled workers unless adequate training and education is given. Technological innovation will demand a new set of skills in the workforce; it will change work tasks, automate jobs and also increase the skills gap for the jobs that remain.

In 2015 Cedefop estimate that of the 107 million job opportunities in the EU projected from 2013 to 2025, about 46 million will be for jobs requiring high level qualifications, 43 million for medium level qualifications and just 10 million for low or no level qualifications. In terms of absolute numbers, in 2025 the proportion of employed people with high, medium and low qualifications is forecast to be 39%, 44%, and 15%, respectively.

The US shows a similar picture with occupations that typically require a Master's degree for entry predicted to grow the fastest (18.4%) from 2012 to 2022; however the majority of the job openings from 2012 to 2022 are projected to be in occupations that typically can be entered with a high school diploma (4.6 million jobs). These occupations include retail salespersons, combined food preparation and serving workers, and secretaries and administration assistants. Many of these are jobs at risk from automation anyway.

Looking at another important aspect of education and training, CSIRO's Data61 report concludes that Australia has a bad record at successfully transitioning workers out of industries in decline and into new roles. That's the biggest threat, not just in Australia, but everywhere.

College and career ready skills in math, reading, computer science, and critical thinking are likely to be among the factors in helping workers successfully navigate through unpredictable changes in the future labour market. Providing the opportunity to obtain those skills will be a critical component of preparing children for success in the future.

Everywhere education is taking a beating as governments cut funding while at the same time increasing the administrative workload. More and more universities are adopting the gig economy approach of increasingly using part time temporary staff and MOOCs. Several British newspapers have highlighted that 50% of vacant United Kingdom teaching posts in 2016 were filled with unqualified staff according to the National Audit Office. If that's not bad enough, according to a survey by Jermaine Ravalier, 50% of United Kingdom teachers plan to leave the profession in the next 18 months. All in all I am not confident that education systems anywhere are poised to prepare us for the future.

Today's devices no longer require that users can read and type; as a result it is much easier for very young children to master computer devices as part of their early learning. AI, chatbots, MOOCs and other technology based tools have been touted as the solution to providing students with skills for the future workplace environment. Experience has shown this can only work when the tools are complemented by teachers who understand and use the technology on a regular basis and so can facilitate the learning process.

The SMS Story project demonstrates that it is possible to orient and motivate teachers in useful ways using technologies already at hand. Daily text message stories and teaching tips are sent by SMS to teachers as an aid to help improve student reading. In Uganda, absenteeism was reduced by combining teacher incentive pay with monitoring technology.

There's another important issue that has not been addressed – how much education should be given to people who will never hold down a job in their lives, yet need to be responsible citizens. Education is expensive and takes a significant chunk of national budgets.

On the other hand, lifelong self-education is one way that unemployed persons could fill their free time. Which brings us on to the next topic...

Use of Leisure Time

Back in the nineteenth century the Luddite workers recognised and attacked the machines in the mills that were taking their jobs. Today governments everywhere promise more employment fuelled growth without having a clue how to achieve it. And their economically vulnerable citizenry flail at globalisation, trade treaties, regulations, the rich, immigrants and low cost Asian labour as they seek a target for their anger at job losses and stagnant wages. When they vote, they increasingly vote for populist, nationalist politicians promising to pull up the drawbridge of international cooperation and return to the security of the local past - even though many of the politicians know in their heart of hearts that this is impossible as the future unfolds inexorably.

The big problem with all of this is that, by and large, companies don't care all that much about the workers they retrench. They just want to make more profits. Many governments also don't care; they think people are unemployed because they are lazy and don't want to work. So companies are going to be able to profit handsomely until the politicians wake up to the fact they could be swept out of office by a swarm of voters who have a vote but little else. Then there will be a scramble to close the stable door after the horse has long escaped with the loot.

I think it's time for a paradigm shift. Instead of discouraging unemployment, we need to encourage it so people can lead more meaningful lives doing what they want to do rather than what they have to do. Organisations should be incentivised to automate and retrench as fast as they can. Governments should institute a universal grant paid to every adult in the country. It must be enough to live on comfortably. Employers would then be able to pay employees much less without reducing their standard of living and a combination of corporate, employee and wealth taxes would pay for the grants.

Last year I stumbled across the results of a survey in which just 34% of the respondents claimed they enjoyed their jobs. Seemingly the other 66% dragged themselves to work, put in the requisite number of hours and then rushed home. As I recall, the survey took place in either North America or Europe so didn't include all the Chinese factory workers, third world farmers or deep level miners sweating away or the negative percentage could have been much higher. No doubt they all work because they need the income in order to be able to eat, have a cell-phone and generally stay alive. The survey made no mention of what the disillusioned would rather do, whether play golf, romp with the kids, pursue home crafts or simply add yet more trivia to their Facebook pages.

In his book *Sapiens*, Yuval Noah Harari claims that Homo Sapiens made their worst, irreversible mistake when they changed from hunter-gatherers to agriculturalists. Evidently early man lived in bands fifty to a hundred strong comprising everyone from babies to greybeards who all knew each other intimately. Gathering and hunting occupied a couple of hours a day and then they could just sit in the sun and chill with their mates, as my kids would say. I have visions of them sitting round a fire slurping fermented berries and laughing uproariously at the notion that one day a descendent could spend his whole adult life in a suit travelling to and from a cell where he languished miserably all day – what could be more posterous!

Back in the first half of the twentieth century Keynes was predicting a future where people would have much more leisure time; however his ideas were overruled in the Bretton Woods discussions at the end of the Second World War and unemployment became a dirty word. Many nineteenth century novels – take Jane Eyre or War and Peace for instance – extolled and described an idyllic world where no one seemed to work. In fact members of the merchant class were decidedly second rate while people who worked with their hands were rarely mentioned. Maybe we need to redevelop that leisurely way of life, rising late, extended lunches or exotic picnics and dancing till dawn – so much nicer than the drudge of working unnecessarily when a robot could take your place!

Some people displaced from the formal workforce will devote their freedom to simple leisure; some will seek to build productive communities outside the workplace; and others will fight, passionately and in many cases fruitlessly, to reclaim their lost income by piecing together jobs in an informal economy. Lonely TV / Internet watching couch potatoes will become prevalent. In an article in the Guardian newspaper, Harari postulates that people would devote their free time to religious matters.

Research by Citibank and the Oxford Martin School speculates that there is a risk increased leisure time may only become a reality for the under-employed or unemployed with the still employed working longer hours with fewer holidays. Technology encourages part-time work. The decline of work will create empty office buildings which could be incubators. The German government gives firms incentives to cut all their workers' hours rather than lay off some of them during hard times. Between 1950 and 2012, annual hours worked per worker fell significantly throughout Europe - by about 40% in Germany and the Netherlands, but by only 10% in the United States.

Government

All these issues are placing pressure on private and state social security systems. As a result, national budget deficits are likely to worsen and could lead to default as politicians fail to face up to proper funding of future liabilities for fear of electoral defeat or even social unrest, already on the rise in countries with high unemployment levels. In Tunisia, where the overall unemployment rate is 15.3% and youth unemployment much higher, there were riots by people demanding jobs. The country has 700,000 unemployed, including 250,000 young people with university degrees.

Governments also have to strike a balance between providing efficient services and being a major employer. Where unemployment levels are low, governments can focus on automating and streamlining processes. When unemployment rises government bureaucracies can become bloated in an attempt to keep the unemployment statistics low. However no government can afford to do this indefinitely and in the end they need to start using technology to outsource government tasks to unpaid citizens in the same manner as AHS.

In India and Indonesia, e-procurement increased competition by making information on government contracts widely available and by encouraging more firms, particularly those outside the region where the project was located, to bid. The Chinese government has modified its policy of censoring the Internet, particularly the internal social media networks, and now has officials following up on social media complaints about corrupt officials and poor service delivery.

A UN report states that efficient service delivery requires a capable government that can implement policies and spend public resources effectively. It also requires an empowered citizenry able to hold politicians and policy makers to account so that governments serve citizens and not themselves or a narrow set of elites. By contrast, politicians in clientelist political institutions are largely accountable to a small set of elites and reject digitally enabled reforms that hurt vested interests; instead, they use these technologies for greater control. And patronage-based bureaucracies resist e-government advances that would reduce discretion and rent-seeking.

Consequences

These workplace changes are not going to happen overnight, just gradually over a period of years. And each time the unemployment rate rises there's going to be a cry from the politicians, the unions and the unemployed for more jobs to be created. It's as though King Canute was back again sitting on his throne on the beach demanding job led economic growth, only this time being swept away by a tide of technology.

The displaced workers will have to live somehow. Liberal governments are already looking at paying a universal income grant. For the sake of an example, let's assume that the American and European governments are generous and set the grant at the equivalent of eight Eurodollars an hour. Then the stores would only need to pay their workers two Eurodollars an hour to give them their pre-income grant salary of ten Eurodollars. This in turn cuts the savings the companies achieve from their automation projects by eighty percent and, on top of that, the government is going to need to tax the company and its owners more in order to afford the basic income grant. Maybe at the end of it all there won't be any savings from the automation at all.

Of course there are some problems in this scenario of widespread automation and unemployment. Most of the retrenched millions of workers won't find another job so they won't have the wherewithal to go online and buy goods from the warehouse. In fact, that's hundreds of billions of Eurodollars that won't be spent in the economy because it hasn't been earned. I hope the store owners factor that in when justifying their automation projects.

In *World without work*, an article in Atlantic Magazine by Derek Thompson, he claims that unemployment in America is leading to depression, suicide, spouse abuse, crime and cultural, community breakdown. Technology, he speculates, could create a separate nation of poor, unskilled, jobless.

Automation is causing unemployment everywhere. Governments have the difficult dual challenge of creating an environment for employment based growth while at the same time providing a safety net for the indigent unfortunate. Increased taxation on the companies profiting from cutting staff is just one piece of the solution.

Automated Electric Vehicles

The Russian Revolution took place one hundred years ago. About the same time, two transport revolutions took place which overnight changed the world of movement. The Wright brothers pioneered manned flight while motorised vehicles put paid to horses, carts, hansom cabs, ox wagons and blacksmiths. Now, three more transport revolutions look poised to roil the world: electric vehicles, automated transport and, finally, automated electric transport.

Back in 1900, when my grandparents were newly married, did the pundits of the day foresee the changes that were coming? Are today's transport experts any better at seeing the future? Only time will tell.

Electric Cars and Trucks

As we have already discussed, renewable energy, powered by the wind and sun, is already cheaper than nuclear, coal and even gas. Batteries are getting both more powerful and much cheaper, allowing electricity to be stored for when the wind doesn't blow and the sun doesn't shine. As a result of both of these, the purchase and running costs of electric vehicles are dropping sharply. And, since they don't use gasoline or diesel they don't pollute the air – unless, of course, their power comes from a coal or gas fired power station.

Electric vehicles have another important advantage compared to a conventional vehicle. An electric car is easier to make than one with a combustion engine because it has many fewer parts: for instance, a Tesla 3 has between 6,000 and 7,000 parts, while Goldman Sachs estimates that a traditional vehicle has 30,000 or more.

Electric vehicles have been on the roads for years. As a boy fifty years ago I remember riding on electric buses and trams. However it's only this decade that sales of electric vehicles started to take off driven both by improved and lower cost battery technology and by the move to reduce emissions from gasoline and diesel vehicles.

Forbes reported that global sales of electric vehicles rose 72% in 2015, and 41% in 2016, with a total of 777,497 electric vehicles sold in 2016. There are now more than two million electric vehicles on the world's roads according to the International Energy Agency but that's out of a global total of 1.1 billion vehicles. Electric vehicles comprised a mere 0.2% of total passenger light-duty vehicles in circulation in 2016. China, the USA and Europe accounted for more than 90% of 2016 sales. Mining company BHP, which has an obvious interest in the metals that go into vehicles, predicts there will be 140 million electric vehicles by 2035.

China remained the largest market for electric vehicles in 2016, with 40% of world sales taking place there. China leads the world in electrical vehicle usage with about 600,000 all electric vehicles, with plans to have five million electric cars on the road by 2020. The government has introduced a compulsory quota of 10% for carmakers from 2019 requiring them to either produce more electric vehicles or else purchase carbon credits from their peers, in a bid to tighten emissions and support companies in developing what the government considers a strategic industry. America's Tesla, which enjoys the electric car limelight, announced an agreement to build a factory in Shanghai. Incidentally, China also has more than 200 million electric bicycles and more than 300,000 electric buses roaming its highways and byways.

Europe is the second biggest market for electric cars after China. In Norway, electric cars had a 29% market share of all car sales in 2016, the highest share globally, followed by the Netherlands with 6.4% and Sweden with 3.4%. As a result Norway has the highest per capita number of electric cars in

the world with more than 500,000 in a country of 5.2 million people. In 2016 Norway also opened the world's largest fast-charging station, which can charge up to 28 vehicles in thirty minutes. There are already 70,000 electric cars in the United Kingdom and 96% of motorway service stations have fast charge points. Europe's most popular electric vehicles were the BMW i3, the Renault Zoe, the Nissan Leaf and Mitsubishi's plug-in Outlander hybrid.

America has fewer than 500,000 electric vehicles. Forbes reported that US sales of electric cars in 2016 were 159,139 vehicles, 38% up on 2015; the four year compound growth rate was 32%. January 2017 sales were 70% up on January 2016. Thirty models were available with the most popular being the Tesla Model S, Tesla Model X, Chevrolet Volt, Nissan Leaf, and Ford Fusion Energi. More than half of all electric vehicle sales took place in California. In the USA there has been a significant increase in electric light duty vehicles sales with a record high of 17.5 million units sold in 2016.

Another source reported US electric car sales jumped approximately 68% in February 2017 versus February 2016. Fully electric car sales were up 74%, while plug-in hybrid sales were up 61%. For the first two months of 2017, that puts all plug-in car sales up 64%, fully electric car sales up 57%, and plug-in hybrid sales up 72%. US sales are projected to grow fourfold from last year to 643,000 in 2021, about 4% of the U.S. auto market, according to estimates by Bloomberg New Energy Finance but the segment is expected to account more than one-third of sales in 2030.

The Tesla Models S and 3 sell for US\$ 35,000 in the USA, a similar price to a regular gasoline model, and 400,000 people have put down a small, refundable deposit towards one. According to analysts, by 2024 the cost of ownership of an electric car in Germany would be the same as a conventional petrol or diesel model. The shift to electric will be underpinned by falling battery costs. In addition, the distance between charges will go from the 200 kilometre range of most models today to 600 kilometre and above in the next decade.

According to Bloomberg New Energy Finance the unsubsidised cost of ownership of an electric vehicle will fall below a petrol driven car by 2022 and electric vehicles will be as cheap as gasoline cars by 2025. Currently batteries make up a third of the cost of an electric car; the cost of lithium ion battery packs has reduced from US\$ 1,000 per kWh in 2010 to US\$ 350 in 2016, falling 35% in 2015 alone. They could drop to US\$ 125 in the near future. Electric vehicles could displace oil demand of 2 million barrels a day as early as 2023. That would create a glut of oil equivalent to what triggered the 2014 oil crisis.

Although Tesla gets huge publicity, the Nissan Leaf is currently the world market leader and the Chevy Bolt is also popular. Volvo announced that from 2019 it will only produce electric and hybrid models. Daimler AG, which was the first in the market in 2009 with its Smart Electric Drive, plans to spend \$1 billion to start production of Mercedes-Benz electric vehicles at its Alabama factory and is bringing forward its 10-model electric vehicle range to 2022. GM announced two electric vehicle models for 2018 followed by a further 18 by 2023. Ford plans 13 electric vehicle models by 2022. From 2020 all Jaguar Land Rover cars will be electric vehicles.

Tesla also unveiled an electric big-rig truck with a working range of 200 to 300 miles. Tesla's Elon Musk, who is aiming for a 20% share of the truck market, has stated he believes electric trucks will be more powerful than diesel equivalents. The Tesla truck is likely to come into full scale production within 18-24 months. Tesla will be providing the batteries and drive trains, but the cabs and other equipment will be contracted out to others. Morgan Stanley expects an electric truck could be 70% cheaper to operate than a diesel powered truck.

Cars with solar panels to charge the batteries are also starting to appear on the market. Audi, which will start marketing its first electric models in 2018, is working with Alta Devices to provide solar charging on its electric and hybrid models. Toyota and Panasonic are prototyping a version of the Prius with a solar panel on the roof. In Germany a new company, Sono Motors, announced an electric car partially powered by solar cells. In China Hanergy launched four cars powered by solar panels, while Karma Automotive is using solar charging on a hybrid car.

As a result of the Volkswagen emissions scandal, Europe no longer has faith that diesel is an environmentally friendly fuel. By 2021, the average emissions of all new cars sold in the EU must be 40% less than what the average car on the road emits today. Research by Belgium's VUB University predicted that the total CO2 emission costs of European electric cars would be half that of a diesel vehicles by 2030. The drops range from 25% in coal fired Poland to 85% in green Sweden. The governments of Norway and the Netherlands say they will ban petrol car sales by 2025, India by 2030, and France and England by 2040. Germany is considering a ban by 2030.

California mandates that a certain percentage of each automaker's sales must be zero emission vehicles. States like New York and Vermont are increasingly offering tax incentives to consumers who buy electric vehicles. Los Angeles, Seattle, San Francisco and Portland are leading a partnership of over thirty cities to mass-purchase electric vehicles for their public fleets including police cruisers, street sweepers and trash haulers.

Elsewhere cities concerned about air quality are taking action: the mayors of Paris, Madrid, Mexico City and Athens plan to ban diesel vehicles from city centres by 2025. Paris has ruled that any electric car is allowed to re-charge at the re-charge stations of its car-sharing program. Norwegian cities provide bus lane access for electric vehicles, frequent recharging stations, privileged parking, and toll-free travel for electric cars. Amsterdam offers to install charging points on public parking spaces to people who make a request. London waives its congestion charge for electric vehicles.

The EU has legislated that as of 2019, every newly built or refurbished house must have a charging station and by 2023 10% of all buildings' parking spaces must have chargers. As a group, BMW, Daimler, Ford, and Volkswagen intend to install thousands of EV fast chargers along European motorways. Tesla is installing a chain of Australian charging points stretching from Adelaide to Brisbane.

Analysts predict there could be between nine and twenty million electric cars in operation by 2020 and between forty and seventy million by 2025, based on estimates from automobile manufacturers. The IEA calculates that in order to limit temperature increases to below 2°C by the end of the century, the number of electric cars on the road will need to reach 600 million by 2040. Morgan Stanley predicts that electric vehicles will form 90% of the global fleet by 2045. Research from UBS predicts 48V mild-hybrid vehicles will overtake diesel engines within five years and diesel will almost entirely disappear from the global car market within a decade.

California aims to have 1.5 million zero emission vehicles in operation by 2025. Dutch bank ING predicts that all new cars sold in Europe will be electric within less than two decades, driven by government support, falling battery costs and economies of scale. Britain's Go Ultra Low, a government and industry-supported scheme to boost ownership of green vehicles, predicts around 1.3 million electric cars will be bought in the United Kingdom in 2027, exceeding petrol and diesel car sales for the first time. Total global sales of light-duty start-stop vehicles are predicted to exceed 61 million by 2025, accounting for nearly 60% of all light-duty vehicle sales.

There are other outcomes from a world of electric vehicles. The air in cities would once more be breathable and their streets quiet. Electric cars would eliminate the need for service stations with their

tanks, pumps and safety regulations to prevent fires or explosions. Instead charging stations could be installed alongside city parking spaces or outside eateries on inter-city routes. Interestingly, research has shown that most existing owners of electric cars tend to charge them in the home garage. The batteries of electric cars also allow owners to store surplus electrical power generated on their rooftops; already some electric car owners are earning as much as US\$ 1,530 a year just by parking their vehicle and feeding excess power back into the grid.

While demand for oil will disappear, instead there will be demand for the metals used in batteries and charging stations, giving new areas of the world export opportunities for lithium, vanadium, copper and other commodities. The proposed ban on the use of diesel vehicles in some European cities has already started to impact the prices realised for used vehicles. At some point in the near future the economics of buying a new gasoline or diesel powered car that has no residual value will start to dent sales of new non electric cars, further accelerating the move to electric vehicles.

Very little press coverage has been given to the fact that electric vehicles will lead to the elimination of taxes on gasoline and diesel which are important income earners for many countries. According to the OECD, the average gas tax rate among the 34 advanced economies is US\$ 2.62 per US gallon. ITEP calculates that in the US the gas tax is the single most important source of transportation funding for the federal government with taxes on gasoline and diesel fuel raising over \$US 30 billion per year. The fifteen countries of the former EU together earn Euros 152 billion in fuel taxes. The Australian Government Productivity Commission has highlighted the need for reform in the funding of and investment in roads, which is the single largest item of infrastructure spending for many governments.

Other Electric Transport

We already take for granted that trains are powered by electricity. The sky is the next space where we will find electric transport taking off and the first signs are already there.

Because of the weight of the batteries, one option being considered is airplanes covered with solar panels which can continuously recharge the batteries. In 2016 the Swiss Solar Impulse aircraft flew around the world using only solar power and electric batteries without having to stop to refuel. However it only carried a crew of two so there's some way to go before this becomes a viable option.

The second option is battery powered aircraft which will, initially, only be able to be used for shorter flights. European budget airliner easyJet announced that it is working with Wright Electric to develop a battery-powered aircraft that it believes can be in commercial operation by 2028. The electric planes would be suitable for the 20% of easyJet flights of below two hours or 500 kilometres. Wright Electric has already built a two seater electric prototype, and hopes to expand this model to the size of a commercial aircraft capable of carrying 120 passengers. The company claims that a typical electric aircraft of that size will be 50% quieter and 10% cheaper to buy and operate.

Wright Electric are not alone in the market. Boeing has bought electric plane company Aurora, while another company, EViation, will complete its certification and commercialization by 2018 and expects to show its first commercial flights of electric aircraft by 2021. Zunum is planning to develop a hybrid electric and jet fuel plane which it will fly between smaller US airports. Meanwhile Toyota has invested in a company developing a small, three wheeled flying car called the Skydrive, showing that flying cars can take off from anywhere and don't have to be big either.

In the meantime carbon taxes levied on flights could raise the cost of flying and discourage tourism, particularly to far flung destinations such as New Zealand and South Africa.

The sky's the limit, it seems, for solar and battery powered flight!

The Future of Oil and Gas

Bloomberg New Energy Finance predicts that electric vehicle sales will lead to displacing eight million barrels of oil a day by the time they overtake sales of gasoline powered cars. This seems somewhat on the low side considering current world oil production is some 92 million barrels per day.

The *BP Statistical Review of World Energy June 2017* records that in 2016 the world produced 33.6 billion barrels of oil. At an average price of US\$ 50 per barrel, that oil was worth US\$ 1.7 trillion, not an insignificant amount of money. The main producers were the USA, Saudi Arabia, Russia, Iran, Canada, Iraq and the United Arab Emirates. Africa's biggest producers were Nigeria, Angola and Algeria. These countries are the ones that are going to be the biggest losers in the bright new world of renewable electric transport and can be expected to fight every step of the way. Already Brazil has been identified as accelerating development of its offshore fields so they earn revenues before become stranded assets. Other countries with reserves are going to do likewise.

Just recently there have been a number of articles in the press speculating on when sales of oil products are likely to go into terminal decline with some experts predicting it could be as early as 2026, just nine years away. When that happens the oil surplus will lead to bargain basement oil prices in the short term and bankruptcies galore.

Automated Cars

Automated cars contain powerful computers which are able to process inputs from a range of sensors in order to steer the vehicle safely to its destination. In recent years a number of companies, both traditional car makers and IT companies, have announced driverless car ventures. These are summarised here to give you an overview of the projects underway.

California's Department of Motor Vehicles has now licensed 27 companies to drive their prototype automated vehicles in the state. Since March 2016, excluding Alphabet (Google) subsidiary Waymo, the number of self-driving cars authorised has more than trebled from 33 to 103. After Waymo, the companies with the largest autonomous fleets today are Cruise, the start up acquired in 2016 by General Motors, with 27 cars, followed by Tesla with 24. By contrast Arizona has a policy of providing no obstacles to autonomous driving in order to attract the tech motor companies to the state.

Waymo has been testing driverless cars in California (since 2009), Texas (2015), Arizona (2016) and Washington state (2016). To date they have driven more than two million miles mostly on city streets building on the one billion miles driven in simulation in 2016. Fiat and Google are collaborating to develop autonomous minivans.

American company NuTonomy launched a self-driving ride service in Singapore in partnership with the Singapore government. NuTonomy expects to have a dozen vehicles in operation by December 2017. The initial cars are modified Renault Zoe and Mitsubishi i-MiEV electrics with a driver in front who is prepared to take back the wheel and a researcher in the back seat who watches the car's computers.

In July 2017 BMW announced it was collaborating with MobilEye and Intel to produce a range of autonomous vehicles by 2021. Mobileye also announced a partnership with Delphi, another leading auto-parts supplier, to develop a near-complete autonomous driving system by 2019. The plan is to create a mass-market, off-the-shelf system that can be plugged into a variety of vehicle types, from smaller cars to SUVs.

Uber, one of whose shareholders is Toyota, signed a US\$ 300 million deal with Volvo, the Scandinavian company owned by China's Geely, to introduce driverless Uber vehicles on a trial basis on Pittsburgh roads. Volvo is also testing a fleet of one hundred driverless vehicles in Sweden and the company's XC90 SUV is due to start self-driving trials in London, England, in 2017.

Ford announced in August 2016 that it plans to be "mass producing vehicles capable of driving fully autonomously" by 2021. In 2017 Ford announced a US\$ one billion investment in Argo AI, a software startup specialising in self-driving cars. Ford is planning vehicles which have neither steering wheels nor pedals as the company doesn't believe humans can react quickly enough in an emergency. The cars will be gasoline / electric hybrids built to be taxis. Dominos Pizzas is already using automated Ford cars for deliveries in Ann Arbor, Michigan.

In March 2017, Toyota's artificial intelligence research institute unveiled its first self-driving car prototype. Tesla too is adding increasingly autonomous systems, bit by bit, to its existing high-end vehicles.

The logical outcome of cars which need no driver is that they will also become cars which need no owner either. Each year there are 41,000 highway deaths in America, most of which could be avoided using autonomous cars and trucks. As a result insurance premiums are likely to drop significantly, as are fines for speeding and other traffic offences that automated vehicles studiously avoid. In fact there might no longer be a need for speed limits at all.

Automated Trucks

The oceans, skies and railroads of the planet could be filled with autonomous ships, planes and trains transporting cargo without any people on board, as driverless car technology spreads to other transport sectors. Trucks that drive themselves can spend more time working because software doesn't need to stop for shift changes or comfort breaks. They are also more predictable in how they do things like pulling up for loading.

David Alexander, an analyst with Navigant Research, forecasts that most truck companies will gradually introduce automated driving technology in the next five to 10 years. Trucking companies are also experimenting with platooning, where vehicles use automated driving technology to drive closer to each other than they would with human operators, saving fuel costs and reducing emissions. The trucks communicate with each other, slowing down when the lead truck slows down, speeding up when the lead one speeds up, without needing to read brake lights or other signs humans might use. Eventually, one driver in this group of trucks could operate the whole platoon – I certainly wouldn't like to be stuck behind such a platoon on a two way highway! Deutsche Bank estimates automation would add \$US 23,000 to the capital cost of a truck, falling to \$US 5,000 over time, compared to a driver's annual salary of \$US 45,000.

Several companies are already in the race to build self driving trucks. Uber acquired fledgling self-driving truck company, Otto, for \$680 million in 2016; Otto is working with Volvo to create self driving delivery trucks which could be hailed by businesses for deliveries of their products using Uber-like technology. A self-driving truck from Otto delivered cans of Budweiser to Colorado Springs back in October 2016. In 2015, Daimler received permission to test a self-driving truck on Nevada roads while in May 2016 Chrysler and Alphabet announced that they would team up to make a driverless minivan.

Rio Tinto is the world's largest owner and operator of autonomous trucks. The Group has 73 autonomous trucks transporting iron ore 24 hours a day across four sites in Australia. The autonomous fleet is roughly 15% cheaper than one with human drivers and moves about 20% of the ore. The human team overseeing the robots work 750 miles away far from being able to physically

take action should something go wrong. The company could cut costs even more by using supervisors in India or some other low wage economy. The trucks, made by Japanese manufacturer Komatsu, weigh 416 tons. They find their way around using precision GPS and look out for obstacles using radar and laser sensors. Komatsu estimates that their autonomous trucks have already hauled 1 billion tons of material, mainly in Australia and Chile.

BHP Billiton is also deploying driverless trucks and drills on iron ore mines in Australia. Canada's largest oil company Suncor has begun testing driverless trucks on oil sands fields in Alberta. A new company Built Robotics is testing an autonomous track loader which uses given GPS coordinates to accurately dig a hole. The New Scientist described a test mining robot that can work underwater which will be a boon in flooded mines.

Autonomous vehicles are already in regular use in the agricultural sector. Automated tractors and harvesting machines using GPS are in operation in North America and Australia performing their tasks day and night leaving the farmer free to concentrate on other activities. The Hands Free Hectare project, run by Harper Adams University and Precision Decisions, demonstrated how to plant, tend and harvest a crop with only autonomous vehicles and drones, with no one setting foot in the test field.

A Guardian newspaper article on autonomous truck driving claims America has 1.8 million heavy truck drivers, mainly men, as well as 1.7 million people who drive taxis, buses and delivery vehicles. In many states truck driving is the most common occupation. Labour accounts for 75% of the cost of transporting shipments by truck. While truckers are prohibited from driving more than 11 hours per day without taking an eight-hour break, a driverless truck can drive for the entire day. California, Florida, Michigan and Utah have already passed laws allowing trucks to drive autonomously in platoons. In fact, a semi-automated platoon of trucks crossed Europe last year in an experiment coordinated by DAF, Daimler, Iveco, MAN, Scania and Volvo. The British government is planning to have driverless trucks in platoons on their motorways by the end of 2018.

Driverless Trains and Planes

Rio Tinto is also testing driverless locomotives for the trains carrying ore and coal from the mines to the coast. London's underground has also mooted the possibility of driverless trains but invariably run into union opposition.

The cockpits of modern airplanes are highly automated and planes regularly fly for long distances on autopilot. However it's drones that are starting to feature in the news, some remote controlled and some fully automated. Matternet and Mercedes-Benz are testing using drones to deliver goods for Swiss e-tailer Siroop to vans at preset locations which would then undertake the final stage of the delivery to the customer. Matternet has also announced a permanent autonomous drone network in Switzerland to transport samples from hospital and clinics to laboratories for testing. The drone network is part of a partnership with Swiss Post, and is significant because it's the first operational drone network flying in dense urban areas that's not a pilot run or in testing. Zipline announced plans to operate a similar blood delivering service by drone in Tanzania by early 2018. Amazon is also investigating delivering to customers by drone, with the drone take photographs of the customers' premises to add to its already massive customer database.

The Consequences

According to the American Trucking Association, there are more than three and a half million truck drivers in the USA earning an average of US\$ 45,000 per year. The US White House, which seemingly has different sources of information, released a report in December 2016 entitled *Artificial*

Intelligence, Automation, and the Economy predicting that automated vehicles could threaten or alter 2.2 million to 3.1 million existing U.S. jobs, including 1.3 million to 1.7 million heavy and tractor-trailer truck-driving jobs. That's 80% to 100% of all truck-driving jobs according to the report. The report comments that long-haul drivers "currently enjoy a wage premium over others in the labor market with the same level of educational attainment."

CEA estimates that 2.2 to 3.1 million existing American jobs, including approximately 364,000 self-employed individuals driving either part- or full-time with ride-sharing services, may be threatened or substantially altered by automated vehicle technology.

Europe reportedly has even more truck drivers than America. Assuming each worker is paid, on average, 40,000 Eurodollars a year, then commercial enterprises in the USA and Europe will save 160 billion Eurodollars a year through the use of automated trucks. Shareholders will be ecstatic at the thought. They might even be tempted to give customers discounts. Of course they could go even further and close their physical stores. Robots in a warehouse would package the goods we order online and load them into self driving trucks or drones for automatic delivery. I just hope they remember to include a robot arm in the design to press my doorbell otherwise they might have to hang around till the late afternoon when I take my dog for a walk and find them lurking with intent outside my gate!

Growing Inequality

The eighth global trend is global inequality.

In his oft-quoted tome, *Capital in the Twenty First Century*, French economist Thomas Piketty emphasised that in discussions of inequality one has to distinguish between wealth and income. Wealth is the sum of the assets one owns, including property, company shares, gold bars, art treasures, antique cars and, of course, money in the bank. For most people income is the money earned for the work one does, whether a salary, wage, commission or proceeds of produce sales in the village marketplace. However it also includes pensions, dividends, interest, share options or any other assets exchanged for services rendered personally.

In 2010, the Millennium Development Goal of halving global poverty rates by 2015 was attained. This goal, which focused exclusively on income, was achieved five years faster than anticipated when the goals were developed. In 1990, some 1.9 billion people (or 43% of the world's population) had incomes of less than US\$ 1 a day; by 2010, there were 1.2 billion people (21% of a larger global population) living below a slightly higher poverty line of US\$ 1.25 a day.

The main cause of this astonishing improvement in human welfare was economic growth. The economies of the three regions of the world that are home to the vast majority of the world's poor had all grown rapidly: at 8% per year in East Asia, 7% in South Asia, and 5% in Africa. This era of global economic growth saw the first fall in global inequality of household income since the early nineteenth century.

Despite the scale of poverty reduction across the world, many people remain in desperate circumstances. Poverty in middle-income countries remains unacceptably high: 68% of Indians live on less than US\$ 1.25 per day, along with 55% of Indonesians, 37% of Filipinos and 33% of South Africans. Large numbers of people also live just above the poverty line and are vulnerable to falling back as many are starting to do in Brazil, Venezuela, Zimbabwe and South Africa as their respective political and economic crises unfold.

The *Gapminder* website of the late Hans Rosling and Max Roser's *Our World in Data* website provide much data on inequality set out with innovative graphics. The number of people living in extreme poverty fell from 47% of the total population of developing countries in 1990 to 22% in 2010, a reduction of 0.7 billion people. It's not just the financial situation of the poor that has improved. World literacy levels have risen from 10% in 1820 to 33% in 1930 to 85% today. By 2100, there will be almost no one without formal education and there will be more than 7 billion minds who will have received at least secondary education.

Asia now has nearly 60% of the world's population, accounts for more than 35% of world output and 26% of world trade and has contributed more than 50% of post 2000 world economic growth. Asian average per capita incomes are now 25% of those of the USA and rising, though 20% still live in poverty. A study by Euromonitor International shows that the average Chinese manufacturing wage is now higher than that in countries such as Brazil, Argentina and Mexico and could soon surpass that of Portugal. This is not what many people believe.

Wage growth has significantly lagged behind labour productivity growth in most countries; since 1999, average real wages have increased by just 5% while labour productivity has grown by 15%. When this happens, those that gain are the shareholders in the companies and sectors where the gains are realized.

Turning from income to wealth, the richest 8.4% of the adult population in the world now commands 83.3% of global wealth, while the poorest 70% possess only 3%. Between 1988 and 2008 more than half of the economic gains went to the richest 5%. Quantitative Easing after the 2008 financial crash led to low interest rates; the rich getting richer; more concentrated corporate wealth; and high property prices everywhere. Forbes Magazine regularly publishes lists of the world's wealthiest people; naturally we don't have a list of the poorest because nobody wants to know who they are. I doubt the Forbes' list includes Latin American drug barons, Eastern European arms merchants and Africa's kleptocrats, nor takes account of the funds stashed away in tax havens by everyone from the Queen of England to sports and pop stars.

According to a UBS / PwC report the world's 1,542 US dollar billionaires increased their combined global wealth by 17% in 2016, reaching US\$ 6 trillion. This was as a result of the performance of their companies and investments, particularly in technology and commodities. Some 98% of billionaires' wealth found its way back into wider society. The world's super-rich employ 27.7 million people. 140 of the world's top sports teams are owned by just 109 billionaires, with two-thirds of NBA and NFL teams owned by billionaires. In the United Kingdom, nine of the 20 Premier League teams have billionaire owners. Analysis by the Institute for Policy Studies shows the three richest men in America together own more than the bottom 50% of Americans. An Oxfam report claimed that in Indonesia the four wealthiest men own more than the one hundred million poorest people.

We tend to think of poverty as though it only exists in the developing world. Some new statistics refute this notion. One study showed 47% of Canadians couldn't pay their outstanding bills if their pay cheque was deferred by just one week. According to research from the Economic Innovation Group think-tank, one in six Americans resides in a zip code it defines as a "distressed community". According to the Urban Institute between 2007 and 2010 the average wealth of white American families fell 11% while that of black families fell 31%. From 1979 to 2013 American productivity grew 64.9% while hourly compensation only grew 8.2% for 80% of workforce but by 153.6% for top 1%.

Back in 2015, Thomas Piketty published his *Capital in the Twenty First Century*, which focused on the growing gap between rich and poor around the world. As mentioned, as part of his analysis, Piketty emphasised the difference between *wealth* and *income*. Obviously wealth can be passed from one generation to the next through inheritance, as can the assets that generate a return. Piketty's conclusion was that the rich are getting richer, both through higher remuneration for their labour and through their increasing ownership of productive assets. To rectify the situation, he proposes taxing the rich though this would need to be done by way of international cooperation to prevent the superrich escaping to tax havens.

The IMF has echoed Piketty's call for higher taxes on the wealthy. However it would seem that it's just the opposite that is happening, perhaps because of legislators in thrall to billionaires. According to the Peterson Institute for International Economics most advanced and large emerging economies have higher top marginal personal income tax rates than statutory corporate income tax rates, in part because governments have realised corporations can select countries for the best rates or lobby for loopholes, but individuals do not have the same resources. Among the world's high-income countries, the United States has the least redistributive government tax and transfer system. The new taxes being proposed will only worsen income and wealth inequality in America. The US government, through its tax system and spending, also does the least to reduce inequality among all high-income advanced economies. Across the Atlantic, the new tax structures being enacted in France will also widen the income and wealth gap there.

Branko Milanovic's highly readable and thought provoking book, *Global Inequality - a New Approach for the Age of Globalization* continues the discussion. Prior to 1988, the twentieth century had seen a narrowing of the inequality gap due both to malign forces such as wars, epidemics and natural

catastrophes, as well as benign forces such as education, social transfers and the introduction of progressive tax regimes. However the period since 1988 has seen the rise of the global middle class, most of whom are in China and the rest of Asia; the income stagnation of lower and middle classes in the rich world; and the emergence of a global plutocracy. Although the gap between rich and poor is growing in every country he studied, he found that the inequality gap between poor nations and rich is narrowing.

Milanovic believes that the political forces pushing for greater inequality will more likely succeed in the presence of surplus labour or technological change that is capital or high skill biased. In particular he compared the manufacturing and services sectors showing how the latter is seeing greater divergence of equality due to lower unionisation, capital proving stronger than labour and the twin effects of technology and globalisation.

He also makes some interesting asides. In one chapter he discusses the impact of migration on levels of inequality and finds all is not what prejudice tells us it should be. In another chapter, he pointed to the tendency of rich, highly qualified people to marry other rich, highly qualified people and the likely impact thereof. Increasingly, rich people are opting out of using state education and health services and at the same time persuading governments to cut funding for programs aimed at helping the poor to access those same state services. Simultaneously the amount being spent by the rich on private security systems is rising. Perhaps his most ominous prediction is that we are seeing the rise of a global plutocracy which is able to distort supposedly democratic elections in favour of tame legislators who then legislate to further favour the plutocrats who funded their election campaigns.

Another French economist, Francois Bourguignon, in his book, *The Globalization of Inequality*, has dug further into the inequality statistics for many countries. He too finds that within each country or community, the rich are getting richer and the poor poorer. At the same time he points out the poor quality of the data extant for many countries where the population is simply divided into ten income deciles whereas he needs to study information for the top 1%, 0.1% or even 0.01% where the megarich reside. Bourguignon is particularly concerned that sub-Saharan Africa is the one region of the world where the poor do not seem to be advancing.

Looking at the impact of IT on work and unemployment, research by Citibank and the Oxford Martin School titled *Technology at work: V2.0*, concluded that the pace of change has accelerated; the scope of technological change is increasing; and unlike innovation in the past, the benefits of technological change are not being widely shared. Real median wages have fallen behind growth in productivity and inequality has increased. Looking at the rate of automation induced unemployment, on the one hand, and potential shareholder returns from automation and ownership of big personal and financial data banks on the other, the gap could once again start to grow, despite recent positive American remuneration data.

The moves by Veneto, Lombardy and Catalonia, all wealthy European regions, to gain greater autonomy have been described in the light of reclaiming ancient privileges. However, the real motive could be that these regions wish to keep more for themselves and don't wish to subsidise the poorer regions of their countries.

While research and data is widely available on the gap between rich and poor, much less research seems to have been undertaken on the wealth gap between old and young. A comment one encounters frequently is that the youth of today will be the first generation that is poorer than their parent's generation. Today it is the elders who have jobs, pensions and mortgage paid houses; the young battle everywhere to get a foot on the ladder.

In Australia, for instance, home ownership for those aged under 40 has dropped from 36% to 25% since 2002. In 2015, 60% of men aged 22-25 and nearly half of women in the same age bracket were living with their parents. Young Australians today have twice as much housing debt as young people in 2002. Recent university graduates are getting paid less than earlier cohorts. Student debt is rising while the high cost of childcare makes it expensive for both parents to work.

Similar reports and anecdotal evidence have emerged in the United Kingdom and the USA. Stories abound about the rental housing markets in Vancouver, London, San Francisco, Melbourne and Silicon Valley squeezing out the young and lower classes. New research shows the fewest property owners existing now in America than at any time since the 1960's.

Questions are being asked about whether the wealthy are ensuring their offspring get the privileged education needed for the complex task of robot manager. In the USA, state universities are being starved of funds while the children of the rich get preferential access to Ivy League universities. Oxford and Cambridge have been accused of the same bias.

Measuring Life

It's nearly a century since a group of American economists came up with the notion of gross domestic product (GDP). The concept was simple. Add up the value of all the goods produced in a country and you have a measure of its economic well-being. Investors, rating agencies, economists and politicians still pore over GDP numbers as though they are the holy grail. But is it still a valid measure of economies?

In 2008, France's President Sarkozy asked Joseph Stiglitz, Amartya Sen and Jean Paul Fitoussi to examine the relevance of GDP as a measure of economies in the twenty first century. Their very readable report concluded it was still a good measure of the goods produced in a country but there also needed to be measures of income, consumption and people's well-being. Because of the variability of equality within a country, they counselled looking at median rather than average per capita numbers.

They went on to comment that market prices are distorted by the fact that there is no charge imposed on carbon emissions and no account is made of these costs in the national accounts. A tendency to measure gradual change does not prepare one for abrupt alterations caused by outlier events. Measuring changing quality is another major challenge. Governments play an important role in modern economies yet productivity changes in the provision of government services are ignored.

They considered that the household perspective should be emphasised taking account of payments between sectors, such as taxes to government, social benefits and interest paid, and should also reflect payment in kind. Consider income and consumption jointly with wealth; a household that spends its wealth on consumption goods increases its current well-being but at the expense of its future well-being. Many services that households produce for themselves are not recognised in official income and production measures. Further, households are increasingly moving from non-market to market provision of services. Finally, they pointed out that no value is placed on leisure.

The report did not comment on the fact that unpaid work undertaken by customers when ordering goods, using automated teller machines and checking out goods from stores is not included in GDP statistics. It's also not clear how successfully governments are measuring the size of the gig economy or of the informal economies that thrive in slums.

Just as I was mulling on all of this I came across the then state of the art laptop I owned twenty one years ago. Today's equivalent is 20% of the price in 1995 currency and, assuming Moore's Law, 500 times more powerful. The value of solar panels and wind turbines produced around the world might

be little changed from year to year, yet the cost per kilowatt-hour has dropped dramatically. Robots in factories working 24 hours a day have cut production costs. How are all these productivity gains factored into GDP?

Then take the Internet. Today you can read top newspapers from around the world free of charge. The incremental cost of producing and delivering an additional electronic book or movie is infinitesimal. When I needed information back in 1994, I would get in my car, drive to the library and look it up; today I just type a couple of keywords into a search engine and up pops the information I need. Everywhere people are adding more information to the web and not expecting a cent of recompense.

In their stimulating book, *The Second Machine Age*, Brynjolfsson and McAfee devote several chapters to exploring this further. Digital products and services might be free but they do have value. Digitisation reduces GDP because prices are lower or free. They recommended measuring the time spent using free services. Online feedback on everything from restaurants to physical products improves quality. They point out that GDP doesn't measure intangible assets such as intellectual property, organisational capital, user generated content, human capital or learning. Although income may drop, households may move from using paid to free online services with no change in standards of living.

As discussed in a previous chapter on automation and unemployment, governments and companies are increasingly outsourcing tasks to customers and citizens, respectively, who then perform the task - whether it be filing a tax return, placing order or checking out in a supermarket - unpaid. This too is not comprehended in calculations of GDP.

My only conclusion is that traditional GDP is a very poor measure of the state and progress of the world we share. What to use instead?

Basic Income Grant and Land Distribution

Piketty and others argue that taxes should be used to redistribute wealth from the rich to the poor. An associated approach would be for governments to introduce a universal basic income grant, a topic explored at length in Guy Standing's book *Basic Income and How We Can Make It Happen*. Though increasingly in today's news, this is actually a concept that has been around for hundreds if not thousands of years.

The way a basic income grant works is that the same modest amount of money is paid unconditionally to everyone in a country or region on a regular basis. There would be no differentiation between rich and poor or single and married persons. The only change in amount paid might be for people under the age of twenty or above the age of sixty. Obviously the tax structures would be tweaked so those already earning well would repay their grants through increased taxes.

The amount of the grant would aim to provide basic economic security for those with no other sources of income. As an example he talks of the amount of the grant being set at about 30% of a country's median income. There would be no conditions attached to the receipt, spending or expected behaviour by each recipient; they would have the freedom to use the grant as they wished. In summary, a basic income gives individuals greater freedom of choice about their lives and they aren't compelled to take jobs they would prefer not to do. Studies have shown recipients tend to spend it wisely.

A big advantage of a basic income grant is that those currently performing unpaid care for the young, the aged and the infirm would be compensated for their efforts. It also provides a basic safety net for

new entrepreneurs and artists. Another benefit is that it reduces poverty and inequality. Trials have shown that side benefits include improved mental and physical well being, better educational performance, lower crime levels and reduced domestic violence. In short, quality of life would improve. Because poorer people tend to spend more on basic necessities than rich people, the retail and local manufacturing sectors would receive a financial boost.

Standing emphasises that the grant is not a minimum income guarantee or negative tax. It is also very different from a one-off basic capital grant. It is not based on need, nor is means or other testing required. Recipients are therefore not required to undergo the indignity of testing or the bureaucratic burden of making a special application. There is no paternalism involved and the grant is paid to each and every person.

One of the big disadvantages of many current unemployment schemes is that people typically experience very high marginal tax rates when moving from welfare to low paying jobs. There is also a huge bureaucratic burden as people move in and out of employment, something that is going to happen more and more in gig economies. With a basic income grant there would be no delays while paperwork is processed.

Guy also sees a basic income grant as social justice compensating residents for the use of the commons and the creation of pollution by companies and the wealthy.

Several chapters in the book address the criticisms that have been aimed at a basic income grant. The most common is affordability; however, a revised tax structure, elimination of subsidies, closure of competing schemes and cutting back redundant government bureaucracy should more than compensate for an income grant set at an appropriate level. At the same time, a basic income grant does not have to completely replace an existing system of grants. The fiscus would also benefit from the stimulus of people spending their grants on taxed items.

Other objections from across the political spectrum include that it has not been done before; it contributes to the dismantling of the welfare state; it is stupid to give money to rich and poor or to give people something for nothing; the money would be spent on “bads”; the grant would reduce already stagnant wages; it will be inflationary; and it will attract migrants. Standing addresses each of these, usually by citing the results of experiments undertaken in various places in the world.

Before devoting chapters to assist advocates of grants in their efforts, Standing briefly describes the trials that have taken place or are underway in Madhya Pradesh, India; Namibia; the Netherlands; Scandinavia; Canada; the USA; and Finland. In 2016 Switzerland held a referendum on implementing a basic income grant. Completed trials showed a sharp decline in poverty; better nutrition; food security; food diversity; educational achievement; increase not decrease in work; reduced crime; and reduced domestic violence.

A basic income grant addresses the problem of inequality of income but no inequality of wealth. In his book, *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*, Peruvian economist Hernando de Soto Polar proposes that poor people living in traditional tribal or communally owned areas should be given title to the land on which they live, thereby giving them ownership of a valuable asset, perhaps for the first time in their lives. They would be able to mortgage or sell the property to raise funds so they can buy a tractor or greenhouse, take an agricultural course or finance a move to the city. They would also have security of tenure and an incentive to improve their property. As the world's population grows and climate change bites, the huge swathes of communally owned land, particularly in the developing world, could be put to more productive use by converting it to private ownership.

Now all of these concepts can only be realised through political change. The problem is that voters in democracies have a track record of voting for leaders who don't actually have the interests of their electors at heart. Instead, the politicians are in hock to wealthy vested interests who fund their ongoing re-election campaigns so they then legislate in their favour. However, as I watch what is happening in North America and Europe, I wonder whether voters, maybe as a result of social media, are starting to wake up to the wool being pulled over their eyes.

Globalisation

Long, long before the poet John Donne so aptly coined the phrase “no man is an island” in his poem *Devotions*, early man was experiencing the effects of globalisation, our ninth and final global trend. Volcanoes erupting on one continent changed the weather patterns thousands of kilometres away. The ancient Greek historian, Herodotus, speculated that glaciers in unseen, unknown mountains dictated the rise and fall in the River Nile. Migrating birds and animals brought disease and new food opportunities. Spores and microbes were carried by the wind.

As time went by it was people and things that were moving. Alien hordes suddenly emerged from over the horizon or long boats full of pillagers came ashore from seemingly nowhere. Primitive craft conveyed grain from North Africa to the European corners of the Roman Empire. Camels carried baskets of salt across the Sahara Desert and a chain of merchants and adventurers along the Silk Road exchanged the merchandise of China and the Middle East.

Ideas and information came along with the people and the trade goods: new techniques for making stronger metal implements and weapons; paper and the notion of writing and printing; religious beliefs and gods; gunpowder, chess and mathematical algorithms. The whole globalisation flow accelerated as European sailors and soldiers colonised the world, taking along with them not only goods and violence, but also the germs that wiped out whole vulnerable communities. Companies established branches throughout the empires to trade with and pillage the locals. Slave traders ferried hapless Africans and Asians east and west. In the near modern era multinational armies engaged in world wars on foreign fields. Globalisation became just that – global.

However it was only in the 1980's and 1990's that the word *globalisation* came into its own. At first it was used to describe how first world companies moved their manufacturing from the high wage factories of North America and Europe to sweatshops in China and other Asian countries. In her book *No Logo: Taking Aim at the Brand Bullies*, Naomi Klein spells out how globally recognized brands exploit cheap labour and practically non-existent standards to produce pedestrian products sold at a huge mark up simply because of the value of the brand embossed on the label. When customers or activists complained, the company would sack the manufacturer and find yet another pliable supplier.

The rise of outsourcing services to countries such as India and the Philippines was underpinned by improvements in the global telecommunications infrastructure. In the financial sector, technology is also allowing stock exchanges of the developed and developing worlds to merge and provide sophisticated trading products. A shift is taking place from traditional money managers to sovereign wealth funds managing the proceeds from huge trade surpluses, hedge funds and private equity groups, all of which are less transparent and relatively unregulated.

One common thread running through all the global issues I have discussed so far in this book is that they don't just affect a region or a country; they all have global consequences. More people means more mouths to feed, more bricks and mortar to build homes and malls and more sewage and litter to clog formerly pristine streams and lakes. To achieve this more goods have to be imported and exported.

Climate change is very much a global issue. The CO₂ emissions in America or China cause temperatures and sea levels to rise everywhere. A Peruvian farmer has successfully sued RWE in a German court because the CO₂ emissions from its European coal fired power stations have led to South American glaciers starting to melt. The garbage flowing into the sea off one continent ends up littering the pristine beaches of another or joining the mass of plastic slowly smothering pelagic life across the oceans that belong to no individual nation, yet belong to us all.

A combination of population growth and climate change is going to accelerate the flow of migrants from overpopulated areas experiencing extreme weather conditions to countries where the grass is greener, literally and metaphorically. Conflict in the Middle East or Africa, often driven by competition for scarce resources, is giving rise to our new refugee neighbours. Corruption and crime, particularly drug and human trafficking, have become huge international money spinners which recognize no borders.

Although reports give the impression of a large scale move in manufacturing capacity from the G7 countries to Eastern Europe and the Far East, where wages are lower, the reality is that the move has been much more gradual and less spectacular. In fact, companies domiciled in developing nations are increasingly buying companies in the developed world. As mentioned in my chapter on inequality, the major benefit of this phase of globalisation was that the income gap between rich and poor countries narrowed appreciably so that today median Chinese incomes, for instance, are not far off those of poorer European countries.

Today some multinational companies have turnovers that dwarf the budgets of smaller nations. They use tax havens as well as their financial heft to gain fiscal and regulatory advantages in the countries and cities they favour with their operations. Amazon, for instance, is advertising for special privileges from the city to be chosen as its second headquarters, while the EU competition and tax authorities clearly have Amazon, Google, Facebook, Apple and Microsoft in their sights. Multinationals are listed on multiple stock exchanges with shareholders ranging from wealthy individuals of no fixed abode to opaque investment funds operating out of tax havens.

Because the unions to which their employees belong – assuming they are even allowed to join a union – are invariably uninationals, the multinationals can play staff in one country off against those in another with impunity. The unemployed, of course, are even worse off with no one to take their side even in their own country, other than politicians who take a sudden interest in their plight just before elections, then, immediately they are elected, move on to more pressing matters.

The days of buying travellers' cheques before travelling abroad are long gone. Today our credit cards are accepted everywhere and, if we really want to experience what the local banknotes feel like, then we can just use a debit card at the nearest ATM. In many countries residents can simply use the electronic funds transfer facilities on their bank's website to move funds between banks and countries. Before too long, East Africans will be able to transfer funds between countries safely stored on their cellphones. Blockchain proponents have established Bitcoin, a borderless, stateless currency that is slowly gaining credibility and more are likely to follow.

Of course, when we make life in international finance easy for ourselves, we also make it much easier for companies to locate their subsidiaries optimally from a tax point of view; for drug barons, arms merchants, kleptocrats and the mafia to launder their ill-gotten gains; and for the wealthy to keep their assets hidden from tax collection agencies.

The information we post on the Internet can instantly be seen across the globe. Every time you use Google to search the Internet or post a photograph on Instagram, do you pause for a moment to consider where the program is running that services your request? Some software will be resident on your phone or computer, but the main operation will take place somewhere in the cloud, in reality on a server located optimally from a performance and cost point of view.

So many of the issues associated with these various aspects of globalisation are essentially unregulated, a global Wild West crying out for effective global governance. Probably the closest we have to a global government is the United Nations and the various bodies associated with it. There world leaders make impressive speeches and delegates pass resolutions. Its organs collect reams of

data and produce excellent reports on all manner of global issues. However, at the end of the day it is not able to effectively regulate and police the global issues facing us. Meanwhile, laws passed by the US Congress are found to apply to residents abroad who never voted for the legislators in the first place. Altogether it's a global regulatory mess allowing multinationals, the wealthy and the unscrupulous to get away with murder, sometimes quite literally.

Despite some British antipathy to the European Union, in many ways it provides a better model for global governance than does the United Nations. Each country is represented in parliament in proportion to its population size. A central bureaucracy implements the policies decided on. Health, safety and other standards are decided centrally obviating the need for each country to have its own officials duplicating the efforts of counterparts elsewhere. In like vein, instead of each country having its own authority to approve drugs and medical treatments, it seems logical that the process should be done once by, say, the WHO. This would cut costs, improve the process and, hopefully, speed the approval of new treatments. The same approach could be applied elsewhere.

Ideally a global government should be a democratic one representing all the citizens of the world. Instead we are prisoners of history and at the United Nations and in other international forums, it's the governments of individual countries that are present, with each country having the same voice, whether they have a population of one and a half billion or one and a half million. Then too, many countries are not true democracies, with leaders that came to power through the gun or by way of fraudulent elections. Even where true democracies are represented, it's only the views of the ruling party that are aired; the opposition parties, no matter how strongly they polled, have little or no say.

Perhaps some of the technologies that are causing unemployment could be brought to bear here. In a short space of time we can expect every adult in the world to have access to, if not ownership of, a smart phone with a camera and software to recognize the face, iris or fingerprint of the user. The precise geographical location of each phone will also be known. So it should be possible for adultkind to use their phones to elect the members of a universal parliament that truly represents them. Of course the same means could be used to elect national and regional representatives.

One of the major shortcomings of political parties as they operate in the current regime is that each party publishes a manifesto setting out their stance on any number of issues – migration, abortion, education, spending cuts, budget deficits and a whole lot more. Voters usually don't agree wholeheartedly with all the items on the platform of the party for which they vote; instead they have to compromise and end up voting for the party that best reflects their interests and concerns. Since a cell phone voting system allows for referenda on individual issues, much like the Swiss, for instance, do at present, it should be possible for voters to vote separately on each plank of the platforms on offer. AI based translation software would make official information available to everyone in their native language.

In fact, technology could be taken even further. Instead of just having a binary vote, yes or no, a cellphone app could allow each person to update a spreadsheet with their views on how the tax system should operate and how the fiscal revenues should be spent. A central computer would upload and merge all the submissions to create a composite budget within which the government would be compelled to operate. Again this approach could be used at all levels of government, not just for global governance.

Companies are already using the Internet to tap into the wisdom or the resources of the crowd. In the United Kingdom the crowd was used to fund a legal challenge to the government's plans to give special grants to Northern Ireland and in New Zealand to create a new chocolate company when Mondelez closed the Cadbury factory. Civil servants are just that, servants of the people so why not

give crowds of citizens AI front-ended mass databases of government information so they can analyse and monitor the performance of their representatives?

Another common attribute of my nine global forces is that they will not be resolved tomorrow; stakeholders need to adopt a long term strategy. One of the problems with politicians today is that they tend to take a short term view with the objective of being re-elected in three or five year's time. Of course investors, especially the fully automated ones, only look a second ahead, while company executives are often focused on the next quarterly results update rather than the long term strategy they developed with the help of expensive consultants. The people with the long term view in mind should be today's young people who are going to be around fifty or a hundred years from now. Perhaps in an online voting system their votes should count more than that of retirees spending their last few years polluting the planet and killing off species.

Conclusion

Globalisation so unpopular everywhere now comprehends the movement not just of physical goods, but also services, finance, people, information, ideas, governance, crime, germs and pollution. As a result – and despite all the nationalist populist rhetoric - the world is becoming ever more interlinked putting pressure on global, national and local governance systems designed in a previous era by those with power and influence at the time and, as tax, trade and environmental agreements are negotiated, even now. At one and the same time, we are seeing the move to larger, and even global, groups covered by the same regulations as well as to the creation of smaller entities with niche interests.

Planning

In my introduction I likened each of the major global forces I have discussed to a herd of elephants striding inexorably through the bush – now you have to imagine nine herds of elephants converging on you from different directions simultaneously! It's instructive to consider how government and business leaders, as well as us ordinary folks, might respond to these nine global forces. Generally they fall into three groups: those, generally educated and affluent, who keep a close watch on the macro picture and have the resources to react timeously; those too absorbed and, for the time being, unaffected, to care; and those, often at the bottom of the economic totem pole, who are angry yet without understanding the causes of their misfortune.

As an individual there's not much you can do about the global forces. If you're lucky you can relocate to some idyllic spot that isn't going to be flooded or scorched as a result of climate change. You can go off grid and install solar PV and hot water systems. You can trade in your carbon driven car for a sleek electric model. You can work from home and ride a bike or walk to the shops nearby. You could even limit your number of offspring to two or less. The trouble is, unless everyone in the world does the same, it's going to have minimal impact - but that shouldn't dissuade you from trying anyway.

Companies and, especially, governments have huge potential to prepare appropriately for the changes that are coming. However, this needs to be done in a logical, integrated way rather than haphazardly. Ideally they should adopt a four stage planning process: document the present; identify future challenges and opportunities arising from the nine global forces; agree a common vision for, say, 2030; and finally prepare a plan to move from the present to the future,

Since taxpayers ultimately pay for any research or data gathering undertaken by or for the state, this information should be shared with the citizenry, ideally by publishing it on the Internet – preferably as a massive dataset with a flexible AI interface - where it can be readily analysed and used by companies and individuals in their own planning.

Document the Present

Population Change

Create a massive database of all the people living – and dying - in your country or region. This can be made available online, only excluding any information that would enable individuals to be identified such as names, passport numbers, tax numbers, GPS coordinates of address or unique identity numbers. For basic demographic planning, date of birth, date of death, cause of death and suburb are the key pieces of information. These provide a starting point for determining how the population is likely to grow, including the number in each age decade, year by year.

Climate Change and a Degraded Environment

Create another massive database, this time showing historic time profiles of temperature, precipitation and humidity for as many locations as possible, including those in neighbouring countries. If possible this database should also record historic levels of CO₂, CO, NO, SO₂ and PM_{2.5} in as many locations as possible. When matched with the massive population database, this might reveal the incidence of environmentally related deaths.

Use standard mapping data to identify low lying coastal areas which could be prone to flooding and produce maps showing the impact of sea rises from 0.5 metres upwards.

Create an inventory of freshwater resources including, where available, historic pollution levels in lakes and rivers.

Find all climate change modelling reports which reference your country or region. Identify which regions will experience more or less rain. Use a series of maps to demonstrate how temperatures and rainfall might change with time.

Conduct a plastics audit which measures how plastic, especially PEP bottles and plastic packaging, is manufactured, used and, importantly, disposed of,

People Movement

Extend the massive people database to record the GPS coordinates of each person's birth, as well as their current nationality. This information will allow researchers to analyse migration patterns, both from foreign countries and from rural areas to the cities.

Low Cost Renewable Energy

A move to renewable energy will lead to the closure of mines and power stations, as well as the end of fuel exports and imports.

Create a massive electrical power database showing historic generating capacity, generation and consumption of electricity by area. Ideally the generation in each area should be broken down by source type (coal, nuclear, gas, hydro, wind, solar, geothermal).

Publish an inventory of electrical generating facilities showing capacity, capital cost, implementation date and source type.

Create a massive mining database showing a history of production and employment in the mining of gas, coal and uranium, as well as exports and imports.

Publish details of gas, coal and uranium reserves.

Mass Data Mining and Storage

Create an inventory of the major databases accessible in your country including nature of data, ownership and whether it is a free Internet resource or not. Ideally try to quantify the volume and value of personal and other data being exported out of the country.

Automation Based Unemployment

Extend the massive people database to record the job title and industry sector of each person. If the job titles are properly chosen, then this provides a crude method for determining how many people might be rendered unemployed by artificial intelligence, robotics, driverless vehicles, digital printing and other technologies as well as by the outsourcing of data entry to customers and citizens.

Autonomous Electric Vehicles

A move to electric vehicles will reduce demand for oil and the components of gasoline and diesel powered vehicles and increase demand for the materials from which electric cars are built.

Create a database including make, fuel, date of original registration, cost and place of manufacture of each vehicle in the country. The massive people database will provide details of the number of people involved in making, servicing, repairing, fuelling and, particularly, driving vehicles.

Extend the massive mining database to include a history of production and employment in the mining of lithium, copper, vanadium, platinum, aluminium, cobalt and other metals and minerals used in electric vehicles and batteries.

Extend the massive mining database showing a history of production and employment in the extraction, refining and distribution of oil and gas products, as well as volumes and values of exports and imports.

Publish details of oil and gas reserves, as well as reserves of lithium, copper, vanadium, cobalt, cadmium, platinum, aluminium and other metals and minerals used in electric vehicles and batteries.

Global Inequality

Extend the massive people database to include information on personal income and assets value.

Create an inventory of land ownership by area with particular emphasis on tribal / communally owned land.

Create a housing inventory including the GPS coordinates of all dwellings. While this information might be available for urban areas, satellite images might need to be used to record details of rural dwellings. This is a project where image recognition AI software could be used.

Globalisation

Create a massive database of imports and exports, including financial flows.

Identify Future Challenges and Opportunities

Population Change

The massive people database allows complex forecasts to be undertaken. A declining birth rate means there will be fewer children to be educated but also that fewer people will be entering the workforce. More people living longer means more financial, medical and social support required for pensioners. Ongoing automation will reduce the number of people who need to be employed. Closure of coal fired power stations and elimination of petrol and diesel fuelled vehicles will improve air quality and improve the health and life expectancy of those living nearby. Automated vehicles will reduce the number of road accidents and associated deaths and injuries. Governments and companies will need to make actuarial calculations and decide on pensions, retirement age and health and education budgets.

Climate Change and a Degraded Environment

Some areas will become drier and others wetter. In the dry areas, irrigation methods will have to improve and there might be opportunities to build desalination plants and dams. Wetter areas will be the future breadbaskets and need to be efficiently farmed in order to feed a growing population and this might be better done if land is not communally owned.

Looking at other areas of the world could also identify new business opportunities to enter new export markets. For example, the wine industry in France, Spain and Italy is already suffering from the effects of climate change, while England now has a fledgling wine industry.

Residents will need to be relocated from low lying areas. Dykes and sea walls will provide employment for construction companies. Tree planting and rehabilitation of polluted areas will provide employment.

America's Government Accountability Office published a report in October 2017 which included maps showing the challenges and opportunities likely to be faced by each region of the USA. Governments in other countries need to do likewise.

People Movement

The massive people database will provide details of immigration and urbanisation. Climate change in neighbouring states could increase immigration, while individual land ownership in rural areas could lead to slower urbanisation. To the extent that countries can improve the governance and quality of life in adjacent countries this could slow the flow of immigrants.

The forecasts recommended in the people change section above will also identify labour shortages which can be filled by immigrants.

Low Cost Renewable Energy

The winners in the low cost renewable energy economy will be the owners, builders and operators of renewable energy facilities, as well as the companies mining and producing the metals needed. While renewable energy will create jobs in the short to medium term, the number of jobs will drop off sharply as countries achieve 100% renewable energy capacity.

The losers will be the utilities with coal fired and nuclear plants together with companies mining, exporting or importing coal, uranium and gas.

Transmission and distribution utilities will need to implement smart grids. Utilities and governments will need to explore new means for charging for electrical power.

Mass Data Mining and Storage

Artificial intelligence and massive databases provide scope for governments and companies to reduce costs and improve strategic intelligence and transparency.

Automation Based Unemployment

The massive people database can be used to calculate future unemployment levels, at the same time factoring in the impacts of renewable energy and autonomous electric vehicles.

Companies and their shareholders will be the big winners from productivity improvements; the big losers will be the workers who are retrenched. Governments will need to budget for increased unemployment benefits or a basic income grant.

Governments will have to address the education of people who might never find employment but need to be responsible citizens.

Automation provides opportunities for governments to provide services more efficiently, thereby freeing up money for health and unemployment safety nets.

Autonomous Electric Vehicles

New vehicle manufacturing plants will be needed. Old plants which cannot be converted will become redundant. Import and exports of vehicles is going to change.

Oil producing and exporting countries are going to be devastated and need to diversify their economies. Oil importing nations will eliminate their most expensive import item. Within each country service stations and oil refineries will become redundant.

Fuel taxes will be eliminated and governments will need a new source of funding for transport infrastructure.

Yet more people will be retrenched and require a state safety net.

Global Inequality

In countries with large tracts of tribal / communally owned land, governments need to look at transferring ownership to those living on the land, as well as providing training and infrastructure for small scale farmers.

Governments need to find a means to increase taxes on the wealthy without frightening them abroad as happened in France when a steep wealth tax was introduced.

For companies there are opportunities to sell goods and services to the wealthy. These include up market properties, luxury cruises and exotic holidays, yachts and personal jets, art works and jewellery and other collectibles.

Globalisation

Improve global governance.

Agree a Common Vision

Depending on individual circumstances, each country and company will have a different vision of the future. The following is a list of topics that might be included in the vision.

Use existing statistics to predict the size of the population, the birth rate, average life expectancy, the number of people aged 65 and above. And the number aged less than 20.

Climate change is going to impact every country. Forecast which regions are going to be wetter and which dryer. Also which are going to be submerged by rising ocean levels.

From this you can determine whether the country is going to be able to feed itself and identify which areas will be food producing.

Predict the unemployment rate and whether there should be a basic income grant.

For most countries low cost, renewable energy should be a competitive advantage they seek. For developing countries the objective should be for all dwellings to have electrical power (probably not delivered via the grid) and clean water.

In a world of robotics and 3D printers, the vision should spell out what local manufacturing will take place.

Countries with minerals used in a renewable energy economy will want to develop mines.

For some countries tourism will be a priority.

Forecast the number of electric vehicles on the roads.

A common theme will be government that uses technology to be efficient, responsive and transparent; improved productivity will be key to releasing funds to pay for a basic income grant or other safety nets.

Prepare a Plan

The plan should list the steps required to navigate from the present situation to the vision.

Conclusion

In the past century mankind learnt to deal with marauding elephants and swarming locusts so I'm sure we have the ability to thwart the nine global forces. However, it's going to demand strong leadership, clear, informed thinking and an unprecedented amount of international, national and local cooperation. I hope we can pull it off.

In the next section I apply this methodology to South Africa; you can use it as a model for preparing a plan for your own country or company.

Blueprint for a Brighter South Africa

Ideally every country and major company should be preparing their own blueprint. This plan for South Africa is intended to provide an exemplar starting point.

Document the Present

The massive databases mentioned in the previous chapter are not available for South Africa. The following narrative documents what data is available in the public domain.

Population Change

In July 2017, Stats South Africa announced that the country's population was 56.52 million, up 902,000 since July 2016, largely as a result of improved HIV/Aids treatment for children. The fertility rate has dropped from 2.7 to 2.4 over the past decade while average life expectancy has increased from 62 to 64 over five years. The number of 15 to 34 year olds is declining, while the populations of the young and elderly are increasing.

The number of South African deaths per year has been steadily declining since 2006. In 2015, 9.6% of deaths were attributable to diseases of the respiratory system and 11% to non natural causes, including 6,300 deaths, mostly male interestingly enough, in traffic accidents and 7,118 resulting from assault. The Institute of Health Metrics and Evaluation lists South Africa's four main causes of premature death as HIV/Aids, violence, lower respiratory disease and road injuries. It's not clear from the numbers I have found whether there is a higher prevalence of diseases of the respiratory system in the polluted areas surrounding Eskom's coal fired power stations.

Climate Change

South Africa contributes 1.5% of global greenhouse gas emissions. While per capita emissions are only slightly above global averages, emissions per unit of economic value added are amongst the highest in the world. This is largely due to the reliance on coal-fired power stations, many of them using poor quality coal. Sasol's oil from coal plants and cement manufacturing are the other major CO2 emitters, along with the gasoline and diesel fuelled vehicles clogging the country's roads. Frequent veld fires further increase pollution and gases.

Climate Change – Briefings from South Africa by Bob Scholes, Mary Scholes and Mike Lucas records that South Africa is warming twice as fast as global averages and temperatures in the interior could rise by 3 to 6°C by 2100. The western interior will experience greater warming than the eastern interior or the coastal regions. As a result South Africa is likely to become drier in the west and wetter in the east with the Western Cape and the Kruger National Park experiencing the largest drops in precipitation. Crop yields are expected to decline on average. More flooding is predicted for the Eastern and Southern Cape. The frequency of flood and hail will increase. Already 98% of South Africa's water is allocated with more than 60% going to agriculture and a significant amount also to power generation. Cape Town is currently suffering water shortages, something Johannesburg and other major cities have also experienced in recent years.

The 2015 Paris climate accord, signed by the leaders of 195 countries, including South Africa, commits each country to taking action to hold the average global temperature to well below 2°C above pre-industrial levels.

Food and Water

South Africa has a land area of 121 million hectares of which 96 million are used for agriculture and 9 million for forestry. The government owns 14% of the land in South Africa. Some 10% of South Africa is arable, with permanent pasture 70% and permanent crops, such as fruit and vines, just 0.3%. South Africa is more or less food self sufficient but will need to continuously increase output to feed a growing population. Returns from farming are low, especially given the uncertain climatic conditions, and debt levels are high.

According to the South African Sugar Association, the South African sugar industry generates an annual estimated average direct income of over R12 billion and creates approximately 79,000 direct jobs, more than 11% of the total agricultural workforce in South Africa.

The South African Bureau for Food and Agricultural Policy calculated that about 17.5 million hectares have been acquired for indigenous farmers since 1994, equal to 21.2% of the 82.8 million hectares of farmland held in freehold. Later research by Agri Development Solutions and Landbouweekblad calculated that 27% of agricultural land is held by indigenous people. It is not clear if the new owners have full rights in the newly acquired land and can freely mortgage or sell it.

About twenty two million people live under tribal authority on the mostly government owned 13% of the country formerly known as the homelands and comprising Ciskei, Gazankulu, Kangwane, KwaNdebele, KwaZulu, Lebowa, Qwaqwa, Transkei, Venda, Bophuthatswana. Residents of these tribal areas are issued with occupation permits by the tribal authorities which have dubious legal status. Kwazulu, Transkei and Ciskei all fall within the area expected to see higher rainfall as a result of climate change.

South Africa's water resources are almost fully utilised with agriculture consuming 63% of the water and mining and electricity also being significant consumers. Domestic usage is about 12% and municipal consumption a further 14%.

People Movement

Stats SA's Community Survey 2016 records that the number of foreign-born persons living in the country declined from about 2,2 million in Census 2011 to 1,6 million, 2,8% of the population, in CS 2016. Proportionally, the Gauteng area around Johannesburg received most migrants, followed by the Western Cape. The countries where most South African immigrants originated are Zimbabwe (574,047), Mozambique (293,405), Lesotho (160,749), Malawi (78,796), the United Kingdom (56,412), Swaziland (38,038) and the Democratic Republic of Congo (31,504). There are also sizeable communities from India, Namibia, Nigeria, Ethiopia and Somalia. Ironically many of these migrants come from African countries whose rulers, aided and abetted by South Africa's own leadership, have decimated their countries' economies.

Urbanisation is taking place rapidly in South Africa, evidenced by the squatter camps growing on the fringes of the major cities despite efforts by the authorities to provide low cost housing. Stats SA's *Community Survey 2016* records that more than five million South Africans, mostly from the largely rural Eastern Cape and Limpopo, have moved to Gauteng and the Western Cape. Moving into a new dwelling or moving to be closer to friends and family was cited as the main reason to have moved.

The total number of households in South Africa has nearly doubled from 9 million households in 1996 to 16,9 million households in 2016. The average household size has decreased from 4.5 in 1996 to 3.3 in 2016. The overall proportion of households living in formal dwellings increased from 68.5% in 2001 to 79.2% in 2016. Households that own and have fully paid off their dwellings in 2016 had increased to 54.7% as compared to 41.3% in 2011.

Meanwhile, the number of agricultural households in the country decreased by 19.1% between the 2011 census and the 2016 community survey. The major contributing provinces to the decrease are KwaZulu-Natal (down 6.3%), Eastern Cape (down 3.5%) and Limpopo (down 2.8%). However, the highest proportion of agricultural households is still in the provinces of the Eastern Cape (27.9%), Limpopo (24.1%) and KwaZulu-Natal (18.6%).

Low Cost Renewable Energy

The *BP Statistical Review of World Energy June 2017* records that in 2016 South Africa produced 251 million tonnes of coal, 3.4% of the world total. According to the Chamber of Mines website, South African coal mines alone employed 77,000 people in 2016. These employees will need to be retrained in the skills needed for the renewable age or deployed to rehabilitate the environmental damage caused by the coal mining. The government will need to provide a safety net for those made redundant as coal mines close.

From an electricity standpoint South Africa is probably typical of many countries. Electricity is generated and distributed by a state-owned utility, Eskom. The bulk of the electricity is produced from coal with some nuclear and hydro and a small amount of renewables.

The *BP Statistical Review of World Energy June 2017* records that South Africa's 2016 electricity generation was 252 Terawatt-hours, up very slightly on 2015. Of this just 3.3 Terawatt-hours was solar, up 18.8% on 2015, and wind was 4.2 Terawatt-hours, up 35.6%. Another source recorded that during the highest periods of load-shedding from January to June in 2015, collectively wind energy and solar power saved the country R 4 billion. In addition many South African homes, including those of low income earners, are now fitted with solar hot water systems which have further reduced the overall demand for electricity, especially at the peak early evening period.

CSIR researchers have calculated that the cost of building new electricity generating plants in South Africa would be R 0.6 /kWh for either solar photovoltaic or wind; R 1.0 for baseload coal from an independent power producer (IPP); above R 1.1 for Eskom variable coal; and above R 1.2 for nuclear. The running costs of solar and wind systems are negligible whereas coal and uranium are major costs for the non renewables.

According to Eskom sources, South Africa currently has a peak requirement of 38 GW. Total Eskom capacity is 44.1 GW, while IPPs, mostly renewable, are committed to 5 GW. Analysis of the Eskom annual reports shows Eskom sells less electricity now than it did in 2007; over the past decade staff numbers have increased 50%; coal costs have tripled; and tariffs and revenues have increased fourfold.

Eskom is currently building the Medupi and Kusile coal fired plants which have a capacity of 4.8 GW each. At a possible combined cost of R 420 billion (US\$ 30 billion), the cost per MW is more than R 43 million even before the cost of purchasing coal is considered.

The 4764 MW Medupi coal-fired power station, situated near Lephalale in Limpopo province, has been under construction since 2007. Medupi, which is currently expected to be completed in 2020, may have a cost to completion of R 195 billion. The April 2007 budget estimate for the first six units of Medupi was R 69.1 billion. By September 2008 it had increased to R 88.5 billion, by May 2013 R 105 billion and by July 2017 R 135 billion. These numbers exclude flue gas desulphurization and plant interest during construction, both significant factors.

The 4800 MW Kusile coal-fired power station, close to Kendal power station in the Nkangala district of Mpumalanga province, has been under construction since 2008. Kusile won't be finished until at least 2022 with a possible cost to completion of R 225 billion. In April 2007, the Eskom board approved R 80.6 billion for the construction of Kusile, including the flue gas desulphurization plant but excluding interest during construction. This had increased to R 160 billion by July 2016.

To date South Africa has 55 renewable energy projects, of which 19 are wind farms that are fully operational, adding 2.94 GW to the grid, and thirty one solar PV developments totalling 1.34 GW. South Africa has five solar panel factories but three have closed because local labour costs made them uncompetitive with imports. The Western Cape is South Africa's only province with a renewable energy objective.

The 96 MW Jasper solar power plant, the largest utility solar PV plant in Africa, is located near Kimberly and commenced commercial operation in October 2014. The 5 MW array on the Mall of Africa near Johannesburg is the largest of South Africa's nearly 150,000 non-utility solar PV installations.

South Africa is a world leader in implementing CPV with the 100 MW KaXu Solar One, 50 MW Bokpoort and Khi Solar One concentrated solar thermal power stations operational and the Ilanga I, Kathu Solar Park, Redstone Solar Thermal Power Plant and Xina Solar One projects in the pipeline. Most of these projects have been developed by Independent Power Producers (IPPs), who contract to supply power to Eskom at mutually agreed prices. Construction times for these projects average less than two years and the electricity price agreed for the projects has declined 68% within three years.

Khi Solar One is a 50 MW solar power tower CSP plant, located in the Northern Cape. The KaXu Solar One, a 100 MW CSP plant near Pofadder, also in the Northern Cape, was commissioned in March 2015 and was the first CSP plant in South Africa to use parabolic trough technology. The 100 MW Xina Solar One, collocated with KaXu Solar One, is a parabolic trough CSP plant using molten salts. The Bokpoort 50 MW CSP plant north of Groblershoop in the Northern Cape incorporates 1,300 MWh molten salt energy storage facility, which will provide approximately 9.3 hours of thermal energy storage.

According to the South African Wind Energy Association, as of mid 2017 South Africa had nineteen wind farms comprising more than 600 wind turbines with a combined capacity of 1.47 GW. Some 3.365 GW of wind energy on 36 separate wind farm developments have been procured through the South African Department of Energy's Renewable Energy Independent Power Producer's Procurement Programme (REIPPPP). Some 98% of those selected have reached commercial operation on time. A total of 14,725 MW of renewable energy have been allocated to the REIPPPP. So far 6,377 MW of that has been procured over 6 bidding rounds and 3,029 MW is operational.

Also according to the South African Wind Energy Association, the price of wind energy in the last round 4 expedited was R 0.62 / kWh, cheaper than Eskom's average cost of supply at R 0.84 / kWh and more than 40% less than forecast prices for Kusile and Medupi. For each kilowatt hour of wind that displaces fossil fuels in the national grid, 1.2 litres of water will be saved. The entire portfolio of the REIPPPP programme will save 52 million litres of water each year.

Since 2013, the construction and operation of renewable energy projects has created 111,835 job years in South Africa. The REIPPPP is also stimulating local manufacturing and creating sustainable jobs. By March 2016 over R 30 billion had been spent on local content and a further R 65.7 billion is expected to be spent by projects that have yet to commence construction. Twelve new industrial facilities have been established as a direct result of the programme. According to a report by the

Council for Scientific and Industrial Research, wind energy produced net savings of R 1.8 billion in the first half of 2015 and was also cash positive for Eskom by R 300 million.

In an interview with EE Publishers investigative editor Chris Yelland on 4 August 2017, Energy Minister Mmamoloko Kubayi would not give any specific timeline for the signing of 37 duly procured renewable energy supply contracts from IPPs, which have now been delayed for over two years.

The development of new renewable energy projects by IPPs is constrained due to the 2007 determination by the Minister of Energy in terms of Section 34 of the Electricity Regulation Act 4 of 2006, which allows Eskom to be the sole purchaser of electricity. Municipalities, businesses and residential groups are thus precluded from purchasing electricity directly from IPPs or from residents or businesses with solar panels on their buildings producing a surplus to their needs. The City of Cape Town is challenging this interpretation of the act through the courts.

The inevitable result, if there are not significant policy changes, is that those that can afford to install stand alone solar systems will take themselves off the grid leaving the poor with the burden of paying for the expensive power provided by Eskom's coal fired plants.

Automation and Unemployment

South Africa's Quarterly Labour Force Survey for the third quarter of 2017 reported an unemployment rate of 27.7%. The number of people employed dropped compared to the previous survey as did the number seeking work. The 2017 South Africa Survey, published by the Institute of Race Relations, recorded that only 43.3% of South Africans of working age are employed. In similar vein to other countries, the employment rate for people with a tertiary education is 75.6%, while that for people with school leaving certificate as their highest level of education is only 50.3%. Of the 9.3 million unemployed people, 6 million are under the age of 35.

In South Africa more than 10% of teachers are classified as unqualified – and that's for teaching the traditional way. The number of teachers up to the task of teaching for a high tech future is likely to be small as will be the number of teacher instructors in the universities. Most will probably be younger teachers who grew up with cell phones and the Internet.

Automated Electric Cars

The *BP Statistical Review of World Energy June 2017* records that in 2016 South Africa consumed 204 million barrels of oil worth US\$ 10.2 billion or R 130 billion at US\$ 50 per barrel. It's not clear whether these numbers include the gasoline, diesel and jet fuel produced by the synfuels plants of Sasol and PetroSA.

According to OICA, South Africa produced 335,539 cars and 263,465 trucks in 2016. These were all powered by gasoline or diesel. According to AIEC, the automotive industry is South Africa's largest manufacturing sector, accounting for 33% of South Africa's manufacturing output in 2016, while the broader automotive industry's contribution to the GDP was 7.4%.in 2016 and accounted for R171.1 billion, 15.6%, of total South African exports. Many of the countries to which South Africa currently exports cars are those moving to electric vehicles.

According to the Chamber of Mines, South Africa produced 275 t of platinum valued at R 94 billion in 2015, some 88% of which is exported. In 2016 172,000 people were directly employed in the platinum mining sector. Most platinum production is used in the manufacture of catalyst convertors used in gasoline and diesel vehicles.

South Africa has one of the highest incidences of traffic accidents in the world, many of them caused by taxi drivers who disobey the rules of the road. Automated electric vehicles would cut congestion, reduce accidents and improve the air quality in South Africa's increasingly congested cities.

The South African government earns some R 55 billion a year from taxes on fuel.

Growing Inequality

Some 33% of South Africans live on less than US\$ 1.25 per day.

Anna Orthofer of Stellenbosch University has calculated that in South Africa the richest 10% own 90 to 95% of assets and earn 55 to 60% of income.

While the overall South African unemployment rate is 36%, it is 58% for under 34's. In the former homelands only 25% are employed so that the median monthly income there of R 2,600 is much lower than the R 4,500 median earned in the cities.

Back in the mid-1990's Guy Standing wrote a proposal for South Africa's new democratic government to implement a basic income grant but it was turned down on the advice of the IMF and the National Party Minister of Finance. Looking at the present disarray in South Africa's social grant system, current poverty levels, student unrest and a whole lot more, one can only conclude it was a major mistake. His proposal is included in a book co-authored with M Samson and published in 2003.

Identify Future Challenges and Opportunities

Population Change

A declining birth rate means there will be fewer children to be educated but also that fewer people will be entering the workforce. More people living longer means more financial, medical and social support required for pensioners. Ongoing automation will reduce the number of people who need to be employed. Closure of coal fired power stations and elimination of petrol and diesel fuelled vehicles will improve air quality and improve the health and life expectancy of those living nearby. Automated vehicles will reduce the number of road accidents and associated deaths and injuries. The government and companies will need to make actuarial calculations and decide on pensions, retirement age, and health and education budgets.

Climate Change and a Degraded Environment

Some areas will become drier and others wetter. In the dry areas, such as the Western Cape, irrigation methods will have to improve and there might be opportunities to build desalination plants and dams. Wetter areas will be the future breadbaskets and need to be efficiently farmed in order to feed a growing population; this might be better done if land is not communally owned.

Looking at other areas of the world impacted adversely by climate change could identify opportunities to enter new export markets.

Residents will need to be relocated from low lying areas. Dykes and sea walls will provide employment for construction companies. Tree planting and rehabilitation of polluted areas will provide employment.

Plastic litter is a major problem in South Africa, causing further degradation of the environment.

People Movement

Climate change in neighbouring states could increase immigration, while individual land ownership in rural areas could lead to slower urbanisation. To the extent that South Africa can improve the governance and quality of life in adjacent countries, this could slow the flow of immigrants.

Increased tourism, particularly by the wealthy, is an opportunity for South Africa though increased carbon taxes on airlines could cause air fares to rise.

Low Cost Renewable Energy

The winners in the low cost renewable energy economy will be the owners, builders and operators of renewable energy facilities, as well as the companies mining and producing the metals needed. While renewable energy will create jobs in the short to medium term, the number of jobs will drop off sharply as South Africa achieves 100% renewable energy capacity.

The loser will be Eskom together with companies mining and exporting coal and uranium or importing natural gas.

Eskom will need to implement a smart grid. The government will need to explore new means for charging for electrical power.

Mass Data Mining and Storage

Artificial intelligence and massive databases provide scope for governments and companies to reduce costs and improve strategic intelligence.

Automation Based Unemployment

Companies and their shareholders will be the big winners from productivity improvements; the big losers will be the workers who are retrenched. The government will need to budget for increased unemployment benefits or a basic income grant.

The governments will have to address the education of people who might never find employment but need to be responsible citizens.

Automation provides opportunities for governments to provide services more efficiently, so freeing up money for health and unemployment safety nets.

Autonomous Electric Vehicles

New vehicle manufacturing plants will be needed. Old plants which cannot be converted will become redundant. Imports and exports of vehicles are going to change.

South Africa will no longer need to import oil, the country's most expensive import item. At the same time, service stations and oil refineries will become redundant.

Fuel taxes will be eliminated and the government will need a new source of funding for transport infrastructure.

Global Inequality

The government needs to look at transferring ownership of communally owned land to those living there, as well as providing training and infrastructure for small scale farmers.

The government needs to find a means to increase taxes on the wealthy.

For companies there are opportunities to sell goods and services to the wealthy. These include up market properties, luxury cruises and exotic holidays, yachts and personal jets, art works and jewellery and other collectibles.

Globalisation

The government needs to work with other governments to improve global governance.

Agree a Common Vision

In 2030 South Africa will be home to a population of seventy million people, of whom 25% will be over the age of 65 and 20% will be younger than 20. The birth rate will have dropped to 2.2 and life expectancy will have risen to 70 years. The number of immigrants will have been reduced by a further 50%.

The government will use technology to be efficient, responsive and transparent. The number of government employees will have halved.

Climate change will have led to average temperatures being higher. The interior of the country and the Western Cape will be drier while the Eastern Cape and KwaZulu Natal will be wetter. No low lying coastal areas would have become submerged but beaches along all the coasts will have eroded and port facilities will have been upgraded to cope with storm surges.

The country will continue to be self-sufficient in food. The Western Cape will have adopted minimal water irrigation systems, while the Eastern Cape and KwaZulu Natal will have replaced the interior as the bread basket of Southern Africa. Small scale farming will predominate in these areas.

The unemployment rate will have risen above 50%. A basic income grant paid via cell phones will be funded by streamlined government operations, higher taxes on the wealthy and the elimination of other grants and payment of intermediaries.

Low cost, renewable energy will give the country a competitive advantage compared to countries which have been tardy in replacing carbon and nuclear power plants. All dwellings will have access to electrical power, much of it via stand alone domestic solar PV, and clean water. 50% of vehicles on the road will be electric.

Coal and platinum mining will have been replaced by mining and exporting minerals and metals used in the renewable energy sector.

A range of small business will use robotics and 3D printing to manufacture products using imported designs.

The wealth gap will have closed with the GINI coefficient improving by 10%. Crime levels will have halved.

Prepare a Plan

Basic Income Grant

Poverty and unemployment are the biggest challenges facing South Africa. The situation is going to get worse as automation bites further and exports of cars, trucks, coal and platinum dry up. The government needs to act promptly and start paying a basic monthly income grant to all South African residents.

With 30% unemployment; 16 million on social assistance; millions caring unpaid for children, the elderly and the infirm; students not making ends meet; and increasing numbers displaced by automation, this would meet a basic need through a period when we can expect rapid change.

The grant would be paid directly into recipient bank accounts or into M-Pesa type systems on cell-phones. There would be no need for Net1, the Post Office or any other expensive intermediary. Biometric recognition software on smart phones would ensure the correct recipients are paid.

The grant would be funded through a much reduced bureaucracy; eliminating other subsidies and grants; higher income taxes; and taxes paid by retailers benefiting from the added consumer spending.

The grant could also lead to lower crime levels, reduced domestic violence and elimination of beggars on street corners. The indigent would no longer have the indignity of means tests or compulsion to join the bakkie brigade. Artists and entrepreneurs would have a safety net.

Land Ownership

The South African government is already transferring title of township houses to those living in them. However, at the same time, title to the housing and land in the former homeland areas should be transferred to those living and working there. The new owners would have full freehold rights. They would be able to mortgage their properties in order to raise funds for improvements or to start a small business. They would have the incentive to upgrade their properties. They would also be free to sell and move to a better life in the city.

One of the reasons for the poor standard of education and healthcare in the rural areas is that teachers and medical staff are unable to buy land, build houses and live in the communities they serve. Instead they have to commute from the nearest town or use the cramped living quarters provided at the rural hospitals. Once the land is privately owned they would be able to buy land and raise families who would use the schools and hospitals where they work. Similarly schools would be able to purchase land which could be used for boarding establishments.

In like vein entrepreneurs would be able to buy land so they set up rural businesses, thereby giving locals access to convenient retail facilities. New world class tourism facilities could be established along the shore providing employment and incomes for the people of the region.

Farmers, too, could consolidate properties to create successful farms on some of South Africa's richest soil in one of the areas least likely to be impacted by climate change. They would provide a valuable source of nutrition as the country's population grew and climate change ravaged other parts of the country. SMS and smart phone technology could be used to provide agricultural extension services to novice or small scale farmers.

Health and Care

The world is short of medical staff as is South Africa. However this needn't be the case. Each year hundreds of high school matriculants with outstanding marks are turned away from medical schools. Qualified doctors have to work excessively long hours in the state system after they graduate and they can wait years before getting registrar posts so they can specialise.

The government needs to urgently examine where the bottlenecks exist in medical education. Instead of forever butting heads with the private medical sector, the health department should be cooperating with them. Some of the training of doctors and nurses should be allowed to take place in private facilities. Wherever possible, technology should be used both during training and while in practice.

Each year South Africa loses valuable medical staff to North America, Europe and the Middle East. Instead South Africa should be looking to treating overseas patients in South Africa. The fees they pay would help to subsidise the care provided to the poorer local communities. The government should also join international efforts to force countries poaching trained staff to compensate the countries they raid.

Tourism

Tourism provides huge potential for economic growth and employment. However as a first step the government needs to streamline the issuing of visas to potential visitors to South Africa.

North America, Europe and Japan all face ageing populations and shrinking pension pots. This provides a unique business opportunity for South Africa to use its competitive advantages of sun, low cost carers and weak exchange rates to create a booming new service industry. Retirees would be able to play golf and bridge, lounge on the beach and enjoy the local cuisine. Every couple of days they could Skype with their family members left behind. When the winter gales strike, they could flee north for a month or so of sponging off relatives and old friends. Life would be blissful. Already Somerset West, just outside Cape Town, is reputed to have the largest German speaking population of any city outside Germany and Austria.

For many pensioners, the ideal holiday is a cruise to an exotic location. South Africa should build world class cruise ship terminals in Cape Town, Port Elizabeth and Durban with excursions to the hinterland of each port. Intercity passenger rail services should be upgraded so visitors can travel overland from Gauteng to join their cruises.

The large numbers of foreign entrepreneurs and academics spurned by Europe and the USA provide another opportunity. In South Africa they could attend international conferences without restrictions. Some might even want to stay on, teach at South African institutions or set up international businesses.

More beach resorts could be built along the Transkei and Ciskei coasts. Across the country disused railway tracks, such as those of the Apple Express, the Kat River citrus line and the line from Queenstown to Tarkastad, could be converted to cycle paths allowing South Africa to provide cycle touring in competition with Europe.

A growing tourism industry is going to need well qualified staff. Priority should be given to recruiting and training staff to world class standards. South Africa is also well placed to provide training for the airline pilots and cabin staff that are going to be needed in the growing African tourism sector.

Pander to the Wealthy

South Africa is already the headquarters of one of the world's foremost luxury goods companies. In addition to providing five start tourism opportunities for the world's wealthy, South Africa should focus on the manufacture and sale of luxury items, including yachts, to the international community of superwealthy.

Electrical Power

Renewable electric power provides the country with huge economic and environmental benefits. The time is ripe to use South Africa's unique features to lead the world in low cost renewable energy.

As a first step, the government should cancel the Medupi and Kusile projects. They are costly white elephants that simply add more CO₂ to the atmosphere. South Africans cannot afford them and those with the means will simply install their own stand alone solar systems leaving the poor to pay the exorbitant tariffs Eskom will need to charge to cover the capital, finance and running costs of these behemoths.

At the same time the government should accelerate the installation of solar and wind projects by IPP's with the objective of ensuring that by 2030 the electricity supply is 100% renewable. In parallel the government should promote small scale solar projects, especially for home owners and locations remote from the grid. Building standards should be revised so that all new homes have solar PV and use low energy, CO₂ absorbing Solidia cement. The new higher quality jobs created through this program will more than offset low skilled job losses incurred in coal mining and burning. Existing renewable energy manufacturing facilities should be expanded so renewable energy infrastructure can be exported to Africa and beyond.

Meanwhile Eskom's transmission infrastructure should be spun off to create a focused smart network operator run professionally by smart young electrical engineers. The rump of Eskom should be downsized leaving it with the role of efficiently operating and gradually closing the coal fired power stations and Koeberg. The coal mines should be closed and the retrenched mineworkers redeployed on mine rehabilitation and renewable energy projects.

The air quality over Gauteng, Limpopo and Mpumalanga will improve leading to fewer deaths from PM_{2.5} and respiratory diseases. Water quality and availability will also improve in the areas downstream of the coal mines and power stations.

Universities should prioritise researching the building of low cost smart high rise homes for the poor which are energy efficient.

Transport

Electric vehicles are the future and provide the opportunity to create a transport system that is efficient, low cost and non-polluting. It will also result in the elimination of crude oil imports, a reduction in pollution and noise levels in cities and lower transport costs for all. The government needs to provide incentives for the manufacture and ownership of electric vehicles.

The redundant Mossgas gas to liquids plant should be closed and plans for a new state refinery and for fracking should be abandoned. At the same time the CEF group of companies should be liquidated; they are inefficient, corrupt and have no role in a renewable energy economy.

Exports of gasoline and diesel powered vehicles are going to drop sharply in the years ahead. The government should provide incentives so that the vehicle manufacturers convert their factories and start mass producing and exporting electric cars. To facilitate the process further, the government should stipulate that all government vehicle purchases after 2022 will be electric vehicles and set a deadline of 2025 for ending the sale of gasoline and diesel power vehicles.

Over time taxes on transport diesel should be raised so freight moves to a newly streamlined electric train system. The metros should be given full control of their local train and bus services so they can optimise the services they provide.

Privatisation

The government should focus on facilitating business, not running companies in competition with the private sector. All parastatals including SAA, Telkom, Denel and the Post Office should be privatised. The only parastatals remaining should be monopolies providing a probably loss making essential service. The railways, ACSA and the smart grid all fit this category.

While the SABC provides free radio and TV services to all, it is likely to be overtaken by technology before too long at which stage it can be closed down.

Mining

South Africa's mining sector faces two major threats. In a world of renewable energy and electric cars there will be no market for coal or platinum. Instead South Africa needs to focus on providing the minerals needed in a high-tech, renewable energy economy – vanadium, lithium and copper.

The second major threat is automation. As manpower costs rise and the capital cost of robot mining equipment reduces, the time is going to come when it is cheaper for the mines to automate. Robots aren't unionised and can work twenty four hours a day in terrible conditions without a break.

Education

Educating South Africans for the brave new high tech world is a major challenge. As a first step the country should raise rather than lower education standards and deploy the best of Finnish, Slovenian and Singapore education practices. In order to take best advantage of technological innovations in education, the government should tap into the glut of highly qualified, tech-savvy young teachers in North America and Europe who are unable to find jobs in schools there.

Information Technology

The government should facilitate the roll out of fibre broadband, free wi-fi and cheap cellular data services by the private sector so that everyone can afford a smart phone and fast Internet access. By 2020 every adult should have a smart phone with biometric identification features.

In the sections that follow I propose a number of government websites which should be easy to develop and populate. All government websites should carry advertising in order to pay for their development and running costs. Initially the government could use Google's AdSense but in the medium term a South African solution should be sought. The crowd of citizens and taxpayers should be encouraged to make active use of the government websites to hold the government to account.

The government should seek ways to tax the revenues generated in South Africa by the major social media networks as well as for all the data they export to the cloud.

Crime Prevention

The police should provide a crime reporting app so that victims can report details, including GPS coordinates, to the police using their smart phones. This will be much more efficient than the current method where police constables laboriously write out statements and open paper files which might well be promptly closed as soon as the victim has left. The victim should be able to access a secure website to follow the progress in solving the cases they have reported.

The crowd would be able to view the date, time, GPS coordinates and nature of all crimes as part of ensuring that the police are doing their job.

Cars would be required to have a SIM card embedded in them. As soon as a crime has been reported, the police would be able to use an interface to the cell phone company databases so police could quickly identify cell phones and cars close to the location of each crime.

Responsible Government by the People for the People

South Africa's constitution, developed before the advent of the Internet, and legislation should be amended to comprehend current and future technology changes, as well as to make representatives more accountable to the electorate.

The electoral system should be changed so that parliamentarians are responsible to voters and not to party and president. This can be achieved by amending the constitution so that members of parliament represent constituencies with nominated members ensuring proportional parity.

The government should also prepare for the day when everyone has a smart phone with biometric recognition software to verify the user of the phone. Voters would be able to use their phones to elect representatives or vote in a referendum.

Civil servants are just that, servants of the people, paid for by the tax payers. The government should create a website which shows the name, title, qualifications and remuneration of every representative and employee at the national, provincial and local levels. The crowd will use the website to identify nepotism, ghost workers, fraudulent qualifications and unqualified appointments.

The government should start appointing people who are competent and honest to positions of responsibility. All appointments to positions in government earning more than R 500,000 per annum should be widely advertised and the CVs of the applicants posted on the government website where they can be viewed by the general public. A public blog would allow people to point out irregular appointments they identify.

All managers within the civil service should be required to post a monthly progress report on the government website. A blog will allow the crowd to comment on performance or lack of it on the part of each manager.

All government and parastatal tenders should be advertised on the government website. Tender proposals submitted should be published on the website immediately after the closing date but before the tender is adjudicated. This will allow the general public to check that the best contractors are appointed.

Details of all items of government expenditure greater than R 20,000 should also be published on the government website. The data will be provided by the banks that run the government's bank accounts

to ensure the information is not manipulated before being posted on the website .Likewise details of all loans and investments made by the DBSA, IDC and the Land Bank should also be published on the government website.

Finally the government needs to govern in a way that is inclusive and not adversarial, setting one South African against another, as happens right now.

Foreign Policy

The government should adopt a clear foreign policy based on human rights and support for the undertrodden in Africa and abroad. As part of this program, the policy should aim at improving conditions in countries from which migrants flee to South Africa.

Implementing the Plan

Distributing this plan through the Internet is the first step in achieving the vision for South Africa in 2030.

Afterword

People everywhere, by and large seem, completely oblivious to the nine global trends and their implications for society. Our political leaders seem incapable of understanding let alone addressing any of these. Maybe it's time ordinary people started telling politicians what we want so they can include our ideas in their manifestos before we vote.

Earlier this year I had the privilege and the pleasure of meeting with a very special group of twenty young South Africans. They had all grown up around Zithulele in South Africa's very rural Eastern Cape, an area distinguished for being one of the worst performing school district in the country. Each school day they had ventured forth from homes with no electricity or plumbing to walk several kilometres to schools where classes of a hundred or more were not exceptional.

Now they are part of the first cohort from the district to have moved on to study at some of South Africa's leading universities. It was fascinating to hear them talk about the transition to life in the big city, mixing for the first time with people from diverse backgrounds. Some planned to be actuaries and lawyers, others teachers or engineers. All wanted to give something back to the community they came from. All were brightly optimistic about a better future. How can we give them that?

This book outlines my analysis and plan for giving them – and my grandchildren – a better future. I hope that you will be stimulated enough by what you have read in this book to use the blog on my website to build on my ideas and add your own. Most of all I would like to hear what the young people of this world, like that cohort of twenty, have to say about their vision and wishes for our future.

Brian Paxton

Brian Paxton is a doting grandfather who has led a varied and interesting life. He was born and grew up in Queenstown, a small farming town in South Africa's rural Eastern Cape. He studied at the University of the Witwatersrand in Johannesburg and qualified as a chemical engineer. While studying there he became fascinated by computers, then in their infancy, so after working in a local data processing department for eighteen months, he ventured abroad and completed a masters degree in systems at England's Lancaster University. Later he qualified as a cost and management accountant.

During the next twenty years he worked on Information Technology projects for a consulting company outside London, England; for the electricity and gas utility in Vancouver, Canada; and for Mobil Oil, now part of ExxonMobil, in Cape Town, New York and Melbourne. In 1991 he returned to South Africa and was appointed chief financial officer of a local listed oil company.

In 1995 with a group of colleagues he founded MBendi Information Services which ran Africa's largest and oldest African business website for more than twenty years. As part of the services provided by the company, Brian authored regular E-mail newsletters on the theme *Signposts to 2020*, which aimed to stimulate the thinking of a large international audience about where the world was headed. More recent newsletters can be found on his website musings.world and were the inspiration for this book.

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