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MOTT
MACDONALD

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Under

The year is 2050 and
global temperature rise
is being kept below 2°C.
This is how.

mississippi

mississippi

Apocalypse

no

The 195 countries that signed the Paris Agreement in December 2015 believe that it's possible to keep climate change in check.

They committed to curb emission of greenhouse gases, to prevent global temperatures exceeding the pre-industrial average by more than 2°C – and they set an aspirational limit of 1.5°C.

This is a story about the range of steps needed to achieve a sub 2°C future. We know it can happen.

So we're setting the journey out as if it's a diary of events – humanity's achievements up to 2050.

Power in your hands

There's no one way to prevent runaway climate change. That's a point demonstrated by the Global Calculator, a modelling tool developed by the UK Department for Energy & Climate Change (now Business, Energy & Industrial Strategy) in 2015. The calculator enables you to test different carbon-reduction options and strategies, and see what impacts they'll have. It draws on comprehensive carbon and climate data, so producing a sophisticated picture of how your choices affect the world.

Search 'Global Calculator, Mott MacDonald' to view the pathway we developed to a climate-stable future. It's environmentally sustainable, technologically advanced, economically prosperous and affordable.

100,000

years ago: Homo sapiens shares the planet with at least six other human species

70,000

years ago: cognitive revolution

12,000

years ago: agricultural revolution

500

years ago: scientific revolution

250

years ago: industrial revolution

2015

We arrive in the early 21st century thanks to a series of momentous changes. You could say our species has been made by change, and is equipped to change.

Throughout history the pace of change has increased exponentially, to the point where, by the start of the 21st century, change is constant, with the digital revolution driving profound alterations in work, family interactions, social networks, transport, production and consumption, and global politics. Change hasn't always been comfortable, yet it has been inevitable.

In the face of potential climate catastrophe, it is clear that politicians, investors, corporations and society have to embrace this and consciously choose the direction of change, advancing solutions to build resilience against unavoidable climate impacts and curb further emissions. Doing so will be good for everyone!

Addressing climate change doesn't have to be about prescription and restriction. It can offer economic and social growth, protect production and consumption, and create new industry and employment.

Acting to curb emissions and build resilience creates new economic and social opportunities.

We must get on with it. Fast!

2015-2020

Momentous start

On 12 December 2015 the Paris Agreement is signed, the result of huge diplomatic and international efforts over 25 years. The agreement is ratified and comes into force on 4 November 2016. By mid-2018, all signatories have enacted more than 1500 climate policies and laws. It signals a major move towards renewable energy and significantly reduced reliance on fossil fuels.

Out with the old

Britain, China, France, India, Norway and others announce their intention to phase out internal combustion engine (ICE) vehicles. Automotive industry investment in alternative fuel vehicle (AFV) technology rises swiftly, outstripping investment in ICEs within a decade.

End in sight

On 22 April 2017 Britain goes a full day without turning on its coal-fired power stations, for the first time in more than 130 years. UK carbon emissions for the year are the lowest since 1890. At the COP23 climate negotiations in November 2017, 19 nations agree to stop using coal for power generation by 2030.



Wake-up call

Investors and insurers begin to demand that companies they lend and provide cover to must disclose the risks they face from climate change, and the potential financial impacts of climate-related events. They commit to divest from companies that are exposed. It is a powerful wake-up call, forcing action on building climate resilience and minimising carbon emissions.

Free electricity

With strong and consistent wind on 1 November 2017, Germany generates so much renewable electricity that it is delivered free of charge to consumers.



Coping with growth

By 2020 major cities and listed companies have put a decarbonisation strategy in place to shape infrastructure growth, investment planning and urban development.

Exponential change

Renewable energy production doubles in these five years, with solar doubling every 30 months. The cost of battery storage falls by 90%.

Peak emissions

Carbon budgeting is included in corporate and national policies, while a global carbon tax incentivises governments and businesses to cut emissions. International carbon pricing and trading is established, with a price of US\$75-100/t.

Lid put on plastics

Thanks to the BBC's primetime TV series Blue Planet, plastic waste is recognised as a global environmental health hazard and a scandalous misuse of resources. With total global production estimated at more than 8bnt since the 1950s and with a 1:5 ratio of plastics to fish in the sea by weight, environmental and resource pressures drive negotiations to curb and ultimately cease production of disposable plastics.

Strategic switch

With 4M electric vehicles (EVs) on the road globally, oil and gas firms recognise the challenge to their business from EVs and battery manufacturers, and step up the pace of their diversification into renewable power generation, power storage, and charging infrastructure for EVs.





Cogs start turning

Lloyd's of London, September 2015: Mark Carney, head of the G20's Financial Stability Board, gave a landmark speech to insurers highlighting in stark terms the risks of climate change to investors, insurers, financial stability and the global economy.

"Climate change is the tragedy of the horizon," he said. "We don't need an army of actuaries to tell us that the catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix."

Carney's highlighting of potential economic and financial catastrophe gave sharp focus to data from the World Economic Forum, which year upon year reported extreme weather as the leading cause of financial losses suffered by companies, economies and societies across the world.

Climate change is driving the increased frequency and severity of extreme weather events, as well as long-term changes to the Earth, such as temperature rise itself, ocean warming and acidification, and sea-level rise. Achieving the Paris Agreement will keep global warming under 2°C, averting catastrophe. But dramatic change cannot be avoided, due to the 'locked-in' effects of past emissions.

Major losses will continue unless very significant capital can be mobilised for investment in resilience.

Looking at the big picture, there is strong logic for investing in resilience. Businesses and economies rely on strong asset systems and supply chains, and a secure and stable society, which provides both customer base and workforce. It is recognised that resilience supports growth and prosperity.



Despite this macroeconomic justification, standard responses to the losses caused by severe weather events are focused on disaster relief, repair and recovery, rather than prevention. This strategy is inadequate in the face of worsening impacts – estimated to cause US\$1trn of losses a year by the 2030s, if unchecked.

Forward-looking organisations have started to address physical risks to their assets with protection and adaptation measures, but remain vulnerable to wider risks posed to their supply chains, workforces and customer base. Damage and disruption to any of these could severely harm business continuity.

Building resilience involves more than investing to protect individual assets and companies. It demands an approach that deals with assets, supply chains, habitats and society as a whole – it requires the creation of ‘community resilience’.

The scale of investment needed to achieve this is huge. The Asian Development Bank calculates that the cost of making new infrastructure low/no carbon and resilient against climate impacts adds 15% to the capital cost. Added to that is the colossal investment needed to decarbonise and protect existing infrastructure. But studies show that the rate of return for creating such resilience, so avoiding both direct and consequential losses, is between 4:1 and 11:1.

The question is: Who will pay?

A culture shift is needed to incentivise the investment of available capital in resilience.



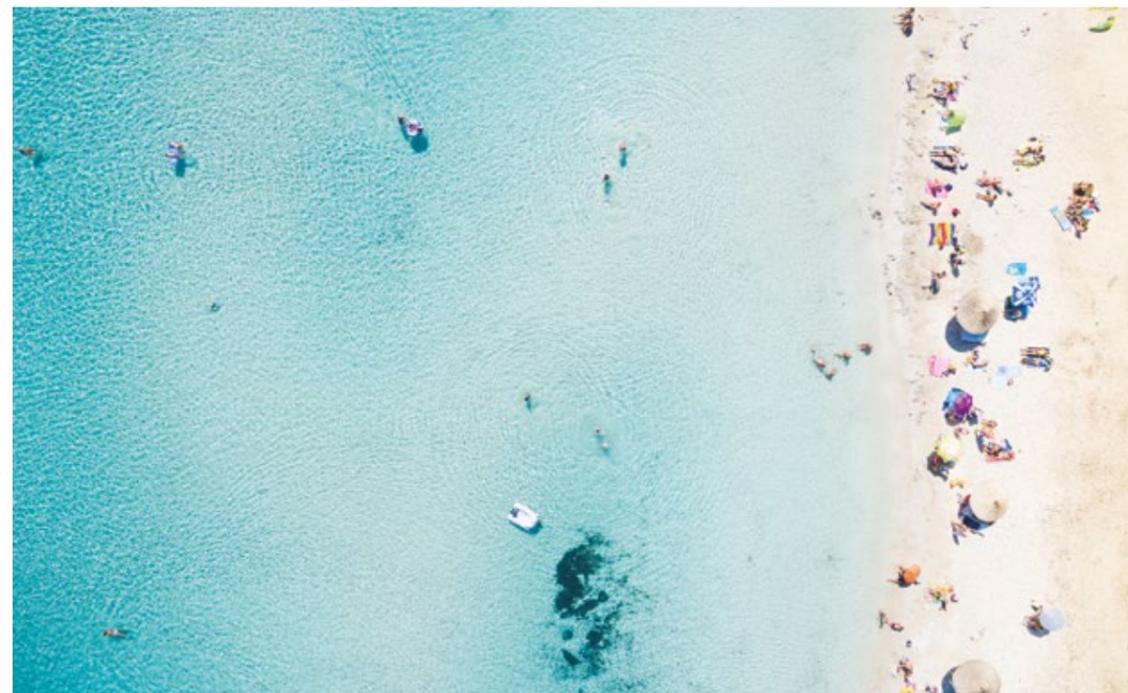
2021-2025

Large-scale sinks

International funding institutions and donors start large-scale investment in reforestation, and smart agriculture practices that replenish soil. Forests and soil act as carbon 'sinks', physically locking up carbon. It is as much about halting the release of embodied carbon into the atmosphere as capturing atmospheric carbon. Smart agriculture ultimately eradicates carbon-intensive fertilisers and reduces waste, while reforestation has the potential to remove 100bntCO₂ by the end of the century.

Dialling down atmospheric carbon

Trials begin on bioenergy carbon capture and storage (BECCS) – plant crops grown for fuel absorb atmospheric carbon; when burned to produce energy, CO₂ is extracted from emissions and locked away. BECCS ultimately delivers 100-500MtCO₂ of sequestration each year.



Emissions peak

As part of the Paris Agreement every country agreed to make a 'nationally determined contribution' to reducing global emissions, with progress assessed and new targets set every five years. Awareness that the first global stocktake won't be good enough leads to civil society and business action to drive a more ambitious response. This halts the further rise of global carbon emissions and starts the turnaround to net zero.

Food for thought

Agricultural innovations pioneered in the Netherlands and piloted in the developing world in the 2010s unleash a productivity revolution, cutting consumption of water, nutrients and pesticides while increasing yields per hectare beyond the wildest dreams of hitherto subsistence farmers. The gains are so dramatic that farms in the developed world are forced into action to stay competitive.

Financial lockdown

The financial and insurance industries refuse to touch carbon-intensive industries and projects, resulting in rapid transition to low-carbon technologies and withdrawal from carbon-intensive industries.

Home economics

Large-scale uptake of energy efficiency measures paves the way for 40-50% reductions in emissions from domestic and industrial sources, with smart technology, smart metering and thermal efficiency playing key roles. In the building and infrastructure sectors, rapid advances in low-carbon design and construction, and design for adaptation, reuse and disassembly contribute to capital carbon reductions of 30-40%.



Walking on sunshine

Global solar power capacity nears 900GW. Successful commissioning of large-scale tidal power pilot projects demonstrate the financial and technical robustness of the technology, paving the way for tens of gigawatts more tidal power worldwide.

Levelled field

Fossil fuel subsidies in the order of US\$700bn (direct) and US\$5trn (indirect) are redeployed to renewables and R&D into zero-carbon technologies. Fossil fuel subsidies cease altogether by 2025.

Hurdling barriers

Organisations and governments across the world recognise the behavioural, political and economic barriers that drag back action on climate change. They act rapidly to remove them, accelerating the uptake of new technologies.



Incentives and mechanisms

It has long been clear that development budgets and governments' emergency funds cannot meet the challenge of creating community resilience. To secure the trillions of dollars needed, the private sector must get involved.

Attempts to leverage private capital have been made, using donor and government funding as seed capital, but this only works for projects offering a 'conventional' commercial return. Private sector investment has been limited and far short of what is needed to address the climate change agenda.

However, a new mindset is emerging. Mark Carney's 2015 'tragedy of the horizon' speech triggered creation of the Financial Stability Board's Taskforce on Climate-related Financial Disclosure (TCFD). In 2017 it recommended that organisations report on climate-related financial risks, with the first disclosures expected alongside financial reports in 2019. Headline risks are:

- Ability to transition to a low-carbon economy, in line with the Paris Agreement – and exposure to regulation and legislation, litigation, reputational harm, reduced market share and loss of share price.
- Physical resilience to the impacts of climate change – and exposure to the costs of repairs and legal action, harm to supply chains, lost productivity, and disruption or loss of markets.

The primary purpose of the TCFD is to protect capital, but is expected to bring wider benefits by turning climate liabilities into financial liabilities, that must be managed. Banks, investors and insurers say they will 'vote with their feet', prioritising organisations aligned with a 2°C future, and withdrawing from those that aren't.

Because the global economy involves complex financial, physical, social and environmental connections and interdependencies,

the management and mitigation of climate-related financial risk is far-reaching. It effectively involves building community resilience spanning advanced and developing markets.

This requires unprecedented collaboration between public and private sectors, and between corporations. Governments and donors have a role to play, using their funds to kickstart projects by taking initial technical and performance-based risks. With the private sector then providing refinancing and reinvestment, the seed capital can be repaid and recycled into the next project, creating a virtuous cycle of resilience investment.

It is a challenging agenda but one that will yield financial and social benefits – a double resilience dividend.



2026-2030

Homeworking

Ongoing exponential development of digital technology and changing employer and employee expectations reduce commuting and work-related travel, and enable professional companies to cut office space per person by up to half, relative to 2015.



Food critics

Climate events highlight the global interconnections and dependencies in the food supply chain. Annual losses from weather and disease peak at 40% in the mid-2020s. Governments and the private sector act to cut food losses by half through better crop science, supply chain resilience, and improved land use. The results: fewer food transport kilometres, improved food security, and alleviation of poverty.

Paying the price

Legal action by citizens' watchdogs against some oil and gas companies results in the first penalties, amounting to billions of dollars. The fossil fuel giants are held responsible for their role in causing climate change. Slow action to curb carbon emissions is presented as a failure in their corporate duty of care to society and the environment. Fines are channelled into building resilience against the impacts of climate change.

Overtaking manoeuvre

By 2026 new car sales have peaked at around 60M a year. Two thirds are alternative fuel vehicles. Driven by the commitment of major motor manufacturers to phase out internal combustion engines, dramatic improvements in fuel cell energy density have been achieved and new power sources developed. Battery-powered road freight is commercially viable.

Electric trains and planes

The world's railways are almost all electrified. Rapid expansion of high-speed networks and better reliability see passengers choosing rail over short-haul air travel. Hybrid planes are in the skies and fully electric flight is edging towards reality.

Diverse is beautiful

The renewable power revolution has been matched by dramatic changes to transmission and distribution, storage and energy trading. Large-scale centralised generation is giving way to smaller, diversified and localised production, giving communities in developing nations unprecedented access to power. Centralised grids have been restructured to cope with the very different loads and flows – portions of it have been rendered redundant and taken out of service. Some industries and settlements are served by independently operated 'microgrids', which give remote communities access to electricity for the first time. Installed chemical battery storage capacity has been doubling every 2.5 years, leaping from 300GWh in 2026 to 1.2TWh in 2030. Rapid growth of pumped hydro, compressed air, flywheel and hydrogen storage boost capacity significantly further. The new grid structure has cut transmission losses by half.



Out with the old, in with the new

China leads 160 other countries in closing coal-fired power plants. Wind, solar, hydro, tidal and nuclear power fill the gap.

Reduced, reused, recycled

Legislation is introduced requiring that all new products are completely reusable, recyclable or biodegradable.

Show and tell

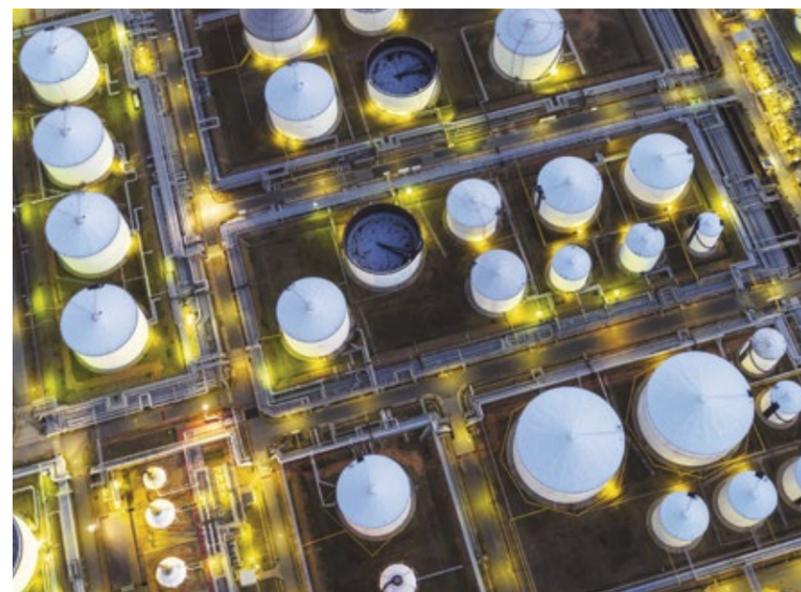
The fourth round of nationally determined contributions to reducing global emissions and the second global progress check in 2028 ratchet action and become the focal point for the sharing of international best practices. Disclosure drives renewed global commitment to carbon pricing, helping to drive down global emissions from industry, transport and agriculture, as well as power generation. Global carbon emissions are now in decline, down from 40Gt CO₂/year in 2020 to 24Gt, approaching 1990s levels.



2031-2040

When change is good
Resilience to climate change in developing countries, the introduction of smart agriculture and climate-resilient crops, and efficient water resource management improve crop yields, offering a tenth of the world's poorest people better economic prospects.

Back to nature
The rewilding of former farmland and pasture, which saw an area roughly the size of Britain handed back to nature each year in the 2010s and 20s, steps up several gears through the 30s.



Heated topic
Thermal energy transfer and storage is increasingly mainstream for large developments, particularly involving mixed building uses and infrastructure. Excess heat from metro stations, IT servers or industrial operations warms homes, hospitals and workplaces. Where used, it cuts primary energy demand for heating and cooling by 25-40%. A new breed of energy services companies has grown to provide the financial and technical know-how.

Around in circles
Awareness of global resource constraints moves the economy away from 'take-make-dispose' to a circular model. It is characterised by resource efficiency, reuse and recycling. Modular design allied with additive manufacturing/3D printing allows products, buildings and infrastructure to be adapted, maintained, repaired and upgraded with ever greater ease and reduced environmental and financial cost.

Scandinavia wins
Having set out their ambition 15 years earlier to become net zero carbon by the 2030s, the Scandinavian countries achieve their goal through a combination of clean energy and mitigation. The race is on to claim second place.

Exit oil
The absolute dominance of clean electricity in the energy economy, combined with ever-tighter nationally determined contributions, mean that oil finally exits the global energy mix. Oil is still used in the production of materials such as plastics that can be recycled and reused, and in pharmaceuticals, but is no longer used as a fuel.

High flying, low emitting
While kerosene is still used, synthetic fuels, biomethane and hydrogen drive down the carbon footprint of the aviation industry. Electric-powered planes are common for short-haul flights, while hybrid air vehicles are used for long-distance passenger journeys and freight. Drones play a key role in freight logistics.

Meat in moderation
High emissions from meat production – beef, dairy and pork in particular – plus increased global awareness of the links between high meat consumption, obesity and cancer, results in portions reducing to less than 100g per person per day.

Carbon neutral construction
Voluntary mechanisms for low-carbon development become mandatory in many countries. Legislation, carbon trading and commercial good sense drive innovation in the reduction of carbon from building, operating and maintaining infrastructure and buildings. Sequestration is used to compensate for unavoidable emissions.

King coal dethroned
Removal of subsidies and the risk of stranded assets or litigation speeds the closure of remaining coal-fired power stations.

Making good past mistakes
Landfill mining has become a major industry, enabling copper, aluminium, steel, plastics and compounds needed by the battery and IT industries to be recovered. Biomass is used for power production (with carbon captured), and inert materials for construction. The industry is worth hundreds of millions of dollars a year worldwide.

Local heroes
The low cost and high quality of additive manufacturing/3D printing enables the local fabrication of products in single numbers and small runs. In 2030, the technology accounts for over 15% of global manufacturing output by value. Compared to conventional manufacturing which produces 20% waste across all industries, it is waste-free. By 2040 additive technologies account for half the world's manufacturing output, reducing international freight transport by a quarter.

Turning off the ignition
All new cars and freight vehicles sold globally are powered by alternative fuels.



Tourist attraction

Tourism, long a major part of the global economy, is among the industries that is quickest to realise that climate change is an existential threat.

Popular destinations and the carriers who get holidaymakers there redesign their offerings to reduce emissions and are actively involved in building resilience. The result is that the tourist industry gets to 2050 continuing to offer great holidays to billions of people, with no end in sight.

How? Rapid growth of the middle class, globally, creates huge numbers of new holidaymakers. And there's a shift in the definition of a great holiday, from traditional northern-European 'sun, sea and sand' to culture- and destination-based tourism. This assigns new monetary value to the environment, and drives investment in protection, enhancement and resilience.

Interventions include large-scale wetland restoration, reforestation, regeneration of coral reefs and the cultivation of natural coastal defences, such as mangroves and dune systems. Because it is such a multisector industry, served by a multitude of local SMEs, protecting tourism also involves safeguarding local businesses, communities and infrastructure.

Resilience that benefits the tourism industry benefits everyone. This is reflected in the exceptional co-operation between private and public sectors, and the prominence of tourism in the planning of nationally determined contributions.

Meanwhile, the growth in electric and other non-carbon propulsion systems make short-to-medium-haul air travel and cruise holidays net zero carbon.



2041-2050

Five below zero

Global CO₂ emissions have fallen from 40Gt/year in 2020 to less than 5Gt by 2050, and BECCS is capturing that. Meanwhile carbon pricing has risen to US\$400/t, at 2015 prices. Further work is needed to achieve an additional 5Gt of capture and make the world net carbon negative, halting temperature rise at less than 2°C by the end of the century.

People power

Half of Europe's electricity is produced by its citizens by 2050.



Deep green energy

Chemical battery farms, flywheels, underground pumped hydro, molten salt, compressed air... a broad range of energy storage technologies have been technically and commercially mature for a decade and eliminated the historic challenges of intermittency and grid regulation associated with renewables. Renewables themselves produce affordable and abundant supply, meeting domestic, infrastructure, commercial and the majority of industrial demand. Small modular nuclear reactors supply baseload for the most energy-intensive industries. Fitted with carbon capture and storage, gas-fired generation provides back-up to national and local supplies, but most of the time lies dormant.

Plastic clean-up

Autonomous drones remove plastic waste from crucial ecosystems, particularly the oceans. Water and waste management utilities ensure that microplastics do not enter the terrestrial or marine environments.



Improving outlook

Low-cost renewable energy and technology transfer enable the poorest communities and most disadvantaged countries to tackle some of the fundamental environmental and social ills that have held them back. Affordable energy is the key to education, healthcare, clean water, sanitation, waste management and entrepreneurial activity.

Peak population

Increasing economic wealth is better distributed across the globe and many more countries are defined as 'developed'. This brings a decline in birth rates. The global population peaks at 9.7bn and starts to fall.

Back from the brink

Despite all the steps taken to cut emissions over the last three decades, the accumulation of historic emissions results in peak concentration of atmospheric carbon – around 450 parts per million. It's perilously close to the point of no return for climate change. But the global economy is net carbon negative. As the concentration of atmospheric carbon declines, temperature rise will slow and stop over coming decades.



The view from 2050



Looking back at the first half of this century, some of the most disruptive changes in human history have occurred. Digital, technological, scientific and agricultural development has been dramatic, influenced by and assisting the race against the causes and effects of climate change.

By mid-century, the world in many respects is in better shape than at the start. Concentrations of atmospheric CO₂ are falling, achieving the aims of the Paris Agreement to deliver a sub-2°C future. The world's population has peaked at 9.7bn and average incomes have risen. The middle class has grown by 3bn, and the world's 2bn poorest people have been lifted out of abject poverty.

For both mature and developing economies, huge progress has been made in achieving the United Nations' Sustainable Development Goals, set in place in 2015 and which galvanised early action. A pivotal realisation was that, without concerted effort to tackle climate change, few goals were achievable. It's hard to end poverty and hunger, promote health and wellbeing, provide sufficient water, and maintain healthy marine and terrestrial ecosystems in the face of runaway climate change.

Buildings, communications, energy, industry, sanitation, transport, waste, water – designs and strategies for the delivery of new assets and the management of existing ones all fulfil three fundamental requirements: to withstand and recover swiftly from climate events, adapt to long-term environmental changes, and contribute to net negative carbon emissions. 'Planet-positive' thinking is standard for business, investment and politics.

The delivery and operation of industry, infrastructure and cities is now hugely efficient, and waste eradicated. That has brought vast benefits in the form of decent employment, greater social and gender inclusion and equality, and reduced competition for and conflict over resources.

For residents of developed economies, the proliferation of choice available in the first years of the century is no longer there. But the knowledge that the world has pulled back from the brink of catastrophe, and that things have in many regards got better, promotes a feeling of 'job well done'.

Of course, it's not all roses. Climate impacts are causing more than US\$200bn of economic losses globally every year in the form of physical

damage and disruption to businesses. But thanks to effective partnerships between corporations, governments and donors, fears that losses would top US\$1trn a year haven't been realised. Spend-to-save logic has mobilised some US\$200bn annual investment to create resilience.

There have been some winners on the way. Organisations and places that acted quickly to develop resilience have gained twin benefits: simply, they've survived and prospered while others suffered, attracting investment and creating a virtuous resilience cycle. Meanwhile, those that decarbonised swiftly have gained efficiencies while avoiding the legal action, reputational damage, loss of shareholder confidence and asset stranding that has dragged down some well-known corporations of the early 21st century.

2015-2050 has seen unprecedented innovation and co-operation. Faced with an existential threat, R&D and learning have advanced at an incredible pace.

That's good news for the future. Catastrophe has been averted, but our climate is more challenging. Humankind has proved: we can respond and thrive.

What did you do?

The big, empowering idea at the start of the climate revolution was a very simple one: that whether you ran a country or did the school run, you could play a part in halting climate change. The journey began with people, in all walks of life, realising that they had influence if not direct control over the trajectory of change – and if they didn't act, then the world's fate was sealed.

The vast majority thought that wasn't OK. They acted.



**Looking back
from 2050,
what story
will you tell?**

Acting on climate change.

We'd love to hear your 2050 story
climate.resilience@mottmac.com

Under 2°C: Mission possible.

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Mott MacDonald, 2018