MEGATRENDS

A Resources and Energy Industry Workforce Report

A NEW HORIZON

THOUGHT LEADERSHIP SERIES

People & Culture | Workforces & Workplaces

AREEA

AUSTRALIAN RESOURCES & ENERGY EMPLOYERS ASSOCIATION

ABOUT THIS DOCUMENT

Megatrends ranging from generative AI to net zero transition are changing the world – and creating challenges and opportunities for businesses and individuals. To be fully prepared and benefit from the opportunities, it is important to spotlight these trends and their potential effects on the resources and energy industry.

One of the most prominent megatrends is the net zero transition. It's driving innovation, investment and government incentives and regulation, with the resources and energy sector to be heavily impacted.

For example, Artificial Intelligence (AI) is utilised to automate many tasks, especially repetitive and menial ones. This frees up workers and may lead to better work-life balance, while concurrently employees can concentrate on more varied or complex tasks. However, those tasks will place more cognitive demands on the worker and require a different skillset. In short, as AI is increasingly incorporated into our workplaces and daily lives, both are set to fundamentally change.

This document is intended as a starting point for discussion and guidance on how megatrends will shape the future of work.

It's the third volume of *AREEA's A New Horizon People & Culture | Workforces & Workplaces* thought leadership series – with a particular focus on current and emerging trends that will transform the resources and energy industry workforce.

EXECUTIVE SUMMARY

Industry, government and researchers agree businesses are operating in a rapidly changing environment. The future ranges from simple acceleration of existing tech trends to ground-breaking structural change due to technological[1, 2, 3], demographic[4] and societal developments.

With stakeholders united in predicting change, it is imperative to stay ahead of the game by preparing for opportunities and potential challenges.

The World Economic Forum (WEF), spanning 803 companies and more than 11 million employees across 27 industry groups in 34 world economies, forecasts the scale and speed of the transformation, with almost a quarter of jobs expected to change within the next five years as a result of net zero and new technologies[5].

The biggest megatrends to impact the resources and energy industry will be climate change adaptation and the net-zero transition, the fourth industrial revolution, the materials revolution, the bio-revolution, increasing uncertainty and growing demand for trust and governance.

As well, disruptive IT trends are affecting all industries including resources and energy. These include the remote and digital work boom, rising AI use, autonomous technologies and next-level process automation, more VR and AR, next-generation computing, enhanced connectivity through Web 3.0, 5G and IoT, trust architecture to defend against cyberattacks, and devaluation of raw data in favour of aggregated data.

In Australia, these international megatrends will coincide with significant demographic shifts. Our ageing population means working age Australians are becoming fewer, while the non-working age segment is expanding[4]. Over the next 40 years, the number of Australians aged 65 and over is forecast to more than double, those aged 85 and over will more than triple and centenarians will increase six-fold[6].

On top of demographic ageing is the drive to increase diversity with net overseas migration[7], which will also help replace 100,000 people moving from the cities to the regions[8,9].

Part of the *A New Horizon Thought Leadership – People & Culture – Workforces and Workplaces* series, this report aims to highlight megatrends and their impact on the workforce of Australia's resources and energy industry, especially around capability, planning and resourcing.

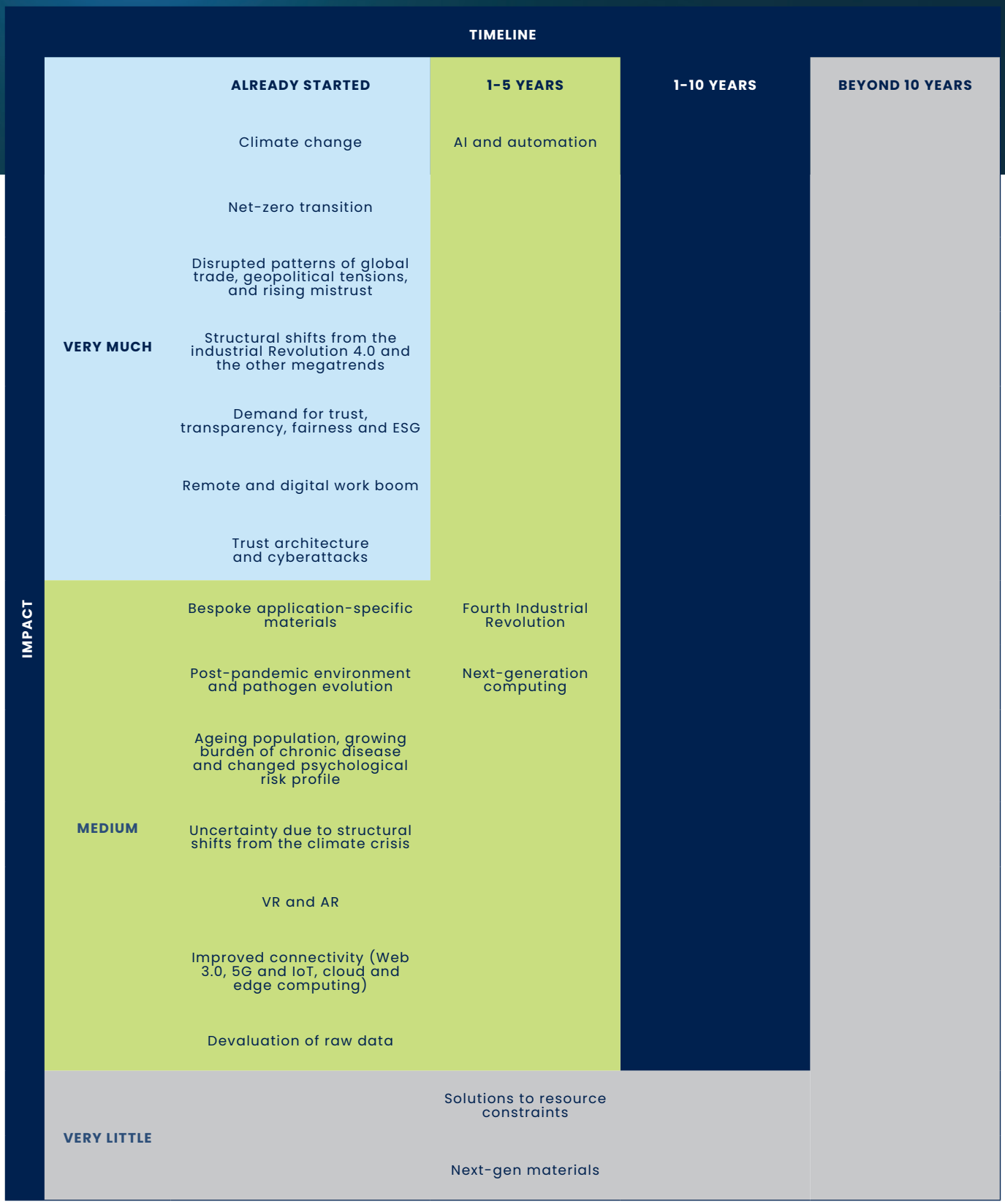
Four overarching themes have emerged for workforce adaptation: increased demand for specialised technology skills, changing workforce demographics (with a decrease in productivity), less demand for low skilled, routine and on-location jobs, and increased workforce expectations.

Megatrend workplace and facilities adaptation includes relocation and upgrades. Business processes will also need to transform.

These megatrends are illustrated in the matrix on the following page, followed by a summary of workforce and workplace impacts. Next is an overview and then detailed analysis of the megatrends and impacts, with an extended reference list.

OVERVIEW

Megatrends: Time vs Severity Impact Matrix



Megatrends: Impacts on Workforces and Workplaces

IMPACTS ON WORKFORCES		IMPACTS ON WORKFORCES	
INCREASED DEMAND FOR SPECIALISED TECHNOLOGY SKILLS	**DECREASED DEMAND FOR LOW SKILLED, ROUTINE, ON-LOCATION JOBS**	**RELOCATING WORKPLACES AND FACILITIES**	**UPGRADING WORKPLACES AND FACILITIES**
• Green technologies, synthetic biology, material science, nanotechnology • Specialised technology, digital skills • ESG skills • Agile project management • Robotics, AI, automation, VR, AR • Next-generation computing • Blockchain, 5G and IoT • Cyber security, distributed-ledger technology • Big data and analytics • Competition for skilled workers from Defence	• Onsite operator roles • Traditional labour • Routine jobs • On-location presence	• Asset re-evaluations and relocations • Closures/restructures of office and site locations • Moving to "safer" location	• Synthetic biology, next-gen materials • Zero energy transition technologies • Agile production, rapid reconfiguration • Higher hygiene, biosafety standards • Accommodating ageing, chronically ill, psychologically distressed workforce • Increased sustainability standards • Scalable and remote-ready IT infrastructure for web 3.0, 5G and IoT • IT infrastructure for AI, next-gen automation, VR/AR, next-gen computing • Decreased demand for offices
CHANGED DEMOGRAPHIC COMPOSITION OF WORKFORCES	**INCREASED WORKFORCE EXPECTATIONS**	**BUSINESS PROCESS ADAPTATIONS**	**INCREASED RISK**
• Changed workforce availability from migration • More diverse workforce • Decreased young, more older workers, more workers with disabilities and more neurodiverse workforce • More sick days, productivity loss • More flexibility required to manage diverse workforce needs • Increasing health impacts from outdoor work in hot climates	• Remote and flexi work, WFH policies • Environmental friendliness • Locations free of climate impacts and emergencies • Job security, future proofness (i.e., up-/re-skilling, PD, etc. provided by employer) • VR/AR use for training assisted remote maintenance etc. • Next-gen materials usage • Hygiene & biosafety standards • Transparency, ESG	• Remote/WFH policies • Productivity and output metrics • Upskilling, continuous learning • Restructuring of production • Agile processes • Automate and digitise • Increased cyber security • Business continuity and contigency planning • Next-gen materials, synthetic biology and related technology • AI, VR/AR, next-gen computing, decentralisation, blockchain, 5G and IoT, distributed-ledger • ESG and transparency	• Increasing impacts from climate and emergencies • Impact on biodiversity and First Nations • Shift in purpose and business direction • Client and marketing impacts • Consumer demand vs climate trade-off • Internal carbon pricing to ensure full cost of capital • Permitting reprioritisation based on carbon content • Readiness for carbon neutral • Eco anxiety in the workforce • Short-term projects and frequent change • Change in management, leadership styles • Changing structure of workforce hierarchy • Ageing/chronically ill/ psychologically distressed workforce, workplace injuries/ illness risk • Demand from communities for transparency, data • Insufficient considerations of AI limitations and risk

INTRODUCTION

Discussions on megatrends are gaining traction, with trend reports issued by some of the big names in consulting[10, 11, 12, 13] as well as the Australian Government[14, 15] and non-governmental organisations[16,5].

The reports are united in predicting change – both opportunities and challenges, while more detailed forecasts drill down on major impacts such as technology-influenced structural upheaval.[1, 2, 3]

The World Economic Forum (WEF) estimates almost a quarter of jobs are expected to change within the next five years – with net-zero transition and new technologies the key drivers[16].

For the resources and energy industry, climate change and the net-zero transition will be the biggest triggers of adaptation.

Simultaneously, megatrends predominantly affecting manufacturing industries will also impact the resources and energy industry, namely: the fourth industrial revolution, the materials revolution and the bio-revolution.

These megatrends signal increasing uncertainty, and, in turn, greater demand for trust and governance.

Additionally, several disruptive IT trends are affecting all industries, including resources and energy: from the remote and digital work boom to rising use of AI and a shift from raw to aggregated data.

These world-wide megatrends come at a time of significant demographic change in Australia.

Over the next 40 years, more and more Australians will become non-workers, with the number aged 65 and over expected to at least double[6].

Net overseas migration[7] will also increase, partially compensating for the shift of 100,000 Australians from the cities to the regions[8,9].

When combined, these trends are anticipated to significantly affect the resources and energy industry[17].

The latest instalment of the *A New Horizon Thought Leadership – People & Culture – Workforces and Workplaces* series, this report investigates the megatrends and their likely impact on Australia's resources and energy sector.

METHODOLOGY OF THIS REPORT

Literature Review

A literature review was conducted to extract relevant topics and provide an overview of the megatrends relevant to the resources and energy industry.

Material with a variety of pedigree was examined, including academic sources as well as the big four consultancies and industry sources.

Relevant topics of interest were consolidated to form a multilevel megatrends list, which informed the remainder of the work.

Subject Matter Expert Survey

The multilevel megatrends list formed the basis of a matrix to illuminate forecast impacts on workforces and workplaces, along with potential timelines.

This matrix was deconstructed into survey questions which were put to 20 senior industry leaders and professionals.

Respondents were asked to agree or disagree with suggested potential impacts and to add their own predictions for the workforce and workplace.

Respondents were also asked to give potential timelines for these impacts.

Data was collated, analysed and used to populate the multilevel megatrends list.

CLIMATE CHANGE ADAPTATION AND NET-ZERO

Adapting to climate change and increasing frequency and impact of natural disasters

There is strong, internationally accepted consensus that global warming has occurred and is likely to continue[18].

NASA's Global Climate Change website notes "climate-warming trends over the past century are extremely likely due to human activities"[19].

The Intergovernmental Panel on Climate Change (IPCC) – the United Nations body for assessing climate change-related science – recently finalised a synthesised report of its assessments.

The IPCC's Climate Change 2023 Synthesis Report is based on work by hundreds of scientists during the Intergovernmental Panel on Climate Change's (IPCC) sixth assessment cycle, beginning in 2015[20]. According to one source, 234 scientists read more than 14,000 research papers to write the IPCC climate report[21].

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian federal government agency responsible for scientific research, maintains a webpage studying climate change in Australia. According to the site, the international scientific community accepts greenhouse gas increases from human activity are the dominant cause of observed global warming since the mid-20th century[22].

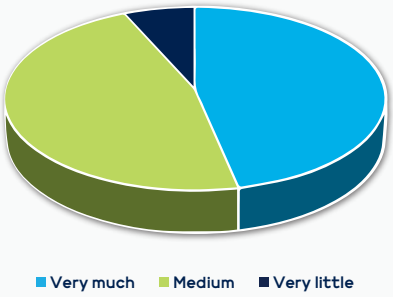
The Australian Academy of Science, representing Australia's leading research scientists, has issued a position statement on climate change. It states the risks and costs of not responding to climate change mean Australia and the world must build on current commitments to rapidly reduce greenhouse gas emissions to net-zero[23].

Australia is already affected by climate change through increases in average temperatures, more frequent heat waves, increasing drought, rising sea levels and threats to species[24].

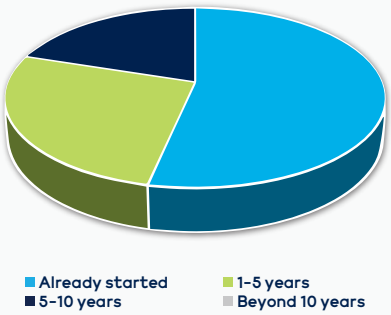
Climate change and associated challenges are recognised by individuals and the business community[22], resulting in changing expectations and increased anxiety among the current and prospective resources and energy industry workforce.

Impact of adapting to climate change and increasing frequency and impact of natural disasters on workforces and workplaces

Impact of climate change



Timeline of climate change



Impacts from climate change

Note: In the above list of potential impacts, percentages indicate the proportion of respondents who rated an item as important. Items without percentages are add-ons suggested by individual participants. This applies to all impact boxes throughout this document.

Potential impact on workforces:

a) Eco anxiety in the workforce (43.8%)
b) Work locations being assessed on harshness of climate and exposure to emergencies such as floods and fires (38% of respondents)
c) Higher demand for certain resources driving demand on labour/skills

Potential impact on workplaces:

a) Asset re-evaluations and relocations (25%)
b) Impact on biodiversity and Indigenous/First Nations communities
c) Shift in purpose and business direction
d) Client impacts
e) Disconnect between public needing/using resources and not understanding the climate trade-off
f) Internal carbon pricing to ensure full cost of capital is explored
g) Permits to access undeveloped resources and exploration will become more difficult
Will also present opportunities to invest in renewables
h) Readiness for carbon neutral

The net-zero energy transition

Climate change adaptation means finding solutions to resource constraints across the net-zero energy transition.

McKinsey has developed a framework to assist with solving the net-zero equation, exploring visionary solutions such as global, multilateral funding to buy out high-carbon assets and invest in low-carbon technologies[25]. According to the consultancy, nine prerequisites are required to ensure an orderly net-zero transition. These include physical building blocks such as technological innovation, scalable supply chains and infrastructure and resource availability. They also include societal adjustments: effective capital and finance solutions, management of shift in demand and cost and compensation for socioeconomic impacts. Finally, governance, commitment from institutions and leaders and public support is required.

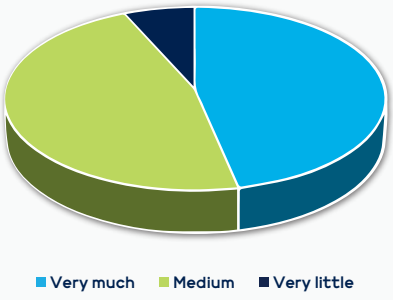
According to the International Renewable Energy Agency (IRENA) and its 2021 World Energy Transitions Outlook, energy intensity improvements, electric vehicle sales growth and increasing hydrogen demand are among the exigencies to reach net zero by 2050[26].

The transition to a net-zero economy will require vast quantities of raw materials, from aluminium to zinc and many rare metals like neodymium and lithium[27].

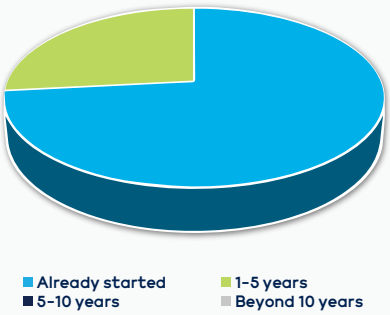
The materials boom expected as a result of the net-zero transition will put the resources and energy sector to the test. In particular, significant challenges are expected in skills shortages and infrastructure.

Impact of the net-zero energy transition on workforces and workplaces

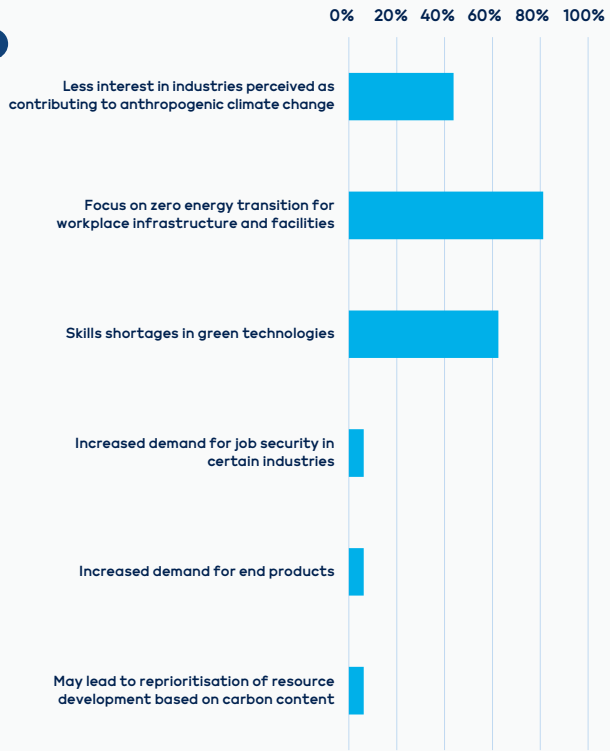
Impact of climate change



Timeline of net-zero transition



Impacts from net-zero transition



Potential impact on workforces:

a) Skills shortages in green technologies (63%)
b) Decreased interest in industries perceived as contributing to anthropogenic climate change 44%)
c) Increased demand for job security in certain industries

Potential impact on workplaces:

a) Focus on zero energy transition for workplace infrastructure and facilities (81%)
b) Increased demand for end products
c) May lead to reprioritisation of resource development based on carbon content

Increased focus on potential solutions to resource constraints through advanced recycling and synthetic biology

The raw materials challenge expected as part of the net-zero transition is forecast to bring significant innovation. For example, advanced recycling technologies could turn plastic waste into valuable secondary raw materials to build Australia's circular economy[28].

The rapidly growing field of synthetic biology has the potential to disrupt many industries, including resources and energy. Synthetic biology involves the design and engineering of biological systems to create and improve processes and products. This technology offers new ways of producing almost everything from foods to fuels[29].

In the mining industry, synthetic biology could help reduce the environmental impact of extracting metals from underground deposits by replacing cyanide-based or other toxic extraction methods with sustainable alternatives. Bacteria-based bio-leaching is also cheaper than traditional crushing and cyanide leaching-based processing. As it needs less management and heavy machinery, it can process low-concentration ores with reduced effort, and results in less landscape damage.[30]

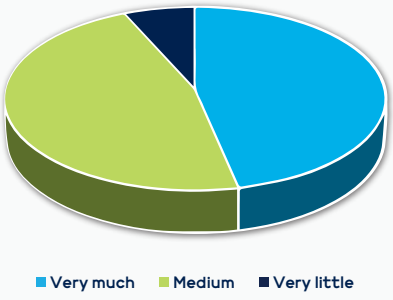
In the oil and gas industry, synthetic biology could also contribute to enhanced productivity and reduced environmental impacts. Microbial enhanced oil recovery (MEOR) has received significant attention in recent years. Requiring less energy and fewer chemicals than traditional methods, MEOR typically can be implemented with low extra capital cost, no additional surface facilities and low toxicity.[30] Biosynthetics can also play a role in remediation of crude oil-contaminated soil and related processes.[31]

Synthetic biology technologies could potentially offer sustainable solutions for many processes in the resources and energy industry. While biosynthetics are expected to first disrupt pharmaceutical and food industries, the resources and energy industry can expect these technologies within the decade.[32]

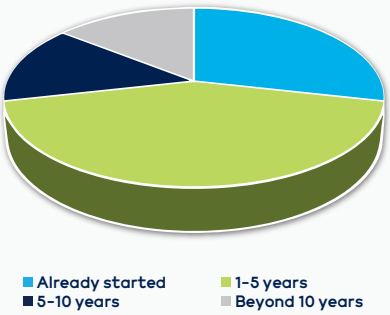
Consequently, there may be a high demand for workers with skills in synthetic biology.

Impact of the increased focus on potential solutions to resource constraints through advanced recycling and synthetic biology on workforces and workplaces

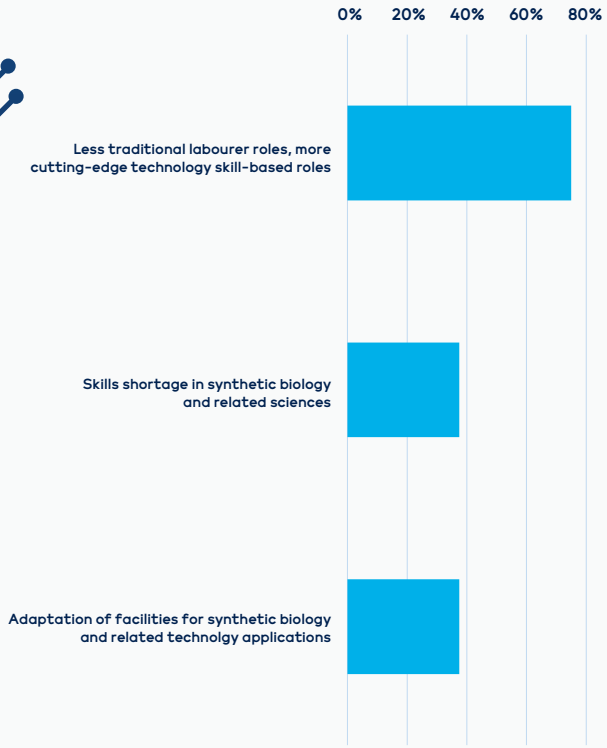
Impact of climate change



Timeline of solutions to resource constraints



Impacts from solutions to resource constraints



Potential impact on workforces:

a) Decreased traditional labourer roles, more cutting-edge technology skill-based roles (75%)

b) Skills shortage in synthetic biology and related sciences (38%)

Potential impact on workplaces:

a) Adaptation of facilities for synthetic biology and related technology applications (38%)

FOURTH INDUSTRIAL REVOLUTION

Technology innovations related to the continuing Fourth Industrial Revolution

The Fourth Industrial Revolution is inspired by the concept "Industrie 4.0", a high-tech strategy for the complete digitisation of industrial production. The idea was introduced to the wider public in 2015 by the World Economic Forum, where it was the theme of the 2016 annual meeting[34].

Characterised by rapid technological innovation, the Fourth Industrial Revolution is driven by technology disruptions such as Big Data, analytics, cloud computing, the Internet of Things (IoT), 3D printing, automation, wireless technologies, augmented and virtual reality, and artificial intelligence[35].

The Fourth Industrial Revolution is ongoing, with many of the innovations significantly underway and continuing to trigger structural changes in many industries, including the resources and energy sector[36].

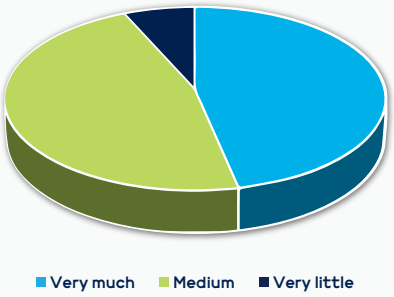
Mining-related innovations of the Fourth Industrial Revolution include biomechanical exoskeletons to give miners super-strength and endurance, augmented reality-enabled maintenance with detailed remote assistance, virtual reality training for high-risk scenarios, wearable sensors for measuring health and wellbeing, radio frequency identification (RFID) tag systems to automate reporting of malfunctioning equipment, collaborative robots for strenuous and repetitive tasks such as loading, 5G and IoT mine networks and analytics for prediction of production-relevant events[37].

In the oil and gas industry, Fourth Industrial Revolution new technologies include thermal imaging drone inspections of pipelines, virtual reality walkthroughs of offshore installations, real time control of production and distribution, integration of production data into 4D seismic exploration models, drilling equipment with smart sensors to aid decision-making, monitoring systems to automate temperature control, real time geolocation of moving assets, pipelines with inbuilt smart leak detectors, smart sensors for refinery process control and predictive analytics for demand forecast and automated supply chain and production control[35].

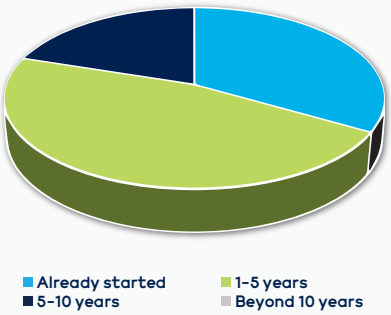
The success of the Fourth Industrial Revolution ultimately hinges on the ability to integrate data with physical processes[38], requiring significant upskilling and restructuring of production facilities.

Impact of technology innovations related to the continuing Fourth Industrial Revolution on workforces and workplaces

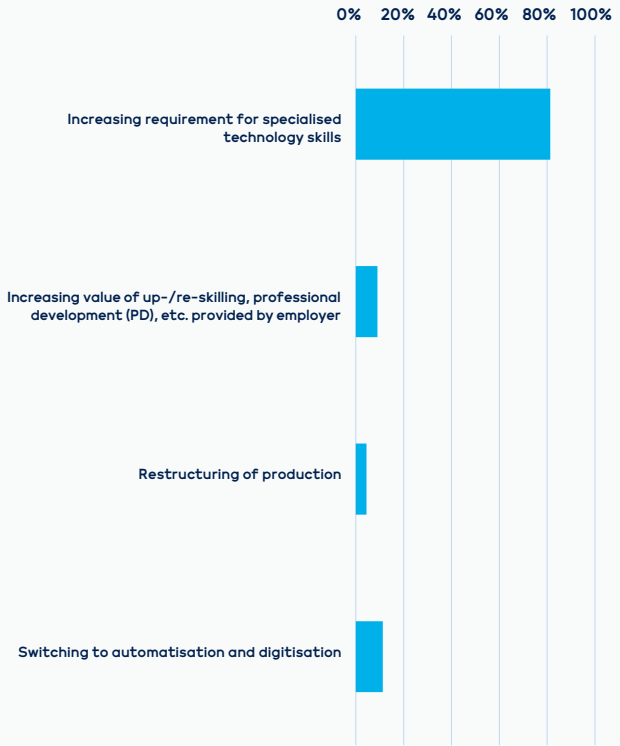
Impact of climate change



Timeline of Fourth Industrial Revolution



Impacts from Fourth Industrial Revolution



Potential impact on workforces:

a) Increasing requirement for specialised technology skills (81%)

b) Increasing value of up-/re-skilling, professional development (PD), etc. provided by employer (9%)

Potential impact on workplaces:

a) Switching to automation and digitisation (11%)

b) Restructuring of production (5%)

MATERIALS REVOLUTION

Next-generation smart, responsive and lightweight materials

Next-generation materials such as graphene and other nanomaterials are further technology with the potential to disrupt and revolutionise the resources and energy industry.

Nanomaterials are an amazing class of materials with at least one dimension in the range of 1 to 100 nm[39]. The name originates from ancient Greek ('nano" meaning "dwarf'), and some use of nanomaterial dates back to the Romans, with the Lycurgus cup – a bicoloured glass containing a nano silver-gold alloy – the oldest known nanomaterial[40]. Contemporary nanotechnology was introduced in 1959 by Nobel Prize laureate Richard Feynman[40] and has since significantly expanded.

Nanomaterials can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties, and with exceptionally high surface areas that surpass the utility of their non-nano versions and offer many industrial applications[39].

Nanomaterials can have many applications in the oil and gas industry. These include nano-enhanced drilling fluid, additives, plugging agents and cements for optimised production and enhanced wellbore stability[41]. Nanomaterials also provide applications for electromagnetic and temperature sensing and optical imaging technologies for exploration and production.

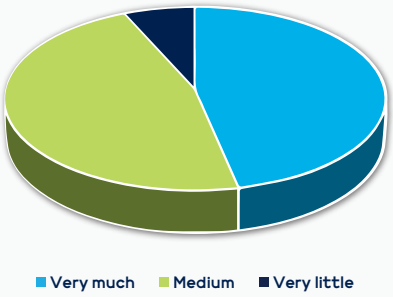
A special nanomaterial is graphene, considered the strongest yet thinnest material in the world with the highest heat and electricity conductivity of any material.

Graphene's many applications[42] include sustainable energy applications, fuel cells[43], corrosion prevention[44] and energy storage[45]. Thereare even methods to convert plastic wastes into valuable 2D graphene-based materials[46].

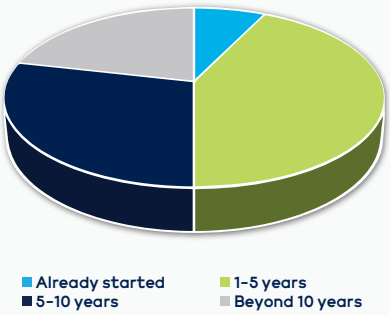
These applications are likely to increase and will require workers skilled in latest advancements of material science and nanotechnology – and workplaces with upgraded infrastructure and facilities.

Impact of next-generation smart, responsive and lightweight materials on workforces and workplaces

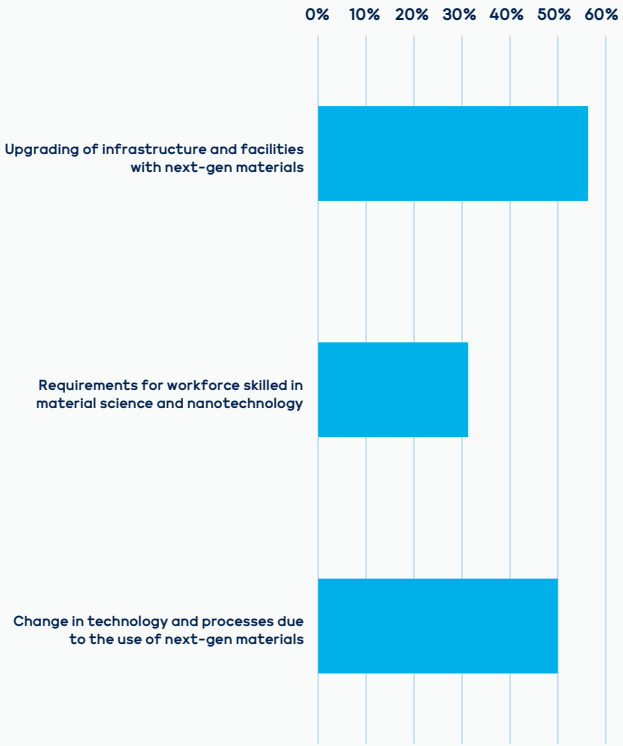
Impact of climate change



Timeline of next-gen materials



Impacts from next-gen materials



Potential impact on workforces:

a) Requirements for workforce skilled in material science and nanotechnology (31%)

Potential impact on workplaces:

a) Upgrading of infrastructure and facilities for use of next-gen materials (56%)

b) Change in technology and processes due to the use of next-gen materials (50%)

Custom industrial processes to deliver bespoke application-specific materials

As material science, nanotechnology, robotics and AI progress, new avenues will open for customisation and automation of industrial processes to specific needs and as yet undiscovered material sources[47].

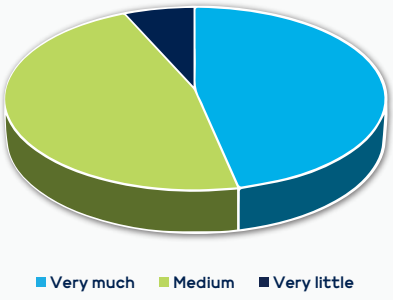
One use of application-specific materials in the resources and energy industry is high-density polyethylene abrasion-resistant plastic pipe, a cost-effective alternative to steel pipe for mining and oil and gas, offering advanced corrosion resistance and light weight[48].

Another example is the dry tailings solution, reducing risks associated with wet tailings dams and decreasing water usage[49].

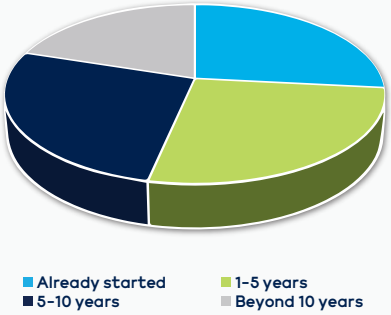
Along with skills shortages in robotics and AI, the proliferation of bespoke application-specific materials is likely to lead to potentially shorter lifecycles and therefore more demand for agile project management skills. Workplaces will also need to be upgraded to accommodate rapid reconfigurations for agile production.

Impact of custom industrial processes to deliver bespoke application-specific materials on workforces and workplaces

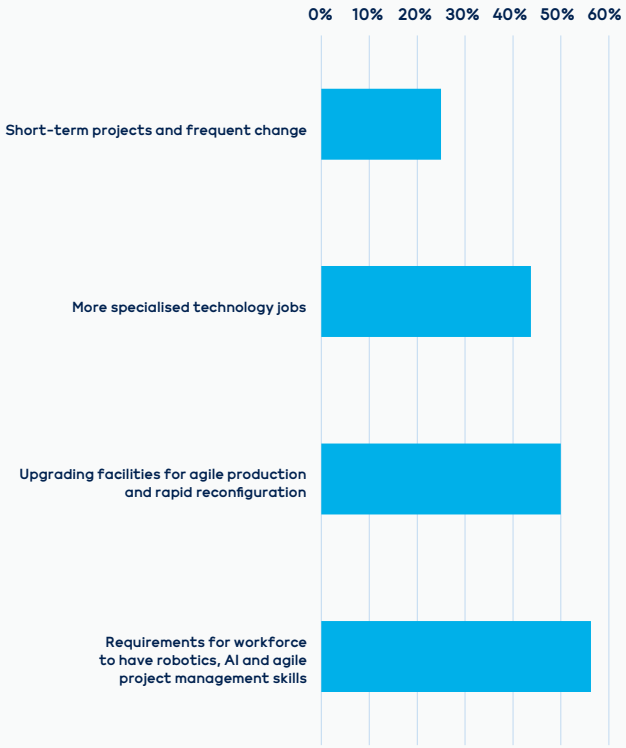
Impact of climate change



Timeline of bespoke application-specific materials



Impacts from bespoke application-specific materials



Potential impact on workforces:

a) Requirements for workforce to have robotics, AI and agile project management skills (56%)

b) More specialised technology jobs (44%)

c) Short-term projects and frequent change (25%)

Potential impact on workplaces:

a) Upgrading facilities for agile production and rapid reconfiguration (50%)

BIO-REVOLUTION

Adapting to escalating challenges posed by the post-pandemic environment and pathogen evolution

The term bio-revolution is applied both to the basket of challenges presented by evolving biological systems (including pandemics and ageing demographics) and opportunities resulting from next-generation applications of biotechnology and related sciences[50].

The COVID-19 pandemic highlighted challenges such as heightened risk of infectious diseases and pathogens resistant to modern antibiotics. The resources and energy industry needs to adapt to these escalating challenges.

The sector has shown adaptability and resilience in its pandemic response[51]. However, post-pandemic, it is facing a fundamentally new risk environment with volatile demand for hydrocarbons and the challenges of the energy transition[52].

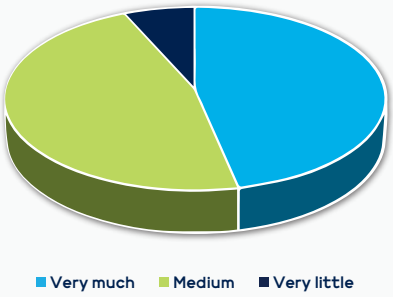
These factors include market instability and fluctuating demand, more production required from reduced investments and smaller projects with faster turnaround[53].

Investors are expecting improved results from decreased resources, while increasingly focusing on governance and ESG. This requires stakeholders to create new partnerships and international cooperation and dialogue[53].

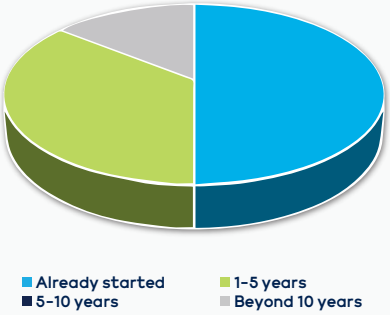
To remain competitive in these conditions, companies must be prepared to comply with higher hygiene and biosafety standards, and upgrade infrastructure and facilities accordingly.

Impact of adapting to escalating challenges posed by the post-pandemic environment and pathogen evolution on workforces and workplaces

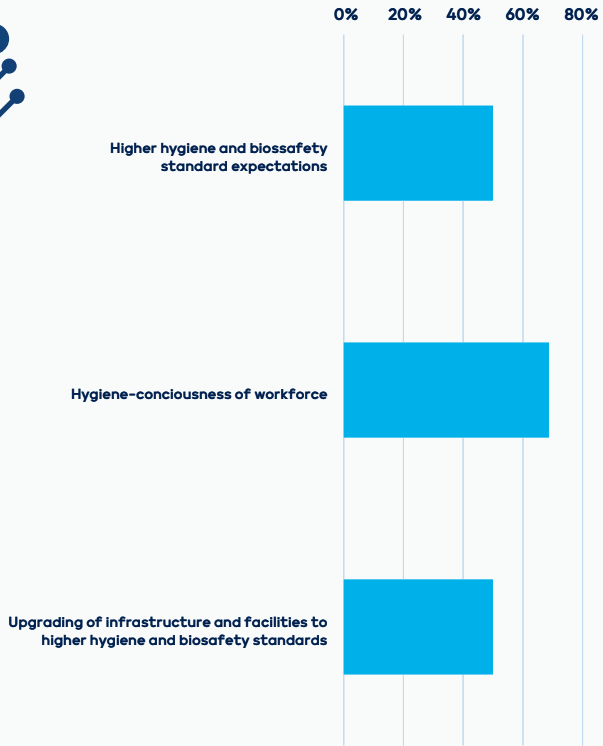
Impact of climate change



Timeline of post-pandemic environment and pathogen evolution



Impacts from post-pandemic environment and pathogen evolution



Potential impact on workforces:

a) Higher hygiene & biosafety standard expectations (69%)

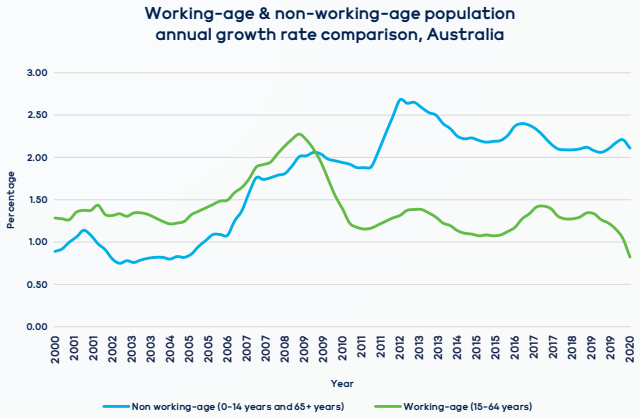
b) Hygiene-consciousness of workforce (50%)

Potential impact on workplaces:

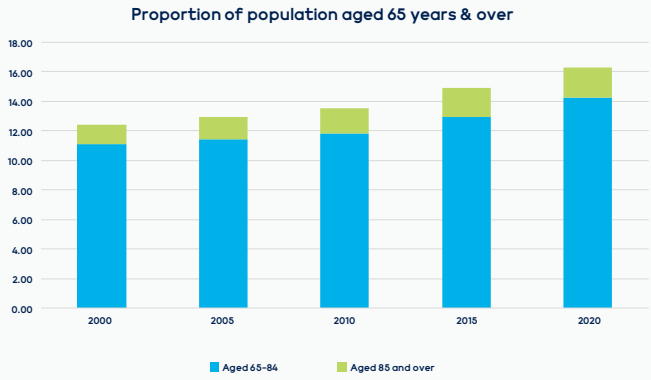
a) Upgrading of infrastructure and facilities to higher hygiene and biosafety standards (50%)

b) Change in technology and processes due to the use of next-gen materials (50%)

Adapting to an ageing population, growing burden of chronic disease and changing psychological profile



Working-age and non-working-age population annual growth rate comparison, Australia[54]. Source: Australian Bureau of Statistics, Twenty years of population change 17/12/2020.



Proportion of the population aged 65 and over[54]. Source: Australian Bureau of Statistics, Twenty years of population change 17/12/2020.

The Australian population is continuing to age[54]. As shown in Figure 1, the working-age population is declining, while the non-working age population is increasing.

Moreover, the proportion of older people is increasing[54]; as shown for the example of over 65 and over 85-year-olds in Figure 2.

Australia's population is expected to continue to age for the foreseeable future. The number of Australians aged 65 and over will more than double, those aged 85 and over will more than triple and centenarians are expected to increase six-fold over the next 40 years[6].

This demographic transformation will also change the face of the workforce, requiring new approaches to recruiting, retention and reskilling.

The challenges ahead encompass physical and mental health. Almost 1 billion people worldwide suffer from a mental disorder[55]. Lost productivity from anxiety and depression costs the global economy US$1 trillion a year. Poor mental health is forecast to cost the world economy about $6 trillion a year by 2030[55].

A significant portion of the resources and energy workforce is Fly In Fly Out (FIFO), with these workers also faced with the challenges of remote sites involving onsite accommodation and significant isolation. Spare time and recreation are effectively subsumed into the workplace, in contrast to residential operations or workplaces where employees get to leave at the end of the shift.

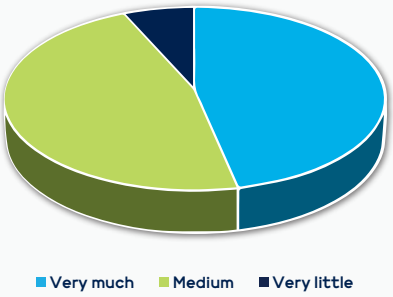
The FIFO dynamic is potentially detrimental in multiple ways. First, psychosocial and mental health issues may get amplified, with incidents escalating. Second, afflicted employees have nowhere to go for release or relief – they are confined to this environment. Last, where issues escalate to an incident, an effective response may be compromised by the difficulty accessing support.

The already significant challenge of low female representation in the workforce is exacerbated at remote sites.

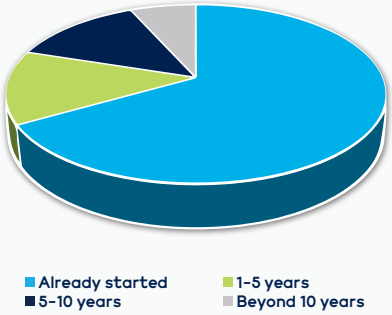
In total, the challenges of increased age and physical and psychological illness profiles will extend to the workforce and productivity – requiring businesses to adapt and upgrade facilities accordingly.

Impact of adapting to an ageing population, growing burden of chronic disease and changing psychological profile on workforces and workplaces

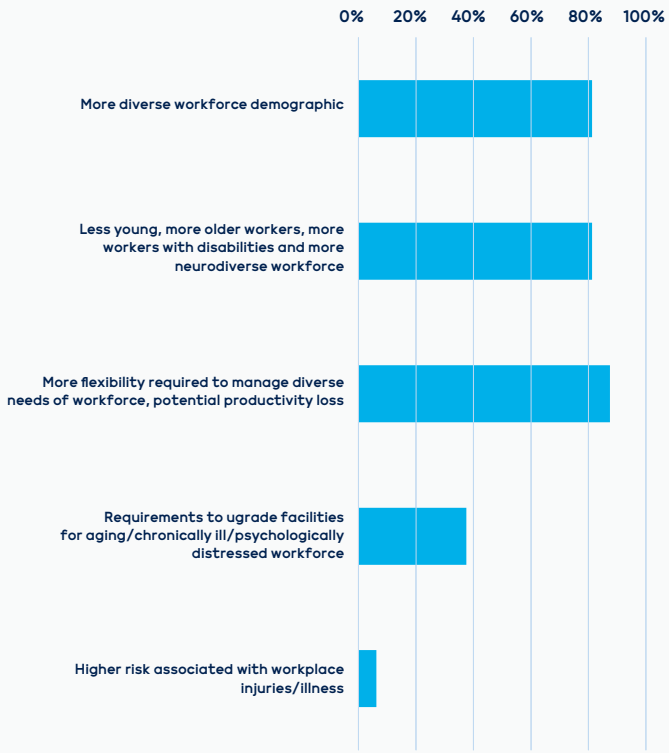
Impact of climate change



Timeline of ageing population, growing burden of chronic disease and changed psychological risk profile



Impacts from ageing population, growing burden of chronic disease and changed psychological risk profile



Potential impact on workforces:

a) More diverse workforce demographic (81%)
b) Decreased young, more older workers, more workers with disabilities and more neurodiverse workforce (81%)
c) More flexibility required to manage diverse needs of workforce, potential productivity loss (88%)

Potential impact on workplaces:

a) Requirements to upgrade facilities for ageing/chronically ill/psychologically distressed workforce (38%)
b) Higher risk associated with workplace injuries/illness

UNCERTAINTY

Disrupted patterns of global trade, geopolitical tensions, and rising mistrust

While the global population is in range of a mobile broadband network, only one in three people go online, mainly due to lack of access to a device or skills[56]. Therefore, online access can still grow by two-thirds with such a surge in interconnectedness to result in more fluid boundaries and increasing opportunities for business.

At the same time, conflict is on the rise. For instance, in 2022 more than 125,700 worldwide events of political violence took place, exposing 20% of the global population[57].

According to the The Armed Conflict Location & Event Data Project (ACLED) Conflict Severity Index, which considers deadliness, danger, diffusion, and fragmentation, 46 countries and territories are currently experiencing severe levels of conflict[57].

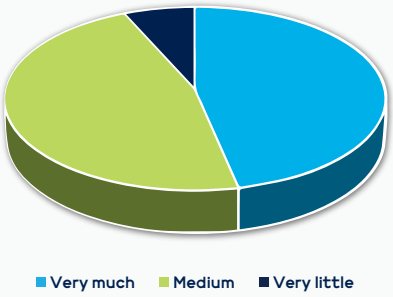
Rising conflict, global trade disruptions from trade wars and increasing protectionism contribute to uncertainty by dampening global commodity demand and disrupting the value chain of the resources and energy industry[58].

Sanctions and protectionism can engender instability and mistrust in the wider global community which in turn can lead to market uncertainty and volatility, hindering company planning and operations[59].

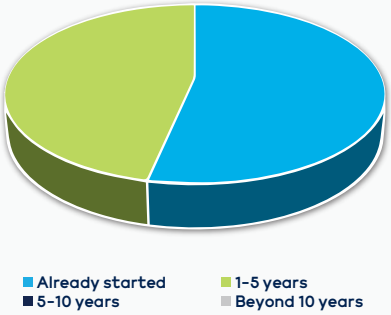
All these influences are likely to place demands on workforce skill levels and lead to workplace restructuring.

Impact of disrupted patterns of global trade, geopolitical tensions, and rising mistrust on workforces and workplaces

Impact of climate change



Timeline of disrupted patterns of global trade, geopolitical tensions, and rising mistrust



Impacts from disrupted patterns of global trade, geopolitical tensions, and rising mistrust

Potential impact on workforces:

a) Changes to workforce availability from migration (38%)

b) Additional competition for skilled workers from defence (31%)

Potential impact on workplaces:

a) Increased security and business continuity/ contingency planning (81%)

b) Closures/restructures of office and site locations (31%)

c) Marketing impacts

Increasing risk and uncertainty due to structural shifts from the Fourth Industrial Revolution

The major technological and economic developments of the Fourth Industrial Revolution such as Big Data, analytics, cloud computing, the Internet of Things (IoT), 3D printing, automation, wireless technologies, augmented and virtual reality and artificial intelligence[35] will trigger structural changes in many industries and industry and market functions[61].

These changes will impact the mining and oil and gas industry[36].

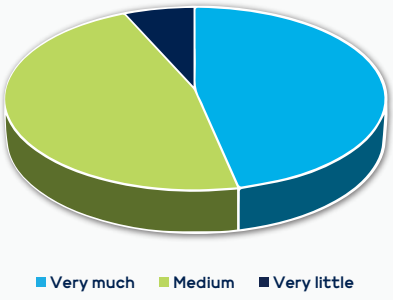
The success of the Fourth Industrial Revolution would ultimately culminate in developments including fully automated mines, refineries, oil rigs and pipelines[38].

Structural shifts from the Fourth Industrial Revolution may also lead to changes in availability of resources such as oil and gas, as well as adjusted supply and demand due to technological and economic developments[61].

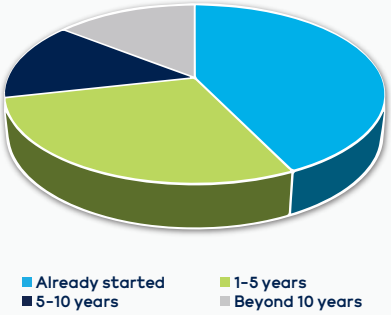
These changes will impact workforce expectations and require upskilling and restructuring.

Impact of increasing risk and uncertainty due to structural shifts from the Fourth Industrial Revolution on workforces and workplaces

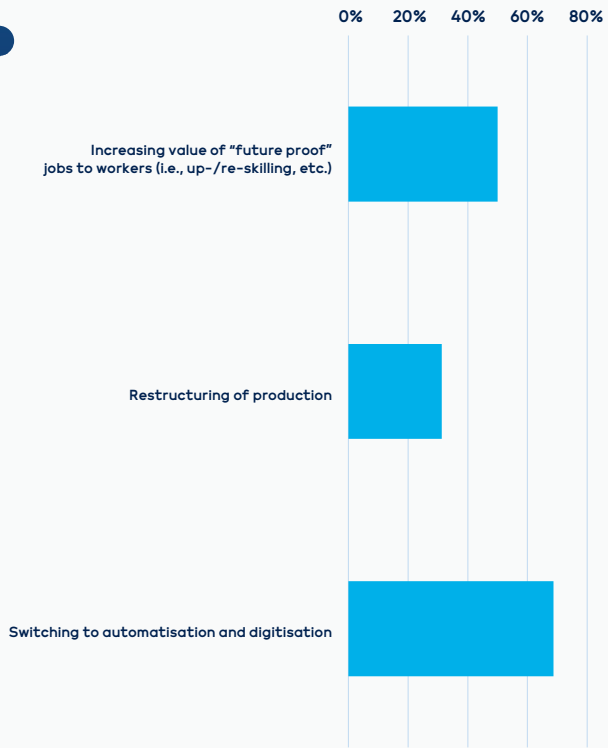
Impact of climate change



Timeline of structural shifts from the Fourth Industrial Revolution



Impacts from structural shifts from the Fourth Industrial Revolution



Potential impact on workforces:

a) Increasing the value of "future proof" jobs to workers (i.e., up-/re-skilling, etc.) (50%)

Potential impact on workplaces:

a) Switching to automatisation and digitisation (69%)

b) Restructuring of production (31%)

Increasing risk and uncertainty due to structural shifts from the climate crisis

The climate crisis will also bring uncertainty, change – and structural shifts.

Half of the global population experienced record temperatures over the last decade, with nearly 40% of the earth's surface exposed to record heat[62].

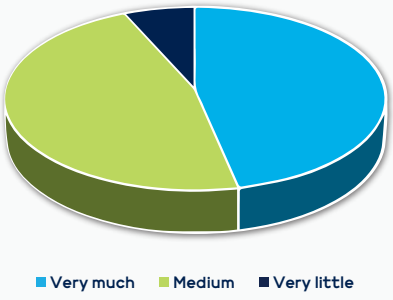
According to the Intergovernmental Panel on Climate Change (IPCC), it is "virtually certain" that "there have been increases in the intensity and duration of heatwaves and in the number of heatwave days at the global scale from 1950"[62].

Increasing heatwaves will impact outdoor workers, especially in hotter climates and tropical latitudes where heatstroke and dehydration are already significant risks. This may require restructuring the workday to avoid exposure to mid-day heat, resulting in scheduling and workforce impacts.

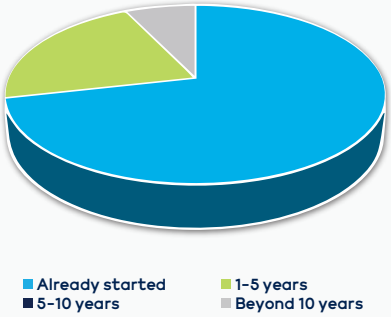
If and when the problem worsens, people and facilities may also need to relocate.

Impact of increasing risk and uncertainty due to structural shifts from the climate crisis on workforces and workplaces

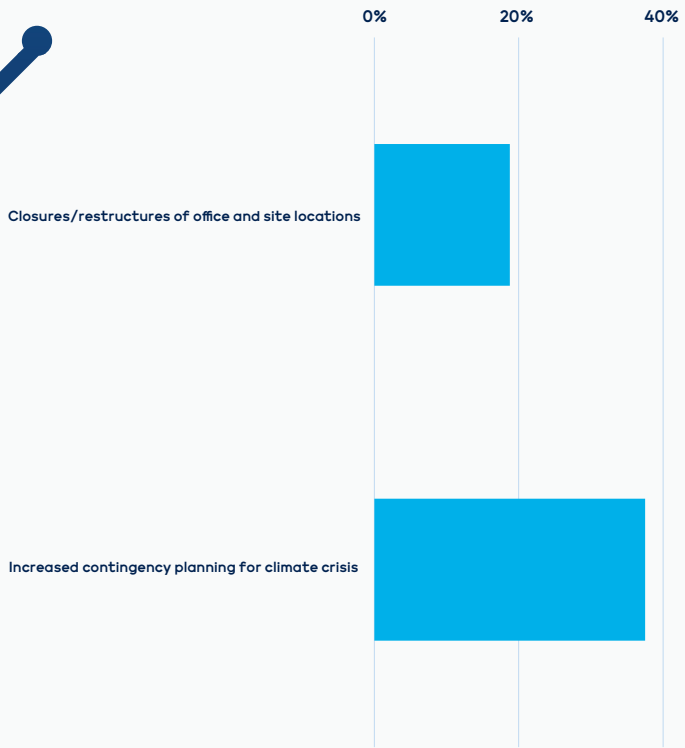
Impact of climate change



Timeline of uncertainty due to structural shifts from the climate crisis



Impacts from uncertainty due to structural shifts from the climate crisis



Potential impact on workforces:

a) Increasing impacts from harshness of climate and exposure to emergencies like floods and fires (no data collected)

b) Increasing value of jobs in locations perceived to be free of climate impacts and emergencies (no data collected)

Potential impact on workplaces:

a) Increased contingency planning for climate crisis (38%)

b) Closures/restructures of office and site locations (19%)

TRUST AND GOVERNANCE

Consumer and citizen demand for trust, transparency, fairness and environmental and social governance (ESG)

People increasingly buy sustainability and ethically, a trend embraced by more than 60% of the population and growing by 10% each year[63].

Sustainable and ethical investments are soaring, with environmental and social governance (ESG) assets potentially surpassing $50 trillion in 2025[64].

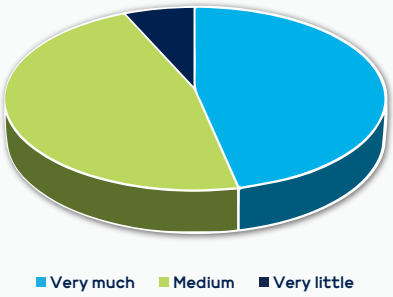
Organisations evolving their ESG priorities are focusing on ethics and integrity, supply chain security, resilience and transparency[63].

There is a priority on transitioning workforces and First Nations inclusion and empowerment, and a spotlight on the dynamic political landscape and expanding regulatory changes[63].

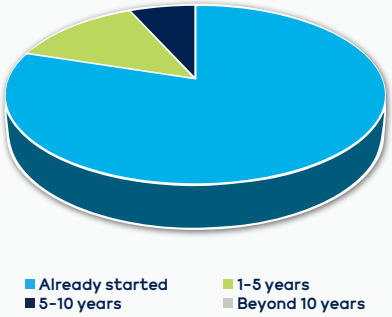
To thrive in this more trust- and ESG-focused business climate, organisations need to embrace transparency and ESG-related values and improve the sustainability of their workplaces and facilities.

Impact of consumer and citizen demand for trust, transparency, fairness and environmental and social governance (ESG) on workforces and workplaces

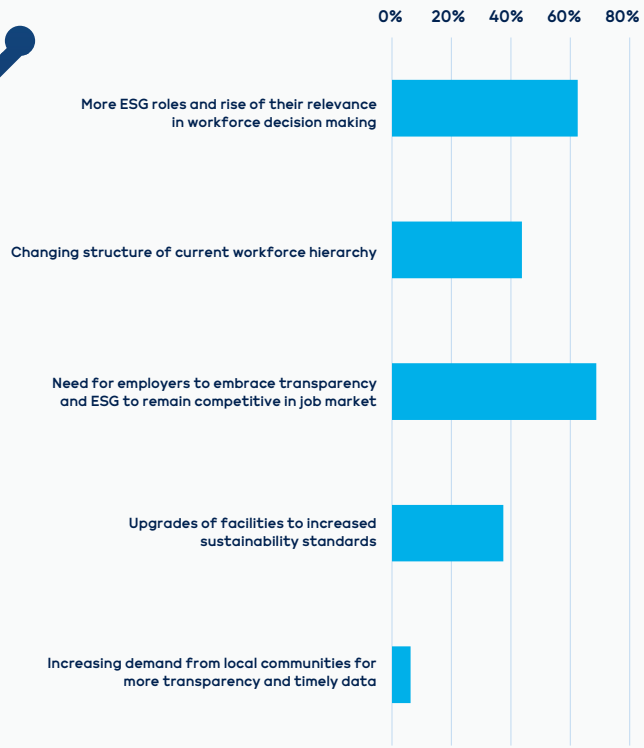
Impact of climate change



Timeline of demand for trust, transparency, fairness and ESG



Impacts from demand for trust, transparency, fairness and ESG



Potential impact on workforces:

a) Need for employers to embrace transparency and ESG to remain competitive in job market (69%)

b) More ESG roles and rise of their relevance in workforce decision making (63%)

c) Changing structure of current workforce hierarchy (44%)

Potential impact on workplaces:

a) Upgrades of facilities to increased sustainability standards (38%)

b) Increasing demand from local communities for more transparency and timely data

DISRUPTIVE IT TRENDS

Remote and digital work boom

The COVID-19 pandemic and burgeoning technology coalesced in an explosion of digitisation, telehealth, online shopping and digital currencies.

Restricted by lockdowns, businesses and consumers increasingly utilised digital technologies to provide and purchase goods and services online[65].

E-commerce's share of global retail trade went from 14% in 2019 to about 17% in 2020[66].

As online services expanded into healthcare, or virtual care, organisations developed stronger support infrastructure and stepped-up investments in digital health capabilities[67,68]. The pandemic also accelerated digital currency growth with consumers preferring contactless payment methods[69,70].

In a seismic shift, employees and employers recognised working from home as a viable option in many industries[71,72].

Australians have grown to value the flexibility of working remotely – chiefly because it eliminates commuting[73].

With more working from home, management practices have changed. More emphasis is placed on flexibility and agility, leadership, health and wellbeing[72] and improved productivity[74].

In 2021 almost half the workforce operated from home[75,76].

With the pandemic over, working from home has normalised. In 2023, the average number of days worked from home varied significantly by state, from 3 days in Victoria to 1 day in Western Australia[77].

The practice is highly desired by prospective employees, with "working from home" the most sought search term on job search site Seek in 2022 [78].

The 2022 Remote Work Report from HR platform Employment Hero found 50% of hybrid and remote employees would consider quitting their jobs if required to return to the office full-time[79].

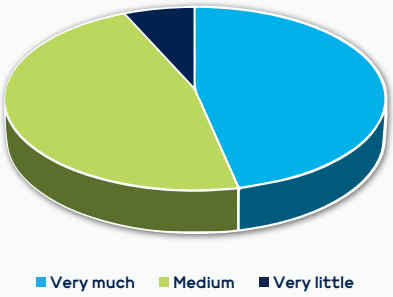
Organisations are therefore challenged to adapt to working from home and modify workplaces accordingly.

Further upheaval will come from the digitisation boom. Australia is projected to need 370,000 digital workers by 2026, including digital experts, digitally-enabled and digitally-informed workers[80].

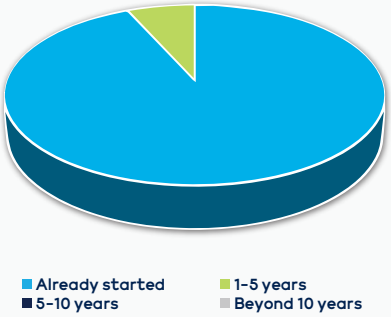
The working from home and digitisation boom has added workforce strain from employee expectations and skills shortages, while requiring significant workplace adjustment.

Impact of the remote and digital work boom on workforces and workplaces

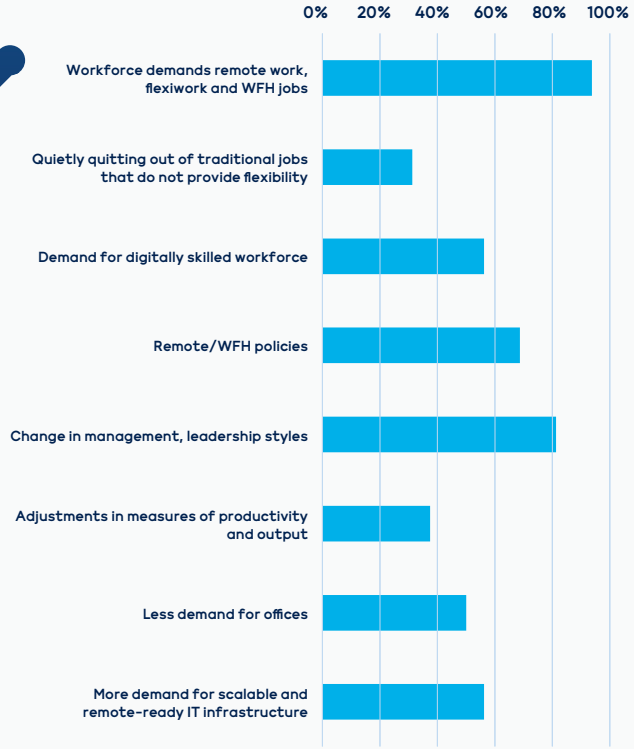
Impact of climate change



Timeline of remote and digital work boom



Impacts from remote and digital work boom



Potential impact on workforces:

a) Workforce demands remote work, flexiwork and WFH jobs (93.8%)
b) Change in management, leadership styles (81.3%)
c) Remote/WFH policies (68.8%)
d) Demand for digitally skilled workforce (56.3%)
e) Adjustments in measures of productivity and output (37.5%)
f) Quietly quitting out of traditional jobs that do not provide flexibility (31.3%)

Potential impact on workplaces:

a) More demand for scalable and remote-ready IT infrastructure (56.3%)
b) Decreased demand for offices (50%)

Rising use of AI, autonomous technologies and next-level process automation

AI reached human performance levels for image recognition in 2015, speech recognition in 2017, reading and handwriting recognition in 2018, language understanding in 2020 and common sense completion in 2023. However, interestingly, AI still lags behind human performance in grade school maths and code generation[81].

Currently, AI is popular among Millennials and Generation Z and largely used for search, research, brainstorming and art[82].

However, according to one source, GPT (an AI model created by OpenAI), will impact a tenth of the work tasks of 60% of the US workforce, while 20% of employees will have 50% of their work tasks affected[83]. Jobs with the highest exposure require a degree and minimal on-the-job training. They include writing, programming, information processing, routine and repetitive work[83].

AI is thought to have the biggest impact on professionals, educators and creatives[84]. Its capabilities continue to evolve, with significant improvements forecast for applications such as generating novel patterns and categories, social and emotional sensing, natural language understanding and coordination with multiple agents[84].

Along with the benefits come threats. In a survey of professionals, the greatest workplace AI fears were reduced accuracy (25%), widespread job loss (19%), demise of the profession altogether (17%), data security (15%) and loss of ethics (15%)[85].

On 30 May 2023, the Centre for AI Safety published a press release signed by more than 350 CEOs, experts, scientists and celebrities highlighting the risks of AI[86]. The Centre of AI Safety's co-founder Dan Hendrycks, a 2022 PhD graduate in computer science from the University of Berkeley in California, co-authored a risk analysis paper[87]. Chief among a list of threats was AI weaponisation.[87] While AI can help identify cyberthreats, its misuse can create malicious code or make phishing emails more sophisticated.

Less sensational – but of direct interest to HR professionals – is the fear that increasing reliance on automation and AI may decrease staff motivation to maintain skills, leading to a shrinking knowledge and skill base[87]. This has already played out in staff shortages for legacy programming languages such as COBOL and FORTRAN in the financial and nuclear industry. More challenges are ahead wherever there is an attempt to modernise legacy systems[88,89].

Another concern is overly simplistic or suboptimal goals that focus on profits at the cost of human values like wellbeing. It begs speculation about what could happen "if a sufficiently powerful AI successfully optimises" such "flawed objectives to an extreme degree"[87]. There are related issues: what if AI decides on a goal strategy that runs contrary to that of the company? If goals are achieved faster, deception may be incentivised (e.g., in advertising).

Dynamic AI systems carry the risk of abetting power-seeking behaviour. It has even been ventured that AI leaders of the near future will rule the world for decades to come[90].

Finally, and importantly, looms the danger of "a reduction in rationality due to a deluge of misinformation" generated from potentially questionable biased data or erroneous language models[91]. While data becomes easier to access, its veracity and provenance is harder to establish – potentially leading to an erosion of consensus reality. Retracting erroneous information is often difficult or futile. For example, a significant proportion of original research in areas like psychology and medicine arrives at different results when the experiment is repeated[92,93,94,95]. Yet research at these potentially questionable stages is cited more frequently than when it has been successfully corroborated by newer research[96,97].

AI proliferation will have wide-ranging workforce impacts. A 2013 Oxford university study estimated AI and other computer technology would replace 47% of employees[98]. A 2017 McKinsey study found the technology already exists to automate 50% of worldwide work[99].

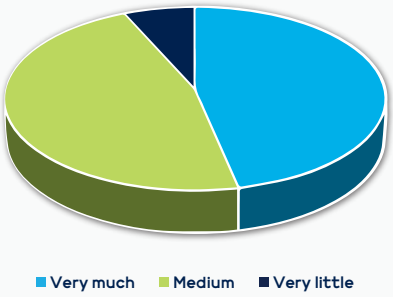
In its 2020 Future of Jobs report, the World Economic Forum calculated automation could displace 85 million jobs by 2025[100]. (The same report noted 97 million new jobs could emerge from the rise of AI, a net job gain).

In the 2023 edition of the same report, a structural labour market churn of 23% of jobs is envisioned across the next five years. Sixty-nine million new forecast jobs are weighed against a predicted decline of 83 million jobs for a net decrease of 14 million jobs (2%)[5]. Forty-two per cent of business tasks are likely to be automated by 2027. Thirty-five per cent of reasoning and decîsion-making and 65% of information and data processing tasks will be automated.

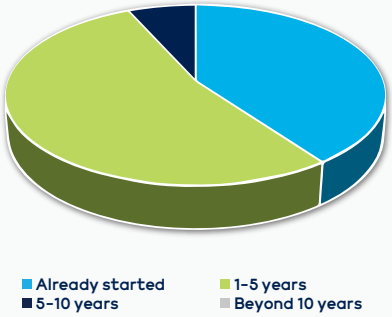
Besides changing supply and demand and differing skill expectations, AI will require adaptive business processes and infrastructure.

Impact of the rising use of AI, autonomous technologies and next-level process automation on workforces and workplaces

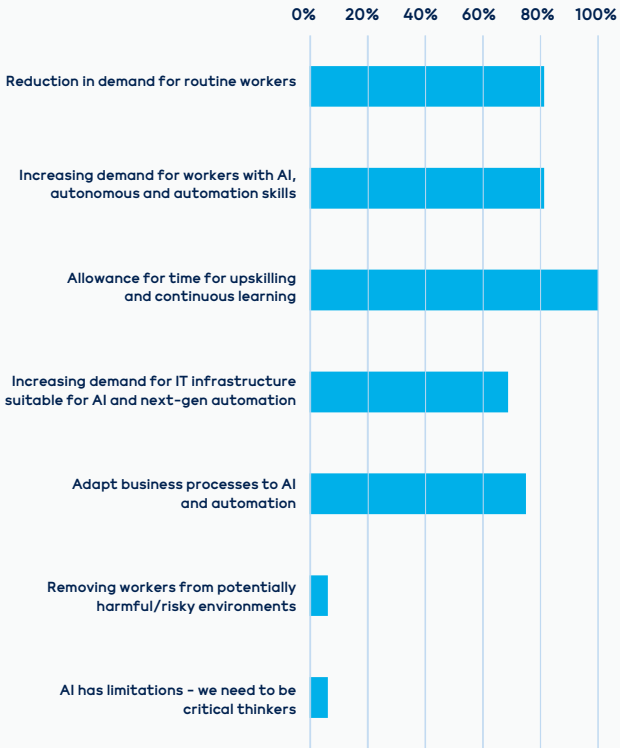
Impact of climate change



Timeline of AI and automation



Impacts from AI and automation



Potential impact on workforces:

a) Allowance for time for upskilling and continuous learning (100%)
b) Reduction in demand for routine workers (81%)
c) Increasing demand for workers with AI, autonomous and automation skills (81%)

Potential impact on workplaces:

a) Adapting business processes to AI and automation (75%)
b) Increasing demand for IT infrastructure suitable for AI and next-gen automation (69%)
c) Allowance for time for upskilling and continuous learning
d) Removing workers from potentially harmful/risky environments
e) AI has limitations - we need to be critical thinkers

To comprehend how far Artificial intelligence (AI) has come, the following passage explaining generative AI – itself produced using generative AI.

Generative AI, or Generative Artificial Intelligence, refers to a class of artificial intelligence systems and models that are designed to generate new data, often in the form of text, images, audio, or other types of content, that is similar to or consistent with existing data. These AI systems are capable of producing creative and novel outputs based on patterns and information learned from a dataset during training. Here are some key aspects of generative AI:

1. Learning from Data: Generative AI models are trained on large datasets, which can be composed of various types of information, such as text, images, or even raw data like stock prices or medical records. During training, the AI system learns statistical patterns, structures, and relationships within the data.
2. Creativity and Novelty: One of the defining features of generative AI is its ability to generate content that is not copied directly from the training data but is instead novel and creative. This allows generative AI to produce new and unique outputs based on the knowledge it has acquired.
3. Variability: Generative AI models can produce a wide range of outputs for a given input or prompt, demonstrating variability in their responses. This variability can be controlled or influenced by adjusting various parameters or conditions.
4. Applications: Generative AI has found applications in various domains, including natural language processing (NLP), computer vision, music composition, art generation, and more. Some well-known examples of generative AI models include GPT-3 for text generation, GANs (Generative Adversarial Networks) for image generation, and DALL-E for creating images from textual descriptions.
5. Challenges: Generative AI also faces challenges, including ethical concerns related to the generation of potentially harmful or misleading content, biases learned from training data, and the need for responsible deployment and regulation.
6. Training: Training generative AI models often requires substantial computational resources and large datasets. Advanced models like GPT-3, for example, are trained on massive amounts of text data and can have billions of parameters.

Generative AI has shown promise in various creative and practical applications, but it also raises important questions about ethics, privacy, and the potential consequences of deploying AI systems that can create content autonomously. It is important to consider the ethical implications and societal impact of generative AI as it continues to evolve and be integrated into various industries and technologies.


help you ?

Rising use of virtual reality and augmented reality

Virtual and augmented reality technologies are on the rise[102] and may benefit not only early-adopter younger generations but the ageing population[102].

These technologies also have far-reaching application in the resources and energy industry.

Virtual Reality (VR) immerses the user in a computer-generated, three-dimensional virtual environment using interactive devices[103].

Augmented Reality (AR) enhances the real world by superimposing computer-generated digital information, providing a composite view[104].

Virtual and augmented reality can improve safety and efficiency in the resources and energy industry through training, modelling, visualisation and remote operation, especially for complex information and concepts[105].

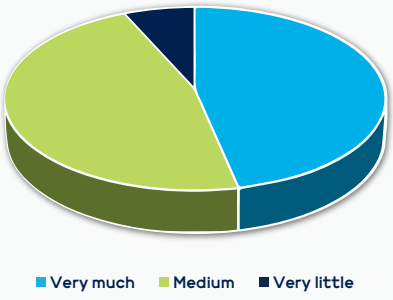
The applications can also make design and maintenance more efficient by allowing employees to interact with virtual models and reduce the need for physical interfaces[105].

Sustainable development also stands to benefit from virtual and augmented reality, which is of particular interest to the mining industry[106].

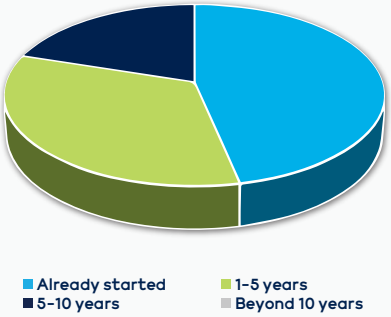
To reap the benefits of virtual and augmented reality, the right technologies must be enabled with support systems established and local knowledge employed – challenging workplaces to adapt.

Impact of the rising use of virtual reality and augmented reality on workforces and workplaces

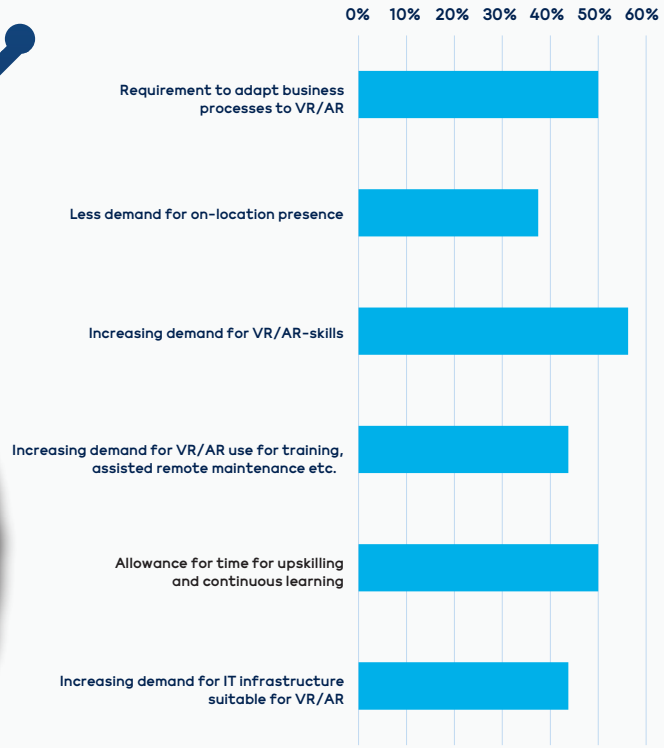
Impact of climate change



Timeline of VR and AR



Impacts from VR and AR



Potential impact on workforces:

a) Increasing demand for VR/AR skills (56%)
b) Allowance for time for upskilling and continuous learning (50%)
c) Increasing demand for VR/AR use for training, assisted remote maintenance etc. (44%)
d) Decreased demand for on-location presence (38%)

Potential impact on workplaces:

a) Requirement to adapt business processes to VR/AR (50%)
b) Increasing demand for IT infrastructure suitable for VR/AR (44%)

Next-generation computing

Next-generation computing refers to a group of technologies including quantum computing, neuromorphic computing and neural networks using machine learning to develop software.

Related to these technologies is virtualisation, referring to the creation of a virtual (software-based) abstraction layer on top of computer hardware, storage devices or network resources and allowing multiple virtual environments to coexist and operate on the same physical hardware[107].

Virtual desktop infrastructure (i.e., multiple desktop environments run off a central server and requiring only "thing clients" or low specification terminals) and "virtual machines" (for running emulations of non-native operating systems on hardware platforms not designed for it) are already ubiquitous. Other applications include virtual networks and virtual storage and data centres[107].

Virtualisation benefits include lower IT expenses, reduced downtime and disaster recovery, increased efficiency and productivity, independent development environments not impacting production and reduced energy expenditure and carbon footprint[108].

Digital transformation has long contributed to data-driven operations and supply chain optimisation, with improved and faster insights, improved transparency and operational efficiency, more agile processes, improved safety and regulatory compliance, enhanced flexibility and reduced cost[109].

Oilfield and mining operations can be optimised with flexible and scalable cloud-based service platforms, simplified and more efficient training and scheduling applications, tools with intuitive and familiar user interfaces, role-based customisation of applications and information sharing across organisational and geographic boundaries.[109]

These technologies are transforming the resources and energy industry, with oil and gas companies projected to spend up to $12 billion by 2023 on cloud computing and analytics[110].

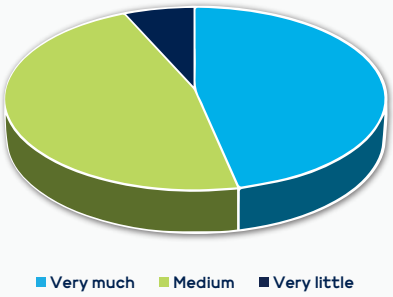
McKinsey's work with the oil and gas sector suggests offshore operators can reduce costs – including operational and capital expenditures – by 20 to 25% per barrel through connectivity to deploy digital tools and analytics[115].

All new technologies – not just next-generation computing – will require training, placing higher demand on companies' learning and development capabilities[112]. According to estimates, around 40% of workers will need retraining for at least six months[112]. Other research forecasts 30% more time needed to learn on the job[113].

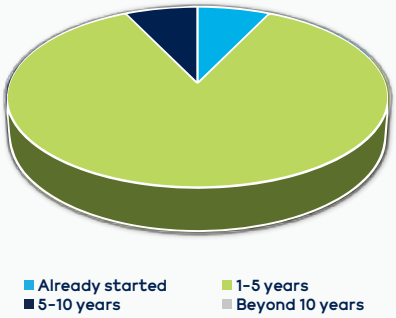
While increasing next-generation computing and related technologies holds great promise for the resources and energy industry, the workforce needs to be upskilled accordingly and workplace infrastructure adapted.

Impact of next-generation computing on workforces and workplaces

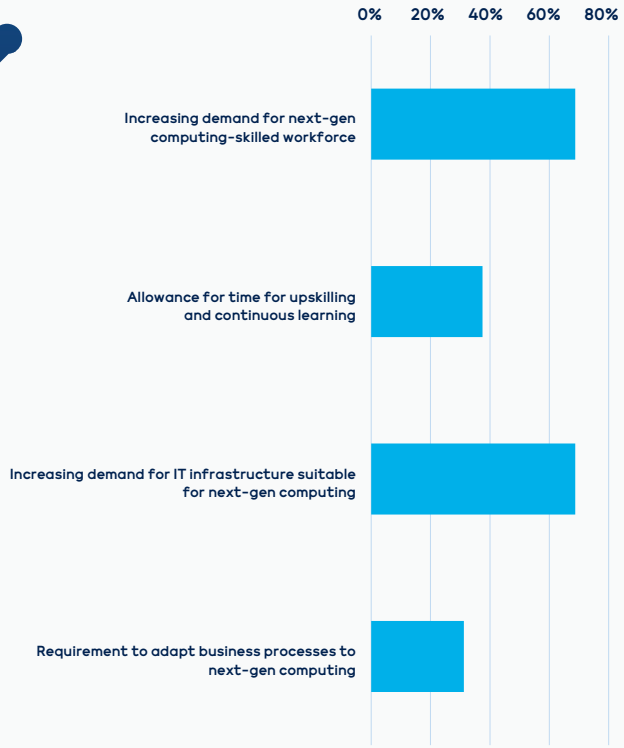
Impact of climate change



Timeline of next-generation computing



Impacts from next generation computing



Potential impact on workforces:

a) Increasing demand for next-gen computing-skilled workforce (69%)

b) Allowance for time for upskilling and continuous learning (38%)

Potential impact on workplaces:

a) Increasing demand for next-gen computing IT infrastructure (69%)

b) Adapting business processes to next-gen computing (31%)

Enhanced connectivity through Web 3.0, 5G and IoT

Fifth-generation (5G) broadband cellular networks and the Internet of Things (IoT) will enhance communication through faster connectivity across longer distances, with exponentially quicker downloads and latency for smart devices and distributed infrastructure – bringing together cloud and edge computing to boost speed and agility.

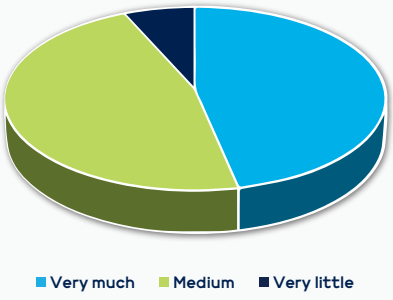
Part of this bold connectivity is Web 3.0: a new iteration of the World Wide Web encompassing decentralisation, blockchain technologies and token-based economics[114].

According to McKinsey, utilising enhanced connectivity to optimise drilling and production throughput and improve maintenance and field operations could add $250 billion of value to the industry's upstream operations by 2030[115].

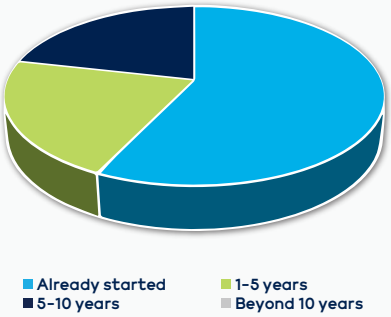
Once again, to fully reap the benefits, the resources and energy industry must upskill workforces and upgrade workplaces and facilities.

Impact of enhanced connectivity through Web 3.0, 5G and IoT on workforces and workplaces

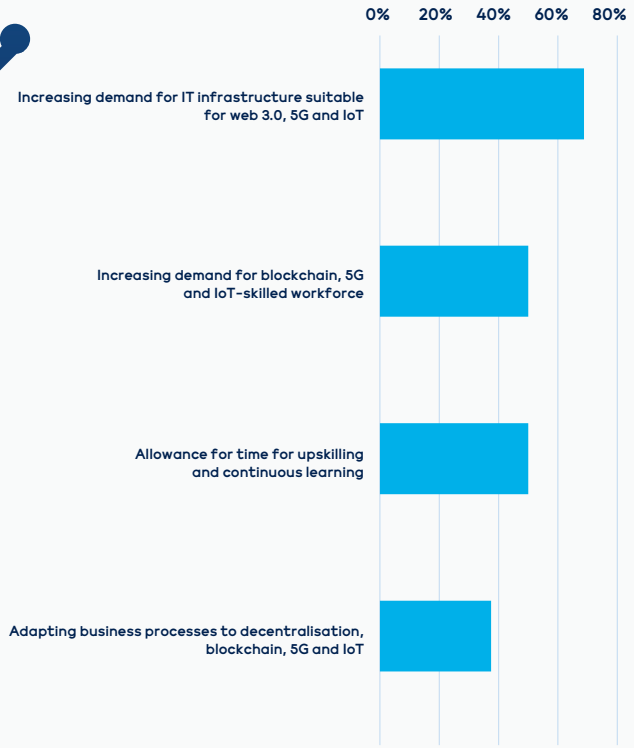
Impact of climate change



Timeline of improved connectivity
(Web 3.0, 5G and IoT, cloud and edge computing)



Impacts from improved connectivity
(Web 3.0, 5G and IoT, cloud and edge computing)



Potential impact on workforces:

a) Increasing demand for blockchain, 5G and IoT-skilled workforce (50%)

b) Allowance for time for upskilling and continuous learning (50%)

Potential impact on workplaces:

a) Increasing demand for IT infrastructure suitable for web 3.0 5G and IoT (69%)

b) Adapting business processes to decentralisation, blockchain, 5G and IoT (38%)

Trust architecture to defend against cyberattacks

Cyberattacks are on the rise in Australia, with cybercrime reports increasing from one every eight to one every 7 minutes (i.e., 13%) between 2021 and 2022[116]. The cost per attack has risen by 14%, averaging $39,000 for small business, $88,000 for medium business, and over $62,000 for large businesses[116]. Public reporting of software vulnerabilities has increased by 25% worldwide[116].

The resources and energy industry is becoming a target for cyberattacks. Risks are growing as the industry employs more connected technology and yet the industry's cyber maturity is relatively low[117].

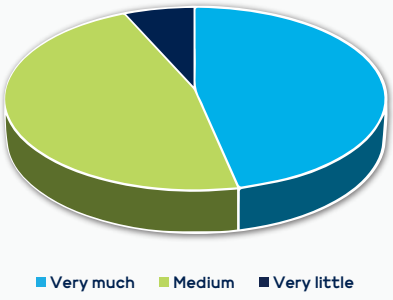
A new trust architecture is required to defend against attacks: distributed-ledger technologies such as blockchain and "zero-trust security" approaches to preventing data breaches can help mitigate cyber risks in the resources and energy industry, keeping people and assets safe and operations reliable[117].

Trust architecture can help prevent infrastructure sabotage, espionage and data theft with comprehensive cybersecurity solutions[118,119].

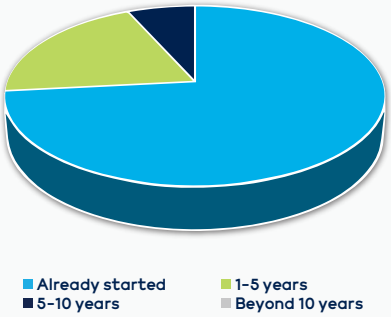
As cyberattacks become more prevalent and sophisticated, organisations need to adapt workforce skills, business processes and facilities and ensure contingency and business continuity planning.

Impact of trust architecture to defend against cyberattacks on workforces and workplaces

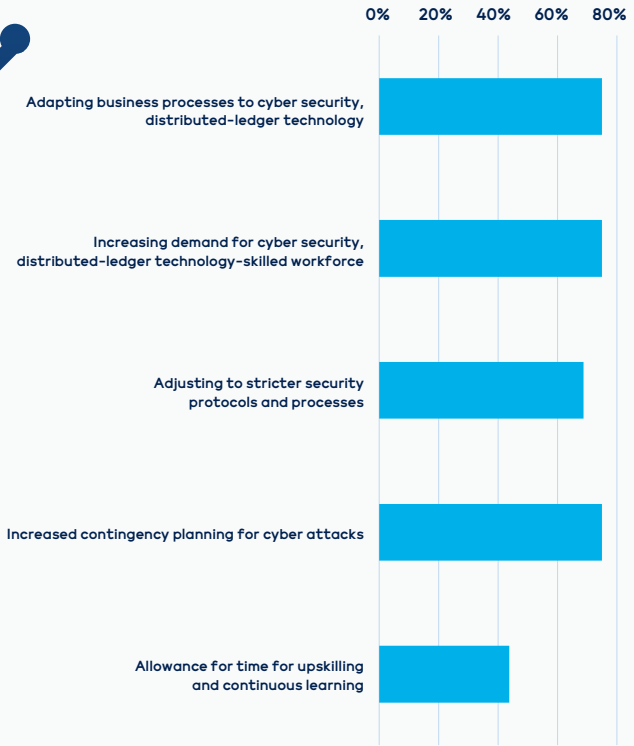
Impact of climate change



Timeline of trust architecture and cyberattacks



Impacts from trust architecture and cyberattacks



Potential impact on workforces:

a) Increasing demand for cyber security, distributed-ledger technology-skilled workforce (75%)

b) Adjusting to stricter security protocols and processes (69%)

c) Allowance for time for upskilling and continuous learning (44%)

Potential impact on workplaces:

a) Adapting business processes to cyber security, distributed-ledger technology (75%)

b) Increased contingency planning for cyberattacks (75%)

Devaluation of raw in favour of aggregated data

The Big Data trend has reached the resources and energy industry[120].

As the proliferation of data increases to its limits, with data privacy regulations covering more industries and data science and analytics maturing, raw data will become devalued in favour of high-level aggregated data[47].

This may diminish budgets for analytics, while pressing the need for more densely aggregated data[121].

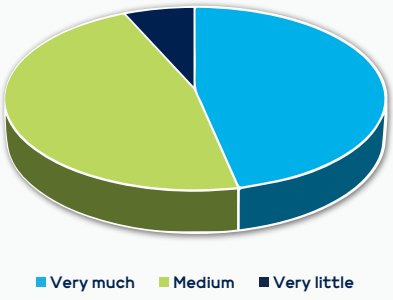
Aggregated data can help businesses make more informed decisions by providing accurate and summarised information, reducing the time and effort required to analyse large datasets and bringing focus to more strategic tasks[122].

Aggregated data can also help resource and energy companies improve their operations via more accurate and timely information about assets, resources and processes, and bridging the gap between acquisition, monitoring, evaluation and control[123].

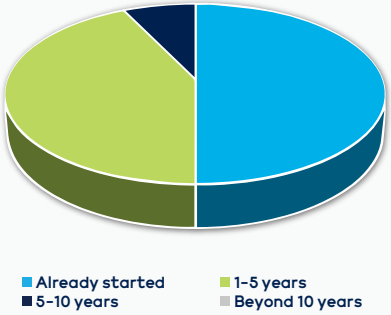
However, Big Data and the desire for aggregated data may also present challenges for resources and energy companies, such as workforce upskilling and investment in the new technologies and processes to aggregate and analyse data, when the budget for analytics is shrinking.

Impact of devaluation of raw in favour of aggregated data on workforces and workplaces

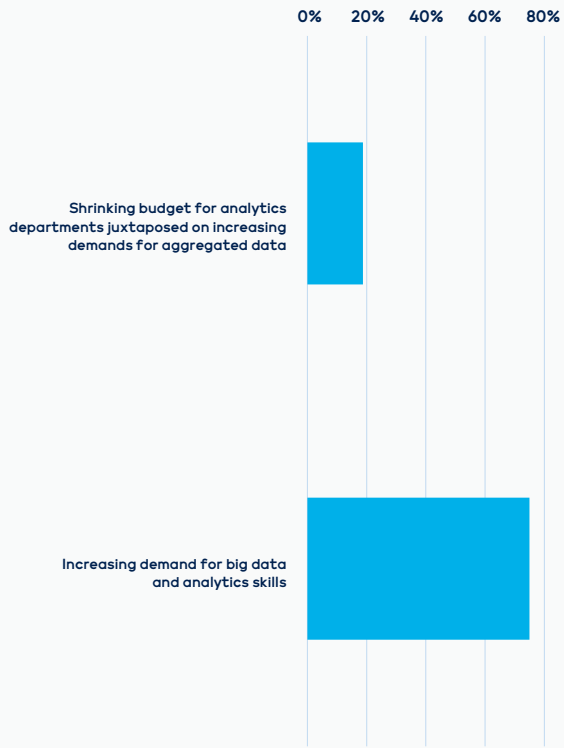
Impact of climate change



Timeline of devaluation of raw data



Impacts from devaluation of raw data



Potential impact on workforces:

a) Increasing demand for big data and analytics skills (75%)

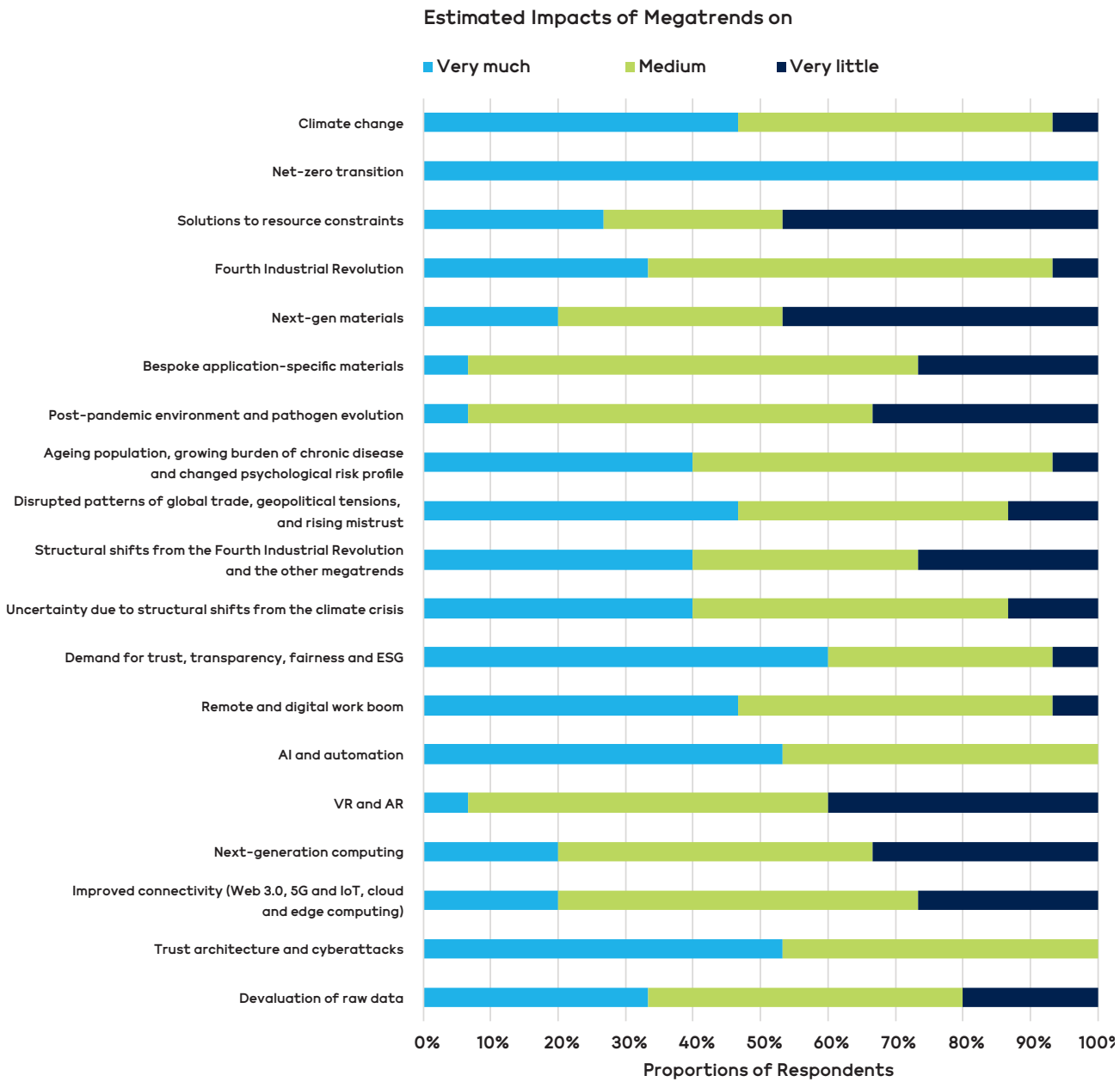
b) Allowance for time for upskilling and continuous learning

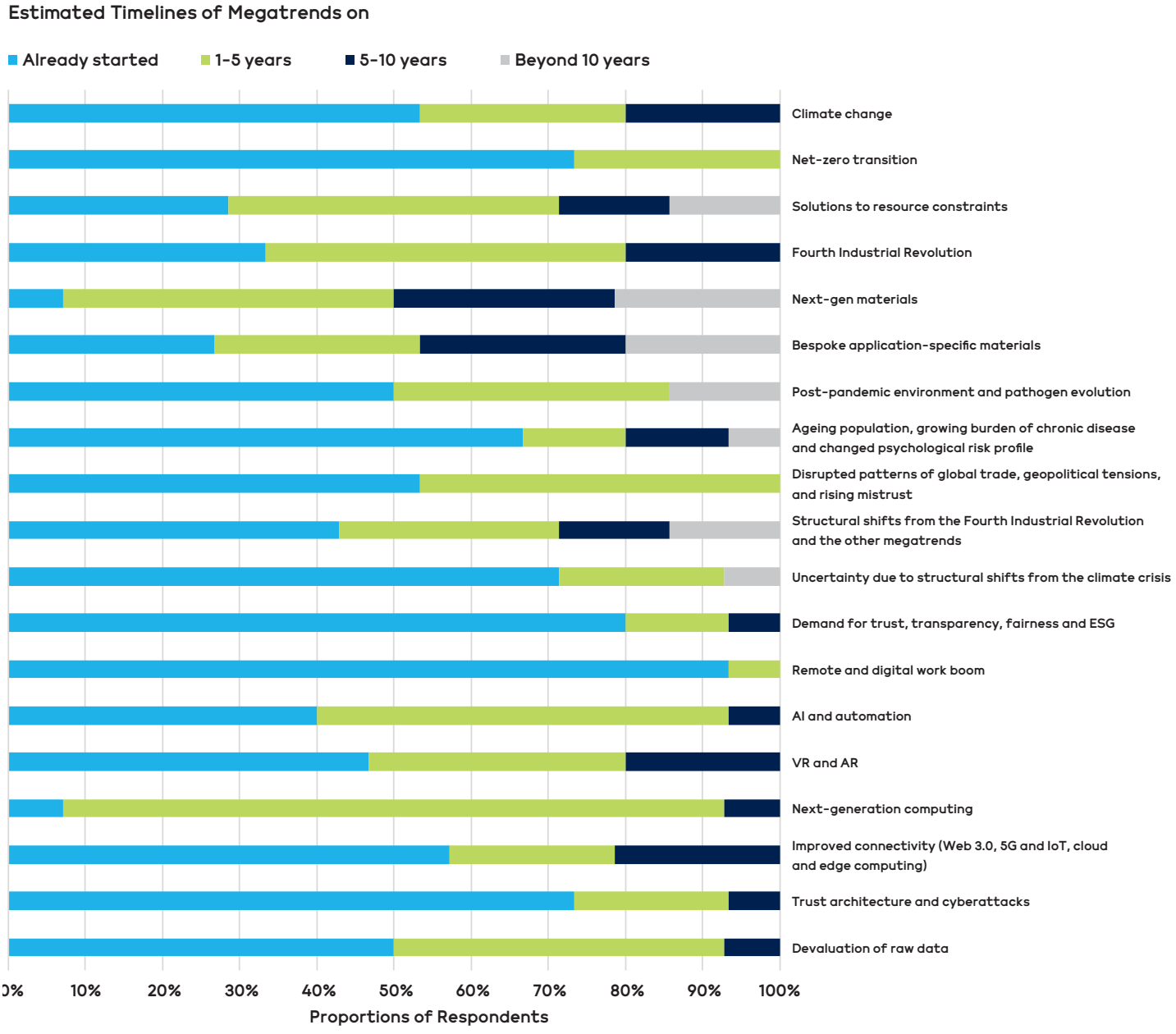
Potential impact on workplaces:

a) Increasing demands for aggregated data (19%)

SUMMARY

Megatrends: Estimated Severity and Timing of Impact




Estimated Timelines of Megatrends on
Already started
1-5 years
5-10 years
Beyond 10 years
Climate change
Net-zero transition
Solutions to resource constraints
Fourth Industrial Revolution
Next-gen materials
Bespoke application-specific materials
Post-pandemic environment and pathogen evolution
Ageing population, growing burden of chronic disease and changed psychological risk profile
Disrupted patterns of global trade, geopolitical tensions, and rising mistrust
Structural shifts from the Fourth Industrial Revolution and the other megatrends
Uncertainty due to structural shifts from the climate crisis
Demand for trust, transparency, fairness and ESG
Remote and digital work boom
AI and automation
VR and AR
Next-generation computing
Improved connectivity (Web 3.0, 5G and IoT, cloud and edge computing)
Trust architecture and cyberattacks
Devaluation of raw data
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Proportions of Respondents

Megatrends: Summary of Impacts on Workforces and Workplaces

MEGA-TRENDS	SUB-TRENDS	IMPACT ON WORKFORCES*	IMPACT ON WORKPLACES*
CLIMATE CHANGE ADAPTATION, NET-ZERO	Adapting to climate change and increasing frequency and impact of natural disasters	• Eco anxiety in the workforce • Work locations being assessed on harshness of climate and exposure to emergencies such as floods and fires • Higher demand for certain resources driving demand on labour/skills	• Asset re-evaluations and relocations • Impact on biodiversity and Indigenous/First Nations communities • Shift in purpose and business direction • Client impacts • Disconnect between public needing/using resources and not understanding the climate trade-off • Internal carbon pricing to ensure full cost of capital is explored • Permits to access undeveloped resources and exploration will become more difficult and will also present opportunities to invest in renewables • Readiness for carbon neutral
	The net-zero transition	• **Skills shortages in green technologies** • Decreased interest in industries perceived as contributing to anthropogenic climate change • Increased demand for job security in certain industries	• **Focus on zero energy transition for workplace infrastructure and facilities** • Increased demand for end products • May lead to reprioritisation of resource development based on carbon content
	Increased focus on advanced recycling & synthetic biology	• **Decreased traditional labourer roles, more technology skill-based roles** • Skills shortage in synthetic biology and related sciences	• Adaptation of facilities for synthetic biology and related technology applications
FOURTH INDUSTRIAL REVOLUTION	Technology innovations related to the continuing Fourth Industrial Revolution	• **Increasing requirement for specialised technology skills** • Increasing value of up-/re-skilling, professional development (PD), etc. provided by employer	• Switching to automation and digitisation • Restructuring of production
MATERIALS REVOLUTION	Next-generation smart, responsive and lightweight materials	• Requirements for workforce skilled in material science and nanotechnology	• **Upgrading of infrastructure, facilities for next-gen materials** • **Change in technology and processes due to next-gen materials**
	Custom industrial processes to deliver bespoke application-specific materials	• **Requirements for workforce to have robotics, AI and agile project management skills** • More specialised technology jobs • Short-term projects and frequent change	• **Upgrading facilities for agile production and rapid reconfiguration**
BIO-REVOLUTION	Adapting to post-pandemic environment, pathogen evolution	• **Higher hygiene & biosafety standard expectations** • **Hygiene-conciousness of workforce**	• **Upgrading of infrastructure and facilities to higher hygiene and biosafety standards**
	Adapting to an ageing population, growing burden of chronic disease and changed psychological risk profile	• **More diverse workforce demographic** • **Decreased young, more older workers, more workers with disabilities and more neurodiverse workforce** • **More flexibility required to manage diverse needs of workforce, potential productivity loss**	• Requirements to upgrade facilities for ageing/chronically ill/psychologically distressed workforce • Higher risk associated with workplace injuries/illness

MEGA-TRENDS	SUB-TRENDS	IMPACT ON WORKFORCES*	IMPACT ON WORKPLACES*
UNCERTAINTY	Disrupted patterns of global trade, geopolitical tensions, rising mistrust	• Changes to workforce availability from migration • Additional competition for skilled workers from Defence	• **Increased security, business continuity, contigency planning** • Closures/restructures of office and site locations • Marketing impacts
	Increasing uncertainty due to structural shifts from the Fourth Industrial Revolution	• **Increasing value of "future proof" jobs to workers (i.e., up-/ re-skilling, etc.)**	• **Switching to automation and digitisation** • Restructuring of production
	Increasing risk and uncertainty due to structural shifts from the climate crisis	• Increasing impacts from harshness of climate and exposure to emergencies like floods and fires (no data collected) • Increasing value of jobs in locations perceived to be free of climate impacts and emergencies (no data collected)	• Increased contingency planning for climate crisis • Closures/restructures of office and site locations
TRUST & GOVERNANCE	Consumer and citizen demand for trust, transparency, fairness and increased environmental and social governance (ESG)	• **Need for employers to embrace transparency and ESG to remain competitive in job market** • **More ESG roles and rise of their relevance in workforce decision making** • Changing structure of current workforce hierarchy	• Upgrades of facilities to increased sustainability standards • Increasing demand from local communities for more transparency and timely data
DISRUPTIVE IT TRENDS	Remote and digital work boom	• **Workforce demands remote work, flexiwork and work from home (WFH) jobs** • **Change in management, leadership styles** • **Remote/WFH policies** • **Demand for digitally skilled workforce** • Adjustments in measures of productivity and output • Quietly quitting out of traditional jobs that do not provide flexibility	• **More demand for scalable and remote-ready IT infrastructure** • **Decreased demand for offices**
	Rising use of AI, autonomous technologies and next-level process automation	• **Allowance for time and resources for upskilling and continuous learning** • **Reduction in demand for routine workers** • **Increasing demand for workers with AI, autonomous and automation skills**	• **Adapting business processes to AI and automation** • **Increasing demand for IT infrastructure suitable for AI and next-gen automation** • Time allowance for upskilling and continuous learning • Removing workers from potentially harmful/risky environments • AI has limitations – we need to be critical thinkers
	Rising use of virtual reality (VR) and augmented reality (AR)	• **Increasing demand for VR/AR skills** • **Time allowance for upskilling and continuous learning** • Increasing demand for VR/AR use for training, assisted remote maintenance etc. • Decreased demand for on-location presence	• **Requirement to adapt business processes to VR, AR** • Increasing demand for IT infrastructure suitable for VR/AR
	Next-generation computing	• **Increasing demand for next-gen computing-skilled workforce** • Time allowance for upskilling and continuous learning	• **Increasing demand for next-gen computing IT infrastructure** • Requirement to adapt business processes to next-gen computing
	Enhanced connectivity through Web 3.0, 5G and Internet of Things (IoT)	• **Increasing demand for blockchain, 5G and IoT-skilled workforce** • **Time allowance for upskilling and continuous learning**	• **Increasing demand for IT infrastructure suitable for web 3.0, 5G and IoT** • Adapting business processes to decentralisation, blockchain, 5G and IoT
	Trust architecture to defend against cyberattacks	• **Increasing demand for cyber security, distributed-ledger technology-skilled workforce** • **Adjusting to stricter security protocols and processes** • Time allowance for upskilling and continuous learning	• **Adapting business processes to cyber security, distributed-ledger technology** • **Increased contingency planning for cyber attacks**
	Devaluation of raw in favour of aggregated data	• **Increasing demand for big data and analytics skills** • Time allowance for upskilling and continuous learning	• Increasing demands for aggregated data

* Items in bold font have been rated as important by 50% or more of respondents.

AREEA SUPPORT

AREEA's advisory team assist resources and energy employers nationally with workforce planning, attraction and retention and all related policies and procedures.

To understand how the AREEA team can assist please contact membership@areea.com.au or phone your local AREEA office or 1800 627 771.

REFERENCES AND READINGS

Below is a list of existing resources and opinion pieces for your perusal. These resources are provided as links wherever possible due to the sizable number of pages.

[1]Visual Capitalist. (2023). *Infographic: 11 Tech Trends to Watch in 2023*. https://www.visualcapitalist.com/11-tech-trends-to-watch-2023/

[2]Van Kuiken, S. (2022). *Tech at the edge: Trends reshaping the future of IT and business*. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/tech-at-the-edge-trends-reshaping-the-future-of-it-and-business

[3]Gartner Insights. (2022). *Gartner Top 10 Strategic Technology Trends for 2023*. https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2023

[4]Australian Bureau of Statistics. (2020, December 17). *Twenty years of population change*. https://www.abs.gov.au/articles/twenty-years-population-change

[5]Di Battista, A., Grayling, S., Hasselaar, E., Leopld, T., Li, R., Rayner, M., & Zahidi, S., (2023). *Future of Jobs Report 2023 | Insight Report May 2023*. World Economic Forum. https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

[6]Australian Government. (2023). *2023 Intergenerational Report*. Australian Government | Treasury. https://treasury.gov.au/publication/2023-intergenerational-report

[7]Australian Bureau of Statistics. (2022, June 28). *Cultural diversity: Census*. https://www.abs.gov.au/statistics/people/people-and-communities/cultural-diversity-census/latest-release

[8]Australian Bureau of Statistics. (2022, November 8). *Population movement in Australia*. https://www.abs.gov.au/articles/population-movement-australia

[9]Australian Bureau of Statistics. (2023, April 20). *Regional population*. https://www.abs.gov.au/statistics/people/population/regional-population/2021-22

[10]Ernest & Young. (2022). *Top 10 business risks and opportunities for mining and metals in 2023*. https://www.ey.com/en_gl/mining-metals/risks-opportunities

[11]Deloitte Insights. 2022). *Tech Trends 2023*. https://www2.deloitte.com/us/en/insights/focus/tech-trends.html.html#explore

[12]Curtis, M., Burke, K., de la Mare, N., McNeely, G., Björnsjö, A. (2022). *Accenture Life Trends 2023: Control and Power*. https://www.accenture.com/au-en/insights/song/accenture-life-trends

[13]Chui, M., Roberts, R., & Yee, L. (2022). *McKinsey Technology Trends Outlook 2022*. McKinsey. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech

[14]Australian Government. (2021). *Digital Economy Strategy on a page – Delivering a modern and digital economy to drive Australia's future prosperity*. https://digitaleconomy.pmc.gov.au/sites/default/files/2021-05/digital-economy-strategy-on-a-page.pdf

[15]Naughtin, C., Hajkowicz, S., Schleiger, E., Bratanova, A., Cameron, A., Zamin, T., Dutta, A. (2022). *Our Future World: Global megatrends impacting the way we live over coming decades*. CSIRO. https://www.csiro.au/en/research/technology-space/data/Our-Future-World

[16]Buckup, S., Keenan, G., Yoon, S., Landale, J., Letzig, J., Mergenthaler, S., Sung, M., Calderwork, L.U. (2023). *Top 10 Emerging Technologies of 2023 | Flagship report June 2023. Centre for the Fourth Industrial Revolution* | World Economic Forum. https://www.weforum.org/reports/top-10-emerging-technologies-of-2023

[17]Word Economic Forum. (2021). *Global forces shaping the future of mining and how to navigate them*. World Economic Forum. https://www.weforum.org/agenda/2021/05/global-forces-shaping-future-mining-industry/

[18]Office of Planning and Research. (2023). *List of Worldwide Scientific Organizations*. https://www.opr.ca.gov/facts/list-of-scientific-organizations.html

[19]NASA. (2019). *Scientific consensus: Earth's climate is warming. Climate Change: Vital Signs of the Planet. NASA*. https://climate.nasa.gov/scientific-consensus

[20]United Nations Environment Programme. (2023). *Climate Change 2023: Synthesis Report. UNEP - UN Environment Programme*. https://www.unep.org/resources/report/climate-change-2023-synthesis-report

[21]Spera, S. (2021). *234 scientists read 14,000+ research papers to write the IPCC climate report – here's what you need to know and why it's a big deal*. The Conversation. https://theconversation.com/234-scientists-read-14-000-research-papers-to-write-the-ipcc-climate-report-heres-what-you-need-to-know-and-why-its-a-big-deal-165587

[22]CSIRO. (2020). *Climate change in Australia*. https://www.csiro.au/en/research/environmental-impacts/climate-change/climate-change-information

[23]Australian Academy of Science. (2021). *Climate change and Australian science*. www.science.org.au. https://www.science.org.au/supporting-science/science-policy-and-analysis/position-statements/climate-change-2021

[24]NSW Department of Planning and Environment. (2000). *Anthropogenic Climate Change - key threatening process listing*. https://www.environment.nsw.gov.au/Topics/Animals-and-plants/Threatened-species/NSW-Threatened-Species-Scientific-Committee/Determinations/Final-determinations/2000-2003/Anthropogenic-Climate-Change-key-threatening-process-listing

[25]McKinsey Sustainability. (2021). *Solving the net-zero equation: Nine requirements for a more orderly transition. McKinsey & Company*. https://www.mckinsey.com/capabilities/sustainability/our-insights/solving-the-net-zero-equation-nine-requirements-for-a-more-orderly-transition

[26]Gielen, D.; Gorini, R.; Prakash, G. (2021). *Energy Experts: Reaching net-zero by 2050 relies on these 7 things. World Economic Forum*. https://www.weforum.org/agenda/2021/05/net-zero-carbon-future-2050-irena-energy-transition/

[27]Azevedo, M., Baczynska, M., Bingoto, P., Callaway, G., Hoffman, K., & Ramsbottom, O. (2022). *The raw-materials challenge: How the metals and mining sector will be at the core of enabling the energy transition*. McKinsey & Company. https://www.mckinsey.com/industries/metals-and-mining/our-insights/the-raw-materials-challenge-how-the-metals-and-mining-sector-will-be-at-the-core-of-enabling-the-energy-transition

[28]Kikken, N. (2021). *Advanced recycling: turning plastic waste into resources*. CSIRO. https://www.csiro.au/en/news/all/articles/2021/august/advanced-recycling-plastic-waste

[29]Schiavone, D. (2022). *Synthetic Biology Class Ignites a Spark in the Future Workforce*. MITRE. https://www.mitre.org/news-insights/impact-story/synthetic-biology-class-ignites-spark-future-workforce

[30]Raney, K. (2019). *New Microbial Approach Advances Enhanced Oil Recovery, Well Stimulation and Paraffin Dispersal*. AOGR. https://www.aogr.com/web-exclusives/exclusive-story/new-microbial-approach-advances-enhanced-oil-recovery-well-stimulation

[31]Cai, P., Ning, Z., Liu, Y., He, Z., Shi, J., & Niu, M. (2020). *Diagnosing bioremediation of crude oil-contaminated soil and related geochemical processes at the field scale through microbial community and functional genes. Annals of Microbiology*, 70(1). https://doi.org/10.1186/s13213-020-01580-x

[32]Candelon, F., Gombeaud, M., Stokol, G., Patel, V., Gourévitch, A., & Goedel, N. (2022). *Synthetic Biology Is About to Disrupt Your Industry*. BCG Global. https://www.bcg.com/publications/2022/synthetic-biology-is-about-to-disrupt-your-industry

[33]Kagerman, H., Wahlster, W., Helbig, J. (2013). *Recommendations for implementing the strategic initiative Industry 4.0*. Acatech, München. https://www.din.de/resource/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf

[34]Wikipedia Contributors. (2019). *Fourth Industrial Revolution*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Fourth_Industrial_Revolution

[35]BDO. (2018). *How Industry 4.0 is Transforming the Oil & Gas Supply Chain*. BDO. https://www.bdo.com/insights/industries/natural-resources/how-industry-4-0-is-transforming-the-oil-gas-supply-chain

[36]Roy, K. (2019). *How is the Fourth Industrial Revolution changing our economy?* World Economic Forum. https://www.weforum.org/agenda/2019/11/the-fourth-industrial-revolution-is-redefining-the-economy-as-we-know-it/

[37]Lööw, J., Abrahamsson, L., & Johansson, J. (2019). *Mining 4.0—the Impact of New Technology from a Work Place Perspective. Mining, Metallurgy & Exploration*, 36(4), 701–707. https://doi.org/10.1007/s42461-019-00104-9

[38]Nel., J. (2020). *Industry 4.0 for the Mining Industry*. Deloitte Insights. https://www2.deloitte.com/us/en/insights/industry/mining-and-metals/tracking-the-trends/2020/industry-4-0-mining.html

[39]Baig, N., Kammakakam, I., & Falath, W. (2021). *Nanomaterials: a review of synthesis methods, properties, recent progress, and challenges. Materials Advances*, 2(6), 1821–1871. https://doi.org/10.1039/d0ma00807a

[40]Bayda, S., Adeel, M., Tuccinardi, T., Cordani, M., & Rizzolio, F. (2019). *The History of Nanoscience and Nanotechnology: From Chemical–Physical Applications to Nanomedicine*. Molecules, 25(1), 112. https://doi.org/10.3390/molecules25010112

[41]Zhe, Z., & Yuxiu, A. (2018). *Nanotechnology for the oil and gas industry – an overview of recent progress. Nanotechnology Reviews*, 7(4), 341–353. https://doi.org/10.1515/ntrev-2018-0061

[42]Lee, S. J., Theerthagiri, J., Nithyadharseni, P., Arunachalam, P., Balaji, D., Madan Kumar, A., Madhavan, J., Mittal, V., & Choi, M. Y. (2021). *Heteroatom-doped graphene-based materials for sustainable energy applications: A review. Renewable and Sustainable Energy Reviews*, 143, 110849. https://doi.org/10.1016/j.rser.2021.110849

[43]Su, H., & Hu, Y. H. (2020). *Recent advances in graphene-based materials for fuel cell applications. Energy Science & Engineering*, 9(7), 958-983. https://doi.org/10.1002/ese3.833

[44]Kulyk, B., Freitas, M. A., Santos, N. F., Mohseni, F., Carvalho, A. F., Yasakau, K., Fernandes, A. J. S., Bernardes, A., Figueiredo, B., Silva, R., Tedim, J., & Costa, F. M. (2021). *A critical review on the production and application of graphene and graphene-based materials in anti-corrosion coatings. Critical Reviews in Solid State and Materials Sciences*, 47(3), 309–355. https://doi.org/10.1080/10408436.2021.1886046

[45]Jiang, Y., Guo, F., Liu, Y., Zhi Ping Xu, & Gao, C. (2021). *Three-dimensional printing of graphene-based materials for energy storage and conversion*. Sustainable Materials, 1(3), 304–323. https://doi.org/10.1002/sus2.27

[46]Vieira, O., Ribeiro, R. S., Diaz de Tuesta, J. L., Gomes, H. T., & Silva, A. M. T. (2022). *A systematic literature review on the conversion of plastic wastes into valuable 2D graphene-based materials*. Chemical Engineering Journal, 428, 131399. https://doi.org/10.1016/j.cej.2021.131399

[47]Dubai Future Foundation. (2023). *10 Megatrends Shaping Our Future in 2023*. https://www.dubaifuture.ae/wp-content/uploads/2023/02/10-Megatrends-Shaping-Our-Future-Eng.pdf

[48]Nummi, E. (2016). *The Use of Plastic Pipe in the Mining and Oil and Gas Industries*. Thermo Fisher. https://www.thermofisher.com/blog/materials/the-use-of-plastic-pipe-in-the-mining-and-oil-and-gas-industries

[49]FLSmidth. (2023). *Cut water cost and risk in tailings*. FLSmidth. https://www.flsmidth.com/en-gb/solutions/tailings-management-solutions

[50]McKinsey & Company. (2020). *The Bio Revolution: Innovations transforming economies, societies, and our lives*. McKinsey & Company. https://www.mckinsey.com/industries/life-sciences/our-insights/the-bio-revolution-innovations-transforming-economies-societies-and-our-lives

[51]Butler, T. (2020). *How has the mining industry responded to COVID-19?* World Economic Forum. https://www.weforum.org/agenda/2020/09/how-has-the-mining-industry-responded-to-covid-19/

[52]Barbosa, F., Bresciani, G., Graham, P., Nyquist, S., & Yanosek, K. (2020, May 15). *Oil and gas after COVID-19: The day of reckoning or a new age of opportunity?* McKinsey. https://www.mckinsey.com/industries/oil-and-gas/our-insights/oil-and-gas-after-covid-19-the-day-of-reckoning-or-a-new-age-of-opportunity

[53]McMonigle, J., Thomson, A., van Agt, C., Fitz, R., & Webster, J. (2020). *Oil and Gas Investment in the New Risk Environment*. BCG Global. https://www.bcg.com/publications/2020/oil-and-gas-investment-during-the-covid-era

[54]Australian Bureau of Statistics. (2020). *Twenty years of population change | Statistics about the population and components of change (births, deaths, migration) for Australia and its states and territories*. https://www.abs.gov.au/articles/twenty-years-population-change

[55]The Lancet Global Health. (2020). *Mental health matters*. The Lancet Global Health, 8(11), e1352. https://doi.org/10.1016/s2214-109x(20)30432-0

[56]International Telecommunication Union. (2022). *Global Connectivity Report 2022*. www.itu.int/itu-d/reports/statistics/global-connectivity-report-2022/

[57]Raleigh, C., Kishi., & Billling., T. *ACLED Conflict Severity Index | A New Measure of the Complexities of Conflict*. Acleddata.com. https://acleddata.com/wp-content/data-viz/index/

[58]Maennling, N., & Perrine Toledano. (2019, March 20). *Seven trends that will shape the future of mining and metals*. World Economic Forum. https://www.weforum.org/agenda/2019/03/seven-trends-shaping-the-future-of-the-mining-and-metals-sector/

[59]Moritsch, S. (2023, May 17). *Oil and gas risk forecast for 2023*. KPMG. https://kpmg.com/xx/en/home/insights/2023/04/oil-and-gas-risk-forecast-for-2023.html

[60]The Australian. (2024, January 10). *Sovereign risk alarm for oil and gas sector*. https://www.theaustralian.com.au/nation/politics/sovereign-risk-alarm-for-oil-and-gas-sector/news-story/27dcafda7c7d68a8f5d4d31d54e5beef

[61]Ganti, A. (2021). *Structural Change Definition*. Investopedia. https://www.investopedia.com/terms/s/structural_change.asp

[62]Prater, D. Z. H., Tom. (2023). *Analysis: Half the global population saw all-time record temperatures over past decade*. Carbon Brief. https://interactive.carbonbrief.org/half-global-population-saw-all-time-record-temperatures-over-past-decade/

[63]PwC. (2023). *ESG trends in 2023 | Key ESG areas to keep a watch on this year*. https://www.pwc.com.au/important-problems/esg/2023-esg-trends.pdf

[64]Bloomberg (2022). *ESG May Surpass $41 Trillion Assets in 2022, But Not Without Challenges, Finds Bloomberg Intelligence*. https://www.bloomberg.com/company/press/esg-may-surpass-41-trillion-assets-in-2022-but-not-without-challenges-finds-bloomberg-intelligence/

[65]Wertz, J. (2022). *Digitization Is Impacting The Retail Industry Online And Offline*. Forbes. https://www.forbes.com/sites/jiawertz/2022/02/26/digitization-is-impacting-the-retail-industry-online-and-offline

[66]UNCTAD. (2021, March 15). *How COVID-19 triggered the digital and e-commerce turning point. United Nations Conference on Trade and Developmen*t https://unctad.org/news/how-covid-19-triggered-digital-and-e-commerce-turning-point

[67]Willige, A. (2021, May 14). *This Is What Healthcare Leaders See as the Future for Digital Health*. World Economic Forum. https://www.weforum.org/agenda/2021/05/digital-health-telemedicine-telehealth-ai-digitalize-health-services/

[68]Glaser, J., Overhage, J. M., Guptill, J., Appleby, C., & Trigg, D. (2020). *What the Pandemic Means for Health Care's Digital Transformation*. Harvard Business Review. https://hbr.org/2020/12/what-the-pandemic-means-for-health-cares-digital-transformation

[69]BIS. (2021). *Covid-19 accelerated the digitalisation of payments*. BIS. https://www.bis.org/statistics/payment_stats/commentary2112.htm

[70]World Economic Forum. (2021). *International cooperation and the era of digital currency growth*. World Economic Forum. https://www.weforum.org/agenda/2021/05/international-cooperation-and-the-era-of-digital-currency-growth/

[71]Endresen, J. (2020). *COVID-19's impact on work, workers, and the workplace of the future*. Cornell SC Johnson College of Business. https://business.cornell.edu/hub/2020/09/25/covid-19s-impact-work-workers-workplace-future/

[72]Vasel, K. (2022). *Two years later, remote work has changed millions of careers*. CNN. https://edition.cnn.com/2022/03/18/success/pandemic-work-from-home-career-changes/index.html

[73]Jones, C. & Colasimone, D. (2022). *Pandora's box has been opened*. ABC News. https://www.abc.net.au/news/2022-10-10/return-to-office-work-from-home-covid-australia/101230206

[74]World Economic Forum. (2021). *New study shows how much more productive a hybrid workforce can be*. World Economic Forum. https://www.weforum.org/agenda/2021/07/work-form-home-hybrid-working-covid-pandemic-us-office/

[75]Australian Bureau of Statistics. (2021). *More than 40% of Australians worked from home*. www.abs.gov.au. https://www.abs.gov.au/media-centre/media-releases/more-40-cent-australians-worked-home

[76]Wilson, J. (2022). *Deep dive – Working from where, and why?* AI Group. https://www.aigroup.com.au/resourcecentre/research-economics/economics-intelligence/2022/work-from-where/

[77]Statista. (2023). *Australia: Average working days and WFH days by state 2023*. Statista. https://www.statista.com/statistics/1341056/australia-average-working-days-and-wfh-days-by-state

[78]Clun, R. (2022). *People are searching for more than just their dream job*. The Sydney Morning Herald. https://www.smh.com.au/politics/federal/people-aren-t-searching-for-their-dream-job-they-just-want-to-do-it-at-home-20221124-p5c0uv.html

[79]Kopittke, M. (2022). *Report finds 50% of workers would rather quit than be in the office full time*. SmartCompany. https://www.smartcompany.com.au/people-human-resources/remote-work/report-workers-hybrid-office-full-time

[80]Digital Skills Organisation. (2023). *Growing Australia's Digital Workforce*. https://digiworkforce.futureskillsorganisation.com.au/

[81]Belan, M. (2023). *AI vs. Humans: Which Performs Certain Skills Better?* Visual Capitalist. https://www.visualcapitalist.com/ai-vs-humans-which-performs-certain-skills-better/

[82]Kastrenakes, J. (2023). *Hope, fear, and AI*. The Verge. https://www.theverge.com/c/23753704/ai-chatgpt-data-survey-research

[83]Schell, H. (2023). *Which Jobs Will Be Most Impacted by ChatGPT?* Visual Capitalist. https://www.visualcapitalist.com/cp/which-jobs-artificial-intelligence-gpt-impact/

[84]McKinsey & Company. (2023). *What's the future of generative AI? An early view in 15 charts*. McKinsey. https://www.mckinsey.com/featured-insights/mckinsey-explainers/whats-the-future-of-generative-ai-an-early-view-in-15-charts

[85]Thomson Reuters. (2023). F*uture of Professionals Report | How AI is the Catalyst for Transforming Every Aspect of Work*. Thomson Reuters. https://www.thomsonreuters.com/content/dam/ewp-m/documents/thomsonreuters/en/pdf/reports/future-of-professionals-august-2023.pdf

[86]Center for AI Safety. (2020). *AI Extinction Statement Press Release | Top AI Scientists Warn: Risk of Extinction from AI on Scale with Nuclear War*. https://www.safe.ai/press-release

[87]Hendrycks, D., & Mazeika, M. (2022). *X-risk analysis for ai research*. arXiv preprint arXiv, 2206.05862. https://doi.org/10.48550/arXiv.2206.05862

[88]Abbany, Z. (2018). *Fail by design: Banking's legacy of dark code*. Deutsche Welle. https://www.dw.com/en/fail-by-design-bankings-legacy-of-dark-code/a-43645522

[89]World Nuclear Association. (2020). *I&C Modernization: Current Status and Difficulties Cooperation in Reactor Design Evaluation and Licensing*. Digital Instrumentation and Control Task Force. https://www.world-nuclear.org/getmedia/d8335248-64a1-4969-9eb3-941d2884c1ff/CORDEL-DICTF-I-C-Modernization-Final.pdf.aspx

[90]Gill, I. (2020). *Whoever leads in artificial intelligence in 2030 will rule the world until 2100*. Brookings. https://www.brookings.edu/articles/whoever-leads-in-artificial-intelligence-in-2030-will-rule-the-world-until-2100/

[91]Klassen, T., Alamdari, A., & Mcilraith, S. (2020). *Epistemic Side Effects & Avoiding Them (Sometimes)*. In: ML Safety Workshop, 36th Conference on Neural Information Processing Systems (NeurIPS 2022). https://openreview.net/pdf?id=7oDZ-6kIW1K

[92]Wikipedia. (2019). *Replication crisis.* Wikimedia Foundation. https://en.wikipedia.org/wiki/Replication_crisis

[93]Open Science Collaboration. (2015). *Estimating the reproducibility of psychological science. Science*, 349(6251), aac4716. https://doi.org/10.1126/science.aac4716

[94]Munafò, M. R., Nosek, B. A., Bishop, D. V., Button, K. S., Chambers, C. D., Percie du Sert, N., ... & Ioannidis, J. (2017). *A manifesto for reproducible science. Nature Human Behaviour*, 1(1), 1-9. https://doi.org/10.1038/s41562-016-0021

[95]Baker, M. (2016). *1,500 scientists lift the lid on reproducibility*. Nature, 533, 452–454. https://doi.org/10.1038/533452a

[96]Nield, D. (2021). *The "Replication Crisis" Could Be Worse Than We Thought, New Analysis Reveals*. ScienceAlert. https://www.sciencealert.com/non-replicable-studies-make-the-most-impact-scientists-find

[97]Smaldino, P. E., & McElreath, R. (2016). *The natural selection of bad science*. Royal Society Open Science, 3(9), 160384. https://royalsocietypublishing.org/doi/full/10.1098/rsos.160384

[98]Frey, C. B., & Osborne, M. A. (2017). *The Future of employment: How Susceptible Are Jobs to computerisation?* Technological Forecasting and Social Change, 114(1), 254–280. https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

[99]Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., ... & Sanghvi, S. (2017). *Jobs lost, jobs gained: Workforce transitions in a time of automation*. McKinsey Global Institute, 150(1), 1-148. https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages

[100]Schwab, K., & Zahidi, S. (2020). *The Future of Jobs Report 2020*. World Economic Forum. https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

[101]Markets and Research. (2021). *Augmented Reality (AR) and Virtual Reality (VR) in Consumer Goods Markets, 2020 Report - Focus on COVID-19, Technologies, Key Use Cases, Impact of VR and AR on FMCG, Retail, and Foodservice*. GlobeNewswire News Room. https://www.globenewswire.com/news-release/2021/01/04/2152461/0/en/Augmented-Reality-AR-and-Virtual-Reality-VR-in-Consumer-Goods-Markets-2020-Report-Focus-on-COVID-19-Technologies-Key-Use-Cases-Impact-of-VR-and-AR-on-FMCG-Retail-and-Foodservice.html

[102]Seifert, A., & Schlomann, A. (2021). *The use of virtual and augmented reality by older adults: Potentials and challenges*. Frontiers in Virtual Reality, 2, 51. https://www.frontiersin.org/articles/10.3389/frvir.2021.639718/full

[103]Lowood, H. E. (2018). *Virtual reality*. Encyclopædia Britannica. https://www.britannica.com/technology/virtual-reality

[104]Wikipedia Contributors. (2018). *Augmented reality*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Augmented_reality

[105]Ganjineh, H. (2022). *Council Post: How AR And VR Are Paving The Way For The Future Of Renewable Energy*. Forbes. https://www.forbes.com/sites/forbestechcouncil/2022/03/31/how-ar-and-vr-are-paving-the-way-for-the-future-of-renewable-energy/

[106]Bogdan-Martin, D. (2021). *What mainstream VR and AR means for sustainable development*. World Economic Forum. https://www.weforum.org/agenda/2021/02/virtual-reality-augmented-reality-sustainable-development/

[107]IBM. (n.d.). *What is Virtualization?* IBM. www.ibm.com. https://www.ibm.com/topics/virtualization

[108]Shamir, J. (2021). *5 Benefits of Virtualization*. IBM Blog. https://www.ibm.com/blog/5-benefits-of-virtualization/

[109]Microsoft Industry Clouds. (2016). *Empowering the Oil & Gas and Mining Industry | How digital transformation creates new opportunities*. Microsoft. https://info.microsoft.com/rs/157-GQE-382/images/Whitepaper%20-%20Oil%20Gas%20Mining%20Strategy%20v2.pdf?aliId=300490449

[110]Johnson, B. (2022, March 22). *Cloud Computing is Transforming the Oil and Gas Industry*. Cybernet Blog. https://www.cybernetman.com/blog/cloud-computing-oil-gas-industry/

[111]Nobels, P., & Baele, S. (2022, March 3). The ever-growing importance of L&D in the future of work. E&Y. https://www.ey.com/en_be/workforce/the-ever-growing-importance-of-l-d-in-the-future-of-work

[112]Li, L. (2022). Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. Information Systems Frontiers, 1-16. https://link.springer.com/article/10.1007/s10796-022-10308-y

[113]Foundation for Young Australians (2017). *The new work smart* | Thriving in the New Work Order | *FYA's New Work Order report series*. https://www.fya.org.au/app/uploads/2021/09/FYA_TheNewWorkSmarts_July2017.pdf

[114]Wikipedia. (2022). Web3. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Web3

[115]Grijpink, F., Katsap, N., Verre, F., & Ward, R. (2020, November 6). *Oil and gas technology: Connectivity for higher performance*. McKinsey. Www.mckinsey.com. https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-tapping-connectivity-in-oil-and-gas-can-fuel-higher-performance

[116]Australian Cyber Security Centre. (2022). *ACSC Annual Cyber Threat Report, July 2021 to June 2022*. Australian Government, Australian Signals Directorate. https://www.cyber.gov.au/about-us/reports-and-statistics/acsc-annual-cyber-threat-report-july-2021-june-2022

[117]Mittal, I., Slaughter, A., Zonneveld, P. (2017). *Cybersecurity in oil and gas*. Deloitte. Global Deloitte Insights. https://www2.deloitte.com/us/en/insights/industry/oil-and-gas/cybersecurity-in-oil-and-gas-upstream-sector.html

[118]Terp, N. (2023). *How cyber-ready is the oil and gas industry?* Siemens Energy. https://www.siemens-energy.com/global/en/news/magazine/2021/oil-and-gas-industry-and-cyber-resilience.html

[119]Trend Micro. (2019). *Drilling Deep: A Look at Cyberattacks on the Oil and Gas Industry*. Trend Micro. https://www.trendmicro.com/vinfo/us/security/news/internet-of-things/drilling-deep-a-look-at-cyberattacks-on-the-oil-and-gas-industry

[120]Padmanabhan, V. (2014). *Big Data Analytics in Oil and Gas*. Bain. https://www.bain.com/insights/big-data-analytics-in-oil-and-gas/

[121]Rogojan, B. (2022). *Reducing Data Analytics Costs In 2023 - Doing More with Less*. Seattle Data Guy. https://www.theseattledataguy.com/reducing-data-analytics-costs-in-2023-doing-more-with-less

[122]Breidenthal, J., Cigala, F., McCreery, J. (2018). *How Digital Improves Management Systems in Oil and Gas*. Bain. https://www.bain.com/insights/how-digital-improves-management-systems-in-oil-and-gas/

[123]Sadlier, A. G., Laing, M. L., & Shields, J. (2012). *Data Aggregation and Drilling Automation: Connecting the Interoperability Bridge between Acquisition, Monitoring, Evaluation, and Control*. https://doi.org/10.2118/151412-ms


AREEA
AUSTRALIAN RESOURCES AND ENERGY
EMPLOYERS ASSOCIATION