CHALLENGE 2030

Scenarios for our future success

Coronavirus has caused unprecedented distruption to the infrastructure industry, making an already uncertain future even more so. However, it is critical for decision makers to take a step back and explore a range of possible scenarios to identify the changes necessary to succeed over the next decade.

FOREWORD

The unpredictability of life has been brought into sharp relief with the arrival of the coronavirus: we are living in turbulent times. What is in store for the infrastructure industry over the next ten years?

The future is more uncertain now than it was twelve months ago, but key forces — such as climate change and automation — were already having a significant impact on the infrastructure sector before the pandemic hit. The 2020s have been identified as 'the climate decade' and some have predicted that what society can achieve by 2030 will determine whether we can mitigate and limit the effects of additional greenhouse gases in the atmosphere. The use of data and automation will probably play a large part in meeting the climate challenge.

In addition, the success of the infrastructure industry over the next ten years is likely to be determined by how quickly we as organisations can adapt to, adopt and maximise the potential of new technologies. They will impact all facets of our modern world: workplace, skills, transport, energy production and distribution, technology, communities, economies and businesses to name but a few.

Predicting the future is impossible, but we can imagine a range of scenarios to understand where we may be going. To that end, the AECOM Challenge 2030 team — comprised of a diverse cross section of our Europe, Middle East and Africa (EMEA) business, including directors and graduates, technical leaders and operational staff — has identified four very different visions of the future that are nonetheless united by common themes.

In theory, each individual scenario is equally likely to occur but in reality, elements of each will come to pass. However, which elements do occur and the depth of their impact will be determined by our acceptance of change, and our ability to come together for the greater good of humanity.

As we look ahead to the next ten years, it is clear that any future disruption will present us with opportunities and threats, both as a society and as an industry.

AECOM is determined to meet the challenges of the coming decade, supporting our clients to build a better world.

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INTRODUCTION

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The future is uncertain, but it is critical to take a step back and explore possible scenarios. In the infrastructure sector, distruption is a part of everyday life for asset owners, governments, contractors, designers and the public alike — and the potential for further disruption, as evidenced by the coronavirus pandemic, is ever-present. This report presents an assessment of what the future may hold for the sector and outlines potential changes that the infrastructure industry needs to make to succeed and progress in a turbulent world.

Over six months a diverse group of AECOM experts and leaders, with support and input from across the organisation, has gone through a scenario planning process to predict what the future may look like.

The emergence of new technologies and services — such as machine learning (ML) or Mobility-as-a-Service (MaaS) — occasionally gives us a glimpse into the future. However, a major challenge in conducting the scenario planning process was predicting the extent to which these new technologies or services would be adopted.

Even predicting just one scenario was very difficult as geopolitical and regulatory uncertainties make the future even more cloudy.

We have hedged this uncertainty by developing four visions of the future.

We identified over 100 uncertainties for the future. Through the process we refined the long list until we had defined two critical uncertainties that we believe will have the largest impact on infrastructure over the next 10 years. The two most critical uncertainties were:

- Widespread adoption of green power technology; and
- The rate of adoption of automation and artificial intelligence (AI) in the delivery of infrastructure projects. These were determined to be the two areas that could be predicted to have the greatest potential to disrupt the infrastructure sector.

The four scenarios, each equally likely to happen, are summarised in Figure 1. The purpose of this report is to help the industry as a whole to prepare and choose how to respond to the these upcoming challenges.

Although, as an industry, we are starting to prepare for this uncertain future, short-term goals often hinder the ability to think about the longer term. We also suffer from optimism bias which is where we expect a positive future to be the most likely scenario, but do not do anything to prepare, position or adapt for it. Unless the infrastructure industry chooses to be more agile and invest heavily in new digital technologies and changes in the energy sector, we are likely to default to preparing to operate the business as if we are in the GROUNDHOG DAY scenario — a future where the pace of change in automation and green energy technology is very slow — regardless of the reality.

As the 2020 coronavirus crisis shows, even the best laid plans can be unexpectedly derailed. We will explain why the pandemic is an outlier for scenario planning in the report.

If the industry does not take a longer-term, more balanced view of the future, we are significantly harming our probability of future success. To thrive in the future we all need to be more adaptable and agile, with a culture of thoughtful risk taking.

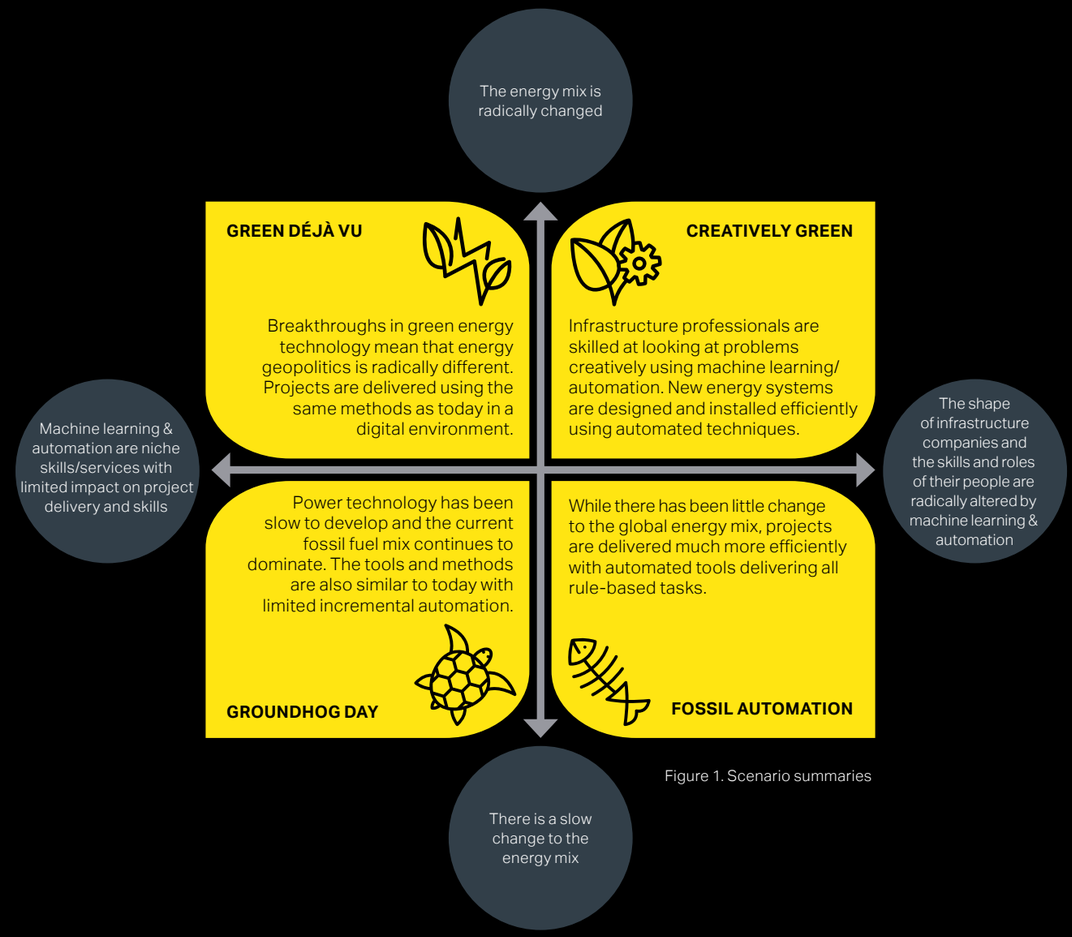


Figure 1. Scenario summaries

REPORT OBJECTIVES

Scenario planning is an effective way to shift the perception of the present and understand what the future may hold.

The Challenge 2030 report, along with the separate supporting analysis, has been produced to help identify the factors which will impact the infrastructure industry in the future. The aim is to provide insights into how the sector could change over the next decade which could then be used to inform future strategic decisions, long-term investments, innovations, and research and development.

DEFINING THE SCENARIO BOUNDARIES

> **An important consideration was how far to look into the future. It needed to be far enough that significant changes could occur, but not too far that current trends would be unable to influence the outcome.**

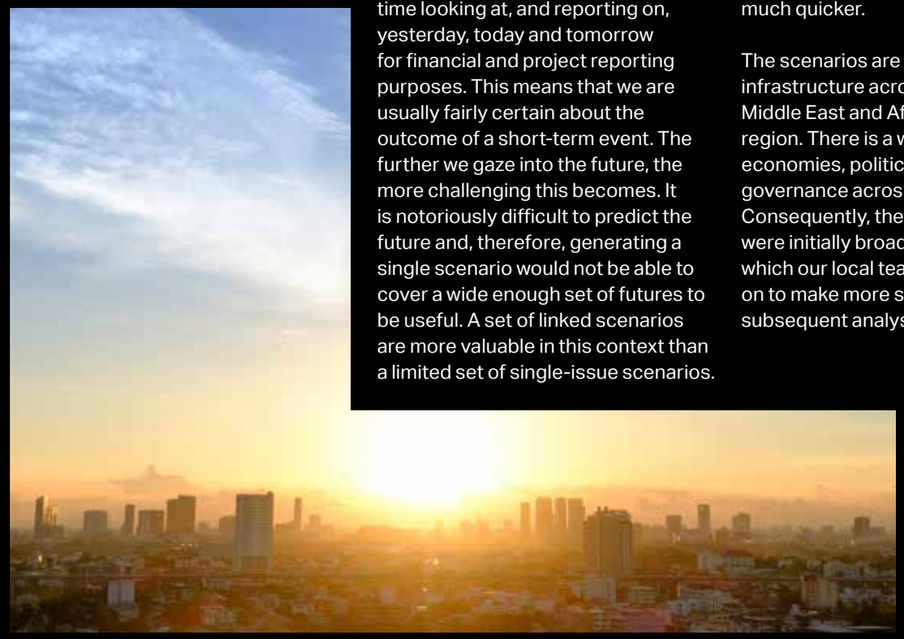
The goal of generating the scenarios was to provide a series of plausible predictions of the key trends that are likely to affect organisations in the infrastructure industry over the next decade.

If you ask anyone, they will make a guess at what the future will look like in their opinion. The goal of this process was to use the breadth of knowledge and experience across AECOM to develop reasonable and plausible futures that can be used to test and steer the future plans for the sector.

As a company, we spend a lot of time looking at, and reporting on, yesterday, today and tomorrow for financial and project reporting purposes. This means that we are usually fairly certain about the outcome of a short-term event. The further we gaze into the future, the more challenging this becomes. It is notoriously difficult to predict the future and, therefore, generating a single scenario would not be able to cover a wide enough set of futures to be useful. A set of linked scenarios are more valuable in this context than a limited set of single-issue scenarios.

Establishing how far to look into the future was an important consideration. The time horizon needed to be far enough that significant changes could occur, but not too far that current trends would be unable to influence the outcomes and lose connection to today's reality. As we have seen with the coronavirus pandemic, many existing trends have been accelerated several years in the last few months. Approximately ten years into the future was chosen as many infrastructure owners work on five-year investment cycles, and new technologies often take around ten years to reach mass adoption — noting that digital products can be much quicker.

The scenarios are focussed on infrastructure across the Europe, Middle East and Africa (EMEA) region. There is a wide variation in the economies, political structures and governance across this large area. Consequently, the resulting scenarios were initially broad generalisations, which our local teams then focussed on to make more specific during the subsequent analysis.



THE RESEARCH APPROACH

The methodology chosen was based on the book 'Scenario Planning' by Woody Wade. This approach is relatively straightforward and similar outputs have been produced by other organisations in the infrastructure sector, including Highways England and the UK Ministry of Defence.

The process has three main steps:

1. Gather information on current trends and identify which two are the most critical
2. Generate four scenarios based on either/or options for each critical uncertainty
3. For each scenario assess the implications, signposts and responses if it becomes a reality.

The process is summarised in the figure below.

We completed the exercise through a mixture of workshops, working group meetings, interviews and a staff survey to gather a wide cross section of views and opinions. The workshop attendees were deliberately diverse across the grades and geography to capture diversity of thought. We also used voting where possible to keep everyone's views equal in importance.

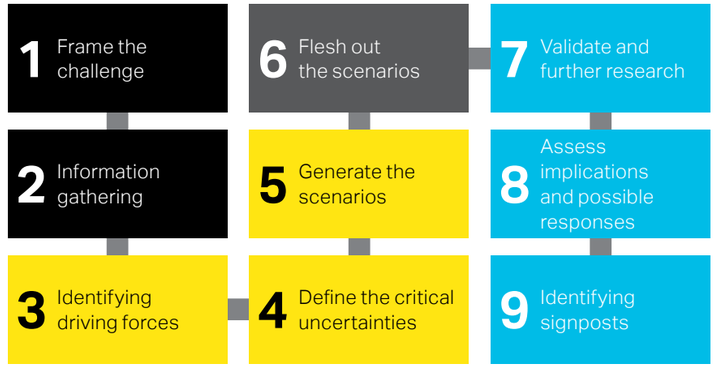


Figure 2. Scenario planning process

The critical uncertainties

The first workshop identified the below draft scenarios. An interim step was first required to identify the critical uncertainties.

What is a critical uncertainty?
This is defined as a possible future event, development or trend that has a low certainty of happening, but if it does it will have a high impact on infrastructure organisations.

Why aren't key events such as a pandemic or economic depression included?
These uncertainties count as 'black swan events.' They cannot be predicted. Another example of a type of uncertainty not included is the western aging population. This is a well-studied phenomenon and therefore has low uncertainty. We can and should already be planning for its impact on the sector.

The workshop groups in each location (UK, Spain, South Africa and UAE) brainstormed what the current trends are, using the information gathered as reference material. These were assessed for their level of impact and uncertainty of happening. The groups each then voted for their top two resulting in a total of eight critical uncertainties in the short list shown in Table 1 below.

During the initial workshop the participants voted that numbers 1 and 3 were the most important and these were used to define the scenarios first generated.

The full set of critical implications were included in the all staff survey and the respondents were asked to rank them in order of importance. The survey returns generally showed agreement with the workshop attendees, with one major exception. The crowd felt that number eight was more significant to the future of the business than the impact of number one. As a result, the working group made the decision to revise the scenarios ahead of the second workshop to focus on numbers three and eight — Energy and Data.

NO.	DEFINITION
1	BRIC countries (Brazil, Russia, India and China) dominate the infrastructure market through large scale investments (loans) restricting market access to their locally owned companies.
2	New and strengthened democracies in the Middle East and Africa leads to a lack of decision-making resulting in postponement or cancellation of many large-scale projects.
3	The source of energy changes away from fossil fuels, (electrifying heat and green energy sources) changing the shape of geopolitics; the way we move and the way we interact.
4	The consequences of a world economic crisis (prolonged depression) will have a profound impact on all aspects of the infrastructure sector.
5	An increased frequency of extreme events caused by climate change, plus other climate effects and population growth causes large scale instability in stressed areas that spread into our core markets.
6	A breakdown of global free trade and increased isolationist political policies reduces the ability of infrastructure companies to work as a global company and reduces the number of large infrastructure projects.
7	The continuing fragmentation of politics and increase of partisan policies significantly reduce the pace of infrastructure investment both in local and especially multi-country projects. Projects are more stop-start as competing interests exert their influence and power.
8	Machine learning and rules-based design techniques change the way that projects are delivered and the skills needed to do them. The structure and staffing of infrastructure companies is radically different.

Table 1: Critical uncertainties chosen

The scenarios

The scenarios are devised by creating 'either — or' statements from the two chosen critical uncertainties:

Either data and automation will remain largely the same with some minor incremental improvements **or** data and automation will radically disrupt the infrastructure sector.

Either energy sources will remain broadly the same, with domination of fossil fuels, **or** new technology enables a massive surge to green and sustainable energy sources.

By taking these two sets of opposites we can generate four scenarios to cover each of the options.

Each of these summaries has been developed further by the attendees at the second workshop and from feedback from the validation interviews.

When reading the scenarios, bear in mind that each scenario is theoretically equally likely to happen, even if you have a personal expectation or preference.

The scenarios at a glance

SCENARIO 1
Limited change in data and automation, coupled with a radical change in the energy mix, gives us **GREEN DÉJÀ VU**:

Breakthroughs in green energy technology mean that energy geopolitics is radically different. Projects are delivered using fundamentally the same methods as today in a digital environment.

SCENARIO 2
Huge advancements in data and automation, coupled with a radical change in the energy mix, gives us **CREATIVELY GREEN**:

Staff are skilled at looking at problems creatively using machine learning / automation. New energy systems are designed and installed efficiently using automated techniques.

SCENARIO 3
With limited change in data and automation, coupled with a continued reliance on fossil fuels we have **GROUNDHOG DAY**:

Power technology has been slow to develop and the current fossil fuel mix continues to dominate. The tools and methods are the same as today with limited incremental automation.

SCENARIO 4
Huge advancements in data and automation, coupled with a continued reliance on fossil fuels, give us **FOSSIL AUTOMATION**:

While there has been little change to the global energy mix, projects are delivered much more efficiently with automated tools delivering all rules-based tasks.

USING THE SCENARIOS TO NAVIGATE A POST-CORONAVIRUS WORLD

The scenarios were originally developed in the summer of 2019, before there was even a hint of the coronavirus crisis that was about to hit the world. This doesn't mean that the scenarios are not relevant now that we are reaching our new normal. The pandemic has accelerated some trends included in the scenarios, while decelerating others. How governments respond in the medium and longer term to the pandemic will significantly influence which of the scenarios becomes dominant.

When reading the scenarios you will see nods to the impact the coronavirus crisis has had. The economic depression is forecast in the Groundhog Day scenario, and the drive for a greener recovery in some parts of the world is picked up in the Green scenarios. The potential impact of a continuing lower oil price is picked up in Fossil Automation and the accelerating shift towards a digital economy will influence the data and automation scenarios.

The four scenarios can help infrastructure authorities target the right investments in infrastructure and technology as a way of responding to the impact of coronavirus and assessing how we build a more sustainable and resilient world for future generations.

We are currently tracking the signposts that have been triggered to get early hints on where the impact of the pandemic will steer the world in these scenarios. As you read the scenarios, take the time to see how many of the statements become more relevant in the new world we find ourselves.

Scenario 1: GREEN DÉJÀ VU

A future where the infrastructure industry sees limited change in data and automation but disruptive change in the energy mix …

Following catastrophic, climate change-fuelled flooding in the Maldives, governments and billionaires are investing in climate change solutions. Breakthroughs in green energy technology have radically changed geopolitics. In some parts of the world, climate challenges have reduced stability, making it harder to conduct business. Projects are delivered using fundamentally the same methods as today from a digital perspective.

Following the implementation of Air Quality zones in 2019 and the introduction of speed-limiting technology in 2022, various EU and UK laws and regulations have driven green investments and the UK 'Future Homes Standard' of low-carbon heating in all new homes from 2025. While the industry is much 'greener' than it was in 2019, Machine Learning (ML) and automation remain a niche capability across the industry with associated tools and skills only slightly improved from a decade ago. While ML and automation were the great hope, they have had limited success in new build projects such as ports and solar farms.

The complexities of integrating with existing infrastructure means that artificial intelligence (AI) is only efficient as a support tool and achieves a small impact. New and cleaner energy systems, such as hydrogen fuel cell systems, home batteries and local grids, are in great demand. However, the industry is struggling to deliver systems quickly and cost-effectively. This is due to manual project delivery processes and a poor resource pool, with many baby boomers retiring and a shortage of skilled STEM replacements.

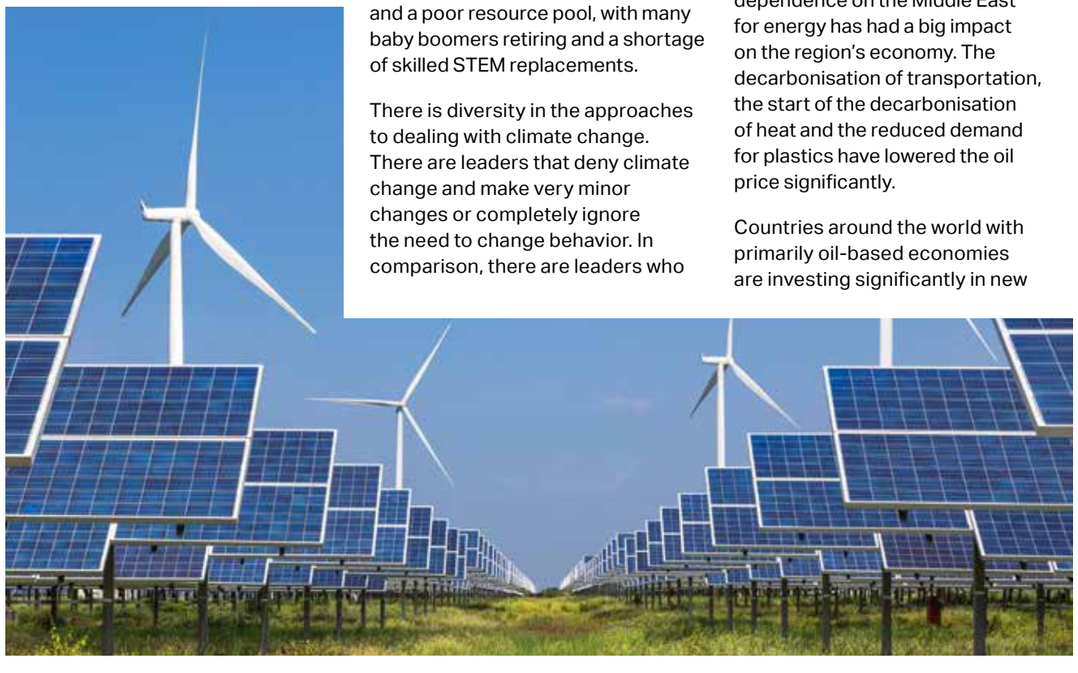
There is diversity in the approaches to dealing with climate change. There are leaders that deny climate change and make very minor changes or completely ignore the need to change behavior. In comparison, there are leaders who make significant contribution to the climate change agenda.

This is a symptom of a world where the concept of a globalised market is breaking down. Governments, and hence companies, are investing more at a regional level to protect their markets.

The move to greener energy has led to a significant shift in geopolitics towards countries that lead on green energy. This shift is especially varied across Africa. Countries with access to reasonably priced financing and mineral deposits required for the new generation of batteries, such as Zambia and Congo, have moved swiftly to renewables such as hydropower and solar, supported by the new generation of batteries. African countries rich in fossil fuels such as Mozambique and Nigeria have been slower to adapt.

Meanwhile, the world's reduced dependence on the Middle East for energy has had a big impact on the region's economy. The decarbonisation of transportation, the start of the decarbonisation of heat and the reduced demand for plastics have lowered the oil price significantly.

Countries around the world with primarily oil-based economies are investing significantly in new infrastructure to diversify their economies. This change in emphasis also alters their relationships with oil importing countries.



In the UK, wind energy is now much cheaper than conventional energy, putting pressure on suitable sites. Domestic wind and solar schemes are providing a significant contribution to the grid, with the use of much better and more cost-effective batteries balancing loads. Because society has reduced its impact on the environment, air quality, especially in big cities, continues to improve.

People's green mindsets have led to significantly greater use of ultra low emission vehicles (ULEVs) and increased use of, and demand for, public transport and Mobility-as-a-Service (MaaS). Due to the proliferation of on-demand services and, in some urban areas, autonomous vehicles, there is an ever-increasing number of vehicles on the roads. Congestion continues at today's levels but is perceived to be worse by the public.

While demand to install greener technologies has grown significantly compared to 10 years ago, there are not enough skilled people to deliver them due to the West's declining working age population. This has been mitigated to a certain extent through the development and use of new global design centres (GDCs) in African countries with the required skills and infrastructure.

Wind and tidal energy generation have brought greater opportunities for infrastructure consultants for environmental impact work, and advisory services. However, new types of infrastructure are harder to implement and take a long time to deliver, due to a shortage of designers and construction workers, and an ageing population. Large solar farms are being installed in desert regions surrounding Europe, including North Africa and parts of the Middle East.

Greater demand for green heating and cooling technology has made home batteries, fuel cell technology, local grids, solar panels and wind turbines popular. The industry is now focused on designing microgrids such as district heat systems, rather than big cables or big nuclear power stations. Gas power stations are kept on standby to provide back-up during long periods of renewable energy power cuts.

Current transport infrastructure has been adapted to accommodate new and greener mobility; our roads, parking, railway stations and maintenance designs now include car-charging capabilities and specific provision for connected vehicles.

Autonomous vehicles are becoming more widespread, requiring new skillsets in highway design. Asset management is an important activity as infrastructure owners maintain and adapt legacy assets in parallel with new ones. Where possible, new technology and sensors are retrofitted to enhance asset lifespan and capacity.

ML remains the preserve of specialist companies because the limited skills available in design consultancies and contractors, plus the prohibitive cost, prevent widespread adoption. Traditional engineering consultants are shifting towards more project implementation and delivery, and away from detailed design.

The way in which people work across the industry has radically changed. More people work remotely from offices and skills are becoming more specialised, leading to an increase in freelancer models. Consequently, offices are more project-related and designed for flexible use which may mean less open plan designs. Teams come together mostly for meetings and at key project milestones. This impacts on public transport use, with fewer people commuting at traditional peak times. Transport providers make more use of flexible dynamic pricing, like that pioneered by Uber.

Scenario 2: CREATIVELY GREEN

A world of improved automation and advanced green energy technology …

Breakthroughs in green energy technology such as new battery technologies and increased hydrogen fuel cell usage for commercial and public transport, together with energy companies looking to future-proof their businesses as heat is decarbonised, have radically changed geopolitics. Energy systems have been designed and installed efficiently using automated techniques. The industry is skilled at looking at problems creatively using machine learning and automation to efficiently test multiple scenarios.

The energy mix has radically changed in the past 10 years. Also, the wider construction industry is now fully embracing machine learning and automation to design and deliver projects. Following the partnership of a Big Tech company and a design software house, transformational changes in what is possible to automatically design and integrate into a fully digital construction process has revolutionised the sector, causing a paradigm shift in the time and cost required to develop a design.

Companies not prepared for this change have struggled to meet the challenge and several big names have been lost. Infrastructure asset owners and operators have also been challenged by this change, but those that have embraced it and ridden the wave are benefiting from significantly more efficient delivery. More and more partnerships across sectors and segments are occurring as technology makes doing business easier and there are more linkages through skills and techniques. Big corporations have diversified their activities to mitigate future risks of disruption in their core businesses.

The move to green energy is overwhelmingly positive for the environment and for the economies of 'green' countries, with the relative overall cost of energy decreasing. The lowering cost of energy means that there has been little innovation in the sector. With the dynamic tariffs and Energy-as-a-Service only operating in niche areas, the large energy companies still dominate the market albeit based on the new green energy generation technologies.

Fossil fuel rich countries use their sovereign wealth funds to invest in this new technology to support their diversification efforts. Projects like NEOM in the Kingdom of Saudi Arabia act as trailblazer projects for other countries to follow.

The risk of white elephant infrastructure increases as each of the oil nations competes to attract people and businesses to fill the spaces, with competing projects elsewhere in the world, including China and a post-Brexit Britain. But because the developed world has greater resources to be the first to invest in green and automated ways of doing things, the countries with the resources to invest in green and automated ways of working are increasingly successful and prosperous.

Automation has led to significantly faster and higher quality project delivery and greater demand for off-site construction, which the industry is now delivering faster and better than ever before. The widespread use of robots has, however, reduced the availability of unskilled jobs, leading to higher unemployment. On the flip side, the automation of once purely human-based jobs has solved the resource constraints of previous decades. Within design teams, far fewer staff are required to deliver designs for new projects, but more staff numbers are needed for the replacement of ageing infrastructure and asset management work.

Automation technologies have disrupted how skills are taught and schools and universities have struggled to keep pace. Companies have invested more in getting new graduates up to speed as well as more on-the-job training as skills and technologies become obsolete within five years.

With automation now productised, the major technology companies have swept into the market, buying engineering services firms and software suppliers that have the datasets that the algorithms need to learn from. The companies not bought by the tech giants have had to either develop their own technology by buying small companies operating in the space and scaling them rapidly, or are forced to rent the technology from the dominant companies and losing control of their own data in the process.

The data companies have brought about the massive open sharing of data as their powerful algorithms are more valuable than the data that they use due to the vast quantities being produced from all types of infrastructure on 5G networks and the pervasive Internet of Things (IoT).

Machine learning is now integrated into the whole project lifecycle from design through to operation, with buildings themselves now intelligent by default and clients increasingly calling on complete end-to-end holistic services.

In the developed world, asset management, and particularly the use of drones, robots and IT skills in asset management has become important. A key skill will be interpreting and analysing the information generated from the many data points now collected using 5G networks and stored in the Cloud. While much of this will be automated, understanding the nuances and how they interact across cities and client organisations will be an important service. As buildings and infrastructure become more integrated using IoT concepts, for example in Connected and Automated Vehicles (CAV), there is more of a need for MEP engineers in a wider range of projects. The more complex the infrastructure becomes, and its ability to feed back in real time, the more asset management becomes a science as it more accurately predicts asset failure rates. Infrastructure from the previous 'manual' world still exists and needs maintaining until the assets reach the end of their useful life. This market is still more manual due to the lack of data and knowledge on the assets but is less financially attractive.

To stay competitive the leading engineering companies have invested heavily in upskilling staff. They have a broad diversity of staff generally and a wide range of specialists, from programmers to automation data validation assessors. The quality assurance and technical specialist roles are in high demand to review and judge the automated design outputs. The specialist role of the digital designer is short lived as the rapid pace of technology change means that all staff need to have a high level of digital competence. Programming languages and tools become ever more natural making it easier than ever to programme technology to solve a specific problem. The industry is making great use of outsourcing to specialists, both individuals and partner organisations, on a project-by project need. There is a polarisation across the sector between those who manage projects and those who have technical skills.

Automation of detailed design has meant that offices have not changed much, as people bring value when they work together in teams to solve the multi-disciplinary engineering and asset management challenges. The only exception is advisory experts who are usually embedded in infrastructure owners and operators organisations.

Future investment in infrastructure is now planned in a much more point-of-use way with less political decision making in democratic economies. How people plan to use infrastructure in the CAV / MaaS world, coupled with a lack of geographic social cohesion and powerful lobby groups, means infrastructure must be more efficiently priced. Political fragmentation and devolution of powers makes delivering large cross border infrastructure projects more difficult, especially with a widespread upswell in green agendas.

Scenario 3: GROUNDHOG DAY

A slow pace of change in both green energy and automation ...

Power technology has been slow to develop with fossil fuels continuing to dominate. Project delivery tools and methods are also like those used in 2019, with only minor incremental automation. A major global economic downturn, similar in scale to 2007, but with a much longer tail, has led to stagnation in many western countries.

With only a very slight change to the energy mix over the past decade, the world is still largely dependent on fossil fuels for energy. Meanwhile, machine learning and automation remain niche skills and services across our industry. The world has remained virtually the same following a global economic crisis. In the European Union, investment banks have been hamstrung by a falling out of the member states split across both nationalistic and geographic lines. Political instability has reduced co-operation and hinders global organisations from sharing data, resources and expertise.

The relatively unchanged conditions mean 'business as usual' for the industry, with little difference in the way projects are delivered and the skills used from ten years ago. Multinational companies are adding only slightly more value than smaller, local companies. It has become a race to the bottom, competition increases reducing profit margins across the board. Infrastructure owners and operators rely on increased efficiency of tried and tested delivery methods to meet their needs. This drive towards extremely efficient delivery results in quality issues caused by insufficient oversight of delivery.

There is an awareness however that larger multinational infrastructure companies need to continue to optimise their processes and solutions using Lean principles to ensure they don't fall behind smaller, more agile and innovative competitors.

Continued fossil fuel consumption coupled with population growth have caused greater environmental damage, especially in major cities, bringing about opportunities for companies to deliver air quality. To get more of existing reserves, advances in fossil fuel extraction technology have been developed. Growing populations continue to cause geopolitical issues e.g. through mass migration from Africa to Europe.

Costs are now a major driver for the industry with infrastructure operators and owners less inclined to pay a premium for quality. To survive in this market, large multinational infrastructure firms have refined what they already do rather than invest in new ways

of doing things. The slow pace of technological change and relatively unchanged way of doing things has ultimately led to an uninspiring and unexciting industry; attracting and retaining staff, especially the younger generation, is now a major problem. Infrastructure owners need to sweat their assets more than ever, and asset management is a core service in high demand.

Data hording is a major challenge to the development of new technologies, and trade wars have meant it is hard to move data across borders with little trust between the software suppliers and the creators of data. Cloud computing is still prevalent, but companies keep proprietary data offline and encrypt their data lakes to prevent theft.

To lower overheads companies are encouraging their staff to work from home, office space is kept to a minimum and extreme agile working has become the norm in most infrastructure companies.

Technology companies have not even looked at the engineering sector as a possible market to invest in, the volumes and margins are too small to be of interest. EU regulations on data make it hard for all companies to build datasets large enough to effectively train their models.

The BRIC country governments play an ever increasing part on the world stage with their investment funds directing and influencing policymaking. The Belt and Road Initiative (BRI) has developed through its implementation to increase Chinese design capabilities to supplement their state-sponsored construction companies.

Western activists continue to push for greener technologies but the oil and gas lobbies remain powerful, preventing any significant movement. Climate change continues to be high in the public consciousness with more and more extreme weather events but public funds are only available for reactive measures, and there is no sign of a global accord to radically cut emissions. The acceptance that irreversible damage to the environment is going to happen starts to be the norm.

Scenario 4: FOSSIL AUTOMATION

A rapid advancement of automation and analytical technologies, with a slow change towards green energy sources ...

While there has been little change to the global energy mix since 2019, automated tools are being used to deliver all rules-based tasks, leading to more efficient project delivery.

There have not been any major breakthroughs in energy technology in the past 10 years although there has been a slow but steady improvement in battery technology. Air quality remains a top priority, with legislation continuing to drive up the use of electric vehicles; 50 per cent of all cars are now electric, fuelling the continued expansion of the national grid and the need for more nuclear power. Some carbon capture and storage technologies have been produced at a commercial scale but they are very expensive and have not been widely adopted.

The move to more environmentally friendly cars in developed countries has however led to diesel cars

flooding developing regions, such as Africa. The globe is split politically between nations that are directly impacted by climate change associated with those without oil reserves that are decarbonising their economies. Against this are the rapidly developing nations, such as the BRICS and those that depend on oil revenues to balance their national budgets. This global division is exacerbated at a regional level where the first water-related conflicts have occurred in the Nile basin and the Ganges-Brahmaputra basin. While these are nominally water-related conflicts they are also initial skirmishes in the shadow wars between the USA and China as the superpowers relative influence adjusts.

With the exhaustion of North Sea oil and gas, and political instability reducing the reliability and increasing the price of oil, the UK and other European governments have looked for alternative supplies.

In the UK the Swansea barrage scheme is resurrected against the protests of the environmental lobbyists.

There are a number of wave energy technologies that are on the verge of becoming commercially viable. As part of its attempt to secure the borders of Europe against illegal migrants, the EU have invested in massive solar power infrastructure in North Africa. This has boosted the use of local labour to deliver the projects whilst at the same time making power available that can be transferred to Europe.

Oil producing countries now need to look further and harder for fossil fuels. The oil price hovers around $100/barrel (at 2019 prices) making many marginal oilfields viable, especially offshore fields in Africa. Parts of the world with mature fields, such as the North Sea and parts of the Middle East invest in technology to be more efficient at collecting all the oil and other related products. Asset management of the infrastructure is important to keep it running well beyond its planned use life to keep costs down.

In more mature energy markets, such as Europe, the energy mix has continued to change with increased penetration of distributed energy

resources. This change has changed the style and operational needs of the basic network equipment, but the network still remains largely unaltered.

Asset management and replacement of end-of-life network equipment is still a largely manual process, supported by tools to help achieve gains in productivity, due to difficulties in collecting digital data on existing infrastructure for ML tools to work with. Engineers continue to manage, coordinate and design, especially as there is more integration of services.

Demand for infrastructure firm's ports, marine and pipeline expertise remains steady, spurred by asset owners and operators continued need to transport their products safely and efficiently.

Automated tools are used to deliver traditionally manual change to rules-based tasks, such as bridge design and building infrastructure, significantly increasing the speed of project delivery, reducing costs and improving consistency. There is, however, a concern around the lack of creativity and new thinking in design.

While infrastructure and building designs are being produced at the click of a button, our mindset hasn't fully moved on; designers and clients do not yet completely trust the accuracy of automated designs. The need to verify machine outputs is stronger than ever, leading to fewer technicians in infrastructure companies but more people with software, computer programming and data analytics skills working alongside those who strengthen human decision-making, such as lead verifiers and peer reviewers.

The move to automated design has changed many companies' business models and there is a shift in perception of productivity from an emphasis on time and office-based activities to outcomes. Those in the industry who come up with the best, smartest and most creative ideas ultimately stay ahead of the competition. There is some pushback from the general public who see that the automation of design is leading to blandness in the outcomes if asset owners and operators are focussed on the lowest cost solution.

The lowering of the required overhead to deliver outputs means that to maintain shareholder value many large corporations have diversified their activities where the technology and skills have started to overlap due to automation.

While cryptocurrencies and distributed ledger technologies never managed to break into the mainstream, spin off technologies such as smart contracts have become more normal. This has allowed asset owners and operators to manage projects more efficiently.

This and other automation advances mean that much of the legal system has been radically disrupted; there are far fewer lawyers, far more lawsuits, but they are dealt with much more quickly. Human lawyers are only required on specific points and nuances of law.

New business models such as Energy-as-a-Service have changed how consumers purchase and use energy, coupled with smart appliances and IoT connectivity. The service providers bundle and optimise their demand to secure the lowest prices. The next generation of smart meters have facilitated time-of-use tariffs.

These smart meters are especially prevalent in areas with newly-built, decarbonised homes, which will become more wide-spread after 2025 in the UK and across large parts of western Europe soon after.

Detailed design is now delivered almost entirely using computer models rather than drawings. Engineering insight is still required at the outset of projects and around the edges where projects interact with existing infrastructure and for asset management.

Automation of all rules-based tasks has reduced staff numbers, with specialists now working on a project-by-project basis, with increased flexible working and outsourcing.

Infratructure company's teams continue to work primarily in an office based setting, but these are more flexible. More advanced video conferencing facilities such as interactive holograms are available in technology companies. The role of the specialist digital designer was a short-lived role as it quickly became a part of everyone's skillset. Many organisations retrained their staff in the role.

There is a need for further education institutions to keep pace. Civil engineering degrees have merged with those that offer digital and programming qualifications.

SCENARIO IMPLICATIONS

Each of the scenarios gives a hint at a possible future that is significantly different from the world we are operating in today. From reading the scenarios, plausible futures and outcomes emerge that seem feasible from where we currently stand. The next step of the process is to consider what the implications are for the infrastructure sector if each of the scenarios were to come to pass.

The main implications for each of the scenarios are summarised below for infrastructure as a whole. The specific implications for different disciples and geographic regions will vary considerably.

The implications of each of the scenarios is unique to every organisation, sector and geography. If you would like to know more about our detailed analysis, please contact:

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GREEN DÉJÀ VU

Infrastructure companies are likely to have more clients at a local level, with a significantly larger, but structured and differently skilled power business. The lack of automation change means that in segments not experiencing major change, companies that are lean and agile will be more successful.

CREATIVELY GREEN

Due to the automation of large parts of the design process, there will be a shift towards the creative solutions / advisory space, bringing efficient project execution to bear and in addition to managing risk and assets. Ownership, commercial use and security of data will become very important, as value will be derived from outcomes, not from time.

GROUNDHOG DAY

Infrastructure companies will need to diversify their work streams to maintain their market leading position as infrastructure owners and operators focus on low cost solutions. Price, however that is defined, will be the primary determinant in bidding. It will be an Opex dominated world with limited investment in new infrastructure.

FOSSIL AUTOMATION

Services will become even more commoditised. The Middle East will continue to be economically strong. There will be a general acceptance that climate change is irreversible, leading to more investment in mitigation and relocation of assets. Professional services contracts are likely to be based on outcomes delivered rather than effort committed.

Responding to the coronavirus crisis

Traditionally, infrastructure investment has been used to help economies rebound from crisis. As well as providing much-needed jobs, it creates dividends for the future, strengthening economies and societies by boosting their potential.

The four scenarios can help infrastructure authorities target the right investments in infrastructure and technology as a way of responding to the impact of coronavirus and assessing how we build a more sustainable and resilient world.

For instance, in Groundhog Day, we discuss the potential impact of a bigger collapse in financial markets than the 2007–8 crisis. The cause of today's crisis is different, but the effect on government spending capacity is similar. In that scenario, we predict a reduction in investment and technology. If governments wish to avoid steering their countries towards this least attractive of scenarios, they need to keep investing in the future.

In the short-term this could include advancing 'shovel ready' infrastructure projects, such as the high speed rail project HS2 in the UK, that have the potential to kickstart short-term economic recovery. While investment in fast broadband programmes can help boost capacity for all those working from home, and consideration for the development of localised green energy schemes can provide resilience and flexibility to the grid.

"It is relatively easy to see from looking at the four scenarios that maintaining the status quo is not an option if we are to be successful in the future.

SCENARIO TIMELINES

To understand which of the scenarios will become a reality in the future we need to recognise trigger events. These are external events which we would expect to signal a movement in the direction of a specific scenario or indicate that one of the critical uncertainties is happening. For example, if a radically new battery technology is invented, this is a strong indicator that there will be a disruptive change to the energy generation mix. The timelines on the following pages were created during a workshop with the Challenge 2030 team, revised following comments received in a validation interview and then refined for consistency by the working group.

An aim of the scenario planning exercise is to generate four scenarios that are an equally probable reality. Personal preferences may encourage people to expect one over the others. The scenarios are very different and the responses to each of them given in the previous section, while having similarities, also have significant differences. The signposts allow reviewers to be objective in determining whether to implement responses to a given scenario. The signposts are recorded below for each scenario as a potential timeline.

> **The signposted events allow reviewers to be objective in determining whether to implement responses to a given scenario.**

GREEN DÉJÀ VU
timeline

2020
Development of new green materials for construction

2021
New battery technology invented — radically shakes up markets

Enhanced green credentials certified rating launched

2022
Law changed to force enhanced compliance on sustainability targets for all companies

Law changed to force enhanced compliance on sustainability targets for infrastructure operator's outputs

Introduction of speed limiting technology in the EU

2023
Static charging points ubiquitous

Integrator service requested in power sector by a client

Automated staff performance management systems for remote working

2024
Investment and opportunities on the adaptation of roads and existing infrastructures to new energy sources

2025
EU/UK —Transportation carbon tax introduced

UK — Low carbon heating in all new homes

2026
Internet of Things (IoT) in cities becomes the norm

Commercialised new green materials for construction

New commercial model for concessionaires that leads to lifecycle optimisation and asset management — true whole life carbon

Mandated energy efficiency requirements for infrastructure (over full lifecycle)

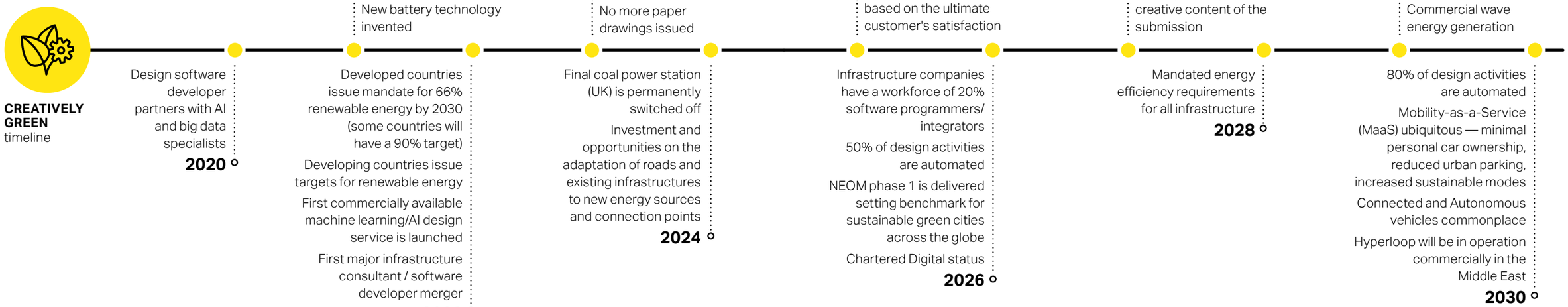
2027
First significant development of microgrids based on new battery technology

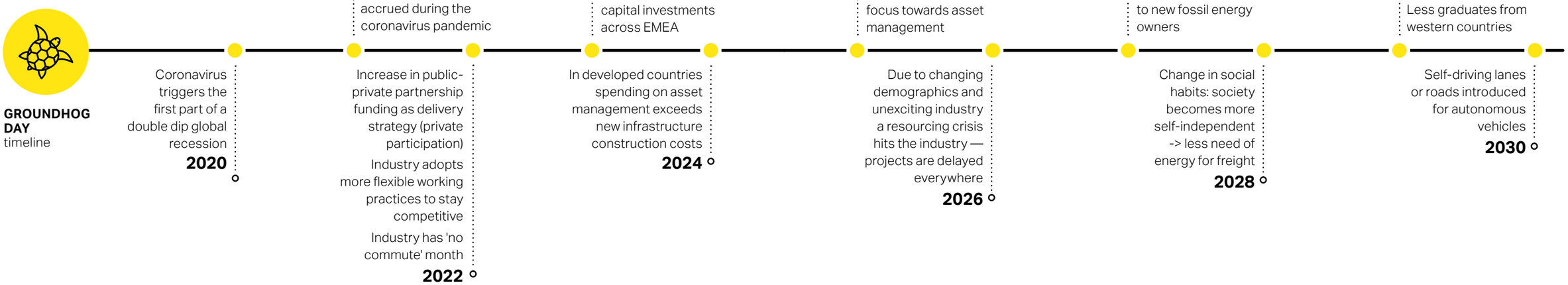
2028
Strategic roads in the UK and cities in the Middle East using online charging facilities

International legislation unanimously accepted by all countries in terms of hydrocarbons, greenhouse emissions, deforestation, fishing etc

2029
Enforcement of international policies agreed so those that don't comply with green policies by the United Nations are penalised

2030
Saudi Arabia gigacity NEOM phase one is delivered setting benchmark for sustainable green cities across the globe


CREATIVELY GREEN timeline
Design software developer partners with AI and big data specialists
2020
2021
Rail infrastructure owner changes procurement policy to focus on value of outcome
Automated staff performance management systems for remote working
Significant changes in the Middle East linked into reduced oil revenues and lower subsidies
New battery technology invented
Developed countries issue mandate for 66% renewable energy by 2030 (some countries will have a 90% target)
Developing countries issue targets for renewable energy
First commercially available machine learning/AI design service is launched
First major infrastructure consultant / software developer merger
2022
2023
Static charging points ubiquitous
BIM Level 3 mandated by governments
100% of designs are issued as models. No more paper drawings issued
Final coal power station (UK) is permanently switched off
Investment and opportunities on the adaptation of roads and existing infrastructures to new energy sources and connection points
2024
2025
Connected and Autonomous Vehicles (Level 5 — no steering wheel) introduced on public highway (Middle East)
First 3D printing household goods store opens
First contract payments based on the ultimate customer's satisfaction
Infrastructure companies have a workforce of 20% software programmers/ integrators
50% of design activities are automated
NEOM phase 1 is delivered setting benchmark for sustainable green cities across the globe
Chartered Digital status
2026
2027
First trials of road-repairing drones
First commercially viable solar road is built
First contract awarded based primarily on the creative content of the submission
Mandated energy efficiency requirements for all infrastructure
2028
2029
Last petrol car built
Commercial wave energy generation
80% of design activities are automated
Mobility-as-a-Service (MaaS) ubiquitous — minimal personal car ownership, reduced urban parking, increased sustainable modes
Connected and Autonomous vehicles commonplace
Hyperloop will be in operation commercially in the Middle East
2030


GROUNDHOG DAY timeline
Coronavirus triggers the first part of a double dip global recession
2020
2021
Major economic downturn (second dip) as goverments struggle to deal with massive debts accrued during the coronavirus pandemic
Increase in public-private partnership funding as delivery strategy (private participation)
Industry adopts more flexible working practices to stay competitive
Industry has 'no commute' month
2022
2023
Lowest ever government planned capital investments across EMEA
In developed countries spending on asset management exceeds new infrastructure construction costs
2024
2025
Developing countries will still see new infrastructure but will start shifting focus towards asset management
Due to changing demographics and unexciting industry a resourcing crisis hits the industry — projects are delayed everywhere
2026
2027
Investment power shifts from current fossil energy owners to new fossil energy owners
Change in social habits: society becomes more self-independent -> less need of energy for freight
2028
2029
Developed countries suffer the change of the age pyramid. Less graduates from western countries
Self-driving lanes or roads introduced for autonomous vehicles
2030

FOSSIL AUTOMATION timeline

2020

An infrastructure company partners with a design software developer and a big data analytics firm — as well as an AI specialist — and integrates the design and delivery process

2021

Mobility-as-a-Service (MaaS) service in large cities

Rail infrastructure owner changes procurement policy to focus on value of outcome

2022

Freelancers make up 25% of infrastructure consultancy effort

20% of tasks automated

Similar to congestion charging there will be penalties for CO2 emissions and higher tax on diesel fuel vehicles. There will be higher fees and penalties in Europe for fossil fuels

2023

Automation specialists win contract to operate and maintain infrastructure under a new business model — using Internet-of-Things for comprehensive remote monitoring

80% of opportunity scouting and market intelligence is through data analytics

2024

First modern tidal lagoon construction starts

Design for Manufacture and Assembly (DfMA) compliant designs for major infrastructure projects

Postgraduate training for digital engineering support skills

2025

BIM Level 3 implemented in UK

BIM Level 2 required in 80% Continental Europe tenders

Infrastructure companies have a workforce of 20% software programmers/ integrators

First 3D printing household goods store opens

2026

Chartered digital status

The share of traditional design capabilities in infrastructure services firms will be less than 50%

Infrastructure companies will have more programme management office (PMO) and human-skills related functions (consultancy, management, etc)

2027

50% of activities automated

First contract awarded based primarily on the creative content of the submission

2028

BIM Level 4 implemented in UK and some countries

BIM Level 3 implemented in some countries

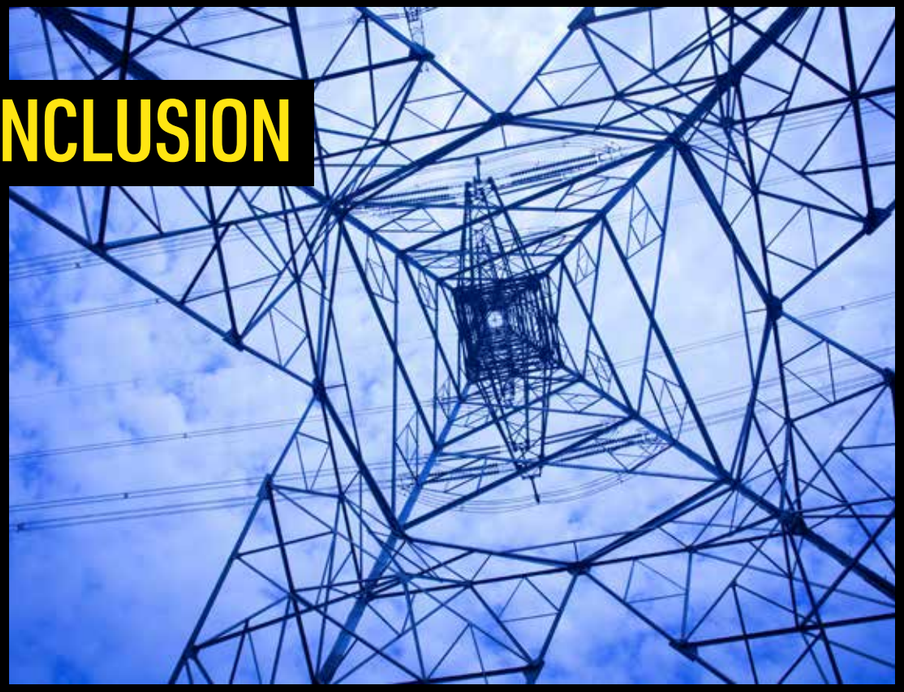
2029

50% of car fleet is electric vehicle or Hybrid

2030

Only 20% of people will have their own car in favour of mass transit and car sharing

CONCLUSION



The significant implications for the infrastructure sector identified by the scenarios are:

- Automation will change the structure of work and require new business models and contractual arrangements throughout supply chains.
- A paradigm shift to green energy and microgrids will disrupt energy provider business models and create more complex energy systems.
- Repeated significant shocks to the economy could reduce the rate of change and the infrastructure industry is likely to fragment in order to keep costs down, preventing productivity gains.
- The industry's ability to meet the challenges of the changing climate vary greatly across the scenarios but it is probably the biggest driver for change in each of them.

Conclusions

The four scenarios predict extremes of the possible outcomes over the next decade, and in all probability the future that comes to pass will resemble parts of each of them. By having strategies and plans in place to respond to each scenario, organisations, and society at large, are better placed to succeed in the future.

Only time will tell how accurate these scenarios are, both in terms of events, and the time it takes for them to happen. If infrastructure companies and organisations are cognisant of the medium-term future, they will remain proactive to changes and trends in the sector.

The scenarios can be used by asset owners, governments, contractors and designers to identify areas to invest in, and be more confident in betting on innovative ideas, making capital investments and focussing growth efforts. Through robust planning and investigation, the sector can make smart decisions to adapt and evolve their organisations to continue to be successful.

While this report is broadly focused on the future of infrastructure, it is equally applicable to a number of related sectors.

SCENARIO RESPONSES

Once the implications of the scenarios have been identified, it is possible to identify responses that an organisation could make to continue being successful. These responses are not supposed to be definitive actions to be taken in the short term, and would only be acted upon if the specific scenario is determined in the future to be becoming reality through the signposting evidence on page 20.

We have identified specific responses for AECOM and we would be happy to help other organisations develop their own responses based on our experience. For more information on the methodology used to create this research, or information on the scenarios, please contact Ian Small: ian.small@aecom.com

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