CLIMATE CHANGE

AND WHAT THE PROJECT MANAGEMENT PROFESSION SHOULD BE DOING ABOUT IT

A UK PERSPECTIVE

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UCL

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ABOUT THE AUTHOR

Peter W.G. Morris is emeritus professor of construction and project management at University College London (UCL). He was head of UCL's Bartlett School of Construction and Project Management between 2002 and 2012. During this time, the school tripled in size.

Professor Morris's research is in the areas of project strategy, competencies, organisational learning and climate change. He has consistently emphasised the importance of managing the front-end of projects and managing projects as organisational entities, using the term 'the management of projects' to reflect this broader focus. He was the recipient of the Project Management Institute's (PMI's) 2000 Research Achievement Award, the International Project Management Association's (IPMA's) 2009 Research Award, and the Association for Project Management's (APM's) 2008 Sir Monty Finniston Lifetime Achievement Award. He was chairman of APM from 1993 to 1996, and has been a vice-president since 1996. He was deputy chairman of IPMA from 1995 to 1997.

He is the author or co-author of more than 120 papers and several books on the management of projects, including: *The Anatomy of Major Projects* (Wiley, 1987); *The Management of Projects* (Thomas Telford, 1994, 1997); *The Wiley Guide to Managing Projects* (Wiley, 2004); *Translating Corporate Strategy into Project Strategy* (PMI, 2004); *The Oxford Handbook on Project Management* (Oxford University Press, 2009); *Reconstructing Project Management* (Wiley, 2016); and *Climate Change and What the Project Management Profession Should Be Doing About It* (APM, 2017). In 2016, his work was honoured by a Festschrift in the *International Journal of Project Management*.

Prior to joining UCL, Professor Morris held academic posts at the universities of Oxford and Manchester. He also worked on major projects in the Middle East, Latin America, Russia, the UK and the US as a project management consultant, and as a director of the global construction company Bovis. •

ABOUT APM

The Association for Project Management (APM), the Chartered body for the project profession, provides leadership and support to the broad and diverse communities of credible, capable and trusted project professionals who are engaged in delivering projects for the public benefit.

APM was granted a Royal Charter by the Privy Council in October 2016 and became a Chartered body on 1 April 2017. It is a significant milestone in the history of the profession, enhancing the status and recognition of project management as a means of delivering effective change that improves our economy and society.

As the Chartered body for the project profession, APM supports its members in meeting contemporary societal challenges and to be in a position to manage change effectively and efficiently, while capitalising on the opportunities available, driving forward new and innovative ways of working.

Our vision

'A world in which all projects succeed with project management as a life skill for all.'
Our profession faces many challenges: there are still too many projects that fail, successful practice is too frequently ignored and failure often lies beyond the boundaries of traditional project management. To deliver our vision, we need to inspire everyone to understand the contribution they can make to project success. We will reach out to different communities and generations, and develop project management as a core skill for all. apm.org.uk

ABOUT UCL

University College London is one of the world's top universities. Founded in 1826, it was the first university in England to accept students of any class or religion, and the first to welcome women on equal terms with men. It now has more than 11,000 staff and 38,000 students drawn from more than 150 countries.

The School of Construction and Project Management sits within The Bartlett, UCL's Faculty of the Built Environment, alongside other renowned schools, such as Architecture, Planning and Energy. Both faculty and schools enjoy global recognition as radical, research-led centres of excellence. The School of Construction and Project Management's focus is on the management of projects (and programs, in all sectors), construction economics and infrastructure finance. It is highly regarded by industry, government and academia for the originality and quality of its research, and the quality of its graduates. Core to its vision is the development of professionals who exhibit the leadership appropriate to the challenges facing our society today, not least climate change.

CREDITS

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FOREWORD

Prediction is always hard, except perhaps when the future is both so obvious and so dramatic. Never before have we known with such confidence that so many of Earth's species and ecosystems face massive change and collapse unless action is taken immediately. This is the result of climate change, caused by the effects of industrialisation, rising population numbers and ongoing resource depletion. Its impact will, for many, although not all, be enormous if not catastrophic. Flooding and storm damage, power outages, drought, loss of biodiversity and changing habitats are inevitable, as are massive social and economic, and political, consequences. Yet, as a human collective, we have, until recently, seemed to be sleepwalking into this new age, doing too little, too late.

Research on climate change has so far been led predominantly by physical scientists, but addressing how to mitigate and adapt to it will also require management and social science skills. Those expert in the world of projects and their management should have a significant role in this. This essay by Professor Peter Morris provides an initial scoping of where and how project management as a profession might address the implications and consequences of climate change.

As the newly Chartered body for the project profession, we believe Professor Morris's paper is a timely and thoughtful contribution to the subject of climate change. The essay reflects the teaching, consulting and research he has been doing over many years, challenging and shaping the way we think about project management. APM supports this work. We see the document as providing a platform and narrative upon which our professional response to climate change can be shaped and developed over the years to come. The field is fast-changing, however, and immensely complex. Responsibility for the data and views expressed in it must rest, ultimately, with Professor Morris. But, as our understanding develops, ownership of the document will, we hope, broaden. It is certainly something that APM intends to promote. After all, challenges don't get much bigger or more significant than this.

Sara Drake
Chief executive
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INTRODUCTION

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INTRODUCTION

In April 2017, the Association for Project Management received its Royal Charter as the UK's project management professional body. Project management is essentially a discipline concerned with the definition, development and delivery of projects. Projects are temporary organisations that follow a common development process (often referred to as the project life cycle). In doing so, project management uses a number of tools and techniques, and deploys practices, processes and procedures, by people having special skill sets, which together form a distinct body of knowledge.

There is, however, a danger that, as a discipline, project management can be more concerned with the use of these practices than with what its impact is on producing outcomes of real value. With about 20 per cent of GDP being based on projects,[1] there is clearly a case for making sure that the discipline focuses on ends rather than just means: on ensuring its work contributes in the most effective way possible to society.

And society faces many challenges – it always has done. One of the most serious in many people's eyes (but not everyone's) currently is climate change. There has always been climate change, but this time the size, speed and consequences are so much greater than before, and have often been so wilfully created that we would surely be foolish not to be addressing it.

This document reviews where society stands regarding the potential impact of climate change and what project management as a discipline could, and should, be doing about it. It does so by first reviewing the dimensions of the challenge, and second by looking at how the discipline could better achieve the targets agreed at the UN Climate Change Conference in Paris in December 2015 (which are now legally binding). This is principally to limit the rise in ambient temperature since pre-industrial times to 2°C.

Many of the actions that contribute to the successful management of projects are taken by people and organisations who are not project management experts or organisations themselves, but who establish policies, goals, regulatory frameworks and strategies within which projects and programs function. This document acknowledges their importance with respect to project management performance, but does not directly address them, important though they obviously are. It is focused on the professional project management community: those charged with developing and shaping the project to the point of receiving sanction to proceed with full execution, and then delivering the project to that defined outcome.

For many, a natural entry into the subject is via sustainability. Climate change poses a challenge bigger than this, however, as we shall now see. •

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WHAT IS CLIMATE CHANGE?

WHAT IS CLIMATE CHANGE?

For many project managers, climate change is seen as a form of sustainability. In reality, it is much more than this. It is the entrance of a whole new geological age of the planet: the Anthropocene – the era shaped by man.[2] But so pervasive is the association with sustainability that it would be well to begin by spelling out the differences between the two.

2.1 More than sustainability

Sustainability began life both as a scientific concept and as a development practice. The concept of 'sustainable development' was introduced by the UN in 1987 in its landmark report *Our Common Future*.[3] Previously, the environment was largely either ignored in the discipline or was accommodated in a rather half-hearted manner. But with the prestige of the UN, the stature of the report's lead author, Gro Harlem Brundtland, ex-prime minister of Norway, and the rising interest in the subject for the public at large, the concept immediately caught on. Suddenly project developers and managers had a sensible, coherent intellectual framework available for addressing the environment.

But what did the UN actually mean by 'sustainability' and 'sustainable development'? Sustainability is the capacity to endure: we are talking of the endurance of systems and processes. Hence, *Our Common Future* defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

But although sustainable development might be feasible along some dimension – planting trees to replace wood used in a project perhaps – it won't be for others. And there may well come times when a project just cannot leave things ready for the next generation to carry forward – in mining and quarrying, for example: a mine has a finite life. Arguing that it needs to have some downstream, associated usages may be desirable, but it is neither possible nor sufficient to make the case that it is sustainable, that the mining activity might somehow allow future generations to continue mining as though nothing had been extracted, or had indeed generated other, spin-off activities.

Through the 1990s and into the 21st century, researchers developed dozens of attributes of sustainability and began systematically to use them to measure intervention effectiveness. The concept of the triple 'bottom line' – economic, social, ecological (or environmental) – became popular as a measure of sustainability, but the idea is questionable. Developing and implementing measures to ensure long-term economic development is what a large part of the field of economics is all about, for example. Meanwhile, during this period, attention began to be given to forces affecting not just specific developments, but the planet as a whole.

ADDRESSING CLIMATE CHANGE IS A MORE URGENT AND TRACTABLE RESPONSIBILITY THAN ADDRESSING SUSTAINABILITY

2.2 The emergence of climate change as an urgent global issue

The significance of climate change, defined in 1992 by the United Nations Framework Convention on Climate Change (UNFCCC) as "a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere",[4] has slowly emerged since the 1990s as a major, potentially more threatening phenomenon. Thus, in 2007, for example, it is mentioned as only one of 44 sub-themes of the UN's then 96 sustainable development indicators (soon reduced to 50, grouped into 14 themes). By January 2016, however, climate change had been accorded equal prominence with another 16 sustainable development goals.

Climate change brings a completely different, more powerful, more urgent perspective to bear on mankind's activities and their impact on the planet than is provided by focusing just on sustainability and sustainable development – one that is more appropriate to the enormity of the change facing the planet, and us, its passengers, over the next century and beyond.

Evidence that climate change is happening took a long time to collect and present as conclusive. Most of this work was coordinated and produced by the Intergovernmental Panel on Climate Change (IPCC), an organisation jointly founded in 1988 by the UN and the World Meteorological Organization. By the second decade of the 21st century, the evidence presented by the IPCC to all but the most sceptical and wilful of critics was overwhelming. Earth's temperature is rising, and climate change will assuredly follow. Indeed, it almost certainly already is.

The prime driver causing climate change is the emission of greenhouse gases, and by far the most significant of these is carbon dioxide (CO_2), with methane and nitrous oxide also contributing, and water vapour. The main sources of these greenhouse gases are electricity generation, transport, land-use changes and agriculture, with electricity generation and transport growing at the fastest rate. The largest single user of electricity in many countries is the heating and cooling of buildings.

To slow the impact of rising temperatures on the planet and its societies, a target was agreed at the UN Climate Change Conference in Paris in December 2015 – known as COP (Conference of the Parties) 21 – namely a limit of a 2°C rise over pre-industrial global temperature levels by 2030. An additional aspiration of trying to get down to 1.5°C was also agreed. These targets have now been ratified in international law, albeit Donald Trump is now (June 2017) seeking to withdraw the USA from the agreement.

The 2°C target is a startlingly simple measure of success, but it sits on top of an immensely complex set of interacting factors, which makes modelling their relations and performance extremely difficult. Thus, for example, the effect of rising temperatures on melting sea ice and permafrost (leading to further CO_2 and methane emissions, further increased temperature rises, and further glacier melting, particularly in Greenland) is immensely complex.

2.3 Consequences of climate change

Fundamentally, the real prime driver is not the emission of greenhouse gases – these are the instruments of climate change. The real driver is increased population numbers, exacerbated by people's desire to improve their living conditions, not least through the use of carbon-emitting, powered equipment. The world's population at the beginning of the 20th century stood at 1.5 billion people. Now it is over seven billion, five billion of whom are not enjoying the lifestyles – using electricity almost without a thought – enjoyed by the other two billion. By 2100, the world's population could be around 10 billion. The challenge is to provide everyone, but especially the poorer eight billion, with a standard of living that is environmentally, and socially, acceptable.

Current pledges to reduce the emission of CO_2 should deliver a temperature rise of 2.7°C. The 1.5°C target is extremely ambitious, requiring, among other things, zero and even negative emissions – in other words, carbon removal – from 2030 and 2050. Whether these goals can be achieved, and whether project management can help, are the questions.

Existing levels of CO_2 emissions are trending to plateau at about 50–55 billion tonnes per annum. To hold to 2°C would require emissions to be capped at about 35 billion, with zero global emissions in the second half of the 21st century, probably falling to negative shortly thereafter. The developing world is likely to be generating 40 billion tonnes by 2030, however, most from China and India. 50–55 billion tonnes would result in a temperature rise of about 3°C. To achieve a 2°C rise, everyone will have to cut emissions – six to four billion tonnes for developing countries, essentially halving their emissions, and 15 to 8 for developed. The EU has pledged to reduce its emissions by 40 per cent by 2030, and the USA, pre-Trump, by 26–28 per cent of 2005 levels by 2025.

And, of course, things do not suddenly stabilise at 2030: we shall have to monitor emission rates after then, with the aim being to tighten the targets further, ideally to zero and below. For it is important to recognise that it is not just the rate of emissions that needs to be cut; what's really critical is the amount of CO_2 in the atmosphere. Cutting the rate of emissions doesn't reduce the quantity of carbon already up there; it just means that the quantity grows more slowly. Negative emissions address this need, although we are still a way short of figuring out how to do it at a scale that is appropriate.

A 4°C rise is generally considered to be a tipping point (although other tipping points may well come earlier). Few studies have looked in detail yet at the consequences of a temperature rise of 4°C or above,

CLIMATE CHANGE IS INCREDIBLY COMPLEX, YET THE TARGET FOR ADDRESSING IT IS INCREDIBLY CLEAR: 2°C. AT CURRENT RATES WE WON'T ACHIEVE THIS TARGET BY 2030, LET ALONE THE MORE AMBITIOUS 1.5°C OR NEGATIVE EMISSIONS

DECISIONS ON CAPITAL EXPENDITURE MADE TODAY REGARDING THE CLIMATE WILL AFFECT GENERATIONS TO COME

but at this level of temperature rise, many climate scientists believe change would be unstoppable.

At around 4°C, we are beginning to be able to suggest trends with some robustness. Thus, for the UK at least, we can predict with high confidence that above 4°C there will be substantial flooding damage due to both weather and rising sea levels, and damage to wildlife, especially bird populations. Even below 4°C there will be large increases in storm-driven flooding and wind damage. By 2100, sea levels are expected to have risen by 50–100cm (they are currently rising at a rate of 3mm a year). Water shortages, as well as flooding, will lead to widespread societal disruption. Demand for water in the UK could be running at 150 per cent of available sources by 2050. Summers will see threats at the other end of the spectrum. Over-heating will have a direct impact on many people's health as well as on our infrastructure, e.g. buckled railway lines and larger, longer and more severe droughts. All of this will lead to sustained disruption of natural capital – reductions in biodiversity, invasions of unwelcome pests and problems with food production.

At 5°C or 6°C, melting of the Antarctic and Greenland ice sheets would accelerate, although how quickly is not well understood. The process would take several decades. By 2120, sea levels would possibly have risen by over three metres. London, Miami, Mumbai, New Orleans, New York, Shanghai, Sydney and Venice would, among many other cities and coastlines, all be seriously threatened.[5] The consequences strategically and financially would be enormous. Large parts of southern Europe would turn to desert. Add to this wider crop failures, large-scale human migration, storm damage, massive species extinction – all of which is happening now, to some degree. The consequences to our way of life and our built environment, while not being felt uniformly or evenly, would to some be catastrophic – globally, socially, economically and politically.

The targets agreed in Paris at COP 21 do not come into effect until 2020 – or by 2030 in the case of China, India and South Africa (and who knows about the USA?). Delaying taking action should not be an option – it means building more 'dirty' power generation and transport facilities, thereby expanding the volume of CO_2 already in the atmosphere. It is also less expensive to act now rather than delay.[6] Surely this is an area that project management, with its emphasis on scheduling and knowledge of the dangers of accelerating schedules – as in concurrent development, for example – can make a contribution to? As we shall see, this is particularly pertinent in the case of large-scale R&D projects like carbon capture and storage, and nuclear fusion.

The scale of investment required to counter the effects of climate change is enormous. The risks of failure and the life-times and lead-times are so large that we should ensure that our capital projects and programs are undertaken with all the professional care and skill at our disposal. This is where project management comes in. •

3

PROJECT MANAGEMENT

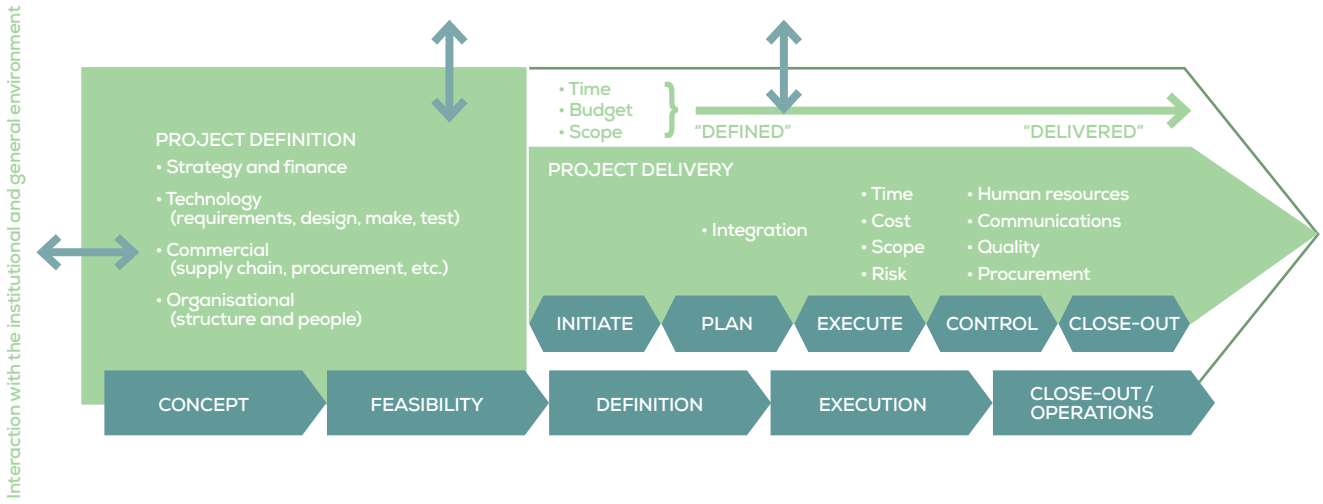
PROJECT MANAGEMENT

Project management as a generic discipline operates in at least two different ways. The most common is that of managing the post-sanction execution phases of a project; the other is the discipline for managing the whole project, from inception to operation. This broader, more holistic, more contextual view of the discipline is most developed as the approach known as 'the management of projects'.[7] In this conception the unit of analysis is the project organisation, the organisational core being the product development cycle (commonly termed 'the project life cycle') that all projects share and that distinguishes projects from non-projects. Shaping the project definition in the front-end here is seen as key.[8] Project definition covers the management of technical and commercial issues, focused ultimately on best meeting the objectives of the sponsor.

But is it right for two such differently scoped functions to share the same name and promote themselves as the same discipline? Well, if other professions are to act as any kind of guide, the answer is probably 'yes'. The same term loosely applies to all members of the engineering professions, for example, who carry out jobs of substantially different degrees of responsibility and maturity. It is the same with medics: all are members of the medical profession but, in pursuing different specialisms, the core medical discipline is focused on one of a number of roles. This is not to say that all members are assumed to be equally competent. In fact, their overall competence can vary quite considerably – in experience, judgement, knowledge, intelligence, acumen, charisma and so on. For us, thinking about climate change, it seems right that project management does similar things at several levels – or ends of the spectrum. We can thus conclude that the project manager, and his or her teams, working at the project front-end particularly, could have a decisive role to play in shaping and directing the project or program.

The 'management of projects' paradigm

FOCUS ON CREATING AN ORGANISATION FIT FOR DELIVERING PROJECT SUCCESS, EMPHASISING THE FRONT-END AND CONTEXT



3.1 Managing the global program

Under the terms of the COP 21 Paris Agreement, each 'Party to the Conference' is responsible for producing its own plans for achieving its emission reduction targets. These plans are spelt out in the parties' 'nationally determined contributions'. Parties are required to report on progress and, beginning in 2023, every five years there will be a 'global stock-take'. Above the level of individual parties there are a number of actions that together form a work program. This is hardly a vigorous approach to managing mankind's response to one of the world's biggest threats to its way of life. It is hardly a good example of what program or project change management could offer.

The disciplines of project and program management comprise an extensive set of practices, processes, and techniques, generally represented as an integrated methodology. Two organisational features, however, stand out as pre-eminently important in its application: the formation of a single point of accountability, and the presence of a project or program support office. These should help create a more proactive, professional approach to managing our response to the causes and consequences of climate change. Let's see.

3.2 Single point of accountability

Recognised good practice in project management is to have a 'single point of accountability' (SPA) where all actions relevant to achieving the project's or program's objectives are focused.[9] This single point provides integration of plans and coordination of actions. The UK, along with most other countries, fails to provide single-point focus for its climate change actions (responsibility for addressing climate change is shared between four ministries). There is the Committee on Climate Change, which reports to parliament on the risks of the country not meeting its emission targets. As such, it performs as a 'single point' of intelligence, but this is not the same as having an SPA. There are also various task forces beavering away, such as the Task Force on Climate-related Financial Disclosures. These in effect act as forms of integration and, as such, are weak cousins, so to speak, of project management.

Should an SPA be identified for addressing climate change (for the program as a whole and/or for national elements of it)? In early discussions on this paper, there was no doubt that it should be, but in discussion with colleagues from around the world the idea began to feel less robust. The target topic is perhaps too broad, the role too multifaceted, and it probably would prove difficult to staff. The idea begs research, however, as does that of a PMO – a project or program management office – dedicated to supporting the management of a climate change program. We shall revert to discussion of the SPA role towards the end of this essay.

THE 'SINGLE POINT OF ACCOUNTABILITY' IS A FOUNDATION CONCEPT BEHIND ALL PROJECT MANAGEMENT: IT IS MISSING IN MUCH THAT HAS BEEN PROPOSED RE CLIMATE CHANGE

3.3 A climate change PMO

At a minimum, a PMO is the function that keeps information on the progress of projects being worked on by the enterprise. But it is more than a simple status-reporting function; the PMO also acts as the keeper of best practices in the enterprise. As such, it has an important institutional role for the discipline. For governments pursuing climate change, this would mean it being the repository of operating procedures – plans, monitoring requirements, processes and procedures, responsibilities, guidance on key functions such as risk management, change control, etc.[10] Hardly any countries seem to have such a function in place for addressing the management of our responses to climate change. The possibility exists, surely, for a pre-formed PMO to be prepared at the UN level to act as a starter kit to help countries get going.

One of the first tasks of the PMO would be to define the expectations and the methods to be used in working in the very early stages of projects: defining the major task elements, interdependencies, durations, risks, benefits, and organisational roles, processes and structures – doing so both within the project or program and with those external to it (stakeholders and governance).

Would these practices work for the types of projects that are needed to counter climate change? We shall address this question by following the distinction made in all discussion on climate change, by looking separately at climate change mitigation and adaptation. •

4

MITIGATION

MITIGATION

Mitigation is about reducing the incidence of climate change; adaptation is about responding to the consequences. In addressing our own particular research question, we shall see that there is merit too in noting the organisational level at which these mitigation and adaptation actions occur. The role of individual members of the project management professional community can be seen as being different:

- when individuals are acting on their own;
- when operating within the processes and practices of the organisation or enterprise they work for;
- at the professional institutional level (e.g. APM, International Project Management Association, Project Management Institute);
- at a regional level (e.g. county, region or state) or city level;
- at a national level; and
- above this (e.g. the EU or international level).

Broadly, we would expect that the bigger and more demanding projects will recruit staff who are more experienced, and more used to addressing issues that are complex and difficult, and making decisions about them that, though they may seem abstract, are often very important.

Note that we are not discussing policy here, whether energy policy, corporate policy, urban management policy or any other form of policy. Project management, even at the very front-end of project work, is about implementation, important though policy obviously is.[11]

4.1 Mitigation projects

The following are examples of the way project management is currently playing a role in mitigating climate change on different classes of projects. These range from 'business-as-usual' everyday endeavours to huge R&D projects, from project portfolio management to nuclear power generation projects. The examples illustrate, *inter alia*, how different aspects of project management emerge at the different levels of organisation – individuals, enterprise/organisation, profession, regional, national, etc.

4.2 Business-as-usual improvement projects

There are multiple examples of everyday projects involving climate change, for example to develop new capabilities to exploit business opportunities, or to meet new customer or governmental requirements and regulatory standards. They often present no particular difficulty. The IPCC gives the following as examples of such projects. They may be expressly targeted at achieving climate change goals, or they may be associated consequences.

- In energy: there are project management issues to do with changing sources of power supply: switching from coal to gas, nuclear power, renewables (hydropower, solar, wind, geothermal and bioenergy), combined heat and power; fracking shale gas; carbon dioxide capture and storage.
- In transport: more fuel-efficient vehicles; shifts from road transport to rail and public transport systems; second generation biofuels; more efficient aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.
- In housing: more efficient lighting, electrical appliances, and heating and cooling devices; improved insulation; passive and active solar design for heating and cooling; alternative refrigeration systems; better environmental controls for commercial buildings.
- In industry: more efficient end-use electrical equipment, material recycling and substitution; control of gas emissions; heat and power recovery.
- Re: waste: enhanced landfill; methane recovery; waste incineration with energy recovery; composting; controlled waste-water treatment; recycling and waste minimisation.
- In agriculture and forestry: improved crop and grazing land management; restoration of peaty soils and degraded lands; improved rice cultivation and livestock and manure management to reduce methane emissions; improved nitrogen fertiliser application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency and crop yields.
- Reforestation and forest management: harvested wood products; forestry products to replace fossil fuel use; tree species improvement to increase biomass productivity and carbon sequestration.

There are no doubt more examples.

Management actions to mitigate climate change may often be bundled in with sustainability actions to create an overall 'green management' approach, and this may prove to be the place where the project management community engages most extensively with climate change. Mixing climate change with sustainability may diminish the attention we give to both, however. The urgency of climate change argues the importance of not losing focus.

4.3 Transformation projects

Within these 'business-as-usual' programs or projects there are some that are especially urgent, difficult, large or complex that could benefit from additional management attention – for example, in encouraging people to buy lower carbon-emitting vehicles or helping influence consumers to turn off electrical appliances when they are not being used.

This particular group represents an interesting challenge to the project management profession in that it has often claimed for itself the role of 'change management'. Transformation projects are a subcategory of general change management projects: they are change programs designed to influence hearts and minds, with an emphasis on achieving long-term behavioural change. But there is a gulf between the literature on organisational change projects and what passes for this in project management: little reference to writers such as Kotter or Schein[12] – to pick just two from a very large number of thinkers in this field.

Enquiries conducted for this research suggest that, currently, a major challenge is to get, early on, as much agreement as possible on the scope of the program and on success measures, organisational responsibilities and plans for the program.

The role of government can be crucial. How firm is the government's commitment to its emission targets, for example? (This is very pertinent for Heathrow Airport, whose third runway, and the associated ground traffic, could cause the UK's targets to be missed unless there is a consequential internal realignment of the UK's emission portfolio.)

Actions that can cause institutions, such as governments, to better meet their emission targets can be intangible as well as tangible. Regulations, fiscal incentives, grants and subsidies are all examples of ways of governing and encouraging a supportive 'management of projects' environment. In fact, we can see policy-makers as a distinct group, active in shaping the front-end.

Actually, any integrated program plan designed and carried out to achieve the COP 21 targets would, quite evidently, have to be cast as a transformation program. Critically, however, and as we'll see later, it would need an owner – a sponsor – to champion the program in government(s) and with financiers, and to make substantive decisions. Is the absence of such a person preventing the creation of a transformation plan?

4.4 Other major R&D projects

We may well find that reducing greenhouse gas emissions ultimately is achieved more easily and effectively by developing new, cleaner means of energy production than by trying to change user behaviour. Changes to human behaviour, across 10 billion people (or even a strongly carbon-emitting minor portion of that 10 billion), may be just too difficult to effect in the time available.

Hopes of major breakthroughs in technology are being invested in two or three major R&D programs, namely carbon capture and storage (CCS) and nuclear fusion, which we will look at in a moment. However, there are dozens of smaller-scale initiatives too. One, promoted by a small band of UK luminaries, is modelled on the Apollo Moon program (and is known as Global Apollo). It proposes that participating nations would pool their research on new technologies and fund the equivalent of 0.02 per cent of their GDP. For and from this there is an annual technology mapping exercise. But there is no proactive planning, no 70-hour weeks to hit a dramatic outcome target. One must be very sceptical.

There is also promising work in improving photovoltaic cell capability and in new battery technology that would allow smart grids to store and distribute power that, in turn, could be used in conjunction with renewable sources of energy.

Another line of development is small modular (nuclear) reactors that might work with gas to provide an attractive baseload supply. However, the government believes that no other new technology yet gives us the amount of baseload security that modern economies require – renewables account for over 20 per cent of the UK's electricity supply – and so realistic amounts of carbon-reduced energy look like being secured primarily, for the time being, from fission nuclear power, with hopes for additional input from these new developments plus CCS and gas.

Hence the importance of the large mitigation R&D projects. Unfortunately, these appear to be in some degree of project management difficulty, being well over budget and schedule. We should be careful about jumping to conclusions though. Design changes are surely inevitable in R&D projects where the nature of the job is to analyse, investigate and test rather than necessarily just complete on time, on budget. The real judgement regarding success is: what are/were the agreed success criteria and how well have these been achieved? The lesson for project management has to be to get clarity right up front on what the owner/sponsor wants from the project – including climate change criteria – and therefore what the project targets are, what the impact on stakeholders could be, and what the risks are of not hitting those targets. All this said, one has to ask, as good project people, are any of these big R&D initiatives likely to produce solutions in time to meet the incoming rise in global temperature? In all likelihood, the answer is 'no'.

Meanwhile help seems to be coming from other directions: the breakthroughs that are taking place at the moment are in the price of photovoltaics and offshore wind. Low-latitude photovoltaics are now routinely coming in at less than the price of electricity generated from natural gas, and approaching one-quarter of the price of electricity from Hinkley Point C (which we'll discuss in a moment). Energy policy is not, however, the responsibility of project management and so is not directly within the remit of this essay – except as a constraint.

The role of project management in most renewables is not unusually difficult. What is difficult is the management of the large R&D mitigation projects, and indeed the larger, more complex adaptation projects being undertaken to find alternative sources of energy. So, for completeness, and indeed as input to the discussion on energy mix, we will now examine CCS and nuclear power.

THE LIKELIHOOD OF THESE BIG R&D PROJECTS PRODUCING TECHNOLOGIES THAT WOULD REDUCE THE RATE OF GLOBAL TEMPERATURE IS MINIMAL

4.5 Carbon capture and storage

Carbon capture and storage is the process of capturing waste CO_2 from emitters such as fossil-fuel power plants, transporting it to a storage site, and then storing it for the long term (designated as over 1,000 years), usually in large underground geological formations such as empty oil or gas wells. It is widely seen as one of the most attractive means for dealing with carbon emissions. Unfortunately, not only is the technology shaky, the economics just don't add up.

Scientifically attractive, in reality, the technology, environmental side-effects and cost of CCS present serious problems. Thus the Kemper Project in Mississippi, a first-of-its-kind power plant employing gasification and carbon capture technologies at scale, has experienced 'project management problems': as of 2016, it was more than two years behind schedule and, at a cost of $6.6bn, three times over budget.

Although capture and scrubbing should technically not be too difficult, transport typically still has unanswered questions – for example, about pipeline network requirements, regulation, cost recovery and safety. Among the biggest problems is guaranteeing no leakage over such a long time. Ultimately, the overall cost benefit is questionable: capturing and compressing CO_2 could increase the energy needs of a coal-fired plant by 25–40 per cent and push up its costs by 20–90 per cent.

Meanwhile, however, the UK's Parliamentary Advisory Group on Carbon Capture and Storage (PAG CCS) recommended in September 2016 that a CCS Delivery Body, closely modelled on the Olympics Development Agency, should be established to organise and deliver the infrastructure that would be needed for CCS to be the successful, necessary element that it is thought it should be for the UK to meet its emission targets.

So what is the contribution of project management to CCS?

First, despite the 22 projects said to be built or under construction, CCS is a long way from being available commercially: the business concept is weak.

Second, clearly the CCS delivery model is not yet robust. The PAG CCS recommends retaining "unique overall ('full-chain') project risk in government, at least initially, while letting private sector companies compete to provide the component parts of the project which they are best placed to deliver at least cost". This implies a CCS development strategy aligned "to the very well-established, deep and efficient supply chains which exist in all the components of CCS".[13]

Third, at the project level, the schedule has to be right. This means, *inter alia*, identifying and managing risk – which affects contingencies and the budget.

Fourth, the key players in all of this are the owner/sponsor and governance. And the key stages for doing this are, of course, at the project front-end.

4.6 Nuclear fusion: Iter

Fusion is potentially the big get-out-of-jail card. It has many potential attractions, not least that, unlike fission, its energy is clean. Iter is a demonstration project near Toulouse, France, designed to show that, working at millions of degrees Celsius, using new, bigger 'tokamak' reactors to fuse atoms of deuterium and tritium, it will be possible to produce 500 megawatts of output power for several seconds while needing only 50 megawatts to operate, thereby producing more energy from the fusion process than is used to initiate it. The basic physics of fusion have been tested at JET, the Joint European Torus project, located at Culham in south Oxfordshire, UK.

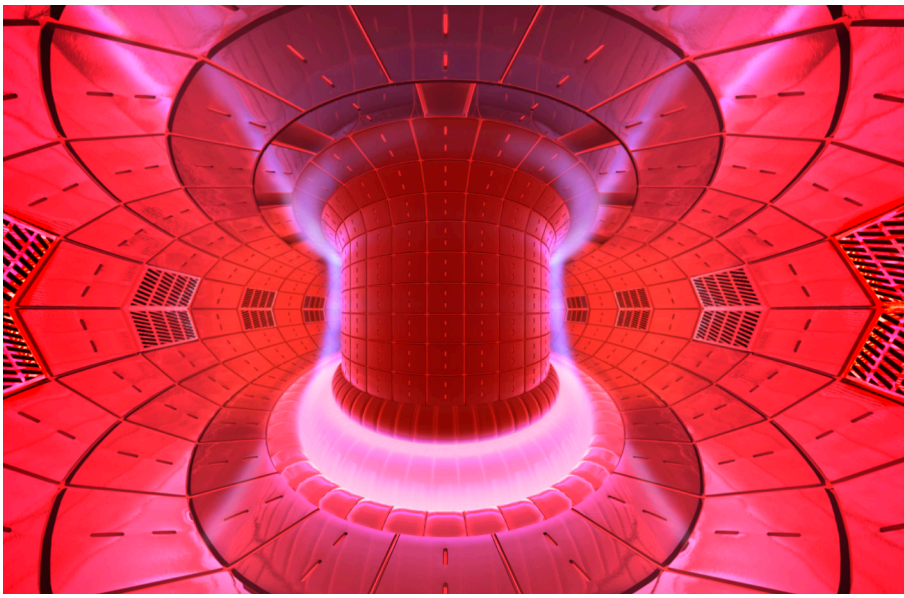
The trouble is, fusion has been forecast as being ready in 40 years' time for at least the last 40 years – well, 50 or 60 actually. The technological environment is extreme, and the project management challenge is not eased by the large international dimension of its work. For Iter involves 34 primary sponsor countries making the individual elements of the tokamak stack, which are then manufactured and assembled by institutions from 114 countries.

Following Iter, it is planned to build DEMO, an electricity-generating, fusion-driven, commercial power station. DEMO should have an output of 2,000 megawatts. No date has yet been put forward for DEMO.

The project got off to a shaky start and, by 2009, was already five months behind schedule. Construction is expected to take 10 years, with commissioning in 2019, but the schedule is being extended by at least six years; that is, first plasma in 2026–27.

The cost of the project is now estimated at over $20bn, some three times its original estimate. Cost growth is primarily due to the rising price of raw materials and changes to the initial design.

The standard of engineering is incredibly high. The project faces many familiar problems; pre-eminent has been scheduling (there is now a phased, milestone-driven approach). Supplier coordination and the challenges of dealing with very intelligent, ambitious individuals from 34 different countries, most with their commercial eyes on DEMO and its siblings, combine to make 'integration' – coordination and control – a major challenge. What the UK's role will be post-Brexit we do not, at the time of writing, know.



DAVID PARKER/SCIENCE PHOTO LIBRARY

The Iter reactor in Toulouse, France

5 ADAPTATION

ADAPTATION

As we've seen, the world's energy needs have, until now, largely been met by burning 'dirty' fossil fuels. This is no longer tenable, not least due to UK and international legislation. The UK's targets are legislated as a 34 per cent cut in emissions by 2020; 50 per cent on 1990 levels by 2025; and 80 per cent on 1990 levels by 2050. Renewables are targeted to provide 20–30 per cent of the UK's energy needs and are on course to achieve this, as we have seen, but that still leaves a sizeable hole to fill. Currently, this is largely being met by gas. Gas is a low-carbon-emitting fossil-based option, but it does not provide the security or levels of carbon emission needed. In the long term, fusion is a possibility, but it is decades away from being a commercial source.

In the short term – which means within the next ten to 30 years at least – the UK government sees no alternative but for the nation's baseload of electrical power to be generated by nuclear fission, although many commentators believe solar power and wind will, with gas, end up being the more appropriate and successful energy sources.

Whether this new generation of fission-based nuclear power plants are mitigation or adaptation projects is, in reality, unimportant. It is adapted technology, but that technology is replacing, and mitigating, fossil fuels. We'll take it here, under adaptation, largely because it's less about R&D and more about commercial implementation, but the choice is a fine one.

Unfortunately, nuclear fission has a long track record of project management failure, due partly to the very high technical demands of construction, partly due to poor management.[14]

5.1 Nuclear fission: Hinkley Point C

Hinkley Point C (HPC) is the first of the UK's next generation of nuclear fission plants to go into design and construction. It is one of the most important and difficult of all major energy projects in the world today, and its project management clearly impacts the treatment of climate change.

The plant is huge: at £18bn (plus financing costs) and rising, it is the most expensive building in Britain, to be responsible for seven per cent of the UK's entire energy needs. Its twin, Sizewell C, to be built later, will be responsible for another seven per cent. Yet its management arrangements are notoriously troubled, partly because it uses new, as-yet-unproven technology, European pressurised reactors (EPRs). Based on past performance with power plants using similar unproven reactor technology, overruns seem very likely.

The go-ahead for construction of the plant was given in June 2016. Considerable work had already been done in anticipation of sanction approval: integrated planning and design, digital mock-ups, and extensive site works. But excellent though this project management might be, there is high risk that the project will suffer serious delays and budget overruns, thereby threatening the UK's ability to meet its climate change commitments, due almost wholly to the difficulties experienced with the new EPRs. Prior to Hinkley, EPRs were being built in just four plants: one in Finland, one in France and two in China. All were experiencing severe problems, leading to substantial schedule delays and cost overruns.[15] It is highly possible that the same thing will happen for HPC.

In addition to the potential problems of the unproven reactors, an inappropriate procurement strategy was arguably being used. The government required that the plant be financed by the private sector, despite financial advice that this would not work. Électricité de France (EDF) owned the Hinkley sites and was therefore nominated – with no competition – as the developer/architect-engineer of the plant. As it happens, EDF is also 85 per cent (French) state owned. Thus the project proceeded on the basis that it was self-financing (albeit with French and Chinese government funding via EDF and the Chinese state-owned CGN).

CHRISTOPHER JONES / ALAMY STOCK PHOTO

Artist's impression of the proposed Hinkley Point C nuclear power station

The UK government's strategy is to offload the build risk onto 'he who can best manage it' (namely EDF). Since the project is to be financed by the private sector, the UK government is effectively excusing itself from any form of managerial responsibility for the project execution. But putting the

risk wholly onto the supplier came to look increasingly problematic as, over the course of 2016, EDF's financial position worsened substantially, leading to the prospect of it not being able to fund the cost of delays, should they materialise (the finance director resigned and, shortly afterwards, several senior technical staff urged that EDF withdraw from negotiations since the project was, in their opinion, too risky). To address this risk the UK government agreed a generous strike (purchase) price, fixed for 35 years from the date of first power out, thus making the price of its electricity the highest in Europe.

It is evident that project management is at the centre of HPC's development, but that it is governance, technology and procurement that are at the heart of the project management challenge: how to avoid major contractual disputes between the government and EDF, and EDF and its subcontractors, should there be reactor problems; and how to mitigate the risks of a procurement strategy that is more appropriate for buying an off-the-shelf product than for one of the biggest and most complex projects in the world. It is a strategy starkly at odds with Heathrow's recent Terminal 5 project, for example, where the owner – the funder, BAA – took the project build risk on the explicit basis that it was in a better position to do so than were its suppliers. On HPC, the UK government declined to be the funder of the project, and in so doing declined too to take build risk.

There are several lessons for project management from HPC, traversing a range from the individual to the institutional, the organisational to the regional:

- poor management of technology (Areva's reactors; EDF's quality management on the EPRs it has been installing);
- the crucial importance of selecting an appropriate contracting strategy (supplier finance; no competitive bidding – because EDF already owned the site); and
- individual inflexibility (disputes at the highest levels over assessment of risk and the project's commercial viability).

The problem is, we know these things – so how do we get the lessons learnt regarding project management, as a discipline, drilled into those people who are building the plants, particularly regarding the set-up arrangements (and hence particularly the sponsor/governance)? Even when we have the lessons laid out before us, it is still extremely difficult, it would seem, for managers of projects and their relevant organisational enterprises to get institutional learning among themselves.

One further point. For many, nuclear power is unacceptable so long as we have no mechanism in place for dealing with its waste (especially its high-level waste). This is a form of intergenerational hazard: today's problems are here being kicked down the road for future generations to deal with. In fact, the delay on getting this issue sorted is more to do with stakeholder management – the local council (Drigg) angling for improved benefits from the Nuclear Decommissioning Agency – than with inherent, intractable technical challenges.[16]

In summary, compared with renewables, nuclear power is more expensive, has greater build risk, produces dangerous waste and has enormous potential for producing major environmental incidents. And project management has not been able to mitigate these negatives, except in the case of France's pressure water reactors or the plants recently completed in Abu Dhabi, where the technology used was unchanged on previous plants. It's only attraction is its low operating costs.

Let's move on and look at project portfolio management.

5.2 Project portfolio management: 'systems of systems'

Front-end decision-making plays an important part in adaptation, particularly in avoiding 'lock-in' on decisions with long lifetimes, such as the unwelcome emissions in the siting of key infrastructure or design of new habitats. Unfortunately, the management arrangements driving such decision-making are too often weak.

Project portfolio management should, *prima facie*, be an important discipline for addressing climate change. Portfolio management is used extensively by enterprises to assess opportunities, resources, and up-side potentials among and between assets in the portfolio (projects, possibilities, etc.), and to analyse integrally the risks, opportunities and priorities associated with them. McKinsey rates it as "one of the most powerful ways of reducing the cost of infrastructure",[17] but doing it for the built and natural environments is more complex than McKinsey suggests. It can be applied at all levels of the investment funnel – the product/project development life cycle – from early stage optioneering to detailed shaping.

Let us take the UK's project portfolio management approach to prioritising and resourcing work on flood and coastal erosion. As of mid-2016, some 1,500 projects with a budget of £2.3bn were scheduled in detail by the Environmental Protection Agency over a six-year time duration and, in broad terms, over a 50-year period. Prioritisation is essentially done on a benefit/cost basis, but flooding is very emotive, and a heavy flood followed by visiting politicians may, quite understandably, make for changed priorities, and funding, as happened in the winter of 2015–16.

As their prioritisation becomes clear, so the projects or programs in the portfolio can be shaped by project and/or program management.

Typically, all of this happens very much from the business side of the sponsor (owner) organisation. (The owner is the owner of the project. The sponsor is the holder of the business case. Generally, the sponsor works for the owner, but may be separate if the source of funding does not come from the owner.) The context the project or program finds itself in is shaped by institutional policies and objectives, and these in turn inform the elaboration of the owner's/sponsor's goals and strategies. Interestingly, as we have seen, the role and actions of clients/sponsors is not always uniform. Thus, HPC's governance is designed to be relatively hands-off once the project requirements have been agreed. Other UK major projects reflect different modes of engagement – quite hands-on in the waste-water (e.g. Thames Tideway Tunnel) and rail sectors, in part at least because of the social impact of their projects, partly because of the richness of their technology issues, and partly, possibly, due to the skills and knowledge of the owner/sponsor personnel in the sector.

A new and little-explored area is the use of project portfolio management to aid in looking at the interdependencies of development opportunities in geographically defined special areas. For example, Oxfordshire in the UK is currently experiencing a dramatic increase in the pace of development: a huge expansion of housing, but with seemingly little regard for any associated increase in infrastructure – i.e. interactions between housing and water (waste and flooding), housing and energy, energy and water (flooding), housing and schooling, medicine, shops, and so on.

Making portfolio decisions with respect to the broader impact of climate change will require modelling not just as projects, but as multi-level systems of functions, located within a geographic area: a 'system of systems'.[18] The UK's *National Flood Resilience Review* recognises this.[19] Logical in theory, such modelling could be very complex in practice: the models should strive to avoid unnecessary complexity. The systems should be multi-level, and be commodified so that their use is not seen as an esoteric luxury for the specialist planner.

So, following from this, we can suggest that both the built and the 'unbuilt upon' environments could be improved by using project portfolio management through better analysis of needs and coordination of opportunities. But we are still left with the problem of who is to own that work – who is to be the owner/sponsor? Currently, the UK's planning system is reactive. What is needed, but is absent, is some form of overarching environmental stewardship – a proactive guiding hand. There would seem to be little recognition or political appetite for such a role at the moment in the UK, however. •

6

PLANS & STRATEGIES & THEIR IMPLEMENTATION

PLANS AND STRATEGIES AND THEIR IMPLEMENTATION

To what extent is it reasonable to expect an integrated approach to reducing our carbon emissions? Do we really know how best to implement a strategy for doing this?

Adaptation requires plans that are both holistic and strategic while also being carefully targeted. Explicit project strategies for climate change mitigation and adaptation are needed for different geographical areas and functions, and some are in fact being devised for local regions, cities and towns (e.g. the Bloomberg mayors), as well as for systems and functions. At the level of firms, however, other than in energy and infrastructure, there would seem to date to be but few explicit climate change strategies. Realising such plans would benefit from the focus and drive of taking a project-based approach. The context will typically be complex and multi-institutional, requiring flexibility both in 'the plan' itself and its implementation. The planning element of this may need to be both deterministic and, to an extent, at times mechanistic, depending on context.

The UK has a *National Adaptation Programme* (NAP)[20] and a *National Infrastructure Delivery Plan 2016–2021* (NIDP). Both are risk led, identifying risks in a number of sectors – water, infrastructure, transport, ICT, health, education, etc. – as well as risks generated through interactions between other risks. Curiously, housing and energy supply are not included: this seems to defy common sense and certainly fractures the country's response to climate change, but overall both the NAP and the NIDP are clear and orderly, a triumph, some might say, of optimism over experience. Yet neither represents a full strategy, or plan, for dealing with climate change. If they did, they would surely say something about, for example, planting trees, addressing demographic change, and regulatory and fiscal measures such as a possible carbon tax. There is a sense that merely listing all the project investments or risks is 'job done', particularly in the plan. There is little of strategy as an act of coping with uncertainty as one moves from stage to stage, as proposed, for example, in Lawrence Freedman's definitive work *Strategy*.[21] There are some big things that are missed too: HPC and subsequent UK nuclear plants, for example – and Heathrow's third runway, whose ground traffic will, it is claimed, breach the UK's carbon targets.

It is expected that both the NAP and NIDP will be followed by updated versions in 2018 and 2021, respectively. It will be interesting to see how the nation's economic health affects these plans – and to see in what form the USA's Clean Power Plan survives, if it does, President Trump's proposed withdrawal from it and the COP 21 agenda.

THERE IS NO SINGLE, INTEGRATED CLIMATE CHANGE STRATEGY IN THE UK

6.1 Good practice hits resource reality

The strategic proposals put forward by the UK's Parliamentary Advisory Group on Carbon Capture and Storage (CCS PAG), on the other hand, demonstrate clearly how government could possibly make a project management contribution to addressing the consequences of climate change and why it should be taken seriously. The only questions are whether it feels the need to, and whether it has the resources.

For the CCS PAG, the need is to organise full-chain sponsorship "while maximising the competition between private sector players in the components at which they excel. This involves realistically allocating risk from the start and hence achieving best value for the consumer where the opportunity exists to do so. Such an approach, it is claimed, maximises private sector involvement, maximises competition and minimises the cost to the consumer."

But buying-in private sector funding would bring increased risk to supply chain members and lead to reduced supply chain integration. It would also require a very substantial organisation, funding and effort. One wonders what the chances are of the UK government agreeing to and promoting this, given the pressures on its shrunken civil-service headcount, the lack of experienced people for such a role, and the demands of negotiating and implementing Brexit. •

7

COMPETENCIES & CAPABILITIES

COMPETENCIES & CAPABILITIES

Who is looking at whether our plans are effectively coordinated? As we've seen, hardly anyone, except for those to whom climate change may mean existential crisis, like The Maldives. Who is really working on the challenge of sea-level rise for New York, New Jersey and Long Island? How could the design/funding/implementation of new build and maintenance be done better? Should we not be looking at active, coordinated regional and sectorial planning, combined with purposeful management of plans involving both a project-based management organisation and appropriate tools, as we have just discussed for project portfolio management?

And what kind of role, then, should the portfolio 'helmsman' – the environmental steward, the sponsor – have? Is he or she to be making decisions largely on a benefits/cost basis or on functional (systems) performance? And what qualifies the project (program or portfolio) manager to have a master role in deciding and directing what to invest, where and why?

The situation is comparable in complexity to the rise of the project manager in construction at the end of the 20th century. The project manager, using the term in its most generic sense, acts as a shaping coordinator of experts' inputs: in effect, as the sponsor. Once again, the sponsor role is critical.

7.1 New roles, new competency building

The active management of implementing development plans is largely unknown territory, dreamt of but rarely adequately implemented. In some locales this happens; in others, e.g. the UK, it doesn't. Too often it is frustrated by poorly aligned responsibilities and professional and governmental restrictions. It is a natural outgrowth of the holistic, integrative character of project, program and portfolio management. Peter Hall in effect argued for it in *Great Planning Disasters* (1980).[22] McKinsey proposes a front-end 'Delivery Unit' where bright government and contractor personnel would be brought together to plan and design projects in the front-end. This could, they claim, but with no supportive evidence, help avoid 60 per cent of downstream problems.[23]

Is it naïve to believe that project managers should be addressing the design of the emerging built, and natural, environment? Maybe, but maybe not. Surely this is the basis of sound project management/capital investment practice? Certainly, there will be times where this is too large a job to be easily done – looking at the impact of new housing on transport, water or waste, for example, let alone the impact on schooling and medical support. But in other sectors the exercise is more tractable – for power generation, gas, water supply, and coastal and fluvial flooding, for example. Here the elements of future build, upgrade and maintenance are lumpier and hence easier to estimate. Surely it should at least be attempted?

7.2 Applying relevant project management techniques

Overall, which aspects of project management are relevant to dealing with climate change? The answer is virtually all of them, addressed in some version of the following:

- Ascertain the aims and objectives against which the success of the project, or program, will or should be assessed. Develop and implement program plans and strategies for achieving those targets. Sponsor effectiveness measures should be developed as well as delivery efficiency ones, such as health, safety and environment. Sustainability and climate change measures should be identified.
- Show how the project's 'requirements' for climate change fit with these targets.
- Identify and influence stakeholders. This is generally easier said than done. Legislators, financiers, authorising bodies, unions, everyday citizens and more beside need to be 'on board' as far as possible. And influencing is the key skill.
- Planning – the most basic of project management techniques – needs to be started as early as possible. And starting with an empty plate, i.e. at the front-end, can be particularly difficult. Start with the work breakdown structure; identify the major milestones and their target dates. Confirm the expected stage gates. Resource the resulting schedule: look for long-lead items. Watch for overlapping design and build (concurrency, fast track, concurrent engineering).
- Establish the estimate and the proposed budget – the business and project risks. What are the triple bottom line targets and the contingencies?
- Identify the measurable 'benefits'. Is a 'benefits management' process being followed?
- Seek out value improvement opportunities within the above.
- Identify the technology risks. What is the fall-back strategy?
- Ensure the procurement/contracting strategy is sensible. Is the project manager happy with it? Is risk being handled properly? Are we encouraging teamwork and value-for-money?
- Ensure the SPA is clearly identified. Is there appropriate organisational integration (with outside bodies as well as within the project)? Are the project teams really acting and performing as high-performing teams? Is leadership being exhibited where and as necessary? Is it clear what to do if it isn't?

7.3 How do we get the required capabilities in position?

The role of the owner/sponsor, with his/her personal abilities, but also policies, practices and processes, which together provide the bigger framework for governing projects, has been increasingly recognised as having a dominant effect on the conduct of the project, and on our ability to gain performance improvements in projects. Yet the hands-off role sought by the UK government in HPC would seem to demonstrate a rejection of this insight. Against this, however, the Parliamentary Advisory Committee has argued for government to take delivery integration leadership, as we have seen. While management generally needs to be adaptive to context, there surely ought to be some following of expected good practice.

These changing roles and circumstances will require new development and educational programs. In the project management domain as a whole there is generally too little institution building – training, education, coaching and mentoring, systems, etc. There is a particular shortage of programs aimed at developing the owner/sponsor roles and communicating better the principles of good governance in the built environment context. The UK government has taken a lead role in mounting such programs at the universities of Oxford and Cranfield.

Suppliers, too, need to develop capabilities that match these demand-side pressures. They need to be more familiar with good project management practice and more proactive in shaping the project environment. Building institutional capability at all levels is essential. Supplier organisations need adequate numbers of qualified, competent people to execute the projects. •

8 EXTERNAL EVIDENCE

EXTERNAL EVIDENCE

Thus far we have relied on case studies and others' work to describe as best we can the opportunities for project management to mitigate and adapt to climate change. But are we right? There is a lot of opinion in the text. What do thought-leaders think about it, and what should be the response of the professional project management community to climate change?

8.1 What the thought-leaders thought

'The truth' in management (and much of social science too) is hard to capture definitively. Some form of sampling is often used to help validate hypotheses or otherwise test proposed theory. But, in this case, how would we concoct a representative sample? And anyway, who would be able to say who was right? A minority view might be right.

To address this issue, we decided to interview six senior, experienced people and invite them to respond to this document. We can then conclude by looking at matters raised, cross-functional issues and recommendations. We interviewed:

- **Sir John Armitt:** deputy chairman, National Infrastructure Commission; chairman, Olympic Delivery Authority 2007–2014; chairman, Engineering and Physical Sciences Research Council 2007–2012; president, Institution of Civil Engineers 2015-16; chairman, National Express Group and City & Guilds; deputy chairman, the Berkeley Group.
- **Keith Clarke:** chief executive, WS Atkins plc, the UK's largest design and engineering consultancy, until July 2011; non-executive chairman, Forum for the Future; non-executive chairman, Tidal Lagoon Swansea Bay; visiting professor for sustainable design, Aston University.
- **Professor Andrew Davies:** professor in the management of projects, University College London; principal research fellow in innovation studies, Imperial College London.
- **John McGlynn:** chairman, Association for Project Management (APM); project delivery director, WS Atkins plc.
- **Tom Taylor:** recent president of APM and founding partner of Buro Four, a project management company.[24]
- **Mark Thurston:** chief executive, High Speed 2, the company responsible for designing and building the UK's £55.7bn London-Birmingham-Leeds-Manchester high-speed rail network.

The following, edited to 500 words maximum each, is what they had to say.

8.1.1 Sir John Armitt

I found this an interesting and useful piece of work. Its concentration on climate change as a principal focus – or measure – is timely. The argument that project management should play a role in reducing carbon emissions is clear, both regarding national and international programs and at the individual project level. Tackling climate change has above all to be politically led, for in the end business will just follow the money. Government sets societal policies; business seeks opportunities. This may be the angle to push. Managing climate change as a project or program should be helpful but, to be effective, project management needs to go hand in glove with ensuring an appropriate context, and responsibility for this must lie with government.

Government should set consistent, challenging targets, not just for climate change, but for many things, as it did for instance with the legislation on zero emissions from new homes (although it changed the requirement after much progress had been made). Business actually enjoys working to meet such targets, providing, to repeat, they are consistent, and that there is a sufficiency of time. It is not a question of regulation, but of standards.

An important lever is government procurement; this can create a huge opportunity to influence project management. We see it, of course, in HPC. The UK's approach to nuclear is problematic. Ultimately, there are two generic models: either the government takes the build risk (off-balance sheet) and once operational sells it to an operator, or the developer takes the build risk. The latter is the Hinkley model. I suggested the former, as a variant of the Olympic Delivery Authority (ODA) model, for the nuclear industry back in 2013. It's actually very like the old Central Electricity Generating Board that managed previous generations of nuclear plants. It's a complicated area though, and its often difficult to get a decision from government, particularly if the matter is not seen as especially urgent. The position we are in now is urgent.

The client has a vital role in establishing what is wanted of project management. The sponsor may or may not be a/the project manager; it all depends on where you put the sponsor organisationally. The West Coast Main Line railway project got in a terrible mess as a consequence of Railtrack, the client, not having a clear sponsor. It was an enormous learning point for me. At the ODA, we had six sponsors, each with a team of about five persons, each focused on a major work package.

I agree that housing is the engine of much rural and urban development. The trouble is that everything has become so disaggregated that it makes coordination enormously more difficult.

8.1.2 Keith Clarke

This is a fantastic document. It cheered me up. The pity is that it needed writing. Climate change directly affects all 16 of the UN's sustainable development goals, yet it is still denied by too many. Partly it's an age thing: those aged under-25 to 30 are generally fully on board; above 50, most are not really interested. Senior people just don't have the science: they don't see what trajectory they need to be on to hit the 2°C target (let alone to achieve negative emissions).

Many people don't even understand the difference between mitigation and adaptation. Discussion tends to default to adaptation. This is easy – and wrong. It's too snug in the comfort zone; it's about more: more and bigger – pumps, flood prevention measures, generating plants, windmills. 'More and bigger' is fun, and it pays well. Resilience becomes the 'nice-to-have' excuse, but resilience is the privilege of the rich: the poor can't afford it. Instead we need original powerful thinking on mitigation (as well as adaptation).

Project management does have a role in addressing the causes and consequences of climate change, but it's much more about engendering innovation than planning and monitoring. The UN has an elementary planning and monitoring capability, but the phenomenon is so complex, physically and socially, that it is unrealistic to look to a traditional, mechanistic approach to manage the 197 signatories to the COP 21 targets.

The Apollo model won't work then. Instead, we should be getting project teams to work together – designers, manufacturers and installers, as well as planners and project managers – to generate new, innovative actions that reduce carbon emissions in line with required trajectories. We need to be thinking beyond capex, beyond opex even. We should be focusing on total cost: totex. In fact, cost should be seen as a key design determinant, not a design constraint.

Time is not on our side: we need to define, develop and deliver new innovative solutions much more quickly than we have traditionally. The requirement to innovate should be central to engineering and project management as disciplines, as professions. Pursuing innovation should considered as ethically central as the Hippocratic oath is to doctors. Leaders need to espouse and champion this new way of working. This will require people with broad minds: T-shaped managers.

We largely have the tools – though there are genuinely exciting new possibilities arising from digitisation and beyond-BIM type modelling. Where we are behind is in articulating the concepts required to underpin and explain this new world. Learning – competency development, training and education in firms and by universities – has a huge role here. Harness the young; engage more women. Keep working away and, suddenly, in about five years' time, managing and designing for climate change will be considered as central and as natural as health and safety, the environment and good governance have become today. But by then, of course, the world will have become inescapably warmer, and the challenge will need inescapably renewing.

DISCUSSION TENDS TO DEFAULT TO ADAPTATION. THIS IS EASY – AND WRONG. ITS TRAJECTORY IS 'MORE AND BIGGER'. RESILIENCE BECOMES THE WAY OUT, BUT RESILIENCE IS THE LAZY SOLUTION: THE PRIVILEGE OF THE RICH

8.1.3 Professor Andrew Davies

Academics typically are interested in knowledge, understanding better how a particular phenomenon works, and what can be done to improve its functioning. The work is often rather slow, but generally it is logical and analytical, and relates to other published research. Its careful tread does not always appeal to colleagues. Nevertheless, the best research typically has a pleasing characteristic of really making an impact on the way people think, and perform. The change in the way we look at project management, with its modern emphasis on managing the project rather than focusing on tools and techniques, is an example that has been noted several times in this report.

Another major contribution is in the work area of innovation and motivation. Innovation requires, first, projects to develop new technologies and solutions to adapt to and mitigate climate change, and second, projects that can absorb innovation and adapt to emergent/unanticipated opportunities when the project is underway (for example using the Infrastructure Industry Innovation (i3) Platform we have created here in London). This very much emphasises Keith Clarke's orientation that we saw above.

In some areas, thinking of this kind is relatively advanced – for example, the concept of a systems integration function residing in the owner/sponsor organisation. In others, it is clear that the new approaches are not yet fully worked out and accepted. How, for example, can it be that we have two such different development and delivery platforms as are found in HPC and HS2? The academic researcher wants to know how two such radically different organisational forms can both claim to provide what is required. The researcher will be interested in how this relates to current theories – for example, that of Schenhar on innovation, Flyvbjerg on estimating, and Morgan, Levitt and Malek on strategy execution.[25] Another pressing issue for the academic community is to dust off our knowledge on organisational learning. In some cases we seem to have learnt almost nothing: how can our learning produce such different approaches?

All this is about how best project management can influence climate change, not indirectly via organisation but directly via the way the problem is framed and assessed.

The key challenge facing academics is resources – human, but particularly financial. So long as there is a dearth of these, and delay in being able to assess impact, the longer we will have to wait for really strong academic interest to make itself felt. Meanwhile, involving academia would be good for the academics and good for practitioners, whether climate change is the direct target or whether it is a by-product of other issues.

8.1.4 John McGlynn

Maybe we have been going too gently with respect to the threat of climate change upon our planet. Stephen Hawking, for example, who after all is no fool, sees mankind as having a hundred to a thousand years only left on this planet if climate change continues to occur at a dangerous rate.

Project management certainly has things that it can do to reduce the rate of carbon emissions and temperature rises. The SPA has to be a core piece of whatever project management can offer on climate change. The same goes for the PMO: it's essential that we get regular, systematic reporting of what progress has been made regarding the growth in carbon emissions and/or predicted ambient temperature rise – or in taking adaptation actions. The SPA/PMO doesn't have to be a single person. It could be a group of people, rather like the UK's Climate Change Committee. It's important that we nail this. Many countries need both these functions – leadership and reporting – urgently for their climate change program.

Climate change is a 'wicked' problem: there are so many moving parts, so many competing agendas. Ethical issues hang high, as, for example, with the recent scandals over diesel fuels and emission testing.

Someone has got to be making decisions on priorities. These priorities should reflect the project targets. The targets will, in practice, require some prioritisation themselves. Prioritisation extends into portfolio management too. We should be wary of targets that have been handed down without buy-in from the people who are going to be asked to deliver them. All this emphasises the importance of the front-end, and of the owner/sponsor.

The problem of language is a serious one. We shouldn't have different meanings for standard terms (like 'project management' itself). Of course, people don't surrender their language easily – but the issue needs addressing. It's actually the conceptual landscape that needs aligning.

We should give more thought to how this report's recommendations could be better implemented. Its Royal Charter gives APM a greater opportunity to promote good practice. We should engage with existing, smaller groups to leverage all our knowledge and strengths. We should be working jointly with, for example, the Institution of Civil Engineers and the Major Projects Association, among others, to help address this really very worrying problem area.

8.1.5 Tom Taylor

The paper is a soundly researched opinion piece. I have a few minor quibbles, but largely agree with what is said.

There probably should be something about the way we combated the threat of ozone depletion in the atmosphere. Although the number of key institutions was much, much smaller than is the case with global warming, it was the first time that a climate-related threat of global magnitude was constrained and curtailed by mankind getting together and organising itself effectively.

It is right that we should be more critical of sustainability. It is not just a question of semantics: the issue is both very complex and urgent.

The SPA and PMO are two quite different things. An effective project manager can make a huge impact, and the presence of someone taking single-point accountability could, depending on the person, make an enormous difference at the project and program levels. However, the challenge is very great and candidates are likely to be apprehensive. The PMO could prove unhelpfully bureaucratic rather than acting as a project management box of delights. Iceland has a minister of the future – a kind of SPA. Something like this would be good. APM has a Corporate Members Group. This comprises 50 to 60 very experienced organisations: we should be leveraging their know-how.

Climate change poses potentially severe ethical questions. Should APM have an ethical advisory function related to climate change?

Perhaps more could have been said on the range of projects bearing on climate change – from barrage schemes to insulation of individual premises – but these are minor observations in the light of the paper as a whole.

Stakeholder management is very important. Its pursuit depends on stakeholder attitudes, power and impact. Stakeholders range from funders to occupiers: their attitudes vary correspondingly.

More could be said about being prepared for threats to business continuity and disaster management, and of risks and opportunities with respect to climate change.

Everyone would benefit from further education, not just sponsors or owners. (There is considerable confusion in the field regarding the roles of the client, sponsor/owner and project manager.)

This document should be just the beginning of an ambitious program of dissemination, action and communication. It's about doing more than just the right things; it's about doing things right.

8.1.6 Mark Thurston

Climate change is front and centre for HS2. The UK's Department for Transport, as sponsor to the project, requires that the design and development of HS2 hold and reduce climate change. It has laid out climate change impact requirements both generally and specifically in a number of areas – for example, agriculture, air quality, community, culture, ecology, landscape, socio-economic, sound, waste, water resources and flood risk. Infrastructural resilience is essential to the project's design. There is already evidence of this – for example, in planting thousands of trees, in flood protection measures, and in connections to existing networks.

Project management has had, and is having, a major role in managing the development and definition of the project. HS2 is being developed in two phases: south of Birmingham (Phase 1) and north. The Phase 1 team is now transitioning from being a development team to being a delivery organisation. As it does so, it has been subjecting the project to a battery of project analyses around value, benefits and risk.

Historically, of course, the profession has been seen as a relatively mechanistic discipline focusing on accomplishment within predefined schedule, cost and technical specifications. Then later, HSE measures became recognised as important. Now we are moving into an era where societal issues are recognised as much more important than they ever were before. These secondary and tertiary issues create a more difficult terrain to operate in. Managing them is a mark that now distinguishes superior project management.

This new, broader, more socially aware environment requires more complex and sophisticated delivery platforms. We have seen some real development and thinking in this area over the last decade or so – the Olympics, Terminal 5, Crossrail and the Thames Tideway Tunnel. Admittedly, HPC may seem an outlier. At the heart of these developments is improved engagement of the supply chain. The supply chain will respond well as long as there is clarity of requirement, and money.

Much of the developments in this new procurement environment come from project personnel migrating from one new large project to the next. The project management professional bodies ought to have a role in supporting and developing our knowledge of how best to develop these practices. And they should be supported by universities. The reality, however, is that the professions could be, and need to be, more proactive – more assertive. Certainly they should be able to help government know what good looks like. To do this, however, they need to be more definitive in their offering. There is still rather too much fluffy language. Universities occupy a more constrained space: many of their faculty have commitments that limit their ability to get out and make major intellectual contributions. There is a trick here that could be worth pursuing, namely that of allying with major firms.

This is a new world. HS2 is keen to support its development.

WE ARE MOVING INTO AN ERA WHERE SOCIETAL ISSUES ARE MUCH MORE IMPORTANT TO THE SUCCESSFUL MANAGEMENT OF PROJECTS THAN THEY EVER WERE BEFORE

8.2 Contested concepts and confused thinking

So, what do we conclude?

Let's begin this final chapter with some good news. Project management, in its broadest sense, is fit for purpose. The model works. There are no fixes immediately needed for the discipline to address the causes and consequences of climate change – although we do need to understand better how best to manage the front-end. However, there is still conceptual and semantic confusion that does need addressing, for it is impeding the effectiveness of the way the discipline is perceived and practised. Both the *PMBOK Guide®* and the new ISO standard on project management (ISO 21500) still see project management as a pre-eminently execution-oriented discipline, kicking-in after the project requirements have been elicited. Yet, as we have seen, much, though by no means all, of the work needed from project management – whether by project managers directly, or by owners and sponsors, investors, regulators, planners, politicians or other stakeholders – in addressing issues arising with regard to climate change needs doing from the very earliest of project stages.

Project management, then, is both a contested term and a contested discipline. Does the project management professional community see its contribution being limited to post requirements (post obtaining board sanction to proceed to full implementation), or does it see it as also covering all the management work needed from the earliest concept definition, front-end stages?

It is not only project management that is contested as a term. So too, partially, is climate change itself: climate change is often treated as a version of sustainability, which, of course, is also a term of some confusion. As we saw in section 2, climate change is a physical fact, more urgent than sustainability.

And the bad news? Despite the euphoria of COP 21, it is unlikely that the planet will hit the 2°C target by 2030, and quite probable that it will not do so within this century. Therefore, it is even less likely that the 1.5°C target will be achieved, and even less likely than that for negative emissions. The behavioural ask on lifestyles and on carbon emissions from industry are just too great. COP 21 was therefore something of an illusion. It lacked implementation realism. (The UN or IPCC should commission a study to review this conclusion.)

What then should the project management professional community be doing? Again, beware the conceptual confusion embedded in the question. Who do we mean by 'the professional community'? Does the term refer only to those who are paid-up members of a relevant professional association, or is it referring to the more general professional corpus? The intent was the latter, though despite the seeming attenuation this might imply, there should still be a strong, relevant professional core to their work. Such a person would, one would hope, be familiar with the general body of knowledge of the domain.

But there would also be ethical challenges and responsibilities. For example, as Tom Taylor pointed out in section 8.1.5, the subject is rich in ethical issues: the individual may be required to make choices regarding his or her behaviour and their effect on the environment. Conflicts of interest may be plentiful. What mode of transport is used? How are the buildings he or she uses warmed and cooled? There will be intergenerational issues: today's older generation is, some say, squandering future generations' standards of living while, from its perspective, the older generation may claim that it is foregoing pleasures today for the sake of a better future for tomorrow's generation. At any rate, the individual will have a role in responding to new standards, innovating, and educating and influencing colleagues and stakeholders generally.

8.3 Addressing the challenge

The 'research question', so to speak, of this essay is: climate change, and what the project management profession should be doing about it. Before addressing that, there are a few lessons for project management that have arisen.

8.3.1 An SPA or not?

A clear lesson from the research seemed to be that having a tightly managed program (per Global Apollo) is, of itself, too difficult and unlikely to work: the task is too great. But on reflection, this is arguable. If this was war and our lives were about to suffer dramatically, our priorities might be different, as would the 'clear lesson'. The thing is, in a sense we are at war. It's just that the invisibility of the threat coupled with the delay in producing a reaction masks the urgency of the situation. Is 'too difficult' acceptable as a conclusion?

Organising single point accountability is surely the start of mobilising project management's support in addressing the causes and consequences of climate change, and we shouldn't shy away from it. John McGlynn of APM was all for it. It would be a tough job, but so was landing man on the moon.

Two things would help enormously: first, having someone with the necessary knowledge, personality and support to act as, effectively, project manager-in-chief (at what level: national, UN?); and second, supporting this SPA role with a bottom-up approach, as Sir John Armitt argued in section 8.1.1, where help is stimulated by standards and regulations: building relevant context, generating institutional support.

8.3.2 To transform or not?

A parallel observation is to wonder why dealing with climate change shouldn't be addressed as a transformation program. A diagnosis of the pickle we're in would surely suggest treatment along project and program lines, but with added emphasis on gaining behavioural change. Conceptually, the transformation response would seem to fit like a glove – yet it hasn't formally been adopted. Why not? One suggestion is because there is no sponsor function active in pushing action. But, as Keith Clarke pointed out, such strategic owner-oriented action shouldn't have to originate only from the owner organisation; it should be the driving credo of the whole project team.

CLIMATE CHANGE HAS NO SPA, NO PMO, AND WEAK ORGANISATIONAL LEARNING AT THE INSTITUTIONAL LEVEL

8.3.3 Who's organising?

The way that the team is organised showed a variation that was revealing. Why should HPC be organised so differently from Heathrow Terminal 5 for example? (Because of the way the project risk has been allocated.) And why should this not be consistent? (Because the structure of the funding relationship varies: specifically, government wanted HPC to be financed by the private sector.) This pattern of project organisation is a direct consequence of the project's procurement strategy, as Alfred Chandler pointed out in the 1960s.[26] (In the case of HPC, we should be reading 'of the government's procurement strategy'.) The strategies being adopted for the UK nuclear power sector – or certainly for HPC – are inconsistent and don't encourage an integrated supply chain, but instead may well foster a culture of contractual claims. It is vital that the key decisions regarding the form of supplier engagement be signed-off by the project's project management function.

8.3.4 Can organisations learn?

One would think that this subject would have been settled by now, yet a feature of the projects reviewed was how inconsistently the insights from past projects and programs have been applied to later generations, given the attention given to it in the recent past. Organisational learning as a subject has been much researched, but more at the execution level than at the strategic – little on the options from which projects are structured. There seems to have been poor learning from those responsible for assessing project management's success on past projects by those responsible for setting up new structures for current and future projects.

8.3.5 Do we know what we've got to achieve?

Both theoretically and practically, defining and agreeing the project targets emerges as a difficult and important task, and could be done better, particularly at the very front-end of the project when the degrees of freedom are potentially huge. In these critical, very early stages of a project, targets can be incomplete and lack adequate meaning, since their appropriateness may not yet be adequately grounded: they can lack realism and relevance. This is an area meriting further research, where appropriate being linked to project portfolio management to look at the interplay between assets, liabilities and project targets.

8.3.6 Technical risk is always present

Mitigating and adapting to climate change requires a good understanding of the relevant science, and invariably involves technical innovation. Poorly assessed technology has, historically, caused many problems in projects, not least in the nuclear power sector. Unfortunately, we cannot yet claim that our insights are generally adequate to the challenge. Computer simulation of mock-ups, for example, may be sensible, but in the end may just not be up to the job. Careful development strategies may reduce the project or program risk, but there is no simple solution.

8.4 So what should project management be doing?

Project management clearly has a role in addressing the causes and consequences of climate change.

At the level of individuals, there are several actions. Time and again in this essay, 'attitude of mind' has come through as the fundamental characteristic that makes the difference between doing things well, OK or poorly. Keeping the subject at the forefront of the discipline; influencing stakeholders; ensuring appropriate competences; maintaining the ethical debates: all require that bit extra in commitment and delivery. A fundamental question for all project management professionals is, as a professional: ethically, how can one not be working actively to reduce the incidence and the effects of climate change?

At the enterprise level, we have only scratched the surface in explicating what management of the front-end really involves (this includes target setting). We should be looking at total costing (totex, section 8.1.2) and its implications for decision-making. Procurement needs to frame its actions with respect to climate change, for example regarding supply-chain integration and the consequences to build or operational risk. We need to recognise the importance of the owner/sponsor in project portfolio management, and how to handle his or her absence. We need to improve strategy implementation – getting all key parties enrolled and acting as a dynamic organism, not as a series of 'to dos' to be ticked-off, done and dusted. And we need to improve our organisational learning so our performance improves through critical positive feedback.

At the international level, we need to see if the SPA/PMO proposal has merit or not. There is an enormous amount of activity at the UNFCCC level, but no evidence of managing the post-COP 21 activities as a controlled program. Most commentators seem to believe that to see it as otherwise is impractical. Should we give up?

And at the professional level? Well, above all, the professions need to create an intellectual space and an attitude of commitment that succours and stimulates all the above. To misquote Donald Schön, they need to create the conditions for the 'reflective professional'.[27]

In broad process or theoretical terms, what needs doing is technically largely known. But in practice, it is hard to guarantee that all that needs doing will be done well. Partly this is because all implementation happens in a context, and that context is never the same. Partly, too, it is because our experience is always limited. The professions, supported by the universities and practitioner organisations, need to continue to frame the debate, equip their members, and assess the impact all this has and should have on our efforts to mitigate and adapt to this truly monumental challenge to our lives. ●

ENDNOTES & REFERENCES

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5. Thus, for example, in 2016 Miami City proposed spending $400m, equivalent to the city's annual budget, installing electric pumps in a Cnut-like attempt to prevent the city from flooding from the ocean. The pumps, being electric, add to the USA's carbon emissions.
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12. Kotter, J. (1996) *Leading Change*, Harvard Business School Press, Cambridge, MA; Schein, E.H., Organisational culture, *American Psychologist*, Vol 25(2): 109-119.
13. Report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage (CCS): *Lowest Cost Decarbonisation for the UK: The Critical Role of CCS*.
14. The UK nuclear power program has been, so long as it stuck with home-engineered plants – Boiling Water Reactors (BWRs) and Advance Gas-cooled Reactors (AGRs) – a complete disaster: scientists tinkering, not managing. The USA suffered from the same disease: a rush of orders from 1965; 102 units ordered between 1965 and 1970, and 105 units between 1971 and 1974; no program management (who was asking where the skilled resources were that were going to build all this high-risk high technology?); and a host of silly mistakes (building a plant on an earthquake fault, building

another back-to-front, ending with Armageddon just missed: Three Mile Island) (Morris, P.W.G. (1984) *The Management of Projects*, Thomas Telford, London). The whole sorry story runs and runs, with Westinghouse going into Chapter 11 in 2017 having acknowledged its two new 'Generation III' plants, being built on fixed-price contracts, were three years late and $10bn over budget.

15. As of 3Q 2016: Olkiluoto 3, Finland: technical problems and poor quality management; five years' (forecast) delays (nine years total schedule) and €4.3bn budget increase (€9bn total). Flamanville 3, France: technical problems; six-and-a-half years' construction delays (11 years total schedule) and €7.2bn budget increase. Taishan 3 and 4, China: currently two years' delay. And one wonders at the risk on the privately financed HPC?
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