Royal Academy of Engineering | Policy Fellowships

Managing complexity:

how systems approaches can deliver better policy

Stories from the Royal Academy of Engineering's Policy Fellowships programme

“What people often see is just the obvious thing, […] they don’t see the deep levels of policy, people and processes involved.”

Acknowledgments

We would like to thank the individuals below, whose collective efforts enabled this publication. We present this work as a testament to how the Policy Fellowships programme’s collaborative spirit and shared vision have inspired each participant to contribute their unique insights, expertise and passion. Together, as a cohesive and enthusiastic community, we aim to inspire our peers and advance knowledge in our field.

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Executive summary

Systems approaches can help policy professionals understand highly complex and adaptive systems and show where effective action can be taken within these systems.

This publication is an invitation to learn from the experiences of the Royal Academy of Engineering's Policy Fellows, explore the benefits and challenges of using systems approaches in policy, and take away practical tips on where to start.

Learn about:

- How systems approaches are a way of understanding and analysing the interrelationships and patterns that shape the behaviour of complex systems
- How systems approaches can help policymakers make better decisions, design more effective interventions, and avoid unintended consequences
- The practical benefits of using systems approaches as an enabler for collaborative policy development, and as a way to communicate complexity
- Resources especially designed for policy professionals, and examples of their application to inspire policy leads and decision-makers.

Hear from:

- Eleanor, who made cool-headed judgments around the heated issue of bovine TB
- Matt, who helped make the UK's infrastructure more resilient
- Louise, who explored ways of ensuring that issues of equality, diversity and inclusion are taken into account in public policymaking
- Hannah G, who worked on transforming the culture of the construction industry
- Owen, who promoted action to reduce greenhouse gas emissions, based on robust scientific evidence
- Ragne, who addressed the challenge of decarbonising buildings
- Hannah P, who improved long-term thinking around big infrastructure projects
- Chris, who supported economic development along the flood-prone River Clyde.

Policy Fellows have found that systems approaches can transform the way they work, leading to better solutions to complex problems. We hope that these stories will inspire others to follow in their footsteps.

In this publication, we use the terms systems approaches and systems thinking to refer to approaches used to navigate complex policy challenges. While we note that there may be contention around terminology, we recognise these as inclusive and accessible terms that encapsulate the programme's aims.

Foreword

by Tamara Finkelstein CB

Permanent Secretary at the Department for Environment, Food and Rural Affairs
Head of the Government's Policy Profession

I am delighted to introduce this publication, which demonstrates the role that systems thinking plays in effective policymaking. It provides lived examples of how systems approaches address important policy challenges. To name just a few:

- How to ensure that our infrastructure has the resilience to withstand both current shocks (such as extreme weather or disruptions in supply) and the growing effects of climate change
- How to manage (and ultimately eradicate) bovine TB
- How to reduce the greenhouse gas emissions that come from heating our homes and places of work and leisure.

The most interesting policy challenges are systems challenges, and policy professionals must work across disciplines to address these challenges. I urge everyone involved in policymaking to understand and apply a systems approach to best serve the public interest and deliver better outcomes for all.

I commend the Policy Fellows for their initiative in producing this valuable resource and in inspiring others by sharing their stories. They show the range of policy challenges that need systems approaches, along with the toolkits that enable these approaches. They are also a source of valuable learning that can support further engagement and collaboration on systems approaches. I also thank the Royal Academy of Engineering for helping public servants to find this expertise and community of peers, supporting them in their journey through complexity.

I am pleased that the partnership between the Academy and the Government's Policy Profession brings this message to our policy community, and I encourage all civil servants to engage in systems thinking.

“It sounds easy to say now, but when I was sitting with my problem and not knowing what to do with it, it was super helpful to find a way of thinking about it differently.”

Engineering better policy

The Policy Fellowships programme and what it offers

The Policy Fellowships programme inspires policymakers to think differently. It encourages policymakers to use engineering and systems thinking to frame complex and difficult problems, and design resilient solutions. The programme has grown a unique network of policymakers, engineers and other experts who are working together to develop fresh insights and approaches to economic, social and technical problems.

Twice a year, the Royal Academy of Engineering selects exceptional policymakers to become Policy Fellows. We welcome applications from civil and public servants who have a variety of insights, expertise and backgrounds from across the policy community.

Access to a prestigious network of experts

As the UK’s national academy for engineering and technology, the Royal Academy of Engineering brings together the most talented and successful engineers, the finest systems thinkers and the most outstanding talent in technology for the benefit of society.

The Academy’s engineering network includes Academy Fellows based in the UK and internationally, and awardees from its prestigious research, enterprise and education programmes. Where appropriate, Policy Fellows have also been introduced to specialist engineering experts from the 40 professional engineering institutions and other partners of the National Engineering Policy Centre, as well as global experts via the international network of national academies for engineering.

The core programme

Over a four-month core programme, each Policy Fellow benefits from regular individual coaching, plus an introduction to engineering and the Academy’s Systems 101 workshop. They then undertake up to 12 one-to-one meetings with leaders in engineering, peer-to-peer discussions about engineering and applying engineering systems approaches to policy, and further introductions to engineering networks and engineering policy work.

The alumni programme

After graduating from the core programme, Policy Fellows join our alumni programme, which brings a rich array of development opportunities, including networking and alumni-led events. It also supports involvement in other Academy policy work relevant to their interests, which to date has included work on decarbonising construction, the safety of complex systems, resilience, and inclusive outcomes for engineering. Policy Fellows are expected to play an active role in this post-Fellowship experience.

For more information about the programme, please visit www.raeng.org.uk/policyfellowships or contact policyfellowships@raeng.org.uk

Managing complexity: how systems approaches can deliver better policy

Systems approaches can help navigate complex challenges across many fields. These complex challenges involve interdependencies and unknowns, and so require an approach that provides a deeper understanding of the system in which they exist. This helps to support the decision-making needed to identify solutions. This is especially useful in the field of policymaking, where systems approaches can help policy professionals to understand highly complex and adaptive systems, and show where effective action can be taken within these systems.

In this publication we share insights from the experiences of eight Policy Fellows of the Royal Academy of Engineering, who applied systems approaches in their work and valued their transformative effect on decision-making between 2020 and 2022. It also incorporates the takeaways from two workshops organised in March 2023, with a group of 25 Policy Fellows exploring the benefits and challenges of using systems thinking in government.

Our Policy Fellows come from many different backgrounds. Most are not engineers by training, and many had little prior knowledge of systems approaches. They work at different levels of government, in different parts of the country. They are working on very different policy challenges. But all of them have found that taking a systems approach offers them an effective way of approaching complex problems, and a suite of practical tools and methodologies for doing so. It helps them to do their jobs, and to do their jobs better.

By reading about their stories and insights, we hope that you will be inspired to learn more about the practical benefits of systems approaches for policy professionals, and how they help to make better policy. If you are working on a complex policy challenge, you may even be inspired to apply for the Policy Fellowships programme yourself, or explore the resources listed in this publication.

What are systems approaches, and how can they help policy professionals?

Put simply, systems approaches offer a way of understanding highly complex and adaptive systems, and seeing what action can be taken to bring about a desired goal, while reducing consequences that negatively affect other parts of the system. They allow us to understand how things work together and interact, and the people and processes that come together to create a system. They include both a way of thinking and of approaching problems, and a range of practical tools and methodologies to help tackle these problems.

> **"What people often see is just the obvious thing: in the maritime industry, say, a boat going from A to B. They don't see the deep levels of policy, people and processes involved in this: the timetabling, the interaction of ports and vessels, the training that is required to make things work. Or the standards and safety regulations that apply (and since this is a global industry, those standards and regulations are mostly set internationally). When we make policy in this area, the system we have to consider is a wide-ranging one."** – *Policy Fellow*

By bringing systems thinking into policymaking, and using systems approaches to address policy challenges, we can come up with better solutions to the many complex problems that face us today.

From tackling climate change to making our infrastructure more resilient, from promoting equality, diversity and inclusion to harnessing the benefits of science and technology, policymaking often takes place within a complex system. Policy professionals often find themselves working in areas where there are blurred lines of responsibility and accountability. There are often multiple stakeholders, with competing interests and different perspectives. There can be siloes between government departments, and barriers between the different levels of government. Systems thinking can bring clarity to this kind of complexity, showing what needs to be done and how to make it happen.

> **"As you become more senior in policymaking (as in other sectors), your discrete area of policy tends to get larger. Almost inevitably therefore, to achieve anything significant you will have to deal with a complex system."** – *Policy Fellow*

> **"Its practical value is in helping you to keep focused on the task, asking the most important questions and making sure you're getting them right, stepping back to see the system and your role within it."** – *Policy Fellow*

Managing complexity

Systems approaches help to break down complexity: they can take a large problem and make it 'tractable.' They help policy professionals to understand the nature of the systems they are working within and what their own role is, and so what interventions they can make to move towards a goal. They are a way of understanding and analysing the interrelationships and patterns that shape the behaviour of complex systems, and can help policymakers make better decisions, design more effective interventions, and avoid unintended consequences.

Systems approaches make it possible to take a broader view of policy challenges. They allow for diversity of thought. They enable policymakers to put themselves in other people's shoes and think about how an issue looks from different perspectives. That might mean considering the operational versus the policy perspective, or taking account of people from different backgrounds, in different locations, or with different characteristics. Systems approaches are good at focusing on the people involved within a given system: of asking who plays a role within it, and how their interests and perspectives may vary.

The emphasis here is on the practical effectiveness of systems approaches. They offer pragmatic ways of dealing with what are genuinely complex problems.

The benefits of using systems approaches to tackle policy issues

A holistic approach to analysis

Compared to other approaches, systems thinking can provide policymakers with a highly nuanced understanding of an issue. The many tools and methods that it uses include, for instance:

- Systems mapping
- Stakeholder mapping
- Causal loop analysis
- Theory of change
- Rich pictures
- Personas
- System of systems
- Monitoring and evaluation strategies
- Canvas tools
- Simulation models.

Some of these involve more quantitative analysis, some more qualitative. Some are thinking tools and relatively simple to use; others are more complicated or require specialist knowledge to ensure quality results. Involving independent experts as facilitators can help to reassure the parties involved that the analysis and resulting findings are robust and not partisan.

Collectively, systems approaches make it possible to think in a rigorous and wide-ranging way about policy problems. In contrast with some other approaches that focus on the economic incentives of individual parties, systems approaches make it possible to think more subtly about the different views of the world, levels of understanding and motives of the various people involved in a given area, and how they relate to each other within a system. That can include considering things that are difficult to quantify – such as the emotive nature of certain issues, or questions of trust.

The emphasis within systems thinking, though, is on its being able to be used alongside other methods for approaching problems and other disciplines. It is not exclusive. Systems approaches are always conceived as being something that can wrap around and nudge up against other approaches, tools and techniques.

> **"It enables you to think your way around a problem: how people act collectively, and how the interrelationships work."**
> *– Policy Fellow*

Enabling collaboration in policy development

Systems thinking tools are useful in building a common understanding of a challenge among a diverse group of stakeholders with slightly different objectives. This encourages a culture of partnership, providing a shared lexicon, and leading to stakeholders finding common ground and having shared objectives. Systems thinking can be especially useful in overcoming the silos that can exist within government.

Personas

One example of a systems thinking tool that can be helpful in a policy context is the use of personas. As a way of thinking about the potential users of a system, or participants within it, the idea is to come up with descriptions of representative people. The descriptions are exaggerated to make clear potential clashes between people with different interests. The aim is to make the personas realistic and recognisable – they are even given names.

Creating personas can help policy professionals get to grips with the diversity of particular populations, in terms of their needs, behaviours, experiences and goals. It can be a way of reminding a policy team to ask: 'who are we doing this for?'

Using personas is not a replacement for talking to real people, but a useful proxy that can help – especially in the early stages of policy development – by representing the diverse range of people whose lives might be impacted by a policy. Policy professionals can consider how these 'people' might respond differently under different scenarios, testing their responses before the policy idea is taken out to wider audiences.

As you will see from the stories featured in this publication, systems thinking can bring benefits at the level of local and regional government, just as much as it can at the national level. Systems approaches can help to co-ordinate national, regional and local government, overcoming the barriers that can exist between them, just as it can help co-ordinate the work of multiple government departments. It can include people from outside government, such as academics and analysts working in thinktanks. It can even extend to multilateral negotiations at the international level, helping to take account of the different interests and ideologies of national governments.

The rigour underlying systems approaches, and the involvement of external experts, can ensure that these issues can be raised in a neutral, non-partisan way, reducing the tensions that can exist between different interest groups.

> **"This is a really useful approach. With our old ways of thinking we could go round and round in circles for years, spending time and energy without really achieving anything. Now we have the confidence that the effort we put in is meaningful. It helps to define our role, and what we can do."** – *Policy Fellow*

Do I need to be an expert?

As our Policy Fellows have discovered, it is not necessary to be an expert in systems thinking to use it effectively in policymaking. Through the Royal Academy of Engineering's Policy Fellowships programme, each of them was introduced to experts in the field, who suggested helpful perspectives and useful tools. Some have commissioned expert consultants or worked with in-house operational research specialists to deepen their analyses, but all have found it transformative just to expand their way of thinking.

Policy professionals design, develop and propose appropriate courses of action to help meet government priorities and ministerial objectives. They are best placed to use systems approaches in their policy area, articulate the outcomes of systems approaches to decision-makers and develop a narrative around the action that needs to be taken. These professionals will be able to ensure that decision makers understand the wide-ranging effects and implications of the decisions that they are making.

Communicating complexity

Systems thinking lends itself well to communicating complexity. The same tools that can be used to develop an understanding of complex systems can also be used to explain the workings of those systems to others, without over-simplification.

Often, systems thinking tools have pictorial elements such as maps or schematics, which are better received, more engaging, and quicker to understand than long verbal descriptions. Many people are visual thinkers: for them, the way that systems thinking generates images can help to bring an issue to life.

Systems approaches bring clarity, breaking down complexity so that the essentials of a system can be communicated. This helps to bring together different communities, including technical experts, policy professionals and decision-makers, and other parties – it helps to 'translate' between them.

The communicability of systems thinking can help to gain the buy-in of senior decision-makers before a decision needs to be taken. It supports the process of decision-making itself. And after the decision has been made, it can be used to explain and justify the chosen solutions. It can show that the interests of many parties have been considered, that different perspectives have been taken into account, and that the risks involved in any policy have been evaluated.

Challenges in applying systems approaches

Of course, no method of policy development is without its challenges. Systems thinking in a policy context can come up against political time pressures. Fully understanding a complex system takes time, something that policy professionals and decision-makers are often short of.

Colleagues may not always be on board with the idea of systems thinking, so there is the challenge of winning hearts and minds regarding the value of this approach. The Government Office for Science's Systems Toolkit provides useful advice to get started, and we hope the eight stories from our Policy Fellows provide further inspiration.

Finally, it can be difficult to know where to 'draw the line' in mapping a complex system. The idea is not to expand the system infinitely, considering every possible relevant factor, but to be aware of the boundary between what can be acted upon, what can be influenced, and what cannot.

Resources to get started

Guidance and support are available, with some especially designed for policy professionals:

- The Government Office for Science, in collaboration with the Government's Policy Profession, the Royal Academy of Engineering and the Systems Thinking Interest Group, has produced a Systems Thinking Toolkit and a case studies bank to promote and embed systems thinking across the Civil Service.
- The Government Office for Science has also produced a Systems Leadership Guide to introduce senior civil servants and team leaders to systems thinking, and give practical guidance for implementing systems approaches and shifting the culture to more systemic ways of working.
- The Royal Academy of Engineering Policy Fellowships inspire policymakers to think differently and to use engineering and systems thinking to frame complex and difficult problems, and design resilient solutions. The Academy also offers its Systems 101 workshop and bespoke workshops for policy teams.
- The Government's Policy Profession is hosting a Systems Thinking Knowledge Series, co-created with the Royal Academy of Engineering's Policy Fellowships programme.

"It enables you to think your way around a problem: how people act collectively, and how the inter-relationships work.

Eleanor Brown
Deputy Director of the Bovine TB Programme,
Department for Environment, Food & Rural Affairs

When feelings run high

Systems thinking can help policymakers make cool-headed judgments around heated issues

The question of how to manage (and ultimately eradicate) bovine TB is not just a hugely complex policy problem: in recent years it's been one of the most contentious issues in the UK. It's an area where hard science meets strong emotion: an exceptionally difficult space in which to make rational, effective policy.

Bovine TB (bTB) is a disease that's hard to control, hard to diagnose and hard to manage. It poses health risks to people as well as cattle, with around 30-40 human cases every year, including among farmers and abattoir workers. There are direct costs involved in managing bTB, both for government and for farmers, and the disease has a damaging effect on trade in beef and dairy products.

This is an issue which has gained widespread public interest. A campaign fronted by Queen guitarist Brian May against the recent policy of culling badgers to prevent them passing TB to cattle gained considerable publicity. Feelings run high on this: badger culling may have been popular among farmers, but it proved extremely unpopular with wildlife groups. And while intensive badger culling is being phased out, to be replaced by a programme of badger vaccination and surveillance, public scrutiny remains high. For their part, many farmers are wary of central government, and are difficult to win over to new policies.

Eleanor Brown, Deputy Director of the bovine TB Programme in DEFRA, is trying to get to grips with this complexity. "I currently head up the bovine TB policy team in DEFRA's TB Programme," says Ele. "We're at a pivotal point in bovine TB control, looking anew at how things are done, following an independent review of the government's Bovine TB Eradication Strategy."

"We already had a multi-disciplinary team looking at the problem: a broad church of vets, scientists, economists and statisticians involved in building and advising on policy. But there has been a growing awareness, post-Covid, that disease control is only partly about the science: it's also about people's behaviour. I thought that getting some different perspectives on what we are doing, through the Royal Academy of Engineering's Policy Fellowships programme, could be helpful. I thought systems thinking, in particular, could give us a new way to approach this problem."

As Ele describes it, what was particularly useful in her Policy Fellowship was the series of one-to-one networking sessions that she had with engineers from across the country. "They really opened my eyes to things I hadn't thought about. I was able to have in-depth conversations around my specific issues."

"Especially helpful was mapping the system around bTB as a group of interconnected organisations and players. Understanding how they interact, including some of the tensions between them. Understanding also that this is not static: in the area of bTB in particular, scientific developments (around testing for example) can quickly change the picture."

Mapping sentiment

For Ele Brown, taking a systems approach has paid off in a number of ways. "First, it gives you a set of tools that you can use to deal with complex problems – ways of breaking them down into manageable, bite-size pieces."

"Then, the emphasis on communications within systems thinking has been very helpful – good both for developing policy and for talking about it with stakeholders. The way that you describe the effectiveness of different approaches [and] the way that you present evidence make all the difference. As we saw with Covid, while it's vital that we have evidence-based policy, it's not enough just to present people with the evidence for a certain course of action, and think that they'll follow it."

"Finally, systems thinking helps you to make rational judgments around heated issues. Bovine TB is an area where feelings can run very high, but you can map sentiment as you can map other kinds of complex system, and use it to predict, for example, how farmers might respond to different incentives, or different arguments. Systems thinking enables you to look coolly at what the system is, including its vital social and behavioural components. It helps you to be more objective about the sentiments involved, so that you can build consensus and get people onside."

Take the badger vaccination programme for example: not as contentious as culling, but it still needs buy-in from farmers. "We need to bring farmers with us as we seek to develop and introduce new technologies which they may be uncomfortable with, or even suspicious of," says Ele. "But we can gain a lot by understanding how the many different players fit together in the system: the relationships between the many different groups that are involved. In the case of support for farmers for example, there are organisations such as the National Farmers' Union, the British Veterinary Association and the British Cattle Vet Association, as well as smaller organisations such as the Farm Community Network, that does a lot of mental health work with farmers in challenging times. DEFRA may not always be seen by farmers as a trusted advisor, but some of these other groups are. Can we leverage their influence, working to promote badger vaccination through the network of trusted advisers that farmers have?"

> "Disease control is only partly about the science."

Systems approaches have contributed to:

- a refreshed Theory of Change for bTB eradication, reflecting the whole system
- a different approach to stakeholder engagement around bTB
- work with agri-tech experts to investigate novel technologies for 'smart' bTB skin test readers, improving the speed and accuracy of testing.

Matt Crossman
Deputy Director Infrastructure,
Department for International Trade

What makes for resilience?

Systems thinking is leading to a different approach to infrastructure

How do we ensure that our infrastructure is resilient: that it can withstand both current shocks (such as extreme weather, or disruptions in supply), and the growing effects of climate change? That was the question that Matt Crossman was grappling with when he applied to be part of the first cohort of Royal Academy of Engineering Policy Fellows.

As a team leader at the National Infrastructure Commission (NIC), which provides the government with impartial, expert advice on major long-term infrastructure challenges, Matt led a study on infrastructure resilience, commissioned by the Chancellor, to ensure that the UK's infrastructure systems can cope with future threats and challenges.

Matt is a chartered civil engineer by background. For him, what the Policy Fellowship offered was an opportunity to interact with a range of experts in broader fields, beyond the 'usual suspects.' "What we were looking to do at the start of the study was to cast the net wider: to talk to more than just the usual people we normally talk to about infrastructure. And the Policy Fellowship was really helpful in doing that. The Academy enabled me to talk to Fellows with a direct interest in infrastructure, whose work was clearly relevant to what I was doing, but also to Fellows who provided a wider perspective, who were able to talk about the applications of things like systems thinking in a slightly different context, so that I could bring that good practice into the work we were doing. For example, talking about healthcare systems and design processes enabled us to challenge some of our thinking, and develop our thought processes through exposure to other approaches."

In particular, Matt was interested in learning from other sectors that analyse and manage risk in complex areas, where there's a tradition of understanding risk in terms of wider systems. That included talking to people involved in safety-critical industries, such as aerospace and medicine. "It's a culture thing," says Matt. "In some of these industries they take a very different approach to near misses, for example: there's an institutional architecture that ensures that you don't wait for something to fail before you start to learn the lessons. Problems are seen as being systemic, and so near misses aren't a matter of blaming individuals. They aren't something to cover up or downplay, they're something to learn from. That's an approach that we could usefully adopt in civil engineering."

For Matt, systems thinking has also been useful in going beyond traditional approaches, which have tended to focus on infrastructure as a set of tangible assets: the pipes and bridges, roads and buildings. "Even now systems approaches are not always well understood, even among civil engineering practitioners. But the Policy Fellowship helped me to understand the relevance of systems thinking in my area. It encourages you to see systems as dynamic: thinking about the resilience of infrastructure, you're building a picture of something that's not static, but fluid. The context of systems is one of constant change: whether that's climate change, or demographic changes which lead to different requirements for services, or changes in technology."

"The fundamental step is to move from an approach which is primarily based on individual assets, to looking at the system in the round. Systems thinking helps you to focus on the services that are required, and the systems and infrastructure that deliver them. The example that I often give is about water supplies. If you want to make sure that we have sustainable supplies in future, you need both to think about the physical infrastructure and to think about demand. Not just the hard pipes in the ground, but also the softer, more intangible things – such as people's behaviour and expectations."

> "You're building a picture of something that's not static, but fluid."

The systems-based analysis that Matt's team undertook has had a considerable influence on public policy. Just in terms of water supplies, it has helped to secure a commitment from industry to halve leakage from water networks. And it's led to a focus within government not just on building more reservoirs, but also on increasing connectivity between different regions, so that water can be more easily moved around.

Moving the discussion

Like many Policy Fellows, Matt has now moved on to a different role: still based around infrastructure, but now focused on trade. As Deputy Director Infrastructure in the Department for International Trade, he helps UK infrastructure companies apply their expertise abroad. But here too, systems thinking is proving relevant and useful.

"The way UK companies can differentiate themselves from their international competition is through their ability to innovate, and apply more complex, advanced solutions. Low-cost competitors will build infrastructure the way it's always been done. Where the UK can compete is in things like the design, development and financing of infrastructure projects. And it's by providing better value – not just being the lowest-cost."

"And again, understanding systems approaches is valuable in this. Where other countries are competing just on the basis of individual assets, our aim is to move the discussion, so that we talk about the infrastructure service that is required. What are the properties of the infrastructure system that you want, including its resilience? Then we're having a different conversation with our international counterparts, and can demonstrate something that UK companies are particularly good at providing. The systems thinking that I developed through the Policy Fellowship enables me to have those discussions, helping UK companies to demonstrate the value they can offer."

Following Matt's Policy Fellowship:

- The Government published a Resilience Framework that commits to taking forward the NIC's recommendations on resilience standards for key infrastructure sectors.
- The NIC noted resilience of infrastructure to impacts from climate change as a strategic theme shaping the second National Infrastructure Assessment.

Louise Dunsby
Deputy Director, Office for Science & Technology Strategy

The fine art of perspective-taking

When it's good policy to consider different points of view

Is systems thinking especially good for ensuring that issues of equality, diversity and inclusion are considered in public policymaking? Does it encourage a kind of perspective-taking, which makes it less likely that the needs of certain groups of people will be overlooked?

When she embarked on her Policy Fellowship in 2020, Louise Dunsby was grappling with just this kind of problem. As Chief of Staff for Industrial Strategy, Science and Innovation at BEIS, Louise was looking at ways of embedding the public sector equality duty (PSED) into policymaking, and ensuring that public authorities meet their obligations under the Equality Act 2010. The PSED requires government departments to think about whether policies might disadvantage people with protected characteristics (such as those around race, age and disability), and to advance equality of opportunity. It aims to ensure that public servants take diversity and inclusivity into account while developing and implementing new policies.

"I wanted to go beyond PSED being something that government departments just feel they have to comply with, to a point where they are more invested and proactively engaged in it," says Louise.

Having worked as an engineer before she joined the Civil Service, Louise already had familiarity with systems thinking. "I'd come across it, but it had been some time since I'd thought about it in depth. And when I'd been working in an engineering firm, I'd thought more about systems thinking in terms of classic systems, rather than applying that kind of thinking to other areas."

How did a broader understanding of systems approaches help? "First, it enabled me to define my problem: non-compliance and institutional resistance to PSED, with low levels of engagement and lack of understanding of the Equality Act. And it helped to suggest approaches to behavioural and organisational change, including practical steps we could take to increase awareness of PSED, and engagement with it."

"But also more broadly, systems thinking can help you to consider the equality, diversity and inclusion aspects of any policy. One of its real strengths is the way it can help you to take different perspectives, including the perspectives of people with protected characteristics. It enables you to see the system from different points of view."

"Government policy teams can be involved in big pieces of work involving lots of people across Whitehall, and yet not think about things from the perspective of their stakeholders. And it's not always obvious how a policy can impact people with protected characteristics. Systems thinking definitely helps in this regard, and it's not specific to the Civil Service. In many different sectors, if you're going to be good at your job you need to understand the people you're working with. The solutions to your problems often lie in knowing why someone isn't doing the thing you want them to do: that's applicable always, in every job and in real life as well."

> "It enables you to see the system from different points of view."

Like a number of the Royal Academy of Engineering Policy Fellows, Louise has now applied the tools and techniques of systems thinking in new roles: in her case, as Deputy Director for Critical and Emerging Technology, in the Office for Science and Technology Strategy at the Cabinet Office. "The job that I do now is about trying to get departments across Whitehall to align around the same goals in relation to science and technology. And here, too, we've found that systems thinking has been helpful. We've taken a systems approach to science and technology policy across the whole of government. Which technologies are especially important across Whitehall, and what levers do we have, to support them? Where are there skills gaps, and what can government as a whole be doing (through its approach to procurement, for example) to foster innovation? It's about approaching it in a systemic way."

Good practice in problem-solving

For Louise Dunsby, one of the impressive things about the Policy Fellowships programme was the calibre of the people that she met through it. "They really are amazing human beings who have done incredible things, and having the opportunity to spend time with them is a privilege. I'm still in touch with many of my peers, and one of the people who coached me is still my mentor."

"In my case, focusing on systems thinking was a reminder of good practice in the way that you think about things. And it's an approach that you can apply in so many different areas. I particularly like what systems approaches teach you about not jumping to a solution, but taking time to define your problem, and understand what the system is. And in particular, you need to understand the people involved in the system, and what it looks and feels like for them."

"With my former team, I arranged for the Royal Academy of Engineering to do some of the things that we did on the Policy Fellowship. I also brought in a secondee from the Royal Academy, whose job was to try and encourage my team to get into this way of thinking. That's how strongly I believe in the systems approach! It's about the tools it gives you. It's about helping you to think, and be better at problem-solving. Whether you apply it to an engineering problem or a policy problem, it gives you better outcomes."

Strategic approaches have helped to:

- embed public sector equality duty (PSED) into policymaking
- bring greater consistency to science and technology policy across government.

Hannah Gibson
Innovation Lead, Industrial Challenge Fund, Innovate UK

Building better

Changing the culture within an industry sector is a complex process. Can systems thinking help?

Some Policy Fellows apply systems thinking to policy areas that might seem to have very little to do with engineering itself. Not so Hannah Gibson, who has been applying her new-found skills in that most traditional of engineering domains, construction.

Hannah is an innovation lead at Innovate UK, responsible for the transforming construction challenge. Supported through the Industrial Strategy Challenge Fund, the transforming construction challenge is the government's £170 million programme to raise standards and change the culture in the construction sector. As Hannah explains, "our role is to work both with the government and with the construction industry to transform the sector, moving it away from a focus on lowest cost and cheapness – a sector of low margins where there is a race to the bottom – to one driven by whole-life value: looking at the economic, environmental and social impacts that a building has over its lifetime. We want to move a sector which has not been known for investing in innovation, to a place where building firms are comfortable using modern methods of construction (such as digital manufacturing and data-driven processes), increasing their productivity, and reducing their carbon emissions. In the wake of the Grenfell Tower disaster and the collapse of Carillion, it was clear that UK construction needs to change."

Hannah was interested in applying for the Royal Academy of Engineering Policy Fellowship after a mentor at Innovate UK, who is an engineer herself, suggested it. "I'd come from a policy and public affairs background, but now found myself working with the construction sector, surrounded by engineers," says Hannah. "The Policy Fellowship was a great way to marry up my existing skills and experience with the sector I was now dealing with."

In terms of the specific policy challenge that she was looking to tackle, "the Policy Fellowship was very timely. I was interested in the policy levers that are available to change the way that people work in the construction industry."

Changing the culture of an industry is difficult. But as Hannah describes it, "through the amazing conversations that the Policy Fellowship enabled me to have with engineers, I started to think about how government and industry play a number of interlocking roles, that can either help or hinder the move we want to bring about."

"For example, government is the construction sector's biggest client. Government doesn't want headlines around over-spending: it may be that they are looking for the cheapest bid when acting as a client. But when it's setting regulations, the government wants to focus on procuring for whole-life value."

"Similarly with the construction industry: in some ways it is beholden to government as a client (leading construction companies to focus on getting their bids as low as possible, and pushing savings through their supply chains). But at the same time the industry also has significant influence over government, as lobbyists and influencers."

"The Policy Fellowship enabled me to delve into some of the different roles that government and industry play that complement each other, or that compete and conflict, and then to develop ideas of how you might communicate to stakeholders at critical points in the system. So, when we're communicating to the government as a client, we might provide examples of new-build properties that are great value. Or speaking to the government in its role as a regulation-setter, we might provide examples of best practice. How we communicate and demonstrate the impact of the transforming construction challenge depends upon the vantage-point of the stakeholder we're speaking to."

Dealing with the unpredictable

Changing culture in the construction sector is a nuanced business. It is complex both in terms of process, and because it's closely bound up with unpredictable human behaviour. "Getting people to change the way they act is difficult to achieve. But by understanding the complex system that government forms with the construction industry, you're able to see what type of story, what form of evidence will be effective at different points within it. You understand the traits, drivers and motivations of the main players."

It takes time to change an industry, but the early signs are that the transforming construction challenge is beginning to do so. The challenge has had a positive independent evaluation, and there has been some monitoring and reporting of how its messages are landing in the construction industry. It is regarded as a successful programme, with a measurable effect in helping the construction industry to improve its productivity, reduce carbon emissions, and innovate.

What has systems thinking contributed to this? For Hannah Gibson, its essence lies in consciously considering interdependencies. "Your aim is to understand the dependencies within a complex system, consider different perspectives, and then try to ensure that the system's components work together."

> "You can really get under the skin of the issues you're facing."

Systems thinking is also good at allowing for uncertainty. "The systems we're considering aren't just a big machine that you can control by playing with levers. People's behaviour can be hard to predict."

And what has the Policy Fellowship provided? "I was very impressed by the engineers that I spent time with. They were some seriously senior people, including some who are virtually celebrities in the construction sector. But they'd done their homework on me and took the time to think about my policy challenge. The Policy Fellowships give you so much time and focus, so you can really get under the skin of the issues you're facing."

Systems thinking has contributed to:

- efforts to change the culture within the construction industry
- attempts by government to act as a smarter client in construction procurement.

Dr Owen Jackson
Director of Policy, Cancer Research UK

Taking action in a complex world

Can systems thinking help policymakers, beset by uncertainties, to understand enough about very complicated subjects in order to act effectively?

Few policy problems are bigger or more wide-ranging than the task of reducing greenhouse gas emissions to net zero by 2050. Practically every UK government department has a stake in it and needs to be involved, and in this area especially, it's important that policy is guided by robust scientific evidence. But how do you turn complex, nuanced science into something that a wide variety of people can understand and get behind?

When he applied for a Policy Fellowship, Owen Jackson was Deputy Director of Global Issues and Opportunities in the Government Office for Science (GO-Science). GO-Science provides the government with direct and independent scientific advice, aiming to ensure that science is effectively brought to bear in policy development, on everything from climate change to global health.

A scientist by background, for Owen the Policy Fellowships offered something different. "For policy professionals, it can be hard to find compelling, interesting and valuable training that isn't leadership training, but that's about making policymaking better. I've spent my career at the interface between policy and evidence, policy and science. I wanted to find a course which got to this part of the problem – how do I get better at turning very complex, nuanced, technical things into something which is understandable and usable by a broad community of people, from a wide variety of backgrounds? How do I make science something which has purchase, to bring about change within a very large and complex system?"

"Other courses are focused on the science, but I knew about that already. I didn't know much about systems thinking at the time that I applied, but it was a phrase I was hearing a lot around the scientific policy community. Sometimes it was being used in a loose way by people who didn't really understand it: I wanted a deeper knowledge of systems thinking, so that I could apply these ideas more rigorously. By systems thinking, people sometimes just mean mind-mapping. But for engineers, it's an entire discipline."

"In general, the Policy Fellowship has opened my eyes to a different way of working. It's given me tools to map extremely complex systems and get a handle on them. But while this kind of technical process is important, the Fellowship has also helped me to appreciate the importance of storytelling. This is a huge thing that I got out of it – realising that storytelling is a vital part of policymaking. If you want to take people with you, if you want to keep a team focused on an end goal, it's essential that you have a clear and coherent story."

Already, a greater focus on systems approaches is starting to be felt across Whitehall. Something that Owen worked on with GO-Science was a systems thinking toolkit: a menu of thirty or so technical tools that is made available to civil servants, to use to improve policymaking.

Systems thinking has also shaped some of the systems mapping work that the Department for Business, Energy and Industrial Strategy (BEIS) carried out in line with its net zero responsibilities, before its successor, the Department for Energy Security and Net Zero, took over. In doing this, BEIS gained a sense of where action needs to be taken across Whitehall to meet the government's target on emissions for net zero. "I genuinely think that BEIS has taken systems thinking on board, and it is starting to percolate into ministerial conversations," says Owen.

Classic cases

In the meantime, Owen has moved on – he is now Director of Policy at Cancer Research UK. Cancer is another hugely multifaceted area. Location in the body is a huge factor, with site-specific cancers such as pancreatic or lung cancers, for example, very different from blood cancers. It's also subject to many different treatment approaches, and interacts in extremely complex ways with people's lifestyles, their genes and the environment they live in. "You could say that combating climate change and fighting cancer are both among the most complex problems," says Owen. "They're classic cases of how you might use systems thinking to take effective action within a large and complicated system."

"In relation to cancer, systems thinking offers a very evidence-based, very specific and tangible way of managing highly complex technical information. It gives you a suite of tools."

"But for me and my team, it's also about thinking about stories. If we're going to try and secure government commitment to changing the law on smoking, for example, systems thinking helps us break the problem down into its constituent elements. Who needs convincing, and of what? What is likely to influence them? What are the stories, in other words, that we need to start developing?"

> "By systems thinking, people sometimes just mean mind-mapping."

"Having been on the Policy Fellowships programme, I feel that I've been given another set of options for solving problems. I'm not an expert on systems thinking now, but I don't think I need to be: systems thinking can be hugely valuable and useful without you needing to be an expert on it. You could say that the role of a good policy official isn't to be the expert, but to know where to find the expert. To be able to talk to them and translate their expertise into something useful. That's exactly what I've got from the Fellowship: I now know how to ask questions differently, and where to find the expertise I need."

Systems approaches have helped:

- improve the use of scientific advice within government
- suggest new approaches in the fight against cancer.

Ragne Low
Deputy Director Onshore Electricity Policy, Strategic Coordination & Energy Consents, Scottish Government

Setting boundaries

What can be influenced through policy, and what can't? Systems thinking can help to draw the line

Ragne Low had been wrestling with the challenge of how to decarbonise buildings – how to reduce the greenhouse gas emissions that come from heating our homes and places of work and leisure. At the time that she applied for a Policy Fellowship, she was Head of the Scottish Government's Heat Strategy Unit, leading on a number of heat decarbonisation policies.

But where to begin to make improvements? Decarbonising buildings is an issue that goes from the global scale to the ultra-local – from where global energy markets affect how much it costs to heat a home, to the needs and behaviours of individual people. It takes in the technology that is available, and the condition of the built environment and other infrastructure. Add to that complexity of national, devolved and local governance – who owns what, who can act, and who should? – and you have the makings of a truly difficult problem.

"The things that I was working on were fiendishly complicated," says Ragne. "They were difficult to get under the skin of. I felt the need to bring in different kinds of thinking, to shine a light on the issues we were facing. To help us get our arms around this complex challenge and make it tractable."

"I had a humanities background, but I was working in a sector where engineering is important. I've long been impressed by the engineers I work with: the way that they think and approach problem-solving."

"I was interested in particular in the potential of systems thinking. Systems thinking can be a marmite thing in the public sector: some love it and embrace it, while others doubt its practical application, believing that it's somehow abstract and highfalutin. For me, the question is ultimately: does it help you on the ground to deliver the policy, or the fund, or the regulatory intervention that you're working on?"

"Being on the Policy Fellowships programme, I was impressed by the focus on people within systems thinking. The engineers I spoke to were consciously bringing that to the fore: thinking about outcomes for people. I found that quite surprising, and I've held onto it since. It made me reflect on what we do as policymakers, which is also all about people, about outcomes for people."

For Ragne, the Policy Fellowship showed her something of the distinctive ways in which engineers think: that it's about the practical application of knowledge. "Really, it's not abstract or indulgent at all. Systems thinking is for a purpose: to improve the way that the system delivers for the people within it."

Applied to the problem of decarbonising buildings, a systems approach has led to different outcomes from what might otherwise have been. "It had an influence on the way that we wrote our 2021 Heat in Buildings Strategy, which is about how we reach the target of net zero emissions from Scotland's buildings. This is a relatively new policy area that cuts across many others. It goes from social policy – being concerned with the affordability of energy and people's comfort levels – to health impacts, through to industrial and economic policy. We wrote a better, more coherent, more joined-up strategy than we would if we'd not had the input of systems thinking."

"We also organised a series of workshops on the approach to regulation that we were going to take in this area. Again, systems thinking has led to a strong focus on the people within the system, and how they're likely to respond to the different regulatory levers that are available. We thought carefully about their concerns and their needs. I'm certain that the regulatory approaches we take will be better than they would have been without the workshops."

> "Systems thinking can be a marmite thing!"

Controlling the complexity

Ragne Low is now applying her new skills in a new role: as Deputy Director of Onshore Electricity, Strategy and Consents within the Scottish Government. Here again though, systems thinking is proving to be very helpful, especially in terms of boundary-setting to make a problem tractable. "In mapping a system, you're not trying to make an already complicated picture more complicated," she says. "You're trying to manage and control the complexity. You're trying to ensure that it's not scary for people. As a civil servant in a leadership role, that's hugely important."

"Complex problems can result in inertia. People don't know where to start, or how to grapple with an issue. Or they feel that pulling on one thread will make the whole thing unravel."

"As a leader it helps to set boundaries: showing what's in and what's not, what we're going to try to influence through the policy we're developing, and what we're not. Of course, you have to understand the consequences of that decision: the risks you have to live with because there are things you cannot control. But it has the effect of reassuring people: it gives them confidence that in working on the bit they're responsible for, we're all moving forward."

Systems thinking has helped:

- improve the process of stress testing potential options for a regulatory framework around decarbonisation
- identify the wide range of assistance or support which may be required by different segments of the population in transitioning to low-carbon heating systems
- to highlight the need for early engagement with stakeholders, and the need to start preparing people as early as possible for any regulations.

Hannah Pullen
Principal Economist, Ofwat

Getting our heads together

Can systems thinking lead to collective understanding of big infrastructure projects, too complex for an individual to comprehend?

Major infrastructure projects, such as building hospitals or transport systems or carrying out large-scale urban regeneration, are notoriously difficult to get right. All too often they take longer than scheduled, and they can run hugely over budget. With infrastructure projects becoming increasingly complex and taking longer to get from the initial idea to shovels in the ground, dealing with this problem is becoming more urgent. There is new impetus to design and build infrastructure more quickly, efficiently and innovatively.

At the time of applying for a Policy Fellowship, Hannah Pullen was Senior Policy Adviser (Infrastructure, Enterprise and Growth) at the Infrastructure and Projects Authority (IPA). Reporting to the Cabinet Office and HM Treasury, the IPA works with ministers and senior officials across government to improve the speed and efficiency of infrastructure delivery.

"In the IPA we weren't involved in the detail of any one specific project," says Hannah. "We sat with a view across the whole portfolio, trying to create the environment in government and industry that would enable these projects to thrive."

Learning more about systems thinking, in particular, appealed to Hannah. "I could see its importance and knew it was what we should be doing. We have complex, seemingly impenetrable problems, but none of the training offered in government seemed to give you the tools that this programme does, for tackling those problems. To me, systems approaches represented a very innovative way of thinking."

Collective problems, collective solutions

Often infrastructure projects run into problems because the main contributors focus solely on their own roles, failing to take account of how these interact with the roles of other stakeholders. The construction industry can also have too narrow a focus, not always considering the services that infrastructure will deliver, and not good at sharing best practice.

Then there is the sheer complexity of a major infrastructure project with its many stages and processes, combining engineering, construction, economics, urban planning, finance, politics and (increasingly) digital technologies. "Often you have a situation where no single person or organisation understands the whole end-to-end project lifecycle holistically. And the timescales involved are long. The person who kicked a project off might not be alive to see the benefits it ultimately delivers. You need a collective approach just to get your head round it."

Systems thinking can help to bring about this kind of collective understanding. First, in the practical tools it provides. "These are particularly useful," says Hannah. "Systems mapping tools, for example, can bring a much wider set of stakeholders to a discussion."

And then, "there are the kinds of discussion that systems thinking encourages you to have. Siloed working across government can work against open communication, putting up barriers, and the same is true of the construction industry. But systems thinking helps you to change the conversation."

> "You have to have a collective approach just to get your head round it."

"The problems we have around infrastructure are collective problems – let's try and understand them together. The tools you gain, and the systems approaches you learn about, are all trying to nudge you in that direction, towards working together. I thought that what the Policy Fellowship would give me would mostly be technical, but actually what's been most useful is this: your starting point should be to bring together the people who have a view on the problem that you're trying to solve, or a role in the solution."

"That can include learning from others who have done something similar. Individually in your project, you may be building a huge thing, once. You have your own specific issues. But by spending a small proportion of your time talking to people doing similar projects, and finding a common language to talk about different projects, you can learn lessons."

Using the skills she picked up on the Policy Fellowships programme, Hannah and her team have set out to change the way that large organisations involved in major projects relate to each other. This involves using systems thinking to understand the complexity of major projects, and putting people at the centre of thinking about infrastructure. This means helping stakeholders to see themselves as players in an interconnected, joint endeavour, and able to achieve more collectively than they can individually.

Given the long lead-times involved, it's too early yet to point to a completed piece of infrastructure that's gone up faster or more efficiently thanks to the systems approach. But it has fed into IPA's Transforming Infrastructure Performance: Roadmap to 2030, which sets out a shared vision for innovation and reform in infrastructure delivery.

This is especially noticeable in the roadmap's emphasis on co-creation and co-design. Not that these are easy, as Hannah Pullen concedes: "it sounds great, but it involves work – there's a lot of explaining, of herding people, of getting people into the right mindset. A lot of effort just to find the right way of describing a problem, so that it means something to all your stakeholders. But systems thinking shows you that this up-front effort is worth it."

"You need to involve a wide range of stakeholders from the beginning in the design of infrastructure projects, to gain the broadest possible understanding of the problem you're trying to solve, and create the environment for successful delivery. This is something that systems thinking is very conducive to."

Since Hannah's Policy Fellowship:

- The UK government has set out a shared vision for innovation and reform in infrastructure delivery in *Transforming Infrastructure Performance: Roadmap to 2030*.

Chris Thompson
Counsellor, Scottish Government USA

A lightbulb moment

What connects the regeneration of the River Clyde with the complex world of diplomacy in Washington, DC? Systems thinking can help to make sense of both, as Policy Fellowship alumnus Chris Thomson has discovered

"I knew I had to deal with one of those complex and difficult problems," says Chris Thomson, who completed his Royal Academy of Engineering Policy Fellowship while he was leading the Scottish Government's Clyde Mission initiative. Clyde Mission aims to make the Clyde an engine of growth for Glasgow, the surrounding region, and for Scotland more widely. But economic development along this flood-prone river is an extremely complicated business, tied up with a host of environmental, financial and legislative issues, and with a complex web of relationships between the many partners involved. How is it possible to know what policies will work on the ground? Or that local preferences, networks and infrastructure have been taken fully into account?

Having had the Policy Fellowship programme recommended to him by a colleague, Chris decided to apply. "I knew I was working in an area where we were going in entirely new policy directions, and where I needed to think differently and strategically."

Chris had had some prior awareness of what systems thinking is. "I'd read Donella Meadows [Thinking in Systems: A Primer, 2008] on systems approaches, and much of it just made perfect sense to me. Some read like poetry, some like a manual for fixing a Ford Escort. What I thought I wanted when I started the Policy Fellowship was mostly the latter: a simple set of tools. I wanted something that I could punch inputs into, and get clear answers from: if you do this, then that will be the result. That's what engineers do, right?"

Soon after joining the Policy Fellowships programme, however, Chris began to realise that it would give him something much richer than just plug-in-and-play tools. "It's helped me to change my whole way of thinking and my approach to problem-solving, and ultimately that has been much more useful."

Soft skills for hard problems

Particularly surprising to Chris was the importance of soft skills, which systems approaches seemed to emphasise again and again. "I was amazed that every engineer I talked to spoke about interpersonal skills, including communication. And that led me especially to think about the language that we use, to frame policy challenges."

"Any competent policy professional will look at their stakeholders – at who they are looking to influence. But systems approaches encourage you to think, long before you get to that point, about the language that you're going to use when you talk to those stakeholders. About how you'll explain things consistently, so that everyone is clear about the concepts involved. You have to take your time on this, so that when you get your policy out there, engaging and interacting with people in the real world, you get their buy-in."

"It's remarkable how often we think that when people disagree, it's because they have different viewpoints. But often the biggest problem is agreeing what question you're answering. That was a lightbulb moment for me – the idea that you need first to make sure that you're all answering the same question."

In the case of the Clyde Mission initiative, Chris's team used systems approaches to help them understand the underlying needs of different communities, engaging with them to develop a shared vision, and getting them onside with the initiative. "We spent a long time working to understand what really matters to the people involved, asking what they wanted to see. We went to local authorities, businesses and community groups, working to reach agreement on what we all wanted from Clyde Mission. Once we had that agreement, and a shared language, the 'how' became a lot easier."

> "The biggest problem is agreeing what question you're answering."

This systems-based approach is already making a concrete difference in the Clyde area. "Before I left, I was standing on mounds of rubble that are now gardens for children," says Chris. "Another project is putting £25 million towards low-carbon heating along the Clyde. That has also come directly from systems thinking."

Chris has now taken the skills he developed through his Policy Fellowship into a new role as Head of USA for the Scottish Government, based in Washington, DC. And here also, systems thinking is proving useful. "I'm now a diplomat in Washington, and the systems approach works here too. It's about figuring out who's who on Capitol Hill, mapping this complex political system and working out who you need to talk to. And again, it's about finding a shared language and identifying shared goals, to bring people along with you."

"These things weren't necessarily what I expected to get out of a Royal Academy of Engineering Policy Fellowship. But the great thing about systems thinking is that it enables you to take a step back. It's about letting the system see itself. It helps you to understand how you're part of the system, and to see how you interact with it. For policy professionals that can be hugely powerful –complex policy problems can really benefit from the perspective that this gives."

Systems approaches have helped:

- navigate the complexities of regenerating the River Clyde
- the Scottish Government to have influence on Capital Hill in Washington DC.

“Its practical value is in helping you to keep focused on the task, asking the most important questions [...] stepping back to see the system and your role within it.”

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