Science advice, public policy and the post-truth dynamic

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I served three NZ Prime Ministers over 9 years, crossing both centre right and centre left coalitions. In 2016 the then Finance Minister Bill English, soon to become PM, asked the science advisors to look into the question of pathways in and out of prison, the underlying challenge being that NZ was facing major capital costs of building new prison stock and Mr English himself had stated prisons to be a manifestation of social policy failure. After the 2017 election, which saw a shift from a centre right to a centre left coalition, the new PM, Jacinda Ardern, asked that that work should continue. There was great cooperation from the Ministry of Justice who had much data. Parenthetically they applauded the engagement of the science advisors as they felt there were things that needed to be said that they could not easily say. Dr Ian Lambie, science advisor to the justice sector, and myself – with inputs from other social sector science advisors – worked on a report which was released in March 2018 (https://www.pmcsa.org.nz/wp-content/uploads/Using-evidence-to-build-a-better-justice-system.pdf). The report had many components, including the unacceptably high levels of young Maori males in prison, most of whom were gang members, and the very high rate of mental health issues amongst the prison muster. These were addressed in the report, but the key focus was on the very high incarceration rates in NZ compared to most OECD countries that NZ would wish to be compared to.

The report pointed out that the rise in prison muster was directly related to policy decisions made by governments of both political persuasions generally, in response to moral panic driven by the media and powerful lobby groups related to individual tragic events. The immediate drivers of the higher prison muster were increased sentences, altered and restrictive bail and parole laws, and increased police numbers. But the underlying drivers related to issues of intergenerational disadvantage, inequalities and continuing issues of creating a bicultural society.

The report goes on to point out that there was little or no evidence that more severe sentences were inhibitory, and in any event crime rates had been falling for some time, despite the overwhelming public opinion that these had been rising. We made the case that restorative and rehabilitatory rather than a retributary approach to crime, especially for young people, was more constructive. The report pointed out the need for a national conversation that got beyond immediate polemical rhetoric. But despite this and the constructive nature of the report, there were immediate knee-jerk reactions from parties in government and the opposition; they still had to be seen to be tough on crime. Yes, the Minister of Justice attempted to start a conversation but public opinion, political tribal agendas and electoral risk once again trumped evidence and inhibited the kind of conversation that is clearly needed. The public narrative soon became dominated by what some might call alternate facts: that there was a crime wave, that tougher sentences worked and

being tough on crime was the only way to go. Besides, rape and muder are now the mainstay of the traditional media – it sells – and no wonder publics believe the crime rate is rising.

We live in an age where polarised media, social media and societal tribalism play increasingly dominant roles in determining public policy and societal decsions. Decision making has become increasingly tactical and short-term rather than strategic and long-term. The reasons are multiple: the slow recovery after the GFC which left many people behind and exposed growing inequities, the fear of rapidly changing societal makeup and the internet, the web, social media and all that is associated have created an environment in which alternate truths can be readily transmitted and accepted. And for a variety of reasons, there has been declining trust in institutions.

The much enhanced accessibility of knowledge of very variable reliability has meant that, increasingly, people see less need for experts. They think they can select the information they require, ignoring their own cognitive filters, and analyse any situation for themselves. Experts to convert information into knowledge are no longer needed and given the explosion of knowledge, the opposite is indeed the reality. But the echo chambers of the 21st century – social media, selective AI driven news feeds and trivial, cherry-picked or biased internet searches – mean that people increasingly only hear what they want to hear from people with world views that align with their own. And so called facts can be manipulated and targeted to reinforce biases and more; false news is easy to promulgate but hard to refute.

We have a world where there has been a decline in trust in experts and institutions, in truth, in facts, and a change in the political dynamic. Yet this is the very time when there are growing domestic and global challenges of achieving social inclusion, of fighting growing inequality, of growing evidence of rising mental health concerns, changed macroeconomic and geostrategic contexts, climate change, biodiversity loss, and massive instability brought about by digitalisation, urbanisation and social change. In each of these areas, progress is only possible if we look to the evidence and build conversations between publics, policy makers, political leaders and the knowledge community.

Effective science advice (and I am using science in the broadest sense to encapsulate all the robust knowledge disciplines) to both publics and policy makers is, in my view, essential to make progress and must be a key bastion against the post-truth, post-trust dynamic.

But this interface is not easy. It has many nuances and needs particular structures, rules and skill-sets to be effective and in the remainder of this talk I will parse this out. While I will take my examples and formulation primarily from the perspective of governmental policy formation, the issues and solutions are generalisable.

But before I do so let me play one commercial. In 2014 the International Network for Government Science Advice, INGSA, was formed as part of what is now the International Science Council. It is focused on all aspects of the science-policy interface at all levels of governance. It has over 4000 members in over 80 countries, provides important resources and operates capacity building workshops for scientists and policy makers in both developed and developing countries, and undertakes research and generates reports – one of which I will return to later in this talk. Membership is free and I encourage you to register at www.ingsa.org – the website is particularly rich in resources related to the interface.

Before we go further it is important to think beyond the post-truth dynamic to many other relevant changes that impact on the science-policy interface. Science itself is changing both in what it can do and in its institutional framing. Science is becoming more transdisciplinary or at least it is

claiming that it is – we have yet to understand and create structures that expedite this. Science is becoming more systems focused. Computational and statistical developments have changed science enormously. Non-linear complex interactions can now be understood whether it is climate science, social areas or medical science. Big data will change this so much more. And the institutions of science are changing – academic science has become an industry driven by bibliometric factors and the individual incentives that follow. Science is often placed within the narrow framing of economic growth. Yet social and environmental health depend on science too; it is essential that a more balanced approach recognising the full taxonomy of impacts is achieved.

And because science can now deal with complex open systems, it is dealing largely with probabilistic approaches rather than deterministic approaches. And much of the science, particularly that most relevant to policy makers, will be incomplete, often ambiguous and require skilled, expert and robust approaches of evidence synthesis to make sense of it. And even then there will be significant gaps in our knowledge. And the very issues that matter – be they social, human, economic or environmental – increasing interface with public values, and those values are in dispute. Indeed such disputes often create the ideological axis of modern politics.

Of course science is not value free. Choices are made in what we study and how we study it. Judgements are needed and in the context of today's talk it is particularly the judgements as to the quality and sufficiency of evidence on which to make a conclusion – not an easy issue, as we shall discuss.

This is the domain of post-normal science and virtually all the science that impacts on policy is of that nature: that is, the facts are incomplete, decision making is urgent and the science interfaces with public values and those values are in dispute. And in this context it is important that the trend to better engage and embed science within the community progresses. Hopefully the behaviours described 50 years ago by Polyani and Merton, which saw scientists as members of a closeted, privileged and inaccessible priesthood preaching to the masses from the altar of truth, are fast disappearing. Still, words like co-design, co-production and extended peer review are easy to say, not easy to deliver.

Big data approaches to complex systems analysis, especially if AI is engaged, will compound matters further. Big data could be an enormous boon to public policy making. It will allow unrecognised relationships to be explored and complex interactions understood, populations to be stratified, interventions to be modelled and cause and effect to be dissected. But there are significant ethical and governance issues, and governments have been slow to establish oversights appropriate to the technologies, especially with respect to their use in policy development. And in this context I worry that there will be a trend for superficial analysis by statisticians or policy analysts. Such data will always need domain experts working alongside both the statistician and the policy maker, as the risks of misinterpretation are high.

But before we go further we need to think about the word evidence. It has different meanings to different stakeholders. It can mean belief, tradition, local knowledge, anecdote or personal observation – the latter often tending to be the most convincing to many politicians.

Against these, it is scientific evidence that claims privilege because of its formal processes. But the so-called crisis in science of reproducibility, of contested disciplines, the excess of papers (3 million last year, most of which are likely never read), the challenge of peer review, the emergence of predator journals and predator conferences, can undermine that privilege. The institution of science needs to look carefully at itself, but that is a topic for another talk.

And it is critical to remember that 'data', 'information' and 'knowledge' are not synonymous. Knowledge requires interpretation of the information, and information requires interpretation of the data and its reliability, integrity, relevance and limitations. When we are talking about scientific 'evidence' we are talking about relative reliable knowledge being applied to a question, and that question is necessarily posed by humans who want to solve a problem. Information generally needs expert interpretation by the knowledge discipline to become relevant knowledge to create evidence.

The implications of this are important to understanding the ongoing discussions, if not debates, about standards of evidence, which I shall return to. By definition, knowledge, data and information only become evidence when applied to a particular problem to solve. There will be wide variance in that framing of the problem and this is at the heart of the evidence to policy challenge.

My final report to the Prime Minister as her Chief Science Advisor was on the issue of mitigating greenhouse gases (GHG) emissions from the NZ agricultural system (https://www.pmcsa.org.nz/wp-content/uploads/Mitigating-agricultural-GHG-emissions-Strategies-for-meeting-NZs-goals.pdf). The issue, put simply, is that NZ's external economy is almost entirely dependent on milk and meat production from cows and sheep, and on tourism that relies on an image of being clean and green. The price of milk has been such that in recent years, much land has been deforested or shifted from low intensity farming to high intensity dairy farming with major impacts on our environment, especially water quality. And NZ has over 50% of its emissions coming from agriculture. Methane is of particular focus given its potency as a GHG although, unlike carbon dioxide, its long term effects are less because its life in the atmosphere is relatively short. But what the question is and how it is framed can be very different to different stakeholders.

The science of methane versus CO_2 is not easy. Climate experts can disagree whether a focus on agricultural methane is a priority or not, and obviously many farmers would rather it is not, so there are politics in that framing. Current knowledge can only lead to minor changes in GHG emissions from agriculture without major changes in land-use. But would these be economic, let alone acceptable to the rural community? And if we cannot measure GHG emission from individual farms, how then can it be incorporated into any regulatory or incentive scheme? And what about new technologies – are there chemical inhibitors that could be used but are they safe and will they have market acceptability? And then there is what animals are fed. GM grasses exist that would have major effect. However, GM was fiercely and polemically discussed 20 years ago and is essentially banned in NZ. Would politicians be up for encouraging a new discussion, as there are cogent non-scientific arguments both for and against any new technology.

My point is, what evidence is brought to bear and how it will be interpreted will depend on the framing of the question both by the policy maker and the knowledge broker. It is easy to see how different communities of scientists will want to address the question in different ways, and how the policy maker may want to constrain the question asked. We will return to this issue presently as, in my view, one of the biggest challenges at the science-policy interface is matching the question and answer.

Policy making is ultimately about making choices between different options that affect different stakeholders in different ways, with uncertain spill-over risks and benefits whatever option is chosen. The policy and political process, at any level down to a small organisation, is fundamentally about trying to decide between these different groups of stakeholders.

And so we have the challenge: policy making is about choices, and many other considerations affect policy making such as cost, effect size and on whom, even diplomatic considerations, electoral contract and public opinion. All these weigh on the policy and political choices, and they are all appropriate but mainly not scientific questions. And indeed the questions that the political decision maker is most interested in are often not related to "what works?", but rather:

- Why do we have to do something? Why is it a priority?
- What we will do in a practical sense?
- Who will it benefit and who will bear the burden of risk?
- What will those risks be?
- What will it cost and what are the costs of doing nothing?
- Are there other ways to do it?
- Do we have to do it now?

So where does science fit in? We must argue that robust evidence is the core base on which other values-rich policy domains are placed. After all what defines science are its processes, which try to reduce bias in the collection and analysis of information, although obviously the use of that scientific knowledge is a value-rich process. While it is complex I think we must focus on what processes are there to incorporate science into the policy process, and these must place it in the context of being the core evidential base, rather than in a relativistic manner.

This is arguing for robust evidence to be placed in a privileged position in the policy process and that also reflects on the need for mechanisms for ensuring its integrity is sustained through the process – rather than simply being an input to be subsequently reinterpreted or filtered. Policy can and sometimes will be made which can be contrary to the evidence, but policy makers need to understand and be cognisant of when and why they are doing so. Importantly, placing science in that somewhat privileged position is a critical part of the war against post-truthism.

Evidence can have multiple roles in the policy process and different skills, approaches and structures are needed to address each. There is neither a singular process nor singular structure. Rather, a sophisticated ecosystem is needed to ensure an effective science-policy interface. I see five major roles.

1. To explain a complex system
2. To explore and define the options for intervention for an outcome
3. To consider a specific intervention
4. To define and plan an intervention
5. To evaluate a programme

So let us explore the components of the science-policy interface. I am going to focus on the supply side (that is the production and transmission of knowledge) and on the demand side (that is the policy and political communities), explore the boundary between them, and argue for the critical role of boundary structures. It is essential to remember that the overall interaction involves the interaction between science and the societies it serves, and the interaction between the policy/political community and the community they serve. I have alluded to these interactions in my earlier discussion of post-normal science and the role of publics in the policy process. In this post-truth era this is even more important than ever.

An example of this interplay is the variable decisions made around the world about GM crops. The science is clear that GM crops are safe, the methodology is safe and that trait-based rather than

process-based regulation is more logical, but that science has been resisted by many. Although GE is a very different technology, the same angst has spread from one to the other. The policy process in different countries has responded variably with very different approaches being taken. For example, some countries accept that GE is not a GM technology and requires minimal trait-based regulation, while others have taken a very different approach reflecting the political process. Like my introductory story regarding prisons, mature discussion of these technologies has difficulty in raising its voice about reactionary rhetoric. Of course, there are valid objections and society, not technocrats, should determine the use and limits on technologies but even having that conversation can be inhibited by the political process.

Scientific knowledge is generated and analysed by academics, by industry, by NGOs and by government agencies. The boundary between brokerage and advocacy conducted by knowledge generators and synthesisers, to use Roger Pielke's terminology, is not always clear. Interpretation of data or scientific knowledge is confounded by discipline/methodology and by prior biases and one's role in the ecosystem. And to give an example let me turn to something we are all familiar with: bread.

One of my last tasks as Chief Science Advisor was, at the request of the Minster of Health, to convene an expert panel and provide a report on folic acid fortification of bread (www.pmcsa.org.nz/wp-content/uploads/The-health-benefits-and-risks-of-folic-acid-fortification-of-food.pdf). The issue was should fortification of bread be mandatory? Many countries do so with the goal of reducing neural tube birth defects. But when last looked at in NZ in 2009, there had been considerable industry objections and safety questions raised. Given this, the government had decided to rely on voluntary fortification. While the evidence was limited, it appeared that voluntary fortification did not reach key populations, especially lower socioeconomic groups, and levels of blood folate were still inadequate in NZ women of reproductive age. In 2017 I was asked to look at the issue, together with our national academy, and put an interdisciplinary team of senior scientists and a lay observer together. The evidence was overwhelming that folic acid fortification in the food supply reduced neural tube defects. But the issue of whether folic acid caused cancer remained. Recent major reports included over 50 meta-analyses and systemic reviews with all concluding that no adverse effects were found. But what did exist beyond this systematic approach were genetic association studies involving genes that affect blood folate levels. The data from these studies could be interpreted as showing that higher folate levels associated with these genetic variants might lead to an overall reduced risk of cancer, a lower rate of breast cancer but a higher rate of colon and prostate cancer. So what weight to give to this indirect evidence?

The obstetricians and paediatricians and the public health experts were clear – folic acid fortification was clearly effective, proven and should be used. The toxicologist was concerned – the benefit was to women and children, the possible risk of colon cancer was to those in middle and old age – note that the focus was on risk and not on the potential benefit. This was an ethical concern to him that the risk and benefit fell on different populations. One member was concerned that, given the uncertainties of how you measure effect size in the older population over time, there was an unknown risk that was perhaps being underestimated. Others pointed to the equity issues that were not being addressed by voluntary fortification.

The panel reflected on this for some weeks. Formal standards of evidence had not helped, other than create a sense of pseudo-objectivity for something that inherently involved judgement. We sought external peer review and in the end made suggestions based on an intermediate position – that is, fortify all packaged bread but leave artisan breads to be fortified on a voluntary basis. Here was an expert panel given a very precise question by the policy maker, yet despite systematic reviews and meta-analyses, and despite discussion over the standards of evidence, the panel

members' perspectives were largely determined by how they interpreted the same evidence from their own disciplinary perspective.

I use this story because it is easy to forget that policy making and implementation is a human endeavour, and there is sometimes a danger of trying to make something sound fully objective when there will always be a subjective element to it. In this case the different scientific disciplines had a very different view of the relevance of the genetic association studies to the question at hand. How they rated some evidence in forming their advice varied considerably. This anecdote hints at the complexity of assessing scientific evidence. It is never done in isolation from context, and formal standards of evidence do not eliminate the difficulties faced.

So let us explore the supply side in some detail. There is no shortage of supply, but the roles in the system differ.

We can see four main types – knowledge generators, knowledge synthesisers, knowledge brokers and implementation/evaluation scientists. There are multiple actors from the individual scientist to a national academy. Some primarily are generating new data and information, others such as academies and expert panels and what-works units are largely synthesising evidence, and then there are those who have the primary role of transmitting that knowledge effectively into the policy community.

As I have mentioned earlier, the boundary between brokerage and advocacy conducted by knowledge generators and synthesisers is not always clear. Whereas individual academics have the right to be advocates, science advisors must act as brokers. Those outside the formal advisory system are largely engaged in deliberative advice and those inside the formal channels within the executive halls of government most often engage in a mix of deliberative and informal advice. Unlike those outside who can only interact at limited points in the policy process, those inside, especially science advisors, can act repeatedly to help keep things on track and prevent the discussion from straying too far from the evidence. Too often evidence informing policy gets compromised by faulty transmission along the way. Those inside are uniquely placed to facilitate sound transmission.

My point is that no one part of the supply system can do it all; a complex ecosystem is required. On occasion we have even seen situations of contestation between components of the system fighting for a privileged position, rather than recognising the essential synergies that are necessary for effective evidence informed processes to exist.

Given this audience let me make one more point about the supply side. We are of course dealing with the problem of too much science, too much data, too much information and how to make sense of often conflicting studies of uneven standard and very variable approach. And the approach taken and that is most useful will vary with the question of interest. Not everything is addressed by RCTs or synthesis reviews. Important observational data often gets ignored in such approaches, and I have already alluded to the possibilities that will emerge with big data, which may mean observations are derived not from samples but from whole populations. This will not be based on analysing interventions. Rather, it will be based on complex data collections, analysis and modelling. There are obviously lots of issues but beyond those of social license, data governance and ethics, here data scientists will need expert advice from those with domain expertise, and policy makers will have to become comfortable with the issues associated with big data analytics. New Zealand is perhaps at the forefront of this trend with the Integrated Data Infrastructure, which is bringing all forms of data related to citizens together specifically to understand systems better, and the many

factors that influence whether or not possible indirect or direct interventions might be to social advantage.

Two weeks ago I was at the OECD to speak at their workshop on the issue of standards of evidence, and it is a topic many of you will be familiar with. The basic conclusion was to focus on having standards for the processes and structures of developing and incorporating evidence into policy, rather than trying to standardise a hierarchy of evidence – this would be very problematic given the broad contextual variations that cannot be reduced to a singular approach.

Indeed, the question of hierarchies of evidence remains contested and we need to ask why that is so. In part it is because the concept of hierarchy is being extrapolated from a context of very specific medical interventions, namely very reproducible contexts as in evidence-based medicine, which is then applied to much more open and complex societal situations where the context is variable. This doesn't work easily because variation in context really matters. Indeed even in medicine, meta-analysis has its weaknesses. It works reasonably well to look at therapeutic interventions such as a particular drug. But even in this, debates can arise because of different contextual factors, populations, and how filters are applied in selecting the papers to include in the analysis**.** This gets more complex with diffuse interventions.

Most systems we are looking at in policy development are relatively open. Unlike evidence based medicine derived from originally looking at a very specific therapeutic target and thus at relatively closed systems, most applications in public policy in areas such as the environment, the social sector and the economic sector involve open systems. And an open system cannot be analysed by treating it as a series of closed systems with minimal interaction with other putative closed systems. To look at health without looking at education, without thinking about welfare and housing and transport, without thinking about their interaction, their compounding and indeed, their feedback effects, will provide only a very limited view and thus limited evidence.

So now let me turn to the demand side. I use this terminology advisedly because one of the most unappreciated aspects of the interface is that, without demand there is usually very little impact of proferred advice. When advice is proffered but has not been solicited, it is generally not well incorporated into the policy space. Academies, for example, are very good at providing unsolicited advice and frustrated when it is not listened to or even considered. Solicited advice is when the demand side asks for it. A key role of the knowledge broker is to create situations where that demand is sought. And then there is a further issue – is there a match between what the demand side wants and the answer provided? Often the demand side does not know how to ask the right question and a knowledge broker can play a major role in negotiating between the players to see that the question is framed correctly. And now to a cautionary tale.

My Office's report on methamphetamine testing (https://www.pmcsa.org.nz/wp-content/uploads/Methamphetamine-contamination-in-residential-properties.pdf) confronted an issue which had flourished because no one had asked the right question. Methamphetamine is NZ's major drug of abuse – it can be imported or is made in so-called clan labs – that is in people's homes and garages. When police find a clan lab the building needs decontamination because artisanal manufacture involves lots of toxins. The easy way to demonstrate cleaning is to require cleaning to a threshold level of methamphetamine on a surface. But in the course of two ministries and government agencies looking at the issue, somewhere policies were developed that applied the same standards to any house where methamphetamine might have been smoked. Applying this level of decontamination standard to a site that is not shown to be a meth lab is not used anywhere else in the world, because there is no evidence that passive exposure to those kinds of surface levels has any ill effect. Nevertheless the standards body and the social housing authority

had incorporated the threshold level to apply to any house where methamphetamine might have been smoked. An unregulated testing industry grew up. Houses were labelled as contaminated based on findings of trace amounts of the drug forcing major (but unnecessary) remediation and eviction of tenants. Huge costs were incurred, both financially and socially, both for the government and private individuals caught up in the testing and remediation saga. When I came to look at the problem it became clear – no-one had asked the core question, which is why are we testing in the first place? Had they simply asked that question, the right question, the focus would have remained on meth labs and the sad saga would not have eventuated.

Paul Cairney in his marvellous little book, *the Politics of Evidence Based Policy Making* – a bad title simply because policy is rarely evidence based, at best it is evidence-informed – points out that policy makers have limited bandwidth. They lurch to problems generally driven by externalities and if they are not provided with a policy and a politically acceptable solution, they will move on. They generally see scientists at good at problem definition, but lousy at providing policy relevant solutions. Furthermore they often see scientists as arrogant, coming with a definitive solution that does not take cognisance of the many values based domains which policy makers are responsible for. They can react negatively if scientists are seen to be entering their space in a judgmental or arrogant way.

The other point to make is that the so called policy cycle is largely mythical. Policy often emerges from very diffuse processes involving both elected and unelected actors. Formal deliberative advice from the outside generally works on the assumption of a formal cycle. Those external to the system cannot easily follow the evidential advice into this messy process, again a key role for an internally placed knowledge broker.

And the demand side has other issues. There has been a trend in public policy administration away from the domain expert to a generic public policy analyst – for them Wikipedia or Mr Google may be seen as sufficient with all the risks that entails. The rise of big data analytics creates both opportunities but also risks in that regard.

So let me now turn finally to the interface itself – the knowledge brokerage interface. I have already pointed out the different dimensions of advice and I am going to focus largely on the first three. Implementation and evaluation merit their own extensive discussion beyond this talk. And to summarise I have pointed out that there are different players and they have different roles – I have pointed out the differences in function and role between external inputs from academies and other structures, and the internal inputs from government scientists, commissions and particularly science advisors.

I have not discussed another core distinction, which is that between formal and informal advice. Formal advice is in the form of a report based on a process such as a synthesis review, and can come from outside or inside government or both. A number of my reports were a joint preparation by my Office and our national academy. But as I have emphasised if it is not solicited, if there is no alignment between question and answer, then its impact is likley remote at best.

Informal advice, that is conversation between policy maker and knowledge broker, plays a very different role. It can help ensure the question and answer are matched, that the question is asked in the first place, it can help ensure the science is not lost through the policy process or misinterpreted or misused, it can explore matters right at the beginning of the policy process and help shape thinking, it can be a check at the end and it is critically important in emergencies and crises. In other words it can act to assist in ensuring that the supply and demand are matched in multiple ways.

Science advisory mechanisms that are properly employed are well placed to do that. There are of course other components needed, and these too will vary according to constitutional arrangements. In some countries parliamentary advice systems become important especially where select committees play a critical role in policy review and evaluation.

So what are the key attributes for knowledge brokers? In many ways the knowledge broker is acting as a diplomat understanding and negotiating between two very different cultures. The broker must understand both cultures. Knowledge brokerage does not have the luxury of advocacy if it is to be trusted. Beyond ensuring alignment, it is about defining what we know, what we do not know, the caveats on what we know, its implications for understanding a system, the options that emerge and the implications of each option. But it is also about leaving the choice of a particular option to the policy community. It requires an unbiased assessment of the implications of the inferential gap between what is known and what is concluded. It requires humility not hubris, and requires a skill-set to maintain trust with different constituencies: the politician, the policy makers, the many publics, the media and the science communities. This is not easy and will be dependent on how the other components of the ecosystem work with the brokerage system. It points to a new kind of career – one in which the skills of science and policy are co-trained. Programmes to do this are emerging and INGSA has taken a lead in this regard.

Underlying this whole talk is a deep question, one that is not easy to ask and virtually impossible to answer. Namely, how can we demonstrate that enhanced evidence-informed policy making leads to better policy making (and what does 'better' mean in this context)? But to misquote an alleged quote of Einstein; not everything that can be asked is important, and not everything that is important can be answered.

Thank you.