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May 2019

Raising the Ambition Level in Norwegian Innovation Policy

Final Report

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Summary

This report was commissioned by the Research Council of Norway (RCN) to support its reflections about how to improve Norwegian innovation policy, in the light of the recent recommendations of an OECD innovation system review of Norway. Subsequently, the industry minister launched a spending review covering the full range of the state's support instruments for business innovation, so we have tried to make our work helpful also to that exercise. We aim to explore how to address the OECD's "triple transition imperative" for Norwegian policy, which is to

- Shift towards a more diversified and robust economy
- Move towards a more competitive, effective and efficient innovation system
- Achieve these structural transformations while supporting research and innovation that can confront an array of societal challenges

It analyses national and international policy trends in order to provide ideas and options for policy development in Norway. It deliberately stops short of identifying specific themes to be prioritised but suggests how these could be identified and selected.

Internationally, we are starting to work with a third generation of research and innovation funding and governance. The first involves funding research and essentially delegating the choice of theme and quality control to the scientific community in the expectation that societal benefits will eventually appear. The second focuses on funding research and innovation in order to get specific societal benefits, especially economic growth. The third shifts attention to the 'societal challenges'. All three generations co-exist in funding systems today. Each of these three generations of government intervention in relation to R&I is associated with particular types of 'failure'.

- Market failure, in the first generation
- Systems failure, in the second
- Transition failure, in the third

Current Norwegian research and innovation policy belongs to the first and second generations, respectively addressing market failure and systems failures. The Research Council of Norway (RCN) and Innovation Norge (IN) are the agencies that dominate innovation funding, with RCN concentrating on technological and IN on non-technological types of innovation. The other major force is the Skattefunn R&D tax incentive scheme, which has become the largest source of innovation support funding in the last few years. While Skattefunn's main objective has been to encourage firms in the early stages of doing R&D, the 'cap' on the amount of benefit firms can claim has been rising, larger firms are slowly getting more of the benefits and there are diminishing marginal returns on society's investment in the scheme, suggesting that more effort should be devoted to direct measures. These can be provided during the course of addressing the OECD's 'transition imperative', and especially in connection with the first of them.

To a large extent, tackling the OECD's "triple transition imperative" requires Norway to become active in third-generation policy, in addition to the earlier two generations, and addressing the societal challenges in a more ambitious way than in the past. In particular, that means making policies that change the way sub-sets of the innovation system work. In certain cases, it can mean changing key socio-technical systems. This is a very ambitious enterprise. The most extreme case is the changes we need to make in order to respond to the climate change crisis, largely eliminating fossil fuels and replacing them with alternatives. In many cases, such an ambition level is beyond the reach of an individual country, so policymakers are defining 'missions' that address sub-sets of socio-technical systems.

Internationally, there is a range of approaches to defining such policies. We explore ten cases and the lessons Norway can learn from them and propose a spectrum of intervention. Different parts of that spectrum address the three components of the OECD's transition imperative.

In our report, we suggest approaches to each of the three imperatives. These suggestions are not exhaustive but exemplify the type of response Norway could make.

A key need in developing a **competitive and efficient innovation system** is partly to do more of what is done today through direct measures, based on the current traditions of bottom-up and thematic funding. The presence of RCN in the Norwegian system means that there is already a mechanism in place that provides a degree of cross-ministry coordination in second-generation R&I Policy. Hence there is little need to reach for the kind of horizontal coordination mechanisms that some other countries need.

Achieving a **more diversified and robust economy** requires a degree of disruption, if Norway wants to increase the rate of restructuring beyond the rather slow rate that is normal. A way forward in Norway could be to establish a national diversification programme, in which

- Consortia are invited to express interest and demonstrate their ability to develop an innovation-based diversification agenda. Consortia members can include companies, research-performing organisations or state organisations, but there must be a mixture of research-performing organisations and potential users
- Promising consortia receive a grant to support the development of a strategic innovation agenda – and may reach out to additional organisations to join the consortium as it develops
- Based on their agendas, consortia then compete for more substantial support over a period of several years, based on the apparent likelihood that their agendas will enable innovation and diversification

In **structural transformations and societal challenges**, we would expect a stronger role for society and the state not only in setting priorities and in legitimating the effort but also in implementation. Addressing these challenges requires the active involvement of much more than the research and innovation system, so the governance system needs to be much broader. It also involves going against the doctrine of 'branch neutrality', which is important to parts of government and society. While that is unavoidable, it will be important to ensure that there is competition at the programme and project level and that state intervention promotes ecosystems or clusters rather than 'picking winners' in advance at the level of individual companies.

Norway is already addressing climate change, though it can be argued that this is not being done in a sufficiently 'joined up' way. The size and resources of the country limits the extent to which additional societal challenges can be addressed, but there is a strong case for focusing on a small number to which Norway can make a significant contribution and where doing so will result in economic as well as social benefits in Norway. This could involve

- A broad consultation, spanning citizens, business, the state and the research community, to identify a set of societal challenges that could be tackled and to ensure the social legitimacy of including them among possible candidates
- A selection process, reducing the number of challenges to be considered to, perhaps, half a dozen
- A foresight exercise, involving panels of informed citizens and stakeholders in creating desirable scenarios involving intervention, setting out the expected impacts and explicitly identifying the unique contributions Norway could make and the benefits to Norway (in business as well as social terms) of doing so. It is especially important that relevant ministries are involved, as they will play big roles in funding and implementing the interventions
- A final selection process, which assesses the proposed scenarios and selects perhaps three for implementation, based primarily on the amount of economic benefit thought likely to accrue to Norway. This is likely to be a good indicator of Norway's overall contribution to addressing the societal challenges
- The government has to own the selection process and its results and devote considerable effort to communicating the results of its process back to the citizens, showing how this connects with the original consultation

Implementation for each challenge Norway decides to address needs to be governed by a sub-set of ministries that will be involved in funding and implementation. That node needs in turn to report directly to government.

We have looked at the history of strategy-building in research and innovation over the past twenty years or so in Norway. Despite the limitations imposed by the sector principle, it is impressive how well it has been possible to devise such national strategies. A constant factor has been RCN's ability to coordinate and support such strategic actions, in addition to its 'business as usual' in mainstream research and innovation policy, where it also acts as a key coordinator. Given the capabilities revealed by this brief history, there are strong reasons to believe that the Norwegian governance system is capable of stepping up to addressing the OECD's imperative.

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1 Introduction

This report was commissioned by the Research Council of Norway (RCN) to support its reflections about how to improve Norwegian innovation policy. The trigger for this report was the delivery of an innovation system review by the OECD (2107), challenging Norwegian innovation policymakers to take a more transformative approach. Subsequently, in 2018, the industry minister launched a spending review covering the full range of the state's support instruments for business innovation, so we have tried to make our work helpful also to that exercise. This report has been developed in interaction with RCN, aiming to consider together both triggers and how to respond to them. Of course, this means that there is a lot of focus on RCN. But both demand responses at the national level, so we hope also to help initiate a much wider debate about taking more radical approaches in Norwegian innovation policy. Our ambition here is to define more ambitious categories if intervention and consider processes that would be needed to set up such approaches. We do not address the specific themes that should be prioritised; that would require a very different kind of exercise.

The spending review provides a significant challenge. Is Norway running its innovation policy in an efficient and effective way? Are there opportunities to improve on these dimensions? These are important questions, which need periodically to be asked. Many different actors are involved in Norwegian innovation policy, each engaging in a degree of policy entrepreneurship. It is difficult to coordinate everything, and the overall portfolio of instruments can become complex. So, it is timely to take a look at the big picture. Our report contains analysis of parts of the overall innovation instrument portfolio and has a particular focus on areas where RCN is involved, which we hope will be a useful contribution to the bigger task. But since, like the spending review itself, this part of our analysis looks at current instruments, it has a flavour of optimising what is done today.

The OECD's challenge is more dynamic and future-orientated in character. The OECD innovation system review of Norway announced on its very first page that "Norway has experienced a remarkable transformation based on research and innovation but is now facing a triple transition imperative", which is to

- Shift towards a more diversified and robust economy
- Move towards a more competitive, effective and efficient innovation system
- Achieve these structural transformations while supporting research and innovation that can confront an array of societal challenges

A shift towards a more diversified and robust economy centrally involves reduced dependence not only on the use but also on the production of oil and gas. The OECD emphasises that Norway has managed periods of major industrial restructuring in the past, pointing to: the creation of the process industries in the late Nineteenth and early Twentieth Centuries, often based on academic inventions; building on Norway's strengths in geology and ship-building to restructure into oil and gas; and the development and roll-out of aquaculture and its associated technologies. Clearly, if Norway is to move over time out of oil and gas, then it has to move into something else – in addition to managing the normal process of incrementally moving from lower to higher productivity sectors so as to maintain the high national income needed to fund Norway's high level of welfare. This may entail increasing the ability of the research and innovation (R&I) support system to work with new as well as existing industries. The OECD points out that Norway has an increasingly capable system for commercialising research-based inventions, though the rest of the 'third mission' needs a dedicated funding stream. The low core funding provided to the institutes provides the government with little leverage over their strategies and therefore their willingness to diversity into supporting new industries.

Moving towards a more competitive, effective and efficient innovation system involves addressing the long-recognised phenomenon of Norwegian research being generally good but not containing many 'peaks of excellence'. This needs to be addressed partly through more competitive funding schemes but

also by reforming university governance so that rectors can develop more focused strategies that involve allocating university resources unequally.

The OECD report is (perhaps excessively) complimentary about Norway's progress in addressing societal challenges and offers a long list of RCN programmes that in various ways do so. We agree that some of RCN's major programmes such as Marinforsk, Miljøforsk, Klimaforsk, Climit and Globvac are considerably more comprehensive than those seen in some other countries. This style of programming has the particular strength that it can combine different types of funding instruments, ranging from bottom-up research to in-company innovation. But, as the OECD points out, RCN's societal challenge portfolio focuses on knowledge generation and does little with the demand side or broader socio-technical systems.

Within the wider policy framework, the OECD report says that the Long-Term Plan

> *… assigns a prominent place to societal challenges. However, it stops short of proposing the systemic new policy approach and instruments that such bold ambitions call for. Moreover, the plan has so far mobilised little new funding for this purpose, and there has been little change in the origin and destination of the limited funds … it contains only a few concrete actions and does not set "hard" priorities …*

The OECD goes on to say that Norway faces a particular challenge of policy coordination because governance is highly sectorised. The issues that need to be addressed in research and innovation increasingly stretch across many sectors and no longer lend themselves to single-sector solutions. It says that Norway has failed to develop sufficiently systemic policy instruments or to address societal challenges in more radical ways that could stimulate socio-technical transitions, as opposed to incremental improvements. Too little attention is paid to 'translational' policies that connect what we already know (partly as a result of research) to innovative solutions or to demand-side policies. Thus

> *While government actors can co-ordinate specific operational issues to ensure continuous incremental progress under the current setting, broader strategic issues are not as well covered, including long-term options with alternative paths, possible directions of which priorities to choose, or larger initiatives combining funding with regulatory issues and cross-policy approaches.*

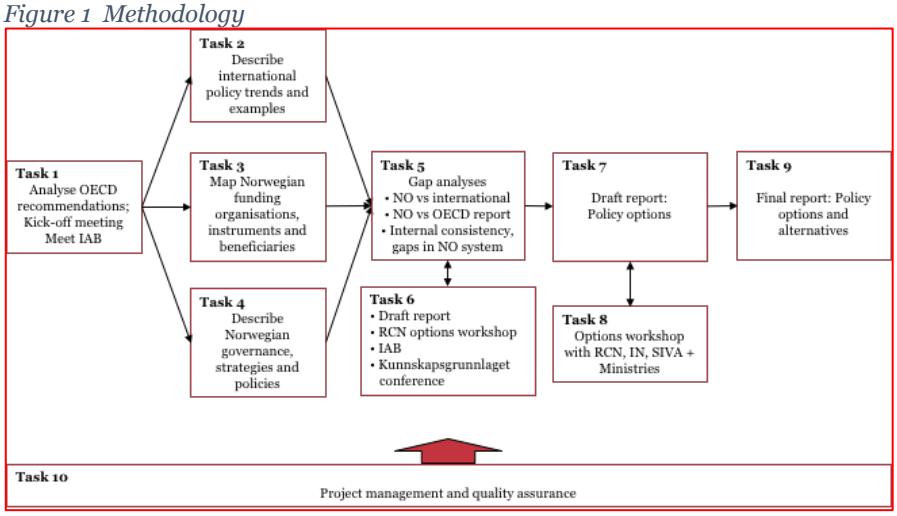
Our report explores policy instruments and governance forms that Norway could use in the course of meeting the challenges the OECD lays out (and which in turn stem essentially from the first long-term plan for research and higher education[1]. It is not our business to propose alternative policy objectives to those set out there or in its successor[2] but to think about ways of reaching them and to trigger a national discussion about ways and means.

[1] St.meld. nr. 7 (2014–2015), Langtidsplan for forskning og høyere utdanning 2015–2024

[2] St.meld. nr. 4 (2018–2019), Langtidsplan for forskning og høyere utdanning 2019–2028

Our method is illustrated in Figure 1. We began by reviewing the OECD report and, in fact, also discussed it with two of its principal authors (Task 1). We then looked at recent policies internationally exemplifying the kind of more radical approach sought buy the OECD, partly through literature review (Chapter 2) and partly by exploring ten cases, which are briefly described in Chapter 4 and more fully set out in Appendix A (Task 2). *Samfunnsøkonomisk Analyse* (SØA) analysed the use of current innovation instruments (Task 3) in a separate report by Maja Tofteng and Rolf Røtnes, *Norwegian Industry-Related R&I Policy Agencies, Measures and Beneficiaries: A Mapping*. That is provided as a separate volume in the overall study and formed a major basis for Chapter 3 in this volume.

Figure 1 Methodology



We looked at how the Norwegian research and innovation governance system has made strategies in the past couple of decades in order to reach a judgement about whether the system has the capacity to attempt the larger-scale and more radical strategies likely to be needed in order to respond to the OECD's challenge (Task 4). This is reported in Chapter 5. Thereafter, we cross-analysed the results of tasks 1-4, looking for gaps and policy opportunities, discussed these with RCN and launched a discussion with a wider group of policymakers. These remaining Tasks are reported in Chapter 6.

We are grateful for continuous support and interaction from Kristin Oxley, Philip Lorentzen, Jon Arne Røttingen and the entire top management team at RCN as well as inputs from RCN's International Advisory Board and comments on an earlier draft from Philippe Larrue and Sylvia Schwaag-Serger. Any remaining mistakes and misunderstandings, of course, are the authors' own responsibility.

2 Policies for funding research and innovation

Addressing the OECD's challenge to Norway will involve going beyond current mainstream approaches in parts of R&I policy, while at the same time maintaining and improving the use of current practices. This Chapter aims to provide a conceptual or theoretical background to R&I policy, in order to provide a framework for thinking about instruments and agencies supporting innovation in Norway today and in the future. We need to understand three generations in research and development (R&D) governance in order to cover this ground. Here, we consider the first two generations rather briefly, since their characteristics are well known. (In the context of the current spending review, however, we think it is useful to set out some of the basic principles that govern current policy.)

We continue by looking at the third generation, exploring the theoretical and policy background to the OECD's more radical recommendations. These are grounded in the increasing policy attention being given internationally to the so-called 'societal challenges' and to an increasing understanding that some of these – most notably the climate crisis and associated systemic changes, such as removing fossil fuels from energy supply chains – demand wholesale change in large and complex systems such as the electricity production and distribution system that have both social and technological components. These very radical transitions seem largely to be attached to sustainability. In practice, not all transition policies are or need to be as radical as those associated with climate change. A spectrum of approaches is emerging, ranging from the completely conventional to the strongly transitional, along which it is possible to design innovation policies.

2.1 Why do we fund R&I today?

This section offers some simple theory about why and how governments support research and innovation, which we need in order to understand the rationality behind the way R&I support systems are organised in Norway as well as elsewhere. There are strong similarities among practices in different countries, precisely because there is consistent underlying theory.

Western economies rely heavily on the idea that that government only intervenes in society in order to remedy problems in the way society runs. They treat the idea of 'problem' widely, so that it includes making best use of opportunities. Hence, Norwegian governments intervened massively to make good use of the discovery of oil and gas under the North Sea, setting up regulations, organisations, laws, a sovereign investment fund and a policy to use the oil and gas windfall to generate the knowledge needed to build up an indigenous oil and gas sector. But beyond fixing problems and making best use of opportunities, governments tend to work on the principle that "If it ain't broke, don't fix it".

Leaving aside the very different way in which defence research is managed, we can distinguish three generations of research and innovation governance since the Second World War, each tied to a different view of the 'social contract' between science and society. It is perhaps best to view these as generations as sedimentary layers: new ones are laid down on top of the old ones, but the old ones do not go away.

The manifesto for first generation governance was *Science, the Endless Frontier* (Bush, 1945) and the relationship between society and science was based on 'blind delegation' (Braun, 2003): the scientific community was seen as being best placed to decide what research should be done, so they were allowed to do so by taking funding decisions in research councils or national science foundations. Bush's original proposal was that scientists should steer all government-funded research, but the research-performing Departments of State objected strongly to this idea. The end result was the creation of the researcher-governed National Science Foundation in 1950 while Health, Defence and so on carried on their own 'mission-oriented' research. This period is characterised by the popularity of the 'linear model of innovation', namely the idea that research and new knowledge drove innovation in society and therefore economic well-being.

The second generation was triggered by a backlash that started in the 1960s, partly led by the OECD, arguing that society needed 'science policy' to direct research towards national, socially-determined goals. It underpinned a period of great technological optimism in the 1960s and 1970s, perhaps

symbolised by US President Kennedy's mission to put a man on the moon. The following few years were the first time that a significant amount of systematic research was done on the relationship between research, innovation and society. An early realisation was the importance of the demand side (Rothwell, et al., 1974) (von Hippel, 1976) and a growing recognition that innovation processes largely happen in business and not in universities. The growing understanding of the complexity of the innovation process led initially to the rejection of simple innovation models such as the linear model and then successively to the idea of research and innovation taking place in 'national innovation systems' (Freeman, 1987) (Lundvall, 1992) (Nelson, 1993).

Since about 2000, in an emerging the third generation, there has been growing concern about the 'societal challenges' (climate change, AIDS/HIV, ageing population, and so on). Key triggers at the EU level included a 'manifesto' published in Nature (Georghiou, 2008) and the 'Lund Declaration'[3], which triggered the inclusion of the societal challenges in the EU Framework Programme. Tackling these challenges generally involves overturning existing technologies, structures and practices in socio-technical systems (that is, big, complex systems in society that involve both social and technical elements, such as the electricity production or healthcare systems). Interventions therefore need to tackle complexity at the same time as they need to promote radical change in socio-technical systems and therefore involve many other parts of society beyond those traditionally engaged in R&I policy.

Each of these three generations of government intervention in relation to R&I is associated with particular types of 'failure'.

- Market failure, in the first generation
- Systems failure, in the second
- Transition failure, in the third

2.2 First generation

Government intervention in the first generation is justified by market failure, which applies to research and to technological innovation, ie innovation that is based on new knowledge that was not already available in the world. 'Market failure' means that (capitalist) markets produce less than the socially optimal amount of research and new knowledge (Nelson, 1959) (Arrow, 1962). It is caused by two fundamental properties of knowledge that make it different from other kinds of commodities. First, knowledge is 'non-rival', meaning that it can be used by many people without being consumed. (Most goods are 'rival', in the sense that once they have been consumed, they are gone and cannot simultaneously be used for something else. As the English seem recently to have forgotten, 'you can't have your cake and eat it'.) Knowledge is also 'non-excludable', meaning that it is difficult or impossible to prevent people from getting hold of it and, hence, using it. Goods that are non-rival and non-excludable are known as 'public goods'. It generally makes little economic sense for entrepreneurs to produce them, because the benefits of public goods spill over to society so firms cannot make any money from them[4]. Hence, governments intervene to fund scientific research and so as to produce knowledge for society to use.

Strictly, full-blown market failure only applies to science, which is routinely shared, openly quality-controlled and published as part of its production process. Once scientific knowledge (or any other kind) starts to be used as a basis for developing processes or products, design-specific knowledge and production know-how are introduced that make it more excludable. Intellectual property rights like patents and registered designs can be used further to increase its excludability. While the entrepreneur is unlikely to risk investing in basic research, the closer the work gets to development, production engineering and market entry, the more attractive the investment becomes. This is why the state normally pays universities 100% of the cost of doing basic research but, when it is subsidising

[3] This appears not to have been formally published, but is widely available, including from the Swedish Research Council http://www.vr.se/download/18.7dac901212646d84fd38000336/

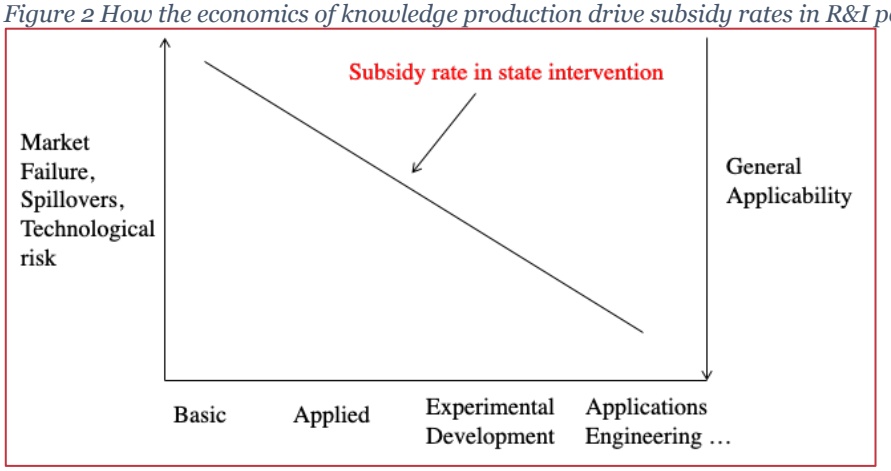
[4] There are exceptions to most rules and there are exceptions to this one (Rosenberg, 1990), but it is a good enough approximation to the truth for it to be useful

innovation, it provides a much lower share. Simply put, where subsidy is used, the closer to market, the less the state is prepared to pay because the ratio of private to public goods gets higher.

The other important thing that changes along the spectrum from basic research to the market is that *technological* risk goes down. That implies that the closer innovative work is to market, the more likely the entrepreneur is to take on the technological risks of innovation. Governments therefore subsidise research and innovation not only because markets under-produce public knowledge goods but also in order to share the risk of innovation with entrepreneurs by contributing a subsidy. The closer the research and development work gets to market, the higher the entrepreneur's risk willingness and therefore the smaller the subsidy that is needed to affect her behaviour. A corollary is that the closer a subsidised project is to market, the greater will be the proportion of the benefits that are private and accrue to the subsidised firm. We will see how this works out in practice below, when we discuss Skattefunn.

Figure 2 summarises the way these arguments connect to subsidy rates in R&I.

Figure 2 How the economics of knowledge production drive subsidy rates in R&I policy



As soon as we move from discussing market failure to talking about innovation, everyday terminology gets imprecise and confusing. The Frascati Manual (OECD, 2015), which defines how we collect R&D statistics, says that innovation is "putting new or significantly improved products on the market or finding better ways (through new or significantly improved processes and methods) of getting products to the market. R&D may or may not be part of the activity of innovation."

In fact, most innovation is based on reconfiguring existing technologies. Only some innovation needs R&D, because there are bits of knowledge missing and these need to be discovered before the innovation can be achieved. We tend to call this second kind of R&D-based innovation 'technological innovation'. What can be confusing is that this kind of technological innovation goes through two stages: first, it fills in the knowledge gap using R&D; second, the work of innovation continues into activities such as routine product development without further R&D – and what happens then is then the same as for non-technological innovation. In terms of subsidy, this means that many countries are prepared to subsidise R&D-based as well as non-technological innovation, but they offer a higher rate of subsidy for R&D and in many cases these subsidies are provided by different organisations with different skills.

All innovation is subject to commercial risk, irrespective of whether R&D is involved. Only technological (R&D-based) innovation suffers from technological risk. 'Non-technological' or 'non-R&D-based' innovation uses technology, but it only uses *established* technology, so it does not suffer from technological risk. We can see this in the case of car manufacturing for example (Figure 3). Large car makers tend to have research departments that do applied research[5] to help them understand future

[5] Sometimes, but not often, they may also do a little basic research

innovation opportunities. They also do 'advanced engineering' or 'pre-development' work, that develops, tests and de-bugs technologies the company intends to use in the short term. Only once the technological choices are made and the uncertainties are removed, does the company move into product development, manufacturing engineering, production and all the other stages of getting from a design in the office to a new car on the streets. Thus, the process of innovating a car has an R&D-based stage and a non-R&D based stage.

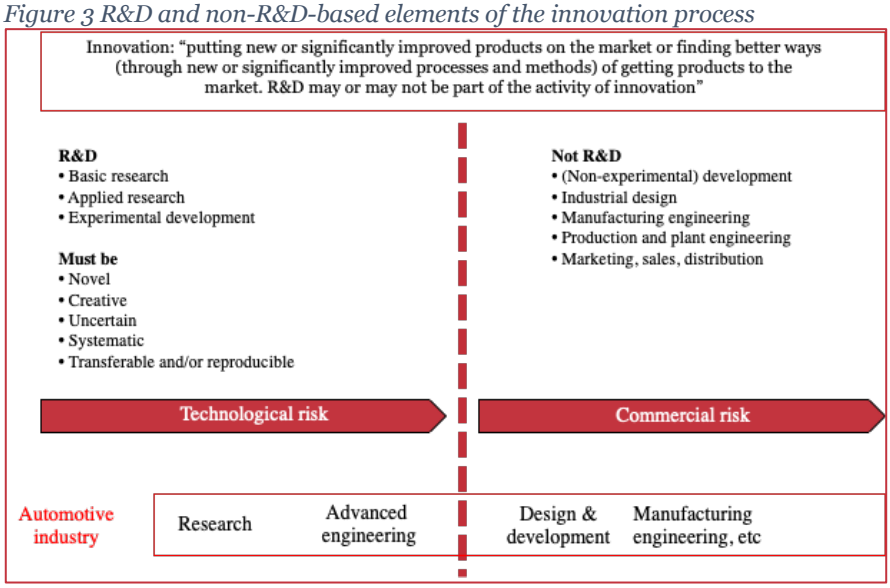
The boundary between the two kinds of innovation is built into the way we collect R&D statistics. The Frascati Manual defines R&D as

- Basic research
- Applied research
- Experimental development

To qualify as R&D, these activities must be novel, creative, uncertain, systematic and transferable or reproducible.

Once R&D is complete, the uncertainties should have been squeezed out and any further work done on the technology is essentially routine and predictable (though it may still be difficult and require a lot of skill). Thus, activities such as (non-experimental) development, industrial design, manufacturing engineering, production and plant engineering, marketing, sales and distribution are excluded from the category of R&D. Figure 3 summarises this discussion. In real life (and as the Manual explains) telling the difference at the boundary between R&D and non-R&D can be difficult, especially in software-based industries. This is why Skattefunn uses science and technology specialists at RCN to decide which projects may count as 'R&D' and benefit from the tax incentive, and which may not. This is not a judgement that non-technical specialists can make.

Figure 3 R&D and non-R&D-based elements of the innovation process



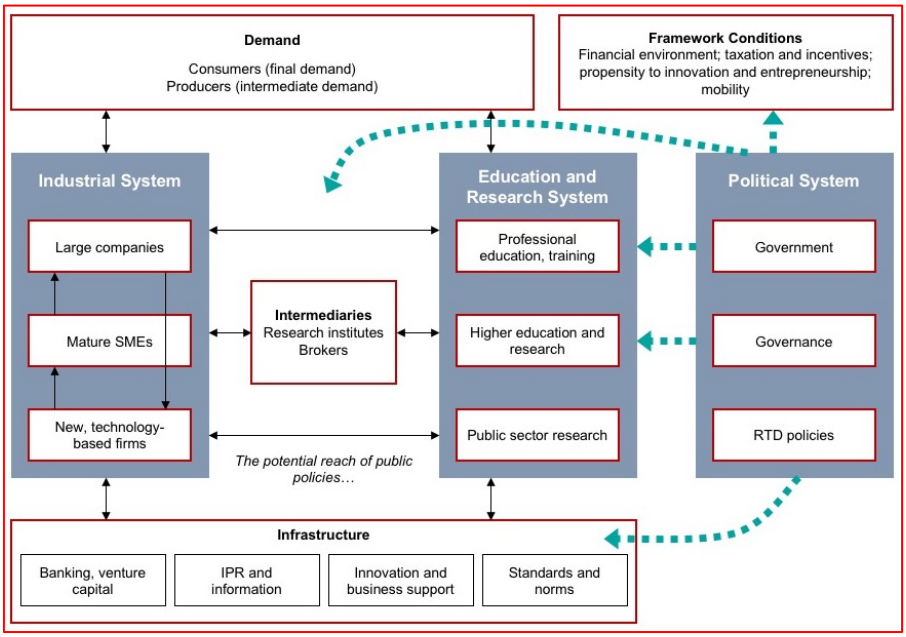
Source: Largely based on the Frascati Manual (OECD, 2015)

Non-technological innovation is much more common than the technological variety. Technological innovation gets a lot of attention because, considered over the longer term, technological change based on new knowledge drives economic development and growth. Non-technological innovation does not, by definition, go beyond the existing state of knowledge and therefore the technological *status quo*. That means that the existing state of technology places an inherent limit on change.

2.3 Systems failure

Like the OECD and most research and innovation policymakers, we make use of the 'national innovation system' heuristic in analysing research and innovation policy. Figure 4 shows one of a number of available representations of that heuristic, emphasising the structure and main components of such a system and illustrating its comprehensive nature. The structural view has, in effect, provided a checklist for the OECD national innovation policy reviews, depending on the idea that a well-functioning innovation system requires that all the components and that the interlinkages among them work well. The reviewers essentially do 'bottleneck analysis' (Arnold, 2004). Authors interested in how to build or transform technological innovation systems (TIS – sub-components of the national innovation system defined by the technology on which they focus) have pointed to the need for various functions to operate within these structures in order to build a new or radically changed TIS (Bergek, et al., 2006) (Hekkert, et al., 2007) and to displace an old one (Kivimaa & Kern, 2016). The concern with socio-technical transitions has permeated the OECD reviews recently. It is evident for example in the Swedish, Finnish and Norwegian studies undertaken in 2016-7 and underlies the "triple transition imperative" of the Norwegian report.

Figure 4 A National Innovation Systems Heuristic



Source: (Kuhlmann & Arnold, 2001)

'Systems failure' was conceived in the context of technological innovation, but any kind of innovation can also be affected by aspects of it. Because the idea of systems failure emerges from the 'systems of innovation' literature – which offers more of a collection of rules of thumb (heuristics) than a unified theory – it is a bit of a rag-bag. Systems failure can mean (see Table 1 for more extended definitions)

- An inadequate knowledge infrastructure, so that innovation is hampered or prevented by lack of knowledge among companies
- Institutional failure, such as shortcomings in formal or informal institutions (laws, culture, values, etc)
- Network failure, where established networks cause lock-ins, or it proves hard to build new networks (such as research-industry links) needed to access new and existing knowledge
- Capability failure, where companies lack the skills, knowledge or information and the ability to access these that is necessary for innovation

Systems failure provides the justification for interventions including reform and restructuring of universities and institutes, changes in laws and regulations, cluster development, building links between business and the research-performing organisations. It underlies the use of 'demand-side' innovation support such as innovative procurement. It also justifies interventions that build needed capabilities in companies. These missing capabilities can be related to R&D and the use of technology – what the literature calls "absorptive capacity" (Cohen & Levinthal, 1990) – but also to other aspects of running a business and doing non-technological innovation such as strategy, marketing, networking or quality management skills.

The early studies of innovation systems focused on their structural elements. More recently, attention has turned towards the *functions* that need to be in place and the *governance* of individual innovation systems. As a result, measures that affect making and implementing strategy (for example through thematic programmes), policy coordination and the production and use of 'strategic intelligence' in policymaking are also justified through the idea of system failure. As we show in the Section 2.4, some of these ideas come back in a reinforced form in policies to address societal challenges and socio-technical transitions in the form of directionality, demand articulation, policy coordination and reflexivity.

2.4 Transitional innovation policy in theory and policy

Since about 2000 there has been growing concern about the so-called societal challenges (sometimes 'grand challenges'). Key triggers at the EU level included a 'manifesto' published in Nature (Georghiou, 2008) and the 'Lund Declaration'[6], from an innovation conference under the Swedish presidency of the EU, which triggered the inclusion of the societal challenges in the EU Framework Programme. Tackling these challenges can involve overturning existing technologies, structures and practices in socio-technical systems. Interventions therefore involve complexity at the same time as they need a wider and more difficult form of governance and collective action even than the challenges posed in innovation system governance. This is why the scope of third-generation policies and instruments has become broader than earlier ones, posing a big new challenge in terms of governance and coordination.

Systems modelling is sometimes (especially in energy and climate research) used to understand and explore options for transitional change and has roots back to the Limits to Growth debate (Meadows, et al., 1972) and earlier. Traditions that explore mechanisms and policy for transitions come primarily from industrial economics and the economics of technological change on the one hand and the history of technology on the other. In the former, 'technological transitions' are conceptualised as changes from one technological configuration to another – for example, transitioning from combustion-engine based cars to electric ones. If we want to promote such transitions, a key issue is how to understand (and manage) the inertia that tends to prevent it from happening. Nelson and Winter explain inertia via 'technological regimes'. Incremental innovation triggers evolution in the technological regime and can often be absorbed without disturbing the logic of the regime itself. However, more radical changes can be disruptive and require learning right across industry, society and government including by users. "Policies and institutions also play a role, as well as infrastructures, cultural discourse or maintenance networks." (Nelson & Winter, 1982)

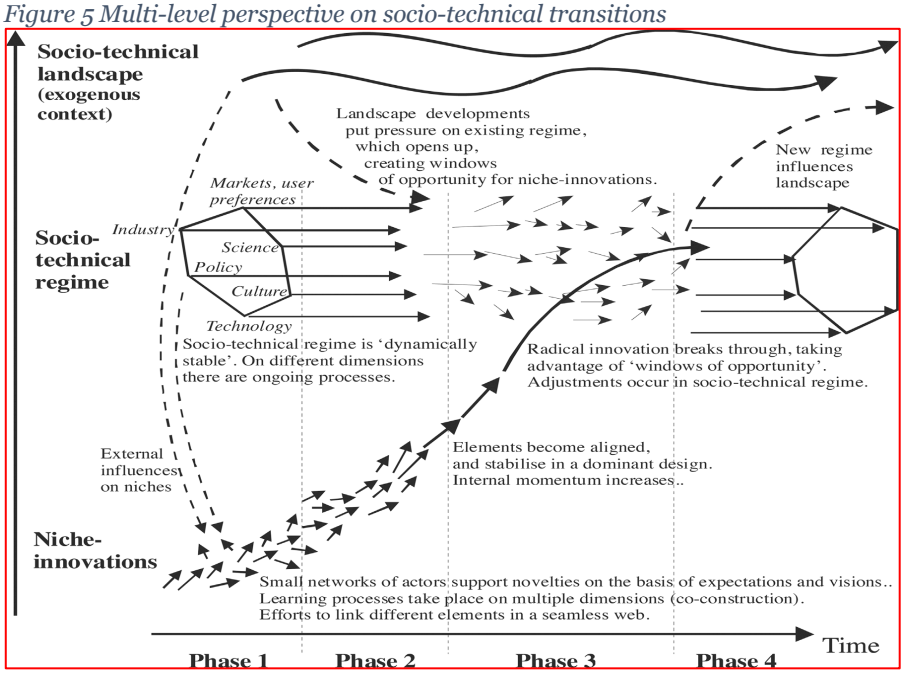
The latter strand tries to understand past radical shifts in dominant technologies – such as the transition from sailing ships to steam (Geels & Schot, 2007). This strand has tended to become dominated by efforts to show how to create and manage sustainability transitions, in the process becoming more prospective than retrospective (Bussels, et al., 2013). It is associated with science and technology studies (STS) community, considering the societal effects of technology as well as the processes by which technology is socially constructed (SCOT). Criticism and societal engagement are important themes in this tradition through activities like technology assessment, foresight and democratic participation, and

[6] This appears not to have been formally published, but is widely available, including from the Swedish Research Council http://www.vr.se/download/18.7dac901212646d84fd38000336/

this is very evident in the approaches taken to transition governance, emphasising wide participation and stakeholder involvement.

Much of the discussion about transitions now uses a multi-level perspective (MLP), which was developed in the period when transitions studies were mainly backwards-looking but is now used in connection with forward-looking societal attempts to manage transitions as well. It describes in a generic way the context in which transitions take place and has three levels. That of Geels (2002) (2010) (2018) is widely employed. Figure 5 shows the most recent version. Together, the two lower levels in the MLP make up what other authors call a technological innovation system.

Figure 5 Multi-level perspective on socio-technical transitions



Source: (Geels, 2018)

The top level in the MLP is the 'landscape', consisting of the broad social, technical, infrastructural, cultural and political environment and other exogenous or external factors that form a context for the socio-technical regime. This is the level at which 'top-down' social and political pressures to address societal challenges emerge. The socio-technical regime is the specific 'world' within which transitions take place and comprises: technology, user practices and application domains (markets), symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge (Geels, 2002). Niche innovations contribute to the development of the regime. Some are absorbed, others lead to incremental changes, yet others trigger transitions of how the regime works.

Past transitions have tended to occur 'naturally' as the result of a combination of social and technological changes and market forces. Undoubtedly, many future transitions will also take place this way. However, others – most notably those relating to climate change and environmental pollution, where society has a need to impose goals and a timetable – clearly require policy actions that override some of the directions in which market forces would naturally have led. While history teaches that this kind of top-down decision-making is error-prone, there is no reasonable doubt that we need to reduce and soon eliminate net emissions of greenhouse gases to the atmosphere or that the unfettered operation of market forces will have the opposite effect. There are thus different degrees of transition – some of which will require strong, top-down social steering and others of which will develop more naturally. Experience, again, suggests that we should use the minimum possible amount of top-down steering and to the greatest extent possible work with market forces.

2.4.1 Making transitional policy

Practice often goes ahead of theory in policy. For example, governments were funding basic research long before the economics profession told them why they were doing it (Nelson, 1959) (Arrow, 1962). The practice of expressing societal problems in the form of 'failures' appears to be a useful way to focus and test the validity of interventions. Table 1 shows three types of failure, roughly associated with the first, second and third governance generations. However, in addition to the first two market failures (which are the traditional Nelson-Arrow market failures associated with research), the authors have added two more market failures that have been made evident by the effects of industrialisation on the environment. More broadly, this scheme extends the number and type of failures on which policy is based from the narrowly economic to the more systemic.

Table 1 Overview of failures in three governance generations

	Type of failure	Failure mechanism
Market failures	Information asymmetries	Uncertainty about outcomes and short time horizon of private investors lead to undersupply of funding for R&D.
	Knowledge spill-over	Public good character of knowledge and leakage of knowledge leas to socially sub-optimal investment in (basic) research and development.
	Externalisation of costs	The possibility to externalise costs leads to innovations that can damage the environment or other social agents.
	Over-exploitation of commons	Public resources are over-used in the absence of institutional rules that limit their exploitation (tragedy of the commons).
Structural system failures	Infrastructure failure	Lack of physical and knowledge infrastructures due to large scale, long time horizon of operation and ultimately too low return on investment for private investors.
	Institutional failures	Hard institutional failure: absence, excess or shortcomings of formal institutions such as laws, regulations, and standards (in particular regarding IPR and investment) create an unfavourable environment for innovation. Soft institutional failure: informal institutions (eg social norms and values, culture, entrepreneurial spirit, trust, risk-taking) that hinder innovation.
	Interaction or network failure	Strong network failure: intensive cooperation in closely tied networks leads to lock-in into established trajectories and a lack of infusion of new ideas, due to too inward-looking behaviour, lack of week ties to third actors and dependence on dominant partners. Weak network failure: too limited interaction and knowledge exchange with other actors inhibits exploitation of complementary sources of knowledge and processes of interactive learning.
	Capabilities failure	Lack of appropriate competencies and resources at actor and firm level prevent access to new knowledge, and lead to an inability to adapt to changing circumstances, to open us novel opportunities, and to switch from an old to a new technological trajectory.
Transformat-ional system failure	Directionality failure	Lack of shared vision regarding the goal and direction of the transformation process: inability of collective coordination of distributed agents involved in shaping systemic change; lack of targeted funding for research, development and demonstration projects and infrastructures to establish corridors of acceptable development paths.
	Demand articulation failure	Insufficient spaces for anticipating and learning about user needs to enable the uptake of innovations by users. Absence of orienting and stimulating signals from public demand. Lack of demand-articulating competencies
	Policy coordination failure	Lack of multi-level policy coordination across different systemic levels (eg regional-national-European) or between technological and sectoral systems; lack of horizontal coordination between research technology and innovation policies on the one hand and sectoral policies (eg transport, energy, agriculture) on the other; lack of vertical coordination between ministries and implementing agencies leads to a deviation between strategic intentions and operational implementation of policies; no coherence between public policies and private sector institutions; no temporal coordination resulting in mismatches related to the timing of interventions by different actors.

	Type of failure	Failure mechanism
	Reflexivity failure	Insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance; lack of distributed reflexive arrangements to connect different discursive spheres, provide spaces for experimentation and learning; no adaptive policy portfolios to keep options open and deal with uncertainty

Source: (Weber & Rohracher, 2012)

Research and innovation policy instruments have evolved through the three governance generations from simple grant funding for individual researchers through bilateral research-industry collaborations to increasingly large-scale and complicated funding programmes involving many actors at once. Eventually, large and complex programmes emerge to address major systemic shifts in national competitiveness and to tackle socio-technical transitions.

Probably because of its roots in technology history and in critical approaches to technology, the transitions literature tends to focus on self-governance rather than on the relationship with government; correspondingly, evaluation has been seen as a process that provides feedback to the intervention managers about how to improve their performance rather than as providing accountability to society. Bringing thinking about transitions into mainstream policy governance is an important precondition for legitimating and funding them (Arnold, et al., 2018).

Politics have so far been given little weight in the literature on socio-technical transitions (Meadowcroft, 2009) (Shove & Walker, 2007) (Smith, et al., 2005). However, as Ehnert et al (2018) point out, more recent studies have put both politics and agency in a much more central position (Avelino & Wittmayer, 2015) (Hess, 2014) (Raven, et al., n.d.) (Geels, 2014) (Markard, et al., 2016) (Normann, 2015). As a result the field has started to move away from the 'governance without government' approach of the earlier transitions management literature and towards the idea that governments have to play key roles in transitions but can only do so in partnership with research, business and wider society (Wittmayer & Loorbach, 2016) (Arnold, et al., 2018).

Inspired by historical examples of niche innovations eventually transforming the socio-technological regime (as was the case with steam ships), the early transitions literature focused on 'strategic niche management' as the way to trigger policy-induced transitions at the regime level. Strategic niche management "is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology". More specifically, the aims of strategic niche management are to

- Articulate the changes in technology and in the institutional framework that are necessary for the economic success of the new technology
- Learn more about the technical and economic feasibility and environmental gains of different technology options, i.e. to learn more about the social desirability of the options
- Stimulate the further development of these technologies, to achieve cost efficiencies in mass production, to promote the development of complementary technologies and skills and to stimulate changes in social organization that are important to the wider diffusion of the new technology
- Build a constituency behind a product - of firms, researchers, public authorities - whose semi-coordinated actions are necessary to bring about a substantial shift in interconnected technologies and practices (Kemp, et al., 1998)

Using strategic niche management to trigger a transition involves betting on a particular and potentially rather narrow range of possible technological solutions to the need for transition at regime level. Later, thinking has moved towards 'transition management', addressing the regime more directly and searching amongst other things for needed niche solutions. Transitions management includes (Loorbach, 2007) (Turnheim, et al., 2018) (Wittmayer, 2016) (Voß & Bornemann, 2011) (Laes, et al., 2014)

- Creating legitimacy for the desired transition and establishing the right of those involved to work towards it
- Transition arena, where the strategy is hammered out and its progress is monitored
- Transition management, which acts as the executive or agent managing change
- Maintaining and modifying a long-term strategy, learning from experiments and experience
- Setting directionality, which may involve searching, foresight, road mapping and agenda setting
- Running experiments and learning by doing
- Involving new actors and stakeholders, beyond those conventionally involved in research and innovation policy
- Coordinating multiple actions and actors
- Reflexivity

Transitions management may make use of the creative and destructive functions identified in the TIS literature and more recently in the transitions literature (Table 2).

Table 2 Creative and destructive functions for regime change

Creation functions	Destruction functions
• Entrepreneurial activities • Knowledge development • Knowledge diffusion through networks, including policy networks • Guidance of the search (more recently discussed as 'directionality') • Market formation • Resources mobilisation • Creation of legitimacy/counteracting resistance to change (Hekkert, et al., 2007)	• Control policies • Significant changes in regime rules • Removal of support for existing technologies • New organisations or replacement of key actors (Kivimaa, et al., 2017)

The main focus of the transitions literature is currently on sustainability transitions: those that are needed in order to respond to 'existential' societal challenges. While we would not for a moment want to understate the importance of sustainability transitions, policy needs to encompass not only these but the management of large, complex innovation programmes and a range of 'lesser' transitions, including those included in the OECD's 'transitions imperatives' for Norway.

We also need to integrate markets into the discussion, since policy experience is that working 'with the flow' of markets can be a powerful way to support change while working against (or ignoring) markets is a very risky policy – as some of the epic failures in *grands projets* and in supporting dying rust-belt industries in the 20th century clearly demonstrated. This means moving beyond the literature's binary approach – either something aims at a regime change and is therefore a socio-technical transition, or it is not. The discussion here implies that while major sustainability transitions are likely to involve regime change and a need to override the market in some respects, there are other transitions that (like steamships in the past) can 'go with the flow' of markets.

The scale of sustainability transitions tends to be global. Evidently, it is unlikely that single nations or programmes can achieve them alone. A positive aspect of such transitions is that they tend to provide big opportunities for investment and innovation as, for example, the producers of wind power and solar photovoltaics know. The wise policy at national level is to try to identify areas within them where national endowments, skills and resources are likely to provide comparative advantages. The broad scope and involvement needed, however, implies a greater need for consensus about these opportunities than might usually be the case in innovation initiatives. That in turn requires wider stakeholder consultation and involvement in the choice of areas to prioritise, strategy development involving stakeholder consultation, foresight, road mapping and so on and their implementation (OECD, 2017).

Other transitions, such as most of those suggested for Norway by the OECD, are smaller in scale yet still tend to need a broader and more inclusive policy approach than conventional second-generation R&I policy. Similar concerns therefore apply: a significant effort is needed in identifying intervention opportunities that will support national comparative advantages and economic activity. Whether the challenges addressed are at the national or the global scale, the effort will need to be attached to one point in government. Big, complicated and complex programmes tend to need multi-level governance, coordinating the implementation of strategy but also providing the local strategic intelligence and flexibility to adapt the programme design to local needs. Such governance seems more powerful and more likely to focus on societal goals if there a degree of central power or compulsion. Even then, however, there is a risk that the higher levels lose touch with the lower ones. But networked governance without strong central authority and links to government easily evolves to follow the goals of the network stakeholders rather than societal goals. That is a situation that obviously needs to be avoided, so central authority is important to the success of third-generation initiatives.

Where a large and complex programme can be handled within a single agency (or even a small number of agencies) there is every reason to use existing structures. When this is not the case, we envisage a system of governance that would involve

- The government designating a point in its structure to which a programme would ultimately answer
- Creating a 'platform' to design and govern the programme, in which a wide range of agencies (or other agents such as cities) and other stakeholders are involved but which has staff resources and a leadership team of its own, able to lead the programme. The platform would coordinate individual interventions managed by existing agencies (or combinations thereof), using their own budgets, resulting in a hierarchical structure of interventions with a reporting structure leading back up to the platform
- The platform would be responsible for revising the strategy and plan periodically. This should be informed by evaluation as well as by consultation with stakeholders and relevant sources of expert knowledge (Arnold, et al., 2018)

There is experience with using both public-private partnerships (PPPs) and public-public partnerships (P2Ps) in such a role.

2.4.2 What about missions?

The European Commission has adopted the idea of using 'missions' to implement the societal challenges, which have proved hard to address, in part because of a lack of coherence in their project portfolios (Mazzucato, 2018). This may be because the Framework Programme actually is a framework: it can involve any kind of R&D and innovation activity that is consistent with its overall objectives (Arnold, et al., 2005), hence it often defines thematic areas within which there are bottom-up project proposal submissions and assessments. The project portfolio does not have to comprise a coherent plan to achieve a single specified goal but may be a collection of projects that have relevance to the goal without necessarily being complete.

The current discussion of mission-oriented policies at EU level effectively melds the former US 'grand challenge' approach of launching competitions to solve scientific and technological challenges with the European, more societal definition of challenges, a duality which Hicks (2016) identified. In current EU understanding, missions address individual targets relevant to responding to societal challenges. "Mission-oriented policies can be defined as systemic public policies that draw on frontier knowledge to attain specific goals" (Mazzucato, 2018) or 'big science deployed to meet big problems" (Ergas, 1987), though they also use a mixture of new and existing knowledge. "Missions should be broad enough to engage the public and attract cross-sectoral investment; and remain focused enough to involve industry and achieve measurable success. By setting the direction for a solution, missions do not specify how to achieve success. Rather, they stimulate the development of a range of different solutions to achieve the objective." They are complex interventions that need to involve the "entire innovation chain". They need more civic engagement than normal research and innovation programmes and normally address problems too large for a single EU Member State to handle. "[T]here is a greater need to combine understandings of sociology, politics and technology … [E]ven though the nature of missions requires

that they be selected at the political level, the selection process must have a strong element of public involvement" in order to ensure their legitimacy and a willingness to sustain them over long periods of time (Mazzucato, 2018).

Criteria for selecting missions are

- Bold, inspirational with societal relevance
- A clear direction: targeted, measurable and time-bound
- Ambitious but realistic research and innovation actions
- Cross-disciplinary, cross-sector and cross-actor innovation
- Multiple, bottom-up solutions

Implementation is to be done through

- Engagement of diverse national and regional stakeholders
- Measurement of instruments to foster bottom-up solutions
- A portfolio of instruments to foster bottom-up solutions
- Flexibility, proactive management and building in-house capabilities

The missions approach, in effect, shares many of the characteristics of transition management – but without there necessarily being a requirement for regime change.

Fischer et al (2018) have analysed examples of existing mission-like programmes and show that while many have the characteristics Mazzucato suggests, there is also a good deal of variation. This seems reasonable enough, given that these programmes were not designed to a single template. The authors suggest mission programmes are characterised by

- Mix of R&D-only initiatives and ones where the demand side is at the core
- Long-term direction setting with strong public leadership and funding
- Horizontal and vertical coordination
- Affecting regulation, policy and legal frameworks
- Demand articulation and engagement of users and citizens
- Rigorous monitoring systems

They add to Mazzucato's definition of missions the observation that

- They are implemented by empowered governance (structure) that can be easily identified and that can be held accountable for achieving the results
- They emerge from a sense of urgency that is shared amongst a broad category of stakeholders, in relation to something that is considered problematic

They distinguish between 'accelerators' with rather well defined scientific and technological objectives and 'transformers', which more broadly address 'wicked' societal problems and involve some kind of system transformation. They conclude that mission programmes are best thought of as lying somewhere on a spectrum from accelerators to transformers, and that transformers may have to deal with a number of problems that call for an accelerator in order to be effective. In the transitions literature's terminology, this means that transformers may have to operate at both niche and regime level, while accelerators are going some of the way to doing niche management.

Fischer et al (2018) point out that the sophistication of mission policies means that they rely on the presence of well-functioning institutions and policies as well as there being considerable experience and capacity in the organisations supporting the policies. They require new forms of governance and perhaps dedicated institutions. They need not to pick winners but to promote the development of ecosystems and clusters from which winners can emerge through competition and selection. New funding mechanisms may be needed for the private sector (especially loan finance) and it will be important to engage not only with the supply but also the demand side. The cases they analysed may not have been effective enough in getting citizen engagement. Overall, they conclude that successful missions will need

> *… a confluence of a clear societal need or urgency, long-term but reflexive direction setting and commitment of public policy-making, adequate public funding combined with private investments, scientific and technological capabilities, and 'buy-in' of stakeholders, with all sharing a common vision, appear to be appropriate ingredients and factors of success. The main characteristics of mission-oriented R&I initiatives, in addition to their directionality and intentionality, defines their multi-faceted nature which implies adaptability in the way they are designed and implemented. Their governance, policy-mix, evaluation and monitoring mechanisms, the involved stakeholders must be determined foremost by the objectives that they aim to achieve and the problems that they need to solve. (Fischer et al, 2018)*

2.4.3 What's the difference?

Table 3 shows differences and similarities between the 'transitions' and missions' approaches. While it inevitably involves simplifications, it highlights the more policy-driven nature of the missions approach and the fact that it is proposed by Mazzucato in a context (the European Commission) with policymaking, accountability and with state-driven governance.

Strikingly, none of this discussion touches on the level of the traditional research and innovation instruments addressed in Chapter 3 It is nonetheless heavily dependent on the strength of the innovation system overall (Mazzucato, 2018) and therefore on these instruments.

The missions approach is more technocratic, providing greater opportunities for prioritisation and planning, identifying and allocating resources towards specific bottlenecks that may stand in the way of transition. It is also more focused. In opting to look for multiple solutions to problems and to let them compete in selection environments (often, but not necessarily only, markets), the missions approach is probably able to move more quickly – but at the likely cost of having to deal with smaller problems.

Unpacking the differences and taking into account the instruments considered in Chapter 2 (ie the first two categories below), we may think of five levels of ambition in relating policy interventions to generate changes in socio-technical regimes.

1. Traditional single-beneficiary projects such as funding basic research in universities (typical of the first governance generation)
2. Multi-actor, multi-measure programmes, (Kuhlmann, et al., 1999) typically involving collaboration and networking within the existing innovation system (second generation)
3. Large and complex innovation programmes (at the boundary between second and third generation)
4. Niche management or accelerator missions (third generation)
5. Transition management or transformational missions (third generation)

Table 3 shows similarities and differences between the 'transitions' and 'missions' approaches.

Table 3 Differences and similarities between the 'transitions' and "missions' approaches

Transitions	**Missions**
Self-governance, primary accountability to the transition managers	Societal governance and accountability through government policy
Transition arena drives the agenda	Policy drives the agenda
Inclusive planning process	Somewhat inclusive planning process but more technocratic with greater use of expertise (eg in sociology or politics)
Central conception of socio-technical regimes extending to a wide range of stakeholders and framework conditions	More focused on 'technological regimes' (Nelson & Winter, 1982), while recognising that these depend on factors outside technology and the economy
Niche and transition management, dealing with entire regimes	Accelerators and transformers address regime change by tackling subsidiary goals and functions in niches or the regime itself. Transformers do not necessarily achieve socio-technical regime change
Creative and destructive functions across the whole regime	Focus in R&I but with some reference to other aspects of the regime
Prefer to proceed by experiment and learning	Focus on competition among alternative solutions in markets
Expects transitions to take a long time	Missions adopted based on a sense of urgency and are "targeted, measurable and time-bound" (Mazzucato, 2018), while nonetheless recognising that they will take time to achieve
Similarities	
Need legitimation, civic consultation and mobilisation, involvement of new stakeholders not normally involved in R&I	
Distinguish niche management/accelerators from transition management/transformers – though scope is not entirely the same	
Long-term, reflexive interventions with rigorous monitoring	
Inherently large scale, though some can be scaled down to smaller countries and others (eg sustainable cities) can be run at a national or regional level in pursuit of local transitions	
Impose directionality	
Programmatic but an important role for experiments and learning	
Roles for PPPs and P2Ps	
Depend upon the existing innovation system and its key actors having high technological capability and strong planning/policymaking capacity	
But …	
Both pay limited attention to markets, product and industry cycles or industrial dynamics	
Both recognise the importance of the demand side but nonetheless in practice focus on the supply side	

3 Norway's current instruments and agencies supporting innovation

This Chapter provides a summary account of the current situation in innovation support in Norway. It uses and extends the analysis in the report by Maja Tofteng and Rolf Røtnes, of Samfunnsøkonomisk Analyse (SØA), *Norwegian Industry-Related R&I Policy Agencies, Measures and Beneficiaries: A Mapping*, which is provided as a separate volume to the overall study.

We build on SØA's analysis of the composition and use of policy instruments for innovation in Norway by rehearsing some of its conclusions. Long-standing policy concern in Norway about the low level of business sector R&D means it is especially important to consider instruments that 'activate' R&D performance by firms. We therefore drill down particularly into the operation of Skattefunn, which has been the programme driving the increase in spending on innovation support in the last five years or so. Thereafter, we look at the issue of bottom-up versus thematic funding and conclude that both are needed at the same time in order to minimise the chance of lock-in, obtain information about new trends and direct R&I resources towards areas of societal need. Finally, we discuss RCN's roles in Norwegian innovation policy, first, as the key actor in research and technological innovation and, second, as a key R&I policy coordinator in Norway.

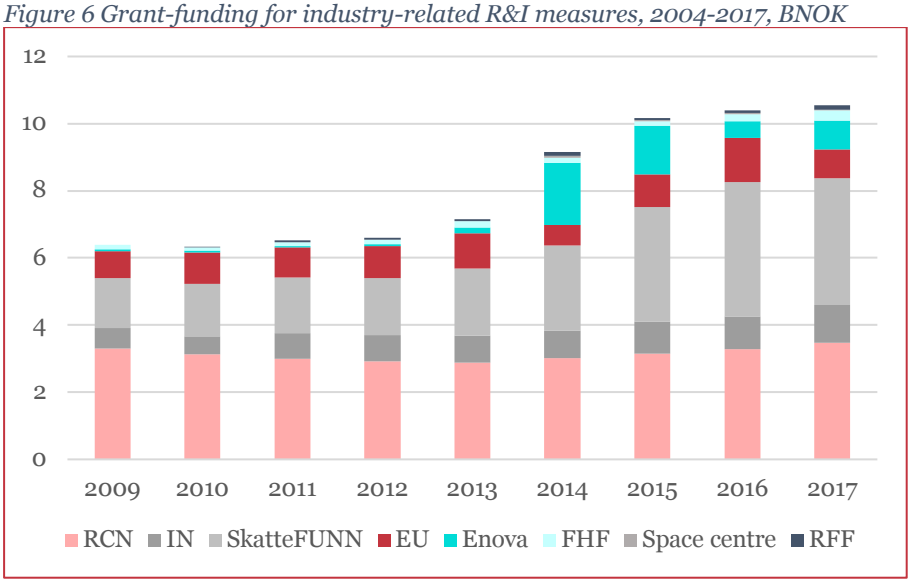
3.1 Building on the SØA analysis

An important finding is that – if we take technological and non-technological innovation together – there is a wide range of actors and a wide range of instruments used in Norway. Most of the diversity is in the 'non-technological' or non-R&D-based area, in which RCN is not involved.

The SØA analysis does not include a check on the completeness of the instrument portfolio. This can only be done based on international practice. Our observation is that the portfolio that SØA analysed is rather complete at the level of traditional first- and second-generation innovation programmes addressing market and systems failure. The one area little represented in the national portfolio is simple *activation* instruments for technological innovation, such as: innovation vouchers that fund a company to use a simple technology service such as testing; graduate placement schemes that subsidise the salary of the first engineer or scientist in a company, allowing it to learn to do technological innovation and start building absorptive capacity; audit and advice programmes such as technology audits, quality audits or manufacturing audits that identify improvement opportunities, which the beneficiary company can then address. It may well be that such things are not needed in a highly-educated, high-income and sophisticated country such as Norway. As it stands, Skattefunn and RCN Innovation Projects (especially in BIA) are the main R&D activation instruments in use.

The three major actors in innovation are RCN, Innovation Norway (IN) and Skattefunn – which is an R&D tax incentive – has a different logic and is anchored in the Finance Ministry, though RCN does help with its administration. SØA find that in the last few years, the innovation spending from these three taken together has risen substantially, driven by the growth of Skattefunn. In parallel, RCN's expenditures have become slightly more focused on research at the cost of innovation, while IN is moving efforts from general business support to (mostly non-technological) innovation. Figure 6 shows that the increase in grants for industry-related R&I measures (including tax incentives) since 2013 has largely been driven by Skattefunn and Enova, a comparatively new agency charged with pilot and demonstration activities in the energy sector. Almost all of the increase since 2013 has gone to the private sector.

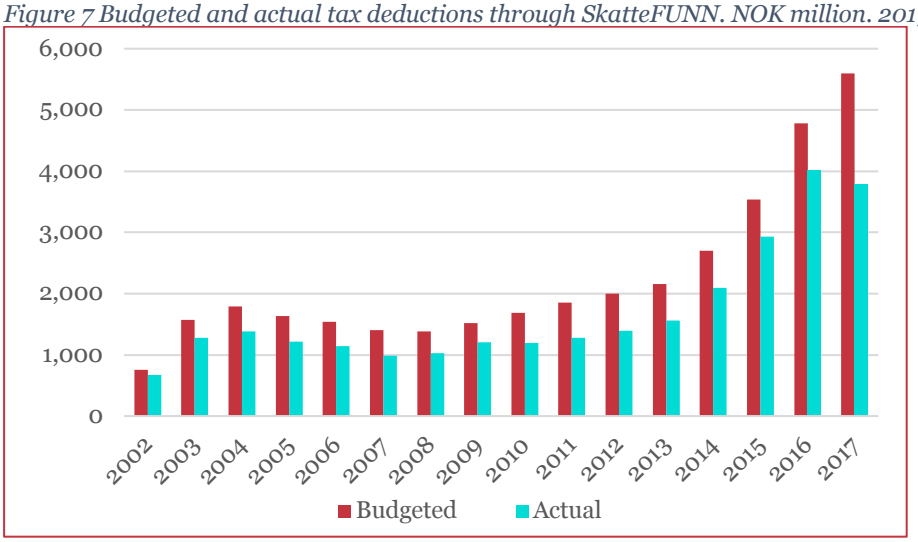
Figure 6 Grant-funding for industry-related R&I measures, 2004-2017, BNOK



Source: SØA

The biggest part of the increase in R&I subsidy has been through Skattefunn, which has grown rapidly since 2013 (Figure 7), though there is a noticeable increase in the difference between the amount of benefit authorised and that actually drawn down by the companies, showing that industry is not able to absorb as much credit as is on offer. The cap on Skattefunn benefits was raised from NOK 11m in 2009 to NOK 22m in 2014, NOK 33m in 2015, NOK 40m in 2016 and up to NOK 50m in 2017.

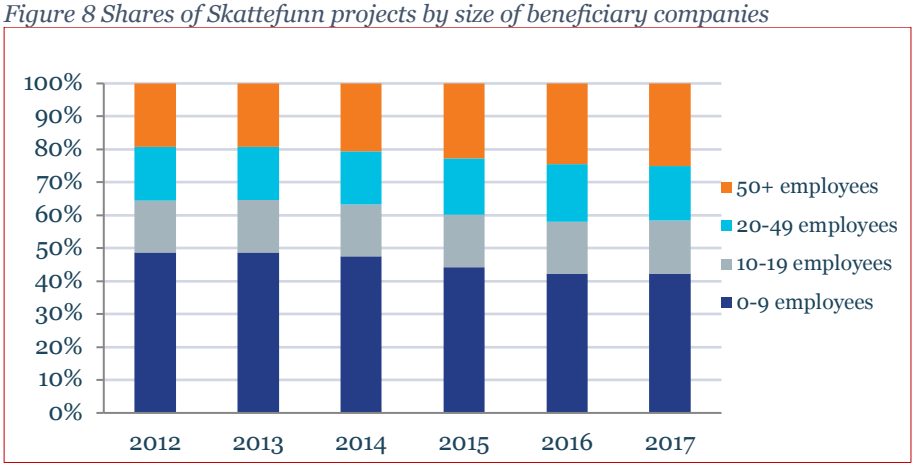
Figure 7 Budgeted and actual tax deductions through SkatteFUNN. NOK million. 2017-NOK



Sources: RCN and the Norwegian Tax Administration, from SØA report

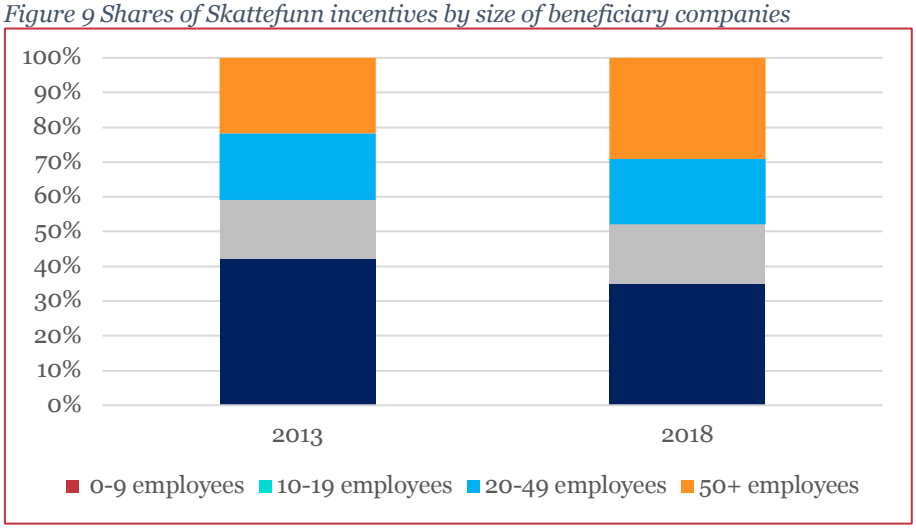
Figure 8 and Figure 9 confirm that the share of Skattefunn projects taken by large firms has grown somewhat, together with the increases in the cap, indicating that the role of Skattefunn has been changing. The share of the benefits going to companies with more than 250 employees rose from 6% to 10% between 2013 and 2918. Its original design as a volume incentive with a low cap orientated it towards activating R&D in small firms. It continues to play this role, but also increasingly provides bigger benefits to bigger companies, so that the state is increasingly sharing via a legal form of state aid the risks of technological innovation by companies that (we assume) already do R&D.

Figure 8 Shares of Skattefunn projects by size of beneficiary companies



Sources: *Forskningsrådet i Tall*, 2017, annexed spreadsheets, Figure 39

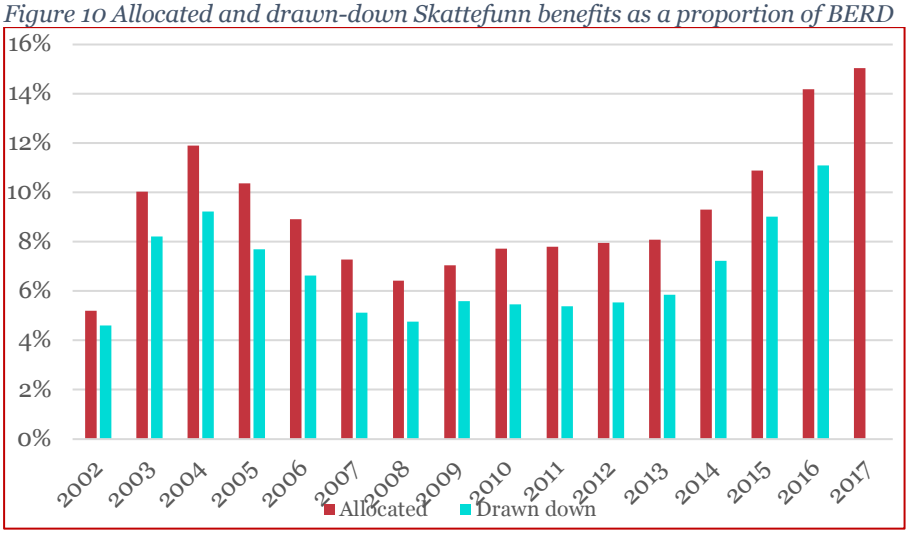
Figure 9 Shares of Skattefunn incentives by size of beneficiary companies



Source: RCN

Figure 10 shows the percentage of BERD funded by Skattefunn benefits, indicating that Skattefunn has grown more quickly than BERD in the last few years, suggesting that at least some of the increase may be absorbed by free-riding.

Figure 10 Allocated and drawn-down Skattefunn benefits as a proportion of BERD



Sources: Calculated from OECD MSTI and *Forskningsrådet i Tall*, 2017, annexed spreadsheets, Figure 37

Skattefunn has unusual characteristics, compared with broader international experience.

The first is its input additionality. Since Hall and van Reenen's classic article (2000), the research literature has tended to find that R&D tax incentive schemes have an input additionality "about 1", meaning that for every krone the state forgoes in tax, the beneficiary spends one krone on R&D. More recent literature is tending to suggest that input additionality is sinking "below 1", so that not all the tax forgone is actually used on R&D. In stark contrast, Skattefunn evaluations find an input additionality of "about 2". The most recent one also has this finding.

The second unusual characteristic is that, while Skattefunn provides relief on corporation tax, it can also be used by companies that do not owe enough tax to cover the amount of the tax relief. In these cases, Skattefunn pays 'negative corporation tax' in the form of cash. This is so in about 60% of the cases, where Skattefunn effectively becomes an R&D grant rather than a tax incentive.

It is possible that the second characteristic at least partly causes the first, especially as it is the smallest credits that have the highest additionality – but this relationship seems not to have been formally investigated.

The recent Skattefunn evaluation (Samfunnsøkonomisk Analyse, 2018) shows among other things that

- Beneficiaries' input additionality, in the sense of the amount of R&D triggered by the credit, goes down over time, so in the later years of a company's participation, Skattefunn is triggering less R&D activity than in the early years
- The greatest amount of input additionality occurs when a company that does not have a history of doing R&D enters the scheme
- The private returns on Skattefunn-subsidised R&D are about the same as those on company-financed R&D
- Input additionality is extremely high (about 4) for tax credits below NOK 100k, but decline as the size of the credit rises and fall "below 1" for credits of NOK 500k and above

The story is consistent with that in earlier evaluations, namely that Skattefunn is most effective in its originally-intended role of R&D activation. In qualitative terms, this means that the project focuses only on the firm's own performance, implying not only maximum private benefit but also minimum spillover. Because the company uses it as it wants, Skattefunn provides high private returns – potentially higher than R&D grants from RCN. However, the evaluations are unable to measure the social returns so no like-for-like comparison of all the benefits is possible between Skattefunn- and RCN-funded projects.

This analysis suggests that Skattefunn is good at its original purpose of activating R&D performance, especially among firms with little or no experience of doing R&D. Its usefulness declines as firms gain experience and it is inherently limited by the fact that its benefits are mainly private. As firms gain experience, therefore, it would be more useful to encourage them into projects that have more spillovers, such as are obtained in RCN projects, in order to increase the overall returns to society. That suggests having a low cap, rather than the rising cap we have seen in recent years. Raising the cap is also inefficient because there are clearly diminishing returns to Skattefunn investment at the total level – as Figure 10 shows, in the most recent few years Skattefunn has cost the taxpayer a growing share of BERD as the cap has risen, project size has gone up and input additionality has fallen. In our view, therefore, Skattefunn should be scaled back to tackling its original purpose, which it does well. Of course, if the Norwegian authorities choose to use Skattefunn as a way to provide legal state aid or to compensate companies for the high costs of research labour compared with other countries that is perfectly possible – but that is not an R&I policy and is therefore out of the scope of this report.

3.2 'Bottom-up' versus thematic R&I Programmes

The economics profession tends to like bottom-up or 'branch-neutral' programmes, because under neoclassical economic assumptions they provide less disturbance to markets than thematic ones. These assumptions include the idea that – left to its own devices – an economy will come to an 'equilibrium', namely a point of rest at which the different economic forces are in balance and social welfare is optimised. The neoclassical assumptions are most useful when they provide a starting-place from which to analyse what happens when certain of them do not hold, for example when there is imperfect competition, imperfect information, technology changes and even, more recently in evolutionary economics, when firms do not behave 'rationally' in the sense of the neoclassical model. These and other factors introduce changes into the economic system, constantly pulling the economy away from equilibrium. It is not always useful, therefore, to make policy as if the neoclassical assumptions are right.

There are some quite important problems with doing all R&I policy bottom-up. In research, this leads the existing structures, institutions and patterns of investment to reproduce themselves (Rip, 2001) rather than to adjust to changing patterns of societal need. Similarly, other things being equal, applications for innovation support will reflect the existing pattern of specialisation in business. A bottom-up support process on its own can get in the way of restructuring the economy, as policymakers might want to do if they aim to refocus into branches with higher total factor productivity or to move the energy system away from fossil fuels and towards renewables. But it is also the case that bottom-up applications for support can *reveal* trends that should inform policy.

R&I policymakers have in practice tended to hedge their bets – largely without consulting the economics profession. Pretty much all countries fund a lot of science bottom-up because that generates new ideas and extends the opportunities for innovation, as well as generating knowledge that is valuable in itself and training people to do research. They then also fund thematic research and innovation as well, in order to restructure where necessary and to direct effort to needs in science and society.

SØA make an important point when they stress that Skattefunn, BIA and many IN programmes are bottom-up. This means that they can respond to changing trends more quickly than thematically programmed resources and can even provide strategic intelligence about emerging thematic opportunities that can be strengthened through programming. They can to a degree mitigate the effects of gaps among the thematic programmes. At the same time, they cannot substitute for the deliberate allocation of resources to societal priorities that thematic programmes provide. In our view, it is important that bottom-up programmes are not forbidden to operate in areas where there are thematic programmes (as was for some years the case with BIA). That amounts to a loss of information and flexibility.

Given that Skattefunn, BIA and the IN non-thematic programmes are complementary in the sense of addressing different needs or stages in R&I and the development of technological and business capacity by firms there is every reason to maintain them alongside thematic programmes, even if – as explained earlier – we see Skattefunn as over-dimensioned.

Norway makes little use of demand-side R&I instruments, the main one being the OFU and IFU innovative procurement schemes operated by IN. Nor is there much use of incentives to encourage the take-up of innovation, like the well-known German subsidies to adopters of renewable energy that have proved instrumental to widespread adoption, especially in the take-up of solar photovoltaics. This is an important gap in the policy portfolio.

3.3 RCN's role in Norwegian innovation policy

RCN has two special roles in Norwegian R&I policy that should be highlighted here. First, it specialises in research and technological innovation, for which it has capabilities that are unique in the Norwegian system. Second, its radical design means that it has a key role in coordinating R&I policy across government, and to a fair degree also wider society.

3.3.1 RCN as the national specialist in research and technological innovation

Table 4 shows where RCN and other actors are positioned in the division of labour for R&I policy in Norway. Ticks in brackets show where there is anecdotal evidence that activities take place, even if in a strict sense they should not. For example, Skattefunn credits are only supposed to go to projects that conform to the Frascati definition of R&D (discussed above), yet in practice they appear to extend into non-technological aspects of innovation when there is also a technological dimension present.

Table 4 De facto division of labour among major actors in Norwegian R&I Policy

Organisation	Basic research	R&D, proof of concept	Pilot and large-scale demo	R&D capacity building	Routine product/ process development	Start-up funding	Business skills	Investments and loans
RCN	√	√	√	√				
IN					√	√	√	√
Norwegian Space Centre	√	√						
SkatteFUNN		√			(√)			
FHF		√						
Enova			√					
RFF		√		√	√			
Pilot-E		√	√					√
EU programmes	√	√		√	(√)			
	Relevant to technological innovation				*Relevant to all kinds of innovation*			

Note: IN funds some technological innovation as well, e.g. though Miljøteknologiordningen and Trebasert innovasjonsprogram.

RCN specialises in funding basic research as well as R&D. It runs large-scale technology demonstration programmes and builds up R&D capacity not only in universities and institutes but also in companies. Table 4 makes the division of labour between RCN and IN clear in principle: it is based on the distinction between technological and non-technological innovation. Skattefunn is in principle limited to technological innovation. It is therefore no great surprise to find, as SØA do, that many companies use both Skattefunn and IN support: quite apart from the fact that companies may take multiple unrelated projects to different funders, Skattefunn and IN fund two different stages of innovation through which R&D-based innovation projects must pass. The regional research funds (RFF) and the Norwegian Seafood Research Fund (FHF) fund R&D, and in fact rely on RCN's competences in R&D funding to manage and quality-control project appraisal and selection. The Norwegian Space Centre funds Basic research and R&D specific to the space sector, echoing a specialisation and division of labour found in almost every country active in space.

Enova pilots and demonstrates energy technologies, in response to the need to move away from fossil fuels. Pilot-E is a programme, jointly run by RCN, Enova and IN, that effectively extends Enova's mission into R&D and infrastructure investment.

If we look at the funding functions (top row) shown in Table 4, then it is clear that RCN dominates technological innovation and IN non-technological innovation and wider business support.

RCN is almost alone among the Norwegian actors in funding research – the exception being the Norwegian Space Centre, which does so in its specialised domain. With the same exception, RCN is dominant in R&D and Proof of Concept, funding its own programmes but also handling proposal assessment in Skattefunn, FHF, RFF and Pilot-E. Enova is the key force today in piloting and large-scale demonstration for energy (both in its own right and in Pilot-E) but RCN also has capabilities and a track record in this function. RCN also builds R&D capacity, directly and through RFF.

IN is almost alone in its non-technological innovation and wider business support role, as a result of a series of mergers that created its predecessor, SND, and then further mergers to build Innovation Norway itself. Like RCN, it dominates its field by design and in turn has been designed to have the skills to operate in its field. There is a long history of agreements between RCN and IN governing activities that can be thought of as inhabiting a 'grey zone', where both organisations have competence, notably in relation to innovative procurement programmes and commercialisation of inventions from the state research sector. It is arguable that the Norwegian implementation of the EU SME Instrument would better fit RCN's skill-set than that of IN, but by and large the division of labour seems to be about as sensible as it can get in the real world. There is also long-established cooperation at working level, with programme officers in RCN and IN referring potential applicants to each other in order to find the best fit with their needs. IN has a practice of encouraging its clients to apply both to Skattefunn and to its own programmes in order to maximise the assistance available to them (and, correspondingly, to minimise the call on its own budget).

The division of labour between RCN and IN is not simply a matter of having tidy administrative boundaries but is grounded in the competences needed to work in R&D-based versus non-technological innovation and business support (Figure 11). RCN's competences cover the two left-hand columns; IN's cover the right-hand one.

Figure 11 Competences needed by funders in research, technological innovation, and non-technological innovation and business development

Research	Technological Innovation	Business Development
Science policy Scientific understanding Peer review Understand research-performing institutions Grant instruments	S&T policy S&T understanding Stakeholder engagement Complex proposal assessment; peer review Understand research-performing institutions Understand technological innovation in businesses Grant instruments	Instruments to help firms access resources Financial instruments Business capabilities

3.3.2 RCN as a policy coordinator

It is easy for those who do not know the history to criticise the degree of complexity built into RCN's organisational design. It is important to remember that RCN was created because the previous system with many R&I agencies could not cope with the task of coordinating the 'Main Target Areas' (*Hovedinnsatsområdene*), which were major national programmes in the late 1980s, cutting across

multiple ministries and funders. This failure led the government in its 1993 White Paper[7] to describe the R&I funding system as complex, intransparent and structurally incapable of dealing with the R&I challenges facing Norway. Creating RCN initially meant simply internalising this complexity, but that providedf the advantage of creating an opportunity to *manage* it that did not exist in the old system. It also explicitly meant that policy coordination was and is a central role of RCN.

In the past, RCN has also had a very large number of instruments but this number has been managed down over time, in part influenced by the two evaluations of the Council (Arnold, et al., 2001) (Arnold & Mahieu, 2012) and by the 2017 RCN spending review[8], but more importantly because management already had set simplification as an objective. The complexity resulted from the need for RCN as a multi-principal agency to satisfy a large number of ministries at the same time. RCN has done a lot of policy coordination across the ministries by building programmes that more than one ministry can fund and by innovating 'large programmes' that are not only cross-ministry but can also span different parts of the research and innovation process, at one and the same time funding research- and more innovation-focused activities. These practices reduce complexity and increase programme scale. They are so established in Norway today that they seem normal, but they are still far ahead of most R&I funding practice internationally.

RCN has not done this policy coordination on its own but in partnership with the Ministry of Education and Research (MER), which has responsibility for coordinating research policy across ministries at the national level.

It is noticeable that a number of new innovation actors have appeared in the last 20 years, apparently complicating what otherwise is an essentially binary funding system. Skattefunn started operations in 2001, with RCN assessing whether proposals conform to the Frascati definition of R&D. FHF was set up in the same year. It is a research association for the fishing industry, funded by a levy on fish sales. The research agenda is agreed within the wild fish and aquaculture sector and is then translated into a series of calls for proposals, which RCN administers. Enova was also set up in 2001, to test, demonstrate and promote new energy solutions but operated at small scale until 2014, from which point it became a significantly-sized funder (Figure 6). The RFFs were established in 2010. Despite their name, their activities are focused on technological innovation rather than research. Like FHF, its proposals are assessed by RCN. Pilot-E was set up in 2016 as a virtual funder, using the resources of RCN, Enova and IN to create a programme of research, innovation and investment in the renewable energy sector large enough to attempt major investments.

This new history demonstrates the importance of RCN's capabilities in research and technological innovation through its involvement in most of the new initiatives. At the same time, it also shows that there are centripetal forces at work, notably in the regions. Enova and Pilot-E, however, represent some first steps towards addressing socio-technical transitions. They raise the question whether, despite RCN's strong history of policy coordination, the existing organisations, notably the twin pillars of RCN and IN, are adequate to this future task.

3.3.3 Conclusions

We draw the following conclusion from the analysis in this chapter.

- The amount of state support to technological innovation on industry has been rising in recent years, owing to increased Skattefunn and Enova funding
- The returns from Skattefunn support in an individual firm diminish over time and – across all beneficiary firms – also diminish with increasing firm size
- Skattefunn appears to be very effective in its original role of activating R&D in small firms, but successive increases to the cap reduce the marginal returns to Skattefunn expenditure. At the same

[7] St Melding nr 36 (1992-93) *Forskning for fellesskapet*. For a description of the history, see Arnold et al (2001) Chapter 4

[8] "Områdegjennomgang av Norges forskningsråd", MER and FIN, 2017

time, industry seems unable to absorb all the money allocated to it under Skattefunn, suggesting that other means of activation are needed

- Hence, if Skattefunn is to focus on innovation, it would probably be efficient to reduce the cap. If, on the other hand, the state has other reasons (such as international competition for foreign direct investment) to subsidise BERD, then it is legal to do so but it is probably incorrect to regard this part of Skattefunn as an innovation incentive. Rather, it should be viewed as an instrument of industry policy
- It is important in innovation as in science not to over-programme. The R&I policy mix should have both thematically-prioritised and bottom-up instruments
- The major agencies involved in innovation policy – widely defined as both technological and non-technological innovation – are RCN and IN. The present division of labour between them is based on differences in the skills needed to deliver these two kinds of innovation support
- RCN's structure and role as R&D funding agency for many ministries put it in a unique position to play an important role in policy coordination

4 International developments in transitional innovation policy

The chapter goes on to provide cases of real policies with ambitions at various levels. We describe how we selected the ten case studies reported here and go on to describe them. Next, we discuss the extent to which each case corresponds to something that is already within the capabilities of the Norwegian R&I support system to address, or whether in runs ahead of Norwegian practice. Finally, we draw some lessons for future Norwegian policy.

4.1 Cases in international innovation policy

We undertook a number of case studies of international practice, in order to supplement the preceding rather theoretical discussion with potentially relevant practical ideas for policies in Norway.

Our criteria for selecting cases were

- Be broadly relevant to Norwegian R&I priorities, as laid down in the updated Long-Term Plan and the latest Research Bill
- Span the three types of "transitions" described by the OECD, so they will encompass a range of transitions from radical improvement of research performance, improving the operation of the national innovation system and addressing societal challenges. Where possible, they should tackle more than one of these at a time
- The tractability of the case study in terms of the availability of documentation describing the initiatives, accessibility of people to interview and the presence of evaluations or other studies that would help us draw conclusions about good practice
- We would aim to include examples that involve new governance structures or processes

We therefore looked for a selection of cases that would span the OECD's three imperatives. The long-list from which we selected the case study interventions is shown at the Appendix.

We used the following criteria to classify potential case studies and to decide which of them to select. Our classification followed the OECD's three imperatives.

- A - Shift towards a more diversified and robust economy
- B - Move towards a more competitive, effective and efficient innovation system
- C - Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges

Specific selection criteria were

- 1 - Does it involve increased coordination across existing actors?
- 2 - Is it extra-ordinary, rather than business as usual?
- 3 - Is it relevant to the Norwegian policy situation (and is Norway not doing it already)?
- 4 - Is it tractable - are there evaluations, is it old enough to have achieved anything, can we understand the documents, are there people to talk to?

Table 5 shows the cases we selected and shows how they fit with the selection criteria A-C. All cases satisfy criteria 1-4, so these are not shown in the Table.

The cases can only be analysed in qualitative terms and via judgement – they are very different from each other, so no standard metrics are available (or, indeed, relevant). The Table includes our judgements on three dimensions.

- The extent to which the political level is actively involved in the programme (as opposed merely to blessing it at the outset)
- Whether the programme includes activities and actors outside the R&I sphere
- Our own qualitative judgement of how radical the programme design is, compared with past policy practice in the country concerned

Table 5 Some case study characteristics

Country	Policy or programme	A	B	C	Political level involved?	Beyond R&I?	How radical?
AT	STI Strategy 2011-2020		√		√		M
DE	High Tech Strategy		√	√	√		H
DE	Energy Transition ('Energiewende')	√		√	√	√	H
DK	Innovation Fund – Grand Solutions grant scheme		√	√			L
DK	Mind lab		√			√	L
FI	Growth engines	√	√		√	√	M
FR	Pôles de Compétitivité (Competitiveness Poles)	√	√		√	√	M
NL	Circular Amsterdam			√	√	√	H
SE	SIP strategic innovation programmes	(√)	√	√		(√)	H
UK	The Industrial Strategy Challenge Fund (ISCF)		√	√			H

Here we briefly describe the case study programmes. Fuller descriptions are given at the appendix.

4.1.1 AT STI Strategy 2011-2020

The STI Strategy was originally proposed by the Austrian Council for Research and Technology Development, which comprises leading figures in science, industry and policy and whose task it to provide policy advice to government. It intended to provoke reform in the higher education system to improve manpower supply, strengthen basic research, increase the rate of innovation in companies and to coordinate R&I Policy across the various ministry silos involved in the Austrian system. While the stated aim was to increase innovation, it therefore provided 'something for everyone' among the key R&I stakeholder groups. A key innovation was to set up an RTI Rask Force to run the strategy, convened by the state chancellery and comprising senior officials from the four main ministries involved with R&I policy,

4.1.2 DE High-Tech Strategy

The High-Tech Strategy intended, and to a fair degree has succeeded, to bring the fragmented R&I efforts of eleven ministries into some alignment and acts as a coordination platform as well as a place for making strategy within the government system. It is guided by a committee of state secretaries, bringing the authority to programme and make changes, is advised by industrial and academic committees to ensure its embedding in those communities and monitored by the top-level council that provides scientific advice to government. It is nearing the end of the third strategy and the agenda has evolved from almost pure coordination towards setting thematic priorities that both address selected societal challenges and bring a promise of improving or maintaining German industrial competitiveness. Broadly viewed as a repackaging exercise at the outset, it has evolved to establish its own identity and a high level of support within the German R&I system.

4.1.3 DE Energy Transition (Energiewende)

The Energy Transition aims, first, to ensure that Germany meets its international CO2 reduction objectives and, as a complicating factor, the need to speed up that process after the Fukushima incident triggered a challenging decision to shut nuclear power down in Germany by 2022. A key concern is to meet these objectives without at the same time making German industry less competitive. Stretching well beyond the R&I sphere, it has a complex system of multi-level governance held together by a central platform and constant, indicator-based monitoring of progress in 6-monthly dialogue with the Chancellor. It has five lower-level platforms – grids, electricity market, energy efficiency, buildings and

R&I. The R&I platform is closely coupled to overall management, helping monitor and revise the direction of the effort.

4.1.4 DK Grand Solutions scheme

Innovation Fund Denmark (IFD) was created as a new funding body in the context of a wider reorganisation of the support for strategic research in 2013/14. IFD describes the Grand Solutions scheme (initially simply called 'large projects') as follows:

> *"With Grand Solutions, IFD invests in collaborative projects between public institutions, companies and universities. Typically, the project participants have a concrete product or process in mind as an end product of the project" (IFD 2018, p. 29)*

It represented a departure in the past in that it was designed to support fewer, large-scale projects rather than more numerous smaller projects (Aagaard, 2013) and funds a broad range of activities including research, development, proof-of-concept and demonstration. Thematic priorities are based on the 5-yearly 'research catalogues' of priorities for government research produced by the Ministry of Higher Education and Science on the basis of extensive consultation in research, business, government and with other stakeholders. (Unlike the similar Dutch process, this does not involve the general public.) In addition to six thematic areas, the Fund also accepts 'bottom-up' applications. Projects that address societal challenges are welcome but there is no priority specifically linked to these challenges. Projects are typically DKK5-30m – in a few rare cases larger (up to DKK64m) – and run for 2-5 years.

4.1.5 DK MindLab

This was one of the first of the innovation labs established in several countries early after the year 2000. It aimed to provide intelligence and techniques to improve the innovative capabilities of government. It was opened by the Ministry of Business Affairs but became a cross-ministerial innovation unit in 2017.Customers were mainly Danish ministries, including in the area of business innovation. Its contributions were largely to trigger individual, small-scale government interventions and it seems to have had no systemic effects. It was repurposed in 2018 to focus on promoting digitalisation in Denmark.

4.1.6 FI Growth Engines

The Finnish growth engines are private-sector consortia chosen in competition by Business Finland (BF) that aim to generate €1bn in new business, exports or investment in Finland across an unspecified time scale. BF funds a coordination function and provides a range of R&D grants, loans and business support as needed. The consortia compete for funding on the basis of a road map and they pass through a series of stage gates in order to retain their right to project funding and loans. The consortium is closed: others may not join and there is little outreach to society; nor is the agenda societally influenced. Successful consortia will, in effect, win business through cooperation in their 'ecosystem' or cluster. The primary concern is competitiveness and wealth generation, establishing greater scale.

4.1.7 FR Competitiveness Clusters (Pôles de compétitivité)

The French government launched the competitiveness cluster policy in 2004, in response to a perceived national competitiveness crisis, aiming to strengthen competitiveness through partnerships within the clusters, public funding for R&D projects and supporting companies in getting access to private funding, internationalising, exercising intellectual property rights and improving human resources. The clusters are membership organisations. A competitiveness cluster is defined as

> *a partnership, based around a specific theme and a specific region [which] brings together large and small firms, research laboratories and educational establishments, all working together in a specific region to develop synergies and cooperative efforts*

Each cluster management organisation has a multi-annual performance contract with the central government and a budget of €15-20m from the state. It answers to both the central and the regional state authorities. In addition to this, members of the cluster can apply for R&D funding from a central

government fund specifically dedicated to the programme as well as from more routing R&D support schemes. Each cluster also has a dedicated R&D zone, where in the past R&D tax benefits have been substantial.

While the clusters are loosely coordinated by the central state, in practice their activities are locally focussed and there is no evidence of longer-term strategic planning or of raising ambitions beyond the regional activities normally handled within regional clusters. Evaluations show that the clusters have managed to enlist substantial numbers of companies. Company R&D expenditure has gone up because of the subsidies available but there appears to be little if any impact on economic performance.

4.1.8 NL Circular Amsterdam

An unusual case where the City set up the programme using specialised consultants together with TNO. This meant that packaged and semi-packaged solutions were at hand for designing and implementing the programme at the level of the overall strategy and at project level. Implementing the programme requires considerable hands-on effort in identifying and encouraging individual opportunities to close and re-use waste streams, requiring involvement from the City as well as the consultants. The City through the vice-mayor and its technical department governs the programme and the technical office is involved in helping participants learn how to operate within the circular economy.

4.1.9 SE Strategic Innovation Programmes (SIPs)

The SIPs were started in 2012 in response to a conservative governments' desire to move innovation funding away from traditional branches and towards new themes, selected bottom-up. Initially, consortia were invited to form and subsidised to write Strategic Research and Innovation Agendas. 136 agendas were published. The SIP programme then invited consortia to implement one or more agendas, resulting in 17 PPPs – some of them in practice in very traditional areas of research policy and cooperation (such as lightweight materials) and others increasingly focused on transitions. The PPPs issue thematic calls for proposals for R&D projects tied to their respective agendas. Applications are assessed funded by Vinnova, the Swedish Energy Agency and Formas. This prevents the PPP members capturing all the project funding for themselves. The state contributes a maximum pf 50% of the total costs of the projects with the balance being financed by the industrial participants in the projects.

4.1.10 UK Industrial Strategy Challenge Fund (ISCF)

The UK government launched a national Industrial Strategy in 2016, following a consultation process with academia and industry based on a green paper, focusing on four Grand Challenges and aiming to increase UK gross expenditure on R&D (GERD) to 2.4% of GDP (in parallel with increasing the generosity of the UK R&D tax credit). The ISCF is run by UKRI, the newly-created umbrella organisation for the UK research councils and Innovate UK. It identifies and funds academic and industrial projects within 'missions', identified by UKRI in consultation with its clients as contributing to one of the Grand Challenges. Within each mission, projects are obtained through a bottom-up application process. UKRI does not appear to establish directionality *within* the individual mission.

Table 6 shows key characteristics of the case studies, from the perspective of more transitional programming requirements.

Table 6 Characteristics of cases

Criterion	AT STI Strategy	DE High-Tech Strategy	DE Energy Transition	DK Innovation Fund Grand Solutions	DK MindLab
Governance	Cabinet-level RTI Task Force	Federal Committee of State Secretaries of 11 ministries	Sophisticated multi-level governance coordinating with federal and state governments and industry plus lower-level platforms for major components of the policy	Government	Government
What drives the agenda	Advice from the Austrian Council for Research and Technology Development	Need to improve innovation and competitiveness in the face of international competition	Climate change targets, decision to shut down DE nuclear stations by 2022, while maintaining competitiveness	5-yearly national 'research catalogue'	Government clients
Planning process	Mostly groups and enlarges existing policy measures, but extends these with road mapping	BMBF orchestrates planning across 11 ministries. Each HTS phase has its own priorities. First HTS rebranded existing activities but thereafter HTS has initiated activities	"Energy Concept' of BMWi and BMU (2010) and the 'energy package' of the Bundesrat 2011. Revisions via ministry planning and governance structure above	Thematic priorities set as above. No portfolio management	Response-mode
Scope of ambitions	Increase GERD and various other innovation indicators	National innovation competitiveness	Energy transition without loss of competitiveness	Economic impacts, chiefly	Limited to individual programmes
Addresses niche or transition level	Includes many conventional programmes but also inter-ministerial coordination group on switching to a CO2-free future	Much of the work is conventional. The third strategy has integrated societal challenges but does not attempt transition or niche management	Transition level, while managing several niches	Ambitions relate to innovation success in general	Neither – worked at a lower level
Role of experimentation and learning	None evident	None evident	None evident	None	Small-scale policy experiments
Time perspective	2011-2020	2006-2020, so far, in 3 phases	2010-	2-5 years	Months
Extension to new	No	The Industry-Science Research Alliance and the High-Tech	Interaction with civil society is limited and formal but the	No	Extensive citizen involvement in innovation projects

Criterion	AT STI Strategy	DE High-Tech Strategy	DE Energy Transition	DK Innovation Fund Grand Solutions	DK MindLab
stakeholders and citizen outreach		Forum (including civil society) advise the HTS	programme enjoys widespread public and political support		
Reflexivity, monitoring	Indicator-based monitoring but no overall evaluation	Commission of Experts for Research and Innovation (EFI) advises DE government and makes an annual assessment of progress in the HTS	Detailed, indicators-based monitoring, reviewed by independent expert group. 3-yearly progress report identifying change needs	Evaluation in progress	None evident, no evaluation
Scale	N/A	€14bn pa	€13bn pa	DKK 700m p a	20-45 people
Directionality	Only in the CO2 sub-activity	Some directionality in most of the pillars	Strong directionality	No	No
Role of PPPs and P2Ps	None	None	None	None	No
Role of markets	Not addressed	Not addressed	Coordination with subsidies for renewables funded by consumer levy An internal platform is dedicated to energy markets	Market success is the primary objective	No
Role of the demand side	Revives an innovative procurement instrument	Does not include demand-side measures	Consumer levy for renewables	Not involved	No

Criterion	FI Growth Engines	FR Competitiveness Clusters	Circular Amsterdam	SE SIPs	UK Industrial Challenge Strategy Fund (ICSF)
Governance	Platform firm and coordinator in PPPs	Jointly by central and regional government	City of Amsterdam	Boards of PPPs, which in turn manage the individual SIPs	Managed as a cross-cutting programme by UKRI
What drives the agenda	Participants who share the €1bn growth goal	Regional innovation plans	Desire by the City to make more of the economy circular	Needs of consortium members, guided by a common Strategic Research Agenda (SRA)	Forms a major component in the government's Industrial Strategy, which identified four grand challenges. ICSF identifies and funds missions within these challenges
Planning process	Internal to the closed shop of participants	Internal to the clusters	Consulting assignment to an external consortium	Begins with SRA, which is turned into a plan, reviewed annually	Grand challenges selected by government after industrial consultation, based on global market size, relevance of UK capabilities, expected societal benefits, evidence that state support will help. Missions selected based on academic/industry consultation
Scope of ambitions	Growth of the participants, in relation to the €1bn goal	Increased competitiveness at the local level	Maximise the extent to which Amsterdam's economy could become circular	Ranges from increased competitiveness to sustainability transitions	Improving productivity, growth and increased GERD to 2.4% of GDP
Addresses niche or transition level	Ambitions only relate to growth of the firms in the project	No – addresses general and technological competitiveness	Various niches	Where relevant, addresses one or more niches	Provides bottom-up funding to academics and industry in prioritised niches ('missions')
Role of experimentation and learning	None	None	Unclear	3-yearly stage-gates and re-planning encourage flexibility and learning	Unclear
Time perspective	6.5 years plus a maturity phase	20 years	Not defined	12 years (4 x 3 years)	2017/18 to 2020/21
Extension to new stakeholders and citizen outreach	No	The clusters are open to new organisations joining	Extensive training and involvement of stakeholder groups in implementation	SIPs are open to new participants and aim to increase their network size in industry and to other stakeholders	No evidence that stakeholder involvement is wider than in traditional UK industry-orientated R&I Policy
Reflexivity, monitoring	Normal Business Finland internal monitoring processes	4-yearly evaluations but not linked to funding	Evaluation was undertaken by the programme management, so not credible	Internal monitoring, 3-yearly external evaluation	First wave of projects being evaluated

Criterion	FI Growth Engines	FR Competitiveness Clusters	Circular Amsterdam	SE SIPs	UK Industrial Challenge Strategy Fund (ICSF)
Scale	Small, limited to the partners in the consortium	Currently 56 regional hubs	City of Amsterdam	Can span entire industries or industrial sub-sectors in Sweden	£450m pa
Directionality	Imposed within the project by a shared vision and road map	Only at the level of the individual cluster	No – the objective of circularity was sought by all available means	Imposed by SRA then frequently revisited	Missions identify thematic priorities but not directions within individual missions
Role of PPPs and P2Ps	Projects are run by PPPs	Cluster management is through membership-based PPPs	None	SIPs are PPP platforms. The platforms are state funded	Partnerships at project level only
Role of markets	Market success is the primary objective	Market success is the primary objective	Unclear	Varies by SIP but generally seek increased competitiveness	None – this is a supply-side intervention
Role of the demand side	Not involved	Not involved	Unclear	Varies by SIP but rising in importance	None

4.2 Gap analysis

Here we classify the ten cases using the five categories of programme developed in Section 2.4.3 and consider the extent to which (based on our analysis of Norwegian strategy formation and governance) Norway is equipped to programme in a more transitional manner.

4.2.1 Traditional single-beneficiary projects

There are (by design) no examples of these considered in this study

4.2.2 Multi-actor, multi-measure programmes (second generation programmes)

Here we should qualify this as relating to large and complex programmes. There are many simpler examples (such as the SFFs in Norway, for example) that are handled routinely by existing agencies.

The Danish Grand Solution Scheme addresses this level by funding large, collaborative R&D projects within a number of broad priorities. Projects can also be funded bottom up and there is no systemic requirement for them to contribute to a bigger plan. Despite its imposing name, the scheme therefore does not appear to go beyond normal second-generation practice. Its main originality compared with the Norwegian system is its ambition to fund *large* projects.

The Finnish Growth Engines programme is a response to the stagnation of Finnish industry and exports in the period since the 2008 financial crisis. It subsidises public-private partnerships or 'ecosystems' involving companies and research organisations via 'orchestration' funding and loans, in the hope of securing at least €1bn in new exports, assisted by various services from Business Finland. The PPP is a closed, self-managing group, limiting spillovers, although the prospect of a dramatic increase in exports is clearly attractive. Given enough capital, IN could orchestrate a similar programme, but it is not clear that it would in any sense have transformative characteristics.

The French Competitiveness Clusters operate at a much greater scale than Norwegian clusters, reflecting the size of the French regions. With their larger scale and regional focus, they are better equipped than the Norwegian ones to coordinate the thematic focus of industry, education, and research-performing organisations towards their goals. There is evidence that companies' R&D expenditure rises when they are associated with one of the French clusters but the cluster instrument itself has not shifted activity towards more transitional objectives. Rather, this remains traditional regional development, informed to a degree of the philosophy of Smart Specialisation that aims to realign the regional innovation system, not just industry. This type of regional cluster development is already being promoted by IN at a smaller scale.

4.2.3 Large and complex innovation programmes

The Austrian STI Strategy addresses a coordination problem that Norway has historically at least partly solved by reducing the number of R&I funders in the system and using RCN as an arena for policy coordination. (We discuss this role of RCN more in the next chapter.) The multi-ministry strategies devised in the past also exemplify attempts to do this kind of coordination. The Long Term Plan provides the current umbrella for such activity in Norway, though it has the limitation of applying chiefly to research and R&D-based innovation, rather than innovation as a whole.

However, the Strategy goes beyond traditional R&I funding to start addressing societal challenges such as climate change, quality of life and demographic change. At present, these activities seem to be at an early stage, with the emphasis on road-mapping and policy coordination among ministries. These appear to define themes for implementation by individual ministries and their agencies rather than resulting in a transversal and systemic policy. Overall, closer to the style of second- than third-generation programming, the Strategy does not appear to do much beyond what can already be achieved in the Norwegian system.

In contrast, the German High-Tech Strategy (HTS) is considerably more advanced, taking large steps from traditional programming and coordination towards addressing societal challenges. More complex and integrating than the Austrian strategy, its approach to the societal challenges is nonetheless to fund many projects potentially relevant to addressing the challenges than establishing something resembling transition management. Norwegian R&I Policymakers are fortunate in not having to confront the large scale and systemic complexity of Germany's federal structure. Nevertheless, the HTS' connection to the Federal Ministry of Education and Research (BMBF) and, through the Commission of Experts for Research and Innovation and the High-Tech Forum, to the federal government gives it strong social as well as budgetary legitimacy. The engagement of state secretaries across 11 ministries gives the HTS a coordinating power much greater than can currently be assembled in Norway.

4.2.4 Niche management or accelerator missions

Circular Amsterdam involves little R&D-based innovation; rather, it focuses on transferring technologies, management processes and business models that strengthen the circular economy. This can involve a fair degree of local adaptation. In transition terms, it works to extend the usefulness and use of largely-existing technologies within circular economy niches. The approach has important strengths, not least that it helps city authorities to put ideas about the circular economy into practice, but it is not a style of intervention where RCN's skills would necessarily be very useful.

4.2.5 Combinations of multi-actor, multi-measure programmes with niche management

Sweden's Strategic Innovation Programmes are much smaller in scale than most of the other cases considered here and appear to use a very flexible instrument, PPPs acting as research associations, defining and implementing strategic innovation agendas in partnership with the three agencies, which handles proposal assessment and selection. The focus of the programmes varies from conventional to transitional, depending on the local needs perceived by the PPP and the instrument is conceptually simple enough to allow platforms to evolve between these extremes. While the more transitional SIPs especially are encouraged to involve non-traditional R&D actors in their activities, the focus of the instrument and the funding are on R&I, potentially limiting their effectiveness in niche management and making it unlikely they could take on the transitional level. Their modest scale means this would be an affordable instrument for Norway but that it also involves the risk of fragmentation.

In our view, the UK Industrial Strategy Challenge Fund is a clear example of an attempt at managing multiple niches that is let down by its traditional supply-side focus, insufficient stakeholder consultation or involvement, lack of orchestration at the mission level or policy connection to non-R&I components of transition. Consistent with Mazzucato's approach (2018), it identifies and prioritises missions as addressable components of addressing Grand Challenge but t then treats these rather like conventional research council or innovation agency programmes and funding them bottom up. There is no mechanism that we can see which connects the contents of the mission programmes to road maps or learns how to refine the approach to the mission through experimentation. The result is a series of rather conventional technology programmes in areas prioritised as 'missions' rather than active niche management.

4.2.6 Transition management or transformational missions

The German Energy Transition is the clearest example of transition management among our cases. Specifically coupled to national goals for CO_2 emissions and the closure of Germany's nuclear power stations, it has the power of law behind it, a multi-level governance structure that both connects it to the relevant stakeholder groups and allows it to manage its affairs and a wider role in energy policy than simply R&I. Connected directly to the head of state, it also has popular support and a wide reach across stakeholder groups in society.

Clearly, this sort of intervention is driven by a far more acute need than R&I. It does, however, provide a strong force for coordinating R&I activities, as well as others. And it is more broadly a reaction to a sense of crisis that has yet to establish itself in Norway – despite the very long time during which the need for industrial restructuring to tackle the post-petroleum age has been obvious and the somewhat

shorter period during which it has become clear that traditional expectations about oil revenues have drastically to be reduced in response to the climate crisis. As the German programme shows, R&I would be only one of several blocks in a policy response. At present, there is little precedent for the degree of wide-ranging policy coordination and governance that would be necessary to make a transition even in a small country. And the strong, short-term economic interest in continued oil and gas production is likely to generate significant resistance.

Counter-intuitively, Norway's strength in oil and gas may position it very well to make money from a more or less inevitable transition out of fossil fuels by seizing the initiative, just as Norway's ship-building industry profited from the oil boom as it was losing its markets in conventional ships. There are other transitions that Norway could address, in which less resistance would be encountered, and it seems unrealistic to expect a small country to play more than a supporting role in most of them. But, as Schumpeter pointed out, a gale of creative destruction clears the way for entrepreneurship – and it may be better to be on the side of the entrepreneur than only to suffer the gale.

4.2.7 Denmark MindLab

This is an outlier in our sample. It was a laboratory for doing policy experiments, in the spirit of trying to identify effective policies, not only in R&D but across the whole of government. It was repurposed to supporting digitalisation in Denmark from 2018. While, clearly, a specialist in policy experimentation could be a useful asset in transitional as well as more traditional policymaking, it could play no more than a supporting role in the kind of large-scale policies discussed here.

4.3 Implications for Norway

Table 7 sets out some initial lessons for Norway at the level of the individual cases. (There is more extensive material in the full cases in the appendix.)

Table 7 Case-level lessons for Norway

Challenge	Case	Comments	Lessons for Norway
B	AT STI Strategy	Groups and expands existing instruments; adds road-mapping and an inter-ministerial working group on CO2 emissions	Cabinet-level coordination mechanism was effective but needed better vertical coordination to ensure implementation System-wide indicator-based monitoring in place before the Strategy (similar to RCN Indicator Report)
B,C	DE High-Tech Strategy	Introduces coordination at the ministry level, which in Norway is partly provided by RCN and the small scale of the system	System-wide approach, multi-ministry coordination, simultaneous orientation towards competitiveness and societal challenges
A,C	DE Energy Transition	Addresses a large-scale problem analogous to Norway's need to restructure away from oil & gas	Strong directionality supported by public and political level. Comprehensive governance, coordination and monitoring. So far generated one third of a million jobs in renewables sector
B,C	DK Grand Solutions	Aims to achieve bigger impact by increasing project size and scope. No mechanisms to deal with transitions	RCN already has the ability to launch projects with similar size and scope within the large programmes, but not bottom-up
B	DK MindLab	Small-scale, programme-level tool for improving policy implementation	Formerly fashionable approach that offers incremental policy implementation improvement. More creative agencies could play the same role
A, B	FI Growth Engines	Uses a combination of business support and innovation funding to drive growth. The beneficiaries form closed groups as the activity is close-to-market	The instruments used are largely within IN's portfolio but with the addition of innovation funding. Not clear that the benefits of moving technological innovation funding into IN to match this offer would be worth the other costs

Challenge	Case	Comments	Lessons for Norway
A, B	FR Competitiveness Clusters	Increased funding and standardisation of regional cluster activities through the involvement of the central state. Creates a specific fund for supporting cluster R&D. Probably improves cluster processes but not clear that there are effects on specialisation or division of labour	Value over and above IN activities not clear, given availability of RCN R&D project funding
C	NL Circular Amsterdam	Programme to increase the extent to which Amsterdam participates in the circular economy	Consulting firm provides ready-packaged tools for designing and implementing circular economy policies; off-the-shelf solutions are then localised in cooperation with the client, in this case Amsterdam City
(A), B, C	SE Strategic Innovation Programmes	Flexible, PPP-based approach to R&I programming that can cope with both traditional and more transformational interventions at a scale appropriate to a small country	Worth considering whether a Norwegian equivalent would be practicable
B,C	UK Industrial Strategy Challenge Fund	Funds missions in support of the four Grand Challenges prioritised in the government's Industrial Strategy via cross-cutting programmes within UKRI	Multi-level implementation of high-level national priorities (challenges) by identifying and funding lower-level programmes (missions)

We need to be cautious about over-generalising from a small number of observations. Nonetheless, the following tendencies seem to be visible.

- The more radical, system-changing programmes tend to involve the political level – at least at the level of ministers and sometimes the level of the head of state
- These are also associated with large budgets, multi-level governance and long time constants, certainly longer than a single government period
- These in turn require periodic re-planning of the programme
- Our *impression* is that these are also the interventions most likely to make a substantial difference
- Competitiveness is a goal in all cases except Circular Amsterdam, and is therefore generally seen as being compatible with addressing societal challenges
- Programme designs are usually specific to the country and the problems addressed, but Circular Amsterdam is a useful reminder that standard or semi-standard instruments can also be deployed within wider strategies
- Some of the programmes in effect repackage existing instruments, then evolve them towards more transformative or transitional goals during the life of the programme. There may be limits to how far this evolution can go, both because programmes will to some extent remain locked in to their original goals and because transitional goals may require significantly stronger directionality and broader stakeholder engagement. However, the evolutionary approach overcomes the need for a disruptive change in policymaking
- In terms of reflexivity, there was widespread use of monitoring indicators but almost no attempts at programme-scale evaluation or exploration of causality and paths to impact
- Most of our cases are national in character, but Circular Amsterdam and the French Competitiveness Clusters indicate that the regional and city levels are also viable for transitional programmes
- Beyond involving the political level, few attempts were made at wider political legitimation. The main exception is the Energy Transition, which appears to enjoy wide popular as well as political support
- Directionality was sometimes absent and was generally addressed through broad thematic prioritisation

- Stakeholders were often consulted and somewhat less often involved in programme management. Only in the Danish case was the wider research community consulted (via the periodic national consultation of goals for research. In no case does such consultation extend to the societal level, as is done by NWO in The Netherlands (not considered here)
- Demand-side policies were little involved in the programmes
- The Energy Transition was the only programme strongly linked to sociotechnical transition
- There was a surprisingly low level of experimentation throughout, given the emphasis the transitions literature places on this

5 R&I strategies in Norway

The purpose of this chapter is to explore the way and the extent to which the Norwegian R&I policy system is able to deal with complex interventions that require both vertical and horizontal coordination within the state system and the ability to integrate other stakeholders (and eventually citizens). These, in effect, are the demands that transitions-orientated policies make of the national governance system.

Our hypothesis is that Norway is unusually well-placed to do this.

- There is a history of cross-ministry R&I strategy development – though this seems to have become less frequent since the emergence of the 21-strategies
- The 21-strategies are stakeholder-based R&I strategies that are intended to support the initiating ministry in developing and implementing its own strategic direction
- RCN, in particular in the large programmes, demonstrate an ability to coordinate strategy implementation across the needs of different ministries to address societal challenges of varying degrees of difficulty

Here, we begin by discussing the way in which the Long-term plan for Research and Higher Education, which is the government's strategy for research and R&D-based innovation, is constructed. We then look at the way a number of top-down, multi-ministry strategies covering R&I and related topics have been built in the past before describing the process for writing the more bottom-up (in the sense of being stakeholder- rather than ministry-driven) 21 strategies. Finally, we discuss the two types of strategy and speculate about the ability of the current system to develop the kind of larger-scale, cross-cutting strategies needed to address socio-technical transitions.

5.1 Government research white papers

With the launch of the white paper "Long-term plan for research and higher education" (LTP) in 2014, the Norwegian government (through MER) discontinued its practice of presenting broad research white papers every four years. Instead LTPs are to be presented every four years.

The 2014 LTP was introduced as the government's most important tool for ensuring good coordination and implementation of research, innovation and higher education policy. It established that the sector principle in research policy, meaning that each ministry is responsible both for formulating policy and for long-term knowledge development in its sector, would continue. The LTP thus took its starting point in both research policy and in sector policy. The LTP explained that research and higher education touch on most policy areas and involve the business community, the public sector, the higher education (HE) sector, research institutes, expert environments and regional health authorities, and noted that Norway is well-integrated in the European research and higher education systems. The LTP concluded that these aspects place great demands on coordination and cooperation, both at the political level and among institutions and stakeholders. The LTP explained that MER is responsible for coordinating the policy for research and higher education, and that the LTP would lay the foundation for more comprehensive coordination of public commitment to research and higher education. Implementation of the LTP would take place in cooperation with the agencies that manage public programmes for HE, research, innovation and business development, including RCN, IN and the Industrial Development Corporation of Norway (SIVA), with RCN as key player. The government has set up annual summits (*toppmøter*) with research and HE communities on challenges and priorities in research and HE policy, to follow up the LTP.[9]

In 2017, MER issued guidelines for the ministries' sector responsibilities which described MER's coordinating role in research. The MER's instruments are[10]

[9] St.meld. nr. 7 (2014–2015), Langtidsplan for forskning og høyere utdanning 2015–2024.

[10] "Veileder for sektoransvaret for forskning", MER, 2018.

- **Coordination in different arenas**: politically, strategically (e.g. the LTP, the governance system for RCN), administratively (through the ministries' research committee (*departementenes forskningsutvalg,* DFU), interdepartmental working groups, advice) and joint tasks (e.g. institute policy, research ethics etc.)
- **Coordination of international research collaboration**: generic bilateral research agreements, research collaboration with the EU, and science collaboration through the OECD
- **Financial instruments**: Responsibility for cross-sectoral research funds including the payment to participate in the Framework Programme, as well as strategic investments ('Budget line 53', which replaced the Research fund (*Forskningsfondet*)) that are to
  - Contribute to monitoring the priorities of the LTP
  - Create the flexibility needed to accomplish long-term and systemic changes
  - Support research of high quality

  MER has a particular responsibility for funding of research that is not earmarked for specific themes or objectives (i.e. basic research). When it comes to the HE sector, MER governs through high-level documents such as the LTP
- **Advice**: MER guides sector ministries in their sectoral responsibilities for research
- **Responsibility for RCN**: MER is responsible for the governance of RCN and for the Council meeting its objectives. This includes managing the sector ministries' governance of RCN. The ambition is that the ministries' governance shall
  - Become more strategic and long-term
  - Focus more on impacts of RCN's activities
  - Be appropriate in terms of scope and attention to detail
  - Be efficient and consistent across ministries

The three principles (sub-bullets) under "Financial instruments" above are influenced by a spending review of RCN that was carried out in 2016/7. The review proposed measures for increased scientific quality in research and reduced administration costs in RCN, and directed its recommendations to the research system, to ministries and to RCN.[11] MER's follow-up took place through the management dialogue with RCN.

The 2017 white papers "A greener, smarter and more innovative industry"[12] and "Humanities in Norway"[13] declared that the government would review the institute sector's role in the R&I system and whether that sector is well adapted to future needs; this work has since started.

A new LTP was presented in 2018. It restates MER's overall responsibility for the Norwegian research system, including institutional funding of the HE sector, as well as its overall responsibility for coordination of the government's research policy. The LTP underlines that it is important that research funding agencies collaborate and coordinate their respective instruments in order to foster efficiency and to maximise results. MER has gradually introduced multi-year performance contracts (3–4 years) with each state higher education institution (HEI), and from 2019 all HEIs are covered by such contracts. These are contracts between MER and an HEI that contain objectives and management parameters for prioritised development areas for the institution. The contracts are expected to contribute to high quality and a diversified HE sector through clearer institutional profiles and better division of labour. Contracts may highlight areas where an HEI sees the need for special attention and are at the same time instruments for national coordination and follow-up of the LTP. The government's annual summits with participants from academia, the business community and the public sector to follow-up the LTP are said to have been important venues to discuss current issues in research and HE

11 "Områdegjennomgang av Norges forskningsråd", MER and FIN, 2017.

12 St.meld. nr. 27 (2016–2017), Industrien – grønnere, smartere og mer nyskapende.

13 St.meld. nr. 25 (2016–2017), *Humaniora i Norge*.

policy, and the government will continue with these summits. The LTP is also said to be an instrument for long-term prioritisation, and the government uses the plan in developing its annual state budgets. The MER is to carry out an analysis of whether and how HEIs have adapted their activities to the priorities in the LTP.[14]

Being responsible for research and higher education, MER led the development of both the original LTP and the 2018 revision, but in close collaboration with other ministries. In practice, MER typically proposed texts and the other departments commented, although the reverse also happened. Naturally, the largest research funding ministries tended to be the most active in the process.

While the LTP has a ten-year perspective, it is more concrete in the four-year timeframe that coincides with government periods. Implementation of the LTP is done though the annual budget discussions, ahead of which ministries propose actions within the framework of the LTP. It is said to be valued for the structure it provides to research and HE funding, and in particular by facilitating prioritisation within government; proposed ministry actions that lie outside the framework of the LTP have little chance of making it into the final version of the budget. Budget line 53 is an important instrument for MER to foster strategic investments in research, including to stimulate other ministries to increase their investments in research. However, the LTP provides direction rather than detail, and both RCN and the HEIs enjoy significant freedom. A notable difference between the LTPs and the broad research white papers of yesteryear are that the latter were not as closely tied to budgetary issues as the LTP.

Participating in the processes of developing and revising the LTPs is said to have made ministries more coordinated and more aware of each other's responsibilities, which has resulted in a better dialogue. Several interviewees explain that DFU plays a vital role in cross-ministry coordination, although it is a forum for information exchange and discussion, not for decision. DFU meetings, where ministries are represented by civil servants, are held once a month. All ministries are invited and almost all usually attend. In addition, meetings between state secretaries are held as needed.

In 2018, NFD initiated a review of the business-oriented instruments in collaboration with other ministries; the review is to be completed in 2020.[15]

5.2 Top-down strategies

The previous government developed a number of national top-down strategies, including:

- Marine bioprospecting:[16] NHD, FKD, KD, MFA (UD) and MVD
- Biotechnology:[17] MER, HOD, LMD, FKD, NHD and MVD
- Environmental technology:[18] NHD and MVD
- Nanotechnology:[19] NHD, KD, MPE, MVD, AD, HOD, FAD, FKD, LMD and MOD (FD)
- Information security:[20] MOD, JD, SD and FAD
- ICT R&D:[21] FAD, MER, SD, NHD and HOD

As indicated above, these national strategies were all multi-ministry initiatives. In the following sub-sections, we describe how three of these were developed and implemented.

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14 St.meld. nr. 4 (2018–2019), Langtidsplan for forskning og høyere utdanning 2019–2028.

15 https://www.regjeringen.no/no/aktuelt/starter-arbeidet-med-a-rydde-opp-i-virkemiddel-jungelen/id2612290/, viewed 16 February 2019.

16 "Marin bioprospektering – en kilde til ny og bærekraftig verdiskaping", FKD, KD, NHD and MFA, 2009.

17 "Nasjonal strategi for bioteknologi", MER, 2011.

18 "Næringsutvikling og grønn vekst", NHD and MVD, 2011.

19 "Regjeringens FoU-strategi for nanoteknologi 2012–2021", Ministries, 2012.

20 "Nasjonal strategi for Informasjonssikkerhet", Ministries, 2012.

21 "Nasjonal strategi IKT-forsking og -utvikling 2013–2020", Ministries, 2013.

5.2.1 Marine bioprospecting

The development of the strategy for marine bioprospecting – which was not solely an R&I strategy – was led by the Ministry of Trade and Industry (NHD) which together with the Ministry of Fisheries and Coastal Affairs (FKD) did most of the work, while MER, the Ministry of Foreign Affairs (MFA) and the Ministry of Environment (MVD) had more peripheral roles. While the division of responsibilities between the two lead ministries apparently was a bit unclear since FKD had most of the knowledge required, the collaboration nevertheless worked quite well since there were no major conflicts of interest and the two ministries managed to establish a good dialogue. The two ministries were responsible for writing different chapters, while the remaining ministries mostly commented on draft texts. Being a government product, it was clearly a top-down strategy, but it was based on expert reports and input from a range of stakeholders including HEIs, institutes, industry, agencies and others.

RCN and IN were instructed to develop action plans to follow up the strategy. NHD was content with the existing instruments of these two agencies. For its part, the government was to develop a regulation on the exploitation of marine organisms, but this regulation has not been yet been finalised (one draft was produced and then the process stalled), possibly in part due to differences in opinion between the Ministry of Trade, Industry and Fisheries (NFD, the successor of NHD and FKD) and MVD, since this is also an environmental issue. Given the change in government in 2013, the present government is not obliged to implement the strategy and it is therefore considered to be history.

5.2.2 Environmental technology

The strategy for environmental technology had its origins in the 2007 innovation white paper "An innovative and sustainable Norway", which called for increased investment in environmental technology as an innovation policy instrument.[22] The development of the strategy was a joint effort between NHD and MVD, since it dealt with both business development and climate and environmental technologies. It was more than an R&I strategy (just like the strategy for marine bioprospecting). The ambiguity as to which ministry was to lead the work led to some friction, in part since NHD wanted to focus on public support instruments while MVD mainly had an interest in regulation and environmental taxes, but to some extent also in public support instruments. The government appointed a Strategic Council for Environmental Technology, with high-level stakeholders from the public and private sectors, as well as universities, environmental organisations and others. The Council was led by the industry minister assisted by the environment minister. A Committee led by the secretary general of MVD with the assistance of the secretary general of NHD that comprised business and employer organisations, as well as agencies including RCN, IN and others, assisted the Council through preparation of meetings. In addition, an external Secretariat at the Confederation of Norwegian Enterprise (NHO) (half-funded by NHD) also prepared material for Council meetings. A group coordinated by the Secretariat ended up producing a complete strategy that had significant impact on the final strategy. On matters where civil servants from the two ministries could not iron out their differences, the political level was involved. The development of the strategy took several years, and the process itself was said to have been valuable; overall collaboration between the two ministries worked quite well.

The strategy was implemented through a temporary Environmental Technology Programme that existed for three years. The programme has in part lived on through IN's new Environmental Technology Instrument (*Miljøteknologiordningen*) for pilot projects. This instrument has grown substantially since then, since it apparently filled a gap in the public support portfolio. This was a known need that had been identified already in the white paper. The strategy also asked IN to follow up the government's priorities within the field of environmental technology, and the agency was instructed to establish a Programme Council to coordinate a range of government agencies in an attempt to use better the existing instruments in the public support portfolio for environmental technologies. The Programme Council was instructed to coordinate its work with related strategies including Energi21, OG21, Klima21 and Maritim21. The thrust to coordinate and exploit better the existing instruments in the public support

[22] St.meld. nr. 7 (2008–2009), Et nyskapende og bærekraftig Norge.

portfolio nevertheless has not been very successful. It is easier to launch a new instrument and it is also more visible, laments an interviewee.

Just as with the strategy for marine bioprospecting, the strategy for environmental technology was a top-down product, although significant stakeholder input was obtained to help guide the process. For the same reasons as with the strategy for marine bioprospecting, the strategy for environmental technology is also history.

5.2.3 Nanotechnology

In contrast to the two strategies discussed previously, the strategy for nanotechnology was a 'pure' R&I strategy. It involved much broader collaboration, since it included ten ministries. NHD led the work while the other ministries participated in a working group throughout the process. The process started with a full-day stakeholder conference and an invitation to put forth written contributions. An Advisory group with representatives from academia, industry and agencies assisted the ministries with expert advice and content quality control. The development of the strategy was timed with the closing of RCN's NANOMAT large programme. RCN had carried out a thorough analysis of user experiences that constituted valuable input to the strategy. An important feature of the strategy was to identify topics for NANOMAT's successor NANO2021; the most important aspect was the need for the new programme to focus more on risks, which became one of three equal pillars. The share of the programme budget to go to R&I on health, environment, security and ethics was to increase from 5 to 15%, which is said to have been achieved.

Just as with the two previous strategies, the strategy for nanotechnology was a top-down product based on significant stakeholder input. On the one hand, this strategy is also (for the same reason) history, but on the other hand it lives on in the LTP which mentions nanotechnology as an enabling technology.

5.3 Bottom-up strategies

In order to foster good interaction between stakeholders and to better utilise total resources, the government has initiated development of a number of area-level national research strategies, the so-called "21 strategies". A 21 process is to promote research-based value creation and development in important areas of society. It is a stakeholder-driven strategy process initiated by a ministry to promote research-based value creation and development in important societal areas. The 21 processes are characterised by

- Meeting challenges in areas of importance to society
- Developing comprehensive national strategies for research
- Broad involvement through public consultations and meetings
- Creating interaction between the business community, research institutions, stakeholder organisations and agencies

Typically, the ministry formulates a mandate and then appoints a steering group and a secretariat (which it funds). It then takes a step back and only participates in a reference group (in some 21 processes together with other ministries) to ensure that the process is followed through and delivers a strategy. The reference group does not participate in the work itself; a 21 process is genuinely bottom-up. After the strategy has been presented it is up to the government to decide what to do with it.

The first 21 process, OG21 (oil and gas), was established by the Ministry of Petroleum and Energy (MPE) in 1999. The first OG21 strategy was presented in 2001, and three more have been presented since then. The same ministry then initiated the Energi21 process in 2008, and with time four strategies have been produced. OG21 and Energi21 are tied to RCN's PETROMAKS and ENERGIX programmes, respectively, and the strategies propose direction for the programmes. OG21 and Energi21 have over the years been blessed with numerous siblings, see Table 8.

Table 8 The 21 strategies.

Name	Publication year(s)	Ministry	Website	Status (based on web activity)
OG21	2001, 2006, 2011, 2016	MPE (OED)	og21.no	Secretariat at RCN; active
Energi21	2008, 2011, 2014, 2018	MPE (OED)	energi21.no	Secretariat at RCN; active
Maritim21	2010, 2016	NHD	maritim21.no	Secretariat at RCN; no activity on website since 2016
Klima21	2010	MER	klima21.no	Secretariat at RCN; no activity on website since 2010; inactive
Hav21	2012	FKD	hav21.no (not available)	Website not available. No (other) activity since 2012; inactive?
Miljø21	2014	RCN	N/A	No website; inactive?
HelseOmsorg21	2014	HOD	www.forskningsradet.no/prognett-helseomsorg21/HO21_sporreundersokelse_2018/1253985487298	Secretariat at RCN; active
Skog22	2015	LMD	www.innovasjonnorge.no/skog22	Secretariat at IN; no activity on website since 2015; inactive?
Bygg21	2017–2019 (8 separate reports)	KMD	bygg21.no	Secretariat at Direktoratet for byggkvalitet; process on-going
Digital21	2018	NFD	digital21.no	Secretariat at Digital Norway
Transport21	2019?	SD	N/A	Secretariat at RCN?; process on-going
Prosess21	2021	KMD	www.forskningsradet.no/prognett-prosess21/Om_programmet/1254036740221	Secretariat at RCN; process on-going

Source: Websites.

Based on their web presence (or lack thereof), it seems that Klima21, Hav21 and Miljø21 are no longer active. It is likely that Maritim21 and Skog22 remain active also after presentation of their respective strategies, but they do not appear overly keen on updating their websites. Bygg21, Transport21 and Prosess21 have not yet presented their strategies (Bygg21 has presented some but not all of its deliverables) so these are obviously work in progress.

The 21 processes that seem to have been the most active after presentation of their strategies are OG21, Energi21 and HelseOmsorg21. An overview of their implementation is provided in the following sub-sections. We also take a brief look at the recently concluded Digital21 process.

5.3.1 OG21

MPE initiated OG21 in 1999 and since then OG21 has presented four strategies, the most recent one in 2016. The OG21 strategy states that the implementation of the strategy is dependent upon efficient communication and engagement of stakeholders. It is OG21's responsibility to communicate the strategy's recommendations to its stakeholders. OG21 argues that a number of actions are important to strengthen stakeholder involvement and engagement.[23]

- Provide well-documented guidance on petroleum R&D to MPE
- Continue the Technology Target Areas also during the periods between strategy document revisions
- Maintain good relationships with Konkraft, Intsok, Norsk Industri and the Norwegian Oil and Gas Association, and provide relevant information to these industry organisations

[23] "Oil and gas for the 21st century. Strategy document", OG21, 2016.

- Strengthen the relationship with relevant technology cluster organisations
- Take on an 'expert role' on petroleum technology in the public domain

The OG21 board monitors the implementation of the strategy on a continuous basis and evaluates whether the following success criteria are met.

- The OG21 strategy continues to be the basis for public investments in petroleum R&D
- The OG21 strategy is well known to decision makers in oil companies, supplier companies, research institutes and academia
- The OG21 strategy influences technology and business investments of oil companies, supplier companies, research institutes and academia

The OG21 secretariat at RCN publishes annual reports. In 2017, three main activities were carried out (within a budget of NOK4.5m):[24]

- Conducting a study on business models and contract strategies for increased technology uptake (by Boston Consulting Group following procurement by the OG21 secretariat))
- Implementation of the OG21 forum
- Communication

At the annual OG21 forum, high-level decision-makers in the petroleum industry (240 participants in 2017) gather to discuss the further importance of technology and innovation for value creation in Norway and on the Norwegian shelf. The objectives of the OG21 forum are

- To be an arena for presenting OG21's findings and analyses
- To be a meeting place for decision-makers
- To provide an opportunity to focus on particularly important issues
- To enhance OG21's visibility

OG21's communication activities are comprehensive and aim to disseminate results and recommendations from both the strategy and in-depth studies to stakeholders within and beyond the petroleum industry. Communication is implemented through lectures and presentations, editorial articles and meetings with stakeholders; activities are carried out by the secretariat, board members and the leaders of OG21's four TTAs. In 2017, activities focused on communicating the 2016 OG21 strategy to key stakeholders, including at conferences and to the boards of RCN's PETROMAKS2 and Demo2000 programmes. Prioritised technology needs and recommendations from the OG21 strategy are followed up by the OG21 board and are documented in the annual report.

5.3.2 Energi21

MPE launched Energi21 in 2008 and since then Energi21 has presented four strategies, the most recent one in 2018. Energi21 is Norway's national strategy for research, development and commercialisation of new climate-friendly energy technology. It aims to contribute to coordinated, efficient and targeted research and technology efforts in the area. The strategy has been prepared by the energy industry and gives advice to agencies and industry on how new technologies for the energy sector should be fostered and coordinated. The strategy prioritises areas that should be reflected in energy R&I funding instruments offered by RCN, Gassnova, Enova, the Norwegian Water Resources and Energy Directorate (NVE) and IN. Figure 12 illustrates the intended role of the Energi21 strategy.[25]

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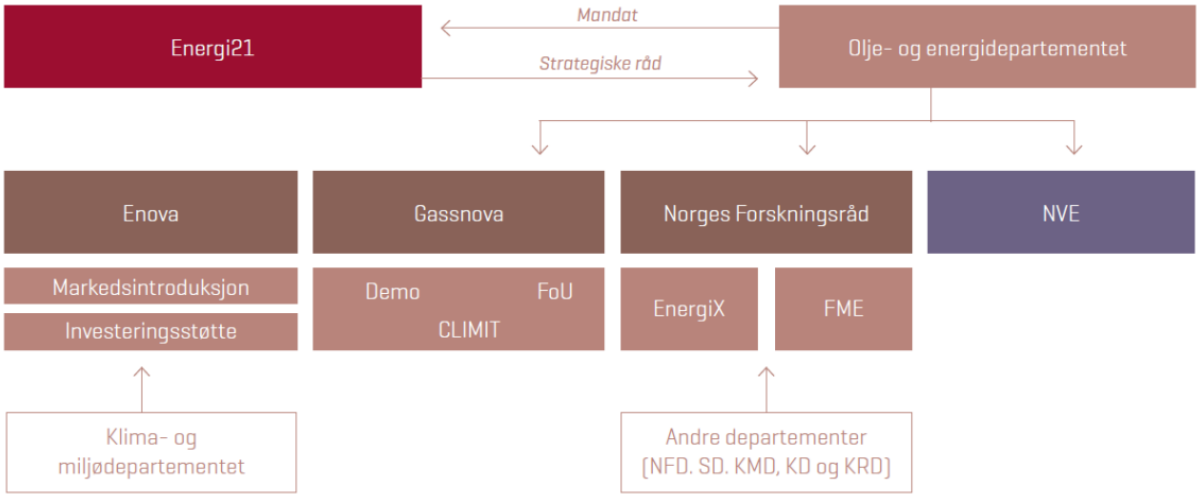
24 "OG21 Årsrapport for 2017", OG21, 2018.

25 "Nasjonal strategi for forskning, utvikling, demonstrasjon og kommersialisering av ny klimavennlig energiteknologi", Energi21, 2018.

Figure 12 Role of the Energi21 strategy.



Source: Energi21 2018 strategy.

The Energi21 strategy emphasises that realisation of several of Energi21's priorities depends on sector cooperation at agency level. Absence of cooperation leads to lack of continuity, technology areas that fall between chairs, and failure to realise necessary knowledge and technology development. Absence of knowledge and technology development is unfortunate for research and business actors and not least for value creation more generally. It is therefore important that ministries continue their good cooperation across sectors, both for development of knowledge and technology and, not least, for industrial development in the energy field. The Energi21 strategy advocates collaboration with OG21, Digital21, Prosess21, Maritim21, Hav21, Skog22, Bygg21 and Transport21 to harmonise strategic foci and to utilise synergies at the interfaces between their respective remits. Such collaboration would ensure holistic research strategies and development within the relevant technology and thematic areas.[26]

5.3.3 HelseOmsorg21

The Ministry of Health and Care Services (HOD) started HelseOmsorg21 in 2013. While HOD formulated the mandate, it was a strategy group that wrote the strategy with the assistance of a secretariat at RCN. HOD only participated as an observer in a reference group to ensure that the process would succeed in producing a strategy; MER, NFD, ASD, KMD, MFA, JD and BLD also participated in the reference group. The Strategy group was also tasked with establishing a permanent High-level group of stakeholders (*Topplederforum*). The HO21 process differed from most other 21 processes due to most stakeholders coming from the public sector, which is explained by hospitals and health services being public.

The HO21 strategy, which was presented in 2014, forms the basis for long-term, comprehensive development of R&D&I in public health and for health and care services. The strategy provides a comprehensive set of key priorities, challenges and capabilities in the Norwegian health sector and related industries.[27]

The eight ministries from the reference group subsequently collaborated in developing a government action plan to follow up the HO21 strategy. The development apparently was the result of smooth collaboration between the ministries, but this was not a given since the strategy was a bottom-up product. Participation in the reference group and in developing the action plan is said to have resulted in tighter collaboration between the eight ministries. The action plan places responsibilities for forty actions within the ten strategic initiatives of the strategy with specific ministries, mostly HOD and MER.

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26 Ibid.

27 "Nasjonal forsknings- og innovasjonsstrategi for helse og omsorg", HelseOmsorg21, 2014.

Most of the actions are for individual ministries, but some are joint responsibilities.[28] The action plan has resulted in commissions to RCN and the Norwegian Directorate of Health. Most of the actions have by now either been completed or initiated. The strategy also includes a number of actions for stakeholders in the system, including the regional health authorities and industry.

RCN's health R&I policy from 2016 aims to increase cohesion between the Council's funding and other strategic initiatives in the health field. The policy is also RCN's tool for monitoring the HO21 strategy. RCN's policy notes that the Council is the source of only 10 percent of national R&I funding in health, but sees two strategic roles for the Council[29]

- To promote quality through offering competitive research funding
- To encourage and provide funding for interdisciplinary and intersectoral R&I cooperation between HEIs, research institutes and hospitals, between specialist and primary care, and between the public and the private sector

In November 2016 RCN launched the HO21-monitor website to provide a one-stop shop for national statistics on health and health care research.[30] The HO21-monitor was one of the actions of the government's action plan.

Another of the actions in the government's action plan was to map barriers and attitudes to cooperation between HEIs and hospital trusts. In 2015, MER and HOD therefore appointed a working group with a mission to identify potential barriers and propose how cooperation could be improved.[31]

Implementation of the HO21 strategy is not mainly a matter of allocating new funding, so most actions need to take place within existing budgets. The strategy is more a matter of forming a mutual understanding on how to get better analyses and more efficient research. The strategy had substantial impact on the 2014 version on the LTP (despite the HO21 strategy being presented the same year).

The High-level group from the HO21 process has been replaced by the HelseOmsorg21 Council, which meets 4–6 times per year. Members are personally appointed to the Council; HOD participates as observer. The Council's mandate, which originally was meant to expire by end of 2018 to coincide with the far end of the government's action plan, has been extended to end of July 2019 to allow for the presentation of an upcoming white paper on the health industry, the development of which is led by NFD in collaboration with HOD. What will happen to HO21 thereafter is not yet decided.

5.3.4 Digital21

The Digital21 process is a result of the government's industry white paper "A greener, smarter and more innovative industry" and was initiated by NFD. Digital21 includes regulation, knowledge, public procurement and more, so it is not only an R&I strategy. There is no obvious public R&I programme to which the strategy can be tied. Since this strategy was intended to be by industry for industry, it was not natural that RCN should host the secretariat (as with most other 21 processes). Instead, the secretariat is hosted by the industry-backed organisation Digital Norway.

In the original 21 processes the strategy group has lived on to implement the strategy, but the Digital21 strategy group has been disbanded – at least while the government decides what to do. The 2018 LTP explains that NOK10m has been allocated for NFD to follow up the Digital21 strategy in 2019, and that the strategy's recommendations will be reviewed together with the Ministry of Local Government and Modernisation (KMD) and MER..[32] So far there has mainly been consensus on how to implement

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28 "Regjeringa sin handlingsplan for oppfølging av HelseOmsorg21-strategien", Ministries, 2015.

29 "Helhetlig helsesatsing i Forskningsrådet", Policy for forskning og innovasjon 2016–2020, RCN, 2016.

30 www.helseomsorg21monitor.no.

31 "Samordning mellom universiteter og helseforetak. Identifikasjon av utfordringsbilder med forslag til løsninger", RCN, 2016.

32 St.meld. nr. 4 (2018–2019), Langtidsplan for forskning og høyere utdanning 2019–2028.

Digital21, so collaboration between ministries has run smoothly. Norway now has a minister of digitalisation, which actually may be one way to implement the Digital21 strategy, since he has been tasked with coordinating all aspects of digitalisation. During 2019 the responsibility for coordination will be moved from NFD to KMD (where the minister is).

5.4 Discussion and conclusions

Norway's sector principle is regarded by the people we spoke to in the ministries as both an asset and a challenge, but all interviewees argue that the advantages are greater than the disadvantages. The sector principle is an asset when it comes to knowing what and where the needs are. The challenges lie in the time and energy required to bridge differences and reach a common understanding. Most ministry interviewees hail the monthly DFU meetings among civil servants as important fora to address challenges arising from the sector principle. However, that meeting cannot make policy decisions, which can only be taken by ministers.[33]

In relation to the *top-down*, multi-ministry strategies, interviewees explain that it is always challenging to coordinate R&I policy between ministries, but even more so if it is unclear which ministry is to lead the development of a strategy. Provided leadership is clearly assigned and all affected ministries are involved throughout the process of developing an R&I strategy, then it is possible to develop the trust and the common understanding required to develop genuinely joint policy. This is a labour-intensive and time-consuming process but is still to be preferred to the too-common situation where one ministry develops an R&I strategy without involving other affected ministries before the required final hearing round. Such an approach prevents development of a common understanding meaning that in practice the strategy is not supported by the entire government.

The extent to which the sector principle creates problems depends on the extent to which different interests are in conflict, between – and sometimes within – ministries. Since it spans the remits of at least eight ministries with differing standpoints and includes a range of thorny issues, the 2016 bioeconomy strategy[34] proved particularly challenging to develop. The greater the differences are, the more important it is to involve all affected ministries from the start of the process, particularly if the intention is to develop entirely new policy. Finding or developing mutually acceptable compromises takes time.

Although the LTP is a multi-ministry strategy, it is a strategy for research and higher education that corresponds to MER's main responsibilities. The LTP therefore does not encompass all aspects of innovation, meaning that it is not an all-encompassing R&I strategy. Rather, it focuses on research and technological innovation.

The 21 strategies are important instruments for conveying *bottom-up* needs from stakeholders to government. They have clearly influenced both the LTP and national strategies and have resulted in many assignments for government agencies.

Programme plans for RCN's programmes are developed by RCN without direct government input, based on the Council's own analyses and background reports, external evaluations, and national strategies (where available). The 21 strategies also provide priorities for RCN's programmes and thus influence calls for proposals. Examples include OG21 influencing PETROMAKS, Energi21 ENERGIX, Klima21 KLIMAFORSK and Digital21 IKTPLUSS.

The ministries that allocate resources to RCN's programmes govern through their annual letters of instruction (*tildelingsbrev*) to RCN. Ministries that are large funders of RCN programmes tend to give the least detailed instructions, whereas small funders provide more detailed (and thus restrictive)

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33 The government's research committee (*regjeringens forskningsutvalg*, RFU) consisting of ministers was discontinued by the present government.

34 "Kjente ressurser–uante muligheter. Regjeringens bioøkonomistrategi", NFD, LMD, KLD, KD, KMD, OED, SD and MFA, 2016.

instructions. In general, the instructions nevertheless give great freedom to RCN, which is typically more restricted by its own operating plans than by ministries' instructions.

We heard little evidence of coordination of annual instructions between ministries that co-fund the same RCN programme. Ministries tend to only concern themselves with their own sector priorities, meaning that it is up to RCN to handle coordination downstream. The sector principle is therefore a concern at programme level since it fragments scientific fields and restricts transition opportunities. There is said to be significant unrealised synergies between ministries' instructions, but their behaviour is not amenable to reaping such synergies.

MER's 2017 guidelines for the ministries' sector responsibilities nevertheless appear to have led to somewhat better coordination between ministries, as well as to ministries writing shorter and less detailed letters of instruction. They may possibly also have led to issues being addressed at a higher abstraction level which has made it easier to coordinate ministries' instructions and given RCN increased flexibility.

The evidence discussed in this Chapter suggests that the strength of the sector principle in Norway, combined with the prime minister's role as *primus (prima) inter pares* rather than having the quasi-presidential authority evident in the UK or Finland, mean that coordination shapes a lot of policies that run across ministry responsibilities. Norway does not tend to make policy by *fiat*. This has many advantages but also means that radical changes can be hard to implement, because everyone has to agree.

The LTP, which has become the key process setting research policy, involves widespread consultation and then cross-ministry coordination to develop a consensus under the leadership of MER. However, the LTP does not include (all of) innovation policy. It has little to say about what IN does, since that is an agency of NFD rather than MER. The clear division of labour between RCN and IN described in Chapter 2 is not only supported by the different competences of the two agencies but also reflects the fact that *overall* policy in the two spheres is separately developed and not well coordinated.

Nonetheless, the strategy development processes described above show that the Norwegian ministries are fully capable of overcoming the barriers inherent in the sector principle and of cooperating in developing common strategies relating to specific challenges. And they can work both in a top-down, ministry-driven mode and in a more bottom-up fashion where stakeholders have stronger influence. Less certain is how well they can combine the multi-ministry approach with involving stakeholders coming from different sectors. RCN has demonstrated its ability to host secretariats for such strategy development as well as to connect the strategies with research and technological innovation programmes, where appropriate.

The effectiveness of strategy deployment is hard to judge, since many strategies are intended to influence ministries' thinking rather than resulting in specific and identifiable actions in society. In the cases where strategies clearly are implemented, this happens through existing agencies and programmes in RCN and uses existing budgetary resources. And so far, strategies have been incremental and easy to embed in the existing system rather than being disruptive by requiring the creation of new organisations or cross-sector operating alliances. A recent case of disruption is the emergence of Enova, which was established by MPE on a small scale in 2001 and which only emerged as a major actor in 2014, when its budget was dramatically increased.

Our overall conclusion is that, if more transitional interventions to address societal challenges require both cross-sector working and widespread stakeholder involvement, then Norway has much of the needed experience with both dimensions but little history of combining them together at scale. This, then, could be a significant organisational challenge for implementing more transitional policies, stretching beyond the R&I sphere.

6 Policy responses

This final Chapter suggests that the international policy climate or 'mood' is moving in the kind of direction the OECD recommended for Norway. It uses the classification of different types of instrument developed above, to suggest what types of intervention could be developed in order to deal with each of the OECD's three strategies. Finally, we sketch some processes that would allow Norway to reach up to a more ambitious and comprehensive level in addressing certain of the issues identified by the OECD, while at the same time retaining existing first- and second-generation instruments.

It would nonetheless be fair to ask the question "Why bother?" Why bother to respond to the OECD's challenges? We see at least four reasons.

First, the Norwegian economy does not show strong signs of spontaneously restructuring in higher-productivity directions or finding economically attractive things to do once the oil and gas adventure comes to an end. It is perfectly possible for the wider restructuring that is taking place at a global level to pass Norway by, reducing its ability to maintain the high levels of welfare to which Norwegians have become accustomed. In the medium term, this would have undesirable political, as well as economic, consequences.

Second, there is no sense of crisis that would automatically trigger a reaction. This was a matter of wide discussion in relation to industrial restructuring already twenty years ago (Reve & Jakobsen, 2001) (Arnold, et al., 2001) and rather little has changed in the intervening years. While, thankfully, there is a growing understanding of climate change as a crisis in Norway as elsewhere, an effort in national reflection is needed in order to appreciate the significance of the other transformations that will be needed in the coming years.

Third, inactivity is reinforced by many of the attractive characteristics of modern Norwegian culture. The egalitarian concern for everyone's welfare and to consult everyone that underpins Norwegian society also promotes 'distribution politics' and a disinclination to tolerate the kind of 'unfair' concentrations of resources that are needed to invest in new trajectories. While these values encourage lock-ins, they are central to the culture and should not easily be given up. The solution is to find ways of making more transformative policy that are socially legitimised. We provide some ideas below about how to do this.

Fourth, the 'societal challenges' and the UN's Sustainable Development Goals (SDGs) are becoming embedded in national policies in many countries around the world. This shift of focus will itself have a big effect on markets – as manufacturers of capital equipment for renewable energy have discovered to their great benefit. If the context is changing, then Norway needs to change too. The kinds of disruptive change that may be unleashed will undoubtedly create economic opportunities. Norway should position itself to benefit from them.

There is thus a set of good economic reasons for responding to the OECD's challenge. It is also important to respond to certain of the societal challenges for ethical reasons and even in order to enable the survival of our species in the medium term. The way to make an effective response is through the economy: identifying aspects of the societal challenges where Norway has or can build competitive advantage and to invest in exploiting these. The societal challenges will be addressed through economic activity. This seems to be an unusual case where doing the right thing and making money can coincide.

6.1 Some wider policy trends

R&I and wider policy are internationally being affected by three trends. The highest-level is perhaps the gradual integration of the SDGs into national policies – not only within R&I but also across a sider set of policies. This poses a certain risk, since the SDGs cover a very wide set of issues, that they will make it more difficult to prioritise. That means, in turn, that prioritisation among the SDGs is important at the national level. The UK Global Challenge Fund works across all parts of UKRI to relate UK research to the SDGs and development. Sweden has gone very far via work in ministries, agencies and the national Agenda 2030 Delegation, embedding SDGs in ministry activities, new legislation and standing orders for authorities, and setting up national and regional Agenda 2030 committees for outreach to civil

society. Norway has mainstreamed the SDGs, attaching specific goals to individual ministries, but so far with limited evident effect on policy.

A second trend is towards wider consultation. In R&I, the most extreme example is perhaps the policy of the Netherlands research funding council NWO periodically to launch a national consultation to discover what research priorities citizens see as important. In the last consultation, some 12,000 citizens made suggestions, which were then processed by NWO with support from the research community and other stakeholders. However, The Netherlands is relatively unusual in reaching out to civil society as a whole. Denmark has a similar process, but more focused on the research community. Norway in turn consults widely within the research community when developing and revising the LTP.

The third trend is that during the last couple of years, there has been discussion in EU member states as well as in the Commission on integrating missions into the 9th Framework Programme, Horizon Europe. Inevitably, this concern has spilled over into developing new policies at Member State as well as at EU level. Little in the form of new programmes has yet to emerge but such programmes can be expected within a short period of time.

These developments suggest that the international policy discussion and climate is moving in the more transitional or transformative direction suggested in the OECD's review of Norway.

6.2 Possible responses to the OECD

Chapter 3 paints a picture of a reasonably complete first- and second-generation innovation support system. There is scope to do more on the demand side beyond the long-established OFU and IFU innovative procurement schemes run by IN. Nor does there appear to be in Norway a tradition of diffusion support to end-users adopting new technologies such as solar photovoltaics. Indeed, R&I policy has a strong supply-side orientation in Norway. This is already somewhat problematic from a second-generation innovation perspective that recognises the important of the demand side and its interplay with supply. It becomes even more problematic in the context of third-generation policy. The other significant issue is activation: how to increase the number of firms doing R&D and the amount they perform, where it seems that existing measures may be encountering diminishing returns.

While the issues raised in Chapter 3 can be addressed within a rather static way of understanding the national research and innovation system, the OECD's challenges are more dynamic and systemic: they involve structural transformations of various kinds. Our review identified five categories of instrument, four of which appear useful in addressing at least some of the OECD's challenges.

1. Traditional single-beneficiary projects such as funding basic research in universities need always to be present, since the failures identified in first-generation governance never go away. However, they address few of the challenges raised by the OECD
2. Multi-actor, multi-measure programmes (MAPs) are typically second-generation, but exist in both in large- and smaller-scale versions, some of which are relevant to the OECD's challenges
3. Large and complex innovation programmes in effect extend category 2, but at greater scale and tackling greater complexity on the policy side, the part of the system in which the policy intervenes, or both
4. Niche management or accelerator missions are unequivocally third generation, operating potentially at a limited scale but still likely be large in relation to the resource of a small country
5. Transition management or transformational missions are the 'big guns' of the third generation, focusing more directly on transforming socio-technical systems and the 'regime' (Figure 5).

The OECD's challenges[35] together cover the five instrument categories. We read the 'innovation systems' challenge as a call to improve the system overall, so that it is widely competitive and efficient but also to an appropriate degree specialised towards national needs. That implies continuing to use first- and

[35] For the purpose of the table, we have re-ordered the challenges, switching the second challenge with the first

second-generation instruments – some bottom-up to ensure there is broad capacity – but also scale and strength in nationally-relevant themes through larger-scale instruments such as MAPs and, potentially, larger and more complex innovation programmes. In addition to small-scale, bottom-up instruments (including activation), MAPs, like SFIs and to some degree larger, complex innovation programmes are relevant. Relevant models include RCN's bottom-up R&I instruments, its large, thematic programmes, Norwegian and French cluster programmes and aspects of the German High-Tech Strategy.

Table 9 How instrument categories relate to the OECD challenges

OECD Challenges	Single-beneficiary	MAPs	Large, complex innovation programmes	Niche and accelerator missions	Transition management or transformational missions
More competitive innovation system	√	√	√		
Diversified, robust economy		√	√	√	
Structural transformations, societal challenges			√	√	√

In addition to supporting bottom-up R&I programmes (including start-ups) on the basis that something may turn up, diversifying the economy requires more structurally orientated instruments that are thematically focused. MAPs will help with this on the supply side, as will larger-scale complex innovation programmes. But significant restructuring will also need measures outside traditional R&I policy. An obvious analogy is the wide range of R&I, regulatory, educational and infrastructural measures that was needed to enable Norway's adventure in oil and gas. Restructuring will certainly require medium-scale interventions, but it may well be necessary to work at the level of one or two national missions, reaching beyond R&I measures, if it is possible to identify and agree upon the thematic focus. Aspects of the German High-Tech Strategy and the Austrian STI strategy are relevant examples, as is the UK, mission-orientated Industrial Strategy Challenge Fund. However, all of these are in our view overly supply-side orientated. A wider approach stretching further beyond traditional R&I Policy would be needed.

The OECD's challenge regarding structural transformations and addressing societal challenges requires a response from the instrument categories to the right in Table 9. The German Energy Transition is the biggest, most radical example but smaller-scale missions and even complex innovation programmes are relevant. The literature suggests that attention to the demand side and to stakeholders and actors outside the normal scope of R&I policy will be especially important here.

In terms of delivery, RCN is fully capable of tackling the second-generation instruments. In Norway's much more centralised system than that of Germany, RCN already does much of the coordination that BMBF has taken on in order to implement the High-Tech Strategy. If Norway were to attempt something similar, it would nonetheless be useful to increase the involvement of the sector ministries in order to increase the degree of coordination and to create a discussion-platform in which it would be possible progressively to make the collective ambition more transitional, which is the path that BMBF has followed in the High-Tech Strategy.

Niche and accelerator missions involve reprioritising national resources towards specific themes. In a system based on the sector principle, that is a demanding requirement. It is difficult to envisage it being met without going beyond the current way of doing prioritisation, obtaining legitimacy not only within the R&I policy community but also more broadly in society.

Our earlier analysis made it clear that RCN has significant coordination capacity and capabilities across R&I policy, typically using the logic of efficient implementation as a way to converge the interests of different ministries. The broader government system has also shown that it can both develop cross-ministry strategies and reach beyond the traditional R&I system in order to involve a wider set of stakeholders – though perhaps not quite as wide as the missions or transitions approaches require. In

some cases, RCN has managed the implementation of such strategies; in others the ministries themselves have been the relevant level for implementation.

It remains an open question (in Norway and elsewhere) whether we need to build dedicated structures to tackle individual missions or transformations. Enova goes some of the way along this road, but its role is confined to piloting and large-scale demonstrations of innovation. Pilot-E, jointly run by RCN, IN and Enova, is a flexible but identifiable construction that bridges very different functions in R&I support *ad hoc*, responding with appropriate combinations of instruments to each new situation.

Our overall conclusion is that Norway has the building-blocks needed to tackle the more ambitious approaches suggested by the OECD, but that in order to put the larger ones in place there will be a need for more joint working across the system.

6.3 What is to be done?

Based on Table 9, this Section provides examples of programmes that could address the OECD's challenge. These possibilities are by no means exhaustive.

A key need in developing a **competitive and efficient innovation system** is partly to do more of the same, based on the current traditions of bottom-up and thematic funding. More effort may be useful on the demand side and the issue of activating R&D in firms needs further attention. Given the diminishing returns to Skattefunn, that probably needs to be done through direct means, such as cluster and supply-chain programmes and stronger innovation supports, both bottom-up (as in BIA) and top-down in thematic programmes. More creative use of functional specifications in state procurement could also be made here.

Norway has already invested in both centres of research excellence (SFFs) and 'competence centres' with industry, in the form of the SFIs. International experience is that these are powerful types of instrument, so it would be useful to test whether there are opportunities to fund more of them – while looking out for diminishing returns caused by exhausting the supply of good centres. Such centres tend to be created bottom-up, based on the availability of capability and interest among firms and researchers, while pursuing their own ends. It is possible to conceive of modifying the SFI logic, in particular, by introducing state funding orientated to reaching mission-related goals set top-down (in a wider process of consultation). That would co-opt bottom-up interest to mission- or transformation-orientated goals, though alone it would not respond to the need to engage the demand side more closely.

The presence of RCN in the Norwegian system means that there is already a mechanism in place that provides a degree of cross-ministry coordination in second-generation R&I Policy. In particular, this means that there is little pressure to create something like the German High-Tech strategy, whose origins are in the need for coordination.

Achieving a **more diversified and robust economy** requires a degree of disruption, if Norway wants to increase the rate of restructuring beyond the rather slow rate that is normal. Hidalgo et al (2007) have shown systematically through analysis of trade patterns that it is easier to diversify into related branches of business by using and modifying existing knowledge and networks than to move into completely new ones. It therefore makes sense to build as far as possible on existing strengths, even when entering new areas, and this needs to be reflected in the way funding programmes work.

Opportunities for diversification can come both from the private and the public sectors. Opportunities in health, social services, education, infrastructure and other areas are likely to involve both. While the state can probably guess at some of the opportunities, others will come as a surprise, so any programme in this area needs (a) to have a strong bottom-up element while (b) permitting (but not requiring) parts of the state to be significant actors. Swedish experience with the SIPs, and earlier the Competence Centres programme, is that a bottom-up call reveals points of strength in the innovation system and can identify viable coalitions of stakeholders willing to act together.

Experience also suggests that common planning work is a useful way to cement such coalitions and to establish some directionality. This is as true of Japan's history of 'visions' that guided the development

of certain parts of industry and of road mapping traditions such as the use of Moore's Law by industry to guide the development of silicon semiconductors. The SIPs, like some of the European Union's large instruments, use the co-development of a common strategic research agenda as a way to chart a course for the coalition.

A way forward in Norway could be to establish a national diversification programme, in which

- Consortia are invited to express interest and demonstrate their ability to develop an innovation-based diversification agenda. Consortia members can include companies, research-performing organisations or state organisations, but there must be a mixture of research-performing organisations and potential users
- Promising consortia receive a grant to support the development of a strategic innovation agenda – and may reach out to additional organisations to join the consortium as it develops
- Based on their agendas, consortia then compete for more substantial support over a period of several years, based on the apparent likelihood that their agendas will enable innovation and diversification

The SIP programme offers a useful model for this more substantial support, which could be adapted to Norwegian circumstances. It involves supporting funded SIPs (a) by paying for a secretariat that manages the programme and runs competitions for project funding and (b) by arranging the assessment and funding of project proposals by a state research and innovation funding agency (so as to prevent the consortium members from capturing the project money). In this way, the Norwegian consortia would build the ability to diversify, partly through their own internal efforts and partly with external project assistance. The secretariat function could be set up as a PPP or could be provided by funders such as RCN and IN (potentially in collaboration).

The expected outcome would be a series of consortia creating new areas of business. By way of illustration, we could for example imagine a consortium with sub-sea oil and gas experience creating a supply chain for sub-sea engineering in off-shore wind power or an aquaculture consortium diversifying through the introduction of new species and new feed technologies.

In **structural transformations and societal challenges**, we would expect a stronger role for society and the state not only in setting priorities and in legitimating the effort but also in implementation. Addressing these challenges requires the active involvement of much more than the research and innovation system, so the governance system needs to be much broader. It also involves going against the doctrine of 'branch neutrality', which is important to parts of government and society. While that is unavoidable, it will be important to ensure that there is competition at the programme and project level and that state intervention promotes ecosystems or clusters rather than 'picking winners' in advance at the level of individual companies.

We see two, conceptually distinct categories. The first comprises existential challenges, notably climate change, whose risks are so high that they need to be addressed irrespective of other policy considerations. Our impression is that the Norwegian climate change effort is fragmented and internally contradictory – on the one hand doing exciting experiments with electric ferries and aircraft while on the other hand continuing to support Norway's role as a major supplier of fossil fuel. It could be useful to look at the way the Energiewende and the UK Climate Change Act of 2008 are being managed, as top-down programmes with multi-level governance and evaluation. The government might wish to put other existential challenges into this category, for example biodiversity. That is a political decision, which is beyond our scope.

The second category covers other societal challenges. These are important but not always existential. Small countries, particularly, have to be selective about which ones to address, so this is an area in which Norway can make choices. Given the size of the country, wider societal challenges need to be addressed selectively at the missions level. The central question is "In which societal challenges can Norway make a contribution by making money?" That means there is a need for a prioritisation process at the national level to select a small number – probably two or three – of missions to be prioritised. This could involve

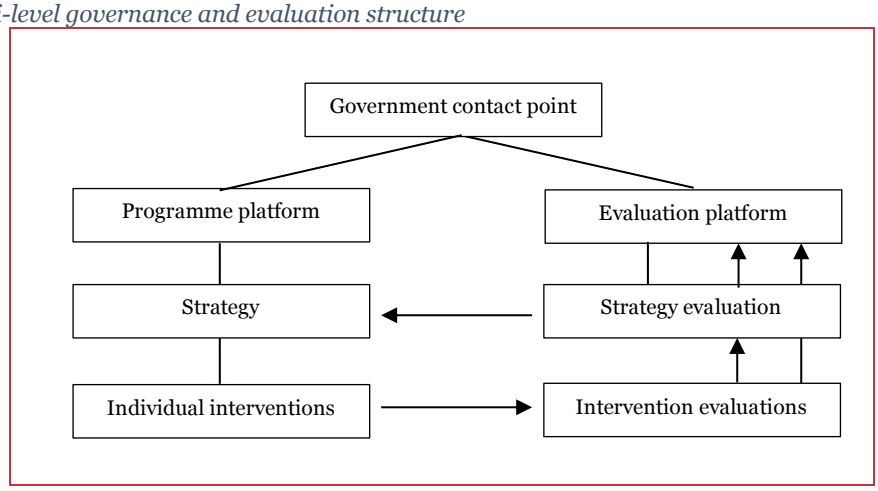
- A broad consultation, spanning citizens, business, the state and the research community, to identify a set of societal challenges that could be tackled and to ensure the social legitimacy of including them among possible candidates
- A selection process, reducing the number of challenges to be considered to, perhaps, half a dozen
- A foresight exercise, involving panels of informed citizens and stakeholders in creating desirable scenarios involving intervention, setting out the expected impacts and explicitly identifying the unique contributions Norway could make and the benefits to Norway (in business as well as social terms) of doing so. It is especially important that relevant ministries are involved, as they will play big roles in funding and implementing the interventions
- A final selection process, which assesses the proposed scenarios and selects perhaps three for implementation, based primarily on the amount of economic benefit thought likely to accrue to Norway. This is likely to be a good indicator of Norway's overall contribution to addressing the societal challenges
- The government has to own the selection process and its results and devote considerable effort to communicating the results of its process back to the citizens, showing how this connects with the original consultation

Implementation for each challenge Norway decides to address needs to be governed by a sub-set of ministries that will be involved in funding and implementation. That node needs in turn to report directly to government.

Each challenge will need an operating agency or programme platform. For us, it is an open question whether these agencies should be constituted ad hoc, separately from the existing policy system, or be built upon existing agencies. RCN has many of the skills needed, but the coordination needs go well beyond research and innovation policy into areas such as regulation, infrastructure investment, demand management and so on, so it could not do this alone with its existing skill set.

Figure 13 illustrates a possible multi-level governance and evaluation structure (Arnold, et al., 2018). On the operative side, the programme platform is appointed by and reports to government. It devises a strategy and implements it through various agencies or other agents. (This could include public-private partnerships.)

Figure 13 Multi-level governance and evaluation structure



It is important that the evaluation function (which we call a platform, but it could be a committee or be assigned to one or more expert groups independent of government) is separate from the programme and does not report to the programme but to the government. This enables accountability as well as objectivity.

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Appendix A Policy Case studies

A.1 Long-list of programmes considered in selecting case studies

Table 10 Long list of programmes considered in selecting case studies

Country	Policy or programme	A	B	C
AT	STI Strategy 2011-2020		v	
AT	Open Innovation Strategy (2016)		v	
AT	Austrian Action Plan on Public Procurement Promoting Innovation (PPPI) (2012)		v	v
AT	Austrian Climate and Energy Fund (KLIEN)		v	v
BE	Flanders circular economy			v
BE	Circular Brussels			V
DE	High Tech Strategy	v	v	v
DE	Energy Transition ('Energiewende')	v		v
DE	The Excellence Initiative		(v)	
DE	5G Strategy	v	v	
DE	German Resource Efficiency Programme (ProgRess)		v	v
DK	Environmental Technology Development and Demonstration Program (MUDP)	(v)		v
DK	Innovation Fund – Grand Solutions grant scheme		v	v
FIN	Team Finland network		v	v
FIN	BEAM programme			v
FIN	NIY and VIGO programme	v	(v)	(v)
FIN	The formation of Business Finland and the instruments used by the organisation	v		v
FIN	Growth engines	v	v	
FIN	SHOK programme		v	
FR	Pôles de Compétitivité (Competitiveness Poles)	(v)	v	
NL	Top Sectors		v	v
NL	Energy transition (circa 2000 onwards)			v
NL	A Circular Economy in the Netherlands by 2050 (2016)		v	v
NL	Circular Amsterdam			v
SWE	SIP; strategic innovation program	v	v	v
SWE	UDI; demand driven innovation		v	(v)
SWE	Policy lab		v	v
SWE	A Committee (linked to the Ministry of enterprise and innovation): coordinating and accelerating policy development	(v)	(v)	v
UK	Industrial Strategy / Grand challenges / the Industrial Strategy Challenge Fund (ISCF)		v	v
UK	Climate Change Act / The Clean Growth Strategy			v
UK	Contracts for Difference		v	v
UK	Prosperity Fund			V
UK	Global Challenge Research Fund		(v)	v

A.2 AT STI Strategy 2011-2020

A.2.1 The policy context, origins and rationale for the intervention

The Austrian Research, Technology and Innovation Strategy (RTI Strategy), entitled "Realising potentials, increasing dynamics, creating the future: Becoming an Innovation Leader", was launched in 2011. As the title suggests, the overall aims of the strategy:

- Join the group of 'innovation leaders' in the EU by 2020.
- Use RTI in a holistic manner to deal with the major societal and economic challenges of the future
- Increase research intensity to 3.76% by 2020, of which at least 66%-70% from the business sector

The strategy was developed on the basis of a series of consultations and studies which had identified the main challenges and opportunities for Austrian research and innovation. This included the Austrian Research Dialogue (2007-08), a 'System evaluation' of government funding for RTI in Austria (2008-09) and recommendations from the Austrian Council for Research and Technology Development (2009).

A number of contextual factors should be taken into account. During the decade preceding the 2011 strategy, the Austrian government had increased public funding for R&I significantly. This had, according to the government's analysis, allowed Austria to 'catch' up' to the pack of 'innovation followers', but there was now a need to take the next step and match the innovation leaders. The Austrian economy, then as now, was dominated by relatively traditional manufacturing industries. Although these firms are doing well in the context of their own sectors, there is relatively small presence of firms in new highly R&I-intensive fields. Among other things, the availability of venture capital for high-risk, high-growth firms was low. In parallel, external factors such as the financial crisis and the development of the new EU Framework Programmes contributed to the framing of the strategy.

The four main objectives of the strategy, supporting the headline aims are:

1. **A sustainable reform of the Austrian education system:** Provide the human resources required for an innovation leader.
2. **Strengthen basic research and its institutions**: Basic research was underfunded in comparative terms and the strategy aimed to increase funding while switching towards more competitive funding processes and performance-based steering.
3. **Strengthen the innovative power of firms**: Improved support direct and indirect support, enhanced knowledge transfer and demand-side policies.
4. **Increase the efficiency of political governance**: Improve coordination across previously isolated silos. and prioritisation to address societal challenges.

Among the underlying principles defined for the strategy was the need for a comprehensive and systemic approach encompassing funding instruments as well as regulatory and organisational measures based on collaborating and coordination across the actors of the system.

A.2.2 Description of the intervention, including its strategy, implementation and budget

The RTI strategy listed numerous objectives and measures to be pursued under each of the four main headings, some of which will have changed. As such, there is no dedicated budget as it encompasses all research and innovation programmes and initiatives undertaken by the federal government. This section highlights the most relevant examples of initiatives undertaken under the umbrella of the RTI strategy.

Table 11 contains an illustrative overview of some of the most pertinent elements related to support for business R&D.

Table 11 Selected types of initiatives to support business R&I under the umbrella of the RTI strategy

Business support	Activity implemented

Public procurement promoting Innovating (PPPI)	first introduced in Austrian R&I policy in 2007 but a new 'PPPI strategy process' shortly after the launch of the RTI strategy and an Action plan was launched in 2012.[36] On that basis, a systematic approach has been developed, including a dedicated governance structure. Among other things, establishing a service point and centres of competence in PPPI as well as pilot projects for pre-commercial procurement. The government has also introduced legislation to define innovation as a secondary objective in public procurement.
Industry 4.0	Industry 4.0, i.e. industrial digitalisation, had not yet been established as a concept when the RTI strategy was launched in 2011 but fit with the broader aim of the RTI strategy. A number of specific programmes have been funded, e.g. under the aegis of the Austrian Research Promotion Agency (FFG) and in 2016, the 'Digital Roadmap for Austria' was launched,[37] bringing together activities in this space from all government departments.
Venture Capital	is not seen as a strength of the Austrian system – often explained by the structure of the Austrian banking system. In line with the RTI Strategy, the Austrian funding landscape includes several schemes aimed at supporting the venture capital industry. Examples include the Austria Wirtschaftsservice's (aws) Start-up Fund and Jump Start Initiative. The VC landscape has further been supplemented by the government's "Alternative Funding Act", introduced in 2015 to support crowdfunding.

Source: Adapted from Polt et al. (2016)

In order to tackle societal challenges, new coordination mechanisms were put in place, including the 'working groups' under the RTI Task Force, as described below. Two specific societal challenge themes were established with a dedicated working group as shown in Table 12.

Table 12 Selected types of initiatives to support business R&I under the umbrella of the RTI strategy

Societal challenges	Activity implemented
Climate change and scarce resources	An inter-ministerial working group (working group 2) under the RTI Task force was established with participation from the Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of Science, Research and Economy (BMWFW), and the Federal Chancellery (BKA) to achieve better alignment between activities across government departments. In 2016, it was reported that the group was working on a roadmap, "Prospects 2050: supporting the switch to a CO2-neutral future", but this may well have been superseded by the subsequent climate and energy strategy published in September 2018.[38] The federal government's funding portfolio includes the KLIEN Climate and Energy Fund (KLIEN, est. 2007), which does not, however, fall under the purview of the working group.[39]
Quality of life and demographic change	Another inter-ministerial working group, Working group 3, focusses on quality of life and demographic change, including issues such as smart homes, mobility and individualised medicine. It is made up of representatives from the Federal Chancellery (BKA), the Federal Ministry of Labour, Social Affairs and Consumer Protection, (BMASK), Ministry of Health (BMG), Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry of Science, Research and Economy (BMWFW). The group published a roadmap The "mobility, quality of life and demographic change" in 2015 defining a series of cross-departmental topics to be implemented from 2015 to 2020.

Source: Adapted from Polt et al. (2016)

A.2.3 The governance of the intervention and of any evaluations undertaken

Governance and steering

The development and implementation of the RTI strategy involved a strong emphasis on cross-ministerial coordination, led by the Chancellery with participation of several sector ministries. An inter-

[36] https://era.gv.at/object/document/2177

[37] https://www.digitalroadmap.gv.at/en/

[38] https://mission2030.info/wp-content/uploads/2018/10/Klima-Energiestrategie_en.pdf

[39] https://www.bmnt.gv.at/english/environment/Climateprotect/Meet-the-Climate-and-Energy-Fund-.html

ministerial 'RTI Task Force' was set up to coordinate the implementation of the strategy. The group is chaired by the chancellery and has members from the key sector ministries involved in the strategy:[40]

- The Federal Chancellery
- Ministry of Finance (BMF)
- Ministry of Education, Science and Research (BMBWF)
  - one member from the education area
  - one from the science and research area
- Ministry of Transport, Innovation and Technology (BMVIT)
- Ministry of Digital and Economic Affairs (BMDW)

Task Force meetings regularly included experts on the specific topics covered and was also advised by the Austrian Council for Research and Technology Development.

In addition, thematic working groups were set up in which relevant ministries and stakeholders could work together to address specific issues. These issues included both environmental and societal issues often considered as 'grand challenges', as well as other STI policy challenges.

- Climate change and scarce resources (RTI working group 2)
- Quality of life and demographic change (RTI working group 3)
- Research infrastructure
- Knowledge transfer
- Internationalisation and RTI foreign policy
- Alignment in the European Research Area
- OECD STI country review (Published in 2018)

Individual programmes and initiatives are implemented with the participation of relevant constellations of actors within the framework of the overall strategy.

Monitoring and evaluation

The implementation and effects of the RTI Strategy has been assessed in the annual Austrian Research and Technology Report, which has contained a section on the implementation of the RTI strategy every year since 2011.

The 2016 report contained an expanded treatment in the form of a mid-term review of the strategy and the 2019 report will contain a final evaluation, currently in progress in parallel with the development of future strategy beyond 2020.

In addition to the strategy-level reviews treated here, some programmes and initiatives which serve to implement specific parts of the strategy have also been evaluated e.g. the evaluation of the PPPI action plan (see above) (Ruhland et al. 2018).

A.2.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

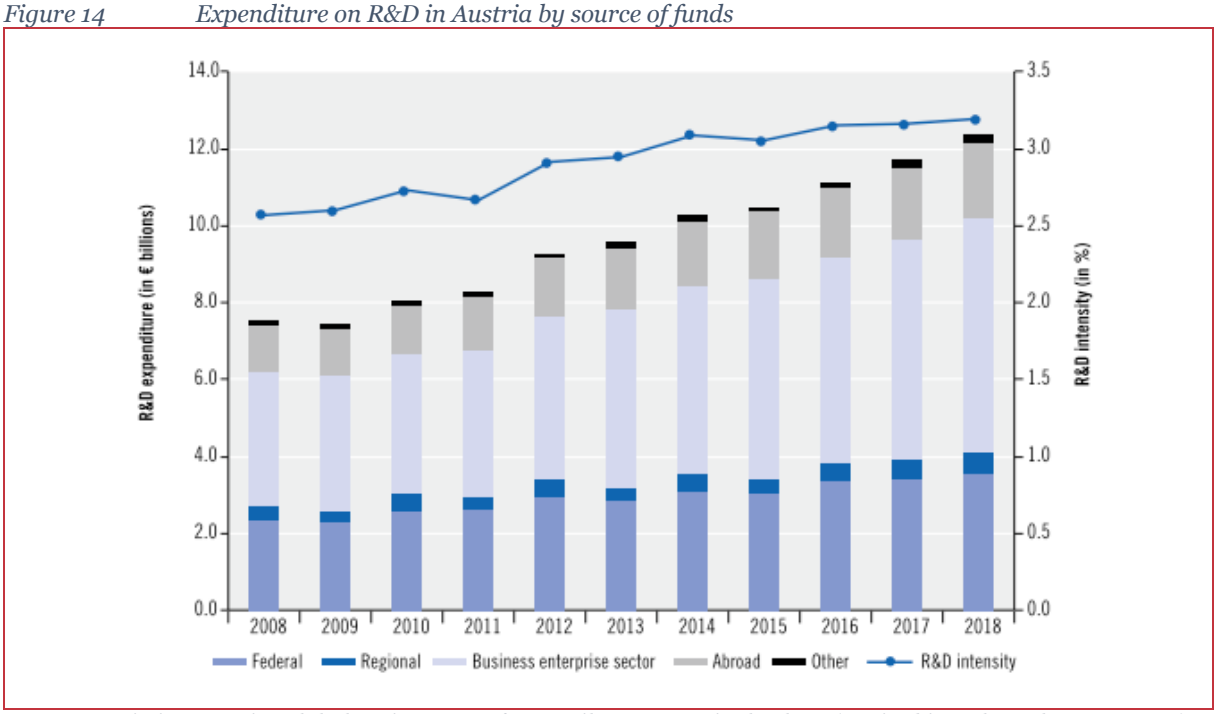
It is challenging to attribute precise effects to the RTI Strategy and the annual reports not so much been 'evaluations' as status updates on the implementation of initiatives under the strategy. In terms of the specific headline targets, it is clear that Austria has made progress but will not achieve the achieve the strategy's aims.

- **Research intensity** in Austria has increased significantly since 2011, surpassing the Lisbon target of 3% in the middle of the period and reaching 3.18% in 2018. The research intensity in the Austrian

[40] https://www.bundeskanzleramt.gv.at/task-force-fti

system is now among the highest in Europe, second only to Sweden in 2016, and above many of the 'innovation leaders' (e.g. Germany). However, Austria is unlikely to reach the RTI strategy's aim of 3.76% (GERD/GDP) by 2020. In particular, it has proved difficult to increase significantly the proportion of privately funded R&D in the system. Between 2011 and 2018, the proportion of R&D expenditure accounted for by the business sector increased from 46.2% to 49.5% but is still far off the target of 66-70%.

Figure 14 Expenditure on R&D in Austria by source of funds



Source: Statistics Austria, Global Estimate as of 19 April 2018, nominal values (as cited in Polt et al., 2018, p. 15)

- **Innovation ranking:** Austria has closed part of the gap to the Innovating Leaders in the EU but has still not joined them. In the European Commission's 2017 Innovation Index, Austria remains sixth among EU member states, classed just outside the group of Innovation leaders.

> *"The slow improvement of Austria's innovation performance, and to a certain degree its position in international innovation rankings, points to successes in efforts by the government, industry, and public research. However it also makes clear that structural changes will be required to tighten the gap to the leading countries and that, in an international environment in which all of the highly developed industrial countries are pushing to strengthen their innovative potential, rapid improvements within this group of countries will be extremely difficult. This is why it is important pursue the current path of ramping up efforts and focusing on the efficiency of the system."* (Polt et al. 2016, p. 8)

In 2018, Polt et al. (2018) reported that Austria was now leading the group of 'Strong innovators' just below the Innovation Leaders, but also anticipated a worsening of Austria's position due to a declined in venture capital investments.

Beyond the headline indicators, the 2016 report focusses primarily on the process, describing the initiatives taken across the various priority areas.

- In the priority area of Innovation and corporate research, the 2016 report notes that initiatives have been successfully implemented to address the priorities of the strategy but that it is too early to tell what the impacts have been.

- As for governance and coordination, the establishment of new coordination mechanisms – such as the RTI Task Force described above – and increased efforts to prioritise grand challenges are noted. The report also notes, however that the primary output of the process had been road mapping strategy development processes:

> *"initial actions have been implemented aimed at better coordination for the purposes of the RTI strategy, both in terms of the societal challenge of "demographic change" and of "climate change". However, these have initially related in essence to the aspects of mapping and developing the strategy in certain sub-areas.* (Polt et al. 2016, p. 80).

The 2016 mid-term report's overall appraisal of the RTI strategy remains somewhat tentative: "Overall the federal government's RTI strategy has created some essential momentum for change in some fields and resulted in some progress." (Polt et al., p. 88).

A new OECD review of Austrian innovation policy was published in December 2018 and pointed to some continued challenges for the country's R&I system and, by implication, for the RTI strategy. Overall, the report emphasised that Austria still needs to transform the increased resource input (R&I intensity) into innovation outcomes. The review also questions the efficacity of the approach to societal challenges, arguing that it lacks a systematic approach for identifying relevant societal challenges (OECD 2018).

A.2.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

The Austrian RTI Strategy (2011-2020) was a broad-based system-wide framework for Austrian Research and Innovation policy. After nearly a decade, some of the strengths and limitations appear to be the following:

- The RTI Strategy appears to have been an important steering tool for the coordination around RTI-related topics.
- Continued increase in public R&D funding has propelled Austria to the very top of R&D intensive countries but this has yet to be translated into innovation outcomes.
- Business R&D has increased but not by rate anticipated. This is no doubt related to the structure of Austrian industry, with a relatively low presence of companies from the most R&I-intensive sectors.
- The initiatives under the strategy do not appear to have helped overcome the weaknesses of the venture capital market and the broader structural imbalances in the structure of Austrian industry.
- As a mechanism for identifying and addressing societal challenges, the RTI strategy may have limitations. As pointed out in the OECD review, no systematic approach to identifying relevant societal challenges has been employed. A comparison to the case studies of UK and Danish approaches to societal challenges could be instructive.
- Also, it is not clear how the strong horizontal coordination at the ministerial level connected to the operational parts of the system. At the time of the 2016 review of the RTI Strategy, the main output from these coordination processes appear to have been mapping and strategy development. It remains to be seen whether these will lead to affective action to address climate change and other challenges.

A.2.6 Policy lessons for Norway

Move towards a more competitive, effective and efficient innovation system:

- At the policy level, the mechanisms put in place to implement the RTI Strategy in Austria appear to have been effective in ensuring cross-departmental communication and coordination. This has ensured a system-wide perspective in the implementation – as well as monitoring – of RTI policy across the range of inter-related knowledge-related areas.
- The Austrian example illustrates that increasing resource input does not by itself improve innovation performance. In Austria, the significant increase in public research and innovation funding has not yet translated into a relative substantial leverage of private sector investment or improvement in innovation performance.

Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges:

- The cabinet-level coordination mechanism – the RTI Task Force and associated working groups – creates a platform from which societal challenges and emerging themes can be addressed by relevant configurations of stakeholders.
- The case also shows, however, that that horizontal coordination at the policy level needs to be complemented by vertical coordination to connect policies and strategies to concrete funding programmes and research initiatives.

A.2.7 Key sources

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A.3 DE High-Tech Strategy

A.3.1 The policy context, origins and rationale for the intervention

The German High-Tech Strategy (HTS) is a long-standing government-wide innovation strategy, launched in 2006. As a comprehensive, interdepartmental innovation strategy, the aim of the HTS is to foster a coherent approach to innovation policy in Germany, and enhancement of the whole innovation system.[41] The strategy aims to improve the environment for innovation in Germany, and to accelerate the translation of ideas into market-ready products, processes and services with a view to strengthening prosperity and economic growth in Germany.[42] The main driver of the strategy is to expand the German innovation base in light of increasing global competition and increasingly globalised value chains (BMBF, 2014).

The latest iteration of the High-Tech Strategy (titled "Innovation for Germany") was published in 2014. The strategy is primarily funded by the Federal Ministry of Education and Research (BMBF) but also receives funding from ten other ministries.

A.3.2 Description of the intervention, including its strategy, implementation and budget

The HTS has evolved considerably over the time since it was first established. A recent report by Arnold et al. (2018) summarised the three phases of the strategy, presenting a clear progression of the strategy's purpose. Phase 1 (2006-2009) focused on key technologies and lead markets. The overall aim of the strategy was to create the conditions to enable researchers and organisations to gain leading positions in markets that were both technologically advanced and likely to grow in importance in the future. Phase 2 (2010-2013) subsequently focused on the use of key technologies to overcome major societal challenges. Between 2006 and 2013, the strategy was supported by a total investment of €27b by the federal government (European Commission, 2014).

The current Phase 3 (2014-2020) takes a broader view than the two preceding phases, and is supported by federal government investment of approximately €14b per year.[43] This evident, significant increase in investment in the new iteration of the strategy is an indicator of its evolution, and has been achieved despite some criticism of the two earlier phases for repackaging already-existing efforts and initiatives (Arnold et al., 2018).

The third phase of the strategy incorporates six priorities that cut across sectors, technologies, and areas of ministerial responsibility (BMBF, 2014):

- **Digital economy and society.** The strategy seeks to address inherent challenges in digital technologies, with a view to exploring how to harness digital technologies to create prosperity. This includes Industry 4.0, smart services, smart data, cloud computing, digital networking, digital science, digital education, and digital life environments
- **Sustainable economy and energy.** The strategy focuses on production and consumption, and how to make both more resource-efficient, environmentally-friendly and socially-compatible. This includes energy research (on energy storage systems, electrical grids, solar construction), the green economy, bioeconomy, sustainable agriculture, supply of raw materials, construction, and sustainable consumption
- **The innovative world of work.** The strategy focuses on the changes taking place in the modern workplace, with attention on creative ideas and economic innovation. This includes work in a digital world, innovative services, and competency-building
- **Healthy living.** The strategy focuses on strengthening research aimed at helping people live healthy, active and independent lives. This includes fighting major diseases, individualised

[41] EFI (2018)

[42] See: https://www.bmwi.de/Redaktion/EN/Artikel/Technology/high-tech-strategy-for-germany.html

[43] See: ibid

medicines, prevention and nutrition, innovations in the care sector, strengthening drug research, and innovations in medical technology

- **Intelligent mobility.** The strategy supports research in support of integrated transport policies and different modes of transport, with attention given to efficiency, capability and interaction. This includes infrastructure, electromobility, vehicle technologies, aviation, and maritime technologies
- **Civil security.** The strategy takes a systems view to supporting infrastructures such as energy supply, communications, mobility and logistics, focusing on ensuring proper functioning and interaction. Areas of focus include civil security research, cyber security, IT security, and secure identities

Around these six priorities are wide-ranging goals to improve the policy and support for innovation in Germany, create better conditions for innovation, and increase participation and collaboration in the innovation system.[44] To achieve these goals, the strategy sets out a need to improve existing support programmes (for example making funding conditions more SME-friendly to expand the number of SMEs that participate in innovation programmes) and expand science communication in order to create more openness and increase opportunities for people to engage with societal and technological changes.[45] In addition, the strategy aims to develop new instruments to support innovation, such as measures to expand German universities' options for cooperation with industry and society.[46]

A.3.3 The governance of the intervention and of any evaluations undertaken

BMBF provides the primary management of and funding for the HTS, supported via coordination with other ministries. A Federal Committee of State Secretaries for the High-Tech Strategy has been proposed to formalise this coordination (Arnold et al., 2018).

Since its inception, the HTS has been supported by two external bodies:

- The Council for Innovation and Growth (2006-2008), an innovation body for the federal government (Bauer et al., 2012)
- The Commission of Experts for Research and Innovation (EFI) (2008 onwards). EFI has a broad role in monitoring and advising on the development of the national research and innovation system (OECD, 2016). As part of this, EFI monitors, reports and advises on the HTS via its annual report to the government on research, innovation and technological performance in Germany (Arnold et al., 2018)

Other advisory bodies support the HTS, too:

- The Industry-Science Research Alliance was dedicated specifically to supporting both the implementation and continued development of the HTS between 2006 and 2013. The Alliance comprised representatives of industry and science (Arnold et al., 2018). The Alliance supported the HTS until the end of Phase 2
- The High-Tech Forum, is a new body made up of civil-society representatives and stakeholders from academia and business. The Forum meets three times per year, and advises on the development of new thematic areas and on the implementation of suitable related programmes under the HTS.[47] The High-Tech Forum reports to the Federal Government, and holds significant influence on the implementation and further development of the HTS.

Industry has played an important role in both the Industry-Science Research Alliance and the High-Tech Forum in terms of advising on the HTS and lobbying for its continuation across successive governments (Arnold et al., 2018). Advisory bodies such as these or the Wissenschaftsrat[48] have

[44] See: https://www.bmwi.de/Redaktion/EN/Artikel/Technology/high-tech-strategy-for-germany.html

[45] ibid

[46] ibid

[47] See: http://www.hightech-forum.de/en/auftrag/

[48] See: https://www.wissenschaftsrat.de/home.html

important roles in Germany, often conducting evaluations, undertaking monitoring activities and providing advice for the development of support instruments.

A.3.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

There is an obligation to evaluate individual funding instruments in Germany, though this obligation relates primarily to individual instruments and the HTS was not evaluated as a whole for a number of years after its introduction in 2006 (Arnold et al., 2018). The one external evaluation report that is in the public domain covers a monitoring exercise undertaken to support the federal ministries in assessing the design and the structure of the HTS up to 2011 (Heimer, et al., 2011). The report did not cover 'classic' evaluation questions (e.g. efficiency and effectiveness). Rather, it focused on contributing to the design and management of the HTS by covering questions such as the framing of challenges and the identification of drivers and barriers in thematic areas of the innovation system. In 2015, the EFI made recommendations for the development of an evaluation strategy, covering the indicators, success criteria and evaluation methods in addition to a pathway for integrating the evaluation outcomes into policy (EFI, 2015).

Arnold et al. (2018) suggested that while it was possible to point to significant improvements in the innovation performance of German industry during the period of the HTS, there was no concrete evaluation evidence to attribute this to the HTS.

A.3.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

It is difficult to make concrete statements based solely on documentary evidence that does not include evaluations. However, the strategy has clearly been consciously developed over time and has reacted to prior critique of being older/existing initiatives simply re-badged. Over time, the HTS has become more system-based, and is seemingly leveraging input and funding across ministries in a collaborative approach. The buy-in from – and support of – multiple ministries for a single strategy speaks to successful attempts to foster a system-wide approach, and is key in addressing societal challenges.

A.3.6 Policy lessons for Norway

The appears to be particular relevance to the transformation imperative, 'Move towards a more competitive, effective and efficient innovation system':

- One of the key ideas behind the HTS is to improve the efficiency of the German innovation system, and the various support mechanisms available for innovation. In doing this, the federal government is taking an open view of the potential limitations or disincentives in existing support mechanisms, such as 'SME-friendliness'
- The system-based approach appears to also aim to mobilise innovations as enablers or verticals, rather than focusing on key sectors. There is therefore a strong emphasis on improving the collaboration between universities, industry and society by, for example, introducing new support mechanisms for universities
- The scope of the HTS is purposefully across multiple ministry areas, and its use of an independent advisory committee appears to be positive for its ongoing development. The long-term perspective of the strategy – having been live since 2006 – may be an enabler to gaining buy-in from ministries

There is also relevance to the transformation imperative: 'Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges':

- The six pillars of the strategy are clearly oriented around grand challenges, ensuring that the development of the innovation system, and any new interventions, does not lose sight of solving these problems

A.3.7 Key sources:

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A.4 DE Energy Transition (*Energiewende*)

A.4.1 The policy context, origins and rationale for the intervention

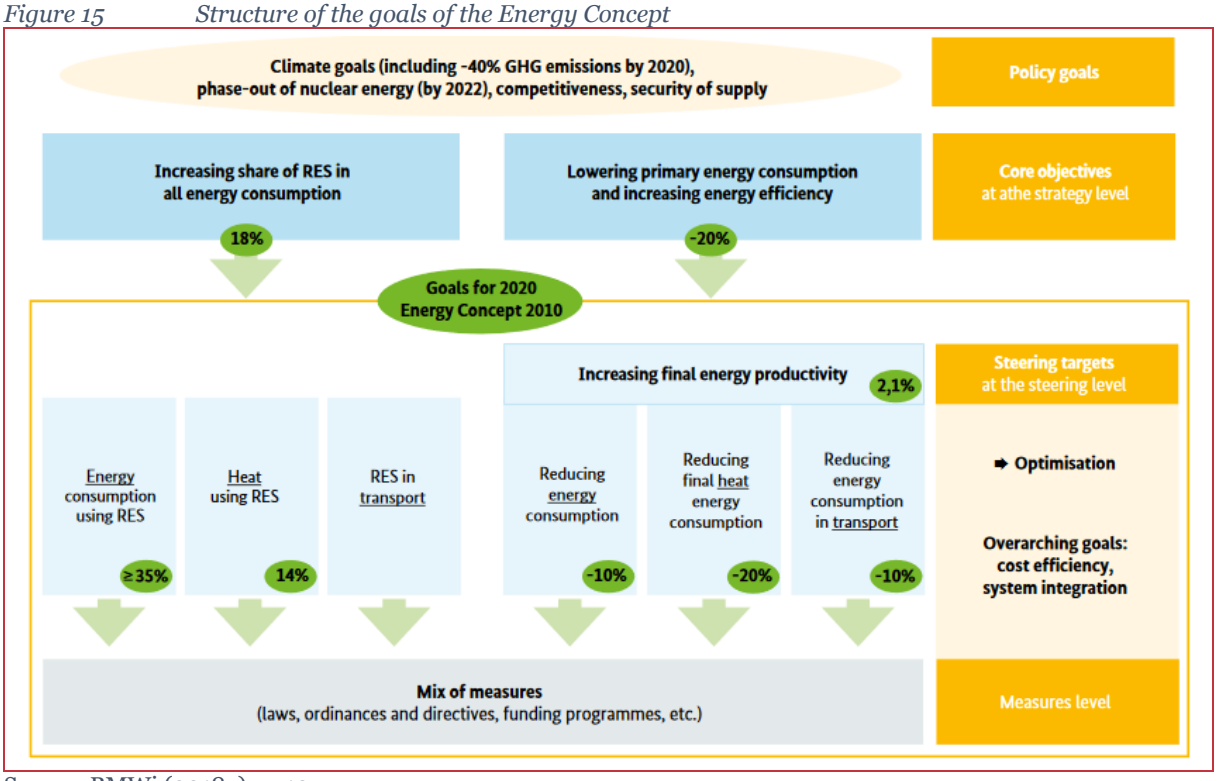
The German energy transition ('Energiewende') policy aims to move energy supply towards more renewable sources and to reduce energy consumption through more efficient use. This will contribute to the broader policy aim of mitigating climate change by reducing the emission of greenhouse gases.

The decision to phase out nuclear energy by 2022 (announced in 2011 shortly after the Fukushima nuclear accident) and commitments to reductions in greenhouse gas emissions are mong the key drivers for the initiative but these are related to a broader set of additional policy concerns:[49]

- Security of supply: Covering the country's own needs
- Affordability and competitiveness: Affordable energy supply to underpin the competitiveness of German industry
- Grid expansion and digitalisation
- Research and innovation: Fostering energy innovations
- Investment growth and jobs: creating jobs and prosperity.

Key goals of the current energy transition policy were set out in the 'Energy concept' (BMWi and BMU 2010) adopted in 2010. This was supplemented by a further 'energy package' adopted by the Bundestag the following year. The chart below summarises the aims set out in the 'Energy Concept'. Figure 15 shows the structure of targets within the plan.

Figure 15 Structure of the goals of the Energy Concept



Source: BMWi (2018a), p. 10.

[49] List adapted from BMWi (2018a, p. 9).

Energiewende enjoys cross-party support in the German political system, reflecting broad support for the initiative among the German public.

A.4.2 Description of the intervention, including its strategy, implementation and budget

The bulk of departmental expenditure on the Energy Transition is spent through the Energy Research Programme.[50] The Federal government in Germany launched its first energy research programmes in the 1970s and the current programme, covering the period 2018-2022, is the 7th in the series, entitled "Innovation for the Energy Transition".

Three 'strategic goals' have been defined for the programme:

- **Expediting the energy transition**
- **Strengthening industrial locations**, i.e. modernising the German economy so as to make it an attractive location for industry
- **Managing societal Risk** by developing a broad range of technological options which allows greater scope to respond to unforeseen future circumstances

With the seventh iteration of the programme, the budget is set to increase to approximately by some 45%, to EUR 1.3bn per year by 2019. The programme is delivered by the Research Ministry (BMBF), which funds fundamental research (TRL 1-3) and the energy ministry BMWi which funds R&D (TRL 3-9) as well as the Ministry of Food which implements a small part of the programme focussed on energy from biomass (BMWi 2018b). The budget covers project funding (about two thirds of the budget) and institutional funding for the Helmholtz Association of German Research Centres (HGF) to support long-term research objectives of government and society, particularly when requiring large-scale equipment.

Compared to the sixth Energy Research Programme, the new, seventh programmes places greater emphasis on *inter-systemic research topics* which may cut across pre-defined thematic areas, such as digitalisation and societal aspects of the energy transition.

A.4.3 The governance of the intervention and of any evaluations undertaken

Governance and monitoring of the energy transition policy

Energiewende is coordinated by Germany's Federal Ministry for the Economy and Energy (BMWi) and involves a great number of government actors and other stakeholders.[51] The different levels of government coordinate twice yearly meetings between the Chancellor the Minister of economic affairs and the head of state, complemented by continuous engagement at lower levels of government

Coordination with stakeholders is organised around five high level Energy Transition Platforms, organised by the BMWi. These platforms provide a forum for representatives from state governments, industry, society and the research community to engage with the Federal government on energy transition. The five platforms are:

- "Energy Grids"
- "Electricity market"
- "Energy efficiency"
- "Buildings"
- "Research and innovation"

The energy research programme

The 'Research and innovation' platform set up for the Energy Transition convenes high-level actors from government science and business twice a year and serves as an advisory body for overarching issues

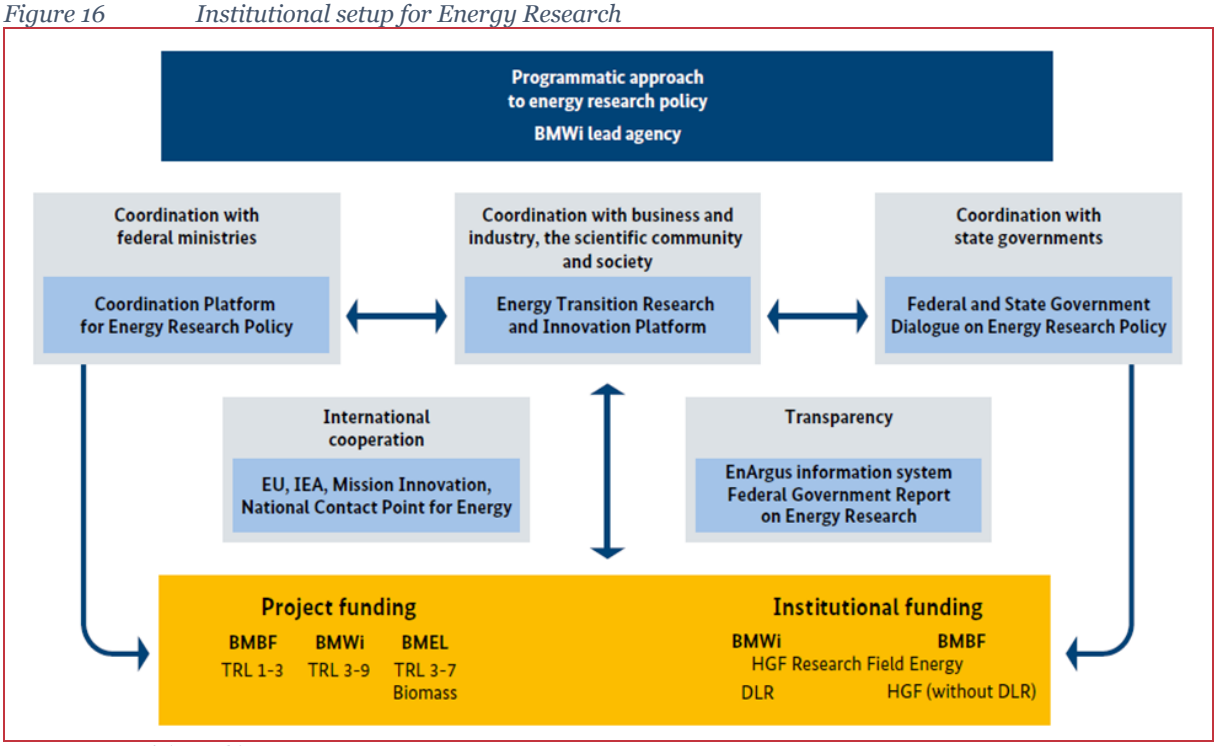
[50]

[51] https://www.auswaertiges-amt.de/blob/216910/7a1be4e46851e6912959e89bc9cd90ee/energiewendewhoiswho-data.pdf

within energy research funding. The platform plays a central role in the governance of the Energy Research Programme and contributed to the preparation of the recently launched Seventh Energy Research Programme through their expert recommendations submitted to the BMWi. (BMWi 2018c).

For the Seventh Energy Research Programme, a new "inter-ministerial, thematic programme setup" has been adopted in order to ensure greater flexibility and coherence across the programme across the three implementing ministries. This necessitates a greater level of inter-ministerial coordination, organised through the Coordination Platform for energy research policy, as shown below.

Figure 16 Institutional setup for Energy Research



Source: BMWi (2018b), p. 16.

Monitoring and evaluation

The energy transition policy and targets and are subject to close scrutiny. An elaborate monitoring system is in place to review progress towards the aims of the energy concept (see above) and the various federal programmes associated with the transition policy. This contains the following main elements:[52]

- The Monitoring report provides a factual overview of progress, based on selected indicators. This report must be approved by the cabinet and submitted to the two chambers of the German Federal parliament.
- In response the to the monitoring report a group of independent experts will provide their assessment of the report, which is published alongside the monitoring report.
- A Progress report every three years (first published in 2014) containing a broader analysis of objectives and potential policy adjustments.

Similarly, for the Energy Research Programme, and an annual report is published summarising progress made and current trends in the field of research promotion are presented in the report, the latest in 2018 (BMWi 2018c). These reports do not contain an assessment of the programme performance or measure

[52] https://www.bmwi.de/Redaktion/EN/Artikel/Energy/monitoring-implementation-of-the-energy-reforms.html

report against performance indicators or pre-defined targets. Rather, they describes the implementation of the programme.

As mentioned, the Energy Transition Research and Innovation Platform plays a role in reviewing and making recommendations about future programmes to the BMWi.

In addition to monitoring reports issued by the German government, the German energy transition has attracted a great deal of attention from international observers and academics and is widely regarded as an example of good practice in terms of transition.

A.4.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

A recent study from the European Commission reviewed the Energiewende. Their findings are summarised in the text box below.

Table 13 Summary of outcomes of the Energiewende initiative

	Description
Outputs	Stimulated significant private investments (2015): • EUR 36.4 billion in residential building energy retrofits and EUR 16.8 billion in non-residential buildings. • EUR 15 billion were invested in the renewable energy installations. EUR 5.9 billion wereinvested in the construction of new infrastructure and in grid reinforcement.
Outcomes	• Energiewende has shown important progress towards the goals set. • Today almost one third (27%) of German electricity is generated fromrenewable energy sources, making it number one source of electricity. • The nuclear phase-out plan is also progressing as planned. • The GHG emission target 2020 is not likely to be met. Simultaneous phase-out of nuclear energy and growing energy demand has led to unchanged levels (same level as 1990) of energy generation from gas, coal and lignite leading to a slower decrease in GHG emission levels. • The progress towards energy-efficiency targets has been positive but moderate.
Impacts	• Creation of globally competitive research and technology capacities and industry. • Value added: Direct value added from renewables is expected to grow in Germany, and scenarios have estimated the value added to rise from EUR 18 billion in 2012 to approximately EUR 25 billion in 2030 (depending on the installation rates). • Jobs: The impact of energy transition on employment is positive, with a yearly net increase of 18000 jobs up to 2020, when compared to a scenario without the Energiewende. Currently, the German renewable energy sector comprises 334000 jobs. • Exports: In 2015 the export ratios reached 70% for PV;66% for wind, 50% of biodiesel and 66% of heat pumps produced in Germany were consigned for export. • Behavioural changes: The transition is co-owned and positively assessed by the German citizens, and a large majority is in favour of Energiewende.

Source: Kuittinen H., Velte D. (2018)

Commentators have noted several unintended consequences of the programme as well, particularly linked to the transition away from nuclear power:

- Despite a greater production of energy from renewable sources, greenhouse gas emissions have increased during certain periods as energy consumption from domestic nuclear power was substituted for important coal-powered electricity.

- The pre-occupation with maintaining the competitiveness of electricity-consuming German industry and the consequent exceptions from the surcharge paid by retail customers has led to examples of perverse incentives and conflicts with European state aid rules.

A.4.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

- The Energy Transition is stands out from other examples by having strong support among the general public in Germany – despite the resulting premium on electricity prices for many consumers. Mazzucato (2017) even describes it as "the result of a bottom-up green movement" in contrast to transitional top-down policies. In any case, the strong public support insulates the programmes from changing political climates and ensures relatively stable framework conditions over time.
- The demand-driven elements of the policy – i.e. the subsidies for producers of renewable energy financed through a surcharge on consumers – may not have worked in the absence of this near-consensus.[53]
- The governance of the Energy Transition is very complex, spanning multiple levels both geographically and in terms of organisational levels. Nevertheless, the governance of the Energy Research Programme is directly embedded within the wider challenge initiative through the high-level research and innovation stakeholder platform. In other cases, research funding programmes are often more loosely coupled to the wider policy framework.
- The elaborate 'target architecture' and monitoring helps provide a focal point for the although not all challenge areas will lend themselves as well to metrics as climate change does.

A.4.6 Policy lessons for Norway

Shift towards a more diversified and robust economy:

- The German energy transition policy is in some ways analogous to the ambition to diversify in the context of the Norwegian economy – moving away from a reliance on existing technological solutions used in the past.
- Demand-driven elements aimed to incentives investment in new, alternative technological solutions – in this case the subsidies for producers of renewable energy financed through a surcharge on consumers – employed to drive this diversification needs to be finely balanced to avoid perverse incentives or legal complications.
- The example illustrates that this type of transition requires a broad social and political process of consensus-building in favour of new solutions and overcoming resistance from incumbent economic actors. Concrete examples include the energy transition platforms which facilitate dialogue between different stakeholders.

Addressing societal challenges:

- The case study illustrates the complexity and range of activities requires to tackle a societal challenge like climate change in a comprehensive fashion, and how the energy research programmes is embedded within this wider societal programme.
- Clear targets and monitoring of progress towards addressing societal challenges provides transparency and direction.

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[53] In comparison, recent attempts to introduce a climate policy-related surcharge on petrol in France had to be abandoned in the face of significant public resistance.

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A.5 Innovation Fund Denmark's 'Grand Solutions' Scheme

A.5.1 The policy context, origins and rationale for the intervention

The Grand Solutions scheme accounts of about half of the budget of Innovation Fund Denmark (IFD) and is the main funding vehicle for strategic and challenge-led research in Denmark.

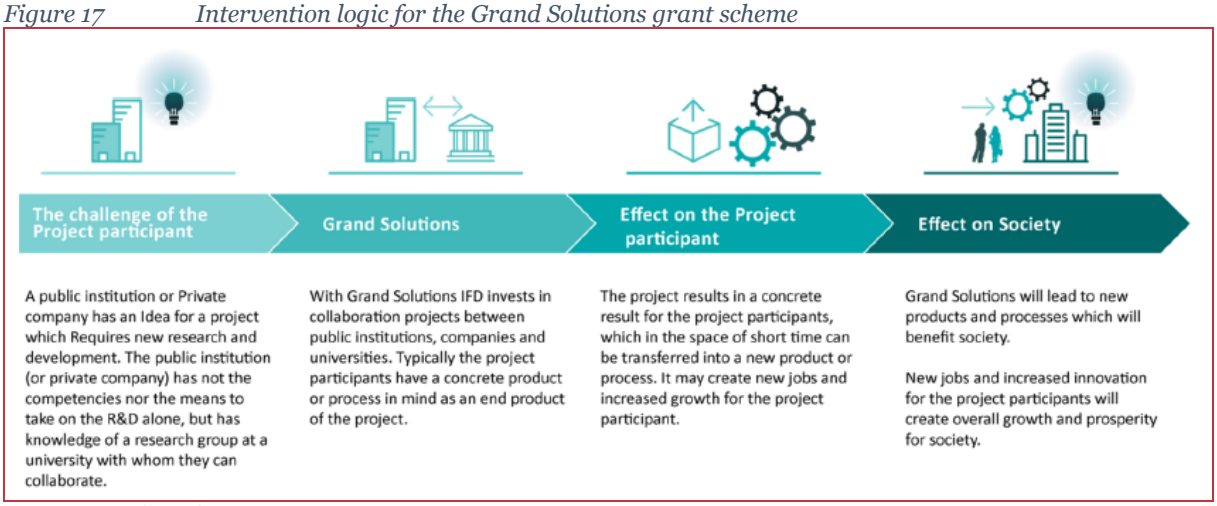
IFD was created as a new funding body in the conext of a wider reorganisation of the support for strategic research in Denmark in 2013/14, based on a review of the Danish Innovation system and a new Innovation Strategy in 2012. The new Fund was created by merging three previously separate funding bodies and was meant to help bring about a simpler and more coherent funding system bridging basic and research and industrial application.

IFD describes the Grand Solutions scheme (intially simply called 'large projects') as follows:

> *"With Grand Solution, IFD invests in collaborative projects between public institutions, companies and universities. Typically the proejct participants have a concrete product or prcess in mind as an end product of the project" (IFD 2018, p. 29)*

It represented a departure the past in that it was designed to support fewer, large-scale projects rather than more numerous smaller projects (Aagaard 2013). Under the scheme, a broad range of activities can be funded, including research, development, Proof-of-Concept and demonstration. The instrument was designed to be able to accommodate a broad range of project profiles but applicants are required to clearly identify the position of the project in the innovation value chain, which in turn will have implications for the composition for the project consortium, the types of activities undertaken and the expected results.[54]

Figure 17 Intervention logic for the Grand Solutions grant scheme



Source: IFD (2018), p. 29.

A.5.2 Description of the intervention, including its strategy, implementation and budget

The thematic priorities of the Grand Solutions scheme are ultimately determined politically but involves a broader process with several steps:

- The ministry undertakes a broad consultation every five years on the basis of which a 'catalogue' of priorities is collated and published. The most recent of these catalogues, 'Research 2025', was published in 2017 (MHSE 2017).

[54] See also Guidelines for Grand Solutions 2017, Op Cit., pp. 9-13, 28.

- Budget allocations for strategic and challenge-led research is determined on an annual basiss as part of the government's Finance Act. With reference to the catalogue, the Act identifies the thematic priorities for the year and specifies a budget allocation for each themes.[55]
- Based on the budget allocation, the IFD announces calls for proposals within the given areas, using the Grand Solutions instrument.

The overall budget of the scheme has been approximately DKK 700m per year in the last few years. The potentially changing nature of annual political funding decisions is tensioned against the need of the IFD for longer term organisational arrangements and strategies. The IDF has established six thematic units within the Grand Solutions directorate and has developed thematic strategies in these areas. In many cases, funding decisions can be anticipated by the confirmed budget allocation may not arrive until after the preparation for the calls for proposals have started. Some areas may be deprioritised by the government, as has been the case for 'social innovation' (a.k.a. 'future welfare').[56]

Table 14 Grand Solutions investments 2015-2018 (in DKK million)

Thematic area	2015	2016	2017	2018
Bioresources Food and Lifestyle	139	221	131	77
Biotech, Medico and Health	116	123	71	137
Energy, Climate and Environment	147	178	128	133
Trade, Service and Society	88	76	38	*30
Infrastructure, Transport and Construction	43	20	-	-
Production, Materials, Digitisation and ICT	228	228	88	**225
Open call	264	43	207	*130
Total	**1,026**	**891**	**663**	**731**

Source: Adapted from IFD (2018, p. 27).
Notes: * Budget; **of which DKK70m is part of the budget for the next round.

IFD typically invests 5-30m DKK in each project, but larger grants are available when deemed justfied (e.g. DKK 64m for MADE, see below). IDF-supported projects typically run for 2-5 years and are expected to achieve results within a time horizon of 2-10 years.

A.5.3 The governance of the intervention and of any evaluations undertaken

Innovation Fund Denmark was created in 2014 on the basis of a 'fund structure'. IFD reports to the Ministry for Education and Research but functions at arm's-length from government. This model was adopted with the aim to ensure a more simple, transparent and flexible programming process and represents a departure from the previously used 'council' model in several respects.

- the Fund no longer has external programme committees but is led by a Board of Directors, composed of nine politically appointed members with research and industry expertise.
- it involves a strengthening of in-house expertise with the introduction of 'scientific officers'. This enables a closer dialogue with the communities and more active management of the portfolio of 'investments'
- the vocabulary has changed and the terms 'investments' and 'clients' are used rather than 'grants' and 'users'.

[55] See e.g. the Finance Act of 2019, section 19:44 (p. 171): https://www.fm.dk/publikationer/2019/finansloven-for-2019

[56] The self-evaluation notes under 'weaknesses': "No political earmarking for social innovation from 2018" (IFD 2018, p. 35).

Collaboration is a central aspect of the programme and IFD insists that each project adopts professional project management and a governance structure and that reflects the aims and challenges of the project.[57] Among other things, project consortia are required to prepare a collaboration agreement before the investment agreement is signed and IFD prescribes the frequency of meetings during the course of the project. In addition, IFD encourages a clear separation between strategic leadership (i.e. the steering committee) and operational management led by the project manager.[58]

IFD have described their approach to evaluating the effect of projects in 2016 (IFD 2016a), and defined three specific targets for their portfolio (including Grand Solutions) (IFD 2016b)

- The majority of projects (minimum 6 of 10) co-financed by IFD should lead to a success – defined as an innovation, a new company or derived project with focus on innovation.
- A large majority of companies (minimum 8 of 10) in projects co-funded by IFD should find it attractive to collaborate with universities and other public research institutions.
- On average, five articles should be published in the best (top 1%) journals for every 100m DKK invested by the fund.

These headline targets are monitored on a rolling basis alongside more qualitative aims. The Fund's aim to contribute to solutions for societal challenges is also addressed more specifically through illustrative case studies.

A.5.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

An evaluation of the Innovation Fund, including the Grand Solutions scheme is currently ongoing. The final report is not expected to be complated in May 2019 but some documents from the process have been published, including a self-evaluation by the Innovation Fund (IFD 2018) and a 'user experience' survey (IRIS 2018).

- The scheme has attracted significant interest with success rates typically at 10-20% depending on the sector, although this oversubscription may also lead to missed opportunities.
- The strengths of the scheme in the report include the ambitious and long-term perspective, the ability to drive collaboration between partners and increased awareness of societal challenges.
- Among the weaknesses identified were the complexity and sometimes weak leadership of the large projects, lack of commitment and financing from industry, relative lack of international participation, and insufficient staff resources within IFD.
- The user experience survey found that users were particularly satisfied with the short application process but less impressed with the interaction with the IFD 'investment managers', who survey respondents would like to spend more time on each project.

A mid-term evaluation of one of the schemes flagship investments, MADE (Manufacturing Academy of Denmark) was published in 2017 (Damvad 2017) and contained estimates of the economic impact:

- The 9 project work packages involved 30 companies, 3 RTOs (GTS institutes), 5 universities and 48 PhD students.
- IFD invested DKK 64m and companies invested DKK 88m out of total project cost of DKK 184m
- Of 9 work packages, 6 resulted in project innovations and all 9 in process evaluations. A total of 120 peer-reviewed publications were produced across the work packages.
- The total potential added value in terms of increased productivity, based on the assumption that innovations are taken up by non-participating companies within the relevant sectors, was estimated to be DKK 6.1bn.

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[57] IFD website: *FAQ - Grand Solutions*, available at: https://innovationsfonden.dk/da/faq

[58] FAQ - Grand Solutions, Op. Cit.

A.5.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

The evidence so far, speaks mostly to the governance, design and implementation of the scheme.

- The 'fund' structure allows for a more stream-lined decision-making process with business representatives in many fo the leading roles.
- There is a potential tension between the broad consultation and concensusbuilding around the Research2025 catalogues which form the basis for theamtic budget priorities, the need for predictability and planning within the IFD and the desire to invest in business- and user-driven projects potentially radically new directions.
- The simplified application process (100 days maximum) appears to be very popular with applicants, whereas the active 'investment management' by the fund's staff has been less successful in the eyes of the users, seemingly because of understaffing.

There is, as yet, limited evidence of the longer-term impact achieved by the projects funded under the scheme but we do see a more explicity focus on 'value creation' and evaluations in the coming years will show to what extent this is borne out in practice.

A.5.6 Policy lessons for Norway

Move towards a more competitive, effective and efficient innovation system:

- The Grand Solutions scheme is an instructive example of how one might go about re-designing and re-organising support for strategic research with an emphasis on creating collaboration between different sectors of the innovation system.
- The support for larger, more complex projects allows for more ambitious, collaborative and longer-term investments but presents its own challenges. Such projects demand a higher level of commitment and organisational capacity on the part of the project leads and the experience with Grand Solutions offers illustration of these issues.
- The case study also provides illustration of challenges for the funding body, in setting-up simple and business-friendly procedures – the short application process appears to be a success in this sense – and providing proactive sparing and support during the life of the project.
- The role of the public sector, even in business-driven projects, is also noteworthy, especially in countries where the public sector plays a signficant role as end-user and/or regulator.

Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges:

- The process for defining research priorities for challenge-led research is complex but overall invovles a stronger orientation towards the political decision-making than towards the 'community' which would be in charge under a traditional research council model.
- The model thus provide responsiveness ot the political system but potentially a lack of consistency over time which may hamper a sustained effort needed to tackle societal challenges.

A.5.7 Sources

Key publications:

- Aagaard, K. (2013), "Ny dansk innovationsfond", *Forskningspolitikk*, (4), 22–23.
- Damvad (2017), *Midtvejsevaluering af MADE, Manufacturing Academy of Denmark*, Innovation Fund Denmark, available at: https://innovationsfonden.dk/sites/ default/files/2018-08/midtvejsevaluering-af-made.pdf
- IFD [Innovation Fund Denmark] (2016a), *Effektmåling af Innovationsfondens projekter*, juni 2016, available at: **Error! Hyperlink reference not valid.**https://innovationsfonden.dk/sites/default/files /2018-08/publikation_innovationsfondens_effektmaling.pdf

- IFD (2016b), *Innovationsfondens effektmål* , available at: https://innovationsfonden.dk/sites/default/files/2018-08/innovationsfondeneffektmaaljuni2016.pdf
- IFD (2018), *Self-evaluation of the role, tasks and organisation of IFD and its position in the Danish Research and Innovation system*, July 2018, available at: https://innovationsfonden.dk/sites/default/files/2018-10/final-ifd-self-evaluation-july-2018.pdf
- IRIS (2018), The Users' Experience of Innovation Fund Denmark: Evaluation Report, June 2018, available at: https://innovationsfonden.dk/sites/default/files/2018-09/the-users-experience-of-innovation-fund-denmark.pdf
- MHES [Ministry of Higher Education and Science] (2017), FORSK2025 – fremtidens løfterige forskningsområder, juni 2017, Copenhagen: Danish Ministry for Higher Education and Science, available at: https://ufm.dk/en/research-and-innovation /political-priority-areas/research2025
- Tilvaxtanalys (2018), *International scanning of research programmes that focus on societal challenges*, PM 2017:18, available at: http://www.tillvaxtanalys.se/download/18.25efc2a915fe149a654a5d93/1513945448959/pm_2017_18_International%20scanning%20of%20research%20programmes%20that%20focus%20on%20societal%20challenges.pdf.

Individuals consulted:

- Tore Duvold, Deputy Director, Grand Solutions.

A.6 DK MindLab

A.6.1 The policy context, origins and rationale for the intervention

MindLab was the one of the first government innovation lab in the world. It was founded in Denmark in 2002 but ended in late 2018. It stood at the forefront, both in theory and practice, of efforts to make government cleverer, faster and more inventive. MindLab's operations are focused on placing citizens' needs at the forefront of government. Denmark was among the very first to recognise the need for such an organisation. Working in partnership with three government ministries and one municipality, MindLab's operations covered a range of key policy areas – education, employment and digital. Due to political priorities, Denmark wanted to establish the next generation innovation labs. So, in December 2018 Mindlab turned into a more focused version, The disruptive Taskforce, with a mission of making Denmark a digital frontrunner.

A.6.2 Description of the intervention, including its strategy, implementation and budget

Effective and inspirational labs exist in many highly developed countries. In Western Europe, MindLab (Denmark) and The Behavioural Insights Team (UK) push their governments to re-imagine public services. In Asia, the Innovation Bureau in Seoul, South Korea, co-designs better services with citizens. Located within the Ministry of Business and Growth, MindLab was a surprisingly small organisation, 20 in total. To be able to operate in several areas, they recruited a wider network "lab rats", so instead of 20 people they became 45.

The projects that MindLabs worked on were often initiated by governmental ministries, issues that they identified as bureaucrats. They used the Co-creation process to involve different partners and social innovation tools to be able to work as an "innovation enabler". Three examples describe their tasks:

- The Danish government's "Away with the Red Tape" plan with a mission to put the citizen and deregulation at the top of the agenda, and to eliminate outdated and unnecessary rules and digitise and simplify complicated administrative procedures and processes. Young tax payers under the age of 30 were interviewed and different studies were carried out by MindLab in collaboration with the Danish Tax and Customs Administration (SKAT), the Danish National Board of Industrial Injuries and the Danish Commerce and Companies Agency (DCCA). MindLab came up with 4 solutions based on citizens subjective experiences.
- Entrepreneurs play an important part in sustaining the Danish economy. The political interest especially concentrates on 'high-growth entrepreneurs' who generate new jobs and high turnover. So MindLab visited a range of Denmark's best entrepreneurs to understand how government initiatives might be designed to help more growth entrepreneurs realize their businesses potential.
- Another example involved seniors. They were asked "what they would like to do again, if they could". Many seniors indicated that they would like to do light housework themselves, instead of having strangers in their home doing it. MindLab helped these seniors through improved nutrition and physiotherapy, with a result of lower long-term home-care costs.

MindLabs was going through several stages from a creative platform into a strategic partner and later to a more user-oriented innovation unit. Mindlab became even a catalyst of an international movement. Despite the success of MindLab the governmental funding of the Lab was unsure from one election to another.

A.6.3 The governance of the intervention and of any evaluations undertaken

In 2002 the Ministry of Business Affairs wanted to incorporate a core organisation within his ministry that had the mission to foster innovation in the public sector. MindLab were though involved in different partnerships with several Ministries: Ministry of Education, Ministry of Employment, Ministry of taxations etc. In 2007 MindLab became a cross-ministerial innovation unit. In 2014 MindLab took a strategic step from being cross-ministerial to become cross-public, adding the municipality of Odense to the circle of owners. Later temporary partnerships with other Danish ministries also became a part of

the work portfolio. MindLab was also involved in many international activities, 2013 they signed a partnership with UNDP and Nesta. They also assisted various governments in setting up innovation labs. MindLab became deeply involved in the international movement of raising the awareness of innovation practice in government and public administrations.

No major evaluations of MindLab can be found.

A report on MindLab by Allison Hewitt, Director of social entrepreneurship, Toronto, Canada was done in 2012[59]. An article by the Deputy Director of Mind Lab, January 2016.

Growing Government innovation labs: an insider's guide, Oct 2017, UNDP and FutureGov[60].

A.6.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

Findings about the design and evolution of a public sector innovation lab[61]:

- Communication is a key success factor for innovation labs. To capture the value proposition and engage collaborators, practitioners need to explain the lab's objectives, methodology and, eventually, its wins.
- With a wave of labs being set up all over the globe, there is an ongoing discussion on their format: should they be internal, external, a non-profit, a consultancy? For MindLab, being an internal government lab has been an asset, as it has helped them build a network inside. "We have been able to work with the people in the ministries as colleagues, engage at an early stage in these projects, and stay longer, for implementation, which consultants often don't do. If you don't adjust your solutions when you implement then you won't meet those intended political effects."
- Measuring impact is a constantly evolving process: "We are experimenting on a good way to do this." They have indicators for every specific process, but, "how do we set up indicators that are right to measure what? In many cases we won't know until years from now."

Findings in the insider's guide:

- Replicate the lab across government, starting up labs in many different departments. Rather than growing like a whale, the lab scales as a school of fish. An internal network of labs has the advantage of tailoring innovation to different contexts and challenges. It becomes more difficult to kill off from the top down, as the labs are owned by many different leaders. Outputs will vary in quality in this option, risking the reputation of government innovation labs as a whole.
- Labs often fail to articulate that they are here for the long-term, to tackle complex issues. Doing so can attract a different type of stakeholder and funder and help root labs in their respective governments.
- It's crucial to find the places where citizens or stakeholders not only are at the centre but also where new or unexpected solutions can be effectively used. Similarly, assess early local conditions before applying innovative tool or process.

A.6.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

- Managing the government machine is time consuming. The pressure for daily decisions and urgent responses together with the media spotlight turns the government often into a bureaucratic and old-fashioned organisation. So, how can governments carve out the time and space they need to think, to plan, to innovate?
- According to the insider's guide from UNDP MindLab delivered three projects per year. Important that labs remain focused and not doing too many things.

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[59] http://sigeneration.ca/documents/MindLabReportMarch2012.pdf

[60] http://www.eurasia.undp.org/content/rbec/en/home/librarypage/growing-government-innovation-labs--an-insider-s-guide.html

[61] http://thegovlab.org/mindlab-the-evolution-of-a-public-innovation-lab/

A.6.6 Policy lessons for Norway

Several policy lessons can be drawn from the Danish experience with the 'Mindlab':

- Move towards a more competitive, effective and efficient innovation system:
  - This case was chosen to illustrate scheme that facilitate a transition towards a more efficient innovation system through it's facilitation role as 'innovation enabler'.
  - MindLab achieved increased coordination across existing actors by involving stakeholders and end-users. MindLab saw their job as "creating the conditions for success." They did not come up with the answers, but rather unveil the options.
  - In terms of societal challenges, it is an example of how to engage with stakeholders to identify needs and develop solutions.
- This is not primarily focussed on business support but there is an example of how MindLab worked to support Danish entrepreneurs. MindLab and the Danish Enterprise and Construction Authority and the Ministry of Economics and Business Affairs visited 6 growth entrepreneurs and asked them to narrate their journey to growth. When was it hard? Who helped them on their way when it was not public sector organizations? What role did professional networks, families and friends play?

  The most important insights from the field research was translated into specific proposals for how to support Danish entrepreneurs. The proposals were subsequently developed into prototypes that were tested with the entrepreneurs.

A.6.7 Sources

Key publications:

- Bazalgette & Craig (2017), Growing government innovation labs: an insider's guide, UNDP and Futuregov.
- Hermosilla (2016), "MindLab: The evolution of a public innovation lab", GovLab Blog, available at: http://thegovlab.org/mindlab-the-evolution-of-a-public-innovation-lab/
- Hewitt (2012), Report on Mindlab, available at: http://sigeneration.ca/documents/MindLabReportMarch2012.pdf

A.7 FI Business-orientated funding instruments for research and innovation: Growth engines

A.7.1 The policy context, origins and rationale for the intervention

Growth engines are business ecosystems that creates more than one billion euros in new business, exports or investments in Finland. Growth Engines are implemented through an enterprise-driven partnership model between companies, research organizations and public actors, which strives to find solutions to global market disruption and create new growth sectors in Finland.

The Government has directed EUR 60 million of capital funding for Growth Engines in 2018 (30 M€) and 2019 (30 M€). In addition, Business Finland directs its normal funding (200 M€ 2018-19) and services to projects that meet the ambitious and funding criteria of companies, research organizations and communities operating in Growth Engines, aiming at achieving a Growth Engine's business objective.

Businesses are no longer successful in international competition alone. To succeed, they need partners from different parts of the value network and from different industries. Cooperation between research and industry is also a key here.

Innovation is the most important source of economic growth. Up to 96% of innovations are generated through ecosystems. The new co-operation platform for various business ecosystems, important for Finland's future, is provided by growth engines funded by Business Finland and flagships funded by the Academy of Finland. So far, Business Finland has funded eight growth engines. The Academy of Finland's flagship program has reached its full potential with six flagships. Closer cooperation between Business Finland and the Academy of Finland plays a key role in renewing our research and innovation policy and seeking new strengths, says the The Minister of Economic Affairs Mika Lintilä**.**

Pekka Soini **,** CEO of Business Finland, says "Our goal is safeguarding Finland's prosperity. He also recalled that ecosystems are at the heart of Business Finland's operations: "Our public goal is to increase the amount of new exports, businesses and investments in Finland to 20 billion by 2025 through ecosystems."

A.7.2 Description of the intervention, including its strategy, implementation and budget

The funding is intended for the goal-oriented and systematic development of innovation cooperation within an enterprise-driven ecosystem. Funding is either grants or loans for R&D&I-projects. The funding provided as grant, so-called orchestration funding, can account for a maximum of 50% of the overall costs, and helps to network different actors and promote innovation cooperation. Funding can be granted for several activities:

- Activities to strengthen the ecosystem
  - Funding for orchestration
  - Capital loan for the platform company
- For renewal, growth and internationalisation of partners of the ecosystem
  - Funding start-ups and SMEs for internationalisation and growth
  - Funding companies' research and development activities, the development of services and business models
  - Funding for networks, which will be renewed through research (Co-creation and Co-innovation funding)
  - Funding for public procurement entities which aim to modernize services and operations
- To increase competence of the ecosystem
  - Co-creation and Co-innovation funding for research
  - Research networks in Finland and EU, research infrastructures and testlabs

  - Invest in services
- To internationalise the ecosystem
  - Global foresight and market opportunities services
  - Services offered by Business Finland's global networks, e.g. contacts
  - Business delegations
  - Information on the target market's business environment
  - Trade fair grants for SMEs

A group of companies and other actors identifies a business spearhead with a global market potential amounting to at least 1 billion euros in new exports, which can only be achieved in collaboration with others. The Finnish competences also contribute to further development of the business spearhead. The companies are prepared to share the information and their professional competences that the cooperation requires within the limits agreed in advance. "The result of the networked collaboration created by the growth motors can result in a superior system, which is extremely difficult to copy," says Development Manager Karin Wikman from Business Finland.

The idea can be developed into a clear joint growth vision and a detailed action plan for the development of a Growth Engine, and into business models and new or renewed business operations with the help of a reliable builder of the cooperation, the orchestrator, and funding targeted for the purpose. Projects can, as a rule, apply for funding on a continuous basis.

In their applications, the platform companies presented a promise of return on the capital loan and an implementation plan on how and with what resources they would create new business and / or new exports or new investments in Finland for at least one billion euros in the growth motors system.

A.7.3 The governance of the intervention and of any evaluations undertaken

Business Finland has chosen the winners of the first growth engine competition. The next funding opportunity for new Growth Engines will be in Mars 2019.

The platform companies now funded are active in the recycling of plastic waste, location-based satellite services, data-based built environment, intelligent mobility services and digital logistics services. The activities of the shipping company must be growth-oriented in order to be able to repay the loan in due time with a reasonable return to the state.

Growth engines funded so far:

- Smart Mobility Ecosystem , Kyyti Group
- Platform of Trust , Finland Responsibility
- Internet of Locations , Iceye
- Vedia CaaS, Vediaf
- Plastic Waste Refining Ecosystem , Griffin Refineries
- Artificial Intelligence , Silo.AI
- One sea , DIMECC
- Baltic Offshore Wind , Gaia Consulting

A.7.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

So far no major evaluation is done since the first 8 Growth engines were launched in 2018.
Programme managers at Business Finland are hopeful that the program will result in:

- Development of comprehensive solutions to the global market disruption
- Working to an agreed extent as an open platform for co-operation between different actors and attracting foreign innovation investors to Finland

- The Growth engines are based on a shared vision and a roadmap for achieving goals (growth vision)
- The Growth Engines will produce new value for both end-users and partners
- The Growth Engines will generate joint innovation projects, pilot projects and demonstrations, as well as openings in the market
- The Growth Engines consist of a credible set of companies from various industries, research organizations, public actors and end customers.

A.7.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

Growth Engines are a business-oriented funding program, where projects can apply for funding *on a continuous basis*. The programme is a mix of different funding (grants/loans). The main stakeholders decide how many and who is going to join the "growth engine".

A.7.6 Policy lessons for Norway

In terms of the RCN's three transformation imperatives, the Finnish growth engines is particularly interest with respect to the need to 'Move towards a more competitive, effective and efficient innovation system':

- Compared to 'business as usual', the programme is designed to develop long term collaborative relationships between actors in the" eco-system", which the actors themselves define. In contrast to the Swedish SIP-Programmes approach, "all onboard", the Growth Engines seem to make the decisions about who is going to be on board. The funded Growth Engines have fewer stakeholders involved, which means that the direction of travel needs to be agreed between fewer actors.
- It is too early to say anything about results and lessons learnt but there has reportedly been considerable interest among companies, especially about the new capital loan facility. At a later stage, it will be interesting analyse to what extent how they managed to get the right stakeholders onboard, convinced them to join forces and to work with common goals and to achieve in-depth collaborations.
- The funding of a programme is based on both grants and loans. That means longer projects can funded. The programmes can therefore focus more on long-term goals due to the grants/loan mix with long cycles and the amount of money.

A.7.7 Sources

Key publications:

- Growth Engines on the Business Finland website: https://www.businessfinland.fi/en/for-finnish-customers/services/funding/growth-engines/growth-engines-funding/

Individuals consulted:

- Tiina Tanninen-Ahonen, Development Manager, Business Finland, Networking businesses and research

A.8 French Competitiveness clusters (Pôles de compétitivité)

A.8.1 The policy context, origins and rationale for the intervention

The French government launched the competitiveness cluster policy in 2004. That year, a prominent report to the Prime Minister, "an ecosystem for growth" (Blanc 2004), concluded that France was in a "state of economic and social emergency" and described the innovation system as top heavy, centralised and out of date. Among other things, the report called for a strengthening of the universities and increased devolution to the regions and a closer alignment with business needs.

Partly as a response this this report, the competitiveness cluster policy aimed to improve competitiveness in the French economy by supporting regional innovation ecosystems. The overarching programme aims were as follows.

- the creation of partnerships between different actors with complementary competences
- the development of collaborative, strategic R&D projects that can benefit from public funding, notably from the single interdepartmental fund (FUI)
- the promotion of a favourable overall environment for innovation and cluster members through promotional events, pooling or accompanying members of the cluster on themes such as access to private funding, international development, industrial property, skills management, human resources etc.

The Competitiveness Cluster policy is positioned among a number of other cluster-related policies, some predating 2005 and others initiated later, such as the 'Grappes d'entreprises' (enterprise clusters), pôles territoriaux de coopération économique (PTCE) among others. Consequently, phase 4 of the Competitiveness Cluster policy has made it an explicit policy to improve coherence between the Competitiveness Cluster policy and these other policies to avoid overlap and ensure synergies (see below).

A.8.2 Description of the intervention, including its strategy, implementation and budget

A competitiveness cluster is defined as

> *"a partnership, based around a specific theme and a specific region [which] brings together large and small firms, research laboratories and educational establishments, all working together in a specific region to develop synergies and cooperative efforts"*
> *(French Government 2011)*

The programme is built around four main elements (Grivot 2017):

- A label given by the government, currently to 56 clusters (as of February 2019).
- A cross-ministerial financial instrument dedicated exclusively to the clusters, 'Fond Unique Interministeriel (FUI). In addition, funding from other sources have been awarded to the clusters, e.g. from the National Research Agency (ANR) and the Future Investments Programme (PIA), as well as regional and supranational sources.
- Designated R&D zones (initially including tax relief but has since become less consequential)
- A contractual relationship between the clusters, the state and the regional authorities defined around a series of multiannual objectives, performance against which are subject to regular evaluation and potential withdrawal of 'cluster' status.

On average, clusters had 187 members in 2011, of which 57%were SMEs. 60% of clusters were in the manufacturing sector where

The programme has completed three programme cycles and its objectives have evolved significantly during this time. The table below summarises the four phases of the programme so far and, included the objectives added during each new phase.

Table 15 Four phases of the competitiveness cluster programme

Phase	Headline	Objectives
Phase 1 (2005-2008)	First labelling and working principles	• Increase innovation through networking, development of synergies and collaboration between companies, research institutes and higher education institutions in a given territory. • Support innovative activities, which create jobs and add value in a given territory • Improve the attractiveness of these territories and more generally, the competitiveness of French industry through increased international reach
Phase 2 (2009-2012)	Confirmation and reinforcement of the cluster policy; "Cluster 2.0"	• Strengthening the coordination and strategic management of the clusters, as well as more demanding "performance contracts" and the strengthening of the role of state correspondents; • The development of structuring projects, including innovation platforms; • Increased support for the development of the innovation and growth ecosystem of cluster companies, in particular through greater use of private funding and the search for better place-based synergies.
Phase 3 (2013-2018)	"A new ambition": reorientation towards economic outcomes and jobs	• Increased emphasis on bringing innovations to market (clusters should evolve from 'project factories' to 'future products factories') • Enhanced support for SMEs (e.g. access to funding, internationalisation, training needs etc.)
Phase 4 (2019-2022)	"a new dynamic" for the competitiveness clusters	• A European ambition, with an objective for each cluster to increase the number of European collaborative projects they engage in (particularly Horizon 2020 and Horizon Europe) • A clearer definition of the 'competitiveness cluster' label, through better defined objectives and more demanding selection criteria as well as better coherence with other initiatives and policies supporting innovation ecosystems.

Sources: Technopolis, compiled and translated from competitivite.gouv.fr [62]

The clusters are supported financially through two main routes:

- Financial support for the functioning of the cluster and the development of the ecosystem. This annual grant for this purpose was initially €12m but has now increased to between €15 and €20m.
- Co-funding of R&D projects, through an inter-ministerial fund ("Fonds Unique Interministériel"). Over the period 2014–2015, the amount given by the State to the FUI represented about 1 percent of all public support to the policy of innovation (including indirect support)

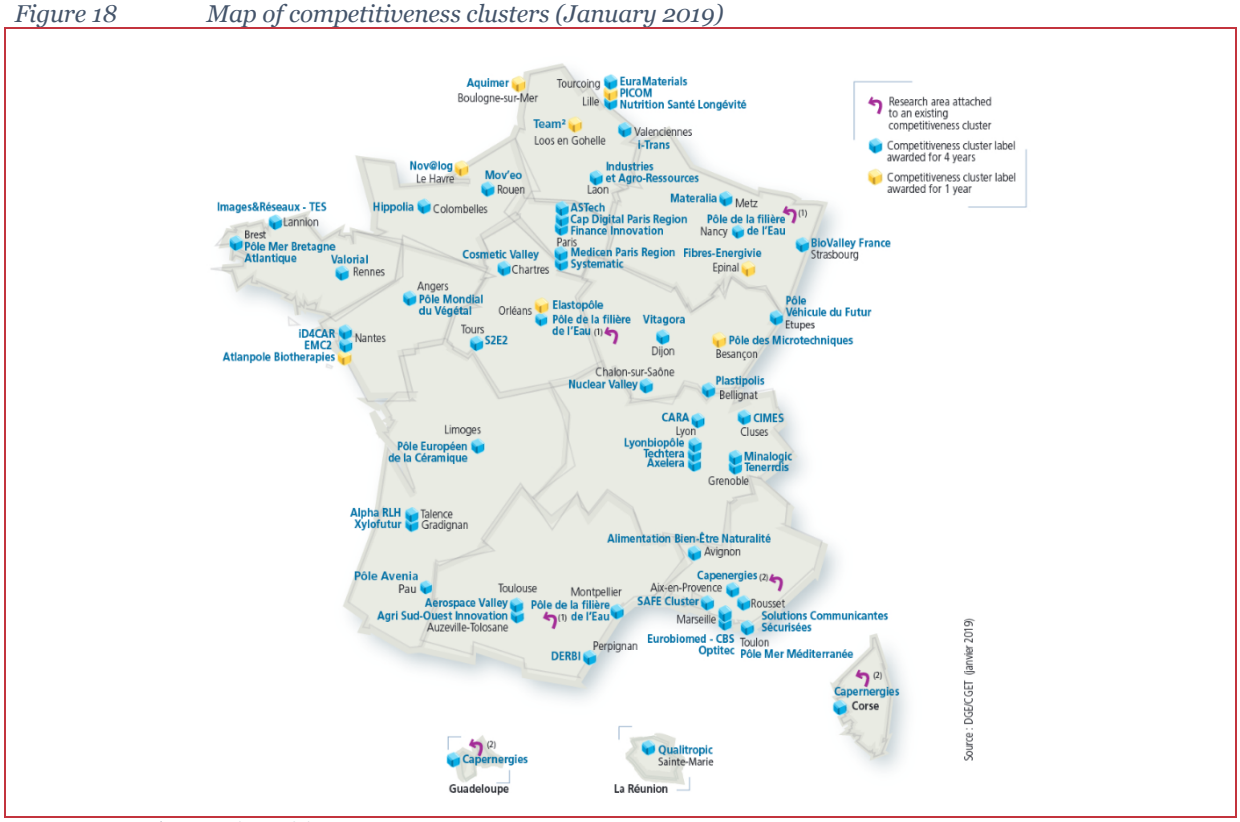
As of 2017 the 22 FUI calls for proposals supported 1,681 collaborative R&D projects, for a total of €6.8b, including €2.7b of public support (€1.7b by the State and €1b by local authorities). In addition, the National Research Agency funded more than 2,200 projects labelled by clusters, with €1.5b between 2005 and 2015, roughly one third of its budget.

In February 2019, 56 clusters were awarded the programme label for period 2019-2022, although 8 initially only for one year.[63]

[62] https://competitivite.gouv.fr/politique-des-poles/phases-245.html

[63] https://competitivite.gouv.fr/fileadmin/DOCUMENTS/Actualites/Communique_de_presse_de_M._Edouard_PHILIPPE_Premier_ministre_-_Poles_de_competitivite_-_05.02.2019.pdf

Figure 18 Map of competitiveness clusters (January 2019)



Source: DGE/CGET (2019)[64]

A.8.3 The governance of the intervention and of any evaluations undertaken

The governance of the policy is divided between the national and the regional level. At the national level, decisions are taken by relevant ministers and in inter-ministerial committees. During phase 3, the implementation of the policy was delegated to a 'Steering Committee' and a 'Technical committee', hosted by the General Commission for Territorial Equality (GCET), the Business directorate (DGE) of the Department for Industry and with representatives from other relevant sector ministries, representatives from local and regional authorities and other stakeholders, such as the national research agency (ANR). The evaluation after of the programme after the phase 2 (BearingPoint France SAS – Erdyn – Technopolis Group-ITD. 2012) highlighted weaknesses in the inter-ministerial coordination and particularly the coordination with other research-related policies (p. 152).

At the regional or local level, each cluster is overseen by a coordinating committee and designated contact persons (correspondant) at the local governmental level and at national level. The regions have become increasingly involved in the steering of the clusters. At its conception, the programme was primarily steered by the national government, but the regions have become increasingly involved both financially and in terms of governance. Since 2013, the regions are also represented at the national-level governance bodies (DNE 2017, p. 22).

A.8.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

The only common system to monitor the progresses of the clusters are the periodic evaluations. At the end of the first (2008) and second (2012) phases, evaluations were conducted, covering both the national policy and the individual performance of the clusters. These evaluations have focussed

[64] https://competitivite.gouv.fr/fileadmin/DOCUMENTS/Documentation/Carte-Poles/Carte_56_poles_Janvier_2019_anglais.pdf

primarily on clusters activities and have not attempted to measure the direct and indirect impacts of the clusters in a wider context.

The most recent round of evaluations was carried out as part of the mid-term evaluation of the third phase of the programme in 2016. This included an econometric impact analysis of data from 2005 to 2012 (Ben Hassine and Mathieu 2017). Among key findings were:

- Clusters had, on average, achieved 77% of their objectives halfway through the third phase and only very few less than 50% (GCET 2017)
- a clear 'cluster effect' on the leverage of R&D spend from the year 2009 onwards: companies participating in the cluster programme spent significantly more of their own money on R&D. This effect has been particularly significant for SMEs in manufacturing clusters, whereas no such effect was seen among companies in the (small number of) knowledge intensive services clusters. (Hassaine & Mathieu 2017)
- The analysis failed to find any significant effect of programme participation on innovation outcomes – e.g. patents, turnover, employment, productivity etc. – three years after the end of the first projects. (ibid)
- Most clusters were also found to be insufficiently internationalised. (GCET)
- Overall, the study concludes that the 'Poles' can be a useful instrument for stimulating innovation and collaboration but that the programmes aims should be better defined to allow for better conclusions. (CNEPI 2017)

A.8.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

The success of the scheme has been qualified:

- The competitiveness clusters have succeeded in creating new partnerships and projects and leveraging funding.
- Evaluations have not been able to identify significant longer-term innovation impacts, but more precise targets and incentives may contribute to producing and capturing impacts beyond the current activity indicators.

A.8.6 Policy lessons for Norway

Move towards a more competitive, effective and efficient innovation system:

- The Competitiveness Cluster policy is an attempt at a radical change of the status quo in direction of creating a more efficient innovation ecosystem.
- The case study provides illustration of the evolution of policy over time. One the one hand, policy was adjusted on the basis of experiences with successive iterations of the programme and, on the other hand, on the external changes with the introduction of new policies.
- The nature of the intervention necessitates horizontal (inter-ministerial) as well as vertical coordination between national and regional authorities. The programme has shown a progressive institutionalisation of regional representation within the programme, but evaluations have also identified weaknesses in inter-ministerial coordination.

Diversification:

- The Competitiveness Cluster policy attempts to create a greater geographical diversity by devolving responsibility for a part of the national policy to regional authorities and stakeholders, tailoring implementation to local needs and circumstances.
- The case study illustrates several ways in which this can be challenging for the programme owners to manage, e.g. the risk of fragmentation and lack of clear direction and monitoring. Initially intended to support some 15 clusters, the number of clusters peaked at 77 before being reduced somewhat in the recent years.

- The most recent phase of the project has sought clarify the aims of programme and create a stronger brand identity and a clearer role. This has also involved introducing stricter selection criteria and consequently reduced the number of clusters to 56.

A.8.7 Key sources:

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A.9 NL: Circular Amsterdam

A.9.1 The policy context, origins and rationale for the intervention

Amsterdam Circular is a strategic initiative, launched in 2016, to develop the circular economy in the Amsterdam Metropolitan Area. This is a main pillar of the city's sustainability agenda (OECD, N.D.), and is a key priority for the European Commission.

In 2015, the City of Amsterdam commissioned a consortium of Circle Economy, TNO and Fabric to create a roadmap and action agenda for the city's transition to a circular economy. The report, 'Circular Amsterdam: A vision and action agenda for the city and metropolitan area', was published in 2016 and comprises a roadmap for increasing circularity in the city region, including guidance and potential steps. The roadmap connects to numerous other initiatives that are already being implemented in the city region (OECD, N.D.).

The initiative aims to create the conditions for circularity to address a number of major challenges, while also increasing economic and social prosperity (Circle Economy, TNO and Fabric, 2016).

A.9.2 Description of the intervention, including its strategy, implementation and budget

Amsterdam Circular has been undertaken through a number of large-scale activities. In 2016, the consortium of Circle Economy, TNO and Fabric conducted the first 'Circle City Scan' for the municipality. The Circle City Scan is a process designed by Circle Economy. It is based on a multi-stakeholder model that allows stakeholders to design intervention points in sectoral value chains based on the city's 'dynamics. Amsterdam's Circle City Scan ran for one year, and focused on the value chains around construction and biomass and food. The scan identified areas where it could be possible to achieve significant progress in realising a circular economy in these value chains.

The results of the scan fed into the production of a roadmap: 'Circular Amsterdam: A vision and action agenda for the city and metropolitan area' (Circle Economy, TNO and Fabric, 2016). The roadmap identifies areas in which circular business models can be applied, and highlights particular strategies for implementation, including how and where to start with tangible projects. The report presents a large number of short- and long term-actions.

The roadmap was followed by two programmes:

- **Amsterdam Circular, Learning by Doing.** A dedicated innovation programme that sought to learn about all aspects of a circular economy and about the role local governments should and could play. The programme was multidisciplinary, with involvement from the city's sustainability department as well as spatial planning, purchasing, real estate, and economic development, as well as industry and citizens[65]
- **Circular Innovation Programme, 2016-2018.** A programme that sought to provide insight into innovation projects in the city of Amsterdam in the field of circular economy, including mapping any restrictive laws and regulations that might obstruct circular innovation projects in the city[66]

Taken together, these programmes combined the testing and implementation of circular innovation in the Amsterdam Metropolitan Area in areas from food, construction, energy, and governance.[67]. A total of 73 projects was supported that address challenges from pressure on raw materials, to energy transition and climate adaptation.[68]

[65] See: https://circulareconomy.europa.eu/platform/en/good-practices/amsterdam-going-circular-smartly-learning-doing

[66] See: https://amsterdamsmartcity.com/projects/circular-innovation-program-dutch

[67] See: https://amsterdamsmartcity.com/circularamsterdam

[68] ibid

A.9.3 The governance of the intervention and of any evaluations undertaken

The City of Amsterdam is the ultimate owner of the initiative. The sustainability team within the vice-mayoral office of the municipality oversees the whole circular economy domain, leveraging the support of other departments, including the innovation team within the Chief Technology Office, and has worked with a variety of companies, research institutes and organisations.

Circle Economy – an independent social enterprise – acts as the central neutral body for the initiative.[69] Its main role is in guiding participants through the process of developing the circular economy. The multi-stakeholder coalition built around developing the circular economy consists of business representatives (both public and private), and an environmental data provider. The stakeholders that are guided through the process are those that live and work in the city, including businesses and policy makers. Circle Economy's international profile[70] also allows it to broker learning relationships with other cities in Europe and as far afield as Japan and China.

A.9.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

An evaluation was published in 2018 by Circle Economy and Copper8. The evaluation which considers five pillars across several value chains:

- Upscaling the construction value chain
- Upscaling the biomass & food value chain
- Upscaling the Consumption goods value chain
- Expanding procurement (as an instrument)
- Expanding research, information provision and networks

The evaluation was positive, finding the approach taken across the Circle City Scan and successive programmes to be successful. In particular, the evaluation praised the 'Learning by Doing' approach. The evaluation found that the transition to a circular economy would be feasible due to i) technical possibilities and new innovations, and ii) the financial competitiveness of circular projects compared to 'traditional' projects demonstrated through the supported projects.

The evaluation praised the City of Amsterdam for taking the lead in knowledge development and sharing experiences, with research, networking and information exchange found to be the most important tools across numerous value chains.

The evaluation concluded by identifying further development needs, and areas for scaling.

A.9.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

The evaluation is very positive about the collaborative approach taken across the initiative, and within specific chains. The mobilisation of other municipal departments, industry and other specialist knowledge has been important, and is testament to the work of the municipality. That a number of projects have led to concrete promises for scaling is very positive, and the commitment to sharing of knowledge has been important. Amsterdam is clearly on a positive trajectory – somewhat substantiated by its winning the World Smart City Award for circular economy at the Smart City Expo World Congress in 2017.

[69] See: https://www.circle-economy.com/about/

[70] Circle Economy have undertaken the Circle City Scan in 15 European cities to date

A.9.6 Policy lessons for Norway

Amsterdam Circular has clear relevance to the third OECD transformation imperative, 'Achieve structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges'.

- The City of Amsterdam is taking a strong leadership role and setting a high level of ambition to develop and implement circular economies in a diverse range of sectoral value chains. There is a significant action learning element in understanding how to achieve this
- The initiative and its constituent parts demonstrate a strong commitment to testing and implementing projects in a real-life setting, which has been imperative to success
- The research undertaken and projects supported through this initiative have focused concretely on addressing specific challenges
- Concrete collaboration with and across departments of the municipality, and with industry and society, has been fundamental to the success of this initiative so far

A.9.7 Key sources:

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A.10 Sweden's Strategic Innovation Programmes (SIP)

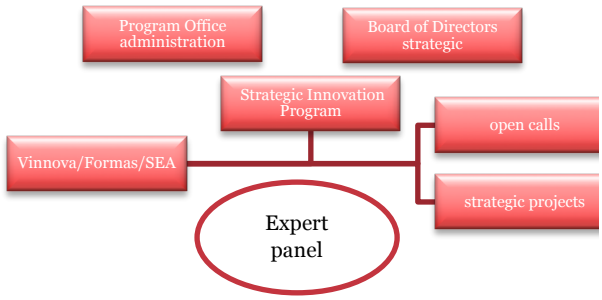
A.10.1 The policy context, origins and rationale for the intervention

The strategic research and innovation agenda initiative that ran from 2012 to 2016 laid the foundation for the current strategic innovation programmes. Under the initiative, the stakeholders active in a certain area jointly formulated a vision and objectives and defined needs and strategies to help develop a particular innovation area. The agendas' main aims were to address important social challenges and create growth and strengthen Sweden's competitiveness in the area. The 136 approved agendas covered a broad spectrum of areas.

The Government's intentions with the strategic innovation programs is based on the descriptions of the Research and Innovation Bill (2012/13: 30). The starting point is that Sweden, together with other countries, needs to create the conditions for sustainable solutions to global societal challenges, such as attractive living environments, demographic change, global health threats, sustainable supply of raw materials and biodiversity, safe, safe and healthy food supply, climate-efficient and sustainable access to energy, security and security and increased international competitiveness. The Government's intention with the strategic innovation areas was to create and join forces in areas of relevance to these societal challenges through long-term and in-depth collaboration programs between the business sector, the public sector, universities and colleges, research institutes, civil society and other actors. The Government meant that these actors should jointly develop long-term strategies with the aim of contributing to meeting societal challenges, stimulate innovation investments, new collaborations, new networks with common goals for international competitiveness.

A.10.2 Description of the intervention, including its strategy, implementation and budget

The Swedish Innovation Agency, Vinnova, the Swedish Energy Agency and the Swedish research council for Environment, Agricultural Sciences and Spatial Planning Formas jointly finance a total of 17 strategic innovation programmes based on several agendas. The 17 programs have been started in four rounds (2013, 2014, 2015, 2016). Strategic innovation programs are long-term investments and individual programs can have a program length of up to 9-12 years if the program is well developed. The funding of the programmes is in total 160 MEuro (2013-2029). Each program receives between 2-5 MEuro per year. This amount is equally matched by the industry. A small amount (450 KEuro) funds the program office and the larger amount funds 1-2 calls a year.



The funding decision of projects is always taken by the Agency/Research Council based on recommendation from a separate expert panel

A.10.3 The governance of the intervention and of any evaluations undertaken

Each of the programs is undergoing a 3-year evaluation. The main purpose of the 3-year evaluation is to evaluate the establishment phase. The evaluation will highlight and create an understanding of the programs' strengths and potential improvements. The result of the evaluation is presented in this report. In the long term, the programs will be developed towards a stronger international position and competitiveness in order to strengthen Swedish areas of strength. The length of individual 17 Strategic innovation programs is linked to the results of the evaluations that take place every three years.

An evaluation of all 17 Strategic Innovation Programmes (SIP) is ongoing by Technopolis Sweden (Faugert & Co Utvärdering AB), in cooperation with Technopolis Ltd and Sweco Society AB. The purposes of the evaluations were to identify results and early impacts as foundation for the agencies' decision on continued funding, and to support both the agencies and the programme offices in ensuring that the SIPs can learn and develop in the best possible way."

A.10.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

The first sixteen programs have undergone an initial 3-year evaluation. The major findings of the evaluation of the first 5 programmes started 2013: [71]

- The Program Office's tasks include supporting the projects that are running, for example, through communication and packaging of results for better dissemination towards the business sector and other stakeholders, to ensure that project results are disseminated and put into use on a broad front. Most programs seem to be struggling with a lack of staff. The resource shortage is also reflected in communication and the support that needs to be given for ongoing projects.
- Overall, the first five Strategic Innovation Programs show that this new program concept has succeeded in establishing actor-driven activities and joint forces in innovation areas that are strategically important for Sweden.
- The link between the activities and the long-term impact targets needs to be clarified. The programs should actively work with the effect logic and ensure that the project portfolio achieves the level of ambition that the programs strive for.
- The programs need to ensure that they focus on the themes and activities that contribute to renewal in their respective areas, especially in addition to technology-driven R&D projects.
- Links to similar areas and initiatives especially internationally can be strengthened and become clearer. Many programs have not yet reached the degree of internationalization that should be pursued.
- Some of the programs need to be broadened to get impulses from neighboring areas or from international actors, while other programs can set limits to what the programs should act within.

Findings in the evaluation of the 6 programmes started from 2014[72]:

- The programs have contributed to solving social challenges differently. Some programs have, in an exemplary manner, addressed societal issues to, for example, skills provision, while others focus exclusively on the technical development of the programs. This can largely be explained by the nature of these areas. The evaluators have nevertheless recommended a program that mainly focuses on technological development to consider the broader perspective in order to create the conditions for strengthened competitiveness and growth.
- An overall conclusion from the evaluation is that virtually all programs 'work on internationalization needs to be strengthened and, in many cases, it can be a relatively simple things such as ensuring that the programs' websites are available in both Swedish and English. Several programs have focused internationalization efforts on trying to influence the EU's framework program for research, which the evaluators thought was too narrow a focus.

[71] https://www.vinnova.se/en/publikationer/utvardering-strategiska-innovationsprogram/

[72] https://www.vinnova.se/en/publikationer/utvardering-strategiska-innovationsprogram2/

- Their communication should take place broadly to several different target groups and via social media. Communication can be a tool to increase the recruitment of young people to the area and thus contribute to meeting the challenges of the supply of skills and gender equality, which is a common problem for several of the programs. No program has a stated strategy for gender equality.
- Effect logic needs to be developed together with the financed authorities so that it also becomes a tool for dialogue and follow-up between the programs and the authorities.

Findings in the evaluation of 5 programmes started in 2015[73]:

- The programs act as nodes for the renewal of and collect relevant stakeholders within each innovation area. The management of all programs shows a good insight into the challenges that arise from the need to cooperate with already known actors as well as new players. The evaluators also note that the programs work in an open and transparent manner that contributes to attracting new players to the programs.
- Most of the programs are recommended to strengthen their work on internationalization, among other things by developing an internationalization strategy. They can also develop communication efforts to enable international actors to search for the programs.
- All programs need to further develop work on gender equality and diversity by developing a strategy for this work, including concrete measures to achieve the goals of this strategy. Such a strategy must not be reduced to counting heads in organization and management of programs and projects but should aim at how the programs can contribute to increased gender equality and diversity at system or community level.
- The programs need to continue working with their effect logic, including by explicitly imposing important underlying assumptions and including barriers that can affect the programs' work towards set goals.

A.10.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

Based on some interviews with SIP program managers, the administrators from the funding agency and industry people, some early observations can be done :

- There are few/no incentives to stimulate radical innovations. Industry lead programs are more often focused on incremental innovations than to radical ones.
- The programs are designed to have 1-2 calls per year, which means few opportunities for the industry to apply for funding. The system is too slow especially for SME if you want the industry to make real progress.
- The programs stimulate the industry to allies with many other actors. They tend to apply for funding to achieve short term goals rather than long term knowledge development.
- The authorities behind the programmes acts very passively and leaves all the strategic decisions to the “industry dominated boards”. The interests within the board do not always reflect what is best for the Swedish society and economy.

A.10.6 Policy lessons for Norway

Move towards a more competitive, effective and efficient innovation system:

- Compared to ‘business as usual’, the programme is designed to develop long term collaborative relationships between actors in the eco-system around joint agendas. In the very beginning Vinnova expressed “all onboard” meaning that this program was aimed to reach more actors than the usual existing stakeholders, and they also expressed a special focus on end users which was important to engage. Some of the programmes have up to 100 stakeholders involved, which means a broad consensus between a lot of actors but less of an efficient innovation system.

[73] https://www.formas.se/analys-och-resultat/publikationer/2019-01-23-utvardering-strategiska-innovationsprogram.html

- It is too early to say anything about lessons learnt but the 136 approved agendas covered a broad spectrum but ended up in 17 strategic programmes. A lot of expectations from stakeholders did not result in any program. The funding agencies gave the mission to several "agendas" to cooperate. Some of the industries were not "onboard" from the start and competitions between leading industries did not ended up in joined forces and in-depth collaborations.
- The funding of a programme is based on 3-year cycles. That means no longer projects are funded. The programme therefore tends to focus more on short term goals due to the cycles and the amount of money.
- The quality of the projects is decided by an external expert panel and they recommend projects to be fund for the Board of Vinnova, who takes the decision. The Board of Directors of each SIP-Programme are taking strategic decisions, what kind of funding instruments to do and in what field the calls are going to be in. This funding decision set-up can slow down the ambition to reach the goals of the programme.

Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges

- The SIP's coordinated approach with joint agendas can often result in successful applications to EU programmes, where more funding and larger projects are seen. One example is the successful "HYBRIT" project, where 3 of the largest industries are making Sweden more fossil-free by solving the carbon dioxide issue in the steel industry (globally). The goal is to have a solution in place for fossil-free steel in 2035. If HYBRIT is successful, this means that Sweden can reduce its carbon dioxide emissions by 10% and Finland by 7%. The SIP program was a first step, funding the feasibility study and the application to EU-program. The project received EU-funding to be able to build and demonstrate a pilot plant.
- The funding agencies/research councils joined forces in this Strategic Innovation Program. This was the first time the three organisations set a long-term cooperation. Before the 3 organisations were more of "competitors" with different view of funding R&I. Nowadays they are more talked together.

A.10.7 Sources

Key publications:

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- Isaksson and Palmberg (2016), *Utvärdering strategiska innovationsprogram: Första utvärderingen av Processindustriell IT och Automation, Produktion2030, Gruv- och metallutvinning, Lättvikt och Metalliska materia*, Vinnnova Rapport VR 2016:10.
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Individuals consulted:

- Susanne Gylesjö, programme manager at Vinnova
- Matz Sandström, programme manager at SIP-STRIM
- Magnus Blinge, Adj. professor at Linköpings University, Dep of Management and Engineering

A.11 UK Industrial Challenge Strategy Fund

A.11.1 The policy context, origins and rationale for the intervention

The term 'industrial policy' has re-emerged in UK policy-making within recent years in the context of a new ambitious series of initiatives to improve the performance of the UK economy. The Government's Industrial Strategy was first launched with the publication of a green paper and a public consultation in 2016. In December 2017, the industrial strategy white paper[74] – "Building a Britain fit for the Future" – set out a policy framework for supporting an innovative economy with higher productivity and growth.

The strategy identifies **four overarching 'Grand Challenges'** for the UK, and subsequent work has identified one or more 'missions' for each grand challenge as summarised in the table below.

Table 16 UK Grand Challenges and missions

Grand Challenges	Missions
Clean Growth	• At least halve the energy use of new buildings by 2030 • Establish the world's first net-zero carbon industrial cluster by 2040 and at least 1 low-carbon cluster by 2030
AI and data	• Use data, Artificial Intelligence and innovation to transform the prevention, early diagnosis and treatment of chronic diseases by 2030
Ageing Society	• Ensure that people can enjoy at least 5 extra healthy, independent years of life by 2035, while narrowing the gap between the experience of the richest and poorest
Future of Mobility	• Put the UK at the forefront of the design and manufacturing of zero emission vehicles, with all new cars and vans effectively zero emission by 2040

Source: BEIS Policy paper: The Grand Challenge missions, Updated 13 December 2018 [75]

The Industrial Strategy identifies 5 key policy areas that will form the foundation of the strategy's ambition of creating a successful economy. 'Ideas' – including research and innovation – is identified one of five 'Foundations' and in this context, the Strategy outlines **four challenges facing UK research and innovation**:[76]

- Increasing government and private sector investment in research and innovation
- improving ability to commercialise world-class science and research and innovation
- building research and innovation excellence
- ensuring the UK's position as world leader in global science and innovation collaboration

The Industrial Strategy Challenge Fund (ISCF) is one of the key policy initiatives under this strand of the industrial strategy. The key policies under 'Ideas' are:[77]

- Raising total research and development (R&D) investment to 2.4% of GDP by 2027
- Increasing the rate of R&D tax credit to 12%
- Investing £725 million in new Industrial Strategy Challenge Fund programmes to capture the value of innovation.

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[74] HM Government (2017), 'Industrial Strategy – Building a Britain fit for the future', White Paper.

[75] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions#zero-emissions

[76] Ibid., pp. 60-63

[77] https://www.gov.uk/government/publications/industrial-strategy-the-foundations/industrial-strategy-the-5-foundations

A.11.2 Description of the intervention, including its strategy, implementation and budget

Concept and selection

The Industrial Strategy Challenge Fund (ISCF) forms one of the key elements of the Government's Industrial Strategy and is part of the Government's £4.7bn increase in investment in research and innovation over a four-year period 2017/18-2020/21. The ISCF will contribute to Industrial Strategy's aims to create the 'world's most innovative economy' by "investing in the UK's world-leading research base and highly-innovative businesses to address the biggest industrial and societal challenges today."[78] Among the models for the ISCF cited in the strategy was the US DARPA programme.

The criteria for deciding what constitutes a challenge to be funded by the ISCF were laid out in the government 2016 green paper (HMG 2016, pp. 30-31):

- the global market is potentially large, or fast growing and sustainable
- the UK has capabilities to meet market needs in terms of research strength and business capacity
- there are significant social and economic benefits
- there is evidence that government support will make a difference

Making some early suggestions based on the 'eight great technologies' defined previously by the government,[79] the green paper launched a consultation process which ran in the early months of 2017. In April 2017,[80] the first three challenge areas – battery technology, medicines manufacturing, and robotics and AI in extreme environments – were confirmed and a number of further challenges have been added since as shown in the table below.

Table 17 ISCF challenge areas (as of March 2019)

Challenge area	Budget
From data to early diagnosis and precision medicine	210m
Faraday battery challenge	£246m
Robots for a safer world (Robotics and AI)	93m
Driverless cars	38m
Audience of the future	33m
Creative industries clusters	39m
Healthy ageing	98m
Leading-edge healthcare	181m
Manufacturing and future materials	26m
National Satellite Test Facility	99m
Next-generation services	20m
Prospering from the energy revolution	102.5m
Quantum technologies	20m
Transforming construction	170m
Transforming food production	90m

[78] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/

[79] https://www.gov.uk/government/speeches/eight-great-technologies

[80] https://www.gov.uk/government/news/business-secretary-announces-industrial-strategy-challenge-fund-investments

Source: Government website: https://www.gov.uk/government/collections/industrial-strategy-challenge-fund-joint-research-and-innovation

Implementation

The ISCF is implemented by UK Research & Innovation (UKRI), often combining academic and industry-led R&D implemented, each element led by the research councils or Innovate UK as appropriate. The combination of support scheme differs between challenges. By way of illustration, the Faraday Battery Challenge includes the following funding streams:[81]

Faraday Battery Challenge funding streams:

- Collaborative research and development projects (Innovate UK)
- Battery industrialisation centre (Innovate UK): £80 million automotive battery industrialisation centre – the first of its kind in the UK. It will allow companies to quickly develop their capabilities to manufacture batteries and get them to market, scale up and go global.
- Faraday Institution (EPSRC):[82] Based at the Harwell Science and Innovation campus, the institution will enable academics to work with industry on research, training and analysis into batteries.

Following the confirmation of the first way of challenge areas in April 2017, the funding competitions for these early challenges have now been completed and the projects are in progress. Challenges selected later are still in an early phase of implementation and the selection process for the third wave of challenges is currently ongoing.[83]

Budget

The budget for the ISCF is a major part of the new National Productivity Investment Fund (NPIF) which is the main vehicle for delivering a planned budget increase in funding for R&I over the period 2017-2022 (4.6bn until 2021 and an additional 2.3bn announced for 2021-22). As such, it is separate from, and additional to, the government's main R&I budget which is relatively stable over the same period. When fully phased in, at least some £450m/year will be allocated to the ISCF, as shown the table below.

Table 18 Planned allocations from the National Productivity Investment Fund

	2017-18	2018-19	2019-20	2020-21	2021-22
Industrial Strategy Challenge Fund	249	386	491	469	2,300
Other NPIF programmes [1]	173	383	674	685	
To be allocated	0	70	344	862	
Total	**423**	**839**	**1,509**	**2,017**	

Source: Adapted from BEIS (2018, pp. 3, 17).
Note [1]: Other NPIF programmes include 'Talent', 'Fund for International Collaboration', 'Quality-Related Funding', 'Commercialisation' and 'Strength in Places'.

A.11.3 The governance of the intervention and of any evaluations undertaken

The governance of the industrial Strategy and the ISCF requires coordination on a number of levels.

- At the policy level, a new Industrial Strategy Council has been set up, composed of 20 senior individuals from industry, academia and civil society, with the role to assess the government's progress towards meeting the commitments from the Industrial strategy.s

[81] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/faraday-battery-challenge/

[82] https://epsrc.ukri.org/files/funding/calls/2017/iscffaradayinstitute/

[83] https://innovateuk.blog.gov.uk/2019/02/05/industrial-strategy-challenge-fund-wave-3-shortlist/

- The programme is implemented by UK Research & Innovation (UKRI) and is governance issues are closely related to the creation of this organisation in 2014. The implementation thus requires working across previously separate parts of the organisations (e.g. research councils and innovate UK) and thus relies on effective organisational processes within the new entity.
- The implementation of individual challenge programmes also requires coordination and each challenge is lead by a dedicated Challenge Director to achieve this.[84]

Evaluations of each ISCF challenge programme as well as an evaluation of the ISCF as a whole are foreseen (Ellis 2018). Some of these evaluation activities have already started.

A.11.4 The findings of any evaluations or other studies that illuminate the effects of the intervention to date and lessons learnt for policy practice

The first wave of ISCF investments are currently being evaluated but these are not to be completed and the results are not yet in the public domain.

In a publication from December 2018, the government took stock one year after the launch of the Industrial Strategy. Within the 'Ideas' section of the strategy, the following achievements, mostly related to implementation of the ISCF, are highlighted (HMG 2018, p. 18):

- 602 new research and development projects supported by government
- £2.7bn addressing R&D challenges through the Industrial Strategy Challenge Fund
- £110m to support international collaboration in science and research

Formal evaluations aside, there is evidence of an evolving policy and governance framework around the challenge approach.

- Although the ISCF and the first challenge areas were launched first, the ISCF is now framed as a means to supporting the grand challenges
- The development of more specific 'missions' to complement each of the four grand challenges as shown above.[85]
- The role of the 'mission-oriented approach' within the broader portfolio is being more clearly defined, e.g. "the Mission-oriented approach cannot dominate domestic funding" (Ellis 2018)

A.11.5 Our own assessment of the successfulness and promise of the intervention, based on the available evidence

It is clear that the scale and scope of the ISCF has the potential to be transformative and have a major impact within the UK research and innovation system. While it is too early to say exactly what the impact will be, it is possible to point to a couple of issues that are key to realising the transformative potential:

At this stage, it is possible to look at the positioning of the new investment. One discussion is around the selection of challenge areas. In her response to the Industrial Strategy green paper, Professor Mazzucato (2016) noted: "It would be a fundamental misconception if the whole industrial strategy were to be based on simply listing areas, sectors and technologies for intervention without considering the systemic dimension of industrial strategy."

A.11.6 Policy lessons for Norway

Move towards a more competitive, effective and efficient innovation system:

- The industrial strategy and the ISCF provides an example of comprehensive approach that attempts to combine policy and funding approach in a coherent way to achieve a more efficient innovation system and wider economy.
- The implementation of the programme necessitates close coordination at several levels:

[84] https://www.ukri.org/news/new-industrial-strategy-challenge-fund-directors-appointed/

[85] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions#zero-emissions

- between previously separate funding agencies, including Innovate UK and relevant research councils
- between programme participants from academia and industry connecting use-inspired basic research with collaborative research and demonstration activities.

Achieve these structural transformations while supporting research and innovation (R&I) that can confront an array of societal challenges:

- The UK has used a consultative process based on a set of explicit selection criteria focused on existing capabilities and future opportunities to select challenges. This is an example of attempts to go beyond the incumbents and identify genuine 'mission' areas with transformative potential as opposed to re-labelling existing initiatives.
- The UK experience provides input in the discussion about the role of challenge or mission-oriented research in the overall funding mix. The ISCF is funded as part of a separate budget allocation, added on top of existing budgets and the UK government appears to have taken the view that such 'mission' research schemes need to be complementary to existing activities, rather than structure the entire portfolio.

A.11.7 Sources

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Appendix B Abbreviations Used

Abbreviation	Definition
AD	Ministry of Labour
AIDS/HIV	Acquired Immuno-Deficiency Syndrome / Human Immunodeficiency Viruses
ASD	Ministry of Labour and Social Affairs
AT	Austria
BERD	Business Expenditure on R&D
BIA	RCN programme of user-directed R&D
BLD	Ministry of Children and Equality
BMBF	German Federal Ministry of Education and Research
BMU	German Federal Ministry of the Environment
BMWi	German Federal Ministry of Industry
DE	Germany
DK	Denmark
EU	European Union
FAD	Ministry of Government Administration, Reform and Church Affairs
FI	Finland
FKD	Ministry of Fisheries and Coastal Affairs
FR	France
GDP	Gross domestic product
GERD	Gross Expenditure on R&D
HE	Higher Education
HEI	Higher Education Institution
HOD	Ministry of Health and Care Services
HTS	German High-Tech Strategy
IFD	Innovation Fund Denmark
IN	Innovation Norway
IPR	Intellectual property rights
ISCF	Industrial Challenge Strategy Fund, UK
JD	Ministry of Agriculture
KD	Ministry of Education and Research
KMD	Ministry of Local; Government and Modernisation
LTP	Long-term plan
MAP	Multi-actor, multi-measure programme

Abbreviation	Definition
MER	Ministry of Education and Research
MLP	Multi-level perspective (on socio-technical transitions)
MPE	Ministry of Petroleum and Energy
MSTI	Main Science and Technology Indicators (of the OECD)
MVD	Ministry of the Environment
NFD	Ministry of Trade, Industry and Fisheries
NHD	Ministry of Trade and Industry
NHO	Confederation of Norwegian Enterprise
NL	The Netherlands
NVE	Norwegian Water Resource and Energy Directirate
NWO	Netherlands Ministry of Education and Research
OECD	Organisation for Economic Cooperation and Development
P2P	Public-to-public partnerships
PPP	Public-private partnership
R&D	Research and development
R&I	Research and innovation
RCN	Research Council of Norway
RFF	Regional research funds
RTI	Research, technology and innovation
SD	Ministry of Transport
SDGs	United Nations Sustainable Development Goals
SE	Sweden
SFF	Sentrum for Fremragende Forskning – Centre of research excellence
SFI	Sentrum for Fremragende Innovasjon – Competence Centre
SIP	Strategic Innovation Programme (Vinnova programme)
SIVA	Industrial Development Corporation of Norway
Skattefunn	Norwegian R&D tax incentive scheme
SØA	Samfunnsøkonomisk Analyse
STI	Science, technology and innovation
TIS	Technological innovation system
UD	Ministry of Foreign Affairs
UK	United Kingdom of Great Britain and Northern Ireland
UKRI	UK Research and Innovation (combined research council and innovation agency)

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