STI POLICY ROADMAPS FOR THE SDGs

inno4sd.net
Innovation for Sustainable Development Network

ISBN: **pending. Brussels, Belgium. March 2019**

Contact: **Dr. Fernando J. Diaz Lopez., Inno4sd Director**

fernando.diazlopez@inno4sd.net

Design: **Inge Conde Moreno (www.ingecreative.com)**

Science, Technology and Innovation Policy Roadmaps for the SDGs

The inno4sd network was initiated by the green.eu project, which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº.641974.The views expressed in this document are those of the author(s) and do not necessarily reflect those of the European Commission.

Science, Technology and Innovation Policy Roadmaps for the SDGs

A Guide for design and implementation

Michal Miedzinski
UCL Institute for Sustainable Resources
m.miedzinski@ucl.ac.uk

Will McDowall
UCL Institute for Sustainable Resources
w.mcdowall@ucl.ac.uk

Jesse Fahnestock
RISE Research Institutes of Sweden
jesse.fahnestock@ri.se

Gerrit Muller
Netherlands Organisation for Applied Scientific Research TNO
& University of South-Eastern Norway
gerrit.muller@gmail.com

Fernando J. Diaz Lopez
Netherlands Organisation for Applied Scientific Research TNO
& Stellenbosch University
fernando.diazlopez@inno4sd.net

Table of contents

Table of figures

Research & Innovation as a Compass for the Sustainable Future We Want

There is little time to lose if we are to achieve an environmentally, socially and economically sustainable Europe by 2030.

It is not just a question of delivering on the people's democratic will and expressed preferences in Europe, but a question of economic leadership, societal wellbeing, and planetary survival. Europe must leverage all its tools in a more comprehensive manner to accelerate its transition. Up until now, the approach has remained too piecemeal.

Yes, we have a strong research base and we have been at the forefront of scientific advances on low-carbon technologies and renewable energies. But, we still underperform when it comes to transforming research into commercial, market-creating innovations. And, where we succeed in coming up with breakthrough technological developments, but all too often, these are bought up by foreign companies or rolled out elsewhere.

We have an opportunity now to do better on research and innovation with a view to accelerating the transition towards a more sustainable Europe by 2030. Our best answer to achieve this is a Strategic Research, Innovation, and Investment Agenda that develops and deploys existing and new solutions on much larger scale. Such a 'new growth agenda' needs to focus on setting long-term directions for investment and delivery to address sustainable development and to accelerate transitions in key systems. This would also result in more job creation and improved competitiveness in Europe, to the benefit of society.

I am proud to say that the guidelines presented in this document to develop Science, Technology and Innovation (STI) policy roadmaps are an important and practicable contribution to developing the new growth agenda, as well as the mission-oriented approach.

This document embodies the inherent value of the Innovation for Sustainable Development Network (INNO4SD), which is in fact the guiding ethos behind all EU funded research projects, namely to garner collective efforts and global partnerships to advance practicable solutions, scientific methodologies, and tools towards more sustainable development.

I fully encourage all readers of this document, including government authorities, development practitioners, and academic researchers, to dig deeper into the extensive knowledge repository and network of global partners that INNO4SD has established over the past years.

Finally, I believe we in our role as policy-makers will find important applications in our daily work for setting long-term directionality towards fairer, more competitive and more sustainable societies in Europe and the World.

Jean-Eric Paquet
Director General
Directorate General Research and Innovation (RTD)
European Commission

Science, Technology and Innovation (STI) stimulates disruptive transformations of social and economic systems through accumulated scientific and technological knowledge and is expected to play a key role in Agenda 2030: the Sustainable Development Goals (SDGs).

Soon after the Agenda was adopted at the 2015 General Assembly of the United Nations, it was made known to policy makers, industry leaders, the scientific community and other stakeholders worldwide that STI for SDGs must accelerate to quickly close the remaining distance to the 17 Goals and 169 Targets.

To this end STI for SDGs roadmaps have been well recognized as key tools for the Technology Facilitation Mechanism lead by the United Nations Inter-Agency Task Team (IATT) and discussed at past Multi-stakeholder Forums on STI (STI Forums). In addition, Expert Group Meetings (EGMs) on STI for SDGs roadmaps were organized by IATT in New York (2018), Tokyo (2018), Brussels (2018) and Nairobi (2019), where inno4sd.net has been making significant contributions in clarifying the concepts and architecture of the roadmaps.

STI for SDGs roadmaps facilitate cyclic processes to define objectives, analyze gaps, co-design pathways, and implement collaborative action plans. They are by nature different from technology roadmaps because they incorporate political, industrial and social elements as well as R&D and technology application plans. They help with the coordination of coherent actions of many stakeholders and the monitoring or evaluation of progress. Roadmaps are drawn at international, national and sectoral levels with emphasis on local priorities and bottom-up approaches with respect for local culture, history, and indigenous knowledge.

STI for SDGs roadmaps encourage transformation of policymaking and implementation. Each country should implement an aggressive but feasible STI policy as an integral element in its own SDGs strategy. Breaking ministerial silos is imperative if we are to encourage holistic and comprehensive policymaking, as is the fostering of public-private partnerships. Bottom-up activities across gender and age boundaries should be properly incorporated.

STI for SDGs roadmaps also encourage transformation of industry, a key source of innovation. Industrial organizations such as the World Business Council for Sustainable Development (WBCSD) have already been discussing sectorial roadmaps which pursue both environmental protection and business growth, backed by responsive investment, entrepreneurship and capacity building.

Finally, the STI for SDGs roadmaps encourage transformation of the scientific community. The community is getting more involved than ever in designing our future society, the integrated efforts of natural sciences, social sciences and humanities giving birth to disruptive SDGs-oriented innovations. Universities and national research institutions can become hubs for local innovation ecosystems, capitalizing on the valuable opportunity Agenda 2030 has given for the scientific community to be with and for society.

The guidelines presented here by inno4sd.net represent a new STI paradigm for multi-stakeholder engagement and depict concrete methods by which to leverage STI for the attainment of the SDGs. They will facilitate the participation of all stakeholders in the challenging voyage to come.

Michiharu Nakamura

Former President and Advisor, Japan Science and Technology Agency (JST)

Member of the Multi-stakeholder Group to support the UN Technology Facilitation Mechanism of the Sustainable Development Goals

INTRODUCTION

Why these guidelines?

Roadmapping has been employed as a framework for strategic planning in technology management for many years. More recently, roadmapping tools have made their way into policy for Science, Technology and Innovation (STI), particularly where policymakers are seeking to understand how STI can contribute to meeting long-term goals, such as the SDGs.

Roadmaps offer STI policy makers tools to enable design, planning and implementation of public policies, and to build partnerships for long-term ambitious sustainability goals.

There are many existing guides for technology roadmapping, but there are fewer guides for helping policymakers understand how to use roadmapping for policy design and implementation, and how to best to translate the benefits of roadmapping beyond a focus on technology.

These guidelines address this gap by proposing a framework for STI policy roadmapping for the SDGs that considers existing practice as well as areas of focus and challenges relevant for sustainable development.

The document contributes to the ongoing work on STI for SDGs roadmaps undertaken by the UN inter-agency task team on science, technology and innovation (UN IATT) in the framework of the Technology Facilitation Mechanism.

This document introduces the context of STI for SDGs roadmaps, and proposes a practical step-wise approach to organising a policy roadmapping exercise.

The key questions

The questions these guidelines respond to include:

- What is technology roadmapping, and what are key design features of roadmaps?
- How to adjust technology roadmapping to apply it to design and implementation of public policies?
- How to design and implement STI for SDGs policy roadmaps?

The guidelines comprise three main sections:

- Section 1 introduces technology roadmapping with a focus on its key features and generalised architecture.
- Section 2 discusses an approach to policy road-mapping and proposes a generalised architecture of STI for SDGs roadmaps.
- Section 3 introduces the step-wise approach to STI for SDGs policy roadmapping highlighting key objectives, possible approaches and methods which can be deployed in different phases of the process.

The document is illustrated with succinct examples of roadmapping exercises implemented around the world, and include a list of relevant sources with suggestions for further reading. A richer discussion and a critical review of some recent road-mapping experiences was presented in the Inno4SD Policy Outlook (Miedzinski et al, 2018).

We hope these guidelines serve as a useful companion and reference for policy makers on international, national and local levels who see policy roadmapping as an important process for harnessing STI for the SDGs.

Why STI policy roadmaps for the SDGs?

2.1. The role of STI policy in meeting the SDGs

The 2030 Agenda for Sustainable Development recognises Science, Technology and Innovation (STI) as a key enabler for societies to become prosperous, inclusive and environmentally sustainable.

Achieving the Sustainable Development Goals (SDGs) will require innovations with the potential to reconfigure entire systems of production and consumption. The challenge for developed and developing countries alike is to create and deploy knowledge and innovation with transformative impact across the society and economy. In other words, innovation is required at the level of systems, not just individual technologies, products or processes.

System innovations call for a concerted effort engaging various stakeholders, often from many countries, operating at different levels of governance. Tackling development challenges will require a smart 'innovation mix' that combines strategic deployment of relatively low-risk technologies with disruptive system innovations seeking longer-term transformative impact.

"The cross-cutting nature of the Sustainable Development Goals (their interdependencies, potential trade-offs and synergies) and of science, technology and innovation requires holistic approaches and strategies."

STI FORUM 2017

Designing policy to support such ambitious innovation objectives requires a long-term perspective, an ability to engage a diversity of relevant stakeholders, and a capacity to work across traditionally separate policy domains. Roadmapping is one possible approach that can help to meet this policy challenge.

Roadmaps are increasingly recognised as a useful tool for policy makers to assist design, implementation and coordination of STI policy portfolios that seek to address the SDGs[1].

"STI roadmaps and action plans that have a particular focus on accelerating progress towards the Goals are essential."

STI FORUM 2017

2.2. Why the focus on roadmapping?

Technology roadmapping is a well-established technique that has been used to support technology management for many decades.
There is a rich body of experience on technology roadmapping, in particular in a business context[2].

"Technology roadmapping represents a powerful technique for supporting technology management and planning, especially for exploring and communicating the dynamic linkages between technological resources, organisational objectives and the changing environment."

Rob Phaal,C. Farrukh and D. Probert (2004)

Roadmapping refers to many related techniques and approaches. There is no single blueprint or protocol for the methodology or format of the roadmapping process. It is a flexible approach that can be tailored to different contexts[3].

Despite diverse approaches most roadmaps are based on a generalisable set of guiding questions and design features[4]:

- The roadmapping process needs a reflection on the current state of development or a baseline (i.e. 'where are we now?').
- Roadmaps need to have an explicit purpose expressed as a vision and strategic priorities and targets (i.e. 'where do we want to go?').
- Roadmaps include an explicit time horizon and timelines illustrating the process of getting to the vision (i.e. 'how do we get there?'). Timelines are often presented with the use of scales, milestones and intervals. Most (though not all) roadmaps include a graphical or visual depiction.

Roadmapping typically involves **stakeholder participation**, enabling representation and exploration of diverse perspectives, and mutual learning among participants.

One distinctive feature of roadmaps is 'the use of a time-bound, structured and often graphical framework to develop, represent and communicate strategic plans, in terms of the co-evolution and development of technology, products and markets'[5] (see Figure 1).

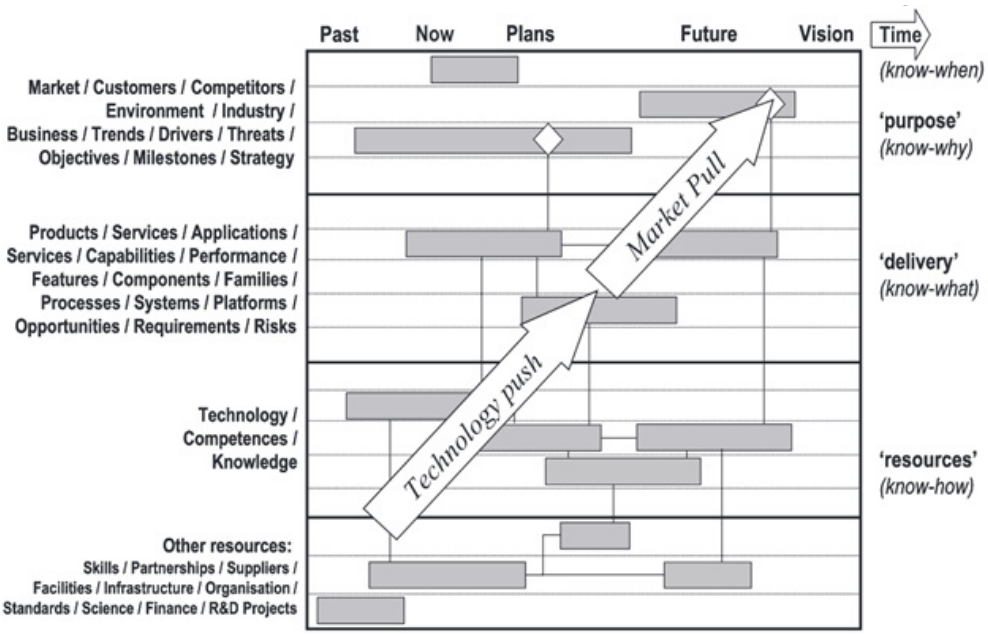
TIFAC Technology Vision 2035 for India

TIFAC Technology Vision brought together elements of several foresight methods, including horizon scanning, visioning, scenario development and technology road-mapping. The overall exercise sought to "create a junction between aspirations and reality" by answering five core roadmapping questions:

1. Where are we now?
2. Where would we like to go?
3. What is the best way to get from here to there?
4. What technological interventions can help us to get from here to there?
5. What impediments will technology throw up along the way?

Source: TIFAC (2016)

Figure 1. Generalised architecture of technology roadmaps.



Source: Phaal et al (2004)

2.3.Policy roadmaps as systemic policy instruments

From its origins in private sector technology management, roadmapping is increasingly applied in public policy contexts. STI policy roadmaps for the SDGs can build on - but need to move beyond - conventional approaches to technology roadmapping.

They should retain the technology foresight dimensions of technology roadmaps but need to refocus attention on the policy and governance aspects of long-term changes which are key for achieving Global Goals.

"STI roadmaps for the Goals can be important strategic tools for ensuring policy coherence and for linking the most pressing development challenges with solutions."

STI FORUM 2018

Roadmapping can be a powerful policy instrument for a number of reasons[6]:

- Roadmapping processes facilitate alignment and communicate a common view on the direction of STI policy across diverse stakeholder groups. Even where consensus is elusive, roadmapping can facilitate mutual learning and sharing of relevant perspectives on priorities for STI developments.
- Roadmaps influence expectations about the development of STI. This is important, because when innovators, scientists, investors and other stakeholders have shared strong expectations about the prospects of a particular area of technology or business model, progress in that area becomes more likely. Roadmaps can help to stimulate positive expectations and facilitate the future that they depict. Roadmapping is not only a process for facilitating and managing STI policy but it is a policy instrument in its own right.
- Roadmaps can be a useful framework for managing ongoing programmes and activities. Roadmaps typically include key milestones and actions, which provide a framework for monitoring and coordination.
- Roadmaps help understanding the problem and solution space. In the process of developing a shared understanding, alternative options for solutions, and technical, economic, social or competence needs are discovered.

It is important not to overstate what roadmapping by itself can achieve. Roadmapping is a supportive framework, which can be useful by itself, but which typically works to facilitate or support other policy processes, investments or business activities.

"It is not a good idea to confuse your roadmapping process with your strategy or innovation management process (or any other process). Roadmapping supports these other business processes; it has limited impact by itself."

Robert Phaal, Cambridge University Institute for Manufacturing

Developing an approach to harness STI potential for the SDGs

Roadmapping can be used in a variety of ways, and thus cannot follow a simple single 'recipe'. Rather, the roadmapping process must be designed to fit the particular policy context. This section draws on the experiences of previous STI policy roadmapping exercises[7] to inform that process of custom designing roadmapping approaches.

This section discusses four key aspects of STI for the SDGs roadmaps:

- Scope and focus: from technology areas to whole systems change;
- Balancing between visions, pathways and plans;
- Fitting the process to the actor and governance context;
- Key elements of the architecture of STI for the SDGs roadmapping.

3.1. Scope and focus: from technology to whole-systems change

Archetypal contexts for STI policy roadmaps with a potential to contribute to the SDGs on the national level include:

- **STI system as a whole** (i.e. reorienting national STI system). Here there is a greater focus on the policy and governance dimensions, with a lower degree of concreteness in terms of scientific and technological developments.

- **Sectors** (e.g. energy or transport). A sectoral focus is a common scope for roadmapping undertaken by industrial associations, often in collaboration with governments. This focus for roadmapping can borrow heavily from the use of roadmapping as a technology management tool in industry.

- **Existing or emerging STI areas** (e.g. technology area or new materials). This is the most common focus of roadmapping. As with the previous example, this focus for roadmapping can also borrow heavily from the use of roadmapping as a technology management tool, as it incorporates a large role for technology foresight activities.

- **Specific challenges or missions** (e.g. reducing urban air pollution or supporting healthy aging). Roadmapping at this scope can be fairly concrete in terms of the specific innovations and areas of technological and scientific development. It has an element of foresight, and borrows from the use of roadmapping as a technology management tool, suitably extended to broader policy concerns.

3.2. Balancing between visions, pathways and plans

While all roadmapping processes tend to include a minimum level of baseline analysis, the focus of the resulting roadmap is typically on the three future-oriented elements: the vision, the pathways, and the action plan. Determining the appropriate relative emphasis on each of these is a key decision in shaping the policy roadmapping process.

Developing and communicating a vision

A priority on visioning is often important in contexts in which policy goals are poorly formulated or not agreed. Roadmapping in support of the SDGs will typically be framed around key SDG targets or visions for the way in which particular areas of STI might facilitate achievement of those goals.

WBCSD Vision 2050

The World Business Councilon Sustainable Development's (WBCSD) Vision 2050 is an example of a 'vision-focused' roadmap. It includes illustrative pathways, but the emphasis is on the overall shared vision. Vision 2050 was an attempt to articulate a proactive engagement with sustainable development challenges by international business.

Source: WBCSD 2010

Establishing plausible pathways

Pathways describe causal mechanisms of change expected to be triggered by various innovations overtime, and consider the role of policy instruments in enabling the desired changes. An emphasis on elaborating pathways is possible when goals are clear, but there is doubt about how the vision can be achieved.

This is often the case when the desirable features of the system can be clearly identified (e.g. zero waste; low emissions) but the technological, business and institutional pathways by which those goals can be achieved is unclear.

Fossil-free Sweden

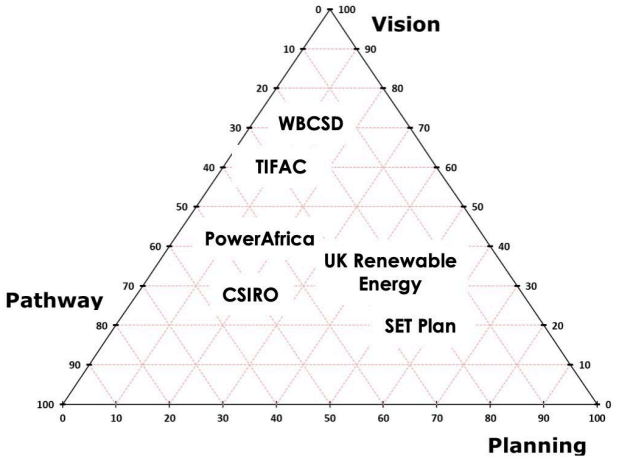
The Swedish government's cross-party agreement on net-zero emissions 2045 created a context where industries and expert bodies could develop and commit to sectoral roadmaps for 'Fossil-free Competitiveness'. This process developed agreed and plausible pathways to achieving the overall goal.
Source: http://fossilfritt-sverige.se/in-english/

Setting out a strategic action plan

A policy roadmapping process can be used principally to develop and communicate a strategic timebound plan of actions with responsibilities assigned to concrete actors.

While most roadmapping processes include some features of all these three elements, they tend to differ in emphasis depending on the goal, scope and context of the exercise (see Figure 2). Clarity about the extent to which the roadmapping process aspires to flesh out each of these elements is an important step, since it influences the ensuing process.

Figure 2. Mapping roadmapping exercises against vision, pathway and plan



Source: Miedzinski et al (2018a)

One of the key issues in the roadmapping process is ensuring that the work on vision and pathways is not captured by one dominant perspective early on in the process. Practitioners advocate a careful differentiation between non-committal and committal phases of the processes. Ensuring openness of the non-committal steps (e.g. vision) helps to keep the discussion of viable options unbiased and creative.

Depending on the policy context, it may be even considered to keep committal planning separate from action plan as the perspective of making commitments may cause participants to think and act defensively, and even reverse-engineer pathways to suit their existing preferences.

STI policy in support of the SDGs is often beset by contested perspectives. While many guidelines on producing roadmaps emphasise the importance of achieving consensus, this may be often unrealistic or even counter-productive in the case of challenge-driven processes. It may be more appropriate to include multiple or even alternative innovation pathways within the roadmap that satisfy different stakeholder interests without full agreement. Multiple pathways may be then tested by carrying out experimental pilot projects.

3.3. Organisational and governance context

A wide variety of organisational and governance contexts are possible. Here we illustrate three archetypal situations:

- **A roadmap for a specific lead organisation and programme**: Single organisations often use roadmapping to assist in the development of strategic planning, and to communicate plans both within and outside the organisation. In the STI policy context, such roadmaps are often associated with specific funding programmes or policy instruments. Here, there is a clear single 'lead' organisation or institutionalised partnership, which can make decisions and credible commitments to implement the roadmap.

- **Roadmapping to create a jointly agreed view across a number of organisations**: Roadmapping processes are also used as a tool for collaborative planning across a group of divergent actors. In such contexts, the process can be valuable in enabling greater alignment of goals and plans, and greater coordination. Here, there is not necessarily a single 'lead' actor.

- **Roadmapping as a way of enrolling key actors in the process of change**: Roadmapping is not always used by actors that hold the power to implement significant change. The approach is often used to communicate the plausibility and desirability of pursuing a particular vision or goal, by those that are not able to drive change themselves. Campaign groups, industry associations and researchers often create roadmaps as tools to communicate the desirability and plausibility of specific pathways and visions, and seek to enroll other (typically more powerful) actors in pursuing those goals.

The position of the roadmap in terms of the actor and governance context helps to clarify the value and limits of the roadmapping process (see Figure 3).

Figure 3. Contextualising visions, pathways and planning in STI policy roadmaps

	Vision	**Pathway**	**Plan**
Strategy or programme implementation	Vision relates strongly to the lead organisation, and communicates the organisation's vision and aspirations. There may be less need for this vision to appeal to others, and it is less important for the vision to be co-developed with a wide range of stakeholders.	The pathway sets out external uncertainties and internal strategies that may influence the achievement of the vision. It shows how the lead organisation's goals might be achieved in the face of external uncertainties.	The action plan sets out strategic measures required to follow the pathway and reach the goals. This can be detailed, and can extend to the normal planning horizon of an organisation. It should be clear about who is responsible for actions, and what the milestones are.
Joint initiative	Visioning can play a key role in building consensus, sense of shared purpose. In such a context, it is important that the vision is developed in a way that ensures it is jointly 'owned' by the participant actors.	The pathway can combine both analytic elements, and the expectations and intended actions of participating organisations. This combination of actor-based and analytic foundations helps provide credibility for the resulting pathway.	The extent to which actors are willing to commit to specific long-term vision and actions is critical. The plan will have credibility where it is clear that there is support and buy-in from senior leaders in the relevant organisations. It is useful to illustrate who is responsible for actions.
Enrolling actors	Vision must be compelling, and sufficiently plausible and desirable to attract other adherents. In some cases, the process of developing the vision can be successful in enrolling actors.	The pathway must be credible, setting out plausible routes by which the vision can be achieved. Pathways are often elaborated through backcasting or systems modelling. Credibility flows from the analytic robustness rather than from the participation and commitment of powerful actors.	Roadmaps that have a principal aim of enrolling new actors are rarely a position to deliver strong, time-based and credible plans for actors over which they have no direct control.

3.4. STI for SDGs: towards a policy roadmapping framework

Policy roadmaps are a mechanism through which STI policies can be better aligned with the SDG targets and deliver on the ambition of the 2030 Agenda.

Given that SDGs will require variety of innovations, policy roadmapping process needs to encompass diverse approaches, cut across governance levels and embrace multiple complementary innovation pathways.

The roadmapping system will need to remain open to a variety of roadmaps ranging from technology focused exercises, mission-oriented approaches to innovation system-wide policy roadmaps (see Figures 5-7).

The proposed **three layers of STI for SDGs policy roadmap** include:

- **Vision and strategic context**
  - Vision, targets and milestones, including SDGs
  - External drivers and trends
- **Innovation and transition pathways**
  - Key innovations and innovation pathways to achieve the targets
  - System conditions enabling and accelerating innovation (finance, market demand, technology trends etc.)
- **Policy action plan**
  - Policy instruments (instrument mix)
  - Governance level and governance mechanisms
  - Evaluation and policy learning
  - Capacity building.

Figure 4 introduces a proposed generic architecture of STI for SDGs policy roadmaps.

Figure 4. Generic architecture for STI for SDGs policy roadmaps[8]

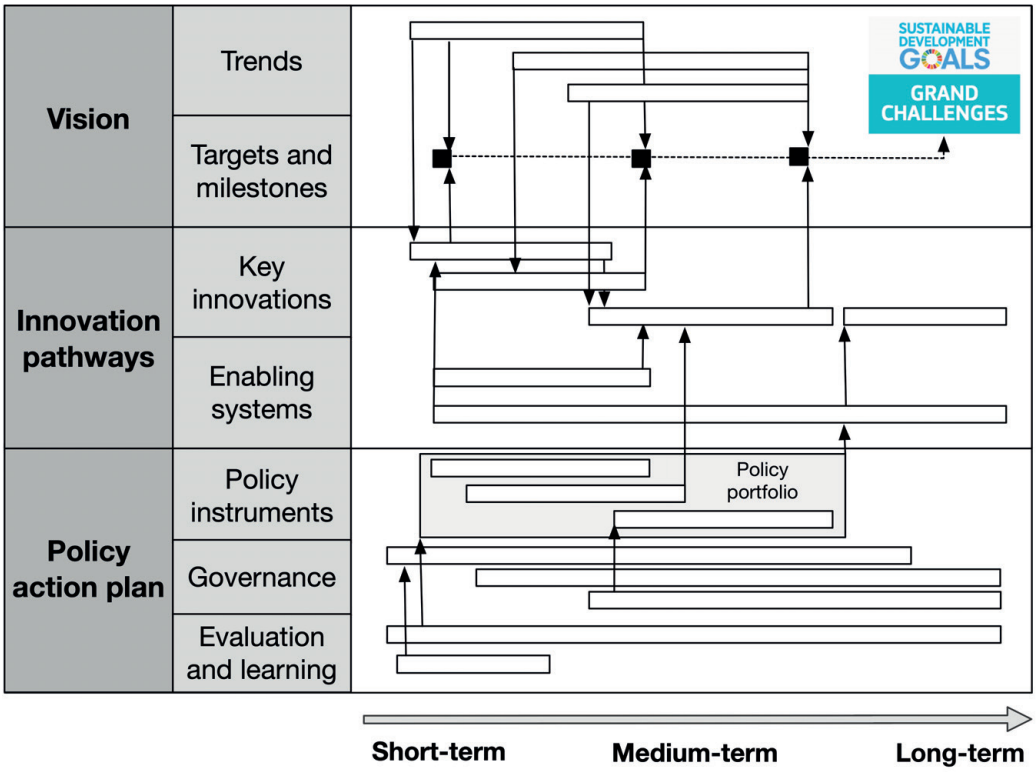


Figure 5. Comparing possible levels of STI for SDGs policy roadmapping

	STI policy roadmapson the level of STI system	STI policy roadmaps for "missions" and "challenges"	STI policy roadmaps for sectors	STI policy roadmaps for technology area and products
Scope and timeframe	STI systems as a whole, including policy, technology, innovation and the entrepreneurship eco-system. System-wide focus means longer-term perspectives (2030 and beyond)	Policy support for selected missions The scope is defined around a specific goal or 'mission'. From short-term to long-term depending on the mission but always with short-term milestones	Visions and targets for sector, technology area or related scoping (e.g. value chain) From short-term to long-term depending on the sector	Policy support for prioritised technology areas or products Depends on the maturity of technology and products (from 2-3 years to 10-15 years)
Governance mechanisms	High-level policy coordination. A whole-of-government approach and policy integration mechanisms.	Broad mission oriented public-private and public-partnerships. Policy integration mechanisms focused on the mission.	Sector-focused and public-private partnerships.	Innovation collaborations and public-private partnerships focused on a specific areas.
Relative advantages and limitations of approaches in respect to the SDGs	Advantages: - Includes entire STI system - Supports coordination and coherence of the STI policy mix - Can rely on existing governance structures and processes Limitations and challenges: - Cannot address specific challenges and problems - May be disconnected from specific policy instruments	Advantages: - Address concrete challenges rather than generic problems - Capture cross-sector and multi-actor nature of the SDGs - Bring together stakeholders driven by the need to resolve a problem Limitations and challenges: - The need to introduce new governance structures and mechanisms - Needs embedding in an integral roadmap, to ensure achieving SDGs	Advantages: - Mobilises sectoral actors - Pre-existing shared language and perspectives of main actors Limitations and challenges: - Limited capacity to forge new cross-sectoral partnership - Limited capacity to consider challenges unrelated to the sector - The risk of capture and "business as usual" approaches driven by sector's interest . - Needs embedding in a roadmap across sectors to ensure achieving SDGs.	Advantages: - Specificity and proximity to innovation and business processes Limitations and challenges: - Essential policies often beyond scope of the exercise (i.e. remain seen as external factors)

Figure 6. Mission-oriented innovation policy roadmapping framework for the SDGs

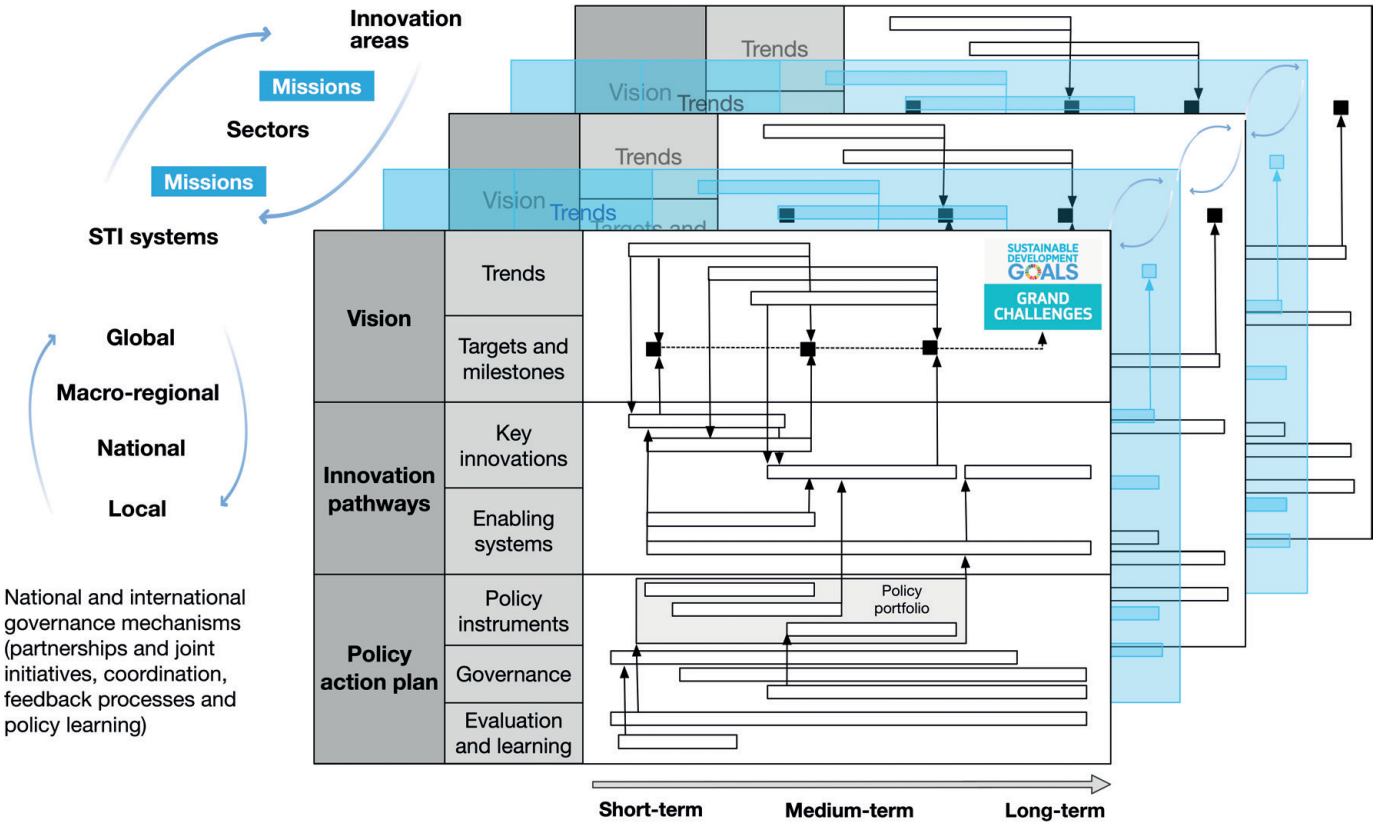
		Where are we?	How are we going to get there?			What do we want to achieve?
		Past Now	Short-term (2020)	Medium-term (2025)	Long-term(2030 and beyond)	Long-term objectives and targets
GRAND CHALLENGE AND MISSIONS	Grand challenge	Collect evidence on systemic determinants and impacts of grand challenge	Indicate key metrics of systemic barriers and drivers, and impacts, of the challenge to monitor its evolution in short, medium and long-term			Identify grand challenge and SDGs to be addressed by the roadmap
	Missions	Identify evidence on systemic determinants and impacts of challenges specific for missions	Agree on specific goals, milestones and targets for the mission Identify links to the relevant SDG targets and national and local goals Agree on indicators to track progress in short, medium and long-term.			Identify and select missions to be addressed by the roadmap
INNOVATION PATHWAYS	Key innovations	Scan existing and emerging technological and non-technological innovations relevant for accomplishing the mission	Identify key STI needs relevant for the mission which require public support in the short, medium and long term Identify key incentives and barriers to innovations and changes needed to accomplish the mission	Identify key innovation strategies and prioritise "innovation portfolios" to be covered by the roadmap Explore alternative innovation pathways and characterise enabling systems needed to accomplish the mission		Identify emerging and imagine new innovations and enabling systems needed to accomplish the mission
	Enabling systems	Analyse enabling systems relevant for the mission, including policy mix and institutions, business and finance, sectors and value chains, absorptive capacity, human capital	Co-design policy roadmap for the selected innovation portfolio (agree and commit to concrete actions and set up goals and targets) Design and compare alternative policy scenarios for selected innovation portfolio (including costs and benefits of policy options)			Imagine policy mix favourable for missions
POLICY ROADMAP	Policy mix	Analyse policy impact of historical and current policy interventions (meta-evaluation)	Design governance structures, incentive systems and mechanisms assisting continuous implementation and adaptation of the roadmap Ensure that governance arrangements underpin the continuous search of alignment between stakeholders.			Imagine governance mechanisms and institutional setting favourable for missions
	Governance Learning and capacity building	Map and analyse governance structures, incentive systems and change mechanisms relevant for mission Assess institutional capacity to design, implement and evaluate relevant policy	Prepare action plan to accompany the roadmap including actions to enable learning, capacity building and roadmap adaptation process Set up monitoring and evaluation system to measure progress towards goals and targets of the mission, and their contribution to the SDGs Conduct experimentation and demonstration projects			Imagine competences and learning environment favourable for missions.

This framework can be used as an analytical tool for assessing existing roadmaps as well as a strategic framework for formulating and implementing mission-driven innovation policy roadmaps. The framework assumes that mission-driven policy roadmapping is a participatory process. When applied to specific societal challenges and missions in specific contexts the framework should be adapted to focus on relevant aspects. The exercise should allow for iterations between horizonal layers and temporal segments (e.g. the selection of key technology areas and innovations to be supported by policy has to consider existing capacity to implement effective policy intervention). Source: Miedzinski, Mazzucato and Ekins (2019)

Achieving the Global Goals requires collaboration and alignment between various actors and initiatives conducted at many levels of governance. Coordination of STI policies globally could be facilitated through a multi-level roadmapping approach.

The global STI for the SDGs roadmapping eco-system could be considered a nested system seeking complementarities and encouraging synergies between variety of STI processes at the global and local levels (see Figure 7).

Figure 7. Towards a nested global eco-system of STI for SDGs roadmaps



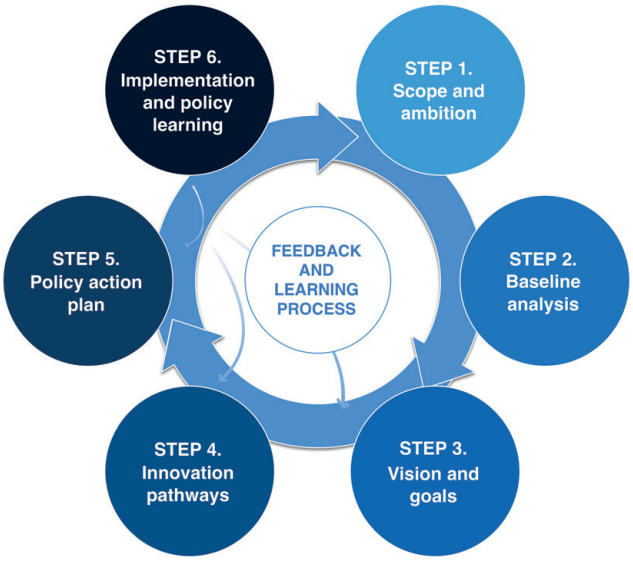
Guidelines for STI for the SDGs policy roadmaps

Six steps in STI for SDGs policy roadmapping

The steps of STI for SDGs policy roadmapping process include:

- **Step 1. Scope and ambition**: Identify focal challenges and the SDGs
- **Step 2. Baseline analysis**: Build evidence base
- **Step 3. Vision and goals**: Elaborate vision, goals and targets
- **Step 4. Innovation pathways**: Explore and select innovation pathways
- **Step 5. Policy action plan**: Design policy roadmap and action plan
- **Step 6. Implementation and policy learning:** Ensure effective implementation and ongoing policy learning.

Figure 8. Generic steps in STI for SDGs policy roadmapping process



Roadmapping is an explorative and learning process for all stakeholders involved. It is likely to be dynamic and highly iterative.

The design of the roadmapping exercise should, therefore, be flexible and envisage mechanisms to take stock of progress, and revisit and refine the initial scope and targets throughout the process.

At each stage of roadmapping, a critical reflection should be encouraged on whether:

- There is sufficient buy-in from key stakeholders to secure credibility for the vision, pathway and plan;
- Enough consensus exists or can be built to enable alignment of stakeholders around the pathway, and
- Sufficient financial and human resources can be mobilised to implement the planned actions.

The diversity of approaches to STI roadmapping precludes a simple set of operational guidelines, as the previous section made clear. Any roadmapping process must be adapted to fit the specific context of the exercise. See boxes with examples of different designs of strategic roadmapping processes below.

WBCSD SDG Sector Roadmaps (WBCSD 2018)

The WBCSD sector roadmaps follow three steps:

Step 1. Establish current position
- Map SDG impacts across the value chain
- Prioritize SDGs for the sector

Step 2. Identify key impact opportunities
- Identify key opportunities to impact the SDGs
- Assess sector apportionment

Step 3. Call for action
- Identify barriers, potential solutions and impact accelerators
- Identify short-, medium- and long-term actions to advance SDG impact opportunities
- Monitor, measure and report progress.

EU Smart Specialisation guide (EC 2012)

The process of developing and implementing research and innovation strategies for Smart Specialisation (RIS3) in the European Union is structured around six steps:

Step 1. Analysing the innovation potential
Step 2. Setting out the RIS3 process and governance
Step 3. Developing a shared vision
Step 4. Identifying the priorities
Step 5. Defining an action plan with a coherent policy mix
Step 6. Monitoring and evaluating

Figure 9. Activities in STI for SDGs policy roadmapping process

Step	Objectives	Duration
Step 1. Scope and ambition	- Agree on a broad challenge and mission to be addressed by roadmap. - Relate the challenge and mission to the SDGs and the SDG targets. - Engage key stakeholders. - Secure necessary resources for the roadmapping process. - Agree on the organisation and governance of the exercise (e.g. define an internal and external champion and a lead facilitator of the process). - Embed in the relevant policy and political processes.	**1-3 months**
Step 2. Baseline analysis	- Define scope: quick scan vs in-depth analysis. - Review the political, economic, social, environmental and legal situation of the country, region, city, sector or any other scope selected for the roadmap. - Review existing evidence and data on the selected challenge and possible solutions (technological and non-technological) and limiting factors. - Perform stakeholder and innovation system analyses; - Integrate the sustainability and innovation analyses: identify, list and relate relevant SDGs and STI goals and targets, priorities, initiatives or concrete projects. - Visualise, relate and map the impact, innovation and policy outcomes and other relevant outputs. - Generate reports and internal/external communication materialto be used in subsequent steps and/or iterations.	**1-6 months**
Step 3. Vision and goals	- Agree on the main objectives, targets and the time horizon for the roadmap, explicitly linking them to the impact hot spots. - Co-create a shared vision for the roadmap. The vision should amount to a brief scenario description include both essential outcomes and descriptions of important enabling conditions - Set quantifiable goals and targets that reflect the outcomes in the vision. - Inventory the key elements of the vision that will be followed in the pathway descriptions and action plans.	**1-3 months**
Step 4. Innovation pathways	- Explore alternative innovation pathways for addressing the impact 'hot spots' and for accomplishing the mission. - Identify drivers, enabling factors and barriers of research and innovation (R&I), including market and system failures, that require adaptation to enable mission-oriented R&I. - Select portfolios of R&I projects (including experimentation and demonstration) to achieve impacts on the targeted 'hot spots' in the short, medium and long term. - Agree on expected timelines of implementation by indicating lead times to impact of research and innovation projects.	**2-6 months**
Step 5. Policy action plan	- Explore key policy instruments and policy portfolios to provide direct and indirect support to the selected innovations. - Co-design a long-term policy action plan with goals, targets and timelines of action (including instrument sequencing) led by public and private actors in the short, medium and long term. - Make sure that the policy action plan is embedded in the relevant policy and political processes. - Assign short and medium-term actions to stakeholders, notably on experimentation and demonstration projects for the mission. - Agree on indicators for monitoring and evaluation of the roadmap.	**1-6 months**
Step 6. Implementation and policy learning	- Set up governance mechanisms and build policy learning environment supporting the implementation and ongoing reflection on the roadmap. - Establish dedicated capacity building processes and design learning environment for stakeholders involved in the roadmap.	**Ongoing**

Source: Based on Miedzinski, Mazzucato and Ekins (2019)

4.1.Step 1: Scope and ambition

What are the objectives of the step?

The first step of any roadmapping process is to find the right scope of the exercise. This is fundamental for the success of the whole exercise, and can prevent many issues at the later stages in the process.

During this stage, stakeholders agree on the societal challenges and broad goals of the roadmap. This is when roadmap is first associated with the SDGs and SDGs targets.

The reflection on scoping should not be limited only to the first step: refining the scope should be taking place throughout the process, especially based on evidence collected for the baseline analysis.

Key issues to consider

Balancing ambition and capacities

Given that SDGs are systemic goals and respond to complex global challenges, the roadmaps need to be scoped with a view of tackling a relevant challenge or accomplishing a mission rather than being constrained by established boundaries of sectors or governance levels (see Figure 10).

The ambition of STI for the SDGs roadmaps has to be in line with the Agenda 2030, and adapted to the context in which the exercise is undertaken. The contribution to the SDGs can be made on many levels: the roadmaps can be designed to introduce changes in specific technology areas, sectors, national or even international STI systems.

The scope and level of roadmaps has to be proportional to the addressed challenge. Scoping has to be based on a healthy dose of pragmatism and consider the existing political climate, institutional capacities and likely engagement of stakeholders.

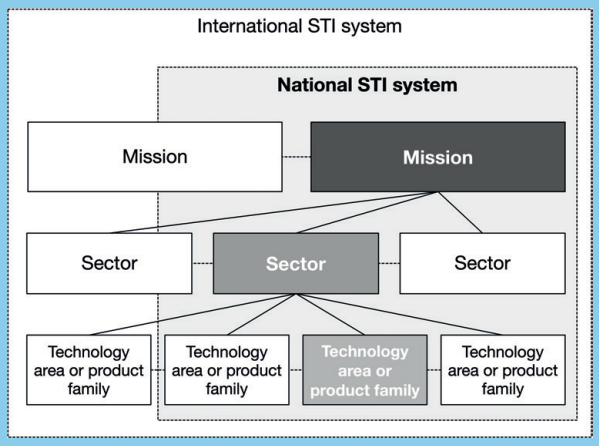
Aligning with the strategic policy context

Roadmaps are versatile and can be used to support and influence all stages of policy process from agenda-setting to implementation. They can be used for a variety of purposes, including:

- Vision building
- Exploring innovation pathways
- Technology advocacy
- Stakeholder alignment
- Support for policy design and planning
- Support for policy implementation.

Scoping and choosing the purpose of roadmaps must carefully consider the strategic context of the exercise. This may mean supporting existing STI policy strategies and partnerships relevant for the SDGs. In some cases it may also mean challenging the existing approaches and setting ambitions that go beyond the formal agenda.

Figure 10. Levels of STI for SDGs policy roadmaps



Roadmaps often cut across diverse sectors and technology areas. Within the Fossil-free Sweden initiative the lead actors from the building sector chose to broaden the roadmap to the entire construction value chain. They engaged materials manufacturers, contractors, engineers, and public authorities responsible for procurement in a dialogue that had brought together more than 170 participants from 70 organisations. The key insight was that each group believed that they could make important changes to current practice if only they had more information or a different level of commitment from one or more other actors in the value chain; the work on the roadmap has shown promise in breaking through this dynamic and allowing organisations to identify commitments for the entire value chain.

Adjusting the scope to the dynamic policy context

Policy roadmaps developed at times of political and policy shifts tend to focus on vision building, stakeholder alignment and technology advocacy. Roadmaps supporting mature policies focus on exploring technology pathways and supporting policy design and implementation. Roadmaps developed to support specific policy processes may also focus on stakeholder alignment, mainly to support implementation.

How to organise this step

1. Choose a central challenge and/or a key mission for the exercise

- Tentatively frame the central problem to resonate with members of your organisation/partnership and with key stakeholders expected to engage in the process.

- Consider conducting "rapid roadmapping" in which you provisionally implement all the roadmapping steps in a very short time. This first iteration is an excellent preparation for the full process.

2. Conduct preparatory desk research

- Map and analyse existing visions, goals, targets and commitments, including the SDG targets, and map key actors relevant for the mission.

3. Hold preparatory meetings with key stakeholders

- Depending on the scope, hold meetings with key stakeholders or, in case of initiatives seeking wider participation, consider open events and surveys.

4. Ensure resources needed for the process

- Ensure sufficient resources, including funding and in-kind contributions. Roadmapping is a project which should be sufficiently resourced and managed.

5. Agree on the key steps of the exercise

- Agree on steps and outcomes of the exercise with the core group making sure the timeline is feasible and considers the available budget.

6. Ensure professional management and coordination

- Set up a transparent organisational structure. Agree on internal milestones and KPIs to monitor project implementation

What are key outputs of this step?

- Short internal document on the purpose and scope of the exercise.

- Summary document for external audience.

- Internal organization, implementation plan and methodology of the roadmap.

Troubleshooting

Challenges	Possible solutions
Lack of interest or opposition from key stakeholders	- Make sure to have a good understanding of incentives underpinning decisions of stakeholder to engage in or disengage from the process. - Consider alternative problem frames and scoping to attract stakeholders.
Turbulent political situation	- See above or consider postponing the exercise considering policy and political cycles in your country and, if relevant, abroad.
Limited resources and funding	- Reduce the scope and ambition of the exercise. - Start the exercise from a smaller pilot to attract attention. - Look for alternative funding sources (e.g. crowd funding, international donors). - Consider postponing the exercise considering policy and political cycles in your country and, if relevant, abroad.
Limited experience in policy roadmapping	- Consult existing materials and case studies on roadmapping. - Consult and engage partners from other thematic areas and/or from other countries. - Employ a competent facilitator. Consider training your own facilitators during the first exercise so they can lead the facilitation of later roadmapping exercises. - Go for it anyway! Roadmapping is a learning process. Make sure, however, that you consider capacity when designing the methodology and timeline of the exercise.

4.2. Step 2: Baseline analysis

What are the objectives of the step?

Baseline analysis builds the evidence base for the roadmapping process, and answers the questions: where are we now, and how have we got here? It identifies key trends and impacts, and explore potential innovations.

Key issues to consider

Research design and methodology

The research design and methodology of baseline analysis should follow established good practices of social science and sustainability research. It is recommended that a variety of methods are used to source and analyse relevant data to ensure the robustness and validity of the analysis, which then underpins deliberation of visions and alternative innovation pathways.

This step should be considered an iterative process with ongoing activities designed to support all subsequent steps in the roadmapping process.

Credibility of the process

A robust baseline analysis is key for the credibility of the roadmapping process. The analysis enables validation of the assumptions made in visions and pathways, and establishes the foundations of an implementation and monitoring system.

Capacities, resources and competences

Baseline analysis requires the capacity to perform or commission studies. Roadmap owners and core partners need to critically assess their capacity to conduct such work, and may decide to engage external researchers, consultants or facilitators to support it.

How to organise this step

Determine the appropriate depth and scope

Baseline analysis can range from a "quick scan" analysis to robust in-depth assessments. The scope will depend on the selected topic, existing capacities, as well as time and budget foreseen for the exercise.

A quick-scan involves conducting desk research and collection of secondary data in reference to the specific challenge of the roadmap. In its most simple form this step can be a gap analysis based on desk research and limited stakeholder engagement seeking relevant expertise. In-depth baseline assessments typically involve more extensive consultations with stakeholders and dedicated collection of primary data via surveys, interviews and expert groups.

Design methodology of the baseline analysis

There are many existing methodological frameworks which can be used to structure baseline analysis, and the choice should be adapted to the topic addressed by the roadmap.

One typical approach for analyzing country's STI performance is innovation system analysis focused on the elements of the system relevant for the challenges or missions addressed by the roadmap. This typically involves analysis of key actors, networks, and the wider enabling environment, including institutional and regulatory frameworks, relevant for innovation activities.

An example of a useful approach to analysing impacts of the SDGs is UNEP's Rapid Integrated Assessment (RIA). The RIA approach involves a technical analysis of the relevance of the SDGs (goals and targets for the country at national and subnational levels. It can include an assessment of existing SDG monitoring capacity. See Further Reading section for other examples.

Roadmaps in SIDS countries

One of the most advanced examples of policy roadmapping in Small Island Developing States (SIDS) is found in the Island of Aruba. Similar initiatives can be found in Bonaire, Tuvalu, Seychelles, Dominican Republic, and Jamaica.

The roadmap Sustainable Aruba 2020 was commissioned by the Aruban Government in 2012. It had a focus on solving pressing issues related to energy, sustainable tourism and waste. The initiative was hosted by the office of the former PM with the internal champion being the CEO of the public energy company. It involved different ministries, public utility companies, private sector, academia and knowledge institutions, and civil society. Expert workshops, online consultations that led into a roadmap with two broad intervention areas: the design of a construction of a smart community and a number of projects supporting the energy transition. Both are currently implemented.

In 2018, with the support of UNDP, a process began to elaborate the Aruba SDG roadmap. An in-depth baseline analysis following UNEP's Rapid Integrated Assessment (RIA) framework was conducted to support mainstreaming of SDGs into national and local plans. The project was hosted by the office of the PM and involved a large number of stakeholders. Six SDG accelerators were identified for the implementation of the SDGs:

- Empowered Youth
- Improved natural resource management
- Achieving the energy transition
- Entrepreneurship and business environment
- Institutional Quality and Effectiveness
- Aruba as a models for sustainable development

Source: TNO

Synthesise and communicate key results

Baseline analysis produces outputs relevant for both external audiences and for internal participants in the roadmapping process. It is important to decide early on about the content and format of the reports and other communication material. It is advisable that the background material includes summary charts, graphs or infographics.

The internal outputs should be designed to become background material informing the subsequent steps in the roadmapping process. It is highly advisable that the internal communication is kept concise, and always includes summaries of previous meetings. The outputs addressed to external audiences are important to ensure the transparency of the process and to engage relevant actors in the roadmap formulation and implementation.

One way of structuring the presentation of the results is to follow the architecture of the roadmap and prepare briefs and mapping documents underpinning key layers of the roadmapping framework.

These could include for example:

- Trend map: mapping key trends and analysing impact pathways relevant for the challenge, including identification of the root causes of the problem, visualizing impact pathways and identifying primary-impact 'hot spots'. A useful tool for a comprehensive trend analysis is PESTEL covering policy and political, economic, societal, technological, environmental and legal issues.
- Innovation landscape: mapping existing and emerging innovations (both technological and non-technological) relevant for the challenge. This can include resources, capabilities and competences needed for implementation of such innovations. The map can indicate the expected level and plausibility of impact.
- Policy landscape: mapping policy instruments and relevant non-governmental initiatives relevant for the challenge.
- SDG targets map: relating the above maps to the specific SDGs and SDGs targets. An in-depth assessment should include an analysis of dynamic interactions between relevant SDGs.

Troubleshooting

Challenges	Possible solutions
Insufficient information and data	- Consult experts and key stakeholders on alternative data sources. - Consider sourcing primary data using quantitative and/or qualitative methods including case studies and interviews. - When interviewing stakeholders additional information can be obtained via the 'snow-ball' technique, where respondents help identify additional respondents for interviews or surveys.
Insufficient capacity and expertise	- Map capacities, competences and resources available to the roadmap team. - Trustworthy external facilitators, consultants and experts can be found with the help of international agencies and knowledge institutions.It is of outmost importance to clearly specify the external competences, knowledge and skills when drafting terms of reference used to engage external expertise.
Replicability and scalability	- In practice no baseline analysis will be ever fully complete and the generalisation of findings must be properly contextualised. - Replicability and scalability are context and challenge/mission specific. Keep in mind baseline assessments are explorative in nature.
Unable to link indicators and data with monitoring system	- It is a good practice to create templates that give a visual indication of missing data and gaps. Take into account standard practices and guidelines for policy monitoring and evaluation when defining indicators.

What are key outputs of this step?

- Synthesis report containing the results and a summary for policy makers;
- Internal and external communication material, including visualizations and summary posters;
- Background papers, technical reports and data gathered during the analysis.

4.3. Step 3: Vision, goals and targets

What are the objectives of the step?

The purpose of Step 3 is to generate a description of "Where do we want to go" that serves as a forward-looking anchor to the roadmap analysis. As with the baseline analysis, subsequent work on pathways and action plans should be checked for consistency against the outputs of this step, i.e. will they support the achievement of the vision?

Key issues to consider

The vision should be sufficiently ambitious and credibly achievable in the eyes of the participating stakeholders. A vision in the roadmap should not be confused with a 'vision statement' of the kind often produced at the level of a single organization (e.g. 'Company X is the leading provider of technology services and the employer of choice in our field.').

The vision in this case should be a brief scenario that credibly describes both the outcomes that STI policy for SDGs are trying to generate and the conditions that make those outcomes possible.

How to organise this step

Such a positive scenario should be developed via an interactive workshop in order to generate creative ideas and engagement from key roadmap stakeholders. Participation of these stakeholders should be complemented by the presence of 'challengers' who may hold alternative views about what is necessary or what represents a positive outcome.

The workshop should ask participants to go beyond their own areas of expertise. A world café approach, where participants contribute to multiple topics, can increase engagement. If this is not feasible, thematic groups should be asked to present their descriptions and allow for discussion during the workshop.

In generating a shared vision or positive scenario, iterations should be limited, and kept within timeline allowed by the exercise. Findings should be presented, discussed, and, to the extent possible, documented as part of the same workshop. This helps to avoid the search for unrealistic precision and full acceptability.

Guiding questions could be:

- Does the vision/scenario describe an outcome that is sufficiently successful on the terms of the relevant SDGs?
- Does the vision/scenario describe an outcome that is broadly positive in the eyes of participants?
- Is the vision/scenario plausibly achievable in the eyes of the participants?

Before introducing the main discussion structure, a single exercise to stimulate the right kind of thinking may be advisable. For example, each participant may be asked to complete a statement: "In [Target Year for Roadmap], my organization is contributing to the SDGs by doing [XX]." Responses would not be included directly in the vision, but are meant to make the exercise that follows feel relevant for all participants.

In some cases the roadmap analysis starts from an assumed, superordinate target or goal, e.g. "Zero emissions" or "Safe drinking water for all." In this case, the structured discussions will focus on issues subordinate to the quantitative goal.

The vision and scenarios are primarily descriptive narratives. The following structure is broadly applicable and can guide the discussion to create the narrative.

1. Describe positive outcomes for the target year in qualitative terms

a. Innovation outcomes (i.e. technologies, products, services, business models)

b. Environmental outcomes

c. Economic outcomes

d. Governance and policy outcomes

e. Social outcomes.

2. Describe the enabling context

What is new in the target year that makes the outcomes possible?

a. Direct enablers

> Markets and related policy (not just STI)

>> Enabling technology and infrastructure and related policies (not just STI)

>>> Enabling networks.

b. Indirect enablers

> Social norms and practices, value systems

> Political and economic trends.

3. Revisit the vision and define quantitative targets and goals related

Targets should be:

a. Manageable in number. A roadmap that tries to deliver on a small number of targets (typically three to six) is more effective than one that tries to deliver on a longer list.

b. Relevant to, if not fully constrained by, the relevant SDGs and targets. A qualitative assessment of whether the targets chosen contribute to the SDG target may suffice.

c. Attributable, at least in part, to STI policy or policy areas leading the exercise (see Step 5). Other policies (see point 2 above) may be more important, but the focal policies must have a role in target realisation.

Troubleshooting

Challenges	Possible solutions
Relating to existing targets and goals (including SDGs) when multiple are relevant and time horizons may vary	- Goals and targets should relate most closely to political goals and targets that directly constrain STI policy. The SDG targets may not be considered key in some STI exercises. In this case, relating STI roadmap goals and targets to the SDG targets can be based on a concordance analysis (e.g. concordance tables).
Relating to important future developments that are beyond the scope set in Step 1	- Descriptions of outcomes should fit tightly with roadmap scope. - Descriptions of enabling context can and should include some issues that are beyond the roadmap scope.
Relating to existing scenarios, visions etc.	- Existing material can be used to inform the 'inventory' exercise so that the vision has similarities to relevant work. - In some cases existing scenarios can be presented as introductory material to set the context. However, this risks constraining stakeholder discussions and engagement.

What are key outputs of this step?

- A short narrative – not a 'vision statement', but one-page long scenario describing a macro theory change and positive outcome for the roadmap's target year;
- A set of quantified goals or targets;
- An 'inventory' of necessary developments that can be mapped onto Step 4's pathways (e.g. via qualitative backcasting) and Step 5's policy action plan.

4.4. Step 4: Innovation pathways

What are the objectives of the step?

The purpose of Step 4 is to compose a portfolio of research and innovation options that when carried out effectively contribute to accomplishing the vision and targets in the short, medium and long term.

Key issues to consider

Be open to variety of alternative innovations and transition pathways

There are many ways to achieve the vision and targets agreed in Step 3. It is key that the deliberations in Step 4 are based on a broad definition of innovation and open to considering a wide variety of alternative transition pathways. The approach to innovation should recognise the role of both technological and non-technological innovations, including new business models and social innovations. These considerations should embrace the role of informal sector and grass-roots innovation.

Be systemic and ensure diversity of the innovation portfolios

The deliberations of innovation pathways should consider the need for system innovation to achieve the SDGs. Pathways, therefore, should envisage a variety of mutually reinforcing innovations and actions rather than fall into a trap of focusing too much on individual technological breakthroughs. The value of disruptive technologies, for example, can only be shared widely if they are enabled by business models and social innovations, and embedded in the social and institutional transition.

Be ambitious yet feasible

The SDGs dictate a high-level of ambition for innovation pathways. The roadmaps, however, need to be feasible in order to materialise and be credible in the eyes of stakeholders and wider public.

The selection of innovation pathways needs to be based on comparative assessments of costs, benefits and feasibility of the proposed projects and activities. The assessments should consider the scale and likelihood of impacts expected in the short, medium and long-term, considering the maturity of innovation itself (e.g. innovation stage; see Figure 11) as well as the maturity of innovation system.

How to organise this step

Step 4 builds on the vision and narratives developed in Step 3. The following logic is proposed to explore, assess and select innovation pathways and activities to be supported by the roadmap:

1. Explore alternative innovation pathways for accomplishing the vision

Methods used in this step should be based on existing evidence and expertise and, at the same time, need to invite diverse perspectives, open-mindedness and creativity. Depending on the topic and the scope of roadmapping, possible pathways can be underpinned by robust scientific knowledge (e.g. energy models as in the IEA's technology roadmaps), expert consultations and comprehensive literature reviews. It is a good practice to build on the existing scientific and expert knowledge and directly engage researchers in this step.

It is key that alternative pathways are not only a result of modeling. Foresight methods can be used to encourage creativity and lateral thinking on how to adapt pathways to specific context. Scenario workshops and design sessions, for example, can be used to co-develop narratives for alternative pathways. It is key that stakeholders representing different interests and views are engaged in these activities.

The outcome of this activity is a set of pathways showing possible ways to achieve progress towards the vision over time. The descrip-tions should include ideas for innovations and environments in which they evolve and scale. It is key that elaboration of alternative pathways considers systemic drivers, enabling factors and barriers to key innovations expected to drive the change in the specific context of the roadmap.

2. Assess alternative innovation pathways considering their impact on SDGs over time

Once the pathways are elaborated, they should be assessed in terms of their social, economic and environmental impacts, costs and benefits, as well as risks and uncertainties associated with alternative propositions. The impacts can be directly associated with SDG targets (see box on the right).

It is key that assessments consider expected timelines of implementation by indicating expected lead times to impacts. They should also consider differences in distribution of costs and benefits of different innovations among social groups and geographical regions. The impact assessments inform the choices of the most impactful and feasible portfolio of actions and projects for the roadmap to support in the short and medium term.

3. Select portfolios of R&I projects roadmap stakeholders can support

Stakeholders take informed decisions on innovation pathways and portfolio(s) of activities to be prioritised and supported by the roadmap. The portfolios can be subject to review after an agreed period (e.g. two years) to consider their performance and changes in the external environment.

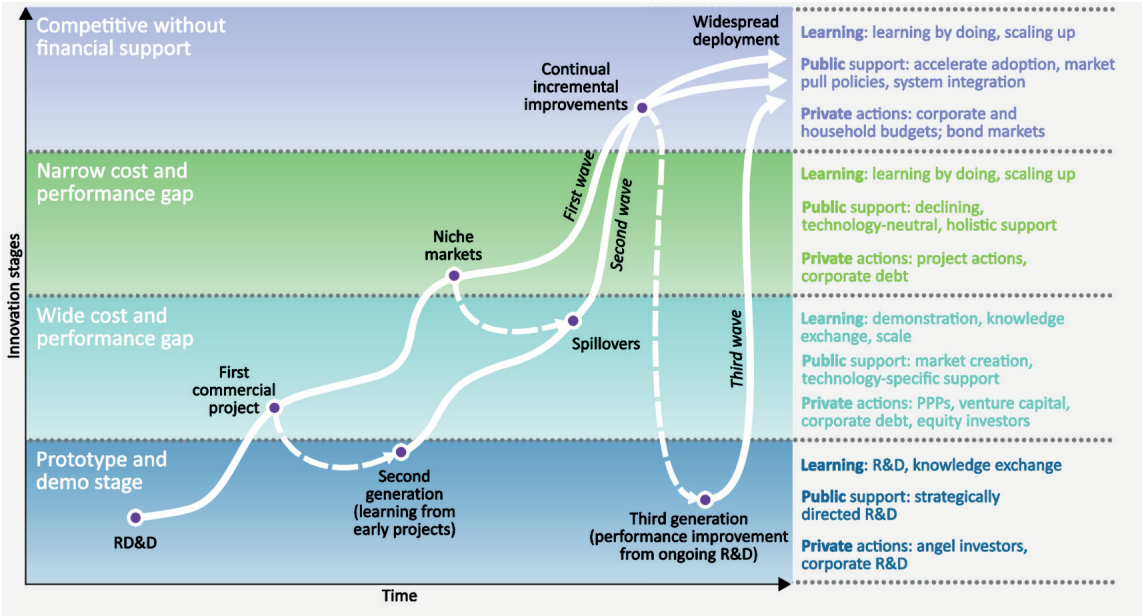
Elements of the WBCSD's SDG mapping template

	SDG1	SDG 2
Relevant SDG targets	1.1, 1.4, 1.5	2.1, 2.3
How can the sector contribute	Invest in local communities; enhance access to energy; contribute to resilience of vulnerable communities to climate risks	Share infrastructure to enhance agricultural productivity
Relevant value chain stage	Upstream, core operations	Operations
Direct or indirect impact	Both	Direct
Key geographies	Africa, Latin America	Africa
Current level of positive impact	H	L
Current level of negative impact	L	L
Sector's potential to contribute	M	M
Potential to add business value	L	M

High H Medium M Low L

Source: WBCSD 2018

Figure 11. Energy technology innovation process



Notes: PPP = public–private partnerships. RD&D = research, development and demonstration. R&D = research and development.

Source: IEA 2017

Selecting priorities in the EU Smart Specialisation strategies (RIS3)

Identifying a limited number of research and innovation priorities is a formal requirement to fulfil the RIS3 ex-ante conditionality check for regions to receive funding from the EU Cohesion Policy. A RIS3 prioritises domains, areas and economic activities where regions or countries have a competitive advantage or have the potential to generate knowledge-driven growth and to bring about the economic transformation needed to tackle the major and most urgent challenges for the society and the environment.

Priorities can be framed in many ways including knowledge fields or activities, sub-systems within a sector or cutting across sectors and corresponding to specific market niches, clusters, technologies, or ranges of application of technologies to specific societal and environmental challenges (e.g. ICT for better accessibility of healthcare, urban mobility solutions to reduce traffic congestion).

Priorities should be identified based on two fundamental processes:

- An entrepreneurial process of discovery utilising entrepreneurial knowledge existing in a region or country and focusing on market opportunities, differentiating from others, taking (and managing) risks and seeking alliances to optimise the access to and use of resources (physical, financial, intellectual, market knowledge, etc.). The essence of the entrepreneurial discovery process lies in its interactive nature that brings the different stakeholders (government, business, academia, NGOs, citizens) together in a participatory leadership process to carve out jointly the smart specialisation fields and develop a suitable policy mix to implement them.

- A comprehensive analysis of the region/country current situation in terms of research, innovation, industrial structures, skills and human capital, demand, public and private budgets for research and innovation, framework conditions, functioning of the innovation eco-systems. The analysis should take into account the economic context with a place-based focus complemented by an outward-looking dimension (e.g. global challenges and competitiveness). It should also examine the gaps, barriers and potentials for future economic development.

RIS3 approaches priority setting as a demanding process requiring a degree of experimentation with new policy tools such as pilot projects which allow for elaboration and modification of the RIS3. The latter requires a strong governance system and a sufficient political backing in order to take risks and embrace possible failures from which lessons can be learned.

The involvement of entrepreneurs is key to developing RIS3, because they are best placed to know what is likely to work in a particular place. This type of institutional capacity building cannot happen overnight and should be reinforced as the strategy is implemented. The entrepreneurial process of discovery is seen as a 'journey' with no start or end.

Source: Text edited from the RIS3 guide (2012) and the FAQs section of the RIS3 online platform (http://s3platform.jrc.ec.europa.eu; visited on 9 January 2019)

Troubleshooting

Challenges	Possible solutions
Lack of consensus between stakeholders on priority pathways and projects	If feasible and relevant, one may accommodate more than one pathways or alternative projects in the roadmap. Consensus should not be pursued at the price of reducing the overall value and impact of the roadmap. Be prepared to implement projects with partial support but be transparent about the logic of choice and targets.
Disagreements on the level of risk of activities supported by the roadmap	Assign the level of risk to projects and actions. When developing project portfolios discuss acceptable ratios of low and high-risk projects (just as in investment portfolios). Stakeholders may sponsor projects with different level of risk.

What are key outputs of the step?

- Descriptions and assessments of innovation pathways, including descriptions of innovations expected to drive the change and comparative impact assessments;
- Portfolio of key research and innovation projects;
- Descriptions of key activities and projects selected for support, including their expected impacts over time.

4.5. Step 5: Policy action plan

What are the objectives of the step?

Step 5 is devoted to developing a policy action plan indicating key instruments and priority actions to be taken to enable the prioritised innovation pathways.

Key issues to consider

Ambition of the policy action plan

The ambition and specificity of the plan depends on the scope of the exercise, engagement and commitment of stakeholders and proximity to policy processes. Action plans can range from fully-fledged policy portfolios with binding commitments to actions and investments to unbinding policy recommendations. Regardless of its formal status, any action plan should include clear description of actions, responsibilities and a clear timeline for implementation.

In order to ensure impact on the SDGs, roadmaps have to place emphasis on implementation. The leading organizations and partnerships should strive to link the roadmapping processes with existing strategies, instruments and investment decisions.

More ambitious approaches may go beyond targets and objectives in existing policy frameworks. They may require innovative instruments and financing, new implementation mecha-nisms and novel forms of collaboration both within public sector (e.g. between cities) and between public bodies and stakeholders.

Building "policy portfolios" for the policy roadmap

In order to have an impact on the SDGs, policy roadmaps should encompass instruments and actions which together can enable innovation and contribute to the selected goals and targets. Building STI for the SDGs policy portfolios may involve:

Making connections between existing policy instruments

- Adjusting their design features (e.g. selection criteria for innovation funding, duration of support, collaboration requirements).

- Introducing dependencies between previously disconnected instruments (e.g. fiscal burden linked to environmental performance).

Introducing new policy instruments and pilot actions

- Introducing new instruments to the portfolio (e.g. new investment schemes).

- Experimental projects to test new ideas and learn for larger scale actions.

Expanding portfolios to include non-government initiatives

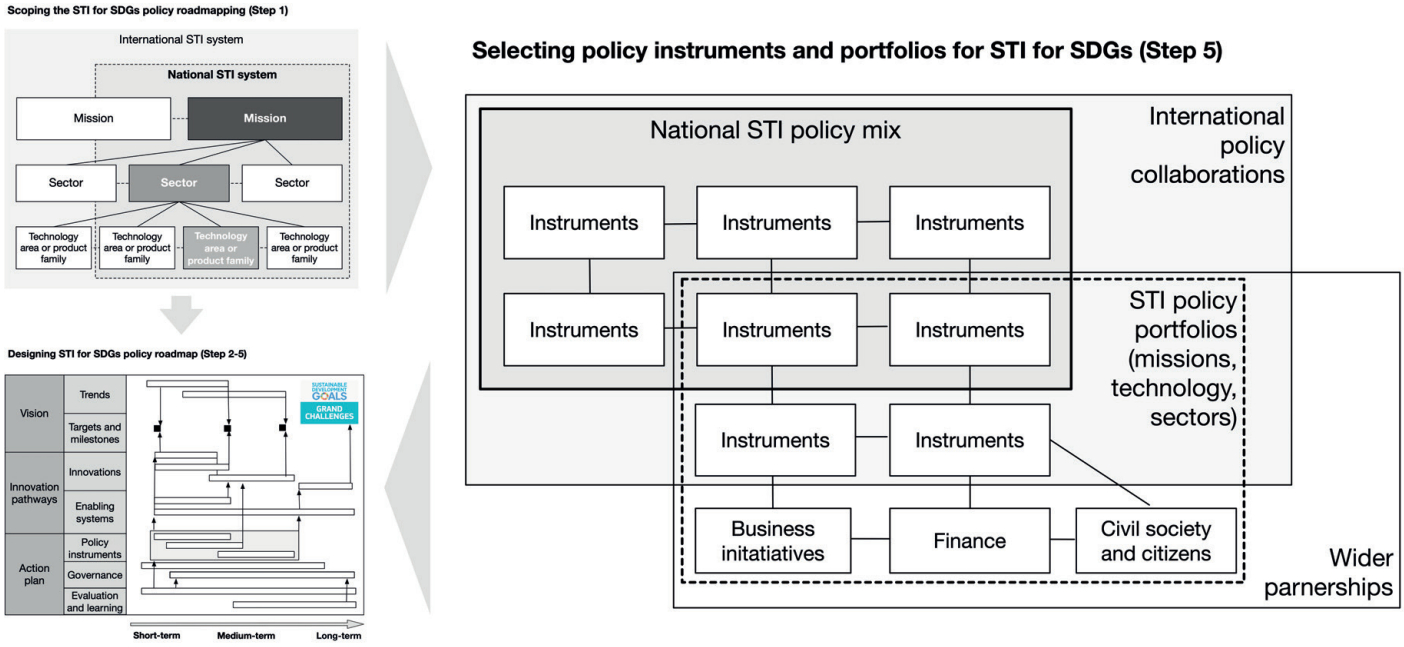
- Making explicit connections between policy instruments and non-government initiatives (e.g. public-private investment funds). Policy portfolios may be limited to one country, however, designing new portfolios focused on STI may also bring about new opportunities for cross-border and wider international collaborations and joint ventures (see Figure 12).

Action plans in different governance contexts

The hydrogen roadmap was developed and used by the US Department of Energy (DOE) to guide their hydrogen energy programme. The roadmap was aligned with the spending commitments and institutional structures of the DOE's hydrogen programme. Key milestones and decision points for the DOE (e.g. decisions to continue or revoke funding for specific areas of technology) provided clarity to all actors about interim goals. The significant funding and support programme associated with the roadmapping bolstered the relevance and credibility of the resulting milestones and targets.

The CSIRO Low Emissions Technology Roadmap provided detailed illustrations of the technology pathways by which Australia might meet deep greenhouse gas emissions reductions. The roadmap developed an action plan with policies that would facilitate the achievement of the emissions reduction pathways, and put forward recommendations for government. As an analytical exercise, the action plan was an advisory document rather than a committed action plan.

Figure 12. Designing portfolios of actions in STI for SDGs policy roadmaps



What to consider in policy action plans?

Action plans may address the following issues:

Key R&I actions, including pilot projects

- Identify key actions lines and their target groups, including policy instruments and concrete projects to be supported by the roadmap;

- Ensure coherence of portfolio (e.g. consider synergies or conflicts between key actions and existing policy mix);

- Indicate funding sources for planned projects (e.g. in the short-term link the roadmap to existing programmes or funds; in the medium-term, make links between the roadmap activities and future programming cycles);

Responsibility and accountability for actions

- Be clear about strategic and operational responsibilities and accountabilities for planned actions;

- Roadmap actions may be linked to existing mandates or may call on new mandates (e.g. newly created partnerships);

Implementation and coordination mechanisms

- Be specific about delivery mechanisms of key projects (e.g. type of instruments and programmes, budgets, timelines, responsible bodies etc.);

- Appoint bodies to give strategic advice and ensure over coordination;

- Ensure resources for carrying out core roadmapping activities (e.g. secretariat, stakeholder meetings, monitoring and evaluation);

Continuous engagement of key stakeholders

- Consider different types of incentives various stakeholders are likely to respond to when engaging in key actions (e.g. economic, reputational, value-driven);

- Ensure continuous commitment of key stakeholders and be active in developing new partnerships (e.g. be aware of synergies or conflicts between the roadmap and business investments);

Dedicated monitoring and evaluation on the level of the portfolio

- Develop a dedicated monitoring and evaluation system for the roadmap allowing for assessing progress towards agreed targets, and the contribution to the SDGs (see Step 6).

Action plans implementing Smart Specialisation strategies (RIS3)

Action plans accompanying Smart Specialisation strategies typically include:

- Broad action lines for the prioritised areas and the challenges faced within these areas;
- Delivery mechanisms and projects;
- Target groups;
- Actors involved in implementation and their responsibilities;
- Timeframes and measurable targets to assess both results and impacts of the actions;
- Identification of the funding sources.

When planned activities are characterised by a high-level of risk, RIS3 recommends experimentation to test novel ideas and policy support schemes to improve effectiveness of larger scale actions.

Source: RIS3 guide (2012)

How to organise this step

The process of developing a policy action plan will typically follow established practices and procedures in a country or a region. Prior to designing the plan, it is key to consider existing experience, capacity and competences needed to adjust or to design a portfolio of policy instruments. This helps to estimate cost, time and effort to deploy or to adjust policy instruments.

It is crucial that the overall goals and implementation mechanisms of STI for the SDGs roadmaps are embedded in and, when needed, temporally aligned with relevant policy (e.g. programming cycles) and political (e.g. electoral cycles) processes and time frames.

Troubleshooting

Challenges	Possible solutions
Limited experience and lack of institutional capacity to design portfolios	- In the short-term the roadmap can focus on actions where experience and capacity is developed (e.g. individual instruments considered key, small scale actions or experimentations) - In the medium to long-term, the roadmap itself could include a dedicated effort and investment in building needed capacity in designing policy portfolios (e.g. by launching capacity building programmes, engaging in international collaboration and building partnerships)
Essential policy instruments outside the scope of the roadmapping process and/or Stakeholders capable of taking necessary actions not included in the processes or unwilling to commit	- This situation should be anticipated and mitigated in Step 1 (see Step 1 description) - Take steps to engage stakeholders responsible for these instruments into the process (e.g. depending on the context, this can be done as an action of the roadmap or as a separate process) - Think of alternative instruments and actions to create incentives to achieve the desired effect (e.g. alternative sources of funding, reward schemes, sources of compliance pressure)
Lack of political will to make commitments and take action	- This situation should be anticipated and mitigated in Step 1 (see Step 1 description) - Think of alternative local or international partners to engage with (e.g. consider engaging relevant local authorities and non-governmental actors or, if politically acceptable, even inter-national organisations)

What are key outputs of this step?

- Policy action plan with actions contributing to the vision and goals (Step 3) by enabling prioritised innovation pathways (Step 4). The plan should include concrete actions, including short-term actions, with clear responsibilities assigned to stakeholders.

4.6. Step 6: Implementation and policy learning

What are the objectives of the step?

This objective of this step is threefold. First, it ensures effective implementation of the policy action plan by setting appropriate implementation mechanisms in motion. Second, it develops a monitoring and evaluation (M&E) framework, including key performance indicators (KPIs), allowing to track progress towards achieving targets. Third, it establishes a learning environment for capacity building, assessing implementation progress and on-going deliberation on target and milestone adjustments in the face of new evidence and changing context.

Key issues to consider

What to consider in setting upa monitoring and evaluation framework for roadmaps

- Existing M&E systems: The M&E frameworks of the STI and SDGs roadmaps are likely to rely on the existing M&E activities underpinning instruments and activities contributing to the roadmap. This step should first focus on reviewing existing data and processes. It can prove to be an opportunity to identify gaps and cater the existing M&E systems in the area of STI for the 2030 Agenda.

- Existing evaluation capacity: The design of the framework has to consider the existing M&E capacity, including accessibility of good quality evidence and skills. This step will be an opportunity to indi-cate areas for capacity building and investment in data collection.

- Existing policy learning and evaluation culture: The design of the policy learning environment has to be based on a good knowledge of established policy processes, practices and networks. This is key for ensuring credibility of the process in the eyes of key stakeholders as well as for establishing effective feedback mechanisms where lessons from implementation are heard and acted upon.

- Existing practice and international experience: Roadmapping should be open for learning from existing practices, and actively engaging in policy dialogues and sharing experience with stakeholders involved in other roadmapping processes.

Evaluation criteria for STI for the SDGs roadmaps

Evaluation of STI for the SDGs roadmaps requires a reflection on their specific characteristics and design features. Figure 13 introduces an example of a set of criteria and questions for assessing roadmaps with an ambition to tackle sustainability challenges.

Figure 13. Criteria for assessments of policy roadmaps addressing the SDGs

Area	Definition	Review questions
Relevance and long-term directionality	The extent to which the vision and objectives of roadmaps are appropriate for sustainability challenges and the SDGs.	What is the main purpose and scope of roadmaps, and how do they relate to SDGs? What is the wider context in which roadmaps emerge?
Roadmap design	The extent to which intervention logic and design of roadmaps consider challenges of sustainability transitions.	What is the architecture of roadmaps, notably how they introduce visions, pathways (e.g. scenarios, targets, milestones, layers) and action plans?
Innovation	The level of ambition and aspiration of innovation promoted by roadmaps, including recognition of the role of experimentation and system innovation.	What types of innovation activity are roadmaps promoting to enable the sustainability transition? What is the level of ambition of innovation?
Strategic specialisation	The extent to which roadmaps encourage innovation specialisation in the most relevant areas for sustainability.	Are roadmaps based on strategic prioritisation considering existing and emerging areas of specialisation? Are roadmaps aiming at changing specialisation patterns to more effectively respond to sustainability challenges?
Alignment	The extent to which roadmaps mobilise actors to align their strategies and activities with the shared vision and pathways.	How are stakeholders consulted and engaged at different phases of the process?
Actionability	The extent to which roadmaps are based on absorptive and implementation capacity of actors in the innovation system.	What are the mechanisms by which roadmaps are implemented?
Coherence	The extent to which roadmaps are internally coherent and coordinated with relevant policy mixes and with the SDGs.	How are roadmaps embedded into wider STI policy mixes?
Learning and adaptability	The extent to which roadmaps support learning and allow for adaptation of its elements based on new evidence.	How is the implementation of roadmaps monitored and evaluated?

Source: Miedzinski M., McDowall, W., Fahnestock, J. (2018)

How to organise this step

1. Define lead evaluation questions and key indicators

- Agree on the key policy questions guiding the scope and approach to M&E.
- Define key indicators to monitor progress and evaluate effects of the roadmap.
  - Define indicators to measure short-, medium- and long-term results of the roadmapping (e.g. inputs, output, outcomes and impact indicators).
  - Be clear about which results are directly attributable to the roadmap's activities and which results the roadmap activities may influence only indirectly.
  - Make sure to include quantitative and qualitative indicators to capture specific outcomes of the roadmapping process (e.g. roadmap credibility or level of trust between stakeholders can be analysed using qualitative indicators).
  - Relate indicators to the roadmap's targets and SDG targets (e.g. indicators to measure distance to achieving targets or the relevant contribution to goals).
  - Agree on a small number of Key Performance Indicators (KPIs) directly attributable to the roadmap activities.
- Engage stakeholders in the process of designing and selecting indicators (e.g. stakeholders can be instrumental in collecting relevant data).

2. Design methodological framework

- Robust: Ensure that a systemic approach underpinned by the use of complementary methods and tools, interdisciplinary knowledge and diverse data sources.
- Reflective: Ensure that the approach emphasises the role of evaluation process and learning (formative approach).
- Innovative: Be open to new methods and data sources to better capture evidence relevant for the SDGs (e.g. big data, citizen science etc).
- Feasible: Consider evaluation capacity and resources available for M&E. Be precise about responsibilities and budgets for gathering and evaluating data. Use (and possible adjust) existing M&E processes where and when possible.
- Transparent: Ensure that evidence is collected and evaluated in a transparent way. Use independent experts and evaluators if possible.

3. Design and implement policy learning environment

- M&E system should ensure effective policy feedback mechanisms.
- Agree on the processes and regular discussions on the results and progress, including independent expert-based assessments and processes engaging key stakeholders directly implementing roadmap actions.
- Agree on the processes on how to adjust the roadmap (e.g. targets, pathways etc.) in face of new evidence and changing context.

Approaches to monitoring and evaluation

The Planning Institute of Jamaica

The Planning Institute of Jamaica developed a transparent system indicating progress towards Jamaica's developmental goals as set out in Jamaica's Vision 2030 National Development Plan. The system was made available to all stakeholders and the general public through an online dashboard with indicators based on key NDP objectives. During a dedicated SDG workshop focused on monitoring SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation and Infrastructure), the main concern identified by stakeholders was on how to 'translate' monitoring data into insight on the barriers and on adequate policy response, which suggests the existing system has to further develop its learning and adaptation capacity.

Power Africa Programme

The Power Africa roadmap elaborates evidence-based approach to making assumptions about reaching the quantitative targets of the programme based on the notion of 'lead times' (or time lags) to reach financial close and to complete construction of renewable energy projects by 2030. It includes data on 'lead times' for the major renewable energy technologies comparing them with the global average. The progress of Power Africa projects was estimated for 2020, 2025 and 2030 based on the transparent assumptions on lead times. Based on the observed progress in project implementation on the ground, the programme can adjust its assumptions and support model. Importantly, the roadmap document does not introduce new targets but is designed to explain how the targets introduced by its 'mother' programme itself can be met. The programme is based on the learning-by-doing approach where lessons learnt during implementation are used to add regional and country-specific and technology-specific advice.

Troubleshooting

Challenges	Possible solutions
Limited availability of good quality data	In the short-term, engage experts, practitioners and relevant stakeholders to share their first-hand experience from the field. Time permitting, organise fact-finding missions focused on key areas relevant for the vision. Emphasise the role of the roadmap to improve data availability and quality in the area addressed by the exercise. In the medium-term, invest in the evaluation capacity and introduce requirements for M&E in the relevant areas of STI.
Limited monitoring and evaluation capacity	In the short-term, learn from established national and international good practices in relevant fields. In the medium-term, invest in the evaluation capacity and introduce requirements for M&E in the relevant areas of STI.
Weak evaluation and policy learning culture	In the medium-term, invest in the evaluation capacity and introduce minimum requirements for M&E in the relevant areas of STI. Emphasise the role of the roadmap to improve evaluation culture (e.g. by establishing evaluation working groups and fora).

What are key outputs of this step?

- M&E plan with the overall approach and organization of policy learning activity;
- Operational guidelines on collecting KPIs and key contextual indicator.

End notes

[1] See https://sustainabledevelopment.un.org/tfm for a list of relevant references.

[2] See e.g. Phaal et al (2004) and Phaal and Muller (2009)

[3] Miedzinski et al (2018b)

[4] Ibid.

[5] Ibid.

[6] McDowall (2012)

[7] Miedzinski et al. (2018) INNO4SD Outlook.

[8] The generic architecture is based on Miedzinski, Mazzucato and Ekins (forthcoming).

Selected sources for further reading

STI for SDG roadmaps

- STI forum webpage on STI roadmaps: https://sustainabledevelopment.un.org/tfm
- Inno4SD website: http://www.inno4sd.net/
- WBCSD SDG Sector roadmaps: https://docs.wbcsd.org/2018/04/SDG_ roadmap% 20Guidelines.pdf
- Japan Science and Technology Agency: https://www.jst.go.jp/sdgs/en/actionplan/index.html

Technology roadmaps in general

- Cambridge Roadmapping: https://www.cambridgeroadmapping.net/
- University of Cambridge, Institute for Manufacturing
- https://www.ifm.eng.cam.ac.uk/ifmecs/business-tools/roadmapping/research/
- Roadmapping bibliography: https://www.ifm.eng.cam.ac.uk/uploads/Research/CTM/ Roadmapping/Roadmapping_Bibliography_Phaal.pdf
- Links to public domain roadmaps (2011): https://www.ifm.eng.cam.ac.uk/uploads/Research/ CTM/Roadmapping/public_domain_roadmaps.pdf

Thematic technology and innovation roadmaps

- IEA'sGuide to Development and Implementation of Energy Technology Roadmaps (2014): https://www.iea.org/publications/freepublications/publication/ TechnologyRoadmapAguidetodevelopmentandimplementation.pdf
- SIDS Lighthouses Initiative - National Energy Roadmaps for Islands: https://irena. org/ publications/2017/Feb/National-Energy-Roadmaps-for-Islands
- UNFCC report on roadmaps: https://unfccc.int/news/synthesis-report-submis-sions-on-the-roadmap-for-global-climate-action
- UN Global Compact – Roadmap for Integrated Sustainability: https://www.unglobal-compact.org/ take-action/leadership/integrate-sustainability/roadmap
- UN Environment - Eco-innovation roadmaps in industry and SMEs: http:// unep.ecoinnovation.org/

On specific tools useful for baseline assessments

Defining visions

- https://transitiepraktijk.nl/en/experiment/visioning-reorienting
- UNDP's RIA - rapid integrated assessments for SDGs: http://www.undp.org/con-tent/dam/ undp/library/SDGs/RIA%20Tool%20-26.12.201-Final.pdf
- UNGP MAPS method: http://www.2030agenda.undp.org/content/2030agenda/en/home/more/ MAPS.html

Innovation system analyses

- UNCTAD STIP Review Framework: http://unctad.org/en/Docs/dtlstict2011d7_ en.pdf
- UNESCO, Global Observatory of Science, Technology and Innovation Policy Instruments (GO-SPIN), Training and Resources: https://en.unesco.org/go-spin/training-resources
- OECD, Reviews of Innovation Policy (Series), http://www.oecd.org/sti/inno/oecd-re-views-of-innovation-policy.htm
- Green Growth Knowledge Platform: A guide to innovation system analysis for green growth: http://www.greengrowthknowledge.org/sites/default/files/downloads/resource/A_Guide_to_Innovation_System_Analysis_for_Green_Growth_GGGI.pdf
- Hekkert, M.P., Negro, S.O., Heimeriks, G., Harmsen, R., & Jong, S.J. (2011). Technological Innova-tion System Analysis A manual for analysts (available online)
- Inno4SD's STIR Framework:http://www.inno4sd.net/

SDGs interactions

- International Science Council: https://council.science/topics/sustainable-develop-ment-goals
- IGES: https://www.iges.or.jp/en/sdgs/index.html and IGES visualisation tool: https://sdginterlinkages.iges.jp/visualisationtool.html
- The World in 2050 (TWI2050) by IIASA, SDSN and the Stockholm Resilience Centre: http://www.iiasa.ac.at/web/home/research/twi/TWI2050.html

Sustainability roadmaps

- Sustainability roadmaps for business: https://sustainabilitymap.org/home
- Gerrit Muller's presentation: https://gaudisite.nl/RoadmappingForSustainabilitySlides.pdf

Mapping complexity

- GIGA-mapping: https://www.systemsorienteddesign.net/index.php/giga-mapping

Country level and international roadmap documents analysed in the Inno4SD policy outlook

- Agenda 2020 Technology Alliance (2010). Forest products industry technology road-map. USA.
- Council for S&T Policy (2013). New Low Carbon Technology Plan. Japan.
- CSIRO (2017). Low Emissions Technology Roadmap. The Commonwealth Scientific and Industrial Research Organisation. Australia.
- DECC (2011). UK Renewable Energy Roadmap. Department of Energy and Climate Change. UK.
- European Commission (2007). Strategic Energy Technologies Plan (SET Plan).
- European Commission (2010). Roadmap to a Resource Efficient Europe.
- European Commission (2012). Energy Roadmap 2050.
- ICC (2012). ICC Green Economy Roadmap – a guide for business, policymakers and society. The International Chamber of Commerce.
- IEA (2017). Technology Roadmap: Delivering Sustainable Bioenergy. International Energy Agency. Paris.
- Ministry of Economic Development (2018). Roadmap for transformation towards circular economy. Poland.
- Ministry of Education and Research (2017). Norwegian ERA Roadmap 2016-2020. Norway.
- NorskIndustri (2016). Veikart for Prosessindustrin. (Roadmap for the Process Industries and value creation with zero emissions 2050)
- RISE (2016). RISEnergy: Roadmaps for energy innovation in Sweden through 2030. Research Institutes of Sweden.
- SPIRE(2012). SPIRE Roadmap. Sustainable Process Industry through Resource and Energy Efficiency. A.SPIRE. Brussels.
- TIFAC (2015). Technology Vision 2035. Technology Information, Forecasting and Assessment Council. India.
- TIFAC (2016). Technology Roadmap Manufacturing. Technology Information, Forecasting and Assessment Council. India.
- USAID (2016).PowerAfrica: The Roadmap.
- WBCSD (2010). Vision 2050. World Business Council for Sustainable Development.

References

Ahlqvist, T., Valovirta, V., Liokkanen, T. (2012). Innovation policy roadmapping as a systemic instrument for forward-looking policy design, Science and Public Policy, 39: 178-190.

Altenburg, T. & Pegels, A. (2012) Sustainability-oriented innovation systems – managing the green transformation. Innovation and Development 2, 5-22.

Carayannis, E., Grebeniuk A., Meisser D. (2016). Smart roadmapping for STI policy. Technological Forecaseting and Social Change. Vol 110: 109-116

Geels, F. W. (2005) Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technology Forecasting and Social Change72: 681-696.

Georghiou, L., Harper, J. C., Keenan, M., Miles, I. & Popper, R. (2008). The handbook of technology foresight: concepts and practice, Edward Elgar.

IEA (2017) Energy Technology Perspectives 2017. Catalysing Energy Technology Transformations. In-ternational Energy Agency. Paris.

Kemp, R., Schot, J. &Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technology Analysis & Strategic Management 10, 175-198.

Kivimaa, P. & Kern, F. (2016). Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. Research Policy 45, 205-217.

Konrad, K. (2010). Governance of and by Expectations, EASST 2010 Conference, Trento, Italy.

Konrad, K., H. van Lente, C. Groves and C. Selin (2017). Performing and Governing the Future in Science and Technology. The Handbook of Science and Technology Studies. U. Felt, R. Fouche, C. A. Miller and L. Smith-Doerr. Cambridge, MA, MIT Press: 465.

McDowall, W. & Eames, M. (2006). Forecasts, scenarios, visions, backcasts and road maps to the hydrogen economy: A review of the hydrogen futures literature. Energy Policy 34, 1236-1250.

McDowall, W. (2012). Technology roadmaps for transition management: the case of hydrogen energy. Technological Forecasting and Social Change79(3): 530-542.

Meissner, D., Carayannis, E. Sokolov A. (2016). Key features of roadmapping for company and policy strategy making. Technological Forecasting and Social Change110, 106-108.

Miedzinski, M., McDowall, W. A. S., & Fahnestock, J. (2018). Paving the pathways towards sustainable future? A critical review of STI policy roadmaps as policy instruments enabling sustainability transitions. IST - International Sustainability Transitions Conference. Manchester.

Miedzinski, M., McDowall, W. A. S., Fahnestock, J., Rataj O. (2018). How to design STI policy roadmaps to foster innovation for sustainable development?. Policy Outlook 10. Inno4SD.

Miedzinski, M., Mazzucato M., Ekins P. (2019) A framework for mission-oriented innovation policy roadmapping for the SDGs. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2019-03). Available at: https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-03

Miles, I., Saritas, O., Sokolov, A. (2016). Foresight for Science, Technology and Innovation. Springer.

Phaal R., Farrukh C., Probert D. (2004). Technology roadmapping - A planning framework for evolution and revolution. Technological Forecasting and Social Change71:5-26

Phaal R., and Muller G. (2009). 'An architectural framework for roadmapping: Towards visual strategy'. Technological Forecasting and Social Change, 76 (1):39-49.

Rogge, K. S. & Reichardt, K. (2016) Policy mixes for sustainability transitions: An extended concept and framework for analysis. Research Policy 45: 1620-1635.

Saritas, O., & Aylen, J. (2010). Using scenarios for roadmapping: The case of clean production. Technological Forecasting and Social Change, 77(7), 1061-1075.

Smith, A., Stirling, A., Berkhout, F. (2005). The governance of sustainable socio-technical transitions. Research Policy 34 (10), 1491–1510.

Smits R. and Kuhlmann S. (2004). 'The rise of systemic instruments in innovation policy', International Journal of Foresight and Innovation Policy1 (1/2): 4-32.

Stirling, A. (2007). "Opening Up" and "Closing Down": Power, Participation, and Pluralism in the Social Appraisal of Technology. Science, Technology and Human Values 33, 262-294.

Stirling, A. (2011). Pluralising progress: From integrative transitions to transformative diversity. Environmental Innovation and Societal Transitions 1, 82-88.

Stirling, A. (2014). Emancipating Transformations: from controlling 'the transition' to culturing plural radical progress. Climate Geoengineering Governance Working Paper Series: 012. Published online 28 May 2014.

Steward, F. (2008). Breaking the boundaries: Transformative innovation for the global good. Provocation 07: April 2008. NESTA.

WBCSD (2018). SDG Sector Roadmaps. How to leverage the power of sectoral collaboration to maximize business impact on the Sustainable Development Goals. Geneva.

Wieczorek, A. and Hekkert M. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. Science and Public Policy. Vol 39(1):74–87

Advancing the state-of-the-art in innovation for global sustainability

The Innovation for Sustainable Development Network (inno4sd.net®) brings together networks dedicated to innovation for sustainable development with the aim of reducing fragmentation and supporting collaboration, whilst engaging policy-makers, research & development, and businesses to achieve the sustainable development goals.

The H2020 Green.eu project and inno4sd® network was coordinated by the Netherlands Organisation for applied Scientific research TNO in the period March 2015-January 2019. As of February 2019 the inno4sd Steering Board oversees the activities and management of the network.

Innovation for Sustainable Development Network - inno4sd

Web: www.inno4sd.net
General enquiries: info@inno4sd.net
Twitter: @inno4sd
Youtube: inno4sd