3 Holistic innovation policy

The complexity of carbon management in terms of the range of economic sectors and the developing technologies suggests that applying policy to only a single part of a value chain or ecosystem of actors is likely to cause knock-on effects elsewhere. In holistic policy formulation, the core policy problems that tend to afflict the activities of innovation systems are identified, including the unintended consequences of policy itself. It is especially important due to the need for a range of both technology-push and market-pull policies.

Carbon transition policies needs whole society engagement.

> *"The Climate Change Committee (CCC) has indicated that the majority (~62%) of emission reductions will require some form of societal and behaviour change including the adoption of low-carbon technologies and changes to the way we live our lives".*
>
> *Demski, 2021*

The green transition comes at a price but with disproportionately high benefits

The decarbonisation of large-scale centralised electricity generation is a major success story of decarbonisation. To reach net zero, however, more far-reaching reductions in carbon emissions are required, some of which will impinge much more on people's lives. Behavioural change desired by governments is always controversial. What might be expected in these behavioural changes are, for example, modifying diets to food sources that are low in emissions, reducing food waste, taking fewer flights and mobilising more mass transport.

As argued previously, the urgency calls for strong and decisive policies. However, measures that are too extreme (and too many) may lead to economic instability and social disruption. Significant challenges will exist for firms that have to change their business models and for workers that are displaced. Skill sets will evolve and here adult skill provision and lifelong learning will be needed for labour market resilience and to meet the evolving demands for competence (Hodgson et al., 2022).

A lack of public support may prevent the implementation of necessary but, in the short term, difficult measures. As seen in recent years, energy controversies have led to significant social unrest in various locations. With internet and the new tools of social media, societal protest and peaceful demonstrations can be organised much more quickly. Unfortunately, a more disturbing aspect of social media is that it can also be used for disinformation[1] or potentially foment forceful riots.

Gilmore and Buhaug (2021) isolated the effects of climate policies on economic performance, income and livelihood, food and energy prices, and land tenure as the four most likely factors to increase conflict risks. Governments need contingencies to tackle the spectre of energy and commodity price rises that may arise in the transition to less efficient (more expensive) carbon feedstocks. Moreover, the public may not appreciate the more long-term job creation potential of carbon management strategies, while job losses from traditional fossil industries will be immediately apparent.

Along the way social acceptance must be secured. Governments and intergovernmental processes need to invest strongly in communication with the general public and innovate in ways for civil society engagement and education. Channels such as television, social media and targeted community meetings work quickly to reach a large proportion of the population.

There are sharply divergent parties involved and vested interests that are opposed to net-zero carbon. There is not a lack of information, but there is a lot of bad information. To secure credible information there is a need for innovation in institutions capable and willing to disseminate information that is informative and trustworthy. To raise awareness of the geopolitical ramifications that lie ahead, the International Renewable Energy Agency (IRENA) established the Global Commission on the Geopolitics of the Energy Transformation[2], with the support of the Governments of Germany, Norway and the United Arab Emirates (IRENA, 2019).

Definitions and terminology facilitate communication

Definitions are necessary in any economic activity to gather data that are comparable across regions, countries and globally. Ultimately, integration of actors across sectors and hence the creation of new value chains is limited by disparity and lack of control of terminology and standards. In short what is called for is *commonly agreed vocabulary throughout value chains, from feedstock suppliers to downstream actors in the application sectors*[3]. Different definitions and pathways to net-zero can have drastically differing outcomes.

Olfe-Kräutlein et al. (2022) pointed to how the inconsistencies in meanings in the current use of terms like CCU, CCUS and CDR have consequences for a variety of stakeholders in industry, policy making, and the public more generally. Policy makers should be aware that even if the expert community perceives little problem, the attitude of the public towards a technology can be greatly influenced simply by its name. The conflation of CCU and CCS in the term CCUS can be particularly problematic. The main value of the paper by Olfe-Kräutlein et al. is that it sets out the problems and potential solutions in a single document. They also direct the reader to glossaries that intend to work towards a common terminology. Of particular relevance to this report is a glossary developed by the International CCU Assessment Harmonization Group[4].

Raising awareness and public acceptance

Communication is vital for public acceptance: up to 70% of the potential of the "Bio-Revolution" may depend on consumer, societal, and regulatory acceptance (McKinsey Global Institute, 2020). From a wider societal perspective, local decision-making, and delivery mechanisms, such as Citizens' Assemblies[5], can help generate policies and projects for sustainable growth that are seen as fair and focused on local needs and perspectives.

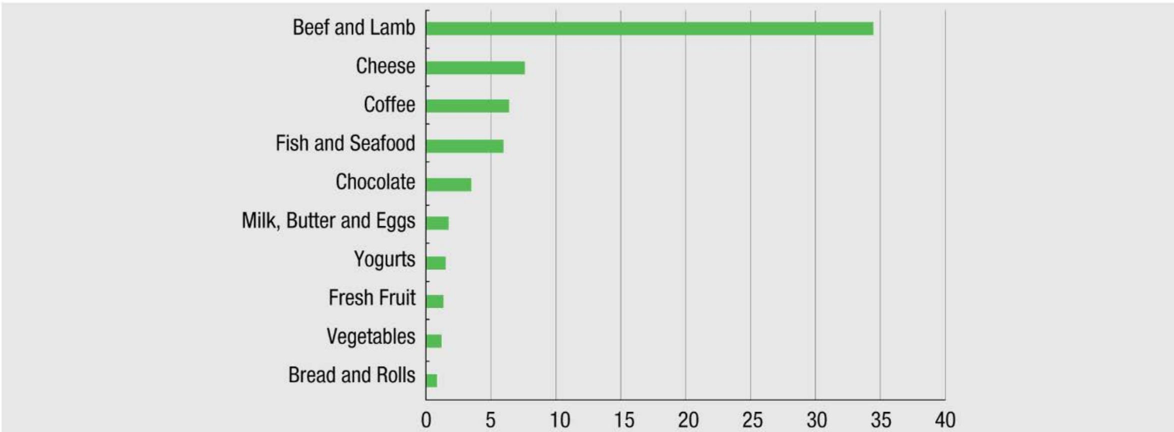
One of the keys to public acceptance is job creation. Recent analysis by Montt et al. (2018) concluded that most economies will experience net job creation in the transition to a low emission society. Governments must find effective ways to communicate such messages, for instance by allying these 'green' jobs to a paradigm of policy certainty and permanence.

For sectors such as chemistry and cement, the difficulties in raising awareness are exacerbated by a lack of customers. Some of the carbon-based sectors are mainly business-to-business models. Chemistry is an exemplar B2B sector. In contrast, production of food or clothing has a distinct advantage due to the communication power of large supermarkets and the much greater familiarity of the public with the products. Hence, there is some tentative evidence that consumers want to make decisions on the environmental sustainability of foods (e.g., UK Food Standards Agency, 2021). Eco-labelling of foods, however, tend to focus on a single factor that may or may not be related to sustainability.

An algorithm-based tool is under development that can assess the environmental impacts of 57 000 foods based on four indicators: GHG emissions, land use, water stress, and eutrophication potential (Clark et al., 2022). Aware that consumers are likely to prefer a simple eco-label, the researchers devised a single estimated composite environmental impact score per 100 g of product ranging from 0 (no impact) to 100 (highest impact) (Figure 3.1).

Figure 3.1. Composite environmental impact of some common foods based on four indicators

Abscissa: the composite environmental impact figure – higher the figure, higher the environmental impact



Source: Derived from data provided by Clark et al. (2022) under Creative Commons Attribution License 4.0

What is clear from such an analysis is that it would need to be more refined to take account of a particular production pathway. For example, beef produced locally within a short distance of a supermarket will have a different environmental impact than beef frozen and transported long distances by sea. Nevertheless, this might represent a first step towards an eventually standardised food sustainability eco-label that integrates emissions information with other sustainability indicators. And if the algorithm can deal with 57 000 different foodstuffs, then perhaps the 70 000+ products of the chemicals industry may not be so daunting. This could be a method to directly compare identical 'drop-in' fossil-based and renewable-based products, data vital to establishing realistic sustainability comparisons.

In the largest survey of public opinion on climate to be conducted to date (UNDP, 2021), the top three policies voted for among the 1.2 million people surveyed were: conservation of forests and land; deploying solar, wind and renewable power, and climate-friendly farming techniques. A recent survey (Cox et al., 2020) sampling populations in the United Kingdom and the United States showed that very few people believed that carbon dioxide removal (CDR) deals with the root cause of emissions. This echoes a recommendation in this report that policy for technologies such as CCS should not obscure the need for genuine low emissions technologies (and, in consequence, for supportive policy).

Cox et al. (2020) discovered in their study that engineered CDR risks a failure to achieve a clear social licence to operate if revealed dilemmas cannot be properly resolved. These dilemmas are entwined with questions regarding the relationship between emissions reduction and carbon removal as means for achieving net zero. It can be expected from their findings that many citizens perceived CDR as a form of 'dumping' rather than contributing to sustainability.

Furthermore, they used an approach of 'deliberative workshops' to give participants an extended period to form their opinion because of demonstrably low prior awareness, which can dramatically impact responses to surveys. Low prior awareness can be a deciding factor in public debate over new or emerging technologies.

Public engagement needs innovation in approach, and it will need to be consistent and long-term. Moreover, an effective public engagement strategy should encourage active participation in decision making. It will be a strategy of joined-up measures including communication strategies, stakeholder engagement, participatory mechanisms, and behaviour change (Demski, 2021). Methods need to not only measure responses across a population, but also reveal why people respond in a certain way. The OECD described twelve different forms of deliberative public engagement with examples from across the world (OECD, 2020).

Carbon management as an overarching framework for policy making

As argued in previous chapters, carbon management provides a more holistic understanding of carbon-based value chains. Moreover, the case studies, workshops, as well as input from national delegates, document how carbon management can serve as an improved basis for policy making. In this chapter a guide to integrated carbon policies is proposed through a framework familiar to innovation policy makers: the combination of supply- and demand (market-making) measures and those that apply to both. These measures are summarised in Table 3.1. Subsequently, such policies should be aligned with more general policies, for example macroeconomic policy, to show how the shocks of net-zero measures may be ameliorated through interaction (Table 3.4).

Table 3.1. The supply- (feedstock/technology push) and demand-side (market pull) measures typical of science and technology policy

Feedstock/Technology push	Market pull	Cross-cutting
Local access to feedstocks	Targets and quotas	Standards and certification
International access and trade of feedstocks	Mandates and bans	Techno-economic analysis
R&D subsidy programmes	Public procurement	Skills and education
Pilot and demonstrator support	Direct financial support	Regional clusters
Flagship financial support	Tax incentives	Definitions, terminology
Tax incentives for industrial R&D	Incentives related to emissions	Governance and regulation
Improved investment conditions	Taxes on fossil carbon	Raising awareness
Innovation clusters	Fossil fuel subsidy reform	Public deliberation

Source: Adapted from OECD (2018)

Borrás and Edquist (2019) examined the following components for the formulation of holistic innovation policy: knowledge production and research and development; education, training, and skills development; functional procurement as demand-side measures; change of organisations through entrepreneurship and intrapreneurship; interaction and innovation networks; changing institutions and regulations; and the public financing of early-stage innovations. Many of these aspects are directly relevant to innovation for carbon management.

The need for policy coherence can be seen in the future of plastics as an example. Sustainable production and use of plastics involves new feedstocks, e.g., bio-based chemical building blocks and more renewable energy input, but also changes in product design and manufacturing to allow for mechanical and chemical recycling, infrastructure and policy for collection and separation, and even changes in consumer behaviour.

Policy coherence is not easy as it requires a high level of inter-ministerial coordination. However, it is necessary to avoid inconsistent policy (e.g., a waste in an environment ministry could be a secondary raw material in an industry ministry). Furthermore, expensive investments in redundant or near-sighted infrastructure may create lock-in situations, e.g., if a national strategy is legally set for the expansion of waste incineration, this prevents initiatives in mechanical or chemical recycling.

To illustrate the point, plastics policy in Europe is linked to at least the following other very important European policies, as well as to the UN Sustainable Development Goals:

- European Green Deal (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en)
- Circular Economy Action Plan https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en#:~:text=The%20new%20action%20plan%20announces,for%20as%20long%20as%20possible)
- European Industrial Strategy (https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en)
- Chemicals Strategy for Sustainability (https://echa.europa.eu/hot-topics/chemicals-strategy-for-sustainability)
- Zero Pollution Action Plan (https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en)
- Biodiversity Strategy to 2030 (https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en)

Complexity sets the scene for policy dilemmas and unintended consequences

For policy makers the questions posed, and the policy dilemmas entailed in sustainability and carbon management are complicated and will inevitably result in compromises and trade-offs. Some overarching policy dilemmas were already identified in Chapter 1:

- Intensified use of bioresources and land use change may lead to biodiversity loss. For example, the use of land to make biomass feedstocks for, say, bioplastics production could easily compete with food production (Rosenboom et al., 2022). In a ‘planetary boundaries’ analysis of the future of the petrochemicals industry by Galán-Martín et al. (2021), the scenario with the lowest carbon footprint in a renewable carbon transition could exceed the biodiversity planetary boundary by at least 30%.
- CCS may slow down innovation and more profound societal and industrial changes, especially if these changes delay genuine low-emissions technologies (Stephens, 2014). This is highlighted as a policy action for policy makers. There is a danger that policy makers make CCS the *de facto* technology, sending signals to industry to continue ‘business as usual’ in the knowledge that CCS is the ‘forever’ technology that inhibits investment in truly low-emissions technologies.
- CCU and DAC require huge amounts of renewable energy, competing with energy needs and electrification of other sectors, such as transportation or domestic heating. Furthermore, to make CCU technologies justifiable, it would be necessary to use renewable energy as the energy source and may compete with other important energy requirements.
- Saygin and Gielen (2021) predicted that deep emissions reductions are possible in the chemical industry by mid-century, but they estimate that product cost may rise by 35% compared to today. As chemistry is virtually ubiquitous in modern manufacturing, how will this be received by society? They estimate that investment needs amount to USD 4.5 trillion between now and 2050. Governments will have an essential role in enabling this transition, but will there be the public and political will to do so?

History is replete with detrimental unintended consequences of well-meaning policies, often leading from too great a focus on intended consequences (Ehrlinger and Eibach, 2011; Herrero et al., 2020). As examples:

- Environmental regulations to preserve wilderness and wildlife can paradoxically result in increased GHG emissions (Severnini, 2019).

- In order to prevent marine pollution and dumping of waste at sea, the London Convention from 1972 (formally the 'Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972') and its update in 1996, the London Protocol[6], enforces restrictions on marine and cross-border transport of CO_2. This has caused problems for current CCS ambitions, for instance the Norwegian Longship project[7].
- Also, the discouragement of plastics in food packaging to reduce pollution may negatively affect food distribution and self-life.

Thus, a further complication for holistic, systemic policy development is that efforts should be made to identify and model the most likely trade-offs involved - or, as expressed by Kotchen (2018), "offsetting goods and bads".

A promising approach is to couple supply chain models to feedstock conversion models (De Buck et al., 2020; Ulonska et al., 2018). As pointed out by De Buck et al., the sustainability and economic feasibility of a biorefinery feedstock supply is as important as the engineering process. Ulonska et al. added other factors, such as market-dependent price developments and design and sustainability, to model "*all main influencing factors*" simultaneously. Similarly, Jonkman et al. (2019), designed a decision support tool for the sustainable design of a biorefinery supply chain network that included all local actors.

An approach that is likely to find favour with policy makers is to couple trade-offs (and co-benefits) to the UN SDGs:

- This would give a framework for international comparability, as the SDGs were adopted by all United Nations member states.
- The analyses will endure as the SDGs are part of a 15-year plan, coming to a conclusion at the critical juncture of 2030.
- The SDGs in theory cover all sectors of human activity, thus lending an aspect of universality.
- The SDGs should be applied in a manner that seeks synergies with other goals to prevent sector silos from creating barriers.

Box 3.1 demonstrates the utility of this approach that analyses bioenergy contributions to the SDGs.

Box 3.1. Contribution of biomass supply chains for bioenergy to sustainable development goals

Blair et al. (2021) adopted a scoring framework devised by Nilsson et al. (2016) to examine how biomass used for bioenergy applied to SDG target 7.2 interacts with other SDGs. The methodology may be adaptable to other sectors and targets than bioenergy if data are available.

The system has positive and negative scored interactions ranging from +3 to -3. A positively scored interaction represents opportunities for synergies and perhaps co-benefits, while a negatively scored interaction would indicate the need for actions to prevent trade-offs (Table 3.2).

Table 3.2. Scoring framework developed by Nilsson et al. (2016)

Interaction	Score	Explanation
Indivisible	+3	Inextricably linked to the achievement of another goal
Reinforcing	+2	Aids the achievement of another goal
Enabling	+1	Creates the conditions that further another goal
Consistent	0	No significant positive or negative interaction
Constraining	-1	Limits options on another goal

Note: The four supply chains used in the analysis by Blair et al. (2021) were: forest biomass, agricultural residues, energy crops and waste of biological origin e.g., the organic fraction of MSW.
Source: Blair et al. (2021).

Singling out SDG 12 and the targets indicated in Table 3.3 below, a matrix of scores indicating a category of consequence (enabler, driver/co-benefit or safeguard) can be obtained. “Safeguard” indicates the need for attention to potential trade-offs, which are described in the final column.

To inform the assessment, each analyst relied on a broad range of synthesis papers, modelling studies, and empirical analyses of bioenergy and biomass supply chains. Thus, the work requires expert knowledge and it not without difficulty, but the results form an analytical, if still qualitative, approach to determining interactions.

Table 3.3. Scoring of synergies and trade-offs between target 7.2 and SDG 12

SDG	Target(s)	Linked with	Score	Category	Interaction identified
12 Sustainable Production and Consumption	Political support	All-supply	+2	Enabler	Bioenergy may be supported as part of national sustainable consumption and production plans, or by other policies supporting sustainable business practices or procurement programmes.
	Knowledge and capacity building	All	+1	Enabler	Improved education and awareness surrounding sustainable consumption, and improved technological capacity may advance bioenergy, particularly in developing countries.
	Sustainable, efficient use of resources	Forest/ Ag. residue	+2	Driver/co-benefit	Use of residues for energy results in more efficient use of resources, and lower material footprint than extracting and burning fossil fuel, especially if residue previously unused or burned.
			-2	Safeguard	If removal of residues is too intense, it may reduce soil quality or crop/forest productivity, and inputs of fertilizers and material footprint may increase. Fibre may be diverted from higher priority uses, e.g., food, construction materials.
	Waste generation, treatment	Waste	+1	Driver/co-benefit	Potentially hazardous waste streams can be diverted/captured to generate energy. Waste to Energy (WTE) may increase the recovery of metals.
			-1	Safeguard	Digestate, generated via anaerobic digestion of waste streams can impact the environment if not treated properly. If waste is used for energy, there may less incentive to improve recycling.

Note: Target 7.2 is: “increase substantially the share of renewable energy in the global energy mix”.
Source: Adapted from Blair et al. (2021)

In holistic policy formulation, the core policy problems that tend to afflict the activities of innovation systems are identified, including the unintended consequences of policy itself (Borrás and Edquist, 2019). The interdependency of different carbon feedstocks, integrated processing of side streams and cascading use, all emphasise the importance of a holistic approach to carbon-based value chains. If an understanding of these complex interactions is lacking, policies may fail to deliver on their sustainability objectives. Conversely, building a holistic policy framework is more likely to succeed with fewer unintended consequences than treating policy questions in isolation[8].

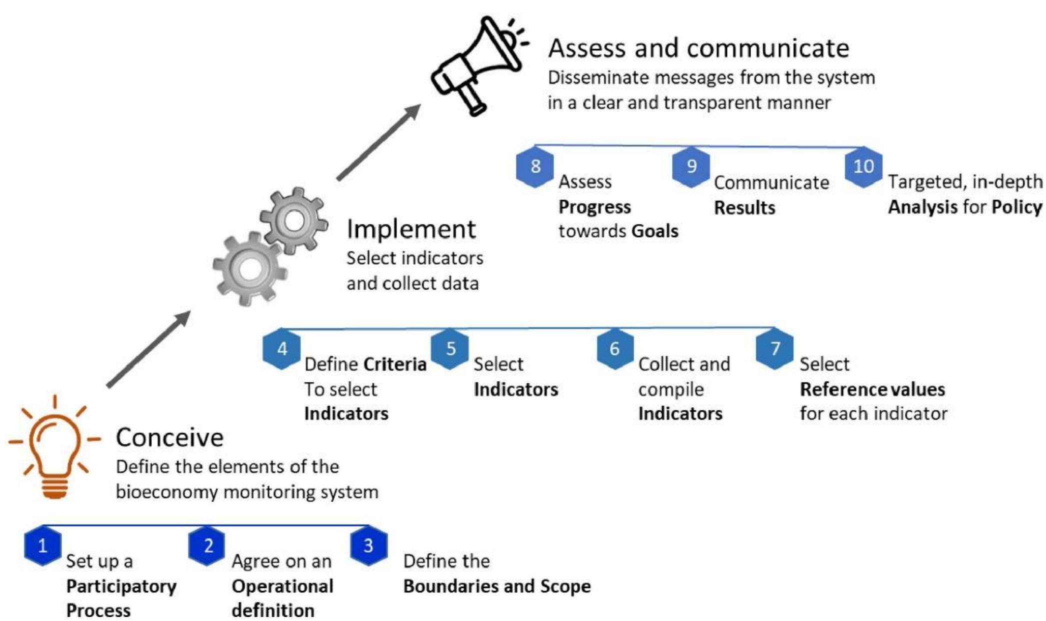
Governance and regulation

OECD analysis suggests that innovation heavily depends on issues of governance and implementation (OECD, 2015). Governance matters in innovation policy due to the various levels of authority and policy competencies involved. Budgetary resources are distributed across various levels of government when horizontal policy is created. Regionalisation and decentralisation have made regional and local governments more powerful and has increased their capacity to operate their own development strategies.

It is worth noting that in many areas, governance frameworks are already in place. The chemicals and materials are for instance governed by REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)[9] in Europe and by TSCA (Toxic Substances Control Act, 1976)[10] in the United States. A main new paradigm would be to adopt sustainability as a mode of governance, reinforcing the need for rational measurement of sustainability.

A robust knowledge base and a fit-for-purpose monitoring system are crucial elements for adaptive and effective governance. The Joint Research Centre of the European Union is developing an approach to bioeconomy monitoring along the entire value chain. The system consists of ten steps to monitoring and evaluation (Figure 3.2), with the selection, collection and compilation of indicators at its core, along with selection of reference values for each indicator. Such an approach could also be adapted to renewable carbon processes outside the bioeconomy.

Figure 3.2. Ten steps to monitoring and evaluation of the bioeconomy



Source: Adapted from De Santi (2021)

Regulation refers to the implementation of rules by public authorities and governmental bodies to influence the behaviours of private actors in the economy. Within innovation policies, the primary purpose of regulation should be to stimulate innovation, although the opposite is undeniably possible. Complex and time-consuming regulation is far more damaging to small companies than it is for large companies. Regulatory barriers take a variety of forms, two of the most relevant (Sira Consulting, 2011) are:

- *Fundamental constraints.* These call for a political and policy approach (e.g., import duties, level playing field, certification of products, and financial feasibility).

- *Operational constraints.* Here the regulation itself is not the problem but its implementation by, for example, local authorities. Especially for SMEs, these lead to substantial barriers to investment.

Putting the framework together: being systemic

It is recognised that public supply-side investments may not be sufficient to drive technology deployment if the market conditions are not favourable. Higher cost and market acceptance are particular challenges in the immature markets based on renewable carbon. Hence, there needs to be a balance of supply- and demand-side measures, and this balance should be calculated in advance, and the policies timetabled.

Policy must address systemic business risks in value chains

A value chain can be defined as “a set of interlinked activities that deliver products/services by adding value to bulk material (feedstock)” (Lokesh et al., 2018). Typically, many of these individual processing and manufacturing steps are new and untried and various public and private actors need to work together to create new industrial ecosystems. The complexity of the renewable carbon web can easily be underestimated, resulting in, for example, unforeseen shortages of critical material(s) (National Academies of Sciences, Engineering, and Medicine, 2020a).

In general terms, Hellström (2003) described “‘negative synergies’ between complex technologies, social institutions and critical infrastructures”. A CCU value chain would typically comprise a cascading series of manufacturing processes, spanning feedstock production/capture, pre-treatment, and conversion, through to the manufacture and marketing of products (and in the case of some products like plastics, even end-of-life). Thus, the new value chains created are characterised by an interdependency between multiple stakeholders. Getting them to work efficiently is threatened by ‘systemic business risk’. Such systemic risk discourages investments and in the early phases of this transition must be addressed by policy (as the markets may not be ready).

A supply or value chain is only as strong as its weakest link (Jażdżewska-Gutta and Borkowski, 2022). Despite large potential for societal benefits, a single failure in the value chain might have the overall effect that the system will not work technically, logistically or financially (Marvik and Philp, 2020). In other words, if policy simply acts on individual parts of a complex industrial system, then there is a substantial risk of wasted resources and effort. This underscores the need for coordination of different policy families along value chains, as well as across disciplines and sectors (Weber and Rohracher, 2012).

Systems thinking in sustainability policies

A critical ‘sustainability system’ is land use. Replacing a major part of current fossil carbon demand with fresh biomass will put huge pressure on agriculture and forestry. Shortage of arable land, water and fertilizers have already led to conflicts between different sustainability goals (D'Amato et al., 2017) related to, for instance food, energy and biodiversity and major concerns from associated land use change and deforestation (Searchinger et al., 2018).

One would expect policies to prioritise the use of renewable carbon in those value chains where no alternatives are available, e.g., food, chemistry and materials, while in fact, public policy attention has mainly been directed towards bioenergy. This indicates a need to better balance the policies (Philp, 2015), in consideration of potentially conflicting sustainability goals. This balance needs to take account of the fact that biomass can achieve multiple goals, as enshrined in the cascading use of biomass.

Dietz et al. (2018) identified the political management of conflicting goals as one of the major challenges for a sustainable bioeconomy governance framework. While it is generally agreed that human primary needs, such as food security, have to be prioritised in the bioeconomy, food production *per se* is typically not the major cause of malnutrition and famine; but rather inefficiencies in food management, distribution and wastage (Berners-Lee et al., 2018). This is an illustration of the complexity to be tackled in the green transition, and highlights the possibilities of unintended consequences, reinforcing the need for a holistic approach.

Innovation policies should incorporate a time dimension

Table 3.1 may have limited utility as it does not imply a temporal strategy and a progression path for policy makers, i.e., it lacks any conception of a sequence of policy implementation. Marvik and Philp (2020) refined the approach by describing the mix of specific and general measures in a widely accepted innovation policy sequence from 'ideas to market' (European Commission, 2020; World Bank Group, 2020), an approach familiar in other sectors e.g., energy (IEA, 2009) and nanotechnology (Lim et al., 2015).

A bioeconomy-specific version of the four-step matrix shown in Table 3.4, was used to develop the Norwegian national bioeconomy strategy (Ministry of Trade, Industry and Fisheries (Norway), 2018). It may give policy makers a broader idea of how to construct a strategy that will connect supply- and demand-side drivers to achieve a stronger and more robust effect on the economic system. Specifically, this matrix may guide different ministries and agencies to know when and where their roles are required, or how and when they need to work together.

Finally, as referred to several times, increases in prices for basic commodities can cause price and inflation hikes. Therefore, a connection to macroeconomics is inevitable, where classical mechanisms like price subsidy reform (IMF, 2000) and central bank control of inflation to the desired levels are triggered.

Table 3.4. A net-zero carbon innovation policy framework

Feedstock	Technology	Industrialisation	Market
Objectives			
Stimulate availability of resources	Strengthen skills and technology base	Trigger investments in new manufacturing	Increased sustainability and value creation
Value chain specific policies			
Resource regulations and permits	Targeted R&D grant programmes	Public technology scale-up and pilot facilities	Product standards and norms
Transportation and logistics infrastructure	Specific education and training programmes	Financial support for flagship projects	Price subsidies and product tax policies
Feedstock specific trade regulations	Technology cluster and network support	Targeted government investment programmes	Product mandates and bans policies
Generic policies			
Feedstock sustainability assessment studies	Broad scope R&D grant programmes	Start-up and SME support	Sustainability labels and communication
Governance and regulation efficiency	Tax incentives for applied R&D	Industry-oriented education programmes	Public awareness and acceptance campaigns
Waste management policies	Stimulate international partnerships	Techno-economic feasibility studies	Tax on CO_2 emissions and fossil fuel subsidy reform
International trade agreements	Exchange programmes and apprenticeship	Private investment stimulating policies	Public procurement of renewable carbon products
Connect to macroeconomics			
In the event of high food and energy prices: price subsidy reform, central banks control inflation to desired levels through the interest rate mechanism or money supply			

Source: Adapted from Marvik and Philp (2020)

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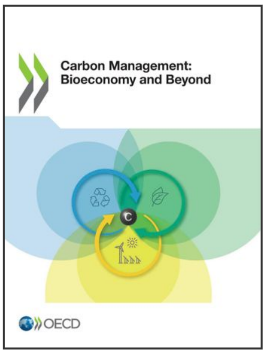

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