Policy instruments for promoting innovation to prevent or control risks of chemicals

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EXECUTIVE SUMMARY

The goal of this study is to explore and present new or improved policy instruments that could be used by the Dutch government and the European Commission to promote safe chemical innovation.

The regulatory framework that regulates chemical substances and mixtures in the Netherlands and across the EU could use new and/or more targeted policy instruments to better encourage innovation. Existing EU regulations and other Dutch policy interventions have made significant steps towards reducing the harm caused by hazardous substances in the Netherlands and the EU as a whole. These regulations are effective at reducing the number of hazardous substances on the market and stimulating innovation as a result of the need to develop alternatives. However, there are still many hazardous substances in use, either in production processes or present in products. These hazardous substances can end up in the environment and impact human and environmental health. A 2022 report by the European Environmental Bureau (EEB) further reported it takes generally 9 years for the REACH regulation to complete an authorisation procedure on a substance of very high concern[1]. In line with this result, the EEA estimated that of 100.000 known chemicals in 2020, only 500 were extensively characterised for their hazards and exposures[2]. Novel substances are also developed regularly in both academic and commercial settings as companies innovate. Information on hazard properties of novel substances and mixtures is often incomplete, particular for the effects of long-term exposure. This leads to the development of substances that could still be hazardous despite being allowed on the market, and in some cases to 'regrettable substitution'.

Promising instruments for targeted policy intervention

Policy interventions can accelerate safe chemical innovation, by promoting the drivers for innovation or taking away obstacles. According to the Zero Pollution Action Plan: "Today, despite numerous calls, pollution is still mainly addressed through regulation and its external costs are not fully internalised. There is scope to promote further use of price instruments". Therefore this report is focused on exploring the use of market-based instruments (MBIs).

Figure 0.1 Longlist of policy instruments and scoring according to legal and technical feasibility, policy coherence, effectiveness, relevance and proportionality. The top in the darker shades represents a high score with the score decreasing with the lighter shades

Pigovian Tax	Grants	Subsidies	Charge/fee	Science-industry network	
Tradable permits	Regional/ national network	Process and usage norms	Network programmes	Knowledge network	
Patent box	Regulatory sandbox	Network cluster	Supply-chain network	Strategic network	Entrepreneurship policy
Policies for training and skills	Awareness building measures	Regulation of product performance and manufacturing	Training and further education	Labels or information campaigns	
Regulation to create a final market	Articulation and foresight	User-producer interaction			
Technology foresight	Deposit-refund	Regulation of product information	Tax incentives	Instrument network	
Innovation inducement prizes	Voluntary approaches	Standardisation and standards	Support of innovation-friendly private regulation activities		
Technical services and advice	Public procurement policies	Equity financing	Pre-commercial procurement		

1 EEB (2022), the need for speed; why it takes the EU a decade to control harmful chemicals and how to secure more rapid protections.

2 EEA (2020), the unknown territory of chemical risk.

Based on a qualitative screening of a longlist of 38 instruments (see Figure 0-1), three policy instruments were selected. These instruments were selected so the study could present 3 different types of instruments to be analysed in more depth. These 3 are also called Policy Mix Options in this study. These are:

A. **A targeted grant/subsidy scheme**, focused on safe chemical innovation. This policy is a strengthening and targeting of the existing technology-focused support schemes that are commonplace in the Netherlands and is most aligned with the existing innovation policy.
B. **A Pigouvian tax**, whereby the use of hazardous substances is discouraged by placing a tax premium on their sale within the supply chain. This instrument has been selected based on experience in Sweden and examples of environmental taxation in other sectors.
C. **An ecolabel + information campaign**, whereby public awareness is increased through improved communication on the hazards of product constituents. This communication should be present throughout the supply chain and to the consumer. Existing pilot projects have taken place in the Netherlands and the EU, and this policy instrument builds on those experiences.

Policy instrument B is an example of a **market-based instrument (MBI)** These can be used in particular to change incentives so that obstacles to innovation are reduced and drivers strengthened, and to help new innovations gain market share. The use of market-based instruments to promote innovation is largely unexplored in EU and EU Member State policy on chemicals.

Drivers and obstacles to safe chemical innovation

In this study, the drivers and obstacles for safe chemical innovation were analysed. This can be used by policy makers to inform on where policy instruments are needed to either promote drivers or remove obstacles. A literature review, multiple interviews (with industry and academic experts) and expert knowledge from the study team have been used to analyse how different policy instruments could be effective at promoting innovation. To model how these instruments may promote innovation, two substance groups have been used as primary considerations: ZZS ('Zeer Zorgwekkende Stoffen'[1]) and active substances in biocidal products.

Four major drivers for innovation are identified:

1. Companies innovate naturally. Innovation literature consistently points at the **innovation culture** within a company as an important explanatory factor for successful innovation. This is often more available in start-ups and SMEs than large established chemical companies.
2. **Existing government funding programmes** can lead successfully to innovations, as these drive companies to move towards alternatives and help fund innovation programmes. This also exists in the form of fiscal benefits for acquiring and using safe chemical innovations.
3. **Existing government restrictions** on chemicals and mixtures are shown to promote innovation. Public policy can also stimulate safe chemical innovation by providing a favourable regulatory environment for innovation activities. Still, the risk of regrettable substitution remains, as generally innovation policies are not targeted towards safe chemical innovation.
4. Finally, **public awareness** of the risk posed by hazardous substances is increasing and companies are responding to this by developing and marketing less hazardous products. The recent concern about PFAS and development of PFAS-free consumer products is a strong example of this. Nevertheless the risk of greenwashing remains, as public awareness concerns could also be addressed without completely switching to less hazardous chemical alternatives.

[1] The Zeer Zorgwekkende Stoffen (ZZS) group includes all Substances of Very High Concern (SVHC) as well as any other substances or mixtures which meet the criteria for classification on one or more hazard classes from Article 57 of REACH.

However, the **obstacles for safe chemical innovation** are often stronger than the drivers. Many obstacles prevent innovation starting in the first place, others result in innovations not reaching the market, or not succeeding in gaining market share. The four most significant **obstacles** are:

1. **High performance standards** are expected by downstream market parties and consumers. Performance is linked to the properties of the hazardous substance, so it is often difficult to find alternatives which meet these standards. Additionally to fit existing processes and supply chains, there is a **focus on drop-in alternatives,** which may lead to regrettable substitution and may not lead to truly safer solutions.

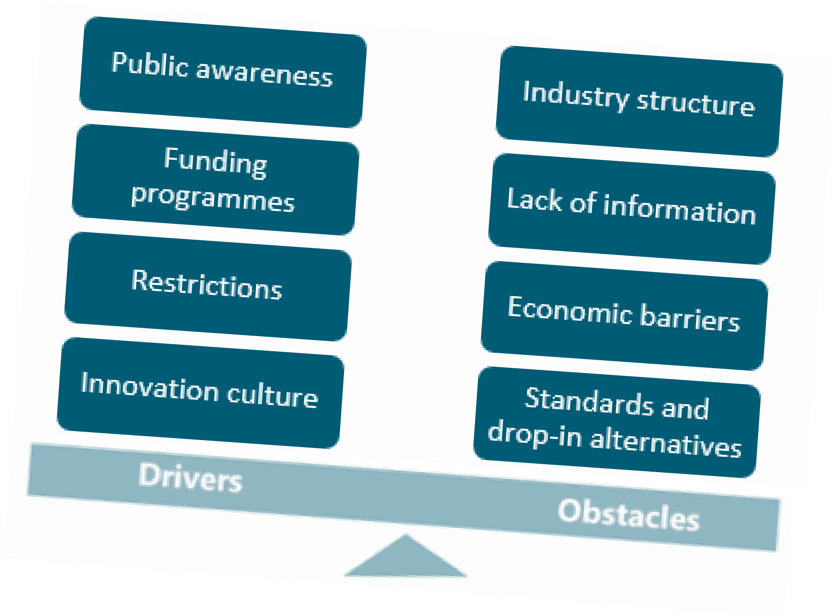
2. There are many economic barriers; Internal **funding capabilities are limited**, in particular for SMEs, and external funding opportunities within the Netherlands and the EU are most often not focused on hazardous substance substitution. This is because **human and environmental damage is still an externality** to the chemical industry. Also, in the case of biocides, there may be other **financial barriers** such as a high regulatory cost for approval of new active substances.

3. **Product information is limited;** for downstream users and retailers, there may not be enough available information on all the substances used in products or in the manufacturing process. This leads to uncertainty on what needs to be innovated on and reduces the ability of downstream market parties to signal a demand for less hazardous alternatives.

4. **The Industry structure** in the Netherlands is not conducive for highly disruptive innovation, due to a very established, high volume supply chain. The size of the industry makes it difficult to make radical changes from within, and creates technological lock-in. Collaboration across supply chains is also difficult to establish by innovators.

The balance of drivers and obstacles is in favour of obstacles. This means that firms on average see more obstacles than drivers to engage in safe chemical innovation. Policy makers should explore the applicability of the policy instruments that are presented in this study to strengthen the drivers or remove or lower the obstacles to safe chemical innovation.

Figure 0.2 The balance of drivers and obstacles to innovation towards alternative substances is skewed towards obstacles



Analysis of impact pathways

By identifying the key stakeholders and the change that these stakeholders should undertake in response to the policy, policy design can be made more tailored. For each of the three policy instruments, this is summarised in an **impact pathway,** that used further literature insights on how stakeholders may react to the policy, and *conditions of their response* for a successful policy implementation.

The targeted grant/subsidy scheme reduces the external funding obstacle and provides more specific funding alongside the more generic, widely applicable funding schemes that already exist in the Netherlands. When providing funding through any new scheme, it is paramount to **strengthen the innovation culture driver,** as well as promote **inter-supply chain collaboration**; companies often cannot engage in disruptive innovation alone and government support is most effective when the length of the supply chain that leads to a product is fully engaged. Targeted innovation subsidies should therefore not just promote fundamental R&D but can also help in market uptake and thereby increasing economies of scale.

A Pigouvian tax may have the goal of promoting innovation but will only do so if the increase in price leads to changed behaviour in companies who can perform innovative activity. The direct **effectiveness of a tax depends on the elasticity of demand** for the taxed product. This elasticity may vary substantially between different ZZS and biocides. A high elasticity of demand will result in a strong demand signal in response to the tax, and therefore an incentive for the supply chain to look for alternatives. Conversely, if there is a weak elasticity of demand then the innovation effect may be reduced, but in this situation the tax revenues from a Pigouvian tax can be used to fund innovation through the grants/subsidies instrument. Further, the taxation measure has **higher short-term effectiveness for products/services which already have alternatives on the market, but which are not yet price competitive.**

Lastly, for the ecolabel and information campaign, this instrument has the least direct effect on innovative activity within companies and works better in combination with other policy instruments. **Pressure from society and public attitudes towards hazardous substances can be a driver for innovation, but the effect of isolated government campaigns here is small**; public awareness is a function of the overall communication in the media landscape and develops over time. As a result effects of this instrument on innovation may take longer to materialise or are difficult to measure.

An overarching finding is that **innovation policy instruments are most effective when combined and may be less effective when used in isolation**. The subsidy measure and a Pigouvian tax can strongly complement each other as tax revenues can directly be used to fund innovation subsidies. It is evident that combinations of the investigated policy instruments can both help pull innovations into the market (demand-side policy including taxation and information sharing) and push innovations to become market ready (subsidies for research and development). Further, it also means that there is a lot of value in considering how the existing policies, relying on restrictions and authorisations, can work together with any new instruments.

Other findings of this report

Within the substance groups of ZZS and biocidal active substances, a recommendation is made on which substance groups may benefit most from targeted innovation policy in the Netherlands. These are summarized in Annex I.1 and I.2. These findings are based on literature research, public emission data from the Netherlands, patent data analysis and expert knowledge on which ZZS and biocidal active substances have hazards of concern and are used in applications where innovation is lacking. These findings can be used to specifically target substance groups in policy instrument design.

The report should be read as a tool to help the market adopt Safe and Sustainable by Design (SSbD) innovation, whereby toxicity is taken into account in the design stage. In this study this is also referred to as safe chemical innovation, which aims to avoid the emissions of hazardous substances into the environment, and thus protect human and environmental health.

MANAGEMENTSAMENVATTING

In dit onderzoek worden kansrijke beleidsinstrumenten verkend die kunnen worden ingezet om veilige chemische stoffen te stimuleren. Deze beleidsinstrumenten kunnen worden ingezet door de Nederlandse regering of de Europese Commissie.

Het beleidspakket in Nederland en de EU om chemische stoffen en mengsels te reguleren heeft baat bij de inzet van gerichte beleidsinstrumenten om veilige innovatie te stimuleren. In het bestaande beleidspakket[1] zijn al significante stappen gezet om de schade van gevaarlijke stoffen in Nederland en de EU te voorkomen en verminderen. Dit beleid is effectief in het verminderen van het aantal gevaarlijke stoffen op de markt en het stimuleren van innovatie, doordat zij een verplichting creëren om alternatieven te ontwikkelen. Echter, er zijn nog steeds zeer veel gevaarlijke stoffen in gebruik, zowel binnen productieprocessen of als onderdeel van producten.

Deze gevaarlijke stoffen kunnen in het milieu belanden en zijn daarmee een gevaar voor mens en milieu. Een bevinding uit 2022 van het European Environmental Bureau (EEB) is dat het ongeveer 9 jaar duurt voordat de REACH Verordening een complete autorisatie procedure om een zeer zorgwekkende stof te reguleren. Ook maakte het Europees Milieuagentschap een inschatting dat van 100.000 bekende stoffen in 2020, er slechts 500 compleet zijn onderzocht op hun gevaren en blootstellingen. Ook worden telkens nieuwe stoffen gemaakt bij universiteiten en bedrijven. Er is vaak niet genoeg data over de risico's van nieuwe stoffen en mengsels, vooral als het gaat om effecten van lange-termijn blootstelling. We blijven stoffen ontwikkelen die gevaarlijk blijven ondanks hun markttoelating, en dit kan weer leiden tot 'regrettable substitution'.

Kansrijke beleidsinstrumenten voor gerichte interventie

Beleidsinterventies kunnen veilige chemische innovatie versnellen, door de stimulerende factoren van innovatie te ondersteunen of remmende factoren weg te nemen. Het EU Zero Pollution Action Plan stelt: 'Vandaag de dag wordt verontreiniging, ondanks talrijke oproepen, nog steeds voornamelijk met regelgeving bestreden en worden de externe kosten ervan niet volledig geïnternaliseerd.

Er is ruimte om verder gebruik van prijsinstrumenten te bevorderen'. Deze benadrukking van 'prijsinstrumenten' betekent dat er in dit onderzoek extra focus is op het verkennen van het gebruik van dit soort instrumenten, binnen een grotere groep van marktinstrumenten.

[1] Dit refereert aan restrictief beleid op het gebruik van stoffen en mengsels, zoals Verordening (EC)) No. 1907/2006 inzake de registratie en beoordeling van en de autorisatie en beperkingen ten aanzien van chemische stoffen (REACH) en Verordening (EU) No. 528/2012 betreffende het op de markt aanbieden en het gebruik van biociden (BPR).

Figuur 0.1 Lijst van beleidsinstrumenten met een score gebaseerd op: juridische en technische haalbaarheid, samenhang met bestaand beleid, effectiviteit, relevantie en proportionaliteit. De donkerder gekleurde instrumenten geven aan dat deze een hoge score behaalden, en de score verlaagt naarmate de kleur lichter wordt

Pigovian Tax	Grants	Subsidies	Charge/fee	Science-industry network	
Tradable permits	Regional/ national network	Process and usage norms	Network programmes	Knowledge network	
Patent box	Regulatory sandbox	Network cluster	Supply-chain network	Strategic network	Entrepreneurship policy
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Technical services and advice	Public procurement policies	Equity financing	Pre-commercial procurement		

Gebaseerd op een kwalitatieve screening van een lijst met 38 instrumenten (Zie Figuur 0-1) zijn er 3 beleidsinstrumenten gekozen. Deze zijn gekozen zodat deze studie 3 verschillende typen instrumenten in meer detail geanalyseerd konden worden. Deze zijn ook genoemd de Beleidsmixopties in deze studie. Deze zijn:

A. **Een gericht steun of subsidie programma,** gefocust op veilige chemische innovatie. Dit is een versterkte en meer gerichte inzet van de bestaande ondersteuningsprogramma's die Nederland al aanbiedt, en is daarmee het meest in lijn met de huidige manier van innovatie stimulering.
B. **Een Pigouviaanse belasting**, waarbij het gebruik van gevaarlijke stoffen wordt belast via een heffing op de verkoop van stoffen in de keten. Dit instrument is gebaseerd op ervaring opgedaan in Zweden en de talrijke voorbeelden van milieubelastingen in andere sectoren.
C. **Een ecolabel + informatie campagne**, waarbij het sociale bewustzijn wordt verhoogd door verbeterde communicatie over de gevaren van stoffen in producten. Deze communicatie wordt gericht aan de hele keten en naar de consument toe. Bestaande pilotprojecten en ervaringen hierover is opgedaan in Nederland, en dit beleidsinstrument bouwt verder op die ervaringen.

Beleidsinstrumenten A en B zijn voorbeelden van **marktinstrumenten.** Deze kunnen specifiek gebruikt worden om prikkels te veranderen zodat remmende factoren voor innovatie worden aangepakt en stimulerende factoren worden versterkt. Dit heeft ook tot doel om bestaande gewenste innovaties te helpen aan meer marktaandeel. Het gebruik van marktinstrumenten om innovatie te stimuleren is wel een grotendeels onbekend terrein in EU- en lidstaatbeleid op het gebied van chemicaliën.

Stimulerende en remmende factoren voor veilige chemische innovatie

De factoren die zorgen dat bedrijven wel of niet overgaan tot veilige chemische innovatie zijn in deze studie geanalyseerd. Dit inzicht kan worden gebruikt door beleidsmakers om te zien waar beleidsinterventie nodig kan zijn. Een literatuurstudie, meerdere interviews (met experts uit het bedrijfsleven en academici) en expert kennis vanuit het projectteam hebben geleid tot inzicht over hoe verschillende beleidsinstrumenten effectief kunnen zijn om veilige innovatie te promoten. Om verder inzicht te verkrijgen hoe deze instrumenten innovatie kunnen stimuleren, is op twee stofgroepen specifiek ingezoomd, namelijk ZZS ('Zeer Zorgwekkende Stoffen') en actieve bestanddelen in biociden.

Vier belangrijke stimulerende factoren voor innovatie zijn:

5. Bedrijven zijn van nature innovatief. Literatuur over innovatie geeft aan dat de **innovatiecultuur** van een bedrijf de meest belangrijke factor is voor succesvolle innovatie. Dit is vaak meer te vinden in startups en bij het MKB dan grote bestaande chemiebedrijven

6. **Bestaande overheidsregulering** in de vorm van restricties kunnen aantoonbaar innovatie stimuleren. Beleid kan ook veilige chemische innovatie stimuleren door een gunstige omgeving te creëren voor innovatie activiteiten. Het risico voor 'regrettable substitution' blijft hiermee wel bestaan, omdat de bestaande innovatiegerichte beleidsinstrumenten in het algemeen niet zijn gericht op veilige chemische innovatie.

7. **Bestaande overheidssubsidies** kunnen leiden tot succesvolle innovatie, omdat dit bedrijven leidt tot alternatieven en fondsen beschikbaar maakt voor innovatieprogramma's. Dit bestaat ook in de vorm van fiscale voordelen voor de aankoop en het gebruik van veilige chemische innovaties.

8. Tenslotte, **sociaal bewustzijn** van het risico van gevaarlijke stoffen neemt gestaag toe. Bedrijven reageren hierop door het ontwikkelen en vermarkten van veiligere producten. De recente zorgen over PFAS en het ontwikkelen van PFAS-vrije consumentenproducten is hier een sterk voorbeeld van. Echter, het risico van greenwashing bestaat hier ook, omdat zorgen in de maatschappij ook kunnen worden aangepakt zonder een complete verandering naar veilige chemische alternatieven.

De remmende factoren voor veilige chemische innovatie zijn vaak sterker dan de drivers. Veel obstakels voorkomen dat innovatie activiteiten beginnen, waar anderen kunnen zorgen dat kansrijke innovaties de markt niet kunnen bereiken, of geen significant marktaandeel kunnen verkrijgen. De vier meest significante **obstakels** zijn:

5. **Hoge prestatienormen** vanuit ketenpartners en consumenten zijn verbonden met de eigenschappen van veel gevaarlijke stoffen. Dit betekent dat het vaak moeilijk kan zijn om alternatieven te vinden. Verder, om bestaande processen in complexe ketens te blijven gebruiken, is er een **focus op 'drop-in alternatieven',** wat kan leiden tot 'regrettable substitution' en niet tot echt veilige oplossingen.

6. Interne **financiële middelen voor innovatie zijn vaak beperkt,** vooral voor het midden- en kleinbedrijf, en externe financiering in Nederland en de EU is vaak niet specifiek gefocust op substitutie van gevaarlijke stoffen. Dit is omdat **schade aan mens en milieu vaak nog steeds een externaliteit** is voor de chemische industrie. Verder, in het geval van biociden, zijn er nog extra financiële barrières in de vorm van de **hoge administratieve kosten** voor het goedkeuren van nieuwe actieve bestanddelen.

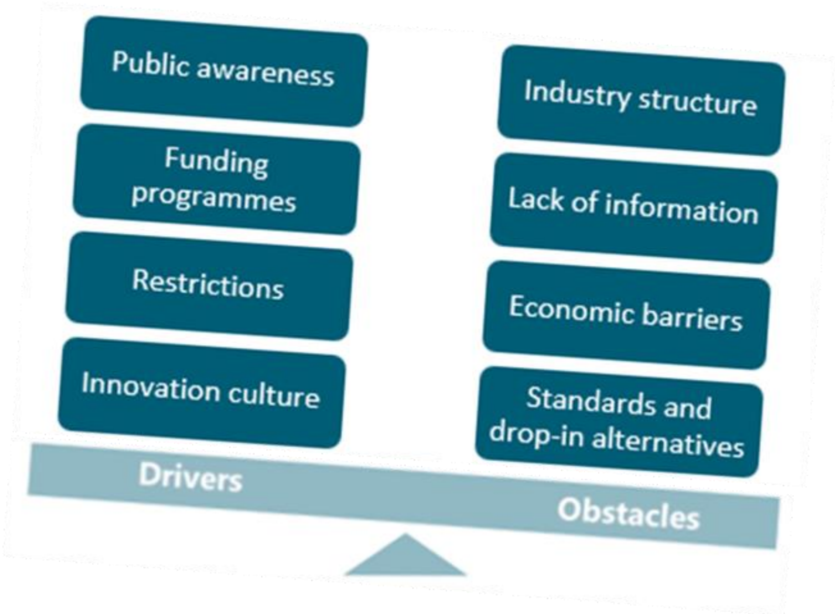
7. **Product informatie is niet geheel beschikbaar**; voor downstream gebruikers en retailers is er vaak niet genoeg informatie beschikbaar over de stoffen die gebruikt worden in producten of in het productieproces. Dit kan leiden tot onzekerheid over waar nu innovatie voor nodig is, en vermindert de mogelijkheid voor downstream ketenpartners om een behoefte aan veiliger alternatieven aan te geven.

8. **De structuur van de chemische industrie** in Nederland is niet optimaal om radicale innovatie op te schalen, doordat de bestaande industrie gebruik maakt van een vastgestelde keten met een hoog volume. De grootte van deze industrie maakt het bovendien moeilijk om significante veranderingen in te zetten van binnenuit. De industrie heeft last van technologische lock-in, en samenwerking binnen de keten is ook moeilijk om van de grond te krijgen door innovatieve bedrijven.

De balans van remmende en stimulerende factoren is negatief

Dit betekent dat bedrijven gemiddeld meer remmende factoren zien dan dat zij worden gestimuleerd om te investeren in veilige innovatie. Beleidsmakers zouden daarom de toepasbaarheid van de beleidsinstrumenten uit deze studie moeten nagaan, om te kijken of hiermee de remmende factoren kunnen worden verminderd of de stimulerende factoren kunnen worden versterkt.

Figuur 0.1 De balans van stimulerende factoren (drivers) en remmende factoren (obstacles)



Analyse van effect routes

Deze studie helpt beleidsmakers ook in het begrijpen van hoe stakeholders zouden moeten reageren op een beleidsinstrument om de doelen van het beleid te halen. Door de belangrijke stakeholders en de veranderingen die deze stakeholders zouden moeten doorvoeren in kaart te brengen, kan het ontwerp van de beleidsinstrumenten beter worden gestuurd. Voor elk van de 3 geselecteerde beleidsinstrumenten is dit samengevat in een **effect route** (Engels: 'impact pathway') dat gebruik maakt van diepgaande literatuurinzichten over hoe stakeholders zouden kunnen reageren op beleid, en welke voorwaarden er zijn voor een effectief beleid.

Het gerichte subsidieschema geeft bedrijven meer mogelijkheden voor externe financiering van innovatie, en geeft meer specifieke subsidie in samenhang met de brede, generiek toepasbare subsidieprogramma's die al bestaan in Nederland. Wanneer men subsidie verschaft via welk programma dan ook, is het vooral belangrijk om daarbij de **innovatiecultuur** te versterken, en daarbij ook **samenwerking in de keten** te stimuleren. Bedrijven kunnen vaak niet op zichzelf radicale innovaties op de markt zetten, en overheidsondersteuning is het meest effectief als de lengte van de hele keten voor een product volledig meedoet. Gerichte subsidies zouden niet alleen moeten leiden tot meer onderzoek en ontwikkeling, maar ook helpen in versterken van marktaandeel en daarmee het behalen van schaalvoordelen die gangbare alternatieven al hebben.

Een Pigouviaanse belasting kan het doel hebben om innovatie te promoten, maar dit werkt alleen als een prijsverhoging tot veranderd gedrag leidt bij de bedrijven die in staat zijn tot zo'n innovatie. De directe **effectiviteit van een belasting hangt af van de prijselasticiteit van de vraag** naar het belaste product. Deze elasticiteit kan sterk variëren tussen verschillende ZZS en biociden. Een hoge vraagelasticiteit leidt tot een sterk vraagsignaal in reactie op de belasting, met als gevolg een prikkel in de keten om te zoeken naar alternatieven. Bij een zwakke vraagelasticiteit is het directe effect op innovatie kleiner. De belastingheffing kan in die tweede situatie wel weer gebruikt worden voor innovatiesubsidies. Verder heeft de belastingmaatregel een **op korte termijn een groter effect voor producten waarvoor al alternatieven op de markt bestaan, maar die nog niet kunnen concurreren op prijs.**

Het gebruik van ecolabels en informatiecampagnes heeft het minste direct effect op innovatieactiviteit binnen bedrijven.

Druk vanuit de maatschappij en de publieke houding over gevaarlijke stoffen kan een stimulans zijn voor innovatie, maar het effect van geïsoleerde overheidscampagnes is beperkt; sociaal bewustzijn is een functie van algehele communicatie in het medialandschap en ontwikkelt zich gedurende langere tijd. Dit betekent dat de effecten van dit instrument op innovatie langer kunnen duren voordat ze zichtbaar worde. Het effect is ook moeilijker te meten.

Een overstijgende bevinding is dat **instrumenten gericht op innovatie het meest effectief zijn in combinatie met elkaar.** De subsidieregeling en de Pigouviaanse belasting kunnen elkaar sterk versterken, vooral omdat de opbrengsten van belasting gebruikt kunnen worden om innovatiesubsidies te bekostigen. Het is duidelijk dat combinaties van instrumenten zowel innovaties naar de markt kunnen 'trekken' (via vraagsturend beleid zoals belastingen en delen van informatie over stoffen), en innovaties de markt op kunnen 'drukken' door ze verder te ontwikkelen via gerichte subsidies voor onderzoek en ontwikkeling. Ook betekent dit dat het meerwaarde heeft om na te gaan hoe het bestaande beleid het beste kan samenwerken met nieuwe instrumenten.

Andere bevindingen van dit rapport

Voor de stofgroepen van ZZS en de actieve stoffen in biociden wordt een aanbeveling gedaan over waar gericht beleid zich het beste op zou kunnen focussen. Deze aanbevelingen worden gedaan in Appendix I.1 en I.2. De aanbevelingen zijn gebaseerd op literatuur onderzoek, publieke informatie over emissies van ZZS in Nederland, patentdata en expertkennis. Het rapport identificeert hiermee ZZS en biociden in productgroepen waar veilige innovatie niet van de grond komt, maar wel gewenst is. Deze bevindingen kunnen worden gebruikt om het ontwerp van nieuw beleid te richten op specifieke stofgroepen.

Het rapport is een hulpmiddel om de markt te helpen het principe van 'Safe and Sustainable by Design' toe te passen, waarbij de toxiciteit van stoffen wordt meegenomen in het ontwerp van nieuwe en bestaande producten. In deze studie wordt dit ook wel 'safe chemical innovation' genoemd, wat zich richt op het verminderen van de emissies van gevaarlijke stoffen naar het milieu, en daarmee het beschermen van gezondheid van mens en milieu.

1

INTRODUCTION

This study is an exploration of various potential policy instruments that could be used in the Netherlands or the EU, to promote innovation to develop alternatives that are less hazardous, moving away from hazardous substance use and towards safe production processes, products and services. This Chapter of the report introduces the aims of the study, the scope of the exploration and the research methods employed.

1.1 The aim of this study

The aim of the study is to find and explore possible policy instruments that promote safe chemical innovation. This study explores a broad base of innovation policy instruments. Further, there is a specific focus in this report on exploring market-based instruments, as these tools are not traditionally used to regulate the chemical industry but have been successful in other sectors.

In this exercise, the policy instruments are analysed to identify how they may stimulate innovation to find alternatives to the substance groups of (in Dutch) "Zeer Zorgwekkende Stoffen'[1] in the Netherlands (ZZS) and hazardous biocidal active substances[2]. These two groups of substances have been selected because of concerns related to the risk to the environment of their continued use across the Netherlands. Additionally, there are a large number of products and services that contain these substances which can result in high dispersive use, increasing environmental exposure.

1.2 What larger goals does this contribute to?

Reducing the risks from hazardous chemicals is underpinned in the European Commission's Chemicals Strategy for Sustainability (CSS). This includes a specific action on 'boosting the investment and innovative capacity for production and use of chemicals that are safe and sustainable by design (SSbD) and throughout their life cycle'. In the Netherlands, the realisation of this ambition is made concrete in the 'Impulsprogramma chemische stoffen 2023 - 2026'' (impulse programme chemical substances). This study is within the scope of the impulse programme, seeking to further explore what policy instruments the Dutch government can enact, as well as what policy instruments can be suggested to the European Commission.

The overarching goal of the abovementioned EU and Dutch policy initiatives is to **protect human and environmental health** from the risks from exposure to chemicals. The current risks from exposure to hazardous substances are largely related to technological innovations that have come to the market over the last century. To prevent further negative impacts on human health and the environment, safe chemical innovation is a method for firms to reach their product and service goals while reducing or eliminating human and environmental health risks. It is key in the transformation to a non-toxic environment in the future.

1 The Zeer Zorgwekkende Stoffen (ZZS) group includes all Substances of Very High Concern (SVHC) as well as any other substances or mixtures which meet the criteria for classification on one or more hazard classes from Article 57 of REACH.

2 Biocidal products are used to protect humans, animals, materials or articles against harmful organisms, the active substances contained in the biocidal product are responsible for the efficacy against organisms.

1.3 Scope of this exploration

The scope of this policy exploration is outlined below, in terms of the substances in scope, the geographical scope of potential impacts, and the depth of analysis in this study on new policy instruments.

Substances in scope: The substances of interest in this study include ZZS and hazardous biocidal active substances. When considering the influence of certain policy instruments in this study, these two substance groups have been used to model the expected impacts. Nevertheless, the findings of this study may be widely applicable to other chemical sectors or substance groups.

Geographical scope of application: The study focuses on the application of potential policy instruments in the context of the current Dutch and European Union regulatory environment. This regulatory environment includes all current relevant policies, from restrictive measures on substances (risk management measures; prohibitions for manufacture, placing on the market or use) to innovation subsidies. The research further uses the experience and data on the success of these policy instruments from global examples.

Policy instruments in scope: This study considered a broad set of policy instruments, which can be seen in Appendix III (the long list of policy instruments), these were then shortlisted. The in-depth policy analysis focuses on three types of policy instrument; command-and-control regulatory instruments, market-based instruments and information instruments. These are the three types of policy instrument considered to promote innovation in the Netherlands and across the EU.

Depth of exploration: This research is intended as a starting point for the development of targeted innovation policy for safe chemical innovation. The report starts broad and discusses a wide variety of policy instruments before selecting three policy mix options for a more in-depth literature review on their potential effectiveness. The analysis first considers these three main policy instruments in isolation, then explores evidence as to how different policies can work together to stimulate innovation. The three policy mix options presented in this study are not policy recommendations, however, they have been highlighted as promising considerations that merit an in-depth review.

Two main criteria outline the choice of policy mix options:
1. There are many market-based instruments/information instruments that have not yet been applied to the chemical sector in the Netherlands, nor as part of EU policy. These instruments have proven useful in other sectors and therefore we have selected at least one market-based/information instrument under each policy mix option.
2. The instruments chosen all have scientific evidence or policy evaluation reports stating their potential effectiveness and efficiency.

1.4 Research methods employed

Multiple targeted literature searches were complimented by expert interviews and in house policy expertise to cultivate a broad and thorough evidence base for analysis.

Literature searches used a combination of key words and covered publications globally, both academic, as well as reports from regulatory bodies, NGO’s and industry.

Expert interviews were conducted in a workshop session with three academic experts from Universities and Research Institutes in the Netherlands and Belgium and a chemical manufacturer. This workshop session focused on the issues encountered by companies to engage in innovation aimed at substitution and development of less hazardous chemical alternatives.

In house expertise was required to thoroughly assess the policy mix options, this included historical experience and knowledge of the EU regulatory system as well as knowledge of the chemical industries responsive approach to regulatory tools.

2

DRIVERS AND OBSTACLES FOR SAFE CHEMICAL INNOVATION

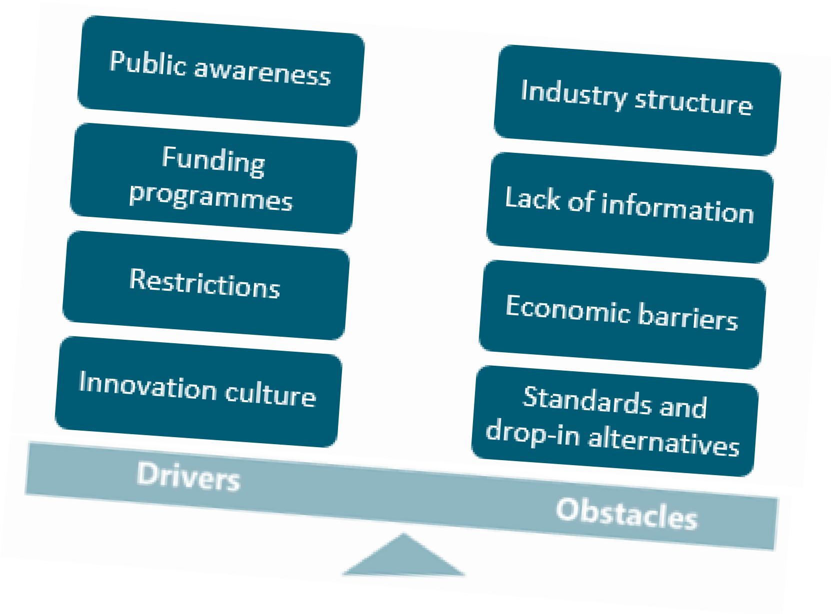
This Chapter presents important drivers for and obstacles to innovation. The Chapter considers the perspective of businesses and firms that would need to engage in innovation and does not consider innovation activities from public sources (universities and research institutes)[1].

First in Chapters 2.1 and 2.2, the general drivers and obstacles to innovation are presented. Then, the way current policy programmes impact innovation is briefly discussed. Finally, Chapter 2.3 summarises the conclusions that can be drawn from this exercise for policy intervention.

The balance of drivers and obstacles for safe chemical innovation

Four major summary drivers and obstacles are identified for safe chemical innovation in the following two chapters. In the current policy environment and chemical product market, the balance of drivers and obstacles for safe chemical innovation is in favour of obstacles. This means that firms on average see more obstacles than drivers to engage in safe chemical innovation. In the next chapter, these obstacles and drivers are further explored.

Figure 2.1 The balance of drivers and obstacles to innovation towards alternative substances is skewed towards obstacles.

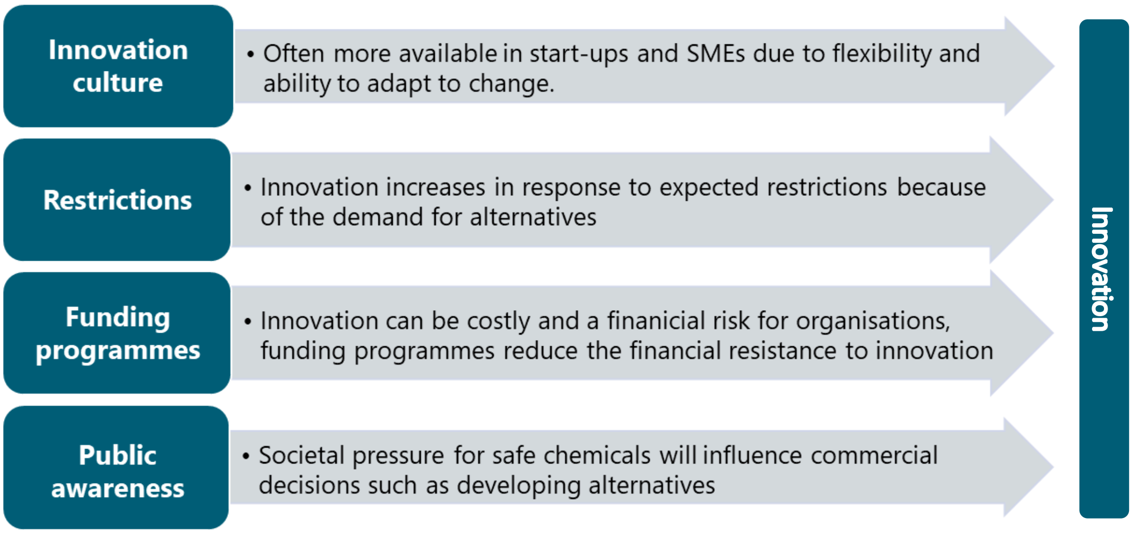


[1] These institutions may play a role in encouraging or discouraging innovation; however this is not the focus of this study.

2.1 Important current drivers for innovation

The stakeholders within a chemical supply chain are subject to many drivers regarding the reduction in use of ZZS and hazardous biocidal active substances in products and processes. The four key identified drivers included in Figure 2.2 have been explained in more detail below.

Figure 2.2 Summary of some of the current drivers for innovation towards alternatives



Innovation culture and willingness to collaborate

The ability to innovate within a firm and ultimately create less hazardous chemical alternative products, is dependent on the ability of people within a firm to make changes to the status quo. This is particularly important for radical innovations that require entirely new resources, manufacturing processes, and marketing to convince the customer base. This is also often why radical innovations within a market do not come from the firms who maintain the status quo, but rather from disruptive outsiders (start-ups and SMEs)[1,2]. Specifically for the chemical industry, empirical evidence from a series of studies in Spain confirms the importance of collaboration. It was found that the willingness of employees to go 'above and beyond' and engage with other firms in an innovative group increases the chances of realising and marketing less hazardous chemical products[3,4].

Engineers from within established large companies also do often create spin-offs that operate as independent start-ups. This is an effective combination, as the combination of significant experience and an innovative, 'start-up environment' is often cited as very conducive to innovation based on sustainable principles, and there may also be patience to wait for long-term investments to make a return. This makes creating separate entities an effective strategy for a large corporate to foster an innovation culture they may have otherwise found difficult to maintain[5].

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1 Orbegozo et al. (2017) Eco-innovation strategic model. A multiple-case study from a highly eco-innovative European Region.

2 Garcia et al. (2020); Measuring eco-innovation dimensions: The role of environmental corporate culture and commercial orientation.

3 Gonzalez-Moreno (2013), Drivers of eco-innovation in chemical industry. Note: Empirical evidence and research in this area is not large and within Europe evidence has concentrated on innovation culture in Spain, as is shown in the references for this Innovation driver in this document. When considering firm culture, it is important to understand how empirical evidence from one country could influence another like the Netherlands. Still, the presented evidence from innovative Spanish companies should be applicable to the Netherlands as firms operate under the same EU policy paradigm and are not expected to have a radically different corporate and start-up culture.

4 Iñigo, Albareda (2016); Understanding sustainable innovation as a complex adaptive system: a systemic approach to the firm.

5 McKinsey & Company (2021); Achieving win-win spin-offs.

Government regulations

Principally, the limitations that the EU places on the use of substances through Regulation (EC) No. 1907/2006 on the Registration Evaluation, Authorisation and Restriction of Chemicals (REACH) [1] have been shown to drive innovation[2]. This is in line with the Porter hypothesis[3], which states that **restrictions on production or use lead to innovation**. The study 'Safe by design' by Bureau KLB[4] concluded that companies tend to move away from hazardous substances when they anticipate that the market for the product will disappear. The study states that this anticipation originates from government regulation primarily, next to market demands and societal pressure.

The current REACH restrictions or authorisations of substances of very high concern (SVHC) and the exclusion criteria (Article 5(1)) for active substances, active substance approval and biocidal product authorisation processes under Regulation (EU) No. 528/2012 concerning the making available on the market and use of biocidal products (BPR) [5] are all examples of regulatory actions which could lead to innovation (for more information on these Regulations see Chapter 4.1). The SPHERE+ project mentioned in the KLB (2019) study is an example of a political programme developed to reduce or completely ban volatile organic compounds (VOCs) from paint and pushed companies to move to alternatives like water-based paint[6].

Where restrictive measures are used, it has been noted that it can take 5 - 10 years from the hazardous substance identification to lead to the implementation of a restriction[7]. Therefore, the impact on innovation and the use of such substances will be gradual up until the enforcement of the restriction. It has been suggested that the innovation effect from REACH is delayed, because the time between identification and restriction of a substance is very long[8]. Therefore, there is a large potential for other types of innovation policy to encourage innovation before a substance is subject to restriction or authorisation under REACH[9].

Government subsidies

Innovation is a cost-intensive activity with uncertain short-term results. Governments including the Netherlands and the EU promote innovation by subsidising innovative activity within firms directly. This allows for long-term investments to be made that are less reliant on diverting internal funds. Significant government funds are available from the EU and the Netherlands for firms to apply for a subsidy. Eurostat estimates that in 2020, the Netherlands invested 2.419 million euros in environmental subsidies and similar transfers. Innovation subsidies with an environmental protection goal are included in this category[10], though this category likely does not include all relevant subsidies. Many subsidy programmes include social or environmental conditions that the firms have to adhere to, and it is very difficult to measure which subsidies do or do not include environmental improvement goals, in particular when it comes to innovation subsidies.

In the Netherlands, funding support is the primary way that firms are supported in their innovation activity. Chapter 3 (which shows an overview of the existing innovation programmes) provides a more detailed overview of how this type of instrument is used in the Netherlands, and to what extent it has any focus on safe chemical innovation away from hazardous substances.

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1 Regulation 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Available from https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907

2 European Commission (2015); Monitoring the Impacts of REACH on Innovation, Competitiveness, and SMEs

3 Mohnen, P., & Van Leeuwen, G. (2015). Revisiting the Porter hypothesis: an empirical analysis of green innovation for the Netherlands. *UNU-MERIT Working Paper Series*, *2*.

4 Bureau KLB (2019) 'Safe by Design: Over substitutie van gevaarlijke stoffen' available at http://bureauklb.nl/downloads/190524_Over_substitutie_van_gevaarlijke_stoffen_-_Bureau_KLB_def.pdf.

5 European Union (2012) Regulation (EU) No. 528/2012 concerning the making available on the market and use of biocidal products. Available from : http://data.europa.eu/eli/reg/2012/528/oj

6 It should be noted that since the publication of the KLB (2019) study, Safe and Sustainable by Design (SSbD) has been introduced to the EU Transition Pathway for the industry, somewhat replacing safe by design.

7 Dienst Analyse en Onderzoek (2020), Zicht op chemische stoffen; sterktes en zwaktes in het Nederlandse en Europese beleid.

8 Regulation 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Available from https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907.

9 Dienst Analyse en Onderzoek (2020), Zicht op chemische stoffen; sterktes en zwaktes in het Nederlandse en Europese beleid.

10 Eurostat (2023); ENV_ESST_GGCP indicator; Total environmental protection and resource management, year 2020.

Public awareness

Societal pressure can be classified as an important driver in reducing the use of hazardous substances. As increased information has become available and companies have started to market less hazardous alternatives, public perception and awareness of chemical risk has increased in the past decades[1,2] .

To substantiate this, an important example are trends in the regulation of PFAS substances, where societal awareness of the PFAS risk was shown to support stronger PFAS policy proposals[3]. This is also expressed in the availability of products such as PFAS-free cookware or PFAS-free high-performance sports attributes. Information available to the public, through news outlets and social media, on the potential risks of hazardous substances influences the desirability of these products and encourages consumers to be aware. Outside of concern expressed via public debate, this is also observed via an increased demand for consumer cosmetics products that advertise low hazardous content, such as ecological washing detergents and similar products advertised 'chemical-free'[4]. These claims are often made about products which would not necessarily fulfil the conditions of 'Safe and Sustainable by Design', so there is a risk that public awareness is partly met by greenwashing on existing products[5].

In this driver, firms Environmental, Social and Governance policies (ESG) are also included. This is based on the perception that ESG policies that go beyond regulatory compliance are part of the same core driver of public awareness about environmental damage. The difference here is now this awareness also exists within the business that sells chemical products, rather than just with its customers. Therefore, a firm's ESG policies may lead to safe chemical innovation. The emphasis is on 'may' because empirical evidence shows mixed results[6], whereby not all firms with outwardly strong ESG claims are actually investing in innovation.

2.2 Important obstacles for innovation

Multiple drivers support a reduction of the use of ZZS and hazardous biocidal active substances through the promotion of innovation, however, numerous obstacles provide resistance to innovations in the Netherlands and across the EU. Some of the key obstacles, when considering innovation away from certain ZZS and hazardous biocidal active substances, have been identified as shown in Figure 2.3 and described in more detail below.

1 Berrone et al. (2012); Necessity as the mother of 'green' inventions: Institutional pressures and environmental innovations.

2 Dangelico, Pujari (2010); Mainstreaming Green Product Innovation: Why and How Companies Integrate Environmental Sustainability.

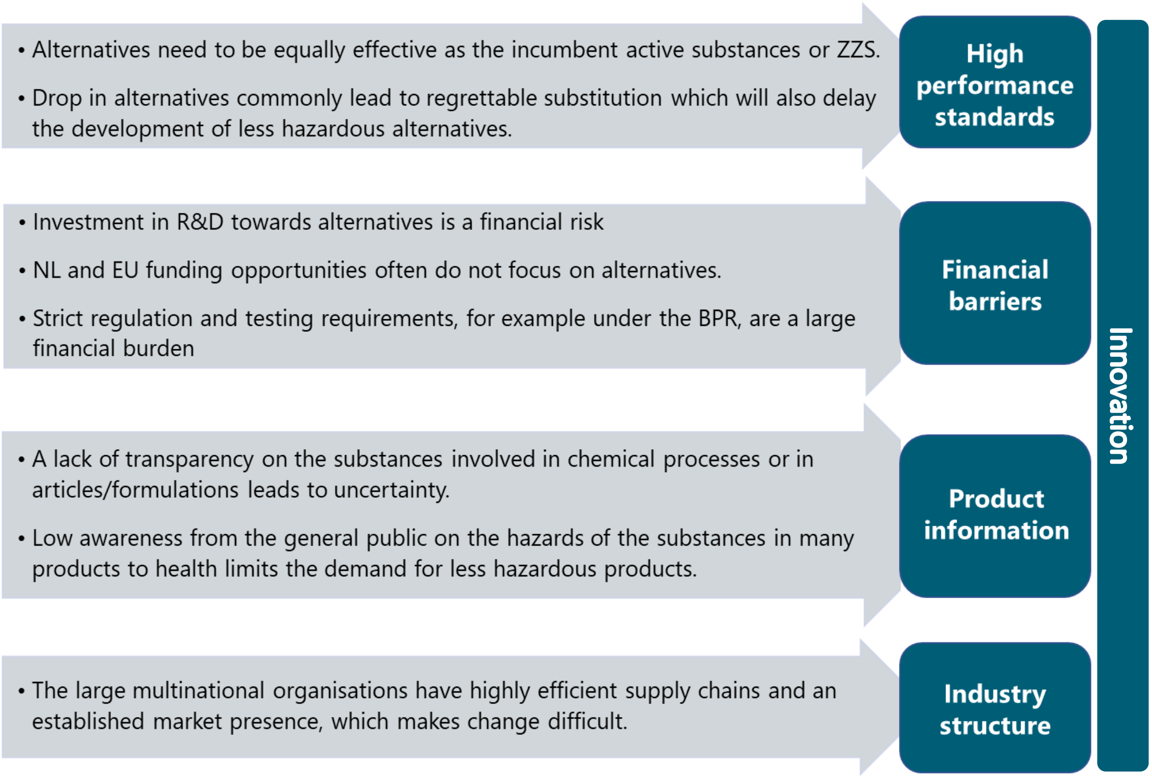
3 Brennan et al. (2021); Trends in the Regulation of Per- and Polyfluoroalkyl Substances (PFAS): A Scoping Review.

4 Eckert, Scheepers, Sommer; Natural & Organic Cosmetics Industry Monitor 2020.

5 Volschenk et al. (2022); The inability of consumers to perceive greenwashing and its influence on purchase intent and willingness to pay; *includes relevant examples for washing detergents.*

6 The ESG-Innovation disconnect; Evidence from Green Patenting.

Figure 2.3 Summary of the key obstacles for innovation towards less hazardous alternatives



High performance standards and drop-in alternatives

Aligning safe chemical R&D with the **high demands of modern society** to produce marketable alternatives can be complex. R&D programmes set out with the goal for the alternatives need to be equally effective as the incumbent substances. The ability to use a 'drop-in' an alternative is also appealing to businesses to avoid reformulation or costly manufacturing process changes. This type of substitution requires less changes in infrastructure or capital investments in the supply chain surrounding the innovating company, which has potential for an ideal solution, but may also hinder SSbD innovative measures when a similar chemical as the original is used. Drop-in alternatives can lead to regrettable substitution due to their similar (or in some cases worse) (eco)toxicological profile, which may not have been known at the time due to a lack of data.

Modern chemicals enable many welfare enhancing innovations, which have become commonplace in economic processes and everyday consumer use. In some cases, there are alternatives available, but they do not reach the market or are not able to displace hazardous alternatives because they may not be as convenient, long-lasting or easy to use as the hazardous alternative. Thus, a high level of product performance set by the incumbent hazardous chemical may be an obstacle for alternatives for which the market is thought to need comparable levels of performance, such as service life, efficacy or ease-of-use, or where new substances do not meet the required testing standards.

Financial barriers (internal funding capabilities and long-term investment needs)

The main challenges voiced in *The Safe Chemicals Innovations Agenda*[1] were on the topic of **financial barriers** to effectively meeting demand and supply alongside cost pressures, competition, collaboration, and coordination issues. For the biocides sector, the industry is heavily regulated by the BPR, which incurs a large financial and administrative burden on organisations developing new active substances or biocidal products. Availability of funds is an issue most-often found in young, new start-up companies who may have to set-up entirely new supply chains.

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[1] The Netherlands, Ministry of Infrastructure and Water Management (2018) Safe Chemicals Innovation Agenda, available at: https://www.chemischestoffengoedgeregeld.nl/sites/default/files/39982%20-%20Safe%20Chemicals%20Innovation%20Agenda%20-%2020180613i6%20final%20copy.pdf.

Human and environmental health is often an external cost to the business costs of the firms that produce, market and use hazardous chemicals. The damage done by hazardous chemicals is thus an **externality**. This reduces the internal financial incentive to engage in safe chemical innovation.

Product information

There is a **lack of information available on the substances used in products and processes. For example,** when buying a food product, all information on the nutritional content is available, but the chemicals used in the packaging do not need to be communicated. This is an obstacle for both the general public (inability to demand change) and across supply chains (no knowledge with retailers on what to change).

Low awareness of the general public on the risks of the substances in products to their wellbeing limits the demand for change. Complex, spider-web chemical supply chains struggle to manage and share information on the hazards of substances used in products, processes and services. Without knowing the potential human and ecological health risks, there is less impetus for innovation in companies at the end of supply chains that market products and services.

Industry structure

A final important trait of the chemical industry in the Netherlands is that the **chemical industry structure may not be conducive to innovation**. The chemical industry that produces and delivers 'base chemicals' in the Netherlands is highly concentrated in 5 chemical clusters. These are Rotterdam-Moerdijk, Chemelot, Noordzeekanaalgebied, Zeeland/West-Brabant, and Noord-Nederland. The chemical industry is capital intensive with high maintenance costs and many older assets that were built in previous century.

This, together with the Netherlands being a high wage country, results in lower margins for innovation combined with very high investment costs for changing assets. The large multinational organisations have highly efficient supply chains and an established market presence, which makes it difficult to move away from hazardous substances, but which in turn also makes competing difficult for innovative start-ups that use entirely different materials. This is also known as '**technological lock-in**', and this is shown to be a negative factor that reduces environmental innovation, and this is a problematic factor for both large companies and for SMEs[1].

Difficulty in establishing collaboration within supply chains

To produce a complex product, any hazardous constituents could travel between multiple businesses before ending up in the final product. A completely new innovation for which there is no established supply chain for alternative or ZZS-free constituents will require a network of innovators, or at least the ability of an innovator to find a new supply chain. This has proved to be difficult in practice. The SNN-innovation monitor (Dutch: Noord-Nederlandse Innovatiemonitor 2018) carried out by the Rijksuniversiteit Groningen also showed that an increasing number of companies cited a difficulty in finding other businesses as collaborators as an obstacle for innovation (from 7 % in 2016 to 13 % in 2018).

To further research this, an interview was carried out as part of this study with a multinational producer of synthetic polymers that used several ZZS within their products. The goal of the interview was to understand the obstacles the firm saw when it came to substitution, their potential solutions, and how they worked with their supply chain to remove ZZS substances. The firm noted difficulty starting innovation projects on their own because of their strict client demands for particular plastics whose properties were partially defined by the ZZS. Similarly, the company did not produce base chemicals and therefore did not have the capability to research new primary, non-hazardous materials itself to replace the functions of the ZZS. Despite this, the company also did not actively try to setup innovation networks, noting that this is difficult to do while also protecting intellectual property and cited that they saw risks to their competitiveness.

A second interview was carried out with a group of academic experts[2] that included the same question of obstacles to successful substitution.

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[1] Triguero, Mondejar, Davia (2014); Leaders and Laggards in Environmental Innovation; An Empirical Analysis of SMEs in Europe

[2] The interview was carried out with experts from University of Utrecht, KU Leuven and TNO

All experts highlighted that collaboration for innovation across the supply chain was not commonplace in the chemical industry, in particular within the established chemical industry based on fossil-fuel based supply lines.

2.3 Moving forward to policy intervention

Overall, ways to reduce the use of hazardous substances, the balance of drivers and obstacles creates a case for possible policy intervention. The drivers for innovation are also shown to have some pitfalls (delayed effectiveness of regulations due to the long-time lag of a restriction, risk of greenwashing in response to public awareness), and policy intervention could thus also strengthen these drivers.

To understand the role new policy instruments can play here, first the current policy environment should be understood. The next chapter briefly outlines how the current Dutch innovation policy package supports safe chemical innovation. Once that has been established, chapter 4 and onwards then define what additional policy instruments could be effective in conjunction with this.

3

THE CURRENT POLICY ENVIRONMENT

This Chapter covers the regulatory environment for ZZS and biocidal active substances currently in use in the Netherlands and the way this regulatory environment promotes innovation to prevent or control risks associated with the use of certain substances. First, relevant policy for protection against chemical risk is covered in 3.1, and relevant innovation policy frameworks in the Netherlands are covered under 3.2. Chapter 3.2 only focuses on the Netherlands, no overview of relevant EU innovation instruments is listed, but this does not mean these are not considered relevant.

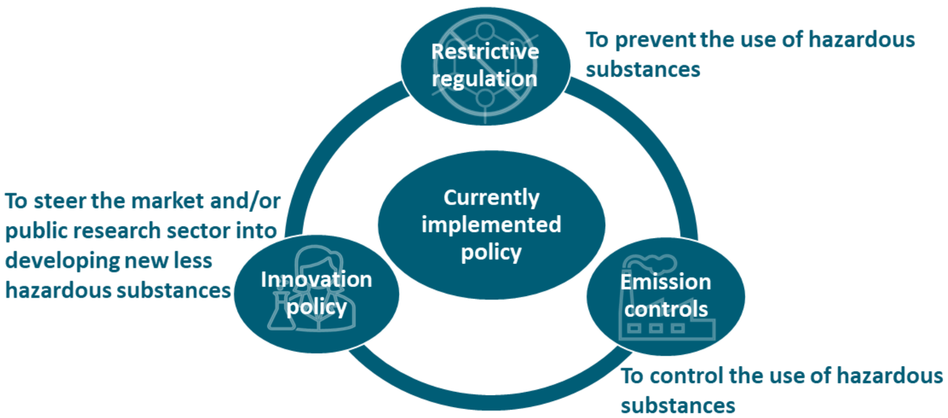
3.1 Existing policy to protect the environment from chemical hazards

The currently implemented policy package that governs the production, placing on the market, and use of hazardous substances contains restrictive regulation, emission control and innovation policy instruments. These are only some of the tools that are available to policy makers to promote safe innovation.

Relevant currently implemented chemicals policy in the Netherlands and the EU

Restrictive regulation includes any policy that directly constrains or even fully bans the production, placing on the market and/or use of certain substances of very high concern or biocidal products.
Emission controls governs at site level (for production sites, and waste disposal sites) the way hazardous substances should be handled, and the maximum emissions allowed into the environment.
Innovation policy includes all instruments currently employed by the Dutch government that explicitly promote innovation of less hazardous alternatives for hazardous substances. This also includes transnational innovation policy (from the EU or other international organisations and cross-border partnerships).

Figure 3.1 The collaborative action of the three current approaches to influencing safe innovation via policy instruments



Restrictive policy or tight emission controls promote innovation by forcing a move to alternatives (or resulting loss of market share), and innovation policy promotes innovation by making it more economically attractive for researchers and investors to invest time and resources into alternative substances, processes and products[1].

Relevance of high-level chemical policy to safe chemical innovation

The use and production of chemicals is governed by a set of mostly EU-based Directives and Regulations. These have the explicit goal of protecting human and environmental health. Table 3.1 lists the most important pieces of legislation, including a note in the final column if and how these regulations have an innovation policy goal.

As noted from the table, safe chemical innovation is an explicit goal in only two of the six pieces of legislation (REACH and ZZS policy). Evidently, innovation policy is not often combined with restrictive regulation or emission control regulation; these goals are most often not combined in the same regulation. This implies that there is room for additional innovation policy instruments, as the major regulations that govern the chemical sector may not currently take advantage of all possibly effective instruments.

Table 3.1 Overview of most relevant large-scale policies, including a note on how they may already target or promote safe chemical innovation

Name	Policy description	Policy scope	Policy type
REACH Regulation (EC No 1907/2006)[24]	The Regulation on the registration, evaluation, authorisation and restriction of chemicals (REACH) is the overarching EU Regulation that governs the manufacture and use of substances and substances in mixtures and articles	All chemical substances, in the EU	Restrictive, **innovation policy** *(Innovation relevance: REACH explicitly has an innovation goal)*
CLP Regulation (EC No 1272/2008)[2]	Classification, labelling and packaging; EU Regulation that implements the UN globally harmonised system (GHS) for classification and labelling of substances and mixtures	All chemical substances, in the EU	Restrictive
ZZS beleid (ZZS policy)[3]	Policy classifies substances and maintains the ZZS (Zeer Zorgwekkende Stoffen) list. Its main instrument is a minimisation obligation	Over 2000 chemical substances, in NL	Emission controls, **innovation policy** *(innovation relevance; ZZS policy prioritises replacement and substitution over end-of-pipe mitigation)*
BPR[4] (EC No 528/2012)	The Biocidal Products Regulation concerns the placing on the market and use of biocidal products. All biocidal products require an authorisation before they can be placed on the market, and the active substances contained in that biocidal product must be previously approved.	All products that are marketed with a biocidal service goal, in the EU	Restrictive

1 European Commission (2015), Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs

2 CLP: https://echa.europa.eu/nl/regulations/clp/legislation

3 ZZS beleid op Infomil: https://www.infomil.nl/onderwerpen/lucht-water/zeer-zorgwekkende/zzs-beleid/

4 BPR: https://echa.europa.eu/regulations/biocidal-products-regulation/understanding-bpr

Name	Policy description	Policy scope	Policy type
WFD[1] (EC No 2000/60/EC)	The Water Framework Directive requires Member States to use their River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) to protect and, where necessary, restore water bodies in order to reach good status, and to prevent deterioration. Good status means both good chemical and good ecological status	All chemical substances, in the EU	Emission controls, but indirectly through permits. WFD governs water quality targets, emission controls may then be imposed through permits
IED[2] (EC No 2010/75/EC)	Industrial Emissions Directive; governs emission limit values from industrial sites, and also prescribes what emission control techniques should be used (Best Available Techniques)	Regulates known large volume emissions from industrial sites in the EU, and for some specific sectors also includes ZZS emission limits.	Emission controls through best available techniques, **innovation policy** by promoting innovation in emerging emission reduction techniques (*does not focus on safe chemical innovation*)
OSPAR[3]	Convention for the Protection of the Marine Environment of the North-East Atlantic; Protecting of water quality in the Atlantic marine environment, including managing	All pollution in the North Atlantic, signed by EU	Restrictive, except OSPAR is a convention so regulation is dependent on implementation by convention signatories

A note on the BPR and innovation

The BPR is not considered an innovation policy, as its instruments are not designed to actively guide innovation. Rather, it regulates the conditions that new biocidal active substances and biocidal products must adhere to. The effect of the BPR on innovation is measured though, and it is explicitly mentioned in a 2021 policy evaluation that low innovation activity for new biocidal active substances occurred during the first 8 years of the BPR[4].

Forward looking chemical policy strategy

In addition to implemented Regulations and Directives at EU and NL level, future policy development is governed by policy strategies. These are the forward-looking roadmaps, which set out the targets that should be reached by society. Chapter 1.2 detailed the main policy programmes (the EU CSS and 'Impulsprogramma Chemische stoffen 2023 - 2026') that contribute to the future of chemical innovation policy.

The overarching goal of the abovementioned EU and Dutch policy action plan and programme is to **protect human and environmental health** from chemical exposure risks. Chemical risk from hazardous substances is largely created through technological innovations from the past 100 years. To combat this, safe chemical innovation is a method for firms to reach their product and service goals while reducing or eliminating human and environmental health risks. It is key in the transformation to a healthy and pollution free environment in the future.

What about other innovation policy?

It is clear that much of chemicals policy is mostly focused on restricting chemical use, or preventing emissions from harmful chemicals, with limited targeted focus on innovation and substitution. Still, to understand the way current policy influences innovation, it is necessary to move beyond targeted chemical policy and into broad-scope innovation policy. The next Chapter looks at the way innovation is supported in the Dutch context, and in what ways this is (or is not) targeted at safe chemical innovation.

1 WFD: https://environment.ec.europa.eu/topics/water/water-framework-directive_en

2 IED: https://environment.ec.europa.eu/topics/industrial-emissions-and-safety/industrial-emissions-directive_en

3 Hazardous substances reference at OSPAR.org; https://www.ospar.org/work-areas/hasec/hazardous-substances

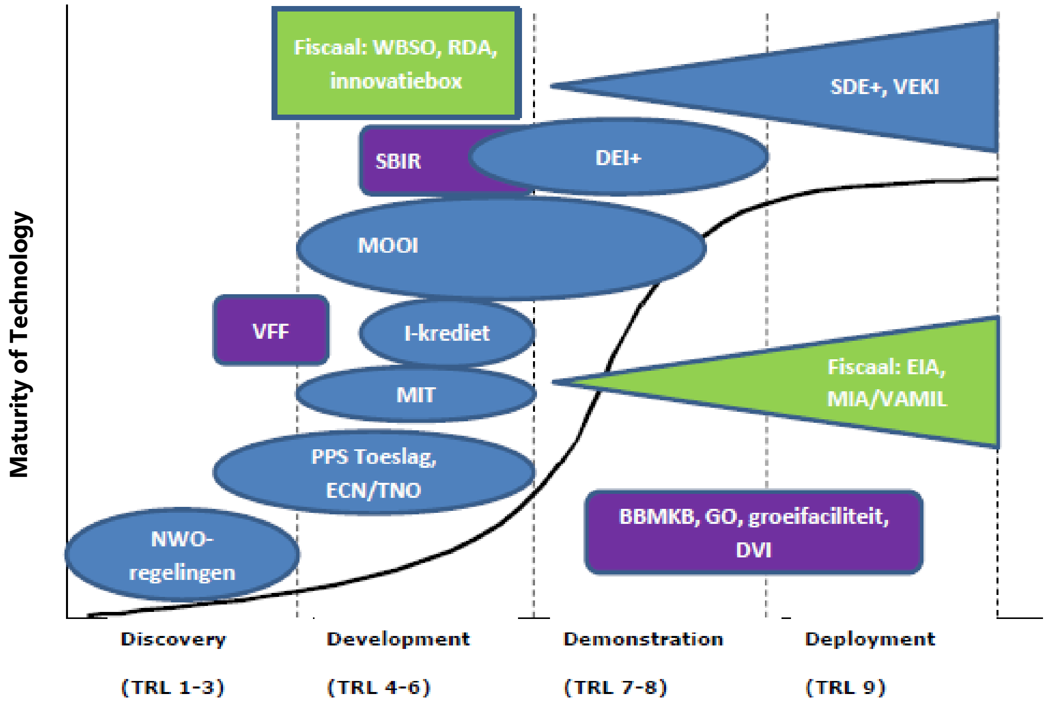
4 EC (2021), On the implementation of Regulation (EU) No 528/2012 of the European Parliament and of the Council concerning the making available on the market and use of biocidal products

3.2 Current innovation policy, programmes and frameworks in NL

The overall landscape of innovation frameworks relevant to this study in the Netherlands are given in Figure 3.2, as listed by the TOP sector chemistry initiative (ChemistryNL). As can be seen in the figure, there are a greater number of distinct innovation support frameworks which focus on the development stage of innovation (Develoment in TRL 4-6) than there are for demonstration and deployment.

For innovations that are already on the market, government support is focused on fiscal instruments that promote market demand (MIA/VAMIL and EIA). The innovation frameworks, specifically for the demonstration and deployment stages, are primarily focused on mitigating climate change by reducing the emissions of greenhouse gases. Also the fiscal instruments, EIA, MIA/VAMIL strongly favour the reduction of greenhouse gases by various business investments. These instruments have been expanding their focus. For example, the 2021 update on the MIA/VAMIL fiscal support list contained an explicit focus to support technologies that enable a shift to a more circular economy, and there are examples of technologies within MIA/VAMIL specifically focused on the substitution of ZZS and biocidal active substances.

Figure 3.2 Overview of the innovation instruments in place, split by fiscal (green), subsidy (blue) and 'investor-linkage' (purple), and listed by Technology Readiness Level (TRL). Figure is adapted from the 'ChemistryNL' initiative



Each of the programmes and initiatives in this figure are briefly explained in Appendix III. An elaboration on each of these programmes is not within the scope of the study. However, from the high-level view on what is currently employed, the following conclusions can be drawn about the Dutch innovation policy.

Availability of funding

There are funding instruments available for all types of enterprises, most of which are in the form of innovation subsidies at early Technology Readiness Levels (TRL). This does not mean that there is more funding available for early TRL levels; rather than there are more distinct instruments which have specific technology targets and goals (See Appendix III). The instruments at higher TRL levels (demonstration and deployment) are more generic and most often open to any kind of economic sector where technological innovation can demonstrate an environmental improvement.

Some of these subsidies focus on environmental legislation with the aim of supporting circularity, the energy- and mobility transition, CO_2-reductions, and waste recycling. Furthermore, two deposit-refund schemes and a tax deduction scheme put focus on environmental topics as well. The WBSO for instance reinforces sustainable technological innovations and the EIA and MIA/VAMIL likewise support topics related to climate neutrality. When it comes to SVHCs specifically, the options to select alternative technologies that replace hazardous alternatives become more limited.

The conditions of the MIA/VAMIL scheme favour the reduction and substitution of raw materials, which links to sub-programs aimed towards mitigating and reducing the presence of substances of very high concern. Other funding programs can be used for ZZS/ biocidal active substance substitution, but do not specifically highlight this topic in their scope. For instance, the WBSO scheme can cover a sustainable innovation that detects SVHC as well. Furthermore, the MIT, that focuses on starting materials in horticulture, the MOOI and DEI+, that focus on built environment, and VEKI, that focuses on waste recycling could all be applied as funding schemes in SVHC related projects.

Safe chemical substitution is not a specific strategic target of the majority of funding instruments
There are no targeted instruments in the Netherlands that specifically focus only on substitution; the instruments are more general and may be used by companies in a safe chemical innovation project. Therefore, while companies could apply for a subsidy in their innovation programme focused on substitution (and no doubt some activity is occurring here), there is no specific focus on solving the environmental issue of chemical pollution. This contrasts some other environmental policy priorities, such as greenhouse gas emissions, which have much more specific targeted programmes dedicated to innovation that reduces carbon emissions.

3.3 Moving forward from the current policy environment

While it has been shown that some of the strong regulatory instruments target innovation, most restrictive and emission control policy does not consider this factor explicitly or does not contain policy instruments that aid firms in innovation. Second, the broad-scope innovation programmes, policies and funding streams maintained by the Netherlands rarely have a specific focus on safe chemical innovation and substitution and they are not specific to economic sectors. This means that while there is funding available for firms who develop and market less hazardous chemical alternatives but are not tailored to their needs.

Further, as established from the discussion on drivers and obstacles, the obstacles that firms encounter may often be stronger than the drivers (including natural drivers and existing policy drivers). This opens up the question: **Can innovation policy instruments that are more specifically targeted at promoting safe chemical innovation better help firms overcome the obstacles?**

The next Chapters will explore this further, by diving deeper into the available policy instruments and making suggestions for three targeted policy types and how they could help reach safe chemical innovation goals

4

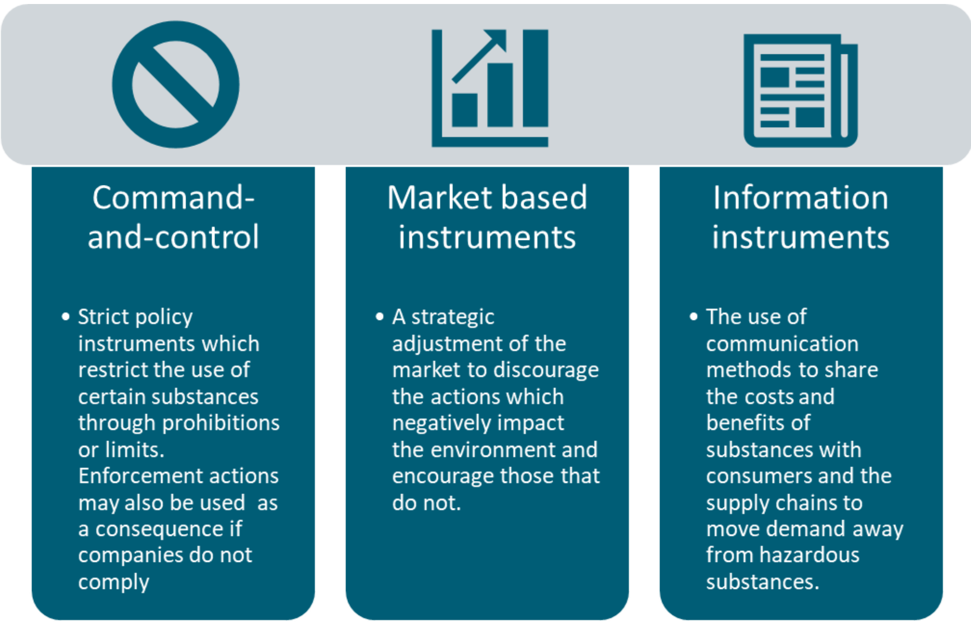
POLICY SOLUTIONS

This Chapter covers the possible policy instruments that could be used to address the obstacles to innovation mentioned in Chapter 2.2 and compliment the already present drivers mentioned in Chapter 2.1. Two key types of policy instrument will be covered (Chapter 4.1), including examples of each. The impact of these instruments on innovation is then explored (Chapter 4.2) as the grounding to then evaluate policy instruments and select three key policy instruments for analysis (Chapter 4.3).

4.1 Overview of policy instruments

Regulation can be defined as 'imposition of rules by government, backed by the use of penalties that are intended to specifically modify the economic behaviour of individuals and firms in the private sector'[1]. The three types of policy instrument of focus in this study include command-and control, market-based instruments (MBIs) and information instruments as shown in Figure 4.1.

Figure 4.1 The three key policy instruments under consideration in this study



[1] OECD (1993) Glossary of Industrial Organisation Economics and Competition Law. Available: https://stats.oecd.org/glossary/detail.asp?ID=3295

Command-and-control is one form of environmental regulation whereby the government prohibits or limits the number of hazardous substances, introduces methods to control production processes or the production outputs of a producer, with the ultimate goal of influencing the behaviour of the polluter[1].

Should a company be incompliant, enforcement actions should be taken. Liao (2018) highlights that where companies are under institutional pressure to meet the requirements of legitimacy and to reduce costs of illegal activities, they will eliminate backwards production capacity and improve production processes to reduce e.g. energy consumption and pollution emissions[2].

Market-based instruments can, in general, be defined as those which 'seek to address the market failure of environmental externalities either by incorporating the external cost of production or consumption activities through taxes or charges on processes or products, or by creating property rights and facilitating the establishment of a proxy market for the use of environmental services'[3]. In essence, a market-based instrument internalises the externalities of environmental pollution and governs such pollution through charges, subsidies, tradeable permits and other means[4],[5]. Additionally in Tool 17 of the European Commission Commission's Better Regulation Guidelines it is noted that the use of MBIs tends to involve other forms of legislation, such as hard regulations (Directives or Regulations).

Information instruments can be considered informal environmental policy instruments. They can be considered a form of market-based instruments in that the goal can be to influence demand, and in particular shift demand from a non-desirable to a desirable product or service. That said, in our assessment we have considered information instruments as a separate category from MBIs. They can take the form of information requirements dictated by government that must be reported by enterprises, to the government and/or the public e.g. emissions, presence of hazardous substances[6]; or they can be instruments that are used on a voluntary basis to provide more detailed information to the public or through the value chain on e.g. pollution control activities, product composition declarations, publicity campaigns, rating systems.

Typology of general policy instruments

Literature suggests that the broad distinction between command-and-control policy, market-based instruments and information instruments can be crude and too general[7]. Complexity is added by the multiple ways in which to characterise policy instruments, as highlighted by Nanne Van Mil (2011) and Sterner. T & Coria. J (2012) [8]. As a first typology, policy instruments can be sorted into four groups: those that use markets to stimulate change; those that create markets; environmental regulations; and those which engage the public. The instruments may overlap somewhat in their core driver e.g. economic, which makes developing a concrete typology of policy instruments difficult. This typology is shown in Figure 4.2.

1 Berquist. A.K., Soderholm. K., Kinneryd. H., Lindmark. M., Soderholm. P. (2013) Command-and-control revisited: environmental compliance and technological change in Swedish industry. 1970-1990. Ecological Economics. 6, 19.

2 Liao, Z (2018) Environmental policy instruments, environmental innovation and the reputation of enterprises. Journal of Cleaner Production 171, 1111-1117.

3 OECD (2007) Business and the Environment: Policy Incentives and Corporate Responses, OECD, Paris. Available: https://stats.oecd.org/glossary/detail.asp?ID=7214.

4 Berquist. A.K., Soderholm. K., Kinneryd. H., Lindmark. M., Soderholm. P. (2013) Command-and-control revisited: environmental compliance and technological change in Swedish industry. 1970-1990. Ecological Economics. 6, 19.

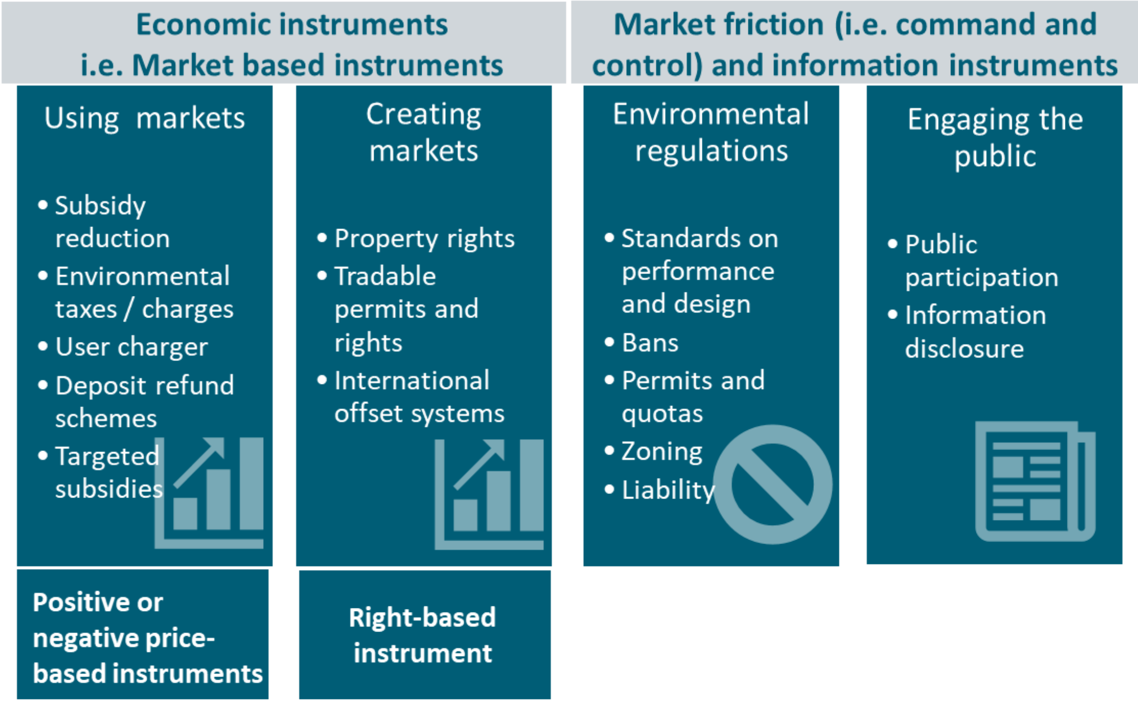
5 Damon, M., Sterner, T. (2012) Policy instruments for sustainable development at Rio+ 20. J. Environ. Dev. 21 (2), 143-151.

6 Lindeneg, K., (1992) Instruments in environmental policy - different approaches. Waste Manag. Res. 10 (3), 281e287.

7 Rene Kemp & Serena Pontoglio (2011) The innovation effects of environmental policy instruments a typical case of the blind men and the elephant?

8 Sterner. T & Coria. J (2012) Policy Instruments for Environmental and Natural Resource Management.

Figure 4.2 Illustrative typology of policy instruments (adapted from van Mil. N (2021) and Sterner. T & Coria. J (2012))



It should be noted that there is no clear distinction between market-based, command-and-control-based and information-based policy instruments as markets, by nature, involve prices and quantities, whilst enforcement of regulations is often backed by economic sanctions.[1]

Command-and-control

Command-and-control policies include restrictions on the use of substances/ mixtures in certain products such as:

- carcinogens, mutagens and reprotoxins in consumer products (REACH Annex XVII, entry 28-30, legal basis Article 68(2) REACH)2;
- limits on the concentration of pollutant discharge from industrial sites;
- or the use of certain technologies.

REACH consists of differing forms of regulatory requirements with a focus on command-and-control. It has the aim of encouraging innovation, with a specific focus of placing on the market substances that are safer and less hazardous, it may also promote process, organizational and marketing innovation. CSES et al (2015) assessed the impact of REACH on innovation. The study found that the impacts of REACH on innovation depended in part on the value chain role and the sector. The use of Candidate Listing of substances of very high concern was found to be both increasing R&D as a result of the need to find substitutes, but also potentially reducing investment in R&D as a result of uncertainty in the continued use of the substance. It should be noted that the relationship between SVHC identification and R&D and innovation expenditure is complex and often substance-specific, related often to availability of alternatives (historical and substances that require development). CSES et al found that for high value added substances such as cobalt compounds, R&D expenditure increased, whereas for arsenic compounds the products were withdrawn. The use of information-based instruments within REACH is considered to have had a positive impact on innovation as the development and access to key tools such as safety data sheets (SDS) and chemical safety reports (CSRs) has fostered better practices and improved supply chain communication.[3]

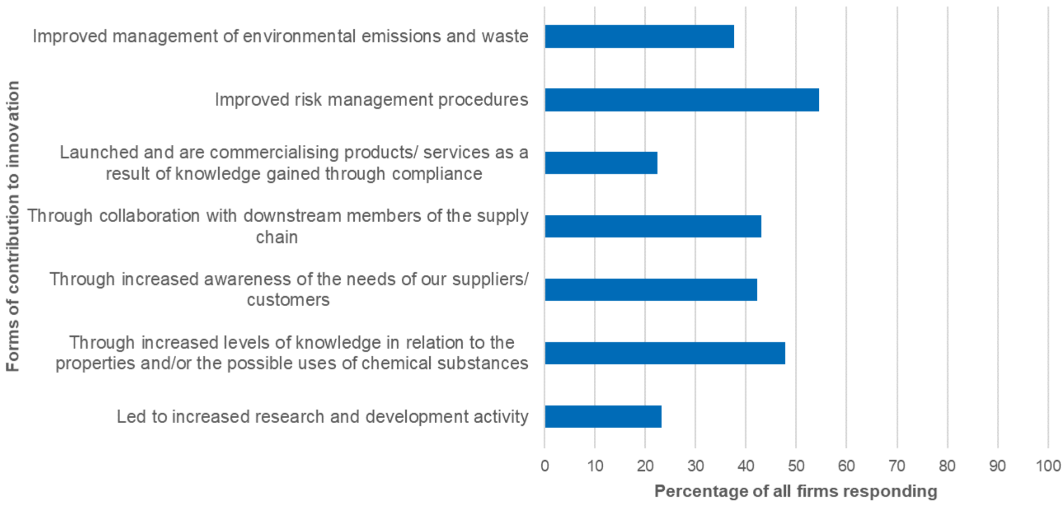
[1] Sterner. T & Coria. J (2012) Policy Instruments for Environmental and Natural Resource Management.

[2] REACH Regulation - REGULATION (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20221217

[3] CSES, RPA & Oekopol (2015) Monitoring the impacts of REACH on innovation, competitiveness and SMEs.

Within the CSES et al study a CATI survey of chemical companies was used to elicit data on the how the implementation of REACH had supported innovation and created new business opportunities (Figure 4.4). It demonstrates that REACH has had an impact on a range of areas, importantly risk management and knowledge of properties and uses of chemical substances.

Figure 4.3 CATI survey results: How has the implementation of REACH encouraged innovation and created new business opportunities (source: CSES et al (2015))



The overall view of industry in 2015 was that in the long-term REACH may see positive results as to innovation that drives competitiveness, but for time being compliance costs were predominant.

The BPR[1] also includes various command-and-control regulatory requirements focused on the placing on the market and use of biocidal products. The BPR covers two main actions, the approval of active substances (at the Union level) to be used in biocidal products, and the authorisation of the resulting biocidal products (at a Member State or Union level), amongst other regulatory requirements. Through these two main processes the biocidal products placed on the market, and the active substances used, are regulated. In Bureau KLB's 2018 report, the impact of the harmonized CLP classifications carcinogen category 1B and mutagen category 2 on the use of formaldehyde in biocidal products was investigated. The impact of these classifications and the consequential regulation under the BPR was analysed with a particular focus on the development of alternatives. Regarding preservatives, tissue preservatives and disinfectants, KLB stated that the substitution for each of the applications was unsuccessful to partially successful, based on the availability of effective alternatives without similar classifications. KLB speculated that this conclusion may indicate that innovation within the scope of the current substances available is limited and the solutions required may be outside of this domain. It was stated that, when focused on disinfectants, where regulation is weaker substitution is less prominent, i.e. market forces do not drive substitution as successfully as regulation. This is important to consider for the use of certain biocidal applications, such as tissue preservation which takes place in less 'institutionalized' settings and can be influenced more by the market conditions than professional uses[2].

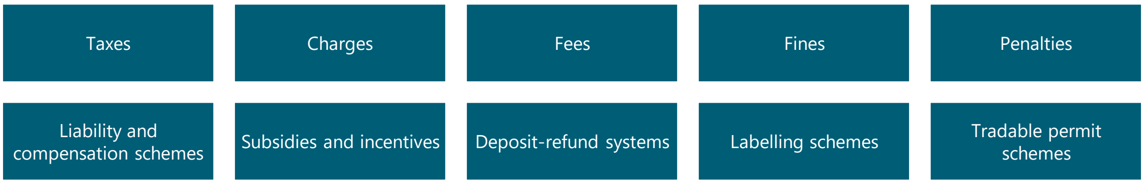
1 European Union (2012) Regulation (EU) No. 528/2012 concerning the making available on the market and use of biocidal products. Available from : http://data.europa.eu/eli/reg/2012/528/oj

2 Bureau KLB (2019) "Safe by Design: Over substitutie van gevaarlijke stoffen" available at http://bureauklb.nl/downloads/190524_Over_substitutie_van_gevaarlijke_stoffen_-_Bureau_KLB_def.pdf.

Market-based instruments

MBIs, according to the European Commission, include the tools listed in Figure 4.4.

Figure 4.4 A list of MBIs as stated by the European Commission



Market-based instruments such as taxes and permits increase the cost of a regulated activity e.g. use of hazardous substances or pollutant discharge and so can stimulate enterprises to adopt more environmentally friendly technologies or processes that would make up the loss of profit brought about by MBIs[1]. Instruments such as subsidies, grants, loans below market rate and discounts that accelerate the depreciation of pollution control equipment seek to reduce the cost of innovation, subsequently encouraging enterprises to innovate. These instruments are particularly important for environmental innovation as, compared with traditional innovation, environmental innovation has spillover effects related to the environment, in addition to the spillover effect of R&D. This means that environmental innovation can reduce the external environmental cost of a production process or product, so called 'double positive externalities'[2]. Market failures in environmental innovation exist, in part, due to these positive externalities not being able to be transformed into market benefits of technologies/ products through the process of technological diffusion.[3]

Market-based instruments can be applied in different ways e.g. on the inputs of production, resulting in a change in production costs, or on outputs, with a change in price. A change in cost is not exclusive to a change in price as cost increases/ decreases may be passed on to the consumer. Behavioural changes may also not be immediate after changes in price as it depends on the price elasticity of demand. Generally, demand is relatively more inelastic in the shorter term due to a lack of suitable alternatives and/or stickiness in consumption patterns.

There are a number of preconditions that must be taken into account when developing MBIs (see Figure 4.5).

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[1] Hojnik, J., Ruzzier, M. (2016) The driving forces of process eco-innovation and its impact on performance: insights from Slovenia. J. Clean. Prod. 133, 812e825.

[2] Rennings, K., (2000) Redefining innovation-eco-innovation research and the contribution from ecological economics. Ecol. Econ. 32 (2), 319e332.

[3] Liao, Z (2018) Environmental policy instruments, environmental innovation and the reputation of enterprises. Journal of Cleaner Production 171, 1111-1117.

Figure 4.5 Preconditions for the use of MBI for reducing hazardous substance use[1]

Information base of policymaker and administrative capacity	•The policy maker needs access to the **costs and benefits** of the product to chose the instrument with the lowest cost to benefit ratio. •The policy maker's **administrative capacity** is also key here to ensure the correct data is collected and going forward the necessary actions can be completed to enforce the policy instrument. **The chemical sector**: For many substances the full health and environmental impacts are not known and the current information base is focused on hazards not the costs and benefits of products. There are also knowledge gaps on mixture effects and alternative substances. Companies have more knowledge than policy makers on product composition but there is no incentive to share this information.
Strong legal structure	•Clear definition and assigning of **property rights** can help the regulator transform the public environmental good into private good. •The rights holder must receive the benefits and costs of the good. **The chemical sector**: Property rights are established for chemical management e.g. REACH and CSS. This does vary by sub sector and compliance varies between firms.
Market structure	•MBIs rely on the incentive effect on the ability of firms to respond to price signals. Therefore MBI's are more effective in **competitive markets** where numerous producers compete with each other •Credit, liability and insurance also play a significant role in the effect of MBIs. •All firms, either big or small, need to have access to these resources so that competitive advantages are not given. **The chemical sector**: It is hard to capture whether this precondition is present in chemical management due to heterogeneity in the market-chemicals used in every industry = not bound to one market. Also trade on global market, not just EU. Policy makers need to know if the substances chosen are placed on the market in NL or EU.
Political feasibility	•Whether policy instrument will be **accepted by stakeholders**. This differs per country and policy area, and is determined by different stakeholders. Lobbyists and societal pressures influence political feasibility. •Unfamiliarity of stakeholders regarding MBIs hinders political feasibility. **The chemical sector**: The public are aware of ongoing environmental concerns and the issues with chemical pollution are known across the Netherlands and the EU and are of political relevance.

Van Mil (2021) states that before economic MBIs can be implemented preconditions (Figure 4.5) must be met and once these conditions are met the MBI can be designed to optimally reduce the use of hazardous chemicals through nine key design elements as shown in Figure 4.6[2] on the next page.

Slunge & Alpizar (2019) found that the use of market-based instruments in chemicals management is limited and currently the most-frequent use is for hazardous waste management, with taxes, fees, charges and deposit-refund schemes frequently being employed for tyres, batteries, accumulators, electrical and electronic products and vehicles[3]. Taxes and charges are also being employed in the management of pesticides, fertilisers, ozone-depleting substances (ODS) and chlorinated solvents, with tradable permit schemes also being applied to the latter two.

An example of the multiple instruments to target the use and exposure to hazardous chemicals is that of trichloroethylene (TCE). Three different instruments have been used: with Sweden banning the use of TCE in 1996, Germany introducing emissions standards for equipment that uses chlorinated solvents for metal degreasing in the early 1990s, and the Norwegian tax on the inputs to production of 50 NOK/ kg tax for TCE and perchloroethylene (PER) (with 40 % of the tax returned when correctly disposing of waste containing TCE and PER), introduced in 2000. TCE and PER are persistent chemicals that are harmful to both human health and the environment. Slunge & Alpizar found that a reduction in use of TCE had begun from the mid-to-late 1980s.

[1] Adapted from van Mil. N (2021) Thesis: Charging the chemical - an analysis of when and how economic market-based instruments lead to a reduction of hazardous chemicals.

[2] ibid

[3] Slunge. D., & Alpizar. F. (2019) Market-based instruments for managing hazardous chemicals: a review of the literature and future research agenda.

However the regulatory management to actively reduce use and exposure in Sweden, Norway and Germany resulted in a more rapid decrease than other EU countries. It was found that enforcement of the Swedish ban was difficult and resulted in continued use after entry into force. Whilst the introduction of the tax in Norway led to a rapid reduction in use, perhaps due to the ease of administration. It should be noted that the German use of emission standards may have been the most effective instrument.[1]

Figure 4.6 Design elements policy makers should be aware of when developing a MBIs[2]

Knowledge	• Need to know what the externality is – chemical and biological effects, health and environmental effects, market dynamics, substitution behaviour, key actors, competition
Linking costs to externalities	• MBIs should directly target the producer so that marginal production costs are influenced. E.g. environmental taxes, have proved to be ineffective to reduce externalities when prices were not directly linked or not high enough
Level playing field	• Equal opportunity for all players in the market. If economic MBIs are only partially applied to the market, there is a risk of leakage effects and an unlevel playing field – location of market and competition
Combination with other instruments	• Economic MBIs have to be combined with other instruments like information instruments or CAC policies. An economic MBI will only be effective when there is enough information about the substance and when consumers are informed
Integral approach	• MBI must complement other environmental regulations
Flexibility	• Instrument needs to be flexible in order to cope with changing chemicals. Needs to be stable over time so that companies can make long-term strategies and can invest in newer technology and innovation
Admin costs	• MBI should focus on the information that is already obtained by other regulations like REACH. This diminishes the administration costs for new economic MBIs
Enforcement	• Need to ensure high sanctions for firms disobeying the rules. High sanctioning costs will incentive firms to behave according rules and decrease the asymmetric information problem

A non-EU example of the use of market-based instruments includes the fertiliser subsidy programme in India. The central government in India subsidises the use of chemical fertilisers in order to incentivise agricultural production, playing a key role in increasing grain production. The subsidy was introduced in the 1970s and the cost of using the subsidy to keep fertiliser prices below market rate has increased (US$12 billion in 2015). Slunge & Alpizar (2019) noted that there is limited evidence concerning the environmental effects of the subsidy, although there is evidence that it has led to imbalanced use of nutrients by farmers as a result of keeping the price of urea at a very low level, impacting soil degradation and water pollution. The Indian government has since (2018) reformed the subsidy programme in an effort to reduce costs of implementation and prevent overuse of certain fertilisers.[3]

[1] Slunge. D., & Alpizar. F. (2019) Market-based instruments for managing hazardous chemicals: a review of the literature and future research agenda.

[2] Adapted from van Mil. N (2021) Thesis: Charging the chemical - an analysis of when and how economic market-based instruments lead to a reduction of hazardous chemicals.

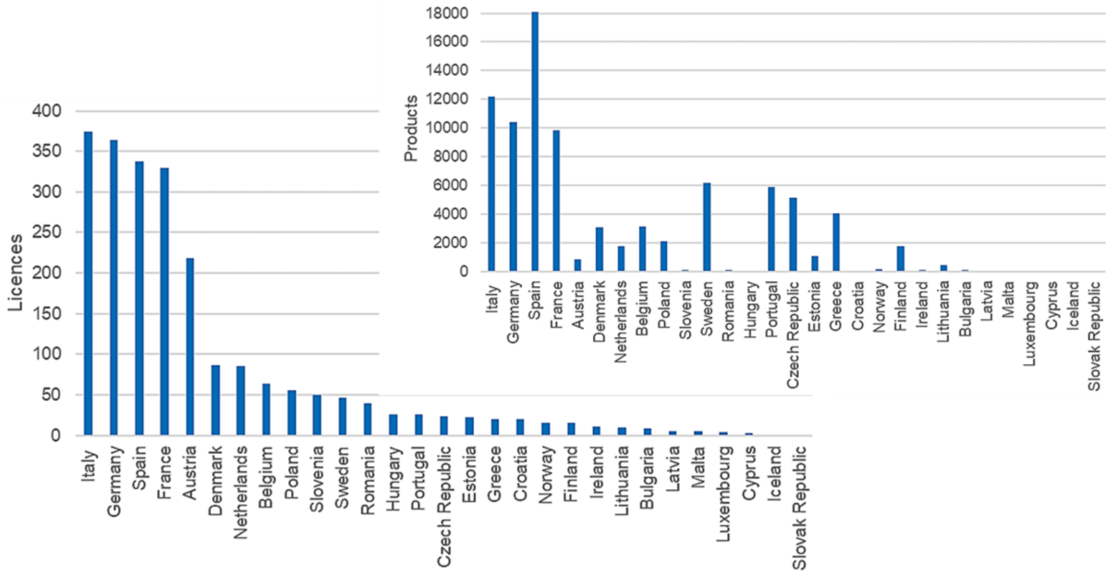
[3] Slunge. D., & Alpizar. F. (2019) Market-based instruments for managing hazardous chemicals: a review of the literature and future research agenda.

Information instruments

Information-based instruments rely on governments, enterprises and the public to voluntarily participate in implementation and allows for companies to be held accountable for their practices. These instruments allow for social pressure to be exerted on industry by stakeholder groups that may encourage them to carry out innovation activities to control their public image and meet demands for environmental control. Liao (2018) notes that 'in the case of enterprises, the information-based instrument can promote self-discipline, strengthen governance of environmental pollution, and ensure implementation of environmental innovation through market-oriented mechanisms. As concerns the public, the information-based instrument can enhance public awareness of environmental protection and improve the public's initiative in participating in environmental governance to promote the environmental innovation of enterprises.'

Information instruments can vary in their aim and target audience. Ecolabels are voluntary information schemes that are intended to promote products that have reduced or preferrable environmental impact during the lifecycle of the product. Ecolabels should provide consumers with accurate, science-based information on product environmental impacts. They 'aim to internalise the external effects on the environment of the production, consumption and disposal of products'[1]. There are a number of ecolabel schemes available in the EU. The EU ecolabel is an EN ISO 14024 type I ecolabelling scheme that uses independent third parties to check product compliance against the ecolabel criteria[2]. The functioning of the ecolabel is set out in Regulation (EC) No. 66/2010 and it is managed by the European Commission and Member States. As of September 2022 there have been 2270 licences awarded for 87, 485 products in the EU market. This data is visible in Figure 4.7.

Figure 4.7 Number of EU Ecolabel licences (left) and products (inset right) held per country[3]



The distribution of products and licences varied greatly per product group, shown in Figure 4.8. The majority of licences are held by tourist accommodation services (22 %), hard surface cleaning products (15 %) and tissue paper and tissue products (9 %). The largest number of products are indoor and outdoor paints and varnishes (41 %), tissue paper and tissue products (17 %) and textiles (9 %). It should be noted that laundry detergents, Industrial and Institutional laundry detergents, Tourist accommodation services, Lubricants,

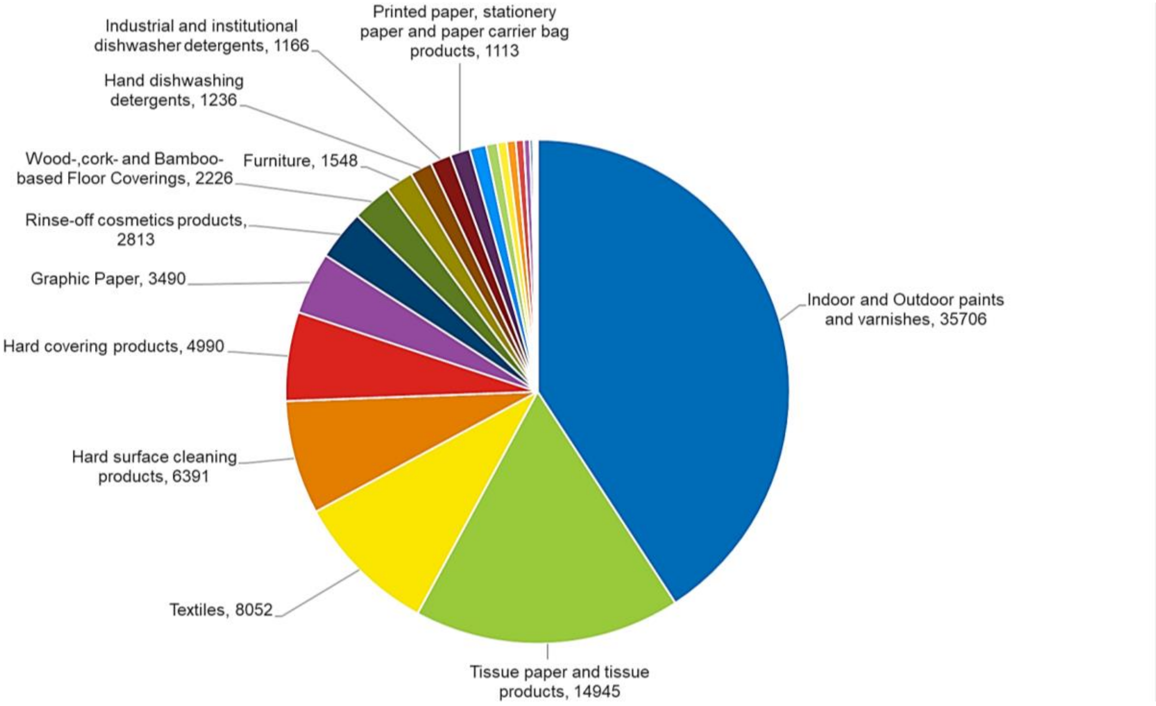
1 Bougherara, Douadia, and Pierre Combris (2009), "Eco-Labelled Food Products: What Are Consumers Paying For?," European Review of Agricultural Economics, 36 (3), 321–41.

2 European Commission (2022) About the EU Ecolabel. Available: https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/about-eu-ecolabel_en

3 European Commission (2022) Available: https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en

Absorbent hygiene products, Dishwasher detergents, Growing media, soil improvers and mulch, and Indoor cleaning services all have less than 1000 products with ecolabels, whilst footwear, cosmetic products, bed mattresses, electronic displays, and animal care products all have less than 100.

Figure 4.8 Distribution of awarded products per group[1]



There are also other private or national government ecolabels that tend to be sector specific such as:

- Blue Angel – initiated by the German government and awarded by independent third parties to products that are more environmentally friendly than others within their product category[2]. The Blue Angel already incorporates some information on hazardous substances, for example by avoiding known carcinogenic substance groups like formaldehyde and plasticizers[3] Further, in 2022 the Blue Angel started to include specific biocide-free ship anti-fouling technology[4].
- Nordic Ecolabel 'Swan' – each Nordic country has organisations that are responsible for criteria development, control checks, and licensing and marketing. It is awarded to products that are considered a good environmental choice within 65 product categories with consideration of the whole lifecycle[5].
- Oekotex Standard 100 – designed for textile raw materials, intermediates and end products throughout the lifecycle with criteria concerning human-ecological attributes such as presence of hazardous chemicals[6].

[1] European Commission (2022) Available: https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en

[2] Blue Angel (2022) Available: https://www.blauer-engel.de/de

[3] Bruckner et al. (2018), Environmental product label - a comparison.

[4] Chemical watch, available: https://chemicalwatch.com/455829/germany-launches-ecolabel-for-biocide-free-antifouling-coatings.

[5] Nordic Ecolabelling (2022) Available: https://www.nordic-ecolabel.org/nordic-swan-ecolabel/

[6] Oekotex (2022) Available: https://www.oeko-tex.com/en/

A study by Atkinson & Rosenthal (2014) examined the use of signalling theory to assess which aspects of ecolabel design yield positive effects. Their literature review found that the desire to make sustainable purchases is obstructed by a perception of credibility and honesty in the advertising of environmental claims[1, 2, 3.] It was noted that even though sustainable consumption may be driven by trust and credibility of claims, there has been insufficient empirical analysis to test these relationships[4], [5]. However, literature does suggest that consumers are willing to pay more for products that come with a 'seal of quality'[6] and that they prefer green claims to be supported by detailed and specific information[7].

Atkinson & Rosenthal (2014) found that label formats and sources have little influence on behavioural outcomes, but they do influence attitudes with regard to trust of claims and towards the product and label source. It was noted that government-sourced labels were trusted more greatly than corporate-sourced labels. This being said, for everyday items such as food and fast-moving consumer goods, companies may benefit from a return in investment as a result of the use of ecolabels as it can generate a more positive attitude towards the product and the corporation. For policymakers, their ecolabel focus should be on the perceived credibility, as they are considered to have the most authority in ensuring the criteria are strict and met. Overall, corporate labels are seen as better indicators of source and product quality, whilst government labels are considered more credible and trustworthy.[8] It should be noted the study by Atkinson & Rosenthal was carried out with undergraduate students enrolled in advertising classes at a university in the United States, where ecolabels have been used for less time than in Europe. Views on the use of ecolabels may be different from EU stakeholders.

Combining Policy Instruments

Liao (2018)[9] examined the relationships between command-and-control policy, market-based instruments and information-based instruments and three dimensions of enterprise environmental innovation: eco-organisation, eco-process innovation and eco-product innovation. The results inferred that when used on its own, command-and-control policies may positively affect eco-organisation innovation but did not exhibit significant effects on eco-process innovation and eco-product innovation. When being used in isolation, it was suggested that market-based instruments and information-based instruments may positively affect eco-organisation, eco-process innovation, and eco-product innovation.

Liao (2018) also considered how the combination of these policy instruments may affect the three dimensions, as shown in Table 4.1.

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1 Crane, A (2000), "Facing the Backlash: Green Marketing and Strategic Reorientation in the 1990s," Journal of Strategic Marketing, 8 (3), 277–96.

2 Hulm, M (2010), Your Brand: At Risk or Ready for Growth? Alterian.

3 Leire, C., and Thidell, A. (2005), "Product-Related Environmental Information to Guide Consumer Purchases—A Review and Analysis of Research on Perceptions, Understanding, and Use among Nordic Consumers," Journal of Cleaner Production, 13 (10/11), 1061–70.

4 McEachern, M G. (2008), "Guest Editorial: The Consumer and Values- Based Labels," International Journal of Consumer Studies, 32 (5), 405–06.

5 Warnaby, G (2004), "Retail 'Quality Assurance' Labels as a Strategic Marketing Communication Mechanism for Fresh Meat," International Review of Retail, Distribution, and Consumer Research, 14, 255–71.

6 Cason, T N., and Gangadharan, L (2002), "Environmental Labeling and Incomplete Consumer Information in Laboratory Markets," Journal of Environmental Economics and Management, 43 (1), 113–34.

7 Manrai, L A., Manrai, A K., Lascu, D-N., and Ryans, J-K (1997), "How Green-Claim Strength and Country Disposition Affect Product Evaluation and Company Image," Psychology and Marketing, 14 (5), 511–37.

8 Atkinson, L. & Rosenthal, S. (2014) Signaling the Green Sell: The Influence of Eco-Label Source, Argument Specificity, and Product Involvement on Consumer Trust, Journal of Advertising, 43:1, 33-45, DOI: 10.1080/00913367.2013.834803.

9 Liao, Z (2018) Environmental policy instruments, environmental innovation and the reputation of enterprises. Journal of Cleaner Production 171, 1111-1117.

Table 4.1 The effect of policy instruments on eco-organisation, eco-process innovation and eco-product innovation

Command-and-control + MBI	**➢ significant positive effects on eco-organization innovation** **➢ no significant effects on eco-process innovation** **➢ no significant effects on eco-product innovation**
Command-and-control + Information	➢ no significant effects on eco-organization innovation ➢ no significant effects on eco-process innovation ➢ significant positive effects on eco-product innovation
MBI + Information	➢ no significant effects on eco-organization innovation ➢ no significant effects on eco-product innovation
Command-and-control + MBI + information	➢ significant positive effects on eco-organization innovation ➢ no significant effects on eco-process innovation ➢ no significant effects on eco-product innovation

The analysis on combinations of policy instruments suggests that the use of command-and-control and MBIs may have synergistic effects that result in positive effects on eco-organization innovation. Also the positive effect of information-based instruments on eco-product innovation is enhanced by combining it with command-and-control policy.

4.2 The influence of regulation on innovation

Although there are many types of regulation, those that can stimulate innovation can be classified into three types. The first follows the Porter hypothesis, of the innovation inducing effect of strict environmental legislation. An example of which is the way the REACH restrictions mean companies have to look for alternatives for banned substances and mixtures. This type of regulation (command- and- control) does not have the primary focus of stimulating innovation but, by achieving other specific objectives such a use restrictions, creates innovation pressure and opportunities for enterprises.
The two other types of regulation (MBIs and information instruments) aim to influence the strategies and activities of enterprises, which can then lead to innovation activity[1].

A study by Stewart (2011) identified two main ways in which regulation can impact innovation:
1 Placing a compliance burden on firms, resulting in a diversion of time and resources from innovative activities.
2 Spurring compliance innovation (regulation scope is broad with product and process innovation remaining in scope of the regulation) and circumventive innovation (regulation scope is narrow and innovation allows firms to get around regulatory constraints).[2]

The ability of regulation to stimulate or stifle innovation depends on which force is greater and it should be noted that resulting innovative activity may not always result in commercial success.

[1] Edler. J, Cunningham. P, Gok. A, Shapira. P (2016) Handbook of Innovation Policy Impact. Edward Elgar Publishing. DOI 10.4337/9781784711856.

[2] Stewart, L. (2011) The impact of regulation on innovation in the United States: a cross-industry literature review.

When considering regulation, sectoral specificities and size of company can be important. In general, larger companies find it easier to comply with regulatory requirements as they have the resources to ensure they can monitor changes and maintain compliance. This is not to say that SMEs are more often incompliant, it is just that the lack of available resource can make it more difficult to remain up to date. The short-term and long-term impacts of regulation can vary, with short-term impacts creating a burden that may have a negative impact on innovation. Flexibility of implementation can also influence a company's inclination towards incremental or radical innovation activities. To note, there is limited empirical evidence on the influence of regulation on innovation. Stewart (2010) distinguishes between compliance innovation, which is often achieved when regulatory coverage is broad and product or process innovation remains within the scope of the regulation; and circumventive innovation which occurs when the scope of regulation is narrow and innovation can allow companies to circumvent the regulation. The impact of regulation on innovation depends on the balance of compliance costs and incentive effect, i.e. where compliance costs are low (or zero) and the incentives are high, a positive impact on innovation could be expected, and vice versa[1].

There are two main types of innovation that can result from regulation. The first is incremental innovation which occurs when firms can make minor improvements to existing products/ processes in order to meet the minimum compliance requirements. The second is radical innovation, which results in new products and processes. Radical innovation has been shown to yield greater benefits than incremental innovation but requires higher costs and can increase the risk of products that are not commercially viable[2].

Stewart (2011) observed that the impact of regulation on innovation is dependent, to varying degrees, on three dimensions – stringency, flexibility and information. Stringency is considered to be the degree of change (minimum compliance burden) required for compliance innovation or of the change in the essential compliance burden of regulation. Stringency can be tightened in two ways: gradually (moving target), which is more likely to stimulate incremental innovation as it is the least costly and risky innovation pathway; or all at once (disruption regulation), which is more likely to stimulate radical innovation with high compliance burdens.

Flexibility of regulation shall impact the cost burden and the occurrence of inventions that are not commercially viable. Command-and-control regulation is considered to enforce behavioural obligations, with incentive-based regulation potentially making a particular behaviour more profitable in the long run. Incentive-based regulation can minimise the compliance burden to industry, in part through a sharing of burden between firms.

An example of such incentive-based regulatory requirements includes tradable permits. Performance standards can also be used to set a benchmark for products or processes whilst allowing firms to choose their path to compliance. As such, they are considered to be more flexible than specification standards. Stewart (2011) found that both incentive-based regulation and performance standards can aid both market and social innovation through their flexibility.

Information asymmetry concerns one side of the market, most notably consumers, having less information on a product than the other side, producers. Regulation such as certification can offset information asymmetry by promoting information sharing and ensuring higher quality and compliance. This would in turn add compliance value for producers. Regulation that promotes information exchange can stimulate both incremental and radical innovation via reduction of information asymmetry for consumers and aiding development of producers.

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1 Edler. J, Cunningham. P, Gok. A, Shapira. P (2016) Handbook of Innovation Policy Impact. Edward Elgar Publishing. DOI 10.4337/9781784711856.

2 Stewart, L. (2011) The impact of regulation on innovation in the United States: a cross-industry literature review.

4.3 Selecting policy instruments for a new policy mix

As outlined in Chapter 4.2 and Appendix III, there are multiple policy instruments that could be considered for the purpose of stimulating innovation. These policy instruments have advantages and disadvantages depending on the target population, the legal structure of the government concerned, sectoral specificities and the driver that seeks to be addressed. These advantages and disadvantages can be added up to all possible policy instruments in a longlist screening exercise (see Appendix II for more information) that followed methodologies employed in other ex-ante studies carried out by the study team for the European Commission. See Figure 4.9 for an overview of all screened policy instruments. The instruments at the top of the diagram have the highest score, the instruments at the bottom have the lowest score.

Figure 4.9 The longlist of policy instruments and scoring. The top in a darker shade represents a high score with the score decreasing with the lighter shades

Pigouvian Tax	Grants	Subsidies	Charge/fee	Science-industry network	
Tradable permits	Regional/ national network	Process and usage norms	Network programmes	Knowledge network	Regional/ national network
Patent box	Regulatory sandbox	Network cluster	Supply-chain network	Strategic network	Awareness building measures
Policies for training and skills	Entrepreneurship policy	Regulation of product performance and manufacturing	Training and further education	Labels or information campaigns	
Regulation to create a final market	Articulation and foresight	User-producer interaction			
Technology foresight	Deposit-refund	Regulation of product information	Tax incentives	Instrument network	
Innovation inducement prizes	Voluntary approaches	Standardisation and standards	Support of innovation-friendly private regulation activities		
Technical services and advice	Public procurement policies	Equity financing	Pre-commercial procurement		

As can be seen from Table 4.2 there are a large number of collaboration instruments that scored highly. These have not been included as, although there are no specific innovation programmes at national level in the Netherlands that focus on reducing risk from hazardous substances, there are already frameworks available that could be expanded to include such a focus. For example, the Multi-year Mission-driven Innovation Programmes (MMIP) within ChemistryNL are related to emission reduction, energy efficiency and resource optimisation rather than risk reduction, but this could be adapted, or a new MMIP could be created.

The remaining policy instruments which scored above 19 (across the longlist of policy instruments scores ranged from 9-21 for more detail see Appendix 9III.1) include 6 MBIs, 5 regulatory instruments and 2 information instruments. All of these instruments scored comparatively highly and will be considered for selection in the next chapter.

Table 4.2 The policy instruments with a score of 19 or above from the longlist of policy instruments[1]

Type of instrument	Policy instruments	Qualitative score
MBI	Grants	21
	Subsidies	21
	Pigovian Tax	21
	Charge/fee	21
	Tradable Permits	20
	Patent box	19
Collaboration	Science-industry network	21
	Knowledge network	20
	Regional/national network	20
	Network cluster	19
	Supply-chain network	19
	Strategic network	19
Regulation	Process and usage norms	20
	Policies for training and skills	19
	Entrepreneurship policy	19
	Regulation of product performance and manufacturing	19
	Regulatory sandbox	19
Information	Awareness building measures	19
	Labels or information campaigns	19

[1] The full longlist of policy instruments can be found in Appendix III and the screening methodology can be found in Appendix III

Selection of three policy mix options for further analysis

A policy mix option is a combination of the existing policy package with a new instrument designed to promote safe chemical innovation. Therefore, in this study when a policy mix is referred to, this always refers to the combination of the existing policy package with one of three specific policy instruments that are selected for further analysis.

The term '**policy mix**' has been used because the instruments are not used in isolation and always consider the existing regulatory background, namely the command & control limitations placed on the use of substances through REACH and the BPR.

Following the screening of the longlist of policy instruments, policy mixes were identified based in part on high scoring policy instruments (those which are most likely to be feasible, effective, relevant etc), but also indications from literature on the interaction of policy with innovation. These include Pigouvian Tax, grants/subsidies, as indicated by the scoring approach, and information campaigns. The shortlisted policy mix options are presented in Chapter 5, and their impacts are described in detail in Chapters 6, 7, and 8.

5

POLICY MIX OPTIONS; OPTIONS SELECTED FOR IN-DEPTH CONSIDERATION

As a result of the qualitative screening exercise based on literature evidence, three policy mix options have been designed that bring together regulation and market-based instruments (MBI), and regulation and MBI - information instruments. This Chapter 5 provides an overview of the options selected, how these were selected, and introduces by which method the three policy mix options analysed in subsequent chapters 6, 7 and 8.

Table 5.1 Policy instruments selected for further consideration in a future policy mix

Policy mix option	Type	Policy instruments included
A	Market-based instrument (MBI)	Expansion of targeted grants and subsidies
B	Market-based instrument (MBI)	Pigouvian environmental taxation
C	Information instrument	Ecolabel + Information campaigns

In a **policy mix,** each of the instruments in Table 5.1 are considered to be implemented alongside the existing policy paradigm that is defined by command & control restrictions, as well as a wide variety of innovation financing instruments.

A note on collaboration instruments

It may be noted that this selection does not include any collaboration instruments, while these did score highly in Table 4.2. Collaboration across the supply chain has been highlighted as an important part of a strong innovation culture driver, but it was not chosen for inclusion in this chapter, because the impact of collaboration instruments is less straightforward to capture and depends very much on the targeted stakeholders, sectors, and the specific design of the collaboration instruments. Compared to the others, more design choices on the policy instrument would have to made in advance in order to produce an added value ex-ante analysis.

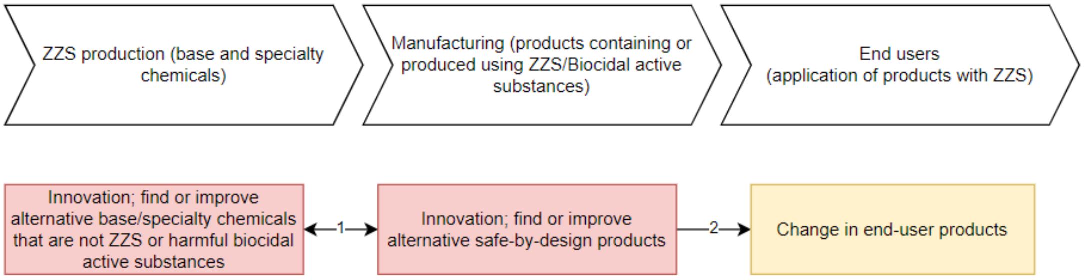
How could the potential impacts of the policy mix options be identified and assessed?

The policy mixes have been selected in the previous chapter based on a selection of literature that provides evidence that these may be effective. The goal of this study is also to explore a variety of different instruments, to understand how different types of instruments could impact innovation. The impact that these instruments may have in the Netherlands and the EU however is dependent on how stakeholders react, and the different instruments A, B and C are influencing innovative firms in different ways. If firms with the potential to innovate react according to the theory underpinning the policy, then the innovation goals may be reached.

To study this, for each of the three policy mix options, an **impact pathway** is defined. An impact pathway is an abstract representation of how signals move through the chemical supply chain in response to a policy. These could be price signals (e.g. a hazardous chemical is now more expensive compared to its safer substitutes), demand signals (customers are demanding more innovative, safe chemical products) or supply signals (new, competitive innovations are being made available).

Figure 5.1 illustrates the basis of an impact pathway for innovation signals. The top line of the figure represents the supply chain, the bottom line is the impact pathway through which the abovementioned signals move. Please see Appendix IV for a more detailed methodology explanation of the theory that underpins this methodology of using impact pathways.

Figure 5.1 Illustrative impact pathway of how innovations in the supply chain could lead to change for end users



Hypotheses that underpin a policy's effectiveness for innovation

In this figure, the number on the arrow is the **hypothesis** that underpins the interaction between stakeholders, that makes sure the following effect in the chain takes place, and to what extent. These arrows represent the following basic hypothesis that govern successful innovation:

- Arrow 1: industry collaborates internally and within the supply chain to use R&D and marketing to find and market new safer products.
- Arrow 2: Users will buy new safer products, and this purchase would eventually lead to a change in the products the end-users use.

As established in Chapter 3, the illustrated innovation pathway from Figure 5.1 does not occur often enough in the context of the Dutch chemical industry and for manufacturers who use ZZS or biocidal active substances in their products. As established in chapter 2.2, hazardous chemical pollution is often an externality. This is particularly true for pollution from the use of non-restricted chemicals that are in products, for which the minimisation clause on ZZS is not as easily enforced as it is for factory emission permits.

The following chapters will thus explore if and how the policy mix options are able to correct for this externality by promoting innovation in the chemical industry.

6

POLICY MIX OPTION A: TARGETED GRANTS AND SUBSIDIES

This chapter describes in detail the policy mix option A. Further, some design choices are defined in order to describe an impact pathway for policy mix option A under 6.2.

6.1 Description of policy mix

Policy mix A brings together two forms of policy instrument: 1) command-and-control regulation, 2) MBI (Table 6.1). Command and control is already a well-established form of regulating the most harmful substances but it is yet to be rolled out as a blanket restriction to cover all hazard categories of SVHCs. A simplified procedure already in place is the generic approach to risk management (GRA) under Article 68(2) of REACH. For all three policy mixes (independent of the use of additional MBIs or Information instruments), It is suggested by the study team to follow the Commission proposal to extend the GRA (via Article 68(2)) to other hazard classifications (e.g. endocrine disruption) and through the exclusion criteria under Article 5(1) of the BPR. It is noted that the criteria already exist under Article 5(1) of the BPR, but the study team feels It is important to maintain this option moving forward.

The MBI of choice is a focusing and targeting of grants and subsidies. These are considered positive price-based instruments that use markets for behavioural change. As established in Chapter 3, there are already numerous grant/subsidy instruments in the Netherlands, but they are not targeted at safe chemical innovation but more generic. This represents a focused new hypothetical instrument with specific targeting for safe chemical innovation.

Table 6.1 Policy mix option A

Type of instrument	Policy instrument	Description
Regulation – Command-and-control	Restriction of hazardous substances in consumer and professional products	Restriction on the placing on the market of substances that are classified, for example, as CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Restriction via REACH Article 68 Restriction on the use of active substances classified as CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Article 5(1) BPR
MBI	Grant/ subsidy	The subsidy reduces the cost to firms to develop safe chemical alternatives. This improves the internal business model for a firm to engage in innovation.

In order for a grant/ subsidy to work, the design elements need to be concrete with consideration of the length of time the instrument is available (annual, fixed term etc.) The award criteria must be transparent, perhaps with the use of external reviews to rank applications, and programme targets must be clearly outlined and structured in a way that it is feasible to check that conditions are being met.

The grant/subsidy should be used to encourage innovation that results in a move away from hazardous substances and not encourage regrettable substitution. This can be avoided through the award criteria and consistent monitoring.

Key considerations:
- Who is eligible for the grant/ subsidy? E.g. SMEs, companies working within certain subsectors, or parts of the supply chain, or as part of inter-supply chain collaborations.
- What are the award criteria?
- What would the value of the grant/ subsidy be based on? E.g. is there are a cap? Is it based on volume reduction or company investments?

6.2 Potential impacts of Policy Mix option A

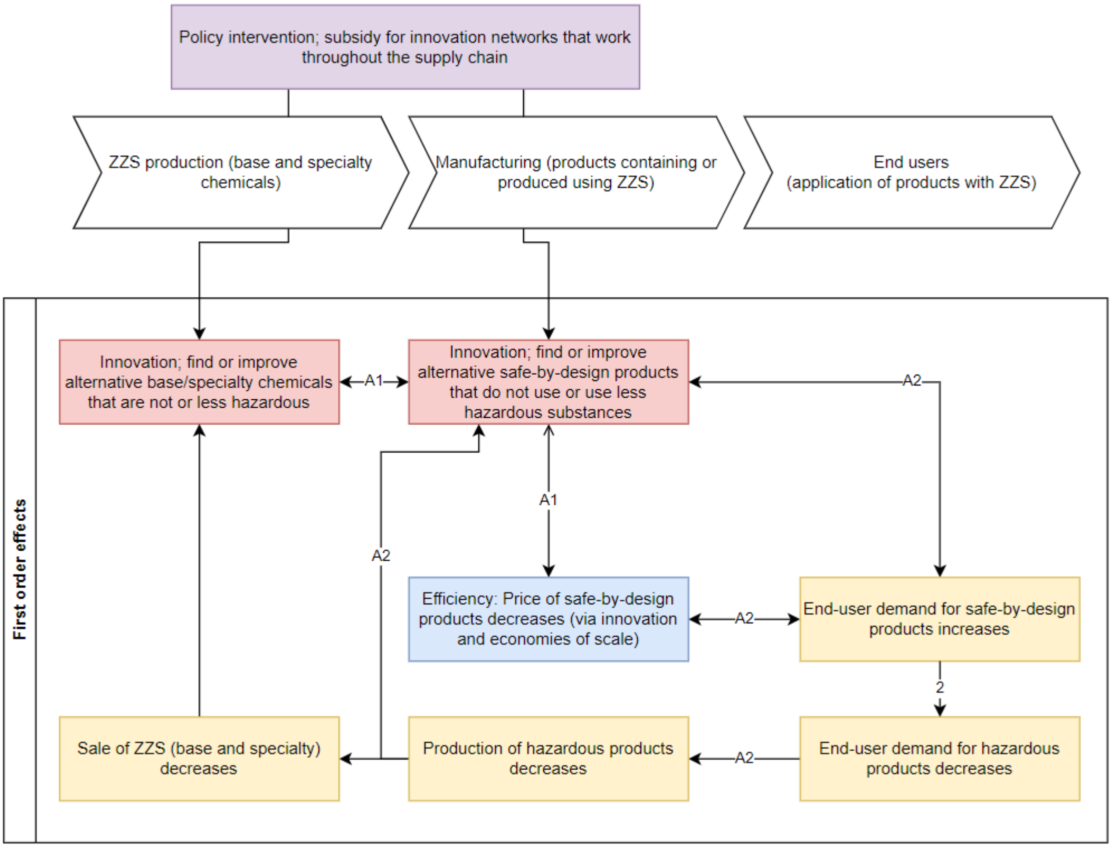
Policy mix option A concerns the use of subsidies/and or grants, in order to encourage direct innovation activities and/or the uptake of innovative, less hazardous alternatives to products with hazardous substances.

As noted in Chapter 3.1, the majority of innovation policy in the Netherlands is focused on providing financial support for technological innovation. Therefore, there are numerous existing programmes which can be used by innovative firms to obtain financial support, either in the form of subsidies, loans or grants. Because these programmes are generic, there is not an example of a targeted subsidy programme entirely focused on chemical substitution. It has also been identified in Chapter 3.2 that despite the availability of funds for innovation programmes, there is not enough successful innovation to substitute harmful chemicals in products and services. Based on this, it is considered that the generic innovation programmes in the Netherlands may not be facilitating or contributing to expanding research into less hazardous chemicals and products in a notable way.

A targeted subsidy programme that is dedicated to chemical substitution has, therefore, been suggested in Chapter 4 as a potential policy instrument for consideration. Together with the existing command-and-control regulation, this targeted subsidy programme forms Policy Mix option A.

To define the impact pathway for a targeted subsidy (illustrated in Figure 6.1), the target stakeholder of the subsidy must be defined. In this case, the target stakeholder of the subsidy under consideration is broad; this would be all companies part of the chemicals supply chain as it is present in the Netherlands, which includes base/specialty chemicals and product manufacturers that obtain goods from chemical producers. This is because supply-chain collaboration has been identified as an obstacle in Chapter 3.2, and the ability to successfully work together with suppliers and clients in a complex supply chain is identified as a key success factor. This definition does not include retailers and end-users, as they are not considered here to generally engage in primary R&D activity to find alternatives. This is not necessarily true (especially in the case of integrated pest management, where the would-be user of a biocidal product may engage in R&D to find alternatives) but for the purposes of this study the scope has been limited to a more traditional supply chain, where such innovations are delivered by external companies.

Figure 6.1 Impact pathway for targeted innovation programme targeted at manufacturers



There are two hypotheses that should be 'tested' or reviewed to consider the potential impact of a policy intervention for policy mix A. These are in the following table. The relationships between stakeholders governed by these hypotheses are indicated by the number on the arrows in the figure.

Please refer back to Chapter 5 for the explanation of what is meant by 'hypothesis' in this study.

Hypothesis
A1: Subsidy leads to successful innovations in less hazardous products and services that are brought to the market at a lower price and increased supply.
A2: There is market demand for alternative, less hazardous products, such that the greater availability and reduced price of these alternatives leads to a reduction in market share for products containing hazardous substances (**similar, but not the same, as B2**)

Hypothesis A1: Innovation is a successful result of targeted subsidies and grants
A firm's ability to innovate and create less hazardous products and services depends on many factors, many of which are not easily observed. Some firms may be less or more able to convert innovation funds into successful SSbD market offerings at a competitive price.

At a core level, the ability of subsidies and grants to enable innovative activity is confirmed by previous research and experience in the Netherlands. An important indicator on the effectiveness of a subsidy is to understand whether firms would have engaged in their innovative activity even if the support was not present. In the first case, the subsidy is effective. In the latter case, there is free-rider behaviour.

A 2018 study by Cecere et al. found that even when accounting for the effect of strict regulations and market dynamics, there is empirical evidence that access to public funds and fiscal incentives is effective for introducing eco-innovations. Further, the study found that it is SME's that suffer most from financial constraints for eco-innovation and suggest that public policy support is therefore most effective when targeting them.

This is aligned with the 2005 CPB finding that the Dutch WBSO is most effective for small, start-up companies[1], and a 2013 study that used more recent data to re-confirm this area of WBSO effectiveness[2]. For bigger firms, there is more mixed empirical evidence of effectiveness and this points to a generally higher risk of free-rider behaviour, whereby use of the financial support is institutionalised without meaningful results.

Literature also identifies a few conditions that must be met before targeted subsidies and grants can be effective. These conditions are described below.

Condition: Innovation requires collaboration within the supply chain

Hypothesis 1 includes the assumption that there is sufficient collaboration between actors within a supply chain to promote innovation. This is not a given, as supply chains can often be long and involve more than two actors before the final product is placed on the market. As established in Chapter 2.2 within the obstacle 'Industry structure', collaboration across the supply chain for innovation programmes is not commonplace in the existing chemical industry. This, while successful innovation is demonstrably linked to collaboration, either with competitors or with universities or private research establishments[3].

The policy mix option in this study in Figure 6-1 is explicitly targeted at the full supply chain. By designing a subsidy scheme that requires a cooperation of companies to apply, the resulting collaboration could not only do R&D on substitute substances, but also find component producers, product producers and retailers to bring a new innovation to the market. This does substantially increase the threshold for applying for a subsidy or grant, so it should be considered first if the market has enough innovative capacity to be able to meet this threshold.

Condition: Innovation should result in a smaller price difference between less hazardous products and hazardous alternatives

The successful market introduction of products via an innovation push requires that the resulting technical innovations are price competitive. At significantly higher relative prices there is high likelihood that the innovative product will not gain traction nor market share. In addition, a less hazardous alternative product may require adaptations in working processes, different types of maintenance, and adaptations in end-user behaviour. These are additional obstacles that already make it more difficult for a product to enter and establish itself in the market.

It is thus crucial that technical innovations are either price competitive and/or are introduced in a market that values their relative environmental benefits and is willing to try and change processes accordingly. It has therefore been suggested that a combination of taxation and subsidy policies is most effective, as it allows for policy to influence both push and pull factors associated with the development and introduction of innovative products into the market. The effect of a tax measure that could complement this subsidy is discussed in Chapter 7.

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1 Hoe effectief is extra fiscale stimulering van speur- en ontwikkelingswerk? Effectmeting op basis van de natuurlijk-experimentmethode | CPB.nl

2 Hoe effectief is de WBSO-regeling door de jaren heen? · Beleidsonderzoek Online · Beleidsonderzoek Online (boombestuurskunde.nl)

3 Van Hemert, Nijkamp, Masurel (2013); From innovation to commercialization through networks and agglomerations: analysis of sources of innovation, innovation capabilities and performance of Dutch SMEs.

Hypothesis A2: Market demand for less hazardous products leads to a reduction in sales of products containing hazardous substances, mixtures and/or materials

Hazardous substances are used in a very wide variety of products and services, and the end-user groups that make up the demand for a product may be less or more willing to invest in alternative, less hazardous products and services. Further, a concrete environmental impact depends heavily on whether current users of hazardous products and services are willing to switch to alternative products, and this may not be a given even if alternatives are technically available at an attractive or competitive price.

In economic terms, these considerations pertain to the price elasticity of demand for ZZS/biocidal products. If end-users do not switch to less hazardous products even if they become more available and attractive, from a price perspective , then the elasticity of demand is low and it is difficult for market-based instruments to achieve the intended effect. There is, however, limited literature and research into the price elasticity of demand of these products. And, as such, it is important to consider these targeted policies in combination with others that would increase the likelihood of a shift to SSbD or less hazardous product alternatives.

Price elasticity of demand for less hazardous products

Firstly, ZZS are not a product type but a group of (mostly) product constituents, and the demand for a product is not related to its hazardous characteristics, but the product's function. As has been established in Chapter 3, consumers are often unaware of hazardous characteristics, in particular if these are environmental risks and do not present acute human health risks that would require a chemical warning label. For example, to understand the price elasticity of demand for PFAS, the aim should be to understand the elasticity of demand for the products and services enabled by PFAS, such as water-repellent materials and non-stick cookware.

In the case of ZZS, the elasticity of demand for the chemicals themselves is not necessarily useful. To understand market-demand for les hazardous products, the question rather concerns the value that is placed by end-users on the characteristics that make a product less hazardous relative to the existing and potentially more hazardous alternatives. If this value is positive and the product provides a similar service, then end-users may be willing to pay a higher price for an alternative product. For an end-user to select a product that is more expensive, less effective or has different usage instructions, it is expected that the characteristics of the product that make it less hazardous would be of very high value.

***Case example**: Price elasticity of demand for biocidal products*

Biocidal products are a niche market that do not have the economic research and empirical interest in literature that would facilitate the derivation of an estimate of the price elasticity of demand.

Some similar chemical products such as plant protection products have been studied more extensively with respect to their elasticity, and some learnings can be taken from this literature, even if limited. Namely, a meta-analysis by Bocker and Finger (2016) specifically analysed the elasticity of demand in the context of pesticide taxation schemes in Europe and North America. The study concluded that pesticide demand is inelastic, and within these, herbicides are the most elastic category. When interpreting this result in the context of biocides, the overall services of pest control and health protection is similar, and the alternatives with which biocides compete (such as in the case of integrated pest management) are also similar to plant protection products. As a caveat, plant protection products provide an agricultural service, and the demand is therefore related to the agricultural market. Biocides deliver a wide variety of services to different economic sectors, which leads to uncertainty in the applicability of these results.

It is concluded that biocides can suffer from similar price inelasticity of demand, which can be underpinned by practical examples. The Dutch case study on ship anti-fouling measures conducted a survey whose results suggested a resistance to change, and most importantly that buyers of biocidal products were not only sensitive to price, but also sensitive to the time and effort it would take to implement an alternative[1].

1 SPPS, Quintens consultants (2022); Evaluatie praktijkproef antifouling.

Expert knowledge from the project team gained through working in the German authority (Umweltbundesamt) on biocide approval suggests that the German experience is similar to the Dutch, where despite efforts to promote alternatives, it is difficult to shift demand from biocidal products for ship anti-fouling.

This does not mean that this has to be the case for all biocide alternatives. Ship anti-fouling is a well-studied example and a strong example of inelastic demand, but a lack of similar information about other biocidal product types means that this conclusion should not be generalised to all biocidal products.

7

POLICY MIX OPTION B: PIGOUVIAN TAX

This chapter describes in detail the policy mix option B. Further, some design choices are defined in order to describe an impact pathway for policy mix option A under 7.2.

7.1 Description of policy mix

Policy mix option B again utilises two forms of policy instrument: 1) command-and-control regulation, 2) MBI (table 6.1). The key difference in this option is the use of a negative price-based instrument that uses markets for behavioural change. The use of a Pigouvian tax would increase compliance costs for companies and so the intention would be to encourage their shift to less hazardous substances that would reduce their compliance costs in the long term. As with the grant/ subsidy, the design of the Pigouvian tax is key to its performance and requires transparency in operation and implementation criteria. The key considerations that must be made relate not only to the functioning of the Fiscal structures of the Netherlands and the EU but also:
1 Who is the tax targeting? E.g. manufacturers, users?
2 What is the rate of tax?
3 What is the rate of tax linked to? E.g. volume, value.

Table 7.1 Policy mix option B

Type of instrument	Policy instrument	Description
Regulation – Command-and-control	Restriction of hazardous substances in consumer and professional products.	Restriction on the placing on the market of substances that are classified, for example, as CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Restriction via REACH Article 68(2) Restriction on the use of active substances classified as CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Article 5(1) BPR
MBI	Pigouvian tax.	Compulsory payment to the government levied on the relevant tax base to incentivize decreased use. Applied only to applications that are not within scope of the extension of the GRA under Article 68(2)

As with policy mix A, the same recommendation applies, to follow the Commission proposal to extend the GRA (via Article 68(2)) to other hazard classifications (e.g. endocrine disruption) and through the exclusion criteria under Article 5(1) of the BPR. This proposal does not cover all substances in all uses (which the ZZS policy of the Netherlands does apply to), so this means the added value and complementarity of a Pigouvian tax is in taxing those substances which fall outside of blanket restriction proposals.

Of these three considerations, the second (rate of tax) and third (specific volume or value link) are very specific to which products and or services are specifically targeted.

If the targeted substance is a very large part of the final product by volume, then the tax on the substance may need to only be relatively small, compared to situations when there are only trace amounts of a substance in a final product, which the tax nonetheless wishes to discourage. In that situation, the tax per volume of hazardous substance may need to be very high.

7.2 Potential impacts of Policy Mix option B

Policy Mix option B concerns the use of taxation to discourage the use of hazardous chemicals and thereby making less hazardous alternatives more attractive. This mechanism should then encourage direct innovation activities and/or the uptake of existing less hazardous alternatives already on the market but without a significant market share.

To describe the impact pathway for the use of taxation, a target stakeholder has to be defined as the start of the impact chain. It has been suggested by economists from PBL[1] that in general environmental taxation in the Netherlands is borne by the end-users, via taxation on end-products[2]. However, it is accepted that the 'polluter pays principle' should be applied more. For this impact pathway the tax is to be placed on the start of the supply chain, the ZZS production/specialty chemical production level. This is also of particular interest to the Netherlands as there is a significantly large base/specialty chemical sector to which such a tax could theoretically be applied.

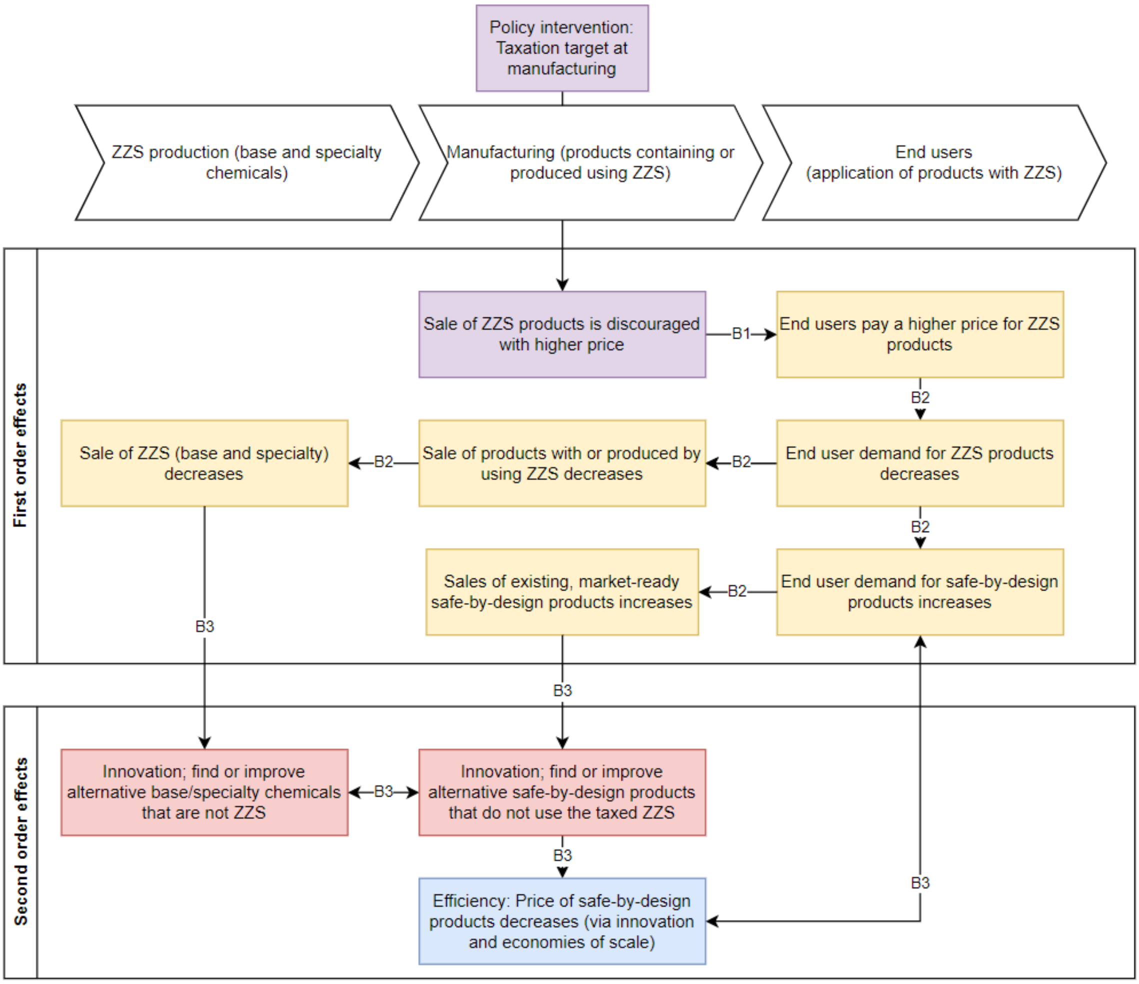
As noted in Chapter 4, there are many specific considerations and variables to implement a taxation on hazardous substances. This is also reflected in Figure 7.1, which shows the most complex impact pathway of the 3 policy mixes. Still, the basic theory behind environmental taxation remains; the taxed party is incentivized to engage in innovation activities as long as the (expected) marginal benefits are larger than marginal costs presented by the tax. This can take place as a result of sales decreases from taxed goods, but an innovator within a business can also already take the tax signal as a forecast of potential future revenue drops and immediately engage in innovation.

In this example, the tax has been levied at the 'middle' of a supply chain, at manufacturing level. This would for example be the producers of electronic equipment that use hazardous flame retardants, but not at the producers of those flame retardants. This choice was made, because the ZZS is in a manufactured product to support a function. Innovation should take place in substances, mixtures or other types of designs that could replace this function without using hazardous substances. Therefore, it is considered more likely that a tax can spur innovation activity because the price signal more directly arrives at the location where the most innovation is expected to happen, rather than indirectly via increased prices of ZZS components, or biocidal active substance components.

1 Planbureau voor de Leefomgeving

2 PBL publication: 'De vervuiler betaalt te weinig' (the polluter pays too little); De vervuiler betaalt te weinig - PBL Planbureau voor de Leefomgeving

Figure 7.1 Impact pathway for hazardous chemical taxation at manufacturer level



To influence R&D level innovation via a tax, three different distinct mechanisms can be isolated. This leads to three hypotheses and these are in the following table. The relationships between stakeholders governed by these hypotheses are indicated by the number placed on the arrows in Figure 7.1.

Please refer back to Chapter 5 for an explanation of what is meant by hypothesis in this study.

Hypothesis
B1: A higher price at the level of base and specialty chemicals leads to a higher price for products and end-users
B2: A higher price of ZZS/biocide products leads to a demand shift towards less hazardous products
B3: In response to the demand shift, manufacturers and base/specialty chemical producers engage in more innovation, that in turn can increase availability and reduce prices for less hazardous products. (**equal to C2**[1])

In this impact pathway, the technological innovation effect increasing availability of less hazardous products would be a **second order effect**. This is because innovation activity is not directly targeted by the policy intervention and is only one of the ways that a stakeholder may respond to a higher price.

[1] In the next chapter, policy Mix option C is discussed, whose effect depends on a similar hypothesis.

Environmental impact can be of both first-order or second order, depending on whether the sale of alternatives requires innovation, or if a price adjustment alone is enough for some markets to improve the market position of an alternative.

Hypothesis B1: A higher price will be passed on the supply chain to result in higher product prices for end-users

The principle goal of a Pigouvian tax is to shift demand from an undesirable product to a desirable product, as established in Chapter 4.1. It does this by correcting for the externality of environmental damage that is not priced into the industry, as has been identified under the obstacles in 2.2. If producers are able to pass on the cost to manufacturers and end-users without losing market share to less hazardous products, they will do so. In the short-term, this is a likely outcome, as any end-user market will need time to adjust and form a response to increased prices. The precedent of climate and air quality related taxation for electric vehicles is a relevant example. While not all taxation on fossil-fuel powered vehicles in the Netherlands has an environmental goal (there is also a general goal of tax returns), this has become an implied goal by exempting greener alternatives of the same tax. It is also shown that end-users are very price-sensitive in the electric vehicle market in the Netherlands[1]. There may be products and services enabled by ZZS for which this precedent is valuable. For electric vehicles, the price differences between the existing 'safe' offering and the 'hazardous' alternative can be very high.

Hypothesis B2: A higher price of ZZS/biocide products leads to a demand shift towards less hazardous products

The main discussion on this topic is under 5.3.1, as this again concerns the price elasticity of demand for the services provided by ZZS/biocides.

In addition to 5.3.1, in comparison to policy mix option A, the price elasticity of demand is more important and the main driver for whether or not this policy intervention can be successful. In the case of the tax, the less hazardous alternatives that are already on the market may become immediately more attractive due to a reduced potential price difference. There is therefore not always a need to wait for technological innovation at the scale of R&D. This can also open the door for a gradual economies of scale on such existing alternative products, by increasing their market share.

Hypothesis B3: In response to the demand shift, manufacturers and base/specialty chemical producers engage in more innovation

The question of how a taxation may spur innovation is very complex. As a second-order effect, it is not a given that a ZZS/biocide producer or a product manufacturer uses the price signal to engage in innovation. There is a heavy dependency on the type of market and what kind of alternatives are already available. For goods and services with no alternative to the service provided by ZZS/biocides, in the short-term firms may not observe a need to change their products. Only through competition with viable alternatives does this effect of the market-based instrument occur. It is therefore also implied that in particularly for product types and services for which clear, viable alternatives exist, but which have struggled to gain market share due to a higher price. This lack of market share could also be because they require a different working process that users need an incentive to change their purchasing behaviours.

Therefore, similar to Hypothesis 1 under policy mix option A, a number of conditions can be defined that should be met before the taxation can have a positive effect on innovation:

Condition: To achieve an effect in the short-term, there should already be less hazardous alternatives available

The impact pathway is shorter if the price signal from the tax can have a direct effect on end-users, in the form of already available alternatives. This could immediately increase demand for those alternatives, as well as increase pressure to resolve their (perceived) obstacles, inefficiencies and lower their price (either through innovation or economies of scale). As an example, the anti-fouling study (Quintens Advies, SPPS, 2022) commissioned by IenW identified that there are plenty of viable alternatives to the currently used biocidal products, but that they are struggling to gain market share[2].

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[1] pbl-2016-quickscan-doelmatigheid-aanschafsubsidies-laadtegoed-elektrische-autos-2527.pdf

[2] Evaluatie Praktijkproef antifouling Bevindingen van interviews en beperkte deskstudie | Rapport | Rijksoverheid.nl

The effort required to switch processes and routines is identified as a major obstacle, and in this situation the welfare cost of switching for the end-user is higher than the price difference between products. This could be compensated if the tax makes the hazardous alternative demonstrably more expensive than the less hazardous alternative, to essentially pull consumers over the line.

Condition: To be able to avoid the tax, clear communication and information sharing within the supply chain is necessary

The chief example of a similar taxation scheme is the tax on hazardous chemicals in consumer appliances as applied on hazardous flame retardants in Sweden. Interviews were conducted with companies on how Sweden's tax scheme for electronic products has impacted their business operations[1]. The research covers mostly retailers/distributors, but some importers/suppliers too. Interesting conclusions are drawn in this study on 'drivers for substitution', whereby only 4 out of 13 interviewed companies noted the Tax as an influence for substitution. The role of information sharing within the supply chain is noted as the largest obstacle, as often it was not possible for retailers to ascertain which product contained the taxed substances, and therefore the only choice was to pay the tax on every product for which the ZZS is suspected. In this example, the tax is levied strictly at the retail level, not in the supply chain. Thus, the burden of having enough information is with the retailer. In many cases, optimal tax advantages from non-hazardous alternatives may not have been realised because the retailer did not have enough information about the product contents to verify this and claim the more favourable tax rate on the product. This information flow and thus the tax advantages for selling less hazardous products did occur over time, but the minimum rate of taxation was rarely reached. This means that the products with a lower environmental impact are not always able to actually realise the competitive advantage that the tax is designed to elicit.

The conclusion here also relates to hypothesis 1 under policy mix option A above. To innovate in a supply chain, collaboration is almost always necessary, and communication about which substances are cascaded into products is a basic element of this collaboration. In the report 'Zicht op chemische stoffen' (2020) it is shown that communication and information sharing is not optimal within the Dutch chemical sector, and that this is a barrier for innovation. This therefore suggests that the issue that Swedish retailers and importers encountered may also occur in the Netherlands if the taxation scheme is not supported by sufficient supply chain collaboration. Despite this, some evidence was found of substitution of hazardous flame retardants in Sweden, to a limited extent. Firms mentioned that the combination of a tax and EU legal requirements is what was expected to inform substitution, as the supply chains for electronics reach outside of Sweden and therefore firms expected the influence of a tax at the retail level to be limited without EU regulation.

[1] Anderson (2020); Taxation of Hazardous Chemicals as a Substitution Measure (Master Thesis).

8

POLICY MIX OPTION C: ECOLABEL AND INFORMATION CAMPAIGN

This chapter describes in detail the policy mix option C. Further, some design choices are defined in order to describe an impact pathway for policy mix option A under 8.2.

8.1 Description of policy mix

Policy mix option C brings together command-and-control regulation and an information instrument (market-based instrument). As with the first two policy mix options, command-and-control regulation through the use of restriction mechanisms are retained.

As with policy mix C, the same recommendation applies, to follow the Commission proposal to extend the GRA (via Article 68(2)) to other hazard classifications (e.g. endocrine disruption) and through the exclusion criteria under Article 5(1) of the BPR. This proposal does not cover all substances in all uses (which the ZZS policy of the Netherlands does apply to), so this means the added value and complementarity of an ecolabelling and information campaigns is in reducing the demand for products with substances which fall outside of blanket restriction proposals.

Although information-based instruments are unlikely to stimulate innovation on their own, evidence outlined in Chapter 5.3 suggests that they can be positive influences when combined with other instruments. There is evidence to suggest that the reputation of companies can be positively affected by the award of ecolabels, in turn potentially having an impact on their sales. As there are a number of ecolabels already in existence, it is suggested to create one at NL-level that goes beyond the requirements of the EU-ecolabel and to combine this with information campaigns that are based on the collaboration of industry and public authorities to boost awareness of the safety of products that do not contain hazardous substances.

Table 8.1 Policy mix option C

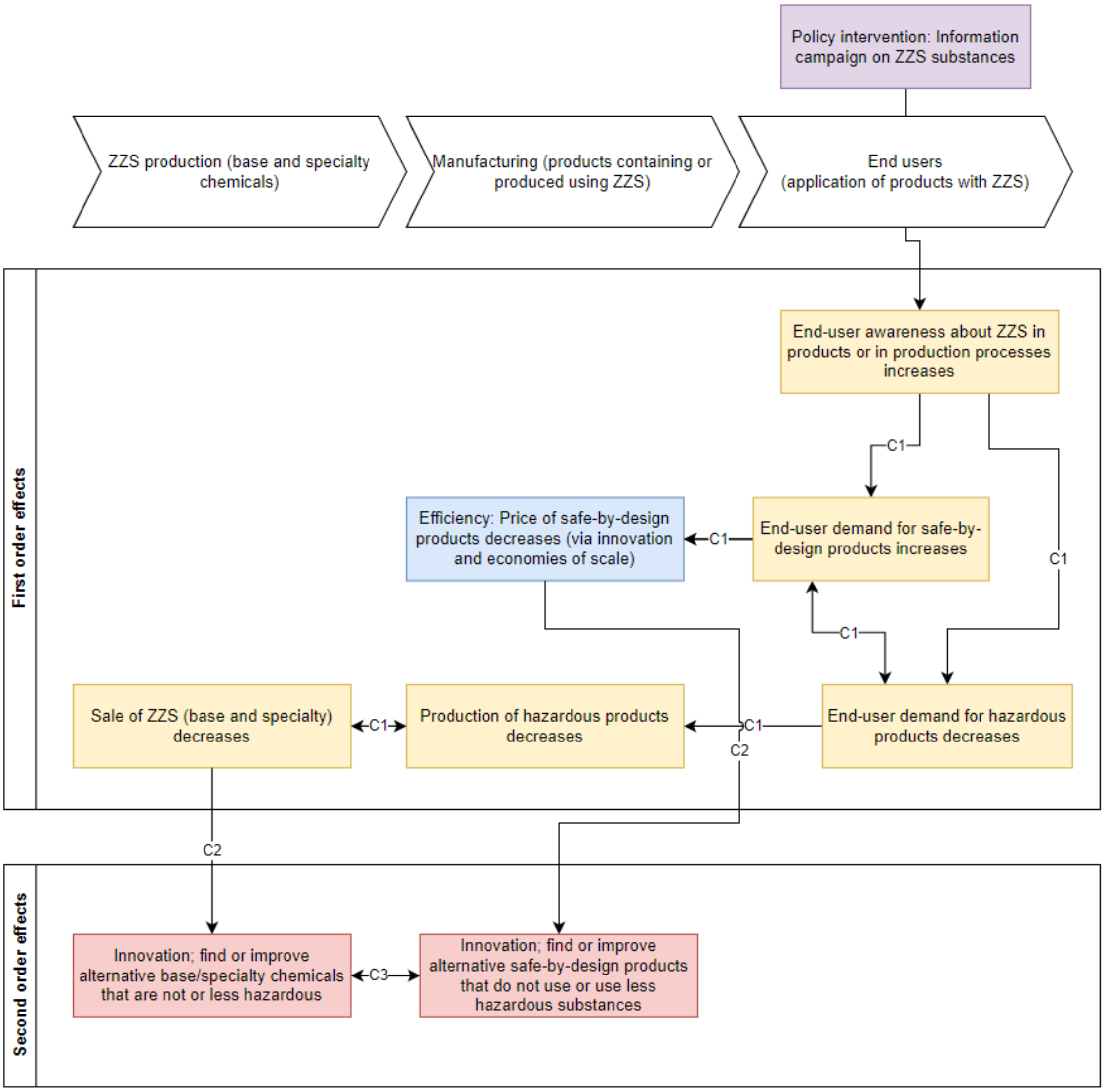
Type of instrument	Policy instrument	Description
Regulation – Command-and-control	Restriction of hazardous substances in consumer and professional products	Restriction on the placing on the market of substances that are classified as, for example, CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Restriction via REACH Article 68 Restriction on the use of active substances classified as CMR cat. 1A/1B; EDC cat. 1,2; PBT; vPvB. Article 5(2) BPR
Information instrument	Labels and information campaigns	The introduction of an ecolabel designed for specific products that goes above the requirements of the EU- ecolabel. In addition the use of campaigns based on collaboration of industry and public authorities to raise awareness of products that do not contain hazardous substances and increase the information flow about hazardous substances within the supply chain

8.2 Potential impacts of Policy Mix option C

Policy mix option C concerns the use of an ecolabel in combination with an information campaign on ZZS and biocidal active substances, in order to encourage end-users to demand more innovative and less hazardous alternatives to products with hazardous substances.

To describe the impact pathway for an information campaign, a target stakeholder has to be defined as the start of the impact chain. For this policy measure, this is naturally the end-user, as the actor that information campaigns generally target. That does not mean other supply chain stakeholders cannot be part of an information campaign. For example, making retailers more aware of the substances present in their product may allow them to properly select their supply chain. However, for the purposes of this study the scope is maintained with end-users.

Figure 8.1 Impact pathway for information campaigns



Information campaigns influence R&D level innovation in a similar way to policy mix option B – tax measures, as it is an innovation 'pull' instrument that aims to influence demand and indirectly, influence innovation as a second order effect. This leads to two hypotheses and these are in the following table.

The relationships between stakeholders governed by these hypotheses are indicated by the number placed on the arrows in Figure 8.1.

Please refer back to Chapter 5. for an explanation of what is meant by hypothesis in this study.

Hypothesis
C1: End-user awareness about ZZS in products and/or about the risks associated with certain and hazardous active substances in biocides, can lead to increased demand for less hazardous products and decreased demand for hazardous products
C2: In response to the demand shift, manufacturers and base/specialty chemical producers engage in more innovation, that in turn can increase availability and reduce prices for less hazardous products. **(equal to B3)**

As noted above, in this impact pathway, innovation is again a **second order effect**. This, because it is not innovation itself that is targeted by the policy measure, but the goal is to shift demand from end-users towards less hazardous products. This may lead to innovation activity to meet demand for such products.

Hypothesis C1: End-user awareness leads to demand shifts

Similar to the tax measure, the goal of an information campaign here would be a demand shift. For information campaigns, this Chapter will consider the hypothesis of whether this increased awareness via an ecolabel can achieve the desired result.

A study by Atkinson & Rosenthal (2014) examined the use of signalling theory to assess which aspects of ecolabel design yield positive effects. Their literature review found that the desire to make sustainable purchases is obstructed by a perception of credibility and honesty in the advertising of environmental claims[1], [2], [3]. It was noted that even though sustainable consumption may be driven by trust and credibility of claims, there has been insufficient empirical analysis to test these relationships[4], [5]. However, literature does suggest that consumers are willing to pay more for products that come with a 'seal of quality'[6] and that they prefer green claims to be supported by detailed and specific information[7].

Atkinson & Rosenthal (2014) found that label formats and sources have little influence on behavioural outcomes, but they do influence attitudes with regard to trust of claims and towards the product and label source. It was noted that government-sourced labels were trusted more greatly than corporate-sourced labels. This being said, for everyday items such as food and fast-moving consumer goods, companies may benefit from a return in investment as a result of the use of ecolabels as it can generate a more positive attitude towards the product and the corporation. For policymakers, their ecolabel focus should be on the perceived credibility, as they are considered to have the most authority in ensuring the criteria are strict and met.

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1 Crane, A (2000), "Facing the Backlash: Green Marketing and Strategic Reorientation in the 1990s," Journal of Strategic Marketing, 8 (3), 277–96.

2 Hulm, M (2010), Your Brand: At Risk or Ready for Growth?

3 Leire, C., and Thidell, A. (2005), "Product-Related Environmental Information to Guide Consumer Purchases—A Review and Analysis of Research on Perceptions, Understanding, and Use among Nordic Consumers," Journal of Cleaner Production, 13 (10/11), 1061–70.

4 McEachern, M G. (2008), "Guest Editorial: The Consumer and Values- Based Labels," International Journal of Consumer Studies, 32 (5), 405–06.

5 Warnaby, G (2004), "Retail 'Quality Assurance' Labels as a Strategic Marketing Communication Mechanism for Fresh Meat," International Review of Retail, Distribution, and Consumer Research, 14, 255–71.

6 Cason, T N., and Gangadharan, L (2002), "Environmental Labeling and Incomplete Consumer Information in Laboratory Markets," Journal of Environmental Economics and Management, 43 (1), 113–34.

7 Manrai, L A., Manrai, A K., Lascu, D-N., and Ryans, J-K (1997), "How Green-Claim Strength and Country Disposition Affect Product Evaluation and Company Image," Psychology and Marketing, 14 (5), 511–37.

Overall, corporate labels are seen as better indicators of source and product quality, whilst government labels are considered more credible and trustworthy[1]. It should be noted the study by Atkinson & Rosenthal was carried out with undergraduate students enrolled in advertising classes at a university in the United States, where ecolabels have been used for less time than in Europe. Views on the use of ecolabels may be different from EU stakeholders.

There exist initiatives in the EU to add information on chemical hazards to ecolabel programmes. Saouter et al. (2018)[2] studied the proposals for the EU Ecolabel and Product Environmental Footprint. These initiatives also list the development (implying innovation) of 'less hazardous products' as a goal of adding this information.

While in theory an increased awareness of environmental impact should lead to end-users making informed purchasing decisions, there are many practical examples of where no significant effect is measured. The example already mentioned under Policy Mix A, Hypothesis A2 (Netherlands 2022 ship antifouling study) used an information campaign as the main method of promoting alternative and less hazardous methods of antifouling. Unfortunately, no measurable effect on sales of the alternative was measured as a result. This reflects the mixed evidence on the efficacy of ecolabels in Europe. As mentioned earlier, attitudes and trust can be influenced and the antifouling pilot has shown that this is possible, at least for a younger audience of boat owners. Other than that, the findings are in line with the findings from Atkinson & Rosenthal (2014).

Finally, it is also possible to derive the potential impact of information campaigns by studying the effect of the absence of information with the end-users. A 2006 study by Iles (2006) noted that innovation to remove harmful chemicals would not often lead to increased sales, despite the high investments needed. This indicates that even if a product is labelled to be safe or improved because of lower environmental and health risk, there can be an implied distrust in the new product.

Hypothesis C2: In response to the demand shift, manufacturers and base/specialty chemical producers engage in more innovation (equal to B3)

How an observable demand shift influences innovation is established under Chapter 5.3.2, hypothesis B3. However, a few additional conditions can be specified here that are a result of a successful information campaign that leads to a meaningful demand shift.

Condition; The innovating firm feels pressure from public awareness and attitudes towards the original hazardous product

An additional element that is not discussed under B3 is the impact of public awareness and attitudes towards a product, and how this may influence a firm's willingness to engage in substitution. If demand shifts according to changing attitudes about the toxicity of a certain chemical, then the reason for the demand shift may be very obvious. This reputational effect may spur the firm to engage in innovation. This effect may also reduce the risk of regrettable substitution, if there is enough overall awareness among the public about the chemical group that regrettable substitutes may be a part of. An example here is the awareness about overall PFAS-free products whereby no form of fluorinated carbon chain could replace a targeted PFAS substance. A negative example the awareness of bisphenol A but not it's analogue Bisphenol S[3].

Condition; the pressure from public awareness is shared across the supply chain

Pressure from public awareness is most felt at the end of supply chains, where firms interact with their customers. If these firms are however not able to do the required innovation, then they would have to active their supply chain by signalling the need for innovation or work together with their supply chain to create and/or improve safe chemical innovations.

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1 Atkinson, L. & Rosenthal, S. (2014) Signaling the Green Sell: The Influence of Eco-Label Source, Argument Specificity, and Product Involvement on Consumer Trust, Journal of Advertising, 43:1, 33-45, DOI: 10.1080/00913367.2013.834803.

2 Erwan Saouter, An De Schryver, Rana Pant, Serenella Sala (2018). Estimating chemical ecotoxicity in EU ecolabel and in EU product environmental footprint. Environment International, 118, Pages 44-47.

3 Maertens et al. (2021) Avoiding Regrettable Substitutions: Green Toxicology for Sustainable Chemistry.

As noted earlier in Chapter 2.2 on the obstacles to collaboration, an expert panel interview was carried out, where collaboration in the supply chain was a topic. A possible solution raised is the added value of eco-certification as a solution.

In other sectors[1], certifications exist that ensures that all parts of the supply chain carry out their activities (production, or otherwise) using the same sustainable principles, but these do not yet exist for most ZZS groups. This is changing, with the recent example of PFAS-free certifications suggested in the USA[2] and the UK[3]. In the Netherlands, there are many examples of companies promoting their products as PFAS-free, but this is not supported by an independently recognized certification scheme. However, there is precedent, such as examples of providers who certify companies based on their handling of dangerous substances, such as hexavalent chromium[4]. Some other ZZS also already are supported by a certification for other reasons, such as the safety certifications that support flame-retardants.

Thus, it is conceivable that similar practices and principles could be used in parallel to manage certifications that guarantee a certain ZZS (group) is not used in production processes. This, in turn, could aid the effectiveness of any innovation policy as certification requires a minimum information flow between companies in a supply chain, which enables collaboration and builds trust within a supply chain. This is how an information instrument could support innovation practices, by establishing an information flow about what needs to be innovated on, and who in the supply chain is responsible for which ZZS substances.

1 A chief example is organic food production, supported by strictly maintained certifications that the supply chain must adhere to. This certification includes the ban on hazardous chemicals such as pesticides.

2 Clean Production Action - Greenscreen PFAS free, sourced from: https://ceh.org/latest/press-releases/first-of-its-kind-certification-eliminates-harmful-pfas-in-foodware-and-shifts-market-to-preferred-alternatives/

3 PFAS Free UK, sourced from: https://www.pfasfree.org.uk/current-initiatives/pfas-free-products.

4 SGS-Research, Onderscheidend Chroom-6 certificaat nu beschikbaar, sourced from: https://www.sgssearch.nl/over-search/search-in-de-media/onderscheidend-chroom-6-certificaat-nu-beschikbaar.html

9

CONCLUSION AND DISCUSSION

Overall conclusions

It is clear that innovation to bring less hazardous alternatives to ZZS and biocidal active substances to the market is needed and that the current rate of substitution is too slow to counteract the increasing presence of hazardous substances in the environment. At present, there are various obstacles which may prevent innovation from taking place. Financial obstacles often relate to a lack of internal or external funding, and regulations with extensive approval and authorisation processes, such as the BPR, can place a high financial burden on companies. This is especially problematic for SMEs.

Further, product performance, such as efficacy or service life, can significantly affect the acceptance of alternatives by users and complex supply chains mean it is often a requirement to collaborate with suppliers and buyers to ensure the success of alternatives. Where the financial costs are high due to regulatory burden, any uncertainty related to commercialisation and acceptance of alternatives can be an obstacle to gaining internal approvals for innovation. This is particularly true for niche applications where the market has not changed in a long time. Innovation may also require greater time and resources to ensure that regrettable substitutions are avoided.

Attitudes in the market are also often defined by a long legacy of using fossil fuel resources in chemical synthesis, while alternative substances may require radically different feedstocks and radically different types of substances or processes (integrated pest management in the case of biocides). In particular, in the Netherlands the multinational base and specialty chemicals industry does not appear to be successful at innovation, and major innovations may have to come from startups or SMEs where a different type of culture is in place. This means that policy interventions should be aimed at both increasing the likelihood that multinationals engage in innovation, and helping SME's in their challenging, cost-intensive innovation process. Combined, these factors strongly influence the level of innovation within the sectors manufacturing and using ZZS and biocidal products.

This study has identified a number of policy instruments that could be used to address these obstacles. From a longlisting process that details all possible types of policy instruments, with a focus on market-based instruments, three options were selected for further study.

The policy instruments suggested in this study focus on three different approaches to reach the goal of protecting the environment proactively through innovation, not solely restriction:
- Policy mix option A - Subsidy/grant schemes aimed at the manufacturing supply chain.
- Policy mix option B - Environmental taxation aimed at base/specialty chemicals producers.
- Policy mix option C - Information schemes aimed at end users of ZZS/ biocidal products and services.

It is suggested that these instruments are used in combination with the existing command-and-control regulatory baseline. To note, the policy instruments assessed in this study are not the only options that could stimulate innovation, rather, literature review and experience in the Netherlands and abroad has shown that these could be promising policy instruments for increasing innovation that may reduce the risks from the use of chemicals.

Policy Mix option A concerns the use of subsidies/and or grants, in order to encourage direct innovation activities and most aligns with the existing policy programmes that companies can use to aid in innovation. As these instruments are almost never targeted specifically at chemical substitution, there is opportunity to add additional focus, and this may help specific companies with innovative projects to bring their alternatives to market. This option may address the issues faced by industry when considering developing alternatives and the large financial burden and risk which will come with this, from a regulatory perspective as well as from a research a development perspective. However the use of grants or subsidies may not be effective across all product types, particularly biocidal product types, where market demand for incumbent (active) substances and a lack of previous acceptance of alternatives may pose a barrier for innovation. Additionally the conditions of the financial incentive will be key for the success of this policy instrument. If the conditions require industry to develop a less hazardous alternative to receive the funding, this may be off putting as it could require greater investment, however without a requirement such as this, the funding may lead to regrettable substitutions and inefficient use of government funding.

Policy Mix option B concerns the use of taxation to discourage the use of hazardous chemicals and thereby making less hazardous alternatives more attractive. Environmental taxation is the most complex of policy instruments, as its relationship to innovation is indirect. The use of discouragement from hazardous substances to seed innovation towards less hazardous substances could be useful to successfully target the substances which have been identified to cause most harm and thus result in an effective method for protecting the environment. The use of a tax can be expected to impact industry's actions and consumer use through an increase in prices. This may lead to innovation and additionally reduce the use of specific identified substances, although this is not a given.

To ensure the effectiveness of taxation, it should be very clear that the targeted product or service has a sufficiently elastic elasticity of demand, to ensure that enough of a demand signal reaches the market to promote innovation. It is also important to design taxation schemes with the key considerations in mind and to identify the conditions that best promote innovation and prevent regrettable substitution. For example, from the active substance analysis (see Annex I for more information) 5-Chloro-2-methyl-4-isothiazolin-3-one (CIT) was identified as a substance with hazards of significance. CIT, although still currently in use, has been widely replaced by an alternative isothiazolinone - Benzisothiazolinone (BIT)[1]. This replacement could be seen as a regrettable substitution as one of the main properties of concern for CIT are sensitisation, which is listed as one of many properties of concern for BIT by ECHA.[2]

Policy Mix option C concerns the use of ecolabels and information campaigns in order to encourage end-users to demand more innovative and less hazardous alternative products. Information campaigns are a policy instrument that have a strong theoretical background, but likely have the least potential to meaningfully shift demand to less hazardous products in the short-term. Ecolabelling is commonplace and expanding in the EU and in the Netherlands, but it is not clear from the evidence that there will be a meaningful demand shift in response to increasing information on the presence of ZZS or biocidal active substances for end-users. For biocidal products this policy option is delicate due to the risks and benefits posed by biocides to society and the environment and how this information can be shared without perpetuating misinformation. However, this option may steer ongoing innovation and over time encourage development of products which satisfy consumer's demands for less hazardous products.

Overall, Policy mix option A and B are expected to be more successful in encouraging innovation towards less hazardous alternatives, and the success of these options will depend on the conditions of the financial incentives or discouragement. The use of a financial incentive is particularly pertinent for the sub-sectors of the chemicals industry (e.g. biocidal products) which face high regulatory costs. As policy mix option C has an indirect effect on innovation, it is expected to be most effective when combined with other policy instruments.

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1 R Nagorka et al. (2015) Isothiazolone emissions from building products Available from: DOI: 10.1111/ina.12126

2 ECHA 1,2-benzisothiazol-3(2H)-one Substance Information - ECHA (europa.eu)

Appendices

I

APPENDIX: OVERVIEW OF TWO SUBSTANCE GROUPS AND THE APPLICABILITY OF INNOVATION POLICY

I.1 ZZS groups and the potential relevance of innovation policy targeted at these groups

The ZZS substance list is continuously developing. In order to ensure that the obstacles which the policy instruments aim to address, have an effective target and to focus the scope of the study, the ZZS list was filtered using the following four criteria, whereby chemical groups were deprioritised in this study if they adhere to one or more of these criteria. This does not mean that the policy instruments are not relevant to all substance groups, but that certain substance groups have unique obstacles that are not considered in this study. Excluded groups are shown in Table AI.1. The criteria for exclusion of a substance group are:

Existing and near-future regulatory action on specific chemical groups
Some chemicals or chemical groups on the list are listed for regulatory action, via their presence on the EU Registry of Restriction Intentions. To avoid a policy focus on substances where innovation may already be spurred via restrictions, the study does not explicitly focus on substances on this list. For example, PFAS are currently (as a group) under consultation for a REACH restriction, the outcome of which is expected to lead to many innovations for existing PFAS applications. Therefore, this study does not focus on specific obstacles related to PFAS (where they do not relate to other substance groups that are not yet subject to an upcoming restriction).

How much policy matters for different policy groups
Not every ZZS chemical group, as identified by the RIVM groupings, is equally sensitive to policy instruments specific to innovation. The Annex will show a complete overview of chemical groups with unique challenges that may require more focused study than the generalised approach in this study, in order to design effective instruments. For example, plant protection products are part of the ZZS group but are regulated heavily through EU regulations and national/international strategic goals. This study does not consider this relevant background and therefore does not focus on the specific obstacles for plant protection products[1].

Chemical group size relevance
Some chemical substance groups are known to be used only in very limited quantities. Further, expert knowledge indicates that some of these groups are not particularly relevant for the Netherlands' industry. Therefore, policy instruments that overcome obstacles specific to these groups are not likely to have a significant effect, as there very few to no economic actors whose operations are linked to these substances, and who would then respond to the policy.

Information availability about a substance and its functionalities
To deploy effective and targeted innovation policy in line with the ECHA guideline for Functional Substitution, it is necessary that policy makers have some idea about the industrial and societal functions of chemicals. Unfortunately, for the majority of substances on the ZZS list there is no such specific information.

[1] Given there is a degree of overlap between biocidal and pesticidal products, the results of the study for Biocides may be, to an extent, generalized to the pesticides group. This study does not provide a detailed view on how the suggested instruments for Biocides could also apply to pesticides, given the very specific regulatory complexity for pesticides.

Therefore, when references are made in this study to how a policy instrument could influence the use of a substance, this is necessarily skewed to substances for which some (expert) knowledge is available on use characteristics.

Table AI.1 Group exclusions based on expert knowledge

Substance group	Reasoning
Plant protection products.	Plant protection products (PPP) are not considered to be sensitive to the type of instruments considered by this study for ZZS substances, given the very international nature of innovation activities at large multinationals, and the low price sensitivity and conservative nature of the agricultural sector.
PFAS	A Restriction proposal[1] was submitted to ECHA in January 2023 for a universal restriction of PFAS. As it is not known what type of restrictions may be placed on PFAS in the short-term, PFAS is excluded in this study as the study outcomes for PFAS may no longer be relevant upon publication.
Arsenic, mercury, chromium (VI) compounds	Already heavily restricted and therefore use if heavily controlled. There is no policy driver for innovation away from these substance groups.
Animal medicines	Animal medicines are governed by a wide array of other regulations, and therefore are not considered to be sensitive to the type of instruments considered by this study, similar to plant protection products.
Dioxins, PCBs and dioxin-like compounds	This group is already heavily restricted. Innovation is currently taking place almost solely on methods to further remove dioxins and PCBs from the environment, effluents, or prevent their creation as by-products. It is not expected that an innovation push is needed for this group.

Results of filtering the ZZS list on the remaining ZZS groups (step 1 through 5) in the table below. Table AI.2 shows the number of substances from the entire group that are subject to a particular filter.

Table AI.2 Result of filtering on the ZZS list (ZZS list published as of Summer 2022)

Substance group	1. Not already restricted under REACH	2. Registry of Restriction intentions Exclusion	3. Not used in significant quantities	4. ZZS not an effective policy target (see table 3.1)
(animal) medicines	12/13	12/13	11/13	0/13
petroleum derivatives	532/532	532/532	532/532	532/532
acetamides	5/5	4/5	4/5	0/5
acrylates	8/9	8/9	8/9	8/9
alkylphenols and alkylphenolethoxylates	78/84	78/84	78/84	78/84
aromatic amines	30/43	30/43	23/43	23/43
arsenic and arsenic compounds	14/77	14/77	14/77	0/77
benzidines	4/16	4/16	3/16	0/16
beryllium and beryllium compounds	25/26	25/26	25/26	0/26
boron compounds	30/37	30/37	30/37	30/37
butadienes	5/5	5/5	5/5	5/5
cadmium and cadmium compounds	3/18	3/18	3/18	3/18
chromium (VI) compounds	20/28	20/28	20/28	0/28
dioxines PCBs and dioxine-like compounds	45/46	45/46	45/46	0/46
phenols	26/27	26/27	24/27	24/27
formamides	5/6	5/6	4/6	0/6
phtalates	19/23	19/23	18/23	18/23
brominated flame retardants	27/32	26/32	24/32	24/32
chlorinated benzenes	11/12	11/12	9/12	9/12
chlorinated and brominated hydrocarbons	50/54	46/54	41/54	41/54

[1] PFAS restriction proposal | RIVM

Substance group	1. Not already restricted under REACH	2. Registry of Restriction intentions Exclusion	3. Not used in significant quantities	4. ZZS not an effective policy target (see table 3.1)
fragrances	20/20	20/20	18/20	0/20
pesticides and biocides	87/87	87/87	87/87	34/87
glycol ethers	11/11	11/11	9/11	9/11
hydrazines	23/23	23/23	23/23	23/23
pigments and azodyes	13/20	13/20	11/20	11/20
cobalt compounds	17/20	12/20	12/20	12/20
mercury and mercury compounds	30/36	30/36	30/36	0/36
lead and lead compounds	46/163	46/163	46/163	46/163
mineral fibers	9/15	8/15	8/15	8/15
nickel and nickel compounds	10/125	10/125	10/125	10/125
nitrotoluenes	8/8	7/8	6/8	0/8
nonylphenols and nonylphenolethoxylates	1/1	1/1	1/1	1/1
ungrouped substances	138/146	134/146	121/146	121/146
organosilicon compounds	1/1	1/1	1/1	0/1
organostannic compounds	21/21	21/21	21/21	0/21
epoxides oxiranes	6/6	6/6	5/6	5/6
PFAS	82/88	43/88	40/88	0/88
polychlorinated naphtalenes (PCN)	7/7	7/7	7/7	7/7
polycyclic aromatic hydrocarbons (PAHs)	38/46	28/46	28/46	28/46
coal derivatives	130/139	130/139	130/139	130/139
toluidines	2/2	2/2	2/2	2/2
total substances	1649	1583	1537	1208

I.2 Active biocidal substances- Substances most urgent and promising to address

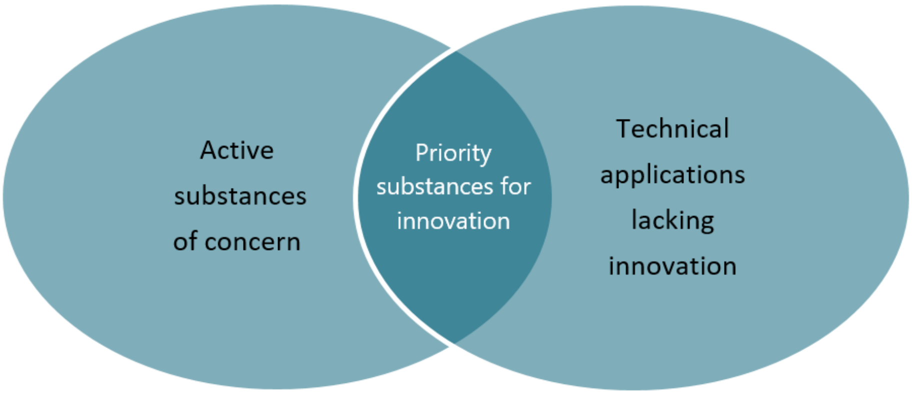
To identify the priority hazardous substances/substance groups which are used in applications which could benefit from innovation to develop less-hazardous alternatives a series of filtering steps were devised and collated to highlight areas for opportunity.

The following data sources were used for this analysis:
- ECHA's list of approved (or under review) active substances and list of biocidal products authorised on the EU/EEA market[1].
- Articles and literature located via key word searched on platforms such as google scholar, science direct and the royal society of chemistry journals.
- Publicly available patent activity data located via keyword, classification, and jurisdiction searches.
- And internal and external expert opinion.

Two approaches were employed, one to locate the active substances of concern and the second to locate the technical areas which could benefit from innovation. The results from these two approaches were then brought together to highlight the specific substances/substance groups of interest.

[1] ECHA (2023) Information on biocides - ECHA (europa.eu)

Figure AI.1 Diagrammatic display of the properties of interest to locate priority substances for innovation



When looking at the role of innovation in the biocide sector to reduce the impact or use of hazardous substances there are four main approaches:
- Reduction in use, including concentration reduction, complimented by alternative technical methods to reduce the need.
- Replacement of the biocide with non-chemical alternative methods.
- Use of alternative less-hazardous active substances.
- Or mitigation of the impacts of the active substance via remediation or filtration techniques, amongst others.

In this assessment we have focused on the development of alternative less-hazardous active substances as, from analysis of literature activity, this is the approach which requires the most stimulation. Innovation towards using integrated pest management, reduction in biocide use, and mitigation methods can be seen in recent literature however the development of new active substances has been described as an issue by industry and academia[1, 2, 3, 4].

Step 1A – Identification of the active substances of concern

To identify a select list of active substances the following refinements were used:
- Active substances detected in the environment as reported in literature.[5,6.]
- Active substances reported to have properties of concern according to ECHA.[7]
- Active substances which are approved or under review.
- Active substances used in biocidal products sold on the NL market.

This approach resulted in 11 active substances of interest. The key identification information (name, CAS and chemical group), information on the biocidal use (the product type PT) and the key properties of concern can be seen in Table AI.3. These 11 substances were located due to their properties of concern, as listed, but also due to being detected contaminants in nature as reported in recent literature.

1 Garvey et al. (2022)Effectiveness of front line and emerging fungal disease prevention and control interventions and opportunities to address appropriate eco-sustainable solutions. Available from: https://doi.org/10.1016/j.scitotenv.2022.158284

2 Lundqvist et al. (2019) Innovative drinking water treatment techniques reduce the disinfection-induced oxidative stress and genotoxic activity, Water Research, Volume 155, https://doi.org/10.1016/j.watres.2019.02.052

3 Klug et al. (2022) A review of nonlethal and lethal control tools for managing the damage of invasive birds to human assets and economic activities. Available from : MBI_2023_Klug_etal_correctedproof.pdf (reabic.net)

4 AISE (2015) Microsoft Word - AISE_EBPF Survey BPR 2015 - Report - Final (biocidesforeurope.org)

5 Sjerps et al (2019) Occurrence of pesticides in Dutch drinking water sources Available from: https://doi.org/10.1016/j.chemosphere.2019.06.207

6 Buijs et al (2022) Presence of pesticides and biocides at Dutch cattle farms participating in bird protection programs and potential impacts on entomofauna. Available from: https://doi.org/10.1016/j.scitotenv.2022.156378

7 ECHA n/a Substance search. [online] Available from: Search for Chemicals - ECHA (europa.eu)

Table AI.3 List of identified active substances of concern located via literature[1] and due to their properties of concern

Name	CAS	Description	PT Type	Key properties of concern Human Health	Key properties of concern Environment
5-Chloro-2-methyl-2H-isothiazol-3-one (CIT)	26172-55-4	Isothiazolinone	PT06	Acute Tox. 2 Skin Corr. 1b Skin Sens. 1 Eye Dam. 1	Aquatic Acute 1
Bendiocarb	22781-23-3	Carbamate	PT18	Acute Tox. 2	Aquatic Acute 1 Aquatic Chronic 1
Brodifacoum 4-hydroxy-3-(3-(4'-bromo-4-biphenylyl)-1,2,3,4-tetrahydro-1-naphthyl)coumarin	56073-10-0	4-hydroxycoumarin vitamin K antagonist anticoagulant	PT14	Repr. 1A- Toxic to Reproduction Acute tox. 1 STOT RE 1	Aquatic Acute 1 Aquatic Chronic 1
Bromadiolone	28772-56-7	4-hydroxycoumarin vitamin K antagonist anticoagulant	PT14	Repr. 1B - Toxic to Reproduction STOT RE 1 Acute tox. 1	Aquatic Acute 1 Aquatic Chronic 1
Fipronil	120068-37-3	Phenylpyrazole	PT18	STOT RE 1 Acute Tox. 3	Aquatic Acute 1 Aquatic Chronic 1
imidacloprid	138261-41-3	Neonicotinoid	PT18	Acute tox 3, Aquatic acute 1, Aquatic chronic 1	
N,N-diethyl-meta-toluamide- DEET	134-62-3	n/a	PT19	Skin Irrit. 2 Acute tox. 4 Eye Irrit. 2	
Permethrin	52645-53-1	Pyrethroid	PT18 PT08	Skin Sens. 1 Acute Tox. 4	Aquatic acute 1 Aquatic chronic 1
Spinosad	168316-95-8	Spinosyn	PT18	Aquatic acute 1, Aquatic chronic 1	
tebuconazole	107534-96-3	Triazole	PT07 PT08 PT10	Repr. 2- Suspected to be Toxic to Reproduction Acute tox. 4	Aquatic acute 1 Aquatic chronic 1
3-iodo-2-propynylbutylcarbamate (IPBC)	55406-53-6	Carbamate	PT06 PT07 PT08 PT09 PT10 PT13	STOT RE 1 Acute Tox. 3 Eye Dam. 1 Skin Sens. 1	Aquatic acute 1 Aquatic chronic 1

[1] Rorije et al. (2022) Characterization of ecotoxicological risks from unintentional mixture exposures calculated from European freshwater monitoring data: Forwarding prospective chemical risk management Available from: https://doi.org/10.1016/j.scitotenv.2022.153385

Step 1B – Identification of select product types where innovation is low

To identify where innovation is struggling three sources were used and compared: patent data, authorised biocidal product data and expert opinion on biocide usage in the Netherlands.

To determine the patent activity of each product type the following factors were used:
- The total number of relevant active patent families.
- The percentage of the relevant patents that are currently active (not including those that have expired, been withdrawn or are inactive due to other reasons).
- And the percentage of active patents which have been applied for in the last 5 and 10 years.

Those with the resulting lowest scores can be seen in the table below, highlighted in column 2 'Low patent activity'.

Alongside this analysis the number of authorised biocidal products under each product type was assessed. It should be noted that although this is a useful indicator, there are many influences on the number of authorised products other than innovation, including:
- The product type application is niche.
- The product type application has only a few authorised products which are effective and popular.[1]
- And the product type application can be completed via non-biocidal methods (i.e. IPM).

Therefore this score should be used in combination with others and not weighted heavily.

Finally we consulted both internal experts and external experts to provide insights into product types where innovation is needed. Complied from these approaches a scoring was used to prioritise the product types of interest.[2] The higher the score the higher the estimated opportunity for innovation in the product type, this can be seen in Table AI.4.

Table AI.4 List of identified biocidal product types and respective scores according to the estimated opportunity for innovation

PT Type	Low patent activity	Low number of authorised biocidal products	Lack of products according to expert opinion	Low SME innovation according to expert opinion	Resulting score
PT01-Human hygiene	✓	✓		✓	2.5
PT03-Veterinary hygiene	✓			✓	2
PT05-Drinking water	✓	✓		✓	2.5
PT06-Preservatives for products during storage		✓	✓		1.5
PT08- Wood preservatives	✓		✓		2
PT12-Slimicides	✓	✓			1.5

1 PT05 – Drinking water - Innovative drinking water treatment techniques reduce the disinfection-induced oxidative stress and genotoxic activity, Water Research, Volume 155, 2019, https://doi.org/10.1016/j.watres.2019.02.052

2 Scoring approach:
Low patent activity = +1
Low product availability according to expert opinion = +1
Low SME innovation according to expert opinion = +1
Low number of authorised biocidal products = +0.5 (lower score due to uncertainty of the connection of this measure to a lack of innovation)

PT Type	Low patent activity	Low number of authorised biocidal products	Lack of products according to expert opinion	Low SME innovation according to expert opinion	Resulting score
PT14- Rodenticides			✓		1
PT18- Insecticides				✓	1
PT21- Anti-fouling paint				✓	1
PT22 - Embalming				✓	1

Step 2 – Collation of Steps 1A and 1B

From the Table it can be seen that product types PT01-Human hygiene, PT05-Drinking water, PT03-Veterinary hygiene, PT08- Wood preservatives, PT06-Preservatives for products during storage and PT12-Slimicides all received high scores regarding the opportunity for innovation. By combining the PT types of focus in Table A1.4 with the substances of concern in Table A1.3 we can conclude that the following substances are of interest both based on properties of concern and innovation opportunity, in Table AI.5.

Table AI.5 Concluding list of active substances of interest due to their associated hazards and application in product types where there is estimated to be opportunity for innovation

Name	CAS	Description	PT Type	Key properties of concern Human Health	Key properties of concern Environment
5-Chloro-2-methyl-2H-isothiazol-3-one (CIT)	26172-55-4	Isothiazolinone	PT06	Acute Tox. 2 Skin Corr. 1b Skin Sens. 1 Eye Dam. 1	Aquatic Acute 1
Permethrin	52645-53-1	Pyrethroid	PT18 PT08	Skin Sens. 1 Acute Tox. 4	Aquatic acute 1 Aquatic chronic 1
tebuconazole	107534-96-3	Triazole	PT07 PT08 PT10	Repr. 2- Suspected to be Toxic to Reproduction Acute tox. 4	Aquatic acute 1 Aquatic chronic 1
3-iodo-2-propynylbutylcarbamate (IPBC)	55406-53-6	Carbamate	PT06 PT07 PT08 PT09 PT10 PT13	STOT RE 1 Acute Tox. 3 Eye Dam. 1 Skin Sens. 1	Aquatic acute 1 Aquatic chronic 1

From these four active substances CIT and IPBC provide the most useful examples. IPBC is used in two applications where there are opportunities for innovation and carbamates as a chemical group are widely used biocides, this means any analysis of IPBC may be applicable to other carbamate active substances. CIT, although still currently in use, has been widely replaced by an alternative isothiazolinone (BIT)[1].

[1] R Nagorka et al. (2015) Isothiazolone emissions from building products Available from: DOI: 10.1111/ina.12126

This replacement could be seen as a regrettable substitution as one of the main properties of concern for CIT are the sensitising properties, BIT has similar properties of concern with skin sensitising listed as one of many properties of concern by ECHA.[1] Therefore the analysis of CIT may provide insight into how to encourage beneficial substitution with alternatives with fewer, or reduced properties of concern.

1 ECHA 1,2-benzisothiazol-3(2H)-one Substance Information - ECHA (europa.eu)

II

APPENDIX: INNOVATION INSTRUMENTS IN THE NETHERLANDS

Table AII.1 provides an overview of the innovation instruments in place, including fiscal instruments, subsidies and 'investor-linkage' this is linked to the figure shown in Chapter 3.2 of the report.

Table AII.1 Overview of instruments and their scope and type

Afkorting	Long name	Scope	Sector focus (generic or specific?)	Type
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek; These are academic subsidies, not an instrument for firms			
VFF	Vroegefasefinanciering	Start-ups (<5 years), SMEs, academic/HBO/TO2 start-ups	Generic	Loan
PPS-toeslag	Privaat-Publieke Samenwerking-toeslag voor Onderzoek en Innovatie	SMEs, large enterprises, and research institutes	Generic	Targeted subsidy
ECN/TNO	The Netherlands Organisation for applied scientific research: These are academic subsidies, not an instrument for firms			
WBSO	Wet Bevordering Speur- en Ontwikkelingswerk	20.000 Enterprises / year	Sustainable technological innovations (product, production process, or scientific research supporting the innovation)	Environmental Taxes and Charges (tax deduction)
SDE++	Stimuleringsregeling Duurzame Energieproductie en Klimaattransitie	Enterprises and non-profit organisations that aim to put the production plant into operation and to exploit it	Renewable energy	Targeted subsidy
MIT	MKB-Innovatiestimulering Regio en Topsectoren	SMEs	HTSM-ICT, Life Science and Health, Agri and Food, Energy, Water, Logistics, Horticulture and starting materials chemistry, Creative industry, Biobased	Targeted subsidy
I-Krediet	Innovatiekrediet	All enterprises	Technical development product, process, or service and clinical development of medicine/device	Targeted subsidy

Afkorting	Long name	Scope	Sector focus (generic or specific?)	Type
MOOI	Missiegedreven Onderzoek, Ontwikkeling en Innovatie	Enterprises, research institutes, social enterprises	Electricity, built environment, and industry	Targeted subsidy
DEI+	Demonstratie Energie- en Klimaatinnovatie	Enterprises with pilots or demonstration projects	Energy, circular economy, infrastructure, industry, built environment, electricity	Targeted subsidy
VEKI	Versnelde Klimaatinvestering Industrie	SMEs with systems/techniques/devices ready for the market	Energy, waste recycling, local infrastructure, CO_2-reduction	Targeted subsidy
SBIR	Small Business Innovation Research	All enterprises	Generic	Precommercial procurement
BBMKB	Besluit-borgstelling MKB-Kredieten	Enterprises with 250 employees max and stable continuity	Generic	Deposit-refund scheme
GO	Garantie Ondernemingsfinanciering	SMEs Netherlands, St. Eustatius, and Saba	Generic, but not in aqua- and agriculture, financial sector, health sector, and property	State guarantee for loan
Groeifaciliteit	Regeling Groeifaciliteit	SMEs Netherlands, St. Eustatius, and Saba with stable continuity	Generic	State guarantee for loan
DVI	Dutch Venture Initiative	Start ups	Generic	Fund
EIA	Energie-investeringsaftrek	Enterprises	Energy, CO_2 -reduction, sustainability	Deposit-refund scheme
MIA/VAMIL	Milieu-investeringsaftrek	Enterprises, governmental organisation	Waste, nitrogen, mobility, emissions, sustainability, circularity, hydrogen, CO_2-reduction, biobased	Deposit-refund scheme
Innovatiebox	Innovatiebox	Enterprises	Generic	Tax deduction over profit related to innovation
Nationaal Groeifonds (not in Figure 3.2)	Nationaal Groeifonds 2021 - 2025	Enterprises, NGOs, academics, other project organisations	Generic	Targeted subsidy

III

APPENDIX: LONGLIST OF POLICY INSTRUMENTS

As set out in Chapter 3, this study concerns multiple connected problems and drivers with respect to innovation for ZZS and biocidal active substances. Following literature review, a longlist of policy instruments were identified that could contribute to the aim of stimulating innovation.

In order to gain greater insight into the definition and workings of the policy instruments, a data collation framework was employed (Excel table) based on project team experience in longlisting of policy instruments and in part on the framework from Edler, Cunningham, Gok, Shapira (2016), Handbook of Innovation Policy Impact. The exercise covered a number of dimensions including, but not limited to:

- Type of instrument (e.g. fiscal incentive, innovation network policy, regulation, fiscal payment).
- Description.
- Support mechanism (direct/ indirect).
- Design elements, application options and considerations.
- Type of incentive.
- Whether the instrument can be combined with others to address the problems.
- Orientation (demand/supply).
- Goals:
  - Increase R&D spend
  - Skills
  - Access to expertise
  - Improve systematic capability, complementarity
  - Enhance demand for innovation
  - Improve framework
  - Improve discourse.

  Examples from international/ EU/ NL chemicals policy and other sectors.
  - provides a summary of selected outputs of the data collation for the longlist of policy instruments identified in this study.

The initial longlist is shown in Table AIII.1

Table AIII.1 Summarised longlist of policy instruments

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Fiscal incentives for R&D	Tradable permits	MBI that provide allowance or permission to engage in an activity	Manufacturers, importers		NL
Fiscal incentives for R&D	Tax incentives	Concessions in tax codes that mean a conscious loss of government budgetary revenue because they reduce either the tax base (tax allowance) or the tax due (tax credit)	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Availability of funds to scale up promising innovations towards market readiness • Mismatched expectations in investment	NL
Fiscal incentives for R&D	Patent box	Grants lower corporate tax rates on profits generated from patents held in a certain country	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Availability of funds to scale up promising innovations towards market readiness • Mismatched expectations in investment	EU NL
Financial incentive	Deposit-refund	MBI consisting of a combination of a product charge and a subsidy for recycling or proper disposal, generally, with the objective to discourage illegal or improper disposal. Surcharge paid when purchasing products, refund given when returning at end-of -life to approved centre	Consumers	Unclear connection to the problems identified in this study.	EU NL
Direct support to firms	Grants	Direct financial contributions for specific activities that support the policy objectives of the EU or the government	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Availability of funds to scale up promising innovations towards market readiness • Mismatched expectations in investment	EU NL
Direct support to firms	Subsidies	Any measure that keeps prices below market levels, or for producers above market levels, or that reduces the costs for consumers and producers. Opposite of a tax. Provides incentives to use an alternative. Subsidies are current payments aiming to influence levels of production or prices	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Availability of funds to scale up promising innovations towards market readiness. • Mismatched expectations in investment	EU NL
Direct support to firms	Equity financing	Provision of capital to a firm, invested directly or indirectly in return for total or partial ownership of that firm and where the equity investor may assume some management control of the firm and may share the firm's profits	Manufacturers, importers	Unclear connection to the problems identified in this study	EU NL

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Fiscal payments	Pigovian Tax	Any compulsory, unrequited payment to general government levied on tax bases deemed to be of particular relevance. Increases the price of a product, incentivising decreased use. Should reflect the damage caused	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Mismatched expectations in investment • High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	NL
Fiscal payments	Charge/ fee	Compulsory and requited payments to general government or bodies outside of government. Similar to tax but revenues earmarked	Manufacturers, importers	• Higher costs of 'less hazardous' products. • Mismatched expectations in investment • High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	EU NL
Regulation	Regulation of product performance and manufacturing	Government sets requirements for production	Manufacturers, importers	• High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities • Lack of transparency about chemicals in products and/or chemicals used to produce products • There is a perceived limited opportunity for innovation within existing product demands	EU
Regulation	Regulation of product information	Smart regulation that allows freedom to choose technologies but changes the incentive structure	Manufacturers, importers	• Lack of transparency about chemicals in products and/or chemicals used to produce products •	EU
Regulation	Process and usage norms	Government creates legal security by introducing clear rules for the use of innovations	Manufacturers, importers	• Mismatched expectations in investment • Keeping ZZS policy enforceable ('handhaafbaar')	EU
Regulation	Support of innovation-friendly private regulation activities	Government stimulates self-regulation of firms and supports or moderates the process	Manufacturers, importers	• Keeping ZZS policy manageable ('uitvoerbaar') • Push back by industry over government intervention and perceived deteriorating 'commercial attractiveness' of the Netherlands related to policies	EU
Regulation	Regulation to create a final market	Government action creates markets for the use of technologies or set market conditions that intensify demand for innovation	Manufacturers, importers	• There is a perceived limited opportunity for innovation within existing product demands	EU
Policies for training and skills	Policies for training and skills	EMPTY	Manufacturers, importers	• Technological progress to create more and more complex synthetic substances of an unknown risk profile • Lack of transparency about chemicals in products and/or chemicals used to produce products • Lack of consumer confidence in new products that do not have strong chemical active ingredients	EU NL

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Entrepreneurship policy	Entrepreneurship policy	Policies aimed at promoting the emergence of new entrepreneurs and facilitating new business start-ups. This could take the form of entrepreneurship education at academic/school level, or study grants/government promotion for firms to engage their staff in entrepreneurship training.	Manufacturers, importers Academia/ research institutions	• Incumbency of large industry	EU NL
Standardisation and standards	EMPTY	Documents produced by consensus and approved by a recognised body, that provides, for common and repeated use, guideline and characteristics for activities and their results, aimed at achievement of the optimum degree of order in a given context (ISO and IEC, 2004)	Manufacturers, importers	• High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	EU NL
Technical services and advice	Technical services and advice	Technology and innovation advisory services provided directly by specialists to support and stimulate improved business performance through technological modernisation and innovation in products, services and methods.	Manufacturers, importers	• There is a perceived limited opportunity for innovation within existing product demands	EU NL
Regulatory sandbox		No commonly agreed definition exists, regulatory sandboxes can be broadly described as schemes that enable firms to test innovations in a controlled real-world environment, under a specific plan developed and monitored by a competent authority. They are usually organised on a case-by-case basis, include a temporary loosening of applicable rules, and feature safeguards to preserve overarching regulatory objectives, such as safety and consumer protection.	Manufacturers, importers Public authorities	• More fundamental R&D is required on common chemical functionalities that use and emit ZZS • Market focus on drop-in alternatives • There is a perceived limited opportunity for innovation within existing product demands • Technological progress to create more and more complex synthetic substances of an unknown risk profile	EU NL
Policies to support collaboration	Collaborative programmes	Empty	Manufacturers, importers academia/ research institutions public authorities	• More fundamental R&D is required on common chemical functionalities that use and emit ZZZS • Market focus on drop-in alternatives • There is a perceived limited opportunity for innovation within existing product demands • Technological progress to create more and more complex synthetic substances of an unknown risk profile	Eu nl

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Innovation network policies	Network programmes	Publicly supported schemes that aim to promote or enhance collaborative innovation between industry and the science base (laboratories, research institutes and higher education). Can also be between competitors or customers. Support for 'clubs' which exchange information and for activities such as foresight programmes which aim to develop common visions around future oriented R&D networks can be formed (EU Commission 2003) Formal collaboration of partners aiming at increasing the competences and innovativeness of partners to generate innovations. Measures aimed at promoting or sustaining the linkage of firms and/or knowledge producers where the activities concerned are centred on a specific technological or problem-oriented topic for the primary purpose of knowledge and information sharing. Government can act as facilitator for the coming together of value-chain-based networks.	Manufacturers, importers Academia/ research institutions Public authorities	• There is a perceived limited opportunity for innovation within existing product demands	EU NL
Innovation network policies	Knowledge network	Learning through networks	Manufacturers, importers Academia/ research institutions Public authorities	• Incumbency of large industry • There is a perceived limited opportunity for innovation within existing product demands	EU NL
Innovation network policies	Instrument network	Sharing of knowledge on investments	Manufacturers, importers Academia/ research institutions Public authorities	• More fundamental R&D is required on common chemical functionalities that use and emit ZZS • Market focus on drop-in alternatives • There is a perceived limited opportunity for innovation within existing product demands • Technological progress to create more and more complex synthetic substances of an unknown risk profile	EU NL
Innovation network policies	Network cluster	Spatial proximity of firms in clusters. Innovation happens in regions, requires actors to all be in one place	Manufacturers, importers Academia/ research	• More fundamental R&D is required on common chemical functionalities that use and emit ZZS • Market focus on drop-in alternatives	NL

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
			institutions Public authorities	• There is a perceived limited opportunity for innovation within existing product demands • Technological progress to create more and more complex synthetic substances of an unknown risk profile	
Innovation network policies	Regional/ national network	Region to region knowledge exchange via networks, importance of international/ cross-regional networking	Manufacturers, importers Academia/ research institutions Public authorities	• Technological progress to create more and more complex synthetic substances of an unknown risk profile	NL
Innovation network policies	Science-industry network	Scientists and engineers work together	Manufacturers, importers Academia/ research institutions Public authorities	• Technological progress to create more and more complex synthetic substances of an unknown risk profile	EU NL
Innovation network policies	Supply-chain network	Information exchange between suppliers and customers, strategic approach to development	Manufacturers, importers Academia/ research institutions Public authorities Consumers	• High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities • • Higher costs of 'less hazardous' products	EU NL
Innovation network policies	Strategic network	Explores how companies can exercise strategic control over relationships and uses network management in strategic planning	Manufacturers, importers Academia/ research institutions Public authorities	• Mismatched expectations in investment	EU NL
Private demand for innovation	Awareness building measures	Information campaigns, advertising new solutions	Manufacturers, importers consumers	• High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities • Higher costs of 'less hazardous' products	Eu nl
Private demand for innovation	Labels or information campaigns	State supports private marketing highlighting performance or safety features	Manufacturers, importers consumers	• High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	Eu nl
Private demand for innovation	Training and further education	Consumers made aware of innovative products/ possibilities and placed in a position to use them	Manufacturers, importers consumers	• Lack of consumer confidence in new products that do not have strong chemical active ingredients • Lack of transparency about chemicals in products and/or chemicals used to produce products	Eu nl

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Private demand for innovation	Articulation and foresight	Societal groups/ potential consumers given voice in the marketplace	Manufacturers, importers consumers	• Lack of transparency about chemicals in products and/or chemicals used to produce products • High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	Eu nl
Private demand for innovation	User-producer interaction	Government supports companies to include users in innovation activities, organises e.g. Innovation platforms	Manufacturers, importers consumers	• Lack of transparency about chemicals in products and/or chemicals used to produce products • High standards on product functionality and durability, and an unwillingness to accept lower standards or changed functionalities	Eu nl
Technology foresight	Technology foresight	Supports the development of priorities. Looks to the longer term future of science, technology the economy and society to identify areas of research. Serves to implement budgetary, structural or cultural changes.	Manufacturers, importers Academia/ research institutions Public authorities	• There is a perceived limited opportunity for innovation within existing product demands • Market focus on drop-in alternatives	EU NL
Public procurement policies		Purchasing activities carried out by government or public agencies that lead to innovation		• Government as launching customer creating demand for alternatives to certain chemicals	
Pre-commercial procurement		Government define a specific need and award support for related R&D services to product solutions. Purchase of research by a contracting authority, develop of prototype to stimulate innovation at a later stage. Not procurement of goods that already exist	Manufacturers, importers Public authorities	• More fundamental R&D is required on common chemical functionalities that use and emit ZZS • Availability of funds to scale up promising innovations towards market readiness • Technological progress to create more and more complex synthetic substances of an unknown risk profile • No innovation policy is explicitly focused on reducing risk of ZZS	NL
Innovation inducement prizes		Prize given for development of innovative solution. Ex ante prize setting, ex post reward.	Manufacturers, importers Public authorities	• No innovation policy is explicitly focused on reducing risk of ZZS • More fundamental R&D is required on common chemical functionalities that use and emit ZZS • Availability of funds to scale up promising innovations towards market readiness • Technological progress to create more and more complex synthetic substances of an unknown risk profile	NL

Type of instrument	Example	Description	Target population	Problem addressed	Most promising geographical applicability
Voluntary approaches	Overall	All voluntary instruments whereby firms or industries make commitments to improve their environmental performance beyond what the law demands	Manufacturers, importers	• Market focus on drop-in alternatives	EU NL

III.1 Screening methodology

The screening of the longlist of policy instruments was performed using a qualitative scoring of six criteria. See Table AIII.3 for the result of the scoring method on each longlist policy instrument.

Table AIII.2 below provides an overview of the qualitative scoring criteria. The basis for these scores was the literature review carried out in order to create the longlist and study team insights into the operation of the legal framework and objectives at EU and NL level. As the drivers for the ZZS and biocidal active substances are so similar, the screening was carried out once. See Table AIII.3 for the result of the scoring method on each longlist policy instrument.

Table AIII.2 Qualitative screening criteria

Score	Legal feasibility	Technical feasibility	Coherence with baseline policy framework (EU/NL)	Effectiveness	Relevance	Proportionality
1	Significant obstacles for implementation in the EU/NL	Difficult/ unknown issues with implementation, enforcement, monitoring	Not coherent with EU/NL baseline/ unclear	Unlikely to meet objectives/ unclear/ inflexible	Unlikely to address the needs/ unclear	Goes above and beyond what is required/ not proportional/ impacts decision making in a negative way/ unclear
2	May be implemented at EU level, possibility at NL level	Is feasible but not an action that is taken by public authorities. Issues with monitoring/ enforcement	Coherent with some aspects of EU/NL baseline. May conflict/ not support others	Could support the objectives depending on design elements/ flexibility concerns	Can address some of the needs but not all	Could be proportional depending on design elements
3	Can be implemented without major obstacles	Can be implemented, monitored and enforced	Fully coherent	Effective at meeting objectives, flexible and cost effective	Fully addresses the needs	Proportional, meets the objectives without restricting decision making

Table AIII.3 Longlist qualitative screening outcomes

Type of Instrument	Policy instrument	Policy instrum ent	Direct support/ encouragem ent	Legal feasibility	Technical feasibility	Coherence with	Coherence with	Effectiveness	Relevance	Proportionality	Overall conclusion
Fiscal incentives for R&D	Tradable permits	MBI	Encourage ment	2	3	3	3	3	3	3	20
Fiscal incentives for R&D	Tax incentives	MBI	Encourage ment	2	3	2	3	2	2	3	17
Fiscal incentives for R&D	Patent box	MBI	Encourage ment	3	3	3	3	2	2	3	19
Financial incentive	Deposit-refund	MBI	Encourage ment	3	3	3	3	1	1	3	17
Direct support to firms	Grants	MBI	Direct support	3	3	3	3	3	3	3	21
Direct support to firms	Subsidies	MBI	Direct support	3	3	3	3	3	3	3	21
Direct support to firms	Equity financing	MBI	Direct support	2	1	1	1	1	3	2	11
Fiscal payments	Pigovian tax	MBI	Encourage ment	3	3	3	3	3	3	3	21
Fiscal payments	Charge/ fee	MBI	Encourage ment	3	3	3	3	3	3	3	21
Regulation	Regulation of product performanc e and manufacturi ng	Comm and and Control	Encourage ment	2	3	3	3	3	2	3	19
Regulation	Regulation of product information	Regulat ion	Encourage ment	2	3	3	2	2	2	3	17
Regulation	Process and usage norms	Comm and and Control	Encourage ment	2	3	3	3	3	3	3	20
Regulation	Support of innovation-friendly private regulation activities	Regulat ion	Encourage ment	2	3	2	1	1	1	3	13
Regulation	Regulation to create a final market	Comm and and Control	Encourage ment	2	3	3	2	2	3	3	18
Policies for training and skills	Policies for training and skills	Regulat ion	Encourage ment	3	3	3	3	2	2	3	19
Entrepreneurship policy	Entrepreneu rship policy	Regulat ion	Encourage ment	3	3	3	3	2	2	3	19

Type of Instrument	Policy instrument	Policy instrument	Direct support/ encouragement	Legal feasibility	Technical feasibility	Coherence with	Coherence with	Effectiveness	Relevance	Proportionality	Overall conclusion
Standardisation and standards		Information	Encouragement	1	3	3	2	2	2	2	15
Technical services and advice	Technical services and advice	Services	Encouragement	3	2	1	1	1	2	1	11
Regulatory sandbox		Regulation	Direct support	3	3	2	2	3	3	3	19
Innovation network policies	Network programmes	Collaboration	Encouragement	3	3	3	3	2	3	3	20
Innovation network policies	Knowledge network	Collaboration	Encouragement	3	3	3	3	2	3	3	20
Innovation network policies	Instrument network	Collaboration	Encouragement	3	3	3	3	1	1	3	17
Innovation network policies	Network cluster	Collaboration	Encouragement	3	3	3	3	2	2	3	19
Innovation network policies	Regional/ national network	Collaboration	Encouragement	3	3	3	3	2	3	3	20
Innovation network policies	Science-industry network	Collaboration	Encouragement	3	3	3	3	3	3	3	21
Innovation network policies	Supply-chain network	Collaboration	Encouragement	3	3	3	3	2	2	3	19
Innovation network policies	Strategic network	Collaboration	Encouragement	3	3	3	3	2	2	3	19
Private demand for innovation	Awareness building measures	Information	Encouragement	3	2	3	3	2	3	3	19
Private demand for innovation	Labels or information campaigns	Information	Encouragement	2	3	3	3	2	3	3	19
Private demand for innovation	Training and further education	Information	Encouragement	3	3	3	3	2	2	3	19
Private demand for innovation	Articulation and foresight	Collaboration	Encouragement	3	3	2	2	2	3	3	18
Private demand for innovation	User-producer interaction	Collaboration	Encouragement	3	3	2	2	2	3	3	18
Technology foresight	Technology foresight	Regulation	Encouragement	2	3	3	3	1	2	3	17
Public procurement policies		Regulation	Direct support	1	3	1	1	1	2	2	11

Type of Instrument	Policy instrument	Policy instrum ent	Direct support/ encouragem ent	Legal feasibility	Technical feasibility	Coherence with	Coherence with	Effectiveness	Relevance	Proportionality	Overall conclusion
Pre-commercial procurement		Regulat ion	Direct support	1	1	1	1	1	2	2	9
Innovation inducement prizes			Encourage ment	3	3	2	2	2	1	3	16
Voluntary approaches			Encourage ment	2	2	3	3	1	1	3	15

Key for scoring boundaries

Qualitative scoring boundaries	
Low	7-11
Medium	12-16
High	17-21

IV

APPENDIX: IMPACT PATHWAY METHODOLOGY NOTES

The 2013 General Guidance for Cost-Benefit Analysis of the Netherlands Bureau for Economic Policy Analysis and the Environmental Assessment Agency outline a framework to evaluate policy mix options ex-ante. This includes identifying the impacts using methods such as intervention logics, impact pathways and Theory of Change (ToC), then assessing these impacts by performing good practice and consistent cost-benefit analysis (CBA), multi-criteria analysis or other equivalent methodologies.

A CBA or impact assessment approach can be deployed to assess, ex-ante, the potential impacts of detailed policy instruments. The scope of this study has focused on providing overviews of policy mix options and, as such, these are not yet a detailed policy proposal nor is the evidence required to perform such assessments readily available. Thus, a detailed CBA or impact assessment are out of scope for this Study.

In this context, however, the identification and analysis of impact pathways remains a useful tool to gain insight into the potential impacts of each policy mix option. Policy impact pathways are similar and complementary to more developed intervention logics and/or ToC and provide a method for highlighting the ways in which change is expected to occur in our local systems as a result of the potential policy intervention. The scope of this assessment is innovation to reduce environmental impacts and so the impact pathways presented in this study primarily focus on this area, which would be positively affected either through a reduction in emissions via production and manufacturing, or indirectly through a reduction in the use and disposal of a ZZS or biocidal product. Other impacts, including potential policy impacts on economic endpoints are not described, except for the intermediate economic processes or pathways that lead to the targeted environmental impacts.

As established in Chapter 3, the illustrated innovation pathways may not occur often enough in the context of the Dutch chemical industry and for manufacturers who use ZZS or biocidal active substances in their products. This could either be because innovation activities (red colour in the Figure) are not sufficiently started, or there is not enough collaboration (arrow 1, hypothesis 1), or the step from innovation to the market is not happening sufficiently (arrow 2, hypothesis 2).

To understand how these policy interventions could contribute or deliver the impact pathway illustrated in Figure 3.2, specific pathways were constructed in this study using hypotheses of how these policy interventions could influence or change the way specific stakeholders interact or behave, resulting in potential impacts on the environment.

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