

# Solving the BECCS Puzzle

*The Role of Knowledge Brokers in the Science-Policy Interface around BECCS in Sweden*

*Jana Föcker*

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Supervisor: Henner Busch, LUCSUS, Lund University

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## **Abstract**

Negative emissions and bioenergy with carbon capture and storage (BECCS) are seen as important strategies in order to reach climate neutrality by 2045 in Sweden. However, it remains largely unclear to what extent scientific knowledge has contributed to the formulation of the climate neutrality policies. This thesis investigates in what way knowledge brokers act as intermediaries in the science-policy interface (SPI) around BECCS in Sweden. By applying a qualitative mixed-methods approach consisting of desk-based research, a survey, semi-structured interviews, and actor network mappings, three main results were found: 1) Knowledge brokering happens in close collaboration and with great interlinkages between actors, 2) Knowledge transfer goes somewhat directly from science to policy-makers, and 3) Certain factors hinder an evidence-based knowledge transfer. If knowledge brokers fulfil the characteristics of independent intermediaries, they have great potential to transfer knowledge for formulating urgently needed economic incentives and targeted policies for BECCS in Sweden.

**Keywords:** Knowledge Brokers, Knowledge Transfer Process, Science-Policy Interface (SPI), Bioenergy with Carbon Capture and Storage (BECCS), Sweden, Climate Neutrality Strategy

**Word count:** 11'908

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## List of Abbreviations

A	Anonymous
BECCS	Bioenergy with Carbon Capture and Storage
CCS	Carbon Capture and Storage
CDR	Carbon Dioxide Removal
CHP	Combined Heat and Power
EASAC	European Academies Science Advisory Council
EU	European Union
FORES	Forum for Reforms, Entrepreneurship and Sustainability
GHG	Greenhouse Gas
GoS	Government of Sweden
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IVL	Svenska Miljöinstitutet AB
NA	National Academies
NET	Negative Emissions Technology
NGO	Non-Governmental Organisation
R	Independent Researchers
RISE	Research Institutes of Sweden
SDG	Sustainable Development Goal
SPI	Science-Policy Interface
WU	What works units etc



## List of Swedish Institutions with English Translation

### Swedish

Energimyndigheten

Energi Industri

Fossilfritt Sverige

Klimatlag

Klimatpolitiska Rådet

Klimatpolitiska Vägvalsutredningen

Naturvårdsverket

Nordiska Ministerrådet

Regering

Regeringskansliet

Riksdag

Vägen till en klimatpositiv framtid

### English

Swedish Energy Agency

Energy Industry

Fossilfree Sweden

Swedish Climate Act

Swedish Climate Policy Council

Public Inquiry

Environmental Protection Agency

The Nordic Council of Ministers

Swedish Government

Swedish Government Offices

Swedish Parliament

The Pathway to a Climate-Positive Future

# 1 Introduction

Net-zero Greenhouse Gas (GHG) emissions by 2045...

...is the overall aim of the new climate neutrality strategy that Sweden has adopted in 2017 (Regeringskansliet, 2021).

It is scientifically proven that climate change is happening due to anthropogenic activity and its irreversible impacts on the Earth's ecosystems are certain. Reducing global GHG emissions is undoubtedly the most important strategy to combat climate change (IPCC, 2023). However, other mitigation technologies, that remove carbon from the atmosphere have been increasingly discussed as supplementary solutions. Thereby, the Negative Emissions Technology (NET) of Bioenergy with Carbon Capture and Storage (BECCS) is one of the most commonly discussed technologies in research and scientific assessments (e.g. Fajardy & Mac Dowell, 2017; IPCC, 2018). Accordingly, Sweden aims to compensate 15% of the national GHG emissions with supplementary measures, such as BECCS, to reach climate neutrality by 2045 and negative GHG emissions beyond 2045 (GoS, 2020; Regeringskansliet, 2021). However, it stays largely undefined how this goal will be achieved and on what basis this number was formulated. This raises the question how scientific knowledge has fed into the formulation of the climate neutrality policies in Sweden.

Research and science not only reveal the causes and impacts of climate change, but also provide evidence-based knowledge to find solutions to the complex nature of climate change (Martens et al., 2016; Reinecke, 2015). Therefore, science is inevitably for the formulation of targeted climate policies (Hering, 2016; Wittmayer & Schöpke, 2014). Scientific assessments, such as the Intergovernmental Panel on Climate Change (IPCC) reports, have provided a basis and paved the way for setting national and international climate targets, but also emphasised the potential for technical solutions, such as BECCS, to mitigate climate change (IPCC, 2018). However, Gluckman (2018) points out that scientific reports are often not considered by the government, because they are not receptive for its content as scientific knowledge is not translated in a way that is understandable and applicable for decision-makers. This "problem of the discrepancy between scientific outcomes and usable knowledge for policy-making" (Wesselink & Hoppe, 2020, p.2) is referred to as science-policy gap. With science becoming increasingly relevant for the decision-making process, the demand for boundary structures to act as intermediaries and translators, such as so-called knowledge brokers, between science and policy rises (Gluckman, 2018; van den Hove, 2007; Watson, 2005; Wiegleb & Bruns, 2022). Even though the literature emphasises that mediators in the Science-Policy Interface (SPI) have a great potential to

enhance evidence-based climate policy-making (e.g. Hering, 2016; Martens et al., 2016), practical studies about knowledge transferring and knowledge brokers are lacking (e.g. Gluckman et al., 2021; MacKillop et al., 2020). The fact that the translation of newly gained scientific knowledge will be key for formulating directed climate policies to successfully address climate change (Martens et al., 2016), highlights the relevance to conduct research in this field. Furthermore, as of today, not only are economic incentives and targeted policies for BECCS in Swedish politics basically non-existent (e.g. Bellamy et al., 2021; Fridahl et al., 2020), but also the practical implementation of BECCS in Sweden is largely understudied (e.g. Lefvert et al., 2022).

As a contribution to these discussions, this thesis will focus on the theory of knowledge brokers as intermediaries between science and policy and their potential of bridging a potential science-policy gap in the discussion around BECCS in Sweden. The thesis aims to investigate if and how scientific knowledge about the novel technology BECCS has contributed to the formulation of Swedish climate policies and pursues to identify relevant actors in the SPI in Sweden. Moreover, this thesis aims to study the role of BECCS as a climate change mitigation strategy on the way to reach climate neutrality in Sweden.

Accordingly, the following overarching research question and three sub-research questions are answered:

**How is knowledge transferred between science and policy in the case of BECCS in Sweden?**

1. Who are the relevant actors in the policy-making process regarding BECCS in Sweden and how are they linked?
2. What role do knowledge brokers play in the policy-making process regarding BECCS in Sweden?
3. What role do identified actors see for BECCS in the Swedish climate neutrality strategy?

This thesis positions itself in sustainability science, a field that “focuses on the dynamic interactions between nature and society” (Clark & Dickson, 2003, p.8059), studying not only how these two spheres shape one another, but also investigating the complexity of the whole social-ecological system (Clark & Dickson, 2003). Studying the role of knowledge brokers in the SPI around BECCS by applying critical thinking is because of two reasons particularly connected to sustainability science. First, the climate change mitigation strategy BECCS is a technological human activity that interacts with the natural system in order to promote sustainable development, and lies therefore at the heart of sustainability science. Second, Kates et al. (2001) emphasise the aim of sustainability science to connect science and

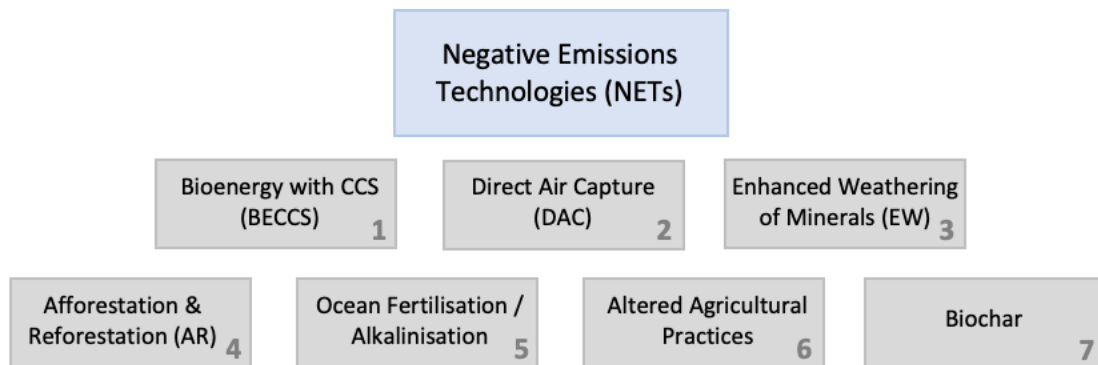
the political agenda in order to push sustainable development, which highlights the need to study the SPI.

## 2 Background

The following chapter introduces the technologies, strategies and the political framework relevant for this thesis.

### 2.1 Carbon Dioxide Removal (CDR) Mitigation Strategies

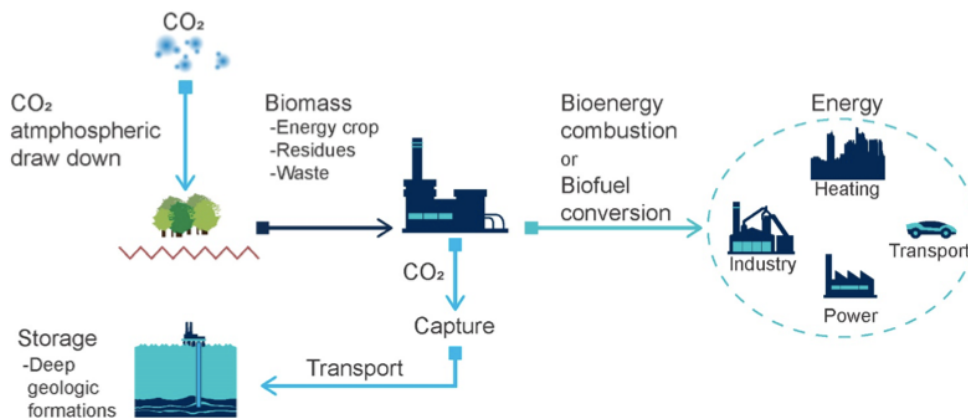
Carbon Dioxide Removal (CDR) refers to the process of removing GHG from the atmosphere. Technologies that use biological or chemical processes to remove GHG emissions are called Negative Emissions Technologies (NET), as they theoretically create a net-negative emission balance (Bellamy et al., 2021; Smith et al., 2015). Smith et al. (2015) group NETs into the following seven categories (see Figure 1):



**Figure 1.** Groups of NET technologies (Source: own visualisation, according to Smith et al., 2015)

Relevant for this thesis is the NET Bioenergy with Carbon Capture and Storage (BECCS). At the basis of BECCS is the technology of Carbon Capture and Storage (CCS) (Fajardy & Mac Dowell, 2017), which “is a process consisting of the separation of CO<sub>2</sub> from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere” (IPCC, 2005, p.3). CCS applied at a plant with biogenic emissions is called BECCS. The fuel for this plant is biomass, coming from organic waste, leftovers from crop or wood production, or from dedicated fast-growing energy crops (EASAC, 2018; Fajardy & Mac Dowell, 2017). At the plant, biomass can either be burnt as a fuel for the generation of heat and power, or the generation of heat for the production of goods such as pulp and paper or cement (see Figure 2). This process is called bioenergy combustion. Alternatively, biomass can be fermented for the production of fuels in liquid or gas form, which is called biofuel conversion. Using biomass as a fuel is considered carbon-neutral and renewable, as it absorbs and stores carbon

from the atmosphere in organic material when it grows (Global CCS Institute, 2019). A BECCS plant can produce negative emissions, as the capturing and storage of carbon avoids the release of already compensated emissions into the atmosphere (Fajardy & Mac Dowell, 2017). The carbon is captured as either flue gas (combustion) or liquidity (conversion), and then transported to its storage site (Fajardy & Mac Dowell, 2017).



**Figure 2.** Process of bioenergy with carbon and capture storage (BECCS) (Source: Global CCS Institute, 2019)

CCS and NETs as climate change mitigation strategies have been rapidly becoming discussed topics in science and politics, particularly starting with the publication of the IPCC special report on Carbon Dioxide Capture and Storage in 2005 (Bäckstrand et al., 2011). The recent IPCC reports emphasise that all pathways aiming to achieve the 1.5° C target set in the Paris Agreement rely on the application of CDR technologies (IPCC, 2018, 2023). In the assessments, BECCS has been identified as the most efficient and promising technology contributing to reach climate neutrality, which puts BECCS in the spotlight of the discussion in research, but also policy (Fuss & Johnsson, 2021; Haikola et al., 2021; Möllersten et al., 2021). The newest IPCC report emphasises the importance of creating supporting policy instruments for CCS and BECCS in order to scale-up the technologies so that they can successfully contribute to climate change mitigation (IPCC, 2023).

Some studies show that BECCS indeed holds great potential as a NET to contribute to reaching climate goals (e.g. Beiron et al., 2022; Lefvert et al., 2022). However, researchers also draw attention to the disadvantages that come with the technology. The most prominently discussed criticism relates to the great land-use demand for biomass production, potentially leading to severe land-use changes impacting ecosystems, food security and livelihoods (Dooley et al., 2022; Fajardy & Mac Dowell, 2017; Fuss & Johnsson, 2021; Smith et al., 2015). A study by European Academies Science Advisory Council (EASAC) (2018) quantifies the required land for BECCS in European countries to be around 1 to 1.7

hectares per tonne of removed CO<sub>2</sub> for biomass sourced from existing forests and residues, and around 0.1 to 0.4 hectares per tonne of specifically grown energy crops. Therefore, a large-scale implementation of BECCS could clash with other sustainability goals, such as biodiversity conservation (Fuss & Johnsson, 2021), or be in competition with other mitigation strategies such as reforestation and afforestation (EASAC, 2018). Furthermore, many researchers point out that as of today BECCS is internationally relatively unexplored in practice at a large-scale (e.g. Fridahl et al., 2020; Haikola et al., 2021). Accompanying uncertainties and the risks of relying on such an unproven technology in practise as an important part of climate mitigation strategies are highlighted by multiple authors (Haikola et al., 2021; IPCC, 2018).

## **2.2 The Swedish Climate Neutrality Policies**

In line with international agreements, the Swedish Parliament introduced a new climate policy framework in 2017, which greatly reforms the country's climate policy (GoS, 2020; Klimatpolitiska rådet, 2022; Regeringskansliet, 2021). The overall long-term goal is to reach net-zero GHG emissions by 2045. Accordingly, national GHG emissions must be reduced by 85 percent compared to the level in 1990. The other 15 percent of emissions from hard-to-abate sectors, such as agriculture, should be compensated with supplementary measures, such as the carbon removal technology BECCS (GoS, 2020; Klimatpolitiska rådet, 2022; Regeringskansliet, 2021). After 2045, Sweden aims to have negative GHG emissions (Regeringskansliet, 2021). Connected to this, a public inquiry (Klimatpolitiska vägvalsutredningen) (see Chapter 5.1.1) has been appointed by the government in 2018. This inquiry was given the task to develop a strategy to reach negative GHG emissions after 2045. As part of this, the inquiry was tasked to investigate the potential BECCS holds for reaching the national's climate goals (Regeringskansliet, 2020). Accordingly, BECCS is supposed to play a significant role in the Swedish climate neutrality strategy.

## **2.3 Current State of BECCS Development in Sweden**

Multiple studies have found that Sweden offers particularly suitable pre-conditions for a successful development of BECCS (e.g. Beiron et al., 2022; Fuss & Johnsson, 2021). Sweden has a great availability of biomass and a strong forest industry (Fuss & Johnsson, 2021; Lefvert et al., 2022). Klimatpolitiska vägvalsutredningen finds that the introduction of BECCS in Sweden does not necessarily need to result in an increased demand for biomass, and is therefore expected to have only little impact on biodiversity and land-use changes (GoS, 2020). In line with this, an assessment by Beiron et al. (2022) finds that the Swedish pulp and paper, and power and heat producing industries already use large

amounts of biomass for their production, and therefore hold great potential to remove biogenic carbon emissions with BECCS. Additionally, Sweden aims to be a forerunner in achieving climate goals, which could potentially help to push the development of new technologies, such as BECCS (Rodriguez et al., 2021).

However, as of today, the technology of CCS and BECCS is not yet established as part of the Swedish energy system. Even though the scientific knowledge about the technology itself is advanced, there is a big knowledge gap about the actual implementation plan of a large-scale rollout of BECCS in Sweden (Lefvert et al., 2022; Rodriguez et al., 2021). The value chain in the case of BECCS is long and complex – from biomass production, to capturing carbon at the burning plant, to transport the carbon until finally storing it at a suitable storage site. This process includes a variety of sites and multiple actors. Consequently, the development of an applicable infrastructure for a large-scale implementation in Sweden requires a high degree of cooperation and collaboration between all included actors (IEA, 2022). In order to store the carbon, Sweden plans to collaborate with Norway, as potential storage sites in Sweden are rather limited due to a high regulation of the Baltic water bodies in order to protect the ecosystems (Lefvert et al., 2022). The current plan envisions a transport of the compressed liquid carbon via ships from Sweden to the Norwegian coast. From there, pipelines will transport the carbon to 2600m under the seabed, where it will be stored permanently in geological formations (Northern Lights, n.d.). These operations will be undertaken by Gassnova, the Norwegian state company responsible for CCS, in a public-private partnership collaboration with the business Northern Lights (Gassnova, 2022; Northern Lights, n.d.).

Currently, there are neither specific policies, nor greatly evolved economic incentives for BECCS fully implemented in Sweden. However, for a successful and sustainable development the emergence of both of these is crucial (Fridahl et al., 2020; Zetterberg et al., 2021). BECCS depends on large public and private funding to be realised (Lefvert et al., 2022). A study by Rodriguez et al. (2021) shows that in order to make investments attractive for companies and the implementation of BECCS feasible, the targets and policy conditions around BECCS have to be clearly formulated (Rodriguez et al., 2021). Recently, the government has decided financial resources for the development of a reversed auctioning system for BECCS, which is a first incentive for the development of NETs (e.g. Klimatpolitiska rådet, 2022).

To sum up, the technology holds a great potential in Sweden, but comes with various disadvantages and uncertainties, which have to be targeted directly in the implementation process of BECCS and its governance.

### 3 Theory

The following chapter introduces the theoretical framework for this thesis, the SPI and knowledge brokers. This framework can help to identify relevant actors in the SPI and how scientific knowledge has been transferred into policies in the case of BECCS in Sweden.

#### 3.1 Science-Policy Interface (SPI)

Science provides a reliable knowledge basis to address societal challenges and is consequently closely connected to society and the environment (Zetterberg et al., 2019). Research and scientific evidence are therefore relevant components in political decision-making (Gluckman et al., 2021; Hering, 2016; van den Hove, 2007). In order to be successful, sustainability transitions need to rely on knowledge from various disciplines (Wittmayer & Schöpke, 2014). However, the flipside of this great variety of available information is a complex science advisory ecosystem. The term science advisory ecosystem refers to a system with plural organisations, such as academies, committees, science advisors, researchers and many more, and multiple values that are influencing the policy processes (Gluckman et al., 2021). Gluckman (2018) categorised the great number of actors in the science advisory ecosystem into four roles/categories: knowledge generators, knowledge synthesisers, knowledge brokers, and knowledge communicators (see Table 1 below). The author has classified the relevant actors into these roles and stated their importance for each role. The importance is indicated with a + in Table 1; the more +, the more important the actor is for the role (Gluckman, 2018; Gluckman et al., 2021).

First, there are the knowledge generators, scientists within universities or research institutes. Second, there exist knowledge synthesizers, who collect knowledge from various disciplines and eventually evaluate and summarise the aggregated evidence about existing scientific knowledge. An example of a synthesis is a literature review. Third, the knowledge brokers aim to translate the synthesised knowledge for policy makers. Fourth, there are the science communicators (Gluckman, 2018; Gluckman et al., 2021). As shown in Table 1, actor groups take up multiple roles in a system. Knowledge brokers for example are in most cases also knowledge synthesizers and even science communicators (Gluckman et al., 2021). This thesis will focus on knowledge brokers, as will be elaborated later.



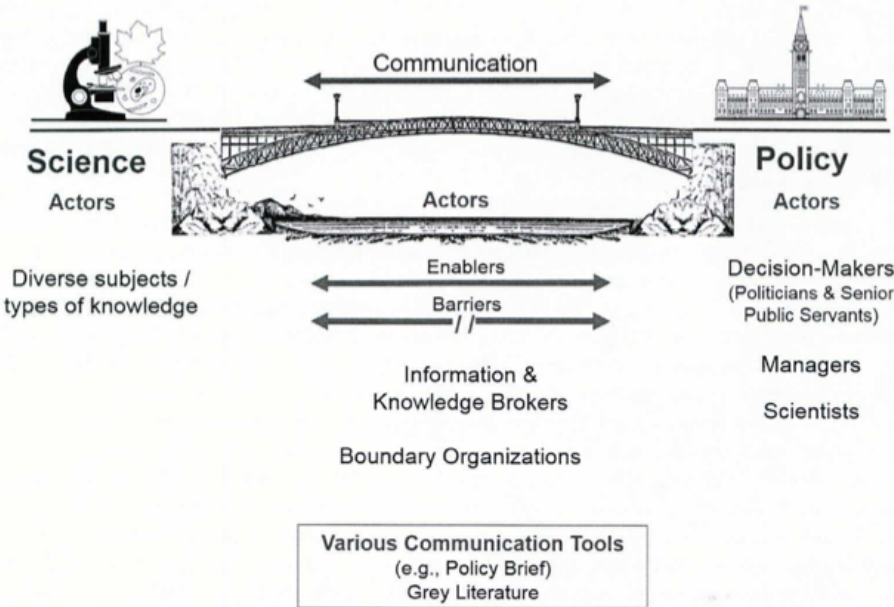
**Table 1.** Roles of different actors within science advisory ecosystem (Source: Gluckman et al., 2021)

<b>Table 1 Highlights the roles of different actors within science advisory ecosystems.</b>				
<b>Different roles in a science advisory ecosystem</b>				
	<b>Knowledge generators</b>	<b>Knowledge synthesizers</b>	<b>Knowledge brokers</b>	<b>Science communication</b>
Individual academics	+++	++		++
Academic societies/professional bodies		++		++
Government employed practicing scientists	+++	+		
Scientist within regulatory agency	+	++	+	
Independent think tanks		+++	+	+
What works units etc.		+++	+	++
National academies		+++	++	+++
Government advisory boards/science councils		++	+++	++
Science advisors to executive of govt		++	++++	++
Science advisors to legislators		+	++	

As Watson (2005) emphasises, the topic of climate change is an ecosystem of particular complexity. Discussions around climate change involve a variety of actors from government to the private sector, to NGOs, to academic institutions and more, and are carried out at different local, national and global levels. Additionally, the global nature of the phenomenon of climate change requires an involvement of all interacting social and political forces in order to formulate policies and real-life practices that can deal with such a multi-level challenge (Watson, 2005).

Even though greatly interlinked, science and policy have to be seen as two separate parts of society with their each own characteristics and culture (Gluckman, 2018; Wiegleb & Bruns, 2022). In an ideal case, science is the producer of information and policy is the user of this information (MacDonald et al., 2015). However, in reality the connection between science and policy is neither a natural, nor a linear process (Gluckman et al., 2021). Scientific knowledge is often not successfully translated into information that can be understood and used by policy-makers. This phenomenon is referred to as science-policy gap (Wesselink & Hoppe, 2020). The SPI aims to bridge this gap and to connect science and policy (Van den Hove, 2007) by creating a system where scientific knowledge is made available and applicable for policy-makers (Gluckman, 2018). Van den Hove (2007) defined SPI's as "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and join construction of knowledge with the aim of enriching decision-making" (van den Hove, 2007, p.824). The SPI is a highly compound system. Firstly, the science part is characterised by a variety of different types of knowledge, e.g. natural science, social science, and traditional knowledge (MacDonald et al., 2015). Secondly, as shown by Gluckman (2018), policy itself is not a cycle but rather a non-linear complex system with multiple organisations, influences and direction flows. Thirdly, the components of the interfaces, such as actors or jurisdictions, are not persistent but can change over time (MacDonald et al., 2015). MacDonald et al. (2015) visualise the SPI as a bridge that connects science with policy (see Figure 3). While communication has the potential

to connect both sides, multiple barriers and enablers can influence the knowledge transfer by allowing or hindering the process. The communication and translation of information can go both ways, either from scientific knowledge to policy or from political knowledge to science. Organisations and individuals that aim to communicate and translate knowledge and act as a boundary function between science and policy are described as boundary organisations or knowledge brokers (Gluckman et al., 2021; MacDonald et al., 2015). Knowledge brokering can either happen in a boundary organisation or by a distinct actor (Hering, 2016). This thesis focuses on the theoretical framework of knowledge brokers as a boundary function.



**Figure 3.** Science-Policy Interface(s) (SPI) (Source: MacDonald et al., 2015)

The Intergovernmental Panel on Climate Change (IPCC) is an example of an established boundary structure at the international level, that translates and provides scientific knowledge for policy-makers (Van den Hove, 2007).

**3.2 Knowledge Brokering and Knowledge Brokers**

MacKillop et al. (2020) describe the literature on knowledge brokering as “varied and confused” (MacKillop et al., 2020, p.336). There is little knowledge about the practical application of knowledge brokers, the influencing components and their impacts (MacKillop et al., 2020).

Whereas multiple definitions of knowledge brokering exist in the literature, most authors refer to the process of transferring and translating knowledge and evidence through intermediaries, so-called knowledge brokers, from science to policy (Gluckman et al., 2021; Hering, 2016; MacKillop et al., 2020;

Reinecke, 2015; Wittmayer & Schöpke, 2014). Very simplified, knowledge brokers are the ones “who have to translate that science to the policymaker” (Gluckman, 2018, p. 98). Thereby, knowledge brokers take up an active role of supporting decision-makers with transparent, reliable and trusted information in an informative but not prescriptive way. For a successful linkage, these intermediaries need to be led by transdisciplinarity and make sure that both parties are understood in terms of language but also cultures (Gluckman et al., 2021).

The theory of knowledge brokering in the SPI has evolved relatively recently with the publication of the book ‘The Honest Broker’ by Pielke in 2007, after which the theory evolved widely in connection with science advise for policy (Gluckman et al., 2021). The concept finds its origin and is widely spread in health policy. A literature review by Gluckman et al. (2021) shows that environmental and sustainability topics are the second largest field using this theory. As shown in the previous chapter (see Chapter 3.1), Gluckman (2018, 2021) categorise knowledge brokers as one of four different roles of actors in the science advisory ecosystem.

Actors that have been identified as knowledge brokers in sustainability and environmental challenges cover a wide range: From ministries within a government, to international institutions, academic institutes, and research institutes, think tanks, NGOs, private actors involved in the environment, to researchers and the science community itself (MacKillop et al., 2020; Watson, 2005). In Gluckman’s words: “There is an immense number of possible players in this ecosystem” (Gluckman, 2018, p.97). Wittmayer & Schöpke (2014) emphasise the particular importance of this knowledge mediating process of researchers in sustainability transitions.

Several studies have identified different criteria on how to apply the theoretical concept in practice for an effective brokering process in the environmental field (MacKillop et al., 2020; Reinecke, 2015). Three relevant factors are accessibility, relevance and timeliness. To be effective, firstly information has to be relevant for policy, and then has to be translated from scientific language to a form that is understandable for policy-makers. Then, scientific knowledge has to be made accessible at the point in time when policy-maker need it (Hering, 2016). Furthermore, the need to communicate uncertainties and limits of scientific knowledge and to acknowledge the complexity of the topic as a basis to discuss the alternatives is emphasised (Gluckman et al., 2021). Hering (2016) adds the importance of distributing the responsibility of brokering between all involved actors of a science-policy ecosystem to ensure effectiveness. Finally, knowledge brokers have to be included in the institutional structures of research institutions (Hering, 2016), but also be connected to policy institutions (Gluckman et al., 2021).

If the above discussed criteria can be ensured, knowledge brokering has the potential to bridge the knowledge gap between science and policy and “can be a key enabler of evidence-informed policymaking” (Gluckman et al., 2021, p. 9). This way, a wide application of knowledge brokering would be highly beneficial to support environmental decision-making with relevant scientific knowledge about underlying environmental processes (Hering, 2016).

## 4 Methodology

In order to answer the posed research questions, a qualitative empirical mixed-methods approach is applied. Qualitative research gathers and analyses data with the aim to gain an understanding of a specific phenomenon (Bassot, 2022). In line with Bassot (2022), this thesis follows a primary data collection approach, as all methods gather data in its original form.

This thesis follows a critical realism approach, which assumes that the directly observed reality does not reflect the ultimate reality. Critical Realism highlights the importance of studying factors and structures that shape the observed reality, to gain an understanding of the whole system (Bryman, 2012). Accordingly, this thesis studies the underlying structures that influence and shape the knowledge transfer in the SPI around BECCS in Sweden.

### 4.1 Analytical Framework

The basis for this analysis provides the theory of knowledge brokers and its respective actor groups by Gluckman et al. (2021) as already introduced in Chapter 3 (see Table 2). In this analysis the categories of science advisors to executive and legislative of government are taken together to the category *Science advisors of government and parliament*, because decisions by parliament and government are very interlinked in the SPI of BECCS. Also, the framework adds another category, *Others*, for potential actors that are necessary for the knowledge brokering process in the case of BECCS in Sweden. Table 2 shows the categories of knowledge brokers and other relevant actors and their importance (indicated with +), according to Gluckman et al. (2021) as the framework for this analysis.

**Table 2.** Actor Groups in the category of knowledge brokers (the + indicate the importance (the more +, the more important) for the respective actor group according to Gluckman et al. (2021))

(Source: own visualisation, according to Gluckman et al., 2021)

Knowledge Brokers						
1	2	3	4	5	6	7
Science advisors of government & parliament	Government advisory boards / science councils	National academies	Scientists within regulatory agency	What works units etc	Independent think tanks	Others
++++	+++	++	+	+	+	

**4.2 Desk-Based Research**

Desk-based research refers to the process of “gathering qualitative data from existing sources” (Bassot, 2022, p.7), such as websites and policy papers. The aim of this research method in this thesis is to identify and collect information from relevant governmental and policy documents, and to help identify relevant actors, and their roles, interests and influence through their websites. However, desk-based research is limited, as it often only provides a part of the relevant required data (Bassot, 2022). Therefore, the missing data is collected by conducting a survey and interviews.

**4.3 Survey**

An online survey is a form of collecting data in a structured online questionnaire (Bryman, 2012). For the analyses a short online survey was created with the Sunet survey tool, with the aim to identify relevant actors in the SPI around BECCS in Sweden. Respondents were asked five questions about their role in the SPI, connection to BECCS and interlinkage with other actors (see survey construction, Appendix A). The link to the survey, together with an invitation to participate in an online interview, was sent by email to relevant actors, who have been identified through desk-based research. Subsequently, more actors were contacted according to the snowball principle.

In total, fifteen relevant actors responded to the online survey. As most of the respondents are linked to more than affiliation, their most relevant affiliation was used to categorise them into the actor groups (see distribution actor groups, Appendix C1).

#### 4.4 Semi-Structured Interviews

Semi-structured interviews are a form of qualitative data collection, whereby the interview process is rather flexible. An interview guide with a list of questions is leading the conversation, but questions can slightly vary between interviews. The questions are asked in an open way so that the interviewee decides the focus of the answers (Bryman, 2012).

The aim of the interviews is to identify additional actors and documents, and to investigate the role of knowledge brokers in the case of BECCS in Sweden and the role of BECCS itself in the climate neutrality strategy. Potential interview partners were contacted by email together with the survey-link. The semi-structured interviews of this thesis were conducted according to the suggested process by Adams (2015). First, suitable respondents were selected through desk-based research. Then, an interview guide was designed among four segments (see Appendix B1), with several questions within these segments. After the interviews, the collected data was transcribed, coded into main groups and sub-groups, and finally analysed (Adams, 2015). The main groups are as follows: 1) SPI in the case of BECCS, 2) Knowledge transfer process in the case of BECCS, 3) Role of BECCS in the Swedish climate neutrality strategy. The interviewees were asked about their consent to be part of this research (see example consent form, Appendix B2).

The main affiliation of the seven interviewees was classified into the categories of knowledge brokers according to Gluckman et al. (2021), using coded abbreviations of the respective actor groups, as shown in Table 3 below.

**Table 3.** Coded affiliations of interviewees  
(Source: own visualisation, classification according to Gluckman et al., 2021)

Categorisation and coded affiliation of interviewee				
<b>Affiliation</b>	Independent researchers (R)	National academies (NA)	What works units etc (WU)	Anonymous (A)
<b>Actor group</b>	Science advisors of government & parliament	National academies	What works units etc	Anonymous
<b>Number of interviews</b>	2	2	1	2
<b>Codes</b>	R1; R2	NA1; NA2	WU1	A1; A2

## **4.5 Actor Mapping Tools**

Actor mappings can help to understand networks by mapping out the relation and collaboration between actors (Shumate & Cooper, 2021). The actor mapping in this thesis is carried out with two different tools.

The aim of the Actor and Policy Mapping tool is to summarise and visualise relevant actors, policies and initiatives in the SPI around BECCS in Sweden. The climate policy planning tool was designed by the New Climate Institute, and others, to map and visualise actors, policies and the underlying processes (NewClimate Institute, n.d.). The analysis-process of the tool is carried out with Excel, and gathers relevant information, such as area of influence of actor or type of policy instrument. This analysis also includes important initiatives in the SPI around BECCS in Sweden, additionally to policies. The final mapping demonstrates a policy and actor landscape, by visualising the development of policies and initiatives and the links between the elements (NewClimate Institute, n.d.). The results from desk-based research, survey and interviews are used as data inputs for this mapping. As the mapping does not show the level of interlinkages of actors, an actor network mapping is additionally carried out with the Software Cytoscape (Version 3.9.1). This tool visualises interpersonal relationships and aims to identify the most interlinked knowledge brokers and relevant actors in the discussion around BECCS in Sweden. The previously identified actor groups are the elements of the mapping. The information about the interlinkages of the actors stems mainly from the answers of the survey and interviews, and partly from desk-based research.

The two tools complement each other and illustrate not only the development of actors and policies in the SPI around BECCS in Sweden, but also the level of interlinkages of relevant actors.

## **4.4 Scope and Limitations**

As the scope of this thesis is the country of Sweden, only Swedish actors or actors that are directly connected to Swedish policies (e.g. the Nordic Council of Ministers) are considered. This thesis does not include a distinct list of potentially relevant actors, policies and initiatives for the development of BECCS in Sweden. However, the focus lies on knowledge brokers in the SPI around BECCS. Consequently, actors who might be relevant but do not fulfil this role are not included. Also, as described in Chapter 3.1, there exist more potential boundary functions, such as boundary organisation, between science and policy, which are however not considered.

Furthermore, even though multiple methods are applied in this thesis to complement each other, some methodological limitations connected to qualitative research have to be mentioned. Among others, the sampling size is relatively small, and the generalisation of the results must be questioned as they clearly apply to a Swedish context (Bryman, 2012). A sampling bias (Bryman, 2012) cannot be completely excluded, as the respondents of the survey and interview were not randomly selected, but after conducting desk-based research and by snowball sampling. Also, a personal bias (Bryman, 2012) can potentially occur with the somewhat flexible structure of semi-structured interviews.

## **5 Results**

This chapter presents the results of the analyses applying the mixed-methods approach.

### **5.1 Relevant Actors, Policies and Initiatives**

The following actors, policies and initiatives have been identified through desk-based research, a survey and interviews (see detailed results, Appendix C2 and C3).

#### ***5.1.1 Actors, their Role and Influence***

Below, the identified knowledge brokers in their actor groups according to Gluckman et al. (2021), and other relevant actors are shortly introduced. Their role as knowledge brokers and their influence in the SPI around BECCS in Sweden are summarised in Table 4.

##### *Science advisors of government & parliament (++++)*

In this category, several independent researchers from natural and social sciences, such as politics and engineering, have been identified. The researchers are called independent as they translate research independently and/or in an academic setting (universities) on CCS and BECCS in Sweden for policy advice. Additionally, some of the researchers have been appointed by the government as experts advisors, for example members of Klimatpolitiska vägvalsutredningen, or are part of another science council. Many of these researchers also work (partly) at national academies or companies or share their knowledge in think tanks (R1). Furthermore, most of them are funded by national funding agencies (R1). The researchers are defined in this thesis as a group rather than individuals for two reasons. Firstly, their names are not mentioned to respect their privacy. Secondly, the actor analysis



shows that current scientific research on BECCS in Sweden is concentrated on a smaller number of very knowledgeable researchers, who often also collaborate with each other.

#### *Government advisory boards/science councils (+++)*

A group of scientists who provide advice to the government, is called a government advisory board or science council, whose members are independent experts from various disciplines. A very important science council for this thesis is the Klimatpolitiska vägvalsutredningen, a group of experts from various agencies, such as ministries, businesses but also from civil society, who have been appointed by the government in 2018 (Klimatpolitiska Vägvalsutredningen (M 2018:07), 2018). According to one of the expert advisors the composition of this inquiry “was really trying to reflect the fact that this (BECCS) is a (...) topic that stretches across many different sectors and involves many different types of perspectives and actors and stakes in designing these kinds of policies” (R1). Another important science council, the Klimatpolitiska rådet (Swedish climate policy council) was funded as part of the climate policy framework in 2017. The council is asked to write a yearly report and a respective action plan about the progress of the government in climate policy (Klimatpolitiska rådet, n.d.; Regeringskansliet, 2021). The latest of the council’s yearly reports (Report 2023) was just released on the 29<sup>th</sup> of March 2023 (GoS, 2020). The Nordiska Ministerrådet (The Nordic Council of Ministers) is an international council for inter-governmental co-operation of the Nordic countries, appointed by the prime ministers of the Nordic countries in the Declaration on Nordic Climate Neutrality (Nordic Co-operation, n.d.-b, n.d.-a). This declaration states that the overall goal of the Nordic countries is “to become the most sustainable and integrated region in the world by 2030” (Nordic Co-operation, n.d.).

#### *National academies (++)*

National academies are independent institutions with the purpose to provide scientific advice to policy-makers. They collaborate closely with a variety of actors of industry, academia, the public sector, and also government authorities. While all identified national academies are independent, their funding varies from state-owned (RISE), to partly state-owned (IVL), to business owned (Energiforsk), to business and university owned (Chalmers Industriteknik) (Arnold et al., 2007; Chalmers Industriteknik, n.d.-b; Energiforsk, n.d.; IVL, 2023; RISE, n.d.-b, n.d.-a). Nordic energy research follows a Nordic perspective authorised by the Nordic Council of Ministers (Nordic Energy Research, n.d.).

#### *Scientists within regulatory agency (+)*

A regulatory agency is a governmental body that carries out tasks appointed by the government. By doing so the agencies not only implement environmental policies, but also develop them. Consequently, scientists who work within these agencies are translating and communicating

knowledge in order to carry out policies. In line with the climate neutrality strategy, Energimyndigheten (Swedish Energy Agency) has been chosen to be the national centre responsible for the planning, promotion and coordination of CCS and BECCS. This task has to be carried out in close collaboration with multiple actors, such as governmental authorities and industry (Swedish Climate Policy Council, 2022; Swedish Energy Agency, 2022). The results of the survey state that Energimyndigheten is, besides the government, the most important actor in the development of BECCS in Sweden (survey). Naturvårdsverket (Environmental Protection Agency) is the governmental agency for environmental issues, responsible for specific tasks in the development of CCS and BECCS (Naturvårdsverket, n.d.-a, n.d.-b). Fossilfritt Sverige was initiated in 2015 by the Swedish Government in order to push the climate transition. The initiative is part of the Swedish Government Offices (GoS), with the aim to act between policy and the business sector (Fossilfritt Sverige, n.d.; NA2). Furthermore, in the case of BECCS independent researchers from outside the agencies are doing commissioned work for agencies, especially Energimyndigheten (R1).

#### *What works units etc (+)*

To this category belong actors, who conduct and synthesise research as individuals or in a group within an organisation. Within the Swedish Energi Industri, researchers carry out studies and pilot projects about BECCS in energy companies (survey). An example of an energy company is Stockholm Exergi, who has opened a pilot and research plant in 2019 with the goal of implementing a large-scale application of BECCS at the existing power and heat bioenergy facility. Stockholm Exergi plans to remove up to 0.8 Mt CO<sub>2</sub> emissions per year, and aims to be an international frontrunner of the BECCS technology (Beccs Stockholm, n.d.; Stockholm Exergi AB, n.d.). The whole Energi Industri is considered in this thesis as one actor group and not as individual companies, as at this stage not many companies are already implementing BECCS in practice, but are discussing and considering the technology. Additionally, all these companies follow a similar purpose of continuing doing their business, while adapting to emerging challenges, such as climate change (e.g. Lefvert et al., 2022). Two relevant consultancy agencies in the case of BECCS are CIT Renergy and Profu AB (Chalmers Industriteknik, n.d.-a; CIT Renergy, n.d.; Profu AB, n.d.). Another actor of this category is Klimpo, an independent interest organisation, or as they describe themselves “a forum for climate positive and carbon sinks” (Klimpo, 2023). Klimpo represents the interests of their members, mainly BECCS companies, when trying to influence policy-makers (NA1, WU1). These actors have been identified to be relevant, as they have been mentioned multiple times in interviews and the survey. There exist more consultancies, such as hallvarsson & halvarsson, and interest organisations, such as Energiföretagen Sverige (Swedenergy AB), that potentially play a role in the discussion around BECCS in Sweden. However, they have not been identified as knowledge brokers in the scope of this thesis.

### *Independent think tanks (+)*

A think tank is an independent organisation supporting interdisciplinary research with the aim of providing policy advice. Fores (Forum for reforms, entrepreneurship and sustainability) is such an independent and non-profit think tank with a green and liberal orientation. They describe themselves as an actor, who links entrepreneurs, policy-makers, citizens, opinion makers and researchers (Fores, n.d.).

### *Additional relevant actors*

In addition to these identified knowledge brokers, the analyses highlight two additional actor groups that are relevant as they are fundamental for the work of knowledge brokers. Firstly, the government (Regering), with parliament (Riksdag) and the Swedish Government Offices (Regeringskansliet), has been mentioned to be one of the most important actors in the SPI around BECCS (survey). These institutions decide and make policies and national regulations, such as the climate neutrality strategy. Accordingly, they set the foundation for the whole SPI around BECCS (Regeringskansliet, n.d.). Secondly, funding agencies fund the work of independent researchers and projects, and therefore make research and the development of CCS and BECCS possible (R1). For the SPI around BECCS two big funders, Formas (Government Research Council) and Vetenskapsrådet (Swedish Research Council), are important, besides funding from the national centre for CCS at Energimyndigheten. Furthermore, research institutes, such as Energiforsk, fund research about BECCS in Sweden (survey). In their role, funding agencies work closely together with governmental bodies and researchers, but also with other actors such as industry and civil society (survey).

**Table 4.** Results analysis knowledge brokers and other relevant actors in the Science-Policy Interface (SPI) around BECCS in Sweden (the + indicate the importance (the more +, the more important) for the respective actor group according to Gluckman et al. (2021)) (Source: own visualization; results interviews, survey and desk-based research)

Knowledge Brokers in the science-policy interface (SPI) around BECCS in Sweden			
	Actor	Role as Knowledge Broker	Influence
<b>1</b> Science advisors of government and parliament (++++)	Independent researchers & experts providing knowledge for the government	Translate and share research to provide evidence-based policy-advice about BECCS (reports, self-driven investigations, or similar)	<ul style="list-style-type: none"> <li>• Direct advisors to policy-makers</li> </ul>
<b>2</b> Government advisory boards / science councils (+++)	Klimatpolitiska vägvalsutredningen (M 2018:70) (Public inquiry)	Translate existing knowledge about supplementary measures, such as BECCS, in order to propose a strategy to reach the goals of negative emissions after 2045	<ul style="list-style-type: none"> <li>• Proposing a strategy on behalf of the government, direct advice to policy-makers</li> </ul>
	Klimatpolitiska rådet (Swedish climate policy council)	Provide independent evaluation of how the government's climate policy is aligned with the overall climate goals of the climate policy framework	<ul style="list-style-type: none"> <li>• Part of Sweden's climate policy framework, direct evaluation of the policy-makers work</li> </ul>
	Nordiska ministerrådet (The Nordic Council of Ministers)	Proposing a strategy for how to cooperate and reach climate neutrality in all 5 Nordic countries (Sweden, Norway, Denmark, Finland and Iceland)	<ul style="list-style-type: none"> <li>• Proposing a strategy on behalf of the Prime Ministers of the Nordic countries, direct advice to Nordic policy-makers</li> </ul>
<b>3</b> National Academies (++)	IVL Svenska Miljöinstitutet AB	Initiate, coordinate, translate and communicate research and projects in the field of BECCS in a Swedish and Nordic context	<ul style="list-style-type: none"> <li>• Provide evidence-based synthesised knowledge to inform policy and industry</li> </ul>
	RISE Research Institutes of Sweden		
	Energiforsk		
	Chalmers Industriteknik		

	Nordic Energy Research	Initiate, coordinate, translate and communicate energy research (incl. BECCS) and policy development in the Nordic countries	<ul style="list-style-type: none"> <li>• Research under Nordic Council of Ministers, connection to policy-makers of Nordic countries</li> </ul>
<b>4</b> Scientists within regulatory agency (+)	Scientists at Energimyndigheten (Swedish Energy Agency)	Coordination and promotion of CCS and BECCS in Sweden	<ul style="list-style-type: none"> <li>• National CCS &amp; BECCS centre, carries out national policies by order of the government</li> </ul>
	Scientists at Naturvårdsverket (Environmental Protection Agency)	Will be responsible for assessments of the process of separation of carbon and potential storage sites for CCS and BECCS technologies	<ul style="list-style-type: none"> <li>• Referral authority for CCS &amp; BECCS storage sites, carries out national policies by order of the government</li> </ul>
	Fossilfritt Sverige	Plans national strategy for BECCS	<ul style="list-style-type: none"> <li>• Directly connected to the government, direct advisor by making political proposals</li> </ul>
	Independent researchers from outside the agencies doing commissioned work	Translate and share research and knowledge about BECCS in form of commissioned work for regulatory agencies as policy advice	<ul style="list-style-type: none"> <li>• Direct advisors to governmental body, which develops and implements environmental &amp; energy policies</li> </ul>
<b>5</b> What works units etc (+)	Researchers within Energi Industri	Translate research and development-projects about CCS and BECCS for policy-makers	<ul style="list-style-type: none"> <li>• Translate research about CCS &amp; BECCS in the industry sector</li> </ul>
	CIT Renergy	Provide expertise, conduct research and translate knowledge around CCS and BECCS	<ul style="list-style-type: none"> <li>• Translate expertise about CCS &amp; BECCS in the business sector and as consultancy</li> </ul>
	Profu AB		
	Klimpo	Organise networking events for BECCS, some kind of lobbying for BECCS	<ul style="list-style-type: none"> <li>• Collaborate with policy-makers, try to influence policy-making process</li> </ul>
<b>6</b> Independent think tanks (+)	Fores	Bring together researchers from various disciplines to translate knowledge and support discussions around CCS and BECCS	<ul style="list-style-type: none"> <li>• Provide advice for policy-makers on BECCS topics, aim to influence policy-making process</li> </ul>

Other relevant actors (7)			
Riksdag (Parliament) & Regering (Government)		No knowledge brokers, but create the environment and legislation for the development of BECCS in Sweden	<ul style="list-style-type: none"> <li>Responsible decision-making and policy-making bodies for BECCS</li> </ul>
Regeringskansliet (Swedish Government Offices)	Klimat- och näringslivsdepartementet (former Miljödepartementet)		<ul style="list-style-type: none"> <li>Responsible governmental department for BECCS</li> </ul>
Funding agencies	<ul style="list-style-type: none"> <li>Vetenskapsrådet (Swedish research council)</li> <li>Formas (Government Research Council)</li> <li>Energimyndigheten (national centre for CCS)</li> <li>National Academies</li> </ul>	No knowledge brokers, fund research about BECCS	<ul style="list-style-type: none"> <li>Enable governmental and non-governmental research</li> </ul>

### **5.1.2 Policies and Initiatives**

On a global level, two main policies have shaped the discussion around BECCS. First, the overall aim of the *Paris Agreement* of 2015 is to limit rising global temperature to maximum 2° Celsius, preferably 1.5° Celsius, by the end of this century. The agreement has been signed by 193 states and the European Union (EU) and includes their commitment to reduce GHG emissions (United Nations, n.d.). BECCS has been increasingly discussed as an important contribution in global pathways aiming to achieve the temperature goals of the Paris Agreement (Fuss & Johnsson, 2021; Möllersten et al., 2021). Sweden's climate policy framework is an important part of the national strategy for achieving the goals of the Paris Agreement (Regeringskansliet, 2021). On an European level, the EU strives to reach climate neutrality by 2050, and the strategy is in line with the goals of the Paris Agreement (European Commission, n.d.). Whereas negative emissions are included in the strategy, the governance of it is currently non-existent at the EU level (GoS, 2020).

On a Nordic level, the *Declaration on Nordic Climate Neutrality (Helsinki Treaty)* is an important document for the development of BECCS. The Declaration was adopted in 2019 by the Nordic Prime Ministers with the goal to increase the cooperation in climate policy. The overall aim is to reach carbon neutrality in all participating countries, and to be a frontrunner in the green transition. Supporting the development of CCS and BECCS technologies has been emphasised in the declaration (Declaration on Nordic Carbon Neutrality, 2019).

The following policies and initiatives have been designed and implemented on a national Swedish level. The *Swedish Climate Policy Framework* consists of three pillars, with a set of ambitious climate goals as the first pillar (GoS, 2020; Klimatpolitiska rådet, 2022; Regeringskansliet, 2021). The second pillar of the framework is the Swedish Climate Act (*Klimatlag 2017:720*), which states the obligation for the government to set a climate policy that acts along the national long-term climate goals. The government is obliged to submit an annual climate report and every four years a climate action plan about the progress to the parliament (Klimatlag (2017:720), 2018; Regeringskansliet, 2021). Klimatpolitiska rådet (Climate policy council) (see actors, Chapter 5.1.1) builds the third pillar of the framework (Klimatpolitiska rådet, n.d.; Regeringskansliet, 2021).

The report *Vägen till en klimatpositiv framtid (SOU 2020:4)* of the Klimatpolitiska vägalsutredningen (see actors, Chapter 5.1.1) has been published in 2020. It proposes a strategy of how to implement a policy and action plan in order to achieve the set goals for supplementary measures in Sweden. BECCS has been identified to play a crucial role in order to meet the goals of negative emissions after 2045.

By 2045, the share of BECCS in the offsetting could lie between 3.0 and 10.0 million metric tons (Mt), CO<sub>2</sub> emissions but at a maximum of 10.7 million Mt CO<sub>2</sub> emissions per year (Fridahl et al., 2020; GoS, 2020).

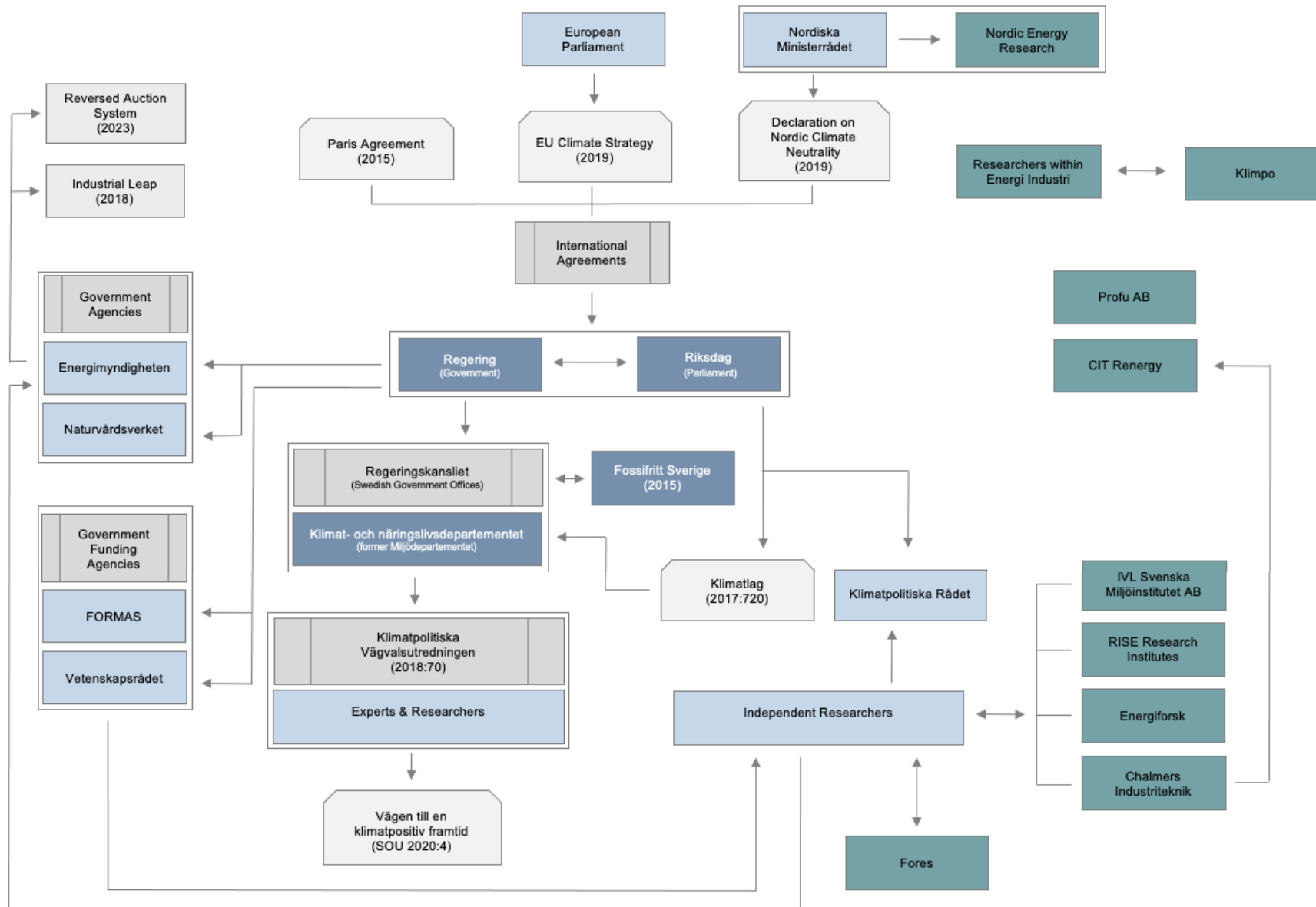
The *Industrial Leap* is a programme that was founded in 2018 by the Government in order to help the green transition of the industrial sector. The responsible agency for the implementation of the initiative is Energimyndigheten (Energimyndigheten, 2023). The funding of the agency allows research on CCS and BECCS and enables pilot projects of companies (NA1).

Energimyndigheten has been appointed by the government to propose a support system for BECCS and is currently collaborating with researchers, IVL, RISE and CIT Renergy, to propose a *reversed auction scheme*. The scheme plans that businesses with biogenic emissions can bid on the amount of CO<sub>2</sub> they will be able to capture and store and the price of it. The plant with the lowest proposed cost wins and their development of BECCS will be supported by the state (Energimyndigheten, 2022; WU1). Accordingly, a state-led demand will be created for the short-term implementation of BECCS. The support system follows the target of capturing a maximum of 10.7 million Mt CO<sub>2</sub> emissions per year with BECCS by 2045 (Beiron et al., 2022; Energimyndigheten, 2022; Fridahl et al., 2020). The funding for the initiative is 36 billion SEK for the period between 2026 to 2046 (WU1).

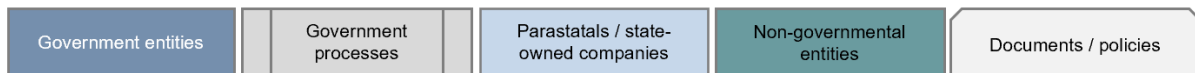
### **5.1.3 Actor and Policy Mapping**

The results of the analyses of relevant actors, policies and initiatives in the SPI around BECCS in Sweden are mapped with the actor and policy mapping tool and shown in Figure 4 below (see also Legend Figure 5).





**Figure 4.** Actor and policy mapping of the policy-making process of BECCS in Sweden (own visualization based on tool of NewClimate Institute, n.d.)



**Figure 5.** Legend of the actor and policy mapping tool  
(own visualization based on tool of NewClimate Institute, n.d.)

## 5.2 The Science-Policy Interface (SPI) around BECCS

It has been pointed out in the interviews that there is a great political will for the development of BECCS in Sweden, but that policymakers “not always (have) so much knowledge about what it takes, (and) about the various opportunities and barriers involved” (NA1). In order to successfully translate knowledge between scientists and policy-makers, the interviewees have pointed out several strategies. Most essentially, interpreters are needed in order to make current knowledge about BECCS understandable for the specific context (NA1). One way of how this can be done, is conducting commissioned work for the government (R2). Further, communicating knowledge is crucial (A2). In order to enhance knowledge exchange, forums, (scientific) conferences, network meetings, and other arenas should be created for involved actors to discuss and meet (R1, WU1). One interviewee also pointed out that the way of creating media and public awareness can influence government decision-making (R2). Such an effort of bridging science and policy in the case of BECCS was creating a network that set a basis for the formation of Klimatpolitiska vägvalsutredningen (R1). Most of the interviewees think that they have the potential to influence policy-making (R1, R2, NA1, NA2, A1).

The results have shown that the SPI in Sweden consists of a nested complex network of actors from various disciplines and roles in society, many of them highly interlinked and in close collaboration (e.g. R1) (compare Chapter 5.5). In these collaborations, actors have different perspectives and follow different interests (WU1).

Especially, a close interaction between researchers and industry has been pointed out (NA1, R2). A great information exchange between them happens through research programmes or individual interactions (NA1). Also, the close interaction between government and industry seems to be crucial in order to gather knowledge at the source where emissions are happening, to make sure targeted policies are formulated (R2). In general, the government works closely together with all stakeholders in initiatives or through governmental agencies to plan a strategy for BECCS (NA1).

### **5.3 Knowledge Transfer Process in the Case of BECCS**

The results show that in general BECCS does not represent a typical knowledge brokering process of actors working clearly in between science and policy in order to translate knowledge for policy-makers. In the SPI around BECCS researchers also “work directly towards agencies that implement policy and define policy” (A1) and the “communication also goes quite directly from the scientific researchers to the authorities” (WU1). This rather unusual direct knowledge transfer has been pointed out by multiple interviewees (A1, R2, WU1).

However, also structures of a more typical and successful knowledge brokering process have been found. A very prominent example of an intermediary between science and policy around BECCS is Klimatpolitiska vägvalsutredningen (R1, NA1) (see Chapter 5.1.2). An example shows that they have acted as a knowledge broker by picking up results of technical and economic research about BECCS and translating it into information that is accessible for policy-makers (WU1). Another example is the implementation of a CCS centre, which has been proposed by researchers, discussed by Klimatpolitiska vägvalsutredningen and then forwarded as a suggestion to the government (R1). Most interviewees also referred to the planned support reversed auction scheme, proposed by researchers and now being planned by a group of interdisciplinary experts, who translate existing knowledge for the government to design a policy instrument (R1, R2, NA2). Also, the initiative Fossilfritt Sverige acts as a bridge between science and policy-makers by transferring relevant knowledge and suggesting an action plan to the government (NA2).

### **5.4 Role of BECCS in the Swedish Climate Neutrality Strategies**

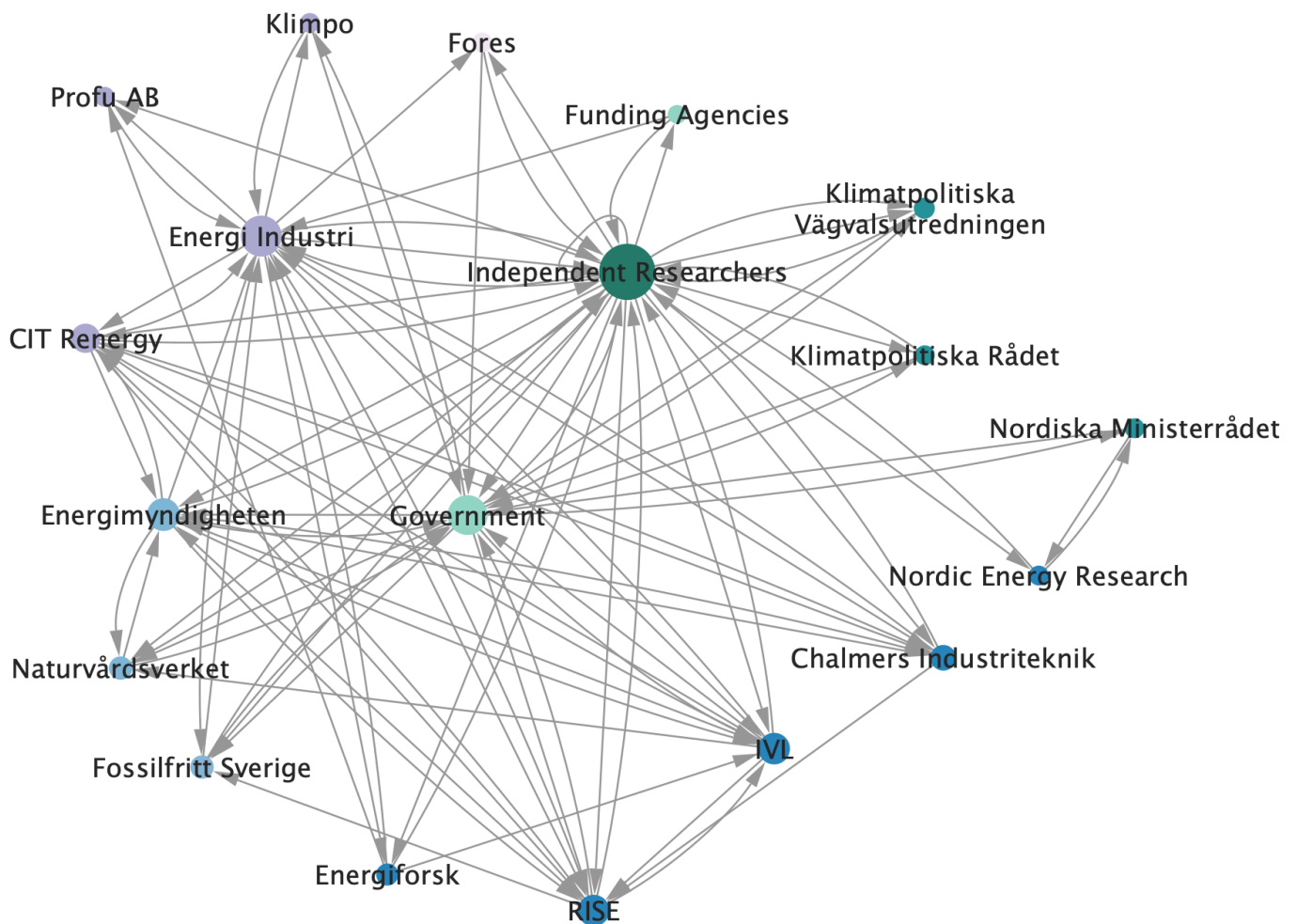
The actual role BECCS will play on the way to reach climate neutrality in Sweden is an “open-ended question” (R1). Many actors have mentioned that reducing GHG emissions is still the most important strategy and has to be prioritised (R1, R2, NA2, WU1). Besides that, all seven interviewees stated that BECCS will be needed to achieving negative emissions in Sweden. In comparison to other negative emissions technologies, BECCS is expected to be favourable regarding costs (A2) and efficiency (A1), have the strongest political support (NA1), and is all in all “most realistic on the scale that is needed” (WU1). In numbers, the current policy framework sees a limit of 10.7 million Mt CO<sub>2</sub> per year removed with BECCS by 2045 (R1). While this number shows the maximum (economically) feasible potential, the actual amount of Mt CO<sub>2</sub> removed with BECCS by 2045 could be between zero and this number. Consequently, Sweden does not “have a separate target for negative emissions in Sweden” (R1), but only targets for supplementary measures overall (R1).

As of today, there is already “a lot of point sources of biogenic carbon dioxide in the Swedish economy” (R1), especially in the pulp and paper industry (WU1) and the heat and power sector (A2). One interviewee demonstrates that BECCS at a combined heat and power (CHP) plant is more favourable, as it results in very little overall energy loss compared to a loss of approximately 30-40% of the produced power at an only power plant (A2). Consequently, many interviewees point out that the potential to implement BECCS is large (R1, A2, WU1), and does not necessarily have to go together with an additional demand for biomass (R1, NA1). However, this prediction is based on the current plan of implementing BECCS. If the technology is scaled-up or strong incentives for BECCS are evolving, the development could potentially clash with environmental objectives, such as food security or biodiversity, in the future (R1).

Most interviewees (R1, NA1, R2, A2) state that the discussion about the implementation of BECCS has to happen as a collaboration between not only researchers, universities and institutes, but also with governmental agencies and the commercial industry. Many interviewees state that politics has to set regulations and create the legislation for economic incentives (R2, NA1, WU1, A1), while following the regulations of environmental integrity and other conventions on the international level (NA1). And then a marketplace for negative emissions will have to be created (NA1, A2, WU1). First, a strong governmental funding is needed in order to create an incentive to start the development (NA1, NA2, A2, WU1). In the long-term this financing is neither feasible nor sustainable. Consequently, a system for private funding in order to cover the great costs needs to be created (NA1, NA2, R2, A2), eventually regulated by mandatory governmental targets (WU1). The actual implementation could be done in different ways, or as a combination of solutions. While the reversed auction system is the most discussed at the moment (R1), also a flat rate subsidy (R1), an additional voluntary carbon market (NA1), or the integration into the EU trading system (NA1) could be options to create economic incentives. In any way, the development of BECCS in Sweden will be dependent on future development of structures in the EU, and most certainly also on EU funding (R2, NA2), as there will be a lack of financing to achieve the set targets for BECCS in Sweden (R1). Overall, the goal is to “reach a sustainable business model for BECCS” (NA2) and “to find long-term policies” (NA2). It has been emphasised that even though the whole value chain for BECCS still has to be developed (NA1) and “a lot of challenges and complexities (have) to be resolved” (R2), the need to start projects is urgent (WU1). It takes 10 to 15 years for individual projects to be financed, developed and implemented in practice. Consequently, policies need to be decided and implemented early in order to have the desired effect (A2).

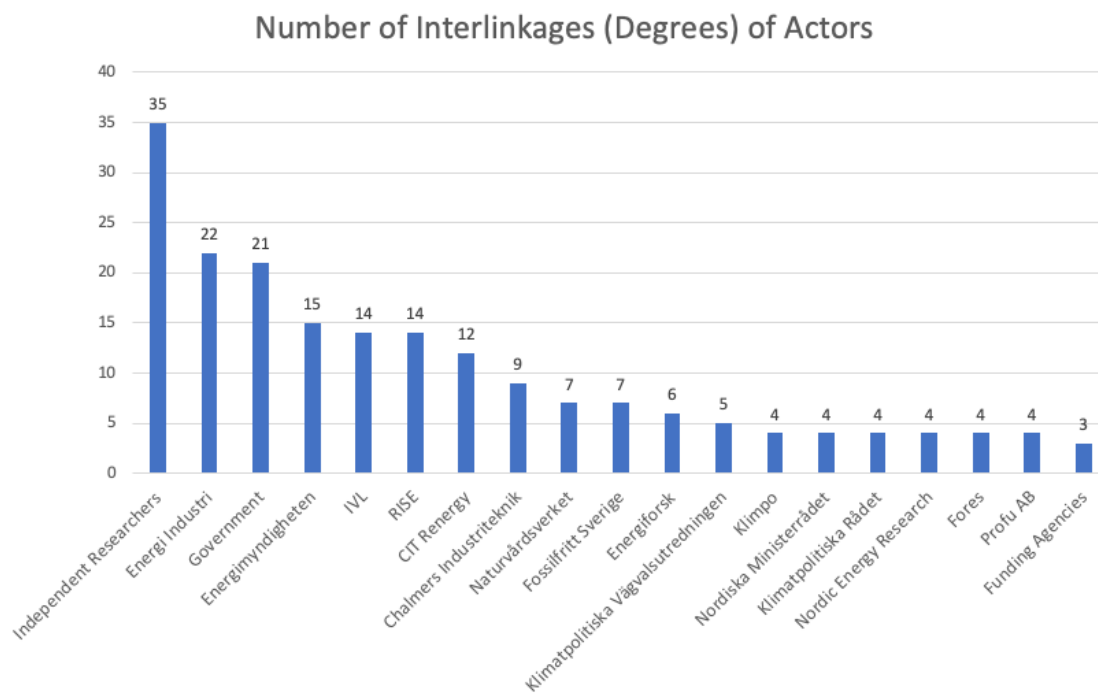
## 5.5 Actor Network Mapping

The actor network mapping (see Figure 6) with the software Cytoscape includes all the interlinkages between actors that have been mentioned in the survey and interviews, plus the interlinkages that have been identified through desk-based research. The size of the actor's shape in the mapping represents the number of interactions (degree) with other actors. That means the bigger the shape, the more the respective actor interacts with others.



**Figure 6:** Actor Network Mapping of the policy-making process of BECCS in Sweden (arrows indicate the direction of the interaction, size of the shape indicates the number of interactions, the colours indicate the actor groups classified according to Gluckman et al. (2021)) (own visualization with software Cytoscape 3.9.1)

Figure 7 below shows the number of degrees for each actor. One degree represents a one-sided interaction from one actor to another. If both actors interact with each other, this means two interactions (degrees) for each actor. Independent researchers are clearly the most interlinked group with 35 degrees, followed by the Energi Industri (22 degrees) and the Government (21 degrees). After this, Energimyndigheten comes with 15 degrees, and IVL and RISE with both 14 degrees.



**Figure 7:** Number of Interlinkages of Actors  
(own visualization with the tool Cytoscape 3.9.1.; arrows indicate the direction of the interaction)

## 6 Discussion

The following chapter discusses the results of the analyses for the SPI around BECCS in Sweden, and then elaborates on what the findings mean for the development of BECCS in Sweden.

### 6.1 The Science-Policy Interface (SPI) in the Case of BECCS in Sweden

In this sub-chapter, the relevant actors and their role in the SPI are discussed, first in general, and then in comparison with the theoretical framework of this thesis. Further, light is shed on the knowledge transfer process and barriers in the case of BECCS.

### **6.1.1 Relevant Actors and their Interlinkage**

The analyses of this thesis have identified multiple relevant actors and actor groups (see Chapter 5.1), who work “in the middle between academia and the real world” (WU1) and therefore act as intermediaries or knowledge brokers in the SPI around BECCS in Sweden. However, these actors are not per se knowledge brokers, but they become brokers once they take up the role of translating knowledge to become understandable for the recipient. A what works unit at an energy company for example only becomes a knowledge broker if they translate the gained knowledge from internal research or pilot projects in an evidence-based and reliant way in the form of reports or similar for policy-makers. Independent researchers become knowledge brokers, when they translate other’s work, or their own, as part of a policy council or similar, in order to provide policy advice. Another way of researchers of becoming knowledge brokers is by doing commissioned work for regulatory agencies, such as Energimyndigheten. This principle of only becoming a broker by fulfilling the role of translating generated knowledge applies to all identified actors. These findings answer the first part of RQ1 about who the relevant actors in the policy-making process of BECCS in Sweden are.

Overall, the results of this thesis demonstrate that the identified knowledge brokers have the potential to be important connectors between science and Swedish policy-makers, and translate scientific knowledge in an evidence-based way. First, the knowledge brokers in the SPI around BECCS cover a variety of actor groups, which is crucial for successful knowledge brokering in environmental challenges as pointed out by MacKillop et al. (2020) and Watson (2005). Second, responsibilities of knowledge brokering activities are distributed among relevant actors, which is mentioned by Hering (2016) to be elementary for an effective knowledge transfer. As such, Energimyndigheten outsources knowledge transfer activities by for example creating an expert group responsible for the reversed auction scheme. However, this thesis shows that the exact role knowledge brokers can play in the SPI around BECCS depends on the environment that is created by the government and responsible agencies, which will be elaborated on further in Chapter 6.1.3. These findings answer RQ2, about the role of knowledge brokers in the policy-making process regarding BECCS in Sweden.

The results of the actor network mapping show that in the specific case of BECCS the SPI is a nested, interlinked and complex network of actors (see Chapter 5.5). On the one hand, the government itself and the government agency Energimyndigheten were mentioned in the survey to be the most important actors for the development of BECCS in Sweden. On the other hand, independent researchers are the most interlinked actors in the network overall, and involved in many other knowledge brokering institutions, such as National Academies, and by doing commissioned work for

governmental agencies. This finding supports a study by Wittmayer & Schöpke (2014), who emphasise the important role of researchers as knowledge brokers in sustainability transitions. Additionally, Klimatpolitiska vägvalsutredningen, and their report (SOU 2020:4) were mentioned frequently in the interviews, but have also been referred to in many initiatives and the literature to be an important piece on the way to reach climate neutrality in Sweden (e.g. Fuss & Johnsson, 2021).

In general, the actor network can be described as a fully connected network, which represents a network, where the number of actual connections compared to the maximum amount of possible connections is high (Shumate & Cooper, 2021). This finding was also supported by the interviewees and the survey results, which emphasised that rather than pointing out one most relevant actor, actors in the SPI are greatly connected. The findings of this thesis shows that collaboration among all involved actors is given which is an important factor for the successful development of BECCS in Sweden (IEA, 2022). This answers the second part of RQ1 about the interlinkage of actors.

### **6.1.2 Theory vs. Reality**

The suggested framework by Gluckman et al. (2021) has shown to be applicable in order to identify the relevant actors, and for all the categories actors could be identified. The results of this thesis are to a certain degree compatible with the rating of the importance of the actor groups suggested by Gluckman et al. (2021) (compare Table 2, Chapter 4). The results support that *science advisors of government & parliament* (in this thesis independent researchers) are among the most important knowledge brokers. Furthermore, the analyses showed that *Government advisory boards / science councils* (in this thesis especially klimatpolitiska vägvalsutredningen) can be very influential as knowledge synthesisers and translators. However, *Energimyndigheten (Scientists within regulatory agency)* plays a much bigger role than suggested by Gluckman et al. (2021). The results show that this can be explained with the fact that Energimyndigheten is the responsible national agency for national coordination and development of CCS and BECCS. In their role, they not only collaborate and work together with many relevant actors, but also fund and commission research on BECCS. Moreover, many relevant actors take on multiple roles in the science advisory ecosystem around BECCS (compare Table 1, Chapter 3.1). Especially knowledge brokering and knowledge synthesising activities are greatly connected in the case of BECCS. This finding is to some extent in line with the applied framework by Gluckman et al. (2021), who state that many knowledge brokers are also knowledge synthesisers. Accordingly, the case of independent researchers shows that they produce and synthesise scientific knowledge but also participate in policy support (NA1), for example as part of a council or by doing commissioned work for governmental agencies. So technically, they fulfil all roles of the science advisory ecosystem. Potential implications of this finding are discussed in Chapter 6.1.3. This result is



different to the suggested allocation of roles by Gluckman et al. (2021), who do not suggest *science advisors of government (and parliament)* to be knowledge generators (see Table 5 below). Also, *National Academies, Scientists within regulatory agencies, and What work units etc.* take on more roles in the SPI around BECCS than suggested by the framework (indicated with a blue check in Table 5).

**Table 5:** Roles of relevant actors in the science advisory ecosystem (black checks indicate the role that respective knowledge broker groups take up according to Gluckman et al. (2021), blue checks indicate the additional roles that knowledge broker groups take up in the SPI around BECCS in Sweden) (Source: own visualization, according to Gluckman et al. (2021))

	Knowledge Generators	Knowledge Synthesizers	Knowledge Brokers	Science Communication
<b>1</b> Science advisors of government and parliament	✓	✓	✓	✓
<b>2</b> Government advisory boards / science councils		✓	✓	✓
<b>3</b> National Academies	✓	✓	✓	✓
<b>4</b> Scientists within regulatory agency	✓	✓	✓	✓
<b>5</b> What works units etc	✓	✓	✓	✓
<b>6</b> Independent think tanks		✓	✓	✓

**6.1.3 Knowledge Transfer Process**

The findings have shown that the SPI around BECCS in Sweden shows characteristics of a direct knowledge transfer process from knowledge generators to policy-makers, which answers the overarching research question. The knowledge transferring happens as a close collaboration between involved actors.

One potential explanation for this more direct knowledge transfer could be that BECCS is still a fairly new technology with little practical implementation, which requires a more direct link between researchers and implementation (WU1). After all, the findings of this thesis demonstrate that the direct knowledge transfer process in the SPI and great interlinkage of actors around BECCS can be explained with three main points. Firstly, independent researchers are the most interlinked actors and also considered as the most relevant actors in their role as direct advisors of government and parliament. The fact that knowledge brokers are sometimes “suggesting policies based on their research” (R2) indicates a very direct translation of scientific knowledge. Second, the fact that many actors take up multiple roles within the science advisory system (see Table 5) shortens the stages the knowledge has to go through to reach policy-makers. Thirdly, many (independent) researchers investigating BECCS are funded by Energimyndigheten, which means their financing comes indirectly from the government, and adds another component to the direct interlinkage of actors researching BECCS in Sweden and the government.

On the one hand, it can be argued that this direct interaction could enhance evidence-based and targeted policy-making, as it allows a greater communication between the actors. Consequently, it potentially increases the government’s receptiveness for translated scientific knowledge, which has been highlighted by Gluckman (2018) to be a challenge if a common understanding of the problem is not given.

However, on the other hand, the direct knowledge transfer could be problematic as the independence of the generated scientific knowledge must be questioned. The SPI involves a great variety of actors, which all have their own interest and perspectives on the development of BECCS (WU1). The visualisation of the actor and policy mapping (see Figure 4, Chapter 5.1.3) illustrates that many relevant actors are non-governmental entities, which indicates that their perspectives differ from the governmental one. In line with this, this analysis finds that the Energi Industri is highly involved in not only the practical application of BECCS, but also in research activities and is closely connected to policy-makers. This close collaboration and integration of the industry in the development process of the technology was shown to be clearly necessary, as the companies will be the ones applying the technology in the end and their practical knowledge is urgently needed for a successful development (R2; Lefvert et al., 2022). On the contrary, energy companies are profit-driven and may follow their own business-interests in the development of BECCS, which has been pointed out to be kept in mind as well by other authors, such as Lefvert et al. (2022). This also applies to other non-governmental entities, such as the interest organisation Klimpo. In the SPI around BECCS that could be problematic as these knowledge brokers are sometimes also knowledge generators, and translate knowledge quite

directly to decision-makers. Accordingly, it has to be questioned if these knowledge brokers fulfil all characteristic of a transparent, independent, evidence-based and reliable intermediary. This could have impacts on the trust in scientific authorities, which is controversial to the statement that trust is key between actors for a functioning science advisory ecosystem (Gluckman, 2018). One suggestion to overcome this problem, could be to purposefully add another independent knowledge broker, an expert, as an evaluator and translator in the middle between these actors and the government. That could be a way to have a control-mechanism of the interests behind and the evidence-base of the research.

The analyses have identified characteristics of an unsuccessful translation from scientific knowledge to policy-making in the climate neutrality strategy. The government seems to partially use a selective approach, adopting only (desired) parts of the proposed strategies, while other plans get lost in the process. This is illustrated by the example of the strategy on how to reach negative emissions after 2045, proposed by Klimatpolitiska vägvalsutredningen. It was pointed out by one interviewee, that “what the government (...) did, was to kind of cherry pick some of the proposals, put forward (...) in the strategy, but without adopting the strategy as a whole” (R1). Consequently, the government situates BECCS in another way than initially suggested and translated by Klimatpolitiska vägvalsutredningen (R1). This selective approach is a common challenge in environmental governance, as a recent case study by Reinar & Lundberg (2023) shows. The authors discuss the difficulty of translating Sustainable Development Goals (SDGs) goals into targeted policies for municipality planning (Reinar & Lundberg, 2023). That supports a statement of one interviewee, who said that it can be a “challenge (to be) really in the middle of” science and policy (NA2). It shows that there exists a science-policy gap to some extent in the case of BECCS in Sweden. However, it lies outside of the competencies of knowledge brokers to decide what the government adopts, but the government has to take the responsibility of considering evidence-based knowledge in policy-making and create the environment for knowledge brokers to be active.

## **6.2 The Future Development of BECCS in Sweden**

The results of the interviews show that BECCS will be a prioritised strategy on the way to reach climate neutrality in Sweden. However, a separate target that quantifies the contribution of BECCS to the climate neutrality target has not been formulated yet (R1). Accordingly, the findings show that the exact role BECCS will play in the transition cannot be answered today and will depend on the emergence of economic incentives and policies on a national and international level. This answers RQ3 about the role of BECCS in the Swedish climate neutrality strategy according to identified actors.

In general, the results of the interviews support the literature stating that in theory Sweden shows favourable conditions, with large biogenic point-sources in industry (e.g. Beiron et al., 2022) and a great availability of biomass (e.g. Fuss & Johnsson, 2021), for a large-scale development of BECCS. However, the interviewees also made clear that supplementary measures, such as BECCS, should not be applied instead of large-scale GHG emissions reductions. Besides, it also has to be questioned if the current biomass is sourced sustainably, as it has been shown by other authors (e.g. Hansen et al., 2021), that the existing forestry practices can clash with factors of the ecological, economic and social dimensions of sustainability.

This thesis finds that in order to make sure that BECCS is implemented in an efficient and sustainable way, and only creates incentives where desired, targeted policies have to be designed. Consequently, the results support earlier findings in the literature that emphasise the urgency to create economic incentives and implement targeted policies so that BECCS can contribute to reach Swedish climate goals (e.g. Fridahl et al., 2020; Zetterberg et al., 2021). The literature emphasises that for companies “the most significant barrier to implementing BECCS is a lack of economic incentive” (Rodriguez et al., 2021, p.10). This thesis finds that the Energi Industri is highly engaged in the SPI around BECCS, which increases the importance to create economic incentives for BECCS in Sweden.

As one interviewee puts it, as of today, “we do not know exactly how the distribution of different” (NA1) incentives will be. The results of this thesis indicate different incentives schemes that will vary in the short- and long-term. In any case, “we (...) need (a) broad palette of policies in general” (NA2), while also the support of “research and development is very important” (NA2) in order to get from the stage we are at today to actually becoming climate negative by and beyond 2045 (NA2). The current realisation of a reversed auction system is a first step on the way to formulate targeted incentives and a clear example of a successful knowledge brokering process. This so-called demand-pull instrument starts to reform the existing policy-mix, which has been pointed out to be absolutely necessary by Fridahl et al. (2020).

As discussed earlier in Chapter 6.1.3, the rather direct knowledge transfer from knowledge generators to policy-makers plus the great collaboration between relevant actors could enhance the efficiency of the process, when it comes to creating and implementing the greatly needed policies and incentives. This gains importance, when considered that the implementation of a BECCS project takes between 10 and 15 years (A2).

However, there are also other factors that will influence the development of BECCS and the respective policies in the future. First, the policies will have to be developed in line with EU and international politics. Not only does Sweden depend on international regulations for the development, but there is also a global need for NETs (WU1). Interviewees have pointed out that Sweden could potentially be a “net exporter of negative emissions” (NA2) in the future and thereby contribute to reaching international targets and EU climate goals. Second, there are still a variety of uncertainties connected to the actual implementation and creation of an infrastructure for BECCS in Sweden, which was highlighted in the interviews (R2), but also in the literature (e.g. Lefvert et al., 2022). Third, there exist potential disadvantages connected to the evolution of the technology, which have to be incorporated in the development process to ensure a sustainable development that considers scientific evidence. Finally, we do not know of today how the world will look like in 2045. One interviewee stated that they “hope (that) in 2045 (...) we have a system where we do not burn biomass (at all), if (...) going to the extreme, (...) for heat” (NA2). Rather biomass could be used for the production of products and biofuels, which then will produce heat as a by-product (NA2). These uncertainties have to be taken into account when designing incentives and policies. Additionally, it shows that the created structures should be evaluated and adopted to future developments.

## **7 Conclusion**

This thesis aimed to investigate the knowledge transfer process and the role that so-called knowledge brokers play as intermediaries in the SPI around BECCS in Sweden. Multiple qualitative research methods were applied in order to identify the puzzle pieces and bring them together to create the whole picture surrounding relevant actors and policies, their interlinkage and the broader knowledge transfer process in the case of BECCS in Sweden. These findings were then visualised and illustrated by actor and network mappings. Additionally, BECCS’ potential role in the Swedish climate neutrality strategy was investigated.

The analyses found three main results. Firstly, the identified knowledge brokers in the SPI around BECCS are closely interlinked and relevant actors collaborate greatly with each other. Independent researchers, the Energi Industri, the Government and Energimyndigheten have been identified to be the most connected actors. This thesis argues that this great interlinkage not only enhances the knowledge transfer process, but is also necessary for a sustainable development of BECCS in Sweden. Secondly, the results indicate a somewhat direct transfer from scientific knowledge generators to policy-makers. The results found that in comparison with the theoretical and analytical framework for

this thesis by Gluckman et al. (2021), relevant actors fulfil more roles in the knowledge transfer process than suggested. Thirdly, the thesis argues that the great interlinkages and the direct knowledge transfer can become problematic. The findings indicate towards factors that potentially hinder an evidence-based knowledge transfer. On the one hand, the results show that involved actors and knowledge brokers might follow their own interests in the development of BECCS and potentially act not fully independent in the policy advising process. On the other hand, the government uses a selective approach when applying proposed knowledge to policies. This shows that even though scientific knowledge has fed the formulation of the Swedish climate neutrality strategy, a science-knowledge gap remains.

The findings indicate clearly that BECCS should not be applied as a substitute for GHG emissions reductions, but holds great potential to contribute to help reaching climate neutrality targets in Sweden. Nevertheless, this thesis also emphasises the uncertainties surrounding the technology and highlights the urgent need for targeted and evidence-based economic incentives and policies to ensure a sustainable transition. Knowledge brokers in the SPI have the potential to greatly contribute to formulating targeted incentives and policies needed for a sustainable development of BECCS in Sweden if they fulfil the characteristics of a transparent, independent, evidence-based and reliable intermediary. Accordingly, an environment should be created where current brokers can exist and additional intermediaries can evolve.

This thesis contributes to closing the knowledge gap on how scientific knowledge is transferred in the case of BECCS in Sweden. Knowledge brokering is studied in a practical case and therefore addresses the lack of empirical work in the field. By studying the SPI and how to connect science and the political agenda the thesis contributes to sustainability science. The actor (network) mappings summarise and visualise an overview of relevant actors, processes and interlinkages in the SPI around BECCS in Sweden, which contributes a basis for future research. Furthermore, the discussion around BECCS is continuously growing, which indicates that additional actors, such as the forestry industry and civil society, will become relevant as intermediaries or other influential actors in Sweden in the future. Therefore, future research on the effectiveness and independence of knowledge brokers in the rapidly evolving development of BECCS in Sweden will be crucial. Moreover, public perception, support and acceptance have been mentioned in the interviews of this thesis and are being discussed in international studies (e.g. Bellamy et al., 2019; Hansen et al., 2021) to be decisive factors for the successful development of BECCS. This highlights the need for research on the role of society in the SPI around BECCS in Sweden. Furthermore, studies on how the development of BECCS impacts social,

ecological and economic factors in a Swedish context are essential to ensure a sustainable development of the bioenergy sector.

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# Appendix

## Appendix A - Survey construction

1. What is your name?

2. Which organisation or institution do you belong to?

- Swedish government / parliament
- Government agency / researcher within government agency
- Science advisor to the government / parliament
- National academy
- Independent think tank organisation
- Independent researcher
- Company
- Other (Please specify)

3. How is your work connected to BECCS?

4. Which people, organisations and/or institutions do you work with in your work on BECCS in Sweden?

5. Who is the most important person, organisation or institution of the ones above in your work on BECCS in Sweden?

## **Appendix B – Interview Documents**

### ***B1 - Interview guide***

#### **A) Role of actor**

- 1) Person, institution, role in institution/organisation
  - What is your professional role and do you work at any institution or organisation?
- 2) Connection to BECCS
  - How did you come to work with BECCS?

#### **B) Knowledge Brokering in the case of BECCS**

The next questions are about the concept of the science-policy gap and knowledge brokering. The science-policy gap in my thesis refers to the difficulty of successfully turning scientific knowledge into policies. Institutions or individuals who transfer and translate knowledge between science and policy (and therefore act as intermediaries between the two) are defined as knowledge brokers in my thesis.

- 3) How do you think institutions/organisations/researchers like you/yours can help to overcome the knowledge gap between science and policy in the case of BECCS in Sweden?
- 4) Do you think you as an institutions/organisations/researchers have an influence on the policy-making process regarding BECCS?
  - 4a) Can you come up with a concrete example of how this influence looks like?

#### **C) Role of BECCS in the Swedish climate neutrality strategy**

- 5) What role do you think BECCS will play on the way to reaching climate neutrality by 2045 in Sweden?
- 6) How would you rate the importance of BECCS for the Swedish climate neutrality strategy in comparison with other mitigation strategies (such as afforestation or direct air capture)?
- 7) Who do you think should decide how BECCS is implemented?
- 8) How do you think BECCS will/ should be financed in Sweden?



**D) Knowledge transfer process**

- 9) Which people, organisations and/or institutions do you work together with in your work on BECCS? *(if not already answered in survey)*
- 10) Who is the most important person, organisation and/or institution of the ones above in your work on BECCS? *(if not already answered in survey)*
- 11) Who do you think is the most important actors in the discussion about BECCS in Sweden?
- 12) Are there any that are important information sources (like conferences, publications etc) for knowledge exchange regarding BECCS?

**E) Closing of the interview**

- 13) Is there anything I forgot to ask or you would like to add?

**B2 – Example Consent Form**

**Interview Consent Form**

**Name of the interviewer:** Jana Föcker  
**Contact information of the interviewer:** [ja4684fo-s@student.lu.se](mailto:ja4684fo-s@student.lu.se) / +46793590844  
**Date of the interview:** .....

Thank you very much for taking the time to talk to me. I have asked you for an interview as part of my Master's thesis which I carry out in the last term of the International Master's Programme in Environmental Studies and Sustainability Science at Lund University in Sweden.

All information is confidential and will not be revealed or associated with your name unless you agree to it. If you do not want to answer a question please tell me, the interview is entirely voluntary and you can discontinue it at any moment. If you want me to explain a question further, please do let me know.

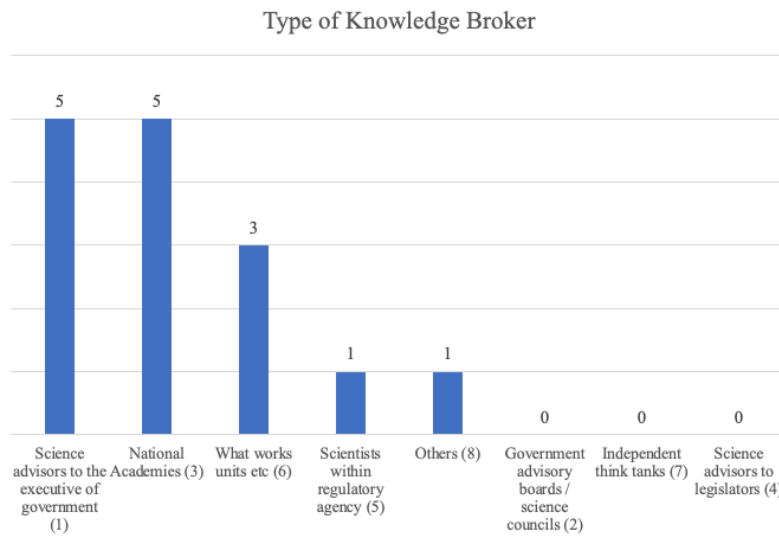
<b>Do you consent that I can use your answers in my Master's thesis?</b> (Yes / No)	.....
Interviewee wants to stay anonymous (Yes / No)	.....
The interviewee's affiliation can be mentioned (company / <del>organisation</del> ) without other personal information (name, position etc.) (Yes / No)	.....
Can I quote you directly or would you prefer me to email you the quotes for approval before using them in my paper? (Yes / No)	.....

**Name of the interviewee:** .....|  
**Organisation and position of interviewee**  
(if respondent agrees to it being noted down and used) .....

.....  
**Date and Place** ..... **Signature interviewee**

## Appendix C - Results

### C1 – Distribution Actor Groups Survey



**Figure a:** Distribution of respondents to the survey according to their actor groups (own visualization)

## C2 – Excel Sheet Actor and Policy Mapping Tool (Actor Component)

Institution / Organisation	Actor type	Actor name (if applicable)	Description of role	Description of level and area of influence	Political economy analysis		Level of influence (as a knowledge broker) - evaluation	Description of position and core interest(s)
					Kind of Organisation (owner, financier...)	Connection to BECCS		
Riksdag (Parliament)	Government							
Regering (Government)	Government							
Regeringskansliet (Swedish Government Offices)	Government	Klimat- och näringslivsdepartementet						
Independent researchers & experts providing knowledge for the government	Science advisors to the executive of government		independent researchers and experts, who use their knowledge to provide scientific advice to the government	*synthesise, translate and share their own scientific knowledge or the one of other researchers for the government and *directly the researchers are able to influence the policy making process by providing solid and evidence-based knowledge in their role as direct advisors of the government	independent, most of them close affiliation to national academies, companies, think tanks or similar	use, share and translate their knowledge to inform about BECCS in various formats	III	
Klimatpolitiska vägvalsutredningen (M 2018:70) (Public inquiry)	Government advisory board/science councils		group of experts appointed by the government with the task to propose a strategy (vägen till klimapositiv framtid) to reach negative emissions after 2045	the inquiry directly provides synthesised knowledge to the government in its strategy and therefore has the ability to inform the government directly with scientific evidence and knowledge	independent, appointed by the government, group of experts from various sectors (ministries, businesses, civil society etc)	synthesising and providing knowledge about BECCS	III	"provide & translate evidence-based and up-to-date scientific advice to the government"
Klimatpolitiska rådet (Swedish Climate Policy Council)	Government advisory board/science councils		independent scientific council with the task to assess if the overall policy of the government is compatible with the climate goals *evaluating government policy *evaluating analytical methods and models which are the basis for policy. *contributing to the debate regarding climate policy -->yearly reports and action plans	the council provides a direct assessment of how the government is doing with its climate policy and directly informs the government with synthesised knowledge	independent, interdisciplinary expert body from various disciplines	synthesising efforts and development in order to reach climate goals, with BECCS as a main technology	III	"provides synthesised knowledge about achievements in climate policy"
Nordiska Ministerrådet (Nordic Council of Ministers)	Government advisory board/science councils		international council for inter-governmental co-operation of the Nordic countries *was asked to propose a strategy for how to cooperate and reach climate neutrality in all 5 countries (Sweden, Denmark, Finland, Norway, Iceland)	the council directly provides synthesised knowledge to the Prime ministers of the Nordic countries in the strategy and has the ability to directly inform the Nordic prime ministers about scientific knowledge	independent, appointed by the prime ministers of the Nordic countries	synthesising and providing knowledge about the role of BECCS in the climate neutrality strategy	III	"to become the most sustainable and integrated region in the world by 2030" "reach climate neutrality in all 5 countries"
IVL Svenska Miljöinstitutet AB (IVL Swedish Environmental Research Institute)	National academies		research and development institute *consultancy and research to promote (ecologically, economically) and socially sustainable growth within business/society *interdisciplinary and system thinking	initiates, coordinates and communicates (energy) research and development	funded, owned, financed by Swedish government and business sector	initiates, coordinates and communicates research and projects in the area of BECCS in a Swedish and Nordic context	II	"promotion of ecologically, economically, and socially sustainable growth within business and society" "vision of a sustainable society"
RISE (Research Institutes of Sweden)	National academies		research institute for a sustainable society and competitiveness of Swedish business community internationally *international collaboration with industry, academia and public sector	research and work interdisciplinary for a sustainable energy system, solutions for storage and use of energy -> initiates, coordinates and communicates (energy) research and development	state-owned	initiates, coordinates and communicates research and projects in the area of BECCS in a Swedish and Nordic context *research projects along the CCS value chain	II	"vision of a sustainable society" "ensure a sustainable energy system"
Energiforsk	National academies		energy research and knowledge institute *initiates, coordinates & communicates energy research and development *offers specialist services within the energy sector **applied science	initiates, coordinates and communicates (energy) research and development	non-profit, owned by energy businesses (private sector)	initiates, coordinates and communicates research and projects in the area of BECCS in a Swedish and Nordic context	II	"We continually strive to remain a natural hub for energy research - impartially working for the benefit of future energy systems." "Our focus is applied science and as a hub for energy research we see a great added value in research where public, private, and academy work together."
Chalmers Industri teknik	National academies		facilitate collaboration in the area of energy efficiency and climate change between researchers and the business community and to promote innovation	initiates, coordinates and communicates (energy) research and development	funded by industry sector, closely connected to Chalmers University	initiates, coordinates and communicates research and projects in the area of BECCS in a Swedish and Nordic context	II	"The mission: to close the gap between research and industry."



### C3 – Excel Sheet Actor and Policy Mapping Tool (Policy Component)

Policy name (official)	Jurisdiction	Responsible institution(s)	Main policy objective	Secondary policy objective(s) (if relevant)	Policy description		Status and timeline						Impact and evaluation				
					Policy/initiative description	Role of BECCS in policy	Type of policy instrument	Enforcement level	Sectoral coverage	Implementation status	Date of decision	Start date of implementation	End date of implementation	Level of impact	Impact evaluation (pre-, ex-post, or during implementation)	Impact indicator (if applicable)	
Miljöplan för Klimatansvar (SOU 2020:4)	National	Regeringskansliet (Swedish Government Office)	Mitigation	Adaptation	<ul style="list-style-type: none"> <li>1) strategy &amp; action plan to set principles and targets for a policy for supplementary measures</li> <li>2) target 1: supplementary measures equivalent to atleast 3.7 million tonnes of carbon dioxide per year by 2030</li> <li>3) target 2: supplementary measures equivalent to atleast 10.7 million tonnes of carbon dioxide per year by 2045</li> <li>4) target 3: increase of investment 2045</li> </ul>		Climate Strategy			Planned	19.07.18	20.01.20	31.12.45	High		equivalent of million tonnes of carbon dioxide	
Klimtlag (2017:720) (The Swedish Climate Act 2017)	National	Riksdag (Parliament), Miljö- och näringslivet/departementet etc	Mitigation	Adaptation	<ul style="list-style-type: none"> <li>1) provides basis and goals for Government's climate policy work (e.g. Government is required to submit an annual climate report to the Parliament and every 4 years an action plan)</li> <li>2) sets along the long-term climate goals set by the Riksdag</li> <li>3) Department</li> </ul>		Climate Strategy	Mandatory	Climate Change	Fully implemented	22.06.17	01.01.18		High	during implementation	annual report 4-year report	
EU climate strategy	International	European Parliament															
Paris Agreement 2015	International	United Nations	Mitigation	Adaptation, Climate Change in general	<ul style="list-style-type: none"> <li>1) limit temperature rise to preferably 1.5 C degrees (max. 2 C degrees) by substantially reducing global GHG emissions</li> <li>2) every countries' commitments to cutting emissions every five years</li> <li>3) provide climate finance to developing countries (mitigate climate change, strengthen resilience, enhance ability to adapt to climate impacts)</li> <li>4) climate action should be increasing and being ambitious over the years</li> <li>5) legally binding international treaty under the UNFCCC</li> </ul>		Climate Strategy	Voluntary and Mandatory	Climate Change	Fully implemented	12.12.15	04.11.16		High	during implementation	<ul style="list-style-type: none"> <li>1) Parties are required to submit an updated national climate plan (Nationally Determined Contribution (NDC)) every 5 years.</li> <li>2) NDC: actions to reduce national GHG emissions in order to reach goals of Paris Agreement + actions to build resilience to adapt to impacts of climate change (binding and mandatory)</li> <li>3) FT-LEDS long-term low GHG emissions development strategies - goals that countries are invited to formulate and support voluntarily</li> </ul>	reduction of national GHG emissions (nationally determined contribution every 5 years)
Declaration on Nordic Climate Neutrality	International	The Nordic Council and the Nordic Council of Ministers	Mitigation	Climate Neutrality	<ul style="list-style-type: none"> <li>1) main aim: climate policy cooperation between the Nordic countries.</li> <li>2) climate neutrality in all 5 countries</li> <li>3) collective scaling up of Nordic sustainable solutions, reducing GHG emissions, maintaining carbon sinks and remove carbon dioxide from the atmosphere (eg. BECCS)</li> <li>4) encourage climate-conscious consumer choices</li> <li>5) encourage Nordic companies, investors, local governments, cities, organisations and consumers to step up their efforts towards carbon neutrality</li> </ul>	includes intensified cooperation in order to further developing technologies such as CCS and BECCS	Climate Strategy		Climate Change	Fully implemented	25.01.19	25.01.19		Medium	not specified		
INDUSTRIAL LEAP																	
Industrial Leap	National	Swedish Energy Agency	Mitigation	Climate Neutrality	<ul style="list-style-type: none"> <li>1) programme to support and fund the green transition of the industrial sector</li> <li>2) funding for research, innovation projects and investments</li> </ul>	one of the three main areas of the programme is the support and funding of the development of negative carbon dioxide emissions, especially BECCS	Climate Strategy		Climate Change	Partially implemented		01.01.18	31.12.30		not specified		
Fossil Free Sverige	National	Regering (Government)	Mitigation	Climate Neutrality	<ul style="list-style-type: none"> <li>1) government initiative to increase the pace of the climate transition</li> <li>2) "start build a strong industrial sector and create more jobs and export opportunities by going fossil free"</li> <li>3) "working together with companies, industries, municipalities and regions"</li> <li>4) "produce public proposals that are presented to the Government and bring together actors to implement measures"</li> <li>5) "within the framework of Fossil Free Sweden, 22 business sectors have produced roadmaps for fossil-free competitiveness including constraints and political proposals"</li> </ul>	focus of the 6th strategy is bio-CCS and CCU	Climate Strategy		Climate Change	Partially implemented	01.01.15	01.01.15			not specified		