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BUILDING MOMENTUM
FOR THE LONG-TERM CCS DEPLOYMENT
IN THE CEE REGION

CCS National Roadmap

Poland

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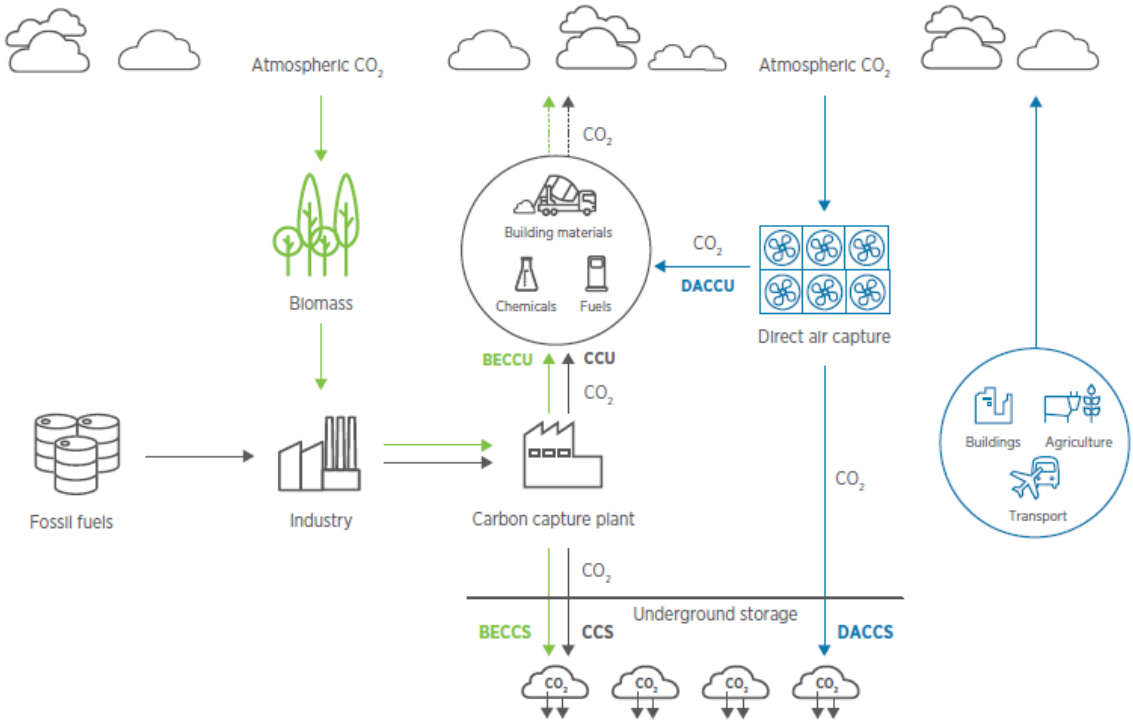
Chapter 1. Role of CCS in decarbonisation pathways

In 2019, the EU launched the European Green Deal to transform the EU into a modern, resource-efficient and competitive economy, cut GHG emissions by at least 55% by 2030 and reach net-zero emissions by 2050. Many 1.5°C compatible scenarios have assessed these targets and shown that a credible but narrow pathway exists and will require the use of all decarbonisation tools available. **Renewables and energy efficiency** are key components of that pathway and account for 80% of emissions reductions and provide solutions to many sectors including power, transport and energy-intensive industries. But to reach net-zero renewables and energy efficiency, they **need to be supplemented by CO_2 capture and storage (CCS) and utilisation (CCU) and carbon dioxide removal (CDR)** (particularly bioenergy with CCS/CCU (BECCS/BECCU)) **technologies** (Figure 1), in sectors such as power and heat, cement, steel, chemicals production and waste incineration. In addition, to address emissions from other sources as well as historic emissions, direct air capture with storage (DACCS) or utilisation (DACCU), can also be deployed. These technologies together can mitigate **20% of global CO_2 emissions**, but to do so, **the scale has to increase significantly** (Figure 2), from the current 0.04 Gt of CO_2 per year to circa 8.5 Gt of CO_2 per year in 2050 (IRENA, 2021).

The benefit of CDR processes is that they remove CO_2 from the atmosphere, they do not simply reduce what was added, and in combination with long-term storage can result in negative emissions. As such they are a critical component of net-zero pathways in the European Green Deal and most recently in line with the Glasgow Climate Pact. There are preconditions to be assessed: biomass for BECCS needs to be sourced sustainably, while DACCS requires access to cheap renewable energy.

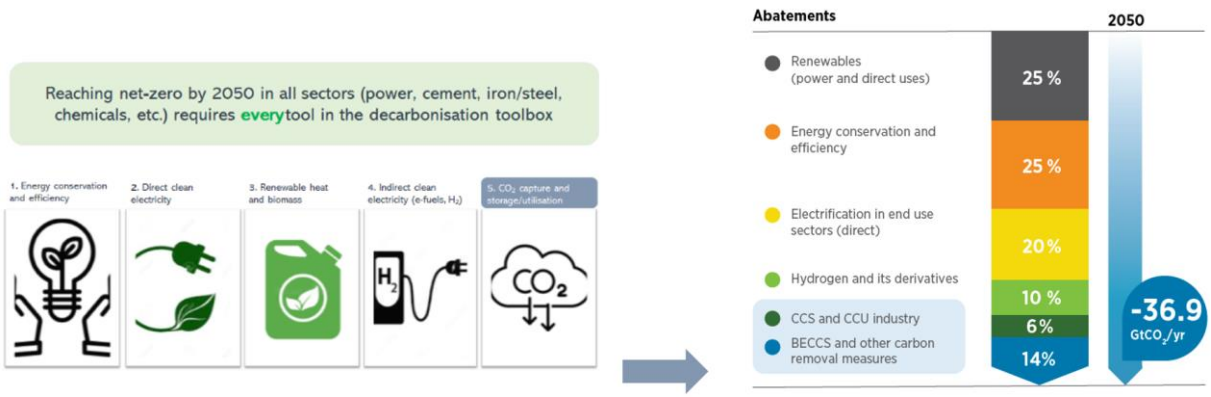
All these technologies utilise the same components of the value chain: the CO_2 transport, storage and utilisation.

Figure 1: Carbon cycle with the use of CCS/CCU, BECCS/BECCU and DACCS/DACCU technologies[1]



Source: (IRENA, 2021)

Figure 2: Carbon capture and storage as a part of the global decarbonisation toolbox[2]



Source: Based on IRENA (2021)

[1] https://irena.org/-/media/Files/IRENA/Agency/Technical-Papers/IRENA_Capturing_Carbon_2021.pdf
[2] Ibid.

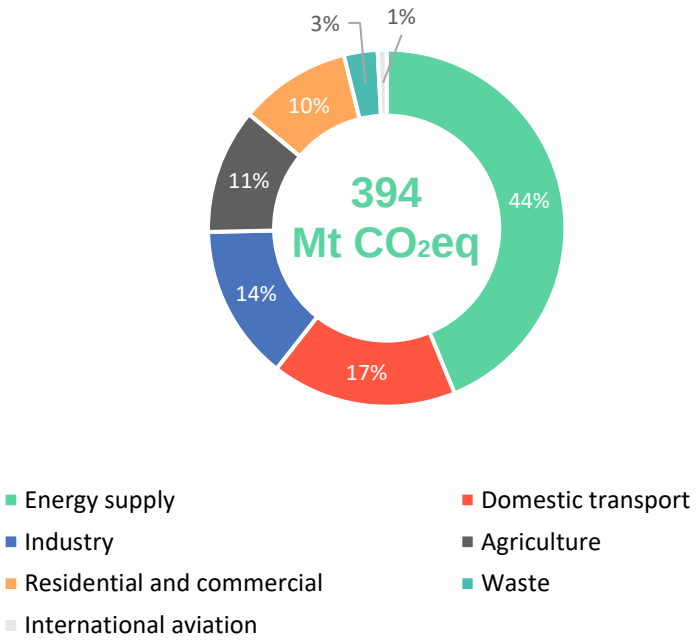
The pace of progress in validating and deploying these technologies across sectors has been slow to date and in many cases with significant costs overruns. There are currently many commercial CCS, CCU and CDR plants globally capturing 40 Mt of CO_2 per year (IRENA, 2021), with many more being developed and an increasing number of pilot and demonstration projects that focus on safety issues, environmental impacts and economic costs, while generating lessons learned to be used to further improve these technologies and bring their costs down.

This current momentum to speed up energy and industrial transition considers these technologies as its necessary component of the transition and **activities at the national and regional levels** may help to **enhance the collective understanding** of the issues surrounding CCS, **build confidence** and **scale up their deployment** to **reduce costs** of these technologies and related infrastructure.

Chapter 2. Opportunities and barriers for deployment of CCS and its related technologies in Poland

CO_2 EMISSIONS IN POLAND

Figure 4. Gross GHG emissions in Poland by sector in 2019 in Mt CO_2eq



Source: Wiseeuropa based on EEA greenhouse gas data

As it can be seen in the Figure 4, Polish carbon-intensive sectors, where carbon capture installations could be applied on a commercial scale, are mainly energy supply (both electricity and heat) and industry. When it comes to industry, the most carbon-intensive branches are: **cement industry** (responsible for 3.5% of total GHG emissions in Poland in 2019), **metallurgy industry** (responsible for over 2% of total GHG emissions in Poland in 2019) and **chemical industry** (responsible for 1.7 of total GHG emissions in Poland in 2019). Therefore, based solely on the data on CO_2 emissions, in Poland **there is a huge potential for CCS deployment** within the process of transition to climate neutrality.

STATE-LEVEL STRATEGIC APPROACH TOWARDS CCS DEPLOYMENT

CCS does not play a major role in Polish national planning documents:

- Polish **NECP** just mentions CCS;

- **Energy Policy of Poland until 2040** declares that CCS technologies will be researched and implemented, but does not provide an in-depth strategy describing how they will be developed in Poland: no specific target and timeline are set out;
- **Polish Hydrogen Strategy** states that until 2030 an installation producing hydrogen from natural gas or coal with the use of CCS may be put into operation.

Therefore, **Poland lacks a strategic approach towards CCS** which would outline how this technology should be included in Polish future industrial and energy system.

NATIONAL CCS LEGISLATION AND REGULATORY BARRIERS

CCS Directive has been implemented to the Polish legal system. Polish legislation did not go further in terms of CCS regulations, but imposed **substantial restrictions** which might have hampered the development of CCS, i.e.:

- a minimum capacity threshold for CCS installations, which excluded the deployment of pilot projects;
- no allowance for onshore CO_2 storage.

Amendments to these regulations are however about to happen shortly: they would allow for the development of CCS installations regardless of their capacity. CO_2 utilization is not covered by Polish legal acts.

PROSPECTS FOR CCS DEPLOYMENT GIVEN THE STAKEHOLDERS' EXPERIENCE AND COUNTRY'S POTENTIAL

Polish stakeholders are quite experienced in CCS/CCU technology, especially when compared to other states from CEE, both in technological and scientific terms. Successful CO_2 capture, storage and utilization projects have been already conducted, though on a limited scale. And well-established technologies of CO_2 capture in ammonia production for further use in chemicals (e.g. in urea) and in other sectors have already been applied for decades[3]. Moreover, Polish research institutes are actively participating in research projects aimed at developing new methods of CCS/CCU.

Table 1. Past, ongoing or planned CCS and CCU projects in Poland (as of summer 2021)[4].

Past, ongoing or planned projects (as of summer 2021)		
R&D	There are numerous examples of past and ongoing research projects conducted by Polish research institutes	
Pilot	**Past**	Both developed by Tauron Polska Energia S.A.: • Two pilot carbon capture installations in coal-fired power plants • CO_2 methanation system for electricity storage through SNG production
Demo	There were two abandoned full-scale demonstration CCS projects. The projects were abandoned in 2011 and 2013.	
Commercial	**Ongoing**	• Industrial installation for capturing and depositing acid gases (H2S, CO_2) underground in a natural gas reservoir in Borzęcin (managed by PGNiG - Polish Oil Mining and Gas Extraction)

[3] Global CCS Institute, *Technology readiness and costs of CCS*, March 2021 (https://www.globalccsinstitute.com/wp-content/uploads/2022/03/CCE-CCS-Technology-Readiness-and-Costs-22-1.pdf).
[4] For more recent developments see: *Recent updates regarding CCS technology in Poland*.

		• CO_2 capture, concentration, purification and reutilization in a sodium carbonate production process (installation designed by IChPW for CIECH Soda Polska S.A.)
	Planned	• CCS applied to the CHP station in Przemyśl (promoted by PGNiG) • Poland EU CCS Interconnector (a multi-modal liquid CO_2 import-export terminal in Gdańsk promoted by an international consortium including Air Liquide Polska and PKN Orlen) • CCS projects envisaged in the *Social agreement* between the government and mining unions – a full CCS chain based on CO_2 captured from coal gasification • CO_2 capture (from fermentation gases), drying, purification and storage in liquid form (potential utilization in food, cosmetics or pharmaceutics), designed for the Polish company from alcohol industry (Transpol) by IChPW

Given the experience of Polish stakeholders, **there are promising prospects for CCS deployment in Poland.** Moreover, except for non-existent CO_2 transport via pipelines, **there are no substantial infrastructural or natural barriers** hampering the development of CCS technology in Poland, especially in terms of CO_2 storage.

Table 2. Technical potential for CCS deployment in Poland

Potential for CCS deployment		
CO_2 capture*	Power generation	150 Mt CO_2 annually (approximately)
	Industry	50 Mt CO_2 annually (approximately)
Transport of CO_2	There is no pipeline dedicated to CO2 transport,; CO_2 however is already being transported by rail and road on a small scale	
CO_2 storage	The estimated geological capacity for CO_2 storage in Poland is between 10.1 Gt and 15.5 Gt, with almost all potential – maximum of nearly 14.5 Gt in saline aquifers; a major part of this capacity is located onshore. Given that annual CO_2 emissions in Poland amounted to nearly 400 Mt in 2019, this geological capacity could allow for the underground storage of Polish CO_2 emissions for several decades.	

**Source: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer (data for 2019)*.

PUBLIC ACCEPTANCE ISSUES

Given the social resistance to geological research performed for the purpose of the abandoned demonstration project in Bełchatów, public perception of CCS **might be an obstacle** to deploy CO_2 storage sites in Poland, especially onshore. Fear of CO_2 leakage, though unjustified from the scientific point of view, was the main concern of the public. However, since awareness of climate change danger is increasing, CCS might gain public acceptance when presented as an effective tool to reduce emissions and energy bills and to save local industry jobs. Moreover, first successful pilot installations can ultimately fight the myths and facilitate favourable attitude for CCS.

KEY STAKEHOLDERS

Key stakeholders are those who were identified as “pace-setters”.

Table 3. The list of stakeholders identified as “pace-setters”

No.	Type of institution	Institution
1	institutional (public administration, government agency)	Ministerstwo Klimatu i Środowiska (Ministry of Climate and Environment)
2		Ministerstwo Rozwoju i Technologii (Ministry of Economic Development and Technology)
3		Krajowy Ośrodek Bilansowania i Zarządzania Emisjami KOBiZE (National Centre for Emissions Management)
4	private sector and state-controlled firms	Air Liquide Polska Sp. z o.o.
5		CIECH Soda Polska S.A. (soda ash producer)
6		EIT KIT InnoEnergy (venture capital)
7		Enea S.A. (energy producer)
8		Grupa Azoty S.A. (chemical industry)
9		Grupa Lotos S.A. and Lotos Petrobaltic S.A.
10		Górażdże Cement S.A. (owned by HeidelbergCement)
11		KGHM Polska Miedź S.A.
12		Lafarge Cement S.A.
13		PGNiG (Polish Oil Mining and Gas Extraction)
14		PKN Orlen S.A. (oil refiner, petrol retailer and chemical company)
15		Tauron Polska Energia S.A. (energy producer)
16	academic and research institutions	AGH University of Science and Technology in Cracow
17		Główny Instytut Górnictwa (Central Mining Institute)
18		Instytut Chemicznej Przeróbki Węgla - IChPW (Institute for Chemical Processing of Coal)
19		Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy (Polish Geological Institute - National Research Institute)
20		Instytut Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk (Mineral and Energy Economy Research Institute of the Polish Academy of Sciences)

RECENT UPDATES REGARDING CCS TECHNOLOGY IN POLAND

Since the publication of the Assessment of current state, past experiences and potential for CCS deployment in the CEE region for Poland, there have been several new developments regarding CCS technology in Poland:

- In August 2021 an assisting body (team) to the Minister of Climate and Environment was created, whose task is to provide recommendations on the development of CCS technology in Poland. The first recommendations are to be delivered in the second half of 2022.

- In September 2021 it was announced that the largest Polish cement producer, Górażdże cement plant owned by HeidelbergCement, will **pilot an innovative post-combustion enzyme-based carbon**

capture technology within the EUR 18 million ACCSESS project co-funded by the EU Horizon 2020 programme. The installation will be the first of this kind in the Eastern Europe, not to mention Poland. The project coordinated by Sintef Energi (Norwegian research institute) will also explore the way to integrate carbon capture unit at a cement plant in Hanover as well as all aspects of transporting CO_2 from sites in mainland Europe to the Northern Lights storage facility in Norway, including all regulatory aspects of cross-border CO_2 transport. The project will run for 48 months, from May 2021 to April 2025.

- **Draft amendment to the Geological and Mining Law** was published by the government and submitted for consultations in October 2021. The proposal is to amend existing regulations on CCS as it recognizes joint extraction of hydrocarbons and CO_2 storage (via a so-called enhanced oil/gas recovery with the use of carbon dioxide), allows for the development of CCS installations regardless of their capacity and reduces the fee for underground CO_2 storage. The consultation period ended on November 15, but the legislative act is still being processed by the Ministry of Climate and Environment and has not been sent to the Parliament yet.

- In October 2021 it was announced that Enea, Polish leading energy utility company is to **pilot a cryogenic-based carbon capture technology together with mineral sequestration of captured CO_2**. The technology is provided by Norwegian entity CAPTICO. The pilot installation will be applied to the heating plant in Bogdanka, Poland.

- In November 2021 Lotos and Azoty, two Polish pace-setters of CCS technology, published a *Green Paper on CCS*, i.e. a set of recommendations concerning regulatory changes which would enable the deployment of large-scale, commercial CCS installations. The document has been submitted to the Ministry of Climate and Environment as part of the consultation of the draft amendment to the Geological and Mining Law.

- **Final version of Polish Hydrogen Strategy was released in November 2021**. The expected installed capacity of hydrogen production installations in 2030 is 2 MW. An installation producing hydrogen from natural gas or coal with the use of CCS/CCU is mentioned as a possible source of hydrogen.

- In November 2022 KGHM, a Polish major copper and silver producer, adopted the climate policy document where the use of CCS/CCU technologies is expected to manage the remaining CO2 emissions from metallurgical processes.

- In April 2022 the fifth list of energy Projects of Common Interest (PCIs) was adopted by the EU institutions. **The list includes Poland – EU CCS Interconnector**, i.e. an open access multi-modal liquid CO_2 import-export terminal in Port of Gdansk, Poland, for emitters from the industrial cluster in the area around Gdansk, with related CO_2 transport infrastructure to European CO_2 transport and storage network in the basin of the North Sea. The commissioning date is July 1, 2026, and the project is scheduled to transport 2.7 million tonnes of CO_2 per year between 2025-2030 period reaching 8.7 million tonnes of CO_2 between 2030-2035 period. Since it is included in the list, the project will be subject to streamlined permitting and regulatory procedures and eligible for financial support from the EU's Connecting Europe Facility (CEF) energy facility.

- In April 2022 the Polish natural gas transmission system operator (TSO) Gaz-System has signed a partnership with other TSOs from Central Eastern Europe (Romania, Slovakia and Hungary) to, i.a., explore CO_2 transportation.

Chapter 3. Policy roadmap for the scaled-up deployment of CCS and its related technologies in Poland

The roadmap provides an overview of various ambitious policy actions along the innovation cycle, from research and development to potential commercialisation of these technologies in order to reach climate targets set by the EU and national strategies. While the roadmap aims to create an enabling environment to deploy CCS projects, it increasingly focuses on ways to develop transferable knowledge and skills by national stakeholders (governments, research organisations, academia, private sector) in one or more stages along the carbon capture, transport, storage and utilisation chain, and create linkages to gain knowledge and experience from more experienced stakeholders across the globe. It also underlines the importance of cross-border activities and joint regional demonstration projects to increase stakeholder access to funding considering their different geographies.

The roadmap has been prepared based on desk research and interviews, conducted within *Assessment of current state, past experiences and potential for CCS deployment in the CEE region – Poland* report, as well as consultations with key stakeholders in a form of interviews and workshop held on April 12, 2022.

The roadmap outlines desirable actions in 4 areas:

A) Scaling-up RD&D activities and building national knowledge and experience;
B) Policy, standards and regulations;
C) Stakeholder engagement, cooperation & know-how dissemination;
D) Social aspects and public support.

The actions are proposed to be achieved in the short term (up to 2025), medium term (up to 2030) and long term (up to 2040). Some of the actions, however, are not single steps but require prolonged, constant efforts within a given time perspective. In such a case the measure is proposed to be implemented “with continuous efforts”.

A) Scaling-up RD&D activities and building national knowledge and experience

Key action	Approach	Stakeholders	Timeline
Knowledge platforms	○ Establishing a knowledge platform led by government with dedicated website that will include available policy papers, data, results of research (for example on the feasibility and security of geological storage), approaching events and Q&A section. Ministry of Climate and Environment in cooperation with Ministry of Economic Development and Technology can organise a kick-off meeting (roundtable discussion) with representatives of industry, research institutions, local governments and NGOs to discuss detailed shape of the knowledge platform. Regular meetings and consultations with the representatives of various groups of stakeholders would be held within the platform. ○ Fact-based approach: preparation and publication of *Fact sheets* on the knowledge platform website.	• **Ministries**, including the *governmental Group for the development of technologies of capture, storage and utilization of CO_2* • **Academia and (national) research institutes** as knowledge providers, especially the AGH University of Science and Technology (as the developer of the CCUS.pl project, the first pilot industrial CCS cluster in Poland conceived as a stimulus for further development of CCS in Poland and aimed, i.a.,	Short-term with continuous efforts

		at building knowledge on this technology) • Representatives of different sectors, including local government representatives, business associations, potential CCS project developers, and NGOs/representatives of the civil society • Media and NGOs as the **disseminators of knowledge**	
Engagement with international fora	○ Either joining international forums (**Advisory Council of the Zero Emission Platform** (**ZEP**) or **CCUS Group** within **Clean Energy Ministerial**) or becoming a more active participant of the already joined initiatives (**ZEP Government Group**) in order to, i.a., influence the development of enabling environment for CCS, exchange knowledge, build Poland's position on the CCS market, accelerate investment and help establish national research and innovation activities.	• Representatives of the Polish government (as observers in the **ZEP Government Group** and potential members of the **CCUS Group** within **Clean Energy Ministerial**) • Private entities, academia and research institutes (as potential members of the **Advisory Council of the ZEP**)	Short-term

Identifying industrial hubs/clusters/CO_2 transport networks	○ Undertaking adequate communication activities in order to promote the Cluster Map[5] by the Polish Agency for Enterprise Development, as part of the ClusterFY project[6], that presents the currently operating clusters in Poland that have decided to be registered in the database tool and encourage other clusters to join this initiative. ○ Communicating to the representatives of industrial clusters the results of the CCUS.pl project (for details on this projects see: *Knowledge platforms*). ○ Organisation of a roundtable discussion, held by the government, with representatives of all potentially interested entities with sessions dedicated to specific topics, such as establishment of CCS clusters and transport networks. ○ Assessment of the CCS readiness of Polish industrial facilities, with mapping possible storage sites, best available capture technologies and transport opportunities, taking the issue of (local) public acceptance into account – in order to identify the most convenient locations of potential CCS clusters. These clusters should be also created in accordance with national strategies. ○ Establishing the transfer of knowledge between businesses and academia within industrial clusters. ○ Conducting consultation with key industrial players regarding consistency of CCS technology with the development of the hydrogen market in Poland.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • KOBiZE • Industrial companies from branches, where CCS could be applied, e.g.: CEMEX Polska, CIECH Soda Polska S.A., Grupa Lotos S.A. and Lotos Petrobaltic S.A., PKN Orlen S.A., Tauron Wytwarzanie S.A., KGHM Polska Miedź S.A., Heidelberg Cement (Grupa Górażdże), Lafarge • Representatives of already existing industrial clusters • AGH University of Science and Technology • WiseEuropa • Gaz-System S.A. (Polish natural gas	Short-term with continuous efforts

[5] https://mapaklastrow.parp.gov.pl/Klastry2/index.html.
[6] https://www.parp.gov.pl/component/site/site/clusterfy.

		transmission system operator exploring the possibilities of CO_2 transportation) • Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy (Polish Geological Institute - National Research Institute) • IChPW	
Funding and financial support for RD&D projects	○ Establishing national, stable and long-term funding scheme for CCS projects by the government that would be in line with strategic documents for CCS deployment and would include public and private investors. Allocated funds should be synchronised with EU funding available options. ○ Providing finance for CCS by national, state-controlled financial institutions. ○ The government should publicly communicate available funding options on dedicated websites and establish official CCS contact points that could offer assistance and Q&A sessions. ○ A new financing model should include both support in the investment (CapEx) and operational (OpEx) phase. Moreover, it needs to involve different actors, including academia and research institutions. ○ Finance provided to RD&D projects should primarily cover high costs of storage (e.g. the costs of monitoring of the storage site, required by law) and transportation. ○ Subsidies allowing upscaling and covering all parts of the value chain.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • National Center for Research and Development • Bank Gospodarstwa Krajowego • Polski Fundusz Rozwoju S.A. • NFOŚiGW (National Fund for Environmental Protection and Water Management) • Representatives of EIB, World Bank, etc. • Polish academia	Short-term with continuous efforts

		• Other public, academic and business actors	
Storage site exploration	○ Allowing for the exploration of potential onshore CO_2 storage (it is now forbidden by law, see: part B). ○ Updating and deepening a 2008-2012 comprehensive study on the CO_2 underground storage potential. ○ Creating geological models of CO_2 storage complexes including the feasibility and safety assessment.	• Ministry of Climate and Environment • Polish Geological Institute	Short-term with continuous efforts
Bridging the valley of death	○ Feasibility studies conducted prior to the project implementation will help minimise risks at any stage of the investment. ○ Knowledge sharing between different stakeholders, specialists and investors can help foresee any future risks linked with economic, technical or environmental aspects, and hence facilitate further deployment of CCS on a large scale. ○ Deploying different parts of the CCS value chain separately (but in a coordinated manner), as not to burden a single (private) entity with excessive costs. ○ Locating CO_2 storage sites and new industrial/power/heating plants in areas that will shorten CO_2 transportation routes. This would decrease transportation costs, making CCS projects more feasible. ○ Focus on conventional road/rail/water CO_2 transport in initial projects of pilot character, which are to investigate the feasibility of CCS technology in Poland. Pipeline transport costs had a very high share both in CapEx and OpEx of the demonstration projects and ultimately stifled their development. Moreover, since as for now carbon storage is allowed only in a particular area under the seabed of the Baltic Sea, today the costs of building a pipeline would be even much higher as the most of Polish industrial facilities are located in the South, and the Baltic Sea is in the North. However, especially in the initial phase, when the amounts of captured CO_2 are not substantial, pipelines are not indispensable; conventional	• Ministry of Economic Development and Technology • Ministry of Climate and Environment • Polish Geological Institute • Gaz-System S.A. • Other public, academic, business and industrial actors	Mid-term[7] with continuous efforts

[7] According to the Polish national report, the implementation of the CCS technology is a very complicated process and because of the necessity of integrating many entities, it will be time-consuming. It is expected that in Poland CO_2 storage could begin 20 years (in the optimistic scenario) after elaborating the initial plans.

	transport would be much cheaper and more cost-efficient (which minimizes financial risk), and secure (in terms of public acceptance risks). ○ Since in the commercial large-scale phase of CCS the CO_2 pipeline grid might be the most feasible solution and given that pipeline costs can be too high for a single company**, cooperation of multiple companies or moving the burden of financing the deployment of pipeline grid to the state is recommended**, especially since the CO_2 pipeline network is expected to be managed by a state-owned enterprise (as it is for now in the case of electricity and natural gas transmission grids). ○ Preparation of a preliminary feasibility project for CO_2 transport. As there are many ways of CO_2 transportation, all of them should be taken into account when planning CCS projects. The state could assess the best business model for a CO_2 transport and storage infrastructure based on a multi-modal CO_2 transport network that could use all available modes of transport, so that emitters can focus on investing in capture and not be burdened with pipelines and storage sites. A major incentive to the development of CO_2 transport network can be provided by the outcome of the ACCSESS project, which is to tackle the issue of transporting CO_2 from Górażdże (located in Southern Poland, i.e. in the proximity of Polish industrial base) and Hanover to the Northern Lights storage facility in the North Sea. ○ Preparation of a business plan/case for CCS technology. ○ In order to make industrial and power plants more eager to invest in CCS on a large scale, either CO_2 must become a valuable commodity one can sell or removing CO_2 must become less or at least equally expansive than emitting CO_2, e.g. by implementing Carbon Contracts for Difference. (see: part B, *Enabling environment for CO_2 market*).		

B) Policy, standards and regulations

Key action	Approach	Stakeholders	Timeline
Policies	○ Enhanced understanding that the development of CCS is not economically feasible at an early stage and therefore requires support from the state. ○ Clear public commitment of the government to support CCS technology through including CCS in strategic documents and climate policies. ○ Maintaining favourable conditions for the deployment and operation of the CCS installations through their life-cycle should be guaranteed by the policy-makers.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology	Short-term with continuous efforts
Guidelines and standards	○ Policy and regulatory environment of the CCS should be stable, clear, precise and cross-cutting. ○ Elaborating uniform conduct guidelines for civil officers and local governments. ○ Adopting and following the standards issued by ISO Technical Committee for carbon dioxide capture, transportation, and geological storage. ○ Loosening requirements envisaged by the regulatory framework regarding composition of CO_2 stream injected into the underground storage, e.g. in terms of allowed quantity of water. ○ Regulations on the technical specification of CO_2 pipelines should be passed. ○ Regulation on the technical conditions which must be satisfied by an installation before connecting to the CO_2 transport network system, envisaged by the Geological and Mining Law, should be enacted. ○ KOBiZE should change the approach to calculating CO_2 emissions and recognize CO_2 emissions transported not via pipeline as avoided emissions that can be deducted from the account of the emitter within the EU ETS. ○ Applying environmental standards to CO_2-intensive materials (see: *Enabling environment for CO_2 market*). ○ Supporting low-carbon products and additional market-pull mechanisms (such as other accreditations schemes).	• Ministry of Climate and Environment • Polish Committee for Standardization • KOBiZE • Future CO_2 transport and storage infrastructure operator(s)	Short-term with continuous efforts

Regulatory framework	○ The act implementing the EU CCS Directive should be revised and amended in order to ensure full compliance with the Directive and to eliminate unnecessary barriers arising from unreasonable implementation of some provisions of the Directive (e.g. on CO_2 transportation and financial security). ○ Inland CO_2 storage isshould be allowed given both the inland geological potential of underground CO_2 storage and safety issues. ○ Removing regulatory limits to the minimum amount of stored CO_2 within a single project, which will allow for the development of pilot projects. ○ Regulations should not allow for the preference of CO_2 transport via pipelines to other modes of CO_2 transport, as it is now (see: *Guidelines and standards*). ○ Removing financial barriers envisaged by the regulatory framework, such as covering the costs of monitoring (which are very high according to the stakeholders) by a developer of a CCS project. ○ Poland, as a party to the London Convention, but not a party to the London Protocol (LP), should investigate whether by virtue of the provisions of international law the export of CO_2 from Poland to other countries for offshore underground storage is allowed, and, therefore, whether there is a need to accede to the LP, ratify the 2009 amendment to the article 6 of the LP, deposit a declaration on provisional application of this amendment, and, finally, sign an angreement with the destination country (e.g. Norway) for the exported CO_2. This issue gains importance in view of planned CCS projects assuming storage of CO_2 captured in Poland in the North Sea (ACCSESS and Poland EU CCS Interconnector, for details on this projects see: Chapter 2).	• Ministry of Climate and Enivronment (in particular personally the Minister of Climate and Enironment who individually amends the *Regulation on the allowed locations of CO_2 storage sites*) • Ministry of Foreign Affairs	Short-term
Strategies for CCS application for industrial decarbonisation and climate neutrality of the economy	○ The state could efficiently implement CCS strategies aimed at sectors which are state-controlled (through state-owned enterprises), i.e. the chemical industry in Poland and national industry associations (e.g. for cement and steel branches) should develop national CCS roadmaps/strategies for its members. ○ Polish Hydrogen Strategy could be more unambiguous when it comes to the use of “blue hudrogen” (derived from methane with the use of CCU/CCS) and set a target for the share/amount of “blue hydrogen” in 2030. ○ Polish Long-term strategy (LTS) is still under preparation, but to the draft envisages CCS as a measure to reduce emissions from natural gas-fired heating plants. However, given the instability in natural gas supply arising from the war in Ukraine, this plan might be revised. Nevertheless, **Polish LTS should definitely include CCS as a decarbonization solution for the industrial sector**.	• Ministry of State Assets • Ministry of Climate and Environment • Ministry of Economic Development and Technology • National sectoral associations, e.g.	Short-term

	○ Preparing a robust strategy for decarbonising the industry sector. ○ Strategies should include effective governance and implementation tools, otherwise they might become a dead letter.	Polish Cement Association	
Enabling environment for CO_2 market	○ Elaborating rules for calculacting and accounting negative CO_2 emissions. ○ Recognizing (both by regulatory framework and KOBiZE) captured CO_2 emissions stored in products or CO_2 emissions transported not via pipelines as avoided emissions that might be deducted from the account of the emitter within the EU ETS, which would translate into the possibility of paying less for emission allowances. ○ Government should support establishing clear accounting rules for CO_2 stored in products at the EU level. ○ In the case of pilot CO_2 capture projects, which might not necessarily include underground storage component, **measures aimed at promoting temporary storage of limited quantities of CO_2 in inland facilities**, such as tanks, are advisable, since as for now Polish law recognizes underground CO_2 storage only. These tanks might be anyway required in the future as buffers securing constant supply of CO_2 to the underground storage site. ○ Implementing Carbon Contracts for Difference. ○ Making public procurement 'green' through applying environmental criteria to CO_2-intensive materials. ○ Implementing tax incentives for CO_2 storage.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • KOBiZE • Public entities (including local governments) launching calls for tenders	Short-term with continuous efforts
Resilience of CCS strategies	○ Presenting CCS as a tool to conduct the just transition of coal and carbon-intensive regions. To that end, political parties should be approached and better informed about the need to decarbonise Polish industry, and the ways to do it (e.g. via CCS). ○ Setting a multipartisan parliamentary group could help build a resilient, cross-party consensus around CCS, notwithstanding changes in the composition of parliament and changes of government. ○ Spreading the IPCC's position on the role of CCS in achieving climate neutrality.	• Ministry of Climate and Environment • Academia and research institutes • NGOs (e.g. WiseEuropa) and media	Short-term with continuous efforts

C) Stakeholder engagement, cooperation & know-how dissemination

Key action	Approach	Stakeholders	Timeline
Engagement with stakeholders	○ Engagement and identification of relevant stakeholders through established knowledge platforms and clusters aimed at expanding the network of public, academic and business actors interested in the CCS technology. ○ Know-how dissemination through clusters of knowledge and technology that bring together different stakeholders. ○ Building links between suppliers of technology and potential customers in the energy and industrial sector. ○ Promoting preparedness of the stakeholders in terms of regulatory challenges and public support.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • National Center for Research and Development • Polish Geological Institute • Mineral and Energy Economy Research Institute of the Polish Academy of Sciences • IChPW • Research institutions, think-tanks, NGOs, other public, academic and business actors	Short-term with continuous efforts
International/ regional cooperation	○ Setting up an international platform facilitating knowledge exchange and networking regarding the possibility of cross-border CCS projects. ○ Building readiness to launch cross-border projects through extensive R&D, pilot and demonstration projects before scaling up the cooperation.	• Ministry of Climate and Environment	Short-term with continuous efforts

	○ Establishing international consortia with more experienced countries/entities and adjust the project to the national potentials and possibilities. ○ Expansion of international CO_2 transportation networks, since such projects offer economies of scale, which translates into lower costs. ○ Active engagement in already established networks (for example the European Strategic Energy Technology Plan - SET Plan, CO2GeoNet - the European Network of Excellence on the geological storage of CO_2) and building on results of the international projects (for instance ERA-NET transnational CCS project that finished in January 2021 and consisted of 10 partners from 9 countries including Germany and Norway).	• Ministry of Economic Development and Technology • National Center for Research and Development • Research institutions, think-tanks, NGOs	
Stakeholder cooperation towards CO_2 market	○ Sector integration is possible between industries that emit CO_2 and could be suppliers of CO_2 for industries that later use it for a different purpose.. ○ CCS incorporation into Waste to Energy (WtE) plants, which leads to negative emissions.	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • Other public, academic and business representatives (for instance HeidelbergCement, Lotos Petrobaltic, Air Liquide)	Short-term with continuous efforts

D) Social aspects and public support

Key action	Approach	Stakeholders	Timeline
Building public support	○ Knowlegde dissemination – coordinated by the government, but carried out by local governments, NGOs, etc. ○ Proactive communication should be built upon two-way dialogue by bringing different stakeholders together: policymakers of all levels (national, regional, local), companies, experts, NGOs, trade unions and local communities. ○ Facilitating public consultations assisted by the representatives of the academia, research institutions and NGOs. ○ Benefitting from the experience of the cancelled demonstration CCS plant in Bełchatów where some mayors and local communities were strongly against the venture as they were lacking information and sufficient knowledge about the CCS technology. Conflicts that arose around the CCS project in Bełchatów showed that NI(U)MBYism is a phenomenon that cannot be ignored in Poland. Therefore, a proper analysis of this specific case study and drawing conclusions from the reasons for failure of building public support for this initiative could facilitate the process of improving public approval of the CCS technology. ○ Creating information centres, websites, and tours of CO_2 storage sites (e.g. already existing ones in Borzęcin, Kaniów (Poland) or Ketzin (Germany)) or natural gas underground storage sites, which would prove the safety of underground storage technology. This should be followed by a survey determining the extent to which these efforts influenced the acceptance of technologies. ○ Combatting fear of CO_2 leakage by: • stressing that storage complexes are located deeply underground and that geological structures chosen for storing CO_2 must satisfy strict requirements imposed by the EU (via the CCS Directive). This should increase the trust into	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • Local governments • Developers of CCS projects • Research institutions (for example Institute of Geological Sciences, Polish Academy of Sciences), academia (for instance Gdańsk University of Technology), think-tanks, NGOs (for instance Institute for Sustainable Development, Fundacja im. Stefana Batorego or WiseEuropa)	Short-term with continuous efforts

	safety of storage, especially since the Polish people trust more the EU institutions than Polish government[8]; • emphasizing that storage complexes are under permanent monitoring by public authorities, even after decommissioning of the CCS installation.		
Building awareness	○ Raising public awareness of climate change and its negative impacts. ○ Providing understandable information showing that CCS is one of the most effective method significantly reducing CO_2 emissions, hence supporting climate change mitigation. ○ Organising open panel discussions (online and in-person). ○ Highlighting challenges and benefits resulting from the implementation of CCS, using i.a. the best practice of CCUS Forum (launched by the European Commission) that brings together different parties and is planned to be carried out annually. ○ Revision of Polish strategic planning documents so that they acknowledge CCS as an effective method in achieving climate neutrality, which will result in improved awareness of other public institutions (e.g. financial ones – if they see that CCS is officially indicated as a measure to mitigate climate change by the government, they will be more prone to develop funding programmes dedicated to CCS initiatives).	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • Developers of CCS projects • Research institutions, academia, think-tanks, NGOs, media	Short-term with continuous efforts
Improving fairness of the decision-making process	○ Conducting public consultation prior to any kind of decision-making process, showing the exact location of the project with clear information of the possible impact on local communities. Information about the meeting should be spread via different media (internet, local newspaper, bulletin board in the city hall). ○ Leaving the decision on approval of the location of CCS installation to a citizens' assembly – a group of randomly selected inhabitants who make the final decision upon being well-informed about the issue.	• Developers of CCS projects • Local governments	Mid-term[9] with continuous efforts

[8] Standard Eurobarometer 95 – Spring 2021: Public opinion in the European Union (https://europa.eu/eurobarometer/api/deliverable/download/file?deliverableId=79223), p. 49.
[9] As the deployment of the first onshore CO_2 storage sites is expected not earlier than in 2030, according to the stakeholders' opinion cited in the Polish national report (https://ccs4cee.eu/wp-content/uploads/2021/11/CCS4CEE-Poland.pdf).

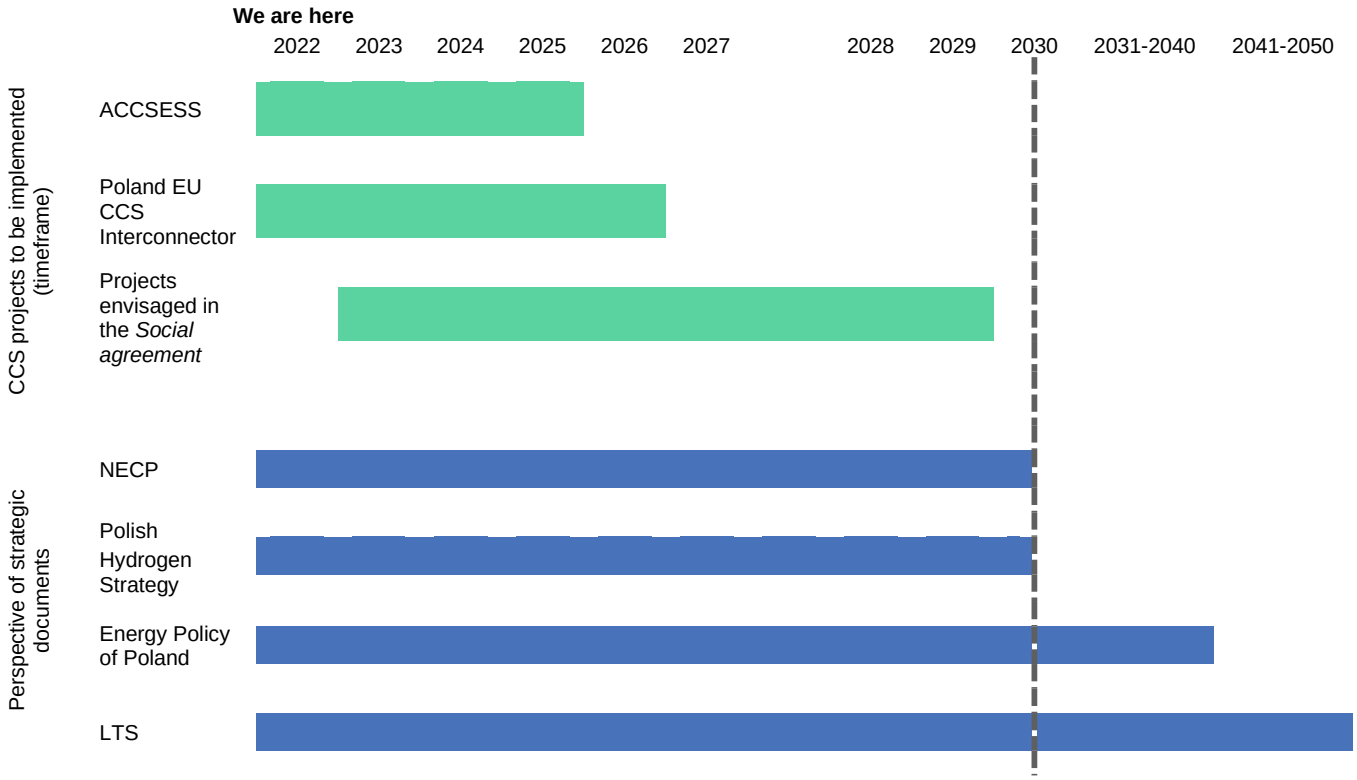
Communication of costs, risks and benefits of CCUS projects	○ Communication should be adjusted to different actors in order to involve everyone in a discussion. ○ Discussions should take into account the phenomenon of NI(U)MBY and assess its extent beforehand with the use of surveys and focus groups. ○ Focus on potential local content of the CCS value chain. ○ The narrative should be built using the language of benefits, showing prospects such as the fact that the technology can generate new jobs, build a regional economy, save existing industrial base and make it more competitive. ○ Discussions with the public could be assisted by an impartial observer (an expert on the topic).	• Ministry of Climate and Environment • Ministry of Economic Development and Technology • Local governments • Research institutions, academia, think-tanks, NGOs • Developers of CCS projects	Short-term with continuous efforts
Making sure the CCS project fits within the local context	○ Aligning specific CCS projects within the local context through a decision-making process that takes into account all requests from local communities using a proactive approach and discussions at every stage of the project.	• Ministry of Climate and Environment • Developers of CCS projects • Think-tanks, NGOs	Mid-term[10] with continuous efforts
Building trust in decision-makers and other relevant stakeholders	○ Successful pilot and demonstration installations will build trust in decision-makers and other stakeholders showing that CCS is an efficient and effective method for mitigating CO_2 emissions and that this technology is safe. ○ Carrying out a comprehensive risk assessment of CO_2 geological storage. ○ Guidelines on conduct with CCS of should be duly followed by investors, authorities and other stakeholders, which will prove to the society that they can be trusted.	• Developers of pilot and demonstration CCS projects • Public and private actors	Short-term with continuous efforts

[10] Once a full-scale CCS project will be being implemented, which might be expected not earlier than in 2030.

Chapter 4. Next and immediate steps

Actions to be taken as soon as possible should be decided upon getting to know with the current and expected course of events in the coming years in the field of CCS (Figure 5).

Figure 5. CCS projects to be implemented in Poland in the perspective of national strategic planning documents



The burning issue is therefore to provide appropriate, enabling environment for already announced projects (ACCSESS, Poland EU CCS Interconnector and projects envisaged in *Social agreement*), as not to hamper their development, since they can provide so much valuable experience for Polish stakeholders, especially in the field of CO_2 transportation, which remains unexplored on a large scale in Poland. To that end, Polish public authorities should:

- **first of all investigate whether the provisions of international law allow for CO_2 export from Poland to Norway** and take necessary measures if required (such as accession to the London Protocol, etc., for details see: Chapter 3, part B, *Regulatory framework*). This is particularly important for ACCSESS project and Poland EU CCS Interconnector which assume CO_2 transportation from Polish industrial plants to offshore storage sites in the North Sea. Given that these initiatives are to be commissioned shortly (in a few years, see: Figure 5), Polish government has to act fast;

- **allow for inland CO_2 underground storage**, which will allow for a deployment of an underground CO_2 storage complex, envisaged by the *Social agreement*, in Silesia; this complex is planned to be commissioned in 2026, so rapid actions in this field are also encouraged.

The abovementioned measures are not only necessary in order to lift the barriers for particular, already announced projects, they would also facilitate the development of other CCS projects (e.g. in the next decade). Moreover, since the proposed urgent measures refer to the regulatory framework, they are quite feasible – they only require enough political will in the parliament and in the government.

The next immediate steps, which could be made in parallel with the previous ones and which can/will be promoted within the WP5, are:

- providing a stimulus for changes in regulatory framework (developed in the Chapter 3, part B), especially when the draft amendments to CCS regulations proposed in October 2021 will be processed and debated in the parliament, which should happen shortly;
- raising the issue of misallocation of the revenues from the EU ETS (as proved by the ClientEarth[11]), whereas at least 50 % of the revenues generated from the auctioning of allowances should be spent on, i.a., "the environmentally safe capture and geological storage of CO2, in particular from solid fossil fuel power stations and a range of industrial sectors and subsectors"[12]. Revenues from the auctioning of allowances could then provide finance essential to develop CCS value chain in Poland, which is highly advisable;
- providing an up-to-date analysis of public approval of CCS or promoting CCS in the public in the context of the recent developments, not only on the energy market: in view of the Russian invasion of Ukraine and its negative ramifications for the energy security, and ever-increasing energy bills, i.a. due to high and volatile carbon price within the EU ETS, etc., CCS can be presented or already perceived as a tool to mitigate these negative impacts, sine it eliminates the necessity to purchase emission allowances and allows for the use of coal of national origin (in place of natural gas) in the longer term, which translates into a delay of the departure from coal and temporal increase in energy security. Therefore, a window of opportunity for CCS might be open and this opportunity should be grasped;
- encouraging the switch to the low-emission energy generation and, in particular, industrial production, by incentives such green public procurement and national funding scheme;
- conducting the **assessment of CCS readiness** of Polish power, heating and industrial plants in order to identify the infrastructural needs in the field of CCS in Poland;
- creating a **knowledge platform** based on a fact-based approach – the initiative should be initiated by the government (possibly with the help of the external institutions) and business associations and aimed at specific industry representatives and technology vendors. The expected additional outcome would be facilitating additional R&D projects and supporting new business models.
- setting up **a new advocacy platform** that would bring together experts on economic, technical, and environmental aspects of CCS with the policymakers and civil society. Preferably, this action will translate into creating an enabling regulatory and policy framework for the deployment of CCS in Poland;
- preparation of a robust **strategy for decarbonising the industrial sector and CCS strategy on a national level**;

11 https://www.clientearth.pl/media/wz5h00b5/20220518-kreatywna-ksi%C4%99gowo%C5%9B%C4%87-jak-polska-marnuje-%C5%9Brodki-z-eu-ets-raport-fundacji-clientearth.pdf.

12 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union, article 10 (3) (e).

- filling the gap in strategic planning – neither any projects are planned for the period 2030-2050, nor CCS is going to be promoted through strategic efforts from the state (see: Figure 5), which might be the reason for no plans by private entities in the field of CCS in Poland for the next decades. Therefore, the revision of national strategic documents, focused on CCS, should be made. Moreover, the LTS (with enough focus on CCS) should be finally submitted to the European Commission.

Although the roadmap provides more specific actions, it is recommended in the first place to focus on more "soft" measures that can be accomplished with a lower financial outlay and can be a basis for further actions. It is also important to remember that CCS technology cannot be properly implemented without the cooperation of different stakeholders and all actions should be properly planned in advance.

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