How to make carbon capture a business opportunity in Poland?

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Abstract of the presentation accompanying the talk „How to make carbon capture a business opportunity in Poland" given at Carbon Capture Forum in Warsaw on November 18 (2014).

Agenda

- Introduction
- National contexts in Poland
- Solutions for Poland including:

  technology, economy, society, regulations and policy
- Conclusions

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Introduction

Making carbon capture a business opportunity is from many reasons a real challenge in Poland. This talk analyses national contexts in Poland and potential solutions that should be prioritised.

One of the major challenges Poland will face in the coming decades is how to make national energy system clean, secure and efficient while reducing greenhouse gases (GHGs) emissions and maintaining economic growth. Meeting 2050 decarbonisation goals set by European Climate Foundation: (i) 80% reduction of GHGs emissions, (ii) zero carbon electricity and (iii) 60% reduction of GHGs in the transport sector would require massive deployment of low-carbon technologies in Poland.

The national power sector is characterised by very large direct CO_2 emissions intensity of electricity production of about 980 gCO_2/kWh_e. To make carbon capture a business opportunity Poland really needs a broad mix of technological, economical, societal, regulatory and political solutions. These solutions cannot be simply adopted from more experienced countries but must be carefully adjusted or set to fit national contexts of Poland.

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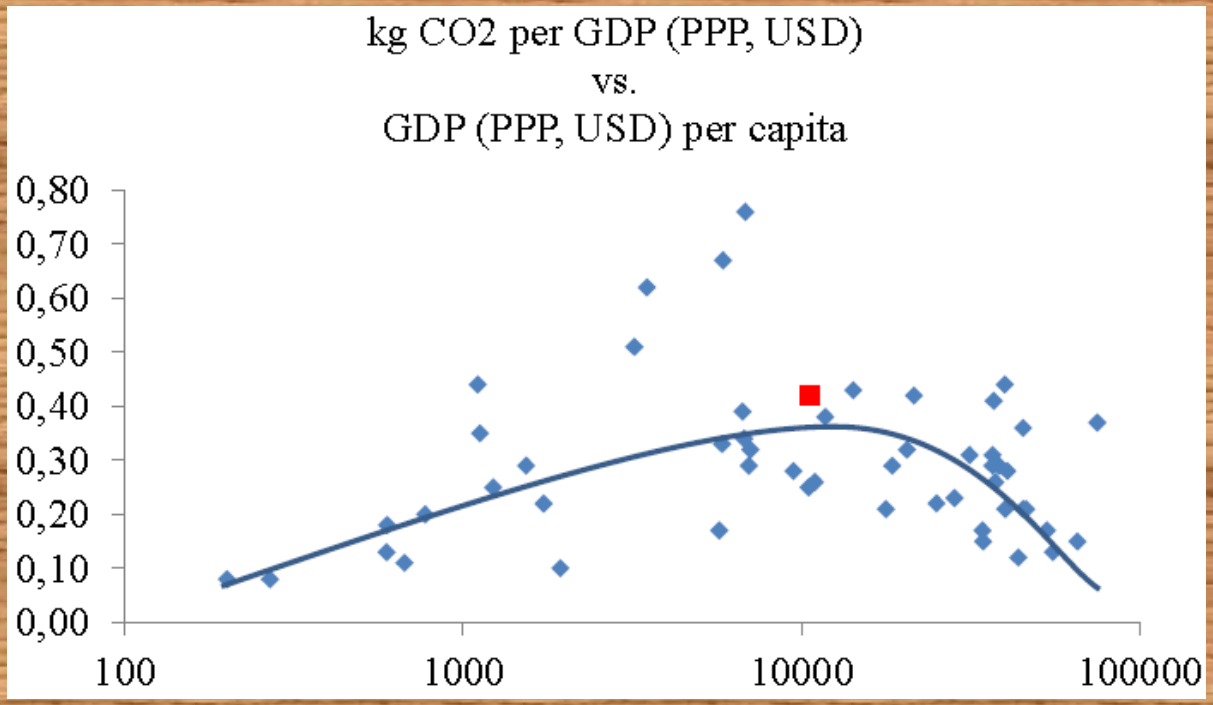
Introduction

Is it possible to combine economic growth and CO_2 emissions reduction in Poland?

Figure Relationship between CO_2 emissions per GDP and GDP per capita for various countries



Data show that many high income countries succeeded in alleviating CO_2 emissions per GDP. The presented relationship proves, that CO_2 emissions per GDP do not have to rise with rising GDP per capita. It follows an environmental Kuznets curve (EKC) type dependence. Since Poland is close to the top of the EKC thus CO_2 emissions per GDP might fall with rising GDP per capita in Poland.

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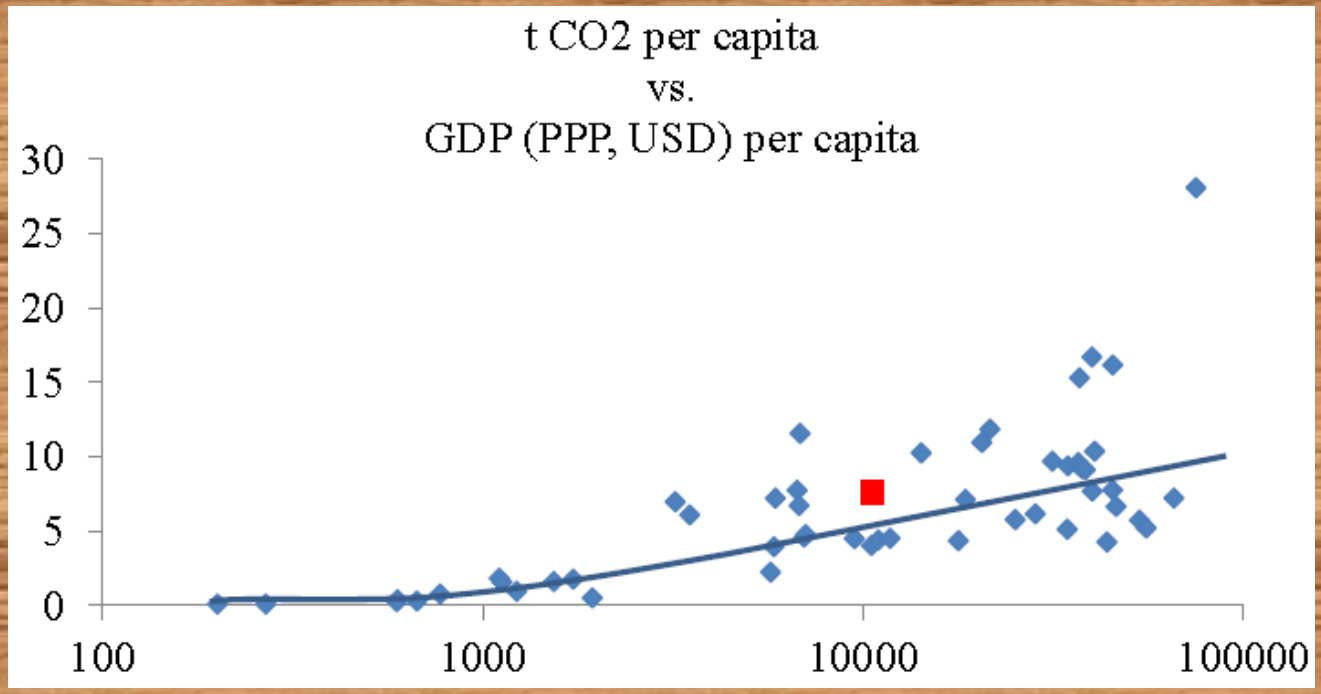
Introduction

Figure Relationship between CO_2 emissions per capita and GDP per capita for various countries



However, CO_2 emissions per capita will rise with rising GDP per capita. Thus assuming stable population total CO_2 emissions will also rise with rising GDP in Poland. There is no longer EKC type dependence.

Thus to combine economic growth and CO_2 emissions reduction Poland will need a challenging set of solutions. They should ensure really low-carbon economic growth and partly employ it to reduce CO_2 emissions in other carbon intensive parts of the economy.

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National contexts in Poland

- Technological contexts

Poland's power sector is dominated by coal firing and hence clean coal technologies are of great interest. However, technologies and experience developed so far seem still insufficient to make carbon capture viable for Poland over the longer term. It would be ideal if the costs of carbon capture could be covered by solutions such as enhanced gas recovery (EGR) or enhanced oil recovery (EOR), but these opportunities due to limited natural gas and oil resources in Poland, could be adopted only for very limited amounts of CO_2.

Poland has limited generation capacity in relation to renewable energy sources (RES), except biomass. Energy efficiency gives more promise but progress is relatively slow. Importantly, expected future economic growth will generate additional energy demands. Therefore, either fossil fuel power generation or unwanted energy import will be needed in future. Consequently, carbon capture utilisation and storage (CCUS) technologies might be indispensable in Poland to maintain the high level of using coal for power generation applications.

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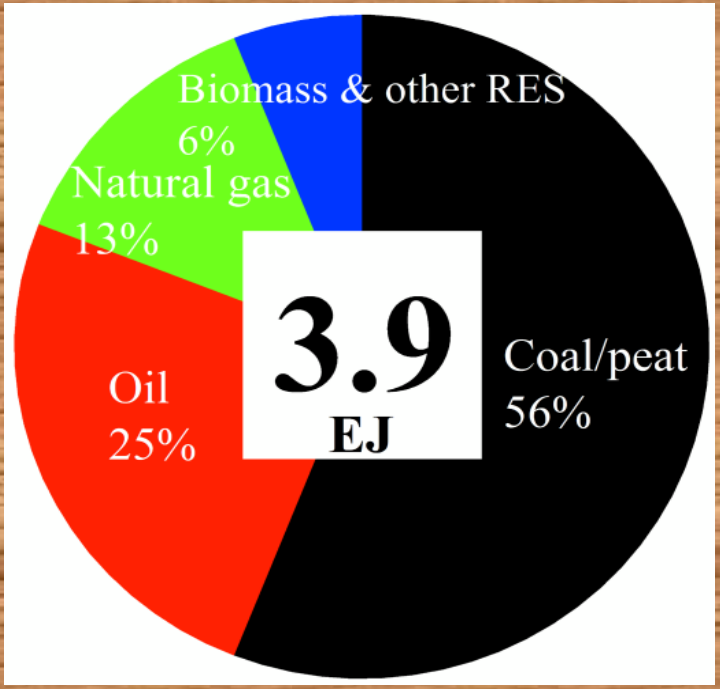
National contexts in Poland

- Technological contexts

The future of CCS in Poland seems closely related with the future of coal.

Figure Poland's primary energy mix by 2009



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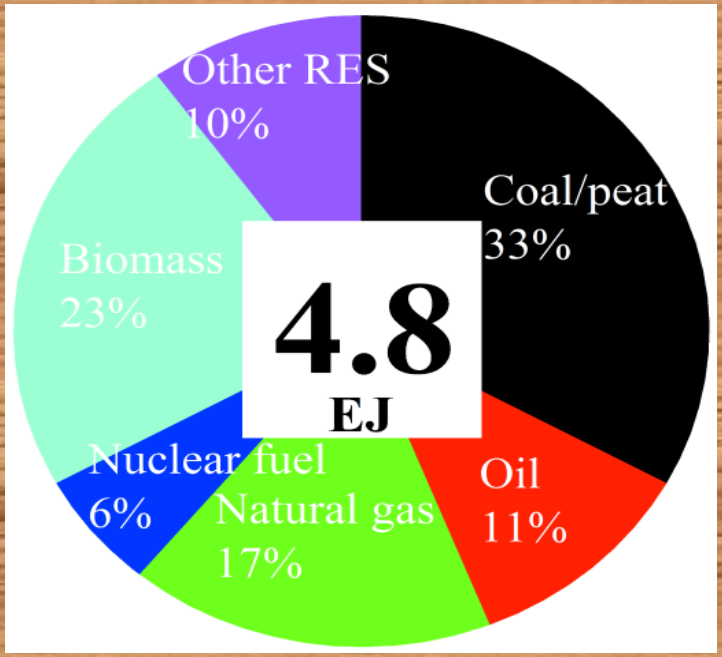
National contexts in Poland

- Technological contexts

In 2050, when CO_2 emissions are to be reduced by 80% from 1990 levels, the share of coal with CCS applied to all large point sources can be estimated at maximum 33%.

Figure Poland's primary energy mix needed to achieve 80% CO_2 reduction from 1990 to 2050



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National contexts in Poland

- Technological contexts

Regarding renewables, nuclear power and clean coal in Poland's energy mix, if CO_2 emissions are to be cut by some 80% until 2050, no CCS likely means no domestic coal utilisation in Poland by 2050. On one hand each of these three power technologies needs a specific business environment and it might be difficult to provide sufficient financial support from the state to all three of them at the same time. On the other hand a combination of power technologies may give synergies and for example minimise the needs for the conventional CO_2 storage option.

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National contexts in Poland

- Economical contexts

Poland is still an economically developing country. GDP (PPP) is about 18 kEUR per capita which is 67% of EU average (in 2013). Labour productivity is 74% of EU average (in 2013). Resource productivity is relatively low, only 0.4 EUR per kg (25% of EU average in 2011).

CO_2 emissions in Poland are above the world average. CO_2 emissions are 0.72 kg CO_2 per USD (124% of world average) and 7.6 Mg CO_2 per capita (169% of world average).

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National contexts in Poland

- Societal contexts

Questionnaires made in 2009 on a sample of 1008 respondents (CBOS, 2009) suggest that Polish society is generally reasonably well educated regarding climate change and accepts actions to combat climate change but might need further education regarding some specific low-carbon technological solutions. Regarding CCS 59% of respondents approve deployment of CCS in Poland while 16% is against. 76% of respondents agree that undertaking actions for climate change mitigation depends more on public opinion than on financial aspects. 42% thinks that climate change mitigation actions should be rather slowly adopted to minimise associated costs and 45% that they should be adopted even if costs are high.

This questionnaire gives good impression regarding public acceptance of CCS. However, there are still many power sector representatives and policy makers, who oppose undertaking any costly actions regarding carbon emissions mitigation. They often believe that carbon capture is not a good solution for Poland today. They are probably motivated by current status of Polish economy in which reductions of carbon emissions in industry will be very costly.

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National contexts in Poland

- Regulatory contexts

The regulatory environment for carbon capture in Poland is far from clear, with some interpretations of the law saying that CO_2 sequestration is illegal. There is no legal act exclusively dedicated to CCS. Two planned CCS projects Bełchatów and Kędzierzyn-Koźle have been recently abandoned due to the lack of European funding but one of the additional reasons has been unclear regulatory background.

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National contexts in Poland

- Political contexts

Energy policy of Poland was defined in 2009 (ME, 2009) with several references made to carbon capture. Currently, coordination in energy efficiency and raw material policies is addressed by the National Energy Efficiency Action Plan and the National Programme for Development of a Low Emission Economy. There is no institution exclusively responsible for dealing with carbon capture activities in Poland.

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Technological solutions for Poland

Many technological solutions can be used to mitigate GHGs emissions either directly, e.g. through carbon capture, or indirectly, e.g. through energy efficiency. Only a part of technologies required for decarbonisation is today available at sufficiently high technology readiness level (TRL) while many are under development.

Comparison of carbon emissions intensities for various power technologies suggests that CCS has potentials to reduce CO_2 emissions intensities from fossil fuels to levels below 100 gCO_2eq/kWh_e and this is less than lifecycle CO_2 emissions intensity of all conventional biopower sources.

One of major limitations of carbon capture is high cost of separating CO_2. Taking into account the scale of carbon capture needed in Poland, the overall cost would be prohibitively high for Poland's economy.

Pillars of decarbonisation in Poland (from 2010 to 2050) include:
- energy intensity of GDP: down by up to 50%
- lifecycle carbon emissions intensity of electricity: down by up to 100%
- share of electricity in final energy: up by up to 100%.

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Technological solutions for Poland

Top 10 broad technological groups of solutions to minimise GHGs emissions that fit Poland's contexts include:
1) renewable energy sources,
2) energy efficiency,
3) highly flexible fossil fuel power plants with optional carbon capture,
4) waste management,
5) carbon negative technologies based on bioresources,
6) resource use efficiency,
7) enhanced gas, oil and coal bed methane recovery,
8) clean coal technologies,
9) CO_2 utilisation to value-added products,
10) CO_2 capture, compression, transportation and geological storage.

These solutions seem to have the highest capacity and lowest cost potentials in Poland. These 10 solutions should receive the highest priority in Poland in next two decades.

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Technological solutions for Poland

Solution 1) Renewable energy sources

RES based power is characterised by very low CO_2 emissions intensities. Poland has however limited production capacity potential, especially in relation to solar, geothermal and also to wind energy. RES also need a lot of infrastructure and modern technologies. Thus 100% renewable energy system of Poland is not feasible in the short term and RES would have to be combined with other power technologies including those based on fossil fuels. In the long term RES might significantly contribute to resolving the problems with GHGs emissions.

Solution 2) Energy efficiency

Energy efficiency brings many advantages to the Polish economy. Shifting to a more energy-efficient industry and buildings will accelerate the spread of innovative technological solutions and improve the competitiveness, boosting economic growth and creating sustainable jobs in several sectors.

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Technological solutions for Poland

Solution 3) Highly flexible fossil fuel power plants with optional carbon capture

RES power supply is highly fluctuating and depends on factors such as time of day and weather conditions. Since RES has priority access to the grid in order to stabilise the grid fossil fuel power plants will have to increasingly shift their role from providing base-load power to providing fluctuating back-up power. Carbon capture may add flexibility to fossil fuel power plants thus improving their overall cost-effectiveness. Namely, carbon loaded sorbents can be temporarily stored and regenerated in a cycling manner by using surplus power not needed by the grid.

Solution 4) Waste management

Waste is a resource to recycle, reuse and recover raw materials. Proper waste prevention and management represents a major opportunity for Poland in terms of job creation, access to valuable raw materials and resources, and cost effective ways of reducing GHGs. It also aims to raise societal awareness in order to use resources more efficiently, turning the waste sector into a carbon sink.

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Technological solutions for Poland

Solution 5) Carbon negative technologies based on bioresources

As it is difficult to achieve near-zero emissions across all sectors it seems more likely that carbon negative technologies will play a major role to offset CO_2 emissions. The following carbon negative technologies might be promising for Poland:
1) carbon storage in forest wood ,
2) carbon storage from native plantations in soils,
3) carbon utilisation and storage in soils achieved through biofuels,
4) replacement of carbon intensive products,
5) carbon utilisation and storage by using emerging technologies, e.g. artificial leaves.

Solution 6) Resource use efficiency

Resource use efficiency is very low in Poland and technologies increasing this efficiency should be deployed across all resource intensive industries. Since the potential is high in Poland, more efficient use of resources, especially of carbonaceous materials, might have significant impact on reduced CO_2 emissions.

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Technological solutions for Poland

Solution 7) Enhanced gas, oil and coal bed methane recovery

Sequestration of CO_2 in mature natural gas reservoirs can enhance natural gas recovery (EGR). With EGR, Poland could increase its natural gas production to satisfy 40-45% of the existing demand.
Sequestration of CO_2 can enhance oil recovery (EOR). Deployment of EOR would allow Poland to increase its oil production by 10-15% for individual deposits, whilst disposing of significant quantities of CO_2.
Coal bed methane recovery (CBMR) relies on coal fracturing and could improve safety in coal mines.

Solution 8) Clean coal technologies

State-of-the-art technologies for cleaner utilisation of hard coal and lignite include: (i) coal for syngas, (ii) coal for F-T fuels, (iii) coal for SNG etc. Conventional clean coal technologies are however carbon intensive and would require carbon capture by itself.
Emerging clean coal technologies that might achieve alleviated carbon intensity include: (i) coal for molten carbonate fuel cell (MCFC), (ii) underground coal gasification, (iii) underground coal bioconversion.

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Technological solutions for Poland

Solution 9) CO_2 utilisation to value-added products

CO_2 utilisation can achieve cost-effectiveness if cheap renewable energy is used and final products are of sufficiently high value. The following processes look particularly promising for Poland: 1) non-conversion CO_2 utilisation, 2) fertilisers, materials and other chemicals from CO_2 reacting, 3) syngas from trireforming, 4) fuels and chemicals by catalytic hydrogenation of CO_2, 5) fuels and chemicals from electrochemical CO_2 splitting and 6) syngas from solar thermochemical cycles for CO_2 splitting.

Solution 10) CO_2 *capture, compression, transportation and geological storage*

Conventional CCS options have to overcome the following problems: 1) post-combustion capture, which has the highest TRL and can be already applied to large scale power plants, needs significant cost reduction, 2) pre-combustion in relation to coal needs R&D dedicated to various gasification options and 3) oxy-fuel combustion, which offers facilitated CO_2 separation by simple water condensation needs to resolve problems with acidic corrosion associated with highly concentrated aqueous CO_2 solutions.
Geological storage, if appropriate storage sites are selected, should be technologically feasible in Poland in near term, in particular that a share of storage in total CCS value chain costs is limited.

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Economical solutions for Poland

GHGs emissions have become a significant limitation for the rapid development of present-day economies in all parts of the world. In particular underdeveloped and developing carbon intensive economies relying on fossil fuels, especially on coal, like Poland, might have serious problems with achieving economic growth while reducing GHGs emissions at the same time. In a decarbonised world, countries with abundant renewable energy resources as well as geological CO_2 storage potential might achieve a new comparative advantage over countries with carbon intensive economies. Besides, countries that have the opportunity to be global leaders in CCUS expertise might commercially benefit from technology deployment in other countries.

Clearly, Poland may suffer a comparative economic disadvantage. For example, it will be difficult to develop or even maintain all energy-intensive manufacturing industries. It is possible that countries with low-carbon economies might attempt to economically isolate countries with carbon intensive economies. Export, which is currently a main driver of the economic growth in Poland, may thus suffer. Huge efforts would be needed in Poland to join global leaders in CCUS expertise but it seems feasible in some niche areas.

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Economical solutions for Poland

Poland has substantial potential for carbon forestry and bioenergy. By strengthening bioeconomy Poland could achieve economic revitalisation of regional and rural communities, improve biodiversity protection and water quality. But much more must be done to significantly cut GHGs emissions in Poland until 2050. There is a need to start making investment decisions today based on the required long-term GHGs emissions reductions targets. An incremental approach would not enable the deep emissions reductions needed, but would rather increase the costs involved in the transition to low-carbon economy. Economical solutions must be stable in the long-term thus making friendly business environment and minimising risks for investors.

Carbon capture and geological storage is not and will not be a profitable technology by itself. At least three factors must simultaneously occur to put pressure on deploying CCS: (i) availability of huge subsidies to CCS projects being stable in the long term, (ii) sufficiently high carbon prices based on European, international or national carbon pricing systems being predictable in the long term and (iii) energy prices from other power technologies e.g. from RES and nuclear must remain at a sufficiently high level. Since RES and nuclear also need some support or at least investment today, there is and will be some sort of conflicts between RES, nuclear and CCS, but Poland should rather try to seek opportunities and synergies as these technologies probably would have to co-exist in Poland.

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Economical solutions for Poland

When carbon capture would be sufficiently massive in Poland, a lot of CO_2 would be available on the domestic market and hence the CO_2 product could have potentials to be a negative value commodity. With a negative CO_2 price in the market CO_2 users could therefore achieve benefits just by using CO_2.

There are many possible scenarios in future, depending on international post-Kyoto and European level regulations.

The economical solutions should be however rather developed at a national level, nevertheless fitting future international and European regulations. They should be designed to give investors the confidence and certainty they need to invest in low carbon electricity generation, helping the national electricity sector to attract greater investment in low-carbon generation, and subsequently reducing carbon emissions.

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Economical solutions for Poland

To make carbon capture viable in Poland economical solutions must be attractive for investors. Top 7 economical solutions to minimise GHGs emissions that fit Poland's contexts and are thus potentially suitable for Poland include:

1) capital grants for first-of-a-kind small-scale demonstration projects,
2) capital grants and operating subsidies for commercial-scale projects,
3) electricity market reform including contracts for difference,
4) carbon pricing,
5) electricity consumption tax,
6) carbon tax as a part of a broader system,
7) export of captured CO_2 from Poland.

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Economical solutions for Poland

Solution 1) Capital grants for first-of-a-kind small-scale demonstration installations

First-of-a-kind small-scale demonstration installations are essential to demonstrate the technical and commercial viability of emerging low-carbon technologies. This solution can help to bring technologies from TRL 1-3 to TRL 8-9. Technologies originally designed to serve only carbon capture might also have potentials to beneficially affect innovativeness in many other sectors of the Polish economy thus carbon capture can indirectly contribute to economic growth.

Solution 2) Capital grants and operating subsidies for commercial-scale projects

When carbon prices remain low capital grants together with operating subsidies can make carbon capture profitable and thus accelerate further technical progress of the technology. Support for commercial-scale projects will improve cost-effectiveness at realistic scales. This solution 2 is suitable for mature technologies at TRL 8-9.

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Economical solutions for Poland

Solution 3) Electricity market reform including contracts for difference

UK passed legislation that allows the government to provide operating support to CCS projects within Electricity Market Reform (EMR) package including four main elements: (i) contracts for difference (CfDs) - long-term contracts to encourage investment in new, low-carbon generation, (ii) the carbon price floor (CPF), (iii) the emissions performance standard (EPS), (iv) the capacity market (CM).
CfDs work by stabilising the prices received by low-carbon generation, reducing the risks they face, and ensuring that eligible technology receives a price for its power that supports investment. CfDs might also reduce costs to consumers by capping the price that consumers pay for low-carbon electricity, requiring generators to pay money back to consumers when electricity prices are high.

Solution 4) Carbon pricing

Carbon pricing is a critical long-term driver that can stimulate wide-scale CCS deployment. Today carbon prices are very low but they will likely rise in future. At high carbon prices there will be greater interests to develop relevant low-carbon infrastructures. The current carbon pricing system ETS is rather out of direct control of Poland's government.

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Economical solutions for Poland

Solution 5) Electricity consumption tax

An electricity consumption tax is capable of providing an assured amount of regular funding even for large-scale projects. At the current GHGs emissions mitigation needs in North America and Europe, such a tax would add approximately 0.01 USD/kWh to present electricity tariffs while in other less developed regions about 0.05 USD/kWh.

Solution 6) Carbon tax as a part of a broader system

An economy-wide carbon tax can relate to either CO_2 emissions or fossil fuels. Companies may use low-carbon technologies to reduce their carbon tax liability. Norway currently has a carbon tax of between 18 and 70 USD/tCO_2.
In Poland carbon tax and electricity consumption tax might be adopted as a part of a broader system in which incomes from tax payers are used to reward other system participants for using low-carbon technologies. The magnitude of carbon tax can be related with a technology specific CO_2 emissions thresholds calibrated based on life cycle assessment. When a company meets these thresholds there is no carbon tax liability. Companies above these thresholds will pay carbon tax while companies below the threshold will receive subsidies from the entire system.

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Economical solutions for Poland

Solution 7) Export of captured CO_2 from Poland

Surplus of captured CO_2 that cannot be economically utilised or stored in Poland can be also exported to other countries, either as a positive or negative value commodity. This option can be mutually beneficial because Poland is likely to have surplus of CO_2 and some other countries might have interests in utilising CO_2, e.g. for EOR or as a carbon resource for synthesising value-added products.

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Societal solutions for Poland

Public perception of the need to mitigate GHGs emissions is moderately positive today in Poland but regarding exclusively CCS technology is less positive and many negative opinions can be heard. So policy makers from various political options have no clear political motivations to entirely support the deployment of carbon capture in Poland. Without broader acceptance of carbon capture by the society the progress in deployment will remain very slow.

The following top 3 societal solutions to minimise GHGs emissions that fit Poland's contexts and are thus potentially suitable for Poland include:
1) education on fundamental issues,
2) high-level societal and socio-economic R&D,
3) public engagement to promote innovativeness driven by low-carbon thinking.

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Societal solutions for Poland

Solution 1) Education on fundamental issues

Education is one of the main fields where society can be informed on issues like climate change or low-carbon technologies and thus provide informed feedback to policy makers. It is also important for society to understand the existing challenges and the implications of their possible solutions, so as to build confidence amongst investors and to ensure sustained public acceptance. Education programmes should be enriched with climate change mitigation issues from primary to academic education levels. A comprehensive social communication campaigns should be developed and implemented on a regular basis.

Solution 2) High-level societal and socio-economic R&D

Support to high-level R&D on societal and socio-economic solutions in Poland will help designing the most convenient pathways to achieve the climate and energy objectives while ensuring growth and creating sustainable jobs in Poland.

Solution 3) Public engagement to promote innovativeness

Climate change issues are capable of engaging society and making it more innovative. It might improve the environment for making climate protection business in Poland.

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Regulatory solutions for Poland

Poland should primarily (1) implement EU Directives to national law. Further, (2) a new legislative act dedicated to climate change mitigation should be created. It should facilitate carbon capture demonstration projects and govern carbon capture, utilisation, transportation and storage. Also, (3) standards for low-carbon technologies would also be needed so as to phase out carbon intensive and resource use intensive technologies in Poland.

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Political solutions for Poland

CCS deployment policy should have three subsequent phases. In a first phase public capital grants and later operating subsidies deliver a sufficient number of projects to achieve TRL 8-9. After an initial operating period of a few years, policy might switch to a second phase, provided that TRL 8-9 was achieved. The second phase could be a period of larger-scale deployment. If CCS technology becomes fully proven at commercial scale, and the supply chain matures, then a third phase could follow in which CCS is stimulated by a price instrument wherever it is a cost-effective solution.

Political solutions should include:
1) creation of an institution exclusively dealing with carbon capture,
2) development of a long-term national decarbonisation strategy to integrate cross-sectorial low-carbon goals and avoid lock-in in emissions intensive technologies.

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Political solutions for Poland

Solution 1) Creation of an institution exclusively dealing with carbon capture

Such a body could coordinate work carried out in several institutions.

Solution 2) Development of a long-term national decarbonisation strategy to integrate cross-sectorial low-carbon goals and avoid lock-in in emissions intensive technologies

Comprehensive and widely accepted national decarbonisation strategy should be adopted in Poland with particular focus on synergies between various sectors and value-added CO_2 applications. Policies enabling gradual disinvestment and retirement of carbon intensive assets should be in place and finally allow for their replacement by low-carbon assets. Poland should avoid lock in of emissions intensive technologies. It will be crucial to provide clear signals about Poland's likely long-term emissions pathways to inform investment decisions.

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Conclusions

Carbon capture is often regarded as a controversial topic in Poland. It should be addressed with emphasis on economic growth and accompanied by other most effective low-carbon technologies. To combine economic growth and CO_2 emissions reduction Poland will need a challenging set of solutions. The solutions should ensure really low-carbon economic growth and partly employ it to reduce CO_2 emissions in other carbon intensive parts of the economy. The set of solutions must be perfectly selected because otherwise it will not work as expected.

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Conclusions

This study analysed 25 such potential solutions fitting the current Polish contexts. By employing the prioritised solutions carbon capture together with other most effective low-carbon technologies can be turned into investible propositions in Poland. They should enable to achieve technology readiness, ensure long term economic predictability and low risks for investors as well as appropriately shape indispensable societal, regulatory and political frameworks. By adopting these solutions Poland can also more easily join international low-carbon technology leaders and thus minimise its future costs from low-carbon know-how import and maximise benefits from know-how export. Due to progressing globalisation and high probability that future world will be dominated by low-carbon technologies, only a low-carbon economic growth strategy based on well-designed solutions seems economically and politically adequate for Poland today. If Poland would employ only incremental approaches, the GHGs emissions reductions will not be sufficient, and the overall costs associated with the transition to low-carbon economy will be greater. Further, the combination of socio-economic solutions will have a significant positive impact on low-carbon innovativeness and business opportunities in Poland, thus the entire society will benefit economically and moreover expected future requirements for living in cleaner environment will be met.

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Conclusions

Regarding specifically carbon capture in Poland, CCU and also CCS technologies will be needed to meet future climate protection policy goals. Carbon capture should be treated as a technological bridge between 2030 and 2050 enabling prolonged use of coal in clean power generation applications. It can also facilitate transition from carbon-intensive industries to future low-carbon industries at acceptable costs for the economy.

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