

Assignment

National CO2 policy report with CCUS

-“your_country”: See your assigned country. Bulgaria, Romania, Greece, UK, Denmark, The Netherlands

According to EU regulations countries need to reduce their emissions. Industry is one of the largest sectors that add to the high emissions. Some sectors are very hard to electrify and therefore countries are discussing the building of Carbon Capture plants to these emitters. Countries would like to explore the opportunities for using the captured CO₂, or storing it in underground reserves. This concept is called Carbon Capture Utilization and Storage (CCUS).

See the link for some basic background in CCUS :

<https://www.youtube.com/watch?v=Ao5gl1ZNlic>

You are a group of experts in Supply Chain Management hired by the government of “your_country” to come up with a report to develop the CCUS network for “your_country”.

You know the following information, assumptions, limitations and considerations.

- According to regulations each factory needs to report their emissions. The database of emitters along with their CO₂ emission amounts are at “Database_emitters_CCUS. xls”.
- You are also provided with information to the storage sites, location, capacities. See “CCUS_NW_SE_Europe-Storage.xlsx”
- The CO₂ can be transported by ships, pipelines or trucks. This also has costs. You will need to analyze this information for your country. We can use a common alias for these costs: Operational cost for transportation by pipeline is PIPEVARCOST euros per km. Operational cost for truck transportation is relatively higher and is TRUCKVARCOST euros per km. For ships the operational cost is SHIPVARCOST.
- You can either send the CO₂ to storage sites to store it permanently in underground storage or send it to utilization sites paying for the associated transportation cost (based on the distance, transportation mode). From the company’s perspective if you send it to storage there is no selling profit. If you send it to other companies that can utilize it then you can actually gain capital. Different end uses have different selling prices (SELLPRICE_PROD_X) (for example ranging from 1-2 euros to 100 euros). Indeed, companies would like to send their CO₂ to utilization sites where they gain the most profit. Note that the government would like you to come up with a plan that requires the least amount of subsidies. Therefore it is important that you come up with a plan that can also operate via the economic market itself. Keep in mind that currently the lack of economic incentives and the lack of business cases for companies are the main reasons hindering the CCUS concept.
- Obviously, since there is no profit in sending the CO₂ to storage, as long as there is demand for the product, the companies would prefer to send their CO₂ to the utilization sites where they can gain some profit. However, there is another economic incentive to send the emitted CO₂ to the permanent storage sites rather than just emitting it into the air. The companies must pay a CO₂ credit price to the government for each amount of CO₂ they emit, CARBONPRICE. See for example emissions trading systems (ETS) and carbon taxes for background. Therefore, in many cases it is economically beneficial for companies to send their CO₂ to storage sites rather than emitting it into the air. Of course they should also consider the costs for transporting to the storage sites etc.
- CO₂ utilization options are diverse. The governing parties would like to focus on four different uses: Methanol, Urea, E-kerosene, Building material. Demand (DEMAND_PROD_X)) and selling prices (SELLPRICE_PROD_X) for each possible end use are important considerations. For some end uses you

may need to think about future probable demand and prices as the market may develop and you would like to come up with a plan that is future proof.

Make a plan for the following case and scenarios. Develop a mathematical (linear programming) optimization model and scenarios for each case depending on the stated restrictions and assumptions. Explain your model and constraints carefully. Provide thorough discussions.

Assume that the government has decided to install 10 capture plants. This will most probably be at the top 10 emitters of each country. Assume the government will be paying for the construction costs (for the capture plants and the pipeline costs). This means you can ignore all the fixed costs when providing results from the companies' perspective. Note that coal plants are excluded from the list of 10 companies as those are expected to be phased out in the long run. Obviously the government would like to install these expensive capture plants to locations where the plant's long term stay is foreseen.

Let's have a closer look at one plant which will help you when making the decisions (and hence the model) for these 10 companies:

Consider the total CO₂ emissions of a plant per year. The company can decide to choose among the three options as to what to do with the CO₂ emission amounts: (1) send (part of) the CO₂ to storage (consider transportation cost, no selling opportunity) or (2) sell (part of) the CO₂ to the four different end uses (consider transportation cost, gains from selling, demand etc) or (3) just emit (part of) it into the air in which case they need to pay for the CO₂ credits.

Take the perspective of these 10 companies. Make a combined distribution plan for these top 10 emitters to maximize the profit while considering the cost of distribution, potential gains from selling the CO₂ to end uses (consider four different end uses, their demand and selling prices) and the price for CO₂ credits. This means that you need to decide on the amount of flows from each plant to end uses, storage sites or air emission. This also means you need to decide on the path the CO₂ flows and which transportation mode it uses. It goes without saying that storage sites have capacities and the end users have total demand amounts.

Consider geographical characteristics as well. So, for example if some of the emitters are closely located to each other cluster them such that there will be a pipeline from that cluster to the end points. This means that although the companies do not pay the costs of the pipeline construction they will make use of it. So you need to be working with an infrastructure that makes sense. Note that your recommendations to the government should be realistic and logical. Discuss when it can be feasible to construct a pipeline among two end points. Note that it is not necessary to construct another optimization model considering the construction costs, you can discuss it with simple calculations.

Provide thorough discussions and argumentations for your input data and results. Use academic/practical references and show them in your text.

- Perform scenario analysis for different probable CO₂ credit prices (decreasing/increasing) Observe the differences in the decisions. Do not forget to add discussions. For example why and when these prices may actually take place .
- Perform scenario analysis for different probable end use amounts (demand) and prices (decreasing/increasing). Observe the differences in the decisions. Provide argumentations and discussions as to why and when these demand amounts/prices may be expected.

Provide a separate conclusion section summarizing all your results and enrich your discussion by providing your opinion (based on references) on the future of CCUS for the country.

Note that for this assignment you need to show your qualitative skills as well your quantitative skills. The locations are country specific. So this will require you to get acquainted with the current developments within the country when proposing the plans. Show your sources for your argumentations and discussions. Discussions of your data and results are an important part of your grade.

You will be provided with the list of emitters and storage sites per country. Other input should be researched, estimated by you by use of practical outlets, news, developments and academic papers. Quality of your resources is important. For example, make sure you have the most recent, reliable information. Show clear references to each of your sources and argue. For the end uses you need to be extra creative. The locations, demand per location and selling price per end use (four in total) are to be researched by your team. You probably need to consider future expected demand for some products if you deem it relevant. One perspective to come up with such estimations could be by looking at the total use of an end product in a country and assume that all (or part of it) will be supplied by the captured CO₂ in the future. These are interesting discussions in your report.

A good point to consider is that you should be convincing in your plans. No weak points. You will be graded with the correctness of your model, code and strength/thoroughness of your discussions and argumentations. Note that the code should be neat, no hard coding, no spaghetti coding.

Your report should be 5 pages including figures and references. Next to the report, hand in the program codes and data files separately.

-Approximate lengths of sections within the report (only to give you an idea of what to deliver).

Total report length: 5 pages

Mathematical Model and the constraint explanations: 0.5-1 page

Explanation of data input, scenario results, maps, figures, discussions etc: 2.5-3 pages

Conclusion: one page

References: half a page

-The maps you provide should be realistic. So use the real coordinates of locations and show them on maps (for example google maps).

Success!