THE ROLE OF CCUS IN NORTH AMERICA ENERGY SYSTEM DECARBONIZATION

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Overview

With the ratification of the Paris Agreement, the world has committed to "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels". Canada, Mexico and the U.S. formally joined the Paris Agreement in April 2016. On June 1, 2017, President Trump has decided to withdraw the U.S. from the Paris climate accord. However, the major U.S. companies and states said that they will go on with their own plans to reduce CO_2 emissions and new alliance of states, cities, and corporations has already vowed to help the U.S. meet the Paris reduction goals. Canada had committed a 30% reduction on 2005 GHG emissions, by 2030 and 80% reduction by 2050. Notwithstanding that Mexico's contribution to global greenhouse gas (GHG) emissions is relatively low, the country has undertaken important challenges to address the problem of climate change. Mexico set priority goals for controlling global warming: reducing GHG emissions by 22% by 2030 a 50% reduction in the volume of emissions by 2050.

One of the key energy technology that can significantly reduce emissions and deliver deep emissions reductions across key industrial processes such as steel, cement and chemicals manufacturing, is carbon capture, utilisation and storage (CCUS). We explore different scenarios of North America long-term energy system development in respect of the CCUS technologies including carbon dioxide enhanced oil recovery (CO_2-EOR). North America (the U.S., Canada and Mexico jointly) could achieve a deep 50% CO_2 reduction since 2005 by 2050 using CO_2 taxation (carbon taxes at $US 35/tonne starting 2020 and increasing at 5% per year until 2055). However, CO_2 taxation policy have effect primarily on power generation sector. Achievement of COP-21 commitments by Canada and Mexico requires immediate deployment of available clean energy technologies and stronger decarbonization policies. Delay in decarbonization might imply the need for more radical intervention, e.g. a massive deployment of negative emissions technologies.

Methods

The MARKet ALlocation (MARKAL) is an integrated energy systems modeling platform that can be used to analyse energy, economic, and environmental issues at the global, national, and municipal level over a timeframe of up to several decades. MARKAL is a bottom-up, dynamic, linear programming optimization model to find the cost-optimal decarbonization pathway within the context of the entire energy system. MARKAL represents energy imports and exports, domestic production of fuels, fuel processing, infrastructures, secondary energy carriers, end-use technologies and energy service demands of the entire economy. MARKAL does not contain an in-built database, so the user is obliged to enter input parameters. In this study, the publicly available EPAUS9r2017 database for the U.S. energy system had been adopted and modified. EPAUS9r2017 with the U.S. Census regions representation was created by EPA in 2017 to model changes in U.S. energy sector through 2055. We extended EPAUS9r2017 and included Canadian and Mexican energy systems as two new regions.

Each of eleven regions (Canada, Mexico and nine the U.S. Census regions) was modeled as an independent energy system with different regional costs, resource availability, existing capacity, and end-use demands. Regions are connected through a trade network that allows transmission of electricity and transport of gas and fuels. Electricity transmission is constrained to reflect existing regional connections between North American Electric Reliability Corporation (NERC) regions as closely as possible. Given the significant role of Canada, Mexico and the U.S. on the world energy system, our results represent also an important contribution for the study of global energy trends.

CO2 emissions and energy system technologies deployments are examined under the following scenarios:

- Reference scenario
- Reference scenario with CO_2-EOR option in Canada and Mexico, and 45Q tax credits in 2020-2055 in the US[1].

[1] Section 45Q is a part of the US Congress Bipartisan Budget Act of 2018. Section 45Q provides a performance-based tax credit to power plants and industrial facilities that capture and store CO_2 that would otherwise be emitted into the atmosphere. The credit is linked to the installation and

- Carbon policy scenario: carbon taxes at $US 35/tonne starting 2020 and increasing at 5% per year until 2055. This scenario includes CO_2-EOR option in Canada and Mexico, and 45Q tax credit option in the US.
- Low natural gas prices and with CO_2-EOR in Canada and Mexico, and 45Q in the US.

Results

Energy system decarbonization in reference scenarios can be observed in all regions in 2015-2030 as a result of the energy use exchange to lower carbon fuels such as natural gas. CO_2 emissions are projected to fall since 2005 through 2030 with 24% decline in Mexico, 17% decline in Canada and 13% decline in the US even without climate policies (see Figure 1), and largely because of a shift away from coal to natural gas to produce electricity (see Figure 2). However, CO_2 emissions are increased after 2030: by 2050 CO_2 emissions are 3% lower in Mexico, 13% higher in Canada and 7% lower in the US. Reference scenario with CO2-EOR results show that CO_2-EOR technologies don't affect energy system CO_2 emissions reductions although have some effect on electricity mix. Modelling results demonstrate that power generation mixes are largely dependent on the price of natural gas in the US and Canada. Though CCUS deployment can be observed in all countries of North America, the highest level of deployment is in the US as a result of 45Q tax credits.

The CO_2 taxation scenario shows that the North America economy decarbonization over the next 35 years requires a large transformation of the energy system. Thus, energy system decarbonization in CO_2 taxation scenario is caused by massive CCUS technologies deployments in Mexico and in the US. In this scenario CO_2 emissions are projected to fall since 2005 through 2050 with 30% decline in Mexico, 25% decline in Canada and 57% decline in the US.

The main finding of this study is that it is technically feasible to achieve 50% CO_2 emissions reduction below the 2005 levels by 2050 in North America through CO_2 taxation and deployment of existing or near-commercially available technologies. This emissions reductions are primarily achieved through high levels of electricity sector decarbonization in the US and Mexico, electrification of end uses in the US, and energy efficiency improvement in Canada. The results show that CO_2 taxation policy accelerate the deployment of CCUS in the US and Mexico, but in lesser degree in Canada where share of renewables and, particularly, hydro is significantly higher than in the US and Mexico.

Conclusions

Though uncertainties on technological change, economic growth, and political agendas affect scenarios projections remain, the following conclusions emerge from this study:

- The analysis reveals that there clearly is momentum towards decarbonization in the short-term future: less efficient coal power plants are disappearing from the generation portfolios and a main factor explaining the observed decarbonization is the switching of coal-based generation to natural gas. However, the emissions of a large natural as-based fleet create issues later in the forecast period without climate policies.

- Reaching the COP 21's 2030 goals are problematic for the US and Canada and reaching 2050 goals is problematic for all North America countries without climate policies that are stronger than CO_2 taxation.

  - The study finds that successful CCUS development depends on regulatory frameworks, such as 45Q tax credits. However, project finance remains the most challenging piece in Canada and Mexico without incentives to encourage CCUS deployment.

Several caveats should be noted regarding the modelling assumptions and results. The scenarios projections are not explicit predictions, but only possible future pathways based on specific modelling assumption. Furthermore, currently there being reductions in cost for solar and wind that are not captured in the study and exploring the impact of those on results could be an avenue for future work.

use of carbon capture equipment on industrial sources, gas or coal power plants, or facilities that would directly remove CO_2 from the atmosphere. The captured carbon can then be utilized in the development of products or EOR, or it can be disposed of as waste in deep saline geologic formations.

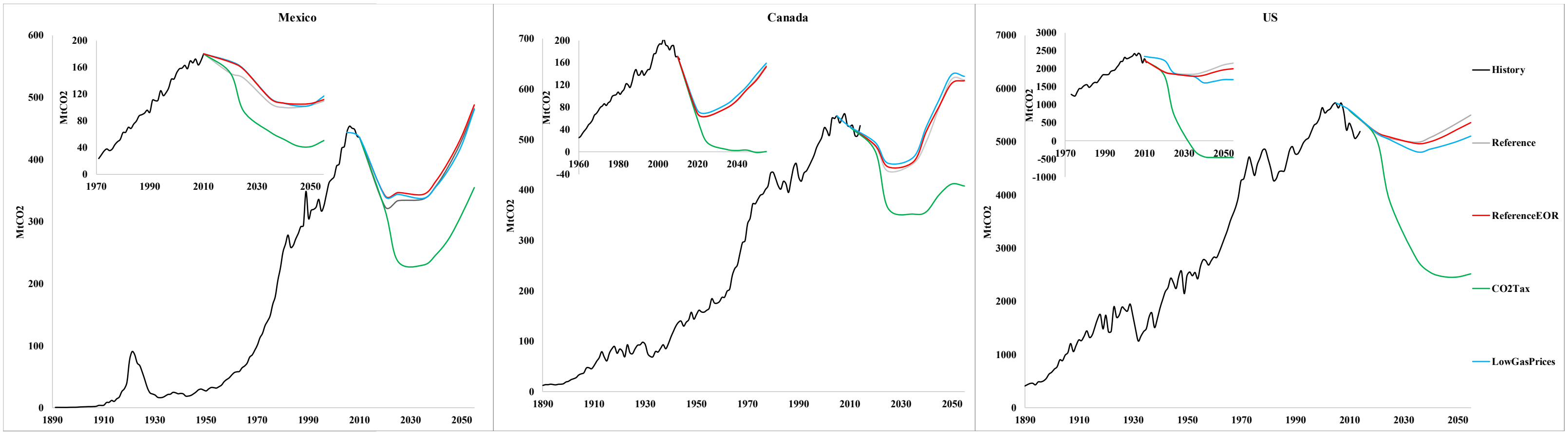

Figure 1. Mexico, Canada and the US total and power sector (left window) CO_2 emissions by scenarios

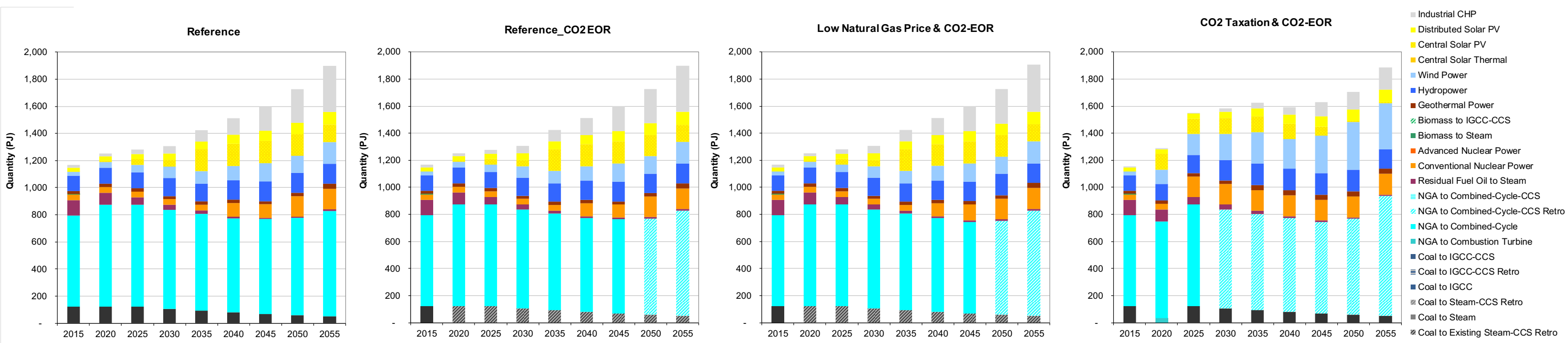

Figure 2. Mexico power generation mix by scenarios

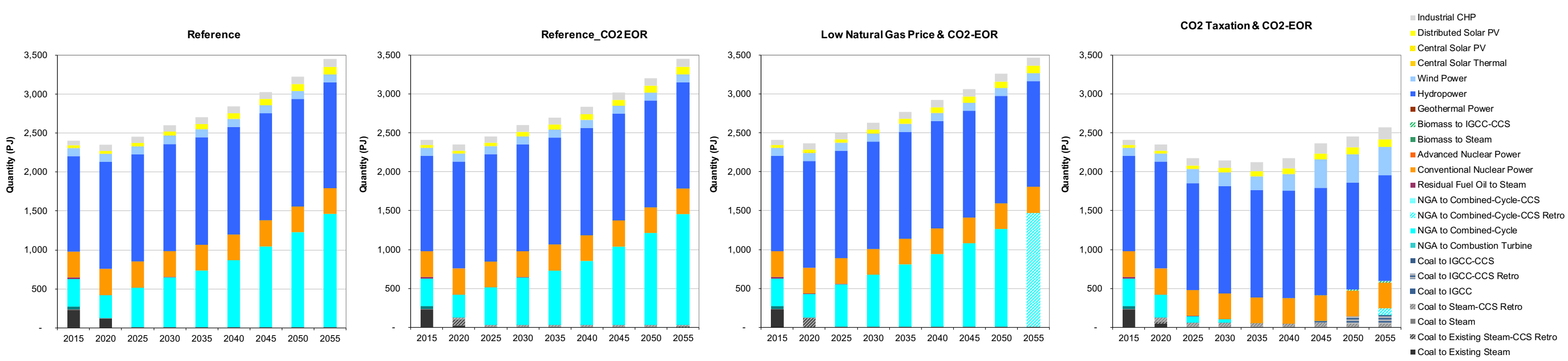

Figure 3. Canada power generation mix by scenarios

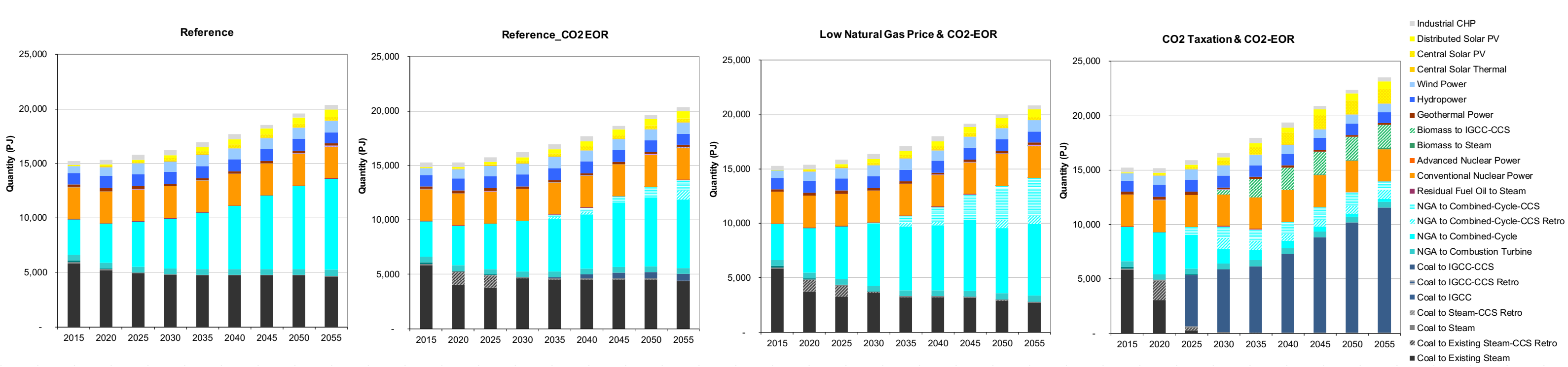

Figure 4. US power generation mix by scenarios