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Attaining carbon neutrality

Alternative electricity market models in support of carbon neutrality

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I. Background

1. This document has been prepared at the request of the Group of Experts on Cleaner Electricity Systems in its fifteenth session on 5-6 November 2020 to support its mandate and deliverables, in particular the discussions about carbon neutrality (see ECE/ENERGY/2019/7).

2. This document represents the personal views of the author and is submitted for discussion and comment.

II. Contributions of carbon capture and storage for carbon neutral electricity

3. Carbon capture and storage (CCS) is expected to contribute to carbon neutrality in electricity generation systems in two main ways:

(a) by capturing and permanently storing CO_2 from fossil power plants burning coal, gas and oil and unconventional fossil resources (e.g. oil shale), either by retrofitting CO_2 capture to existing plants or by building new power plants that either capture CO_2 directly or produce hydrogen with CCS that is then used for power generation;

(b) by capturing and permanently storing CO_2 from biomass energy with CCS (BECCS) power plants, with the expectation that overall net negative lifecycle emissions can then be achieved and that these negative emissions can be used to offset residual CO_2 emissions from elsewhere in the electricity system, e.g. peaking plants, small amounts of CO_2 not captured in CCS plants.

4. For completeness, there are two other varieties of CCS relevant to the electricity sector, but which will not be considered further in this document because they are outside the

direct scope of the electricity sector. They can be expected to be implemented in the longer term as part of wider actions to support global delivery of net zero emissions.

5. Direct Air Carbon Capture and Storage (DACCS), capturing CO_2 directly from air and then securely sequestering it, with the only purpose of negative emissions, could be used, in a similar way to negative emissions from BECCS, as described above.

6. CCS can also be used to reduce CO_2 emissions from the extraction, conversion and transport of fossil fuels used for power generation, e.g. in gas sweetening and LNG plants.

III. Challenges for introducing CCS into electricity markets

7. The overall challenge is that CCS power plant revenue prospects must give investors an expectation of being able to make reasonable returns on their investments and that operators must be able to meet the costs of CCS power plant operation plus a reasonable margin.

8. There are a number of risks for achieving this, including:

- Liberalised electricity market prices are frequently based on marginal generation costs rather than the full costs that also include the cost of capital
- Fossil power plants may be able to emit CO_2 at a low enough cost to allow them to sell into the market at lower prices than CCS plants
- Increasing amounts of intermittent renewable generation, often with guaranteed selling prices for its output, means that all fossil and biomass plants face progressive decreases in average load factors and increasingly erratic operating patterns
- For BECCS plants, there is currently no way that negative emissions can be recognised and rewarded
- CCS power plants and infrastructure will need to recover capital costs over periods of typically 15-30 years and there is a risk of policy changes over this period that will affect operating costs and revenues
- CCS deployment, including the CO_2 transport and storage infrastructure, also presents some technical and permitting challenges, but adequate solutions already exist; inevitably, though, costs are currently higher now than they will be after reductions through application at scale and learning through experience
- Access to secure geological CO_2 storage is also an issue in some locations, although innovations such as CO_2 transport by ship may sometimes be able to reduce/mitigate/lessen these.

IV. Electricity market features to aid CCS deployment

A. Long term vs. short term measures

9. The immediate problem is that CCS deployment in the power sector is currently almost zero, with just one small plant currently being operated by a state-owned utility in Canada (SaskPower in Saskatchewan[1]). Starting from this point, multiple GWs of CCS power deployment needs to take place rapidly to provide reference plants and initiate learning, as a basis for expansion to tens of GWs installed by early in the next decade and then hundreds to thousands of GWs of CCS capacity by 2050.

10. In the longer term, if carbon neutrality is to be achieved, then electricity markets will probably have to change. These new markets will have to cover all forms of electricity generation (and storage and other grid services) and ensure security of supply and reasonable

[1] https://www.saskpower.com/Our-Power-Future/Infrastructure-Projects/Carbon-Capture-and-Storage/Boundary-Dam-Carbon-Capture-Project

costs for consumers as well as carbon neutrality, and these requirements will have to continue to be delivered successfully through a number of investment cycles. But, while new market arrangements can be expected to support the implementation of the required amounts of CCS in the longer term, in the short term measures are needed that can meet the needs of CCS power projects that will be built and operate in current markets for the foreseeable future, if they are to happen at all.

B. Principles for market measures to support CCS deployment

11. The following principles are primarily directed towards more liberalised electricity markets. Regulated or state-owned utilities may be able to take more direct measures to implement CCS on fossil and biomass plants and to count the benefits described as part of an improved performance for their whole fleet:

(a) Accept higher initial costs for the next tranche of CCS power plants (as in the initial stages of renewables deployment) to encourage learning by doing, including offering a premium for projects that explore improvements and are able to share knowledge freely;

(b) Facilitate the implementation of shared CO_2 transport and storage infrastructure, to give cost reductions from increased scale;

(c) Provide a two-part payment for CCS power:

- a fixed payment, based on plant availability, to cover fixed costs;
- a variable payment, linked to electricity output and adjusted for required operating patterns, to cover variable costs.

(d) For biomass plants, provide an additional payment for negative emissions, based on CO_2 captured and securely stored less the certified lifecycle CO_2 emissions for the biomass fuel;

(e) Require these subsidised CCS power plants to be designed for a reasonable level of flexible operation consistent with their fuel (and with their existing technology if retrofits) to facilitate operation in future electricity systems, including the ability to provide an ‘emergency boost’ by operating without capture at times when grid stability interventions are required. These measures will greatly facilitate secure electricity supplies in systems with growing amounts of intermittent renewables;

(f) CCS power plants should generally be operated as specified below to provide the maximum benefits, but it must be accepted that this may have to be achieved by direct scheduling rather than being left purely to market signals (i.e. effective CCS support measures may not incentivise effective CCS plant operation vis-à-vis all the other generators in the market);

(g) CCS power plant operation to support effective grid operation or system security takes precedence;

(i) BECCS power plants (reverse order of operating costs, taking into account net negative emission values) operate behind zero marginal cost generation plants (e.g. solar, wind, nuclear) and ahead of fossil CCS power plants;

(j) Fossil power plants with CCS (in reverse order of operating costs, including a cost for residual CO_2 emissions) operate next, ahead of fossil power plants without CCS;

(k) Provide long-term contracts for these measures with a reliable counterparty to minimise project risks and reduce financing costs.

V. Conclusions

12. Electricity markets worldwide have been transformed by the introduction of renewable generation from wind and solar, but these have taken over 40 years to reach their current stage of development since receiving a first impetus from the energy shocks of the 1970s. If CCS is to contribute to power sector carbon neutrality by 2050 then it will require

analogous levels of support to those historically received by renewables. Note that CCS power generation is needed for carbon neutrality specifically because it has different characteristics to renewables; accordingly, the details of the support it requires also differ.

13. In the longer term electricity markets can be expected to adjust to encourage all forms of generation that promote carbon neutrality, but in the short term pragmatic measures, different in detail from those for renewables, are urgently required to see a new tranche of multiple GWs of CCS power plants deployed, using coal, gas biomass and other fuels, that can provide a basis for further rapid expansion.

14. While the details of national electricity markets differ between countries and regions across the ECE, a clear set of principles, matched to the inherent costs that CCS power plants incur and to the benefits that they can deliver, can aid regulators and project developers everywhere to formulate effective support mechanisms while still meeting local electricity market requirements.