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Coal phase out and renewable electricity expansion under Paris targets

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Key Messages

- Accounting for over a third of global electricity generation, coal plants need to be almost completely phased out by 2050 to meet international climate targets.
- With no new coal capacity additions, rapid scale-up of renewable generation will be required, with generation shares up to 80% by 2050.
- One strategy for facilitating this transition is through regionally interconnected grids, allowing for regions of high RE potential to supply electricity to areas of high demand.
- Policies that support the transition of coal dependent regions will be critical, including financing of renewable projects and grid infrastructure.

Introduction

While the Paris Agreement developed at COP21 strengthened international consensus on the need to tackle climate change, COP26 needs to bring about real change on the ground. The timing is particularly important, as countries continue to reinvest in their economies following the COVID-19 pandemic. Existing plans suggest many countries are foregoing the opportunity to build back greener [1]. One such initiative of focus at COP26 is the Powering Past Coal Alliance (PPCA) [2], aimed at phasing out existing coal generation plants and a moratorium on building new unabated coal, and in doing so, accelerating the transition towards cleaner energy systems.

This is a huge challenge for the international community, implying the phase out of generation that accounts for over one third of global electricity production and replacing it with a reliable supply of low carbon power, mainly from renewable sources. Not only will renewables need to replace coal generation but they will also need to be scaled to a capacity level that is twice the size of the existing global electricity system.

For regions that are much more dependent on coal, this has significant implications for national policy and investment support. China, for example, sources 65% of its generation from coal, while for India it is higher, at 72%. Combined, these countries account for 61% of global coal generation capacity [3].

Using an ensemble of established global energy models, including TIAM-UCL [4], TIAM-Grantham [5], MUSE [6], and GLUCOSE [7], this policy brief explores the speed of transition away from coal and the scale-up of renewables in the electricity generation sector, under a scenario where a Paris-aligned target of 'well below 2°C' is met [8]. It shows how quickly this transition has to happen, and the very different implications for regions, which depend on their current dependence on coal generation, and the rate at which renewables and other low carbon generation can be deployed.

The policy brief then considers the role of regional grid interconnection as a key strategy for supplying high coal dependent regions of growing demand with electricity from regions of high renewable resource. The example used is the India–Gulf Co-operation Council (GCC) region.

Pathways to coal phase out and renewable scale-up

The Paris-aligned scenario considered here sees global net-zero emissions reached by 2060 and emission reduction rates of 7–9% each year, requiring a rapid phase out of coal. All models estimate that coal generation will need to drop below 5% in 2050. The decline results in the unabated coal share falling from 37% in 2020 to 18–25% in 2030, and to under 10% by 2040. No new unabated coal is invested in post-2030, and new investments do not recover their economic costs; by 2040, both capacity level and load factors have halved relative to 2020.

The share of generation from coal in high dependent regions, including China and India (**Figure 1, left-hand panel**) highlights the scale of action that will be needed to 2050 to phase out coal. The analysis raises questions of feasibility around these rates of phase out, which need further consideration. For example, one model shows near phase out of coal by 2030, whilst the others show rapid decline between 2030 and 2050.

As coal phases out, the modelling shows the need for rapid expansion of low carbon generation, to both fill the gap left by coal but crucially to meet increasing demand for electricity as a key decarbonization lever (**Figure 1, right-hand panel**). Current levels of generation of around 100 EJ are estimated to scale to between 150–250 EJ by 2050, the growth driven by wind and solar in the main. This would see renewables accounting for 70–80% of generation, highlighting significant challenges of mobilizing such high levels of investment but also ensuring a reliable system to meet this growing demand.

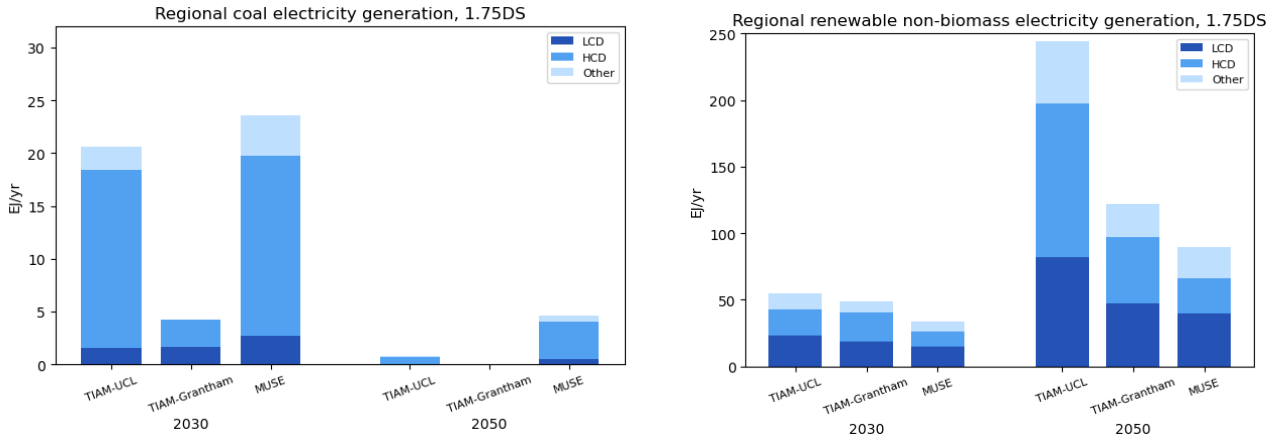

Figure 1. Regional generation from unabated coal and non-bioenergy renewables under 1.75°C target, 2030/50. Global generation in 2019 was in the region of 35 EJ for coal and 23 EJ for non-bioenergy renewables. LCD = Lower Coal Dependent (includes EU, USA, UK, Canada, Japan, South Korea, Australia, and Mexico); HCD = Higher Coal Dependent (China, India, and Other Developing Asia); Other = other regions not listed above.

Prospects for regional interconnection

An important option for enabling renewable scale-up and coal phase out is to interconnect national and regional grids. This could enable areas of high renewables to supply systems that have high levels of coal, providing clean electricity. Interconnections can also provide system flexibility, with one system providing excess electricity to another depending on demand requirements. To assess this, a regional study was undertaken, including India, with its large coal generation fleet, and the Gulf region with its high renewable potential. A range of possible electricity capacity mixes in 2050 were first generated using OSeMOSYS Global [9]. This modelling identified that, in 75% of scenarios run, investment in interconnection between the Gulf region and India made economic sense. The results showed that in the interconnection scenarios, the carbon intensity of the power sector reduced with lower reliance on coal power.

PLEXOS-World [10] was then used to assess how such an interconnected system might be operated. It identified benefits such as reduced curtailment of renewables, a lower need for domestic generator reserves, and an overall higher system adequacy (e.g., dealing with peak load). The analysis showed that interconnection allows for reduced curtailment in both regions, allowing for flow of surplus electricity in both directions (**Figure 2**).

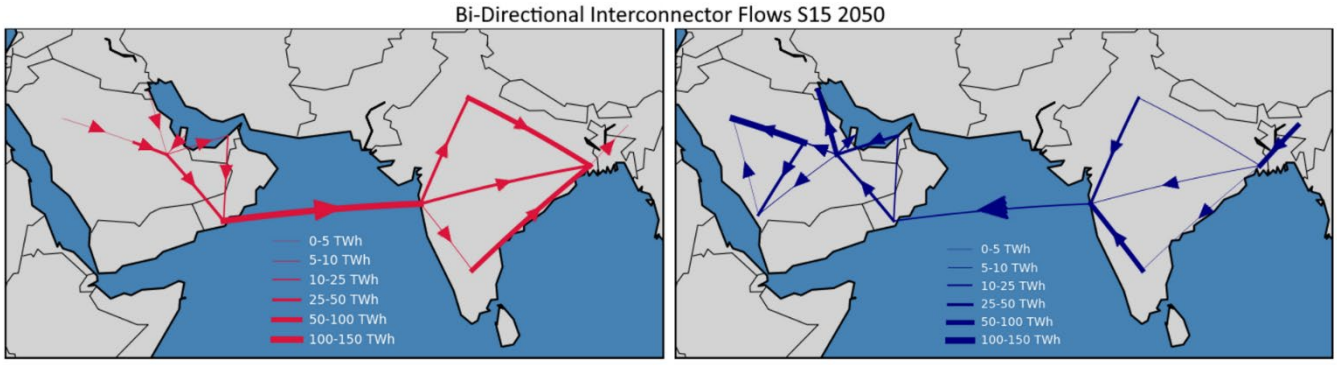

Figure 2. Bi-directional interconnector flows for high RE supply scenario

Recommendations

This policy brief highlights the need for rapid scaling of renewable generation investment and in turn the phase out of coal generation plants. If existing coal assets and those under construction were to be fully utilized over their lifetime, the objectives of the Paris Agreement would not be met. Therefore, **policies that both incentivize renewable deployment and their system integration, and which force early retirement of coal plants and disincentivize any new investment, will be crucial.** The wider benefits will also need to be highlighted, such as reduced air pollution and the growth of industries around green technologies.

The challenge is huge; **countries not yet in the Powering Past Coal Alliance (PPCA) will need to be persuaded that resilient systems can be built on the back of renewables, which are subject to the challenge of intermittency.** Such countries can be some distance from a coal phase out strategy due to new capacity being recently installed. There will also need to be financial support for decommissioning recently built assets. While a range of countries have made the transition away from coal dependency, none have been at the scale of large economies such as China and India.

A key part of facilitating the transition in high coal dependent regions towards renewable based systems is through regionally connected grids, allowing for the transmission and supply of electricity from high renewable resource regions to large demand centres previously reliant on coal power. In this study, the case for an interconnection between India and the Gulf region was explored, showing that integration of renewables in most cases leads to lower use of coal power plants without necessarily having to force it out through targeted climate policies.

While the economics of such a strategy often make sense, **there are still important challenges to address in terms of finance flows for the necessary investments strengthening grids to enable very high renewables shares** and the extent to which such support achieves the aim of global green grids as opposed to inadvertently supporting further unabated coal investment.

For more detail on this research, see the working paper by Pye *et al.* [11]

References

1. Vivid Economics. *Greenness of Stimulus Index*. https://www.vivideconomics.com/wp-content/uploads/2021/02/Greennes-of-Stimulus-Index-5th-Edition-FINAL-VERSION-09.02.21.pdf (2021).
2. Powering Past Coal Alliance (PPCA). *PPCA Global Summit strengthens international commitment to accelerate coal power-phase-out ahead of COP26*. https://www.poweringpastcoal.org/news/PPCA-news/ppca-global-summit-strengthens-international-commitment-to-accelerate-coal-power-phase-out-ahead-of-cop26 (2021).
3. IEA. *World Energy Outlook 2020*. (2020).
4. Pye, S. *et al.* An equitable redistribution of unburnable carbon. *Nat. Commun.* **11**, 3968 (2020).
5. Realmonte, G. *et al.* An inter-model assessment of the role of direct air capture in deep mitigation pathways. *Nat. Commun.* (2019) doi:10.1038/s41467-019-10842-5.
6. Giarola, S. *et al.* The role of energy storage in the uptake of renewable energy: A model comparison approach. *Energy Policy* **151**, 112159 (2021).

7. Beltramo, A., Ramos, E. P., Taliotis, C., Howells, M. & Usher, W. The Global Least-cost user-friendly CLEWs Open-Source Exploratory model. *Environ. Model. Softw.* **143**, 105091 (2021).

8. United Nations. *Adoption of the Paris Agreement*. *Conference of the Parties on its twenty-first session* vol. 21932 https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf (2015).

9. Shivakumar, A., Brinkerink, M., Niet, T. & Usher, W. *OSeMOSYS/osemosys_global: Development release for CCG*. (2021).

10. Brinkerink, M., Gallachóir, B. Ó. & Deane, P. Building and Calibrating a Country-Level Detailed Global Electricity Model Based on Public Data. *Energy Strateg. Rev.* **33**, 100592 (2021).

11. Pye, S. *et al. Coal phase out and renewable electricity expansion under Paris targets*. https://www.researchsquare.com/article/rs-380763/v3 (2021) doi:10.21203/rs.3.rs-380763/v3.

Notes

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