Can plant conversions and abatement technologies prevent asset stranding in the power sector?

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The fossil fuel power plants

Global coal power plants in 2020
Yellow: Operating; Pink and purple: under construction and planned

Illustration: Carbon Brief
Stranded assets

- Emissions from existing fossil fuel power plants go beyond carbon budgets consistent with Paris Agreement
  (Davis et al., 2010; Davis and Socolow, 2014; Rozenberg et al., 2015; McGlade and Ekins, 2015; Pfeiffer et al., 2016; Shearer et al., 2017; Tong et al., 2019)

- Fossil fuel assets may suffer from premature write-downs, devaluations, or conversion to liabilities
  (Caldecott et al., 2016; Carbon Tracker Initiative, 2015; McGlade and Ekins, 2015; Mercure et al., 2018; Pfeiffer et al., 2018)
Bet on abatement technologies

- CCS: prevent emissions from going to the atmosphere (Haszeldine 2009; Schrag 2007; Sgouridis et al. 2019)
- Bioenergy: absorb CO₂
- BECCS: negative emissions could expand carbon budget (Fuss et al. 2014; Griscom et al. 2017; Humpenöder et al. 2014)
Alternative solution: plant conversions

- Fuel switching
  - **Coal-to-gas**: More than 100 coal-fired plants in the US have been converted to natural gas since 2011 (Aramayo, 2020)
  - **Coal-to-biomass**: Europe and Canada have projects in operation (IEA and IRENA 2013; Stutzman et al. 2017; Carbon Brief, 2015)
- **CCS**: 55% of existing coal fleet in China suitable for retrofit (IEA 2016)

Drax (Yorkshire, UK) and OPG (Ontario, Canada)

Illustration: Bioenergy International/Power Engineering
This Paper

- **Research gap:** No study has rigorously analysed whether plant conversions and abatement technologies could mitigate asset stranding risk in the power sector.
Overview of Data

- **Global power plants**
  - Estimate current power plants’ future production level
  - Compile unit-level data from CoalSwarm, WEPP, and WRI

- **Climate scenarios**
  - Model pathways of electricity production required to attain 2 °C target
  - Retrieve scenarios from AMPERE project
    - Model different technology availabilities

<table>
<thead>
<tr>
<th>Technology scenarios</th>
<th>All technologies deployed scenarios</th>
<th>Single technology change scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCS</td>
<td>Fully available</td>
<td>Not available</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>Fully available</td>
<td>Limited to 100EJ/year</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Fully available</td>
<td>Not available</td>
</tr>
<tr>
<td>Wind and Solar</td>
<td>Advanced</td>
<td>Limited to 20%</td>
</tr>
</tbody>
</table>

- **Other scenarios**
  - Energy intensity
    - Improves at historical rates
    - Improves 1.5 times faster
Overview of method(1)

- **Definition of stranded assets:**
  - Lower electricity generation due to climate constraints (PWh)
  - Difference of electricity generation between existing power plants and climate scenarios

- **Four step method**
  - Compute future electricity generation from existing power plants
  - Estimate asset stranding for each climate scenario
  - Take plant conversions into account
  - Quantify the impact of technology availability
    - Compare between technology pair-wise scenarios
Overview of method (2)

- **Plant conversion assumptions**

<table>
<thead>
<tr>
<th>Plant suitabilty</th>
<th>Conversion percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-to-gas</td>
<td>25% to 50%</td>
</tr>
<tr>
<td>Have access to gas</td>
<td></td>
</tr>
<tr>
<td>Coal-to-biomass</td>
<td>20% to 50%</td>
</tr>
<tr>
<td>All coal-fired units</td>
<td></td>
</tr>
<tr>
<td>CCS</td>
<td>50% to 100%</td>
</tr>
<tr>
<td>Capacity &gt; 100MW, &lt;20 years</td>
<td></td>
</tr>
<tr>
<td>emit &lt; 1000g CO₂/KWh,</td>
<td></td>
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<tr>
<td>located within CCS suitable area</td>
<td></td>
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</tbody>
</table>

1. Around 98% coal-fired units are located in countries having access to gas
2. 25% is the coal-to-gas conversion percentage in the US from 2011 to 2019
3. Biomass co-firing could replace between 20% and 50% of coal (IEA 2013)
4. Follow Caldecott et al. (2016), around 24% global fossil fuel units are CCS suitable
Estimates of future electricity generation

- In total: 540 PWh could be produced from current plants

**Fig.1** Forecasted electricity generation between 2021 and 2100 (a) by fuel, (b) by region
Estimates of stranded assets

- In total: 270 PWh risk of stranding

Fig.2 Estimated stranded assets in 2 °C “all technologies deployed” climate scenarios (2021-2100)
Impact of plant conversions

- **Baseline:** 0% conversion, 270PWh asset stranding

![Fig. 3 Impact of plant conversions on global asset stranding](image_url)
Depending on CCS and bioenergy availability

- **Baseline**: "all technologies deployed" scenarios

![Impact of technology availability on global asset stranding](image)

**Fig.4** Impact of technology availability on global asset stranding
Conclusions

- High stranding risk even under optimistic technology assumptions
  - 270 PWh ≈ 10 times global electricity generation in 2018

- Plant conversions have limited impact
  - Reduce to 220 PWh

- Stranding may be 68% or 44% higher if CCS or bioenergy not deployed
  - CCS: high cost, storage sites availability (Reiner, 2016; Scott et al., 2013)
  - Bioenergy: feedstock availability, deforestation, food security, biodiversity loss (Creutzig et al., 2015; Ember, 2019)
Implications

- **Abatement technologies could reduce asset stranding**
  - Should strongly push the development of CCS and bioenergy

- **However, asset stranding risk remains substantial**
  - Stakeholders should act swiftly to minimize stranding risk
  - Existing plants: fuel-switching remains as an option with limited impact
  - Pipeline plants: very little or no fossil fuel plants can be commissioned
Thank you!

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