THE ECONOMIC IMPLICATIONS OF PHASING OUT COAL IN UKRAINE BY 2030

16.07.2021
Agenda

I. Introduction

II. Power sector results

III. Macro-economic implications

IV. Policy considerations

V. Discussion
We analysed a coal phase-out by 2030 and its macro-economic implications

Power system decomposition, mining costs, welfare policies for two scenarios:
- Reference scenario (BAU)
- Transition scenario (TRA)

**Installed coal capacity (GW)**

<table>
<thead>
<tr>
<th>Year</th>
<th>BAU</th>
<th>TRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>17.1</td>
<td>17.1</td>
</tr>
<tr>
<td>2022</td>
<td>17.1</td>
<td>13.4</td>
</tr>
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<td>2024</td>
<td>17.1</td>
<td>9.7</td>
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<td>2026</td>
<td>17.1</td>
<td>6.0</td>
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<td>2028</td>
<td>17.1</td>
<td>2.4</td>
</tr>
<tr>
<td>2030</td>
<td>17.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- Business as usual (BAU)
- Transition (TRA)
The macroeconomic modelling takes into account impacts on the mining sector, jobs, power system cost and public budgets.

Power system decomposition, mining costs, welfare policies for two scenarios:
- Reference scenario (BAU)
- Transition scenario (TRA)

Gross margins were used to determine order and costs of closure:
- Selydivvugillia
- Lysychanskvugillia
- Volynvugillia
- Pervomayskvugillia
- Toretskvugillia
- Myrnogradvugillya
- Pivdenodonbaske #1
- Vugillia Imeni Surgaya

Macro-economic model

- Power system optimisation model

Power system effects
- Power sector and value chain economics
- Public finance
- Macro-economic effects
- Environmental effects
A coal phase-out in the Ukraine could be achieved by 2030

1. A coal phase-out is technically feasible.
   - Stable electricity supply can be ensured while transitioning into a high RES electricity system
   - Currently, overcapacity exists
   - Flexibility, not capacity adequacy is the key challenge.

2. While coal regions are impacted, the energy transition offers large potential for economic benefits
   - More than a billion Euros would be paid as subsidies in the state-owned mines in the next decade.
   - Deployment of renewable energy in the Ukraine can create new jobs

3. Reflecting about the Ukrainian energy transition is in line with global developments
   - Just transition
   - Industrial policy
   - System planning and mobilisation of investment
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Renewable generation in the transition scenario supplies more than half of the electricity by 2030

Power generation mix in BAU

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
<th>Coal</th>
<th>CCGT</th>
<th>OCGT</th>
<th>Chp</th>
<th>Hydro</th>
<th>Biomass</th>
<th>Wind</th>
<th>PV</th>
<th>Storage</th>
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<td>54%</td>
<td>52%</td>
<td>52%</td>
<td>52%</td>
<td>51%</td>
<td>50%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>2022</td>
<td>54%</td>
<td>52%</td>
<td>52%</td>
<td>52%</td>
<td>51%</td>
<td>50%</td>
<td>1%</td>
<td>4%</td>
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<td>52%</td>
<td>52%</td>
<td>51%</td>
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<td>52%</td>
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<td>50%</td>
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<td>4%</td>
<td>2%</td>
<td>1%</td>
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<tr>
<td>2028</td>
<td>54%</td>
<td>52%</td>
<td>52%</td>
<td>52%</td>
<td>51%</td>
<td>50%</td>
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<td>4%</td>
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<tr>
<td>2030</td>
<td>54%</td>
<td>52%</td>
<td>52%</td>
<td>52%</td>
<td>51%</td>
<td>50%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Power demand TWh:
- 2020: 147
- 2022: 155
- 2024: 157
- 2026: 158
- 2028: 160
- 2030: 161

Power generation mix in TRA

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
<th>Coal</th>
<th>CCGT</th>
<th>OCGT</th>
<th>Chp</th>
<th>Hydro</th>
<th>Biomass</th>
<th>Wind</th>
<th>PV</th>
<th>Storage</th>
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<tr>
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<td>4%</td>
<td>1%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>2024</td>
<td>4%</td>
<td>1%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
<td>7%</td>
<td>7%</td>
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<td>2028</td>
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<td>6%</td>
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<tr>
<td>2030</td>
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<td>6%</td>
<td>1%</td>
<td>0%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Power demand TWh:
- 2020: 147
- 2022: 155
- 2024: 157
- 2026: 158
- 2028: 160
- 2030: 161

Sources: Aurora Energy Research
In the transition scenario, coal leaves the system, being replaced by RES and flexible generation capacity.
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Difference in installed generation capacity

GW

Sources: Aurora Energy Research
The coal phase-out could half Ukraine’s CO2 emissions for this decade and reduce them by over 80% going forward.

Power sector CO2-emissions
Mt CO$_{2\text{eq}}$

Note: Numbers for 2020 are estimates based on historical emissions. Emissions include CHP plants, which provide both heat and power. No official 2020 data has been published; we interpolate actual 2018 emissions data with 2022 modelling results.

Total CO$_2$ emission savings of 247 Mt till 2030.
Sub-conclusion: Power sector

1. A coal phase-out by 2030 does not threaten system stability and is technically achievable.
2. A combination of available and commercialised technologies, like OCGT, gas peakers and battery storages, as well as smart grid management, is sufficient to phase out coal by 2030.
3. The power mix resulting from an accelerated energy transition implies less baseload generation (especially nuclear) and requires additional flexibility to integrate RES generation.
4. CO2 emissions thus can be reduced significantly, leading to 84% less emissions in 2030 compared to BAU, and the cumulative emissions of 50% less in TRA in comparison to BAU during 2021-2030.
5. Transition will require EUR 22.5 bln more investment into new capacities then BAU (TRA: EUR 28.8 bln, BAU: EUR 6.3 bln). However, BAU relies on coal power plants being able to operate smoothly for 10 more years. The Ukrainian power sector will require new investments in the medium-term future to rehabilitate or replace aging assets.
6. BUT higher investment into the power sector will trigger a chain reaction in the whole economy.
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Mine closures lead to more than 35,000 jobs being lost...

Jobs in mines lost per region and year

<table>
<thead>
<tr>
<th>Year</th>
<th>Donetsk</th>
<th>Luhansk</th>
<th>Volyn</th>
<th>Lviv</th>
<th>Already announced for closure</th>
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<tbody>
<tr>
<td>2021</td>
<td>1,413</td>
<td></td>
<td>1,358</td>
<td></td>
<td>522*</td>
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<tr>
<td>2022</td>
<td>6,164</td>
<td>7,522</td>
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<td></td>
<td>891*</td>
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<tr>
<td>2023</td>
<td>3,160</td>
<td>2,497</td>
<td>663*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>3,181</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>2,865</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td></td>
<td></td>
<td>6,455</td>
<td>2,207</td>
<td></td>
</tr>
<tr>
<td>2027</td>
<td></td>
<td></td>
<td>4,285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>2,434</td>
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<td>2029</td>
<td>3,181</td>
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</tr>
<tr>
<td>2030</td>
<td>2,395</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These mines were already announced for closure. These jobs would be lost, both, in business-as-usual and in the transition scenario.

Sources: Aurora Energy Research
...in turn the build-up of renewable capacities allows for the creation of up to 161,000 new jobs.

Total job creation per sector in TRA (in thousand)

Source: Aurora Energy Research
The system costs of the transition scenarios are around 35% higher than in the business as usual scenario.

The system costs of the transition scenarios are around 35% higher than in the business as usual scenario.

Source: Aurora Energy Research

1) Includes capital cost for new builds, fuel cost and CO₂ cost
...lower costs associated with mines...

Mine-related costs
mEUR

Note: Net present value with the 10% ROR

Source: Aurora Energy Research
... and 56% higher tax revenues.

Tax revenue breakdown
mEUR

BAU                TRA

Carbon tax  | 11,036 | 17,228
Social security tax | 272  | 2,838
Personal income tax | 9,930| 11,770
VAT                | 442  | 1,231

Note: Net present value with 10% discounting factor

Source: Aurora Energy Research
Hence, a positive impact on the public budget

Public budget balance
mEUR

BAU

TRA

Note: Net present value with the 10% ROR

Source: Aurora Energy Research
Driven by investment inflow, CGE modelling shows a strong positive impact on GDP under the transition scenario

Change in GDP in % (for first-order and second-order effects)

- CGE modelling shows that the TRA scenario through the mobilised investments has a strong positive effect on GDP in comparison to the 2018 equilibrium
- This result is robust across sensitivities that take into account the impact on electricity prices and domestic coal supply.
- This validates the findings in the direct economic impacts, showing the energy transition can create big economic opportunities and induce growth
- Impacts on individual sectors vary and policy interventions can be considered to alleviate negative impacts

Source: Aurora Energy Research
The impacts across different sectors varies, with construction and more service-oriented sectors benefitting.


Source: Aurora Energy Research
Sub-conclusion: Macroeconomic implications

1. Shutdown of public coal mines causes the loss of 36,000 jobs by 2030. In return, energy sources substituting coal are assumed to create up to 161,000 jobs in 2030. 44,000 of the newly created jobs will be permanent, thus they will stay past 2030.

2. System costs in TRA rise mainly due to capital costs of new instalments. In contrast, operational costs decrease in TRA. Fuel costs stay comparable, because biomass takes over coal in the CHPs.

3. Higher tax revenues in TRA are a result of increased revenues from carbon tax, VAT and taxes relate to individuals’ salaries. The largest proportional increase in taxes arises from income and social security tax revenues growing with higher employment level.

4. Mines-related costs decrease by more than 400 mEUR by shutting inefficient mines first. The public expenditures spent on compensation of miners and mines decommissioning combined with a continuous process of closures (starting from the least efficient) in TRA does not exceed the costs of operation in BAU.

5. Accumulated impact of TRA on the public budget is positive and saves up to 7 bnEUR within 10 years of the transitioning process.
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Next questions for policy makers

To facilitate a transition to a modern energy system, there are several key policy considerations:

1. How can the future Ukrainian energy system look like?
   - What policies are needed to support the transition in light of the market liberalisation?
   - What mechanisms can help to ensure flexibility?

2. How can investments into the Ukrainian power sector be attracted?
   - How can the perceived risk of the sector (for investors) be reduced?
   - What incentives can be created for investments in flexible assets?
   - What EU & climate finance support can be mobilised?

3. What is the political economy behind the energy transition? Who are the key actors in the process that could facilitate change?

4. How can a just transition be designed? How can structurally affected regions and workers be best supported?
   - What policy options can support affected regions, especially monotowns?
   - What international practices could be replicated?
   - How can the impact for affected workers be softened? What support mechanisms are adequate and most effective?
   - How can the impact of new investment needs on household power prices be softened? Is support for vulnerable households necessary?

5. Which processes can facilitate the energy transition?
   - What formats (e.g. expert commission, stakeholder committees etc.) can help enable the transition?

6. What industrial policy can complement the energy transition?
   - Which existing sectors might need exemptions or policy support (energy-intense sectors)?
   - What emerging industries can be attracted and build up for the future? What enabling policies are necessary?

Sources: Aurora Energy Research
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