By the TiLT Capital Partners team, on April 3rd, 2020

Dethroning king coal

Government officials around the world are wrestling with one of the biggest challenges they have ever faced: **how to transform their countries' energy systems**, conform with the Paris Agreement[1], and provide reliable, affordable energy to citizens. The reason this challenge is so vexing is **that there are no easy answers—all forms of energy entail some kind of trade-off** in terms of cost, safety, reliability, or greenhouse-gas emissions. And all countries have sizable investments in legacy infrastructure, making it expensive —and often politically tough—to transition to other sources.

But amid all the trade-offs, one aspect is already clear: if countries want to generate the biggest impact in transitioning their energy system over the coming decade, **the reign of king coal must end**. As a power source, it's temptingly cheap and readily accessible, making it the default option for most countries' energy systems. Yet its extremely high level of greenhouse-gas emissions puts coal exit at the top of the list of countries looking to stay on track to comply with the Paris Agreement.

Comprehensive analysis needed

It's tempting to look at the advances in renewable energy and think that solar and wind power are the obvious replacement for coal. In fact, both are starting to become cost-competitive with traditional sources of power. Yet, as the following table shows, **all forms of power have drawbacks and relative impacts on the environment and society**, in the form of CO_2 emissions, waste, resource depletion, or other factors.

Technology	Levelized cost of Energy[2,3] (in €/MWh)	LCA[4] GHG emissions (in $kgCO_2eq/MWh$)	Negative Externalities / drawbacks
Hydro	**40-60** for run of river plants **80-120** for peak plants or smaller plants	**20-30**, mostly due to decomposition and of biomass in reservoir and construction	- Potential sites limited by geography - Hydrology risk - GHG emissions in case of reservoirs
Nuclear	**40-50** for existing plants **80-120** for new built	**20-30** due to construction	- Length of development and construction time - Nuclear waste management - Plant dismantling - Water usage - Nuclear safety risk
Coal *(excl. lignite)*	**40-80** depending on logistical costs	**800-900** linked directly to the combustion of coal	- Highest GHG impact of all technologies - Particles emissions and soil contamination - Water usage

[1] The Paris Agreement, structured through the UN, requires that governments keep global temperature increases "well below 2 degrees Celsius" above pre-industrial levels by 2100.

[2] Levelized cost of energy: the price of electricity (generally expressed in monetary unit / MWh) needed over the lifetime of a power generation asset to recoup all its costs: investment, operating expenditures, cost of capital. It allows comparison across technologies.

[3] Ranges of LCOE explained by difference in underlying assumptions (production level, investment and operational costs). Change in CO_2 pricing mechanisms would also affect coal and gas, upwards in all likelihood.

[4] Life Cycle Analysis: include all emissions from construction, operation and dismantling.

Gas	**60-90** depending on logistical costs and running hours	**400-500** linked directly to the combustion of gas	- GHG emissions - Energy security linked to concentrated gas supplies - Cost of infrastructure and risk of stranded assets
Wind	**20-80** for onshore depending on load factor **40-100** for offshore depending on location	**20-30** linked mostly to turbines manufacturing (steel)	- NIMBY syndrome - Intermittency - Potential constraints around rare earth materials
Solar	**20-70** depending on irradiation	**70-90** linked mostly to silicon transformation and wafer manufacturing	- Highest intermittency of all technologies - Recycling of solar panels - Land use and competition with agricultural land

To truly compare energy sources against each other, you need to compare all costs—not only the cost to produce energy from an existing asset (like a coal-burning plant, a solar panel, or a hydroelectric dam), but the cost to build that asset itself. For example, solar power is essentially a free resource once panels are in place, but it costs money to manufacture and install the panels.

For this reason, power analyses usually look at the "levelized cost of energy" (LCOE), defined as the expense required to generate a megawatt-hour of electricity, including the initial investment to build a plant, that plant's operating expenses over time, and even the cost of capital required to finance it. LCOE is usually expressed as a range, in that some facilities are more efficient than others—both to build and to run—and the cost of capital varies.

Using LCOE as a benchmark, coal is still among the cheapest sources of power on the planet, costing roughly $45 to $90 per megawatt-hour. Solar and wind can be as low as $25/MWh, but the actual cost varies according to the placement of the facility and environmental conditions like solar intensity and prevailing winds.

But the bigger drawback of coal shows up in an analysis of greenhouse gas emissions. As with costs, most energy analyses apply a comprehensive metric to better understand the true environmental impact from a given source. For CO2 emissions, that metric is a life-cycle analysis (LCA), which includes all emissions from constructing, operating, and dismantling a power source. (The unit of measurement for LCA is a kilogram of CO2, or its equivalent, per megawatt-hour.) **And the LCA numbers show just how dirty coal can be**.

Consider that renewable sources like hydroelectric or wind power generate about 20 to 30 kilograms of CO2 for every megawatt-hour of electricity they generate. Those emissions are primarily from the initial construction (or, for wind turbines, the manufacturing processes required to build the massive blades). Same for a nuclear power plant, which doesn't actually emit any greenhouse gases when it's operating; the bulk of its emissions comes from the construction of the plant itself. Solar generates slightly more greenhouse gases, 70 to 90 kilograms of CO2 per MWh, again due to the need to process silicon and manufacture the panels.

Looking at power generation from natural gas, the emissions numbers jump significantly, to a range of 400 to 500 kilograms of CO2 per MWh, mostly from the combustion of gas. And coal is dramatically worse than that—with greenhouse gas emissions of 800 to 900 kilograms of CO2 for every megawatt-hour generated. That is a ***forty-fold increase*** **compared to renewables**.

Worldwide, **power generation from coal generates nearly 10 Gt of CO2 emissions every year, or 30% of global CO2 emissions**, and that is the primary reason that king coal needs to be dethroned. Coal is an undeniably cheap source of power, but only if you look exclusively at the front-end costs. In terms of its environmental impact, it's staggeringly expensive. The difference, of course, is that no one has to pay an actual bill for greenhouse-gas emissions. Or rather, the entire planet gets billed, which accrues to a critical tipping point and then we all pay.

Drawbacks to all sources

In addition to front-end costs and greenhouse-gas emissions, all sources of power also have tradeoffs and unique externalities—even renewables. For example, both solar and wind are intermittent; they only generate power when conditions are right, and there's no means—yet—of efficiently storing that power for future use. **Because of this intermittency, they need to be built to a much higher capacity than the typical power demand they would need to meet**. In fact, if you were to build a power generation system entirely of these sources, its capacity would need to be three to four times that of a standard, fossil full-based system. That would, of course, make generation three to four times more expensive than what the LCOE of renewables would suggest — though still retaining the advantages in terms of their environmental impact**. In the next decade, renewables can be the dominant power source but not fully replace fossil fuel-based sources**.

Other sources have similar externalities. Consider:

- Hydroelectric dams can only go in certain places, and they can dramatically affect the landscape around them.
- Wind turbines can trigger a "not in my backyard" reaction among local landowners.
- Nuclear plants generate nuclear waste, consume significant amounts of water, and carry (a perception of) safety risks.

Because of these externalities, **no single power technology is sufficient on its own**. Instead, countries are increasingly applying a portfolio approach based on several power sources. How does coal factor into this mix? In short, it doesn't. By 2050, we believe that technology will have sufficiently advanced that electricity in most markets will be generated predominantly through renewable sources. **The more pressing question is how governments can navigate the transition to get there**. For the next 10 to 15 years, the energy industry and governments should have one sole priority: **taking coal out of the energy equation**.

This may seem like an overly simplistic and obvious solution, yet eliminating coal is the single measure with the biggest environmental impact. To stay on track with the objectives of the Paris Agreement—limiting global warming well below 2 degrees Celsius by 2100—countries will need to have reduce greenhouse gas emissions by about 13 Gt $C02_{eq}$ by 2030. If all coal plants on the planet were replaced with renewables sources in the next 10 to 12 years, that would achieve 70% of the total goal—with no changes to cars, trucks, factories, or any other sources of emissions.

We realize that such a move is simply not possible, given the importance of coal as an energy source in countries like China, India, Indonesia, Australia, Germany, Poland and others. The cost to wind down every coal-burning plant on the planet and build new renewables facilities would be enormous, making it impossible in both political and practical terms.

A less-ambitious measure would be to replace coal plants with modern gas-burning power plants. That approach would eliminate 6 Gt CO2eq, or nearly half the reduction needed to be in line in

2030 with a 2°C trajectory. This could be done with minimal impact on power grids (though it would require significant investments in gas infrastructure).

Replacing those coal plants with a mix of energy sources— say **half new gas power plants and half wind and solar**—is a more appealing option. That would drastically reduce the current emissions while allowing gas facilities to cover for the periods when environmental conditions don't support renewables (for example, when the wind isn't blowing or the sun isn't shining). That approach would result in **an estimated 7.7 Gt CO2eq reduction, or 60% of the target by 2030**.

In fact, this is our proposed solution for the coming decade. Governments should focus on eliminating coal from their energy systems (not only stopping any investments in new coal plants but retiring all coal plants from the generation mix). In its place, they **should make massive investments in renewables *and* gas-powered plants.**

NB: Nuclear fission power is a CO2 free option that could team up with renewables to achieve an even greater GHG emissions reduction. However, until sustainable and cost-effective solutions including for waste handling are proposed and universally adopted, this is a challenging path to follow. Nuclear fusion, would of course totally change this picture.

Folding an entire economic sector is a huge challenge. It would generate massive unemployment in traditional coal basins, meaning that any such proposal would likely result in local authorities and residents fighting with rage against what they will see as an unfair bargain. **Transitioning away from coal would require government support and initiatives** to offer decent exit conditions and reallocate some resources and people to different parts of the energy sector. It would be a huge disruption, and governments would need to structure the transition in realistic steps, **to ensure that it doesn't turn people—especially the most vulnerable—or companies against the larger goal of reducing carbon emissions**.

It's admittedly a big challenge. But the environmental impact of most countries' current power system is unsustainable and delaying that transition won't make it any easier. As governments struggle to find the right energy balance, they need to focus on the steps with the biggest immediate impact. In that regard, at least, the path is clear: **let's take out coal**, develop renewables and gas as a relevant generation mix of transition for the next decade or so, **and we'll phase out from gas over time**.



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