Aerial image of crushing and washing of gravel iron ore at a quarry in Felgar, Municipality of Torre de Moncorvo, Portugal

UNJUST TRANSITION

Reclaiming the energy future from climate colonialism

Methodology Note

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Contents

Stat 1: Energy inequality and the consumption gap

a) **A single person in the richest 1% of Global North countries consumes enough energy in one year to meet the modern energy needs of more than 440 people in the Global South.**

b) **An average person in the Global North consumes enough energy in one year to meet the modern energy needs of over 45 people in the Global South.**

c) **If redistributed, the annual energy consumption of the richest 1% could meet the modern energy needs of people without electricity access more than seven times.**

Global energy inequality is a systemic problem which will be discussed frequently in this methodology note. While nearly a billion people still lack electricity access, the richest 1% in high-income countries consume energy at levels that far exceed even the most generous definitions of sufficiency.

We begin by defining a benchmark. The modern energy minimum (MEM) is set at 1,000 kilowatt-hours (kWh) per person per year, a threshold proposed by the Energy for Growth Hub to represent sufficient access for a dignified modern life.[1] This includes basic services like lighting, refrigeration, communication and public infrastructure. It is significantly more ambitious than the SDG Tier 1 or 2 thresholds, which require as little as 50–365 kWh per household per year.[2]

In contrast, the average person in the OECD[3] – the wealthiest bloc of core countries – uses approximately 44,300 kWh per year, according to Our World in Data (2023), which compiles data from the Energy Institute and the US Energy Information Administration.[4] This figure reflects total final energy use, including electricity, gas, oil and other fuels, across all sectors: residential, transport, industrial and public. However, for a more accurate representation of the core Global North countries,[5] the number becomes approximately 46,957 kWh per person per year.

With these figures, the average Global North citizen uses approximately 47 times the energy of a person at the MEM level (46,957/1,000 = 46.96).

To isolate the richest 1%, we apply conservative but evidence-backed assumptions. Based on World Inequality Lab estimates,[6] across Global North countries, the top 1% of income earners capture between 7% of total national income – as in the case of Norway or Slovakia – and 21%, as seen in the United States. Economic literature suggests that energy use rises with income, but not linearly: it increases at about 0.7 to 0.9 times the rate of income (an elasticity of 0.8), meaning a doubling in income leads to an 80% increase in energy consumption, according to an econometric study.[7]

We estimate that countries like the United States would consume with the following multiplier:

$$20.7^{0.8} = 11.29, or\ just\ 11$$

The table in Appendix 1 also shows how we estimate the energy-use multiplier using the formula *(income share ÷ population share) ^elasticity*. For example, if the top 1% capture 15% of national income (their income per person is 15 times the average) and the elasticity is 0.8, then their per-capita energy use is 15^0.8, which is nearly 9 times the average. Under plausible ranges – an income share of 7–21% and elasticity of 0.7 to 0.9 – the multiplier lies between 4 and 15.5, which can be estimated to be nearly 10. But to be more specific, the average income share of the core Global North countries is 12.163%, according to our analysis of a dataset by Our World in Data.[8]

As such, the numbers would be as follows.

Table 1: Top 1% Energy Use under Different Income–Energy Elasticity Assumptions

Income share of top 1%	**Elasticity**	**Energy-use multiplier×**	**Energy per top-1% person (kWh)**	**Equivalent MEM persons (≈ kWh ÷ 1000)**
12.16%	**0.7**	5.75	269916.13	**269.92**
12.16%	**0.8**	7.38	346523.67	**346.52**
12.16%	**0.9**	**9.47**	**444873.95**	**444.87**

Using our estimate of 0.9×, a single top-1% person uses about 444,874 kWh per year.

A single top 1% person from the core Global North therefore consumes ~9.5× more energy than the average.

Dividing this by the modern energy minimum:

$$\frac{444{,}874}{1{,}000} = 444.87$$

This implies that a single energy user from the top 1% consumes as much as 445 people living at the threshold of modern energy sufficiency – or, rounding for simplicity, more than 440 people.

To grasp the scale of global energy inequality, consider this: the core Global North has a population of roughly 1.2 billion,[9] meaning the top 1% equals 12 million people. If each of them uses approximately 444,874 kWh per year, then their total energy consumption adds up to 5.3 trillion kWh, as seen below:

$$12\ million \times 444{,}874 = 5.338\ trillion\ kWh/year$$

Meanwhile, regarding the most deprived people in the Global South – namely, the 733 million people without any electricity access[10] – their total energy requirement at the MEM level is:

$$733\ million \times 1{,}000 = 0.733\ trillion\ kWh/yea$$

Compare that to the 5.338 trillion kWh used by the elite:

$$5.338 \div 0.733 = 7.28$$

That is, the richest 1% in the Global North consume nearly seven times more energy than what is needed to provide basic energy access to the entire electricity-deprived population of the world.

Stat 2: Energy inequality and excess energy

a) **Today, the top 10% of global energy consumers use more than half of the world's energy, while the bottom 50% consume only 8%.**

b) **If just one year's worth of energy consumed by the top 10% were redistributed, it could meet the basic energy needs of the entire Global South more than nine times over.**[11]

c) **Over the last 60 years, high-income countries have used more than 3,300 petawatt hours (PWh) – enough to power the whole world for nearly 20 years.**

d) **On average, each person in the Global North has used six times more excess energy than a person in the Global South. If we use a conservative global electricity price of US$0.165/kWh, this historical surplus would be worth more than US$454 trillion.**[12]

Foreword

Excess energy

In our analysis, excess energy refers to energy consumption beyond basic needs, defined by the MEM threshold of 1,000 kWh per person per year. This benchmark (inclusive of household and non-household use) represents the energy required for fundamental needs and economic participation – anything above 1,000 kWh/person/year is considered consumption beyond those basic needs. We emphasize that 'excess' here highlights structural inequality in energy access.

Global North vs. high-income countries

The term Global North generally denotes highly industrialized, high-income economies (primarily in North America, Europe and developed parts of Asia-Pacific). For quantitative rigor, we approximate the Global North as countries classified as high income by the World Bank. High-income countries (HICs) in our data correspond to this World Bank category and substantially overlap with the Global North.[13]

The top 10% of global energy consumers

Here, we refer to the top decile of individuals worldwide by energy footprint. It is a household-level, distributional concept (not a country grouping). The top 10% of individuals worldwide by household energy footprint would today represent about 810 million people (10% of ~8.1B).

In Oswald et al.’s dataset of 86 countries (~550M people per decile), this top decile consumed ~39% of total final energy — nearly as much as the bottom 80% combined.[14]

These individuals – who are predominantly in high-income or upper-middle income societies – account for a disproportionate share of energy use.

In contrast, the poorest 10% of people consume a negligible slice of global energy at around 2%. Moreover, the average person in the top 10% uses on the order of 20× more energy than someone in the bottom 10% – a staggering inequality.[15] These estimates rely on household energy footprint data (including direct and indirect energy use) from Oswald et al., ensuring that our inequality claims are rooted in micro-level consumption patterns.

In summary, ‘top 10% of global energy consumers’ = ~810 million people with outsized energy footprints (primarily in the Global North), whereas ‘high-income countries/Global North’ refers to whole nations with advanced economies (data for which we use national aggregates).

Methodology

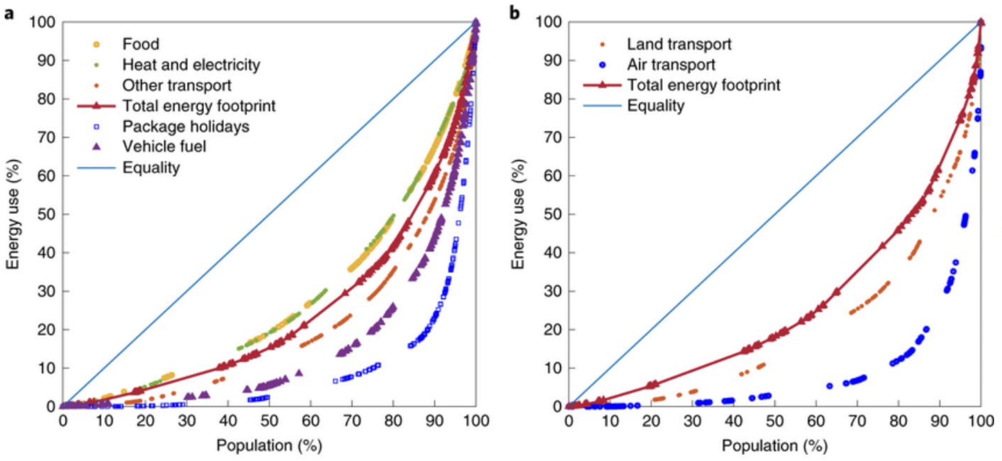
According to Oswald et al. (2020), the richest 10% of people worldwide — roughly 810 million individuals — consume about 39% of total final energy, nearly as much as the bottom 80% combined. By contrast, the poorest 50% (over 4 billion people) use only 8–12%, and the poorest 10% just 2%. On an individual level, each member of the global top 1% consumes more than 70 times as much energy as someone in the poorest decile.

If the energy used by the top 10% in just one year were redistributed, it would cover the Modern Energy Minimum (MEM) for the entire Global South more than nine times over. Likewise, carbon pollution mirrors this inequality: in 2019, the richest 10% were responsible for about half of global CO_2 emissions.

Looking historically, the Global North has consumed over 3,300 petawatt hours (PWh) of excess energy in the past 60 years — more than the entire world now uses in 19 years. At a conservative electricity price of US$0.165/kWh, this excess amounts to more than US$554 trillion.

For all calculations, we apply the MEM benchmark of 1,000 kWh per person per year, as outlined in Stat 1.

Figure 1: Lorenz curves showing global energy inequality



The top 10% of people account for more than 50% of total energy use, while the bottom 50% consume just a fraction. Transport-related energy use is especially unequal. Source: Oswald et al. (2020), *Nature Energy*. [16]

Firstly, to understand how this elite energy privilege compares to basic human needs, we use the MEM benchmark. Contemporary inequality will be assessed by comparing the top 10% of global energy consumers to the bottom half of the world's population, while historical excess consumption is calculated by totalling energy used above the MEM threshold for every country from 1965–2023.[17] The Our World in Data dataset used, on country-level total primary energy consumption, compiles statistics from the International Energy Agency (IEA) and the Energy Institute.

To contextualize the data, or rather the inequality, Oswald et al. (2020) provide a framework and analysis for the final energy footprints across 86 countries, which shows that the top 10% of consumers use about 39% of total final energy while the bottom 10% use roughly 2%.[18] They also find extreme inequality in transport energy: in low-income countries, the bottom 50% receive only 'a bit more than 10%' of land-transport energy and less than 5% of air-transport energy, while the top 10% use around 45% of land-transport energy and ≈75% of air-transport energy. These figures support the assumption that national averages underestimate elite consumption and overstate energy access for the poor.

Finally, recent estimates show that global energy consumption reached a record 620 exajoules (EJ) in 2023, equivalent to ≈170 PWh.[19] The Global South accounts for roughly 56% of this total, 85% of which stems from Asia-Pacific.[20]

Calculation

Step 1: Per-capita energy use

For each country (indexed i) and year t, total primary energy consumption (Ei,t, in kWh) was divided by population (Pi,t) to obtain per-capita energy use:

$$E^{per\ capita}{}_{i,t} = \frac{E_{i,t}}{P_{i,t}}$$

This metric measures the average amount of primary energy used per person annually. All energy values were converted to kWh before calculating per-capita use.

Step 2 – Defining 'excess' energy

The MEM was set at 1,000 kWh per person per year, consistent with Stat 1. Energy use above this threshold was treated as 'excess':

$$E_{i,t} = max\left(0, \frac{E_{i,t}}{P_{i,t}} - E_{min}\right)$$

$$E_{i,t} = max\left(0, E^{per\ capita}{}_{i,t} - 1{,}000\right)$$

Negative values (countries using less than 1,000 kWh per person) were set to zero. This ensures that countries below the MEM are not penalized.

Step 3 – Total excess per country-year

Excess energy per person was multiplied by the national population to obtain total excess energy in each country and year:

$$T^{excess}{}_{i} = E^{excess}{}_{i,t} \times P_{i,t}$$

This gives the volume of energy (in kWh) that a country consumed beyond basic needs in a given year.

Step 4 – Aggregating historical excess energy

Annual excess energy values were summed across countries in each income group and across the full period 1965-2023:

$$T_{Global\ North} = \sum_{t=1965}^{2023} \sum_{i\ \epsilon\ GN} T^{excess},$$

$$T_{Global\ South} = \sum_{t=1965}^{2023} \sum_{i\ \epsilon\ GS} T^{excess}$$

Global North excess: The cumulative excess energy of high-income countries was ≈3,360 PWh. Converting from kWh to PWh uses 1 PWh = 10^{15} kWh.

Global South excess: Low- and middle-income countries produced ≈2,264 PWh of excess energy over the same period.

Step 5 – Per-capita historical excess

Cumulative excess energy was divided by the sum of the annual populations over 1965–2023 to compute per-person excess energy:

$$Excess\ per\ person_{GN} = \frac{T_{GN}}{\sum_{t=1965}^{2023} \sum_{i \in GN} P_{i,t}},$$

$$Excess\ per\ person_{GS} = \frac{T_{GN}}{\sum_{t=1965}^{2023} \sum_{i \in GS} P_{i,t}}$$

The resulting values were ≈54.4 MWh per person in the Global North and ≈8.7 MWh per person in the Global South – meaning that people in the North accumulated six times more excess energy than those in the South.

Step 6 – Valuing excess energy

To monetize the historical surplus, total excess energy was multiplied by a conservative global electricity price:

$$V_r = {T^{excess}}_r \times c$$

Where c = US$0.165/kWh (or US$0.166/kWh using the 2023 global average). The Global North's 3,360 PWh of excess energy is thus worth US$554.4 trillion (using US$0.165/kWh).

Step 7 – Present-day inequality (2023)

Sorting countries: Using 2023 per-capita energy use, countries were sorted from highest to lowest and populations were cumulated to identify the top 10% of the global population (≈810 million people) and the bottom 50% (≈4 billion).[21]

Group energy shares: The share of global energy consumption attributable to each group was obtained by summing energy use and dividing by the global total. The bottom half consumed roughly 12% of primary energy, while the top decile consumed ~34%. Because national averages mask inequality within countries, these are conservative figures.

Top-decile consumption (E_top10): Summing the energy used by the top 10% of the global population gives ≈58,235 terawatt-hours (TWh) in 2023. By comparison, providing the MEM (1,000 kWh per person) to everyone in the Global South (≈6.83 billion people) requires ≈6,831 TWh.

The ratio:

$$R = \frac{E_{top\ 10}}{E_{Basic\ South}} = 8.5 \approx 9$$

Interpretation and Implications

From 1965–2023, high-income countries consumed 3,360 PWh of energy beyond the MEM. At current global consumption (=170 PWh per year), this surplus could power the entire world for about 19.76 years.[22] The Global South's excess (=2,264 PWh) is smaller despite a larger population and higher share of global demand (56%). As for individual levels of inequality, people in the Global North accumulated =54.4 MWh of excess energy each over six decades, compared with 8.7 MWh for those in the South – a 6:1 disparity.[23]

Valued at US$0.165/kWh, the North's excess energy is worth = US$554 trillion, showcasing how historical overconsumption represents an enormous transfer of energy wealth.

Finally, it is worth noting that while the OWID–IEA dataset provides the most comprehensive global energy coverage available, historical data for many Global South countries – particularly prior to the 1980s – remains less complete and consistent, introducing greater uncertainty in early-period excess energy estimates compared to the Global North.

Stat 3: Energy inequality in a single appliance

A single air conditioner in a European household uses as much energy in a year as the total annual energy access of over five households in energy-poor communities in sub-Saharan Africa.

According to the European Commission's *Air Conditioners and Comfort Fans* 2024 report,[24] by the year 2020, an approximate 57m room air conditioners (RACs) were used across the EU. In order to provide cooling, the RACs used a total of 15 TWh per year, while 29 TWh were used for providing heating.

At the same time, according to the 2018 paper *Sub-Saharan Africa Is Lighting Up: Uneven Progress on Electrification*,[25] the average annual energy consumption per household in sub-Saharan Africa in 2015 ranged from 143 kWh in Somalia to 7,742 kWh in South Africa, with the lowest consumption found in rural communities.

Calculation:

Calculating energy used per RAC. We combined the TWh used per all RACs annually for both cooling and heating. We used the total TWh used annually per RACs and divided it by the number of RACs being used across the EU in that same year.

$$\frac{(hTWh + cTWh)}{RAC} \approx kWh/RAC$$

Where:

cTWh is the energy used for cooling in TWh

hTWh is the energy used for heating in TWh

RAC is the number of room air conditioners used in the EU during 2020

kWh/RAC is the average amount of energy used per room air conditioner in the EU during 2020

Therefore:

$$\frac{(29\,TWh + 15\,TWh)}{57\,million\,RAC} \approx 771.93\,kWh/RAC - year$$

The total amount of energy used by each room air conditioner in the EU during 2020 was 771.93 kWh.

Calculating the ratio between annual RAC energy usage and energy consumption in sub-Saharan Africa. Taking kWh/RAC-year as a reference, we divided it by the lowest national average for energy consumption in sub-Saharan Africa.

$$\frac{EUkWh}{SAkWh} \approx p$$

Where:

EUkWh is equal to kWh/RAC-year

SAkWh is the lowest average energy consumption by households in sub-Saharan Africa

As explained previously, Somalia has the lowest average energy consumption, at 143 kWh. The previous calculation gave us the total amount of energy used by each room air conditioner in the EU during 2020, which was 771.93 kWh. Therefore:

$$\frac{772\ kWh}{143\ kWh} \approx 5.4$$

We can thus conclude that the energy used by an EU household's air conditioner per year is proportional to over five times the energy used by a household in the sub-Saharan African country with the lowest annual energy consumption per household.

Stat 4: Indigenous land and the energy transition

a) **Sixty percent of Indigenous-recognized lands – 22.7 million km² – are under current or imminent threat from industrial development linked to the energy transition, including mining, large-scale renewable projects, oil, gas and industrial agriculture. This is an area even larger than Brazil, the United States and India combined.**

b) **Industrial development linked to the Global North's extractive energy transition – including mining, large-scale renewables, oil, gas, industrial agriculture and biofuels – could disrupt or displace up to 22.7 million km² of Indigenous-recognized lands. This area is nearly twice as large as the French colonial empire at its peak.**

Here, we combine two perspectives on one statistic: first, its present-day total footprint and cross-country scope, and second, its continuity with a history of extractive power structures. This fact directly addresses the layers of threat to Indigenous-recognized territories under the current energy transition.

The first and most comprehensive threat category comes from a landmark 2023 study published in *One Earth* and led by researchers from The Nature Conservancy.[26] It estimates that 22.7 million km², or roughly 60% of Indigenous-recognized lands, are under current or imminent threat from mining, large-scale renewables, oil and gas, and commercial agriculture, including for biofuels. It mapped the overlap between:

Indigenous-recognized lands in good ecological condition, and

Areas of high industrial development potential, based on projected global demand and infrastructure growth.

The baseline global Indigenous land area (~38 million km²) comes from Garnett et al. (2018),[27] which includes lands that are legally recognized, mapped or claimed by Indigenous peoples in national datasets. The 60% figure is calculated as follows:

$$\textbf{22.7 million} \div \textbf{38 million} = \textbf{0.597} \approx \textbf{60\%}$$

For scale, the combined landmass of Brazil (8.5 million km²), the United States (9.4 million km²), and India (3.3 million km²)[28] totals ~21.2 million km² – meaning the at-risk area is significantly larger.

The French colonial empire at its height covered ~12.35 million km².[29] By comparison, today's projected land pressures from the energy transition could affect an area nearly 1.84 times larger.

Stat 5: Transition mineral reserves in the Global South

The Global South holds roughly 70% of transition mineral reserves, including up to 72% of cobalt, 64% of lithium, 71% of nickel, 64% of copper and 87% of rare earth reserves.

We used the dataset from the *Our World in Data* 2024 article on the locations of transition minerals.[30] This uses United States Geological Survey (USGS) data, and numbers may vary slightly when compared with other international sources, so they should therefore be treated as indicative estimates rather than an absolute value. We used this dataset to identify the reserves of the top five transition minerals in the Global South.[31]

A sample was created by selecting cobalt, lithium, nickel and copper – given their widespread use and impact on core clean energy technologies – along with rare earths, due to their vital role in the manufacture of high-performance technologies.[32] These minerals also hold considerable geopolitical importance.

We then calculated the percentages of reserves for each of these minerals in Global South countries, summed them up, and produced a rough approximation of overall transition mineral concentration in the Global South.

One important limitation of the dataset is that, for four of the five selected minerals, the category ‘Other’ (not attributed to any specific country) accounted for around 10% of the total. To address this, we allocated half of that value to the Global South totals, in order to arrive at a rough approximation of its share. If the ‘Other’ category is excluded entirely, the share is 67%, while if fully included, it rises to 76%. Assigning half of the value to the Global South gives 71.5%, so a reasonable midpoint estimate is around 70%.

According to the final figures, the Global South’s share of reserves is as follows: cobalt 71.75%, lithium 64.28%, nickel 70.50%, copper 63.90% and rare earths 86.89%, with an overall Global South average share of 71.46%. All numbers were rounded for simplicity (see the complete table of reserves per Global South country in Appendix 2). The 70% overall figure is a simple average across minerals, not a weighted average by reserve size, and should therefore be understood as an indicative concentration rather than an exact share.

Stat 6: DRC and the cobalt value chain

a) **Democratic Republic of Congo (DRC) produces over 70% of the world's cobalt and nearly 99% of its export earnings come from minerals, yet it only captures about 14% of the total supply chain revenue,[33] while foreign investors and entities retain over 86%.[34]**

b) **If DRC retained the full value of its cobalt industry, it could generate an additional US$4.13bn per year – equivalent to 5.2% of its GDP (US$79.12bn).[35] This would be enough to provide modern clean energy access for more than half its entire population each year.[36]**

c) **At that pace, the approximately 84 million people currently without electricity in DRC could gain access in just nine months.[37,38]**

DRC produces over 70% of the world's cobalt,[39] yet the vast majority of profits flow to foreign companies operating in the country or refining the metal abroad. DRC's national revenue remains limited – in fact, cobalt and other extractives account for nearly 99% of DRC's total exports, but because most of the high-value processing and sales happen outside the country, the sector contributes only about 13.8% of GDP and 46% of government revenue.[40] Revisions to its Mining Code in 2018 declared cobalt a 'strategic mineral,' allowing for a royalty increase from 2% to 10% of export value.[41] Moreover, companies must pay a 30% corporate tax,[42] and the government holds a 10% free-carry equity stake in mining projects.[43]

If we assume an average net profit margin of 9%, which is a standard estimate for large-scale cobalt mining,[44] then the 10% royalty can be applied directly to the gross value. Corporate tax on the 9% profit margin yields 2.7% of gross value, and the 10% state equity share of profits yields 0.9% of gross value.

- Royalty: 10% of gross export value
- Corporate tax: 30% of 9% profit margin = 2.7% of gross value
- State equity share: 10% of 9% profit margin = 0.9% of gross value

The total government capture equals: 10% + 2.7% + 0.9% = 13.6%.
So approximately 14% of the total supply chain revenue.

Export value, 2023 (and how we got it)

DRC's exports of cobalt oxides and hydroxides (HS 282200) in 2023 totalled US$4,778,874,390 (US$4.78bn).[45] This category covers the main processed cobalt intermediate exported from DRC and constitutes the bulk of its cobalt value.

With this sum, we can calculate the amount retained domestically, considering our 13.6% capture (see Appendix 3, Definitions of value capture):

- Retained domestically = 0.136 × 4,778,874,390 = US$649,926,917
- Value not retained ('lost') = 4,778,874,390 − 649,926,917 ≈ US$4,128,947,473

To understand the national impact, we relate this to DRC's GDP. The IMF reports DRC's 2023 GDP at US$79.12 bn.[46] Therefore, US$4.129 bn ÷ US$79.12 bn = 0.0522 or roughly 5.2% of GDP.

Energy-access conversion (MEM basis)

We apply the modern energy minimum (MEM) standard used throughout the report at 1,000 kWh per person per year at US$0.064/kWh.[47]

Per-person annual cost = 1,000 × US$0.064 = US$64/person/year.

Universal MEM cost for DRC (population 109.3 million[48]) = 109.3 million × US$64 = US$6.995bn/year.

Using the lost cobalt value (US$4.129bn), the share of the annual universal MEM cost that could be covered each year is calculated by:

US$4.129bn ÷ US$6.995bn ≈ 59% (equivalent to 7.1 months of a full year).

For those currently without electricity (84 million people), the annual MEM cost is 84 million × US$64 = US$5.376bn. The time to cover this with redirected cobalt value is

Months = (US$4.129bn ÷ US$5.376bn) × 12 ≈ 9.2 months.

Stat 7: The cobalt value chain, Tesla and DRC

a) **In 2024, Tesla reported a GAAP net income of US$5.63bn from its electric vehicles sales. Per vehicle, it makes about 321 times what DRC gains from cobalt royalties (US$9.79).[49]**

b) **Tesla makes nearly US$3,145 in profit per electric vehicle sold – 183 times more than what DRC receives in both royalties (US$9.79) and artisanal wages (US$7.40) for the 2.961kg of cobalt used in each EV:[50] just US$17.20. A Congolese miner earning US$5 a day would have to work every day for nearly two years (629 days[51] or 1.7 years) to make what Tesla gains in profit from a single electric vehicle.**

Cobalt from DRC and Tesla's EV profits

DRC is by far the world's leading source of cobalt, producing roughly 70% of global supply. But despite being the source, most of the value is captured elsewhere: companies outside DRC dominate refining, battery manufacturing and final EV assembly. According to Vera Songwe, former UN Under-Secretary General and Executive Secretary of the United Nations Economic Commission for Africa, DRC captures only 3% of the battery and electric vehicle value chain.[52] On top of that, there are government royalties (10%), and some local employment & taxes, though reliable public data for all of them is limited.[53]

Tesla's profit per electric vehicle in 2024

In 2024, Tesla's total GAAP net income was US$7.1bn. However, this includes all of Tesla's business segments (automotive, energy storage, services, etc.). Since about 79% of Tesla's revenue in 2024 came from the automotive (EV) segment, we allocate a similar proportion of the profit to core EV sales. Using this multiplier, we estimate Tesla's GAAP net income from vehicle sales at roughly US$5.63bn for 2024 (79% of US$7.1bn total net income). This is consistent with Tesla's own financial report, which states that total revenue was US$97.7bn in 2024, with automotive revenue around US$77.1bn (78.9%) – indicating that automotive activities were indeed the primary profit driver.

Tesla delivered 1.79m vehicles in 2024.[54] Dividing the automotive net income by the number of cars sold gives the profit per vehicle:

US$5.63bn / 1,790,000 ≈ US$3,145 per vehicle

This figure represents the average GAAP profit Tesla retained per electric car sold in 2024. We use GAAP (Generally Accepted Accounting Principles) net income to reflect real profits after all expenses, consistent with standard financial reporting.

Figure 2: Tesla’s 2024 financial results

FINANCIAL SUMMARY
(Unaudited)

($ in millions, except percentages and per share data)	2020	2021	2022	2023	2024	YoY
Total automotive revenues	27,236	47,232	71,462	82,419	77,070	-6%
Energy generation and storage revenue	1,994	2,789	3,909	6,035	10,086	67%
Services and other revenue	2,306	3,802	6,091	8,319	10,534	27%
Total revenues	31,536	53,823	81,462	96,773	97,690	1%
Total gross profit	6,630	13,606	20,853	17,660	17,450	-1%
Total GAAP gross margin	21.0%	25.3%	25.6%	18.2%	17.9%	-39 bp
Operating expenses	4,636	7,083	7,197	8,769	10,374	18%
Income from operations	1,994	6,523	13,656	8,891	7,076	-20%
Operating margin	6.3%	12.1%	16.8%	9.2%	7.2%	-194 bp
Adjusted EBITDA	5,817	11,621	19,186	16,631	16,645	0%
Adjusted EBITDA margin	18.4%	21.6%	23.6%	17.2%	17.0%	-15 bp
Net income attributable to common stockholders (GAAP)	721	5,519	12,556	14,997	7,091	-53%
Net income attributable to common stockholders (non-GAAP)	2,455	7,640	14,116	10,882	8,419	-23%
EPS attributable to common stockholders, diluted (GAAP)	0.21	1.63	3.62	4.30	2.04	-53%
EPS attributable to common stockholders, diluted (non-GAAP)	0.75	2.26	4.07	3.12	2.42	-22%
Net cash provided by operating activities	5,943	11,497	14,724	13,256	14,923	13%
Capital expenditures	(3,157)	(6,482)	(7,158)	(8,898)	(11,339)	27%
Free cash flow	2,786	5,015	7,566	4,358	3,584	-18%
Cash, cash equivalents and investments	19,384	17,707	22,185	29,094	36,563	26%

Source: Tesla, 2025[55]

Cobalt content and value per Tesla car

Each Tesla vehicle contains a certain amount of cobalt in its battery. This varies by model and battery chemistry. Tesla’s early models (e.g. the first Model S in 2012) used high-cobalt battery cathodes with about 11kg of cobalt per car, whereas the newer high-volume Model 3 (launched in 2018) uses a nickel-cobalt-aluminium (NCA) chemistry with only about 4.5kg of cobalt.[56] Tesla has also begun using cobalt-free lithium iron phosphate (LFP) batteries in some standard-range models.[57] As of 2024, an estimated 34% of Tesla’s fleet used LFP cells (0kg cobalt), and ~70% used nickel-cobalt chemistries.

However, that estimation depends on the region/country the cars were sold to. While Tesla hasn’t published exact regional breakdowns for 2024, we can find the sales per region for 2023, calculate the percentage per region and apply that to current day deliveries.[58] The available dataset gives the following figures.

Table 2: Tesla Sales and LFP adoption rate per region

Region	Tesla sales (2023)	LFP adoption rate	Share of total sales	Weighted LFP share
China	603,664	75%	33.7%	0.2528
Europe	354,756	10%	19.9%	0.0199
Rest of world	68,797	50%	5.7%	0.0285
USA/Canada	727,730	10%	40.7%	0.0407

When these regional delivery shares are weighted by the LFP adoption rates cited in the IEA's 2025 *Global EV Outlook* – namely 75% LFP in China (for nuance, it also reached 80% in some months, but we can stick to 75% as a confirmed annual number), 10% in North America, just over 10% in Europe[59] and 50% in the rest of the world[60] – we obtain a fleet-wide LFP share of approximately 34.1% of Tesla's global output, as seen below:

(33.7% × 75%) + (40.7% × 10%) + (19.9% × 10%) + (5.7% × 50%) = 34.19% fleet-wide LFP adoption

The weighted cobalt content per vehicle thus becomes:

(65.8% × 4.5kg) + (34.2% × 0kg) = 2.961kg cobalt per Tesla vehicle on weighted average

This calculation is grounded in delivery volume estimates and documented battery chemistry deployment by geographical region. It underpins the assumption in a verifiable way that ~66% fleet-wide is a defensible baseline for cobalt-using vehicles, which leads in our analysis to a weighted cobalt content per vehicle equal to 2.961 kg.

Cobalt is a globally traded commodity, and in 2024, cobalt prices averaged roughly US$33,000 per metric ton (about US$33 per kg), amid a supply glut that kept prices relatively low compared to peaks in 2022.[61] By mid-2025, cobalt was trading around US$33–34,000/ton on international markets. We will use US$33 per kg as a representative price in 2024 for battery-grade cobalt.

Given 2.961kg of Cobalt per vehicle at US$33/kg, the raw cobalt in each Tesla is worth roughly:

2.961kg * US$33/kg = US$97.85 worth of cobalt per car.

This is the notional value of cobalt contained in one vehicle's battery, based on market price. It's important to note this is not what DRC earns; it's the gross commodity value before refining and logistics, and without considering who captures that value (much of which occurs outside DRC, as we'll see).

DRC's cobalt revenue per vehicle

DRC's government earns income from cobalt primarily through mining royalties and taxes. In 2018, DRC classified cobalt as a 'strategic mineral,' granting the government additional powers to impose higher taxes and tighter controls over extraction, trade and exports, and raised the royalty rate from 2% to currently 10% of the cobalt's export value.

Assuming Tesla sources cobalt from DRC mines (e.g. Glencore's Kamoto Copper Company), the royalty per vehicle is calculated as:

US$97.85 cobalt value × 10% = US$9.785 (≈US$9.79) per vehicle in royalties.

However, US$10 per car is an upper-bound estimate based purely on the statutory royalty. In reality, the effective value retained in DRC may be much lower than the full cobalt price would suggest, for a few reasons:

- Foreign profit leakage: 90% of cobalt value accrues to mining companies/intermediaries (often foreign owned).
- Minuscule EV value-chain share: DRC captures just ~3% of the total battery/EV value chain, as most value-add occurs abroad.[62]

Artisanal miners extract 1.5–3kg of cobalt daily, implying a labour range of 0.988–1.976 miner-days per Tesla vehicle (2.961 kg ÷ 3 and ÷ 1.5, respectively).[63] An average of the range, that being 1.482 miner-days, and with a daily minimum wage of just US$5, would be US$4.94–9.88 per vehicle – or an average of US$7.40. That's still well below Kolwezi's living wage of US$520/month.[64] Even if a miner worked every day, they'd still be paid a fraction of what's needed to live – while Tesla retains billions in profits.

On DRC's capture, the table below shows how the calculation was arrived at through government royalties as well as artisanal wages.

Table 3: Tesla vs. DRC – Profit vs. cobalt revenue per car

Component	Value per vehicle	Calculation and sources
Cobalt content	2.96kg	Tesla battery mix (65.8% Ni-Co @ 4.5kg, 34.2% LFP @ 0kg)
Royalties (10%)	US$9.79	US$97.85 × 10%
Artisanal wages	US$7.40	1.48 miner-days × US$5/day
Total DRC capture	US$17.20	US$9.79 (govt) + US$7.40 (wages)

(See Definitions of value capture in Appendix 3.)

Bringing the above pieces together:

- Tesla’s profit per vehicle (2024): ≈ US$3,145 in GAAP net income retained by Tesla per car sold.
- DRC government revenue per vehicle (cobalt-related): ≈ US$17.20 in cobalt royalties + wages – and equivalent value capture per car (see Definitions of value capture in Appendix 3).
    - But only US$7.40 stays with miners; US$9.79 is government royalty

Thus:

US$3,145 / US$17.20 ≈ 183 times more.

To phrase it succinctly: Tesla’s profit per electric car (US$3.15k) is roughly 183 times DRC’s cobalt revenue per car (US$17.20).

It’s worth noting that this comparison is per vehicle. In aggregate terms, the disparity is also enormous. If Tesla sold 1.79m EVs in 2024, its total profit (US$7.1bn) vastly outstripped DRC’s total cobalt royalties from those cars. Assuming all cobalt in those Teslas came from DRC, the total DRC cobalt capture would be around US$30.79m at most (1.79m cars × US$17.20 each).

Stat 8: The Lithium Triangle and extraction

a) **Latin America holds nearly half of the world's lithium but captures only about 10% of the lithium battery value chain at the national and regional level, mostly through royalties, taxes and limited domestic processing. Miners themselves take home less than two cents for every dollar of battery value.**

b) **In just 11 years, South America will extract more lithium than Spain looted silver during 300 years of colonial rule – yet more than 90% of the value is captured outside the region, largely by companies in China, Europe and the United States.**

c) **Between 2015 and 2030, the Lithium Triangle will produce 1.6m metric tonnes of lithium – enough to cover the entire city of Madrid in a 5 mm layer of 'white gold'.**

Latin America holds a dominant share of the world's lithium resources and is a major supplier of the raw mineral. Estimates indicate that about 56m metric tons of all identified lithium lies in Latin America (primarily in Argentina with 23m metric tons; Bolivia, 23m metric tons; and Chile, 11m metric tons) according to the 2025 USGS mineral report. [65] With global supplies reaching 115m metric tons, this would mean the Lithium Triangle holds nearly 50% of the total amount of lithium. In terms of production, globally it reached 240,000 metric tons, of which Argentina (18,000 metric tons), Bolivia (a mere 900 metric tons) and Chile (49,000 metric tons)[66] formed a 20% share. Meanwhile, the UN Development Programme (UNDP) notes that around 60% of identified lithium is in Latin America and points out that Bolivia, Argentina and Chile dominate this resource base. Having large resources does not mean supplying most of the world's lithium. Our World in Data shows that in 2023 Australia produced 48% of global lithium, Chile 24%, China 18% and Argentina 5.3%.[67] A trade publication notes that 94% of global supply in 2023 came from just these four countries, and by 2034 South America is forecast to supply about 28% of global lithium.[68]

The ~10% value-capture figure refers to the share of the lithium battery value chain retained within Latin America at the national and regional level – primarily through royalties, taxes and domestic corporate participation in extraction and processing. At the miner level, capture is far smaller. A study by Beyond Zero Emissions calculates that Australia – the world's largest lithium producer – captures only 0.53% of the lithium-ion battery value chain when exporting raw lithium ore.[69] Given similar mining cost structures, this is a reasonable proxy for Latin America.

Even at the high end of the estimated 1–2% range, miners earn less than US$0.02 for every $1 of final battery value; the remaining 98% accrues to firms engaged in refining, manufacturing and assembling batteries (see Definitions of value capture in Appendix 3).

Government royalty rates further illustrate the limited local retention of value. Argentina levies a fixed 3% royalty on the value of extracted minerals and offers 30 years of tax stability,[70] while Chile applies a sliding royalty of 6.8–40% on the export price of lithium. Even the highest rates are far below profit margins earned in downstream stages, reinforcing the structural imbalance.

To compare modern lithium output with colonial-era silver looting, a historical baseline is required. Economic historians estimate that Spanish America produced about 150,000 tons of silver between 1500 and 1800, amounting to more than 80% of world supply.[71,72] Much of this metal came from the Cerro Rico mines at Potosí (in present-day Bolivia). This figure is used as the denominator when comparing cumulative lithium output in the 21st century.

To paint a picture of how much lithium this is: one tonne of lithium equals 1,000kg, and its density is 0.534g/cm^3, which is equivalent to 534kg/m^3.[73] The projected extraction of 1.6m metric tonnes of lithium therefore has a mass of 1.6×10^9kg. Dividing by 534kg/m^3 gives a volume of: 3.0×10^6m^3.

Thus, 1.6m metric tonnes of lithium metal occupies roughly three million cubic metres, which serves as the basis for the analogy. DBpedia records that the municipality of Madrid covers 604.3km^2,[74] equivalent to 604,300,000m^2. Spreading 3.0×10^6m^3 of lithium uniformly over that area yields a layer depth:

$$h = \frac{3.0 \times 10^6 m^3}{6.043 \times 10^8 m^2} = 5.0 \times 10^{-3}\ or\ 5\ mm$$

Thus, the projected lithium output could cover the entire surface of Madrid with a sheet of metal approximately five millimetres thick.

Stat 9: Investment and cost of capital in renewable energy

a) **In 2024, high-income countries accounted for roughly 50% of global clean energy investment, and China for 29%, while Africa received just 2%, despite sub-Saharan Africa being home to 80% of the world's unelectrified population.**

b) **Renewable energy projects in the Global South face interest rates of 9–13.5%, compared to 3–6% in the Global North.[75]**

c) **The cost of powering 100,000 people with clean energy is approximately 45% higher in emerging market and developing economies (EMDEs) (US$139m) like India, and approximately 97% higher in African countries (US$188M) like Nigeria, than in advanced economies (US$95m) like the UK.**

According to the IEA's *World Energy Investment 2025* report, total energy investment in 2024 will reach US$3.3 trillion, of which US$2.2 trillion is clean energy.[76] But the geographical distribution is far from equal: high-income countries receive roughly 50% of global investment, or about US$1 trillion. These include the US with 19% (US$400bn), the EU with 18% (US$386bn), Japan and Korea with 5% (US$103 bn), and other advanced economies with 8% (US$175 bn) of global investment in renewable energy, as per the IEA data. China alone accounts for 29% of global investment.[77]

In contrast, Latin America received 3%, while Africa, the Middle East and Southeast Asia each received only 2%.[78] This means that for every US$1 flowing to clean energy in Africa, the Middle East and Southeast Asia, about US$25 flows to wealthier nations.

$$\frac{\$1.064\ trillion}{\$44\ billion} = \$24.18$$

This disparity exists even though over 600 million people in sub-Saharan Africa still lack modern energy access, about 80% of the global total.[79]

Using the post-tax nominal weighted average cost of capital (WACC) for 100 megawatt (MW) solar-photovoltaic (PV) projects, renewable energy projects in the Global South face interest rates of approximately 9–12.5% compared to 3–6% in the Global North. Specifically, the IEA's *Cost of Capital Observatory* reports India's WACC for these projects at 10.0–12.5% in 2023.[80] In EMDEs on average, solar PV WACCs are at least twice those in advanced economies.[81] Meanwhile, the Clean Air Task Force finds Africa's average WACC stands at 15.6%,[82] more than triple that of Western Europe (4.2%), the US (5.1%) or Japan (2.4%).[83]

These disparities are a major driver of higher levelized costs of electricity (LCOE) in Africa – solar PV typically costs 10-15 US¢/kWh,[84] two to three times the cost in Europe or Asia, even with identical technology.

To illustrate the impact of finance on access, we model the cost of providing the modern energy minimum (MEM) of 1,000 kWh per person per year to 100,000 people using a standard PV system with a 20% capacity factor. Delivering 100 gigawatt-hours (GWh) per year (100,000 people × 1,000 kWh) requires a PV array of nearly 57 MW ((100,000 MWh ÷ 8,760 h) ÷ 0.20).

$$\left(\frac{100{,}000\ MWh}{8{,}760\ hr}\right) \div 0.20 = 57MW$$

At a conservative US$1,000 per kW for PV hardware, the upfront investment is US$57m. We annualize this cost over 20 years using the capital-recovery factor (CRF):

$$CRF(r,n) = \frac{r(1+r)^n}{(1+r)^n - 1}$$

Where *r* is the interest rate (WACC) and *n* the project lifetime, that is, 20 years.

Table 4: Annualized costs and total lifetime capital payments of providing MEM to 100,000 people using a standard PV system

Region (WACC)	CRF[85]	Annual payment[86]	20-year total[87]
Advanced economies (5.5%)	0.0837	US$4.77m/yr	US$95.40m
EMDE average (10.5%)	0.1215	US$6.93m/yr	US$138.5m
Africa (15.6%)	0.1651	US$9.41m/yr	US$188.2m

For a WACC of 5.5%[88] (advanced economies), 10.5%[89] (EMDEs) and 15.6%[90] (Africa), CRFs are 0.0837, 0.1215 and 0.1651, respectively. The annualized costs are therefore: US$4.77m/year in advanced economies, US$6.93m/year in EMDEs, and US$9.41m/year in Africa. Over 20 years, the total lifetime capital payments are US$95m (advanced economies), US$139m (EMDEs) and US$188m (Africa).

To calculate the relative cost, we compared 20-year total costs to the advanced economies baseline (US$95,638,754):

EMDE average difference: US$138,502,020 - US$95,394,436 = US$43,107,886 (approx. 45.19% higher)[91];

Africa difference: US$188,202,600 - US$95,394,436 = US$92,808,164 (approx. 97.29% higher).

Thus, the same 57 MW solar system – with identical hardware and sunlight – costs approximately 45% more in EMDEs and 97% more in Africa, purely because of the cost of finance.

Note: The numbers used for the WACC are illustrative and based on averages and midpoints of ranges offered by different sources. They were used to homogenize the data, as interest rates varied across countries and regions, and were standardized by looking at the post-tax rates.

Stat 10: Renewable energy in the Global South (solar)

a) The total solar energy reaching Earth's surface in just one hour is enough to meet global energy demand for an entire year.

b) The Global South is often credited with nearly 70% of global renewable (solar + wind) potential. Solar-only data paints a clearer picture:

  i. 60% of the world's best solar resources are located in Africa (yet deployment is <1%).[92]

  ii. Africa accounts for roughly 40% of total global solar potential.[93]

c) Harnessing less than 1% of the Sahara desert's annual solar energy could provide enough energy to meet the modern needs of the entire MENA region for a whole year.

According to an MIT energy report, 173,000 terawatts (TW) of solar energy continually strikes the Earth's surface – a number 10,000 times more than global human energy use.[94] This equates to 173,000 TWh, while global primary energy consumption in 2023 was about 620 exajoules (172,000 TWh).[95] Therefore, one hour of sunshine supplies more energy than humanity uses in an entire year.

The Global South is often credited with nearly 70% of global renewable potential.[96] Meanwhile, analyses of global solar-irradiance maps show that most high-irradiance land lies in tropical and subtropical regions. The International Energy Agency notes that Africa alone is home to about 60% of the world's best solar resources, yet the continent hosts only around 1% of installed solar capacity.[97] When other high-irradiance regions in Latin America, the Middle East and South/Southeast Asia are included, roughly two-thirds of renewable energy potential lies in the Global South – even though these regions receive only a fraction of clean energy.[98] More specifically, while this renewable energy potential includes both solar and wind, solar dominates in the estimates due to the tropics/subtropics receiving stronger, more consistent sunlight.[99]

Take the Sahara as an example. As an area that covers 9.2 million km² (or 9.2 trillion m²) and an annual solar resource of 2,400 Wh/m²/year,[100] it would then receive about 2.208×10^{16} kWh/year by multiplying the area with the solar global horizontal irradiation (GHI).

*Unit conversion: 1 PWh is equal to 10^{12} kWh, thus:

$$E_{Sahara} = \frac{2.208 \times 10^{16}}{10^{12}} = 22{,}080\ PWh/year$$

To calculate the potential electricity output from just a tiny share of that sunlight, we assume that if we had the ability to harness 0.025% of this energy, using 15%-efficient solar panels, then we could produce approximately 0.828 PWh per year of electricity.

$$22{,}080 \text{ PWh} \times 0.00025 \times 0.15 = 0.828 \text{ PWh/yr}$$

To compare that to the MEM for MENA[101], we first estimate that the population of MENA is 616 million people.[102] With an MEM of 1,000 kWh/person/year, we get:

$$616 \times 10^{16} \times 1000\, kWh/person/yr = 616 \times 10^{11}\, kWh/year\ or\ 0.616\, PWh/y$$

The coverage ratio is thus: $\frac{0.828\, PWh}{0.616\, PWh} = 1.344$

This means that harnessing 0.025% of this energy could provide more than enough energy to meet the needs of the entire MENA region. If we assume that the solar panels were 25% efficient, such as the top-tier monocrystalline panels that can reach 24.8%, or the tandem solar panels developed by Oxford PV that can reach 25%,[103] then that number goes up to 22,080 PWh × 0.00025 × 0.25 = 1.38 PWh/year. That means the coverage ratio is 2.24.

To reiterate, at that rate, 0.025% of the Sahara's solar resource could power the MENA region about 1.3 times over with current standard panels, or more than twice with the most advanced solar technologies.

Stat 11: Renewable energy in the Global South (kinetic)

a) **The kinetic energy in global wind flows is 900 terawatts – more than 45 times the world's total energy consumption.**

b) **Tapping just 22% of global wind flows could generate 520,000 TWh/year of usable electricity – nearly 800 times the annual electricity needed to meet the MEM benchmark for Southeast Asia's 677 million residents.**

   i. **Tapping just 0.03% of the world's usable wind energy could provide a decent standard of electricity to all 677 million people in Southeast Asia.**

c) **The investment needed to electrify Southeast Asia to the MEM level through wind energy (US$331bn) could be paid off with just 10 months of fossil fuel excess profits.**

The atmosphere generates far more wind energy than humanity uses. A 2011 study in *Earth System Dynamics* explains that interactions between the atmosphere, oceans and land convert about 900 TW of differential solar heating into kinetic wind energy each year. By comparison, global primary energy consumption in 2023 was 620 EJ,[104] or 172,000 TWh annually, meaning the kinetic energy in wind flows is more than 45 times larger. Only a tiny fraction of this potential is currently captured. This was calculated by dividing the global energy consumption of 172,000 TWh/year by 8,760 h/year, giving us 19.6 TW, and then 900 TW was divided by 19.6 TW, giving us 45.9.

Adjusting for electrification efficiency

Southeast Asia's ten ASEAN countries have a population of about 676.6 million people.[105] They have a share of global energy use of nearly 5%, according to IEA analysis of Southeast Asia, which implies that ASEAN's total primary energy supply is around 30 exajoules (EJ) in recent years.[106] To estimate ASEAN's annual energy needs in TWh, we converted EJ to TWh. 1 EJ equals 277.78 TWh, so 30 EJ ≈ 8,333 TWh. However, not all primary energy would need to be replaced one-for-one with electricity due to efficiency gains.

Electrification of transport, industry and buildings eliminates the large losses inherent in burning fossil fuels (for example, electric motors and heat pumps are far more efficient than combustion engines and boilers). Studies have found that a fully electrified energy system could deliver the same services with roughly one-half to one-third of the final energy compared to today's fossil fuel-based system.[107] We applied a conservative factor of 22% to represent the portion of primary energy that would need to be supplied as useful electricity after these efficiency improvements.

In other words, instead of 8,300 TWh (if one simply converted all primary energy to electricity with 100% efficiency), we assume on the order of 1,830 TWh would actually be required per year to meet ASEAN's needs if it was largely electrified. For additional caution, we then added 30% (multiplied 1,830 by 1.3) to that figure to account for hard-to-electrify sectors and storage/balancing overhead – effectively assuming about 2,380 TWh/year needed. This 30% cushion reflects that some energy uses (like heavy industry or backup reserves) may still require extra input or storage losses.

While 22% and 30% are used as simplifying assumptions, we include them here for transparency: they are meant to illustrate a plausible scale of reduction in energy needs (22% of primary) and a buffer (30% extra) rather than precise values. Even with less optimistic assumptions, the overall conclusion holds that the required electricity is in the low thousands of TWh per year.

Meeting the MEM (1,000 kWh per person) requires approximately 676.6 TWh per year, which we get by multiplying 676.6m[108] by 1,000 kWh.

The 900 TW global wind energy figure represents the total kinetic power available. If just 22% of that were harnessed:

$$900 \text{ TW} \times 0.22 = 198 \text{ TW}$$

Over a year, this equals:

$$198 \text{ TW} \times 8{,}760 \text{ h/year} = 1{,}734{,}480 \text{ TWh/year.}$$

If only 30% of this kinetic energy could be converted to electricity (due to ecological, technical and practical limits), the usable supply would still be:

$$1{,}734{,}480 \text{ TWh} \times 0.3 \approx 520{,}344 \text{ TWh/year.}$$

This is nearly 800 times greater than the MEM requirement for ASEAN (520,344 ÷ 676.6 ≈ 769) and more than 200 times greater than the post-electrification requirement – which we got by multiplying with the 30% cushion above (520,344 ÷ 2,380 ≈ 218). In plain terms: even after factoring in efficiency limits, technical constraints and harder-to-electrify sectors, harnessing just a fraction of global wind flows could supply many times the electricity needed for ASEAN's population.

The 22% figure here is purely illustrative, chosen to demonstrate that tapping even a modest fraction of global wind flows could electrify the region – which represents about 8% of the planet's population.

Costing and feasibility

To generate 676.6 TWh/year (the MEM benchmark for ASEAN) from wind power at a 35% capacity factor would require:

676.6 TWh ÷ 8,760 h/year ÷ 0.35 ≈ 220 gigawatts (GW) of wind capacity.

According to the University of Michigan's wind-energy factsheet, the installed cost of land-based wind projects in 2022 averaged about US$1,370 per kilowatt.[109] At this cost, 220 GW would require:

220 GW × US$1,370/kW = US$301bn.

Adding a 10% allowance for grid integration and storage brings the total to roughly US$331bn.

Oxfam's analysis of 2024 corporate results found that the world's largest fossil fuel firms made about US$583bn in profits that year.[110] A modest 'polluter profit' tax could raise up to US$400bn annually, or about US$33.3bn per month – enough to finance ASEAN's wind-powered electrification in less than 10 months (US$331bn ÷ US$33.3bn/month ≈ 9.9 months).

Stat 12. Namibia and green hydrogen exports

Namibia plans to export green hydrogen equivalent to around 6.4 TWh of usable energy annually to Europe by 2030. However, with the same US$10bn investment, it could provide clean electricity to its entire population – and provide power to more than 1.3 million people in each of its five neighbouring countries.

In 2023, Namibia's government signed a US$10bn green hydrogen deal with Hyphen Hydrogen Energy to develop a green-hydrogen complex in the Tsau Khaeb National Park. The project is said to combine around seven gigawatts of wind and solar capacity and produce approximately two million tonnes of green ammonia per year.[111] Yet Namibia has a population of only around three million people, meaning meeting the modern energy minimum (MEM) of 1,000 kWh per person requires just 3 TWh per year.

Each tonne of green ammonia requires roughly 10 MWh of renewable electricity input, according to Grundt and Christiansen (1982),[112] which is the estimate used for industry averages as reported by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA).[113] At 1.7m tonnes/year,[114] the Hyphen project will therefore commit around 17 TWh/year of renewable electricity generation before any conversion losses – over five and a half times the electricity Namibia needs to achieve the MEM for all its citizens. Nearly all of this generation will be allocated for export while domestic needs remain unmet.

Ammonia has a lower heating value, or energy content, of about 18.6 megajoules (MJ) per kg.[115] In other words, per tonne of ammonia, that's approximately 5.17 MWh of chemical energy:

$$18.6 \text{ MJ/kg} \times 1{,}000 \text{ kg} = 18{,}600 \text{ MJ} = 5.17 \text{ MWh}$$

To account for losses during cracking and compression, we look to the CSIRO study on ammonia as a hydrogen carrier, which states that cracking losses are close to 1.41 MWh per tonne of ammonia, corresponding to an overall cracking efficiency of about 76%. Compression and storage losses are between 0.54–0.67 MWh per tonne.[116]

$$5.17 \text{ MWh} - (1.41+0.6) \text{ MWh} = 3.2 \text{ MWh}$$

Therefore, after conversion losses from hydrogen production, ammonia synthesis and re-electrification, each tonne of ammonia provides about 3.2 MWh of usable hydrogen energy. At 2m tonnes/year, this equals roughly 6.4 TWh/year of hydrogen output – more than three times Namibia's domestic requirement.

This distinction between the 17 TWh/year renewable input and 6.4 TWh/year usable output illustrates both the scale of Namibia's renewable resources being committed to exports and the opportunity cost of not prioritizing domestic electrification first.

Redirecting just a portion of the US$10bn investment towards domestic infrastructure could allow Namibia to achieve full energy access. Off-grid electrification programmes across sub-Saharan Africa suggest that providing reliable solar-based electricity can cost an illustrative average of US$0.56 per kWh. Delivering 1,000 kWh/person/year to Namibia's 3 million residents would therefore cost around US$1.68bn (3 million × $560 per person). Even with generous allowances for transmission, storage and grid upgrades, the total remains well under US$3bn– less than a third of the hydrogen project cost.

If the remaining US$7bn were redirected at the same cost per person, it could electrify an additional 6.5 million people across the region.

US$7bn ÷ US$560/person ≈ 12.5 million person-years of electricity access; assuming provision for one year, this equals 12.5 million people. Half is allocated to Namibia, and half (≈6.5 million) distributed equally among five neighbours.

Spread equally among Namibia's five neighbouring countries – Angola, Botswana, South Africa, Zambia and Zimbabwe – this equates to approximately 1.3 million people in each. This estimate uses a conservative cost benchmark; actual costs vary by context and may be higher in some settings.

Stat 13: External debt and clean energy access

a) **Low-income and middle-income countries currently carry US$11.7 trillion in external debt – more than 30 times the additional investment needed to achieve universal access to electricity and clean cooking by 2030.**

b) **In 2024, countries in the Global South were estimated to pay US$400bn in external debt service. If that same amount had been invested in energy access, it could have provided clean electricity and clean cooking solutions for 690 million people still living without them.**

According to data from the UN Trade and Development *Costlier debt servicing undermines the achievement of the SDGs* 2025 report,[117] by 2024, low and middle-income countries had accumulated over US$11.7 trillion in external debt.

Based on data from the IEA's *Energy Access Outlook 2017: WEO Special Report*, US$391bn of additional investment (beyond base scenario investments) would be needed to guarantee universal electricity and clean cooking access by 2030, impacting 674 million people.[118] This represents the investment gap for universal access.

We took as a reference the figures from the Debt Relief for Green and Inclusive Recovery Project's *Default on Development and Climate* report in 2024,[119] which looks at the estimated amount of USD spent by low and middle-income countries on paying external debt by 2024.

Calculations:

Calculate the ratio between external debt owed and investment. First, we convert the accumulated external debt by low and middle-income countries from trillions to billions. This allows us to make a direct comparison between the accumulated debt and the estimated extra investment needed.

Therefore,

$$11.7\ trillion \approx 11{,}700\ billion$$

$$\frac{11{,}700\ billion}{391\ billion} = 29.92 \approx 30$$

Based on this calculation, we can estimate that by 2024, low and middle-income countries accumulated external debt was approximately 30 times the additional investment required to provide universal electricity access and clean cooking.

Calculate the ratio between external debt paid and potential impact.
We take as a reference that by 2024, low and middle-income countries are estimated to have paid US$400bn in external debt. At the same time, we know that an estimated extra investment of US$391bn to provide universal electricity and clean cooking would potentially impact over 674 million people.

Therefore,

$$\frac{391\ billion}{674\ million} \approx \ 580\ USD\ per\ person$$

$$\frac{400\ billion\ USD}{580\ USD/person} \approx \ 689.66\ million\ people$$

Through these calculations we can see that if the estimated external debt paid by low and middle-income countries had instead been invested in universal electricity access and clean cooking, 690 million people could have benefitted.

Stat 14. Gender, unpaid care work and the energy transition

a) **Women in rural South Asian communities collectively spend an estimated 507.38m hours each day collecting fuel – equivalent to US$1.52bn in unpaid care work daily, assuming a wage of US$3 per hour.**

b) **Expanding equitable energy to over 389 million women globally who currently rely on emission-intensive fuels could prevent more than 3.2 million premature deaths annually from household air pollution and free up an average of 20 hours of labour per week per woman globally.**

According to the *Gender and Livelihoods Impacts of Clean Cookstoves in South Asia* report by the Global Alliance for Clean Cookstoves in 2021, households across India, Nepal and Bangladesh that rely on traditional cooking stoves fuelled by biomass spend around 660 hours annually on firewood collection.[120] Over half (56.7%) of the workload falls on women, amounting to 374 hours annually.

The references consulted indicate that energy poverty is predominantly concentrated in rural areas. For the calculations, we take as a reference the reported rural population in each country, as well as the reported share of the female population nationally. Assuming that the number of women is the same in rural areas, we can calculate the estimated female population in rural areas. The following table compiles the estimated population of women in rural areas in those same South Asian countries based on national population census.

Table 5: Estimated population of rural women

Country	Female population share	Rural population	Estimated population of rural women
India	48.07%	904.8 million	434.9 million[121]
Nepal	52.66%	24.5 million	12.9 million[122]
Bangladesh	49.57%	100 million	49.6 million[123]

Separately, we know from the *Estimating the Number of Women Household Biomass Producers, the Largest Segment of the Global Energy Labor Force* 2024 report by Columbia's Center for Global Energy Policy[124] that 389 million women in the Global South rely on emission-intensive cooking and heating methods, taking as reference numbers from sub-Saharan Africa, low-income Asian countries, Latin America and the Caribbean.

Additionally, a 2025 article from the World Health Organization[125] highlighted that ensuring universal access to electricity and clean cooking could prevent up to four million annual premature deaths from air pollution at home.

Lastly, from Columbia's Center for Global Energy Policy 2023 research on *Invisible Women in Energy: Millions of Household Biomass Producers* we know that universal electricity access and clean cooking would free up to 20 hours weekly of unpaid care work currently used on collecting firewood by women globally.[126]

Calculations:

Calculate the average hours per day women spend collecting firewood. If we know that women across India, Nepal and Bangladesh collectively spend around 374 hours annually on this task, we can calculate the daily hours by dividing the total annual hours by the number of days in a year.

Therefore,

$$\frac{374\ hours}{365\ days} = 1.02\ hours/day$$

Calculate the total number of women in rural India, Nepal and Bangladesh. In Table 1, we calculated the estimated populations of rural women in each country. Therefore,

$$434{,}948{,}416.10 + 12{,}901{,}963.30 + 49{,}580{,}905.40 = 497{,}431{,}284.80 \approx 497.43\ million$$

This gives us a total current estimation of 497.43 million women living in rural India, Nepal and Bangladesh combined.

Calculate the collective hours per day across this region. Taking as a reference that women spend an average of 1.02 hours of daily labour collecting fuel in these countries, we can then calculate that:

$$497.43\ million\ women \times 1.02\ hours/day \approx 507.38\ million\ hours/day$$

Calculate the estimated economic value. Assigning a global average value of salary per hour (US$3), we multiply this by the estimated collective hours spent collecting firewood.

Therefore,

$$507.38\ million\ hours/day \times 3\ USD\ /hour = 1.52\ billion\ USD/day$$

Since collecting firewood can be considered a form of care work, given the impact that it has on households, this is equivalent to US$1.52bn in unpaid care work each day.

Appendix

Appendix 1: Estimation of the energy-use multiplier

Income share of top 1%	Elasticity	Energy-use multiplier×	Energy per top-1% person (kWh)	Equivalent MEM persons (≈ kWh ÷ 1 000)
7%	0.7	3.90	183344.96	183.34
7%	0.8	4.74	222730.03	222.73
7%	0.9	5.76	270575.57	270.58
10%	0.7	5.01	235342.49	235.34
10%	0.8	6.31	296278.64	296.28
10%	0.9	7.94	372992.71	372.99
15%	0.7	6.66	312582.19	312.58
15%	0.8	8.73	409801.32	409.80
15%	0.9	11.44	537257.49	537.26
20%	0.7	8.14	382315.00	382.32
20%	0.8	10.99	515851.07	515.85
20%	0.9	14.82	696029.01	696.03
21%	0.7	8.42	395597.78	395.60
21%	0.8	11.42	536383.96	536.38
21%	0.9	15.49	727273.41	727.27

Appendix 2: Renewable energy investment 2024 per Global South country

Transition mineral	Country 1	Country 2	Country 3	Country 4	Country 5	Country 6	Country 7	Country 8	Country 9	Global South %	Total %
Cobalt	DRC	Indonesia	Cuba	Philippines	Madagascar	Turkey	Papua New Guinea	Other		71.75%	71.46%
	54.55%	4.55%	4.55%	2.36%	0.91%	0.83%	0.45%	3.55%			
Lithium	Chile	Argentina	China	Brazil	Zimbabwe	Other				64.28%	
	33.21%	12.86%	10.71%	1.39%	1.11%	5%					
Nickel	Indonesia	Brazil	New Caledonia	Philippines	China	Other				70.50%	
	42.31%	12.31%	5.46%	3.69%	3.23%	3.50%					
Copper	Chile	Peru	DRC	Mexico	China	Indonesia	Zambia	Kazakhstan	Other	63.90%	
	19.00%	12.00%	8.00%	5.30%	4.10%	2.40%	2.10%	2.00%	9.00%		
Rare earth	China	Vietnam	Brazil	India	Tanzania	South Africa				86.89%	
	40.00%	20.00%	19.09%	6.27%	0.81%	0.72%					

Appendix 3: Definitions of value capture across stats 6-8

Level of capture	Definition	Example for lithium (stat 8)
Miner-level capture	Share of downstream product value that accrues directly to workers as wages, measured as a percentage of the final product's market value.	~1–2% of downstream lithium battery value (less than US$0.02 per US$1), using Australia's 0.53% as a proxy for similar mining economics in Latin America.
Government/national capture	Share of the value chain retained domestically through royalties, taxes and domestic corporate participation in extraction and processing.	~10% of lithium battery value chain retained in Latin America.
External/downstream capture	Share of value captured outside the producing region through refining, manufacturing and product assembly.	>90% captured outside Latin America, mainly by companies in China, Europe and the US.

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For further information on the issues raised in this paper please email
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