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The Coal Cost of Aluminum

Adaro's Phase 1 aluminum smelter and captive coal power plant will struggle to pay back the capital expenditure of US$2 billion while adding nearly 1% to national CO_2 emissions in Indonesia

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Key Findings

The Indonesian Adaro Group's planned Phase 1 development of an aluminum smelter of 500 kilotonnes per annum and a 1,100 megawatt coal plant will need eight to 11 years to recoup capex of US$2 billion under a best-case price scenario of US$2,800 per tonne of aluminum.

The smelter and coal plant could add 5.2 million tonnes of CO_2, almost 1% of Indonesia's 2021 carbon emissions.

Captive power plants may boost coal capacity by 52% from 2023 levels and coal consumption by 17%.

Standard Chartered and DBS Bank, two financial institutions with coal exit policies in place, have declined to finance Adaro's Phase 1 aluminum smelter and coal power plant, which later secured funding from five Indonesian banks.

Executive Summary

A major Indonesian coalminer, the Adaro Group, has been signaling an intention since 2020 to expand its business into aluminum smelting.

The plant complex will be located in Kaltara Industrial Park, North Kalimantan province. It is to be constructed in three phases, each phase building smelter facilities with an output capacity of 500 kilotonnes per annum (ktpa).

Adaro's Phase 1 aluminum smelter will have a supporting 1,100 megawatt (MW) coal-fired captive power plant to supply energy. Total capital expenditure of the project is US$2 billion. However, the financial case for the development is shaky at best as the payback period at US$2,800 per tonne of aluminum, the upper bound of the global price range in the last five years, is eight to 11 years. Phase 1 will also add 5.2 million tonnes (Mt) of carbon dioxide emissions to the environment.

Weak Financial Case for Adaro Smelter Project

From its research and calculations, the Institute for Energy Economics and Financial Analysis (IEEFA) has arrived at the following findings:

- The financial case for Adaro Phase 1's 500ktpa Adaro smelter and 1,100MW captive coal plant is weak as they will make losses under the current aluminum price of US$2,200/tonne.
- The Phase 1 aluminum smelter needs prices to rise 30% to US$2,800/tonne, and to stay at that level for eight years, to get back the capex of US$2 billion.
- The Adaro smelter complex aims to create value, but it appears that it may need high aluminum prices or very low costs to do so.
- Financing has been difficult given the rejection from Standard Chartered and DBS Bank to support the project, despite five local banks subsequently stepping in to provide loans.
- The issue of captive power plants looms large as those in the pipeline could add 21 gigawatts (GW), or 52%, to Indonesia's 2023 installed coal capacity of 40.5GW.
- The smelter and captive coal plant could collectively produce 5.2Mt of CO_2, which is close to 1% of Indonesia's 2021 total emissions of 619.3Mt.

Table 1: Value Created Under Aluminum After Non-Material Cost of US$750/Tonne

Value Created	Price Per Tonne (US$)		
	2,200	**2,500**	**2,800**
Total amount of aluminum (Mt)	0.5	0.5	0.5
Power required per tonne (kWh)	15,700	15,700	15,700
Cost of coal power (US$/kWh)	0.06	0.06	0.06
Aluminum price per tonne (US$)	2,200	2,500	2,800
Alumina cost per tonne of aluminum (US$)	600	600	600
Power cost per tonne of aluminum using coal (US$)	942	942	942
Other costs per tonne (US$)	750	750	750
Total cost per tonne (US$)	2,292	2,292	2,292
Profit per tonne (US$)	-92	208	508
Total value created (US$ million)	-46.0	104.0	254.0

Source: Statista; Bloomberg; IEEFA estimates.
Note: kWh/tonne = kilowatt-hour per tonne.

In this report, IEEFA will demonstrate why the financial justification for this aluminum smelter project can be difficult and how we arrived at the aforesaid findings. In addition, beyond this project, IEEFA is of the view that planned captive power plants across Indonesia and their coal power capacity are worth monitoring, given especially that recent developments in Indonesia's green taxonomy may heighten greenwashing risks.

Adaro Aluminum Plant and Captive Coal Power

Indonesia's coal-based energy company, the Adaro Group, has been indicating expansion plans into aluminum smelting since May 2020.[1]

The plant complex will be located in Kaltara Industrial Park in North Kalimantan province, and construction will take place in three phases. Each phase is to build one smelter with an output capacity of 500 kilotonnes per annum (ktpa) when completed.

In addition to the smelters, Adaro plans to build two supporting coal plants of 1,100 megawatts (MW) to support phases 1 and 2, plus a hydropower plant of 1,400MW[2] to supply the Phase 3 smelter.

Table 2: Adaro Aluminum Smelter Complex at Kaltara Industrial Park

Smelter Construction	Aluminum Capacity (tonnes/year)	Power Type	Power Needs (GWh)	Power Plant Capacity (MW)	Completion
Phase 1	500,000	Coal	7,850	1,100	1Q 2025
Phase 2	500,000	Coal	7,850	1,100	4Q 2026
Phase 3	500,000	Hydro	7,850	1,400	4Q 2029
Total	1,500,000		23,550	3,600	

Source: Adaro Investor Presentations; IEEFA estimates.
Note: GWh = gigawatt-hour.

Aluminum smelting is a very power-intensive process. The smelting of one tonne of aluminum requires 15,700 kilowatt-hours (kWh) of energy.[3]

A plant with a capacity of 500ktpa would need 7,850GWh per year. This would require a 1,100MW power plant operating at 85% capacity, or 310 days round the clock per year, to generate the power required. To put this in perspective, a planned Jawa-5 coal-fired plant unit that was shelved in 2021 was meant to have a capacity of 1,000MW.[4]

Based on the above energy needs, the carbon emissions have been estimated at 5.2 million tonnes (Mt) of carbon dioxide per annum.[5] The Institute for Energy Economics and Financial Analysis (IEEFA) estimates that this figure alone is equivalent to 0.8% of Indonesia's total 2021 emissions of 619.3Mt.[6]

[1] Global Energy Monitor. Adaro Aluminum Smelter power station.
[2] Adaro Energy. PT Adaro Energy Indonesia Tbk. May 2023.
[3] Bundesanstalt für Geowissenschaften und Rohstoffe. Aluminum - Sustainability Information. July 2020.
[4] Global Energy Monitor. Jawa-5 power station.
[5] Market Forces. Banks can't fund Adaro's smelter without funding coal. Accessed on September 21, 2023.
[6] Statista. Territorial carbon dioxide (CO_2) emissions in Southeast Asia from 1960 to 2021, by country. February 2023.

Table 3: Power Requirements of Adaro Phase 1 Aluminum Smelter

Calculations	Power Needs	Power Output
Power per tonne of aluminum (kWh)	15,700	
Power to produce 500kt of aluminum (GWh)	7,850	
Plant capacity required (MW)		1,100
Hours operated per day		24
Days operated annually		310.25
Utilization rate (%)		85
Total power produced per year (GWh)		8,191
As % of power required to support 500kt of aluminum production		104.3

Source: Adaro Investor Presentations; IEEFA estimates.

Based on the total power output of 8,191GWh and the Adaro average coal calorific value (cv) of 4,500 kilocalories per kilogram (kcal/kg), 1.6Mt of coal would need to be burned annually to support the Phase 1 aluminum smelter output of 500ktpa.

Table 4: Adaro Phase 1 Smelter Coal Requirements Per Year

Calculation	Energy Measure	Coal Measure
Average CV of Adaro coal (kcal)	4,500	
Average CV of Adaro coal (Btu)	17,865	
BTU per kwh	3,412	
Adaro coal required per kWh (kg)		0.2
Adaro coal required per GWh (tonnes)		191.0
Coal required to generate 8,191GWh (Mt)		1.6

Source: Adaro Investor Presentations; IEEFA estimates.
Note: Btu = British thermal unit.

Bank Financing for Phase 1

Capital expenditure (capex) for both the aluminum smelter and the power plant has been estimated at US$2 billion.[7] The investment required for the Phase 1 aluminum smelter has been reported at US$728 million,[8] so this implies that the power plant would cost about US$1.3 billion.

[7] Market Forces. Banks can't fund Adaro's smelter without funding coal.
[8] Mining Technology. Adaro plans to build $728m aluminum smelter in Indonesia. December 24, 2021.

In February 2023, Standard Chartered and DBS Bank were reported to have declined to finance the Adaro smelter project.[9]

The decisions of the two banks were not surprising, given their climate commitments. In May, IEEFA published a report on 200 financial institutions and their policies on exiting coal,[10] the details of which are outlined on the IEEFA website.[11]

The coal exit policies of Standard Chartered[12] and DBS[13] are summarized in Table 4.

Table 5: DBS, Standard Chartered Coal Exit Policies

Bank	Country	Policy Date	Policy Details
DBS	Singapore	April 2021	With immediate effect: ceased the onboarding of new customers who derive more than a quarter of revenue from thermal coal. To lower the threshold over time. From January 2026: to stop financing customers who derive more than half of revenue from thermal coal.
Standard Chartered	United Kingdom	March 2023	Excludes both coalmining and coal-fired power plants.

Source: DBS; Standard Chartered Investor Presentation; IEEFA estimates.

On May 12, local media reported that five Indonesian banks were financing the Bangun aluminum smelter.[14] They were Mandiri Bank, Bank Negara Indonesia, Bank Central Asia, Bank Rakyat Indonesia and Permata Bank.[15] Loans totaling US$1.09 billion were directed to the Kalimantan Aluminium Industry smelter and US$666 million to the Kaltara Power Indonesia coal-fired plant, both of which are Adaro subsidiaries.[16]

IEEFA notes that the supporting coal power facility can be considered a "captive plant" as it is not connected to a grid. Recent news say that Indonesian authorities may view such plants as part of green power.[17]

[9] Indonesia Business Post. Global banks decline to finance Adaro's smelter project. February 15, 2023.
[10] IEEFA. 200 and counting: Global financial institutions are exiting coal. Trivedi and Srivastava. May 4, 2023.
[11] IEEFA. Coal Divestment. May 4, 2023.
[12] Standard Chartered. Power Generation Position Statement. Accessed on September 21, 2023.
[13] DBS Bank. DBS Bank commits to zero thermal coal exposure by 2039. April 16, 2021.
[14] CNBC Indonesia. Bangun Smelter, Adaro Minerals Kantongi Kredit dari 5 Bank. May 16, 2023.
[15] Market Forces. Banks can't fund Adaro's smelter without funding coal.
[16] Ibid.
[17] Business Insight. OJK Akan Pasang Lampu Hijau Bagi Pembiayaan PLTU Batubara. August 29, 2023.

The Problem with Captive Coal Plants

There are two major questions surrounding captive coal plants in Indonesia:

- Should captive coal plants that support industries such as aluminum and nickel to produce raw materials for the green transition be considered green? If so, this would make it easier to attract financing.
- What is the total scale of captive plants in Indonesia? IEEFA notes that according to Bloomberg, current captive capacity is 13GW, with another 10GW being built right now.

On August 29, news broke that Indonesia's Financial Services Authority (OJK) would revisit the national green taxonomy to include newly built coal-powered generation as a "green" activity as long as it was aimed at the energy transition, for example, if the plant supplied power to a smelter project.[18]

IEEFA published a commentary in response, explaining why it was extremely concerning that new coal-powered generation could now be seen as protecting or improving the environment, [19] given such a stance would go against scientific evidence.

The official rationale for coloring certain coal-fired power plants as green is that those plants would be developed "for the sake of the energy transition." It sends out a bad signal to global sustainability-focused investors and administrations who are counting on the Indonesian government for policy certainty and the country's seriousness in making the transition toward a clean energy future.[20]

Indonesian captive power capacity is now at 13GW, and there is another 21GW in the pipeline, of which 10GW is under construction.[21] Plans are for the remaining 11GW to be built after the 10GW is completed. Accordingly, IEEFA calculates that the current captive power capacity is already 32% of Indonesia's 2023 coal-fired capacity of 40.5GW. With the planned 21GW fully completed, the country could add a staggering 52% to 2023 coal power capacity.

IEEFA further estimates 1.6Mt of annual coal demand per gigawatt, so the forthcoming 21GW would boost coal demand by up to 34Mt, equivalent to 17% of the Indonesian 2022 coal demand of 198.5Mt.

[18] Ibid.
[19] IEEFA. Indonesia signals it could abandon science-based taxonomy for coal power plants. Ng and Adhiguna. September 5, 2023.
[20] Ibid.
[21] Bloomberg. Money and politics put world's biggest climate deal at risk. September 4, 2023.

Table 6: Indonesian Coal Capacity and Potential Demand

Coal Capacity and Demand	Coal Power Capacity	Coal Usage
2023 installed coal capacity (MW)	40,467	
Captive power capacity (MW)	13,000	
2022 coal demand (Mt)		198.5
Captive capacity in construction (MW)	10,000	
As % of 2023 total capacity	24.7	
Potential additional coal demand (Mt)		16.0
As % of 2022 coal use		8.1
Captive capacity to come (MW)	11,000	
As % of 2023 total capacity	27.2	
Potential additional coal demand (Mt)		17.6
As % of 2022 coal use		8.9

Source: Statista; Bloomberg; IEEFA estimates.

Captive plants currently account for 32% of total Indonesian coal plant capacity. Since 10GW is under construction, including the 1.1GW meant to support Adaro's Phase 1 aluminum smelter, another 25% could be added to 2023 coal power capacity.

With another 11GW in the pipeline, a further 27% could be added to 2023 coal power capacity. The issue of captive plants is therefore significant to the growth of coal demand in Indonesia.

Aluminum: Moving Up the Value Chain?

The construction of new aluminum smelting capacity in Indonesia can be attributed to two possible reasons: to ease the domestic shortfall, and to use the country's bauxite resources to create more value for the economy.

First, IEEFA notes that Indonesian 2021 aluminum demand totaled 350kt, while current aluminum capacity comes from a 250ktpa smelter operated by PT Indonesia Asahan Aluminium (Inalum).[22] Adaro has noted that 2025 Indonesian aluminum demand could reach 2Mt.

Inalum plans to expand capacity to 750ktpa,[23] but this would meet only 37.5% of projected 2025 demand. In this regard, Adaro's Phase 1 addition of 500ktpa by the first quarter of 2025[24] would help alleviate the shortfall of 1.25Mt.

[22] Mining Weekly. Indonesian mining giant seeks to triple aluminium production. January 22, 2020.
[23] Ibid.
[24] Global Energy Monitor. Adaro Aluminium smelter power station. September 6, 2023.

Table 7: Indonesian Aluminum Supply and Demand

Aluminum Supply and Demand	2020	2021	2025F
Domestic supply (kt)	245.6	200.6	750.0
Domestic demand (kt)	240.0	350.0	2,000.0
Implied imports (kt)	-5.6	149.4	1,250.0
As % of domestic demand	NM	42.7	62.5

Source: Statista; Adaro Investor Presentations; IEEFA estimates.

North Kalimantan has abundant bauxite resources where the Adaro aluminum smelter will be located. In 2020, Indonesia produced 25.9Mt of bauxite ore[25] and, as Table 6 shows, 245.6kt of aluminum, suggesting a huge output of bauxite ore that was not used to extract aluminum domestically. However, the country banned the export of unprocessed bauxite ore from June 2023[26] to boost its capacity in refining ore to alumina.

On average, it takes 4 to 5 tonnes of bauxite to produce 2 tonnes of alumina, which then yields a tonne of aluminum.[27]

From IEEFA calculations, up to 1.25Mt of bauxite was used to produce the aluminum in 2020, meaning Indonesia exported 24.6Mt of the bauxite it mined. The country's bauxite export value in the same year was reported to be about US$580 million, or around US$23.5/tonne.[28]

The export ban would triple the value of bauxite ore exports from US$1.35 billion to at least US$4.1 billion, according to Indonesian President Joko Widodo.[29]

IEEFA notes that in the case of Australian exports in 2022, the price differential between refined alumina, sold at US$359/tonne, and bauxite ore was 16.5 times.

Table 8: Australian Alumina and Bauxite Export Prices

Products	Export Price	2018	2019	2020	2021	2022
Bauxite	US$/tonne	31	28	27	27	22
Alumina	US$/tonne	435	334	264	317	359
Aluminum	US$/tonne	2,108	1,794	1,704	2,473	2,795

Source: Statista; Australian Government Department of Industry, Science and Resources; IEEFA estimates.

[25] Statista. Production of bauxite in Indonesia from 2011 to 2021. 2023.
[26] Reuters. Bauxite miners urge Indonesia to rethink export ban as deadline looms. June 6, 2023.
[27] GRID-Arendal. Mining waste generated from aluminium production. 2009.
[28] Nikkei Asia. Indonesia's Jokowi bans bauxite exports from June, China likely hurt. December 21, 2022.
[29] Ibid.

High Aluminum Prices Needed to Create Value

Given that a tonne of aluminum output requires 5 tonnes of bauxite and 2 tonnes of alumina, the value created can be calculated after deducting production costs.

In the calculations, IEEFA estimates the cost of mining 2.5Mt of bauxite which would yield 500ktpa of aluminum. The operating price is US$25/tonne and the cost of digging up the bauxite is US$8/tonne. The total value created would be US$43 million, as Table 8 shows.

IEEFA estimates that an operating price of US$360/tonne of alumina is involved in producing 500ktpa of aluminum from 1Mt of alumina. Taking the example of Australian company AWC, alumina production cost in 2022 was US$250/tonne.[30] This would create US$110 million of profit, which is 2.6 times that created by bauxite sold.

Table 9: Value Created Under Bauxite and Alumina Output After Costs

Value Created	Bauxite	Alumina
Amount required to produce 500kt of aluminum (Mt)	2.5	1.0
Price per tonne (US$)	25	360
Cost per tonne (US$)	8	250
Profit per tonne (US$)	17	110
Profit margin (%)	68	31
Total value created (US$ million)	42.5	110

Source: AWC investor reports; IEEFA estimates.

However, the issue is whether advancing to full aluminum smelting can create the equivalent amount of value. Aluminum production costs are divided into three main categories:

- Power cost: One tonne of aluminum output requires 15,700kWh of energy. IEEFA assumes that coal power will cost US$0.06/kWh.
- Alumina cost: IEEFA assumes alumina will be supplied at US$300/tonne.
- Non-material cost: This normally accounts for 40% of total aluminum production costs.[31] IEEFA assumes two scenarios, of US$750/tonne (33% of total cost) and US$900/tonne (37% of total cost).

Global aluminum prices in the last five years ranged from US$1,800-US$2,800/tonne. The current level is at US$2,200/tonne. IEEFA assumes three scenarios, of US$2,200, US$2,500 and US$2,800/tonne.

[30] AWC Group. Annual Report 2022.
[31] Energy Technology Systems Analysis Programme. Aluminium Production. March 2012.

Under the non-material cost scenario of US$750/tonne, IEEFA estimates the value created would range from a loss of US$92 million at the current spot price of US$2,200/tonne to a profit of US$508 million at US$2,800/tonne.

Table 10: Value Created Under Aluminum After Non-Material Cost of US$750/Tonne

Value Created	Price Per Tonne (US$)		
	2,200	**2,500**	**2,800**
Aluminum output (Mt)	0.5	0.5	0.5
Power required per tonne (kWh)	15,700	15,700	15,700
Cost of coal power per kWh (US$)	0.06	0.06	0.06
Aluminum price per tonne (US$)	2,200	2,500	2,800
Alumina cost per tonne of aluminum (US$)	600	600	600
Power cost per tonne of aluminum using coal (US$)	942	942	942
Other costs per tonne (US$)	750	750	750
Total cost per tonne (US$)	2,292	2,292	2,292
Profit per tonne (US$)	-92	208	508
Total value created (US$ million)	-46.0	104.0	254.0

Source: International Energy Agency (IEA); IEEFA estimates.

Under the non-material cost scenario of US$900/tonne, IEEFA estimates the value created would range from a loss of US$121 million at the current spot price of US$2,200/tonne to a profit of US$179 million at US$2,800/tonne.

Table 11: Value Created Under Aluminum After Non-Material Cost of US$900/Tonne

Value Created	Price Per Tonne (US$)		
	2,200	**2,500**	**2,800**
Aluminum output (Mt)	0.5	0.5	0.5
Power required per tonne (kWh)	15,700	15,700	15,700
Cost of coal power per kWh (US$)	0.06	0.06	0.06
Aluminum price per tonne (US$)	2,200	2,500	2,800
Alumina cost per tonne of aluminum (US$)	600	600	600
Power cost per tonne of aluminum using coal (US$)	942	942	942
Other costs per tonne (US$)	900	900	900
Total cost per tonne (US$)	2,442	2,442	2,442
Profit per tonne (US$)	-242	58	358
Total value created (US$ million)	-121.0	29.0	179.0

Source: IEA; IEEFA estimates.

IEEFA concludes that for the Adaro Phase 1 smelter to produce value, either non material costs have to be kept very low at the industry low range of US$750/tonne at industry or aluminum prices have to be at the five-year high of US$2,800/tonne.

Payback Period at Best 8-11 Years

IEEFA notes that under aluminum prices of US$2,500/tonne and US$2,800/tonne, profits are possible. The issue is how long the payback period would be. As discussed earlier in the report, the capex required for Adaro's Phase 1 aluminum smelter is US$728 million, while the coal plant will need US$1.3 billion. Under this scenario, even with an aluminum price of US$2,800/tonne, the payback period is at best eight to 11 years.

Table 12: Payback Period for Phase 1 Aluminum Smelter and Coal Plant Under 2 Price Scenarios

Payback Period	Price Per Tonne (US$)	
	2,500	2,800
Capex for smelter (US$ million)	728	728
Capex for coal plant (US$ million)	1,300	1,300
Total capex for smelter and plant (US$ million)	2,028	2,028
Profit under @US$750 cost (US$ million)	104	254
Payback period (years)	20	8
Profit under @US$900 cost (US$ million)	29	179
Payback period (years)	70	11

Source: IEA; IEEFA estimates.

IEEFA finds that under the aluminum price scenario of US$2,500/tonne, the payback period can range from 20 to 70 years, which effectively means a sunk cost. The current aluminum price is US$2,200/tonne, so prices have to rise about 30% and to remain at that level for eight years for Adaro Phase 1 to recover the capital invested.

Counting the Emissions: Nearly 1% of National Total

The final issue regarding the Adaro Phase 1 coal plant concerns emissions. According to Market Forces, which based its calculations on the power required as stated by the International Aluminium Institute, and on coal emission intensity as stated by the IEA, annual emissions would amount to 5.2Mt of CO_2.[32] The calculation assumes the coal power plant uses the best available technology (ultra-supercritical).

[32] Market Forces. Banks can't fund Adaro's smelter without funding coal.

Table 13: CO_2 Emissions from Adaro Phase 1 Project versus Indonesia Total in 2021

Comparison	CO_2 Measure
Adaro Phase 1 CO_2 emissions, estimated (Mt)	5.2
Indonesia CO_2 emissions in 2021 (Mt)	619.3
Emissions of Adaro Phase 1, including coal plant, as % of total Indonesian emissions	0.8

Source: Statista; Market Forces; IEEFA estimates.

IEEFA estimates that the 5.2Mt of CO_2 emissions represent about 0.8% of Indonesia's total 2021 CO_2 emissions, as Table 12 shows. Thus, there is also a significant emission angle to the proposed Adaro Phase 1 aluminum smelter and captive coal plant, in addition to the challenges in financing and the payback period.

Conclusion

The argument for building an aluminum smelter was to take advantage of North Kalimantan's abundant bauxite resources and hydro and coal power.

However, IEEFA's analysis shows that the smelter will need high aluminum prices over a sustained period to recoup the expected capex of US$2 billion.

IEEFA calculations indicate that aluminum prices would have to rise 30%, from the current US$2,200/tonne to US$2,800/tonne, and remain at that level for eight years or more to recover the capex. The proposed plant complex would also be adding 5.2Mt of CO_2 emissions, which is nearly 1% of Indonesia's total CO_2 emissions in 2021.

Captive power plants present another looming issue. Not only is the financial case for such installations shaky, but they may be considered green by the Indonesian government if they support the production of materials, such as aluminum and nickel, that can aid the green transition.

IEEFA notes further that captive power plants could add 52% to installed coal power capacity and 17% to coal demand if all 21GW in the pipeline is completed.

Adaro's Phase 1 aluminum smelter of 500ktpa and 1,100MW coal plant do not really create value even under a sustained period of high aluminum prices, not to mention the significant CO_2 emissions that can be expected from the project.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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