



HASHRATE
INDEX **PREMIUM**

S21 Design and Performance Review

By: Hashrate Index

About Hashrate Index

[Hashrate Index](#) is a Bitcoin mining data, analytics and research platform. Our platform offers novel data sets that enable miners, traders, content creators, and investors to gain key insights into the mining industry and generate alpha. Hashrate Index is a product of [Luxor Technology Corporation](#), a mining software and services company.



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Introduction

Bitmain unveiled its newest miner, the Antminer S21, at the 2023 World Digital Mining Summit in Hong Kong.

The much-anticipated S21 series features the most efficient and powerful Bitcoin mining ASICs to date. Bitmain released two versions of the S21 at launch: an air-cooled version and a hydro version. At 200 TH/s and 17.5 J/TH, the Antminer S21 is the most powerful and efficient air-cooled Bitcoin mining rig available on the market today, and the Antminer S21 hydro is one of the most powerful and efficient ASIC miners in the water-cooled class of mining rigs.

Bitcoin Mining ASICs	Release Date	Hashrate	Efficiency	Wattage
Antminer S21 Hydro	Sept 2023	355 TH/s	16 J/TH	5360 W
Antminer S21	Sept 2023	200 TH/s	17.5 J/TH	3500 W
S19 XP Hydro	Nov 2021	255 TH/s	20.8 J/TH	5304 W
S19j XP	May 2023	151 TH/s	21.5 J/TH	3241 W
S19 XP	Nov 2021	140 TH/s	21.5 J/TH	3010 W
S19k Pro	April 2023	120 TH/s	23.0 J/TH	2760 W
S19j Pro+	Dec 2022	122 TH/s	27.5 J/TH	3355 W

Bitmain began shipping this model in January of this year. The manufacturer still has outstanding orders for the S19 XP and other S19 series ASICs, but once these are filled, it will divert the majority of its manufacturing capacity to the S21. Once this occurs, Bitmain will manufacture up to 50,000 or even 100,000 of the rigs a month depending on market demand.

Luxor had the privilege of securing an air-cooled Antminer S21 in November 2023 to test and review. This report documents our observations and findings. We also provide return-on-investment (ROI) and price analysis for the S21 compared to other Bitcoin mining ASICs and a summary of key takeaways at the end of the report.

Antminer S21 Design

The S21 series features identical dimensions to the S19 series (400*195*290 mm). However, the S21 exceeds S19 series rigs in weight by at least 1 kg, and it has a 5°C higher maximum operating temperature threshold. The table below provides a comparison of the weight and operating temperature for the S21 model versus the S19 series.

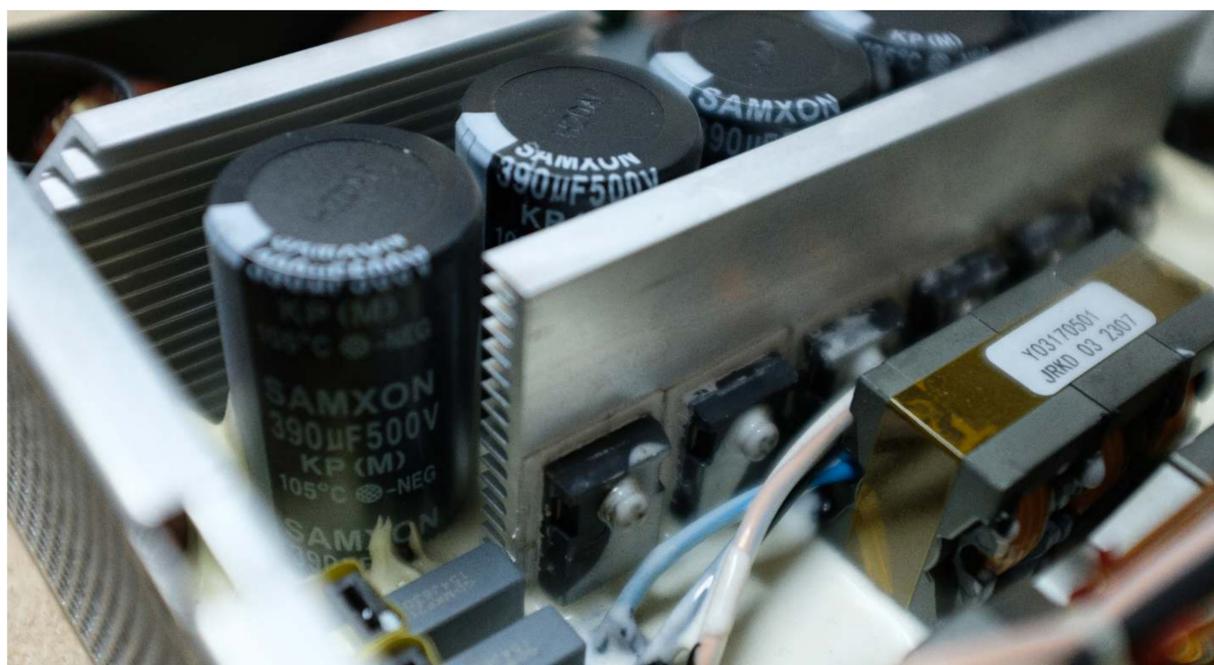
Model	Net Weight (Kg)	Max Operating Temp (°C)
S21	15.40	45
S19 XP	14.40	40
S19k Pro	12.85	40
S19j Pro+	13.70	40
S19j Pro	13.20	40
S19 Pro	14.60	40

Power Supply Unit and Antwire Cord

The S21 will introduce a PSU variant first seen on S19j XP, the APW171215a. This power supply unit features an input voltage range of 220-277V and an output voltage range of 12-15V. Upon inspecting the PSU internals, we noticed that this PSU model incorporates 5 capacitors with increased voltages of 500V, surpassing those of the S19 series, such as the S19j Pro+, which utilizes 450V capacitors. These capacitors highlight Bitmain's efforts to revise and improve their ASIC miners' power supply design over time to help ensure power stability and capacity for overclocking, and the S21 will certainly benefit from these improvements.



PSU specifications



PSU internal view with capacitors

The most notable difference with this new PSU versus most S19 PSUs is that it features a novel type of socket, which uses the 4-pin PA45 plug, also known as the “P14” on the PSU side and “P13” on the power cord side. As a result, miners will need to buy one of two versions of the “Antwire” power cord with a P13 connector on one end and an industry standard (IEC 60320) C20 or specialized AntPDU connector to plug into their power source. Industry standard (IEC 60320) C19 sockets are common with existing S19 deployments, so the C20-to-P13 cable will benefit those miners upgrading existing infrastructure with S21s.



PSU inlet plug on S21

The “Antwire” power cord for the S21 was previously intended to be used on the S19j Pro+ but it was delayed until the S19j XP release. It is a 3-conductor, 12 AWG 300V 105°C rated wire. Compared to the conventional S19 cords, Antwire is a single connector with a locking mechanism when plugged in. However, because of its novel design, it may not be as readily available in the open market as the S19 cords which use standard C14 connectors to plug into the S19-series PSUs with dual C13 power connectors.



C20-P13 cable



Antwire power cord

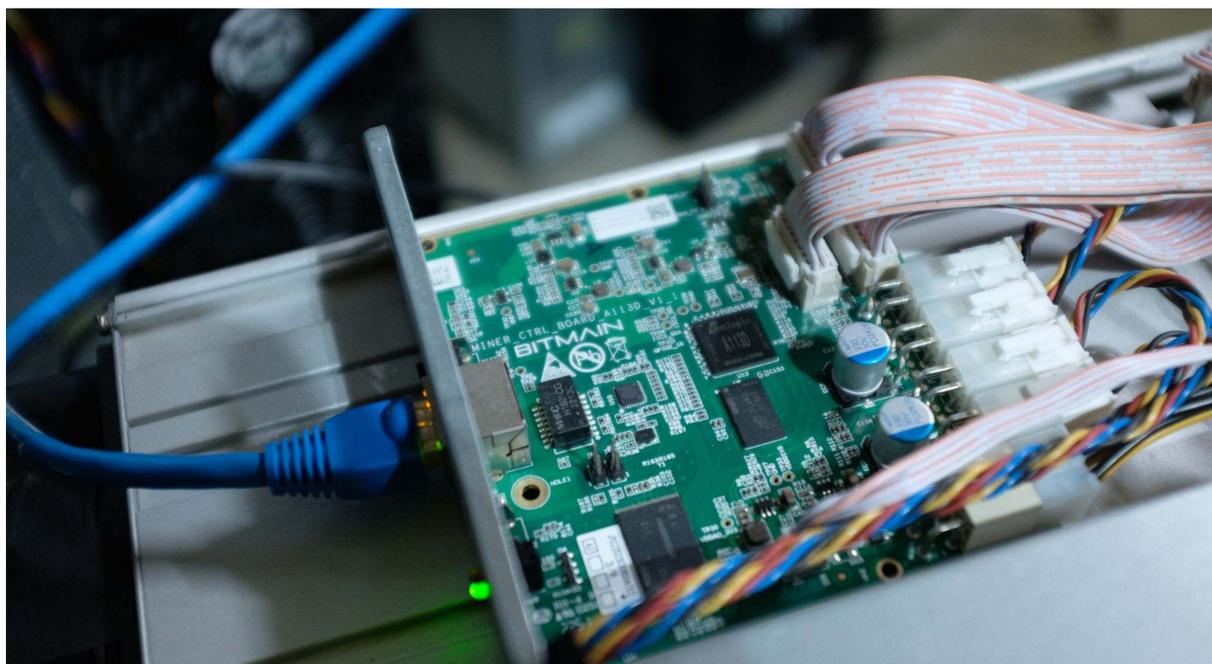
Fans

The S21 features 12V, 6.4 amp fans on both the front and rear of the machine. With their 6.4 amp ratings, the fans on the S21 are more powerful than the fans featured on the S19 series, which makes it much easier for the S21 to draw air to keep the machines cool.

Model	Input Adaptation
S21	12V/6.4A
S19 XP	12V/2.7A
S19k Pro	12v/2.7A-12v/3.3A
S19j Pro+	12V/2.35A
S19j Pro	12V/2.4A

Control Board

The S21 we received came with a standard Amlogic A113D control board which employs four 2×2 Molex Mini-Fit connectors (the same connector type as the S19k Pro) in order to support the powerful fans. As a result of this design choice, if miners replace the control board, they will need to replace the connectors on the control board or find / make adapter cables to be able to make the connection. Replacing fans could be an option as well, but miners should pay attention to the fan specifications as this could lead to decreased cooling capacity.



Amlogic control board

Hashboards and Heatsinks

The Antminer S21 uses 3 BHB68603 hashboards, with each board housing 108 BM1368 series ASIC chips. By comparison, the S19k Pro has 77 chips per board, the S19j Pro has 126, the S19 XP has 110, and the S19 j Pro+ has 120. The S21 strikes a balance between the high chip count in older S19 models and the lower chip count in newer S19 models, likely thanks to its dual-heatsink design.



Hashboards inside S21 chassis

Expanding on the heatsink design, the S21's hashboards feature bolted-on aluminum heatsinks that do not have PIC controllers, similar to the S19 XP. Also like the S19 XP, the S21 features a new type of lightweight, one-piece aluminum heatsink on the front of the hashboard to ensure that it disperses heat evenly. The front heatsinks connect many chips at once to collectively dissipate their heat, rather than the individually soldered heatsinks in other models which dissipate heat on a more individual chip basis.



Front heatsink



Back heatsink

Antminer S21 Test

Methodology

In our test of the Antminer S21, we subjected it to a range of different temperatures.

To start, we powered on the machine for 30 to 60 minutes until hashrate and power draw clearly stabilized. Then we inserted the rig into a temperature controlled box and tested it at a range of temperatures for 30 to 60 minutes: 10, 20, 25, and 40 degrees celsius.

Results

The table below presents the real-time hashrate, power consumption, and efficiency metrics of the S21 at various temperatures. Notably, at 10 and 20 degrees celsius, the S21 operated at its advertised specifications.

Temperature (°C)	Hashrate (TH)	Power (W)	Efficiency
10	200	3470	17.4
20	201	3529	17.5
25	202	3620	17.9
40 (before underclocking)	202	4000	19.8
40+ (after underclocking)	185	3700	20

Another noteworthy observation is that the default firmware of the S21 tends to increase the PSU voltage in colder conditions and automatically initiate underclocking when the temperature approaches approximately 40°C based on our testing. The specific temperature at which the S21 begins underclocking may vary depending on the environment, but generally, the range of 40°C ±3°C is standard for underclocking according to Bitmain. We believe that this stock firmware feature gives the S21 its advertised operating temperature of up to 45°C. Furthermore, users have the option to adjust their voltage and frequency settings by utilizing third party firmware, such as LuxOS, if they wish to establish different thresholds for underclocking or overclocking.

```

2023-11-30 17:17:43 set_voltage_by_steps to 1340.
2023-11-30 17:17:45 Tempture has returned to normal, fequency restoration start!
2023-11-30 17:17:45 Tempture has returned to normal, fequency restoration over!
2023-11-30 17:24:47 dec_vol = 10, new_dec_vol = 20
2023-11-30 17:24:47 set_voltage_by_steps to 1330.
2023-11-30 17:24:50 Tempture is too high, drop frequency start!
2023-11-30 17:24:50 Tempture is too high, drop frequency over!
2023-11-30 17:26:15 dec_vol = 20, new_dec_vol = 30

```

S21 operational log with automatic command to drop frequency underlined in red

Antminer S21 Pricing and ROI Modeling

Upon release, Bitmain offered promotional pricing for the S21 at \$14/TH for orders of 1.2 EH/s or greater, which equates to \$2,800 per unit for an air-cooled and \$4,690 for hydro models. As these ASICs proliferate on the secondary market and Bitcoin's price rose above \$40,000, we started seeing air-cooled models sell for \$17-20/TH depending on order quantity.

The first deliveries for the S21 series began in January 2024, a few months before Bitcoin's fourth block subsidy halving in late April. Naturally, miners will want to know just how much a next-generation rig like the S21 will help them remain profitable in a post-halving environment.

To this end, we have modeled out the S21's return-on-investment (ROI) timeframe using Hashrate Index's Q1-2024 Hashprice, Hashrate, and Difficulty projections. For the model, we assume \$0.06/kWh power cost, 98% uptime, and a February 1, 2024 deployment date. We used Luxor ASIC Trading Desk data for each model: \$21.7/TH for the S21, \$22/TH for S19 XP, and \$9.8/TH for S19j Pro.

The model includes four different hashprice scenarios: a bull scenario with 50% annualized BTC price growth, a base case scenario with 25% annualized price growth; a flat case with no price growth, and a bear case with a 10% annualized decline in price.

ROI Forecast																		
S21 (\$4,340 CAPEX)	Feb-24 P	Mar-24 P	Apr-24 P	May-24 P	Jun-24 P	Jul-24 P	Aug-24 P	Sep-24 P	Oct-24 P	Nov-24 P	Dec-24 P	Jan-25 P	Feb-25 P	Mar-25 P	April-25 P	May-25 P	June-25 P	
Bear Case Hashprice USD	7.40%	15.04%	22.43%	25.71%	28.81%	31.88%	34.83%	37.61%	40.42%	42.99%	45.55%	48.01%	50.15%	52.45%	54.57%	56.67%	58.69%	
Flat Case Hashprice USD	9.99%	20.44%	30.66%	35.94%	40.92%	45.96%	50.95%	55.62%	60.37%	64.89%	69.48%	73.99%	77.98%	82.33%	86.48%	90.69%	94.70%	
Base Case Hashprice USD	9.75%	20.00%	30.28%	35.28%	40.14%	45.16%	50.19%	55.06%	60.13%	65.10%	70.33%	75.61%	80.43%	85.82%	91.12%	96.69%	102.16%	
Bull Case Hashprice USD	13.08%	27.93%	43.11%	52.20%	61.31%	71.10%	81.29%	91.53%	102.49%	113.61%	125.51%	137.94%	149.68%	163.17%	176.68%	191.31%	206.14%	
S19 XP (\$3,102 CAPEX)	Feb-24 P	Mar-24 P	Apr-24 P	May-24 P	Jun-24 P	Jul-24 P	Aug-24 P	Sep-24 P	Oct-24 P	Nov-24 P	Dec-24 P	Jan-25 P	Feb-25 P	Mar-25 P	April-25 P	May-25 P	June-25 P	
Bear Case Hashprice USD	6.42%	13.03%	19.07%	21.45%	23.68%	25.86%	27.91%	29.84%	31.76%	33.48%	35.17%	36.75%	38.11%	39.67%	40.96%	42.20%	43.38%	
Flat Case Hashprice USD	8.93%	18.25%	26.94%	31.27%	35.32%	39.40%	43.44%	47.19%	50.99%	54.60%	58.24%	61.82%	64.96%	68.52%	71.76%	75.05%	78.16%	
Base Case Hashprice USD	8.69%	17.82%	26.57%	30.62%	34.55%	38.63%	42.70%	46.65%	50.76%	54.80%	59.07%	63.39%	67.33%	71.89%	76.25%	80.85%	85.38%	
Bull Case Hashprice USD	11.92%	25.50%	38.84%	46.86%	54.91%	63.59%	72.65%	81.80%	91.62%	101.62%	112.34%	123.58%	134.23%	146.63%	158.94%	172.31%	185.90%	
S19j Pro (\$980 CAPEX)	Feb-24 P	Mar-24 P	Apr-24 P	May-24 P	Jun-24 P	Jul-24 P	Aug-24 P	Sep-24 P	Oct-24 P	Nov-24 P	Dec-24 P	Jan-25 P	Feb-25 P	Mar-25 P	April-25 P	May-25 P	June-25 P	
Bear Case Hashprice USD	10.65%	21.47%	31.15%	32.48%	33.60%	34.46%	35.06%	35.49%	35.79%	35.77%	35.53%	35.07%	34.48%	33.67%	32.66%	31.43%	30.20%	
Flat Case Hashprice USD	16.28%	33.19%	48.82%	54.51%	59.72%	64.86%	69.91%	74.44%	78.95%	83.17%	87.34%	91.34%	94.77%	98.43%	101.82%	105.18%	108.27%	
Base Case Hashprice USD	15.76%	32.24%	47.99%	53.06%	58.00%	63.13%	68.26%	73.22%	78.44%	83.62%	89.19%	94.87%	100.09%	106.00%	111.90%	118.20%	124.48%	
Bull Case Hashprice USD	22.99%	49.47%	75.53%	89.50%	103.69%	119.16%	135.49%	152.14%	170.16%	188.72%	208.77%	229.99%	250.26%	273.77%	297.52%	323.52%	350.14%	

Under this model, the Antminer S21 earned a return on investment in 9 months in our bullish hashprice scenario, and it ROI'd in 17 months in our base case hashprice scenario. It outperformed the S19 XP in all scenarios, and it outperformed the S19j Pro in the bear case scenario. It's worth noting that the S19j Pro has a strong ROI timeframe under this model because the S19j Pro is an older model that has a very low price point and our model itself doesn't account for depreciation.

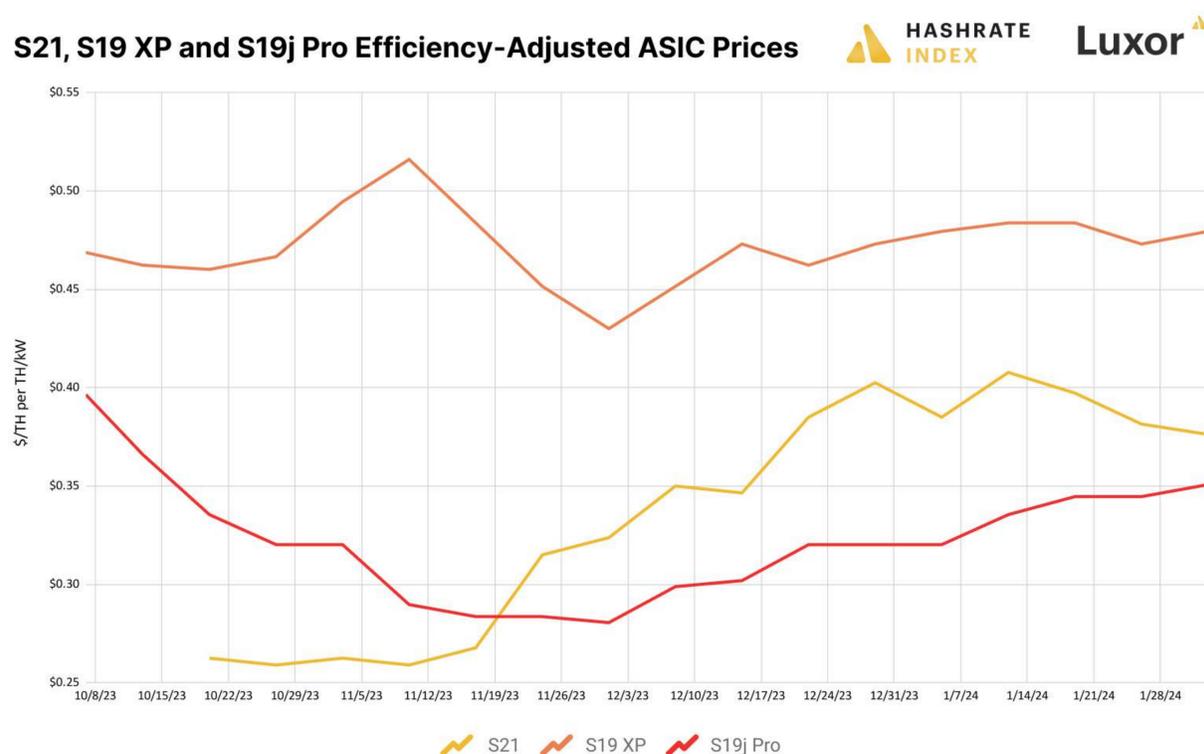
Antminer S21 Efficiency-Adjusted ASIC Price

To weigh the Antminer S21's price versus other Bitcoin ASIC miner models, we can use the Efficiency-Adjusted ASIC Price metric, a new method for valuing ASIC miners that Hashrate Index proposed this November.

When comparing different ASIC models, it's important for miners to consider not just the upfront cost or the hashrate output of a machine, but also how efficiently each ASIC miner uses electricity to generate hashrate. To account for efficiency across models, the Efficiency-Adjusted ASIC Price which looks at an ASIC model's dollar per terahash price (\$/TH) relative to its efficiency for converting electricity into a terahash (TH/kW); this price is presented as \$/TH per TH/kW. The formula is as follows:

$$\text{Efficiency-Adjusted ASIC Price} = (\$/\text{TH}) \div (\text{TH}/\text{kW})$$

While this is only one variable, it can serve as a useful benchmark for ASIC traders when evaluating market opportunities; it is particularly useful for valuing ASICs that are in the same generation, such as next generation rigs like the S21 and S19 XP. For example, if we look at the S21's efficiency-adjusted ASIC price, we can see that the model is very attractively priced compared to the S19 XP, the most efficient ASIC miner currently on the market.



On an efficiency-adjusted basis, the S21's efficiency-adjusted price only rose above the S19j pro's efficiency-adjusted price in November. Further, as of February 2, 2024, the S19 XP is priced at a 27% premium to the S21 when we use efficiency-adjusted price – a hefty difference when we consider the S21's efficiency and hashrate gains. It's worth noting that both the S19 XP and S19j Pro's efficiency-adjusted prices decreased significantly when the S21 was released, a testament to the S21's superiority from both a hashrate production and power efficiency standpoint, although these prices have rallied into the New Year thanks to Bitcoin's own price rally. We should caveat that the prices for the S21 that we examined are futures orders of course, but the efficiency-adjusted ASIC price still underscores the value that this new rig carries compared to older models.

Conclusion

The Antminer S21 provides industry-leading hashrate capacity and power efficiency, making it the most attractive ASIC miner from a specifications standpoint going into the April 2024 Halving. Additionally, the S21 performed well under high temperature tests during our review, while also achieving its nameplate hashrate and efficiency during testing.

Its high-powered fans and dual-sided heatsinks should ensure that the rig stays operational and avoids overheating in hot environments, as evidenced by the fact that it stayed operational at 40 celsius.

When examining its profitability, the Antminer S21 outperformed the S19 XP in each hashprice scenario and the S19j Pro in a bearish scenario, which conveys that the ASIC is well equipped to handle the Bitcoin's halving's compression of mining margins.

Overall, we recommend the Antminer S21 to any miner looking for a sturdy next-generation rig to weather the 2024 Bitcoin Halving. If you are in the market for an S21, [the Luxor ASIC Trading Desk team is here to help you find the best deal on this best-in-class miner.](#)