Sustainable Cryptocurrency Mining

Introduction

Storing critical data in a centralized environment under a modifiable structure exposes it to several risks, including unauthorized alterations, privacy breaches, and abiding by the data warehouse's legislative policies, which may be undesirable in some situations. Unfortunately, all public and major commercial sectors, such as banks, hospitals and airports, operate on this conventional method. However, over the last decade, blockchain technology has offered a very practical solution to this problem by storing the data in a decentralized (also known as peer-to-peer or serverless) environment. In this system, data are saved in an append-only structure in chronological order, secured by one-way encryption (or hashing) functions. Several peers (or nodes), which are essentially not under the control of a single authority, keep the up-to-date full copy of the data. To validate any data, several of these nodes are queried and a decision about the authenticity of the returned data is taken based on the majority response. Therefore, if the data on one or a few nodes has been manipulated, those nodes can be easily filtered out.

To date, several applications of blockchain have been proposed for areas such as health, education, manufacturing, and e-government sectors. One of the largest and most popular applications of blockchain is the revolutionization of public ledgers, which were traditionally controlled by intermediary institutions such as banks. The operating nodes in such systems are rewarded for their uptime and technology in the form of newly minted virtual currency (known as cryptocurrency). Some of these popular currencies are Bitcoin (BTC), Ethereum (ETH) and Dodgecoin (DOGE). Initially, these currencies had no monetary value. However, over time several global businesses, including Microsoft, PayPal and Starbucks, started accepting these currencies in return for their products and services. These days, the total market cap for all cryptocurrencies is around US$2.3 trillion.

Although blockchain has drastically improved transparency, security, privacy, and independence in the process of storing data, its widespread implementation and overwhelming growth is creating challenges with regard to sustainability. One of the major concerns is the consumption of energy to run the large number of nodes. In public ledger systems, these nodes keep the records and perform validations of new transactions. To earn the rewards, these nodes must help the network write the new records to the blockchain. Since every node wants to earn a reward, a mechanism known as Proof-of-Work was developed, which requires nodes to first solve a complicated puzzle before writing the record. This process is known as mining. Only the node that solves the puzzle first gets the reward. Alternatively, if the miner is connected to a pool and some miner solves the puzzle, all the connected miners get the reward. Over time, the algorithm running behind the network updates the difficulty of these puzzles such that each puzzle can be solved within a set time (e.g. 10-20 seconds for ETH). Since there are more people entering the mining business, the difficulty level has become so high that mining now requires extremely energy-intensive miners to solve the puzzles, such as Graphical Processing Units (GPUs) and Application-Specific Integrated Circuits (ASICs). According to Cambridge's Centre for Alternative Finances (cbeci.org), the yearly energy consumption of the bitcoin mining network is around 79.73 TWh, which is almost double the annual electricity generation of New Zealand. Seeing such an alarming impact, many sustainability activists, influencers and government officials have begun protesting against mining.

It is possible that running the mining computations using renewable energy systems (RESs) such as solar energy can solve this problem. However, there is a dearth of literature on this topic. Some initial attempts included using small miners powered by less than 100W PV systems (Lippman & Ekblaw, 2016; Purnama, Irwansyah, & Usagawa, 2019). These systems were found to be not financially viable. Later, a theoretical study showed that mining using RESs can be profitable if it is done on a large scale (Govender, 2019). Very recently, Zhai (2019) tested a 2kW mining rig run by a 6.9 kW PV system. The payback time for the overall system was found to be 7 years.

This work is an attempt to analyze and compare the feasibility of one high-powered and one low-powered cryptocurrency mining setup running on an off-grid solar energy system.

Data

The "Antiminer E9 (ASIC)" and "AMD Radeon RX 6800 (GPU)" were used as the high- and low-powered miners, respectively. Both miners are state-of-the-art machines in their niches. Their specifications and prices are shown in Table I. These miners are assumed to be connected to a large mining pool; e.g. the F2Pool, which comprises 11% of the global miners (f2pool.com). These miners are set to mine ETH, operating continuously throughout the year. The market prices of ETH and other network parameters were taken from whattomine.com and are presented in

Table **II**. These parameters are assumed to be constant throughout the analysis period. A more accurate analysis should account for fluctuations in these parameters; for example, by representing them using probabilistic models. For installing the PV system, a large, flat area of land was hypothetically selected in New Zealand. The year-round average Peak Sun Hours and ambient temperatures are 4 hr/day and 16 ºC, respectively (solarelectricityhandbook.com).

Table **III** lists all the parameters considered while designing the PV system. The per-unit costs of the components are presented in Table IV. These costs were evaluated by taking the average unit cost of several components from aliexpress.com. Finally, the financial assumptions are listed in Table V.

Table I. Specifications and prices for the chosen miners

Miner	Cost	Hash rate	Power requirement
Antiminer E9	$ 30,000 (notebookcheck.net)	3.0 Th/s	2,600 W
AMD Radeon RX 6800	$ 2,143 (mightyape.co.nz)	64 Mh/s	150 W

Table II. Ethereum (ETH) market price and network parameters

Parameter	Value
Market price	$ 2,370 / ETH
Net hash	523 Th/s
Block time	13.57 s/block
Block reward	2.38 coins

Table III. Design paramerters for the solar photovoltaic (PV) system

Parameter	Value
Days of autonomy	2 days
System voltage	48 V
PV panel rated power	455 watts (aasolar.co.nz)
PV panel surface area	2.17 m^2
PV panel voltage	48 V
Battery capacity	440 Ah
Battery voltage	24 V
PV panel temperature coefficient	-0.37% /ºC
PV panel tolerance	±1%
PV panel temperature coefficient	-0.37% /ºC
PV panel dirt related losses	2%
Inverter losses	10%
Battery losses	5%
Witing losses	5%
Losses due to suboptimum tilt and orientation angles and shadowing	3%

Table IV. Solar photovoltaic (PV) system components' pricing

Component	Unit price
PV panel	0.7 $/watt
Inverter	0.31 $/watt
Charge controller	3.5 $/A
Battery	1.0 $/A

Table V. Financial assumptions

Parameter	Assumption
Down payment (upfront payment)	10%
Mortgage interest	30%
Mortgage tenure	2

Results

To power-up the miners using the off-grid PV system, designs were produced using the method explained by Chel, Tiwari and Chandra (2019). These designs are shown in Table VI. Due to the high electricity demand, the PV system size for the Antiminer E9 (ASIC) was found to be very large compared to the AMD Radeon RX 6800 (GPU) miner. The total system costs, along with their component-wise breakdown, are shown in

Table **VII**. In both cases, the cost of panels, the cost of the balance of the system (considering only the inverter, charge controller and batteries) and the mining hardware costs were found to be around 25%, 35% and 40% of the total cost, respectively. The daily yields from mining, in the form of blocks, cryptocurrency (ETH) and fiat currency (US$), are shown in

Table **VIII**. The Antiminer E9 (ASIC) miner was found to generate a revenue of $206 per day day, while the AMD Radeon RX 6800 (GPU) miner was found to generate $4 per day. Finally, the simple payback periods were evaluated and are shown in

Table **IX**. For the Antiminer E9 (ASIC) miner and the AMD Radeon RX 6800 (GPU) miner, these paybacks were found to be nearly 1 year and more than 2.5 years, respectively.

Table VI. Photovoltaic (PV) system design

Design parameters	Antiminer E9 (ASIC)	AMD Radeon RX 6800 (GPU)
Daily energy demand	90 kWhr/day	4 kWhr/day
PV array peak	22 kW	1 kW
PV panels	51	3
Inverter	25 kW	1.5 kW
Charge controller	460 A	25 A
Battery bank capacity	7325 Ah	370 Ah
Number of batteries	18	2

Table VII. Total system cost

Design parameters	Antiminer E9 (ASIC)	AMD Radeon RX 6800 (GPU)
PV panels	$ 15,530	$ 914
Inverter	$ 7,494	$ 375
Charge Controller	$ 1,602	$ 80
Batteries	$ 7,920	$ 880
Mining hardware	$ 30,000	$ 1,800
Total	$ 62,546	$ 4,048

Table VIII. Daily yield from miners

Daily earning	Antiminer E9 (ASIC)	AMD Radeon RX 6800 (GPU)
Blocks	0.03653099 blocks/day	0.00070748 blocks/day
Cryptocurrency (ETH)	0.08694375 ETH/day	0.00168381 ETH/day
Revenue	206 $/day	4 $/day

Table IX. Simple payback period

Design parameters	Antiminer E9 (ASIC)	AMD Radeon RX 6800 (GPU)
Without financing	0.83 years	2.78 years
With financing	1.06 years	3.53 years

Spreadsheet Calculator

To make future calculations easier, a spreadsheet calculator was developed and is made available for free download at: http://www.naveedurrehman.com/SolarCrypto/

Conclusion

Technical and financial analyses of the off-grid solar PV systems required to power an ASIC and a GPU miner are presented in this work. It was found that:

- sustainable, solar-powered cryptocurrency mining is feasible and,
- high-powered mining setups have a high upfront cost, but they also have faster payback periods.

Legal Disclaimer

There are risks associated with investing in solar-powered cryptocurrency mining. We recommend you seek advice from your financial adviser before taking any action.

References

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