Bitcoin Energy Use

An alternative approach estimate

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Introduction

Bitcoin mining uses a Proof-of-Work (POW) consensus mechanism. This is controversial because that requires a lot of electrical energy. We see claims the Bitcoin network "*uses as much electricity as a small country*", or "*requires as much electricity as Belgium, or Chile.*"

This study tests that notion by using the following economic test: ***presuming Bitcoin mining is marginally profitable, how much energy can be used compared to mining block rewards and fees?***

Bitcoin price, block rewards, and fees

This paper uses Canadian dollars, partly because that's my fiat currency, and because Canada publishes particularly good statistics about electricity generation and costs.

Bitcoin Price

For the purpose of discussion, what is the current price of Bitcoin in Canadian dollars?

In[534]:=
```
Now
```
Out[534]=

Sun 8 Oct 2023 14:17:13 GMT–4

In[535]:=
```
BTCPrice =
 CurrencyConvert[Quantity[1, "Bitcoin"], Quantity[1, "CanadianDollars"]]
```
Out[535]=

C$38 345.05

Bitcoin Block Rewards

Bitcoin miners are compensated with the block reward for blocks they successfully mine, plus all the transaction fees in that block. In the current epoch (2020 - 2024) the block reward is 6 1/4 BTC.

In[536]:=
```
blockreward = Quantity[6.25, "BTC"]
```
Out[536]=
```
฿6.25
```

ASSUMPTION: the average of transaction fees per block is 0.08 BTC.

In[537]:=
```
blockfees = Quantity[0.08, "BTC"]
```
Out[537]=
```
฿0.08
```

Therefore, the total Bitcoin paid to miners for an average block.

In[538]:=
```
blockRewardPlusFees = (blockreward + blockfees)
```
Out[538]=
```
฿6.33
```

Block Rate

Bitcoin blocks land every 10-minutes, give or take. That's 6-blocks per hour.

In[557]:=
```
blockRewardPlusFeesPerHour = blockRewardPlusFees * Quantity[6, "per hour"]
```
Out[557]=
```
฿37.98 per hour
```

Hourly Economics

Global Revenue Per Hour

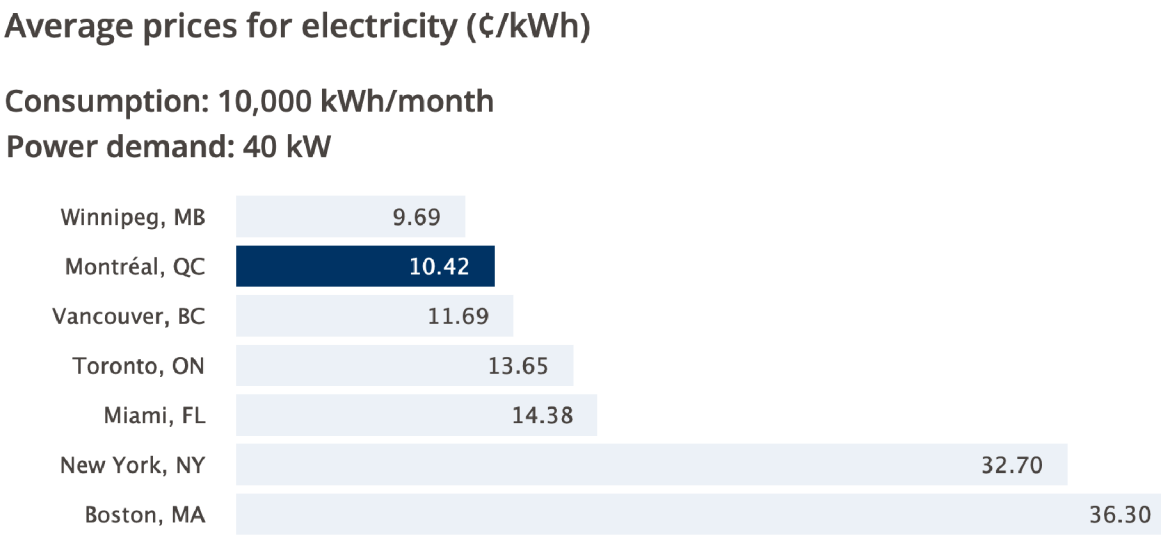
The value, in Canadian Dollars, of all Bitcoin mined globally, per hour.

In[540]:=
```
blockCADperHour = CurrencyConvert[blockRewardPlusFeesPerHour, C$1.00 ✓] /
   Quantity[1, "Hours"] // IntegerPart
```
Out[540]=
```
C$1 456 345 per hour
```

Electricity Cost, Per Hour

See: https://www.hydroquebec.com/business/customer-space/rates/comparison-electricity-prices.html

The figures below show a comparison of electricity average prices for four consumption levels in major Nort American cities.



Let's presume that nobody in their right mind would want to mine Bitcoin in New York or Boston.

In[541]:=
```
electricityInputCost =
  Quantity[Around[{0.0969, 0.1042, 0.1169, 0.1365, 0.1438}], "Canadian Dollars"] / Quantity[1, "KWH"];
(*electricityInputCost = Quantity[0.1042,"Canadian Dollars"] / Quantity[1,"KWH"] *)
```

Business Cost Assumption

Let's presume 85% of revenue is available to pay electricity cost.

In[542]:=
```
availableForElectricity = 0.85
```

Out[542]=
```
0.85
```

Energy Economically Sustainable

In[543]:=
```
btcPower = blockCADperHour * availableForElectricity / electricityInputCost // UnitSimplify
```

Out[543]=
```
(1.03 ± 0.17) × 10^7 kW
```

Cognitively we can say, Bitcoin's power consumption is in the order of 10 GW.

In[544]:=
```
AnnualEnergyConsumption = UnitConvert[
   btcPower * Quantity[365 * 24, "Hours"], "Hours Terawatts"] // IntegerPart
```
Out[544]=
```
90 h TW
```

Comparisons

Let's compare the energy that can be economically used by the Bitcoin network with various things.

Robert-Bourassa generating station — a.k.a. "LG-2"

See https://en.wikipedia.org/wiki/Robert-Bourassa_generating_station

In[545]:=
```
RobertBourassaDam = 5616 MW // UnitSimplify // N
```
Out[545]=
```
5.616 GW
```

What is Bitcoin's global energy use in terms of LG-2?

In[546]:=
```
btcPower / RobertBourassaDam
```
Out[546]=
```
(1.84 ± 0.31)
```

Province of Québec

In 2019 the Province of Québec produced 212.9 TWh of electricity.

What is Bitcoin's global energy use as a proportion of Québec's electricity production in 2019?

In[547]:=
```
Québec2019 = 212.9 h TW
```
Out[547]=
```
212.9 h TW
```

In[548]:=
```
Québec2019day = Québec2019 / 365 days // UnitSimplify
```
Out[548]=
```
24.3037 GW
```

In[549]:=
```
btcPower / Québec2019day // PercentForm
```
Out[549]//PercentForm=
```
(0.43 ± 0.07)
```

Alternate calculation:

In[550]:=
```
AnnualEnergyConsumption / Québec2019 // PercentForm
```
Out[550]//PercentForm=
```
42.27%
```

Province of Ontario

See https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-ontario.html

In 2019, annual electricity consumption per capita in Ontario was 9.6 megawatt-hours (MWh).

In[551]:=
```
Ontario2019PerCapita = Quantity[9.6, "Hours" * "Megawatts" / "People"] / Quantity[24 * 354, "Hours"];
Ontario2019PerCapita = UnitConvert[Ontario2019PerCapita, kW / people]
```
Out[552]=
```
1.12994 kW/person
```

In[553]:=
```
(btcPower / Ontario2019PerCapita) // IntegerPart
```
Out[553]=
```
9 155 403 people
```

United States

See https://www.worlddata.info/america/usa/energy-consumption.php

In[554]:=
```
USAPerCapita = Quantity[11.757, "Hours" * "Megawatts" / "People"] / Quantity[24 * 354, "Hours"];
USAPerCapita = UnitConvert[USAPerCapita, kW / people]
```
Out[555]=
```
1.38383 kW/person
```

In[556]:=
```
(btcPower / USAPerCapita) // IntegerPart
```
Out[556]=
```
7 475 705 people
```