

Bitcoin, Energy & The Environment

Conflations, Comparisons & Conclusions

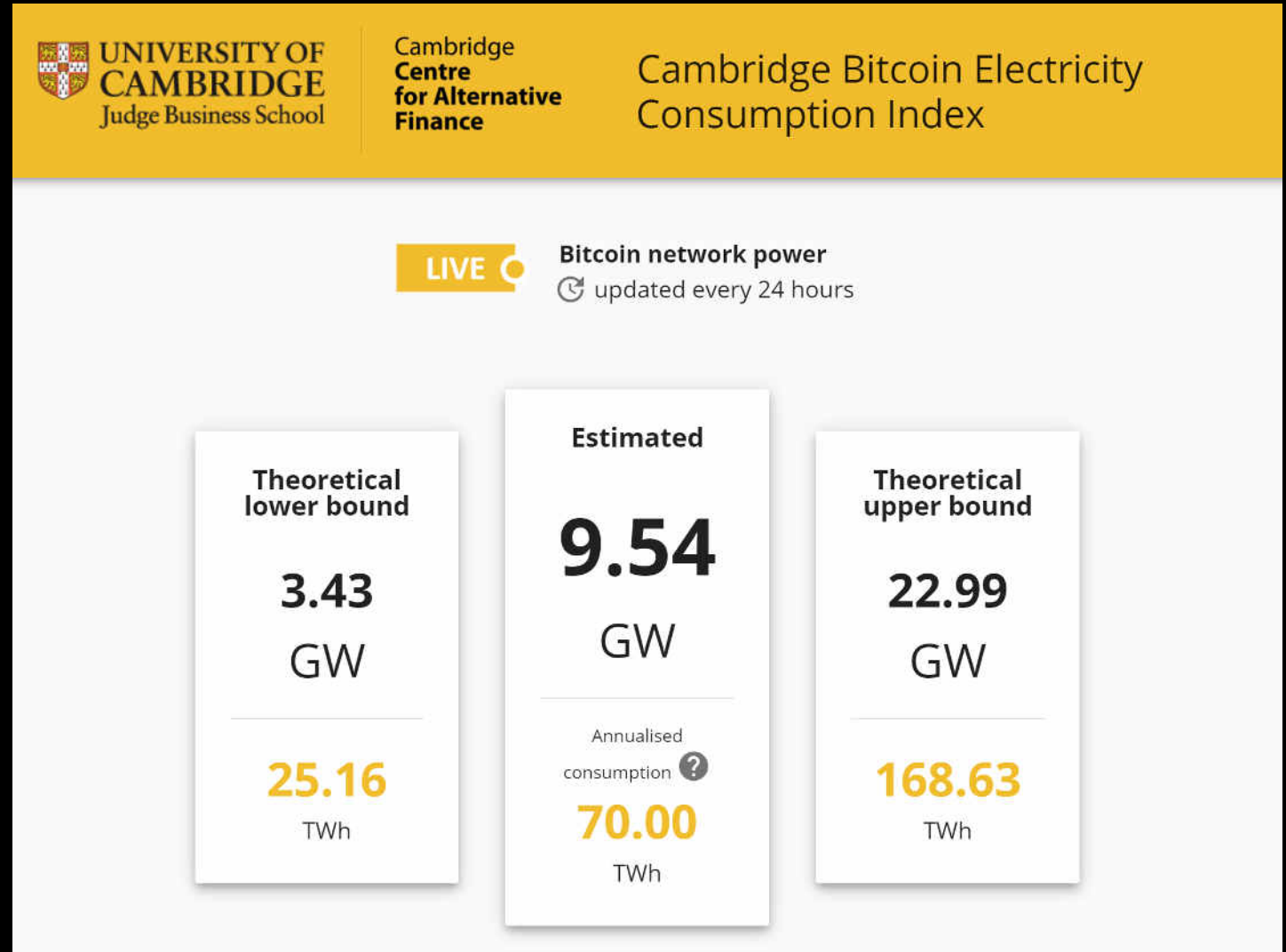
Presented by Hass McCook

Introduction

- Critics & “The Four Major Conflations”
- Comparison of Bitcoin to Legacy Systems
- Projecting Bitcoin’s Future Energy Use

State of Bitcoin – 15 July 2021

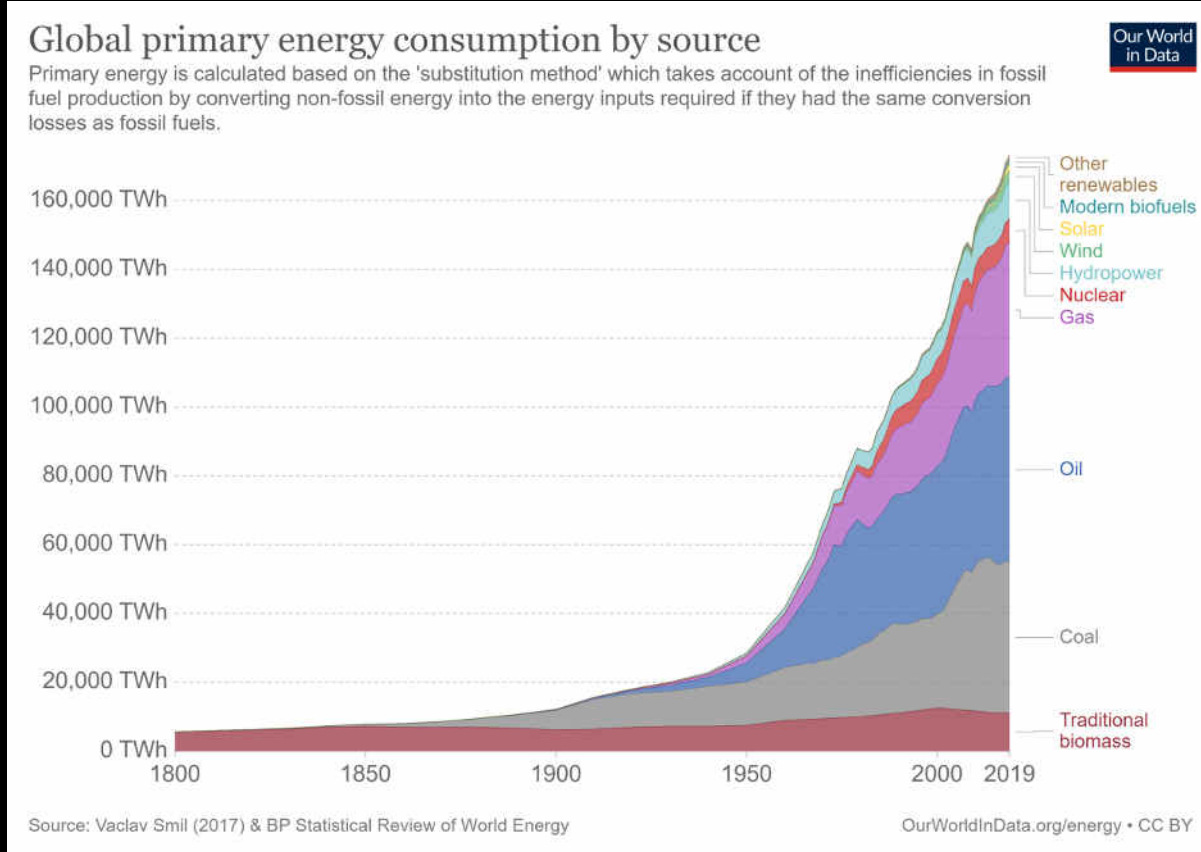
- Energy Use:
~70 TWh
- Carbon Intensity:
~0.42 MT/TWh
- GHG Emissions:
~30 MT CO₂e



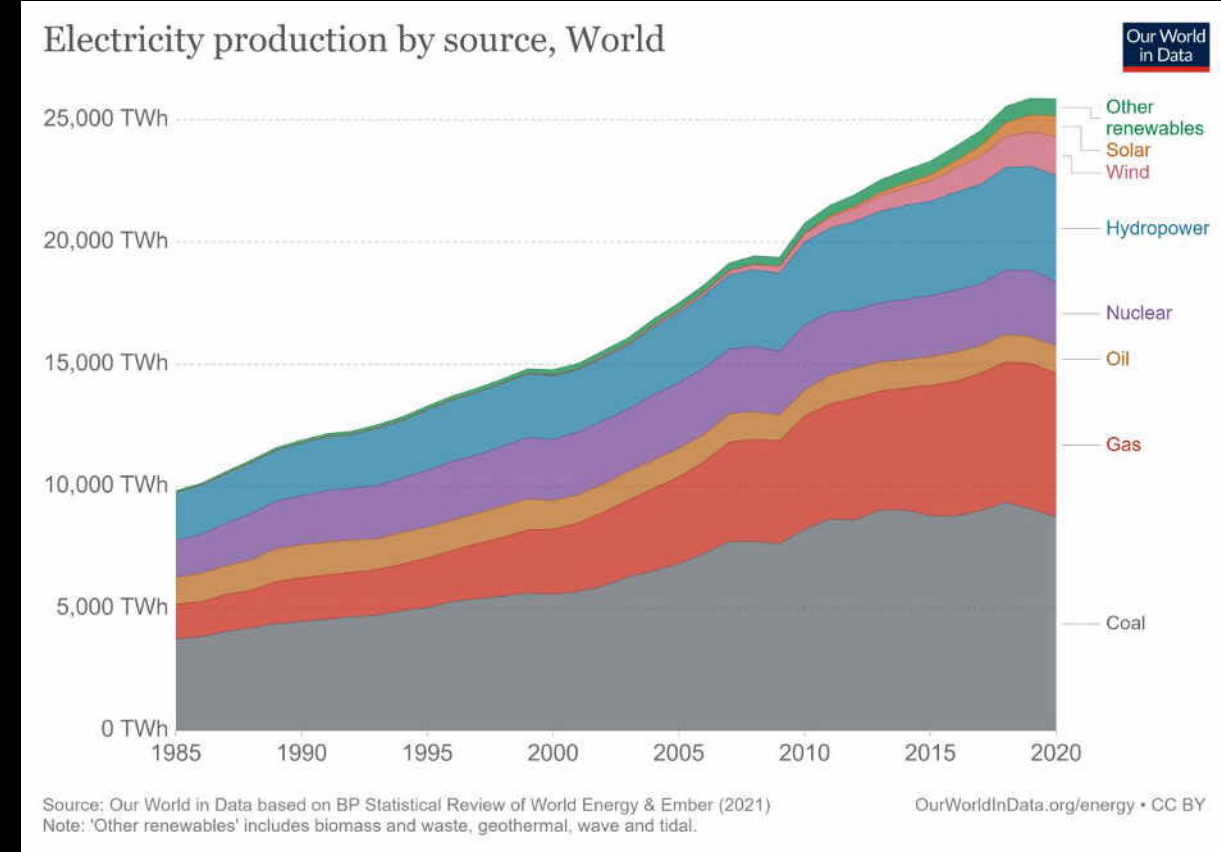
Critics & “The Four Major Conflations”

Conflation 1 – Energy $\neq$ Electricity

Energy ≠ Electricity



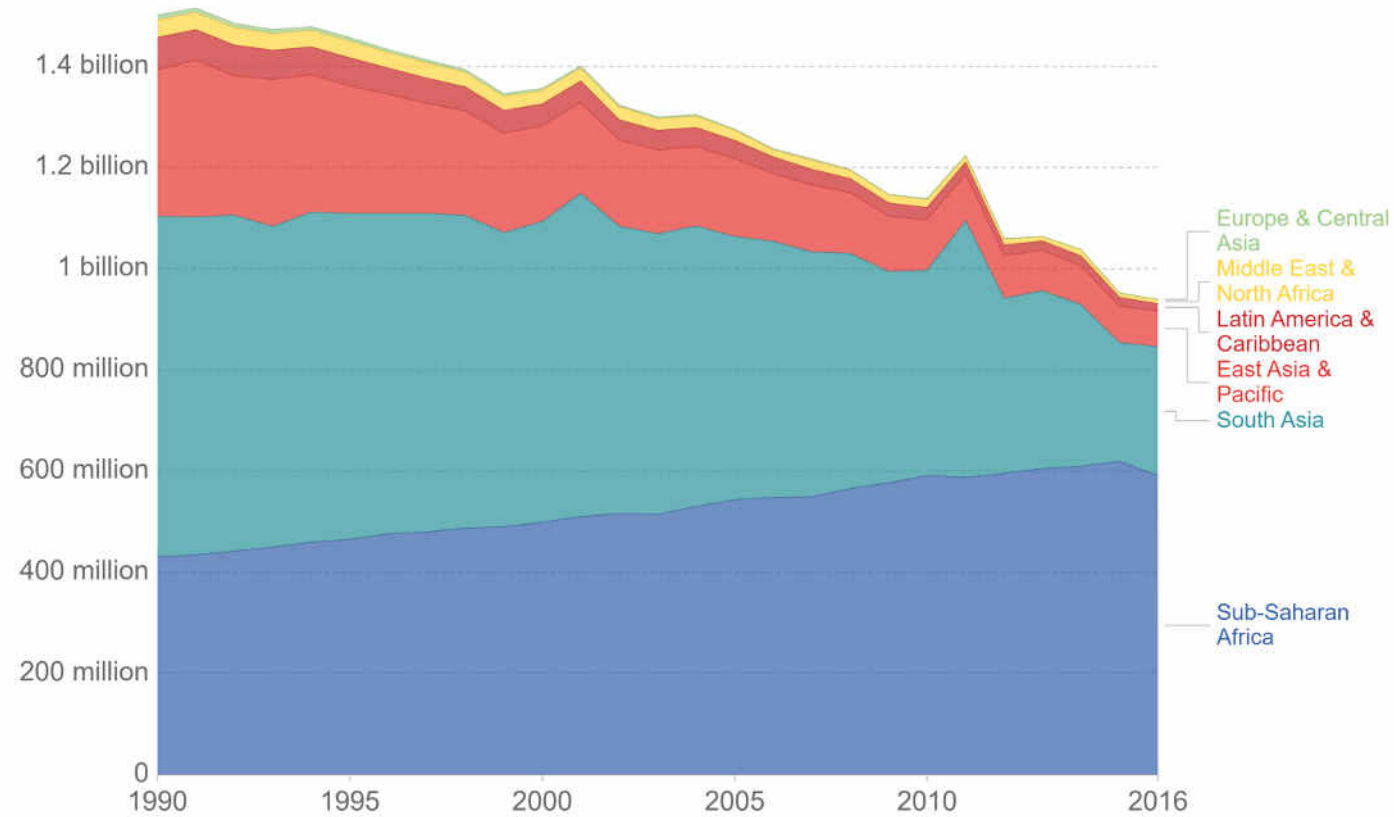
173,340 TWh of Primary Energy Consumed in **2019**. Note how Bitcoin updates its data every 24 hours, whereas we only get energy data every 24 months!



25,866 TWh of Electricity Generated in **2020**. Note how Electricity makes up under 15% of all energy produced

Number of people without access to electricity

Our World
in Data



Source: OWID based on World Bank, Sustainable Energy for All (SE4ALL), & UNWPP

OurWorldInData.org/energy-access • CC BY

Like hundreds of millions of people around the world today, Bitcoin doesn't need electricity, it only needs energy

As can be seen, over 30% of all energy produced is wasted

Source: International Energy Agency via en.wikipedia.org/wiki/World_energy_consumption

Bitcoin uses a lot of waste and is “non-rival” ...

Key figures (TWh)

Year	Primary energy supply (TPES) ¹	Final energy consumption ¹	Electricity generation	Ref
1973	71,013 (Mtoe 6,106)	54,335 (Mtoe 4,672)	6,129	[3]
1990	102,569	—	11,821	—
2000	117,687	—	15,395	—
2010	147,899 (Mtoe 12,717)	100,914 (Mtoe 8,677)	21,431	[8]
2011	152,504 (Mtoe 13,113)	103,716 (Mtoe 8,918)	22,126	[9]
2012	155,505 (Mtoe 13,371)	104,426 (Mtoe 8,979)	22,668	[10]
2013	157,482 (Mtoe 13,541)	108,171 (Mtoe 9,301)	23,322	[11]
2014	155,481 (Mtoe 13,369)	109,613 (Mtoe 9,425)	23,816	[12]
2015	158,715 (Mtoe 13,647)	109,136 (Mtoe 9,384)		[13][14]
2017	162,494 (Mtoe 13,972)	113,009 (Mtoe 9,717)	25,606	[15]

¹ converted from Mtoe into TWh (1 Mtoe = 11.63 TWh)
and from Quad BTU into TWh (1 Quad BTU = 293.07 TWh)

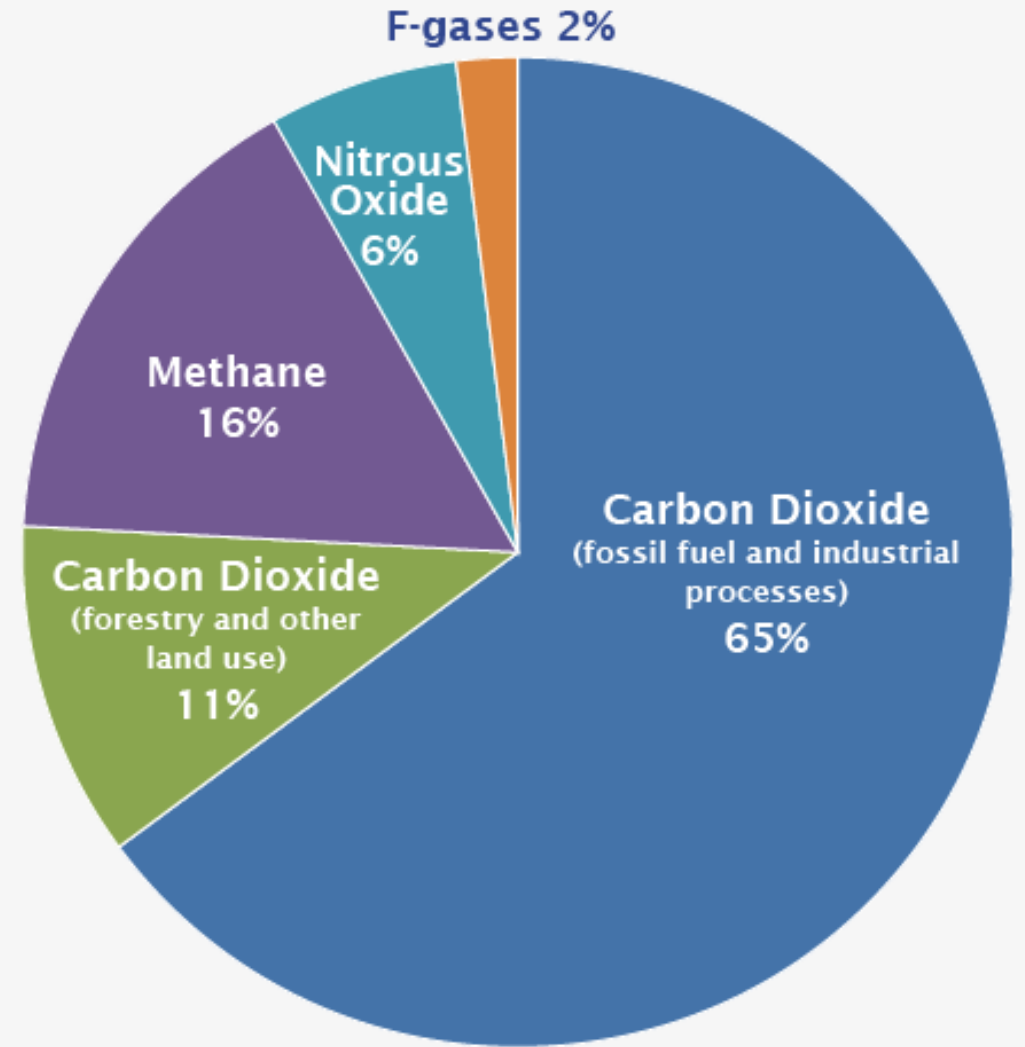
Conflation 2 – $\text{CO}_2 \neq$ Greenhouse Gases

CO₂ is not the only greenhouse gas that contributes to climate change...

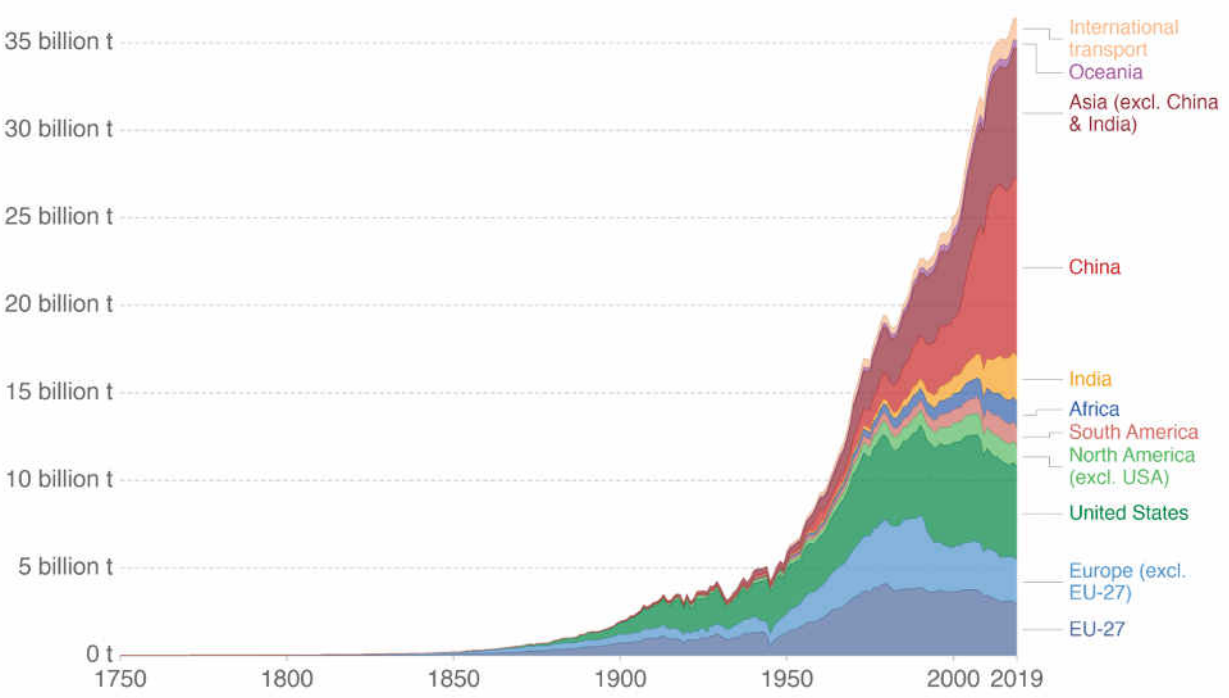
Source:

<https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

Global Greenhouse Gas Emissions by Gas



Annual total CO2 emissions, by world region

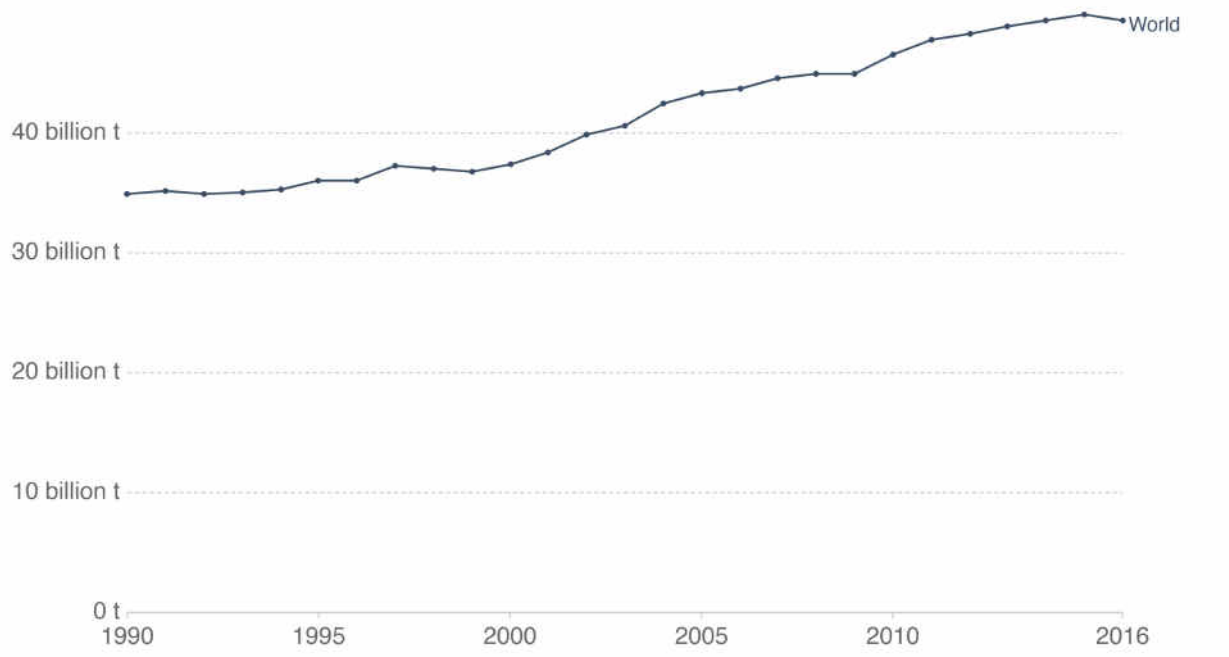


Source: Our World in Data based on the Global Carbon Project
Note: This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

In 2016, The World produced 35,200 Mt CO₂
In 2019, The World produced 36,420 Mt CO₂

Total greenhouse gas emissions

Greenhouse gas emissions – from carbon dioxide, methane, nitrous oxide, and F-gases – are summed up and measured in tonnes of carbon-dioxide equivalents (CO₂e), where “equivalent” means “having the same warming effect as CO₂ over a period of 100 years”. Emissions from land use change – which can be positive or negative – are taken into account.



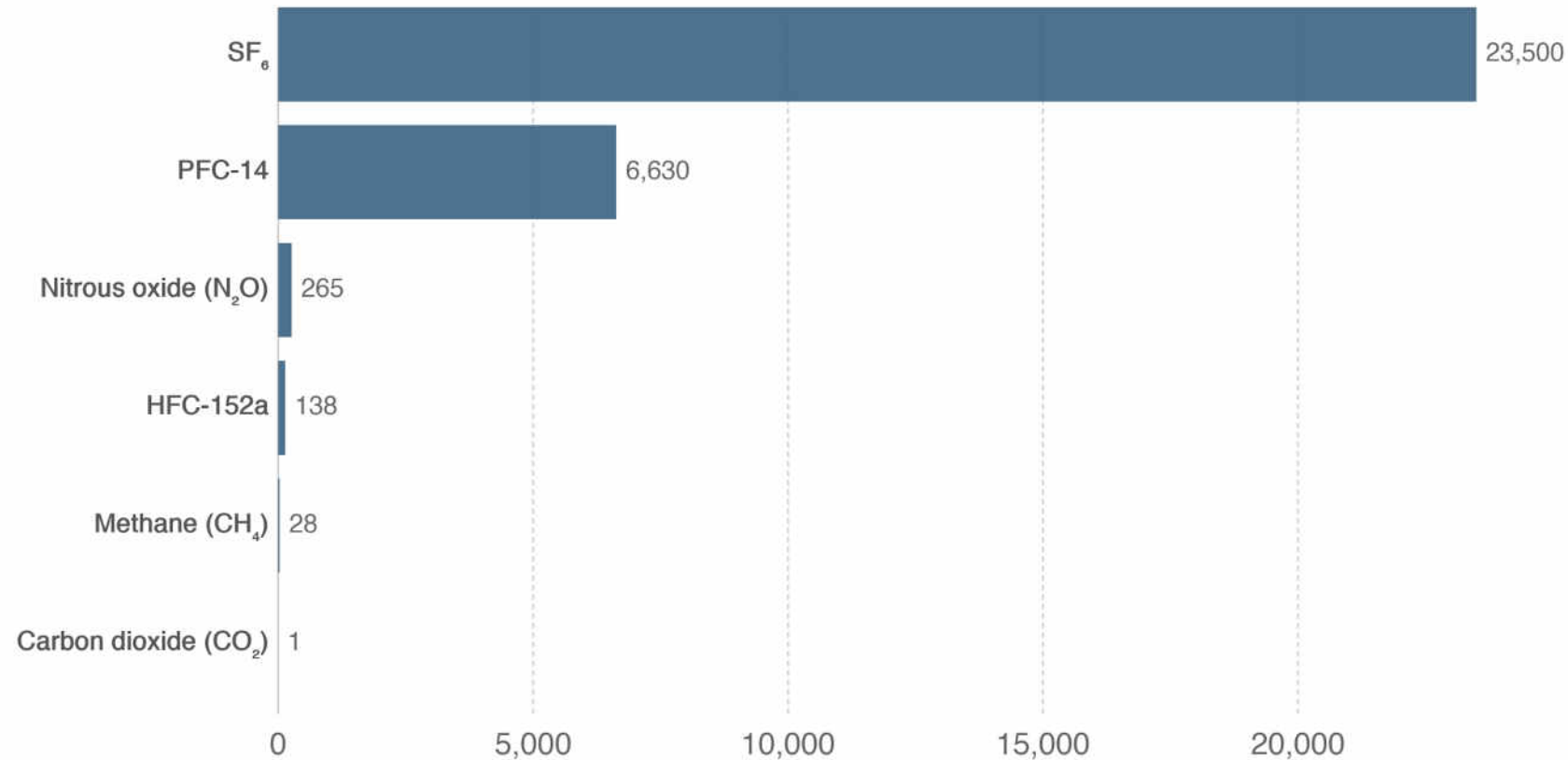
Source: CAIT Climate Data Explorer via. Climate Watch
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

In 2016, The World produced 49,360 Mt CO₂e
Yes, 2016 numbers are indeed the latest...

Global warming potential of greenhouse gases over 100-year timescale (GWP₁₀₀)

Our World
in Data

GWP measures the relative warming impact of one unit mass of a greenhouse gas relative to carbon dioxide. A GWP₁₀₀ value of 28 therefore means one tonne of methane has 28 times the warming impact of one tonne of carbon dioxide over a 100-year timescale. These figures do not include climate change feedback effects.



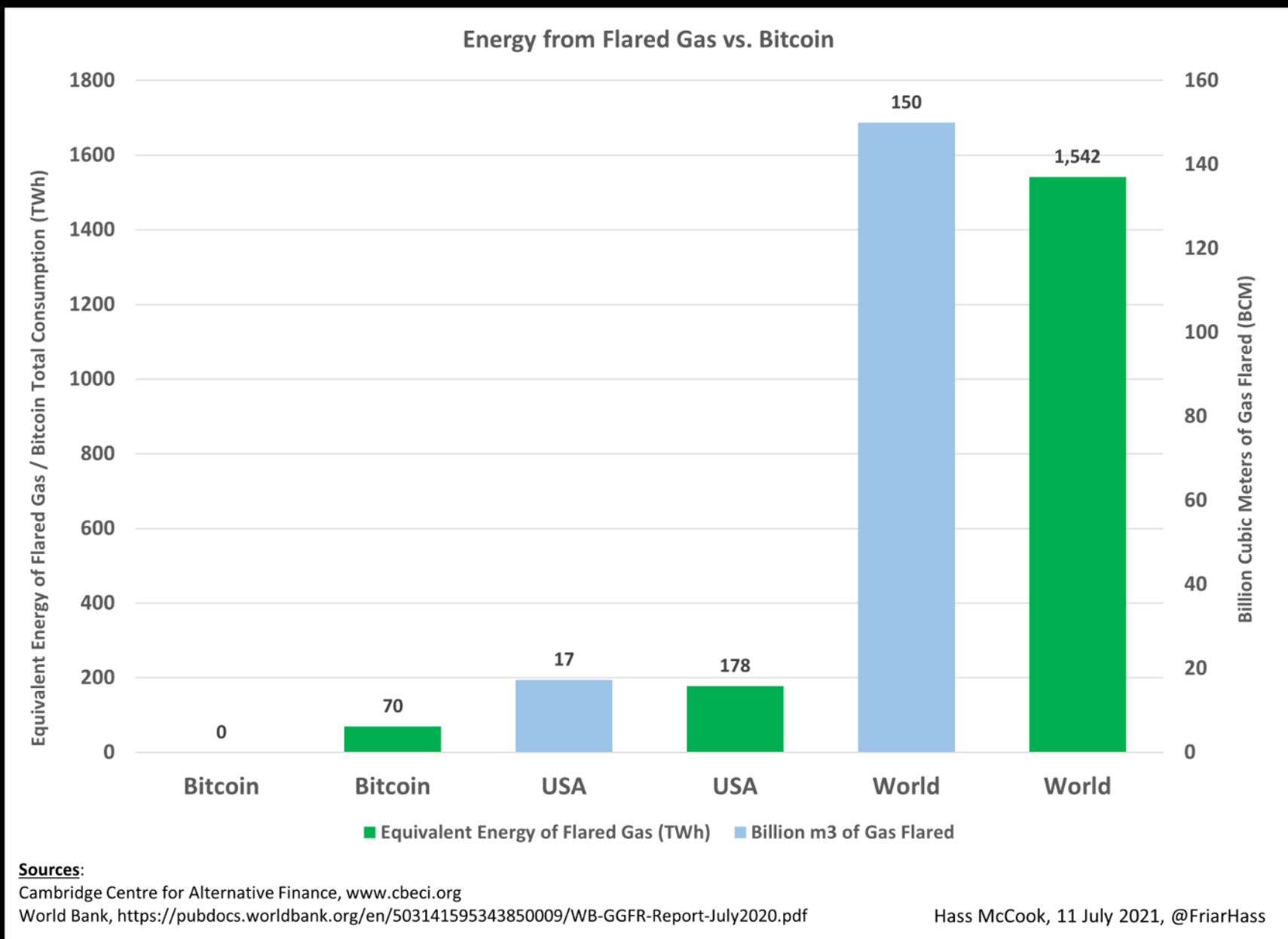
Source: IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

Source: <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions>

Species	Chemical formula	Lifetime (years)	Global Warming Potential (Time Horizon)		
			20 years	100 years	500 years
Carbon dioxide	CO ₂	variable	1	1	1
Methane *	CH ₄	12±3	56	21	6.5
Nitrous oxide	N ₂ O	120	280	310	170
HFC-23	CHF ₃	264	9100	11700	9800
HFC-32	CH ₂ F ₂	5.6	2100	650	200
HFC-41	CH ₃ F	3.7	490	150	45
HFC-43-10mee	C ₅ H ₂ F ₁₀	17.1	3000	1300	400
HFC-125	C ₂ HF ₅	32.6	4600	2800	920
HFC-134	C ₂ H ₂ F ₄	10.6	2900	1000	310
HFC-134a	CH ₂ FCF ₃	14.6	3400	1300	420
HFC-152a	C ₂ H ₄ F ₂	1.5	460	140	42

HFC-143	C ₂ H ₃ F ₃	3.8	1000	300	94
HFC-143a	C ₂ H ₃ F ₃	48.3	5000	3800	1400
HFC-227ea	C ₃ HF ₇	36.5	4300	2900	950
HFC-236fa	C ₃ H ₂ F ₆	209	5100	6300	4700
HFC-245ca	C ₃ H ₃ F ₅	6.6	1800	560	170
Sulphur hexafluoride	SF ₆	3200	16300	23900	34900
Perfluoromethane	CF ₄	50000	4400	6500	10000
Perfluoroethane	C ₂ F ₆	10000	6200	9200	14000
Perfluoropropane	C ₃ F ₈	2600	4800	7000	10100
Perfluorobutane	C ₄ F ₁₀	2600	4800	7000	10100
Perfluorocyclobutane	c-C ₄ F ₈	3200	6000	8700	12700
Perfluoropentane	C ₅ F ₁₂	4100	5100	7500	11000
Perfluorohexane	C ₆ F ₁₄	3200	5000	7400	10700

Source: <https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials>



There is currently enough flared methane in the world to power Bitcoin over TWENTY times over

If all O&G companies were to use all waste methane to power Bitcoin starting tomorrow, we would instantly lower total global CO₂e emissions by ~3%, and they'll all make a great profit too. Maybe even fund/speed up their sustainable transition?

Bitcoin is the epitome of ESG.

Conflation 3 – Energy $\neq$ Emissions

Table A.II.4 | Aggregated results of literature review of LCAs of GHG emissions from electricity generation technologies as displayed in Figure 9.8 (g CO₂eq/kWh).

Values	Bio-power	Solar		Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Nuclear Energy	Natural Gas	Oil	Coal
		PV	CSP								
Minimum	-633	5	7	6	0	2	2	1	290	510	675
25th percentile	360	29	14	20	3	6	8	8	422	722	877
50th percentile	18	46	22	45	4	8	12	16	469	840	1001
75th percentile	37	80	32	57	7	9	20	45	548	907	1130
Maximum	75	217	89	79	43	23	81	220	930	1170	1689
CCS min	-1368								65		98
CCS max	-594								245		396

Note: CCS = Carbon capture and storage, PV = Photovoltaic, CSP = Concentrating solar power.

Source: https://archive.ipcc.ch/pdf/special-reports/srren/SRREN_FD_SPM_final.pdf

Global Energy

<https://ourworldindata.org/energy-production-consumption>

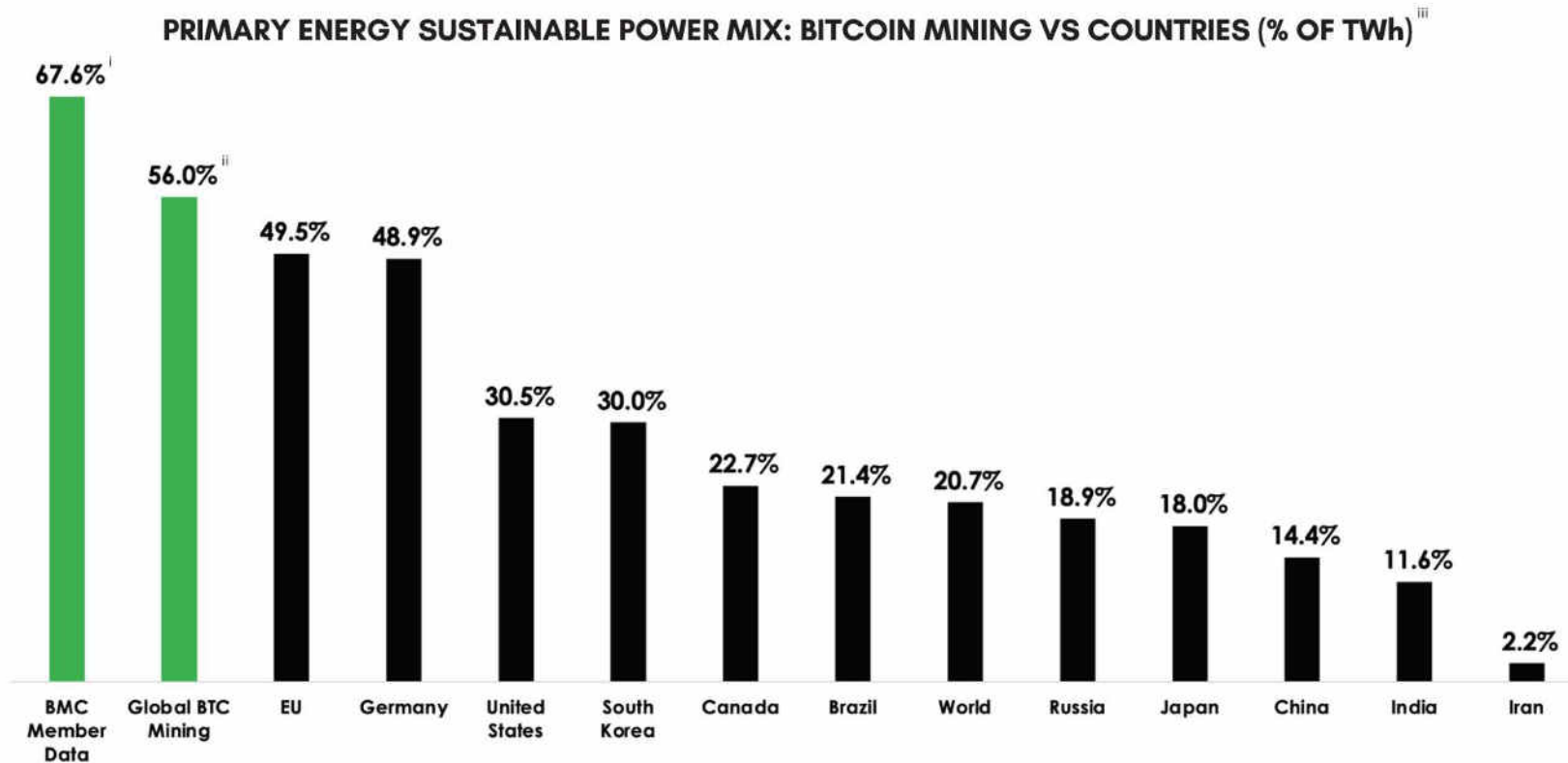
Primary Energy Source (PES)	% PES (2013)	% PES (2020)	Bitcoin Mix (29% Renewable)	Bitcoin Mix (39% Renewable)	Carbon Intensity (T CO2/MWh)
Biofuels & Waste	10%	7.07%	0%	0%	18
Coal	27.30%	25.30%	35.00%	30.00%	1001
Oil	32.40%	30.93%	6.00%	4.00%	840
Natural Gas	21.40%	22.67%	20.00%	17.00%	469
Nuclear	5.70%	3.99%	10.00%	10.00%	16
Hydroelectric	2.30%	6.03%	20.00%	28.00%	4
Other (Wind, Solar, Geothermal)	0.90%	4.01%	9.00%	11.00%	18
Total % Renewable	13.20%	17.11%	29.00%	39.00%	
Grid Carbon Intensity (T CO2/MWh)	648.77	622.27	498.59	418.51	

Global Grid

<https://ourworldindata.org/grapher/electricity-prod-source-stacked>

Electricity Source	% Grid (2013)	% Grid (2020)	Bitcoin Mix (29% Renewable)	Bitcoin Mix (39% Renewable)	Carbon Intensity (T CO2/MWh)
Coal	40.1%	33.8%	35.0%	30.0%	1001
Oil	5.4%	4.4%	6.0%	4.0%	840
Gas	21.6%	22.8%	20.0%	17.0%	469
Nuclear	10.7%	10.1%	10.0%	10.0%	16
Hydroelectric	16.6%	16.8%	20.0%	28.0%	4
Solar	0.6%	3.3%	2.0%	3.0%	40
Wind	2.9%	6.1%	7.0%	8.0%	12
Other renewables	2.2%	2.7%	0.0%	0.0%	45
Total % Renewable	22.30%	28.97%	29.00%	39.00%	
Grid Carbon Intensity (T CO2/MWh)	551.16	487.12	498.59	418.51	

GLOBAL BITCOIN MINING HAS THE HIGHEST SUSTAINABLE ENERGY MIX²



Bitcoin
Mining
Council

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SOURCES: ⁱ VALUE REPRESENTS DATA COMPILED FROM BMC ADVISORY COUNCIL MINERS, ANNUALIZED PRIMARY ENERGY USE.
ⁱⁱ ESTIMATED GLOBAL BITCOIN NETWORK ANNUALIZED POWER BASED ON BMC ANALYSIS, ASSUMPTIONS AND EXTRAPOLATION.
ⁱⁱⁱ COUNTRY DATA COMPILED FROM BP'S STATISTICAL REVIEW OF WORLD ENERGY (2021). [HTTPS://WWW.BP.COM/EN/GLOBAL/CORPORATE/ENERGY-ECONOMICS/STATISTICAL-REVIEW-OF-WORLD-ENERGY/PRIMARY-ENERGY](https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/primary-energy).

Conflation 4 – Transactions $\neq$ Settlements

Settlements and Transactions

- **All settlements are transactions, but not all transactions are settlements**
- To that end, Bitcoin currently has a throughput of ~3.5 “settlements” per second, increasing with the Taproot upgrade in late-November 2021
- It is unfortunate that the term “transaction” is a fundamental part of Bitcoin nomenclature, as the nonsensical “energy per transaction” metric is frequently used against Bitcoin

Settlements and Transactions

- With Layer 2 solutions like The Lightning Network (LN) and Liquid, you can theoretically undertake infinite transactions before an on-chain settlement is required
- Therefore, it can be said that while Bitcoin can make ~3.5 on-chain settlements per second, it can make infinite transactions per second.
- Therefore, total energy use per transaction = Total Energy Used / ∞ = Zero.
- El Salvador's Bitcoin adoption is largely Lightning-Network based
- NOTE: A LN transaction is also a settlement!

Settlements and Transactions

- Regardless, transacting on Bitcoin is actually a marginal use of the Bitcoin protocol. Transactions consume **ZERO** energy.
- Whether there is one transaction per millennium, or one octillion transactions per nanosecond, Bitcoin will use the identical amount of energy, that is, the hash rate being provided to secure and guarantee the network, driven by the market price of Bitcoin

Comparisons...

The Banking & Insurance Sector

Scope Definition

- All Finance & Insurance Activities
- All Support Services
- All Offices, branches & ATMs
- All employee transport
- All industry procurement

Section K Financial and insurance activities

Division	Group	Class	Description
Division 64			Financial service activities, except insurance and pension funding
	641		Monetary intermediation
		6411	Central banking
		6419	Other monetary intermediation
	642	6420	Activities of holding companies
	643	6430	Trusts, funds and similar financial entities
	649		Other financial service activities, except insurance and pension funding activities
		6491	Financial leasing
		6492	Other credit granting
		6499	Other financial service activities, except insurance and pension funding activities, n.e.c.
Division 65			Insurance, reinsurance and pension funding, except compulsory social security
	651		Insurance
		6511	Life insurance
		6512	Non-life insurance
	652	6520	Reinsurance
	653	6530	Pension funding
Division 66			Activities auxiliary to financial service and insurance activities
	661		Activities auxiliary to financial service activities, except insurance and pension funding
		6611	Administration of financial markets
		6612	Security and commodity contracts brokerage
		6619	Other activities auxiliary to financial service activities
	662		Activities auxiliary to insurance and pension funding
		6621	Risk and damage evaluation
		6622	Activities of insurance agents and brokers
		6629	Other activities auxiliary to insurance and pension funding
	663	6630	Fund management activities

Highlights

- Uses “World Average Grid” => Carbon Intensity = 487 T CO₂e/MWh
- Over 600k bank branches, 2.3m ATMs – 1m facilities in total covering over 60 million square meters
- Employs 1.8% of The World’s Workforce (61m people), many who travel by air extensively. Their office waste and procurement footprint is immense
- Industry revenue of \$10.55tr/yr (\$5.52trn Finance, \$5.03trn Insurance)
- **1368 MT CO₂e emitted per year**

Gold Mining & Jewellery

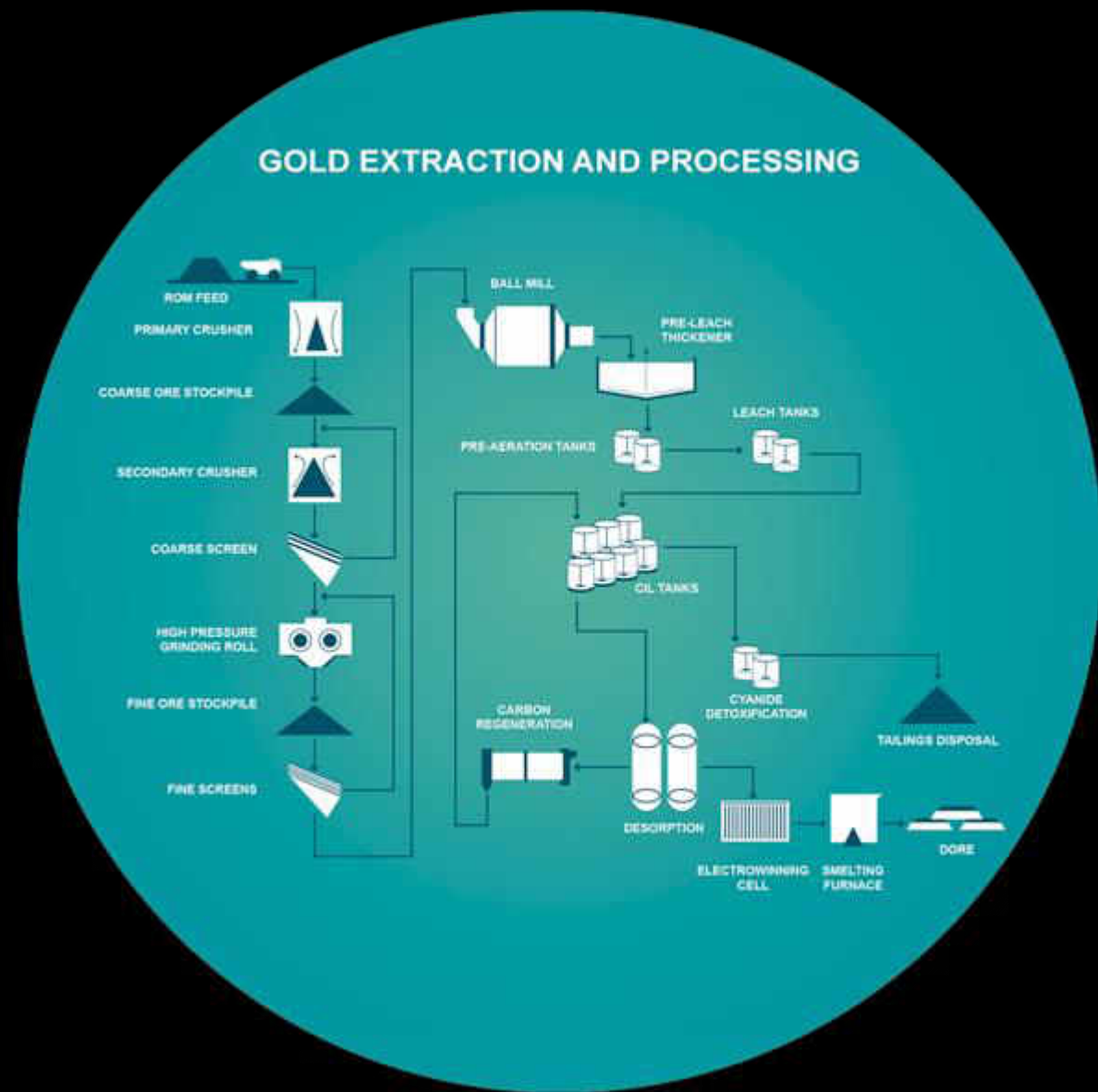
Scope Definition

Includes:

- All mining & conversion to Doré bar
- Extra refining for Jewelry

Excludes:

- Gold + Jewelry retail industry
- Extra refining for industrial use



Highlights

- Over 5 Billion Tonnes Waste Rock Produced
- Over 1 Trillion Litres of Waste Water Produced
- Cyanide Used
- Untold human consequences (especially in Africa)
- 3500 tonnes mined, 1300 tonnes recycled, 2400 tonnes dedicated to Jewelry
- Emits 144 MT CO₂e per year
- Uses > 300 TWh per year

Visualising the Yearly Environmental Destruction...

**>1000 GIGALITERS OF
WATER**



**OR, 400,000 OLYMPIC
SWIMMING POOLS**

**>500,000 TONNES OF
CYANIDE**



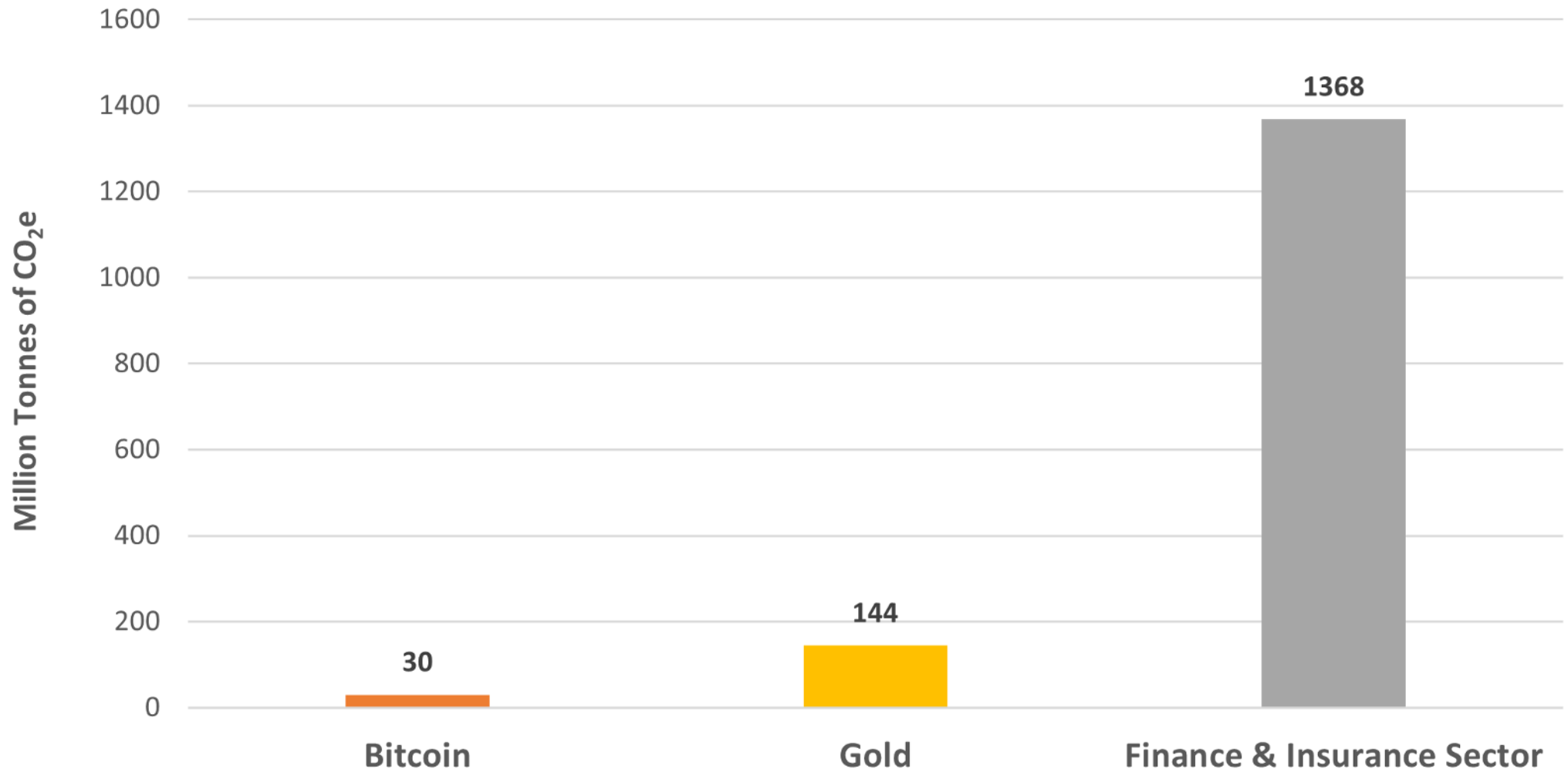
**OR, 1 TRILLION
SUICIDE PILLS**

**>5 BILLION TONNES OF
WASTE ROCK**



**OR, 1000 GREAT
PYRAMIDS OF GIZA**

Annual GHG Emissions (MT CO₂e)



Hass McCook (@FriarHass) July 2021

Projecting Future Energy Consumption & Emissions

Determining Factors

- Price Assumptions
 - It is assumed that Bitcoin will continue to grow between 20-50% YoY
- The Chip Crisis of 2021-2023
 - It is assumed that the Chip Crisis will not be resolved until the end of 2023
- State of Technology
 - It is assumed that technology will continue to improve between 20-40% YoY until 2030 at least
- Energy Mix Assumptions
 - The IEA provides world targets for 2030, which call for a reduction in carbon intensity by 50% from 2019 figures to 240g CO₂e/kWh

Projections

- Because of unholy levels of international competition, Bitcoin miners will either have to be cost or innovation leaders to stay solvent
- That is, they will have the most cost efficient hardware and power available. Moving forward, this is most likely to be renewable or non-rival waste power anyway. Globally, Bitcoin already uses >50% sustainable energy to mine, and will continue to improve with China out of the picture

Projections

- By 2026, Bitcoin's carbon intensity will decrease from 400g CO₂e/kWh to 100g CO₂e/kWh, with total energy use only increasing by about 30%, mainly due to chip supply constraints
- By 2031, Bitcoin's carbon intensity will decrease from 100g CO₂e/kWh in 2026 to **ZERO** grams CO₂e/kWh, with total energy use over the 5 year period likely doubling to tripling following the resolution of the international chip crisis
- Full analysis here: bitcoinmagazine.com/business/projecting-bitcoins-future-energy-use

Conclusions

- Bitcoin's energy use is a rounding error when viewed in the appropriate context (*0.04% of World Energy Production*)
- Increased energy use is good for humanity. Emissions are bad
- Bitcoin is already the most sustainable industry in the world
- Bitcoin is good for the environment & can literally clean it through methane offsetting
- Bitcoin is good for society and governance – guaranteed property rights for all humans for the first time in history
- If you care about the environment, get yourself some Bitcoin!