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THE DEEP TIME OF BITCOIN: EXCAVATING THE "WORK" IN PROOF-OF-WORK CRYPTOCURRENCY SYSTEMS

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The generation[1] of Bitcoins requires a radically, intimately material relationship between information and energy–a relationship that is often dirty, messy, heavy, and above all things, extremely hot. While all data infrastructures depend on vast amounts of thermal maintenance (Moro, 2021), as a single-purpose data practice, proof-of-work (PoW) blockchain systems, and Bitcoin specifically, bring these thermocultural relationships (Starosielski, 2016) into sharp relief, and at a profoundly large scale. Additionally, contrary to the infrastructural disappearing acts of general-purpose cloud computing, the tactility of Bitcoin generation, and proximity to its heat and metal, remain pivotal indicators of its value and functionality. As such, PoW blockchain systems represent a prime case study for excavating and interrogating longstanding assumptions about the relationship between data and energy, and what these assumptions both conceal and reveal about the infrastructural futures of high-density computing.

Estimates place Bitcoin's current energy consumption at 141.83 terawatt-hours/year, an amount comparable to Ukraine. While Bitcoin's energy problem has become increasingly visible in both academic and popular discourse (Lally et al. 2019), the computational mechanisms through which the Bitcoin network generates coins, proof-of-work, has gone under-examined. This paper interrogates the "work" in PoW systems. What is this work, and how did it come to be accepted as "work" in the first place? I trace this history through a media archaeology of computational heat, in an attempt to better situate the intimate relationship between information and energy in PoW systems. Well before it is money, Bitcoin is a computing practice with a long infrastructural history. Rather than focusing on the monetary histories of proof-of-work blockchains, as many have done, I draw attention to the material conditions that have afforded their industrial scaling. Considering this scaling, the deeper story of Bitcoin does not so much concern the familiar rag-tag gangs of crypto-pirates duct-taping GPUs together, but rather a richer *longue durée* of heat management in complex technical systems. While, at first, the Bitcoin network only required minute amounts of desktop CPU power, today bitcoins are generated in large data centers, with proprietary machines called Application Specific Integrated Circuts (ASICs), which contain specialized microchips designed for a single purpose–the perpetual running of the SHA-256 algorithm. Running this algorithm is an extremely energy intensive process, and as such, the primary material "work" involves the interscalar management of heat and energy moving into,

[1] I use the term "generation" because, "mining", as a metaphor for the practice, did not become common vernacular until the beginnings of widespread use of external GPUs in late 2010.

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within, and out of these chips. Following Brunton (2019), I argue that the “work” in PoW systems is principally heat-work, in which excess heat must consistently be managed, mitigated, and either expelled as waste, or rerouted to other systems. All data infrastructures operate like this, but the very theory of proof-of-work explicitly defines data as an irreversibly directional outcome, its value and security dependent on proof of exhaust–or heat. The logic of this work, and the system of machinic trust it attempts to enable, can be excavated from the history of thermodynamic science.

PoW blockchains radically re-center digital information’s often opaque theoretical and material entanglements with the history of thermodynamics–a history largely de-linked from broader information science. The fundamental logic behind proof-of-work (or proof of heat/exhaust) traces to the rise of thermodynamic science in the mid-nineteenth century, and the reframing of doing work as something exhaustible, directional, and irreversible (Prigogine & Stengers 1984). Thermodynamics redefined what work meant, and as Daggett (2019) shows, this redefinition of work (as an exhaustible, irrecoverable asset) became a necessary tool for the expansion of empire and capital. Ideas of work and its relationship to entropy migrated and mutated across a multitude of disciplines including Economics, Sociology, and eventually Information Science. The idea of information as negative entropy became a cornerstone of early cybernetics. However, much of the heat-work undergirding the functioning of what Claude Shannon came to call a “bit” became obscured and compartmentalized, allowing *information* to be productively abstracted apart from its energetic infrastructures (Hayles 1999; Kline 2015). This has created profound tensions between the material engineering of information infrastructures, and the more abstract, contextless theories of information inaugurated by Shannon. Since the 1940s, abstract ideas about relationships between information, energy, and entropy have expanded into collections of cosmological principles, and can be found embedded in everything from the containerized global logistics industry (Klose, 2015), to the proliferation of single-body principles dominating the designs of digital devices. These systems excel at offsetting and externalizing their exhaustive inefficiencies, maintaining illusions of frictionlessness, even though the logics undergirding their operations remain inextricably tied to assumptions about work and energy that emerged out of the scientific investigations of coal-fired heat engines in the 19th century. PoW systems, by their very design, trouble these precarious boundaries.

The tactility and visibility of heat-work in PoW blockchains have made Bitcoin an easy target for its obscene energy use. However, as a computing practice, Bitcoin is not a radical exception to the status quo, but rather a reflection of it. PoW systems have merely thrown information’s thermodynamic relationships into sharper relief than ever before. Bitcoin has only grown so rapidly because it has been able to situate itself in certain spaces as a particular kind of high-performance computing practice, taking full advantage of existing infrastructures, such as building out operations in existing colocation data centers in places like Iceland, and utilizing the long-standing foundry model of microchip manufacturing to streamline delivery of ASICs. If Bitcoin disappeared tomorrow, the modular, high-density computing infrastructures it helped model, and the ASIC industry it rejuvenated, would persist (see Taylor et al., 2020). Thus, Bitcoin provides a crucial lens through which to consider computing’s problematic relationship to energy, and ultimately, how this relationship could be different–especially as structurally similar high-density computing infrastructures for AI and machine learning continue to expand.

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