Project on the Energy
and Environmental Impacts
of the Digital Economy

A framework for assessing the direct energy use of blockchain technology systems

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What problem(s) did your research address?

- Problem:
  - Blockchain technologies are being applied to more and more energy applications, but little is understood about their direct energy use
  - In parallel, a narrative is proliferating that digitalization leads to surging electricity use
- Why is this problem important?
  - Understanding the potential scale and drivers of energy use will enable better energy management and policy
  - Nearly all attention has been given to cryptocurrency, which is an extreme case
    - ➢ More holistic consideration of all blockchain variations is needed to avoid misperceptions

Innogy distributed, P2P charging marketplace

https://www.pv-magazine.com/2018/09/29/the-weekend-read-ev-charging-meets-blockchain/

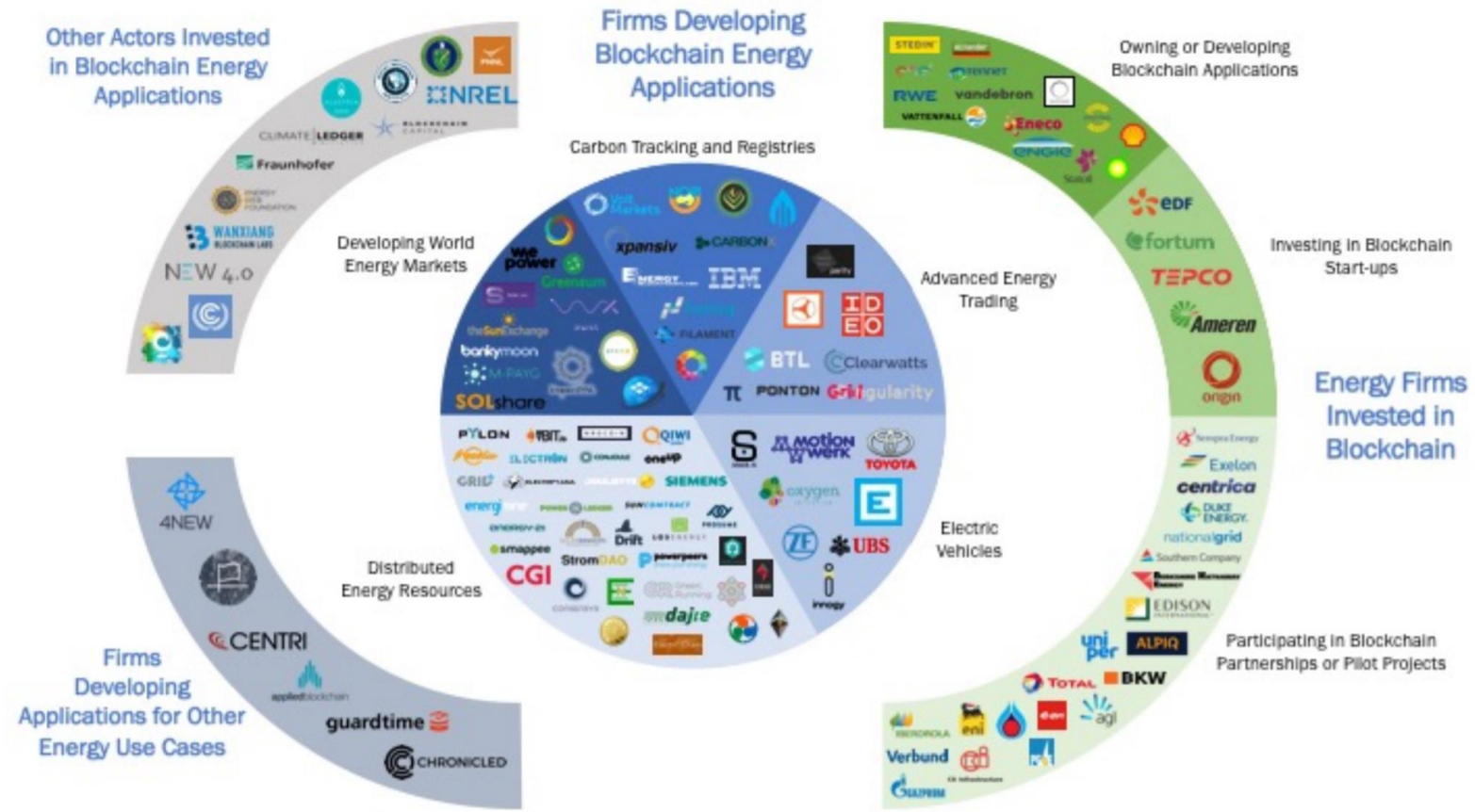
PowerLedger's xGrid electricity trading platform

https://pv-magazine-usa.com/2019/02/21/a-blockchain-trading-solar-power-system-in-the-real-world/

Methodology

1. Literature review of major blockchain applications and equipment types

Methodology



ENERGY FUTURES INITIATIVE

THE BLOCKCHAIN-ENERGY ECOSYSTEM

https://energyfuturesinitiative.org/efi-reports

Methodology

1. Literature review of major blockchain applications and equipment types
2. Establish a best-practice analysis framework for estimating the direct energy use of blockchain technology systems

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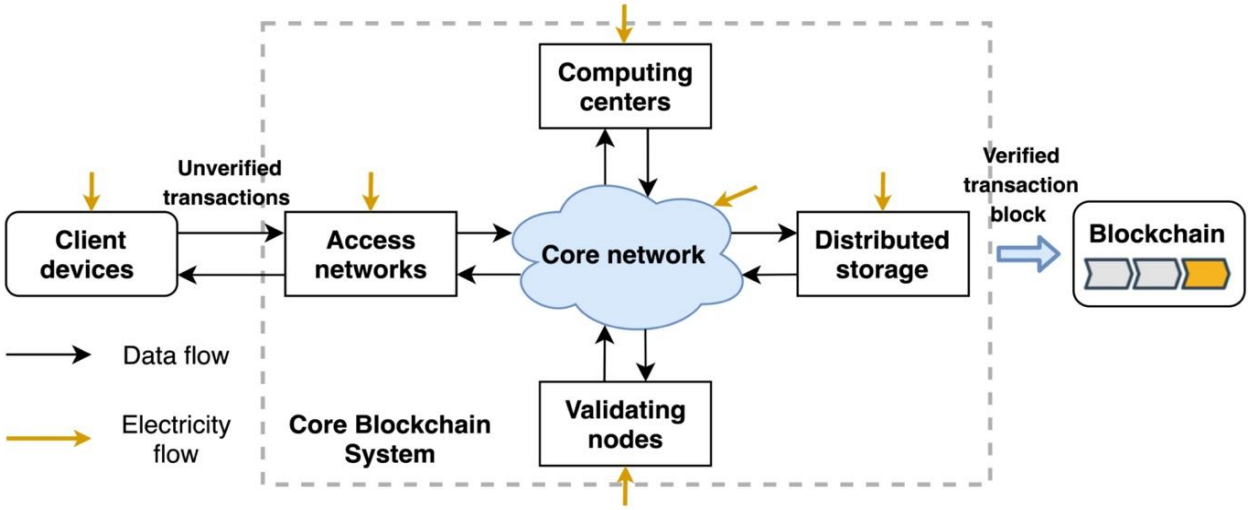

Subsystem	Equipment examples
Client devices	IoT devices, smart meters, EV charging stations, PCs, mobile phones, etc.
Access networks	Gateways, routers, modems, local access network switches and links, etc.
Distributed storage	Storage equipment (hard disk drive, solid-state drive, etc.), and supporting infrastructure for cooling and power supply.
Validating nodes	Computing devices (CPUs, GPUs, FPGAs, ASICs, etc.) and supporting infrastructure for cooling and power supply.
Computing centers	Servers, mining rigs, storage equipment, power and cooling devices, etc.
Core network	IP core/metro/edge switches and routers, transmission link elements (copper, fiber optic, radio links, etc.), and supporting devices for cooling and power supply.

Methodology

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2. Establish a best-practice analysis framework for estimating the direct energy use of blockchain technology systems
3. Develop a future research agenda for applying the framework

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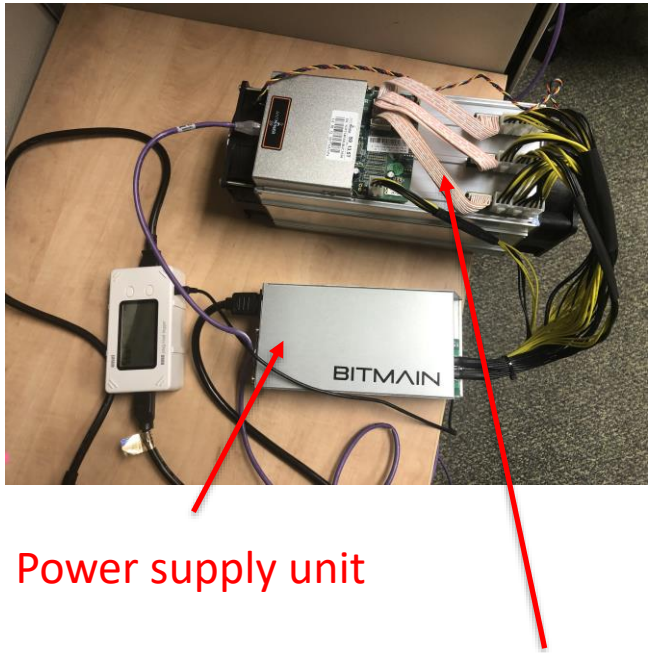
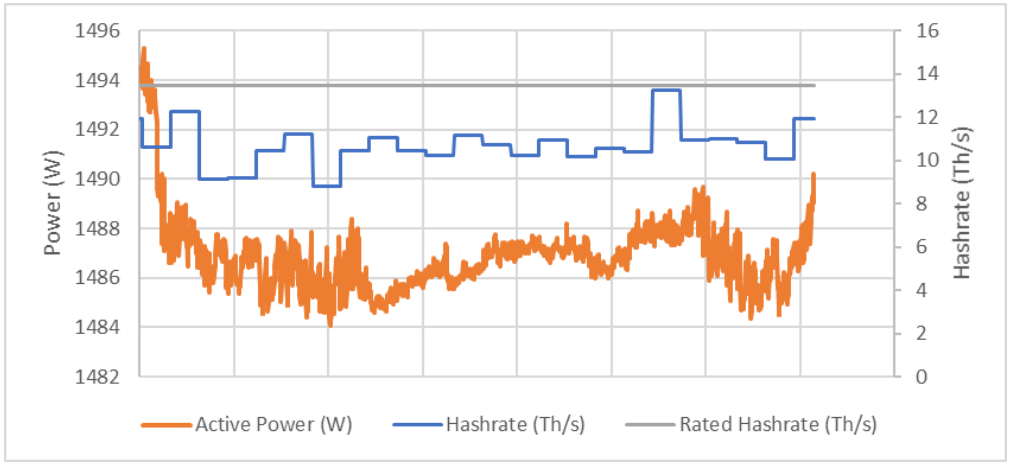
4. Direct energy use measurements of a mining rig

Methodology

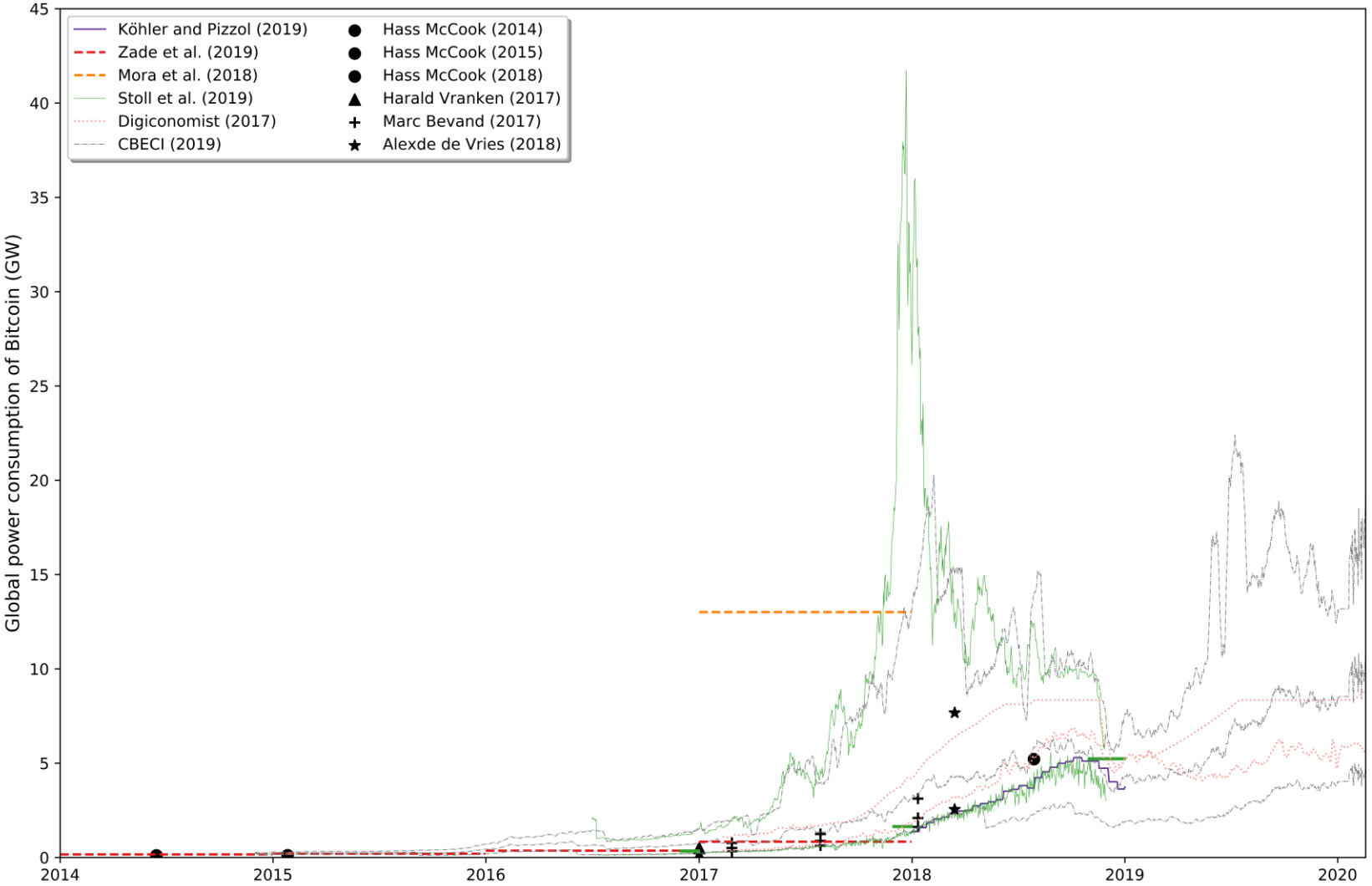
Experimental setup



Power vs. hashrate (measured, rated)



Major Findings:
Variations in methods and results



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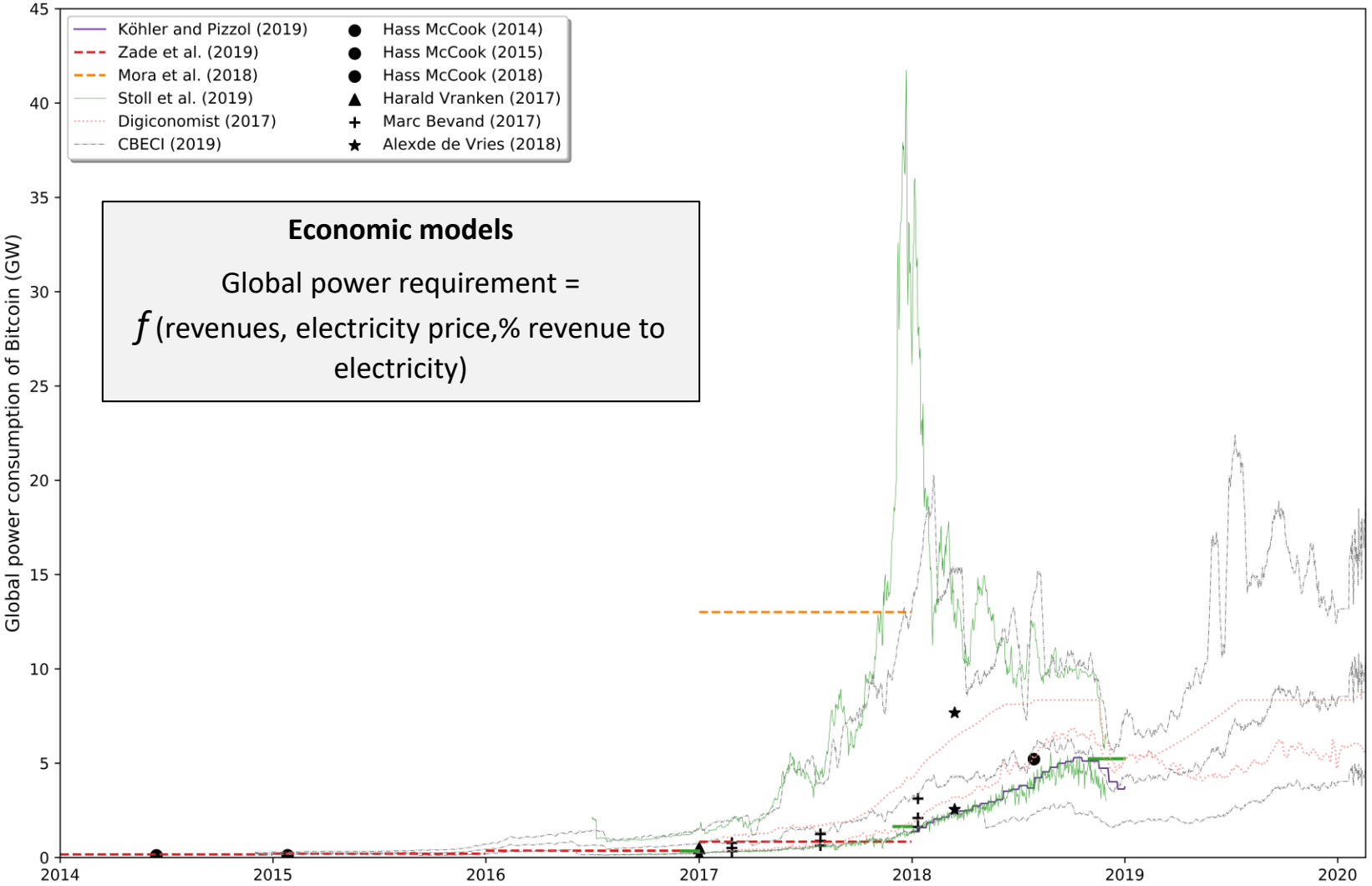

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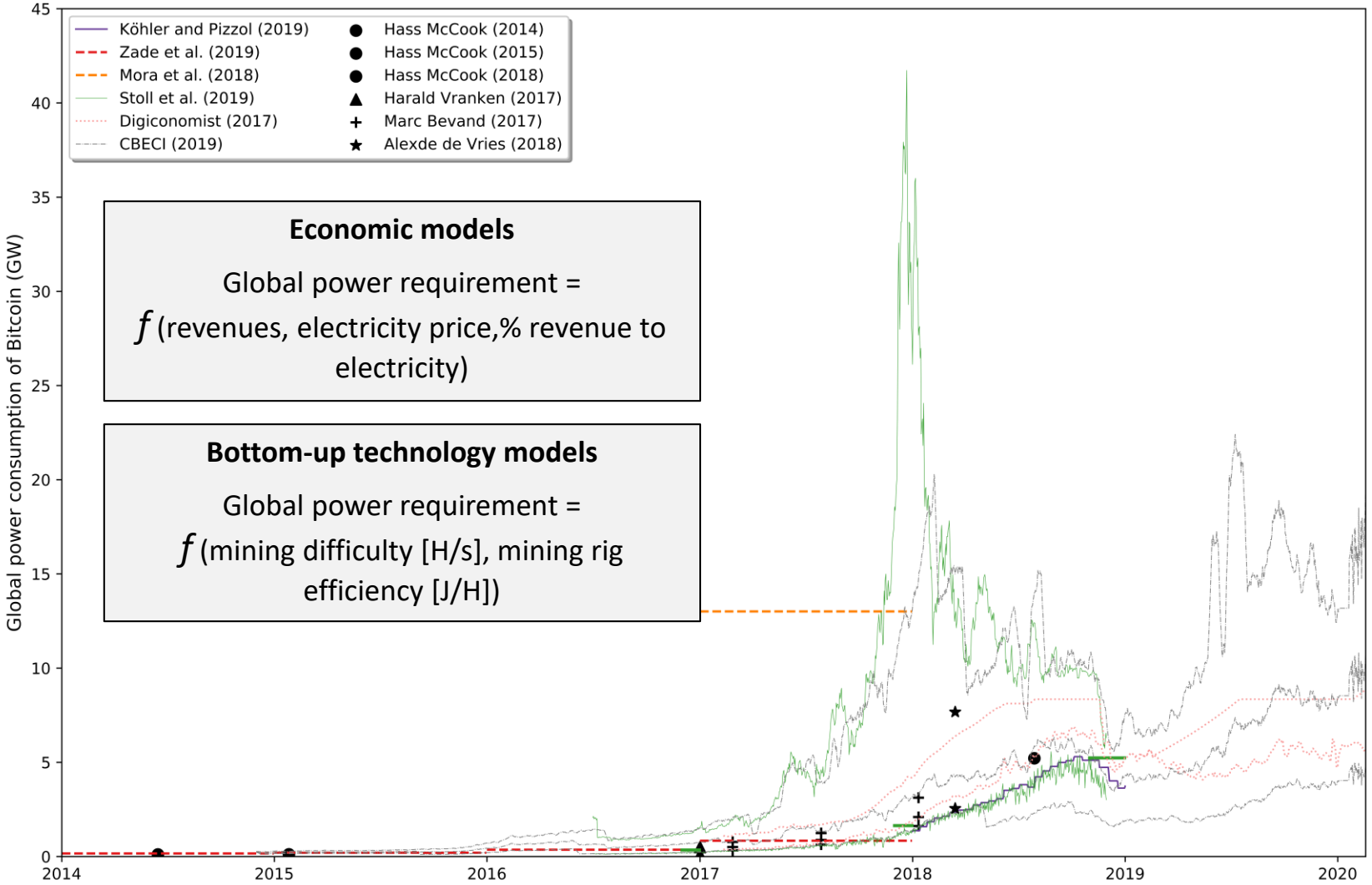

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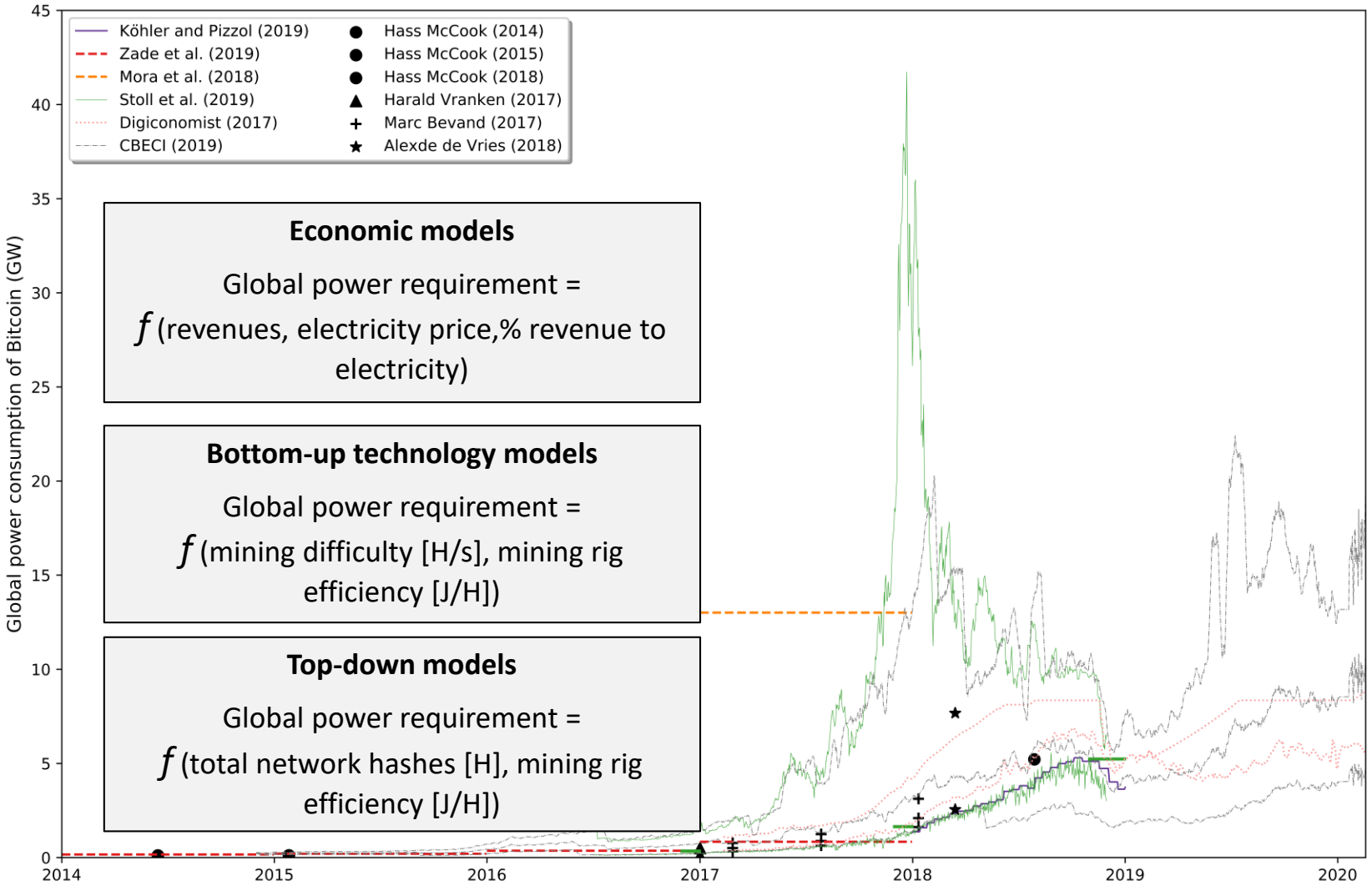

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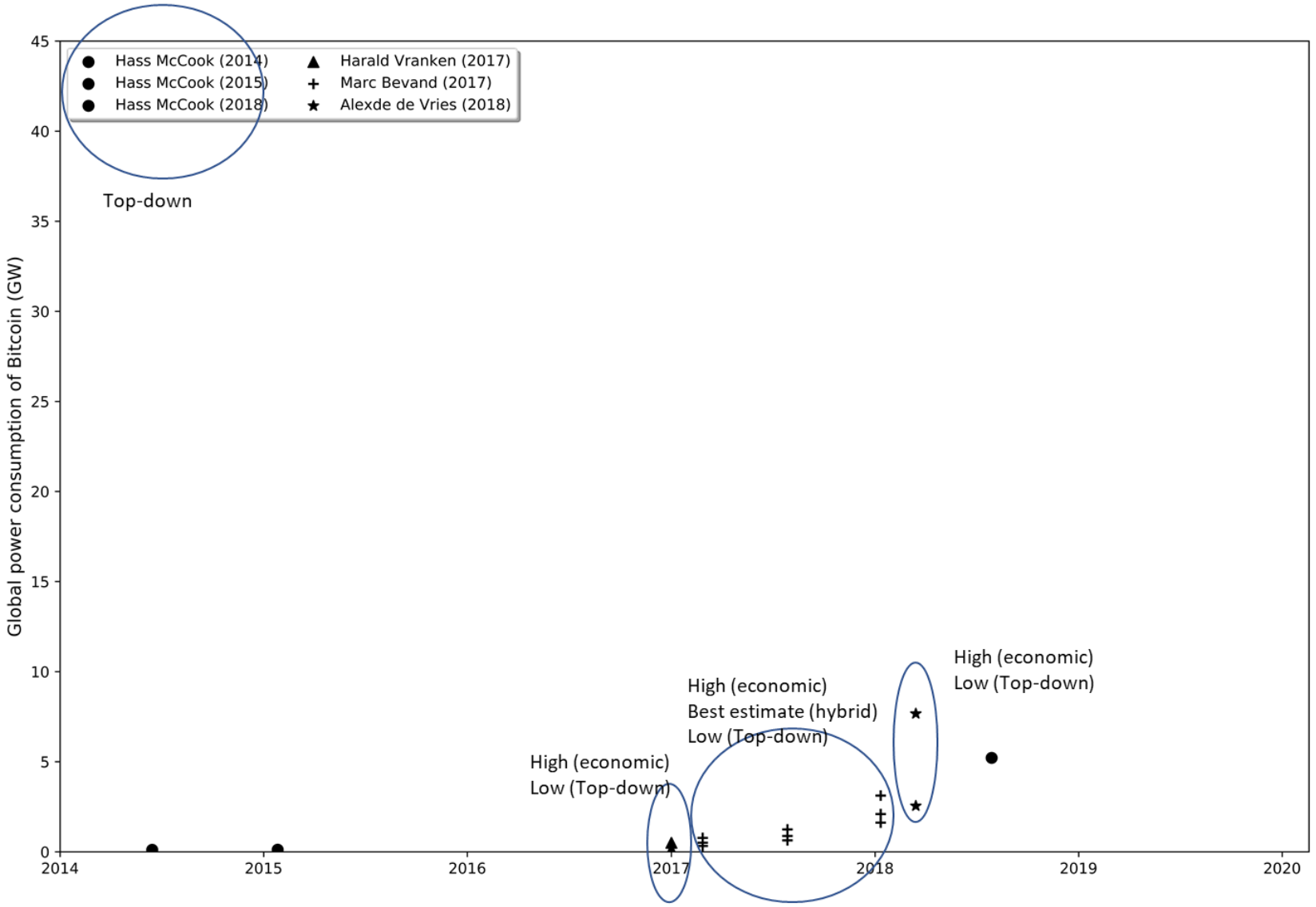

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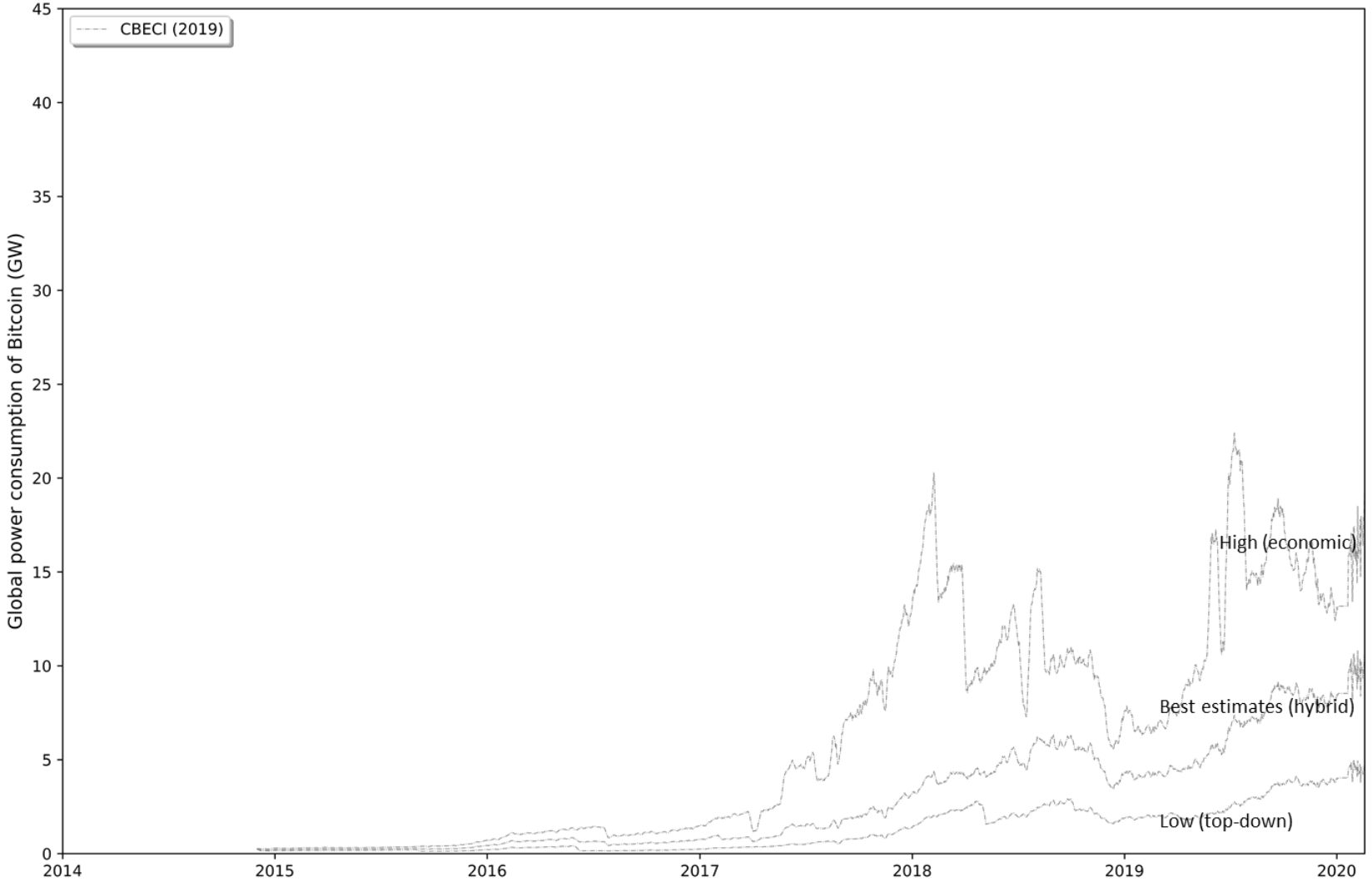
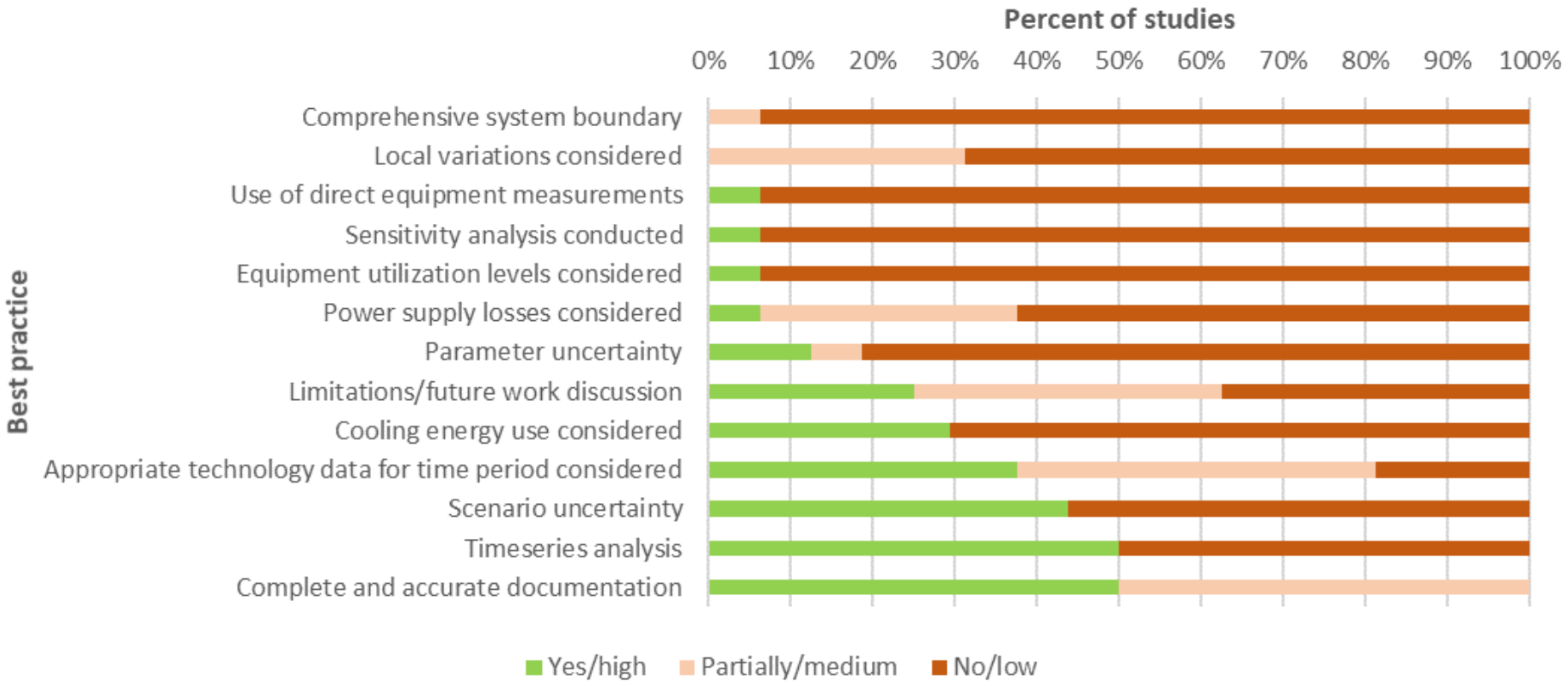


Major Findings:
Research/best-practice gaps



Barriers and Surprises

- What were the major barriers you confronted?
  - No documentation of blockchain technology system components besides cryptocurrencies
  - Very little empirical data on direct energy use characteristics of system components
  - No published energy analyses for blockchain technologies besides cryptocurrencies
  - Lack of proper experimental equipment for direct measurement
- What surprised you during the research?
  - Despite the huge hype surrounding blockchain as a transformative energy system technology, almost nothing is known about its direct energy use
  - Wide variation in analytical rigor in cryptocurrency studies

Research Opportunities

- What would you do if you had more funding?
  - Field visits to observe, document, and measure blockchain technology installations
  - Structured interviews with blockchain technology companies
  - Better energy measurement equipment
  - Convening of technology experts and analysts to brainstorm modeling approaches
- Other knowledge gaps that should be addressed
  - What are the options for less compute-intensive verification algorithms?
  - What are long-term implications for compute, storage, and network traffic requirements?
  - Real-world system case studies with open access data
  - Frameworks/case studies assessing net system benefits, since direct energy use must be viewed in proper context

Final observations

- Lots of blockchain hype, but little understanding of its energy use implications
- Risk of “energy intensive” reputation due to cryptocurrency, but other less power-hungry forms of blockchain exist
- Blockchain’s direct and net energy use effects are a major blind spot
- Investments in better analysis frameworks, data, and prospective modeling capabilities needed for smarter applications and policies