# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

# PGR2023-00039

# SECOND DECLARATION OF DR. FENGQI YOU

I, Fengqi You, declare as follows:

1. I have been retained on behalf of Upstream Data Inc. ("Upstream" or "Patent Owner" or "PO") to offer technical opinions relating to U.S. Patent No. 11,574,372 (the "'372 patent"). I understand that the '372 patent is subject to a petition by Crusoe Energy Systems, LLC ("Crusoe" or "Petitioner") requesting the Patent Trial and Appeal Board ("PTAB" or "Board") to institute a post-grant review ("PGR").

2. I have been asked to provide my independent analysis of the '372 patent, Crusoe's PGR petition, the prior art cited therein and the arguments and analysis in the petition and declarations submitted by Crusoe, in particular the declarations by Dr. Michael Nikolaou (EX1003) and Mr. Vernon Kasdorf (EX1004) stating their opinions regarding the validity of the '372 patent. For this declaration I was asked to focus on certain aspects of the petition and declarations, such as the motivation to combine and whether the prior art in the petition was substantially similar to prior art considered during '372 patent prosecution. I also address patentability of the challenged claims under 35 U.S.C. § 101 and the related opinions by Nikolaou and Kasdorf.

3. This is my second declaration concerning the '372 patent. My first declaration was EX2001, summarizing my opinions in support of Patent Owner's POPR. This second declaration summarizes my opinions in support of Patent

Owner's Response (POR). Accordingly, in preparing this declaration I have also reviewed the Board's Institution Decision (Paper 14). For completeness, I also reviewed the Decision Denying Institution (Paper 9) in PGR2023-00052.

4. My opinions in this declaration are made from the perspective of one of ordinary skill in the art at the time of the invention.

5. I am not and never have been an employee of Upstream. I received no compensation for this declaration beyond my normal hourly compensation for my time actually spent preparing this declaration, including analysis of the petition and materials cited therein. This compensation is not contingent on the nature of my findings or the outcome of this PGR or any other proceeding or litigation related to the '372 patent.

## I. QUALIFICATIONS

6. I am a Professor at Cornell University, where I also hold the Roxanne E. and Michael J. Zak Chair Professorship in the School of Chemical and Biomolecular Engineering. Within Cornell, I also serve as the Chair of Ph.D. Studies in Systems Engineering, Co-Director of the Cornell University AI for Science Institute, Co-Lead of the Schmidt AI in Science Program, and Co-Director of the Cornell Institute for Digital Agriculture. I also have teaching and research appointments in eight other engineering and science departments at Cornell University. These include Computer Science, Electrical and Computer

Engineering, Operations Research and Information Engineering, Systems Engineering, Mechanical and Aerospace Engineering, Civil and Environmental Engineering, Applied Information Systems, and Applied Mathematics. I actively mentor over 30 graduate students across the aforementioned science and engineering departments, guiding them in their original research projects and assisting with their dissertations. I also routinely supervise 5 post-doctoral scholars, in addition to dozens of undergraduate students.

7. I earned a Bachelor of Engineering degree in Chemical Engineering from Tsinghua University in Beijing, China, in 2005, followed by a PhD in Chemical Engineering with a concentration on Process Systems Engineering and Artificial Intelligence (AI) from Carnegie Mellon University in Pittsburgh, Pennsylvania, in 2009. Before joining Cornell University in 2016, I spent two years in the Mathematics and Computer Science Division at Argonne National Laboratory. I also served for five years at Northwestern University as an Assistant Professor of Chemical and Biological Engineering, and of Industrial Engineering and Management Sciences.

8. In my role as a Professor at Cornell University I teach both undergraduate and graduate courses and give guest lectures every year for the various engineering and science departments listed above. The courses and lectures cover a wide range of topics, ranging from chemical engineering, energy systems,

process engineering, artificial intelligence (AI), renewable energy, sustainability, computational modeling, computer science and engineering, process design, industrial manufacturing, chemistry, physics, materials science and processing, biological engineering, life sciences, food and agriculture, climate, automation and control, electrical and electronic engineering, quantum computing, infrastructure, transportation, buildings and architecture, among many others.

9. I have authored over 250 refereed articles in high-impact journals such as *Science*, *Nature Sustainability*, *Nature Communications*, *Science Advances*, and *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS)*. I have also published over 160 peer-reviewed conference proceedings, one book and authored nine book chapters on various aspects of science and engineering. Parts of my research have earned editorial highlights in *Science* and *Nature*, features on dozens of journal covers (e.g., *Energy & Environmental Science*, *Environmental Science & Technology*, *ACS Sustainable Chemistry & Engineering*, *AIChE Journal*, *Industrial & Engineering Chemistry Research*), and coverage in leading media outlets (e.g., *New York Times*, *BBC*, *Reuters*, *Washington Post*, *Wall Street Journal*, *Fortune*, *Daily Mail*, *Agence France-Presse*, *Bloomberg*, *Scientific American*, *Newsweek*, *BusinessWeek*, *Hill*, *Guardian*, *New Scientist*, *Popular Science*, and *National Geographic*). I serve as an editor of *Computers & Chemical Engineering*; associate editor of AAAS journal

*Science Advances* and *IEEE Transactions on Control Systems Technology*; consulting editor of *AIChE Journal*; subject editor of *Advances in Applied Energy*; guest editor of *Energy*, *Journal of Cleaner Production*, and *Renewable & Sustainable Energy Review*s; and is on the editorial boards of *ACS Sustainable Chemistry & Engineering*, *Industrial & Engineering Chemistry Research*, *PRX Energy*, and more. I have delivered over 100 plenary or keynote lectures at leading academic conference domestically and abroad. I was invited by the USPTO's Patent Examiners Technical Training Program (PETTP) to present a lecture on the topic of AI in process industries in the past spring.

10. I serve regularly as a peer reviewer at dozens of major engineering and scientific journals as well as at federal and international funding agencies, including National Science Foundation (NSF), Department of Energy, ACS Petroleum Research Fund, ETH Research Commission, Switzerland, Qatar National Research Fund, Ontario Research Fund, Canada, Ministry of Education and Science, Republic of Kazakhstan, Natural Sciences and Engineering Research Council, Canada, Engineering and Physical Sciences Research Council, UK, United Arab Emirates University Advanced Research Program, UAE, Swiss National Science Foundation, Austrian Science Fund (FWF), Technology Foundation STW, Netherlands, Fondazione Cariplo, Italy, Israeli Ministry of Science, Technology and Space, Netherlands Organisation for Scientific Research

(NWO), Chilean National Science and Technology Commission (CONICYT – Chile), São Paulo Research Foundation (FAPESP), Luxembourg National Research Fund (FNR), French National Research Agency (ANR), Czech Science Foundation, Italian Medicines Agency (AIFA), National Research Foundation of Singapore, National Science Center, Poland, The Science Foundation Ireland (SFI), Ministry of Earth Sciences (MoES) in India, Indian Council of Social Science Research (ICSSR), among others.

11. I have been recognized as an award-winning scholar and teacher, earning over 20 major national and international accolades in the last six years. These come from notable professional organizations and societies, such as the American Institute of Chemical Engineers (AIChE), American Chemical Society (ACS), Royal Society of Chemistry (RSC), American Society for Engineering Education (ASEE), American Automatic Control Council (AACC), in addition to multiple best paper awards. Selected ones include NSF CAREER Award (2016), AIChE Environmental Division Early Career Award (2017), AIChE Research Excellence in Sustainable Engineering Award (2017), Computing and Systems Technology (CAST) Outstanding Young Researcher Award from AIChE (2018), Cornell Engineering Research Excellence Award (2018), ACS Sustainable Chemistry & Engineering Lectureship Award (2018), AIChE Excellence in Process Development Research Award (2019), AIChE Innovations in Green Process

Engineering Award (2020), Mr. & Mrs. Richard F. Tucker Excellence in Teaching Award (2020), ASEE Curtis W. McGraw Research Award (2020), O. Hugo Schuck Award from AACC (2020), AIChE Sustainable Engineering Forum Education Award (2021), AIChE George Lappin Award (2022), and Stratis V. Sotirchos Lectureship Award by Foundation for Research & Technology – Hellas (FORTH) (2022). Furthermore, I am an elected Fellow of the Royal Society of Chemistry (FRSC), Fellow of the American Institute of Chemical Engineers (AIChE), and Fellow of the American Association for the Advancement of Science (AAAS).

12. My research interests and broad research experience span multiple disciplines across engineering, chemistry, physical sciences, and life sciences. For instance, I have authored over 50 peer-reviewed publications in the realm of fuel and natural gas processing in the last decade. My work encompasses a range of topics, including modular chemical manufacturing for natural gas and energy systems for blockchain mining. My research in energy systems for blockchain mining has been published in high-impacts journals, including *Proceedings of the National Academy of Sciences* (*PNAS*) [Lal and You, 2023; Lal and You, 2024], *Energy & Environmental Science* [Niaz, Shams, Liu, and You, 2022], *ACS Sustainable Chemistry & Engineering* [Lal, Zhu, and You, 2023], and *Journal of Cleaner Production* [Niaz, Liu, and You, 2022; Lal, Niaz, Liu, and You, 2024]. The papers in *Energy & Environmental Science* and *ACS Sustainable Chemistry &*

*Engineering* have been featured on the covers of these high-impact journals. The PNAS papers were reported by leading media outlets, including *Fortune*, *ScienceDaily*, and *Tech Xplore*.

13. My curriculum vitae, which includes a complete list of my publications, is included as Appendix A. I am being compensated at a rate of $700 per hour for my work in this case. This compensation is not contingent on the nature of my findings or the outcome of this litigation.

14. I am over the age of 18 and am competent to write this declaration. I have personal knowledge, or have developed knowledge, of the technologies discussed in this declaration based upon my education, training, or experience with the matters discussed herein.

## II. SUMMARY OF OPINIONS

15. With regard to the five grounds asserting obviousness:

- **Ground 1:** Challenged claims (1-4, 8, 16-30, and 34) are not obvious over Dickerson and CryptoKube in view of Szhmigielski and Kheterpal at least because a person of ordinary skill in the art (or "POSITA") would not have motivation to combine said references and would not expect a reasonable expectation of success. Moreover, for this and all other grounds, secondary considerations of non-obviousness demonstrate that the claims are patentable over the prior

art. In addition, the references do not disclose certain claim elements, discussed below.

- **Ground 2:** Challenged claims (1-4, 8, 10-12, 15-30, 34-37, and 40) are not obvious over Dickerson, CryptoKube, and Belady-989 in view of Szhmigielski and Kheterpal at least because a POSITA would not have motivation to combine said references and would not expect a reasonable expectation of success. In addition, the references do not disclose certain claim elements, discussed below.
- **Ground 3:** Challenged claims (1-4, 7-12, 15-30, 34-37, and 40) are not obvious over Dickerson, CryptoKube, Belady-989, and Boot in view of Szmigielski and Kheterpal at least because a POSITA would not have motivation to combine said references and would not expect a reasonable expectation of success.
- **Ground 4:** Challenged claims (1-4, 8, 16-30, and 34) are not obvious over MAGS system and the Polivka miner at least because a POSITA would not have motivation to combine said references and would not expect a reasonable expectation of success. In addition, the references do not disclose certain claim elements, discussed below.
- **Ground 5:** Challenged claims (1-4, 8, 10-12, 15-30, 34-37, and 40) are not obvious over MAGS system, the Polivka miner, and Belady-

989 at least because a POSITA would not have motivation to combine said references and would not expect a reasonable expectation of success. In addition, the references do not disclose certain claim elements, discussed below.

## III. PERSON OF ORDINARY SKILL IN THE ART

16. I have reviewed Petitioner's proposal for a POSITA definition, and I disagree to the extent it implies that a POSITA did not need to have experience in oil and gas industry, including with wellsite power generation, *and* experience with crypto mining. The '372 patent advanced the state of the art by combining these two previously separate fields. While this combination of casinghead gas power generation and crypto mining was beyond the ordinary skill at the time, a POSITA would have needed at least a reasonable grounding in both technologies.

17. For purposes of forming my opinions expressed in this declaration I assumed the definition proposed by Petitioner. My opinions and conclusions in this declaration would not change if a POSITA had some experience in both technologies.

## IV. LEGAL PRINCIPLES

18. I have been advised of the following legal standards and principles which I have applied in forming my opinions.

### 1. Claim Construction

19. Patent claim terms are construed by referring to intrinsic evidence, which includes the claim language, the patent specification, and the prosecution history and extrinsic evidence. The words of patent claims are to be given their ordinary or customary meaning (also referred to as plain and ordinary meaning) unless the inventor has defined them (acted as their own lexicographer) or used them differently (i.e., in a manner inconsistent with the ordinary and customary meaning). The prosecution history of a patent, and related patents and applications, may limit the interpretation of the claim, especially if the patentee disavowed or disclaimed any claim scope in order to obtain allowance of the claim.

**2. Obviousness**

20. I understand that a patent claim is rendered obvious if the claimed invention would have been obvious to a person of ordinary skill in the art as of the date of invention. A determination of obviousness is made after weighing the following factors: (1) level of ordinary skill in the pertinent art; (2) the scope and content of the prior art; (3) the differences between the prior art as a whole and the claim at issue; and (4) as appropriate, secondary considerations of non-obviousness.

21. In evaluating obviousness, both the prior art and claimed invention should be viewed through the knowledge and understanding of a person of ordinary skill in the art at the time of the invention – one should not use his or her

own insight or hindsight in deciding whether a claim is obvious. A claim may be rendered obvious if a person of ordinary skill in the art would understand the claimed invention as a predictable variation of a prior art reference. I further understand that an obviousness evaluation can be made on a single reference or a combination of several prior art references. I understand that where the claim is an obvious variant of a prior art product or system, any modification of the prior art product or system must be supported by a suggestion, motivation, or reason to make the modification. I further understand that obviousness analysis recognizes that market demand often drives innovation, and that a motivation to modify a product or system may be supplied by the direction of the marketplace.

22. On the other hand, I further understand that a claim may not be obvious if a person of ordinary skill would not be motivated to combine or modify the prior art, or would not have a reasonable expectation of success in doing so.

23. A particular modification of a prior art system or product may be made by showing that it was obvious to try the modification. For example, common sense is a good reason for a person of ordinary skill to pursue known options when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions. I understand that obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ under the circumstances. I

understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it. If a person of ordinary skill in the art can implement a predictable variation, then the patent claim may be obvious.

24. I understand that at least the following rationales may support a finding of obviousness: (1) combining prior art elements according to known methods to yield predictable results; (2) simple substitution of one known element for another to obtain predictable results; (3) use of a known technique to improve similar devices (methods, or products) in the same way; (4) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (5) "obvious to try"—choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; (6) a predictable variation of work in the same or a different field of endeavor if a person of ordinary skill would be able to implement the variation; (7) there existed a known problem for which there was an obvious solution encompassed by the patent's claims at the time of the claimed invention; (8) known work in one field may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; and (9) some teaching, suggestion, or

motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

25. I have been informed that one or more so-called "secondary considerations of non-obviousness" may impact the obviousness analysis if they are present. I have been informed that secondary considerations may include: (1) whether the invention proceeded in a direction contrary to accepted wisdom in the field; (2) whether there was a long felt but unresolved need in the art that was satisfied by the invention; (3) whether others had tried but failed to make the invention; (4) whether others copied the invention; (5) whether the invention achieved unexpected results; (6) whether the invention was praised by others; (7) whether others have taken licenses to use the invention; (8) whether experts or those skilled in the art at the making of the invention expressed surprise or disbelief regarding the invention; and (9) whether products incorporating the invention have achieved commercial success that is attributable to the invention.

26. I also understand that another indication of obviousness may be that others having ordinary skill in the field independently made the claimed invention at about the same time the inventor made the invention.

27. I also understand that for any such secondary consideration to be relevant, there must be a connection or "nexus" between the secondary

consideration and the claimed invention. For example, commercial success of a product is relevant to obviousness only if the success of the product is attributable to the patented features of the claimed invention. If, on the other hand, commercial success is due to features of the product not claimed in the patent, due to claimed features that existed in the prior art, and/or due to advertising, promotion, salesmanship or the like, then any commercial success should not be considered an indication of non-obviousness.

**3. Section 101**

28. I understand that a two-step framework is used to determine whether patent claims are directed towards patent-eligible subject matter. First, a determination must be made as to whether the claims are directed towards one of the three patent-ineligible subjects: laws of nature, natural phenomena, and abstract ideas. If the claims do not fall within one of these three patent-ineligible subjects, I understand that the claims satisfy 35 U.S.C. § 101 and there is no need to proceed to the second step. However, if the claims are determined to be directed towards one of these patent-ineligible subjects, then the analysis must proceed to step two. I further understand that the examination of whether a claim is directed to an abstract idea may also weigh whether the claim recites the practical application of the subject matter of the claim.

29. At step two, I am informed that the inquiry is whether an inventive concept such as an element or combination of elements is recited that is sufficient to ensure that the patent in practice amounts to significantly more than a patent upon the abstract idea itself. At step two, I understand it is also necessary to consider whether the claim elements or the claimed combination are well-understood, routine, conventional.

## V. OVERVIEW OF '372 PATENT

30. The following is a brief summary of the '372 patent based on my review. The '372 patent claims priority to provisional application 62/456,380, filed on February 8, 2017. *See* EX1001. The patent is "related to blockchain mining at an oil or gas facility." EX1001, 1:6-7. The '372 patent explains that "[i]n upstream production of oil and gas, natural gas may be produced … as a by-product of oil production, for example from an oil well." EX1001, 6:51-54. This form of natural gas is referred to as undesirable casinghead gas, casing gas or simply raw gas. EX1001, 4:62-63, 8:66-9:3.

31. The prior art knew some ways to utilize casinghead gas. For example, it was known to consume it as "on-site fuel or for instrumentation pressure." EX1001, 6:56-58. If there was a significant gas volume beyond what could be consumed onsite, gas could be sold to market through a connection to a pipeline network, compression, or liquefaction for delivery to a counterparty. EX1001,

6:59-64. If a grid connection was available, casinghead gas could be used to generate electricity for sale to the power grid. EX1001, 6:63-67.

32. However, gas "may be located at a remote oil and gas site" that lacks "accessible infrastructure such as an external pipeline network (sales line) or external power grid to sell into" and may be "hundreds of kilometers outside of the nearest town." EX1001, 7:46-49, 8:20-23. In such cases "it may not be economically feasible … to take the gas, or resultant electricity … to market, for example due to significant capital expense required or when the volume of gas is insufficient to pay out the investment." EX1001, 7:49-54, 8:11-23. As is known in the art, the gas is "stranded." EX1001, 7:54-56.

33. In such cases, a common solution is to vent or flare (burn) the stranded gas. EX1001, 1:11-13, 7:61-8:10. However, this prior art solution is undesirable because it creates greenhouse gas emissions, wastes the potential energy of the gas, requires capital expenditure, and may pose health risks. *Id.*

34. The novel solution taught by the '372 patent avoided the flaring of stranded gas at a hydrocarbon facility by providing the continuous flow of stranded gas to a generator used to power a portable blockchain mining device. *Id.*, 2:18-24.

35. As discussed in the '372 patent, "[a] blockchain is a form of database, which may be saved as a distributed ledger in a network of nodes that maintains a continuously-growing list of records called blocks." EX1001, 11:45-47. "The

administration of BITCOIN currency is currently the primary use for blockchain technology." EX1001, 11:57-60. "Maintaining a blockchain database is referred to as mining, which refers to the distributed computational review process performed on each block of data in a block-chain." EX1001, 13:5-7. "Those involved in BITCOIN mining are rewarded for their effort with newly created BITCOINs and transaction fees." EX1001, 13:9-13.

36. Blockchain mining (also referred to as crypto mining) differs from many other types of computing in that it is "intentionally designed to be resource-intensive and difficult so that the number of blocks found each day by miners remains steady." EX1001, 13:29-33, 13:44-48. This is unlike most other computational loads (such as those running in a conventional data center) which are typically designed to be as efficient and computationally economical as possible. This intentionally energy-intensive problem comprises "a cryptographic hashing algorithm." EX1001, 13:49-52.

37. Since the energy cost of crypto mining is the primary operating cost, the prior art mines were located primarily in places with low-cost hydroelectric power such as China or the Pacific Northwest in the United States. EX1001, 14:4-20; EX1009, 105.

38. Decentralizing crypto mining away from hydroelectric power to make use of stranded gas at remote hydrocarbon production facilities required innovative

thinking and solutions disclosed in the ’372 patent. For example, unlike existing crypto mines which could depend on reliable power sources (e.g., a hydroelectric power plant connected to the grid), the ’372 patent’s bitcoin mine in some cases had to solve the problem of variable, albeit continuous, casinghead gas production. The ’372 patent discloses solving this problem by, for example, the mining controller modulating the mining power load (also referred to as the hashrate) in real time to respond “to variations in a supply or production rate of natural gas.” EX1001, 17:61-18:15. In addition, crypto mining power levels may be adjusted to a daily minimum or maximum gas production rate as different strategies to mitigate the variable production. EX1001, 18:34-19:13.

## VI. CLAIM CONSTRUCTION

39. I have considered Petitioner’s proposals for construction of certain claim terms from the perspective of one of ordinary skill at the time of the invention, taking into account the ’372 patent’s teachings, the prosecution file history, and the knowledge of a POSITA. For the following reasons, I disagree with the Petitioner’s proposals regarding the meaning of the claim terms addressed below.

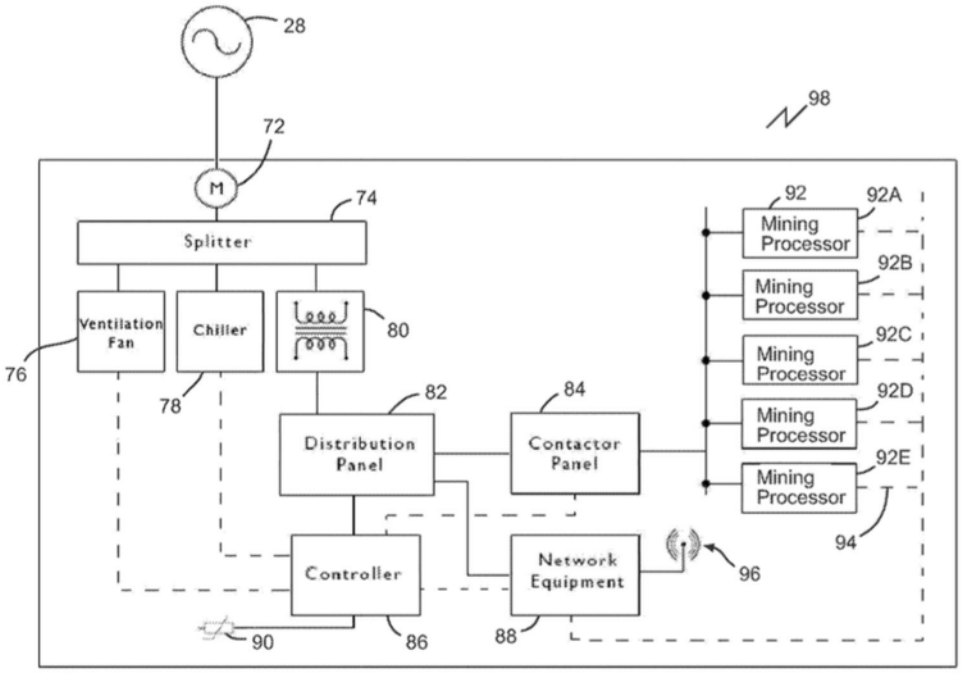
### 1. “Blockchain Mining Devices” and “Mining Processor”

40. In my opinion, the ’372 patent specification and claims do not support Petitioner’s constructions. First, Petitioner nearly equates the meaning of a



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"blockchain mining devices" with a "mining processor." Petition, at 4-6. However, the specification makes clear (including with reference to Figure 4) that the "mining device 12" is made up of many components, including "a controller 86, network equipment 88 such as a modem and a network switch, … and one or more mining processors 92 such as processors 92A-E." EX1001, 16:32-39; *see also* 15:21-25; 17:23-29; 19:59-62. The relationship between a blockchain mining device (in this embodiment the system within enclosure 98) and its mining processors 92 is further illustrated in Fig. 4:




The plain language of the claims tracks the disclosure of the specification and confirms that the term "blockchain mining devices" refers to, for example, not just one or more mining processors, but also a specialized network interface that

communicates with a blockchain database. *See e.g.*, EX1001, 16:32-39, 17:23-29, claims 1, 24. As such, in my opinion no construction of the term "blockchain mining devices" is necessary.

41. With respect to the mining processors, the '372 patent details that "[e]ach mining processor 92 may have a variety of configurations, but generally may include at least a power supply, a controller board and mining circuity, such an ASIC circuit." EX1001, 17:9-12. The specification further discloses that an embodiment of a mining processor includes "the hash boards (each board has numerous chips that is doing the hashing) …" where hashing refers to the "computational effort … to run a cryptographic hashing algorithm associated with the particular blockchain protocol." EX1001, 17:15-17; 13:49-52. The plain language of the claims again tracks the disclosure in the specification and recites that "the mining processors are connected to the network interface and adapted to mine transactions associated with the blockchain database and to communicate with the blockchain database." EX1001, 19:66-20:2. A POSITA, therefore, would understand that at a minimum, a mining processor is "a processor with blockchain mining circuitry."

42. Petitioner's faulty constructions derive in part from Petitioner's reliance on disclosure pertaining to a "network of nodes" to reach its conclusion regarding the terms "blockchain mining devices" and "mining processor." But, the

specification teaches that nodes simply "maintain … records" (EX1001, 14:22-43) versus mining processors that "perform data mining operations, for example verifying cryptocurrency transactions." EX1001, 14:62-63. As the specification makes plain, a simple node may be "desktop computers, laptop computers, tablet computers, cellular telephones, servers, or other suitable devices" used for storing already computed blocks within a blockchain. EX1001,14:30-33. But, the mining processor provides the "require[d] computational effort" measured by the "hashrate." EX1001,13:49-58.

43. Finally, Petitioner offers no support for its proposal to attach the negative limitation "without regard to processor speed or power" to either identified claim term. There is no claim language in the '372 patent, no specification support within the '372 patent, and no reason to be gleaned from the prosecution history to graft the notion of "any processor … without regard to processor speed or power" into the claims. To the contrary, the specification repeatedly teaches that the "computation effort" is important, so much so that the '372 patent teaches optimizing the hashrate by, for example, "changing … the clock rate of the processor." *See* EX1001, 13:49-54. For these reasons, a POSITA would find no support in the intrinsic record for a requirement that the blockchain mining devices" or "mining processor" exist "without regard to processor speed or power."

**2. "Continuous Flow of Combustible Gas"**

44. In my opinion, Petitioner's construction of "continuous flow of combustible gas" similarly divorces the claim term from the surrounding claim language, the specification's description of the source of combustible gas, and ignores the prosecution history. Petitioner's proposal renders superfluous the word "continuous" in the claim because it suggests that any "time period" where "a flow" is momentarily present is "continuous." For example, under a literal reading of Petitioner's proposal, a flow of combustible gas that occurred for a few minutes and then disappeared would meet the limits of "a flow of combustible gas that is continuous for at least a time period." Thus, Petitioner's proposal is inconsistent with the plain meaning of the claim language requiring a *continuous* flow.

45. The '372 patent specification confirms that the "continuous" character of the flare gas in the '372 patent derives from the fact it is a by-product of hydrocarbon (oil) production, storage, or processing, and cannot be avoided during production. EX1001, 6:35-39 ("Natural gas may naturally separate from the oil stream as it is produced up the well …"), 6:48-51 ("Natural gas may also be liberated out of solution from the oil as it is treated …"). In remote areas, where an oil field operator is confronted with this continuous source of natural gas, "the operator is forced to do something with the excess or stranded gas and is left with few options" such as "venting … flar[ing], … or ceasing production…." EX1001,

7:54-60. The natural gas that is the focus of the '372 patent is "[c]asing gas, also known as casinghead gas, [that] is produced as a byproduct from a producing oil well …." EX1001, 8:66-9:1; 9:63-66. The recitation of a "continuous flow of combustible gas" reflects that the combustible gas is a continuous (albeit at varying production rates) byproduct of "hydrocarbon production, storage, or processing." This is consistent with the ordinary meaning of a "continuous flow of combustible gas" that would be applied by a person of ordinary skill in the field.

46. Petitioner identifies a portion of the '372 patent specification describing an embodiment of the invention that uses a controller to modulate the blockchain mine load in relationship to a varying gas supply. EX1001, 17:47-60. The portion of the specification identified by Petitioner teaches the advantageous use of controller settings to deliver a stable and consistent load from the mining processors throughout the day, even during periods of time where the production rate of combustible gas exceeds the minimum production rate. EX1001, 18:16-27. Contrary to Petitioner's proposed construction, the implementation of these controller settings does not disclose a supply of combustible gas present for merely "a time period," but instead describes a varying production rate between a minimum and maximum production rate.

47. Finally, Petitioner and its declarant opine that "the gas supply from any given oil field is limited, and will eventually dry up" to support their proposal

requiring a supply of combustible gas during "any time period." This opinion does not find support in the specification and is not pertinent to the problem of flare gas that is a byproduct of hydrocarbon production described in the '372 patent. That a well may at some point stop producing hydrocarbons does not justify the "any time period" language because the '372 patent is directed to a problem that exists while flare gas is produced. Thus, a POSITA would not accept Petitioner's proposed construction for the "continuous flow of combustible gas."

## VII. GROUND 1

### 1. Motivation To Combine

48. I have reviewed the Petition's description of the motivation to combine the references in this ground and the corresponding portions of the Nikolaou and Kasdorf declarations. I note that the Nikolaou and Kasdorf declarations are virtually identical for this and the other grounds and closely track the Petition. Accordingly, for ease of reference I will cite to the Petition unless I am specifically addressing the declarations. For the following reasons it is my opinion that Petitioner and Messrs. Nikolaou and Kasdorf have not shown a motivation to combine or a reasonable expectation of success which I understand it is their burden to demonstrate.

#### a. Hindsight

49. Petitioner asserts that the claimed invention had "been done before," (Petition, 1), but Ground 1 relies on *four* references even for the independent claims. Petitioner ignores the pioneering nature of the '372 invention which materially advanced the knowledge in the art and engages in hindsight reconstruction of the claims using references that a POSITA would not have combined.

50. The CryptoKube system purportedly discloses "a commercialized industrial Bitcoin mining system." EX1004, ¶63. The CryptoKube Brochure discloses that "CryptoKube can run inside a large warehouse, outside in a parking lot or in a server pod farm where the power is cheapest." EX1006, 4. Yet there is no indication in the CryptoKube references of *any* actual or even hypothetical use of CryptoKube with a generator at an oil or gas production facility which "are typically located in remote areas where no utility power is available" as explained by Dickerson. EX1005, ¶24. Nor does Petitioner's declarant Mr. Kasdorf – identified as "the owner and partner in KubeData Systems Inc." – provide even a single instance of CryptoKube powered by flare gas at a remote oil or gas production facility.

51. At his recent deposition Mr. Kasdorf confirmed that he is not aware of any CryptoKube systems *ever* being used with a flare gas powered generator.

EX2022, 20:14-20. Nor is he aware of *any* cryptocurrency miner powered with a flare gas generator before the '372 patent's priority date. EX2022, 20:23-21:7.

52. As discussed in more detail below, before the pioneering invention of the '372 patent, persons of ordinary skill in the blockchain or cryptocurrency mining field had limited awareness of oil and gas industry generally and certainly did not consider flare gas as a suitable energy source for mining. Thus, Mr. Kasdorf admitted that "I don't consider myself a POSITA in the gas and oil industry," nor was he aware of any persons of ordinary skill in the Bitcoin mining industry who were also a POSITA in the oil and gas industry. EX2022, 16:17-17:3.

53. Likewise, those in the oil and gas industry did not consider bitcoin mining as a suitable way to manage stranded gas. For example, a CNBC article (EX2016, further discussed below in connection with secondary considerations of validity) quotes Adam Ortolf, Patent Owner's current sales manager: "In 2018, I got laughed out of the room when I talked about mining bitcoin on flared gas." EX2016, 7.

54. Thus, in my opinion objective evidence shows that as of the February 8, 2017, filing date of the '372 patent's provisional application, those of ordinary skill did not consider obvious a combination of flare gas powered generator and a bitcoin miner.

**b. Szhmigielski cannot supply missing motivation to combine**

55. Petitioner relies on Szmigielski's statement that "[o]ne of the biggest costs for Bitcoin miners is the cost of electricity" as the motivation to combine Dickerson and CryptoKube. Petition, 20; EX1009, 105. The Institution Decision likewise credits this statement as supplying the motivation to combine. PGR2023-00039 Paper 14 at 34 ("[B]ased on Smigielski's teachings, Petitioner contends that one of ordinary skill in the art would have been motivated to combine Dickerson's mobile power generation system and CryptoKube's mobile Bitcoin miner in order to utilize the free excess electricity generated by Dickerson's system.")

56. Szhmigielski wasn't saying anything new as the cost of electricity was one known driver of cryptocurrency mining profitability. However, neither the statements in Szhmigielski nor the generally known desirability of cheap power ever *actually* motivated a combination of a cryptocurrency miner with flare gas power generation before the invention of the '372 patent, which in my opinion further shows the hindsight bias of the motivation to combine proposed by Petitioner.

57. Put another way, if the combination was so "easy" as alleged by Petitioner, why was it never attempted? The answer is that, for a number of reasons, there was no motivation to combine a cryptocurrency miner with flare gas power generation and no reasonable expectation of success.



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58. As an initial matter, the idea that Dickerson supplies "free excess electricity" is misplaced because it ignores the significant cost of Dickerson's complex system. Petitioner does not specify whether the proposed combination involves a POSITA financing both a Dickerson system and a CryptoKube. Petitioner's expert testified that a CryptoKube system sold for approximately $60,000.00. EX2022, 28:24-29:17. A POSITA would understand that Dickerson's system would cost at least hundreds of thousands of dollars due to its complexity, several multiples of the cost of a CryptoKube. This capital expense, further including ongoing expenditure to maintain Dickerson's membranes and gensets, would more than offset any operational cost savings on power relative to established lower-cost power sources such as hydro. Therefore, a POSITA would connect a CryptoKube to a known source of cheap and reliable electricity like hydroelectric power (EX1009, 105) that does not require any appreciable capital investment. Accordingly, in my opinion a POSITA would not be motivated to combine a new Dickerson system and a CryptoKube.

59. A combination comprising an existing Dickerson installation and a CryptoKube would also make no sense to a POSITA. First, considering the perspective of the oil and gas industry, Dickerson's purpose was to power oil and gas production: "The invention includes a mobile apparatus equipped to convert raw natural gas into a suitable fuel and to use the fuel to provide electricity to an

oil or gas production facility that generated the raw natural gas." EX1005, ¶11. It was well known that components such as those illustrated in Dickerson Fig. 1, including gas engine 110, generator 112 and gas conditioning system 100 (EX1005, ¶26), should be sized for the expected primary power load to eliminate the expense of buying unneeded power capacity. Therefore, an existing Dickerson system would be sized to generate power sufficient to run the oil and gas operation. A CryptoKube Launch 200 required a 200A service and up to 72kW of power. EX1006, 1. A POSITA would not expect an existing Dickerson installation sized for its primary load to consistently supply that much excess power (especially given the known variability of the continuous flow of flare gas) and therefore would not be motivated to make the proposed combination.

60. Dickerson does state that "[i]n some cases the amount of electrical power required on an oil field pumping site may be small compared to the amount of power that can be produced with the gas available." EX1005, ¶39. However, in this scenario Dickerson teaches to export excess power to the grid. *Id.* Thus, if a grid connection was available, a POSITA knew that the power generation components in Dickerson could be upsized to profitably export electricity to the grid. There is no teaching or suggestion in Dickerson or elsewhere that expensive power generation components should be upsized unless export to the grid was possible.

61. This illustrates the state of the art in the oil and gas industry before the '372 invention. Flare gas mitigation with an expensive system such as Dickerson was only considered to (1) power the oil and gas operation or (2) generate additional power if a counterparty (*i.e.*, the electric grid in Dickerson) was available. Otherwise, stranded gas was simply released in the atmosphere (thereby contributing to methane pollution) or flared. It is for this reason that in 2018 Adam Ortolf, Patent Owner's current sales manager, "got laughed out of the room when I talked about mining bitcoin on flared gas:" "The concept of bringing hydrocarbons to market without a counterparty was laughable." EX2016, 6.

62. The industry at that time had no knowledge of cryptocurrency mining and did not understand whether it was technologically or commercially feasible to mitigate flare gas by generating power for a connected miner. Therefore, there was no motivation to combine flare gas-powered generators like Dickerson or MAGS with cryptocurrency miners and no reasonable expectation of success.

63. Second, considering the perspective of the cryptocurrency mining industry also shows lack of a motivation to combine.

64. In this regard, Szmigielski teaches that, in addition to being inexpensive, electric power for crypto mining must be "*reliable*" to power "the hardware and the associated cooling systems." EX1009, 105. The only example in Szhmigielski that satisfies *both* requirements is hydroelectric power. EX1009, 105.

The ’372 patent likewise identifies hydroelectric power as the state of the art for the industry: “Since the energy cost of running blockchain mining equipment is its primary operating cost, a trend towards mining on low-cost hydroelectric power has become prevalent.” EX1001, 14:4-7. The industry’s embrace of hydroelectric power was due not just to its low cost but also its reliability. Simply put, hydroelectric power is abundant and can power energy-hungry crypto miners at full hashrate, without interruption – that is, *reliably*.

65. Crypto mining operations are highly computationally and energy-intensive by design, as explained in the ’372 patent and known in the art. EX1001, 13:29-36, 13:49-58. Szhmigielski likewise emphasized that “Bitcoin mining is inefficient on purpose.” EX1009, 121. This is unlike typical data center computing at the time of the invention which was commonly optimized to consume the least possible computational resources.

66. The need for *reliability* derives from the fact that cryptocurrency mining is expensive and can be profitable (which is the goal of a POSITA) only if the miner puts in enough resources to outpace others. As discussed above, even a single CryptoKube at a mere 72kW capacity was a $60,000.00 investment. To make the investment worthwhile, it was known in the art to run the miners at full hashrate twenty-four hours a day. This is demonstrated by Szhmigielski’s discussion of ASIC mining profitability where the “percentage of the total network

hashing power" is one of four main factors (along with electricity, ASIC and cooling costs) determining whether the miner will have success. EX1009, 88; This percentage is dependent on the hashrate, motivating a POSITA to run the equipment at full power. The available reward is also dependent on equipment operating all the time, with Szhmigielski assuming a full twenty-four hour cycle in the profitability calculation:

## Profitability of ASIC mining

In calculating your potential profit, keep in mind the following factors:

- The cost of your ASICs
- Electricity costs to run the hardware
- Cooling costs—ASICs generate a decent amount of heat
- Your percentage of the total network hashing power

To calculate the expected rewards from mining, we can do the following. First, calculate what percentage of total hashing power you command. To look up the network mining speed, execute the `getmininginfo` command in the console of the Bitcoin Core wallet. We will do our calculations with an ASIC that can hash at 1 TH/s.

If the Bitcoin network hashes at 400000 TH/s, then our proportion of the hashing power is as follows:

```
1 /  400 000 = 0.0000025 of the total mining power.
```

On average, a Bitcoin block is found every 10 minutes, so six per hour and 144 for a 24-hour period. The current reward per block is 25 BTC, therefore in a day we have *144*25 = 3600* BTC mined.

EX1009, 88.

67. Thus, the conventional knowledge in the art before the invention of the '372 patent held that industrial ASIC miners like CryptoKube should operate at maximum uptime and at full hashrate. These requirements informed a POSITA as to what power sources were sufficiently *reliable* in addition to inexpensive – a

POSITA chose a power source that could drive its crypto miners at (1) lowest cost (Szhmigielski's "inexpensive" requirement) while (2) sustaining full hashrate and maximum uptime (Szhmigielski's "reliable" requirement).

68. Applying this conventional understanding to Dickerson, in my opinion a POSITA would not be motivated to use it as a power source for an industrial miner such as CryptoKube. As explained above, if the combination involved a dedicated Dickerson system, a POSITA would not consider it because the large expense of purchasing, installing and maintaining Dickerson would outweigh any reduction in power cost per kW versus a conventional low-cost source such as hydropower. If the combination involved an existing Dickerson system where some amount of excess power was available, a POSITA would not consider Dickerson *reliable* because there would be no guarantee that excess power from a system sized for its primary load of oil and gas equipment (as an existing Dickerson system would be) could run a CryptoKube at full hashrate and maximum uptime.

69. The Institution Decision states that "Petitioner was required to show that its proposed combination would have been desirable, but not necessarily the most desirable option available" to a POSITA. PGR2023-00039, Paper 14 at 30. However, as demonstrated above and further discussed below, Dickerson's system would be *undesirable*. A new Dickerson installation would be expensive compared

to available and accepted power sources such as hydro, and therefore undesirable. An existing Dickerson installation would be undesirable because a POSITA desired to run CryptoKube at full hashrate and minimum downtime as was the conventional knowledge in the art. A POSITA understood that any excess output of an existing Dickerson system conventionally sized for its primary load would be too *unreliable* – variable and even episodic depending on flare gas flow rates – to run CryptoKube at maximum power and minimum downtime.

70. Dickerson teaches that its electrical power is *unreliable* because the system is located "in remote areas" where "no utility power is available." EX1005, ¶24. The main purpose of the Dickerson generator is "to generate electricity that is returned to the facility" rather than powering a power-hungry crypto miner. EX1005, ¶6. Moreover, the amount of gas available to power Dickerson's generator varies such that only "in some cases the amount of electrical power required… may be small compared to the amount of power that can be produced with the gas available." EX1005, 39. Even in these cases, Dickerson teaches sending any excess power to the grid if it is connected. *Id.* In fact, Dickerson teaches that "raw natural gas flow will be interrupted" and "there will likely be periods when the production facility will require electricity but will be generating no or low levels of raw natural gas" to run its generator, underscoring the

*unreliability* of its power to run the production facility, let alone to supply "excess power" to CryptoKube. EX1005, ¶21.

71. Dickerson further teaches using a diesel generator as a backup source to mitigate unreliability. EX1005, ¶21. However, backup power would not comprise free or cheap "excess" electric power derived from waste gas that could motivate a POSITA to combine a crypto miner with Dickerson. Instead, a POSITA would understand that the backup fuel would be relatively expensive (Dickerson acknowledges fuel, transportation and storage costs of diesel fuel at remote sites, EX1005, 1004) and would be used to power the primary load, not to supply excess power. Therefore, a POSITA would consider excess power to be unavailable to power CryptoKube during periods of backup diesel power use in Dickerson. In this regard the Board's suggestion that "on the whole… Dickerson would still provide cheaper power" even with a diesel backup (PGR2023-00039, Paper 14 at 32) does not consider a POSITA's expectation that backup power was sized to power the primary oil and gas equipment load, leading to yet more undesirable downtime during backup power periods.

**2. No Reasonable Expectation of Success**

72. Aside from the unsupported, conclusory allegation that it was "easy" to combine Dickerson and CryptoKube (Petition, 20), the Petition does not address the reasonable expectation of success prong of obviousness analysis.



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73. As I discuss above, before the ’372 invention, a POSITA would have considered the variable and even occasional excess power generation in Dickerson to be *unreliable* and therefore unsuitable for a bitcoin miner such as CryptoKube. This was contrary to conventional understanding which was to run the miner at full hashrate any time the miner was operating. Therefore, contrary to Petitioner, a POSITA would not consider it “easy” to combine Dickerson and CryptoKube even assuming, *arguendo*, that a POSITA considered the combination at all.

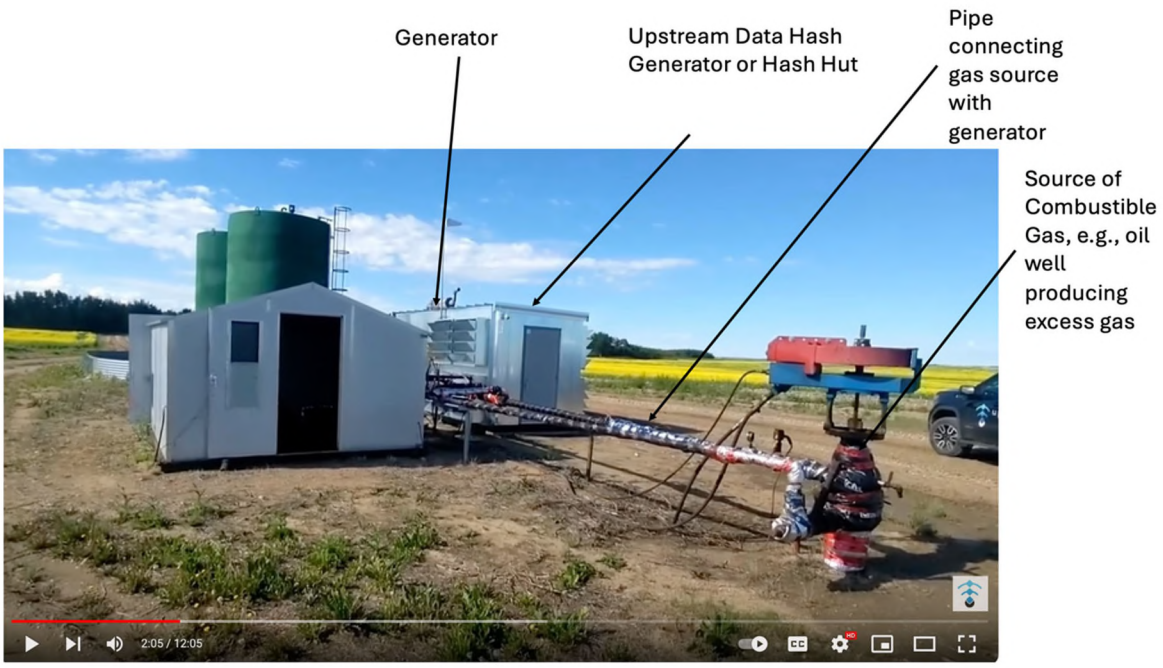
### 3. Secondary Considerations of Non-Obviousness

74. For this portion of my declaration, I have relied on the declaration of Mr. Barbour (EX2011), the named inventor of the ’372 patent and founder of Patent Owner, Upstream Data. For consistency, I have copied relevant portions of Mr. Barbour’s declaration, modifying them as needed to reflect my opinions. As set forth below, I agree with Mr. Barbour’s analysis of how Upstream Data products embody certain ’372 patent claims; I also agree with his views on issues such as long-felt need, industry skepticism and praise.

75. In my opinion, the secondary considerations of non-obviousness discussed below apply equally and in the same manner to all five obviousness grounds in the Petition.

#### a. Patent Owner’s systems embody the claimed invention

76. In my opinion, Patent Owner's systems such as Upstream Data Hash Hut and Hash Generator embody claims 1 and 24 of the '372 patent. (For this analysis I applied the parties' proposed claim constructions. I applied plain meaning to claim terms without a proposed construction. I have included parentheticals identifying exemplary claim limitations met by Patent Owner's systems.) For example, as illustrated in the following annotated diagram using a screenshot from an Upstream Data promotional video available on YouTube, Hash Hut and Hash Generator systems are installed with a source of combustible gas such as gas produced at an oil wellhead (limitations *[1 pre], [1a]*). EX2011, ¶¶7, 7-10. A continuous flow of this gas is supplied to a generator through a pipe where the generator may be co-housed with blockchain mining equipment as illustrated in the screenshot (Hash Generator model), or located in a separate adjacent enclosure (Hash Hut model) (limitations *[1b], 1[c]*):




EX2011, ¶10.

77. Petitioner has identified a single CryptoKube or Polivka system with multiple ASIC mining servers as satisfying the "blockchain mining devices each having a mining processor" limitations. Under this view an installation with a single Upstream Data system with plural mining servers likewise meets the limitation.

78. While the above example shows an installation with a single Upstream Data system, many such installations comprise multiple systems. The following photograph shows an installation with multiple Hash Generator systems running on stranded gas at an oil production facility (*[1b], [1c]*):



EX2011, ¶11.

79. The next screenshot shows the generator in its section of the enclosure (limitation *[1b]*):




EX2011, ¶12.

80. Each Upstream Data blockchain mining device such as a Hash Generator or a Hash Hut houses a number of mining processors - shown in the next screenshot are racks of blockchain miners inside the enclosure, in this case Bitmain Antminer S9 ASIC miners (limitation *[1c_i]*):

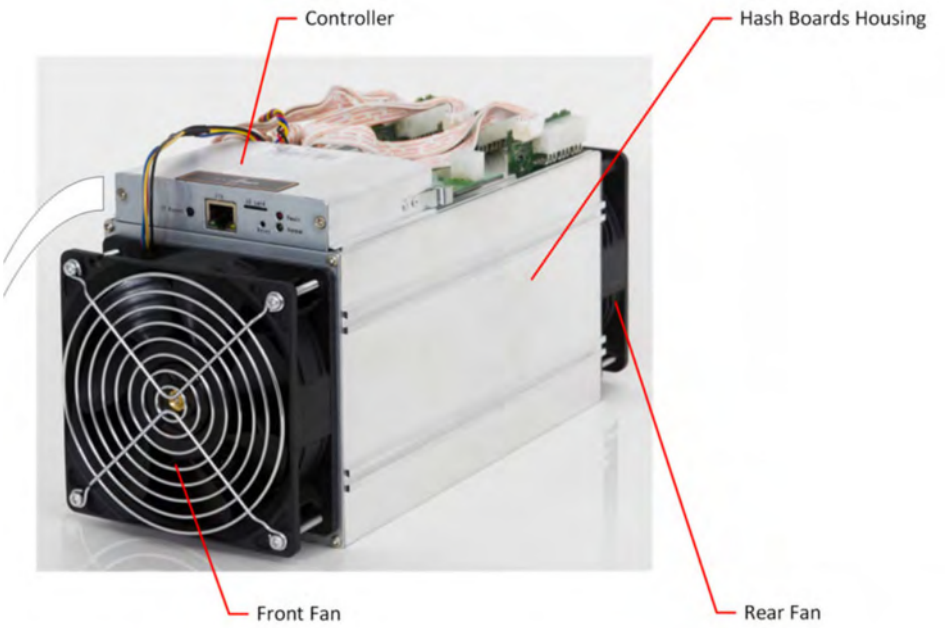



EX2011, ¶13.

81. Each miner is connected to the Hash Generator's or Hash Hut's network interface as illustrated by the blue Ethernet cables in the screenshot above. The network interface typically comprises a cellular or satellite modem, including the corresponding antennas visible in the image of a multiple Hash Generator installation above. (limitation *[1c_ii]*). The modem comprises an internet connection with access to nodes comprising a blockchain database. EX2011, ¶14.

82. A miner such as the S9 (a mining processor) comprises hash boards with dedicated blockchain mining ASICS and a controller performing a number of

functions, including network communication with blockchain database nodes as illustrated in the following diagram from an S9 installation guide (limitation *[1c_iii]*):




EX2015, 5; EX2011, ¶15.

83. In addition, Petitioner contends that ASIC chips disclose element *[1c_iii]*. If this is accepted, ASIC chips in an S9 or similar miner likewise meet this limitation for this additional reason. Under this reasoning, each S9 or similar miner is the claimed "blockchain mining device" and each ASIC integrated circuit is a "mining processor."

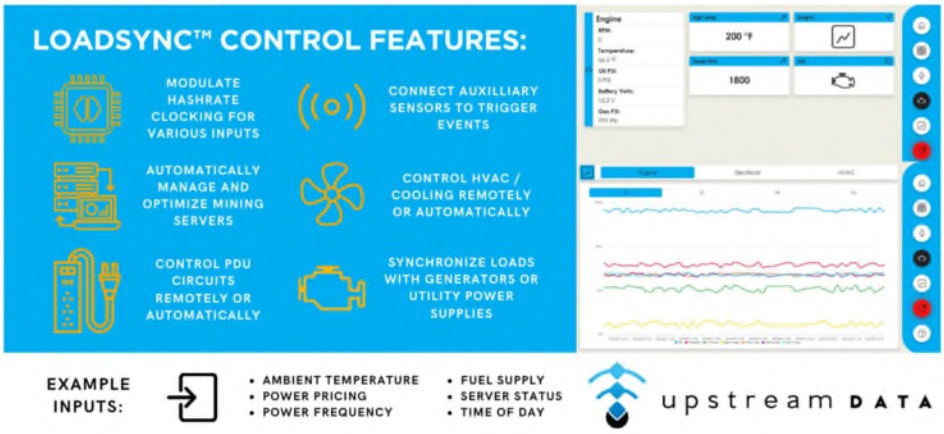
84. Bitcoin protocol defines a peer-to-peer network for accessing nodes of a distributed blockchain database storing Bitcoin transactional information (limitations *[1c_iv], [1c_v], [1c_vi]*).

85. Claim 24 is substantially similar to claim 1 and is embodied in Upstream Data's products for the same reasons.

86. Moreover, in my opinion Patent Owner's systems such as the Upstream Data Hash Hut and Hash Generator embody claims 10-12 and 29, 34-37 of the '372 patent. These systems are available with an optional controller to perform load balancing by increasing or decreasing mining activity (claims 10 and 35). EX2011, ¶18. This was done by controlling circuits to increase or decrease number of active servers (claims 11 and 36), including in response to variable gas production rate (claims 12 and 37). The current generation controller (LoadSync), illustrated in a capture from Upstream Data's website and reproduced below) continues to offer these functionalities, e.g., "automatic load balancing… to align variable natural gas fuel supply with generator loading:"

*"Our patented LoadSync™ controller can be seamlessly integrated into any Hash Hut™ or Hash Generator™ loadcenter. This controller adjusts the hashrate (loading) on the energy system to maintain a perfect balance with energy supply and demand based on user requirements. LoadSync™ offers full remote management of the loadcenter while also automating loading to balance the power system. For example, it can be used to align variable natural gas fuel supply with generator loading in order to conserve vented or flared gas, or it can be employed to regulate energy consumption in accordance with fluctuating power prices from utility providers. The LoadSync™ controller is adaptable to all scenarios requiring load matching to variable energy supply! Additionally it functions as a mining server management tool, facilitating user set up, monitoring and optimization of their mining farm from anywhere in the world."*

*- Steve Barbour, President*




EX2011, ¶18.

87. As seen in the images above, Upstream Data systems are connected to gas sources comprising remote oil and gas wells (claim 29). Hash Generator and Hash Hut systems mine Bitcoin transactions with their ASIC mining servers such as Antminer S9 and communicate wirelessly through cellular or satellite modems (claim 34).

**b. Commercial success**

88. For this factor, I rely on Mr. Barbour's declaration (EX2011, including ¶¶20-25) which I have reviewed. I agree that Upstream Data's systems embodying the '372 patent have achieved substantial commercial success, selling hundreds of

units in a competitive market landscape and leading industry adoption of cryptocurrency mining as a viable way of mitigating the stranded gas problem.

**c. Long-felt unmet need**

89. Patent Owner's pioneering products solved a widely recognized and long-standing problem of stranded gas that was either released or flared at oil and gas production facilities. The problem was well-described in a 2022 CNBC article regarding Bitcoin mining powered by stranded gas: "For years, oil and gas companies have struggled with the problem of what to do when they accidentally hit a natural gas formation while drilling for oil. Whereas oil can easily be trucked out to a remote destination, gas delivery requires a pipeline. If a drilling site is right next door to a pipeline, they chuck the gas in and take whatever cash the buyer on the other end is willing to pay that day. But if it's 20 miles from a pipeline, drillers often burn it off, or flare it. That is why you will typically see flames rising from oil fields." EX2016, 2.

90. As further noted in the '372 patent, "[v]enting gas to atmosphere is the most cost effective option for the operator but may have the most negative impact on the environment." EX1001, 7:61-64. Flaring gas is likewise problematic because it is expensive and wasteful. EX1001, 8:1-10. Yet, in the absence of a counterparty (*e.g.,* a pipeline or electric grid), venting or flaring were the only stranded gas disposal methods recognized in the art.

91. Petitioner recognized the same long-felt unmet need in its own patents. In August 2018, approximately a year and a half after the priority date of the ’372 patent, Petitioner filed provisional U.S. patent application No. 62/713,368 which is related to U.S. Pat. No. 10,862,307, assigned to Petitioner. EX2002. Like the challenged ’372 patent, Petitioner’s ’307 patent was directed to a “natural gas processing system [which] may process raw natural gas into a fuel gas stream that may be used to power any number of on-site power generation modules” including “mobile data centers… adapted to mine cryptocurrency.” EX2002, Abstract. During prosecution Petitioner’s patent claims were rejected over U.S. Pat. Pub. 2020/0051184 to Barbour which corresponds to the ’372 patent. EX2003, 05-07-2020 Office Action.

92. In the ’307 specification’s Background section Petitioner noted that “large-scale flaring of natural gas has raised serious environmental and health concerns” and asserted that “there remains a need for systems and methods for generating electricity from natural gas produced from oil wells,” and that “[i]t would be beneficial if such electricity could be produced and consumed on-site, for example by using it to operate power-intensive, modular processing units… employed to mine cryptocurrency.” EX2002, 1:55-57, 2:35-42. The ’307 summary section described “convert[ing] raw natural gas into a fuel gas stream to power any number of on-site power generation modules” which in turn power “distributed

computing units" that "may be adapted to mine cryptocurrency." *Id.*, 2:45-55. Thus, as acknowledged by Petitioner's expert, its '307 patent in 2018 proposed to combine power generated from flare gas with computing units adapted to mine cryptocurrency as a solution to an existing problem. EX2022, 44:5-14.

**d. Industry skepticism**

93. As I discussed above in connection with the lack of motivation to combine, the oil and gas industry did not know about crypto mining and therefore rejected it as a way to reduce the stranded gas problem. Instead, the industry believed that a counterparty such as a grid or pipeline were necessary if flaring was to be avoided. The crypto-mining industry was not knowledgeable about the oil and gas business, was unaware of the stranded gas issue and did not understand that flare gas could profitably and reliably power a cryptocurrency miner. Below are some examples of this universal skepticism:

94. ***"Laughed out of the room:"*** in 2018 Adam Ortolf, Patent Owner's current sales manager, "'got laughed out of the room when I talked about mining bitcoin on flared gas:' 'The concept of bringing hydrocarbons to market without a counterparty was laughable.'" "Fast forward four years, and business at Upstream is booming. It now works with 140 bitcoin mines across North America." EX2016, 6.

95. ***"Stupidest thing I've ever heard:"*** in a 2022 interview the founders of Giga, one of Patent Owner's early customers and current competitors, described their interactions at a 2020 industry conference when they handed out materials describing powering Bitcoin miners with stranded gas: "A lot of people didn't know about it. Most people laughed at us. Most people said, 'It's the stupidest thing I've ever heard.'" EX2016, 8-9. Notably, Giga's founders also described the idea of crypto-mining with stranded gas as an "obvious solution" to them in 2019 after they purchased Patent Owner's system, three years after the '372 priority date. EX2016, 2-3.

96. ***"Bewildered Crowd:"*** '372 inventor Mr. Barbour, in an interview with the Wall Street Journal in March 2019, noted continuing industry skepticism: "But he has struggled to get oil-industry veterans interested in mining cryptocurrencies. In September, he showcased a rough version of his mining container at an oil show in Lloydminster, a city on the Alberta and Saskatchewan border, to a bewildered crowd. 'Locally, pretty much nobody knows what bitcoin is,' he said." EX2017, 6.

97. ***"Pipe Dream:"*** a 2018 article with that title describes Wall Street analysts with a "unique idea" to mine Bitcoin with stranded gas in the Permian basin: "shale producers would capture the excess natural gas and use it to produce electricity, which would then be used to power an on-site Bitcoin mining operation." EX2018, 4-5. However, bowing to ingrained conventional wisdom in

the industry the analysts concluded that such a project "will remain, for now, a dream." *Id.*

98. ***"No version of this will ever work:"*** Petitioner's co-founder and named inventor on '307 patent, Cully Cavness, gave a presentation at a TEDx event, a video of which is available on YouTube at https://www.youtube.com/watch?v=0CerPYbKx78. Mr. Cavness discussed Petitioner's technology which, like the earlier invention of the '372 patent, comprised powering Bitcoin miners with energy generated from stranded gas; at approximately the 15:36 mark Mr. Cavness described pitching this concept to a potential partner whose reaction was "No version of this will ever work." EX2019; EX2011, ¶35.

99. At his deposition Petitioner's expert recalled telephone discussions with potential customers in the 2014-16 timeframe regarding connecting a CryptoKube to a flare gas-powered generator but testified that none resulted in a sale and that "[t]hey did not connect a Crypto Kube to their flare gas powered generator." EX2022, 19:3-20:10. This is unsurprising in view of the skepticism in the industry about the technological and financial feasibility of this combination before the invention of the '372 patent.

**e. Industry Praise**

100. Patent Owner and its technology embodying the ’372 patent invention have been recognized as industry pioneers. For example, a September 5, 2022 report by K33 Research, an industry publication, asserted in its title that “Bitcoin mining using stranded natural gas is the most cost-effective way to reduce emissions.” EX2020, 1. The report acknowledges Upstream Data as a “leading company” and credits Patent Owner with having “***pioneered the concept in 2017***.” *Id.*, 7. (emphasis added).

101. Writing five years after the ’372 patent priority date, K33 Research noted the advantages of Bitcoin mining as a way to soak up stranded gas: “Because bitcoin mining is an unconstrained location-agnostic process, bitcoin miners can come directly to oil wells to eat up the excess natural gas. In addition, since oil sites typically produce declining amounts of excess natural gas as they mature, an offtaker must be able to scale down its operation modularly. Bitcoin mining is a modular process since you can combine different numbers of machines into varying energy usage levels.” EX2020, 7.

102. Patent Owner’s pioneering technology is what allowed the industry to recognize these advantages in the face of pervasive industry skepticism. As discussed above, the oil and gas industry believed that only a traditional counterparty such as an electric grid or gas pipeline made it worthwhile to invest in equipment to offload stranded gas. The cryptocurrency mining industry believed

that industrial miners such as CryptoKube or Polivka needed to run at maximum hashrate and little downtime to make a profit, therefore fixating on hydroelectric power as the low-cost and reliable solution. Patent Owner's Hash Hut and Hash Generator technology embodying '372 patent claims changed the paradigm of both industries, thereby giving rise to what the K33 Research report characterized as "massive oil field bitcoin mining growth over the past few years" and creating a "valuable tool in our toolbox for mitigating gas flaring." EX2020, 6, 8.

**4. Ground 1 Does Not Disclose Challenged Claims**

**a. Claim 1**

*1[c_i] the blockchain mining devices each have a mining processor and are connected to a network interface;*

*[1c_iii] the mining processors are connected to the network interface and adapted to mine transactions associated with the blockchain database and to communicate with the blockchain database;*

103. The Petition does not identify the claimed "mining processor" in the proposed combination. Petition, 23, 25. However, the Petition clearly identifies "spondooliestech SP35 servers" as the claimed "blockchain mining devices:" "CryptoKube is built inside an ISO shipping container and is filled with spondooliestech SP35 servers, that is, blockchain mining devices, each necessarily having a mining processor." Petition, 23.

104. If spondooliestech SP35 servers in a single CryptoKube container are the plural "blockchain mining devices" required by the independent claims, then some unidentified component of the spondooliestech SP35 server must be the "mining processor." A POSITA would understand these to be distinct claim limitations.

105. At his recent deposition Petitioner's expert for the first time specified that the "mining processor" was an ASIC chip in a spondooliestech server:

Q. You did not opine that the Spondoolies-Tech SP31 or SP35 servers themselves have a claimed mining processor, correct?
A. Correct.
Q. You did not identify any specific processor in these servers as the alleged mining processor, correct?
A. I didn't identify specifically, no.
Q. You don't know what processor allegedly was in the Spondoolies-Tech SP31 or SP35 servers, right?
A. I did in 2015. I don't recall the actual processor now.
Q. Okay. And you didn't identify it in your declaration, correct?
A. I did not.
Q. Now, the processor that in your opinion is necessarily present in the Spondoolies-Tech SP 31or SP35 servers is an ASIC, correct?
A. That is an ASIC processor of Spondoolies, correct.
Q. And in fact, there would be some number of these ASIC processors, correct?
There would be multiple ASIC processors in a Spondoolies SP35.
Q. And the ASIC processor is an integrated circuit, correct?
A. You would identify it as an integrated circuit.
Q. So in other words, it's a chip, right?
A. ASIC processor is a chip.
Q. And so the mining processor that you are saying is necessarily present is an ASIC chip, correct?

A. The mining processor in an SP35 or SP31 is an ASIC chip.

EX2022, 59:9-60:16 (emphasis added).

106. In my opinion an ASIC chip in a spondooliestech server does not meet the "connected to the network interface and adapted to. . . communicate with the blockchain database" limitations in element *1[c_iii]*.

107. While Petitioner has not provided any evidence regarding ASIC chips in spondooliestech SP35 servers, the '372 patent specification illustrates a POSITA's understanding. The specification at col. 17:9-22 describes typical mining processors known to a POSITA at the time of the invention and explains that "[e]ach mining processor 92 may have a variety of configurations, but generally may include at least a power supply, a controller board and mining circuitry, such as an ASIC circuit." EX1001, 17:9-22.

108. The specification further describes an "ASIC mining processor" that a POSITA would recognize as exemplary of spondooliestech SP35 and similar ASIC mining servers known at the time of the invention. EX1001, 17:15-21; EX2022, 64:7-25. The ASIC mining processor includes hash boards, a controller, and a power supply. EX1001, 17:15-21. The hash boards comprise "numerous chips that is *[sic]* doing the hashing." EX1001, 17:15-17. A POSITA understood that "hashing" refers to the computations required to mine blockchain transactions performed by the ASIC chips on hashboards. EX1001, 13:57-58.

109. Accordingly, mining was the *only* activity performed by ASIC chips such as those in spondooliestech SP35 and similar ASIC mining servers known at the time of the invention and used in miners such as CryptoKube. EX1001, 17:15-21; EX2022, 61:1-7. Therefore, such ASIC chips were not "connected to the network" or "adapted… to communicate with the blockchain database" as required by the claim language. EX1001, claims 1, 24.

110. Network connection and communication with the blockchain database was handled by other components in ASIC mining servers known at the time of the invention and used in miners like CryptoKube. For example, the '372 patent specification discloses a controller component of an ASIC mining processor "to communicate with the network." EX1001, 17:15-19. However, a POSITA would not understand this component to be a "mining processor" and Petitioner has not identified it as such. Moreover, unlike the ASIC chip, the controller component does not mine transactions as required by the claim language.

111. More generally, the '372 specification describes (and illustrates in Figs. 6A-6B) nodes 122 on a blockchain network with a distributed blockchain database stored on the nodes. EX1001, 14:21-25. A node comprises "[m]ining circuitry 130, for example an integrated circuit chip, may be used to perform data mining operations, for example verifying cryptocurrency transactions," while "[n]etwork communication hardware 131 may be used to communicate with other

nodes and the network in general." EX1001, 14:61-65, Figs. 6A-6B. This is another illustration of the distinction between mining operations performed by an integrated circuit chip and communication operations with the network and blockchain database which use other components. In view of these teachings a POSITA would not understand an ASIC integrated circuit in a spondooliestech or similar prior art ASIC mining server to be "connected to the network" or "adapted… to communicate with the blockchain database" as claimed.

112. The Szhmigielski reference likewise describes mining ASICs as "microprocessors built for a single function," that is "to perform the SHA-256 hash function that is used in Bitcoin." EX1009, 76. Thus, a POSITA would understand that functions other than computing the hash function are performed by other components. Mining was typically performed with mining software such as cgminer. EX1009, 30. In the case of an ASIC miner, the software ran on a controlling computer and establishes communication with the network and blockchain database. EX1009, 77, 82. The software constructed a candidate block that is then hashed. EX1009, 30. A POSITA would understand that in an ASIC miner the hashing is offloaded to ASIC integrated circuits which are specifically designed solely for this purpose. "When a successful hash is found, the software submits the solved block to the network for verification." EX1009, 30. Thus, considered from the software perspective, it is the mining software that

communicated with the blockchain database through network communication components. Mining software did not run on the ASICs themselves because they were dedicated hashing circuits rather than CPUs. These teachings further illustrate that a POSITA would not understand an ASIC integrated circuit in a spondooliestech or similar prior art ASIC mining server to be "connected to the network" or "adapted… to communicate with the blockchain database" as claimed.

**113. Claim 24**

114. Petitioner relies on its discussion of claim 1 for these limitations. Petition, 44. Accordingly, they are not met by the proposed combination for the same reasons as claim 1.

## VIII. GROUND 2

### 1. Motivation to Combine and Reasonable Expectation of Success

115. My review of Ground 2 shows that it combines the primary references of Ground 1 (Dickerson and CryptoKube) with Belady-989. Petition, 99-100. Petitioner does not offer any additional rationales for combining Dickerson and CryptoKube beyond those discussed above for Ground 1. Accordingly, as I already explained for that ground, in my opinion a POSITA did not have a motivation to combine or reasonable expectation of success for those two references.

116. In Ground 2, Petitioner alleges that it was obvious to combine Belady-989's so-called gas shock absorber with the "Dickerson's mobile power generation

system" and the "CryptoKube's mobile Bitcoin miner." Petition, 50. The purported motivation for this further combination is to "improve the energy usage efficiency." Petition, 51.

117. I note that the Petition does not explain how a POSITA was supposed to combine the Belady-989 gas shock absorber with Dickerson, nor does the Petition address the reasonable expectation of success.

118. In my opinion, there are several reasons why a POSITA would not be motivated to combine Belady-989 shock absorber with Dickerson or with CryptoKube.

119. As an initial matter, Dickerson already teaches addressing "no or low levels of raw natural gas" with "an auxiliary means for providing electricity" comprising a "stand-by diesel generator" or a CCHP (combined cooling, heating, and power) unit. EX1005, ¶21. There is no evidence that a POSITA would consider layering the complex gas shock absorber in Belady-989 on top of the proven solutions already provided by Dickerson.

120. Furthermore, as I discussed for Ground 1, the main purpose of the Dickerson generator is "to generate electricity that is returned to the facility" rather than powering another load. EX1005, ¶6. Moreover, the amount of gas available to power Dickerson's generator varies such that only "in some cases the amount of electrical power required… may be small compared to the amount of power that

can be produced with the gas available." EX1005, 39. Even in these cases, Dickerson taught sending any excess power to the grid if it was connected. *Id.* A POSITA would understand that at times when auxiliary power is required due to lack of feed gas, Dickerson's generator could not supply "excess" power to an external load such as CryptoKube because no "excess" power is available.

121. Likewise, if Belady-989's shock absorber was hypothetically substituted for Dickerson's auxiliary power, a POSITA would understand that gas from the shock absorber tank would be drawn at times when not enough feed gas was available from the well. In this regard, Belady-989 taught that gas was provided by the shock absorber at times of a "negative pressure spike" when feed gas pressure is low. EX1011, ¶25. A POSITA would understand that during such a "negative pressure spike" Dickerson's generator would then use the provided gas for its primary purpose of powering the oil production facility rather than an external load.

122. Accordingly, a POSITA would not be motivated to add Belady-989's complex gas shock absorber because doing so would not solve the unreliability of Dickerson's "excess" electrical output for powering a power-hungry external load like CryptoKube.

123. Moreover, Belady-989's gas shock absorber operated in a manner that was incompatible with crypto mining's need for reliable power as articulated by

Szhmigielski. EX1009, 105. Gas shutoff during positive pressure spikes interrupted gas flow to the Belady-989 generator which would prevent CryptoKube miner from operating. EX1011, ¶23. The incompatibility of Belady-989's operation during positive pressure spikes with CryptoKube's requirement of reliable power indicates that a POSITA would not have considered the combination and would not have had a reasonable expectation of success.

124. Gas shutoff would also disable Dickerson's generator, preventing it from powering oil field equipment or CryptoKube. The incompatibility of Belady-989's gas shock absorber with Dickerson's requirement to power mining equipment indicates that a POSITA would not have considered the combination and would not have had a reasonable expectation of success.

**2. Ground 2 Combination Does not Disclose Challenged Claims**

**a. Claims 1, 24**

125. Petitioner relies on CryptoKube in the same manner as Ground 1 and does not provide any additional analysis for limitations *[1c_i]* and *[1c_iii]* regarding "mining processor." Petition, 52-53. Accordingly, these limitations and the corresponding limitations in claim 24 are not met for the reasons stated for Ground 1 above.

**b. Claims 10-13**

126. Petitioner alleges that CryptoKube's DCIM software "can be customized to monitor and control the individual miners," citing EX1023, 0:00:08. Petition, 57. However, the video EX1023 does not disclose that this software *controls* the servers or that there is hardware that can be controlled by software to "turn[] off a certain number of mining processors" as alleged by Petitioner. For example, there is no evidence that CryptoKube's PDU (power distribution unit) could be controlled remotely to selectively power off miners. Therefore, the modification to CryptoKube suggested by Petitioner would involve significant changes to both hardware and DCIM software. Petitioner has not shown that these modifications were within the ordinary skill or could be accomplished without undue experimentation and with a reasonable expectation of success.

127. Moreover, there was no motivation for a POSITA to attempt this modification. As discussed above, the conventional knowledge in the art before the invention of the '372 patent held that industrial ASIC miners like CryptoKube should operate at maximum uptime and full hashrate. Accordingly, if sufficient power was not available, a POSITA expected an industrial miner like CryptoKube to shut down all of the mining hardware to prevent potential damage. For example, mining servers could be damaged by voltage and frequency drop in the power supply. Likewise, unlike typical data center servers, ASIC miners generated intense heat in a small form factor such that the failure or reduced flow rate of CryptoKube

cooling in case of insufficient power could damage the miners. This would lead a POSITA to turn off all the miners rather than modulate the load by selectively turning on or off some of them as suggested by Petitioner.[1] For this reason there was no need for hardware or software support for the kind of event-driven selective turn-off as suggested by Petitioner.

128. In this regard an industrial miner like CryptoKube or Polivka differed from a data center in Belady-989 that would throttle down or offload processing. EX1011, Abstract. Petitioner relies on Szhmigielski's statement that "[i]ndustrial miners face almost the same issues as data centers" for the motivation to combine. Petition, 54; EX1009, 103. However, Petitioner ignores Szhmigielski's teaching that, in addition to common challenges, "largescale Bitcoin mines face numerous unique issues." EX1009, 105. Unlike a data center, there was no way to offload blockchain processing from a CryptoKube. Moreover, unlike a data center, before the invention of the '372 patent a POSITA expected industrial miners to operate in

[1] Petitioner has not suggested that turning off all the mining processors at the same time meets the "modulate a power load level" limitation in claims 10 and 11 or "increasing or decreasing a maximum number of mining processors" limitation in claim 11. A POSITA would not understand a total shutoff of a CryptoKube or its miners to meet these "modulating" limitations.

an all-or-nothing fashion for the reasons discussed above. Accordingly, a POSITA would not consider Belady-'989's solution of throttling down or offloading applicable to industrial miners like CryptoKube.

129. Petitioner's proposed modifications to DCIM software, even if implemented, would control whether a spondooliestech miner is on or off. Petition, 57. The claims at issue are directed to "increasing or decreasing the mining activity of the mining processor," (claim 10) which Petitioner's expert reads on the ASIC chip. A POSITA would expect individual ASIC chips to be un-addressable by CryptoKube's DCIM and Petitioner has not presented any evidence to the contrary. Therefore, CryptoKube's own DCIM software could not turn on or off individual ASIC chips within a miner (claim 11) or increase or decrease the mining activity of an ASIC chip (claim 10) in some other unspecified manner.

130. Finally, as discussed above, a POSITA in the oil and gas industry was not a POSITA in the Bitcoin mining industry and vice versa. (Petitioner's expert conceded that he was not aware of any persons of ordinary skill in the Bitcoin mining industry who were also a POSITA in the oil and gas industry. EX2022, 16:23-17:3.) An oil and gas industry POSITA who could, *arguendo*, attempt to modify Dickerson "to use Belady-'989's gas supply shock absorber," Petition, 51, was not a POSITA in the Bitcoin industry. Therefore, they could not attempt to reprogram DCIM software in the CryptoKube miner as suggested by Petitioner

without undue experimentation and with a reasonable expectation of success for this additional reason.

**c. Claims 35-37**

131. These claims are substantially similar to claims 10-12 and are not obvious for the same reasons.

## IX. GROUND 3

### 1. Ground 3 is Unclear

132. I note the lack of clarity in the Petition and declarations regarding what elements of Boot are being combined. For example, Petitioner's analysis of limitation 1[b] implies that it is relying on Boot for the "generator" limitation. Petition, 69-70. If that is the case, the Petition is silent on what role, if any, Dickerson's generator or other components play in the proposed combination. In this regard, for limitation 1[c], which recites "blockchain mining devices connected to the generator," the Petition cites to Ground 2 without any further explanation. Petition, 70. However, Ground 2 does not include Boot so it is unclear whether Petitioner is relying on Boot's, Dickerson's or Belady-989's generator for element 1[c].

### 2. Motivation to Combine and Reasonable Expectation of Success

133. Ground 3 combines the primary references of Ground 1 (Dickerson and CryptoKube) and Ground 2 (Belady-989) with Boot. Petition, 67-68. Petitioner does not offer any additional rationales for combining Dickerson, CryptoKube and

Belady-989 beyond those discussed above for Grounds 1 and 2. Accordingly, there would be no motivation to further combine the references in Grounds 1 and 2 with Boot for at least the same reasons as above.

134. Petitioner has not shown a motivation to combine for the following additional reasons. Boot teaches a specialized system "to provide electrical power to an electric submersible pumping system positioned in a well that produces petroleum products." EX1012, 1:50-53. Boot's specialized system is unlike Dickerson's generator that supplied power for the entire oil or gas production facility. EX1005, ¶11. The small number and power requirements of the pump-related loads supplied by Boot "cause the power demand to be relatively volatile." EX1012, 2:55-58. To keep the genset engine from over-revving when a load goes offline, Boot proposed a load bank 110 "activated to take-up the excess power and stop the engine 112 from racing." EX1012, 3:8-10. Boot described the load bank as optional even in its specialized system. EX1012, 2:27-28.

135. Boot is not directed to full-facility generators like Dickerson. A POSITA would understand that a load bank was unnecessary in Dickerson's system (and therefore an unneeded expense) because it powered a larger number of loads and included other mechanisms for soaking up excess power. For example, Dickerson teaches adding a gas chiller where "only a small portion of the raw natural gas generated by the facility is needed to power the facility." EX1005, ¶22.

Unlike a load bank that dissipates energy unproductively, "the chiller is powered by electricity from the generator, and the chiller's consumption of electricity furthers the goal of reducing flaring, since the added electricity demand enables the generator to unitize more methane." *Id*. Thus, instead of dissipating energy in a load bank, the chiller soaked up electricity, reduced flaring by keeping up methane consumption, and produced NGLs (natural gas liquids) that could be sold offsite. EX1005, ¶22. To a POSITA the differences between Boot and Dickerson would not be a mere matter of relative desirability of Boot's solution. Rather, a POSITA would consider Boot's load bank to be entirely unnecessary in Dickerson's system. Therefore, in my opinion a POSITA would not seek to combine Boot's load bank with Dickerson.

## X. GROUND 4

### 1. Motivation to Combine and Reasonable Expectation of Success

136. For the following reasons it is my opinion that Petitioner and Messrs. Nikolaou and Kasdorf have not shown a motivation to combine or a reasonable expectation of success with regard to Ground 4.

137. Like the Dickerson-based grounds considered above, Ground 4 relies on a hindsight-driven combination of gas processing equipment (MAGS) and a crypto miner (Polivka). The relevant aspects of these references as presented by Petitioner are similar to Dickerson and CryptoKube such that many of the same

reasons would lead a POSITA to *not* combine these references. For example, like CryptoKube, Polivka was a containerized industrial cryptocurrency miner. MAGS, like Dickerson, conditioned flare gas as fuel for a generator powering the oil and gas facility. EX1013, 2. A comparison of the Petition's motivation to combine sections for Grounds 1 and 4 reveals that Petitioner has merely substituted MAGS for Dickerson and Polivka for CryptoKube while repeating almost verbatim the same flawed rationale based on Szmigielski. Petition, 19-20, 81-83.

138. Accordingly, a POSITA lacked a motivation to combine MAGS and Polivka for the same reasons as Dickerson and CryptoKube. Likewise, the same secondary considerations of validity established for Dickerson Grounds 1-3 above apply equally to the MAGS-based Grounds 4 and 5.

139. Moreover, a POSITA would consider MAGS to be even less suitable for the proposed combination than Dickerson. This is because there is no teaching that MAGS could produce sufficient excess electrical output to power Polivka even occasionally. In fact, there is evidence to the contrary. As described by Petitioner, MAGS separated input gases into three streams: "one can be captured in tanks and shipped off for sale, another powers generators that run the drilling operation, and a third powers MAGS itself." Petition, 81-82. Thus, all the energy produced by MAGS – whether in the form of gas or electric power – was already spoken for. Some of the output was separated from the gas stream so it could be shipped for

sale to a remote counterparty; some energy went to power the operation that produced the input gas; and the rest went to power MAGS itself. EX1013, 2.

140. Therefore, Petitioner is incorrect in stating that "a POSITA would have understood that MAGS can produce cheap or free electricity using flare gases" because the electrical output supplied either MAGS itself or the oil or gas production equipment. Petition, 82. Accordingly, there is no evidence that MAGS was suitable to power a notoriously power-hungry external load such as Polivka's bitcoin miner.

141. A POSITA would consider even the best-case electrical output in MAGS as insufficient for Polivka's miner. For example, the Young reference describes a MAGS-200 system consuming gas of a composition typical for the Bakken formation. EX1014, ¶¶143-145. The system was projected to produce about 450kWh of electrical power per day. EX1014, ¶144. The Polivka reference provides an example of Polivka's miner consuming 120.3kW. EX1015, 25. At that power level Polivka's miner would consume the entire daily electrical output of MAGS in less than four hours even assuming an extremely unlikely scenario where none of the power was used to power MAGS or wellhead equipment.

142. Operating an expensive crypto miner for a few hours every day was and is prohibitively uneconomical. Like the $60,000 CryptoKube, a POSITA understood the even more powerful (100+kW) Polivka to require a full hashrate

and minimum downtime. Therefore, a POSITA would not be motivated to combine Polivka with an unsuitable power source in MAGS.

143. In any case, evidence shows that MAGS could not supply the power necessary to operate Polivka for *any* amount of time. At his deposition Petitioner's expert stated that he relied on the "power generator that also runs the drilling operation" in MAGS. EX2022, 83:4-9. He then admitted that his declaration (and therefore the Petition) presented no evidence as to whether there would be enough power left over in MAGS to power a Polivka miner. EX2022, 85:14-17.

144. With regard to the Young reference that allegedly describes MAGS, Petitioner's expert identified the engine in par. 242 as "the one that's powering the load."[2] EX2022, 89:8-13; EX1014, ¶242. Young teaches that this engine is rated for 150kW, but only "about 100kW" is required. EX1014, ¶242. Therefore, Petitioner's expert testified that a maximum of 50kW would be left over for this engine. EX2022, 89:17-24. This is plainly insufficient to operate Polivka's miner, which was advertised as approximately 100kW and shown operating at 120.3kW. EX1015, 1, 25.

[2] According to Petitioner's expert, this is in contrast to the engine in Young par. 241 which "powers the MAGS system." EX2022, 89:4-7.

145. A POSITA would not consider derating Polivka by running only a few mining servers – it would make no sense to invest in Polivka and then derate it to use an inadequate power source like MAGS. There also is no indication that the power output in MAGS could be scaled without undue experimentation as that would require changes to its complex gas conditioning components (described in Young as comprising "many innovations," EX1014, ¶173) as well as the generators. Moreover, as with Dickerson, a POSITA would not consider a separate MAGS to power Polivka because they understood MAGS was a multi-hundred-thousand dollar capital investment that would make crypto-mining cost-prohibitive compared to established power sources such as hydro. For these reasons a POSITA would have *no* expectation of success and would not consider the proposed combination.

146. With respect to reasonable expectation of success, the Petition states only that a "POSITA would have had a reasonable expectation of success in the combination at least because 'the first MAGS field unit was tested in the spring of 2014 and units were sent to North Dakota later that fall.'" Petition, 83, *citing* EX1013, 3. It is unclear how the testing of MAGS in North Dakota could bear on the expectation of success in combining MAGS with Polivka. A POSITA would not be motivated to combine MAGS with a crypto miner just because MAGS had been tested, where there was no evidence of success of said testing and no

indication of testing with a power-hungry external load like a crypto miner. In any case, a POSITA would have no reasonable expectation of success given the incompatibility of MAGS power output with Polivka's requirements discussed above.

147. As with Ground 1, in my opinion Szhmigielski teaches away from the combination of MAGS and Polivka because it sets forth the requirement that electrical power for crypto mining must be reliable, unlike MAGS' variable, inadequate or unavailable electrical output. EX1009, 105.

**2. Ground 4 Combination Does Not Disclose Challenged Claims**

**a. Claims 1, 24**

148. Petitioner's analysis of claim elements *[1c_i]* and *[1c_iii]* suffers from the same defects as Ground 1. The Petition does not identify the claimed "mining processor" in the proposed combination. Petition, 84-85. However, the Petition clearly identifies "spondooliestech SP31 servers" as the claimed "blockchain mining devices:" "blockchain mining devices (e.g., Spondoolies-Tech SP31) each have a mining processor and are connected to a network interface (e.g., a modem or a router)." Petition, 84.

149. If spondooliestech SP31 servers in a Polivka container are the plural "blockchain mining devices" required by the independent claims, then some

unidentified component of the spondooliestech SP31 server must be the "mining processor." To a POSITA these are distinct claim terms.

150. However, Petitioner's expert also identified the very same spondooliestech SP31 servers as a "mining processor." EX1004, ¶314. Thus, in contradiction to each other and the claim's recitation of separate "blockchain mining device" and "mining processor," the Petition and Petitioner's expert identified the *same* component as meeting the two limitations.[3] These conclusory and contradictory statements make the Petition incomprehensible.

151. If the "blockchain mining device" in this ground is a spondooliestech SP31 server (as Petitioner alleged for limitation *[1c_i]*, Petition, 84), then, as with Ground 1, Petitioner must be relying on an ASIC chip in the server as the claimed "mining processor." In this case, as established in Ground 1, the ASIC chip (or a hashboard comprising multiple such chips) does not meet at least limitation

[3] In PGR2023-00052, Petitioner's expert stated that "[i]f the term 'blockchain mining devices' refers to mining servers, then the term 'mining processor' cannot also mean mining servers." EX2021, ¶60. Accordingly, his identification of a spondooliestech SP31 mining server as both a blockchain mining device (EX1004, ¶306) and mining processor (EX1004, ¶314) contradicts his opinion in that proceeding.

*[1c_iii]* because it is not connected to the network interface and is not adapted to communicate with the blockchain database; instead, its only function is to hash.

152. If the "mining processor" is the spondooliestech server itself then some other devices must be the "blockchain mining devices" of the claims. What these other devices may be is not disclosed in the Petition or by Petitioner's expert. There is certainly no identification of any devices other than spondoolisestech servers as the "blockchain mining devices" and no analysis of why such an unidentified combination would be obvious.

153. Petitioner relies on its discussion of claim 1 for these limitations of claim 24. Petition, 96-97. Accordingly, they are not met by the proposed combination for the same reasons as claim 1.

## XI. GROUND 5

### 1. Motivation to Combine and Reasonable Expectation of Success

154. Ground 5 combines the primary references of Ground 4 (MAGS and Polivka) with Belady-'989. Petition, 99-100. Petitioner does not offer any additional rationales for combining MAGS and Polivka beyond those discussed above for Ground 4. Accordingly, there would be no motivation to further combine the references in Ground 4 and Belady-989 for at least the same reasons as Ground 4 above.

155. In Ground 5, Petitioner alleges that it was obvious to combine Belady-989's gas shock absorber with the "MAGS mobile power generation system" and the "Polivka mobile Bitcoin miner." Petition, 100. The purported motivation for this further combination is to "improve the energy usage efficiency." *Id.*

156. Petitioner does not explain how a POSITA was supposed to combine the gas shock absorber system with MAGS, nor does Petitioner address the reasonable expectation of success in even a cursory fashion.

157. In fact, no reasonable expectation of success was possible because a POSITA would conclude that Belady's gas shock absorber was incompatible with MAGS. For example, Belady-989 taught shutting off gas flow to the generator when supply gas pressure rises: "were the gas supply 110 to experience a positive gas pressure spike, the gas pressure sensor 171 of the pressure regulating valve 170 could detect such a high-pressure and could trigger the gas shutoff valve 171 to stop the flow of pressurized gas to the gas-to-electricity converter 180." EX1011, ¶23.

158. If Belady's system was connected to MAGS as proposed in Ground 5, a POSITA would understand that the sudden loss of feed gas could be substantially detrimental to MAGS operation. This is because inlet gas flow rate and system operating pressure were two "key" system parameters in MAGS. EX1014, ¶16; MAGS required the use of specialized flow controllers and valves to carefully

manipulate these parameters to achieve the desired methane number of the dry gas stream. EX1014, ¶18. Young further noted that MAGS required its inventors to "carefully select[] the process operations and process parameters." EX1014, ¶167. The sudden loss of gas pressure caused by Belady-989 gas shock absorber operation during a positive pressure spike could disrupt MAGS' carefully selected and adjusted gas flow and system pressure process parameters and even damage the MAGS equipment.

159. Accordingly, a POSITA would understand that at the very least an undue amount of experimentation and changes to MAGS and Belady-'989 would be required to determine whether these systems could operate together. The outcome would be uncertain at best because MAGS was so dependent on controlling gas flow rates. In any case, combining Belady-989 and MAGS would require a volume of experimentation and process knowledge beyond the level of one of ordinary skill.

**2. Ground 5 Combination Does Not Disclose Challenged Claims**

**a. Claims 1, 24**

160. Petitioner relies on Polivka in the same manner as Ground 4 and does not provide any additional analysis for limitations *[1c_i]* and *[1c_iii]* regarding "mining processor" and "blockchain mining devices." Petition, 101-102.

Accordingly, these limitations and the corresponding limitations in claim 24 are not met for the reasons stated for Ground 4 above.

**b. Claims 10-13**

161. Petitioner's conclusory analysis of claims 10-13 is substantially similar to Ground 2 with the substitution of Polivka for CryptoKube. Petition, 103-105. Accordingly, these claims are not invalid for the same reasons as Ground 2.

162. Petitioner alleges that a "POSITA would have found it obvious to control power load level of Polivka (e.g., by turning off a certain number of mining processors) using Belady- 989's method based on input from Belady-989's tank pressure sensor." Petition, 103. However, there is no evidence that Polivka had hardware and software that would permit this modification without undue experimentation and with a reasonable expectation of success.

163. Moreover, there was no motivation for a POSITA to attempt this modification. As discussed above, the conventional knowledge in the art before the invention of the '372 patent held that industrial ASIC miners like Polivka should operate at maximum uptime and full hashrate. Accordingly, if sufficient power was not available, a POSITA expected an industrial miner like Polivka to shut down all of the mining hardware to prevent potential damage. For example, mining servers could be damaged by voltage and frequency drop in the power supply. Likewise, unlike typical data center servers, ASIC miners generated intense heat in a small

form factor such that the failure or reduced flow rate of Polivka cooling in case of insufficient power could damage the miners. This would lead a POSITA to turn off all the miners rather than modulate the load by selectively turning on or off some of them as suggested by Petitioner. For this reason there was no need for hardware or software support for the kind of event-driven selective turn-off as suggested by Petitioner.

164. In this regard an industrial miner like Polivka differed from a data center in Belady-989 that would throttle down or offload processing. EX1011, Abstract. Petitioner relies on Szhmigielski's statement that "[i]ndustrial miners face almost the same issues as data centers" for the motivation to combine. Petition, 100; EX1009, 103. However, Petitioner ignores Szhmigielski's teaching that, in addition to common challenges, "largescale Bitcoin mines face numerous unique issues." EX1009, 105. Unlike a data center, there was no way to offload blockchain processing from Polivka. Moreover, unlike a data center, before the invention of the '372 patent a POSITA expected industrial miners to operate in an all-or-nothing fashion for the reasons discussed above. Accordingly, a POSITA would not consider Belady-'989's solution of throttling down or offloading as applicable to industrial miners like Polivka.

165. Finally, as discussed above, a POSITA in the oil and gas industry was not a POSITA in the Bitcoin mining industry and vice versa An oil and gas industry

POSITA who could, *arguendo*, attempt to modify MAGS "to use Belady-'989's gas supply shock absorber," Petition, 100, was not a POSITA in the Bitcoin industry. Therefore, they could not attempt to modify the Polivka miner as suggested by Petitioner without undue experimentation and with a reasonable expectation of success for this additional reason.

**c. Claims 35-37**

166. These claims are substantially similar to claims 10-12 and are not obvious for the same reasons.

## XII. SECTION 101

167. I have reviewed the Petition's discussion of whether the '372 patent claims cover subject matter that is appropriate for patenting and the related opinions by Dr. Nikolaou and Mr. Kasdorf.

168. I disagree with the opinions expressed by Nikolaou and Kasdorf regarding whether the focus of the challenged '372 patent claims is the idea of using natural gas to power a block chain mine. It is my opinion that both the '372 patent specification and the claims of the '372 patent make clear that much more is required from a technology or engineering standpoint than simply the use of natural gas to power a blockchain mine. For example, claims 1 and 24 recite a generator capable of using a continuous flow of natural gas (including raw natural gas as known as casinghead gas) from a hydrocarbon production, storage or

processing facility to electrically power mining processors within blockchain mining devices that connect to a network interface with access to a blockchain database storing transactions associated with digital currency. To arrive at their opinions, the declarations of Nikolaou and Kasdorf ignore the majority of the claim language. A POSITA, both when reading the claims as separate elements and as a whole system, would readily conclude that the claims are a recitation of concrete, physical elements (which includes the combination of the generator, the blockchain mining devices, the mining processors, the network interfaces, etc.) and that the claims are not directed to an abstract idea.

169. For one, the Petition and the declarations of Nikolaou and Kasdorf ignore several limitations of the claims that require that the source of combustible gas for the generator recited in the claims of the ’372 patent not simply be a residential gas line that can be turned-off without consequences. To the contrary, the claims are directed to sources of combustible gas from a hydrocarbon facility that continuously flows combustible gas used by the generator. The Petition and the declarations of Nikolaou and Kasdorf also ignore that the mining processors must be “adapted to mine transactions associated with the blockchain database” which are energy intensive thus requiring multiple blockchain mining devices. Instead, the Petition and the declarations of Nikolaou and Kasdorf suggest that the mining processors are common laptops or common computers. To the contrary, the

claims of the ’372 patent recite computer architectures that incorporate mining processors within multiple larger blockchain mining devices to affect the mining of digital currency. EX1001, Claims 1 & 24.

170. Each independent claim resoundingly emphasizes the presence of a specialized generator that can receive raw natural gas as a continuous flow to produce electrical power and resilient mining processors that are powered from the generator’s electrical output (and not solely from a connection to electrical grid power) to mine digital currency using a network interface. Both as separate elements, and as combination, the challenged independent claims do not cover every instance of using natural gas, which supports the conclusion that the ’372 patent claims do not claim an abstract idea.

171. The integration of the special-purpose generator of the independent claims that receives the continuous flow of combustible casinghead gas and the mining processors within the supportive blockchain mining devices represents a significantly concrete practical application of technology to a POSITA.

172. For example, the independent claims 1 and 24 recite “mining processors … adapted to mine transaction associated with the blockchain database” which embody a practical application of the independent claims. EX1001, claim 1. The specification explains that mining processor 92 performs “mining activity” or “hashrate,” described in the ’372 patent and known to a POSITA as computational

power used to mine transactions on a proof-of-work blockchain. EX1001, 17:54-55, 18:6-9, 13:21-36, 13:49-58. Using Bitcoin as an example of blockchain transactions, the specification further explains that "[m]ining is the process of adding transaction records to BITCOIN™'s public ledger of past transactions." EX1001, 13:22-23. More generally, "[m]ining requires computational effort in the form of CPU cycles… to run a cryptographic hashing algorithm associated with the particular blockchain layout." EX1001, 13:49-52. From these descriptions a POSITA understands that "min[ing] transactions" in the claims refers to running algorithms which typically are specific for each kind of blockchain to generate transactions in that blockchain. This is a common meaning of "mining transactions" in the art of blockchain mining, familiar to a POSITA. The recitation of "min[ing] transactions" is accomplished by the "mining processors." As also explained in the specification, mining processors can have different kinds of mining circuitry such as a CPU, GPU, FPGA, and ASIC. EX1001, 17:12-15. A POSITA understands that some types of mining circuitry, such as a CPU, are designed to run software programs; other types, such as an ASIC (application-specific integrated circuit), comprise hardware logic to perform specific functions, though there may also be software programmable elements. Accordingly, if a mining processor has at least some programmable mining circuitry (*e.g.*, a CPU), then it is adapted to mine transactions because it is programmed to run mining

algorithms, *e.g.*, programmed to run Bitcoin's cryptographic hashing algorithms. In the case of a mining processor with hardware-implemented logic (*e.g.*, an ASIC), it is adapted to mine transactions because it is designed to run mining algorithms. Thus, in the context of the '372 patent, a POSITA understands "mining processors … adapted to mine transactions" refers to mining circuitry such as a CPU, GPU, FPGA or ASIC that is programmed to run mining algorithms.

173. The challenged claims expressly include practical applications because, for example, (1) the generator of the independent claims uses natural gas from a hydrocarbon production, storage, or processing facility (not from a utility sales-gas line) that produces a continuous flow to improve oil field waste gas technologies, (2) the independent claims recite multiple (not only one) blockchain mining devices that allow the modulation of the load applied to the generator to improve the cost effectiveness of blockchain mining and overall power generation reliability, (3) the generator, mining processors, and network interface of the independent claims form a particular machine that is integral to the claims.

174. Of course, the Petition misapprehends the independent claims insofar as it contends that the claimed system and method need not be proximate to the hydrocarbon facility that is the source of the claimed "continuous flow of combustible gas." The claims themselves recite that the "generator [is] connected to the source of combustible gas" that is "produced from a … hydrocarbon

production, storage, or processing facility." EX1001, claims 1 & 24. By disassociating the claimed elements, the Petition is incorrect in its assertion that the claims do "not require the computers be located at or near such a facility." Pet. at 116.

175. Relatedly, the Petitioner and the declarations of Nikolaou and Kasdorf wrongfully dilute the inventive concept of the challenged claims by proposing a construction of "continuous flow of combustible gas" that does not ascribe meaning to the term "continuous." I discuss the meaning of "continuous flow of combustible gas" from the perspective of one of ordinary skill in the art above in my declaration. The '372 patent explains that "[i]n upstream production of oil and gas, natural gas may be produced … as a by-product of oil production, for example from an oil well." EX1001, 6:51-54; 4:62-63 ("The source of combustible gas comprises raw natural gas."); 8:66-9:3. The '372 patent describes this source of raw gas as having a "continuous flow" that must be consumed or otherwise disposed of. *Id.*, 9:28-32. Often oil wells are remote, and with respect to the natural gas, may be "lacking in accessible infrastructure such as an external pipeline network (sales line) …." *Id.*, 7:46-49; 8:49-63. The '372 patent teaches that the oil well operator is left with few desirable options to dispose of the raw natural gas, such as "venting the gas to atmosphere un-combusted [or] combusting the gas on site via flare …." *Id.*, 7:56-60; 8:5-10. The '372 patent therefore directs

the casinghead gas to a generator used to operate blockchain mining devices with mining processors. *Id.*, 11:24-36. The ’372 patent teaches the ability to “[c]hang[e] the blockchain mine electrical load over time in response to changes in the excess or stranded gas volume availability.” *Id.*, 5:35-37. Using the ’372 patent’s invention, a well operator can “[m]inimize[e] the vented or flared gas volumes by changing the mining hardware load in reaction to observed changes in average natural gas source rates over time.” *Id.*, 5:38-41. Thereby, “relatively less gas is wasted during operation.” *Id.*, 11:35-36. This advantage of the invention is captured in the first two limitations of the challenged independent claims, which Petitioner incorrectly proposes to allow for the mere presence of any type of gas from any source, for any duration of time. Without this error, it is clear that the elements of the independent claims reveal an inventive concept that is significantly more than using natural gas to power a blockchain mine.

176. The Petition commits a similar error where it divorces the blockchain mining devices that each include mining processors and network interfaces from their application to blockchain mining. I discuss the meaning of “blockchain mining devices” and “mining processor” in the context of the ’372 patent from the perspective of one of ordinary skill in the art above in my declaration. The Petition alludes to a “conventional blockchain miner,” but provides no evidentiary support for that “conventional” blockchain miners existed, and certainly applications of

blockchain were far from conventional at the time the inventor filed the '372 patent. The '372 patent recounts that "[t]he first block chain was conceptualized by Satoshi Nakamoto in 2008 and implemented the following year as a core component of the digital currency, BITCOIN…." EX1001, 11:51-55. With respect to the claimed "mining processor," the '372 patent recommends the capability to control the "hashrate" by "changing the core voltage or the clock rate of the processor[s]." *Id.,* 13:52-58. The '372 patent details that "[e]ach mining processor 92 may have a variety of configurations, but generally may include at least a power supply, a controller board and ***mining circuity, such as an ASIC circuit***. Various mining circuitry examples include CPU (central processing unit), GPU (graphics processing unit), FPGA (Field-Programmable Gate Array), and ASIC (application specific integrated circuit). The components of an ***ASIC mining processor*** include the hash boards (each board has numerous chips that is doing the hashing), a controller (to communicate with the network and optimize the mining processors chip frequency and fans for colling), and a power supply (typically converts AC input power to DC power for the ASIC)." *Id.,* 17:9-21 (emphasis added). The '372 patent explained that it is the "[m]ining circuitry 130, for example integrated circuit chip, [that] may be used to perform data mining operations, for example verifying cryptocurrency transactions." *Id.,* 14:57-63. Far from being a generic home computer as the Petition suggests, the mining processor is described and

recited as a specialized computer processor. The mining processor was far from conventional at the time of the filing of the '372 patent.

177. Even the references relied upon in the Petition confirm that the challenged claims, especially when read as the combination of elements, were far from conventional or routine. The '372 patent explains that blockchain mining operations are highly computationally and energy-intensive by design. EX1001, 13:29-36, 13:49-58. The Szhmigielski reference (which Petitioner identifies as pertinent prior art) teaches that, in addition to being inexpensive, electrical power for crypto mining must be "*reliable*" to power "the hardware and the associated cooling systems." EX1009, 105. Yet, Petitioner's other art, including particularly the Dickerson reference, teaches that its electrical power is *unreliable* because the system is located "in remote areas" where "no utility power is available." EX1005, ¶24. As such, a POSITA would not view the '372 patent claims as conventional or routine, but instead would be skeptical that such a system would work reliably.

178. Thus, having studied the '372 patent claims from the perspective of a POSITA at the time of the filing of the '372 patent, it is my opinion as I have detailed in this section that the (1) the '372 patent claims are not focused on an abstract idea, (2) the '372 patent claims recite the practical application of the limitations of the claims, and (3) the '372 patent claims provide an inventive



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concept that was not conventional or routine at the time of the filing of the '372 patent.

179. I reserve the right to supplement my testimony and this declaration in response to any judicial determinations, in response to the opinions expressed by Petitioner' experts in this proceeding, and/or in light of additional evidence or testimony brought forth at trial or otherwise brought to my attention after the date of my signature below.

I declare under penalty of perjury that the foregoing is true and correct.

Dated: April 16, 2024



Dr. Fengqi You

# Appendix A



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# FENGQI YOU

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## EDUCATION

**Argonne National Laboratory** Argonne, IL
Argonne Scholar - Director's Postdoc Fellow in Mathematics and Computer Science 12/2009 – 08/2011

- **Research Focus:** Advanced Computational Methods for Energy, Environmental and Economic Systems Analysis and Optimization of Sustainable Energy Systems

**Carnegie Mellon University** Pittsburgh, PA
Ph.D. in Chemical Engineering. Advised by Prof. Ignacio E. Grossmann 09/2005 – 10/2009

- **Research Focus:** Process Systems Engineering and Operations Research
- **Doctoral Thesis:** Mixed-Integer Nonlinear Programming (MINLP) Models and Algorithms for Enterprise-Wide Supply Chain Optimization under Uncertainty

**Tsinghua University** Beijing, China
B.Eng. in Chemical Engineering 09/2001 – 07/2005

- **Research Focus**: Density Functional Theory and Grand Canonical Monte Carlo Simulation

## PROFESSIONAL EXPERIENCE

**Academic Experience**

- Roxanne E. and Michael J. Zak Professor, *Cornell University*, Ithaca, NY (07/2016 - present)
    - Smith School of Chemical and Biomolecular Engineering (primary)
    - Computer Science
    - Operations Research and Information Engineering
    - Electrical and Computer Engineering
    - Civil and Environmental Engineering
    - Center for Applied Mathematics
    - Applied Information Systems
    - Mechanical Engineering
    - Systems Engineering (*Chair of Ph.D. Studies*)
    - Cornell University AI for Science Institute (*Co-Director*)
    - Schmidt AI in Science Fellowships Program at Cornell (*Co-Lead*)
    - Cornell Institute for Digital Agriculture (*Co-Director*)
    - Cornell Atkinson Center for Sustainability (*Senior Faculty Fellow*)
    - Cornell Energy Systems Institute (*Associate Director*)
- Assistant Professor, *Northwestern University*, Evanston, IL (09/2011 – 06/2016)
    - Chemical and Biological Engineering (primary)
    - Industrial Engineering and Management Sciences
- Argonne Scholar, *Argonne National Laboratory*, Argonne, IL (12/2009 – 08/2011)
    - Mathematics and Computer Science (primary)

- Decision and Information Science
- Energy Systems

**Industrial Experience**

- Consultant for multiple companies in the energy, agri-food, chemical, pharmaceutical, building, finance, and information technology sectors (since 2011)
- Research Intern, *The Dow Chemical Company*, Midland, MI (05/2007 – 08/2007 & 06/2008 – 08/2008)
- Research Consultant, *Praxair, Inc.*, Danbury, CT (03/2008 – 10/2009)

## HONORS AND AWARDS

- AAAS Fellow, 2023
- Fellow of the American Institute of Chemical Engineers (AIChE Fellow), 2022
- AIChE George Lappin Award, 2022
- Stratis V. Sotirchos Lectureship Award, Foundation for Research & Technology - Hellas, 2022
- Fellow, Royal Society of Chemistry (FRSC), 2021
- AIChE Sustainable Engineering Forum Education Award, 2021
- De Gruyter Best Paper Award, 2021
- American Automatic Control Council (AACC) O. Hugo Schuck Award, 2020
- Curtis W. McGraw Research Award, ASEE, 2020
- AIChE Innovations in Green Process Engineering Award, 2020
- Mr. & Mrs. Richard F. Tucker Excellence in Teaching Award, 2020
- Associate Editor, *Science Advances*, 2020 – present
- Associate Editor, *IEEE Transactions on Control Systems Technology*, 2020 – present
- Senior Member, IEEE, 2020
- AIChE Excellence in Process Development Research Award, 2019
- ACS Sustainable Chemistry & Engineering Lectureship Award, 2018
- Computing and Systems Technology (CAST) Outstanding Young Researcher Award, AIChE, 2018
- Cornell Engineering Research Excellence Award, 2018
- Editorial Board, *Industrial & Engineering Chemistry Research*, 2018 – present
- AIChE Sustainable Engineering Research Excellence Award, 2017
- Consulting Editor and Editorial Board, *AIChE Journal*, 2017 – present
- AIChE Environmental Division Early Career Award, 2017
- Editorial Board, *ACS Sustainable Chemistry & Engineering*, 2017 – present
- *I&EC Research* Inaugural Class of Influential Researcher, 2017
- Zdenek Burianec Memorial Award, 2017, 2022
- Editor, *Computers & Chemical Engineering*, 2016 – present
- Roxanne E. and Michael J. Zak Professorship, Cornell University, 2016 – present
- National Science Foundation CAREER Award, 2016-2021
- Croll Sesquicentennial Faculty Fellow, Cornell University, 2016
- No. 1 Top cited article published in *AIChE Journal*, from 2012, from 2013, from 2014, & from 2015
- Excellence in Review Award, *Industrial & Engineering Chemistry Research*, 2016, 2017, 2018, 2019, 2020
- Northwestern-Argonne Early Career Investigator Award for Energy Research, 2013
- Searle Center for Teaching Excellence Faculty Fellow, Northwestern University, 2012-2013
- Top Reviewer Award, *Computers & Chemical Engineering*, 2011 and 2013



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- Most cited articles published in *Computers & Chemical Engineering*, 2010-2012
- W. David Smith Jr. Best Publication Award, AIChE CAST Division, 2011
- Northwestern University Faculty Recognition Award, 2011
- Ken Meyer Award for the Best Doctoral Thesis, Carnegie Mellon University, 2010
- Argonne Director's Postdoctoral Fellowship, Argonne National Laboratory, 2009-2011
- Symposium Award, 30th ChEGSA Symposium, Carnegie Mellon University, 2008
- Yang Outstanding Research Award, Yang Foundation, 2005
- Best Undergraduate Diploma Thesis, Tsinghua University, 2005
- First-Class Scholarship for Academic Excellence, Tsinghua University, 2003 and 2004

## TEACHING EXPERIENCE

**Cornell University** Ithaca, NY
*Instructor and Lecturer* 07/2016 – present

- ChemE 6888 / SysEn 5888: Deep Learning (Fall 2023)
- ChemE 6880 / SysEn 5880: Industrial Big Data Analytics and Machine Learning (Spring 2023)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2022)
- ChemE 6880 / SysEn 5880: Industrial Big Data Analytics and Machine Learning (Spring 2022)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2021)
- ChemE 6888 / SysEn 5888: Deep Learning (Summer 2021)
- ChemE 6880 / SysEn 5880: Industrial Big Data Analytics and Machine Learning (Spring 2021)
- ChemE 6886 / SysEn 5886: Quantum Computing and Artificial Intelligence (Spring 2021)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2020)
- ChemE 6888 / SysEn 5888: Deep Learning (Summer 2020)
- ORIE 3310/5310: Optimization II (Summer 2020)
- ChemE 6880 / SysEn 5880: Industrial Big Data Analytics and Machine Learning (Spring 2020)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2019)
- ChemE 6888 / SysEn 5888: Deep Learning (Summer 2019)
- ORIE 3310/5310: Optimization II (Summer 2019)
- ChemE 6880 / SysEn 5880: Industrial Big Data Analytics and Machine Learning (Spring 2019)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2018)
- ORIE 3310/5310: Optimization II (Summer 2018)
- ChemE 6880 / SysEn 6880: Industrial Big Data Analytics and Machine Learning (Spring 2018)
- ChemE 4620: Chemical Process Design (Spring 2018)
- ChemE 6800 / SysEn 6800: Computational Optimization (Fall 2017)
- ChemE 4620: Chemical Process Design (Spring 2017)

**Northwestern University** Evanston, IL
*Instructor and Lecturer* 09/2011 – present

- Chem Eng 352: Chemical Engineering Design Projects (Winter 2016)
- Chem Eng 322: Heat Transfer (Winter 2016)
- Chem Eng 352: Chemical Engineering Design Projects (Winter 2015)
- Chem Eng 345: Process Optimization for Energy and Sustainability (Spring 2015)



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- Chem Eng 352: Chemical Engineering Design Projects (Winter 2014)
- Chem Eng 345: Process Optimization for Energy and Sustainability (Spring 2014)
- Chem Eng 352: Chemical Engineering Design Projects (Winter 2013)
- Chem Eng 345: Process Optimization (Spring 2013)
- Chem Eng 352: Chemical Engineering Design Projects (Winter 2012)
- Chem Eng 345: Process Optimization (Spring 2012)

**Carnegie Mellon University** Pittsburgh, PA
*Teaching Assistant* 08/2005 – 05/2008

- Tutor and grader, *06-361: Unit Operations of Chemical Engineering*, Fall 2006
- Substitute lecturer, tutor and grader, *06-720: Advanced Process System Engineering*, Spring 2007
- Substitute lecturer, tutor and grader, *06-461: Process Design Project*, Spring 2008
- Substitute lecturer, tutor and grader, *06-462: Economics and Optimization*, Spring 2008
- Assistant for course document preparation and project evaluator, *06-815: Special Topic in Process System Engineering*, Spring 2008

**Tsinghua University** Beijing, China
*Teaching Assistant* 02/2005 – 06/2005

- Assisted in preparing course documents and held tutorial sessions for *Computer Simulation of Fluids and Its Advances*, Spring 2005.

## PUBLICATIONS

Google Scholar (Citations: 21,056; *h*-index: 80): scholar.google.com/citations?user=3ixInr8AAAAJ&hl
Scopus (Citations: 16,038; *h*-index: 71): www.scopus.com/authid/detail.url?authorId=56750277000

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[J2] Tao, Y., Yang, L.*, Jaffe, S., Amini, F., Bergen, P., Hecht, B., & You, F.* (2023). Climate mitigation potentials of teleworking are sensitive to changes in lifestyle and workplace rather than ICT usage. *Proceedings of the National Academy of Sciences (PNAS)*, 120, e2304099120. [Research Highlight in ***Nature*** (September 19, 2023).] – [**Select Media Coverage:** *Cornell Chronicle* (September 18, 2023), ***Scientific American*** (September 18, 2023), ***The Washington Post*** (September 18, 2023), ***Fortune*** (September 21, 2023), ***The Guardian*** (September 18, 2023), *ScienMag* (September 18, 2023), *Science Daily* (September 18, 2023), *ScienMag* (September 18, 2023), *Phys.org* (September 18, 2023), ***The Hill*** (September 19, 2023), *Anthropocene* (September 19, 2023), ***The Boston Globe*** (September 19, 2023), *My Droll* (September 19, 2023), *SwiftTelecast* (September 19, 2023), *Business Mayor* (September 19, 2023), *Daily Kos* (September 19, 2023), *WION* (September 19, 2023), *Today Headline* (September 19, 2023), *The Science Times* (September 19, 2023), *Stern* (September 19, 2023), *Weekly Voice* (September 19, 2023), *Prokerala* (September 19, 2023), *East Coast Daily* (September 19, 2023), (September 19, 2023), *Wonderful Engineering* (September 19, 2023), *L'Indépendant* (September 19, 2023), *ABC News* (September 19, 2023), *Herald* (September



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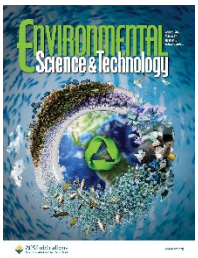
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[J9] Zhao, X., & You, F.* (2023). Cascading Polymer Macro-Debris Upcycling and Microparticle Removal As An Effective Life Cycle Plastic Pollution Mitigation Strategy. *Environmental Science & Technology*, 57, 16, 6506–6519. [**Cover Art of April 2023 issue of *Environmental Science & Technology***]




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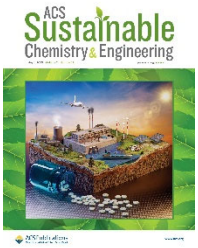
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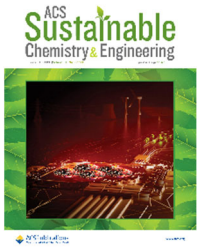



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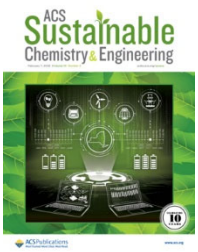
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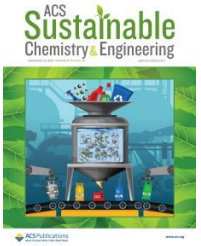
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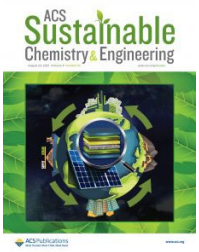
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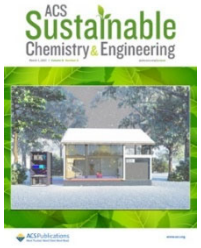
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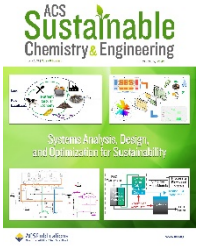
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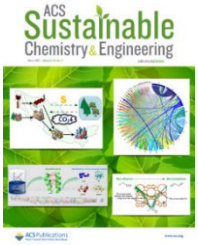
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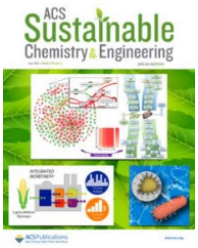
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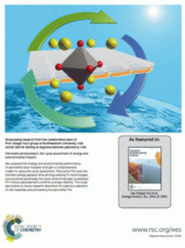
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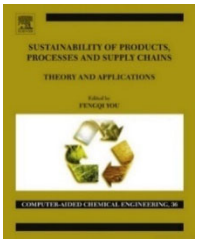
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## PRESS AND MEDIA COVERAGE

**Journals and Magazines**

- *ACS Sustainable Chemistry & Engineering* (June 2016; March 2017; June 2018; March 2021; August 2021; September 2021; February 2022; April 2023)
- *Chemical Engineering Progress* (January 1, 2023; July 1, 2023)
- *Communications of the ACM* (October 4, 2021; March 3, 2022)
- *Energy & Environmental Science* (September 2011; July 2015; September 2022; June 2023)
- *Environmental Science & Technology* (April 2023)
- *IEEE Spectrum* (August 26, 2014)
- *Nature* (June 18, 2014; September 19, 2023)
- *Nature Sustainability* (June 24, 2021)
- *Industrial & Engineering Chemistry Research* (May 2017; May 2018)
- *Optics & Photonics News* (July 2015)
- *Science* (February 2, 2015; August 30, 2018)



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- *The Ecologist* (August 5, 2015)

**Major Media**

- *BBC News* (May 12, 2015)
- *Reuters* (January 28, 2022; May 31, 2022)
- *New York Times* (June 2, 2014; October 16, 2023)
- *Businessweek* (June 2, 2014)
- *The Wall Street Journal* (July 31, 2021)
- *Scientific American* (September 18, 2023)
- *The Washington Post* (September 18, 2023)
- *National Geographic* (November 11, 2014)
- *New Scientist* (July 31, 2020)
- *Newsweek* (February 1, 2022; September 22, 2022)
- *NBC News* (September 8, 2021)
- *Fox News* (October 2, 2021)
- *Daily Mail* (January 28, 2022)
- *World Economic Forum* (February 7, 2019; April 21, 2022)
- *The Hill* (November 9, 2021; September 19, 2023)
- *Fortune* (September 26, 2022; September 21, 2023)
- *The Guardian* (September 18, 2023)
- *Bloomberg* (September 26, 2023)
- *Agence France-Presse (AFP)* (April 26, 2023)
- *Voice of America (VOA)* (October 28, 2021)
- *CNN News* (September 20, 2023)
- *CBC News* (May 18, 2023)
- *ABC News* (September 19, 2023)
- *The Boston Globe* (September 19, 2023)
- *National Science Foundation (NSF) Research News* (December 9, 2021; May 8, 2023)
- *National Institutes of Health (NIH) Extramural Nexus* (February 24, 2022)
- *Observer* (June 8, 2022)
- *HuffPost* (August 16, 2023; September 22, 2023)
- *Cornell Chronicle* (August 29, 2017; November 30, 2017; July 6, 2018; February 4, 2019; May 31, 2019; June 12, 2019; June 14, 2019; July 16, 2019; April 22, 2020; July 31, 2020; October 7, 2020; December 17, 2020; April 1, 2021; June 24, 2021; September 20, 2021; September 29, 2021; November 8, 2021; December 16, 2021; January 27, 2022; December 16, 2021; January 27, 2022; February 23, 2022; September 14, 2022; October 26, 2022; December 15, 2022; January 9, 2023; March 9, 2023; April 11, 2023; May 8 , 2023; June 14, 2023; July 10, 2023; September 18, 2023)
- *Northwestern University News* (October 10, 2011; June 10, 2013; May 29, 2014)
- *NC State News* (October 22, 2020)
- *Technical University of Denmark* (November 12, 2021)
- *University of Washington* (January 4, 2022)

- *Tsinghua University News* (August 30, 2017; January 11, 2018; November 11, 2018)
- *Argonne National Laboratory Headline* (February 7, 2011; June 12, 2013; May 29, 2014; July 20, 2015)
- *Argonne Science Highlights* (February 17, 2011)
- *Oak Ridge National Laboratory News* (December 13, 2021; August 14, 2022)
- *Carnegie Mellon University Press* (July 20, 2011)
- *Chemical & Engineering News* (May 21, 2019, July 31, 2020)
- *China Daily* (July 3, 2014)
- *The Center Square* (April 25, 2022)
- *Nasdaq* (January 28, 2022; May 30, 2022)
- *Times Union* (April 11, 2021)
- *Yale Climate Connections* (April 2, 2021)
- *Big Ten Network* (July 17, 2015)
- *MSN* (January 28, 2022)
- *Yahoo!* (January 28, 2022; May 31, 2022)
- *Yahoo! News* (December 20, 2021; April 14, 2022)
- *Yahoo!Finance* (October 2, 2021; January 28, 2022)
- *Yahoo!Life* (September 21, 2021)
- *CNN-News18* (December 22, 2021)
- *NewTalk* (June 2, 2014)
- *World News* (July 21, 2015)
- *Florida News* (December 23, 2021)
- *IMPO Magazine* (June 29, 2015)
- *Kavli Foundation* (December 16, 2021)
- *GovInsider* (May 19, 2022)
- *Euronews* (December 17, 2021; May 31, 2022)
- *News 24* (December 22, 2021)
- *Morning News* (May 19, 2023)
- *Taipei Times* (September 22, 2023)
- *Foreign Affairs New Zealand* (April 14, 2022; May 9, 2023)
- *South Africa Today* (December 23, 2021; January 7, 2022; April 23, 2023)
- *Hareetz* (January 28, 2022)
- *Zimbabwe On 24 News* (January 4, 2022)
- *Botswana on 24* (January 4, 2022)
- *Ghana On 24 News* (January 27, 2022)
- *News 1* (October 18, 2016)
- *News Spain-24* (January 5, 2022)
- *SME in Slovakia* (January 17, 2022)
- *Head Topics* (May 31, 2022)

- *The Pioneer* (September 20, 2023)
- *World News* (May 31, 2022)
- *Doha News* (May 31, 2022)
- *Herald* (September 1, 2022; September 19, 2023)
- *Hindustan Times* (December 21, 2022)
- *Jersey Tribune* (June 25, 2015), *Evanston Tribal* (October 14, 2011), *Chicago Inno* (July 9, 2015; July 20, 2015), *Asharq Al-awsat* (February 12, 2019), *WKBW Buffalo* (April 22, 2020), *MPNnow* (April 22, 2020), *Fox 40* (April 22, 2020), *Toronto Sun* (August 7, 2021), *Nigeria On 24 News* (December 9, 2021), *ESI Africa* (December 11, 2021), *The Denver Channel* (December 21, 2021), *California News Times* (December 21, 2021), *USPOST* (December 21, 2021), *WTVB* (January 28, 2022), *KFGO* (January 28, 2022), *WIKY* (January 28, 2022), *WSAU-AM* (January 28, 2022), *WKZO* (January 28, 2022), *WHBL* (January 28, 2022), *Toronto Telegraph* (April 14, 2022), *Iosco County News Herald* (April 25, 2022), *The Independent* (May 7, 2022), *Tompkins Weekly* (July 13, 2022), *Vermont News* (September 14, 2022), *WENY* (November 28, 2022), *KrAsia* (September 26, 2023), *L'Indépendant* (September 19, 2023).

**Technical Media**

- *Science Daily* (May 29, 2014; June 25, 2015; July 20, 2015; October 17, 2016; August 30, 2018; July 19, 2019; August 3, 2020; December 18, 2020; June 24, 2021; September 20, 2021; November 9, 2021; December 20, 2022; April 11, 2023; June 14, 2023; July 10, 2023; September 18, 2023)
- *R&D Magazine* (February 8, 2011; May 30, 2014; June 26, 2015; July 21, 2015; October 27, 2016)
- *Popular Science* (March 24, 2022; May 31, 2022)
- *Chemistry World* (February 8, 2011; June 10, 2014; August 17, 2015; February 16, 2016; June 21, 2016)
- *ChemistryViews* (May 5, 2015)
- *American Institute of Physics Inside Science* (November 7, 2016)
- *DOE - Science - ASCR - Monthly News* (January 2011)
- *Phys.Org* (May 29, 2014; June 25, 2015; July 21, 2015; October 17, 2016; August 30, 2018; February 6, 2019; July 17, 2019; October 22, 2020; September 20, 2021; December 16, 2021; December 16, 2022; May 8, 2023; September 18, 2023)
- *Materials Today* (July 29, 2015; November 2, 2016)
- *Tech Xplore* (February 6, 2019; August 3, 2020; December 18, 2020; June 24, 2021; September 29, 2021; November 8, 2021; January 27, 2022; February 23, 2022; September 14, 2022; March 9, 2023; April 11, 2023; June 14, 2023; June 15, 2023; July 10, 2023)
- *Inside Higher Ed* (August 3, 2022)
- *PhysicsCentral* (November 14, 2016)
- *Marketplace* (December 27, 2021)
- *Mongabay* (January 4, 2022; April 20, 2023; September 6, 2023)
- *The Conversation* (April 14, 2022)
- *Global Advisors* (April 14, 2022)
- *Geography Directions* (April 21, 2022)
- *Anthropocene Magazine* (July 19, 2022; March 21, 2023; September 19, 2023)

*ClickGreen* (May 29, 2014), *Today's Energy Solutions* (February 14, 2011), *PV Magazine* (June 2, 2014; June 30, 2021; March 20, 2023), *Photonics* (May 30, 2014), *Manufacturing.Net* (June 26, 2015), *ChemInfo*

(June 26, 2015), *Science Island* (July 21, 2015), *Science Newsline* (May 29, 2014; June 26, 2015), *ScienceBlog* (May 30, 2014), *Green Building Elements* (May 29, 2014), *ClimateWire* (June 4, 2014), *Renewable Energy World* (June 5, 2014), *Technobahn* (May 29, 2014), *Softpedia* (May 30, 2014), *SiliconIndia* (May 30, 2014), *Nanowerk* (May 30, 2014; July 20, 2015; April 11, 2023), *Manufacturers' Monthly* (May 30, 2014), *PCBDesign* (June 1, 2014), *Solar Daily* (June 1, 2014; July 7, 2021; March 13, 2023), *Solar Power Today* (June 2, 2014), *Daily Fusion* (June 2, 2014), *PV Buzz* (June 5, 2014), *TechNews* (August 29, 2014; July 13, 2021), *Peak Oil News* (June 2, 2014), *Chinatopix* (June 2, 2014), *Hot Air* (June 3, 2014), *Daily Energy Dump* (June 4, 2014), *Topix* (May 30, 2014), *SolarBe* (June 2, 2014), *EnergyTrend* (June 3, 2014), *QualEnergia* (June 9, 2014), *Nextgen* (May 30, 2014; August 7, 2015), *Devon Eco Energy* (June 25, 2014), *Renewable Energy Jobs* (February 7, 2011), *Sun and Wind Energy* (February 9, 2011), *Photovoltaik-Kosten* (February 11, 2011), *SciGuru.com* (February 12, 2011), *Green Future Energy* (February 13, 2011), *Solar Server* (February 10, 2011), *Solar Knowledge* (February 19, 2011), *Electronics News* (February 9, 2011), *Scandinavian Oil-Gas Magazine* (February 9, 2011), *Marcellus Drilling News* (June 25, 2015), *My Solar News* (February 10, 2011), *Solar Energy Guide* (February 13, 2011), *BioFuels Journal* (June 13, 2013), *Biomass Magazine* (July 22, 2013), P*rocurement Insight* (March 16, 2011), *Military Technologies News* (June 25, 2015), *ECN Magazine* (June 26, 2015), *Oil Gas Daily* (June 28, 2015), *ECN Magazine* (July 20, 2015), *I-Connect007* (July 21, 2015), *Science and Technology Research News* (July 20, 2015), *Technology.org* (July 22, 2015; February 27, 2022; September 16, 2022; May 14, 2023; June 24, 2023), *Nanotechnology Now* (July 20, 2015), *Solarify* (July 25, 2015; September 25, 2021), *Relia Wire* (July 21, 2015), *Manufacturing Business Technology* (June 29, 2015), *Silicon Public* (August 6, 2015), *Energy Harvesting Journal* (August 7, 2015), *PlanetSave* (July 28, 2015), *Space Daily* (October 26, 2016), *Network for Business Sustainability* (August 2, 2017), *Investing News Network* (April 30, 2018), *The Maritime Executive* (August 30, 2018), *Ingeniøren* (August 31, 2018), *Sciences et Avenir* (August 31, 2018), *Eurasia Review* (September 1, 2018), *AZoCleantech* (September 3, 2018; December 17, 2021; April 27, 2022; July 7, 2022; September 20, 2022; December 21, 2022; March 16, 2023; April 12, 2023; May 8 , 2023; July 11, 2023), *Gazette Byte* (September 3, 2018), *Futurity: Research News* (February 5, 2019), *Lab Manager* (February 5, 2019; July 22, 2019; September 21, 2021; December 17, 2021; January 28, 2022; September 19, 2023), *ScienceBlog* (February 5, 2019), *Environmental News Network* (February 6, 2019; July 19, 2019; June 25, 2021; July 6, 2022; September 19, 2022; March 10, 2023), *Energy Daily* (February 7, 2019), *Engineering.com* (February 7, 2019), *Market Business News* (February 7, 2019), *Green News* (February 7, 2019), *Tech2.Org* (February 7, 2019), *Energy Manager Today* (February 7, 2019), *Technology Networks* (February 7, 2019; September 21, 2021; November 10, 2021; September 19, 2023), *Knowridge* (February 7, 2019), *15 Minute News* (February 7, 2019), *Brightsurf* (February 7, 2019), *Engerati* (February 7, 2019), *TechZiffy* (May 21, 2019), *Water Online* ( July 17, 2019), *Ruminantia* (July 19, 2019), *Eurasia Review* (July 20, 2019), *Water Canada* (July 22, 2019), *Sonnenseite* (July 25, 2019), *DairyBusiness* (July 25, 2019), *Post Journal* (July 30, 2019), *Ars Technica* (October 1, 2019), *Medical Xpress* (April 23, 2020), *News AKMI* (July 31, 2020), *ScienceNewsNet* (August 3, 2020; September 20, 2021; November 9, 2021; July 10, 2023), *NewsWise* (August 2, 2020; October 8, 2020; June 24, 2021; September 20, 2021; November 9, 2021; December 16, 2021; August 31, 2022; September 19, 2022; March 10, 2023; April 11, 2023; May 8 , 2023; *Newswise*), *Plug-In Solar* (August 3, 2020), *Scienmag* (August 3, 2020; June 24, 2021; April 11, 2023; July 10, 2023; September 18, 2023), *7thSpace* (August 3, 2020), *Everydaynews* (August 4, 2020), *Sortiwa* (August 4, 2020), *Knowridge* (August 4, 2020), *RealClearEnergy* (August 5, 2020), *Innovation Toronto* (August 5, 2020), *NCYT* (August 5, 2020), *Energy in Demand* (August 8, 2020), Climax News Room (August 9, 2020), *Printed Electronics World* (August 10, 2020), *All About Circuits* (August 19, 2020), *WRAL TechWire* (October 21, 2020), *Mirage News* (June 25, 2021; September 20, 2021; November 8, 2021; December 16, 2021; February 23, 2022; September 14, 2022; June 14, 2023; June 15, 2023), *List.Solar* (June 26, 2021), *Daily Solar Power News* (June 26, 2021), *EcoInventos* (June 27, 2021), *PVbuzz* (June 27, 2021), *Printed Electronics World* (June 28, 2021), *DeepTech* (August 6, 2021), *MIT Technology Review* (August 6, 2021, November 17, 2021), *ANI News* (September 26, 2021), *Big News Network* (September 21, 2021; December 21, 2021; April 14, 2022), *True Viral News* (September 21, 2021), *Dailyhunt* (September 21, 2021), *Chem Europe* (September 22, 2021; December 22, 2021), *New Kerala*

(September 22, 2021), *Waste Advantage Magazine* (September 22, 2021; February 1, 2022), *Devdiscourse* (September 26, 2021; January 28, 2022; April 15, 2022), *LatestLY* (September 26, 2021), *DailyHunt* (September 26, 2021), *The Hindustan Times* (September 27, 2021), *News4Social* (September 27, 2021), *RepublicWorld* (September 27, 2021), *Waste Management World* (September 28, 2021), *The Times of Truth* (September 28, 2021), *HPCwire* (September 30, 2021), *Roxxcloud* (September 29, 2021), *The Hack Posts* (September 29, 2021; November 8, 2021), *The Logical Indian* (September 29, 2021), *MCUTimes* (September 29, 2021), *QNewsHub* (September 30, 2021), *Energy Metal News* (September 30, 2021), *Tech Orange* (October 1, 2021), *Smart Energy* (October 1, 2021), *European Business Press* (October 4, 2021), *New York Ag Connection* (October 5, 2021), *Energy Central* (November 13, 2021), *AZoM* (November 12, 2021), *TechiAI* (November 13, 2021), *ESI Africa* (December 11, 2021), *Technology.org* (December 12, 2021), *Innovation News Network* (December 13, 2021), *Wonderful Engineering* (December 14, 2021; September 19, 2023), *Kavli Foundation* (December 16, 2021), *Market Research Biz Reports* (December 21, 2021), *TrueViralNews* (December 16, 2021), *E-ACADEMY* (December 17, 2021), *News Concerns* (December 17, 2021), *Newsaxes* (December 17, 2021; January 27, 2022), *Verve Times* (December 17, 2021; July 10, 2023), *TweakTown* (December 17, 2021), *NNM.WORLD* (December 18, 2021), *P-Education* (December 19, 2021), *Axios* (December 20, 2021), *Green Savers* (December 20, 2021), *24Tech.dk* (December 20, 2021), *Yumda* (December 21, 2021), *Sustainability Times* (December 21, 2021), *Bionity* (December 22, 2021), *Somag News* (December 23, 2021), *EcoPortal* (December 26, 2021), *Future Timeline* (December 29, 2021), *El Confidencial* (January 3, 2022), *EnviroLink* (January 4, 2022), *Eco-Business* (January 5, 2022), *ZME Science* (January 5, 2022), *News Logged* (January 5, 2022), *The Planetary Press* (January 11, 2022), *Covering Climate Now* (January 12, 2022), *The Energy Mix* (January 13, 2022), *The Indian Wire* (January 16, 2022), *Stuff* (January 17, 2022), *Business Standard* (January 28, 2022), *Sharenet* (January 28, 2022), *DailyAdvent* (January 28, 2022), *GreenBiz* (February 1, 2022), *Aron Health* (February 1, 2022), *News of the World* (February 1, 2022), *Callaway Climate Insights* (February 1, 2022), *DigitalGarner* (January 27, 2022), *NewsTime* (January 27, 2022), *AZoNetwork* (January 28, 2022), *Waste Today* (January 31, 2022), *Laboratory Equipment* (January 31, 2022), *India Education* (January 31, 2022; February 26, 2022; June 30, 2022; November 10, 2022), , *Sustainability Matters* (February 3, 2022), *LocalSyr* (February 10, 2022), *WETM* (February 10, 2022), *NEWS10 ABC* (February 11, 2022), *EQ Mag Pro* (February 25, 2022), *Energy Tower* (February 25, 2022), *EnviroTec Magazine* (March 7, 2022), *Habere Guven* (April 17, 2022), *Fast Company* (April 18, 2022), *Green Building Africa* (April 18, 2022), *BusinessFast* (April 18, 2022), *BusinessMayor* (April 18, 2022), *The Next Web* (April 18, 2022), *Interesting Engineering* (April 23, 2022), *KPVI* (April 25, 2022), *New India Tech* (April 27, 2022), *Tech Register* (May 7, 2022), *Environmental News Bits* (May 17, 2022), *Engineers Ireland* (May 23, 2022), *Batteries News* (June 6, 2022), *News Update* (September 14, 2022), *Morning News* (September 14, 2022), *Tech Newsboy* (September 14, 2022), *News Azi* (September 14, 2022; March 10, 2023; June 14, 2023; June 15, 2023; July 10, 2023), *AskByGeeks* (September 15, 2022), *Barlettaweb* (September 19, 2022), *NSF News Prime* (September 19, 2022), *SmartechEnergy* (September 19, 2022), *Barlettaweb* (September 19, 2022), *CrypDesk* (September 25, 2022), *MoneySenator* (September 26, 2022), *Crypto News BTC* (September 26, 2022), *Evisos* (September 26, 2022), *ZME Science* (October 19, 2022; September 20, 2023), *Lokmat Times* (December 21, 2022), *MINT* (December 21, 2022), *ResearchMD* (December 22, 2022), *Medindia* (December 22, 2022), *Digital Journal* (December 24, 2022), *MedicalUpdateOnline* (December 24, 2022), *QS Study* (December 24, 2022), *Study Finds* (December 27, 2022), *Tech Explorist* (December 29, 2022), *India Education* (January 3, 2023), *Current Science Daily* (January 3, 2023), *AZoRobotics* (January 10, 2023), *The Engineer* (January 13, 2023), *NBIC+* (January 13, 2023), *SciTechDaily* (January 28, 2023), *TechNewsBoy* (March 10, 2023), *Today Headline* (March 10, 2023; June 15, 2023), *Utility Dive* (March 16, 2023), *electrek* (March 25, 2023), *Daily Tidings* (April 9, 2023), *SpaceDaily* (April 12, 2023), *Rinnovabili* (April 12, 2023), *Homeland Security News Wire* (April 13, 2023), *Swift Telecast* (April 14, 2023), *Green Car Congress* (April 17, 2023), *Rinnovabili* (April 17, 2023), *greenreport* (April 17, 2023), *mining.com* (April 18, 2023), *wpn.pl* (April 18, 2023), *CleanTechnica* (May 9, 2023), *TheBigCircuit* (May 14, 2023), *Knowledia* (June 15, 2023), *Verve Times* (June 17, 2023), *Swift Telecast* (June 17, 2023), *DT Next* (June 17, 2023), *Hubli Express* (June 17, 2023), *Digital Information World* (June 18, 2023),

*Environmental Leader* (June 19, 2023), *Ahmedabad Mirror* (June 19, 2023), *News9 Live* (June 19, 2023), *NFTevening* (June 20, 2023), *Smart Energy International* (June 26, 2023), *Tech Times* (July 11, 2023), *Swift Telecast* (July 11, 2023; September 19, 2023), *Scitech Daily* (August 27, 2023), *The Science Times* (August 28, 2023; September 19, 2023), *My Droll* (September 19, 2023), *Business Mayor* (September 19, 2023), *Daily Kos* (September 19, 2023), *WION* (September 19, 2023), *Today Headline* (September 19, 2023), *Stern* (September 19, 2023), *Weekly Voice* (September 19, 2023), *Prokerala* (September 19, 2023), *East Coast Daily* (September 19, 2023), *The Telegraph* (September 19, 2023), *Centre Times Daily* (September 19, 2023), *The Olympian* (September 19, 2023), (September 19, 2023), *Entrepreneur* (September 19, 2023), *The Costa Rica News* (September 27, 2023).

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## PROFESSIONAL SERVICE

- **Journal Editorial Role**
    - Associate Editor*, Science Advances,* 2020 – present
    - Associate Editor*, IEEE Transactions on Control Systems Technology*, 2020 – present
    - Consulting Editor*, AIChE Journal,* 2017 – present
    - Editor, *Computers & Chemical Engineering*, 2018 – present
    - Editorial Board Member, *ACS Sustainable Chemistry & Engineering,* 2017 – present
    - Field Chief Editor, *Frontiers in Chemical Engineering,* 2019 – present
    - Editorial Board, *PRX Energy*, 2021-present
    - Editorial Board, *IEEE Quantum Computing Newsletter*, 2021- present
    - Subject Editor, *Advances in Applied Energy*, 2021-present
    - Editorial Advisory Board, *Industrial & Engineering Chemistry Research*, 2019 – present
    - Guest Editor, *ACS Sustainable Chemistry & Engineering,* 2017 – 2018
    - Guest Editor, *Energy,* 2018 – 2019
    - Guest Editor, *Renewable & Sustainable Energy Review,* 2021 – present
    - Guest Editor, *Journal of Cleaner Production,* 2021 – present
    - Editorial Board Member, *Computers & Chemical Engineering*, 2015 – present

- **Conference Committees**
    - International Programming Committee, Winter Simulation Conference (WSC), 2023.
    - Scientific Committee and Theme Coordinator, the 33$^{th}$ European Symposium on Computer Aided Process Engineering (ESCAPE-33), 2023
    - Scientific Planning Committee, ACS Campaign for a Sustainable Future, 2022
    - International Program Committee, 11$^{th}$ Symposium on Control of Power and Energy Systems (CPES), 2022
    - International Program Committee, 13$^{th}$ IFAC Symposium of Dynamics and Control of Process Systems (DYCOPS), 2022
    - Scientific Committee, the 32$^{nd}$ European Symposium on Computer Aided Process Engineering (ESCAPE-32), 2022
    - International Programming Committee, 11$^{th}$ International Symposium on Advanced Control of Chemical Processes (ADCHEM), 2021
    - International Programming Committee, The 14$^{th}$ International Symposium on Process Systems Engineering (PSE), 2021



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- Scientific Committee, the 31st European Symposium on Computer Aided Process Engineering (ESCAPE-31), 2021
- International Program Committee, 7th International Symposium on Advanced Control of Industrial Processes (AdCONIP), 2020
- Associate Editor, IFAC World Congress, 2020
- International Program Committee, 6th IFAC Conference on Sensing, Control and Automation Technologies for Agriculture (AgriControl 2019), 2019
- International Programming Committee, Winter Simulation Conference (WSC), 2019.
- International Scientific Committee, 17th Global Conference on Sustainable Manufacturing (GCSM), 2019
- Advisory Committee, Foundations of Process Analytics and Machine learning (FOPAM), 2019
- International Programming Committee, the 9th International Conference on Foundations of Computer-Aided Process Design (FOCAPD), 2019
- Steering Committee, 8th International Congress on Sustainability Science & Engineering (ICOSSE), 2019
- International Advisory Committee, 5th International Conference on Sustainable Chemical Product and Process Engineering (SCPPE), 2019
- Scientific Committee, the 29st European Symposium on Computer Aided Process Engineering (ESCAPE-29), 2019
- Program Committee, 6th World Congress on Global Optimization (WCGO 2019), Metz, France.
- Organizing Committee and International Scientific Committee, MIT Applied Energy Conference, 2019
- Scientific Advisory Committee, 14th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES), 2019
- International Programming Committee, Winter Simulation Conference (WSC), 2018.
- International Programming Committee, 10th International Symposium on Advanced Control of Chemical Processes (ADCHEM), 2018
- International Program Committee, the 13th International Symposium on Process Systems Engineering (PSE-2018), 2018.
- Topic Coordinator & Scientific Committee, the 28st European Symposium on Computer Aided Process Engineering (ESCAPE-28), 2018.
- International Programming Committee, Winter Simulation Conference (WSC), 2018.
- International Scientific Committee, 16th Global Conference on Sustainable Manufacturing (GCSM), 2018
- Program Committee, 14th Int'l Global Optimization Workshop (LeGO-2018), 2018.
- Program Committee, Global Optimization Conference (GOC-2017), 2017
- Technical Advisory Committee, the 7th International Conference on Foundations of Computer-Aided Process Operations (FOCAPO), 2017.
- Scientific Advisor & International Scientific Committee, the 27st European Symposium on Computer Aided Process Engineering (ESCAPE-27), 2017.
- International Programming Committee, Winter Simulation Conference (WSC), 2017.
- International Scientific Committee, Jubilee 20th Conference Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction (PRES'17), 2017.

- Associate Editor & International Program Committee, 6th International Symposium on Advanced Control of Industrial Processes (AdCONIP), 2017
- Scientific Committee, Workshop: PSE State of the Art, 2017
- International Advisory Committee, 4th International Conference on Sustainable Chemical Product and Process Engineering (SCPPE), 2016.
- International Scientific Committee, the 26st European Symposium on Computer Aided Process Engineering (ESCAPE-26), 2016.
- Technical Committee, International Symposium on Sustainable Systems and Technology (ISSST), 2016
- International Scientific Committee, 19th Conference Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction (PRES 2016), 2016.
- International Programming Committee, Winter Simulation Conference (WSC), 2016.
- International Scientific Committee, the 12th International Symposium on Process Systems Engineering and 25st European Symposium on Computer Aided Process Engineering (PSE-2015/ESCAPE-25), 2015.
- International Scientific Committee, the 12th International Conference on Chemical and Process Engineering (ICheaP12), 2015.
- International Programming Committee, Winter Simulation Conference (WSC), 2015.
- International Programming Committee, the 8th International Conference on Foundations of Computer-Aided Process Design (FOCAPD), 2014.
- International Academic Committee, 3rd International Conference on Sustainable Chemical Product and Process Engineering (SCPPE), 2013.
- Scientific Committee, the 4th International Conference on Biorefinery (ICBB), 2013.
- Organizing Committee, the 6th International Conference on Foundations of Computer-Aided Process Operations (FOCAPO), 2012.

- **Panelist/Reviewer of Grant Proposals**
  - Multiple programs at National Science Foundation, 2011, 2012, 2013, 2014, 2015, 2017, 2018, 2019, 2020
    - Process and Reaction Engineering
    - Environmental Sustainability
    - SusChEM
    - Manufacturing Machines and Equipment
    - National Artificial Intelligence (AI) Research Institutes
    - Graduate Research Fellowships Program
  - Department of Energy
  - ACS Petroleum Research Fund
  - ETH Research Commission, Switzerland
  - Qatar National Research Fund
  - Ontario Research Fund, Canada
  - Ministry of Education and Science, Republic of Kazakhstan
  - Natural Sciences and Engineering Research Council, Canada
  - Engineering and Physical Sciences Research Council, UK
  - United Arab Emirates University Advanced Research Program, UAE



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- Swiss National Science Foundation
- Austrian Science Fund (FWF)
- Technology Foundation STW, Netherlands
- Fondazione Cariplo, Italy
- Israeli Ministry of Science, Technology and Space
- Netherlands Organisation for Scientific Research (NWO)
- Chilean National Science and Technology Commission (CONICYT - Chile)
- São Paulo Research Foundation (FAPESP)
- Luxembourg National Research Fund (FNR)
- French National Research Agency (ANR)
- Czech Science Foundation
- Italian Medicines Agency (AIFA)
- National Research Foundation of Singapore
- National Science Center, Poland
- The Science Foundation Ireland (SFI)
- Ministry of Earth Sciences (MoES) in India
- Indian Council of Social Science Research (ICSSR)
- Dutch Research Council
- European Science Foundation

- **Reviewer for Journals** (600+ papers from 100+ journals)

  *ACS Sustainable Chemistry & Engineering, AIChE Journal, Annals of Operations Research, Applied Energy, Applied Mathematical Modelling, Applied Thermal Engineering, Biochemical Engineering Journal, Biofuels, Bioproducts & Biorefining, Bioresource Technology, Catalysis Today, Chemical Engineering Communications, Chemical Engineering Research and Design, Chemical Engineering Science, Chemosphere, Computational Optimization and Applications, Computers & Chemical Engineering, Computers & Electrical Engineering, Computers & Industrial Engineering, Decision Support Systems, Energies, Energy, Energy and Buildings, Energy Conversion and Management, Energy & Environmental Science, Energy & Fuels, Environment, Development and Sustainability, Environmental Science & Technology, Environmental Technology, European Journal of Operational Research, Frontiers in Energy Research, Frontiers in Robotics and AI, Greenhouse Gases: Science and Technology, IBM Journal of Research & Development, IEEE Systems, Man and Cybernetics, IEEE Transactions on Control Systems Technology, IIE Transactions, Industrial & Engineering Chemistry Research, INFORMS Journal on Computing, International Journal of Control, International Journal of Hydrogen Energy, International Journal of Information Technology & Decision Making, International Journal of Life Cycle Assessment, International Journal of Production Research, International Journal of Production Economics, International Journal of Sustainable Engineering, Journal of Agricultural Research, Journal of Applied Mathematics, Journal of Cleaner Production, Journal of Energy Engineering, Journal of Engineering Manufacture, Journal of Global Optimization, Journal of Hazardous Materials, Journal of Heuristics, Journal of Industrial Ecology, Journal of Optimization Theory and Applications, Journal of Process Control, Journal of the Operational Research Society, Journal of the Royal Society Interface, Journal of Scheduling, Journal of Service Science and Management, Journal of System Science and System Engineering, Mathematical Problems in Engineering, Nano Energy, Nature, Nature Energy, Nature Materials, Omega, Operational Research, Operations Research, Operations Research for Health Care, Optimization and Engineering, Optimization Letters, PLOS ONE, Processes, Progress in Photovoltaics: Research and Applications,*

*RSC Advances, Science, Science Advances, Science of the Total Environment, Scientific Research and Essays, Sustainable Production and Consumption, Transportmetrica A: Transport Science, Transportation Research Part B, Transportation Research Part D, Transportation Research Part E, Transportation Science, Water Research*

- **Reviewer for Publishers**
    - Wiley
    - Springer
    - Elsevier
    - Taylor & Francis

- **Service at Northwestern University**
    - Departmental Seminar Organizer, Department of Chemical and Biological Engineering, 2012 – 2016
    - Undergraduate Advisor, McCormick School of Engineering, 2011 – 2016
    - Graduate Admissions Committee, Department of Chemical and Biological Engineering, 2011 – 2015

- **Service at Cornell University**
    - Undergraduate Advisor, College of Engineering, 2016 - present
    - Chair of Ph.D. Studies, Systems Engineering Program, 2016 – present
    - Executive Committee, Systems Engineering Program, 2016 – present
    - Graduate Field Committee, Smith School of Chemical and Biomolecular Engineering, 2016 – present
    - Space Committee, Smith School of Chemical and Biomolecular Engineering, 2016 – present
    - Computing Committee, Smith School of Chemical and Biomolecular Engineering, 2018 – present
    - Website Committee, Smith School of Chemical and Biomolecular Engineering, 2018 – present
    - Awards Committee, Smith School of Chemical and Biomolecular Engineering, 2019 – present
    - Teaching Awards Committee, College of Engineering, 2018-2020
    - Ad Hoc Tenure Review Committee, 2017 – present
    - Faculty Search Committee, Systems Engineering Program and School of Electrical and Computer Engineering, 2017 – 2018
    - Faculty Search Committee, School of Operations Research and Information Engineering, 2017 – 2018
    - Energy Institute Strategic Planning Committee, 2017 – 2018
    - University Travel Expense Policy Committee, 2018 – present
    - Faculty Leadership Committee, Cornell Institute of Digital Agriculture, 2017 – present
    - Faculty Advisor, Cornell Energy Systems Club, 2018 – present
    - Associate Director, Cornell Energy Systems Institute, 2018 – present
    - Faculty Search Committee, Department of Computer Science and Systems Engineering Program, 2018 – 2019

- Faculty Senator on behalf of Smith School of Chemical and Biomolecular Engineering, Cornell University Faculty Senate, 2020 – 2022
- Faculty Search Committee Co-Chair, Smith School of Chemical and Biomolecular Engineering, 2021 – 2022
- CESI Director Search Committee, Cornell Energy Systems Institute (CESI), 2021 – present
- Awards & Recognitions Committee, Smith School of Chemical and Biomolecular Engineering, 2021 – present
- Communication Committee, Smith School of Chemical and Biomolecular Engineering, 2021 – present
- M.Eng. Committee, Smith School of Chemical and Biomolecular Engineering, 2021 – present
- Chair of Energy & Sustainability Graduate Admission Sub-Committee, Smith School of Chemical and Biomolecular Engineering, 2021 – present
- Associate Director, Cornell Institute of Digital Agriculture, 2021 – present
- Senior Faculty Fellow, Cornell Atkinson Center for Sustainability, 2021 – present
- Co-Director, Cornell University AI for Science Institute, 2022 – present
- Program Co-Lead, Schmidt AI in Science Fellowships at Cornell, 2022 – present

## STUDENTS AND SCHOLARS MENTORED

- **Postdoctoral Researchers**
  - Xin Sun (09/2023 – present)
  - Shuangqi Li (09/2023 – present)
  - Bu Zhao (09/2023 – present)
  - Benjamin Decardi-Nelson (07/2022 – present)
  - Qianzhi Zhang (05/2022 – 06/2023)
    - Placement: Assistant Professor of ECE, University of Alabama
  - Chunbo Zhang (02/2022 – 11/2022)
    - Placement: Postdoc, University College London
  - Shiyu Yang (07/2021 – present)
    - Placement: Assistant Professor (ECE), Oregon Tech
  - Chao Ning (08/2020 – 02/2021)
    - Placement: Assistant Professor of Automation, Shanghai Jiaotong University
  - Lu Sun (04/2021 – 09/2021)
    - Placement: Associate Professor, Xi'an Jiaotong University
  - Inkyu Lee (09/2018 – 08/2019)
    - Placement: Assistant Professor, Pusan National University
  - Daison Manuel Yancy Caballero (04/2018 – 07/2020)
    - Placement: Research Scientist, National Energy Technology Laboratory
  - Chao Shang (10/2016 – 10/2018)
    - Placement: Assistant Professor, Department of Automation, Tsinghua University
  - Yunfei Chu (09/2011 – 08/2014)
    - Placement: Research Engineer, ExxonMobil Chemical
  - Berhane H. Gebreslassie (12/2011 – 09/2012)



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- Placement: Research Engineer, Vishwamitra Research Institute

- **Ph.D. Students**
  - Chao Shang (08/2023 – present)
  - Bingzheng Wang (08/2023 – present)
  - Apoorv Lal (08/2023 – present)
  - Nathan Preuss (08/2022 – present)
  - Tianqi Xiao (08/2022 – present)
  - Fah Kumdokrub (08/2021 – present)
  - Anye Shi (08/2021 – present)
  - Guoqing Hu (08/2020 – present)
  - Wei-Han Chen (08/2020 – present)
  - Yanqiu Tao (08/2021 – present)
    - Thesis Title: Climate and environmental sustainability of trend toward occupational-dependent hybrid work
  - Xiang Zhao (01/2020 – present)
    - Thesis Title: Sustainable Chemical Recycling of Plastic Debris From Macro to Micro Levels
  - Xueyu Tian (09/2020 – present)
    - Thesis Title: Perovskite Materials and Scalable Manufacturing in The Era of Multi-Terawatt Photovoltaics Deployment
  - Abdulelah Alshehri (08/2019 – present)
    - Thesis Title: Deep Learning for Computational Molecular Design
  - Akshay Ajagekar (08/2018 – present)
    - Thesis Title: Quantum Computing and Quantum Artificial Intelligence for Renewable and Sustainable Energy
  - Chao Ning (12/2015 – 08/2020)
    - Thesis Title: Data-Driven Optimization Under Uncertainty in The Era of Big Data and Deep Learning: General Frameworks, Algorithms, and Applications
    - O. Hugo Schuck Award, AACC, 2020
    - SEF Student Paper Award, AIChE, 2019
    - Placement: Assistant Professor of Automation, Shanghai Jiaotong University
  - Daniel J. Garcia (03/2014 – 02/2019)
    - Thesis Title: Life Cycle Optimization of Sustainable Water-Energy-Food Nexus Systems and Networks
    - Honorable Mention, NSF Graduate Research Fellowship, 2014, 2015
    - Ryan Fellow, 2013-2015
    - ISEN Cluster Fellow, 2015-2016
    - Presidential Fellowship of Northwestern University, 2017 – 2018
    - SEF Student Paper Award, AIChE, 2018
    - Placement: Research Engineer, ExxonMobil
  - Karson T. Leperi (12/2013 – 07/2018) co-advised with Prof. Randall Q. Snurr
    - Thesis Title: Integrated Material and Process Development for Metal-Organic Frameworks in Post-Combustion Carbon Capture Applications
    - Ryan Fellow, 2013-2015

        - Placement: Systems Design Engineer, Intel
    - Jiyao Gao (12/2013 – 07/2018)
        - Thesis Title: Sustainable Design and Optimization of Shale Gas Energy Systems
        - SEF Student Paper Award, AIChE, 2017
        - Graduate Student Travel Award, CAST Division, AIChE, 2017
        - Placement: Senior Algorithm Engineer, Cardinal Operations
    - Jian Gong (12/2012 – 07/2017)
        - Thesis Title: Sustainable Design and Synthesis of Energy Systems
        - Zdenek Burianec Memorial Award, PRES, 2017
        - Placement: Senior Analyst, Goldman Sachs
    - Dajun Yue (12/2011 – 06/2016)
        - Thesis Title: Multi-Scale Optimization of Biomass-to-Bioenergy Supply Chains
        - Graduate Student Travel Award, CAST Division, AIChE, 2013
        - 3M Fellow, 2014-2015
        - Honorable Mention, SEF Student Paper Award, AIChE, 2014
        - Outstanding Self-financed Student Abroad Award, 2015
        - Distinguished Graduate Researcher Award, ChBE, Northwestern Univ., 2015
        - Placement: Operations Research Scientist, Amazon.com

- **M.S. Students**
    - Rishi Balaji (08/2022 – present)
    - Roohi Menon (08/2021 – present)
    - Vikram Raghavan (08/2021 – present)
    - Akash Ajagekar (08/2021 – present)
    - Jeet Dhoriyani (08/2021 – present)
    - Tianhong Tan (10/2021 – 10/2023)
        - Thesis Title: Soil Organic Carbon Predicted by Terrain More Than Climate
        - Placement: PhD student, Cornell University
    - Shoudong Zhu (10/2021 – 08/2023)
        - Thesis Title: Advancing sustainable development goals with machine learning and optimization for wet waste biomass to renewable energy
        - Placement: PhD student, Cornell University
    - Apoorv Lal (10/2021 – 03/2023)
        - Thesis Title: Targeting climate‐neutral hydrogen production: Integrating brown and blue pathways with green hydrogen infrastructure
        - Placement: PhD student, Cornell University
    - Jason Huang (01/2020 – 12/2022)
        - Thesis Title: Impacts of Battery Energy Storage Technologies and Renewable Integration on the Energy Transition in the New York State
        - Placement: Data Scientist, Geico
    - Yanqiu Tao (08/2018 – 10/2020)
        - Thesis Title: Second life and recycling: Energy and environmental sustainability perspectives for high-performance lithium-ion batteries
        - Placement: PhD student, Cornell University
    - Xueyu Tian (09/2017 – 10/2020)

        - Thesis Title: Carbon-neutral hybrid energy systems with deep water source cooling, biomass heating, and geothermal heat and power
        - Placement: PhD student, Cornell University
    - Wenhe Ye (12/2013 – 06/2015)
        - Placement: ATCG Solutions
    - Emeline Sukamtoh (12/2013 – 12/2014)
        - Placement: Solidarity Bridge
    - Rongzhi Xu (12/2013 – 12/2014)
        - Placement: Nielsen
    - Jian Gong (12/2012 – 11/2013)
        - Placement: PhD student, Northwestern University
    - Prasad Khatav (12/2011 – 06/2012)
        - Placement: Process Control Engineer, PiControl Solutions LLC
    - Yuan Yao (12/2011 – 10/2012)
        - Placement: Assistant Professor, Yale University
    - Victoria Perez (12/2011 – 11/2012)
        - Placement: Oak Tree Investments
    - Belinda Wang (02/2011 – 11/2012)
        - Placement: Research Scientist, Honeywell

- **M.Eng. Students**
    - Sindhuja Vaddeboina (09/2023 – 12/2023)
    - Ivan Bourov (09/2023 – 12/2023)
    - Zidong Huang (09/2023 – 05/2024)
    - Ruiyang Jiang (09/2023 – 05/2024)
    - Fanchen Kong (09/2023 – 05/2024)
    - Sanath Kumar (09/2023 – 05/2024)
    - Miaocheng Li (09/2023 – 05/2024)
    - Zekai Li (09/2023 – 05/2024)
    - Yijun Lu (09/2023 – 05/2024)
    - Teppei Matsutake (09/2023 – 05/2024)
    - Han Meng (09/2023 – 05/2024)
    - James Jun Hao Ong (09/2023 – 05/2024)
    - Kaili Sun (09/2023 – 05/2024)
    - Fengkai Tang (09/2023 – 05/2024)
    - Allison Virgo (09/2023 – 05/2024)
    - Shuchen Wu (09/2023 – 05/2024)
    - Tongze Xu (09/2023 – 05/2024)
    - Jieying Yang (09/2023 – 05/2024)
    - Rui Yang (09/2023 – 05/2024)
    - Jacob Lashin (01/2023 – 05/2023)
    - Hao Chen (09/2022 – 05/2023)
    - Wooyoung Cho (09/2022 – 05/2023)
    - Sizhe Gao (09/2022 – 05/2023)
    - Shuxian Jiang (09/2022 – 05/2023)

- Xiang Lan (09/2022 – 05/2023)
- Xingze Li (09/2022 – 05/2023)
- Ziyuan Lin (09/2022 – 05/2023)
- Yifan Liu (09/2022 – 05/2023)
- Zihao Liu (09/2022 – 05/2023)
- Anusha Nambiar (09/2022 – 05/2023)
- Kingsley Odae (09/2022 – 05/2023)
- Xuning Shao (09/2022 – 05/2023)
- Kailing Shen (09/2022 – 05/2023)
- Zhongqi Tao (09/2022 – 05/2023)
- Jinxuan Wang (09/2022 – 05/2023)
- Yuning Xia (09/2022 – 05/2023)
- Xin Zhang (09/2022 – 05/2023)
- Yunquan Zhang (09/2022 – 05/2023)
- Zhiyuan Zhang (09/2022 – 05/2023)
- Weizhe Zhao (09/2022 – 05/2023)
- Xi Zhao (09/2022 – 05/2023)
- Xianmin Zhao (09/2022 – 05/2023)
- Keyi Zhou (09/2022 – 05/2023)
- Yuting Zhou (09/2022 – 05/2023)
- Guanlin Zhu (09/2022 – 05/2023)
- Sarah Alruwaily (09/2022 – 05/2023)
- Sanjana Namreen (09/2022 – 05/2023)
- Emily Chou (09/2022 – 12/2022)
- Rachel Lee (09/2022 – 12/2022)
- Yousef Dakhel Aloufi (01/2022 – 05/2022)
- Naif Alghamdi (01/2022 – 05/2022)
- Bryan Tantisujjatham (09/2021 – 05/2022)
- Ruobing Shui (09/2021 – 05/2022)
- George Pan (09/2021 – 05/2022)
- Owais Khalid (09/2021 – 05/2022)
- Sindhu Iyer (09/2021 – 05/2022)
- Jinyang Dai (09/2021 – 05/2022)
- Chenghui Li (09/2021 – 05/2022)
- Nuo Tan (09/2021 – 05/2022)
- Ziyin Wang (09/2021 – 05/2022)
- Rong Xu (09/2021 – 05/2022)
- Haiyang Yu (09/2021 – 05/2022)
- Mingkai Zheng (09/2021 – 05/2022)
- Hanxin Yu (01/2021 – 05/2021)
- Ruobing Shui (09/2020 – 12/2020)
- Chang Wei (09/2020 – 12/2020)
- Ruby Jin (09/2020 – 12/2020)
- Shristi Varshney (09/2020 – 12/2020)

- Raaj Bora (08/2018 – 08/2020)
- Khalid Fihat Alanazi (01/2020 – 12/2020)
- Karthik Suresh Menon (01/2020 – 12/2020)
- Anmol Singh (01/2020 – 12/2020)
- Jianmin Su (01/2020 – 12/2020)
- Yangmengyuan Zhao (09/2019 – 05/2020)
- Xinyi Cai (09/2019 – 05/2020)
- Tiancheng Yuan (09/2019 – 05/2020)
- Shivam Tewari (09/2019 – 05/2020)
- Yuhua Ma (09/2019 – 05/2020)
- Xinni Cheng (09/2019 – 05/2020)
- Akshit Patel (09/2019 – 05/2020)
    - Outstanding M. Eng. Project Award (Spring 2021)
- Jessica Hwang (09/2019 – 05/2020)
- Yiying Sheng (09/2019 – 05/2020)
- Alwin Thomas (09/2019 – 05/2020)
    - Outstanding M. Eng. TA Award (Spring 2021)
    - Placement: Merck
- Boru Wang (09/2019 – 05/2020)
- Lesley Sun (09/2019 – 05/2020)
- Venkat Akshay Chintalapati (09/2019 – 05/2020)
- Brian Davey (09/2019 – 05/2020)
- Tigran Mehrabyan (09/2019 – 12/2019)
    - Outstanding M. Eng. Project Award (Fall 2020)
- Raaj Bora (01/2019 – 08/2020)
- Jiwei Yao (01/2019 – 08/2020)
- Siming Zou (01/2019 – 12/2019)
- Allen Yang (01/2019 – 12/2019)
- Aasim Ayaz Wani (01/2019 – 12/2019)
- Sivaji Gudipati (01/2019 – 12/2019)
- Yuan Jiang (09/2018 – 12/2019)
- Minghan Shi (01/2019 – 05/2019)
- Tsung-Hsun Lin (09/2018 – 05/2019)
- Jiahe Zhou (09/2018 – 05/2019)
- Deeksha Anand (09/2018 – 05/2019)
- Xuyang Xiao (09/2018 – 05/2019)
- Chengnan Xu (09/2018 – 05/2019)
- Yiqi Shao (09/2018 – 05/2019)
- Heena Ugale (09/2018 – 05/2019)
- Yiyang Huang (09/2018 – 05/2019)
- Wei Shih Tu (09/2018 – 05/2019)
- Varun Harnathka (09/2018 – 05/2019)
- Rosa Wu (09/2018 – 05/2019)
- Qixuan Li (09/2018 – 05/2019)

        - Outstanding M. Eng. Project Award (Spring 2019)
    - Mengyun Wang (09/2018 – 05/2019)
    - Tian Yu (09/2018 – 05/2019)
    - Zeyu Zhang (09/2018 – 05/2019)
    - Yifan Zhu (09/2018 – 05/2019)
    - Ziqi Wang (09/2018 – 05/2019)
    - Zhaoqi Song (09/2018 – 05/2019)
    - Lianghui Li (09/2018 – 12/2018)
    - Jieneng Yang (09/2018 – 12/2018)
    - Mengyu Ye (09/2018 – 12/2018)
    - Wei-Han Chen (09/2017 – 05/2018)
        - Outstanding M. Eng. Project Award (Spring 2018)
    - Raquel R Mayorga (03/2018 – 05/2018)
    - Haokai Huang (09/2017 – 05/2018)
    - Xinyan Bai (09/2017 – 05/2018)
    - Xiu Wang (09/2017 – 05/2018)
    - Jun Yang (09/2017 – 05/2018)
    - Natalia L. Juncua (09/2017 – 05/2018)
    - Azhir Barodawala (09/2017 – 05/2018)
    - Schuyler Gardner (09/2017 – 12/2017)
        - Outstanding M. Eng. Project Award (Fall 2017)
        - Placement: Celgene
    - Kenny Wronka (09/2016 – 05/2017)
    - Ivy Lai Miller (09/2016 – 05/2017)
        - Outstanding M. Eng. TA Award (Spring 2017)
        - Placement: Symetra Financial
    - Imran Yasin (09/2016 – 05/2017)
        - Outstanding M. Eng. Project Award (Spring 2017)
        - Placement: BASF
    - Aqdas Nida (09/2016 – 05/2017)
        - Placement: Commonwealth Edison
    - Bingqing Ma (09/2016 – 12/2016)
        - Placement: Cornell CS PhD program
    - Minhao Li (09/2016 – 12/2016)
        - Outstanding M. Eng. Project Award (Fall 2016)
    - Mandy Teng (09/2016 – 12/2016)
        - Placement: Merck
    - Yuting Tian (09/2016 – 12/2016)