Thirdpath

Humanity, Energy & AI, Part II:

Humanity's Energy Arbitrage with Information and Mind

Tim Lee September 2026

Senior Managing Director, Co-head of Buyouts

Energy, from Muscle to Mind and Beyond

Part I ended with a rider on a horse and a bird in the sky, both spending energy to move something that weighed almost nothing: a handful of words. This part of the story moves fast. It moves faster than fire, faster than steam, faster than rail.

Once humanity started arbitraging the energy cost of moving information instead of matter, it was only a matter of time before it started arbitraging the energy cost of making sense of that information too.

A signal fire could cross a mountain range in minutes. A telegraph could cross an ocean in minutes too, except now the mountain range and the ocean did not matter at all. In barely two human lifetimes, the same electrical current that used to carry a signal across the ocean has started to do much more than that. It started to deliver a question, and, more strangely still, it started to carry back an answer.

Here is the pattern once more, because it never really changes: find a way to move something for less energy than it used to take, and the world reorganizes itself around the new price tag, whether that is the price of moving things or the price of moving information.

Wires did it to information. Radio did it to distance. And somewhere in a chess match in 1997, a Jeopardy! studio in 2011, and a research paper in 2017, machines quietly started doing it to human judgment.

This is the story of that arbitrage: humanity taught a pigeon to fly home so a message could travel without a human ever having to carry it, then taught a machine to compute, and subsequently to think. And, without quite meaning to, to reason.

And it unfolds from there.

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SECTION I: ENERGY ARBITRAGE FOR INFORMATION DELIVERY

1. Signals: Fire, Smoke, and the Semaphore

Long before a wire carried a signal, nature did. Fire, smoke, and sound were all used to move a message faster than any human body could carry it. Information is power, and delivering a message quickly is the arbitrage that carries the value.

Key Milestones

- Fire and smoke, from roughly the 8th century BC in China onward.[1] Beacon towers relayed warnings of invasion across vast distances, centuries before any writing system could travel that fast.
- Sound and sirens, from ancient warning horns to the electric siren in 1799.[2] A single burst of sound could alert an entire village at once, useful exactly where fire and smoke could not be seen: at night, in fog, or through dense forest.
- Semaphore, 1792, the Chappe system in France.[3] A relay of towers and telescopes turned mechanical arm positions into coded language, the direct conceptual ancestor of the electric telegraph.

The Energy, Social, and Economic Impact of Signals

The Chappe semaphore line from Paris to Lille, roughly 230 kilometers, could pass the first symbol of a message through 15 towers in just nine minutes, with a full message typically taking about 32 minutes.[4] That works out to an effective signal speed of over 500 kilometers an hour, against a horse courier at roughly 10 kilometers an hour.[4] It is worth pausing on that: in 1794, more than a century before the airplane, a message could already outrun anything on legs by fifty times, using nothing but wood, rope, and a telescope.

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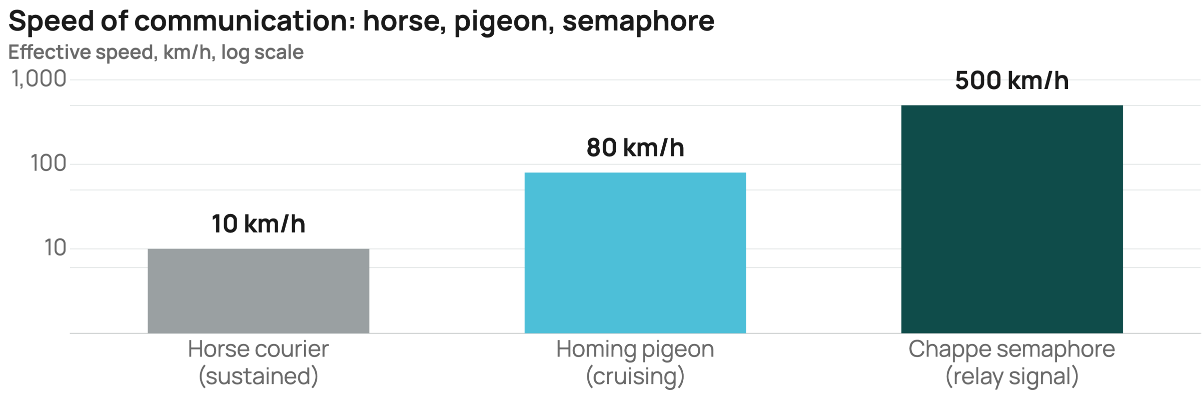
[1] TravelChinaGuide, "Great Wall Beacon Towers: China's Ancient Telegraph System."
[2] Wikipedia, "Siren (Alarm)."
[3] Wikipedia, "Chappe Telegraph."
[4] Xoxzo Blog, "A Brief History of Optical Telegraph"; History of Information, "The Optical Telegraph."



Source: Xoxzo[5]

The homing pigeon from Part I's postlude sits in between: cruising at roughly 50 miles an hour, about 80 kilometers an hour, far slower than the semaphore's 500 but far faster than a horse.[6] And unlike the semaphore, a pigeon needed no towers, no operators, and no government funding, just a bird that knew its way home. Speed was not the only currency in this arbitrage. Cost was too.

[5] Xoxzo Blog, "A Brief History of Optical Telegraph"; History of Information, "The Optical Telegraph."
[6] The Donut Whole, "How Far Can a Messenger Pigeon Travel in a Day?"

2. Wires: The Telegraph, the Telephone, and the Atlantic Cable

The semaphore proved a message could outrun a horse. The electric wire proved a message did not need a body, or even open air, at all. Distance stopped being a matter of geography and became simply a matter of price.

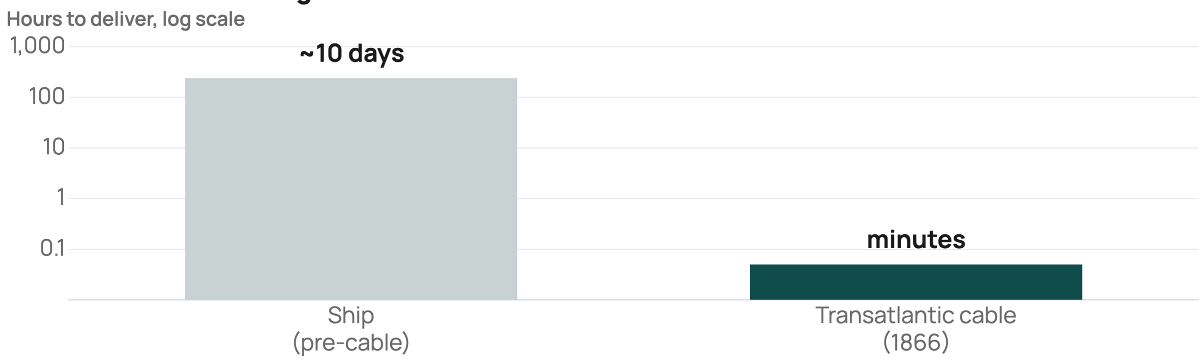
Key Milestones

- The electric telegraph, 1837 with Cooke and Wheatstone in Britain, 1844 with Morse in the United States.[7] Electrical pulses replaced mechanical towers, carrying messages through a wire regardless of weather, darkness, or line of sight.
- The telephone, 1876, Alexander Graham Bell.[8] The wire learned to carry a human voice directly, not just a code, collapsing the distance between speaking and being heard.
- The transatlantic cable, 1858, made durable in 1866.[9] A cable laid across the ocean floor connected two continents that had never before exchanged a message in less than a week.

The Energy, Social, and Economic Impact of Wires

Before 1866, a message between Europe and North America had only one path: a ship, and a journey of roughly 10 to 12 days at sea, against minutes once the cable held.[10] The phrase coined at the time, "two weeks to two minutes," undersold it slightly, but not by much.[11] News, prices, and diplomatic instructions that once needed a week to cross the Atlantic now needed less time than it took to read them.

Time to send a message across the Atlantic



Source: Science Museum[10]

The telephone took it to a different level: it removed the operator and the code in between. A voice could travel the wire directly, and for the first time two people could hold something like a conversation across a distance neither could walk in a day.

[7] Wikipedia, "Electrical Telegraph."
[8] Encyclopaedia Britannica, "Alexander Graham Bell."
[9] Engineering and Technology History Wiki, "Transatlantic Cable."
[10] Science Museum, "How Perseverance Laid the First Transatlantic Telegraph Cable."
[11] Smithsonian, "The 1866 Transatlantic Communications Cable" (Amusing Planet); ABC27, "July 27, 1866: The Transatlantic Cable That Worked."

3. Air: Radio and the Satellite

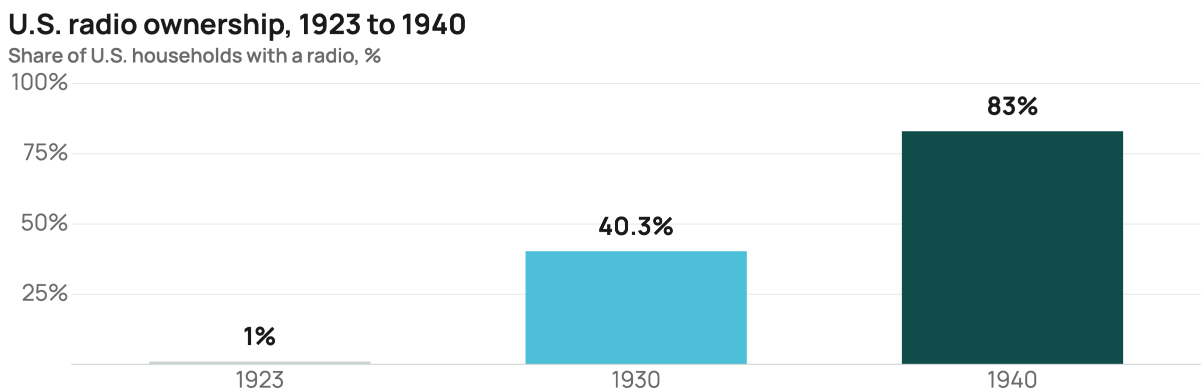
Wires were fast, but they still had to be laid, mile after physical mile. The next arbitrage removed the wire entirely. A signal no longer needed anything between sender and receiver but open sky, and the fixed infrastructure cost went with it.

Key Milestones

- Radio, 1890s to 1901, Guglielmo Marconi.[12] Marconi's wireless transmissions proved a message could cross an ocean with no cable at all, culminating in a transatlantic signal in 1901.
- Commercial broadcast radio, from 1920, with KDKA in Pittsburgh.[13] Radio moved from a point-to-point signal into a one-to-many broadcast, reaching an entire country at once and giving rise to true mass communication.
- Communications satellites, 1962 to 1978, from Telstar to the first GPS satellite.[14] A relay station in orbit did for global signals what the Persian Royal Road's relay stations had done for a horse messenger, except now at the speed of light.

The Energy, Social, and Economic Impact of Air Transmission

Radio's adoption curve is among the steepest in this history. In 1923, essentially no American household owned a radio; by 1930, 40% did; by 1940, 83%.[15] In under two decades, radio went from a novelty to more common than indoor plumbing had been a generation earlier.



Source: The Spokesman-Review[15]

Satellites later did to radio what radio had done to the wire: they removed the last physical constraint, the need for a receiving tower within line of sight of a transmitter. A signal bounced off a satellite could reach anywhere on Earth with a clear view of the sky.

[12] Encyclopaedia Britannica, "Guglielmo Marconi."
[13] APM Reports, "Radio: The Internet of the 1930s."
[14] Wikipedia, "Telstar"; "Global Positioning System."
[15] The Spokesman-Review, "On the Air: The Spread of Home Radio"; History Hub, "Census Fun Fact #3" (U.S. Census, 1930).

4. Bytes: The Internet and Near-Zero Marginal Cost

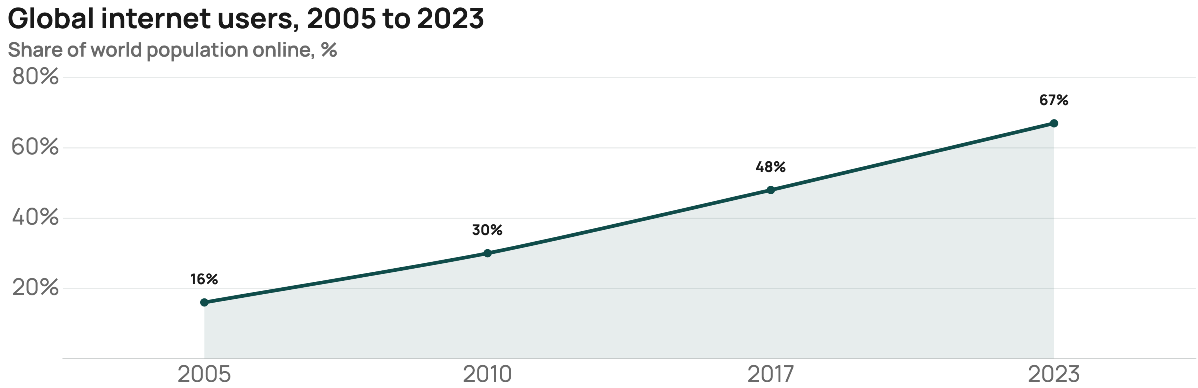
Radio could broadcast the same message to everyone at once. The next arbitrage let every person send a different message to anyone else, at almost no cost. Innovation followed quickly, and new business models with it.

Key Milestones

- ARPANET, 1969.[16] The first operational packet-switched network connected four university computers, the earliest working piece of what became the internet.
- The World Wide Web, 1991, Tim Berners-Lee.[17] A simple system of linked documents turned a research network into something almost anyone could use, not just programmers.
- Video communication, from AT&T's Picturephone in 1964 to FaceTime in 2010.[18] Real-time video finally let a conversation carry a face as well as a voice, without either person leaving their room.

The Energy, Social, and Economic Impact of Bytes

In 2005, roughly 16% of the world's population was online. By 2017, 48%. By 2023, 67%, better than two out of three people on Earth.[19] We are not aware of a prior technology that reached that share of humanity as quickly.



Source: Wikipedia[19]

What makes the internet different is not speed, it is the marginal cost. A telegraph was billed by the word, a satellite call by the minute. An email or a video call, once the network exists, costs almost nothing to send again. That is what started the modern technology era, the world of smartphones and social media as we know it.

Information delivery had finally been arbitraged down to nearly free.

[16] Wikipedia, "ARPANET."
[17] CERN, "The Birth of the Web."
[18] Wikipedia, "Videotelephony."
[19] Wikipedia, "Global Internet Usage," citing International Telecommunication Union data.

Interlude: Beyond the Delivery of Information

In July 1948, a thirty-two-year-old engineer at Bell Labs published a paper that made no headlines. It ran forty-four dense pages in the Bell System Technical Journal, and it did something almost nobody had thought to do before: it gave the word "information" a precise, measurable meaning.[20]

Before Claude Shannon's "A Mathematical Theory of Communication," information was a human idea, felt rather than counted: a good letter, a useful signal, an important message. Shannon reduced it to something a machine could work with, a sequence of yes-or-no choices, a string of what a colleague at Bell Labs had already started calling a "bit."[21] A telegram, a photograph, and a phone call were suddenly, underneath, the same kind of thing: information, encoded in binary, indifferent to what it was made of.

This is the quiet turn this series has been circling toward since Part I's postlude. Every technology in the section above solved the same problem, how to move a message from one place to another faster and more cheaply than the last. None of them asked what a message actually was, or what a machine might do with one besides carry it. Shannon's method is the reason a computer can hold a photograph, a symphony, and a sentence in the same memory, as the same kind of thing.

Two years later, in 1950, the British mathematician Alan Turing, who had spent the war years breaking codes, asked a stranger and far more provocative question: if a machine could hold information the way a mind holds a thought, could it reason with that information the way a mind does?

Little did humanity know the significance of that question.

[20] Quanta Magazine, "How Claude Shannon Invented the Future"; Kronecker Wallis, "Claude Shannon's Information Theory."
[21] History of Information, "Shannon's 'A Mathematical Theory of Communication.'"

SECTION II: ENERGY ARBITRAGE FOR THE MIND

1. To Compute: Deep Blue and Brute Force

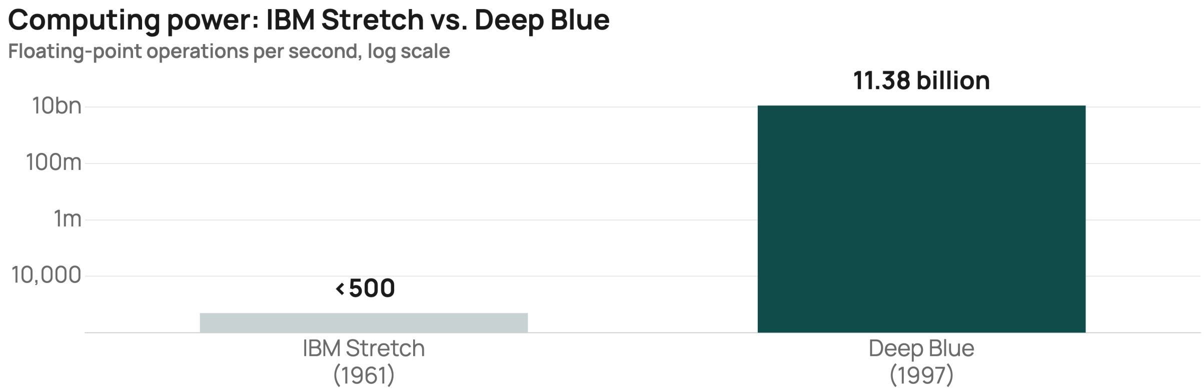
Before a machine could think, it first had to prove it could out-calculate a human: brute force over insight.

Key Milestones

- Turing's theoretical foundation, 1950.[22] Alan Turing's paper "Computing Machinery and Intelligence" posed the question of whether a machine could think, and proposed a practical test for judging the answer.
- Deep Blue defeats Garry Kasparov, May 1997.[23] IBM's Deep Blue became the first computer to beat a reigning world chess champion in a full match under standard tournament rules.

The Energy, Social, and Economic Impact of Compute

Deep Blue won through raw calculation: 200 million chess positions evaluated every second, and 11.38 billion floating-point operations per second.[23] IBM's own first supercomputer, the Stretch, introduced in 1961, had managed well under 500.[23] On those figures, IBM's own hardware gained roughly twenty million times the computing power in thirty-six years, applied, in this case, to a single chessboard.



Source: IBM[23]

Kasparov's loss was not proof that a machine could think. It was proof that, given enough energy converted into raw calculation, a machine could out-compute a human at a narrow, well-defined task: the same arbitrage this series has been tracking, now applied to judgment instead of grain, iron, or a message.

[22] Wikipedia, "Computing Machinery and Intelligence."
[23] IBM, "Deep Blue," including comparison to IBM Stretch (1961) performance.

2. To Think: Watson and the Open Question

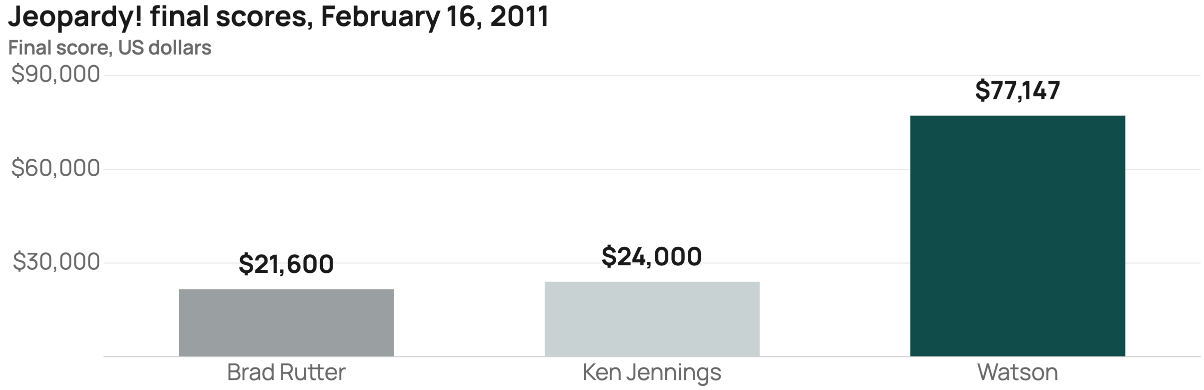
Deep Blue could only play chess. The next milestone had to handle something messier: an open-ended human question, asked in ordinary language.

Key Milestones

- IBM Watson defeats the Jeopardy! champions, 2011.[24] Watson, a natural-language question-answering system, defeated the show's two greatest all-time champions, Ken Jennings and Brad Rutter, with no connection to the internet during play.

The Energy, Social, and Economic Impact of Thinking

The final scores were not close. Watson finished with $77,147, more than three times either Jennings's $24,000 or Rutter's $21,600 on their own.[25] What made Watson different from Deep Blue was not the margin, it was the domain. Chess has fixed rules and a finite board. Jeopardy! clues involve puns and ordinary human phrasing, exactly what brute-force search cannot calculate its way through.



Source: ABC News[25]

Watson's win, and the $1 million prize IBM donated to charity, marked the moment a machine first parsed an ordinary question and retrieved a correct answer from a vast, unstructured body of knowledge, not just a rulebook. That is a meaningfully different arbitrage: not brute calculation, but broad, general recall.

Little did we know that IBM had led us into a new era of energy arbitrage of the mind, by way of a machine that could play chess and Jeopardy!, compute and understand language, and recall what it had learned.

We now give this new form of energy arbitrage a shorter name: AI.

[24] IBM, "Watson, Jeopardy! Champion."
[25] ABC News, "Watson Computer Crushes Humans in Night Three of Jeopardy! Challenge."

3. To Learn: AlexNet and the Neural Network

Watson could retrieve an answer someone had already written down. The next leap was a machine that could learn to recognize something no one had explicitly told it how to see.

Key Milestones

- AlexNet wins the ImageNet competition, 2012.[26] A deep convolutional neural network, trained on 1.2 million labeled images, outperformed every hand-engineered computer vision method before it by a wide margin.

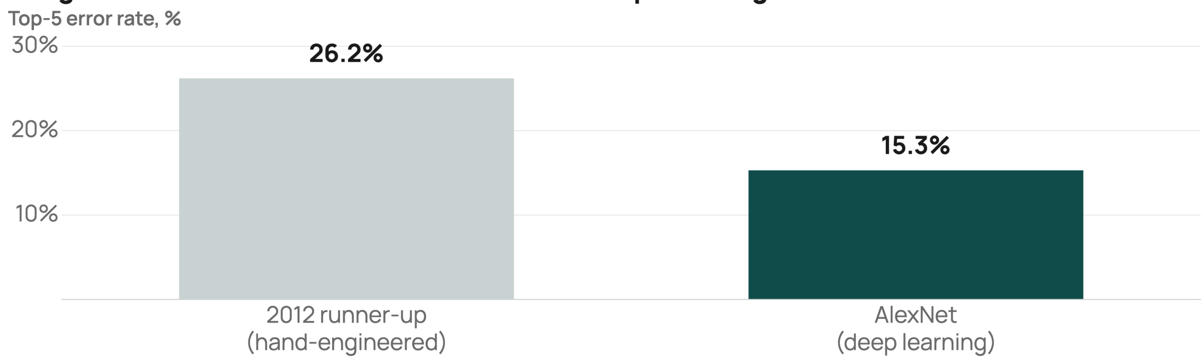
The Energy, Social, and Economic Impact of Learning

ImageNet was a large public test: 1.2 million photos, each labeled with what is in it, a dog, a bicycle, a coffee cup, and the challenge was simple to state and hard to solve. Build a program that looks at a new photo it has never seen and correctly names what is in it.

For years, researchers did this by hand, writing rules such as "look for round shapes and pointed ears to spot a cat." AlexNet discarded that approach. It was a neural network, simply shown millions of labeled photos and left to work out the visual patterns itself.

The gap was not subtle. The best 2012 entry using hand-engineered techniques posted a top-5 error rate of 26.2%, meaning the correct answer was not even in its top five guesses more than a quarter of the time. AlexNet, using its self-taught approach, posted 15.3%, nearly eleven points better.[26] We believe every serious computer vision system built since descends from what AlexNet proved: a large enough neural network, trained on enough data, with enough GPU power, could outlearn methods engineers had spent a decade hand-tuning.

ImageNet 2012: error rate before and after deep learning



Source: Krizhevsky[26]

This is where the arbitrage in this series quietly changed shape. Deep Blue and Watson were both, in their own way, told what to look for. AlexNet was not. It was shown data and left to find the pattern itself: energy converted not into an answer, but into the capacity to learn one.

This marked the arrival of the neural network, the architecture nearly every AI system since has been built on.

[26] Krizhevsky, Sutskever, and Hinton, "ImageNet Classification with Deep Convolutional Neural Networks," NeurIPS, 2012.

4. To Understand: The Transformer and Scale

AlexNet could learn to see. It could not hold a conversation, or follow an idea across a paragraph. That required an architecture actually suited to language and context, not just images.

Key Milestones

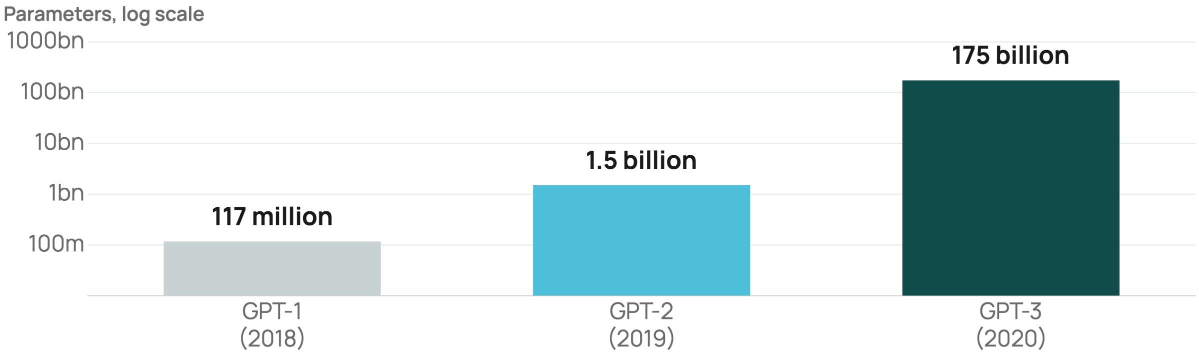
- The Transformer architecture, 2017, Google, "Attention Is All You Need."[27] A new architecture let a model weigh the relationships between every word in a passage at once, rather than reading strictly left to right, unlocking a far deeper grasp of context.

The Energy, Social, and Economic Impact of Understanding

The Transformer made language models worth scaling up substantially, and scaling meant adding parameters. A parameter is one small adjustable number inside the model, a dial that gets tuned, bit by bit, as the model reads through training text, until the whole collection of dials together can predict language well. More parameters mean more capacity to represent nuance: the difference between a word's ten most common meanings instead of just its first, or between a flat instruction and one that picks up on tone.

OpenAI's GPT-1, in 2018, had 117 million of these parameters. GPT-2, a year later, had 1.5 billion. GPT-3, in 2020, had 175 billion, roughly 1,500 times larger than the model that started the line two years earlier.[28] That jump mattered because capability did not scale in a straight line with size, it scaled in jumps: skills such as basic arithmetic, translating between languages it was never explicitly taught to translate, and following multi-step instructions only became reliable once the model, and its energy bill, crossed a certain scale. Bigger, in this narrow sense, kept buying genuinely new behavior, not just a marginally better version of the old one.

Growth in model size after the Transformer, 2018 to 2020



Source: Radford[28]

We believe this architecture made the rest of this series possible. Every large language model since, including the ones many of us use today, descends from the core idea published in that 2017 paper.

[27] Vaswani et al., "Attention Is All You Need," arXiv, 2017.

[28] Radford et al., "Improving Language Understanding by Generative Pre-Training," OpenAI, 2018; Radford et al., "Language Models are Unsupervised Multitask Learners," OpenAI, 2019; Brown et al., "Language Models are Few-Shot Learners," OpenAI, 2020.

5. To Reason: ChatGPT and the Fastest Adoption on Record

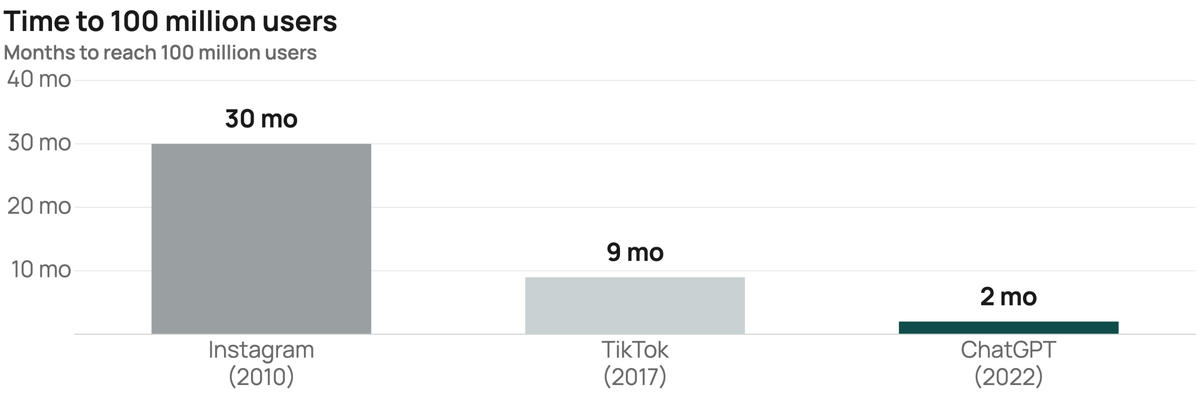
Understanding context is not the same as reasoning through a problem. The final milestone here is still unfolding: a machine that can be asked a genuinely open-ended question and reason its way to a useful answer.

Key Milestones

- ChatGPT launches, November 30, 2022, OpenAI.[29] A conversational interface built on a large language model let anyone, not just researchers or programmers, hold an open-ended exchange with an AI system.

The Energy, Social, and Economic Impact of Reasoning

The adoption curve is unlike anything else in this series. Instagram took roughly 2.5 years to reach 100 million users. TikTok took about 9 months. ChatGPT took about two.[30] A UBS analysis noted that in two decades of tracking internet products, its analysts had not seen a consumer application scale that quickly.[31]



Source: CBS News[30]

What made the adoption so fast was not novelty alone. For the first time, energy, once converted into computation and language, could be spent asking and answering questions. We believe that is an energy arbitrage of a different kind from moving matter or delivering information.

Energy has, however imperfectly, gone from moving matter and messages to replicating a piece of human judgment itself.

[29] OpenAI, "Introducing ChatGPT."
[30] CBS News, "ChatGPT Acquired 100 Million Active Users Faster Than TikTok and Instagram."
[31] Time, "How ChatGPT Managed to Grow Faster Than TikTok or Instagram," citing UBS research.

Conclusion: The Same Trade, Run on Thought

This series began with a hominid who did not run from a fire, and a brain that used the surplus to grow. It ends with a different kind of surplus entirely: energy, converted into computation, and then into something that can answer a question.

Fire arbitraged calories into cognition. Coal and rail arbitraged distance into motion. The telegraph and the internet swapped distance for near-zero-cost information transmission. And now, computation is being arbitraged into judgment.

The pattern never changed, only the material did: the same trade, run one more time, on the most valuable material humanity has ever had to spend, our own thinking.

A surplus of calories bought a bigger brain. A bigger brain built the tools that bought a surplus of energy. That surplus built the wires and satellites that moved information almost for free. And that free-flowing information in turn became the raw fuel, literally billions of documents, images, and conversations, that trained the machines now doing a piece of humanity's thinking for it. Each stage made the next one possible, not by coincidence, but by compounding.

Whether that is humanity's greatest arbitrage yet, or its riskiest, is not a question this paper can answer. What we can say is that the trade is not new. It is the same one a hominid made near a fire more than a million years ago: spend energy now, so that something more valuable, time, reach, or thought, can be bought with the savings.

This paper has traced the arbitrage; it has not priced it. If energy arbitrage is now being applied to thought, the natural next question is what that is worth, and to whom.

Where should capital go when the thing being manufactured is judgment itself, who captures the value it creates, and what gets displaced along the way? That is where this series turns next: AI and investment, the arbitrage described here seen through the lens of where the money actually flows.

Fire bought us time. Pigeons bought us reach. And now, it seems, energy is buying us thought.

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Sam Howard
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Analyst, Investments

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Thalia Gietzen
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4. Brown et al., "Language Models are Few-Shot Learners," OpenAI, 2020.

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8. Engineering and Technology History Wiki, "Transatlantic Cable" (online).

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26. Wikipedia, entries consulted: "Siren (Alarm)," "Chappe Telegraph," "Electrical Telegraph," "Telstar," "Global Positioning System," "ARPANET," "Videotelephony," "Global Internet Usage," "Computing Machinery and Intelligence" (online).

27. Xoxzo Blog, "A Brief History of Optical Telegraph" (online).

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