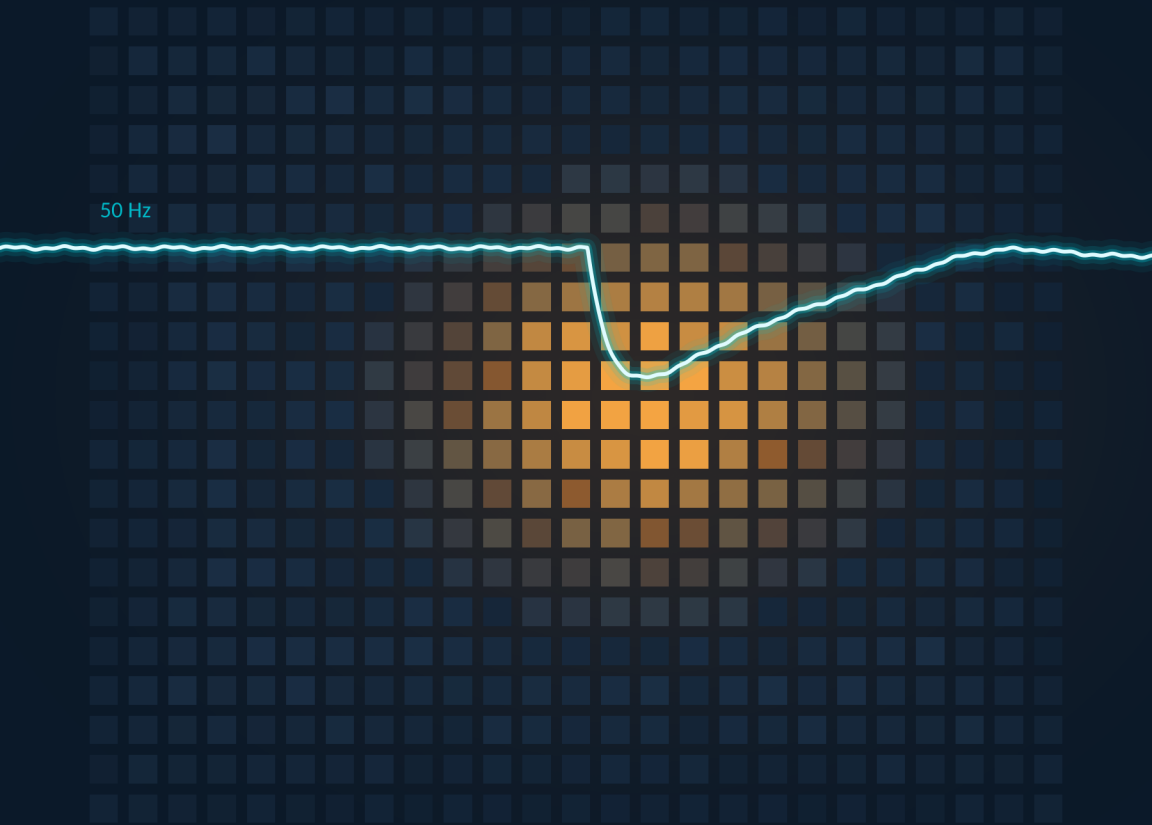
GRIDSTAB NEWS

The Unseen Load

How AI Data Centers Are Testing the Stability of the Power Grid



GILLES CHASPIERRE

No equations. Real events. The physics of the grid, in plain words.

The Unseen Load

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PROLOGUE

A City That Wasn't There Last Year

Drive west out of Washington, DC, along the highway toward Dulles airport. After about forty minutes the landscape changes.

The buildings are long and low and have no windows. They have no signs. Some are the size of aircraft hangars. They sit in rows behind fences, with cooling plant humming along their walls and substations at their corners. There are hundreds of them. More are going up. Loudoun County, Virginia, holds the largest concentration of computing on earth, and most of it did not exist fifteen years ago.

One large campus of these buildings draws as much electricity as a city of several hundred thousand people. And a campus can be built, from an empty field to a working machine, in about eighteen months.

That is the first thing to hold onto. Cities take a century to grow. These appear in the time it takes to build a supermarket.

Here is a number to go with the picture. In 2024, data centers used 22 per cent of all the electricity generated in

Ireland. More than a fifth of a country's power, going to buildings full of servers, nearly all of them built in the last decade. The Irish grid operator expects the figure to reach 31 per cent by 2034.



Figure P.1 — A fifth of a country. The share of Ireland's electricity used by data centers in 2024, and the operator's forecast for 2034. Nearly all of the buildings that use it were built in the last ten years.

Now here is the second thing, and it is the reason this book exists.

On a Wednesday evening in July 2024, something went wrong on a transmission line in Northern Virginia. It was a small thing, of the kind the grid deals with every day. But in the eighty-two seconds that followed, about sixty of those windowless buildings made a decision. Each one, on its own, judged that the grid outside its fence was no longer safe, and cut itself loose. Fifteen hundred megawatts of demand, the consumption of a mid-sized city, vanished from the system in less time than it takes to read this page.

The grid held. Nobody's lights went out. But the body that oversees the reliability of the North American grid wrote afterwards that nothing like it had ever happened before. Two years later, almost to the day, it happened again, at twice the size.

That is the collision at the heart of this book. The fastest-growing load in the history of electricity is arriving on a grid that is changing underneath it. And the load turns out to be able to do something that no factory, no steel mill, and no city ever could. It can leave. All at once. And when it leaves, it can shake the thing that feeds it.

So the question this book asks is a simple one. What happens when the thing you are feeding can also break the thing that feeds it?

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A few words about what this book is, and is not.

It is not a book about whether artificial intelligence is worth the electricity. Reasonable people disagree about that, and nothing here will settle it. It is not a book about the water data centers drink, or the land they take, or the noise they make. Those are real subjects with their own books.

This is a book about the power grid. About what a data center actually is, electrically, and why it behaves unlike anything the grid has carried before. About what the grid is losing at the same moment, and why the two changes make each other worse. About the rules now being written in a hurry on three continents, the engineers in control rooms trying to see a system that moves faster than their instruments, and the companies large enough to build their own power stations when the grid says no.

It is written for the reader who has never had to think about how the lights stay on. There are no equations in it. There are a small number of ideas. Each one is explained

with something you already know: a heavy wheel, a folding table, a device that leaves at the first sign of trouble. Keep those ideas in mind, and the rest follows.

And it is written by someone who has spent a career inside this problem, running the simulations that grid operators use to decide whether a system is safe. That experience shapes the book in one way above all. The events in it are real. The numbers are checked. Where something is uncertain, it says so.

The grid is the largest machine humans have ever built. For a century it was invisible to the people it served, because it worked. This book is about the moment it stopped being possible to ignore, and about the strange new load that made it so.

PART I

The Collision

Two changes happening at the same time, and the load that sits where they meet.

CHAPTER ONE

The Two Curves

In December 2023, a small consultancy in Washington published a report with a clear title. *The Era of Flat Power Demand Is Over.*

For twenty years, the amount of electricity America used had barely moved. The economy grew. The population grew. Homes filled with devices. And demand for electricity stayed flat, because everything got more efficient at about the same rate that everything got bigger. Utilities planned for a world without growth, because that was the world they lived in.

The report looked at the forecasts that utilities and grid operators file with the federal government each year. It asked how much demand they expected to add over the next five years. In 2022 the answer had been about 23 gigawatts. A year later it was 38. The report called this shocking, and it was.

It was also wrong, in the direction nobody expected. A year after that, the same firm ran the same numbers and found 128 gigawatts. A year after that, 166. In four years the five-year forecast had grown sixfold. The new demand was

equal to fifteen times the peak load of New York City. And more than half of it, about 90 gigawatts, was data centers.

The firm itself warns that utilities may be overstating. Some data center projects are announced twice, or never built. Even so, the direction is not in doubt. In 2023, data centers used about 4.4 per cent of all the electricity in the United States. By 2028, the government's own laboratory expects that to be somewhere between 6.7 and 12 per cent. Around the world, data centers used about 415 terawatt-hours in 2024. The International Energy Agency expects that to more than double by 2030. The electricity used by the AI-focused sites alone rose by half in a single year.

Whatever the exact number turns out to be, the flat era is over. That is the first curve.

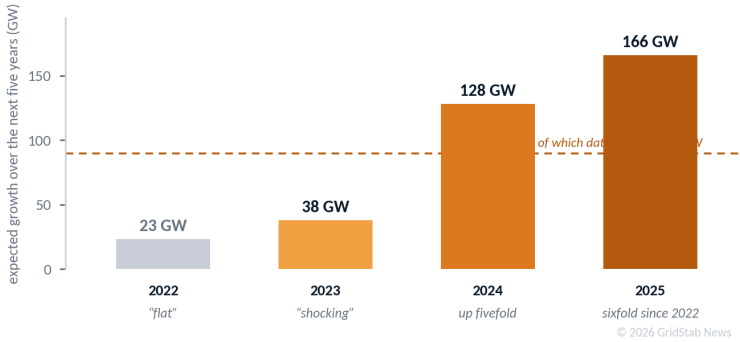


Figure 1.1 — The forecast that kept doubling. How much new peak demand American utilities expected over the following five years, by the year they made the forecast. In 2022 they planned for a world without growth. Four years later the number had grown sixfold.

Now go to a canteen in the English Midlands.

On the last day of September 2024, the remaining staff of the Ratcliffe-on-Soar power station gathered there to watch

a screen. It showed a live feed from their own control room. At the appointed moment, the generating units were switched off for the last time, and the men and women who had run them watched it happen on television.

Ratcliffe had burned coal since 1968. Its eight cooling towers are a landmark for millions of people driving on the M1 motorway. At full power it could supply two million homes. It was the last coal-fired power station in Britain, and when it stopped, 142 years of coal-fired electricity in the country that invented it came to an end. The world's first coal power station had opened in London in 1882.

The speed of the change is easy to miss. In 1990, coal supplied about two-thirds of Britain's electricity. Ten years before Ratcliffe closed, it still supplied a third. Then it was gone. Today, more than half of Britain's electricity comes from renewable sources, most of it wind.

This is not a book about coal, and it takes no view on whether Ratcliffe should have closed. But something left the grid that afternoon that has nothing to do with the fuel, and it is the reason a book about data centers begins here.

A coal-fired power station is, at its heart, a very large spinning machine. Steam drives a turbine. The turbine drives a generator. Hundreds of tonnes of steel turn at three thousand revolutions a minute, locked to every other spinning machine on the grid. The same is true of a gas plant, a nuclear plant, and a hydro station. For a century, almost all electricity came from machines that spin.

Wind turbines and solar panels are different. Solar panels do not spin at all. Wind turbines spin, but their rotors are connected to the grid through power electronics, which

means the grid cannot feel them turning. The new generation is made of silicon, not steel.

And it turns out that the spinning steel was doing something for the grid that nobody paid for and few people noticed. Something like a shock absorber. Chapter 3 will explain exactly what it is, and why it matters. For now, the point is simply this. As the machines are retired, that something leaves with them.

That is the second curve. The first is demand, rising after twenty flat years. The second is the share of the grid that spins, falling faster than most people realise.

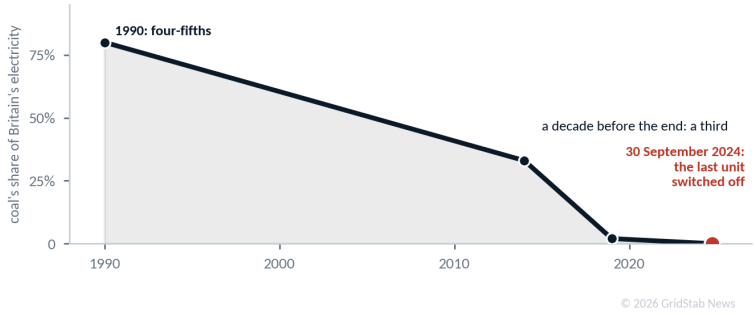


Figure 1.2 — The second curve, in one country. Coal's share of Britain's electricity, from four-fifths in 1990 to nothing on 30 September 2024. What matters for this book is not the fuel but the machine: every coal plant was a spinning generator, and the things that replaced it are not.

The two curves would each be a story on their own. This book is about where they cross.

They cross at the data center, and they cross for three reasons.

The first is size. Data centers are the largest single reason that demand is rising. A single campus can draw as much

power as a mid-sized city. Nothing that new has ever been added to the grid this fast.

The second is what they are made of. Open up a data center's electrical system and you find no spinning machines at all. Every watt passes through converters, the same kind of power electronics that connect a wind farm or a solar plant. So the fastest-growing load on the grid is built from the same silicon as the fastest-growing generation. The new demand is arriving on a grid that has never had more electronics on it, and never had fewer machines, and the demand itself adds to the electronics.

The third is where they go. Data centers cluster. They want to be near each other, near the fibre, near the cities. So the new load does not spread evenly across the grid. It piles onto a handful of places, and some of those places are exactly where the spinning machines have already left.

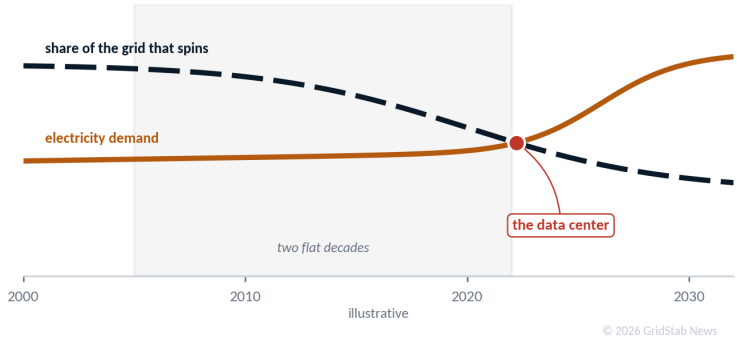


Figure 1.3 — The two curves. Demand rising after two flat decades, and the share of the grid that spins falling, drawn on the same timeline. The data center sits where they cross.

Put the three together and you have the collision this book is about. The grid is losing its shock absorbers at the moment it is being asked to carry its heaviest, fastest, most

electronically peculiar load. And the load is landing hardest in the places least able to bear it.

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None of this is a prediction of disaster. The events in this book are real, and several of them were close calls, but the lights stayed on in every one. The grid is run by capable people who have managed harder transitions than this.

But it does say that the grid will be under more pressure than it has been for a century. And that is where the interesting questions are.

The book that follows is in six parts. Part I, this one, sets up the collision. Part II explains just enough physics to see why it matters, and it does so without a single equation. Part III goes inside the data center to see what is really there. Part IV is about the rules that are being written, in a hurry, on three continents. Part V is about the people in the control rooms who have to hold the system together. And Part VI is about where all of this is going: private reactors, private power stations, and companies large enough to negotiate with governments about who plans the grid.

Before any of that, though, there is one more thing to say about the two curves. It is not about how big they are. It is about how fast they move, and it is the subject of the next chapter.

YOU HAVE JUST READ THE PROLOGUE AND CHAPTER 1

The rest of the book

Eighteen more chapters follow, in six parts: why demand is rising faster than the grid can grow; what the grid is losing, and why a fault that was harmless in 2005 is dangerous today; the UPS, the batteries, the 600-kilowatt rack and the "breathing" of an AI training job; the rules now being written in Ireland, Texas, Australia and Washington; the instruments that cannot see what is happening and the curtailment that wastes clean energy; and the futures on offer, from nuclear restarts and off-grid campuses to data centers that get paid to help the grid.

Every chapter starts from a real, dated event. Every number has been checked. Sixty-two colour figures. No equations.

GET THE BOOK

PDF edition — gridstab.com

Paperback — on Amazon, 6 × 9 in, 204 pages, colour

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