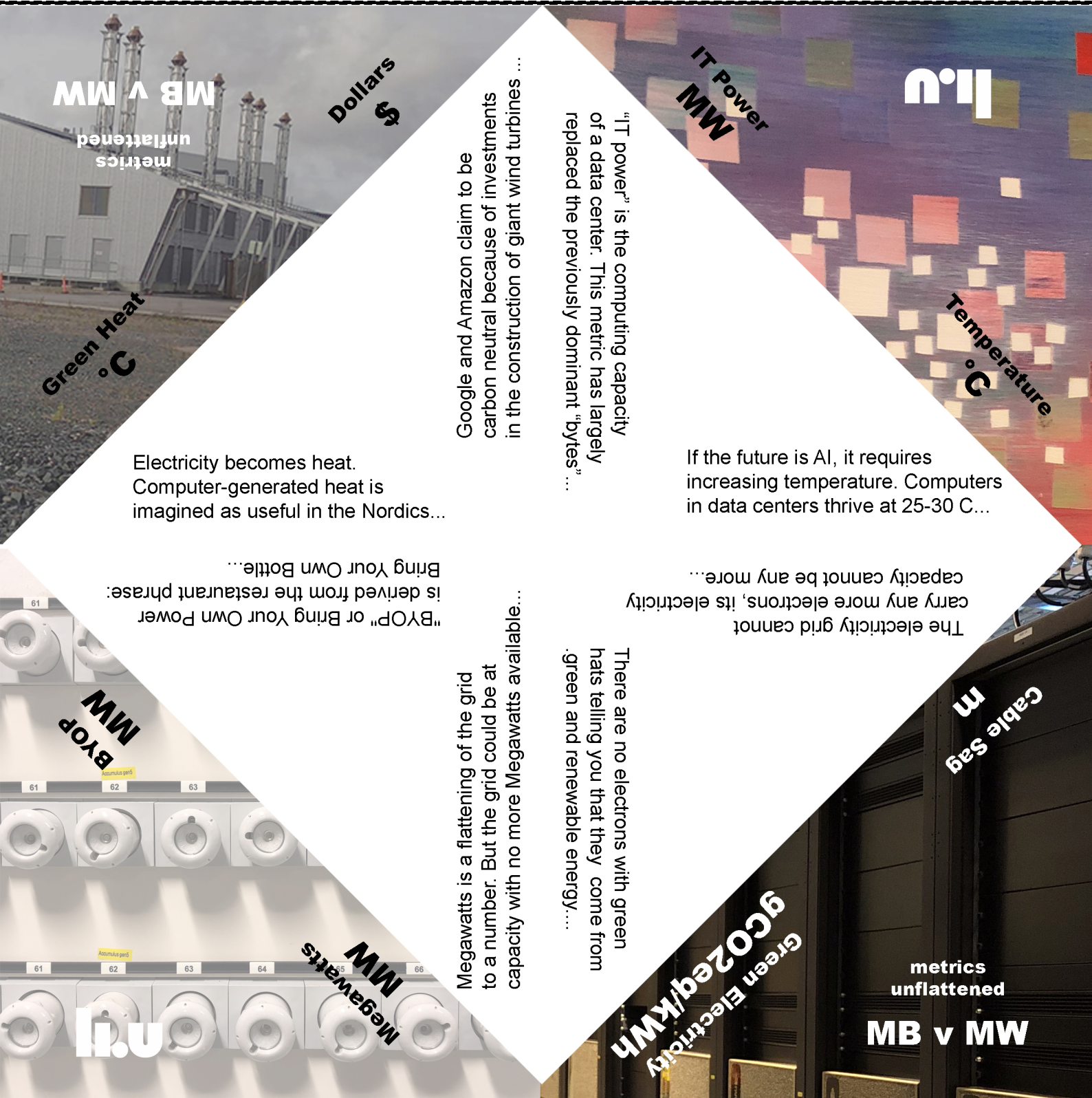


Megabytes versus Megawatts ^ Folding Paper Game

by Laura Watts & Julia Velkova
see accompanying instructions



MB v MW

metrics
unflattened

Dollars \$

Green Heat °C

Google and Amazon claim to be carbon neutral because of investments in the construction of giant wind turbines ...

Electricity becomes heat. Computer-generated heat is imagined as useful in the Nordics...

"BYOP" or Bring Your Own Power is derived from the restaurant phrase: Bring Your Own Bottle...

Megawatts is a flattening of the grid to a number. But the grid could be at capacity with no more Megawatts available...

There are no electrons with green hats telling you that they come from green and renewable energy...

"IT power" is the computing capacity of a data center. This metric has largely replaced the previously dominant "bytes" ...

If the future is AI, it requires increasing temperature. Computers in data centers thrive at 25-30 C...

The electricity grid cannot carry any more electrons, its electricity capacity cannot be any more...

IT

IT Power MW

Temperature °C

Cable Sag m

BYOP MW

Green Electricity 90202eq/kWh

metrics
unflattened

MB v MW

Megawatts

IT

Megabytes v. Megawatts ^ Folding Paper Game

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^ Introduction

This game derives from our research project 'Megabytes vs Megawatts: Understanding Infrastructural Frictions Between Data Centers and Energy Grids for Sustainable Digitalization'. The project explores the challenges that arise when industries try to imagine and make data center infrastructure more environmentally sustainable. We aim to understand how sustainable futures are made and what frictions arise between data infrastructures and electricity grids as they are transformed. For example, we look at societal challenges and inequalities that arise when companies source renewable electricity to power their data centers and how these challenges are imagined by those involved.

As part of this project we have researched how metrics and values are used to communicate important issues (such as environmental impacts) between the energy and data industries. When these issues are reduced to a number the 'multidimensional' complexities behind this metric are often 'lost in translation' between the energy and data industries. We refer to this process as "flattening" – when important social and technical connections are flattened into a numeric point. As anthropologist Marilyn Strathern has said: so-called 'transparent metrics' are often poor and misleading descriptions of the social and technical world they purport to make visible.

In response we have created this playful paper game. Through folded paper, it is the literal unflattening of metrics into a more complex and rich description. Play it to discover what we find when we unflattened the energy and data industry encounter.

^ How to play

- Print the sheet and cut into a square as shown
- Fold the square paper into the familiar hand game; for help watch this video <https://youtu.be/xNklqS3TLqc>
- Choose a number or ask a colleague to choose a number
- Count that number with the hand game, opening and closing
- Choose from one of the four displayed metrics
- Open the paper flap of that metric and read the corresponding entry below

^ Metrics Unflattened

^ Green Heat (°C)

All electricity becomes heat. Computer-generated heat is considered useful in the Nordic countries. This heat is imagined heating homes and grocery stores over time and over generations. The usefulness of waste heat makes it appear “green”. But heat, just like electrons, has no color. Nor is it a stable commodity to be “used”. Heat dissipates and alters the temperature of materials. Heat has no predetermined duration. “Green heat” durations are culturally constructed and in the era of planned obsolescence, computer generated heat lasts as long as the lifetime of a computer, technology, and data center, and these are far from eternal or stretch far into the future.

^ Dollars (\$) of Investment in Renewable Electricity

Google and Amazon claim to be carbon neutral because of investments in the construction of giant wind turbines in Europe, the most sizeable ones currently being in Sweden and Norway. Numbers of investment say nothing about the conflicts on the ground around wind extraction. Dollars become wind turbines that become frontiers for wind extraction that stand on reindeer herding land of Sàmi people, reducing the life prospects of reindeers and the economy of reindeer husbandry. They extend legacies of hydropower extraction and landscape transformation in Sweden and they divide local people. Whose life and livelihood prospects are more worthy of care? What would a digital future that sets as a goal to proliferate and sustain reindeer herding and indigenous people lifestyles look like?

^ Megawatts of IT Power (MW)

“IT power” is the computing capacity of a data center. This metric has largely replaced the previously dominant “bytes” of information as a referent to the computation capacities of the digital industries. But the megawatts of IT power are not merely numbers – they are a performative currency and a powerful material relation. As a performative metric, megawatts of IT power allow actors in the digital market to speculate about their own growth and compare among each other (e.g. does Amazon have more or less Megawatts than Microsoft?). “Megawatts of IT power” are an expression of an anticipated future development of a digital tech company. However, this number is also material -- to materialise scales, tech companies need to engage with energy infrastructures in practice and reserve real megawatts from the existing electricity grid, taking these from other industries and pushing electricity grid capacities to their limits.

^ Temperature (°C)

If the future is AI, it requires engaging with temperature. Computers in data centers thrive at 25-30 degrees Celsius but quickly deteriorate in a different climate. Maintaining temperature is a resourceful and cultural activity. It transforms Nordic landscapes, species relations and environments by heating seas and air. In the Baltic sea fish populations change as Google pours heated data center water in the sea. The energy futures of AI are thermocultural and based on techniques of cooling and heating, of calibrating the world towards the right temperature for computers.

^ Cable Sag (m)

The electricity grid cannot carry any more electrons, its electricity capacity cannot be any more than this: a resulting cable sag due to thermal resistance of 7.2 meters above the ground. This height above ground fixes the capacity of the grid through a complicated calculation involving the thermal properties of the cable. The temperature of any material is not just defined by the current it carries, however. The external weather is going to have an impact, too. Islanders in Orkney told Laura Watts in frustration that their electricity operator calculated the cable sag in Orkney using a mean annual temperature—a mean annual temperature for the whole of the UK. But Orkney is a northern archipelago of islands, and notably cooler than southern England. It's cables could, in theory, carry more electricity. But that is not how the metric is calculated.

^ Green Electricity (gCO₂eq/kWh)

There are no electrons with green hats telling you that they come from green and renewable energy generators. Renewable energy becomes a data point because electrons do not have green hats or little flags saying: I come from wind energy. You cannot measure green electricity in a cable, like you can its voltage. You cannot say how much green electricity is at point in the grid, unless you know the grid topology e.g. at that point, only wind turbines are connected to the grid and it is exporting capacity. Generally, this metric is an average of carbon emissions calculated for a region, such as a nation state or large grid zone. It is given in grams of Carbon equivalents per kilowatt-hour. Not even actual grams, but an equivalent to. And the data center industry uses these regional calculations, often the size of a country, to make claims about how green its data is in a particular location.

^ Megawatts of Grid Capacity (MW)

Megawatts is a flattening of the electricity grid to a number. But the grid could be at capacity with no more Megawatts available, but plenty more generation possible. Electricity is finite because infrastructure has material limits. In some places you have to make a choice: power homes or power a data center? Power a manufacturing business or power a data center. You cannot always do both. In the UK, offshore wind turbine farms are waiting 10 years for a connection to the grid, because the onshore cables are at capacity, and you cannot get the power to cities. Renewable energy is not when and where you want it, and it is finite. (And LLMs take huge amounts of energy). Energistyrelsen, the energy regulator in Denmark, might predict an exponential curve of growing capacity in Megawatts for the country, but that does not mean it will be available everywhere in Denmark. Do we want electricity cables hanging over our heads to feed cat gifs and tiktok and ChatGPT? Megawatts have politics. The sustainability of data centers is the sustainability of the grid: both must be considered together.

^ Bring Your Own Power (MW)

"BYOP" or Bring Your Own Power is derived from the restaurant phrase, Bring Your Own Bottle. It means that data center operators are building their own solar panels and wind farms. The data center industry is increasingly building its own power stations, where they cannot guarantee power from the grid; Google Hamina in Finland has its own wind power, for example. Most data centers already have back up generators (Uninterruptible Power Supply) in the form of batteries or diesel generators. So the data industry is becoming its own energy operator, serving its

own data center. BYOP is impacting the grid: the Irish national grid is using data center back up generators to cover peak load; data centers are selling their excess power to the grid for profit. But do we want to Amazon or Google or Microsoft to be running our energy network and our wind turbines?