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The Missing Piece of a Sustainable Grid: Modular Data Centers

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September 13, 2022

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The computing accomplished by data centers has become an indispensable part of modern society. The energy requirements and efficiency of large-scale computing in its current form provide a challenge on at least two fronts:

1. They struggle to adapt to the use of renewable energy sources
2. They were designed for processing data in terms of a web 2.0 model, which can create unnecessary waste.

We propose a solution in the form of modular data centers (MDCs). Shifting to a batch processing computing model more suited to web 3.0 allows for greater flexibility in power grids, the efficient integration of renewable energy sources at scale, and a reduction in overall waste or "digital exhaust."

Traditional Data Centers Have a Problem

Most modern data centers are maladapted to current needs. Current computing models center around the needs of the consumer, which often involves real-time computing (think streaming, gaming, cloud computing, etc.).[1]

This can lead to the use of more computing power than necessary, which wastes energy and processing power, leading to increased "digital exhaust."

A parallel problem in the energy sector is that of stranded energy, or "curtailment," which we've covered extensively in the past.[2] A 2014 report by the US National Renewable Energy Laboratory (NREL) estimated that in the absence of infrastructure upgrades, renewable energy curtailment could reach levels of 15.5%.[3] This problem has only compounded in the years since. In our own research, we've noted that curtailment of individual producers can reach levels as high as 40%. Mitigating curtailment effectively reduces generation costs and monetizes energy that would otherwise have $0 value, incentivizing the integration of more renewable sources into the grid. A central challenge to mitigating curtailment is inefficient transmission, or the ability to move energy from where it is generated to where it is needed. Proposed projects to increase transmission effectiveness can only help reduce curtailment by about half, the NREL report states.

Over the last several years, Soluna has conducted interviews with over 35 independent power producers (IPPs) across the US, all of them identifying curtailed power as an acute and persistent problem. Other nations find themselves facing the same issue, with China, Germany, Ireland, and Australia all suffering similar curtailment losses.[4]

Combined with humanity's ever-increasing need for computing power, the impacts of curtailment aren't sustainable, especially as greater integration of renewable sources into the grid increases the problem of curtailment. According to the International Energy Agency (IEA), "global internet traffic surged by over 40% in 2020, driven by increased video streaming, video conferencing, online gaming and social networking. This growth comes on top of the past decade's already-rising demand for digital services: since 2010, the number of internet users worldwide has doubled, while global internet traffic has increased 15-fold or ~30% per year."[5] They also note that global data center electricity use in 2020 was 200-250 TWh1, or around 1% of total global electricity demand.

Without making use of stranded energy, accelerating the growth of renewables and reaching a zero-carbon future is impossible.

Web 3.0 Requires New Methods of Computing

Current data centers were designed for web 2.0. They tend to function using real-time stream processing, a combination of streaming and real-time analytics. Streaming refers to data "that is continuously generated and delivered rather than processed in batches or micro-batches."[6] Real-time data is that which can be made available immediately without delay. Stream processing is used for data sets that need to be processed in real-time and are time-sensitive but not computation-heavy (think Netflix streaming services). Batch processing, on the other hand, is better suited for large, repetitive data sets that are computation-heavy but not time-sensitive (think the algorithm that recommends a show to watch).

The term "batch processing" dates back more than a century, from a time when computers were run using punched cards that contained programmatic instructions.[7] Multiple card decks, each one representing a different job, would be stacked on top of one other and run in batches.

Web 2.0 methods aren't going away anytime soon. But in some applications, they capture unnecessary data due to constant real-time capturing and processing of information. This results in the use of excess computing power.

The Problems Will Continue Compounding Without a Solution

Increasing amounts of computing lead to more digital exhaust. As web 2.0-style computing increases, so too does its digital exhaust and associated carbon footprint.

It seems reasonable to assume that the computing needs of humanity are infinite. As with any human activity, increased usage of computing leads to greater energy needs and more waste. If left unchecked, this will continue to be a significant contributing factor to climate change, which becomes an increasing burden on and threat to society with every passing year.

According to a 2020 report by the United Nations Office for Disaster Risk Reduction, natural disasters have been growing in terms of frequency and intensity, extracting greater human and economic costs. From 2000 to 2019, the report states, there were 7,348 major disasters, which affected 4.2 billion people, claimed 1.23 million lives, and resulted in $2.87 trillion USD in global economic losses.[8] The prior 20-year period, between 1980 and 1999, saw only 4,212 disasters worldwide,


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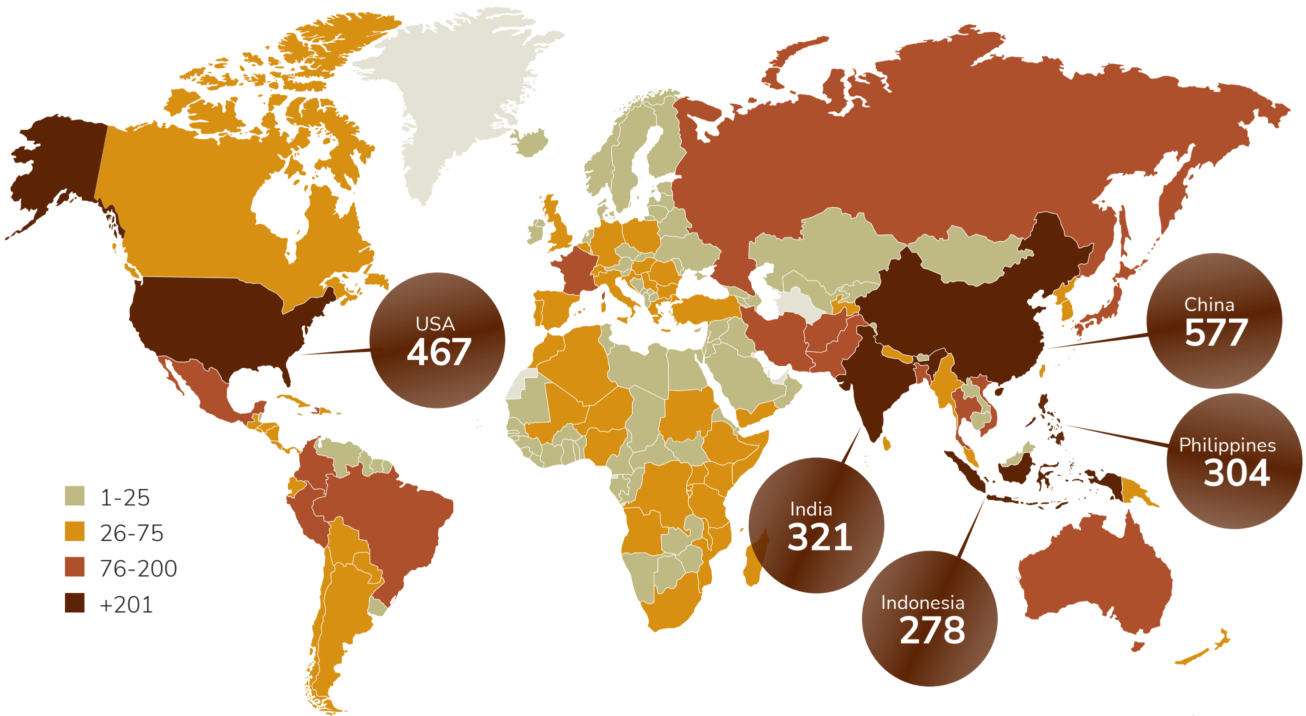
affecting 3.25 billion people, claiming 1.19 million lives, and taking a toll of about 1.63 trillion US dollars. Much of the recent increases can be attributed to a rise in climate-related disasters, including major floods, storms, drought, wildfires, and extreme heat waves.

fig 3.1: Reported Disaster Tolls (2000-2019), *United Nations Office of Disaster Risk Reduction*



These facts paint a grim picture, but they don't present an insurmountable problem. By making use of stranded energy and creating data centers that can adapt to changing power needs, we can dramatically improve the climate toll of data centers worldwide. Humanity's increasing need for computing and energy can be used as a catalyst for positive change, incentivizing the use of more renewable sources to power specialized, compact data centers. This new model for data centers can provide greater flexibility, adapting the grid to the changing computing needs of individuals and organizations.

Modular Data Centers Provide a Solution

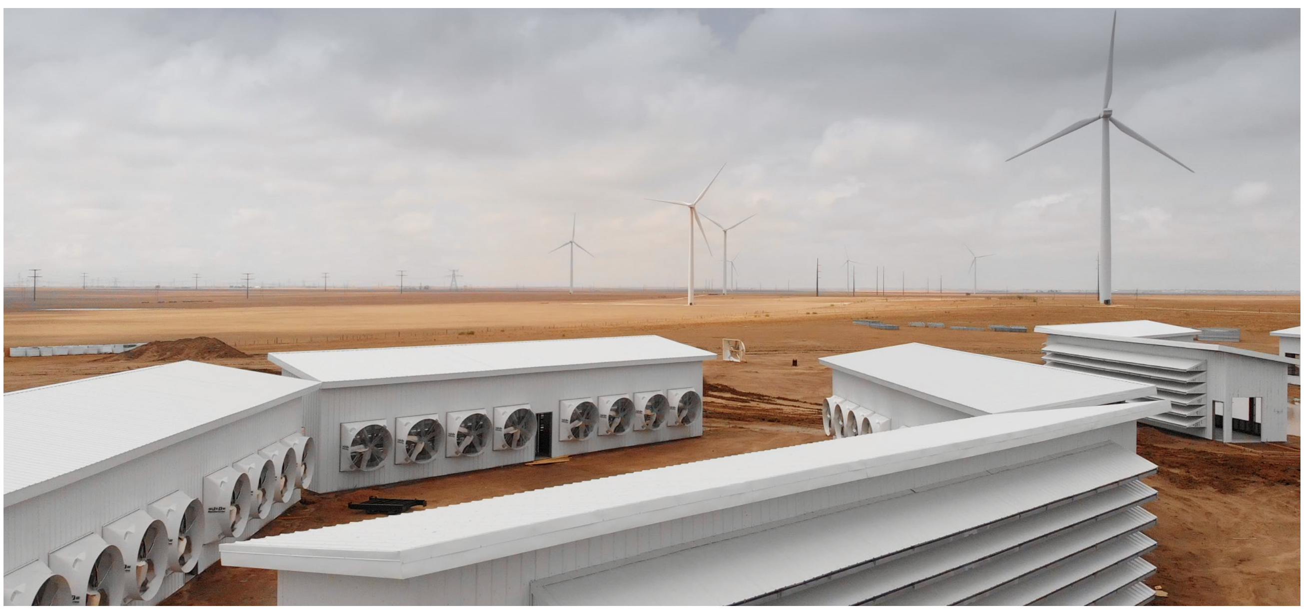
A Modular Data Center (MDC) is defined as "an approach to data center design that implies either a prefabricated data center module or a deployment method for delivering data center infrastructure in a modular, quick and flexible method."[9]

This model can provide a way to address many of the problems currently facing legacy data centers and renewable energy sources. Utilizing forms of batchable computing such as cryptocurrency mining and scientific computing, MDCs can adapt to the fluctuations in a power system's supply at a moment's notice. This reduces waste, makes use of energy that might otherwise be stranded (i.e., wasted), and allows for the use of renewables at scale. MDCs can be used to create a scalable and flexible data center network.

Traditional data centers require both strong, high-speed internet connection and persistent, abundant supply of energy, but modular data centers do not, which allows them to be established at almost any location, rather than being limited to places where broadband connections intersect.

MDCs can therefore be brought directly to the source of energy. What's more, they can be used to consume the exact amount of energy that power plants cannot sell back to the grid, eliminating waste. Soluna MDCs operate on 100% renewable energy and can tailor their energy consumption to current demand in a matter of minutes.

fig 4.1: Soluna's Project Dorothy



Soluna's MDCs can be dropped onto any site and be up and running in six months while costing 90% less than traditional data centers. Like Lego® blocks, new buildings can be added to a site as it scales, a more efficient and scalable model than building a single monolithic facility from the ground up. This ensures that a site can be built in proportion to the amount of energy supplied and computing power required.

Using this model, these facilities can be easily located right next to the renewable power plants that supply their energy. The energy doesn't have to travel anywhere, eliminating risk of transmission loss. Everything is designed to be as efficient as possible, including a specialized air-cooling system that makes for highly efficient thermodynamics.

We believe that these MDCs will be a key part in creating sustainable infrastructure that can serve the ever-growing and ever-changing computing needs of our world.

Flexible Data Centers Are Efficient and Scalable

At Soluna, we've designed our MDCs to specifically run batchable computing processes.

Renewable energy data centers that rely on batchable computing are more suited to the challenges presented by integrating sustainable energy sources into the grid. This model provides a degree of dynamism previously unavailable. By focusing on batchable computing, data centers can adjust their power needs at a moment's notice, allowing the supporting grid to become more resilient to abrupt changes in supply and demand.

Flexible data centers can serve as a new class of infrastructure company, vital to a sustainable grid.

Batchable computing includes applications like cryptocurrency mining, scientific computing, and a slew of artificial intelligence and machine learning tasks.

Soluna's MDCs currently focus on Bitcoin mining. By breaking into this more niche market first, we aim to create a truly zero-carbon cloud for computing needs that traditional data centers can't currently serve at scale. After establishing this model, we can expand into other markets.

Scalable, efficient data centers that run on batchable computing can supply power grids with the flexibility they need to integrate renewable energy sources while eliminating waste and curtailment.


carbon
computing for the planet.

Batchable Computing Creates A Flexible Load

The Union of Concerned Scientists has identified "flexible resources," those that can adjust to sudden increases and decreases in demand, as one of many potential solutions to curtailment.[10] Modular data centers like those built by Soluna have been designed with this purpose in mind.

MDCs act as a flexible load in that they can be built in service to the grid rather than as a burden on it. Batch processing can be paused in accordance with changes in the availability of energy.

This allows the facilities to be powered by renewable energy sources, which provide varying and unpredictable amounts of power. When the sun is shining or the wind is blowing, wind and solar plants often produce more energy than can be used. One potential solution would be to store this energy for later use. Several different methods for energy storage have been proposed, including batteries, high-speed rotating disks, and underground thermal energy storage. These options are often expensive and impractical.

Batchable computing provides a new kind of solution. Being able to dynamically adapt to changing supply and demand of available power reduces the need to create a storehouse of excess energy for future use.

Flexible power loads, including batchable computing, might be an ideal way to work around the need to store extra energy, as noted by Andrew Chien, Professor of Computer Science at the University of Chicago and William Eckhardt, Senior Computer Scientist at Argonne National Labs.[12] In a 2020 podcast interview with Soluna discussing the potential for a zero-carbon cloud, Chien stated that *"one of the things I learned working at Cal Iso is they're very concerned about this problem [of curtailment] and they're looking for all kinds of adaptive load because in some ideal sense, the only way to solve this problem is to have the load ultimately conform to the supply that's available and when it's available. And the degree to which you can deviate from that you have to make up for with energy storage or variable controllable dispatchable generation."* He went on to imply that increased energy demand from data centers isn't necessarily a bad thing, considering the fact that *"the bigger the total data center consumption is, the more chance it has to make a difference."*

MDCs go a long way toward being a part of this solution. Bitcoin mining can be a particularly appealing part of this process.

The Efficiency of Bitcoin Mining

Bitcoin mining is often condemned as a wasteful, dirty, or excessive use of energy. When used as part of the computing operations of a modular data center, however, the energy use of Bitcoin mining can play a key role in making use of stranded energy and providing flexibility to the grid.

Soluna CEO John Belizaire testified before Congress in a hearing on crypto assets in January 2022 regarding this narrative around crypto, stating that "crypto's energy consumption is a feature, not a bug."[13] The energy used by Bitcoin, and other proof-of-work digital assets, serves to protect the entire network, allowing decentralized coins to stay decentralized.

Using a lot of electricity also doesn't necessarily equate to leaving a large carbon footprint. Add to that the capability of miners to play a key role in the infrastructure of modular data centers that can reduce curtailment and waste, and that energy usage becomes even more of a catalyst for green energy.

Bitcoin mining is an excellent example of the kind of batchable computing that allows a data center to make use of stranded energy when it's available and reduce energy usage when the grid becomes strained.

Beyond Cryptocurrency Mining

With the rise of Web 3.0, the demand for batchable computing is on the rise.[14] Modular data centers built to power batchable applications are ideally suited for a world that increasingly relies on AI – computation-heavy but not time-sensitive processes.

To this end, Soluna is currently working on launching phase two of our business, which will focus on GPU-supported cloud computing applications like video transcoding. The possibilities for expanding out into other batchable computing applications are virtually endless. Climate analysis and modeling, finite element analysis, computational fluid dynamics, and grid modeling and simulation are a few other areas we're looking to break into.

As society's computing needs increase, the need to manage data in a sustainable way does as well. Modular data centers powered by renewable energy can become an integral part of a sustainable grid by increasing the practicality of solar, wind, and other renewable sources while maintaining an efficient power system. The integration of batchable computing into specialized data centers allows the facilities to act in service to the grid rather than as a burden on it. Simple changes to the ways in which data centers are built, deployed, and operated can help create a sustainable solution to some of the world's biggest green energy problems.

With the infrastructure already in place, the transition from Bitcoin mining to a broader array of batchable applications will allow Soluna to grow this business model at scale, partnering with both renewable energy power producers and computing enterprises to help build the next generation of clean cloud computing.

The Soluna Team

We're Solving Renewable Energy's Biggest Problem.

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To learn more about how Soluna is bringing renewable computing to the grid, join our community here.

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