Grid-interactive data centers: enabling decarbonization and system stability

Jussi Vihersalo, *Manager, Business Development, Eaton EMEA*

Mark Monroe, *Principal Engineer, Datacenter Advanced Development Group, Microsoft*

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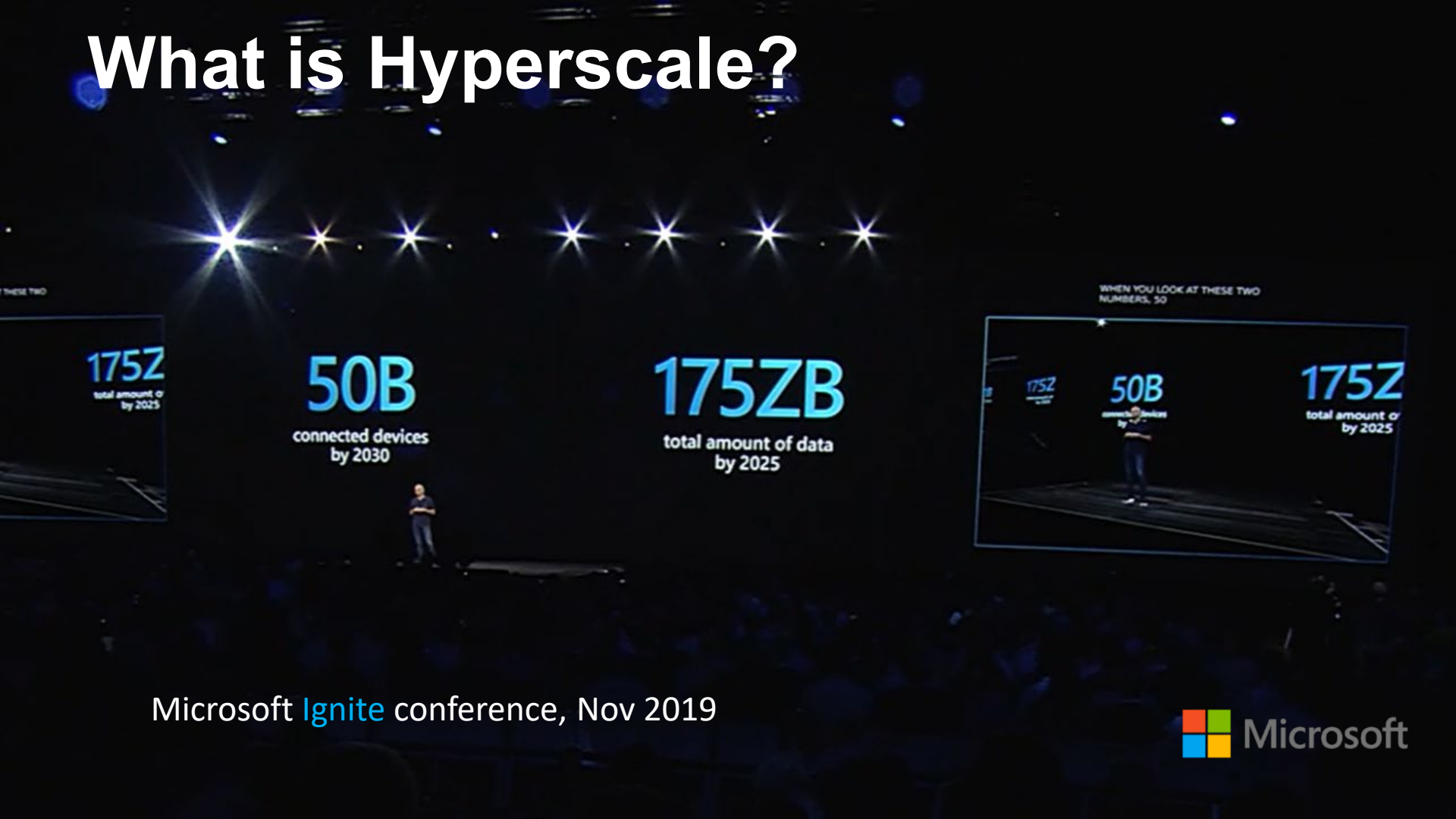
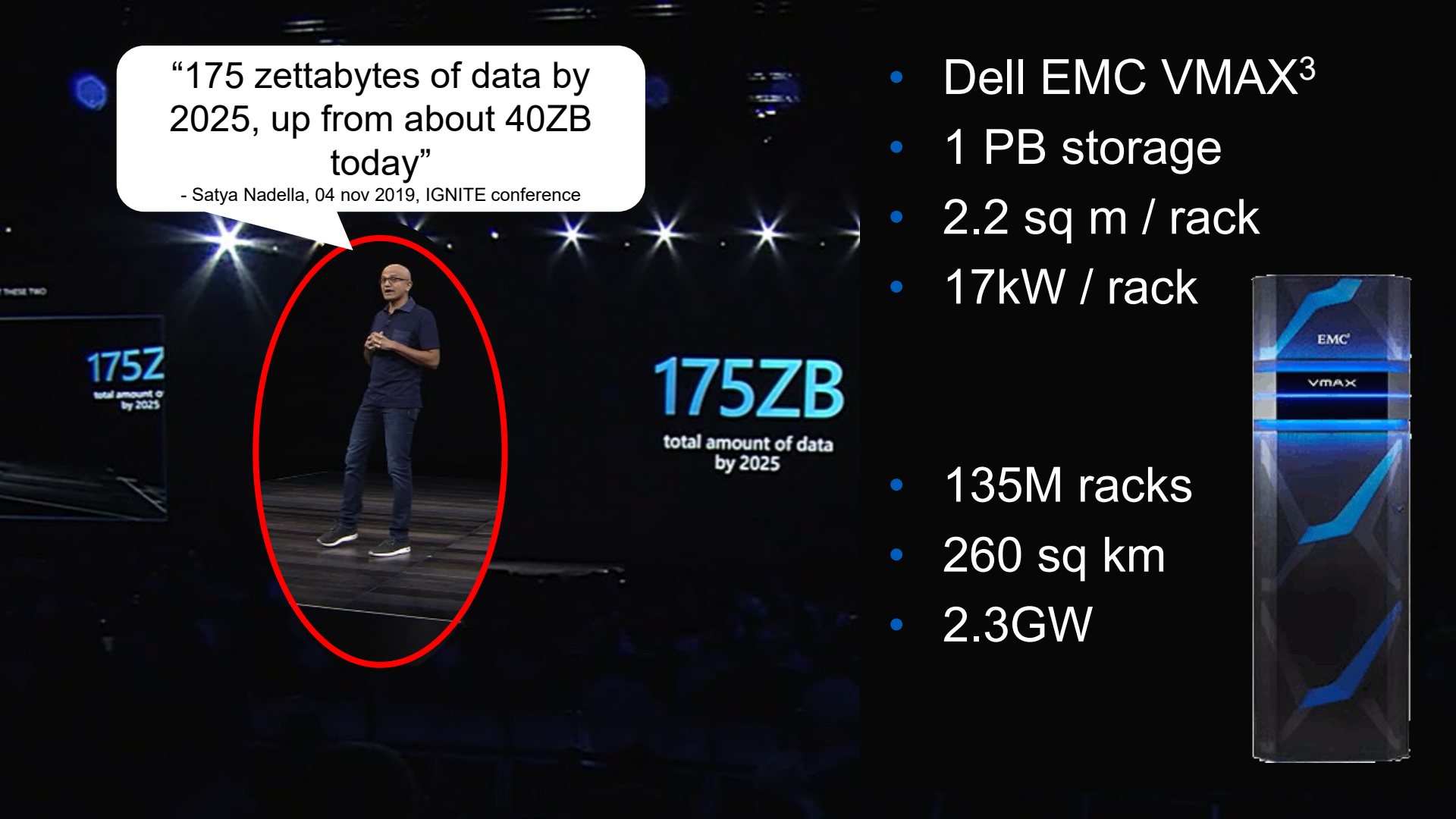
What is Hyperscale?



Microsoft Ignite conference, Nov 2019

Microsoft

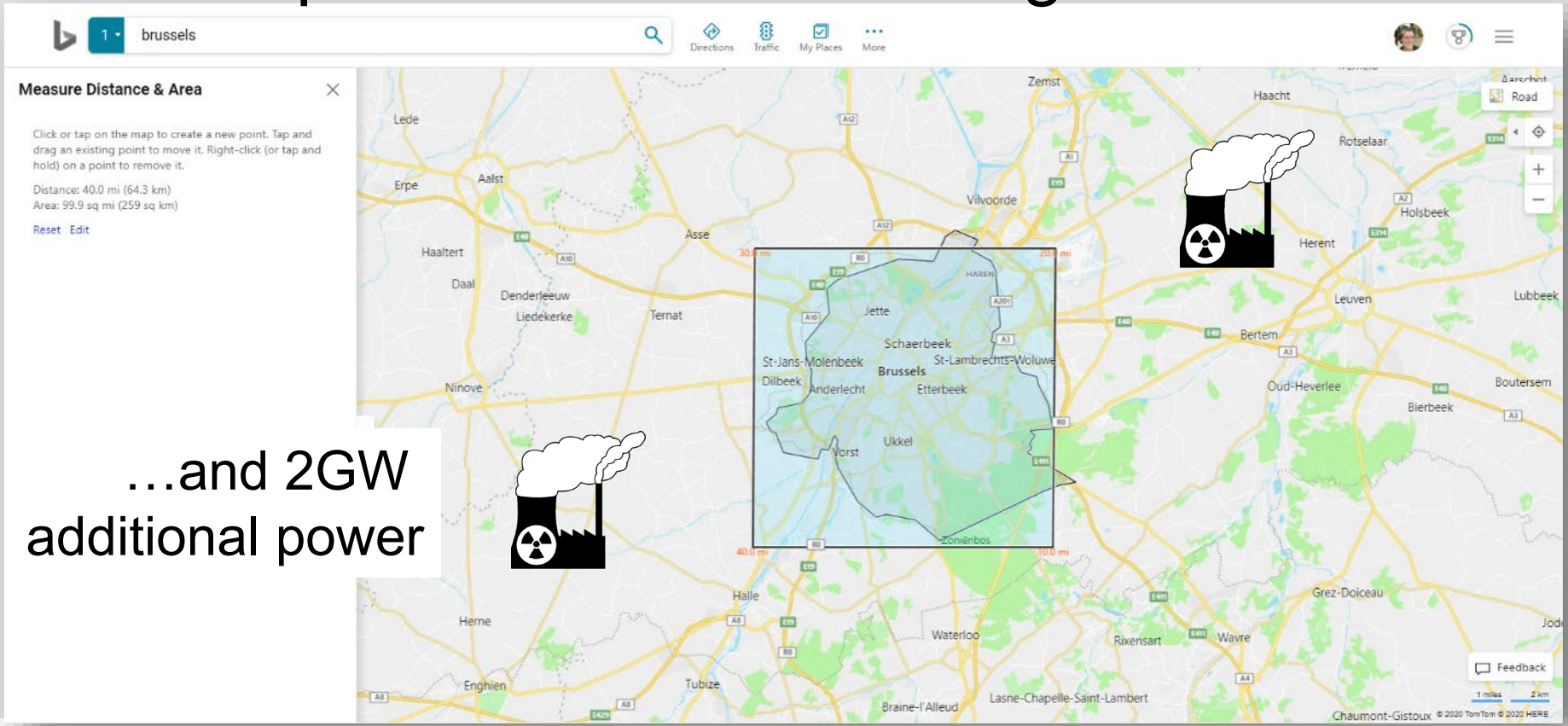

“175 zettabytes of data by 2025, up from about 40ZB today”
- Satya Nadella, 04 nov 2019, IGNITE conference
175ZB
total amount of data by 2025
Mega
Giga
Tera
Peta
Exa
Zetta
Yotta
Xena
Veca
Microsoft



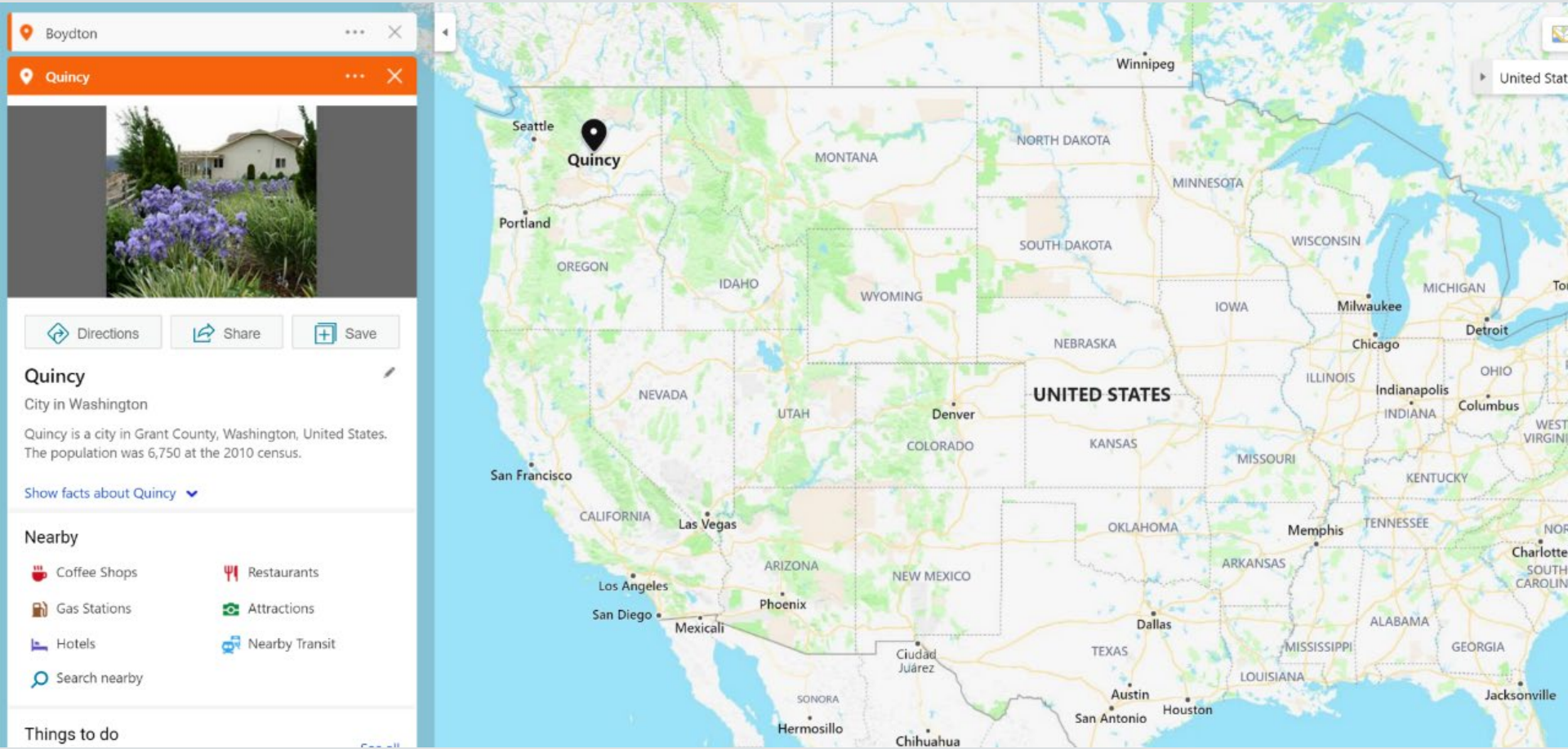
- Dell EMC VMAX^3
- 1 PB storage
- 2.2 sq m / rack
- 17kW / rack

- 135M racks
- 260 sq km
- 2.3GW

260 Square km of Data Storage Alone…



…and 2GW additional power



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July 2018
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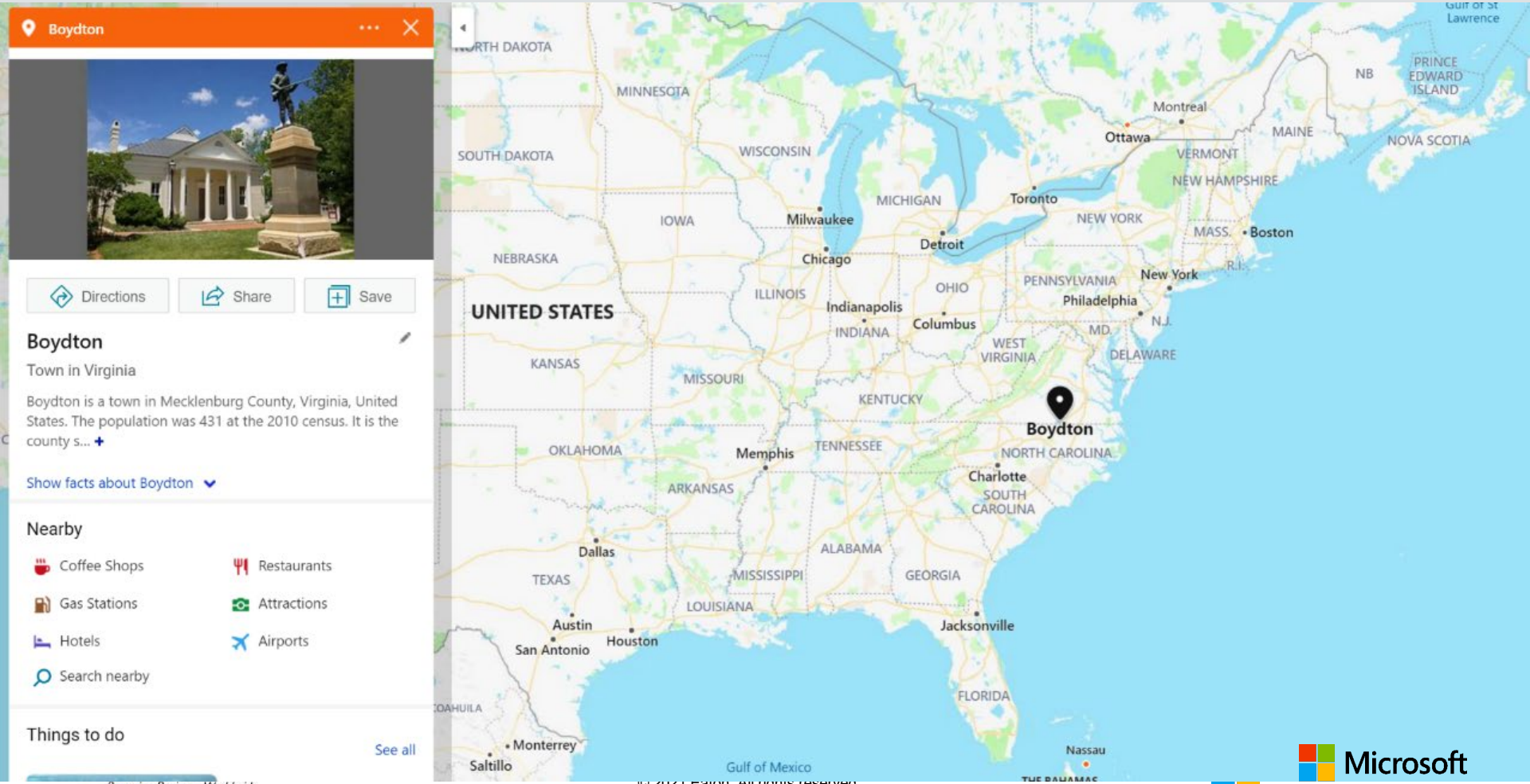
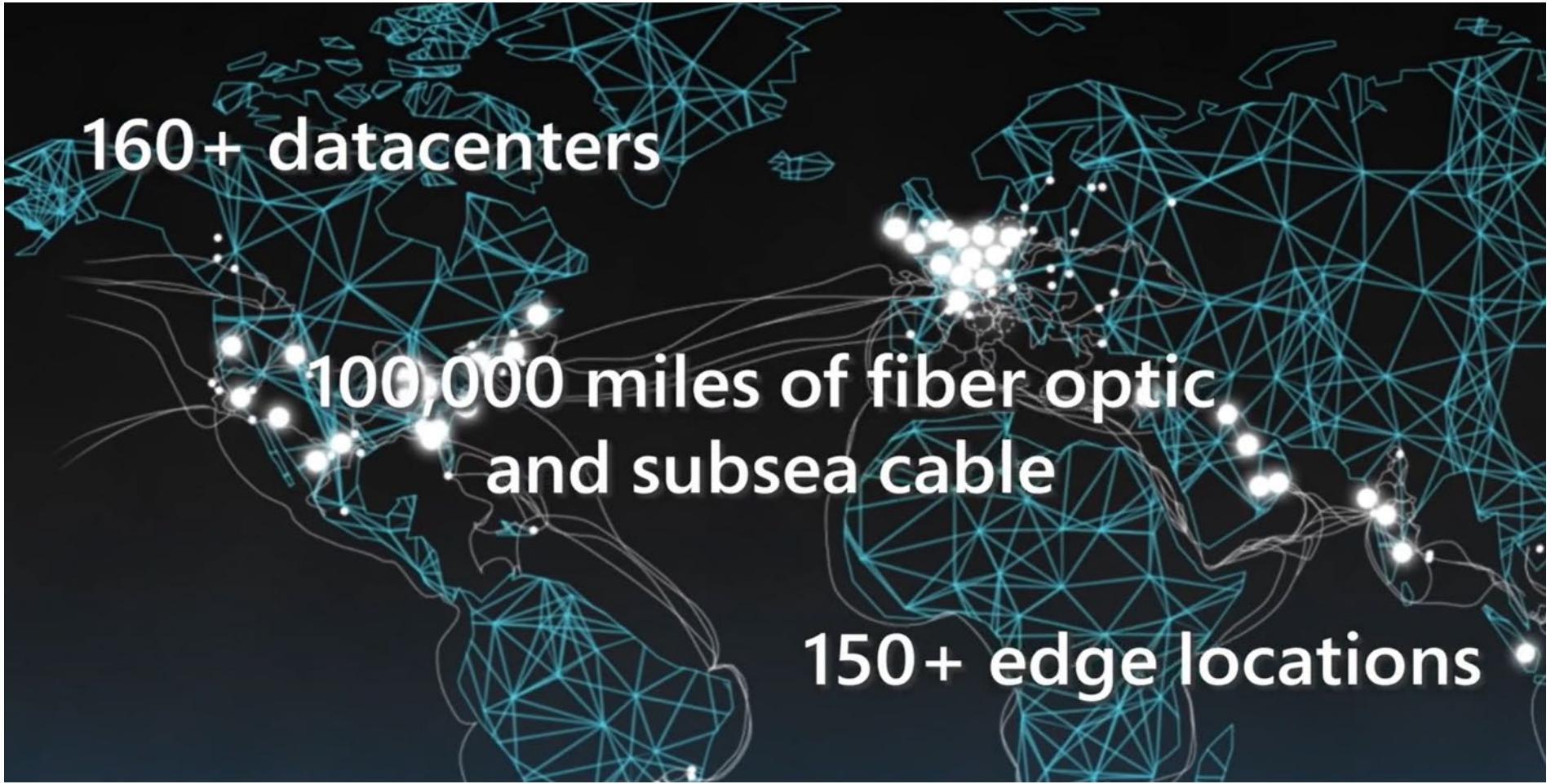
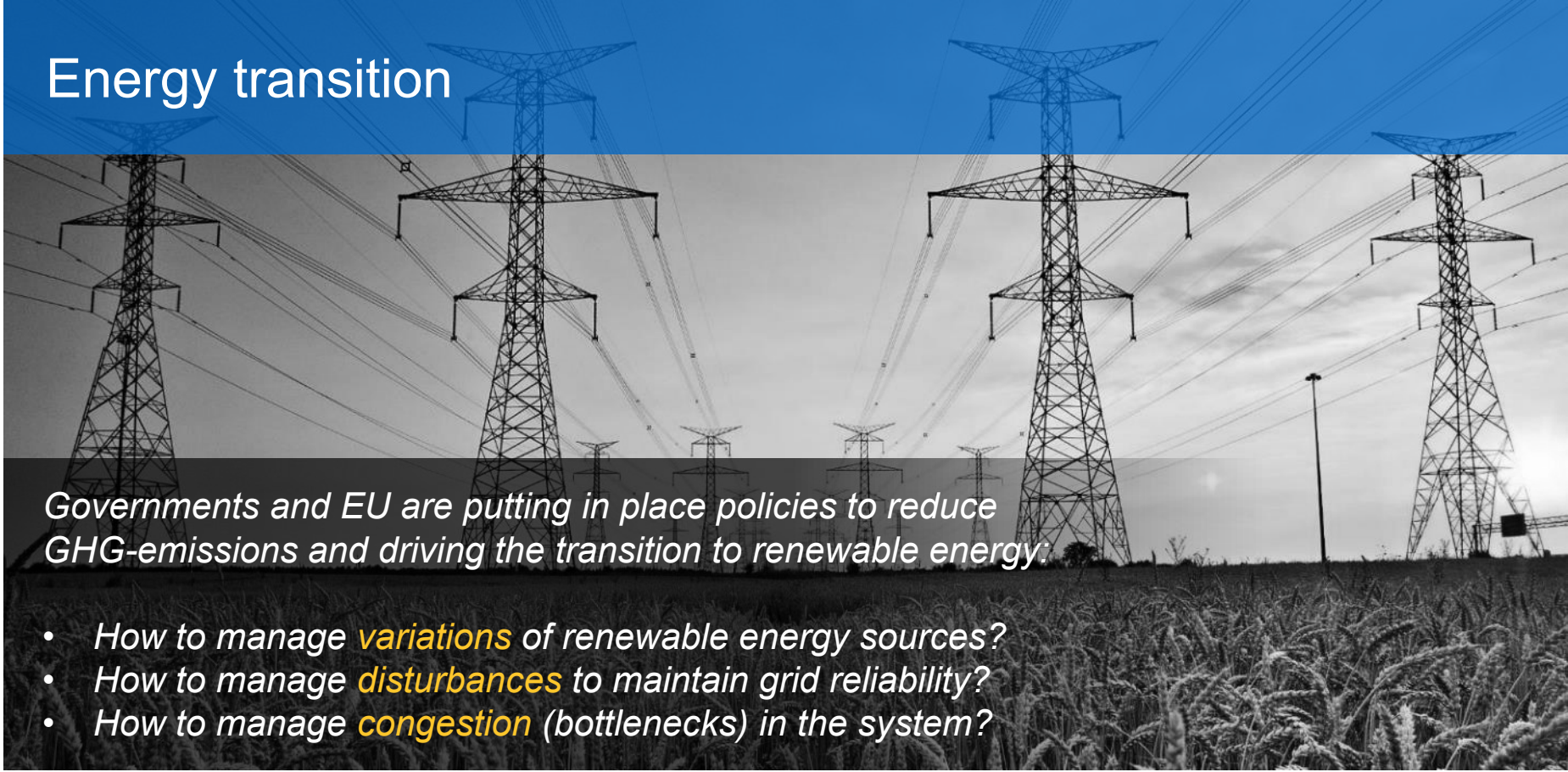
July 2021
Aerial
United States • WA • Grant Co. • Quincy
Road R
Road 10.5 NW
Port Industrial Pky NW
13th Ave NW
Port Industrial Pk
B St SW




Boydton
Mecklenburg



Energy transition



Governments and EU are putting in place policies to reduce GHG-emissions and driving the transition to renewable energy:

- *How to manage variations of renewable energy sources?*
- *How to manage disturbances to maintain grid reliability?*
- *How to manage congestion (bottlenecks) in the system?*

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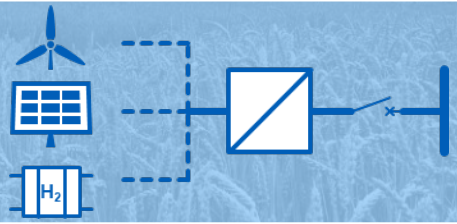
Power generation technologies

NON-RENEWABLE	High CO_2eq	Liquid and gaseous fossil fuels	SYNCHRONOUS
		Solid fossil fuels	
		Nuclear	
		Biomass	
RENEWABLE	Low CO_2eq	Hydro	
		Wind	NON-SYNCHRONOUS
		Solar	
		Hydrogen (from renewable)	



Transition introduces:

Faster and higher frequency variations

More difficulties to contain the frequency

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Becoming Grid Interactive

The past:

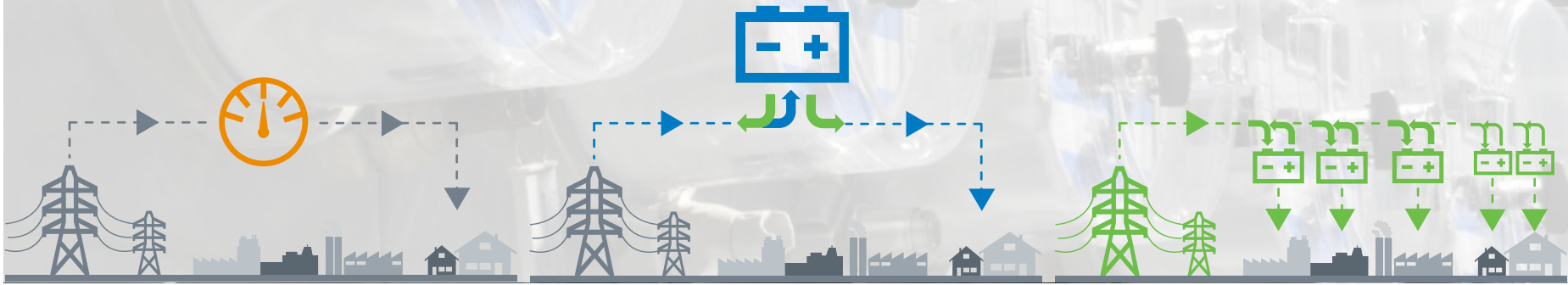
- Energy has been a **commodity** and treated as a **waste** after first use
- Sectors (energy, transport, industry, buildings) were viewed in **isolation**

The present:

- Storing and using energy when having **highest value**, or to provide services, turns energy into **an asset**
- **Energy storages** providing **flexibility** to system

The future:

- **Grid-interactive** building and data centres using assets to enable higher penetration of renewable energy
- **Coupling sectors** for holistic approach to energy system



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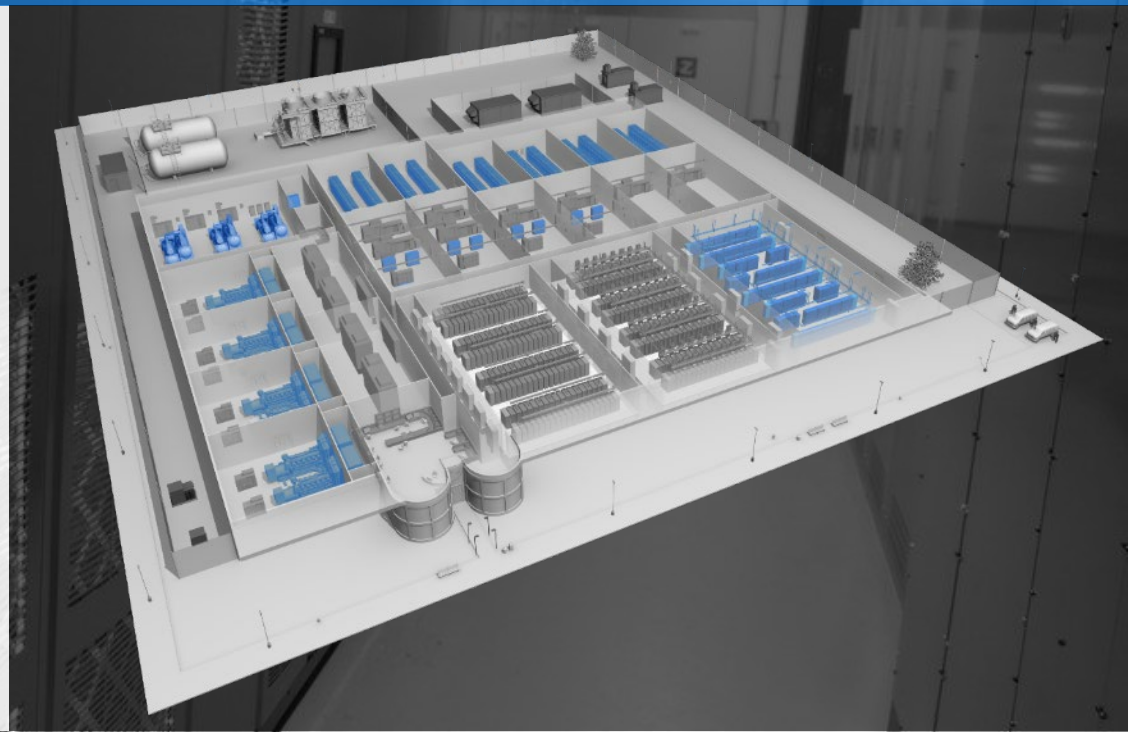
Technologies for a “data and energy centre”

- Data centres have high design power density
- Data centre power infrastructure:
  - HV or MV grid connection
  - UPS
  - Batteries
  - Generators
  - HVAC
- Redundant hardware
- Actual vs design load



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Technology for a “grid interactive data centre”

Seamless control of grid demand and bidirectional operation enables load independent response and allows to use full hardware capacity for smart energy management.

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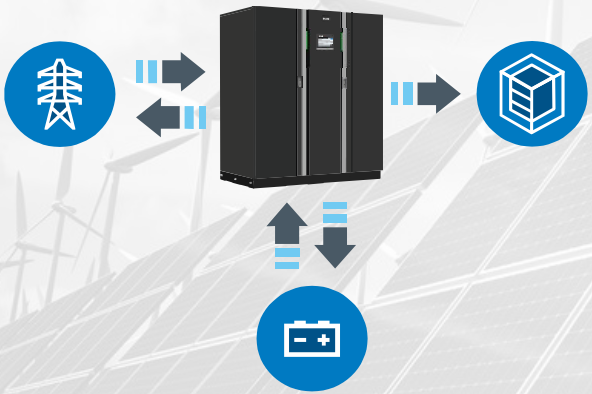
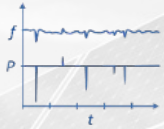
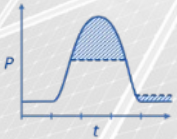
EnergyAware UPS enabling smart energy management

EnergyAware





Frequency containment



Peak shaving

Time of use

Generator replacement

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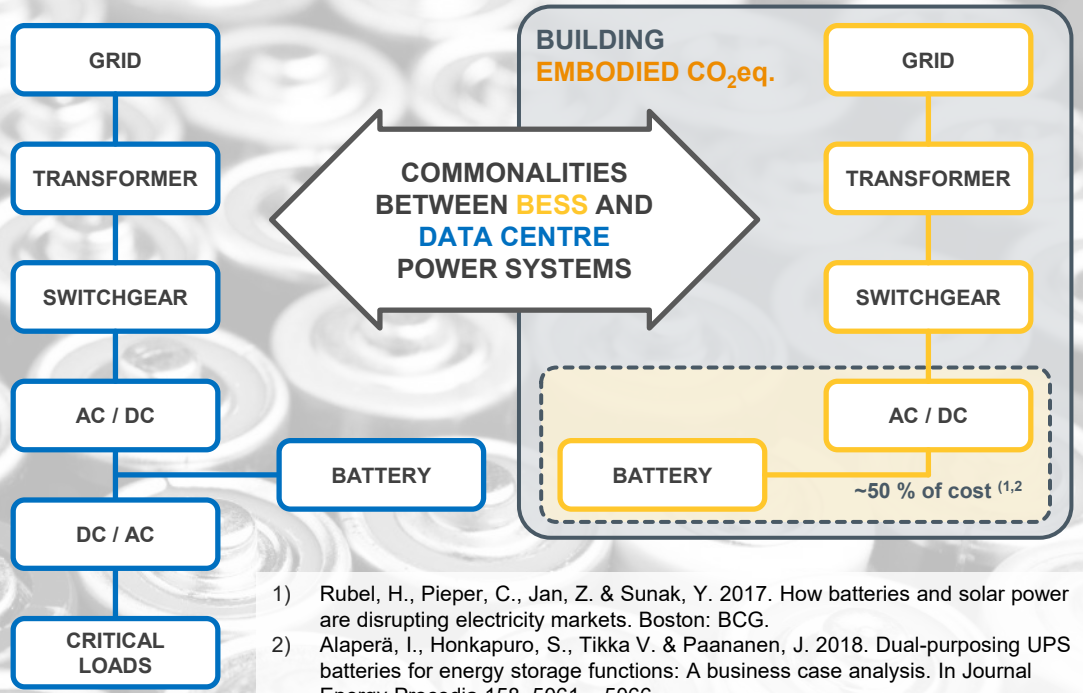
Carbon handprint

Smarter and more efficient use of assets:

- provides new opportunities for asset owners
- reduces the cost of system balancing
- enables higher penetration of renewable energy in the grid
- reduces embodied carbon outside data centre



1) Rubel, H., Pieper, C., Jan, Z. & Sunak, Y. 2017. How batteries and solar power are disrupting electricity markets. Boston: BCG.
2) Alaperä, I., Honkapuro, S., Tikka V. & Paananen, J. 2018. Dual-purposing UPS batteries for energy storage functions: A business case analysis. In Journal Energy Procedia 158, 5061 – 5066.

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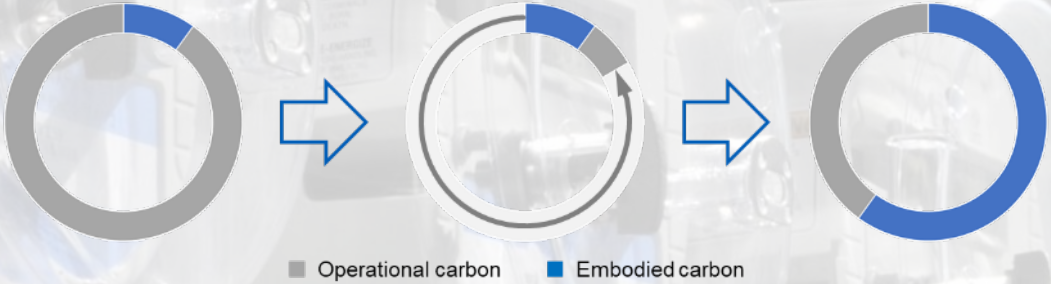
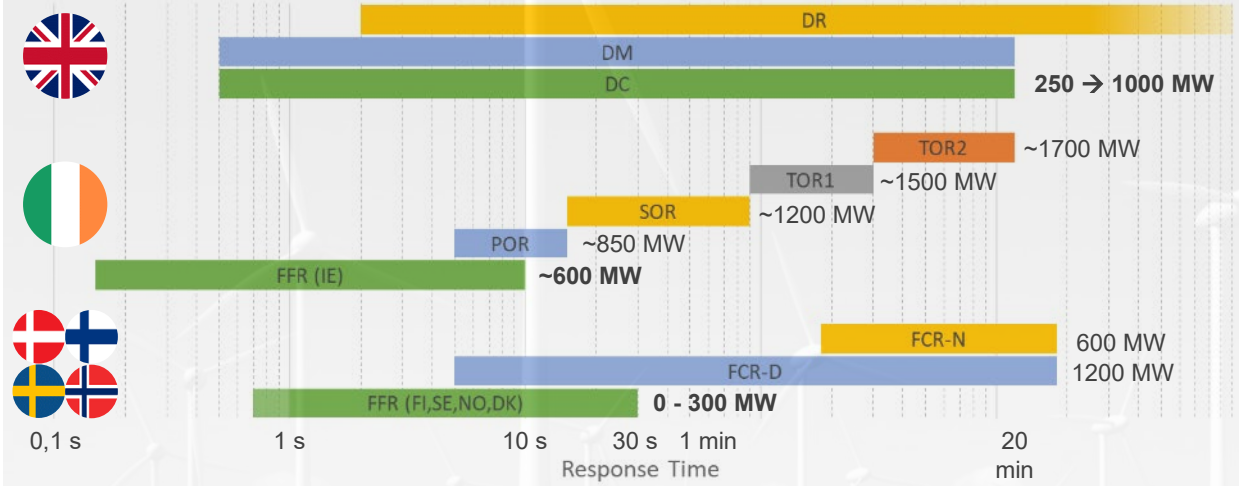
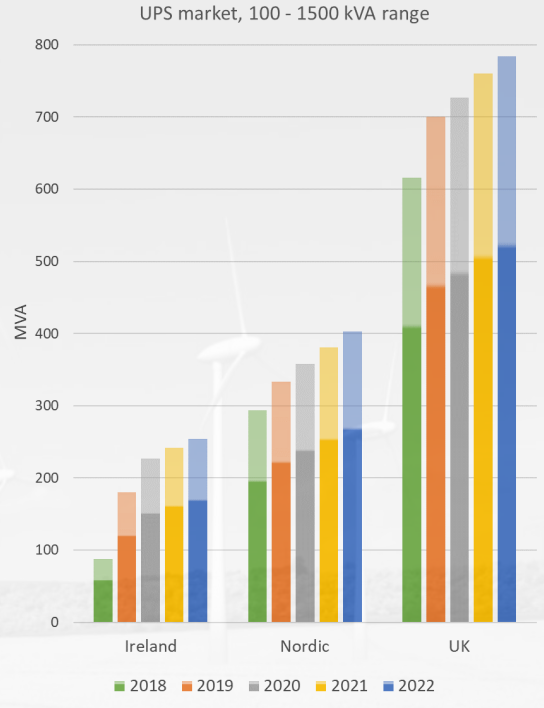
Efficiency vs. sustainability



- As we move towards cleaner energy system, the embodied carbon footprint becomes dominating
- A new approach needed for evaluating the sustainability
- Need to break artificial boundaries to meter the true sustainability and to include carbon handprint
- How to guide the demand to truly sustainable products?

Frequency containment – reserve types and volumes





- Approximately ~67% of large UPS units go into ICT applications in data centres or server rooms
- Data centres often use 2N architecture, UPS / IT ratio 2:1 (kW) with additional UPS for cooling systems (not in all designs)

https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services/dynamic-containment
https://www.fingrid.fi/globalassets/dokumentit/fi/sahkomarkkinat/reservit/ffr-keskustelutilaisuuden-esitysmateriaali.pdf
http://www.eirgridgroup.com/site-files/library/EirGrid/Procurement-Summary-Gate-1.pdf

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Datacenter Grid Interaction

RegD Fast Frequency Regulation

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Microsoft will be carbon negative by 2030

Jan 16, 2020 | Brad Smith - President

Microsoft President Brad Smith, Chief Financial Officer Amy Hood and CEO Satya Nadella preparing to announce Microsoft's plan to be carbon negative by 2030. (Jan. 15, 2020/Photo by Brian Smale)

Progress on our goal to be carbon negative by 2030

Jul 21, 2020 | Lucas Joppa - Chief Environmental Officer

Reducing our own carbon emissions

To reduce our Scope 1 and 2 emissions to near zero, we need to change how we operate. We're on the path to obtaining renewable energy power purchase agreements for 100% of the day-to-day power of our data centers by the middle of this decade. Today, we're additionally announcing that we're aiming to eliminate our dependency on diesel fuel by 2030.

Removing our own carbon emissions

Our climate commitments require us to reduce our carbon emissions by more than half by 2030 and remove the rest, while also removing all of our historical emissions since we were founded in 1975 by 2050. We aren't waiting until 2030 to get started. This fiscal year, Microsoft is taking concrete steps to remove 1 million metric tons of carbon from the environment. As the first step, this week we will issue a groundbreaking request for proposal (RFP) to source that carbon removal from a range of nature- and technology-based solutions that are net negative and verified to a high degree of scientific integrity.

Investing in climate equity and environmental justice

Finally, we're taking a step beyond what we announced in January. We recognize that climate and environmental issues don't affect every community the same way and that we need to address environmental equity as a broader issue. Today, we're announcing a new innovative partnership with Sol Systems, a renewable energy developer and investor, for 500 megawatts (MW) of renewable energy that includes investments in communities disproportionately affected by environmental challenges.

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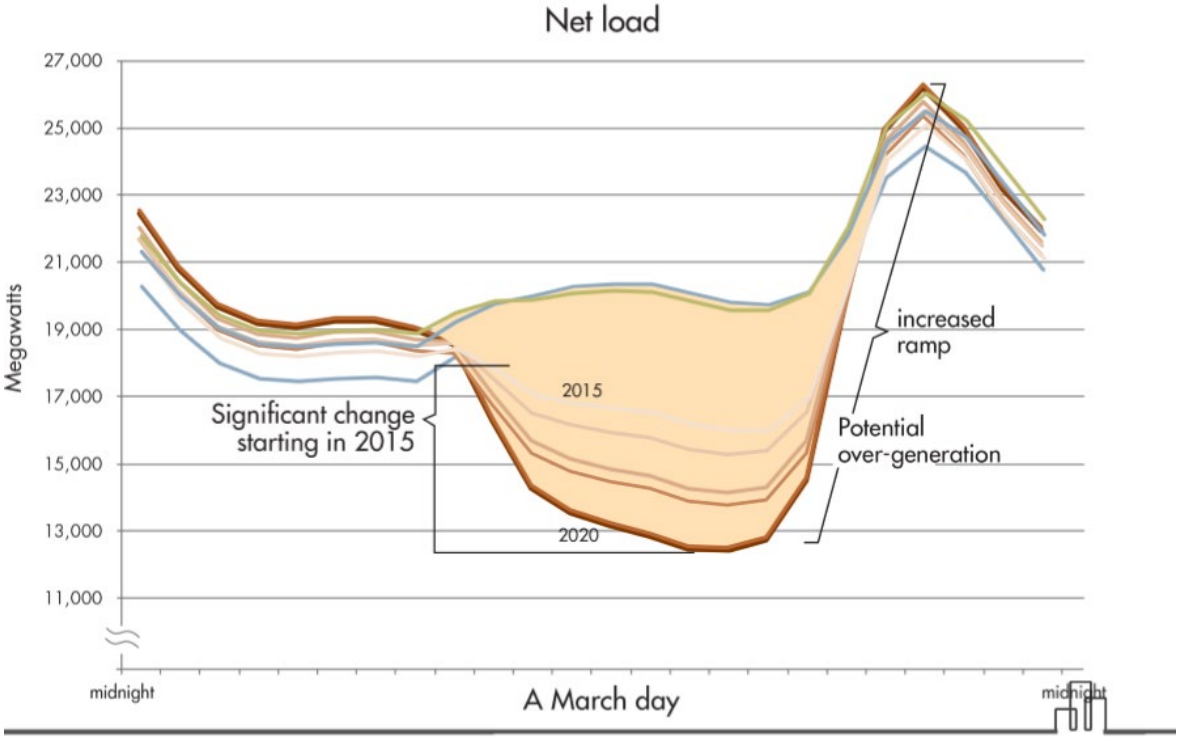
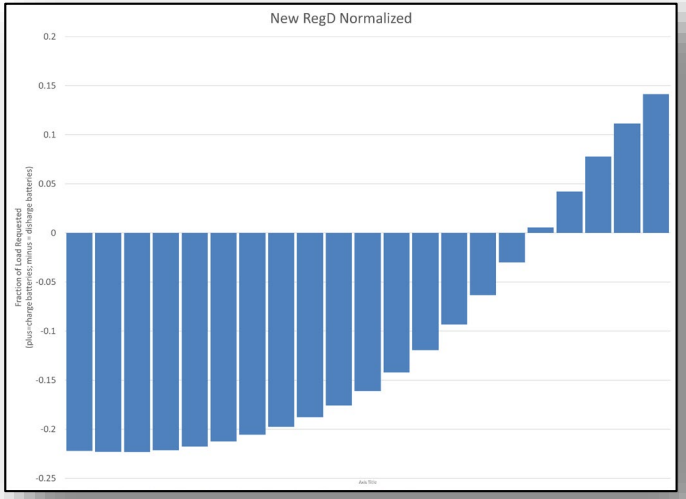
Storage Resources Help Flatten the “Duck Curve”



Datacenters Have Storage Capacity

Frequency Regulation Signal

- Assist grid operator in Frequency Regulation by incrementally adding or decreasing load
- Changes in 2-second intervals



EPT	New RegD Normalized	Cu
4/6/2015 10:11:18	-0.22218	
4/6/2015 10:11:20	-0.223172	
4/6/2015 10:11:22	-0.223456	
4/6/2015 10:11:24	-0.2214	
4/6/2015 10:11:26	-0.217748	
4/6/2015 10:11:28	-0.21242	
4/6/2015 10:11:30	-0.205432	
4/6/2015 10:11:32	-0.197508	
4/6/2015 10:11:34	-0.187724	
4/6/2015 10:11:36	-0.175724	
4/6/2015 10:11:38	-0.160988	
4/6/2015 10:11:40	-0.142184	
4/6/2015 10:11:42	-0.11948	
4/6/2015 10:11:44	-0.0934	
4/6/2015 10:11:46	-0.063472	
4/6/2015 10:11:48	-0.030084	
4/6/2015 10:11:50	0.005488	
4/6/2015 10:11:52	0.04212	
4/6/2015 10:11:54	0.077856	
4/6/2015 10:11:56	0.11156	
4/6/2015 10:11:58	0.141248	
4/6/2015 10:12:00	0.166092	
4/6/2015 10:12:02	0.186828	

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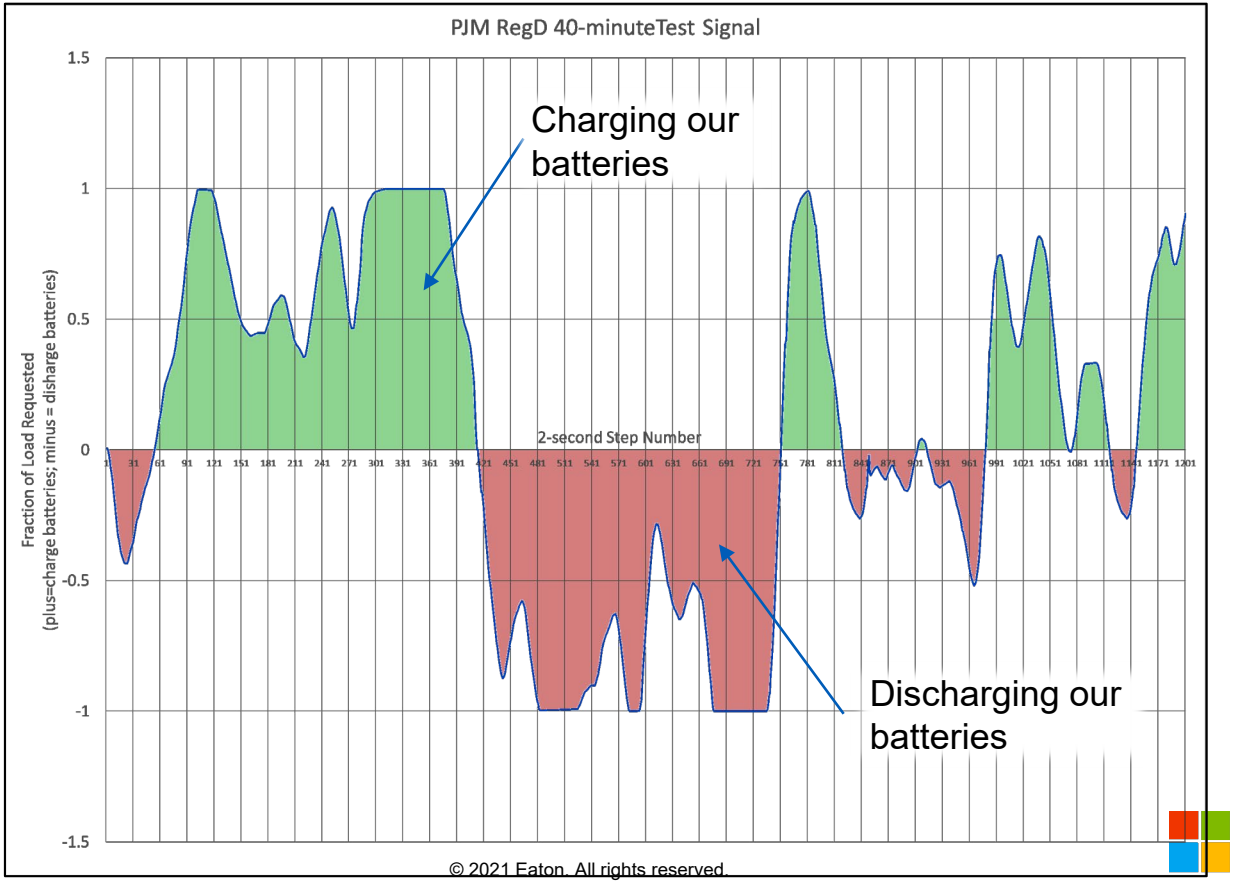
40-minute Example



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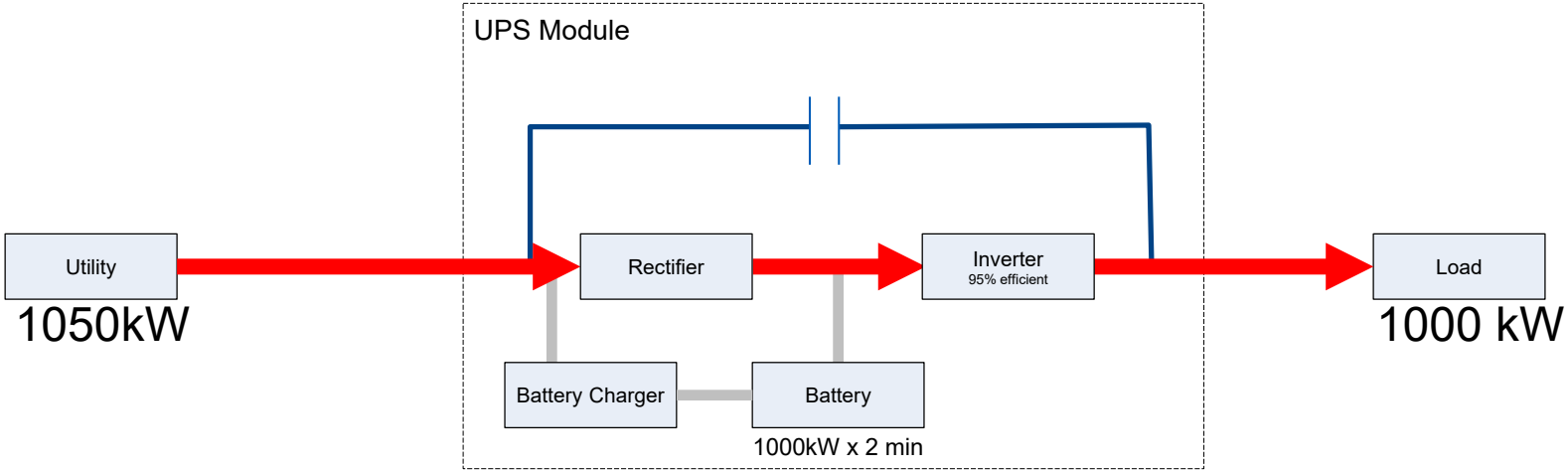
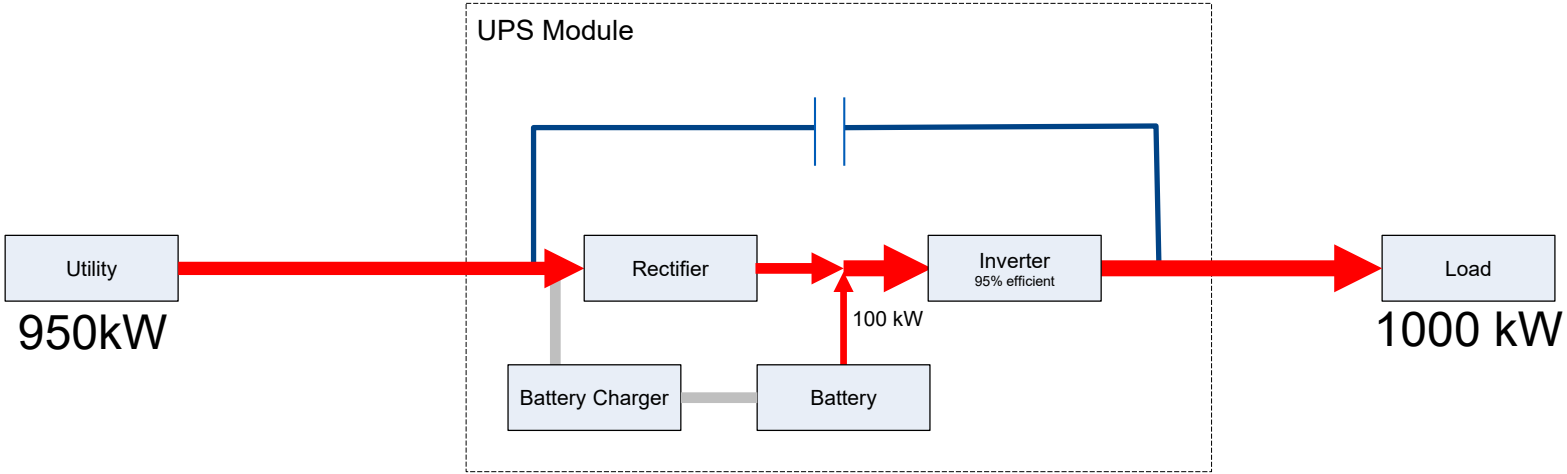
Normal Datacenter UPS Operation



Utility Signal: “Reduce Utility Draw 100kW”



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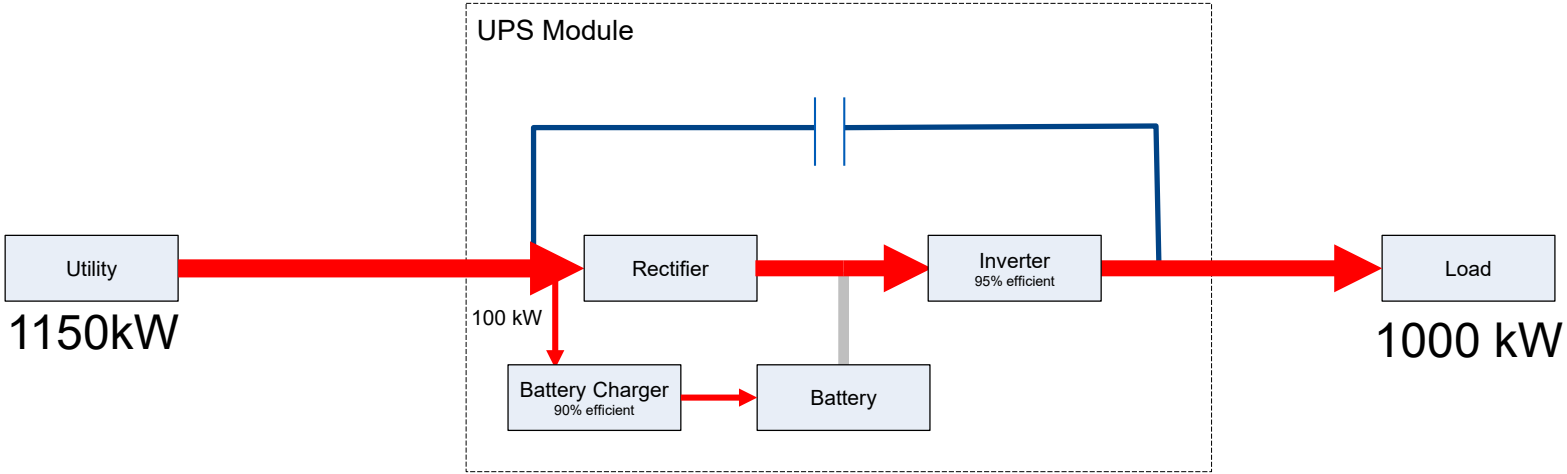
Utility Signal: “Increase Utility Draw 100kW”



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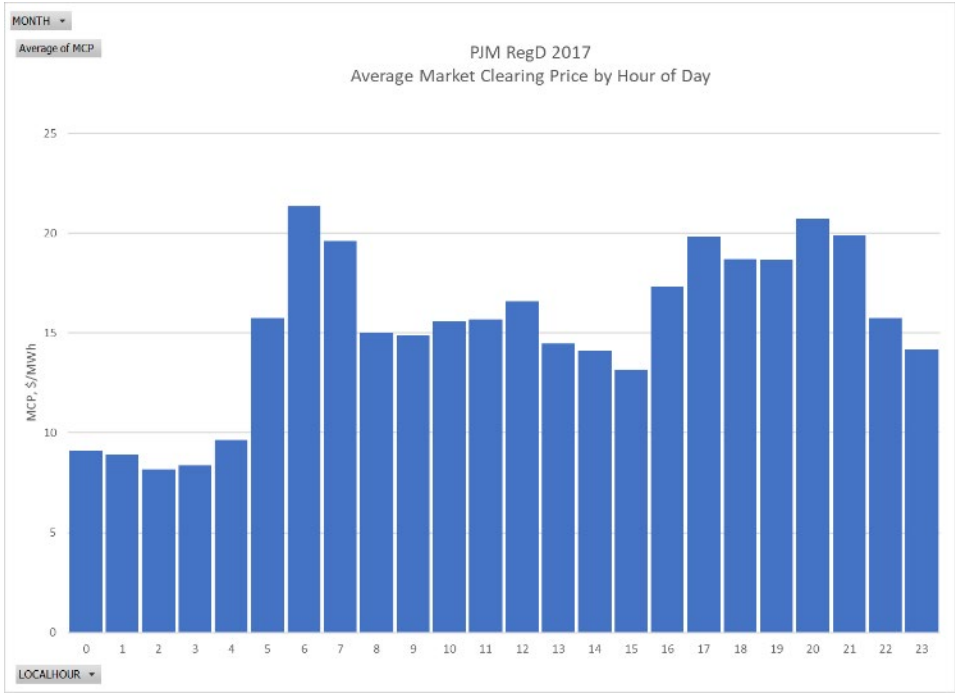
Frequency Regulation Monetary Analysis



Heatmap of Hourly Average MCP

Month of Year

Hou	1	2	3	4	5	6	7	8	9	10
0	9.55	7.87	7.05	9.81	8.67	7.33	6.86	8.52	15.22	10.31
1	10.06	7.32	6.09	8.50	10.64	9.13	6.99	9.68	12.23	8.27
2	8.47	7.99	5.35	8.63	9.35	7.51	5.42	9.86	11.25	7.82
3	7.69	6.99	5.52	8.44	10.91	7.85	5.56	9.61	10.44	10.73
4	19.75	9.43	5.14	9.59	11.90	8.40	5.35	7.96	9.94	9.08
5	22.51	12.21	17.46	14.82	20.75	12.24	9.34	12.70	19.31	15.97
6	26.79	23.05	31.77	20.70	27.07	14.24	10.64	11.45	23.03	24.83
7	17.18	20.45	26.61	19.75	22.76	15.78	11.07	12.77	27.82	22.08
8	12.25	13.92	13.67	11.12	15.99	12.16	11.48	14.92	27.40	17.37
9	14.05	7.94	15.25	13.34	17.11	15.67	13.22	14.04	22.12	15.52
10	8.51	6.85	16.14	13.97	15.25	18.00	26.86	16.86	13.95	18.45
11	12.08	7.90	24.46	11.52	12.59	19.86	25.63	16.54	11.04	14.17
12	14.66	7.49	13.53	15.11	16.82	16.13	25.36	23.94	12.83	18.88
13	9.77	6.35	10.92	16.27	13.67	15.67	21.63	16.14	20.28	13.49
14	8.25	6.17	9.31	14.61	16.69	8.51	15.28	10.55	40.64	10.90
15	8.38	6.25	6.56	16.95	17.07	10.37	17.28	10.18	27.32	11.02
16	15.06	11.93	6.75	15.55	23.57	11.69	22.65	13.33	41.01	11.85
17	16.48	10.49	14.24	25.76	29.84	11.17	19.34	11.08	30.86	28.54
18	14.28	18.92	24.03	18.15	26.38	15.34	17.72	14.04	17.16	20.81
19	13.24	10.33	27.51	20.99	18.79	16.75	17.33	13.49	22.94	24.64
20	15.46	10.46	28.97	27.85	22.74	17.43	17.94	19.15	24.39	22.17
21	19.38	11.58	19.55	21.28	26.44	19.63	22.60	16.71	21.44	19.67
22	11.61	10.24	16.89	16.52	19.16	15.28	14.10	12.98	24.92	15.67
23	11.33	13.12	13.67	14.73	15.27	11.48	12.28	11.22	24.41	14.34

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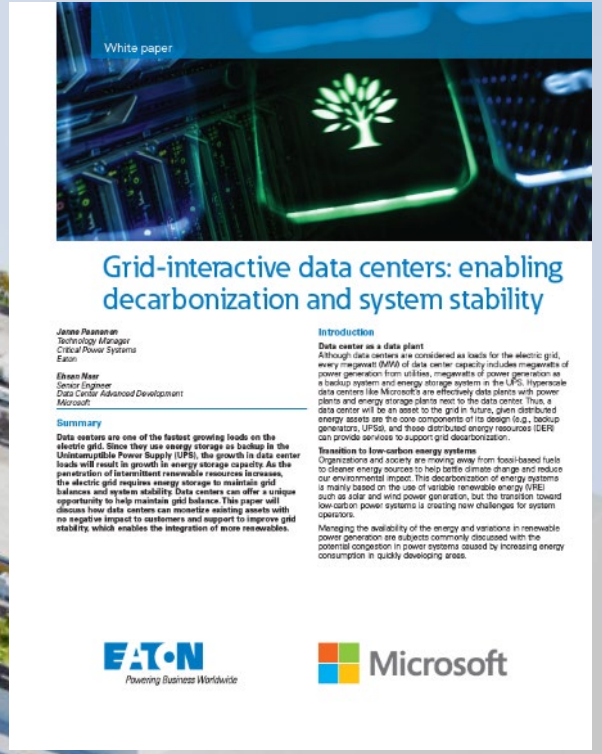
Eaton and Microsoft published a white paper that explains how Grid-Interactive Datacenter could look like and what kind of impact it could give to Energy System

www.eaton.com/EnergyAware


White paper

Grid-interactive data centers: enabling decarbonization and system stability

Jonne Paananen
Technology Manager
Critical Power Systems
Eaton

Ehsan Nasr
Senior Engineer
Data Center Advanced Development
Microsoft

Summary

Data centers are one of the fastest growing loads on the electric grid. Since they use energy storage as backup in the Uninterruptible Power Supply (UPS), the growth in data center loads will result in growth in energy storage capacity. As the penetration of intermittent renewable resources increases, the electric grid requires energy storage to maintain grid balances and system stability. Data centers can offer a unique opportunity to help maintain grid balance. This paper will discuss how data centers can monetize existing assets with no negative impact to customers and support to improve grid stability, which enables the integration of more renewables.

Introduction

Data center as a data plant

Although data centers are considered as loads for the electric grid, every megawatt (MW) of data center capacity includes megawatts of power generation from utilities, megawatts of power generation as a backup system and energy storage system in the UPS. Hyperscale data centers like Microsoft's are effectively data plants with power plants and energy storage plants next to the data center. Thus, a data center will be an asset to the grid in future, given distributed energy assets are the core components of its design (e.g., backup generators, UPSs), and these distributed energy resources (DER) can provide services to support grid decarbonization.

Transition to low-carbon energy systems

Organizations and society are moving away from fossil-based fuels to cleaner energy sources to help battle climate change and reduce our environmental impact. This decarbonization of energy systems is mainly based on the use of variable renewable energy (VRE) such as solar and wind power generation, but the transition toward low-carbon power systems is creating new challenges for system operators.

Managing the availability of the energy and variations in renewable power generation are subjects commonly discussed with the potential congestion in power systems caused by increasing energy consumption in quickly developing areas.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