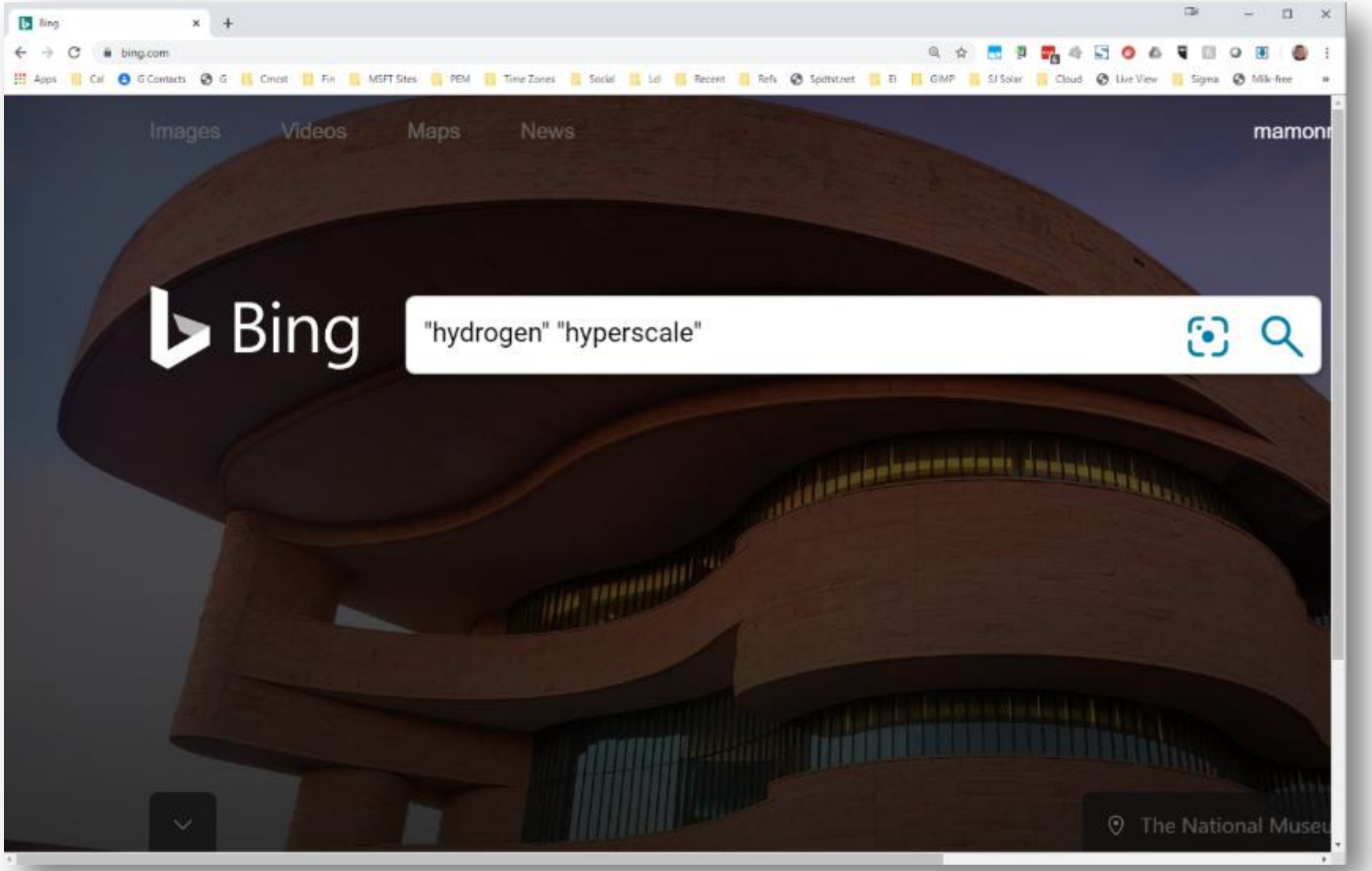
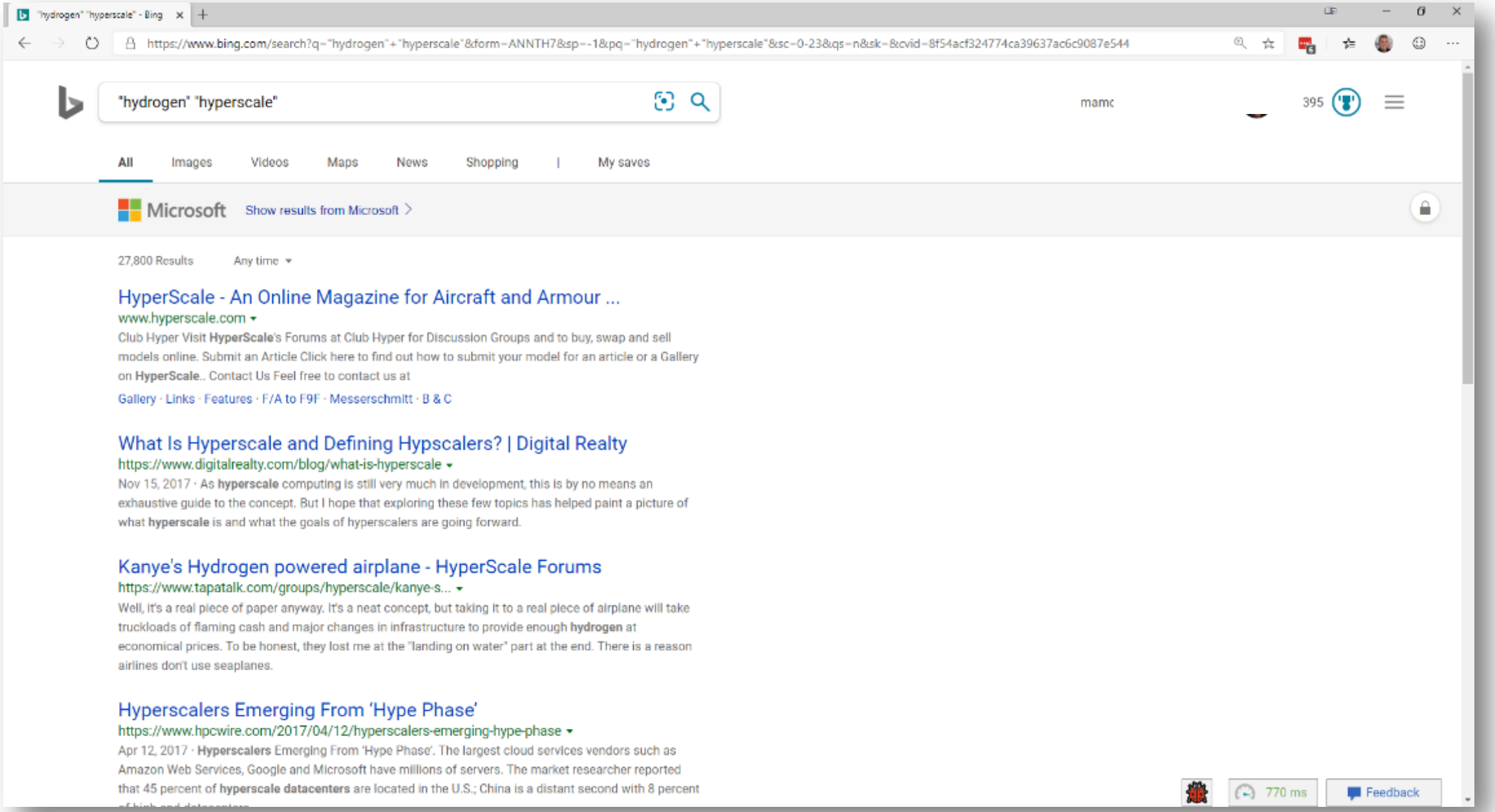
Hydrogen-Powered Backup Generators for Hyperscale Datacenters

(non-polluting diesel generator replacement)

Mark Monroe, Datacenter Advanced Development

Hydrogen + Hyperscale

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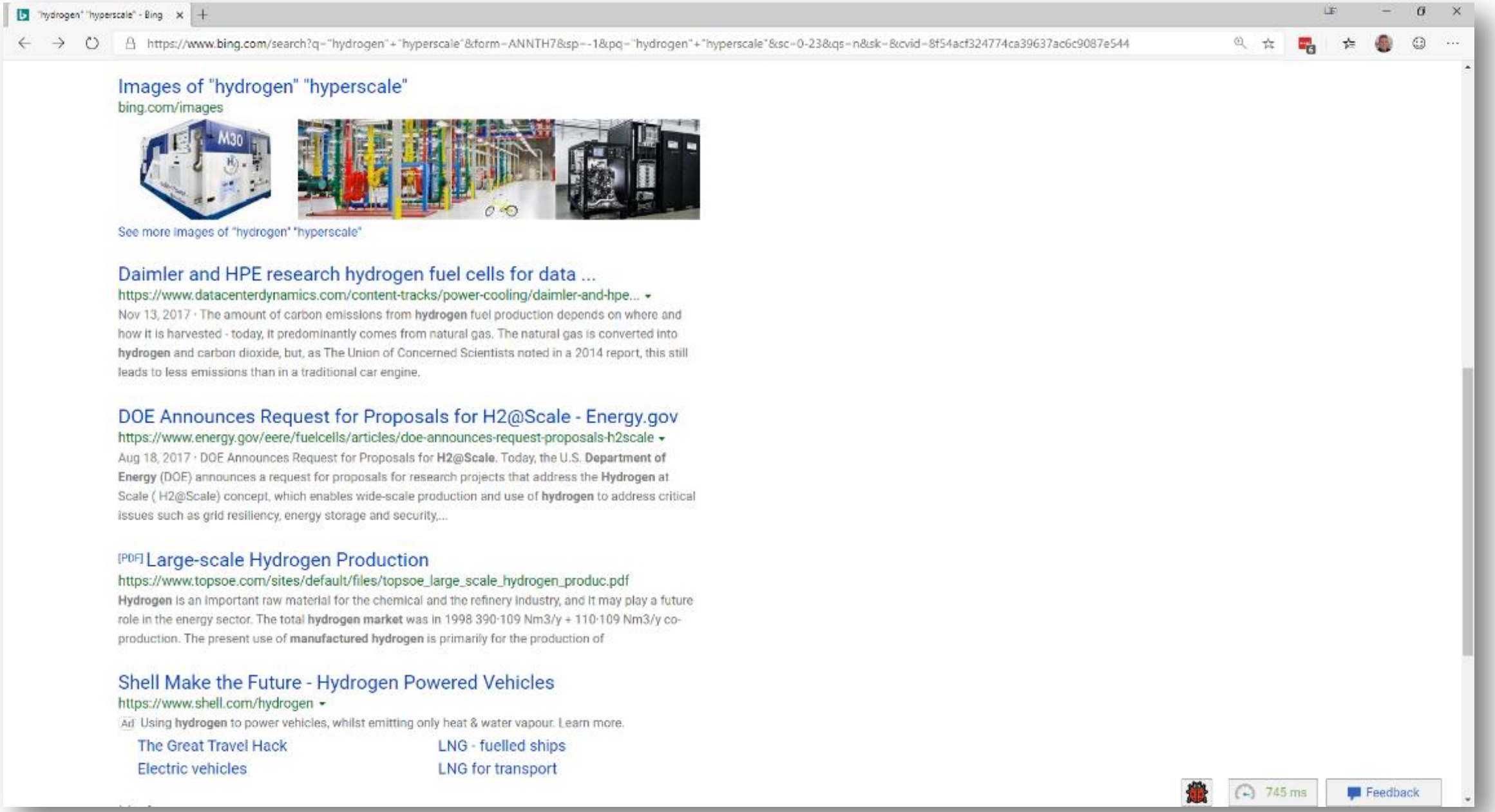
What Is Hyperscale and Defining Hypscalers? | Digital Realty
https://www.digitalrealty.com/blog/what-is-hyperscale
Nov 15, 2017 · As hyperscale computing is still very much in development, this is by no means an exhaustive guide to the concept. But I hope that exploring these few topics has helped paint a picture of what hyperscale is and what the goals of hyperscalers are going forward.
Kanye's Hydrogen powered airplane - HyperScale Forums
https://www.tapatalk.com/groups/hyperscale/kanye-s...
Well, it's a real piece of paper anyway. It's a neat concept, but taking it to a real piece of airplane will take truckloads of flaming cash and major changes in infrastructure to provide enough hydrogen at economical prices. To be honest, they lost me at the "landing on water" part at the end. There is a reason airlines don't use seaplanes.
Hyperscalers Emerging From 'Hype Phase'
https://www.hpcwire.com/2017/04/12/hyperscalers-emerging-hype-phase
Apr 12, 2017 · Hyperscalers Emerging From 'Hype Phase'. The largest cloud services vendors such as Amazon Web Services, Google and Microsoft have millions of servers. The market researcher reported that 45 percent of hyperscale datacenters are located in the U.S.; China is a distant second with 8 percent
770 ms
Feedback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Daimler and HPE research hydrogen fuel cells for data ...
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Nov 13, 2017 · The amount of carbon emissions from hydrogen fuel production depends on where and how it is harvested - today, it predominantly comes from natural gas. The natural gas is converted into hydrogen and carbon dioxide, but, as The Union of Concerned Scientists noted in a 2014 report, this still leads to less emissions than in a traditional car engine.
DOE Announces Request for Proposals for H2@Scale - Energy.gov
https://www.energy.gov/eere/fuelcells/articles/doe-announces-request-proposals-h2scale
Aug 18, 2017 · DOE Announces Request for Proposals for H2@Scale. Today, the U.S. Department of Energy (DOE) announces a request for proposals for research projects that address the Hydrogen at Scale (H2@Scale) concept, which enables wide-scale production and use of hydrogen to address critical issues such as grid resiliency, energy storage and security,...
[PDF] Large-scale Hydrogen Production
https://www.topsoe.com/sites/default/files/topsoe_large_scale_hydrogen_produc.pdf
Hydrogen is an important raw material for the chemical and the refinery industry, and it may play a future role in the energy sector. The total hydrogen market was in 1998 390·109 Nm3/y + 110·109 Nm3/y co-production. The present use of manufactured hydrogen is primarily for the production of
Shell Make the Future - Hydrogen Powered Vehicles
https://www.shell.com/hydrogen
Ad Using hydrogen to power vehicles, whilst emitting only heat & water vapour. Learn more.
The Great Travel Hack
Electric vehicles
LNG - fuelled ships
LNG for transport
745 ms
Feedback

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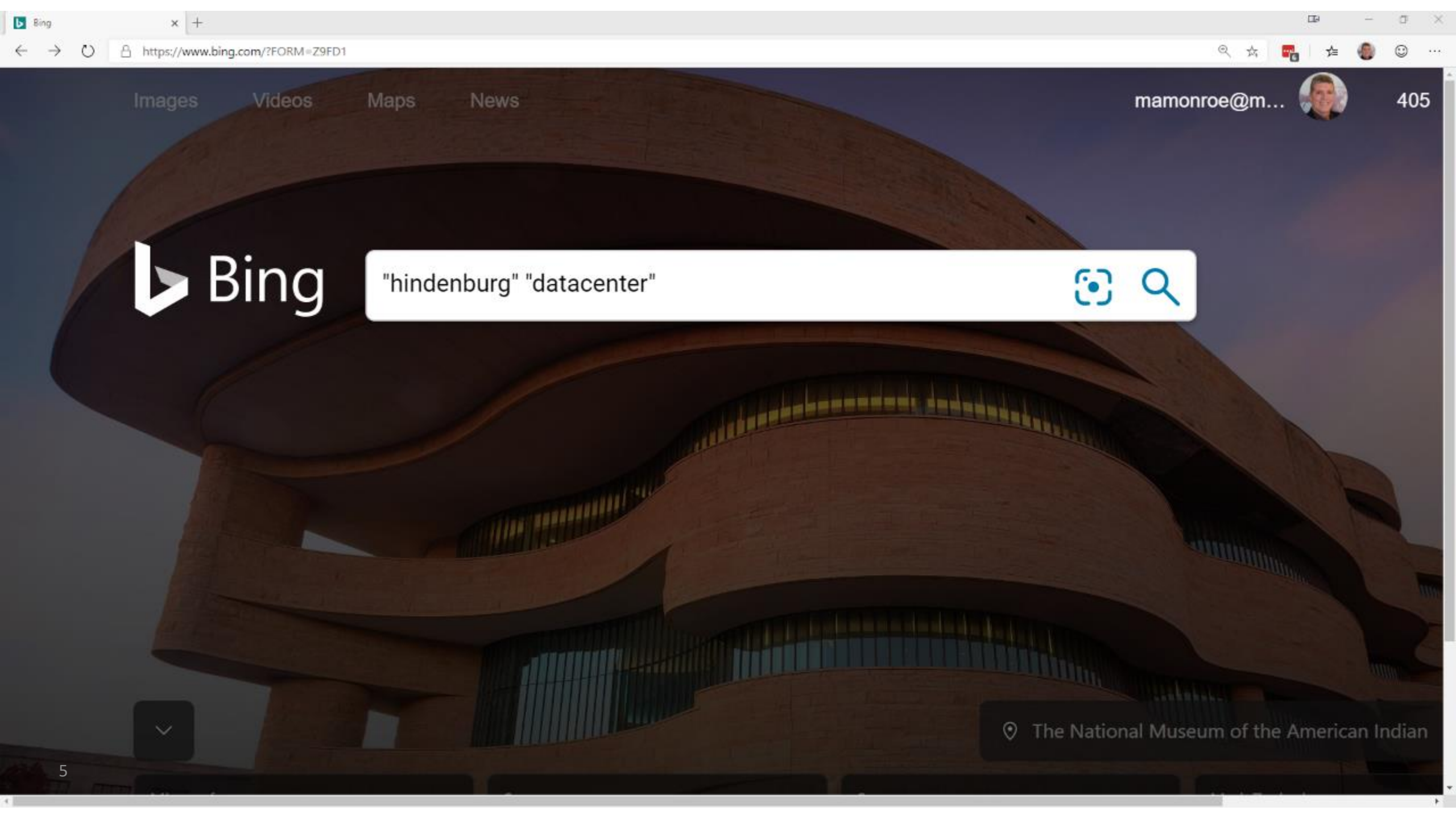
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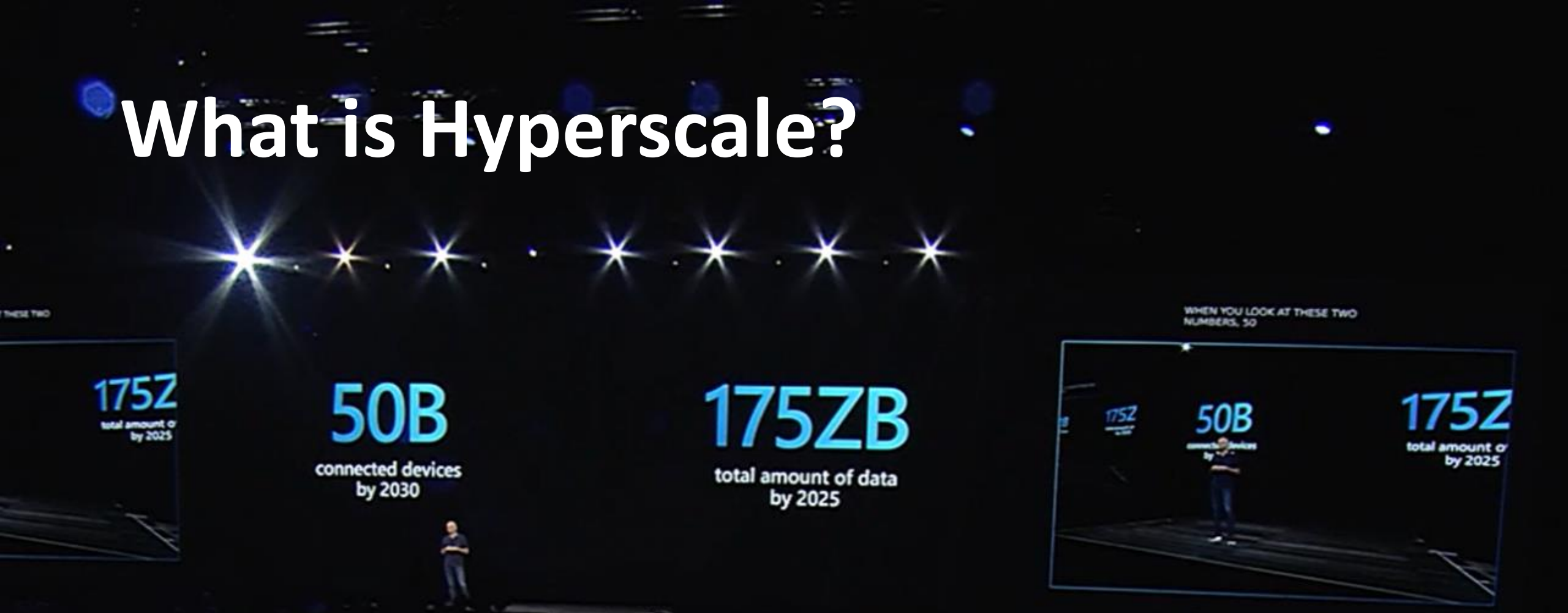
The National Museum of the American Indian

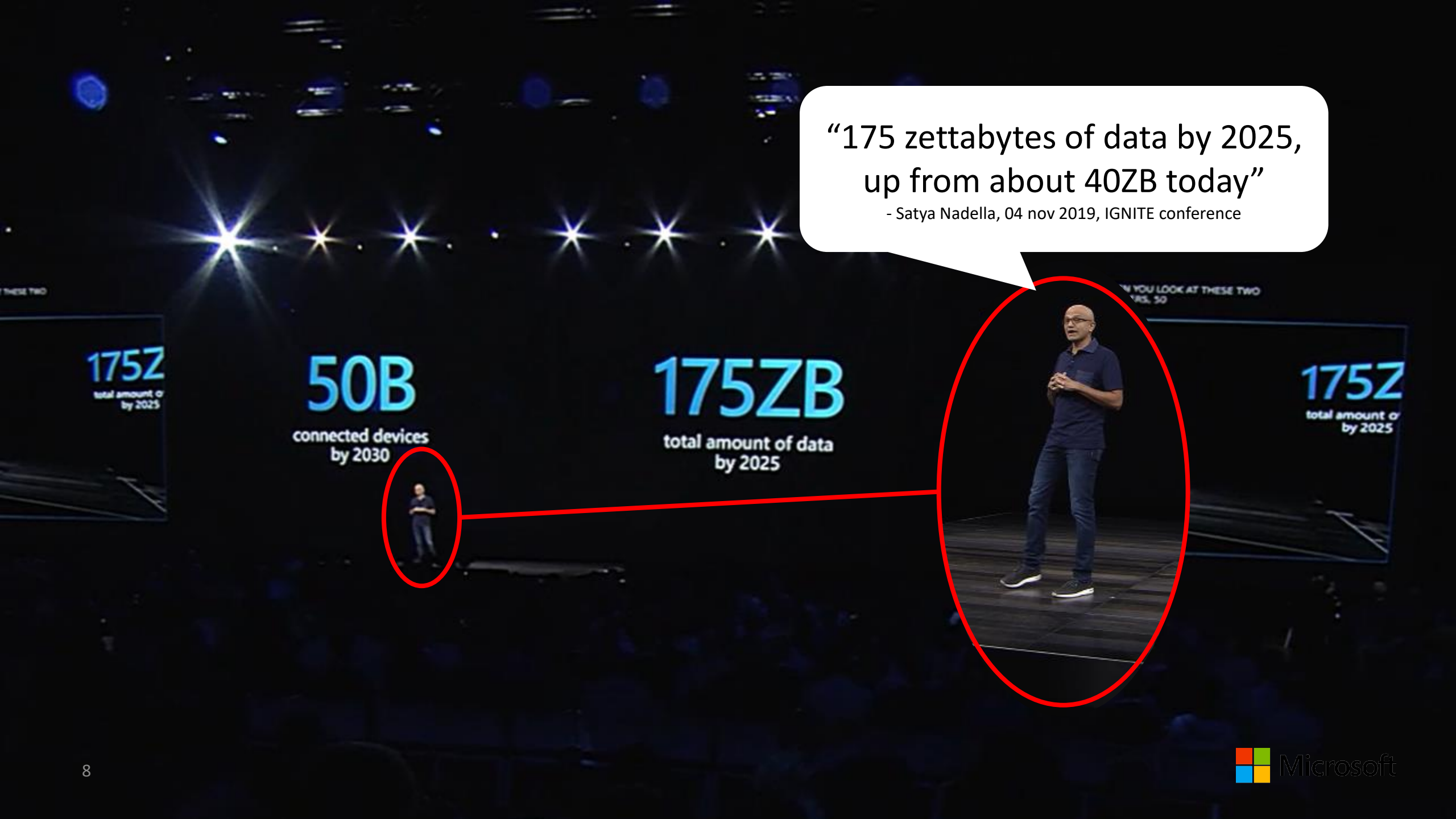
What is Hyperscale Computing?

What is Hyperscale?



Microsoft Ignite conference, 04 Nov 2019, 08:07am ET

Microsoft



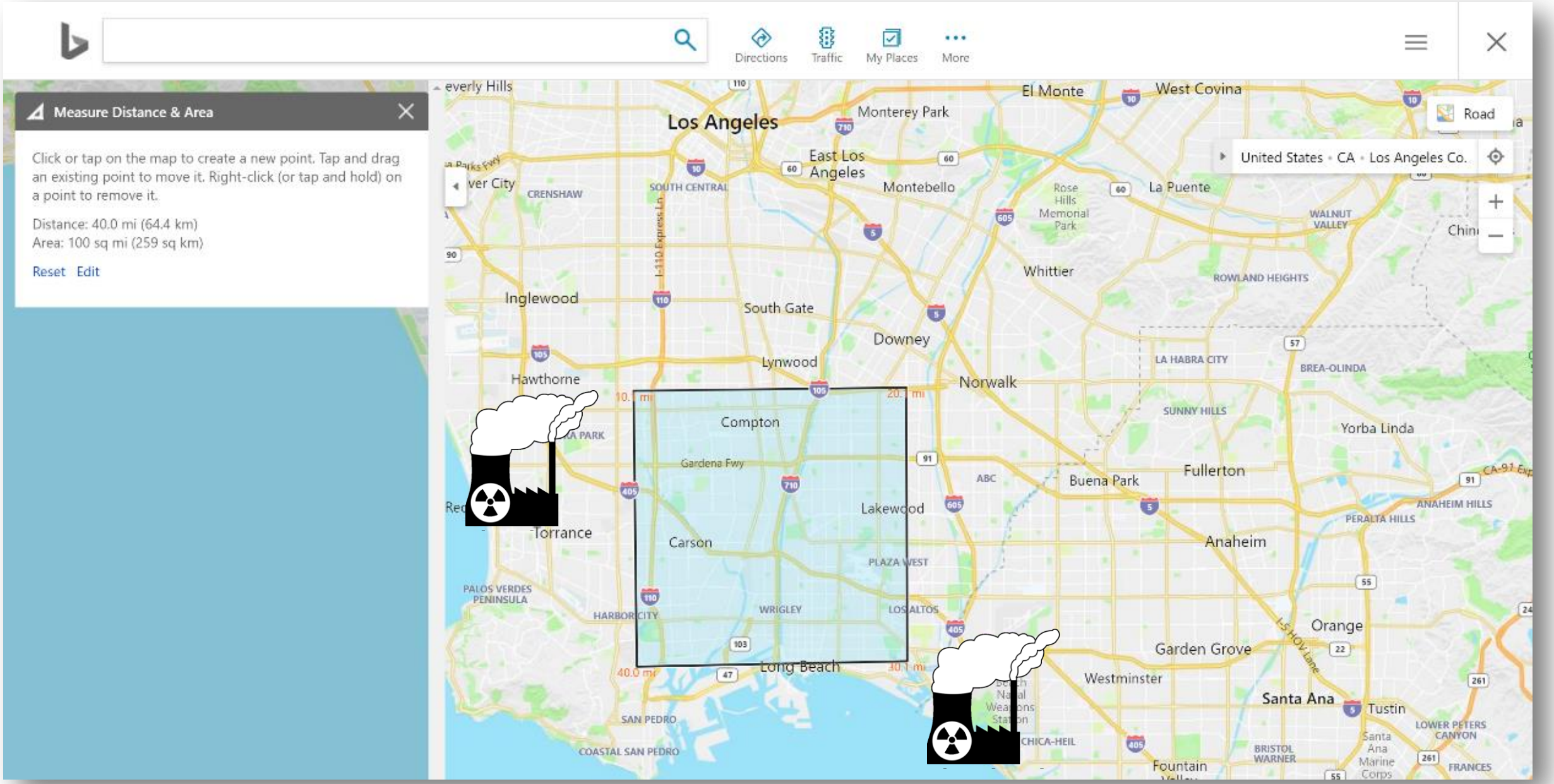
"175 zettabytes of data by 2025, up from about 40ZB today"

- Satya Nadella, 04 nov 2019, IGNITE conference

Microsoft

- EMC VMAX^3
- 1 PB storage
- 22 sq ft / rack
- 17kW / rack

- 135M racks
- 105 sq mi
- 2.3GW



Microsoft

Cloud Operations + Innovation

Safe, fast and always reliable – the future of cloud infrastructure

Azure regions

Azure has more global regions than any other cloud provider—offering the scale needed to bring applications closer to users around the world, preserving data residency, and offering comprehensive compliance and resiliency options for customers.

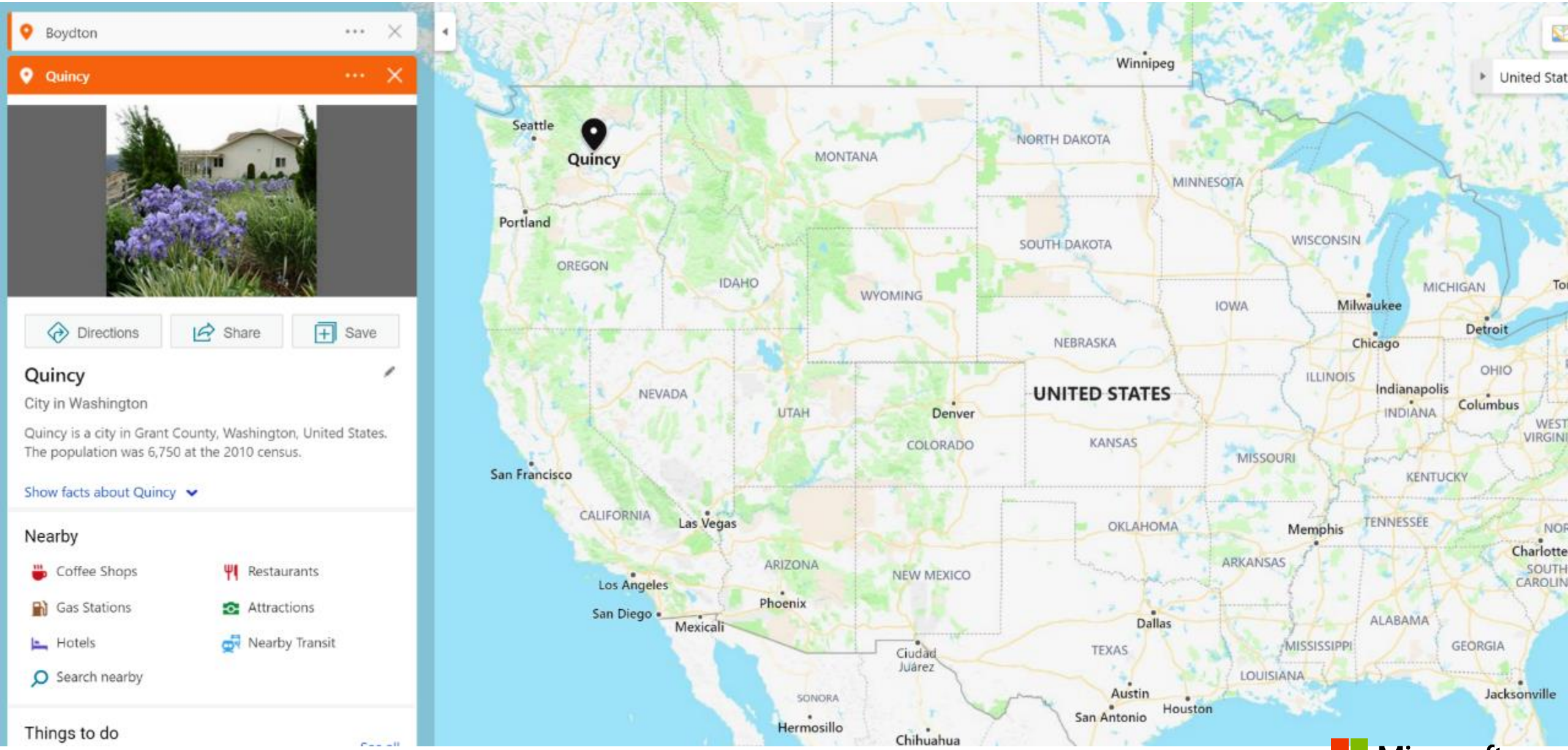
54 regions worldwide

140 available in 140 countries

160 data centers worldwide

2M+ miles of fiber

3M+ computer servers



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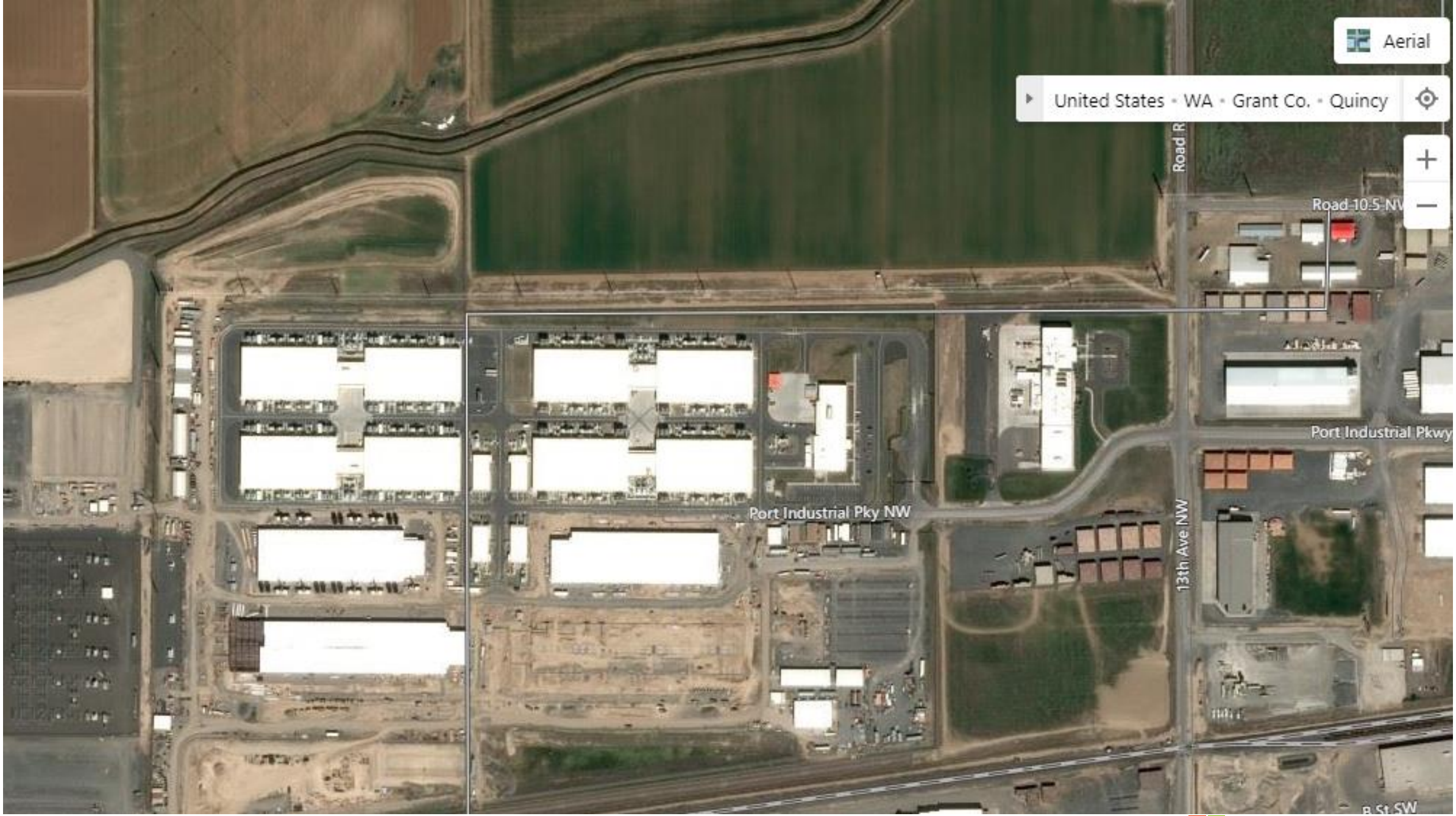

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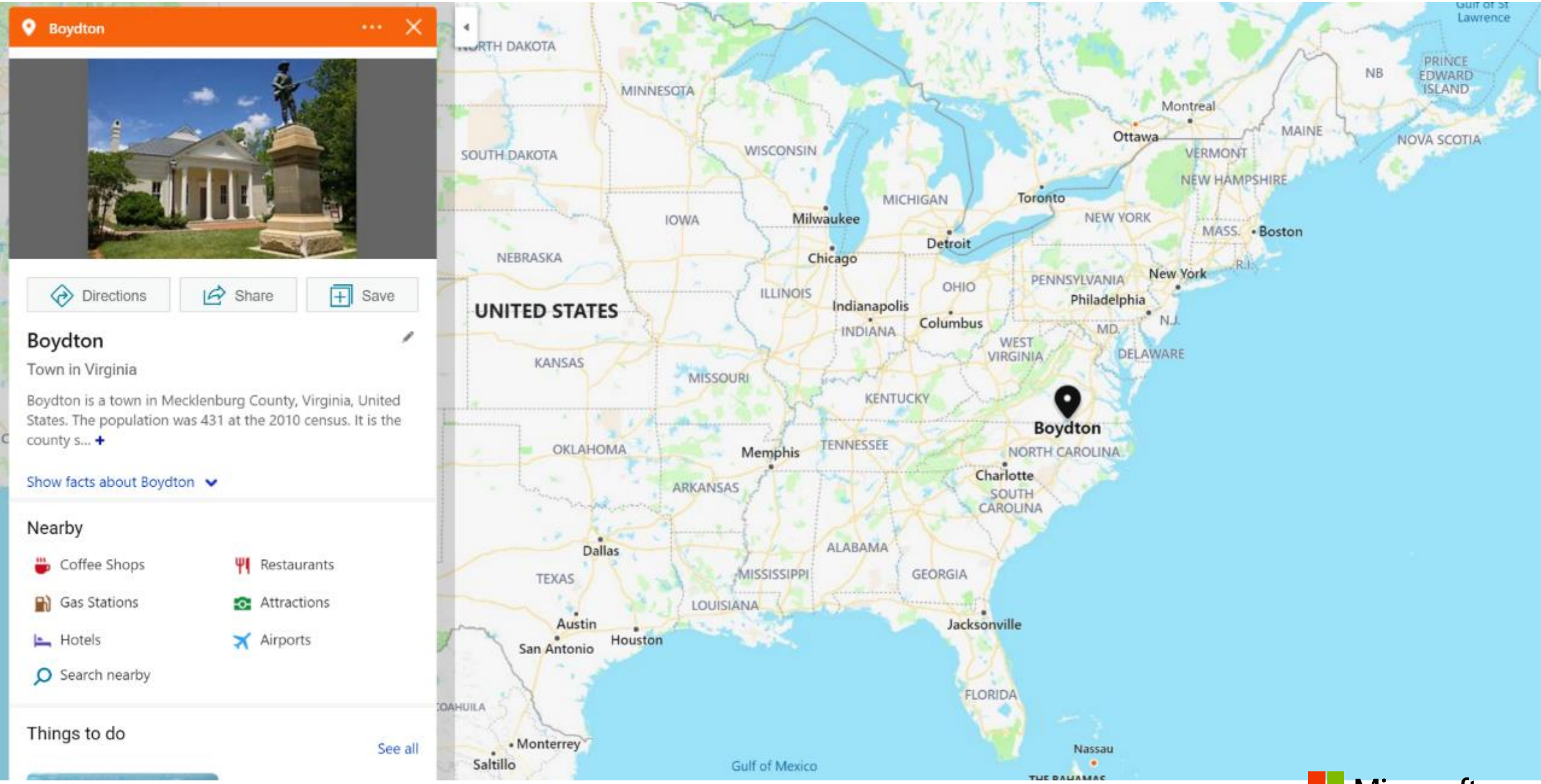

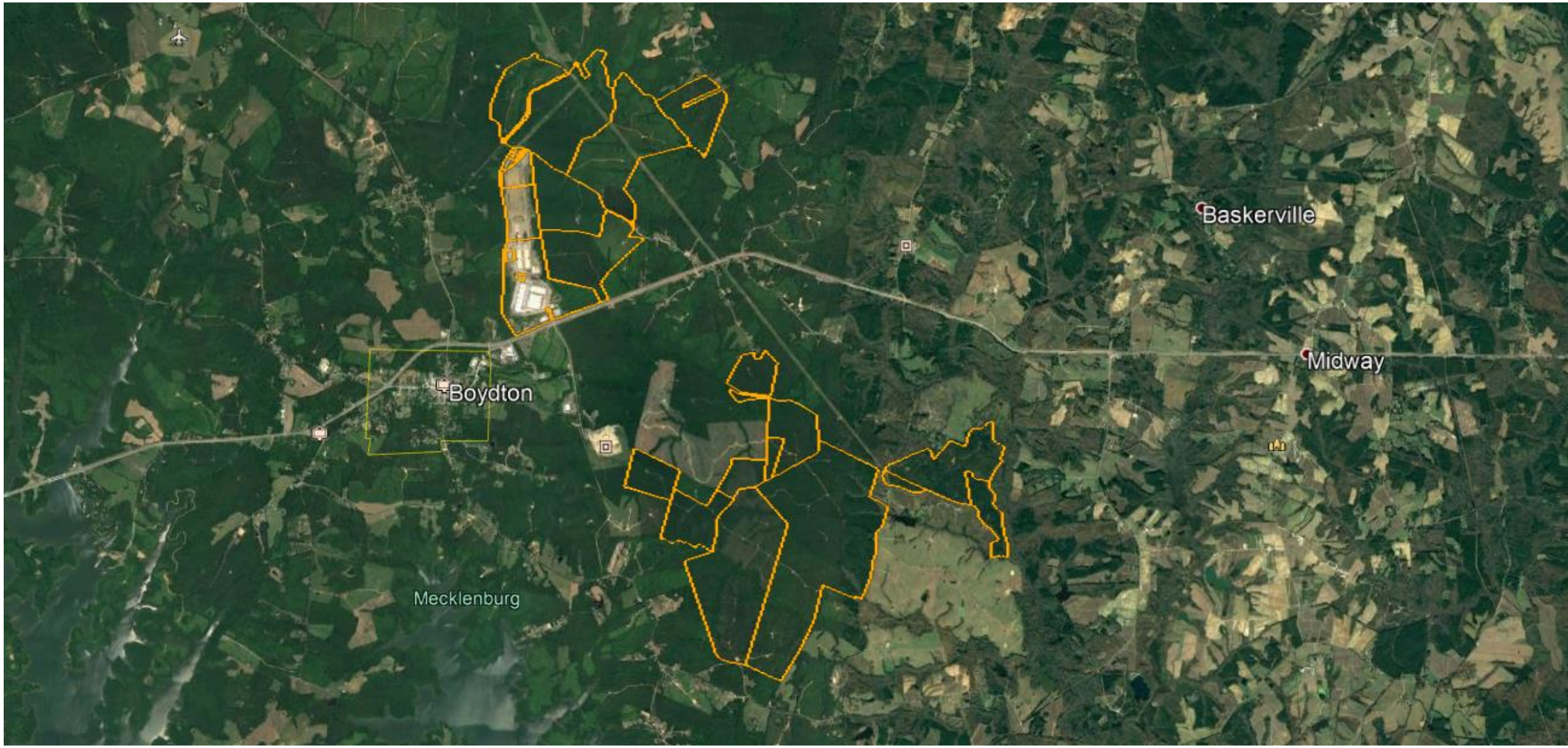

What is Hyperscale?

First Quarter
Fiscal Year 2020 Results

Satya Nadella
Amy Hood
Michael Spencer

October 23, 2019

Quarterly Commercial Highlights

Investor Metrics	FY19 Q1	FY19 Q2	FY19 Q3	FY19 Q4	FY20 Q1
Commercial bookings growth *(y/y)*	15% / 16%	18% / 22%	30% / 34%	22% / 25%	30% / 35%
Commercial remaining performance obligation *(in billions)*	$68	$69	$72	$87	$86
Commercial revenue annuity mix	90%	89%	90%	90%	91%
Commercial cloud revenue *(in billions)*	$8.5	$9.0	$9.6	$11.0	$11.6
Commercial cloud gross margin percentage	62%	62%	63%	65%	66%

Growth rates include non-GAAP CC growth (GAAP % / CC%).

Commercial business

Strong results driven by increased customer commitment to commercial cloud

- Commercial bookings growth of 30% year-over-year (up 35% CC) driven by strong new business and renewal execution
- Commercial remaining performance obligation $86 billion, up 26% (up 27% CC) year-over-year
- Commercial revenue annuity mix of 91%, up 1 point year-over-year

Commercial cloud

- Commercial cloud revenue $11.6 billion, up 36% (up 39% CC) year-over-year
- Commercial cloud gross margin percentage 66%, up 4 points year-over-year primarily driven by material improvement in Azure gross margin

Commercial cloud includes Office 365 Commercial, Azure, the commercial portion of LinkedIn, Dynamics 365, and other cloud properties.
Includes non-GAAP constant currency ("CC") growth. See Appendix for reconciliation of GAAP and non-GAAP measures. Growth rates in GAAP and CC are equivalent unless otherwise noted.

Microsoft

Quarterly Business Highlights

Productivity and Business Processes	• Office Commercial products and cloud services revenue grew 13% (up 15% CC) driven by Office 365 Commercial revenue growth of 25% (up 28% CC) • Office Consumer products and cloud services revenue grew 5% (up 6% CC) with continued growth in O365 Consumer subscribers to 35.6 million • LinkedIn revenue grew 25% (up 26% CC) • Dynamics products and cloud services revenue grew 14% (up 16% CC) driven by Dynamics 365 revenue growth of 41% (up 44% CC)
Intelligent Cloud	• Server products and cloud services revenue grew 30% (up 33% CC) driven by Azure revenue growth of 59% (up 63% CC) • Enterprise Services revenue grew 7% (up 8% CC)
More Personal Computing	• Windows OEM revenue grew 9% • Windows Commercial products and cloud services revenue grew 26% (up 29% CC) • Search advertising revenue excluding traffic acquisition costs grew 11% (up 13% CC) • Xbox content and services revenue was relatively unchanged (up 1% CC) • Surface revenue declined 4% (down 2% CC)

Includes non-GAAP constant currency ("CC") growth. See Appendix for reconciliation of GAAP and non-GAAP measures. Growth rates in GAAP and CC are equivalent unless otherwise noted.

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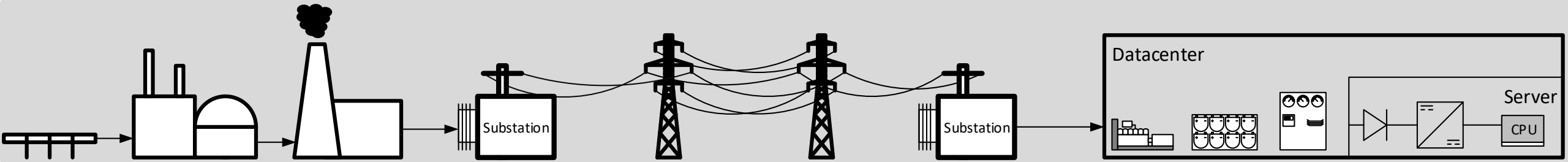
SOFC Fuel Cells for Primary Power

Traditional Datacenter Power Chain



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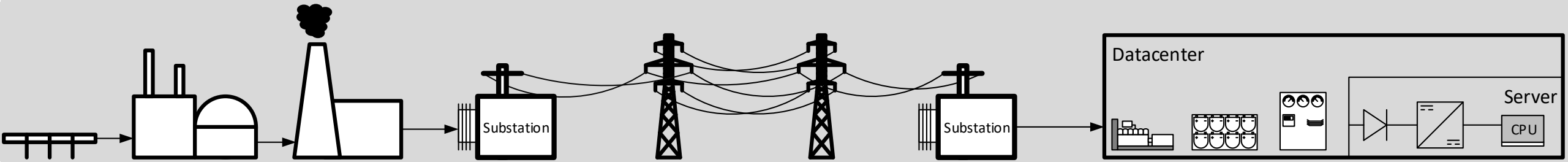
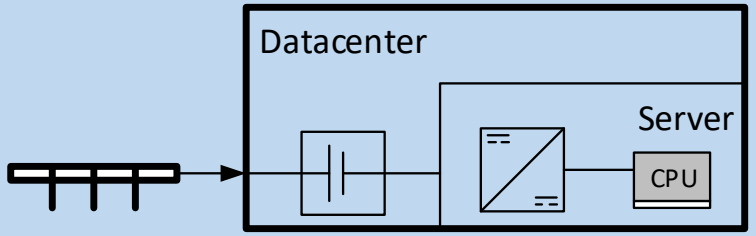
Stark and Simple

Traditional Datacenter Power Chain



Stark and Simple Datacenter

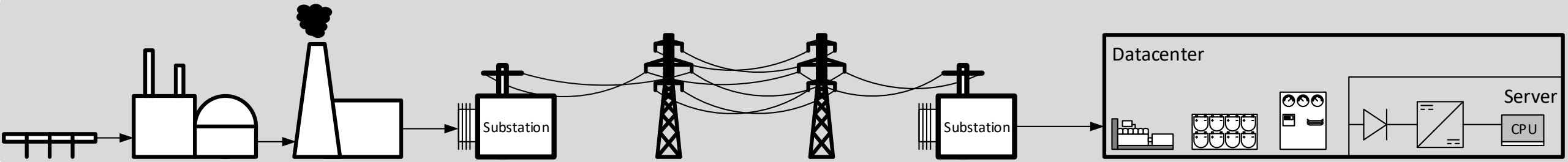


Less Infrastructure + Less Complexity = Reduced Cost & Risk

Microsoft

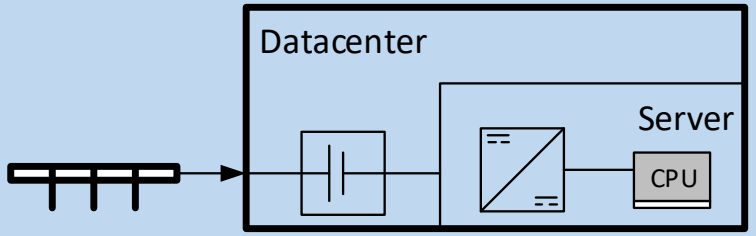
Stark and Simple

Traditional Datacenter Power Chain



100% -65-70% loss -7-10% loss -10-15% loss -5-10% loss

Stark and Simple Datacenter



100% -40-50% loss -5-10% loss

Less Infrastructure + Less Complexity = Reduced Cost & Risk

Microsoft

SOFC / Primary Power Applications

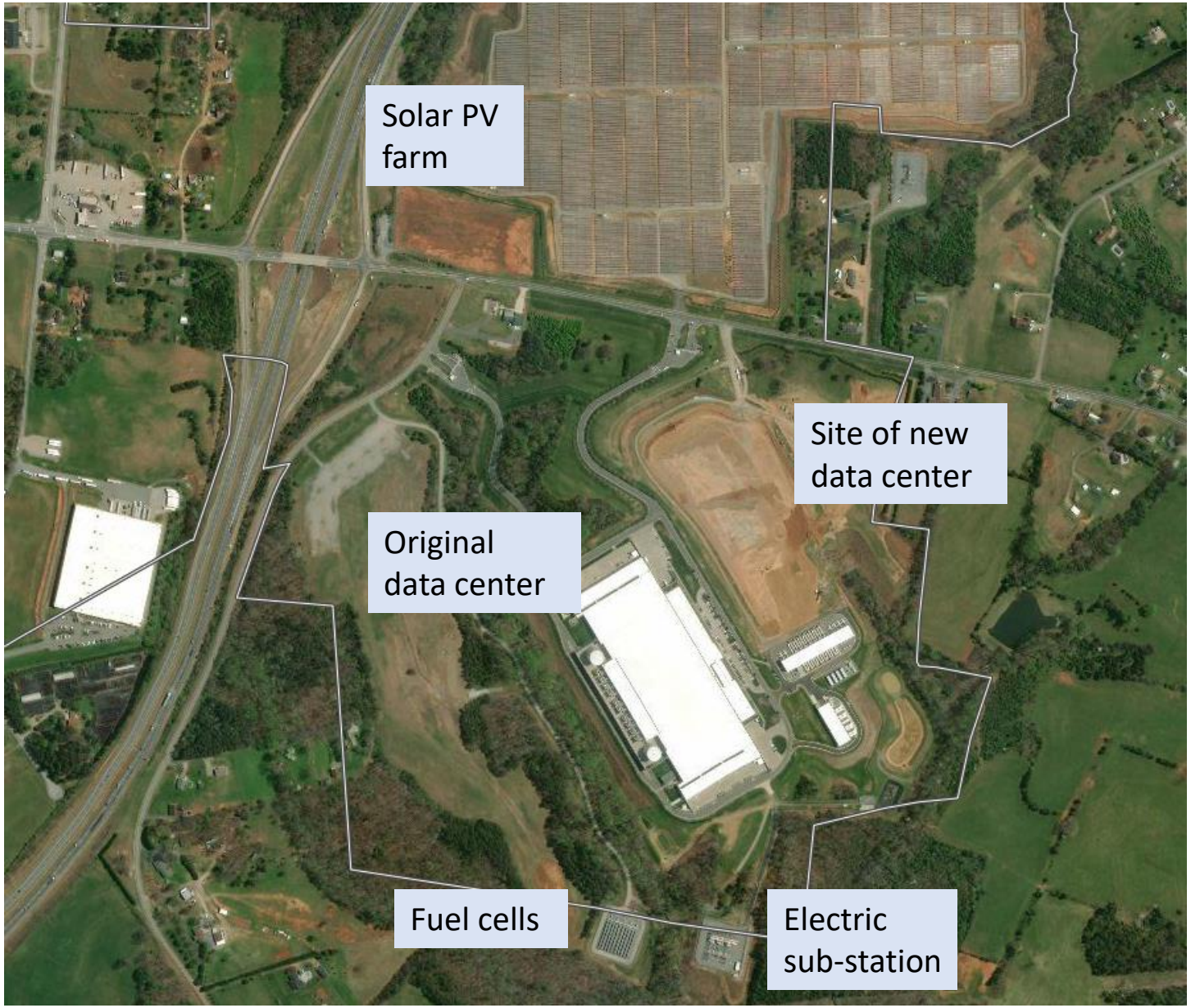
AT&T

- 7.5MW across 11 sites
- 2011 early adopter

Ebay Facility, South Jordan, Utah

Map data: Google, SIO, NOAA, U.S. Navy, NGA, GEBCO Landsat/Copernicus.

Apple Facility, Maiden, North Carolina



Microsoft product screen shot reprinted with permission from Microsoft Corporation.

PEM Fuel Cells for Backup Power

Strategic Problem

- Diesel generators enable our 5-9's datacenters
  - 99.999% available, ~ 5 min/year unscheduled downtime
- But diesels are noisy, polluting, air quality permitting difficult at 100MW+ scale
- Investigating several alternatives
- Current specification 12-48 hours on-site fuel storage

Fuel Cells for Backup Power

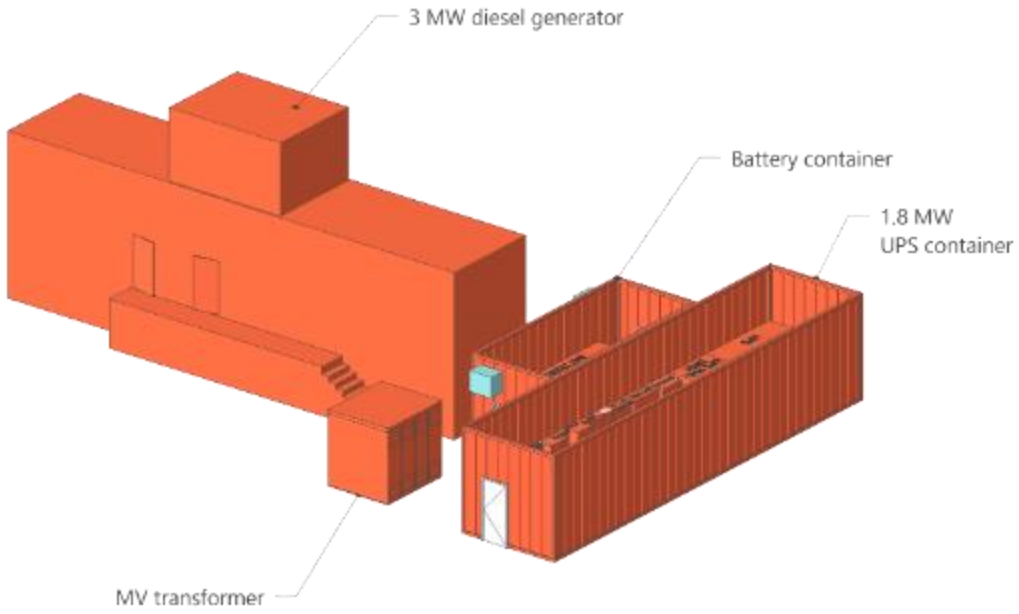
NREL-Daimler-HPE-Power Innovations Demonstration

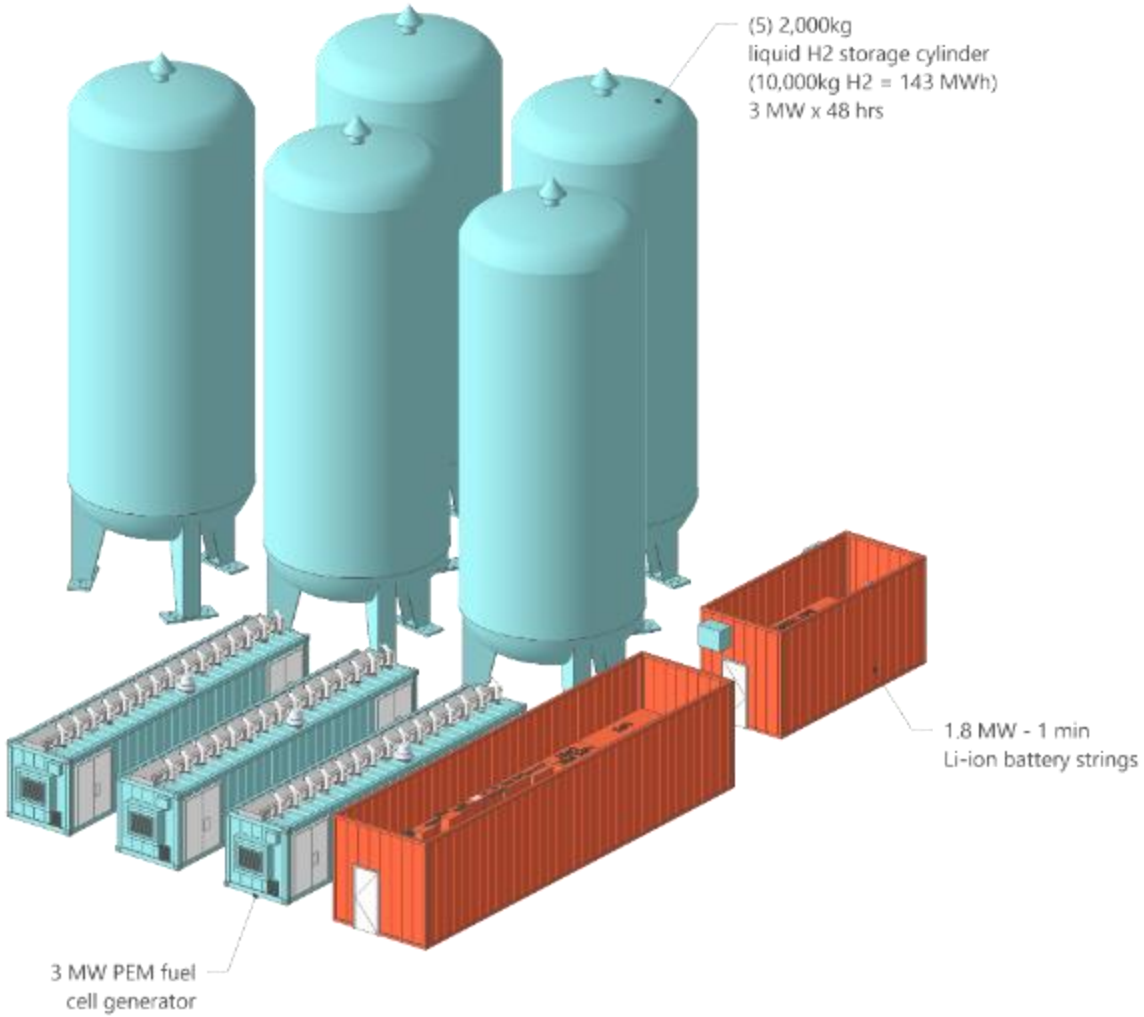
Photo credit: Daimler

- Daimler - 65kW H2 fuel cell
- HP - Cloudline computers
- Power Innovations - integrator

- Basic functional demo

Production Scale





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30 MW x 48 hours = 100,000kg H_2

Photo credit: NASA/Frankie Martin.

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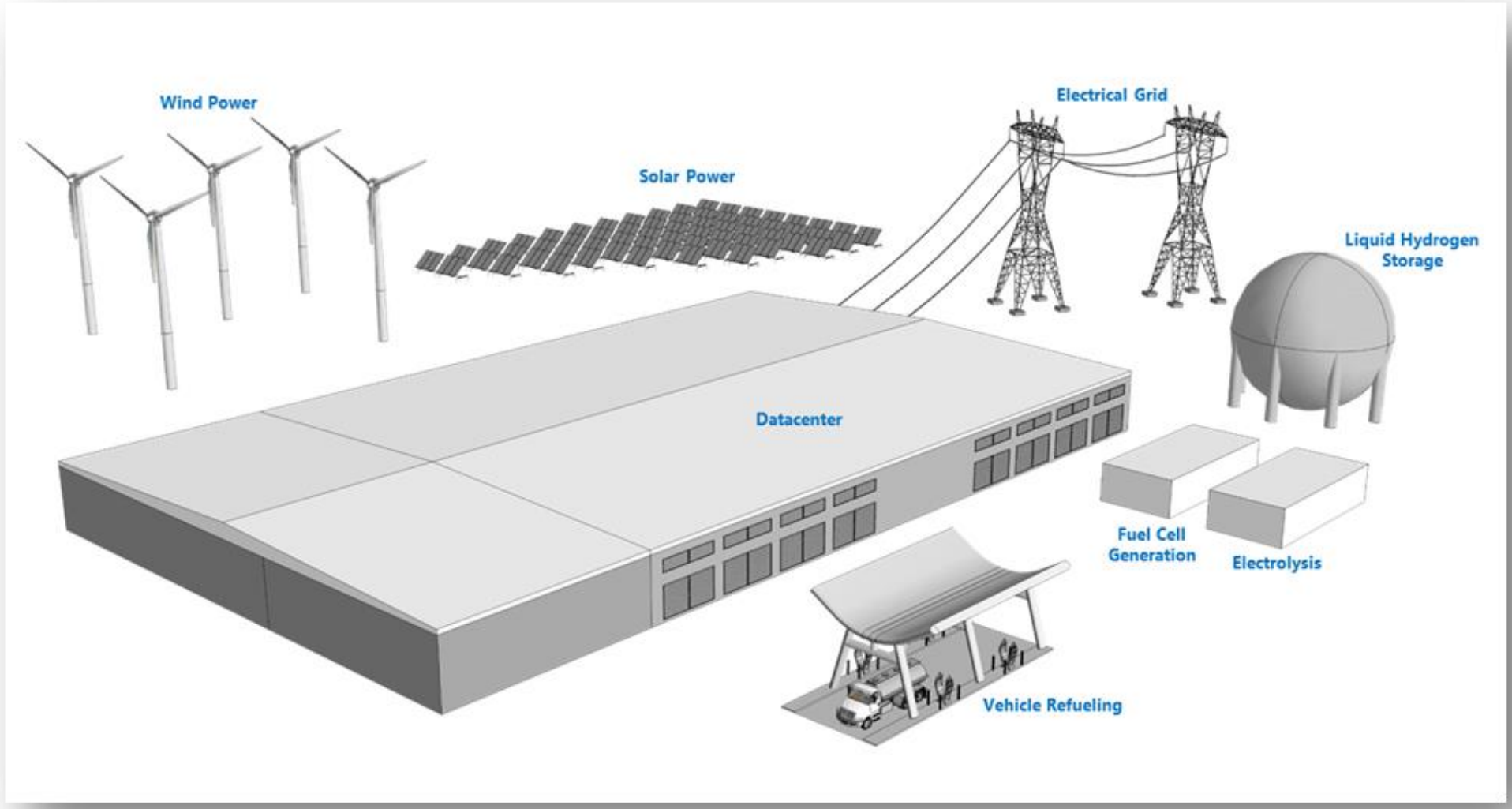
Integrated Hydrogen Economy



Microsoft

End of Presentation

Thank you

Mark Monroe, Principle Infrastructure Engineer
mark.monroe@microsoft.com