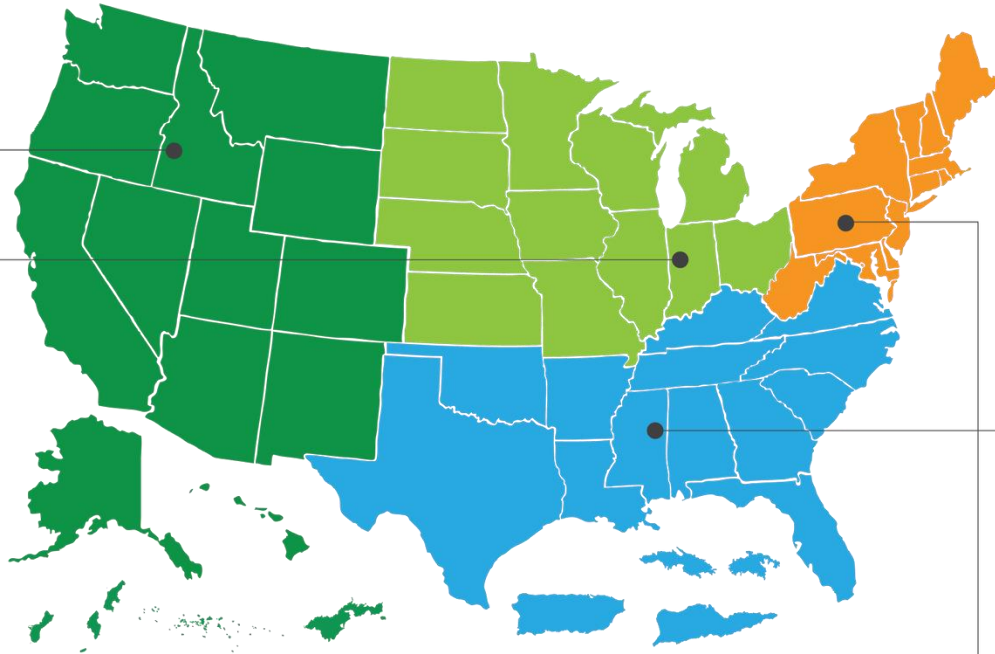




Data Centers: Assisting Communities in Understanding the Challenges and Opportunities

February 24, 2026



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Data Centers: Assisting Communities in Understanding the Challenges and Opportunities

Presenters

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Regional Center for Rural Development





The Data Center Puzzle: Understanding Current Land, Water, and Energy Claims

Tom Beresnyak & Jim Ladlee, Penn State Extension

February 24, 2026



PennState Extension



The Data Center Puzzle

AI Overview

Data Centers Defined

Water & Cooling

Energy & Environment

Community & Land Use

Note: Where trade names appear, no discrimination is intended, and no endorsement by Penn State Extension is implied.

The AI Genie is Already Out of the Bottle!



Navigating the Jagged Frontier: How AI Supercharges Consultant Performance

A study of 758 Boston Consulting Group (BCG) consultants revealed a “jagged technological frontier,” where AI-assisted consultants significantly outperformed peers in speed, volume, and quality, with impact varying by baseline skill.

The AI Productivity & Quality Surge

12.2% More
Tasks Completed



Consultants using GPT-4 successfully finished a higher volume of complex subtasks within allotted timeframes.

25.1%
Faster Completion



Professionals with AI access navigated knowledge-intensive workflows significantly more quickly than the control group.

40% Higher
Quality Results



Human graders rated AI-augmented work as significantly superior across creativity, analytical thinking, and persuasiveness.

43%

The Great Equalizer

17%
Increase

43%
Increase



Bottom-Half Skilled



Top-Half Skilled

Bridging the Skill Gap

While all participants benefited, AI provided the largest boost to those starting below the average performance threshold.

Why use AI?

AI Reality Check: Capabilities vs. Theory

REALITY TODAY

Narrow AI: The Only Existing Reality



Also called “Weak AI,” it excels at single tasks like Siri or ChatGPT but cannot function outside its training.

Narrow AI Types:



Reactive Machines

No memory
(e.g., Deep Blue).



Limited Memory

Uses past data
(e.g., self-driving cars).

THEORETICAL FUTURE

General and Super AI are Theoretical



These future concepts would match or surpass human intelligence, possessing emotions, needs, and self-awareness.



Data Centers Defined



PennState Extension



Hyperscale

- Extremely large facilities - usually a campus of multiple buildings
- Supporting global-scale cloud, AI, and data services
- Reference scale
 - 100,000+ sq ft
 - 100-1000+ acres
 - 100+ Megawatts
 - 10,000+ servers
 - 10,000-5,000,000+ gallons per day



Note: Definitions are provided as a rule-of-thumb. Actual project specifications may vary based on design, location, technology, and operational goals.

Cloud Data



- Large facilities
- National or regional cloud & enterprise services
- Reference scale
 - 50,000-200,000 sq ft
 - 10-40+ acres
 - 10-99 Megawatts
 - 1,000+ servers
 - 1,000+ gallons per day

Note: Definitions are provided as a rule-of-thumb. Actual project specifications may vary based on design, location, technology, and operational goals.

Enterprise or Regional Centers



- Serving specific organizations, institutions, or agencies
- Reference scale
 - 10,000-50,000 sq ft
 - 5-15+ acres
 - 1-10 Megawatts
 - 100s - 1,000+ servers
 - 100s - 1,000+ gallons per day

Note: Definitions are provided as a rule-of-thumb. Actual project specifications may vary based on design, location, technology, and operational goals.

Edge or Micro Data Centers

- Small, localized
- Designed for super low latency and real-time service
- Reference scale
 - <10,000 sq ft
 - <1 acre
 - <1 Megawatt
 - <100 server racks
 - Little to no water needs



Note: Definitions are provided as a rule-of-thumb. Actual project specifications may vary based on design, location, technology, and operational goals.

Cryptocurrency Mining Centers



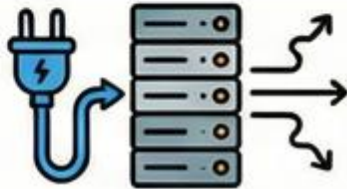
- Usually small and localized
- Dedicated to blockchain transaction validation only
- Typically use high-density Application-Specific Integrated Circuits (ASIC) or Graphics Processing Units (GPU) hardware
- Reference scale
 - Modular, containerized, or warehouse-based
 - <5 acres
 - 10-100 Megawatts
 - <100 Server racks
 - Little to no water needs

Note: Definitions are provided as a rule-of-thumb. Actual project specifications may vary based on design, location, technology, and operational goals.

Data Center Efficiency: The Three Pillars

The three primary metrics for evaluating holistic data center environmental impact.

PUE: Power Usage Effectiveness



Measures energy reaching IT equipment versus energy wasted on cooling; the ideal score is 1.0.



CUE: Carbon Usage Effectiveness



Measures greenhouse gas emissions relative to energy use; the ideal score is 0.0.



WUE: Water Usage Effectiveness



Measures water consumed for cooling per kilowatt-hour; the ideal score is 0.0.

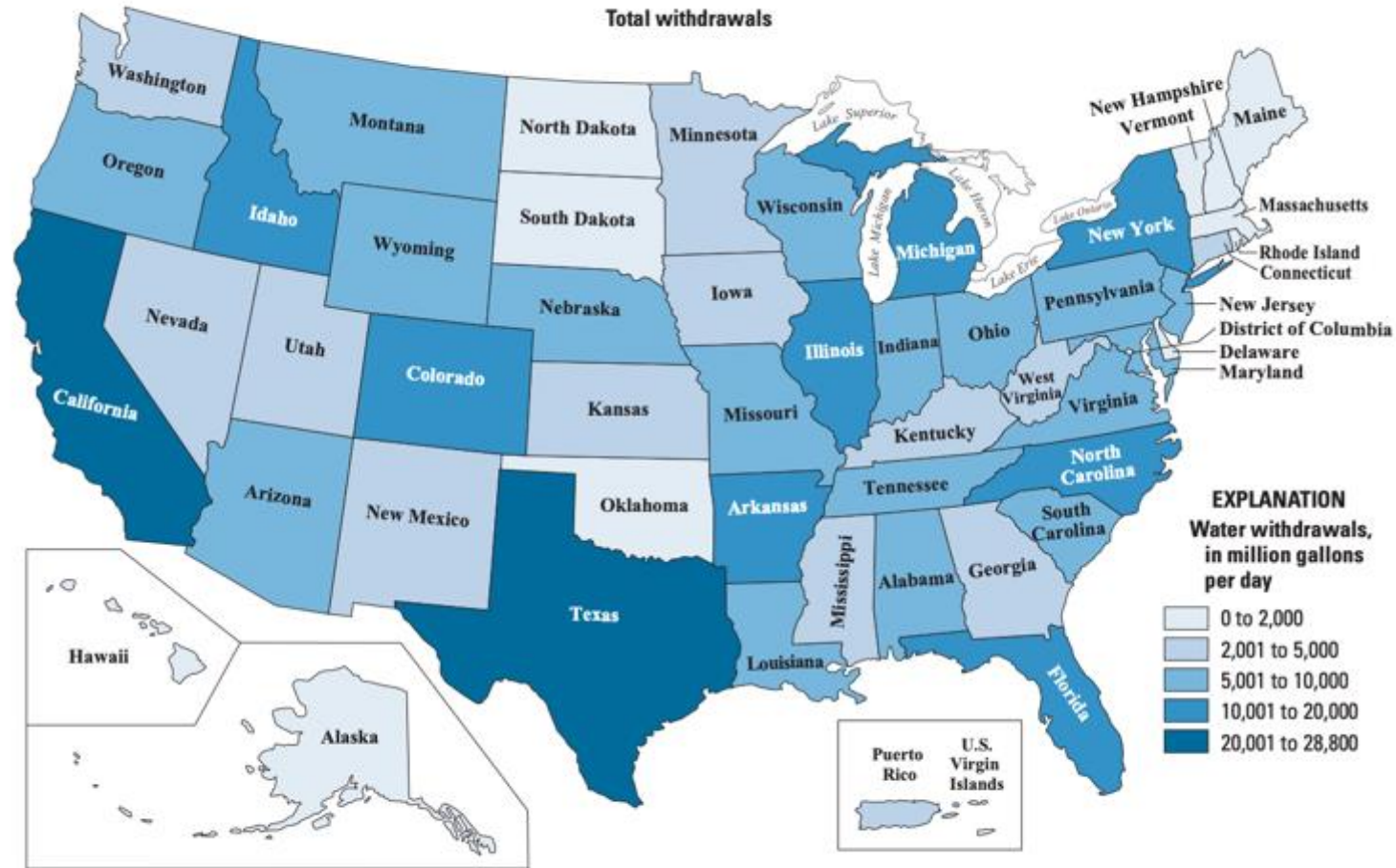




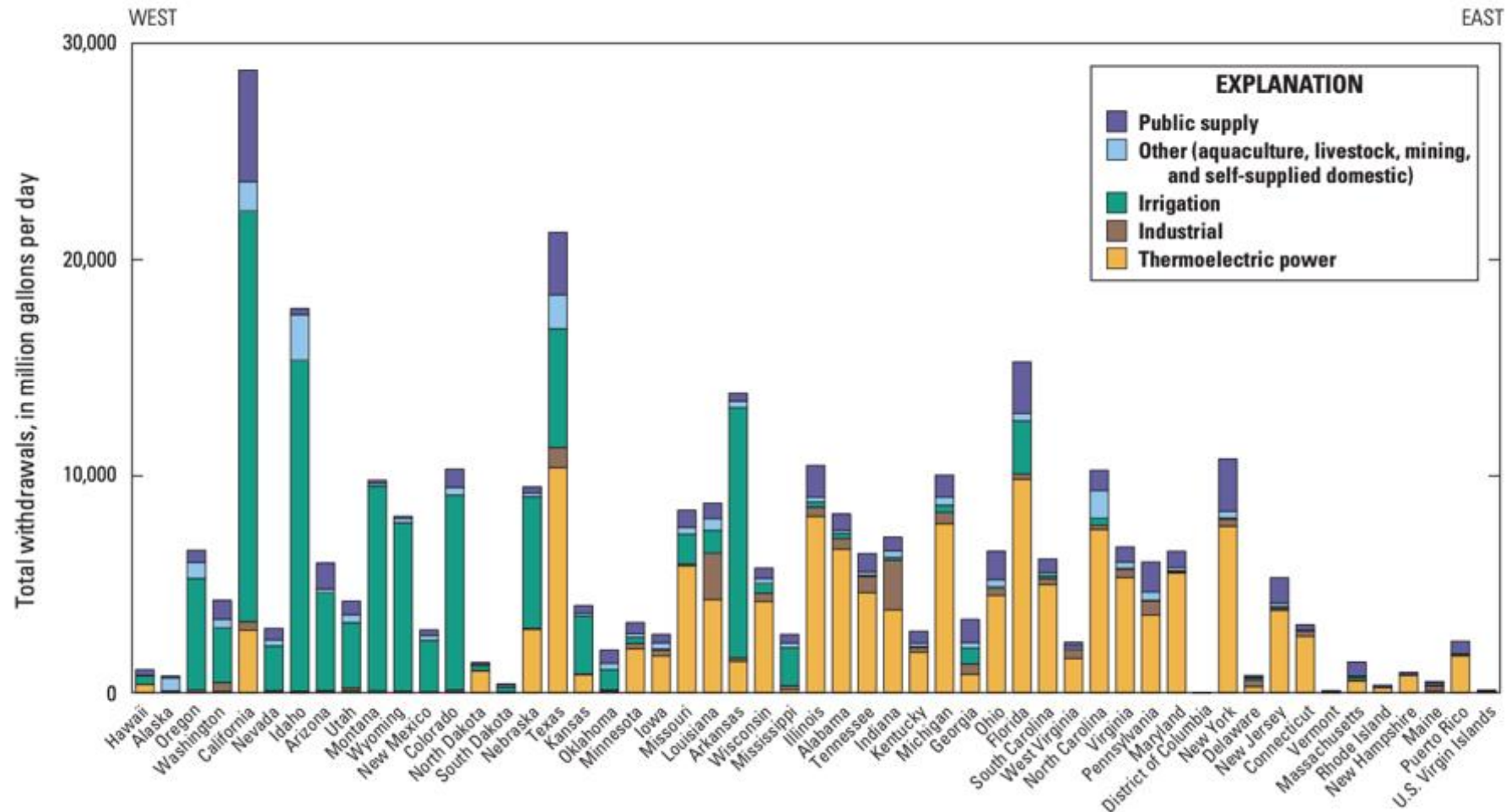
Water & Cooling

Total Water Withdrawals by State

(In million gallons per day)



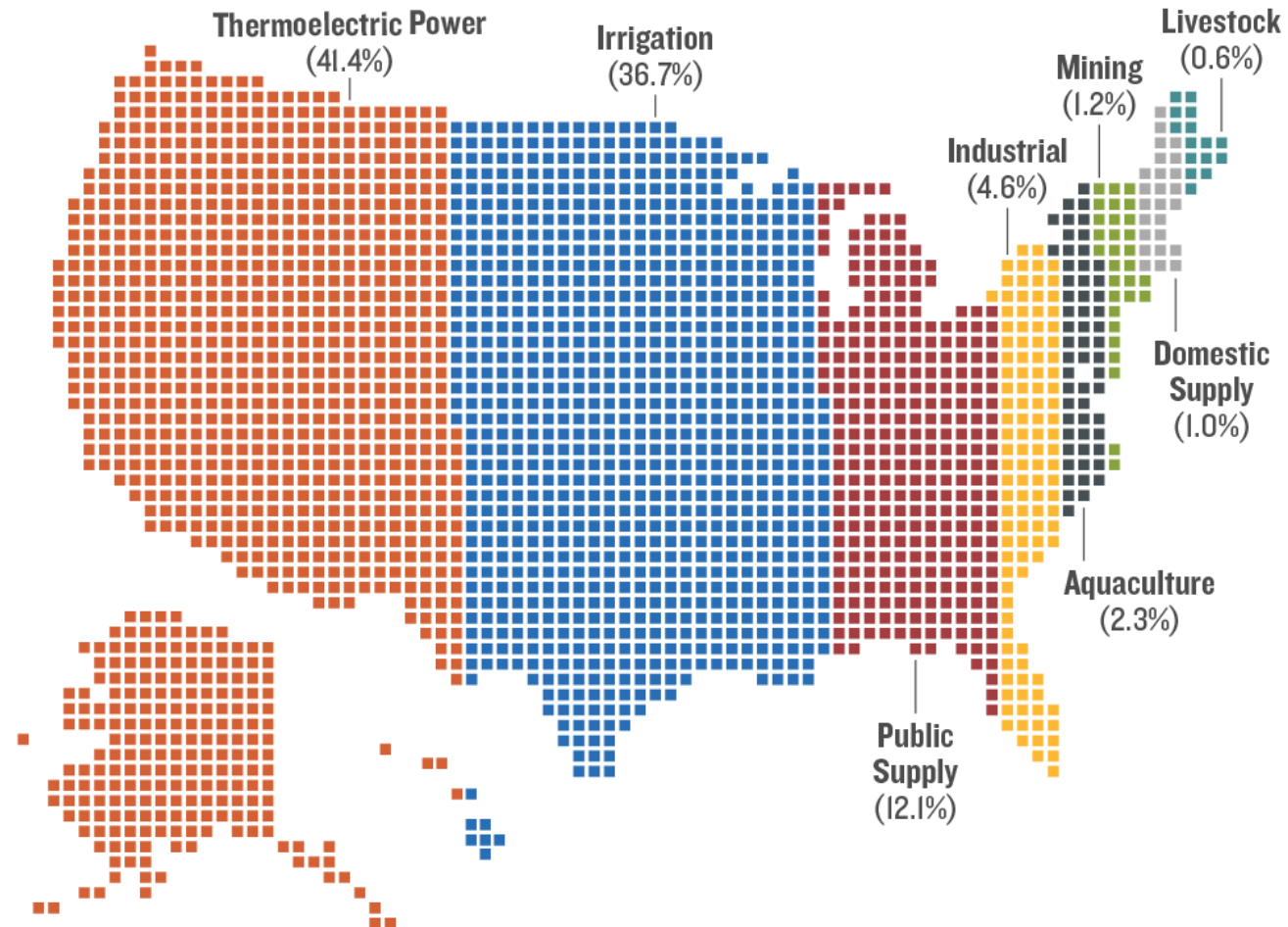
Water Use Categories by State (West-East)



How Water is Used in the US

U.S. WATER WITHDRAWALS IN 2015

How does America use its water?



Source: Dieter et al. (2018) Estimated Use of Water in the United States in 2015. USGS Circular 1441.

Data Center Cooling: The Big Trade-Off

Choose the right cooling method based on climate and resource availability.

Wet Cooling: Max Efficiency, High Waste



Uses evaporation to achieve the lowest temperatures but consumes millions of gallons of water daily.

Dry Cooling: Zero Water, High Energy



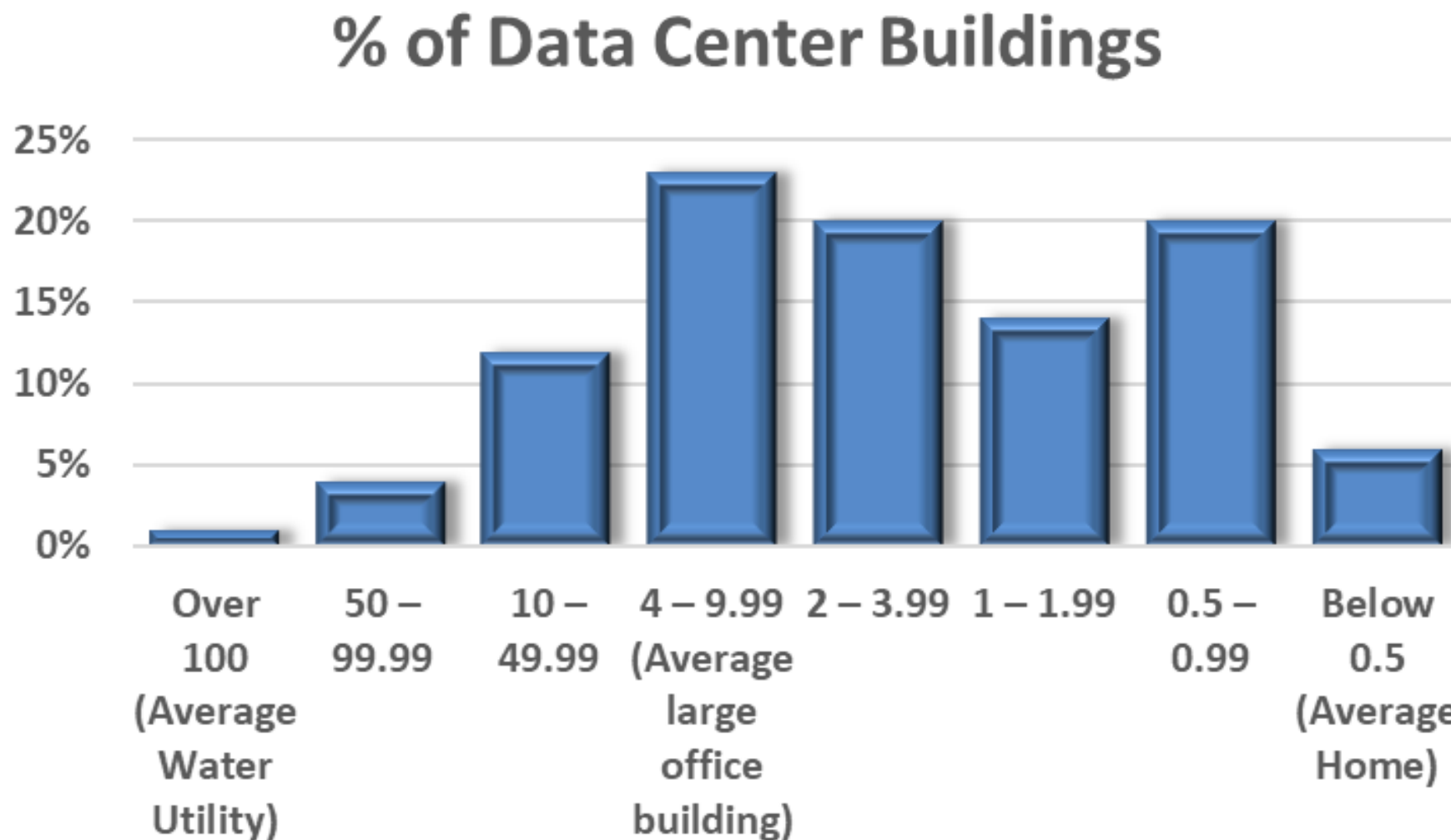
Operates like a car radiator with zero water loss, though energy costs spike during hot weather.

Adiabatic: The Sustainable Hybrid Choice



Uses 70–90% less water than wet systems by only using evaporation when outdoor temperatures peak.

Virginia Data Center Water Use



Source: [Data Centers in Virginia 2024](#)

Penn State Extension Water Team

Table 1. Direct water use by several large Google data centers near Pennsylvania

Data Center Name & Location*	Year 2024 Water Withdrawal (gallons per year)	Year 2024 Water Consumed (gallons per year)	Year 2024 Water Discharged (gallons per year)
Ashburn, VA	59,500,000	56,000,000	3,500,000
Bristow, VA	105,700,000	84,400,000	21,300,000
Sterling, VA	201,200,000	158,200,000	43,000,000
New Albany, OH	405,300,000	352,700,000	52,600,000

*Google does not release size data for all its DCs but does reveal their facility in New Albany, Ohio is 275,000 square feet.

Source: [Data Centers and Water Use in Pennsylvania](#)

The Hidden Thirst of AI: Data Centers and the Global Water Crisis

Data centers consume billions of gallons of water annually for cooling and manufacturing, a demand currently surging due to AI processing. While traditional cooling methods strain local freshwater supplies, innovative liquid cooling and renewable energy transitions offer a path toward significantly reducing this 'water footprint'.

THE HIGH COST OF DIGITAL CONNECTIVITY



1
**AI Prompt =
1 Bottle of Water**

A single 100-word AI prompt consumes roughly 519 milliliters of freshwater.

Large Centers Drink Like Small Towns

One large data center uses up to 5 million gallons of water daily.



Entity	Daily Water Consumption
Large Date Center	5,000,000 Gallons
Town (10,000-50,000 people)	5,000,000 Gallons
US Data Centers (Total 2021)	449,000,000 Gallons

SUSTAINABLE COOLING & ENERGY SOLUTIONS



Targeting a "Zero" WUE Score

Water Usage Effectiveness (WUE) measures liters consumed per kilowatt-hour of energy used.



Advanced Liquid Cooling



Immersion cooling and closed-loop systems can reduce freshwater use by up to 70%.



The Renewable Energy Advantage

Wind and solar power require zero cooling water compared to water-intensive coal.

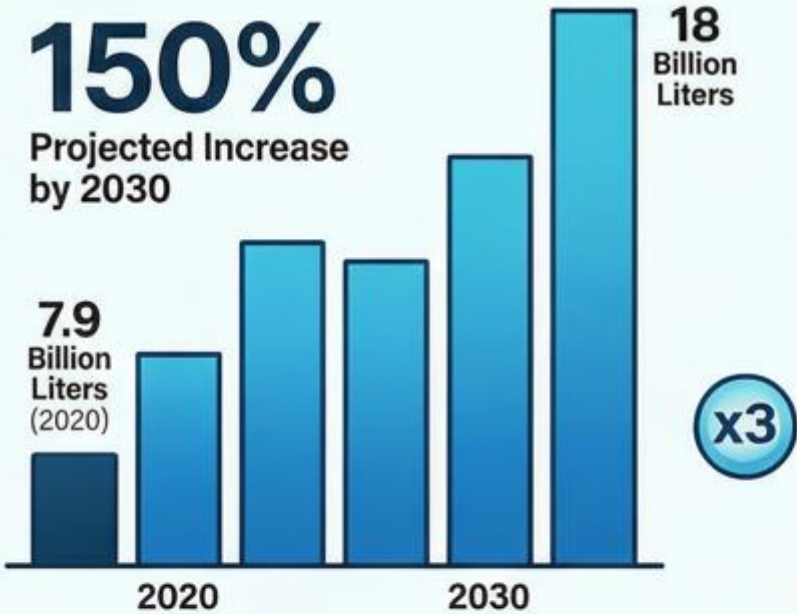


THE INVISIBLE INDIRECT FOOTPRINT

Fossil fuel power plants consume massive water volumes to generate data center electricity.

The AI Thirst: Microsoft's Data Center Water Dilemma

THE AI SURGE: DATA CENTERS UNDER PRESSURE



The Power-Water "Multiplier Effect"

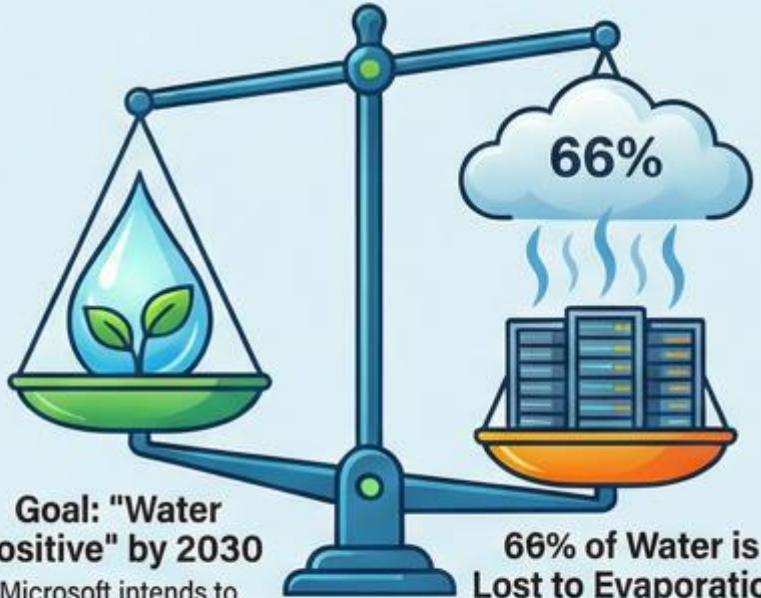
Water used by power plants to generate electricity could triple a data center's footprint

Regional Impact: Strain on Water-Stressed Areas

Location	Current/Recent Estimate	2030 Projected Use
 Phoenix, AZ	2.9 Billion Liters (2024)	2.0 Billion Liters
 Jakarta, Indonesia	380 Million Liters (2024)	664 Million Liters
 Pune, India	1.0 Billion Liters (2028)	237 Million Liters*

*Note: Microsoft recently revised several forecasts downward but declined to state why.

THE PLEDGE VS. THE RESOURCE REALITY



QUOTE

"Water Took a Back Seat"

Internal reports suggest energy and cost were prioritized over water conservation during the AI race

<https://www.nytimes.com/2026/01/27/technology/microsoft-water-ai-data-centers.html>

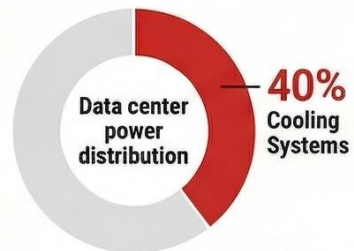
The Cooling Revolution: Powering the AI Infrastructure Era

THE AI THERMAL CHALLENGE

AI Queries Use 10x More Power

Each AI query consumes 2.9 Wh compared to traditional search engine requests.

Cooling Consumes 40% of Energy



Cooling systems represent the **largest non-IT power burden** in modern data centers.

\$584 Billion Market Projection

The global data center market is expected to nearly triple by 2032.

NEXT-GEN COOLING SOLUTIONS

22% Reduction in Power Use

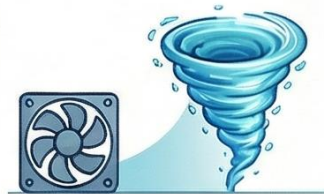
Integrating AI-driven predictive control dynamically optimizes airflow and cooling equipment speeds.

94% Heat Capture Ratio

Direct-to-chip liquid cooling achieves superior efficiency by placing cold plates on processors.

1,000x Better Heat Transfer

Immersion cooling offers significantly higher thermal conductivity than traditional air-based methods.



Ineffective Air Fan

Immersion Cooling

Comparison: Energy Performance & Heat Management

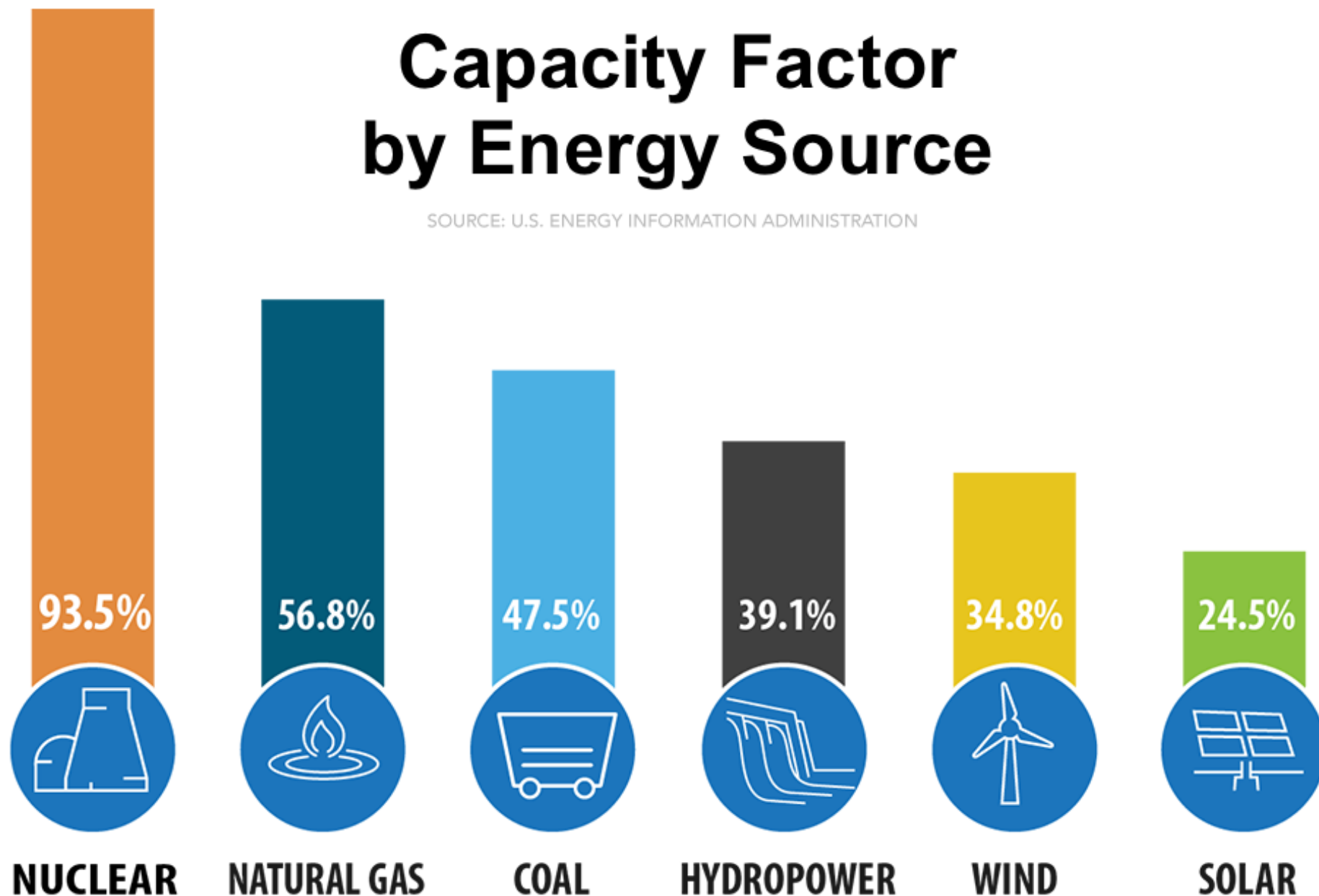
Cooling Method	Heat Transfer Potential	Typical PUE
Performance Comparison		
Traditional Air (CRAC)	Baseline	1.35 - 1.50
Cold Plate (DLC)	High	~1.15
Immersion Cooling	Up to 1,000x Air	< 1.10



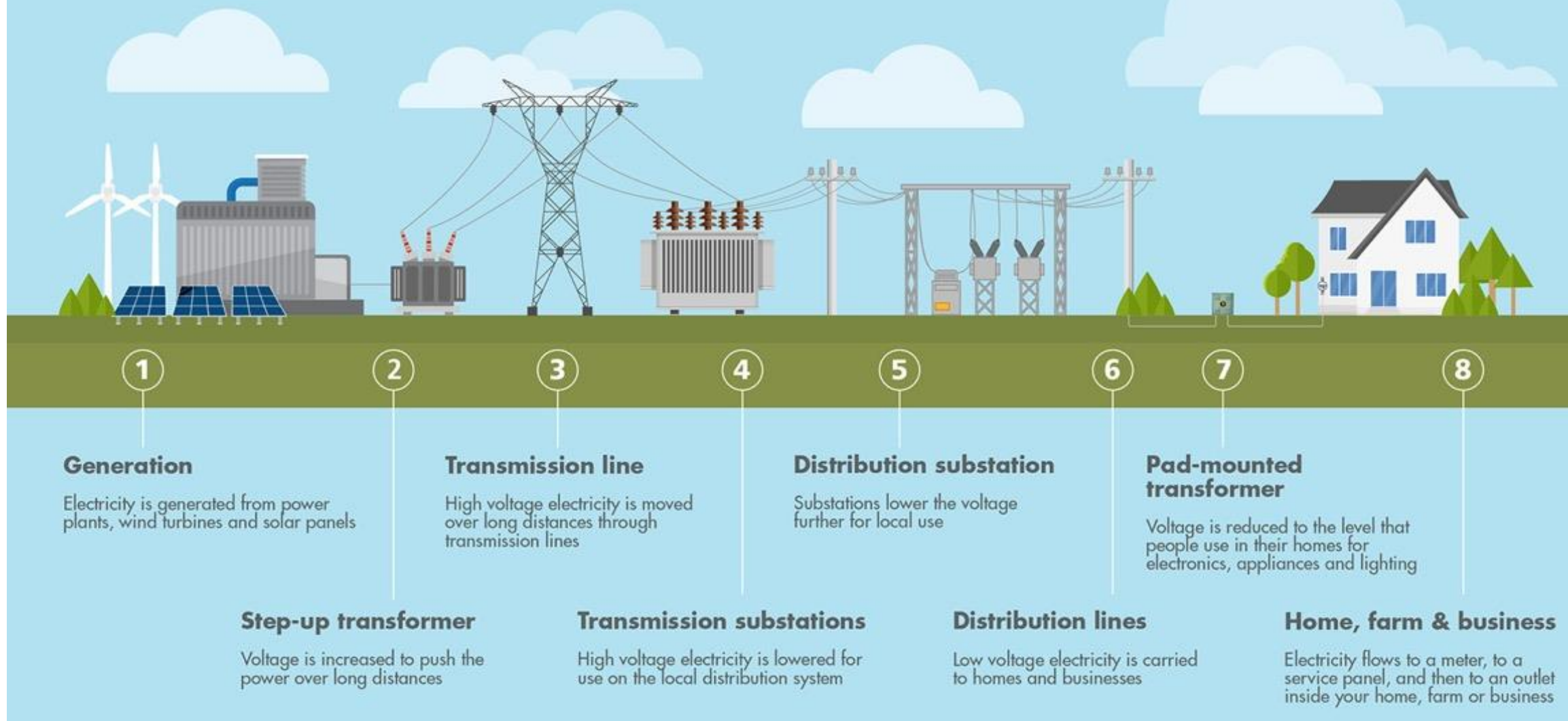
Energy

Capacity Factor by Energy Source

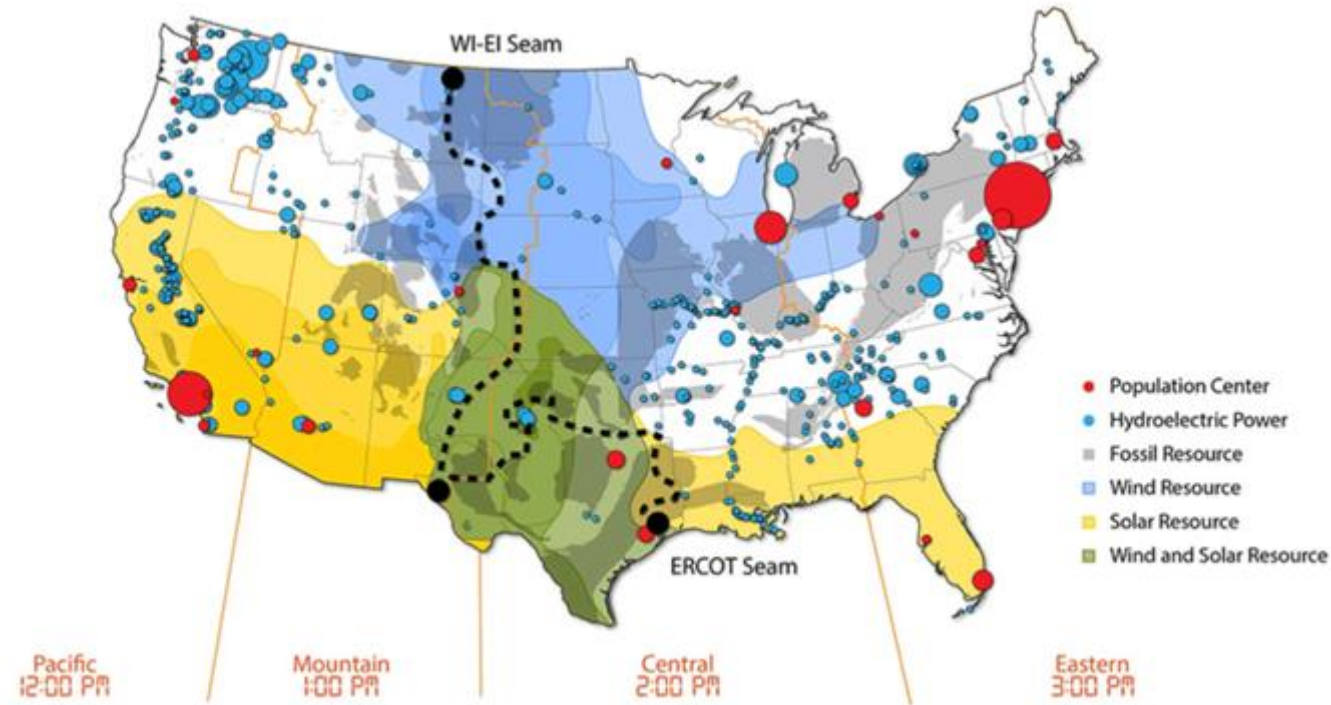
SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION



How electricity gets to you



Interconnections Seam Study



Electric Transmission Challenges

Transmission not aligned with renewable potential

Details:

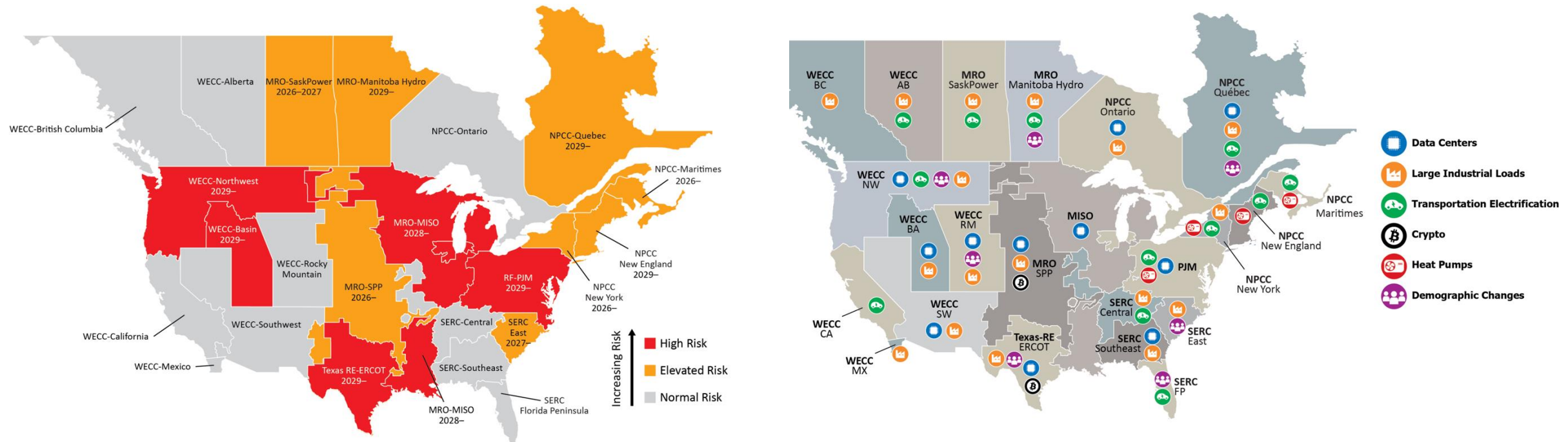
- Wind and solar often in remote areas (e.g., Great Plains, Southwest)
- Aging grid infrastructure limits capacity
- High costs and regulatory hurdles

Impact:

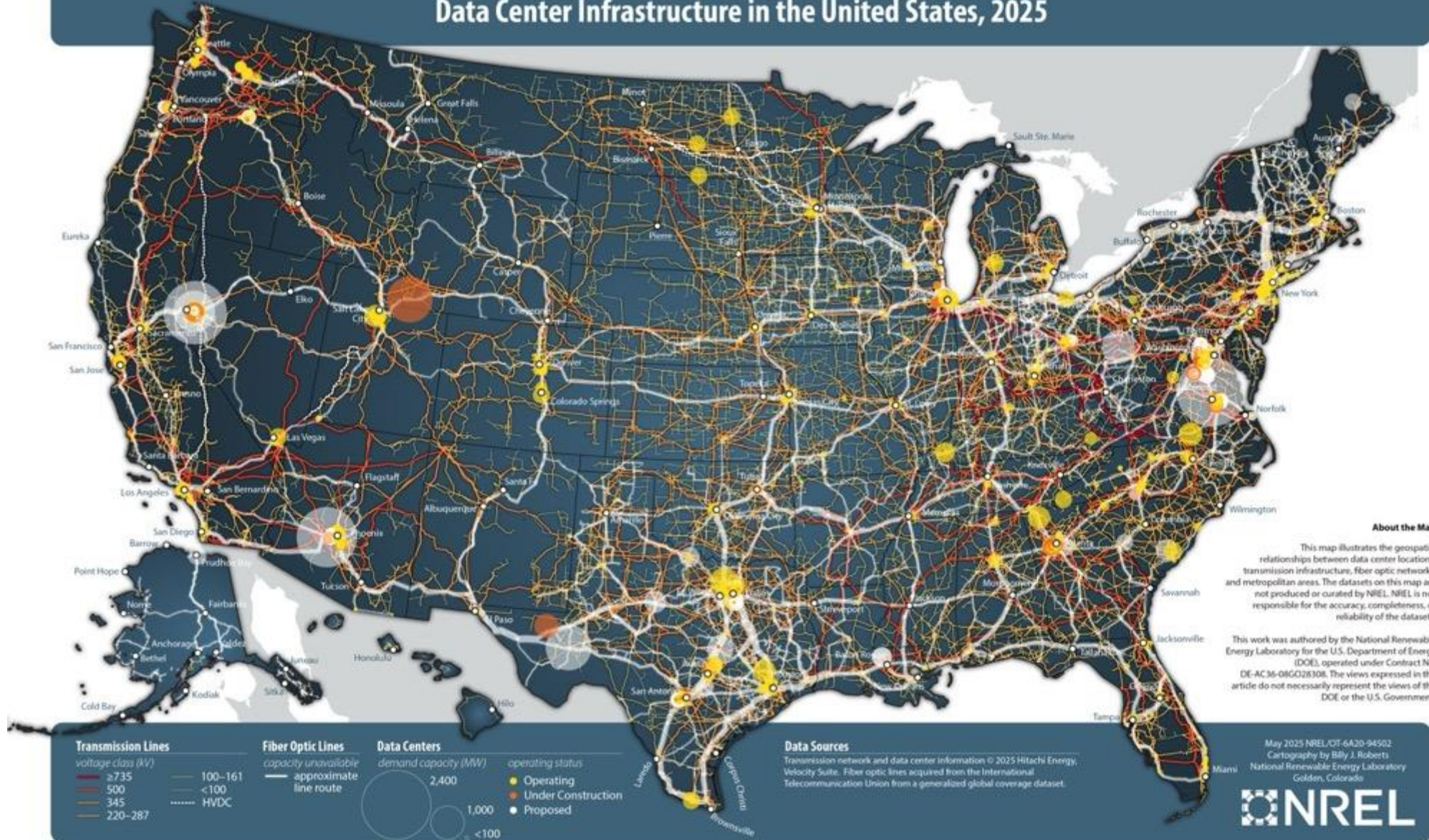
- Bottlenecks prevent renewable energy from reaching urban demand centers

North American Electric Reliability Corporation

Long-Term Reliability Assessment – January 2026

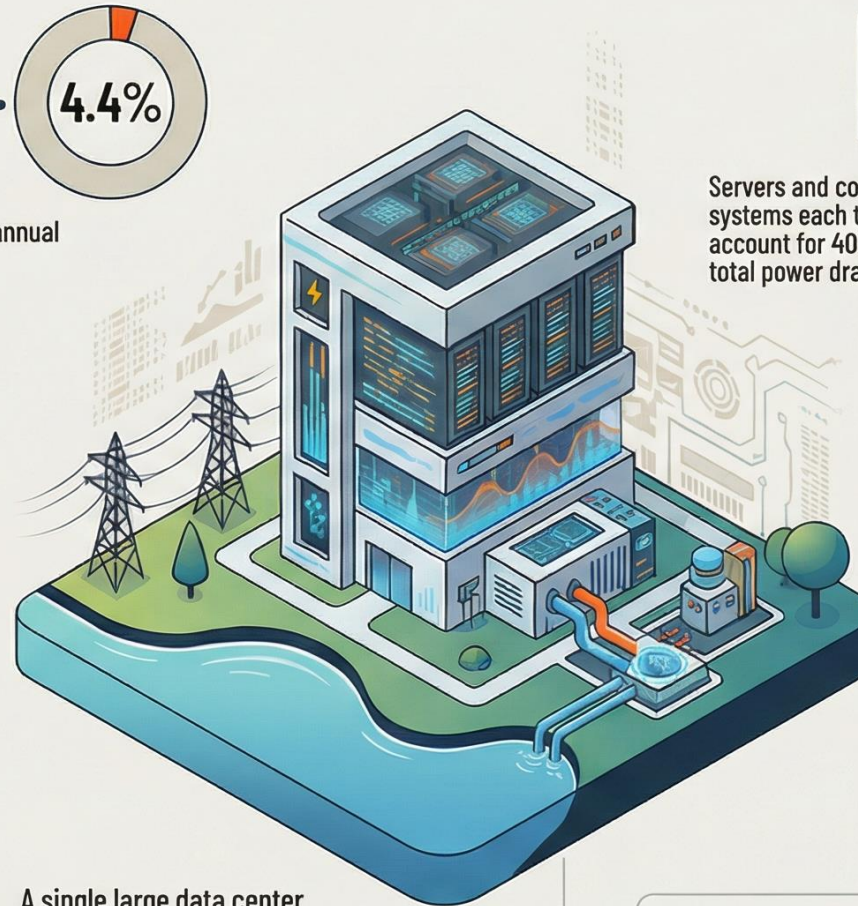
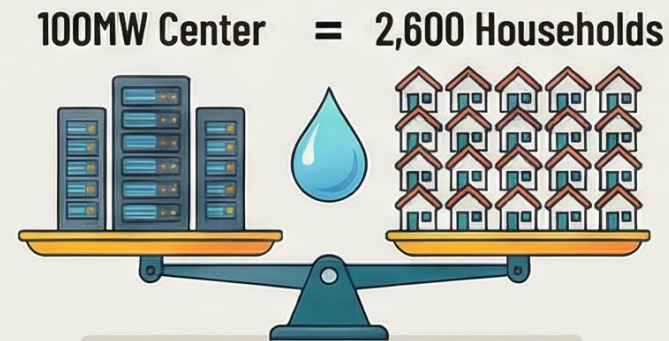
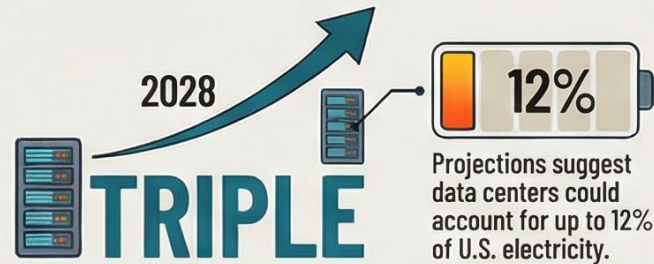
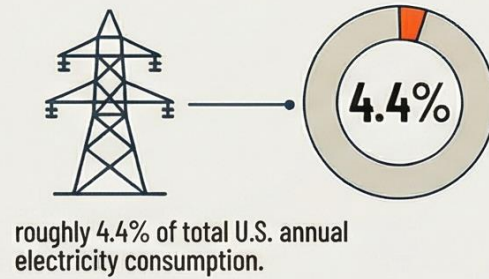


Data Center Infrastructure in the United States, 2025



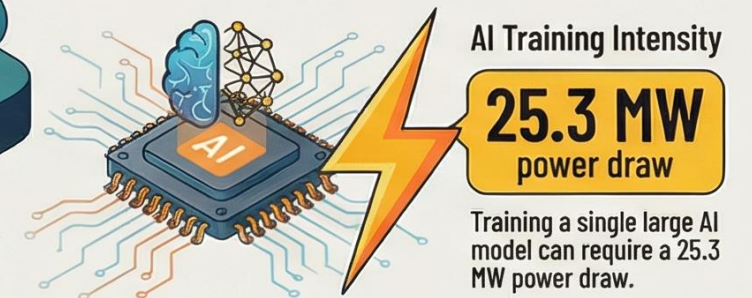
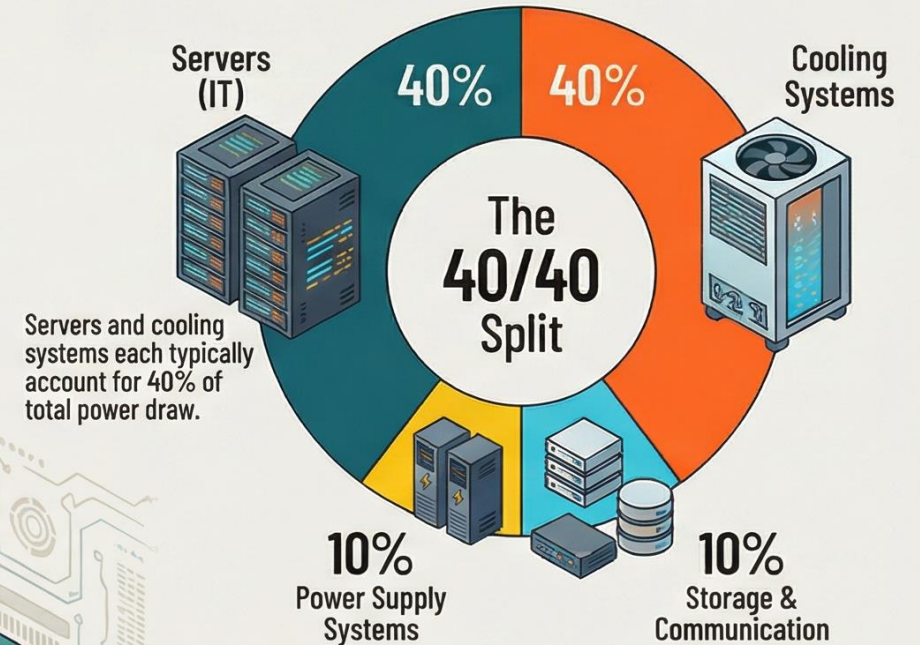
The Rising Resource Footprint of U.S. Data Centers

GROWING ENERGY AND WATER DEMANDS



A single large data center can consume as much water as 2,600 homes.

WHERE THE POWER GOES



$$\text{PUE} = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

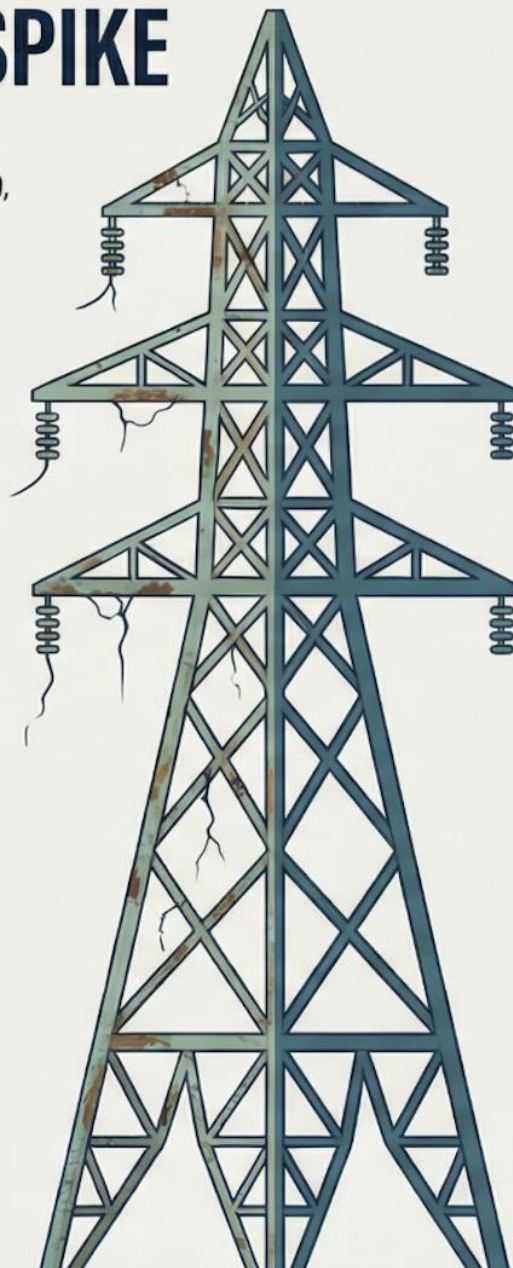
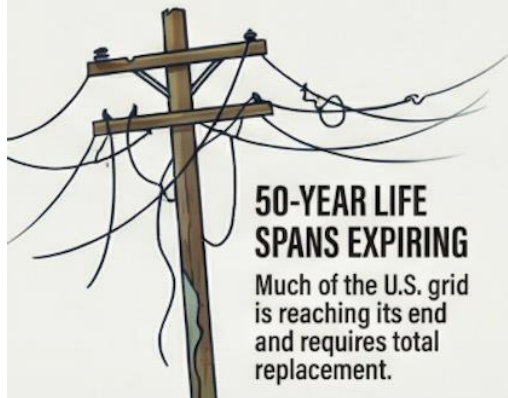
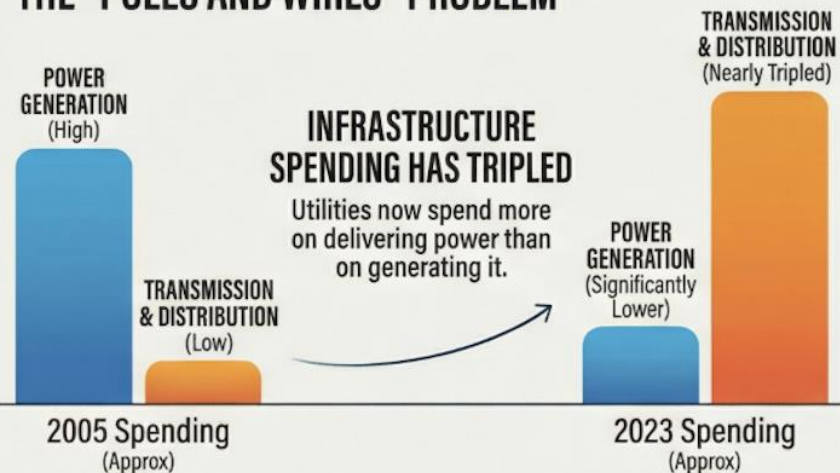
Power Usage Effectiveness (PUE)
The ratio of total facility power to the power used specifically by IT equipment.

THE SPARK BEHIND THE SPIKE

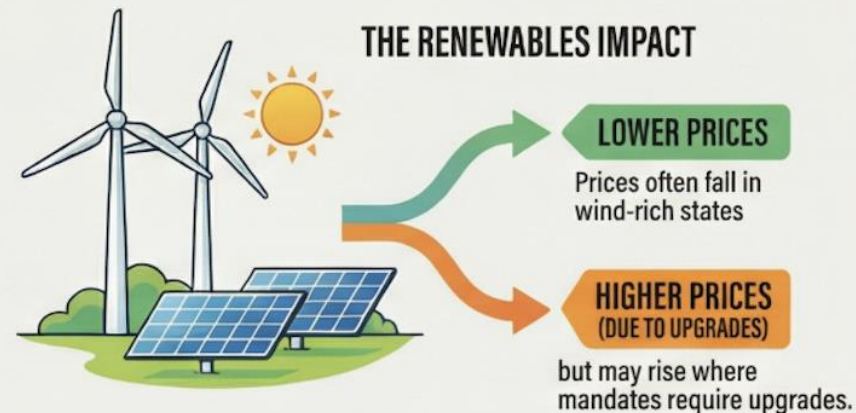
Why U.S. Electricity Prices are Rising

While electricity prices have risen faster than inflation in 28 states since 2019, the primary driver nationwide is no longer the cost of fuel, but the massive investment required to modernize and harden the aging electrical grid.

THE "POLES AND WIRES" PROBLEM



REGIONAL PRICE DRIVERS



NATURAL GAS VULNERABILITY

The Northeast faces higher spikes due to a heavy reliance on imported gas.



THE DATA CENTER BOTTLENECK



Powering Big Tech at Public Expense: How Data Centers Shift Costs to You

THE PROBLEM: How Costs Are Shifted to the Public



Discounted Rates

Opaque "Special Contracts"
Hide Subsidies



Big Tech



Utilities



Residential Ratepayers

Utilities often use confidential, non-public contracts to offer Big Tech discounted rates that are later recovered by raising prices for captive residential ratepayers.

Unprecedented Surge in Power Demand



Data centers may consume 13% of all U.S. electricity by 2030, forcing massive, expensive system expansions that utilities profit from.

Data Center Consumption

Transmission Costs Socialized to Residents

Infrastructure built specifically for data centers is often billed to residential users through regional cost-sharing formulas designed for broad public benefits.

Residential Share of Transmission Costs & Driver



THE SOLUTION: Strategies to Protect Ratepayers



Transition from Secret Deals to Standard Tariffs

Regulators should require data centers to take service under public, standardized tariffs rather than one-off negotiated special contracts.

Promote Independent "Energy Parks"

Allow data centers to power themselves off-the-grid or through competitive suppliers to completely insulate the public from their infrastructure costs.



Mandate Operational Flexibility

Condition utility service on data centers reducing consumption during peak demand hours to avoid building unnecessary, expensive power plants.

HOW TO BUILD A GREENER DATA CENTER: A SIMPLE GUIDE

SMARTER ENERGY & AIR USE

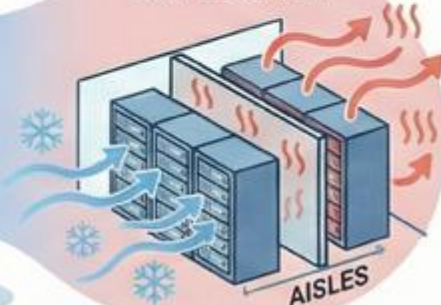
Use ENERGY STAR Equipment



Equipment

Choosing ENERGY STAR servers can make a computer room 30% more energy efficient.

Separate Hot and Cold Air



Separate Hot and Cold Air

Using 'aisles' to keep hot exhaust away from cool intake air prevents overheating.

SAVING WATER & USING CLEAN POWER



Recycle Waste Heat

The hot air from computers can be used to heat nearby office buildings.

Switch to Dry Cooling



WATER-BASED SYSTEM

DRY COOLER

Using 'dry coolers' instead of water-based systems helps save thousands of gallons of water.



Raise the Temperature

Keeping the room slightly warmer saves huge amounts of energy on air conditioning.

MEASURING SUCCESS: GREEN SCORECARD

SCORE NAME	WHAT IT TRACKS	A "GOOD" SCORE
 PUE	Electricity Waste	1.4 or lower
 WUE	Water Usage	Lower is better
 CUE	Carbon Pollution	0 (Goal)



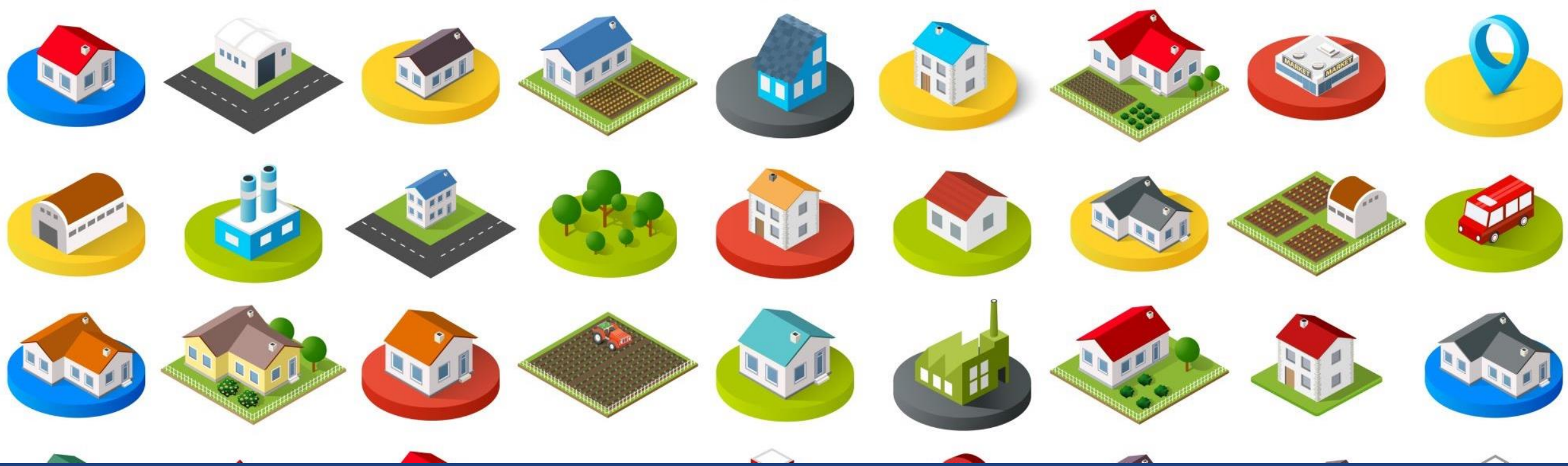
Move to 100% Clean Energy

Data centers should aim to use wind and solar power for all their needs.

Estimated Energy Comparison

	Electricity Consumption (Wh) Est		Compared to Google Search	
Query Type	Low	High	Low	High
Google Search	0.3	NA		
AI Text Response	2.9	NA	~10x	
AI Image Generation	15	NA	~50x	
1-Second AI Video Generation	Let's not overlook a discussion about the energy consumption range for video & image production <u>without</u> AI?			
480p (basic)				
1080p (HD)				
4K (high-end)				
	25	50	~83x	~167x
	100	200	~333x	~667x

Note: Estimates are based on the best available triangulated data at this time; however, consistently reliable sources are scarce, and estimates will change!



Community & Land Use

Community & Land Use Considerations

1. Power Requirements
2. Water Needs
3. Broadband Infrastructure
4. Land Availability
5. Workforce by Project Phase



Jobs

- All Jobs Depend on Data Center Scale
- Construction
 - 100s – 1,000s (total FTE equivalent)
 - Note: may include direct, indirect, and induced jobs
 - ~0.7–2.0 workers per MW (est. peak on-site)
 - Location dependent
 - Move from site to site
 - Likely specialized

Operational Jobs Rule-of-Thumb

- Location-based jobs
 - ~15-35 per 100 MW
 - 0.15–0.35 full-time employees per MW
- Regional-based jobs
 - ~15-35 per 100 MW





Community & Land Use Considerations

- 6. Zoning & Permitting
- 7. Policy, Taxes, & Incentives
- 8. Environment and Climate
- 9. Other Considerations, Evolving Challenges, and Opportunities?



The Data Center Puzzle



Thank You!

AF DFFGTRHGFDB BGBSDGF
DFGDFBFD8 FDGDSFBGDFB



PennState Extension



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Office of the Assistant Secretary for Civil Rights
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Washington, D.C. 20250-9410; or

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(833) 256-1665 or (202) 690-7442;

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Para presentar una queja por discriminación en el programa, el reclamante debe completar un formulario AD-3027, Formulario de queja por discriminación del programa del USDA, que se puede obtener en línea, en <https://www.ascr.usda.gov/sites/default/files/USDA-OASCR%20P-Complaint-Form-0508-0002-508-11-28-17Fax2Mail.pdf>, en cualquier oficina del USDA, llamando al (866) 632-9992, o escribiendo una carta dirigida al USDA. La carta debe contener el nombre, la dirección y el número de teléfono del reclamante, y una descripción escrita de la supuesta acción discriminatoria con suficiente detalle para informar al Subsecretario de Derechos Civiles (ASCR, por sus siglas en inglés) sobre la naturaleza y la fecha de la presunta violación de los derechos civiles. La carta o el formulario AD-3027 completado debe enviarse al USDA por medio de:

correo postal:
U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410; o

fax:
(833) 256-1665 o (202) 690-7442;

correo electrónico:
program.intake@usda.gov.

Esta institución ofrece igualdad de oportunidades.

Form AD-415-A—Assisted Poster/ Revised September 2019

Miche complementaria al Formulario AD-415-A/Revisado Septiembre 2019

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