How AI-Driven Data Centers Impact Carbon Emissions in the United States

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CPSC 370 Final Project

Why This Topic Matters

1

Rapid growth of AI → increasing electricity demand

2

Data centers = major drivers of energy use & emissions

3

Emissions vary by regional grid carbon intensity

4

Key Question: Are cleaner grids enough to offset AI-driven electricity growth?

Data Sources

- EPA - eGRID (2012 - 2023):

  Regions analyzed: CAMX, NWPP, ERCT, RFCW, SRVC, NYUP

- IEA (2020 - 2030)

  AI/data-center electricity (TWh)

  Includes recent values + projections

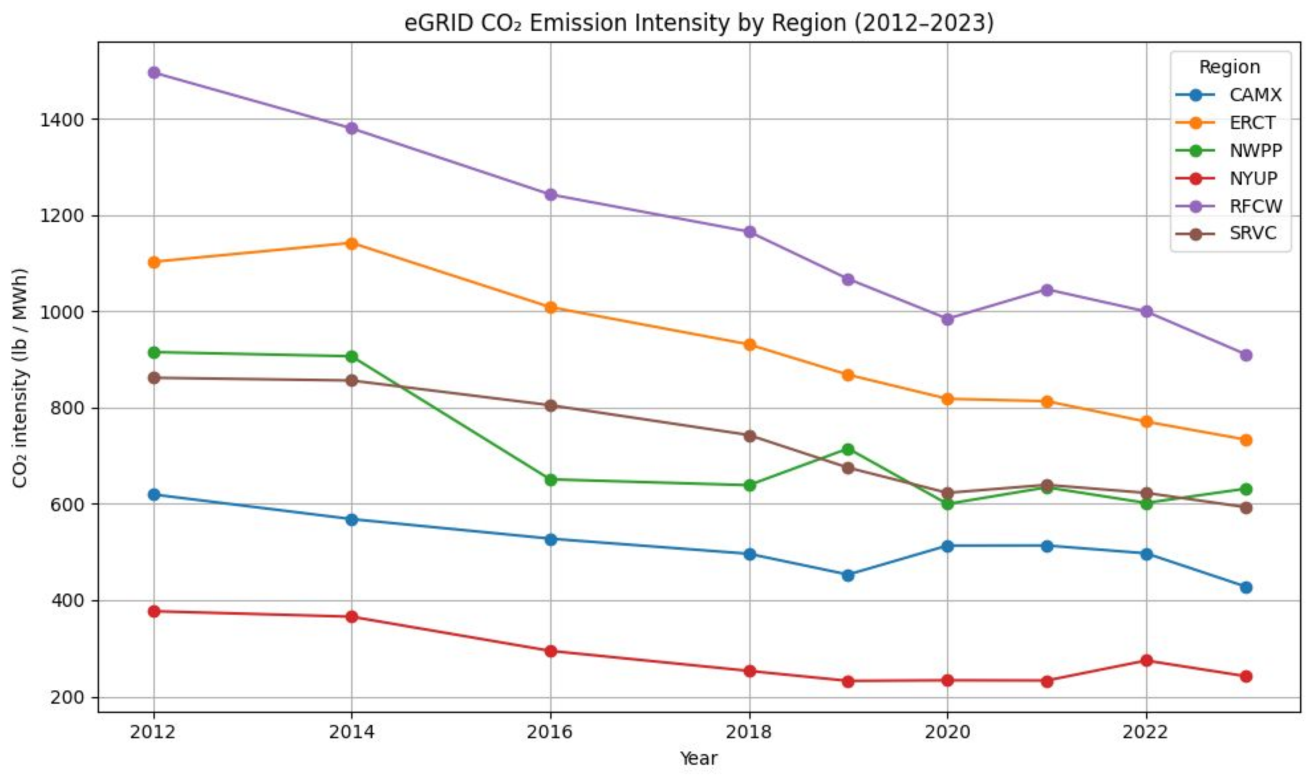
Methods

	2020	2023	2024	Base 2030	Base 2035*	Lift-Off 2030	Lift-Off 2035*	High Efficiency 2030	High Efficiency 2035*	Headwinds 2030	Headwinds 2035*
Electricity consumption (TWh)											
Total	**269**	**361**	**416**	**946**	**1 193**	**1 264**	**1 719**	**792**	**972**	**669**	**707**
Hyperscale	100	148	166	378	466	479	626	397	472	279	293
Colocation and service provider	85	112	144	355	493	482	721	385	490	246	285
Enterprise	85	100	106	213	234	303	372	10	10	144	128
IT	**176**	**252**	**295**	**733**	**985**	**972**	**1 409**	**657**	**864**	**522**	**587**
Hyperscale	84	129	146	342	427	434	574	360	432	253	269
Colocation and service provider	51	72	94	266	406	361	594	291	425	185	235
Enterprise	42	51	55	124	153	176	242	6	7	84	84

*2035 numbers serve as exploratory scenarios given the high level of uncertainty around data centre demand growth.

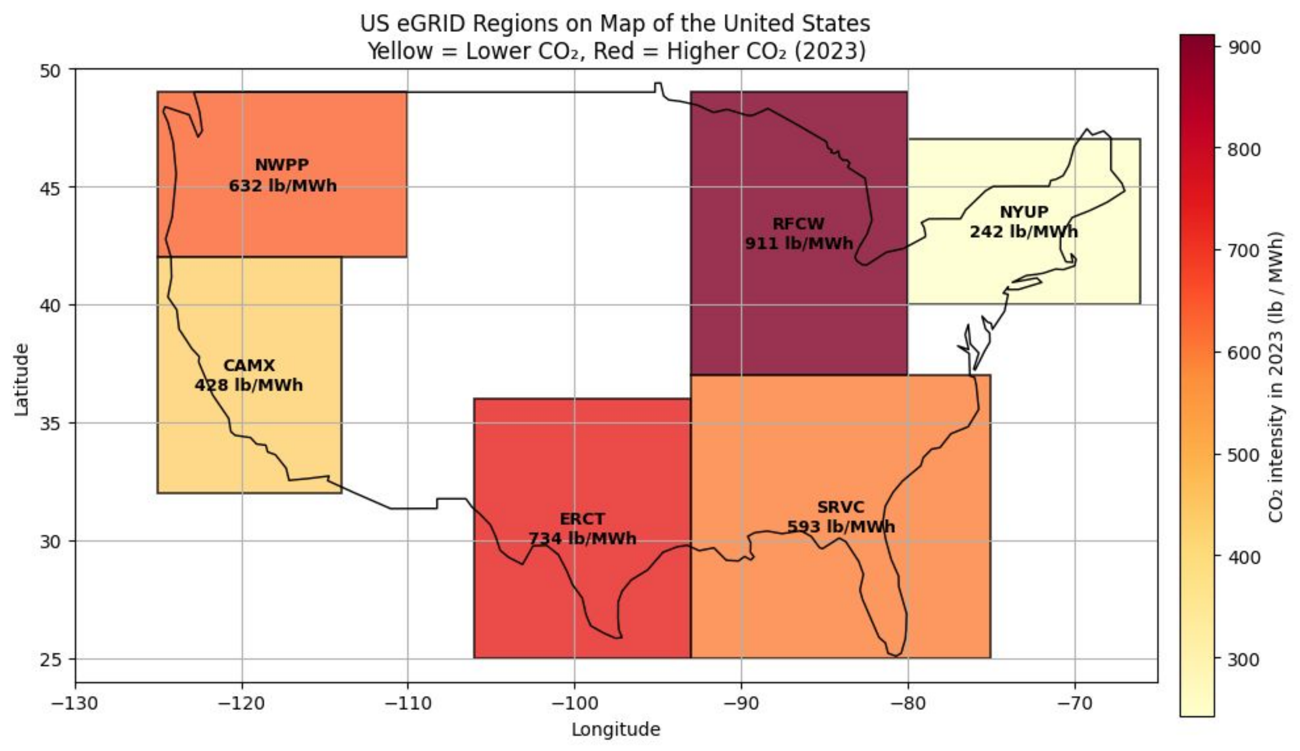
1. Time-series analysis of carbon intensity change (2012–2023)
2. Spatial comparison of 2023 grid emissions
3. Time-series of AI electricity demand growth (2020–2030)
4. Simple emissions estimate: Emissions = Carbon Intensity × Electricity Use

Results: Grid Decarbonization



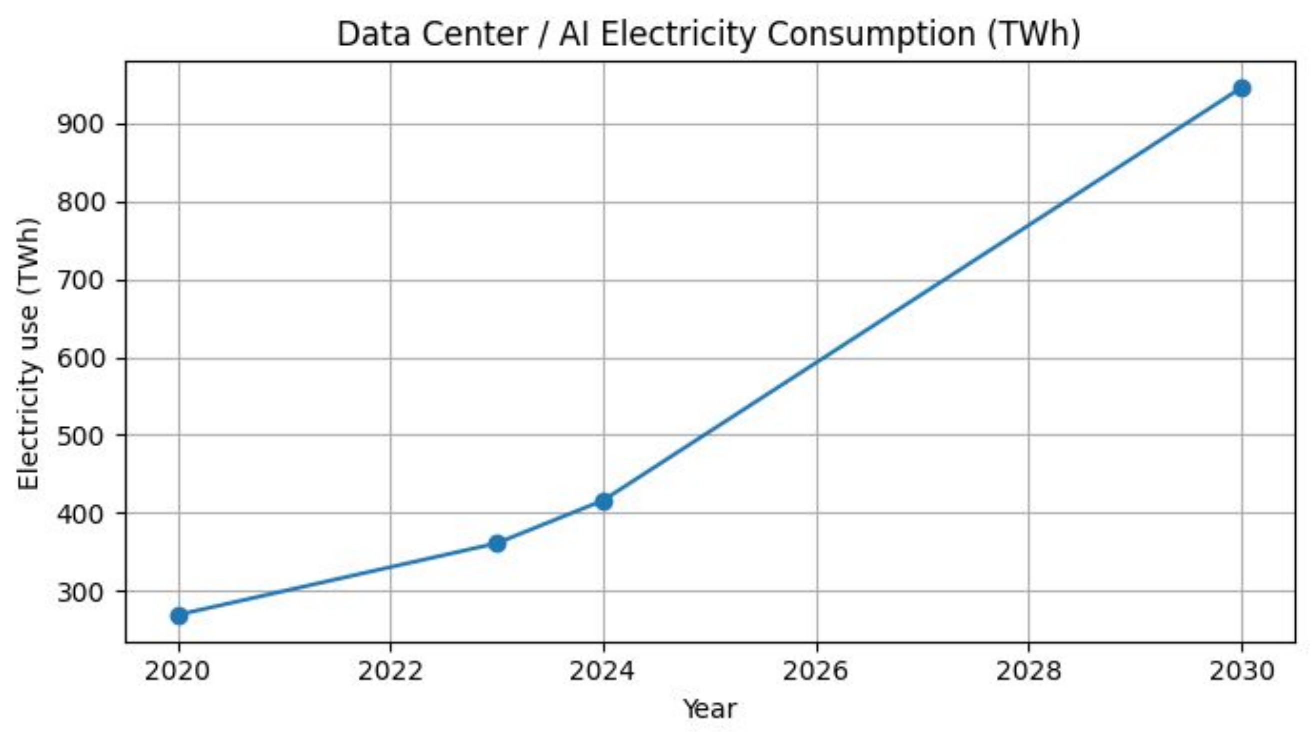
- All regions show declines in CO_2 intensity from 2012–2023
- CAMX & NWPP = already clean → improved further
- ERCT & RFCW = high emissions → declining but still high

Results: Spatial Differences (Carbon Intensity, 2023)



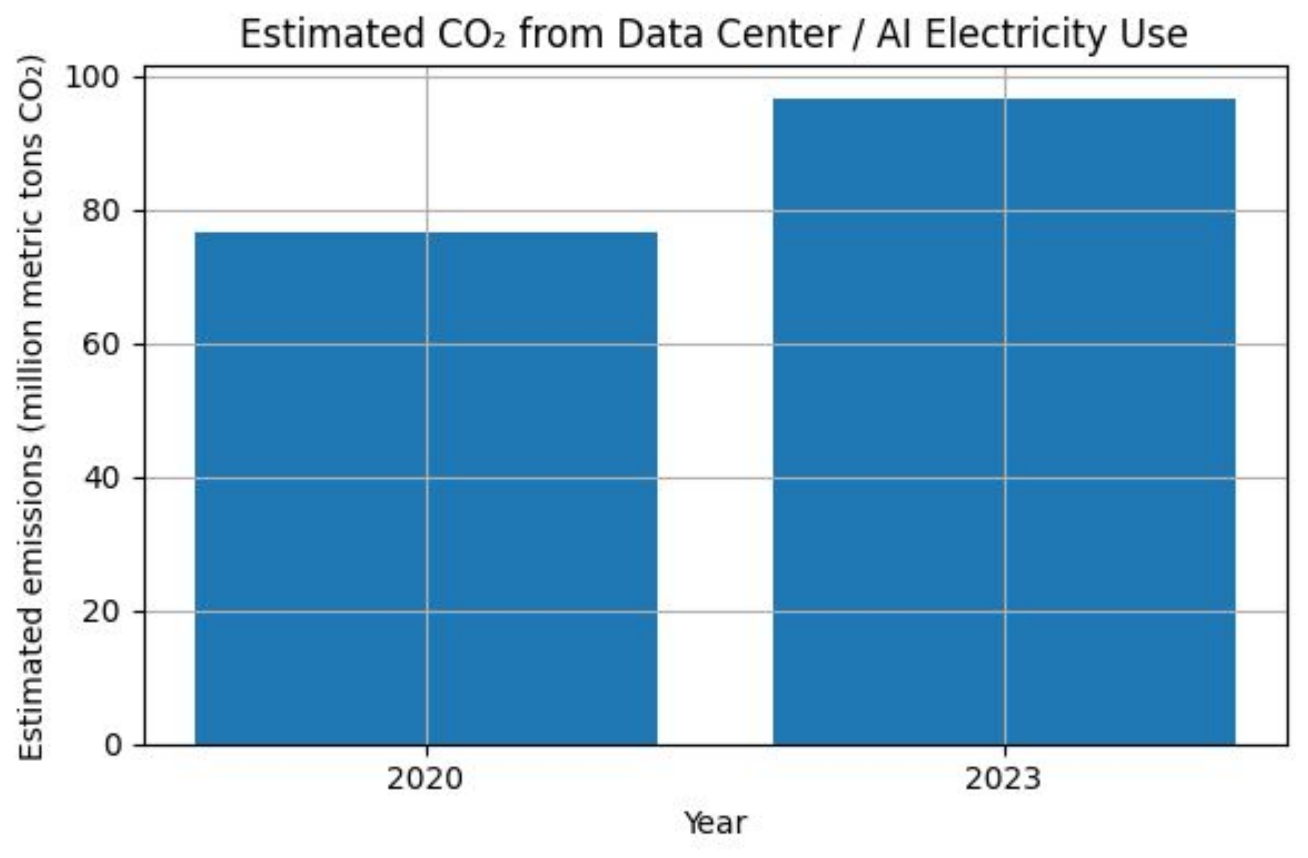
- Large spatial variation persists in 2023
- RFCW = highest CO_2/MWh
- NYUP = lowest
- Major data center hubs often located in mid-to-high carbon regions

Results: AI & Data-Center Energy Growth



- AI/data center electricity use skyrocketing
- 269 TWh (2020) → 361 TWh (2023) → 416 TWh (2024)
- 2030 projection: 946 TWh (nearly 3× 2023 levels)

Results: Combined Emissions Estimate



- Grid gets cleaner
- AI demand skyrockets
- Net emissions still go up, not down

Highlights of Study

1

Grid decarbonization is real and consistent across regions

2

Without cleaner siting + renewable sourcing → total emissions continue rising

3

AI electricity growth is exponential and outpacing grid improvements

4

Key insight: AI growth trajectory is more influential than grid improvements alone

Conclusion / Policy Implications

1

Cleaner grids help but cannot offset rapid electricity growth

2

- Emissions future depends on:
  - Where data centers are built
  - How they source power (renewables, PPAs)
  - Efficiency improvements

3

Future:

- More regions
- Hourly Margin Emissions