

LONG-TERM PROJECTIONS OF DATA CENTRE ENERGY DEMAND

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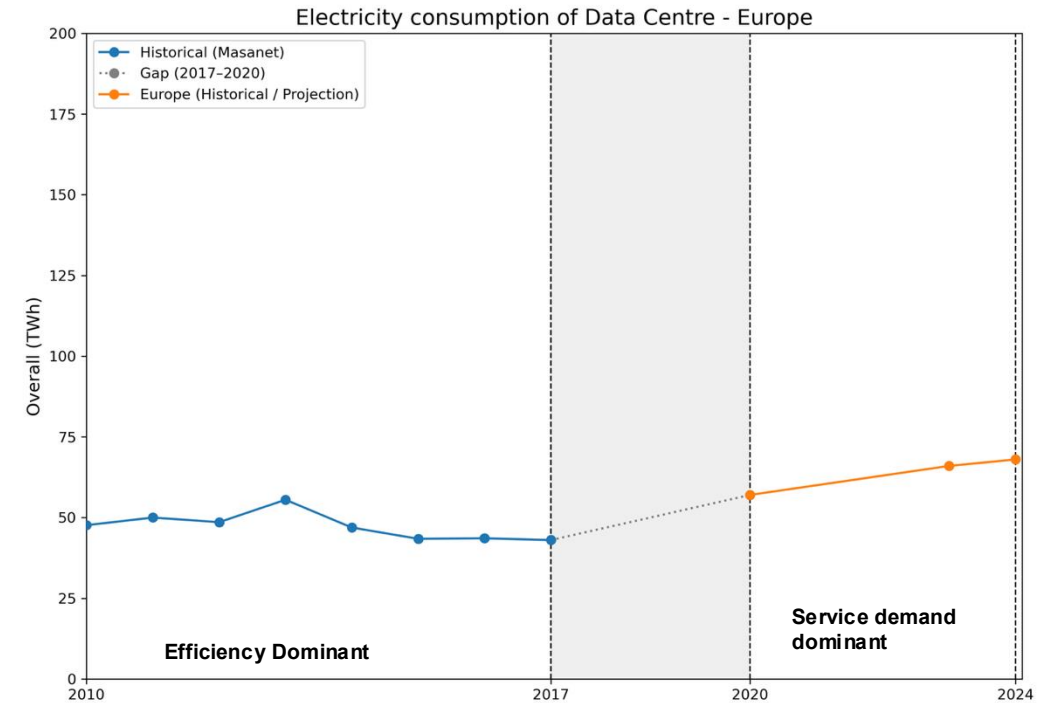
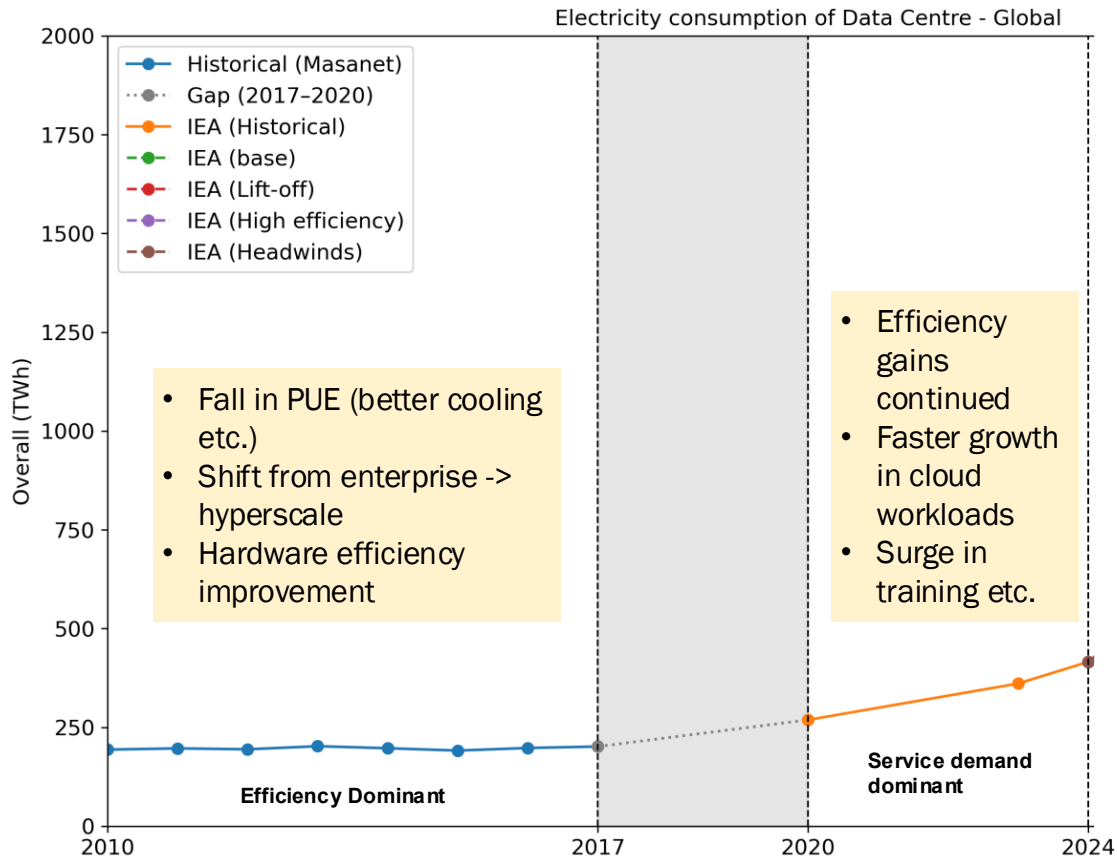


A growing source of emissions not fully captured in climate pathways

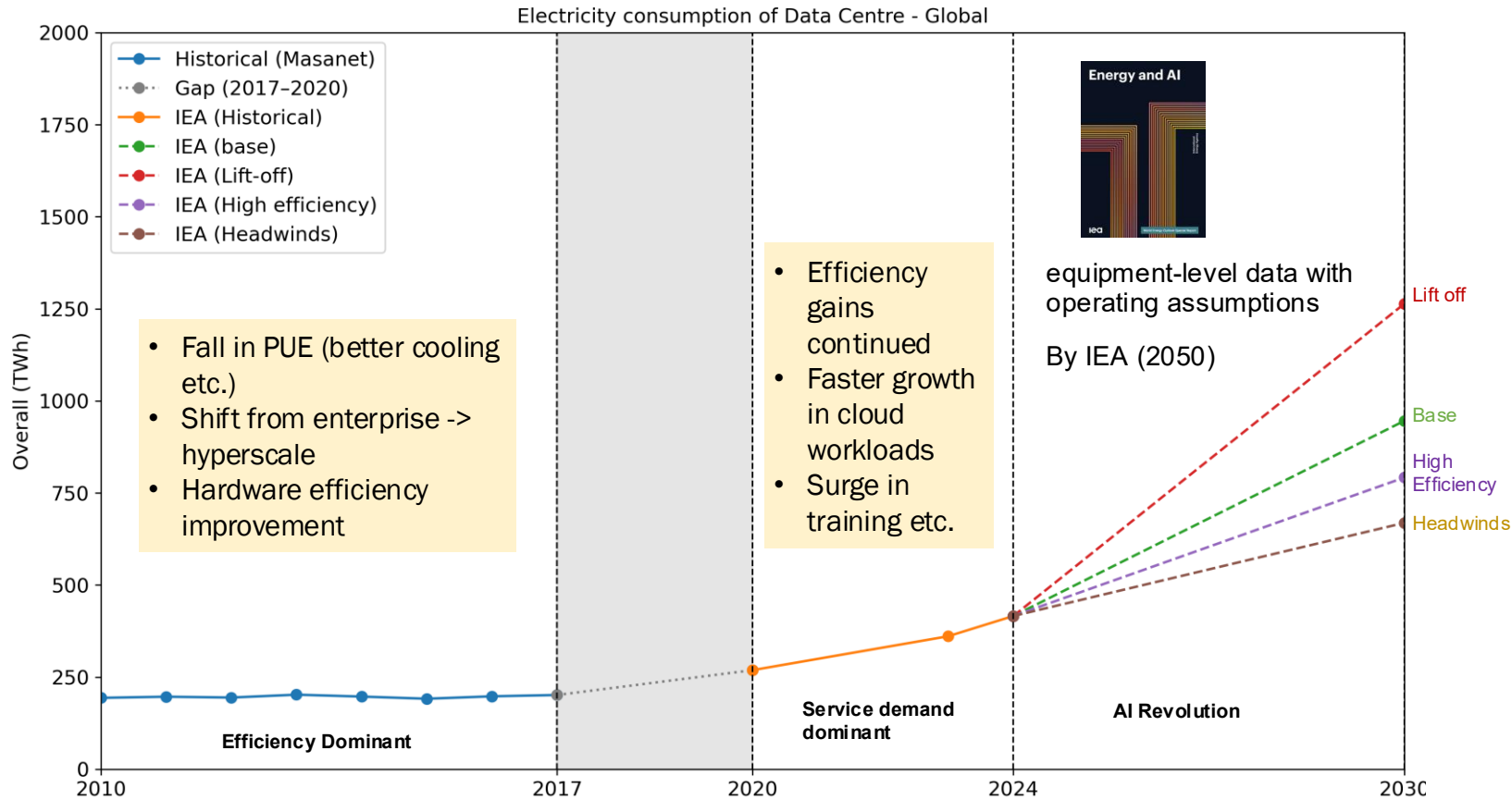
- Driven by AI, data centres are becoming an increasingly important and uncertain component of future electricity demand and emissions
- Yet most projections only model this growth to 2030
- **Long-term projections** are needed for climate planning and to assess system-wide impact



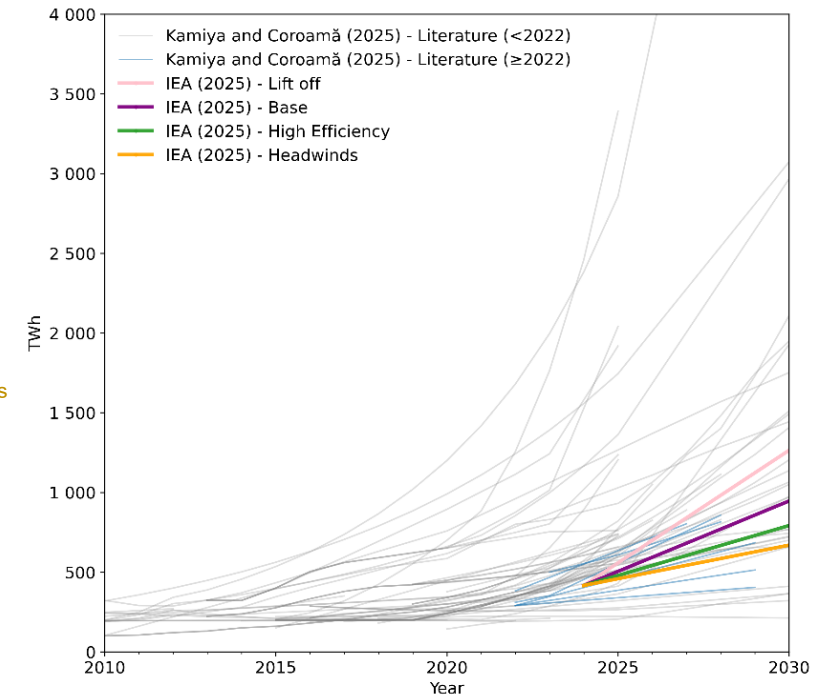
Data centre energy demand has grown steadily but is now entering a new phase of acceleration



Near-term projections diverge widely, uncertainty is already high by 2030



- Uncertainty
- Risk of overestimation



We model long-term demand using calibrated historical trends

- How DC energy related to **digital transformation** across regions historically
- Future uncertainty: based on observed **historical variations**
- Additional uncertainty: 5 possible futures digital transformation levels
- Not modelled by changes in e.g. chip and server shipment, compute demand, hardware performance

Lower Bound

Efficiency dominant trends (2010-2017)

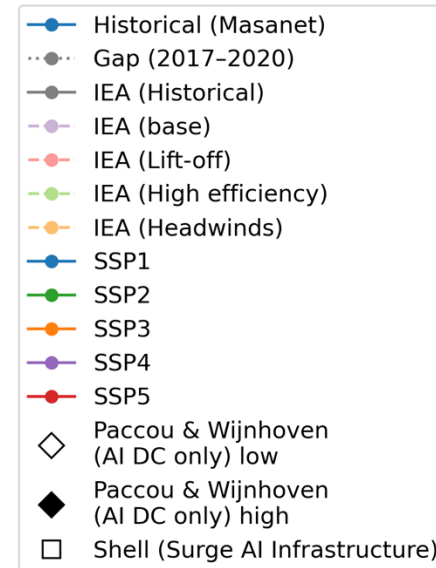
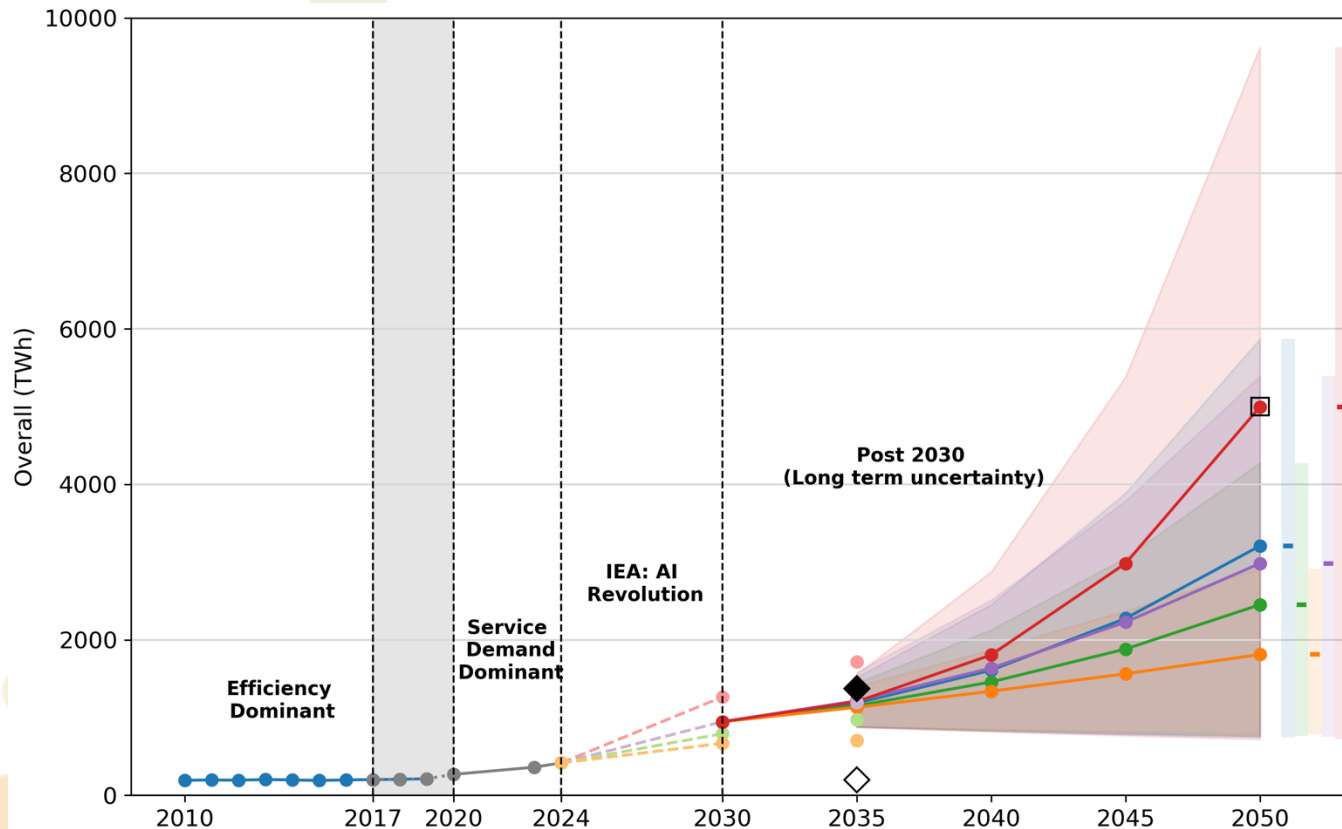
- Steady growth (stabilised role, or local bottlenecks, tight supply chain (delay expansion), regulated)
- Stronger progress on energy efficiency in software, hardware and Infrastructure

Upper Bound

Service demand dominant trends (2020-2024)

- Wide AI adoption
- Increase dependency in daily life
- Minimal governance

Global electricity demand of data centre remains a small share but surging and uncertain



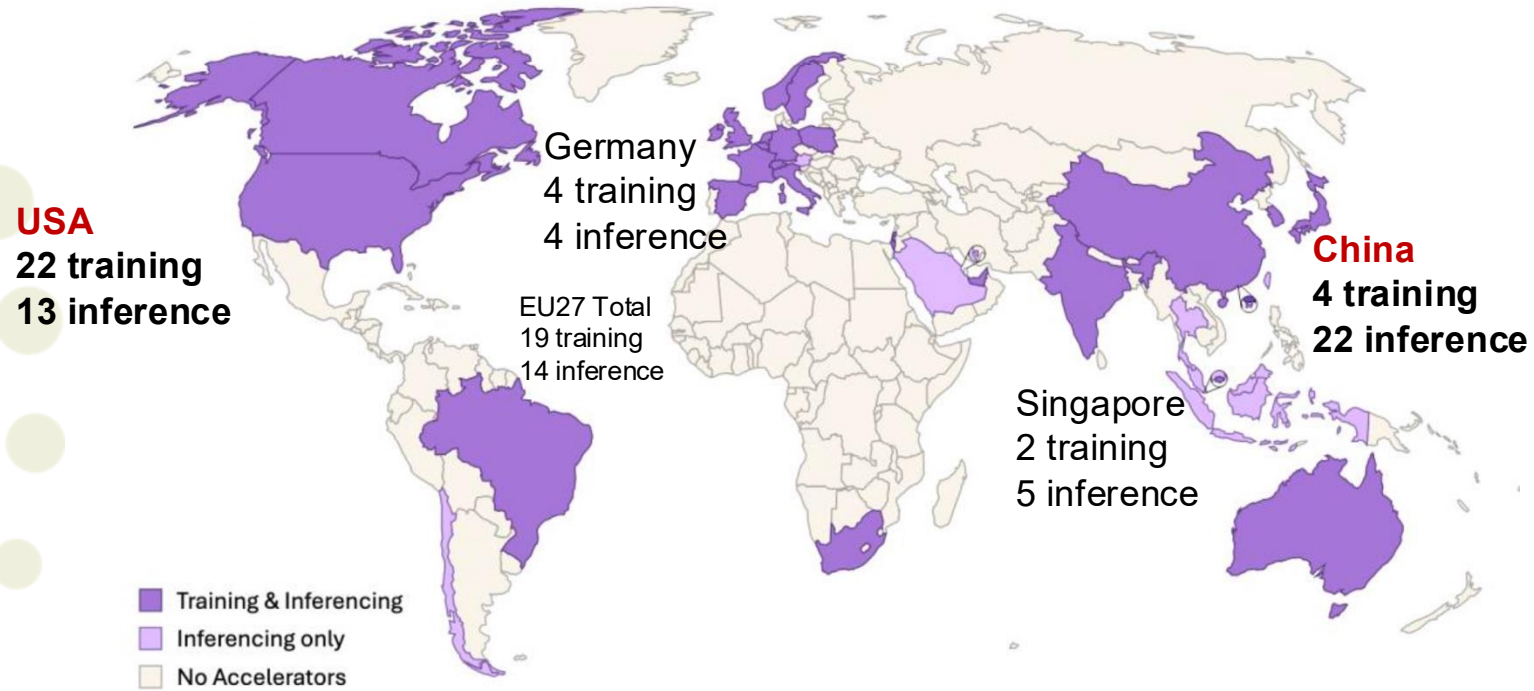
- **Small Share:** ~5% of the electricity demand by 2050
- **Large uncertainty:** ~1,800-5,000 TWh by 2050
- **Grow faster** than residential buildings demand: 2-fold vs 9-fold from 2020 – 2050

SSP = different global development storylines that vary GDP, pop, tech, urban, etc.

SSP2 = "middle of the road"

Only 33 countries have cloud data centres capable of running AI workloads

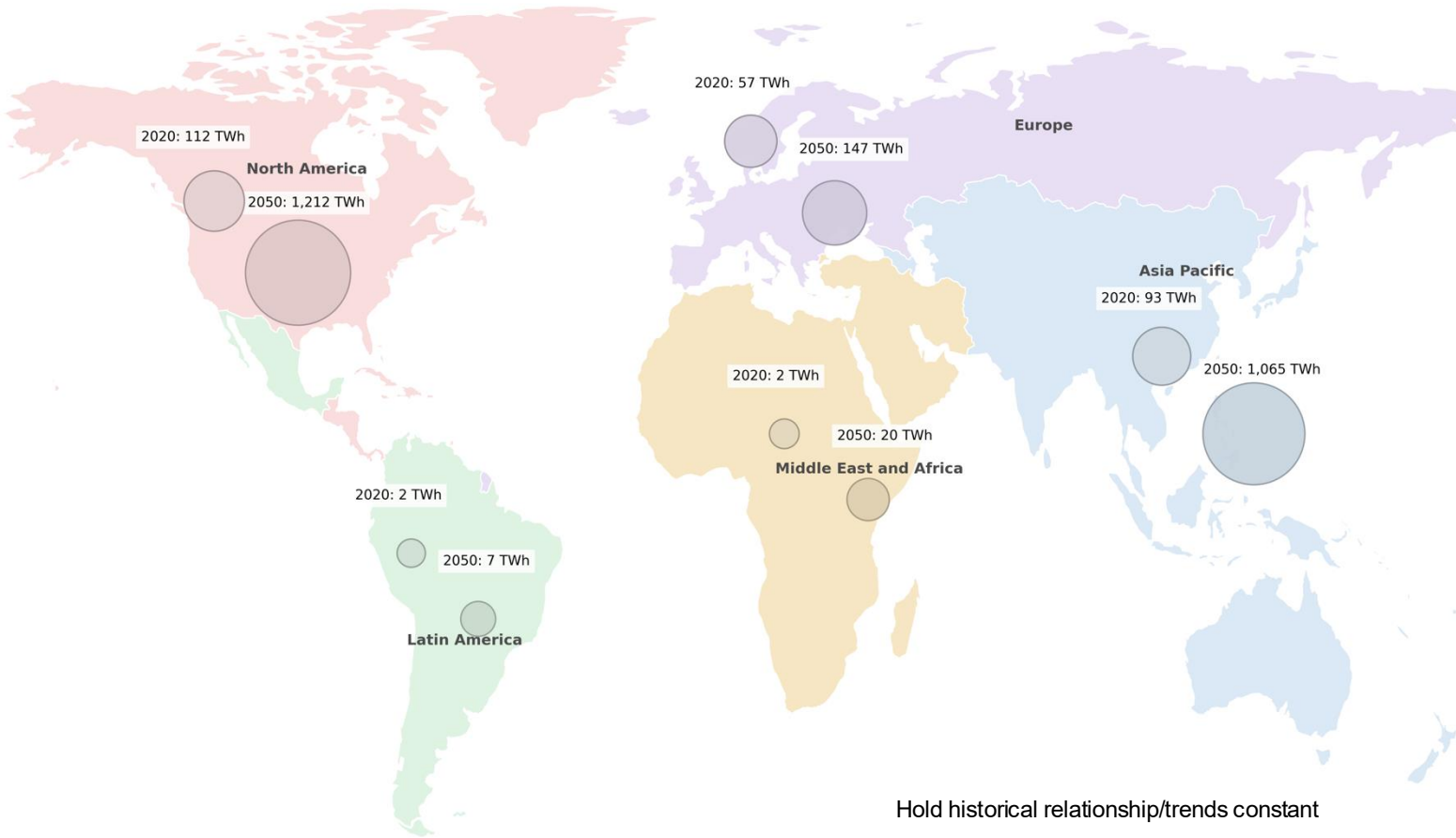
In-country public cloud AI compute availability by country



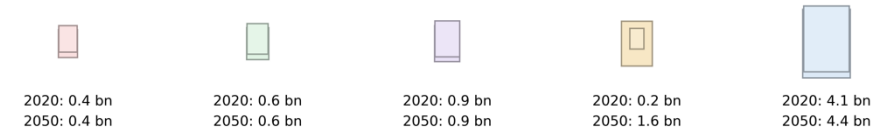
- 9 countries out of 33 hosted only inference relevant AI compute
- Most countries do not have their own AI computing infrastructure
- And only the US and China host AI accelerators sourced from domestic chip vendors

Future demand is concentrated in a few regions (SSP2)

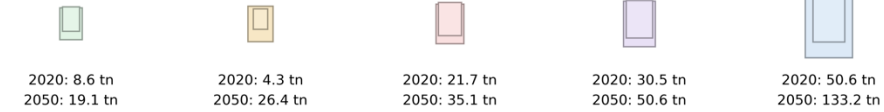
Regional DC Electricity Demand (TWh): 2020 and 2050



Population



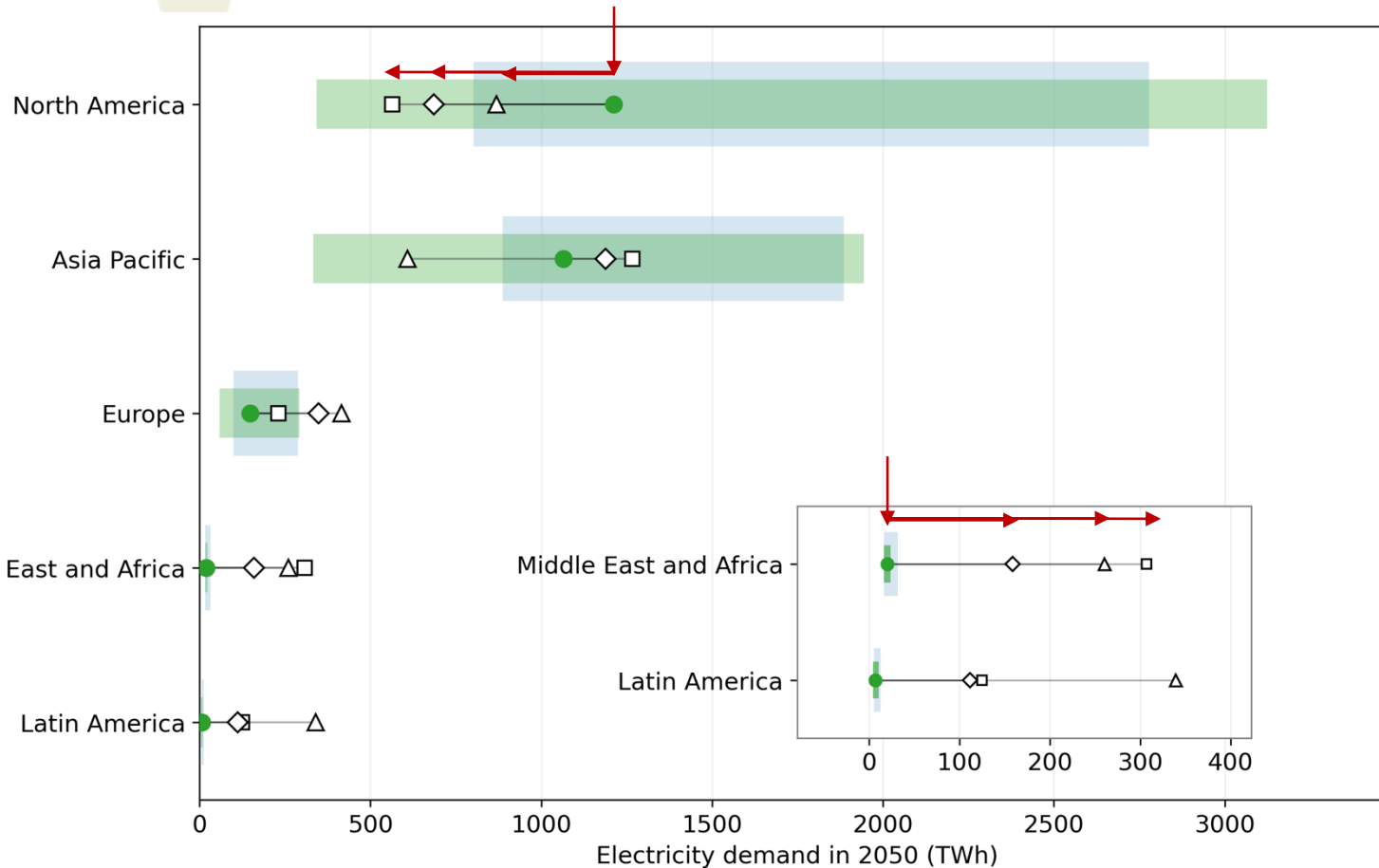
GDP



Global Average (2050) | 300 kWh/person | 9 kWh/1k USD

Asia Pacific	241	8
Europe	164	3
Latin America	10	0.35
Middle East and Africa	13	0.75
North America	2891	35

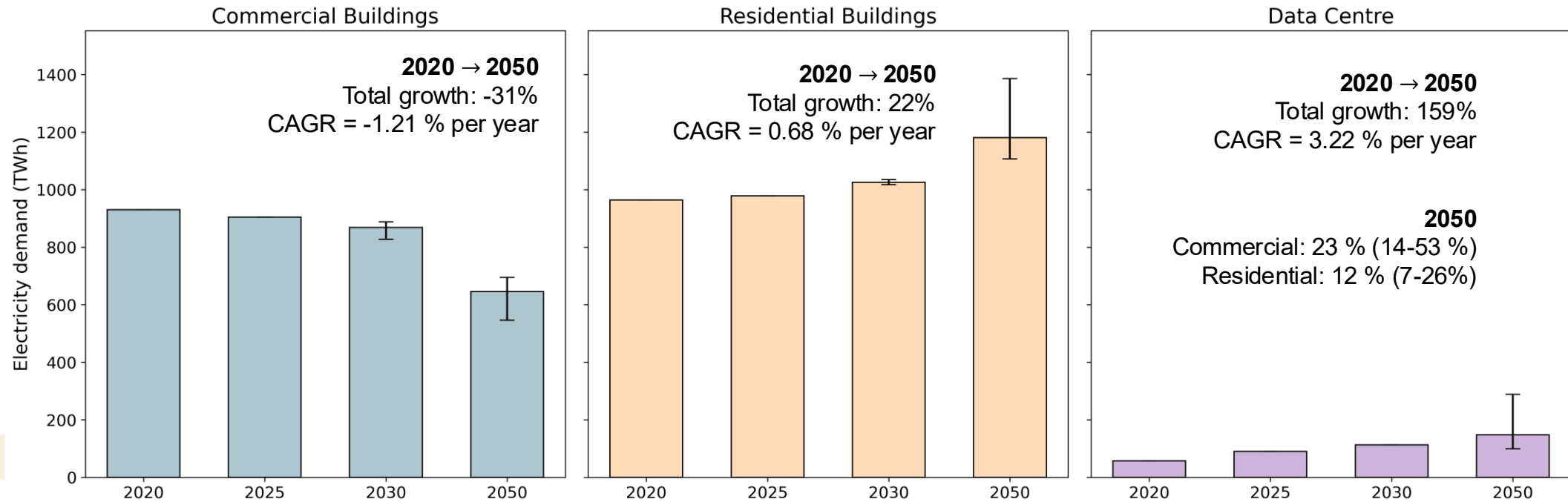
Convergence drives gains in lagging regions



- Socioeconomic Development Uncertainty (range of SSP1-SSP5 centrals)
- DC Development Uncertainty (median Lower-Upper across SSPs)
- SSP2
- SSP2 + Population convergence
- ◇ SSP2 + GDP convergence
- △ SSP2 + Renewable convergence

- The effect is strongest in the Middle East and Africa, and Latin America.
- It shifts outcomes (from dot to diamond and square markers) beyond the uncertainty range.
- In Europe, renewable convergence has a stronger shifting effect

Europe: Data centre demand could become significant relative to buildings sectors



- Model: MESSAGEix-Buildings
- Shows different future dynamics from the commercial buildings sector (currently a subsector) as a whole
- Needs to be represented explicitly in future scenario modelling.

Summary

- Our long-term projections rely on digital transformation level (drives by socioeconomic development) as a proxy – relationship could weaken or break
- Lack of data centre specific predictors
- Main projection is with static regional distribution assumptions – potential shifts driven by equity or renewable energy availability etc
- Global outlook appears manageable, but local constraints may be significant

Main Reference

- Fan YV, Wilson C, Kamiya G, Mastrucci, 2026, Data Centre Energy Demand Projections within Shared Socioeconomic Pathways, Energy and Climate Change (Under Review)
- Fan YV, Wilson C, Andrijevic M., Carlsen H, Joshi S., 2025, Digital Transformation in Shared Socioeconomic Pathways, npj climate action, 4, 79, <https://doi.org/10.1038/s44168-025-00283-w>



**The CircEular project is funded
by the European Union**

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