IEEE Smart Cities

Measured, Not Guessed: Rethinking Datacenter Sustainability

Babak Falsafi, President
Swiss Datacenter Efficiency Association

www.sdea.ch | info@sdea.ch

IEEE Smart Cities

IEEE Advancing Technology for Humanity

Presentation Guidelines

- Presentation is 45 minutes long. Slides containing **content** should be no more than 20 slides
- Please define all acronyms in the presentation
- Overall theme of presentation is educational. Following IEEE Guidelines, references to specific marketing programs, companies and solutions should be avoided. The exception to this requirement/recommendation is for open source or other publicly available (free to the user) resource
- Contact information including email, company and presenter name should be on one slide – title or the 2nd slide
- Do not include videos or automations in the presentation. This content doesn't format well when converted to a PDF for Resource Center.
- Guidelines of the Template. Please use the formatting, including fonts, font size, titles and headings, etc. so that slide deck is consistent, and consistent with other presentations in the program. Verify that content does not cover borders or IEEE logos
- Where possible, avoid reuse of copyrighted materials unless explicit permission has been granted and can be demonstrated.
- Final version should be sent to IEEE staff in PPT (not pdf). Opening/closing slides will be added. Staff loads the presentation, and the presenter will control the slides.

OUR DIGITAL UNIVERSE

Fueled by:

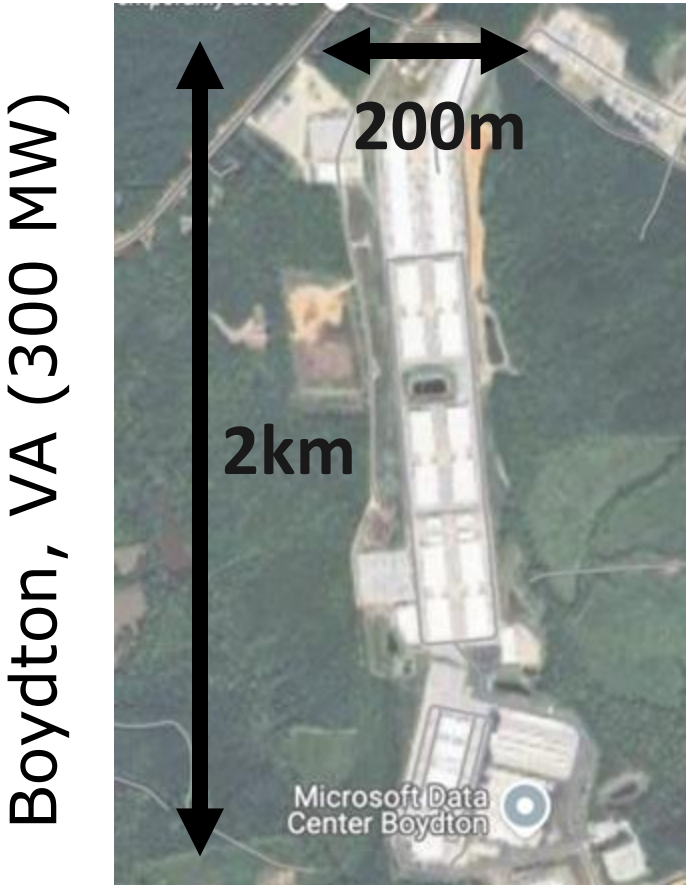
- Data volume
- Data growth rate
- Monetization of data
- Data's impact on GDP
- ….now AI

IEEE Smart Cities

IEEE Advancing Technology for Humanity

DATACENTERS
THE BACKBONE OF OUR DIGITAL UNIVERSE

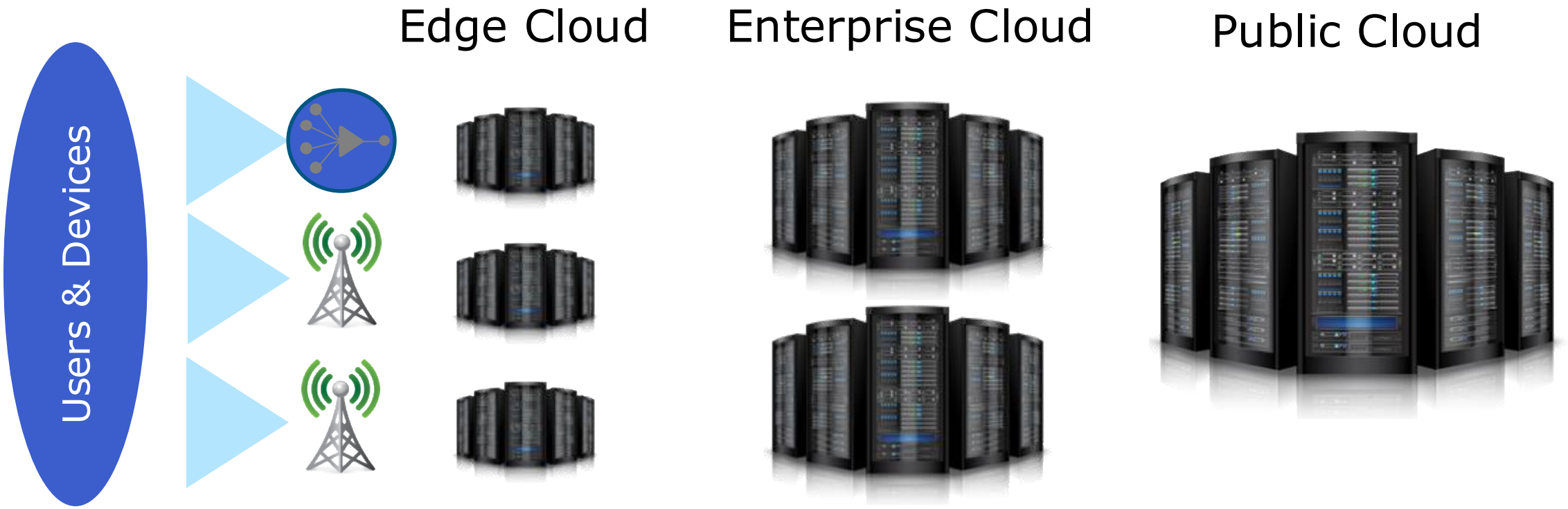
- 100s of thousands of commodity or home-brewed servers
  - Consuming 10s to 100s MW
- Centralized to exploit economies of scale
- Network fabric w/ µ-second connectivity
- Often limited by ingress
  - Electricity
  - Network
  - Cooling



IEEE Smart Cities

IEEE Advancing Technology for Humanity

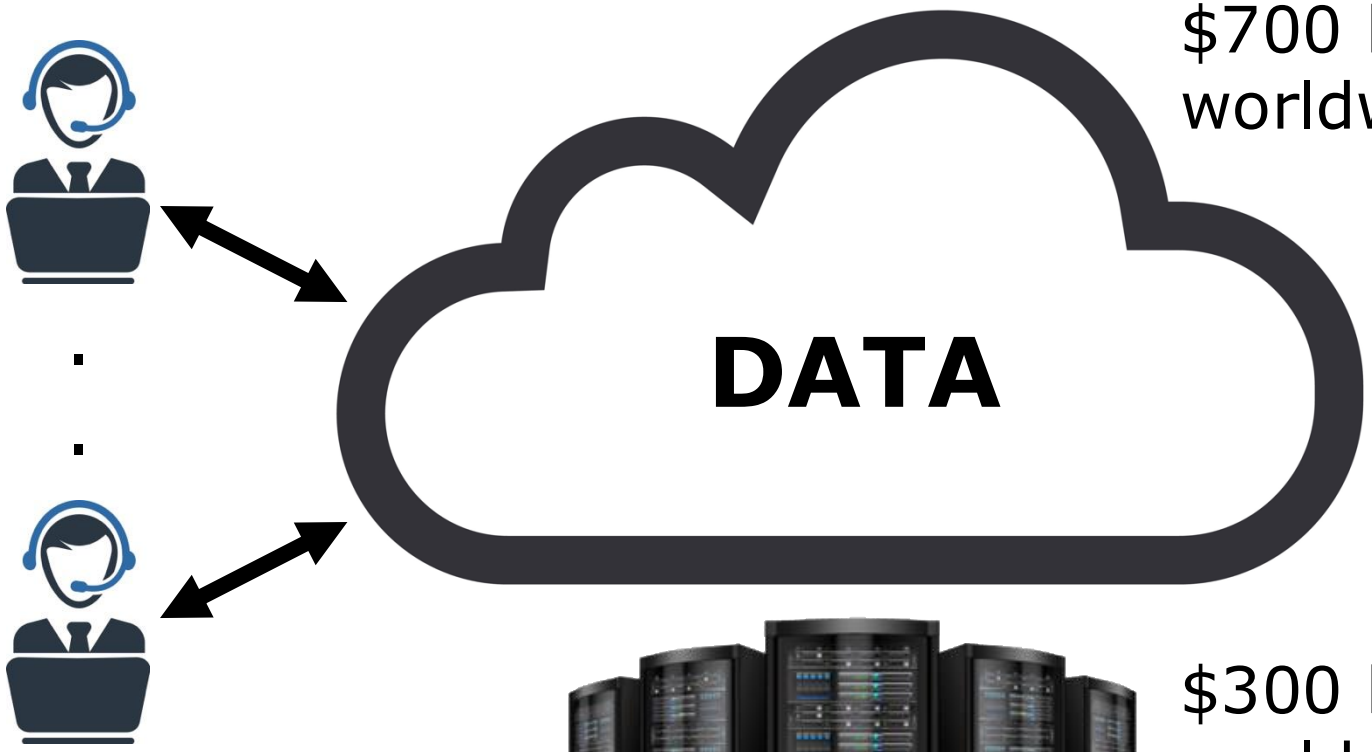
CLOUDS TURN DATA INTO VALUE/SERVICE



IEEE Smart Cities

IEEE Advancing Technology for Humanity

CLOUD IS AN ECONOMIC MODEL



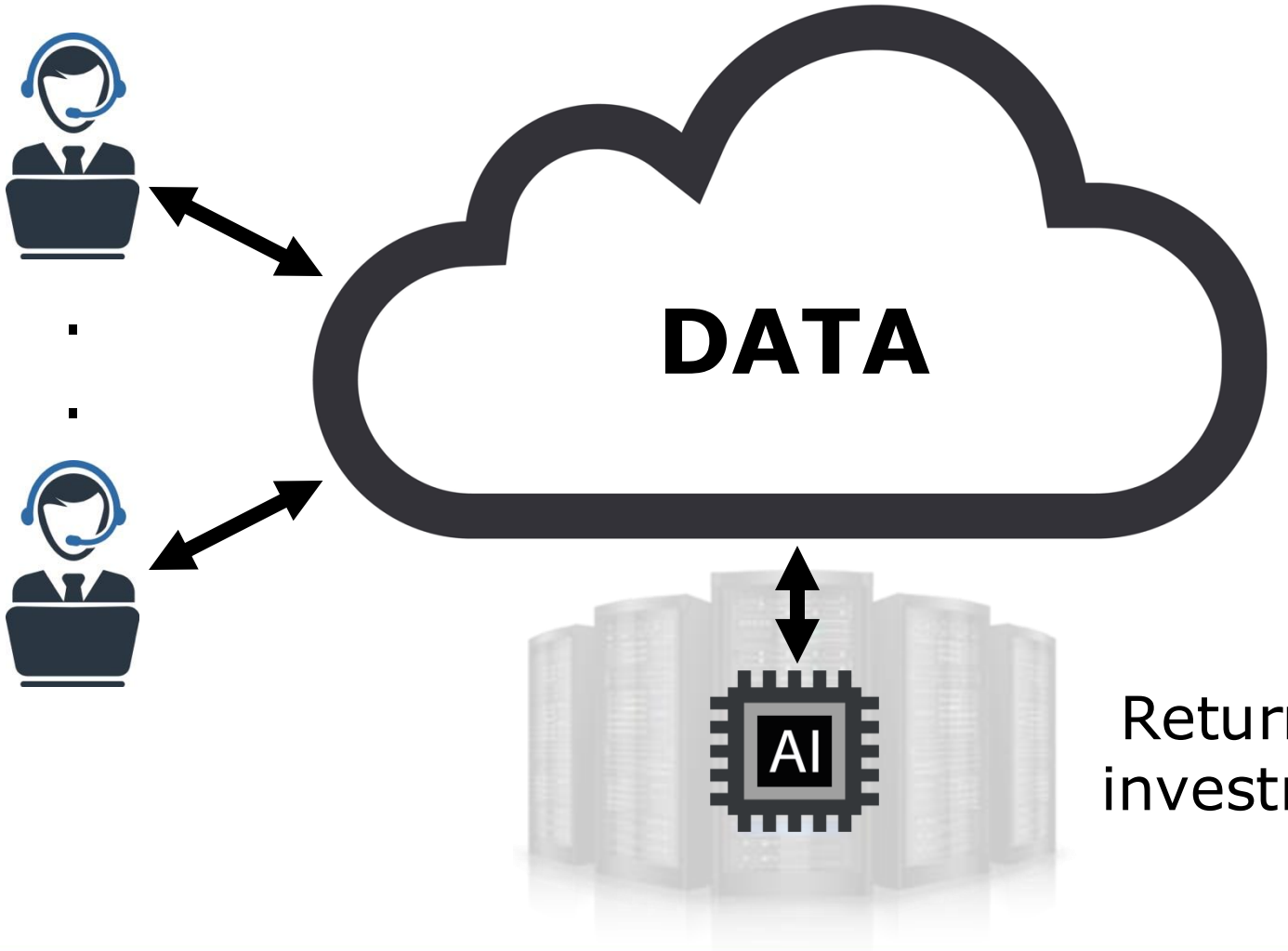
$700 billion
worldwide c.a. 2024

$300 billion
worldwide c.a. 2024

IEEE Smart Cities

IEEE Advancing Technology for Humanity

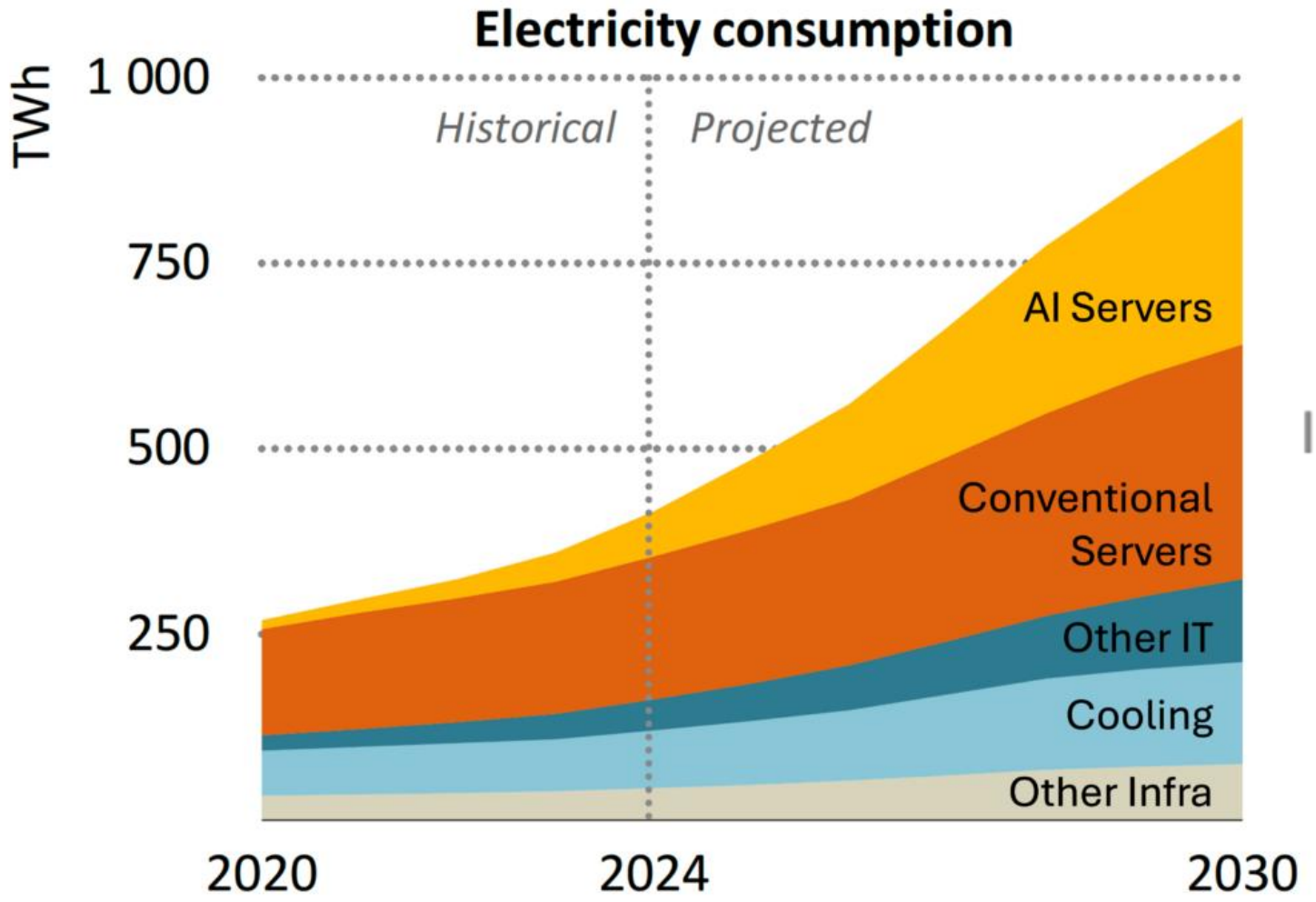
WHERE DOES AI FIT IN ALL THIS?



AI ALSO HAS PROS

- Helps optimize energy exploartion, supply and consumption
- Balances management of electricity networks
- Application in transport to save energy and cost
- Can optimize energy management in buildings
- Is a powerful tool for scientific discovery
- …

ENERGY GROWTH PROJECTIONS

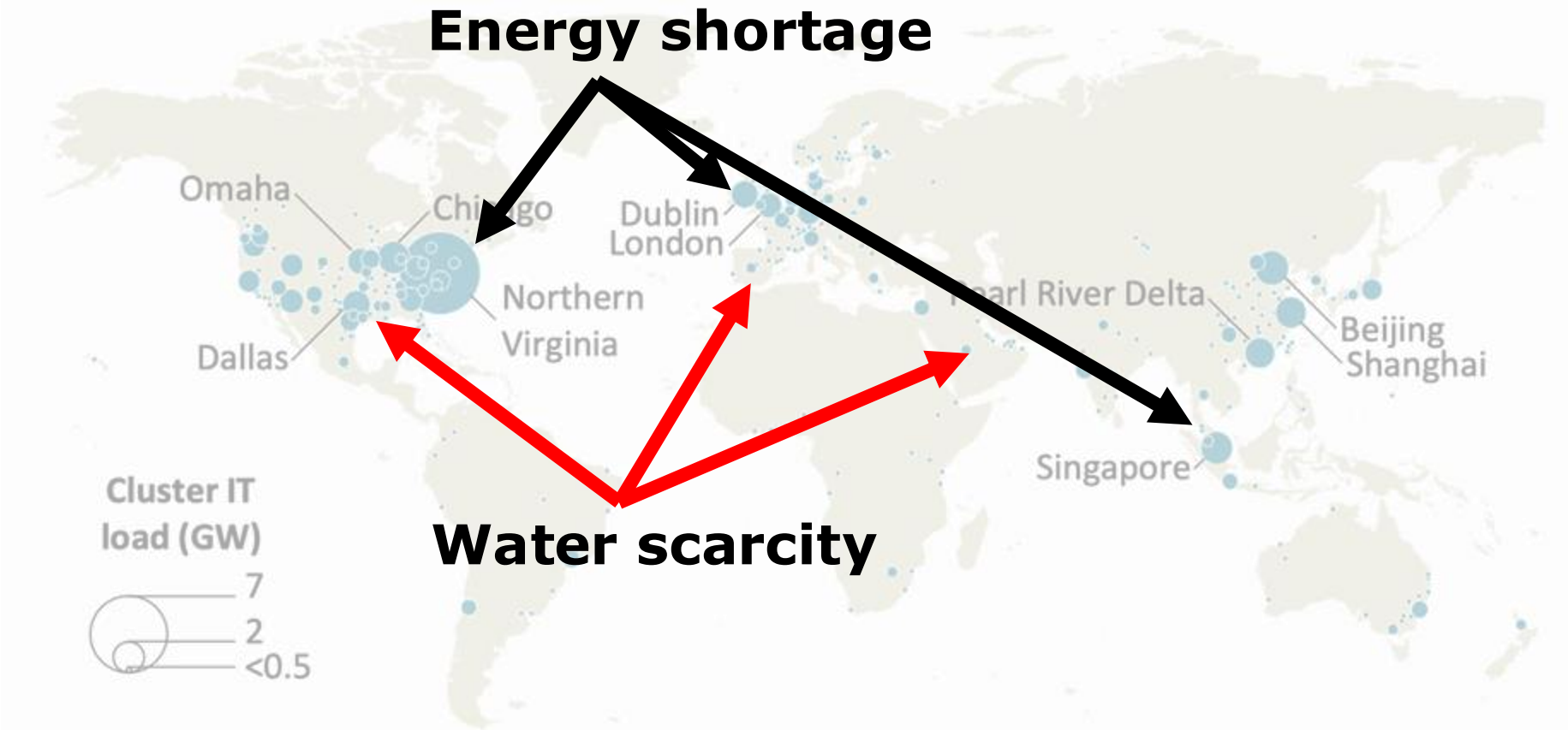


IEA. CC BY 4.0.

THE SKEWED DEMOGRAPHICS OF DATACENTERS

IEA. CC BY 4.0.

THE SKEWED DEMOGRAPHICS OF DATACENTERS

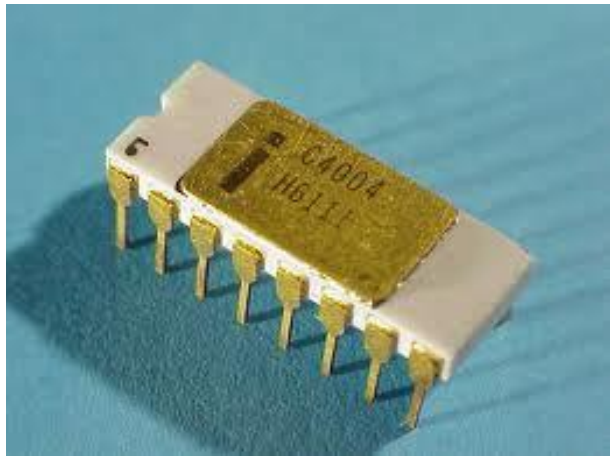


IEEE Smart Cities

IEEE Advancing Technology for Humanity

TECHNOLOGICAL FORECAST: MOORE'S LAW

1971
Intel 4004



92,000 ops/s
1 Watt

2021
Intel Ice Lake

1,200,000,000,000 ops/s
270 Watts

IEEE Smart Cities

IEEE Advancing Technology for Humanity

TECHNOLOGICAL FORECAST: MOORE'S LAW

1971
Intel 4004

2021
Intel Ice Lake

In 50 years:
13 million times faster
48 thousand times more efficient

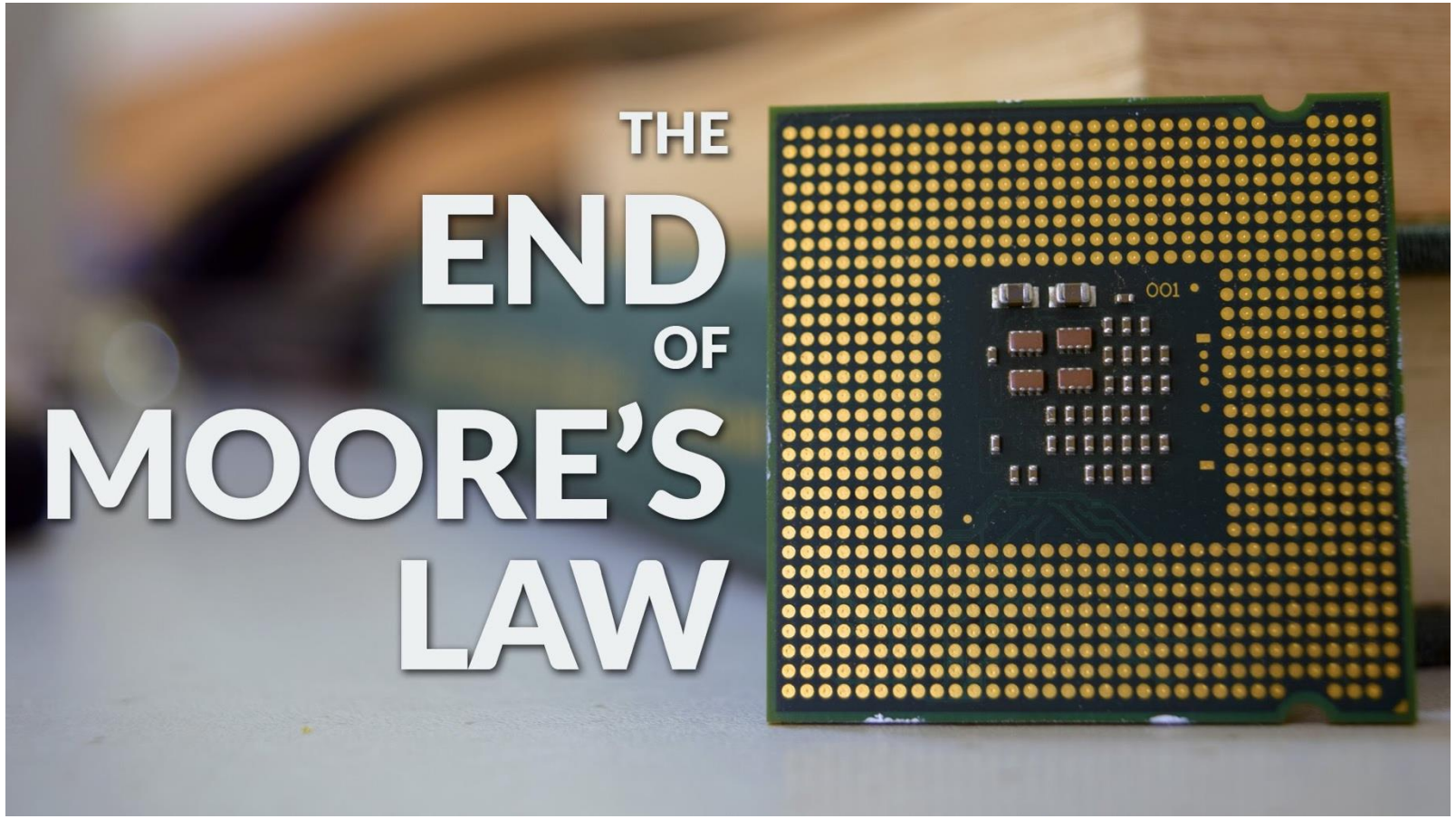
92,000 ops/s
1 Watt

1,200,000,000,000 ops/s
270 Watts

IEEE Smart Cities

IEEE Advancing Technology for Humanity

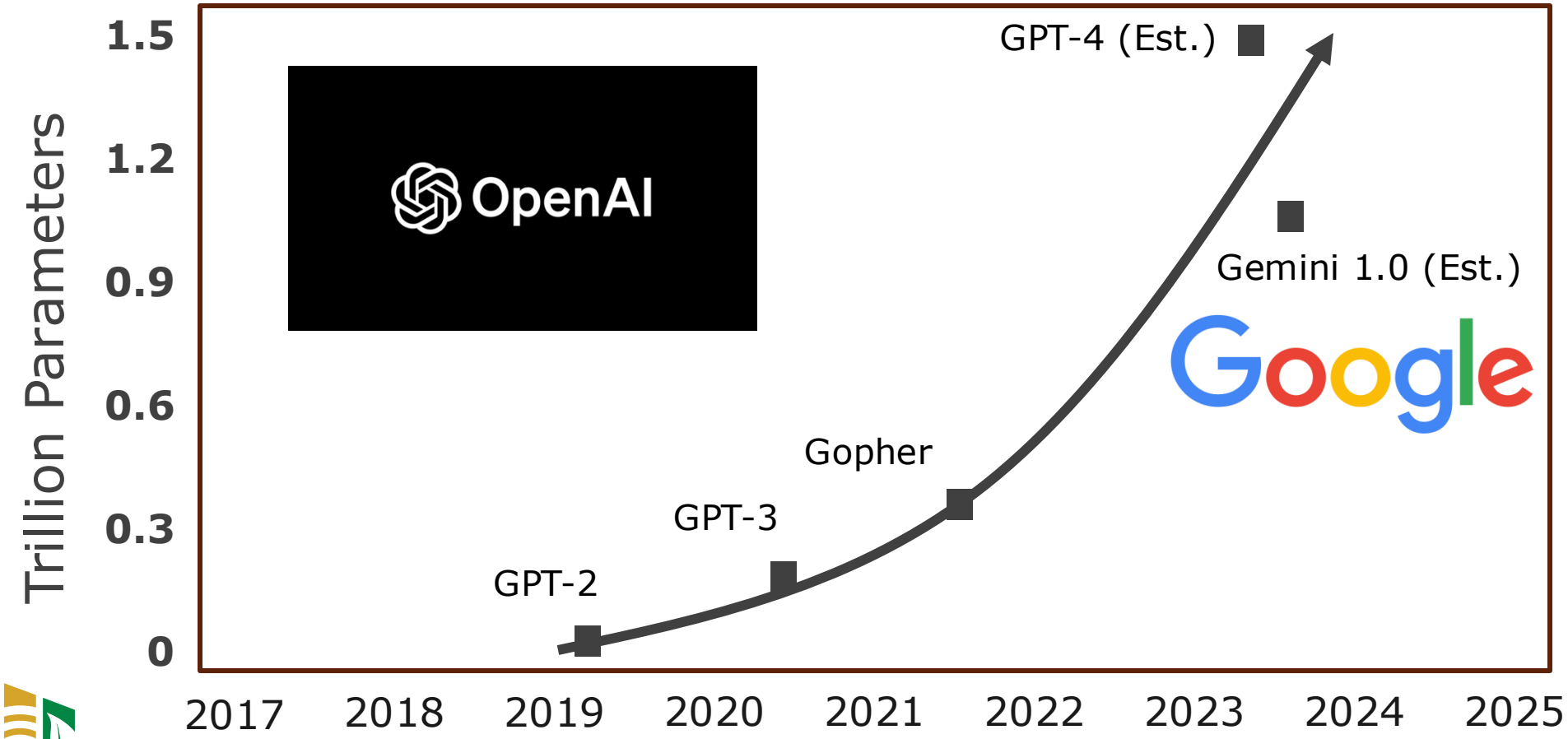
WHAT HAPPENS WITHOUT MOORE'S LAW



IEEE Smart Cities

IEEE Advancing Technology for Humanity

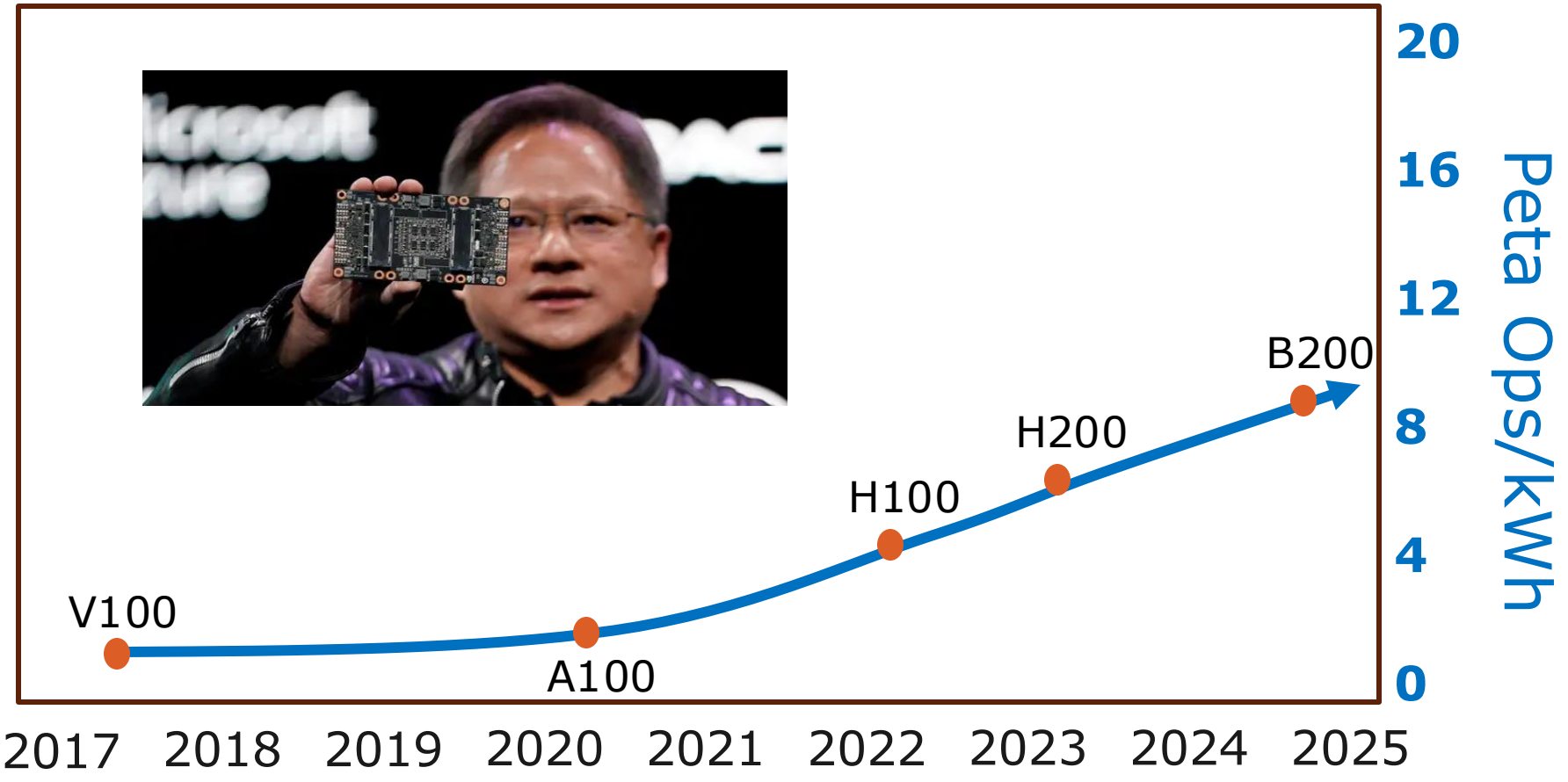
AI GROWTH



IEEE Smart Cities

IEEE Advancing Technology for Humanity

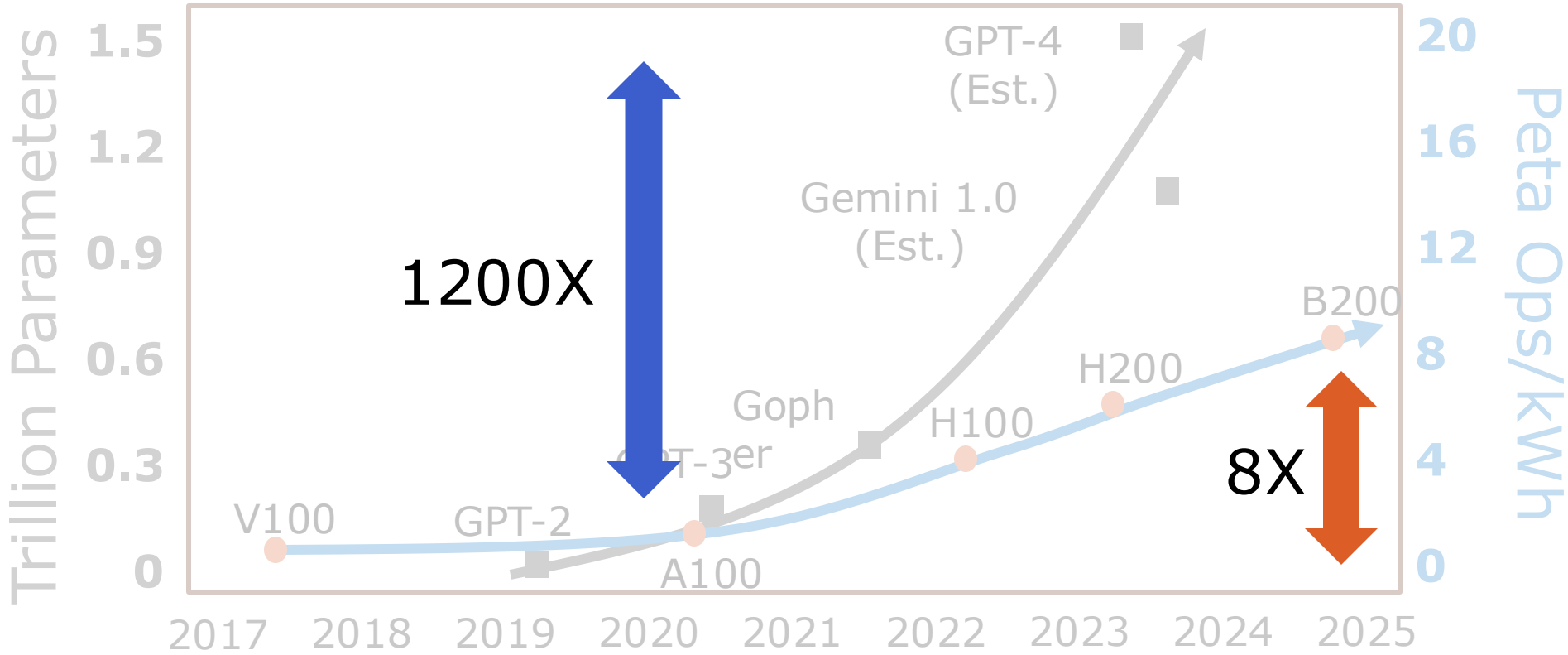
AI GROWTH VS. CHIP GROWTH



IEEE Smart Cities

IEEE Advancing Technology for Humanity

AI GROWTH VS. CHIP GROWTH



IEEE Smart Cities

IEEE Advancing Technology for Humanity

POST-MOORE DATACENTERS

Design for "ISA"

- **I**ntegration
  - reduce data movement
- **S**pecialization
  - cut resources to analyze data
- **A**pproximation
  - compress data & computation

From algorithms to infrastructure

IEEE Smart Cities

IEEE Advancing Technology for Humanity

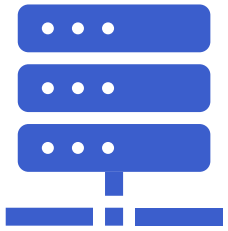
EMISSIONS: OPERATIONAL VS. EMBODIED

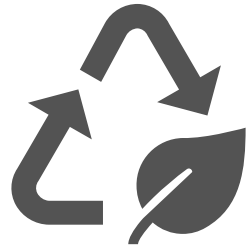
The **use stage** GHG emissions in 2020 relating to electricity use account for the **majority of total GHG emissions**.

- *Malmodin et al. (2020)*

OPERATIONAL EMISSIONS
Scope 1 & Scope 2

EMBODIED EMISSIONS
Scope 3



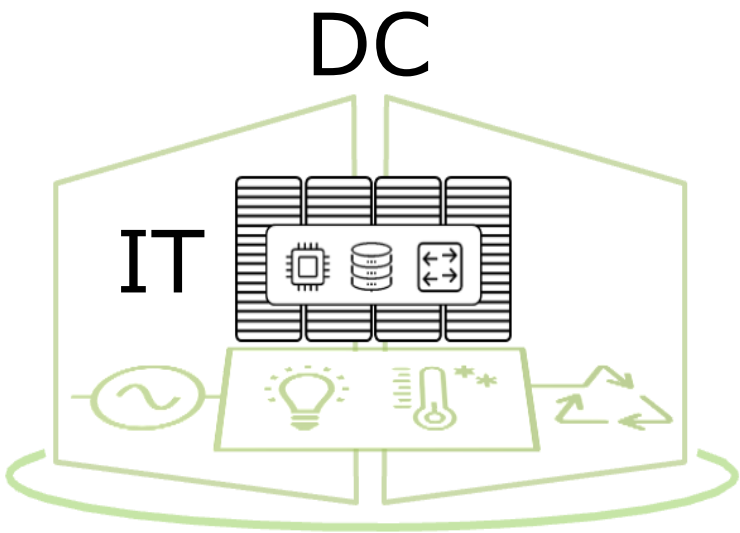


IEEE Smart Cities

IEEE Advancing Technology for Humanity

EFFICIENCY: THE INDUSTRY STANDARD
POWER USAGE EFFECTIVENESS (PUE)

$$PUE = \frac{\text{Total DC Power}}{\text{IT Power}}$$



- PUE has been around for two decades
- Easy to calculate, industry-wide adoption, benchmarking
- Global Average (2024): 1.56 *(= 64% of the electricity flows into IT)*

IEEE Smart Cities

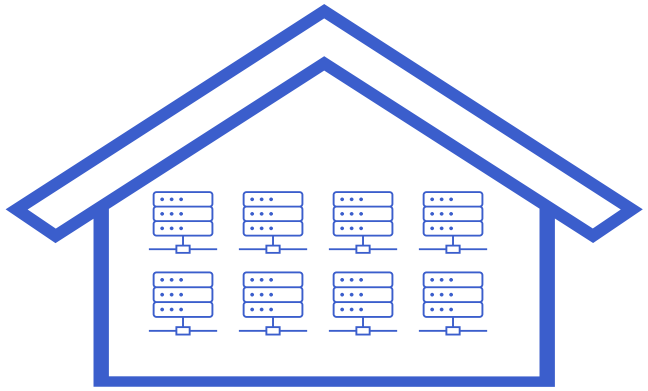
IEEE Advancing Technology for Humanity

LIMITS OF PUE
IGNORES IT EFFICIENCY

Inefficient or underutilized servers
make the PUE look good

PUE: 1.2

Av. Server Utilization: 15%



PUE: 1.5

Av. Server Utilization: 60%

IEEE Smart Cities

IEEE Advancing Technology for Humanity

LIMITS OF PUE
IGNORES END-TO-END ENERGY FLOW

PUE ignores on-premise renewables
or heat recycling

PUE: 1.2

20 MW

PUE: 1.5

20 MW

3 MW
Thermal Energy

IEEE Smart Cities

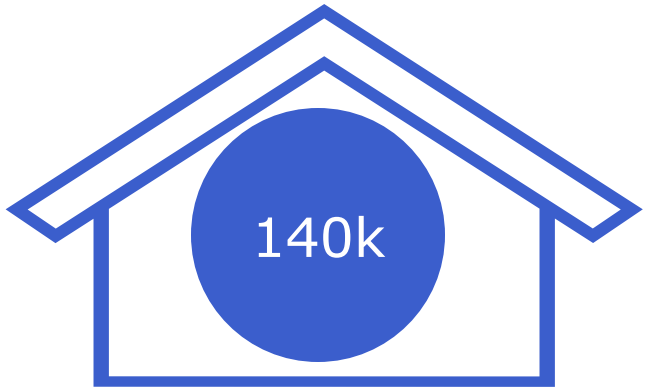
IEEE Advancing Technology for Humanity

LIMITS OF PUE
IGNORES CO_2 EMISSIONS

PUE ignores the
source of electricity

PUE: 1.2

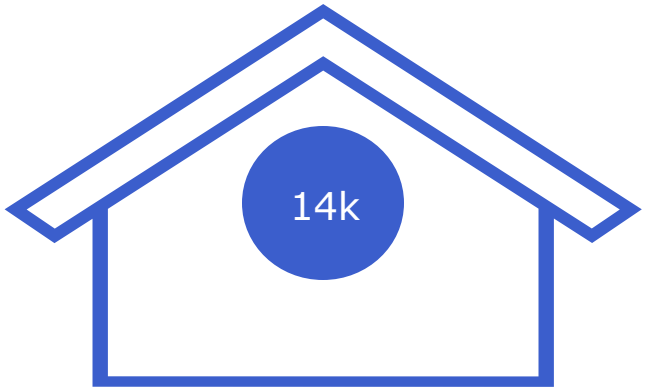
20 MW – 100% Coal Power



tons CO_2/y

PUE: 1.5

20 MW – 100% Renewables



tons CO_2/y

IEEE Smart Cities

IEEE Advancing Technology for Humanity

TRUE OPERATIONAL SUSTAINABILITY
FULL-STACK ASSESSMENT

DC INFRASTRUCTURE

- Power Usage
- Water Efficiency
- Waste Heat Recycling
- Renewables

IT INFRASTRUCTURE

- Watts/op in compute, storage, network
- Utilization
- Efficiency in non-compute components

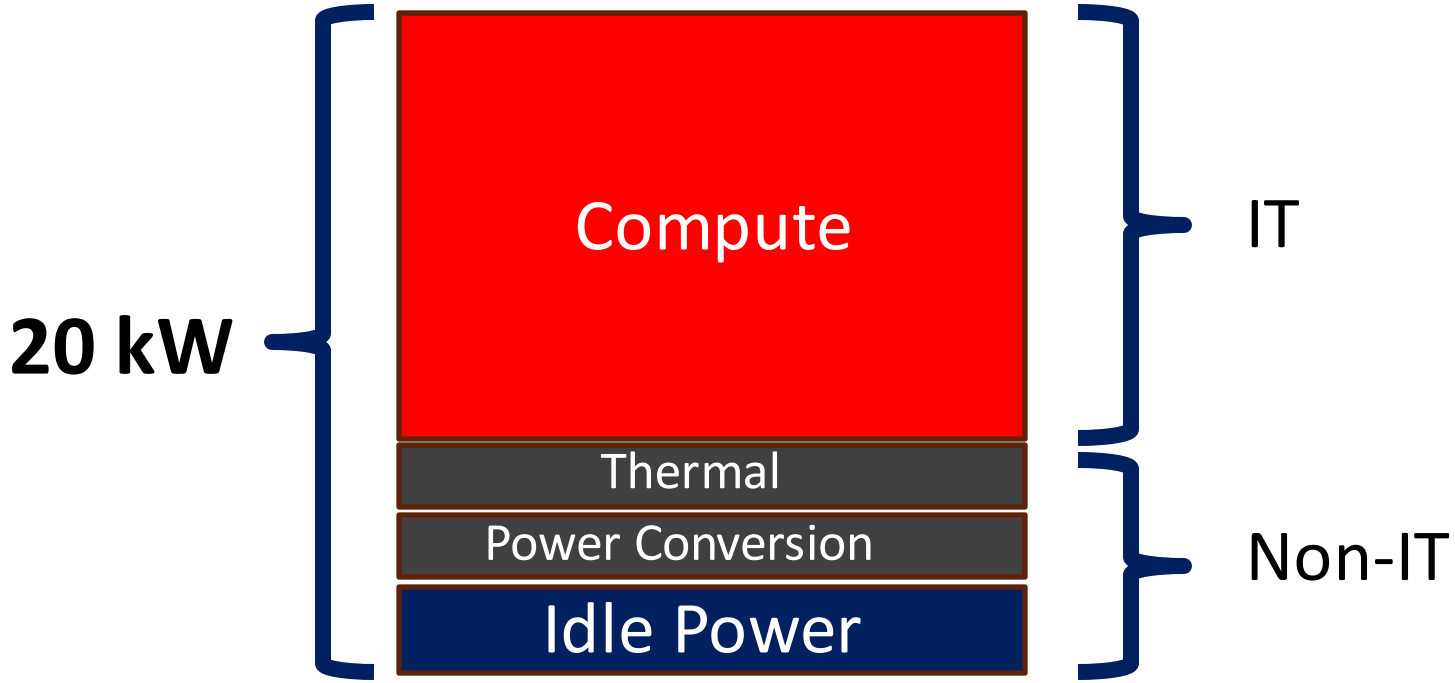
CO_2 FOOTPRINT

- Operational Emissions
- CO_2 value of ingress energy and self-produced energy

IEEE Smart Cities

IEEE Advancing Technology for Humanity

IT INFRASTRUCTURE
WHERE DOES ENERGY GO?



DC Efficiency Metrics Workstream, Open Compute Project (OCP)
EMEA Summit, April 29, 2025

SUSTAINABILITY INITIATIVES
FROM THE INDUSTRY

DATA CENTER EFFICIENCY

SDEA Navigator / SDEA Label

OPEN Compute Project®

Data Center Efficiency Metrics (DCEM) / Sustainability Metrics workstream

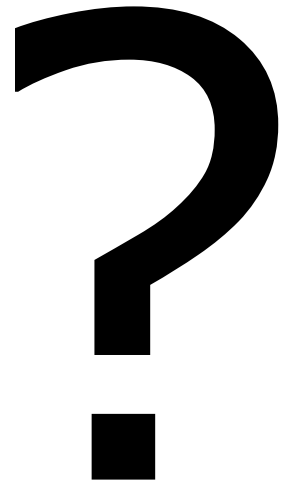
the green grid® enabling data center efficiency

Data Center Resource Effectiveness (DCRE) Metric

IEEE Smart Cities

IEEE Advancing Technology for Humanity

Q&A



IEEE Smart Cities

IEEE Advancing Technology for Humanity