The Efficiency Death-March

The Unintended Consequences of Large-scale Systems Research upon Climate Change

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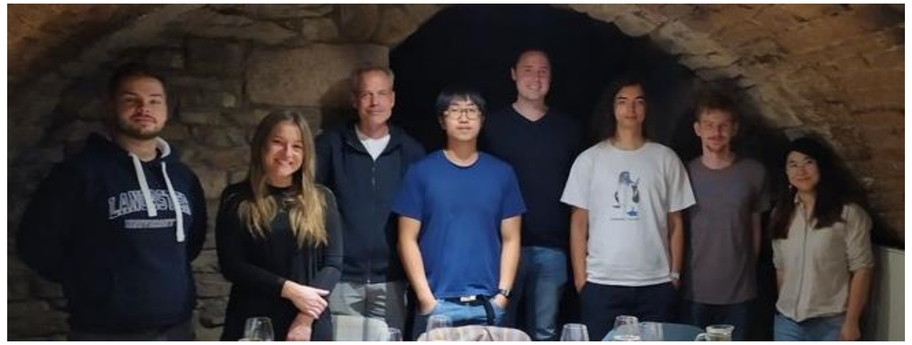
PROFILE



Lecturer in Distributed Systems, EPSRC Fellow

Founder of EDS Lab @ Lancaster University

Next Generation Computing Systems at Scale

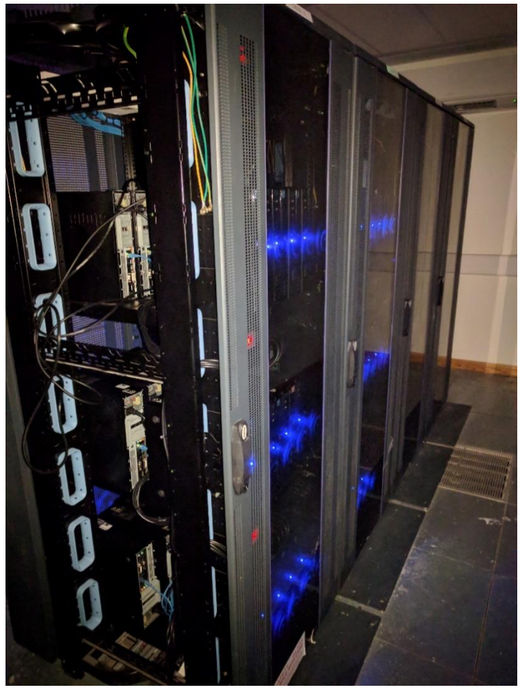
Sustainability, Machine Learning, Datacentres, Resilience, Security

Strong emphasis on experimentation

– Peta-scale cluster schedulers & resource management

– Energy-aware & secure Deep Learning systems

– Operate a considerably large datacenter experiment lab!



ICT Energy Consumption

2019

8-10% electricity, 1% emissions

2025

14-20% electricity, 4% emissions

2040

25-40% electricity, 14% emissions

None of these capture AI impact

ML & Energy

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- Requires **high-power** compute infrastructures:
  - ➢Buildings filled with **extremely complex hair dryers**…
- Continuous improvement in energy efficiency of ML
- However… scale produces non-trivial problems

x 1000 =

FUELLING THE AI RAT RACE

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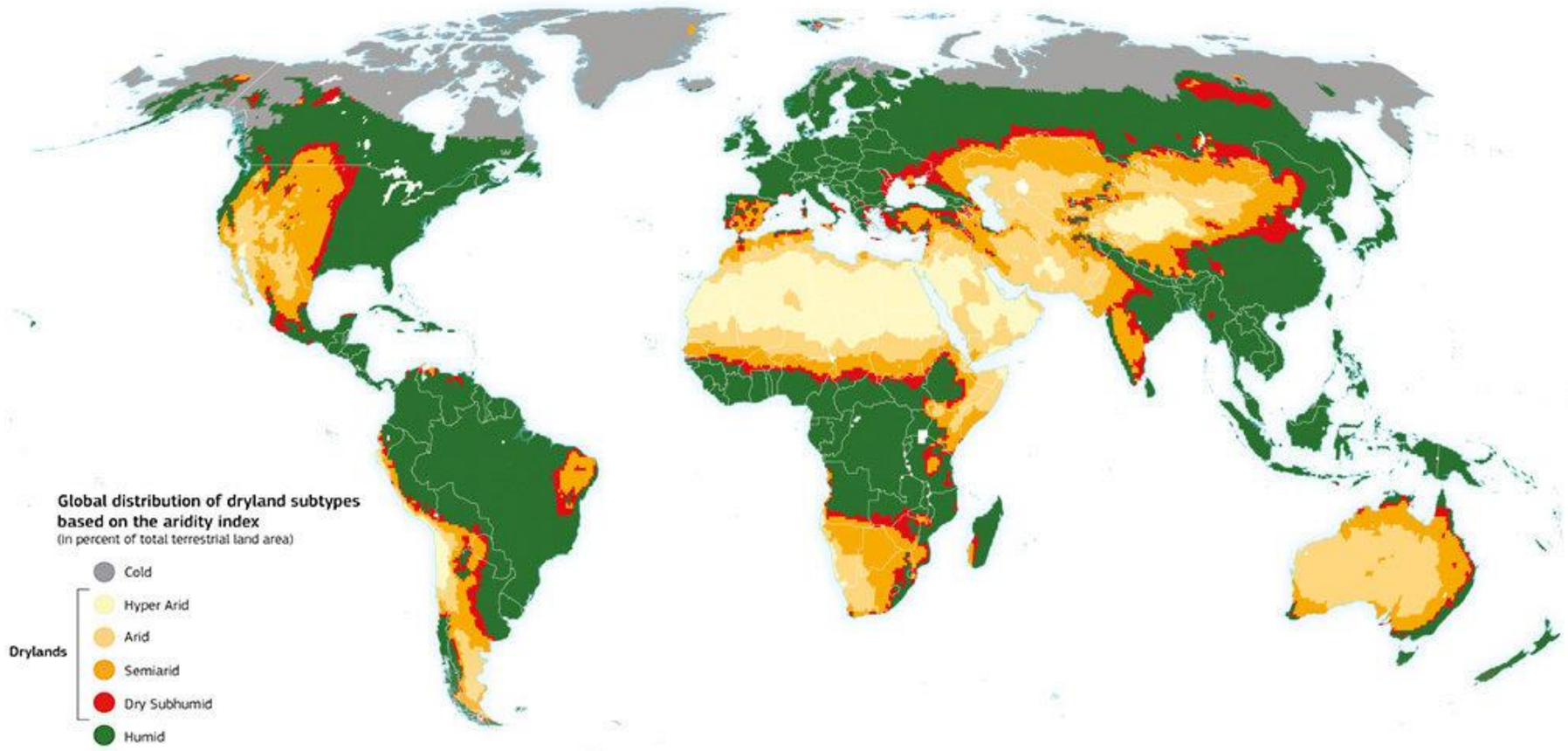
- **Rat-race** towards **accuracy** and **generality** in ML
  - My model is 0.6% more accurate at recognising cats
  - And recognise some dogs
- Leader-boards incentivise **"buying results"**
- AlphaGo – Beating humans at playing Go
  - **960** hours**, 5000** devices
  - $\mathbf{200,000\ kWh}$
  - **40t of CO2** (assuming natural gas)
  - **80,000** vehicle miles

CONSEQUENCE



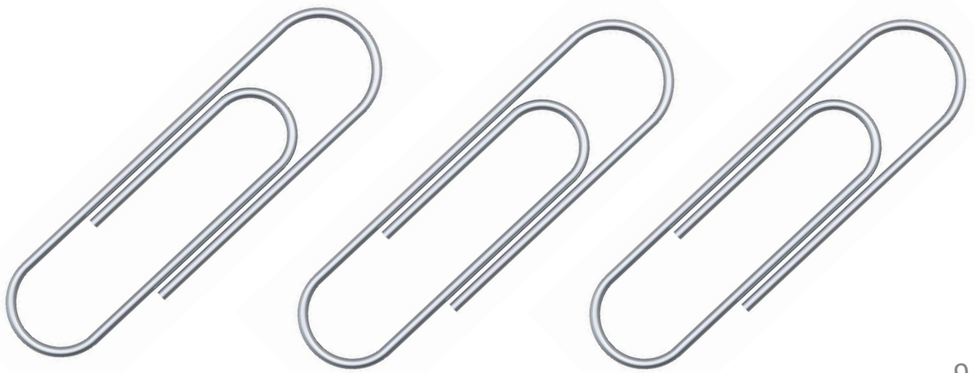
Credit: Global Drylands: A UN system-wide response, United Nations

Typical Approaches

- Technological Innovation
- Understand end-use
- New energy sources
- Social & legal reform

Why has the global ICT footprint not decreased?

The Trouble of Efficiency

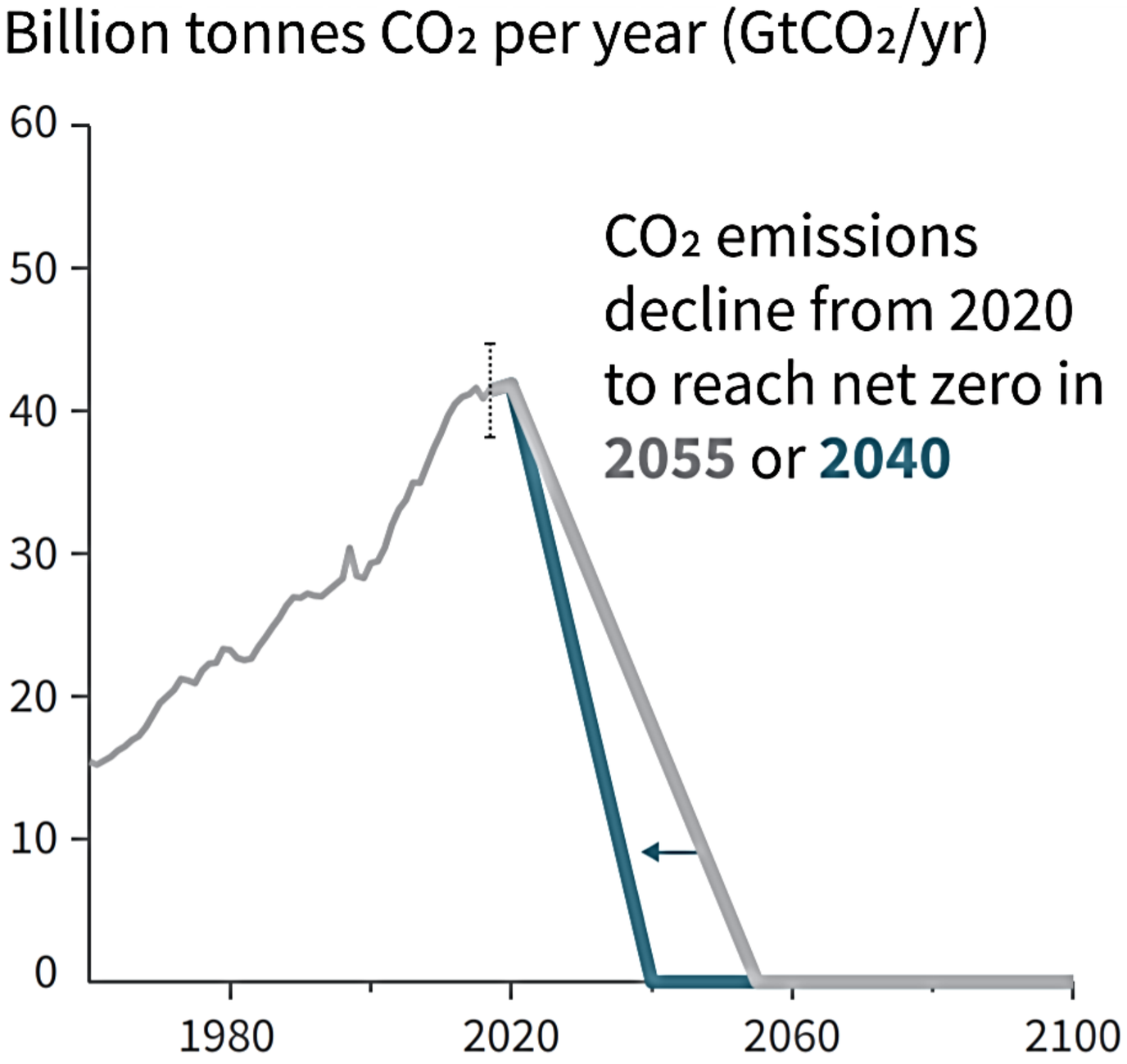


JEVON'S PARADOX

- Technology progress/government policy increases resource efficiency, but increases consumption
  - Network use & data
  - High quality images
  - Faster compute
- **A lot our efforts may have accelerated this!**
  - *"Its outside of my remit…"*
  - The Efficiency Death-March

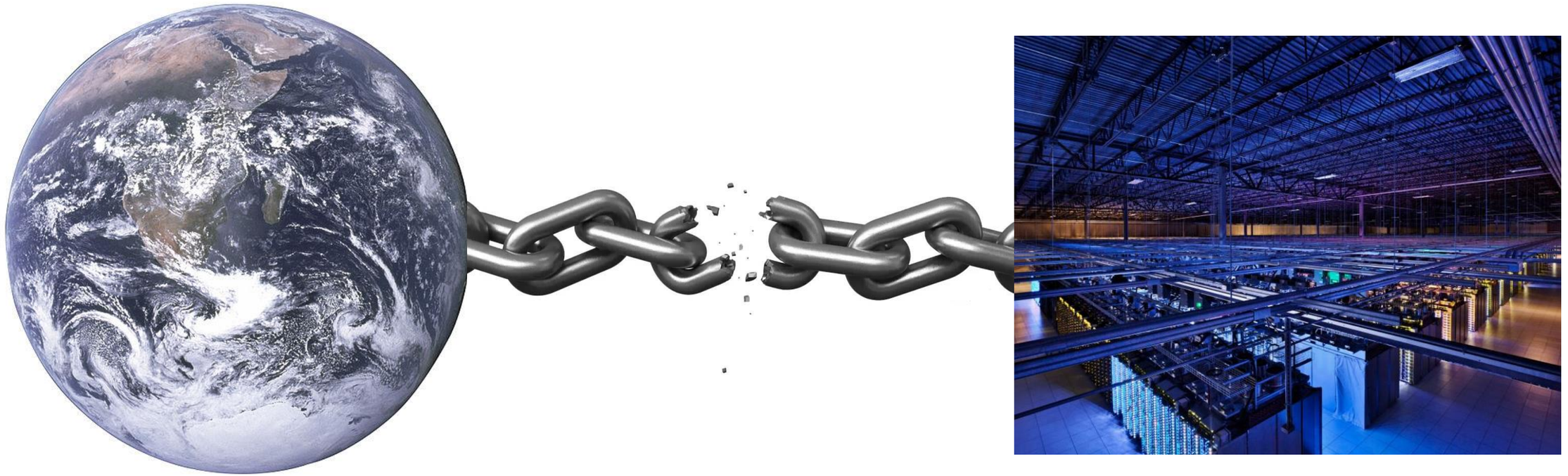
Thought Experiment

- The perfectly efficient system would not solve the problem of demand


Billion tonnes CO_2 per year ($GtCO_2$/yr)
60
50
40
30
20
10
0
1980
2020
2060
2100
CO_2 emissions decline from 2020 to reach net zero in 2055 or 2040

RECOMMENDATIONS

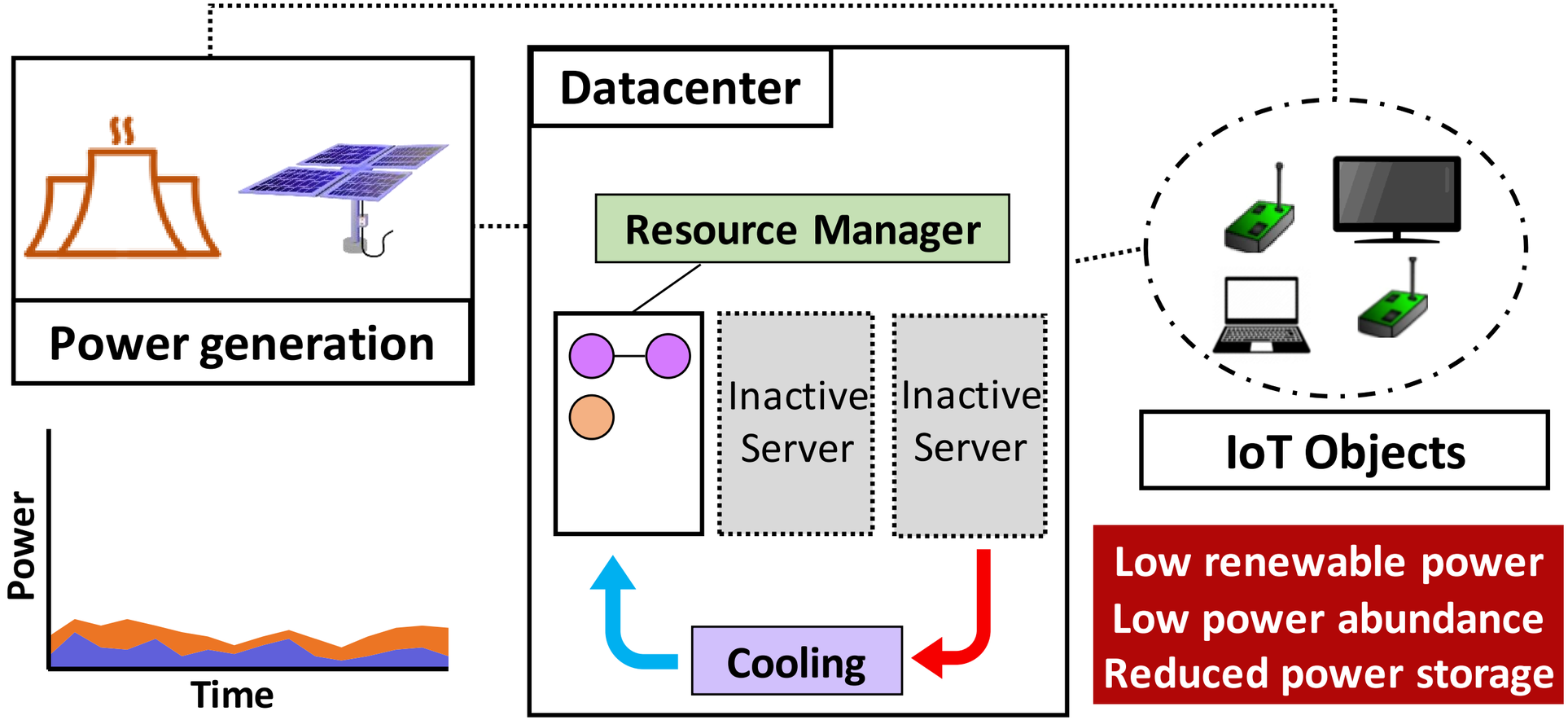
- More carefully worded introductions
- Responsible sustainability text
- Better metric/evaluation than efficiency?
- Gratuitous cognitive ability (more energy = more intelligent)
- Energy-adaptive ICT systems

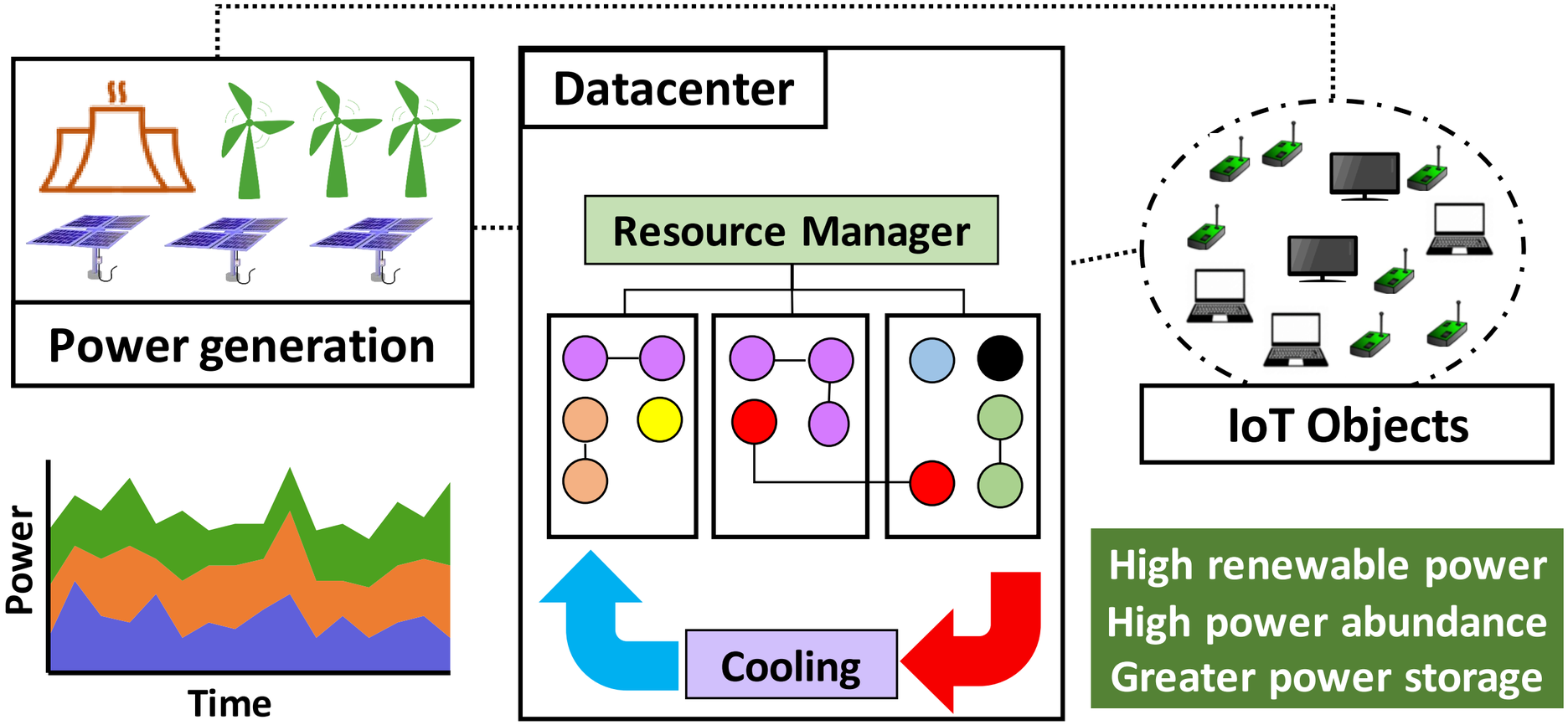


Unshackle digitalisation demand from the environment

Reverse global ICT footprint & attack climate change

AI will have critical importance yet also hinder


Power generation
Datacenter
Resource Manager
Inactive Server
Inactive Server
Cooling
IoT Objects
Power
Time
Low renewable power
Low power abundance
Reduced power storage


Datacenter
Resource Manager
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Power generation
IoT Objects
Power
Time
High renewable power
High power abundance
Greater power storage

Final Thoughts

The cost of large-scale systems (and ML) will be enormous

- Digitizing other industries
- Jevon's paradox, rebound effect
- 10% to 40% global electricity in several decades?
- Embedded objects, robotics, autonomous vehicles

Need radical rethink – what is "Green Computing"?

- Surely not just greater energy-efficiency
- Gratuitous cognitive ability (more energy = more intelligent)
- Self-adapt ML assembly based on energy availability

Recently funded project in this space
Multiple PhD and postdoc positions available

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