Artificial Intelligence:
A High Level Perspective

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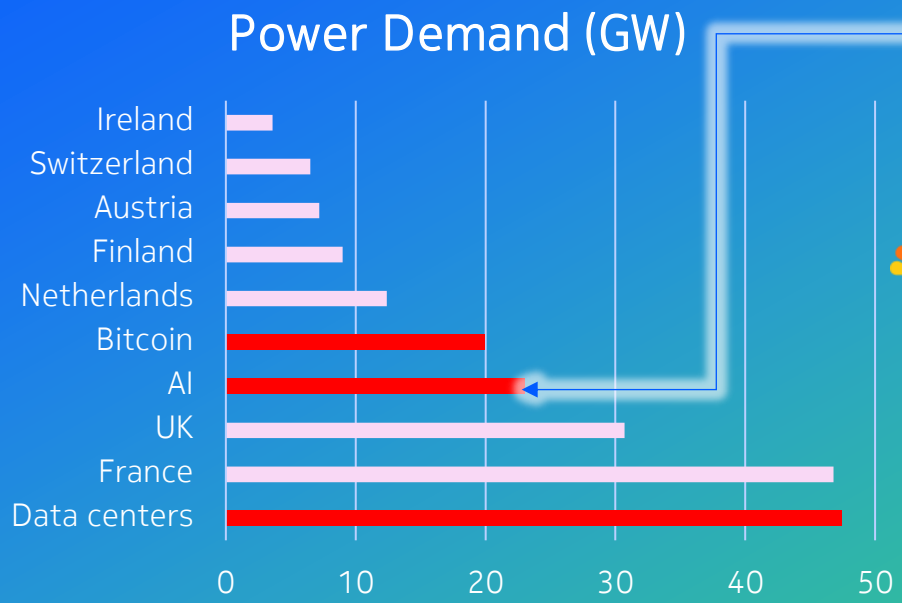
AI Power Consumption Is Growing At Dramatic Rates



The Guardian

AI could account for nearly half of datacentre power usage 'by end of year' (2025) Link

CNBC

Google says U.S. is facing a power capacity crisis in AI race against China

PUBLISHED WED, FEB 12 2025 1:02 PM EST Link

MIT Technology Review

"We did the math on AI's energy footprint. Here's the story you haven't heard." Link

Source: Alex de Vries-Gao. "Artificial intelligence: Supply chain constraints and energy implications": Link

Notes: situation at the end of 2024, AI end 2025. 'Datacenters' excludes crypto mining.
AI is considered 'all-in' including training power consumption, for instance.

Why did I start with that slide?

National power grids are already under stress dealing with intermittent renewables

And they don't always cope well

The appearance of Gigawatt scale AI data centers can only make the situation worse in the short term

Will AI really be good for the environment?

This is the focus of my presentation

The Good News?

"AI will be help rather than hindrance in hitting climate targets, Bill Gates says"

The Guardian

Link to story

"Growth in global electricity demand is set to accelerate in the coming years as power-hungry sectors expand"

IEA

Link to story

The world's electricity consumption is forecast to rise at its fastest pace in recent years, growing at close to 4% annually through 2027

"Can the climate survive the insatiable energy demands of the AI arms race?"

The Guardian

Link to story

Dgtl Infra — Data Center Water Usage: A Comprehensive Guide

ING — Growth in water consumption of data centers needs more attention

World Economic Forum — Why circular water solutions are key to sustainable data centers

NOKIA

But why do we seem to be *rushing headlong* into an AI future?

The “once in a lifetime” AI opportunity

...and...

Why companies are building huge AI data centers

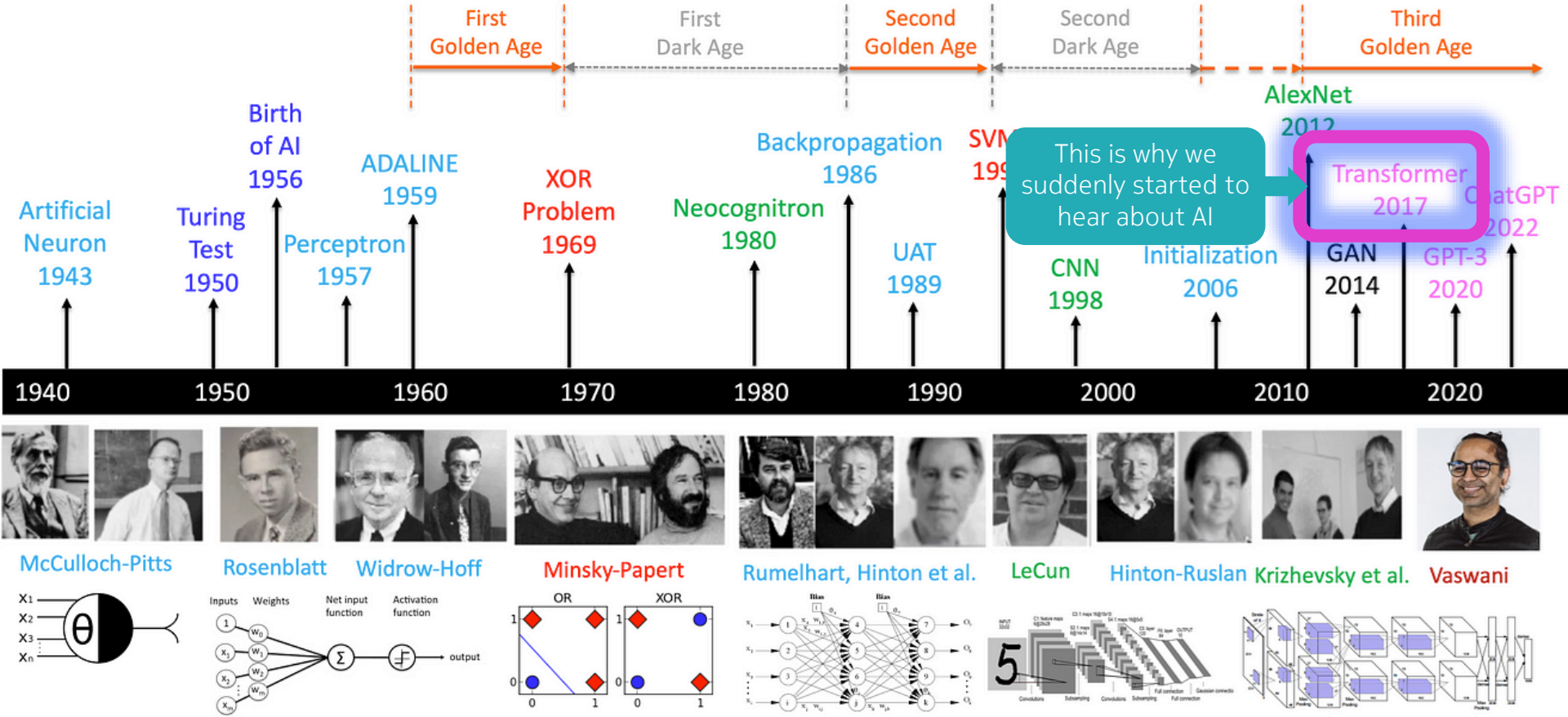
Here’s a clue ☺

Money
+
FOMO { Link Link Link Link

Yes…but why now?

A Brief History of AI with Deep Learning

Author: LM Po



Read the full article here – highly recommended!

The Once-In-A-Lifetime AI Opportunity - $$$

How did we get to the doorstep of the next leap in prosperity?

In three words: *deep learning worked*.

In 15 words: *deep learning worked, **got predictably better with scale, and we dedicated increasing resources to it***.

Sam Altman, OpenAI

Hyperscaler DC Investments in 2025

Google $75B

Microsoft $75B

Meta $60B

amazon $100B[1]

Stargate LLC

OpenAI ORACLE

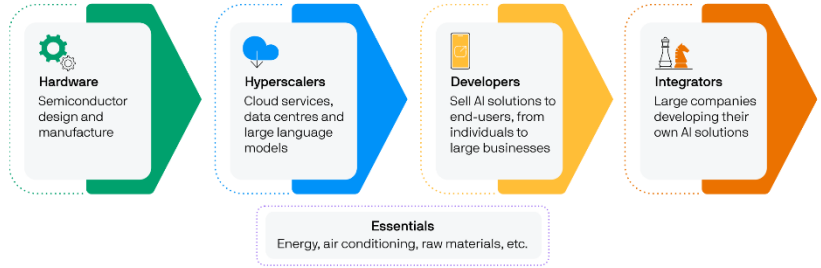
Crusoe SoftBank

$100B → $500B

MGX

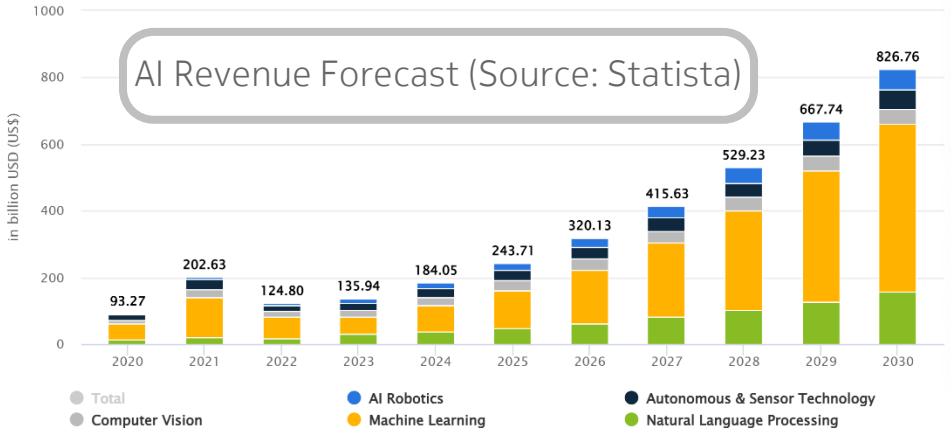
[1]Reported as total CapEx, not just DC

Emerging AI Ecosystem



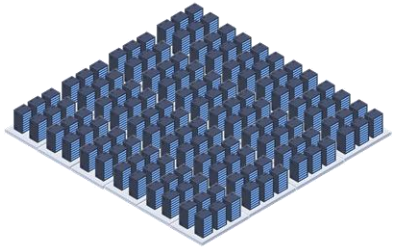
Source: J.P. Morgan Asset Management, as of November 2024.

AI Revenue Forecast (Source: Statista)



Data Centers Are Getting Bigger!

Note: These examples are to show the headlong rush to mega scale data centers is real. The actual ranking of current future data centers is not clear cut – especially in China, where past claims have been challenged.



AI is resetting the expectation of what a "large Data Center" is

2013

Then… largest DC in Europe

Meta's Lulea Data Center

30 MW*

84,000 m^2

*267,471 MWh of electricity annually and withdraws 25.4 million litres of water

Source: Baxtel

2025

Largest DC in the World

China Telecom IMIP

150 MW

1,000,000m^2

Note – China occupies the first 7 places in at least one Data Center Top 10 list

2028

Largest DC Announced

Jeollanam-do Province South Korea

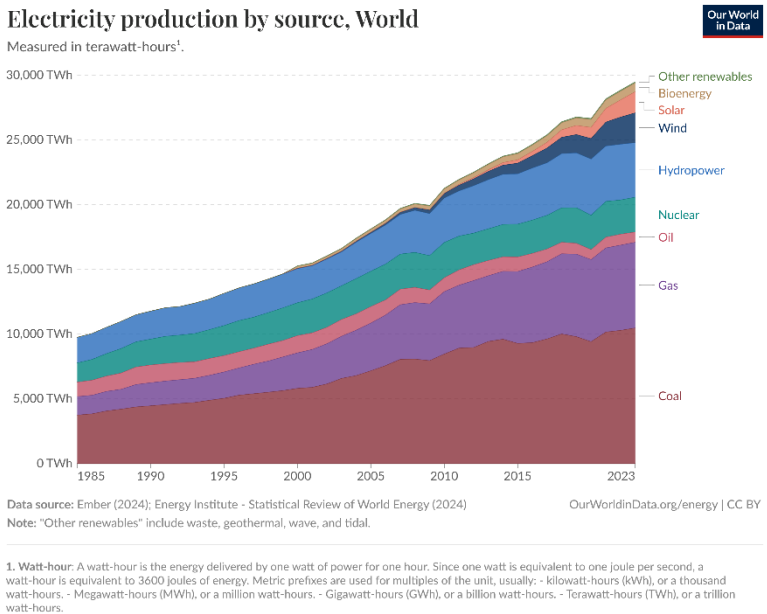
3,000 MW

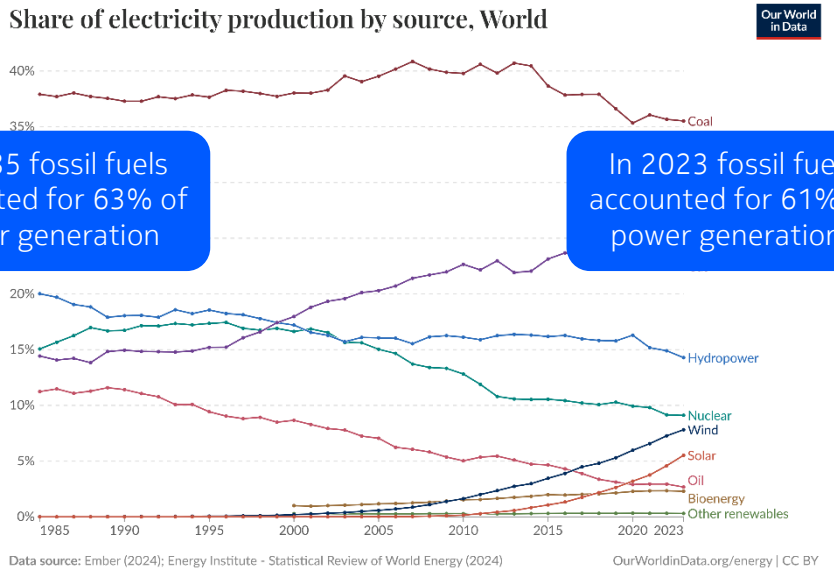
$35B Investment

Source: Capacity

A Few Basics About Our Electricity

How Does The World Generate Electricity?





In 1985 fossil fuels accounted for 63% of power generation

In 2023 fossil fuels accounted for 61% of power generation*

*2023 data includes 2.3% bioenergy, and some forms have significant CO2 footprint

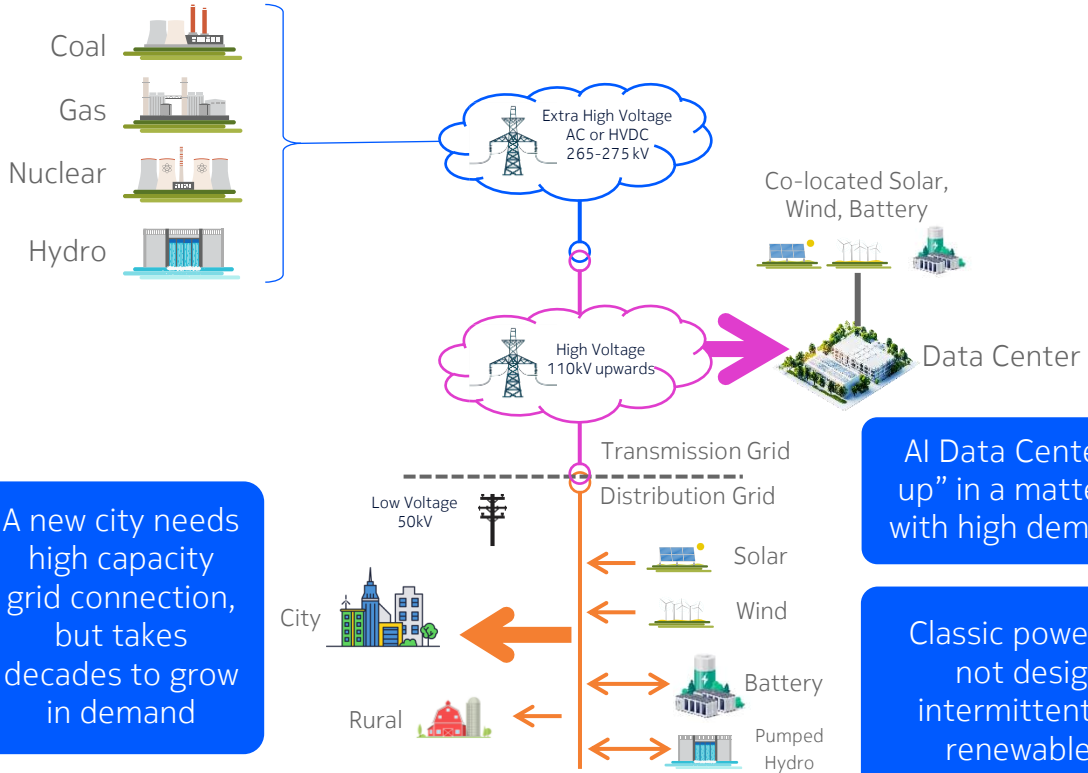
Energy consumption is rising

This is a good thing! Energy = Prosperity
Don't feel guilty that this is chart is rising…

Little or no progress on decarbonization

…we need to be far more focused on ***how*** we generate this power

Power Grids are a Vital National Asset



A new city needs high capacity grid connection, but takes decades to grow in demand

AI Data Centers can "pop up" in a matter of months with high demand on Day 1

Classic power grids were not designed with intermittent, DC power renewables in mind

Think about grid in same way as the internet – a cloud…maybe ☺

The Grid is fed from power stations that generate AC

Different voltage levels for efficient transmission and distribution

Normal scale users – like cities and farms – use Distribution Grid

Renewable installations usually feed into the Distribution Grid – and generate DC

Storage systems also have 2-way connection to Distribution Grid and may generate DC or AC

Very high demand users will connect directly to the HV transmission grid

Data Center may have local Solar, Wind and Battery Storage

Needs Grid connection for reliability against intermittent renewables

Many Countries Experiencing Grid Congestion Issues

1,100 Renewable Energy Projects Stuck in Grid Queue: Breaking Down the Delays in the UK

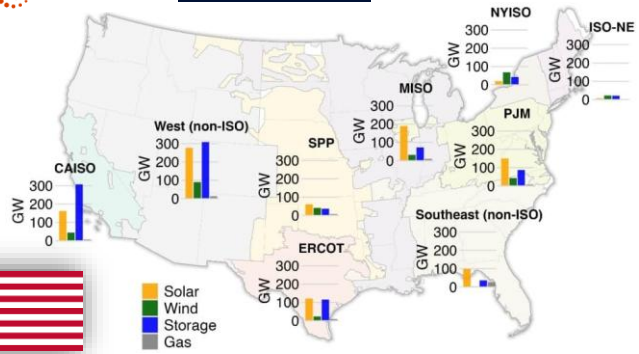
Link to article

Capacity crunch on National Grid is delaying new homes in UK by years

Council leaders warn of 'infrastructure crisis' that will also affect green energy schemes and hinder growth

Link to article

Reuters Link to article



Size of grid connection queues across USA

Solar Energy UK

About us So

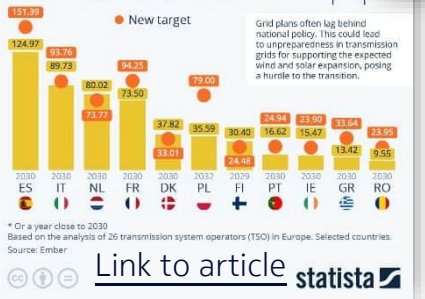
MPs to be told grid delays are descending into farce

Solar Energy UK
7 February 2024

Link to article

Grid Bottlenecks on the Way in Europe?

TSO grid plans for solar/wind capacity versus 2030* energy policy targets (in gigawatts)



Link to article statista

Size of wind farm connection queues across Europe

Link to article

It's OK – I ticked the box to offset my carbon footprint 😇

UNIVERSITY OF CAMBRIDGE

Link to report

Millions of carbon credits are generated by overestimating forest preservation

Study analyses major carbon offset projects, and finds that – of a potential 89 million credits – only 5.4 million (6%) were linked to additional carbon reductions through tree conservation.

Reel

The Problem With "Green" Energy Certificates

Link to article

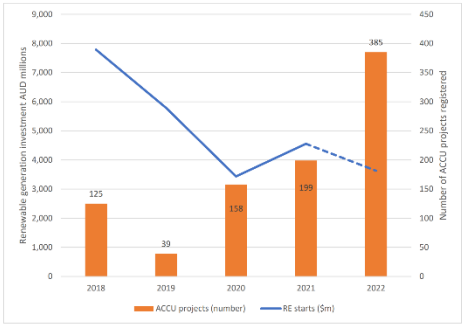
Problem: Carbon credit schemes are poorly regulated and, in a hugely shocking revelation, it seems that humans can be rather unscrupulous

Australia's experience – Carbon Credit Schemes increasing while Renewable Energy projects decreasing

Link to report

ACCU = Australian Carbon Credit Units

Figure 7: Renewable generation commencements vs number of ACCU projects



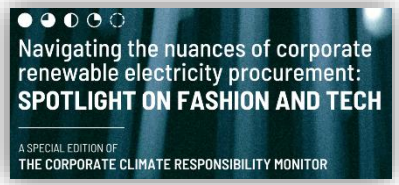
Sources: ABS (2022) Value of renewable energy construction; Emissions Reduction Fund (2023) Emissions Reduction Fund project register. Note: 2022 data for renewable energy starts is only available for March and June quarters. Figure 8 extrapolates the average of the March and June quarters across the calander year.

Clean Energy Agreements

Why use "real" clean energy when you can buy "virtual" clean energy?

Issues in the domestic market...

...and with big corporations



Link to report

Problem: Companies are trading in Clean Energy Contracts as a quick fix – allowing them to delay or avoid taking *effective* energy decisions

Long term this actually reduces the number of real clean energy projects being started

NOKIA

Let’s pause for some case studies

The Challenges of Data Center Success: Virginia

TREND: BYOP
(Bring Your Own Power)

What do they need?

11 GW of new data center capacity by **2030** in Northern Virginia alone

40% of VA's *peak* demand today

How do they get there?

10-15GW of firm generation capacity

Why is this a challenge?

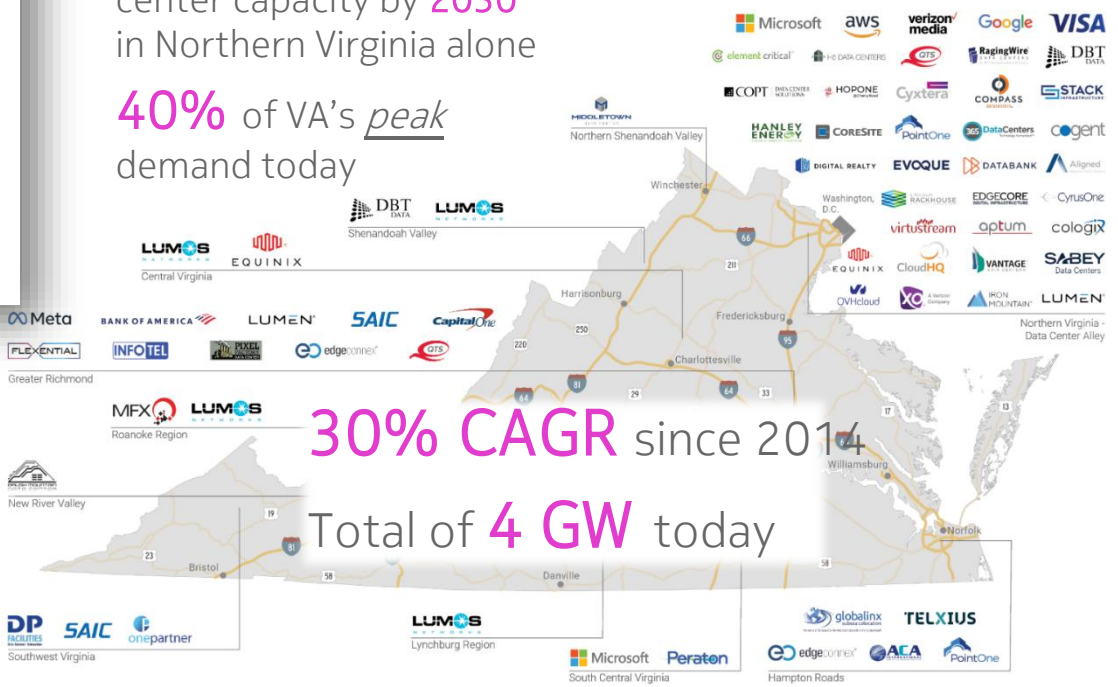
It can take 3-4 years to approve a new gas-fired generating plant (e.g. 1 GW)

Market prices are too low for developers to build the required capacity

Wasted effort if you can't connect to the grid!

→ Free Market Challenges!

Virginia Data Center Market



30% CAGR since 2014

Total of **4 GW** today

Is Gigawatt-Scale BYOP Viable? Let's look at xAI's Colossus in Memphis

Today
100,000
H100 GPUs

Tomorrow
200,000
H100 GPUs

100,000 H100s will require 150 MW

MLGW

Local grid supply*: 8 MW

*As of August 2024

Smog levels in Shelby County have exceeded recommended levels for the past 3 years

X14 

35 MW

Natural gas powered mobile generators

X4 

64 MW

MLGW has agreed to upgrade site to: 50 MW*

*At a cost of $760,000 to local taxpayers

SOUTHERN ENVIRONMENTAL LAW CENTER

*The grid is already overloaded**

*Not a direct quote

A 150 MW, $24M new substation is about to come online

But… where does the power actually come from?

Article: "xAI cluster is now the most powerful AI training system in the world"

Breaking News – xAI to expand Colossus to 1 million nodes!

The local people of Memphis are not happy

Link to article

- xAI filed for permit for *15 gas turbines*.
- Didn't bother waiting for approval – and they are now operating *35 turbines*!
- According to SELC these emit *1,200-2,000* tons of Nitrogen oxides per year…compared to…
  - Valero oil refinery (*342* tons)
  - Draslovka chemical plant (*743* tons)
  - Memphis International Airport (*1,077* tons)

Q: Where are they going to get 10X (1,500 MW) the power? Rumor has it: *Another* 40-90 gas turbine generators! Link

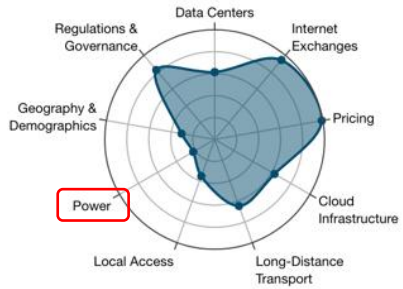
Where could we build Gigawatt scale Data Centers?

Source: Telegeography

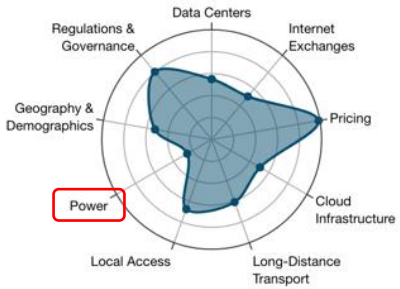
Telegeography Market Connectivity Scores 2Q25

Europe:

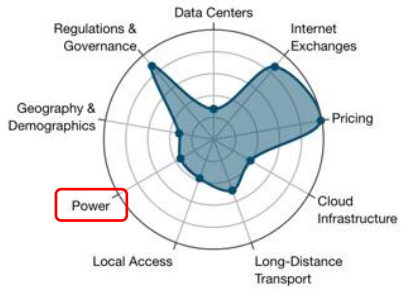
Frankfurt



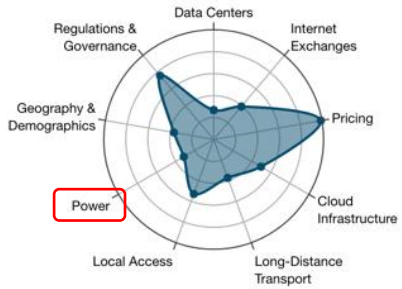
London



Amsterdam



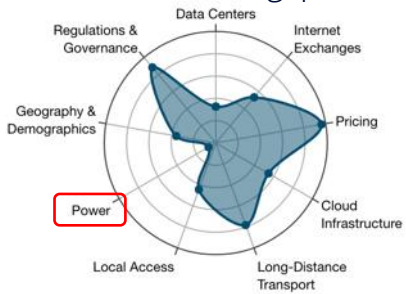
Paris



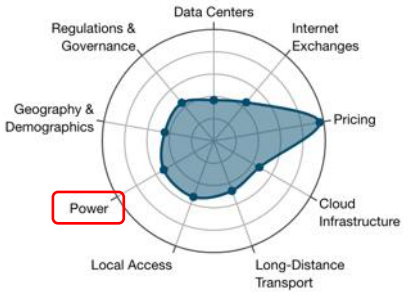
RoW:

Tokyo

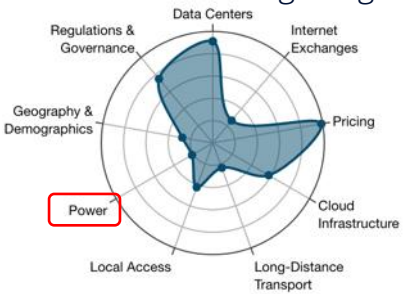
Singapore



New York



Hong Kong



How Do We Power AI Data Centers?

What do AI data center operators really need?

1 Gigawatt Scale

*City examples that can be powered with 1 GW**

Dublin	Southampton
Nice	Liverpool
Islamabad	
Amsterdam	Forth Worth
Cologne	Jacksonville
Oslo	Austin
Cartagena	San Jose

*Assumes a population of around 1 million, Source: Wikipedia

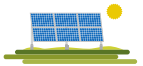
2 24/7/365 Energy Supply


Coal


Gas


Nuclear

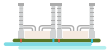
24/7/365 Power Sources


Solar

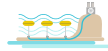

Wind

Intermittent Power Sources


Hydro

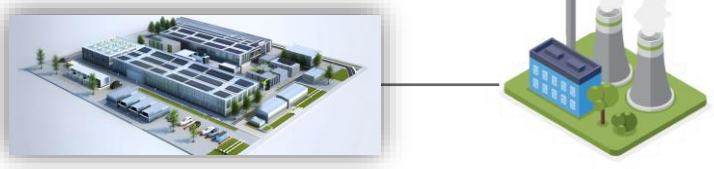

Geothermal


Tidal


Wave

Location-Specific Power Sources

3 Compact Installation



Co-locate power and Data Center

Avoid grid connection?

4 Low CO_2 Emission (has become "optional")

Google

Goal: "Carbon neutral by 2030"

Reality: 48% increase in CO_2 emissions since 2020

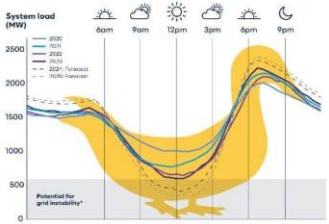
Microsoft:

Goal: "Remove all MSFT CO_2 emissions by 2050"

Reality: 29.1% increase in CO_2 since 2020

Source: Hyperscalers versus the sustainability pushback

What About Batteries?



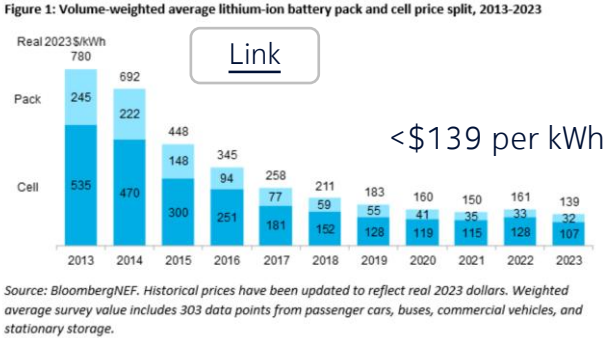
BESS* technology is *specifically intended* to "flatten the duck curve"

*Battery Energy Storage System

- 864 MW of solar PV
- 3,287 MWh of battery storage

The largest BESS in the world could only power a Gigawatt-scale data center for 3 hours!

The largest BESS in Europe would only last 40 minutes!



In addition to becoming cheaper, battery tech has moved away from using Nickel and Cobalt in the battery chemistry

Solar Panel Waste

$20-30
Cost to recycle a panel

<$2
Send to landfill

Lithium Battery Recycling

What % are recycled today?

Between 5% and 59%*

*Difficult to find accurate estimate because it is unregulated

Power Options for AI Data Centers..Two Potential Winners

Gigawatt Scale

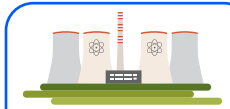
24/7/365
Assume >50% CF

Compact
Assume <5m² per MWh

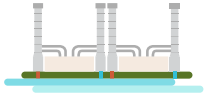
Low CO_2
Assume <50g per kWh


Coal


Natural Gas


Nuclear


Hydro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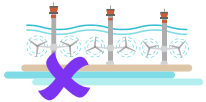
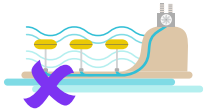
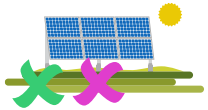
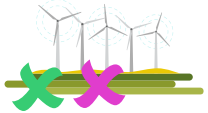

Tidal

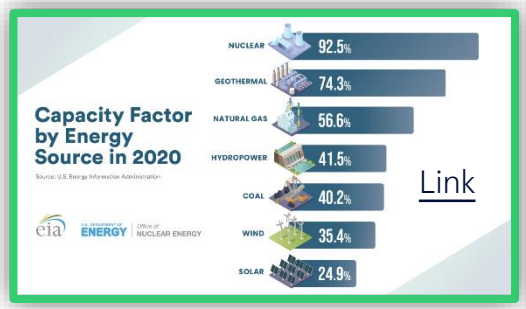

Wave

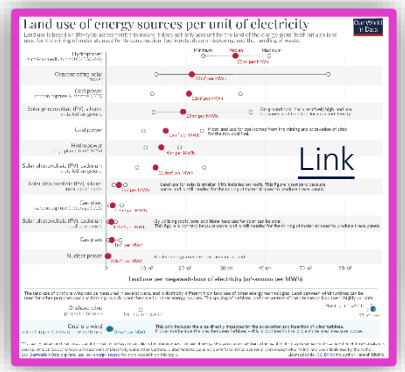

Solar

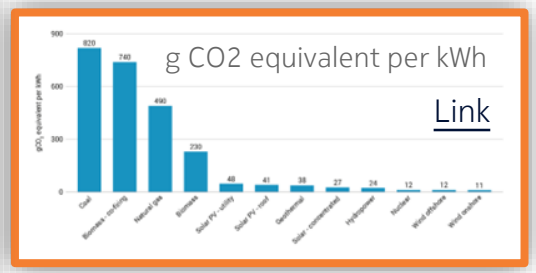

Wind

TYPE	POWER OUTPUT
Hydro	22,500 MW
Wind	20,000 MW
Natural Gas	8,600 MW
Nuclear	7,900 MW
Coal	6,720 MW
Solar	5,000 MW
Geothermal	1,590 MW
Wave	77 MW
Tidal	254 MW

List of largest power stations by type

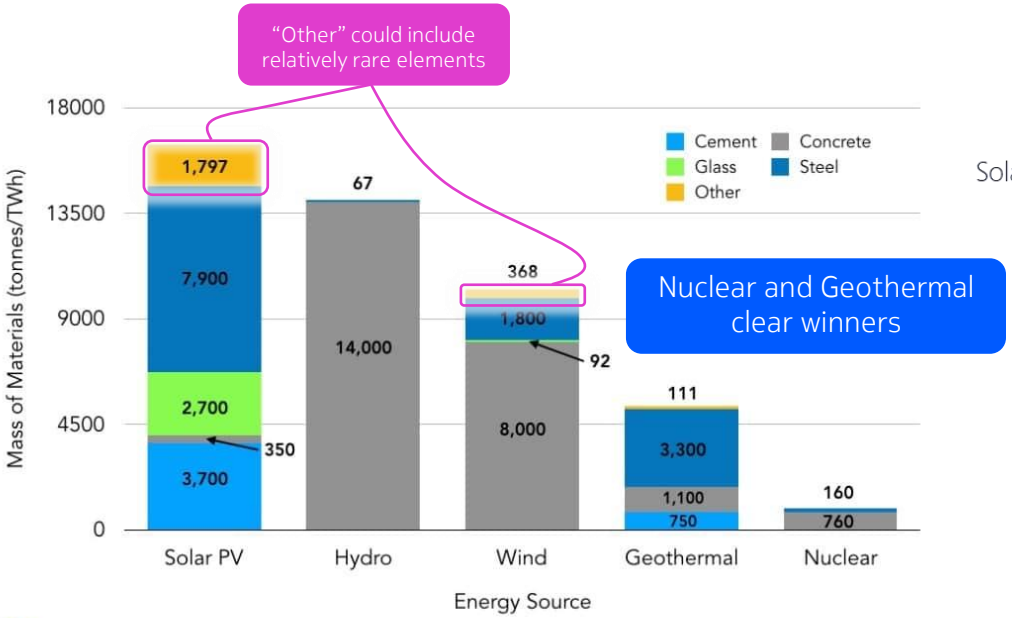






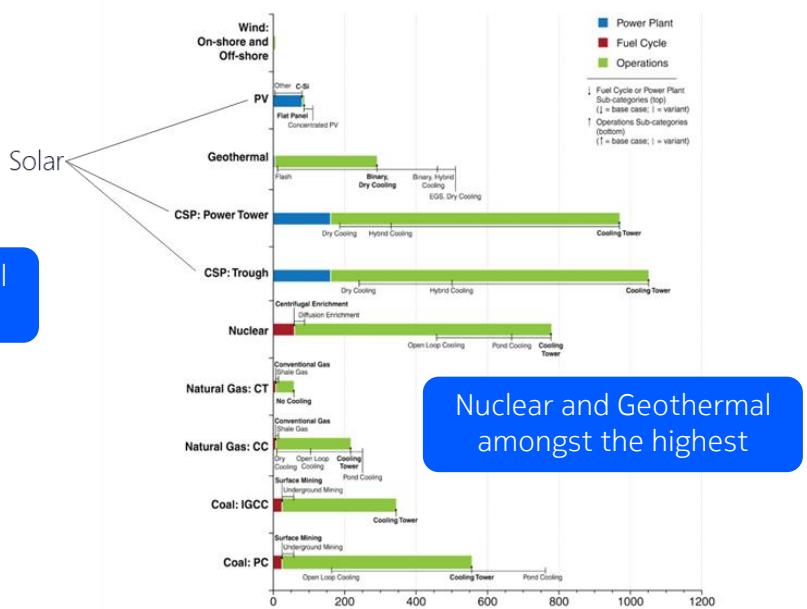
Materials Use By Power Generation Type

Manufacturing Materials



"Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities," Table 10. September 2015. United States Department of Energy. Nuclear and hydro require 10 tonnes/TWh and 1 tonne/TWh of other materials, respectively, but are unable to be labeled on the graph.

Water Consumption



Link: Figure 10.C

Notes: Not all cooling options are shown; for instance, more expensive, dry cooling (with zero water consumption and withdrawal) is an option for most plants. Key: **PV** = solar photovoltaic; **C-Si** = crystalline silicon; **EGS** = enhanced geothermal system; **CSP** = concentrating solar power; **CT** = combustion turbine; **CC** = combined cycle; **IGCC** = integrated gasification combined cycle; and **PC** = pulverized coal, sub-critical.

Geothermal

Focus on promoting new geothermal

International Energy Agency Report: Future of Geothermal Energy 2025

The Future of Geothermal Energy (US-specific report)

The ground below the earth's surface is hot because of the *radioactive decay* of natural elements like uranium and thorium

In some places around the world this heat is easier to get to – *Conventional Geothermal*

Conventional Geothermal provides *less than 1%* of global energy today – because it tends to be used in the "easiest" geothermal locations

United States, Iceland, Indonesia, Turkey, Kenya, Italy

Enhanced Geothermal Systems use fracking techniques to open up many more locations

Enhanced Geothermal Pros

Potentially low CO_2*

24/7/365 operation

Small footprint

Skillsets match Oil/Gas industry

Enhanced Geothermal Cons

Potential emissions

Potential waste production

Potential for seismic disturbances

Most designs are "megawatt" scale

Potentially need lots of water

New EGS systems are unproven

Potential to create *100 GW* of new geothermal generation within *50 years*

Total cost of *$600-900M*

*Geothermal may release CO_2 from underground. This *can* be removed before release, but the USA is not a Kyoto treaty signatory so it is unclear if CO_2 emissions would be monitored or enforced for EGS plants.

And what you've all been waiting for...

Nuclear

Because nuclear seems like the *perfect solution* to power AI Data Centers

Or does it? 😁

Nuclear may have…issues… and we've lost lost a generation of experience

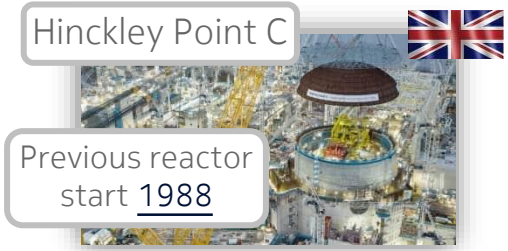
Georgia, USA

4.5 GW Power Output

Westinghouse AP1000 PWR

Original timeframe of 2017 slipped to 2025

Costs have risen from $14B to $37B (over 2.6X)



Somerset, UK

3.2 GW Power Output

Framatome EPR1750 PWR

Original timeframe of 2025 has now slipped to 2029-31

Costs have risen from $12B to $56B (over 4X)

Normandy, France

1.65 GW Power Output

Areva EPR1750 PWR

Original timeframe of 2012 has now slipped to 2025

Costs have risen from $3.4B to $19.6B (almost 6X)

Fun fact: where do all these reactors get their fuel from?

TVEL ROSATOM

From Russia with love ☺

LINK: Nuclear energy and international relations: the external strategy of Russia's Rosatom

LINK: Russian nuclear energy diplomacy and its implications for energy security in the context of the war in Ukraine

Does *anybody* still know how to build nuclear power stations?

In 2007 Vladimir Putin ordered the total integration of >350 individual companies in the Russian nuclear supply chain

ROSATOM

Imagine you are an "unaligned" country with no nuclear experience, but a desire to deploy clean energy

...nuclear seems complicated

If you approach the USA, France or Korea – they can only help with part of the solution

Example: Google working with ElementL for nuclear reactor projects

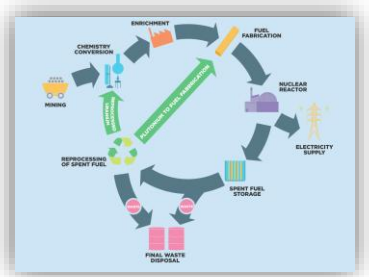
Site planning
Finance
Project management
Personnel training
Operational support
Fuel supply
Waste management

It's either "your problem" or you have to work with "partners"

Ready-made for time and budget over-runs

But they still have a very "Soviet" attitude towards secrecy

Rosatom is a one-stop shop



Not just for fuel

LINK: What caused a plume of radioactive ruthenium in Europe in 2017?

ROSATOM

Site planning
Finance
Project management
Personnel training
Operational support
Fuel supply
Waste management

And others have huge ambitions

Link to article

57 Operational Reactors
28 under construction

Goal to build 150 new reactors by 2040

Replace *all coal fired plants* by 2060

Goal to sell 30 reactors to Belt and Road partners by 2030

22 Countries Pledge to Triple Nuclear Capacity in Push to Cut Fossil Fuels

COP28 Nuclear Agreement

Lots of political celebration ☺

Little or no action* ☹

*Apart from Russia and China

The Hyperscalers' Plans for Power: BYOP* *(Bring your own power) SMR = Small Modular Reactor

	Short Term	Long Term
amazon	Purchased 900 MW Data Center next to Susquehanna Nuclear Plant	SMR plans in 3 US locations (inc. VA and WA) X energy Anchor investor
Google	*Geothermal investments* FERVO ENERGY	October 2024: Google announced agreement with Kairos Power for SMRs — Kairos Power Elementl Power and Google Sign Strategic Agreement to Develop Locations for Advanced Nuclear Projects — ELEMENTL
Microsoft	September 2024: Microsoft sign agreement to reactivate reactor at Three Mile Island & CEC and SMR deal with OPG	Nuclear Fusion deal with Helion — HELION
ORACLE	Talking about a 130k Nvidia cluster	"Intention to build Gigawatt-scale AI data centers powered by Small Modular Nuclear Reactors"
Meta	Plan to build Data Center near nuclear facility blocked by discovery of rare bees	August 2024: Agreement with Sage Geosystems for Geopressurized Geothermal System — SAGE GEOSYSTEMS

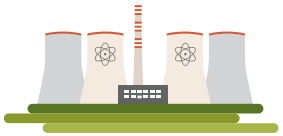
NOKIA

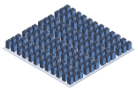
What is a Small Modular Reactor?

Source IAEA

The SMR Booklet 2022

Conventional Nuclear Reactor
700 MW-1.6 GW





Power a city or Mega Data Center

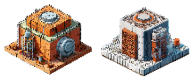
Small Modular Nuclear Reactor
<700 MW

Power a town or regular Data Center

Micro Reactor
10 MW

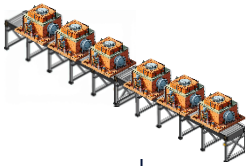
Power a factory or small Data Center

In a world of "joined up" thinking you would...



...choose 1 or 2 designs...

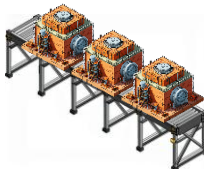
...test them carefully...



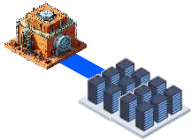
...crank them out

The idea is to build SMRs in factories on a production line

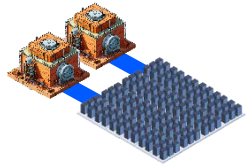
Reduce cost and time to build while improving quality

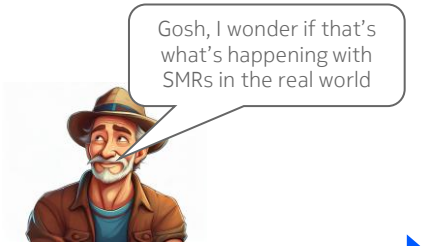


Small enough for co-location to avoid grid connection delays



If you need more power or resilience, just deploy more SMRs





Selection of Companies Building 60+ SMR Designs

10+ Years

Operational

中国华能集团有限公司 CHINA HUANENG GROUP CO.,LTD.

HTGR: Grid connection 2021

ОКБ АФРИКАНТОВ РОСАТОМ

OKBM Afrikantov
PWR: Akademik Lomonosov
May 2020

Under Construction

中核集团 CNNC

PWR: China National Nuclear Corporation
MSR: Thorium Reactor

ATOM ENERGO PROM

LFR: Atomenergoprom

CNEA

PWR: Comisión Nacional de Energía Atómica

2X ОКБ АФРИКАНТОВ РОСАТОМ

PWR: OKBM Afrikantov

*Licensed**

*In at least one country

KAERI HYUNDAI

PWR: Korea Atomic Energy Research Institute

NUSCALE

PWR: Nuscale

Kairos Power

Hermes 50 MW MSR
Demonstrator licensed

*Seeking License**

*In at least one country

ROLLS ROYCE

PWR: Rolls Royce

HOLTEC INTERNATIONAL

PWR: Holtec

In Design

energy

OKLO

TOSHIBA

HITACHI

LAST ENERGY

copenhagen atomics

Westinghouse

NOKIA

Glossary

HTGR: High Temp Gas-Cooled Reactor
PWR: Pressurized Water Reactor
MSR: Molten Salt Reactor
LFR: Lead-cooled Fast Reactor

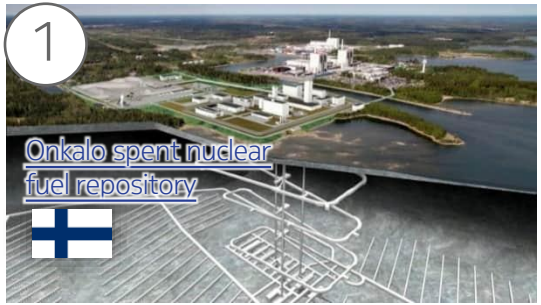
Nuclear Waste: It's a choice, not an inevitability

All of the high level waste produced 70 years of global commercial nuclear power fit into a space the size of a football stadium piled 14 feet deep

Note: ***Always*** show nuclear waste in corroding barrels, preferably with glowing green ooze leaking out

Nuclear waste is ***highly regulated*** and is the easiest form of industrial waste to detect and measure

1



Store it as "glass" in geologically stable repositories

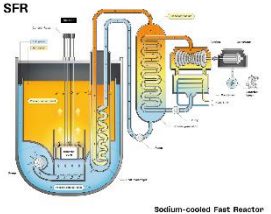
2

Reprocess the >95% of useable nuclear fuel in "spent" fuel rods

Management of Spent Fuel from Nuclear Power Reactors

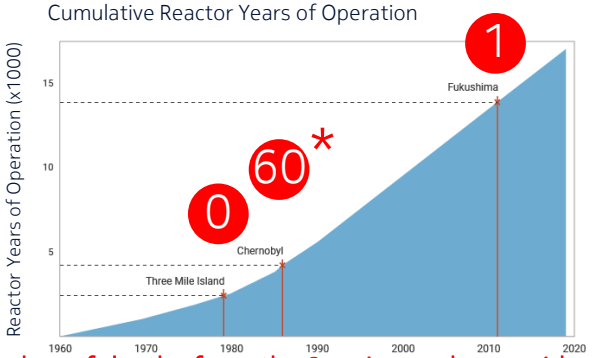
3

Use a fast neutron reactor to process new fuel during normal operation



About 20 FNRs operating since the 1950s

Wait! Isn't Nuclear Power Dangerous?



Number of deaths from the 3 major nuclear accidents
*Higher estimates exist, but are highly disputed

Following the Fukushima accident in 2011 German leaders committed to phasing out nuclear power by 2022/23

But they had to extend the use of coal, and buy Russian gas


Forbes

EDITORS' PICK | BUSINESS > ENERGY

Greta Thunberg Has Embraced Nuclear Power: Will The Greens Follow?

Link to article

By Ariel Cohen, Contributor. Ariel Cohen is a D.C.-based contributor who covers ...

Apr 03, 2023, 09:00am EDT

1,100

The number of incremental deaths *per year* in Germany from air pollution caused by coal and gas

$12B

Annual *social cost* of reactor closures

NBER Link to article

Organizations arguing that nuclear power is dangerous

CAN Europe — Myth buster: Nuclear energy is a dangerous distraction

Friends of the Earth Europe — Is Nuclear Power Bad for the Environment?

GREENPEACE — 6 reasons why nuclear energy is not the way to a green and peaceful world

In the UK, 6,000 people die each year in home accidents

"We calculate a mean value of **1.84 million human deaths prevented** by world nuclear power production from 1971 to 2009"


Environmental Science & Technology

Article

pubs.acs.org/est

Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power

Pushker A. Kharecha* and James E. Hansen

NASA Goddard Institute for Space Studies and Columbia University Earth Institute, 2880 Broadway, New York, New York 10025, United States

Link to paper

What are the safest and cleanest sources of energy?

Our World in Data

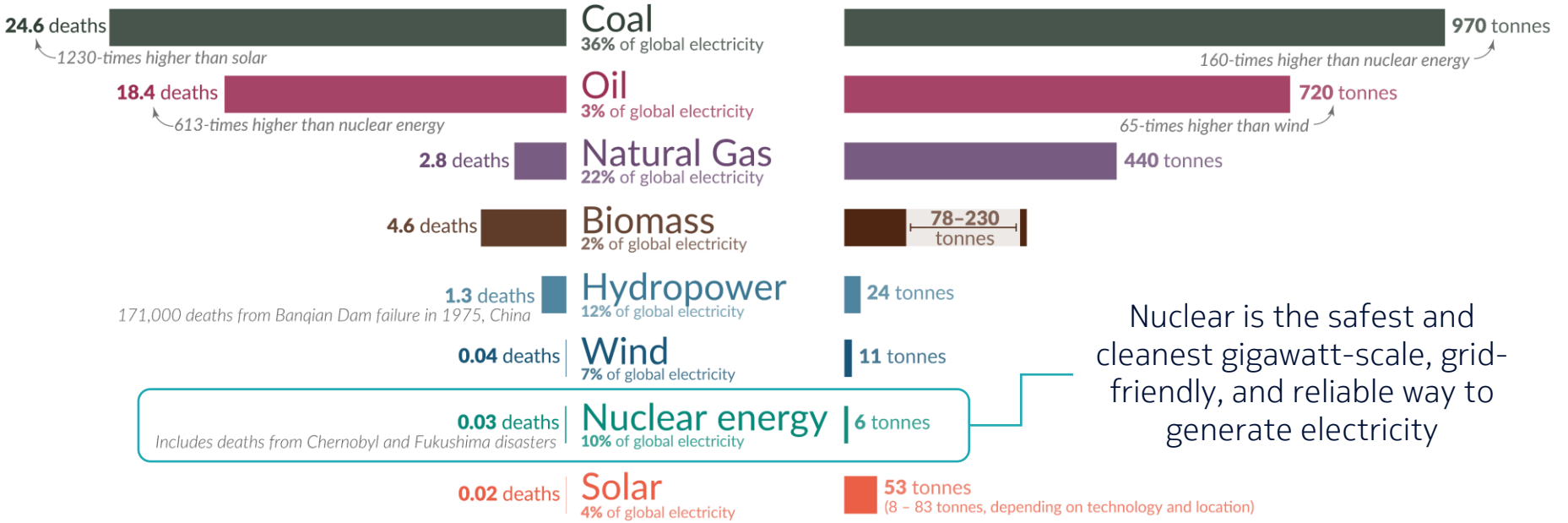
Link to paper

Death rate from accidents and air pollution

Measured as deaths per terawatt-hour of electricity production.
1 terawatt-hour is the annual electricity consumption of 150,000 people in the EU.

Greenhouse gas emissions

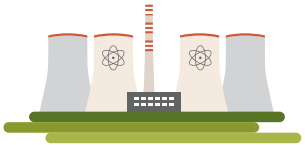
Measured in emissions of CO_2-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant.
1 gigawatt-hour is the annual electricity consumption of 150 people in the EU.



Nuclear is the safest and cleanest gigawatt-scale, grid-friendly, and reliable way to generate electricity

Death rates from fossil fuels and biomass are based on state-of-the art plants with pollution controls in Europe, and are based on older models of the impacts of air pollution on health. This means these death rates are likely to be very conservative. For further discussion, see our article: OurWorldinData.org/safest-sources-of-energy. Electricity shares are given for 2021.
Data sources: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC AR5 (2014); UNECE (2022); Ember Energy (2021).

We could assume that…



Nuclear Power is…

…too expensive, and takes too long to build…

…only Russia and China have plans to build plants on a large scale…

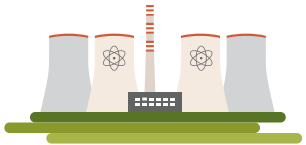
…it has a bad image and people will try to block it

Nuclear Power may not be the right option to produce general purpose clean energy

But producing general purpose clean energy is not what the AI Hyperscalers' are concerned about

The AI hyperscalers have insane amounts of money to spend on AI Data Center construction

If there's no way to power them…why build them?
(*Unless your name is Elon*)



Nuclear is not just the *best option*, it's really the *only option for AI hyperscalers*

And if they pay for the problems of nuclear to be solved then…

The dream of cheap, clean, safe and abundant nuclear energy may finally be realized for the whole world

"Narcissistic altruism"

Link to Forbes article

Huzzah for us!

Once in a lifetime AI opportunity

Need better AI

AI provides massive productivity boost

Isn't this great?

But we all lose our jobs ☹

Wait...who buys all our stuff?

"An imbalance between rich and poor is the oldest and most fatal ailment of all republics."

Plutarch CE46-120

"Better" means more processing power

Which implies more electrical power

Pesky corporate sustainability goals!

Nuclear seems like a great option

But we forgot how to build nuclear stuff!

Bwahaha! We still know how, comrade!

You guys are losers!

Absolute

Relative

Some of ~~us~~ them

Bwahahah! Let's go to Mars!

What's happening today

We were only kidding – carry on burning that coal and gas!

Consequences

But renewables aren't a great fit for AI Data Centers

>80% of solar panels are made in China

>70% EV batteries are made in China

NOKIA

Thank You

Geoff Bennett
geoff.bennett@nokia.com