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SEPTEMBER TECH TALK STATE POLICY EDITION

Brian Thiry, Director External Affairs

and Entity Engagement

September 18, 2023

External Presentation content may not reflect the opinions and views of RF and the ERO Enterprise.

RELIABILITY FIRST

TECH TALK-STATE POLICY EDITION

Diane Holder
ReliabilityFirst
Vice President, Entity Engagement and Corporate Services

RELIABILITY FIRST

AGENDA

Presentation	Presenter
Welcome and Introductions	Diane Holder, RF Vice President of Entity Engagement and Corporate Services; Brian Thiry, Director Entity Engagement and External Affairs
Success of the Delaware Energy Stakeholders' Group	Delaware State Senator Stephanie Hansen, 10th District
Energy Economics with the Energy Transition	Dr. Lars Schernikau, Energy Economist and Author
Interconnection and Transmission Planning	Abe Silverman, Director, Non-Technical Barriers to the Clean Energy Transition – Center on Global Energy Policy
Closing Remarks	Brian Thiry, Director Entity Engagement and External Affairs

Public

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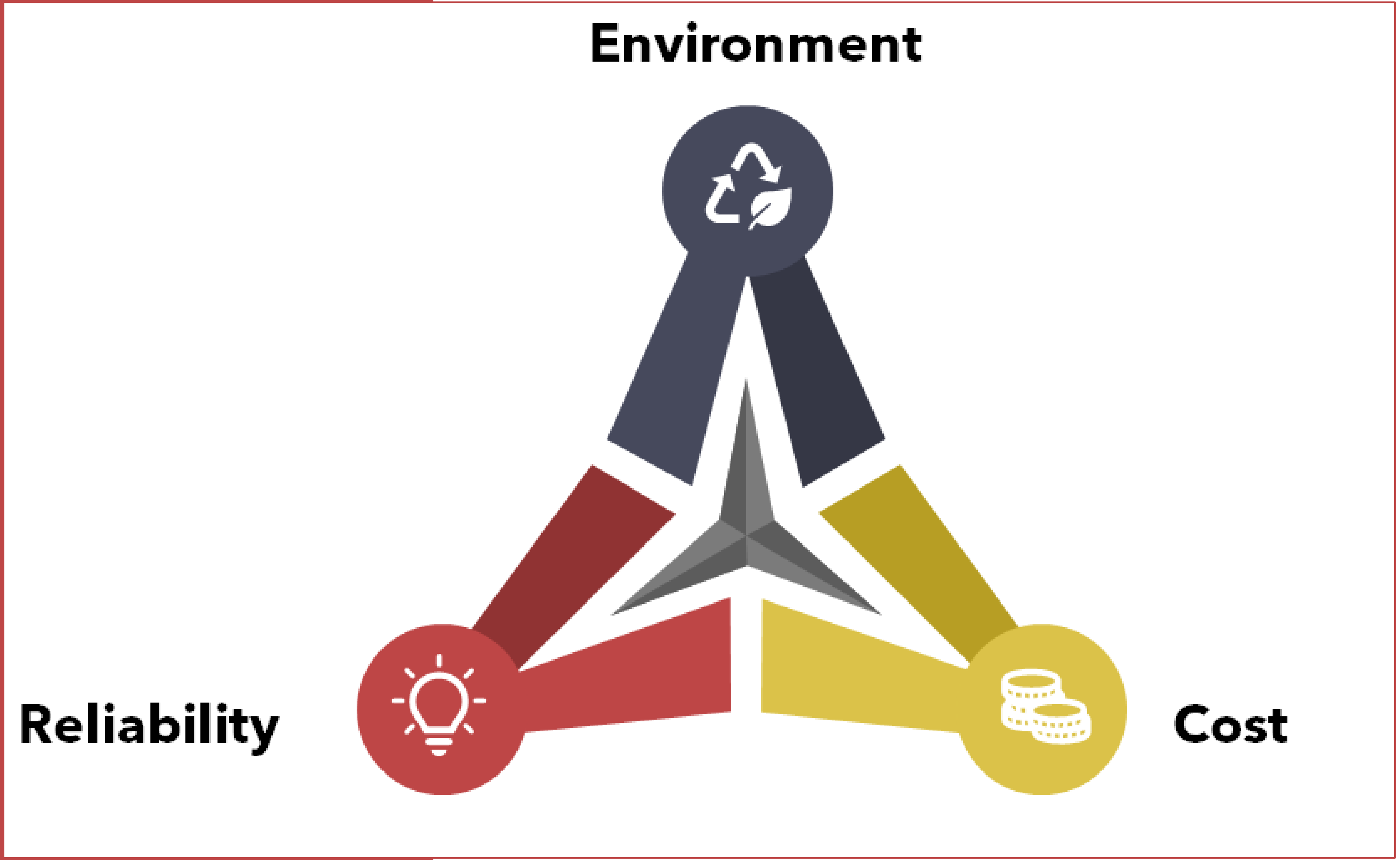
STATE OUTREACH

ENERGY TRILEMMA

ENERGY POLICY

GRID TRANSFORMATION

ENERGY TRILEMMA



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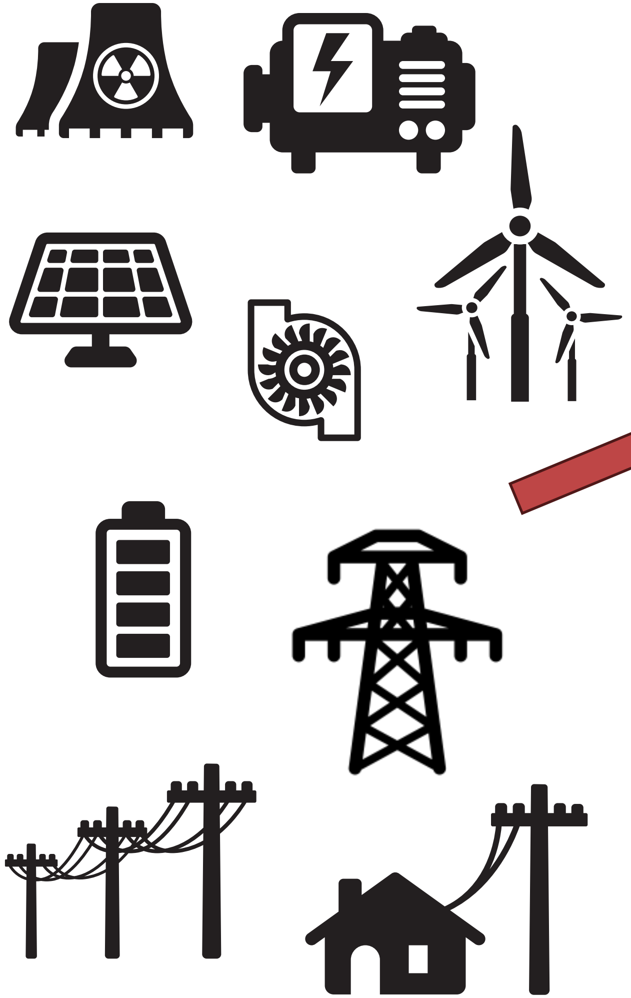
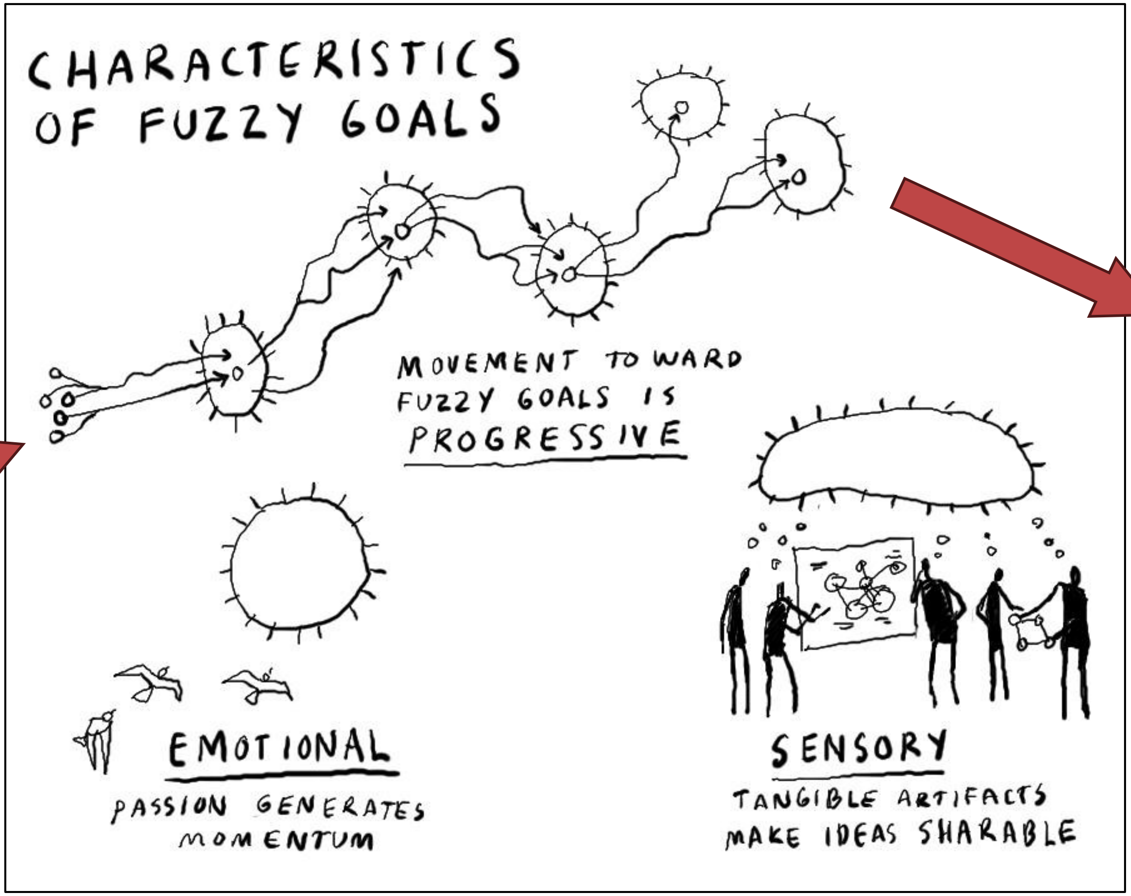
CLEAN, AFFORDABLE, RELIABLE ENERGY FUTURE





Gamestorming: A Playbook for Innovators, Rulebreakers, and Changemakers
by David Gray, Sunni Brown, and James Macanufo
https://gamestorming.com/

ENERGY TRILEMMA CONSIDERATIONS

Reliability

- Resource Adequacy and Fuel Assurance
- Essential Reliability Services
  - Voltage
  - Frequency Response
  - Inertia and Short-Circuit
- Blackstart Resources
- Transfer Capabilities
- Distributed Energy Resources
- Energy Efficiency and Demand Response

Cost

- Affordability and Energy Equity
- Supply Chain Considerations
- Net Energy Efficiency
- Impact on Economy
- Job Growth (short-term and long-term)
- Life-expectancy of new resources

Environment / Sustainability

- Land / Water usage
- Carbon and Emissions
- Siting and Permitting
- Wildlife and deforestation
- Recycling and Decommissioning
- Renewable Resources

2023 ERO RELIABILITY RISK PRIORITIES REPORT

Risk Profile 1: Energy Policy

Risk Profile 2: Grid Transformation

Risk Profile 3: Resilience to Extreme Events

Risk Profile 4: Security Risks

Risk Profile 5: Critical Infrastructure Interdependencies

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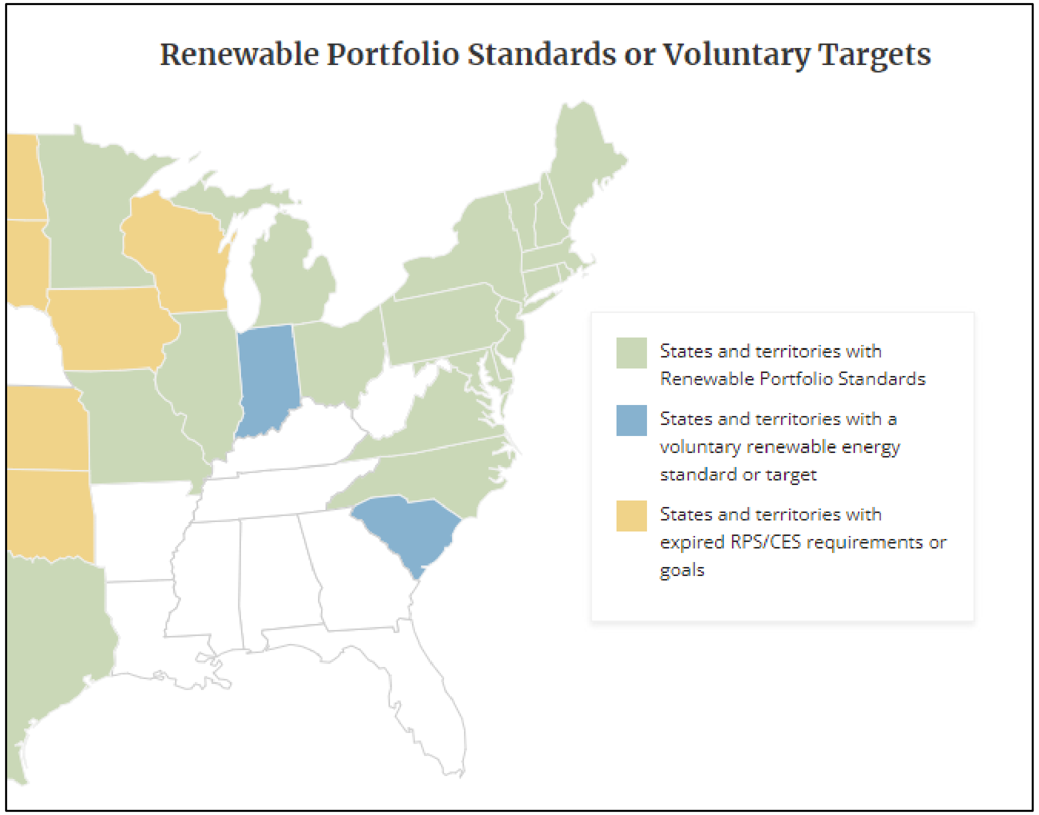
ENERGY POLICY

- Energy Sufficiency is increasingly critical
- Natural Gas and Electric Interdependency impacts
- Reliably incorporating aggregate Distributed Energy Resources (DER)

Recommendations from Report

- Increased communication, coordination, and collaboration are needed between federal, provincial, and state policy makers, regulators, owners, and operators of the Bulk Power System; as well with the critical interdependent sections



National Conference of State Legislatures
https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals

GRID TRANSFORMATION

- Decarbonization, Decentralization, and Digitization
- Electrification and load growth
- New technologies and innovations

Recommendations from Report

- Develop Energy Sufficiency in planning and operating
- Ensure sufficient operating flexibility during grid transformation
- Consider impacts and benefits of DER
- Plan for large and rapid load growth
- Develop workforce of the future
- Be open to new grid operation approaches

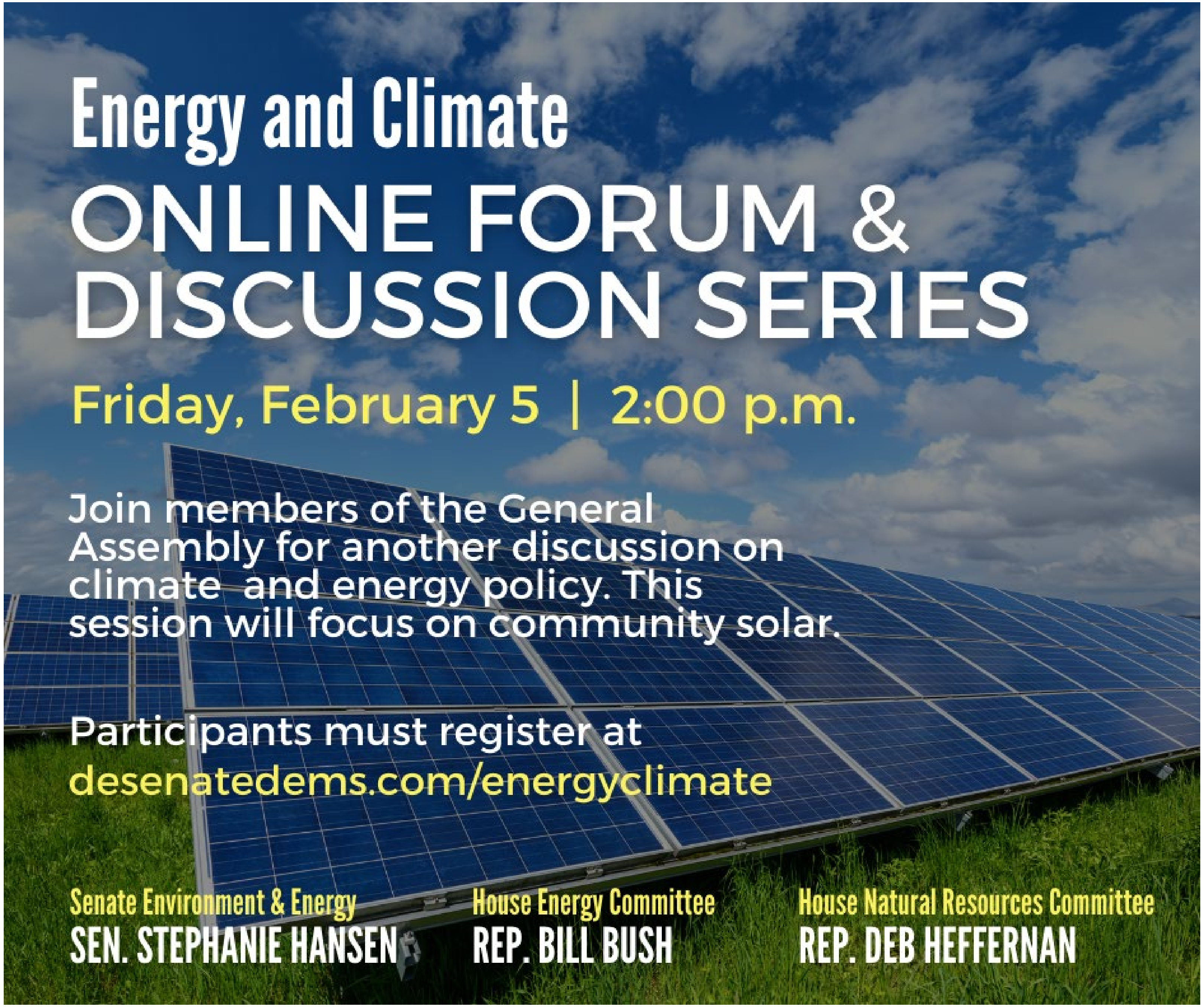
STATE CONSIDERATIONS

- Identify ALL stakeholders and collect input
- Outline and prioritize goals
- Develop state energy plans and seek comments
- Review / revise legislation
- Maintain flexibility and continue to assess progress

BRINGING PEOPLE TO THE TABLE

SENATOR STEPHANIE HANSEN

- DELAWARE GENERAL ASSEMBLY


Energy and Climate
ONLINE FORUM & DISCUSSION SERIES
Friday, February 5 | 2:00 p.m.
Join members of the General Assembly for another discussion on climate and energy policy. This session will focus on community solar.
Participants must register at
desenatedems.com/energyclimate
Senate Environment & Energy
SEN. STEPHANIE HANSEN
House Energy Committee
REP. BILL BUSH
House Natural Resources Committee
REP. DEB HEFFERNAN

Delaware Energy Stakeholders Group - 2023		
Category	**Stakeholder**	**Notes**
Group Leader	Sen. Stephanie Hansen	Chair of DE Senate Environment, Energy & Transportation Comm.
Utilities	Delmarva Power	Investor-Owned
	Delaware Electric Cooperative	Cooperative – Board Controlled
	Delaware Municipal Electric Corporation	Membership consists of all of the municipal electric companies in DE except for City of Dover
	Dover Electric Utility	City of Dover
	Chesapeake Utilities	Natural Gas, Propane Supplier
	PJM	Regional Transmission Org.
Government	DE Office of the Public Advocate	
	DE Public Service Commission	
	DE of Natural Resources and Environmental Control (DNREC)	
	DE Sustainable Energy Utility	Created by General Assembly; functions listed in DE Code; Board Controlled
	DE Senate	Chair of EET Committee
	DE House of Representatives	Chair or V. Chair of Natural Resources Comm.
	Senate Attorney	Legislative drafting functions
	Senate Intern & Staff	Legislative research functions
Environmental Advocacy	DE Solar Energy Coalition	
	Special Initiative for Offshore Wind	
	Sierra Club, DE Chapter	
	MidAtlantic Alliance for Climate and Health	
	Underserved Communities	Minority-owned solar tech company specializing in serving underserved communities
	Local Energy Expert	Univ. of DE
	Regional Energy Expert	
Business	Caesar Rodney Institute	Conservative, non-profit think tank
	Mid- Atlantic Petroleum Dist. Assoc.	
	DE Large Energy Users Group	
	DE Farm Bureau	
	DE Labor	
	DE State Chamber of Commerce	

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BRINGING PEOPLE TO THE TABLE

DR LARS SCHERNIKAU

- ENERGY ECONOMIST, ENTREPRENEUR, COMMODITY TRADER, AUTHOR, AND STRATEGIC ADVISOR

www.unpopular-truth.com

What is, and what is not, the Future of Energy?

… the Laws of Thermodynamics are still relevant

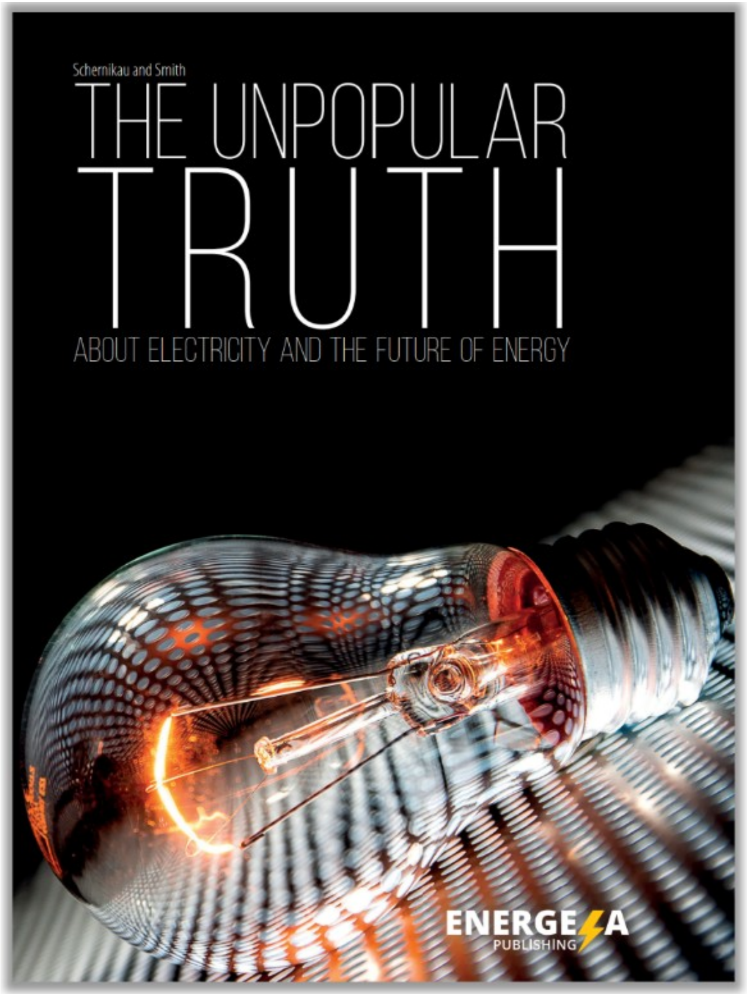
18 September 2023 – Cleveland (OH), USA

Dr. Lars Schernikau
commodity trader, energy economist, author (www.hms-ag.com)

About Lars

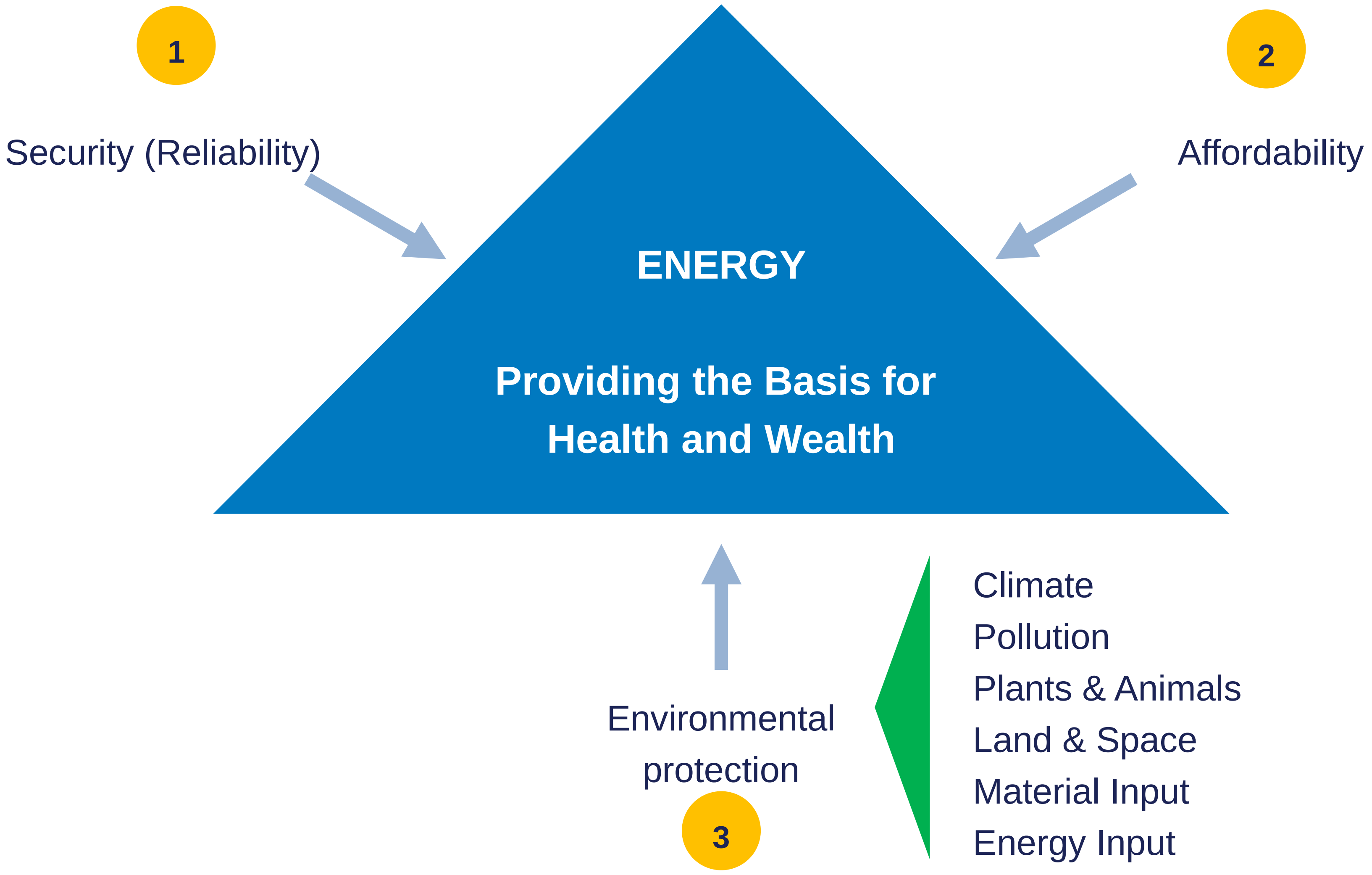
Dr. Lars Schernikau

- Lives in Switzerland & Singapore, married with 4 children, shareholder www.hms-ag.com
- Studied in US (Finance @NYU), France (MBA @INSEAD) and Germany (Economics @TU-Berlin)
- 6+ years at The Boston Consulting Group: M&A, start-ups
- Joined raw materials business 20 years ago, today focusing on strategy and marketing HMS group‘s products in Asia, Africa, Americas, and Middle East
- Wrote „The Renaissance of Steam Coal“ 2010 (Springer), “Why Coal Continues to Power the World” 2017 (Springer), “Unpopular Truth…about Electricity and the Future of Energy” 2022 (Energeia), several articles, and scientific papers, book- and peer-reviews
- Serves and served on the board of several energy raw material producers and marketing companies in (Eastern-)Europe, Americas, Africa, and Asia
- Regular speaker at international conferences. Has advised governments, banks and multinationals on energy policy and sustainability



Available on Amazon
https://amzn.to/3togypC

Triangle of Objectives in Energy Policy – The Famous Trilemma



Source: Schernikau research; i343

Recommendation:
Check everything yourself

The opinions expressed in this presentation and on the following slides are solely those of the presenter and not necessarily those of any company/organization. The presenter does not guarantee the accuracy or reliability of the information provided herein.

PERSONAL DISCLAIMER – Conflict of Interest Declaration:

I agree that

1. **The world is warming (with positive and negative consequences)**
2. **Humans contribute to measured temperature increase**
3. **CO_2 is a greenhouse gas and higher levels contribute to warming**

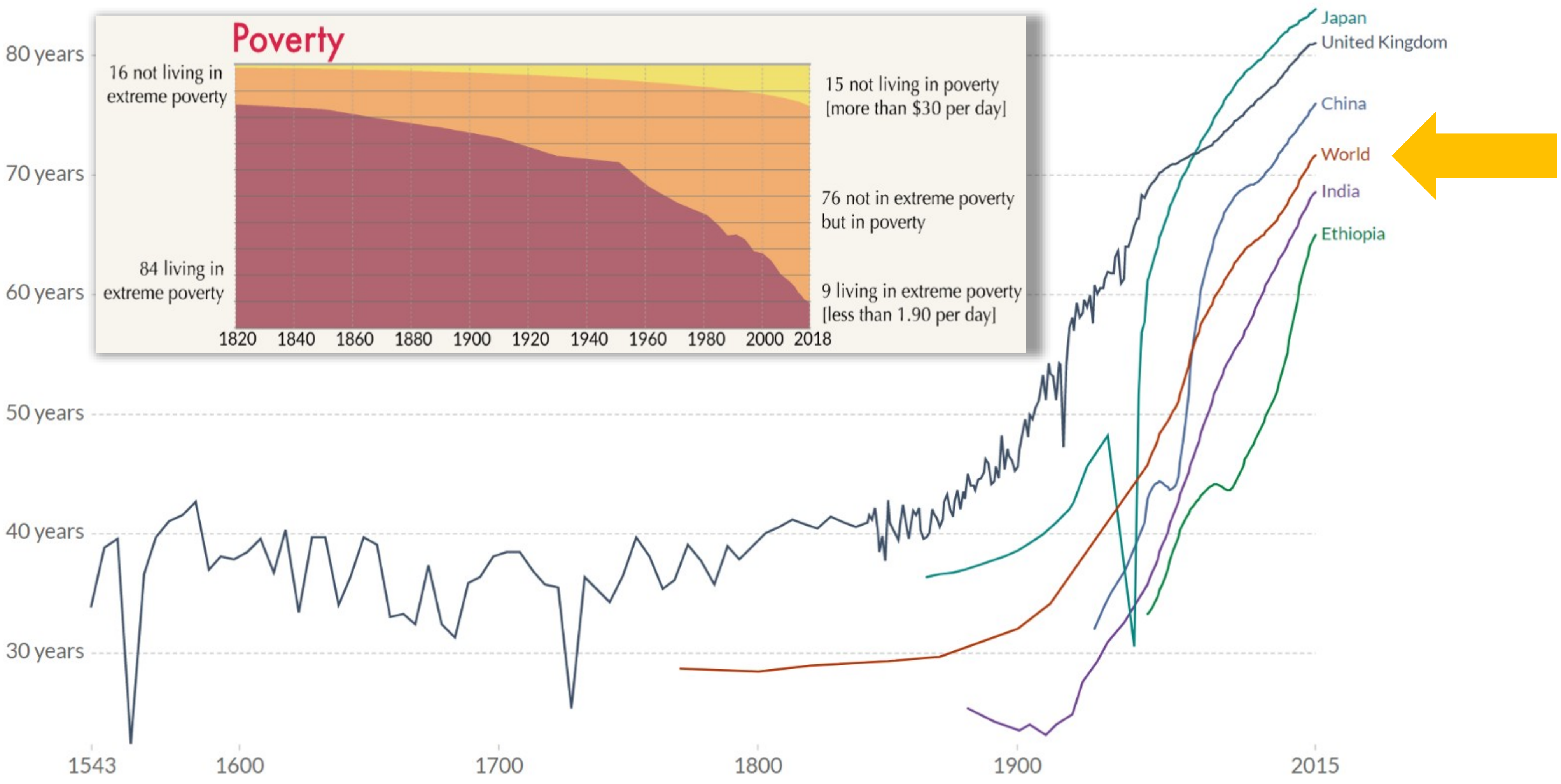
However, I am from the energy commodities industry

I own shares in coal, gas, and fusion/fission companies, thus, I am biased

I am a significant shareholder in German publicly listed commodity trader HMS Bergbau AG (www.hms-ag.com)

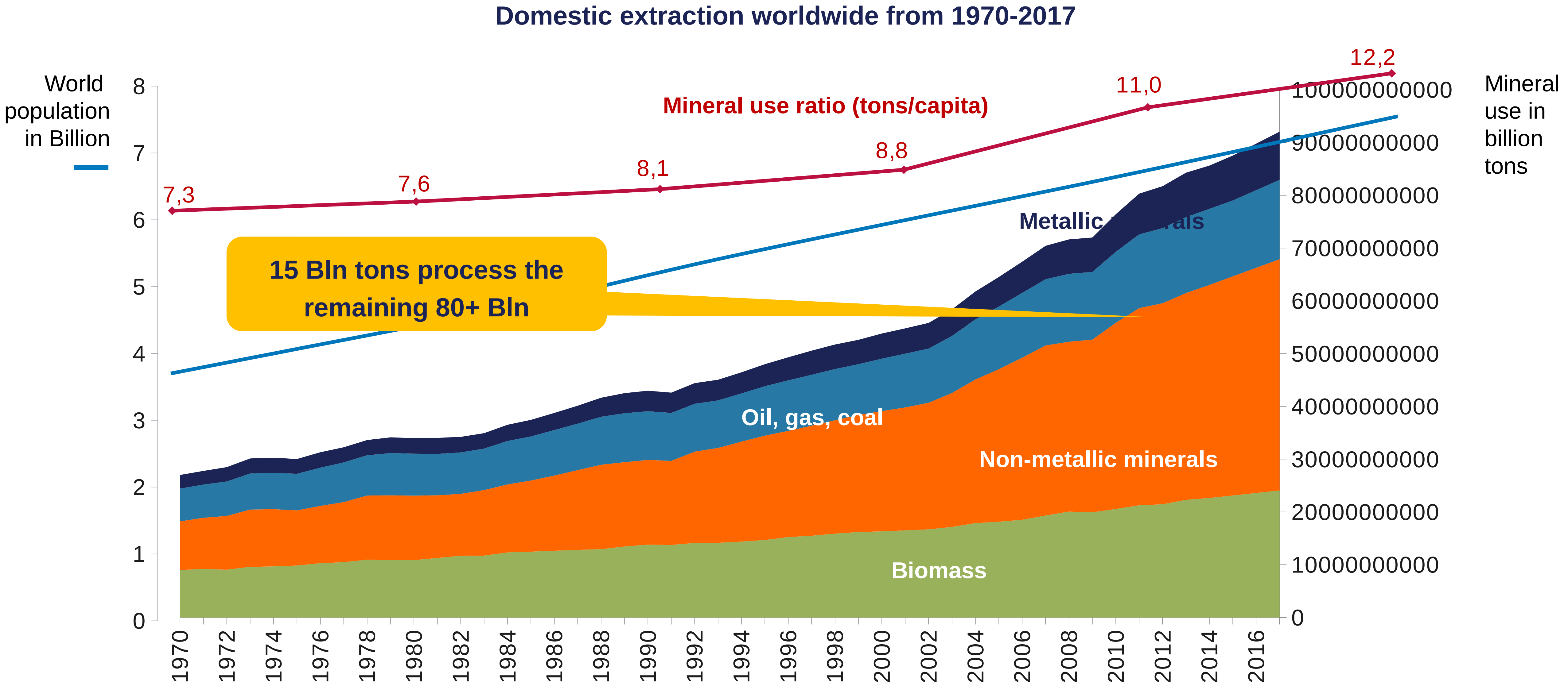
Positive News About Life Expectancy

Life Expectancy 1543 to 2015
(at birth, if conditions wouldn't change throughout life)



Note: Shown is period life expectancy at birth, the average number of years a newborn would live if the pattern of mortality in the given year were to stay the same throughout its life
Source: Our World in Data. "OurWorldInData: Life Expectancy," July 2021. https://ourworldindata.org/grapher/life-expectancy.

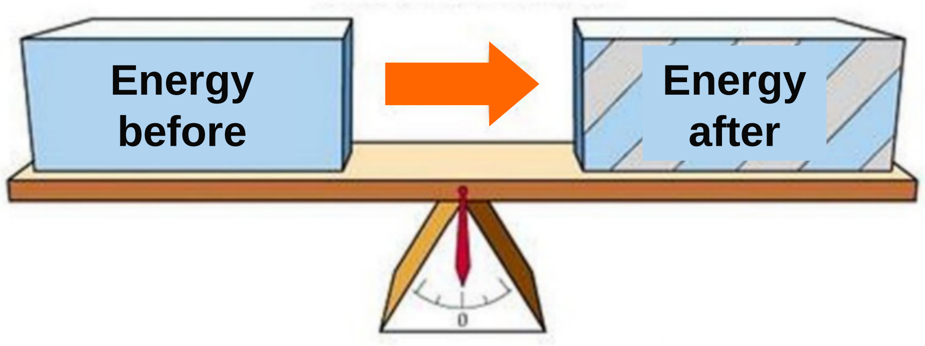
Global Material/Mineral Extraction Reaches Close to 100 Billion Tons p.a.



Note: WU Vienna (2020): Material flows by material group, 1970-2017. Visualisation based upon the UN IRP Global Material Flows Database. Vienna University of Economics and Business
Source: Autthors Research and Analysis based on http://www.materialflows.net/visualisation-centre/data-visualisations/?_inputs_&sidebar=%22bar_chart_1%22; Population division, UN, 2019 (https://population.un.org/wpp)

Two Important Laws of Thermodynamics

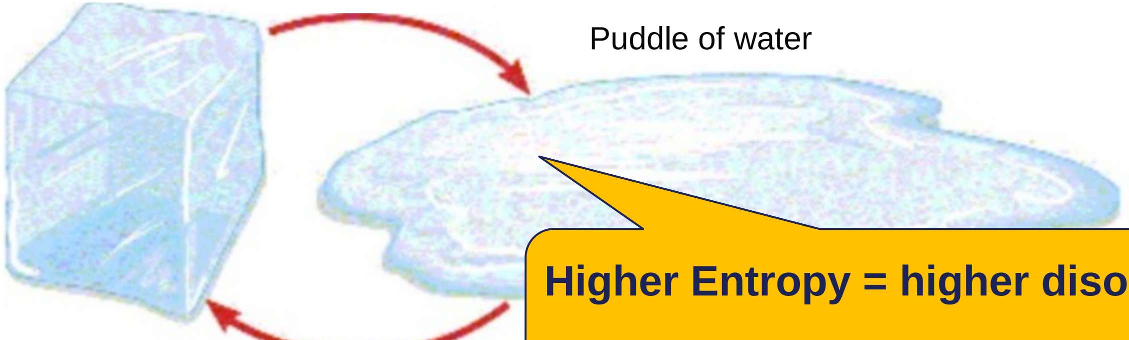
1st Law of Thermodynamics
(energy is never lost)



Internal Energy

2nd Law of Thermodynamics
«Entropy always increases» or energy loses 'value' with conversion

Entropy increases when melting



Higher Entropy = higher disorder

or lower value, irreversable

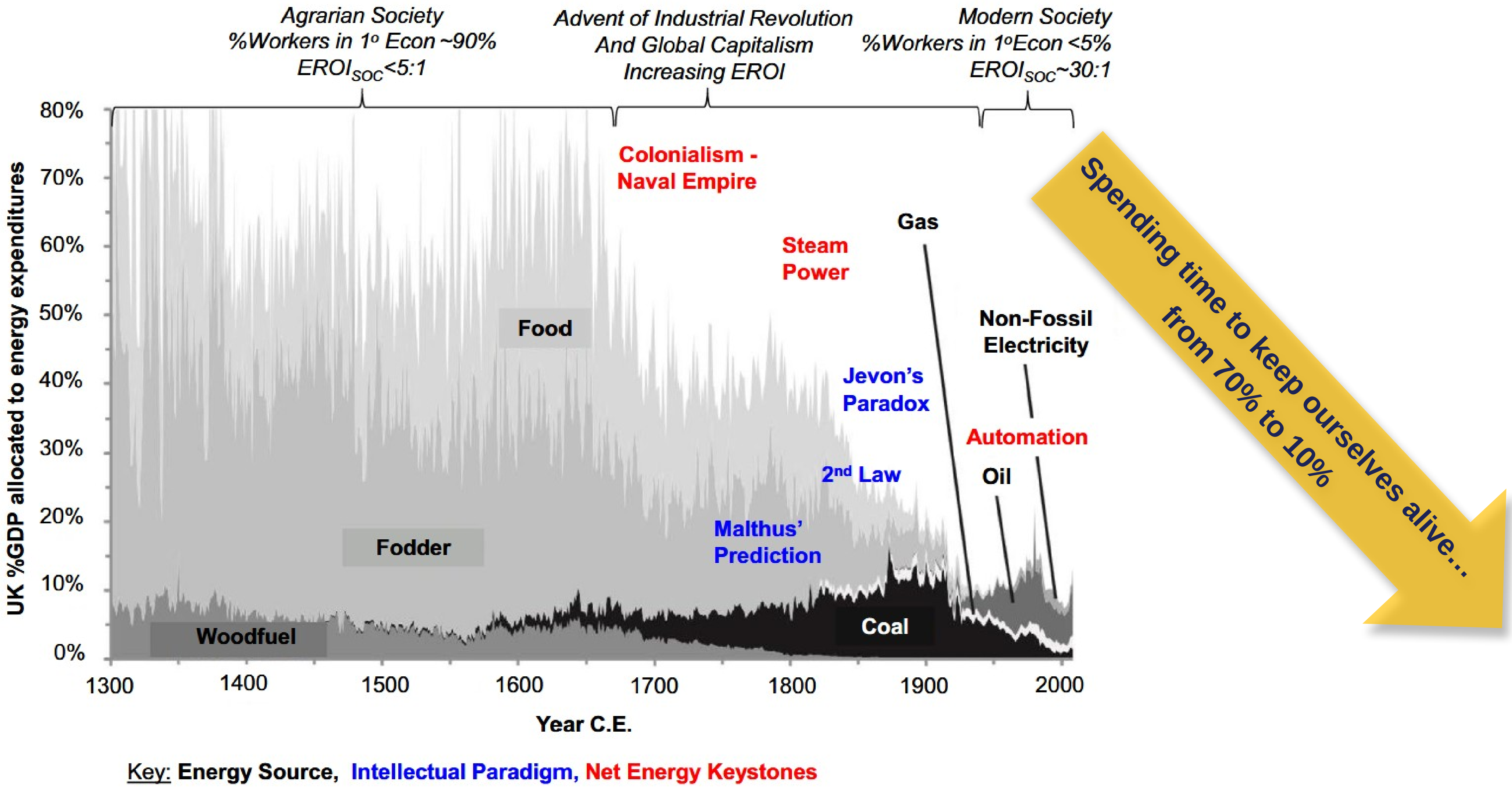
Entropy decreases when freezing

Conversion or storage of energy always means loosing useful energy

Note: Planck: Every process occurring in nature always increases the sum of the entropies of all bodies taking part in the process, at best the sum remains unchanged.
Source: Scherrnikau research and analysis, graphs from 10.3 - Entropy and the 2nd law (slideshare.net) and https://i.ytimg.com/vi/IyNNzOT4jO0/maxresdefault.jpg

GDP Spent on Energy Generation in UK

Share of GDP spent on Energy in UK (Economic share of acquiring food and fuel)



Note;: fooder = food, especially dried hay or feed, for cattle and other livestock.; Percent of GDP allocated to energy expenditure in the United Kingdom from 1300 to 2008. Energy sources are labeled in black; keystone innovations are labeled in red, and intellectual paradigms are in blue (Reproduced with permission from Fizaine and Court 2016). (Color figure online)
Source: Day et al 2018 "The Energy Pillars of Society: Perverse Interactions of Human Resource Use, the Economy, and Environmental Degradation." *BioPhysical Economics and Resource Quality* 3, no. 1 (February 2018, https://doi.org/10.1007/s41247-018-0035-6

What does Energy Density mean?

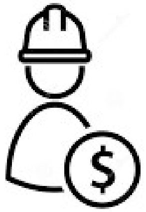
One ton of coal

= 7.000 kWh

= ~30 years of labor
 after energy conversion loss still
10+ years of human labor useful energy

One ton of coal costs US$ 150

8 billion tons of coal per year means labor of about 250 billion humans



One day of human labor

= 0.6 kWh

4 years human labor at US$ 5k per month
= US$ 240.000 worth labor

= ~850 kWh

One barrel oil

= 1.700 kWh

= ~10 years of labor
 after energy conversion loss still
4+ years of human labor useful energy

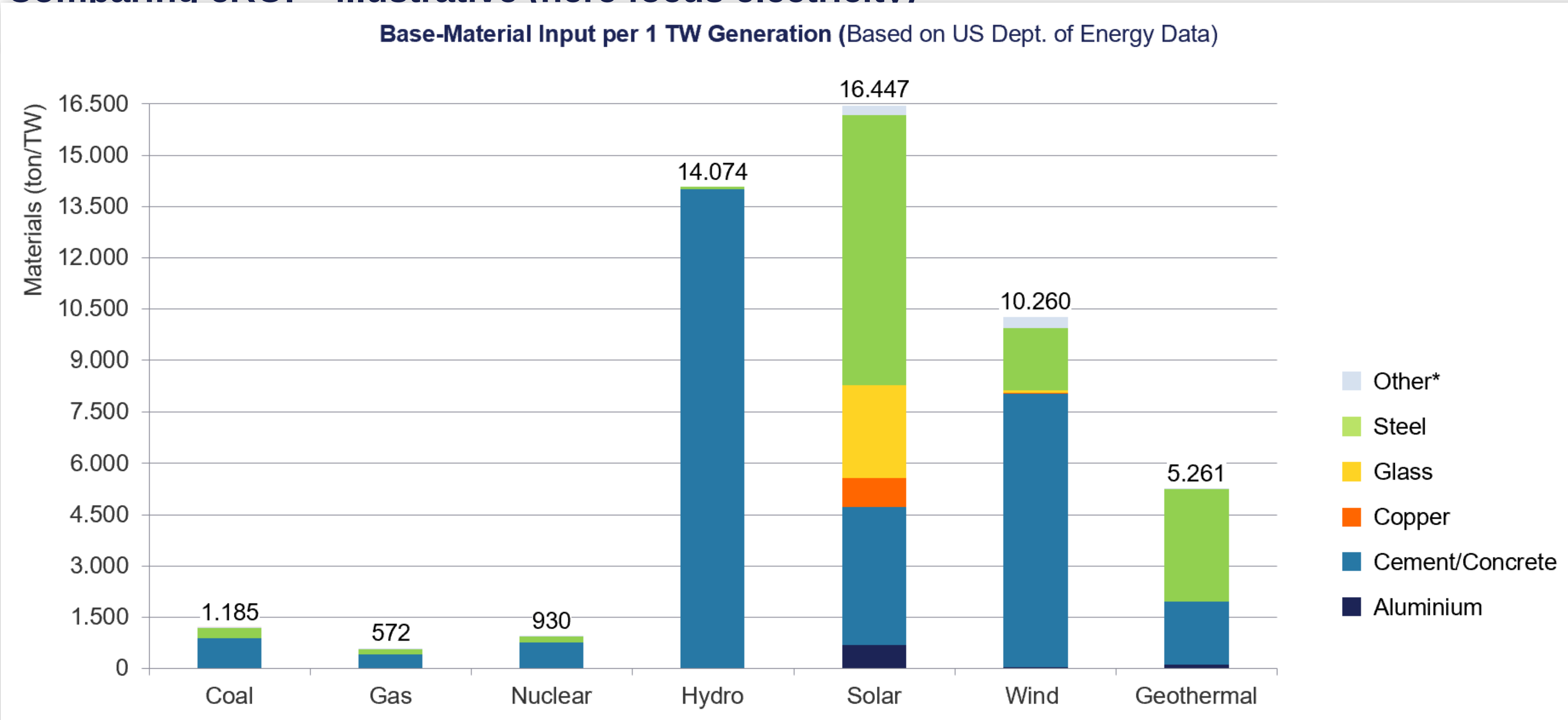
One barrel costs US$ 100

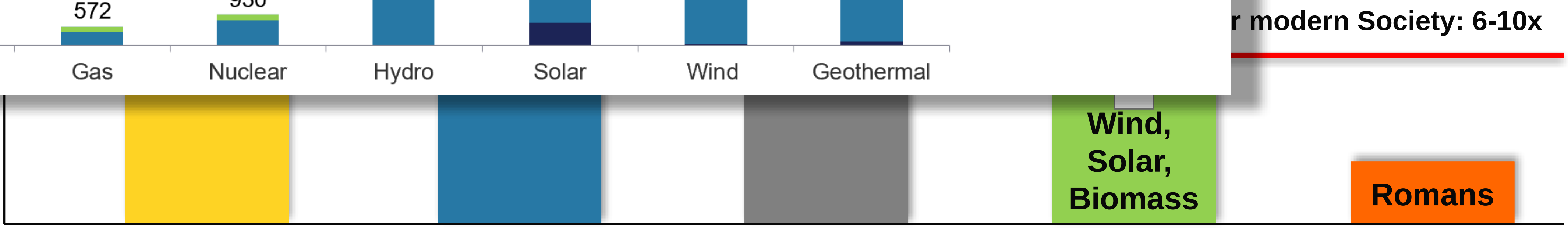
100 million barrels per day globally means labor of almost 150 billion humans per year

Note: Coal assumes 6.000 kcal/kg
Source: Schernikau based on market knowledge

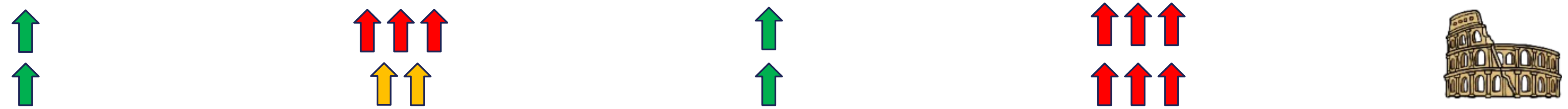
Comparing eROI – illustrative (here focus electricity)

Schernikau on Energy Policy



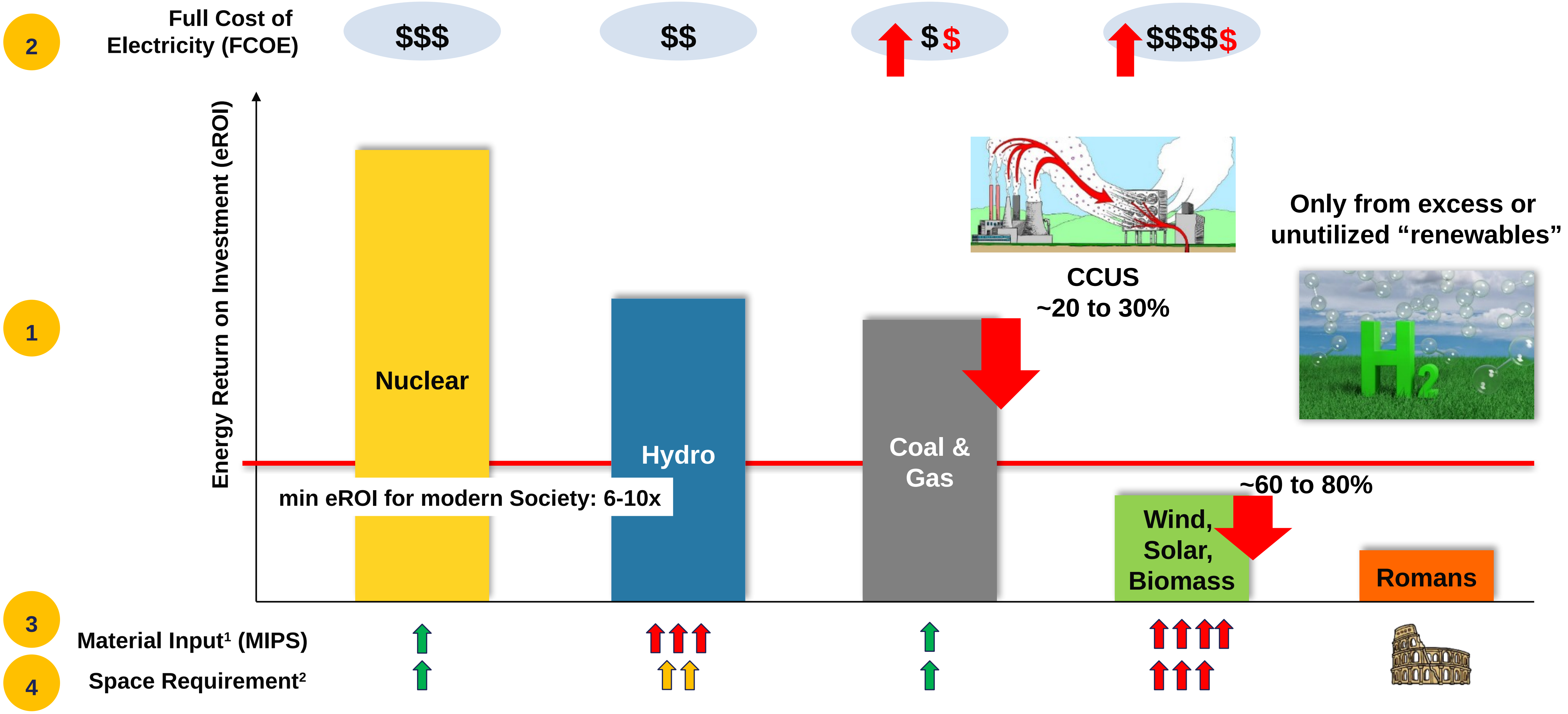


Material Input¹ (MIPS)
Space Requirement²



(1) Tonnage of material input per energy output, such as cement, steel, aluminum, lithium, rare earth, etc; (2) land area required per unit of energy output per annum… part of Room Cost which includes all costs of occupying large areas of land
Source: Schernikau research and analysis

Comparing eROI – Illustrative (Here Focus Electricity)



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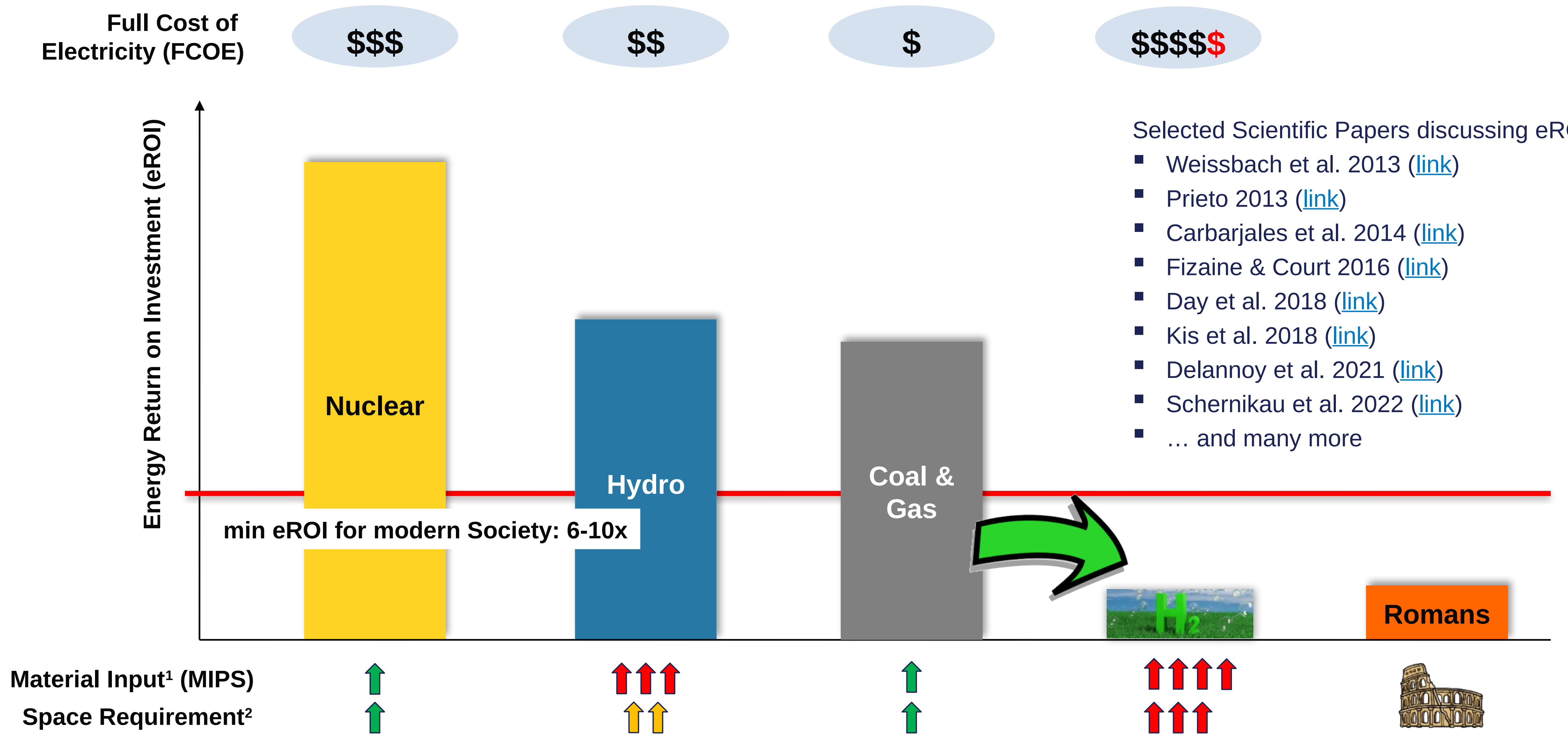


Selected Scientific Papers discussing eROI

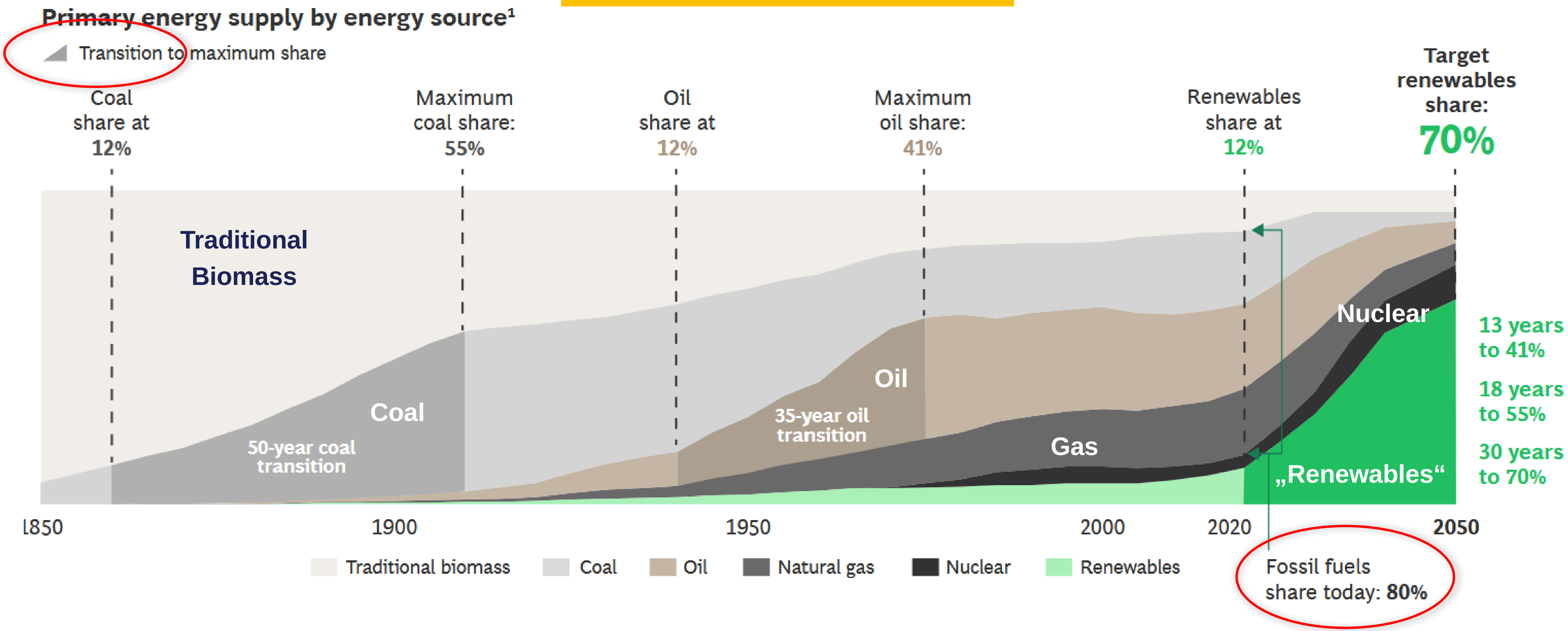
- Weissbach et al. 2013 (link)
- Prieto 2013 (link)
- Carbarjales et al. 2014 (link)
- Fizaine & Court 2016 (link)
- Day et al. 2018 (link)
- Kis et al. 2018 (link)
- Delannoy et al. 2021 (link)
- Schernikau et al. 2022 (link)
- … and many more

(1) Tonnage of material input per energy output, such as cement, steel, aluminum, lithium, rare earth, etc; (2) land area required per unit of energy output per annum… part of Room Cost which includes all costs of occupying large areas of land
Source: Schernikau research and analysis; Energiekosten: 200.000 Jobs in Gefahr – Stahlindustrie im Klima-Dilemma - WELT

BCG: The “Transition to Net Zero” Needs to Happen 3x Faster Than Previous “Transitions”

… after 20 years “Energiewende”

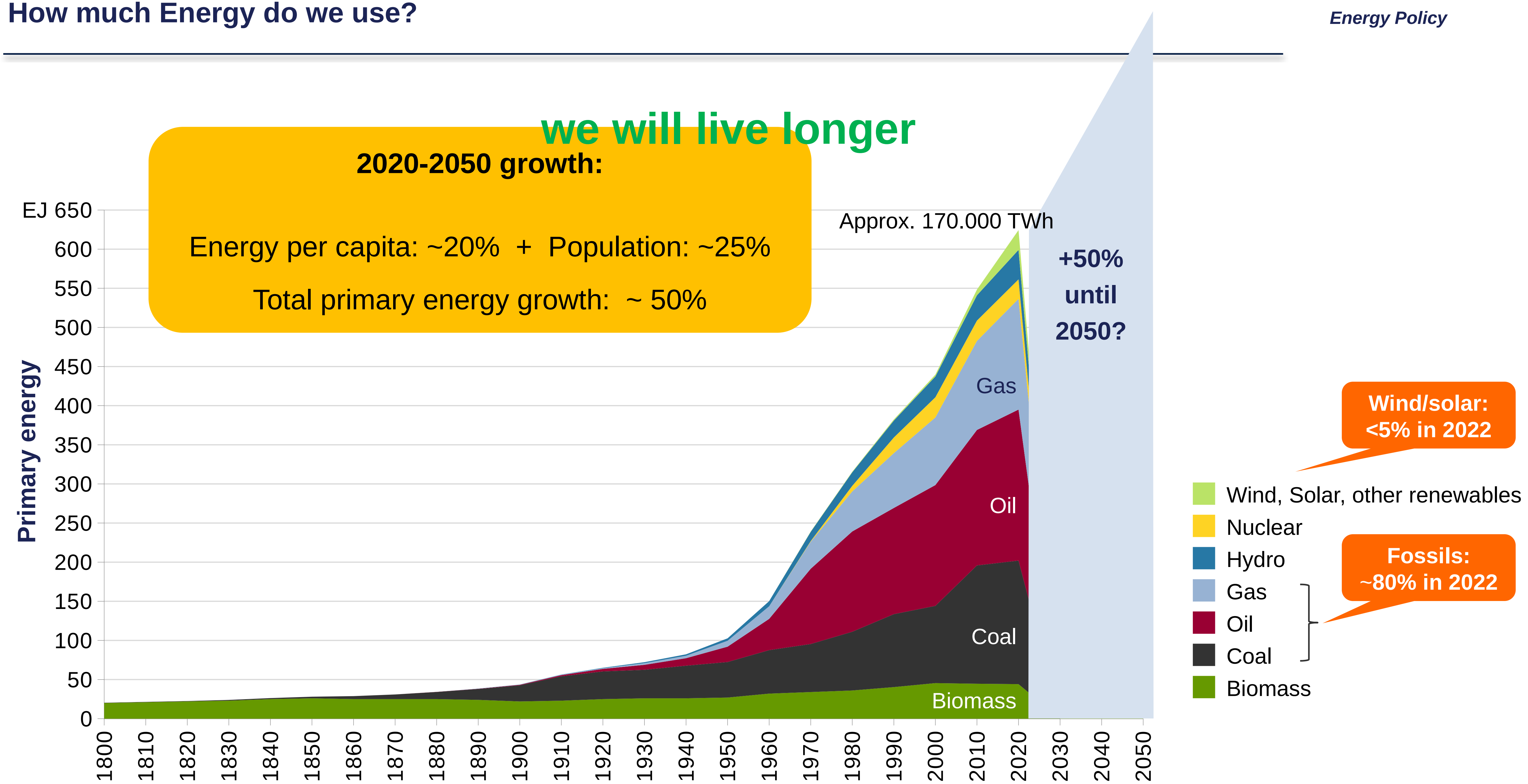
History of Energy Transitions?



() 2050 estimates based on the Net Zero Emissions by 2050 scenario from IEA.; Note: Renewables include biofuels, solar, wind, and hydrogen, among others.
Sources: BCG: A Blueprint for the Energy Transition, Sep 2023, based on Vaclav Smil, “Our World in Data” (2017); BP Statistical Review of World Energy; IEA, Net Zero Emissions by 2050; BCG CEI analysis.

How much Energy do we use?

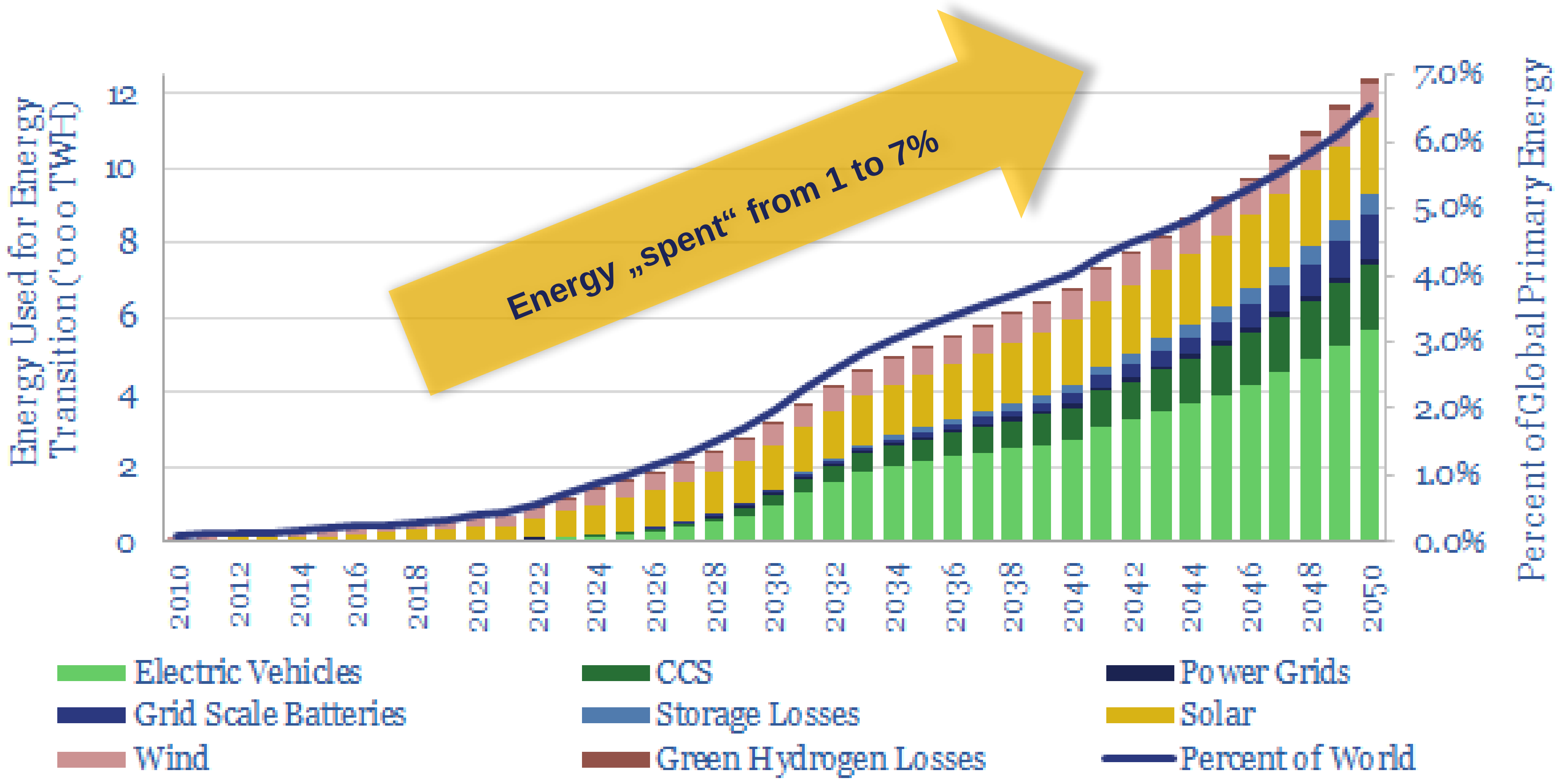
Schernikau on Energy Policy



Note: Original values in TWh, converted to EJ using a factor of 278; Indonesia consumed about 2,8 TWh in 2021
Source: Our World in Data based on Vaclav Smil 2017 and BP Review of World Energy (link); Ritchie and Dowlatabadi 2017, https://linkinghub.elsevier.com/retrieve/pii/S0360544217314597

Energy Needs for the «Energy Transition» multiply by 2050

% of Global Energy needed for the "Energy Transition"



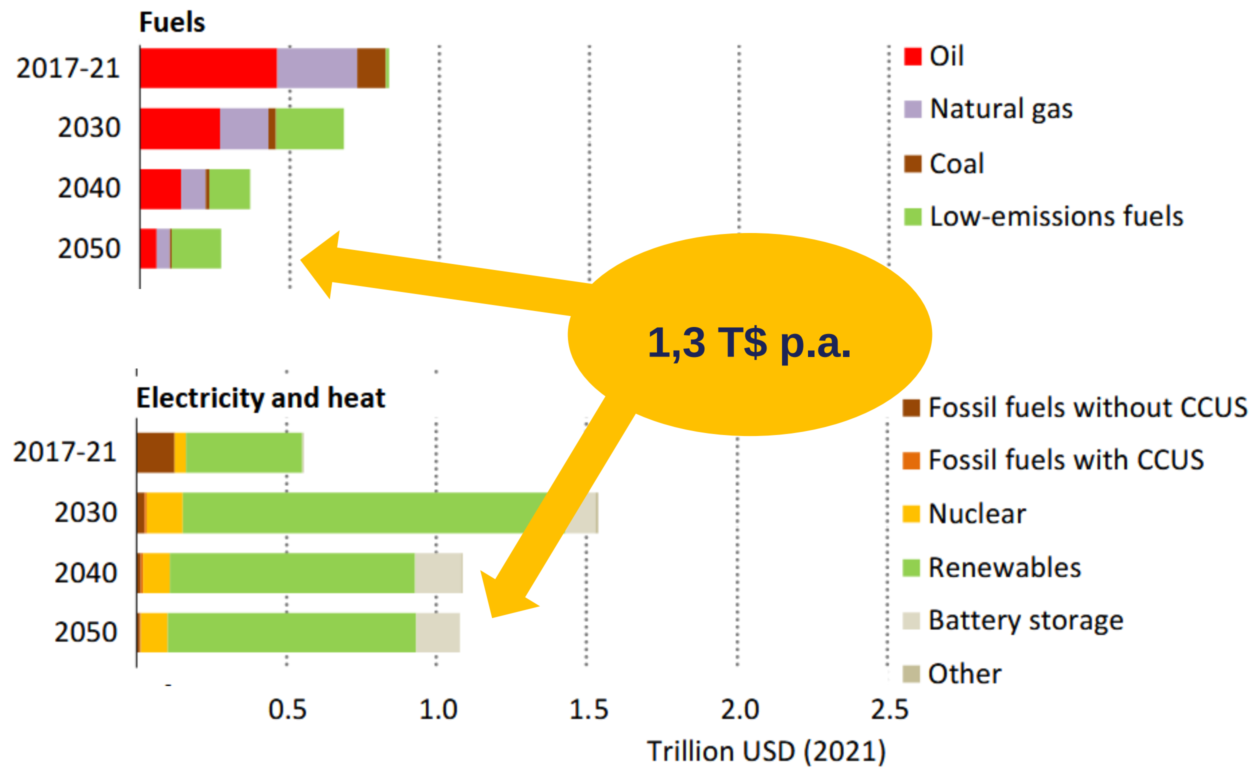
The "energy transition" is materially easier to achieve from a period of "energy surplus"

Note;: Reaching net zero requires building wind, solar, grid infrastructure, energy storage, electric vehicles and capturing CO2. Energy is needed to build all of these things.
Source: Based on Thunger Energy, https://thundersaidenergy.com/downloads/energy-costs-of-energy-transition/

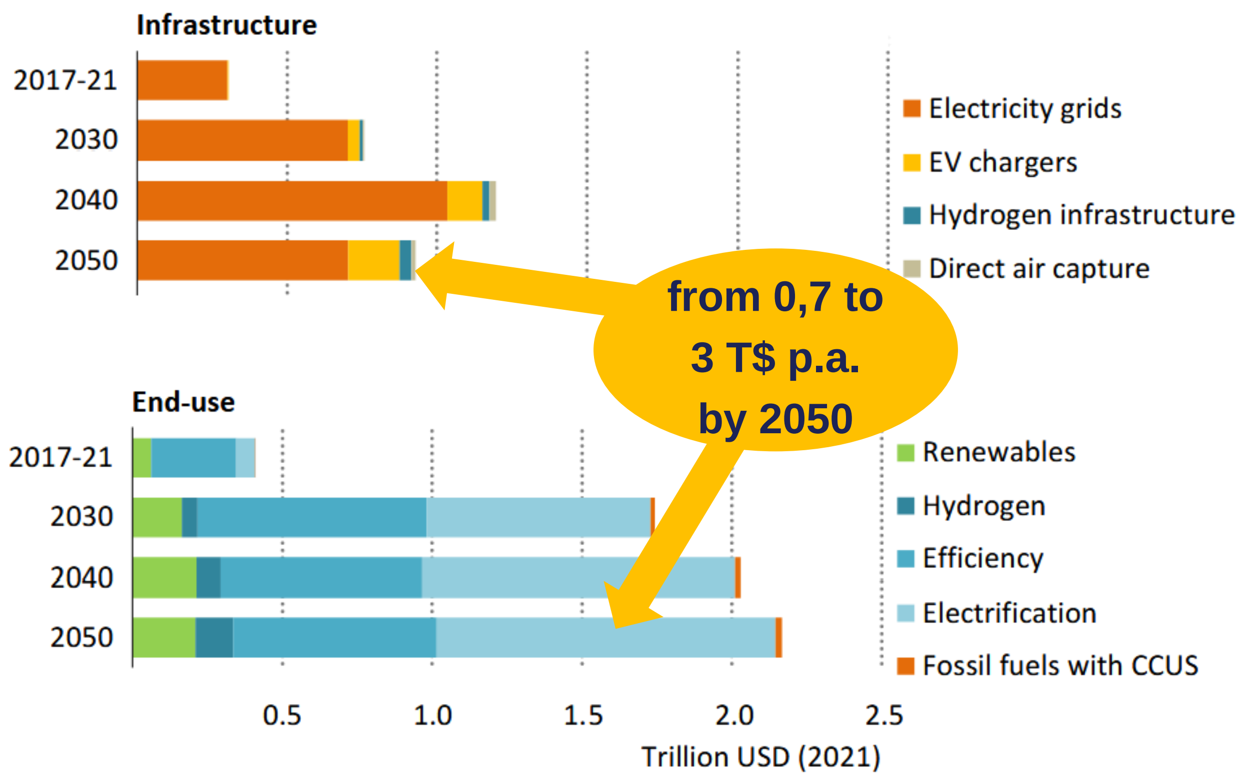
Investments in Energy Supply, vs Energy Consumption

Global average annual energy investment by sector and technology in the IEAs "Net-Zero" Scenario NZE

Supply of Energy



Consumption of Energy



Source: Schernikau, based on IEA WEO 2022, p163

Germany?

EU
ENERGY POVERTY
Observatory
European
Commission

About | Knowledge & Resources | Indicators & Data | News & E

09 Jul 2014

Energy Poverty in Germany – Highlights of a Beginning Debate

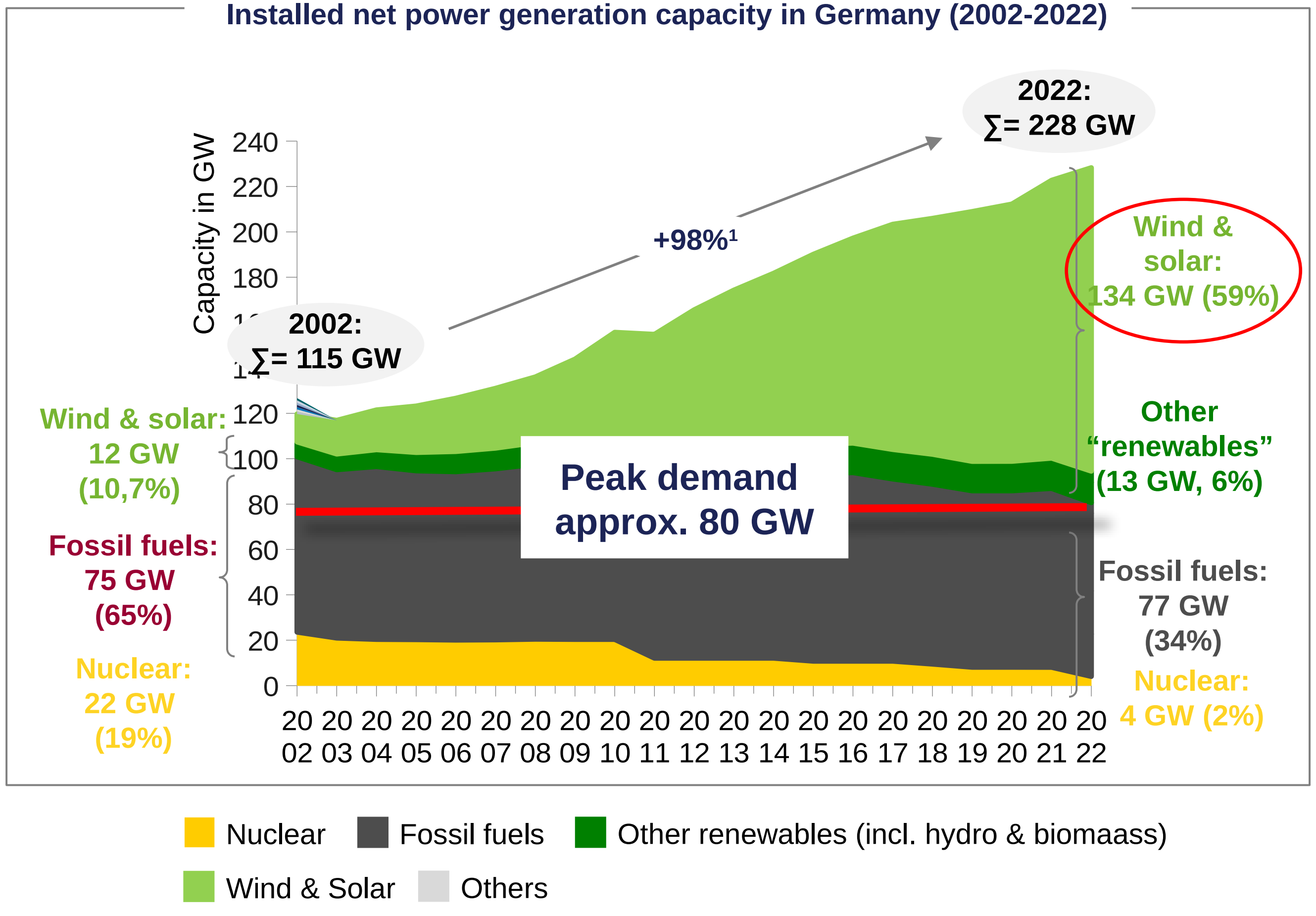
EUFPN | Perspective | Germany

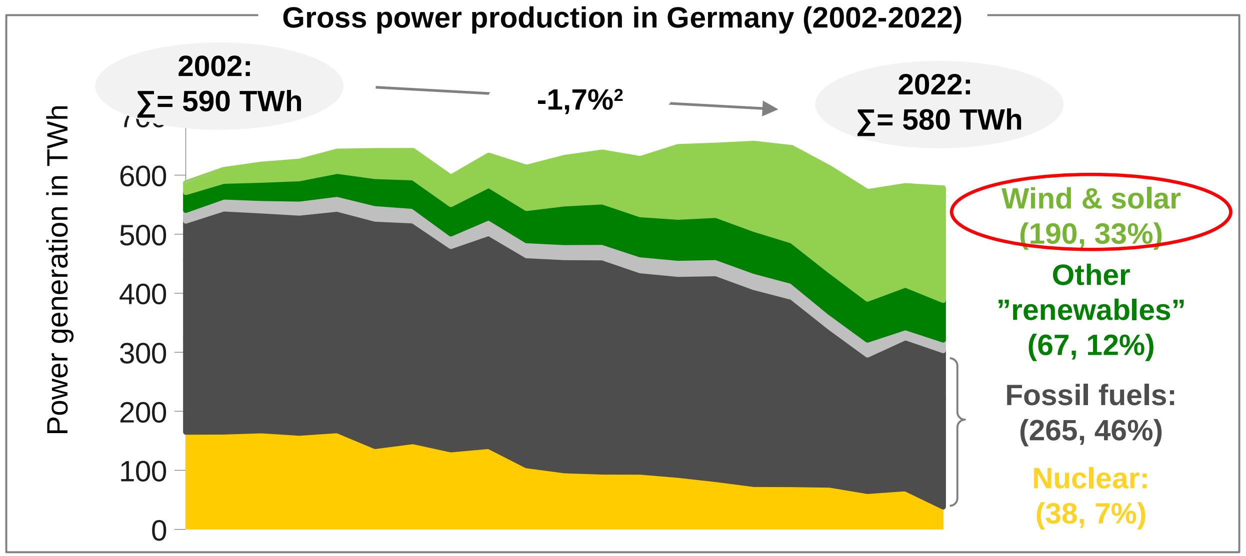
Germany 2022: Renewable Installed Capacity vs. Power Generation and Primary Energy

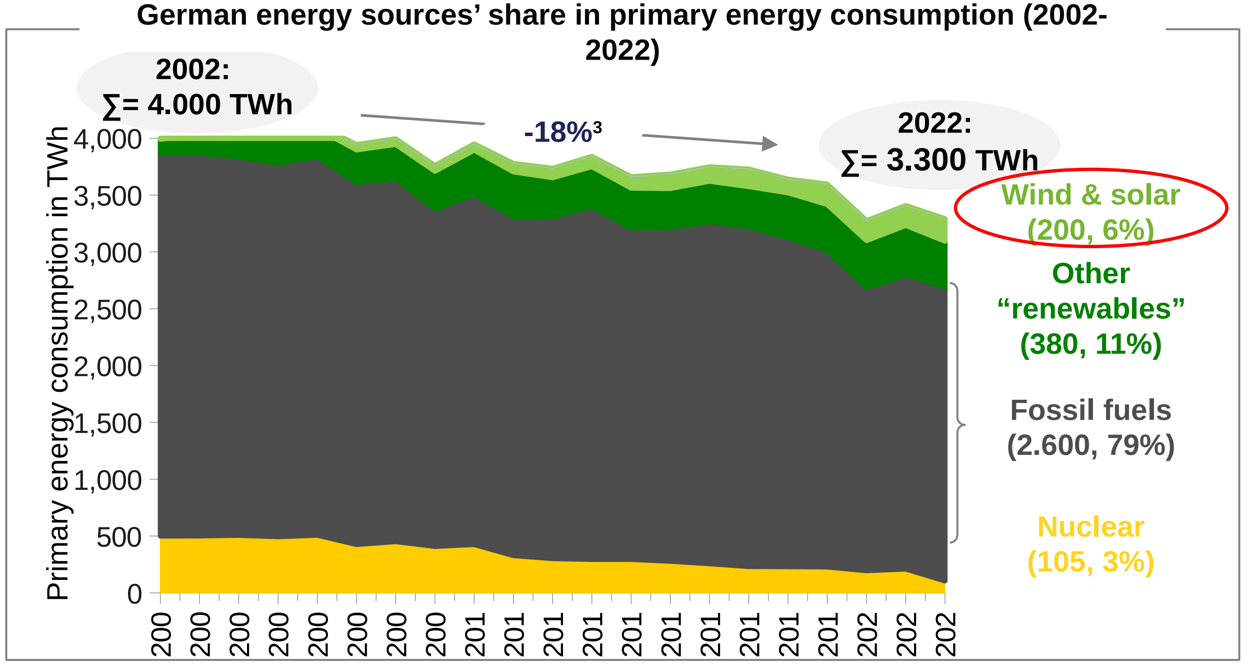
Wind & Solar: 59% Capacity Gave Germany 33% Electricity and 6% Primary Energy

∑ = ~8.000 GW = 8 TW in 2020

Total global installed capacity







(1) CAGR: +3,5%; (2) CAGR: -0,09%; (3) CAGR -1%

Sources: Schernikau Research and Analysis based on Fraunhofer Institute (https://energy-charts.info/charts/installed_power/chart.htm?l=de&c=DE&chartColumnSorting=default&year=2022), Agora Energiewende (https://www.agora-energiewende.de/veroeffentlichungen/die-energiewende-in-deutschland-stand-der-dinge-2022/), and AG Energiebilanzen (https://ag-energiebilanzen.de/wp-content/uploads/2023/01/quartalsbericht_q4_2022.pdf)

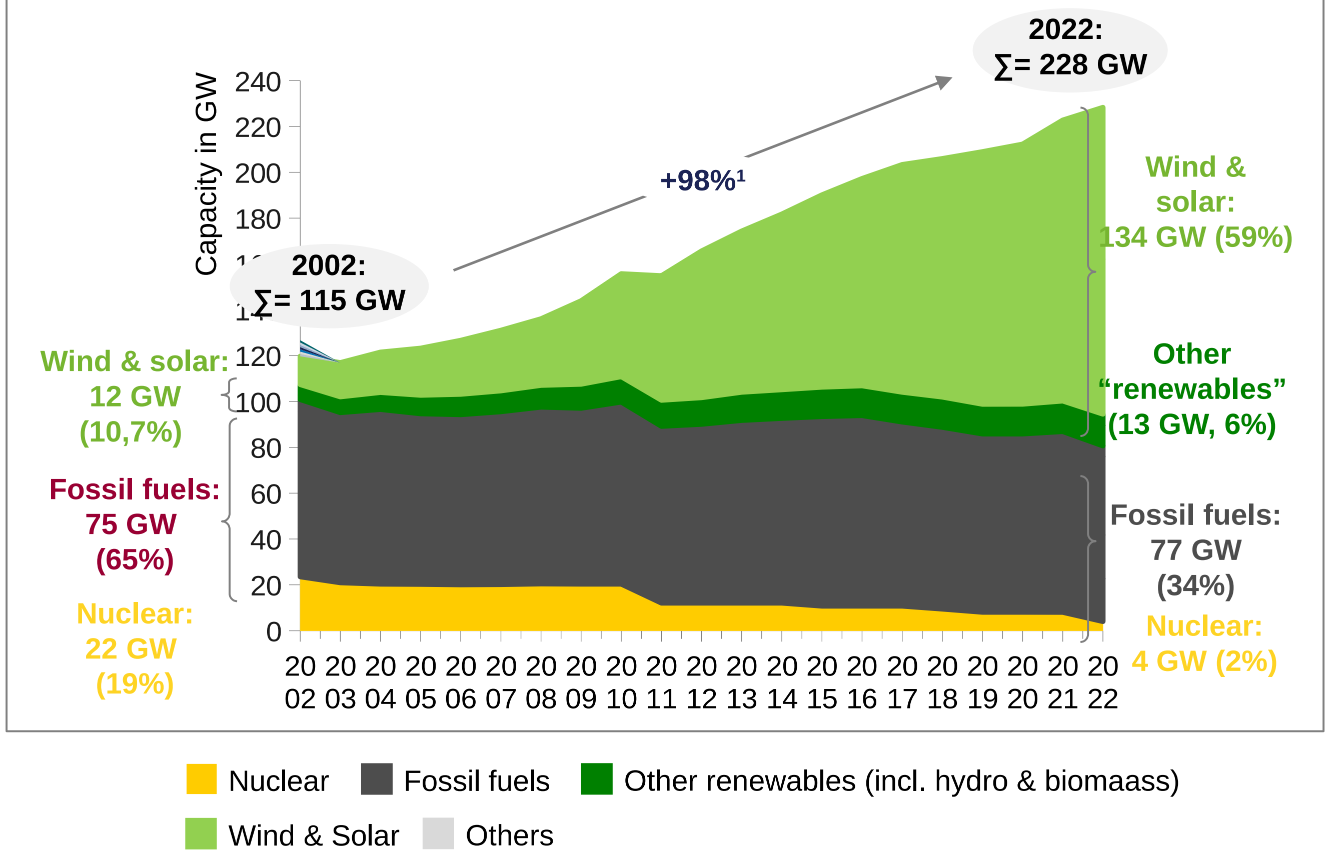
Germany 2022: Renewable Installed Capacity vs. Power Generation and Primary Energy

Schernikau on Energy Policy

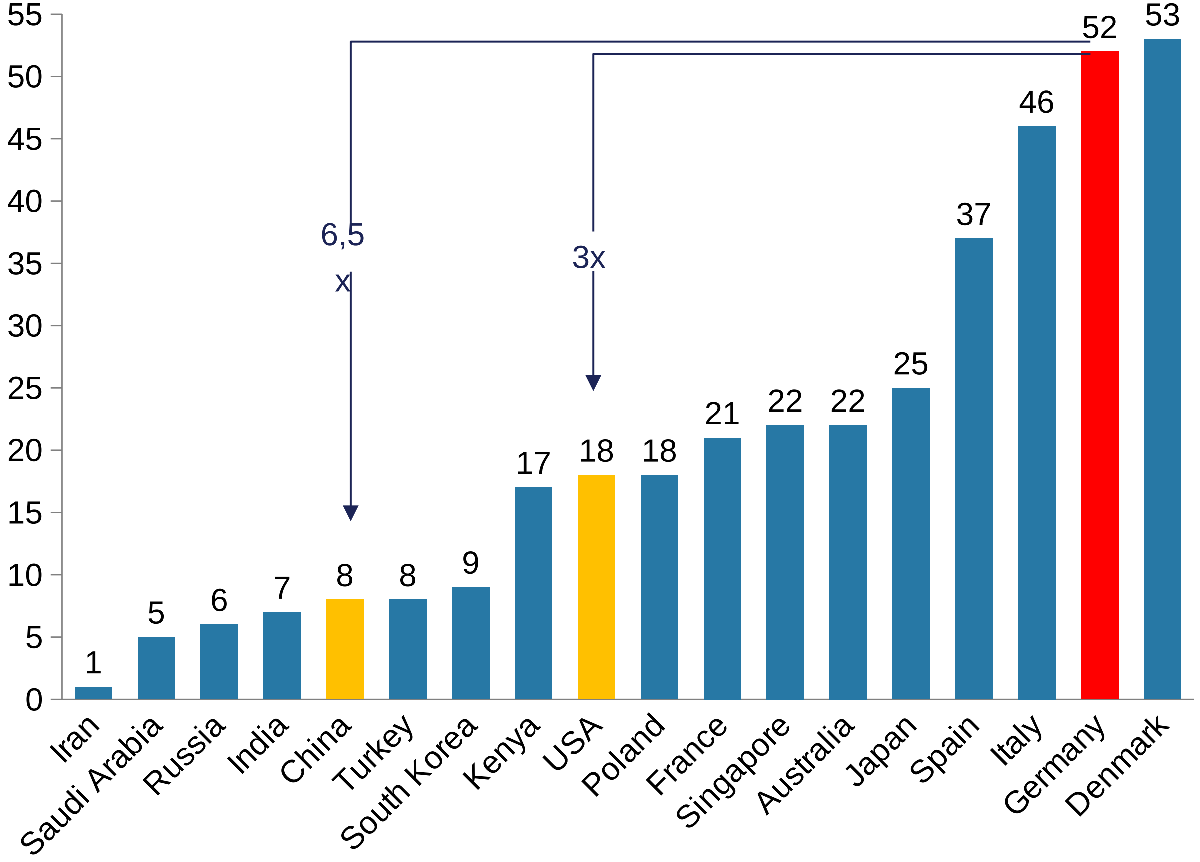
Germa Industrial Electricity Prices:

2002: 7 ct / kWh
2023: 40 ct / kWh

Installed net power generation capacity in Germany (2002-2022)



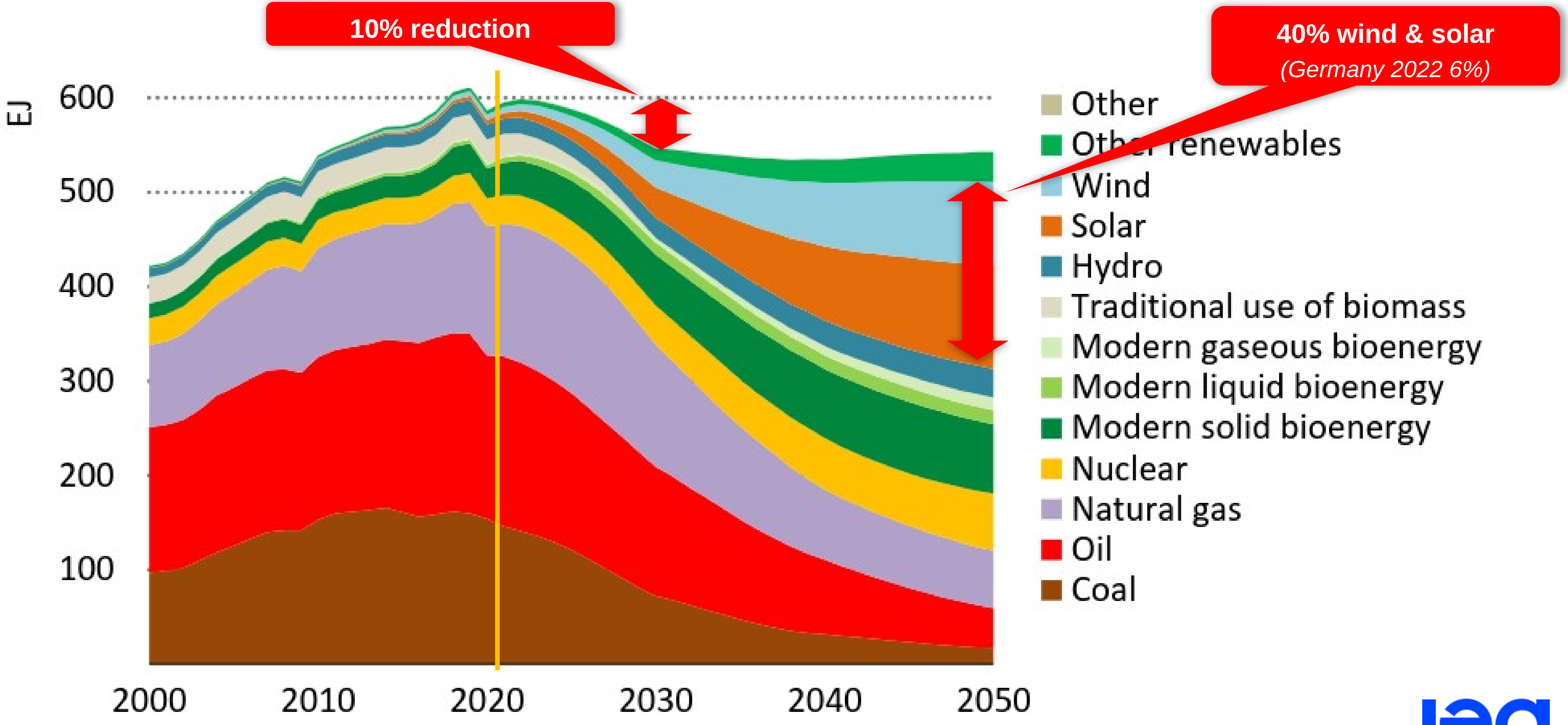
Consumer electricity prices
by country in 2022 (US$c/kWh)



(1) CAGR: +3,5%; (2) CAGR: +0,1%; (3) CAGR -0,9%; (4) Including hydro & biomass

Sources: Schernikau Research and Analysis based on Frauenhofer Institute (link), Agora Energiewende (https://static.agora-energiewende.de/fileadmin/Projekte/2022/2022_01_DE-JAW2021/A-EW_247_Energiewende-Deutschland-Stand-2021_WEB.pdf), AG Energiebilanzen (https://ag-energiebilanzen.de/daten-und-fakten/primaerenergieverbrauch/ and https://ag-energiebilanzen.de/daten-und-fakten/zusatzinformationen/); Statista for industrial power prices https://www.statista.com/statistics/1050448/industrial-electricity-prices-including-tax-germany/

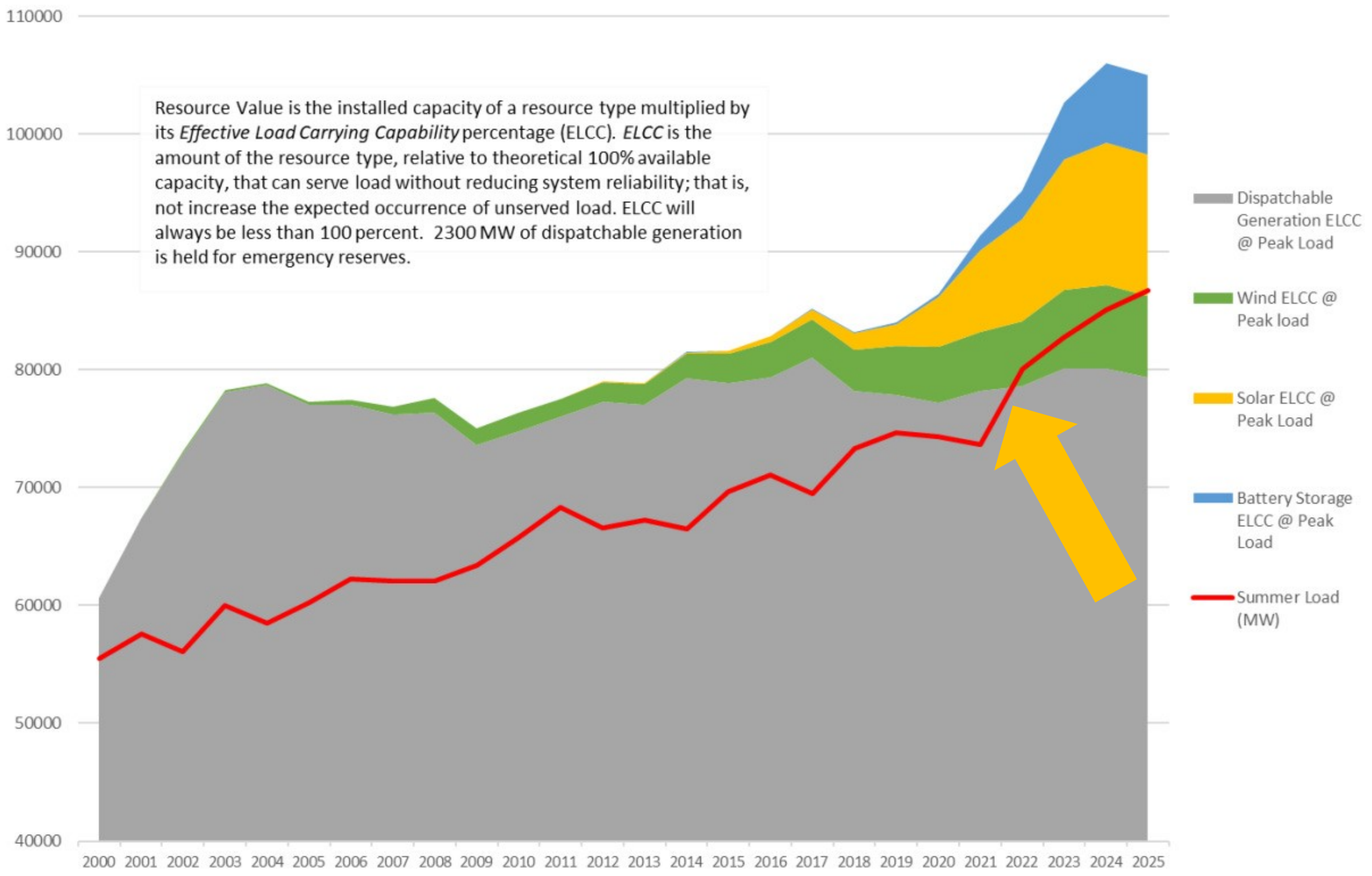
IEA 2021 Net-Zero Pathway: Total Energy Down by 2050, About 20% from Coal, Oil & Gas



Source: "IEA: Net Zero by 2050 – Analysis," May 2021. https://www.iea.org/reports/net-zero-by-2050, p57.

Texas - ERCOT: Cannot sustain power supply all times since 2022

TEXAS: MW Resource Value vs. Summer Peak Load
(actual vs planned generation capacity, GW)



Source: Aug 2023: https://www.douglewin.com/p/ercot-and-texas-need-a-different

Reliability First Looks better (MISO & PJM)

Region: Midwest US from Wisconsin to NJ

=> ***sufficient reserve margin***

Installed capacity

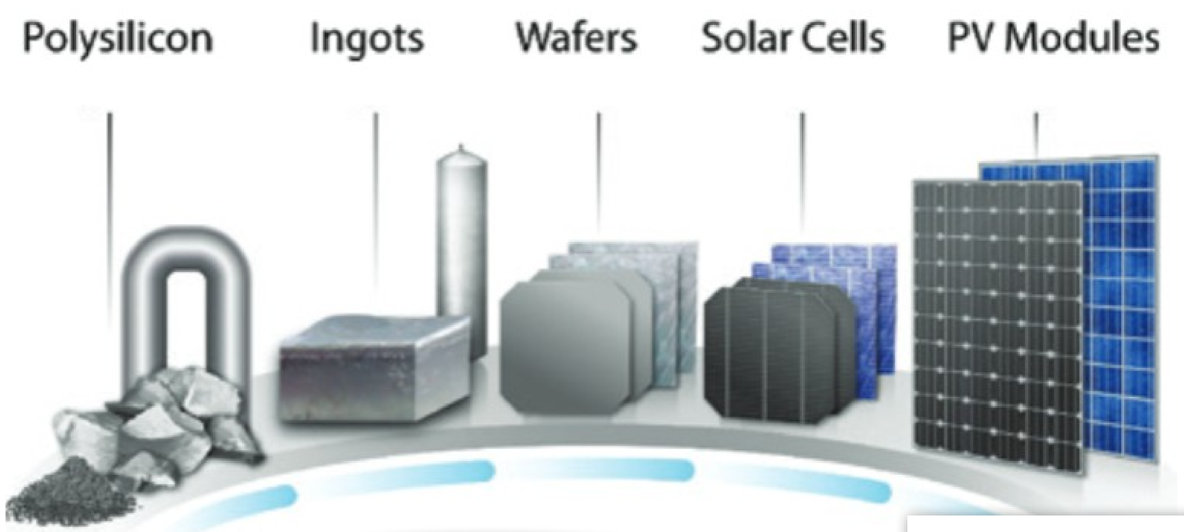
- 220+ GW total
- 170 GW peak demand
- currently about 15 GW wind and solar growing to almost 40 GW by 2030
- Reducing coal by over 40 GW until 2030

Generation

- 70% Coal and Gas
- 15% Nuclear
- 3% Wind and Solar

=> Reducing Reserve Margin until 2030

Solar Energy Needs Fossil Fuels for its Existence



And we have not discussed

Short lifetime (recycling)
Environmental effects
Backup/Storage requirement
low Energy Density => eROI …

Why do we burn coal and trees to make solar panels?

Thomas A. Troszak (2019/11/14 revision)

called "smelting." **($SiO_2 + 2C = Si + 2CO$)** Several **carbon sources** are used as **reductants** in the silicon smelting plant, which requires ~20 MWh/t of electricity, and releases CO - resulting in up to 5 - 6 t of CO_2 produced per ton of metallurgical grade (mg-Si) silicon smelted. [1] Thus, **the first step** of solar PV production is gathering, transporting, and **burning millions of tons of coal, coke and petroleum coke - along with charcoal and wood chips** made from hardwood trees - to smelt >97% pure mg-Si from quartz "ore" (silica rocks). [1][2][3][4][5][6][7][8][9][10]

2. WHY IS CARBON NEEDED FOR SOLAR PV PRODUCTION?

Elemental silicon (Si) cannot be found by itself anywhere in nature. It must be extracted from the mineral quartz (SiO_2) using carbon (C) and heat (from an electric arc) in the "carbothermic" (carbon + heat) reduction process called smelting ($SiO_2 + 2C = Si + 2CO$).

The Dirty Secret of Solar Industry

How is the carbon intensity of photovoltaic energy calculated?

Enrico Mariutti
07/04/2023

There is no solar panel without
quartz sand, coal, wood, silver, steel, aluminum, or glass

McKinsey 2023: demand for finished steel (for example, plates for wind turbine towers) **40 Mt per TW solar, and 150 Mt per TW wind**
Source: Schernikau, based on Troszak, Mariuitti, and others; McKinsey "The Resilience of Steel: Navigating the Crossroads, April 2023. linkt, p8

Negative effects of Large-Scale Solar Farms have been Documented

«temperature rise, redistribution of precipitation»

Geophysical Research Letters

RESEARCH LETTER

10.1029/2020GL090789

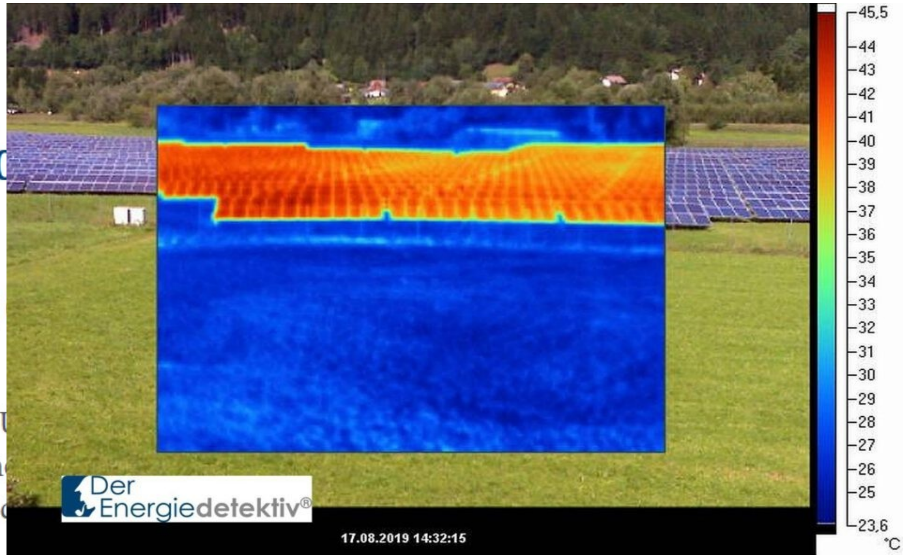
Key Points:

- A set of state-of-the-art Earth-system model simulations are used to study the impacts of large-scale (20% coverage or more) Sahara solar farms
- These hypothetical solar farms increase local rainfall and vegetation cover through positive atmosphere–land(albedo)–vegetation feedbacks

Impacts of Large-Scale Sahara Sc[...] Climate and Vegetation Cover

Zhengyao Lu[1], Qiong Zhang[2], Paul A. Miller[1,3], Benjamin Smith[1,4]

[1]Department of Physical Geography and Ecosystem Science, Lund U[...] Physical Geography and Bolin Centre for Climate Research, Stockh[...] Environmental and Climate Research, Lund University, Lund, Swe[...] Western Sydney University, Penrith, NSW, Australia



Plain Language Summary Solar energy can contribute to the attainment of global climate mitigation goals by reducing reliance on fossil fuel energy. It is proposed that massive solar farms in the Sahara desert (e.g., 20% coverage) can produce energy enough for the world's consumption, and at the same time more rainfall and the recovery of vegetation in the desert. However, by employing an advanced Earth-system model (coupled atmosphere, ocean, sea-ice, terrestrial ecosystem), we show the unintended remote effects of Sahara solar farms on global climate and vegetation cover through shifted atmospheric circulation. These effects include global temperature rise, particularly over the Arctic; the redistribution of precipitation (most notably droughts and forest degradation in the Amazon) and northward shift of the Intertropical Convergence Zone; the northward expansion of deciduous forests in the Northern Hemisphere; and the weakened El Niño-Southern Oscillation and Atlantic Niño variability and enhanced tropical cyclone activity. All these remote effects are in line with the global impacts of the Sahara land-cover transition ~6,000 years ago when Sahara desert was wetter and greener. The improved understanding of the forcing mechanisms of massive Sahara solar farms can be helpful for the future site selection of large-scale desert solar energy facilities.

Source: Lu et al 2020, https://doi.org/10.1029/2020GL090789

Biomass power plants emit 50 to 85 percent more carbon dioxide than modern coal plants, and more than three times as much carbon dioxide as natural gas-fueled power plants.[3]

Energy at a Glance

Biomass for Energy

By Linnea Lueken

"Although it may make sense to get as much use out of timber scraps and garbage as possible, ***growing trees with the intent of using them strictly for densified biomass fuel does not make sense over the short- or long-term***."

MIT Climate Portal

ASK MIT CLIMATE

Why aren't we looking at more hydropower?

MIT: There's still room for hydro to grow, but most countries ***will not build out as much hydropower*** as they theoretically could—***and that may be for the best***.

EPA United States Environmental Protection Agency

…biofuels.. require land, water, and other resources, … biofuel production may give rise to several undesirable effects… drawbacks include changes to land use … ***may increase GHG emissions***, pressure on water resources, air and water pollution, and increased food costs.

EMBER — About · Research · Data · Commentary

UK biomass emits more CO2 than coal

Source: Ember on Biomass, EPA on Biomass, MIT on Hyropower; Heartland study on Biomass

Harvard Study on „down side“ of Wind


The Harvard Gazette

SCIENCE & TECHNOLOGY

The down side to wind power

Wind farms will cause more environmental impact than previously thought

This research was funded by the Fund for Innovative Climate and Energy Research

The key messages in the Harvard article are

the transition to wind or solar power in the U.S. would require five to 20 times more land than previously thought

Schernikau Smith 2023: Energy Restoration Rate ERR 1,5 – 2 MW/km²

… neglected to accurately account for interactions between turbines and atmosphere

… average wind power density —rate of energy generation divided by encompassing area of the wind plant —up to 100 times lower than estimates by some leading energy experts

If your perspective is next 10 years, wind power actually has — in some respects — more climate impact than coal or gas…**If your perspective is next thousand years, *then wind power has enormously less climatic impact than coal or gas***

- Harvard researchers found that warming effect of wind turbines in the U.S. was larger than effect of reduced emissions for first century of its operation.

We find that generating today's US electricity demand (0.5 TWe) with wind power would warm Continental US surface temperatures by 0.24°C. Warming arises, in part, from turbines redistributing heat by mixing the boundary layer.

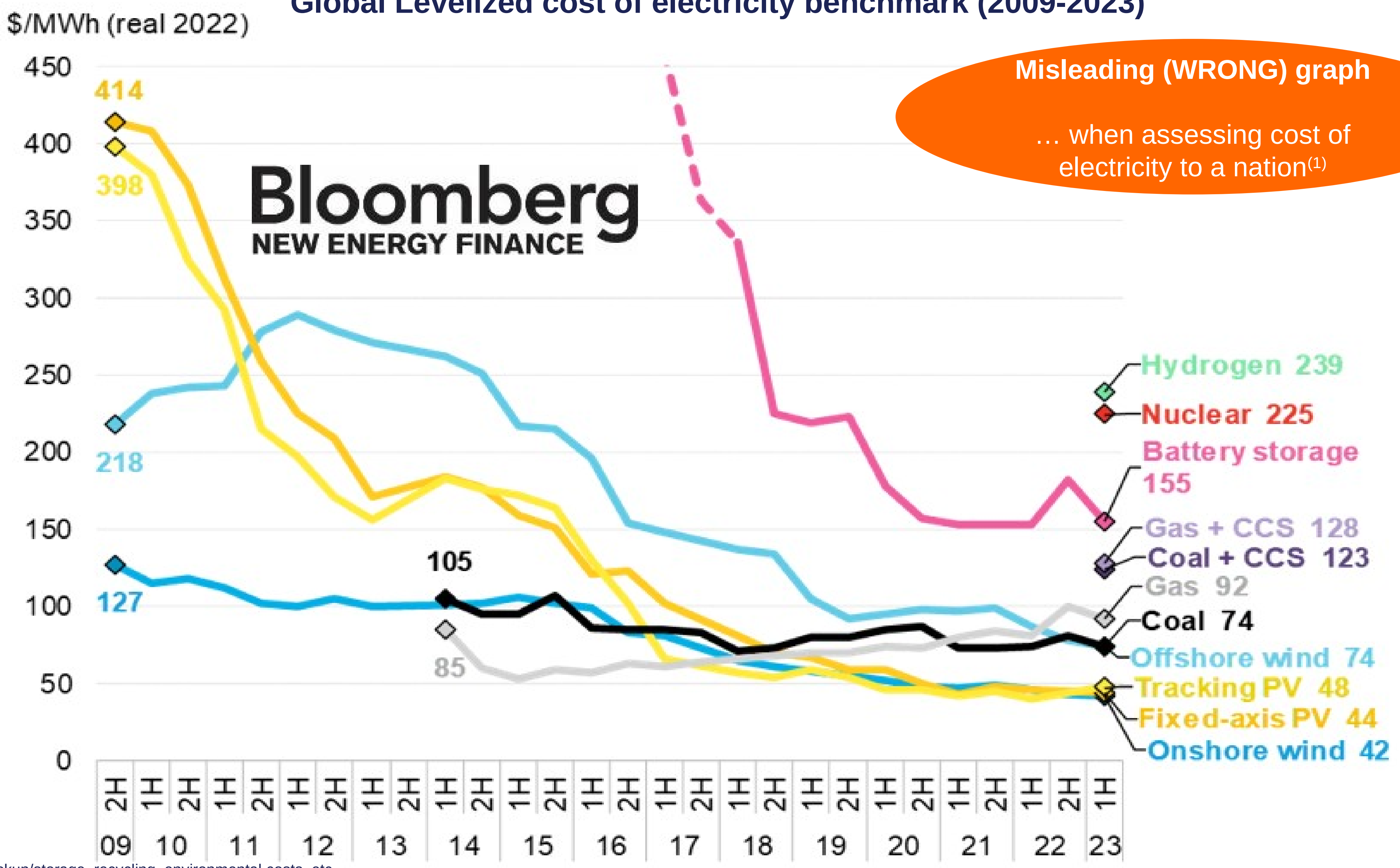
“The direct climate impacts of wind power are instant, while the benefits of reduced emissions accumulate slowly”

Sources: Miller, Lee, and David Keith. “Miller Keith 2018 - Climatic Impacts of Wind Power.” *Joule* 2 (2018). https://doi.org/10.1016/j.joule.2018.09.009.

Understanding Cost of Electricity (LCOE?) Is Crucial for New Builds …

… but only for comparing apples with apples (not for comparing renewables with conventionals)

Global Levelized cost of electricity benchmark (2009-2023)



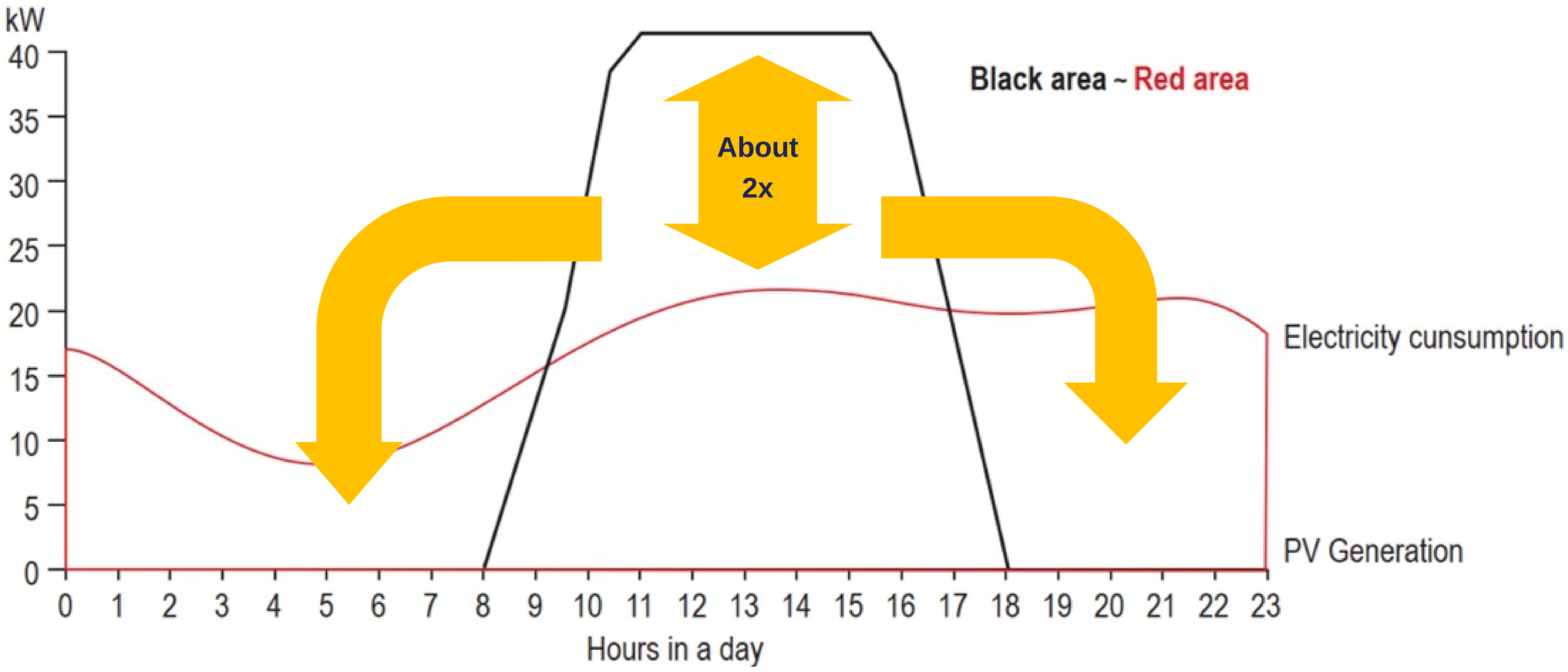
(1) Misses network integration, backup/storage, recycling, environmental costs, etc

Source: Schernikau basd on Jun 2023, BNEF, https://about.bnef.com/blog/cost-of-clean-energy-technologies-drop-as-expensive-debt-offset-by-cooling-commodity-prices/

Typical Electricity Demand Curve and PV Production – a Sunny Day around the Equator

Schernikau on Energy Policy

Electricity demand curve with required PV production



Note: The photovoltaic peak must be approximately twice the demand peak.

Source: Nominal electricity demand curve with photovoltaic production schematic by the author, adapted from EnergyMag accessed 4 Sep 2020 at this link.

Typical Electricity Demand Curv… d … Day around the Equator

Schernikau on Energy Policy

Illustrative

n … production

x12

to

x20

GER:

x27

to

x45

With H_2

as

backup

About

x3 to x5

California

avg.

CF 25%

x4

Germany 11% (x9)

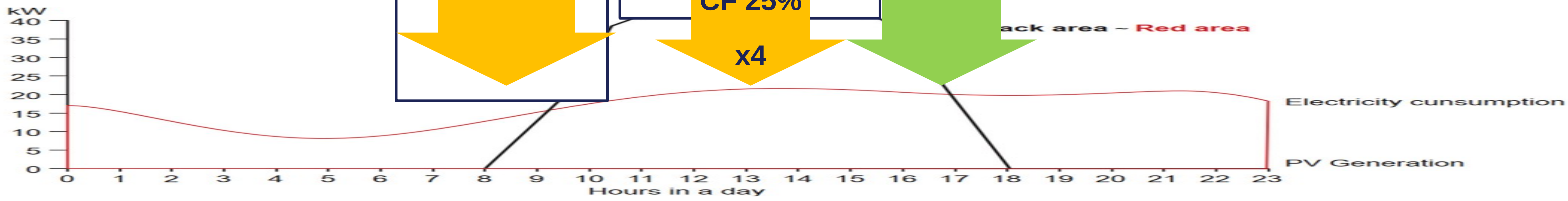
seasonal and weather variations

Charge

long duration energy storage (LDES)

5, 10, 30, 60 days?

= 270x (@10x)



Note: The photovoltaic peak must be approximately twice the demand peak.

Source: Nominal electricity demand curve with photovoltaic production schematic by the author, adapted from EnergyMag accessed 4 Sep 2020 at this link.

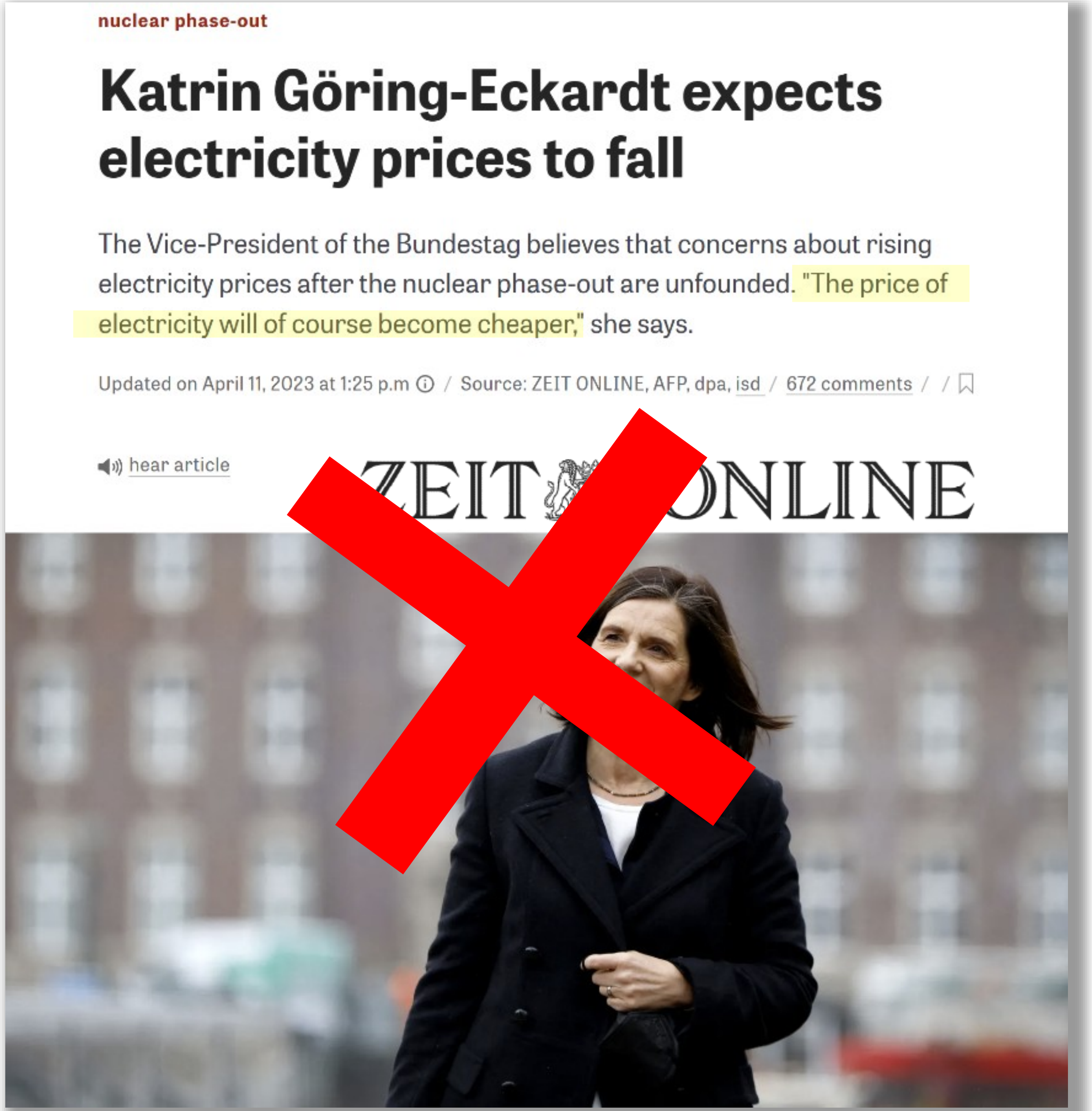
Media and Politicians continue to Mislead (or be mislead?)


Switching to renewable energy could save trillions - study

By Jonah Fisher
BBC Environment Correspondent

2 days ago

The cost of green energy like wind and solar has been falling for decades


nuclear phase-out

Katrin Göring-Eckardt expects electricity prices to fall

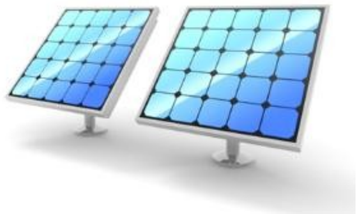
The Vice-President of the Bundestag believes that concerns about rising electricity prices after the nuclear phase-out are unfounded. "The price of electricity will of course become cheaper," she says.

Updated on April 11, 2023 at 1:25 p.m / Source: ZEIT ONLINE, AFP, dpa, isd / 672 comments / /

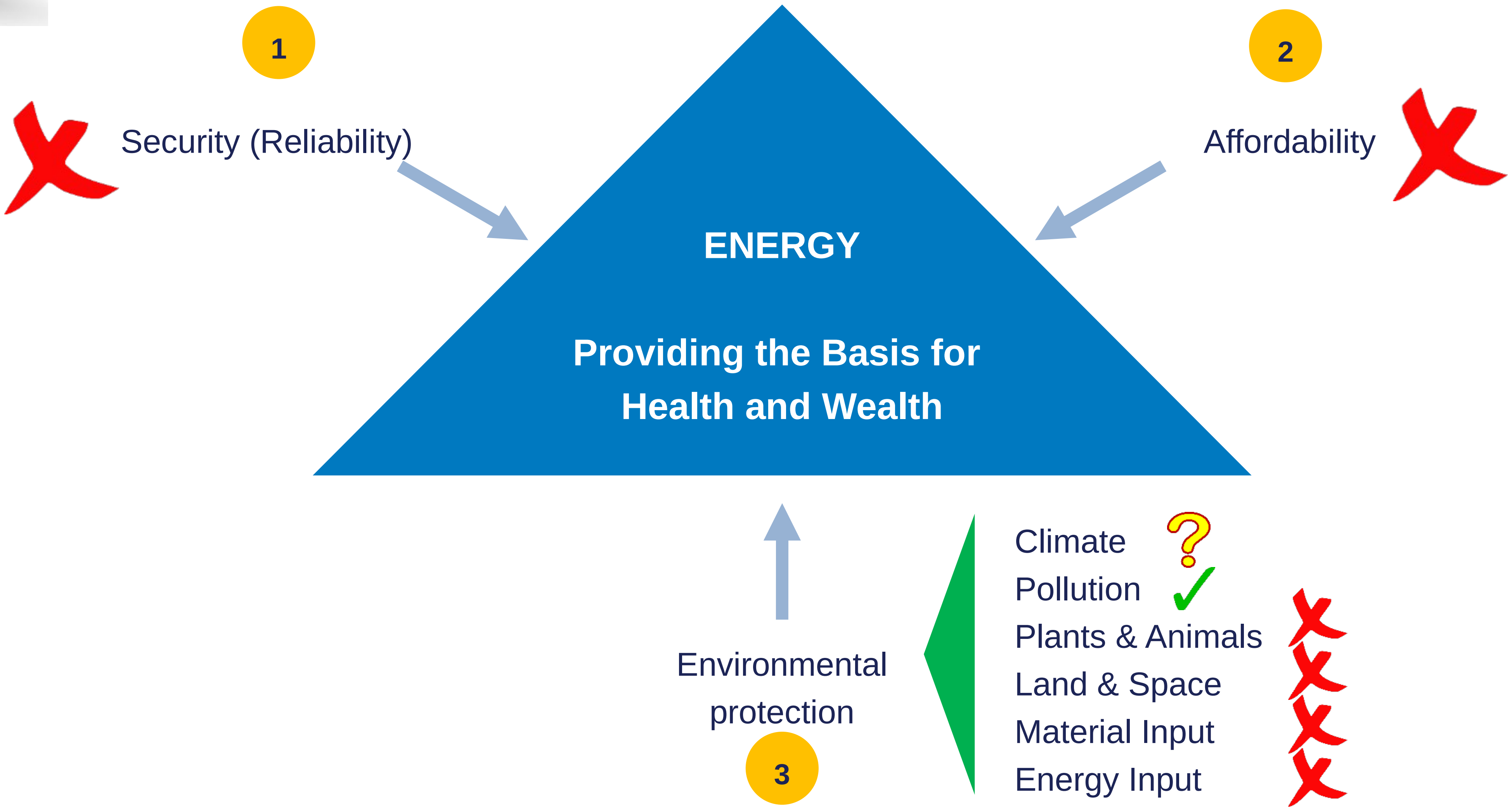
hear article

Source: BBC Sep 2022 and Die Zeit Apr 2023

Triangle of Objectives in Energy Policy – The Famous Trilemma



Examining Wind & Solar



Source: Schernikau research; i343

The New Energy Revolution

1. Invest in base research

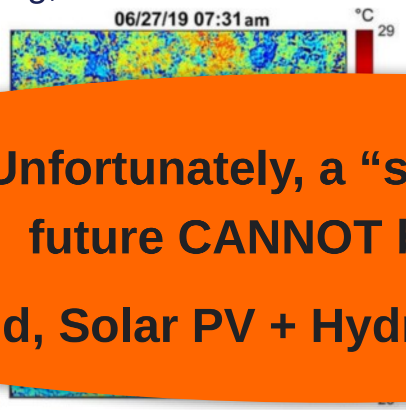
to sustainably wean off fossil fuels

energy generation, material extraction & processing, storage, superconductors, recycling, etc.

2. Invest in existing energy & steel making technology/infrastructure

to reduce environmental burden and increase energy efficiencies

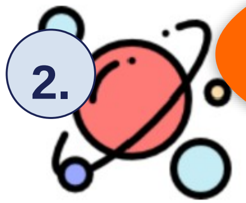
✓ *Reduce the waste we generate (e.g., WtP)*
Reduce poverty to weather climatic changes



Unfortunately, a "sustainable" future CANNOT be built on

Wind, Solar PV + Hydrogen/Batteries

1. nuclear force



2. "power" of our planetary system (i.e., sun)

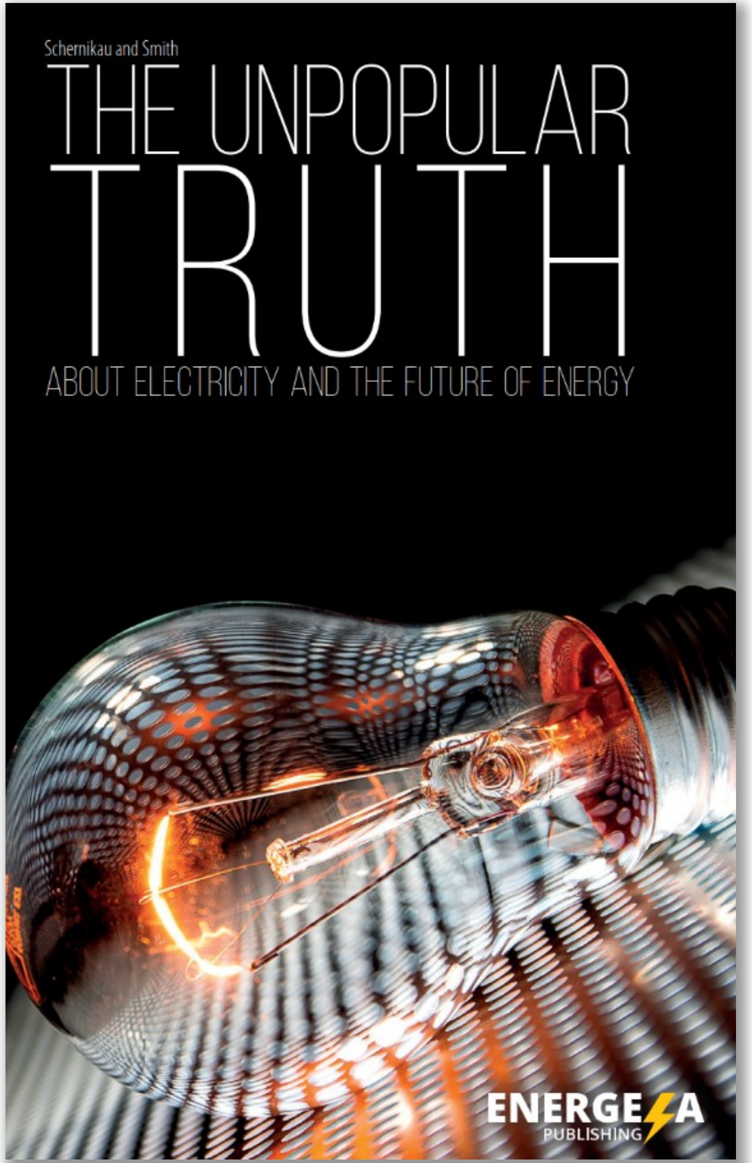
3. energy from within our planet

4. ***"Such new energy system may be completely new, … a presently unknown energy source?"***

"If investments in fossil fuels will not increase substantially, a prolonged global energy crisis is difficult to avoid this decade"

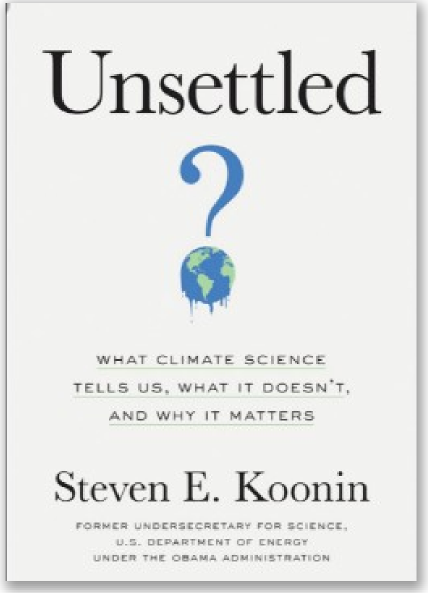
Source: Schernikau et al. 2022

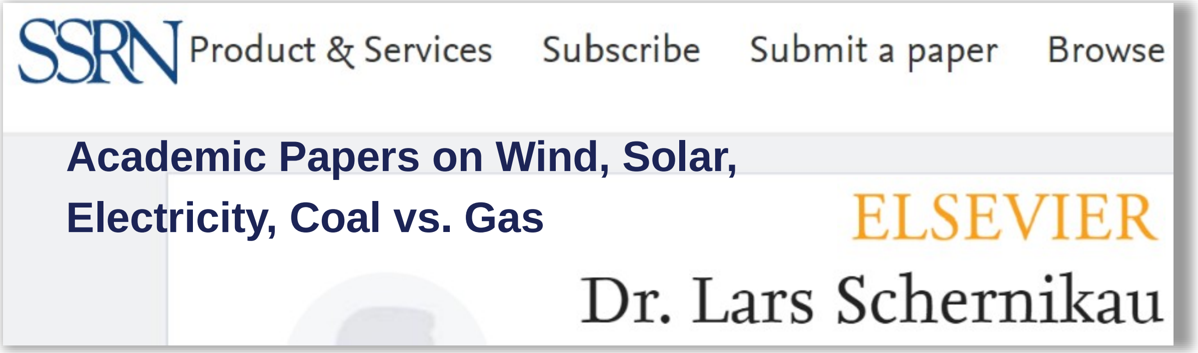
Recommended Papers and Books (www.unpopular-truth.com)



Available on Amazon now
https://amzn.to/3togypC

https://youtu.be/k_uBiHoIZIw/





Academic Papers on Wind, Solar, Electricity, Coal vs. Gas

https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=4356382

THANK YOU

Please contact me for clarification where needed

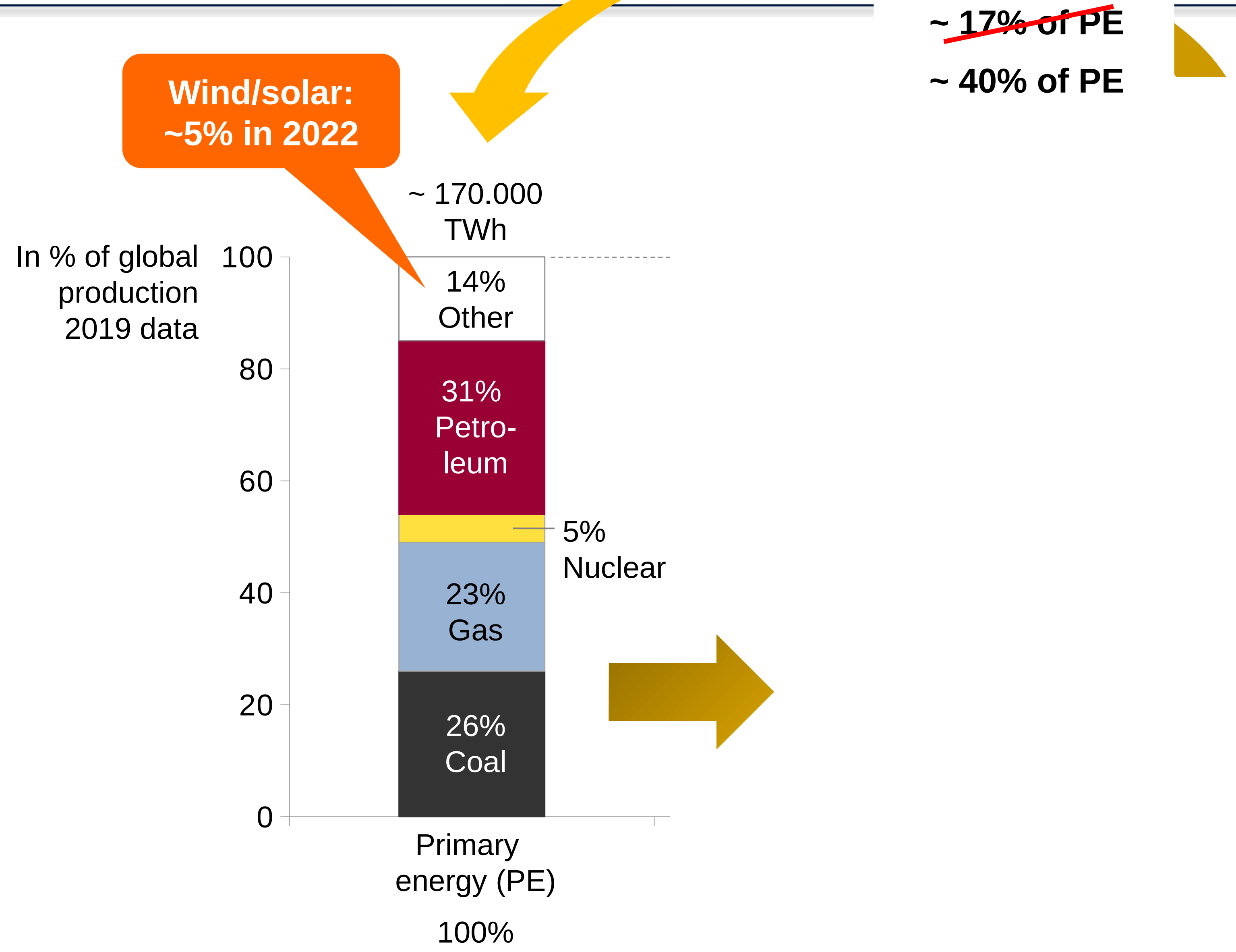
I am available selectively for presentations/workshops

- Energy economics and policy
- Science of climate change
- „Renewable“ vs. conventional energy

BACKUP

Electricity: About 40% of Global Primary Energy

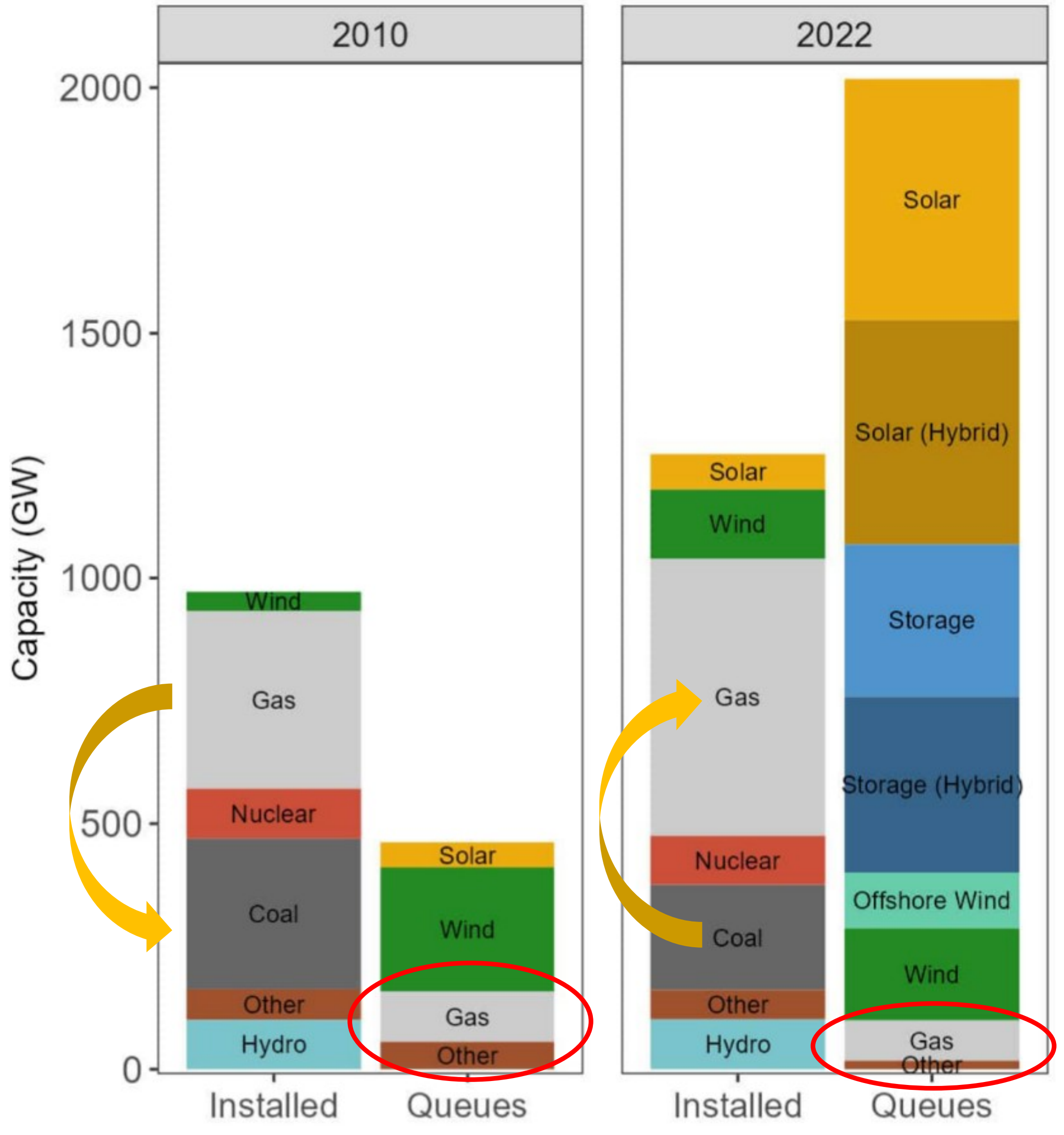
Fossil Fuels: About 60% of Electricity and 80% of Global Primary Energy



(1) Only the portion of Industry/Transport/Building that is not included under electricity; (2) assumed worldwide net efficiency of about 33% for nuclear, 37% for coal, 42% for gas, assume avg. ~40% efficiency => 27.000TWh becomes 68.000 TWh or 40% of 170.000TWh
Sources: Schernikau analysis based on IEA Energy Technology Perspectives 2020 (link), BP Statistical Review of World Energy 2020 (link), see also World in Data

US: 2 TWs of generation and storage capacity sits in interconnection queues

US Installed Capacity vs. Active Queues



Despatchable Capacity Growth hardly present

Growing backlog has become major bottleneck for project development:

- **Projects are taking longer to complete the interconnection study and to come online, and most of interconnection requests are ultimately canceled.**

What are interconnection queues?

Utilities and regional grid operators require projects seeking to connect to the grid to undergo a series of studies before they can be built.

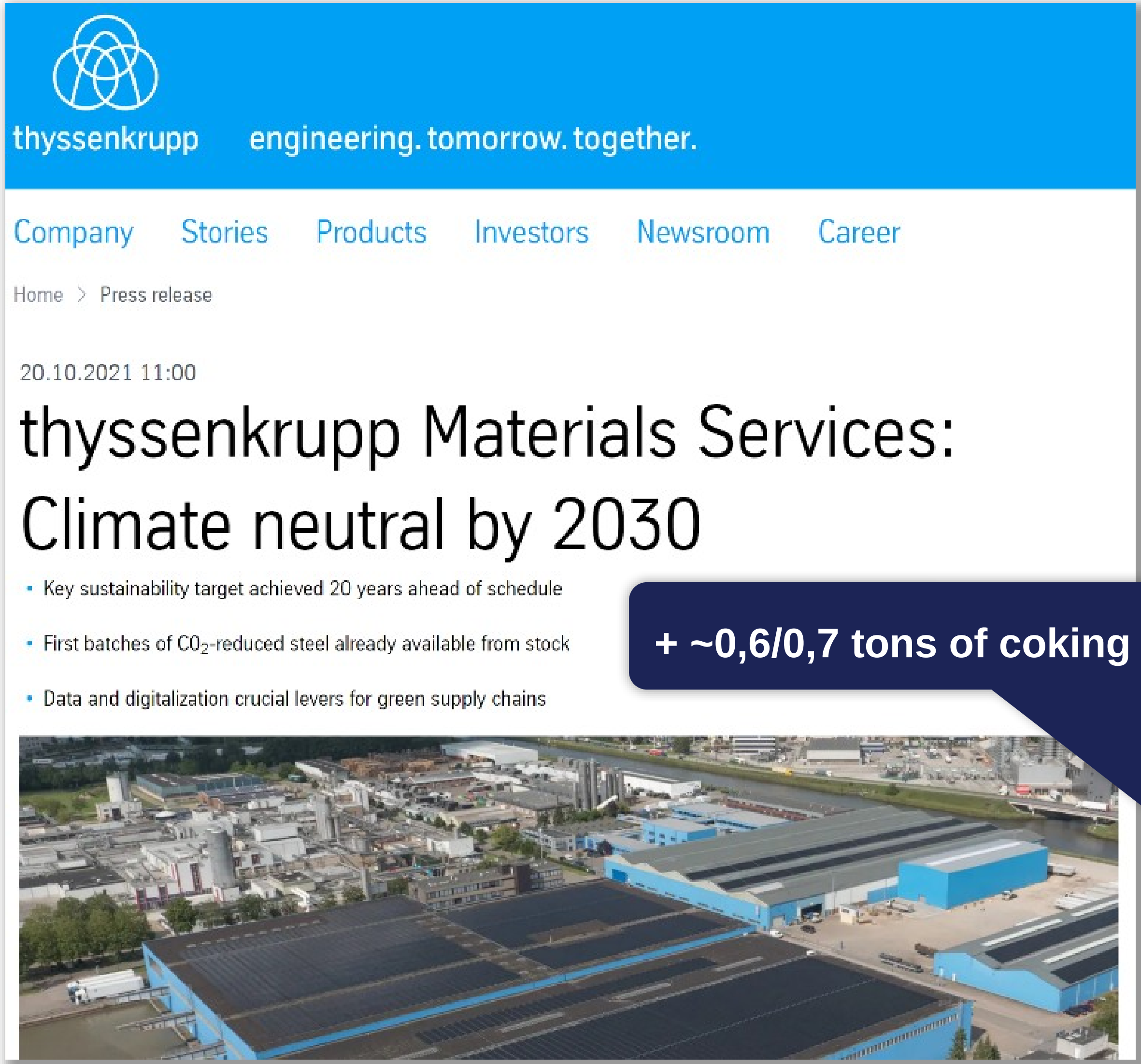
This process establishes what new grid system upgrades may be needed before a project can connect to the system and then estimates and assigns the costs of that equipment.

The lists of projects that have applied to connect to the grid and initiated this study process are known as "interconnection queues".

Source: Schernikau based on Rand, Joseph, Mark Bolinger, Ryan Wiser, Seongeun Jeong, and Bentham Paulos. "Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2020," April 2023. https://doi.org/10.2172/1784303.

The Logic of „Green Steel“

replace 0,6/0,7 tons of coking coal – or 5-6 MWh of primary energy – with 3 MWh of „green“ electricity


thyssenkrupp engineering. tomorrow. together.

Company Stories Products Investors Newsroom Career

Home > Press release

20.10.2021 11:00

thyssenkrupp Materials Services: Climate neutral by 2030

- Key sustainability target achieved 20 years ahead of schedule
- First batches of CO_2-reduced steel already available from stock
- Data and digitalization crucial levers for green supply chains

+ ~0,6/0,7 tons of coking coal

200.000 Jobs in Gefahr – Die Stahlindustrie steckt im Klima-Dilemma

Stand: 17.02.2022 | Lesedauer: 7 Minuten

Thyssen Steel Chairman Osburg:

«going climate neutral will increase energy demand 10x

from 4,5 TWh to 45 TWh for Duisburg plant alone»

(4x city of Hamburg demand, all p.a.)

McKinsey 2023: … production of **1 ton of green steel** using H_2-based DRI and EAF route will require more than **3 MWh** of “renewable” power…

… while production of **1 ton of steel** using a fully integrated blast furnace–basic oxygen furnace (BF-BOF) route requires **about 0,1 MWh** electricity.

Source: Schernikau research and analysis; Energiekosten: 200.000 Jobs in Gefahr – Stahlindustrie im Klima-Dilemma – WELT; McKinsey “The Resilience of Steel: Navigating the Crossroads, April 2023. linkt, p8

Solar Panels Are Starting to Die. Will We be Able to Recycle the E-Waste?

IRENA – EcoWatch

Schernikau on Energy Policy

SOLAR

Solar Panels Are Starting to Die. Will We be Able to Recycle the E-Waste?

By Tiffany Duong | Aug. 30, 2020 09:00AM EST

ENERGY

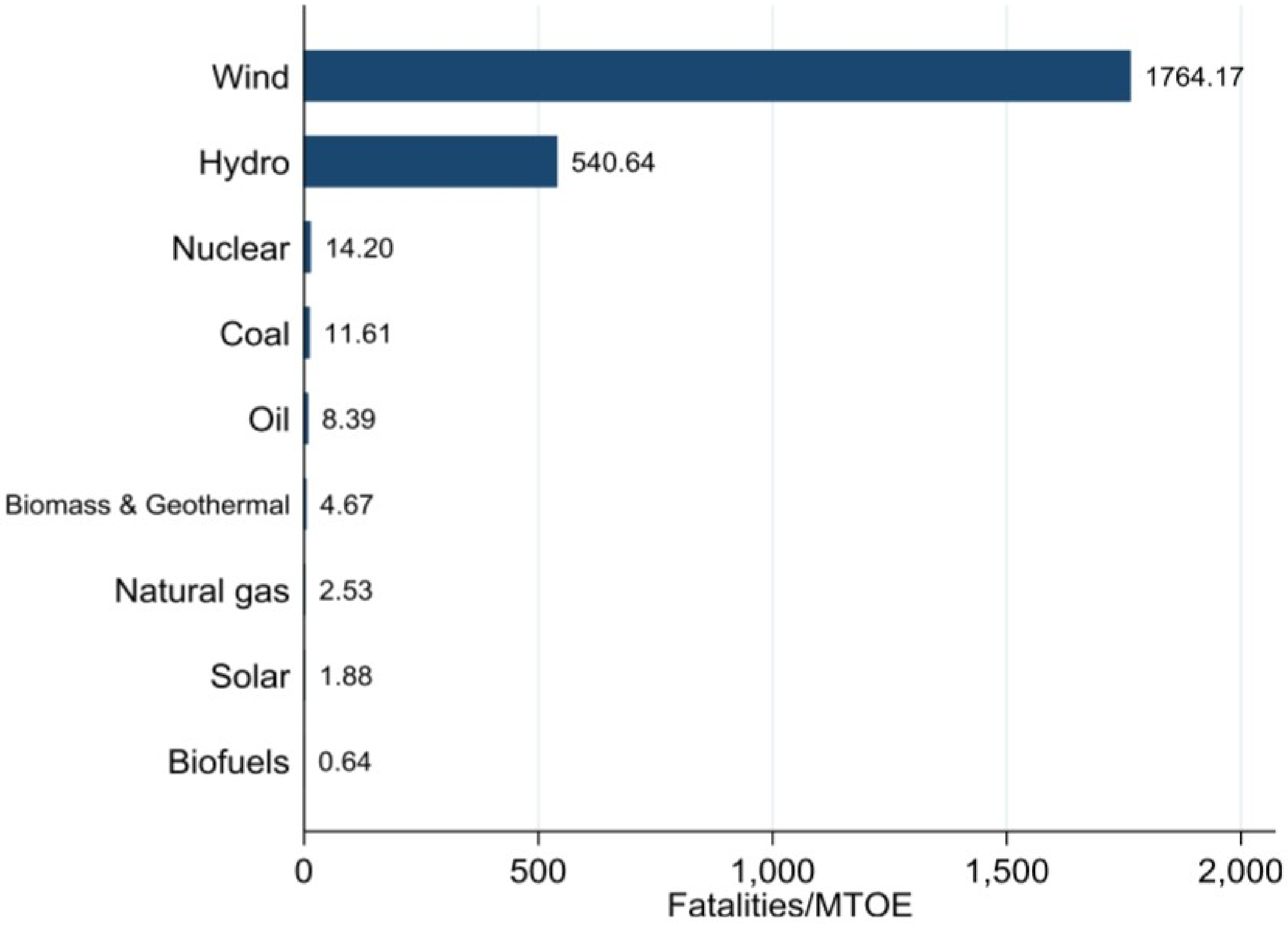
Solar photovoltaic (PV) panels convert sunlight into energy and continue to play an essential role in the fight to stop the climate crisis. As the pioneering panels of the early 2000s near the end of their 30-year electronic lives, however, they are at risk of becoming the world's next big wave of e-waste.

International Renewable Energy Agency (IRENA), a leading energy agency, projected that up to 78 million metric tons of solar panels will have reached the end of their life by 2050, resulting in about 6 million metric tons of new solar e-waste annually, reported Grist.

Source: EcoWatch, Aug 2020, Will We be Able to Recycle Solar Panels When They Die? - EcoWatch,

Energy accidents of «green» wind and hydro compared

Energy accident fatalities by technology normalized by energy produced



The Extractive Industries and Society 8 (2021) 100885

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Original article

Critically assessing and projecting the frequency, severity, and cost of major energy accidents

Jinsoo Kim[a,b,*], Donghoon Ryu[a], Benjamin K. Sovacool[b,c,*]

[a] Department of Earth Resources and Environmental Engineering, Hanyang University, Republic of Korea
[b] Science Policy Research Unit, University of Sussex, United Kingdom
[c] Aarhus University, Denmark

ARTICLE INFO

Keywords:
Energy disasters
Safety
Security
Risk
Accident prevention

ABSTRACT

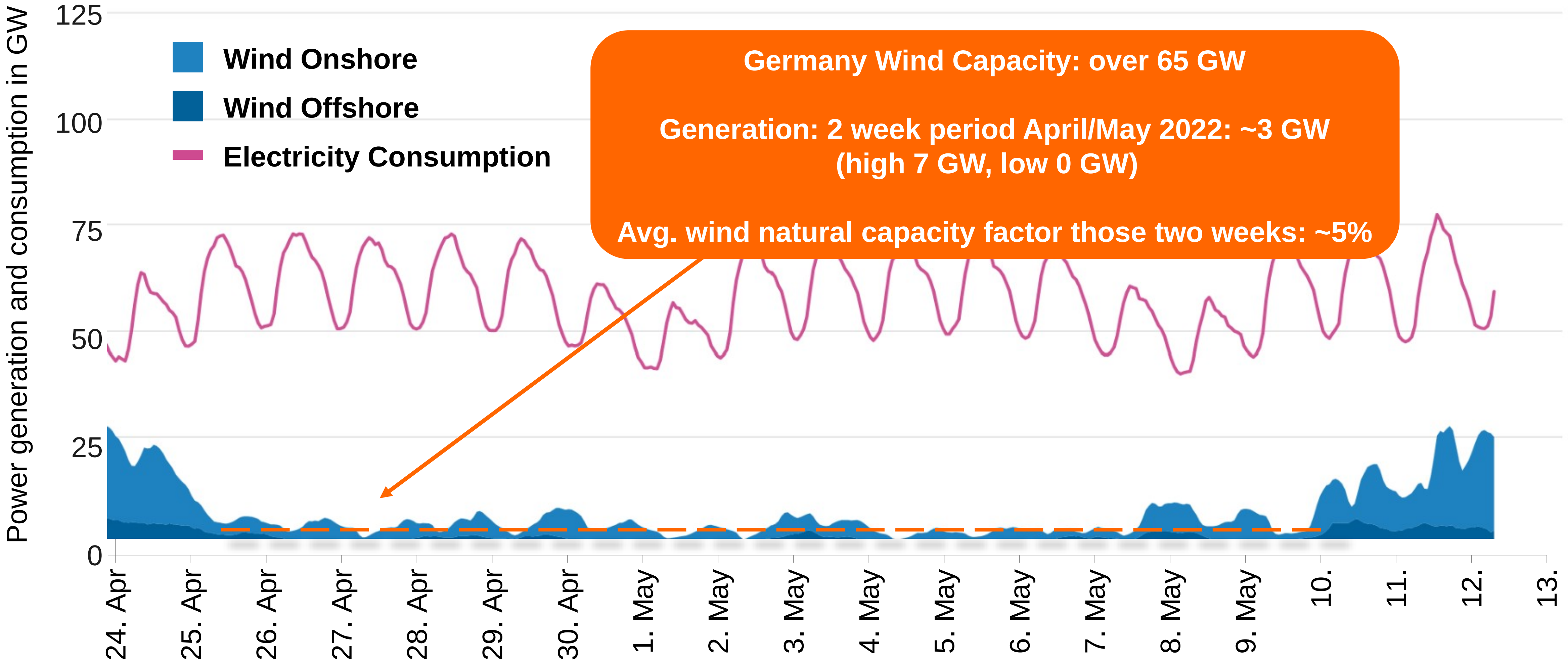
Although energy systems are well known to lead to positive or negative externalities, one less explored attribute has been a rigorous historical and future looking assessment of energy accidents. In this study, we analyze an extensive dataset of 4,450 energy accidents from 1800 to 2018 across eleven energy systems. Our analysis reveals that these collective energy systems resulted in more than 278,000 human fatalities and approximately $421.3 billion in economic damages. Historically, coal accidents are the most frequent, accounting for almost half of all accidents. In terms of severity, accidents at hydroelectric dams were the most fatal, accounting for 67 percent. In terms of cost, nuclear power accidents are by far the most expensive, accounting for 62 percent of damages. Coupling our data and an econometric model with future projections of energy demand underscores the magnitude of the trends identified: 986,000 to 1.72 million potential energy accident deaths in 2040, as well as almost $1 trillion in damages. This leads to compelling policy implications, especially concerning the need for safety improvements in energy systems such as bioenergy and nuclear power, as well as the need for the IEA and IRENA, among others, to begin to better track and account for energy accident trends. We find that across all accidents, fuel extraction and processing, transmission and distribution, and transportation have the most fatalities, and yet conversion and operation, transmission and distribution, and transportation have the most damages. Moreover, achieving strong climate goals leads to an unacceptably higher risk of accidents and human health and economic consequences. Finally, as its economic development propels increases in energy consumption, Africa will become the future center for energy accident fatalities.

Moreover, achieving strong climate goals leads to an unacceptably higher risk of accidents and human health and economic consequences.

Africa will become the future center for energy accident fatalities.

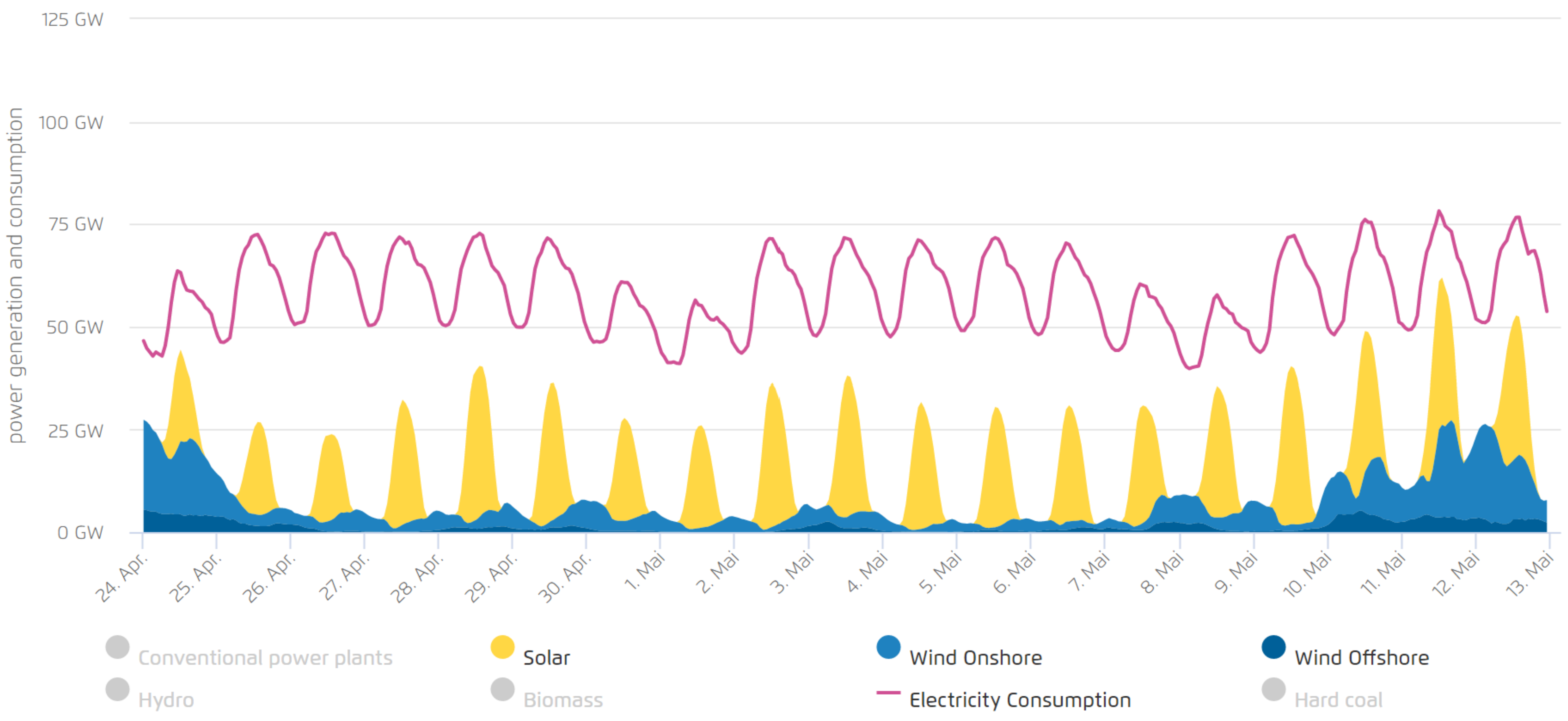
Notes: Our analysis reveals that these collective energy systems resulted in more than 278,000 human fatalities and approximately $421.3 billion in economic damages.
Source: "Kim et al 2021: Critically Assessing and Projecting the Frequency, Severity, and Cost of Major Energy Accidents." *The Extractive Industries and Society* 8, no. 2 (July 2021): 100885. https://doi.org/10.1016/j.exis.2021.02.005.

Germany April/May 2022: Wind Lull



Source: April May 2022 Data, Agora: https://www.agora-energiewende.de/en/service/recent-electricity-data/chart/power_generation/24.04.2022/12.05.2022/today/

Germany April/May 2022: Wind Lull

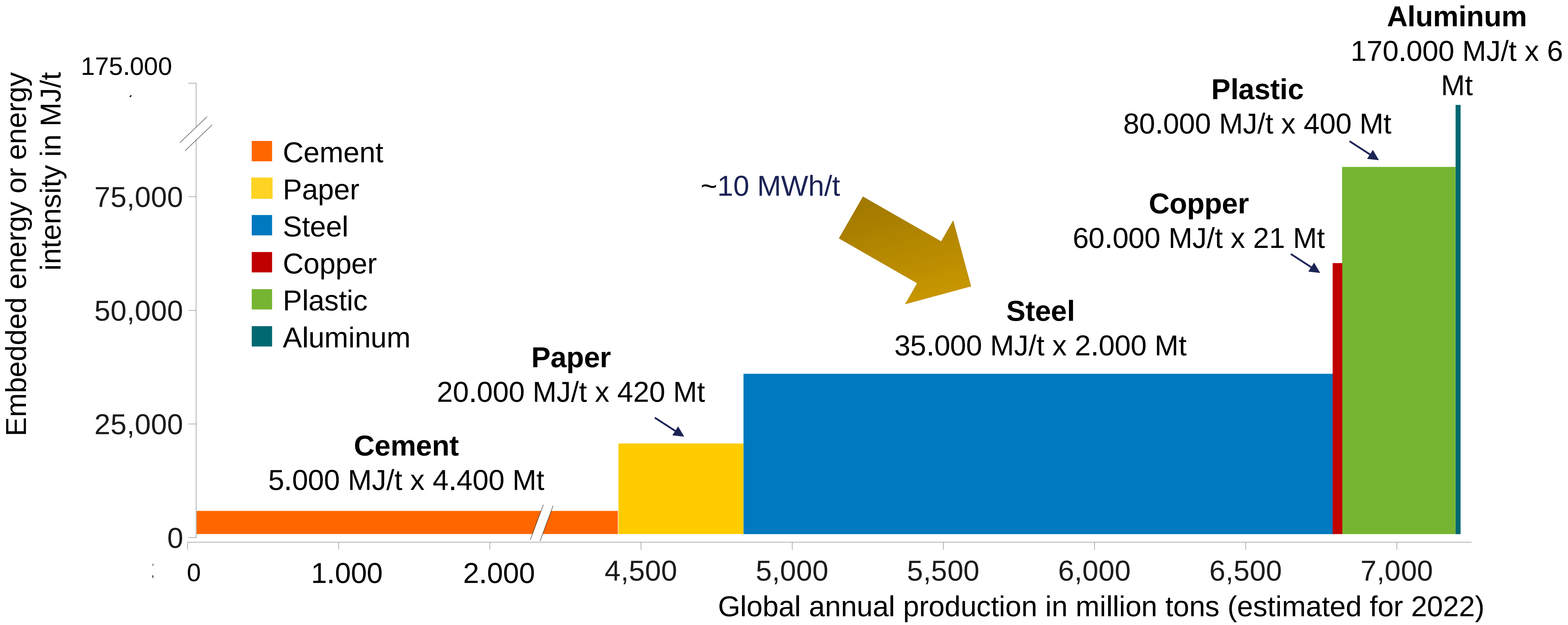


Source: April May 2022 Data, Agora: https://www.agora-energiewende.de/en/service/recent-electricity-data/chart/power_generation/24.04.2022/12.05.2022/today/

Figure 20: Embedded Energy: Energy Intensity of Key Industrial Materials

Material Intensity is Entirely Different

Embodied energy for selected industrial materials, or better “base products”



The average life expectancy for a steel product is 34 years, and for aluminum is 21 year

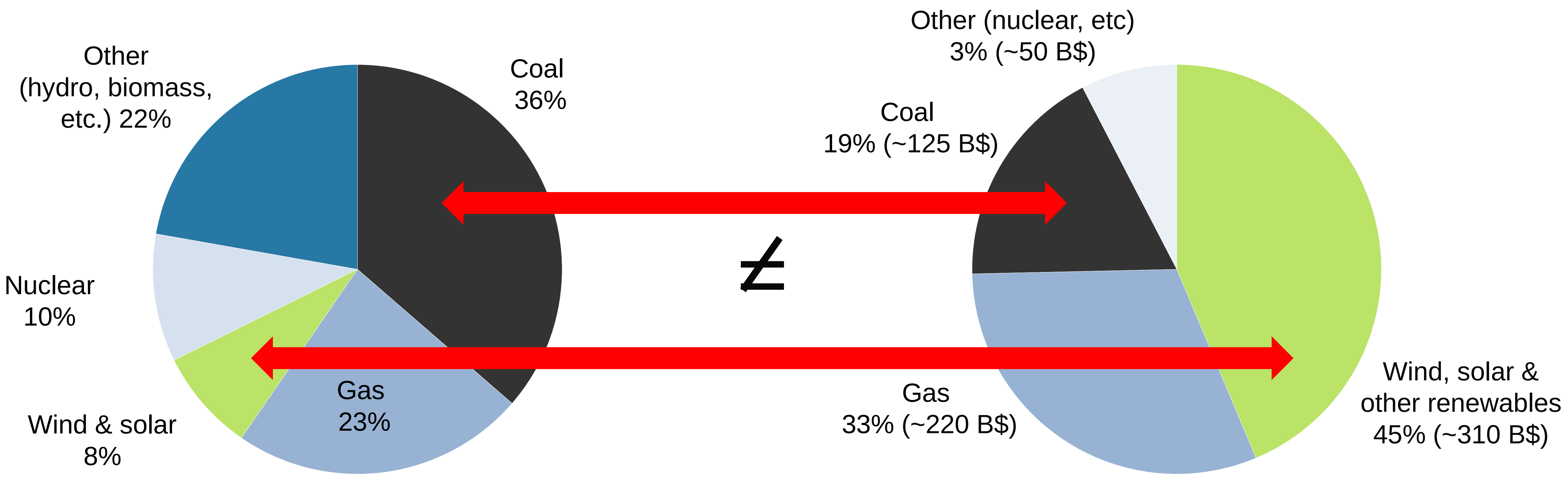
Note: copper embodied energy estimated from https://www.princeton.edu/~ota/disk2/1988/8808/880809.PDF and from https://publications.csiro.au/rpr/download?pid=csiro:EP12183&dsid=DS3,
Note: 1 kWh = 860 kcal = 0,086 kg oe = 3.600 kj; 1 kcal = 4,186 kj; 1 Gj = 278 kWh = 23,9 kg oe = 43,5 kg of coal
Source: Schernikau research and analysis based on Sustainable materials, Allwood/Cullen/Carruth et al., annual production for 2022 based on worldsteel.org, statista.com, international-aluminium.org

Investments in Coal Less than Half of Wind/Solar

… While Coal Provides 4x More Energy

Global electricity generation (estimated 2019)

Global investments in power (estimated 2019/20)



∑ = 27.000 TWh

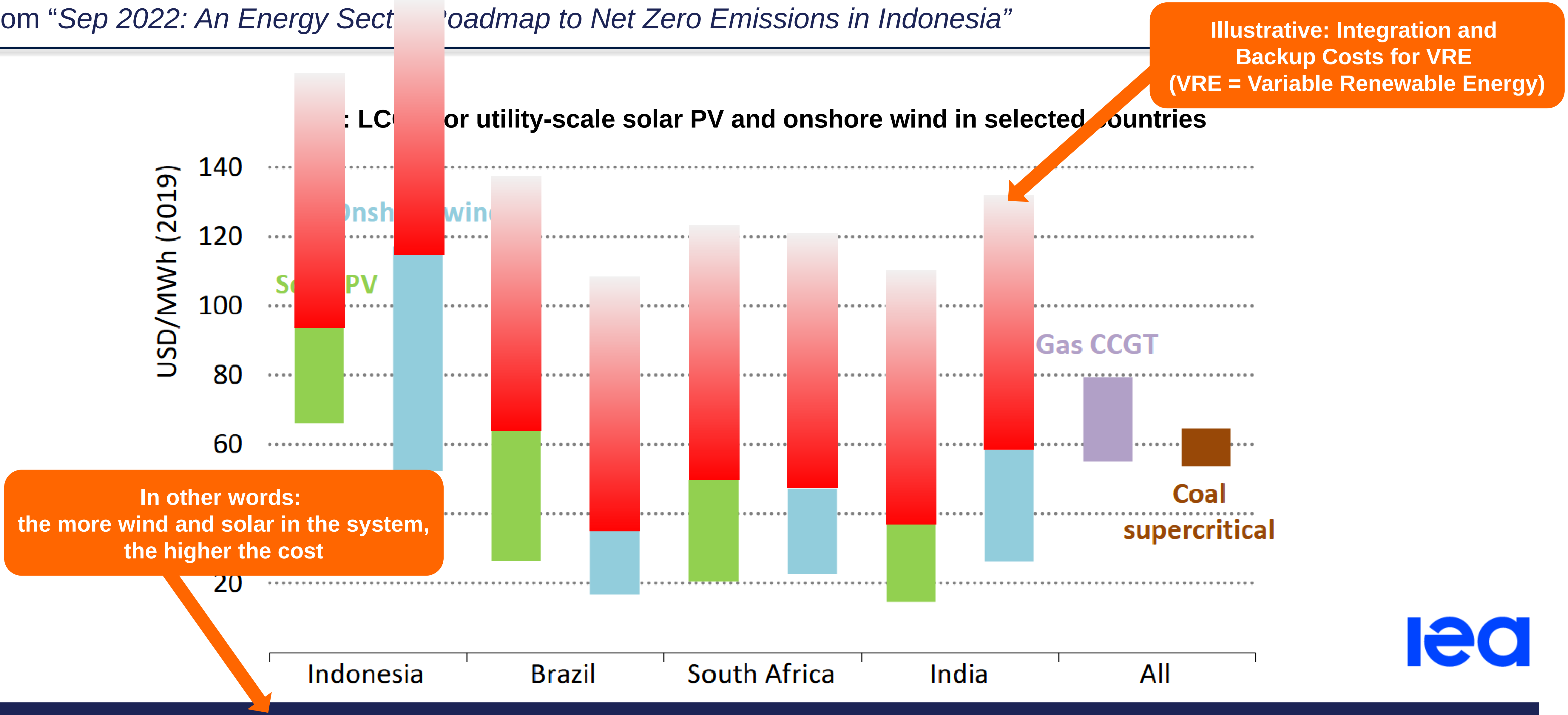
∑ = ~ 670 B$

Note: Right side includes investments in fuel supply and power; for Gas it is assumed that 50% of total “oil & gas” fuel supply investments went into gas (511 B$ x 0,5 = 255 B$)
Sources: Schernikau Research & Analysis based no IEA and BNEF Data; [Fuel supply – World Energy Investment 2020 – Analysis - IEA]

IEA's Misleading LCOE Comparison of Intermittent Solar/Wind Next to Dispatchable Gas and Coal

Schernikau on

From "*Sep 2022: An Energy Sect[…]oadmap to Net Zero Emissions in Indonesia*"



IEA Dec 2020: „ … *the system value of variable renewables such as wind and solar decreases as their share in the power supply increases*"

Notes: IEA note: LCOE = levelised cost of electricity; CCGT = combined-cycle gas turbine. LCOEs are based on projects with final investment decisions in 2020, Source: IEA (2021b).
Source: Schernikau based on "IEA: Projected Costs of Generating Electricity 2020 – Analysis," December 2020. https://www.iea.org/reports/projected-costs-of-generating-electricity-2020, p13

Summary List of Shortcomings for Electricity Generation of Variable Renewable Energy

Wind and Solar

Schernikau on Energy Policy

1.	Capacity factor & intermittency	Low natural capacity factors due to site characteristics, unpredictability of wind/solar, resulting in intermittency.
2.	Energy density space requirement	Low en… quirements incre…
3.	Environmental damage	Env… , such as wa…
4.	Energy efficiency	Low… onditioning, and…
5.	Correlated wind/solar resources	Co…
6.	Lifetime	Sh…
7.	Backup/storage	Cri… ge systems tha… m. ine…
8.	Mineral resources	Natu… g of wind & solar ins…
9.	Recycling	Increased recycling challenges due to complex chemistry and short lifetime affecting economics and the environment.
10.	eROI and material efficiency	All the above translates to inadequate energy return on investment and low material efficiency, accounting for all embodied energy of the total energy system.

The benefit of wind and solar?

It reduces the amount of coal and gas produced & combusted!

(and with it the amount of CO_2 emitted …

… during combustion, not necessarily overall)

Assuming NO INCREASE in energy demand

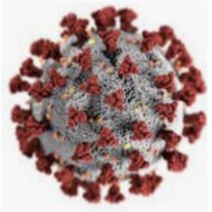
That's it!!!

Source: Schernikau et al. 2022

Summary: “non-climate”, “climate”, and “Net-Zero” impact on GDP

Impact of Russia-Ukraine war or Covid19 on global GDP

bp Energy Outlook
2023 edition



statista

2 – 8% of GDP in 2050?

Impact of Climate Change on global GDP

ipcc
INTERGOVERNMENTAL PANEL ON climate change
Global Warming of 1.5°C

United Nations
Climate Change

0,5 – 4% of GDP in 2100

from 2,5 °C warming

75 – 275 Tln USD
Cost of “Net-Zero”

Bloomberg
NEW ENERGY FINANCE

Wood Mackenzie

McKinsey & Company

BCG

“low-income economies will bear disproportionally high burden”

7 – 10% of (per capita) GDP in 2050?

Note: BP estimates Ukraine war 2% drop in Western World and up o 8% in developing world, Statista says global GDP fell 3,4% in 2020… from original 2% gain can expect 5-6% drop
Source: “BP Energy Outlook 2023,” January 2023. BP2023, p24; IPCC “IPCC SR15, 1,5 Deg Special Report,” 2018; http://www.ipcc.ch/report/sr15/. p256 in Chapter 3; “UN Climate Change: Climate Plans Remain Insufficient: More Ambitious Action Needed Now | UNFCCC,” October 2022, unfccc.

IPCC and UNFCCC language on GDP impact of Climate Change

Impact of Climate Change as per IPCC

UN globally government funded body studying climate change

„Intergovernmental Panel on Climate Change“

IPCC — Intergovernmental Panel on Climate Change — Global Warming of 1.5°C

Oct 2018

2,6% GDP loss
from 3,7 °C temperature rise
in year 2100

al. (2018c) of 15 trillion USD. Under the no-policy baseline scenario, temperature rises by 3.66°C by 2100, resulting in a global gross domestic product (GDP) loss of 2.6% (5–95% percentile range 0.5–8.2%), compared with 0.3% (0.1–0.5%) by 2100 under the 1.5°C

“… GDP loss of 1,2% per degree of warming…”

Of course, not linear, so very approximate

United Nations Climate Change

Oct 2022

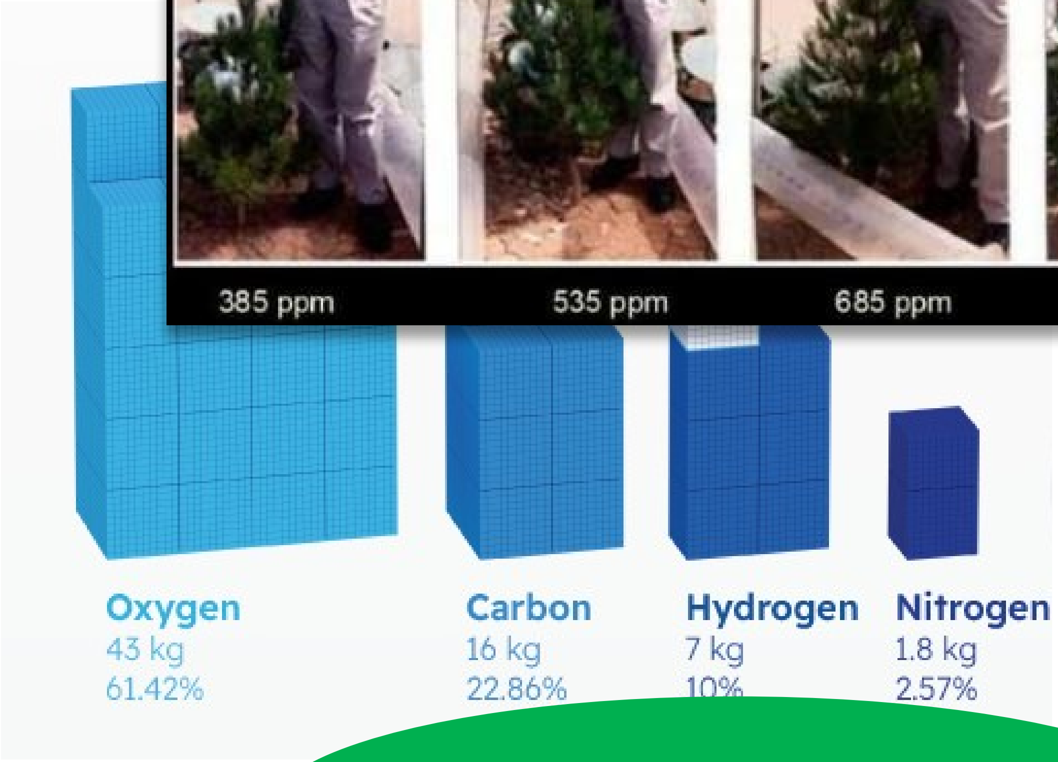
“… combined climate pledges of 193 Parties under the Paris Agreement could put the world on track for around 2.5 degrees Celsius of warming by the end of the century.”

Thus, about 1,2% GDP loss from 2,5 °C warming

(5-95% percentile range 0,25-3,8% GDP loss)

Note: IPCC names several studies in the Chapter 3.5.2.4 “Global Aggregate Impacts”: including Warren et al 2018, Pretis et al 2018, Burke et al 2018, Shindell et al 2018
Note: UNFCCC = UN Climate Change or United Nations Framework Convention on Climate Change
Source: “1,5 Deg Special Report,” 2018; http://www.ipcc.ch/report/sr15/. p256 in Chapter 3; “UN Climate Change: Climate Plans Remain Insufficient: More Ambitious Action Needed Now | UNFCCC,” October 2022, unfccc.

The Human Body Consists of 21 Elements



Carbon (23%)
= Atmospheric CO_2

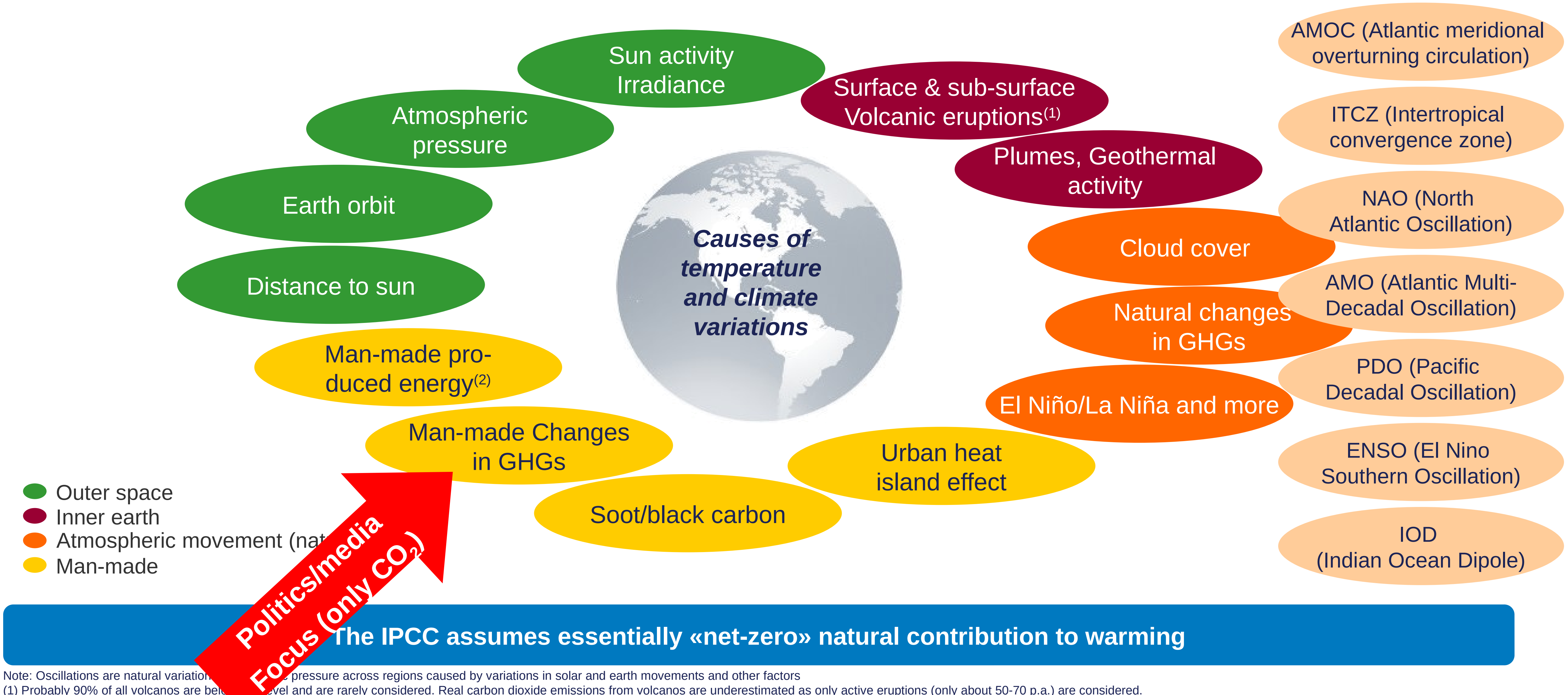
Essential Elements (3%)
Calcium, Phosphorus, Potassium, Sulfur, Chlorine, Sodium, Magnesium, Iron

Trace Elements (1%)
Flourine, Zinc, Copper, Iodine, Manganese, Molybdenium, Selenium, Chromium, Cobalt

CO_2 is NOT pollution

Source: What Chemical Elements Make up the Human Body? (visualcapitalist.com)

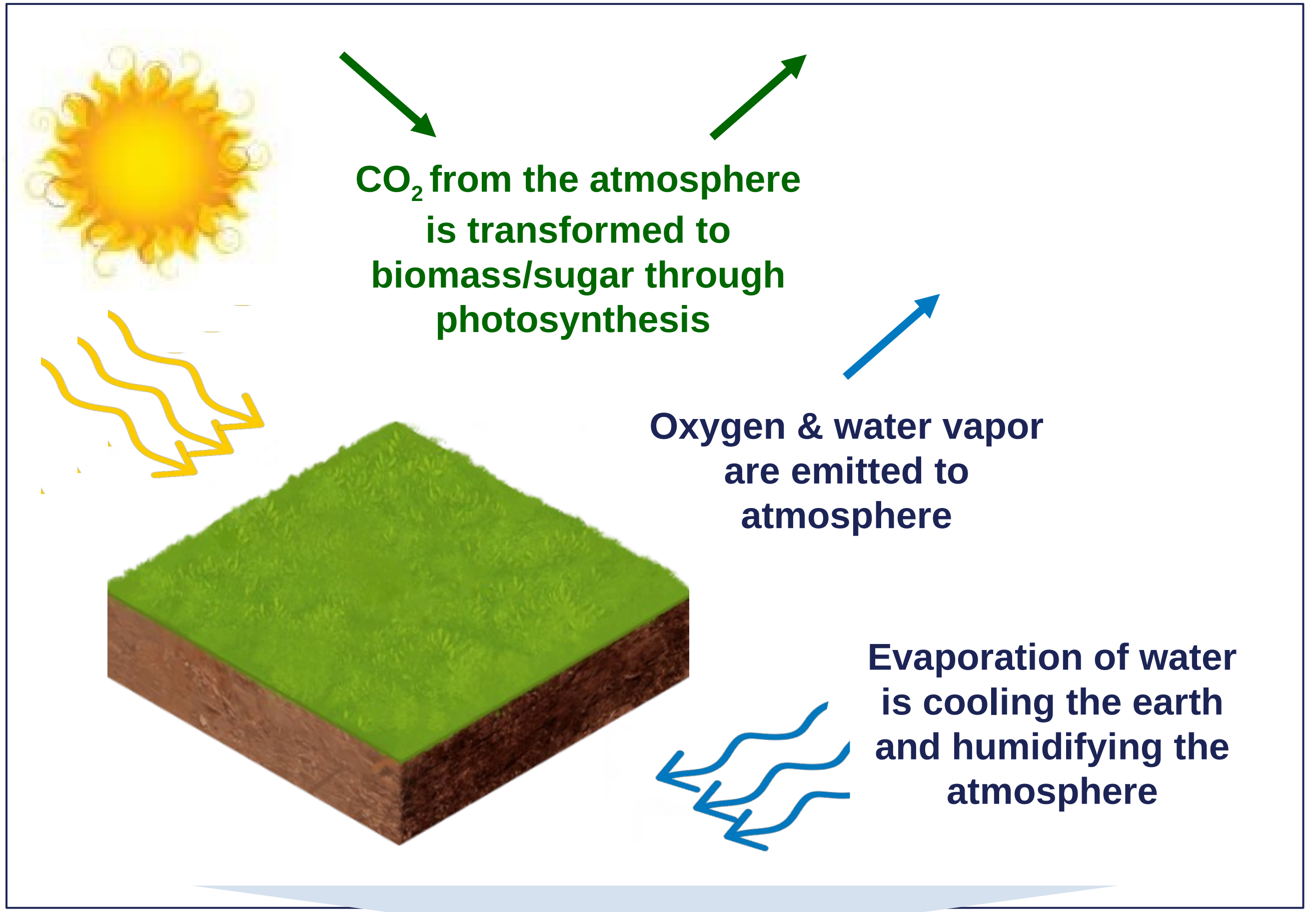
What Causes Temperature and Climate Variations? We Are Not 100% Sure!



Note: Oscillations are natural variation ... pressure across regions caused by variations in solar and earth movements and other factors
(1) Probably 90% of all volcanos are bel... vel and are rarely considered. Real carbon dioxide emissions from volcanos are underestimated as only active eruptions (only about 50-70 p.a.) are considered.
(2) According to the law of conservation of ...rgy no energy is ever lost, only converted. Any energy that humans generate (which does not come from the sun) and then utilize will always end up in heat radiation. This heat will either radiate back to space or warm the biosphere (not because of CO_2).
Source: Schernikau analysis based on Soon 2005; s852; i342

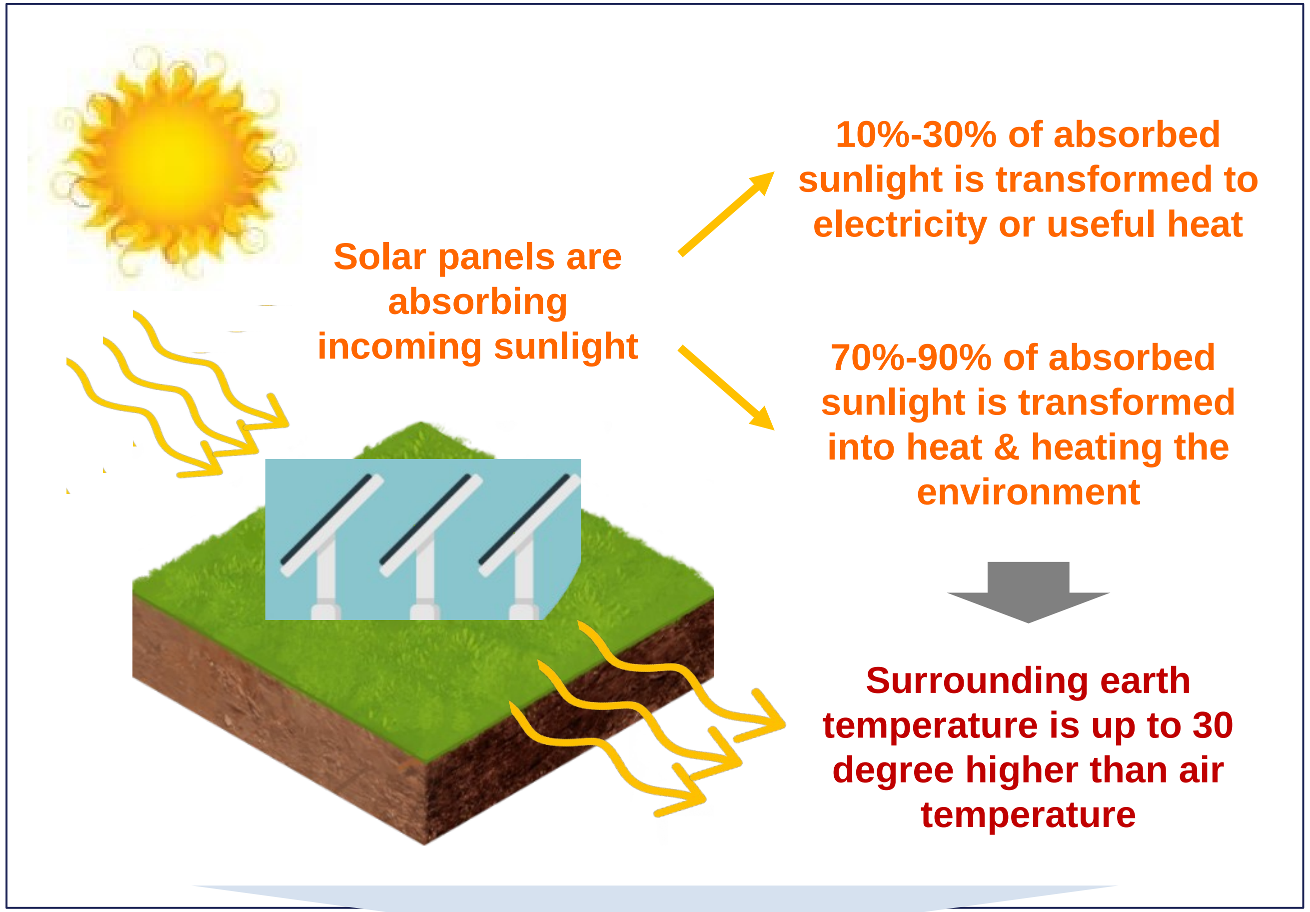
Why Solar Panels Increase Air Temperatures

Natural cycle without solar panels



Sunlight is supporting plant growth and evaporation supports cooling

Effects of installing solar panels



Sunlight is warming the atmosphere

Source: Schernikau research and analysis based on Dipl.-Ing. Jürgen A Weigl: Erwärmung durch Solaranlagen, Energiedetektiv, November 2020, link

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Natural cycle without solar panels

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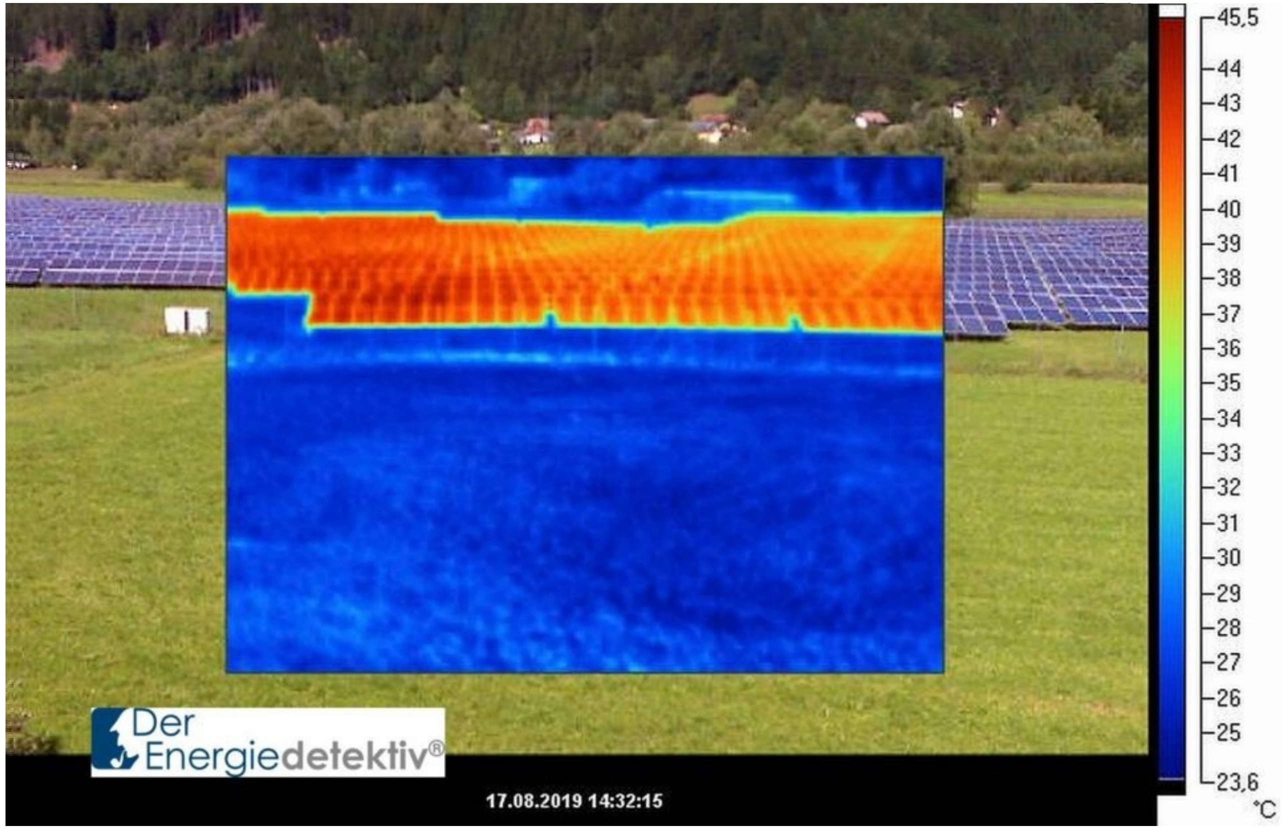


Sunlight is warming the atmosphere

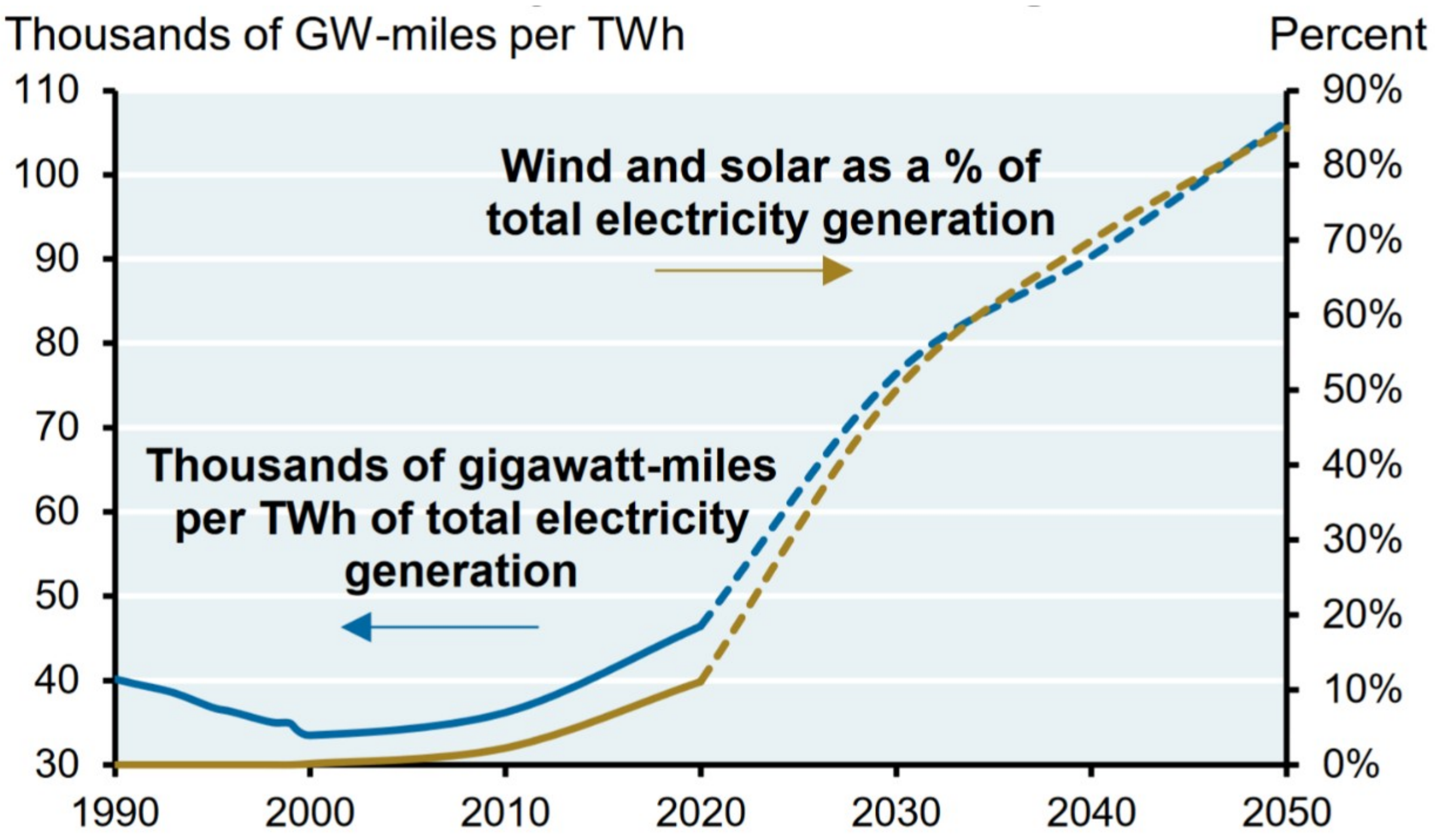
Source: Schernikau research and analysis based on Dipl.-Ing. Jürgen A Weigl: Erwärmung durch Solaranlagen, Energiedetektiv, November 2020, link

Transmission: Inefficiency Rises with higher Wind and Solar penetratrion

For past 30 years, US grid operated with 35-45 miles transmission per TWh electricity

Using a typical deep decarbonization plan, we estimate that "transmission intensity" of high renewable systems would be at least double the current level

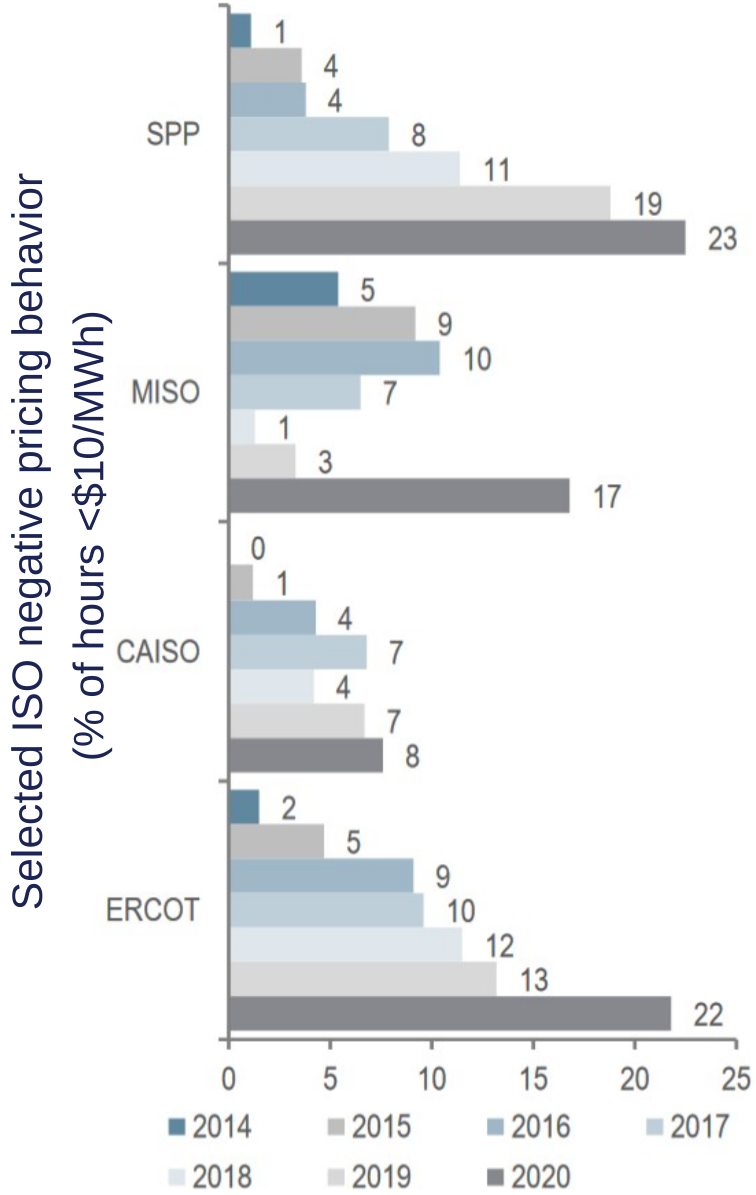
Long-term trends in global coal generation
(Electricity Generation (TWh) and share of electricity (%))

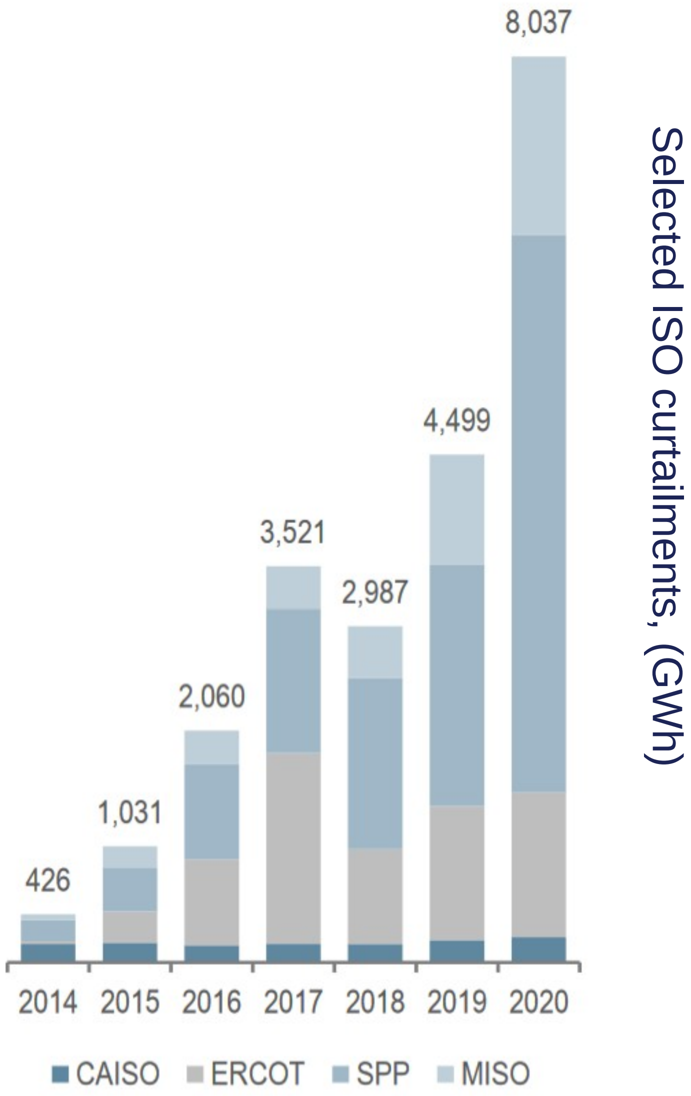


‚Source Schernikau based "JPMorgan: 13th Annual Energy Paper | J.P. Morgan Private Bank," March 2023. https://privatebank.jpmorgan.com/gl/en/insights/investing/eotm/annual-energy-paper, they based DOE, UT Austin, Princeton NetZero

Lazard: Impact of higher renewable share in System (USA)

US Grid Impacts of Increasing Renewable Energy Penetration

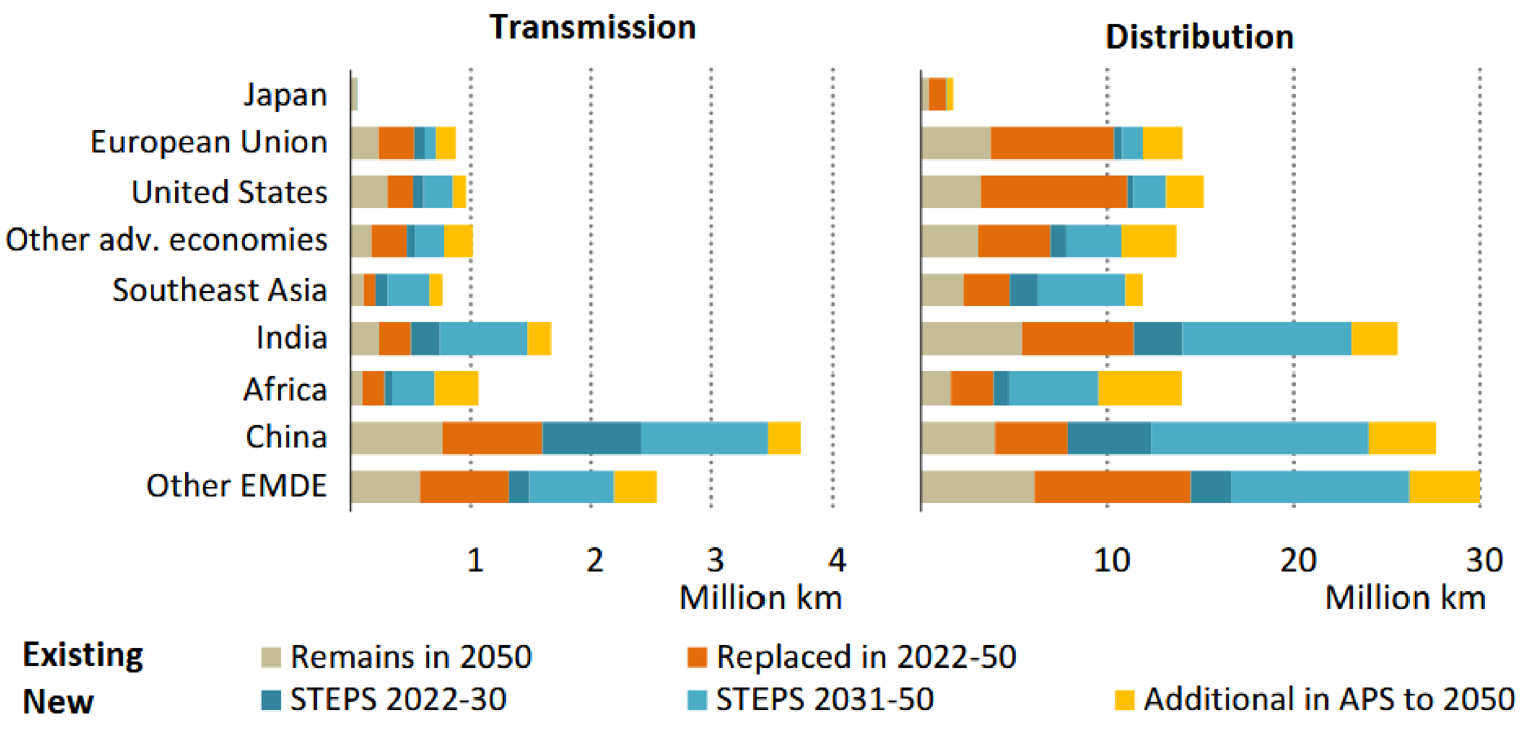




Source: "Lazard Levelized Cost of Storage Analysis - V7," 2021. https://www.lazard.com/media/451882/lazards-levelized-cost-of-storage-version-70-vf.pdf.

Tranmission and Distribution – A Herculean Task in "Net-Zero"

Grid Development by Type, Region and Scenario 2022-2050



IEA does write about the herculean task to build grid infrastructure

- compare 100 million km required globally vs. 1.600km in Germany
- "*As an example for an advanced economy, in Germany, out of the 1.655 km of line projects approved in a 2009 network development plan, less than 50% were operational a decade later*."

Note: Adv. = advanced; EMDE = emerging market and developing economies.
Source: IEA WEO 2022, p313

Carrying Energy over DC Lines is Energy Inefficient

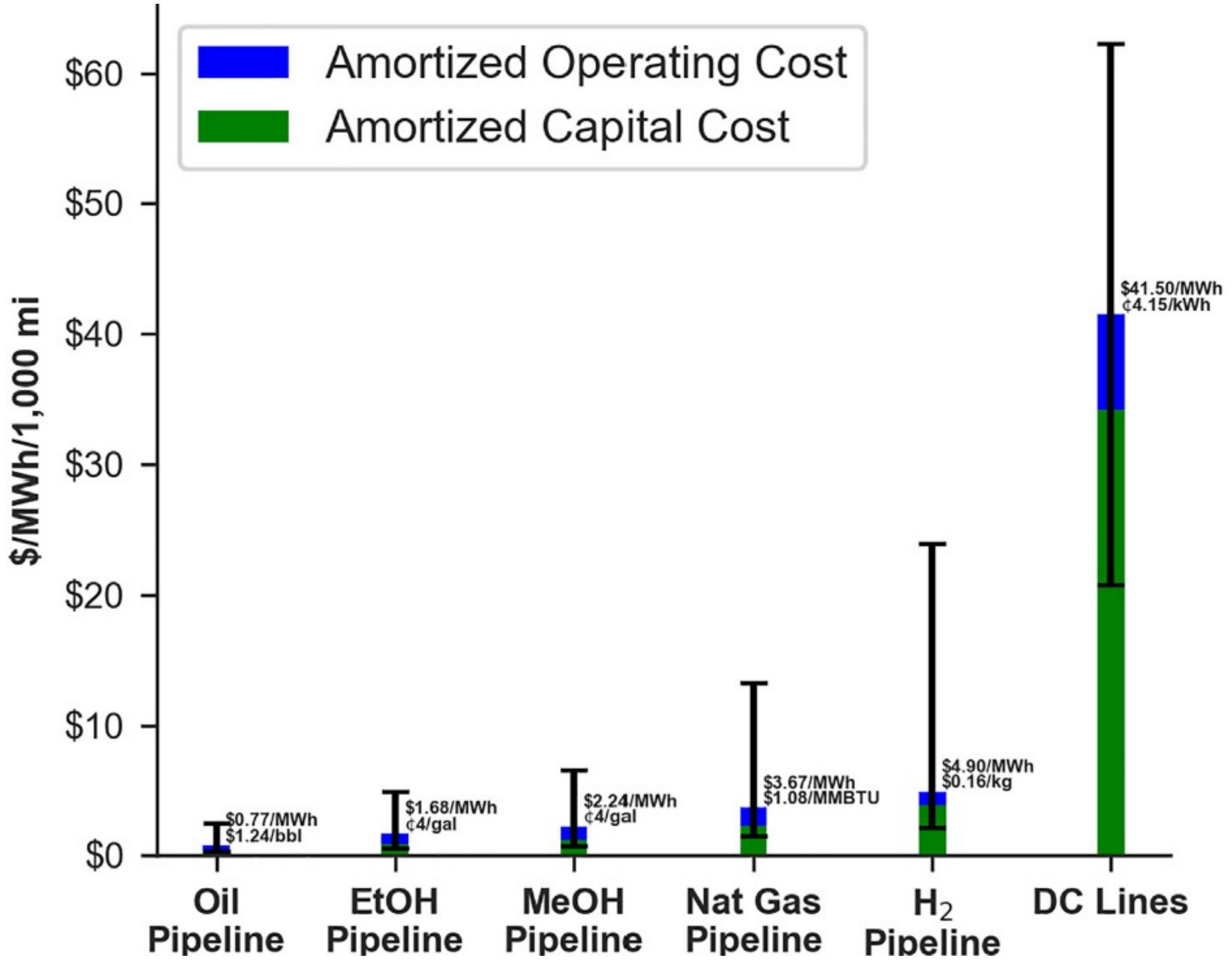
Amortized Transmission Costs per 1.000 miles (1.600 km)

DeSantis et al. 2022 (iScience, peer-reviewed)

… cost of electricity transmission per MWh can be

- Up to 8x higher than for H_2 pipelines
- About 11x higher than for natural gas pipelines
- About 20-50x higher than for liquid fuels pipelines
- These differences are also true for shorter distances

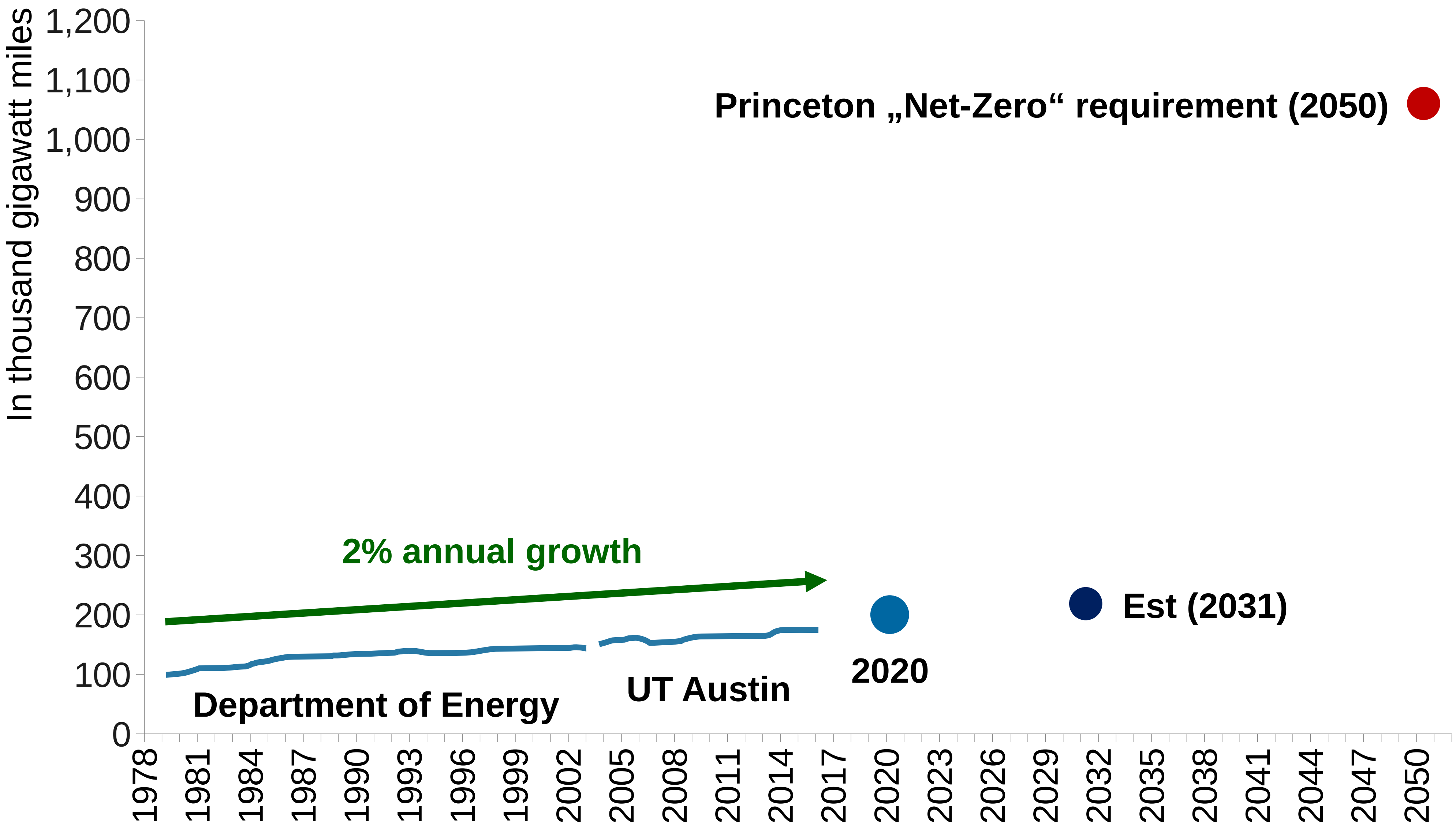
Higher transmission costs is primarily caused by lower carrying capacity (MW per line) of transmission lines



Source: DeSantis et al 2021, iScience. 2021 Dec 17; 24(12): 103495, Published online 2021 Nov 22. doi: 10.1016/j.isci.2021.103495; https://www.sciencedirect.com/science/article/pii/S2589004221014668

Figure 12: US Transmission Grid Growth Pales "Net-Zero" Requirements

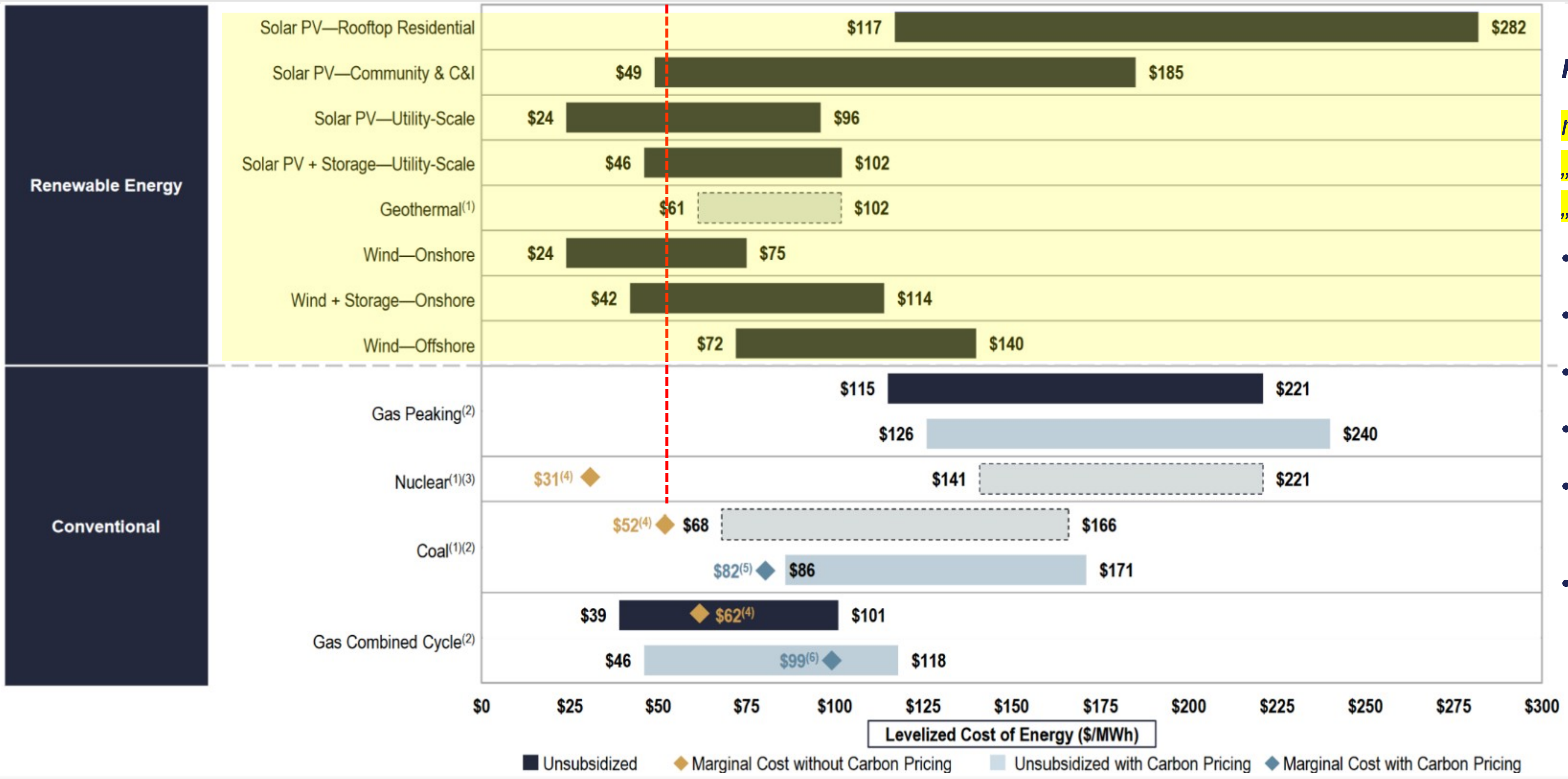
Electricity Book



Source: JP Morgan 2022, page 12

Lazard April 2023: Levelized Cost of Energy Comparison—Unsubsidized Analysis

Lazard: "selected renewables are cost-competitive with conventionals under certain circumstances"



Key Assumptions

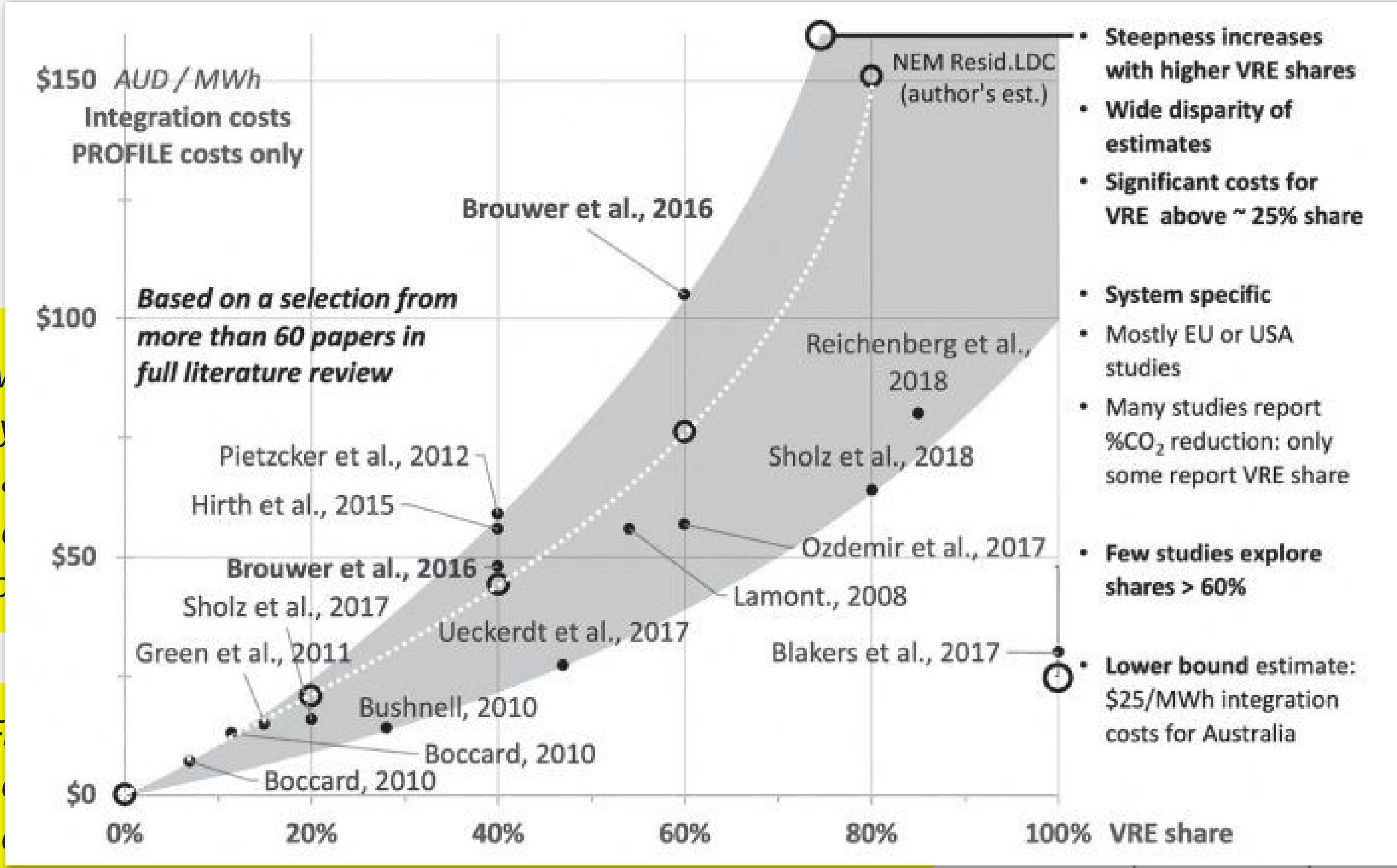
*no differentiation between „**natural capacity factor**" and „**utilization**"*

- *Solar 15-30%* *<= Global: 11-13%*
- *Wind 30-55%* *<= Global: 21-24%*
- ***Coal 35-85%***
- *Gas CCG 30-90%*
- *No consideration of network integration*
- *No long duration energy storage*

***Disclaimer**: Other factors would also have a potentially significant effect on the results contained herein, but have not been examined in the scope of this current analysis. These additional factors, among others, could include: implementation and interpretation of the full scope of the Inflation Reduction Act ("IRA"); network upgrades, transmission, congestion or other integration-related costs; permitting or other development costs, unless otherwise noted; and costs of complying with various environmental regulations (e.g., carbon emissions offsets or emissions control systems). This analysis also does not address potential social and environmental externalities, including, e.g., the social costs and rate consequences for those who cannot afford distributed generation solutions, as well as the long-term residual and societal consequences of various conventional generation technologies that are difficult to measure (e.g., nuclear waste disposal, airborne pollutants, GHGs, etc.)*

Source: Lazard April 2023, https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/

OECD confirms higher costs of wind and solar



“V
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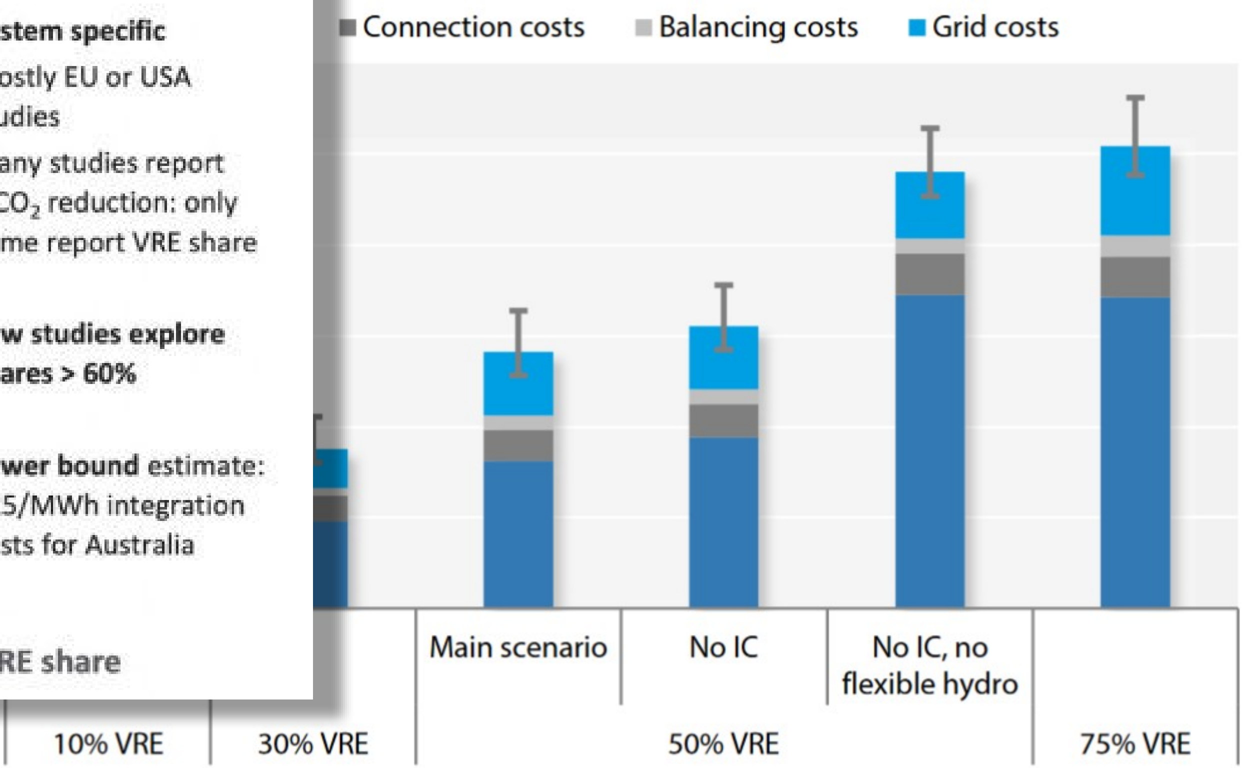
...ts per MWh of Variable “Renewable”



Note on profile cost Profile Costs of Wind Energy: Why are Utilities Overpaying? - Master Resource, profile cost measures the relative value of energy based on the time of day and how reliable it is to the electrical grid.
Source: OECD: The Full Costs of Electricity Provision | En | OECD,” June 2018. https://www.oecd.org/publications/the-full-costs-of-electricity-provision-9789264303119-en.htm, p48, Nuclear Energy Agency. “OECD: The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables.” OECD, January 2019. https://doi.org/10.1787/9789264312180-en, p19

What Is the Cost of Energy? = NOT Levelized Cost of Electricity (LCOE)

… but Full Cost of Electricity (FCOE) … to Society or a Country

LCOE is incomplete

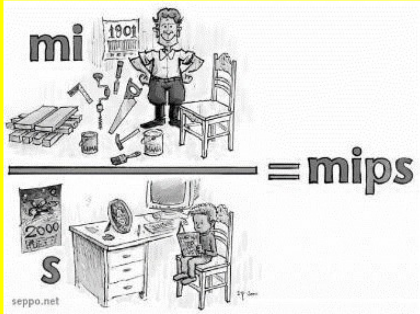
1. Cost of Building
2. Cost of Fuel
3. Cost of Operating

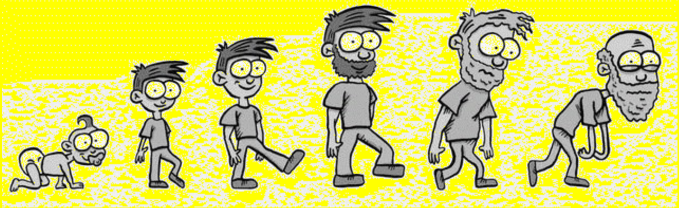
LCOE

4. Cost of Transmission/
& Conditioning/Balancing
5. Cost of Storage
6. Cost of Backup

7. Cost to Environment
8. Cost of Recycling
9. Room Costs

Non-USD Metrics

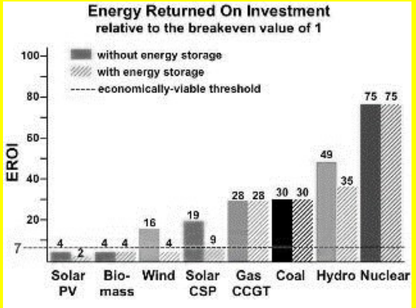


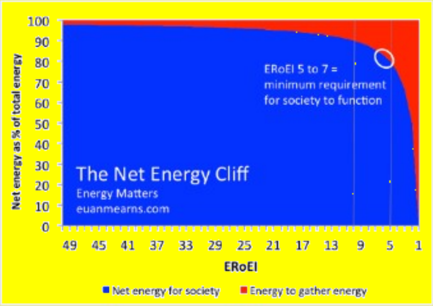


10a: MIPS – Material Input Per Unit of Service

10b: Lifetime

10c: eROI – energy Return On energy Invested





Full Cost of Electricity (FCOE)

Source: Schernikau et al 2022, Energy Primer, to be published

BRINGING PEOPLE TO THE TABLE

ABE SILVERMAN

- DIRECTOR, NON-TECHNICAL BARRIERS TO THE CLEAN ENERGY TRANSITION, CENTER ON GLOBAL ENERGY POLICY

Center on
Global Energy Policy
at COLUMBIA | SIPA

A Former State Regulator’s Reflections on Resource Adequacy

17

Abe Silverman

as7064@columbia.edu * 301-949-5406

> Ensuring reliability during and after policy driven transitions should be a key consideration in setting Energy Policy. The implementation of policy decisions can significantly affect the reliability and resilience of the [bulk power system].

NERC — NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

ERO Reliability Risk Priorities Report

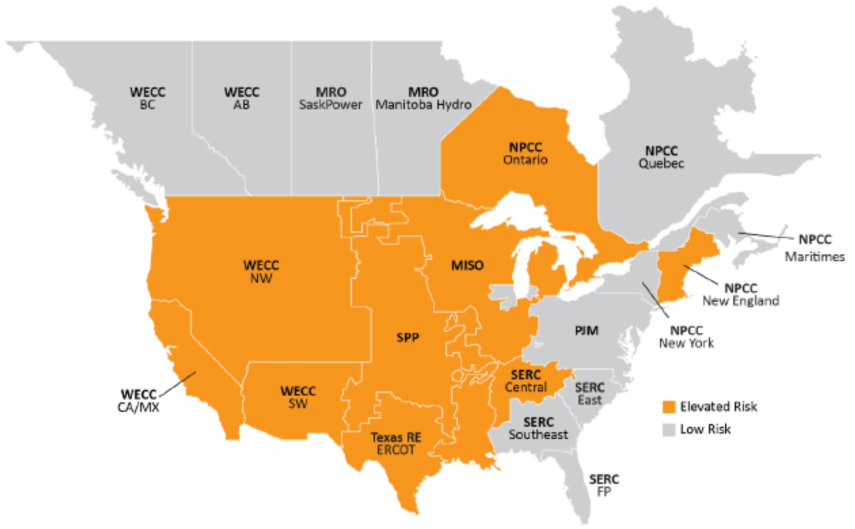
North American Electric Reliability Corporation – August 2023

Overall Theme: Energy Policy *is* Reliability

In 2023, NERC included "Energy Policy" as a key reliability risk factor, and stated that "time lines for implementation can be a reliability risk factor."

NERC identified two-thirds of the United States electric grid at an elevated summer reliability risk this summer.

MISO & PJM are just two of many regions highlighting concerns in the 2025 – 2028 timeframe.



Seasonal Risk Assessment Summary	
High	Potential for insufficient operating reserves in normal peak conditions
Elevated	Potential for insufficient operating reserves in above-normal conditions
Low	Sufficient operating reserves expected

Figure 1: Summer Reliability Risk Area Summary

Source: The North American Electric Reliability Corporation 2023 Summer Reliability Assessment

Elements of Resource Adequacy

$$Existing\ Gen + New\ Gen\ - Retirements > Peak\ Load + Reserve\ Margin$$

- Fix accreditation of existing generation to account for correlated outages
- Derate of fos
  and clean energy resources
- Effective Loa
  Carrying Capability

- Generator interconnection study delays
- Tx construction timelines
- Supply chain

- State public policy retirements
- Economic retirements
- Federal

- Building electrification
- Electrification of transportation
- Data center

- How we measure reserve margin
- Shift to winter reliability metrics
- ransition to
  xpected
  Inserved
  nergy (EUE)

Balance Sheet Summary (2022–2030)				
Retirements	**New Entry Wind/Solar[6]**	**New Entry Standalone Storage**	**New Entry Thermal**	**Load Growth**
40 GW **60% Coal** **30% Natural Gas** **10% Other**	**Low =** 48 GW-nameplate / 8 GW-capacity **High =** 94 GW-nameplate / 17 GW-capacity	**Low =** 3 GW **High =** 4 GW	**Low =** 4 GW **High =** 9 GW	**2023 Forecast =** 11 GW **Electrification Forecast =** 13 GW

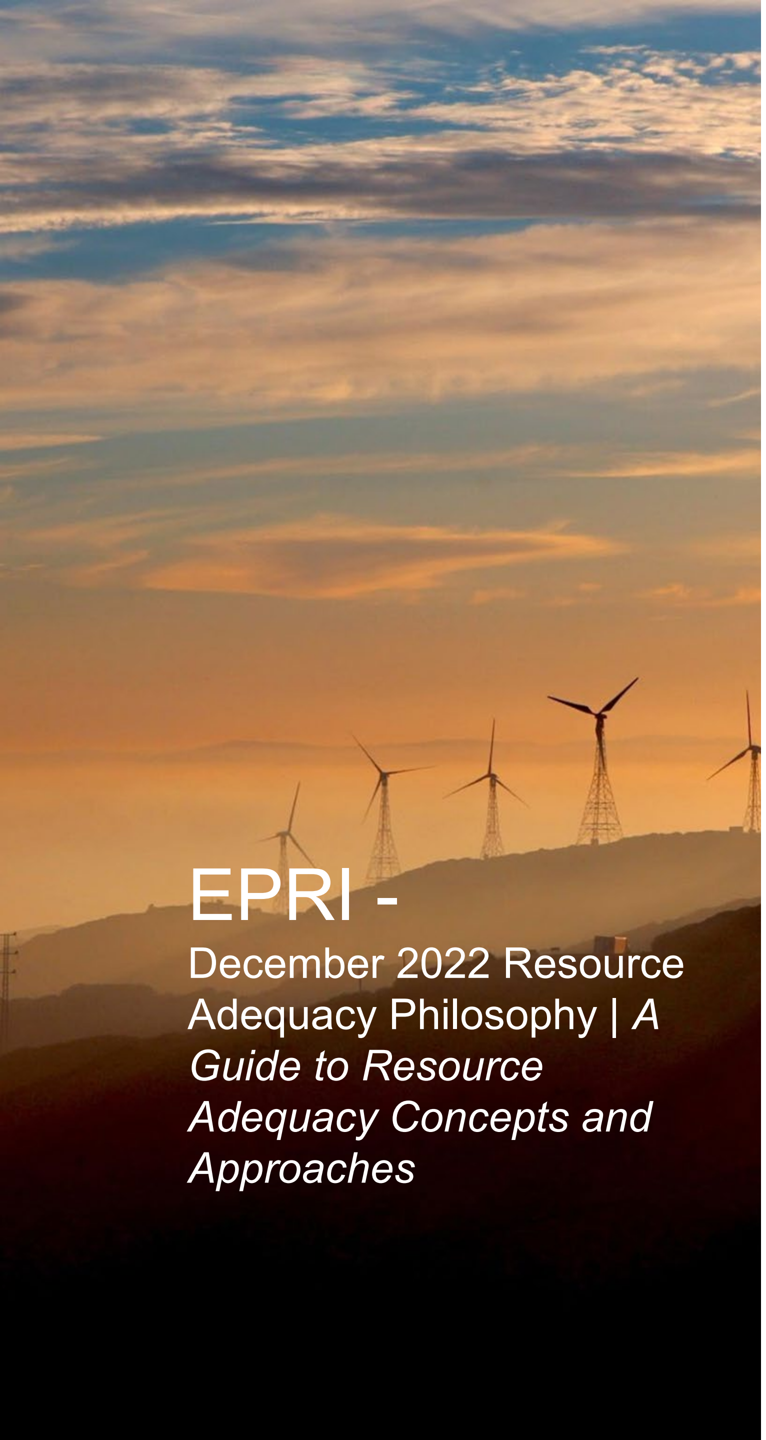
Unless otherwise noted, thermal capacity values are expressed in ICAP, without adjustment for EFORd.

> “The ability of the electricity system to supply the aggregate electric power and energy requirements of the electricity consumers at all times, taking into account scheduled and reasonably expected unscheduled outages of system components.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2023 Summer Reliability Assessment: North American Electric Reliability Corporation - May 2023

The Right Resource Adequacy Questions

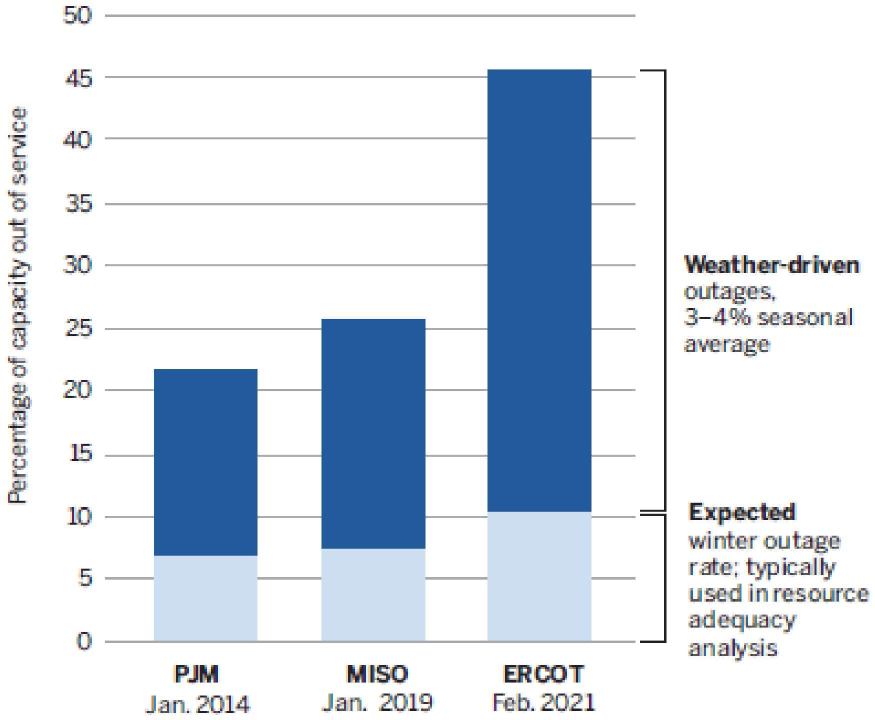


- Fundamentally, resource adequacy assessments should answer the following questions:
    - What are the time periods during which the system is at risk of an adequacy event?
    - What is the probable magnitude of that event?
    - What is the underlying cause for that event?
    - Adequacy assessments are primarily carried in two settings:
        - In long-term planning from a year to decades ahead, adequacy studies inform the need for investment in generation, demand-side measures, inter-regional transmission, mothballing, retirement, and fuel supply.
        - In the operational planning time frame from several days to seasons ahead, adequacy studies inform decisions about generator planned maintenance.

Trends in Resource Adequacy #1: Planning for Extreme Weather

FIGURE 12

Total Unplanned Outages During Recent Cold Weather Events



Includes forced outages plus derates for all technology types

Source: Energy Systems Integration Group.

“

…while randomly occurring forced outages are still important to consider, it is increasingly important to consider correlated generator failures and outages, due to either the underlying weather or other root causes.

ESIG ENERGY SYSTEMS INTEGRATION GROUP

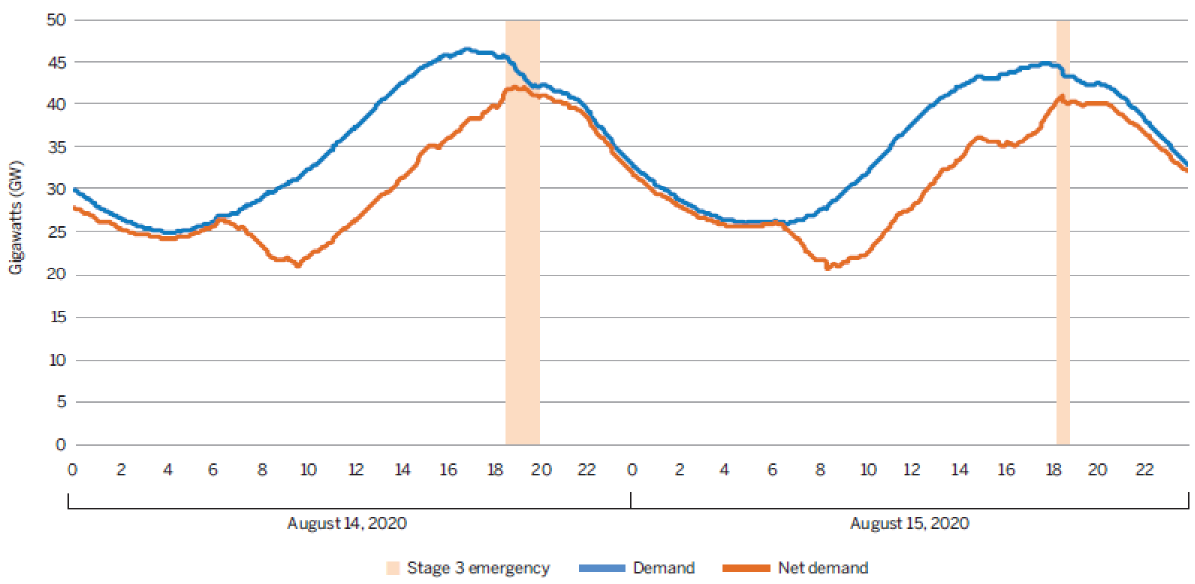
Redefining Resource Adequacy for Modern Power Systems:

Energy Systems Integration Group - 2021

Trends in Resource Adequacy #2: Reliability Risk is Less Correlated with Peak Load

FIGURE 9

Gross and Net Load During the 2020 California Reliability Event



Source: Energy Systems Integration Group; data from California Independent System Operator (2021).

“ Resource adequacy assessments have historically focused on ensuring generation and transmission capacity to serve peak demand…

It is now insufficient to assume that the system is adequately planned by comparing the peak load hours with the generation capacity.

Assessments must look at the magnitude, duration, and impact of resource adequacy across all hours and many years while considering that future events may be outside of historical patterns.

NERC NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

2023 Summer Reliability Assessment

North American Electric Reliability Corporation – May 2023

(Emphasis added)

American electricity policy is at a crossroads where state & federal environmental policies are shuttering existing fossil resource…

… but delays in interconnection, siting & permitting and supply chain are preventing new resources from coming online fast enough to replace them.

Trends in Resource Adequacy #3:

Interconnection as a Decisive Reliability Metric

- Many future reliability assessments hinge on assumptions around how long it takes to study, site, and construct new generation resources.
    - ➢ Over 2 terawatts of new generation is currently in the queue – enough to replace every generator in the United States.
    - ➢ Interconnection study delays are *in addition* to construction & supply chain challenges.
- FERC's recent interconnection reform effort, Order No. 2023 will help, but is unlikely to solve the fundamental interconnection challenge.

Definitive source of interconnection analysis is the All Queued Up project at the Berkeley Energy National Lab.

Interconnection's Impact on Reliability: PJM

"Despite the sizable nameplate capacity of renewables in the interconnection queue (290 GW), the historical rate of completion for renewable projects has been approximately 5%.

-- PJM Interconnection

Energy Transition in PJM: Resource Retirements, Replacements & Risks

Figure 1. Total Forecast Retirement by Year (2022–2030)

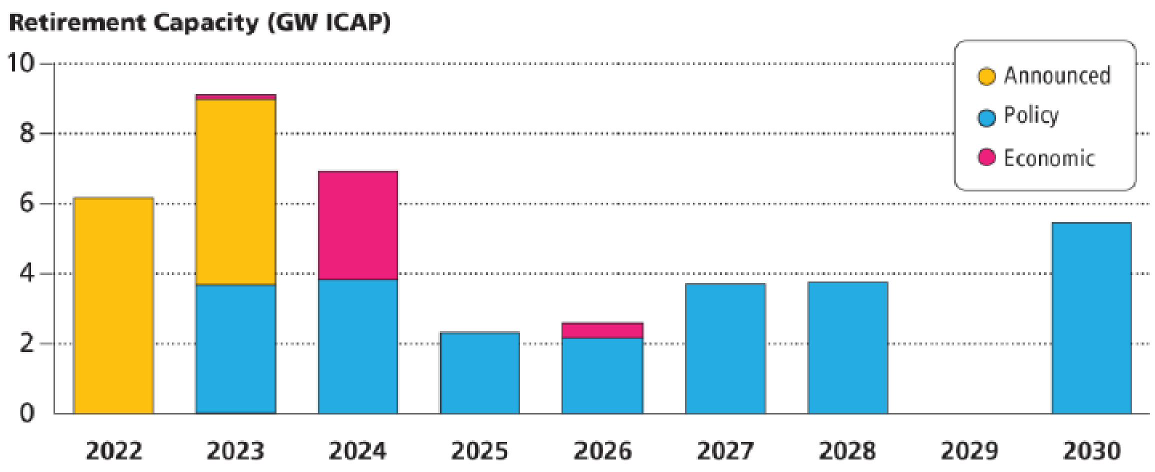
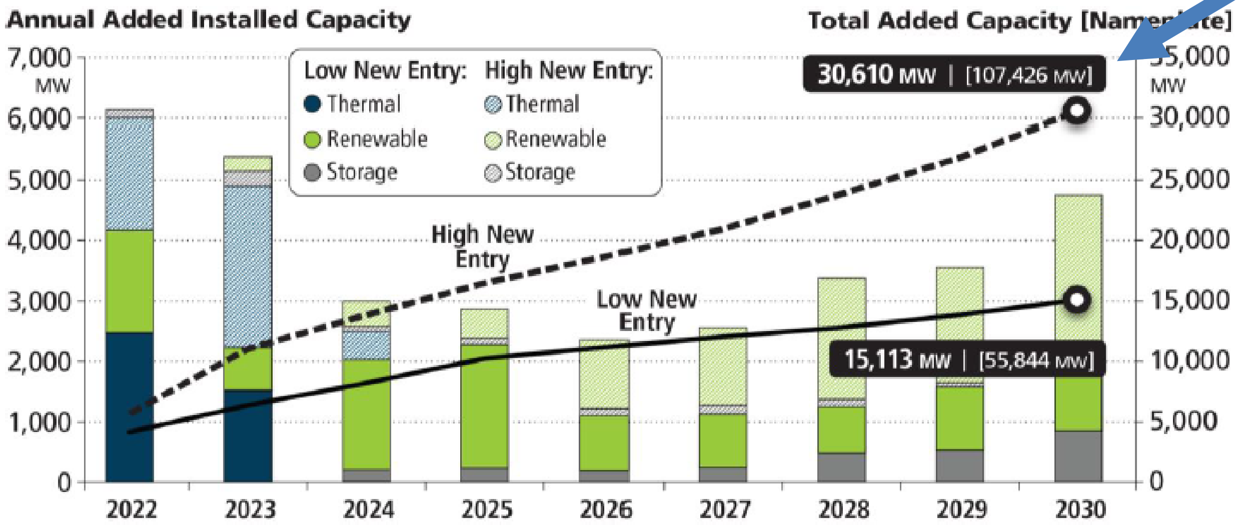


Figure 4. Forecast Added Capacity



~ 40 GW of cumulative retirements by 2030

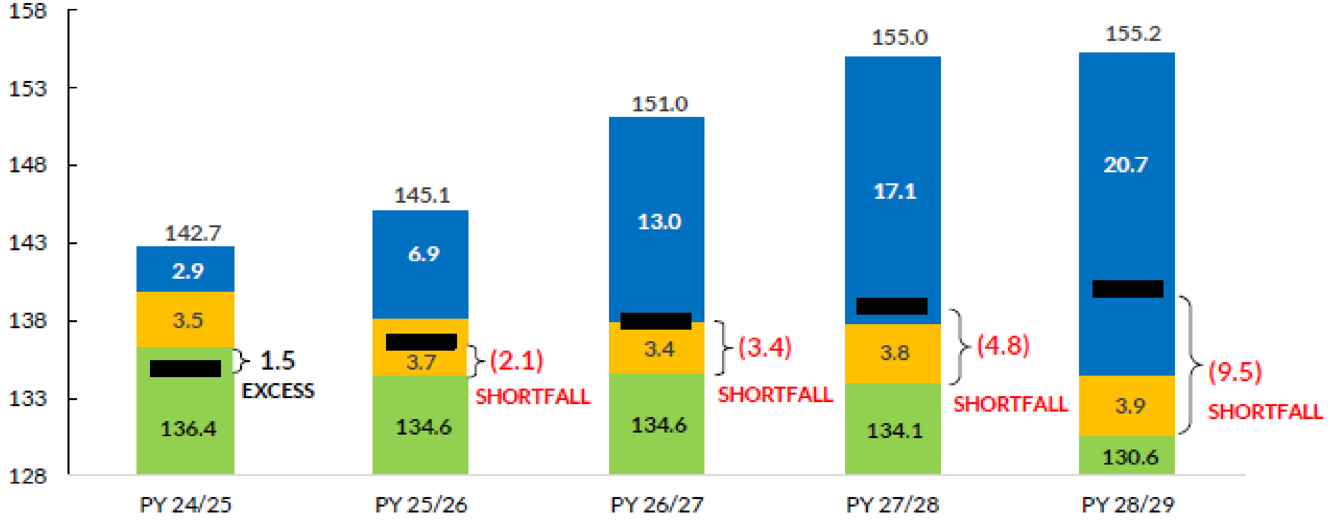
Interconnection's Impact on Reliability: MISO

Analysis from MISO presented to MISO Board of Directors on September 12, 2023

Committed capacity projections from the OMS-MISO Survey show an increasing deficit beginning in 2025-26; capacity additions are needed, and retirements may need to be delayed to mitigate reliability risks

Summer Seasonal Accredited Capacity Projections (GW)

2023 OMS-MISO Survey

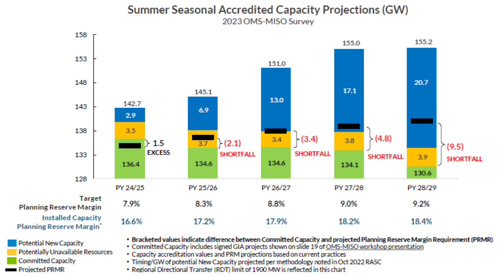


	PY 24/25	PY 25/26	PY 26/27	PY 27/28	PY 28/29
Target Planning Reserve Margin	7.9%	8.3%	8.8%	9.0%	9.2%
Installed Capacity Planning Reserve Margin*	16.6%	17.2%	17.9%	18.2%	18.4%

- Potential New Capacity
- Potentially Unavailable Resources
- Committed Capacity
- Projected PRMR

- **Bracketed values indicate difference between Committed Capacity and projected Planning Reserve Margin Requirement (PRMR)**
- Committed Capacity includes signed GIA projects shown on slide 19 of OMS-MISO workshop presentation
- Capacity accreditation values and PRM projections based on current practices
- Timing/GW of potential New Capacity projected per methodology noted in Oct 2022 RASC
- Regional Directional Transfer (RDT) limit of 1900 MW is reflected in this chart

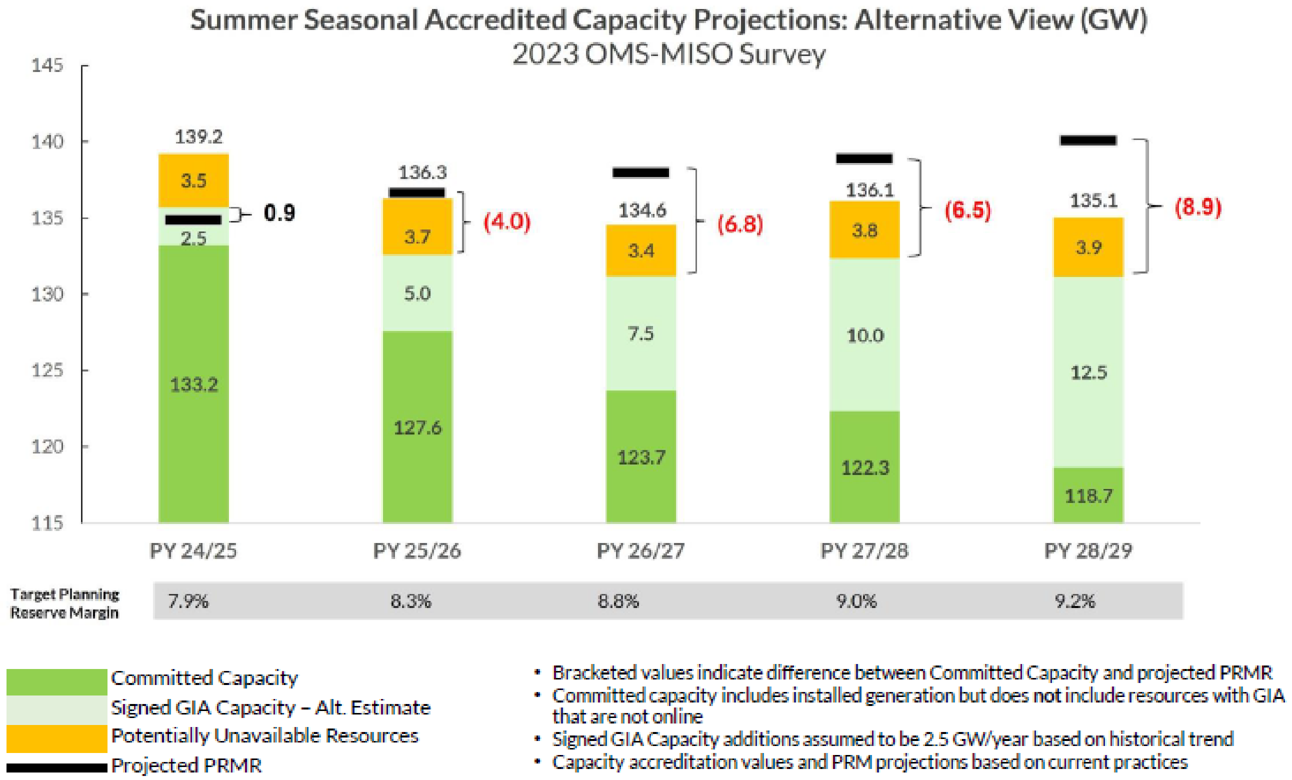
Committed capacity projections from the OMS-MISO Survey show an increasing deficit beginning in 2025-26; capacity additions are needed, and retirements may need to be delayed to mitigate reliability risks



Interconnection’s Impact on Reliability: MISO

Analysis from MISO presented to MISO Board of Directors on September 12, 2023

Alternative capacity projections based on historical annual additions of 2.5 GW show greater risk beginning in planning year 2025/26

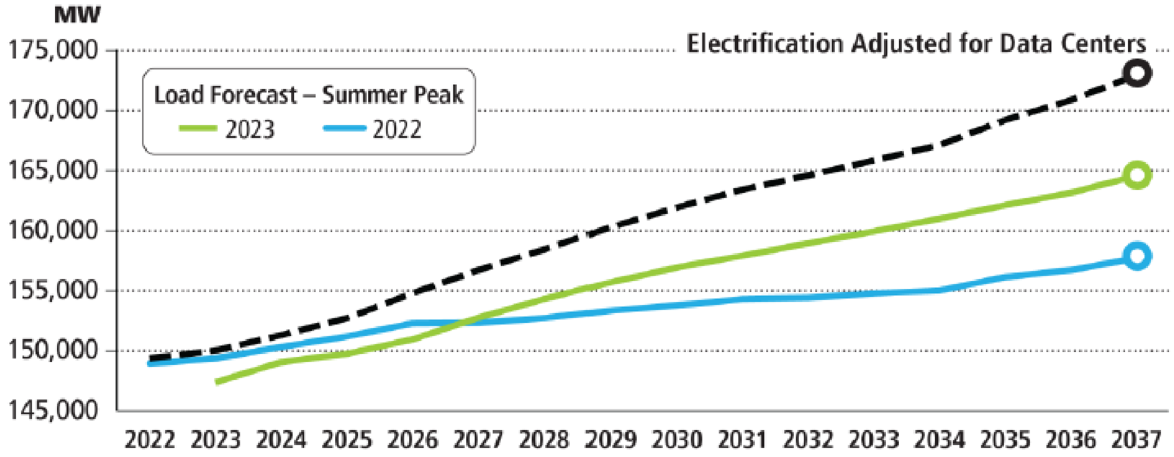


Reliability Shortfall Summary:

Planning Year	All Interconnections Assumed to be in Service & Scheduled Retirements (in GW)	Using MISO’s Adjustments based on Historic Deployments (in GW)
2024/2025	0.9	0.9
2025/2026	3.2	(4.0)
2026/2027	9.6	(6.8)
2027/2028	13.3	(6.5)
2028/2029	16.8	(8.9)

Trends in Resource Adequacy #4: Load Growth

Figure 6. Impacts of Electrification and Data Center Load on Forecasts



Source: **Energy Transition in PJM:** Resource Retirements, Replacements & Risks - February, 2023, PJM Interconnection, LLC

“

Driven by electrification, hydrogen production, data centers, crypto mining, and other computational and energy-intensive methods such as artificial intelligence (AI), **new loads can emerge and grow faster than generation and transmission can be built.**

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

ERO Reliability Risk Priorities Report

North American Electric Reliability Corporation – August 2023
(Emphasis added)

Trends in Resource Adequacy #5: Generation Accreditation

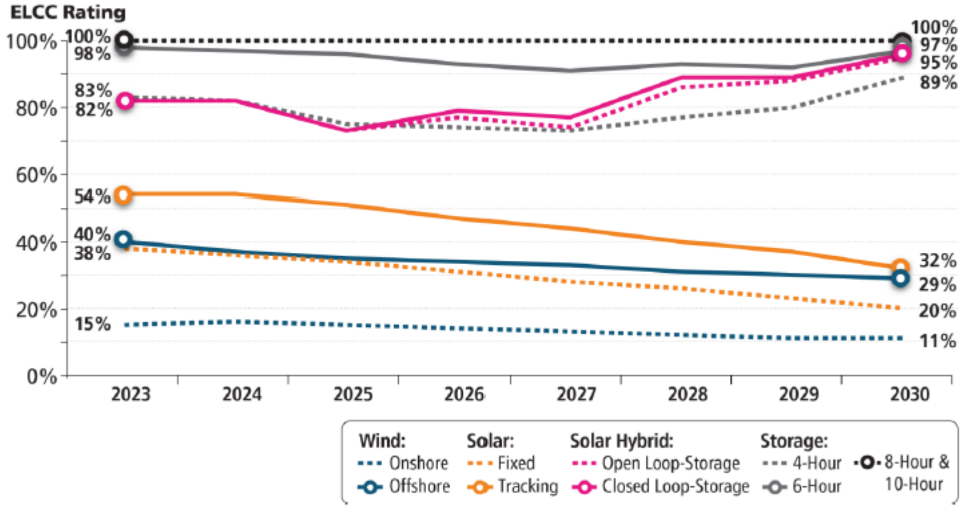
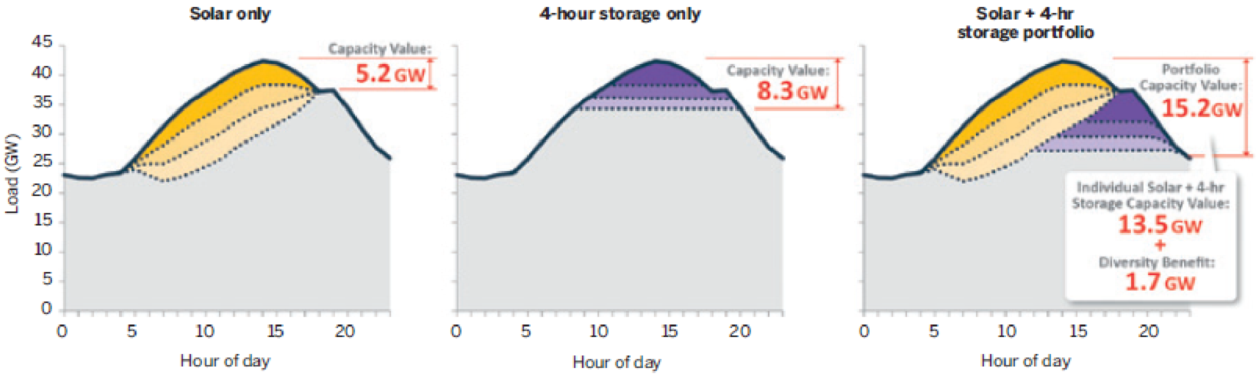


FIGURE 13

The ELCC of Solar Alone, Storage Alone, and the Two Resources in Combination



Source: Energy and Environmental Economics (E3) / Schlag et al. (2020).

“ **PRINCIPLE 3: There is no such thing as perfect capacity.**

…gas plants are not always available on demand, as they experience planned as well as weather-related outages. The false dichotomy between the perfect resource and resources with only partial “firm capacity” is due to be replaced by analysis applying the effective load carrying capability (ELCC) metric to all resource types.

ESIG ENERGY SYSTEMS INTEGRATION GROUP

Redefining Resource Adequacy for Modern Power Systems:
Energy Systems Integration Group - 2021

10 Questions I Asked (Or Wished I'd Asked)

1. Am I working with my environmental regulator colleagues to understand how environmental rule changes (federal & state) will affect the resource adequacy outlook?

2. How well do we understand drivers of projected load growth in our state?

3. Are we requiring our utilities to track new "super-users," like data centers or EV charging depots?

4. How far in advance is the ISO/RTO evaluating resource adequacy and does that match with our policy objectives?

5. What happens to that evaluation if new planned generation resources take longer than expected to come online or if perspective resources cancel?

10 Questions I Asked (Or Wished I'd Asked)

6. What are my state's options if there is a reliability shortfall?

7. Do we have a reliability "safety valve" built into our statutes or regulations if public policy retirements cause reliability issues?

8. Do we have a strategy for avoiding hideously expensive Reliability Must Run contracts?

9. How much more am I willing to pay to accelerate emissions reductions or reduce reliability risk?

10. Bonus Question: How would our regulator colleagues in neighboring states answer these questions?

Center on Global Energy Policy at COLUMBIA | SIPA

Non-Technical Barriers to the Clean Energy Transition Initiative

Mission:

“ **To address regulatory barriers to a reliable, affordable, clean, and just energy future.** ”

Abe Silverman
301-949-5406 * as7064@columbia.edu

State Capacity Building Program

- Identify issues of interest to state regulators and promote high-quality research into those issues.
- Proactively support state regulators through policy briefings, convenings and discussions of cutting edge research.
- Provide professional growth opportunities to state employees through Columbia University’s educational mission as a non-partisan, non-advocacy, institution of higher education.

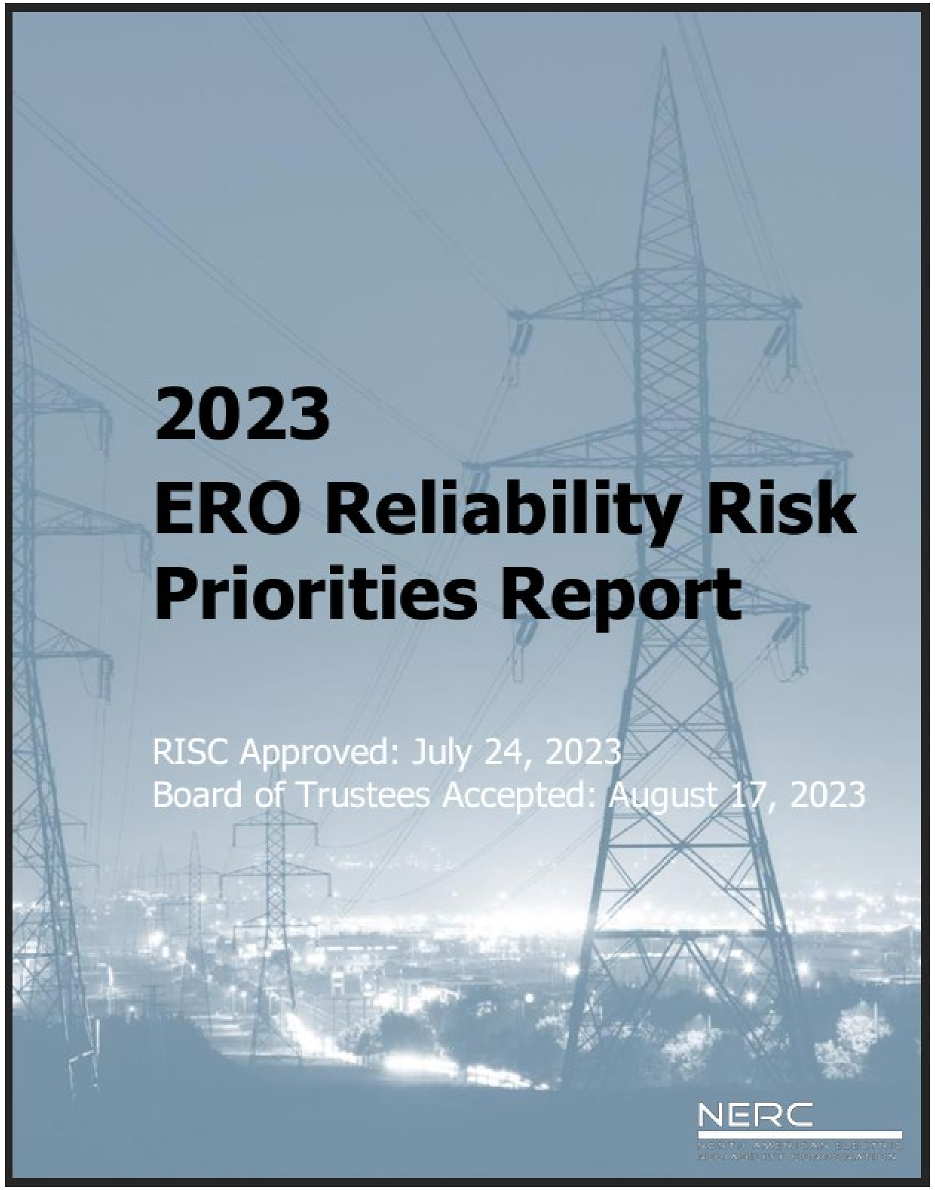
TECH TALK REMINDER

Tech Talk with RF announcements are posted on our calendar on www.rfirst.org under UPCOMING EVENTS

TECH TALK ANNOUNCEMENT

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Check out the latest *2023 ERO Reliability Risk Priorities Report*



TECH TALK ANNOUNCEMENT

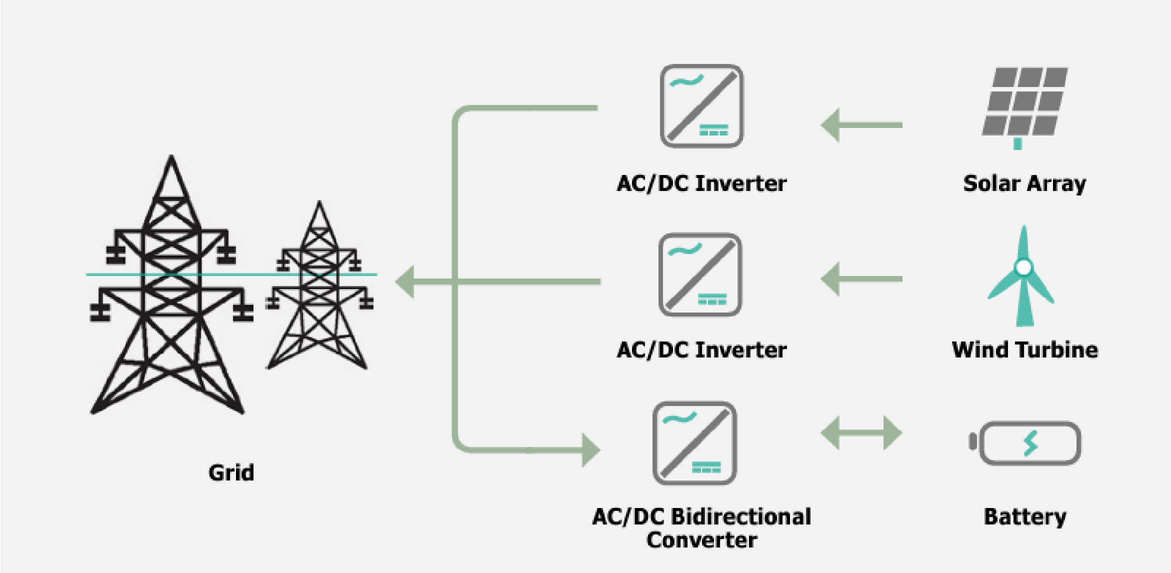
NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Introduction to Inverter-Based Resources (IBRs) on the Bulk Power System

Guide for policy makers here

Webinar Series here

FAQ here

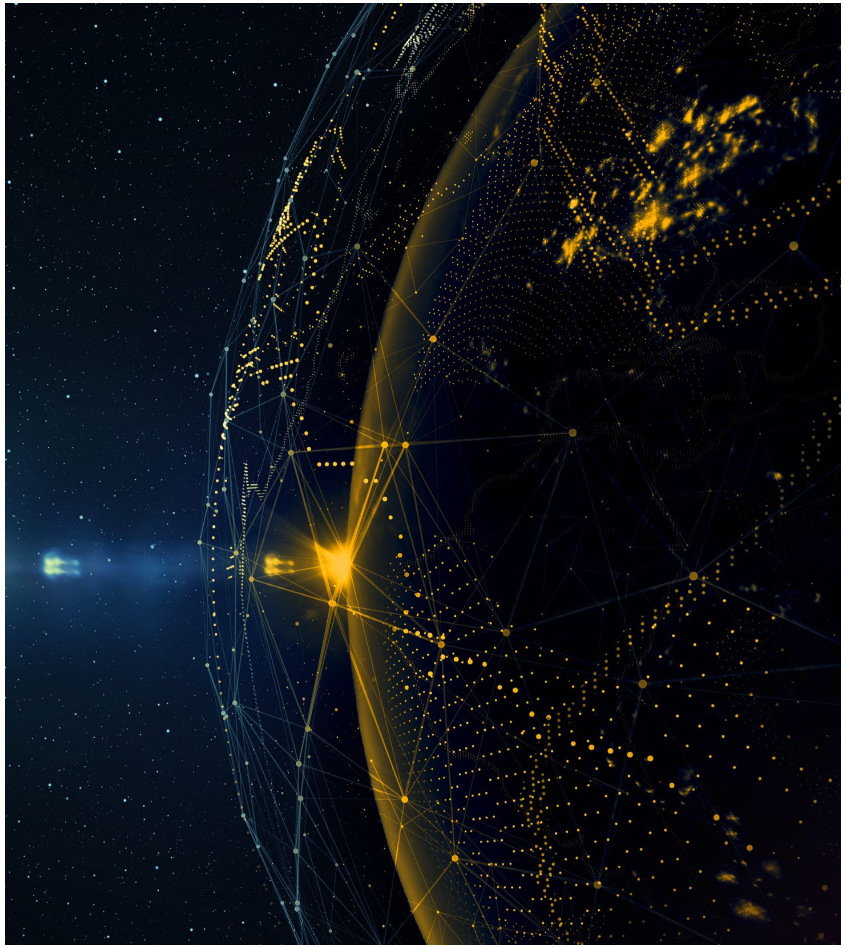


TECH TALK ANNOUNCEMENT

GridSecCon 2023

Quebec City, October 17-20

Registration



GridSecCon brings together cyber and physical security leaders from industry and government to deliver expert training sessions, share best practices and effective threat mitigation programs, and present lessons learned. Conference and hotel registration opened in May and more details are available on the E-ISAC, NERC and NPCC websites.

FORWARD TOGETHER RELIABILITYFIRST

TECH TALK ANNOUNCEMENT

NERC NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

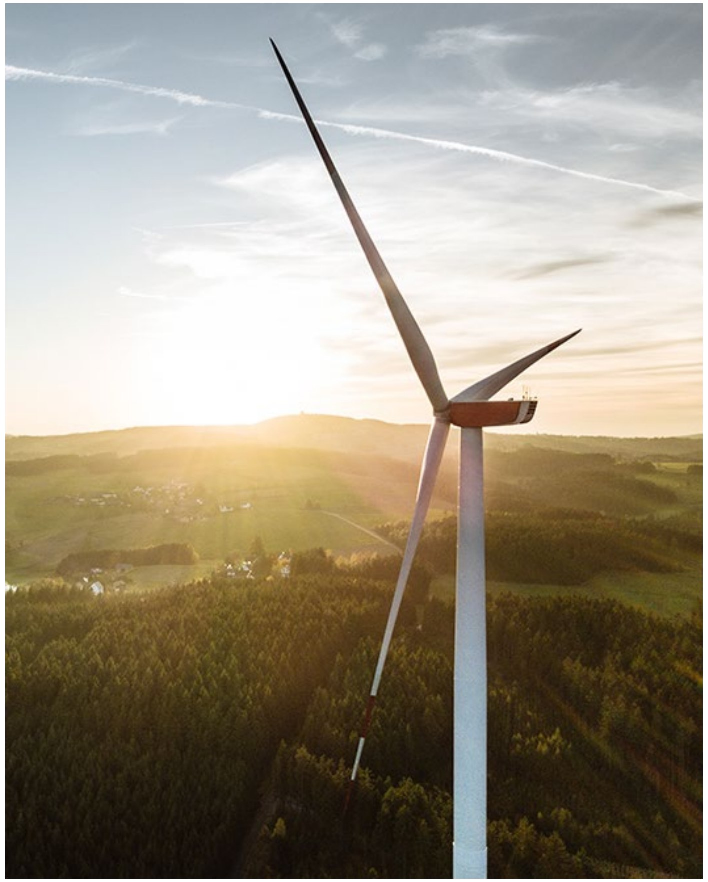
North American Transmission FORUM

EPRI

NERC-NATF-EPRI Annual Transmission Planning and Modeling Workshop

November 1-2, 1:00 – 5:00 PM Eastern

This year's seminar will focus on bulk power system load modeling, integrated system planning practices, IBR risk mitigation, and updates on the latest research and activities across the industry.



FORWARD TOGETHER RELIABILITYFIRST

ReliabilityFirst Fall Workshop 2023

PUBLIC

Please join us for the 2023 Fall Workshop at the Omni William Penn Hotel in Pittsburgh! On Day One, breakfast and lunch will be served prior to the start of the workshop, and a reception will follow Tuesday evening. On Day Two, breakfast will be served prior to the start of the workshop and lunch will be served afterward. Please see details below on the topics and speakers planned for the event.

Day One, Tuesday, Sept. 26, 2023

Topic	Speaker(s)
Welcome	Brian Thiry, Director of External Affairs and Entity Engagement, ReliabilityFirst
Working Together with State Public Utility Commissions amid the Great Energy Transition	Stephen DeFrank, Chairman, Pennsylvania Public Utility Commission
Human Performance in the Energy Industry	Lesley Evancho, Chief Human Resources Officer, EQT and Independent Director, RF Board of Directors
Securing in Small Bytes: Tactically Addressing Cybersecurity in Critical Infrastructure	Matthew E. Luallen, Lead Research Scientist, Information Trust Institute at the University of Illinois, Urbana-Champaign
Parallels and Interdependencies between the Water and Electric Industries	Justin Ladner, President, Pennsylvania American Water
Panel Discussion: Electric Grid Interdependencies with State Government, Natural Gas, Cybersecurity and Water Industries	Host: Kevin Walker, President and CEO, Duquesne Light Holdings, Inc. Panelists: • Chairman Stephen DeFrank, PA PUC • Lesley Evancho, EQT • Matt Luallen, UIUC • Justin Ladner, Pennsylvania American Water

Day Two, Wednesday, Sept. 27, 2023

Topic	Speaker(s)
Welcome	Brian Thiry, Director of External Affairs and Entity Engagement, ReliabilityFirst
Federal Energy Regulatory Commission (FERC) Notice of Proposed Rulemaking (NOPR) Updates	Kal Ayoub, Critical Infrastructure and Resilience Advisor to the Chairman, FERC
Updates on NERC Projects	Latrice Harkness, Director of Standards Development, Jamie Calderon, Manager of Standards Development, and Alison Oswald, Manager of Standards Development, NERC
The Journey to Building a Successful Internal Controls Program	Nicholas Poluch, Senior Manager, NERC Cyber Protection and Ops Program, and Colleen Dolan, Manager, NERC Internal Controls, Talen Energy
CMEP Updates	Zack Brinkman, Manager, CIP Compliance Monitoring, Jim Kubrak, Manager, Operations and Planning Compliance Monitoring, and Max Reisinger, Senior Counsel, ReliabilityFirst

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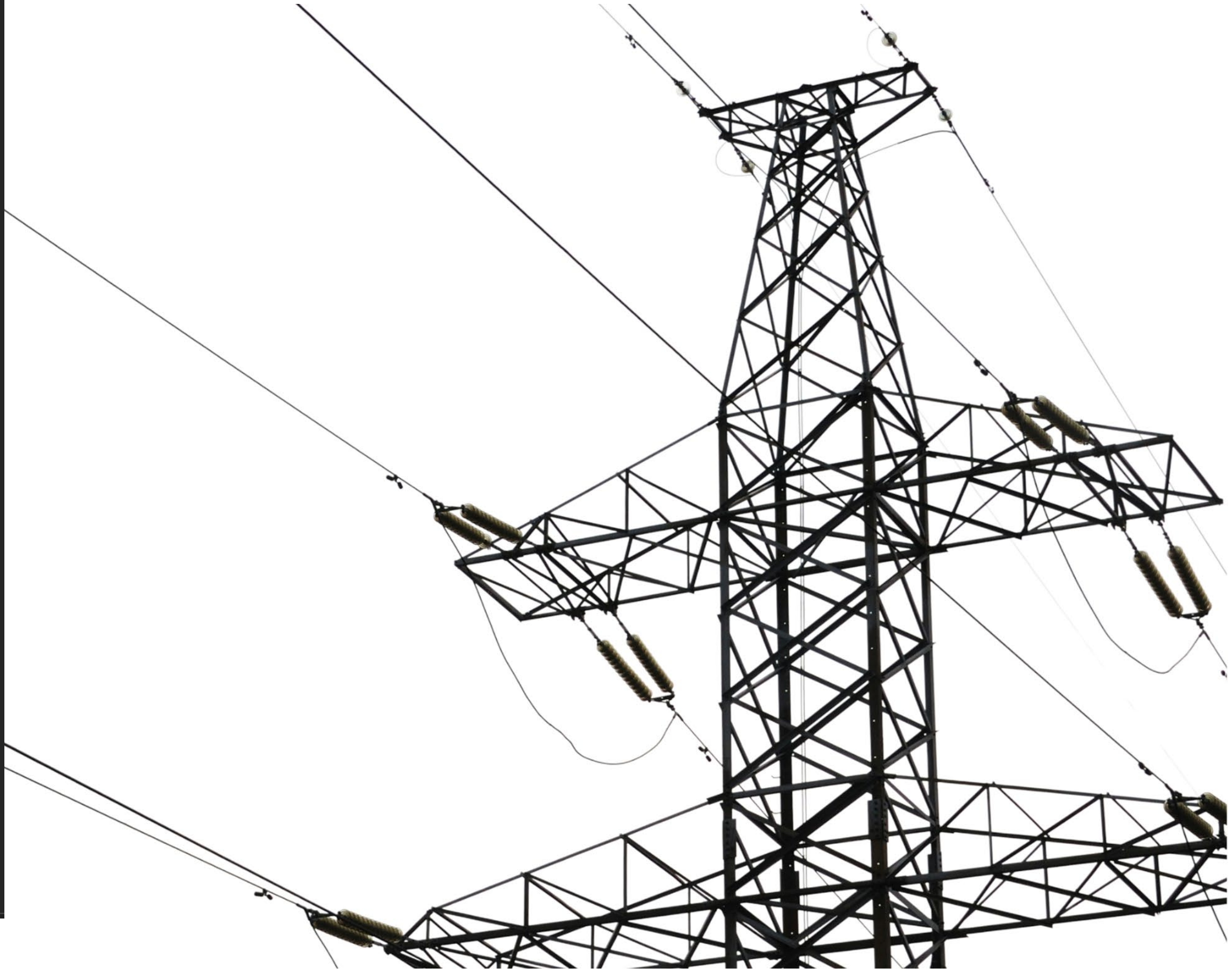
See you soon!

Sept 26-27 Omni William Penn, Pittsburgh, PA



RF UPCOMING WEBINARS

October Tech Talk with RF

- Cyber-security Awareness Month
- October 9, 2:00-3:30 PM EST
- Tentative Topics:
  - Software Bills of Materials
  - CIP-004-7 (Personnel & Training)
  - CIP-011-3 (Information Protection)

November Tech Talk with RF

- State Policy Edition
- November 13, 2:00-3:30 PM EST
- Tentative Topics:
  - Emerging Technologies
  - Transfer Studies

Check our calendar www.rfirst.org for more details!