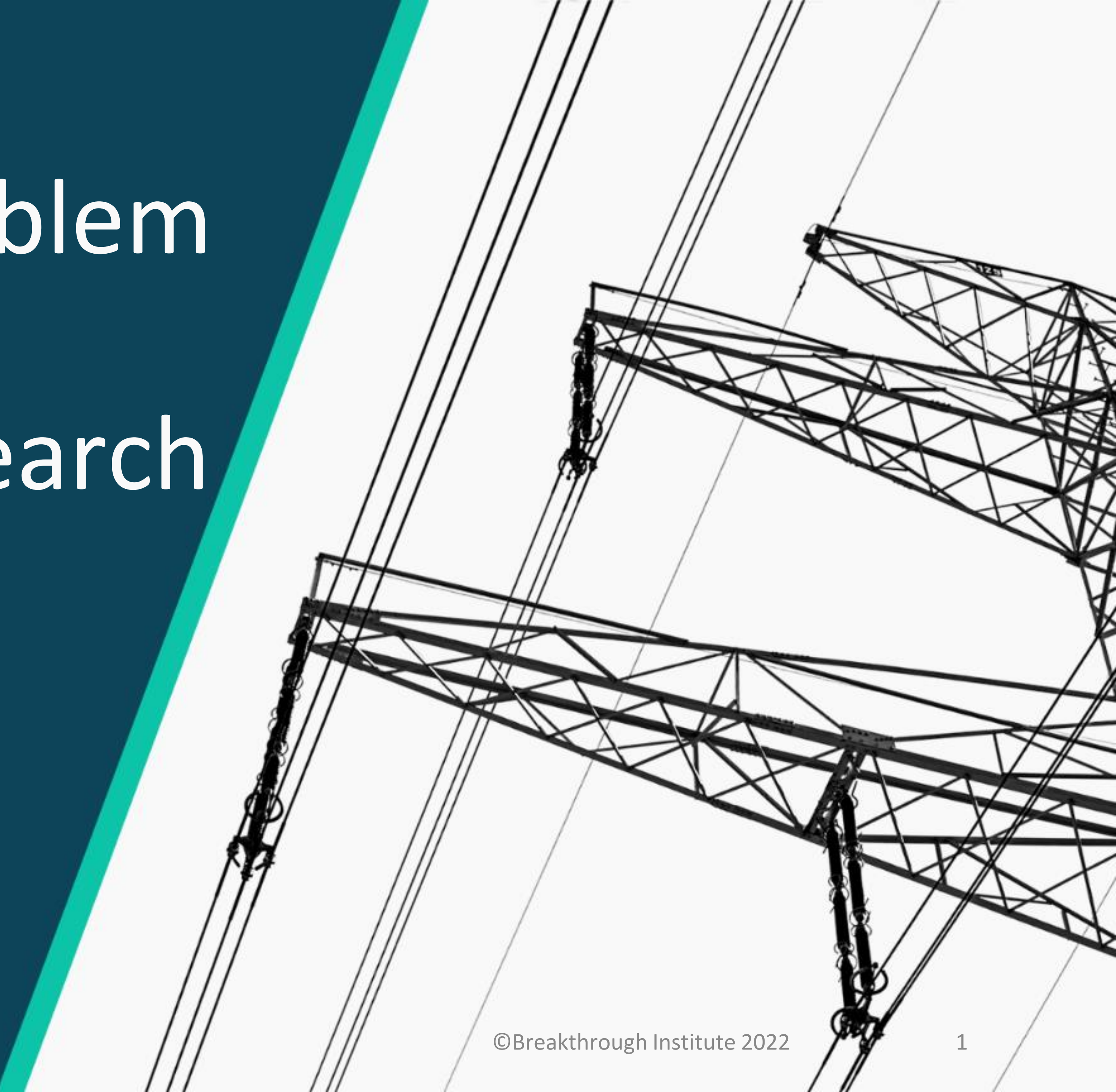
The Growing Problem of Hollow 100% Renewables Research

Dr. Seaver Wang



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About Breakthrough

- Nonprofit environmental think tank and research center
  - Berkeley, California and Washington D.C.
- Analytical research and policy development
- Ecomodernism - solving environmental problems alongside economic growth using technological innovation
- Practical and realistic political approaches

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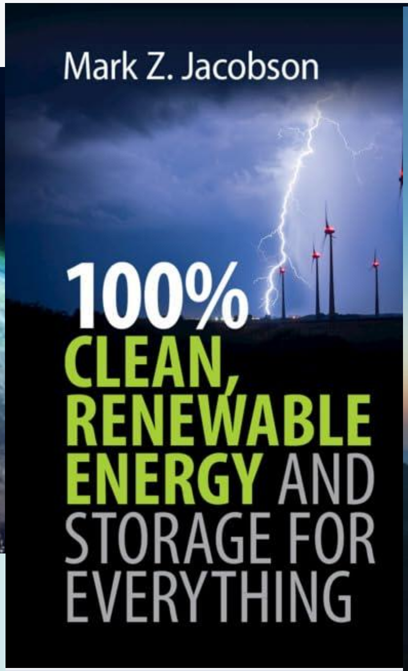
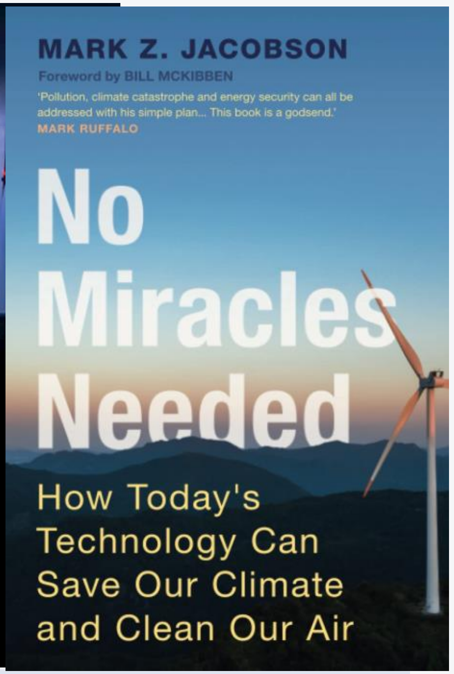
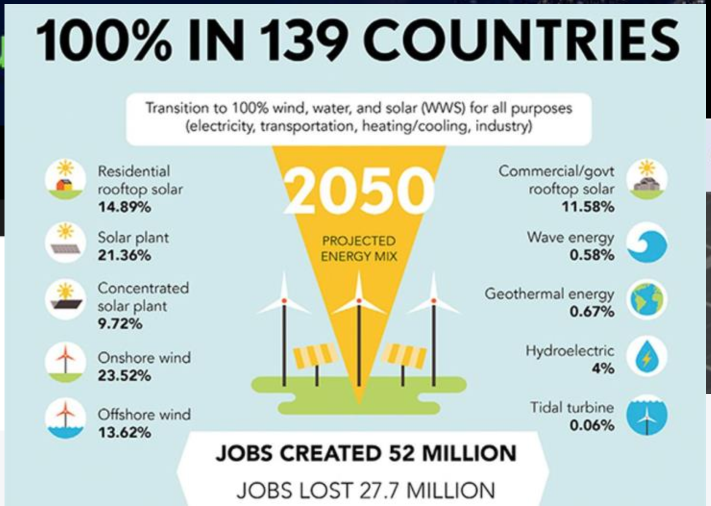
Many people believe renewable energy challenges are solved







more examples

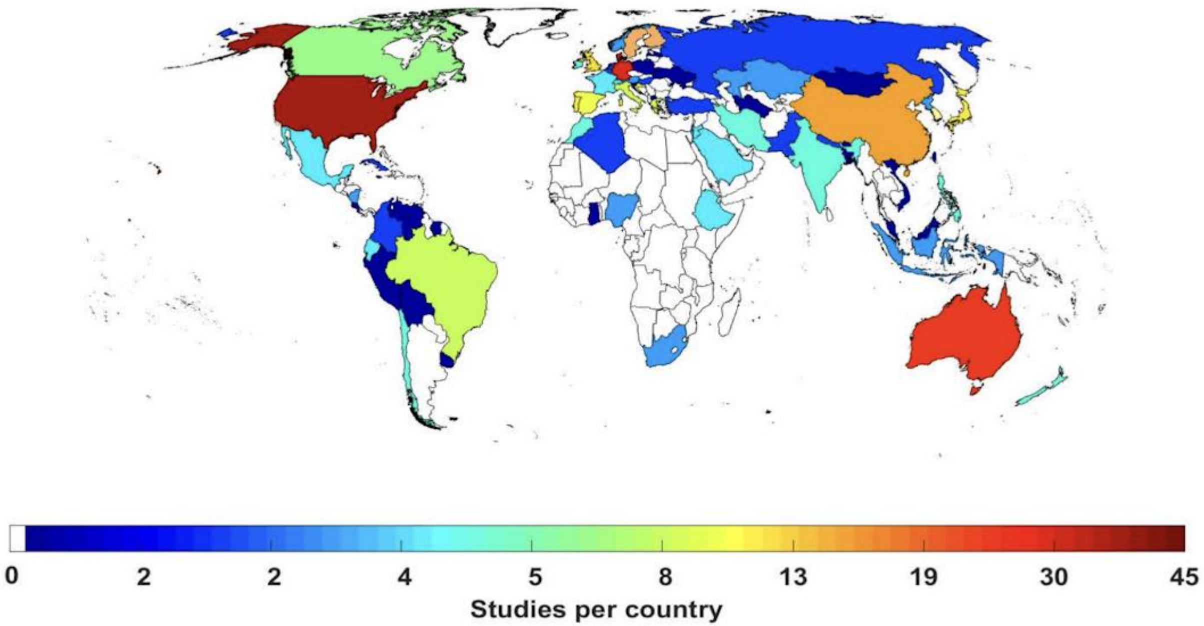
Researchers claim renewables can power world at low cost

IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

TOPICAL REVIEW

On the History and Future of 100% Renewable Energy Systems Research

CHRISTIAN BREYER[1], SIAVASH KHALILI[1], DMITRII BOGDANOV[1], MANISH RAM[1], AYOBAMI SOLOMON OYEWO[1], ARMAN AGHAHOSSEINI[1], ASHISH GULAGI[1], A. A. SOLOMON[1], DOMINIK KEINER[1], GABRIEL LOPEZ[1], POUL ALBERG ØSTERGAARD[2], HENRIK LUND[2], BRIAN V. MATHIESEN[3], MARK Z. JACOBSON[4], MARTA VICTORIA[5], SVEN TESKE[6], THOMAS PREGGER[7], VASILIS FTHENAKIS[8], (Fellow, IEEE), MARCO RAUGEI[8,9], HANNELE HOLTTINEN[10,11], (Senior Member, IEEE), UGO BARDI[12], AUKE HOEKSTRA[13], AND BENJAMIN K. SOVACOOL[14,15,16]

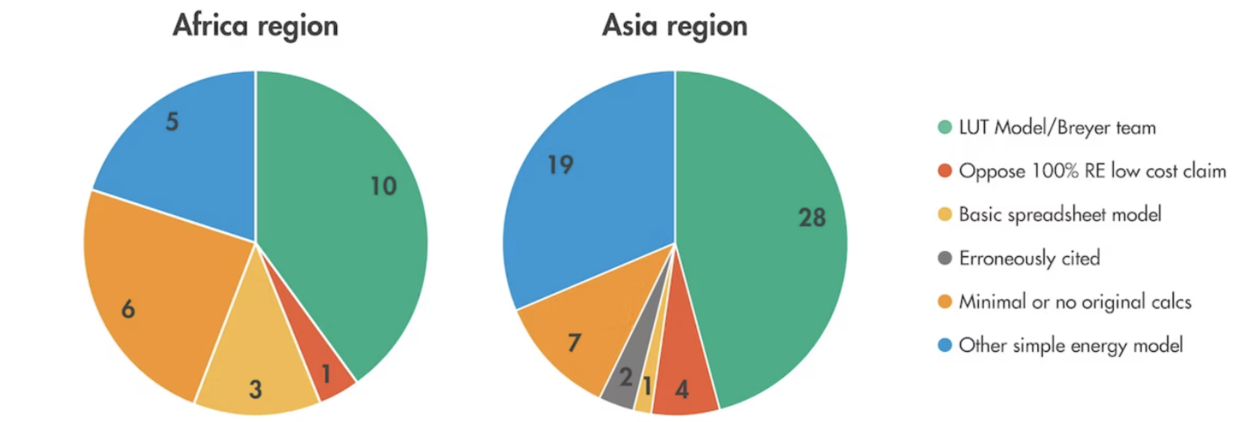


“The main conclusion of the vast majority of 100% renewable energy systems studies is that such systems can power all energy in all regions of the world at low cost.”

What is the quality of these studies?

- We reviewed studies on Asia and Africa (86 papers in total)
- What is the quality of these studies?
- Essentially all are poor quality, some are very low quality
- This significantly affects the claim that cheap 100% renewables is possible globally

Figure 7: Categorization and evaluation of 25 and 61 studies cited by Khalili and Breyer



https://thebreakthrough.org/issues/energy/what-the-100-renewables-literature-gets-wrong

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No analysis, discussion only

- 13 of 86 papers (15%) conduct no quantitative analysis, or very little analysis
- Some only discuss positives and negatives
- If a paper includes no calculations, can it really prove 100% RE systems are superior?

Pumped hydro energy storage and 100 % renewable electricity for East Asia

Cheng Cheng[1], Andrew Blakers[1], Matthew Stocks[1], Bin Lu[1]
1. Research School of Electrical, Energy, and Materials Engineering, Australian National University, Canberra, 2601, Australia

Mongol dream beyond fossil fuels: Prosperity of greenification

Zolboo Gansukh
School of Economics and Management Science, Yanshan University, 066004, Qinhuangdao, PR China

Potential of renewable energy systems in China

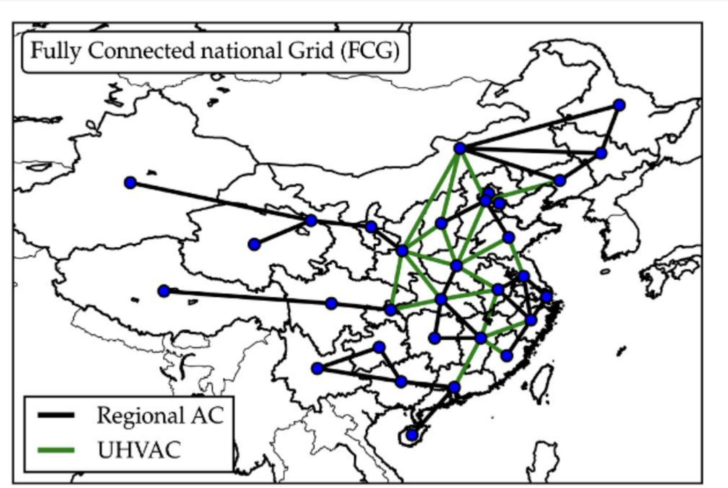
Wen Liu [a,*], Henrik Lund [a], Brian Vad Mathiesen [a], Xiliang Zhang [b]
[a] *Department of Development and Planning, Aalborg University, Fibigerstraede 13, DK-9220 Aalborg, Denmark*
[b] *Institute of Energy, Environment, and Economy, Tsinghua University, Energy Science Building C301, Tsinghua University, Beijing 100086, China*

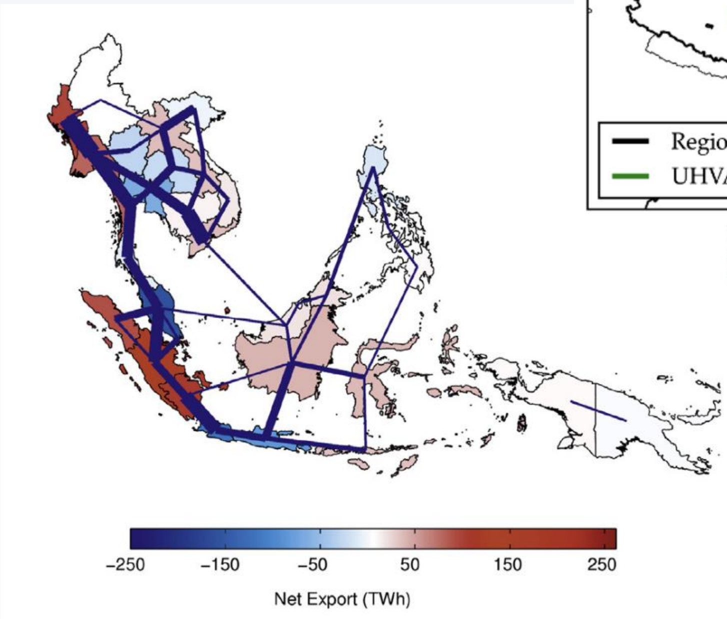
Towards 100% renewable energy in Nigeria

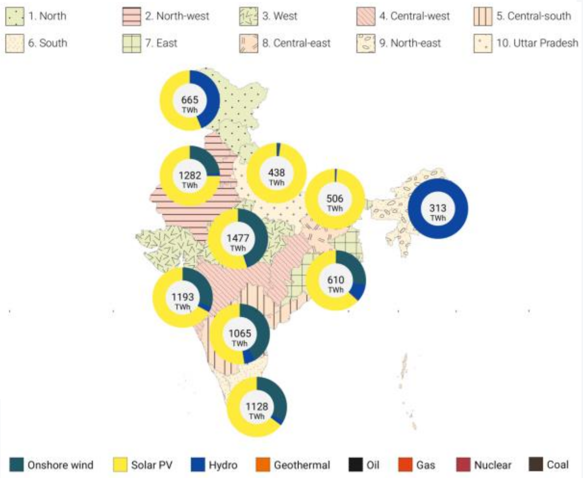
Udochukwu B. Akuru[a,*], Ifeanyichukwu E. Onukwube[b], Ogbonnaya I. Okoro[c], Emeka S. Obe[a]
[a] *Department of Electrical Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria*
[b] *Pilgrim Micropower Limited, Ajah, Lagos State, Nigeria*
[c] *Department of Electrical and Electronic Engineering, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria*

Many simple 100%RE models are missing important factors

- 62 of 86 papers (72%) use only very simple energy models
- Distribution and transmission network with few points
- Only looking at weather data for a few days in each year
- No transmission losses or limits







https://www.sciencedirect.com/science/article/abs/pii/S0306261919302995?via%3Dihub
https://www.sciencedirect.com/science/article/abs/pii/S0360544215005204
https://www.mdpi.com/1996-1073/11/11/3001

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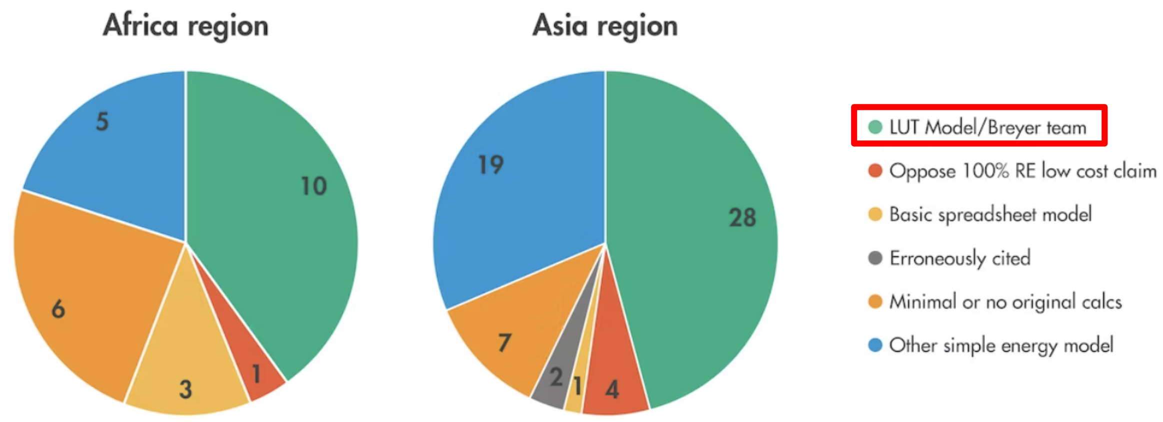
High number of studies from one group

- Almost half (44%) of studies published by Prof. Christian Breyer's own research group—the same group writing the famous review papers

Figure 7: Categorization and evaluation of 25 and 61 studies cited by Khalili and Breyer



https://thebreakthrough.org/issues/energy/what-the-100-renewables-literature-gets-wrong

On the History and Future of 100% Renewable Energy Systems Research

CHRISTIAN BREYER[1], SIAVASH KHALILI[1], DMITRII BOGDANOV[1], MANISH RAM[1], AYOBAMI SOLOMON OYEWO[1], ARMAN AGHAHOSSEINI[1], ASHISH GULAGI[1], A. A. SOLOMON[1], DOMINIK KEINER[1], GABRIEL LOPEZ[1], POUL ALBERG ØSTERGAARD[2], HENRIK LUND[2], BRIAN V. MATHIESEN[3], MARK Z. JACOBSON[4], MARTA VICTORIA[5], SVEN TESKE[6], THOMAS PREGGER[7], VASILIS FTHENAKIS[8], (Fellow, IEEE), MARCO RAUGEI[8,9], HANNELE HOLTTINEN[10,11], (Senior Member, IEEE), UGO BARDI[12], AUKE HOEKSTRA[13], AND BENJAMIN K. SOVACOOL[14,15,16]

Problems with Breyer group work

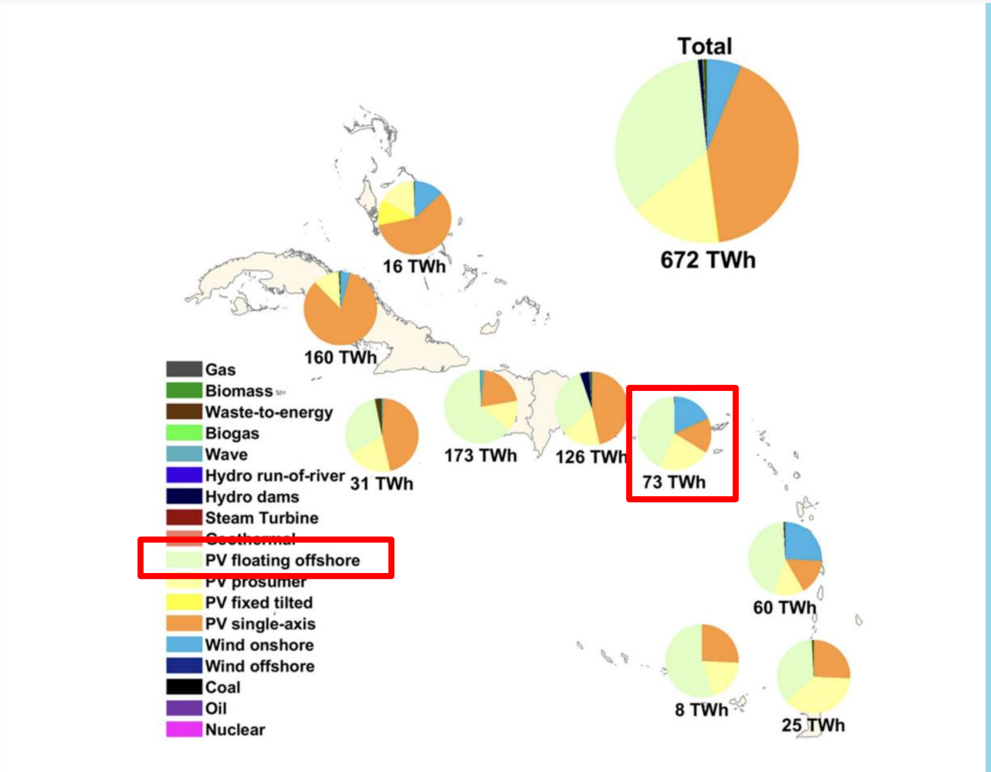
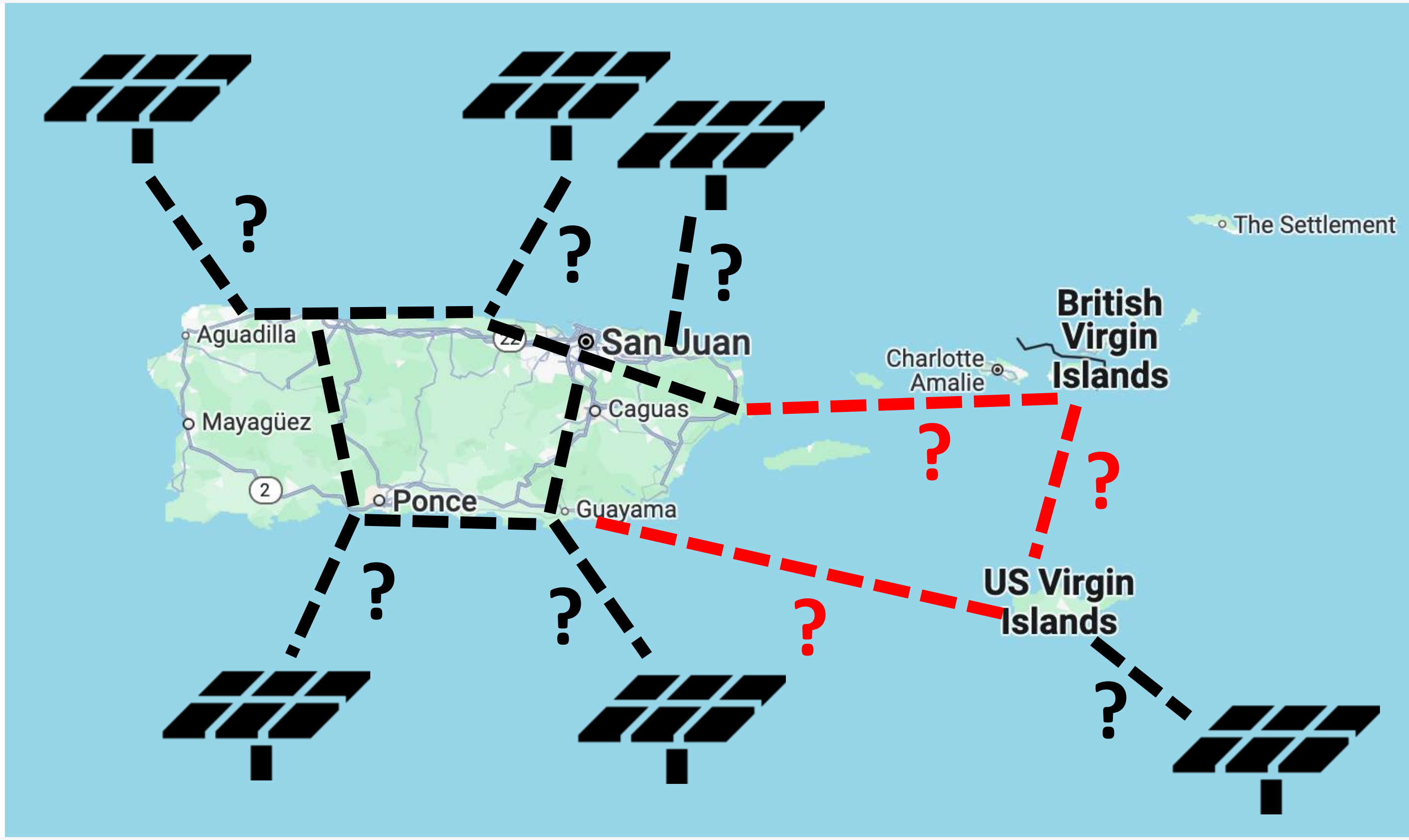


Fig. 9. Electricity generation in 2050 in the BPS-CAR-1.



“Role of Solar Photovoltaics for a Sustainable Energy System in Puerto Rico in the Context of the Entire Caribbean Featuring the Value of Offshore Floating Systems”

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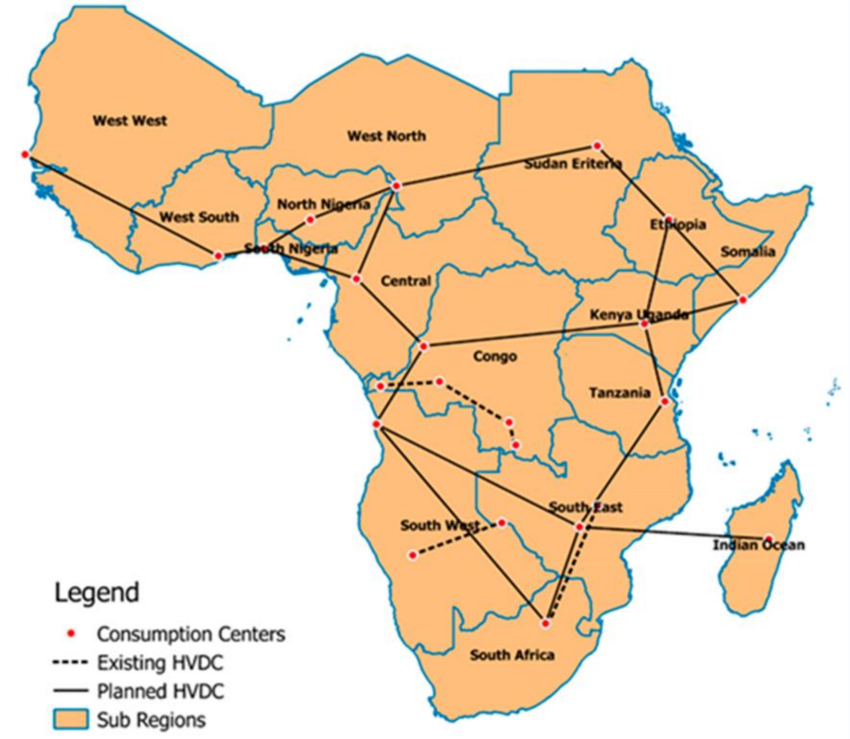
Problems with Breyer group work

A cost optimal resolution for Sub-Saharan Africa powered by 100% renewables in 2030

Maulidi Barasa, Dmitrii Bogdanov, Ayobami Solomon Oyewo, Christian Breyer*

Lappeenranta University of Technology, Skinnarilankatu 34, 53850 Lappeenranta, Finland



https://www.sciencedirect.com/science/article/abs/pii/S1364032118303277

"The findings of this research is that 100% RE is already low cost based on 2030 financial assumption."

"This research work establishes that a 100% renewable resource-based energy system is a technically and economically practical solution for Sub-Saharan Africa. RE technologies can generate sufficient power to provide for all electricity demand in Sub-Saharan Africa for the year 2030 at a low overall cost of 47–58 €/MWhel, and this depends on the intensity of geographic integration and energy sector coupling"

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Is this 100%RE energy system realistic?

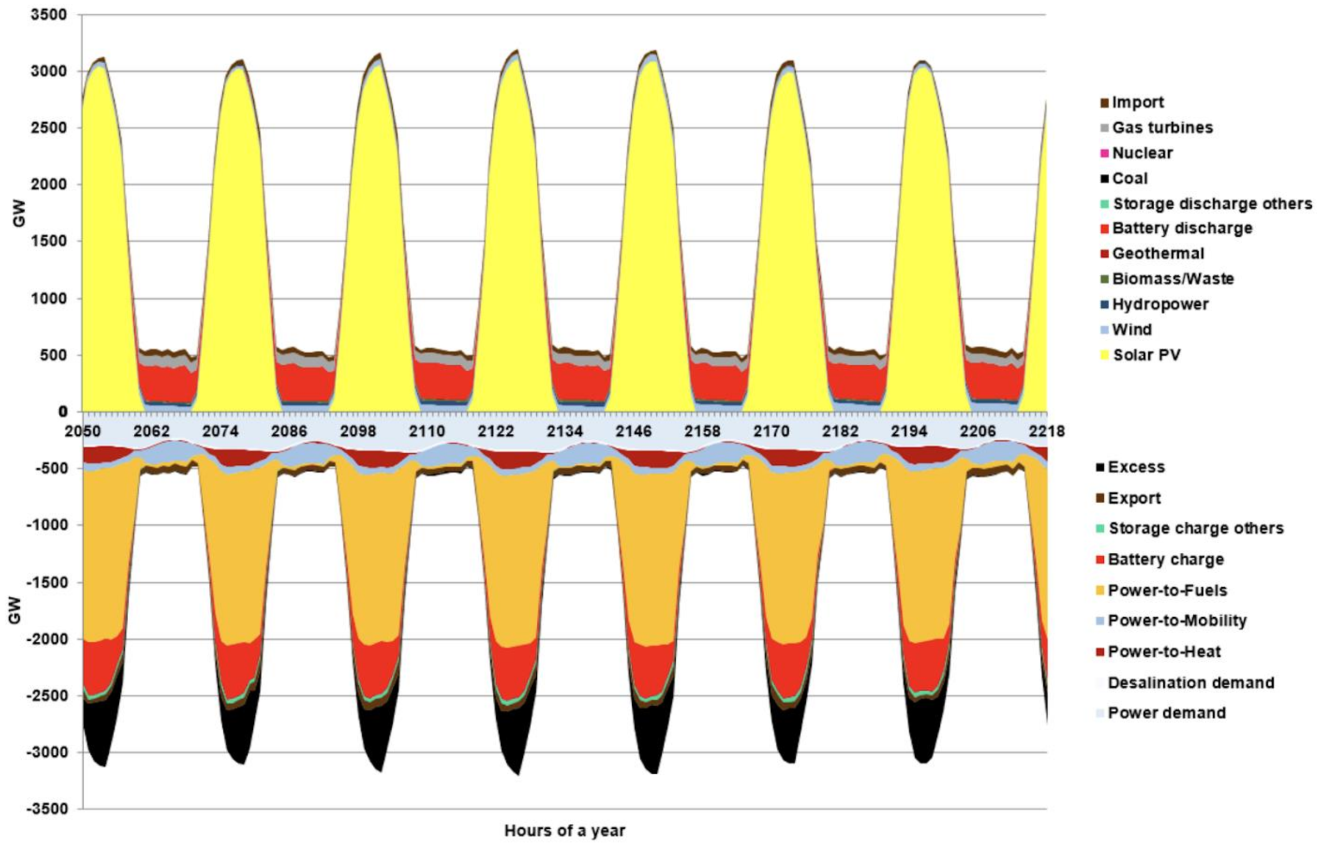
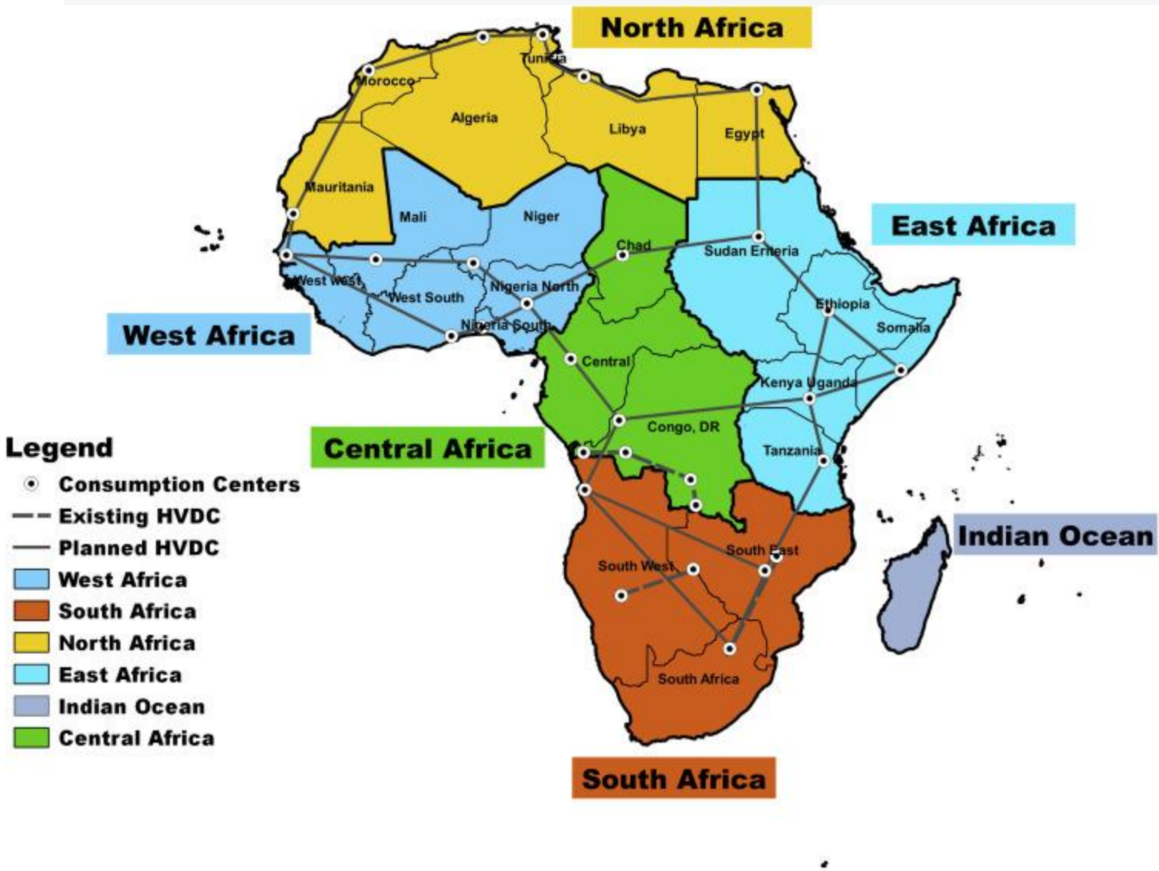


Figure S11: Hourly operation of the energy system during the best week regarding total renewable electricity availability for the BPS, related to Figure 2A.



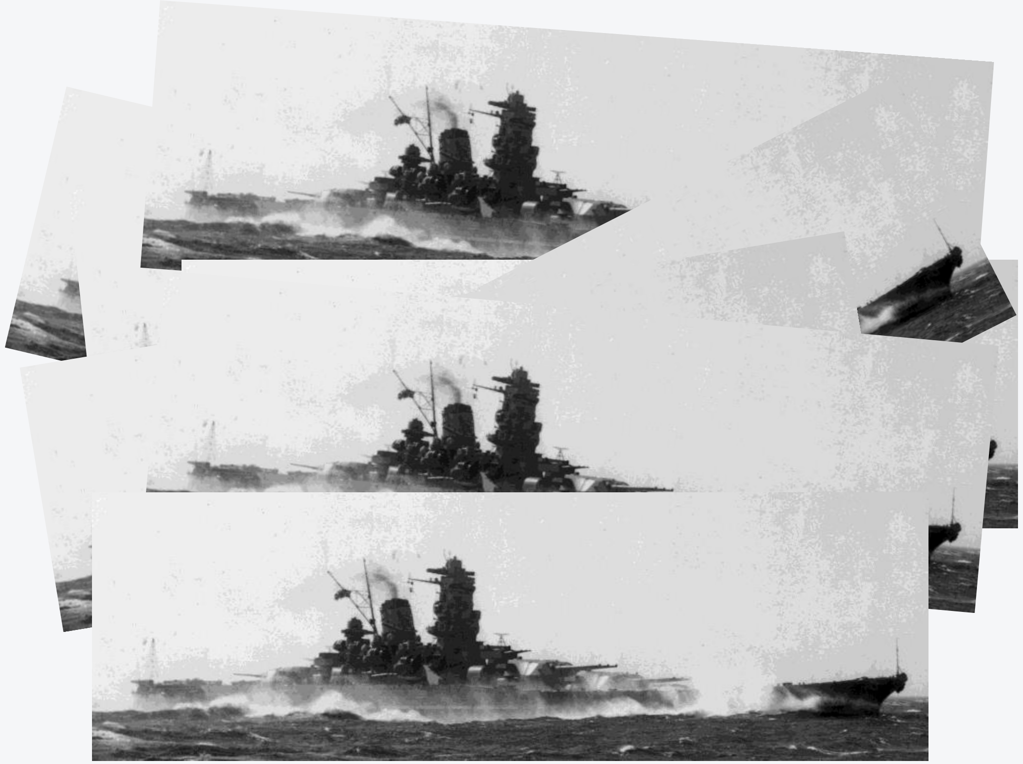
https://www.cell.com/iscience/fulltext/S2589-0042(22)01237-8

Fuels from direct air CO2 capture?

- By 2035, Africa has:
  - 38 million metric tons/yr of direct air CO2 capture capacity
  - 99 GW of methanation capacity
- By 2050 , Africa has :
  - 55 million metric tons/yr of direct air CO2 capture capacity
  - 492 GW (methane) of methanation capacity

How much is 38 million metric tons/yr? By 2035, Africa has enough direct air CO2 capture infrastructure to source 527.7 Yamato-class battleships' mass in CO2/yr from the air.

Today, Africa still has 580 million people without power.



Length: 263 meters.
Displacement: 72,000 tons.

Studies use very low renewable energy costs

2020 CAPEX costs (2015 Euros)	Africa	India	United Kingdom
	Oyewo et al., 2022	Gulagi et al., 2022	Diesing et al., 2023
	https://www.cell.com/iscience/fulltext/	https://www.nature.cc	https://100percentrenewableuk.org/
Solar, ground-mount utility-scale, fixed tilt	475	432	475
Solar, ground-mount utility-scale, single-axis tracking	523	475	523
Solar, rooftop, residential	1150	1045	1150
Onshore wind	1150	800	1150
Offshore wind	n/a	2003	2973
Nuclear	4672	4571	9170
OCGT	475	445	475
CCGT	775	637	775
Biomass CHP	2620	1463	n/a
Geothermal	4970	4970	4970
Hydro, Reservoir	1650	1650	n/a
Battery, Li-ion	234/kWh storage, 117/kW interface	270	234/kWh storage, 117/kW interface
Compressed air storage	75/kWh storage, 540/kW interface	80.4	35/kWh storage, 600/kW interface
Water electrolysis (per kW H2)	685	685	803
Methanation (per kW CH4)	502	502	558
Direct air capture (per ton CO2 per year)	730	730	730
Synthetic methane gas storage	.1/kWh storage; 100/kW interface	.05/kWh storage	.05/kWh storage; 25.8/kW interface

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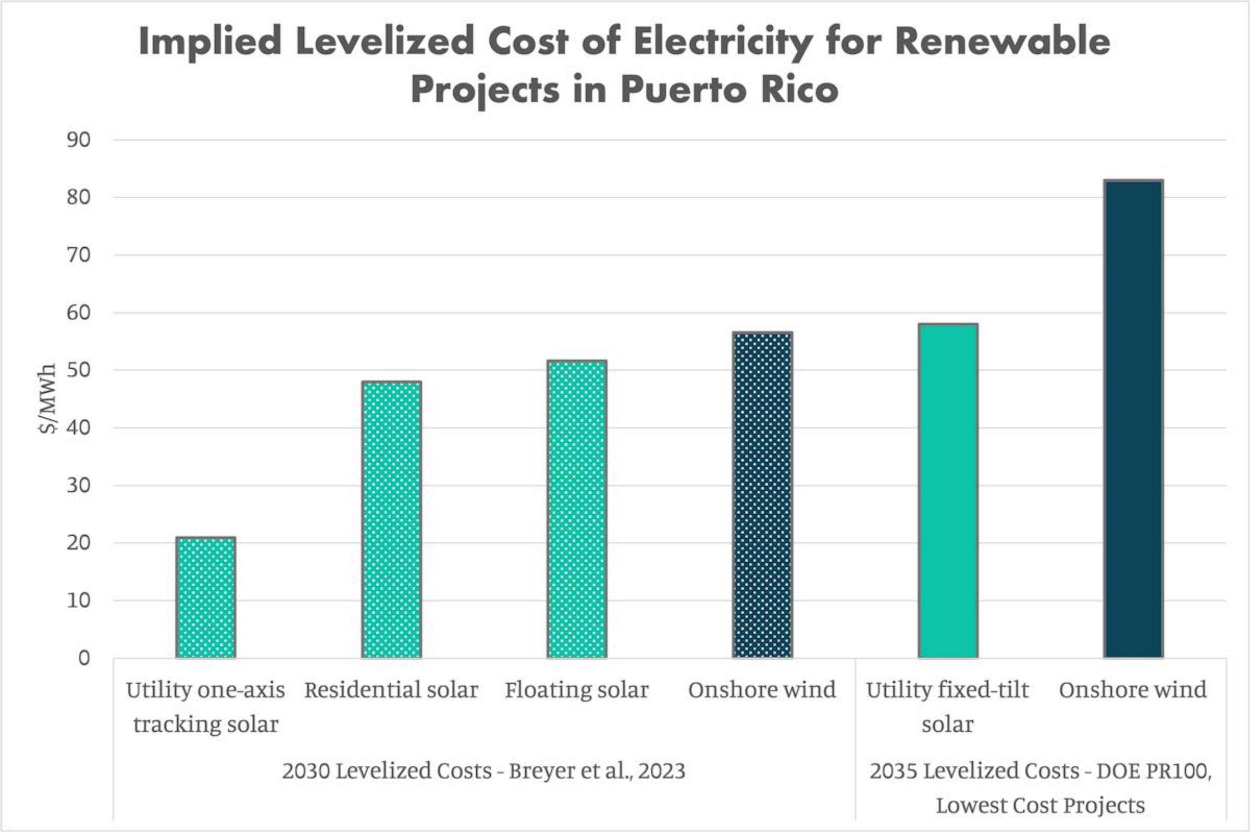
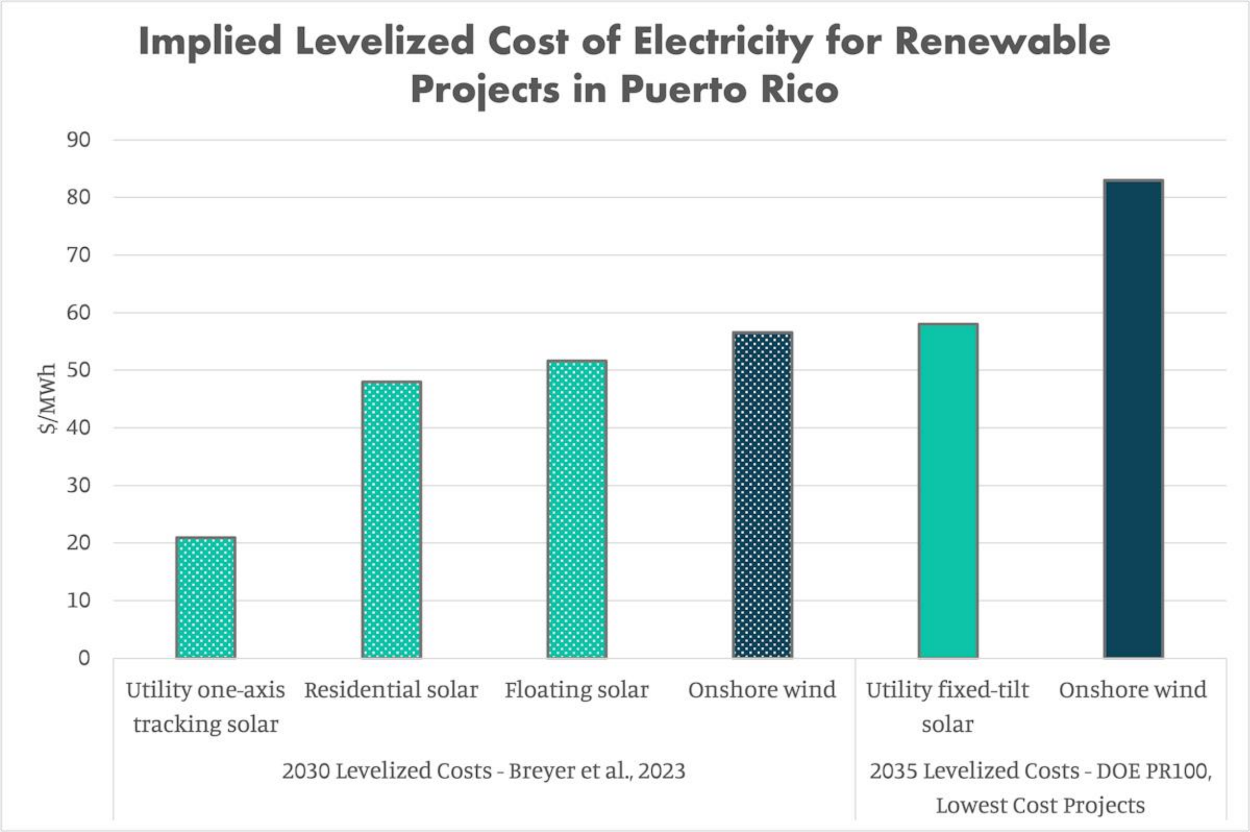
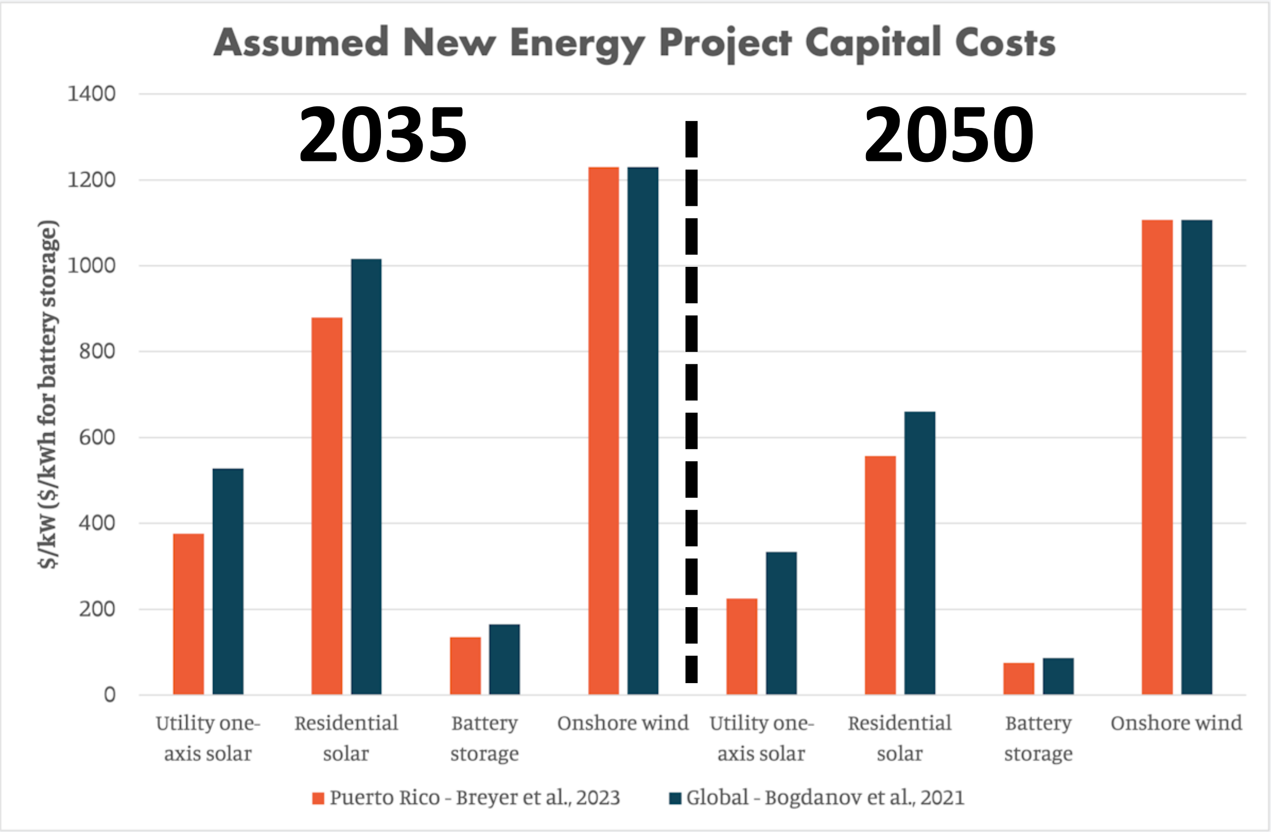
Puerto Rico: low costs, copy-pasted from other papers



Floating solar costs less in 2030 than U.S. Dept. of Energy estimates regular solar in Puerto Rico will cost in 2035.

Puerto Rico: low costs, copy-pasted from other papers





Floating solar costs less in 2030 than U.S. Dept. of Energy estimates regular solar in Puerto Rico will cost in 2035.

Other technology costs are copy-pasted from different papers, or assumed even lower

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German salt caverns throughout Africa…

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ARTICLE · Volume 25, Issue 9, 104965, September 16, 2022 · *Open Access*

Contextualizing the scope, scale, and speed of energy pathways toward sustainable development in Africa

Ayobami S. Oyewo [2] · Dmitrii Bogdanov · Arman Aghahosseini · Theophilus N.O. Mensah · Christian Breyer

International Journal of Hydrogen Energy
Volume 42, Issue 19, 11 May 2017, Pages 13427-13443

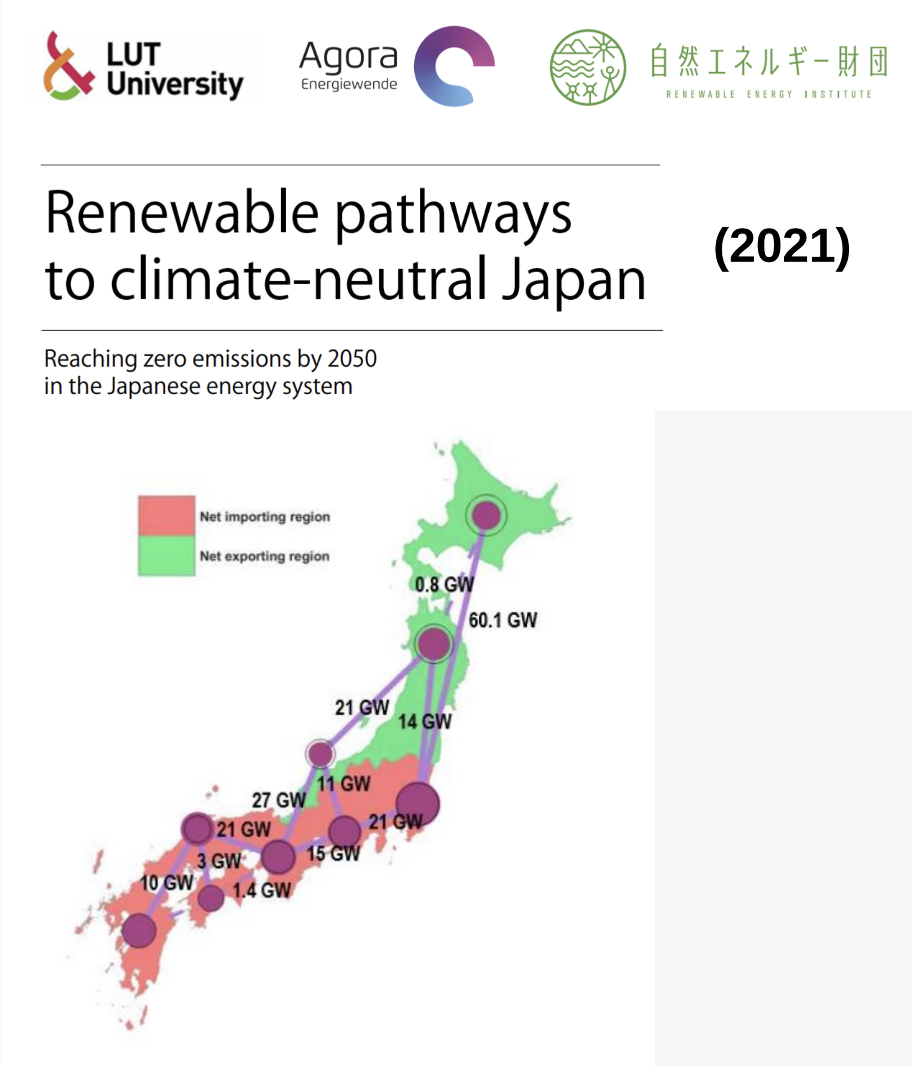
Hydrogen generation by electrolysis and storage in salt caverns: Potentials, economics and systems aspects with regard to the German energy transition

Jan Michalski [a], Ulrich Bünger [a], Fritz Crotogino [b], Sabine Donadei [b], Gregor-Sönke Schneider [b], Thomas Pregger [c], Karl-Kiên Cao [c], Dominik Heide [c 1]

Hydrogen Storage	Capex	€/kWh$_{th}$	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
	Opex fix	€/(kWh$_{th}$ a)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
	Opex var	€/(kWh$_{th}$)	0	0	0	0	0	0	0	0	Michalski et al. (2017)
	Efficiency	%	100	100	100	100	100	100	100	100	
	Lifetime	years	15	15	15	15	15	15	15	15	
Hydrogen Storage interface	Capex	€/kW$_{th}$	100	100	100	100	100	100	100	100	
	Opex fix	€/(kW$_{th}$ a)	4	4	4	4	4	4	4	4	Michalski et al. (2017)
	Opex var	€/(kWh$_{th}$)	0	0	0	0	0	0	0	0	
	Lifetime	years	15	15	15	15	15	15	15	15	

These problems continue

- Breyer group study for Japan, partnering with the Renewable Energy Institute (REI), in 2021:
  - Solar and onshore wind hit maximum limits, using 5.1% of Japan's land area
    - (by my calculations likely closer to 9.3%)
  - 858 TWh of offshore wind generation in 2050
    - Power lines not modeled
    - Total national 2020 generation in Japan was 962 TWh
  - Nuclear phaseout by 2030



https://www.renewable-ei.org/pdfdownload/activities/LUT-Agora-REI_2021_study.pdf

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Much of this work is German-led and funded

LUT University

Agora Energiewende

自然エネルギー財団 RENEWABLE ENERGY INSTITUTE

Renewable pathways to climate-neutral Japan

Reaching zero emissions by 2050 in the Japanese energy system

STUDY

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

IESR Institute for Essential Services Reform

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Deep decarbonization of Indonesia's energy system: A Pathway to zero emissions by 2050

IESR, Agora Energiewende, and LUT University are investigating this question by analyzing several pathways for Indonesia to reduce its GHG emission. The study is the first of its kind in Indonesia, involving several new aspects of energy transition which makes it quite revolutionary. Can Indonesia entirely rely on Renewables as energy sources? What if the whole country from Sabang to Merauke is interconnected?

Author :

Agus Praditya Tampubolon, Fabby Tumiwa, Pamela Simamora, Mentari Pujantoro (Agora Energiewende), Philipp Godron, Prof. Christian Breyer, Ashish Gulagi, Ayobami Solomon Oyewo, Dimitrii Bogdanov (LUT University)

ENERGY WATCH GROUP

Our Focus Studies Network

A Green Power Pathway for Taiwan

Berlin, Germany/ Hsinchu City, Taiwan (21 October 2020). The Berlin-based think tank Energy Watch Group (EWG) has received a mandate from the Industrial Technology Research Institute (ITRI), a world-leading applied technology research institute headquartered in Taiwan. The aim of the strategic cooperation is to outline a detailed pathway towards a fully sustainable power system for Taiwan by 2050 or earlier. Along with a comprehensive scientific simulation of a cost-efficient and technology-rich transformation towards a 100% renewable power sector, policy recommendations for the implementation of the green power pathway in Taiwan will be developed.

The project period starts immediately and lasts 15 months, with results expected by the end of 2021. The modelling study is carried out by an international team of experts under the scientific direction of Dr. Christian Breyer, Professor for Solar Economy at LUT University, Finland and Chairman of the EWG Scientific Board.

Conclusions

- Much of this research and thinking comes from a very small group of activist researchers
- The papers are simple and biased, and cannot accurately model the cost of 100% renewable systems.
    - Global challenges for renewable energy systems remain difficult to solve.
- Real progress towards a clean energy system requires more realistic problem-solving and technologies like nuclear energy.

Thank you!

Extra slides

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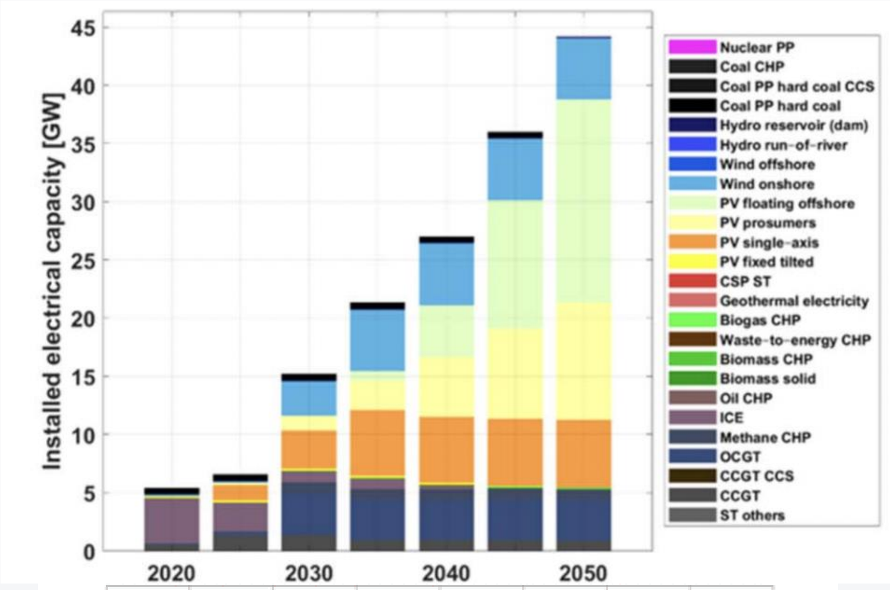
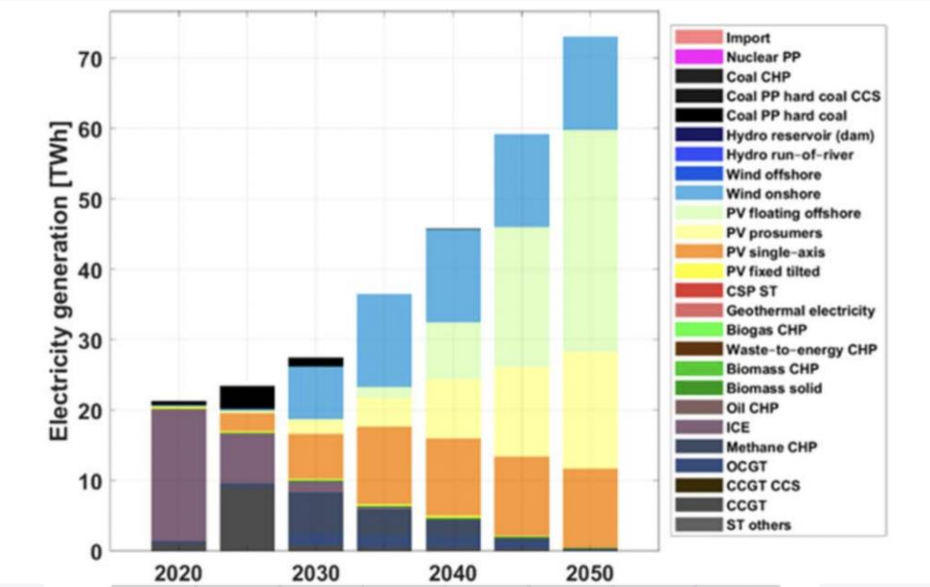
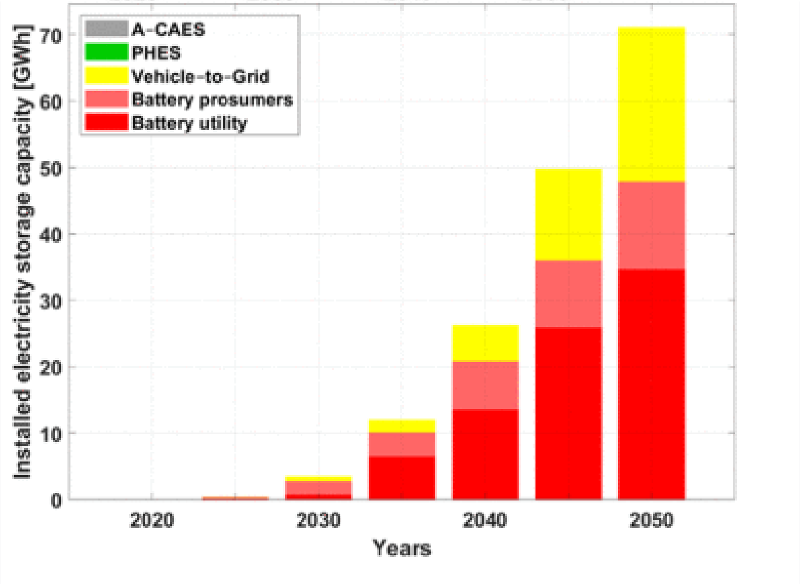
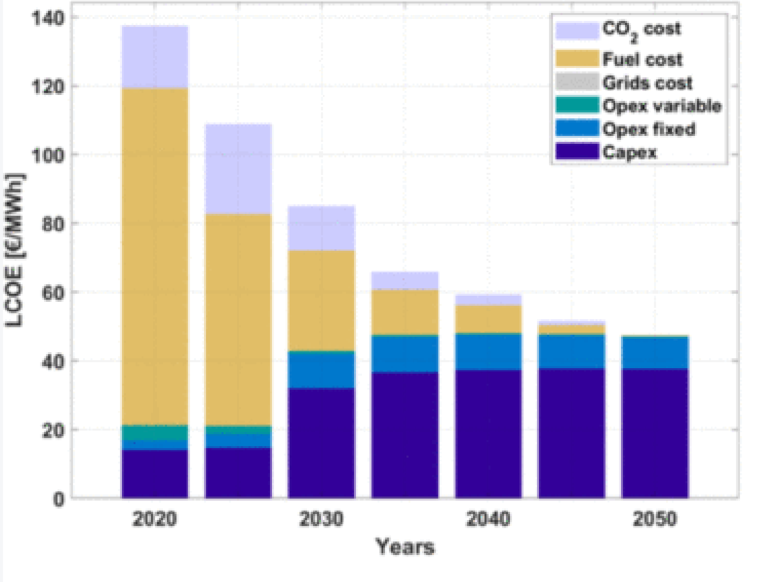
Puerto Rico









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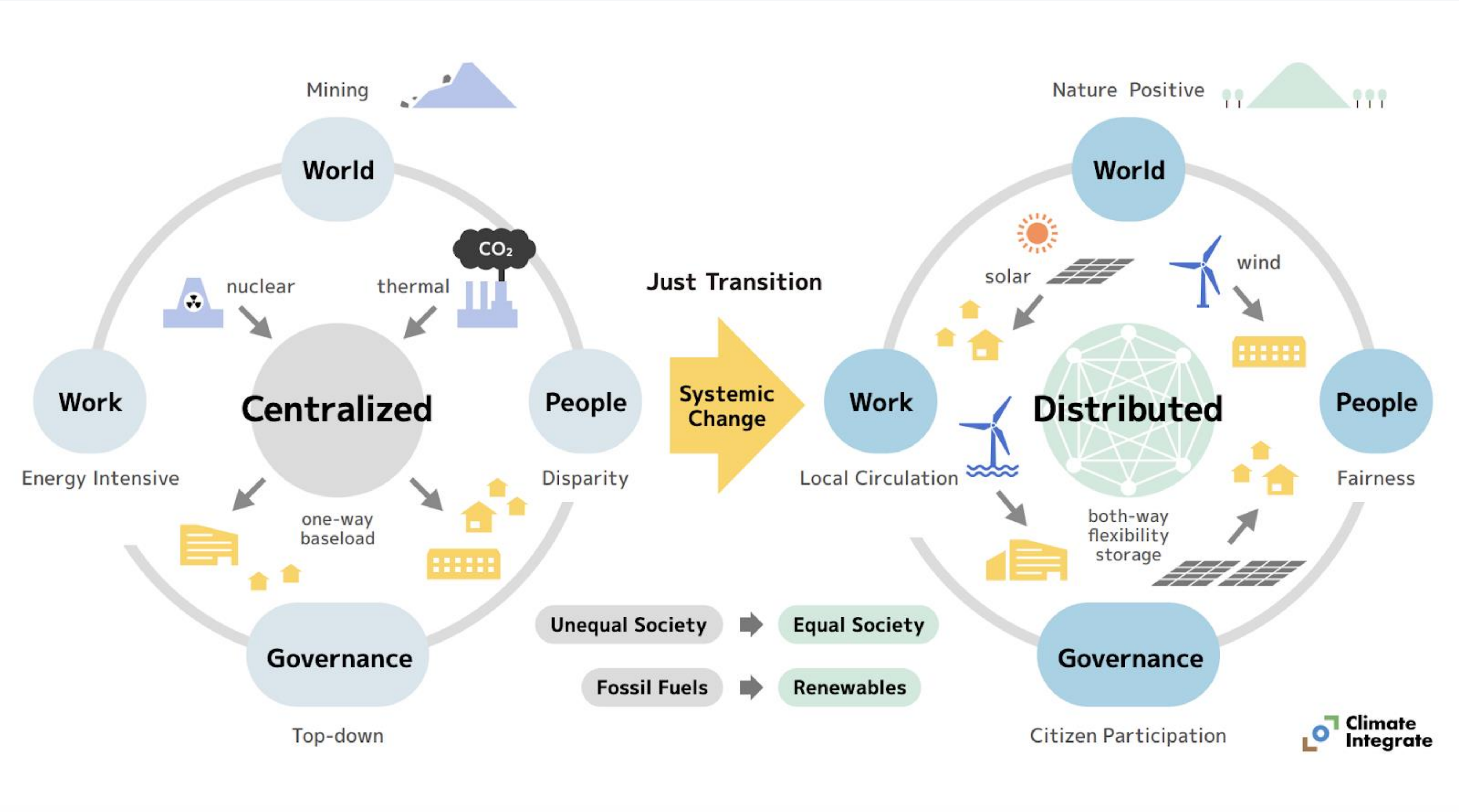
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thermal
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People
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Disparity
one-way
baseload
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Top-down
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Systemic Change
Unequal Society
Equal Society
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Nature Positive
World
solar
wind
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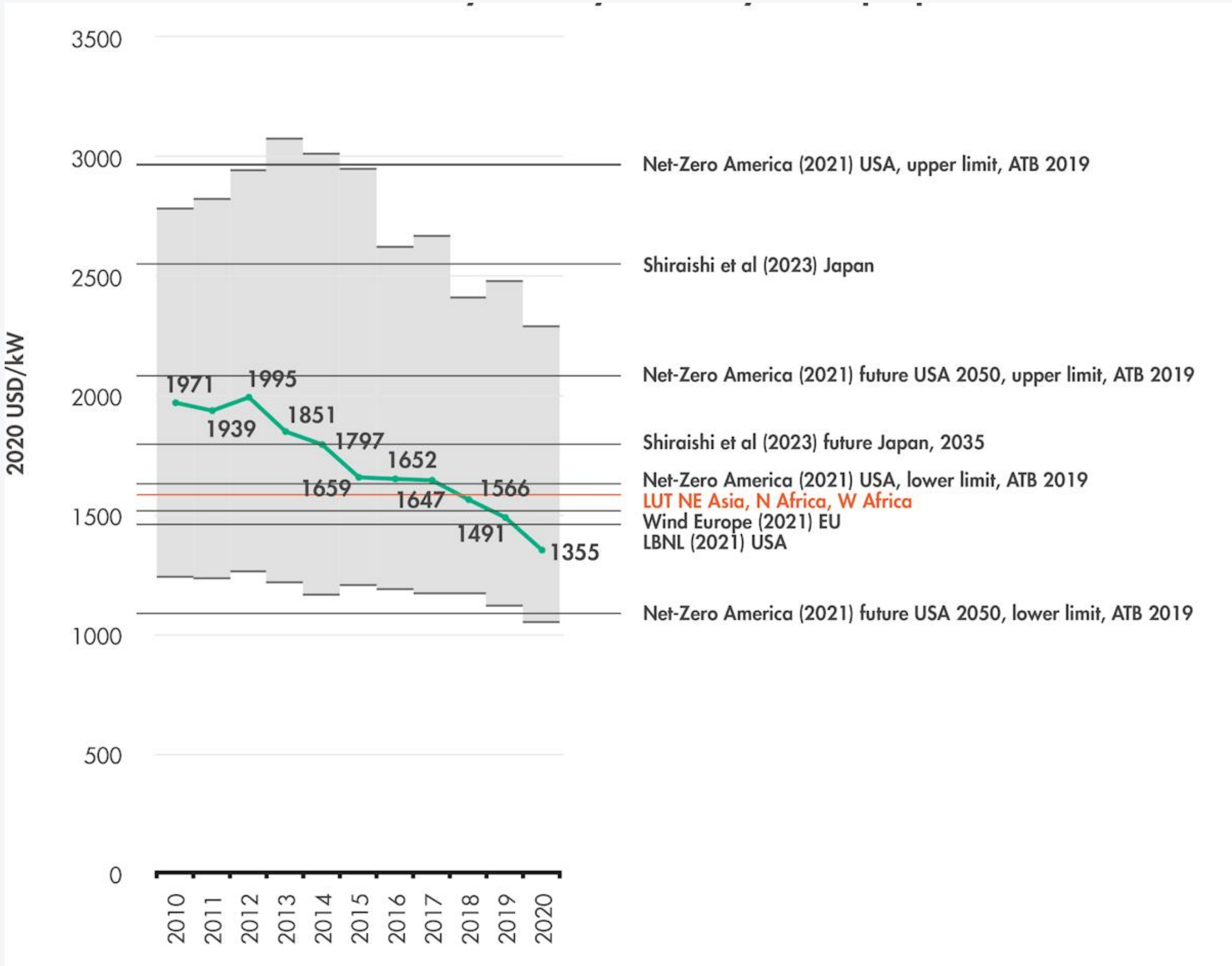
Distributed
People
Local Circulation
Fairness
both-way
flexibility
storage
Governance
Citizen Participation
Climate Integrate

Global cost comparison - wind



Global cost comparison - solar