ENGAGE Work Package 4 Task 4.3

Feasibility of national decarbonisation strategies

Aleh Cherp, **Marta Vetier** (Central European University)
Contribution from **Avi Jakhmola, Vadim Vinichenko and Jessica Jewell** (Chalmers University of Technology)
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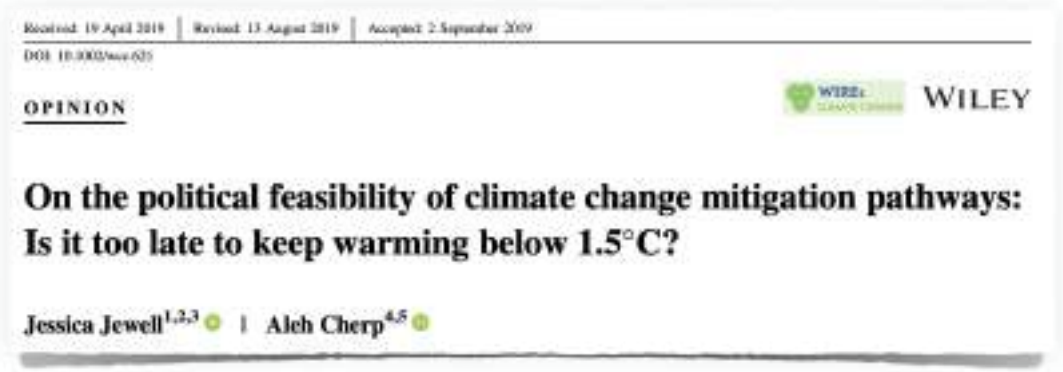
September 2021

draft. do not circulate

Feasibility of energy transitions



Received: 19 April 2019 | Revised: 13 August 2019 | Accepted: 2 September 2019

DOI: 10.1002/wcc.621

OPINION

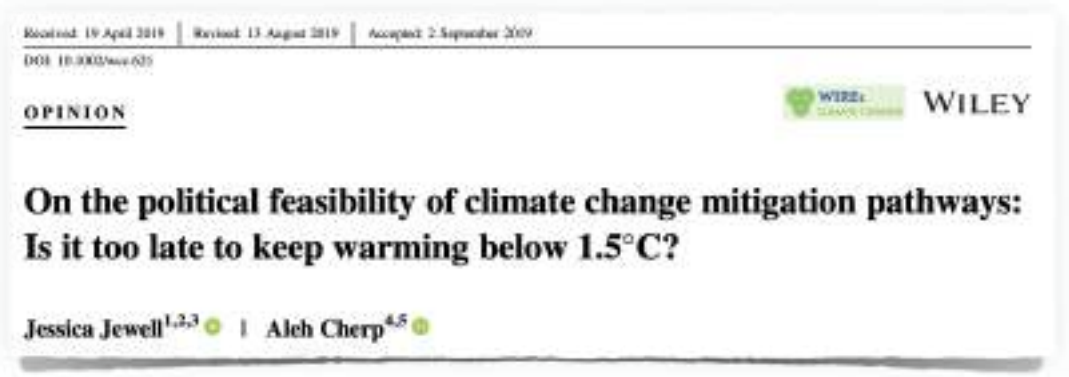
WILEY

On the political feasibility of climate change mitigation pathways: Is it too late to keep warming below 1.5°C?

Jessica Jewell[1,2,3] | Aleh Cherp[4,5]

[an outcome is feasible] if there is an agent or group of agents who have the capacity to carry out a set of actions which will lead to that outcome in a given context (Gilabert & Lawford-Smith, 2012)

Feasibility of energy transitions



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Examples of actions we evaluate

	India	S.Korea	Vietnam
Wind and solar power	✔	✔	✔
Fossil fuel decline	✔	✔	✔
Energy use / intensity	✔		✔
Nuclear power	✔		
CCS			✔
Biomass			✔

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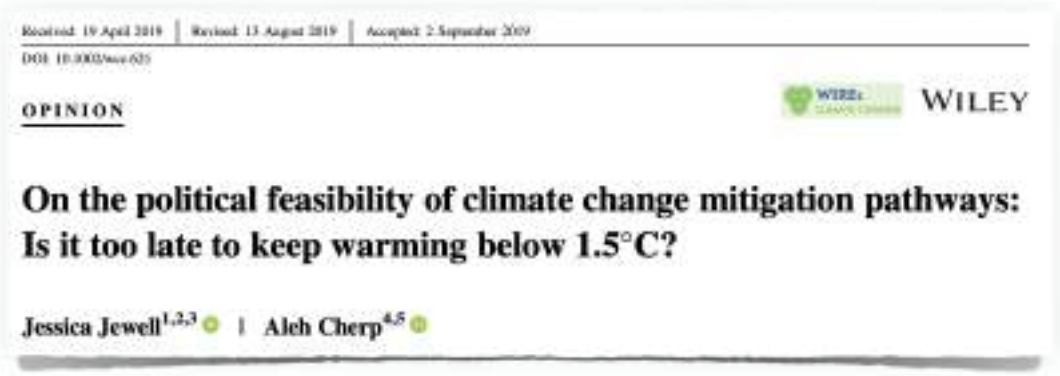
Feasibility of energy transitions



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agents and context

- Many different actors (e.g. governments, investors, foreign companies)
- Complex interplay between actors and the context of their action
  - Interests?
  - Capabilities?

?

- Both actors and contexts change over time
- Complex and diverse evidence is required for feasibility assessment

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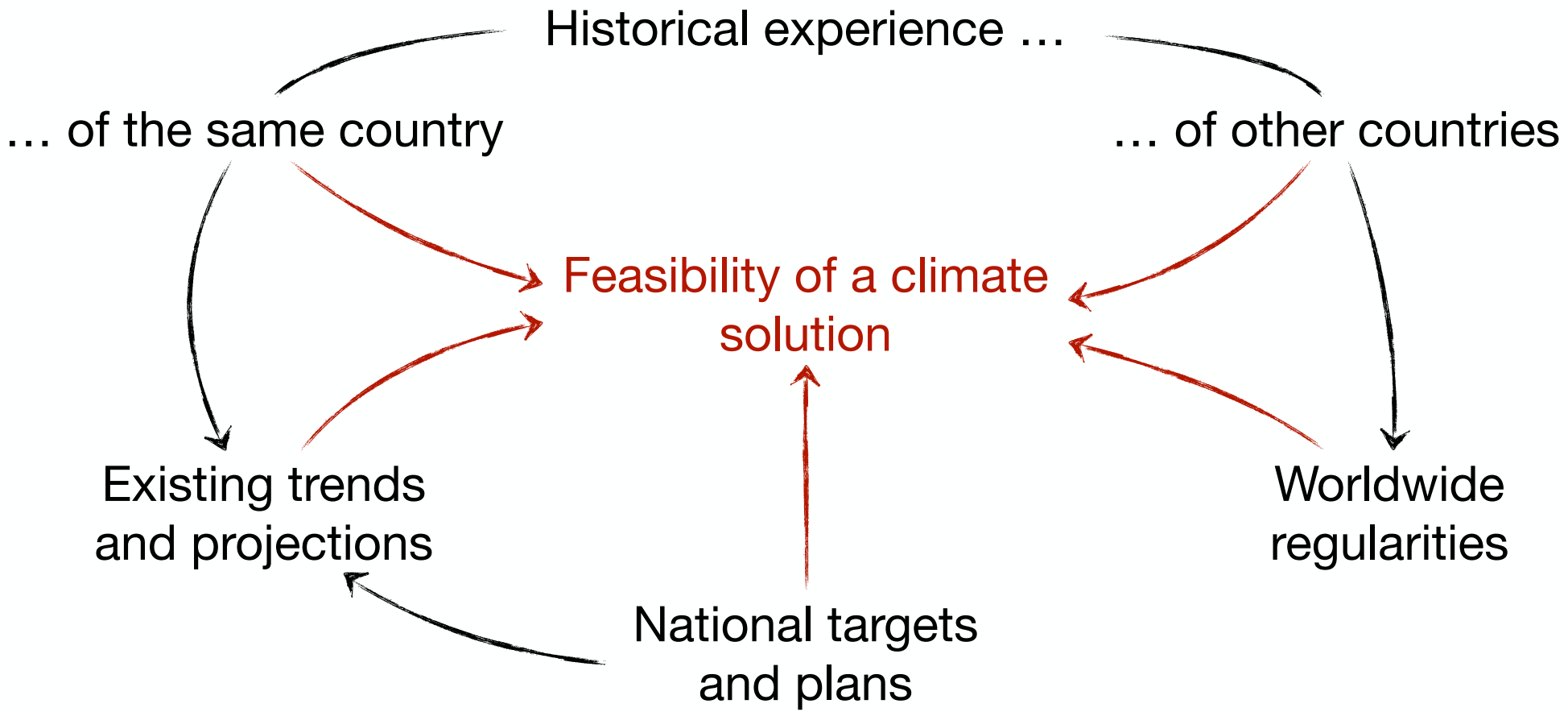
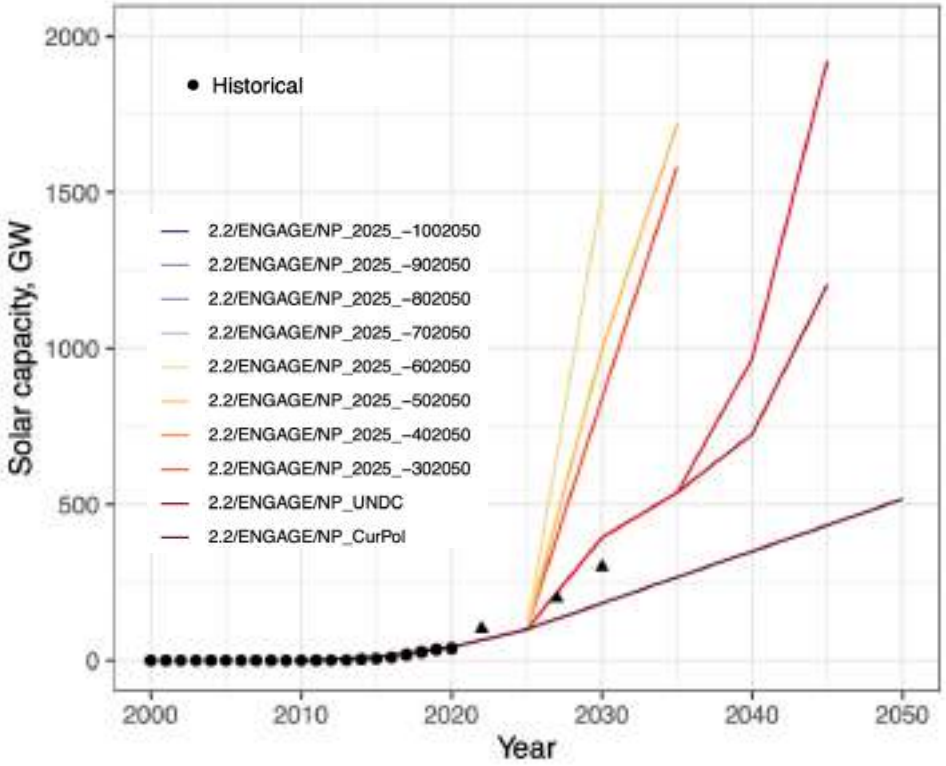
Evidence for feasibility assessment



Method 1a: trends analysis

Assumption: recently observed values affect feasibility



Solar capacity growth rates, GW/year

Empirical rates	Unconditional NDC	Climate scenarios
6-9	10-17	150 - 350

25-50 times faster

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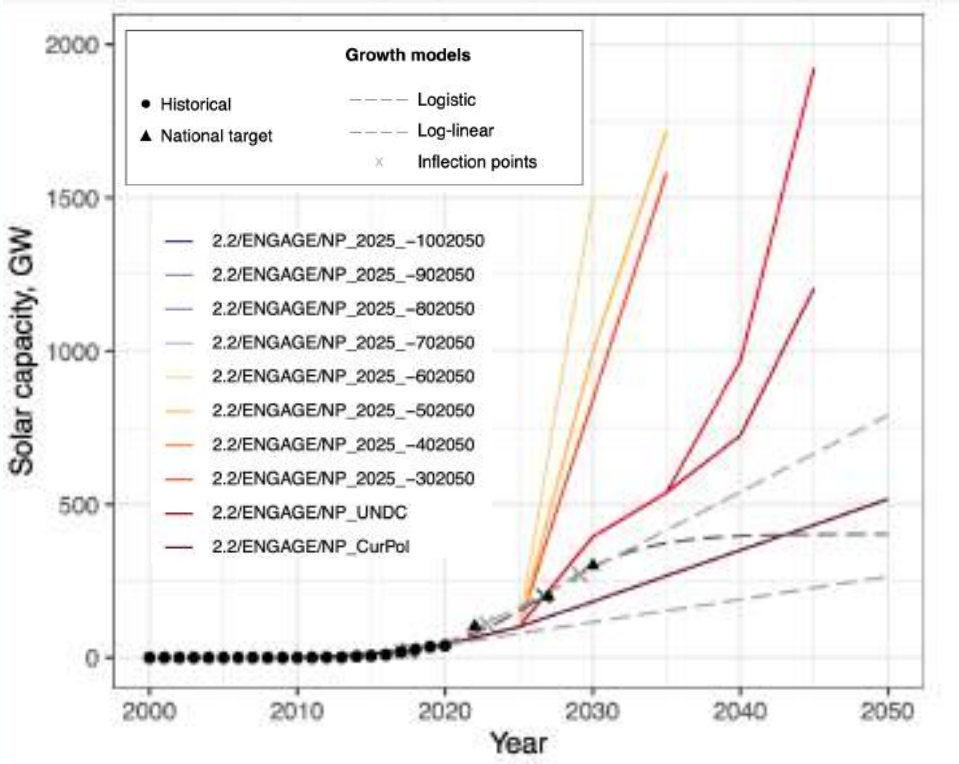
Method 1b: trends and plans projection

Assumption: projections and plans affect feasibility



Solar capacity growth rates, GW/year

Empirical rates	Unconditional NDC	National targets	Climate scenarios
6-9	10-17	25-30	150 - 350

5-14 times faster

3-5 times faster

20-50 times faster

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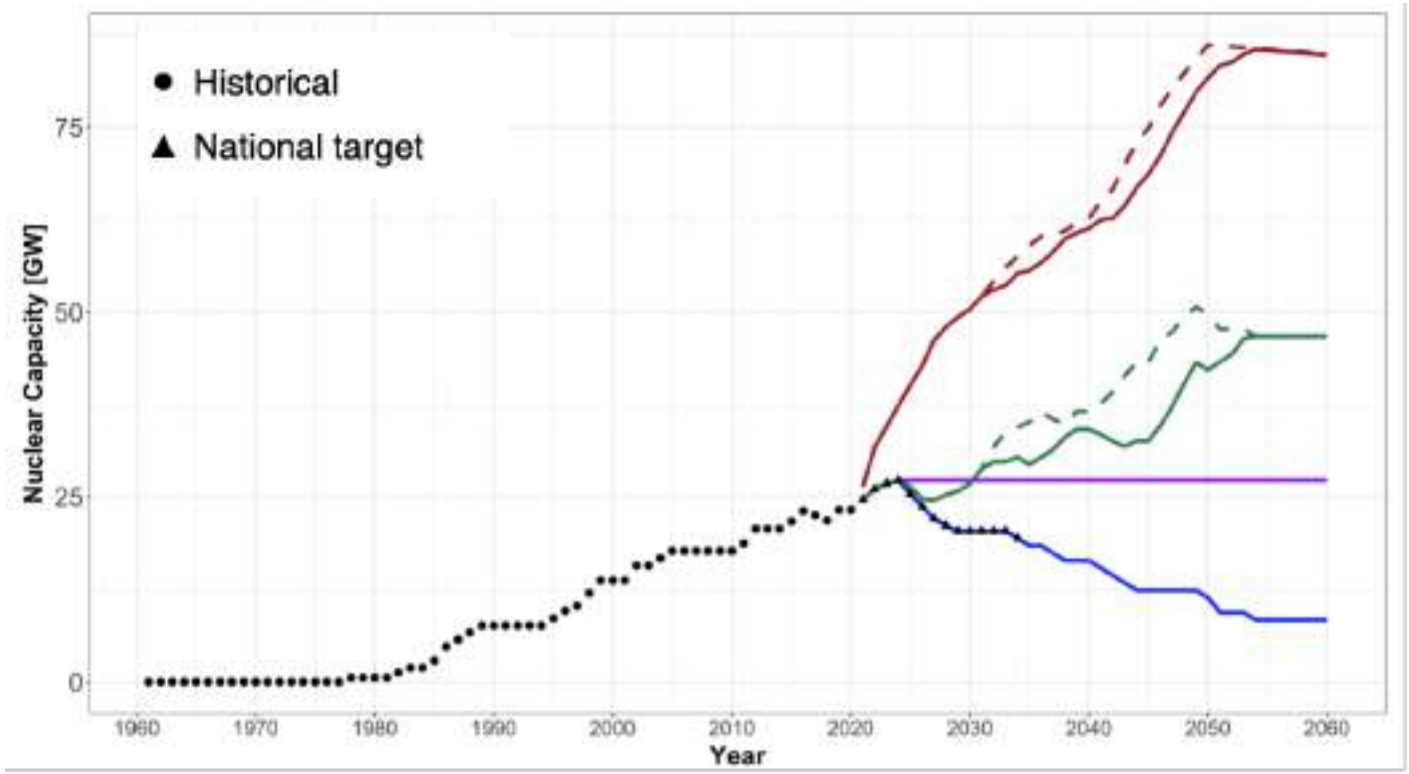
Method 2a: Counterfactuals - own history

What-if? The country behaved as in the past (nuclear power in this example)



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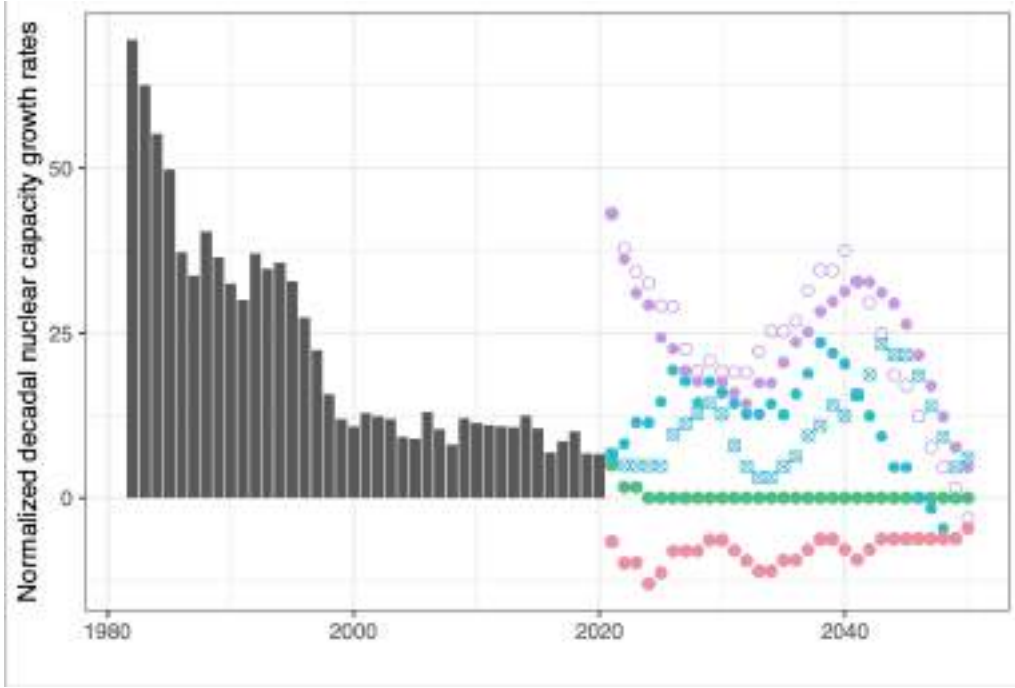
Hyun et al. in preparation

Method 2a: Counterfactuals - own history

What-if? The country behaved as in the past (nuclear power in this example)

Normalised nuclear capacity



Scenario	Annual growth (MW/TWh/y)	5-year growth (MW/TWh/5y)	Decadal growth (MW/TWh/10y)
Empirical (1977-2020)	29.4 (1986)	77.7 (1986)	132.6 (1987)
Scenario 1	2.4 (2021)	8.5 (2023)	11.7 (2024)
Scenario 2	2.4 (2021)	8.5 (2023)	11.7 (2024)
Scenario 3	4.9 (2048)	16.5 (2049)	22.6 (2053)
Scenario 4	4.8 (2032)	13.8 (2034)	22.8 (2048)
Scenario 5	9.0 (2022)	28.2 (2025)	44.7 (2030)

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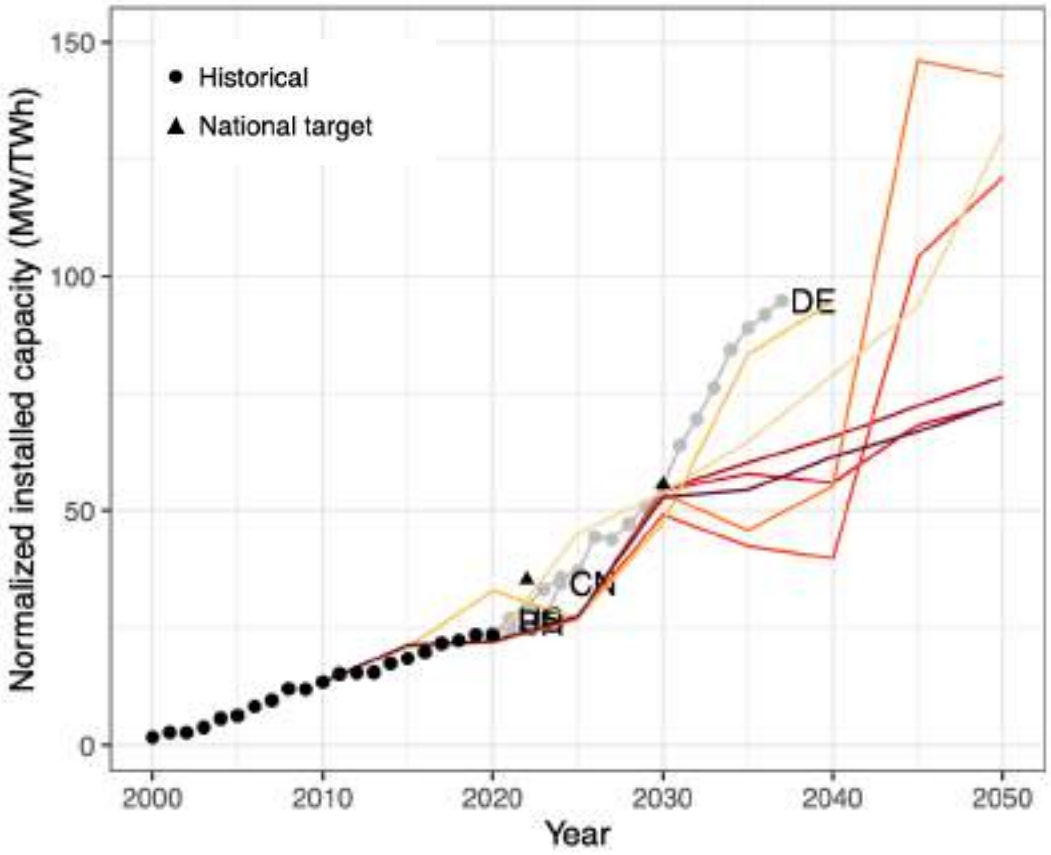
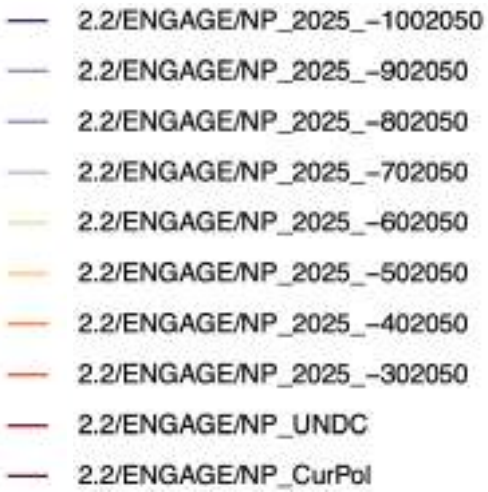
Hyun et al. in preparation

Method 2b: Counterfactuals - other countries' history

What-if? The country behaved as other countries in the past

Wind power capacity (normalised)





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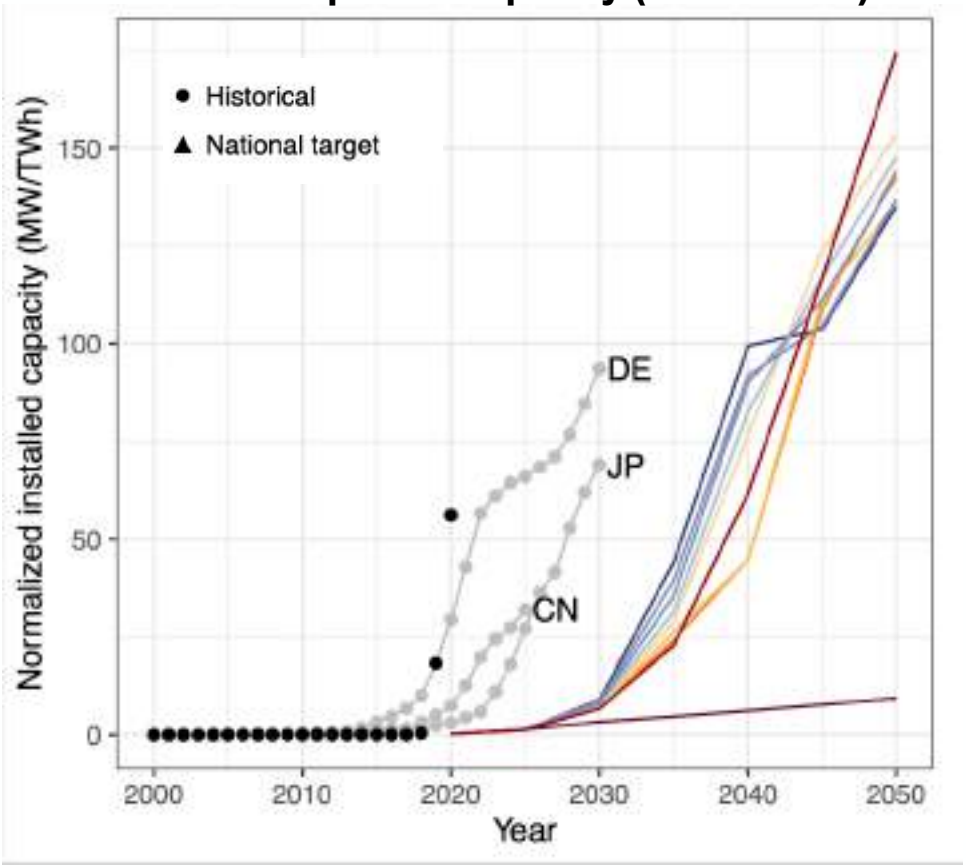
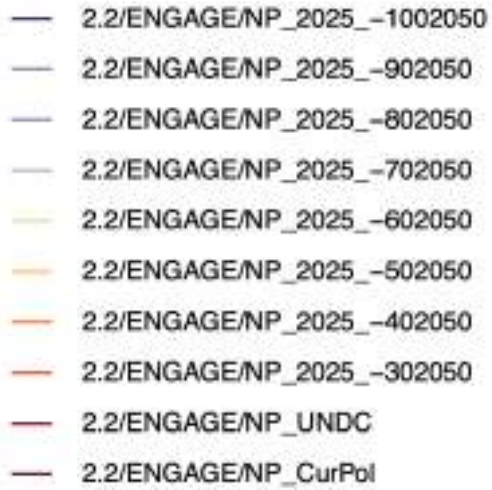
Method 2b: Counterfactuals - other countries' history

What-if? The country behaved as other countries in the past

Solar power capacity (normalised)





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Method 2b: Counterfactuals - other countries' history

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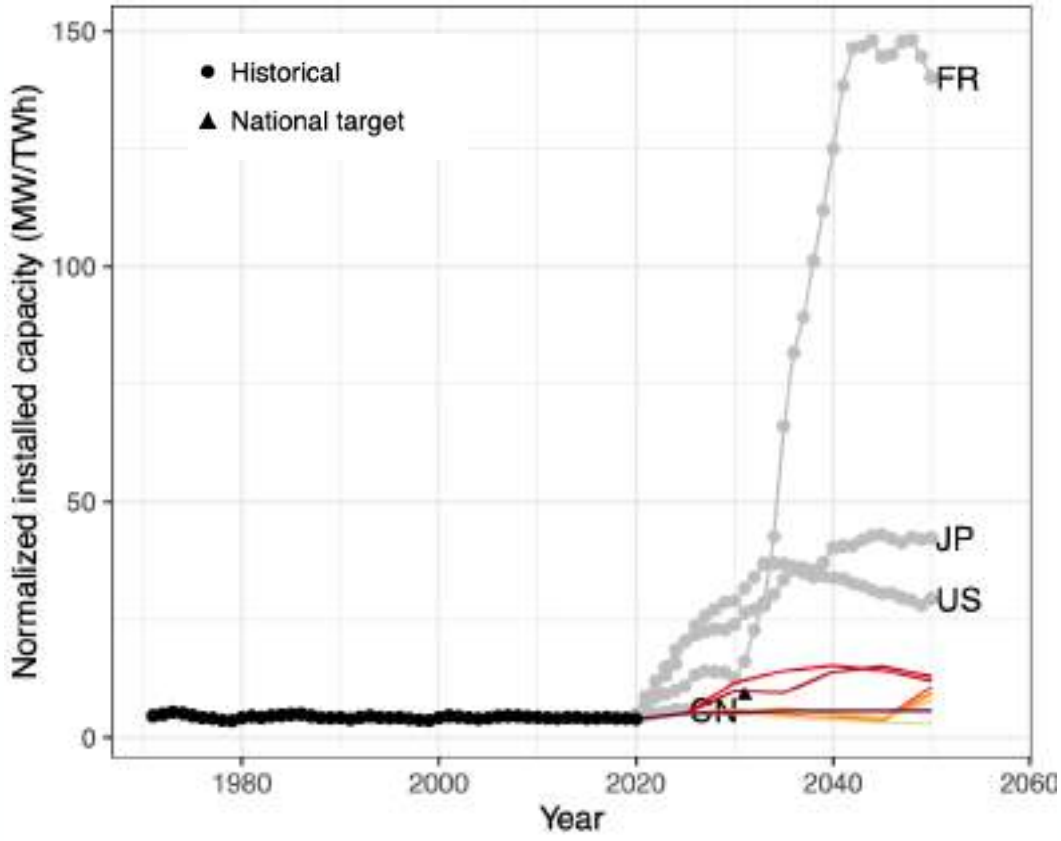

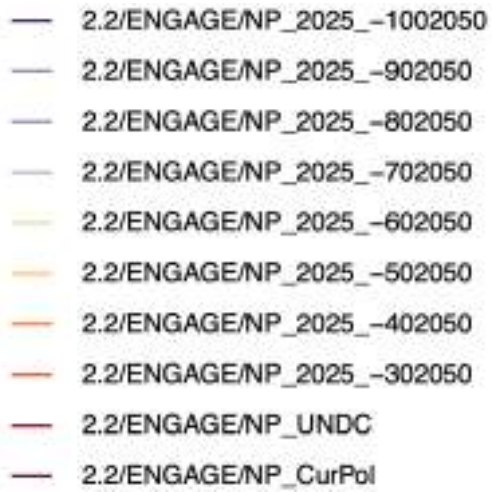

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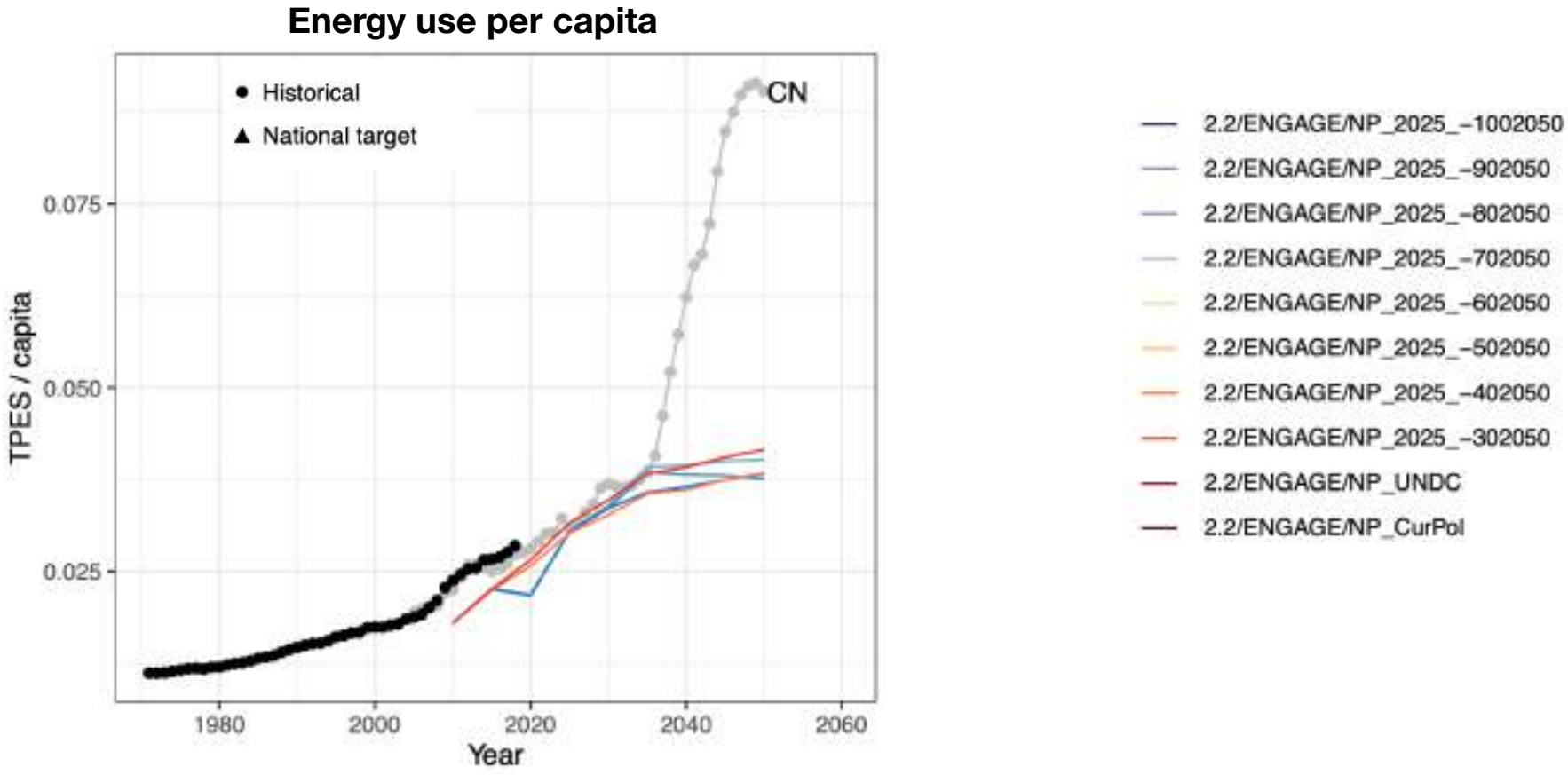

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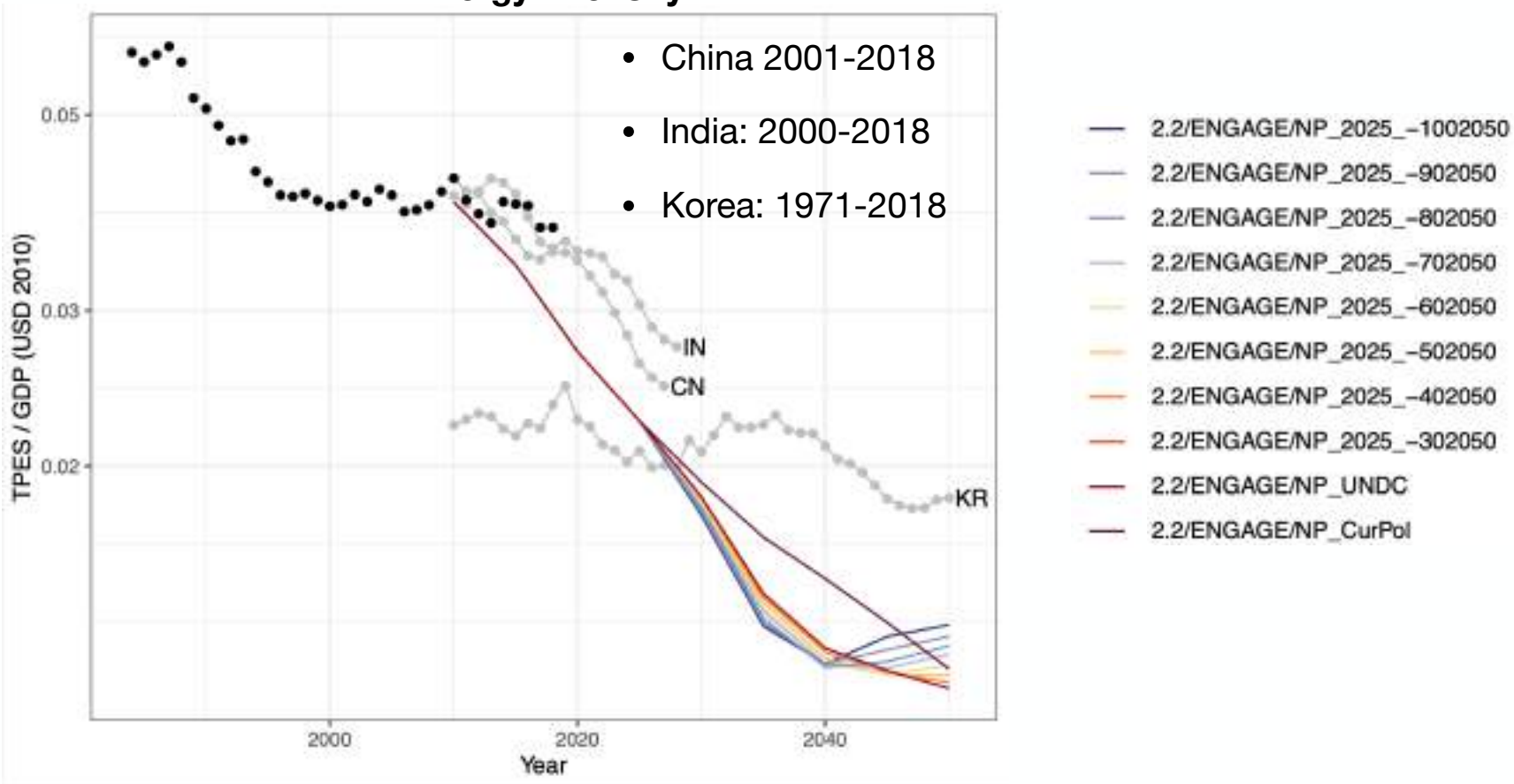
Method 2b: Counterfactuals - other countries' history

What-if? The country behaved as other countries in the past

Energy intensity



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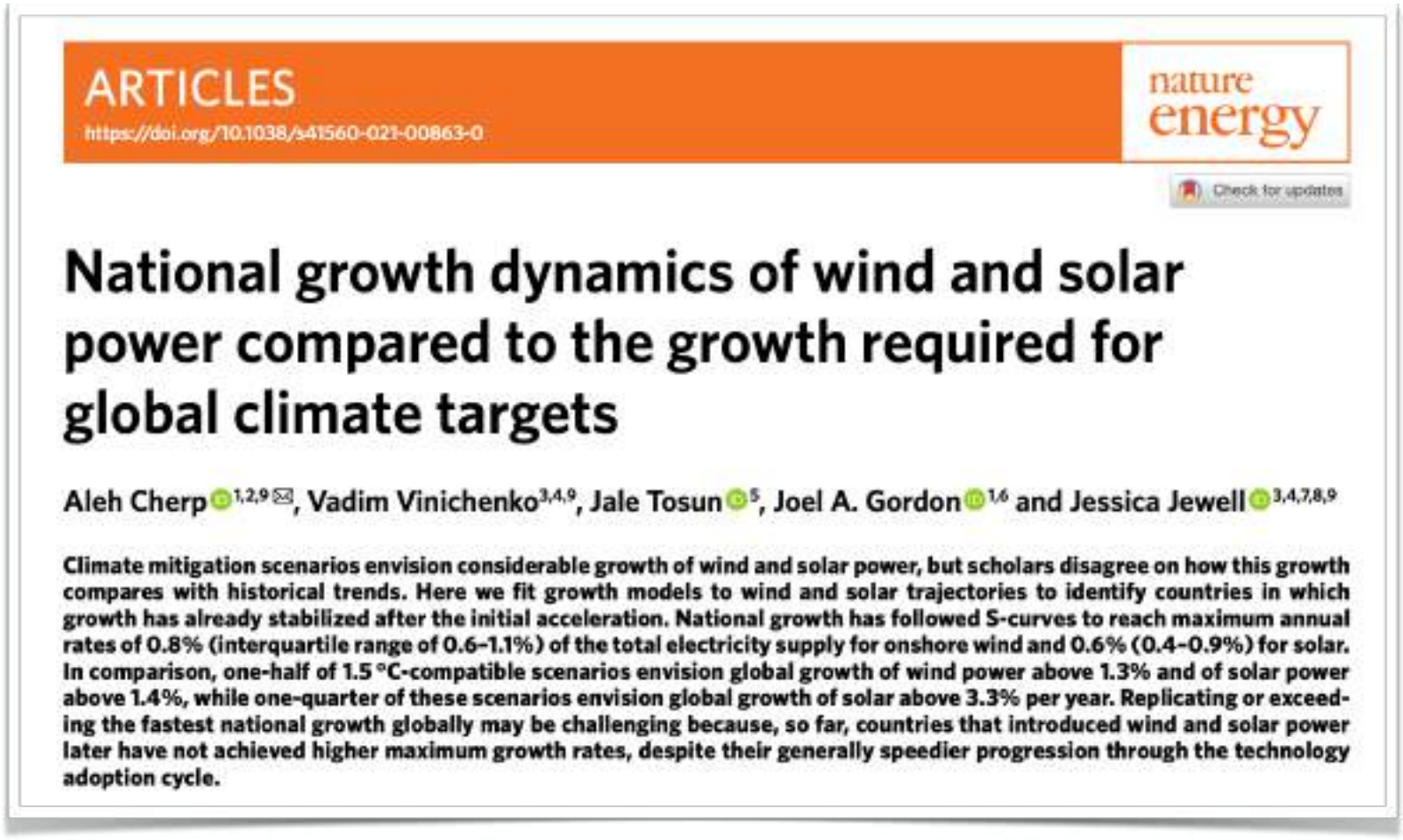
Method 3a: Worldwide regularities (max growth rates)



ARTICLES
https://doi.org/10.1038/s41560-021-00863-0
nature energy

Check for updates

National growth dynamics of wind and solar power compared to the growth required for global climate targets

Aleh Cherp[1,2,9]✉, Vadim Vinichenko[3,4,9], Jale Tosun[5], Joel A. Gordon[1,6] and Jessica Jewell[3,4,7,8,9]

Climate mitigation scenarios envision considerable growth of wind and solar power, but scholars disagree on how this growth compares with historical trends. Here we fit growth models to wind and solar trajectories to identify countries in which growth has already stabilized after the initial acceleration. National growth has followed S-curves to reach maximum annual rates of 0.8% (interquartile range of 0.6–1.1%) of the total electricity supply for onshore wind and 0.6% (0.4–0.9%) for solar. In comparison, one-half of 1.5 °C-compatible scenarios envision global growth of wind power above 1.3% and of solar power above 1.4%, while one-quarter of these scenarios envision global growth of solar above 3.3% per year. Replicating or exceeding the fastest national growth globally may be challenging because, so far, countries that introduced wind and solar power later have not achieved higher maximum growth rates, despite their generally speedier progression through the technology adoption cycle.

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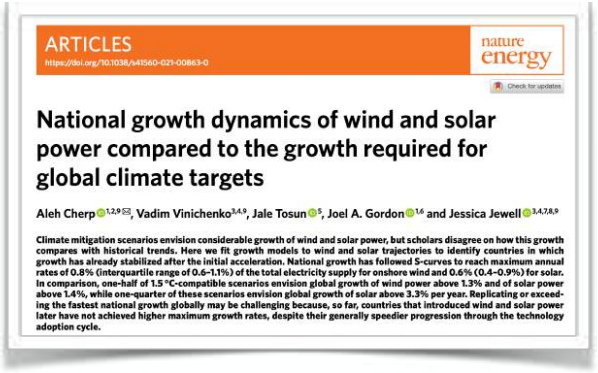

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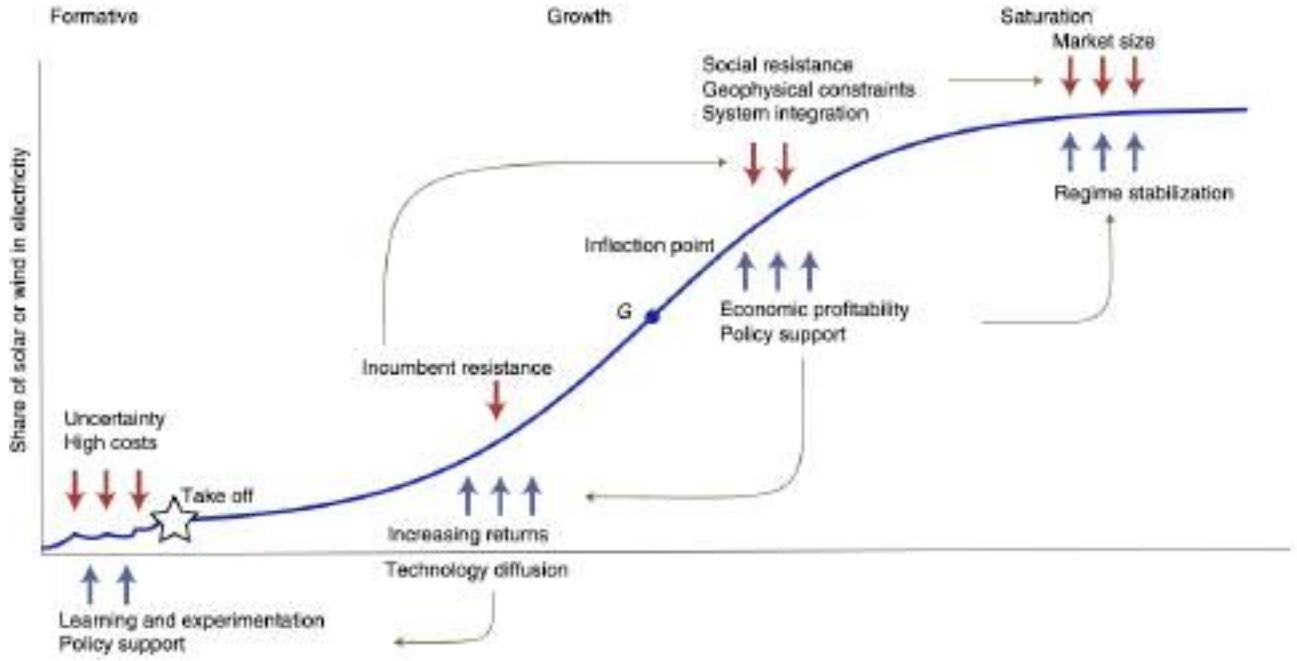

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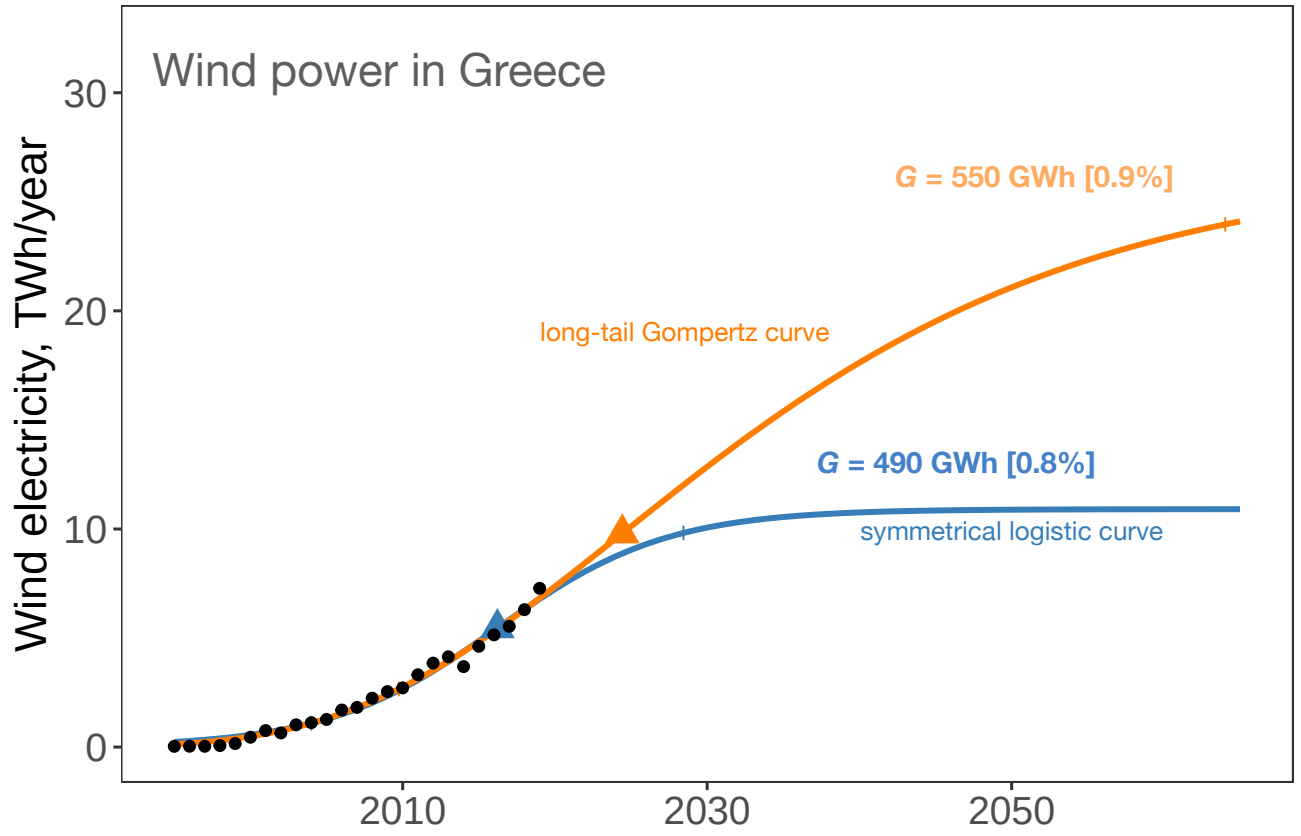
Method 3a: Worldwide regularities (max growth rates)

New approach: measuring the maximum growth rate (G)



Cherp et al. *Nature Energy* 2021

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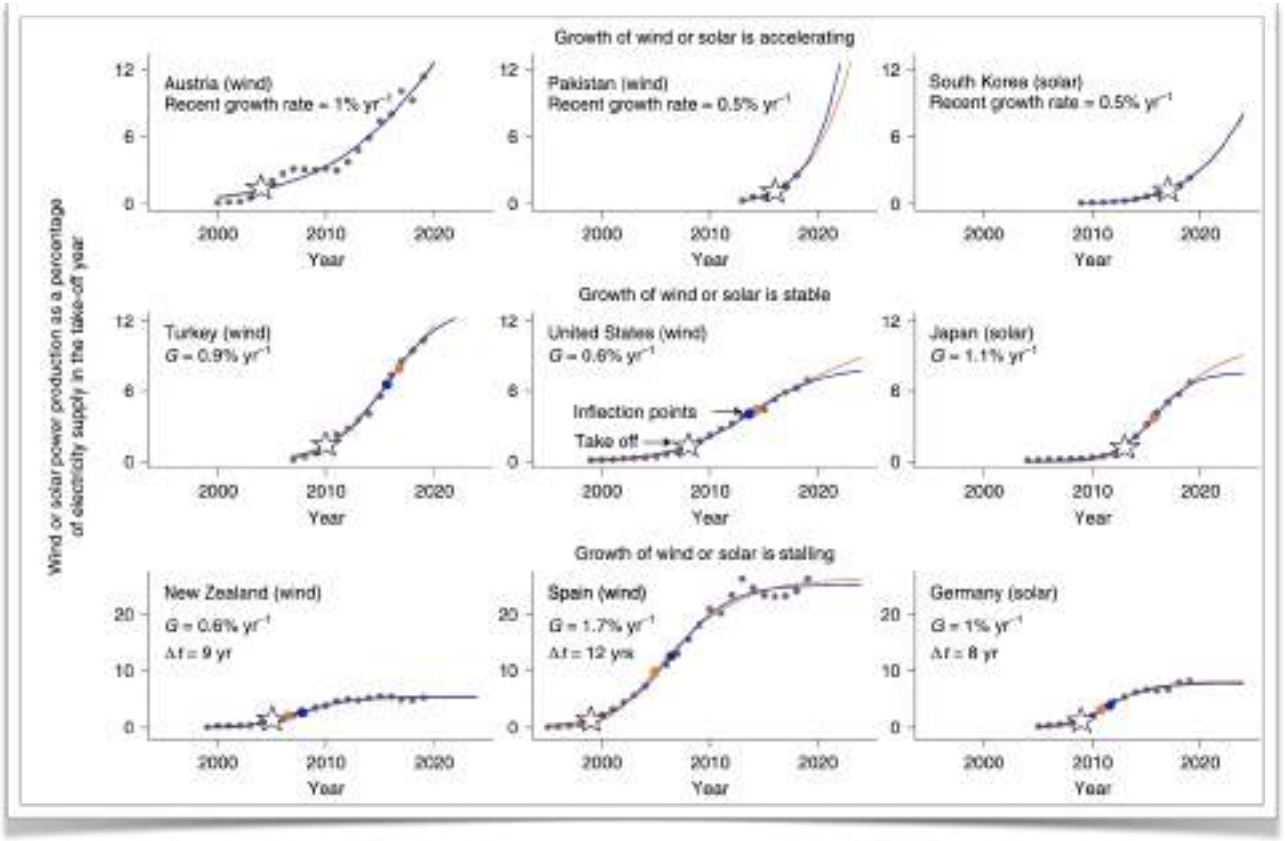

Cherp et al. *Nature Energy* 2021

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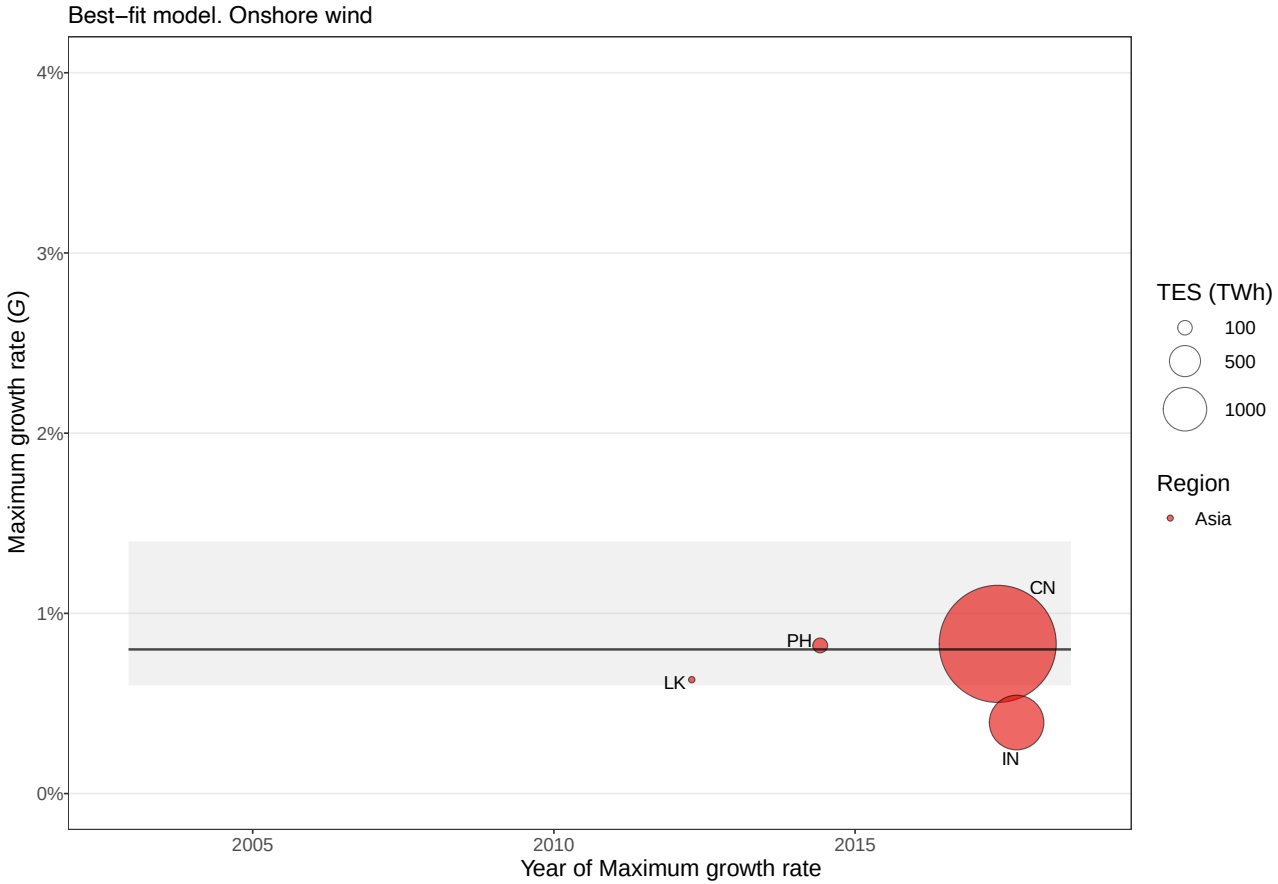
Method 3a: Worldwide regularities (growth rates)

Maximum growth rates of onshore wind: Asia



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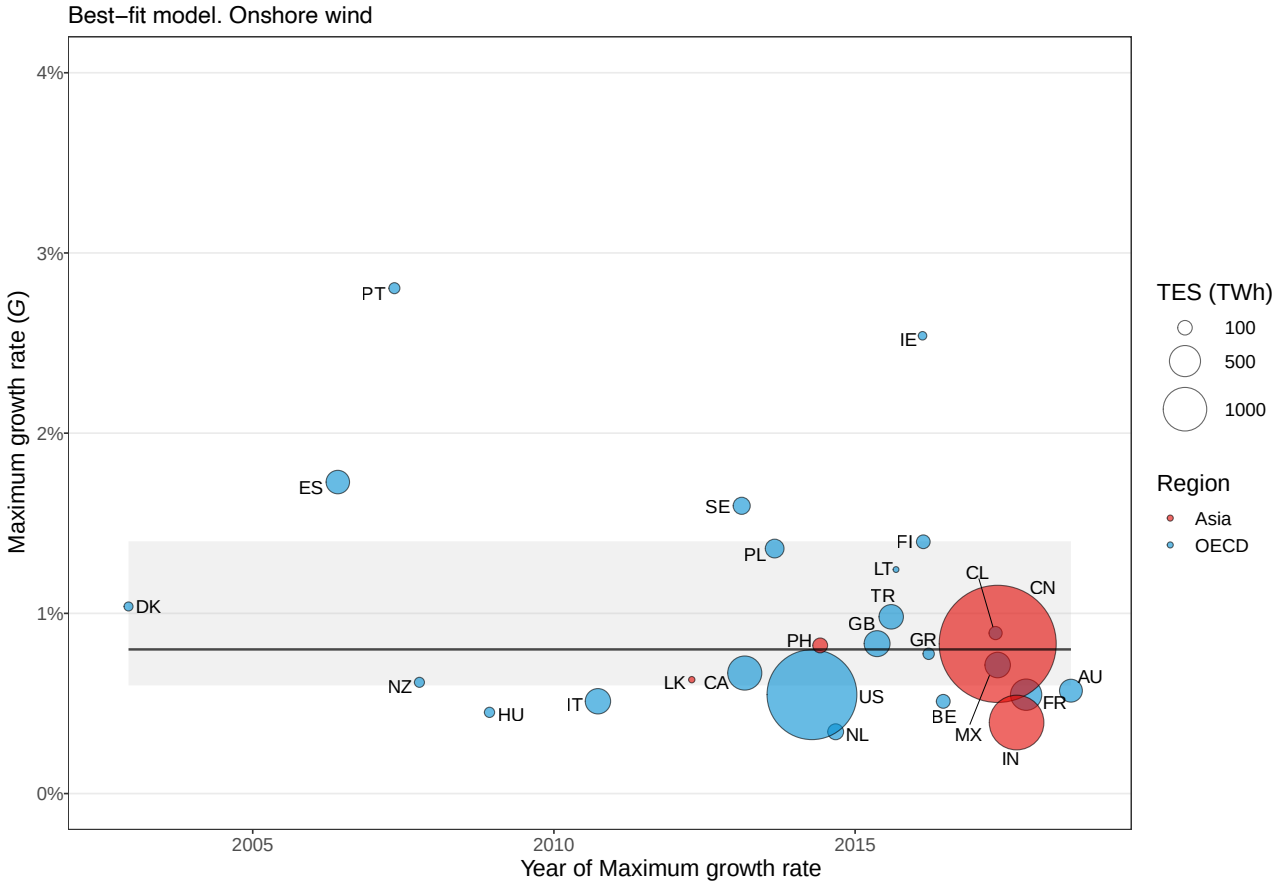
Method 3a: Worldwide regularities (growth rates)

Maximum growth rates of onshore wind: Asia + OECD



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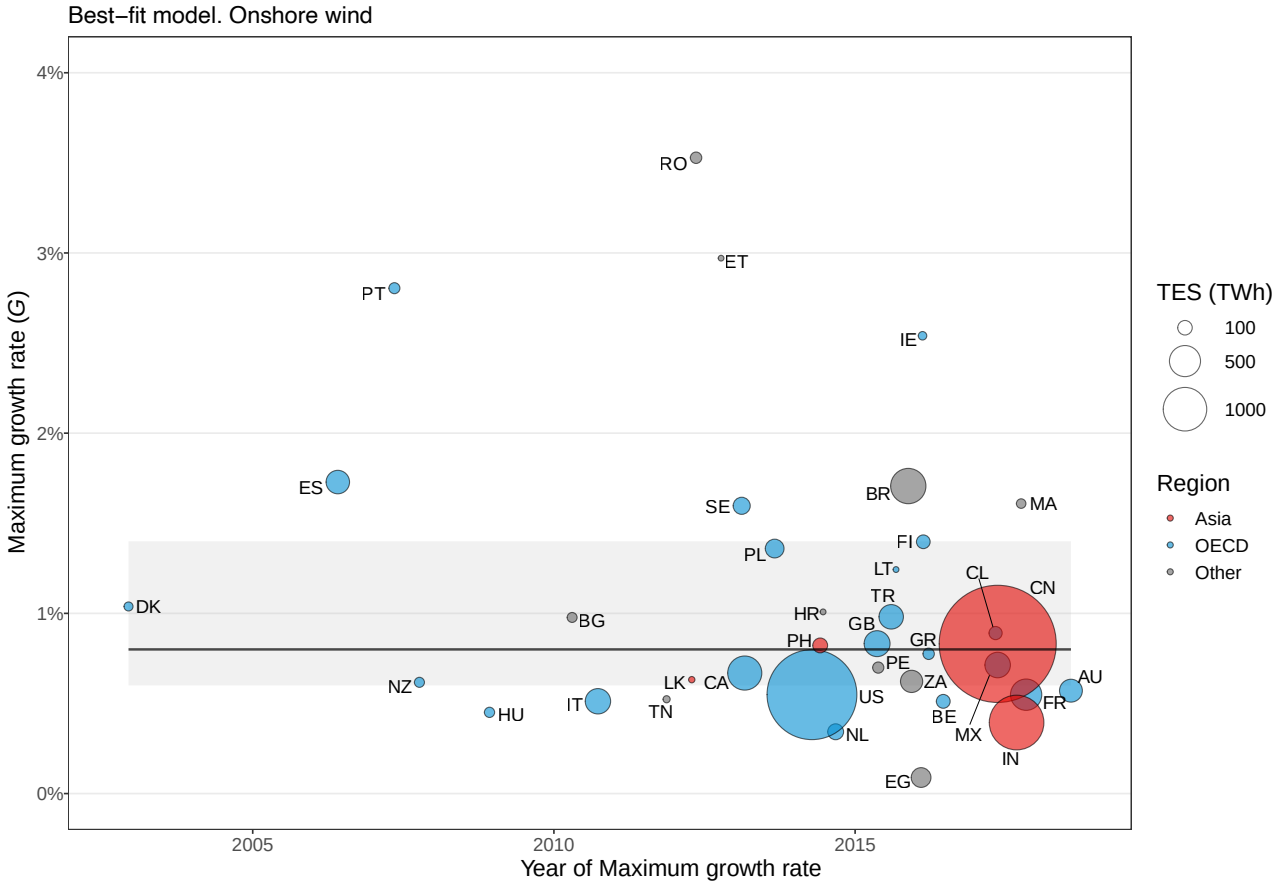
Method 3a: Worldwide regularities (growth rates)

Maximum growth rates of onshore wind: Asia + OECD + other



Maximum growth rates (of total electricity supply per year):

- 0.8% (IQR 0.6-1.1%)
- Higher in smaller countries

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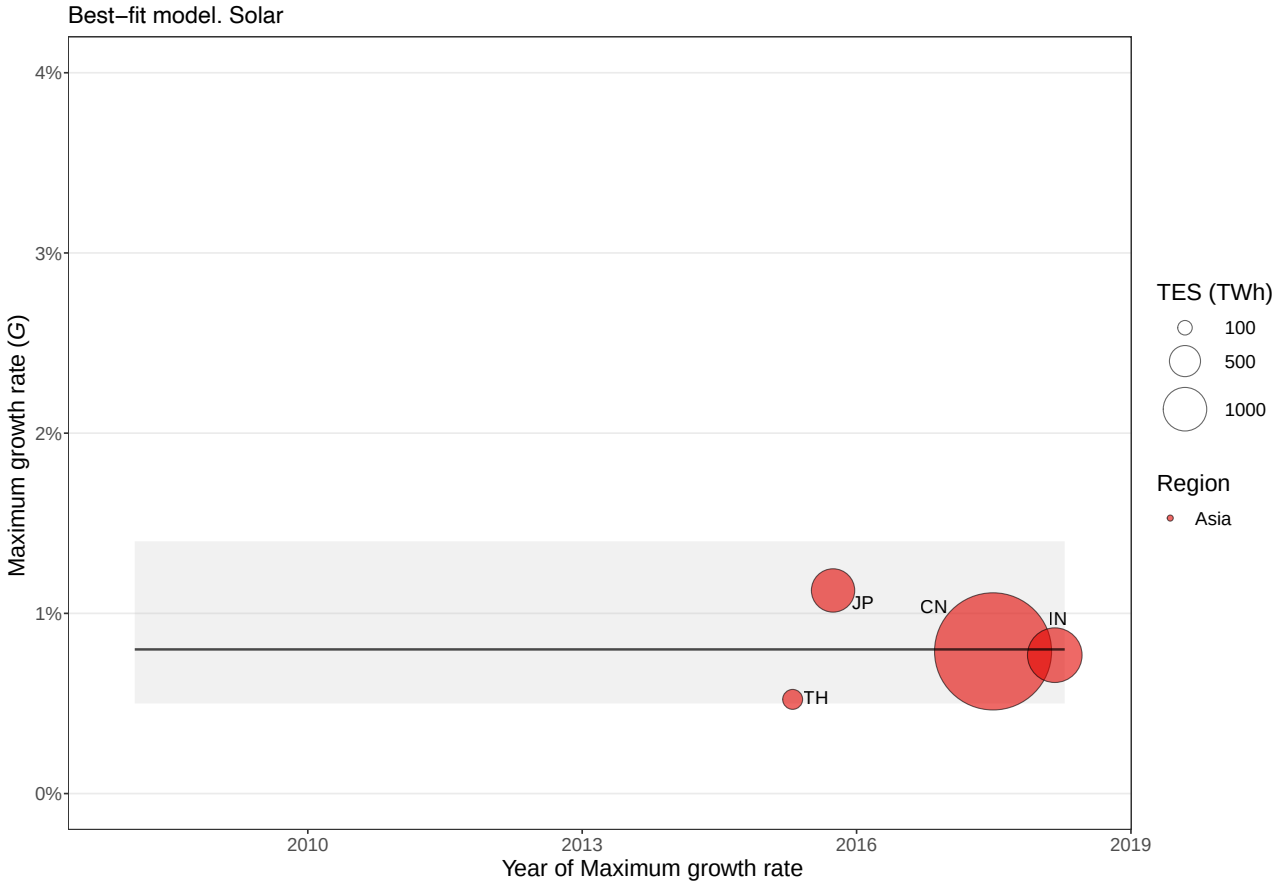
Method 3a: Worldwide regularities (growth rates)

Maximum growth rates of solar PV: Asia



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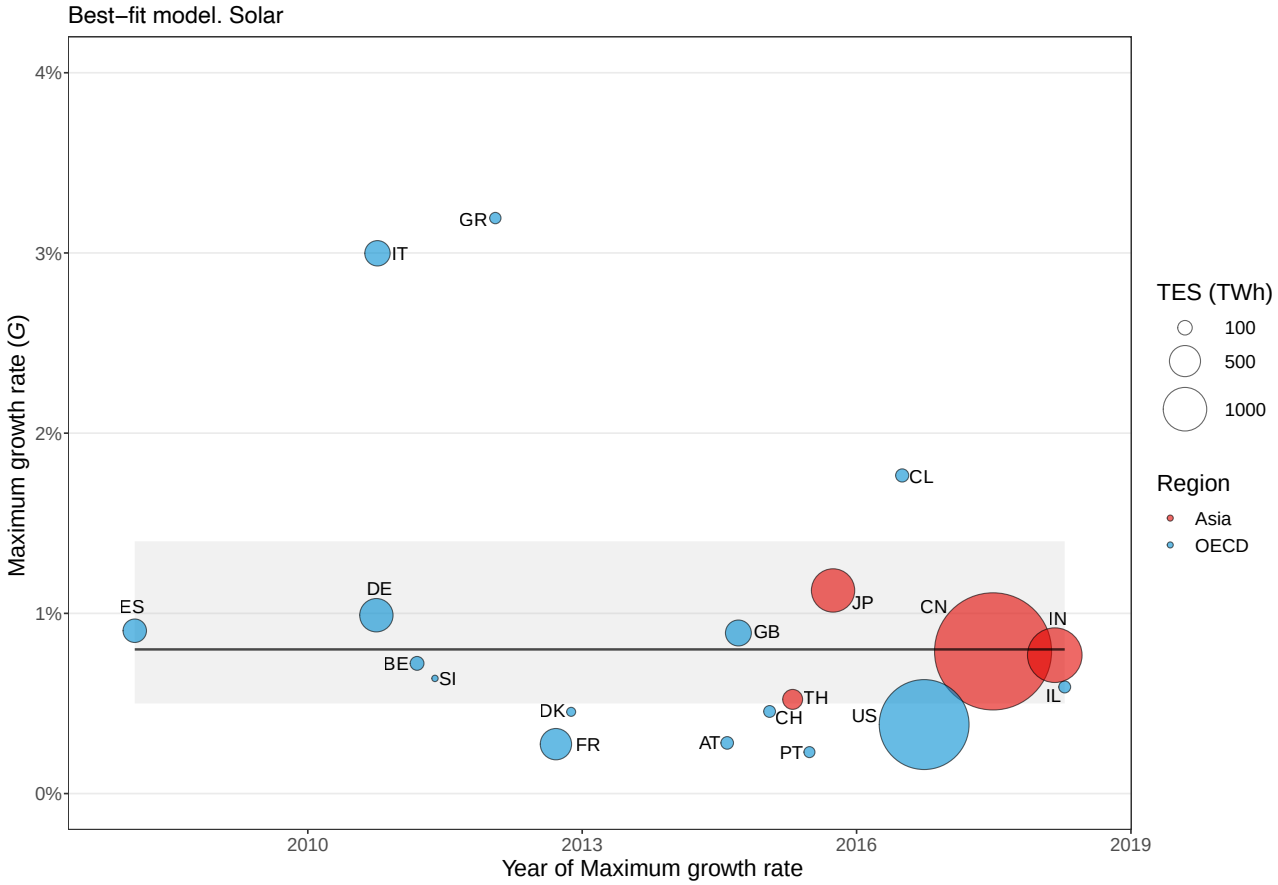

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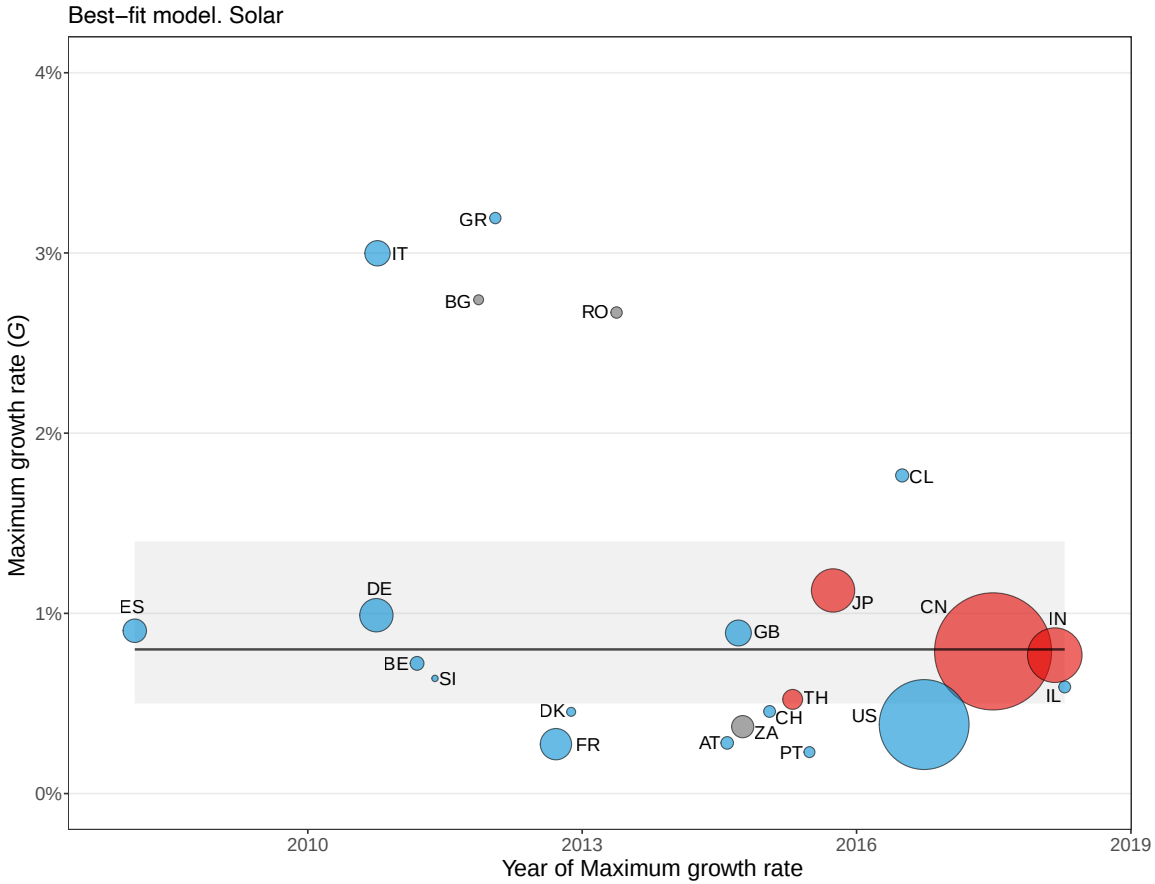
Method 3a: Worldwide regularities (growth rates)

Maximum growth rates of solar PV: Asia + OECD + other



Maximum growth rates (of total electricity supply per year):

- 0.6% (IQR 0.4-0.9%)
- Higher in smaller countries

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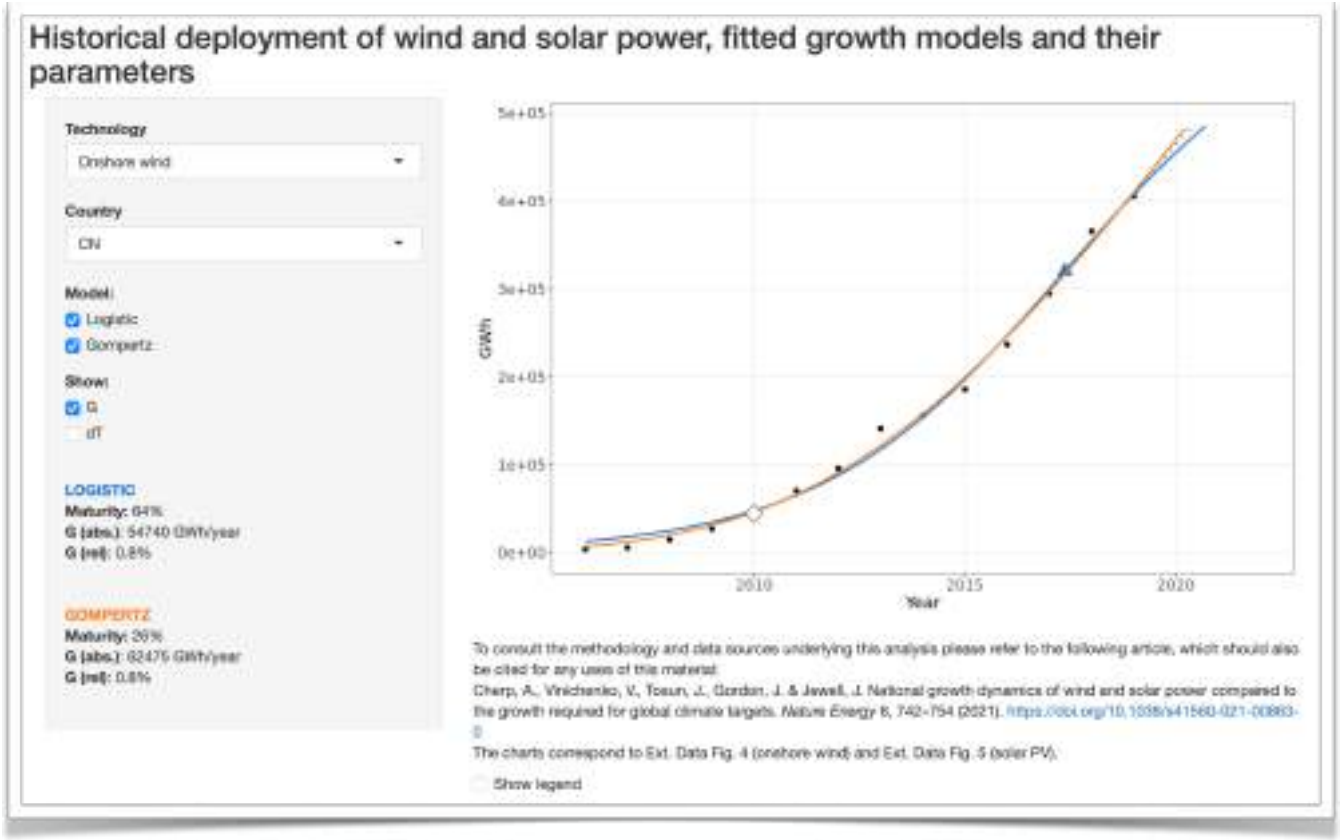
Cherp et al. *Nature Energy* 2021

Visualisation of growth curves

http://applets.polet.network/shiny/fitted_curves/



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Method 3a: Worldwide regularities (growth rates)

Feasibility of growth rates of solar power in selected scenarios

Scenario	Fuel	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
NP_2025_-602050	Solar.total	1.07%	11.96%	3.61%	2.52%	2.86%	-0.71%
NP_2025_-502050	Solar.total	1.07%	8.49%	5.12%	3.22%	-0.87%	3.00%
NP_2025_-402050	Solar.total	1.07%	8.48%	6.35%	3.94%	-0.67%	1.42%
NP_2025_-302050	Solar.total	1.07%	7.05%	6.68%	3.69%	0.76%	0.04%
NP_2025_-202050	Solar.total	1.07%	3.56%	1.54%	4.05%	2.56%	3.86%
NP_2025_-102050	Solar.total	1.07%	3.55%	1.56%	1.58%	2.51%	4.29%
NP_UNDC	Solar.total	1.08%	1.24%	1.04%	0.92%	0.81%	0.75%

Legend

-1%	Decline in solar generation
	Frequent precendents
	Precendents in about 1/2 of the countries
	Precedents only in small countries
	Unprecedented growth

Table shows normalized annual growth/decline rates

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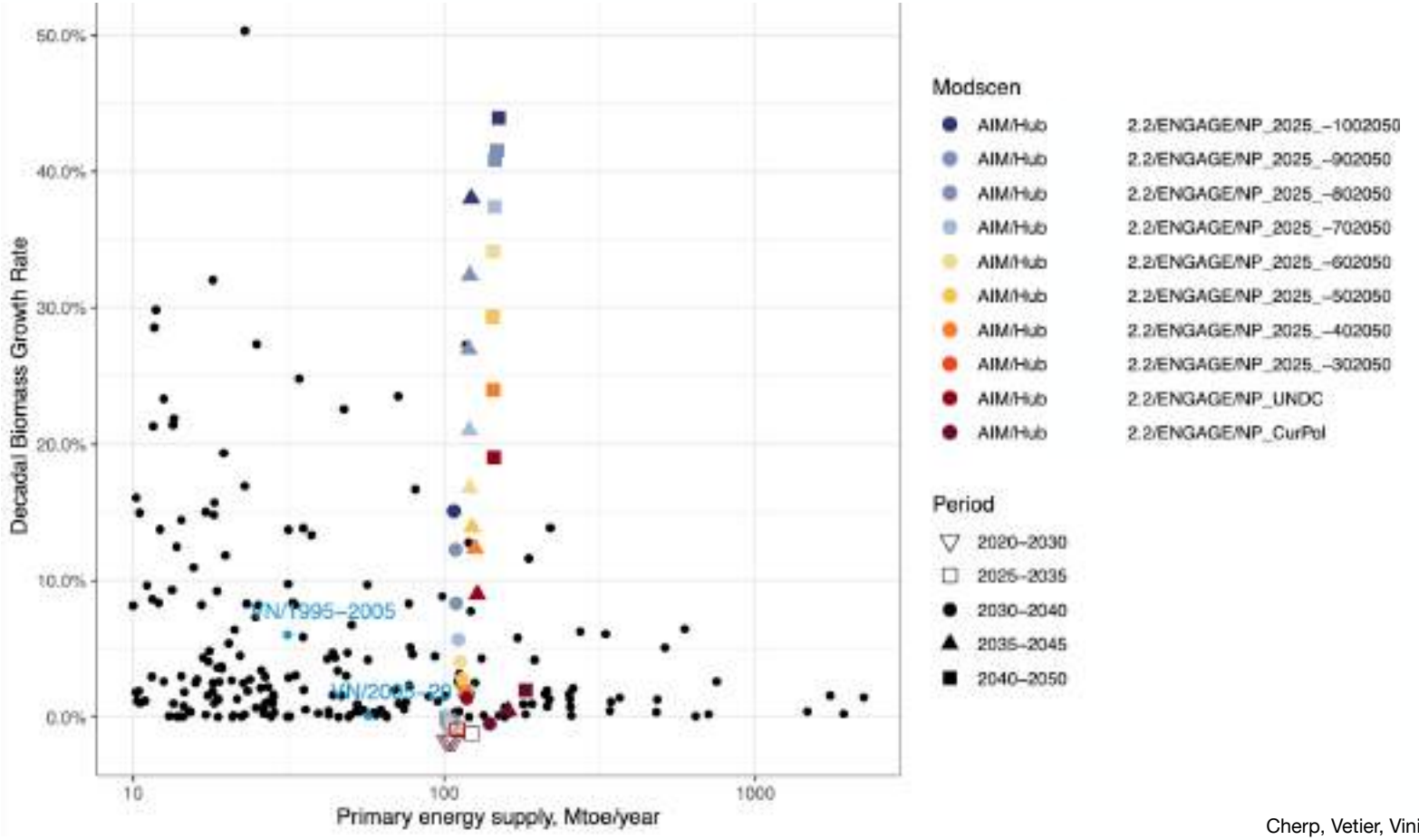
Method 3b: Worldwide regularities (growth rates)

Decadal rates of biomass increase as function of energy system size



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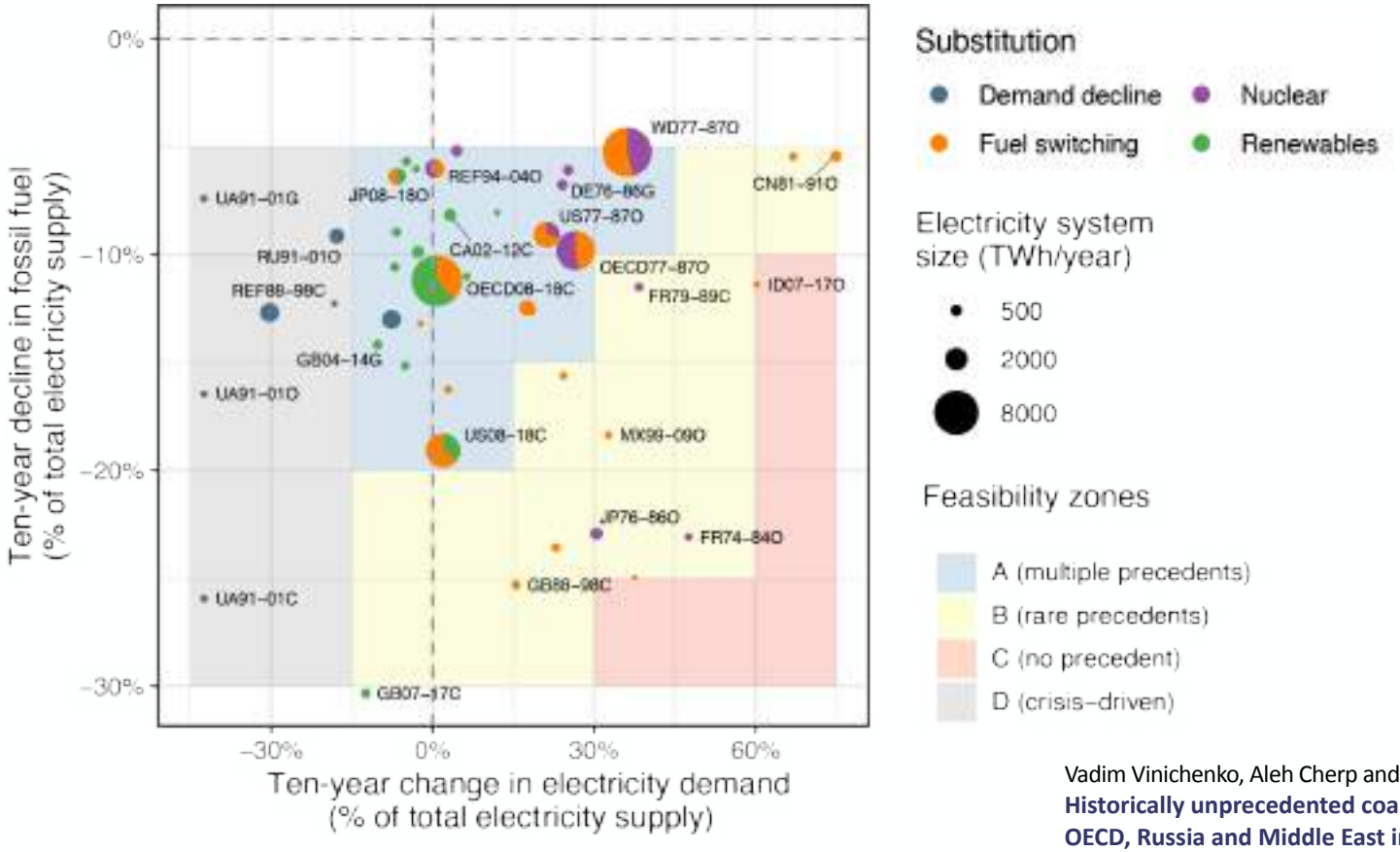
Cherp, Vetier, Vinichenko, forthcoming

Method 3c: Worldwide regularities (decline rates)

Feasibility zones of fossil fuel decline as function of electricity demand growth



Vadim Vinichenko, Aleh Cherp and Jessica Jewell (in Review)
Historically unprecedented coal and gas decline in Asia, OECD, Russia and Middle East in 1.5°C scenarios

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Method 3a: Worldwide regularities (decline rates)

Feasibility of fossil fuel decline in selected scenarios

Scenario	Fuel	2020-2030	2025-2035	2030-2040	2035-2045	2040-2050
NP_2025_-60Z050	Coal.total	-32%	-36%	-6%	-2%	-2%
NP_2025_-50Z050	Coal.total	-14%	-37%	-17%	-3%	-2%
NP_2025_-40Z050	Coal.total	-33%	-39%	-9%	-2%	-2%
NP_2025_-30Z050	Coal.total	-15%	-31%	-15%	-5%	-3%
NP_2025_-20Z050	Coal.total	-10%	-25%	-17%	-10%	-3%
NP_2025_-10Z050	Coal.total	-10%	-23%	-20%	-11%	-2%
NP_UNDC	Coal.total	8%	7%	9%	8%	5%

Legend

1%	Growth in generation
	Frequent precendents
	Rare precedents
	Unprecedented decline

Table shows normalized decadal growth/decline rates

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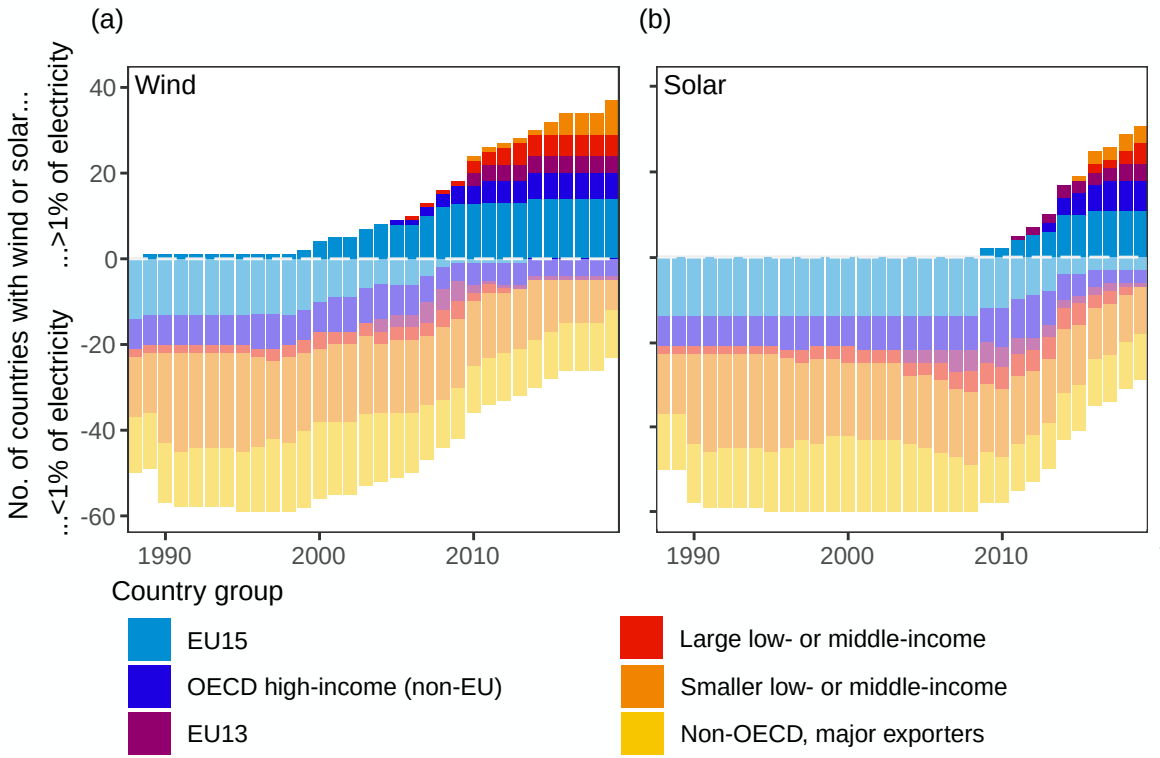
Method 4: Technology diffusion insights (for immature technologies)

Diffusion of solar and wind power (EU → OECD → large countries → the rest)



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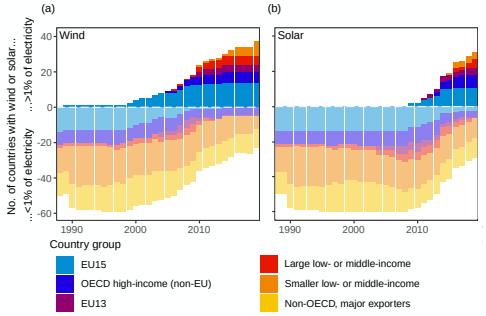
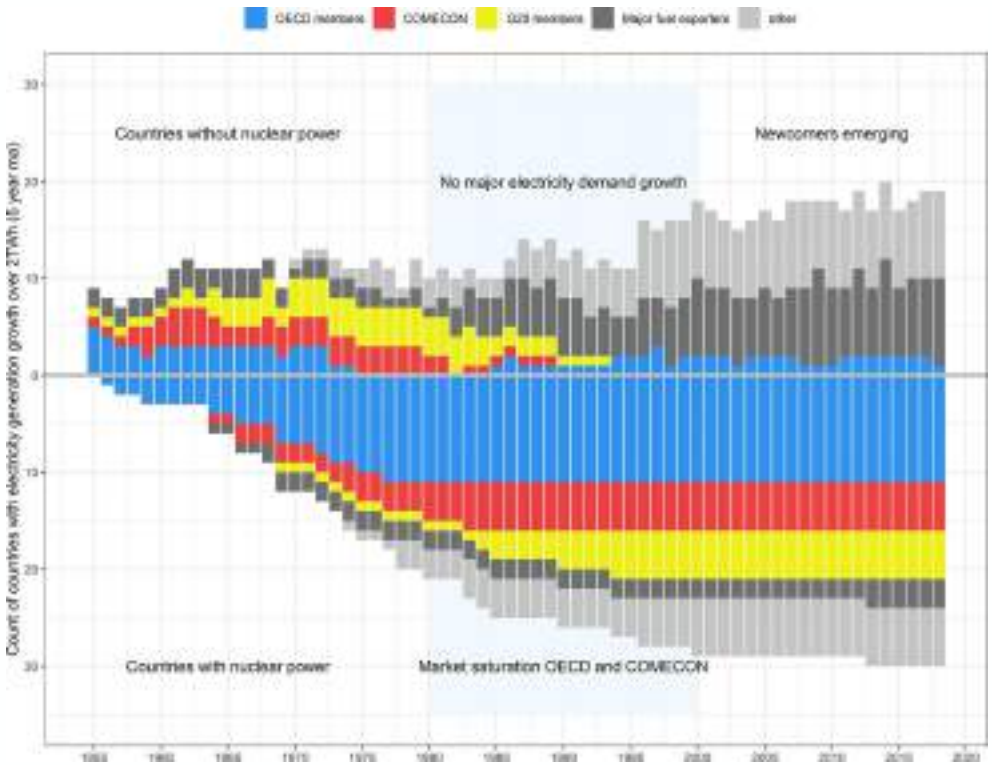
Cherp et al. *Nature Energy* 2021

Method 4: Technology diffusion insights (for immature technologies)

Diffusion of nuclear power (US/USSR → OECD/COMECON → large countries → the rest)





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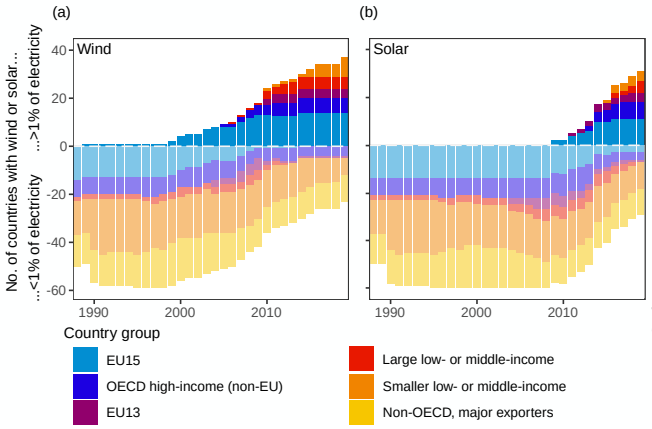
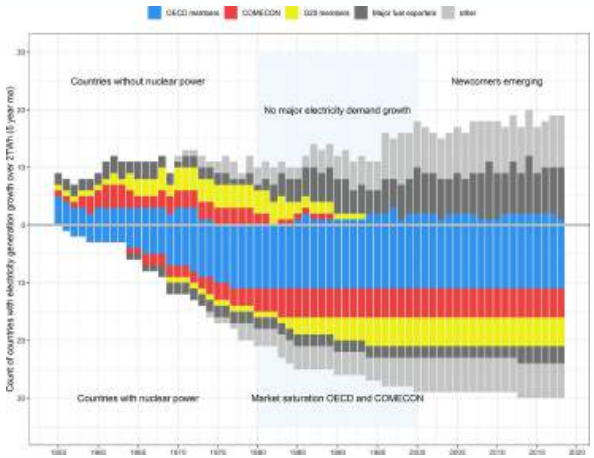
Method 4: Technology diffusion insights (for immature technologies)

Renewables



Nuclear



Other new technologies: (BE)CCS, Hydrogen, etc.?

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Main feasibility concerns across countries/scenarios

- **Unprecedented**
  - Expansion rates of renewable electricity, especially solar (many countries/climate scenarios)
  - High economic growth under low energy consumption (low middle income countries, all scenarios)
  - Decline rates of coal/gas (some countries/climate scenarios)
- **Under-ambitious**
  - Nuclear power growth (virtually all countries/scenarios)
  - Solar power growth (some countries/scenarios)
- **Highly uncertain**
  - Rapid and massive introduction of CCS (some countries/scenarios)

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