SUSTAINABLE ENERGY WEEK

AALBORG UNIVERSITY DENMARK

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Challenges in pathways towards a 100% renewable energy system

Thursday 20 June 2019, 14.00-15.30, Charlemagne, Jenkins, Rue de la Loi 170, 1000 Brussels, Belgium

sEEnergies INNOPATHS reINVEST

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Challenges in pathways towards a 100% renewable energy system

Modelling 100% Renewable Energy
Highlighting some sector coupling effects

Christian Breyer

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100% RE articles in recent years

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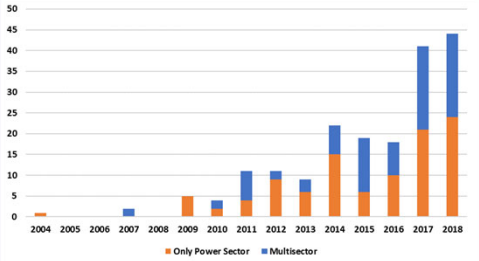

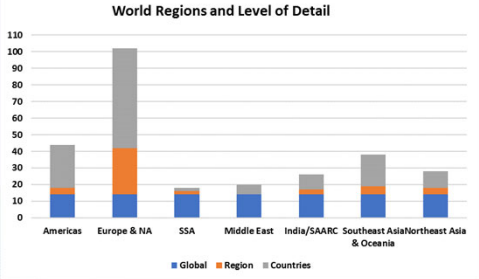

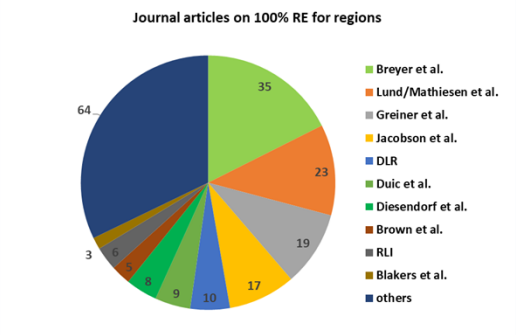

Key insights:

- Research field exists since about 10 years
- Most publications are in hourly resolution
- About half of articles are multisector publications
- Europe (FI, DK, DE) is hot spot of 100% RE research
- Gaps are in regional coverage and sectoral coverage (industry, NETs), temporal range (21st century)
- Community starts to get impact on neighbouring fields (e.g. IAMs, IPCC), but still ignored for major reports (IEA, Shell & Co., most governments)

source: Hansen, Breyer, Lund H., 2019. Energy, 175, 471-480

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Global Overview on LUT model

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- The world is structured into 9 major regions, which are further divided to 145 sub-regions
- Some sub-regions represent more than one country, others parts of a larger country
- The sub-regions are interconnected by power lines within the same country
- The results shown are for the Power, Heat, Transport, Desalination sectors
- The energy transition scenario is carried out in full hourly resolution for all energy sectors
- In total 106 different technologies are applied

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LUT/EWG: 100% RE for Power Sector

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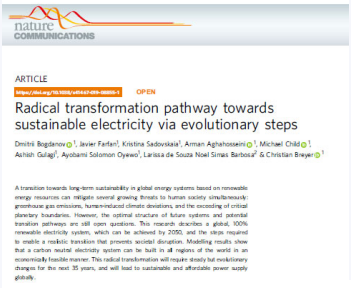

nature COMMUNICATIONS

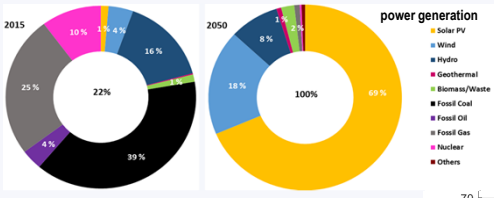
ARTICLE

https://doi.org/10.1038/s41467-019-08855-1 OPEN

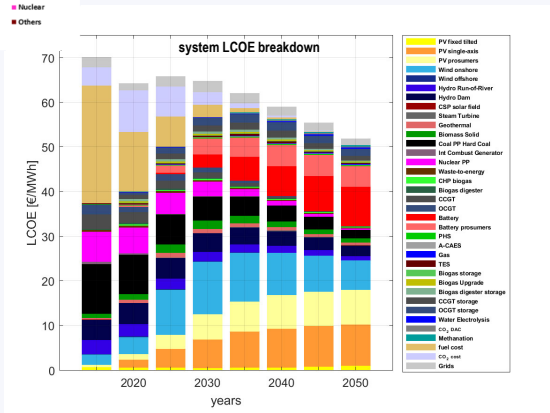
Radical transformation pathway towards sustainable electricity via evolutionary steps

Dmitrii Bogdanov[1], Javier Farfan[1], Kristina Sadovskaia[1], Arman Aghahosseini[1], Michael Child[1], Ashish Gulagi[1], Ayobami Solomon Oyewo[1], Larissa de Souza Noel Simas Barbosa[1] & Christian Breyer[1]

A transition towards long-term sustainability in global energy systems based on renewable energy resources can mitigate several growing threats to human society simultaneously: greenhouse gas emissions, human-induced climate deviations, and the exceeding of critical planetary boundaries. However, the optimal structure of future systems and potential transition pathways are still open questions. This research describes a global, 100% renewable electricity system, which can be achieved by 2050, and the steps required to enable a realistic transition that prevents societal disruption. Modelling results show that a carbon neutral electricity system can be built in all regions of the world in an economically feasible manner. This radical transformation will require steady but evolutionary changes for the next 35 years, and will lead to sustainable and affordable power supply globally.

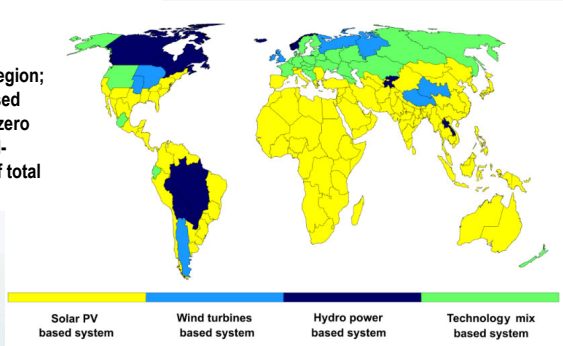


source:
Breyer et al., 2018., Progress in Photovoltaics, 26, 505-523;
Bogdanov et al., 2019. Nature Communications, 10, 1077



Area demand:

- Wind: 4% max per region; 0.3% of land area used
- Solar PV rooftop is zero impact area; ground-mounted is 0.14% of total global land area



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LUT/EWG 100% RE for all sectors

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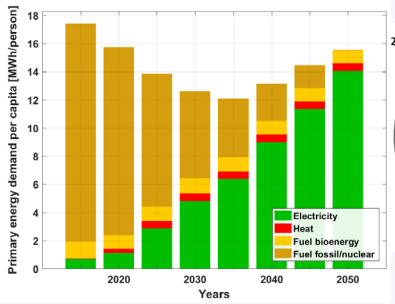
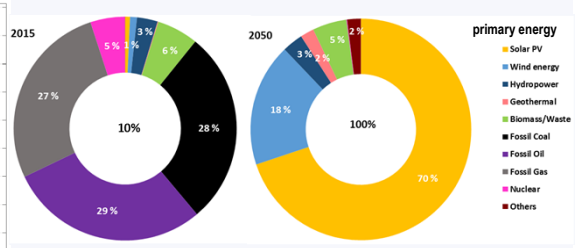
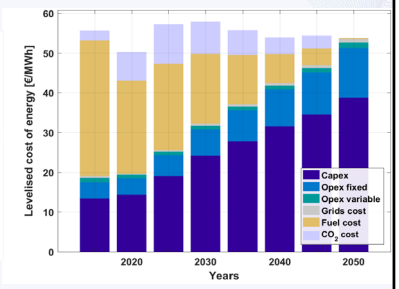
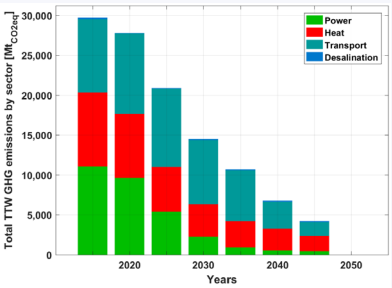


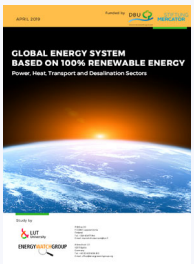


report accessible: www.energywatchgroup.org





- 1.5°C scenario with zero GHG emissions in 2050
- Specific energy cost shrink slightly
- Broad electrification of the entire energy system
- Energy services expand, while primary energy grow slowly
- Solar PV, wind energy, batteries, heat pumps and synthetic fuel conversion technologies are central
- Methods used: full hourly and high geo-spatial resolution and cost optimisation for applied constraints
- No risk technologies required
- Political will and ambitious execution drive transition



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Sector coupling learnings

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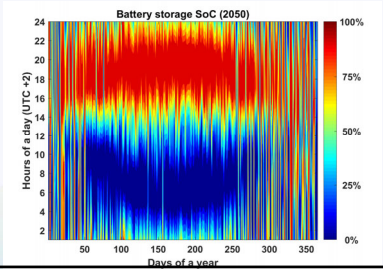
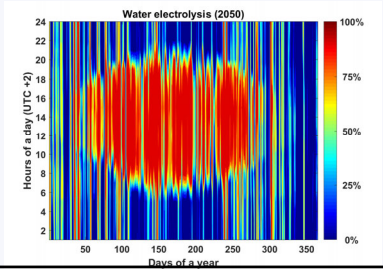
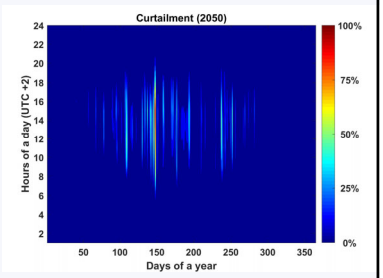
Key insights:

- Power-to-X is the central element of a future energy system, since electricity is the universal platform
- Electricity-based hydrogen emerges to the second most relevant energy carrier (for fuels, chemicals)
- Flexibility in the energy system is key:
  - Supply response (hydro reservoirs, bioenergy) for indirect balancing of solar and wind
  - Grid interconnections, in particular for balancing wind energy
  - Smart demand response: battery electric vehicles (smart charging, V2G), heat pumps, electrolysers
  - Storage (hours, days, weeks, seasons; electricity, heat, fuels)
- Cross-border cost reduction may be less important than cross-sectoral cost reduction
- Efficient sector coupling substantially reduces curtailment
- Low-capex batteries and low-capex electrolysers are key for the energy transition
- No flexibility from CO_2 direct air capture units, H_2-to-X synthesis and desalination







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Special note on solar PV

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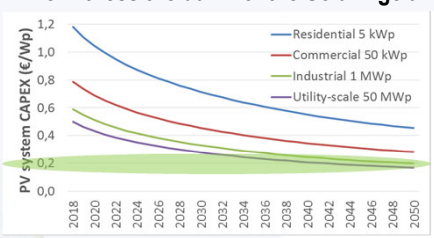
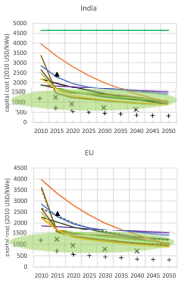
Key insights:

- Solar PV emerges to the major source of energy till 2050, in Europe and globally
- Practically ALL global scenarios dramatically fail in the right role of solar PV
- Fast cost decline of the last 10 years is ignored by IEA, IPCC (based on IAMs), and others
- Climate change mitigation could be more powerful, if major institutions would perform better
- Massive and fundamental re-thinking on solar PV, plus supporting batteries, is needed
- Rollback of energy transition in Europe, in Germany, had been major failure in past 10 years
- Fridays For Future increase pressure and massively punishes low-performing parties
- We witness the dawn of the Solar Age and should take benefits instead of destroying the future

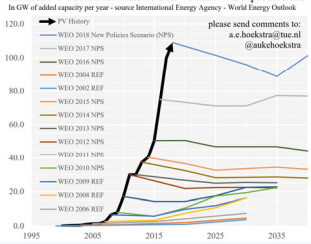


numbers by ETIP PV
https://bit.ly/2K0sFV7



IAM assumptions in IPCC
Krey et al., 2019. Energy, 172, 1254-1267

articles based on real PV cost
Heagel et al. 2019. Science, 364(6443), 836-838
Breyer et al., 2018. PIP, 26, 505-523
Breyer et al., 2017. PIP, 25, 727-745



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