

# Solar PV Deployment in Europe



Open your mind. LUT.  
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PV Magazine, Roundtable  
online, December 6, 2023

# Global: Power Market Development: 2007 - 2021



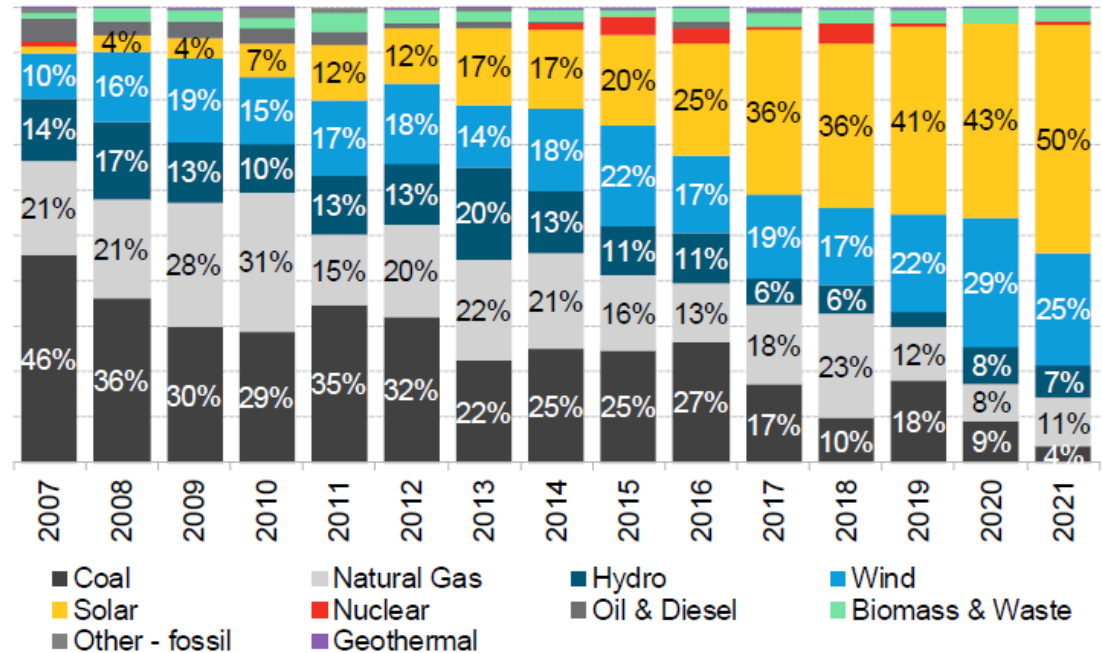
## Empiric trends:

Electricity supply dominated by PV and wind power

Generation mix will adapt to the mix of new installations, year by year

Fossil-nuclear generation will be increasingly irrelevant

Share of global capacity additions by technology

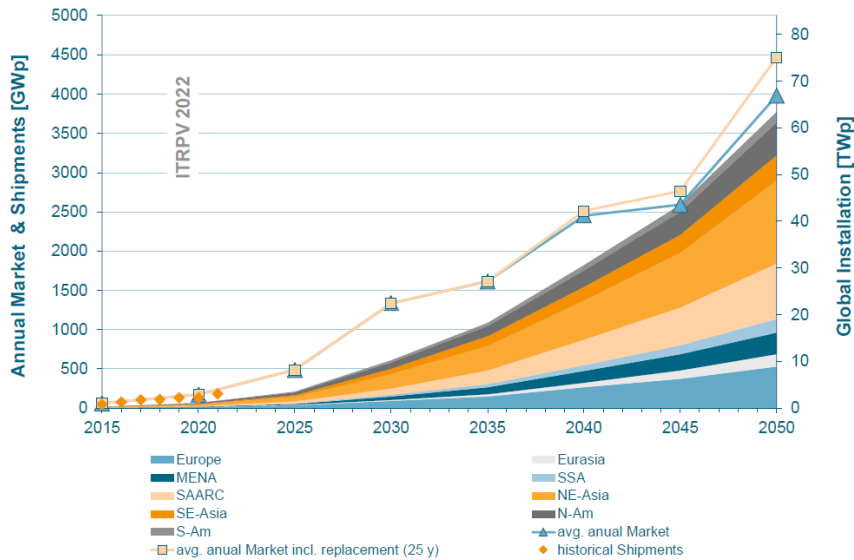


Source: BloombergNEF

## Key insights:

- PV and wind power dominate new installations, with clear growth trends for PV
- Hydropower share declines, a consequence of overall capacity rise, and sustainability limits
- Bioenergy (incl. waste) remain on a constant low share
- New coal plants are close to fade out
- New gas plants decline, with very high gas prices pushing them towards peaking operation
- Nuclear is close to be negligible, the heated debate about nuclear lacks empirical facts

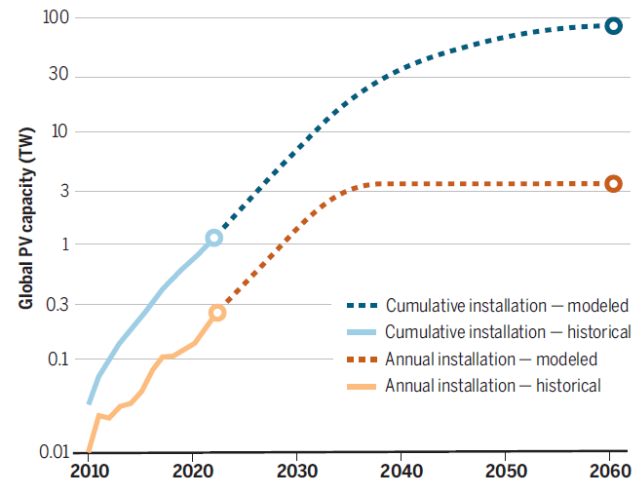
# Global: 100% Renewable Energy System by 2050



source: [VDMA, 2022. ITRPV](#)  
[Haegel et al., 2023. Science](#)

## PV installations and growth toward 75 TW by 2050

Modeled cumulative capacity going forward is based on sustaining 25% production rate growth over the next 7 years and then reducing slowly to steady state. Replacement needs are included by simple subtraction of installations 25 years before the modeled date.

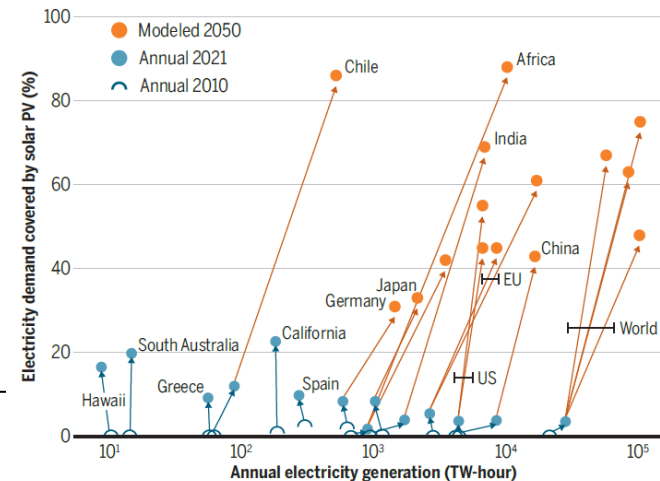


## Key insights:

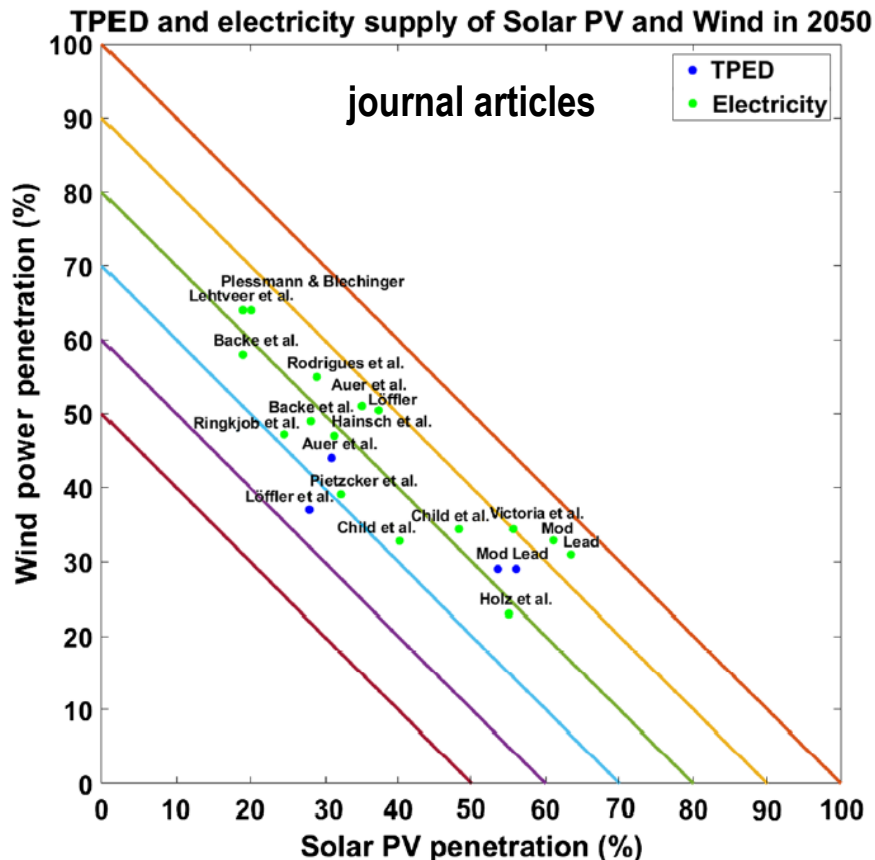
- Low-cost PV leads to a cost-neutral energy transition towards 2050
- This implies about **63 TW of PV by 2050** for the energy system & about **75 TW of PV** for the energy-industry system (chemicals, etc.)
- This leads to about **3 TW/a of PV** installations in 2040s
- This view is now common sense among PV experts
  - **ITRPV** uses this scenario as the most progressive scenario
  - **ISE & NREL & AIST** et al. use this scenario
  - **Pierre Verlinden** based the manufacturing ramping on it

## Regional electricity demand supplied by solar PV

The data reflect annual percentages of historical regional demand (2010 and 2021) and modeled demand projections (2050). See supplementary materials for details.



# Europe: Solar PV Share in 100% RE Studies



## Key insights:

- 2 main groups:
  - high PV & wind: more PV
  - high PV & wind: more wind
- PV & wind electricity share >80% standard
- PV & wind TPED share in 65-85% range
- PV shares around 30-40% by 2050 standard for Europe
- Victoria et al. finds 56% PV share
- This research finds 61-63% PV share
- Reasons for PV shares >50%
  - low-cost of PV & batteries & electrolysers
  - high levels of electrification
  - high levels of PtX: PV benefits strongly from H<sub>2</sub> buffering
- Difference between 50% and 60% PV share
  - PV differentiation: PV prosumers (RES, COM, IND), fixed and 1-axis plants
  - independent optimisation of PV options

- Major reports for public discourse document lack of up-to-date knowledge of consultants
  - McKinsey (20% PV share in 2050), DNV (15%), Navigant (14%); IEA WEO SDS (13%) NZE without regional data
  - lack of ambition: no 100% RE scenario known, much fossil CCS and nuclear, low levels of electrification
  - oversimplified models: low temporal and spatial resolution, no cost optimisation, low levels of PtX and sector coupling
  - cost assumptions used often violate market trends (too high renewables cost, too low CCS & nuclear costs)

# Europe: Scientific studies in journals for PV



Authors	Year	Model	Temporal resolution	Sectors	Regions	electricity generation		generation share		TPED share		RE share	Target year
						PV [TWh]	Wind [TWh]	PV	Wind	PV	Wind		
Breyer et al. – Moderate	2022	LUT-ESTM	Hourly	all	20	10600	5630	61%	33%	54%	29%	99.5%	2050
Breyer et al. - Leadership	2022	LUT-ESTM	Hourly	all	20	12345	6400	63%	32%	56%	29%	100%	2040
Rodrigues et al.	2022	REMIND, PRIMES, TIMES	time slices	all	11	1550	2940	29%	55%	n/a	n/a	96%	2050
Backe et al.]	2022	EMPIRE	Hourly	P,H	35	2050	3550	28%	49%	n/a	n/a	97%	2050
Hainsch et al.	2022	OSeMOSYS - GENeSYS-MOD	time slices	all	-	n/a	n/a	n/a	n/a	n/a	n/a	95%	2050
Backe et al.	2022	EMPIRE	Hourly	P	35	765	2365	19%	58%	n/a	n/a	100%	2050
Holz et al.	2021	EMPIRE	Hourly	P,H,I	-	2140	890	55%	23%	n/a	n/a	96%	2050
Löffler]	2021	OSeMOSYS - GENeSYS-MOD	time slices	P	30	1730	860	37%	50%	n/a	n/a	100%	2050
Lehtveer et al.	2021	H2D	Annually	all	12	480	1600	19%	64%	n/a	n/a	98%	2050
Hainsch et al.	2021	OSeMOSYS - GENeSYS-MOD	time slices	P,H	17	2160	3360	30%	47%	n/a	n/a	96.0%	2050
Pietzcker et al.	2021	LIMES-EU	time slices	P	29	1870	2310	32%	39%	n/a	n/a	99.8%	2050
Victoria et al.	2020	PyPSA	Hourly	all	30	3360	2025	56%	34%	n/a	n/a	98%	2040
Ringkjøb et al.	2020	TIMES	time slices	all	28	970	1870	25%	47%	n/a	n/a	97%	2050
Auer et al.	2020	OSeMOSYS - GENeSYS-MOD	time slices	all	30	2800	3950	35%	50%	31%	44%	100%	2045
Child et al.	2019	LUT-ESTM	Hourly	P	20	2340	1900	41%	33%	n/a	n/a	99.8%	2035
Löffler et al.	2019	OSeMOSYS - GENeSYS-MOD	time slices	all	17	2330	3080	n/a	n/a	28%	37%	97%	2050
Child et al.	2018	LUT-ESTM	Hourly	P	20	2750	1960	48%	34%	n/a	n/a	99.8%	2035
Pleißmann and Blechinger	2017	elesplan-m	Hourly	P	18	1200	3800	20%	64%	n/a	n/a	98%	2040

- **PV shares around 30-40% by 2050** standard for Europe
- **3 studies are at PV share of >50%**
  - **Victoria et al. at 56% PV share**
  - **Breyer et al. (with SPE) at 61-63% PV share**
  - **Holz et al. at 55% PV share**

# Europe: Reports of stakeholders for PV



Authors	Year	Model	Temporal resolution	Sectors	Regions	electricity generation		electricity generation share		TPED share		RE share <sup>1</sup>	Target year <sup>2</sup>
						PV [TWh]	Wind [TWh]	PV	Wind	PV	Wind		
Breyer et al. – Moderate	2022	LUT-ESTM	Hourly	all	20	10600	5630	61%	33%	54%	29%	99.5%	2050
Breyer et al. - Leadership <sup>1</sup>	2022	LUT-ESTM	Hourly	all	20	12345	6400	63%	32%	56%	29%	100%	2040
ENTSO-E, TYNDP 2022	2021	n/a	n/a	all	n/a	1105	3803	18%	63%	12%	42%	98%	2050
Eurelectric Scenario 3	2018	McKinsey	n/a	all	8	1200	4000	20%	67%	n/a	n/a	82%	2045
WindEurope Paris Compatible	2018	DNV ETO	Annual	all	1	900	2223	15%	36%	n/a	n/a	78%	2050
EC 1.5 TECH	2018	PRIMES	Time slices	all	1	1232	4252	16%	53%	n/a	n/a	83%	2050
CAN Europe PAC	2021	unspecified	n/a	all <sup>3</sup>	1	2500	3600	38%	55%	32%	46%	100%	2050
Navigant Optimised gas	2019	Navigant Energy System Model	Hourly	all	1	1000	4000	14%	56%	n/a	n/a	88%	2050
IEA WEO SDS <sup>4</sup>	2020	IEA World Energy Model	Annual	all	1	747	2131	13%	38%	4%	13%	76%	2040
Greenpeace Adv E[R]	2015	Mesap/PlaNet (DLR-EM)	Annual	all	1	1080	2351	19%	41%	9%	21%	100%	2050

<sup>1</sup> RE share in electricity generation

<sup>2</sup> target year of displayed numbers

<sup>3</sup> electric vehicles and power-to-heat are excluded

<sup>4</sup> IEA WEO NZE no regional numbers disclosed due to lacking transparency

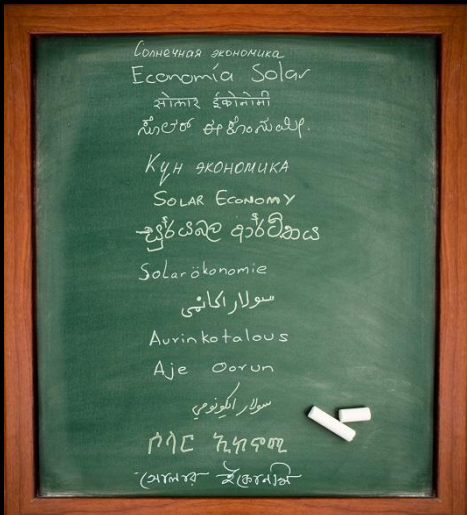
- **PV shares around 15-20% by 2050 for Europe**
- **Massive lack of knowledge at key stakeholders, in particular consultants lacking behind many years**
- **Lack of visions, lack of proper modelling tools, lack of sector coupling & electrification knowledge**
- **PV community have to push stakeholders on basis of scientific studies published in journals**

# Key messages



- **PV is the least cost source of electricity, globally and in Europe**
- **PV and wind power are the central and dominant pillars of energy supply**
- **PV share (science) found at 30-40% as standard, with 50-60% in relevant studies**
- **PV share (stakeholders) found at 15-20%, due to multiple deficits**
- **PV community needs to push stakeholders for catching up with science**

# Thank you for your attention ... ... and to the team!



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