UNIVERSITÀ
DEGLI STUDI
DI TRIESTE

La transizione dai combustibili fossili alle fonti rinnovabili di energia

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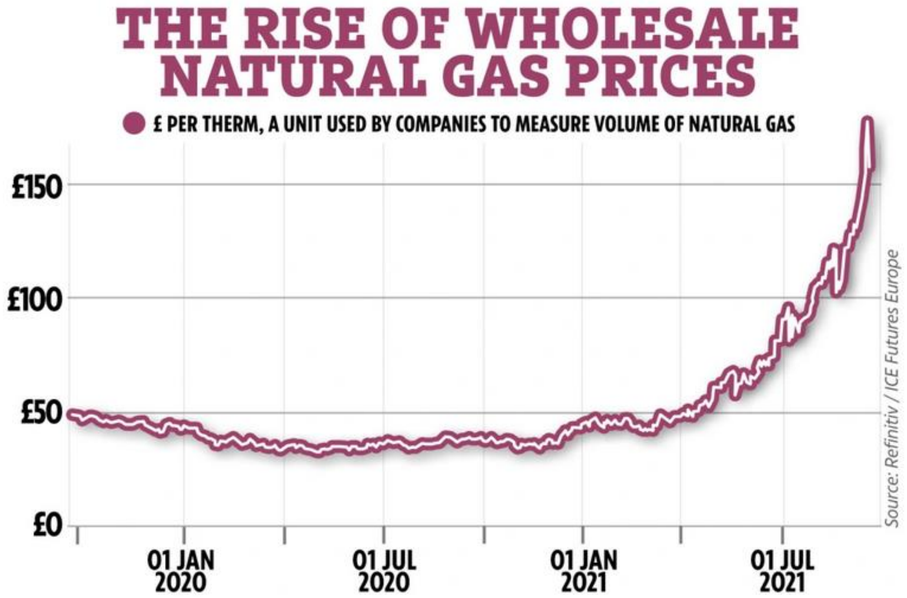
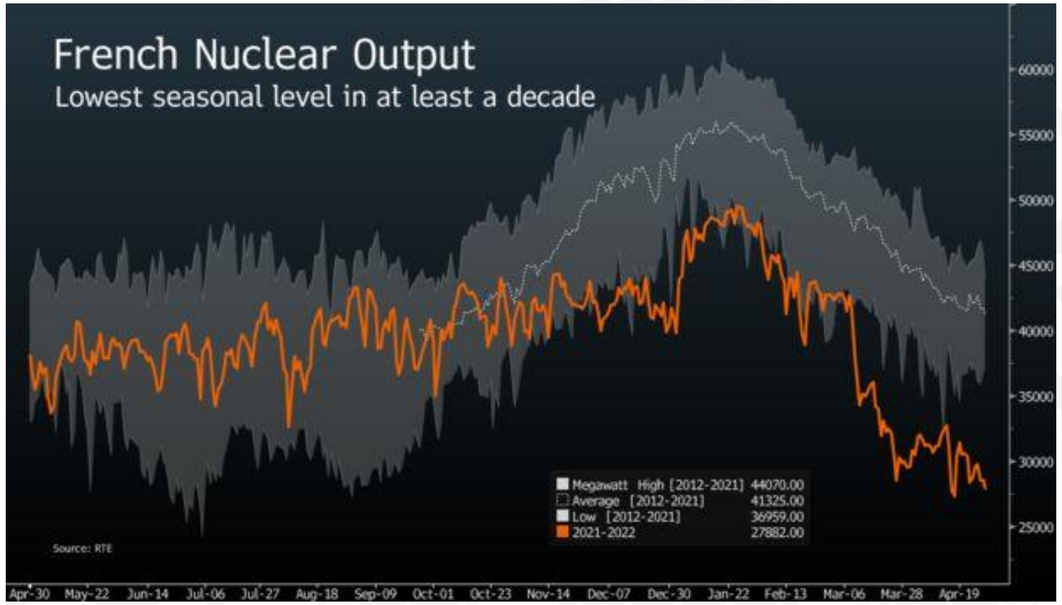
Coordinatore del Centro Interdipartimentale Giacomo Ciamician

TRIESTE, 21 SETTEMBRE 2023

Centro Interdipartimentale
per l'Energia, l'Ambiente e i Trasporti
Giacomo Ciamician

Energia: al centro di un sistema in crisi



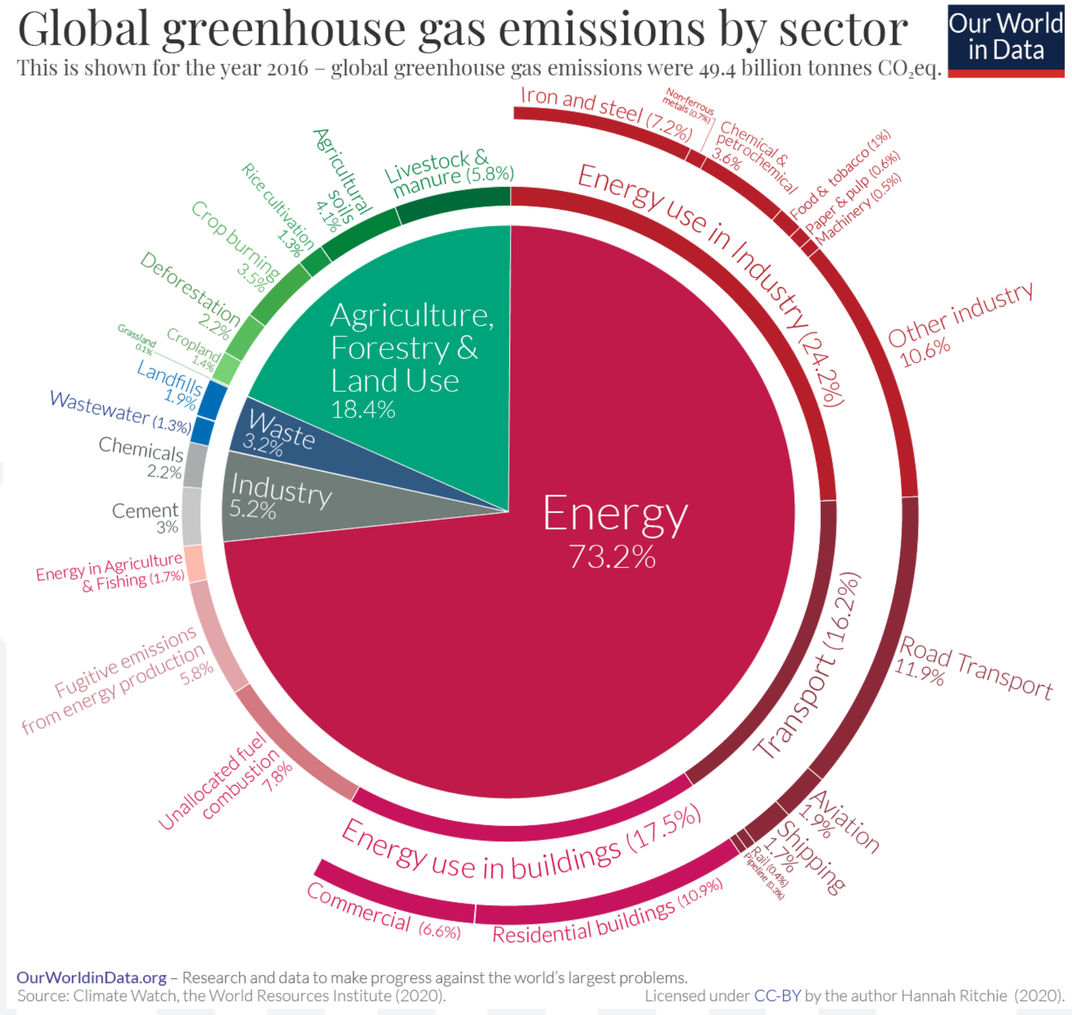


GWh	2015	2016	2017	2018	2019	2020	2021	2022
Idrica	**45.537,3**	**42.431,8**	**36.198,7**	**48.786,4**	**46.318,5**	**47.551,8**	**45.388,2**	**28.397,6**
0 - 1 MW	*2.556,2*	*2.644,7*	*2.328,0*	*3.036,2*	*3.037,9*	*3.161,3*	*3.087,9*	*2.086,1*
1 - 10 MW	*8.308,2*	*8.169,3*	*6.979,2*	*9.084,0*	*8.722,7*	*9.033,7*	*8.500,9*	*5.254,4*
> 10 MW	*34.672,9*	*31.617,7*	*26.891,5*	*36.666,2*	*34.557,9*	*35.356,8*	*33.799,3*	*21.057,1*

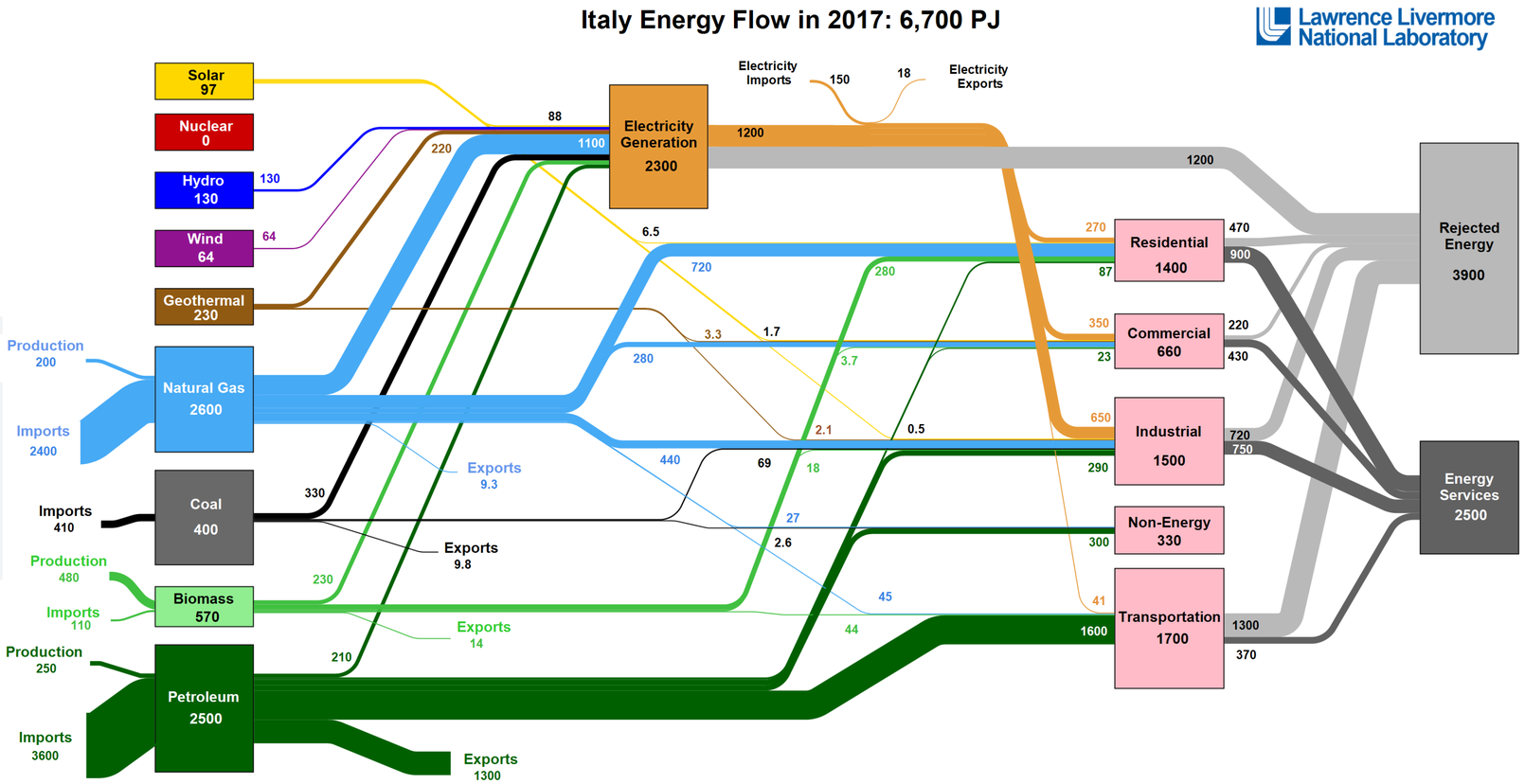
China's Hydro Power Crisis Is Just the Start

Climate-fueled droughts could make climate change even worse. Plus, more of the week's top opinions.

Il grande emettitore



Un sistema inefficiente: il fossile non è sostenibile!



- Bruciare combustibili fossili per produrre energia elettrica determina perdite pari al 50%
- Bruciarne per muovere automobili perdite pari al 75%

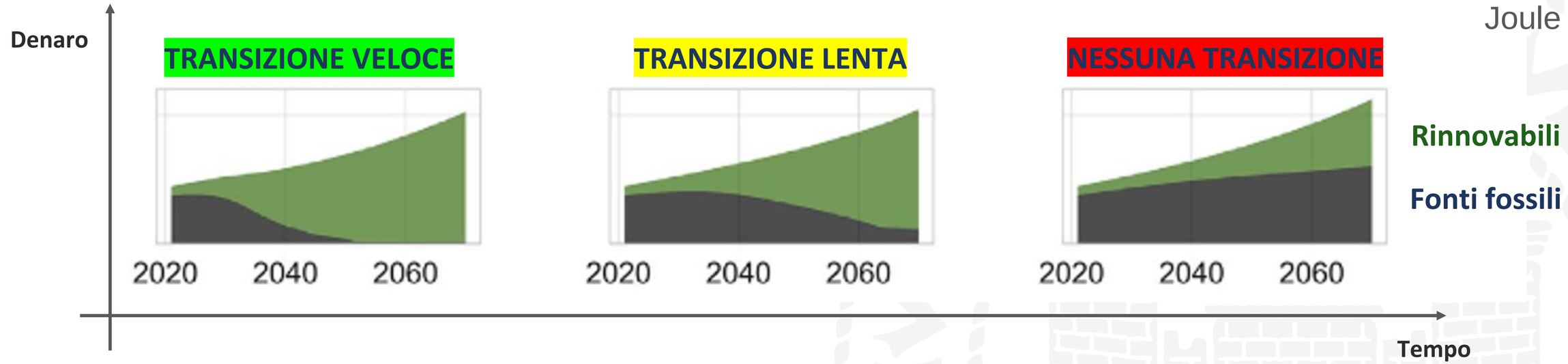
Buttiamo via il 61% di energia primaria!!!

I costi della «non transizione»

Joule

Way et al.
Joule 2022

TRE DIVERSI SCENARI ENERGETICI



La transizione verso le rinnovabili comporta un risparmio pari a diverse migliaia di miliardi di euro al 2050

Supporti a quali fonti?!

Support for fossil fuels almost doubled in 2021, slowing progress toward international climate goals, according to new analysis from OECD and IEA

29 August 2022

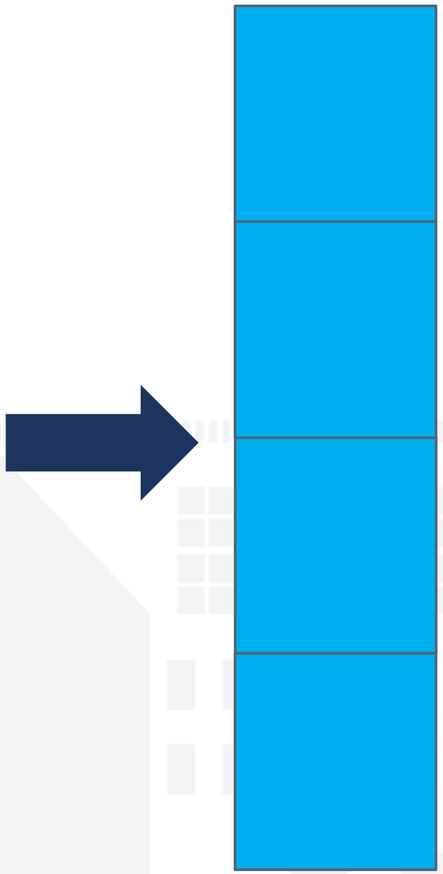
International Energy Agency

I supporti globali alle fonti fossili sono passati da 362 G$ nel 2020 a 697 G$ nel 2021!!!

I supporti globali alle fonti rinnovabili nel 2021 non hanno superato i 500 G$ …

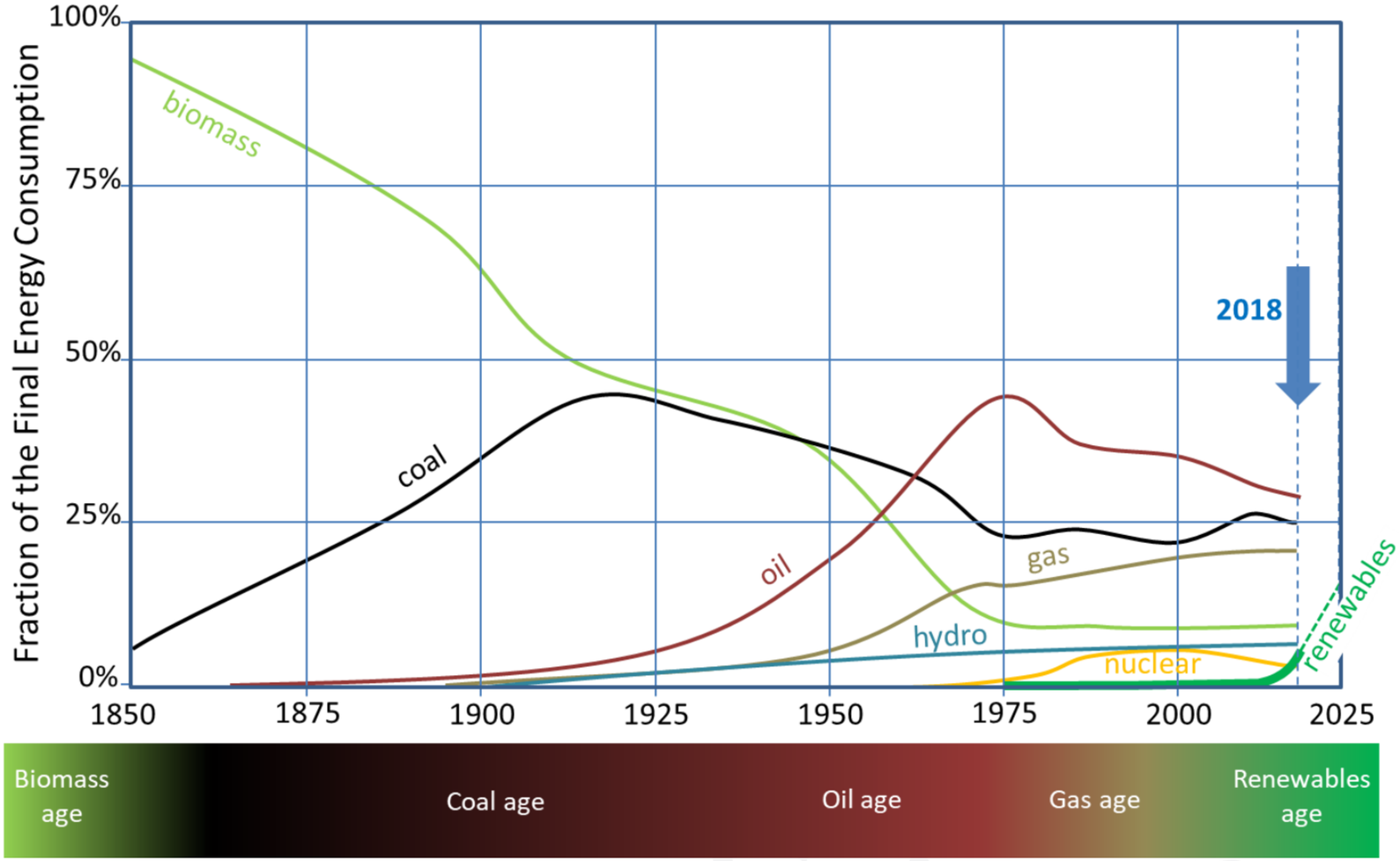
Perdite del sistema energetico

Efficientare la catena energetica



Risparmiare energia

Transizioni energetiche



MRS ENERGY & SUSTAINABILITY

PERSPECTIVE

How to avoid the perfect storm: The role of energy and photovoltaics

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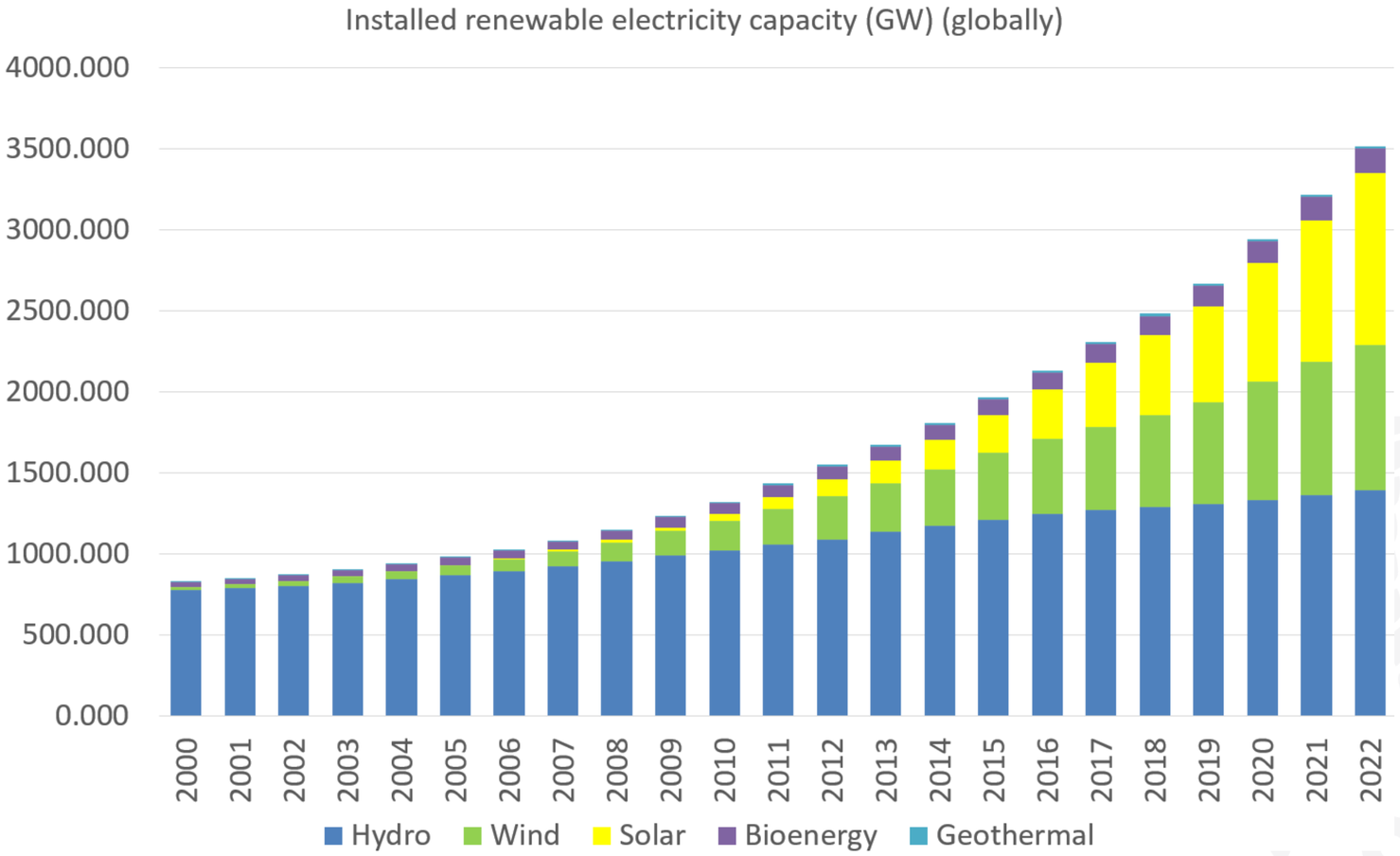
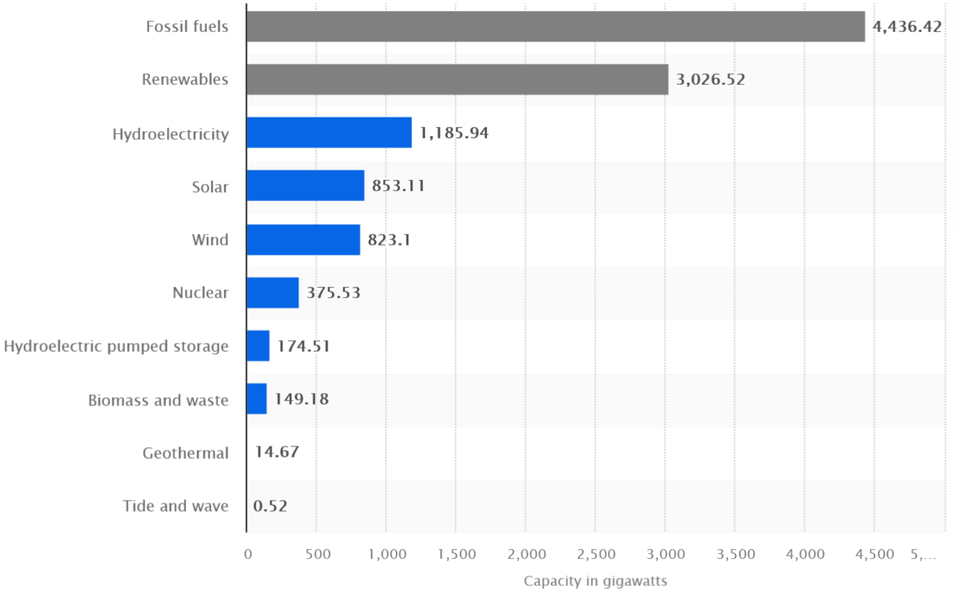
Transizioni energetiche

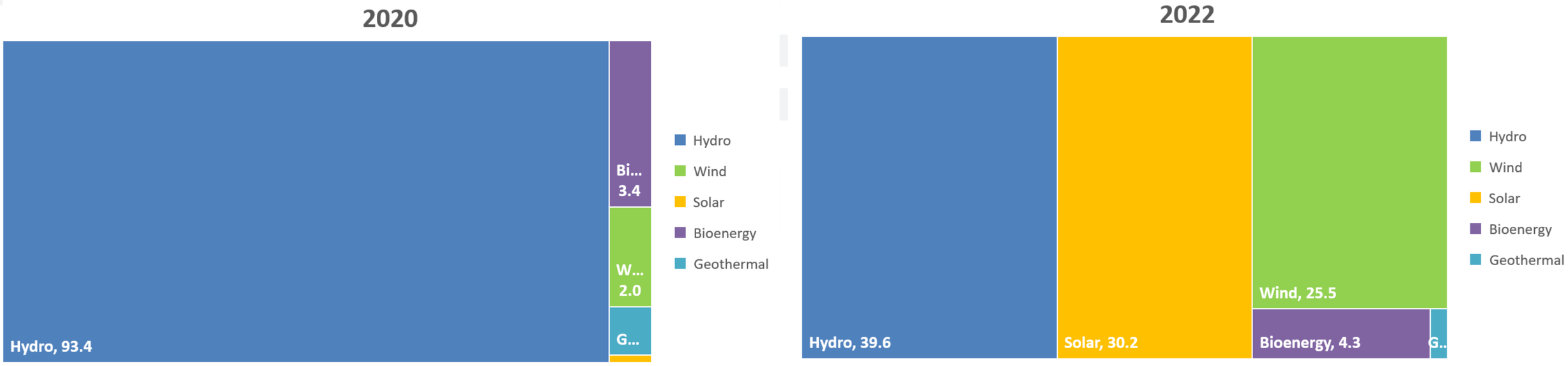




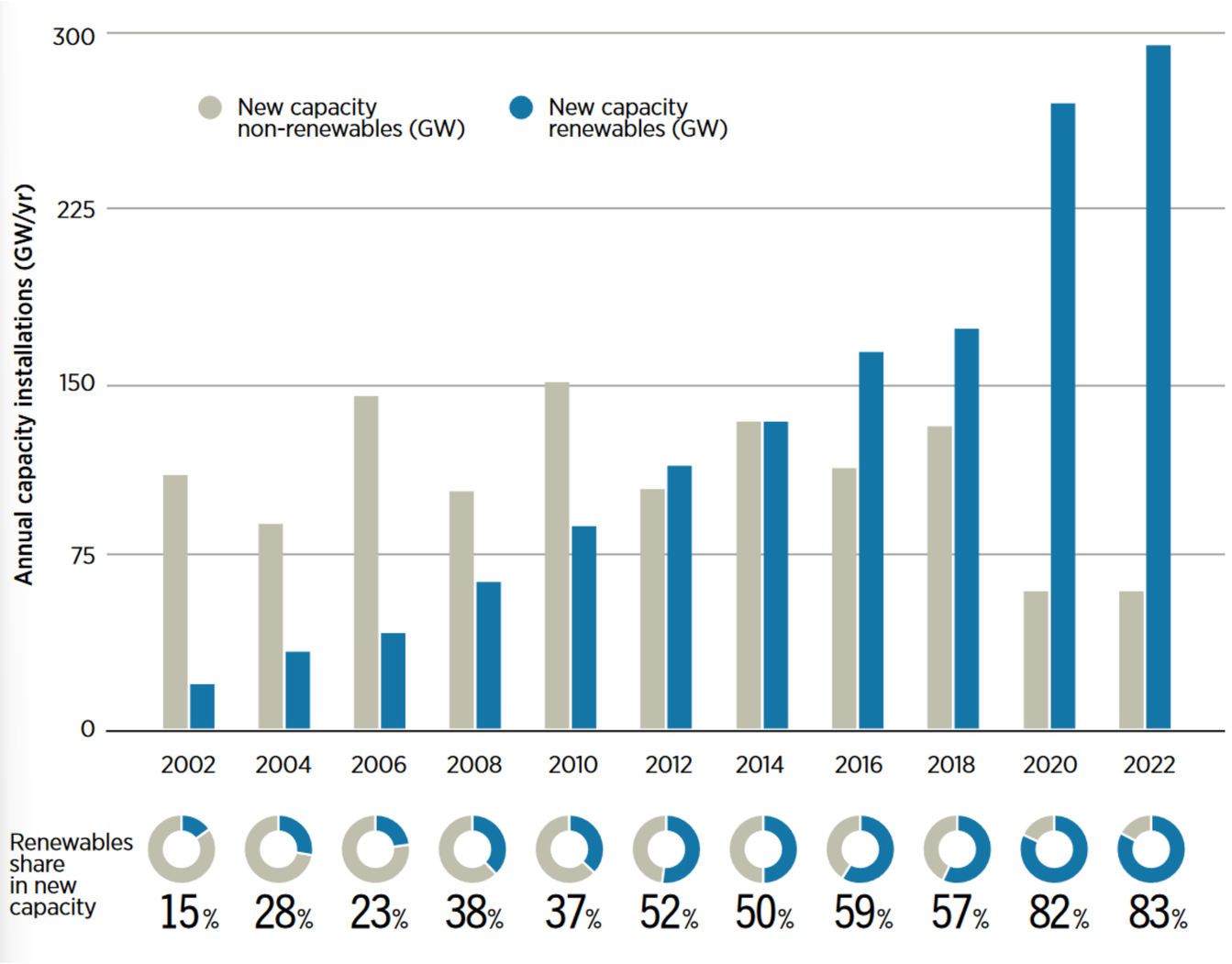
NEW INSTALLATIONS

TECHNOLOGY	2022 [GW]	2021 [GW]	VARIATION [%]
PHOTOVOLTAICS	1055	866	21.8
WIND	899	826	8.8
BIOMASS, SOLID BIOFUELS AND WASTE	277	262	5.7
GAS	1895	1853	2.3
HYDROPOWER	1392	1360	2.4
COAL	2142	2139	0.1
NUCLEAR	371	390	-4.9

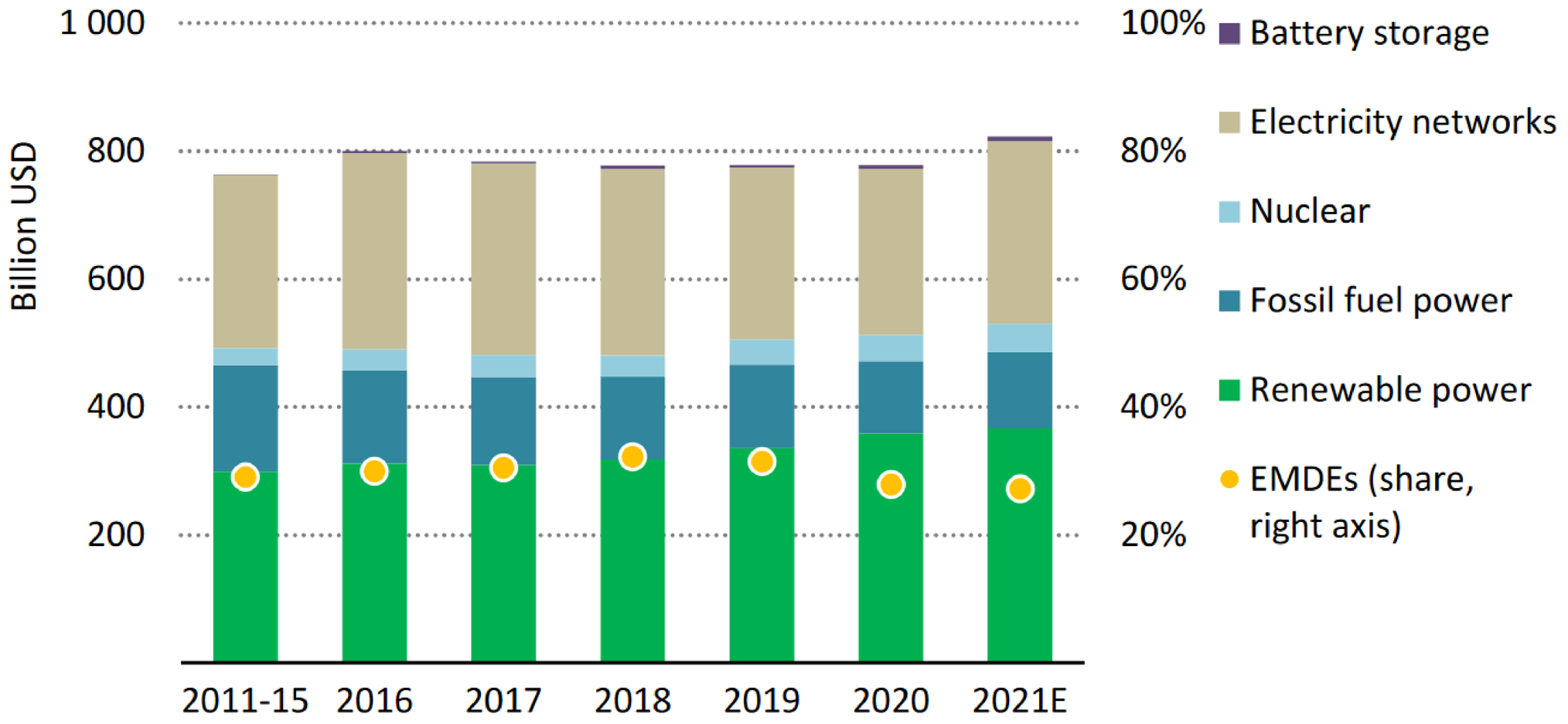
Concentrated Solar Power (CSP) and Marine Energy account for 7 and less than 1 GW respectively

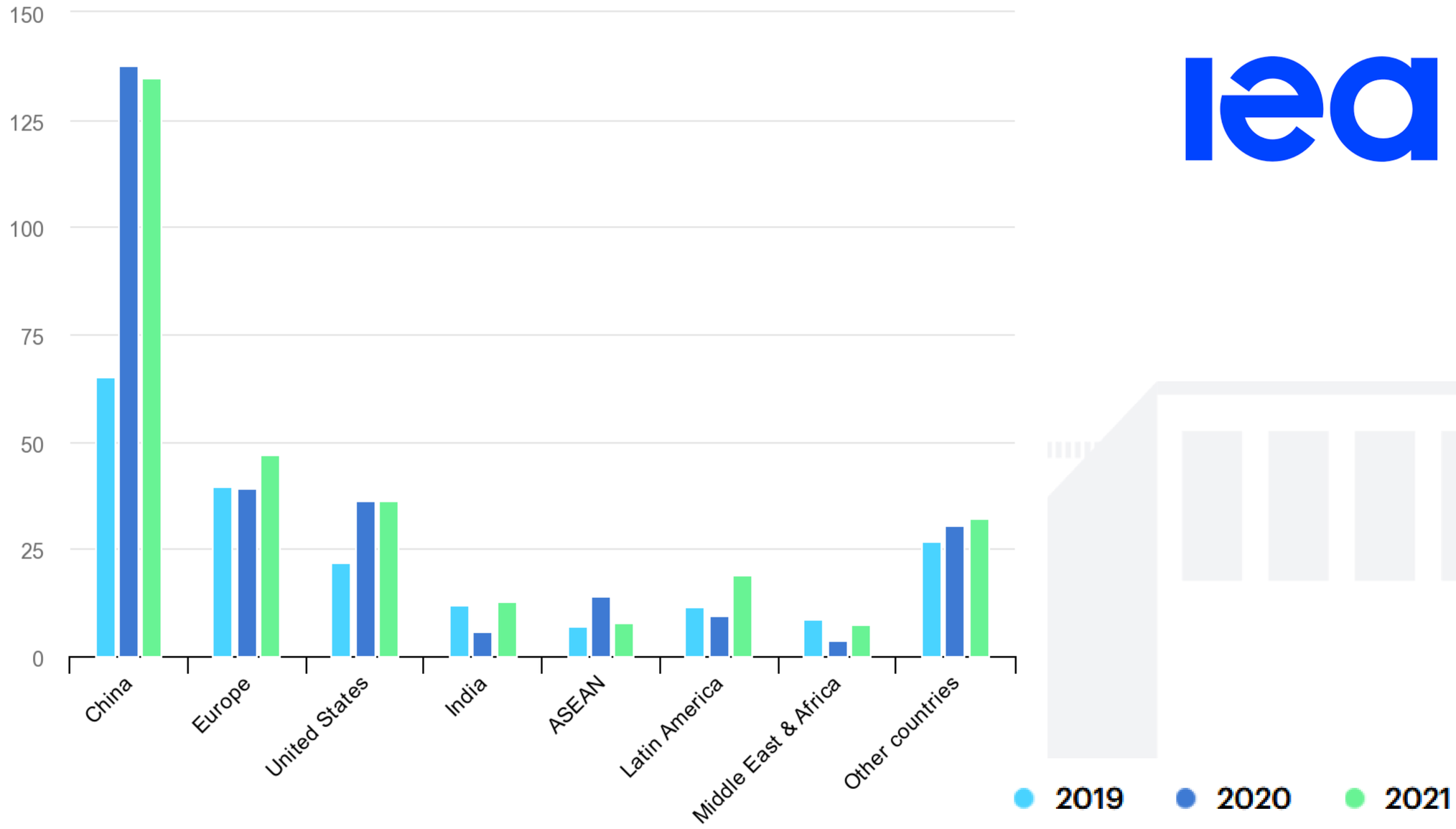


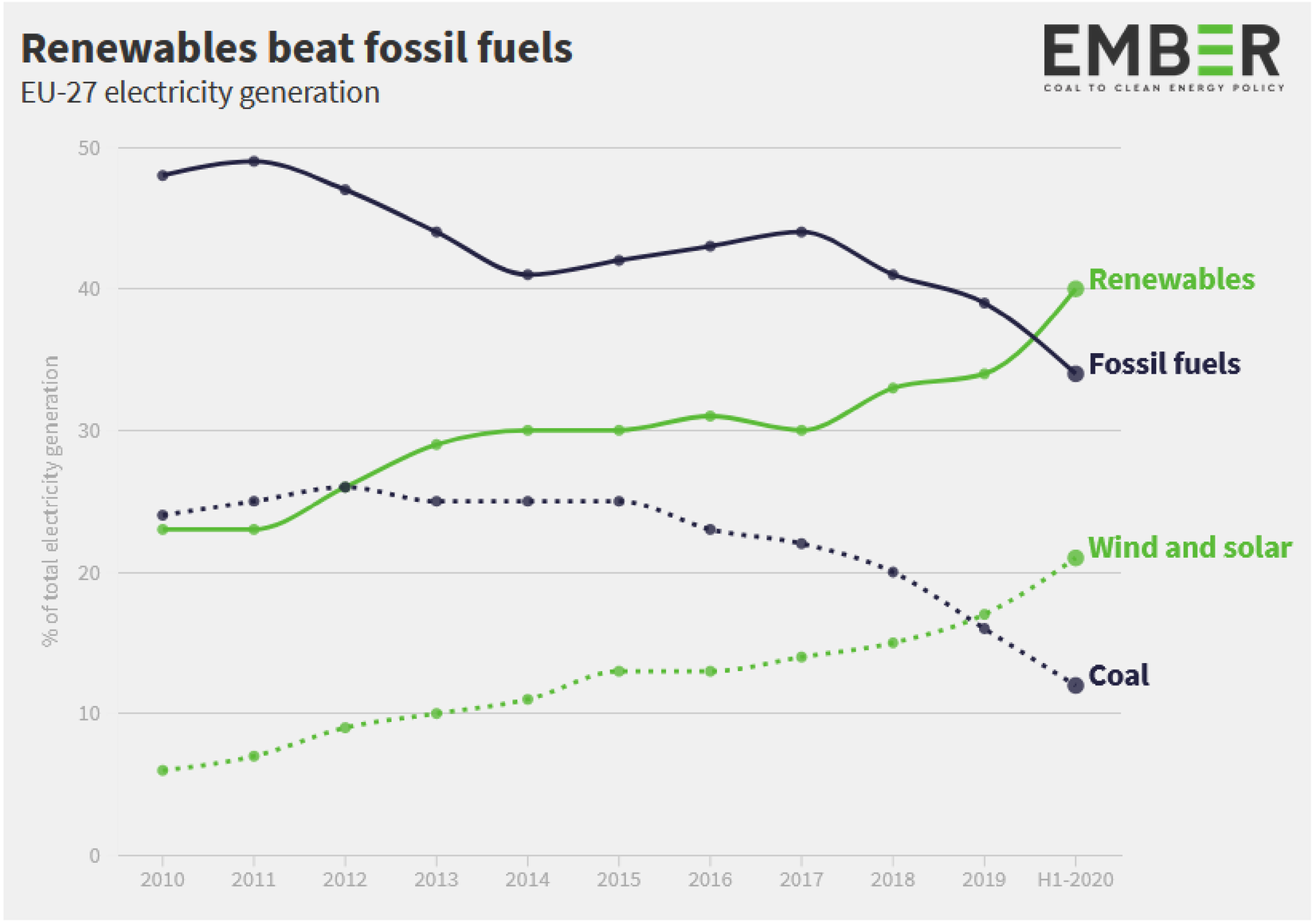
A livello globale «solo» rinnovabili!



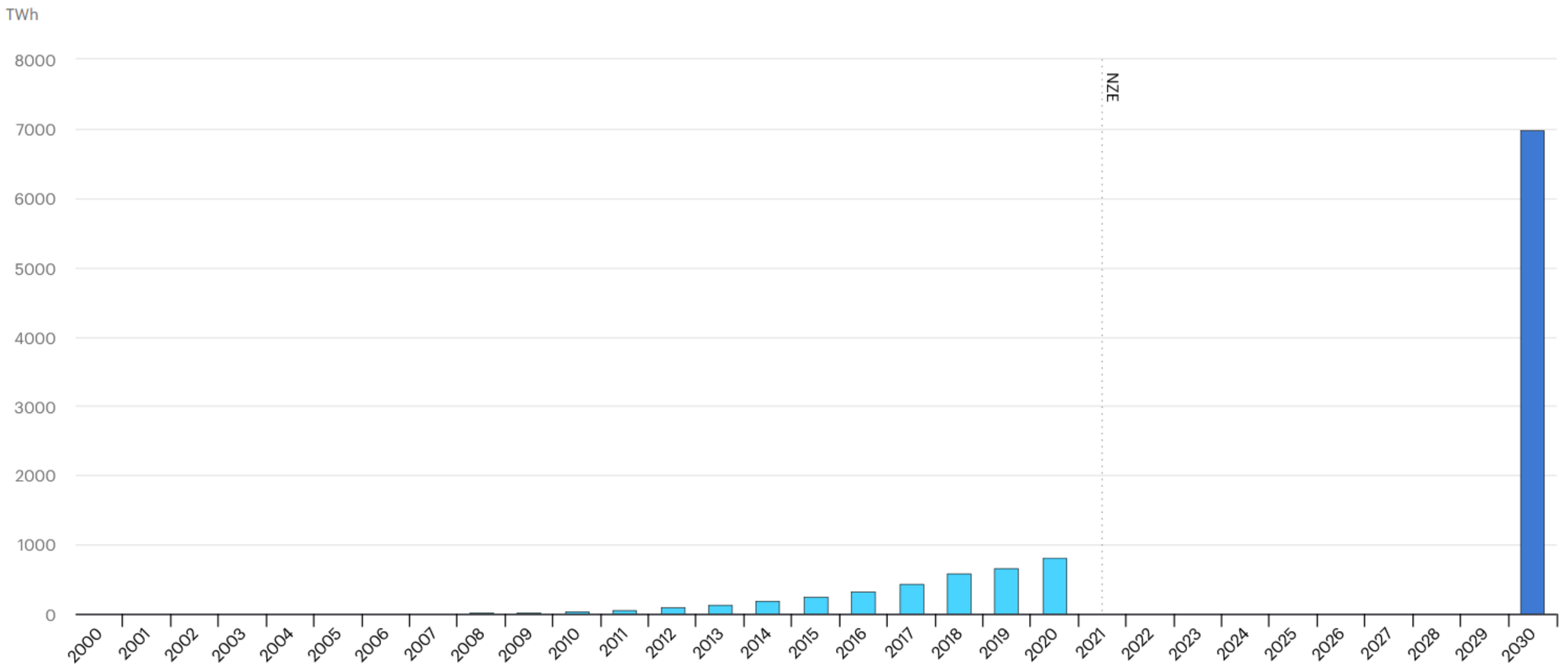
Investimenti globali




150
125
100
75
50
25
0
China
Europe
United States
India
ASEAN
Latin America
Middle East & Africa
Other countries
2019
2020
2021


Renewables beat fossil fuels
EU-27 electricity generation
EMBER
COAL TO CLEAN ENERGY POLICY
% of total electricity generation
50
40
30
20
10
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
H1-2020
Renewables
Fossil fuels
Wind and solar
Coal

Bisogna fare di più!



Power generation in Italy

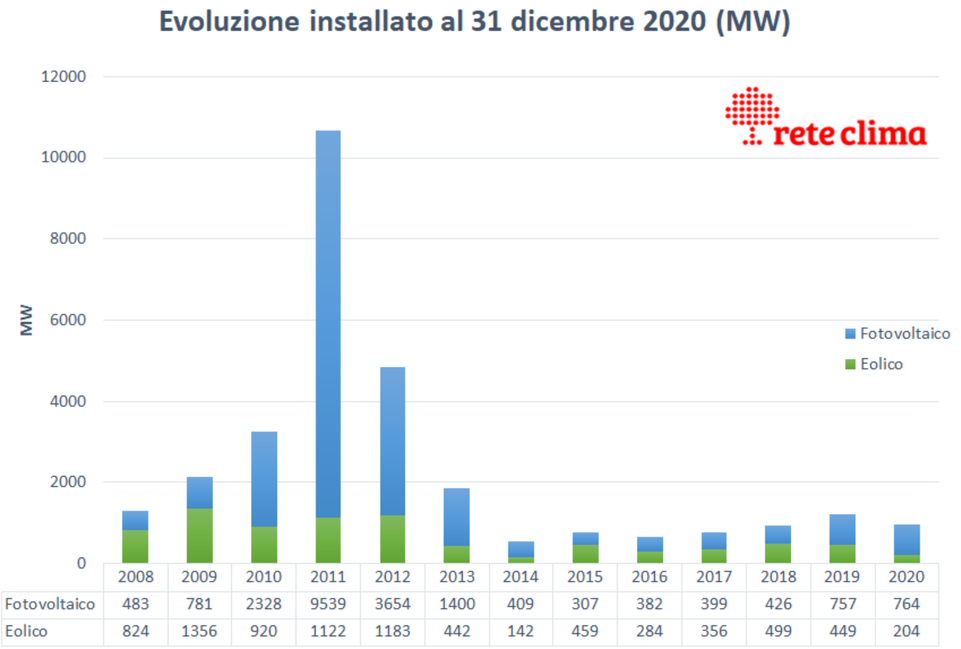
TECHNOLOGY	2005	2020	2022
THERMAL POWER	81%	60%	**67%**
HYDROPOWER	15%	17%	**9%**
PHOTOVOLTAICS	0%	9%	9%
WIND POWER	1%	6%	7%
BIOMASS	2%	6%	6%
GEOTHERMAL	2%	2%	2%

Renewables doubled from 20 to 40% in 15 years!

Power in Italy in 2030

Tabella 10 - Obiettivi di crescita della potenza da fonte rinnovabile al 2030 (MW) [Fonte: RSE, GSE]

	2020	2021	2025	2030
Idrica*	19.106	19.172	19.172	19.172
Geotermica	817	817	954	1.000
Eolica	10.907	11.290	17.314	28.140
- di cui off shore	0	0	300	2.100
Bioenergie	4.106	4.106	3.777	3.052
Solare	21.650	22.594	44.848	79.921
- di cui a concentrazione	0	0	300	873
Totale	**56.586**	**57.979**	**86.065**	**131.285**



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fotovoltaico	483	781	2328	9539	3654	1400	409	307	382	399	426	757	764
Eolico	824	1356	920	1122	1183	442	142	459	284	356	499	449	204

55 GW of PV in 8 years >> 7GW/year

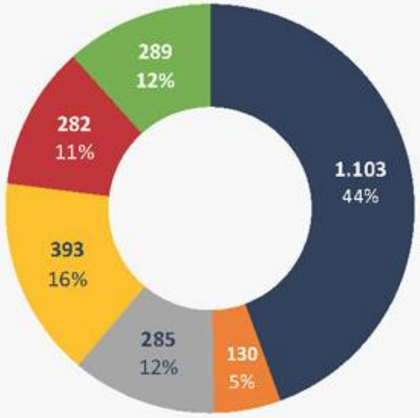
8 GW of wind power >> 2GW/year

Photovoltaics in Italy 2022

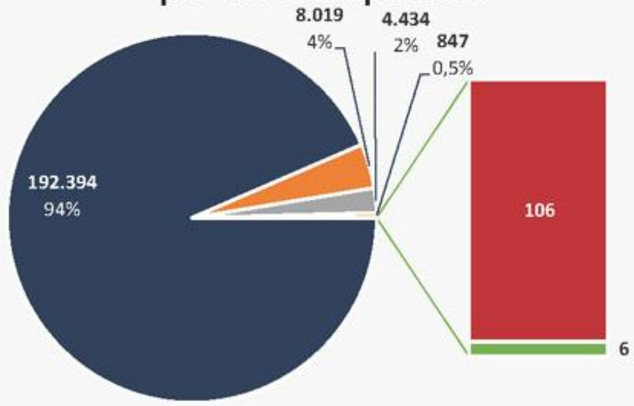
2022: connessioni per classe di potenza

ITALIA SOLARE
Il fotovoltaico è di tutti

Potenza connessa per classe di potenza (MW)



N. Impianti connessi per classe di potenza



Totale potenza connessa:

2.482 MW (+164% rispetto al 2021)

Totale N. Impianti connessi:

205.806 (+158% rispetto al 2021)

Potenza media impianto connesso per classe di potenza (kW)

P < 12 kW	12 kW ≤ P < 20 kW	20 kW ≤ P < 200 kW	200 kW ≤ P < 1 MW	1 MW ≤ P < 10 MW	P ≥ 10 MW
5,73	16,27	64,24	463,90	2.657,83	48.182,75

Dati riferiti al periodo 01/01/2022 - 31/12/2022. Fonte: Dati Gaudì.

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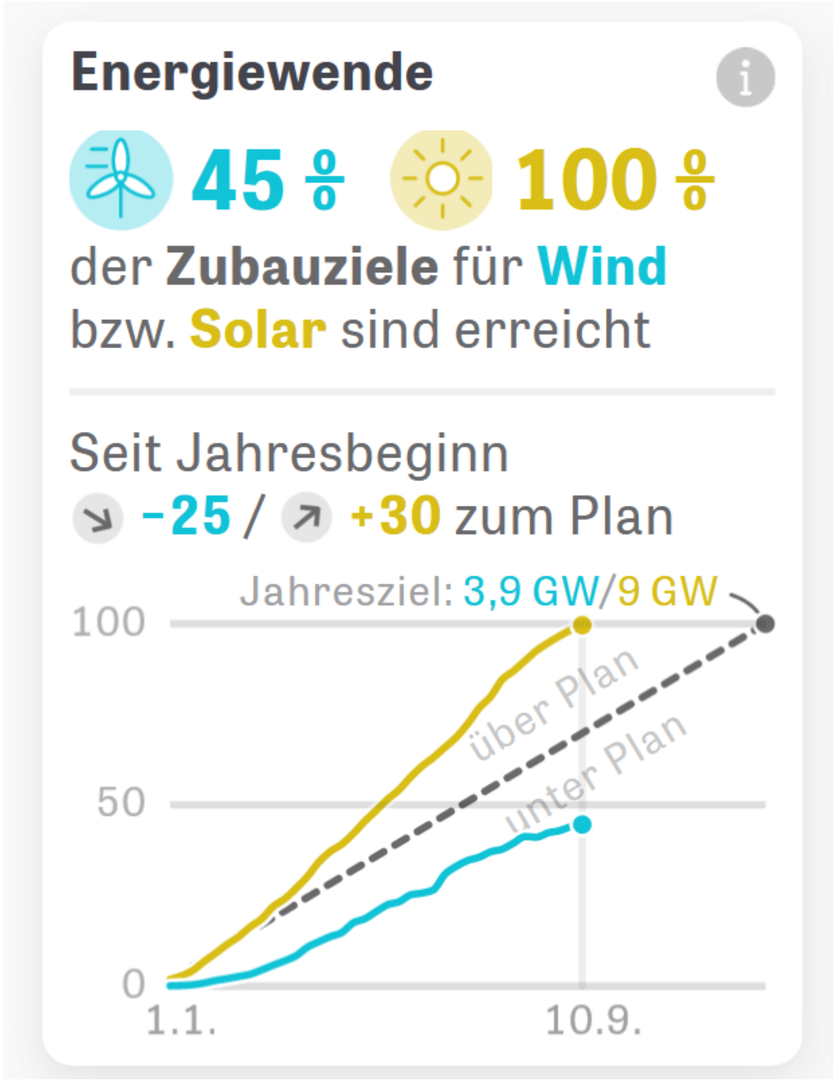
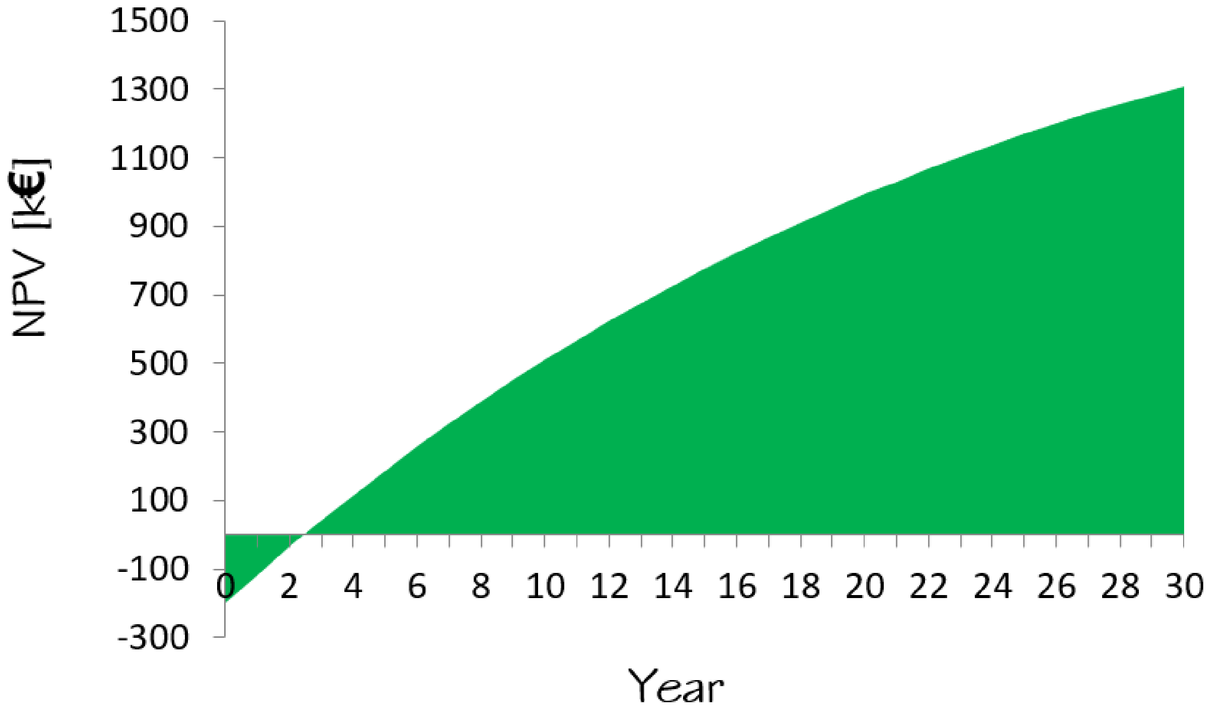
Photovoltaics in Germany, 2023



6.74GW in 2022

Convenienza economica del fotovoltaico

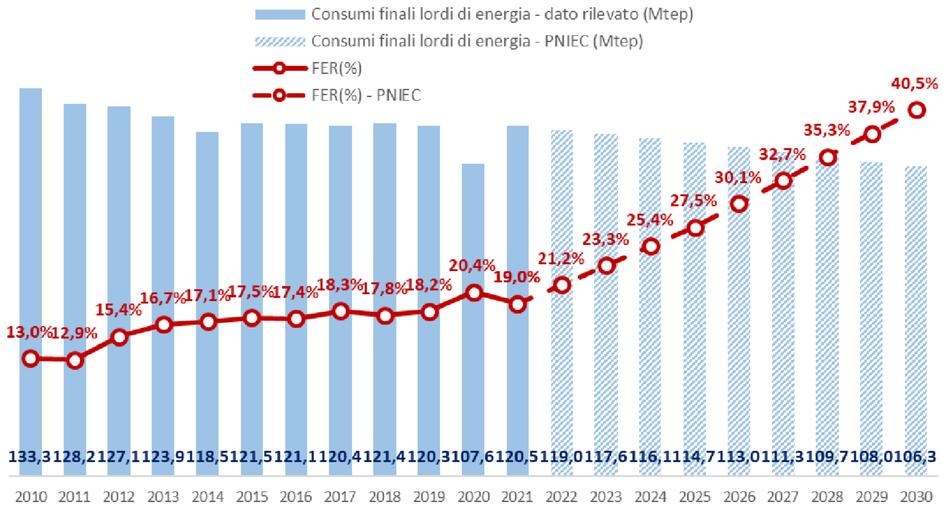
- Autoconsumo: 100%
- **Prezzo energia elettrica 0,30 €/kWh**
- **Energia elettrica fotovoltaica 0.046 €/kWh**
- Tempo di ritorno: <3 anni
- Rendimento dell'investimento: >20%



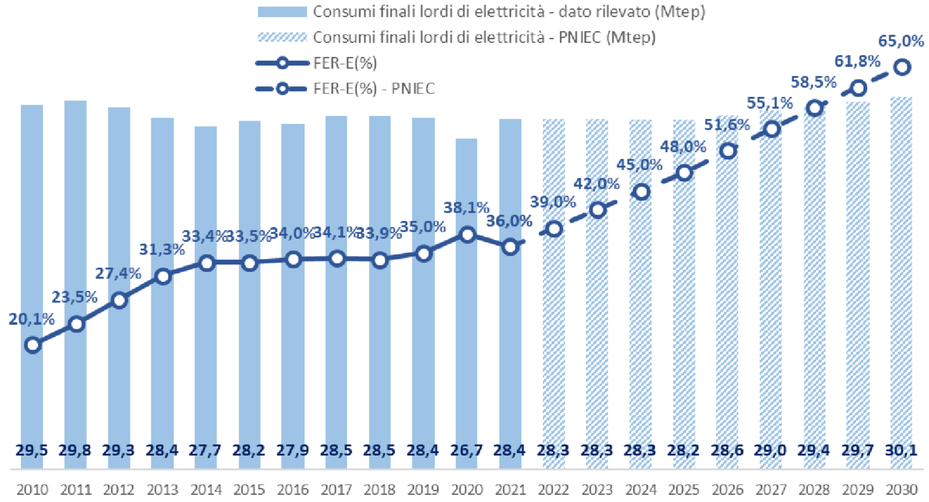
Costo dell’energia elettrica

There is not only power – The example of Italy

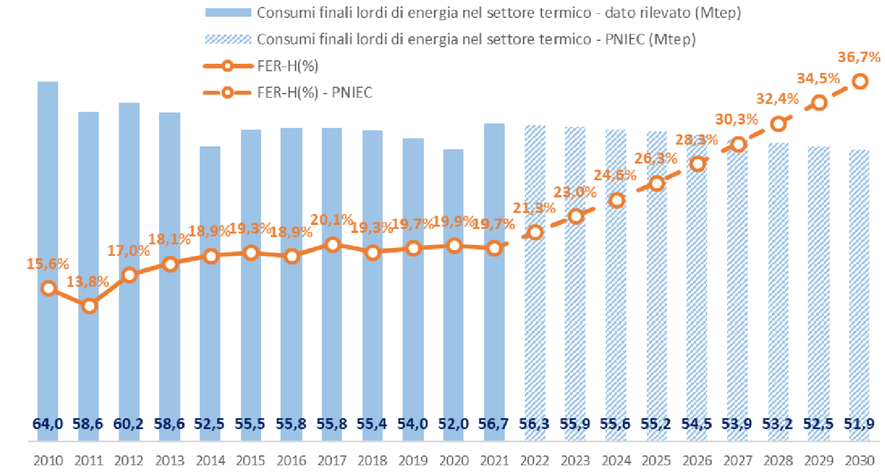
RES - TOTAL



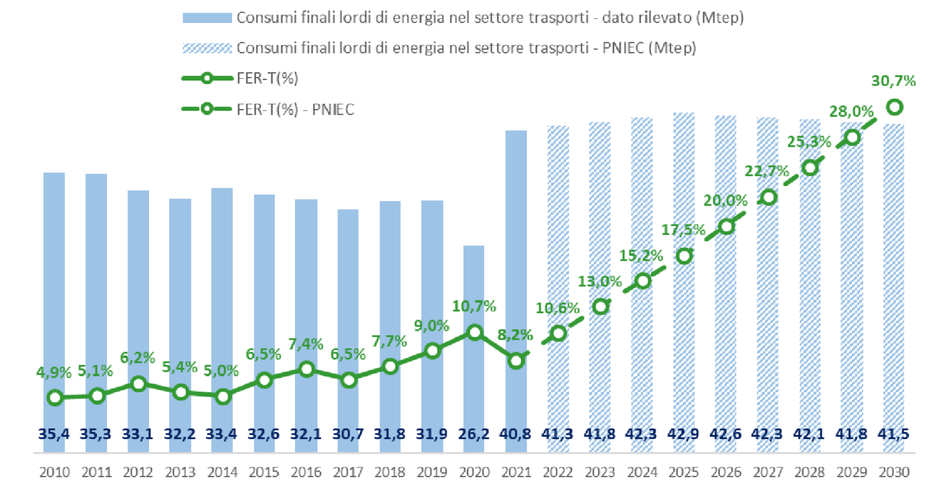
RES - POWER



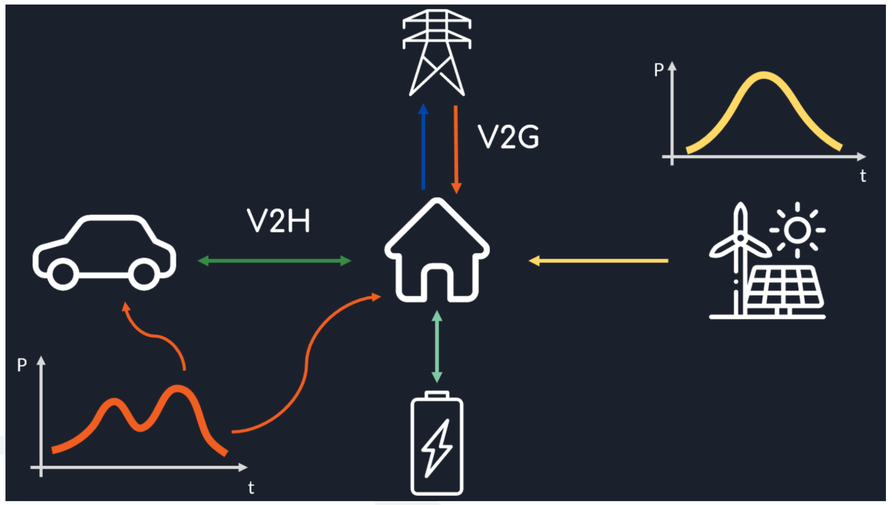
RES - HEAT

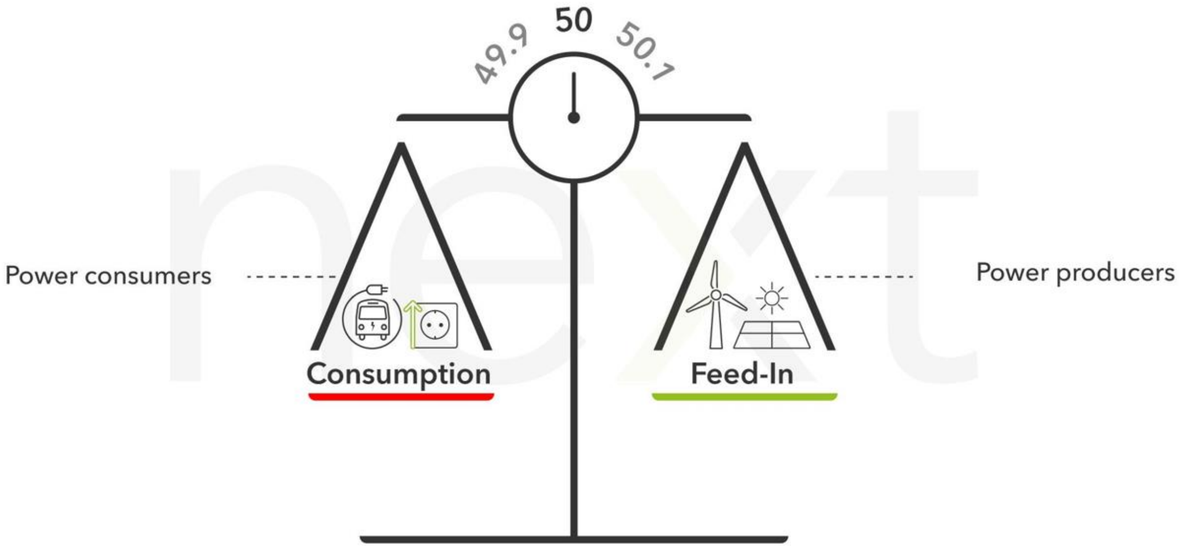


RES - TRANSPORTATION



Sistemi di accumulo «gratuiti»





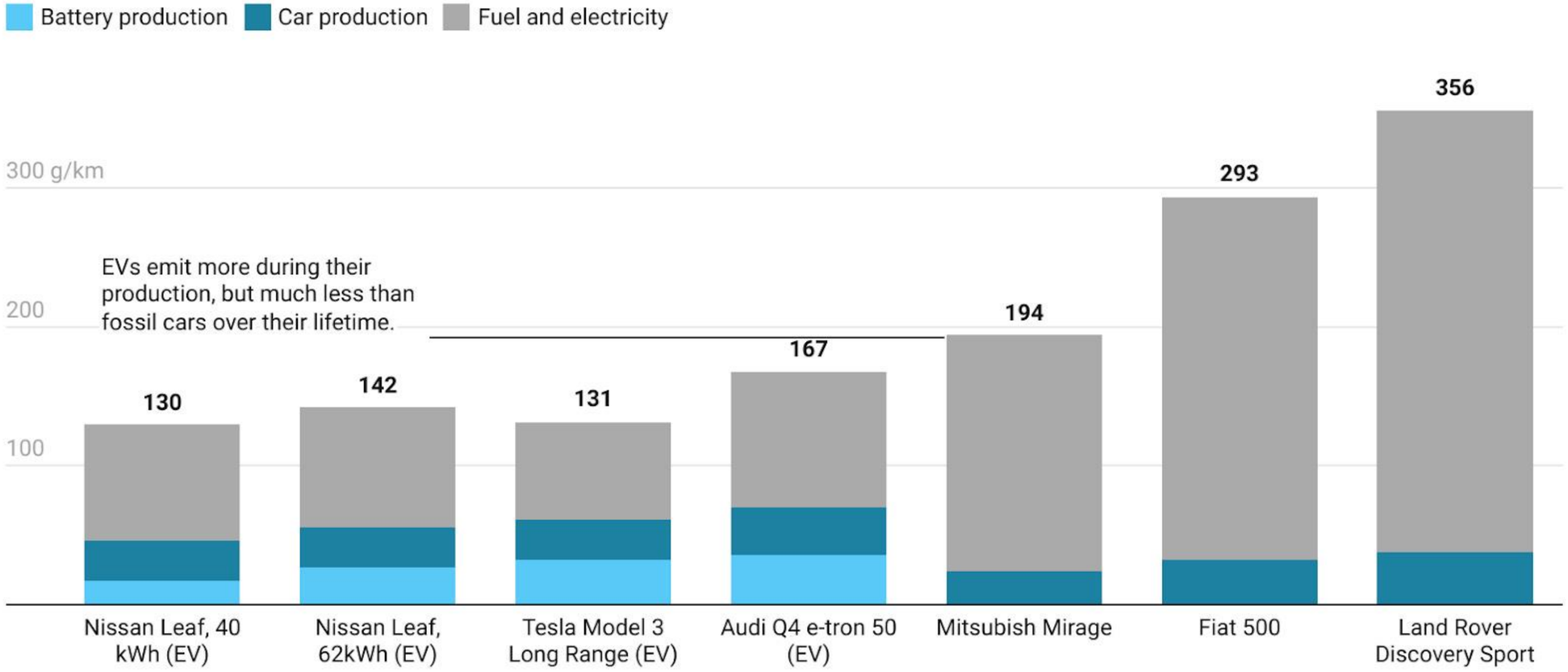
Smart Grid and E-Mobility Lab

UNIVERSITÀ DEGLI STUDI DI TRIESTE

Dipartimento di Ingegneria e Architettura

Emissions of electric vehicles vs. fossil fuel cars, US average energy mix

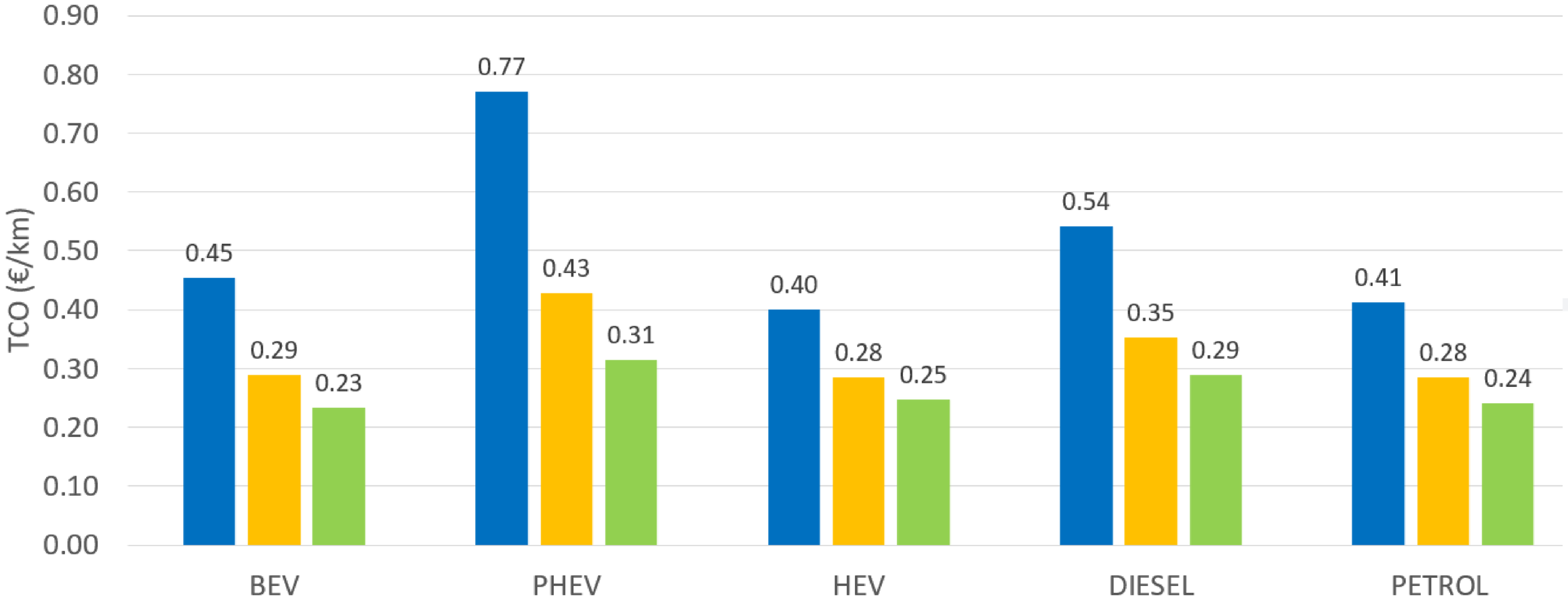
Life-cycle emissions of electric vehicles (EVs) versus fossil fuel cars. This is based on production and fuelling of the car in the US. Emissions are measured in grams CO_2 per kilometer.



Assumes a mileage of 14,000 miles per year, which is the average in the US, and a car lifetime of 10 years.

Chart: Hannah Ritchie • Source: Based on data from CarbonCounter.com • Created with Datawrapper

Total Cost of Ownership (TCO)



Fiat 500e

Jeep Compass 1.3 Turbo T4xe

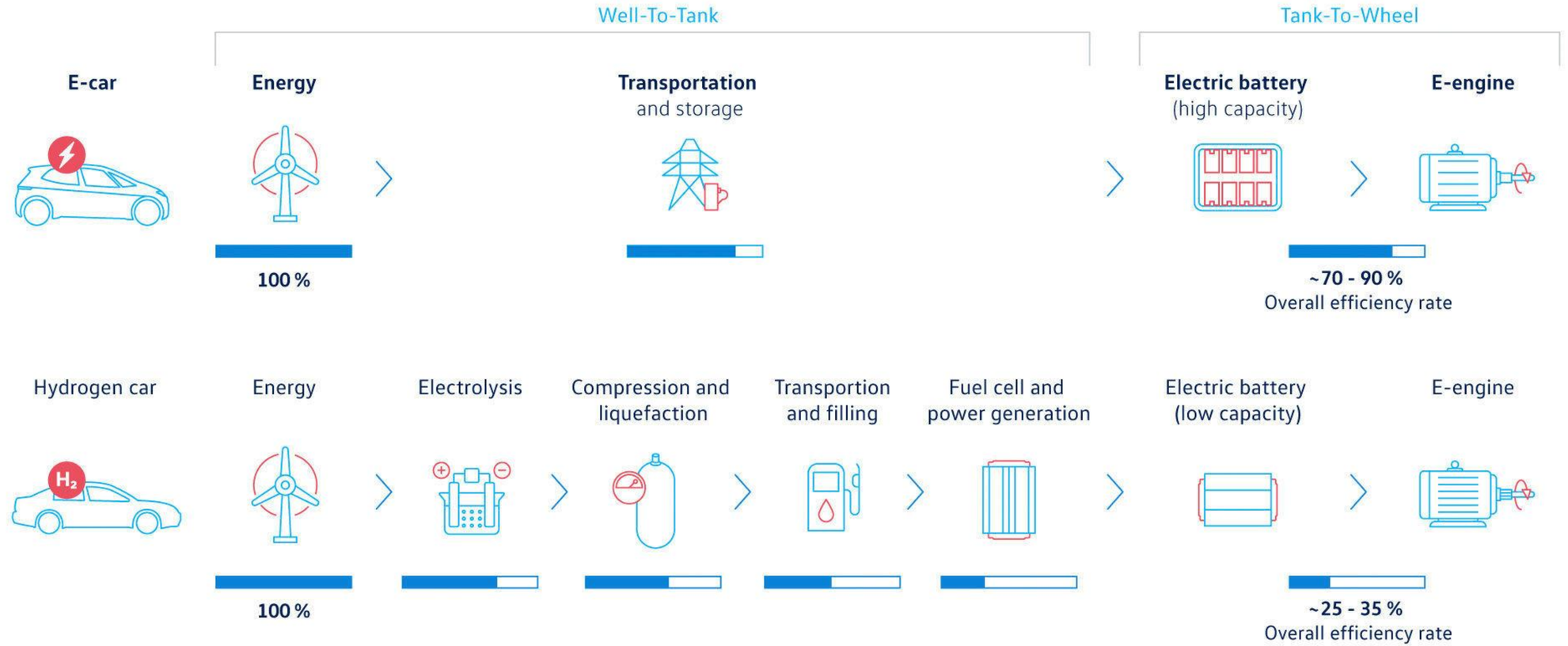
Fiat Panda 1.0 Hybrid

Fiat 500X 1.3 Multijet Club

Citroen C3 1.2 PureTech You

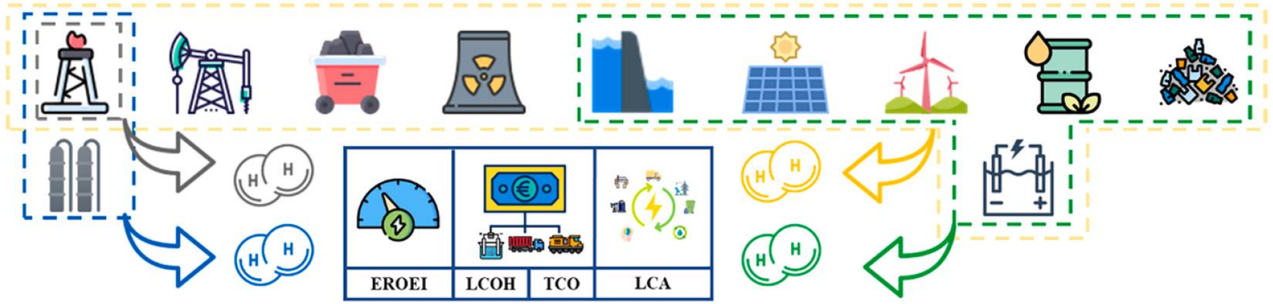
Hydrogen **and electric drive**

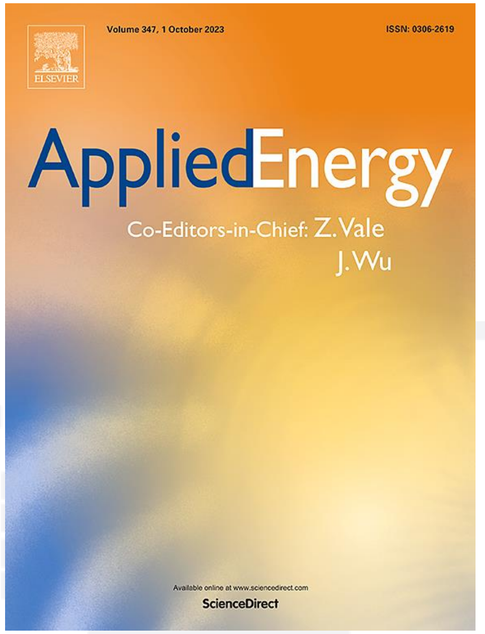
Efficiency rates in comparison using eco-friendly energy



Source Volkswagen

Idrogeno



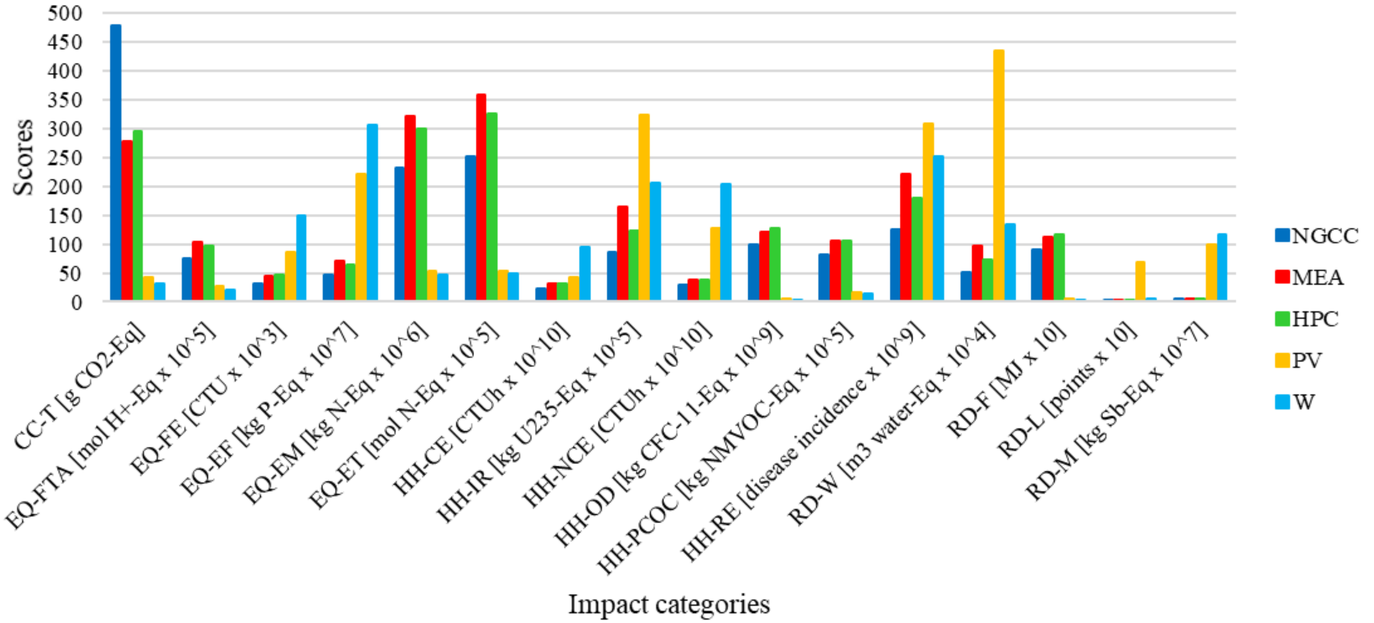


- Idrogeno da diversi processi nel porto di Trieste
- EROEI, LCOH, TCO, LCA
- Locotrattori e camion
- Solo idrogeno verde

Analysis of the energetic, economic, and environmental performance of hydrogen utilization for port logistic activities

Andrea Mio [a,d], Elena Barbera [b,f,*], Alessandro Massi Pavan [a,d], Romeo Danielis [c,d], Alberto Bertucco [b,e], Maurizio Fermeglia [a,d]

Carbon Capture and Storage

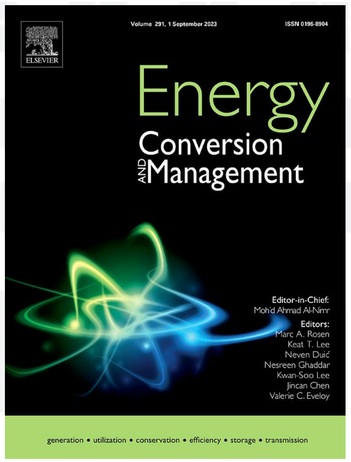


Calculated values of EROEI [-] and EROC [GJ / tCO_2] for the systems studied at two different values of cf.

Process	cf	EROEI	EROC
NGCC	0.40	17.60	16.81
	0.85	21.37	16.99
NGCC + CCS MEA	0.40	7.73	163.1
	0.85	12.36	167.1
NGCC + CCS HPC	0.40	5.21	163.1
	0.85	9.06	167.1

LCOEs expressed in €/MWh for an NGCC power plant using the two considered CCS technologies as a function of the capacity factor for a plant life time L = 30 years.

cf	NGCC with MEA	Extra cost due to MEA	NGCC with HPC	Extra cost due to HPC
0.40	[131 – 153]	53	[178 – 200]	100
0.85	[102 – 124]	24	[126 – 148]	48



Fuelling power plants by natural gas: An analysis of energy efficiency, economical aspects and environmental footprint based on detailed process simulation of the whole carbon capture and storage system

Elena Barbera [a], Andrea Mio [b,d,*], Alessandro Massi Pavan [b,d], Alberto Bertucco [a,c], Maurizio Fermeglia [b,d]

Tecnologie abilitanti la transizione 100% rinnovabile

- Fotovoltaico ed eolico sovradimensionati
- Interconnessioni
- Demand response
- Sistemi di stoccaggio (batterie, idroelettrico, termico, …)
- Elettrolizzatori e celle a combustibile (idrogeno)
- Vehicle-to-grid (V2G) and Vehicle-to-home (V2H)
- Corrente continua e generazione distribuita
- Smart Grid (previsione della produzione e dei consumi)
- Trasformazione digitale (IoT, Big data, Block Chain, 5G, …)
- Comunità energetiche
- …. W la ricerca!!