Incontro con le commisioni III e VI della citta'di Torino

Comune di Torino
12 maggio 2023

CAReGIVER

Energy & Power

Difference between energy and power

Energy and power are two terms that are frequently used interchangeably, but this is their definition: The amount of energy per unit of time required to perform a task is measured as power.

What is energy

Energy is movement or the ability to move. Therefore, energy can neither be created nor utilized, but only converted to other forms. Nevertheless, for the sake of simplicity, terms such as energy source, energy generation and energy consumption are used.

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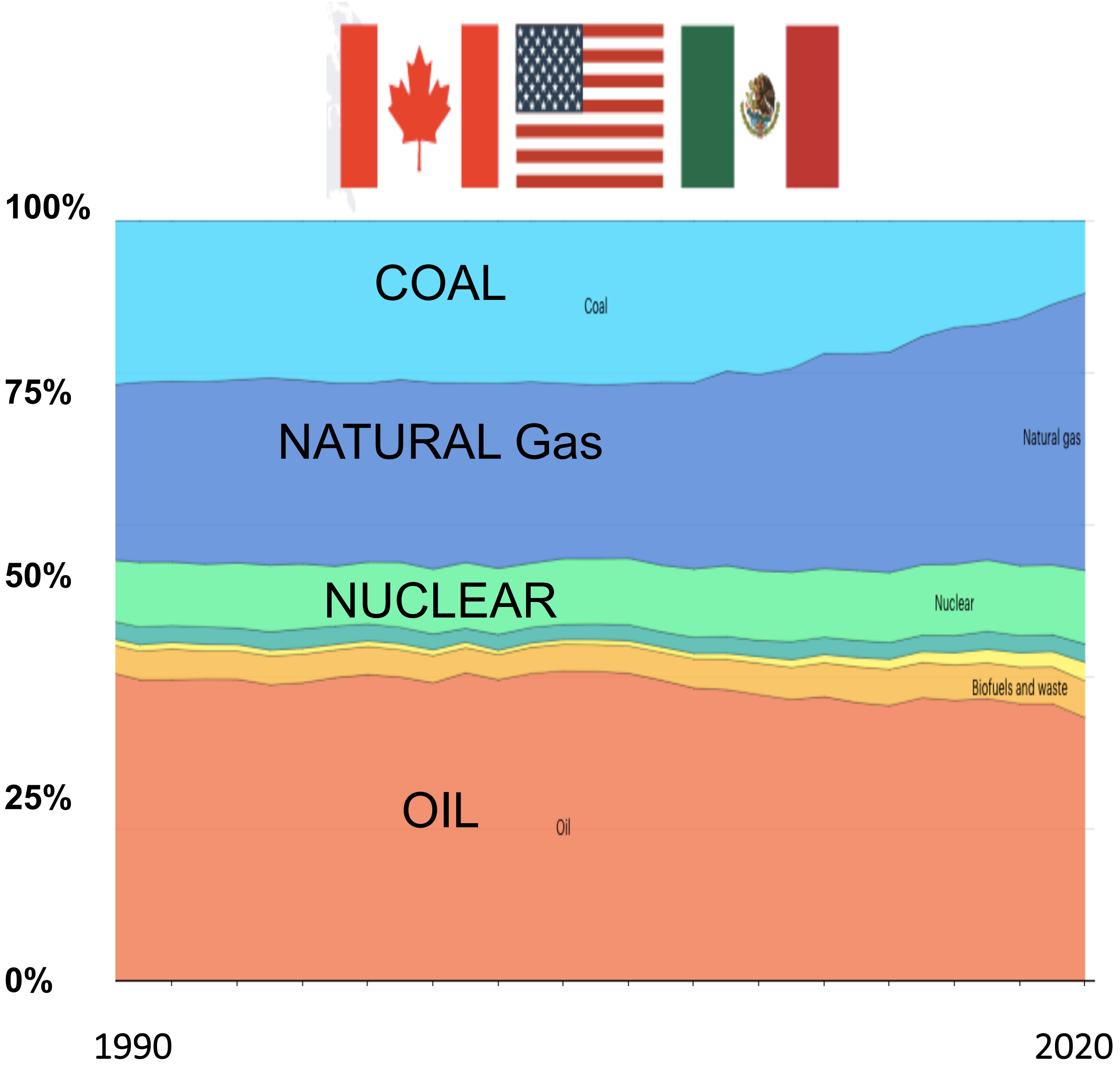
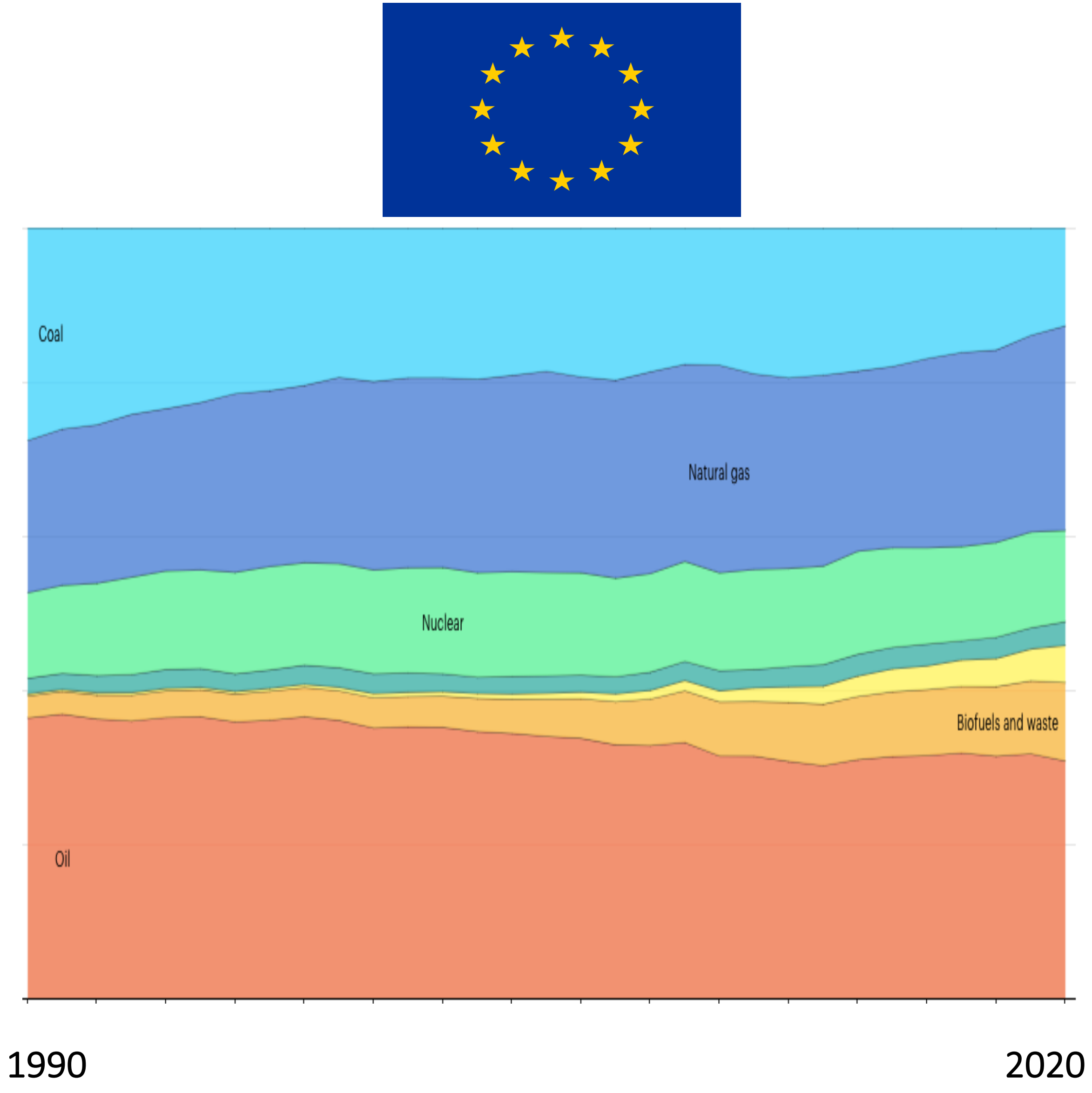
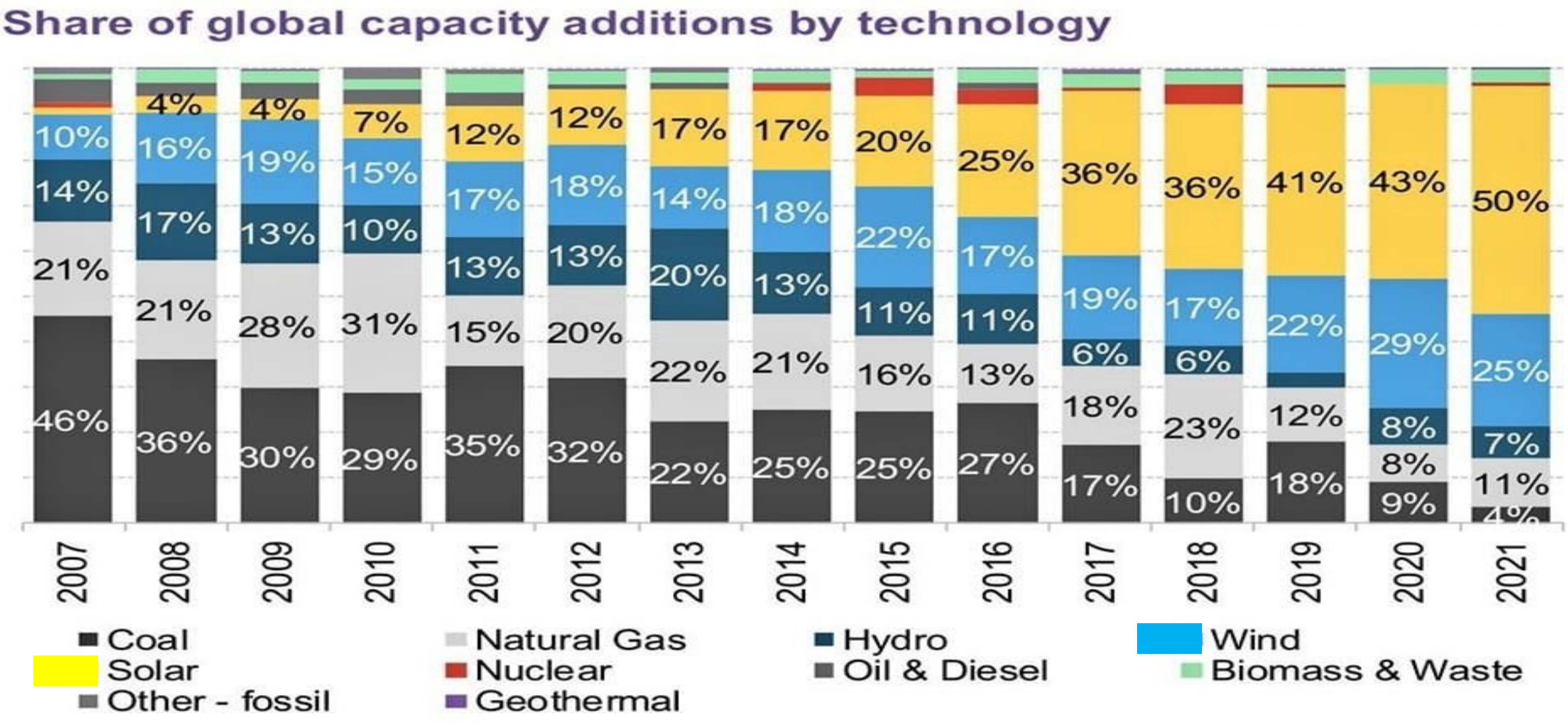
Total Energy – by fuel NAR (Canada, Usa, Mexico) & EU

https://www.iea.org/regions/europe



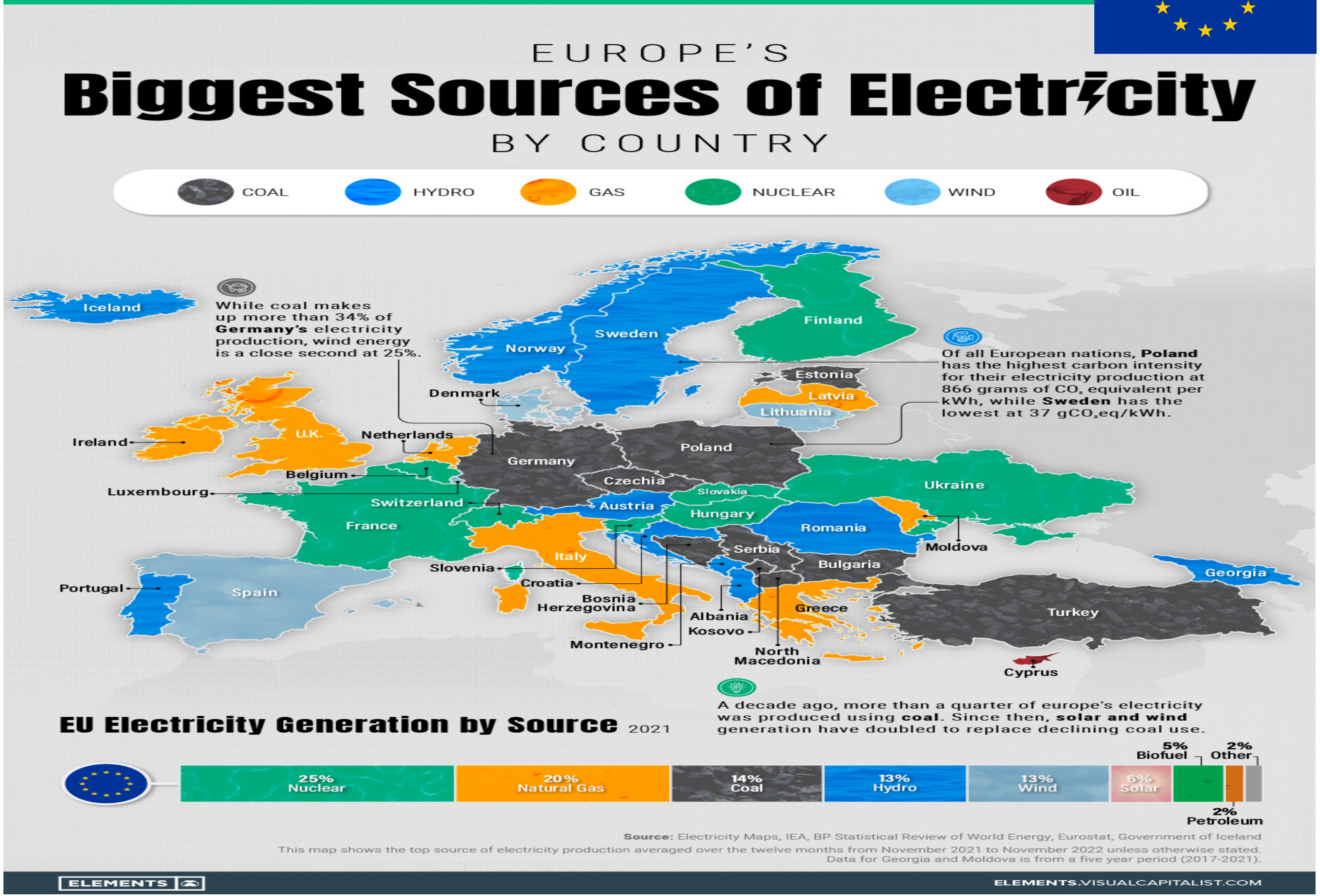


Energy - New electric Power Plant – additions by tech



Source: BloombergNEF. Note: Share of global capacity additions excluding retirements.

Energy – main source in EU



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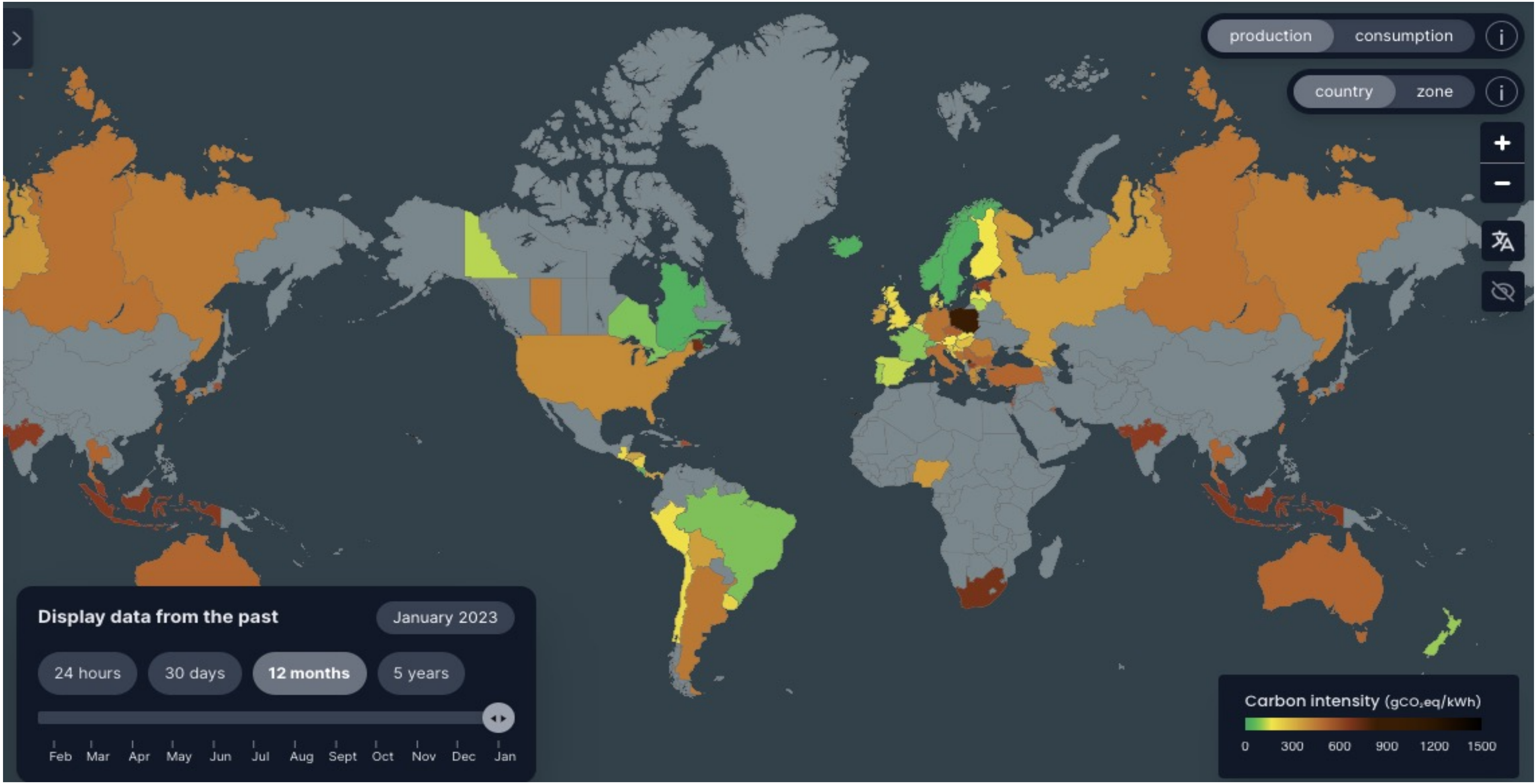
Emissions - view by country

https://app.electricitymaps.com/map



Power Plant – LCOE comparison in USA

$$\text{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}}$$

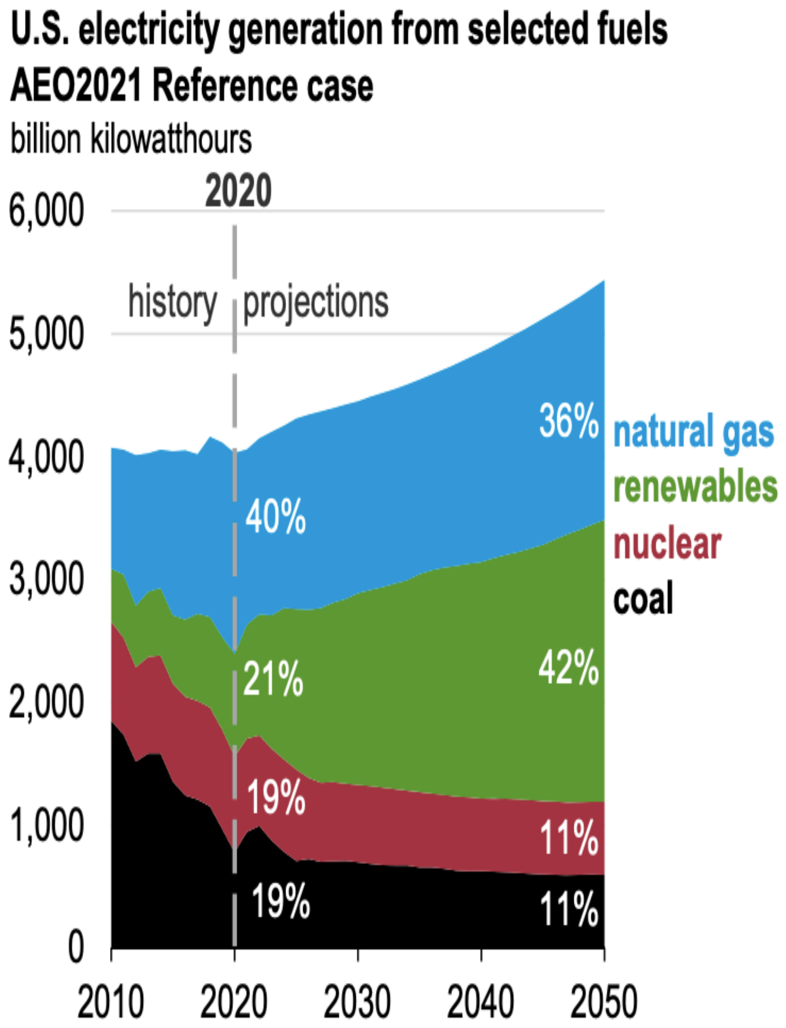


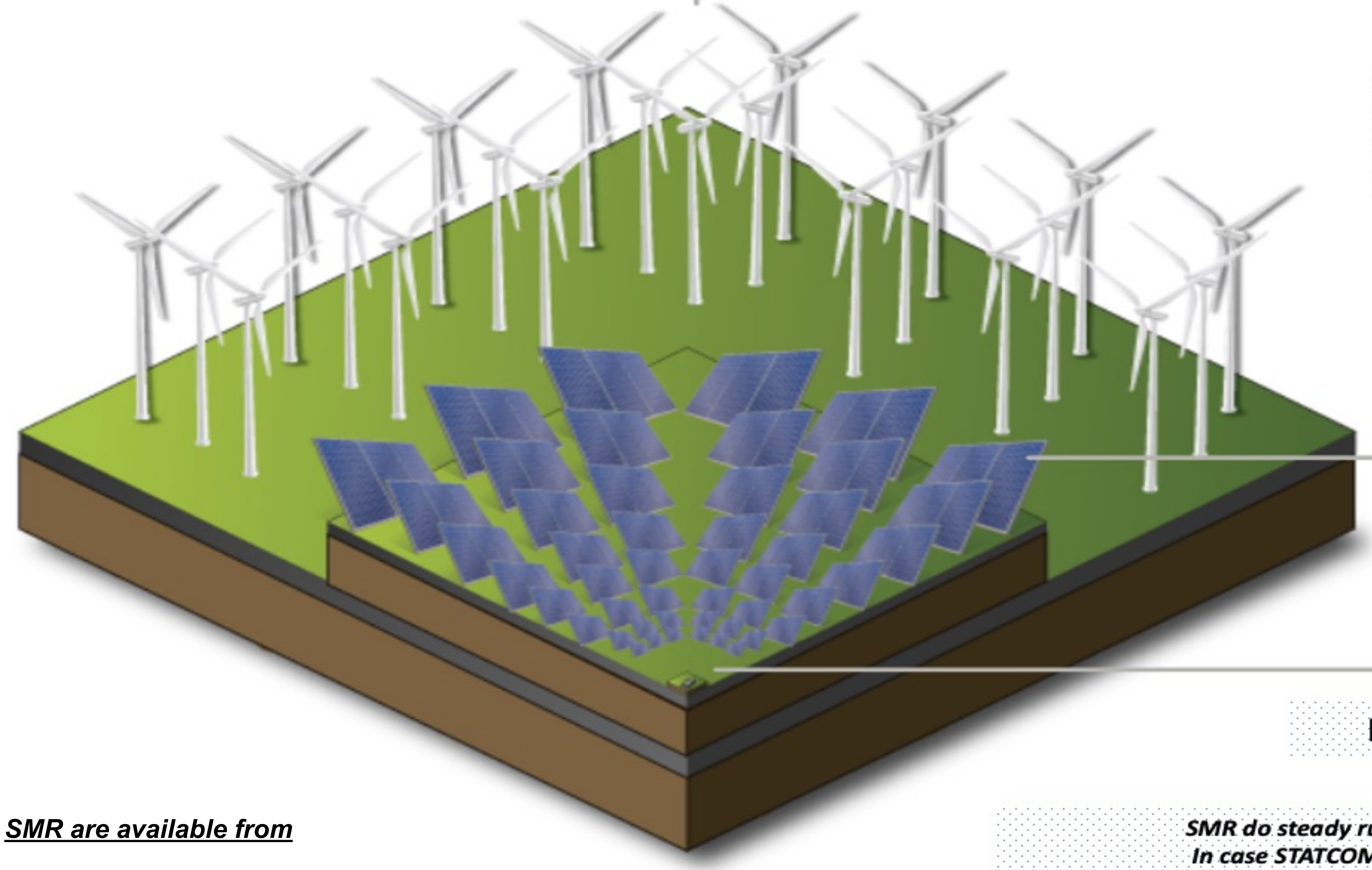
Table 1b. Estimated unweighted levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2027 (2021 dollars per megawatthour)

Plant type	Capacity factor (percent)	Levelized capital cost	Levelized fixed O&M[a]	Levelized variable cost	Levelized transmis-sion cost	Total system LCOE or LCOS	Levelized tax credit[b]	Total LCOE or LCOS including tax credit
Dispatchable technologies								
Ultra-supercritical coal	85%	$52.11	$5.71	$23.67	$1.12	$82.61	*NA*	$82.61
Combined cycle	87%	$9.36	$1.68	$27.77	$1.14	$39.94	*NA*	$39.94
Advanced nuclear	90%	$60.71	$16.15	$10.30	$1.08	$88.24	-$6.52	$81.71
Geothermal	90%	$22.04	$15.18	$1.21	$1.40	$39.82	-$2.20	$37.62
Biomass	83%	$40.80	$18.10	$30.07	$1.19	$90.17	*NA*	$90.17
Resource-constrained technologies								
Wind, onshore	41%	$29.90	$7.70	$0.00	$2.63	$40.23	*NA*	$40.23
Wind, offshore	44%	$103.77	$30.17	$0.00	$2.57	$136.51	-$31.13	$105.38
Solar, standalone[c]	29%	$26.60	$6.38	$0.00	$3.52	$36.49	-$2.66	$33.83
Solar, hybrid[c,d]	28%	$34.98	$13.92	$0.00	$3.63	$52.53	-$3.50	$49.03
Hydroelectric[d]	54%	$46.58	$11.48	$4.13	$2.08	$64.27	*NA*	$64.27
Capacity resource technologies								
Combustion turbine	10%	$53.78	$8.37	$45.83	$9.89	$117.86	*NA*	$117.86
Battery storage	10%	$64.03	$29.64	$24.83	$10.05	$128.55	*NA*	$128.55

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2022*

[a] O&M = operations and maintenance

Power Plant – surface by type



Wind Power
225 MWe on 60,000 acres of land

Wind & Solar are not suitable for the steady run and can't be properly connected to grid, without a large MWh-BESS (battery energy storage). To provide either peak shaving & steady energy release

Solar Power
225 MWe on 2400 acres of land

Nuclear - Small Modular Reactor - SMR
225+ MWe on only 15 acres of land

SMR do steady run and can follow load change of +- 10% power. In case STATCOM technology is enough to link the grid properly

<u>SMR are available from</u>

Westinghouse
RollsRoyce
NuScale
NewCleo – start-up HQ in Torino-Ita

Energy & Power - electric

https://www.cia.gov/the-world-factbook/countries/

Electricity

122 GW – 287 TWh

installed generating capacity: 121.442 million kW (2020 est.)

consumption: 286.375 billion kWh (2020 est.)

exports: 7.587 billion kWh (2020 est.)

imports: 39.787 billion kWh (2020 est.)

transmission/distribution losses: 17.702 billion kWh (2020 est.)

Electricity generation sources

fossil fuels: 55.9% of total installed capacity (2020 est.) **56 %**

nuclear: 0% of total installed capacity (2020 est.)

solar: 9.2% of total installed capacity (2020 est.)

wind: 6.9% of total installed capacity (2020 est.)

hydroelectricity: 17.5% of total installed capacity (2020 est **18 %**

tide and wave: 0.2% of total installed capacity (2020 est.)

geothermal: 2.2% of total installed capacity (2020 est.)

biomass and waste: 8.1% of total installed capacity (2020 est.)

Electricity

139 GW – 473 TWh

installed generating capacity: 138.611 million kW (2020 est.)

consumption: 472.699 billion kWh (2020 est.)

exports: 64.425 billion kWh (2020 est.)

imports: 19.613 billion kWh (2020 est.)

transmission/distribution losses: 36.203 billion kWh (2020 est.)

Electricity generation sources

8 %

fossil fuels: 8% of total installed capacity (2020 est.)

nuclear: 68.4% of total installed capacity (2020 est.) **69 %**

solar: 2.5% of total installed capacity (2020 est.)

wind: 7.3% of total installed capacity (2020 est.)

hydroelectricity: 11.7% of total installed capacity (202 **12 %**

tide and wave: 0.2% of total installed capacity (2020 est.)

geothermal: 0% of total installed capacity (2020 est.)

biomass and waste: 2% of total installed capacity (202 https://www.cia.gov/the-world-factbook/countries/

Energy & Power - electric

Electricity

122 GW – 287 TWh

installed generating capacity: 121.442 million kW (2020 est.)

consumption: 286.375 billion kWh (2020 est.)

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transmission/distribution losses: 17.702 billion kWh (2020 est.)

Electricity generation sources

fossil fuels: 55.9% of total installed capacity (2020 est.) **56 %**

nuclear: 0% of total installed capacity (2020 est.)

solar: 9.2% of total installed capacity (2020 est.)

wind: 6.9% of total installed capacity (2020 est.)

hydroelectricity: 17.5% of total installed capacity (2020 est **18 %**

tide and wave: 0.2% of total installed capacity (2020 est.)

geothermal: 2.2% of total installed capacity (2020 est.)

biomass and waste: 8.1% of total installed capacity (2020 est.)

Electricity

115 GW – 233 TWh

installed generating capacity: 115.837 million kW (2020 est.)

consumption: 233.267 billion kWh (2020 est.)

exports: 14.649 billion kWh (2020 est.)

imports: 17.928 billion kWh (2020 est.)

transmission/distribution losses: 23.999 billion kWh (2020 est.)

Electricity generation sources

33 %

fossil fuels: 32.4% of total installed capacity (2020 est.)

nuclear: 21.9% of total installed capacity (2020 est.) **22 %**

solar: 8.1% of total installed capacity (2020 est.)

22 %

wind: 22.1% of total installed capacity (2020 est.)

hydroelectricity: 13.1% of total installed capacity (202 **13 %**

tide and wave: 0% of total installed capacity (2020 est.)

geothermal: 0% of total installed capacity (2020 est.)

biomass and waste: 2.6% of total installed capa... est.)

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https://www.cia.gov/the-world-factbook/countries/

Energy & Power - electric

Electricity

248 GW – 500 TWh

installed generating capacity: 248.265 million kW (2020 est.)

consumption: 500.35 billion kWh (2020 est.)

exports: 66.931 billion kWh (2020 est.)

imports: 48.047 billion kWh (2020 est.)

transmission/distribution losses: 25.97 billion kWh (2020 est.)

Electricity generation sources

fossil fuels: 40.5% of total installed capacity (2020 est.) **40 %**

nuclear: 11.1% of total installed capacity (2020 est.) **10 %**

solar: 9.2% of total installed capacity (2020 est.)

wind: 23.9% of total installed capacity (2020 est.) **24 %**

hydroelectricity: 4.5% of total installed capacity (2020 est.)

tide and wave: 0.2% of total installed capacity (2020 est.)

geothermal: 0% of total installed capacity (2020 est.)

biomass and waste: 10.4% of total installed capacity (2020 est.)

Electricity

349 GW – 904 TWh

installed generating capacity: 348.666 million kW (2020 est.)

consumption: 903,698,740,000 kWh (2019 est.)

exports: 0 kWh (2020 est.)

imports: 0 kWh (2020 est.)

transmission/distribution losses: 44.094 billion kWh (2019 est.)

Electricity generation sources

fossil fuels: 73.5% of total installed capacity (2020 est.) **73 %**

nuclear: 4.8% of total installed capacity (2020 est.)

solar: 8.8% of total installed capacity (2020 est.)

wind: 1% of total installed capacity (2020 est.)

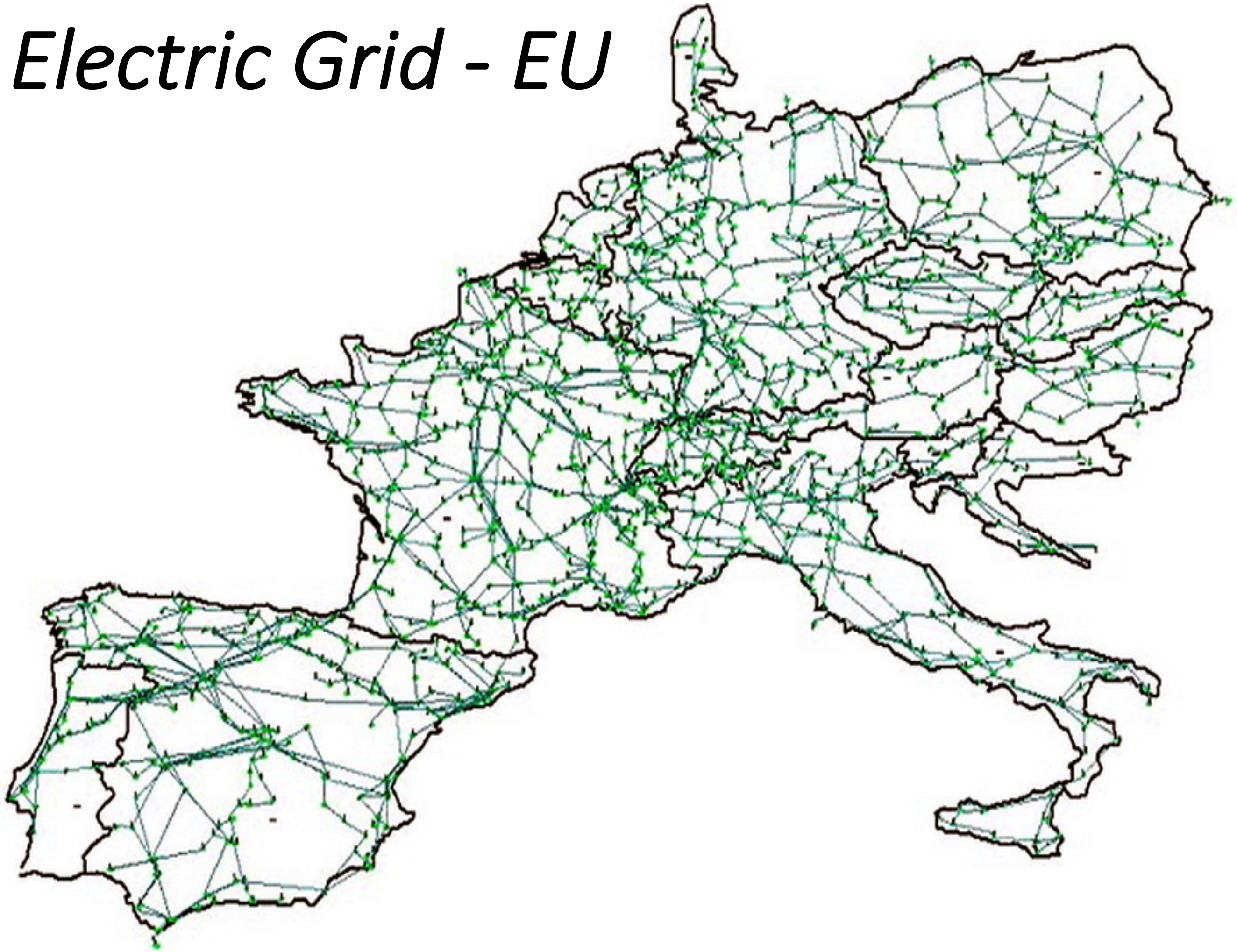
hydroelectricity: 10% of total installed capacity (202 **10 %**

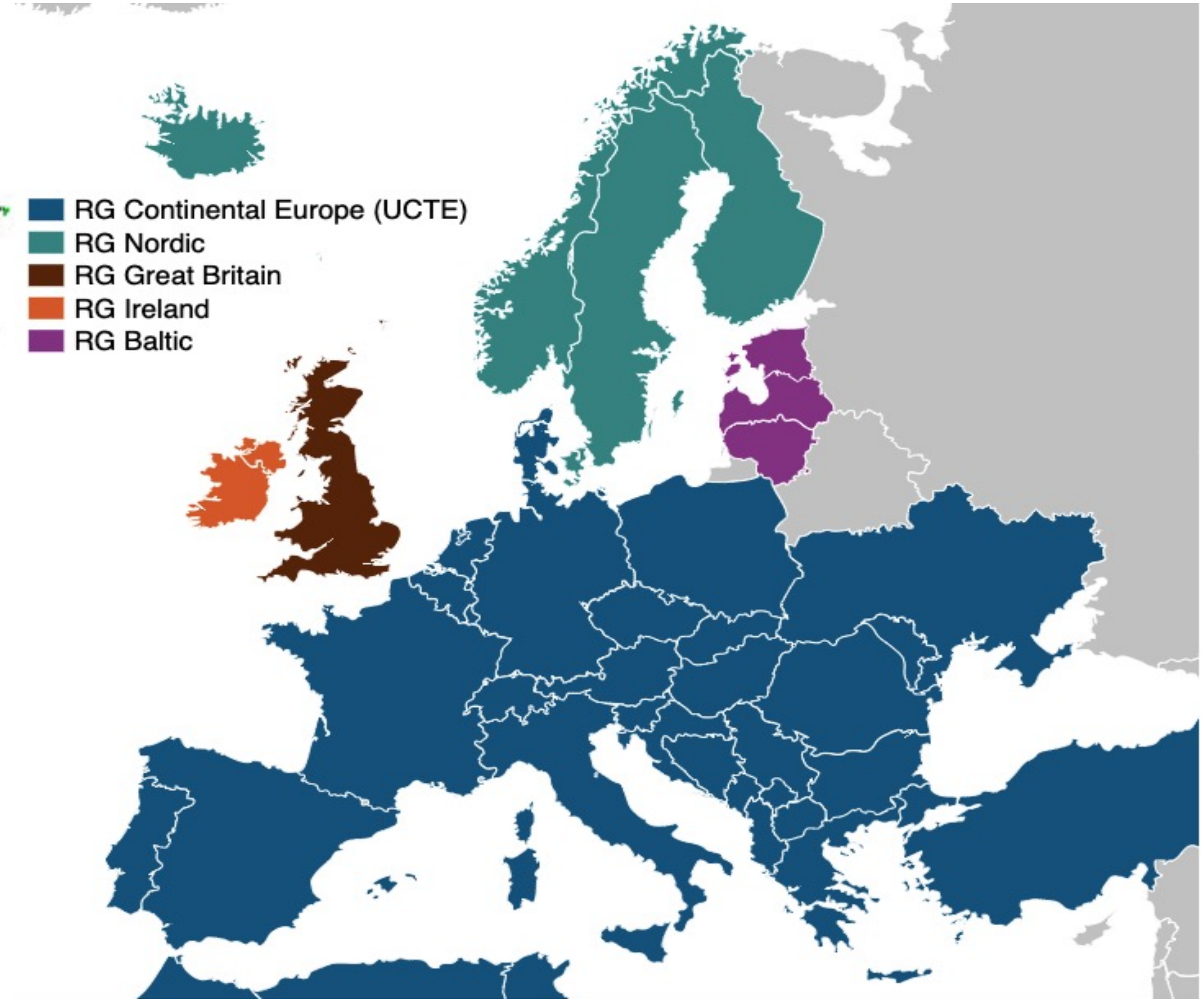
tide and wave: 0% of total installed capacity (2020 est.)

geothermal: 0.3% of total installed capacity (2020 est.)

biomass and waste: 1.6% of total installed capac y (20 est.)

Electric Grid - EU

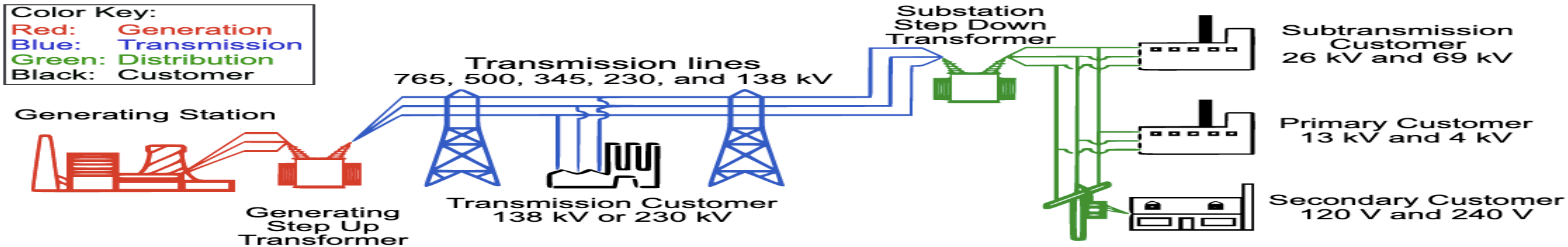




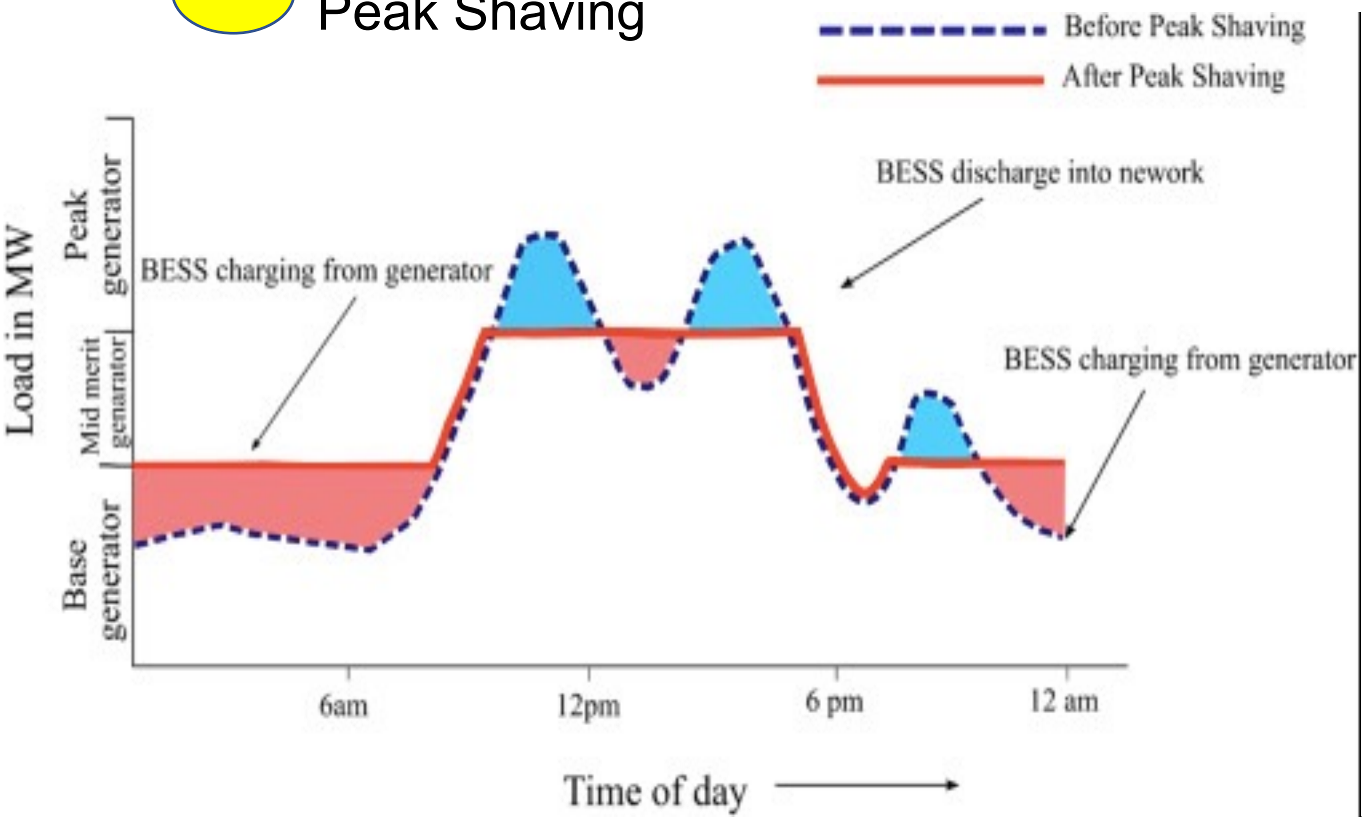
The **synchronous grid of Continental Europe** (also known as **Continental Synchronous Area**; formerly known as the **UCTE grid**) is the largest synchronous electrical grid (by connected power) in the world. It is interconnected as a single phase-locked 50 Hz mains frequency electricity grid that supplies over 400 million customers in 24 countries, including most of the European Union.

€ zone > 750 GW
UCTE > 1000 GW

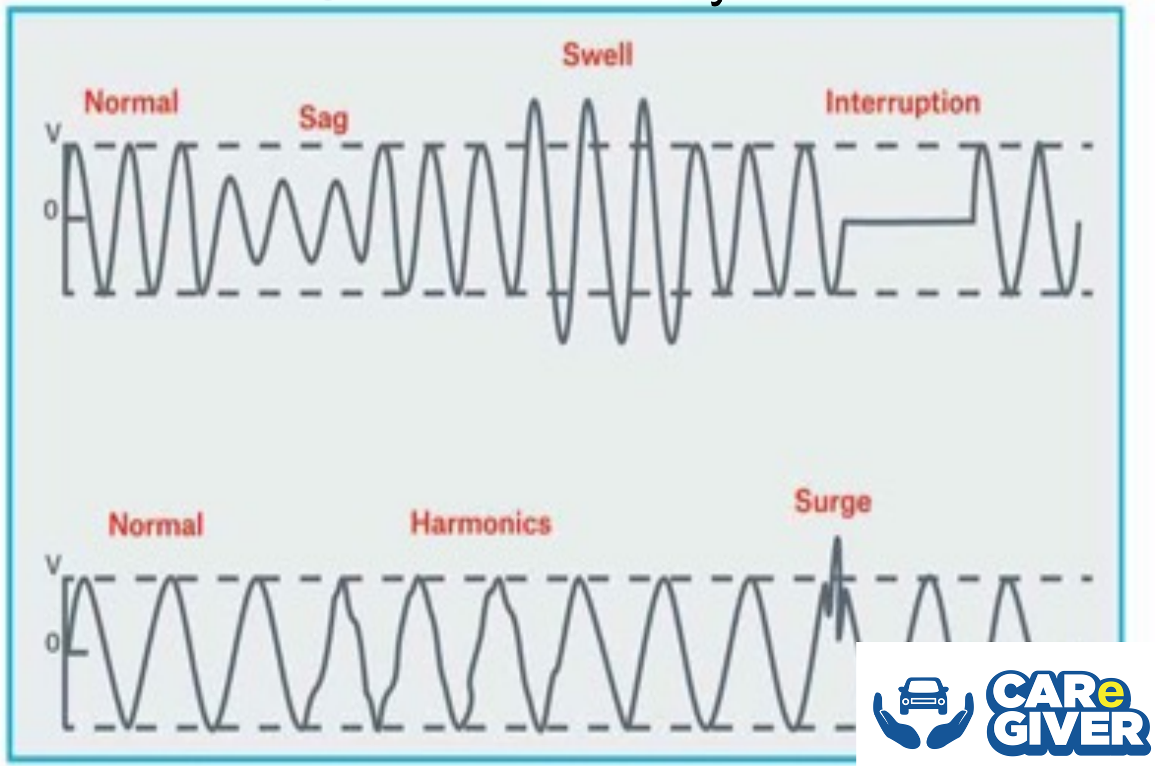
Electric Grid - stability



Peak Shaving

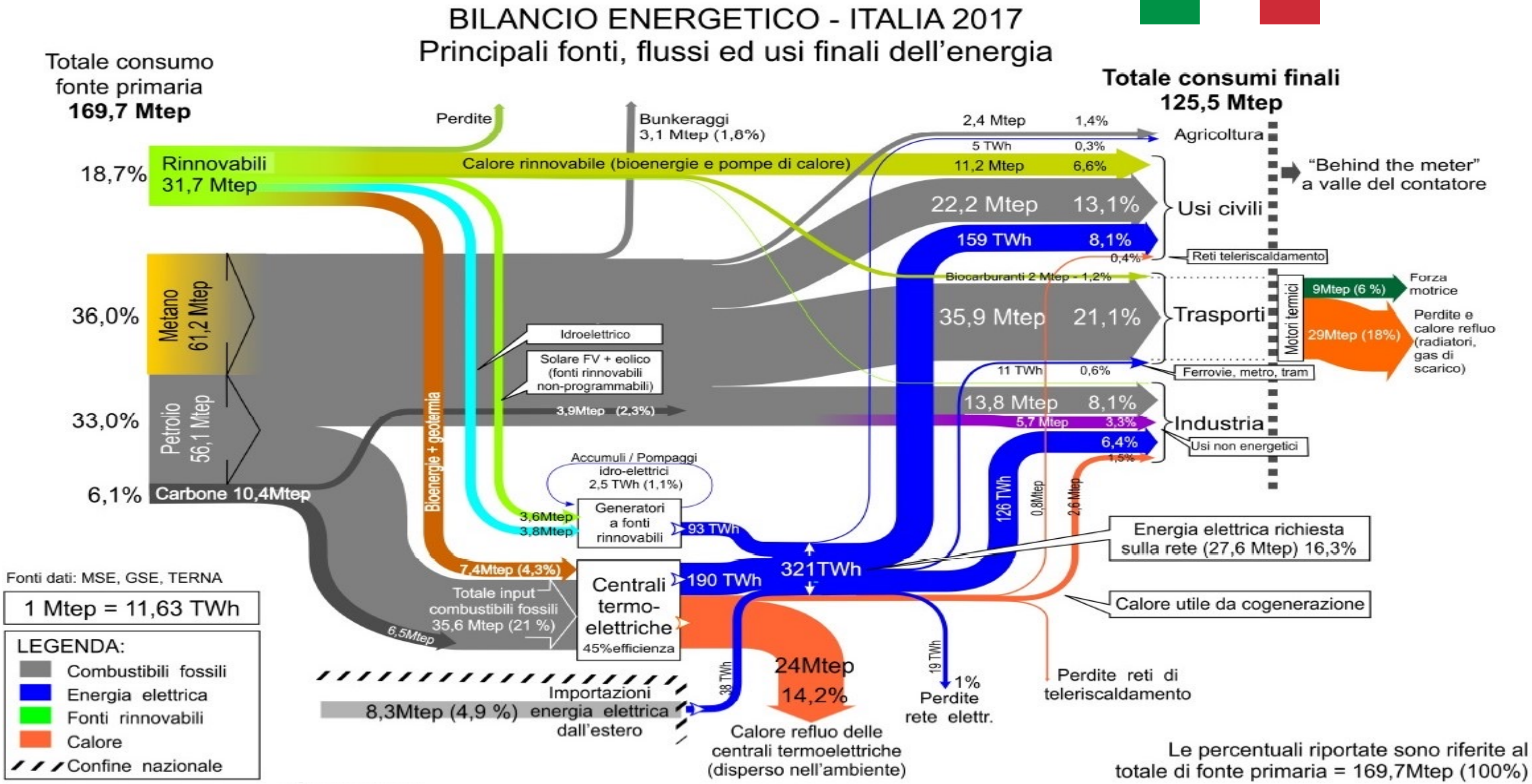


Power Quality



Total Energy Balance

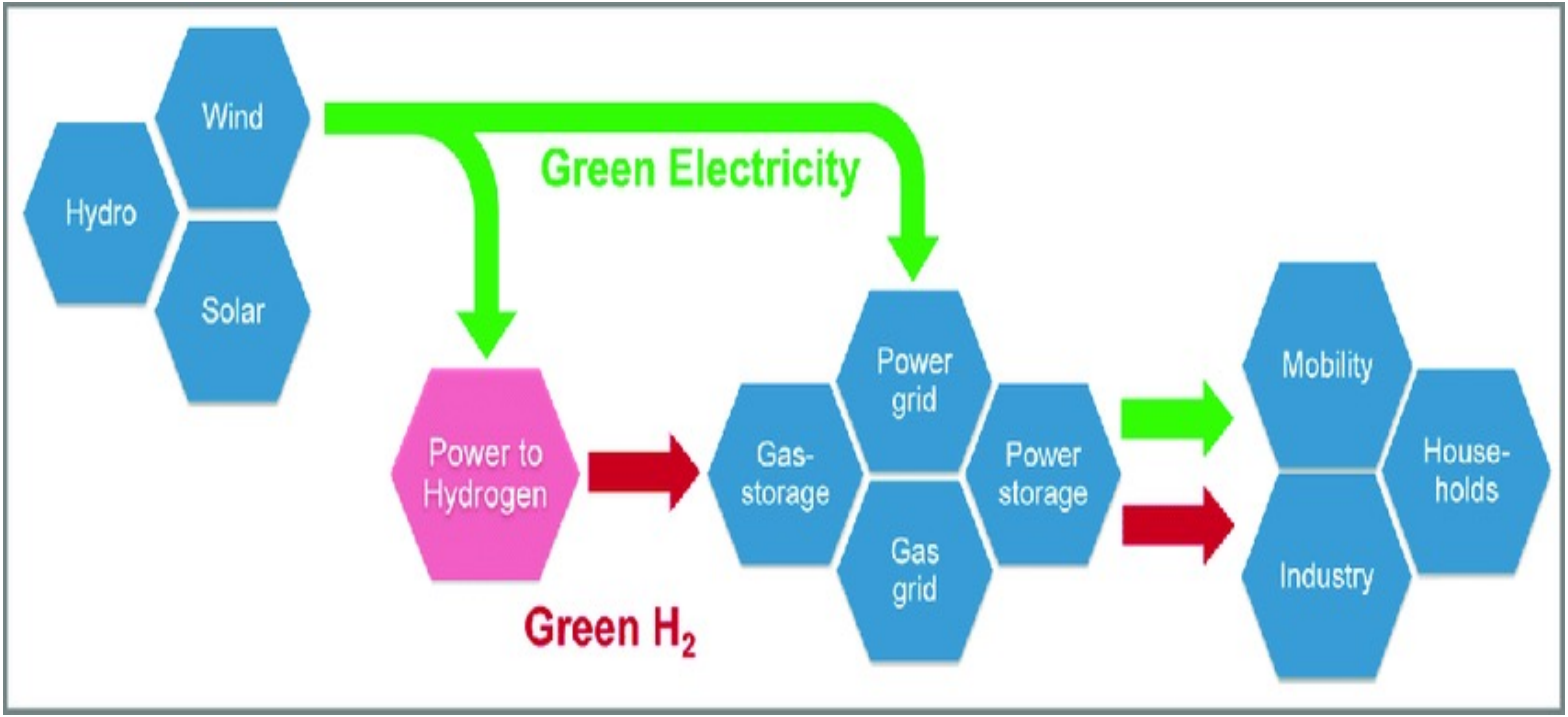
https://www.qualenergia.it/



Energy – type of fuel *(H2 better E/Kg, vs battery also better E/m3)*

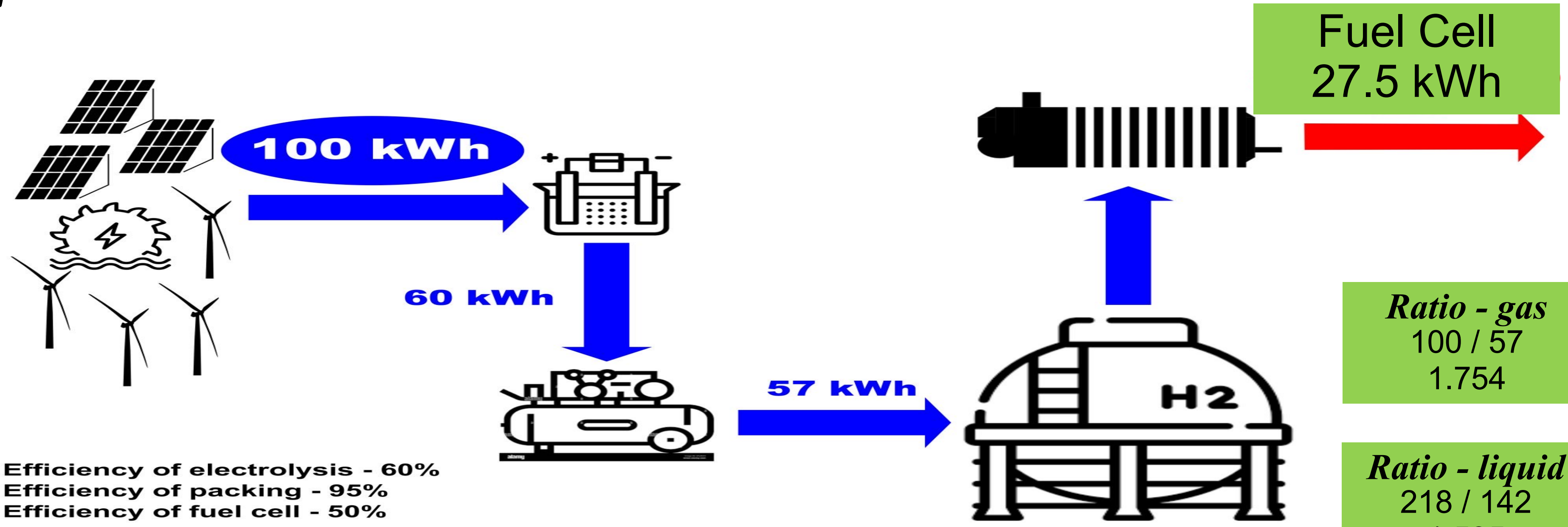
Fuel type	Specific density [kg/m3]	Gravitometric energy density [kWh/kg]	Volumetric energy density [kWh/m3]	Storage pressure [MPa]	Storage temperature [°C]
Marine gas oil	900 kg/m3	12 kWh/kg	10800 kWh/m3	0.1	20
Diesel	850 kg/m3	12.6 kWh/kg	10710 kWh/m3	0.1	20
Kerosene	800 kg/m3	12 kWh/kg	9600 kWh/m3	0.1	20
Ethanol	790 kg/m3	7.5 kWh/kg	5900 kWh/m3	0.1	20
Gasoline	740 kg/m3	13 kWh/kg	9620 kWh/m3	0.1	20
Methanol	790 kg/m3	6.2 kWh/kg	4900 kWh/m3	0.1	20
LNG	424 kg/m3	13.9 kWh/kg	5900 kWh/m3	0.1	-162
Methane 70 MPa	305 kg/m3	13.9 kWh/kg	4240 kWh/m3	70	20
Liquid NH3	717 kg/m3	5.2 kWh/kg	3730 kWh/m3	1	-20
Liquid H2	70 kg/m3	33.6 kWh/kg	2350 kWh/m3	0.1	-253
H2 0.1 MPa	0.089 kg/m3	33.6 kWh/kg	3 kWh/m3	0.1	20
H2 20 MPa	14.5 kg/m3	33.6 kWh/kg	487 kWh/m3	20	20
H2 35 MPa	24 kg/m3	33.6 kWh/kg	806 kWh/m3	35	20
H2 70 MPa	42 kg/m3	33.6 kWh/kg	1411 kWh/m3	70	20
Tesla 4680 NMC811	~2670 kg/m3	~0.244 kWh/kg	~651 kWh/m3	0.1	20

H2 & final users



H2 - Energy chain

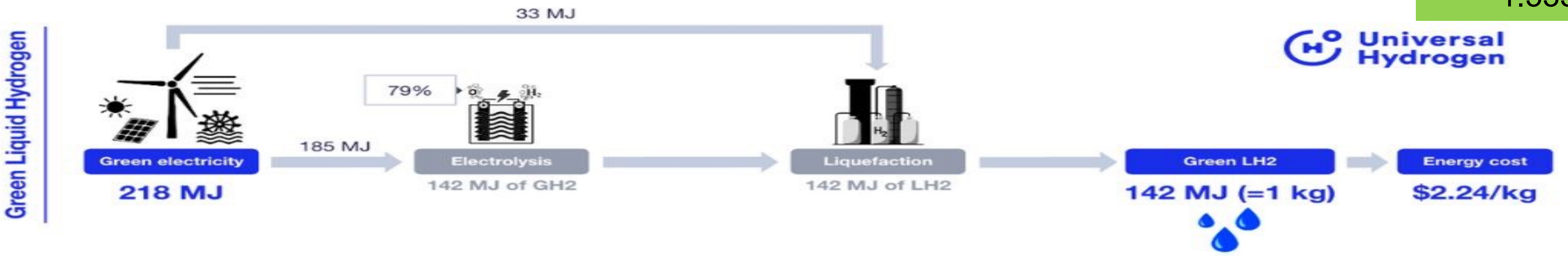
Green H2 base energy chain



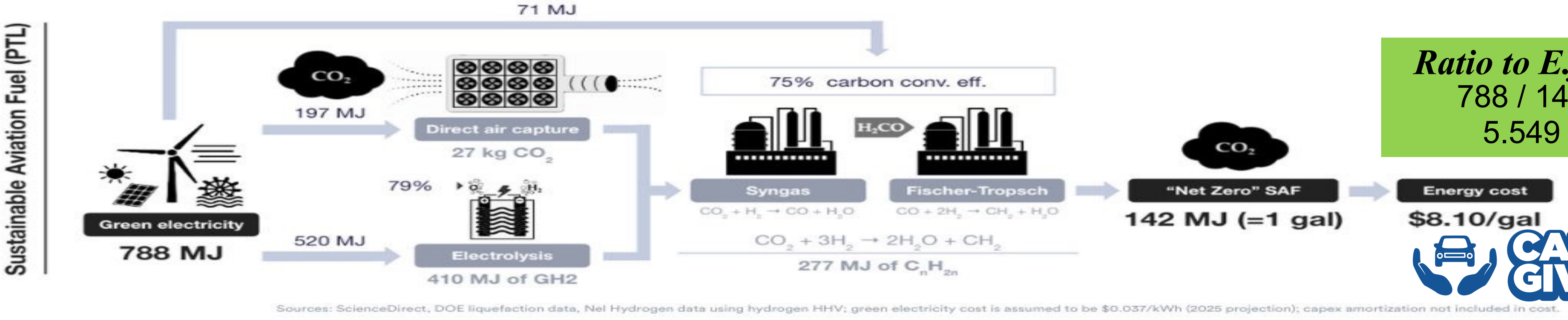
Ratio - gas
100 / 57
1.754

Ratio - liquid
218 / 142
1.535

Green Liquid H2

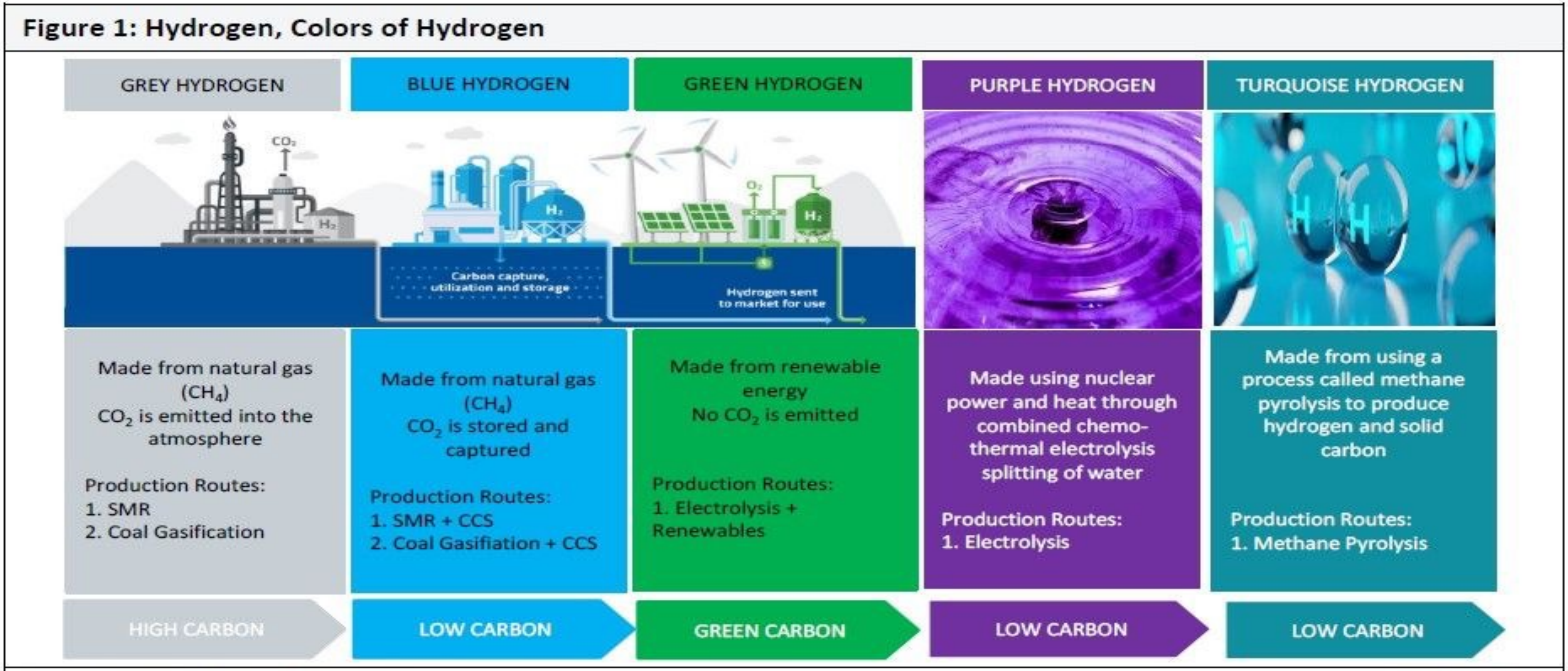


Aviation Fuel by H2



Ratio to E.fuel
788 / 142
5.549

H2 & Energy sources



Source: GlobalData Power Intelligence Center

Energy – E.automobiles vs Grid & E.fuel

Porsche-E
Battery capacity: 79-95 kWh Li-Ion
UFC DC ***320 kW@800V***
T_{EV} = (15 min)

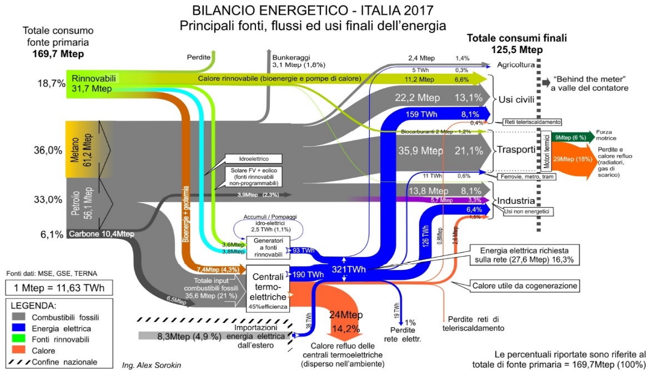
Ebus = 4xPorsche-E
Battery LFP Li-iron-Phosphate

Audi e-Tron
Battery capacity : 70-95 kWh Li-Ion
UFC DC ***160 kW@400V***
T_{EV} = (22 min)

Nissan Leaf
Battery capacity : 30 kWh Li-Ion
UFC DC ***45 kW@400V***
T_{EV} = (30 min)

FIAT 500 Ev 2020
Battery 42 kWh Li-Ion
UFC DC ***85kW@400V***
T_{EV} = (30 min)

Tesla model 3
Battery capacity 55-75 kWh Li-Ion
UFC DC ***150kW@350V***
T_{EV} = (40 min)



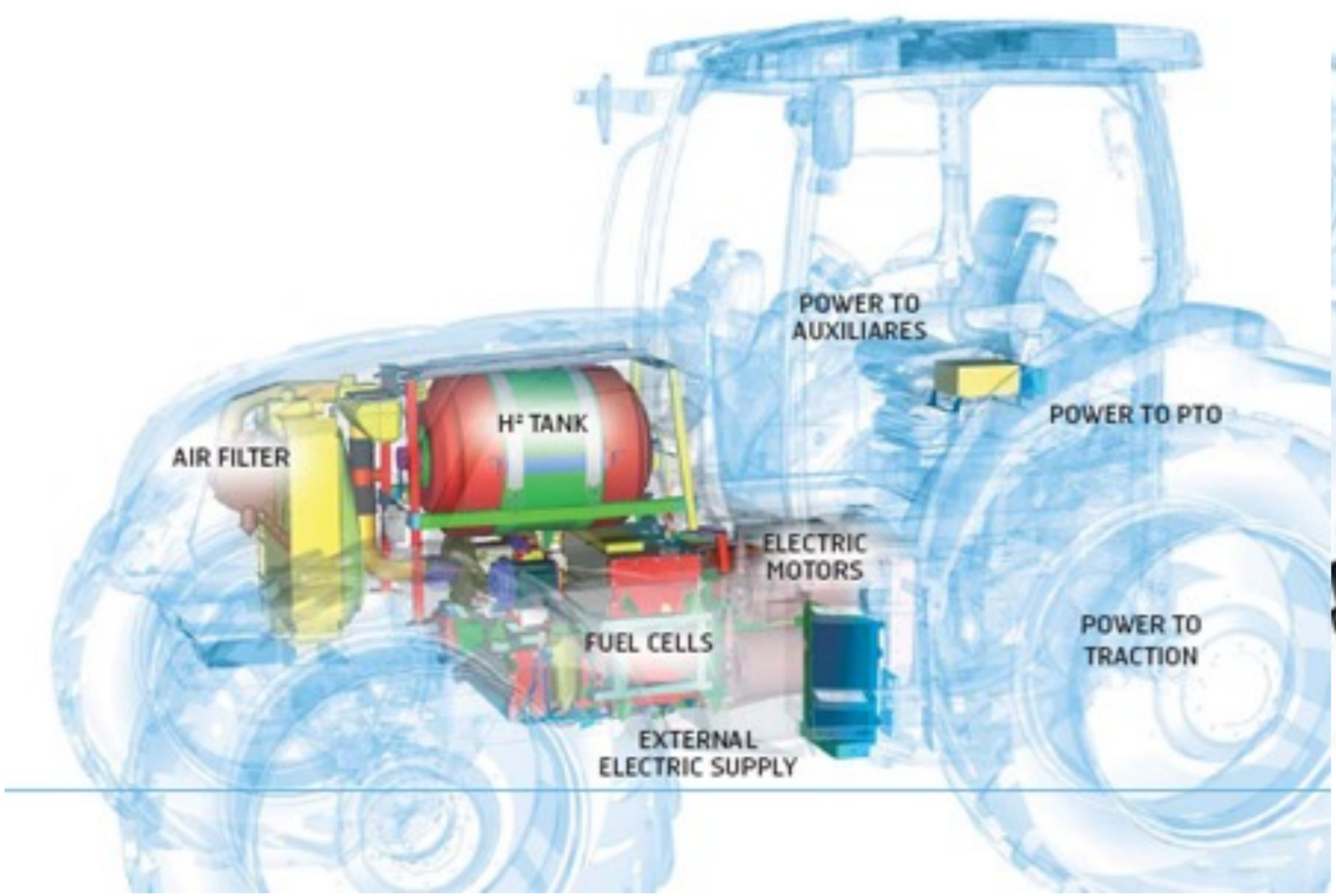
ENERGY

40 mio	Cars running
50 kWh	Batt.capacity on average & range 500Km
20	Recharge/year on average 10000km/year
40 TWh	E.energy in 1 year. vs . 11TWh (train, metro, tram)
40 TWh = 3.4 Mtep	E.fuel needs 665 TWh = 40*3*5.54 = 57 Mtep

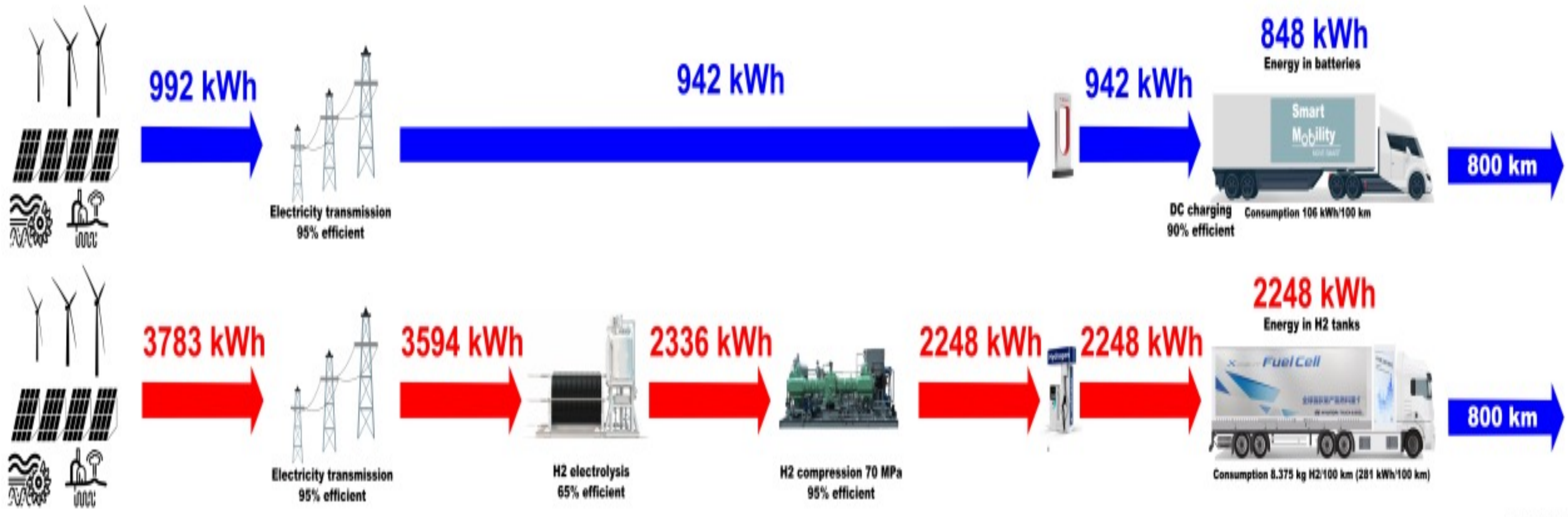
H2 Tractor

New Holland's Energy Independent Farm and NH2™ tractor concept offers farmers autonomous future

New Holland's Energy Independent Farm concept has far-reaching benefits for its customers, allowing them to create, store and use power in a convenient format. Central to the concept is the ability to produce electricity from natural, environmentally-friendly sources and then reuse that electricity in a convenient and practical way. The impressive hydrogen-powered NH2™ tractor, which won a Gold Medal at the SIMA Innovation Awards 2009, is just one part of a greater vision to free farmers from the increasing cost of fuel.



H2 - Energy chain on E.trucks



E.Truck & H2 ICE.truck	**range = 800 Km**
H2-FuelCell.truck	**range > 800 Km**

FuelCell efficiency > ICE efficiency

H2 - Energy chain on E.trucks

Hydrogen vs battery electric trucks - Long distance

Trips up to 400 km represent 62% of EU truck activity

Parameters	Fuel cell electric truck	Battery electric truck
		
	2030	
Total cost of ownership over first 5-year user period (based on France)	**€ 459 k**	**€ 393 k**
Vehicle purchase costs	€ 139 k	€ 167 k
Annual renewable fuel costs[1]	€ 38 k	€ 22 k
Cost parity with diesel without subsidies	**Mid 2040s**	**Early 2030s**
Economies of scale with cars	**Low**	**High**
Max range without refuelling / recharging	**1200 km**	**800 km**
Refuelling / recharging time (full)	**10-20 minutes**	**8 hours (overnight) 60 minutes (opportunity)**
Net payload loss (weight)[2]	**None**	**None**

1: Renewable fuel costs are incl. taxes, levies and charges, transport and distribution costs for electricity and fuel; assuming renewable hydrogen cost for the end user of € 5.40/kg (2030) and renewable electricity cost for the end user of €-cent 15.26/kWh (2030).

2: Additional weight from the onboard battery pack (assumed energy density of 318 Wh/kg in 2030) of 4.2 t is compensated for by the additional ZEV weight allowance (2 t) under the EU Weights & Dimensions Directive and net savings from replacing a conventional with an electric drivetrain (2.4 t).

Better →

TRANSPORT & ENVIRONMENT

transportenvironment.org

For methodology and sources see also:
https://www.transportenvironment.org/sites/te/files/2020_06_TE_comparison_hydrogen_battery_electric_trucks_methodology.pdf

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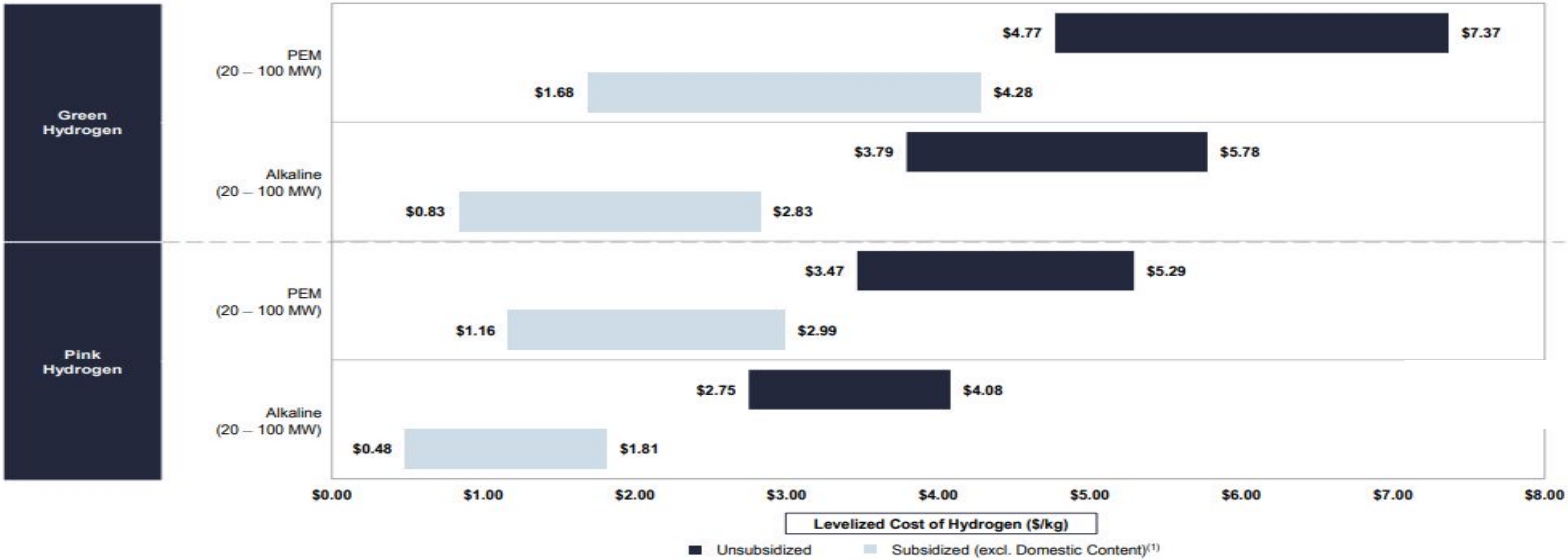
H2 & levelized costs

LCOE | LAZARD'S LEVELIZED COST OF HYDROGEN ANALYSIS—VERSION 3.0

Levelized Cost of Hydrogen Analysis—Illustrative Results

Subsidized Green and Pink hydrogen can reach levelized production costs under \$2/kg—fully depreciated operating nuclear plants yield higher capacity factors and, when only accounting for operating expenses, Pink can reach production levels lower than Green hydrogen



Source: *Lazard and Roland Berger estimates and publicly available information.*

Note: Here and throughout this presentation, unless otherwise indicated, this analysis assumes electrolyzer capital expenditure assumptions based on high and low values of sample ranges, with additional capital expenditure for hydrogen storage. Capital expenditure for underground hydrogen storage assumes \$20/kg storage cost, sized at 120 tons for Green H_2 and 200 tons for Pink H_2 (size is driven by electrolyzer capacity factors). Pink hydrogen costs are based on marginal costs for an existing nuclear plant (see Appendix for detailed assumptions).

(1) This sensitivity analysis assumes that projects qualify for the full PTC and have a capital structure that includes sponsor equity, debt and tax equity. The IRA is comprehensive legislation that is still being implemented and remains subject to interpretation—important elements of the IRA are not included in our analysis and could impact outcomes.

H2 - network in Europe

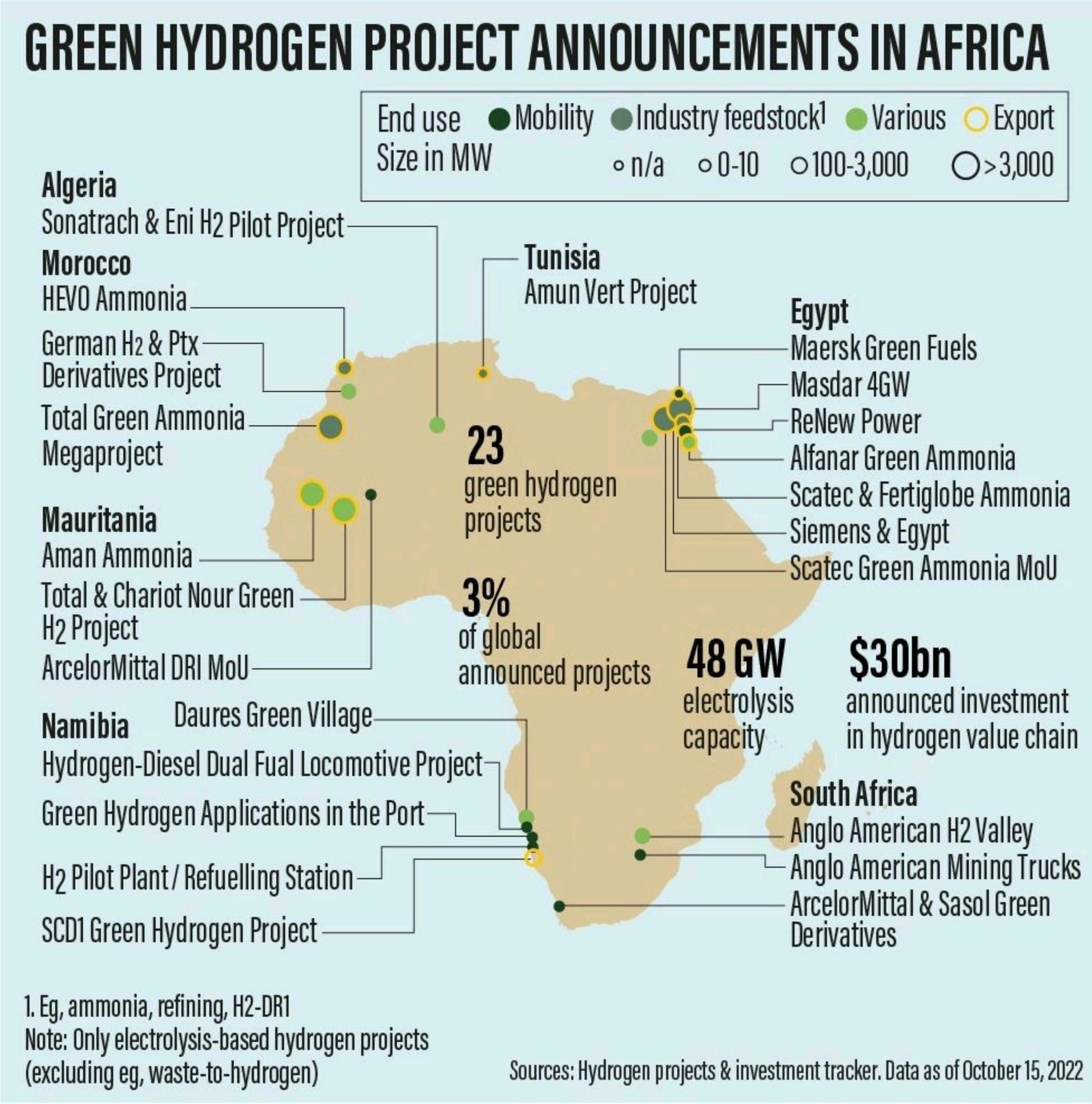
H2 - network in Europe

Snam is Europe's leading operator in natural gas transport and storage, with an infrastructure capable of delivering the transition to hydrogen.

Snam operates a transport network of approximately 41,000 km in EU.

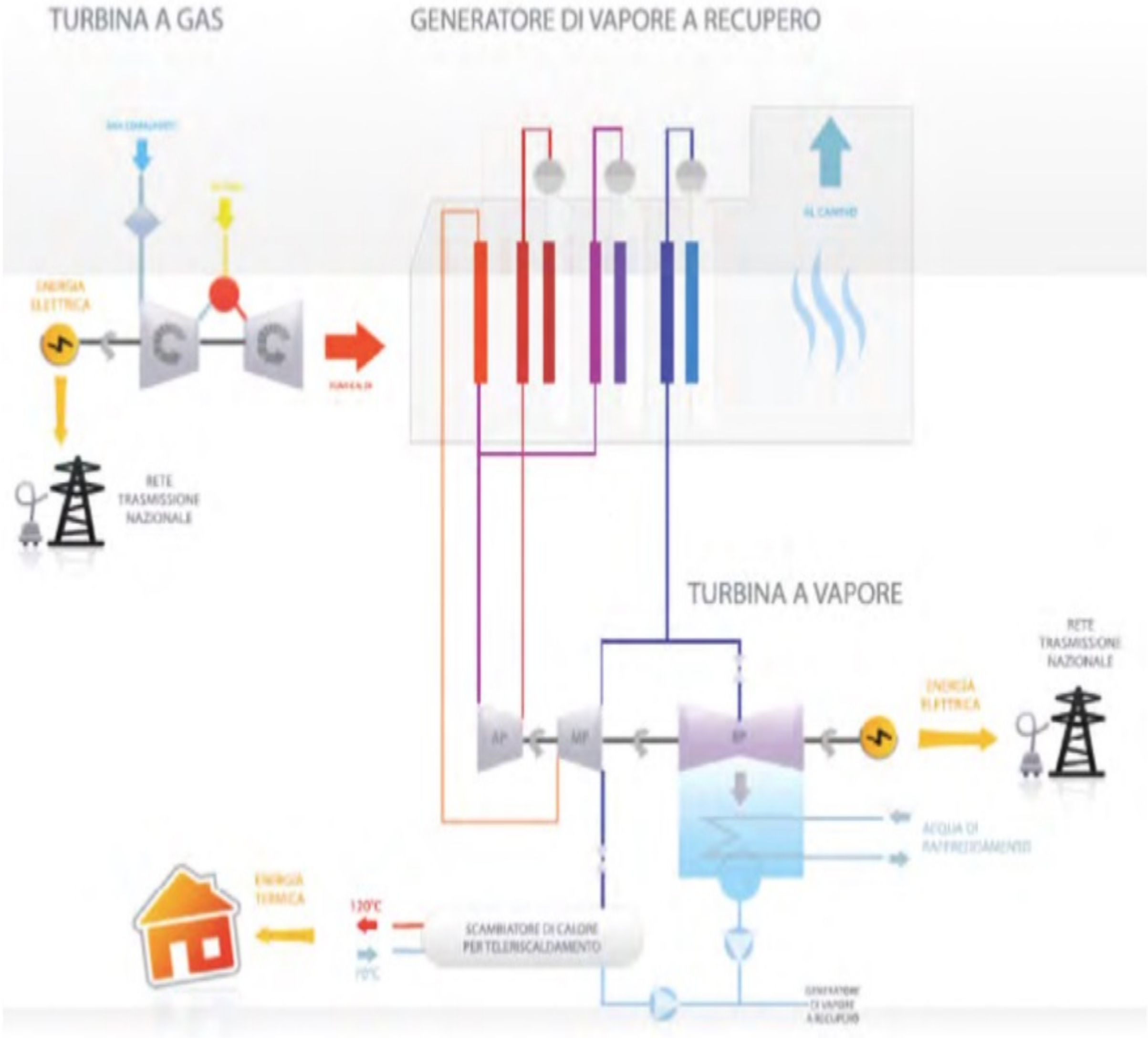
Snam and De Nora to build 2GW hydrogen electrolyser gigafactory outside Milan after acquiring land

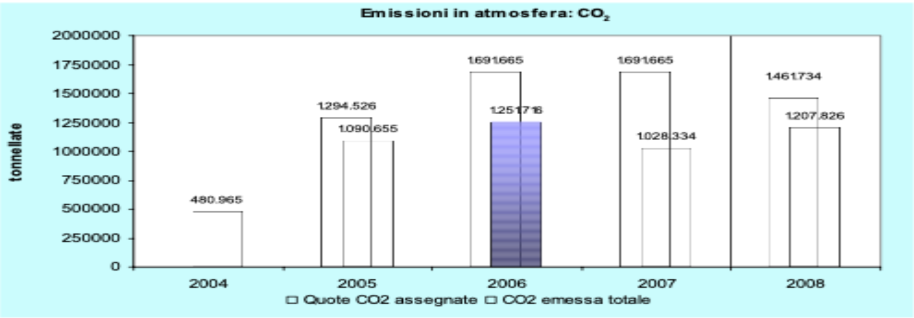
Electrode maker De Nora already holds a 34% stake in electrolyser manufacturer Thyssenkrupp Nucera, while gas system operator Snam owns 33% of its joint venture partner



Energy – re.use *(example - IREN Moncalieri PowerPlant)*

CICLO COMBINATO IN COGENERAZIONE (a 3 livelli di pressione con RISURRISCALDAMENTO)





Emissioni totali di CO_2 [t]

	2004	2005	2006	2007	2008
3° GT	-	692.811	897.479	734.038	814.600
RPW 2° GT	-	-	-	-	262.214
2° GT	442.130	363.242	341.978	280.988	106.012
Caldaie int. e ris.	38.835	34.602	12.259	13.308	25.000
CO_2 emessa Tot.	480.965	1.090.655	1.251.716	1.028.334	1.207.826
CO_2 quote assegnate	-	1.294.526	1.691.665	1.691.665	1.461.734

Il grafico riporta la quantità di CO_2 prodotta dagli impianti di cogenerazione in esercizio nella Centrale di Moncalieri (3° GT, RPW 2° GT e 2° GT) e dalle Caldaie di integrazione e riserva. L'aumento di CO_2 nel 2008 è dovuto al maggior funzionamento del 3° GT, delle Caldaie e del nuovo Gruppo a ciclo combinato RPW 2° GT.

	CHP	OHB	ACC
MONCALIERI	520 MWt	140 MWt	-
BIT	-	255 MWt	-
POLITECNICO	-	255 MWt	2.500 m³
MIRAFIORI NORD	-	35 MWt	-
TORINO NORD (da ottobre 2011)	220 MWt	340 MWt	5.000 m³
MARTINETTO (da ottobre 2013)			5.000 m³
TOTALE IREN	**740 MWt**	**1.025 MWt**	**12.500 m³**

TORINO = CITTA' + TELERISCALDATA DI ITALIA

56 M/m3 riscaldati – 550.000 abitanti

Energy – H2 & E.fuel (example - IREN Moncalieri PowerPlant)

https://www.sciencedirect.com/science/article/abs/pii/S2212982021000263

The present study conducted a comprehensive performance and techno-economic analysis of e-fuels liquid FT fuel production from H_2 and CO_2. Performance analysis shows 223 metric ton/day of H_2 and 2387 metric ton/day of CO_2 are converted into 351 metric ton/day of a liquid FT fuel mixture with an overall energy conversion efficiency of 57.5 % and 52.2 % based on lower heating value and higher heating value, respectively.

Capture the CO2 waste = 1.2 Mtons CO2 / year

(2387 CO2 + 223 H2) ton/day = 351 ton/day E.fuel

CO2 / H2 = 10.7
CO2 / E.fuel = 6.8

x month
(0.1 CO2 + 0.009 H2) Mtons = 0.014 Mtons E.fuel

Power Available Vs. Chemical ratios & Energy ratios

7000 tons E.fuel x month

Chemical ratios

Energy ratios

when Tele-Heat is Off
Power supply to the process up to 520 MW

Power / H2 product	= 1.51	520/1.51	344
Power / CO2 capture	= 4	520/4	130
Power / E.fuel process	= 11	520/11	47

Produce H2 & CO2 using Power = 520 MW

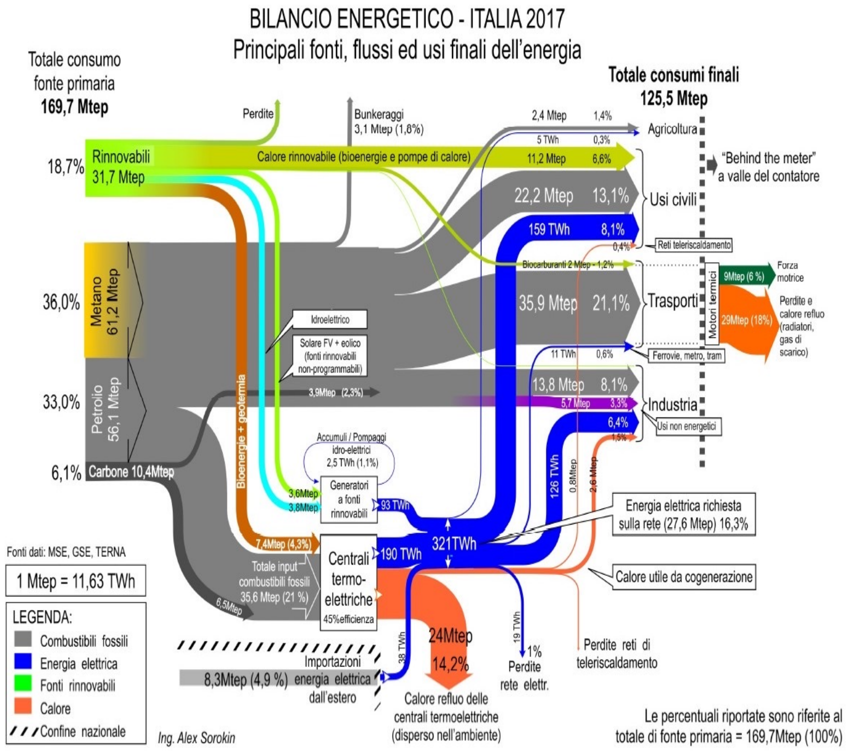
Kg.H2/month = 344*1000*30*24*0.65 / 33.6
H2 = 4791 tons/month = *almost 0.0048 Mtons*

Kg.CO2/month = 130*1000*30*24 / 2
CO2 = 46800 tons/month = *almost 0.047 Mtons*

CARe GIVER

Take-Away

L'obiettivo e' rimuovere quanti piu' Mtep da fonti fossili dal bilancio totale di energia (chart a sinistra), cioe' il colore "GRIGIO" …..

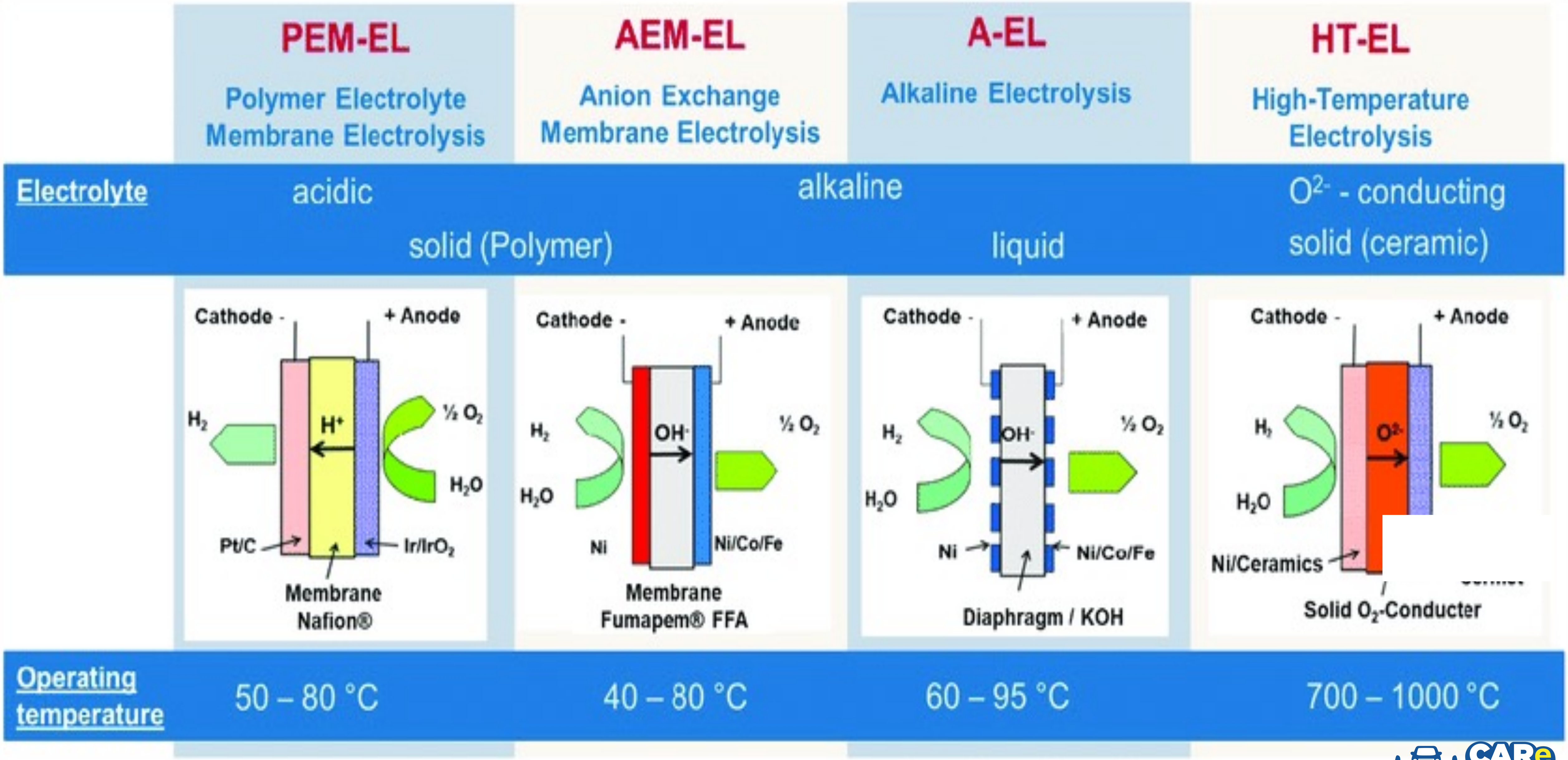


Elettrificazione : Ok Auto, Bus e veicoli industriali light duty Elettrici, ma potrebbe non essere la soluzione per quelli heavy duty.

H2 : e' una forma di accumulo di energia e puo' essere usata per attivita' industriali e civili.
Possibile combustibile per i veicoli heavy duty al posto di soluzioni elettriche con batterie.
Potrebbe essere il combustibile di nuove generazioni di ICE che operano come Co-Generatori di energia Elettrica e Termica, in questo caso gli ICE sono tra i dispositive piu' efficienti.

Energia elettrica : sia l'Elettrificazione che l'H2 necessitano di elettricita' prodotta a zero emissioni per dare poi lo stesso contributo.
Le tecnologie che lo consentono sono il nucleare, il solare ed il wind, che hanno caratteristiche, performance e difficolta' di esecuzione diverse fra loro. Ma fonti integrabili tra loro.

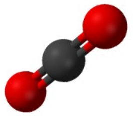
H2 & Electrolizers - type



NIPPON GASES

The Gas Professionals

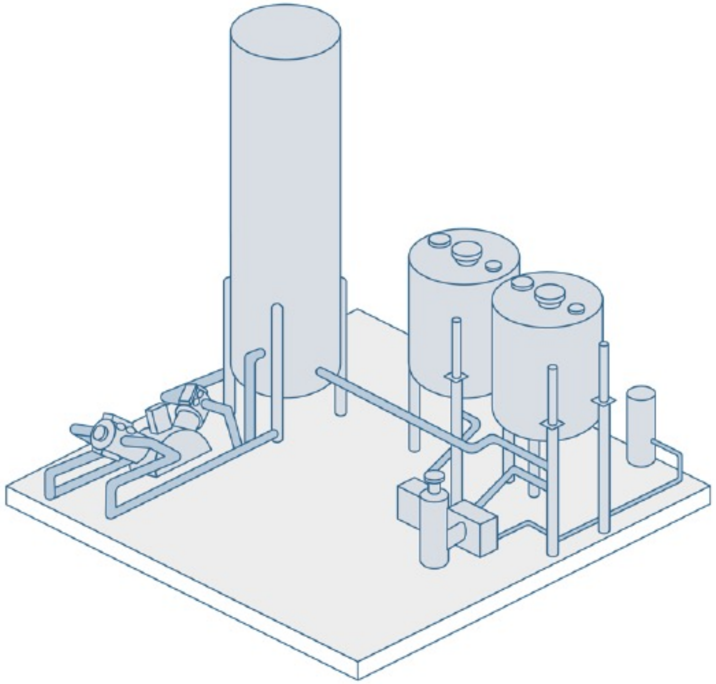
Recupero CO_2



Front-End: è composto da colonna di assorbimento e strippaggio con circuito chiuso con solvente a base amminica (MEA, MDEA, UCarsol, OASE, Mitsubishi HPC-hot potassium carbonate).

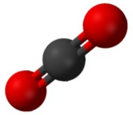
I solventi che vengono utilizzati sono selezionati in funzione delle impurezze contenute nel raw gas e delle specificità di T e P in ingresso.

Come riferimento il consumo di MEA in un impianto di estrazione è intorno ai **2 kg per ton CO2 estratta**



Tutti i solventi hanno bisogno di calore per la rigenerazione del solvente stesso:
3 kg di vapore (@ 140°C) o analoga fonte di calore per Kg di CO_2 estratta, per rigenerare la MEA che è il solvente meno costoso, non protetto da licenza, sempre disponibile sul mercato e che non richiede apparecchiature in pressione.
Il consumo elettrico per questa parte è dovuto esclusivamente alle pompe di ricircolo del solvente stesso:
circa **0.06 kW/kg CO2 estratta.**

Recupero CO_2



Back-End: è l'impianto di compressione e liquefazione standard che prende la CO2 al 99% in uscita dal front end. Qui i valori di riferimento che vengono utilizzati per le valutazioni sono **0.2 kW/kg CO2 trattata all'aspirazione del compressore**.

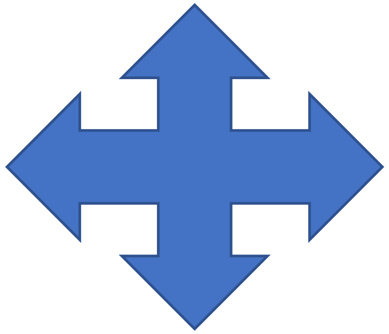
Il consumo elettrico totale dell'impianto di estrazione/liquefazione CO2 per le prime valutazioni è intorno a **0.32-0.35 kW/kg CO2 liquefatta** a specifica alimentare.

Impianto «Small-Scale» Nippon Gases

Ogni progetto prevede la ricerca dell'ottimo tra:

PUREZZA CO2

CONSUMO DI CALORE



CAPEX

COSTO DEL SOLVENTE e LICENZE

La sezione di Back-End non è necessaria in caso di uso in loco della CO_2 (sintesi di biopolimeri, E-Fuels, stoccaggio sotterraneo).

Roadmap Applicazioni

Fully deployed

- Oxycombustion
- CO_2 recovery purification/liquefaction
- CO_2 utilization – pH /GHG
- Biogas Upgrading
- Bio LNG
- H_2 – SR / Dry reforming / Electrolyzer I

Demo Scale

- Burners 100% H_2
- Burners 100% NH_3
- H_2 low C
- H_2 Electrolyzer II
- CO_2 recovery (PSA/membrane)
- Green NH_3

Pilot

- CO_2 reutilization – plastics
- CO_2 mineralization
- Gasification
- CO_2 to biofuels