Nature Alphabet

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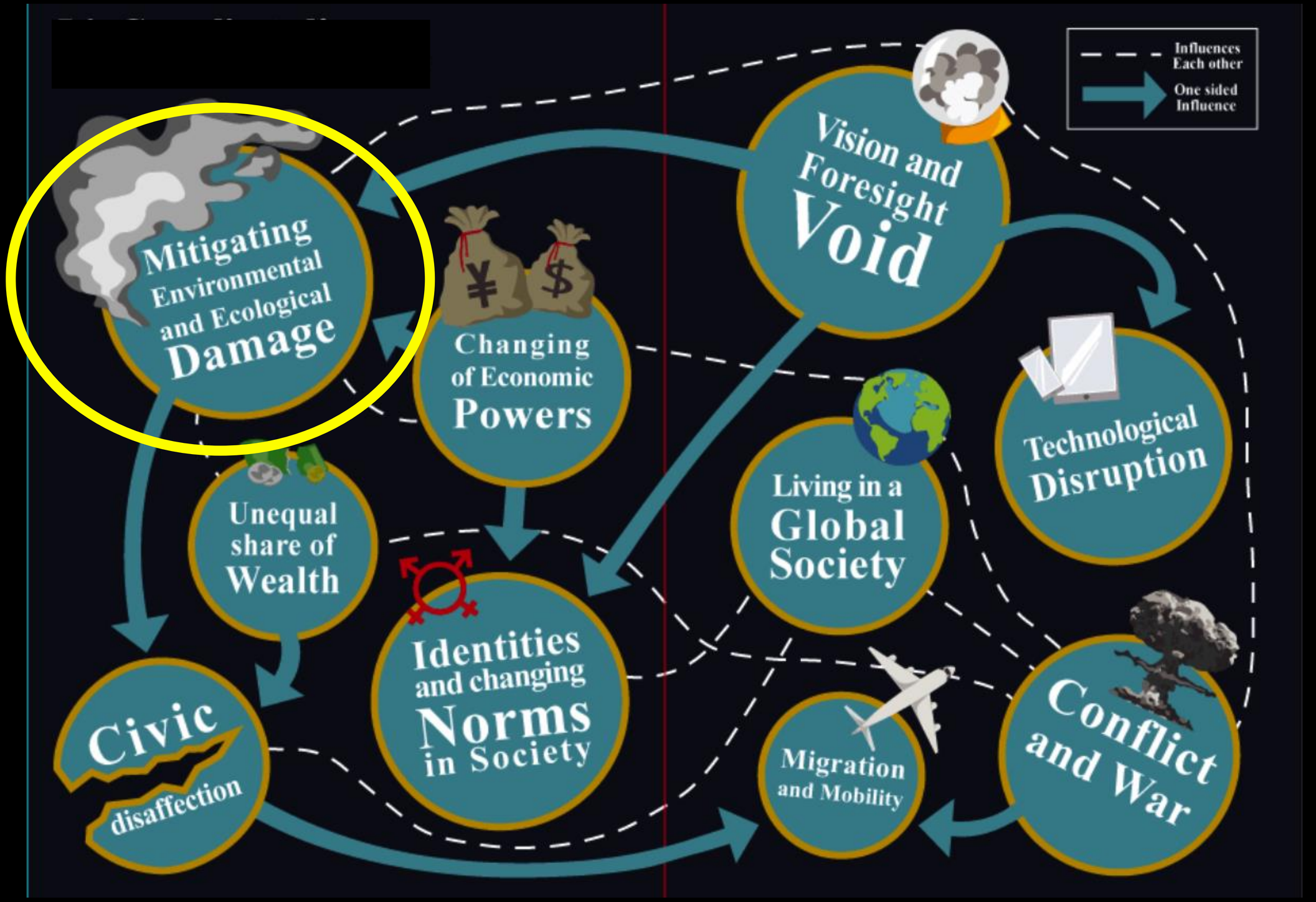
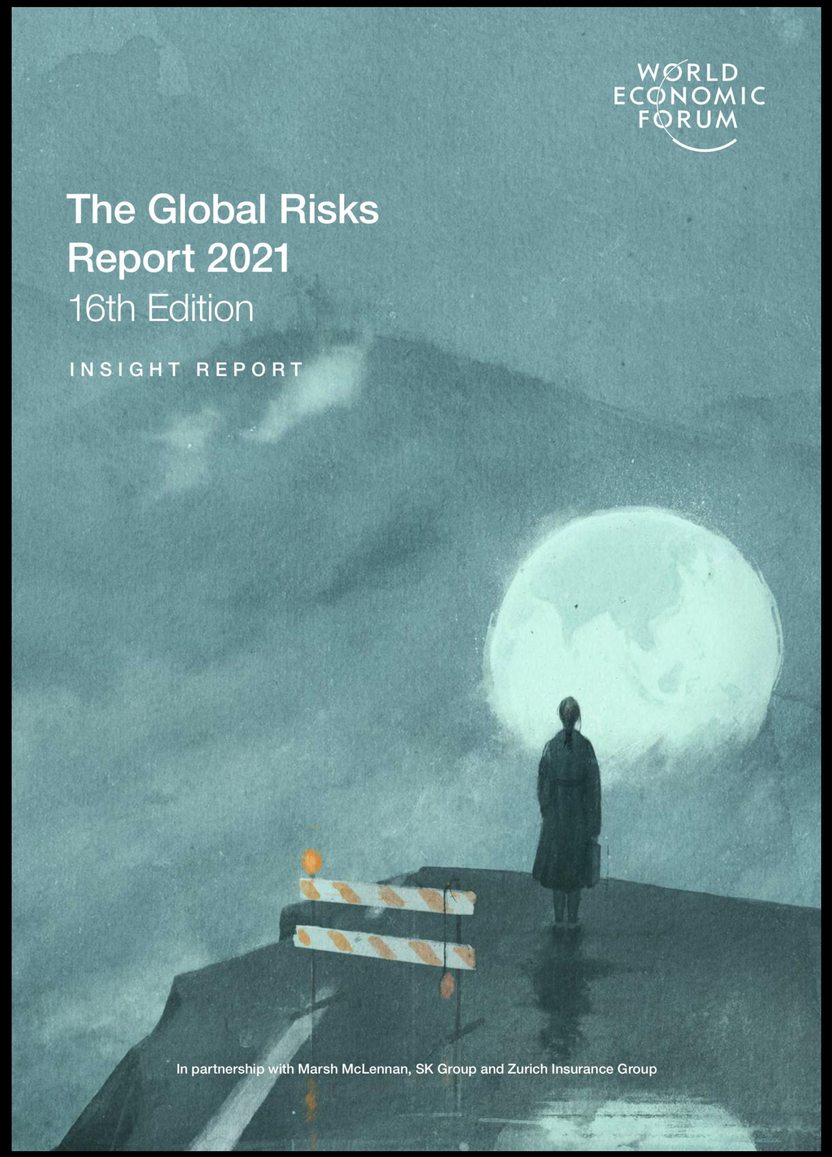
OCTOBER 20-21, 20221

You can't fool nature

Richard Feynman
(1918-1988)


E A N
C E
P


Influences Each other
One sided Influence
Mitigating Environmental and Ecological Damage
Changing of Economic Powers
Vision and Foresight Void
Technological Disruption
Living in a Global Society
Unequal share of Wealth
Identities and changing Norms in Society
Civic disaffection
Migration and Mobility
Conflict and War



8th	6th	4th	2nd	1st	3rd	5th	7th	9th
Extreme Weather	Debt Crises	Social Cohesion Erosion	Infectious Diseases	Climate Action Failure	Livelihood Crises	Biodiversity Loss	Prolonged Stagnation	Human Environmental Damage

Worl Economic Forum 2021 Global Risks Report

"Complex" problems are not addressed with "complicated" solutions

A "complex" problem is dealt with

by looking for its root causes and acting

accordingly in a logical and rational manner

Just as scientists do to find the laws of

nature, which, once found and verified,

necessarily must be obeyed

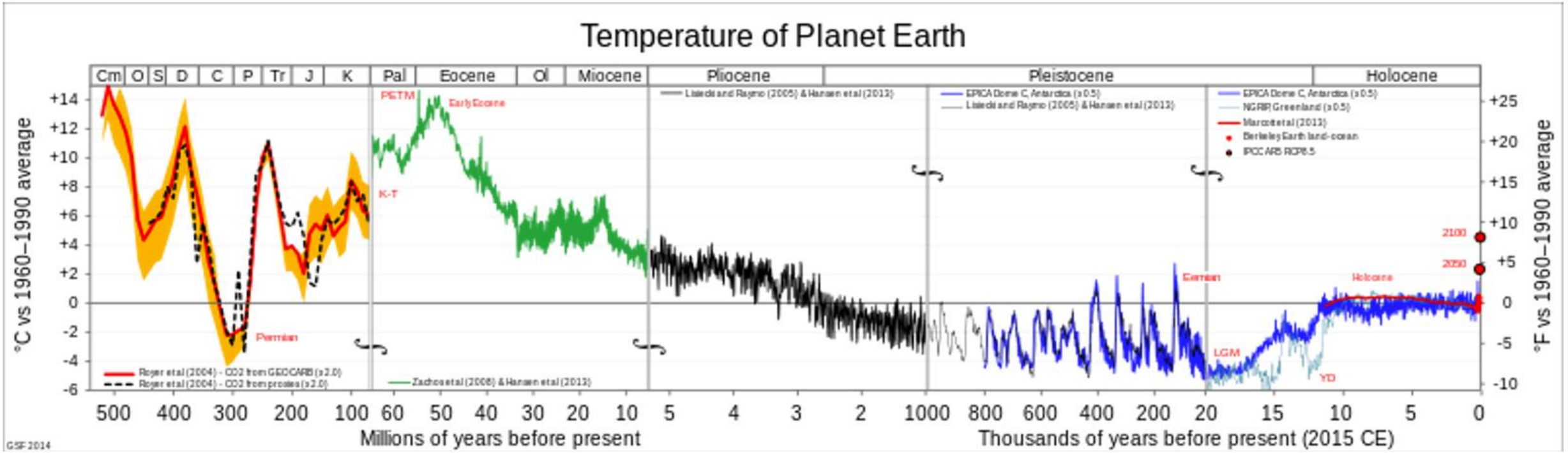
If you can't explain something in simple terms it means you don't understand it

Richard Feyman
(1918-1988)

Climate change explained in three steps

1

500.000.000 years



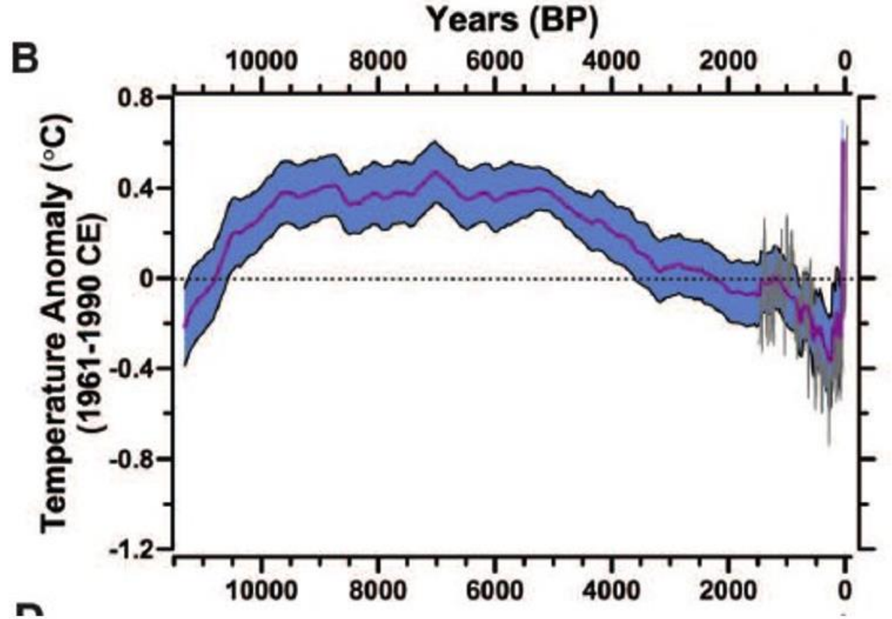
Analisi paleoclimatica dell'andamento della temperatura negli ultimi 500 milioni di anni [1]. La linea orizzontaleche definisce lo zero indica la temperatura media della seconda metà del secolo scorso.

2

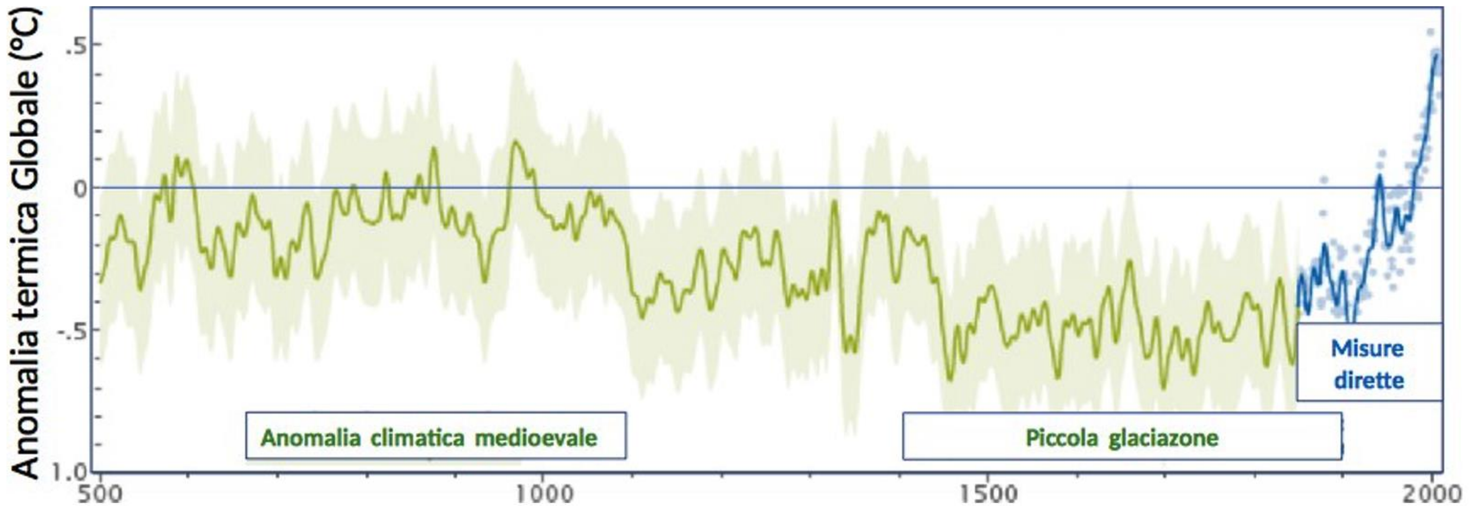
11.000 years

3

1.500 years



Analisi paleoclimatica dell'andamento dellatemperatura negli ultimi 11 mila di anni [2].



Andamento della temperatura negli ultimi 1500 anni ricavato da dati paleoclimatici (linea verde) confrontato con l'andamento basato su misure strumentali moderne (linea blu). I dati indicano come la temperatura globale sia più alta oggi di quanto non sia stata almeno negli ultimi 15 secoli (adattato da Mann et al. 2008 [3]). La linea dello zero indica la temperatura media degli anni '70 del secolo scorso.

But how really is "big" our need for energy ?

$T_{\text{solar radiation}}$: 5500 K

$T_{\text{Earth's radiation}}$: 290 K

for every solar photon absorbed, 22.5 photons are re-emitted from Earth

large increase in Entropy but substantial Energy balance

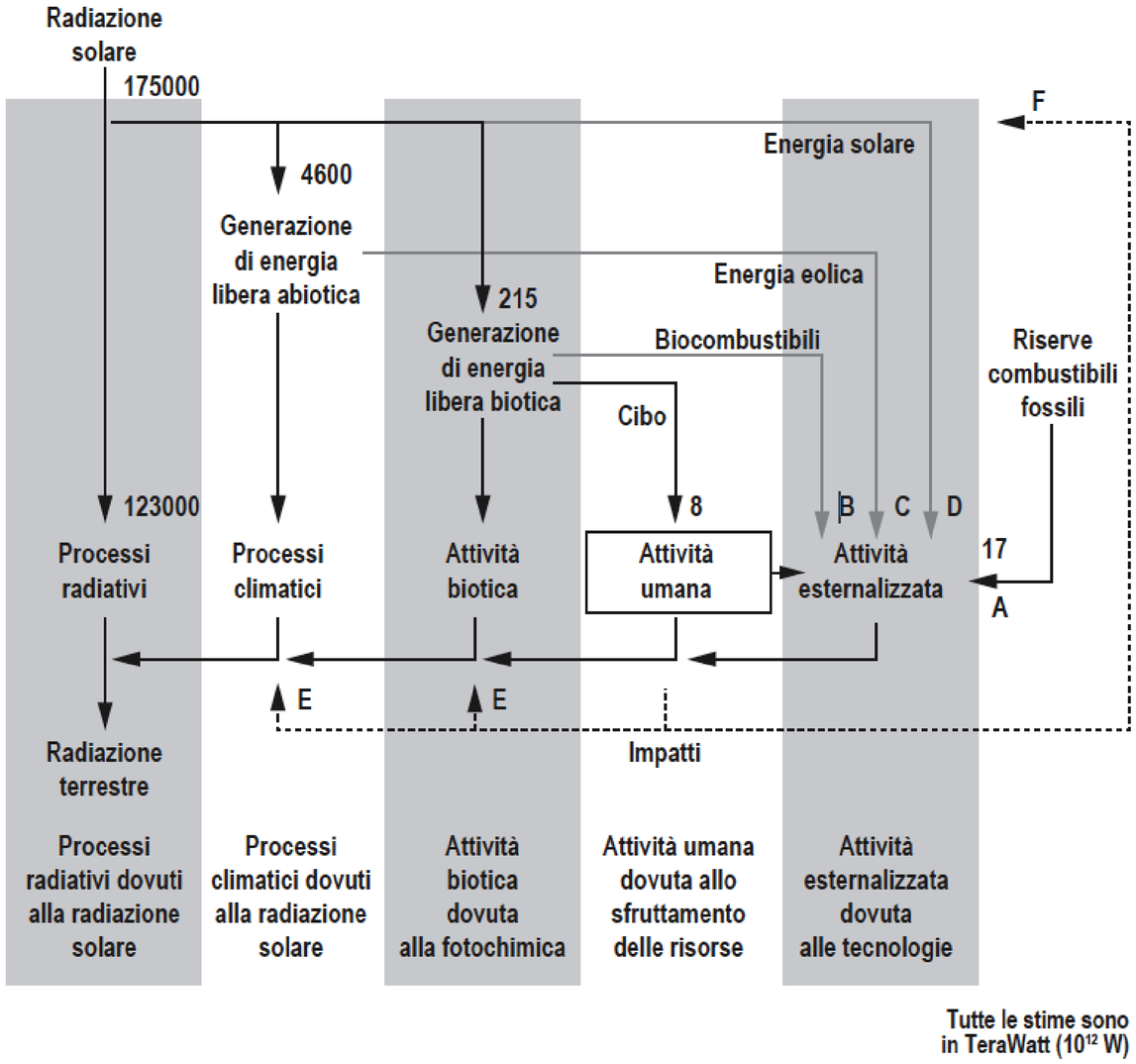


Figura 6: Schema delle attività umane in termini di utilizzo energetico in relazione ad altri processi terrestri. I numeri rappresentano il valore dei flussi radiativi o di energia libera in TW. Notare il contributo di 17 TW dovuto all'utilizzo delle sorgenti fossili di energia. Fonte: Axel Kleidon, *Thermodynamical Foundations of the Earth System*, Cambridge University Press, Cambridge 2016.

Humanity

=

8 TeraWatt (biomass and renewable)

+

17 TeraWatt (fossil)

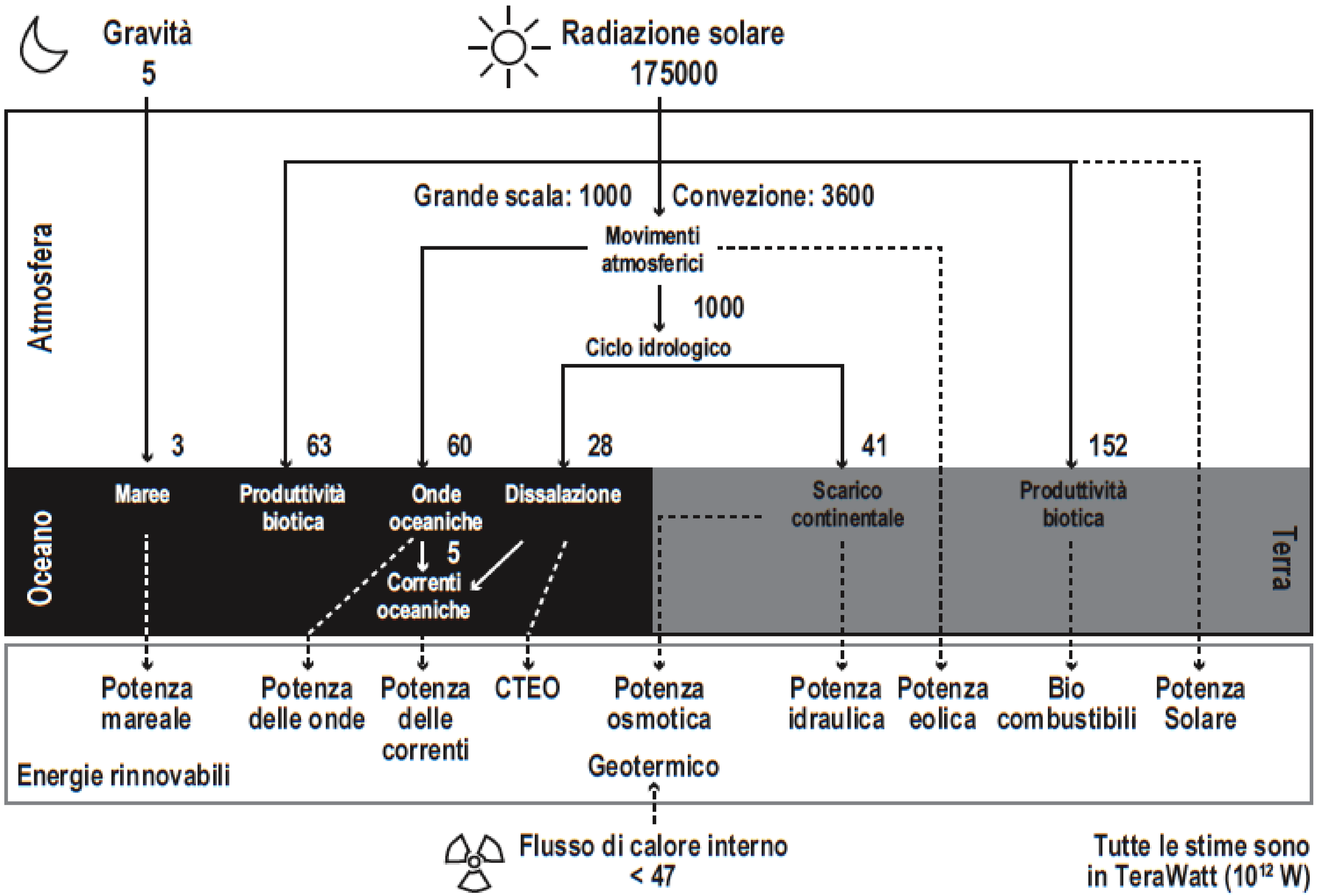
=

25 TeraWatt

But how "big" really is our need for energy ?

→ About one part in 10,000 compared to what the Sun sends to the Earth !


….and Nature knows it well……



Humanity

=

8 TeraWatt (biomass and renewable)

+

17 TeraWatt (fossil)

=

25 TeraWatt

…what’s Entropy?

no entropy ? no party !

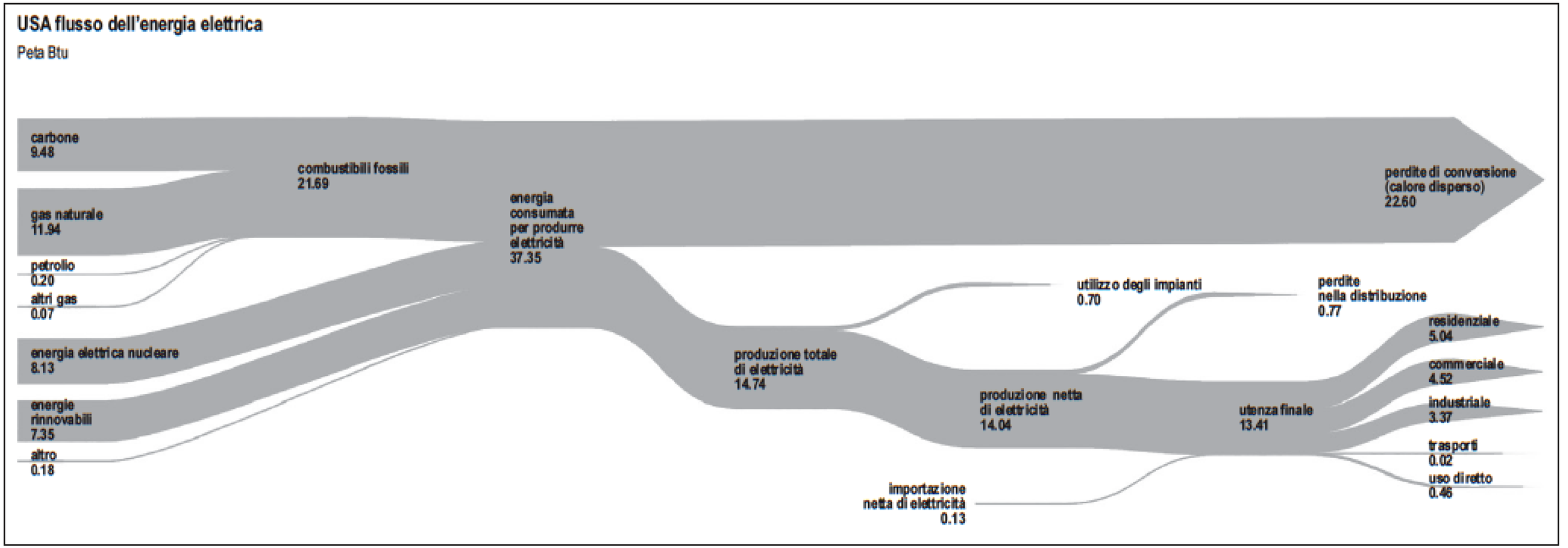
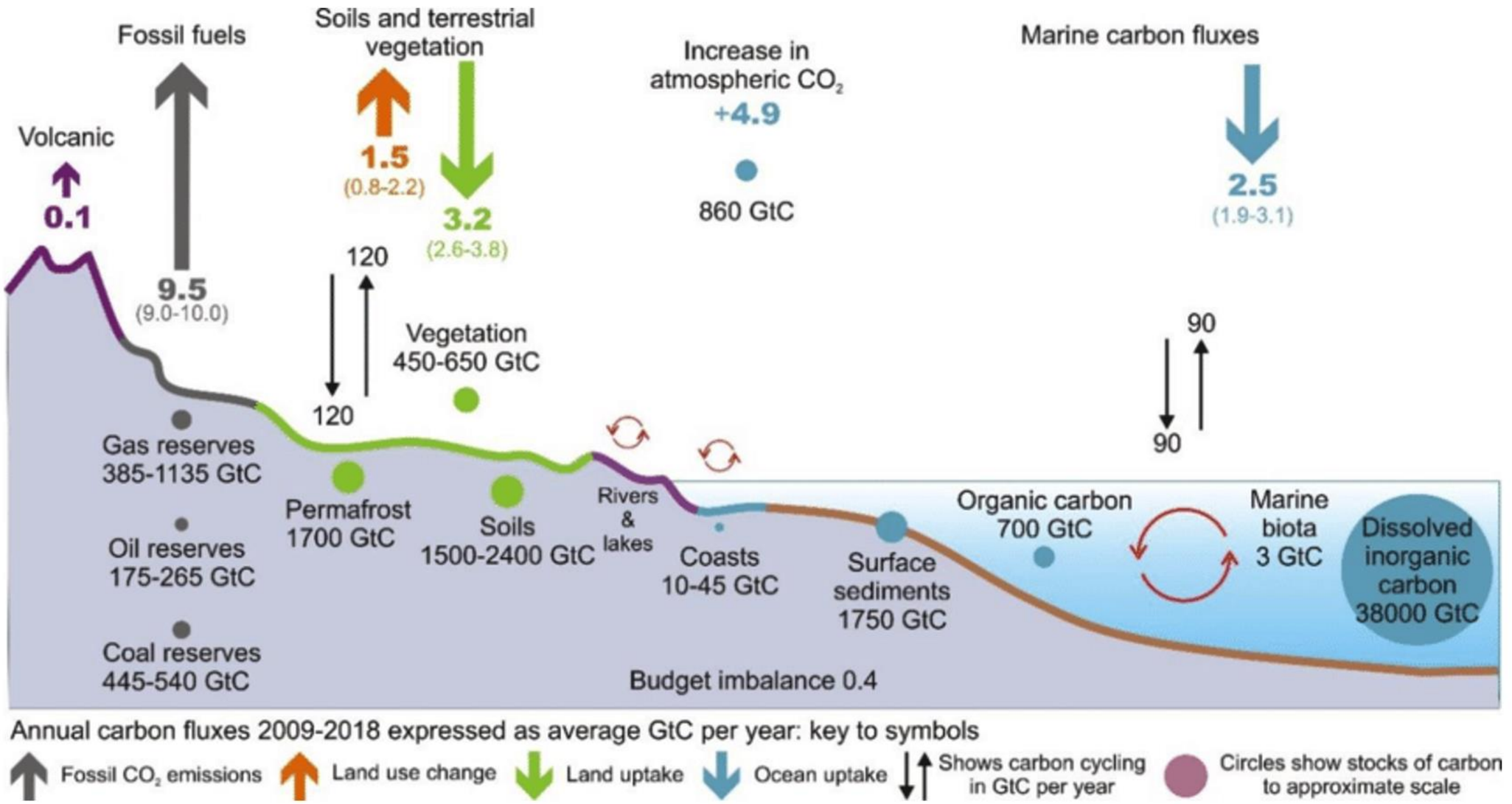


Figura 2: Flusso dell'energia collegata alla produzione di energia elettrica negli Stati Uniti nel 2021. 22,6 BTU (6,6 PWh), pari al 63% dell'energia utilizzata in questo processo, vengono dissipati in calore e dispersi nell'ambiente.
Fonte: EIA 2021.

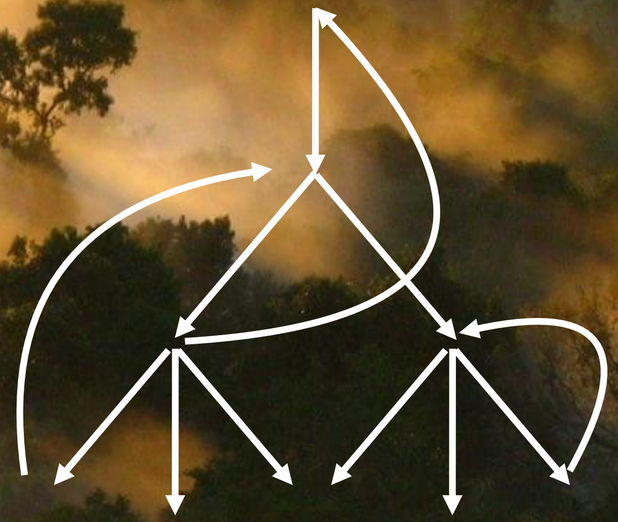


Rappresentazione schematica del ciclo annuale medio del carbonio nel decennio 2009-2018, enfatizzando i contributi dovuti alle attività antropiche (unità: Giga Tonnellate di Carbonio(GtC)/anno). Nel decennio 2009-2018 la CO_2 accumulata nell' atmosfera ha raggiunto 860 GtC. I dati coprono il decennio 2009-2018.

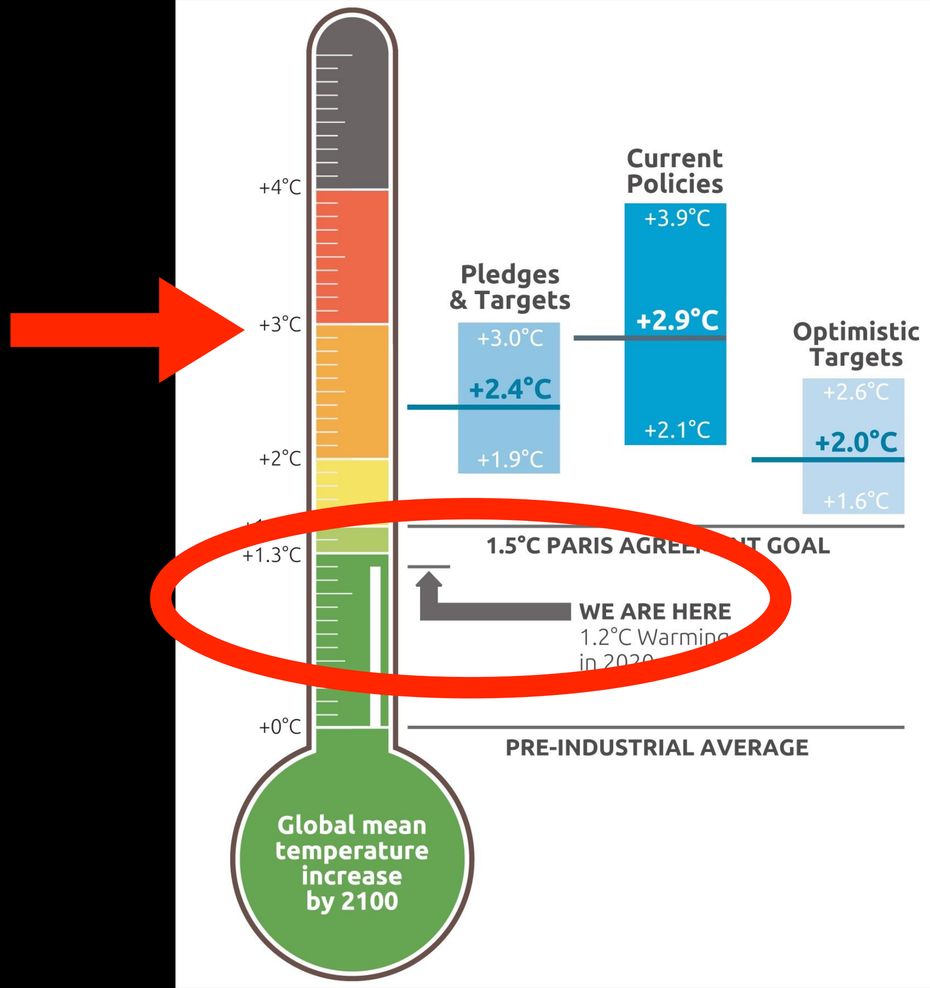

we have atered
planet’s energy
balance

As the temperature rises

- The world warms up
- Ice and snow melt
- Sea levels rise
- Circulation patterns of the ocean and atmosphere change
- The water cycle accelerates
- Extreme weather events increase
- Ecosystems react
- Food and water supplies are affected
- Infrastructure is damaged or in need of upgrades
- People and species are impacted
- Economic and political stability are affected



© Danish Defence Command via REUTERS

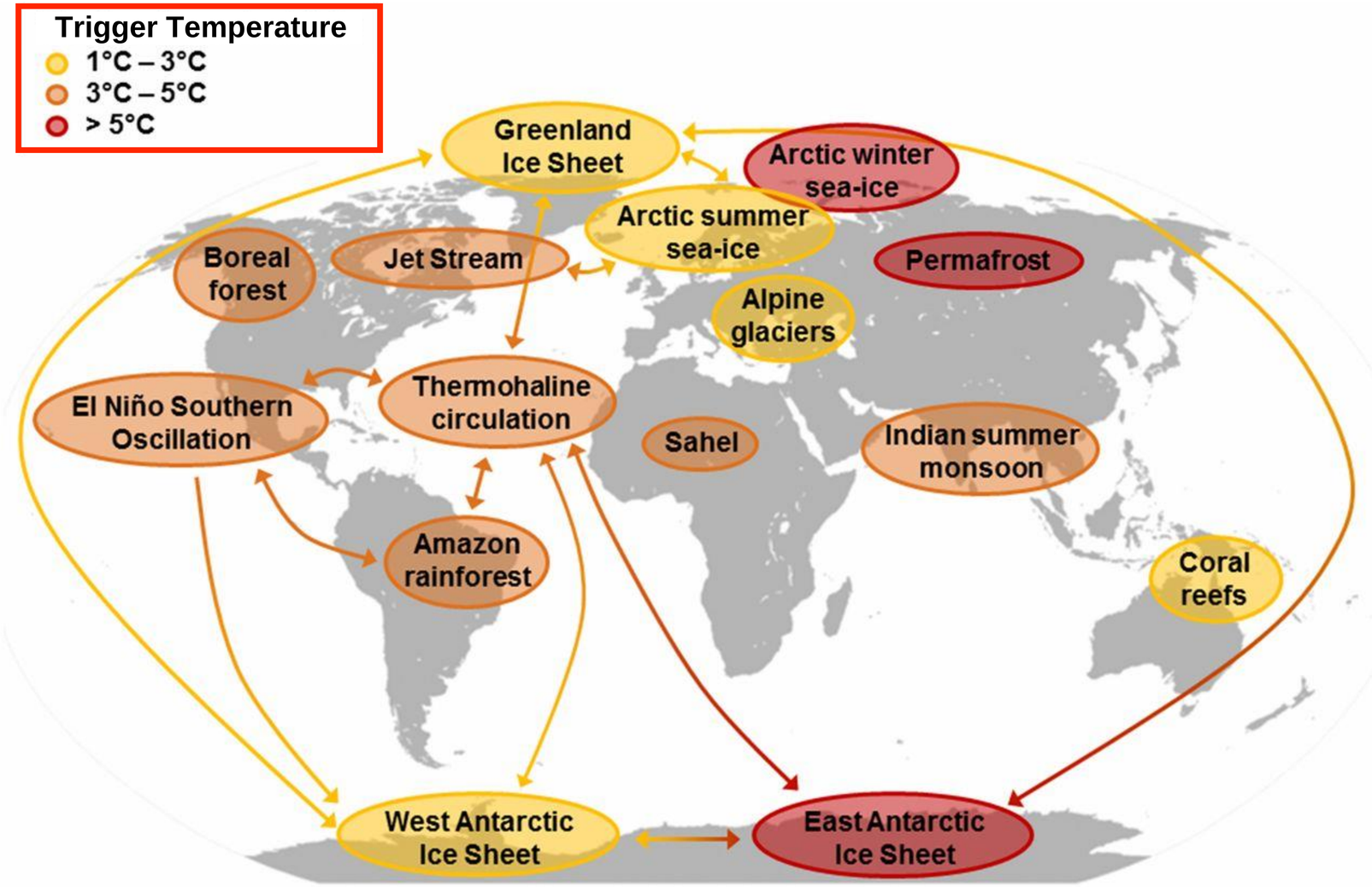


>3°C?

Half of the IPCC Scenarios to Limit Warming Don't Work

The Intergovernmental Panel on Climate Change showcased 50 scenarios to limit global warming to 1.5°C above preindustrial temperatures. A new study finds that only half of those scenarios are realistic.

Warszawski et al Environmental Research Letters, Volume 16, Number 6 (2021)



Tipping Points

How to address the climate problem in three steps

- Renewable energy sources
- Renewable energy storage
- CO_2 capture from the air

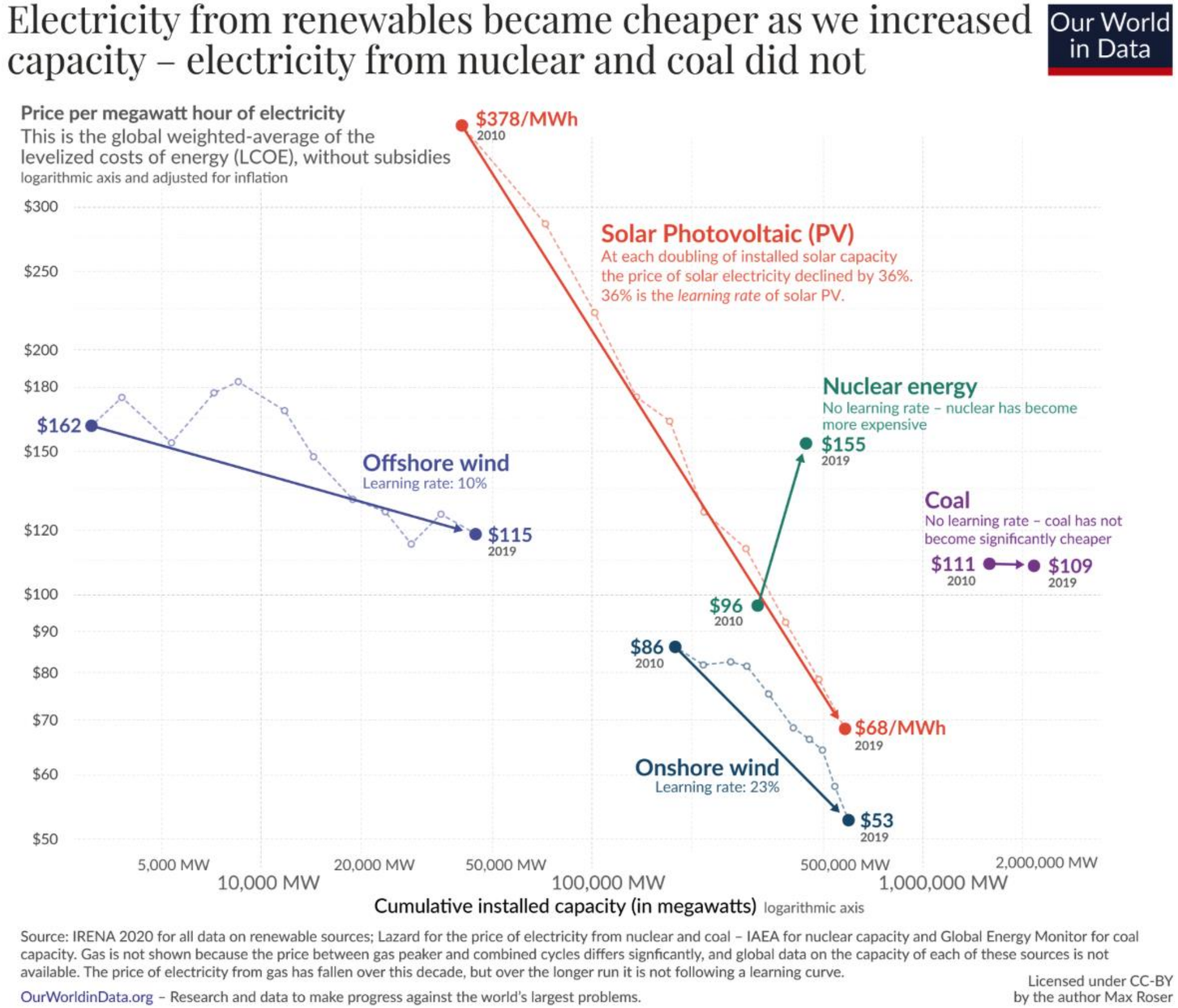
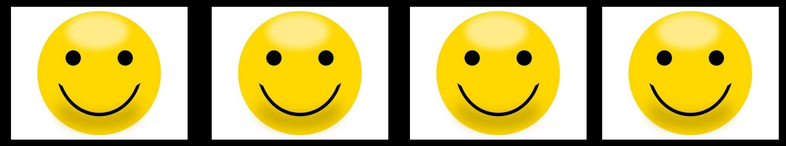
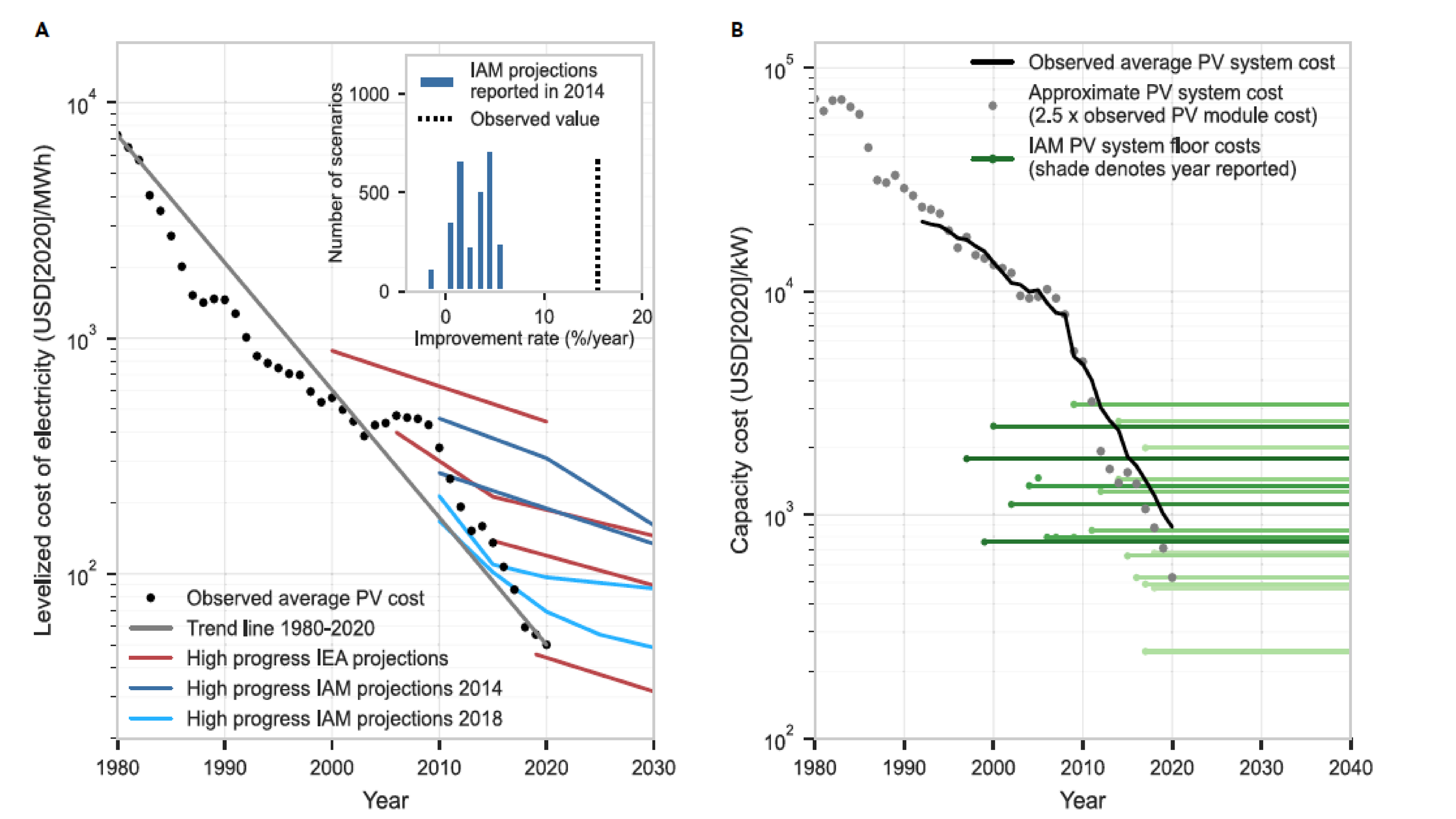


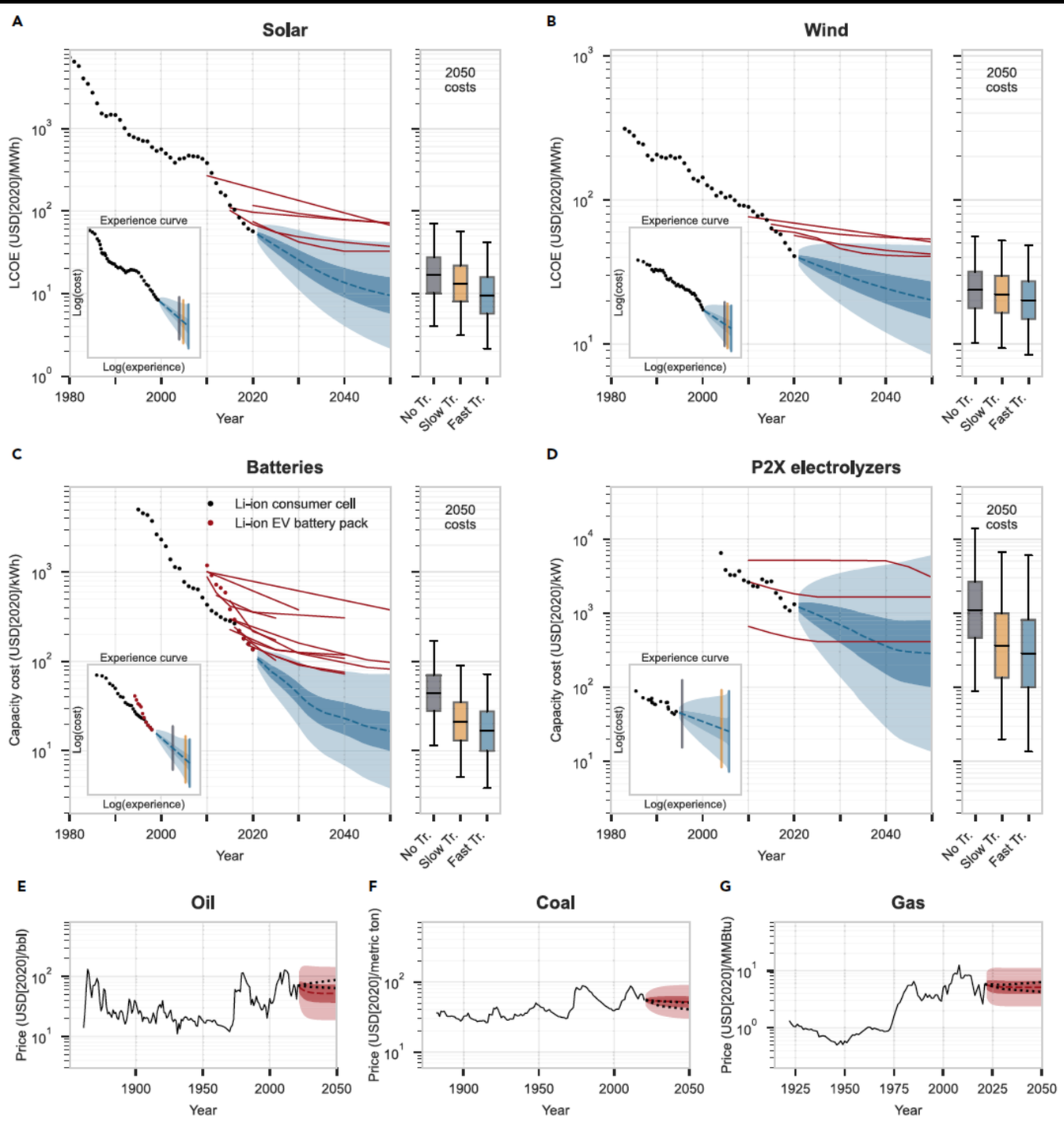
Figura 8: Prezzo medio globale per MWh di elettricità in funzione della potenza installata, senza considerare sovvenzioni. L'elettricità dalle sorgenti rinnovabili è calata molto di costo all' aumentare della quantità prodotta, cosa che non è successa con l'elettricità dal nucleare o dal carbone.

During the past few years the ratios in the cost between renewables and fossils have been reversing !



In the future, this decline will continue, energy will cost much less and can also be put to uses that are not cost-effective today: hydrolysis, desalination, capture and sequestration of CO_2 in the air


A
Levelized cost of electricity (USD[2020]/MWh)
Year
Observed average PV cost
Trend line 1980-2020
High progress IEA projections
High progress IAM projections 2014
High progress IAM projections 2018
IAM projections reported in 2014
Observed value
Number of scenarios
Improvement rate (%/year)
B
Capacity cost (USD[2020]/kW)
Year
Observed average PV system cost
Approximate PV system cost
(2.5 x observed PV module cost)
IAM PV system floor costs
(shade denotes year reported)


A
Solar
LCOE (USD[2020]/MWh)
Experience curve
Log(cost)
Log(experience)
Year
2050 costs
No Tr.
Slow Tr.
Fast Tr.
B
Wind
C
Batteries
Li-ion consumer cell
Li-ion EV battery pack
Capacity cost (USD[2020]/kWh)
D
P2X electrolyzers
Capacity cost (USD[2020]/kW)
E
Oil
Price (USD[2020]/bbl)
F
Coal
Price (USD[2020]/metric ton)
G
Gas
Price (USD[2020]/MMBtu)

Accumulo: Batterie



Storage: breakthroughs

EnergyDome (I)

StEnSea (De)

CO_2 EXTRACTION from the air

Orca (Is)

up to 5,000 less area than a forest (but still too expensive)

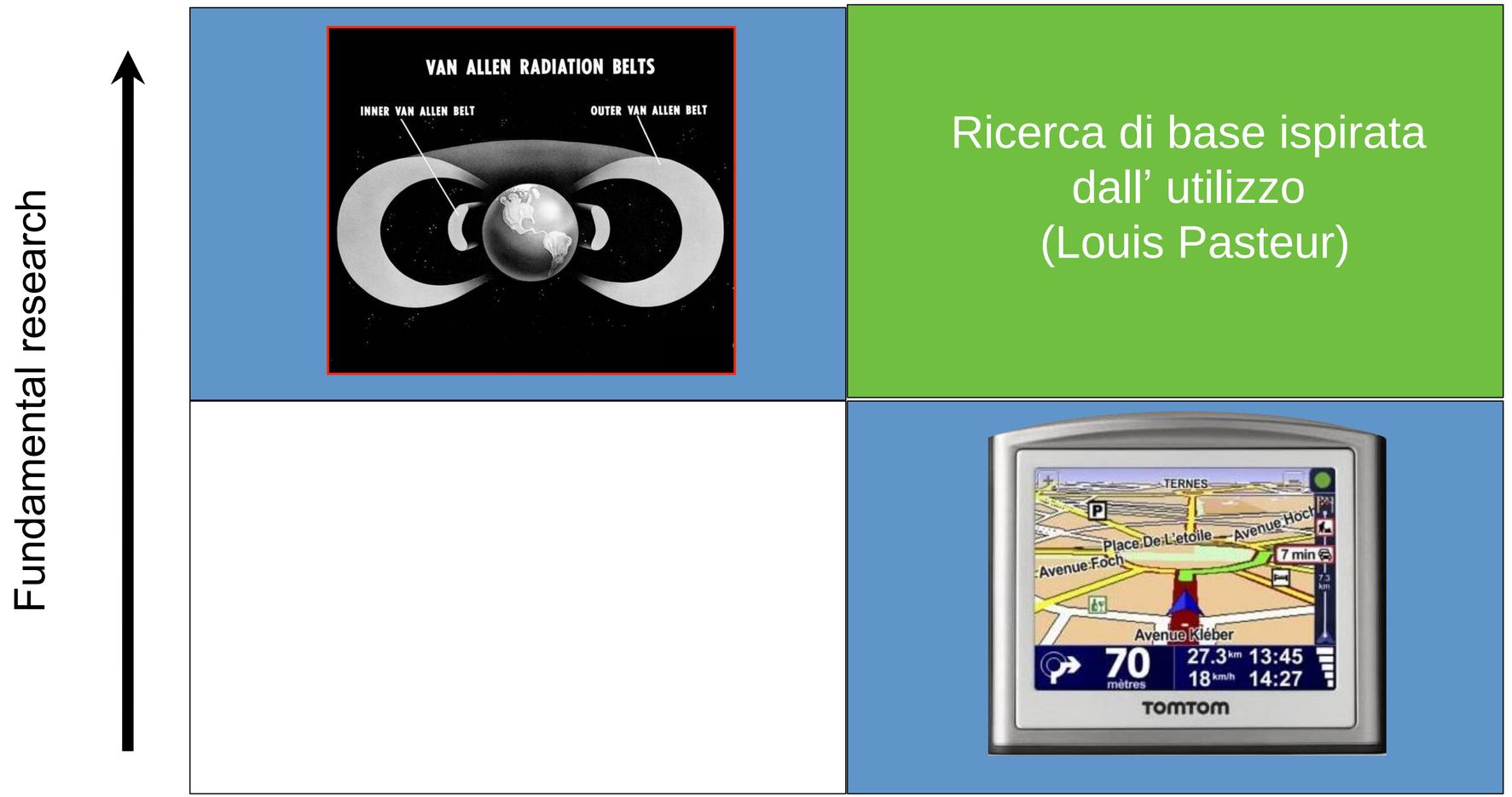
How to address the climate problem in three steps

✓✓ • Renewable energy sources

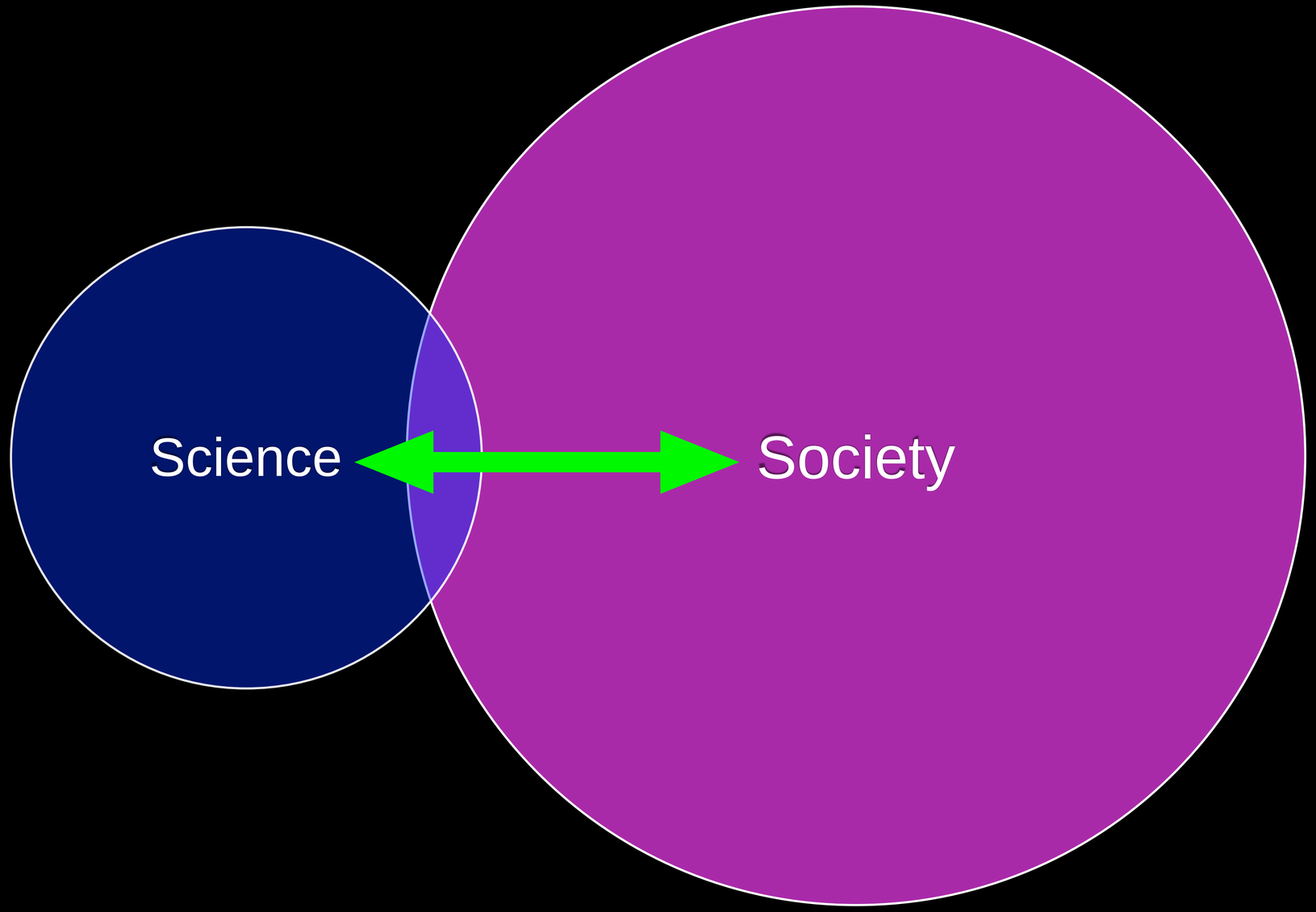
✓ • Renewable energy storage

• CO_2 capture from air

How science can contribute ?



DIscovery → Availability



Le azioni guidano le convinzioni !

Dobbiamo agire ora

Roberto
BATTISTON

L'alfabeto della NATURA

La lezione della scienza per interpretare la realtà

Rizzoli