National Technical University of Athens

School of Civil Engineering

Art and Infrastructures

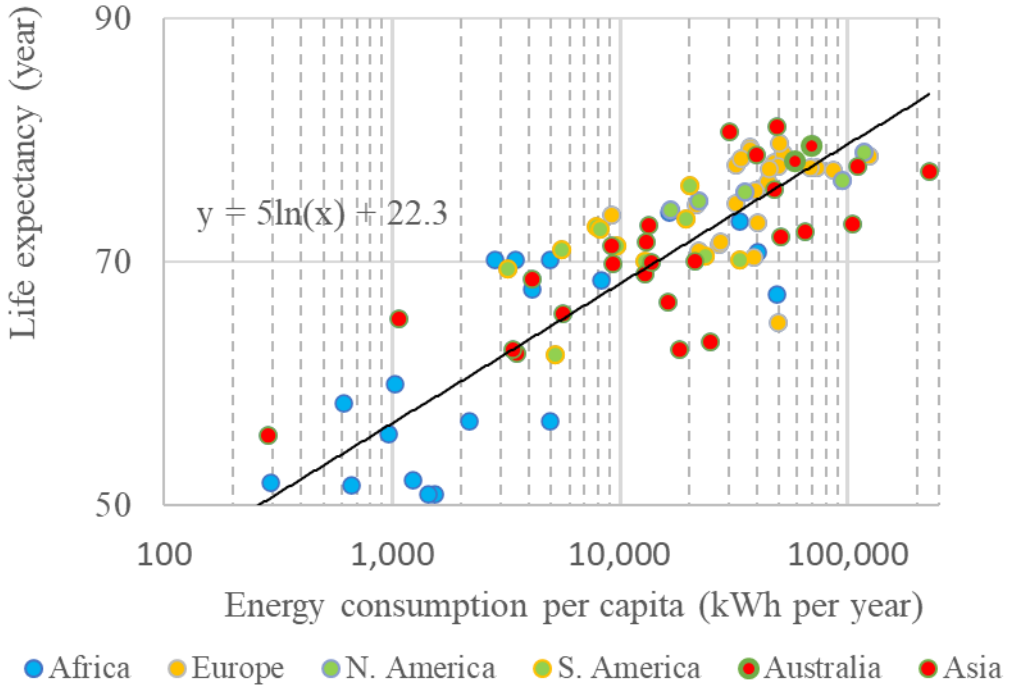
G.-Fivos Sargentis

December 2025

Human needs

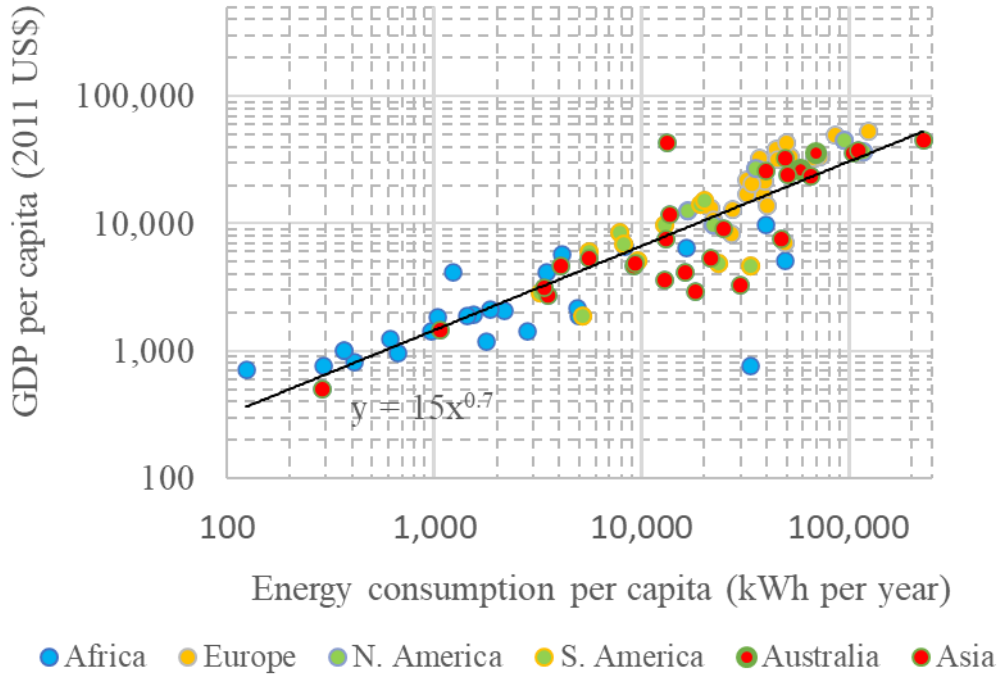
Pyramid of human needs (update)

Energy and life expectancy(2020)



Sargentis, G.F.; Lagaros, N.D.; Cascella, G.L.; Koutsoyiannis, D. Threats in Water–Energy–Food–Land Nexus by the 2022 Military and Economic Conflict. Land 2022, 11, 1569. https://doi.org/10.3390/land11091569

Energy and GDP per capita (2020)



Sargentis, G.F.; Lagaros, N.D.; Cascella, G.L.; Koutsoyiannis, D. Threats in Water–Energy–Food–Land Nexus by the 2022 Military and Economic Conflict. Land 2022, 11, 1569. https://doi.org/10.3390/land11091569

In order to cover the needs,
we need infrastructures

What form should these infrastructure have?

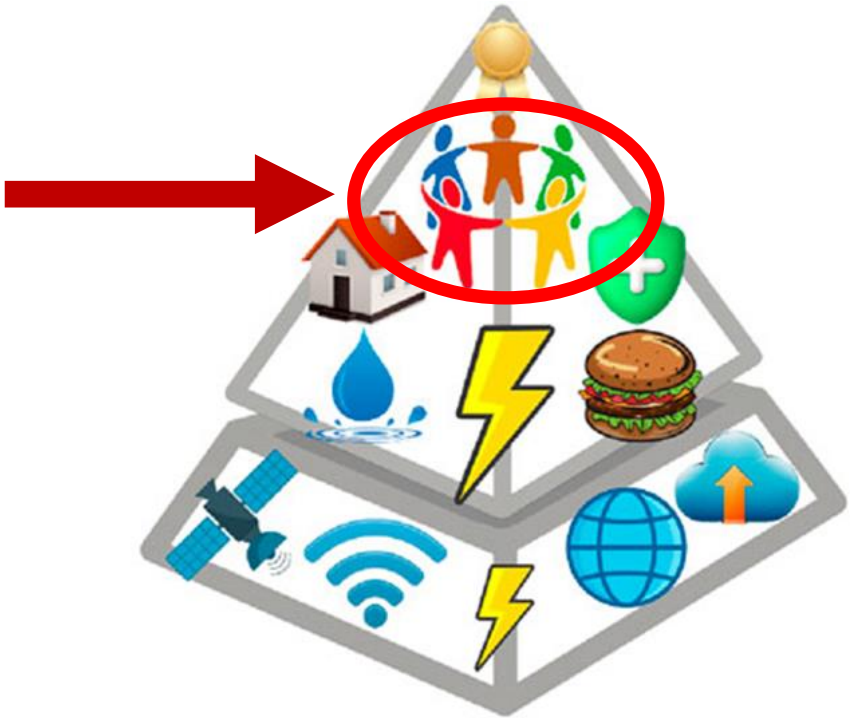
Why beautiful?

"The history of civilization has never valued a construction merely because it stands upright, but because it appears to stand beautifully."

"Every construction is a means for creating an architectural form whose purpose is to serve the human being, not only practically, but also aesthetically."
(P. Michelis, 1954)

Human needs

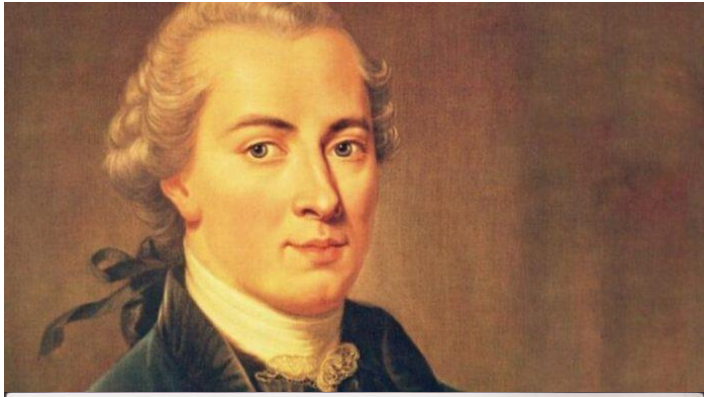
Pyramid of human needs (update)

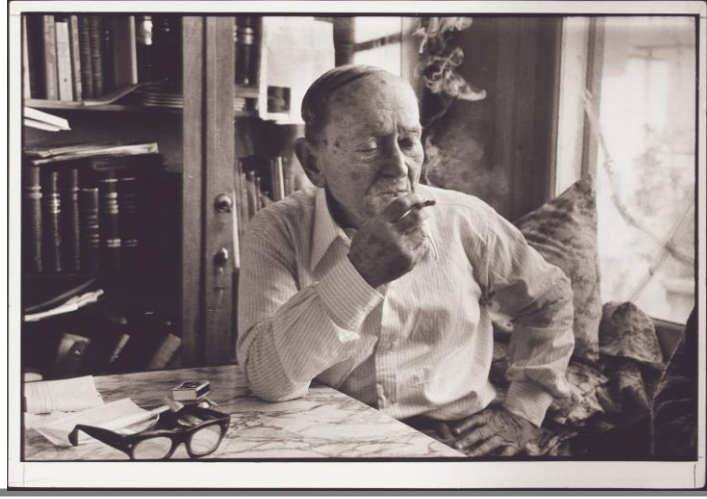


What is beautiful?

«… There can be no objective rule of taste which shall determine by means of concepts what is beautiful. … To seek for a principle of taste which shall furnish, by means of definite concepts, a universal criterion of the beautiful, is fruitless trouble; because what is sought is impossible and intrinsically self-contradictory.»
Emanuel Kant (1724-1804)

«For everything there is a law, but not for the eyes… If there is one, it's illegal...»
Ioannis Skaribas (1893-1984)





The variability in the perception of the beauty

Ancient Egypt

Ancient Greece

Medieval

Japan

Renaissance

Italy

18th c.

W. Europe

Today

The variability in the perception of the beauty

Ancient Greece

Renaissance
Italy

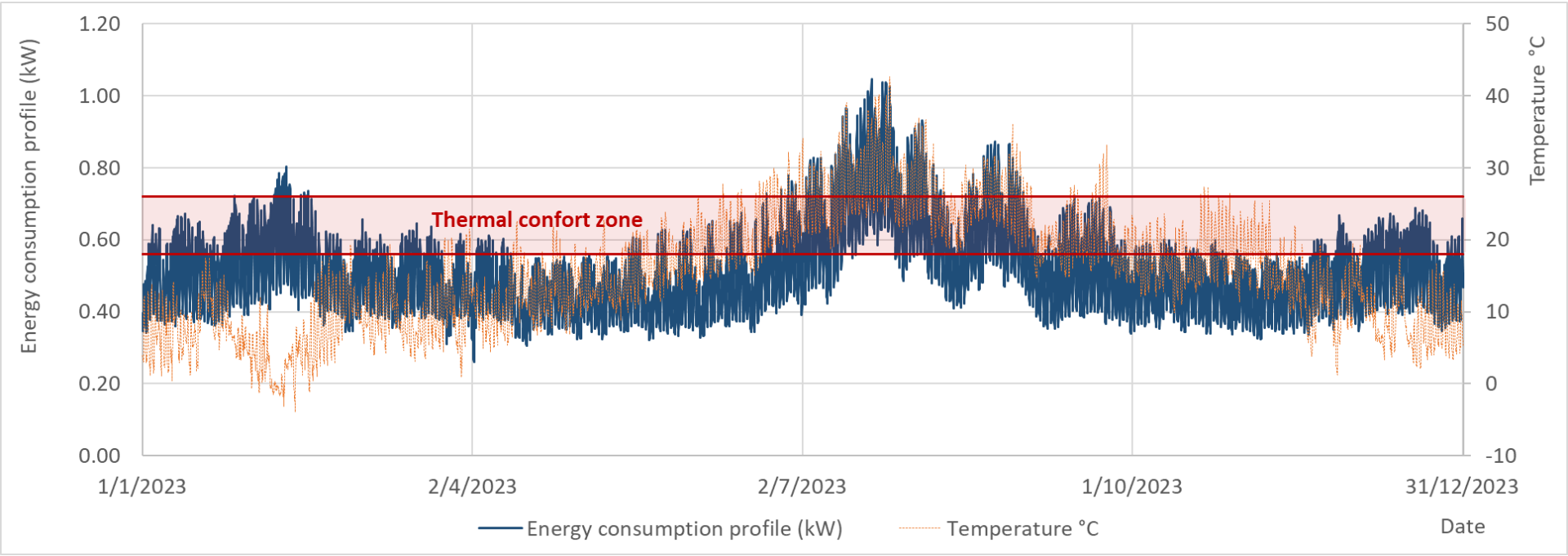
18th c.
W. Europe
N. America

Today?

Production and consumption of energy

Markantonis, D.; Sargentis, G.-F.; Dimitriadis, P.; Iliopoulou, T.; Siganou, A.; Moraiti, K.; Nikolinakou, M.; Meletopoulos, I.T.; Mamassis, N.; Koutsoyiannis, D. Stochastic Evaluation of the Investment Risk by the Scale of Water Infrastructures—Case Study: The Municipality of West Mani (Greece). World 2023, 4, 1-20. https://doi.org/10.3390/world4010001

Energy consumption profile (per capita)



Production and consumption of energy

Energy needs per capita 30 000 kWh/year (electricity ~1/6)

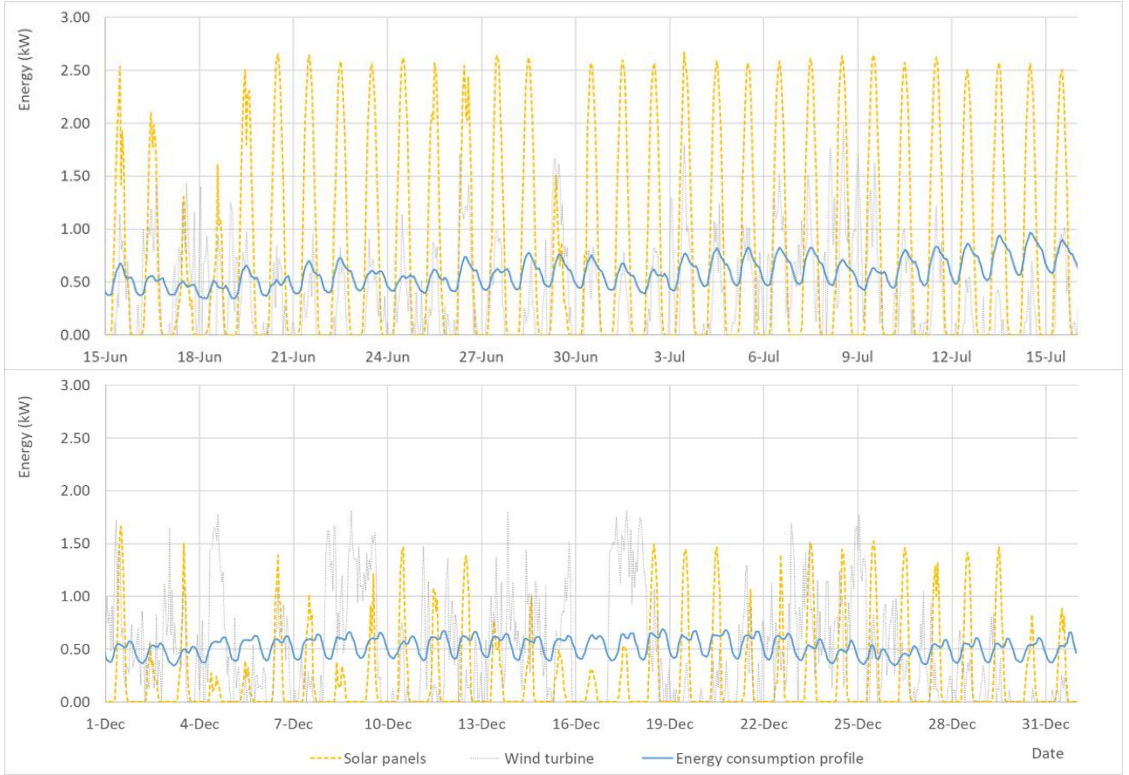
Energy needs per capita: 4,567 kWh

Solar panels annual production 4,567 kWh corresponds to 13.7 m^2

- No battery: 32% reliability
- Battery 6 kWh (half of the daily energy production): 71% reliability

Wind turbine 3 MW annual production 8,359,826 kWh corresponds to energy needs of 1,830 capita

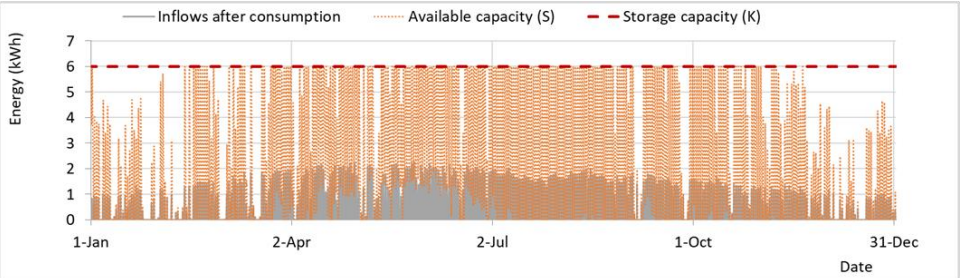
- No battery: 44% reliability
- Battery (half of the daily energy production): 70% reliability

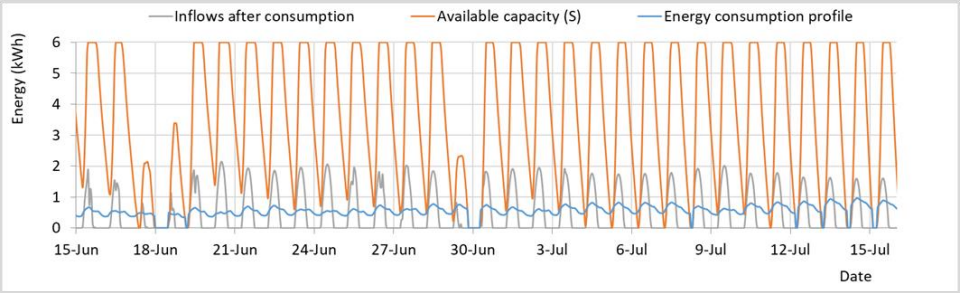


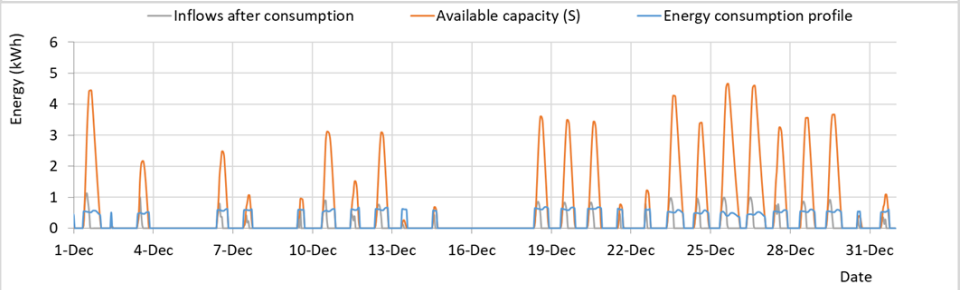
Production and consumption of energy (battery)

Battery ~1/2 of average daily production of energy

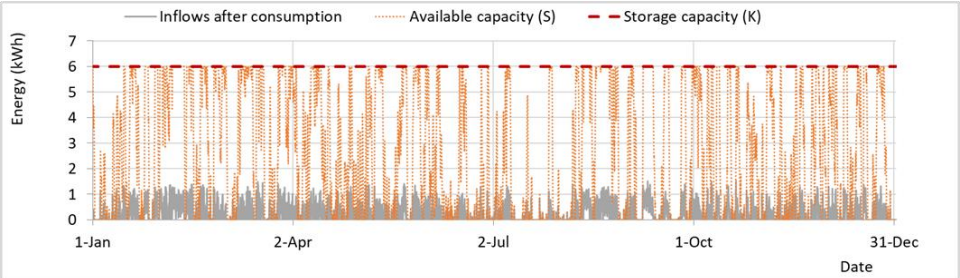
Solar

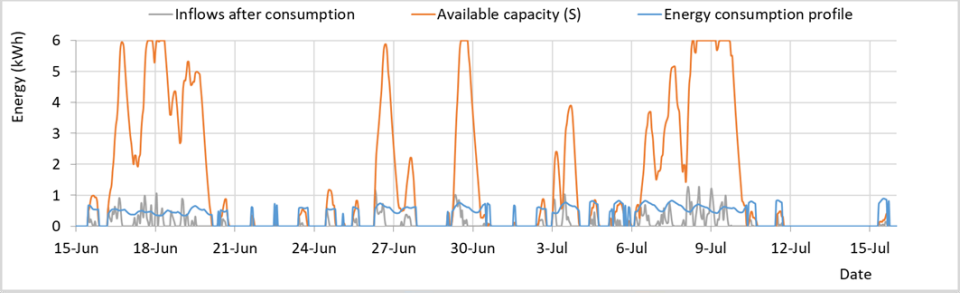


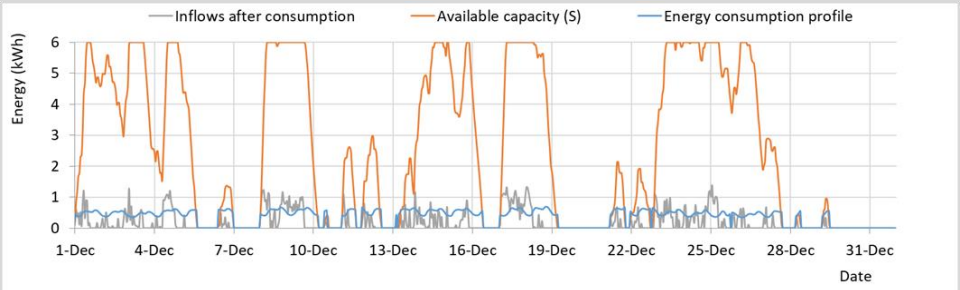




Wind







What can go wrong

Batteries

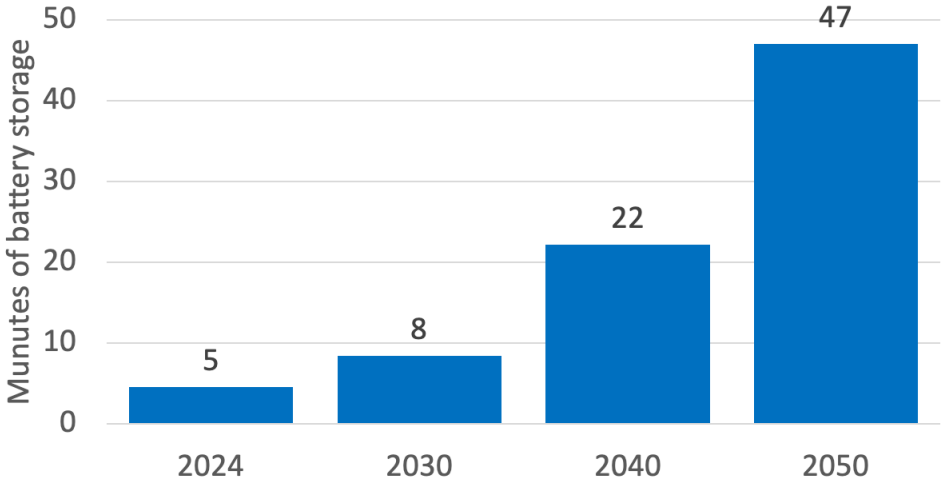
In 2024, the available batteries could store only 5 minutes of the energy produced by renewables.

By 2050, they are expected to be able to store 47 minutes.

However, achieving 100% renewable energy requires storage capacity for 40–50 days.

No, batteries won't save us

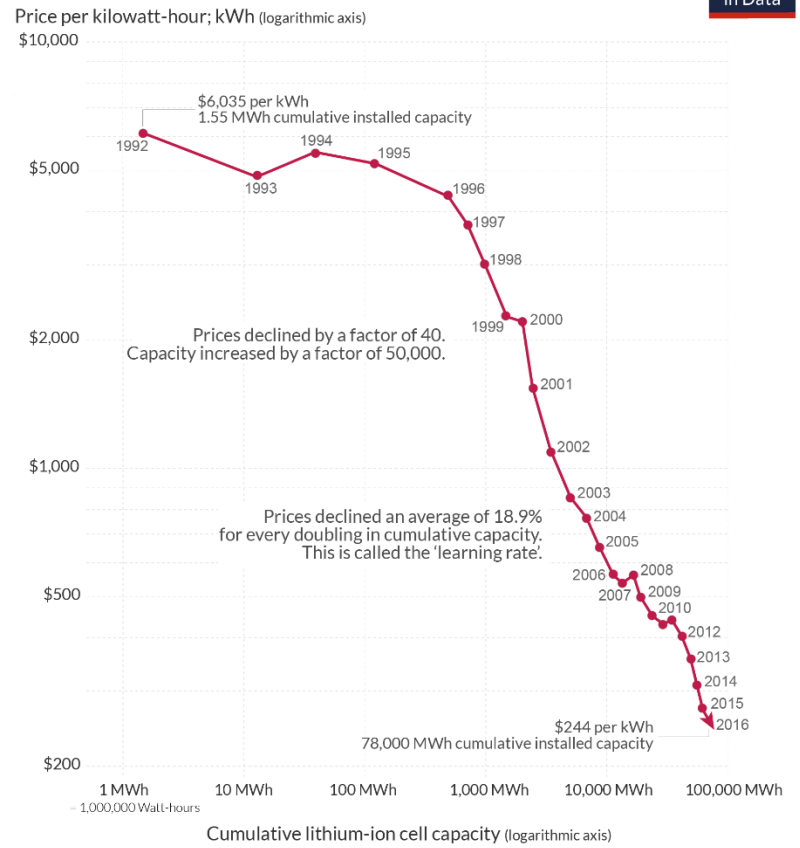
In 2024, batteries can supply nearly 5 minutes of world's electricity
Even in 2050, with 15x batteries, they can supply just 47 minutes
Problem? 100% solar and wind needs 3 months, or ~2,600x more



*From Biden's Energy Information Administration's International Energy Outlook, October 2023, https://www.eia.gov/outlooks/ieo/data.php, battery storage from Table E01.cap and global generation from Table E01.gen. In 2024, EIA estimates global battery generation at 62.9GW, and each holds 4 hours (https://www.eia.gov/outlooks/ieo/narrative/index.php), meaning 251.4GWh. Since electricity production is 29,065TWh/year or 55.3GWh/minute, that leaves 4.5 minutes of storage. In reality, throughput is not anywhere close to covering everything. Instead, the total battery capacity will be able to cover 1.9% of all electricity generation for 4 hours (1.9%*4 hours = 4.5 minutes). 2023 paper "Storage requirements to mitigate intermittent renewable energy sources: analysis for the US Northeast" (https://www.frontiersin.org/articles/10.3389/fenvs.2023.1076830), estimates that a renewable energy future solely using solar power needs 22.4% of annual electricity generation in storage, and wind 24.9%. The average is 23.65% or almost three months of storage, 124,390 minutes or 2,647 times more than storage in 2050. Twitter.com/bjornlomborg*

Price and market size of lithium-ion batteries since 1992

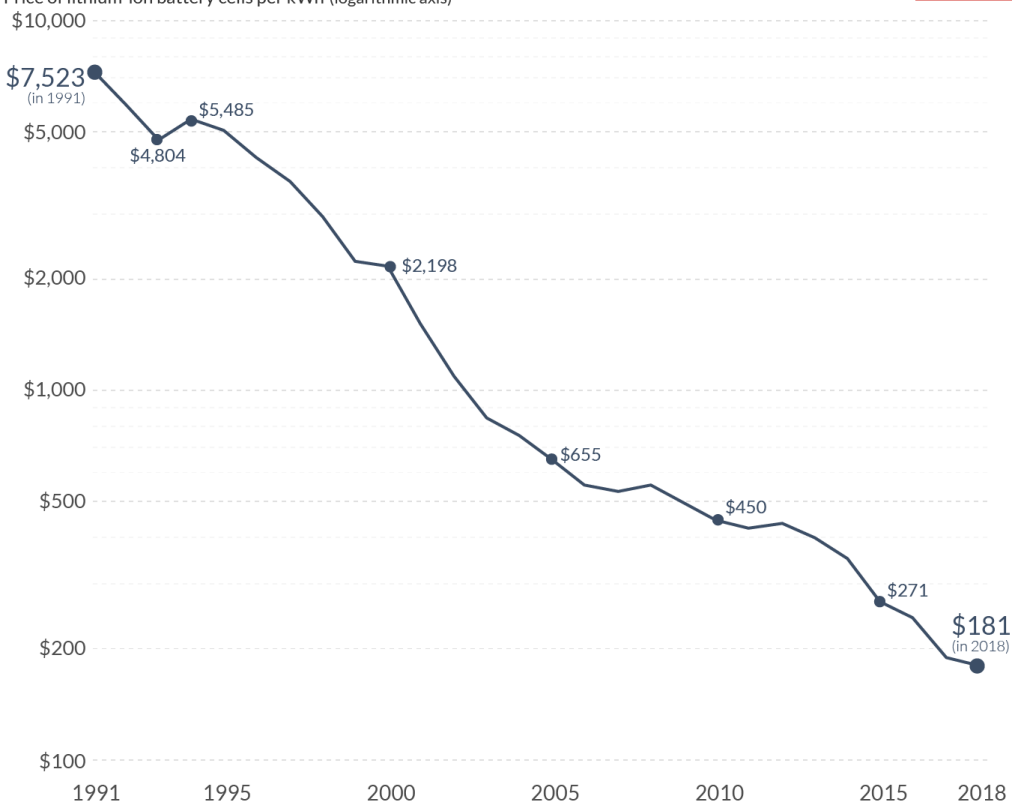
Our World in Data



Prices are adjusted for inflation and given in 2018 US-$ per kilowatt-hour (kWh).
Source: Micah Ziegler and Jessika Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.
OurWorldinData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Hannah Ritchie.

The price of lithium-ion batteries fell by 97%

Our World in Data



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Source: Micah Ziegler and Jessika Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.
OurWorldinData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Hannah Ritchie.

What can go wrong

Report this ad

REUTERS

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Energy | Fuel Oil | Wind

Siemens Energy shares slide 39% after company seeks guarantees from German govt

Reuters

October 26, 2023 6:45 AM CDT · Updated 10 min ago

The logo of energy technology company Siemens Energy is displayed during the LNG 2023 energy trade show in Vancouver, British Columbia, Canada, July 12, 2023. REUTERS/Chris Helgren/File Photo *Acquire Licensing Rights*

Siemens Energy shares

Shares of the power engineering company plunged after it revealed it was in talks with the German government about state guarantees.

Source: LSEG | Reuters, Oct. 26, 2023 | By Tom Sims

What can go wrong

pv magazine

Weekend Read: A 10 GW time bomb

It is estimated that 10 GW of solar modules in Germany suffer from prematurely aging backsheets, with sites of all sizes affected. **pv magazine Germany**'s **Cornelia Lichner** looks at how to detect and repair such defects.

SEPTEMBER 9, 2023 CORNELIA LICHNER

INSURANCE | MODULES & UPSTREAM MANUFACTURING | QUALITY | UTILITY SCALE PV | GERMANY

If the back foil tears, it is only a matter of time before the stability of a module fails completely.

Photo: Bernhard Weinreich, HaWe Engineering

ParisTech REVIEW

ABOUT US

INDUSTRIES | BUSINESS | SOCIETY | SCIENCE & TECHNOLOGY

The German solar energy crisis: looking for the right incentive scheme

ParisTech Review / Editors / April 13th, 2012

green economy renewable energy technology adoption technology and business

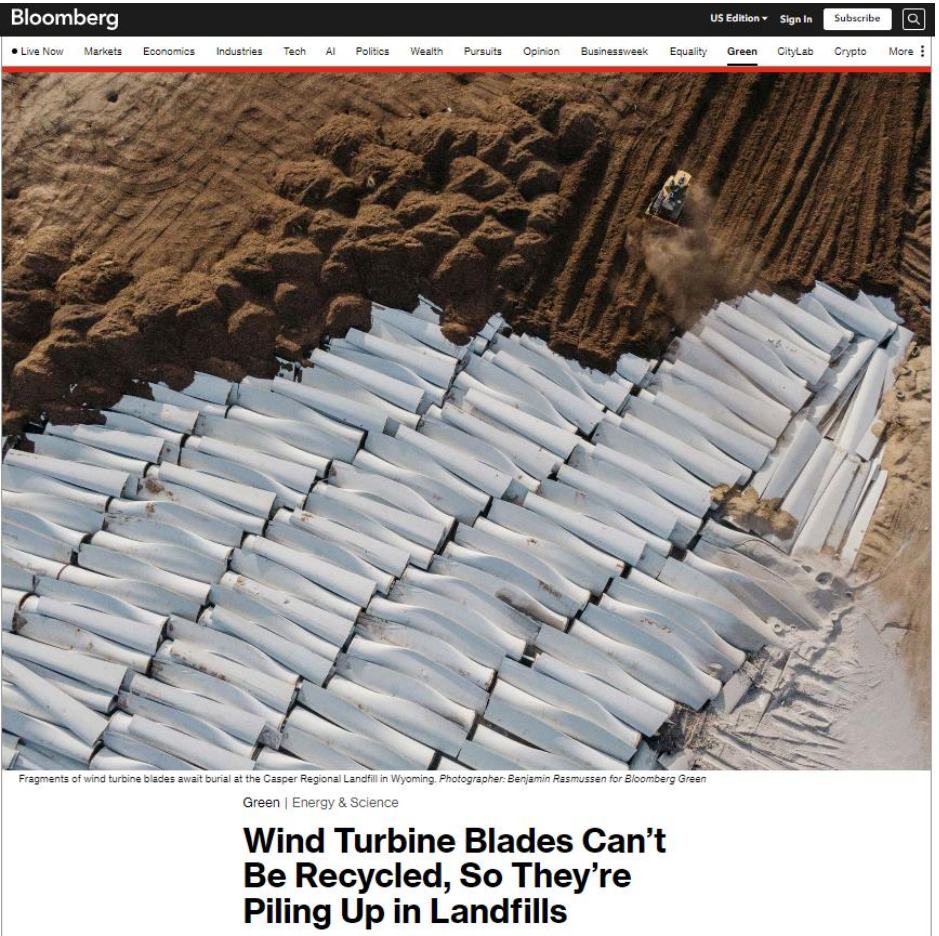
The German photovoltaic industry is in chaos. Overwhelmed by the boom of solar home systems, the government has had to brutally halt subsidies whose costs were threatening to... go through the roof. Caught between Chinese competition and the falling price of solar panels, several of the flagships of this young industry are now on the brink of bankruptcy. After having enjoyed a heyday of several years, the sector suddenly has to adjust to new conditions. And, if it hopes to recover, must adapt.

3. Sustainable Development

27. Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.

to meet the needs of the present without compromising the needs of the future

What can go wrong



Fragments of wind turbine blades await burial at the Casper Regional Landfill in Wyoming. *Photographer: Benjamin Rasmussen for Bloomberg Green*

Green | Energy & Science

Wind Turbine Blades Can't Be Recycled, So They're Piling Up in Landfills

The cost of electricity in Greece (1965-2023)

Ἄρθρον 3.

1. Ἡ Δ.Ε.Η. θὰ καθορίζῃ τὰς τιμὰς τῆς πωληθησομένης ὑπ' αὐτῆς ἠλεκτρικῆς ἐνεργείας, ἀποβλέπουσα ἀφ' ἑνὸς μὲν ἵνα αὗται εἶναι ὅσον τὸ δυνατὸν χαμηλότεραι, ἀφ' ἑτέρου δὲ ἵνα ἐπιτρέπουν τὴν πραγματοποίησιν ἐσόδων ἀνωτέρων τοῦ ἐξ οἱασδήποτε αἰτίας κόστους, προσδιοριζομένων ἐπὶ τῇ βάσει ὑγειῶν οἰκονομικῶν ἀρχῶν, ὡς καὶ τῶν σχετικῶν διατάξεων τοῦ παρόντος.

Sargentis G.-F.; Ioannidis R.; Mamassis N.; Zoukos V.; Koutsoyiannis D. A Review of the Energy Policy in Greece in the Last 50 Years and Its Implications for Prosperity. Clean Energy and Sustainability 2024, 2, 10021. https://doi.org/10.70322/ces.2024.10021

The cost of electricity in Greece (1965-2023)

ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ

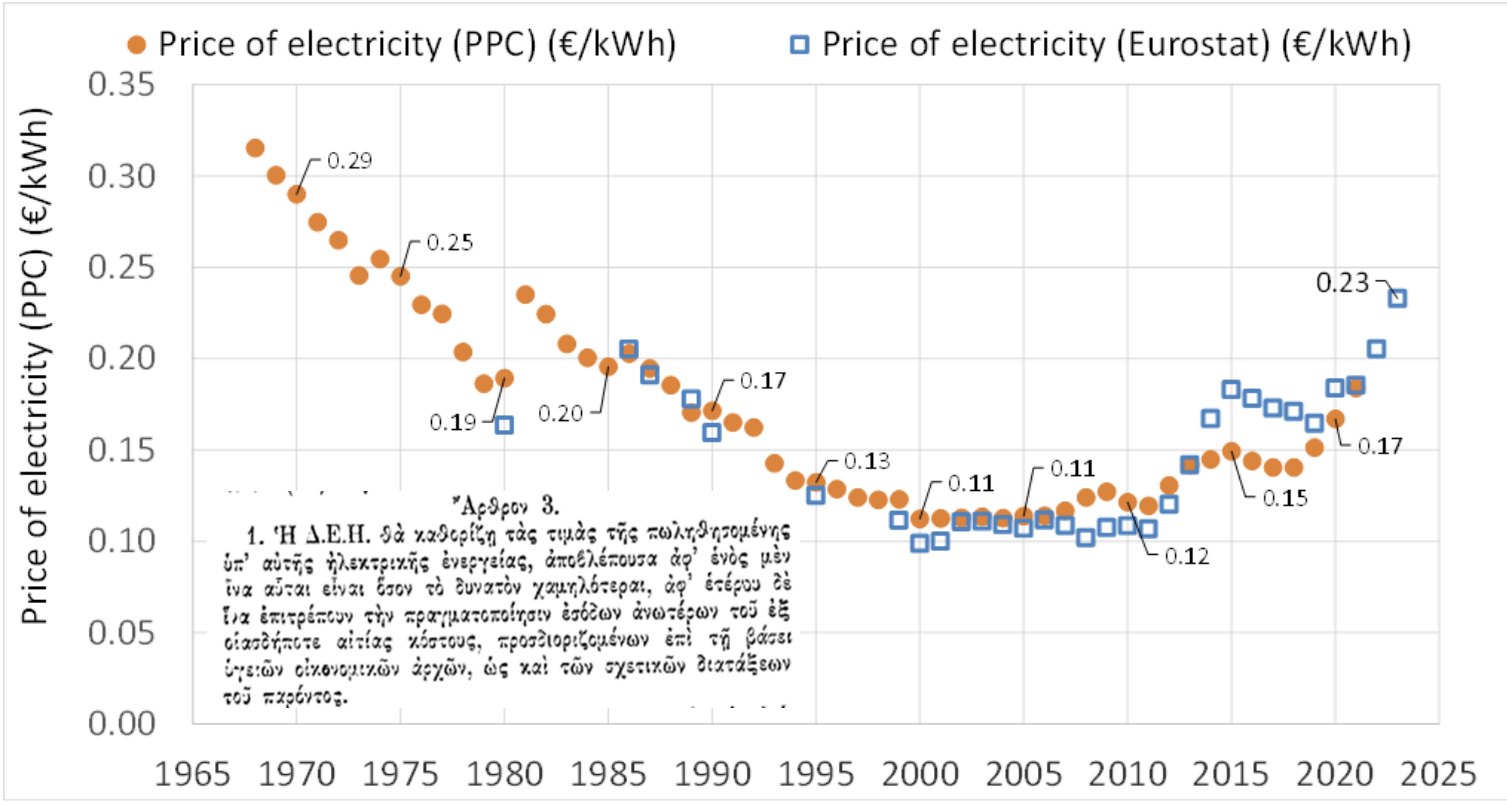
ΤΟΥ ΒΑΣΙΛΕΙΟΥ ΤΗΣ ΕΛΛΑΔΟΣ

ΤΕΥΧΟΣ ΠΡΩΤΟΝ

ΠΕΡΙΕΧΟΜΕΝΑ

ΔΙΑΤΑΓΜΑΤΑ

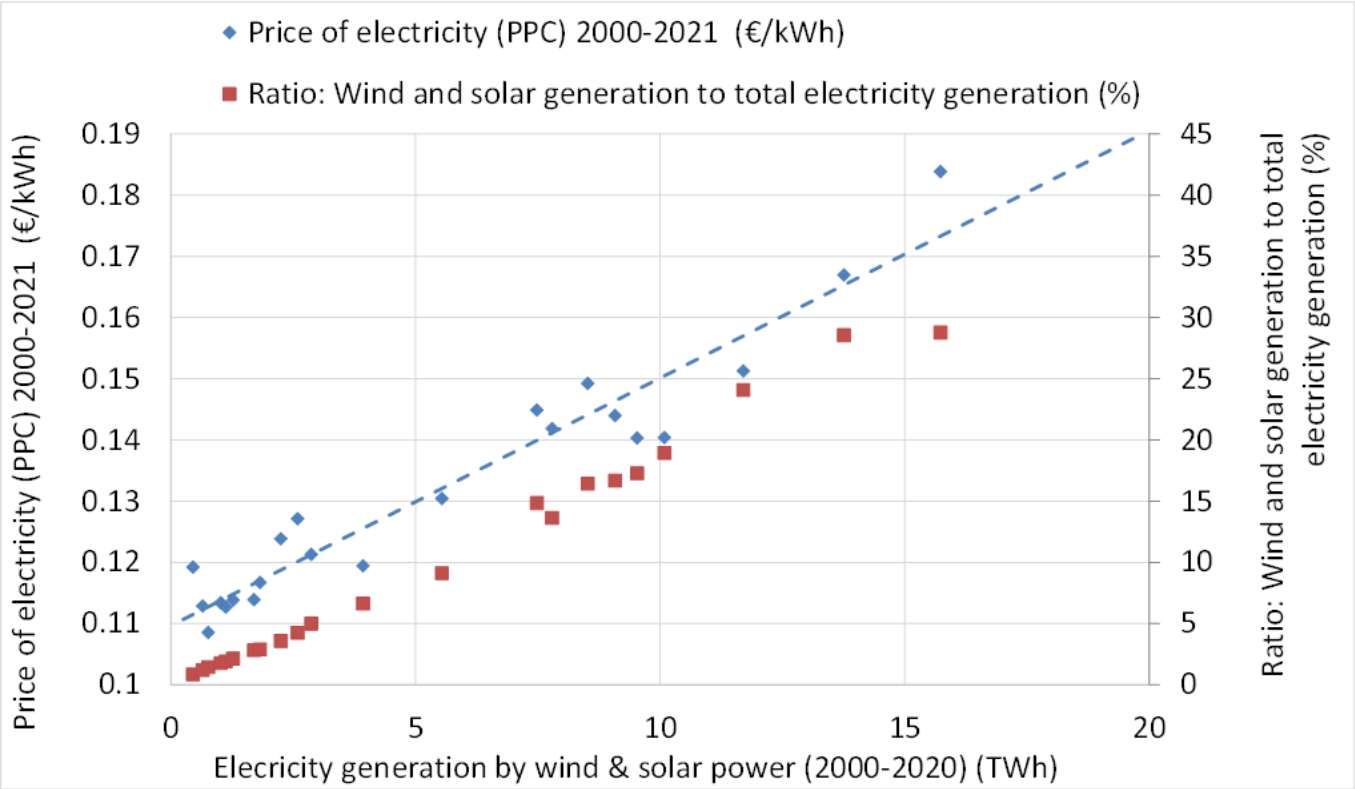
ΠΑΤΑΣΘΕ ΤΟΝ ΕΛΛΗΝΩΝ



Sargentis, G.-F.; Ioannidis, R.; Mamassis, N.; Zoukos, V.; Koutsoyiannis D. A review of the energy policy in Greece in the last 50 years and its implications to prosperity (Under review) Preprint at Researchgate: http://dx.doi.org/10.13140/RG.2.2.13834.27846

Sargentis G.-F.; Ioannidis R.; Mamassis N.; Zoukos V.; Koutsoyiannis D. A Review of the Energy Policy in Greece in the Last 50 Years and Its Implications for Prosperity. Clean Energy and Sustainability 2024, 2, 10021. https://doi.org/10.70322/ces.2024.10021

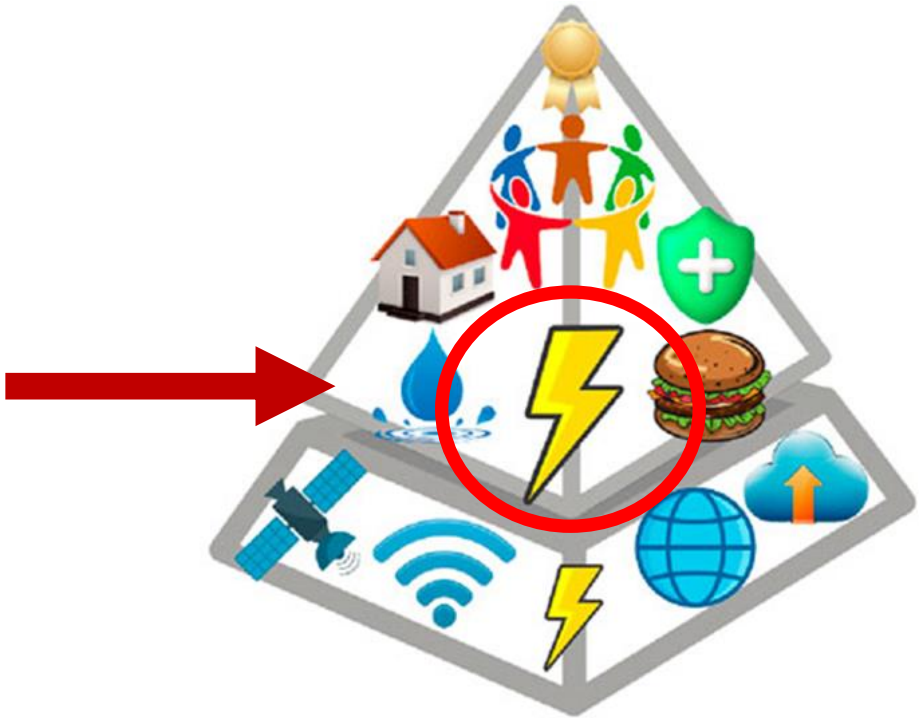
The energy mix in Greece (1990-2023)



Sargentis, G.-F.; Ioannidis, R.; Mamassis, N.; Zoukos, V.; Koutsoyiannis D. A review of the energy policy in Greece in the last 50 years and its implications to prosperity (Under review)
Preprint at Researchgate: http://dx.doi.org/10.13140/RG.2.2.13834.27846

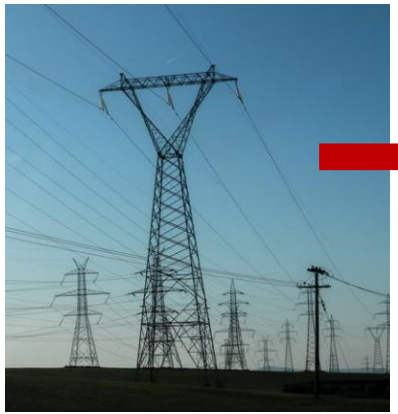
Sargentis G.-F.; Ioannidis R.; Mamassis N.; Zoukos V.; Koutsoyiannis D. A Review of the Energy Policy in Greece in the Last 50 Years and Its Implications for Prosperity. Clean Energy and Sustainability 2024, 2, 10021.
https://doi.org/10.70322/ces.2024.10021

What can go wrong: are they useful?

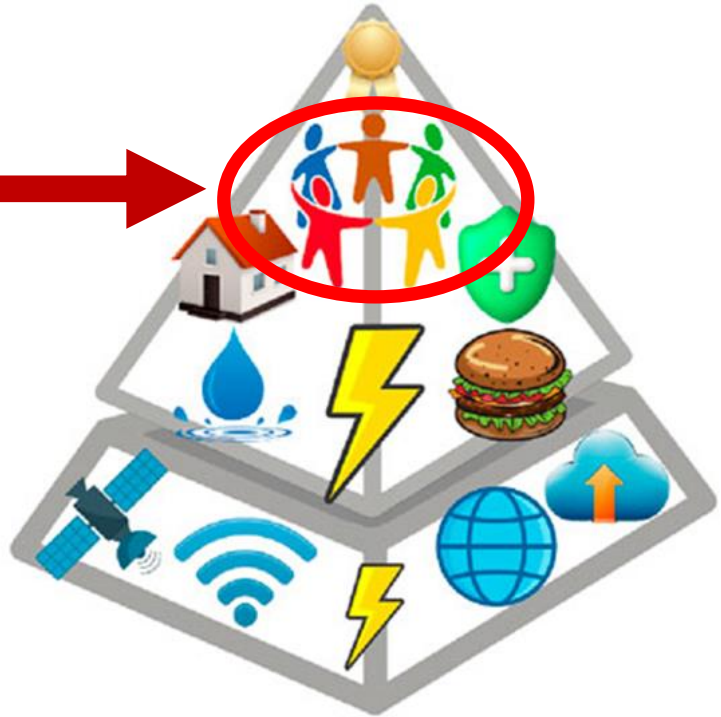


Sargentis G-F (2025) Fragility in human progress. A perspective on governance, technology and societal resilience. Front. Complex Syst. 3:1609467 https://doi.10.3389/fcpxs.2025.1609467

What can go wrong: industrial landscapes



Question: Why aren't we concerned with their aesthetics?



Question: They are considered less disruptive than pillars.

Why are we concerned with their aesthetics and not with pillars?

Sargentis G-F (2025) Fragility in human progress. A perspective on governance, technology and societal resilience. Front. Complex Syst. 3:1609467 https://doi.10.3389/fcpxs.2025.1609467

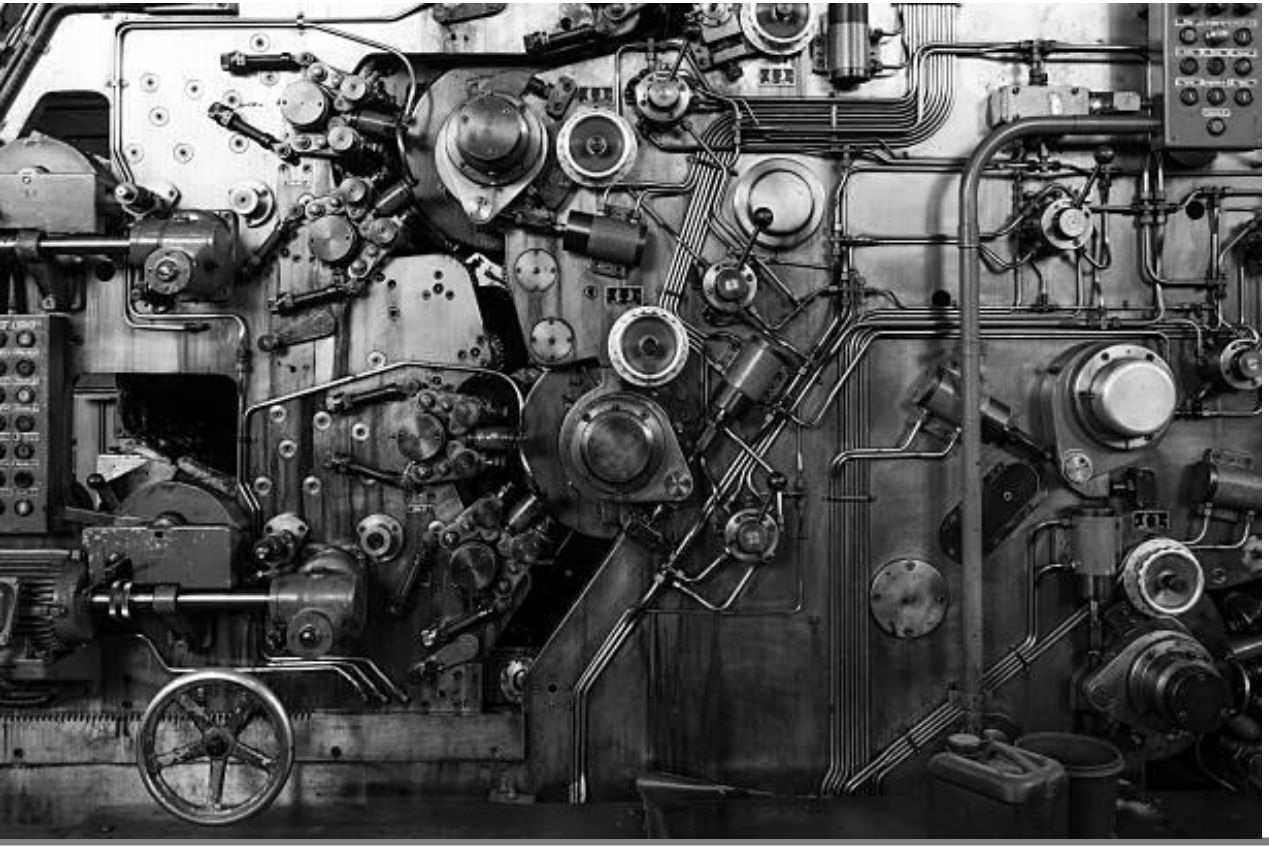
Industrial landscapes

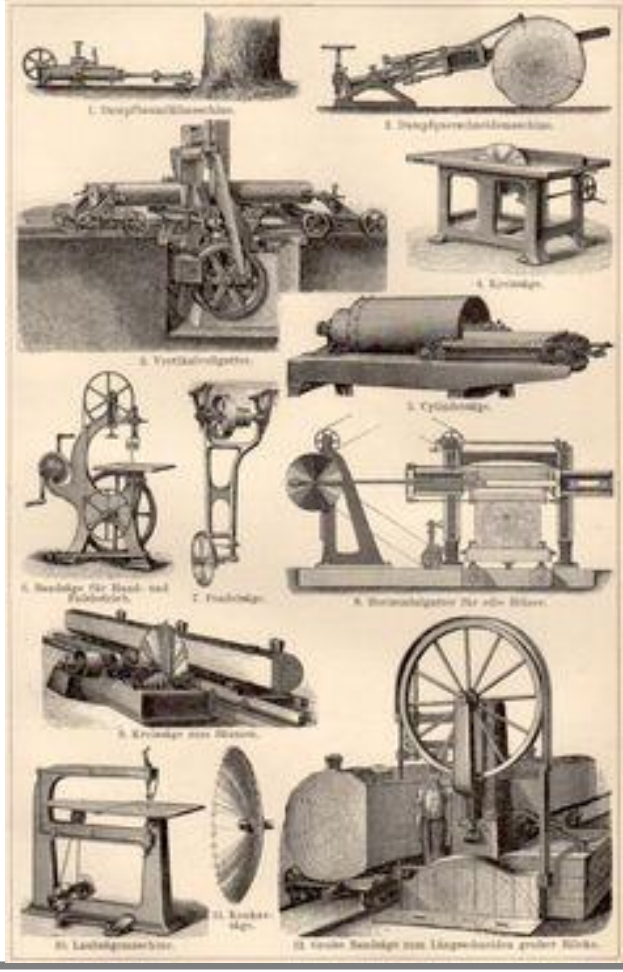
What can go wrong

Manta, E.; Ioannidis, R.; Sargentis, G.-F.; Efstratiadis, A. Aesthetic evaluation of wind turbines in stochastic setting: Case study of Tinos island Greece, European Geosciences Union General Assembly 2020, Geophysical Research Abstracts, Vol. 22, Online, EGU2020- 5484, https://doi.org/10.5194/egusphere-egu2020-5484, European Geosciences Union, 2020.

Can art be useful?

Can art be useful?

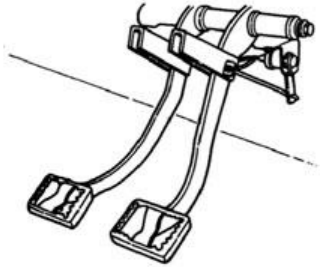




Can art be useful?

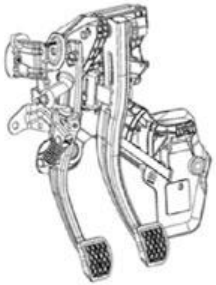
Can art be useful?

(a)



(b)

(c)



(d)

Can art be useful? "form follows function"

An "umbrella on four wheels" that could carry four adults and 50 kg of farm goods across a ploughed field without breaking a basket of eggs.

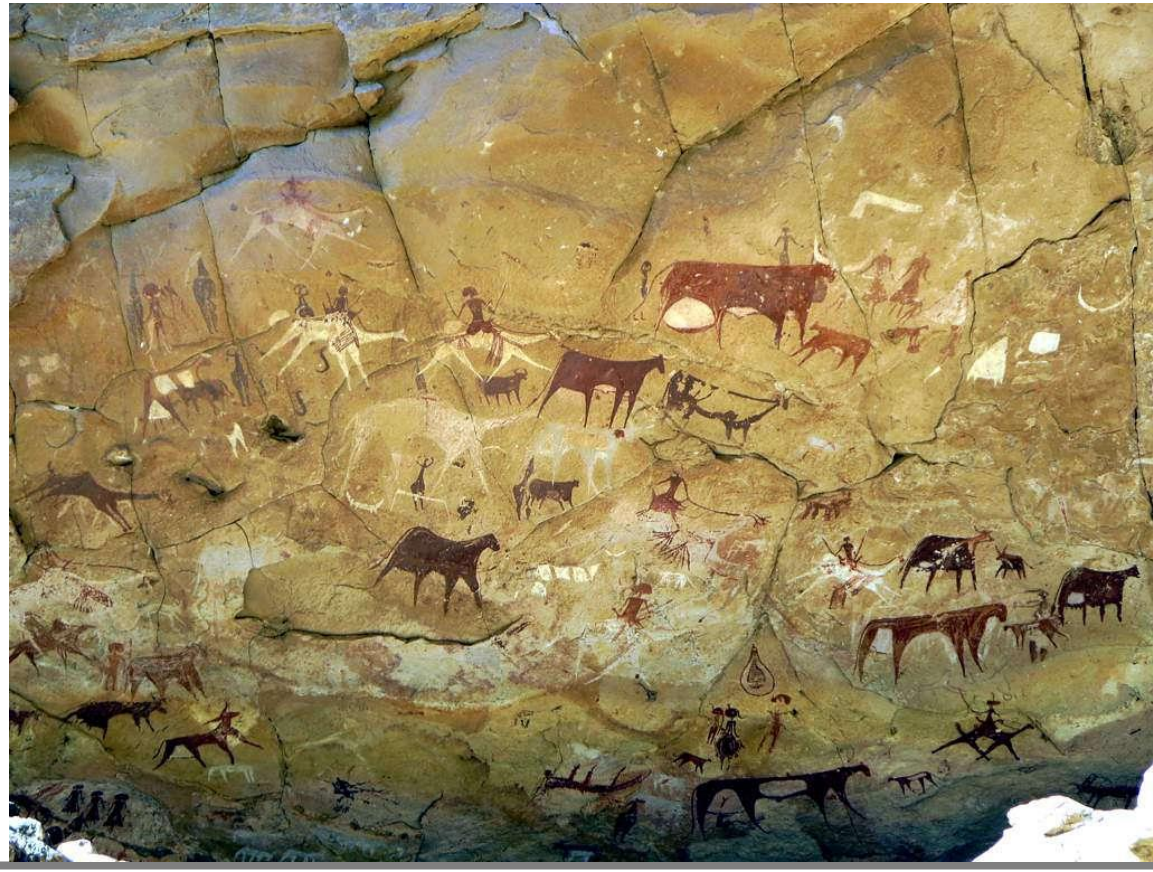
Can art be useful? "form follows function"

A tough little four-wheel mule that could take four soldiers, a machine gun, and a week of rations up a steep hill, cross rivers, and still pull a stuck tank out of the mud.

How to communicate a message with art

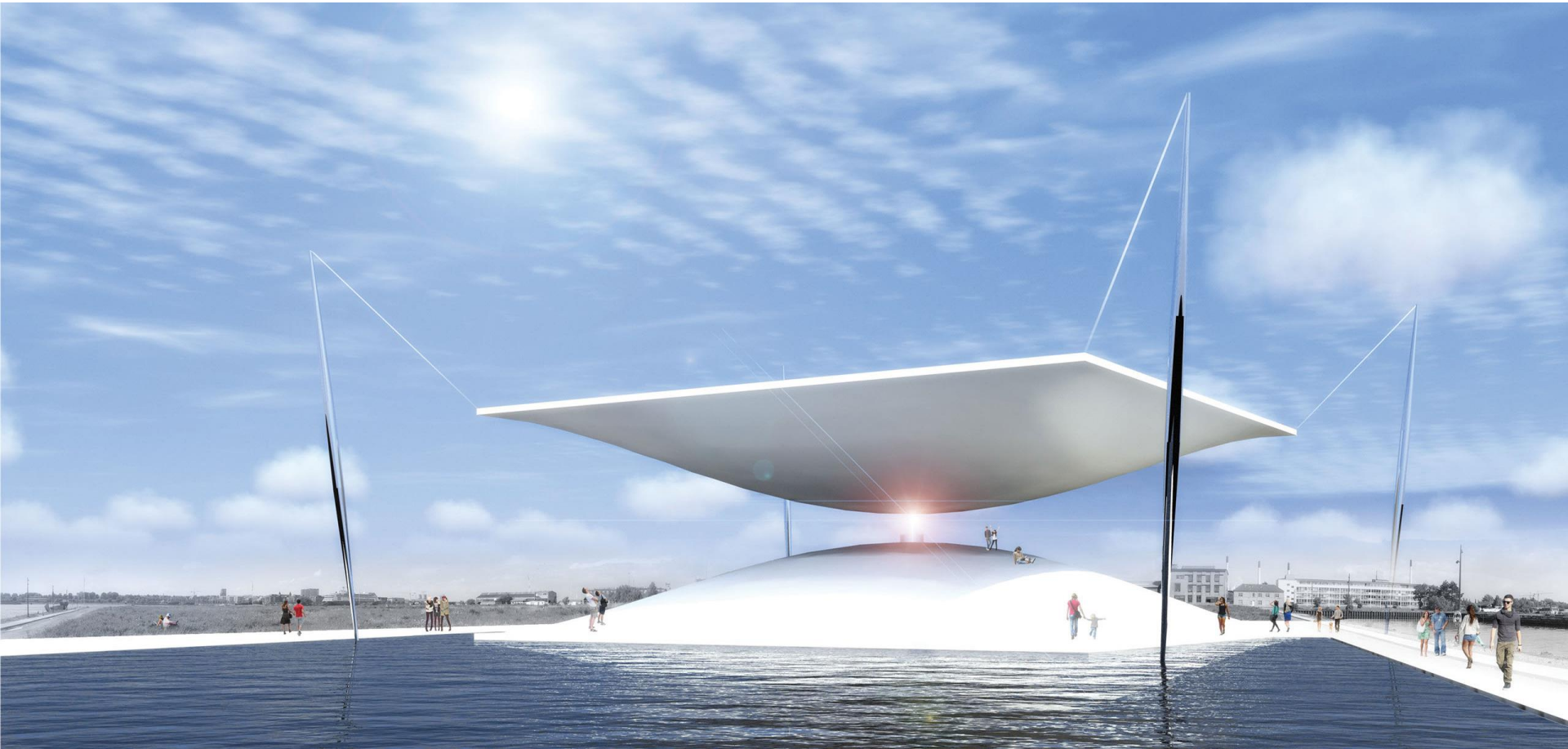
Emotion, critique, and ideas into reality

- Art doesn’t just decorate – it speaks when words fail.
- From cave paintings to protest graffiti, humans have always used images to send urgent messages.



Emotion, critique, and ideas into reality

LAGI: Land Art Generator (https://landartgenerator.org/)



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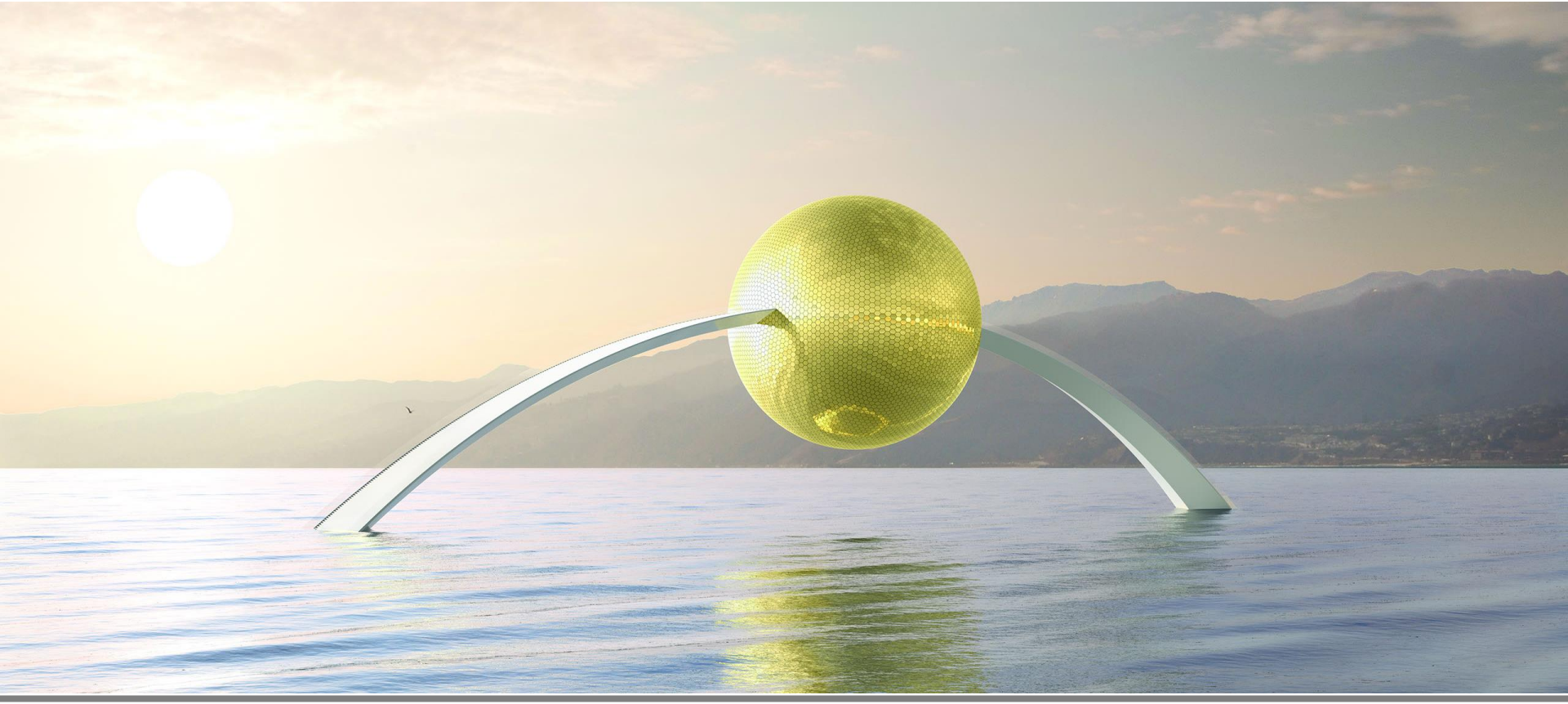


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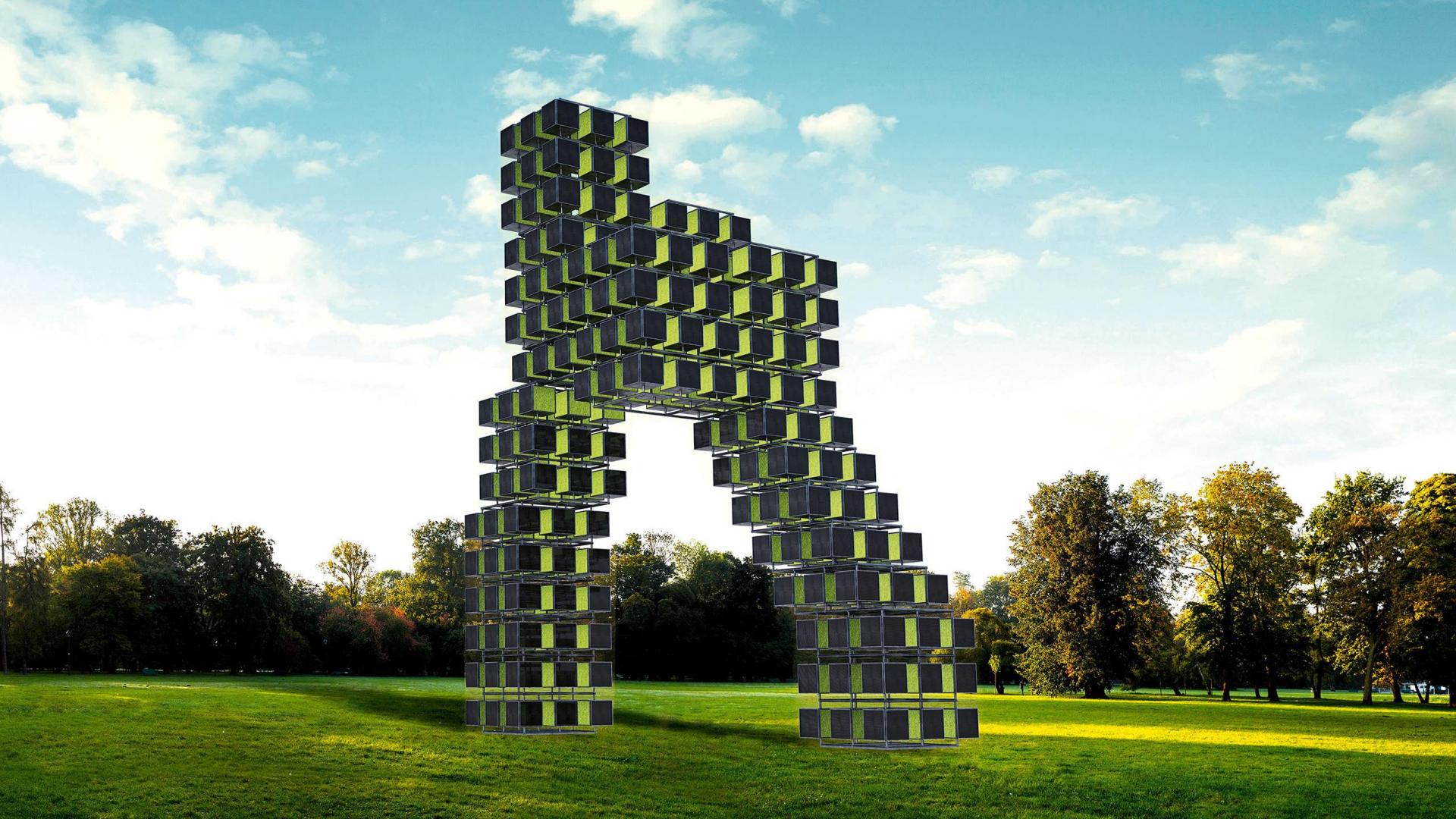
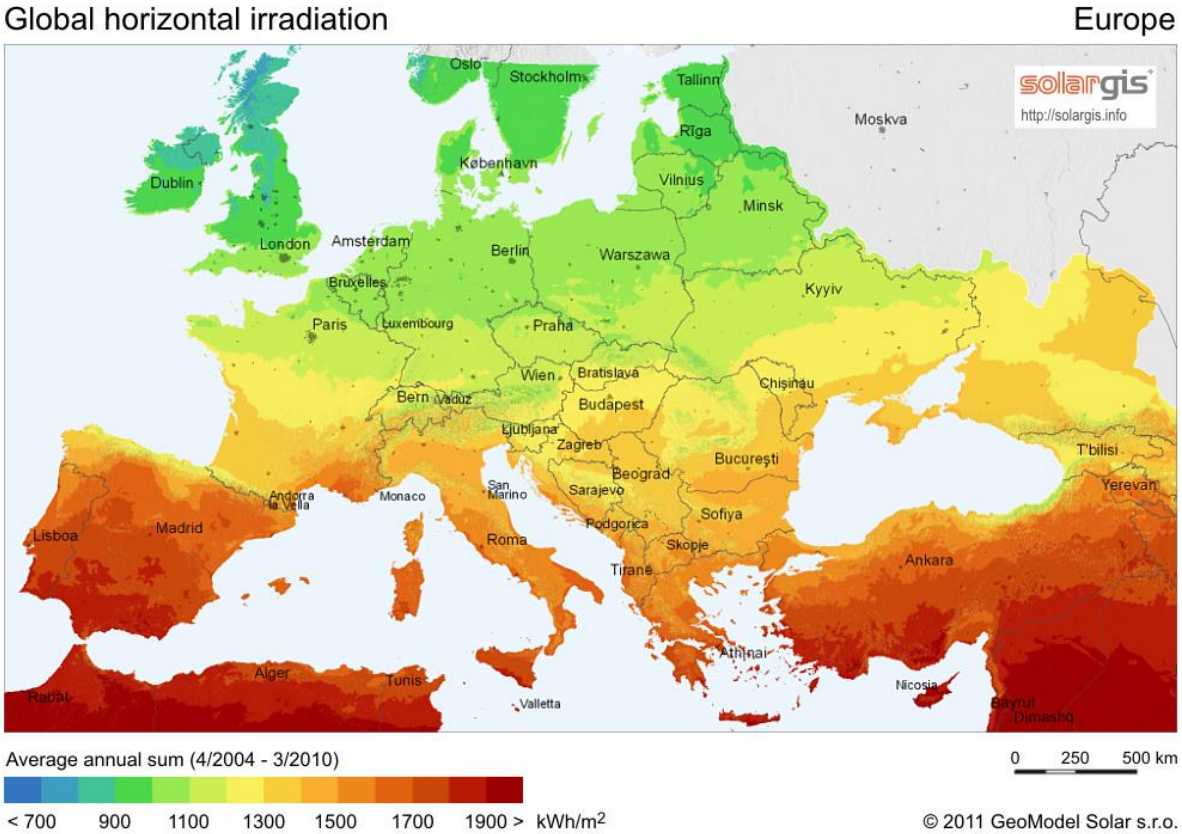


Understanding of the sources

The basic principals

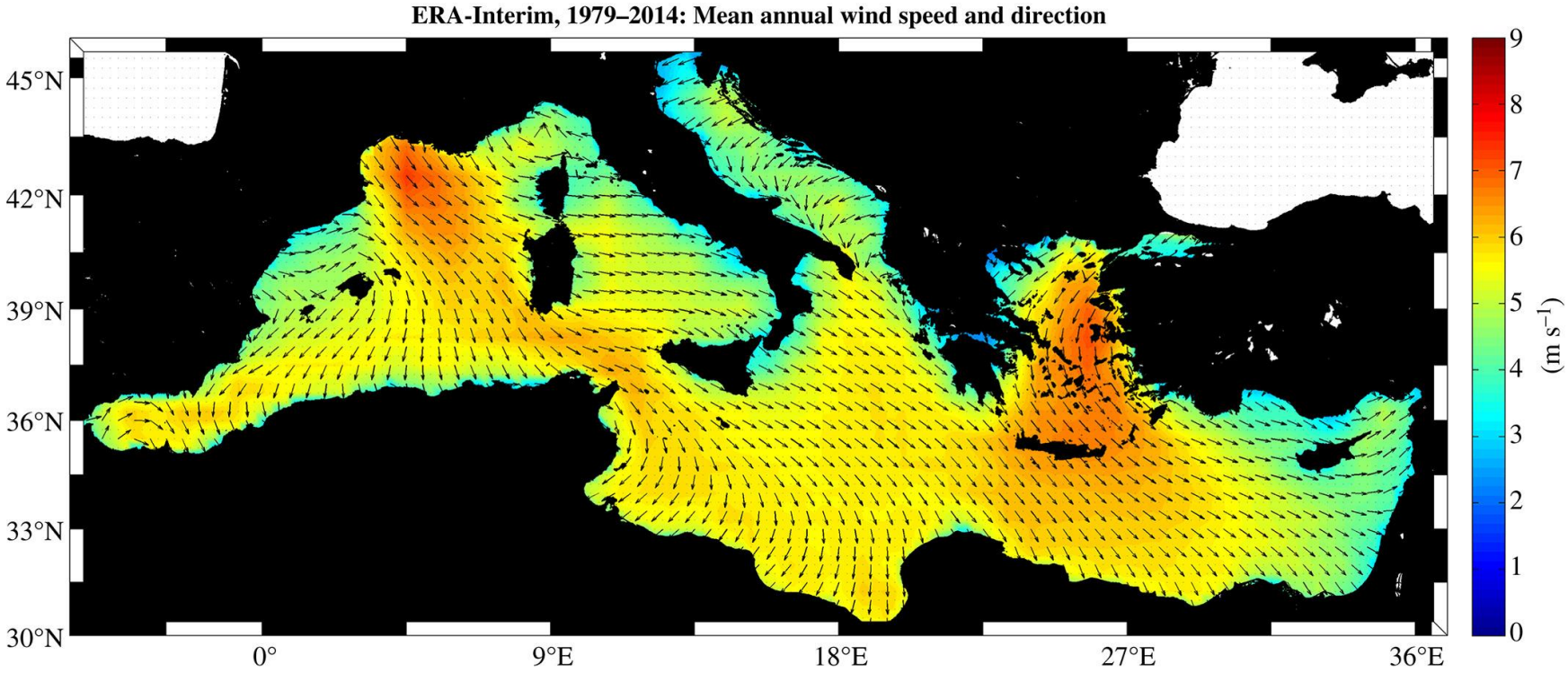
Energy sources

Europe Average Daily Solar Hours



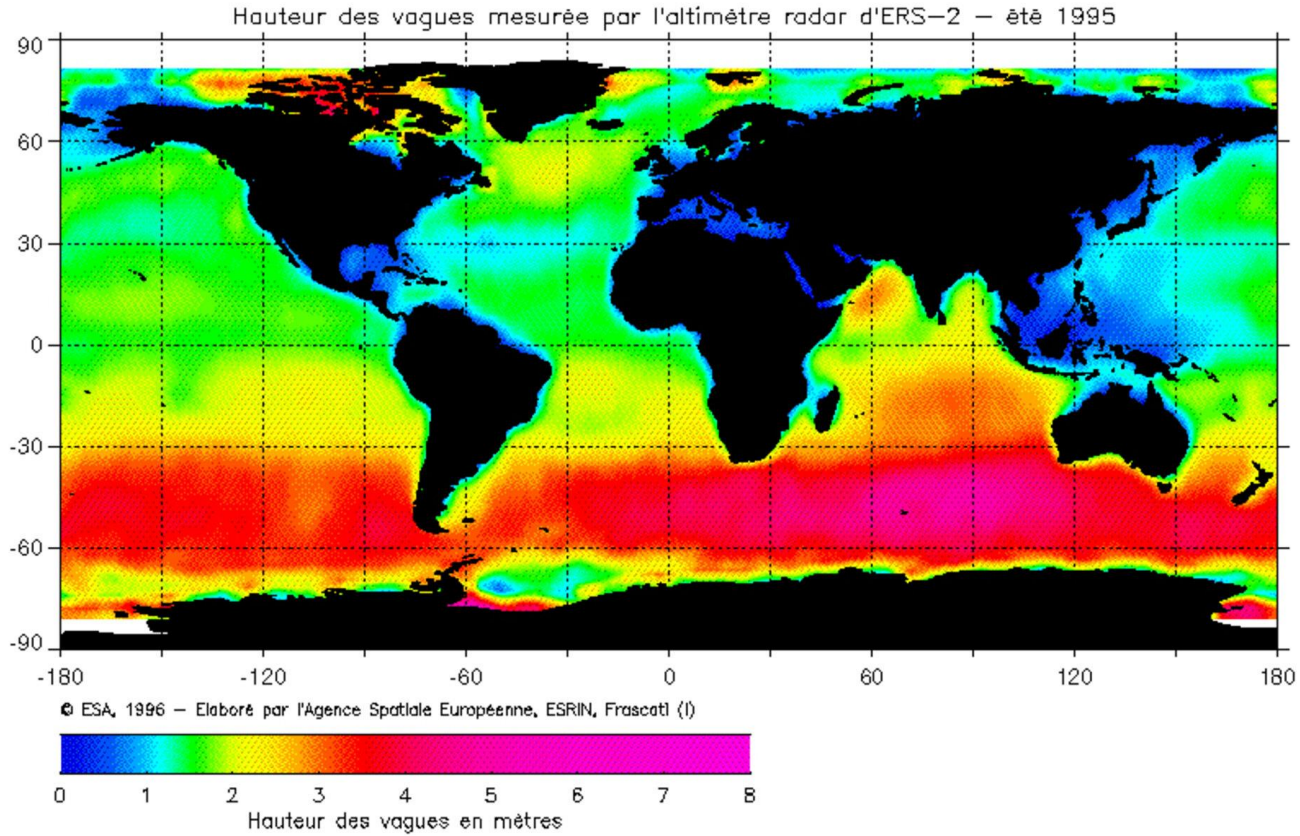
https://www.hotspotenergy.com/DC-air-conditioner/europe-solar-hours.php

Offshore wind climate analysis and variability in the Mediterranean Sea



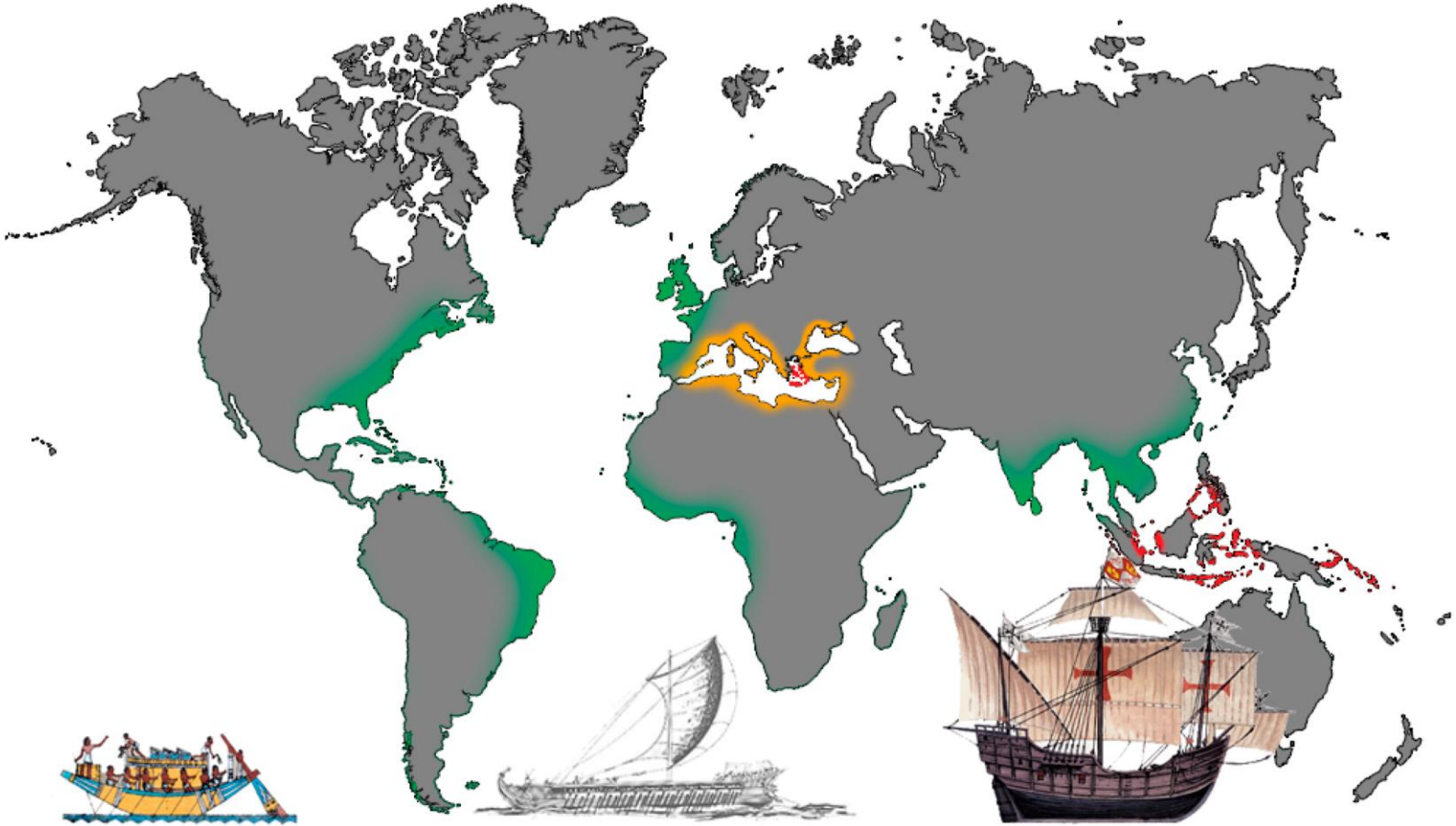
https://rmets.onlinelibrary.wiley.com/doi/10.1002/joc.5182

Significant Wave Height



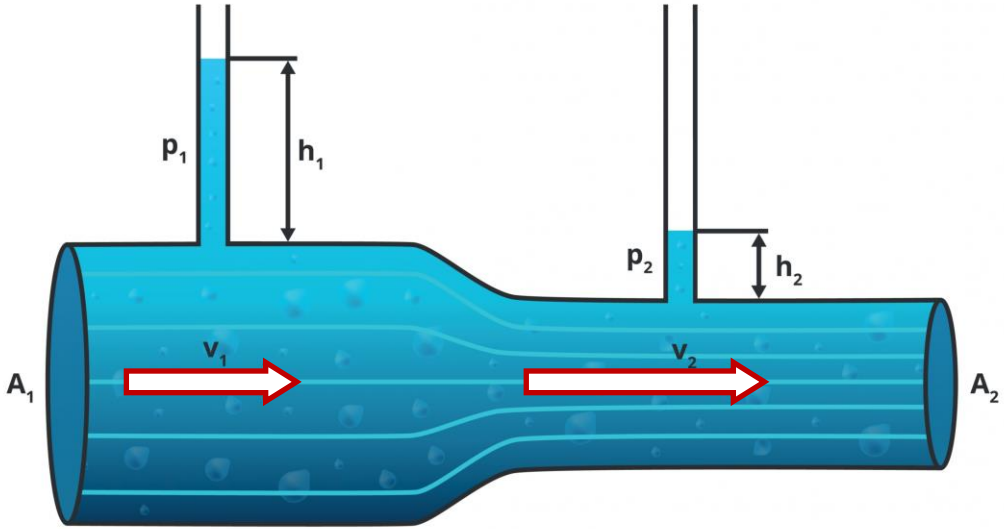
https://www.esa.int/ESA_Multimedia/Images/2002/03/Significant_Wave_Height_Measured_by_the_ERS_Radar_Altimeter

The use of wind

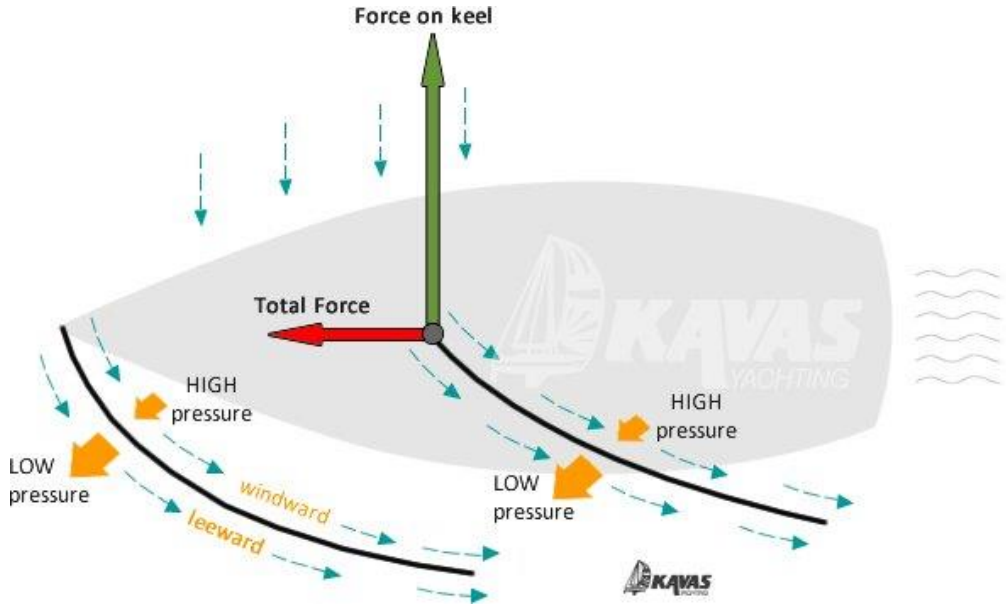


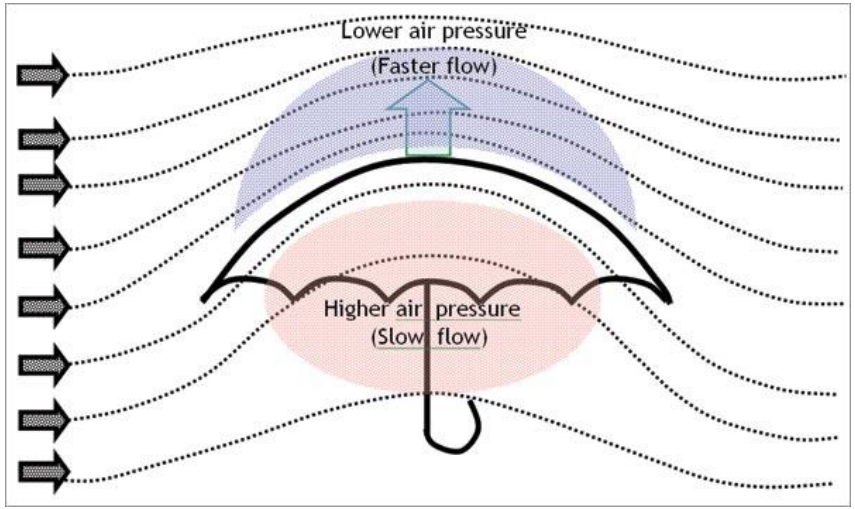
Sargentis, G.-F.; Iliopoulou, T.; Dimitriadis, P.; Mamassis, N.; Koutsoyiannis, D. Stratification: An Entropic View of Society's Structure. World 2021, 2, 153-174. https://doi.org/10.3390/world2020011

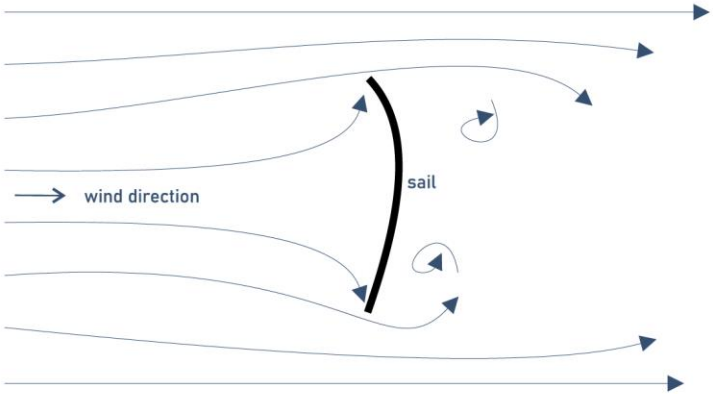
Bernoulli's principle

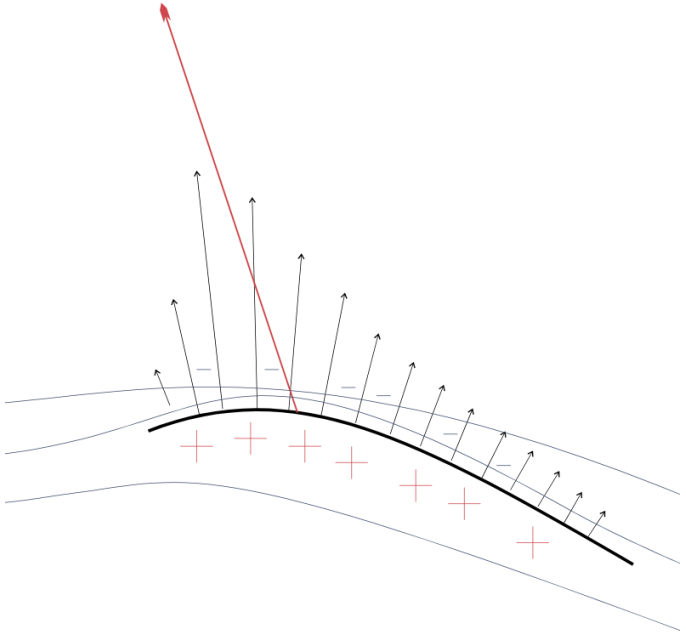



ATLAS

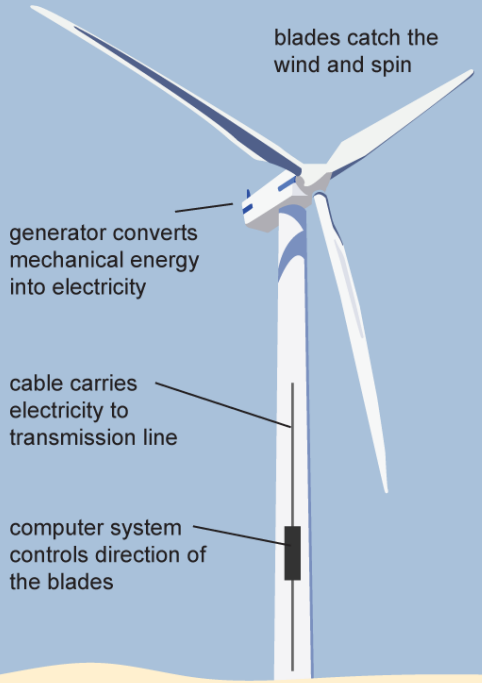

Force on keel
Total Force
HIGH
pressure
HIGH
pressure
LOW
pressure
LOW
pressure
windward
leeward


Lower air pressure
(Faster flow)
Higher air pressure
(Slow flow)

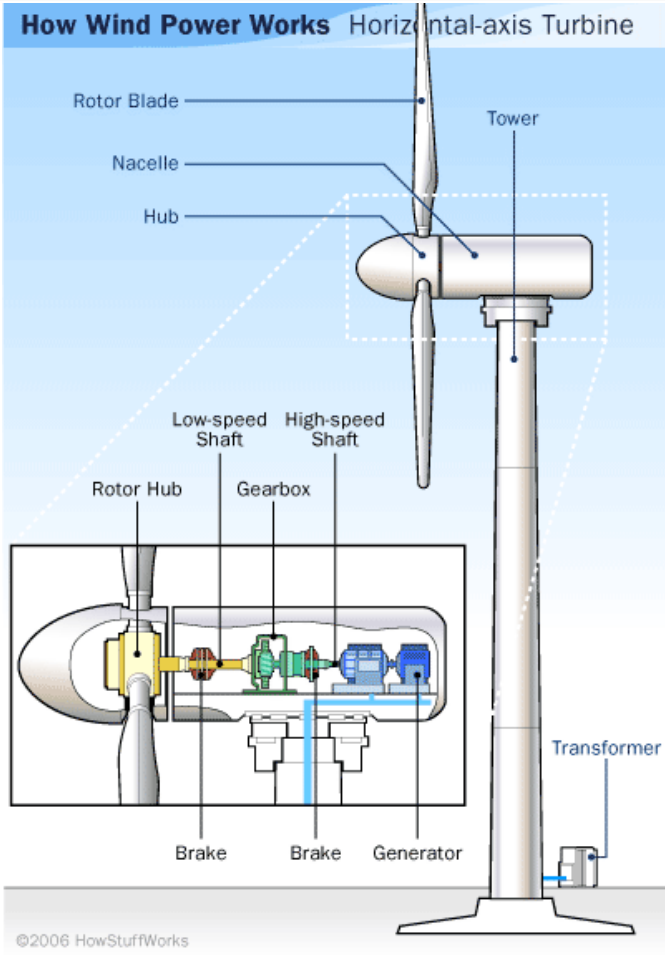

wind direction
sail



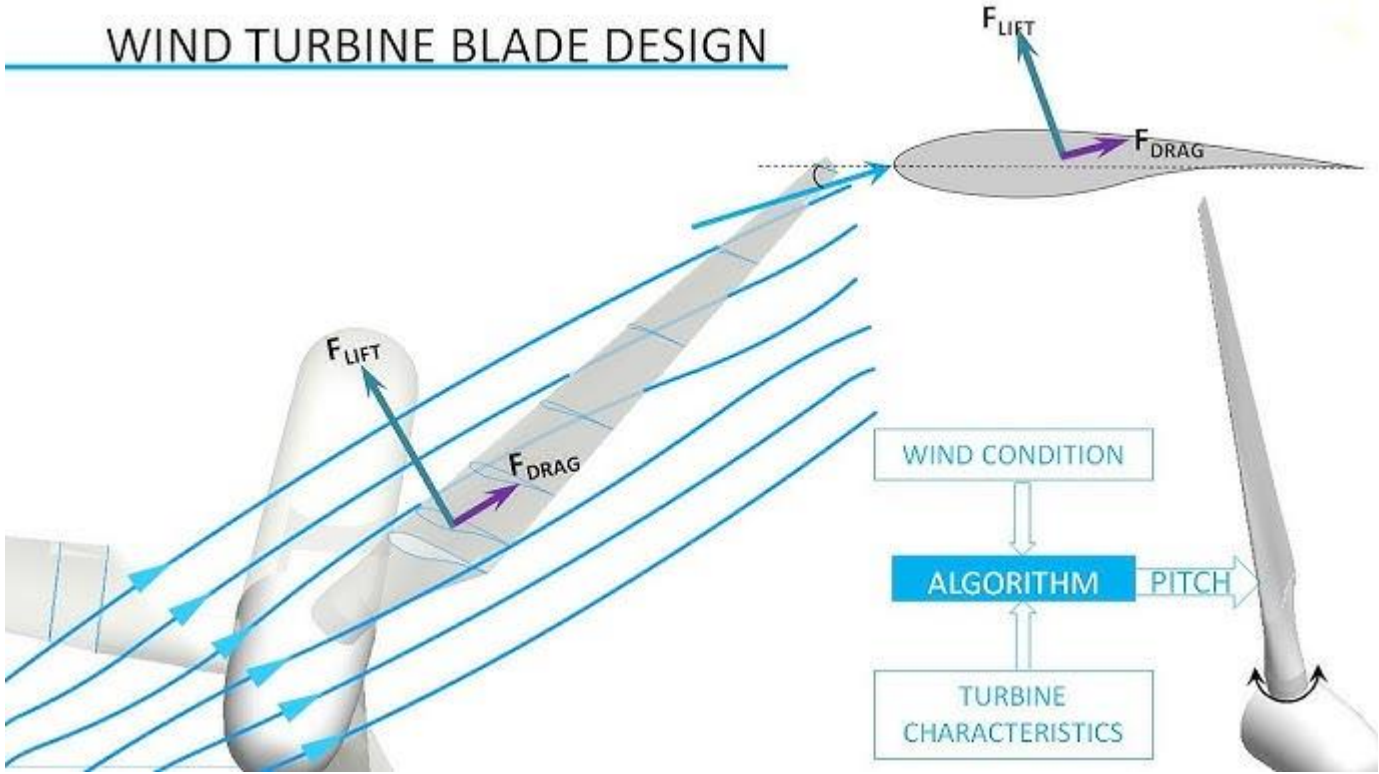
Horizontal-axis wind turbine



Source: Adapted from National Energy Education Development Project (public domain)

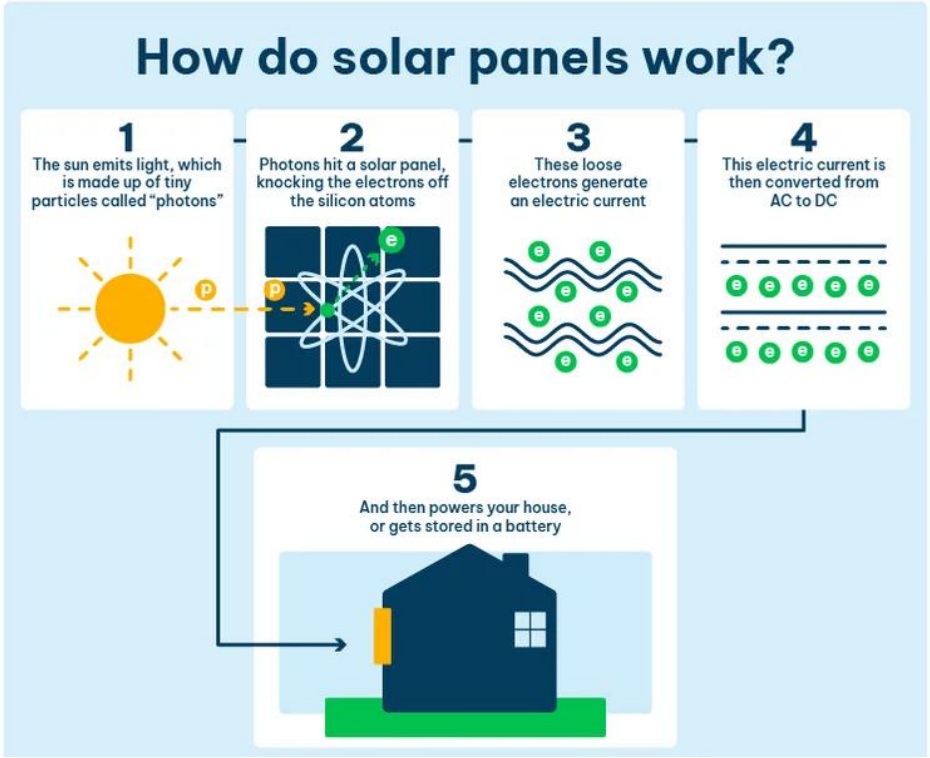


WIND TURBINE BLADE DESIGN



The use of sun

The use of sun



Energy storage

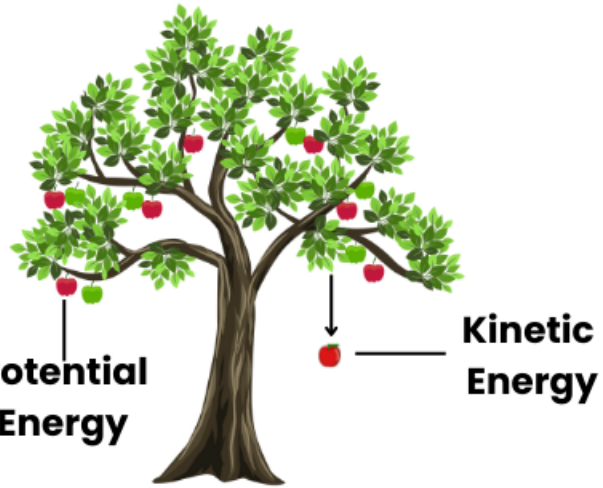
Law of Conservation of Energy

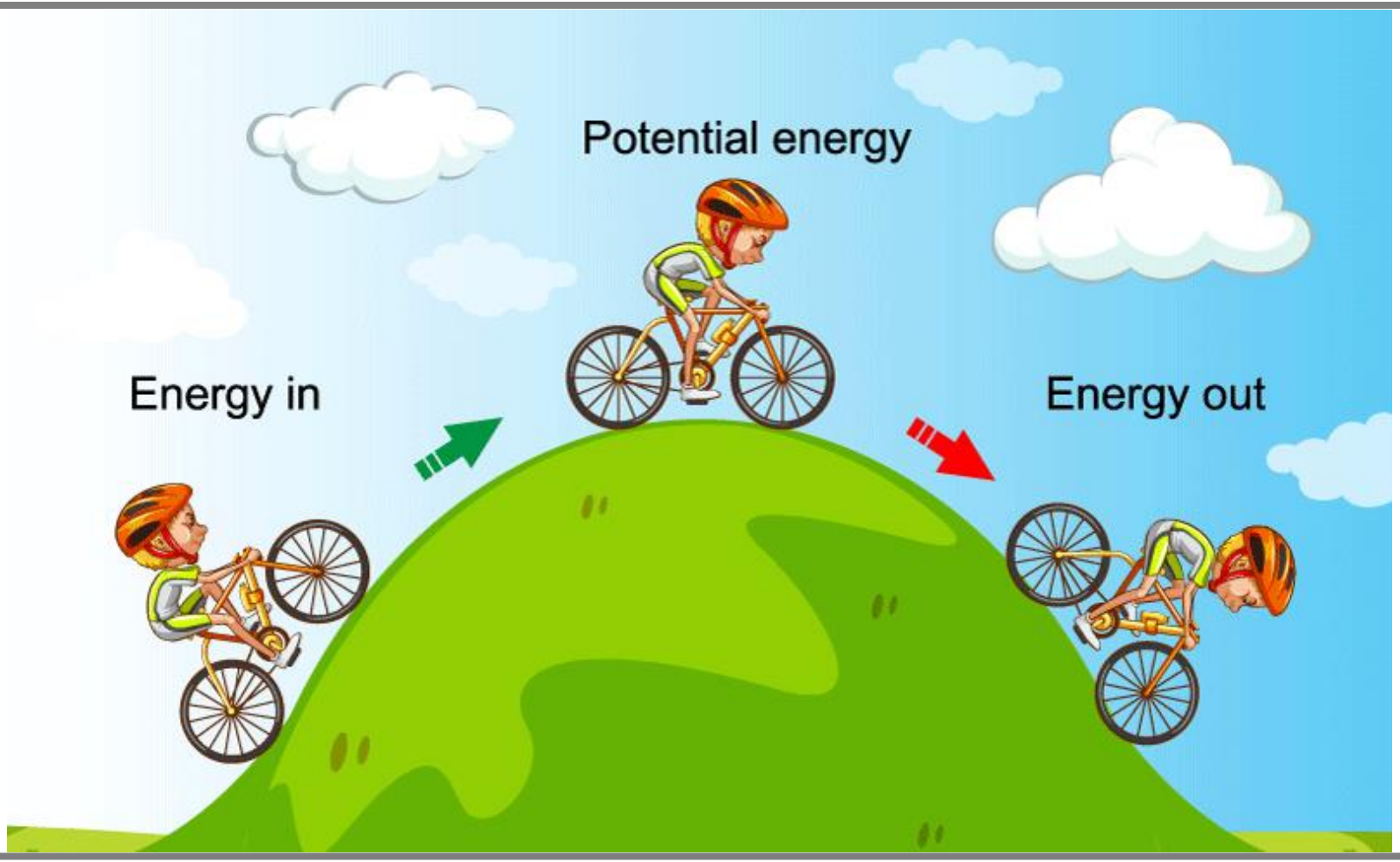
Definition:

The Law of Conservation of Energy states that energy cannot be created or destroyed in an isolated system; it can only be transformed from one form to another.

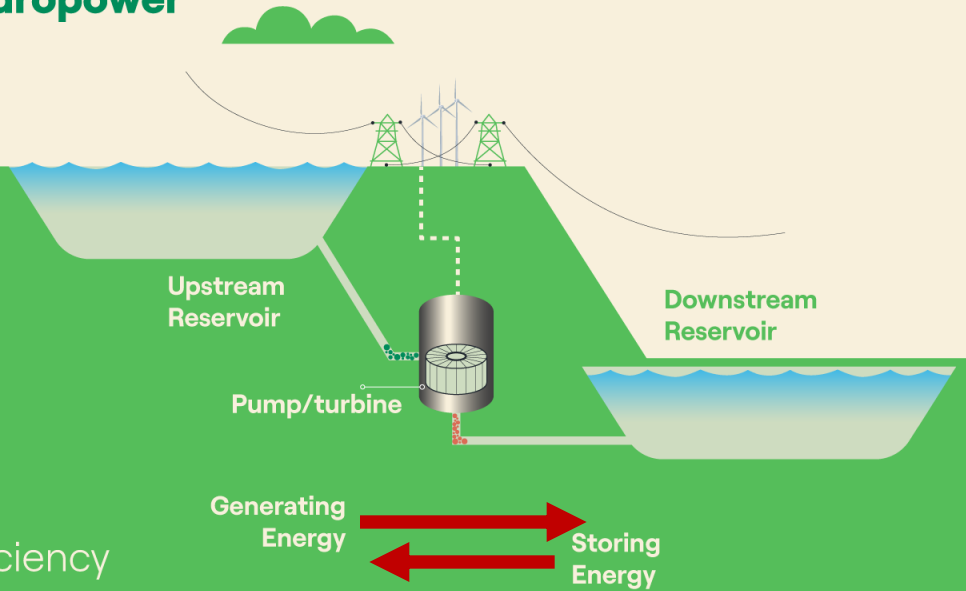
Chemical Energy

Mechanical Energy




Potential energy
Energy in
Energy out

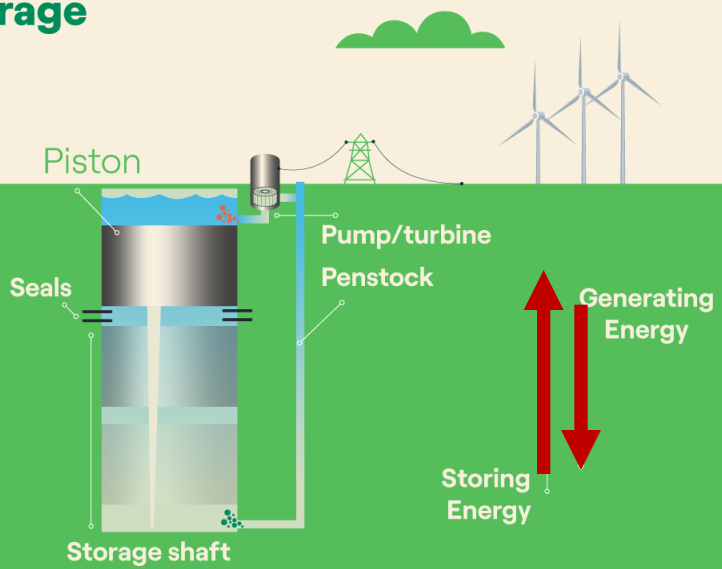
Pumped Storage Hydropower



Efficiency

70–75%

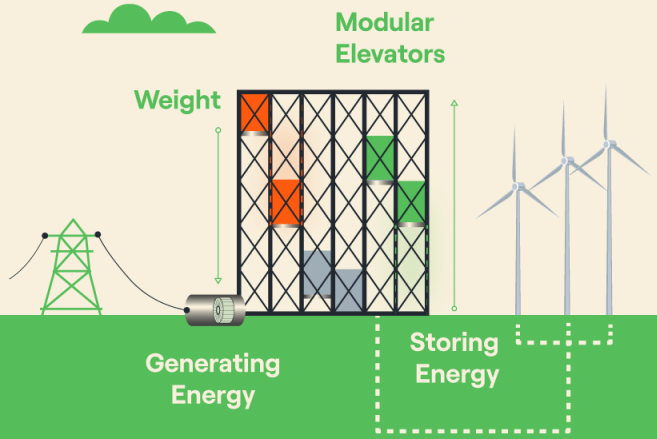
Underground Gravity Storage



Efficiency

65–70%

Gravity Energy Storage Tower



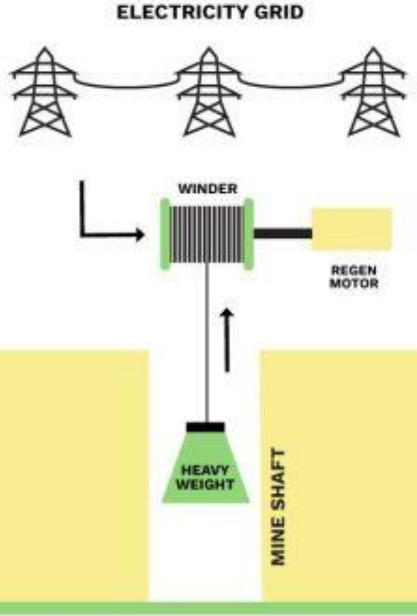
Efficiency

75–80%

STEP 1

CHARGE SYSTEM

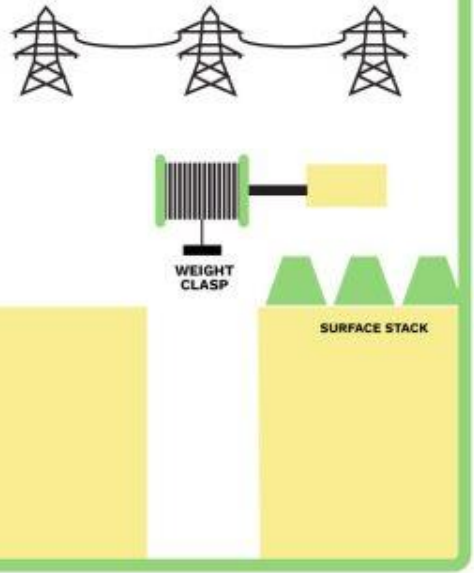
Lift weights to the surface, consuming renewable electricity from the grid.



STEP 2

STORE ENERGY

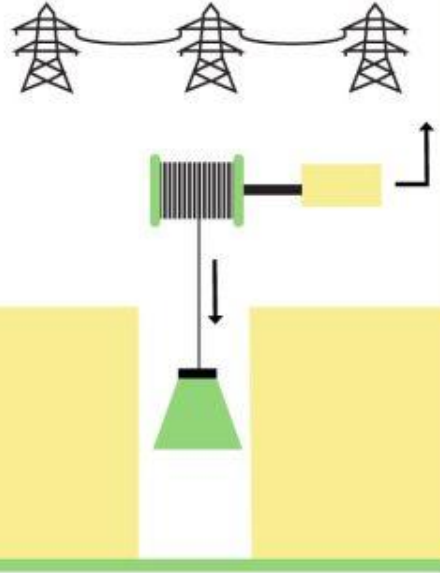
Store weights on the surface.



STEP 3

DISCHARGE SYSTEM

Lower weights back down the mine shaft, generating electricity to the grid.



The questionable investment in art

The value in Cultural Investment

Sargentis, G.-F., & Papadodimas, N. Questioning Canvas Capital: Risks and Resilience in Art Markets. Cultural Arts Research and Development, 5(2), 167–184 2025. https://doi.org/10.55121/card.v5i2.720

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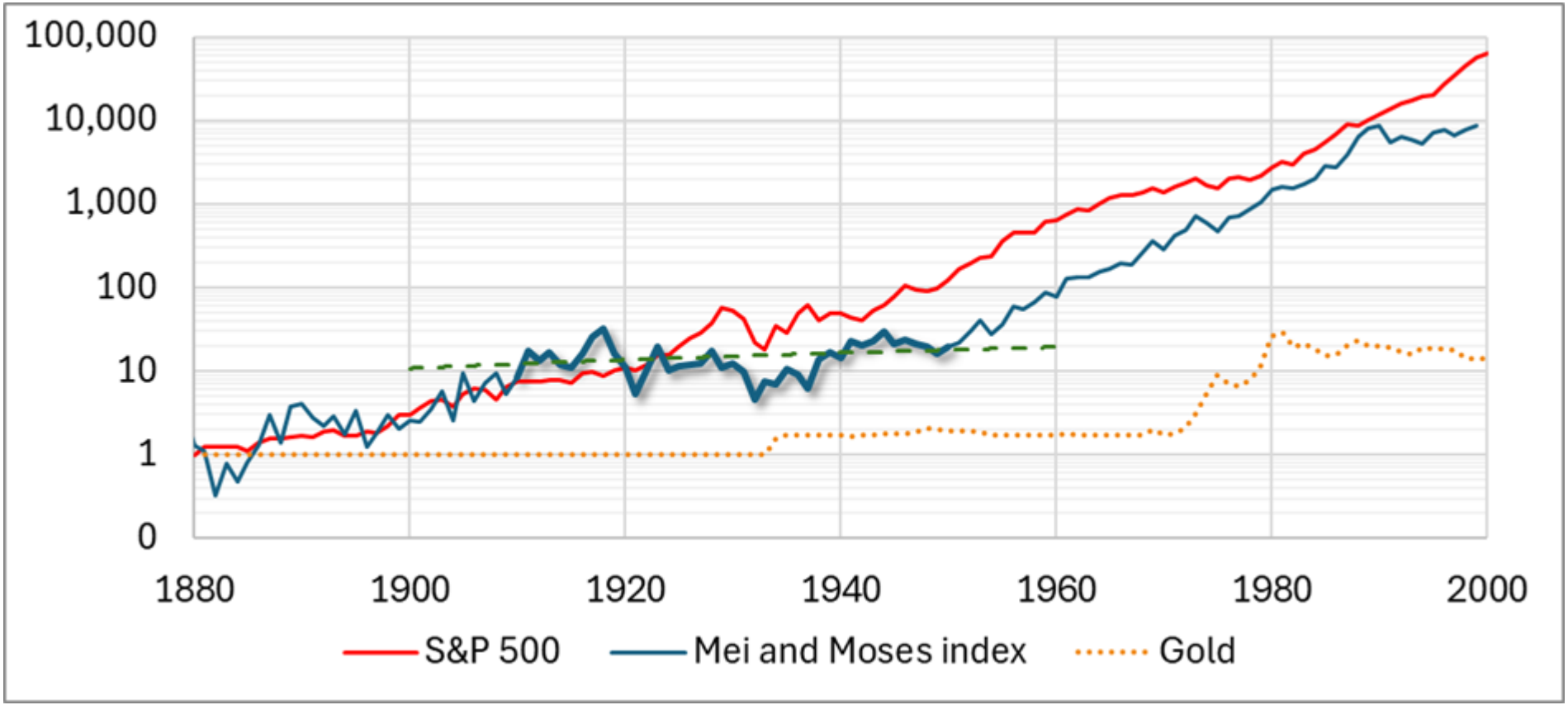
The Economics of Art: Stability, Value, and Crisis



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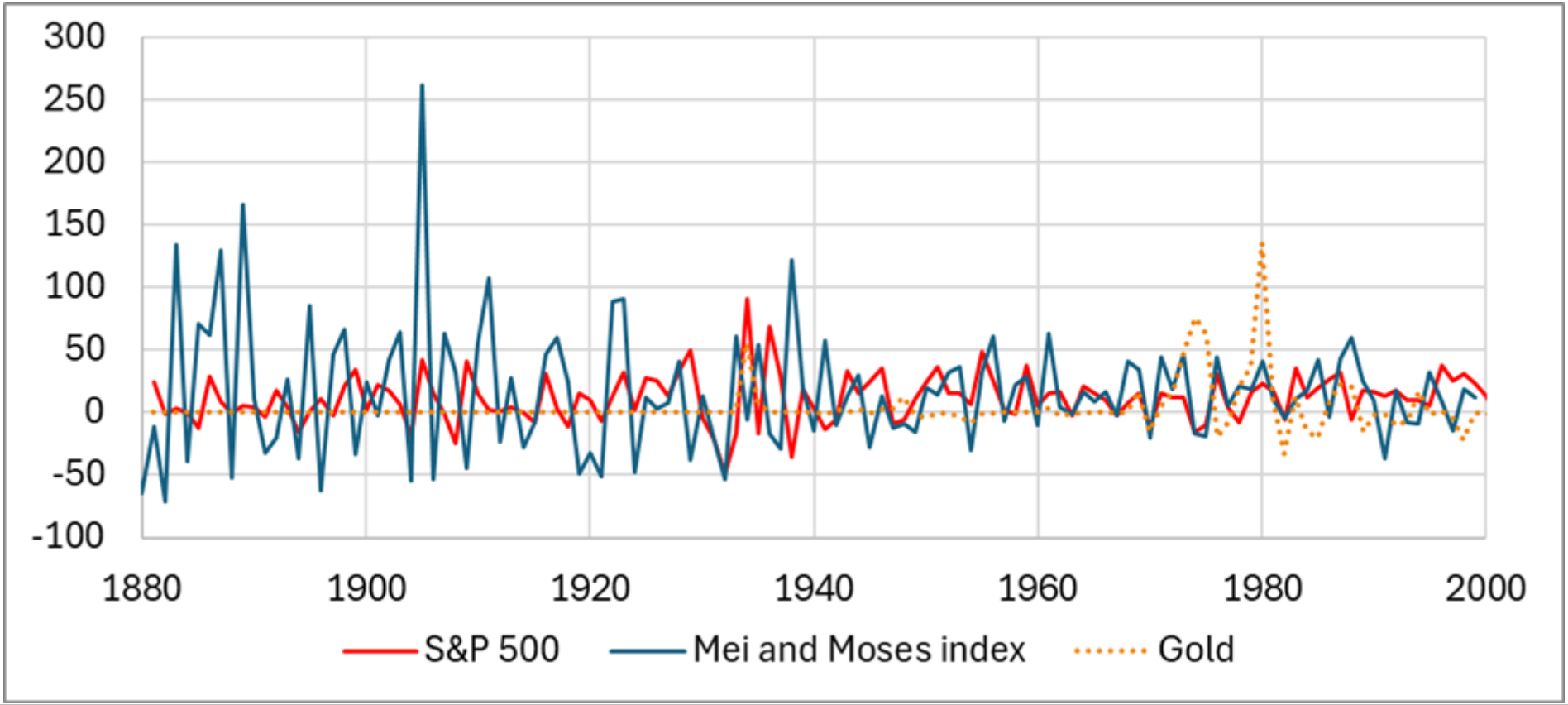

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