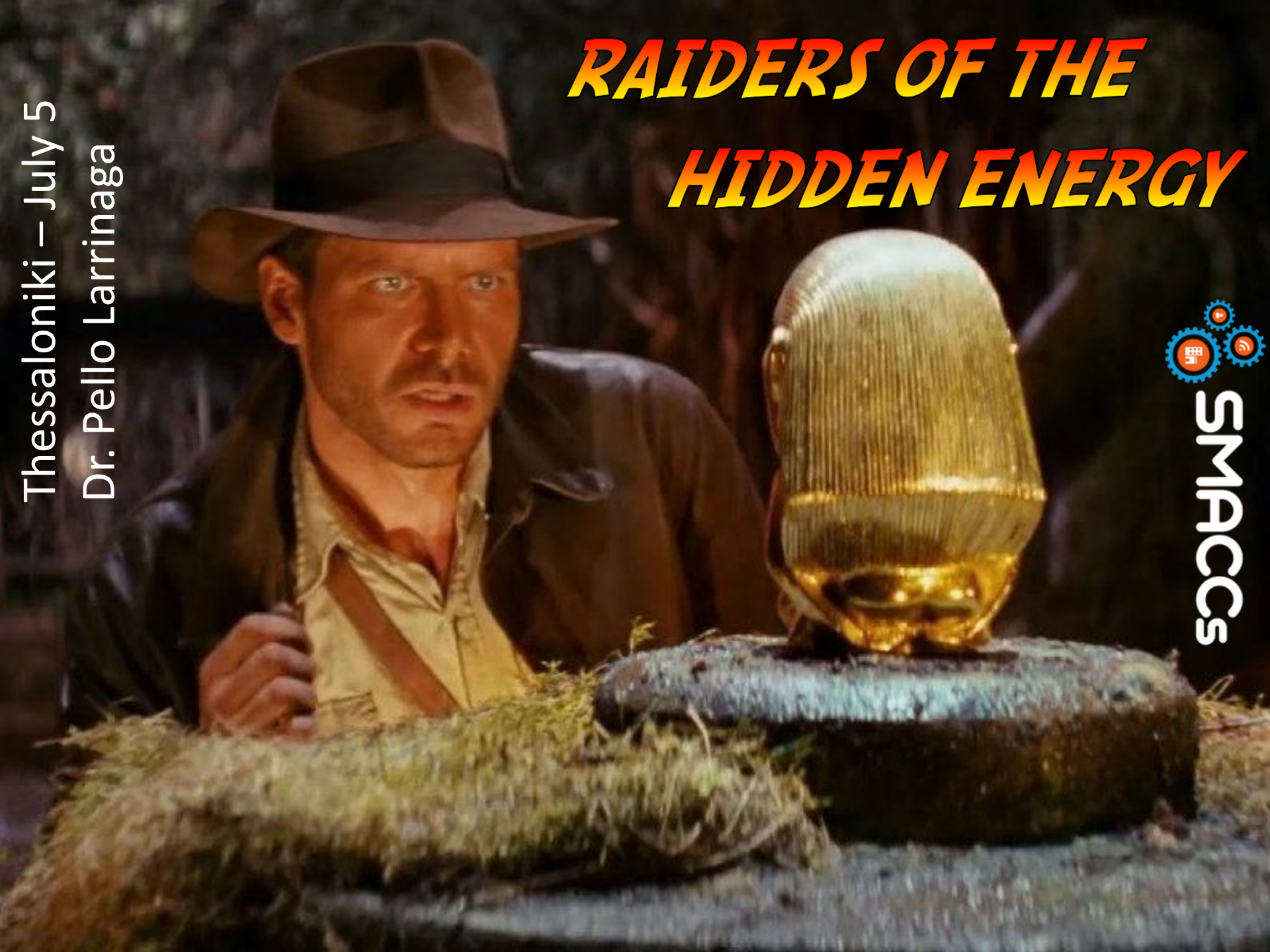
RAIDERS OF THE
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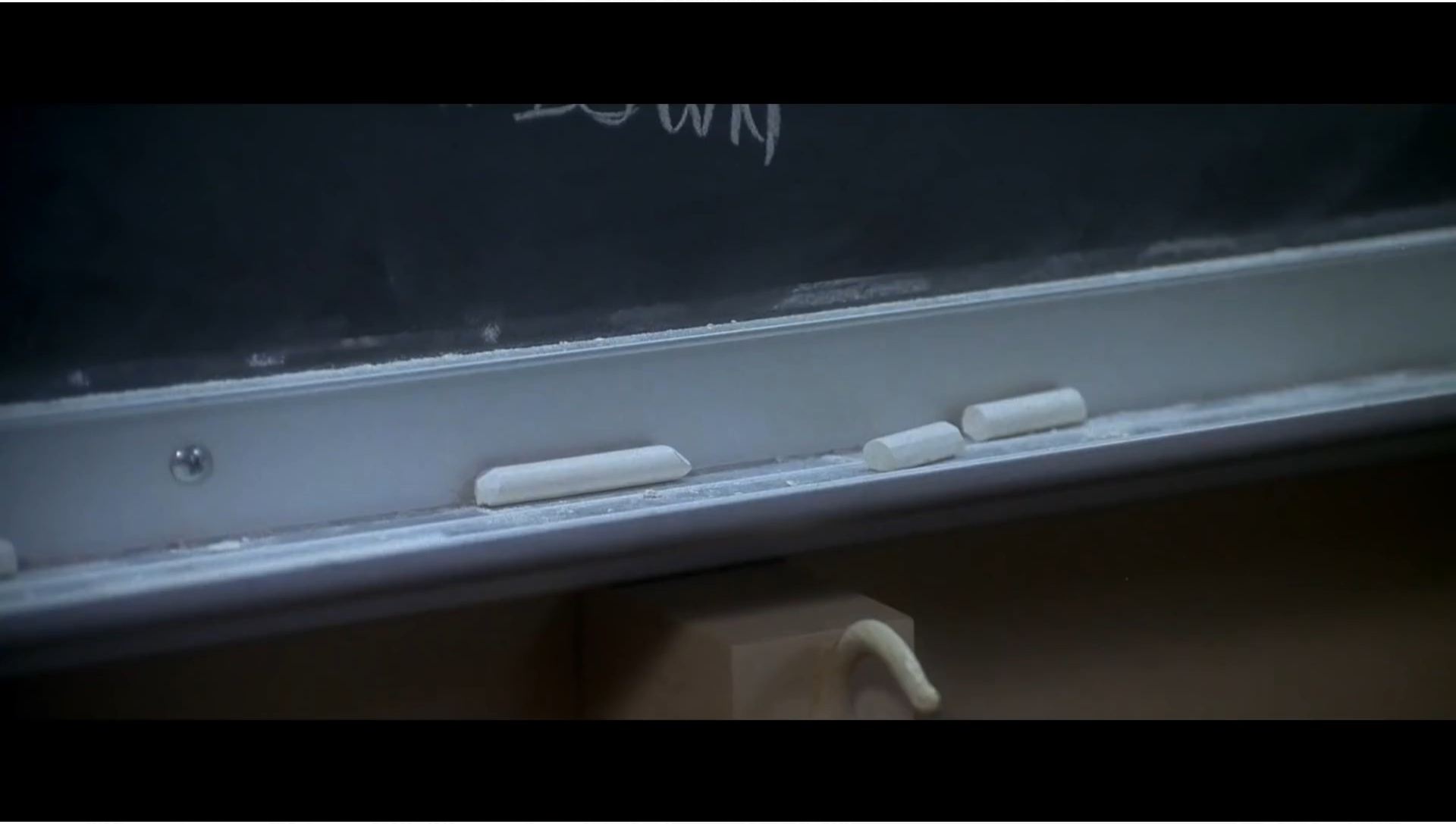
Energy is everything

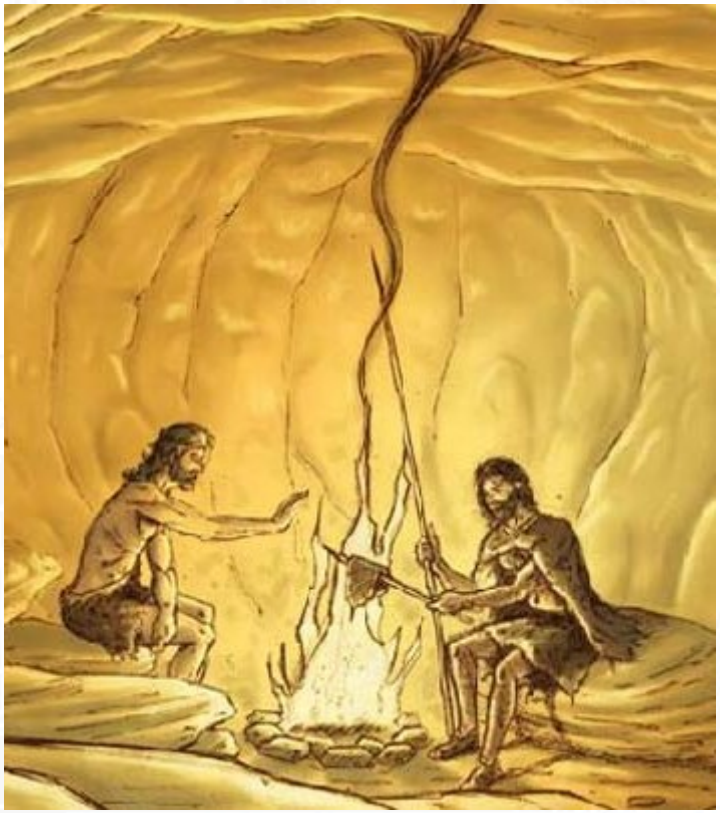


What is energy?

What is energy?

More than the “standard” concept

Hunter-gatherer

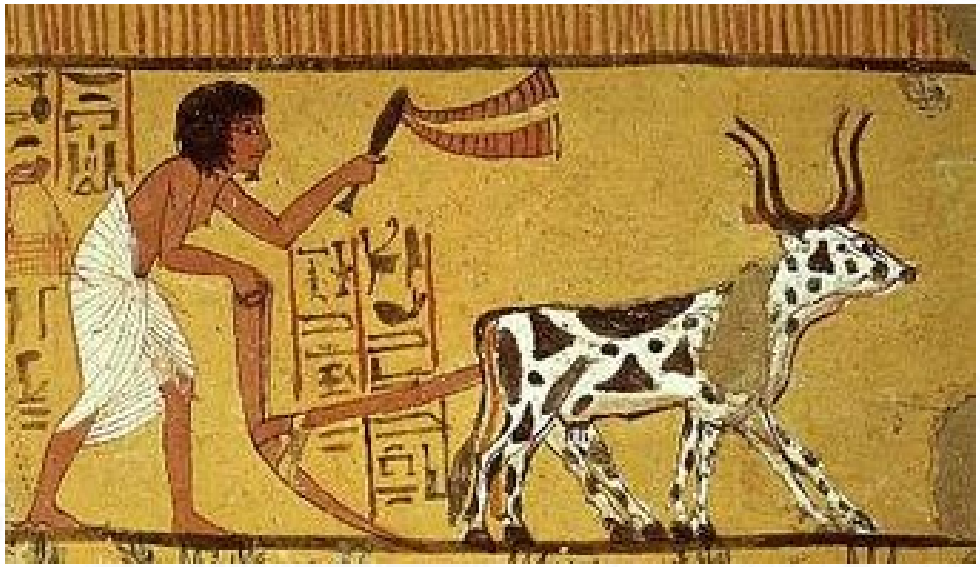


Fire

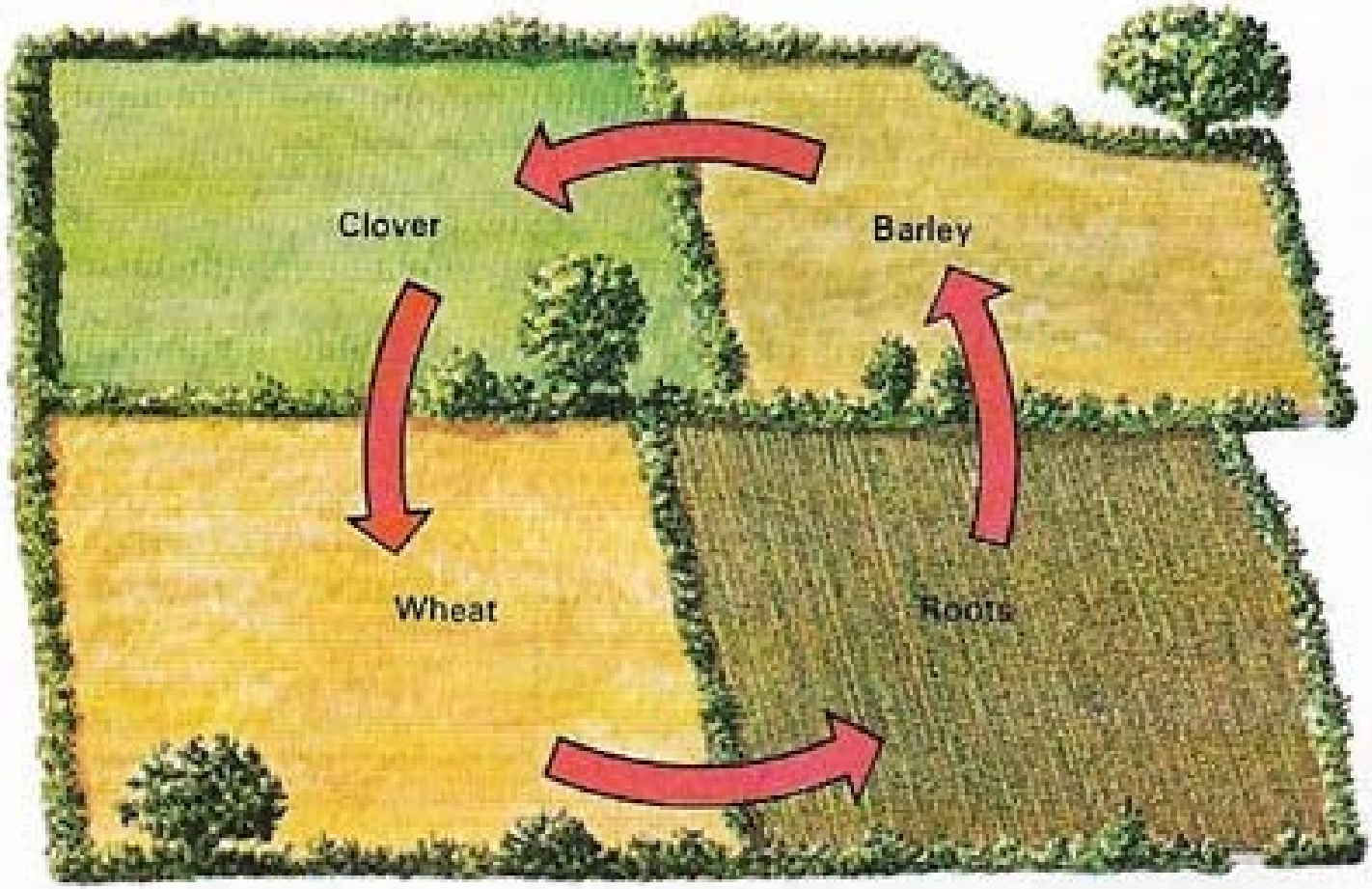
What is energy?

First energy management

Energy & human development

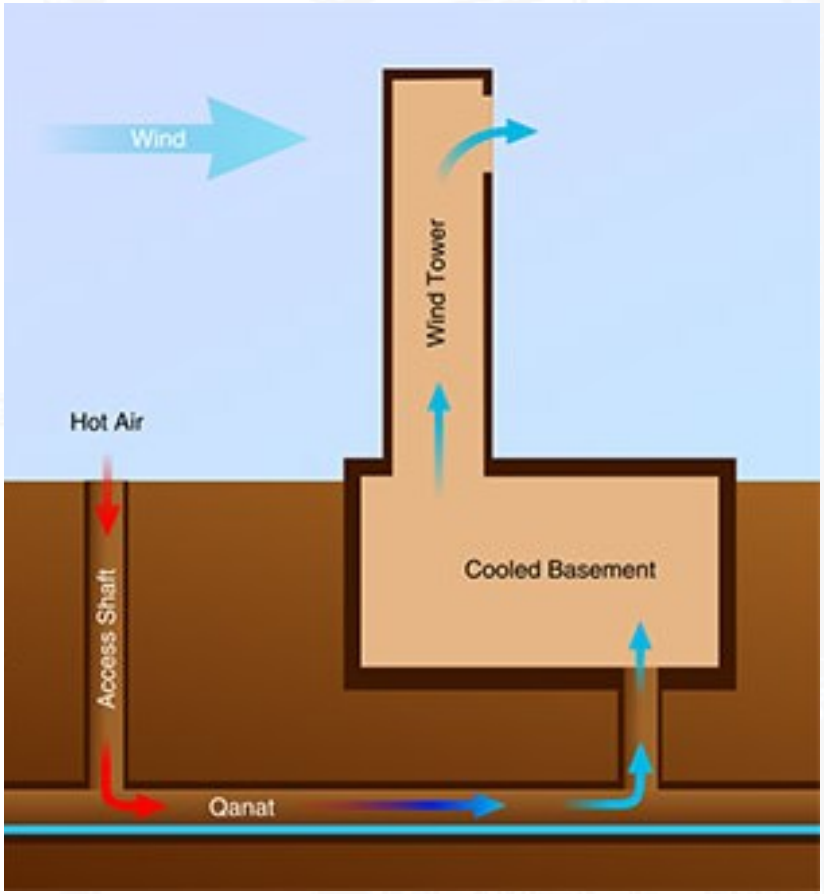


Energy & human development



First energy optimization

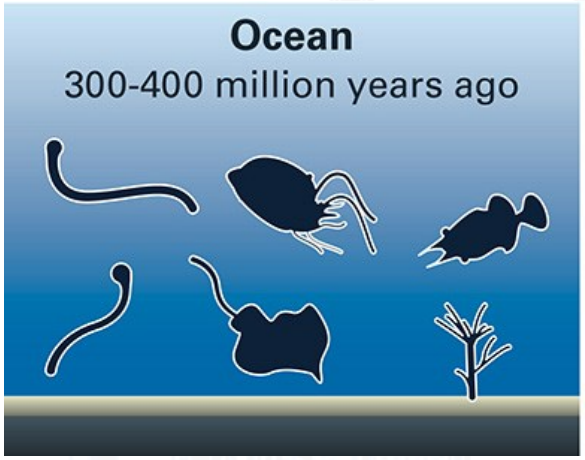
Energy & human development

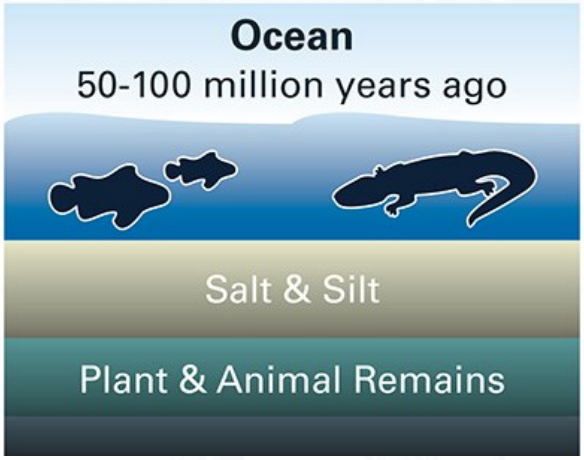


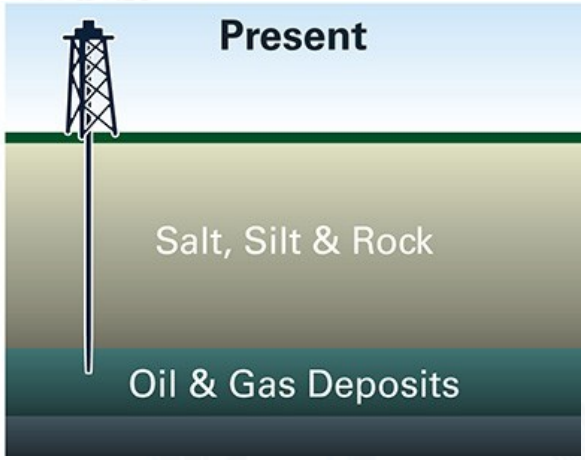
Energy & human development

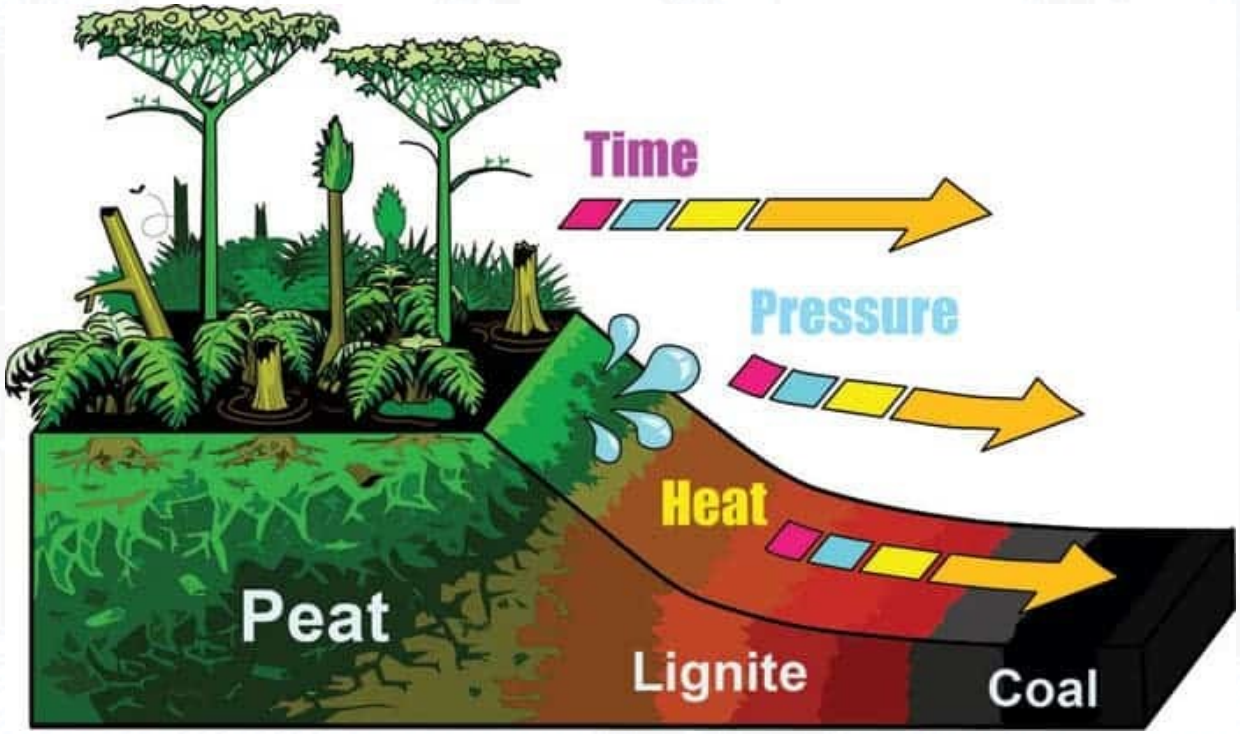
Fossil fuels

Fossil fuels

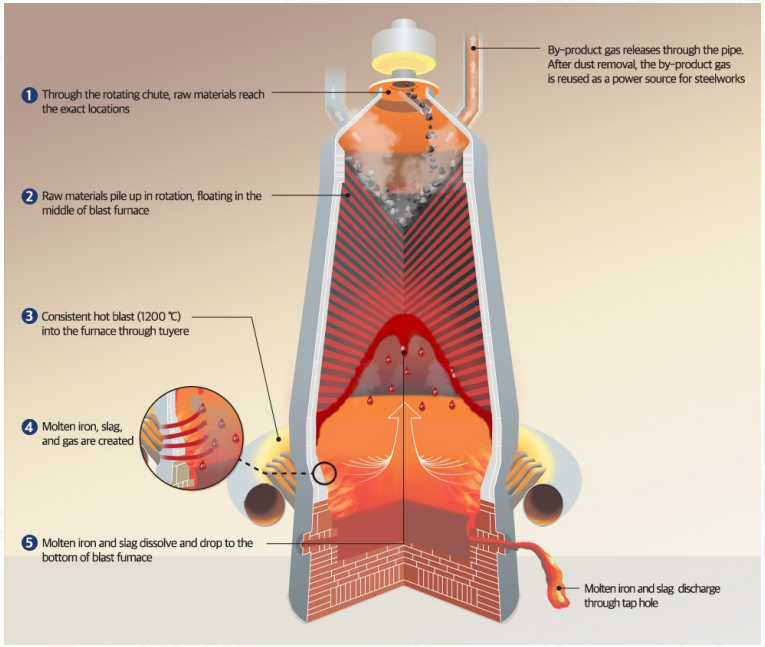


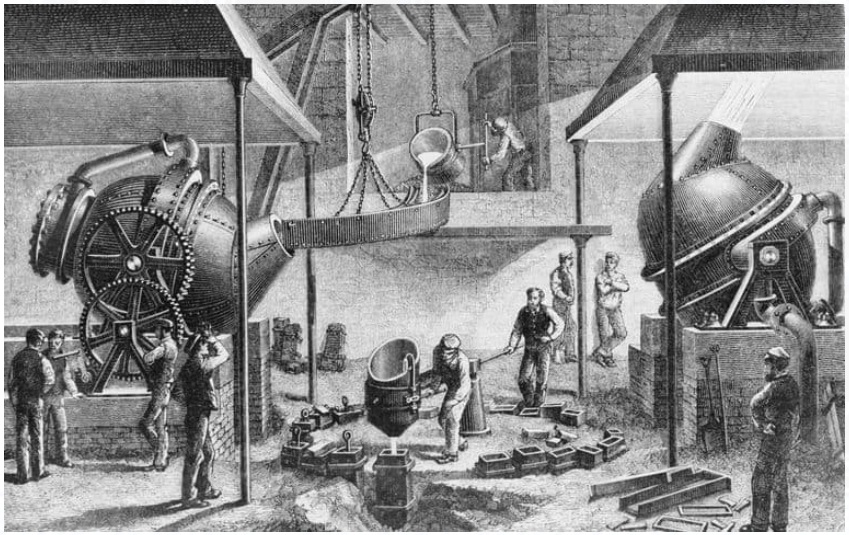


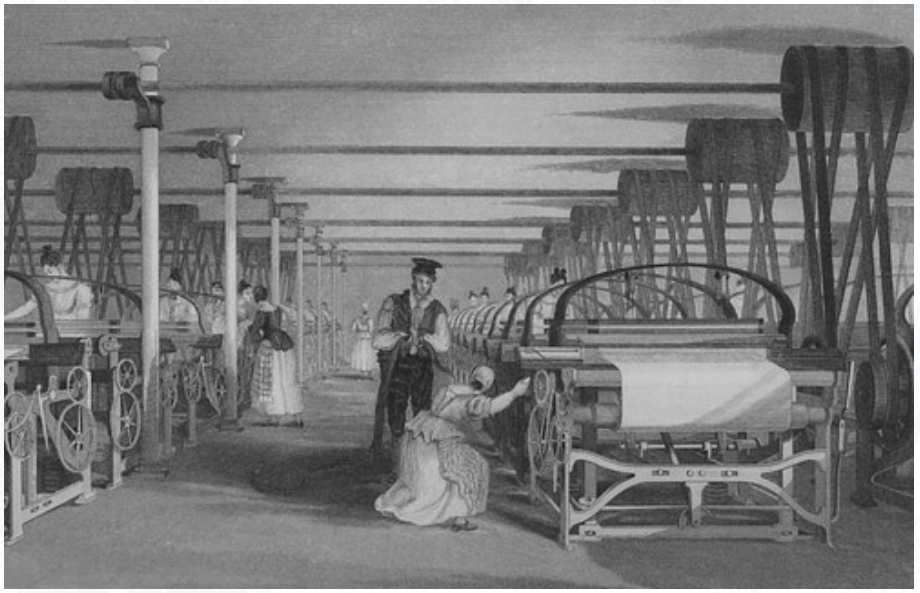




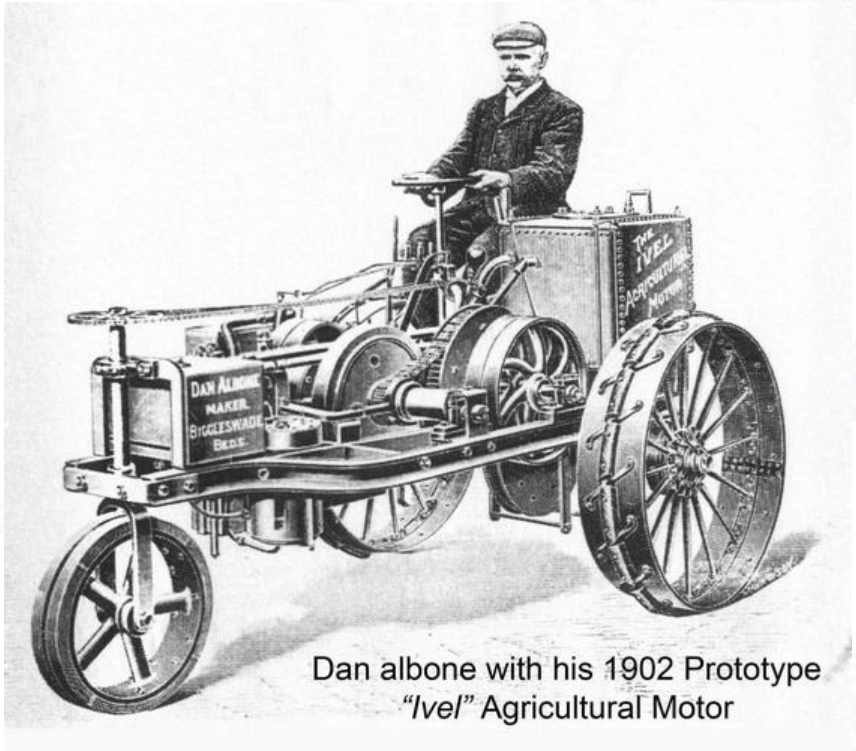
New era


By-product gas releases through the pipe. After dust removal, the by-product gas is reused as a power source for steelworks
1 Through the rotating chute, raw materials reach the exact locations
2 Raw materials pile up in rotation, floating in the middle of blast furnace
3 Consistent hot blast (1200 ℃) into the furnace through tuyere
4 Molten iron, slag, and gas are created
5 Molten iron and slag dissolve and drop to the bottom of blast furnace
Molten iron and slag discharge through tap hole

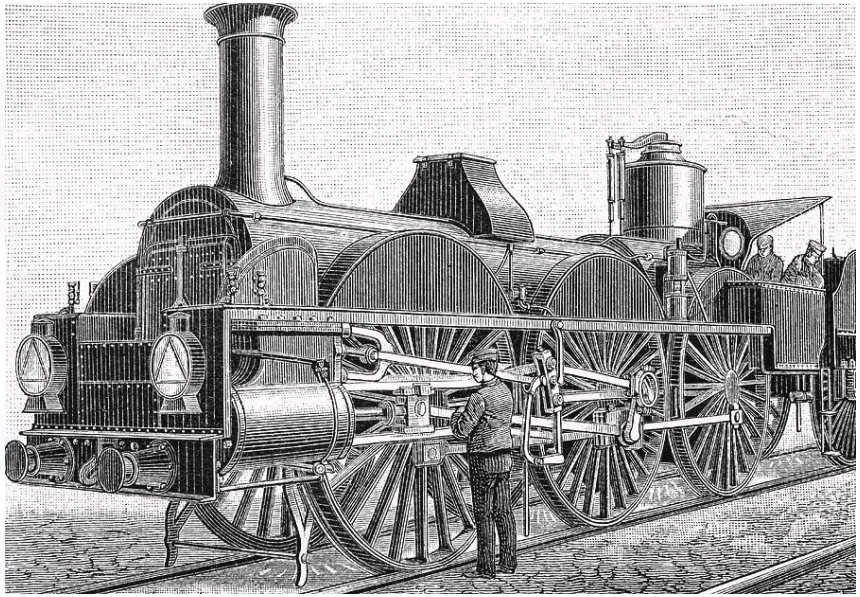




New era

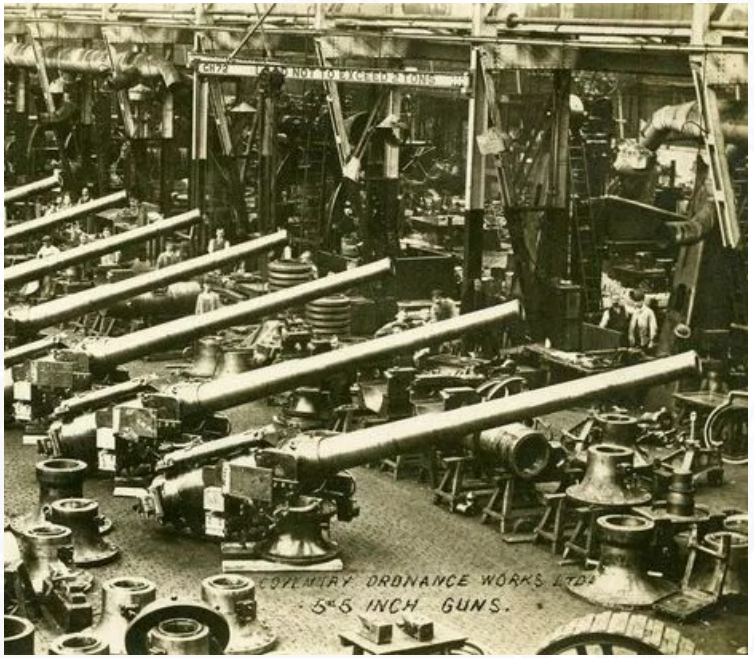


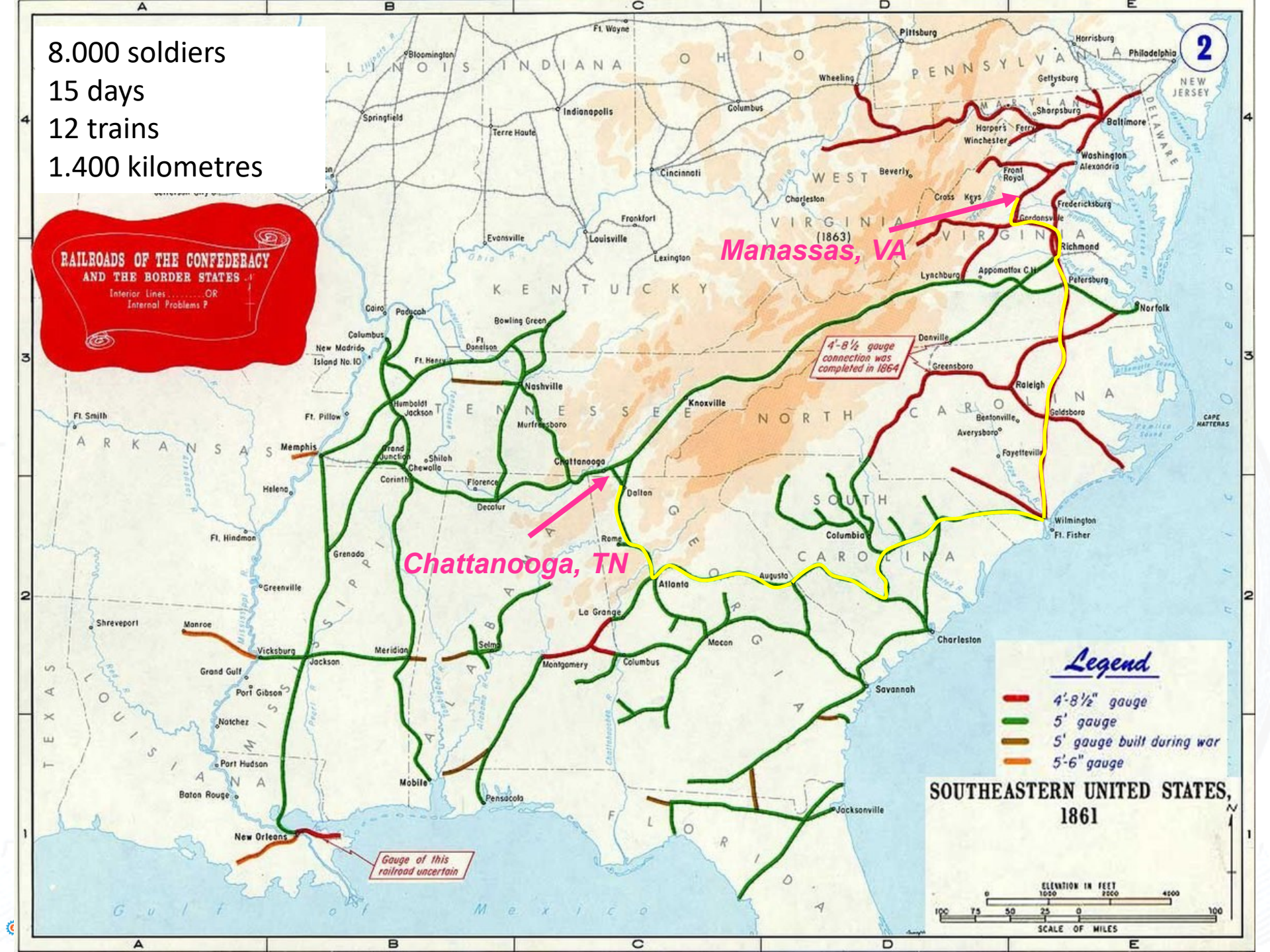
Dan albone with his 1902 Prototype
"Ivel" Agricultural Motor



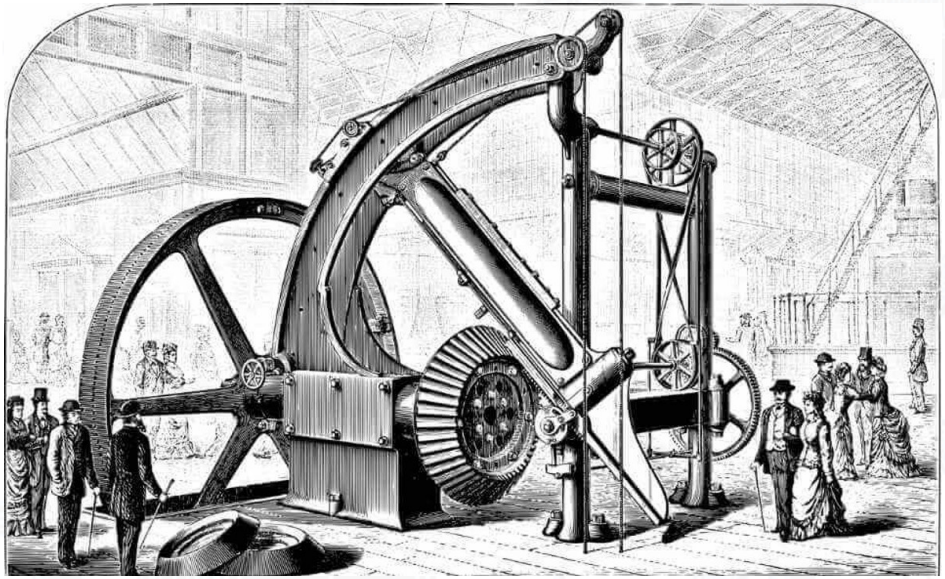
Courtesy www.greatships.net

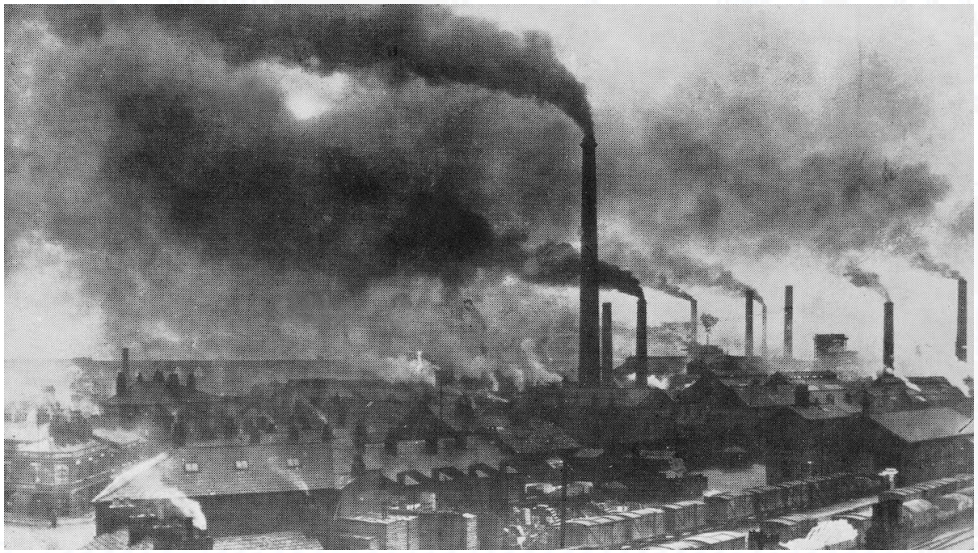
New era

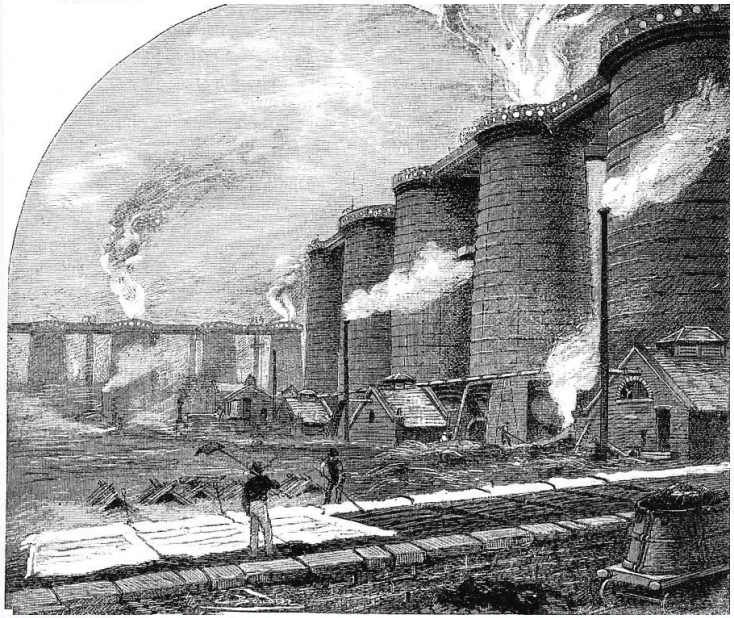



8.000 soldiers
15 days
12 trains
1.400 kilometres
RAILROADS OF THE CONFEDERACY
AND THE BORDER STATES
Interior Lines ..... OR
Internal Problems ?
Manassas, VA
(1863)
Chattanooga, TN
4'-8½ gauge connection was completed in 1864
Gauge of this railroad uncertain
Legend
4'-8½" gauge
5' gauge
5' gauge built during war
5'-6" gauge
SOUTHEASTERN UNITED STATES, 1861
ELEVATION IN FEET
SCALE OF MILES
2

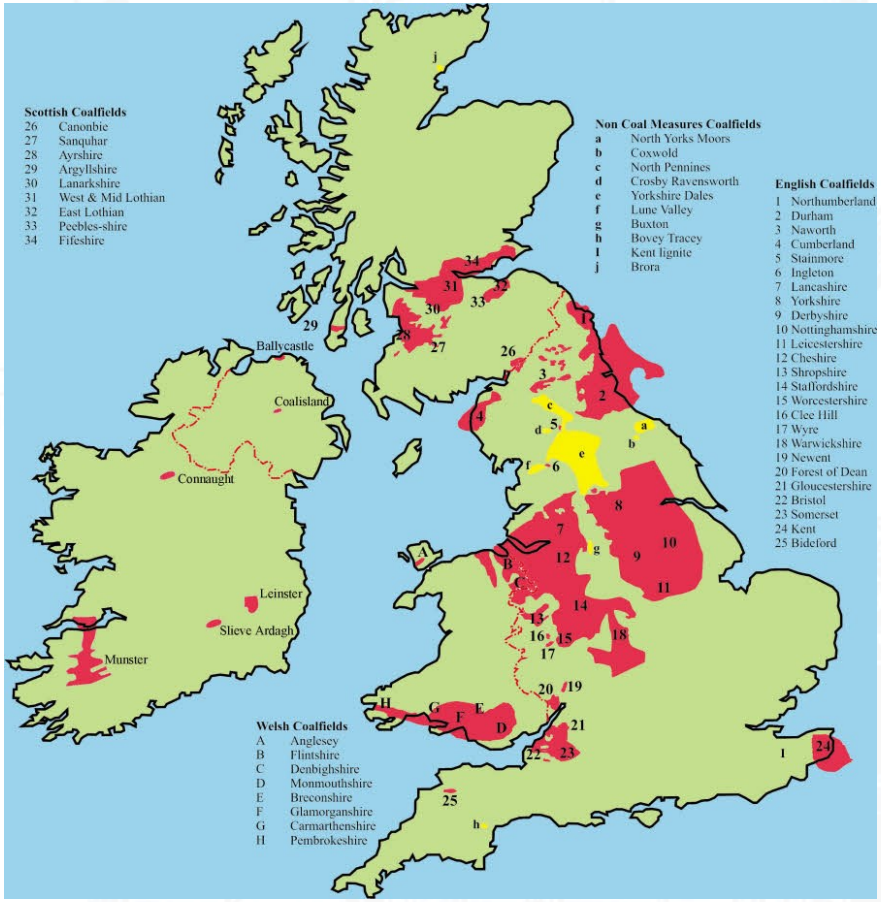
“Spoiling” energy

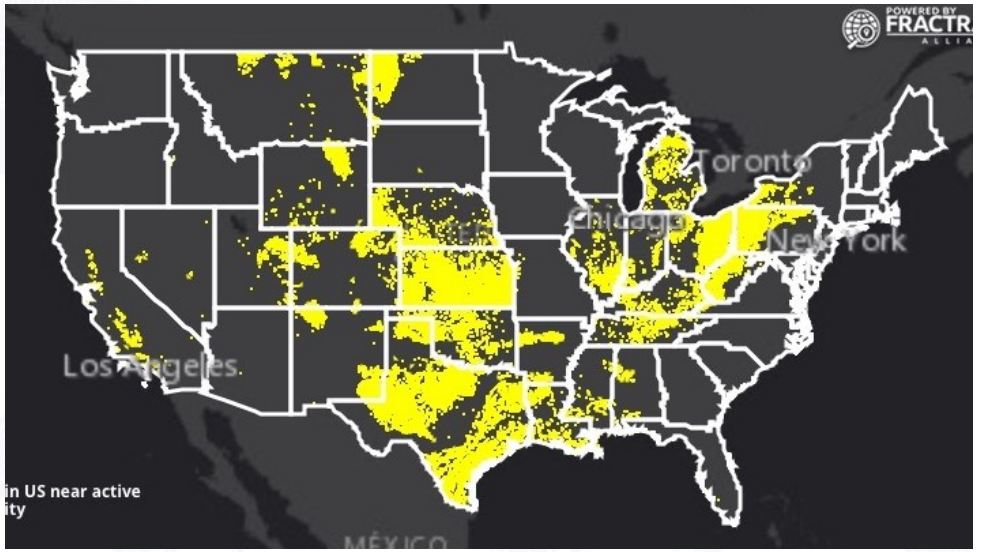






“Spoiling” energy





“Spoiling” energy

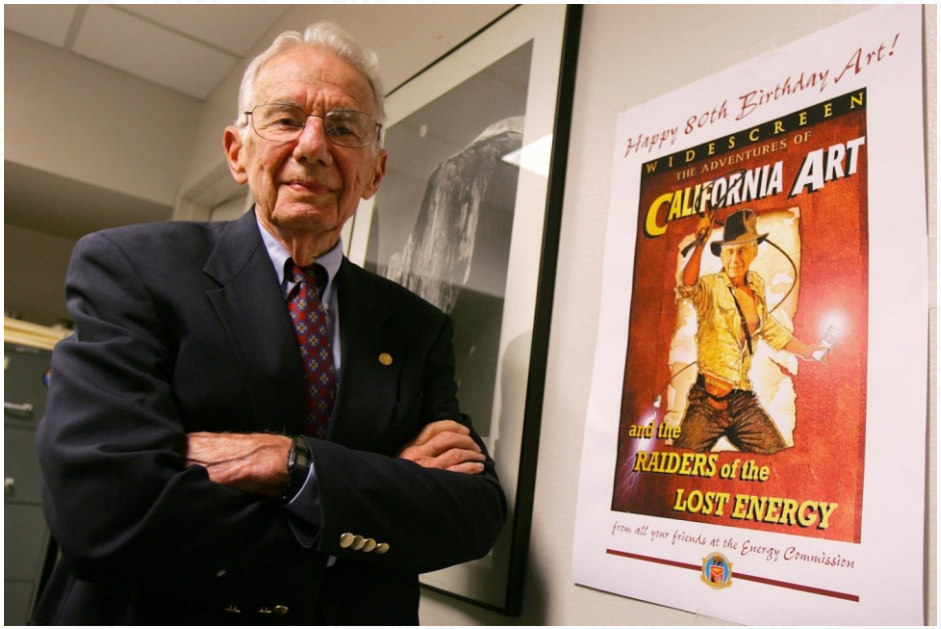
Energy crisis & energy efficiency

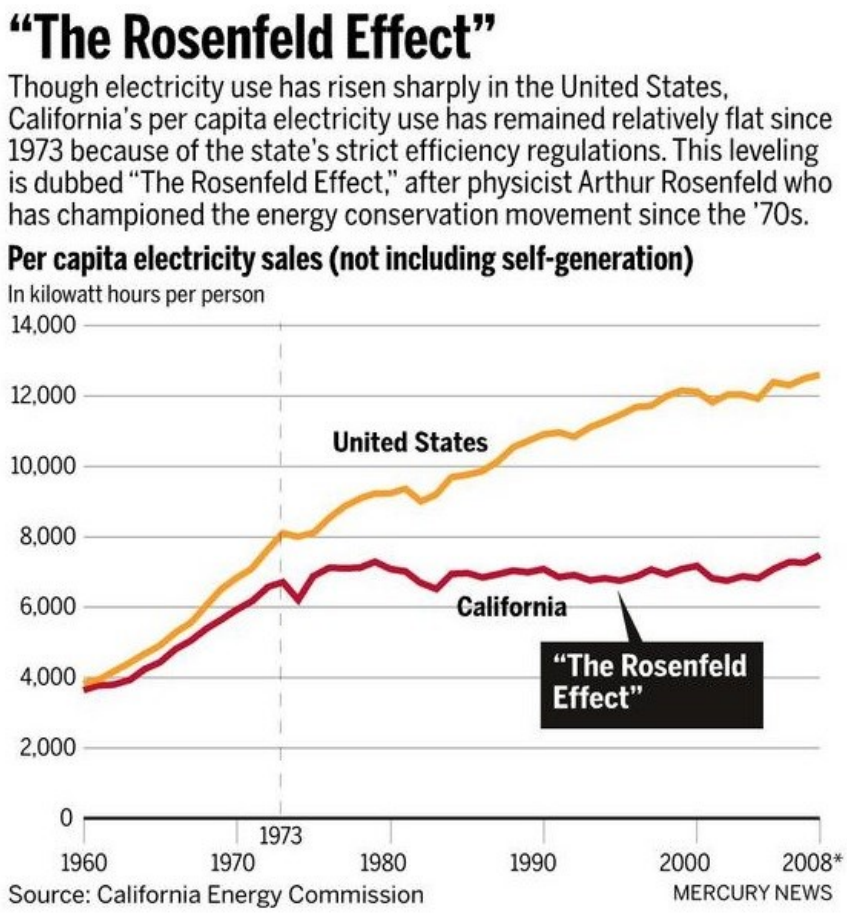
Not new concepts

1973 oil crisis

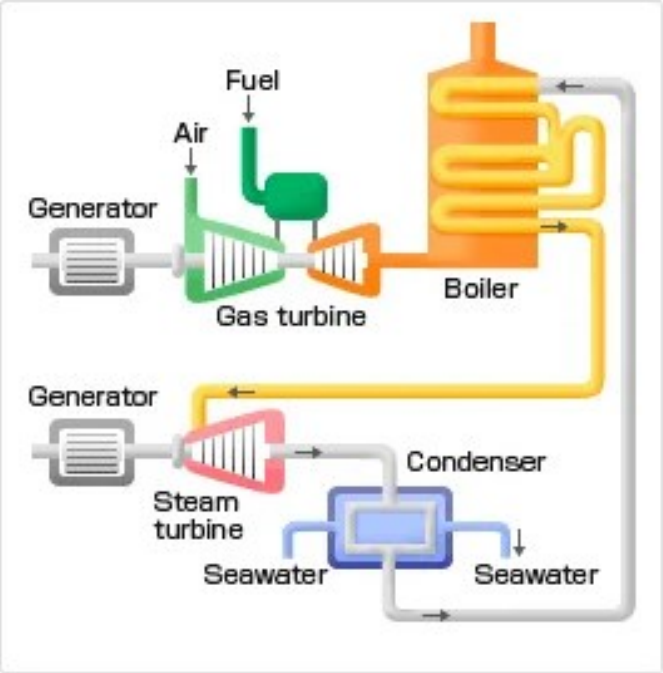
Energy crisis & energy efficiency

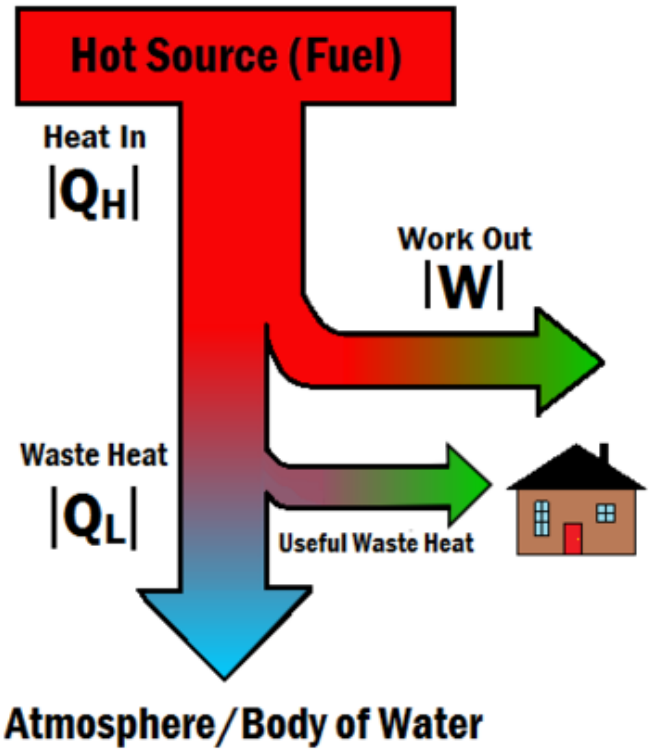
Arthur H. Rosenfeld: “father” of the energy efficiency

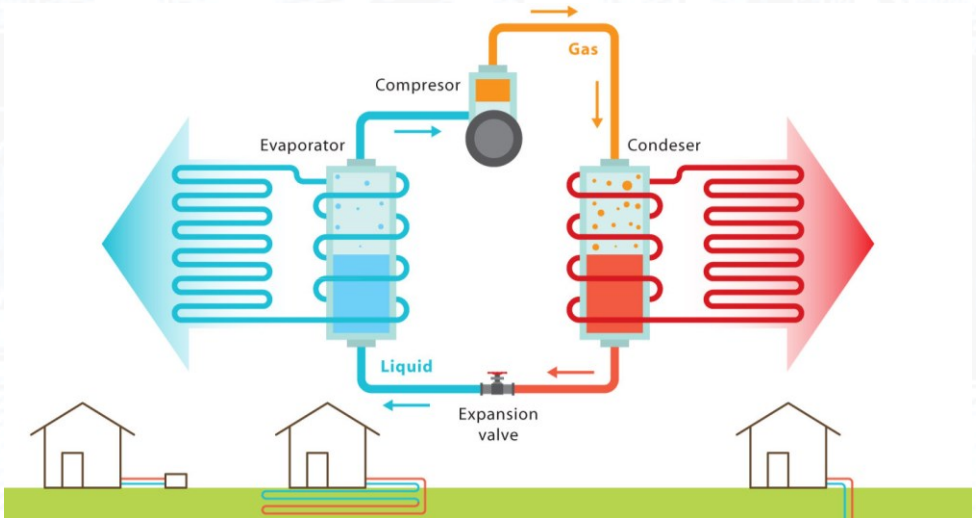




Adopted measures







Adopted measures

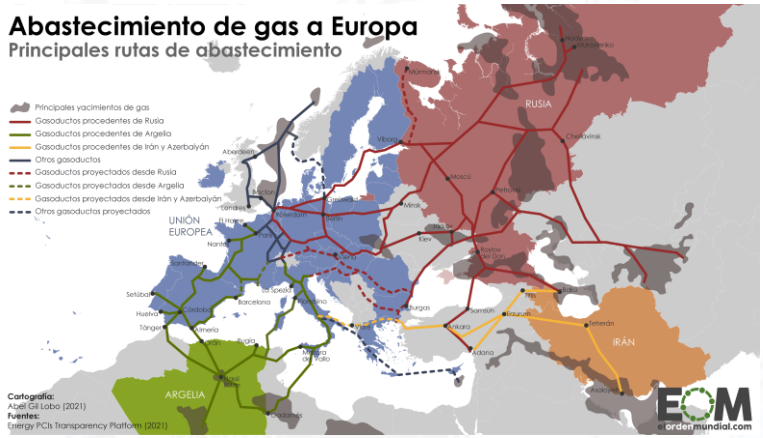
Technology	Discovered	First use
Cogeneration	Mid -19th century	1882
Combined cycle	1940	1960
Heat pump	1855	1928

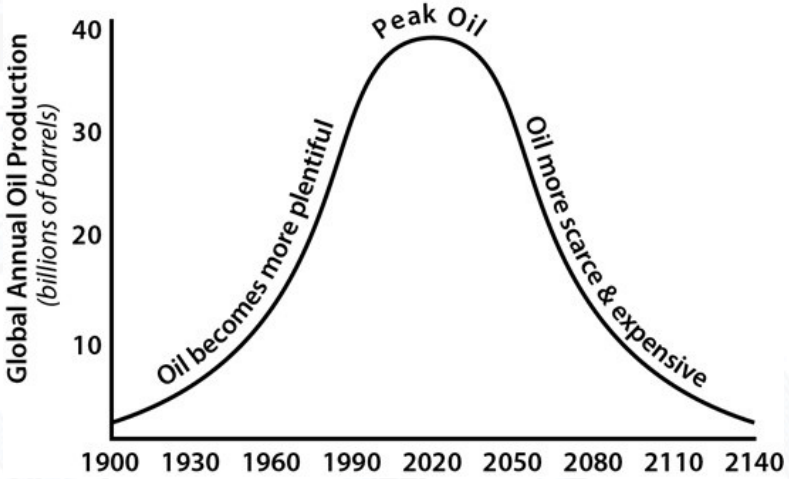
Adopted measures

With low energy prices

Now – End of the fossil regime

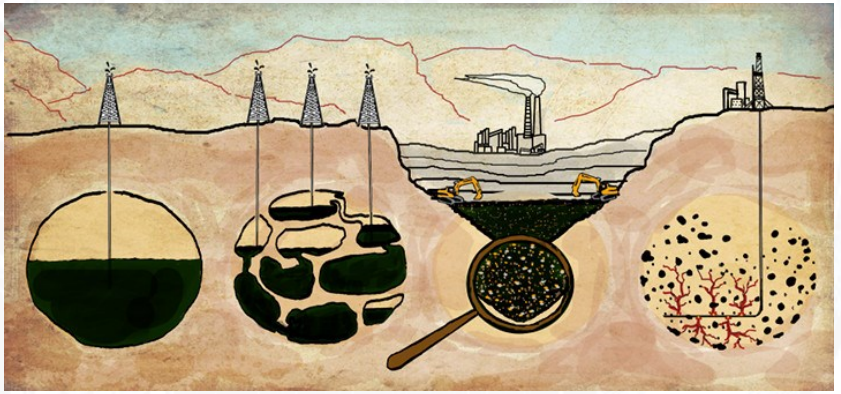
Geopolithics





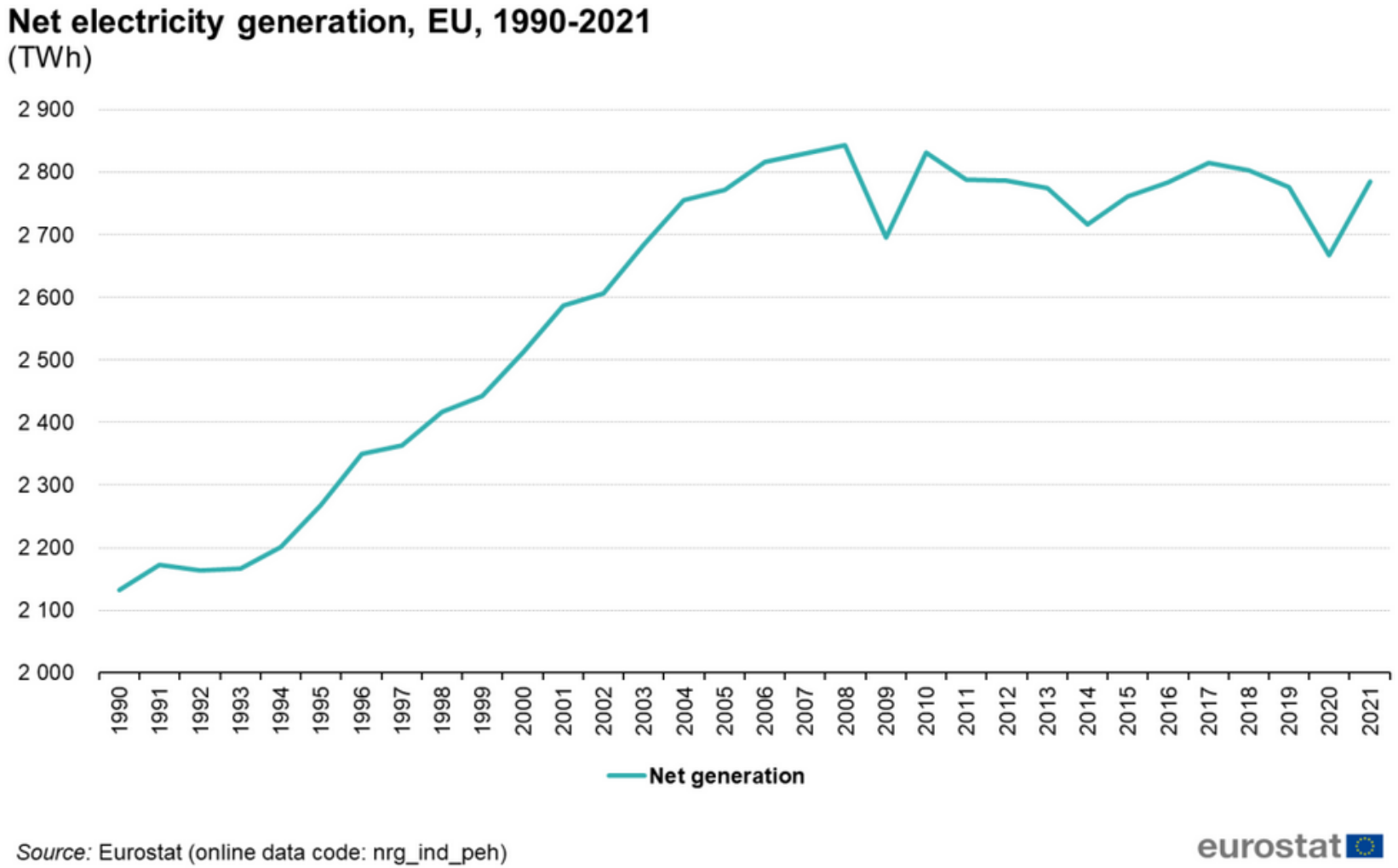
Finite resources

Increasing demand



Greater difficulty of exploitation

Now – End of the fossil regime



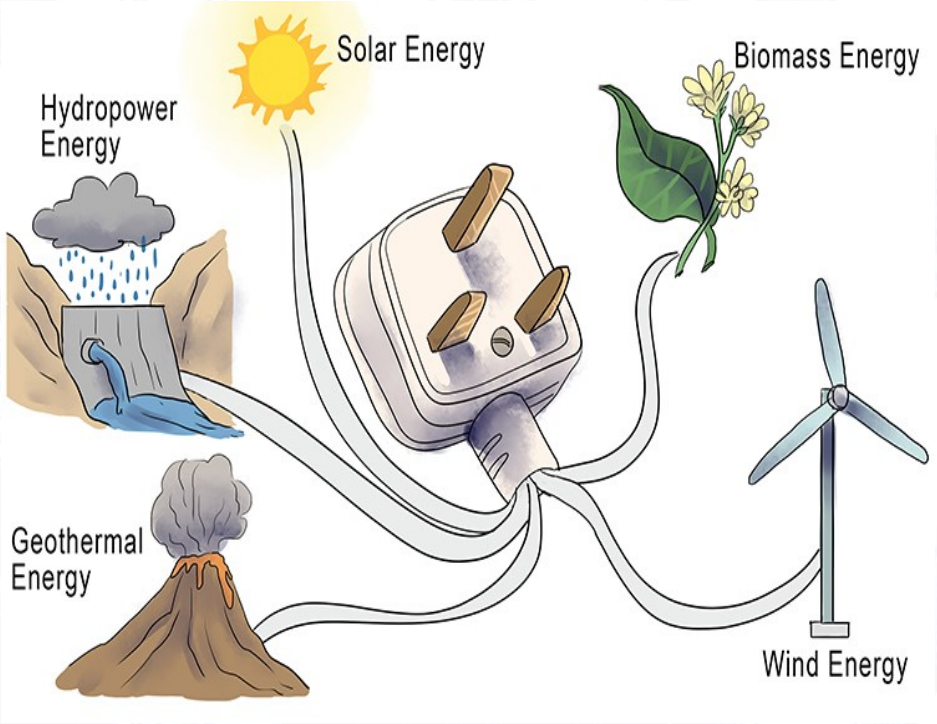
Now – End of the fossil regime

Source: Opcions magazine [58]

Now – End of the fossil regime

Techno-optimism

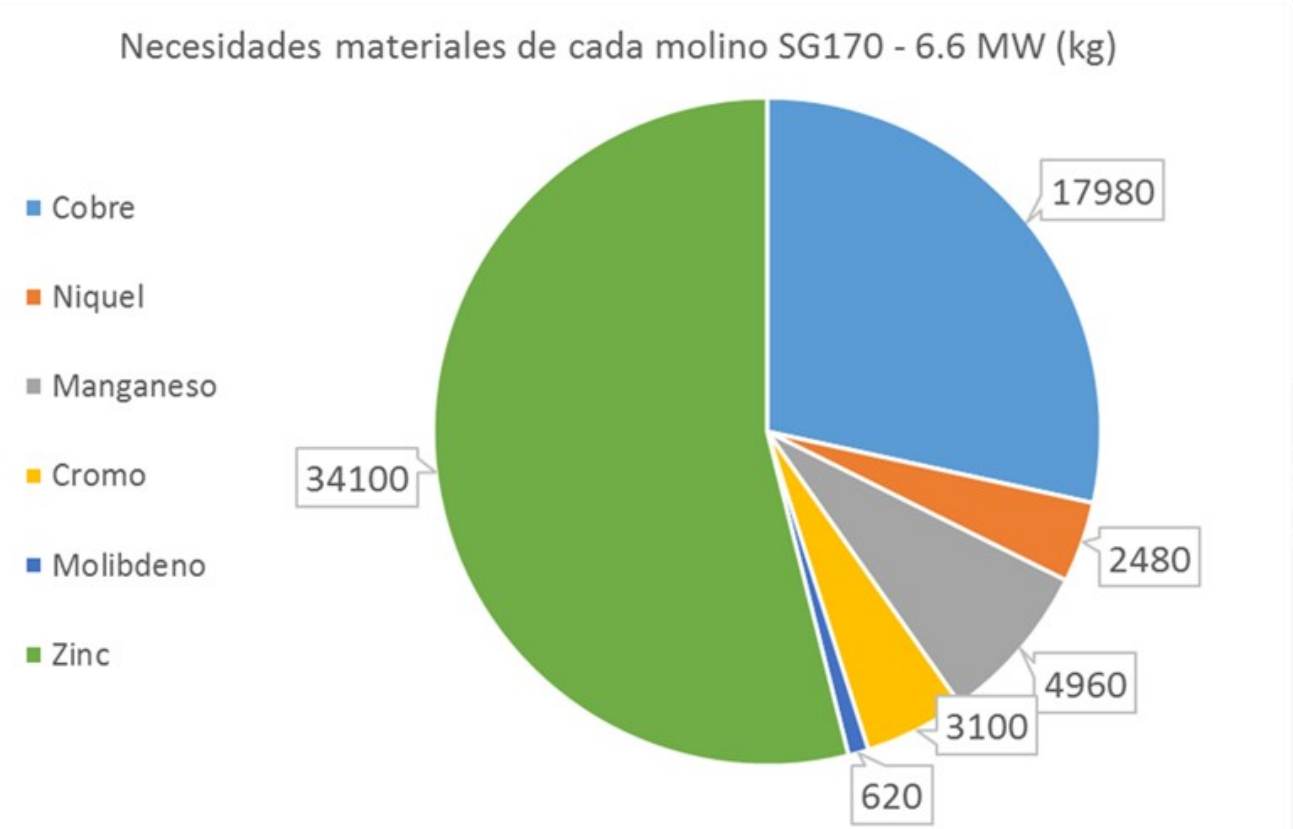
"The belief that technology plays a vital role in solving the most pressing threats to humankind"

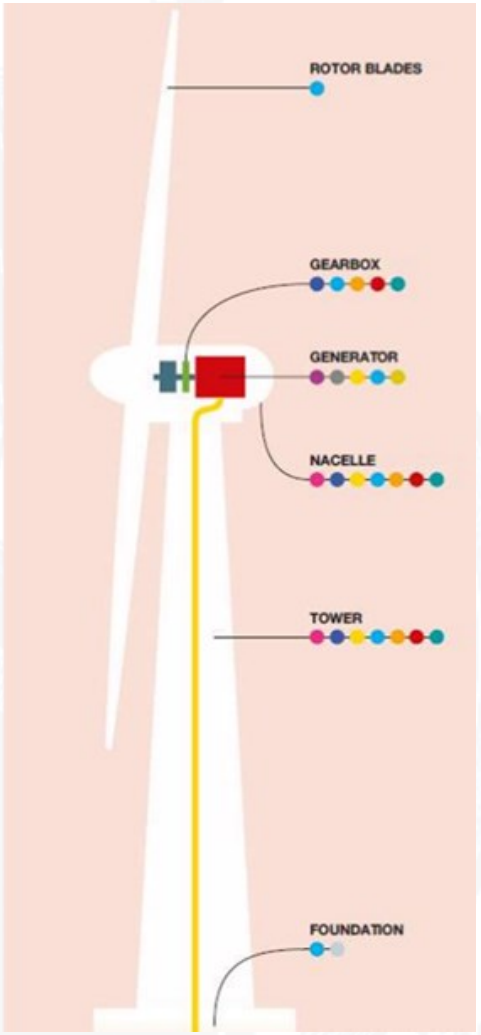


Techno-optimism

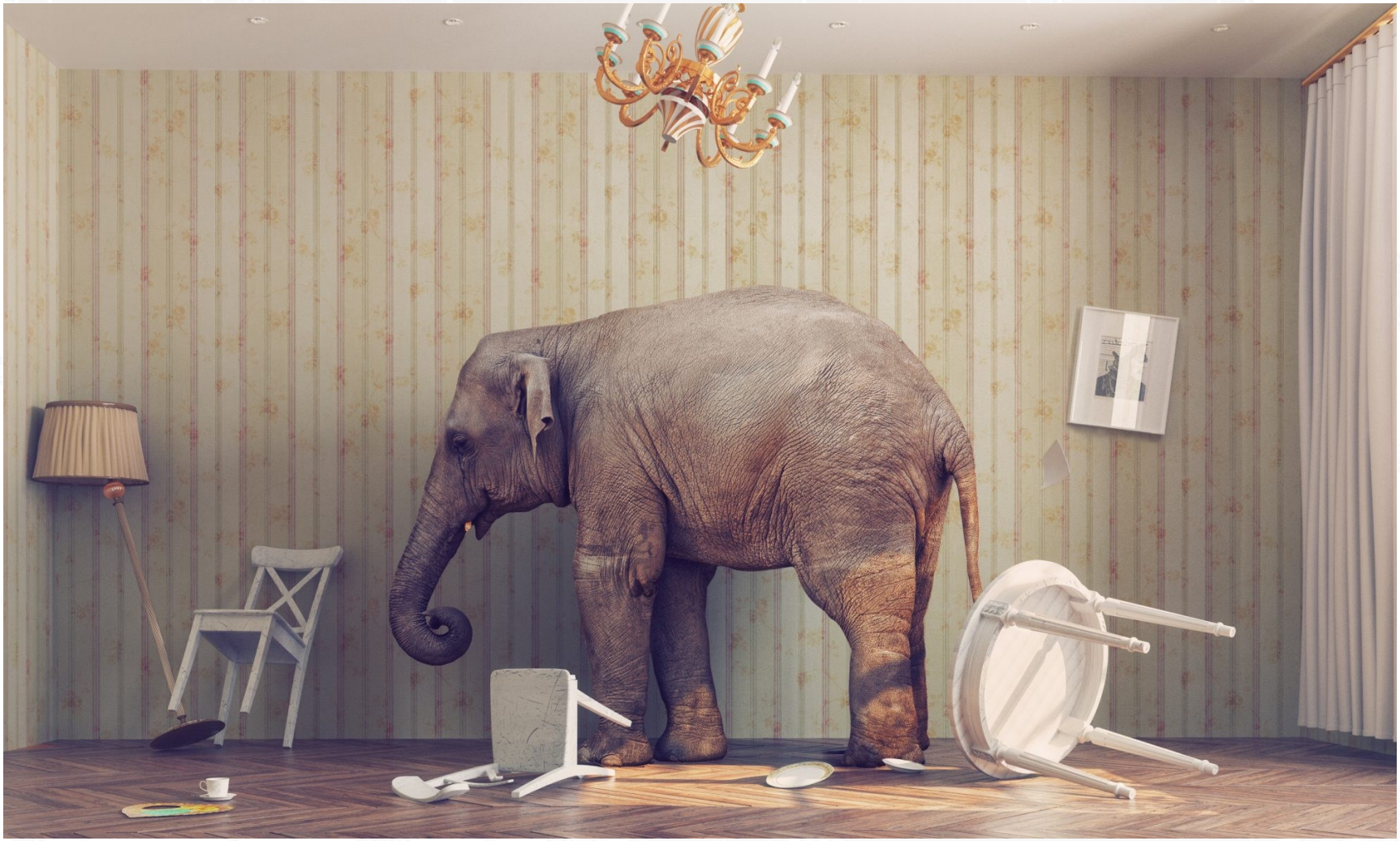
Techno-optimism

Basque Country – 1800 windmills





Degrowth? – Elephant in the room



More timber!

Raiders of the hidden energy

Use every kJ.

Waste heat recovery

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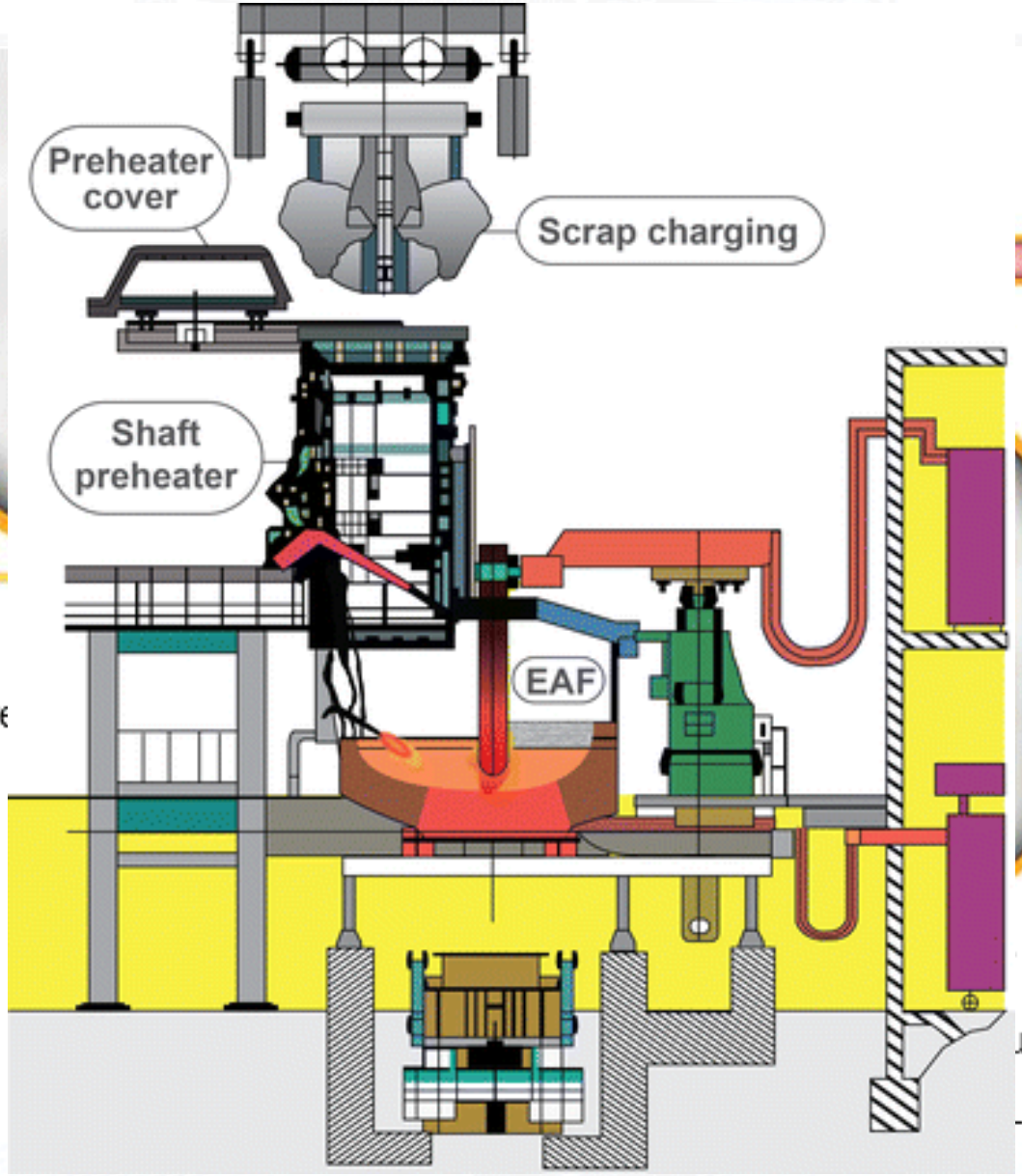

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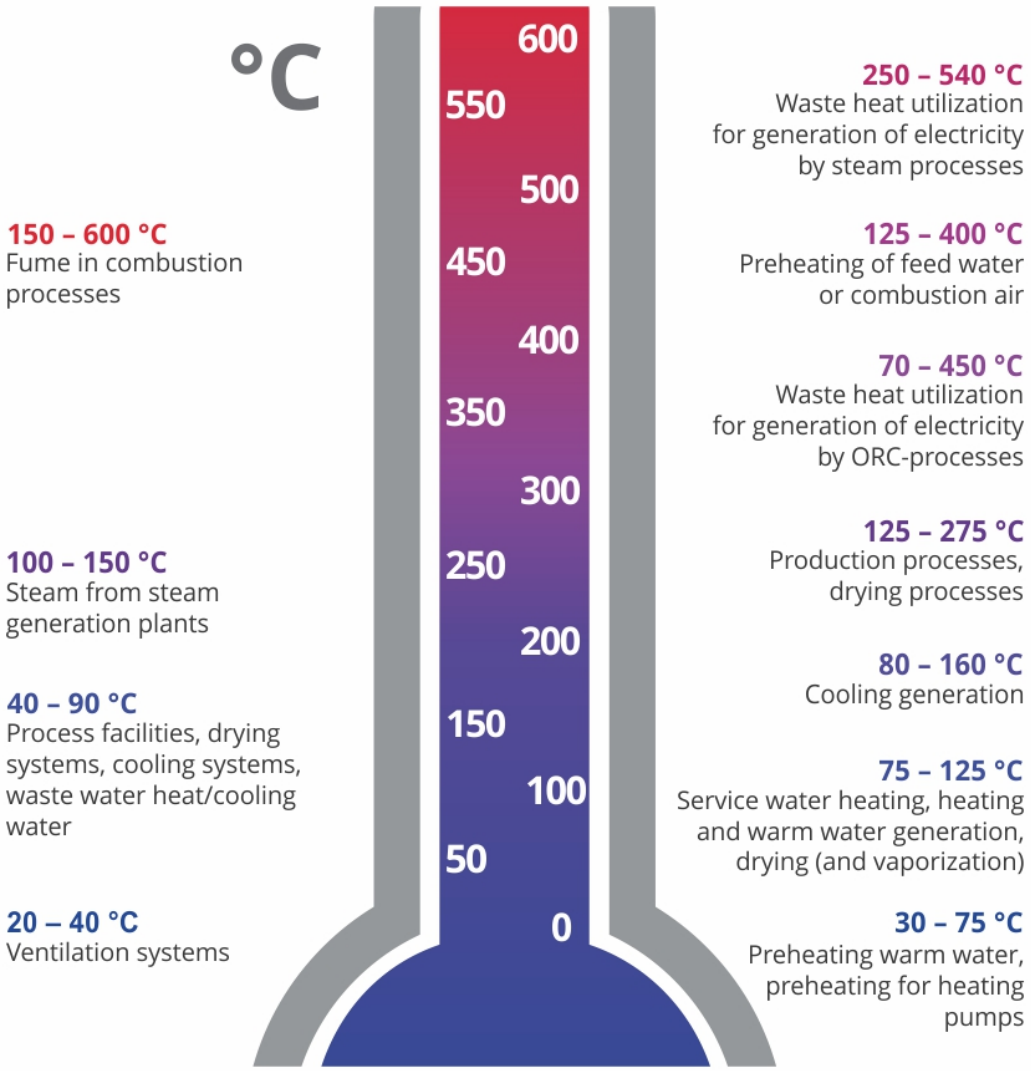
Waste heat recovery



Waste heat recovery

How we recover it? Depends on:

- Mass flow rate / Amount of energy
- Temperature of the waste heat
- Involved substances (air/liquid/solid)
- Accesibility to the source
- Distance to the final use point
- Nature of the final use
- Coupling between supply and demand

Waste heat recovery

4 examples to analyse:

Waste heat recovery

To design strategies that exploit this potential, it is necessary to have data about the quantity and characteristics of **Industrial Waste Heat (IWH)** flows.

Bottom-up methodologies to estimate that recovery potential by means of key transfer figures are useful tools within this field.

Waste heat recovery

4 bottom-up methos in the bibliography:

Summary of the main characteristics of the four used methods.

	Method 1	Method 2	Method 3	Method 4
Study's original region	Sweden	Germany	EU-27	UK
Company's input data	Natural gas + diesel oil	Natural gas + diesel oil	CO_2 emissions	Natural gas + diesel oil
Year of the data	<2002	2008	2010	2000/03
Type of potential obtained	Technical	Theoretical	Theoretical	Technical
Industrial clustering classification system	SNI 1992	NACE rev 2	Own	Own
Number of used industrial clusters	23	22	6	7
Discretization per temperature levels	No	No	No	Yes

Waste heat recovery

4 bottom-up methods in the bibliography:

$$Q_{IWH,1} = f_{M,1}\left(Q_{natural\ gas} + Q_{diesel\ oil}\right)$$

$$Q_{IWH,2} = f_{M,2}\left(Q_{natural\ gas} + Q_{diesel\ oil}\right)$$

$$Q_{IWH,3} = f_{M,3} \cdot CO_{2\ emissions}$$

Waste heat recovery

Key figures to define IWH from fuel consumption data in Method 1 in the Basque Country (Miró et al., 2016).

NACE sectors	f_{m1}
10, 11, 12	0.067
13, 14, 15, 16, 18	0
17	0.031
19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32	0.096
24	0.2

Key Transfer Figures

Recovery efficiencies and carbon dioxide emissions factor by sector proposed by Persson et al. for Spain (Persson et al., 2014).

Main activity sector category	Recovery efficiency	CO_2 emission factor [$kgCO_2/MWh$]	Combined f_{M3} [$MWh/kgCO_2$]
Chemical and petrochemical	0.25	225	0.0011111
Iron and steel	0.25	279.72	0.0008938
Non-ferrous metals	0.25	231.48	0.00108
Non-metallic minerals	0.25	246.96	0.0010123
Paper, pulp and printing	0.25	272.2	0.0009019
Food and beverage	0.10	263.16	0.0003799

Waste heat recovery

Temperature distribution of the determined IWH per sector.

Main activity sector category	Percentage [%] of the IWH calculated per sector					
	100/ 200 °C	200/ 300°	300/ 400°	400/ 500°	500/ 1000°	>1000°
Chemical and petrochemical	30	–	–	70	–	–
Iron and steel	–	31	8.9	–	46.4	13.7
Non-ferrous metals	100	–	–	–	–	–
Non-metallic minerals	64.4	–	6.8	–	28.8	–
Paper, pulp and printing	100	–	–	–	–	–
Food and beverage	100	–	–	–	–	–
Others	100	–	–	–	–	–

IWH Temperature

Waste heat recovery

Bottom-up methods inputs:

- Company´s category
- Energy consumption
- CO_2 emissions

https://en.prtr-es.es/

Waste heat recovery

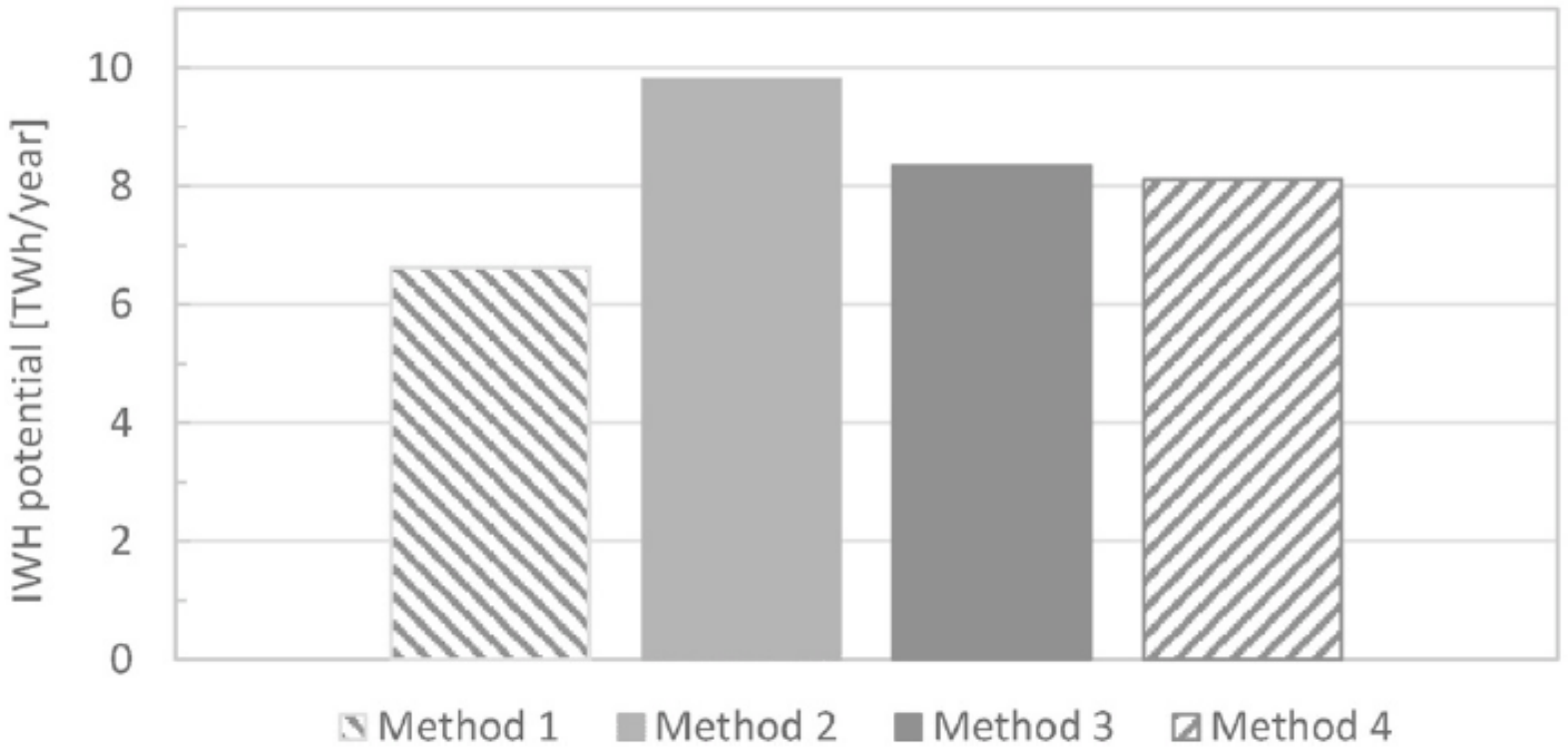
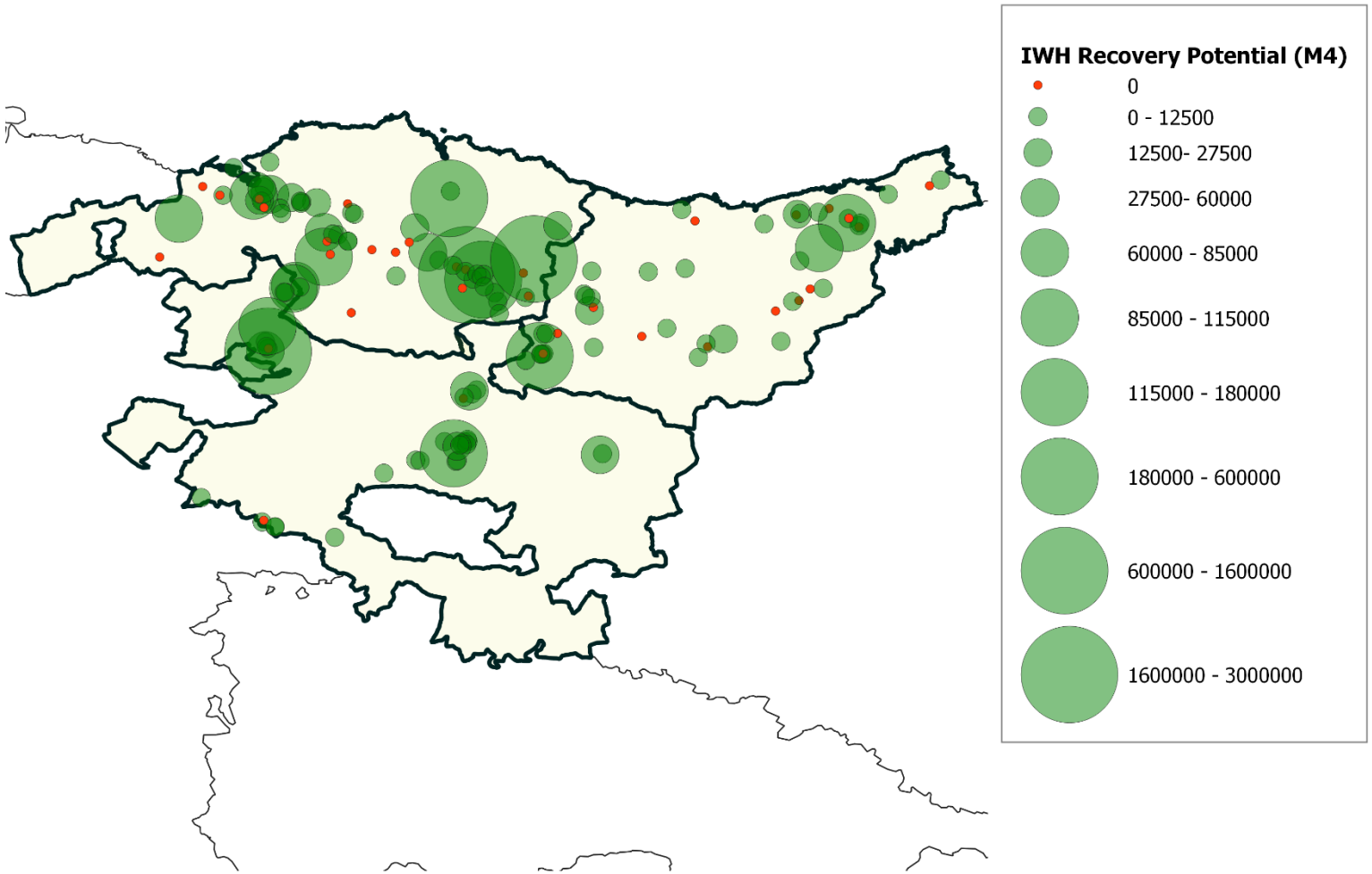


Fig. 4. Estimated IWH recovery potential for the 126 companies that offer both input data, calculated by each method. Striped columns for technical potential, plain for theoretical.

Waste heat recovery



Waste heat recovery

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/jclepro

Evaluation of the theoretical, technical and economic potential of industrial waste heat recovery in the Basque Country

Pello Larrinaga [a,*], Álvaro Campos-Celador [b], Jon Legarreta [a], Gonzalo Diarce [a]

[a] ENEDI Research Group, Dpto. de Ingeniería Energética, Escuela de Ingeniería de Bilbao, University of the Basque Country - UPV/EHU, Rafael Moreno Pitxitxi 2, 48103, Bilbao, Spain

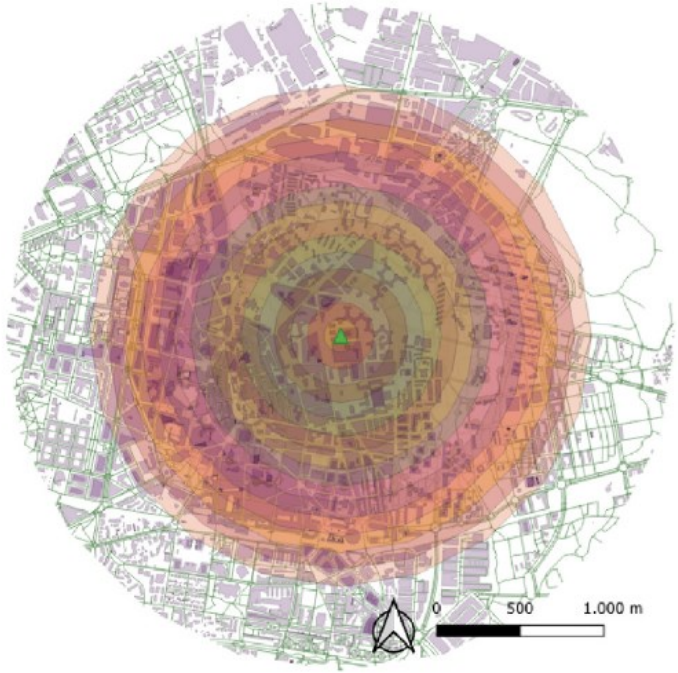
[b] ENEDI Research Group, Dpto. de Ingeniería Energética, Escuela de Ingeniería de Gipuzkoa (sección Eibar), University of the Basque Country - UPV/EHU, Av. Otaola 29, 20600, Eibar, Spain

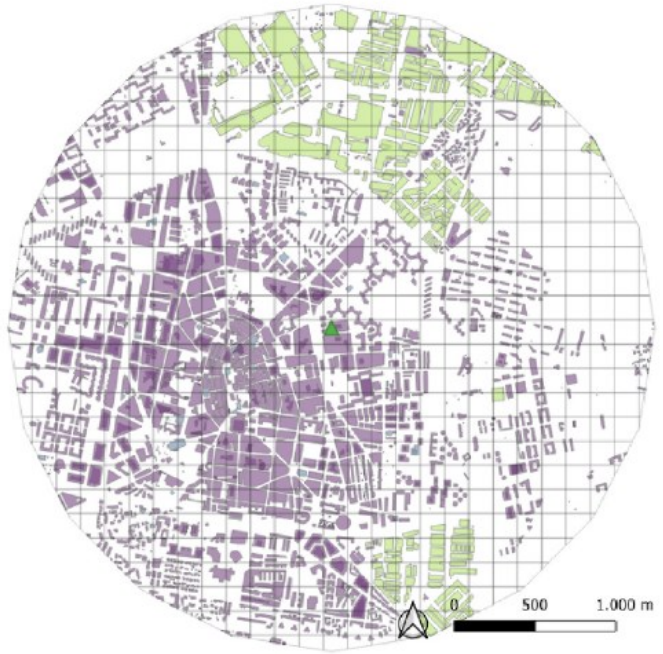
Fig. 5. Basque Country IWH recovery potential distribution by temperature ranges, obtained by Method 4, and number of companies that generate IWH flows at those ranges.

Waste heat recovery

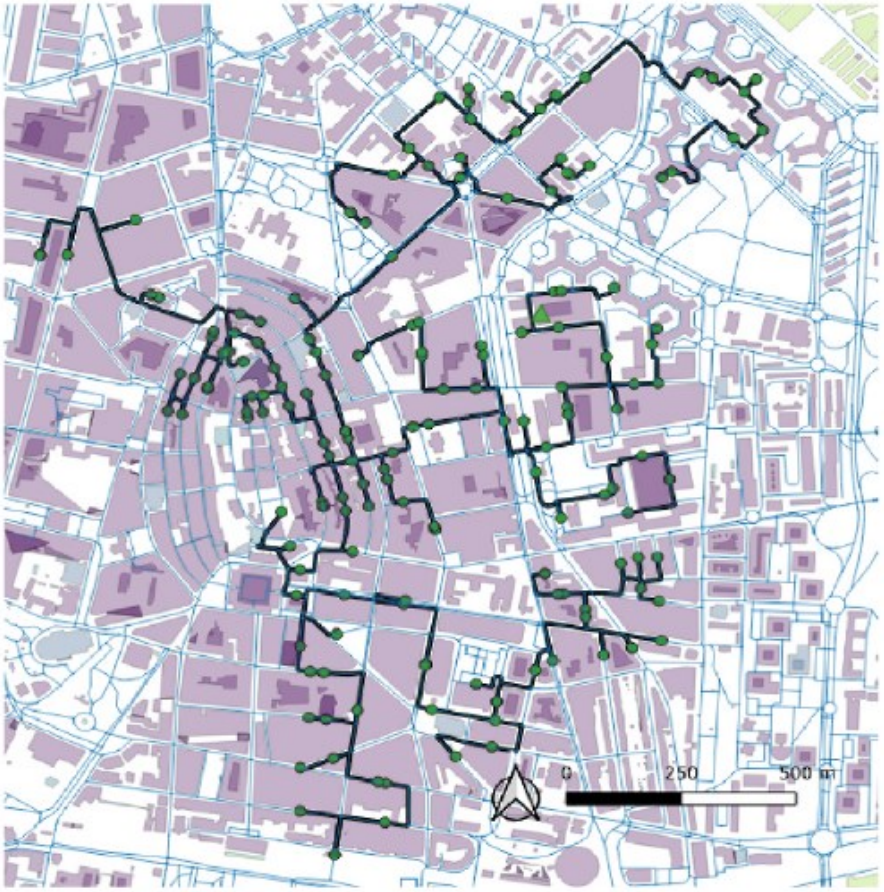
Further work: design of district heating networks in built environments fed by Industrial Waste Heat using GIS.

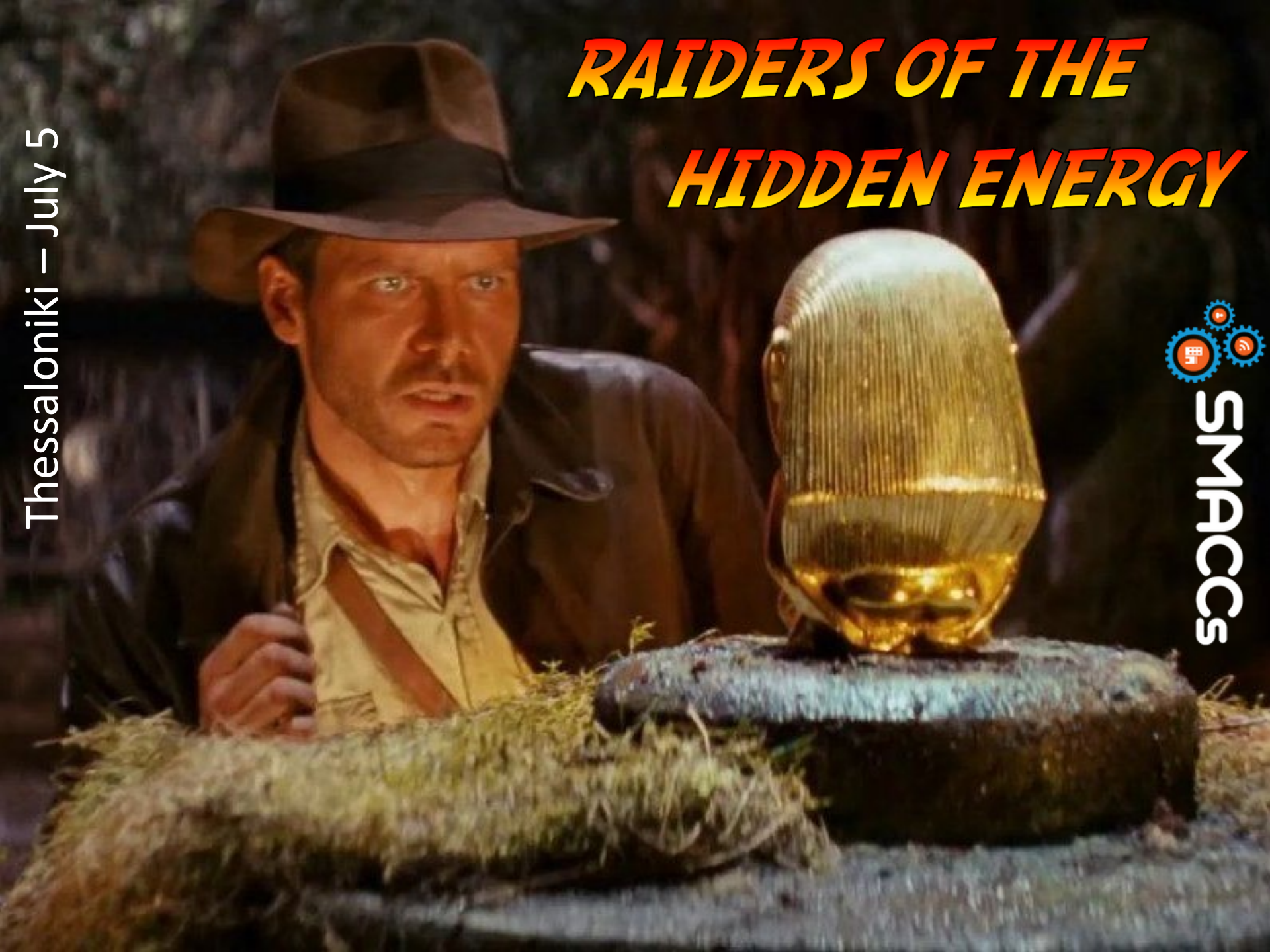
Case study in Vitoria-Gasteiz, Spain





Waste heat recovery




RAIDERS OF THE
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Group 3	**Group 4**
Elina Farida Nayely Kamrul Moontasir Iryna Nikos	Sergei Qasem Fakhriy Jannatul Victoria Asham Paul Aristeidis