Gravity Energy Storage, a solution for long term energy storage

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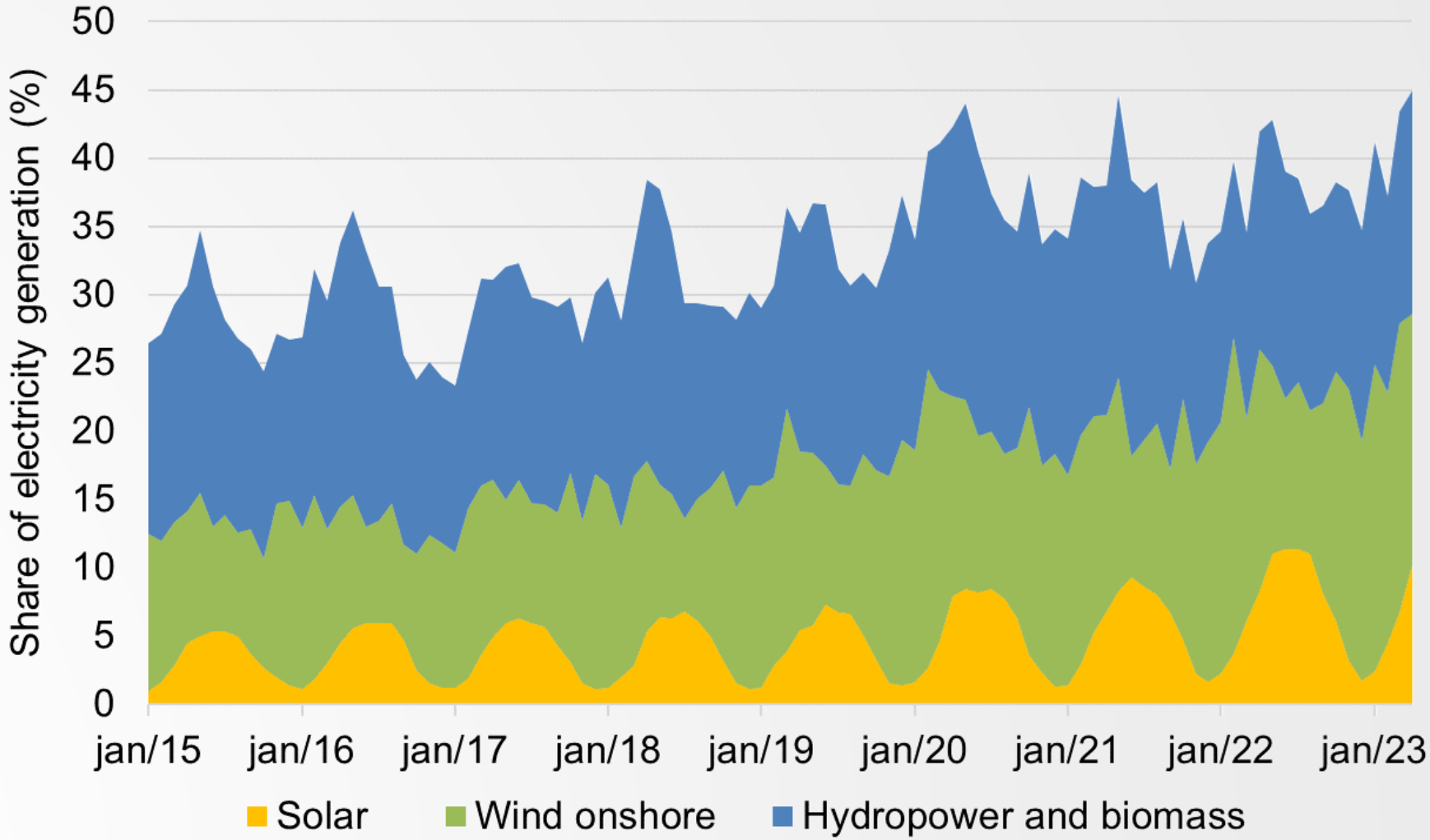
Motivation

- There is a rapid increase in renewables in the grid.
- Which is increaseing the demand for hourly, daily, weekly, monthly, seasonal and pluriannual energy storage is increasing.

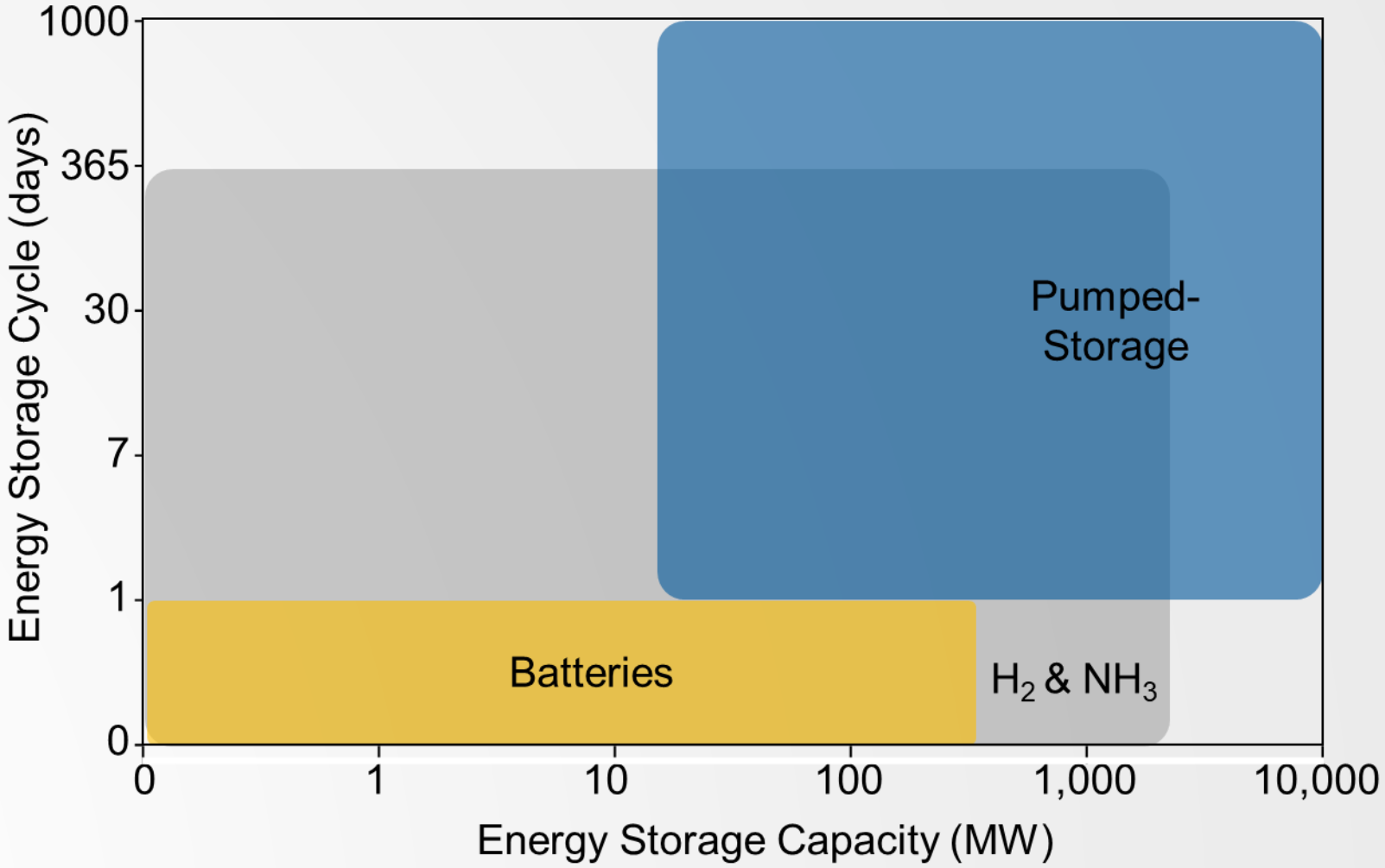
Share of electricity generation from renewable energy sources in the European Union from 2015 to 2023



REF: Energy-Charts. Monthly renewable share of public electricity generation in the European Union. Fraunhofer ISE 2023.

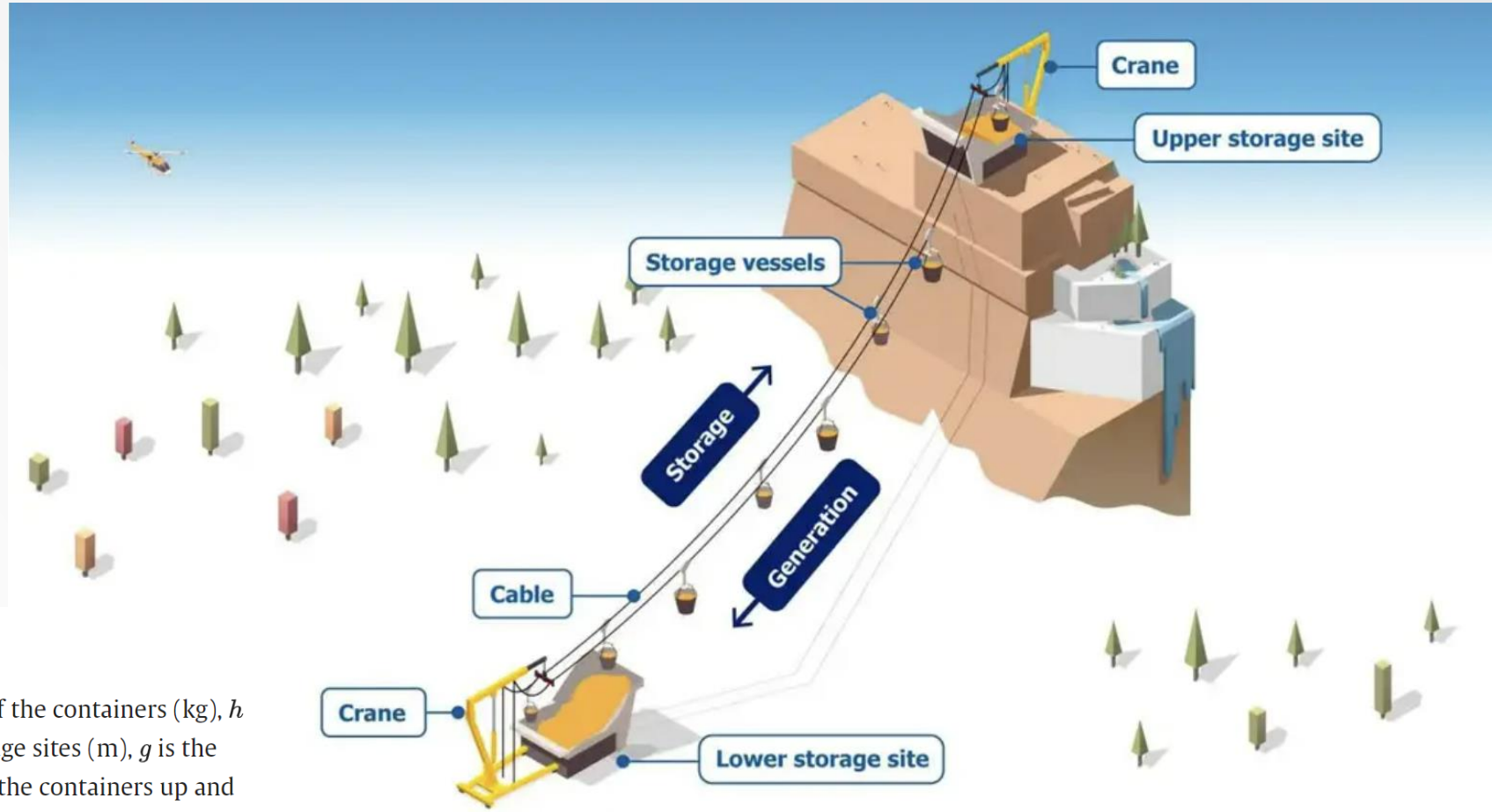
Motivation

- Batteries can provide hourly and daily storage.
- Pumped storage can provide daily, weekly, monthly, seasonal and pluriannual storage. But it is restricted to topography and water.
- H2 and ammonia, com provide seasonal storage, but depend on underground storage (salt caverns, depleted reservoirs). It is also expensive and has low efficiency.



Gravity Energy Storage

- Gravity energy storage consists of storing energy by lifting weight from a lower storage site to an upper storage site.

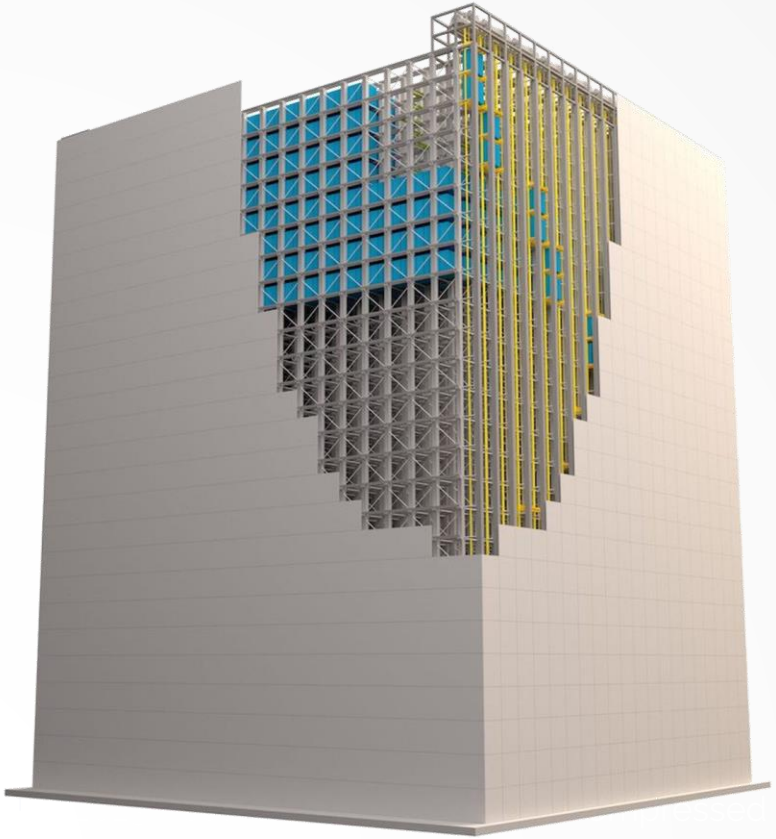


$$E = m \times h \times g \times e$$

where, E is the energy stored in the containers (J), m is the mass of the containers (kg), h is the average height difference between the upper and lower storage sites (m), g is the acceleration of gravity (m/s^2), e is the efficiency of the lift to move the containers up and down, assumed to be 80% based on [47].

Energy Vault

- Energy Vault is a company in the New York stock exchange that is building a gravity energy storage prototype in China.
- It will have 25 MW and 100 MWh storage capacity.



Gravity Energy Storage

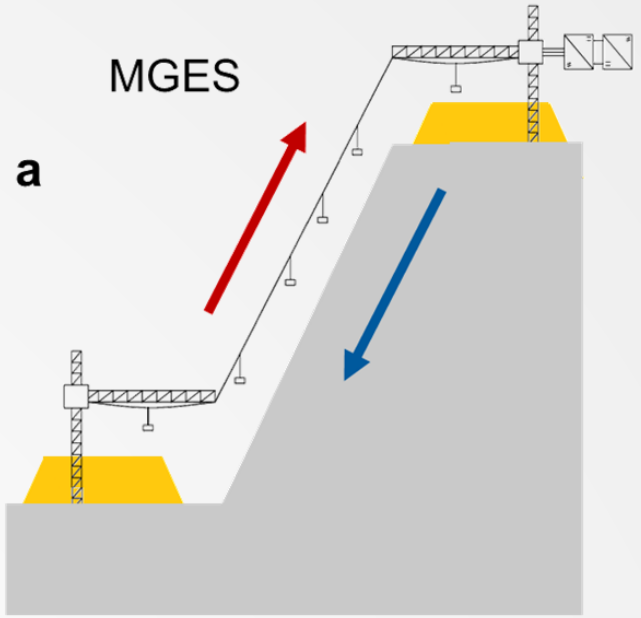
- Armazenar energia sazonalmente movendo areia em diferentes altitudes.

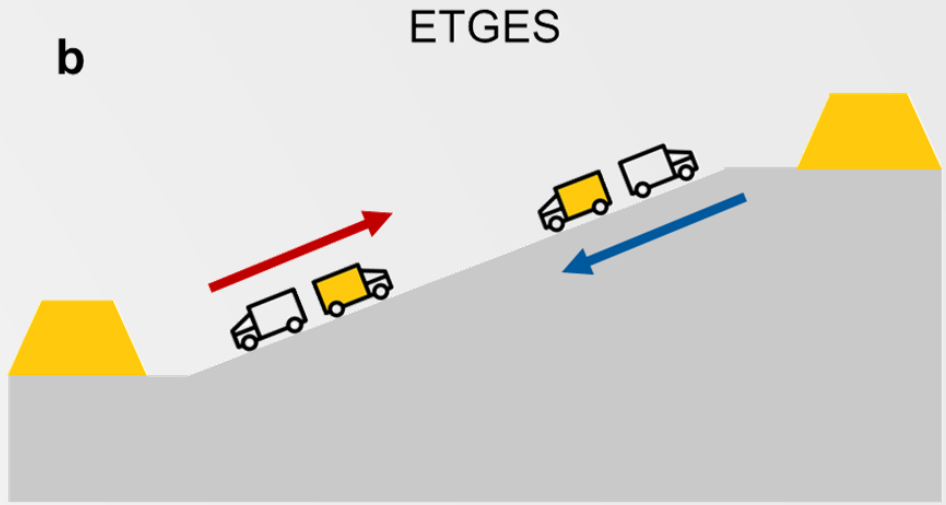
MGES – Mountain Gravity Energy Storage

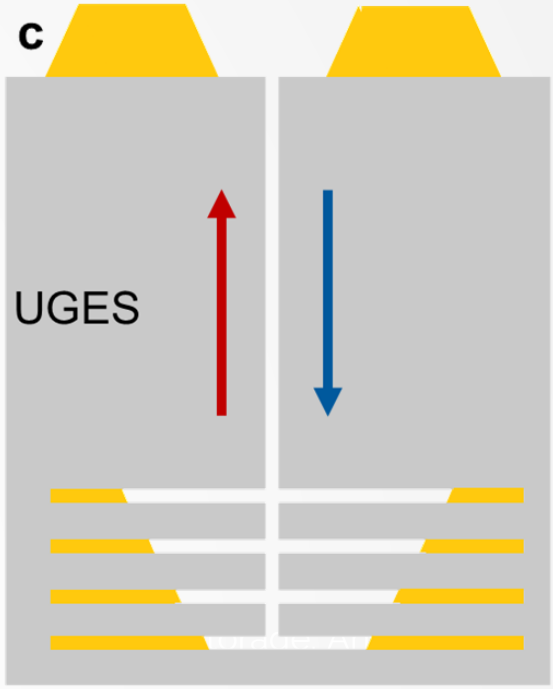
ETGES – Electric Truck Gravity Energy Storage

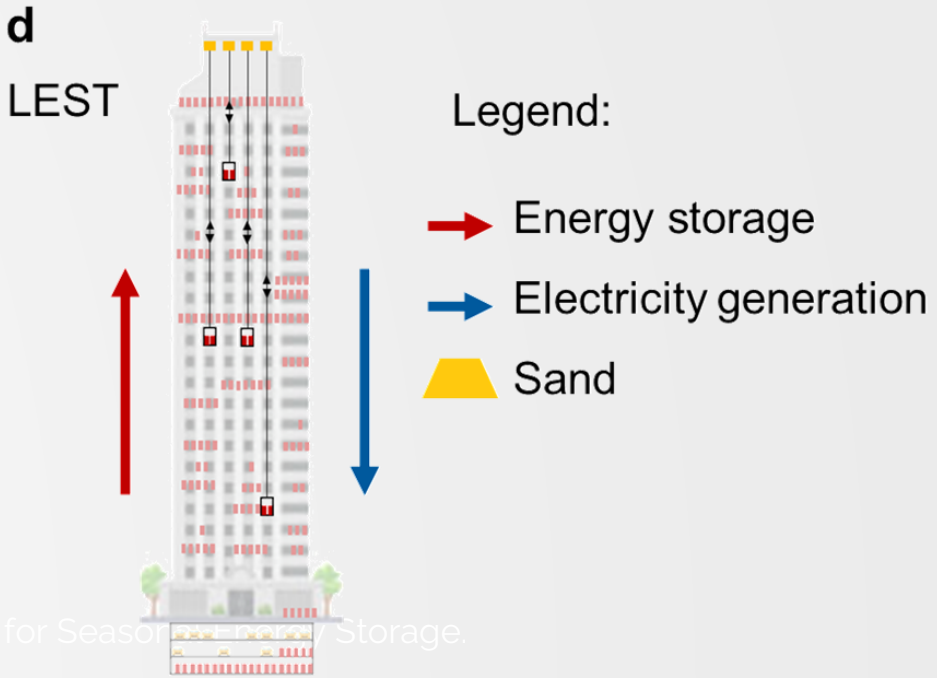
UGES – Underground Gravity Energy Storage

LEST - Lift Energy Storage Technology



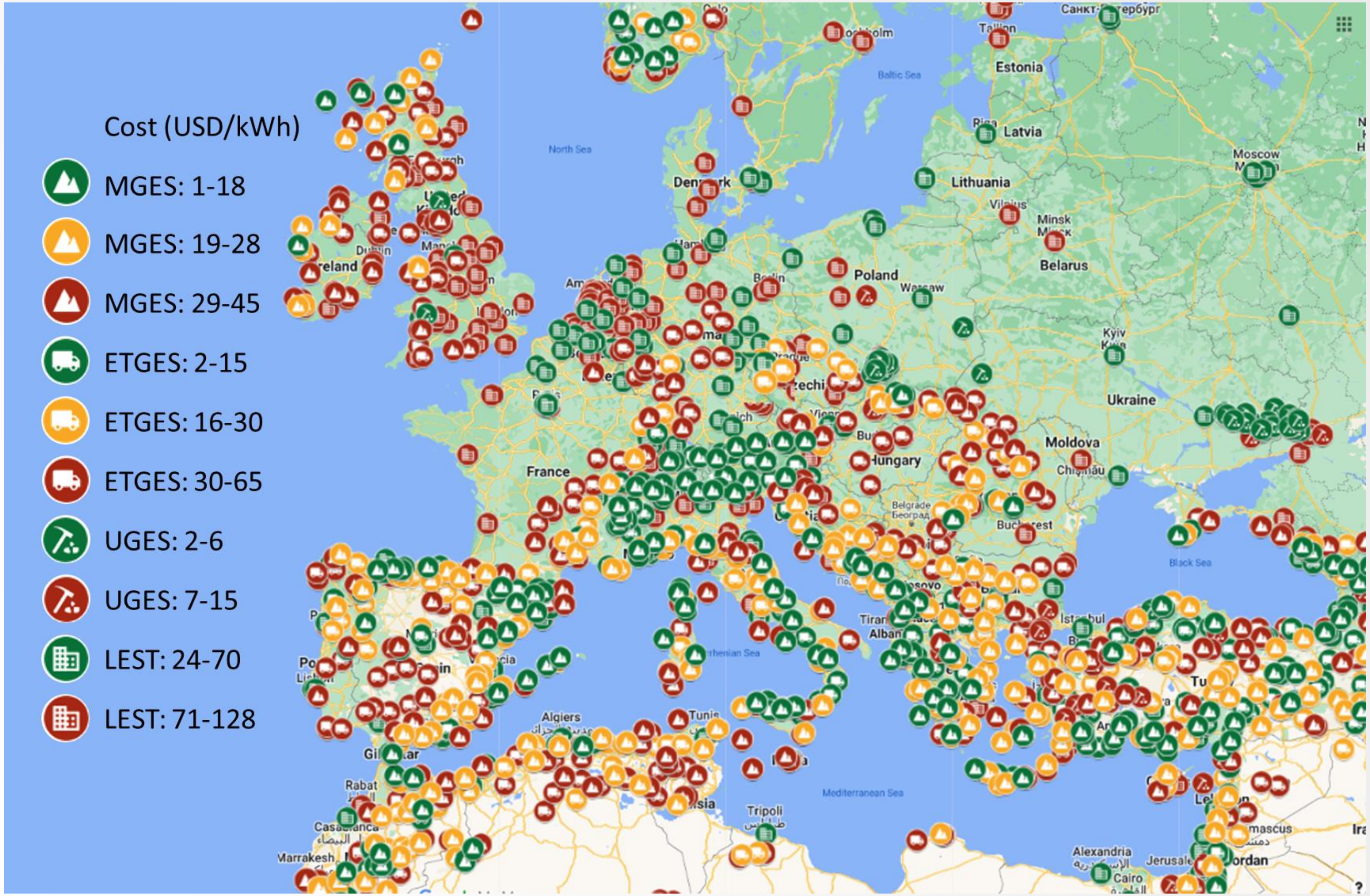






Energy from Compressed Air: An Innovative Solution for Seasonal Energy Storage.

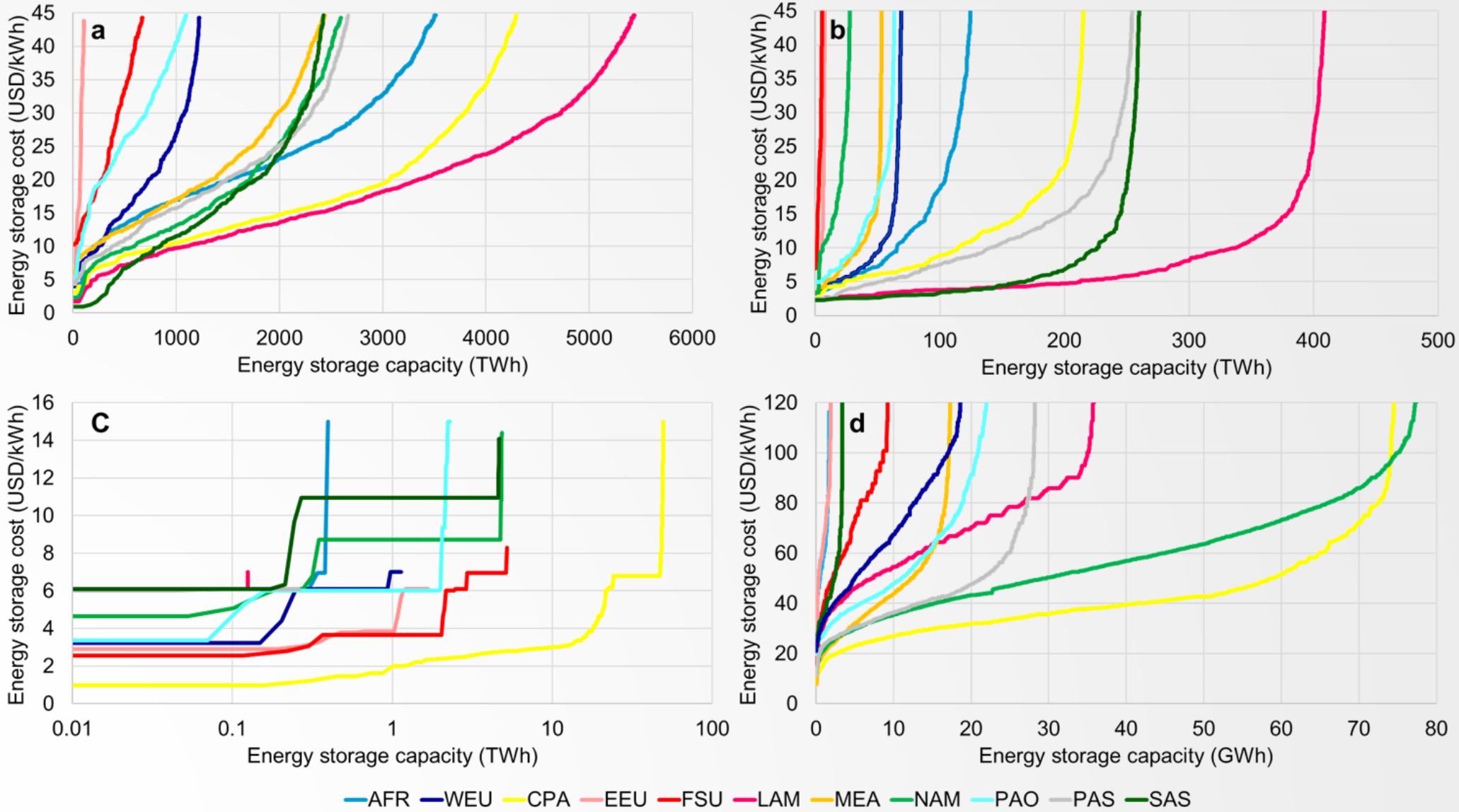
Gravity Energy Storage



Gravity energy storage interactive map

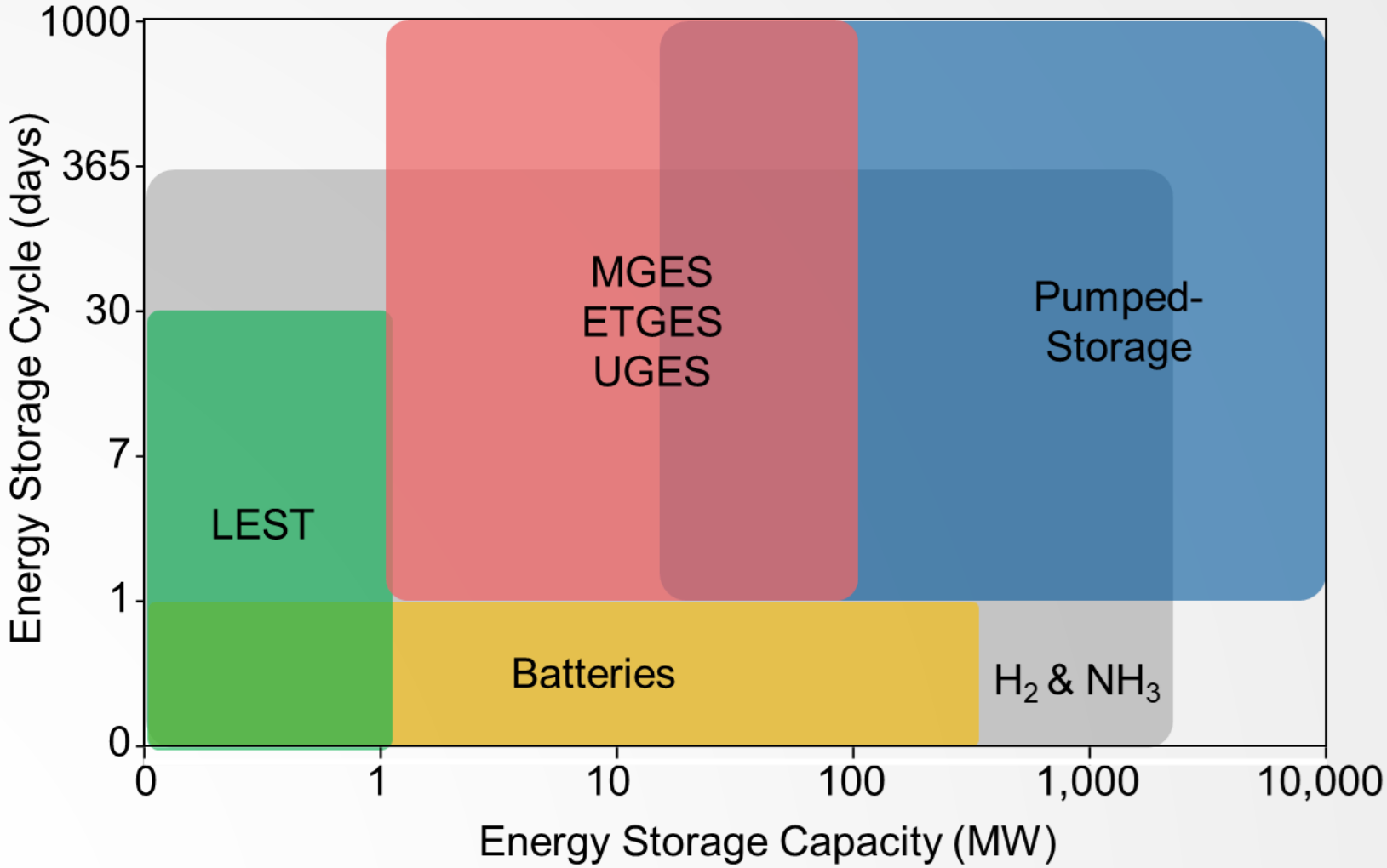
https://www.google.com/maps/d/edit?mid=191ZjmVYCa-6qiQBi0wMNMIA9o6oV_Ek&usp=sharing

Gravity Energy Storage



Gravity energy storage cost curves. a MGES, b ETGES, c UGES, d LEST

Gravity Energy Storage

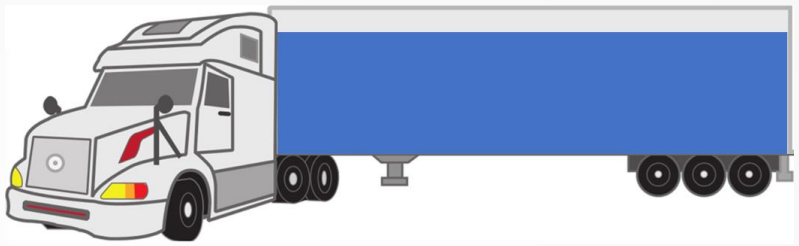


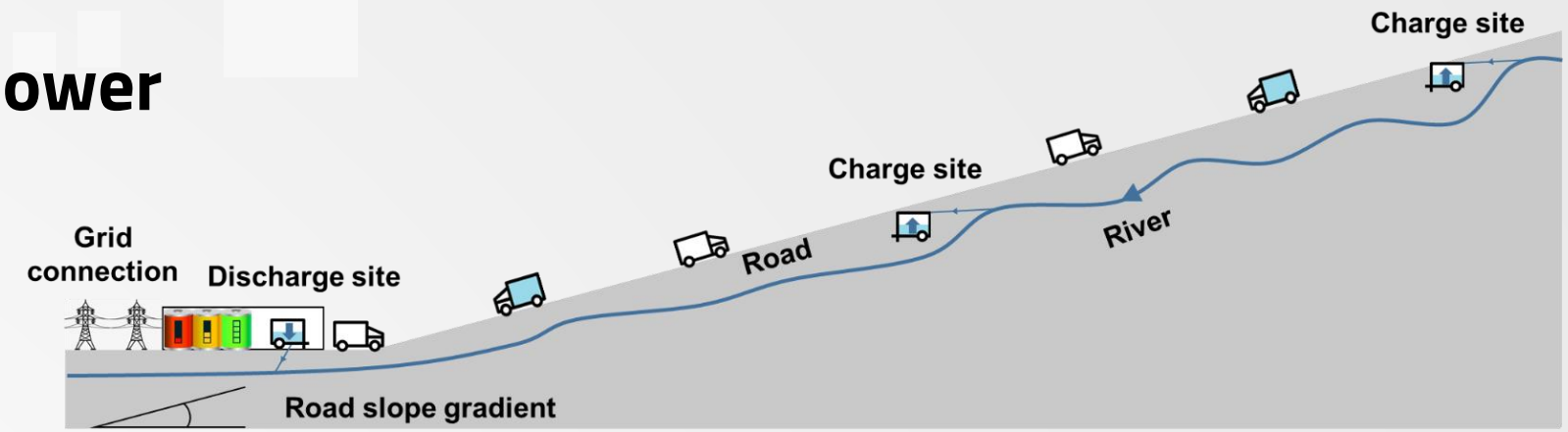
Gravity energy storage cycle and installed capacity compared with other storage technologies.

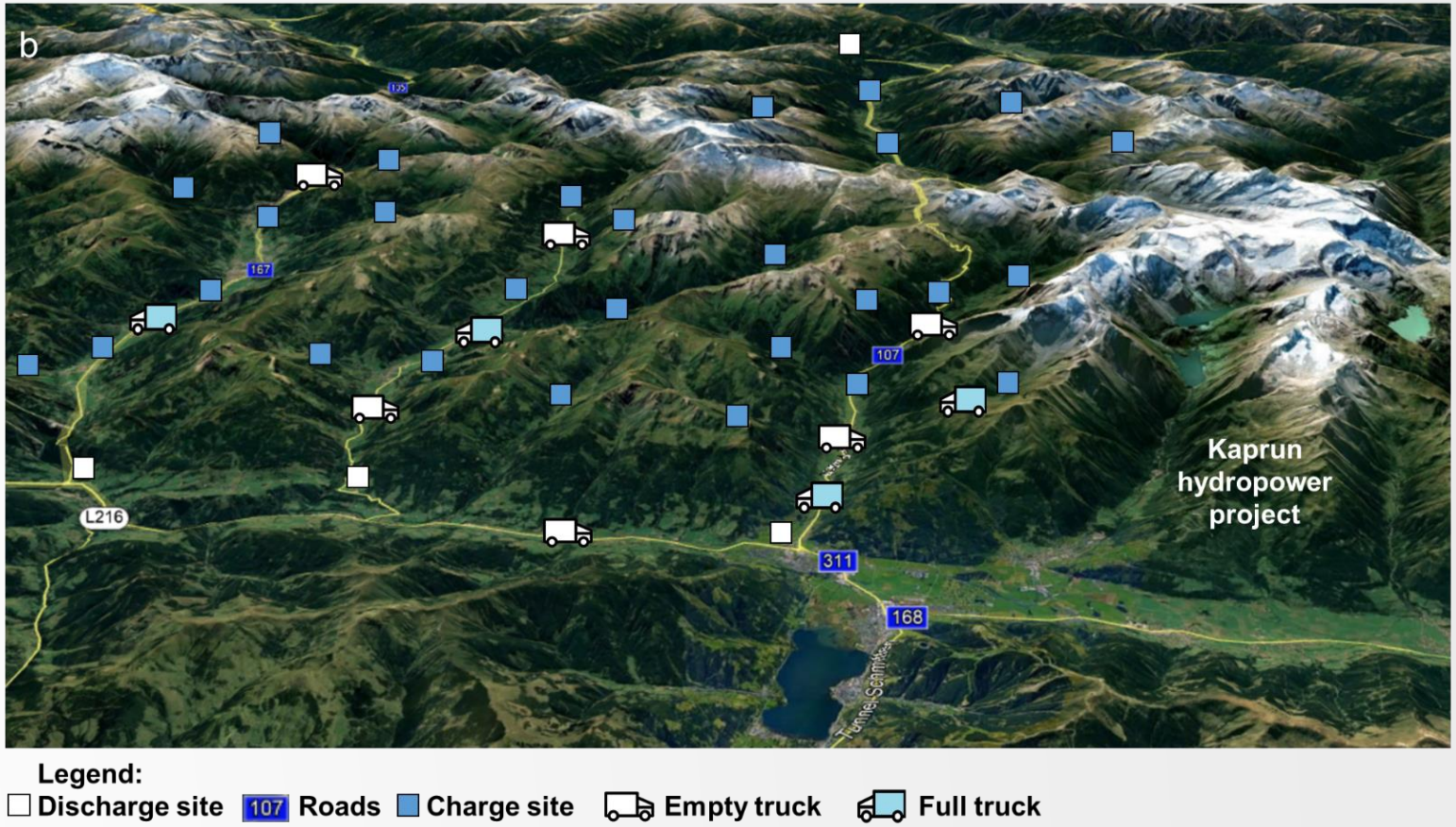
Gravity Energy Storage

Name	Installed capacity cost (USD/KW)	Energy Storage cost (USD/kWh)	Installed capacity per project (MW)	Storage Cycles	Global Potential (TWh)
Mountain Gravity Energy Storage (MGES)	1,000 – 2,000	1 – 100	1 - 20	Seasonal, pluriannual	26,481
Electric Truck Gravity Energy Storage (ETGES)	1,200	2 – 100	20 – 100	Monthly, seasonal, pluriannual	1,500
Underground Gravity Energy Storage (UGES)	1,000 – 2,000	2 – 15	1 – 50	Seasonal, pluriannual	70
Lift Energy Storage (LEST)	500 – 1,000	20 – 120	0.02 – 1 (per building)	Ancillary, daily, weekly, monthly	0.3
Seasonal pumped hydropower storage (SPHS)	600 – 1000	2 – 50	10 – 1000	Ancillary, hourly, daily, weekly, monthly, seasonal, pluriannual	17,300
Li-ion batteries	300 – 500	150 – 200	0.01 – 500	Ancillary, hourly, daily	Not site-limited but material needs
Compressed air energy storage (CAES)	750 –1000	1 – 100	10 – 500	Ancillary, hourly, daily	Not available
Hydrogen	300 – 1000	0.02 – 100	0.01 – 1000	Ancillary, hourly, daily, weekly, monthly, seasonal, pluriannual	Not site-limited

Electric Truck Hydropower





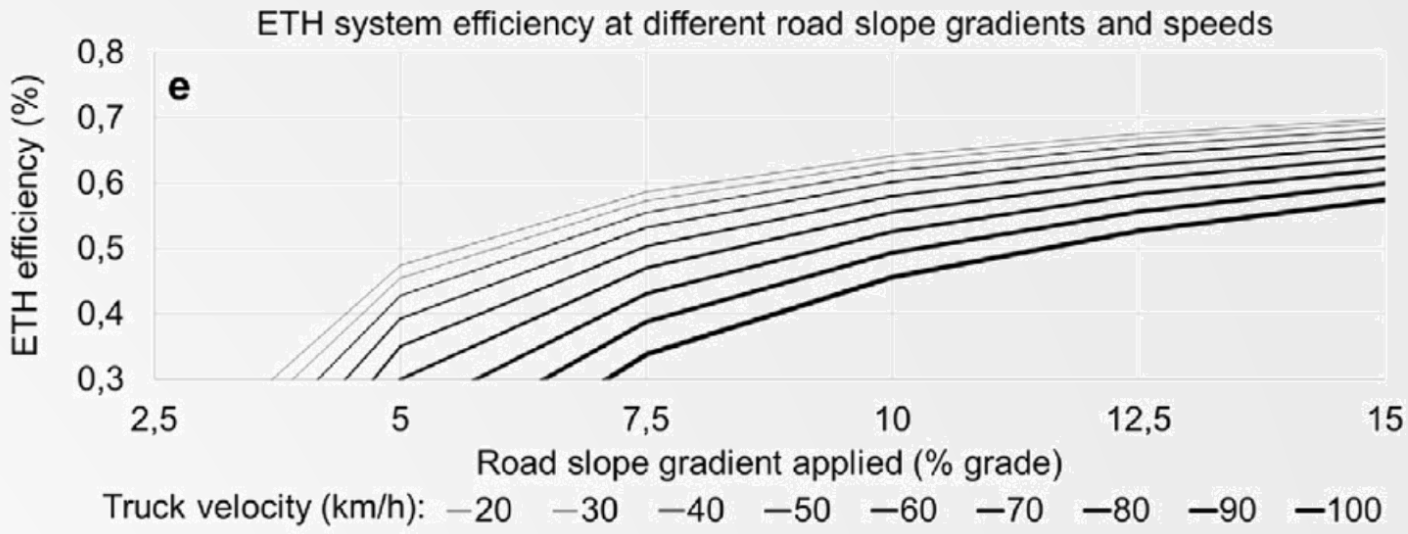


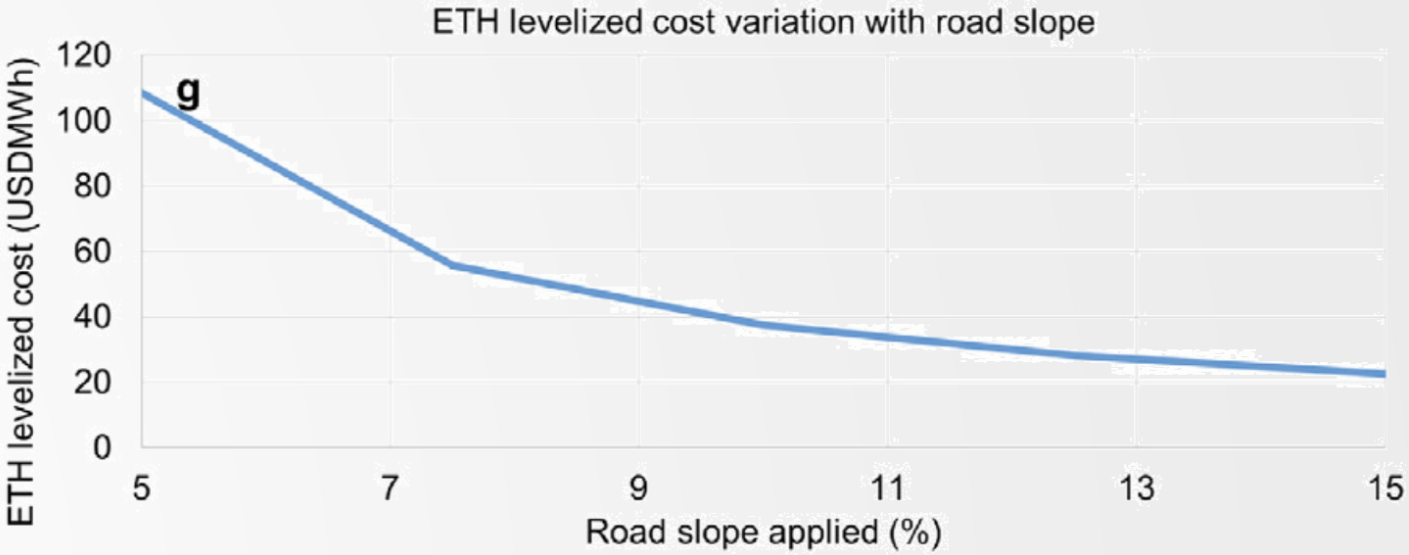
Hunt. J. Energy Electric Truck Hydropower, a flexible solution to hydropower in mountainous regions Author links open overlay panel. Energy. 248. 2022

Electric Truck Hydropower

Custo nivelado da eletricidade do caminhão hidrelétrico é de 30-100 USD/MWh, o que é barato quando comparado com hidrelétricas convencionais de 50-200 USD/MWh.

O potencial mundial de geração de eletricidade para essa tecnologia é estimado em 1,2 PWh por ano, equivalente a cerca de 4% do consumo global de energia em 2019.





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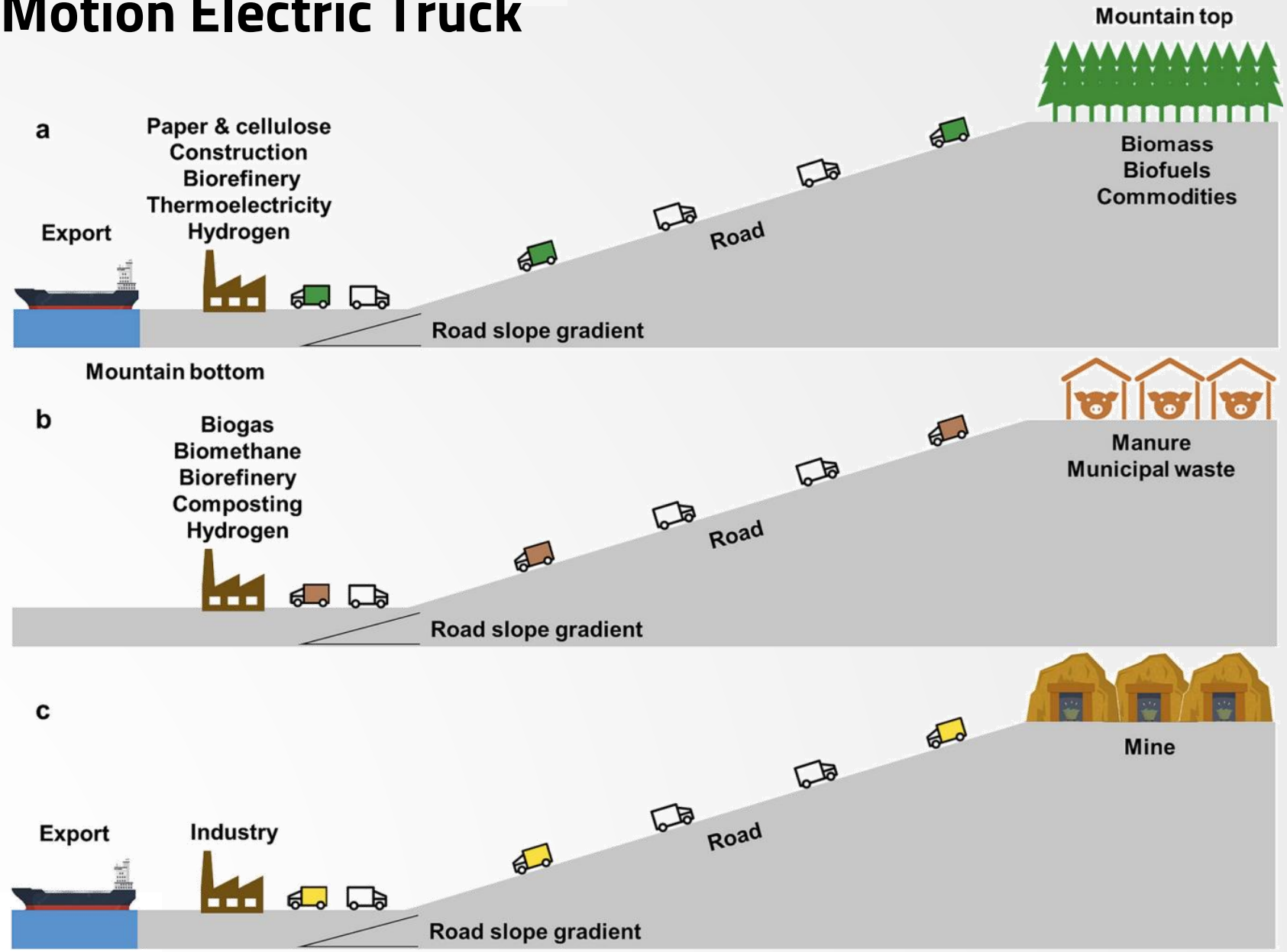
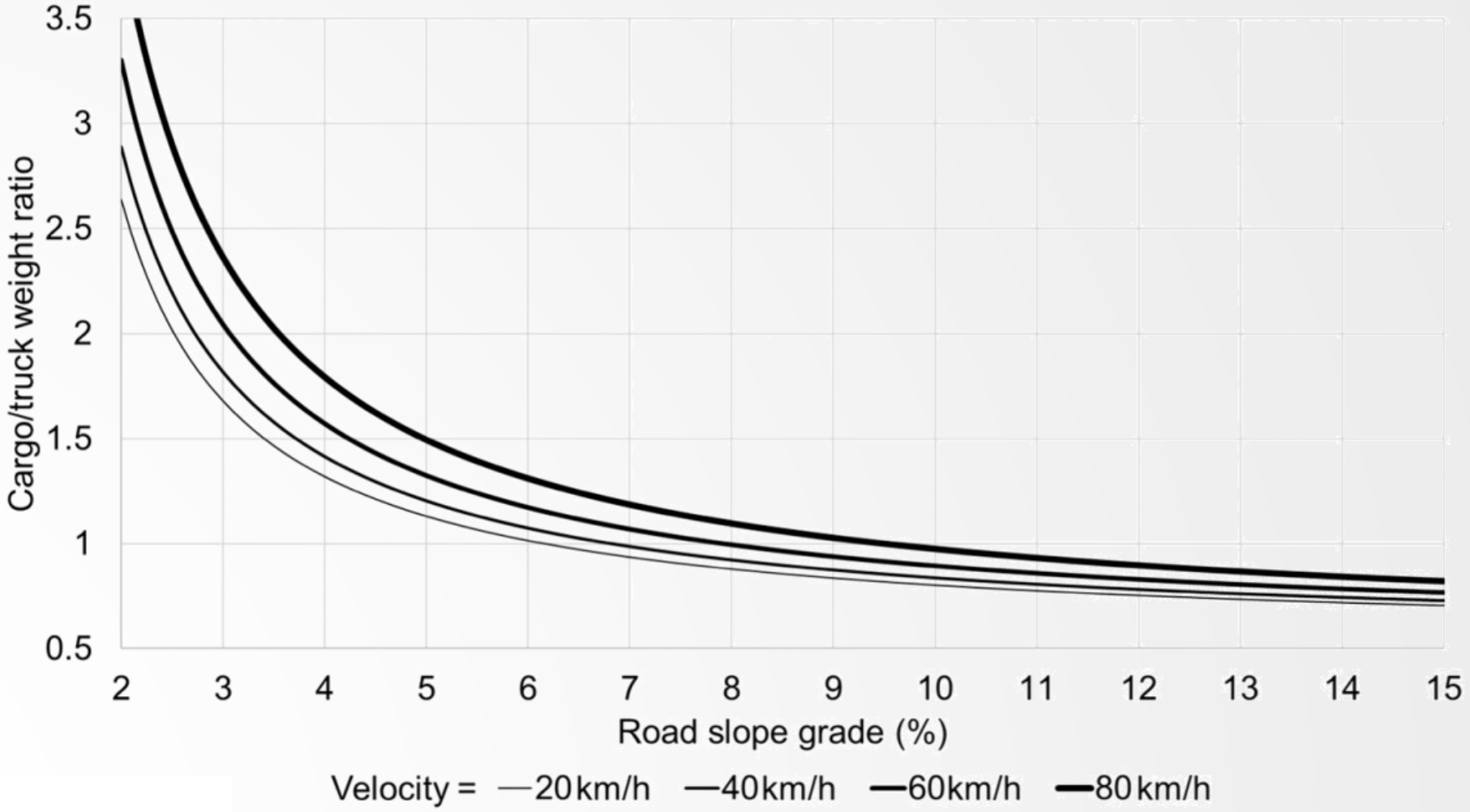
Perpetial Motion Electric Truck



Hunt, J. et. al. Perpetual motion electric truck, transporting cargo with zero fuel costs. Journal of Eneergy Storage. 2023

Perpetial Motion Electric Truck



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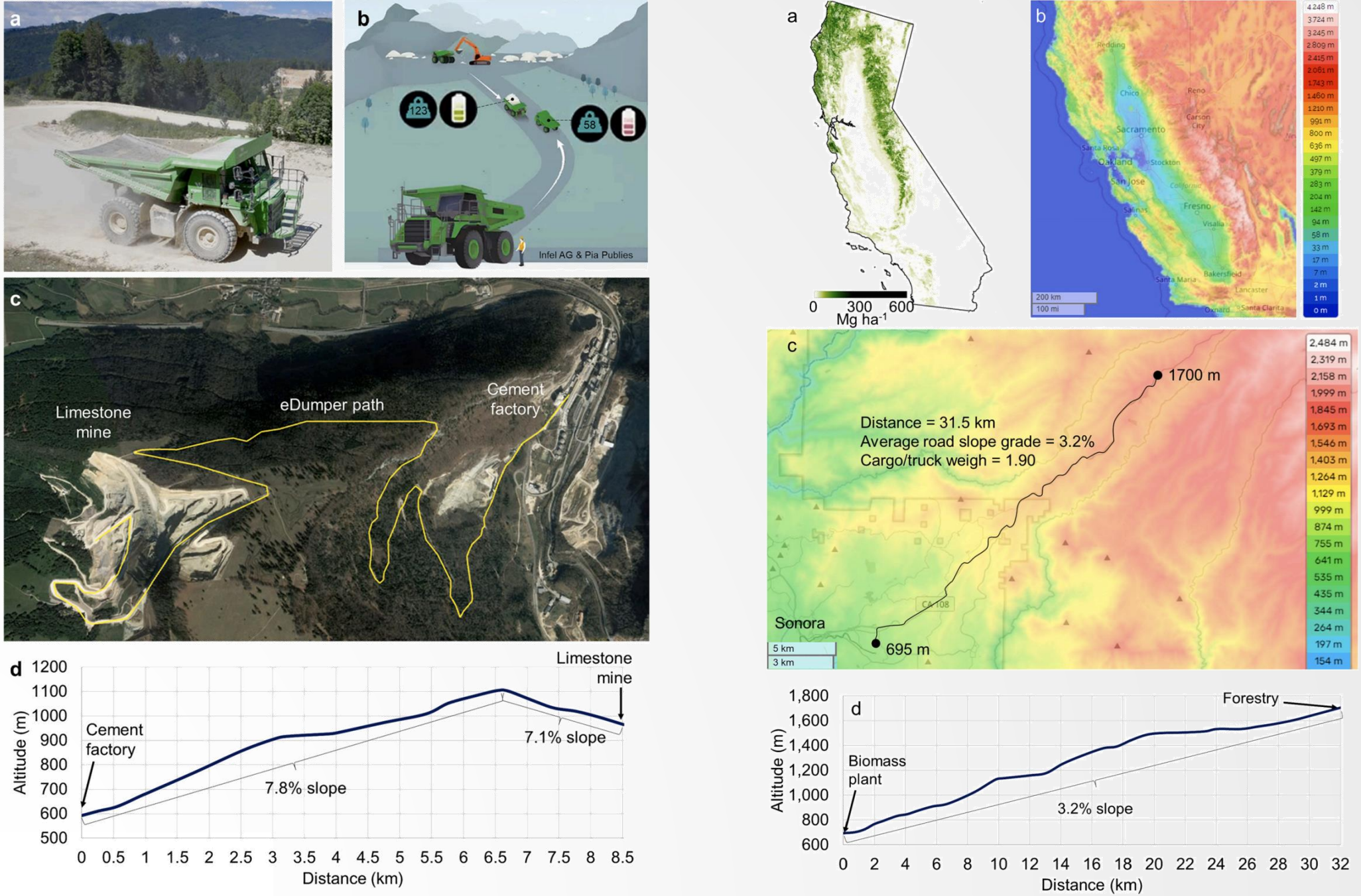

Hunt, J. et. al. Perpetual motion electric truck, transporting cargo with zero fuel costs. Journal of Energy Storage. 2023

Conclusion

- Overall power costs are high and energy storage costs are low.
- Gravity energy storage might not be competitive if used for hourly and daily storage.
- But it might be an interesting alternative for monthly, seasonal, pluriannual energy storage.

Thanks for your attention!

Quesitons?

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