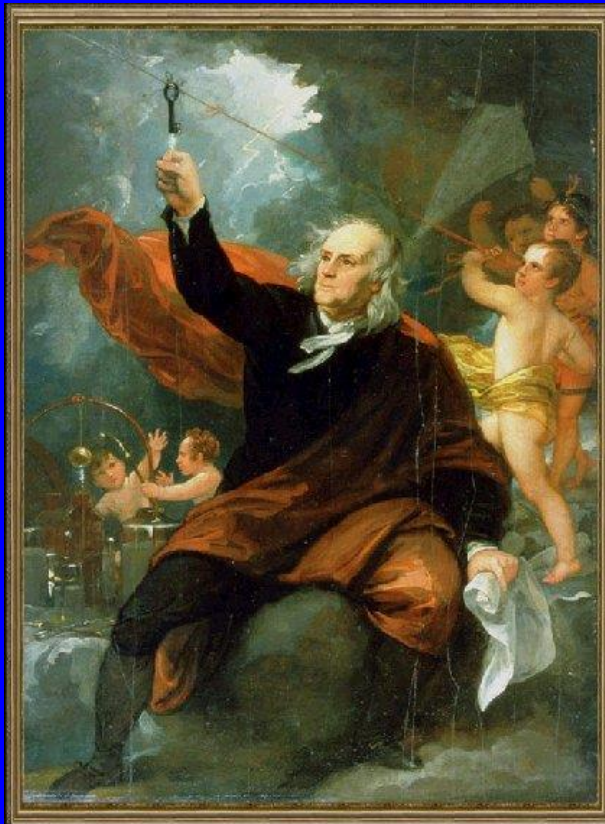


# Towards the Future: Energy Storage Transforming the Grid

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IMRE GYUK, DIRECTOR,  
ENERGY STORAGE RESEARCH, DOE-OE

# Electricity: Stored Lightning!



Ben Franklin:  
Sparks from the Clouds

Ca 1750



The Leyden Jar: The first Capacitor!

# The Battery!

1800

Alessandro Volta's  
Electric Organ

aka

Columnar Apparatus

aka

Voltaic Pile

Silver, Zinc  
and Salt Water



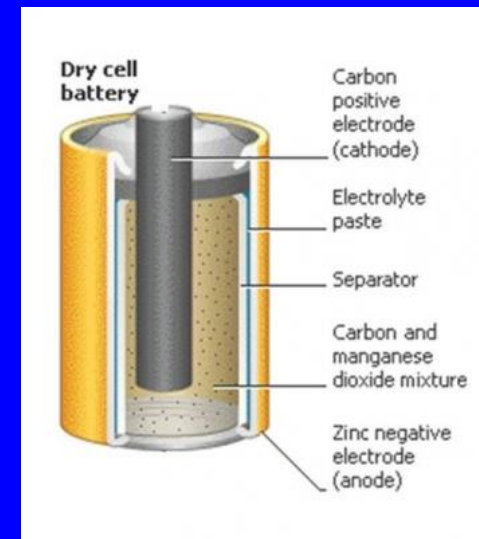
# Reversible Lead / Acid Battery



1859 - Planté

# 1866 Leclanché cell

- Zn-MnO<sub>2</sub> 1.4V
- Ammonium Chloride
- Porous Pot!



During the early nineteenth Century  
the DC Grid was born  
allowing Electricity Transmission  
over large Distances.  
Batteries were relegated to Cars.

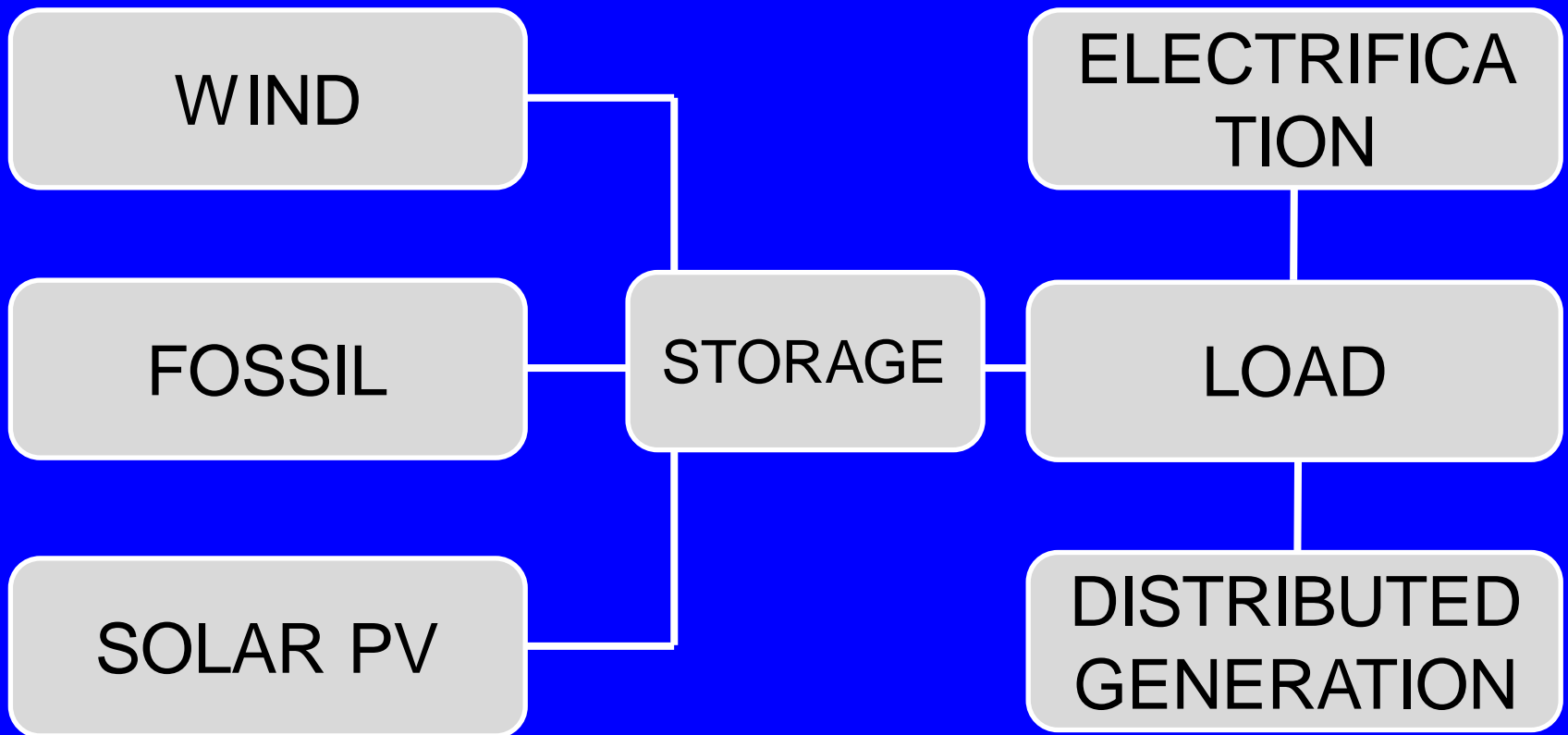
The grid used to be Simple  
and Deterministic!



During the early twentieth Century  
Renewable Generation was born



# The grid has become stochastic!



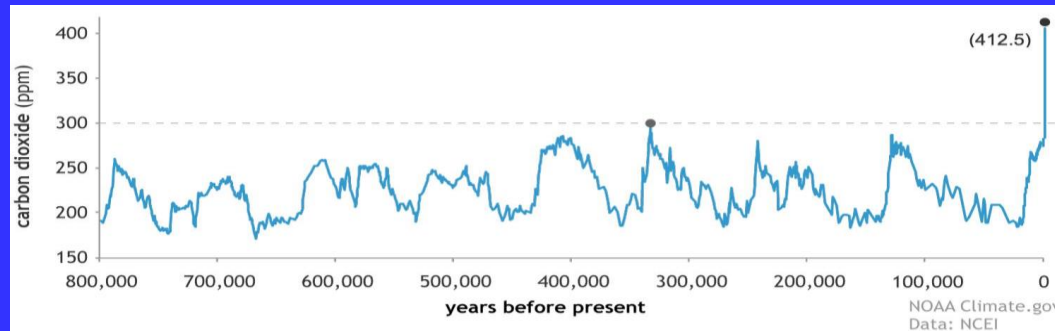
Energy Storage provides Energy

**when** it is needed

just as Transmission provides Energy

**where** it is needed

# Burning Coal, Oil, Natural Gas: for our Electric Grid, Transportation, and Industry



800,000 years Atmospheric Carbon Dioxide

We must Decarbonize,  
We must change  
to Renewable Energy!

And we have to do it  
soon!

Along with Electricity Generation  
all other sectors must also Decarbonize:  
Buildings, Transportation, Agriculture,  
Manufacturing

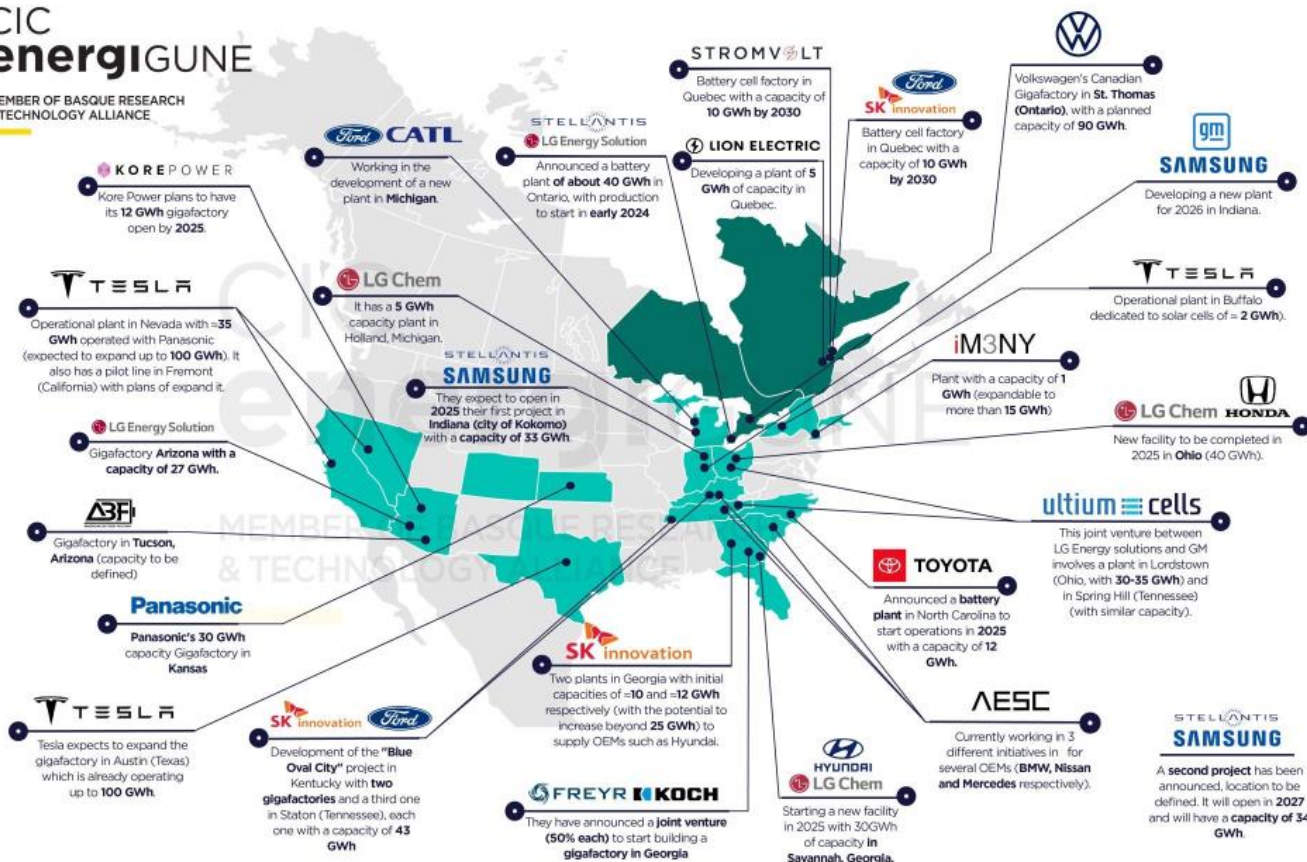
But Renewable Energy is Variable  
particularly on the Diurnal Scale  
and so, Energy Storage  
becomes a Necessity

Energy Storage has finally  
Gained International  
Acceptance!

# NORTH AMERICAN BATTERY INITIATIVES

CIC  
**energigUNE**

MEMBER OF BASQUE RESEARCH  
& TECHNOLOGY ALLIANCE



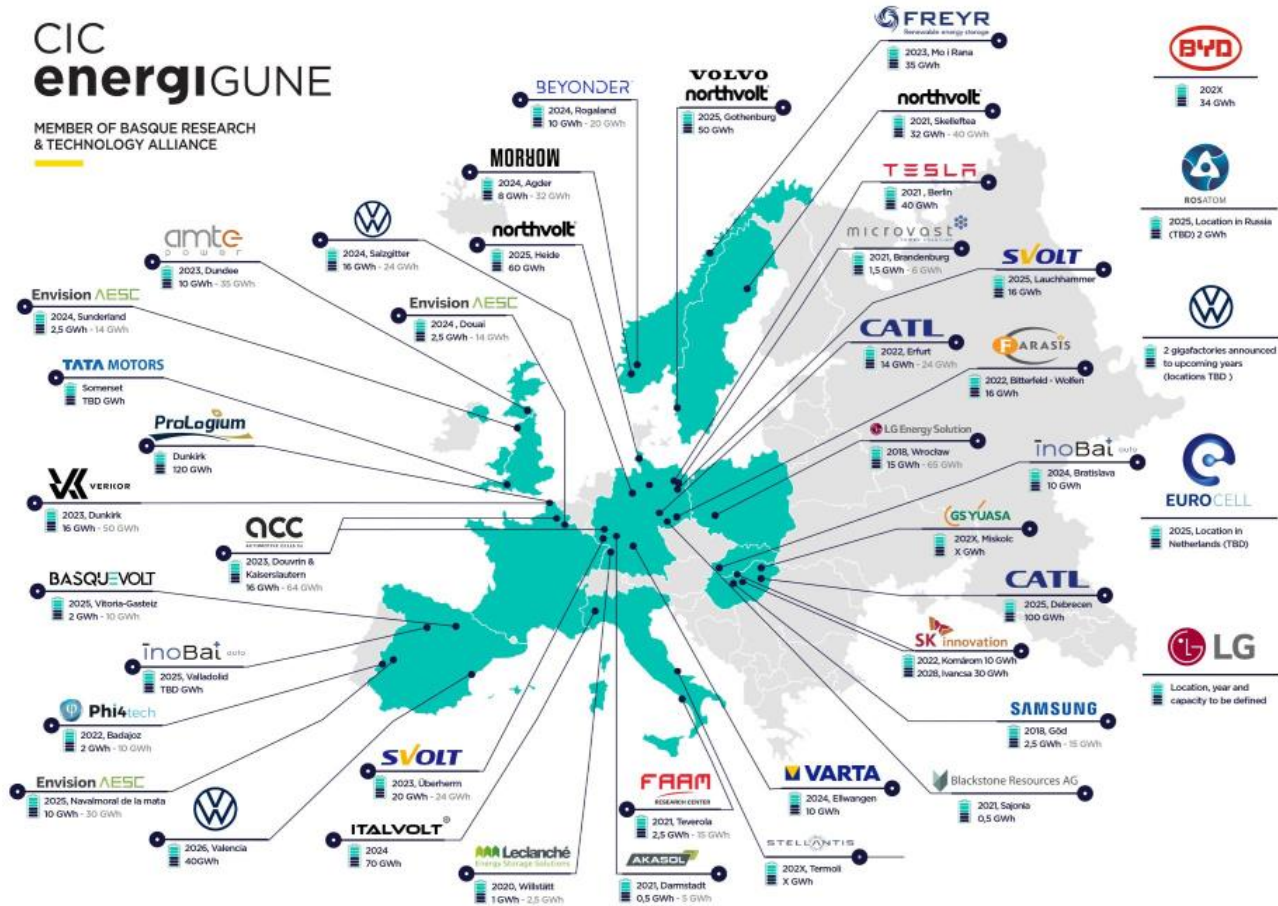


..... also in Europe  
Australia, China, Korea .....

# EUROPEAN GIGAFACTORIES MAP

**CIC energigUNE**

MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

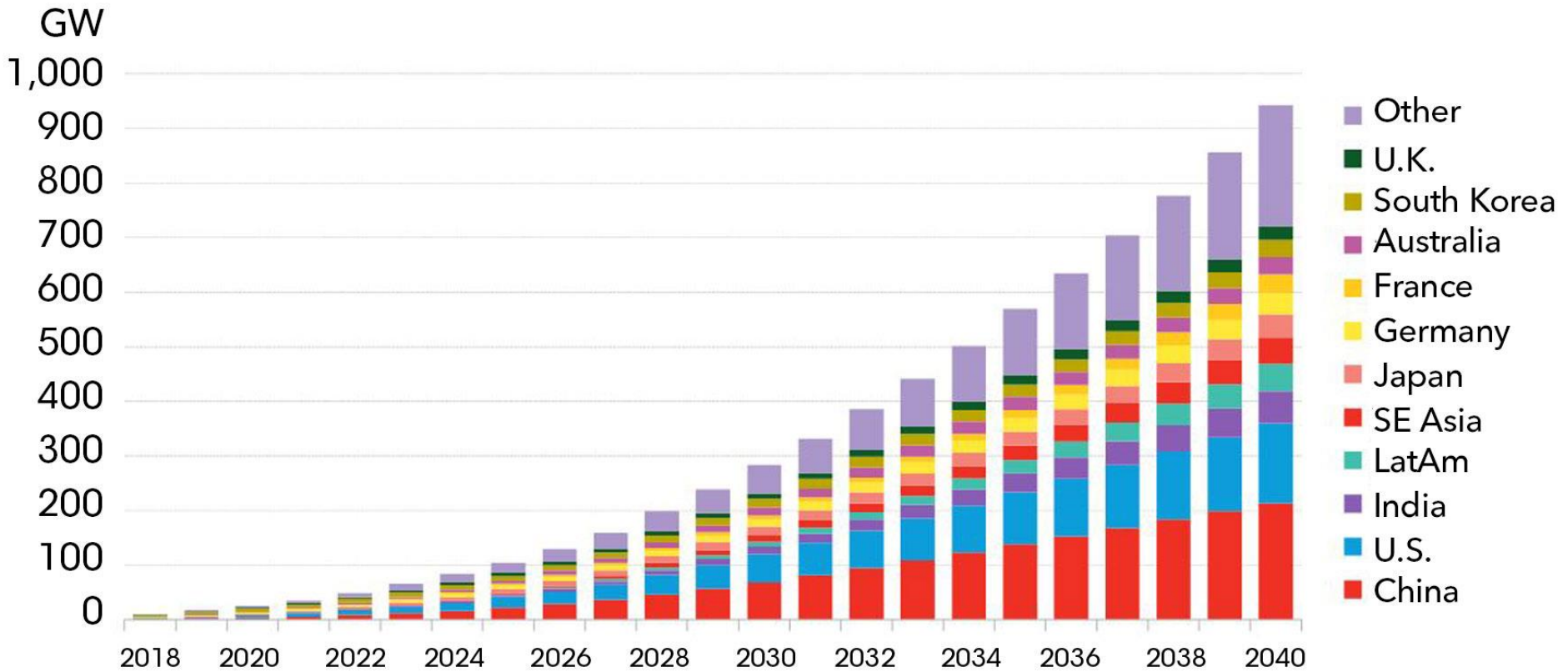


Source: Own elaboration from public information

Version 13. Last update: 09/2023

Cumulative Deployment of Storage  
is continually Increasing  
around the World.

# Global cumulative storage deployments



Source: BloombergNEF

Is there  
a Limit to how much  
Lithium we will need  
and how much  
we can produce?