# The Future of Energy Storage for Stationary Applications.

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# Global Climate Change is Real!

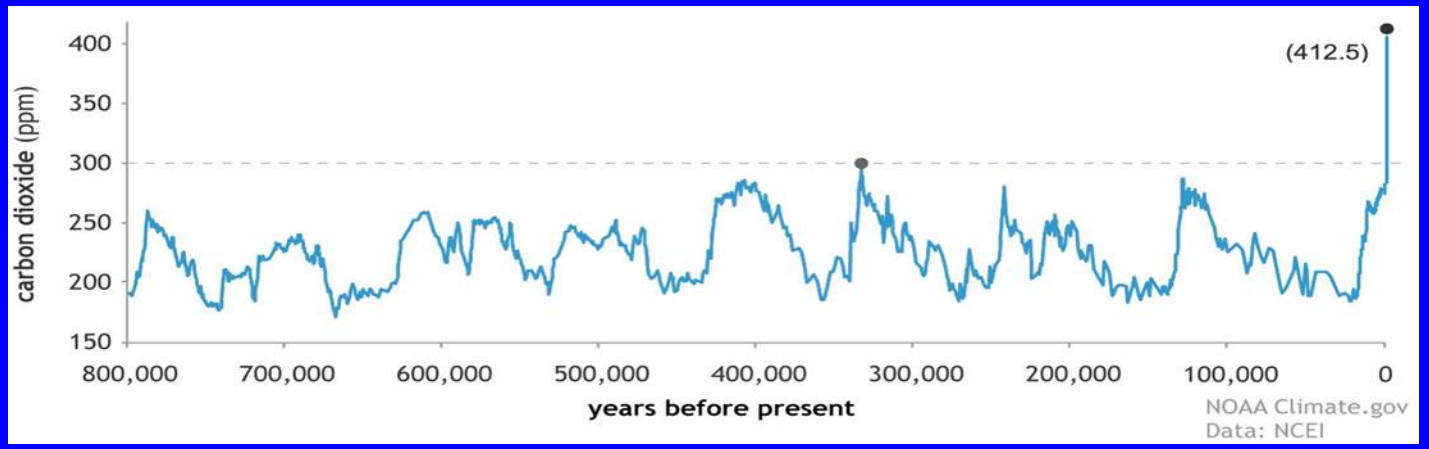
California, +104 deg,
Record Heat, Sep. 2022
4, 000 MW of Storage
Deployed to avert Outages

Florida
Hurricane Ian, Sep. 2022
Damage: $65 Billion
2.3 Million without Power

Floods and Droughts,
but also
Sea Level Rise, Coastal Erosion,
Reduced Crop Yield, Wild Fires,
and Health Impacts

Global Warming has Emerged
as a Paramount Issue - World Wide!

# Burning Coal. Oil, Natural Gas: for our Electric Grid, Transportation, and Industry has increased CO2 to twice the Highest Levels In 800,000 Years!

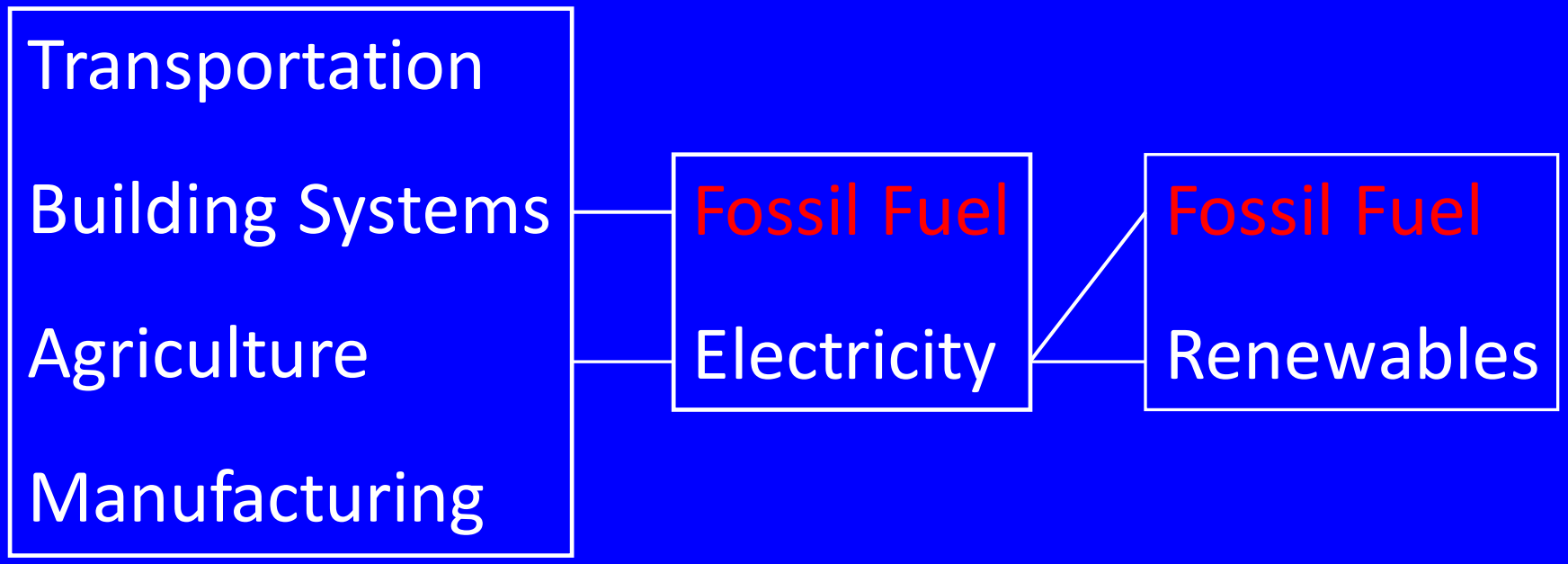



800,000 years Atmospheric Carbon Dioxide

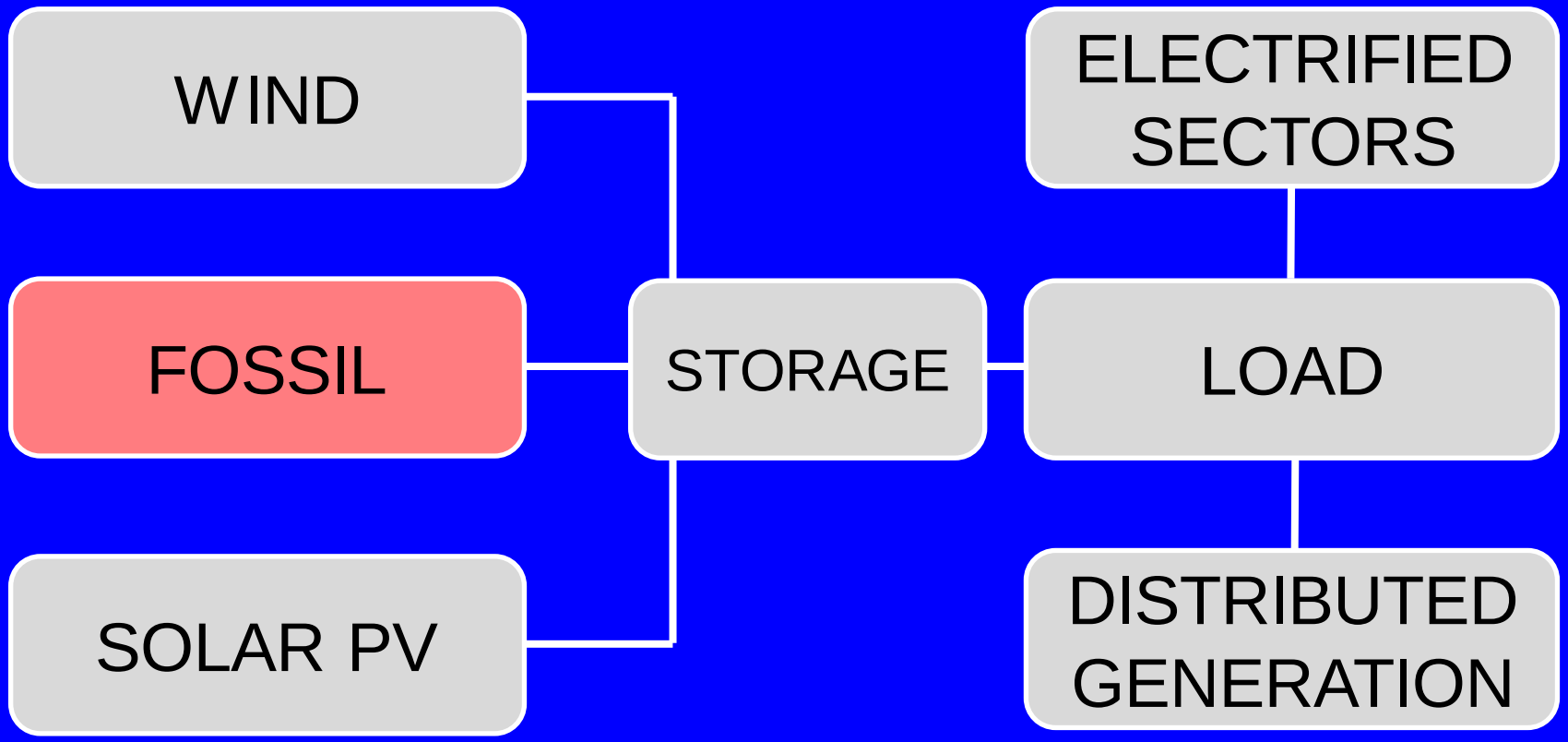
We must Decarbonize,
we must change
to Renewable Energy!

And we have to do it soon!

# Sector Coupling!



# Generation has become Variable - and so has the Load!




Storage is needed for reliable Resource Adequacy

Renewable Energy
requires
Energy Storage

# Storage of Various Durations will be Needed: Short, Medium, and Long

15 min – 4 hrs: smoothing renewables. Li-ion

4 – 12 hrs: day/night PV storage. Flow Batteries

12h – 3 days: bad weather backup. Thermal/Gravity

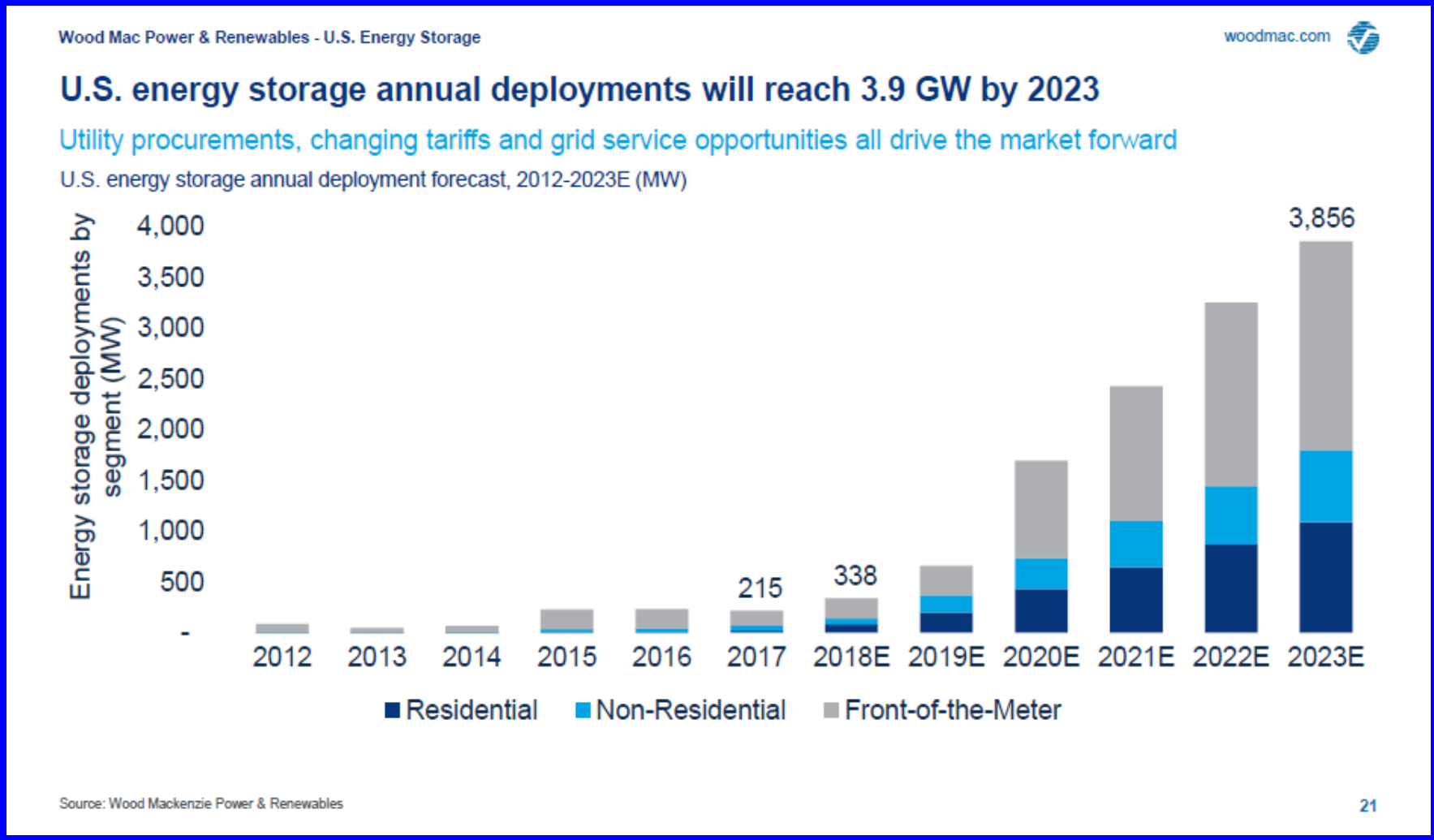
## We will need some1200-2300 GWh of Energy Storage!

We have done well with Short Duration Energy Storage and Li-ion Technology

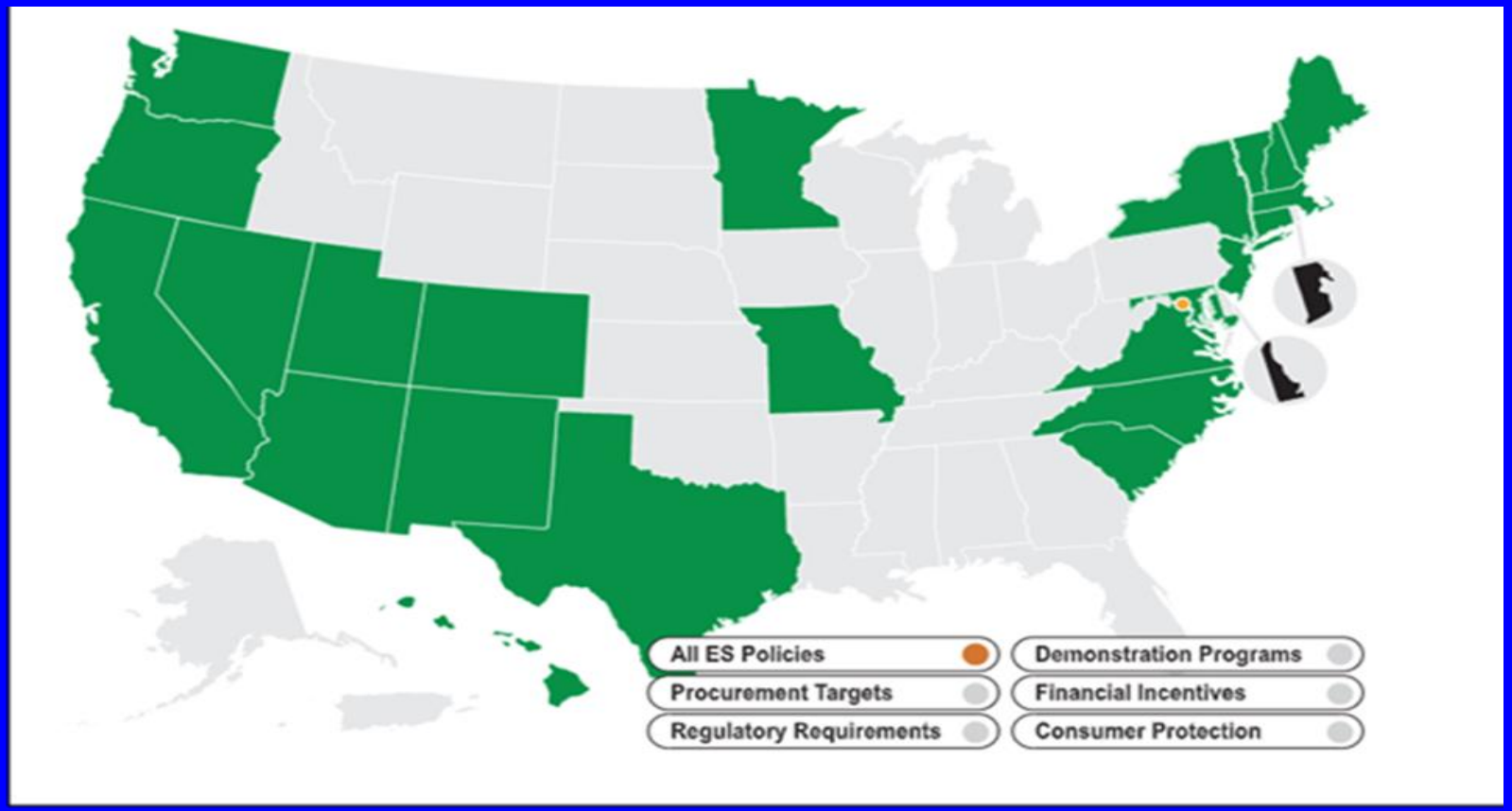
Frequency Regulation
Smoothing Renewables
Demand Charge Reduction
Substation Upgrade Deferral

We have created Evaluation and Planning Tools (e.g. Quest), Developed viable Business Models

# Energy Storage has become a Resounding Success!



# Many States have established Regulatory Structure but many have not!




*https://energystorage.pnnl.gov/regulatoryactivities.asp*

From ES Policy Data Base

# Incumbent Lithium Ion Technology:

Sourcing, Ecological, and Sociological Issues

Safety, Reliability,

Re-Use, Recycling, Disposal


# A Future Dichotomy:

## Transportation (EVs etc.)

Requires high Energy Density Batteries
and there is nothing available except Li-ion

## Stationary Applications

Can afford lower Energy Density
and accept higher Foot-print

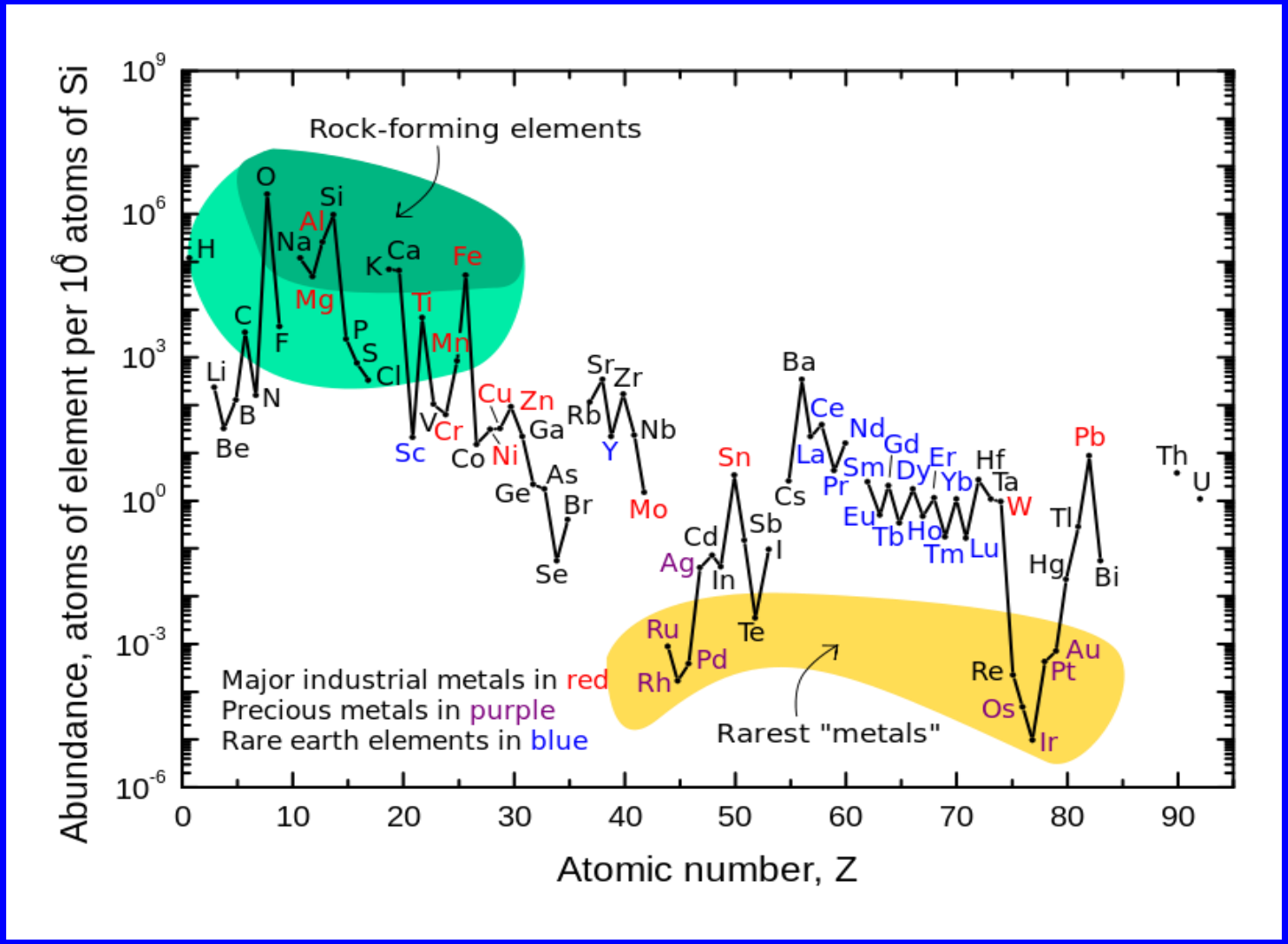
## Lithium Resources

are Geographically Limited

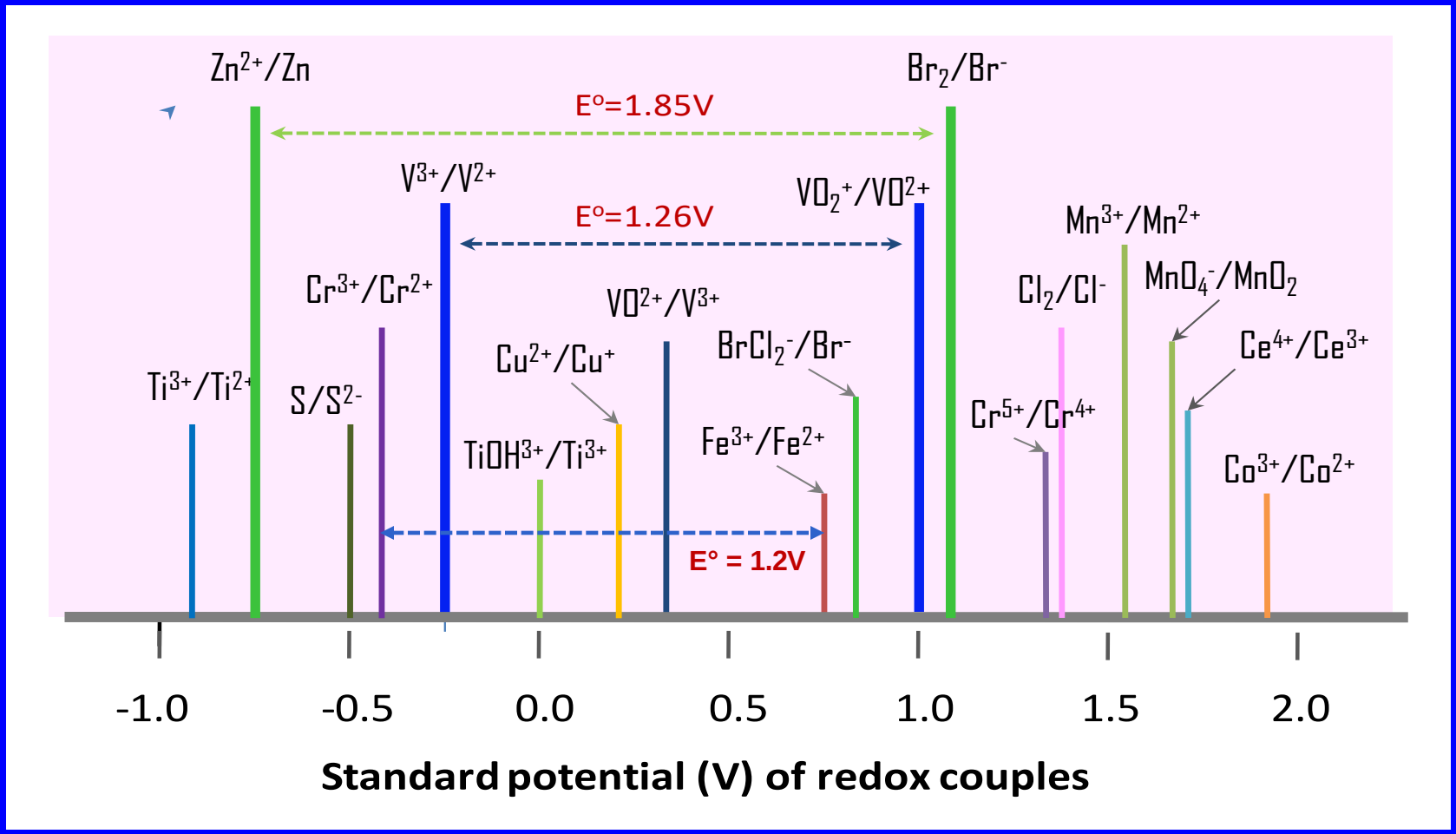
In Competition for Lithium,
Stationary Applications will lose
because Transportation must have Lithium,
while Stationary Applications must have low price

Thus, Transportation will continue to use Lithium,
while Stationary Applications will have to
look for other  Storage Technologies

I would expect Li to continue
as the dominant storage technology
for the next Decade.
However, for Stationary Applications,
other technologies
will slowly come to the forefront!
Zinc is eminently suited
to accept this role!




Earth-abundant Materials! Na, S, Fe, Zn, organics




We want high Potential !

# ZnBr
# $ZnMnO_2$
# Zn-Air

RedFlow 2MWh ZnBr Installation
Dec. 2021, California

UEP 3kW $ZnMnO_2$ Installation in Navajo Nation

# Medium Duration Storage

4 – 12 hours

Will bring the next Wave
Of Batteries including
Flow Batteries, Zn, Fe, Na-ion

To achieve real Sustainability
we would Ultimately like
to have a Circular Technology
Based on
Earth Abundant and Inexpensive
Materials!

Supply Chain and Waste Stream
Must be part of the design!

# Long Duration Storage

12h – 3 days …

Mechanical, Gravity,
Thermal (Sensible Heat, Phase Change),
Chemical Energy Storage ($H_2$, $NH_3$)

Long Duration Energy Storage

is essential for the Development

of a Decarbonized, Reliable Grid

but it will require

New Technology, New Business Cases

and New Regulatory Frameworks!

And a lot of Funding
for Research, Development,
and Deployment!!

# Current CEC Long Duration Projects – Grants Awarded

| MW/MWh | Technology | Vendor | Expected Completion |
|---|---|---|---|
| 400kW / 10hr X2 | Vanadium Redox Flow Battery | Invinity Energy Systems | 2023, 2024 |
| 400kW / 10hr X2 | Zinc Hybrid Cathode Battery | EOS | 2023, 2024 |
| 10kW / 100hr X2 | Iron Air | Form Energy | 2023 |
| 10kW / 100hr X2 | Zinc Air | E-Zinc | 2023 |
| 10kW / 100hr | Thermal Storage | Antora Energy | 2024 |

DOE /Sandia Support for CEC Projects through joint MOU

As decarbonization proceeds
we will have to turn to new
Non-lithium storage media such as Zinc
for stationary applications.
However, development of many alternative
Types of storage and of their supply chains
is essential !