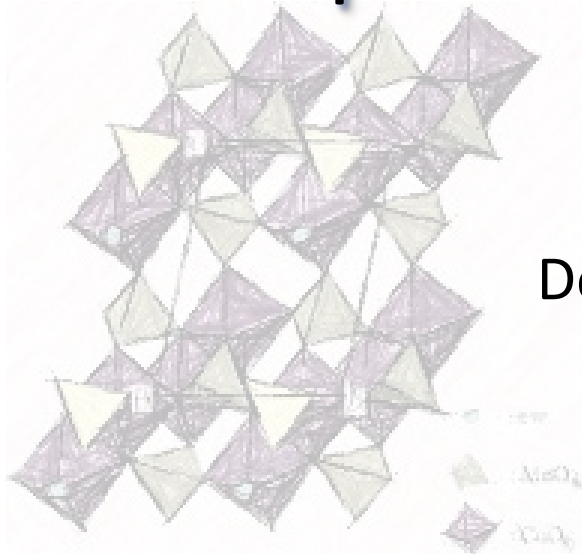
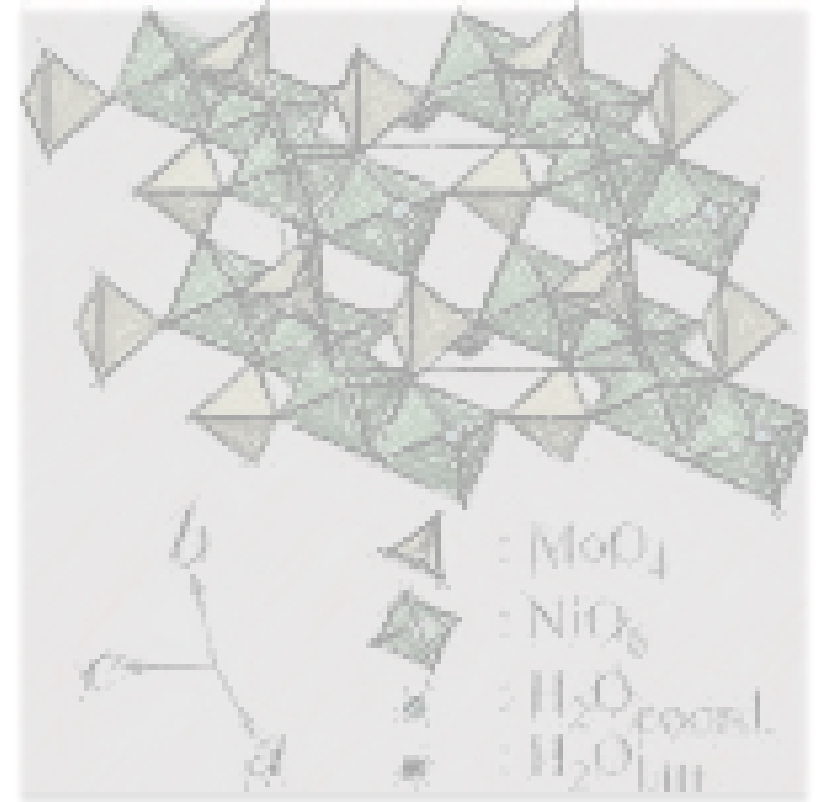


Synthesis of Nano-Structured Transition Metal Oxides and Sulfides for Overall Water Splitting and Supercapacitors



Authors: Kelsey Thompson and Ram Gupta

Department of Chemistry & Kansans Polymer Research
Center, Pittsburg State University

Presented By: Kelsey Thompson

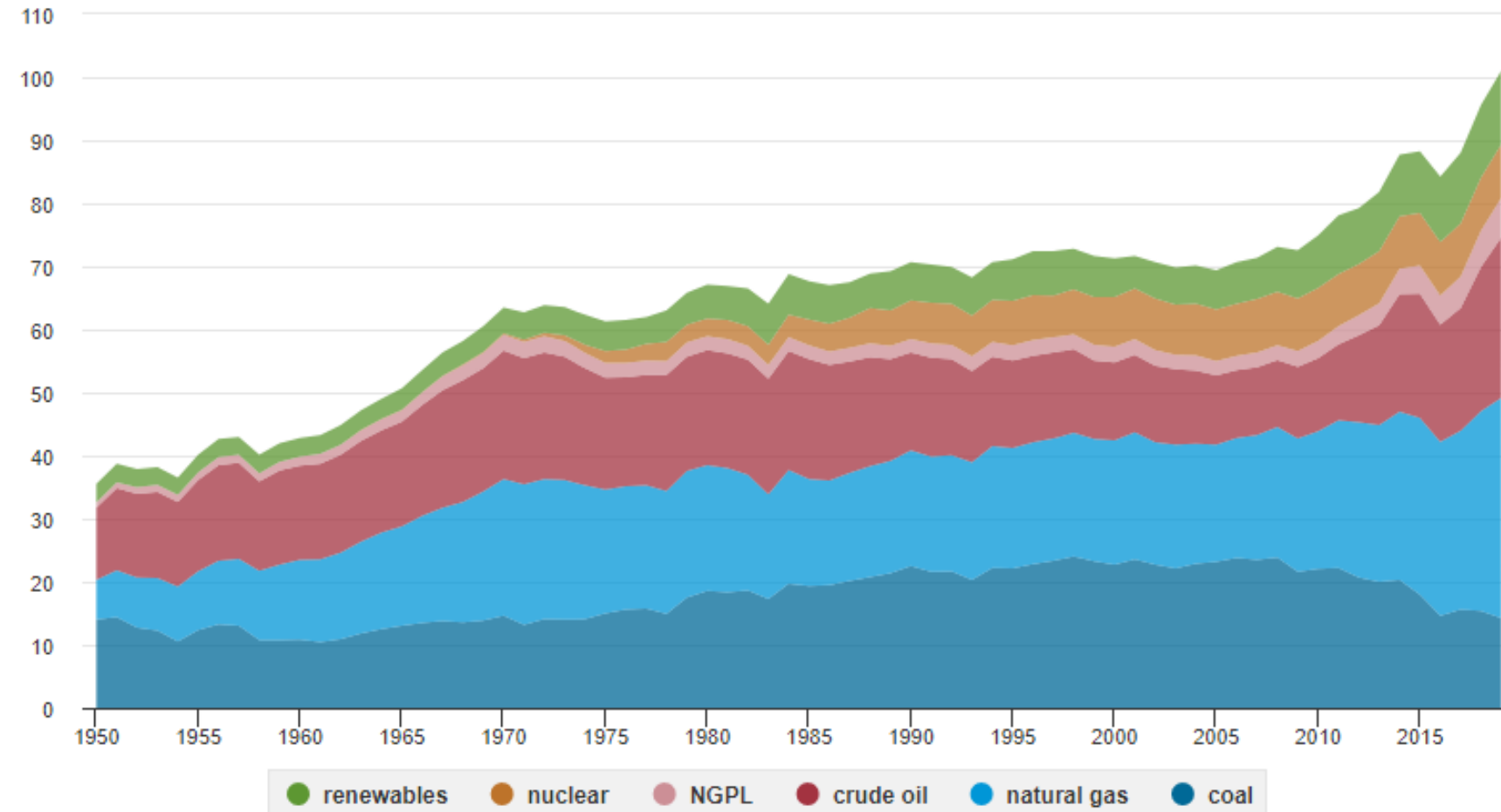


Growing Energy Needs

- Energy production is increasing.
- Renewables % not increasing with production.
- Polar vortex of Feb 2021 shows more versatility in storage is needed.

U.S. primary energy production by major sources, 1950-2019

quadrillion British thermal units



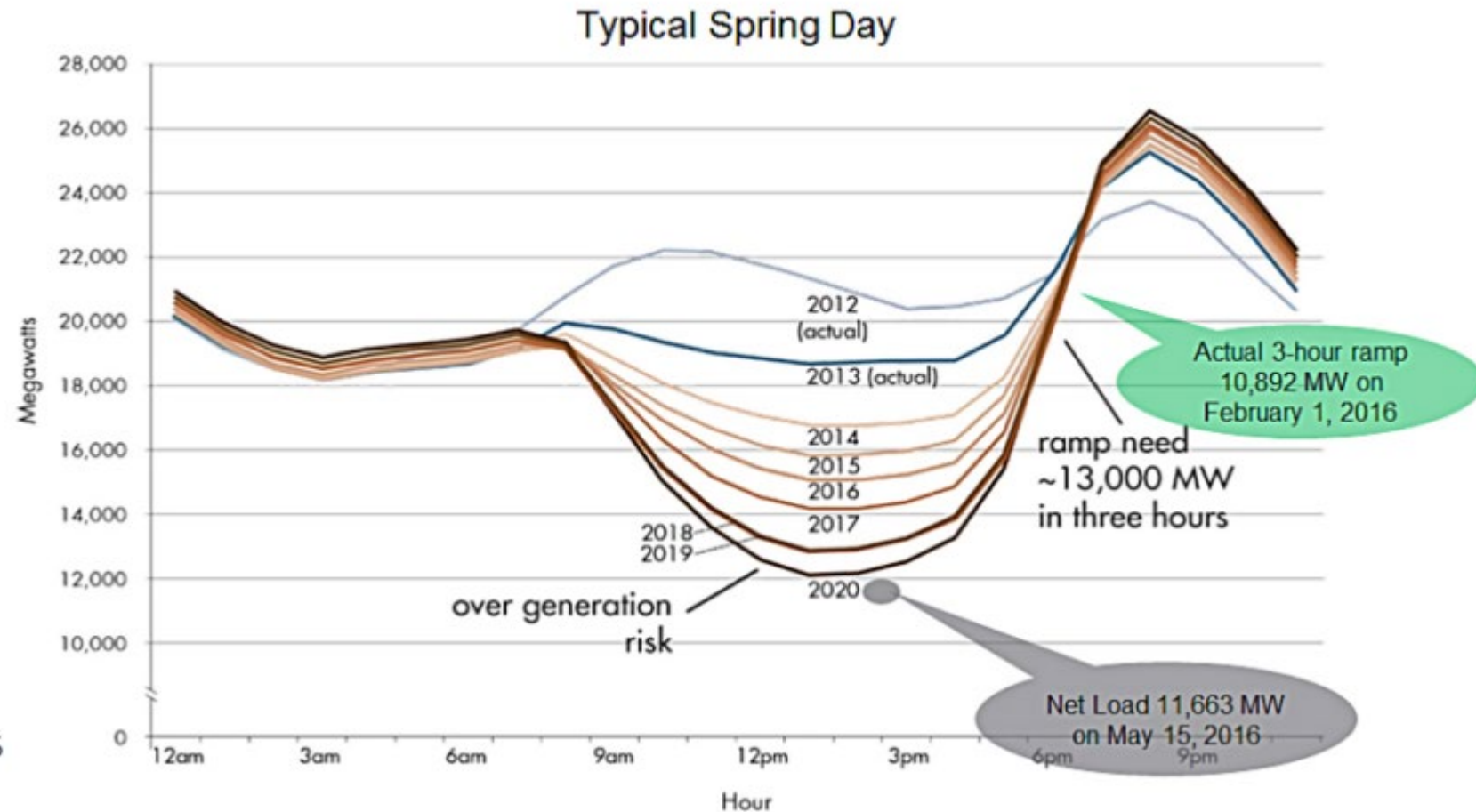
Note: NGPL is natural gas plant liquids.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.2, April 2020, preliminary data for 2019

The Problem with Renewables

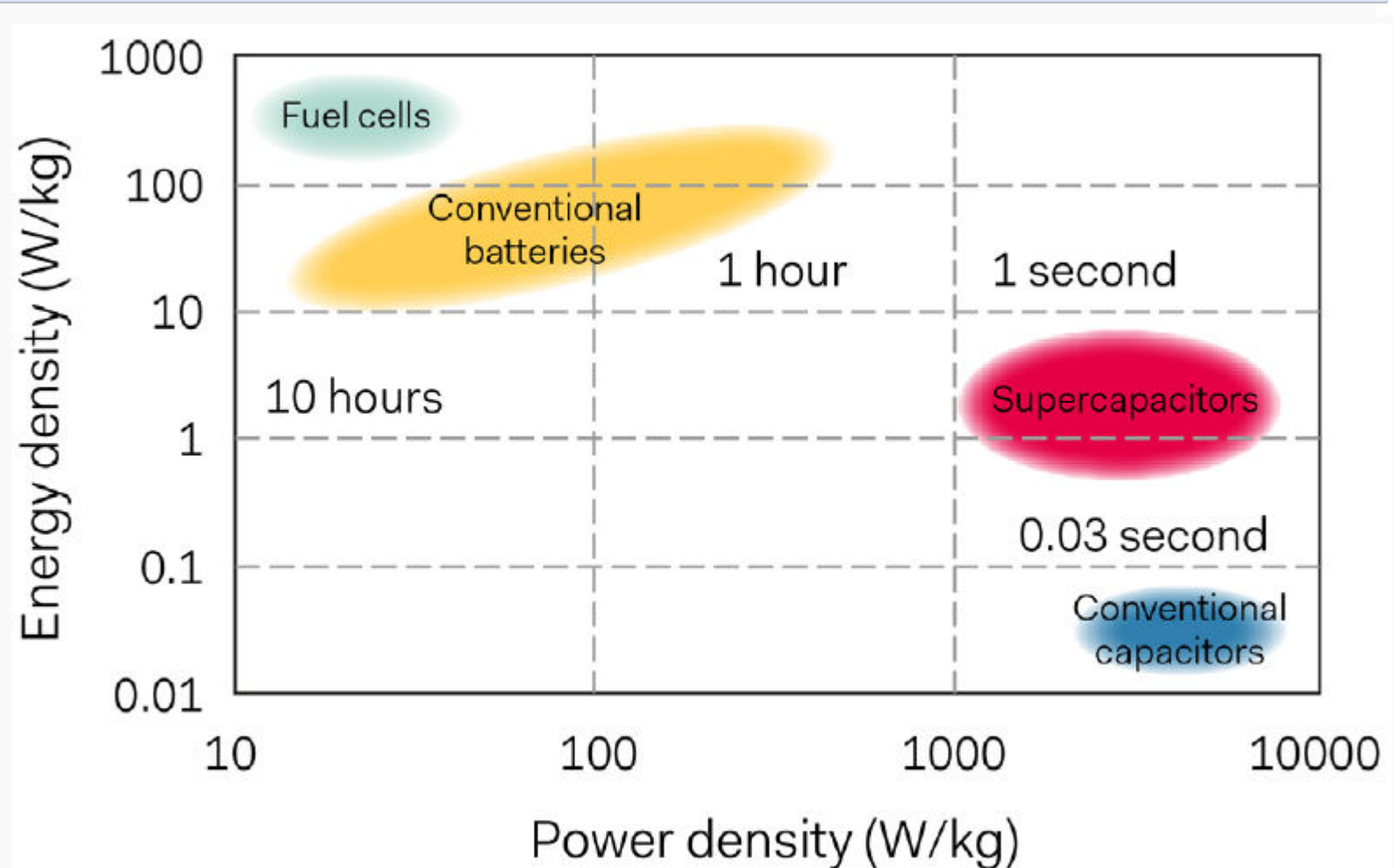
- Peak demand is not peak generation time.
- More storage options are needed.
- Ways to supply the grid quickly are needed.

Reverse Demand Response?



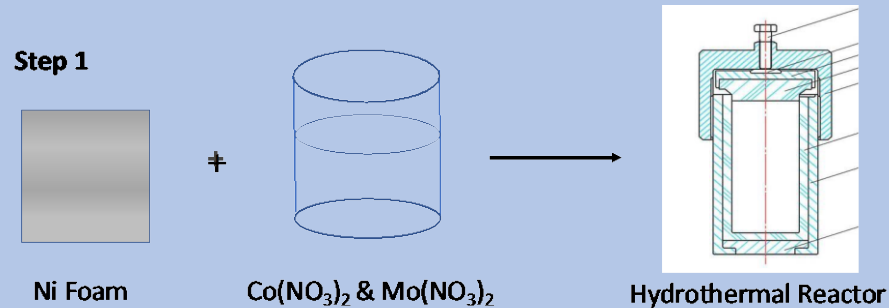
Meeting the Need

- Supercapacitors' high power density allows for rapid discharge of energy into the grid.
- Some supercapacitor materials double as fuel cell electrodes for hydrogen generation.

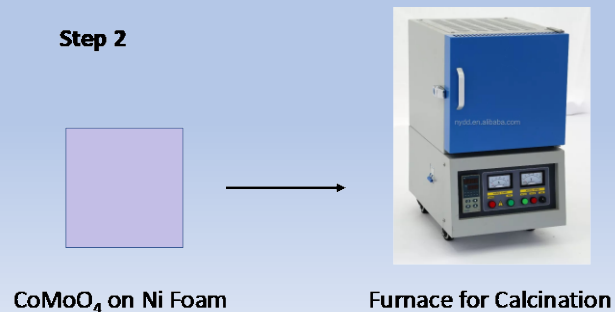


Synthesis of Electrodes

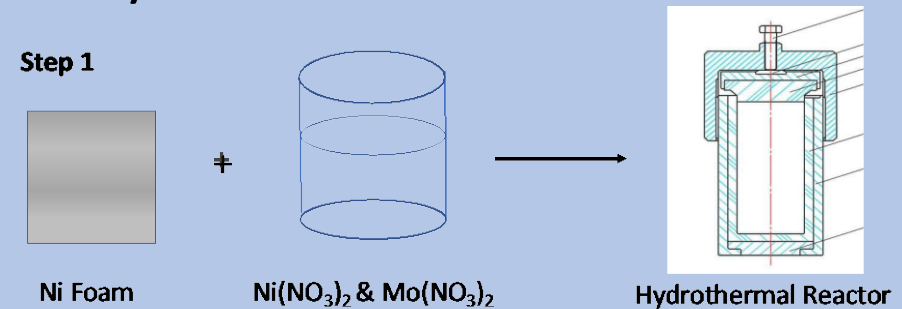
- Oxide electrodes
 - Hydrothermal Reaction



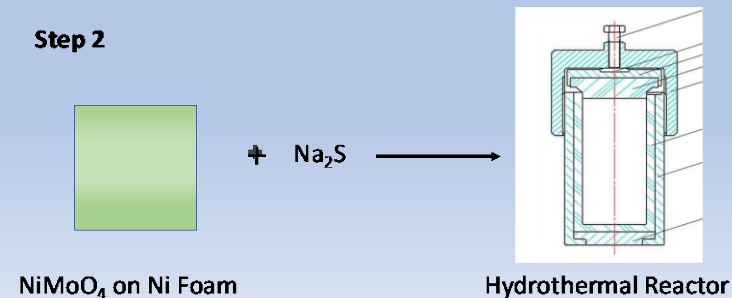
- Calcination in furnace



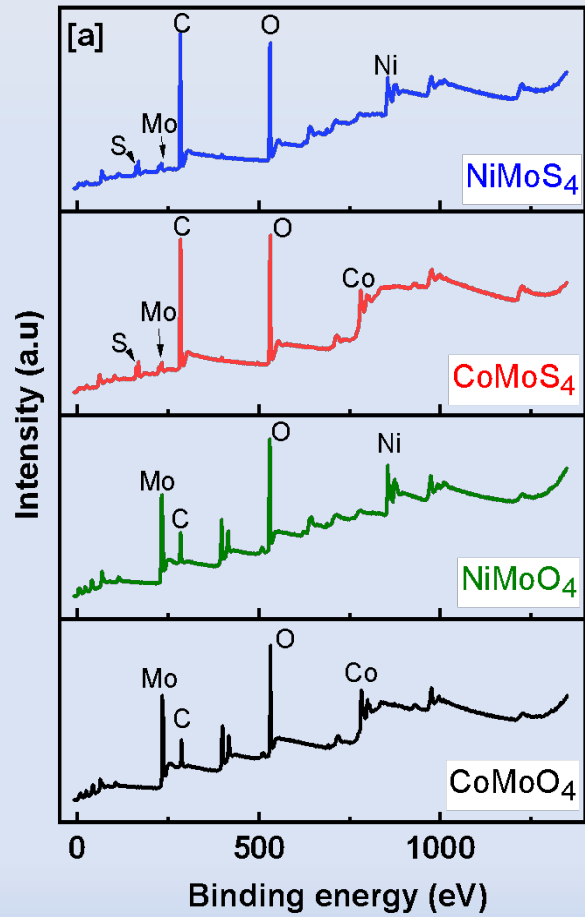
- Sulfide electrodes
 - Hydrothermal Reaction



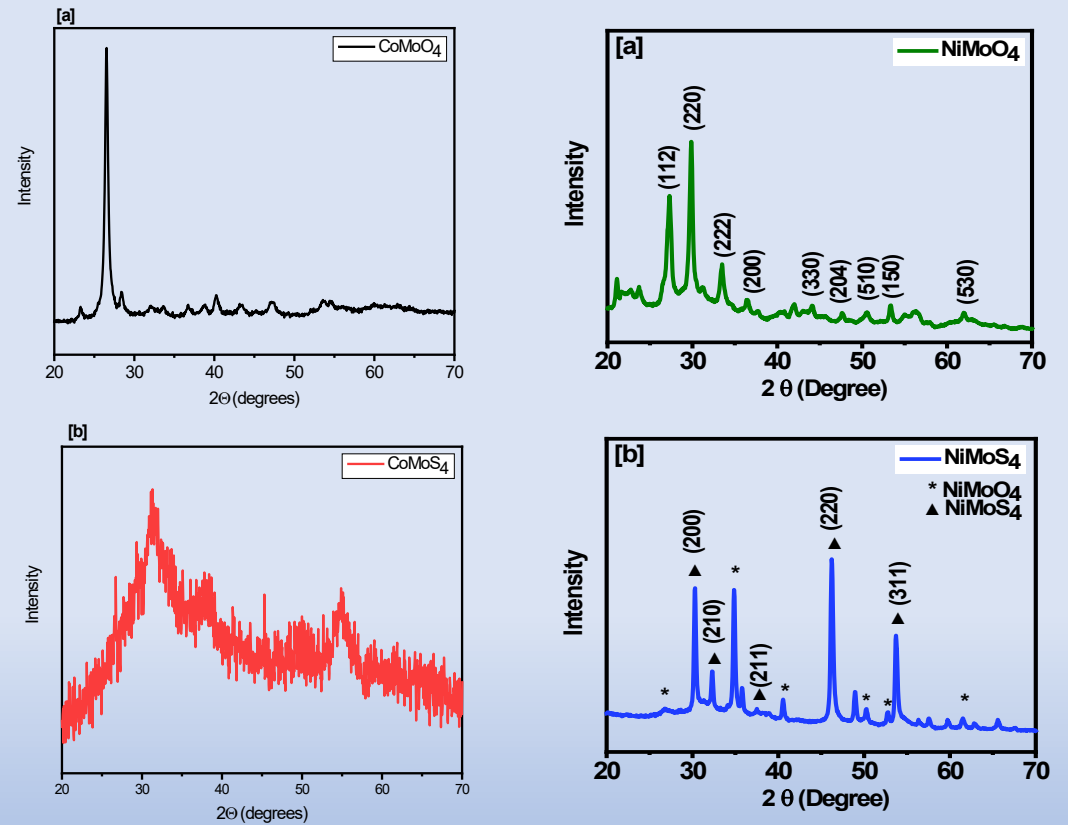
- Solvothermal Reaction



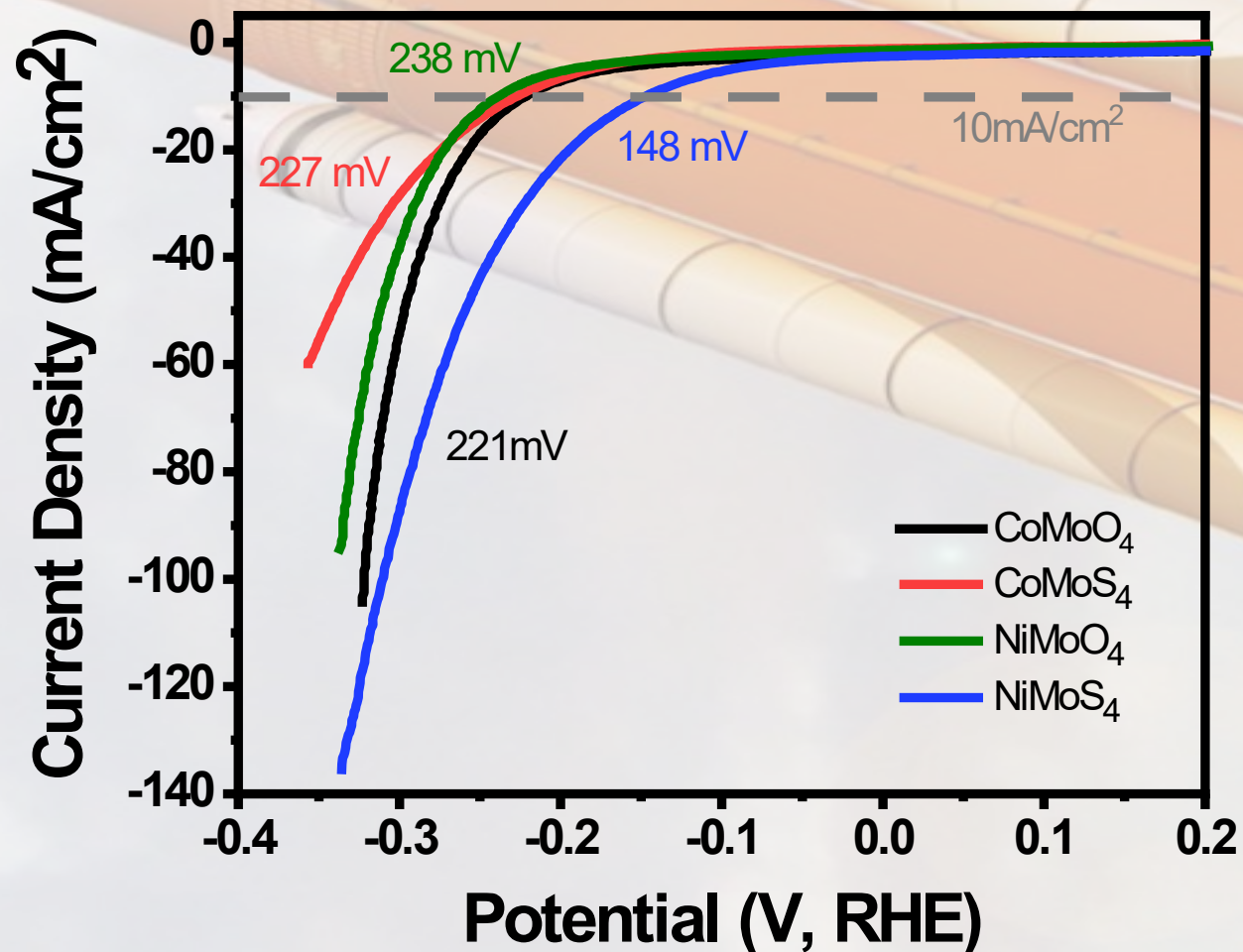
XPS Data



XRD Data

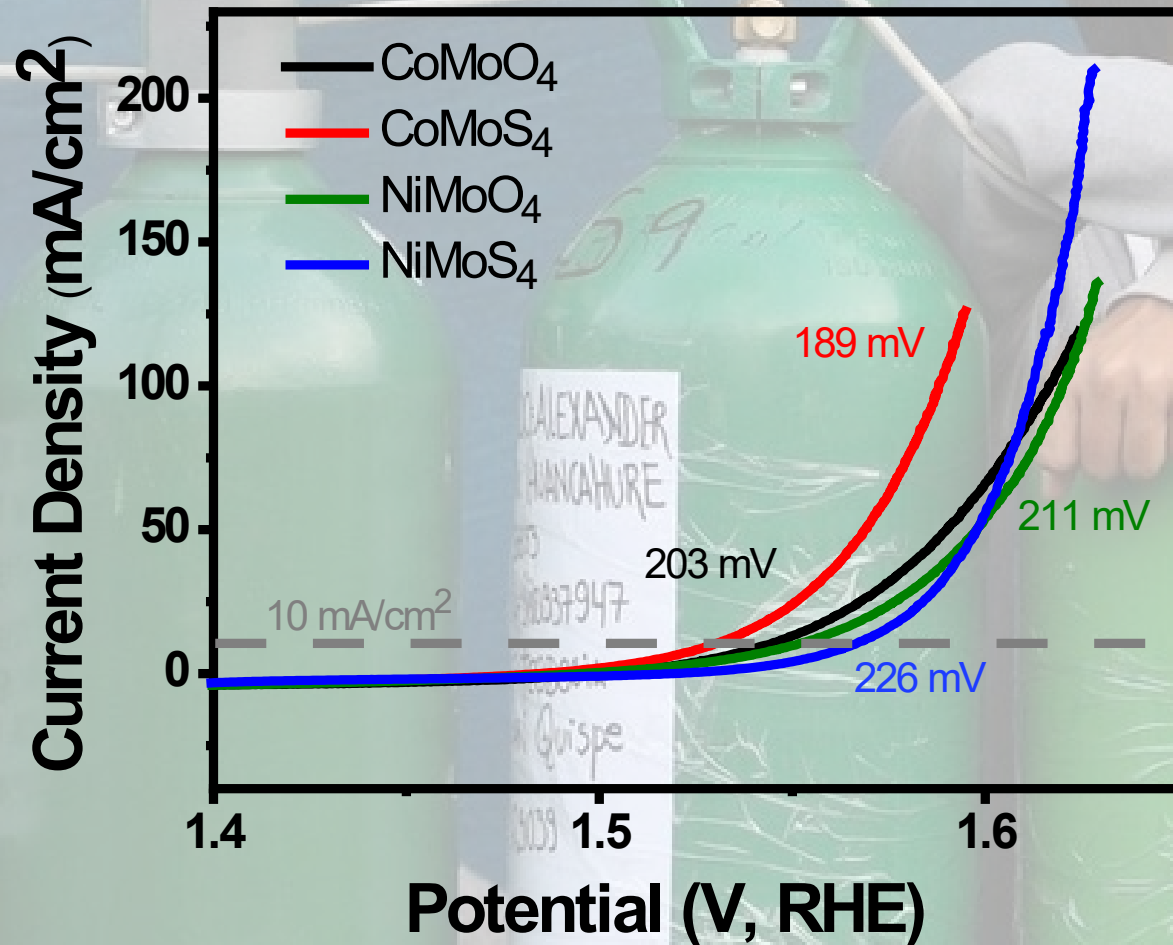


Hydrogen Evolution Reaction



- $2H_2O + 2e^- \rightarrow 2OH^- + H_2$
 - Theoretical Potential = 0 V.
 - Pt electrodes are the commercial standard.
- NiMoS₄ best result for HER
 - 148 mV @ 10 mA/cm²
- Other reported values fr/ 308 to 141 mV.^{1,2}

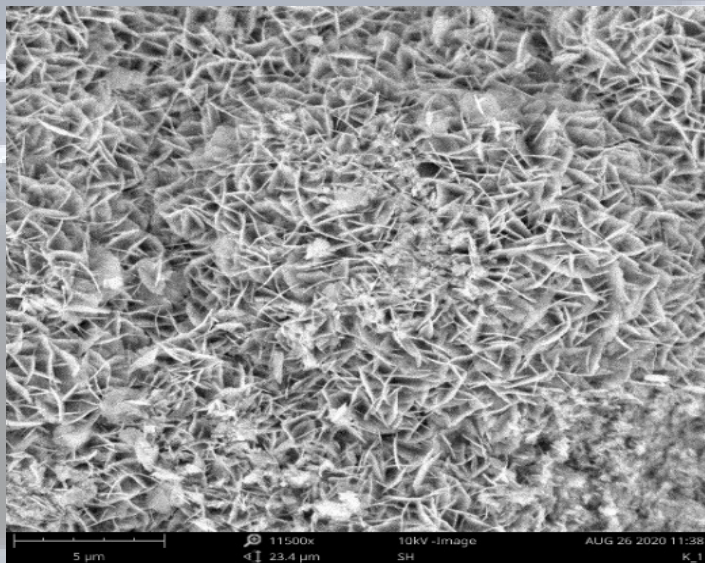
Oxygen Evolution Reaction



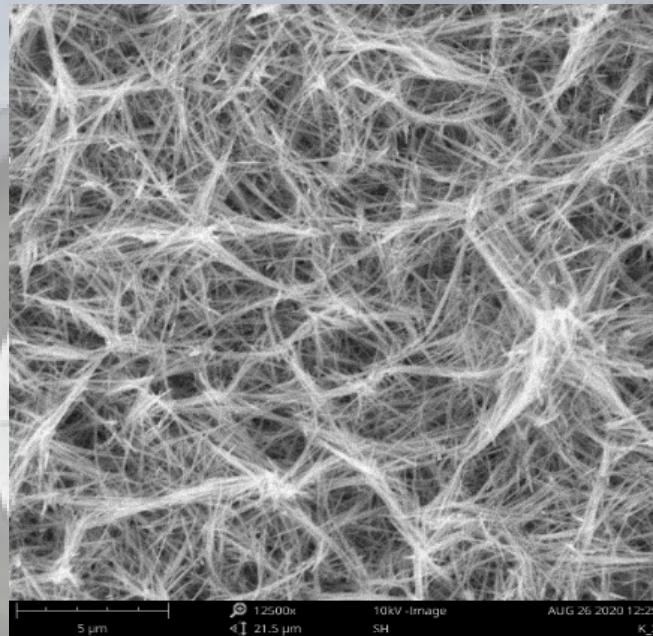
- $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$
- Theoretical Potential = 1.23 V
- Ru and Ir electrodes are the commercial standards.
- CoMoS₄ best result for OER.
 - 189 mV @ 10 mA/cm²
- Other results run fr/ 379 to 136 mV.^{1,3}

Specific Capacitance of Devices

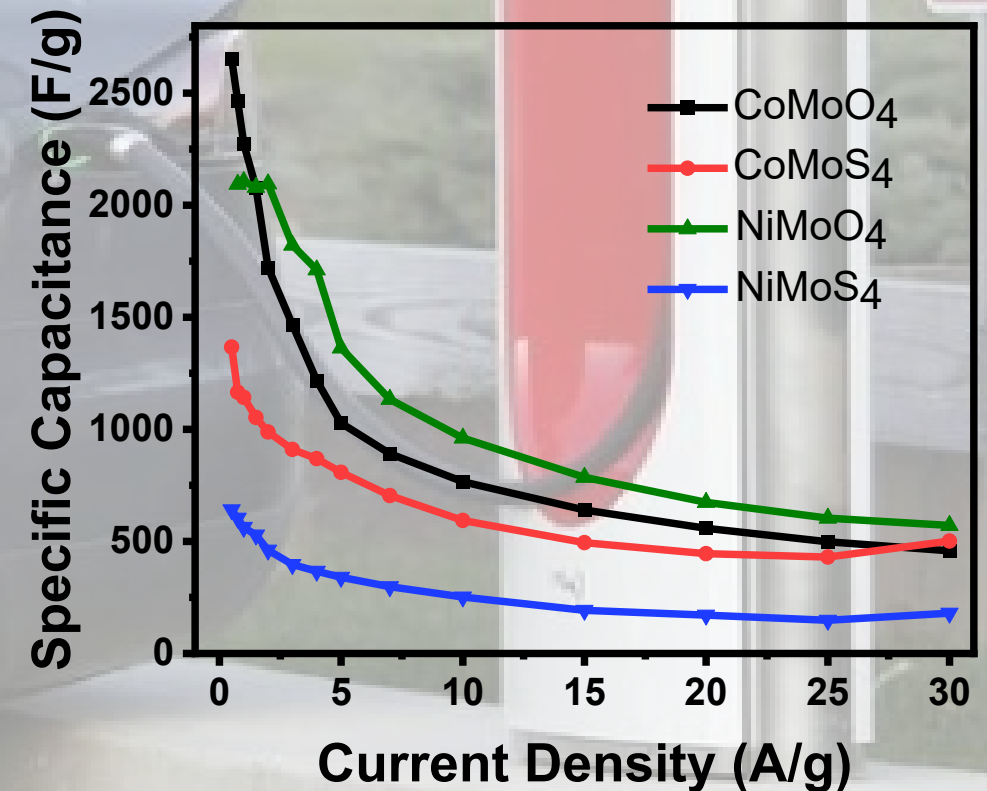
- Oxide samples had more surface area for better charging at low current density.



← CoMoO_4

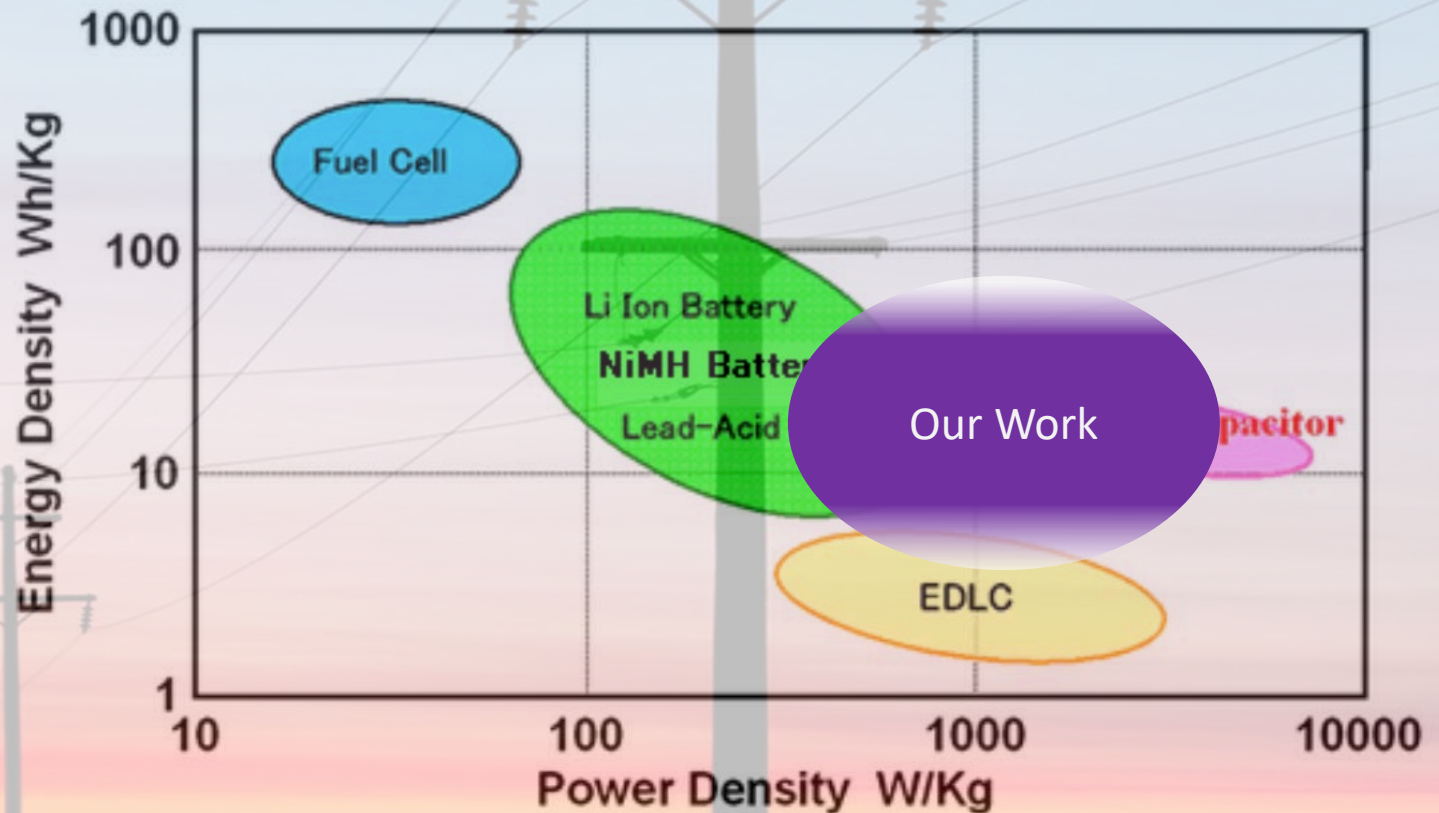
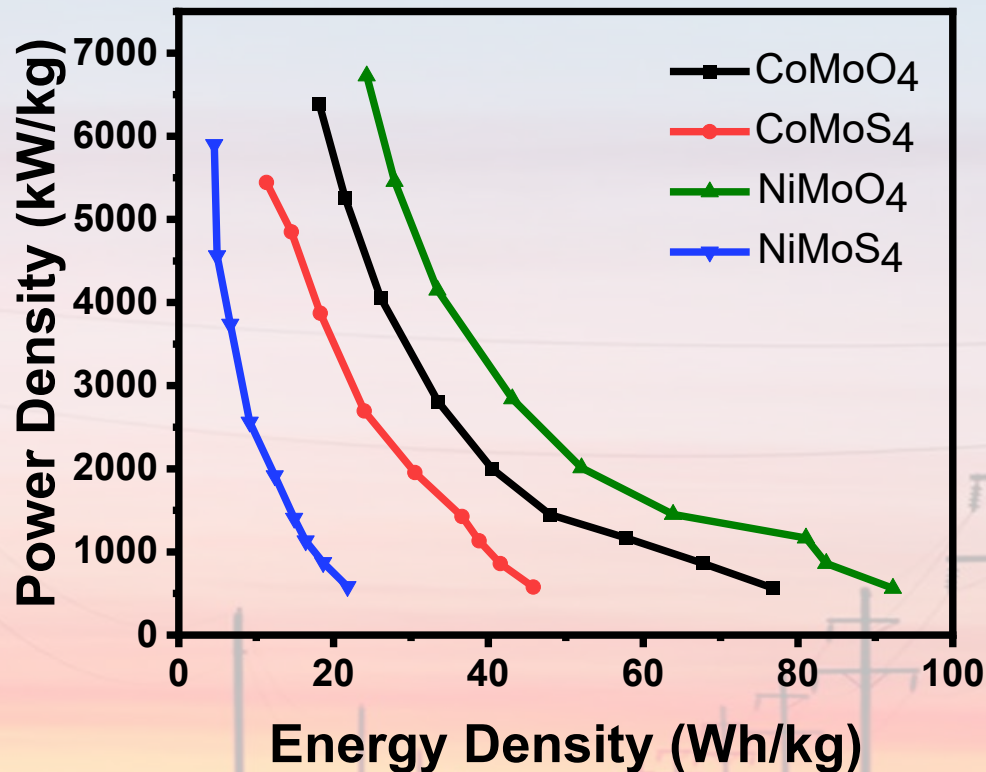


→ NiMoO_4



As Energy Storage Device

- Energy density comparable to some batteries.
- Power density comparable to currently capacitors.



Acknowledgements

- Thank you to the audience and judges.
- Kansas Polymer Research Center based in the Tyler Research Center for the use of its resources.
- Wang Lin for assistance in synthesizing electrodes and electrochemical testing.
- Special thanks to Dr. Ram Gupta for insight and guidance during the project.

