

# Benefits

- Identify metrics
  - Energy, capacity, ancillary services, resilience, sustainability, affordability, security
  - Value of dispatchable power
- Replacement for LCOE
- Quantify synergies
  - Why not a single winner or simpler option
  - How compelling is the solution / for whom
- Profitability
  - Impacts of a grid with high penetrations of zero-marginal-cost generation
- Revenue risk
  - Low marginal costs
  - Under uncertainty & variable conditions
- Tradeoffs – Multivariate optimization

## Benefits

- Identify Metrics
- Quantity Synergies
  - (Why not a single <sup>winner or</sup> simplest)
  - How compelling is our solution <sup>for whom</sup>
- More than LCOE
  - Need a replacement
- Profitability
- Revenue Risk
  - Low Marginal Costs
  - Under Uncertain Variable Conditions
- Tradeoffs
  - Value of Dispatch...

# Environment / Economic / Policy

- Services provided
  - Inventory & Implications for product
- Other key metrics: water, security,
- Identification of scenarios (e.g., H2@Scale)
- Transition strategy
- Regional variability
  - modeling and solutions
  - Policies, their implications & recommend new
  - Market structures
  - Resource availability
  - Industrial locations (and types of industry)
- Long-term markets & models with uncertainty
  - Internalize reliability and ability to support ramping requirements
  - Both nuclear & renewables have high up-front costs and low operating costs. How can markets support these types of systems?
- Contract opportunities and needs
  - How might long-term contracts support new generation resources
  - How might long-term environmental benefits be incorporated
- Life Cycle Assessment – full end-to-end including materials

# Environmental Economic Policy

Water Analysis

Security Analysis

Service Inventory

- Implications for Policy

Regional Modeling & Solutions

Understand implications of regional pol.

- Recommend New

Long term Markets

- Models w/ Uncertainty

Contact opportunities

- w/ Env banks

# Grid

- Electricity market design
  - If the secondary products are more valuable than electricity, what does this imply for the future of electricity markets?
- Expansion & dispatch optimization of markets
  - Investigate scenarios without new transmission lines because they may be difficult to build
- Regional variations
- Impacts of high DER on overall market and how that will impact other generation resources
- Reliability and resilience
  - Robustness to external shocks (e.g., weather, solar weather)
- Investigate massive thermal energy storage for long-term weather impacts
- Investigate other energy storage for grid support

# Grid

∴ Electrical Mkt Design

- Expansion & Dispatch optimization  
of Mkt

- Regional Variations

- High DER

- Reliability  
Resilience

- Storage Support

# Integrated System

- Integrated assessment
  - Impacts of flexibility
  - Capacity factors
    - What alternatives exist to improve both NE and RE capacity factors?
  - Potential for HES to provide energy price support (limit suppression) leading to increased penetration
- Market survey
  - Don't forget remote/Islanded systems
- Multiproduct market analysis
  - Cosimulation may be an option
  - Incorporation into unit commitment model may be useful
  - Make sure the variability of electricity prices are captured
  - Uncertainty
  - Business models may be different between different subsystems
  - Investigate potential of both LT and HT electrolysis
  - Opportunities for storage
- Time signatures
  - Feasibility of running industrial processes outside of steady state
  - Control design and capability to manage full N-R HESs
- Safety
  - Issues with time signatures and multiple sinks for heat from nuclear reactors
  - Reliability impacts
  - Response in emergencies and accident scenarios
  - Basis for licensing
    - Safety/Risk analysis (PRA) of integration between reactors and renewable operations to establish basis for licensing
  - Can reduction of combustion make chemical plants safer?

# Industrial System

## - Integrated Simulation

### - Multiproduct Market

- Business Models Analysis
- Market Survey

### - Control design + Capability

### - Time Signatures

- Uncertainty
- Stochasticity
- Capacity Factors
- Impact of flexibility

w/ policies

### - Remote / Isolated Learning

Safety  
Issues w/  
Time Signatures

Reliability  
impacts

Emergency

Basis for  
Licensing

Does elimination  
of combustion increase  
safety

# Communication & Policy

- Implications of market surveys and competition
- Need for initial demonstration and quantification of benefits
- Clear communication of when and where synergies are unique between RE & NE
- Where RE is well supported, how to communicate value of NE
  - May be regionally specific. E.g., in Jordan RE could be used for electricity and NE for water desalination
- How to overcome bias against commercial nuclear while not as biased against defense requirements

# Communication / Policy

- Where RE is well liked, how to support

tion  
m?

NE

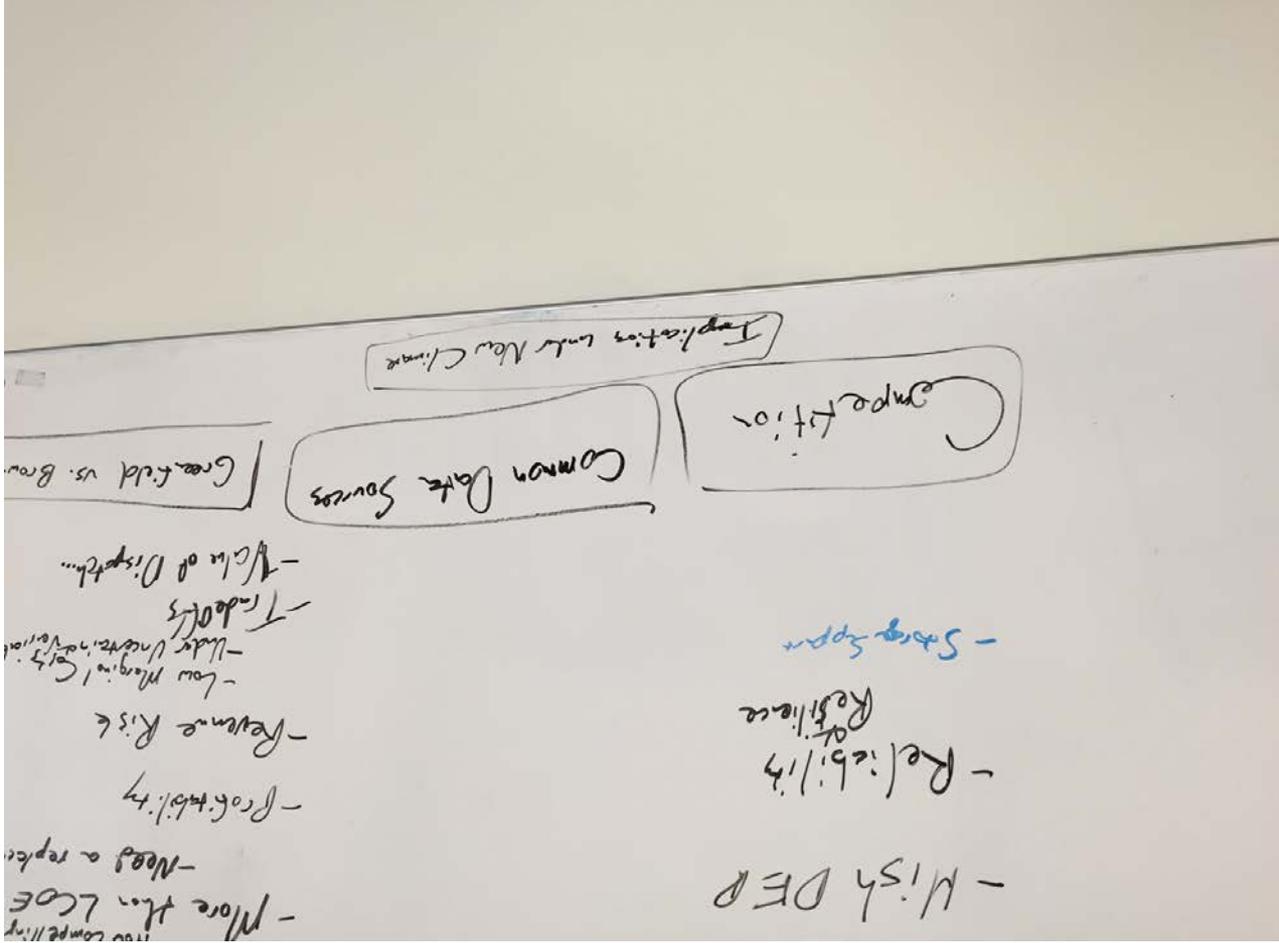
- Implications of Mkt Surveys of Competition

- Need an initial case of benefits

- How do we overcome bias against commercial nuclear but still support for defense

# Fundamentals

- All analyses compared to competition
- Implications under climate change on both loads and generators
  - Temperature, Water, others
- Greenfield vs brownfield – look for both sets of opportunities
- Don't overthink the problem
- Foundational
  - Dynamic modeling capabilities
    - Can we actually operate a NE-RE system with real end users? Which end users?
  - Common data sources
  - Education



Implications under New Climate

Competition

- Reliability
- Resilience
- Storage Support
- High DER

Common Data Sources

- More than LCOE
- Need a replacement
- Procurability
- Revenue Risk
- Low Marginal Cost
- Under Uncertainty
- Tradeoffs
- Value of Dispatch

Greenfield vs. Brownfield

