

## H2@Scale CRADA Kickoff

# *Region Specific Merchant Hydrogen Market Assessment and Techno-Economic Assessment of Electrolytic Hydrogen Generation*

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## Timeline and Budget

- Project Start Date: 09/01/2018
- Project End Date: 05/30/2019
- Total Project Budget: \$350,000
  - Total Recipient Share: \$200,000
  - Total Federal Share: \$100,000
  - Total DOE Funds Spent\*: \$0

## CRADA Partners

- Southern Company
- Exelon Corporation
- Xcel Energy (cash-in)
- Idaho National Laboratory
- National Renewable Energy Laboratory
- Argonne National Laboratory



## Barriers

- Tools and methods for assessment of optimization of regional natural resources and energy production
- Detailed capital investment pro-forma and life-cycle assessments for hydrogen markets
- Market options for otherwise-curtailed electricity
- Understanding interfaces for connecting variable and baseload plants to industry in hybrid operation

## DOE Sponsors

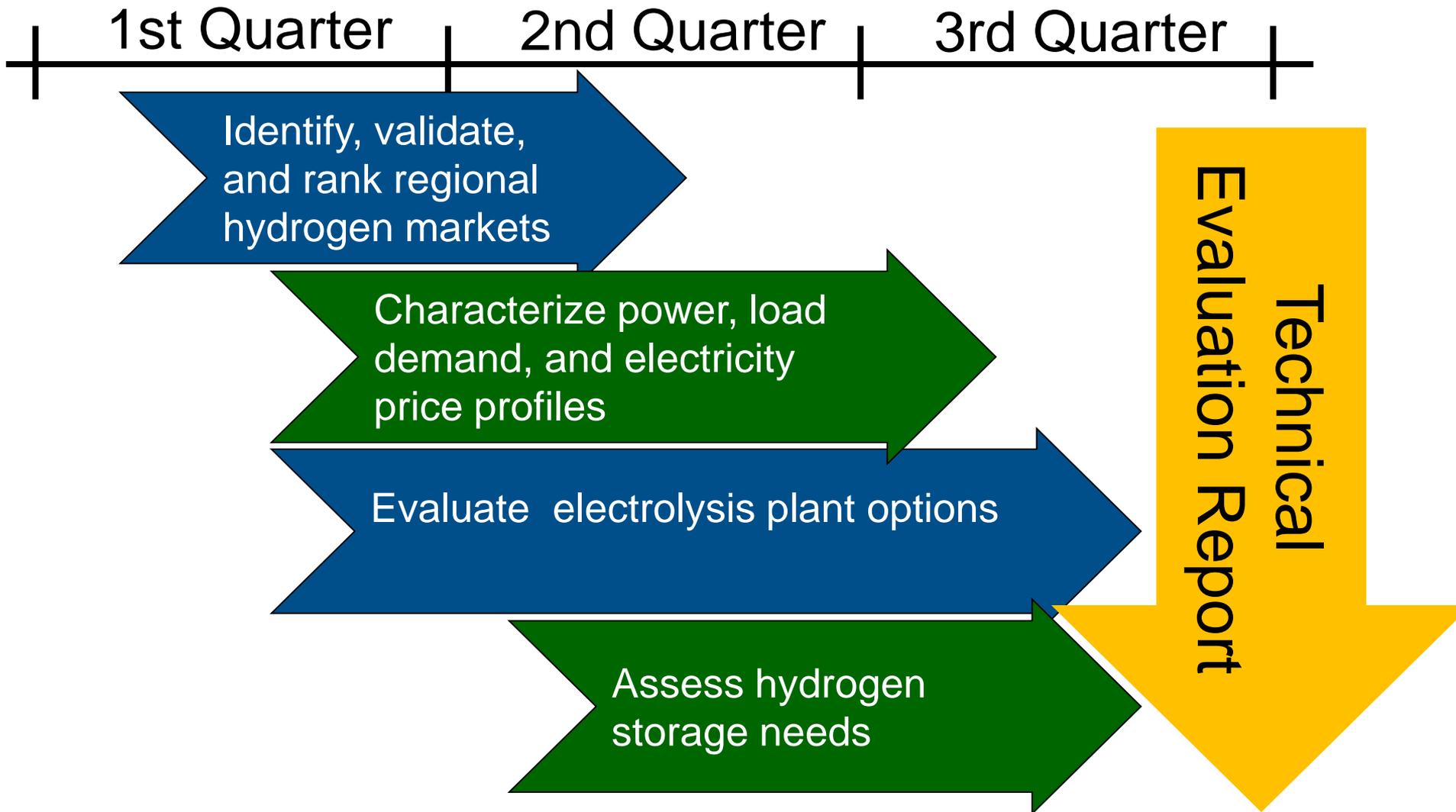
- EERE- Fuel Cell Technology Office

# Relevance

*This project will analyze regional hydrogen market opportunities (especially for low-CO<sub>2</sub> hydrogen). It will identify and characterize industrial demand for clean hydrogen in the service territories of SCS (Southeast U.S.), Exelon (Upper Midwest), and Xcel Energy (West-Central Plains States). Based on the projected industrial utilization markets, a cursory technical-economic assessment of large-scale, centralized hydrogen generation plant will be completed- considering existing nuclear plants and renewables in each region.*

- Electricity markets vary by region
- Renewable energy growth varies by region
- Regional hydrogen markets depend on logistics of natural resources, transportation systems, and other infrastructure

# Approach: 9 Month Activity



# Methods: Electricity Prices

- Collect historical grid price information relative to participating CRADA partners
- Assess regional grid markets for each Utility/CRADA Partner
  - Regulated vs Deregulated
  - Vertically integrated Utility vs Merchant nuclear plants
  - Renewable energy targets and trends
- Develop price duration curves pertinent to hydrogen production plant
- Determine nuclear plant energy production costs
- Establish geographic locations of renewable energy

➤ Regional hydrogen markets depend on logistics of natural resources, transportation systems, and other infrastructure

➤ Nuclear plants can be provide energy directly to H<sub>2</sub> plants

# Methods: Hydrogen Demand

- Survey of existing industries using hydrogen
- Projections for hydrogen demand growth
  - Fuel Cell Vehicles
  - Near-term hydrogen customers; for example ammonia plants
  - Potential long-term hydrogen users; for example Synthetic fuels
- Develop geographical map of hydrogen use customers

- Leverage H2@Scale Analysis Team studies for county-by-county hydrogen demand opportunities
- Develop local demand curves vs price of hydrogen



# Methods: Hydrogen Production

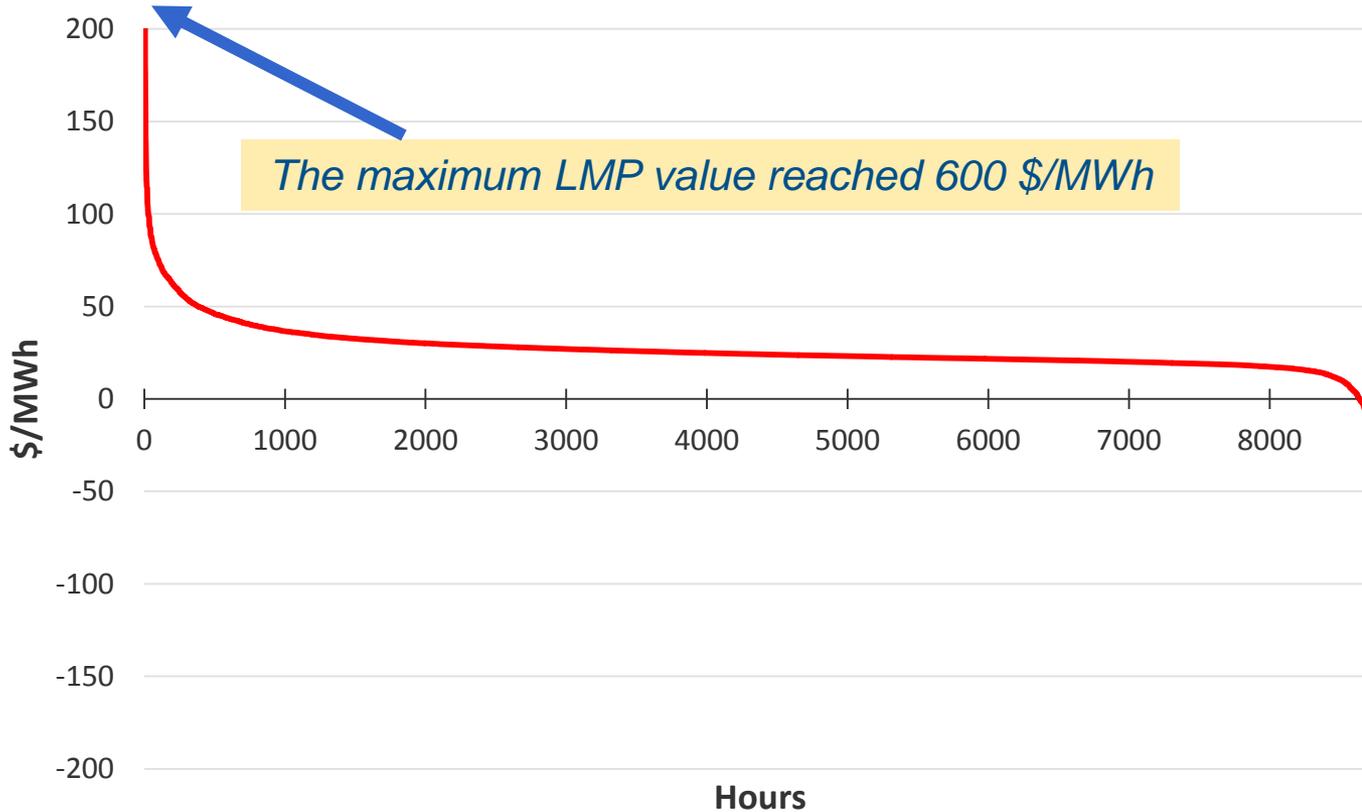
- Use H2A model for hydrogen production costs
- Large centralized H<sub>2</sub> plants vs Distributed H<sub>2</sub> plants
- Steam electrolysis based on Dominion Engineering design
- Aspen model for balance of plant to derive balance of plant capital and operative costs
- Compare to natural gas reforming relative to regional natural gas price projects
  - DOE-AEO Natural Gas Projection: Reference Case, High Cost, Low Cost
- Independent H2A cost calculations review

➤ Leverage H2A model development by DOE-NE program for high temperature steam electrolysis



➤ Develop hydrogen supply curve costs

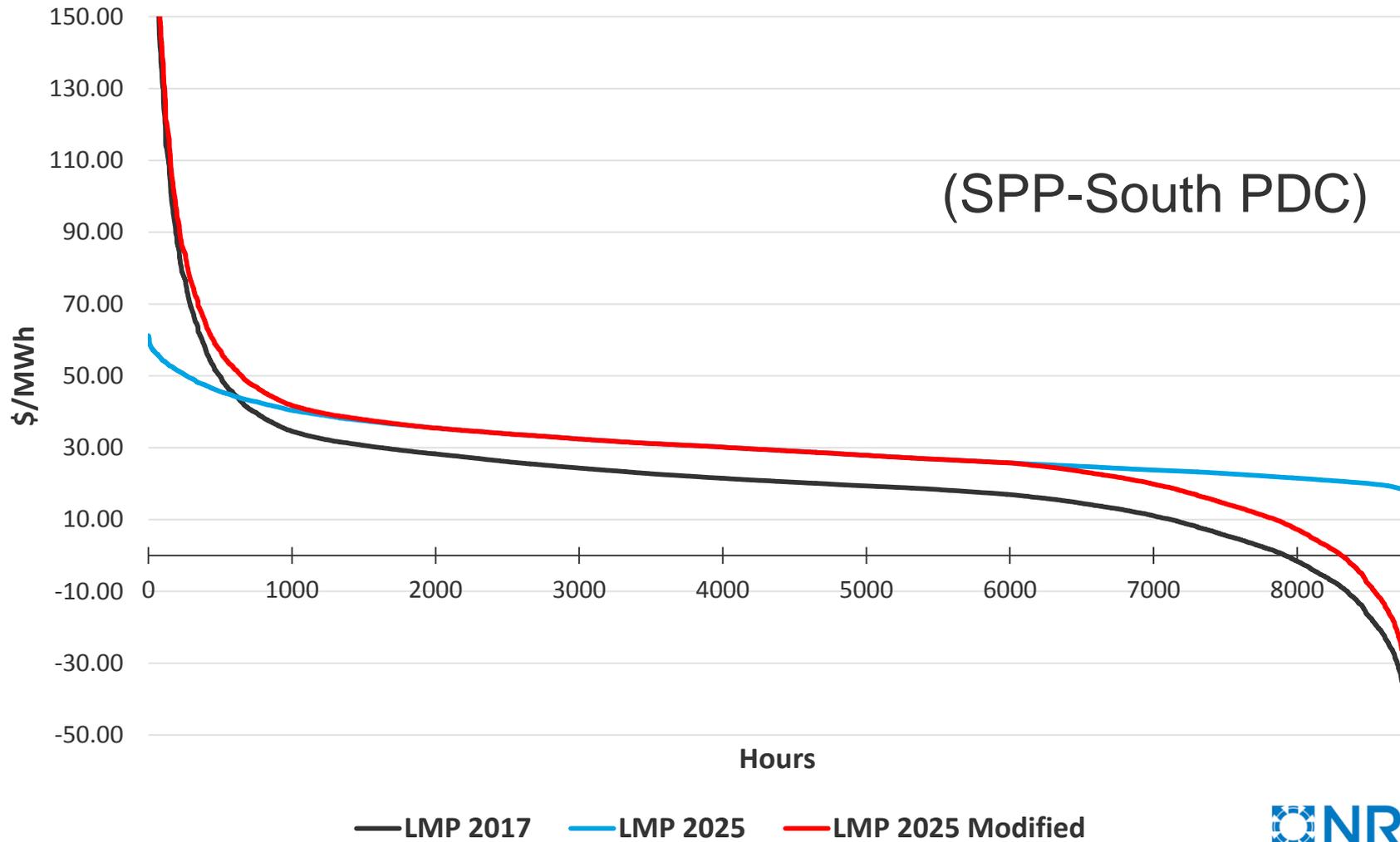
# Progress: Grid LMP Profiles & Trends



LMP \$/MWh	Number of Hours
>\$50	385
>\$45	542
>\$40	764
>\$35	1175
>\$30	2026
>\$25	3902
>\$20	7042
>\$15	8313
>\$10	8513
>\$5	8587
>\$0	8639
<\$0	121

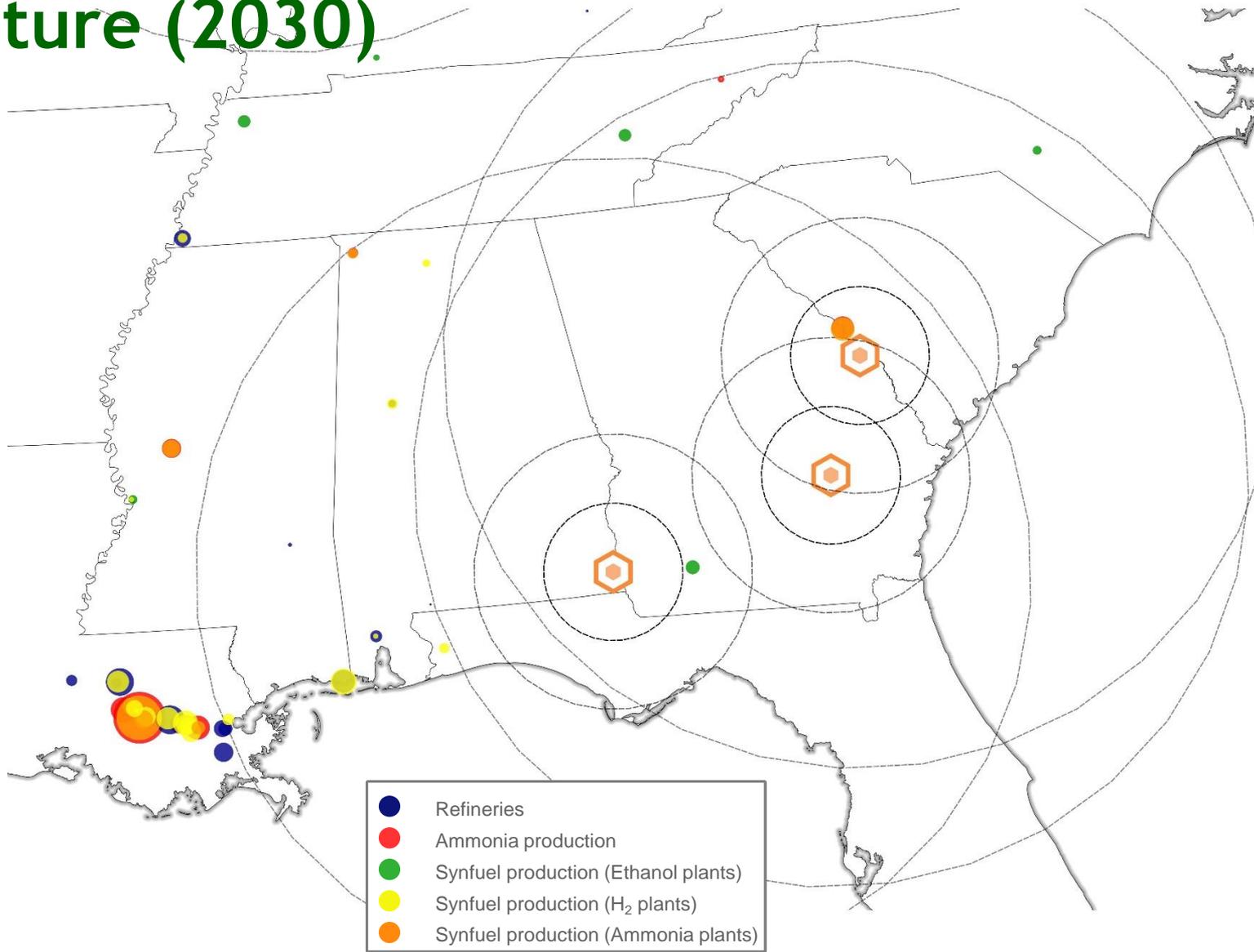
Northern Illinois Hub 2017 Price Duration Curve

# Progress: Grid LMP Profiles & Trends

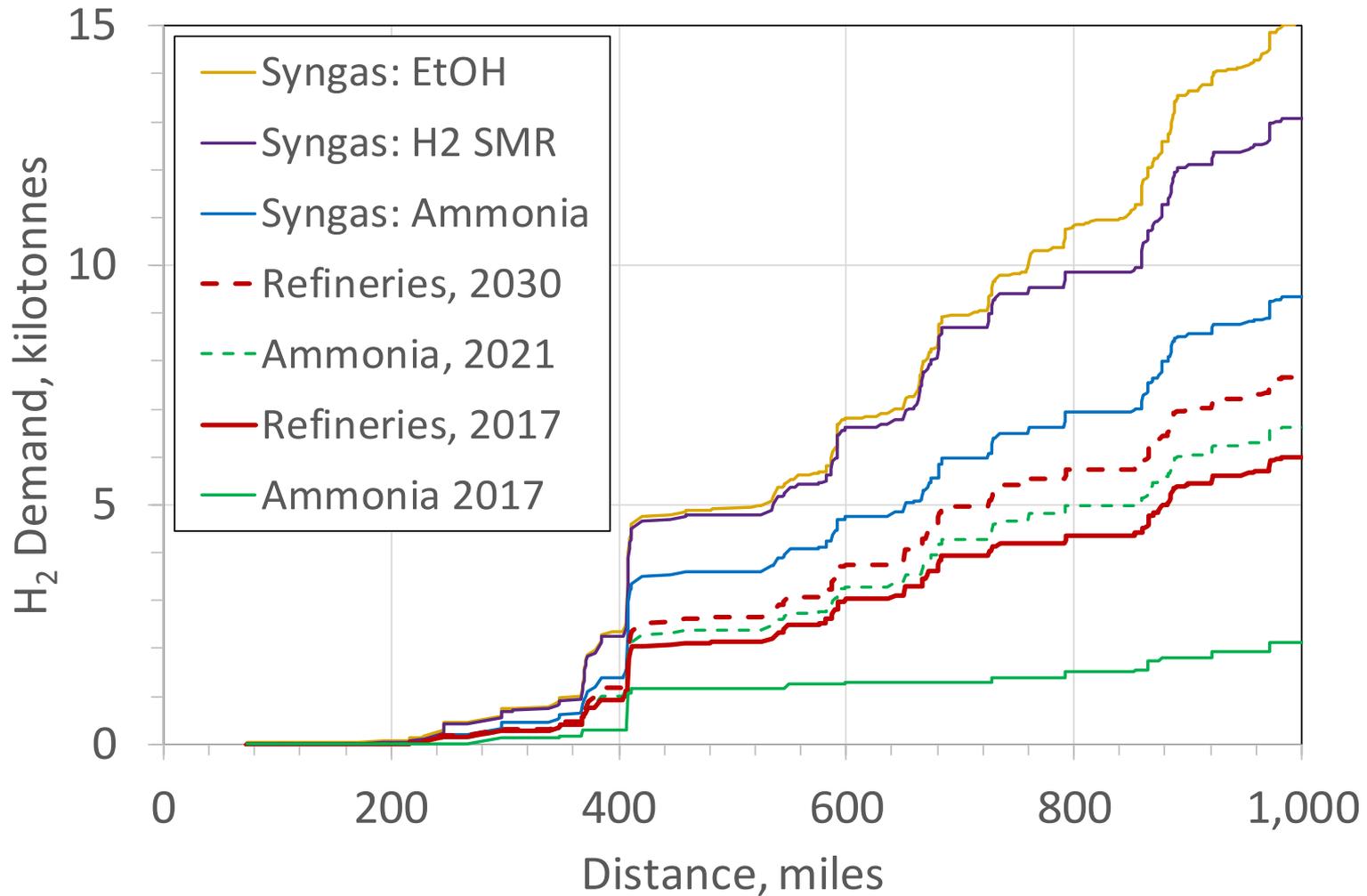


Aligning Xcel Energy Projected PDC with 2017 Volatility

# Progress: Potential Hydrogen Demand, Future (2030)

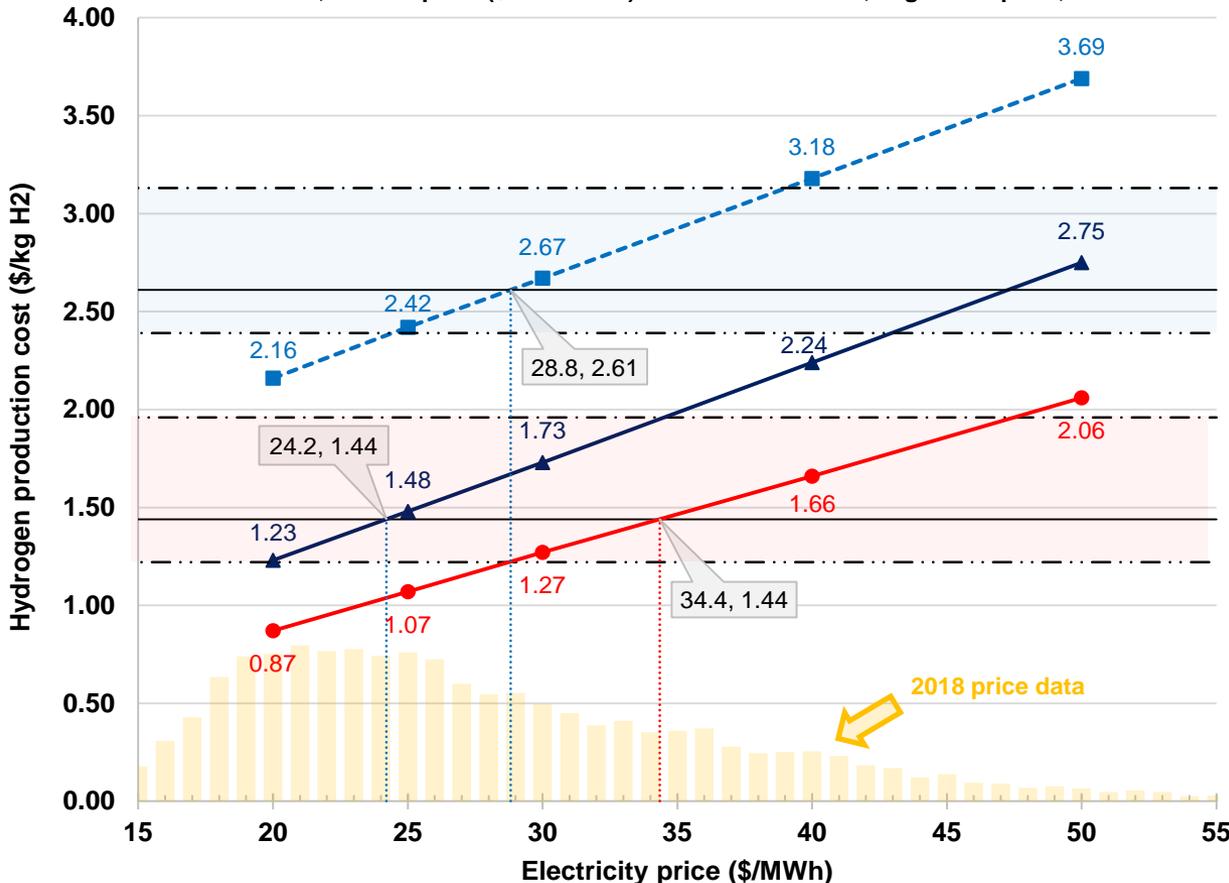


# Progress: H<sub>2</sub> Demand near the Farly Generating Station



# Progress: H<sub>2</sub> Production Cost Results

- SMR, high NG price (\$8.0/MMBtu)
- SMR, avg. NG price (\$5.4/MMBtu)
- - - SMR, low NG price (\$4.2/MMBtu)
- LTE, avg. stack price, 50MWe
- ▲- LTE, avg. stack price, 1191MWe
- HTE, avg. stack price, 1191MWe



## □ LTE (small scale)

- 50 MWe
- 23.9 tons/day H<sub>2</sub>
- 97% OCF
- \$329/kWe (DC power input)
- TCI of \$15.3 M

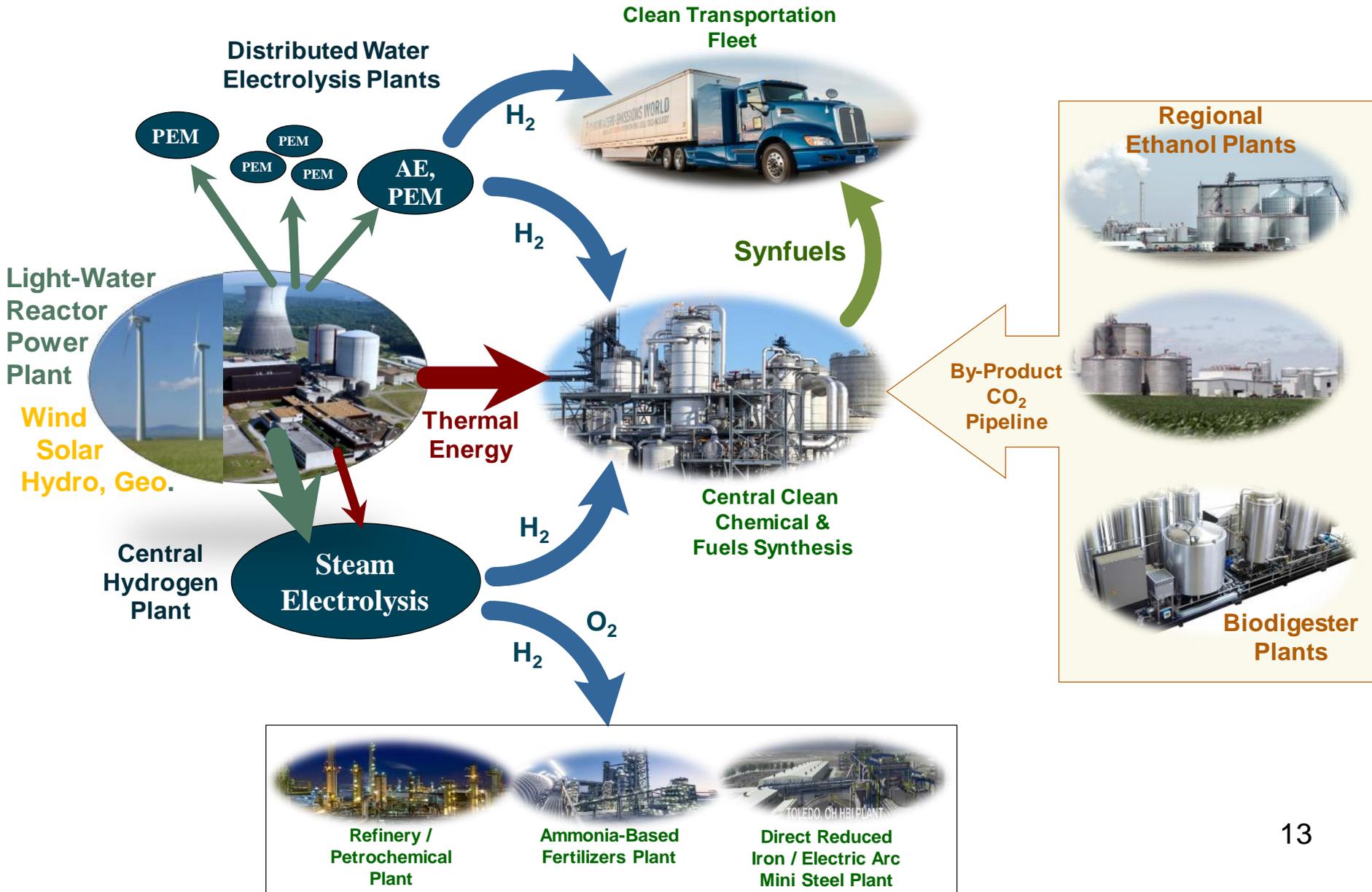
## □ LWR/LTE (large scale)

- 1191 MWe
- 569 tons/day H<sub>2</sub>
- 90% OCF
- \$329/kWe (DC power input)
- TCI of \$365 M

## □ LWR/HTE (large scale)

- 1191 MWe
- 755 tons/day H<sub>2</sub>
- 84.7% OCF
- \$403/kWe (DC power input)
- TCI of \$434 M

# Overview of Primary and Emerging H<sub>2</sub> Markets



# Summary

- This CRADA addresses hydrogen merchant markets in three different regions
- Electricity market price duration characteristics for the different regions have been obtained and are being used to calculate hydrogen costs
- Hydrogen markets have been evaluated for each Exelon
- H2A model revisions were completed to compare distributed and centralized hydrogen plants with steam methane reforming in the Upper Midwest

# Future Work

1. Wrap up hydrogen market opportunities for Xcel Energy
2. Determine hydrogen production costs for Xcel Energy and Southern Company Services regions
3. Evaluate region-specific hydrogen storage needs and costs
4. Provide project report