

Exelon actions and analysis of Hydrogen value propositions



\$21B

Being invested
in utilities
through 2021

\$52M

In 2017, Exelon gave
approx. \$52 million
to charitable and
community causes

#1

zero-carbon
energy
provider
in America

210 TWh

Customer load
served

35,200

Megawatts of
total power
generation
capacity

10M

Six utilities serving
10M electric and
gas customers, the
most in the U.S.

34,600

employees

\$33.5B

Operating
revenue in 2017

FORTUNE
100

Exelon is a
FORTUNE 100
company

2M
(Approx.)

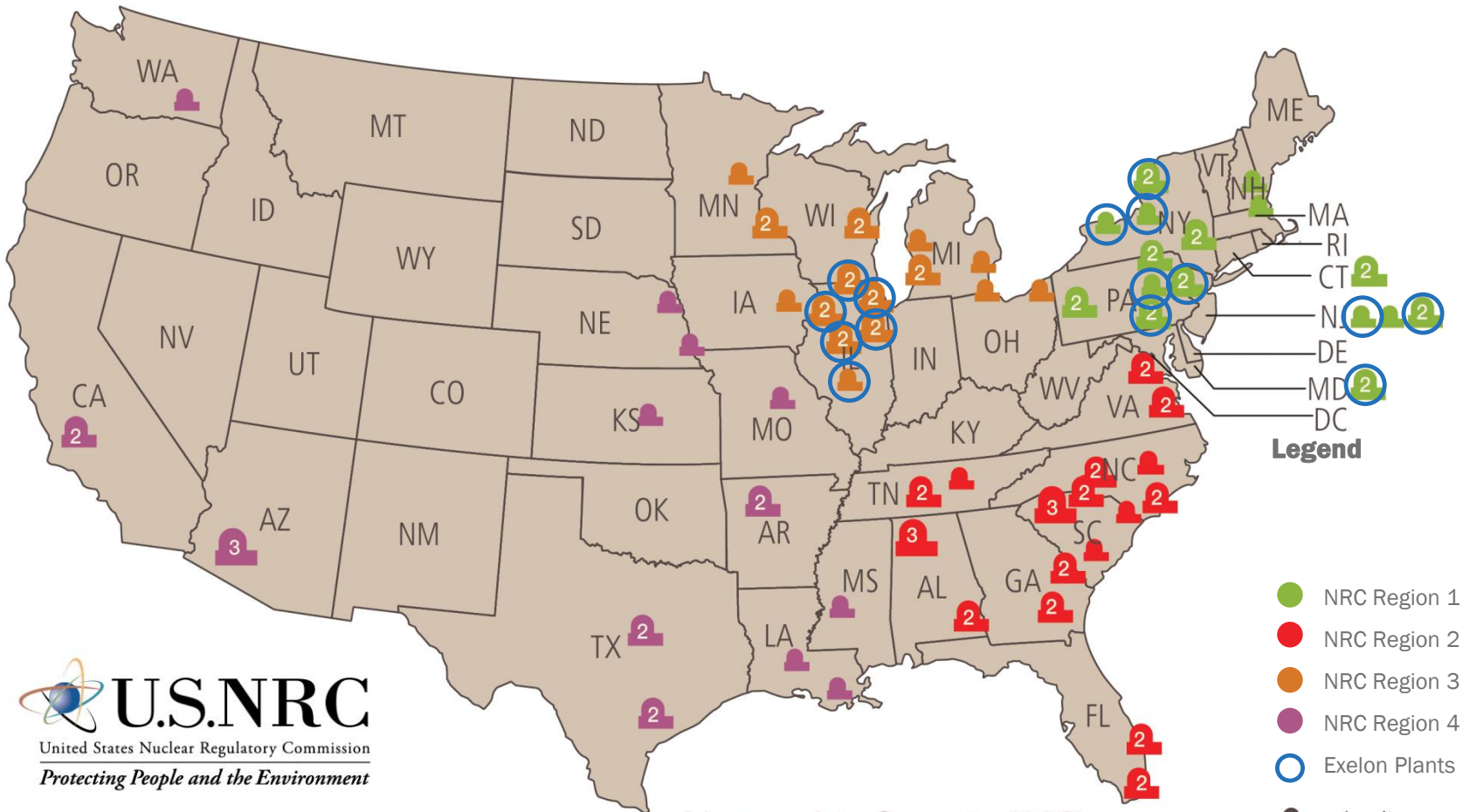
Exelon's
Constellation
business serves
residential, public
sector and
business
customers

11,470

transmission
line miles for
utilities

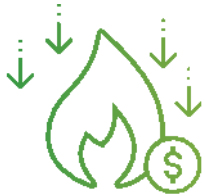
9.5M

Smart meters
installed



Licensed to Operate (100)

- Legend**
- NRC Region 1
 - NRC Region 2
 - NRC Region 3
 - NRC Region 4
 - Exelon Plants
 - = 1 units
 - = 2 units
 - = 3 units



Natural gas prices (which fuels marginal generators in many regions) have **dropped by more than 50%**



Load growth is down due to both the economy and increased energy efficiency programs



Renewables penetration has **suppressed wholesale energy prices** in some regions



Across the U.S. nuclear fleet, **operating costs have increased** (albeit with reductions in recent years)



Between 2013 and 2014, **four nuclear plants that generated more electricity than all solar electricity produced in the U.S.** in 2014 were prematurely closed. Their closure resulted in the **carbon dioxide equivalent of adding three million new cars on the road.**



If all at-risk reactors close, the US will **lose the power equivalent of five times all solar power generated** in 2015, and emissions will rise, adding the carbon dioxide-equivalent of **13 million new cars on the road.**



Nuclear plants generally employ **400 – 700 workers each**, at salaries that are more than **30% higher than typical wages** in their areas.

*EnvironmentalProgress.org

Project Vision: Address technical feasibility and business case for using a nuclear power plant to produce bulk hydrogen for energy storage, industrial uses, and fuel-cell vehicle filling stations.

Research Partners

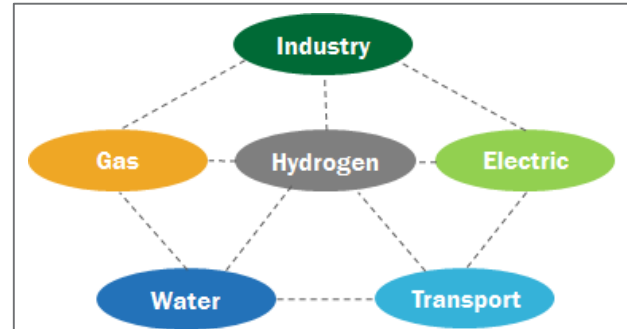


Technology Description

- Deeply evaluate the technical and economic potential for expanding the markets for existing nuclear reactors
- Provide a basis for converting baseload nuclear plants into hybrid plants that produce hydrogen, resulting in commercial investments and industry growth
- Broadly support the nuclear industry through the evaluation of opportunities that can economically support existing U.S. nuclear plants

Implications for Exelon

- This project will focus on hydrogen generation and use by existing and new industries located in proximity to an Exelon nuclear power plant.
- It supports Exelon's initiative to Repurpose existing nuclear plants by producing alternative products to electricity



Phase 1,2,3 task list

1. Specify location of nuclear plant, plant technical specification and operating boundaries, and ramp rate characteristics
2. Indicate the cost of nuclear plant operations and the incremental operating cost under projected flexible operation
3. NREL and Exelon will collaborate on this task to develop reasonably representative curves for cost to serve load at discrete times during the projected life of a hybrid project for use in subsequent analyses.
4. Develop design basis for utility connections to a centralized hydrogen plant
5. Develop custom Modelica submodel of heat delivery systems and integration with the hydrogen plant
6. Develop a conceptual design layout and preliminary cost estimate of hydrogen production plant relative to CAPEX and OPEX scaling factors
7. Select hydrogen user process, and indicate plant operating parameters and relative CAPEX and OPEX scaling factors
8. Specify infrastructure for hydrogen storage and delivery and provide storage systems CAPEX and OPEX profiles as a function of scale
9. Assess codes and regulations, permitting requirements relative to co-location of a large commercial hydrogen plant near a nuclear reactor
10. Complete life cycle assessment of emissions of overall scenario and compare emissions footprint to conventional process of similar production
11. Complete preliminary (copperplate) technical/economic assessment of repurposed nuclear plant with centralized hydrogen plants based on HTE and LTE
12. Review current and future potential of capacity market payments and survey literature and external assessments of capacity payments options
13. Use Raven tool scenario optimization and economic assessment analysis for hybrid operation and system optimization
14. Complete preliminary engineering design and technical/economic evaluation
15. Complete DOE/Public CRADA project report

