Future Grid Challenges and Possible Solutions

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DOE Hydrogen and Fuel Cell Technical Advisory Committee
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EPRI's Mission

Advancing ***safe***, ***reliable***, ***affordable,*** and ***environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation

Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

Nonprofit

Chartered to serve the public benefit

Collaborative

Bring together scientists, engineers, academic researchers, and industry experts

EPRI Energy Storage and Distributed Generation Program Mission

Advance safe, reliable, and environmentally responsible energy storage and distributed generation options

- Track and evaluate energy storage technologies and products
- Assess economics and technical impacts through tool development and analysis
- Support project implementation practices and develop of common approaches to integration and use
- Industry engagement to advance common approaches

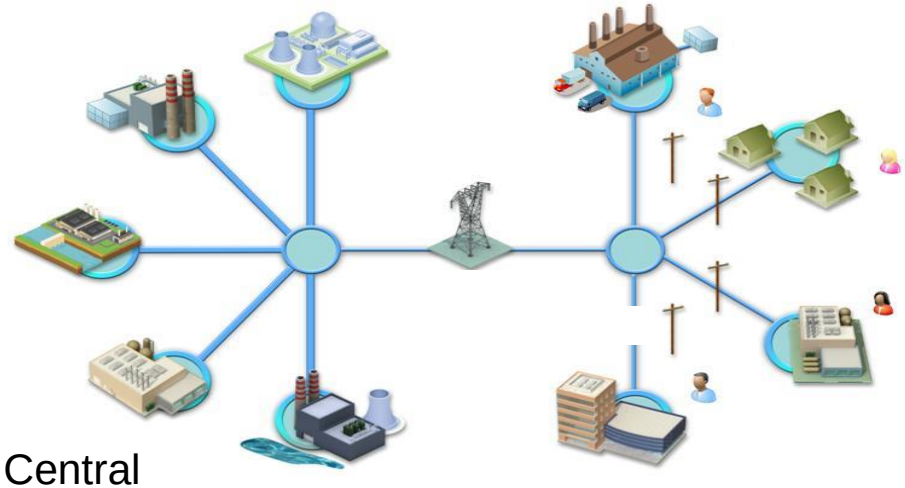




EPRI Technology Innovation Program

The Power Grid is *Changing*….

Traditional Grid:



Predictable Load

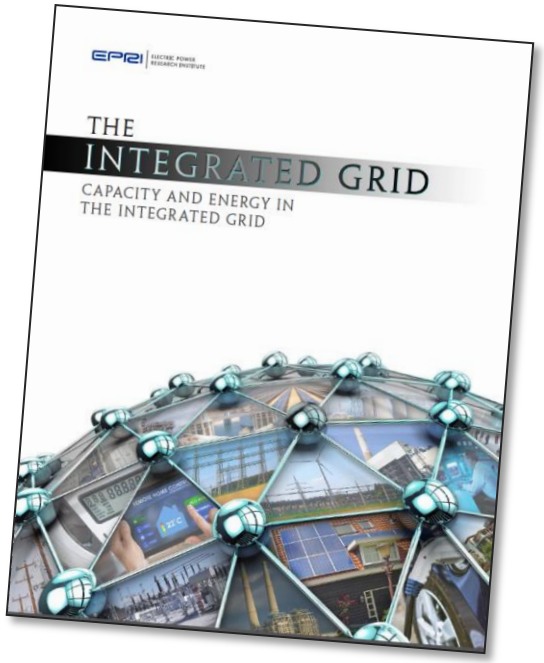
Central Generation

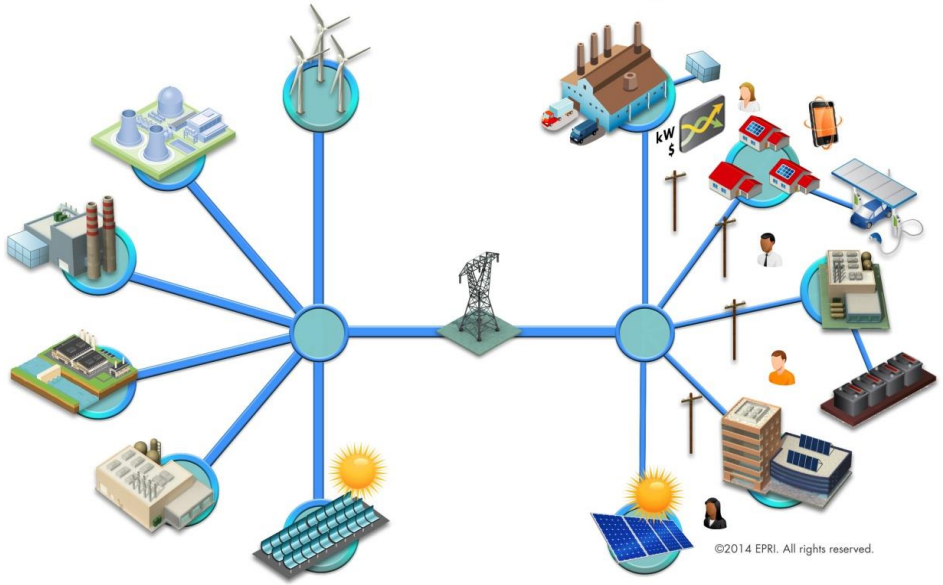
Looking Forward:

Renewables – wind & solar farms

Distributed generation – roof top solar

Changing consumer – electric cars

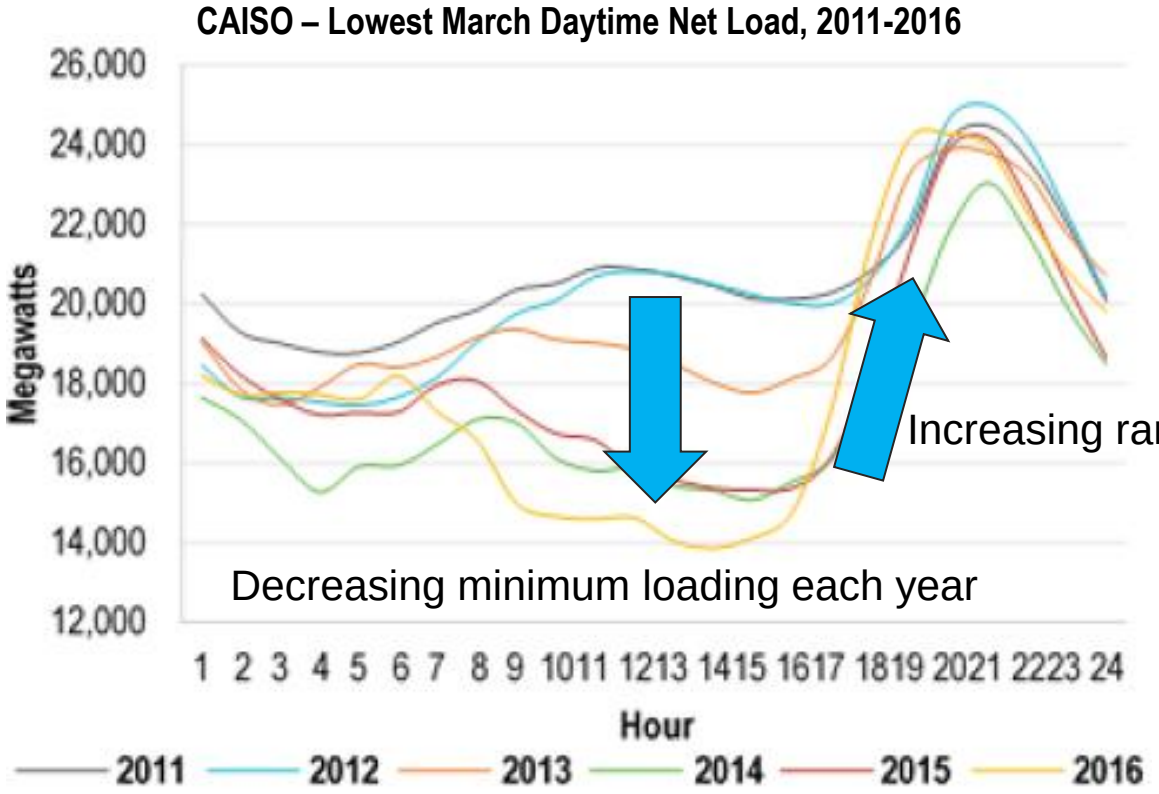




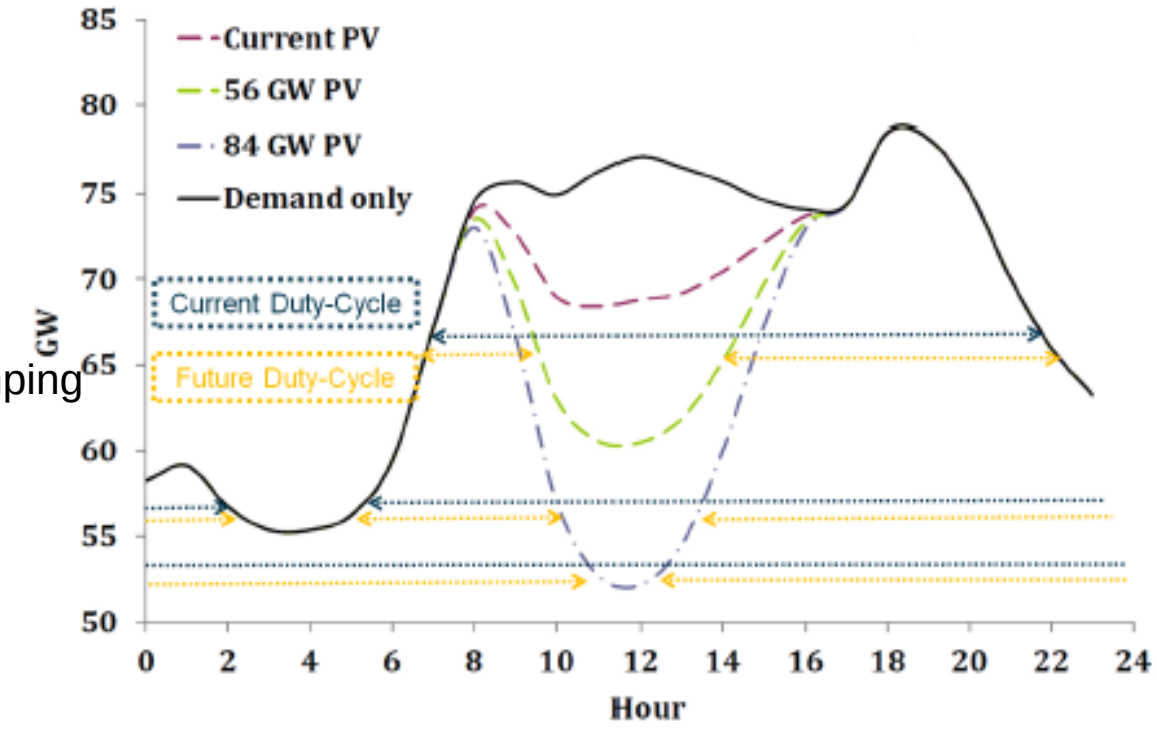
A More Dynamic End-to-End Power System

Renewable Generation is Driving New Flexibility Needs

California "Duck Curve"



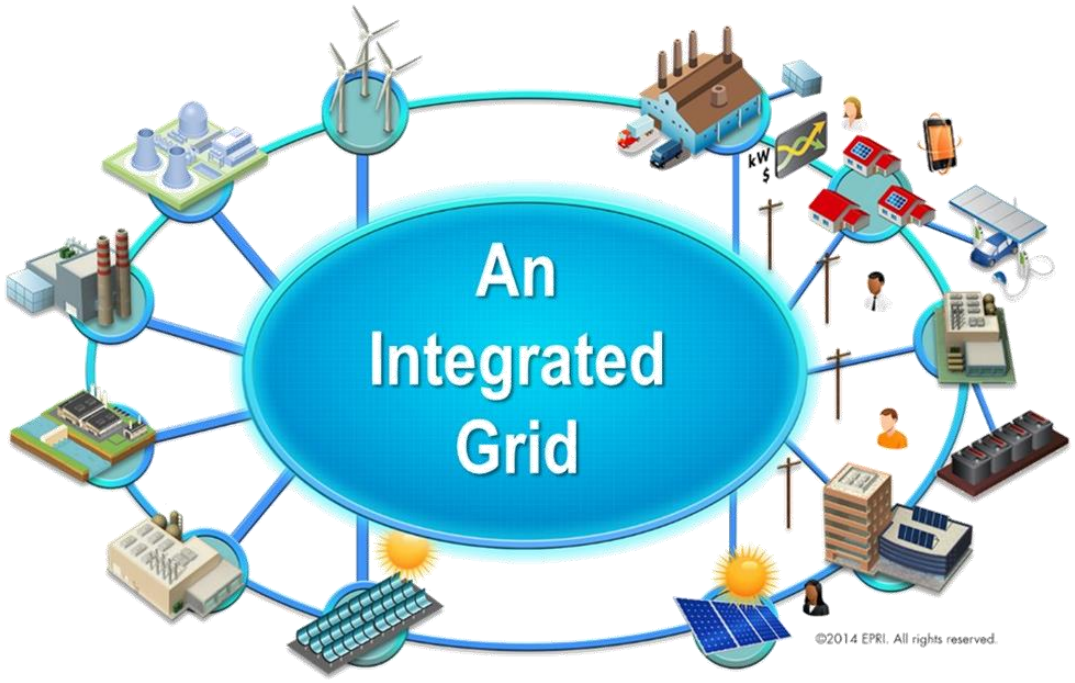
Germany "Duck Curve"



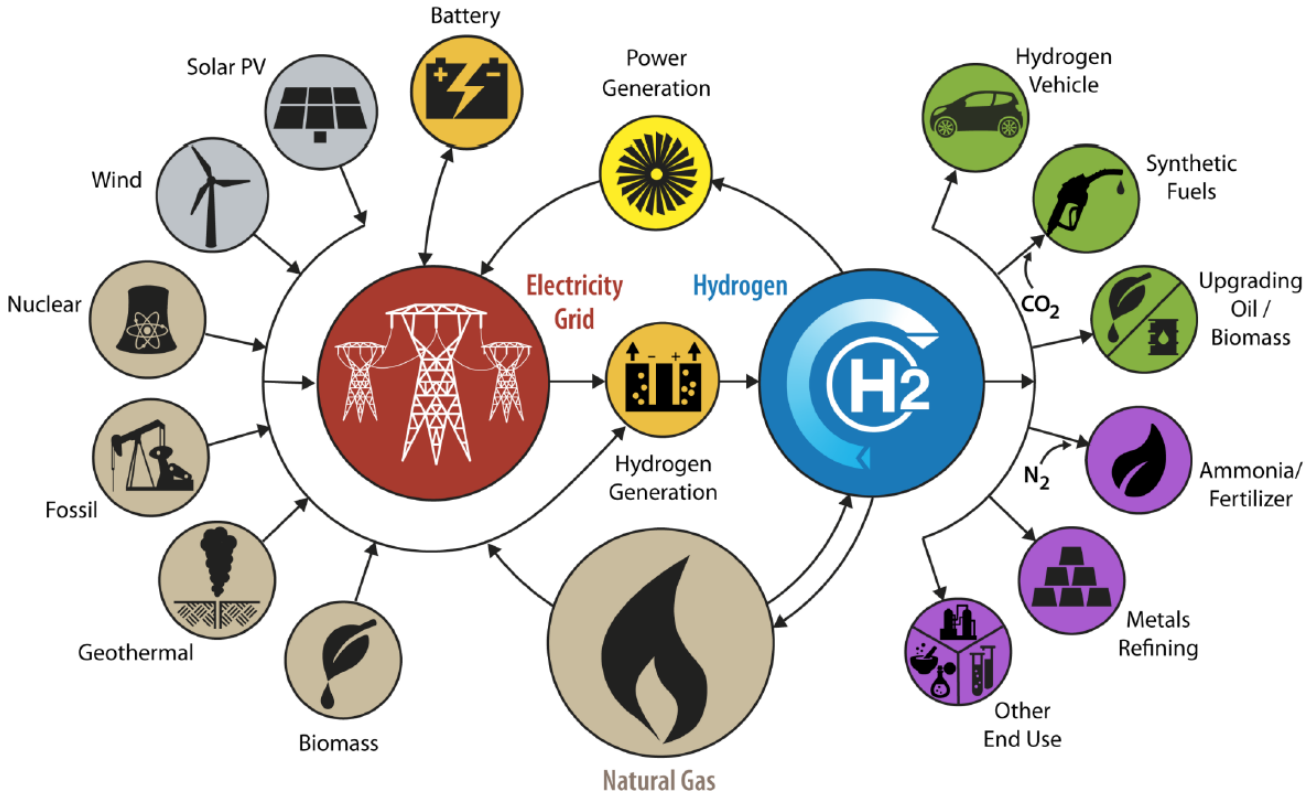
Solar PV-driven over generation in midday and increased evening ramp drives value for flexibility and energy storage

Hydrogen as a Potential Solution

EPRI's Vision of An Integrated Grid



DOE's H2@Scale – vision for hydrogen's role in sector coupling



Source: DOE

EPRI is Investigating Hydrogen Technology…

- As Part of a Low or No Carbon Future
- To Enabling Renewables and High RPS Goals
- For Dual Fuel Utilities – as a generation energy carrier
- As an Enabling Technology for Flexible Generation
- For Grid Storage – Seasonal and Longer Term
- On the Distribution Grid
  - Constrained Natural Gas
  - Dynamic Grid Services

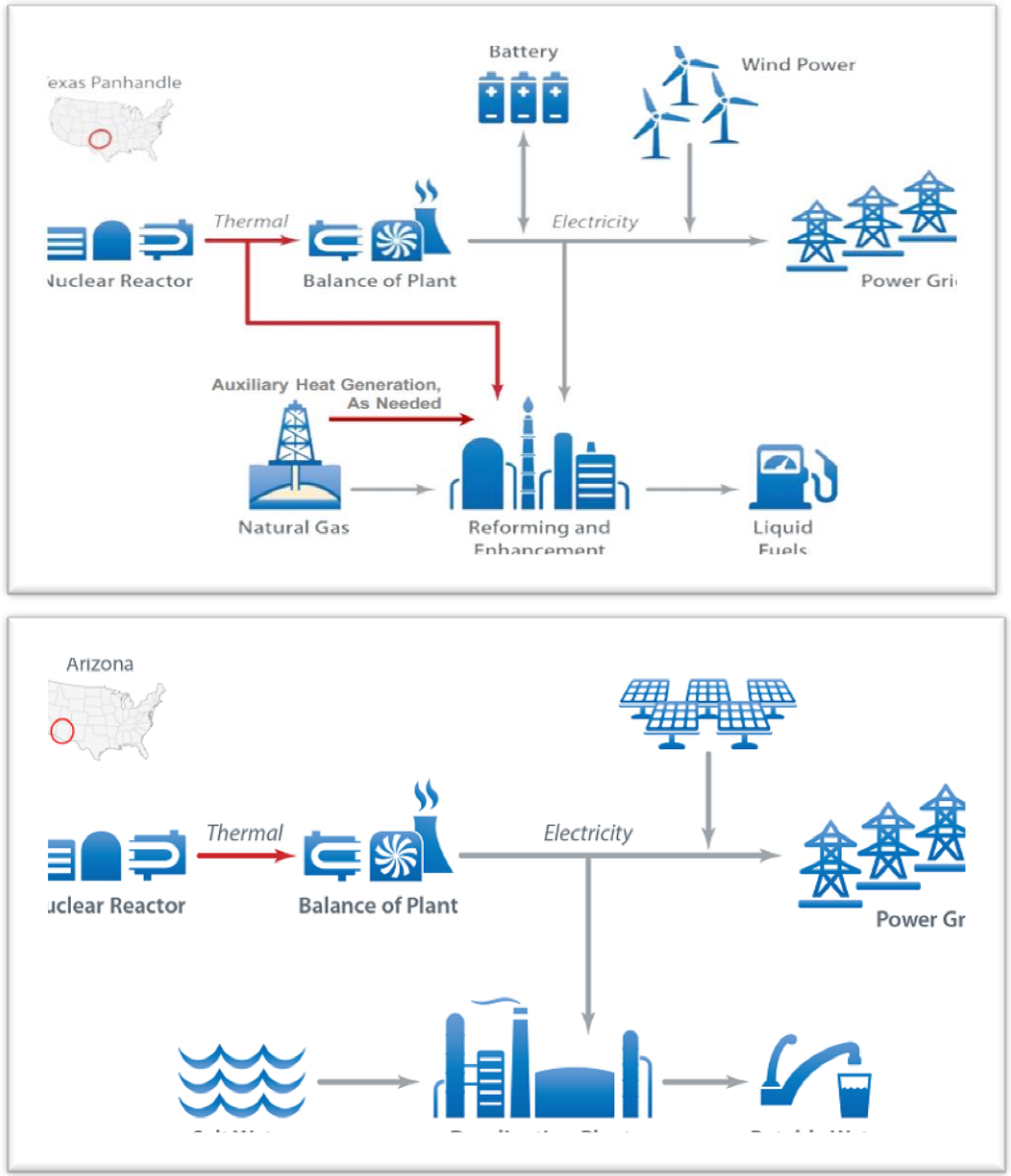
For Utility Investment, hydrogen must compete with alternatives

Must be Economic, Safe, and Reliable

- Utilities Need Clarity on:
  - Technology Performance
  - Competitive Business Case (in current and future grid environment)
- Comparing to Alternatives
  - Planning Process
  - Procurement
- Understand Operations and Maintenance
- End-of-Life and Disposal

Example: Value Proposition for Hydrogen Energy Storage in Flexible Nuclear Operation

- Optimize operation of the nuclear asset with respect to energy to storage vs. selling electricity to the grid while continuing to provide grid reliability, resiliency and fuel diversity.
- Reduce or eliminate curtailment of renewables during periods of electricity over generation.
- Produce a valuable product for end users:
  - H2 to feedstock or fuel
  - Thermal energy to electrical energy
  - Thermal or electrical energy to de-salinization
- Possibility to bid into other markets:
  - Ancillary services
  - Capacity market
  - Ramping services

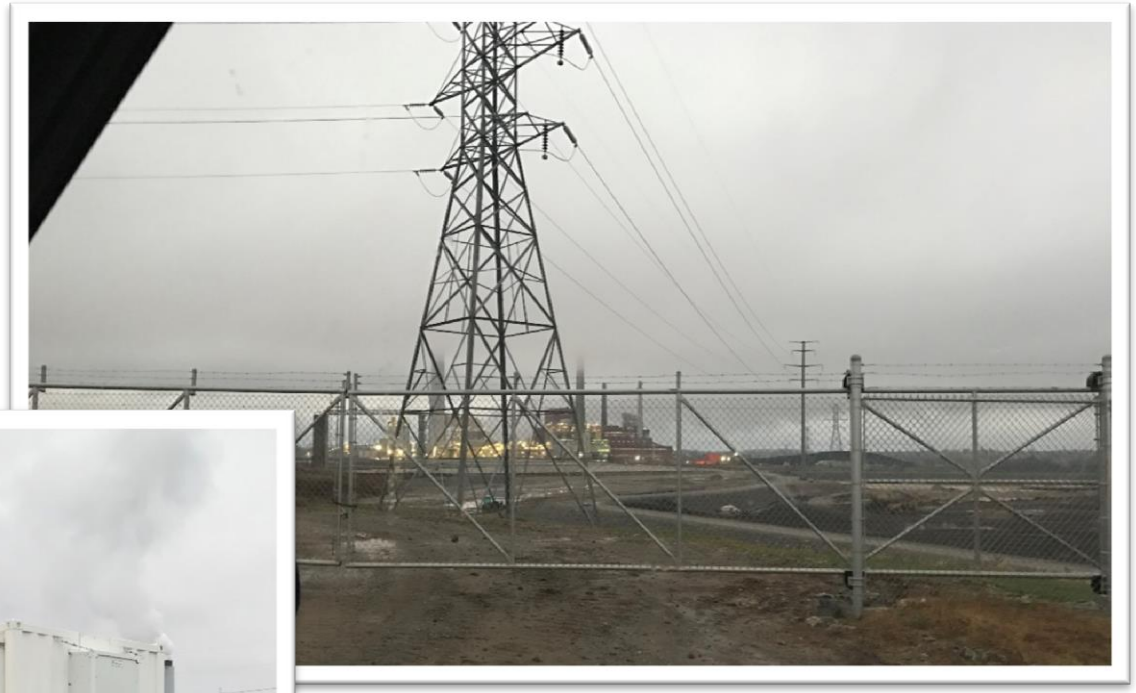


How to Approach Hydrogen ES From the NPP Operator Side

- What are your flexible demands?
  - Daily, Weekly, Seasonal
  - Short-term, minute by minute or long-term on the order of hours
- What product do you want from the ES system based on plant and local needs?
  - H2 as a fuel to inject into a pipeline
  - H2 as a feedstock to 'green' an industrial process
  - Gas to electricity
  - Thermal to electricity
- Are you willing/able to provide electrical energy or thermal energy?
  - Higher capital and licensing cost with thermal energy, but higher system efficiency
- Cost of the energy diverted to ES
  - Will it be consider a house loads or retail?
- Licensing considerations, i.e.,
  - H2 need to address site hazards analysis and control room habitability
  - Thermal need to considering licensing basis implications and control systems
  - Thermal need to consider where to extract the steam and impacts on the turbine-generator
- Siting considerations
  - Storage units on the MW scale are large – is there a footprint to locate storage on-site
  - How far from the site can it be located and be efficient
- All in life-cycle costs of the entire process:
  - Production, Storage, Transportation, O&M
- Economic evaluation
  - What is the benchmark the ES is being compared against

Example: Installing Storage versus or alongside Traditional Generation

Solar Generation



Coal and Natural Gas Generation

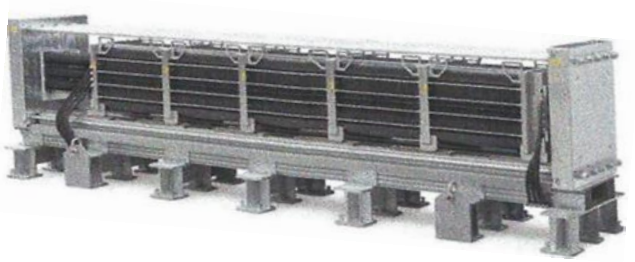
Energy Storage

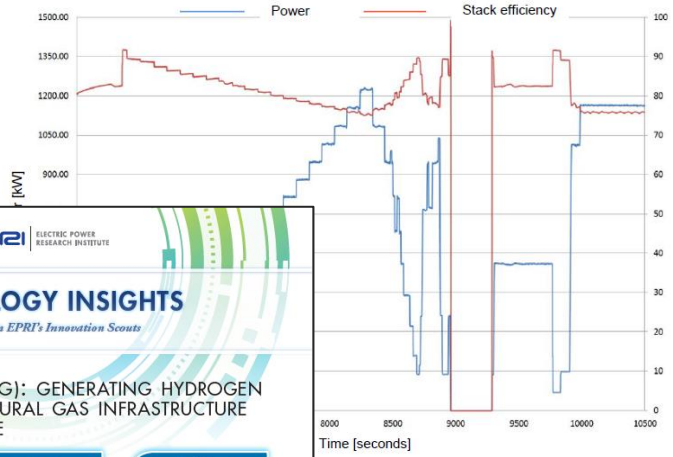
Utilities Looking for Solutions for the Electric Grid

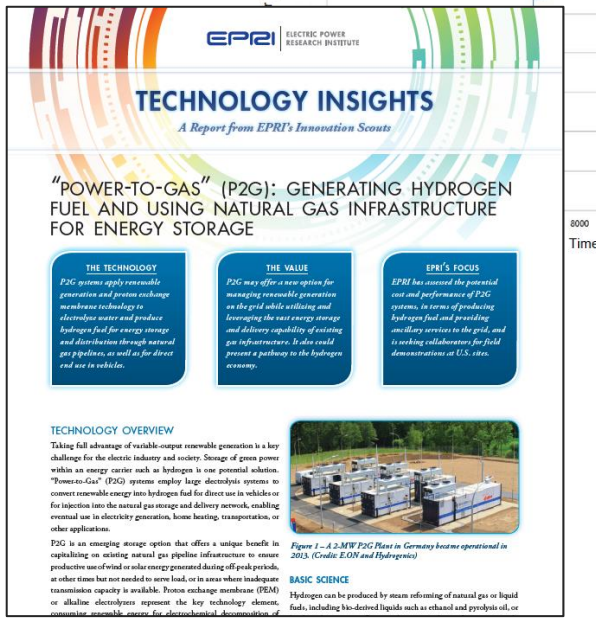
http://integratedgrid.com/

Recent EPRI Hydrogen Publications

- ***Prospects for Large-Scale Production of Hydrogen by Water Electrolysis*** (2019) 3002014766
- ***Status and Prospects of Automotive Polymer Electrolyte Membrane Fuel Cells*** (2017) 3002010624
- *Program on Technology Innovation:* ***Review of the Uniper Energy Storage GmbH Power-To-Gas (P2G) Demonstration Projects*** *at Falkenhagen and Hamburg-Reitbrook, Germany* (2017) 3002011519
- *Technology Innovation:* ***Hydrogen Energy Systems Development in Europe*** (2016) 3002007274
- *Technology Insight:* ***"Power-to-Gas" (P2G): Generating Hydrogen Fuel and Using Natural Gas Infrastructure for Energy Storage*** (2014) 3002004285






EPRI ELECTRIC POWER RESEARCH INSTITUTE

TECHNOLOGY INSIGHTS

A Report from EPRI's Innovation Scouts

"POWER-TO-GAS" (P2G): GENERATING HYDROGEN FUEL AND USING NATURAL GAS INFRASTRUCTURE FOR ENERGY STORAGE

THE TECHNOLOGY

THE VALUE

EPRI'S FOCUS

TECHNOLOGY OVERVIEW

BASIC SCIENCE

Together…Shaping the Future of Electricity

Questions or Comments?

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