ELECTRIC POWER RESEARCH INSTITUTE

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

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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

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EPRI Technology Innovation Program

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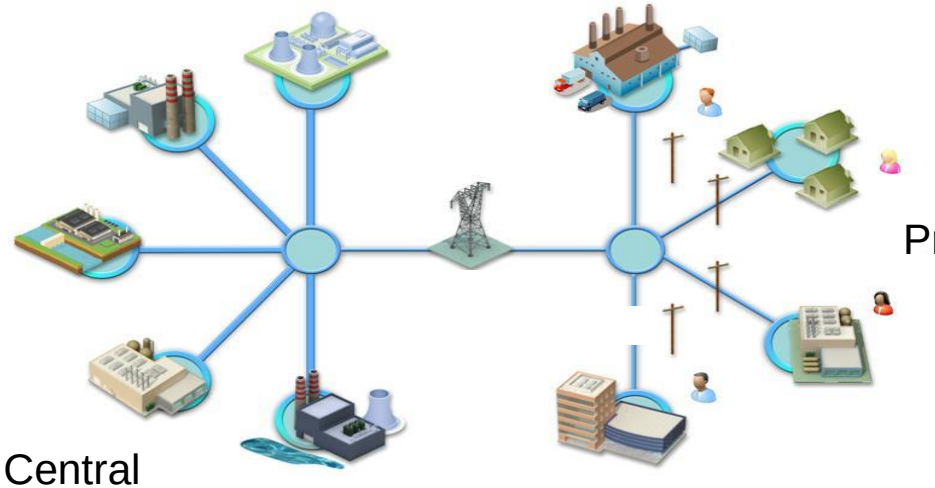
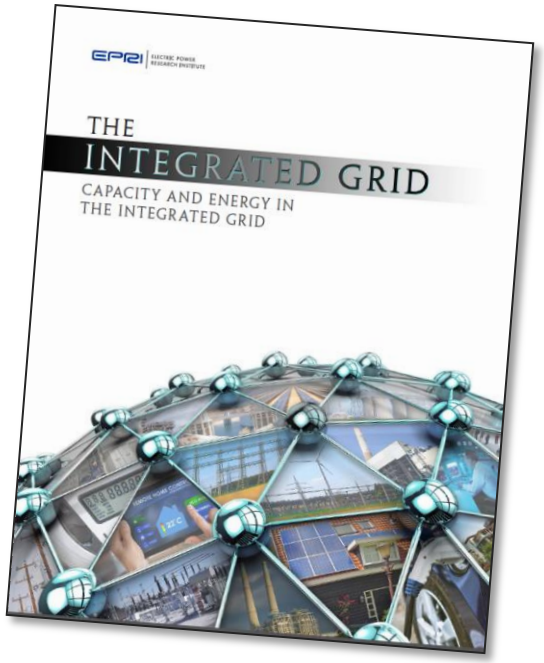
The Power Grid is *Changing….*

Traditional Grid:



Predictable Load

Central Generation

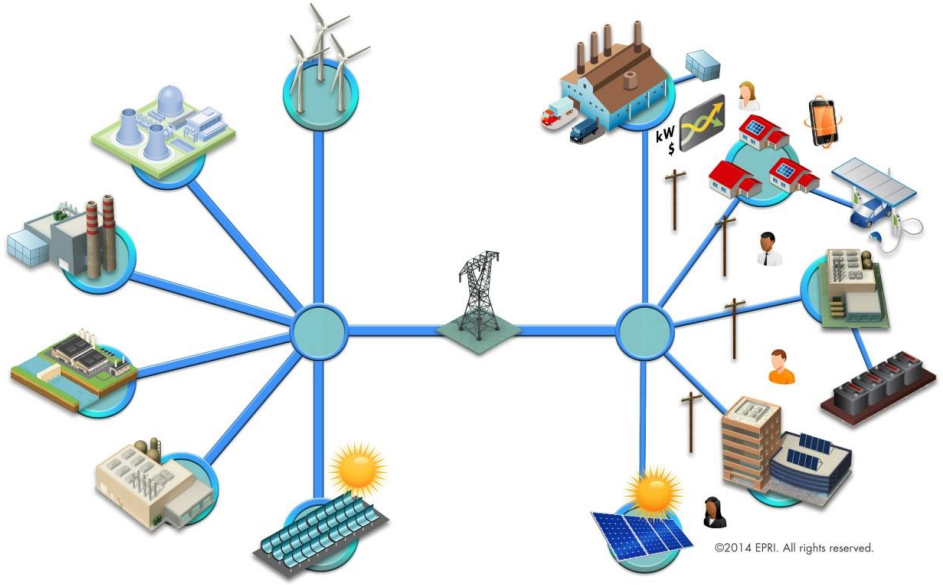


Looking Forward:

Renewables – wind & solar farms

Distributed generation – roof top solar

Changing consumer – electric cars



A More Dynamic End-to-End Power System

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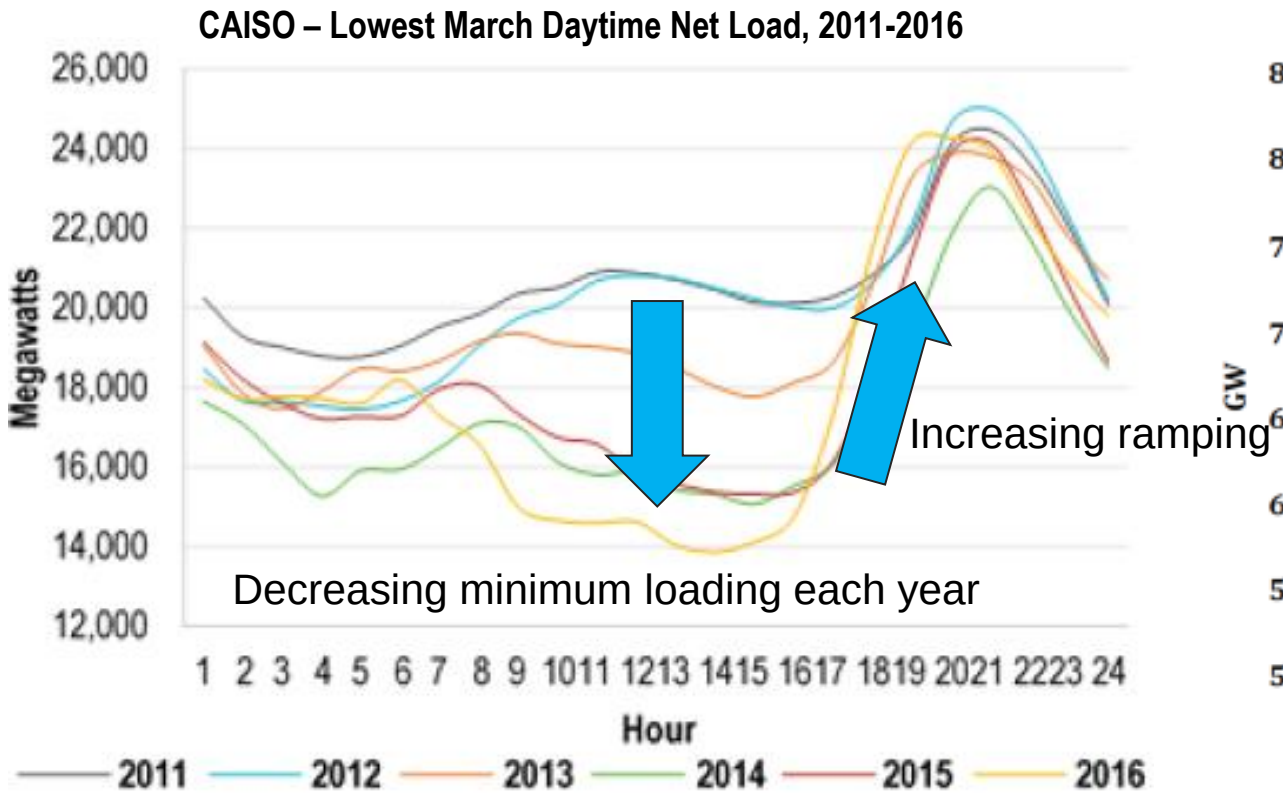
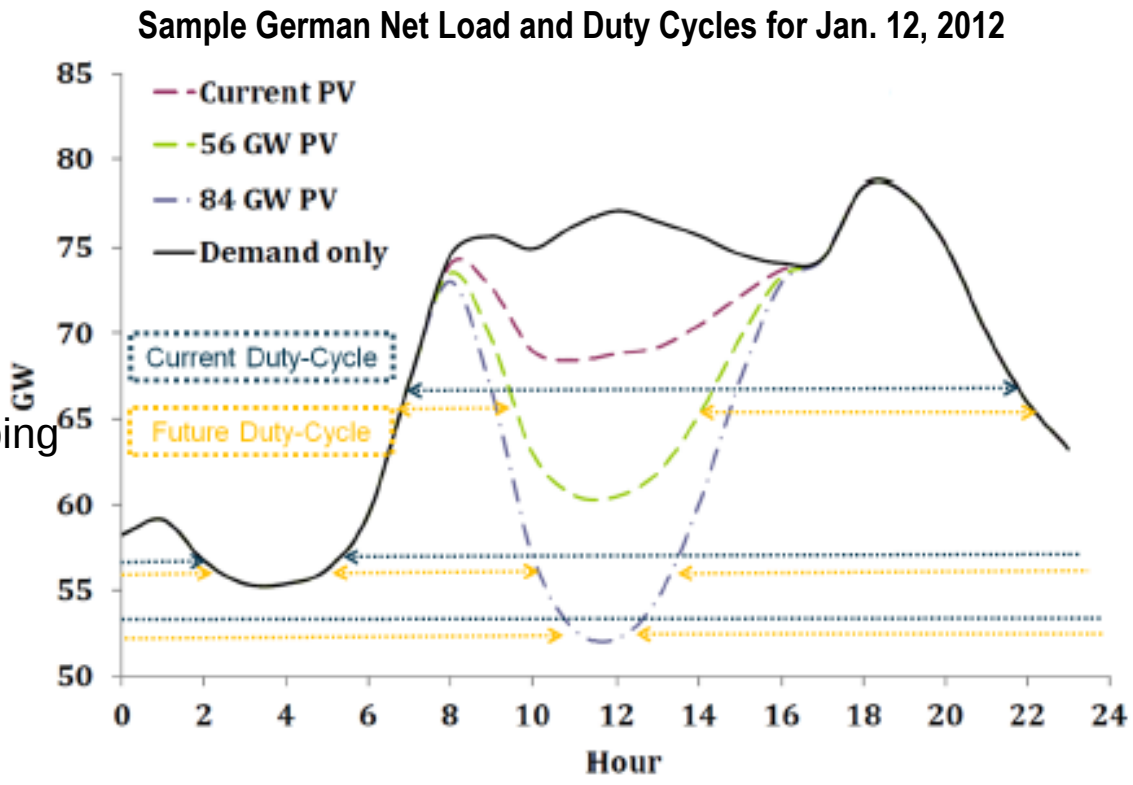
Renewable Generation is Driving New Flexibility Needs

California "Duck Curve"



Germany "Duck Curve"



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

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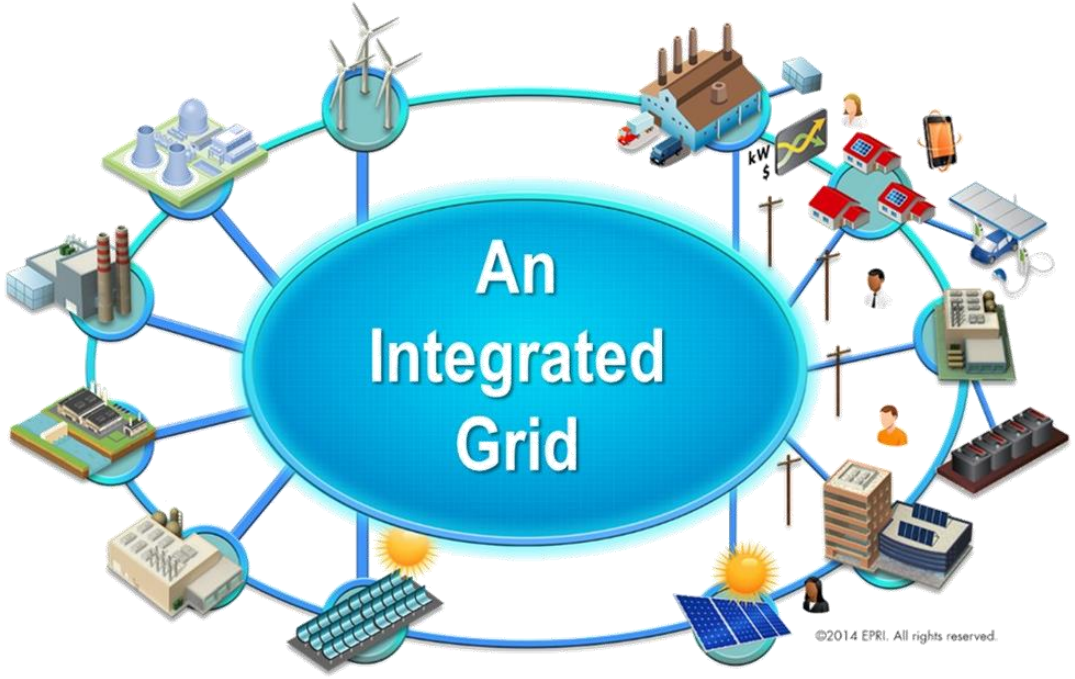
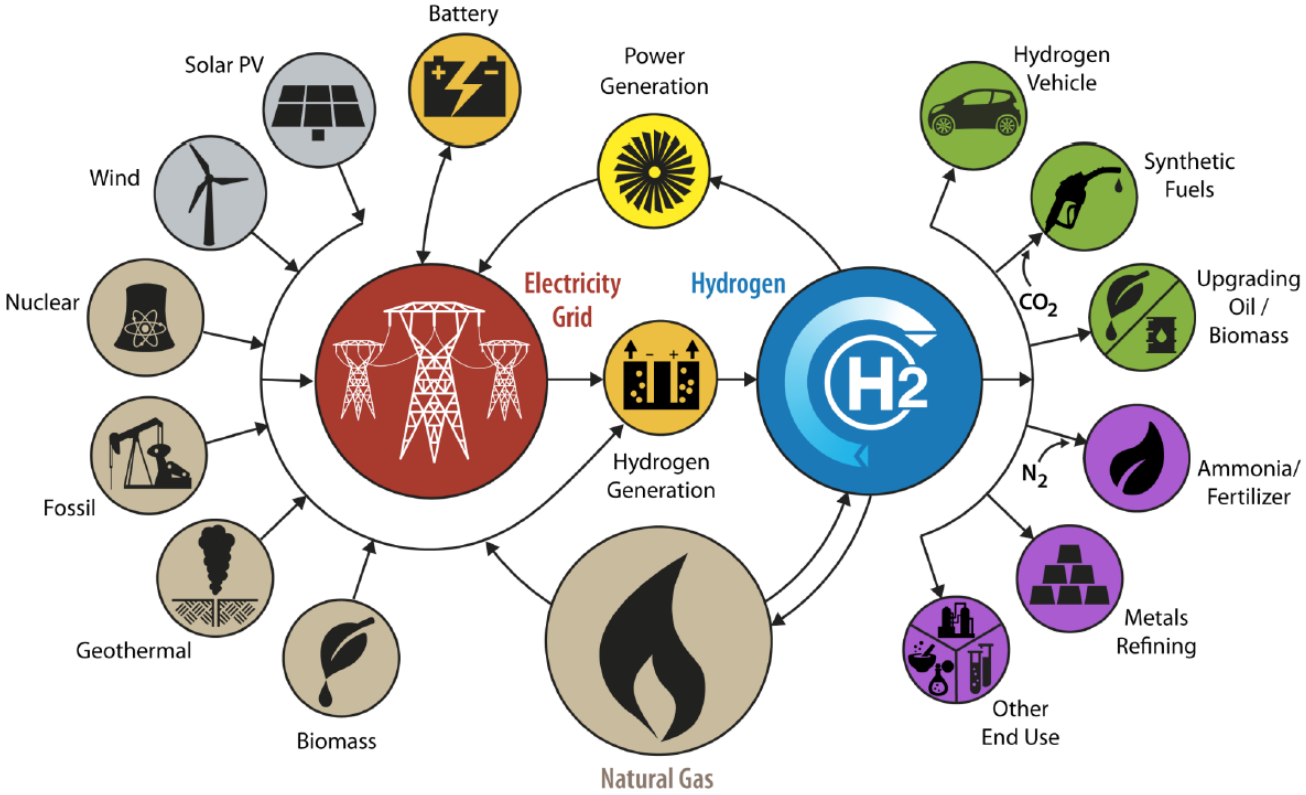
Hydrogen as a Potential Solution

EPRI's Vision of An Integrated Grid



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



Source: DOE

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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

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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

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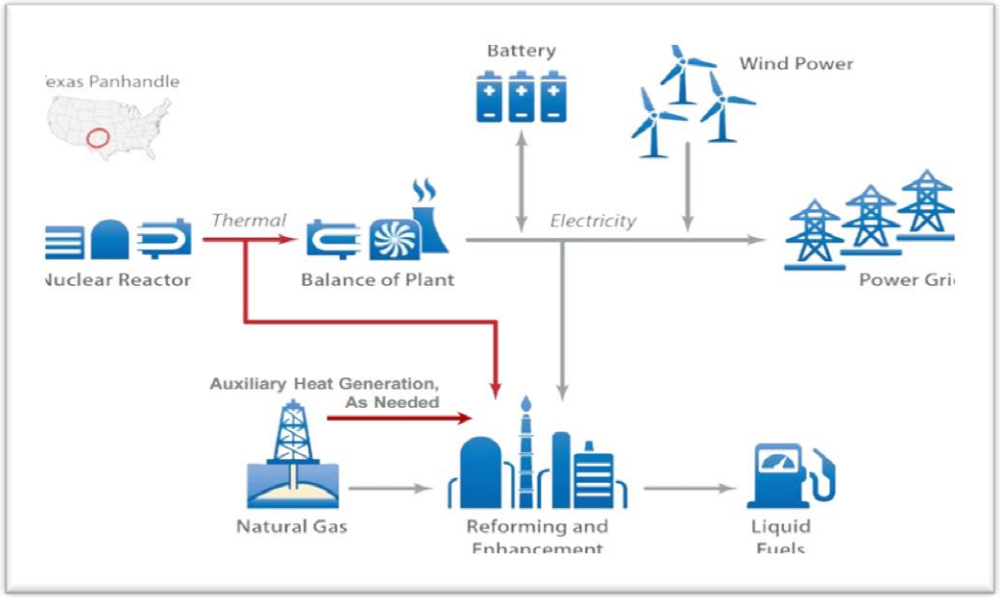
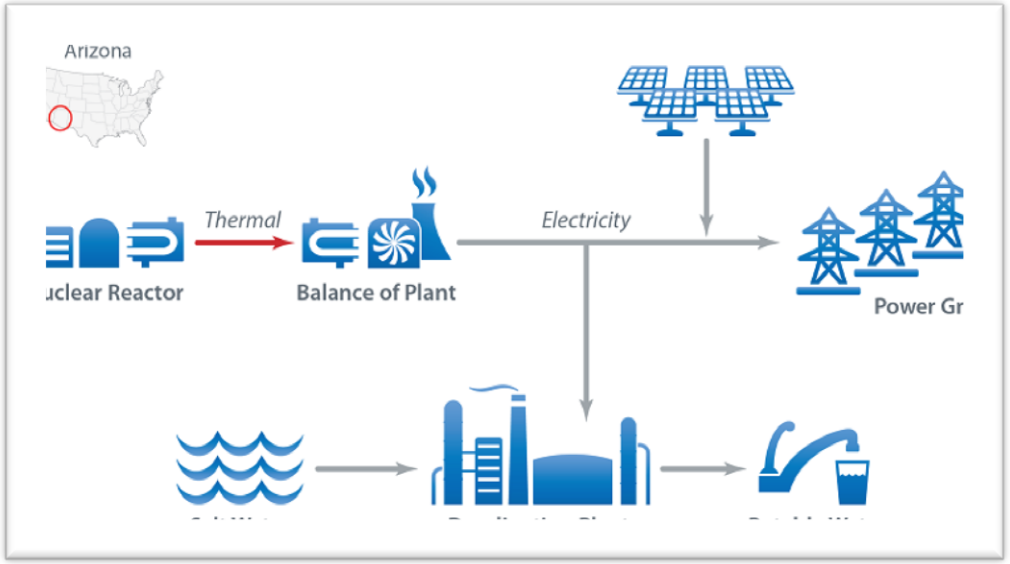
Example: Value Proposition for Hydrogen Energy Storage in Flexible Nuclear Operation

- 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





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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

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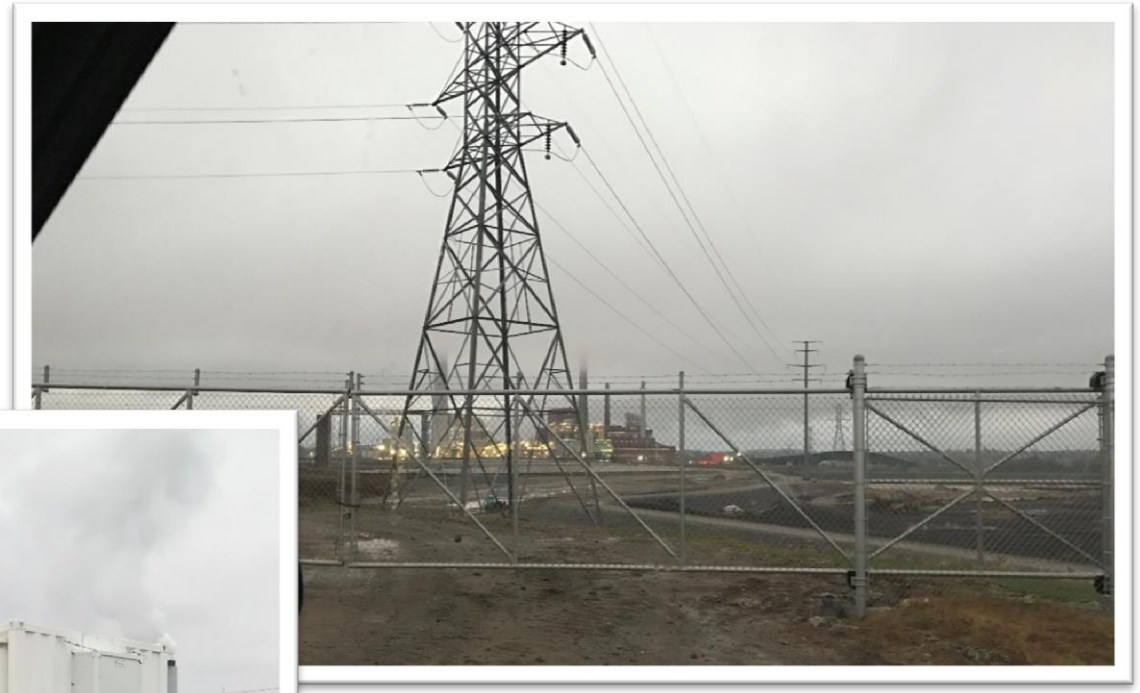
Example: Installing Storage versus or alongside Traditional Generation

Solar Generation



Coal and Natural Gas Generation

Energy Storage

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Utilities Looking for Solutions for the Electric Grid

http://integratedgrid.com/

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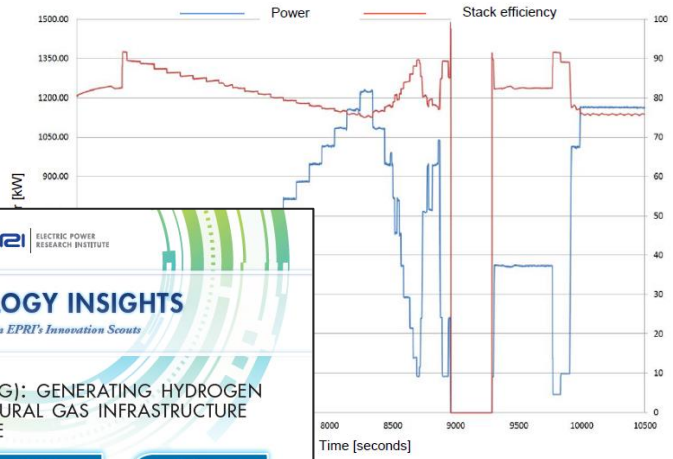
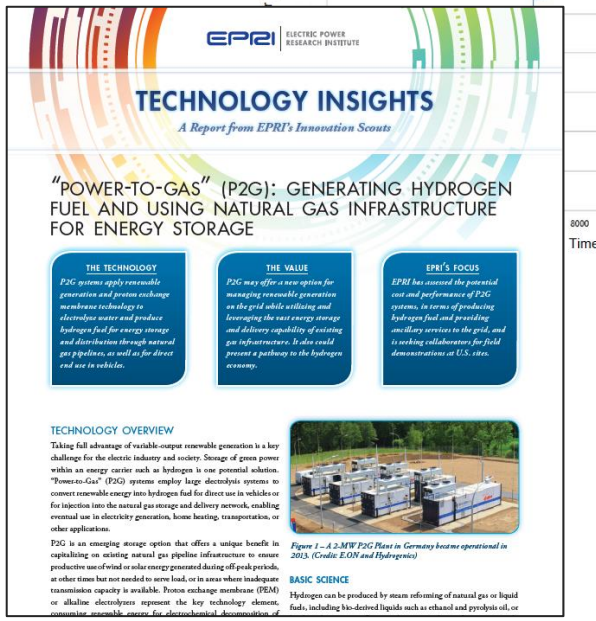
Recent EPRI Hydrogen Publications

- ***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

P2G systems apply renewable generation and proton exchange membrane technology to electrolyze water and produce hydrogen fuel for energy storage and distribution through natural gas pipelines, as well as for direct end use in vehicles.

THE VALUE

P2G may offer a new option for managing renewable generation on the grid while utilizing and leveraging the vast energy storage and delivery capability of existing gas infrastructure. It also could present a pathway to the hydrogen economy.

EPRI'S FOCUS

EPRI has assessed the potential cost and performance of P2G systems, in terms of producing hydrogen fuel and providing ancillary services to the grid, and is seeking collaborators for field demonstrations at U.S. sites.

TECHNOLOGY OVERVIEW

Taking full advantage of variable-output renewable generation is a key challenge for the electric industry and society. Storage of green power within an energy carrier such as hydrogen is one potential solution. "Power-to-Gas" (P2G) systems employ large electrolysis systems to convert renewable energy into hydrogen fuel for direct use in vehicles or for injection into the natural gas storage and delivery network, enabling eventual use in electricity generation, home heating, transportation, or other applications.

P2G is an emerging storage option that offers a unique benefit in capitalizing on existing natural gas pipeline infrastructure to ensure productive use of wind or solar energy generated during off-peak periods, at other times but not needed to serve load, or in areas where inadequate transmission capacity is available. Proton exchange membrane (PEM) or alkaline electrolyzers represent the key technology element, consuming renewable energy for electrochemical decomposition of

Figure 1 – A 2-MW P2G Plant in Germany became operational in 2013. (Credit: E.ON and Hydrogenics)

BASIC SCIENCE

Hydrogen can be produced by steam reforming of natural gas or liquid fuels, including bio-derived liquids such as ethanol and pyrolysis oil, or

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Together…Shaping the Future of Electricity

Questions or Comments?

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