

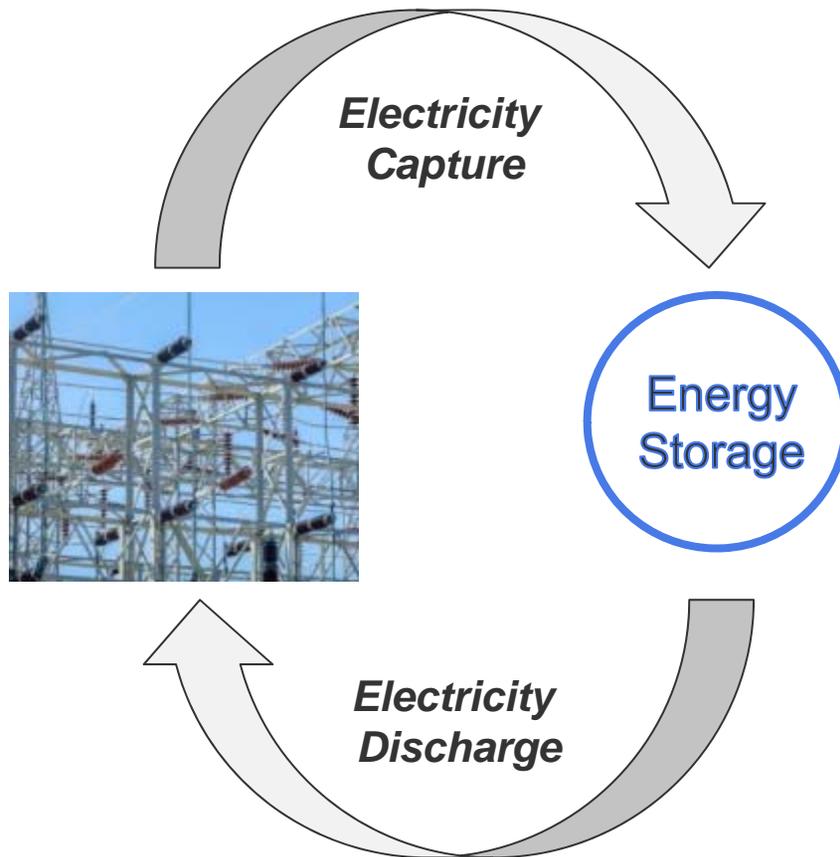
# Power-to-Gas: Utility Scale Energy Storage

Presentation to the  
Hydrogen and Fuel Technical Advisory Committee  
of the Department of Energy

Daryl Wilson  
Chief Executive Officer  
Hydrogenics Corporation

May 9, 2012

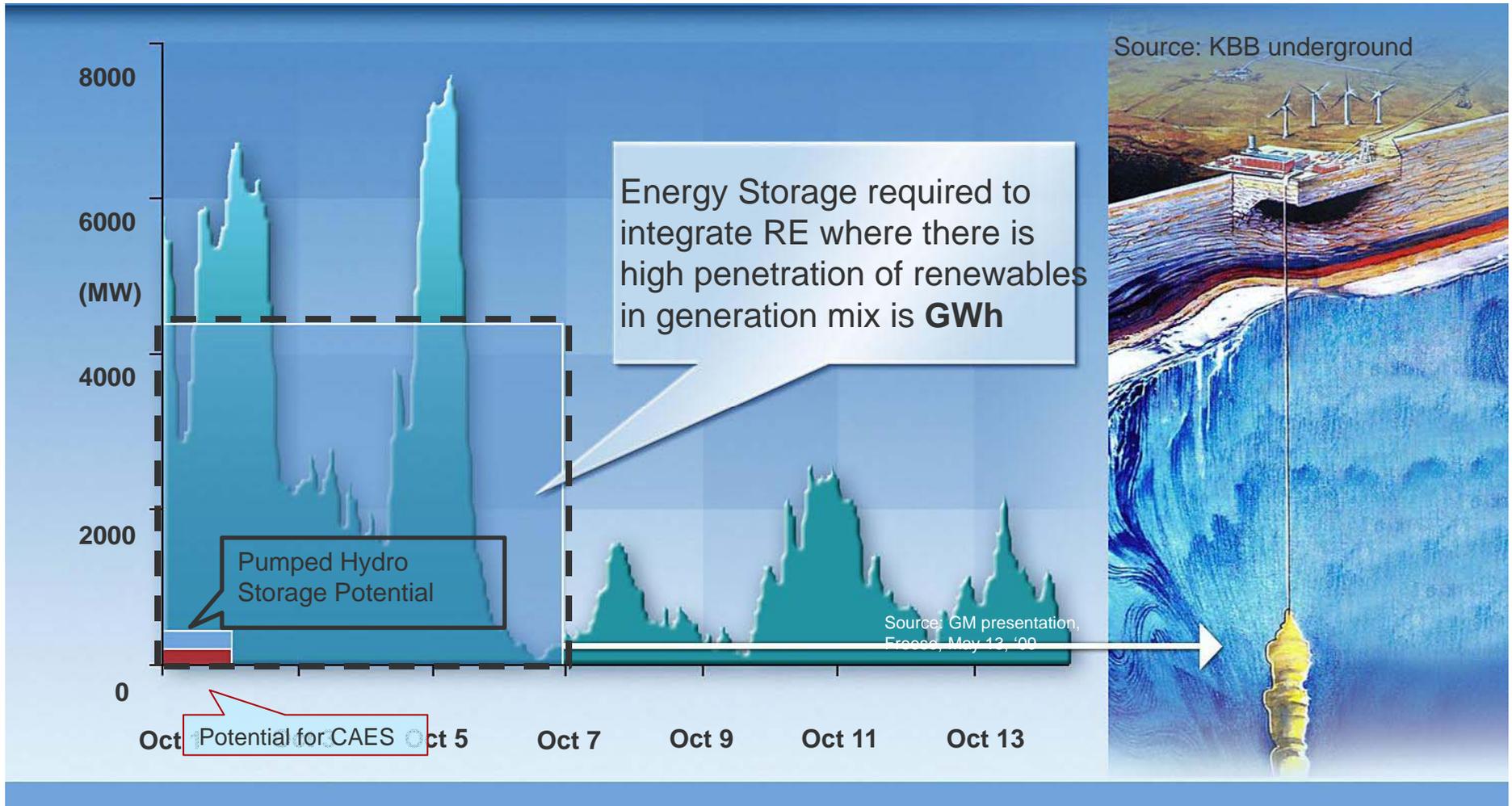
## The traditional measures for Energy Storage are Levelized Cost and Round-Trip Efficiency



### Traditional Metrics

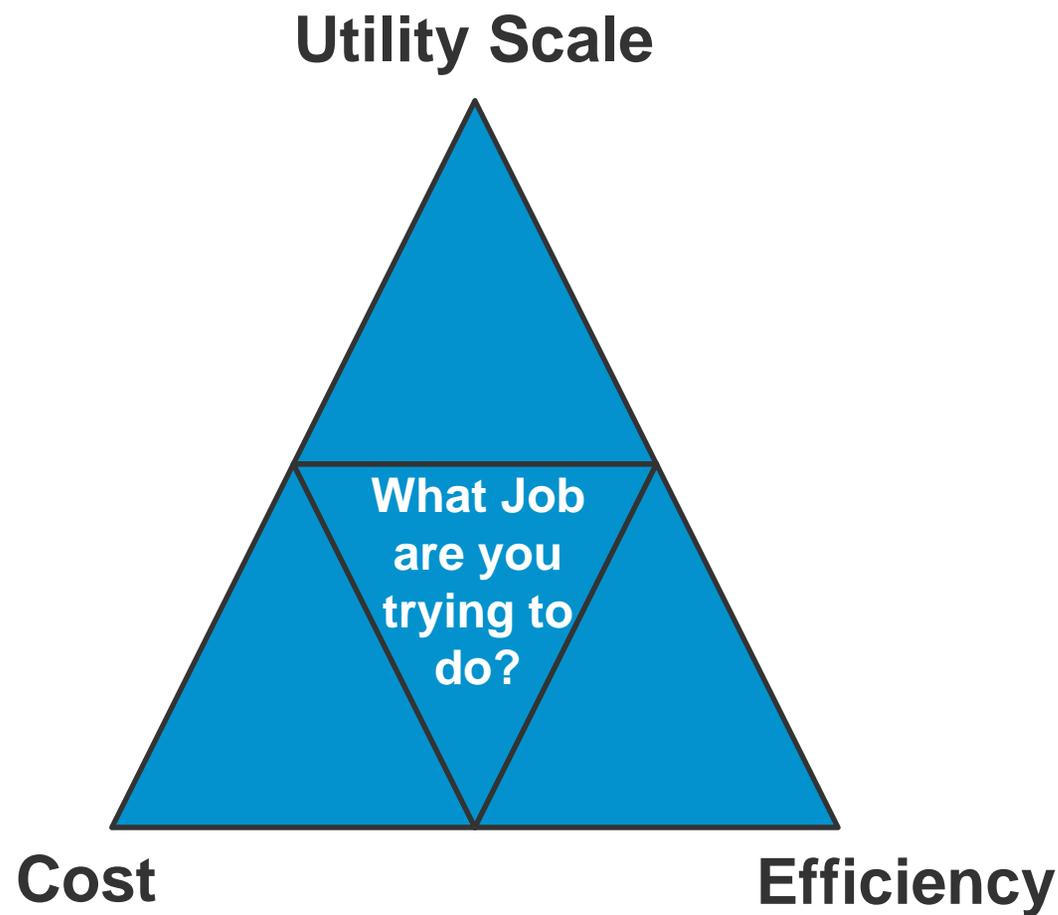
- Measure Round Trip Cycle
  - Full Charge
  - Max Practical Discharge
- Performance Drivers
  - Capital Cost
  - Conversion Efficiency
- Levelized Cost of Electric Energy (\$/kWh) has worked well for existing applications

## However, storage capacity is a larger driver for Renewable Generation Storage than efficiency



Only hydrogen offers storage capacity for several days or weeks

The job for a flexible grid asset is to absorb GWh of surplus RE while meeting utility ROI



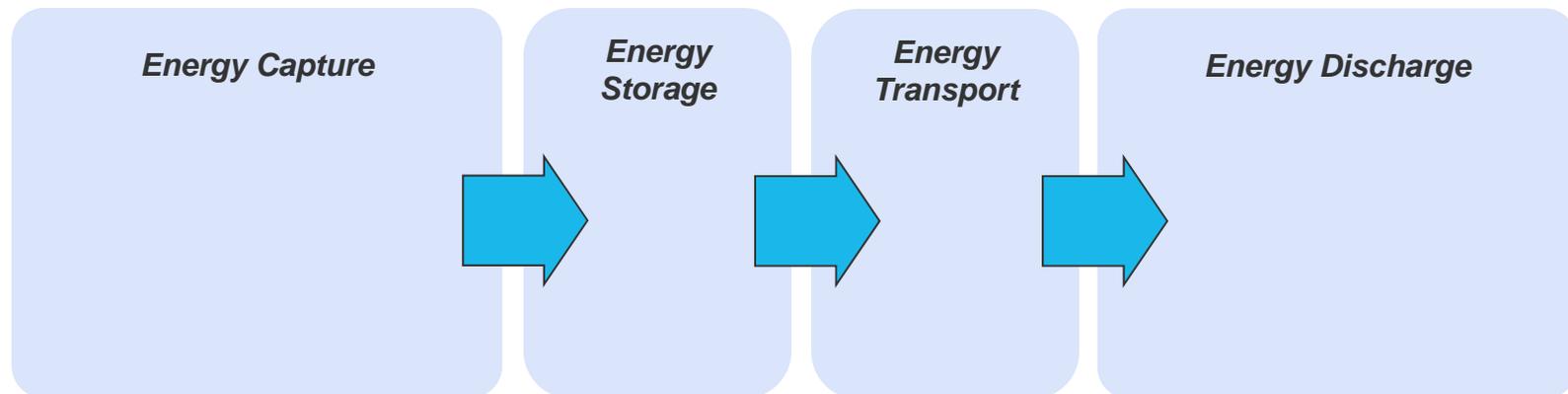
## What have we learned?

- Batteries
  - Scale limitations
  - Limited and indeterminate cycle life
- Sodium Sulphur
  - Safety and reliability concerns
- Compressed Air Energy Storage
  - Exploration and proving geology is expensive
- Pumped Hydro
  - Geographic limits on suitable sites

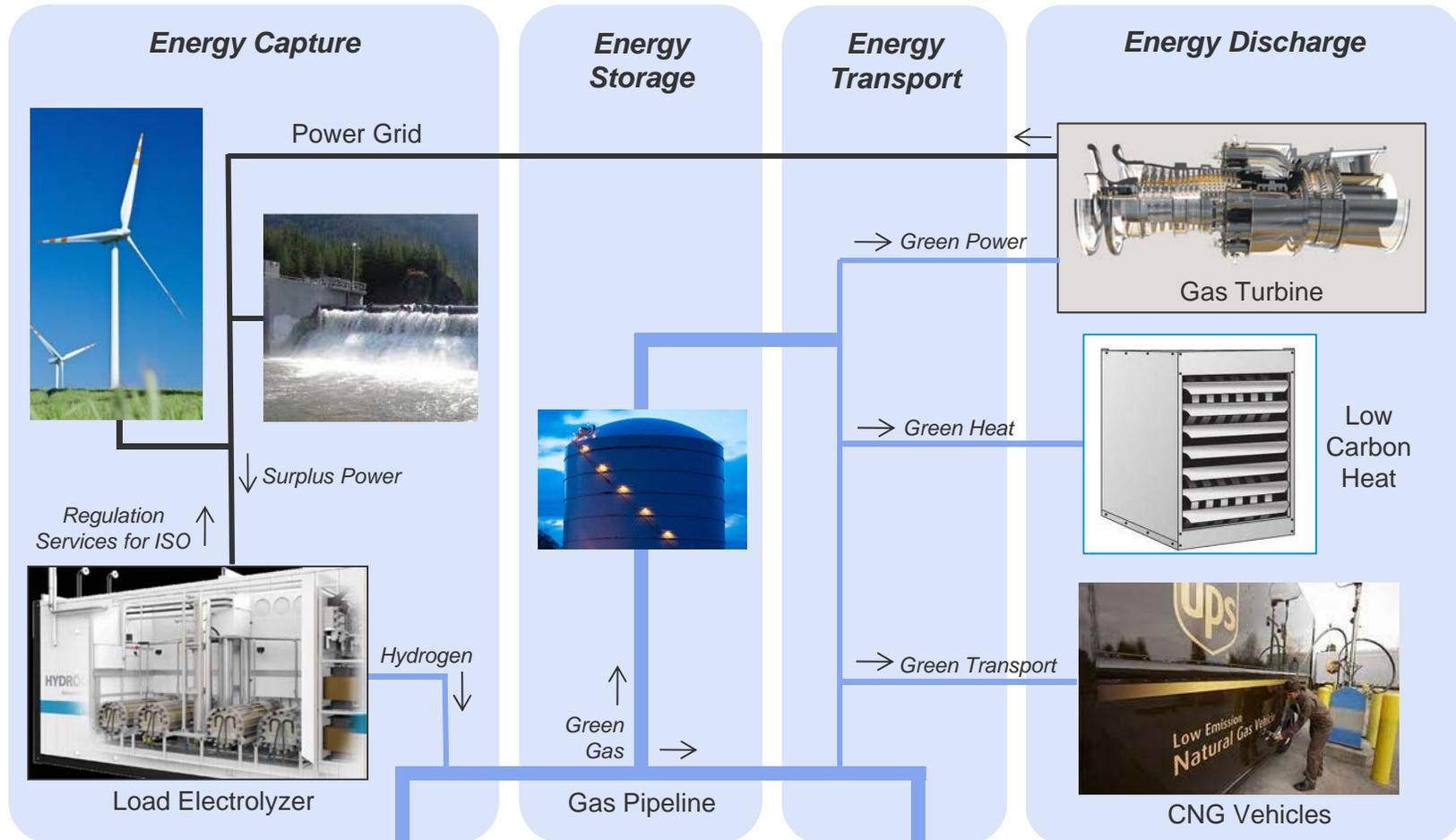
Power-to-Gas is a hybrid solution which:

- a) integrates renewable generation while helping to stabilize the grid,
- b) converts surplus renewable generation to hydrogen using electrolyzers,
- c) banks the energy using the existing natural gas infrastructure, and
- d) enables the discharge of the stored green gas at any time and place it is needed as gas turbine power, low carbon heat or CNG transport fuel

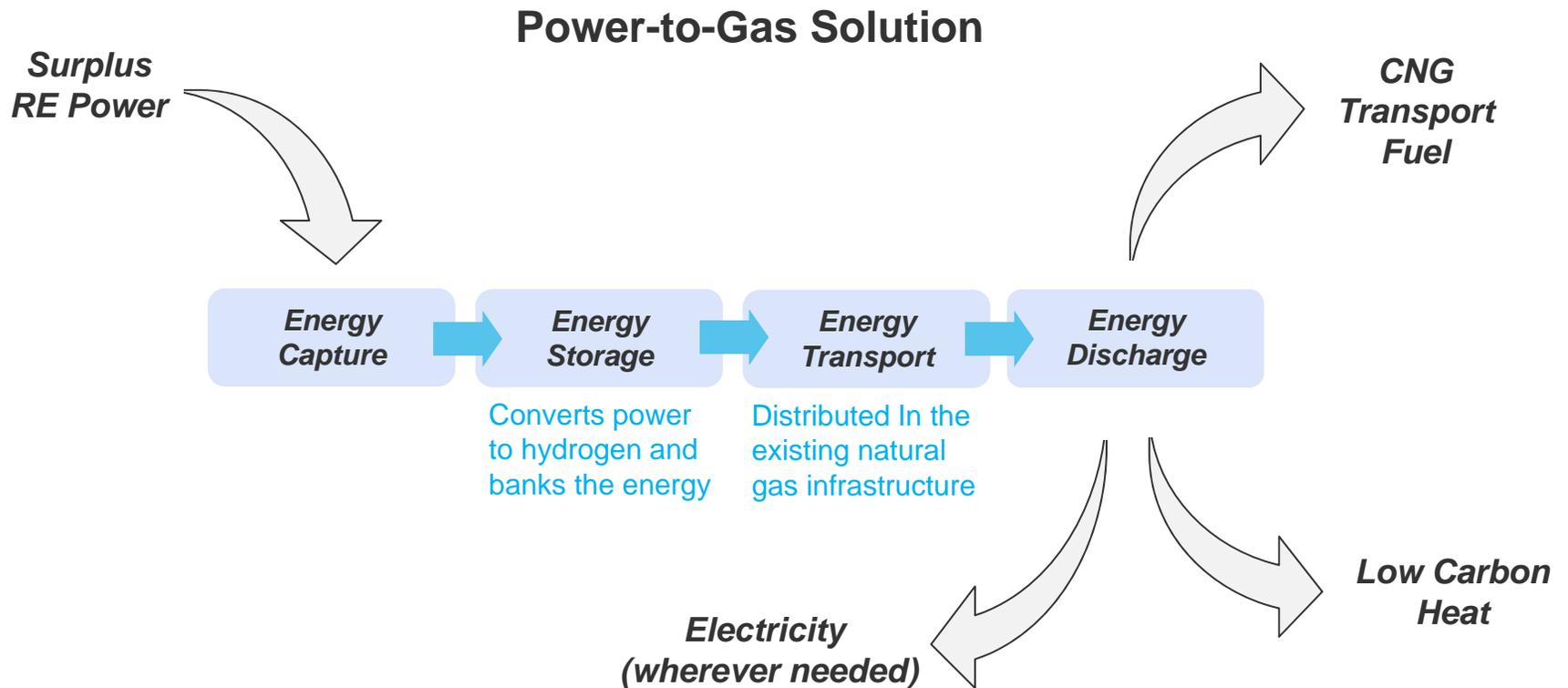
**Power-to-Gas Hybrid Solution**



## Power-to-Gas Hybrid Solution

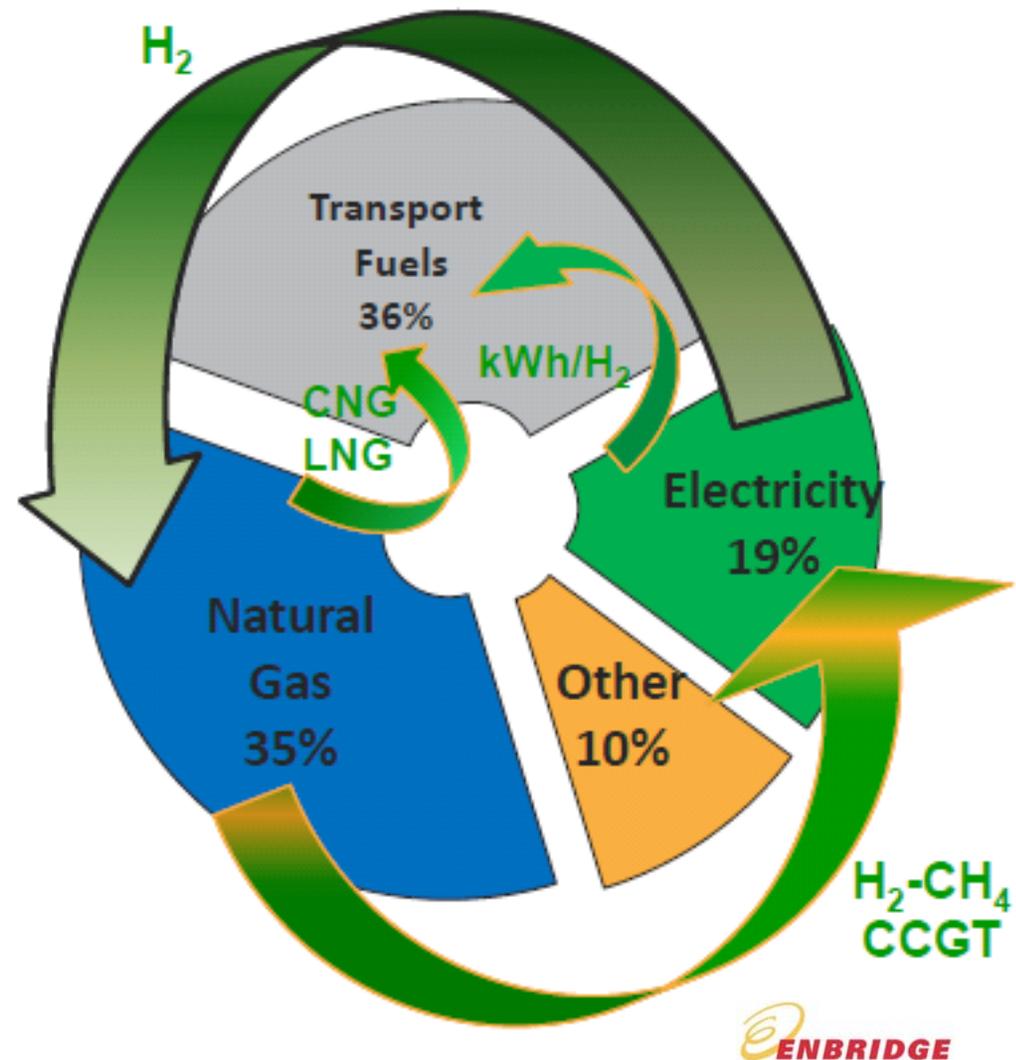


# Power-to-Gas represents a new Energy Storage paradigm



## Power-to-Gas

A Power-to-Gas Solution brings new economic and technology flexibility between the traditional energy silos of power grids, gas pipelines and transport



Source data: National Energy Board secondary energy demand forecast, Rethinking Energy Conservation in Ontario, May 2010 report

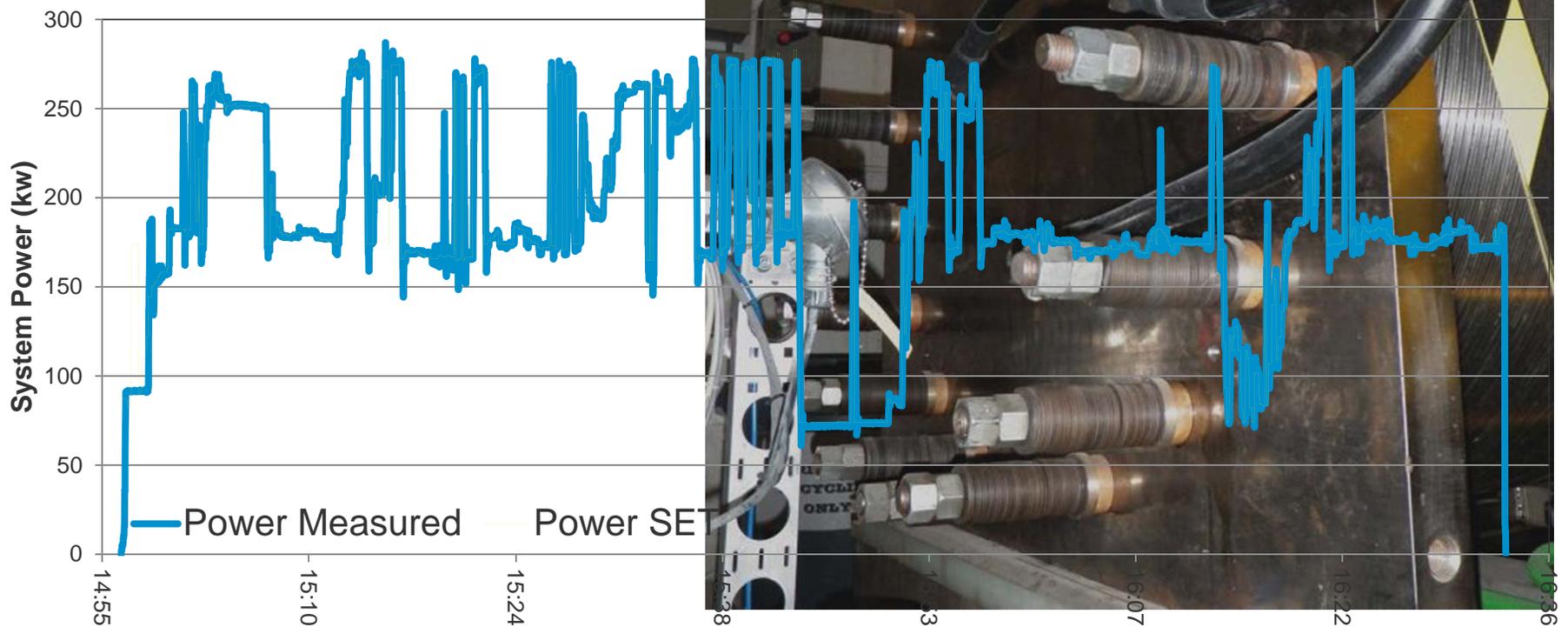
## Power-to-Gas is a scalable solution that offers virtually unlimited storage capacity and flexibility



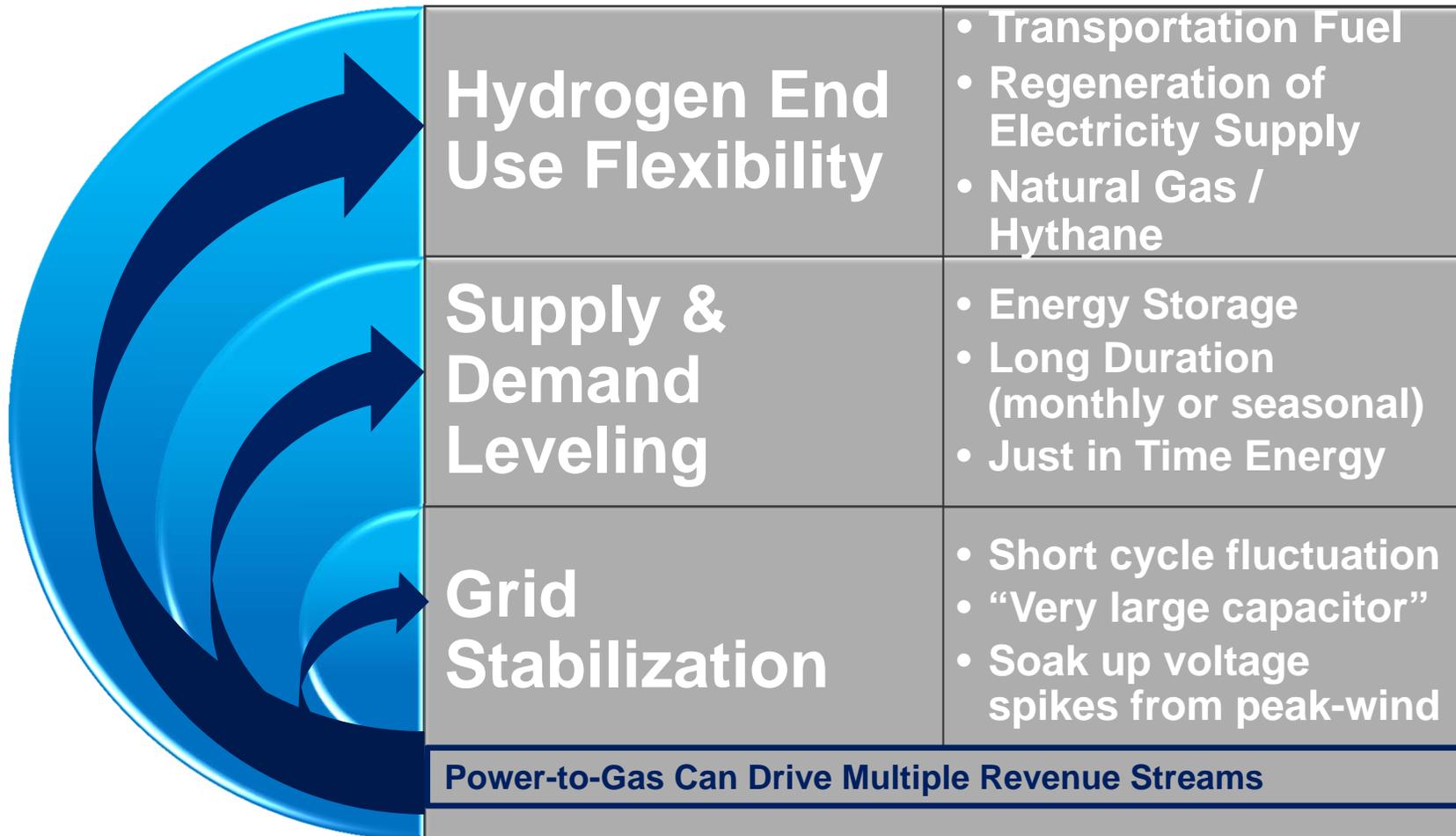
Batteries	Various technologies	Up to 60 MWh	Not applicable	• Power
Pumped Hydro	Hydro plant storage reservoir	Up to 60 GWh	Not applicable	• Power
Compressed Air Energy Storage	Underground cavern	Up to 7 GWh	Not applicable	• Power
<b>Power-to-Gas</b>	Anywhere both gas and electric supply available	Virtually unlimited short term and seasonal storage	Anywhere on gas or electric system network	<ul style="list-style-type: none"> <li>• Green Power</li> <li>• Low Carbon Heat</li> <li>• Green Transport</li> </ul>

*Uses existing third party assets;  
no additional investment required*

# Power-to-Gas electrolyzers also provide real time frequency regulation response (FERC Order 755)



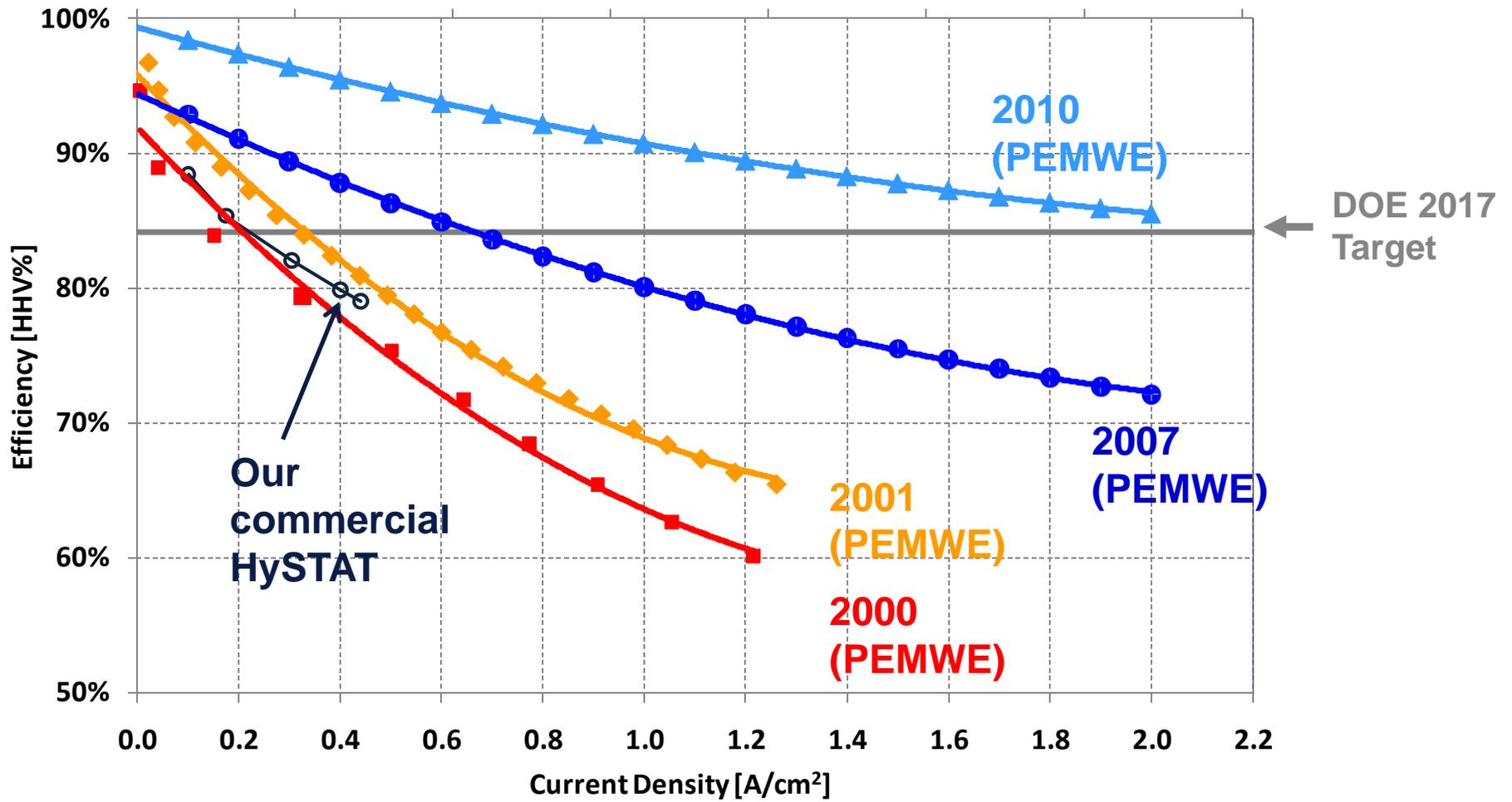
## A New Energy Storage Currency



## Highlights of Hydrogenics-Enbridge Agreement

- Purpose is to jointly develop utility scale energy storage projects in North America
  - Initial focus in Ontario
  - Hydrogenics has opportunity to participate in up to 50% ownership of Build Own Operate Power-to-Gas Projects
  
- Collaboration will bring together capabilities needed to develop Power-to-Gas projects
  - Hydrogenics' expertise in water electrolysis
  - Enbridge's expertise in operation of natural gas pipeline networks and renewable energy
  
- Under agreement, Enbridge has made CA\$5 million investment in Hydrogenics

# Hydrogenics brings leading hydrogen electrolysis technology





Source Image: Enbridge map library; www.enbridge.com

## About Enbridge

- World's largest liquid pipeline system
- Canada's largest natural gas distributor
- Substantial investment in North America's midstream natural gas assets
- Significant renewable energy footprint including wind, solar, geothermal, fuel cells and waste heat to power
- Approximately 6,900 employees
- One of the Global 100 Most Sustainable Corporations
- Traded on the Toronto and New York exchanges (Symbol ENB)

## Next Steps

- Detailed dynamics study of Power-to-Gas
- Discussion paper to differentiate unique attributes of value of Power-to-Gas solution
- EPRI – NREL – DOE – HUG cooperative project to create an Implementation Road Map
- 10MW Power-to-Gas Demonstration Project

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