

Advanced Power Controls &

Hydrogen Hybrid Microgrids (HHMs)

... **With Thermal Storage**

Resilient Power Works!



NATIONAL ENERGY TECHNOLOGY LABORATORY
Albany, OR • Morgantown, WV • Pittsburgh, PA



All Testing and Laboratory Work Performed using a Cyber-Physical System at the HyPer (Hybrid Performance) Lab at NETL Morgantown, WV.

Research using the HyPer Facility has identified:

- Control Methods Enabling Extensive Turn-down Capabilities
- Fuel Composition Flexibility
- A potential 10-fold Increase in Component Lifetime

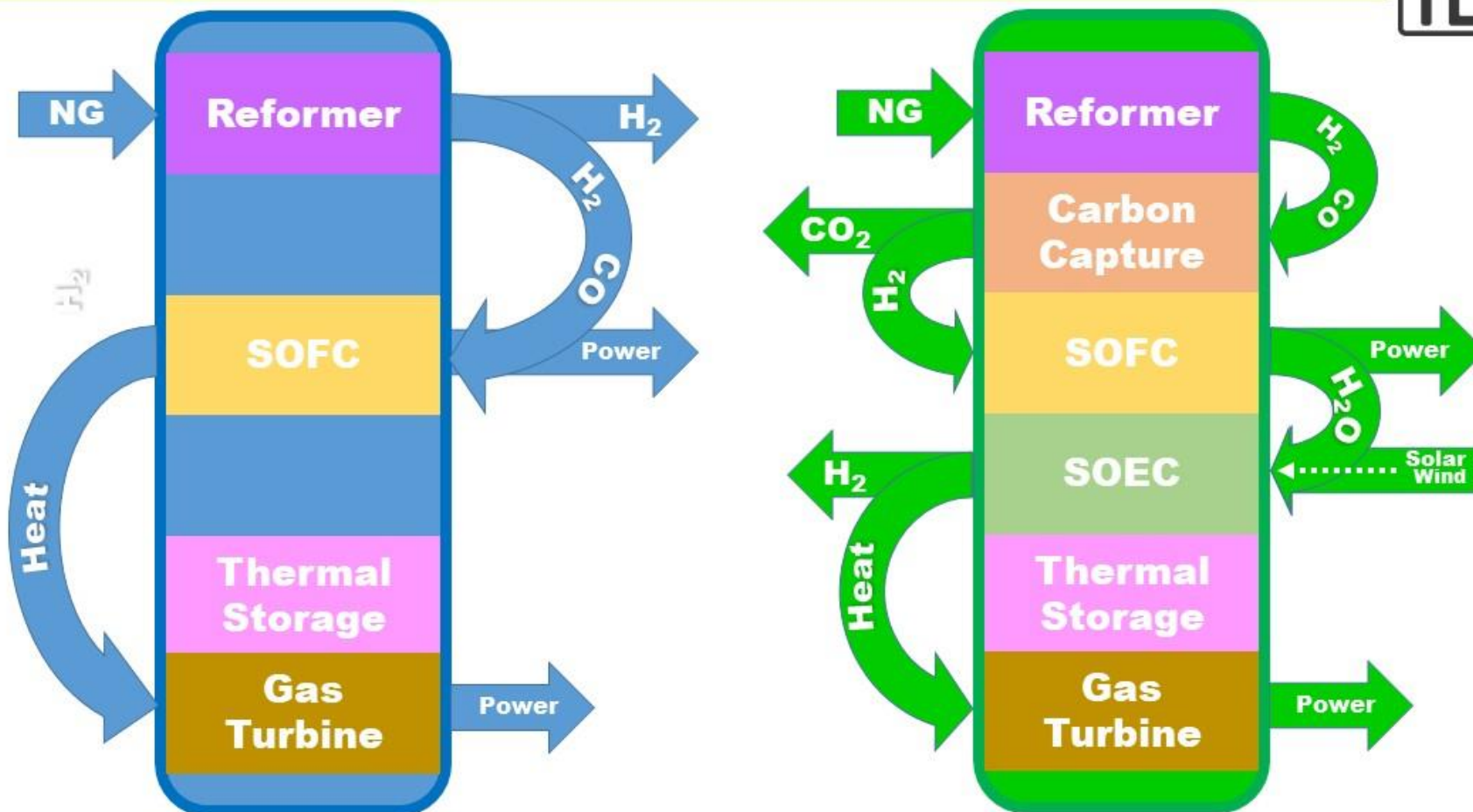


NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY

- HYDROGEN “BLUE” & “GREEN”
and now... “Dr. Tucker’s Turquoise”
- HYBRID SOFC, NG TURBINE & REFORMER
- MICROGRIDS

APPLICATIONS & CONTROLS

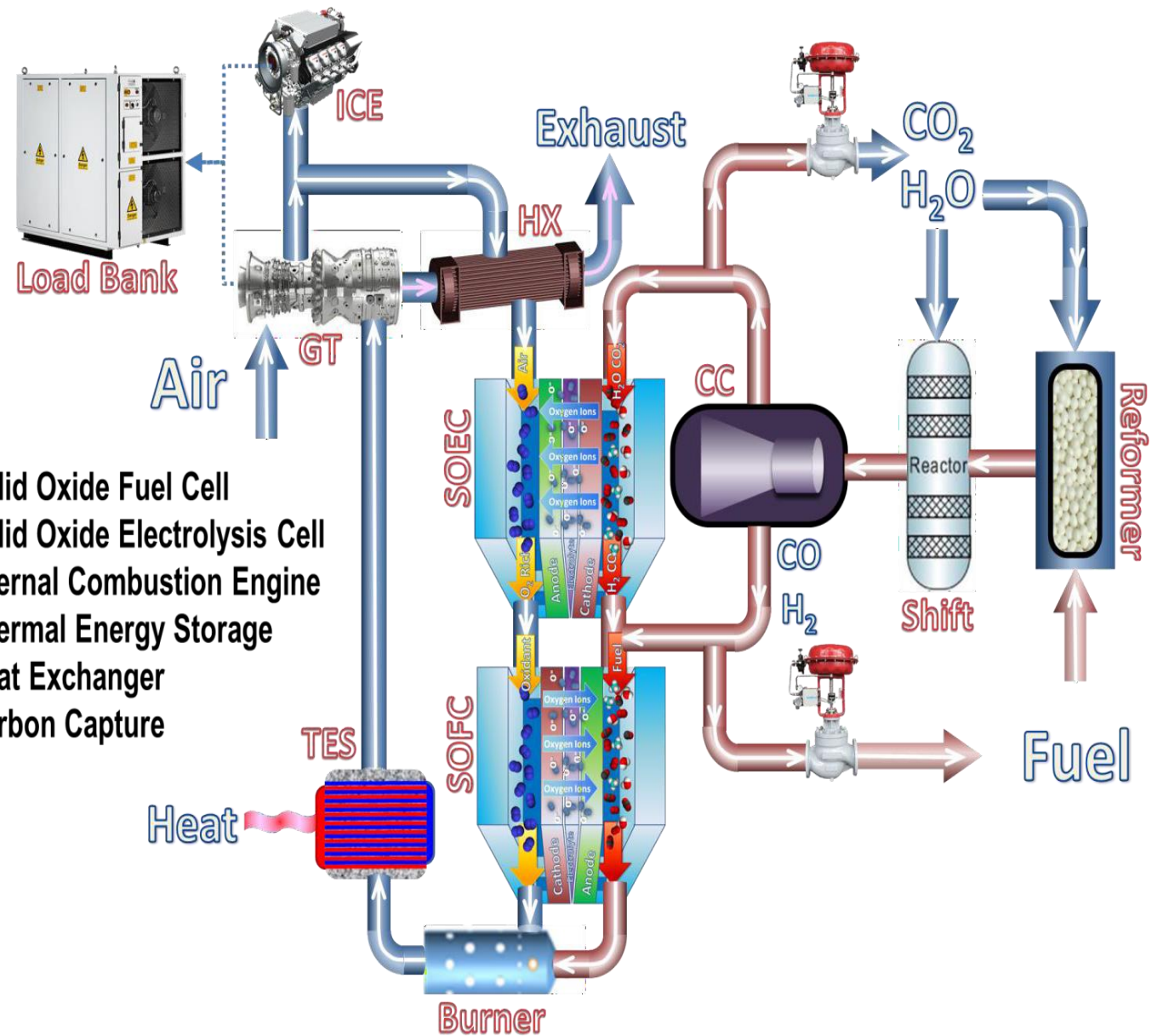
Turquoise Hydrogen



- **Our Focus: ADVANCED POWER CONTROLS**
Precision Power Platform™ (PPP)
- **Supervisory (SCADA), Dynamic & Cyber-Security Control Elements**
- **Before-the-Meter & Utility-Side Applications**
- **PPP for one or more Networked Microgrids**
- **SCALABLE-100kw+**
- **FLEXIBLE – Hybrid w/ or w/o renewables**

On Demand Produced On- Site

SOFC- Solid Oxide Fuel Cell
SOEC- Solid Oxide Electrolysis Cell
ICE- Internal Combustion Engine
TES- Thermal Energy Storage
HX- Heat Exchanger
CC- Carbon Capture



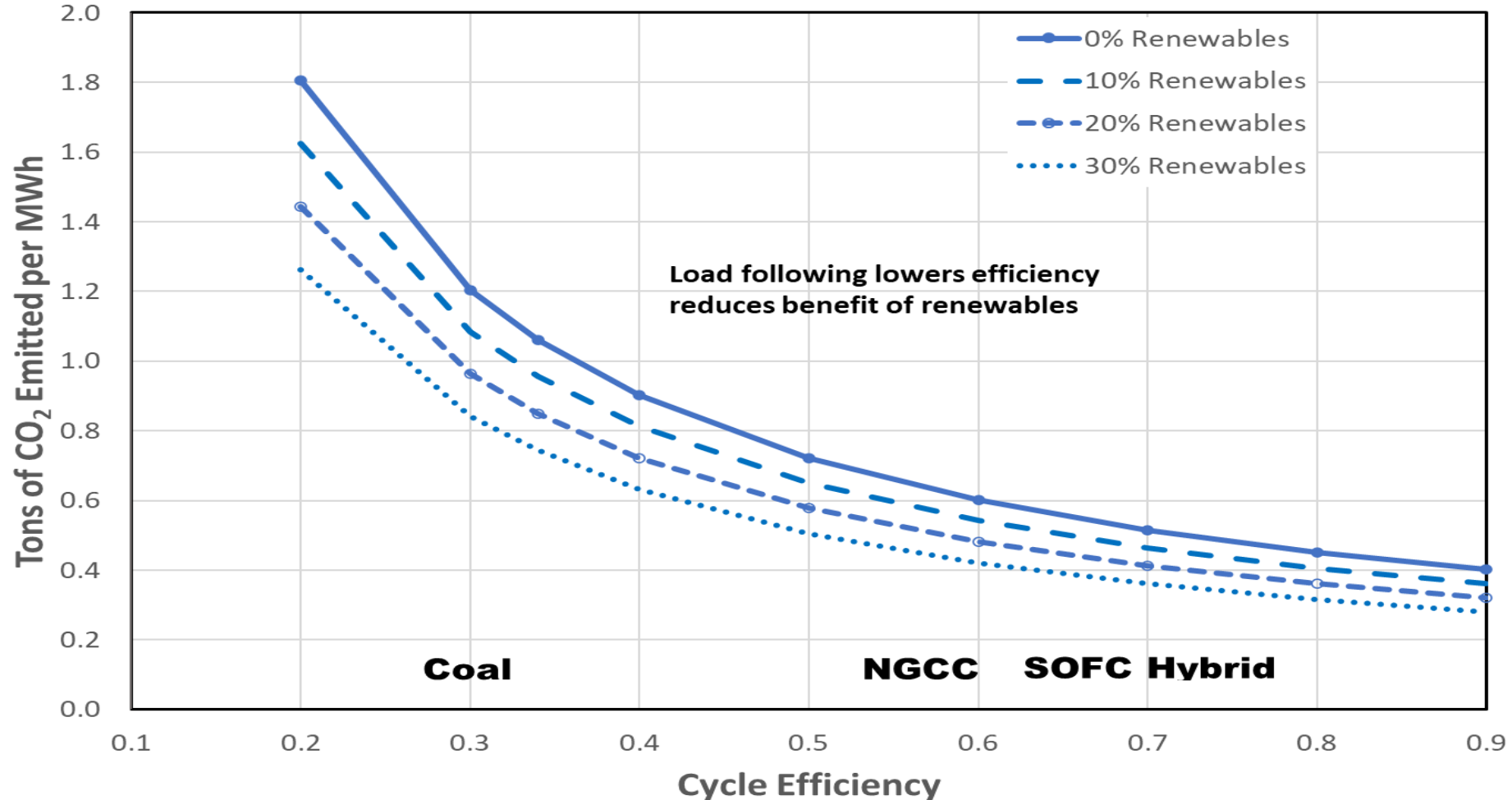
Key features of the HHM model are:

- Potential turndown ratios of 90% or more
- Fast ramp rates allow rapid transitions for load following capabilities
- Extend SOFC life by up to 7-times: enhanced ROI

HHM makes an economically viable transition to a clean hydrogen-based distributed generation future.

Making the Transition to a Cleaner Grid

Impact of Efficiency and Renewables on CO₂ Emissions



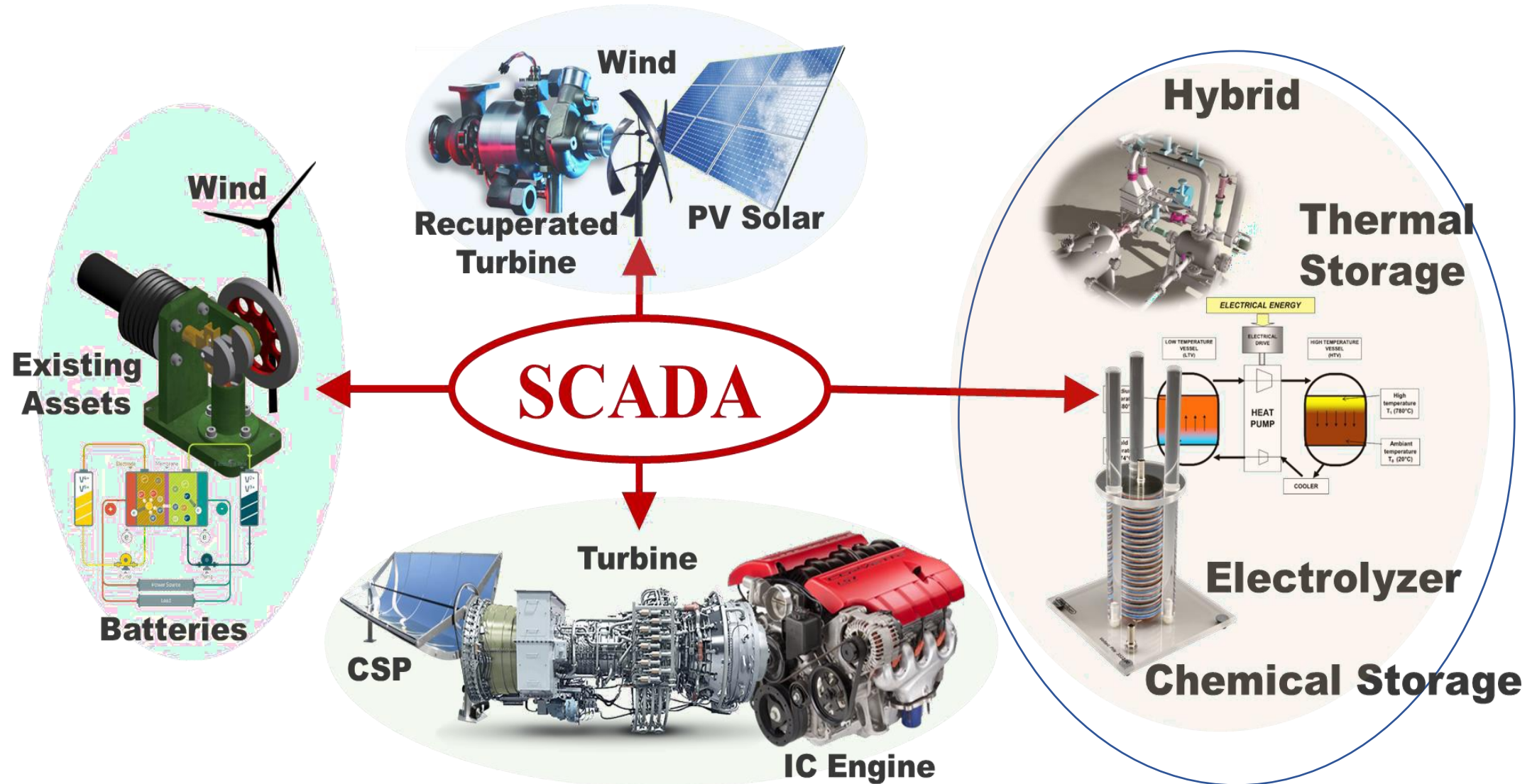
Applying Hydrogen-Hybrid Microgrid Models:

- Grid-tied and Stand-alone (Islanded)
- 2 functions: electricity only & CHP

Areas Requiring Additional Research:

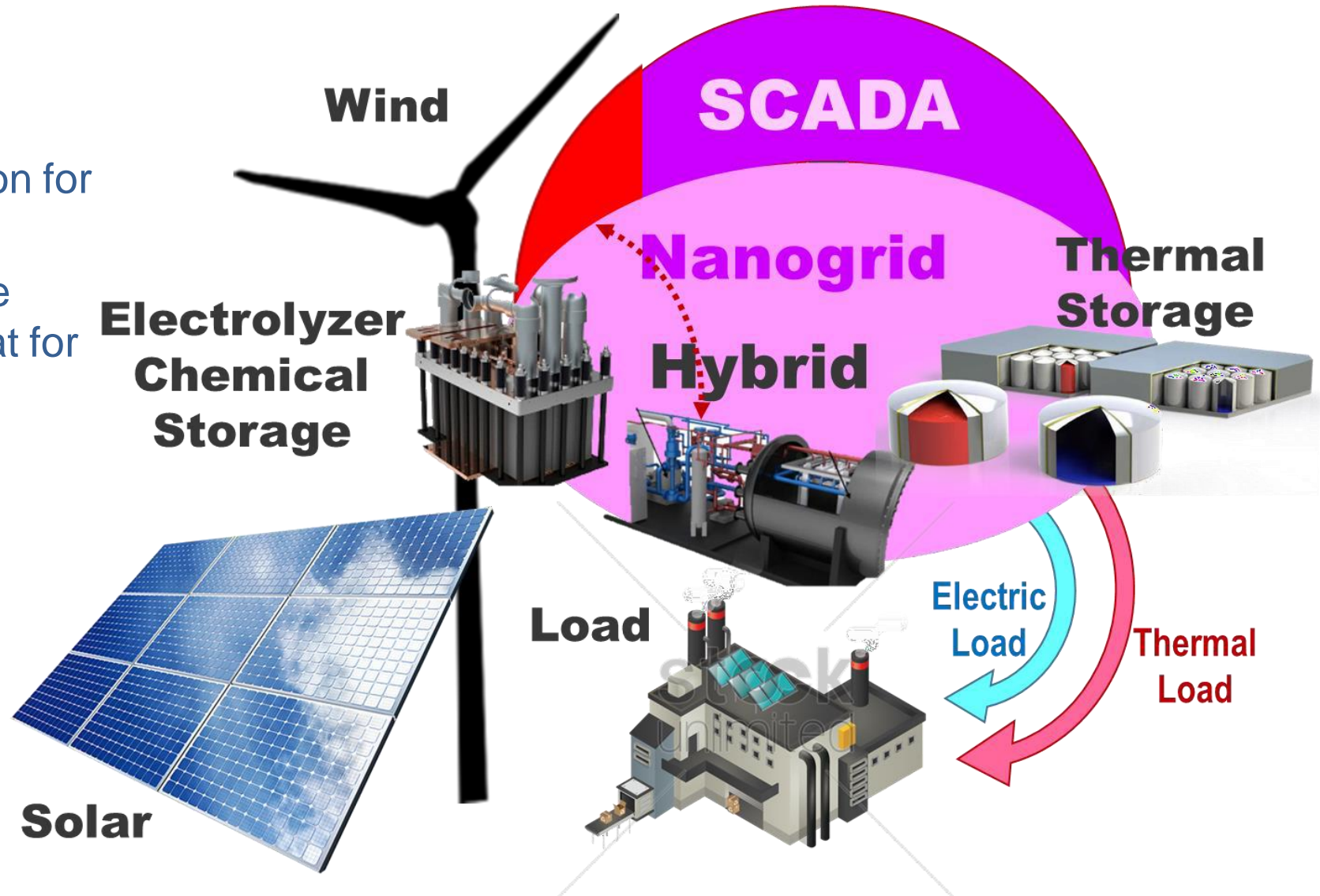
- Load Following for a More Resilient Grid
- Increased Compressor Efficiency
- Increased Stability at Higher Efficiencies

Smart Microgrid Design Utilizing the PPP



Smart Microgrid Design Integrated with the PPP

- ✓ Chemical Storage using an electrolyzer with fuel conversion for high energy density
- ✓ Thermal Storage for low-grade heat loads and high-grade heat for electric transients
- ✓ Hybrid System for dynamics and transient load conditions
- ✓ Intermittent wind and solar Integrated with dispatchable assets

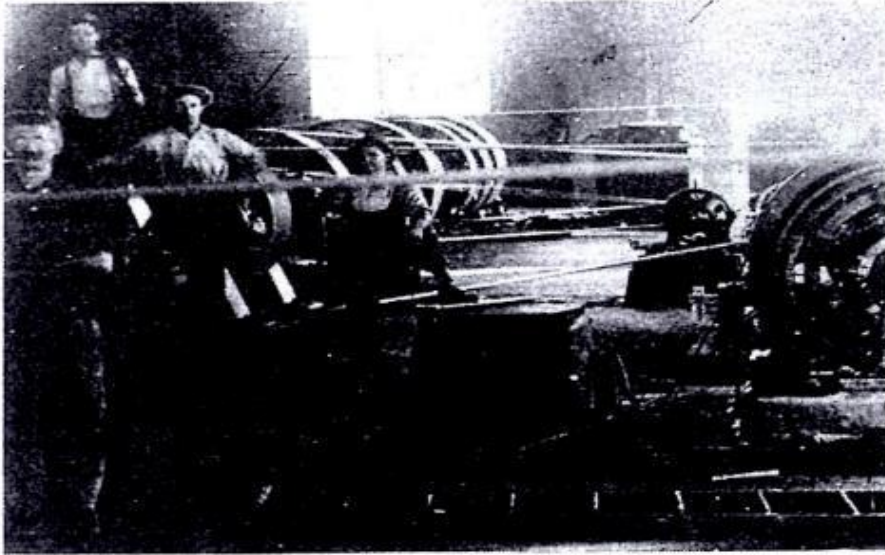


THANK YOU FOR YOUR TIME....

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Equipment and personnel at the H. & F. Railway Company plant at Lee and Summit Streets in Hagerstown in the early 1900's.



And Reddy is already planning for a big electrical future here. New generating units, new power lines, new facilities to help you Live Better...Electrically.

THE POTOMAC EDISON COMPANY

**SERVING THIS
GROWING COMMUNITY
SINCE 1896**

**WITH CHEAP and AMPLE
ELECTRIC POWER**

The Hagerstown and Frederick Railway Co. (a predecessor of The Potomac Edison Co.) purchased Hagerstown's first light plant in 1896.

Since this small beginning, P.E.'s electric power facilities have grown until today when 21 sources of power are now available to customers in this area.