Hydrogen Energy Research Operation (HERO)

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GTI Energy

Outline

- End State and Mission
- 2-Phase Project Plan
- Preliminary Framework for Prototype System Assessment
- Summary

End State

Demonstration of
a **Viable Framework** for
Designing and **Deploying Hydrogen-Based**
Resilient Energy Systems
that can be **Replicated Globally**

Mission : Resiliency

How?

- Incorporation of integrated hydrogen-based systems at DoD facilities

Comprising?

- Systems that are site-specific and span the value chain:

Source → Generation → Delivery → Storage → End Use

Why?

- Ensure continuity & protection of critical missions, capability & infrastructure

Mission : Resiliency

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What?

14 days of energy supply for people and processes in support of critical missions without negatively impacting water resiliency

Mission : Resiliency

“When the duration of the critical mission(s) has not been stipulated, the Army will plan to sustain energy and water for a minimum of 14 days.”

- Army Directive 2020-3 (Installation Energy and Water Resiliency Policy)

SECRETARY OF THE ARMY
WASHINGTON

3 1 MAR 2020

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Army Directive 2020-03 (Installation Energy and Water Resilience Policy)

1. For references, see enclosure 1. For definitions, see enclosure 2.

2. Purpose. This directive issues policy to strengthen energy and water resilience to reduce the risk to Army missions posed by utility disruptions affecting installations. This directive supersedes Army Directive 2017-07 (Installation Energy and Water Security Policy) and revises provisions in chapter 22 of Army Regulation (AR) 420–1 (Army Facilities Management). The directive also assigns the roles and responsibilities of Headquarters, Department of the Army Principal Officials; commanders and senior Army officials responsible for Army commands, Army service component commands, and direct reporting units; commanders of landholding commands; and senior and garrison commanders.

3. Background. Secure and reliable access to energy and water on Army installations is essential to the Total Army and its ability to deploy, fight, and win in a complex world. Threats, both man-made and natural, associated with the interdependent electric power grids, natural gas pipelines, and water resources and systems can jeopardize mission capabilities. The Army must identify and mitigate vulnerabilities and ensure installations can continue critical missions through any disruption of utility services. Resilient energy and water systems directly affect the success of the strategic support area in multi-domain operations.

4. Applicability. This directive applies to the Regular Army, Army National Guard/Army National Guard of the United States, and U.S. Army Reserve. It also applies to tenants on active Army installations.

5. Policy. This directive establishes energy and water resilience requirements for Army installations in support of the 2018 National Defense Strategy and Army Vision. To reduce mission risk, the Army will prioritize providing resilient energy and water supplies, facilities, and infrastructure that support critical missions. The Army will reduce risk to all other missions when it is life-cycle cost-effective. Army real property affected by this policy are installations, sites, and facilities operated and/or maintained by Federal funds in and outside the continental United States. This policy does not apply to Army contingency bases or U.S. Army Corps of Engineers civil works facilities.

a. The Army will sustain critical missions by being capable of withstanding an extended utility outage for a duration set by the senior commander or higher

https://www.asaie.army.mil/sites/default/files/PDF/ARN21644_AD2020-03_Web_Final.pdf

IL ARMY NG Installation Energy and Water Plan

- 26 Facilities in IL reviewed
- Focus : Resiliency
  - Electricity and Natural Gas supply and ability to sustain critical missions in event of a disruption to either
- Partner : ILARNG North Riverside Site

ILARNG IL- Installation Energy and Water Plan

August 1, 2022

Prepared with support from Ross & Baruzzini under contract with the Office of the Deputy Assistant Secretary of the Army for Energy & Sustainability.

2-Phase Project Plan

PHASE 1
Prototype Equipment Identified, Installed & Tested at GTI Energy

PHASE 2
Prototype Designed, Installed & Commissioned at DoD Site

Task 4
Virtual Reality Training & Outreach
3Q’24-2Q’25

Phase 1:

- Task 1 – Installation Priorities – 2Q-3Q’23
- Task 2 – **Technology** Selection – 3Q-4Q’23
- Task 3 – Design, Testing & Digital Twin – 1Q’24-1Q’25

Phase 2:

- Task 1 – Site-Specific Planning and Engineering – 2Q’25-1Q’26
- Task 2 – Equipment Procurement – 3Q’25-2Q’26
- Task 3 – Construction, Installation, Commissioning – 4Q’25-4Q’26
- Task 4 – Training & Operations – 1Q’26-1Q’27

End State

(Timeline refers to Calendar Year)

General Framework for Tasks 1 and 2

Methodology

1. Quantitative threat (probability and severity assessment)
2. Baseline assessment of installation resiliency metrics
3. Assessment of resiliency metrics of proposed improvements

References

B.Morton, R.Liesen, M.Case, M.Wallace, B.Oberg and A.Zhivov, "The Energy Resilience of Interacting Networks (ERIN) Tool for Resilience Planning in Cold Climates," ASHRAE and SCANVAC HVAC Cold Climate Conference 2023.

A.Zhivov, "International Energy Agency Energy Master Planning for Net-Zero Energy Resilient Public Communities Guide (Annex 73) : Project Summary Report," May 2022, annex73.iea-ebc.org/publications.

Modified Framework for Tasks 1 and 2

1. Quantitative threat (probability and severity assessment)
   - Typically created by the Directorate of Plans, Training, Mobilization & Security
   - Replaced with definition of "Disruption Scenarios"
2. Baseline assessment of site and establishment of a monitoring plan
3. Identification of equipment options for prototype system
4. Development of H_2 safety plan for off-site evaluation
5. Assessment of prototype system configuration options
   - Requires definition of appropriate metrics
6. Design prototype system for off-site evaluation
7. Develop Digital Twin of the prototype system

1. Disruption Scenarios

- **Loss of Electrical Grid**
  - Most common disruption for North Riverside
- **Loss of Everything**
  - Loss of Electrical Grid
  - Loss of Municipal Natural Gas Supply
  - Loss of Municipal Water Supply
  - Loss of Sufficient Sunlight
  - Loss of Wind
  - Loss of Transportation to/from Site

2. Baseline Site Assessment & Monitoring Plan

- **Topics**
  - Energy usage
  - Equipment
  - Monitoring schemes
  - **Data acquisition and Instrumentation**
  - **Planned new monitoring equipment**
  - Data recording procedures
  - Data quality assurance and validation
  - Contingency plans for data loss
- **Equipment**
  - Boilers
  - Water heaters
  - Makeup air units
  - Dual-fuel gas generator
  - Cooking equipment
  - Air conditioner condensers
  - Mobility

Examples for Makeup Air Units (MAUs)

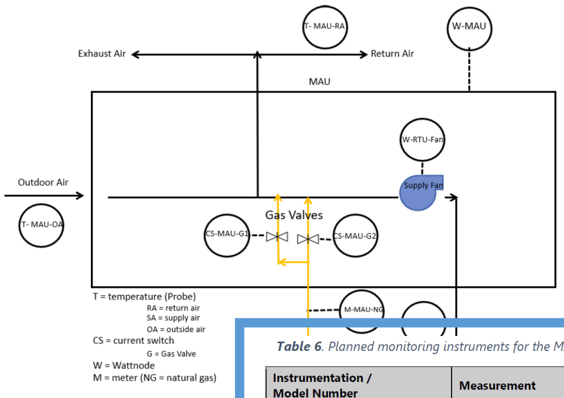
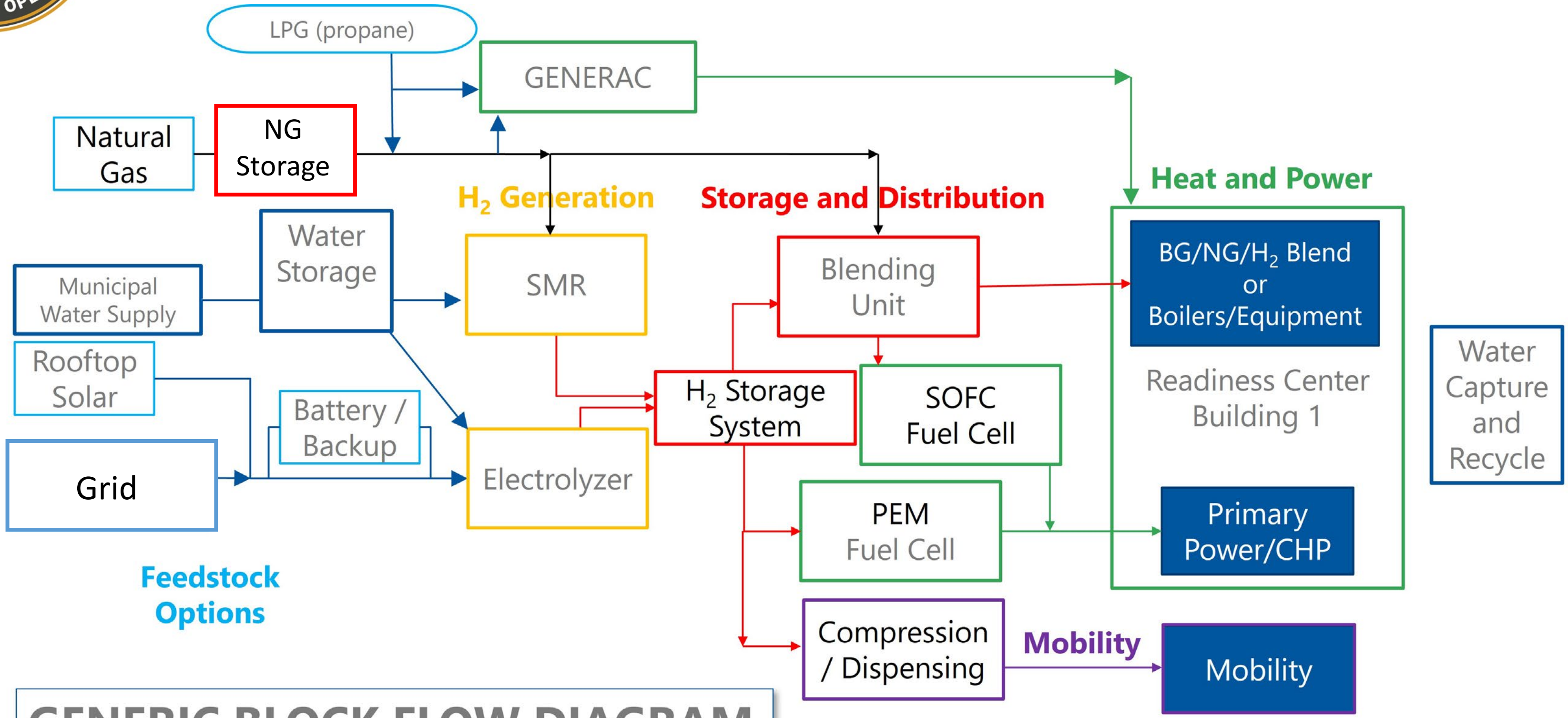


Table 6. Planned monitoring instruments for the MAU (to be installed as part of this project)

Instrumentation / Model Number	Measurement	Accuracy	Units	Signal Type
Natural gas meter (M-NG) Honeywell Rotary Gas Meter RABO 3.5M	MAU gas consumption	1 pulse per 1 cf	cubic foot	digital
Current switch (CS-MAU-Fan) Setra CSCGFN015NN	MAU fan runtime	Fixed 0.15 A setpoint and 0.15 to 200 A range	N/A	digital
Wattnode Pulse (W-MAU) Continental Control Systems WNB-3D-240-P with 3 ACTL-0750-100 Current Transformers	MAU total electrical consumption	0.5% nominal	Wh	digital
Type T thermocouple (T-MAU-OA) Omega 5TC-TT-T-24-120	Outside air temperature (surface thermocouple)	± 1°F	°F	analog
Type T thermocouple (T-MAU-SA) Omega 5TC-TT-T-24-120	Supply air temperature (surface thermocouple)	± 1°F	°F	analog
Type T thermocouples(T-MAU-RA) Omega 5TC-TT-T-24-120	Return air temperature (surface thermocouple)	± 1°F	°F	analog

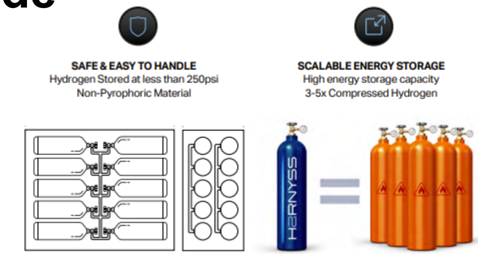
3. ID of Prototype System Equipment Options

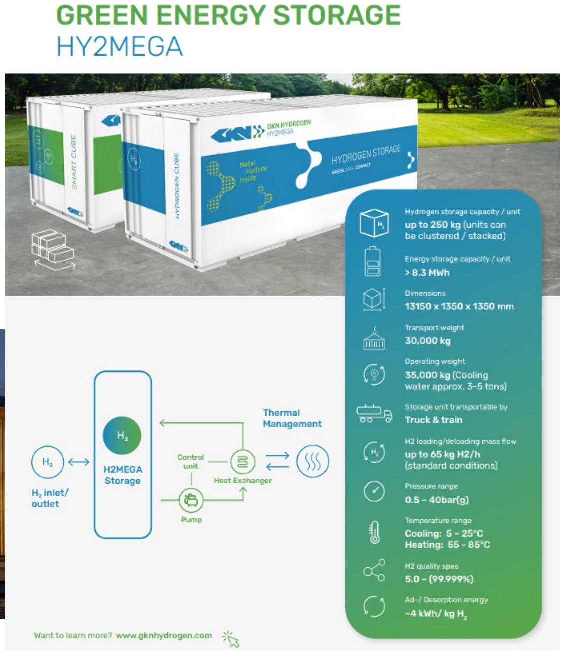


GENERIC BLOCK FLOW DIAGRAM

3. Example : Metal Hydride Based Storage

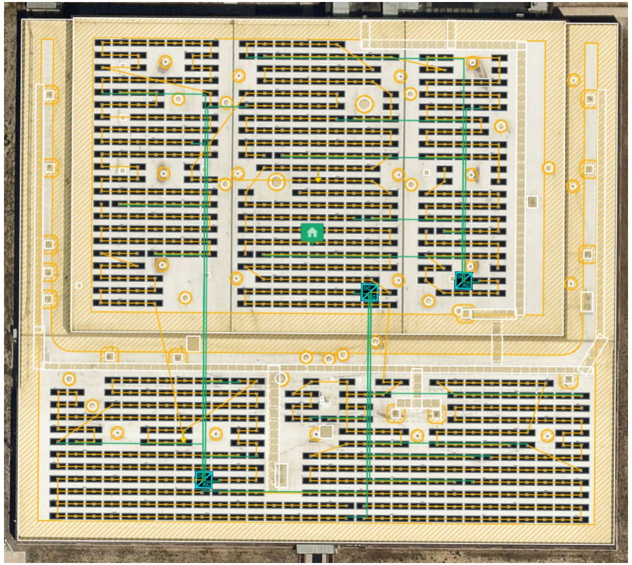
- **Reasoning to Study Metal Hydride**
  - Safety Considerations
    - Lower pressure than GH2
    - Higher Temperature than LH2
  - Potential lower footprint
  - Potential energy savings benefits
- **Commercial Options**
  - GKN Hydrogen
  - Harnyss
  - LAVO
- **Key Evaluation Criteria**
  - Commercial Availability in the USA
  - Technology Maturity
  - Performance envelope / flexibility
  - System costs



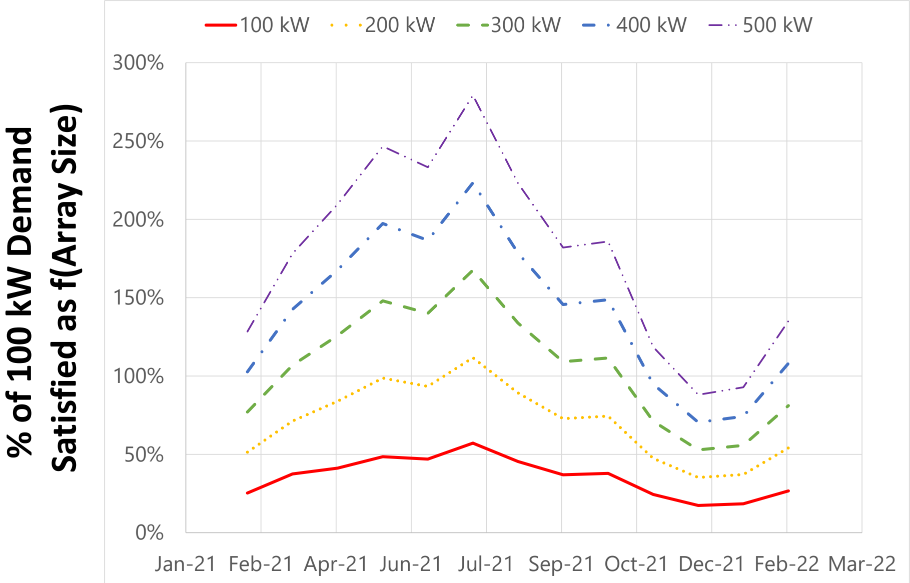


3. Example : Solar

334 kW Solar Photovoltaic Array on Readiness Center Roof



Rooftop Solar Required
to Minimize Footprint



Estimates made with NREL PVWatts
(pvwatts.nrel.gov/pvwatts.php)

4. H_2 Safety Plan for Off-Site Assessment

- **Scope**
  - Focus = Phase 1 at GTI Energy
  - Phase 2 at IL AR NG in mind
- **Example : RMP Rule 40 CFR 68**
  - 10,000 lb_m EPA "threshold quantity" limit for H_2
  - Phase 1 : Limit won't be exceeded
  - Phase 2 : Limit could be exceeded

Table 1. Draft H_2 Safety Plan Contents

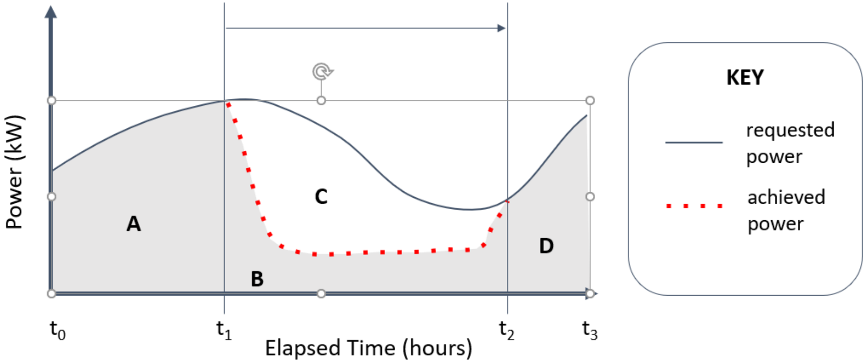
Section	Contents
1	Scope and Description of Work
2	Roles and Responsbilities
3	Organizational Policies and Procedures
4	Identification of Safety Vulnerabilities
5	Hydrogen Properties and Behavior
6	Process Safety Controls
7	Emergency Preparedness and Response
8	Training and Education
9	Safety Reviews : Startup, Maintenance, Inspection and Auditing
10	Code & Regulation Compliance
11	Management of Change
12	Accident Investigation & Lessons Learned
13	References, Appendices, and Supporting Documents

5. Assessment of Prototype Options : Metrics

- **Resiliency**
  - Minimum = 99.9%
  - Downtime over 14 days = 20 min : 10 s
- **Sustainability**
  - kg $CO_{2,eq}$/kWh
- **Footprint or Areal Power Capacity**
  - ft^2 or kW/ft^2
- **Installed Cost**
  - $/kW

Key : Understanding the impacts of incorporating hydrogen on each metric

Resiliency



Energy Availability (%) = [(($t_1 - t_0$) + ($t_3 - t_2$)) x 100%] / (t_3 - t_0)

Energy Robustness (%) = [(A + B + D) x 100%] / (A + B + C + D)

Max Downtime (hours) = $t_2 - t_1$

Load Not Served (kWh) = C

$$Energy\ Availability\ (EA)\ (\%) = \left(\frac{Uptime}{Uptime + Downtime}\right)$$

A.Zhihov (Editor), "Energy Master Planning toward Net Zero Energy Resilient Public Communities Guide," Springer Nature, Switzerland, 2022.

5. Assessment of Prototype Options : Model

Site-Specific Information is User-Input

Average Power Demand (kW)		DoD Resiliency Factor	Planned Electric Power Demand (kW)
Electrical	115	2	229
Mobility	28	2	56
Total	142		285
HVAC + DHW Building Loads (kW)		**DoD Resiliency Factor**	**Planned Heating Loads (kW)**
Heat Max Load	1,171	1.25	1,464
Heat Design	795	1	795
Heat Typical	168	1	168
Heat Typical x2	168	2	336

Location (for Grid Emissions Calculation) (eGRID2021)	
State or Subregion for Analysis =	State
State (or US Average) =	IL
Subregion =	RFCW
Value for Calculations =	IL
Grid CO2eq Emissions for Calculations =	657

(lb$_m$/MWh)

Disruption Scenario Options are Discrete Variables

Disruption	
Include H_2 in System =	Yes
Scenario =	Lose Everything

System Storage and Key Metrics Directly Calculated

Delivery & Storage Output		
Maximum Required H2 Storage =	6,306	kg
Maximum Required CH4 Storage (Total) =	36,313	kg
LPG Storage =	3,740	kg
Water Storage =	-	kg
Battery Capacity	3,499	kWh (to enable EA = 99.9%)
Results Output		
EA w/o Battery	96.24%	
Equivalent CO2 Emission	0.35	kg CO2eq/kWh Power + Heat Demand
Areal Power	0.07	kW/ft2
Installed CapEx	$ 21,304	$/kW Power + Heat Demand

Summary

- **HERO End State and Mission**
  - Demonstration of a Viable Framework for Designing and Deploying Hydrogen-Based Resilient Energy Systems that can be Replicated Globally
  - Target Minimum duration of sustaining Installation Critical Mission = 14 days
- **HERO 2-Phase Project Plan**
  - Phase 1 : Prototype Equipment Identified, Installed & Tested at GTI Energy
  - Phase 2 : Prototype Designed, Installed & Commissioned at ILARNG N.Riverside site
- **HERO Preliminary Framework for Prototype System Assessment**
  - Key Metrics : Energy Availability, Sustainability, Footprint, and Cost

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