Southwest Energy Partnership
Creating a Network of Renewable Energy Centers in the American Southwest

Hydrogen Power System for Remote Applications

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Overview

- Project description and objectives
- System description
- Field site testing
- Results to date
- Current Work

Project Description

10,000 Off-Grid locations in Nevada with a cost of up to $500,000 to be on the grid

Multi-phase effort to develop a cost-effective renewable H2 based off-grid-power system for rural Nevada and the Southwest

- System attributes:
  - Renewable energy (solar and wind) to generate hydrogen using an electrolyzer and store energy in a battery bank
  - Dual fuel ICE (H2 and propane) for power generation

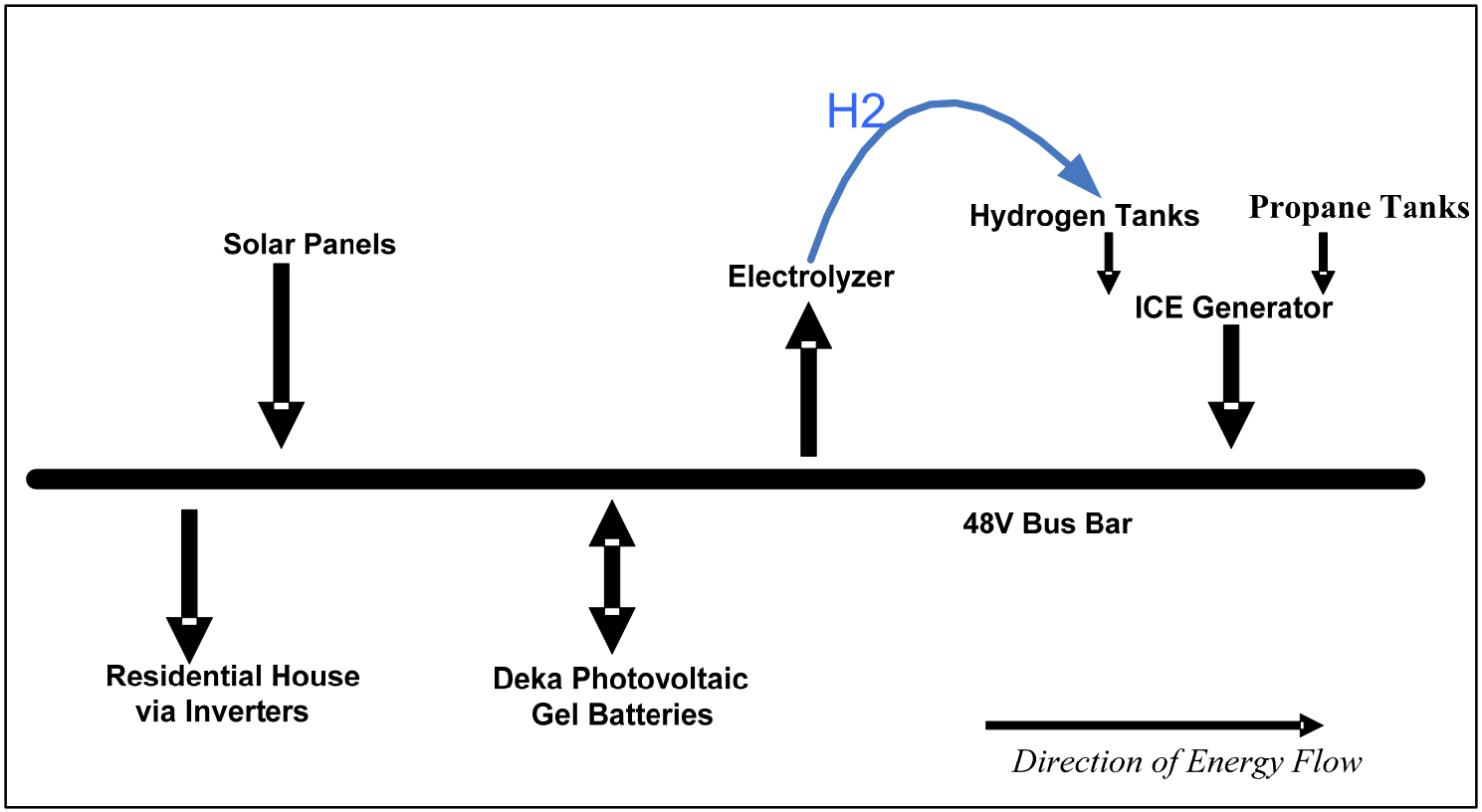
Project Objectives

- Investigate the application of H2 off-grid power generation using renewable energy
- Optimize the integrated system
  - Increased energy storage as H2
  - Embedded controller for maximum efficiency and minimal human interface
- Study the use of a compact proton exchange membrane (PEM) electrolyzer
- Evaluate system performance in a real-world, off-grid application

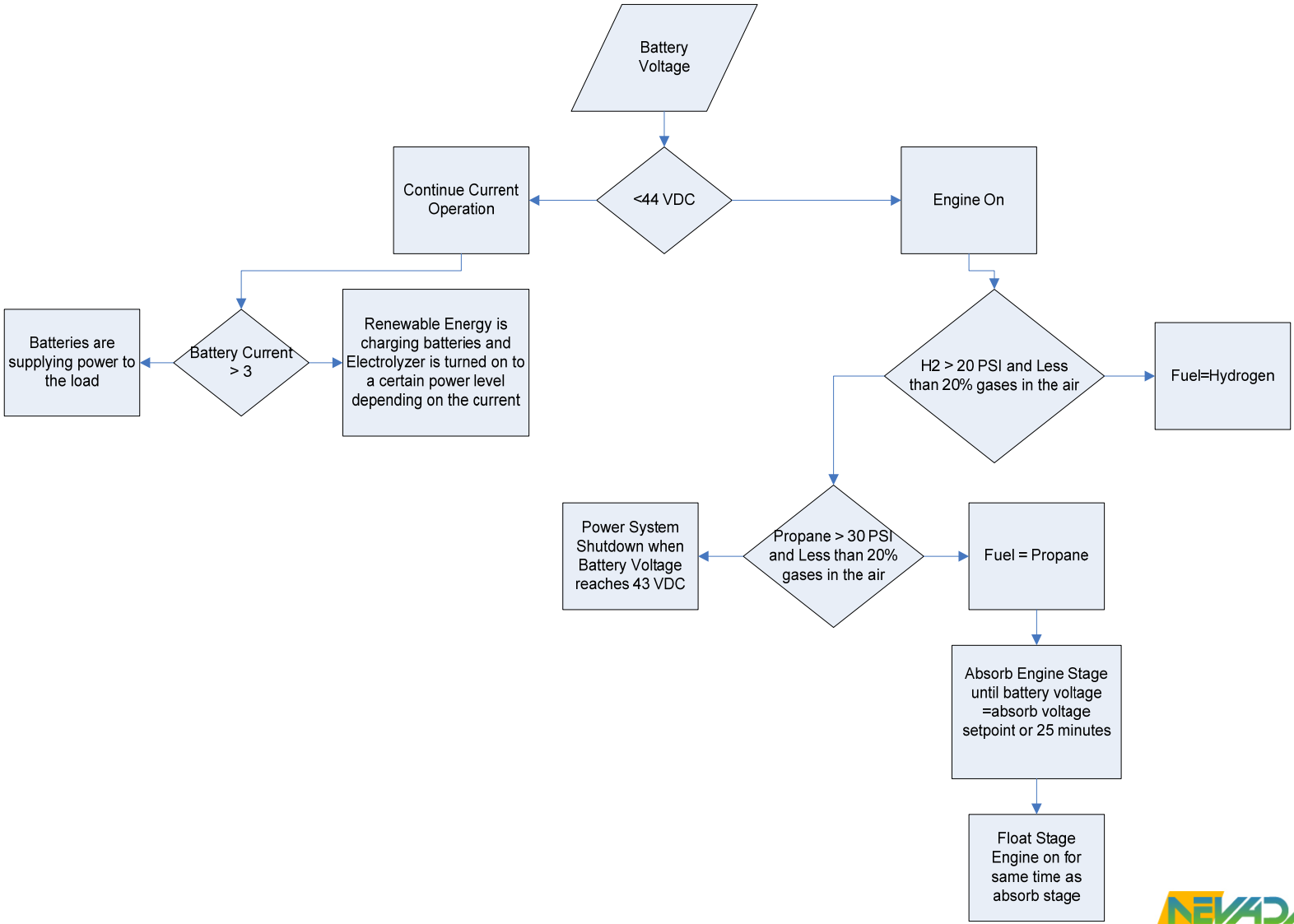
Trailer Components

- 12 Foot Wells Cargo enclosed trailer
- Outback Power Systems 48 VDC/120VAC dual inverter unit
- Twelve 12VDC Gelled Electrolyte Batteries providing 1.3 kWhr of stored energy
- 600 cc/min 200 PSI PEM Electrolyzer
- 4 110 ft^3 storage tanks holding .2 kg of Hydrogen
- Converted Lister Petter 2 cylinder, 4 stroke engine and 1800 rpm 3 kWe generator

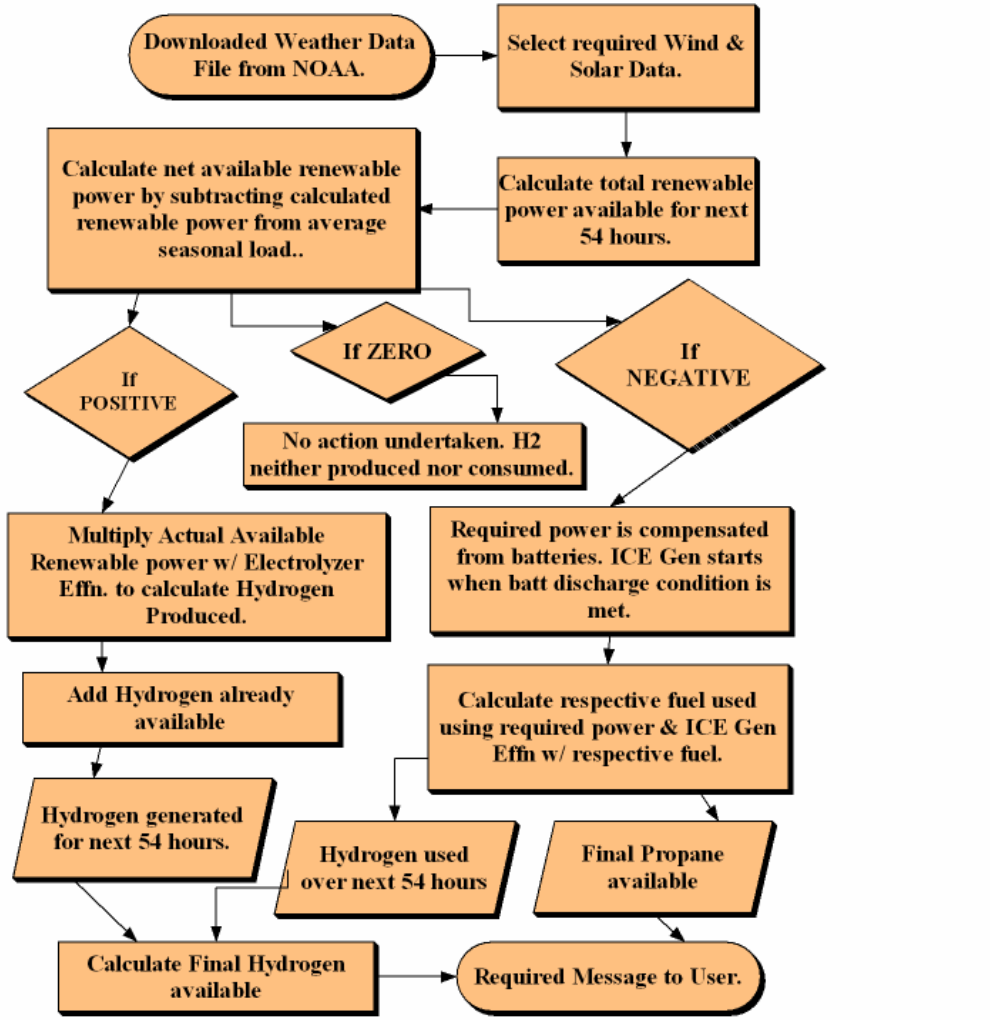
System Schematic



Engine Control Logic



Weather based System Controls



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Trailer

Field Test Site #1

- Galena, NV
- 6 Solar thermal panels
- Passive solar
- PV-Direct well
- Two 1.5 kW tracking solar arrays
- Average winter house load of 21 kW/day

Test Site #2

- Two 1 kW solar arrays
- Two 1.5 kW wind turbines
- 5 kW KOH Electrolyzer producing .1 kg/hr hydrogen
- Average Summer power demand of 6-7 kWhr/day

Test Site #1 Operation

- Over 30 days of operation at test site from February into March
- One 1.5 kW solar array available for power system
- Limited electrolyzer capacity

Test Site #1 Results

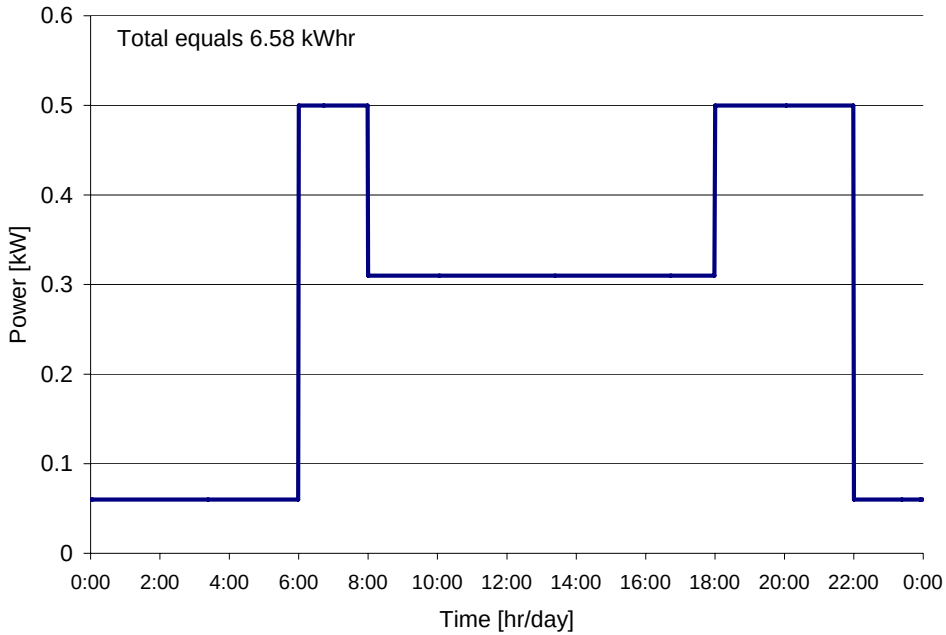
- 1.5 kWe rated solar array observed up to 1.3 kWe
- 6 engine cycles per day to meet the winter load demand
- 40-90 minute engine cycles
- 2-2.5 kg of Hydrogen necessary
- Sufficient data for system evaluation

Upgrades for test site #2

- Engine
  - Retuned
    - Including spark timing maps
  - Removed turbocharger
- Better H2 production control
- Convert DRI Renewable to 48 VDC
- Appropriate Load Profile
- Simplified Software program

Test Site #2 Operation

- Easily observed at DRI location
- 1 array powering PEM electrolyzer
- 1 array and wind turbines for KOH electrolyzer
- Over 20 days of summer data



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Test Site #2 Results

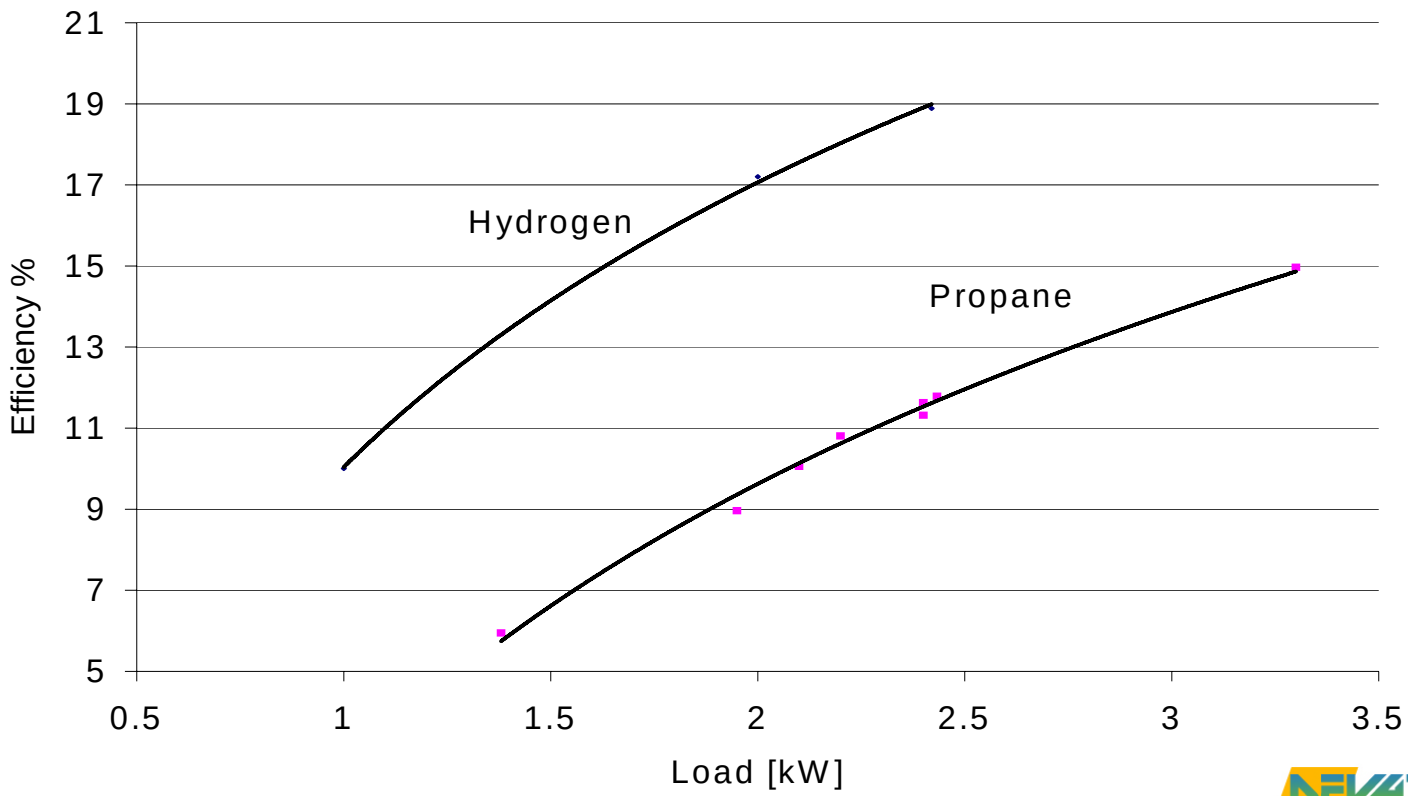
- PV array producing over 700 Watts continuously
- 2 Engine cycles per day at 50 minutes and .32 kg per cycle
- Engine efficiency normal for engine size
  - 11-18% on hydrogen
- PEM electrolyzer produced up to 560 cc/min drawing 500 W

Site #2 Requirements

6.5 kW 24-hour Summer Load Profile				
Item	Description	Quantity	Supplied Power (kW)	Power Consumption (kW)
Renewable Energy	Solar or Wind	3	3.00	
Battery	12 VDC Gelled Electrolyte	12	1.3	
Electrolyzer	Proton Energy HOGEN 600	2		3 kW
H2 Storage	200 PSI storage tank 1 m^3	1	(.66 kg/day H2 in Summer)	90,000 BTU Hydrogen
Engine	ListerPetter 2 cylinder Genset	1	3- Propane 2.5- Hydrogen	.32 kg/cycle, 1 cycle is 50 minutes, 2 cycles per day
Propane Backup	25 lb. Propane Tank	2		1,000,000 BTU

Fuel Efficiency

$$\frac{\text{Power Output}}{\text{Fuel Energy}}$$



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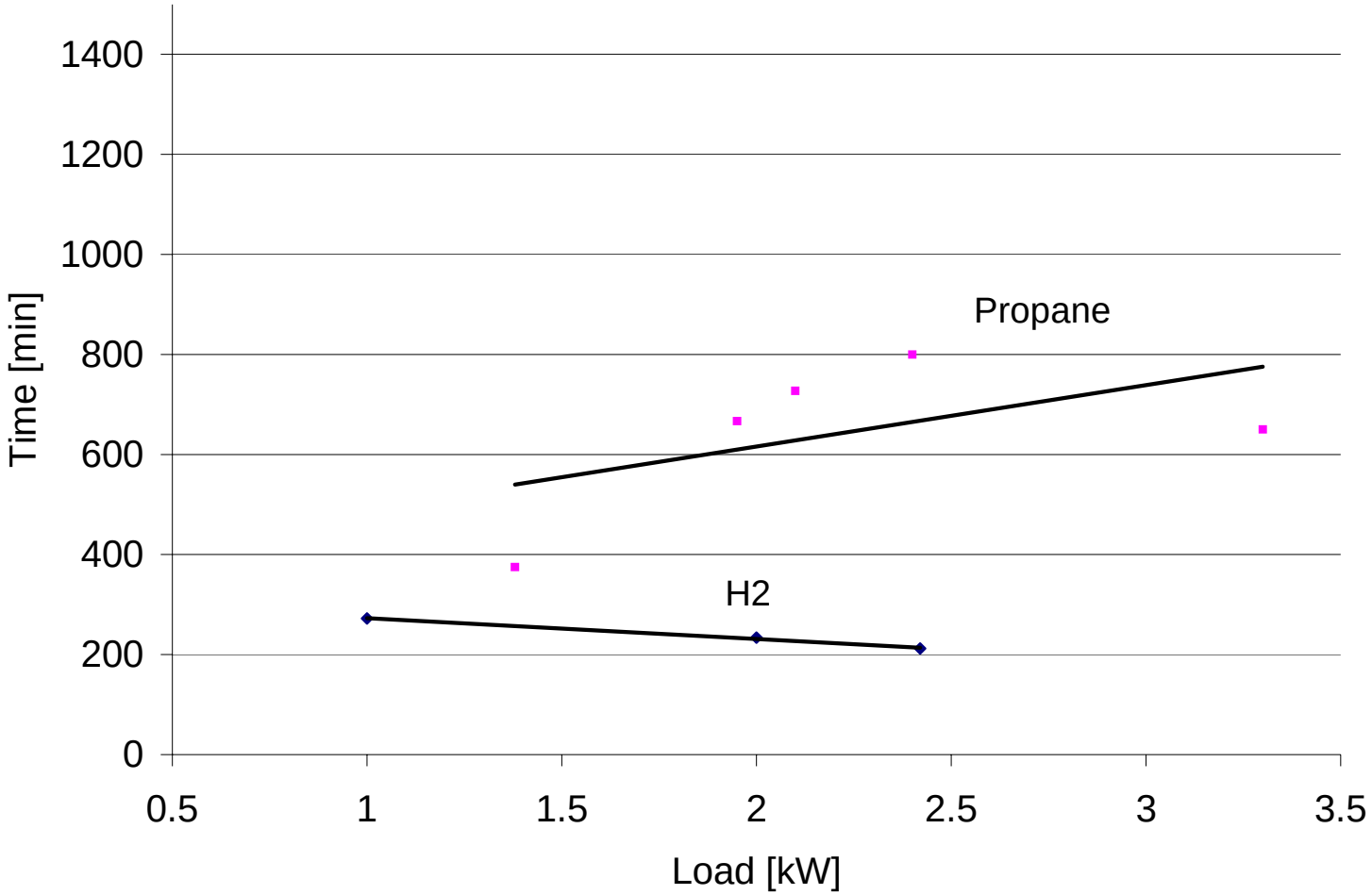
Site #2 Run Time



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Summary 1

Ideal Situation

- 2 Electrolyzer's
- 1 m^3 or .7 kg hydrogen storage
- 3 kW renewable energy in summer would require minimum propane use

Summary 2

- Developed and tested mobile renewable energy power system
- Unique aspects include hydrogen production, dual fuel ICE, mobile unit
- Limitations of electrolyzer and engine design
- Current work includes more control over different fuels in ICE, Maximizing engine performance, more efficient system control, ultra capacitors, and hydrogen production/storage options

Questions