



**Residential Energy Storage and Propane Fuel Cell  
Demonstration Project  
by the Delaware County Electric Cooperative, Inc**

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- DCEC and Gaia wish to acknowledge the technical and financial contributions of the following organizations:
  - Department of Energy (DOE) Golden Field Office
  - NYSERDA / DOE Energy Storage Initiative<sup>1</sup>
  - Propane Education and Research Council



[1] This project is part of the Joint Initiative between the New York State Energy Research and Development Authority (NYSERDA) and the Energy Storage Systems Program of the U.S. Department of Energy (DOE/ESS) through Sandia National Laboratories (SNL). Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



- Plug Power – Fuel Cell Manufacturer
- Gaia Power Technologies – Energy Storage Partner
- Mirabito Fuel Group – Propane
- State University of New York at Delhi – Education and Outreach
- Cooperative Research Network (CRN) – Technology Transfer
- Sandia National Labs } – Data Collection and Analysis
- EnerNex Corporation }
- Energy Now Incorporated – Sister project in Manhattan
- New York Power Authority – Regulatory and Technical Advisors

**Project team comprised of policy, technical, and outreach experts.**



- Rural Electric Cooperatives frequently must service
  - Very rural
  - Remote
  - Previously un-served or newly expanded residential loads
- Looking for alternatives to our current costly service model
  - ~\$50,000 per mile to build or rebuild distribution lines
  - ~\$4,000 per year per mile to maintain rights of way and lines
- Residential Energy Storage can
  - Reduce need for line upgrades
  - Enable off-grid residences with reasonably-sized, coop-owned distributed generation



- Demonstrate viability of grid-independent residence
  - Typical upstate NY residence
  - Total electrical energy needs met by fuel cell
  - Intelligently managed energy storage
  - In-home load control
  - Increased efficiency through thermal recovery
- Validate objectives of propane fuel cells for edge-of-grid residences
  - Measure and report technical performance
  - Provide cost data and economic viability analysis
  - Document maintenance and operations concept enhancements specific to fuel cells in combination with energy storage
  - Promote education of national, state, and local consumers



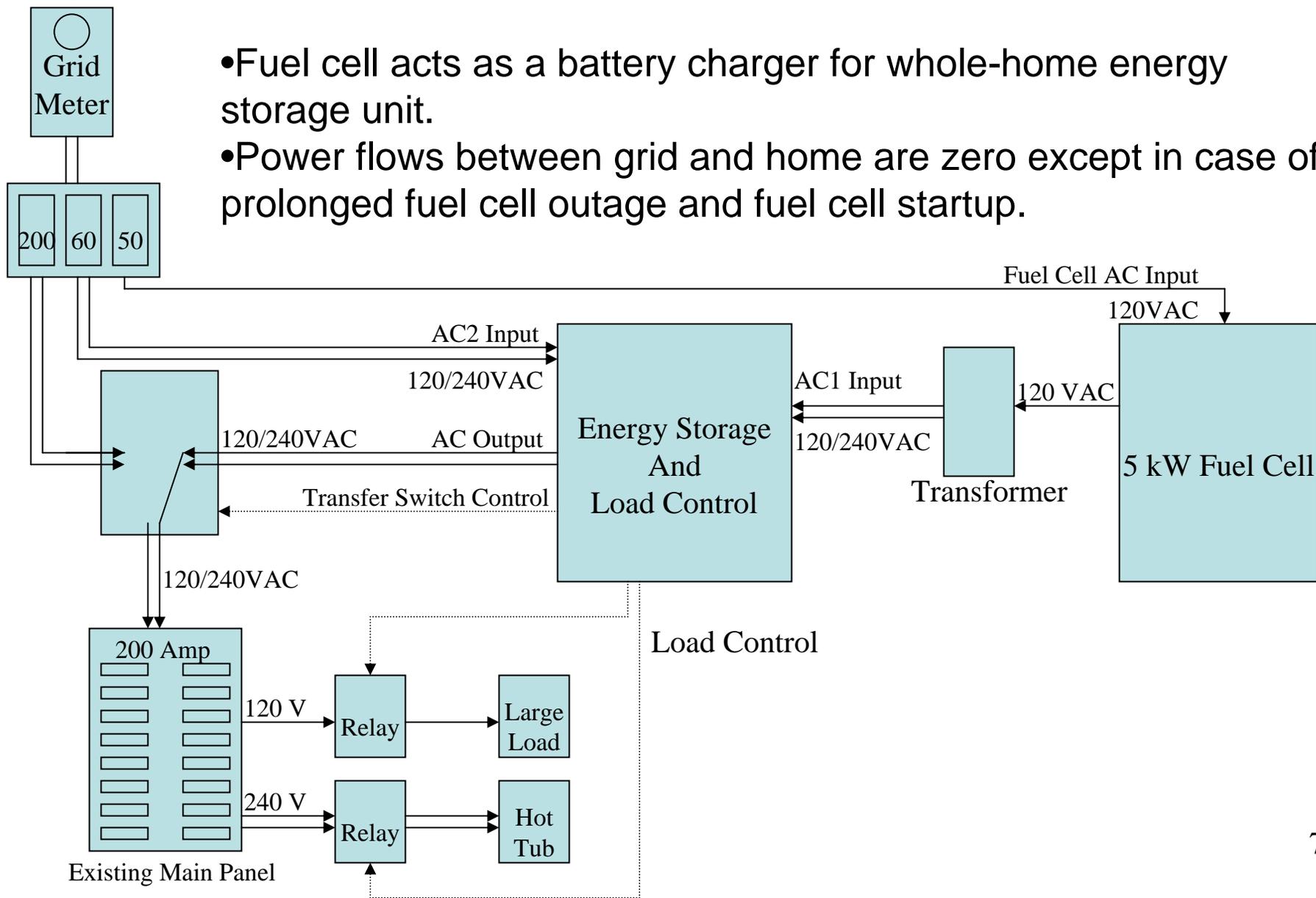
- Avg. Energy use per day: 47.6 kWh
- Max. Energy Usage in 1 day: 67 kWh
- Avg. power draw: 1.98 kW
- Max. power draw: 15.2 kW



- 3 years of 15-minute data
- 3 months of 1-minute data
- Measuring real-time load characteristics and power quality events during the demonstration period



- Fuel cell acts as a battery charger for whole-home energy storage unit.
- Power flows between grid and home are zero except in case of prolonged fuel cell outage and fuel cell startup.





- Installation May 2005, Commissioning June 2005
  - 1000 gal propane tank
  - 5 kW fuel cell
  - Thermal recovery for hot water and space heating
  - Data acquisition and communications equipment



- Gaia PowerTower
- 11 kW capacity (2x5.5)
- 600 Ah deep-cycle, lead-acid batteries
- 1 Controller for charge control, inverters, fuel cell output, and in-home load control
- Peak shaving for grid-connected and off-grid



- Responsibilities

- Charger Control, Inverter Control
- Fuel Cell Control, In-Home Load Control



- Constraints

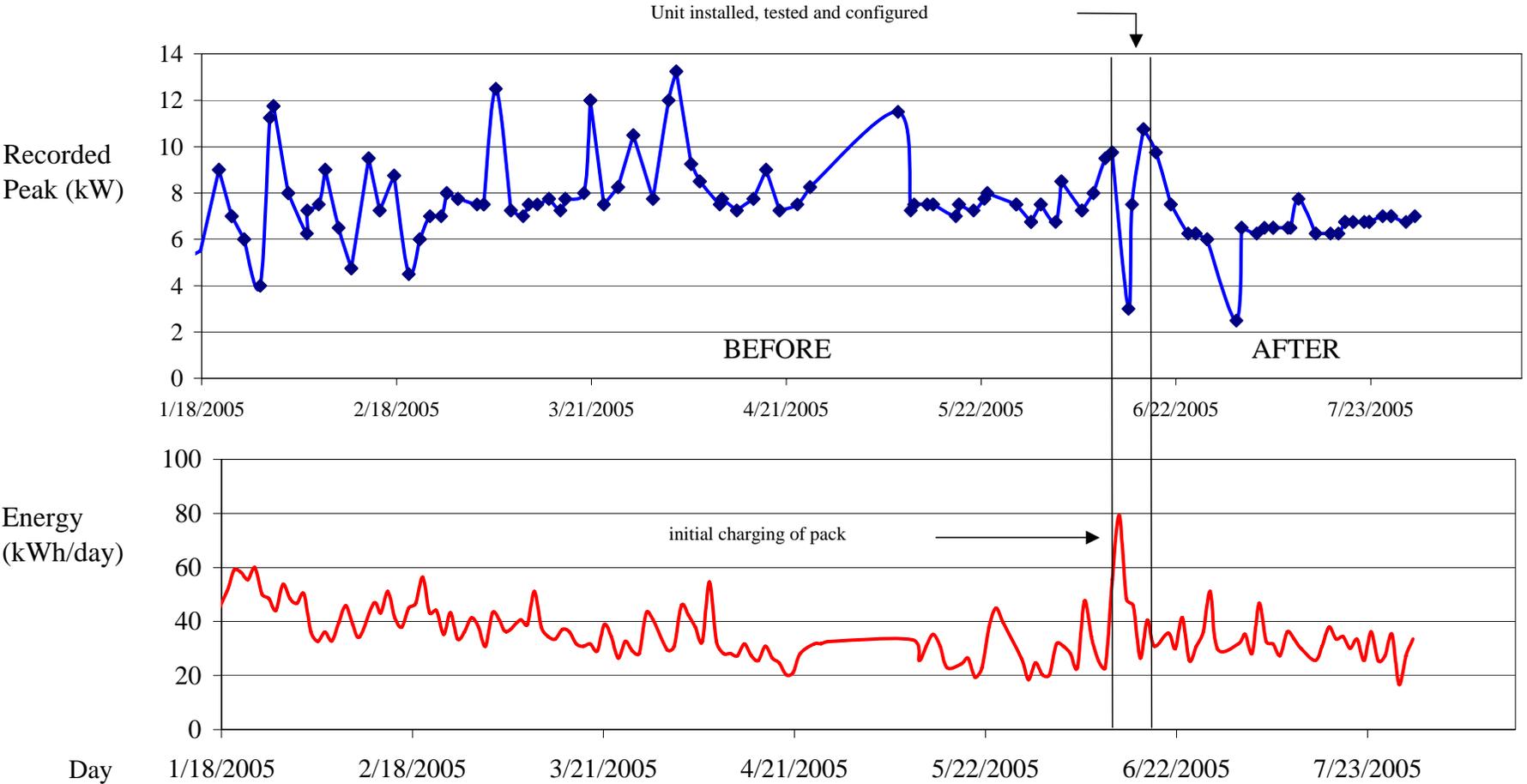
- Limit inverter output below 5.5 kW per leg
- Limited input to 5 kW from fuel cell
- Currently 6 kW load shedding capability

- Goals

- Maintain battery charge state between 50 and 80%
- Limit fuel cell output set point changes to 6 or fewer per day
- Minimize or eliminate full load transfers to grid power

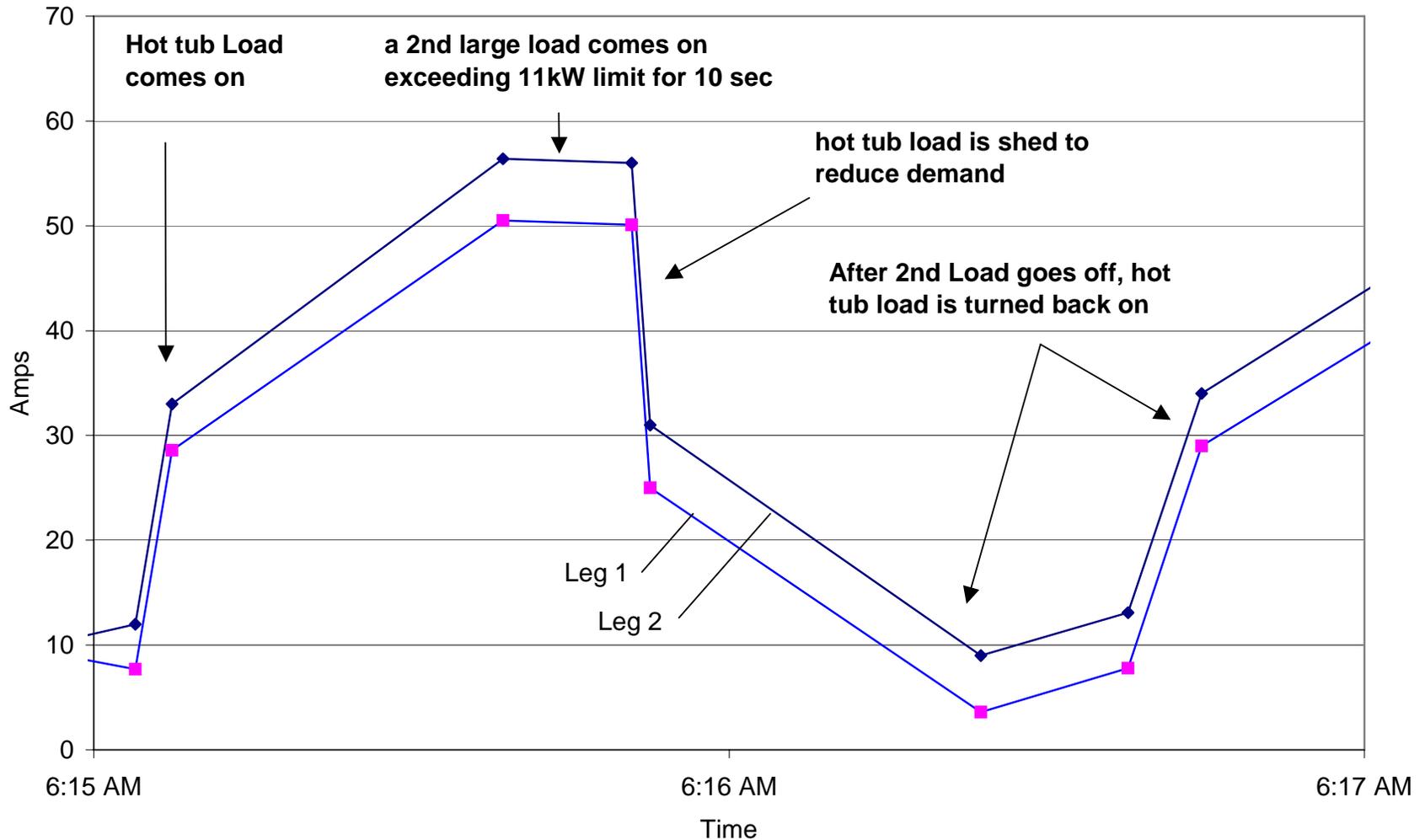


Tweedie Residence Utility Data before and after installation of Gaia PowerTower





## Load Shedding Response Event 6/22/05 Tweedie Residence

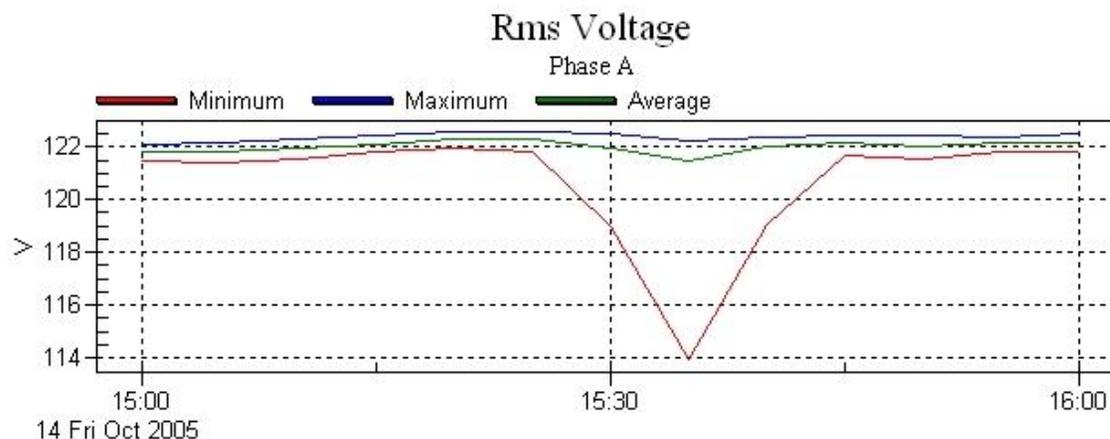




### •Propane Fuel Cell Related

- Potential incompatibility between propane tank dehydration additives and fuel reformer/scrubber
- Integration of controls with energy storage controller
- Distributed generation products not designed to efficiently and easily integrate with battery storage (e.g. regulated direct current output is not available and modes of operation do not include off-grid constant-output)





- Electrical Design and Energy Storage Related
  - 11 kW inverter limit may not be compatible with a load this large without further optimization of load profile
  - 10 to 20% voltage dips (noticeable to consumer) associated with large startup surge currents of hot tub heater
    - ~2 second delay before PowerTower peak limiting threshold settles in
    - Undersized wiring from fuel cell for this short term pass through current



- Immediate

- Continue data analysis related to power quality issues
- Resolve remaining issues with control protocol between energy storage and distributed generation devices

- Short term

- Work with SUNY Delhi to develop curriculum material to be made freely available to other institutions
- Continue to improve energy storage controller algorithms for optimum performance

- Long term

- Complete 1-year demonstration with fuel cell
- Operate additional 6 months with energy storage in grid-connected mode
- Final analysis, reporting, and technology transfer



- Rural electric cooperatives have energy storage needs that are critical to our core operations and our economic position
  - Residential scale
  - Substation scale
- Look forward to working with many of you on energy storage projects and technologies of common interest
- DCEC thanks our project partners and the EESAT organizers for the opportunity to participate in EESAT 2005

**Questions?**



## EESAT 2005

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