Smart Storage and Control Electric Water Heaters

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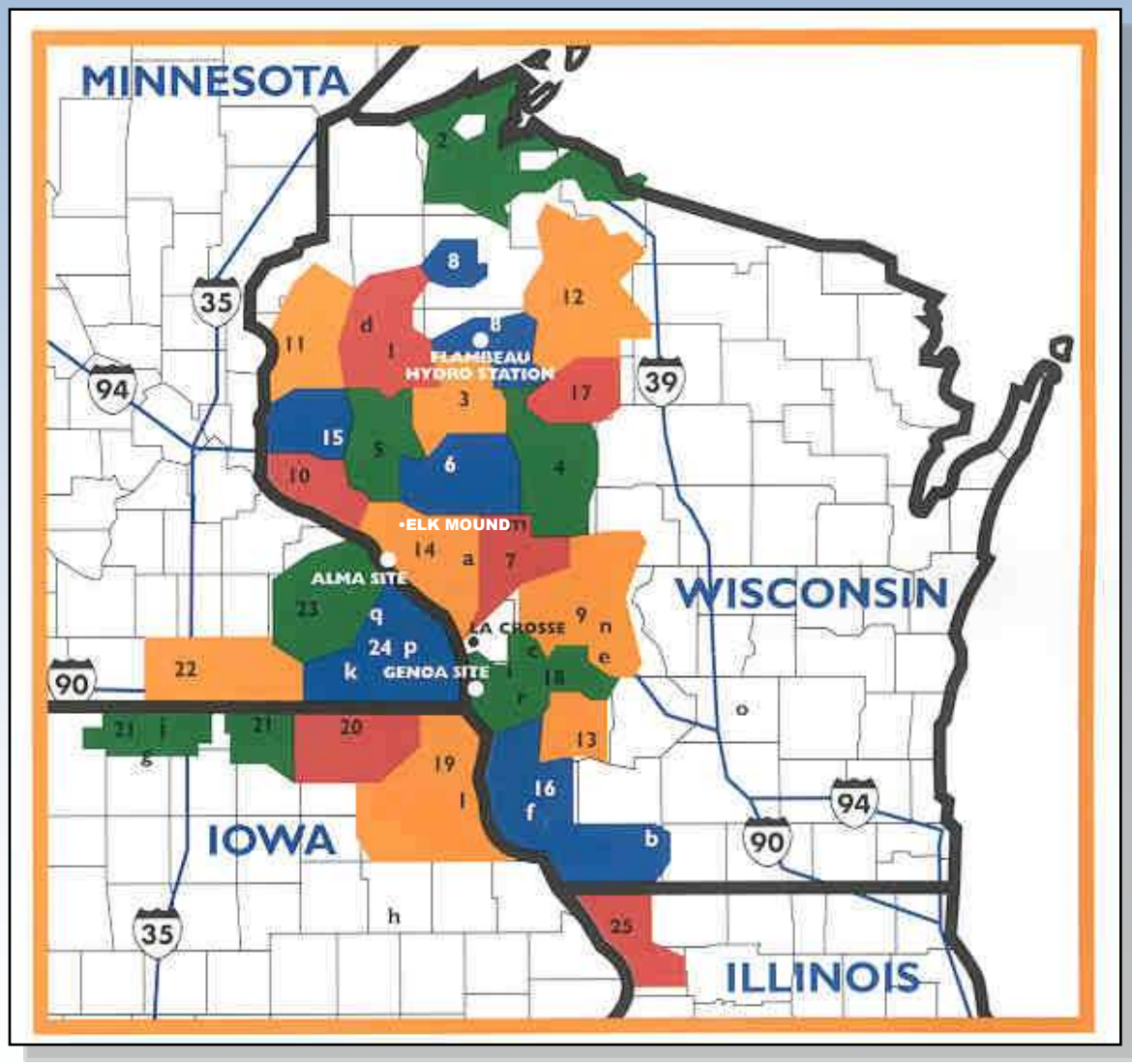
DAIRYLAND POWER COOPERATIVE

A Touchstone Energy® Cooperative

Dairyland Power Cooperative

- 25 Member Co-ops
- 16 Municipals
- 253,000 Customers
- 1,421 MW Generation
- 3,150 Miles of Transmission Lines
- 280 Substations
- 44,500 Square Mile Service Area
- 916 MW Peak

Dairyland Power System



Load Management at Dairyland: A Valuable Asset for 30 Years

- System went live in 1982
- Over 130,000 loads controlled by radio receivers
- Transmitters cover 44,500 sq mile service area
- Operational Uses of Load Management
  - Peak load control
  - Economic dispatch
  - Generation operating reserves
  - System reliability
  - Load shedding during substation or feeder maintenance
  - Energy storage
  - Renewable integration

Load Management System

Qty	Customer Class	Controlled
82,000	Residential	Electric water heaters
30,000	Residential	Dual fuel heating systems
15,000	Residential	Air conditioners
11,000	Residential	Heat storage systems
400	C & I	Generators
170	C & I	Peal Alert voluntary load reduction
5	C & I	Bulk interruptible under direct control
250	Agricultural	Irrigation systems
190	Agricultural	Grain dryers

Control Capability: **Summer 50 to 80 MW**
Winter 90 to 140 MW

Plus 35 MW storage heat held off the peak daily in Winter

Why Has It Worked?

- Integrated into System Operations Balancing Desk
- Dairyland's distribution cooperatives (and their members) are involved in ongoing program direction
- Notification to End Use Members
  - Web
  - Phone
  - Email
  - Text Message
  - Alert Devices

Dairyland Power Cooperative

Load Control Status:

Commercial-Industrial-Agricultural

Advisory Message (08/16/2006): ----- NO Peak Alert - Full Load Control for Today -----

Load Class	Status	Typical Load
Dairy Water Heaters (4A)	No_Control	dairy water heaters
C&I Generators (5A/AE1)	No_Control	automatic backup generators
C&I Peak Alert (5B)	No_Control	automatic or manual load reduction or generators
Grain Drying (24)	No_Control	low temperature grain dryers and grain handling facilities
Irrigation (8)	No_Control	irrigation pumps

last changed at 7:01AM 08/17/2006

NOTE: Some Load Class options may not be available in your area.

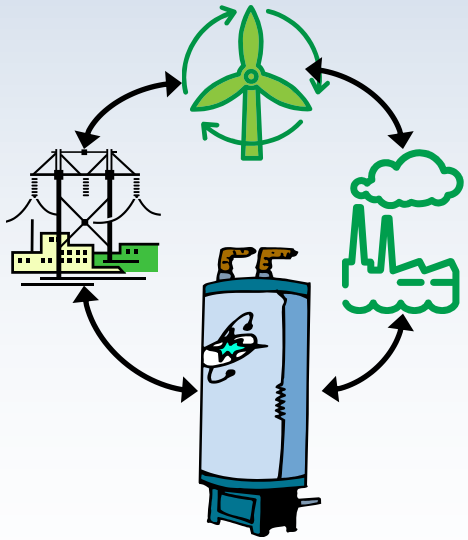
Interactive Water Heater Control

Project Overview

- Purpose is to test new grid-interactive control technology and develop new load management and energy storage strategies
- Project partners
  - Dairyland Power Cooperative
  - Heartland Power Cooperative
  - Steffes Corporation
  - Cooper Power Systems

System Basics

- Smart communication link to real-time generation and other critical grid information
- Adjusts the target temperature (or input wattage) up or down in response to power availability or price conditions
- Continuous reporting of storage capability
- Comfort assurance features



Thermal Battery

- Think of a 105 gallon water heater as a 26 kWh thermal battery
- Nominal two day supply of hot water
- Temperature is a measure of battery charge level

Interactive Water Heater Control

Main Components

1. Temperature Sensor
2. Control Module
3. Mixing Valve
4. Data Collection

Why Is Smart Storage Important?

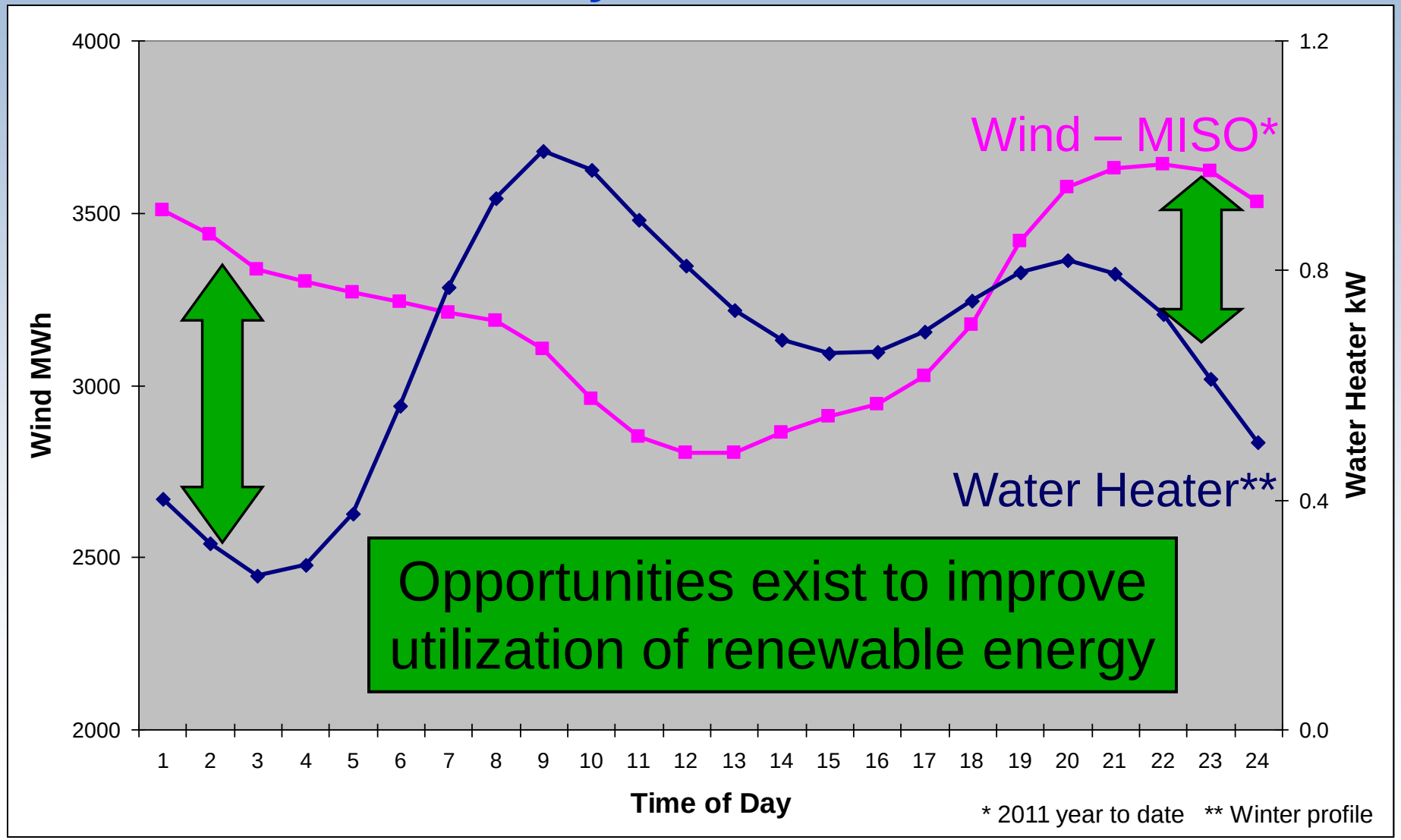
- Renewable integration
- Economic value
- Ancillary value
- Conservation benefits

Renewable Integration

- Wind and solar are variable energy resources
- Grid interactive controls adjust quickly in response to resource availability
- Allows greater utilization of renewable energy
- Reduces carbon footprint
- Lowers consumers' cost

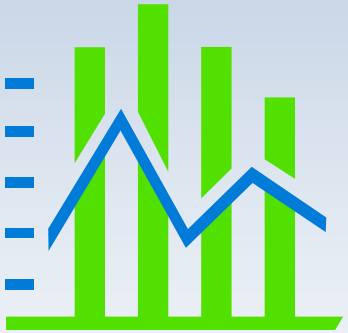
Renewable Integration

Wind Availability & Water Heater Load



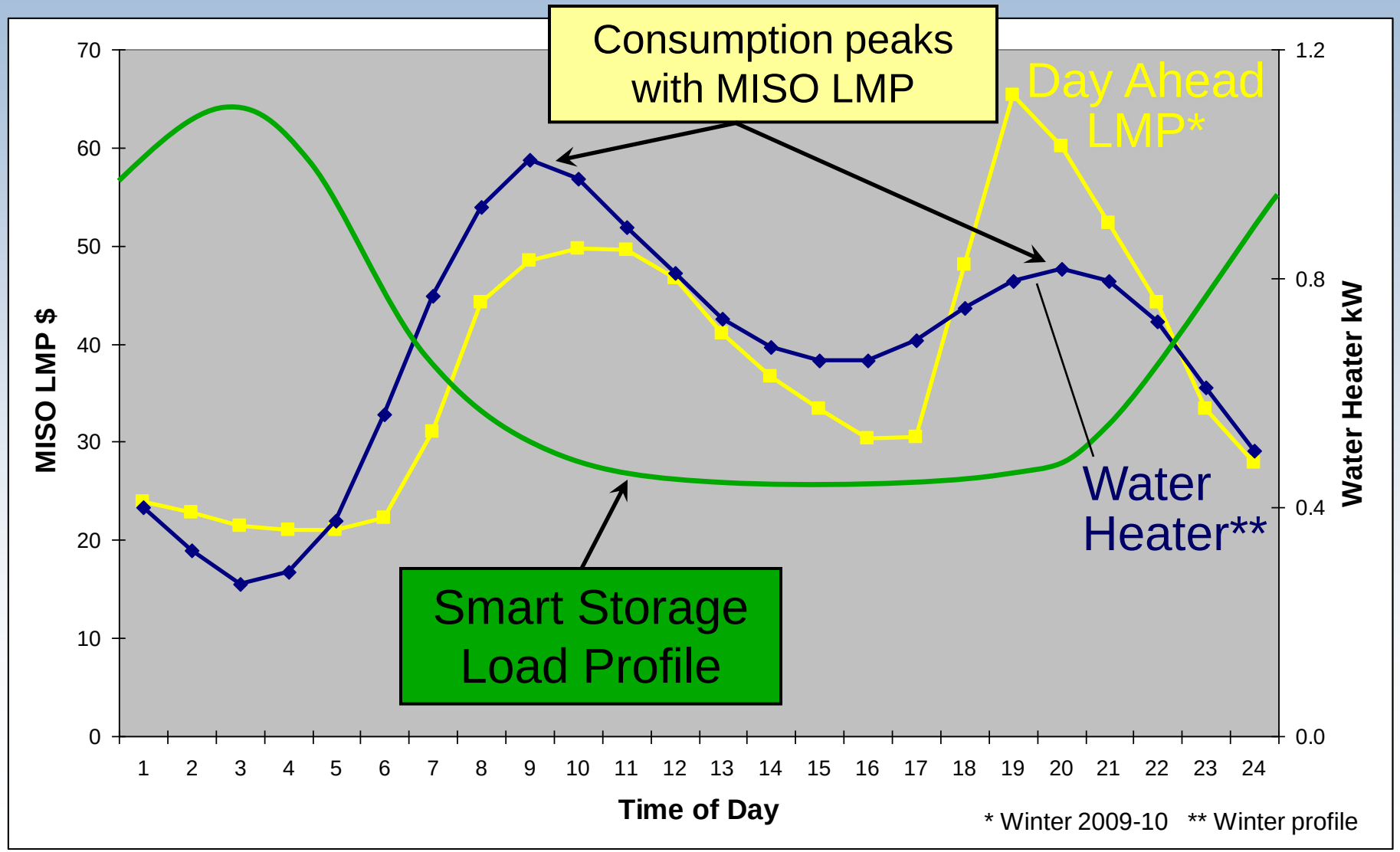
Economic Value

- Energy Price Arbitrage
  - Time-of-day price differences exist in market
  - Store low-cost energy and use stored energy when prices are high
- Real-Time LMP Following
  - LMP = Locational Marginal Price
  - Real-time LMPs change hourly, sometimes dramatically
  - Grid-interactive systems vary the storage / charge rate based on projected real-time LMP



Economic Value

MISO LMP & Uncontrolled Water Heater



Economic Value

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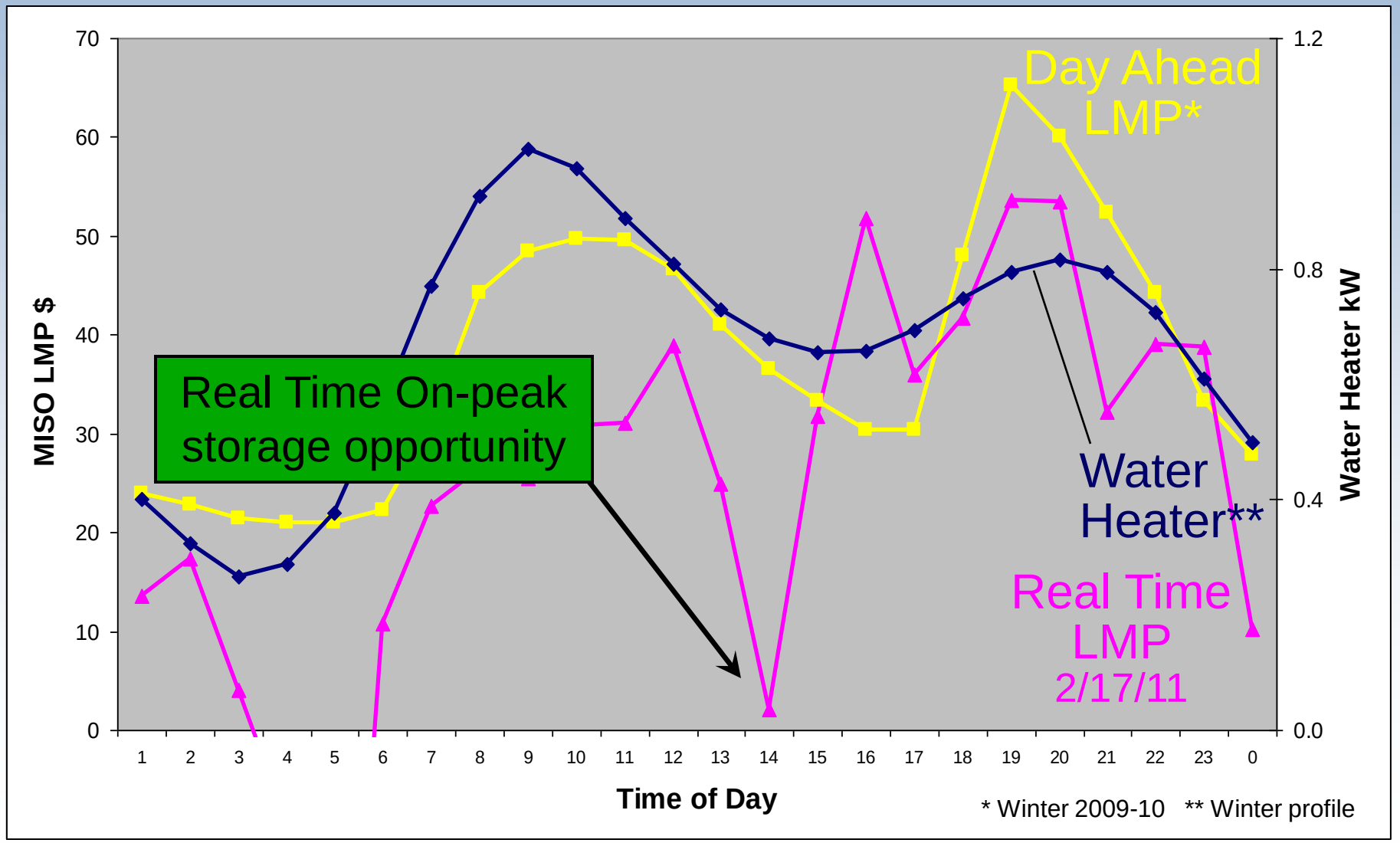
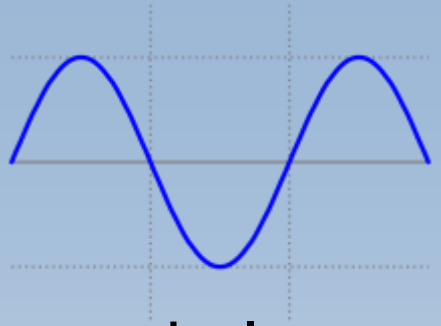


Ancillary Value



- Electric grid requires constant adjustment to balance generation and load
  - Maintain system frequency and grid reliability
  - Traditionally provided by generation resources
- Grid-interactive storage can provide balancing services
  - Fast up and down regulation (second-by-second)
  - Spinning reserves
- Regulating with non fuel consuming resource reduces fuel consumption and system CO_2 footprint
- Economic value from ancillary value payments

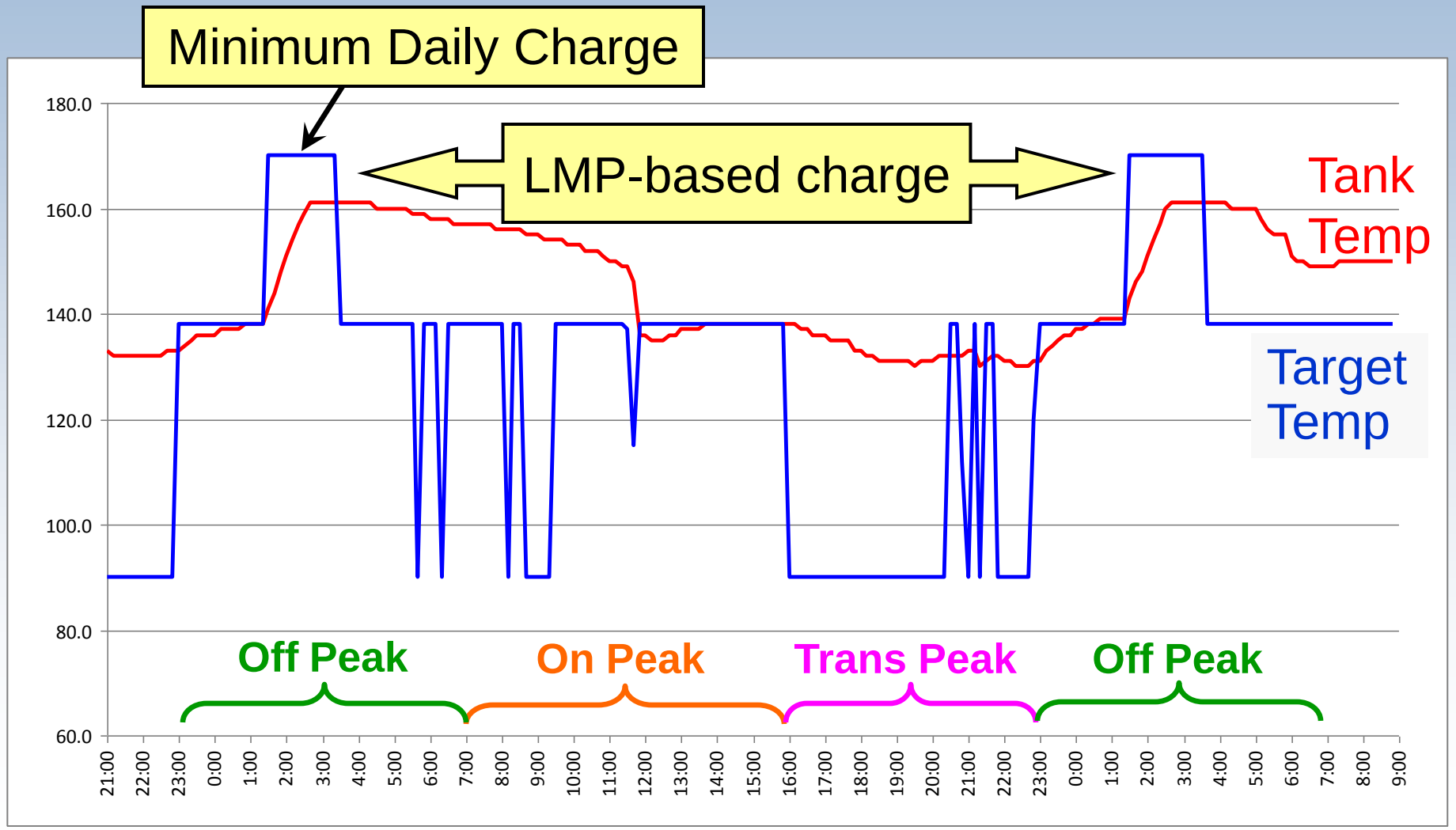
Interactive Water Heater Control

Project Details

- Installations completed at 10 residential sites
- Initial focus
  - LMP optimization
  - Comfort Assurance capability
  - Understand control technology & water heater data
- Several evolutions of control
  - Time-of-day control
  - Price-based control (based on MISO LMP)
  - Improved price-based control with min. daily charge

Interactive Water Heater Control

Example Control Strategy



Interactive Water Heater Control

Next Steps

- Continuously analyze each site's consumption history to determine minimum daily storage requirements
- Automatically target the most economic hours for charging *each day* based on recent data
- Cost – Benefit analysis of control
- Expand project to test technology's potential for providing fast regulation

Questions?

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