The Smart Grid at Minnesota Power

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Safety First! Couple Quick Facts

- Annually, 36% of service/meter installers were permanently disabled or killed on the job between 1887 and 1907
- Average wage for service/meter installers nationwide was $0.50/hr or $20.00/week , inflation adjusted to $10.28/hr in 1907

Overview

- The Smart Grid at a National Level
- Regional Impacts of the Smart Grid Investment Grants (SGIG)
- Grid Development at Minnesota Power (MP)
- Current AMI Initiative
- Challenges
- Summary

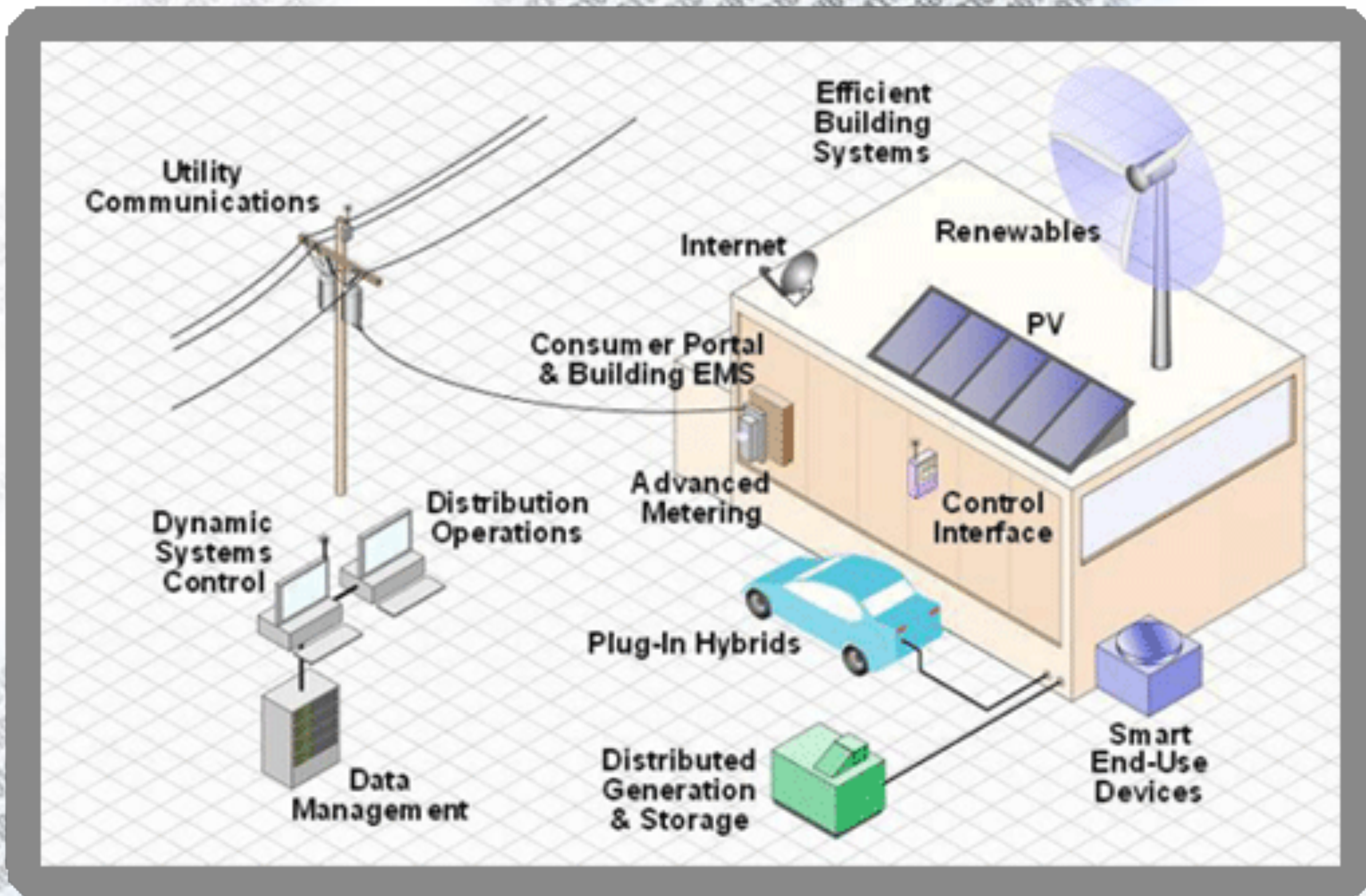
What is The Smart Grid?

- **DOE** : *The Smart Grid transforms the current grid to one that functions more cooperatively, responsively and organically.*
- **Wiki**: *A **smart grid** delivers electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy, reduce cost and increase reliability and transparency.*

What is The Smart Grid?

- **EPRI** : *Electric Power Research Institute's (EPRI) definition: Smart Grid is one that incorporates information and communications technology into every aspect of electricity generation, delivery and consumption in order to minimize environmental impact, enhance markets, improve reliability and service, reduce costs, and improve efficiency*
- **Gunderson** : *The ongoing evolution of the current electrical grid intended to improve reliability, reduce operating costs and increase efficiency, integrate renewable energy, improve measurement systems, and open new opportunities to customers.*

The Smart Grid In Concept



C/O EPRI Smart Grid Resources

NIST and Smart Grid

Under the Energy Independence and Security Act of 2007 (EISA), the National Institute of Standards and Technology (NIST) is assigned the "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems…" [EISA Title XIII, Section 1305].

NIST Work To Date

- *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*
- *Smart Grid Interoperability Panel Creation*
- *Smart Grid Interoperability Panel - http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIPGoverningBoard*

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Why is the NIST Work Important?

- NIST is laying out the rules around which the future Grid will operate and could potentially impact everything that we purchase and how we operate as utilities!
- Currently, both utility participation and general understanding of the process and its impacts throughout the industry is low.

Regional ARRA Smart Grid Project Awards – Wisconsin

- **American Transmission Company -Waukesha, WI: Build a fiber optics communications network for high-speed communications to maximize the full capability of phasor measurement networks across ATC's transmission system ($11.44M)**

- **Madison Gas & Electric Co – Madison, WI: Install a network of 1,750 smart meters, automate distribution, and install a network of 12 public charging stations and 25 in-home vehicle charging management systems for plug-in hybrid and electric vehicles. ($5.55M)**

- **Wisconsin Power and Light Co. – Madison, WI: Capitalize on current smart meter network by implementing a power factor management system to minimize overload on distribution lines, transformers and feeder segments, reduce distribution waste, and limit unnecessary power generation. ($2.3M)**

- **American Transmission Company -Waukesha, WI: Expand the collection of real time data by installing an additional 3-5 phasor measurement units in geographically diverse sites throughout the ATC electric transmission system in Wisconsin, which will improve monitoring, reduce congestion, and limit cost. ($1.3M)**

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Regional ARRA Smart Grid Project Awards - Iowa

- Iowa Association of Municipal Utilities – Alkeney, IA: 75 consumer-owned utilities, serving over 96,000 customers in 3 states, will implement a broad based load control and dynamic pricing program using smart thermostats and web based energy portals. ($5.0M)

Regional ARRA Smart Grid Project Awards – South Dakota

- Sioux Valley Southwestern Electric Cooperative, Inc. – Coleman, SD: Install a smart grid network across the full customer base 23,000 smart meters - that will allow for automated electricity readings and additional monitoring of the system in case of outages or disruptions. Will also benefit customers in MN. ($4.0M)

- Black Hills Power – Rapid City, SD: Install 69,000 smart meters, along with the communications infrastructure, IT software, and equipment necessary to operate a fully functional Smart Grid system in service area. Will also benefit customers in MN and ND ($5.6M)

Regional ARRA Smart Grid Project Awards – Minnesota

- Allete – Minnesota Power – Duluth, MN: Expand the implementation of Minnesota Power's existing smart meter network by deploying an additional 8,000 meters and new measurement and automation equipment. Experimental dynamic pricing program. ($1.54M)

Minnesota Power Overview

- Regulated, Investor Owned Utility serving Northeastern Minnesota
- Customer Base:
  - 141,000 Retail Customers
  - 16 Municipal Customers
  - 12 Large Industrial Customers account for approximately 50% of our kilowatt hour sales
  - Natural Resource Economy
    - Timber, Mining, Pipelines

How we Got here: Necessity Drives "Stepping Stones" of MP Grid Development To Today

Pre-1976:	Leased line substation communication
1976:	Initial use of analog wireless substation communication towers
1978:	First U.S. utility owned fiber-optic link used for operational data
1992:	Use of public wireless networks (AMPS) for meter data retrieval
1994:	Substation communication converted to digital wireless
2000:	Began investment in power line carrier Automatic Meter Reading (AMR)
2007:	Final conversion of AMPS wireless to digital
2008:	Advanced Metering Infrastructure (AMI) smart meters deployed
2010/11:	Expand AMI Pilot

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MP's Current AMI Initiative as part of the overall Smart Grid Picture

- Began technology evaluation late 2007
- Pilot driven by desire to provide customers with rate options/enhance system operational requirements (demand response, outage management)
- Installed system infrastructure in Q4 2008
- Received DOE "Smart Grid Investment Grant" Award notice to expand pilot through 2010-2012; logical next step in continued technology deployment

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Why "Smart" Metering?

- With the advent of solid state meters in the late 90's, advanced measurement of electrical energy at all customer levels became feasible
- New Meter functionality allow utilities to offer new rate structures due to advanced measurement capability and incorporate renewable energy
- Other time and logic based functions made it possible to detect outages, tampering, and other service level issues.

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First, Some Perspective……..

- First meters commercially sold in 1889 by the Thomson corporation, sold for an average price of $150.00 in 1889, inflation adjusted to $3083.32
- The modern electrical-mechanical watt-hour socket based meter design varied little for more than 70 years (1930’s – present) and pricing held fairly for the last 25 years at under $30 in large volumes for utilities. Only two vendors of Electro-Mechanical Meters Remain.
- Watt-hour meter functionality has advanced more in the last 12 years than in the previous 110 years combined. With the advent of Home Area Networks (HAN), AMI, and other Interfaces, the watt-hour meter of the future portends to be a very complex customer gateway in the future.

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Dan's Prediction:

"The watthour meter will have more advancements in the next 10 years than in the previous 120 combined…However, a standardized meter, with consistent hardware and software interfaces will not be available for more than 15 years from today."

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Smart Grid Meter Investment: Customer Focus

- Continue/expand transparent, collaborative approach to information sharing with customers:
  1. "Smart meters" at large industrial customers already provide energy pricing, electric operations and power quality data; equal access to information for both parties
  2. Begin providing residential options via direct control, enabling technologies and rates that allow customer choices in achieving energy efficiency
- Seek improved reliability through better outage management/distribution system monitoring
- Seamless interconnection of renewable energy
- Bottom line goal: investments improve/enhance customer service

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Customer Focused Rates and Options

- New Experimental Rate Development –

  Why A Critical Peak Pricing Rate?

- Enhancements to traditional Load Control Programs
- Renewable Energy Interconnections

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What Does Metering Have to Do with Renewable Energy?

- As the customer gateway, advanced meter infrastructure allows for bi-directional metering rates.
- With bi-directional capability, combined with other advanced functions, will allow for advanced incentive rates for small scale renewable customers
- Future advancements point to potential large growth in small scale renewable energy, especially in the MIDWEST!

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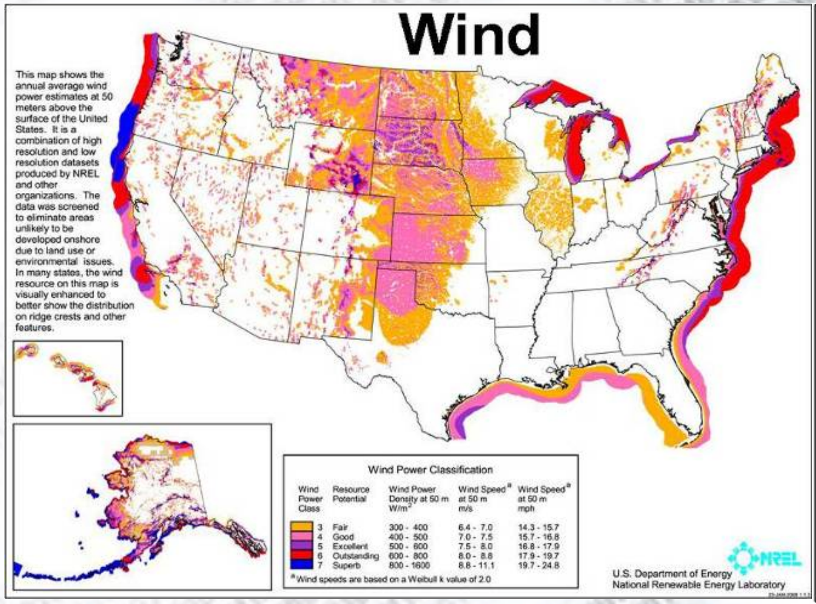
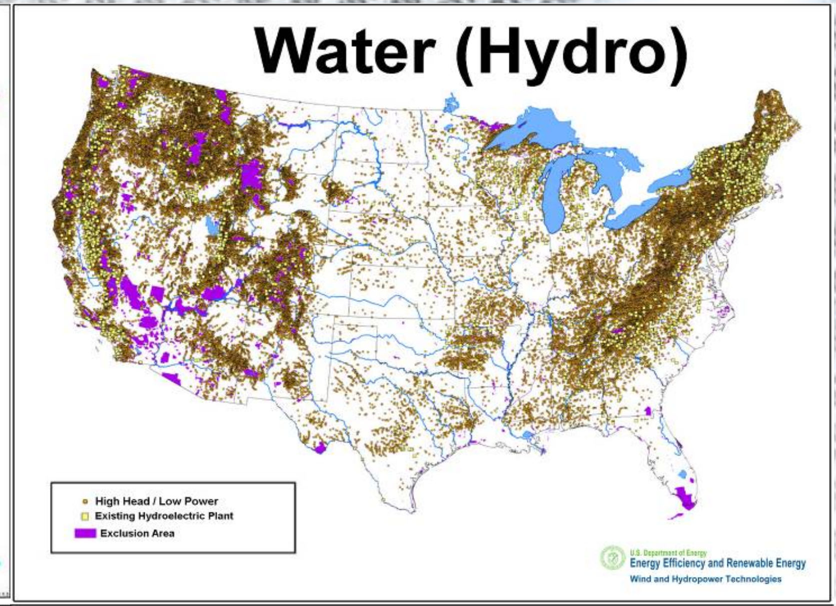
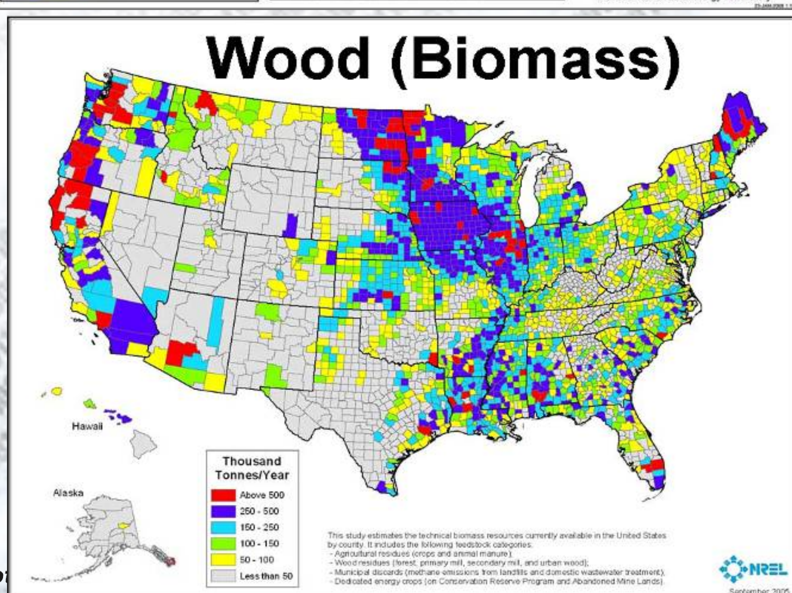
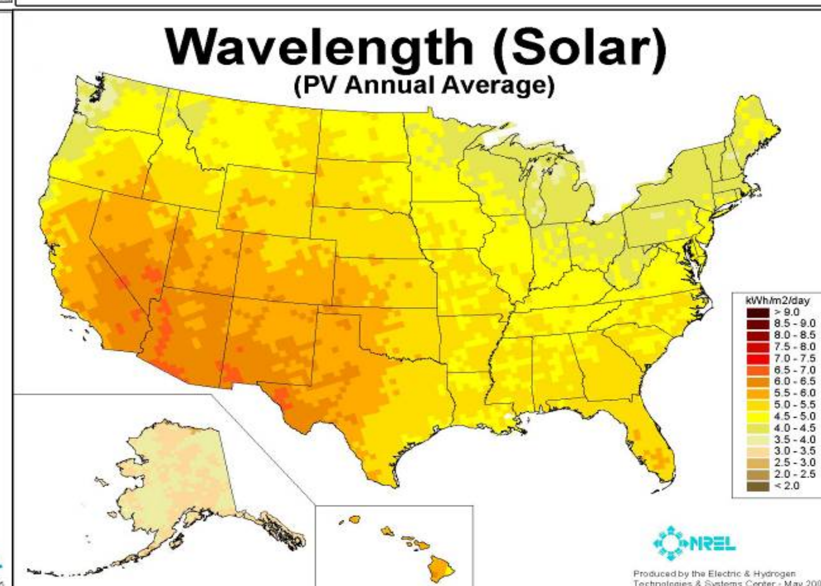
The Renewable “Fuels” of the United States









Overview of Minnesota Power Smart Grid Project Functions

- Outage Management
- Voltage Monitoring
- Load Control / Remote Disconnect
- Distribution Automation

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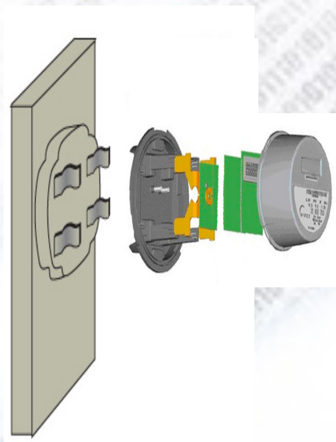
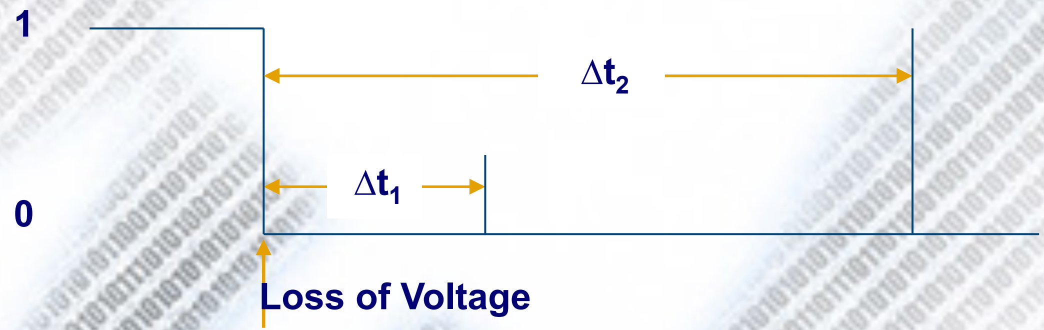
Outage Management Function Overview



Meter Signals Transmitted



Δt_1 Once Exceeded Increments "Momentary" Counter

500 mS Typical

Δt_2 Once Exceeded Generates Outage Alarm

120 Seconds Typical

Outage Time Threshold

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Outage Management Function…Cont'd

- Outage messages sent across network to notify on system outages
- Power-up notifications sent across as power is restored.
- Momentary outages are counted locally at the meter, but are not transmitted across network until read packet is sent.

Voltage Monitoring

- Watthour meter points log voltages and alarm on programmable under-voltage or over-voltage situations
- Most recent voltage available for diagnostic purposes
- Voltage profiling programmable for storage purposes.
- Voltage monitoring is critical to diagnosing temporary or recurring distribution issues.

Load Control System

- Meters W/ Integrated Disconnect Contained in Meter housing for Dedicated Load Control Services (Dual Fuel/Off Peak)
- Limited to 200A Services, 200A Rated Disconnect (48kW Single Phase Load)
- Meters provide verification of disconnec re-connect operation through signal
- Load Profile data available for load verification

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Integrated Disconnect Features

- Can Be used for service disconnect for transient/rental accounts or problem accounts with non-payment.
- Minnesota Power is choosing not to use this feature at this time

Distribution Automation

- Currently plan to install 6 automated switches on a problematic feeder using remote telemetry module and intelligent switches
- Re-closer monitoring will be installed
- All distribution automation equipment will operate on same network, but different bandwidth dedicated to DA applications

Overall Project Goals

- Complete Implementation of Critical Peak Pricing Rate
- Continuous monitoring of customer endpoints (99%+ Daily read Rate)
- Support and Expanded Flexibility Load Control System
- Integration of priority outage messaging into OMS system
- Implementation of Distribution Automation System

Challenges

- Interoperability first and foremost– Standard interfaces and profiles for connected systems and equipment are critical for long term cost control and managing privacy/security issues
- Cyber-security requirements and system modeling
- Information overload – processing data from modern systems can be overwhelming – qualified people and good scope needed for project focus
- Realistic expectations/honest results assessment; smart grid not a panacea for energy conservation/efficiency
- Collaboration vs. competition will streamline grid development

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Summary

- Minnesota Power has been making prudent investments in a smarter grid for more than 30 years
- To continue that effort, AMI and Distribution Automation projects cast a broad net to prove out system functionality and scalability
- In the long term, standard interfaces for hardware and software profiles are required to achieve proper economies of scale and make functionality affordable and efficient to implement.