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## **Outline of Broadcast-based H2G Communication Solutions**

Background:

Power utilities can significantly reduce operating costs by sending appropriate control signals to loads as control-responsive loads enter the market in order to assist the balancing of power supply and demand in real-time. Broadcast communication tools have been used by utilities for decades to implement direct load control commands that limit loads at times of system peak demand. This paper explores a more robust use of broadcast tools in the 21<sup>st</sup> century.

More recently the integration of renewable energy into the supply-side mix has added a significant complication into that equation. In the case of large industrial, commercial, or institutional customers, sophisticated customized solutions can be put in place to achieve that balance. These solutions typically are expensive, but the utility can justify deploying them by the load sizes and the benefits achieved. In the case of residential and small commercial customer sectors, the sheer number of end-use devices in the field demands a more economical and homogeneous approach. The solution must be easily and readily scalable, easy to adopt, and able harness a limitless number of devices. The purpose of this paper is to investigate the merits of a broadcast based solution.

Significant benefits to be derived by the Smart Grid broadcast architecture from the broadcast solution:

- Employs existing infrastructure thereby:
  - reducing project approvals, capital expenditures, and deployment timelines;
  - eliminating incremental environmental assessments, reviews, and impacts;
  - minimizing regulatory review;
  - accelerating mass deployment timelines;
  - lowering ongoing operating and maintenance costs.
- Fast response time of a broadcast system would facilitate:
  - improved Demand Response (Hourly, minutes, seconds);
  - increased frequency regulation and spinning reserve applications;
  - enhanced integration of renewable generation;
  - Hourly and more advanced dynamic pricing schemes.
- Broadcast with group addressing capability enables locational response to:
  - Reflect time & location specific marginal costs;
  - Alleviate specific distribution constraints;

- Provide 5 minute Location marginal price (LMP).

Leverage/Harmonize with SGIP Business & Policy Working Group: Broadcast of real time price data

Highlights of Paul Centolella's presentation in Irving, TX (Dec 2012):

1. Majority of our electric infrastructure is at or approaching the end of its expected useful life
2. American Society of Civil Engineers: Maintaining electric infrastructure requires \$673 billion in new investment by 2020
3. Most electric utilities have credit ratings of BBB or lower, compared to 1 in 5 in 1992
4. Capacity factor for U.S. generation: 45%
5. Average Capacity Utilization in Other Capital Intensive Industries: >75%
6. Financing the next investment cycle will be difficult without improving load factors and asset utilization
7. Beyond Demand Response: Facilitating Demand Optimization
8. Dynamically Responding Devices Could Provide Much Greater Value
9. Demand Optimization Strategy
  - a) Energy's "Holy Grail" – Storage Capabilities of End Use Devices (HVAC, Fridge, HW, etc.)
  - b) Optimizing the Timing of Electricity Demand
  - c) Creates a More Agile Infrastructure:
10. SGIP Objective: Identify a Standard Data Model for Communicating Price Signals to Devices
11. Prices to Devices: Communicating with End Use Devices
  - a) Inexpensive one-way broadcast approaches, e.g. FM Radio Sidebands

Consumer mass adoption is key to reaching residential loads in large numbers; however standardization is needed in three aspects:

- 1) standardized price and/or control signals,
- 2) a low-cost, low-latency, ubiquitous communication path to the loads, and
- 3) with standards in place, end devices, at nearly the same price as today, that can be responsive to the standard application signal.

This paper addresses an option for the second need, specifically broadcast communications:

1. Minimize consumer actions required
2. Minimize costs

3. Inform consumers while preserving privacy
4. Enable consumer override capability at any time

Leverage/Harmonize with GE/PNNL “Demand Responsive Residential Applications Interface” work within H2G. Some highlights of the document relative to this paper as follows: (alternate format: used as reference document in appendix at specific passages)

1. Line 50: Successful demand response implementation at the residential consumer level must be attractive to consumers through incentives, and, more importantly, ease of use – perhaps even automated use – requiring very little, or no consumer interaction whatsoever.
2. Line 66: In particular, the potential for managing the grid based on a more interactive residential appliance demand response system could not only help reduce peak load, but could also support better integration of significantly higher penetration of intermittent renewable resources to the grid. As an example, a robust residential demand response market can help ameliorate the need for spilling (very affordable) base load hydropower to allow for load following and integration of renewable wind farms as have now become common in the Bonneville Power Administration balancing authority.
3. Line 122: There are huge economic benefits from demand response when the cost to implement signaling (per device) is lowered through an aggregator. However, this can only be accomplished through the use of unified, industry-wide, accepted standards of interface with the customer/customer appliances. Yet, even with customer agreements under an aggregator to engage in demand response via appliances and equipment, a barrier remains with no clear path forward to transfer RTO/ISO or utility benefits to the residential customers.
4. Line 150: Water heater demand response programs over the past several years given us some insights into residential participation, behavior, and value-added. For example, the Oconto Electric Cooperative has actively controlled large capacity residential electric water heaters for over 35 years to aid in managing the utility peak load. The utility has in excess of 2,300 water heaters in the program representing 49% of their residential customers. The demand response program has resulted in a ~13% reduction in the utility peak load with an overall economic benefit to the customers over \$265K in 2011. ... Therefore, for some utilities, a water heater demand response program has experienced considerable engagement by their residential customers with significant benefits to both the utility (peak load reduction and cost savings) and to the customers (monetary incentives) with little apparent customer disruption.
5. Line 249: The study should look at what technologies represent “low hanging fruit” (easily adaptable) and which technologies will require substantial research and development investments
6. Line 260: Ultimately, the key to residential smart grid appliance systems success will be implementing a single, unified data communications standard that defines smart grid data sets, and how they are maintained. The standards need to be applied across all of the primary stakeholder interfaces where communications and dynamic, real-time interactions are the key to success.
7. Line 379: A grid friendly appliance or HEM needs to be easy for the consumer to adjust to their personal settings whenever and where ever they want. However, if we assume that consumer

understanding of their electricity rates are too burdensome, the appliance or system will have to be smart enough to communicate with the consumer to make the decision process as simple as possible. ...The premise here is that automation is a result of user motivation as opposed to utility control (“inform and motivate” versus “command and control”). (see EPRI whitepaper 1020432)

8. Line 389: Privacy is a current issue and will likely be a concern for many consumers if the utility has access to individual energy monitoring/control programs. Consumers need to be assured their system only sends appropriate consumption information and that their system in-turn receives the information necessary to make predetermined adjustments.
9. Line 416: Controllers for user interface devices will have to be designed to allow consumers to communicate with smart grid-enabled appliances and assess their function to modify and increase their efficiency, but with some level of autonomy. However, there is a cost related to each device and specifically the technology each requires to communicate with the system. For manufacturers to be willing to invest in research and development of products supporting smart appliances and interactive demand response, there will need to be a clear picture of the potential financial reward.
10. Line 423: Similarly, the utilities and aggregators will be very interested in how implementing a solution gets paid for, and will want to understand what the implications are for smart residential appliances changing electricity market prices. Getting a significant percentage of the consumer base involved will be challenging. It will be a sales job, for sure. Utility incentives for pilot programs may help, but ultimately, consumers will have to be convinced that the benefit outweighs the burden, both from a fiscal perspective and from a usability/functionality improvement in life perspective.

## Overview of requirements

1. Desired characteristics
  1. Single nationwide physical layer standard
  2. International compatibility for OEMs
  3. Full market coverage
  4. Redundancy and reliability
  5. Time stability of solution
  6. Time to deployment
  7. Availability of Hardware
  8. Ease of System integration
  9. Low Capital and operating cost of infrastructure
  10. Low Capital and operating cost to consumer devices
  11. Consumer centric characteristics
  
2. Technical requirements [is our intent to just list/explain requirement or to identify available technology and/or possible solutions, identify gaps in technology etc.? I am hoping the latter or at least as far as we can take it.]
  1. Authentication
    1. Encryption capable
  2. Security of infrastructure
    1. Physical
    2. Cyber
      1. Defenses against hacking
  3. Multiple broadcast frequencies/towers to minimize risk of too many MW on one tower
  4. Redundancy of key elements
  5. Role of network paths in hybrid broadcast/2-way system [Where 2-way might be AMI or Internet]
  6. Stability of solution
    1. Decades of demonstrated stability
  7. Performance specifications
    1. Actual field performance (in a variety of home structures)
    2. Location filtering/targeting

3. Types of control packets (use cases)
4. Packet length constraints for each technology class
5. Missed packet expectations/consequences/end-device work around logic
6. Enable IP packet protocol
  1. Flow through
  2. Translation
    1. Bearer Application protocol

## Background of Technology

1. Overview of FM broadcasting
  1. Sample architecture diagram of an FM-RDS or FM HD solution
  2. Strengths and weakness of this approach
  3. Real world data and field deployment sample cases
  4. Support of smart grid efforts by the broadcaster community
2. Overview of weather radio
  1. Sample architecture diagram of a NOAA radio based solution
  2. Strengths and weakness of this approach
3. Overview of other broadcast based solutions
  1. Paging
  2. Others

Appendix 1 Value of broadcast: Efficacy comparison to biologic and social analogies

1. *Parables and analogies*

1. *Biological systems as design inspiration*

1. *Biological systems tend to be highly optimized as to survive the test of time*
2. *Human physiology as inspirational model (as outlined verbally by Conrad during SGIP H2G call of Sep 7<sup>th</sup> 2012)*
3. *Sample numerical analysis of suitable biological analogue to electrical system Demand Response here. (amount and speed of data vs. application needs)*

2. *Another view (social)*

1. *A parent can be “connected” to their college aged kids without the need for highly detailed “whereabouts”.*
2. *The kids don’t want nor would consent to “detailed” whereabouts. In fact the insistence on “whereabouts” would harm the relationship*