Whirlpool Energy Research

Energy Research
by Whirlpool Corp

MI 21st Century Energy Plan
Why did a consumer appliance manufacturer invest in energy management research?

- We believe energy consumption will be a cooperative effort in the future.
- To research technology issues in the energy managed home.
- Learn how we can assist consumers in managing their energy needs in a non-intrusive manner.
- To understand the consumer attitudes and expectations.

Annual Average kWh Usage

- Ref
- Wash
- Dish
Significant appliance energy efficiency gains... are being offset by the growth in TV, PC, entertainment and other residential devices.
The Whirlpool view ...
The energy landscape
(as we see it)

- many players
- complex
- overlapping accountabilities
- conflicting motivators

The energy landscape includes various players and stakeholders such as 3,316 utilities, grid owners, ISO, state PUCs, federal government, labs & special programs, power utility, utility technology providers, public utilities, investor-owned utilities, rural electric cooperatives, transmission grid ISO/RTO, generation facilities, and federal-owned power admin (e.g., BPA). This landscape is characterized by complexity, overlapping accountabilities, and conflicting motivators.
The energy landscape
Trends and directions

- Growing focus on real-time-pricing, (review of TOU tariff)
- Demand management is a utility industry focus area
- PJM (ISO/RTO) pioneering concept of an independent curtailment service provider
- Utilities and DOE gained interest in consumer behavior issues
- “Green Builder” programs gaining focus with large builders
- Grid-friendly concept being piloted in the Pacific NW
- 2-way communication power meter deployments
Time-of-Use Tariffs – as a form of DR
Numerous demand management programs exist with residential installations totaling well over 1,000,000 homes.

Program types include:

- Electric water heater DR
- Thermostat setback
- Critical peak pricing – thermostat, pool pump
- Water heater under-frequency and under-voltage
- Voluntary consumer response (energy ORB)
- Under-frequency load shedding / GFA (water heaters, clothes dryers)
Demand Response Programs

Current residential demand response systems tend to focus on a basic class of products. Advantages include:

- can retrofit
- model independent
- addresses largest users of residential energy
- methodology cannot, in turn, damage other downstream processes
- minimal direct consumer impact

Disadvantages include:

- access to a limited number of devices
- limited consumer interaction
- limited amount of energy that is controllable
- doesn’t enable newer micro-based devices
- tends to focus on curtailment rather than a base platform enabling RTP, peak management, load leveling, and grid stability.
Devices that perform a process on other consumer products (such as clothing or food) have not been feasible because:

- risk of damage to consumer products
- requires knowledge of both internal components as well as the status of internal processes.
- safety concerns

NEXT STEP:
Pilot a ADR with a device that processes consumer Goods

Control Basic Elements

Allow Consumer Preferences

AMR / AMI & 2-Way Communications
What tools can an appliance manufacturer provide?
Each appliance has something different to offer depending on the specific issue to be addressed.
How much energy demand can be managed?

General Questions:
• What product or device?
• At what time of day?
• At what cost?
• Instantaneous vs kWh

Additional questions by the product manufacturer:
• During what phase of the process?
• With what level of consumer acceptance?
• Can the appliance say “yes”, “no”, “wait”, or “meet me half way”?
What’s wrong with the assumption that:

“We can simply control an appliance at the circuit.”:

• Damage to consumer products
• Pause / Restart issues
• Safety Issues
• Inadequate process temperature control
• Loss of the effectiveness of consumables
• Consumer acceptance and satisfaction
Appliances, unlike some other residential products, are *Process-Oriented* devices.

They perform a multi-step process involving a variety of critical factors.

Consumers have a passion for the appliance process.

(Clean and admire unlike HVAC /HW)
Two main categories of appliances

Persistant

Single persistent task such as:
• Maintaining room temperature
• Keeping water warm

--- Forced power interruption ---

may be acceptable

Process-Oriented

Start-to-finish process involving multiple steps, sensors, temperatures and consumables often performing the task upon other consumer products such as food, clothing, and dishes.

NOT acceptable
Appliances as *process oriented* devices:

**Perform a process on consumer products**
- preserve food
- food preparation
- clean clothing or dishes

**An interruption may be objectionable depending on:**
- the state of the process
- the duration of the interruption

**Because of:**
- risk of damage to the consumer products
- potential to render the process ineffective
- the urgency of the consumer
- related safety issues
Need: The ability to include both Process-Oriented and Persistent appliances in energy & demand management

Persistent     Process-Oriented

Whirlpool Appliance Energy Interface enables:
- Tailoring to any appliance type or model
- Scaleable to handle a variety of control structures
- Accessible via any infrastructure, simple or complex
- Offers distributed energy demand intelligence
An energy-managed appliance:

- **Grid Friendly (GFA)** - brief instantaneous load shedding
- **Curtailment** - a load reduction request
- **Critical Peak Pricing (CPP)** - a temporary price change
- **Load / Peak Leveling** - coordinated energy consumption

Key Concept:
Each appliance model & type may have a different response depending on

- the capability of the appliance hardware
- flexibility of the appliance control system
- ability to meet the energy request without objectionable consumer disruption
- the general discretion of the designer / manufacturer
Could we define an **energy-managed appliance**?

Appliance actions defined as implementing one or more of these characteristics:

- **Grid Friendly (GFA)** - brief instantaneous load shedding
- **Curtailment** - response to external signal requesting a load reduction
- **Critical Peak Pricing (CPP)** – response to external CPP signal indicating a temporary price change
- **Load / Peak Leveling** - internal, external, or coordinated energy consumption limitation.
Speaking an “energy language” to an appliance or device
More specifically, what could a communications-enabled energy-managed appliance offer?

Consider an appliance device that may:

- Restrict use of the device (don’t start a new process)
- Limit certain capabilities of the device / process
- Wait to activate steps in process
- Inform the consumer of an energy restriction
- Continue process due to risk caused by interruption or delay
Whirlpool consumers have successfully shifted energy consumption to off-peak or non-critical peak time of day.

Two methods have been piloted in consumer homes:

1) Pilot consumers were able to load their dishwasher, dryer, or washer and simply press the **delay** button to automatically start the appliance during off-peak time of day.

2) Dryers report RTP/CPP price signal on the display panel.

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**DSM - Pilot Washer/Dryer/Dishwasher**

1) **LEDs indicate Peak or Off-Peak**
   - “Delay Util Off Peak” Button

2) **Price** – The dryer has received a critical peak pricing indicator.
In the Whirlpool Woodridge Pilot consumers have successfully shifted energy consumption to off-peak time of day:

Tool Features:

- LEDs indicate Peak or Off-Peak
- “Delay Util Off Peak” Button

Woodridge consumers can load their dishwasher, dryer, or washer and simply press the delay button to automatically start the appliance during off-peak time of day.
Comparing weekend with weekday for Non-DSM appliances
Comparing weekend with weekday for DSM appliances with \(\bullet/\bullet\) TOU LED and automatic off-peak start feature

Observation:
DSM feature seems to have driven usage to weekends and evening off-peak times.

Note:
These are appliances that interact with the consumer & invoke a process upon other consumer products.
**WeekDAY** total home energy consumption comparing DSM, Non-DSM, & other loads.
(same 4-homes, 1 year weekday data)

**Observation:**
DSM did not follow this non-DSM evening peak.
Woodridge: clothes dryer data

(ELCAP Study)

Dryer

Successfully shifted off-peak
Envision the future

RTP-enabled Demand Managed Appliance:

Features:

- LEDs indicate Peak or Off-Peak
- “Delay Until Off Peak” Button

Future Considerations

- Receive broadcast of Peak & Off-Peak times
- Receive broadcast pricing signals
Whirlpool energy monitoring system:

“What gets measured gets managed”
Our homes don’t have a Dashboard?
Without a “Dashboard”, energy cost is unknown.

You don’t drive your car without knowing the fuel cost.

You shouldn’t have to “drive” your home without managing energy cost.
Heat Pump used 543.87 kwh at cost of $22.55

Dryer responsible for 4% of energy cost & 3% of energy consumed
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The Energy-Managed Dryer
Manufactured by Whirlpool Corp

Dryer panel

GridWise™ Demonstration Project

Grid-Friendly™
Consumer Friendly
Demand Management Enabled
Real-Time Pricing Support
Energy Efficient Platform

PacNW Project
PacNW Pilot / Grid Friendly Appliance (GFA)

• The instant load shedding for a brief period (e.g. several minutes). A simple Boolean (Yes/No) signal from a hardware switch or software can provide a GFA message.

• GFA provides a cost-effective alternative to spinning reserves

• Typical appliance response could include:
  – continue process but trim major load
  – halt the entire process for a short period of time
  – the appliance control may override to ensure the success of the process.
GFA - Grid Stability Sensor Example

With GFA: Frequency Excursion Arrests at 59.950 Hz within 0.7 sec.

Without GFA: Frequency Drops to 59.886 Hz within 5.8 sec.

With GFA: Frequency Excursion Arrests at 59.950 Hz within 0.7 sec.

Deactivate heat for 50 seconds ...

Appliance Responds (Average duration of 2 minutes)

“Spinning Reserve” power applied From running backup generators

Grid-Friendly Appliances Respond faster without cost of running backup generators

PNNL Sensor Detects grid frequency & triggers at appropriate time

Future System

Current System
Clothes Dryer - used in the PacNW Pilot

Example appliance response:
- turn off the internal heating element
- continue drum rotation
- reduce the heat/temperature
- automatically extend the drying time to compensate for the reduced energy mode
- allow consumer override / continue
  (after specified time interval)

GFA event reduces pilot dryer from approximately 5,700 watts to approximately 280 watts.
PacNW Pilot / Pricing Experiment

**Pr** ice – The dryer has received a critical peak pricing indicator.

Consumer notified of a temporary energy price increase.
The definition of an **Appliance Energy Interface** enables:

- Tailoring to any appliance type or model
- Scaleable to handle a variety of control structures
- Accessible via any infrastructure, simple or complex
PacNW Project

Limited Run 19-Jan-2006

PRODUCTION

Energy-Managed Dryer

Install pre-assembled CCU (control/Iso bd) bracket

First “Power-Up” in test room
The path to an Energy Optimized Home enabled by energy interfaces in the controls

- Control Basic Elements
- Allow Consumer Preferences
- Grid-friendly appliances
- AMR & 2-Way Communications
- Include devices that processes consumer Goods
- Multi-device energy synchronization
- Combined residential contribution to grid stability, TOU, Peak, & Curtailment.

- Large Reduction in Maximum Incremental Energy Demand
- Max Kw limitations can be imposed with TOU periods.
Questions & Comments?

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