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Residential IoT: Evolving Opportunities and Challenges for Plug Load DR and Energy Management

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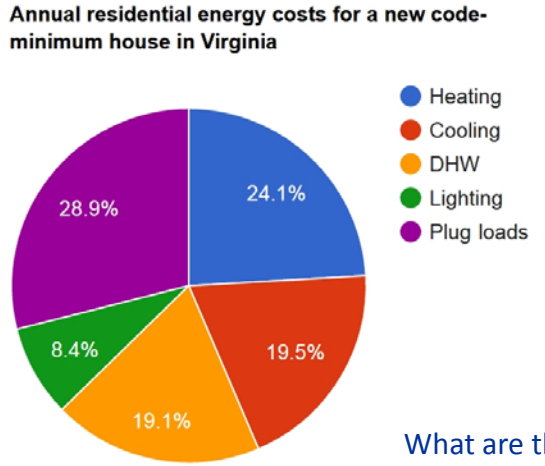
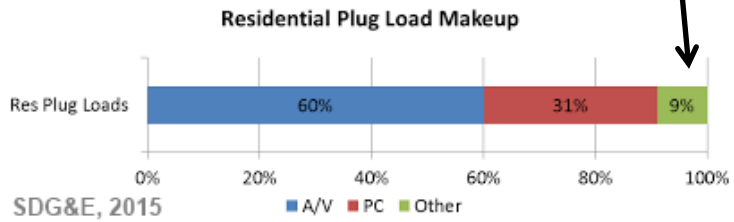
But First: Why Study Plug Loads?

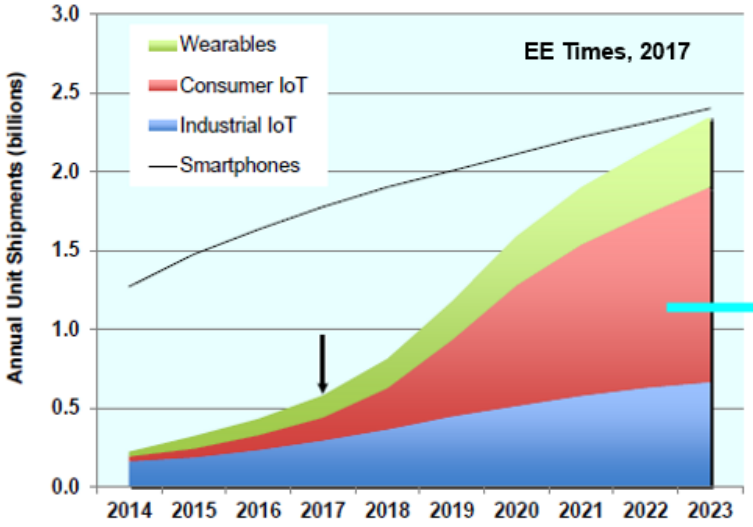
Figure Sources: P. Delforge, NRDC; SDG&E, Green Building Advisor

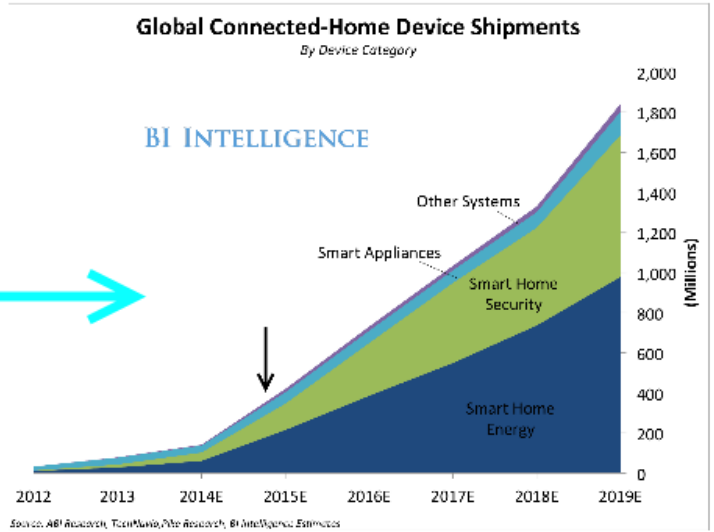


What are the contributors to this "other" category, and how can this issue be addressed?



A check-in on the Residential IoT market



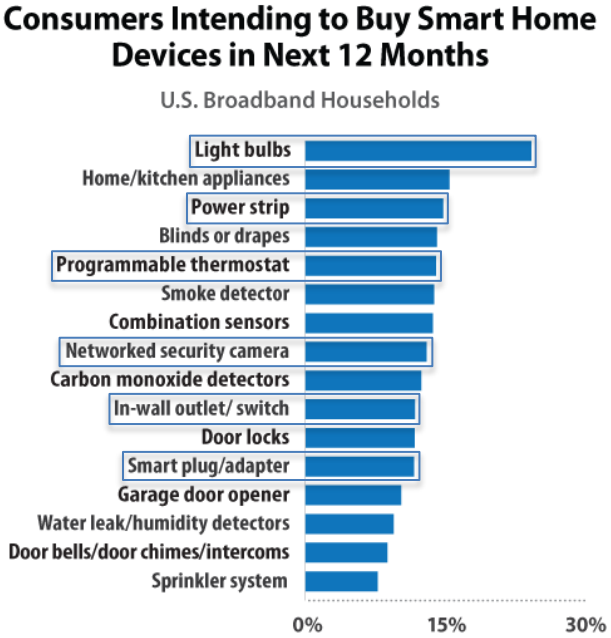


Data Source: EE Times, BI Intelligence

Residential IoT:
What is the value proposition for home connectivity and automation?

1. Safety and Security
2. Chore Automation / Convenience
3. Resource and Energy Savings
4. Health and Wellness

How effective is IoT-managed energy savings and DR control? How does this fit into integrated strategies? Blurring of EE and DR Lines



Why consider IoT technology in Residential EE and DR programs?

1. A continually growing new paradigm for connectivity, monitoring and controllability, AI and data analysis capability being improved
2. Potential to both add capability to manage and add to load.
3. A wild market still evolving in residential and commercial applications
4. Integrating with other consumer tech. trends: home health, autonomous/connected vehicles, mobile apps, etc.

IoT's Potential Role: Assisting Economical & Persistent ZNE
(The 5 R's of ZNE Implementation)

- **Reduce**
  Reduce structure on-peak demands followed by total demand
- **Replace**
  Generate energy to offset building use, either as possible on an annual basis (net-metering) or as much as economically possible on a momentary basis. Co-gen is viable in some applications for energy offset.
- **Relocate:**
  Generation on a campus or community can be shifted between localized over-generation and under-generation/overuse between structures or entities. Campus co-gen viable for energy offset in some cases.
- **Retain:**
  Energy storage to offset campus-wide or individual building usage.
- **Reevaluate:**
  Functional ZNE is dynamic equilibrium. Changes in devices, user behavior, equipment age or control system disintegration may cause reduced performance. Inspections potentially followed with training, tuning, or control system adjustments may be needed to maintain continued performance.

Continued Consumer IoT market uptake drivers for EE/DR

- 2019 residential Time of Use (TOU) rates
  Intrinsic customer price motivation / Some blurring between EE and DR efforts
- Reducing cost, improving features, improving interconnectivity of devices
  Overall improvement of utility and value to the customer for multiple applications
- Tech diffusion maturity: fringe to routine
  Matured along with other adopted energy/connectivity technologies
- Smart speakers providing voice interface
  Improved usability with better command and control interfacing

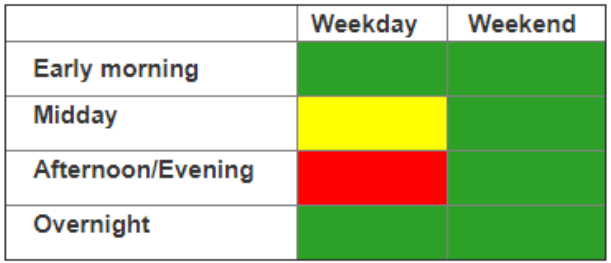


Image Credit: CPUC

Device Control Prioritization

- Avoid devices in which control overhead and user impact deemed too high
  - Avoid user frustration and future non-participation.
  - DR effects causing additional energy use or user frustration
- User actionability of information
  - *Clear notification of the user of actions and ability to opt out on an event basis.*
  - *Avoid frustrating, confusing or unintentionally mis-training users of typical/logical device operation.*
  - Provide external information to empower decisions proactively or prime for reactive efforts

Automation for DR Applications

- The classics: HVAC, Water Heating 
- The strugglers: Major appliances, lighting 
- The newcomers: Electric Vehicles, personal device charging 
- The “be careful's”: STBs, Security, Refrigeration, in use AV equipment/game consoles, in use computers and computer accessories 

Considering both “Heavy Touch” and “Light Touch” approaches

Image Sources: flaticon.com

DR Control Intervention Approaches

Light Touch - (Passive Targeting): Notification, behavior encouragement, EE measures focused on peak load reduction via cost motivation mechanism (assuming TOU rates).

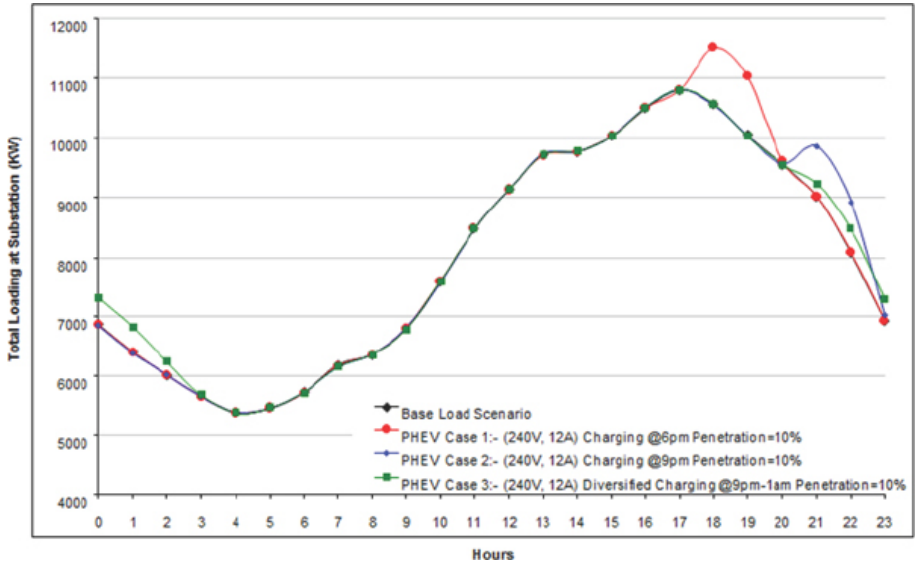
Heavy Touch - (Active Targeting): Notification, external direct control, local managed control with reporting or locally managed control with triggering, use curtailment.

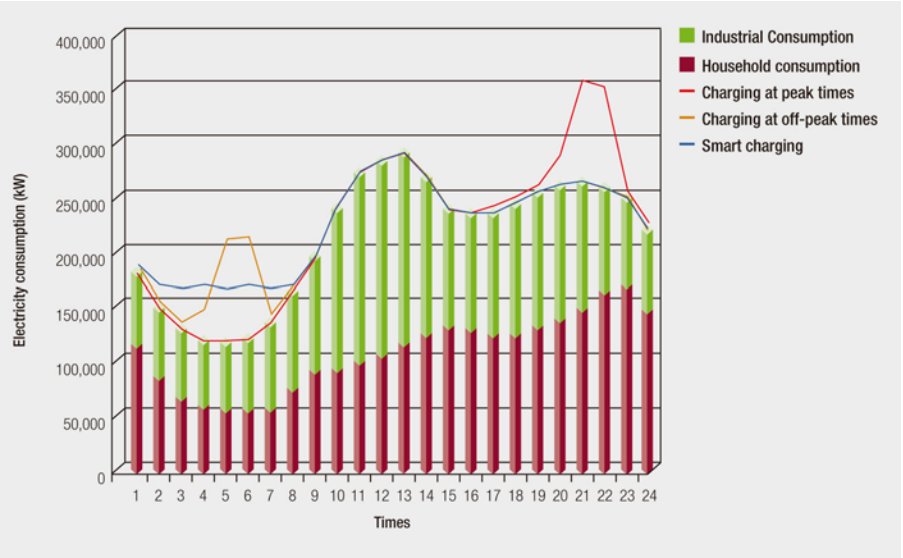
Image Source flaticon.com

Considerations for Implementing Energy Management / DR Control

1. Prevent disruption or degradation of user experience, especially with no warning or opt-out control.
2. Prevent complication of user's normal routine without substantial, clear value added while not compromising the inherent image of reliability and quality.
3. Prevent user confusion by expected and clear operation with intuitive operation and small operation learning curve.
4. EASY TO USE Require little to no maintenance for continued use, resilient in operation.
5. Respect users' privacy, wishes / intentions, and data security.
6. **With external controls**: Target devices with multiple operational states with periods of waste to target: either via cutout, state shifting, or throttling with high load reduction potential to offset cost of controllability.

Example 1: EV Charging Management





Neaimeh, et. al., 2015, Frias, Mateo, Perez-Arriaga, Oct. 2011

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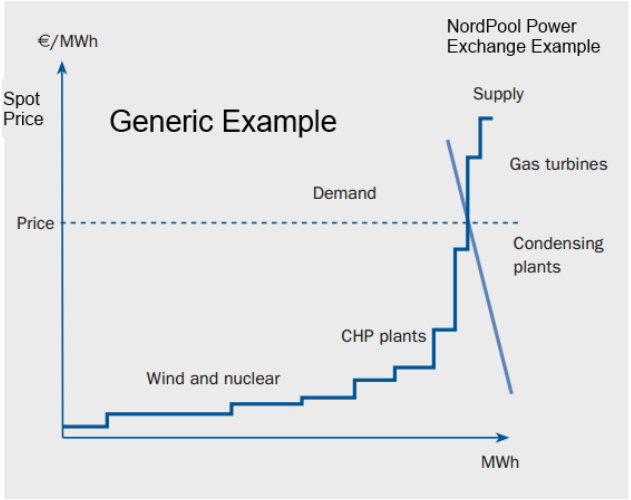
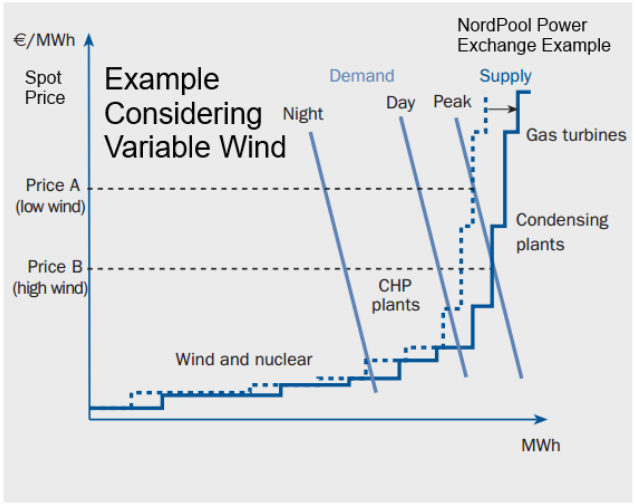
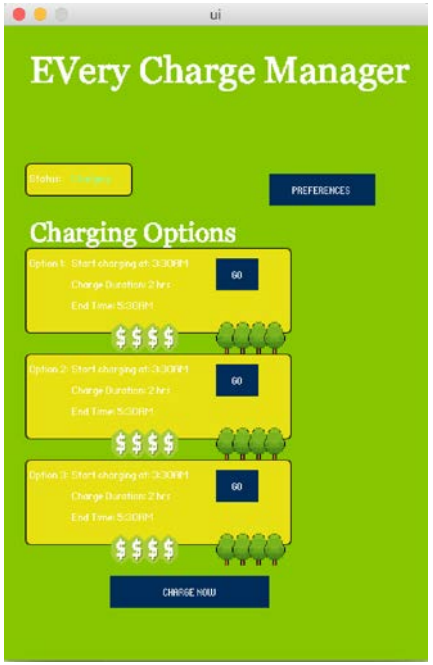


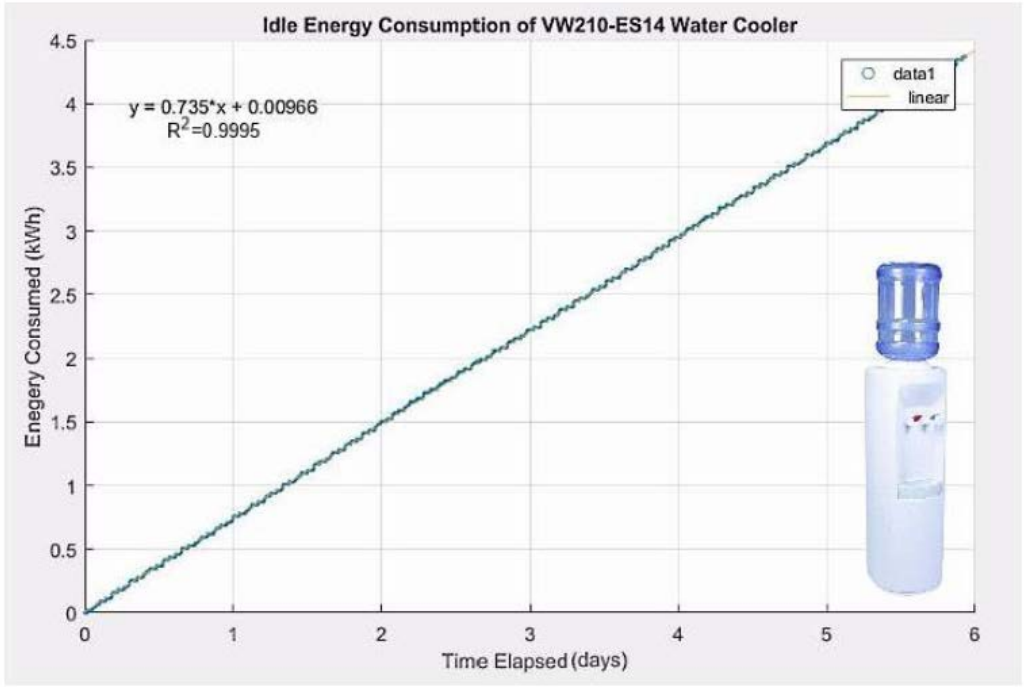


Source: Risø DTU



Consideration of control, forecasting, and dispatchability of both supply and demand for EV Charging

Example 2: Point-of-Use Hot Water Heating



Klopfer et. al,, EEDAL, 2017

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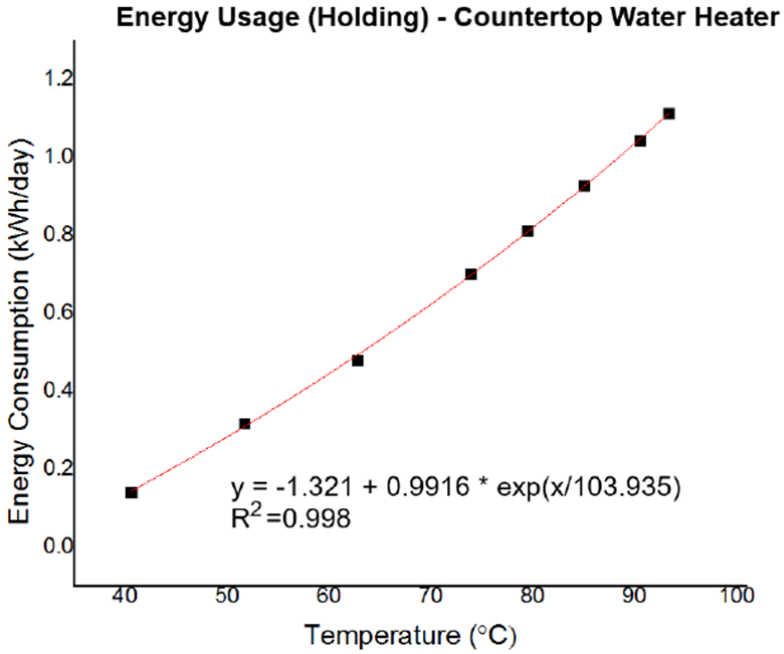

Klopfer et. al,, EEDAL, 2017

Conclusions

1. IoT technology can provide improved control but can add load.
2. EE and DR programs focusing on residential device control have overlapping targets in TOU scenarios
3. Communication is key to help leverage market forces to drive user decisions
4. Strategic “Hardness” of targeting can be considered per device
5. Customer education and outreach
6. Direct targeted devices depend on impact and ease of use, general EE programs can have peak reduction effects.
7. Continued work with demand shifting using AI and pattern recognition can lead to extended reduction impacts with tighter controllability

Thank You!

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Extra Material

IoT Technology: Capability for Energy Management

1. Control and moderated self management of IoT integrated devices (Smart appliances, smart bulbs, connected devices)
   Direct or moderated self management of energy use and reporting, deep integration possible
2. Use of IoT Sensor/actuators (smart plugs, thermostats, connected controllers, controlled EV chargers, etc.)
   Direct management of energy use and reporting, shallow integration typically possible
3. Interfaces and input/feedback control
   Use of sensor networks
4. Local device processing and control capabilities (gateways, HEMS, and local managers)
5. Remote processing and externally mediate control (With direct/indirect external processing, DR control signals)