Smart Grid 2.0 – Beyond Meters and onto Intelligent Energy Management

The world's first smart grid installation Back in 2001, Enel—Italy's dominant utility—started a five-year program to install smart meters across its customer base of 30 million homes and businesses. The goal was to improve efficiency, create higher margins, reduce power theft, and help customers reduce their energy bills. Enel created its smart grid using Echelon's power line communications technology and data concentrators.

Enel Project – at a glance:

- Deployed 2001-2005
- 30 million meters
- Installation rate 700,000 meters/month for 3 years
- Installed price: € 2.2 billion
- ROI: € 500 million/year in operational savings, approximately 4-year system payback

Enel's smart grid project includes multi-tiered tariffs for TOU pricing, integrated pre-pay, integrated meter disconnects in every residential meter, support for in-home displays, support for water and gas metering, theft detection, power quality measurements, and metering at the distribution transformer (theft detection, phase balancing).

Smart Grid 2.0 – What's Next?

Almost 10 years later, we've now moved beyond two-way communications and remote meter reading towards the smart grid 2.0. The smart grid 2.0 puts intelligence and communications in devices throughout the grid from distribution equipment (meters, transformers, capacitor banks, etc.) to commercial electrical devices (chillers, boilers, air handlers, lighting, etc.) and home appliances like electric water heaters, air conditioners, and rooftop solar arrays.

These "smart" devices can now become a part of the grid, able to interact in real-time to changing conditions on the grid. The smart grid 2.0 uses the grid network and the devices connected to it as a communicating, intelligent system for the delivery of additional services and increased operation efficiency, such as demand response programs.

Another significant benefit of the smart grid 2.0 is asset management. Because of this network infrastructure approach to the smart grid, utilities can see all equipment and how the power lines interconnect that equipment to monitor the health of the systems in real time.

Conservation as an Alternative Energy Source

Electrical generating capacity from fossil fuel sources may become capped – either economically, legislatively, or due to environmental concerns, making energy conservation and renewable resources essential elements of today's energy market.

U.S. utilities experience peak demand just 2% of the year, but to serve customers on such days, utilities incur 15% of the total costs for the year. If the peak electricity loads on these days could be better anticipated and lowered, utilities would experience fewer black-outs and brown-outs and could significantly reduce costs. Electric utilities, being regulated, are allowed to charge for their operating expenses plus a return on their investment. The ratepayers thus fund the utility's expenses and profits. Lowering the operating expenses by curtailing peak demand will result in lower costs to the ratepayers.

First it is necessary to look at the highest energy users: Commercial buildings account for 72% of overall electricity consumption in the U.S., and offices, retail, hospital, and grocery stores use 75% of the total lighting energy. Cities also have large electricity demands, specifically for streetlights, which use 40% of the average city's electricity budget.

Aggregators and utilities can shave peak demand with automated demand response programs. The smart grid 2.0 enables demand response programs which significantly reduce the strain on the grid at times of peak use. These energy savings could provide enough power to fuel electric or hybrid vehicles and reduce the need for additional coal-powered energy plants. Currently only 14% of the commercial U.S. electricity market is enrolled in demand response programs, leaving an 86% potential market, a huge commercial opportunity for demand response providers.

Business Drivers

Economic forces are aligning toward the development and deployment of the smart grid. Recent energy legislation, governmental policy and regulation, the U.S. stimulus package, increased investment in green tech and alternative energy, and increased public awareness regarding efficient energy use are all contributing to the growing smart grid market.

A recent poll of North American utilities shows that 70% regard smart grid projects as a strong or highest priority to their overall business. Combined stimulus package funding and incentives to improve the grid are leading to rapid growth in the energy market.

Achieving Smart Grid 2.0 Benefits

The benefits of the smart grid 2.0 include higher economic productivity, decreased pollution and lower CO_2 emissions from conservation, electric vehicles, and renewable electricity sources. In order to procure and deploy systems that meet a true smart grid 2.0 definition, several requirements must be met.
First, power line communications are necessary from the meter to the distribution transformer in order to know the network topology and identify failures. Knowing the topology allows intelligent management of EV chargers, distributed generation, distributed storage and protects distribution equipment life. Secondly, sensing and control at the distribution transformer are needed to take timely action on any failures even before they occur. And lastly, utilities need to avoid systems that are meter-centric and fail to encompass the notion of the grid as a network. These meter-centric systems, useful only for enforcing new pricing models on the consumer, will be outdated in 10 years or less, leaving many utilities with "stranded assets", an asset that becomes obsolete prior to being fully depreciated.

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Attached: Robert's presentation to this paper

Smart Grid 2.0 – Beyond Meters and onto Intelligent Energy Management

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Session 101 – Operations

May 11, 2010

Smart Grid 1.0

- First deployed by ENEL in Italy from 2001-2005
  - 27 Million residential and light commercial meters, 95% of the meters in Italy
  - Installation rate was 700,000 meters/month for 3 years
- Installed price: 2.2 Billion Euro, returns 500 Million Euro/year in operational savings
- Key features:
  - Multi-tiered tariffs for TOU pricing, integrated pre-pay, integrated disconnects, support for in-home displays, water and gas metering, theft detection, power quality measurements, metering at the distribution transformer (theft detection, phase balancing)

What’s Next?

- Smart Grid 2.0
  - Using the grid and the devices connected to it as a communicating, intelligent system
  - Increased efficiencies
    - Beyond pricing plans enforced by intelligent meters
    - Beyond operational efficiencies from remote disconnects and power quality data

Why is the Smart Grid Important?

- Energy is a principle raw material for GDP formation
- If GDP grows, the standard of living improves
- If electrical generating capacity from fossil fuel sources is capped – either economically, legislatively, or due to environmental concerns…
  - Energy to grow GDP must come from conservation and renewable resources

Conservation *Could* Come from Commercial Buildings

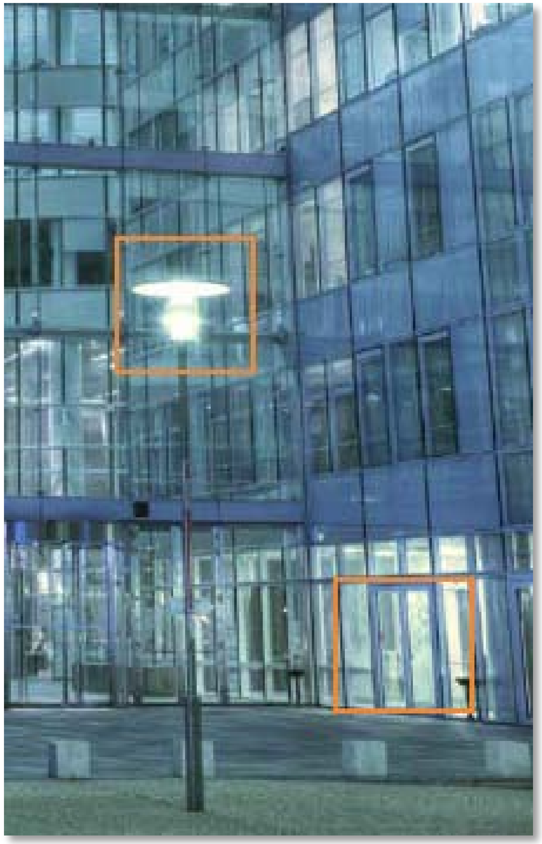
US buildings account for 72% of electricity consumption

Source: Department of Energy

Commercial Buildings *Could* Reduce or Dim Lighting

Offices, retail, hospital, grocery stores use 75% of total lighting energy

This translates to 30% of total energy demand during summer peak hours 2-5 pm *(compared to 32% for air conditioning)*



Source: Demand Response Research Center

Aggregators and Utilities *Could* Shave Peak Demand

US utilities experience peak demand just 2% of the year

To serve customers on such days, utilities incur 15% of the total costs for the year

Source: Fortune

Off-Peak Power *Could* Fuel Electric and Hybrid Vehicles

Did you know that 40% of the average US city's electricity for lighting is consumed by its streetlights?

Source: Fortune

What is Smart Grid 2.0?

- Smart Grid 2.0 puts intelligence and communications in:
  - Distribution equipment
    - Meters, transformers, capacitor banks, etc.
  - Significant commercial electrical loads
    - Chillers, boilers, air handlers, lighting, etc.
  - Home appliances
    - Electric water heaters, air conditioners, etc.
  - Rooftop solar arrays, EVs, etc.

When Will We Need Smart Grid 2.0?

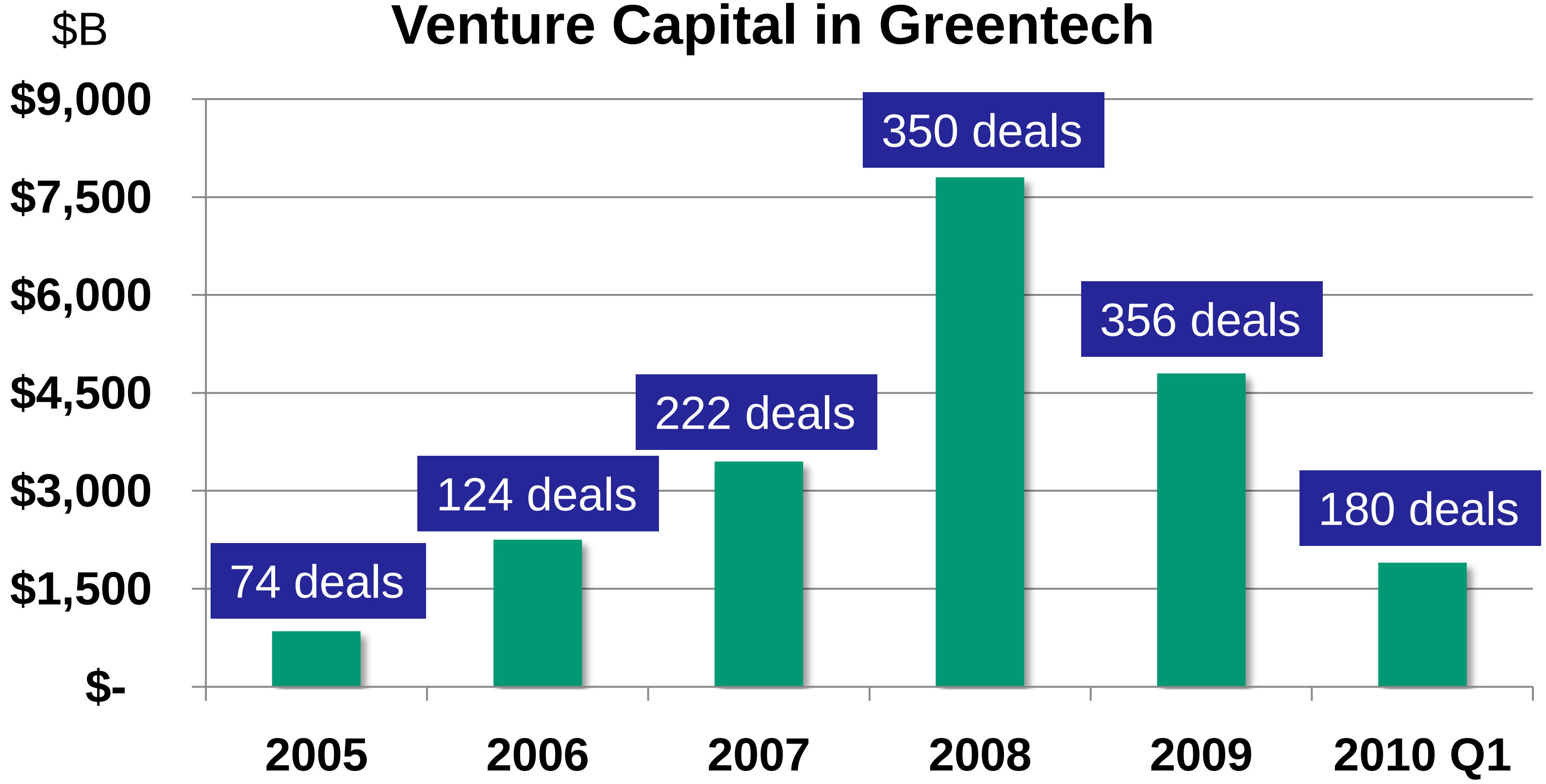
- Economic forces are aligning toward the development and deployment of the Smart Grid
  - Business drivers
  - U.S. Stimulus Package
  - U.S. legislation

Business Drivers

- Growing focus on alternative energy and clean tech
  - Increased public awareness of the green movement
  - Businesses and consumers actively participating in efficient use of energy
- Global governmental policy and regulation
  - Incentivizing energy efficient buildings and homes
- Economic stimulus and incentives to improve the smart grid
- Growth in emerging energy markets
  - Demand response, branch management, street lighting and smart metering

Investment in Greentech and Alternative Energy

Venture Capital in Greentech

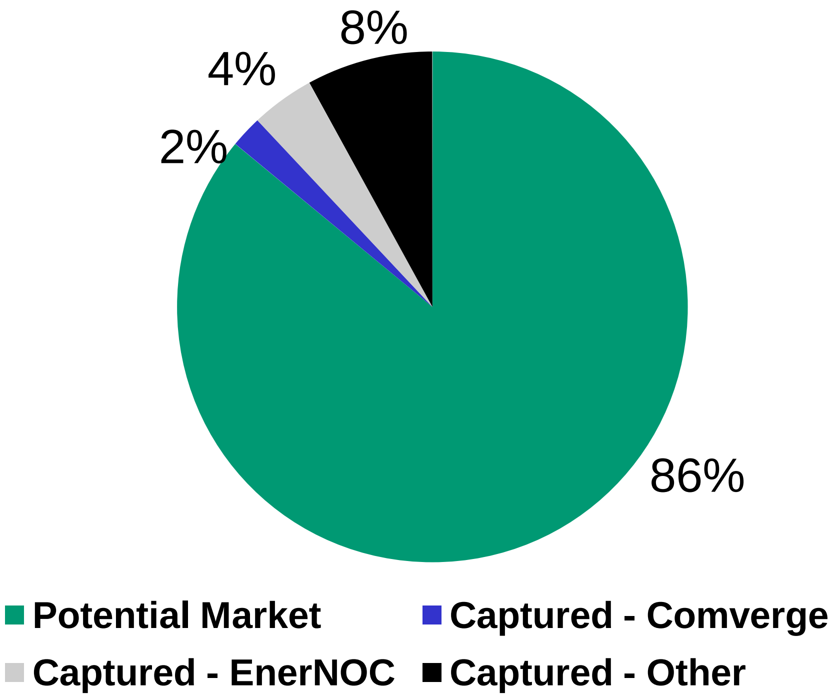


Source: Cleantech Group and Deloitte

Commercial Opportunity – Demand Response

Recall that 15% of a utility's operating expenses are for providing for peaks that occur only 2% of the time!

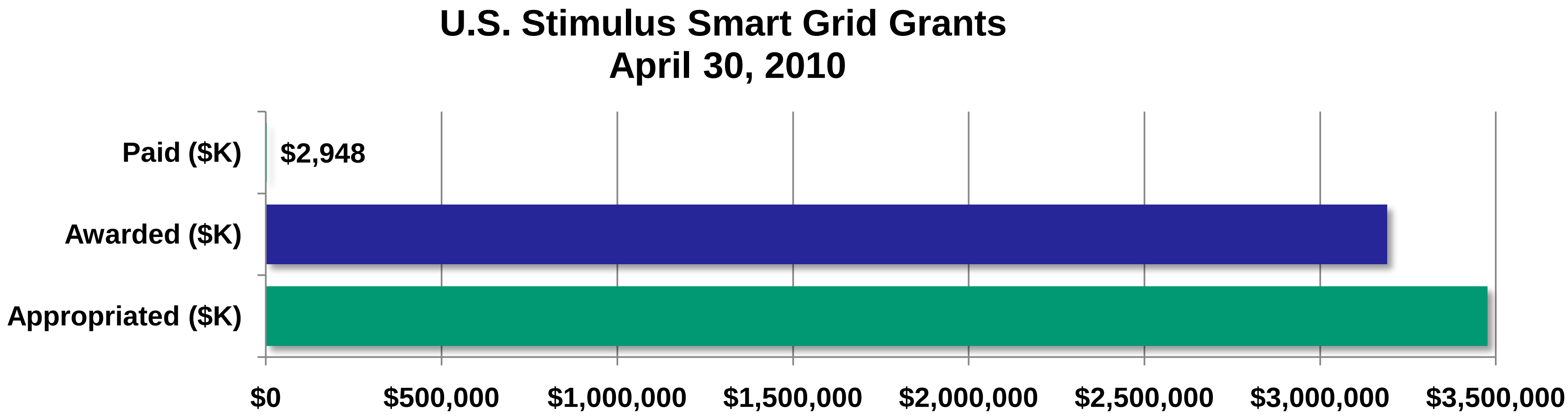
U.S. Commercial Demand Response Market



Source: Fortune & Pike Research

U.S. Stimulus Package

- Smart Grid - $3.5B for modernization of the nation's electricity grid
- Good news…except the majority hasn't been disbursed yet



Source: Recovery.org

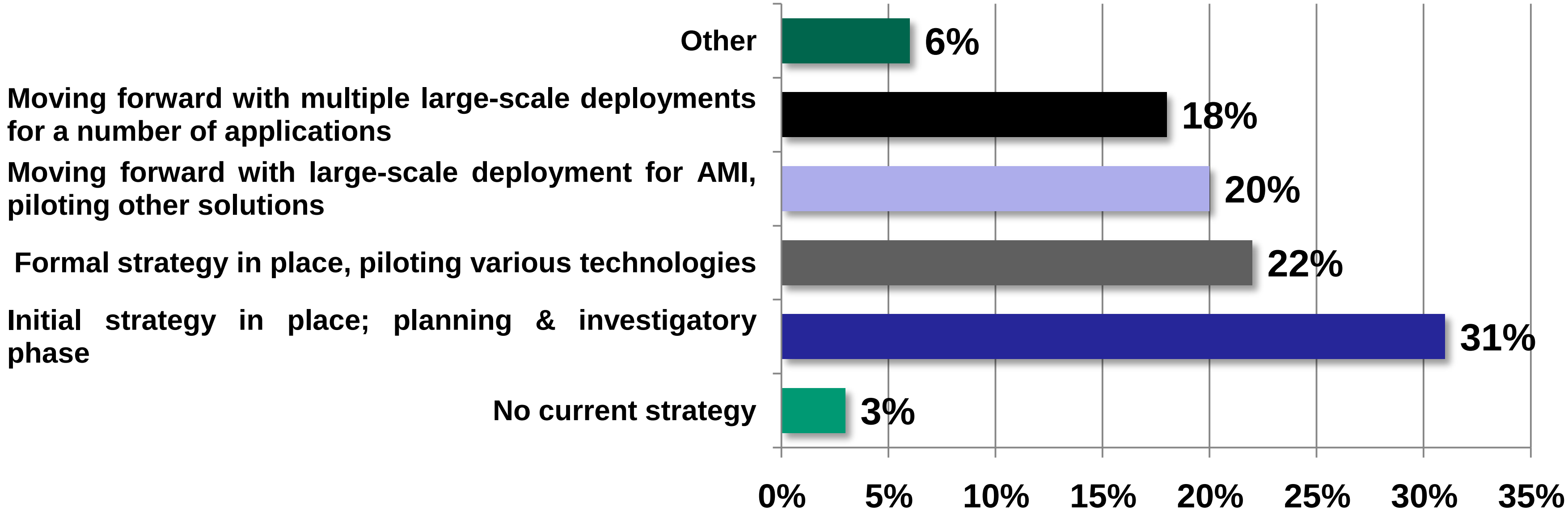
Clean Air Bill

- Transition US to a *"clean energy economy"*
- Utilities must generate 20% of their electricity through renewable energy and energy efficiency by 2020
- Sets new energy efficiency standards
  - 50% higher energy efficiency building codes by 2016
  - Higher standards ratings programs such as Energy Star for lighting and appliance efficiency
- Invests $90B in energy efficiency and renewable energy by 2025
- Status – Approved by House; awaiting Senate review

North American Utilities Have Smart Grid Plans in Place

70% regard smart grid projects as a strong or highest priority to their overall business

How would you describe your current Smart Grid deployment status?



Source: GMT Research

Smart Grid 2.0 Implications

- Communication and computation capacity must increase dramatically!
  - Geographically disbursed, renewable energy sources with variable energy output must be balanced with demand
    - Energy supply from renewable sources must be made predictable in the near term
  - Demand must also be managed in real time
    - Buildings and residences must shed peak loads
  - The shift to electric and hybrid transportation will change energy usage patterns and demand cycles

Use Case – Asset Management

- Mapping customers to distribution transformers
- Mapping EVs/PEHVs to customers
- Mapping rooftop solar generation to customers

Asset Management – Duke Energy Experience

The picture to the left shows the relationship of the meters to the transformers as depicted in Atlas and CIS

The picture to the right shows the meter to transformer relationship as determined using the PLC network

Maps courtesy of Duke Energy

Residential Opportunity – Time of Use Pricing

- It's coming…and you're not prepared
  - You need a smart, automated way to manage consumption so the consumer doesn't have to
- Managing HVAC loads
  - Today – programmable thermostats used to manage load can result in customer ill will
  - Future – knowledge at transformer allows utility to stagger compressor cycle
    - Shaving peaks, thus reducing costs while keeping the A/C on
      - Possible through intelligence and visibility of power line communications

Use Case – Micro Grids

- Multiple customers on a transformer opt for rooftop solar arrays – incentives are rebates, TOU pricing, etc.
- Residential generation capacity exceeds transformer rating to supply reverse power to the grid on a sunny day
- Instead of failing, intelligence at the transformer shuts down an inverter, issues alarm for undersized transformer, head end issues work order, larger transformer is installed

Use Case – Electric Vehicles

- Consumers will want longer range and faster charging of their EVs
  - Higher ampere chargers over a shorter time, for example, Tesla Roadster Charger is 70Amps @ 220v with a 240+ mile range in ~3 hours
- Consumer plugs in a vehicle, causing the distribution transformer to overload
- Instead of failing, intelligence at the transformer knows *which* charger to put into "slow charge" mode

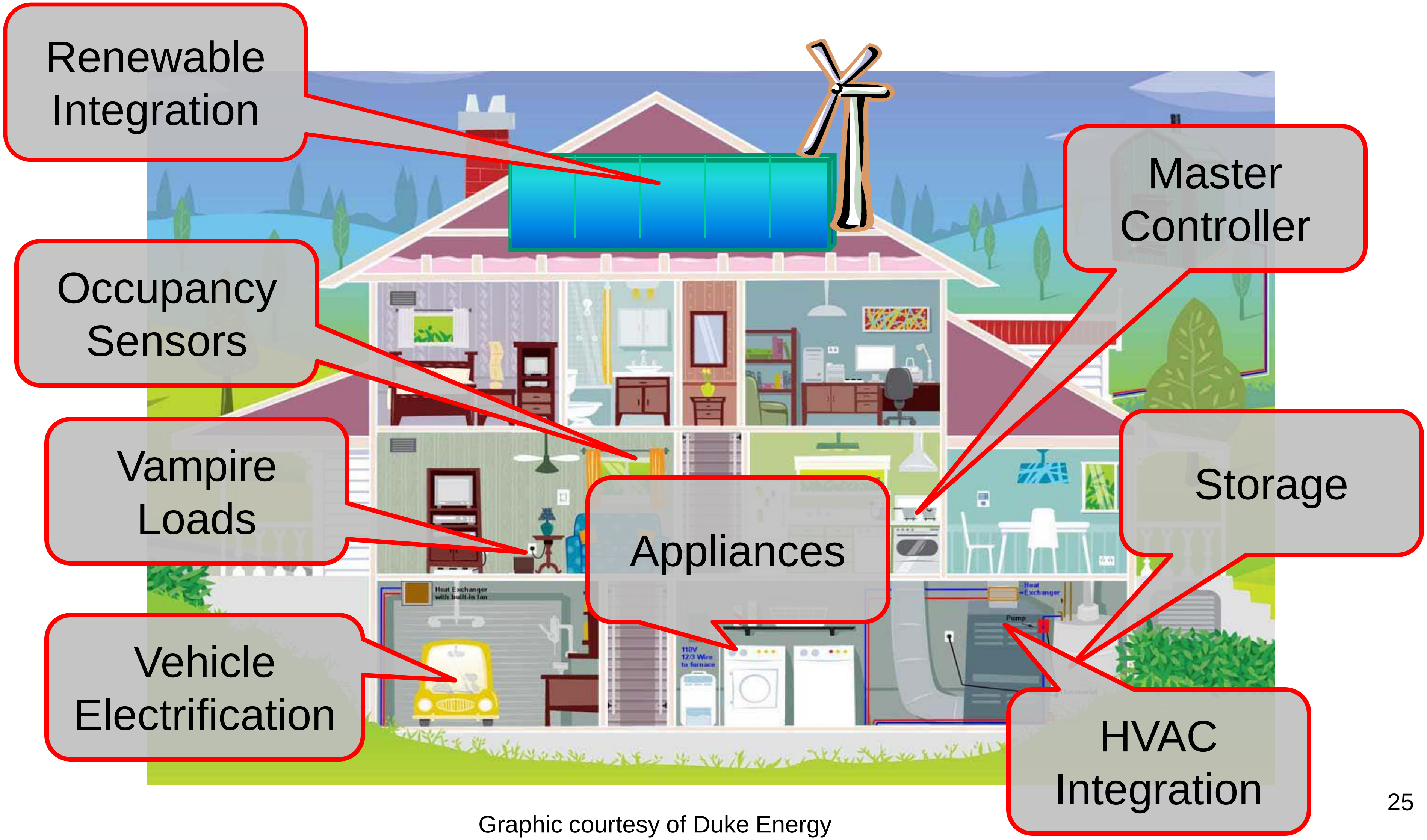
Residential Opportunity

- Manage your energy consumption
  - Transparency – line item detail
  - Control – red light?
- Automated *back-of-mind*
  - Preference-based approach
  - Integrated
  - Self-learning
  - Interactive - configurable

Residential Opportunity

- What are we *really* trying to accomplish?
  - Energy efficiency
  - *Maybe* smarter energy consumption
  - Universal access
  - Framework for a smart grid (transformational products)
  - *Win cubed*
- How might this look?

Customer Experience



Graphic courtesy of Duke Energy

Results

- Automatic scheduling to shift demand produces real energy savings
  - Turn off the water heater when no one is home
  - Manage vampire loads
  - Shift appliance cycles to off peak
- Managing the HVAC loads across a distribution transformer minimizes peaks
  - HVAC is ~50% of the bill so managing it is key
  - Most AC compressors cycle at 7 minutes on & 15 minutes off
- A more efficient utility can bill customers for less money, keep their customers comfortable and happy,earn more profit, and through conservation, benefit the environment

Use Case Requirements

- Distributed intelligence and control for rapid decision making and reactions
  - Meter, transformer, inverter, charger, etc.
- Accurate topology information
  - Where do the low voltage distribution cables go?
- Centralized policy
  - Policy applied across the service area

Distributed Decision Making

- Sensing and control at individual grid elements makes it possible for timely autonomous action
  - A scalable solution versus sending everything up to a central site and then back down to the grid

Automatic Topology Management

- Utilities all have drawings of their grid
- In the chaos of construction the drawings are not updated to “as built”
- In the haste of service restoration the drawings are not updated
- In the end, keeping this information up to date is too expensive – unless it is automatic
  - Use the grid to map the grid – low voltage power line communications provides this benefit

Centralized Policy

- Distributed intelligence needs provisioning
  - Which customers “opt in” for which plans and services
  - Which loads are O.K. to shed
  - What is the alarm threshold value for a given distribution transformer’s internal temperature or current flowing through it
- Data must trigger actions
  - Work orders, repair verifications, etc.

The New "Stranded Assets"

- A "Stranded Asset" is an asset that becomes obsolete prior to being fully depreciated
- If we have a Smart Grid in 10 years, and systems are being deployed today that:
  - Don't have intelligence at major grid elements
  - Don't make local decisions and implement control
  - Don't know and automatically update the grid topology
- Then those systems are stranded assets and prevent the Smart Grid
  - Who will pay to update those systems with 10+ years of depreciation left on them?

Smart Grid 2.0 Benefits

- Economic productivity – lower costs to produce the GDP
- Less pollution from the transition to electric vehicles and renewable electricity sources
- Lower CO_2 emissions from conservation, EVs, and renewable electricity sources

Achieving Smart Grid 2.0 Benefits

- Procure and deploy systems that meet the envisioned Smart Grid use cases
  - Power line communications from meters to distribution transformers to know the topology
  - Sensing and control at the distribution transformer to take timely action
- Avoid systems that are meter centric and fail to encompass the notion of the grid as a network

Thank You!