Smart Grids

& Electric Drive Transportation's Impact

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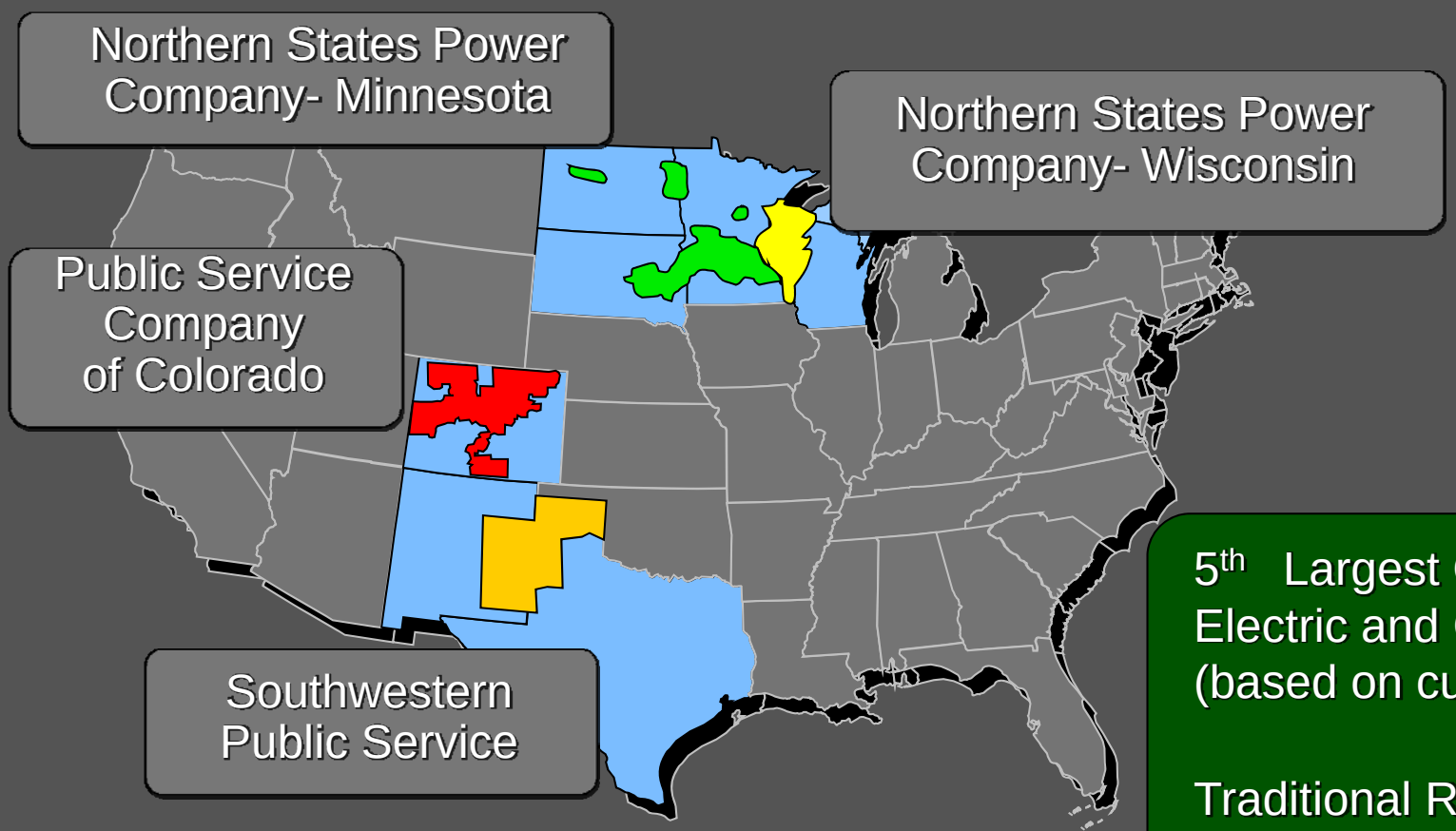
Xcel Energy®

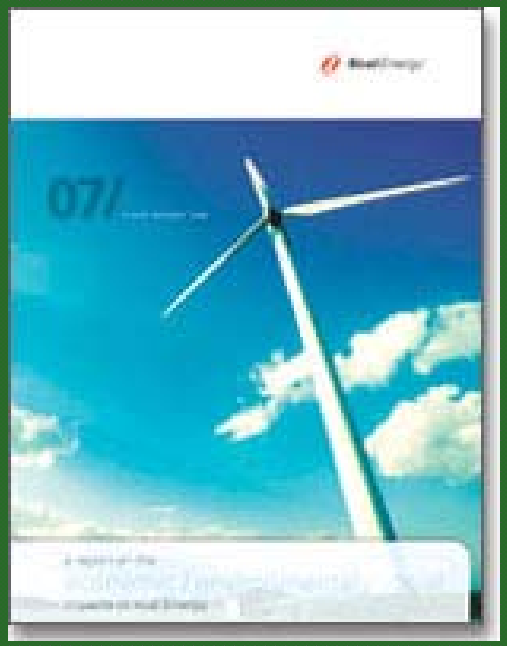


5th Largest Combination Electric and Gas Utility (based on customers)

Traditional Regulation

Xcel Energy's Environmental Leadership

- No. 1 wind energy provider
- Industry-leading voluntary emission/carbon reductions
- Transmission system upgrades enabling renewables
- Investments in solar future
- New technologies
- Member of Dow Jones Sustainability Indexes Member 2006/07

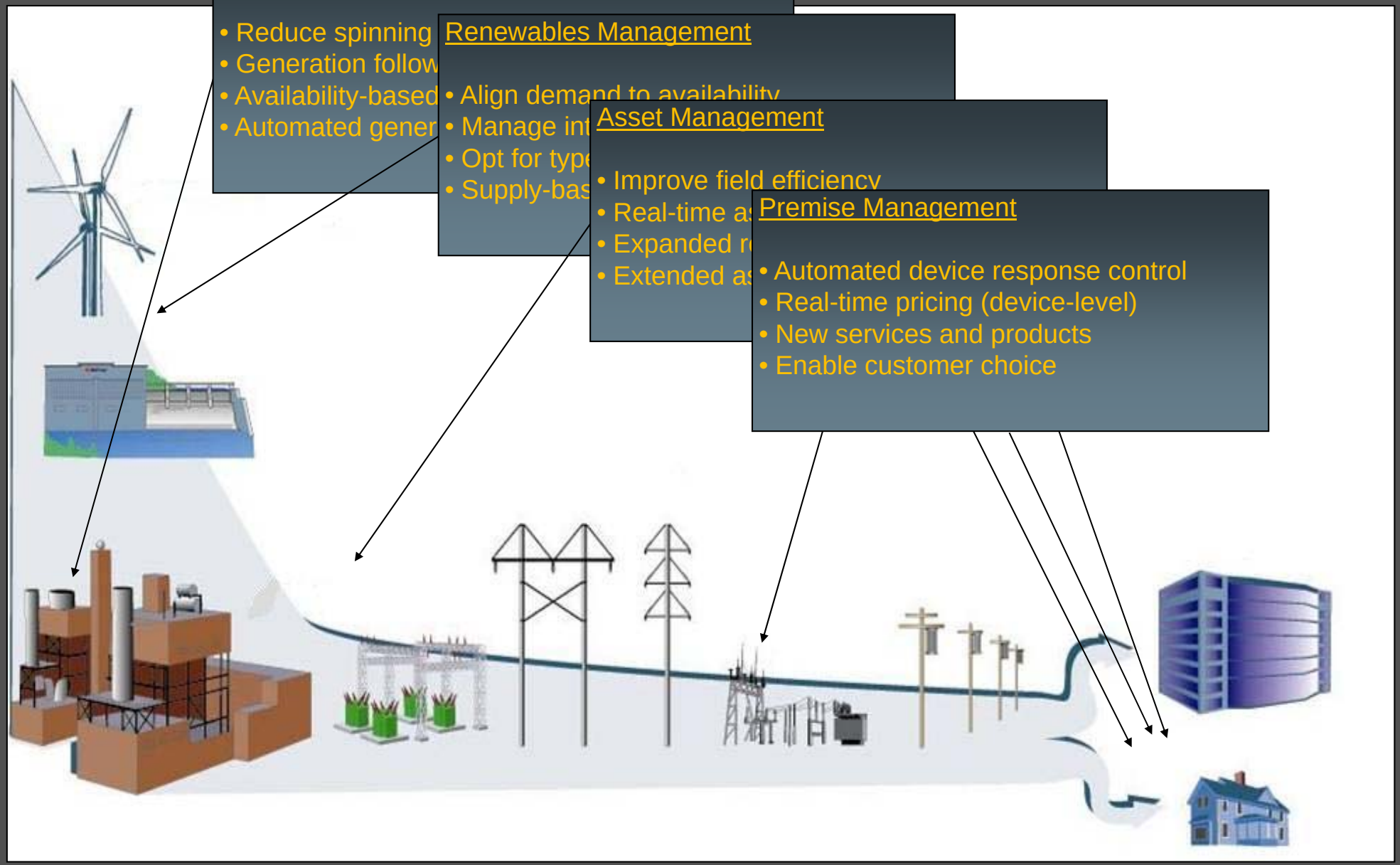


Smart Grid City

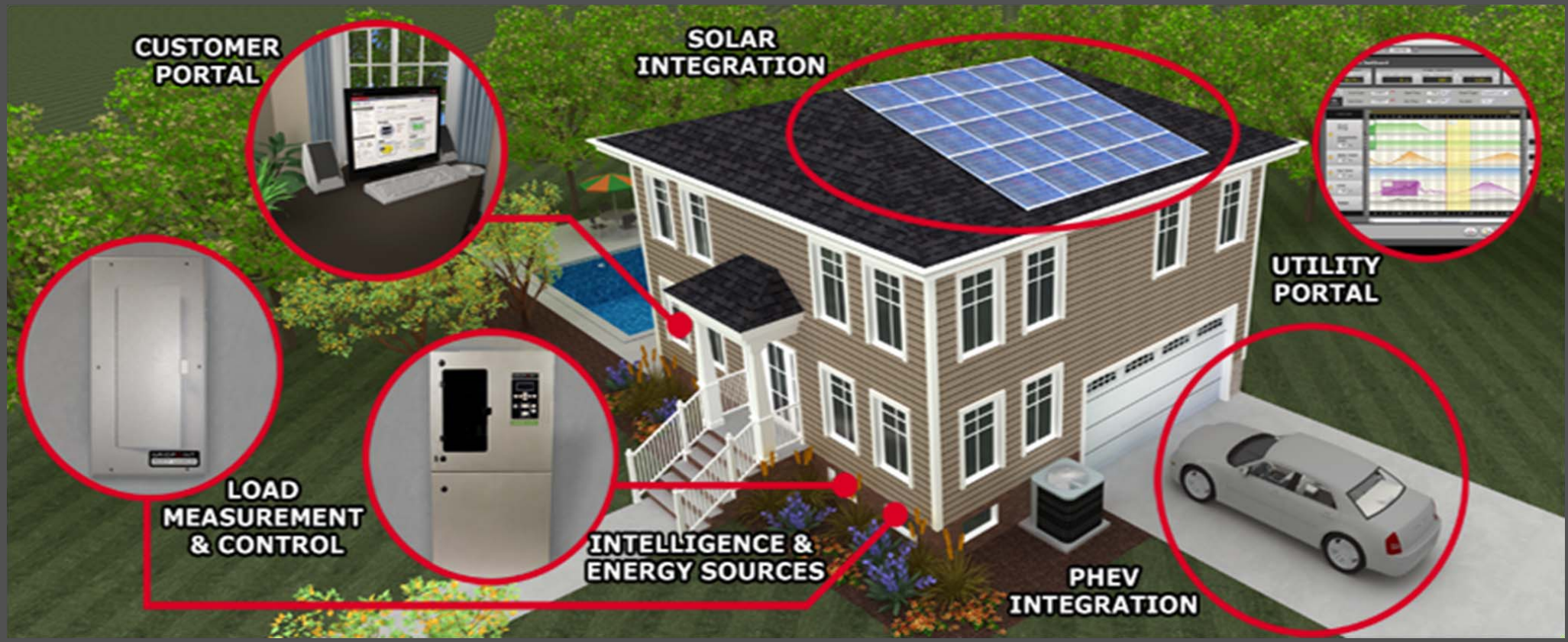
What is a Smart Grid?

- **Real time integrated energy management system that improves grid reliability while reducing the risk of higher and accelerating expenditures.**

SmartGridCity – Key Values



Smart House Platform



Graphic Source: Xcel Energy Smart Grid Consortium Partner, GridPoint

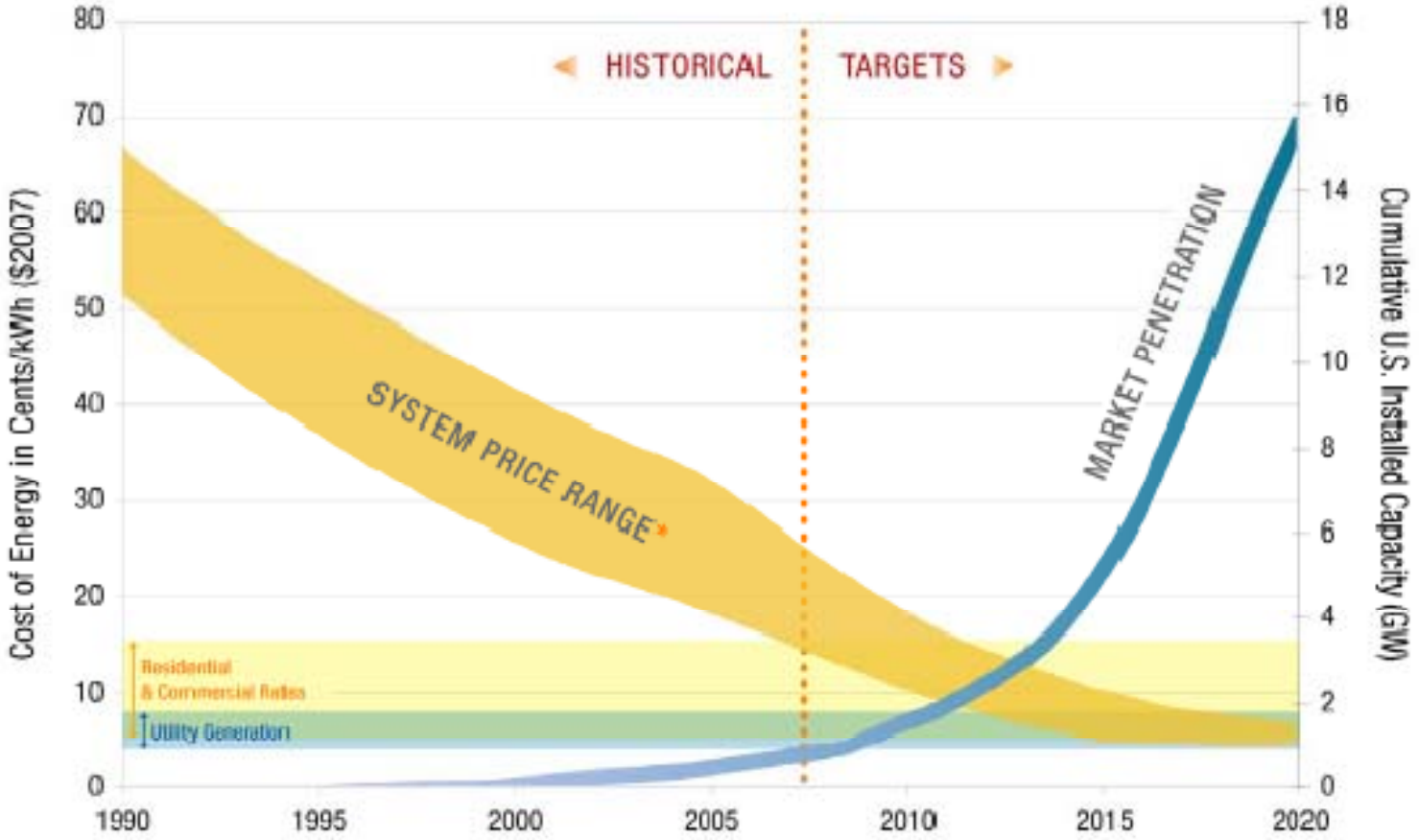
Status of SGC

- City - City of Boulder - 100,000 people, 50,000 homes
- Smart Meters - 14,398 as of 1/28/09
- Premises - 16,616 BPL enabled homes as of 1/28/09
- Telecom Fiber - 120 miles planned by June 2009
- Delivery Dates - build out complete by 6/30/2009
- Systems - plug and play demand and generation response (in process)

Drivers for Smart Grid

- **Energy Security** - decreasing supplies and volatile nations
- **Grid Security** - grid terrorism and variable generation
- **Rising Asset Cost** - costs increasing faster and beyond original plans
- **Rising Fuel Costs** - even before factoring increases beyond historical norms for carbon fuels
- **Green House Gases (GHG)** - cap and trade, climate impact
- **Increasing Demand** - including electric cars
- **Aging Work Force** - 25% of Xcel is expected to retire in 10 years

the Cost of Renewables (e.g. Solar)...

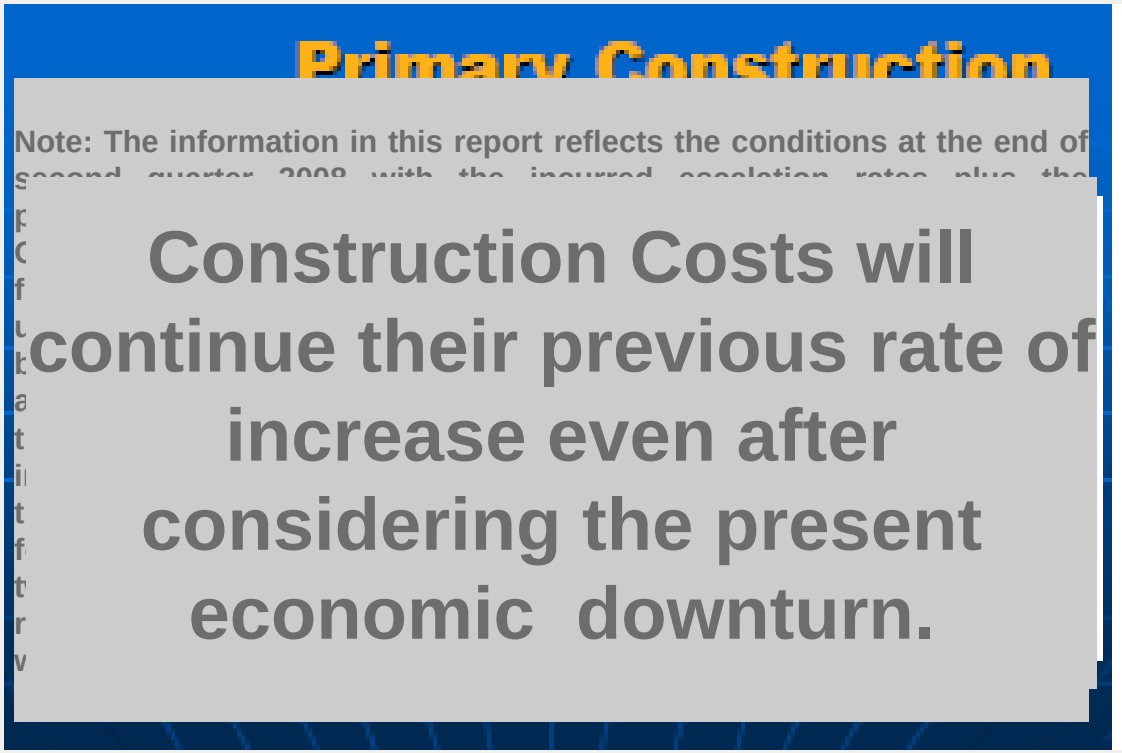


Market Sector	Current U.S. Market Price Range (¢/kWh)	Cost (¢/kWh) Benchmark 2005	Cost (¢/kWh) Target 2010	Cost (¢/kWh) Target 2015
Residential	5.8 - 16.7	23 - 32	13 - 18	8 - 10
Commercial	5.4 - 15.0	16 - 22	9 - 12	6 - 8
Utility	4.0 - 7.6	13 - 22	10 - 15	5 - 7

Graph from John P. Benner, Manager, PV Industry Partnerships, National Renewable Energy Laboratory, 303-384-6496

Capital Cost Avoidance

- Cost of Steel
- Cost of Cement

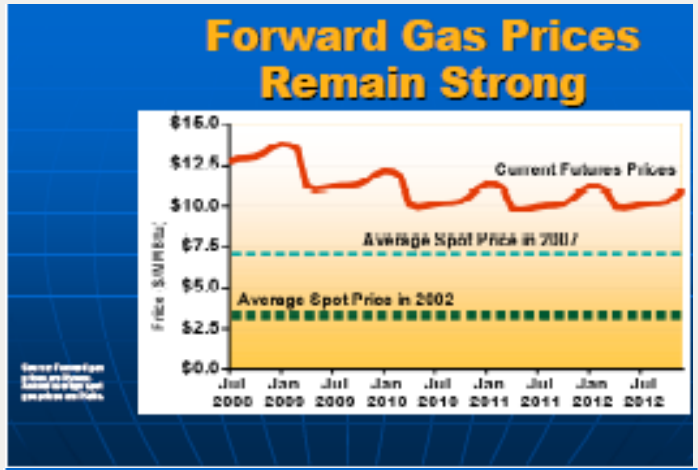


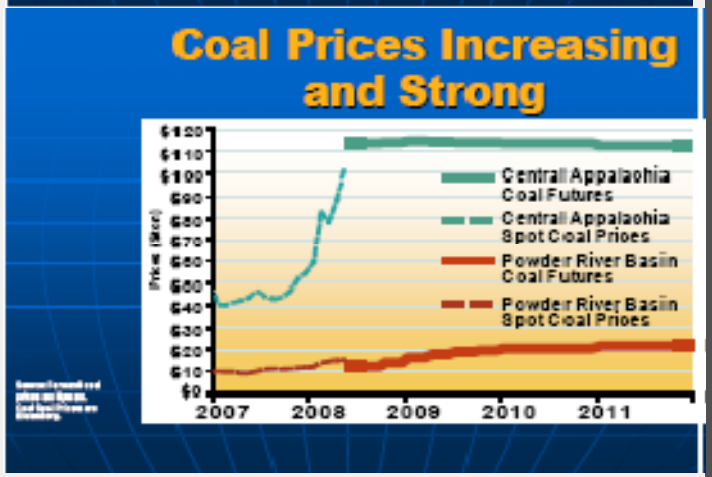
- $ / Watt build costs is increasing - 1.3% from 1996 to 2003, 8.8% from 2004 to mid-2008*
- Approval to build costs from Regulation

* EPRI's Generation and Storage Technologies Cost and performance estimates in the Technical Assessment Guide (reports 1016845 and 1018359)

Rising Fuel Costs

- Cost of Natural Gas
- Cost of Coal





Electric Drive Vehicles

Increased Demand

- Until now, base growth of 1% per year for USA system
  - At 25% of US vehicle fleet is “only” 2% of total MW*hr (but billions of $ in generation and distribution costs)
  - On distribution a car’s 6 KW connection for an average home’s peak usage of 3 KW is +200% & is very significant

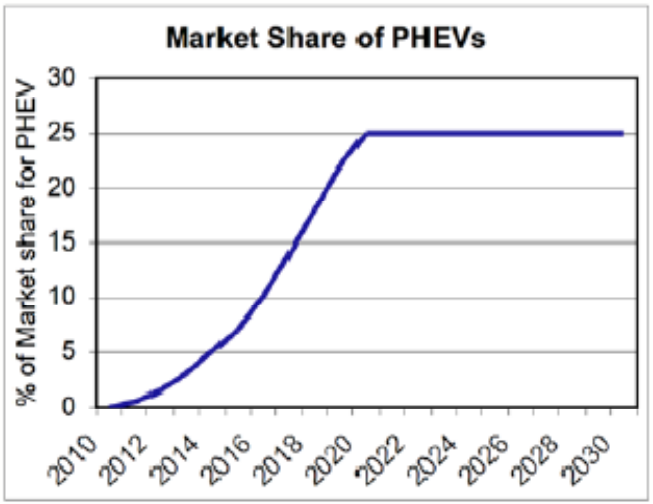


Figure 2. Projected market share of PHEVs.

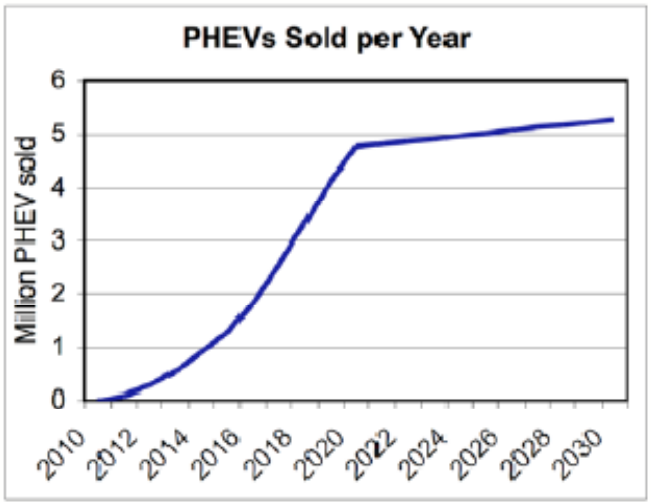


Figure 3. Projected number of PHEVs sold per year.

http://www.ornl.gov/info/ornlreview/v41_1_08/regional_phev_analysis.pdf

2007 PHEV Impact Study

In partnership with the National Renewable Energy Lab (NREL)

Examined impacts of varied driving and charging habits on overall PHEV emission “footprint” within our Colorado service territory.

2007 Xcel Energy / NREL PHEV Study

Scenarios	Production Cost	Capacity Cost	Avoided Gasoline	Emissions	Distribution Impacts
Do Nothing	G			Better	Worse*
Delay to 10pm	Be			Good	Best
Optimized to Off-peak	B			Worse	Best
Opportunity Charging	W			Best	Worse*

- We discovered that for any utility:
  - Time of charging matters…
  - Coincident peak loading matters…
  - Tailpipe versus upstream emissions matter…

We discovered that for Xcel Energy with night time coal baseload:

Smart Charge after 10 PM avoids Capital Costs and Green House Gasses

* Could be mitigated with control technology / incentives

2008 Demonstration & Field Trials

Photo by ASC Designs 303-522-0066

Vehicle Specifications

Stock Vehicle

- 133HP 2.3L I-4 Gasoline Engine
- 94HP Electric Motor (Parallel Configuration)
- 1.8kWh NiMH Battery (3.6 miles in battery only mode)

Enhanced

- 133HP 2.3L I-4 Gasoline Engine
- 94HP Electric Motor (Parallel Configuration)
- 12kWh Li-Ion Battery (24 miles in battery only mode)
- GPRS-enabled SmartCharging and Telemetry

2008 Xcel Energy / NREL PHEV Study

- 6 Converted Ford Escapes (3 fleet, 3 personal use) and driven 40 miles per day (as do 85% of US commuters) at $7500 / car
  - **Results** (yet not statistically significant)

- Used only top 1/3 of 25 mile battery pack (parallel hybrid)
- Averaged over 6 months, 56.84 MPG in a SUV at $0.03 vs $0.11*
- Extremely consistent availability (except Sunday post 5:00 PM)
- Plugged In MORE often over time (from 50% to 80% over 6 months)
- Availability to utility at 60% - 85% with all factors considered
- Infrastructure is EVERYWHERE - “power to the curb” is there but what is the “tipping point”?

* at $2.00 / gal gas for 18 MPG for 12,000 per year at with $0.08 / kW*hr
* payoff at $7,500 cost to implement is 93,750 miles or 7.8 years while GM’s Volt is expected to have 140 MPG or 3.2 year payoff

Grid Impacts from PHEVs & EVs

- Without SmartCharging:

130 new power plants needed with 25% PHEV/EV penetration (source: ORNL), but still 40% less emissions when “filled” with coal based generation

- With SmartCharging:

Theoretically ZERO new power plants needed (source: ORNL) until 73% of total fleet with generation “valley fill”

- With SmartCharging:

Reduce to 85% fewer car emissions by reducing total number of power plants (source: NREL, and being studied by Xcel Energy)

2009 Boulder V2G PHEV

- Status of 2009 Cars
- Wind 2 Battery
  - AGC and Market Signals
  - Wind Smoothing
  - Renewables Integration

Next Step: Commercial V2G Test

- Phase I: Convert four PHEVs w/ V2G - design complete
  - (1) Xcel Energy Escape - completed October 2008
  - (3) Boulder County Prius - in progress
  - (1) Boulder City Prius - in queue
  - Integrated with Wind 2 Battery (W2B) project
- Phase II: Convert 60 PHEVs w/ V2G (City of Boulder, County of Boulder and University of Colorado fleet vehicles)
- Subsequent Phases: Aim to convert an additional 500 PHEVs w/ V2G including trucks and buses with curb-side and underbody charging

Wind 2 Battery (W2B) Project Description

- 1 MW NaS Battery System
  - Can deliver 1 MW for 7 hrs
  - Power Conditioning Equipment
  - Wind farm/grid interconnection
  - Local and remote data and communication equipment
- Two Phases of Study
  - Understand how system could optimize wind farm economies
  - Understand how system could optimize utility integration of wind resources

Impact of V2G PEV on Smart Grids via W2B

- Grid Balancing
- Renewable Integration
- Outage Support
- Capital Cost Avoidance
- Emissions Savings
- Transmission Support
- Firm Renewable Power Pricing

Contacts and Communications

All experts are experts for things that did happen.
There are no experts for things that may happen.
- David Ben-Gurion

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