Negative Marginal Cost Electricity: An opportunity for low-cost value-added hydrogen production

Jason W. Hoyle

HYDRAIL 2013 – 8th International Hydrail Conference
Ryerson University
Toronto, Canada
11-12 June 2013

Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY

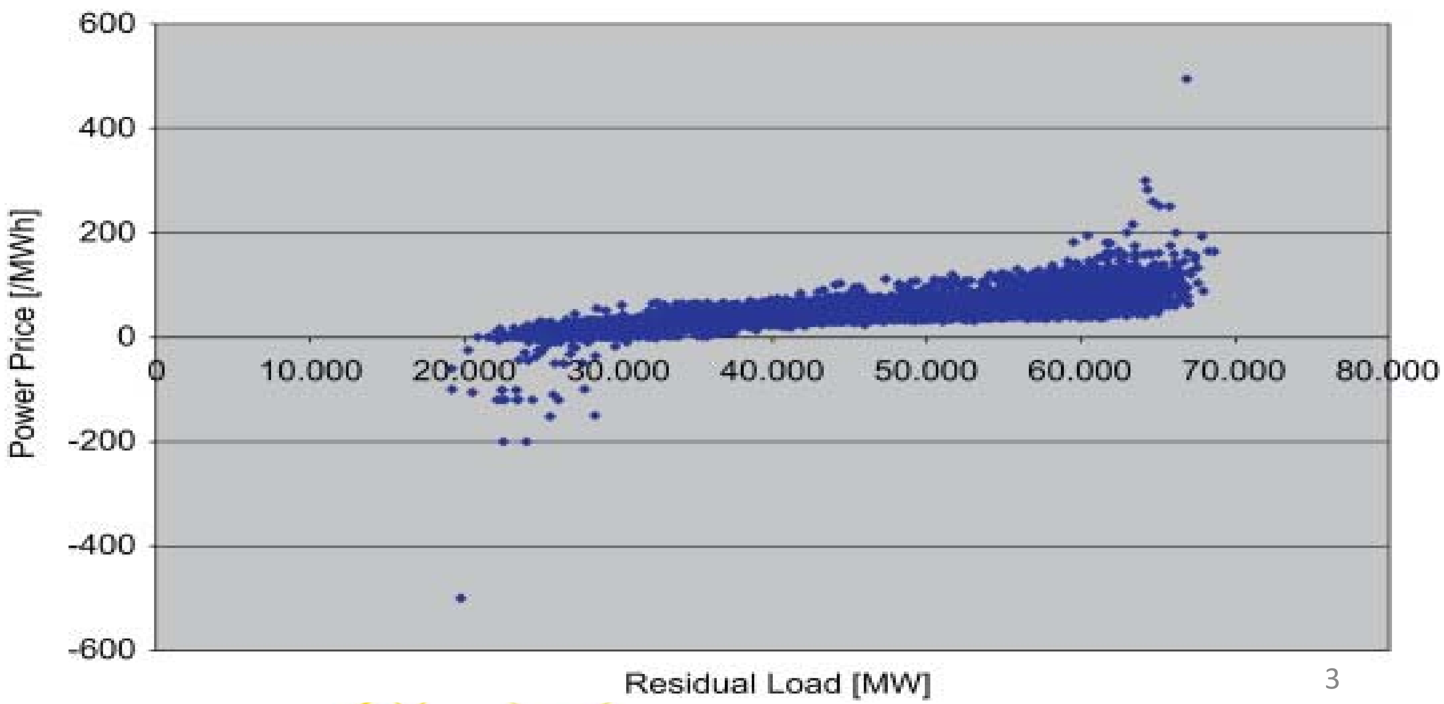
Negative Electricity Prices

- Two types of negative electricity price
  - Negative price (P) < $0
  - Negative marginal price (P) ≤ variable cost (VC)
- Characteristics
  - Typically found in competitive wholesale markets
  - Increasing prevalence in N. America and Europe
  - Symptom of inherent inefficiency in balance of electricity supply and demand
  - Inverse of peaking problem (occurs when supply > demand), but similar economic outcome

Negative Electricity Prices: Prevalence

- European Energy Exchange (EEX)
  - Began allowing negative price bids in Sept. 2008, first market occurrence in Oct. 2008
  - About 1% of prices in 2009 were < 0€/MWh

EEX (2010) spot prices and residual load (10/2008 - 12/2009).
Source: Marco Nicolosi , based on data from EEX, BDEW and ENTSO-E; Nicolosi, Marco. Wind power integration and power system flexibility? An empirical analysis of extreme events in Germany under the new negative price regime. Energy Policy Volume 38, Issue 11 2010 7257 - 7268

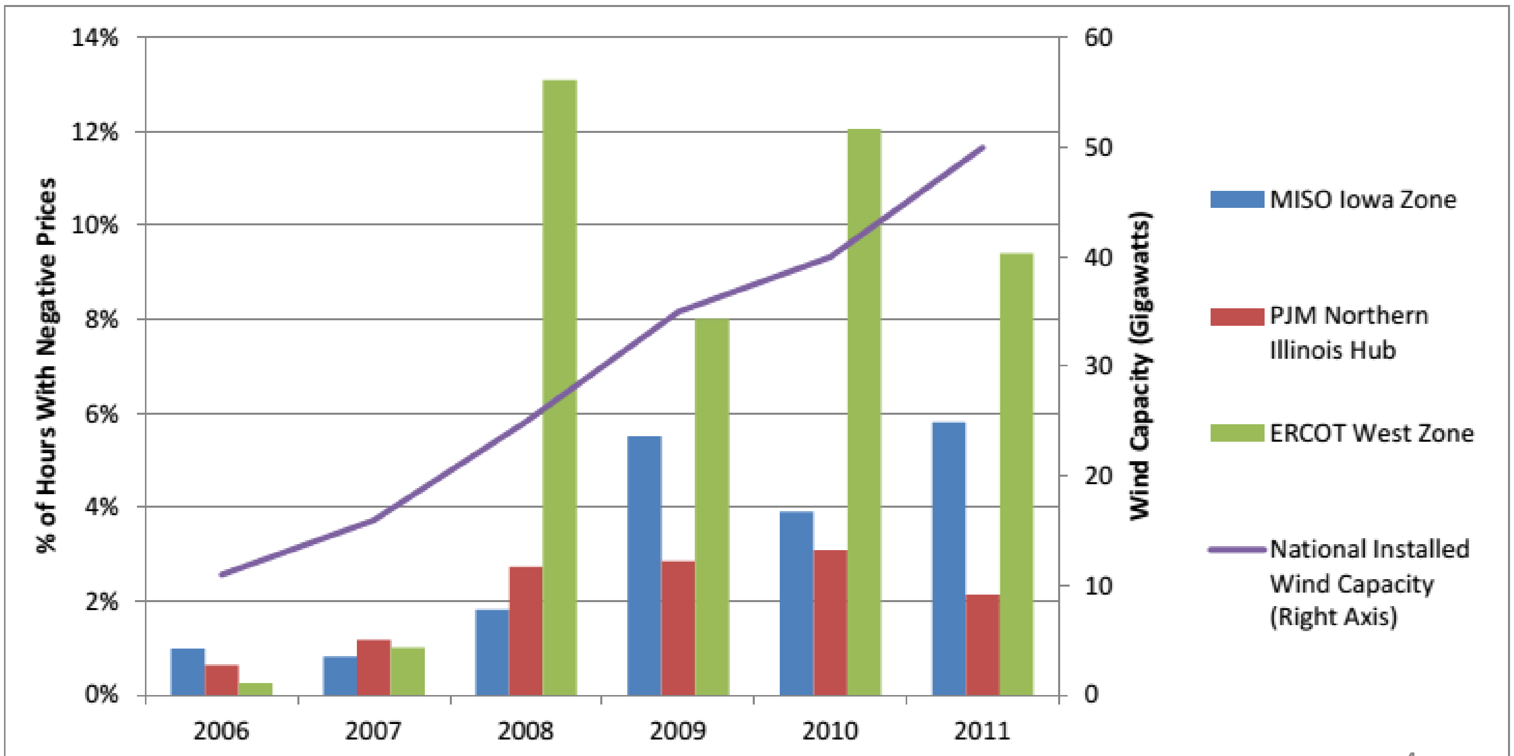


Negative Electricity Prices: Prevalence

- U.S. Regional Power Markets
  - Areas with a large share of wind capacity, limited demand flexibility, and transmission constraints

Percent of hours with negative prices in selected U.S. wholesale markets.

Source: Huntowski, Frank, Patterson, Aaron, and Schnitzer, Michael. Negative Electricity Prices and the Production Tax Credit. The NorthBridge Group. September 2012.



Source: Ventyx Velocity Suite; U.S. Energy Information Administration.

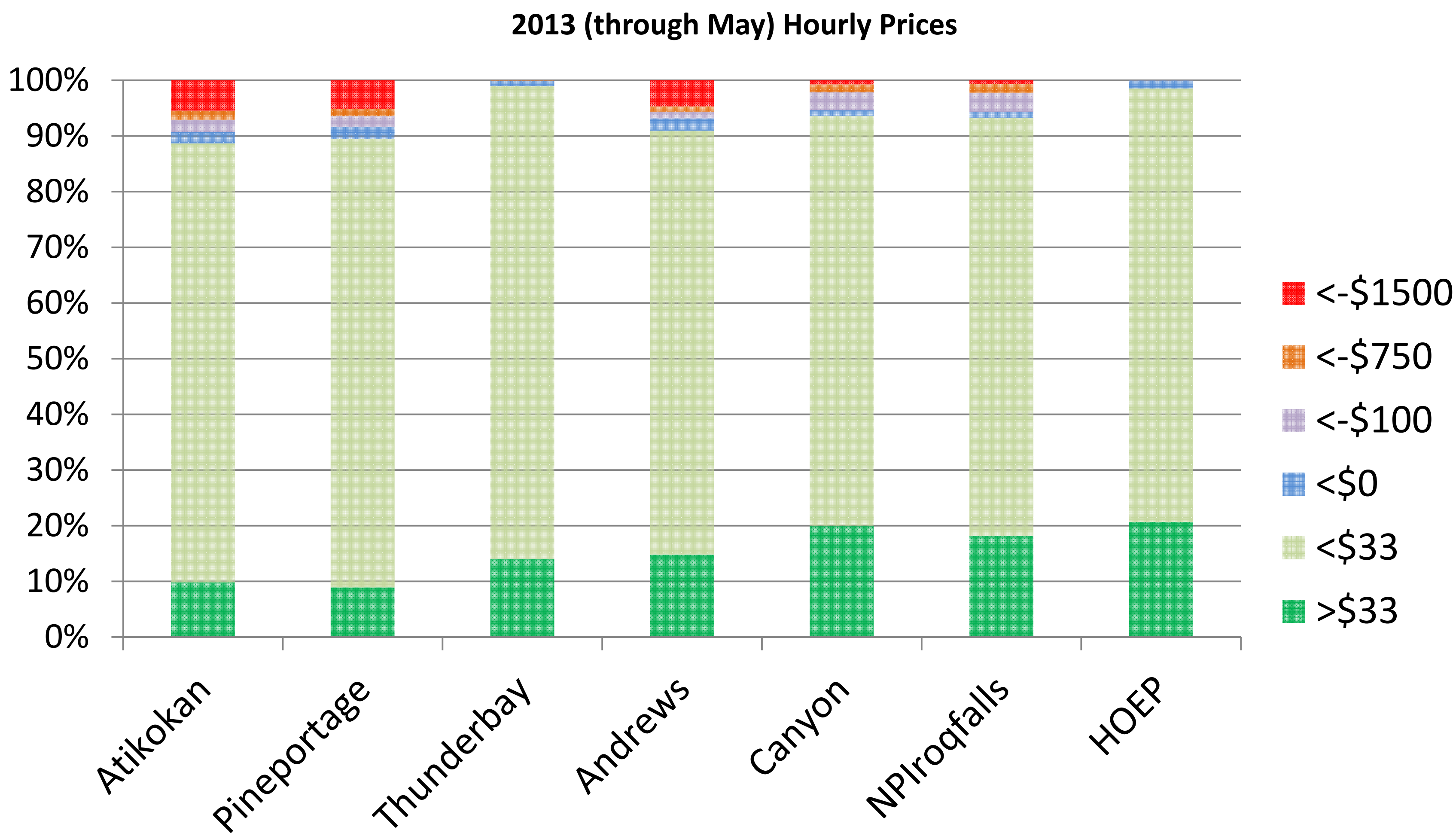
APPALACHIAN STATE UNIVERSITY

Negative Electricity Prices: Drivers

- Efficient markets incorporate marginally relevant opportunity costs (Nicolosi, 2010)
- Technical constraints on supply-side flexibility (IESO, 2011)
- Policy-driven market effects value non-core attributes irrespective of underlying value of electricity (Huntowski, 2012)
- Price Inelasticity of Demand for electricity
- Market manipulation, i.e. loss-leader strategy and other anti-competitive actions

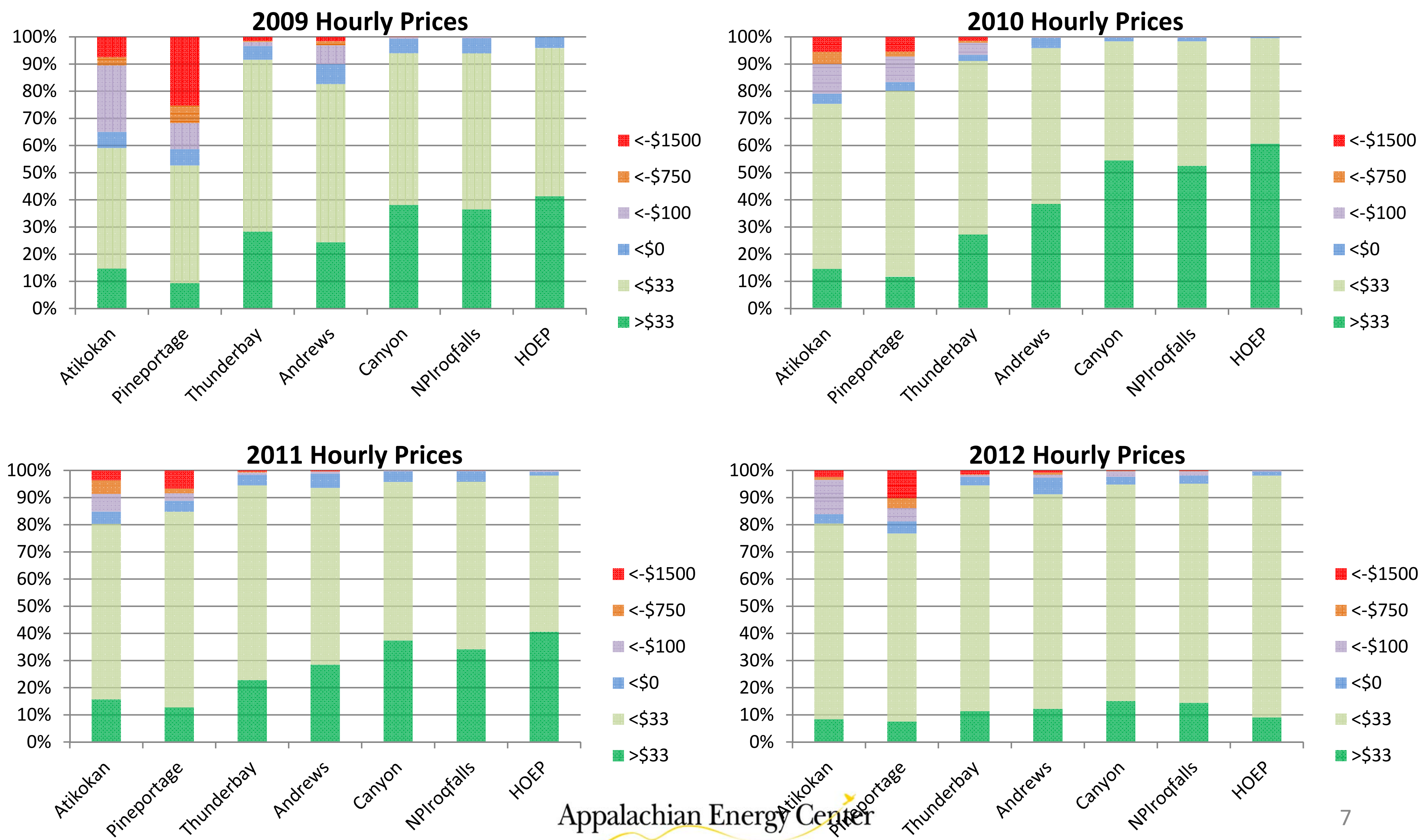
IESO. Dispatch Order for Baseload Generation: Discussion Paper for Stakeholder Engagement 01 November 2011..

HOEP & Zone Hourly Price – Jan-May '13



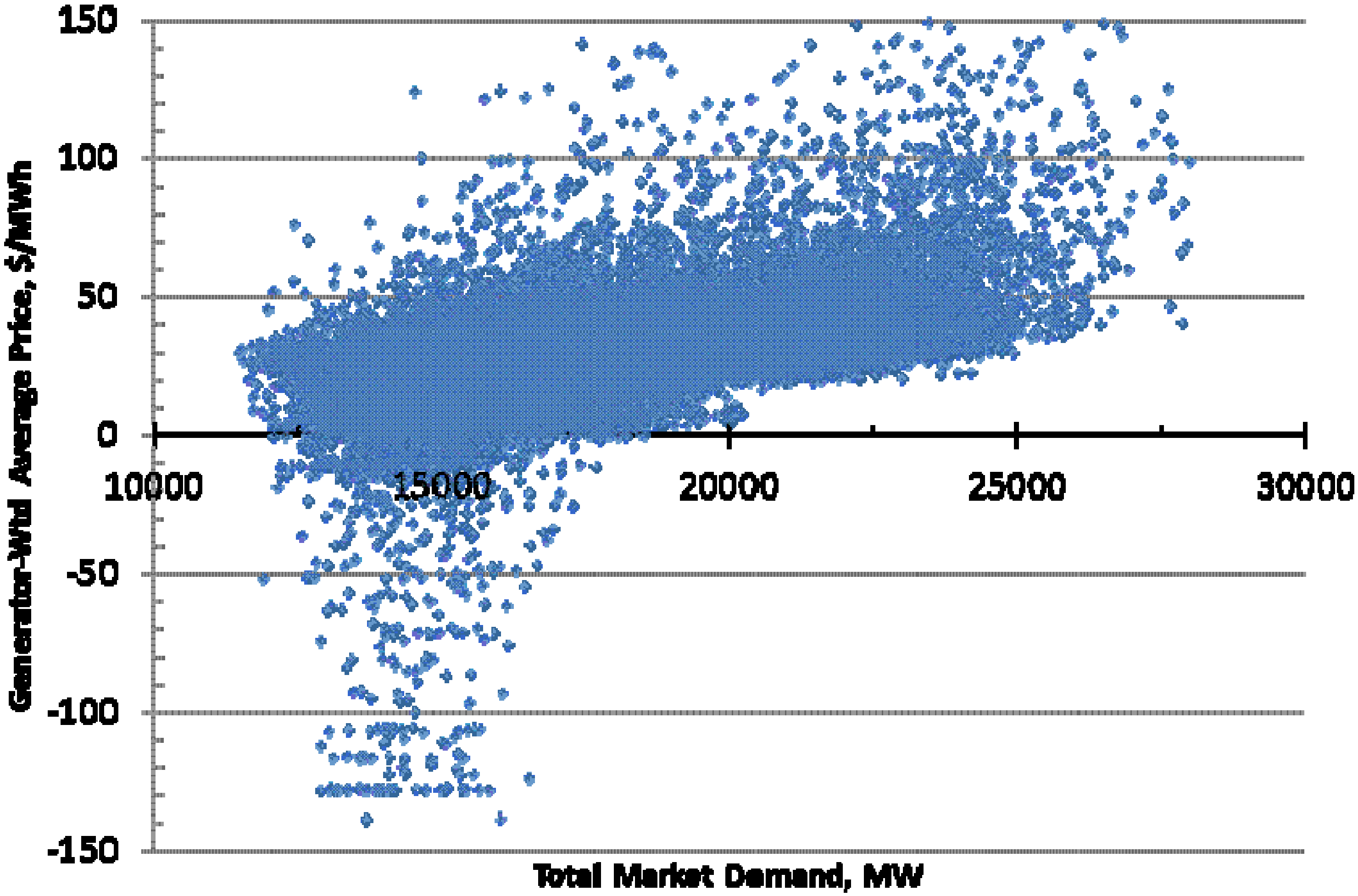
Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY

Ontario – HOEP and Zones Prices



Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY

Bid Price by Demand, 2009-May 2013



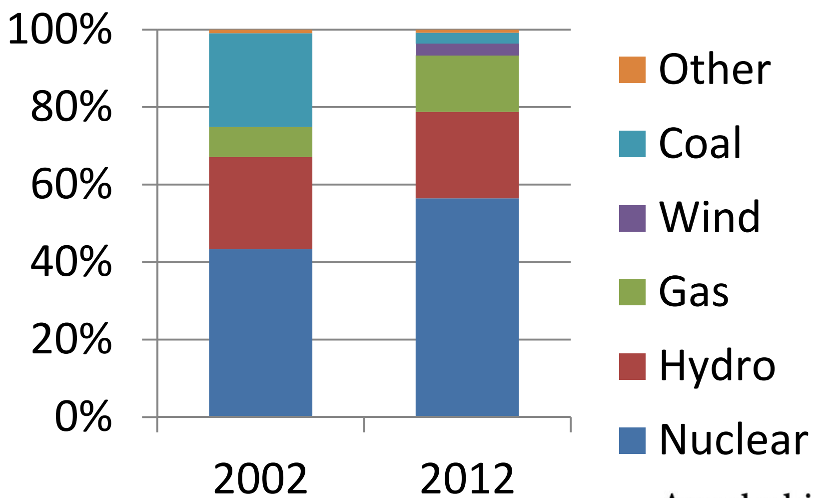
Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY

Ontario's Wholesale Electricity Market

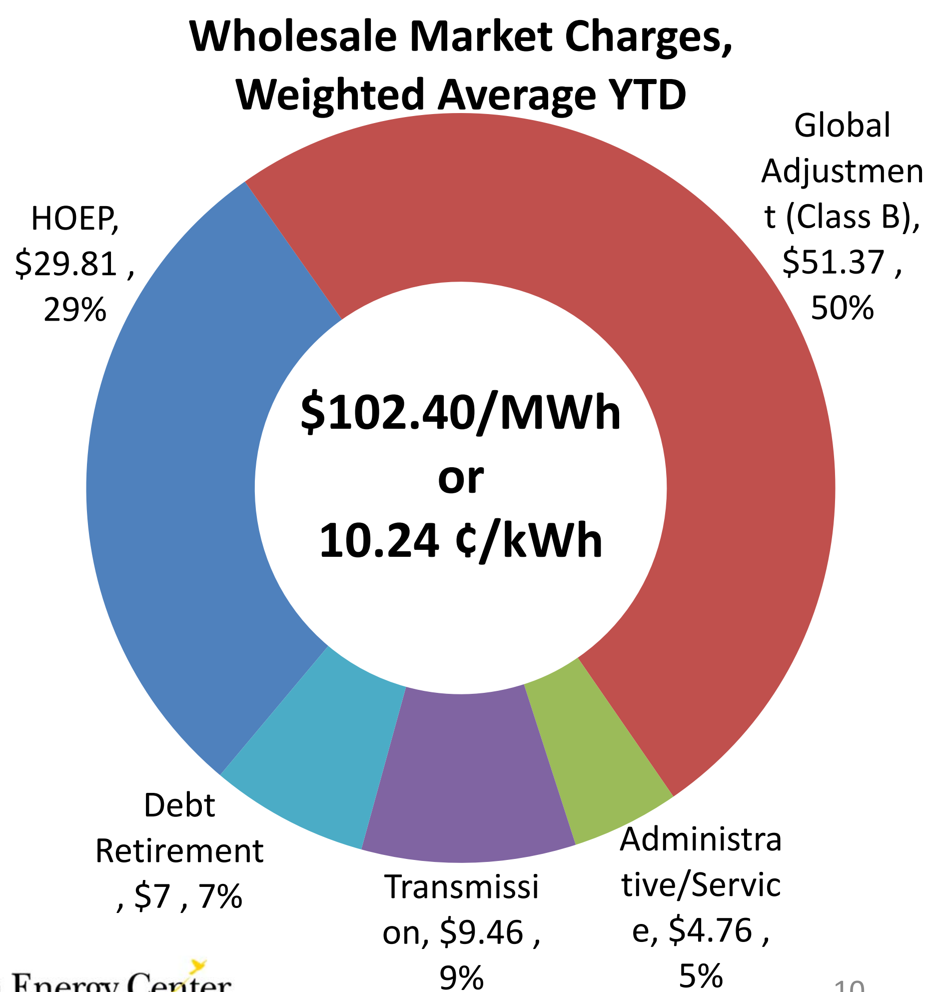
- Hybrid structure with competitive bidders and quasi-regulated/contractual participants
- Energy-only market, i.e. no capacity auctions
- Recent trends and future directions
  - Reduced supply flexibility from gas/oil/renewable displacement of coal
  - Retrofitted baseload plants for increased flexibility
  - Increasing demand responsiveness (reducing peak only) via smart grid technologies and variable retail pricing structures
  - Greatly increased renewable capacity (particularly wind) online during next 5 years, wind dispatch in 9/2013

Wholesale Power Market Inefficiencies

- Supply and demand disconnects
  - Geographic
  - Temporal
  - Value



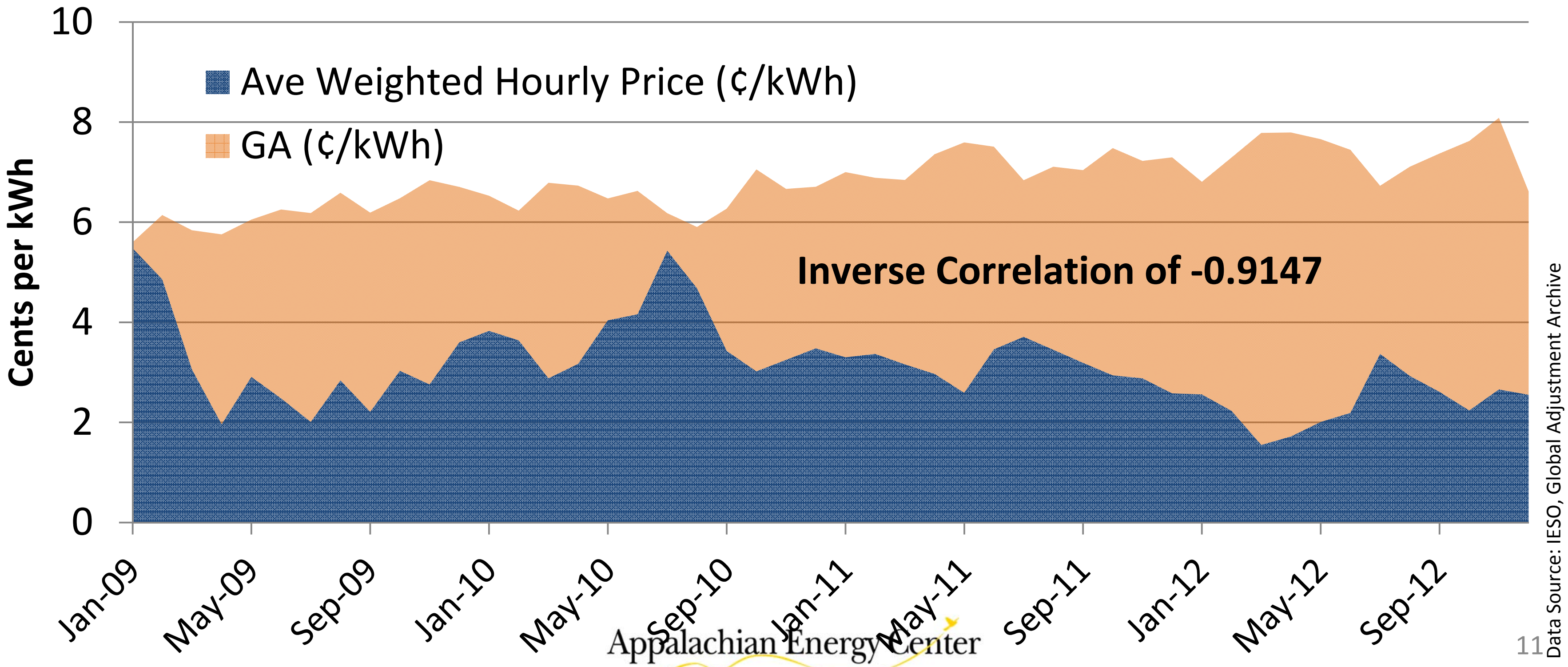
Source: Independent Electricity System Operator. 2012 Annual Report.



Source: Independent Electricity System Operator. Monthly Market Report April 2013

Global Adjustment (GA) Effect

- Global Adjustment charge = difference between market prices and guaranteed generator payments - $6.46 bill. and more than twice average weighted HOEP in 2012



Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY

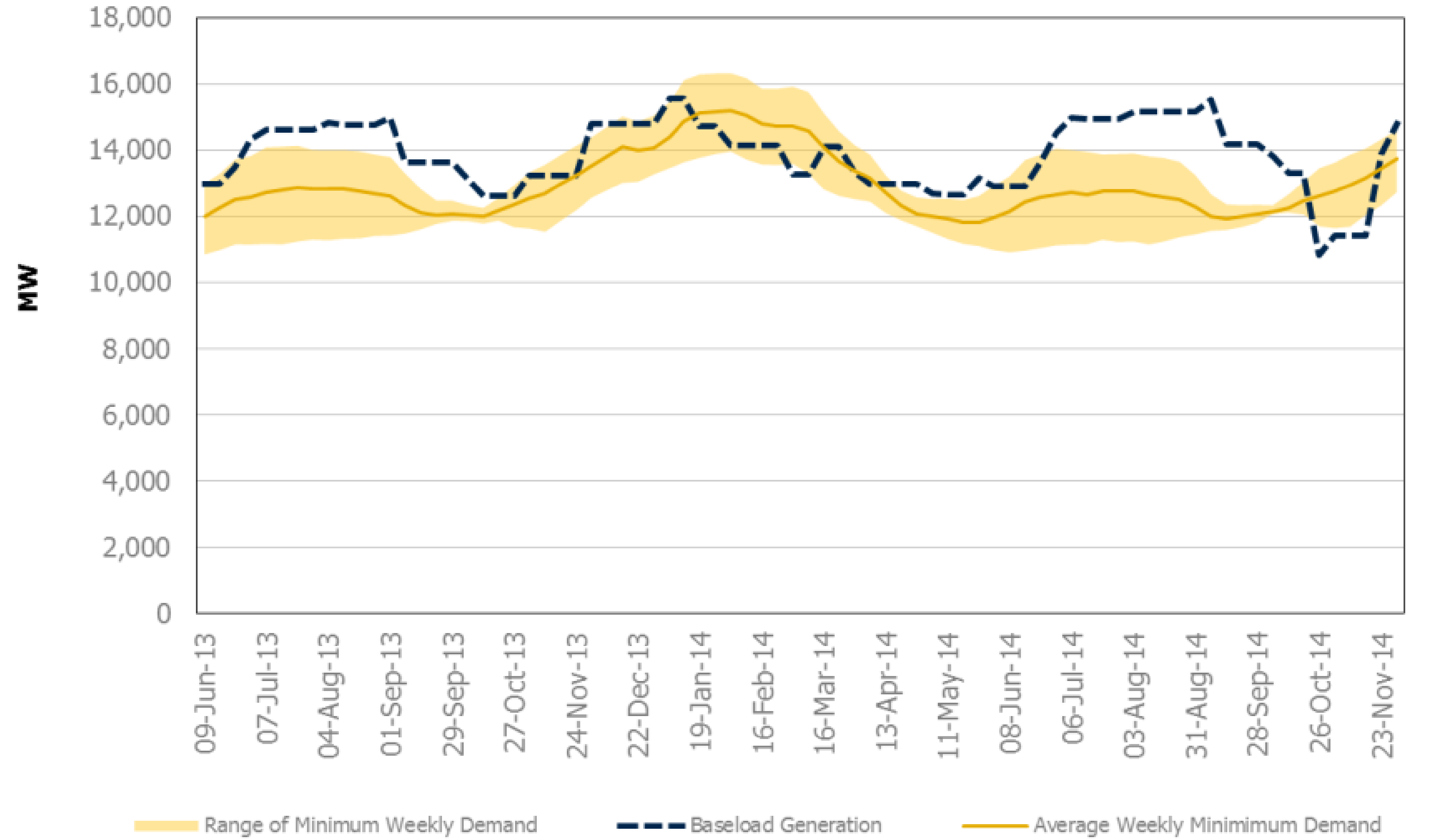
Further From Equilibrium

- Power buyers pay total charge, and are indifferent among allocation of components
- 18-Month forecast HOEP range between CA$15.07 and CA$23.11 per MWh (Navigant, 2013)
- GA charge is "cost" of low HOEP; non-market payment that yields no additional output
- Surplus Baseload Generation (SBG) shutdown events tripled losses in early 2013 to 310 GWh from 106 GWh in same period of 2012 (IESO, 2013)

Navigant Consulting. Ontario Wholesale Electricity Market Price Forecast: For the Period May 1, 2013 through October 31, 2014. March 2013.
IESO. 18-Month Outlook from June 2013 to November 2014. May 24, 2013.

REP-28v1.0 18-Month Outlook Update

Figure 6.1.2 Minimum Ontario Demand and Baseload Generation (includes Net Export assumption)



Source: IESO. 18-Month Outlook from June 2013 to November 2014. May 21, 2013.

Market Efficiency – Future Trends

- Resource Shift: lower supply flexibility, increased price volatility
- Higher Baseload Generation: increase curtailment/shutdown events -> capacity utilization and fixed cost recovery
- Lower HOEP/MCP: increased Global Adjustment charge, reduced productivity of electricity payments
- Increased GHG Focus: shift greater share of emissions to transportation sector

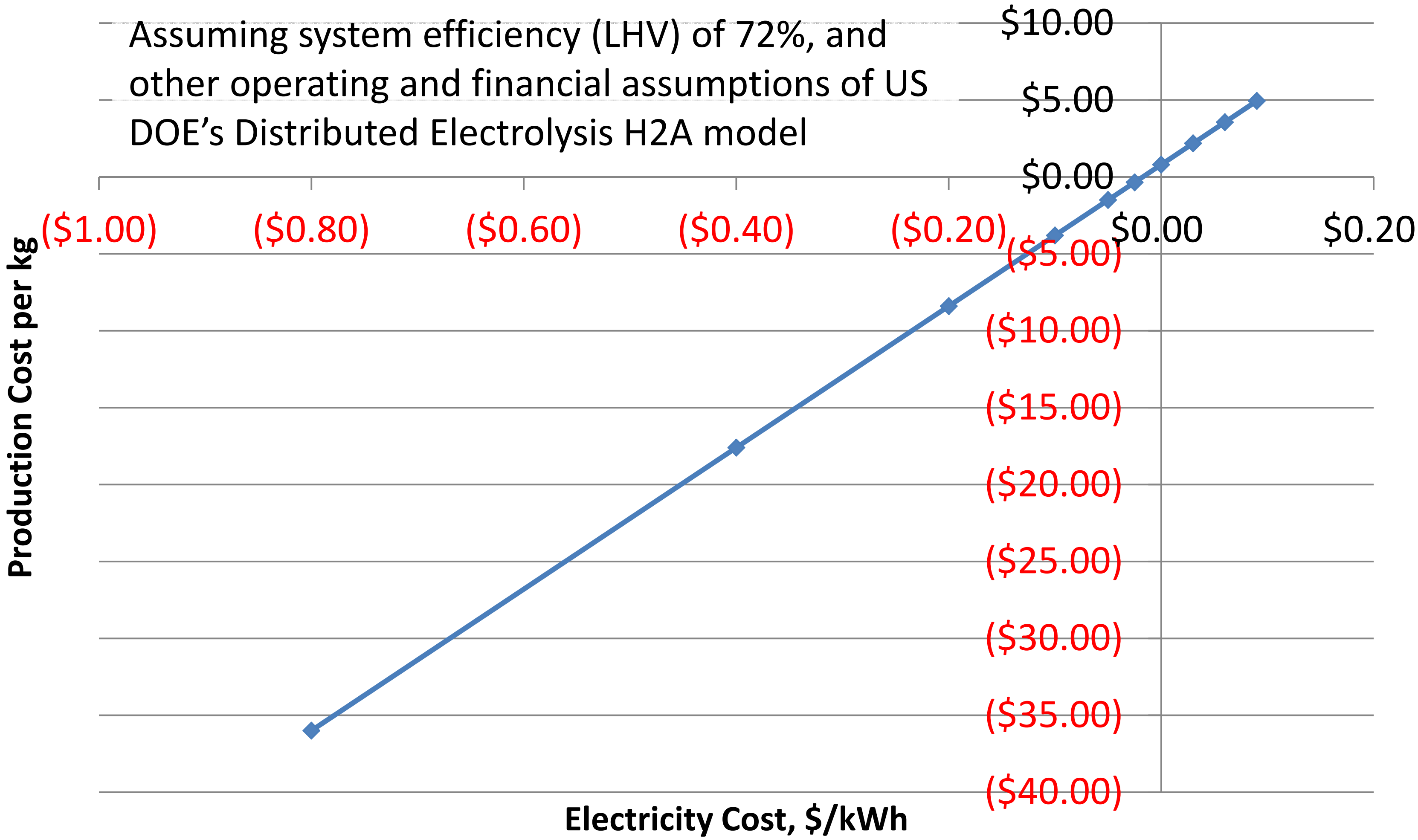
Conceiving a Solution

- Traditional electric system management strategies
  - Peak-oriented: manage (i.e., lower) peak demand
  - Reliability-oriented: ensure adequate peak supply
- NEW PROBLEM: increasing amount of price-inelastic electricity supply and unproductive electricity charges
- Increase demand via dispatchable load to achieve optimal MCP; reduce GA charge, increase available reserves, productivity of electricity payments, and improve fixed cost recovery for baseload generators

Cost of Hydrogen Electrolysis

Cost of Hydrogen Production from Water Electrolysis, 2015 DOE Target		
Component	%/kg H_2	% Cost
Electrolysis System	$0.50	12.8%
Electricity	$3.10	79.5%
Production Fixed O&M	$0.20	5.1%
Production Variable Costs	$0.10	2.6%
Total Cost	$3.90	-
Notes:		
Does not include cost of compression, storage, dispensing hydrogen		
Electricity cost assumed at average of $0.07/kWh		
Source: U.S. DOE, Multi-Year Research Development and Demonstration Plan. 2012.		

Production Cost per kg of H_2



Incorporating Dispatchable Hydrogen Production via Electrolysis

- Two approaches
  - Dispatch to eliminate negative electricity prices, i.e. pay for H_2 production by eliminating marginal opportunity costs
  - Dispatch to target floor MCP (or HOEP) so that payments being made anyway support additional units of output

Applications of Hydrogen

- Since Hydrogen is produced to increase efficiency of electric system, good case for its consideration and use as a public good
- Potential benefits
  - Use to facilitate transition to hydrogen-based transport system
  - Stationary electric generation during peak
  - Hydrail on urban lines during peak demand times provides additional demand/supply flexibility

Questions?

Thank You

Jason W. Hoyle
P.O. Box 32131
Boone, NC 28607-2131 USA
Appalachian State University
+1 828.262.7934
hoylejw@appstate.edu

Appalachian Energy Center
APPALACHIAN STATE UNIVERSITY