

# Potential Impacts of an *Advanced Energy Portfolio Standard* in Pennsylvania



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# Study Objective

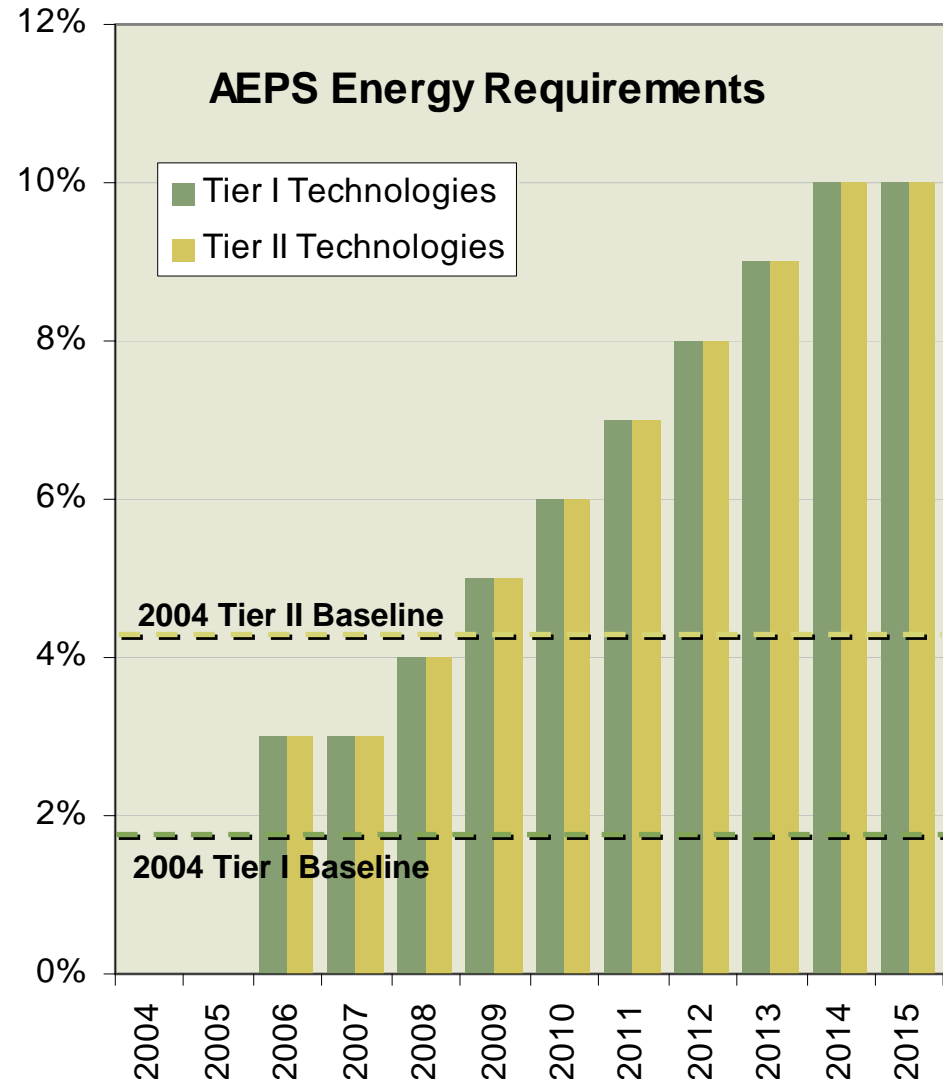
## **Assess the Potential Economic Impacts of a 20 Percent Advanced Energy Portfolio Standard (AEPS) in Pennsylvania**

1. Identify most cost effective mix of resources built in response to AEPS
2. Identify economic benefits or costs



# General AEPS Assumptions

- Timeframe
  - 2006 – 6%
  - Increases 2%/year
  - 2014 – 20%
- Evenly split in two-tiers:
  - Tier I – RE & EE
  - Tier II – waste coal, greenhouse gas, advanced technologies
- No imports or exports (simplification for analysis)
- Production Tax Credit through 2009



# AEPS Resource Assessment Methodology



- Screen Technologies
- Characterize Resources
- Estimate Cost to Generate and Transmit Electricity
- Apply Avoided Cost of Power Model
- Develop Supply Curves
- Develop Least-Cost Portfolio of Projects



# AEPS Eligible Resources

## Tier I

- Wind
  - Low-impact hydro
  - Biogas and coal mine methane
  - Biomass
  - Solar photovoltaics
  - “Energy conservation” – demand side, ie, consumers
  - “Energy efficiency” – supply side, ie, power plants
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- Solar thermal
  - Ocean and lake energy
  - Solid waste (non combustion)
  - Fuel cells fueled by Tier I resources

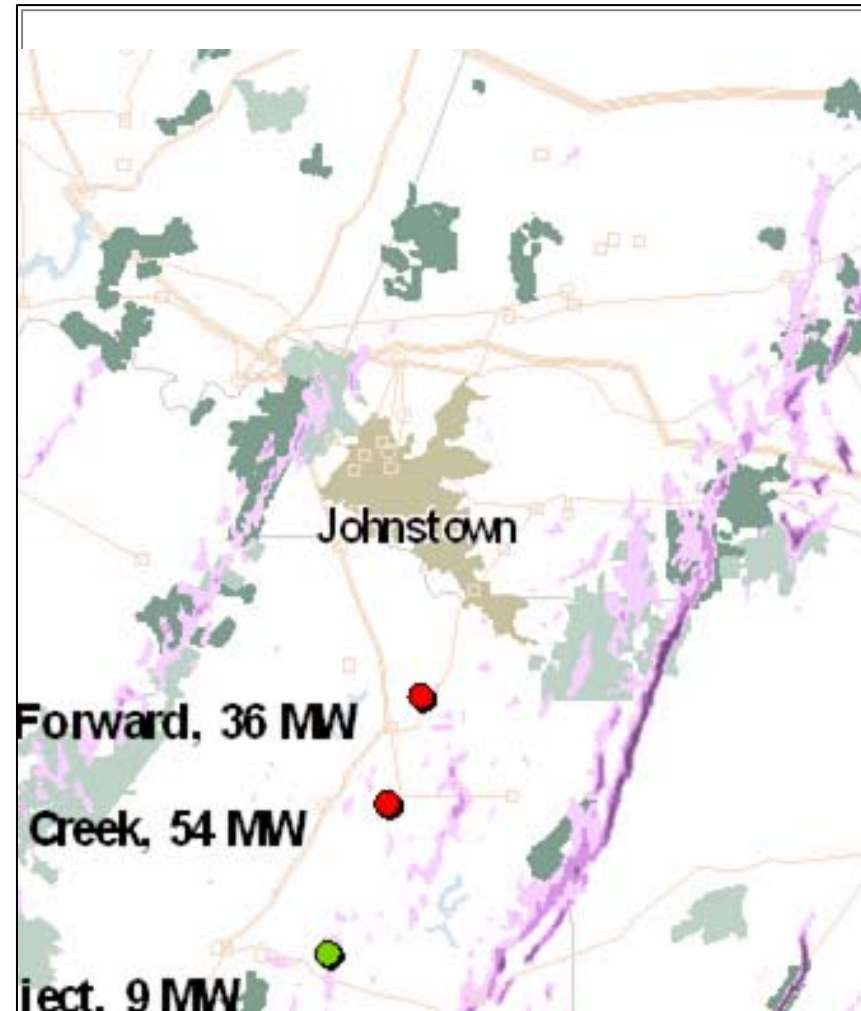
## Tier II Resources

- Waste Coal
    - New facilities
    - Air pollution controls at existing facilities
- 
- Integrated gasification combined cycle
  - Fuel cells fueled by non-Tier I resources
  - Greenhouse gas (GHG) reductions



# Wind Assessment

- Pennsylvania wind resources relatively modest
- GIS analysis based on latest NREL data
- Capital Cost:
  - Base: \$1,175-\$1,275/kW
  - Transmission: +\$20-\$110/kW
  - “Expensive” resources: +\$500/kW (50% of total)
- Included 300 MW, class 5, offshore wind farm in Lake Erie





# Biomass Cofiring Assessment

- Pennsylvania has good biomass resources and lots of coal plants
- Focused on cofiring at 38 existing coal units
  - Capital cost: \$100-\$700/kW
- Biomass resources
  - Only sustainable and clean resources identified
  - Assessment based on ORNL database
  - Biomass collected from 75 mile radius around plants



# Energy Conservation / Efficiency Assessment



- Good opportunity for energy conservation/efficiency in PA
- Analysis Based on B&V, ACEEE assessments
  - Residential measures
  - Commercial & Industrial measures
- Over 16,000 GWh of potential identified over 20 years
  - About 10% of PA consumption
  - Wide range of costs and payback potential
  - Consumers won't necessarily implement measures even if economical







# Waste Coal Combustion

- Excellent waste coal resource in Pennsylvania
- To be eligible for AEPS, waste coal projects must be low emissions
- Analysis Based on PA DEP waste coal assessments
  - 3 Planned New Site Developments
  - 15 Environmental control upgrades at existing plants
- Environmental control upgrade projects also receive substantial revenue from emissions credit markets

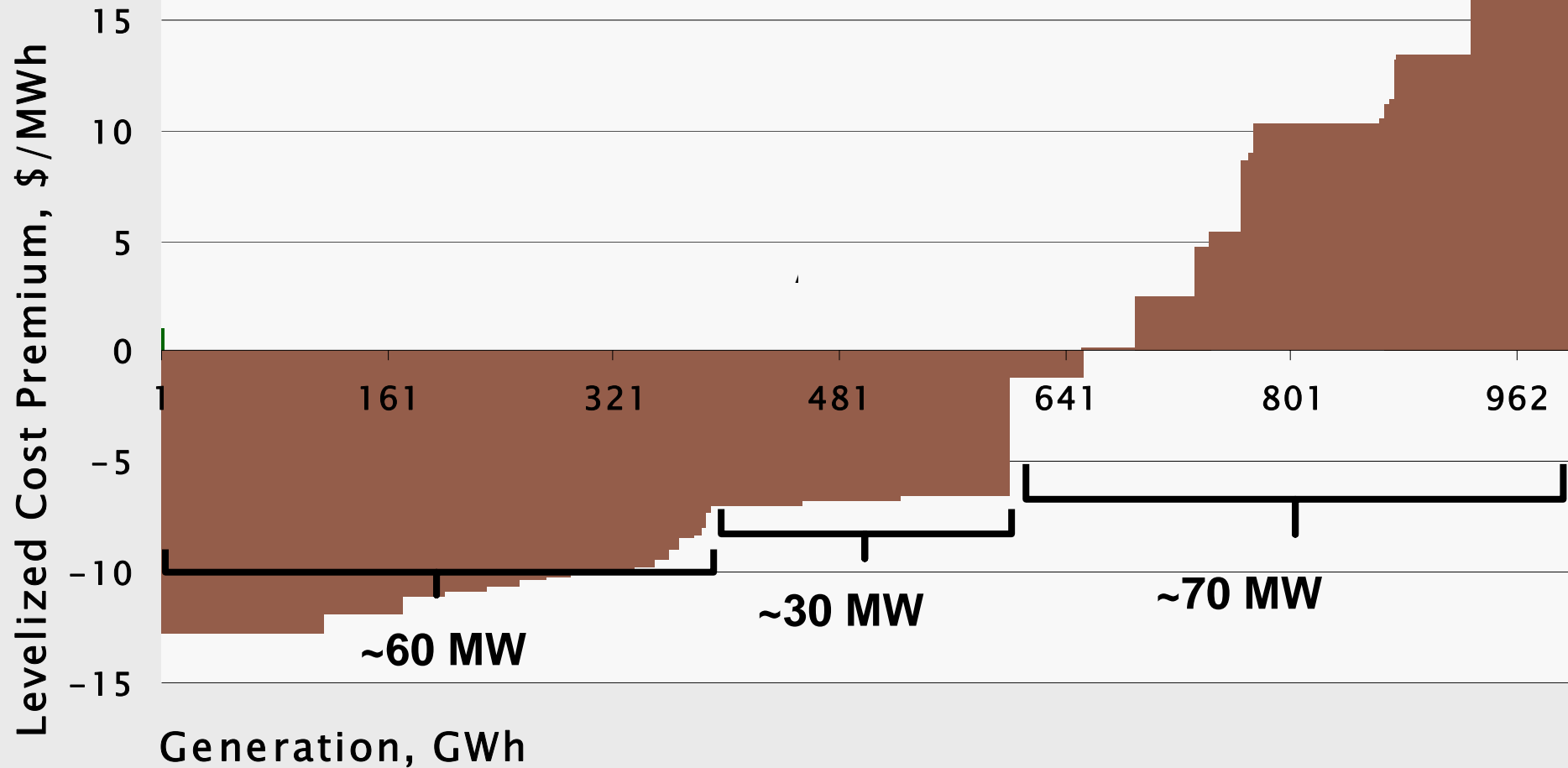


## Properly Characterizing Resource Cost

- One of the largest modeling differences between renewables and fossil fuels is that costs vary tremendously based on renewable resource quality
- There are a limited number of very good renewable / advanced project sites
- Costs rise as “low-hanging” projects are developed
- Supply curves capture these effects

# Biogas Supply Curve 2006

## Premium over Avoided Costs

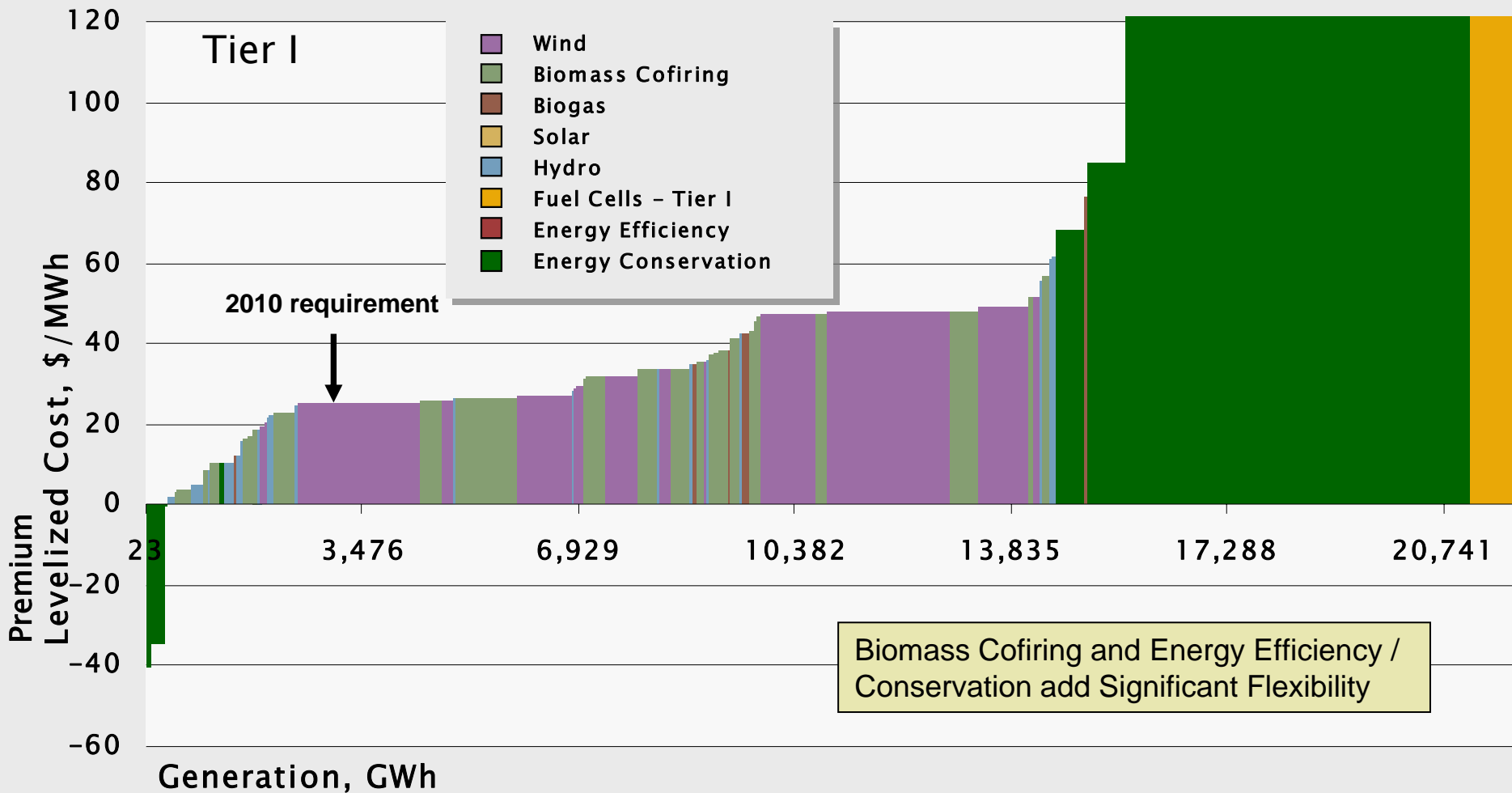


# Aggregate Tier I Supply Curve 2010



## 2010 Supply Curve

Additional Renewable Generation Required: 3154 GWh

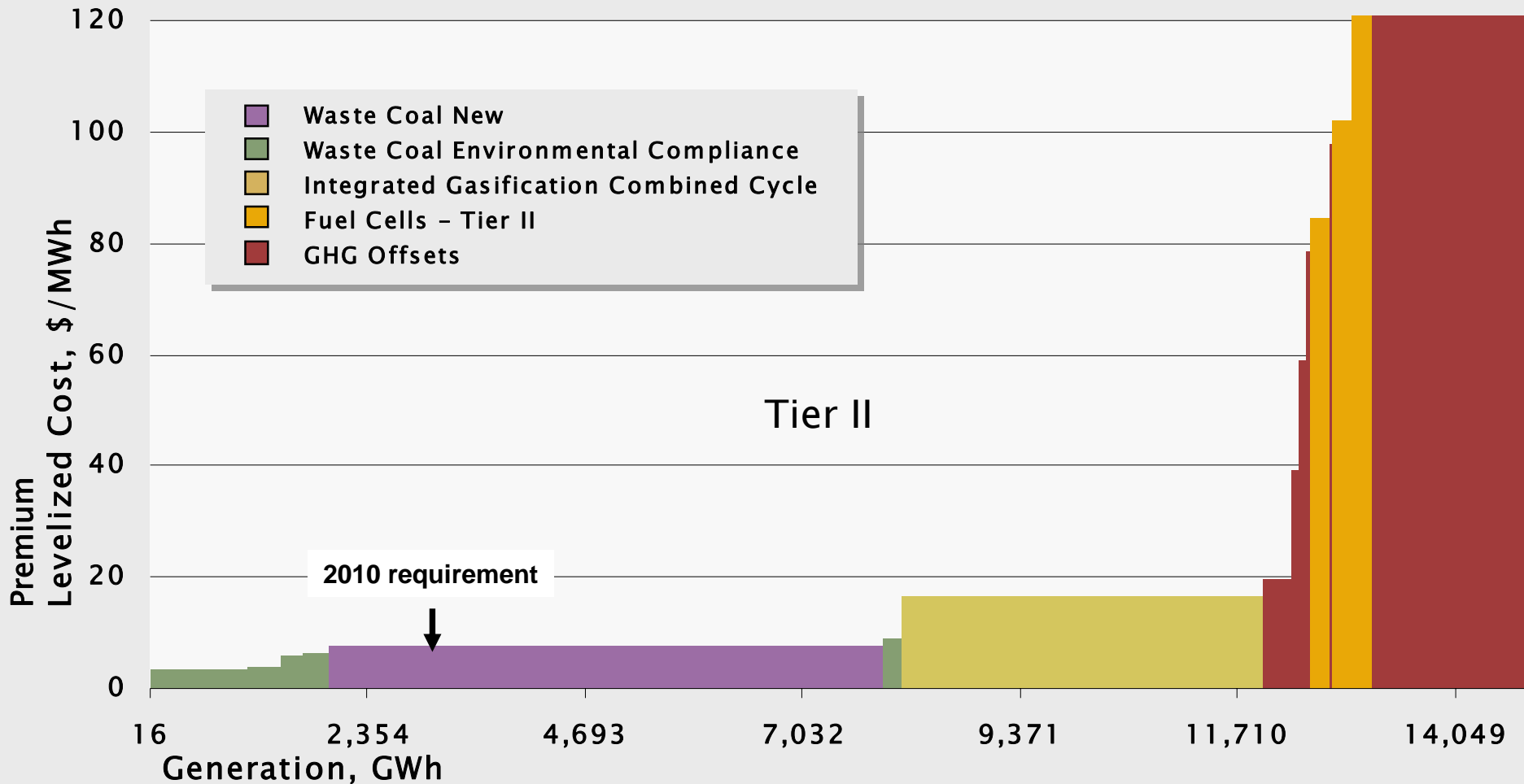


# Aggregate Tier II Supply Curve 2010



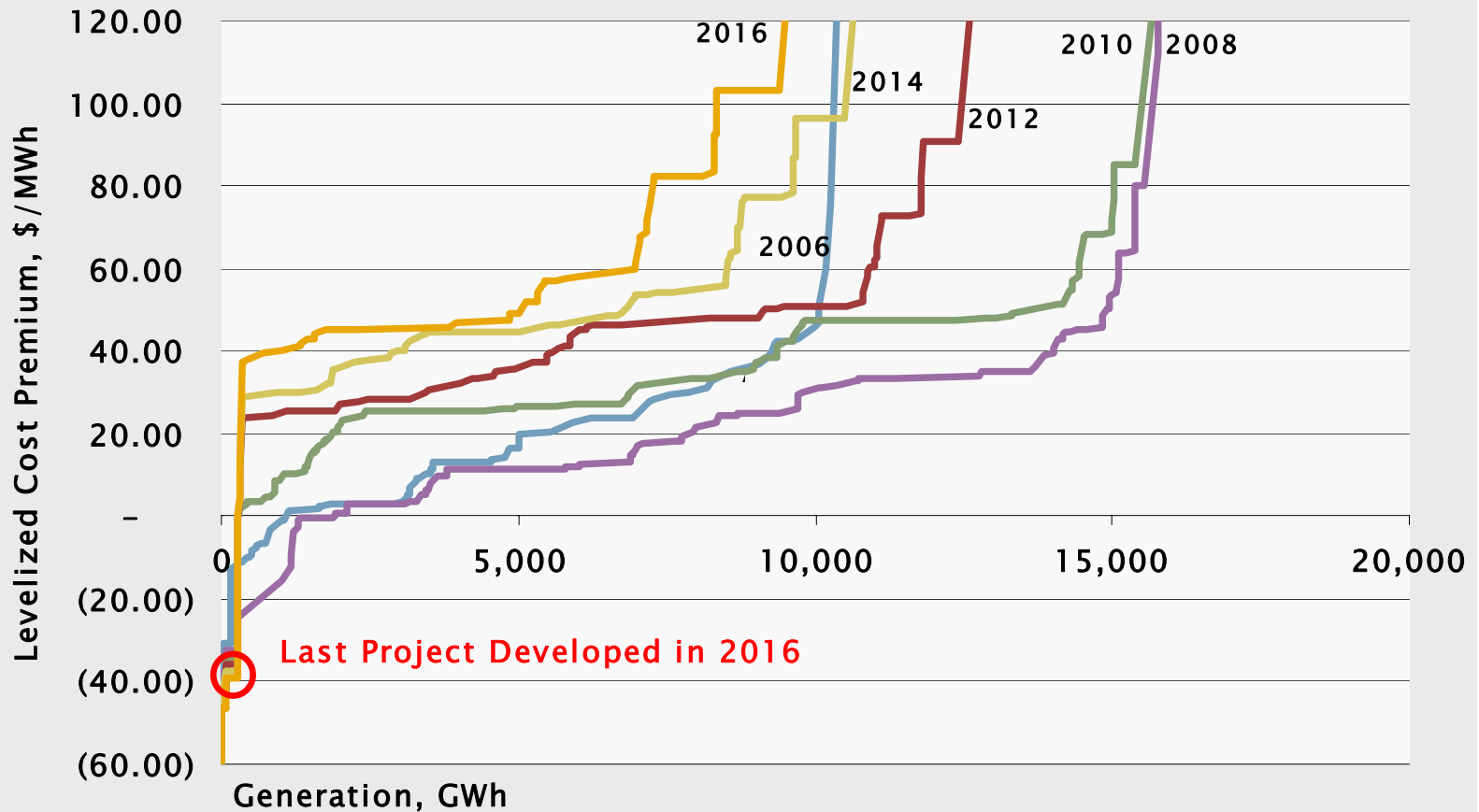
## 2010 Supply Curve

Additional Renewable Generation Required: 2955 GWh

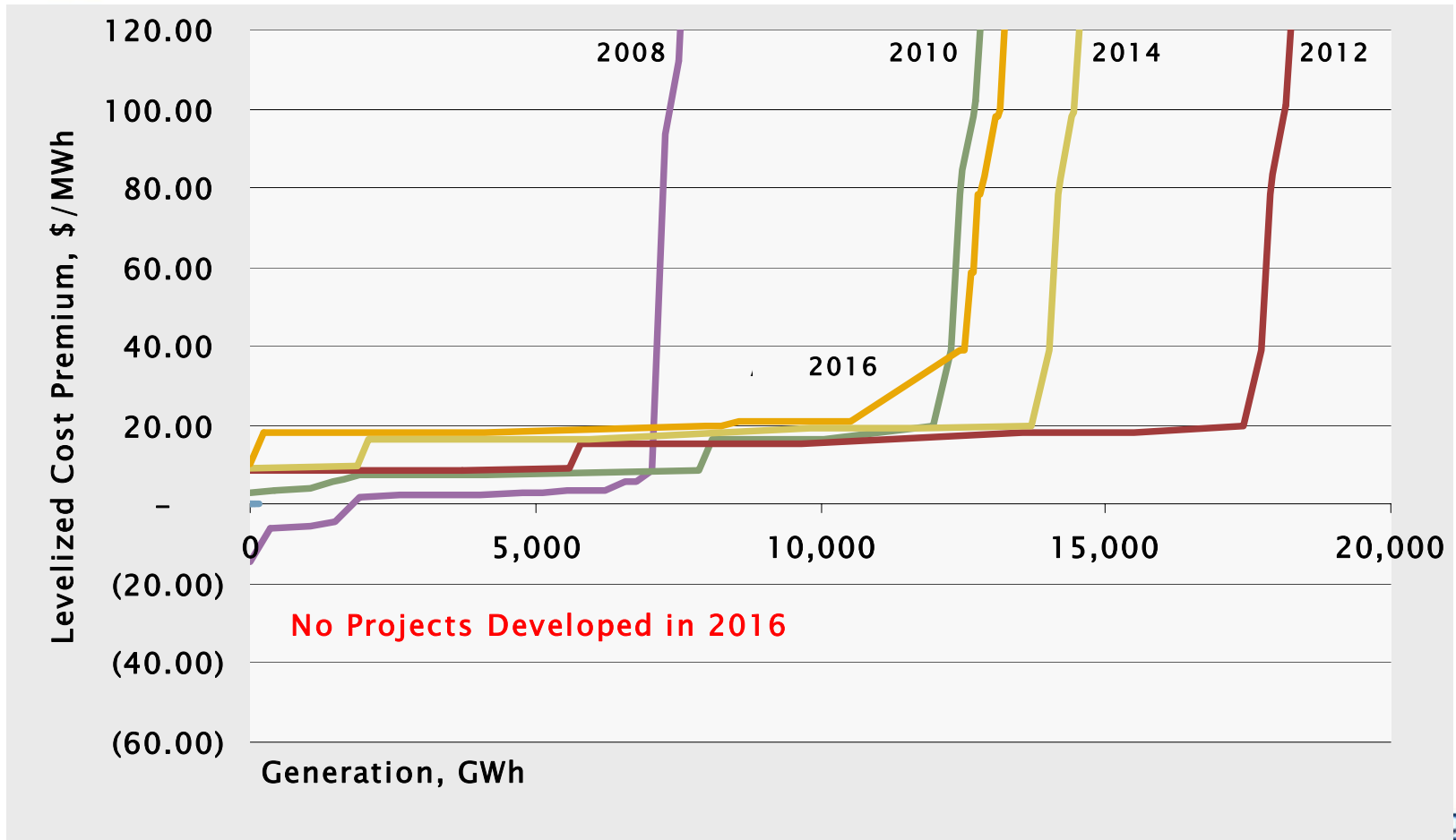




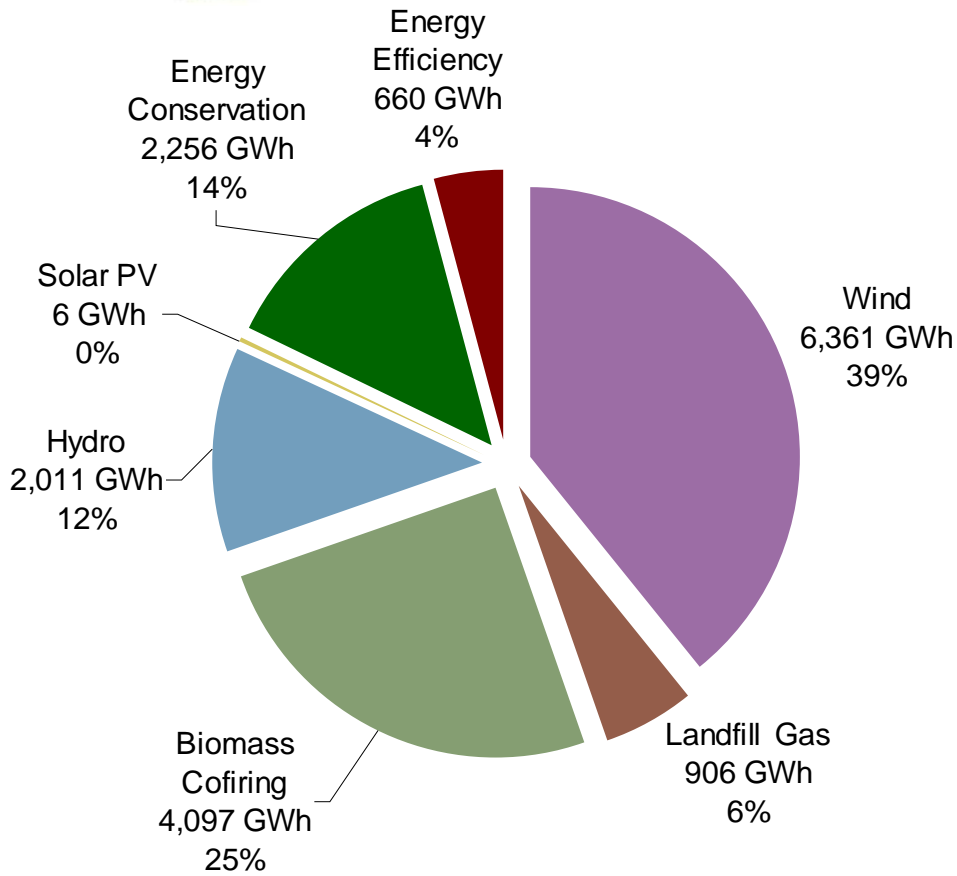
# Tier I Cost Premium Supply Curves



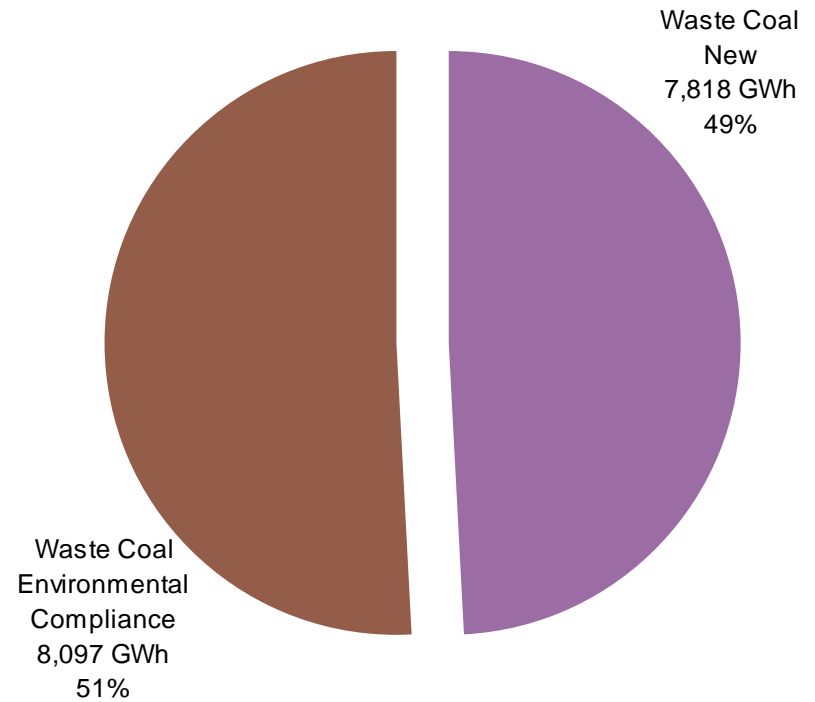
# Tier II Cost Premium Supply Curves



# Optimum Mix of Resources to Meet the AEPS Requirements



**Tier I Energy Mix**



**Tier II Energy Mix**







# Tier I Least Cost Mix

Technology	Wind	Landfill Gas	Biomass Cofiring	Hydro	Solar PV	Energy Conservation	Energy Efficiency
Share of RPS Mix (energy), %	38.6%	5.7%	24.9%	12.6%	0.0%	14.0%	4.1%
Energy, GWh	6,361	906	4,097	2,011	6	2,256	660
Capacity, MW	2,315	129	637	460	5	555	120
Capacity Factor, %	31%	80%	73%	50%	14%	46%	63%
Capital Cost, \$/kW	1,498	2,083	283	1,791	6,534	975	2
Average Cost Premium, \$/MWh	12.56	(1.51)	12.02	10.96	517.2	(30.85)	(0.34)

- Wind, biomass cofiring, and energy conservation comprise about 80 percent of mix
- Some solar (4 MW) assumed to be built, even though not economical



# Economic Impacts Assessment

- Compared building a 20% AEPS portfolio to building the “Business As Usual” (BAU) portfolio
  - Cost of electricity
  - Economic impacts (Jobs, Output, Earnings)
  - Fossil fuel prices
- BAU Portfolio: 50% coal, 40% combined cycle, 10% simple cycle
- Portfolios equated on an equivalent energy production basis
  - RPS portfolio: 6,470 MW
  - BAU portfolio: 2,460 MW
- Environmental externalities purposely not assessed



# Cumulative Economic Impacts

	Cost of Electricity	Employment Impact (job-years)	Earnings Impact	Output Impact
AEPS Portfolio	\$ 3.9 Billion	165,689	\$ 6.6 Billion	\$ 18.9 Billion
BAU Portfolio	\$ 6.6 Billion	94,753	\$ 4.1 Billion	\$ 11.9 Billion
Difference	-\$ 2.7 Billion	70,937	\$ 2.5 Billion	\$ 6.9 Billion

- Economic Benefits of the AEPS Portfolio compared to Business as Usual
  - **Cost of electricity:** reduced by \$2.7 billion (cumulative present value), about 1% when spread over all consumption
  - **Employment:** Creates over 70,000 additional job-years over 20 years (average of new 3,500 jobs)
  - **State output:** Creates about \$7 billion in increased state output
  - **Personal Income:** Creates about \$2.5 billion in additional earnings

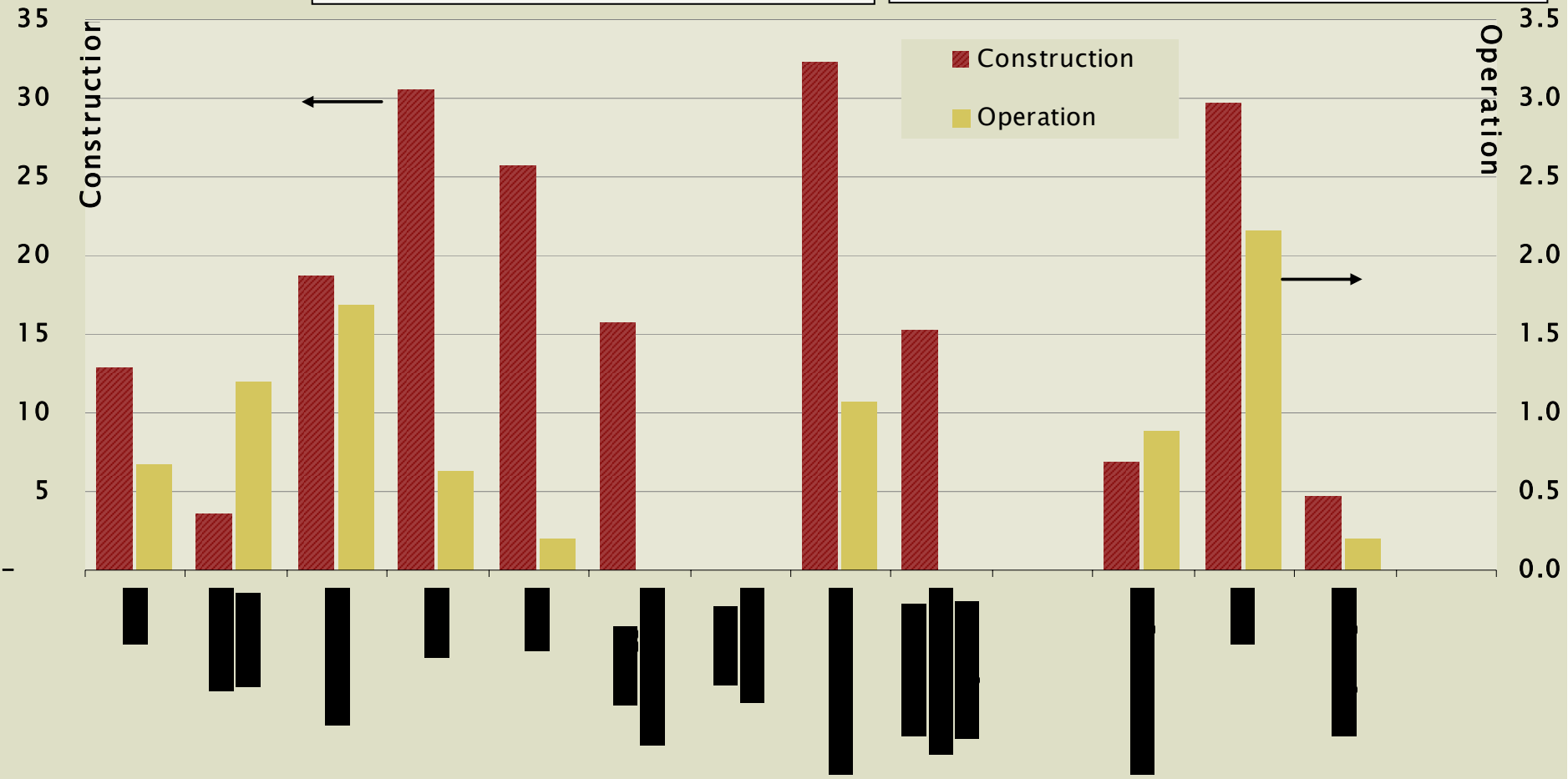
# Pennsylvania Employment Impacts, "Job-years" per MW



RPS portfolio: 6,470 MW

BAU portfolio: 2,460 MW

Impacts proportional to the percent of project expenditures made in PA in various industries





# AEPS Enacted into Law in Late 2004

- Our model does not match what was finally signed into law
  - Solar PV Standard - 0.5% of electricity demand in 15 years (~680 MW)
- Implementation Challenges
  - Ensuring new projects are deployed to meet the requirements of Tier I
    - ◆ Geographic Scope
    - ◆ Definition of Low-Impact Hydro
    - ◆ Long-Term Contracts
  - Encouraging demand-side management
    - ◆ Tier II over-subscription
    - ◆ Developing rules



# Conclusions and Acknowledgements

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