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# **Process Overview and DRAFT Results Discussion**

**April 2011**

# Agenda

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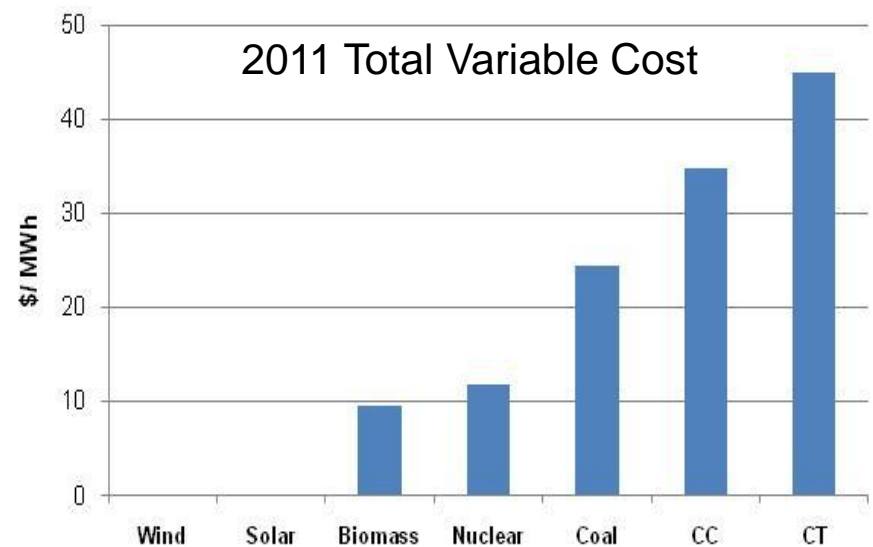
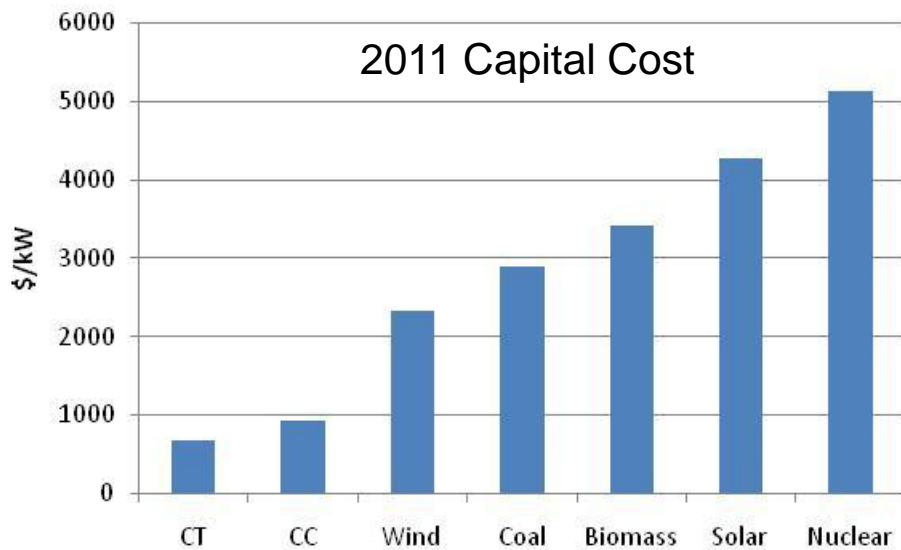
- **Generic Generator Data Spreadsheet**
- **BAU Scenario**
  - Process Overview
  - Draft Results for Process/Modeling Discussion
- **Identification of Key Sensitivities for next runs**

# Software Descriptions

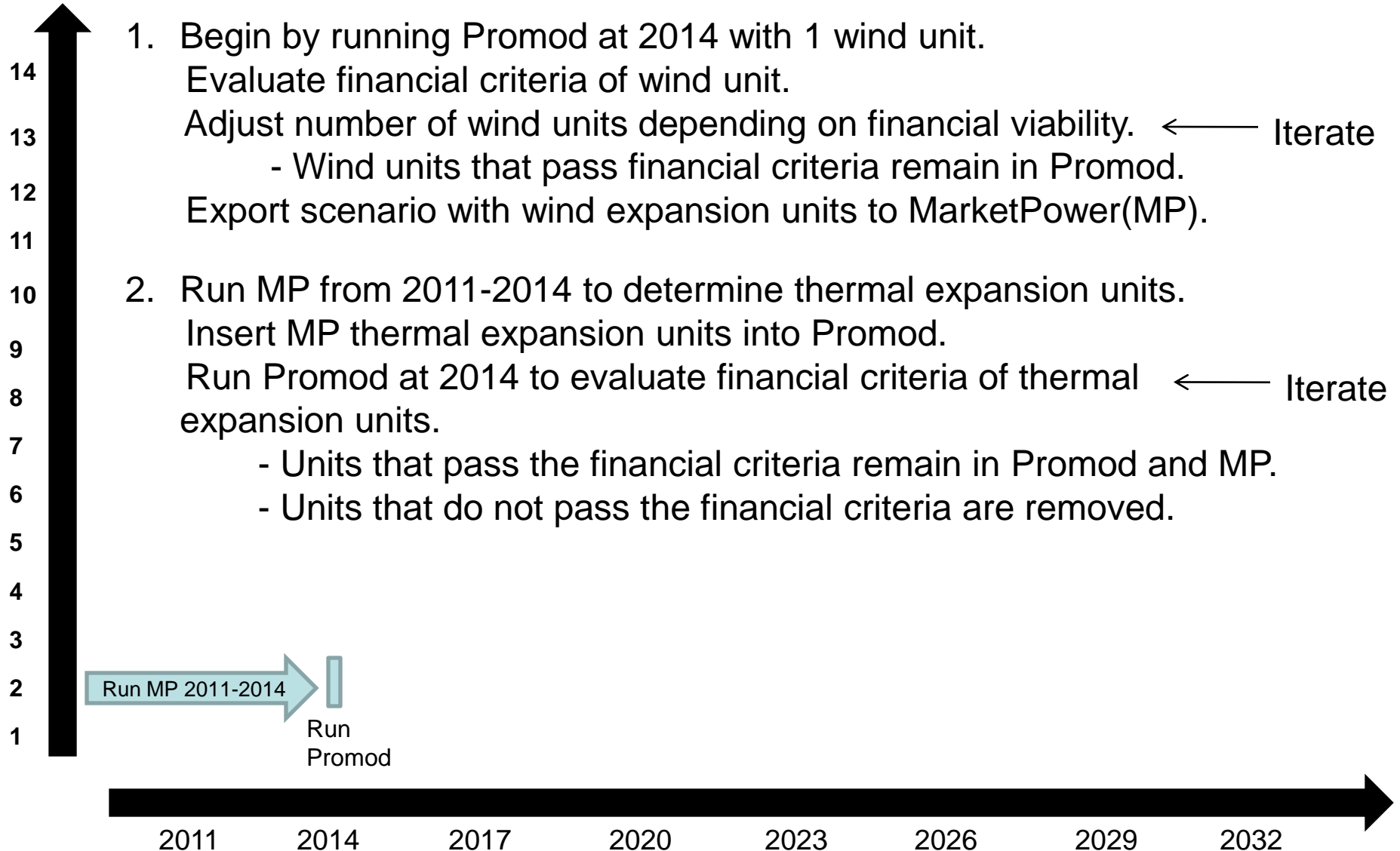
- **MarketPower**
  - Provides the ability to simulate longer term studies of energy and capacity prices along with market based expansion plans
- **PROMOD**
  - Provides the ability to conduct multiyear detailed production cost simulations for forecasting generating unit cost and revenues, asset profitability assessments, LMP calculations, CRR valuations and transmission analysis

# Generic Database

- **Contains data used in the Promod model**
  - Generic characteristics for existing units
  - Generic characteristics for expansion units (Prototypes)
  - Fuel and load forecasts
  - Capital cost projections
  - Financing assumptions
  - Data sources



# Process Overview



# Process Overview

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3. Run Promod at 2017 with 1 wind unit.  
Evaluate financial criteria of wind unit.  
Adjust number of wind units depending on financial viability. ← Iterate
    - Wind units that pass financial criteria remain in Promod.Export scenario with wind expansion units to MP.
  4. Run MP from 2011-2017 to determine thermal expansion.  
Insert MP thermal expansion units into Promod.  
Run Promod at 2017 to evaluate financial criteria of thermal expansion units. ← Iterate
    - Units that pass the financial criteria remain in Promod and MP.
    - Units that do not pass the financial criteria are removed.

2011

2014

2017

2020

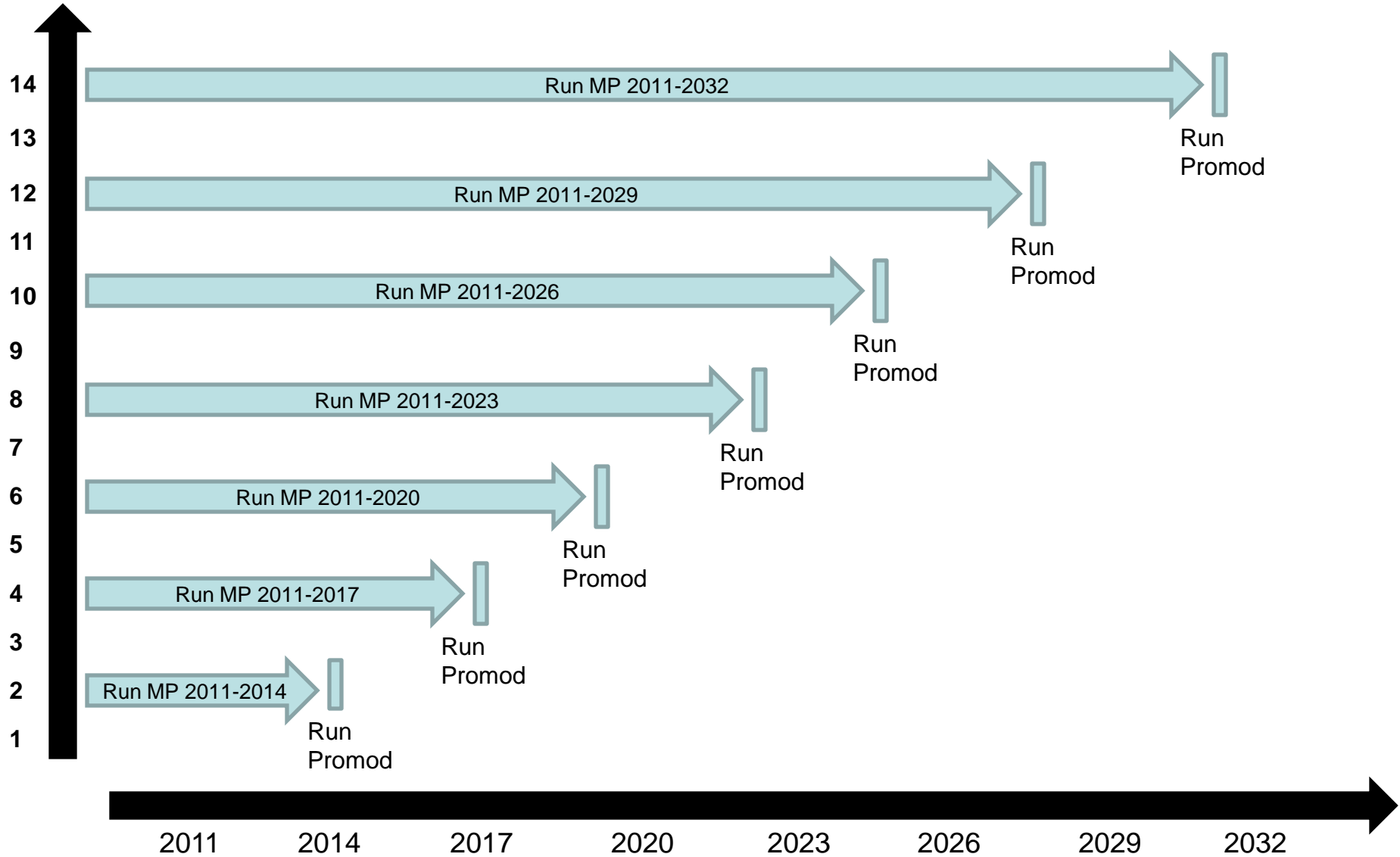
2023

2026

2029

2032

# Process Overview





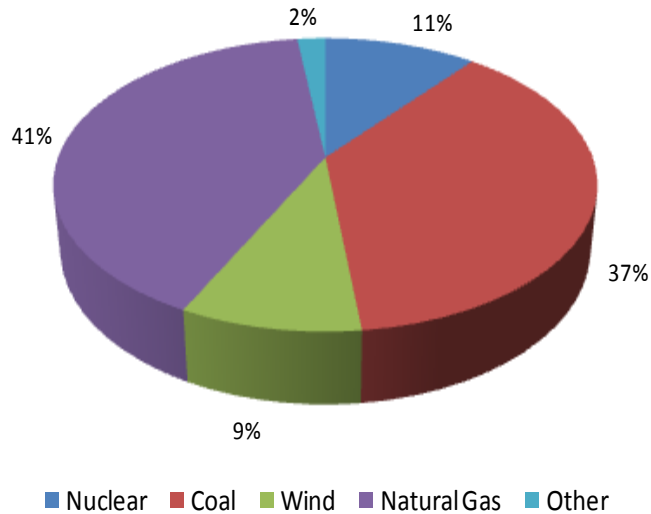
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# **Preliminary Expansion Results**



# 2011 BAU Starting Point

## 2011 Annual Generation (GWh)



Annual Energy: 367,414 GWh

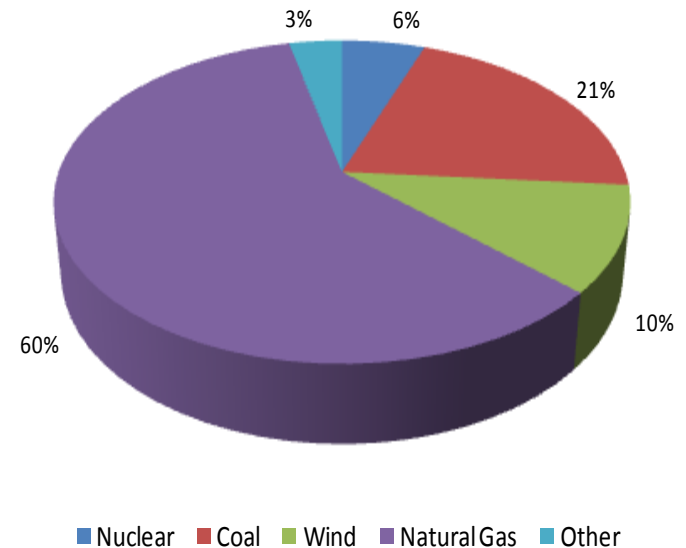
Annual Peak: 68,759 MW

Total System Cost: \$11.8 billion

Total Energy Revenues: \$14.18 billion

Average LMP: \$37.42/MWh

## 2011 Annual Capacity (MW)



# BAU Starting Point: 2011

Description	Units	2011
CC Adds	MWs	
CT Adds	MWs	
Coal Adds	MWs	
Nuclear Adds	MWs	
Wind Adds	MWs	
Other Adds	MWs	
Approximate Reserve Margin	%	18
Average LMP	\$/MWh	37.4
Henry Hub Price	\$/mmbtu	4.50
Average Market Heat Rate	mmbtu	8.31
% NG Gen	%	40.7
Scarcity Hours	HRS	0
Unserved Energy	GWhs	0

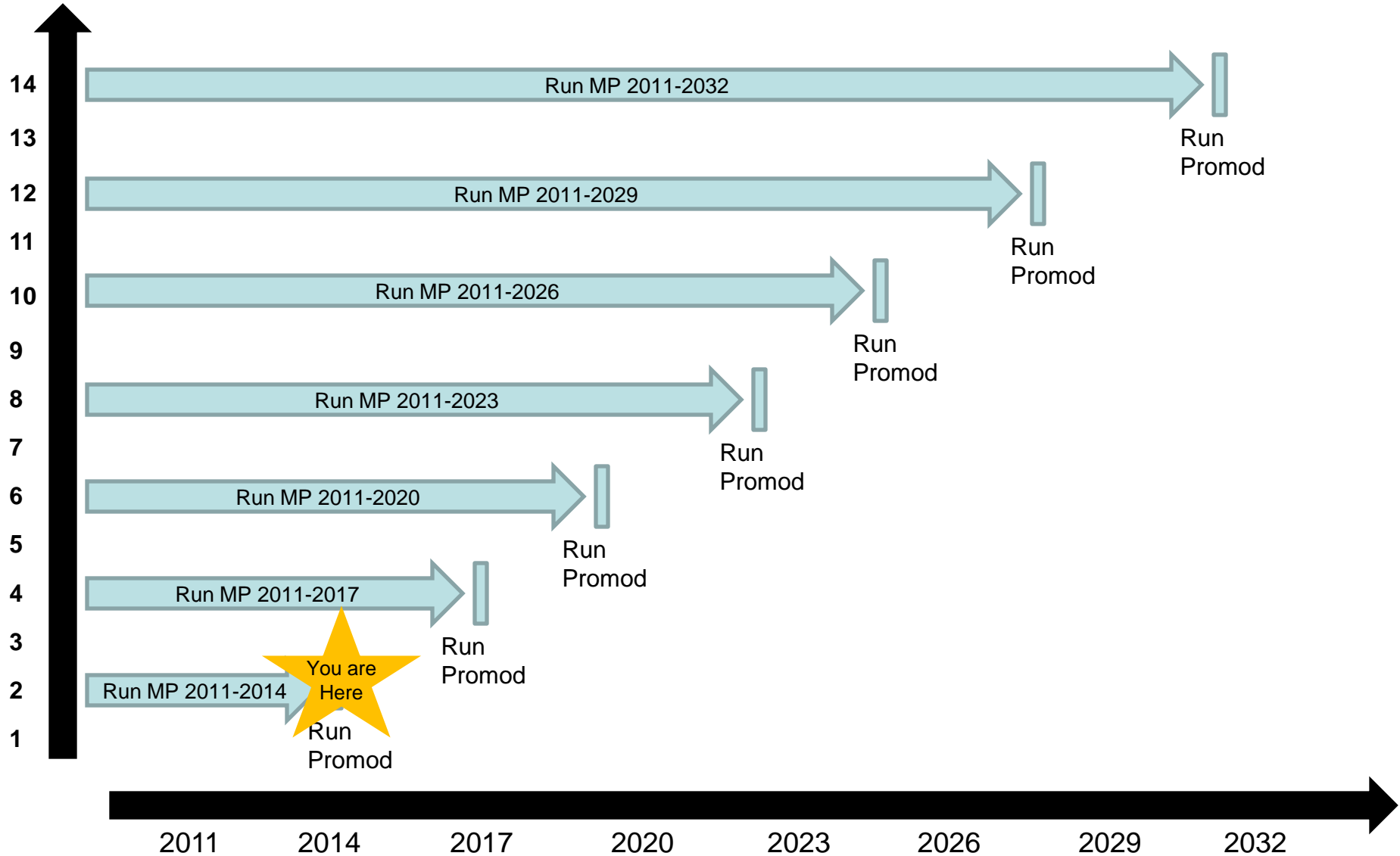
## • Initial Model Considerations

- No transmission constraints
- Average weather year
- Marginal cost bidding only
- No Ancillary Services
  - To be evaluated in future analyses
- MarketPower set to meet forecasted load with no reserve margin
- Reserve Margin uses the ELCC (Electric Load Carrying Capability) of wind at 8.7%

# Generation Expansion: 2014

- **Started with 2011 BAU and added one wind expansion unit**
- **Wind Expansion Unit Characteristics**
  - 250 MW
  - 40% Average Capacity Factor
  - \$2452/kW Capital Cost
  - \$29.65/kW-yr Fixed O&M
  - Initial expansion plan assumed PTC would not continue
    - Would be \$23.24/MWh if continued
  - Wind Profile: average weather hourly wind generation pattern provided by AWS Truewind for the Central CREZ zone
- **Ran Promod at 2014**

# Process Overview

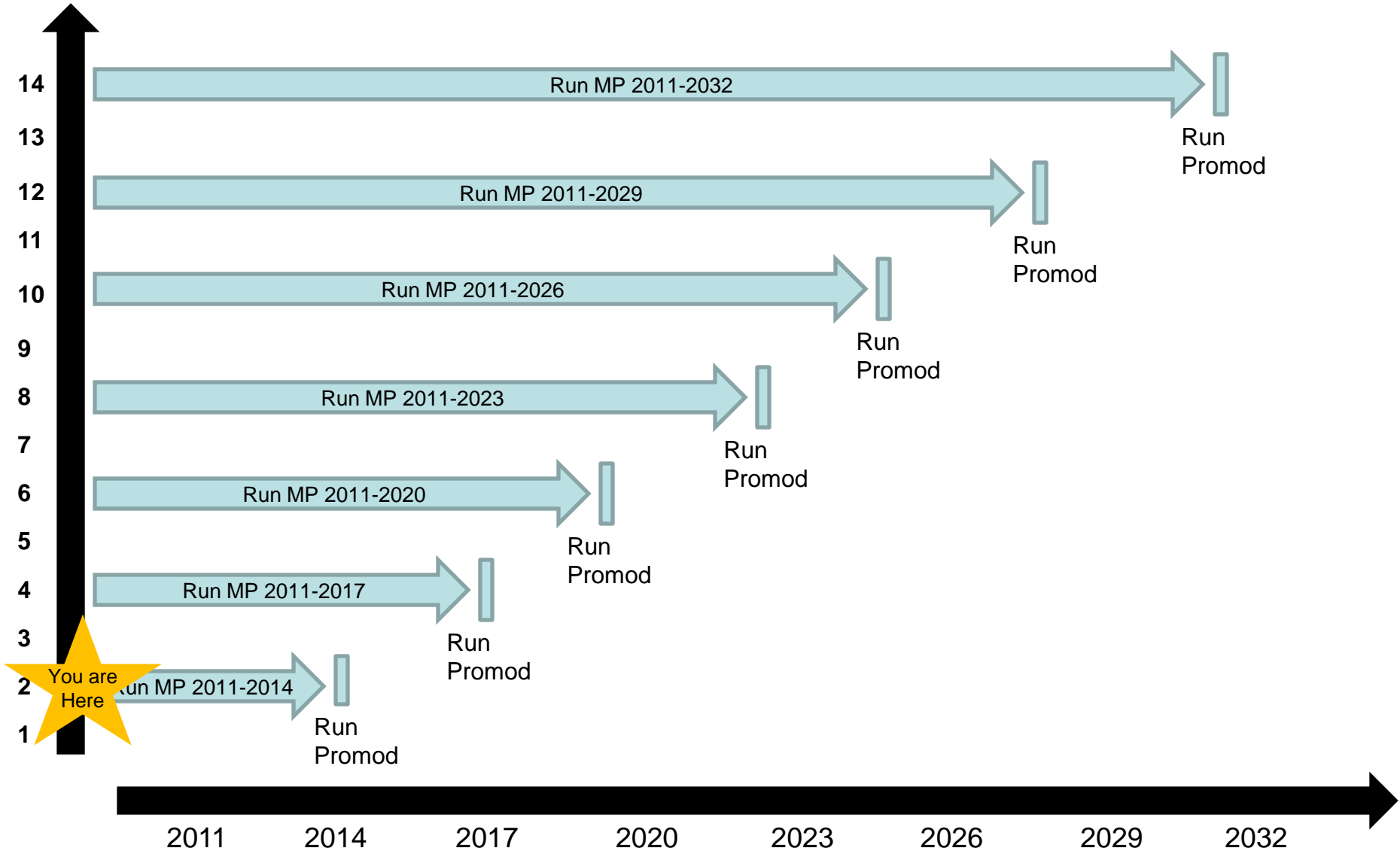


# Promod Wind Expansion Unit Results: 2014

- **Generation: 880,941 MWh**
  - **Average Capacity Factor: 40%**
  - **Revenue received: \$33.5 million**
    - \$38.03/MWh
  - **Revenue needed : \$81.4 million**
    - \$92.36/MWh (using EIA capital costs of \$2452/kW in 2014)
  - **Difference : -\$47.9 million**
  - **Wind unit did not recover costs**
    - Removed unit from expansion plan
  - **Exported Scenario to MarketPower (MP)**
- |         |            |
|---------|------------|
| \$33.5  | Revenue    |
| -\$81.4 | Needed     |
| <hr/>   |            |
| -\$47.9 | Difference |

If PTC were included:  
PTC : \$20.4 million;  
\$23.24/MWh

# Process Overview

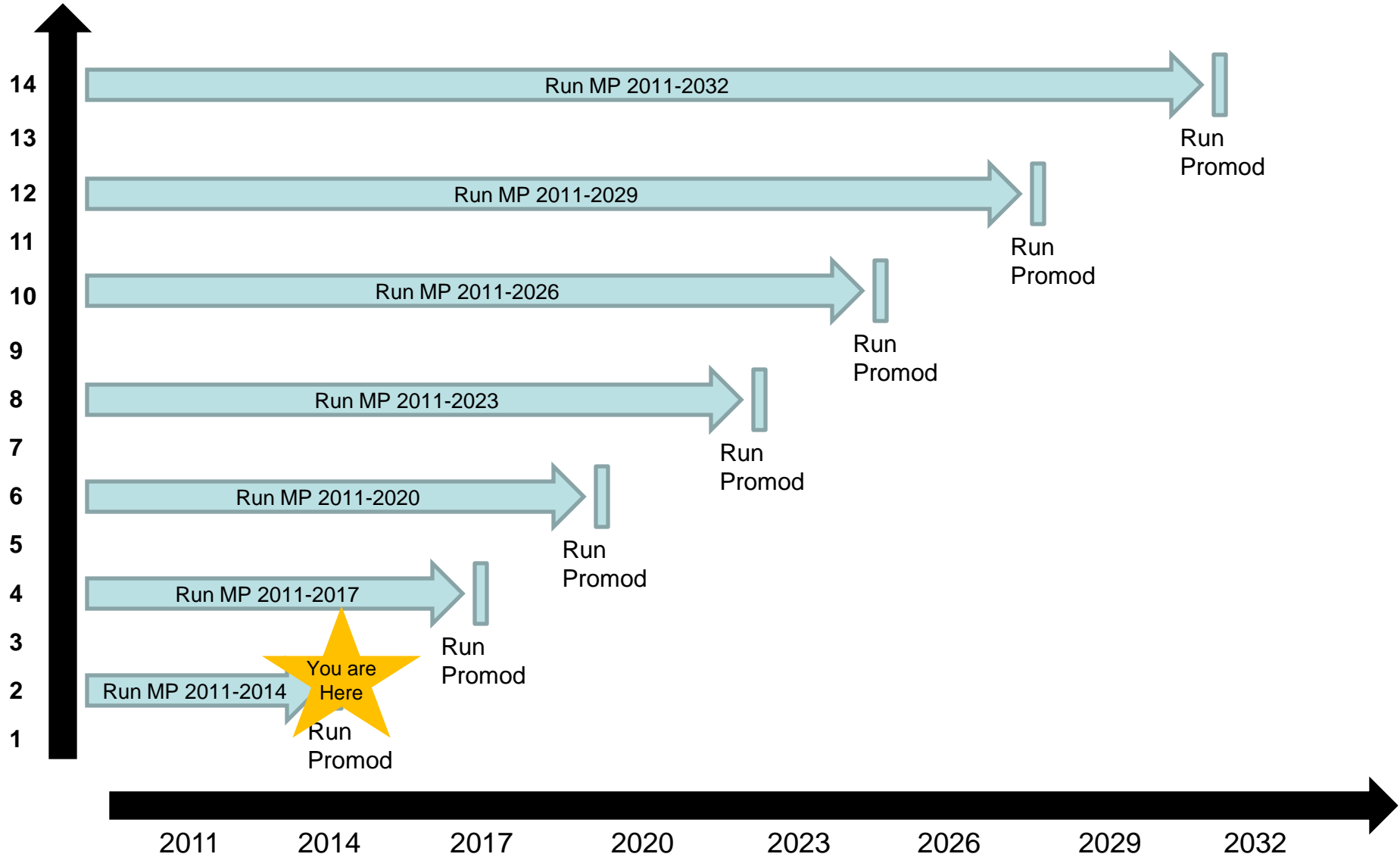


# MarketPower : 2014

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- **Ran MP from 2011-2014 to determine initial amount of economic thermal units**
- **Imported MP thermal expansion to Promod and re-ran at 2014 to produce chronological revenues**
- **Evaluated MP thermal expansion units using Promod results against financial criteria**

# Process Overview





# MarketPower Expansion Build: 2014

- **MP initially built 15 Advanced Combustion Turbine (ACT) Units**
  - LMS100
  - 100 MW
  - \$711/kW Capital Cost
  - \$7.08/kW-yr Fixed O&M
  - \$56.33/MWh Total Variable Cost
  - \$4.63/mmbtu Natural Gas price
- **Operation Results from Promod (average across the 15 units):**
  - Generation: 51,410 MWh
  - Capacity Factor: 5.9%
  - Revenue received: \$3.32 million
    - \$59.92/MWh
  - Revenue needed : \$13.63 million
    - \$265.12/MWh
  - Difference : **-\$10.31 million**

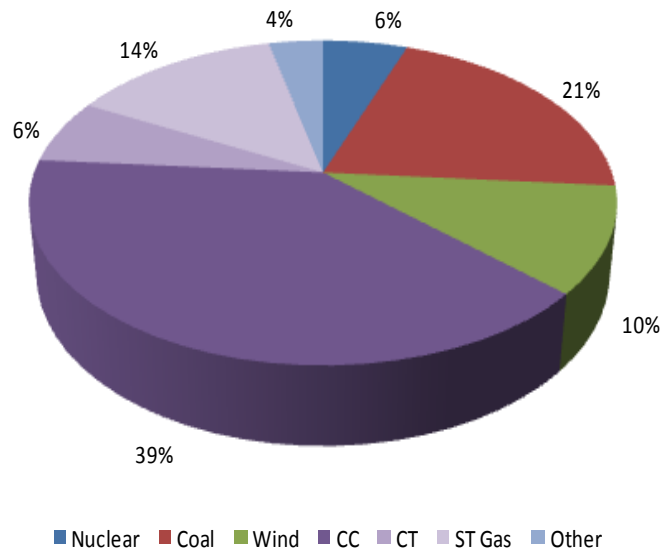
# Promod Iterations: 2014

- None of the 15 ACT units met the financial criteria
- Removed added units until the remaining units were economic
- Reduced number of units to 1 ACT
- Re-ran Promod at 2014 with 1 ACT
- Evaluated the 1 ACT financial criteria
- Results
  - Generation: 56,555 MWh
  - Revenue received: \$4.18 million
    - \$73.91/MWh
  - Needed: \$13.63 million
    - \$241/MWh
  - Difference: **-\$9.45 million**
    - Did not recover costs
    - All expansion units removed

# 2011-2014 Changes: Annual Capacity (MW)

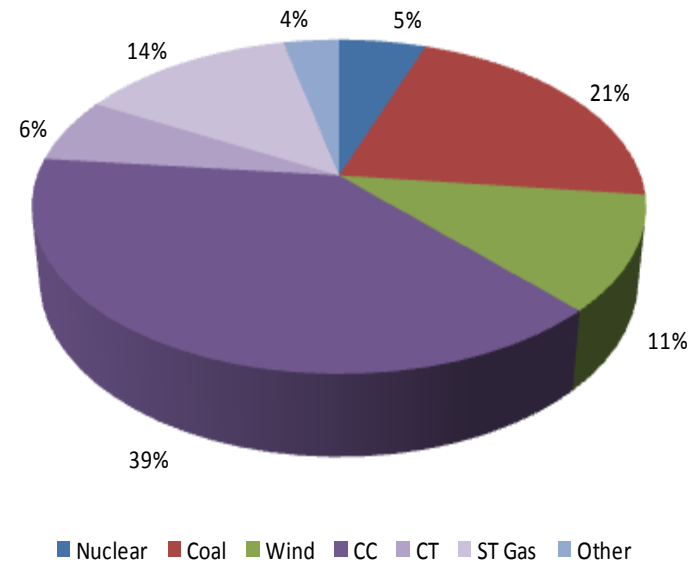
- Wind capacity increased from 9,719 MW to 10,359 MW due to units with signed Interconnection Agreements
- Coal capacity increased due to Sandy Creek (925 MW) coming online in 2012

## 2011 Capacity by Technology



\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

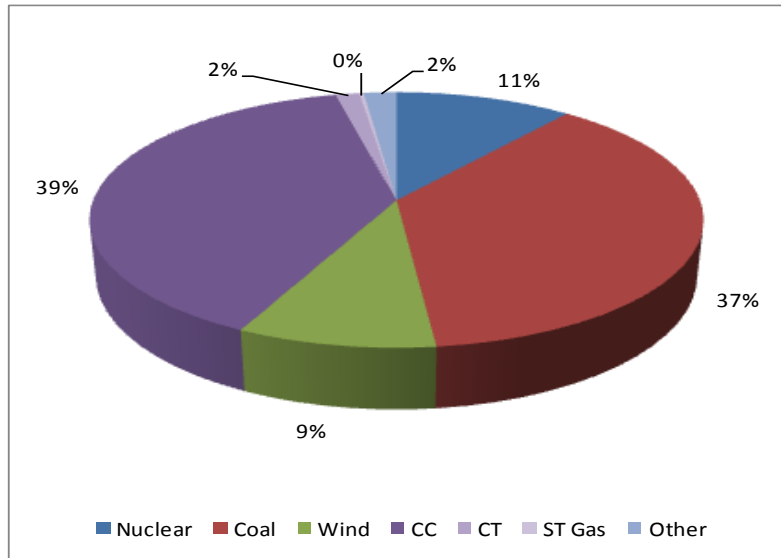
## 2014 Capacity by Technology



**2014**  
 Comb Cycle: 36,312 MW  
 Comb Turbine: 5,923 MW  
 ST Gas: 12,640 MW  
 Coal: 20,018 MW  
 Nuclear: 5,132 MW  
 Wind: 10,359 MW  
 Other: 3,287 MW

# 2011-2014 Changes : Annual Generation (GWh) by Technology

- Generation increased for all unit types except nuclear
- Annual average LMP increased from \$37.42/MWh to \$40.80/MWh
- Natural Gas Price increased from \$4.50/mmbtu to \$4.63/mmbtu

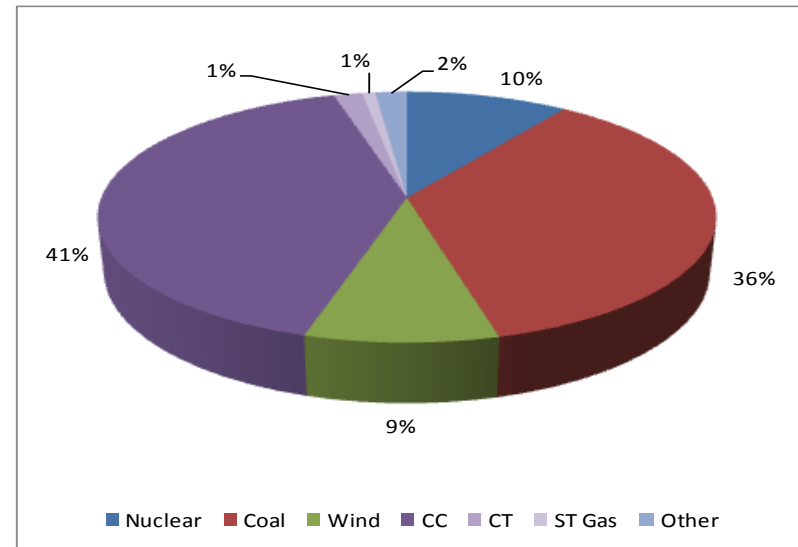


Comb Cycle: 143,250 GWh  
 Comb Turbine: 5,366 GWh  
 ST Gas: 984 GWh  
 Coal: 137,357 GWh  
 Nuclear: 39,805 GWh  
 Wind: 33,321 GWh  
 Other: 7,331 GWh  
 Total: 367,414 GWh

2011

2014

Comb Cycle: 165,932 GWh  
 Comb Turbine: 6,949 GWh  
 ST Gas: 3,260 GWh  
 Coal: 146,069 GWh  
 Nuclear: 39,805 GWh  
 Wind: 35,497 GWh  
 Other: 7,774 GWh  
 Total: 405,286 GWh



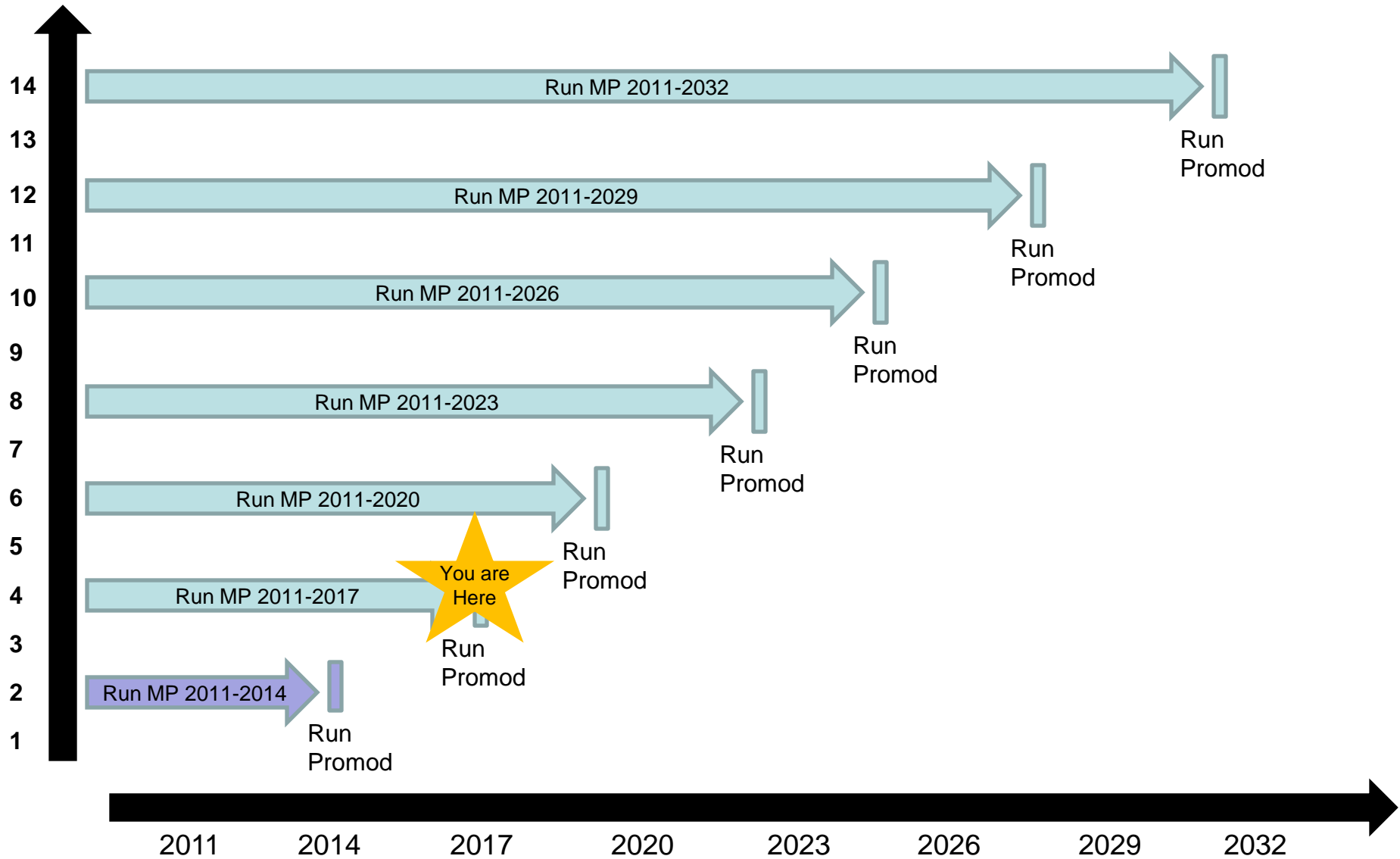
\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2014 Changes: Promod Output

Description	Units	2011	2014
CC Adds	MWs		0
CT Adds	MWs		0
Coal Adds	MWs		0
Nuclear Adds	MWs		0
Wind Adds	MWs		0
Other Adds	MWs		0
Approximate Reserve Margin	%	18	11
Average LMP	\$/MWh	37.4	40.8
Henry Hub Price	\$/mmbtu	4.50	4.63
Average Market Heat Rate	mmbtu	8.31	8.81
% NG Gen	%	40.7	43.5
Scarcity Hours	HRS	0	0
Unserved Energy	GWhs	0	0

- No new units are added to the system, the existing units increase their generation to meet load.
- Combustion turbine and steam gas units operate during more hours to meet load, the market heat rate increases.

# Process Overview

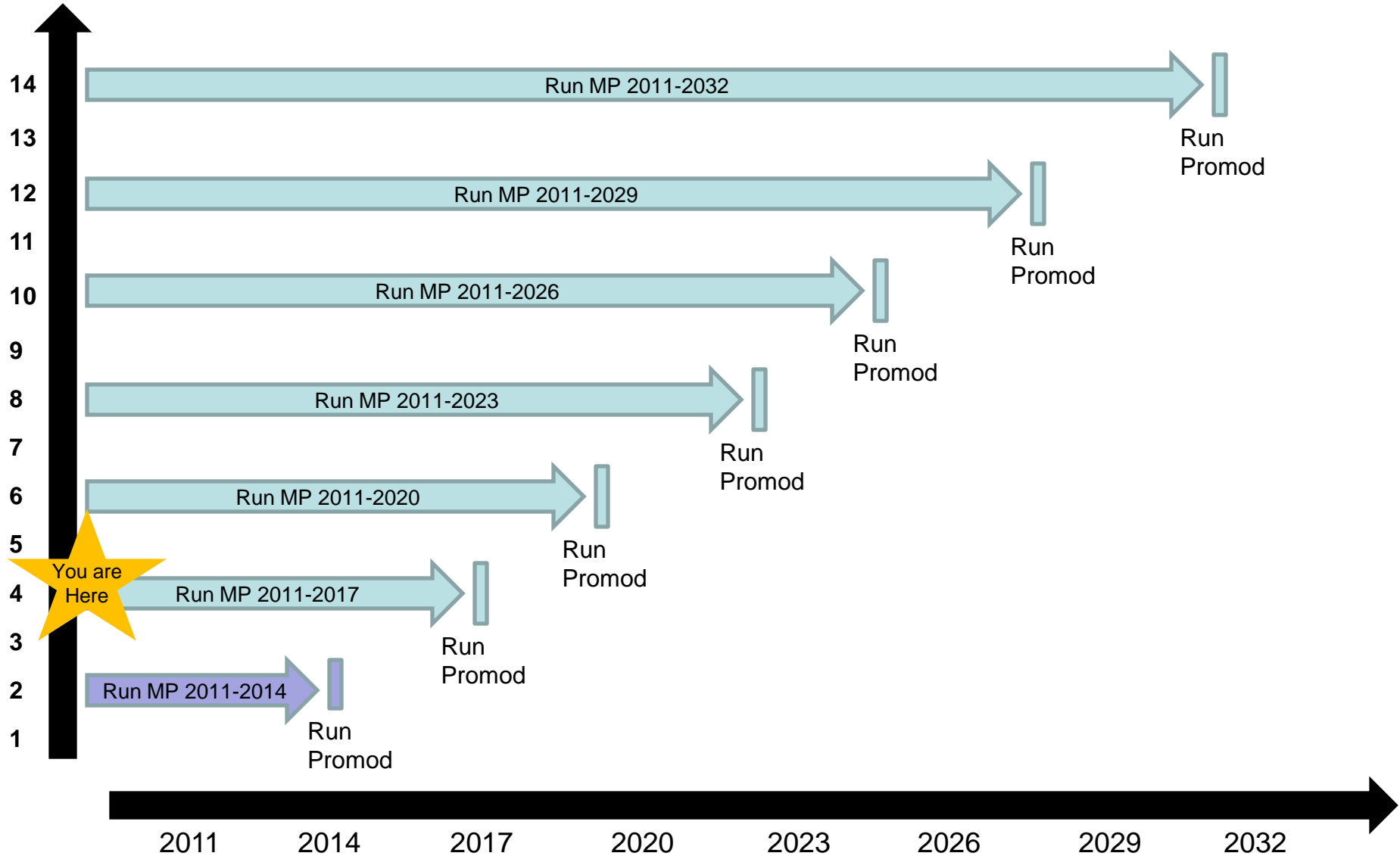


# Promod Wind Expansion Results: 2017

- Final Expansion from 2014 resulted in zero units built
- Run Promod at 2017 with 1 wind unit
- Results of wind unit run
  - Revenue received: \$40.6 million
    - \$46.09/MWh
  - Revenue required: \$84.9 million
    - \$96.38/MWh at \$2,552/kW
  - Difference: **-\$44.3 million**
  - Did not recover costs
- Removed wind unit from expansion plan
- Exported Promod Scenario to MP
- Ran MP from 2011-2017

If PTC were included:  
PTC: \$21.6 million;  
\$24.54/MWh

# Process Overview

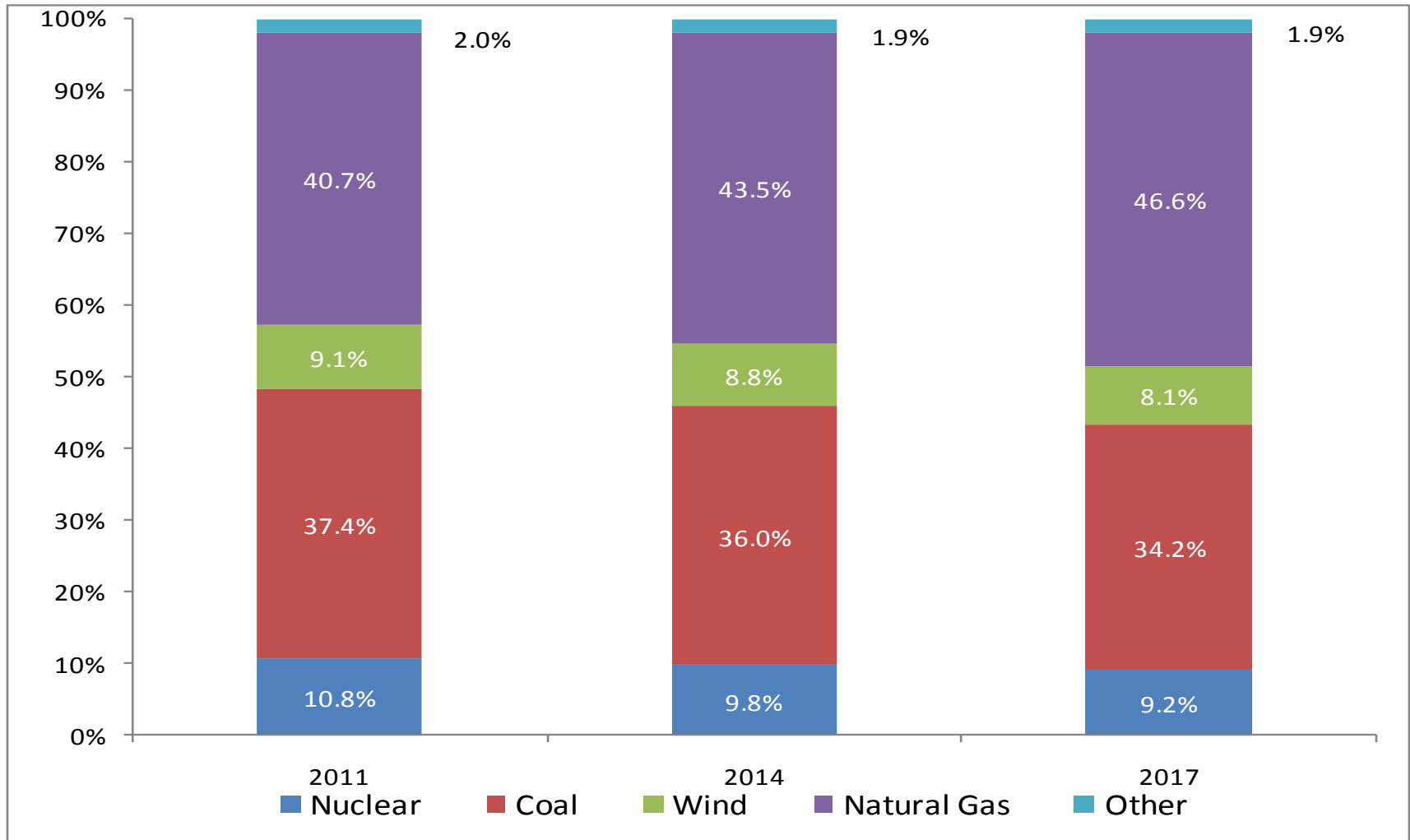




# MarketPower Expansion Build: 2017

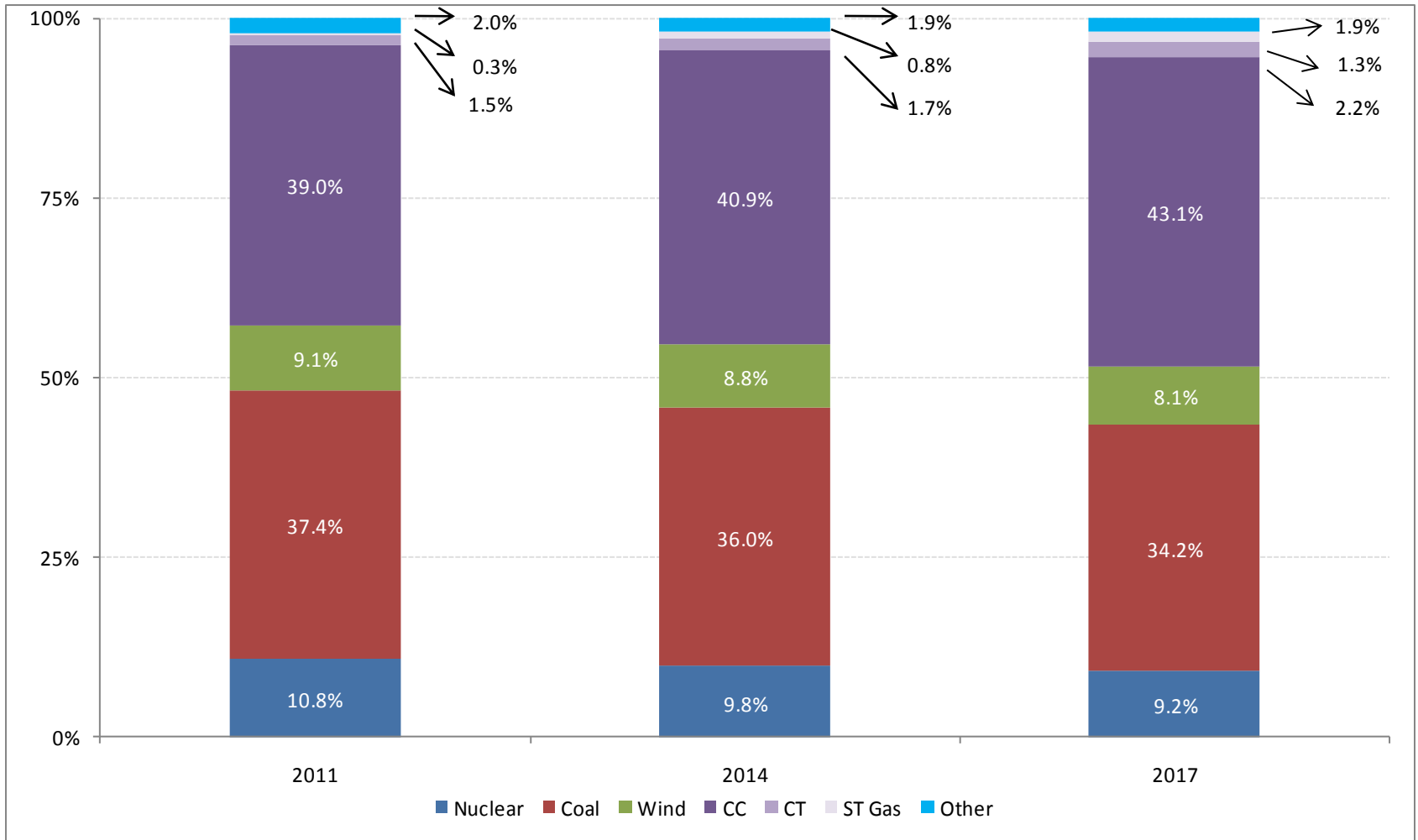
- MarketPower initially built 48 ACT units
  - LMS100
  - 100 MW
  - \$742/kW
  - \$7.47/kW-yr Fixed O&M
  - \$61.38/MWh Total Variable Cost
  - \$5.10/mmbtu Natural Gas price
- Re-ran multiple test runs in Promod of different amounts of ACT units to determine the final expansion for 2017 where all units were meeting the financial criteria
- Final expansion resulted in 13 ACT units built
  - Average across the 13 units:
    - Generation: 88.89 GWh
    - Capacity Factor: 10.3%
    - Revenue: \$15.4 million
      - \$173.25/MWh
    - Revenue needed : \$14.1 million
      - \$159.09/MWh
    - Difference : \$ 1.3 million

# 2011-2017 Changes : Annual Generation (GWh) by Fuel Type



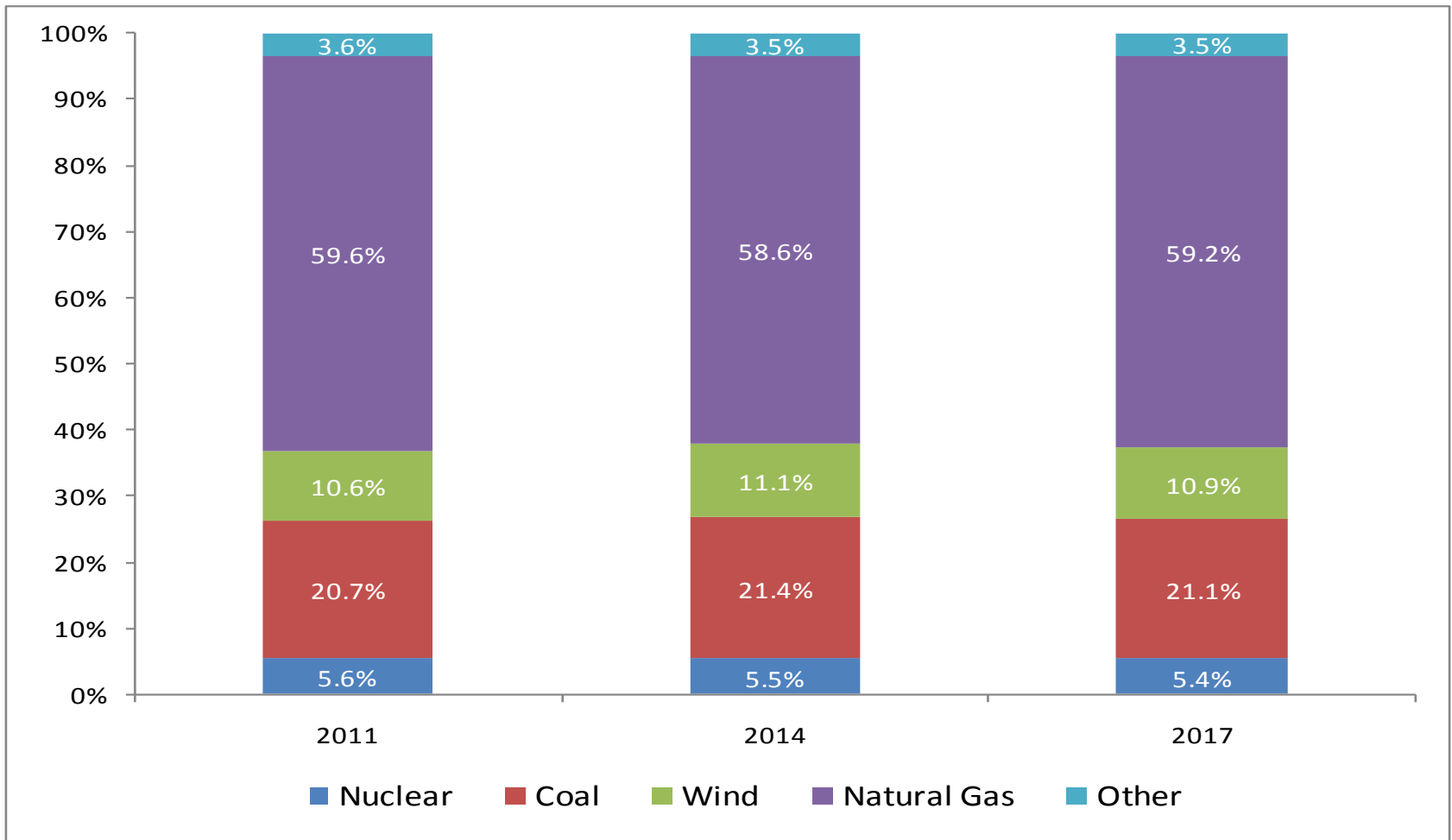
\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2017 Changes: Annual Generation (GWh) by Technology



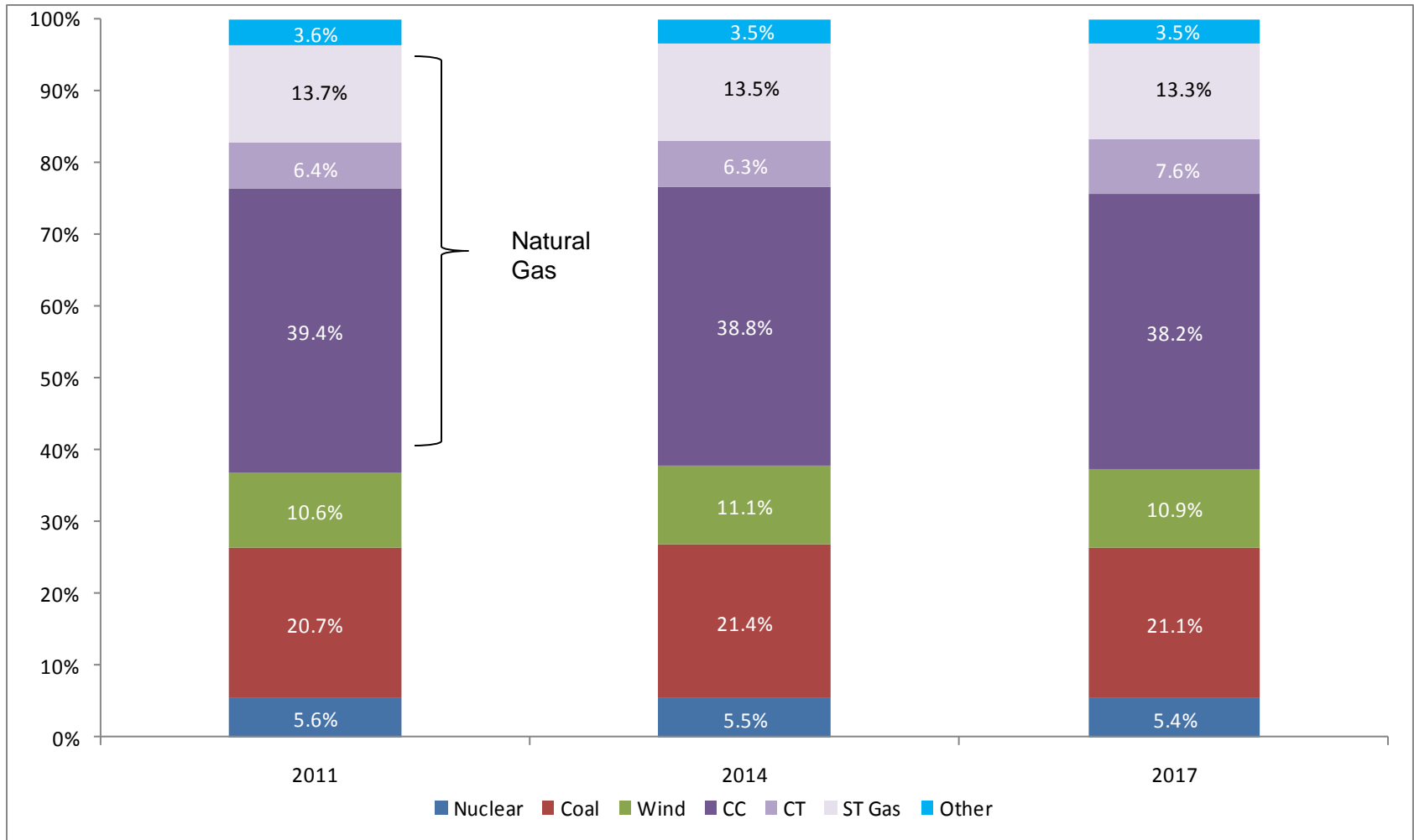
\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2017 Changes: Annual Capacity (MW) by Fuel Type



\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2017 Changes: Annual Capacity (MW) by Technology



\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2017 Changes: Promod Output

Description	Units	2011	2014	2017
CC Adds	MWs		0	0
CT Adds	MWs		0	1,300
Coal Adds	MWs		0	0
Nuclear Adds	MWs		0	0
Wind Adds	MWs		0	0
Other Adds	MWs		0	0
Approximate Reserve Margin	%	18	11	7
Average LMP	\$/MWh	37.4	40.8	56.7
Henry Hub Price	\$/mmbtu	4.50	4.63	5.10
Average Market Heat Rate	mmbtu	8.31	8.81	11.1
% NG Gen	%	40.7	43.5	46.6
Scarcity Hours	HRS	0	0	28
Unserved Energy	GWhs	0	0	37.9

- In 2017, we see scarcity hours where the LMPs hit \$3,000/MWh.
- Unserved energy results from the decreasing reserve margin.
- Current modeling is not capturing all scarcity pricing and A/S revenues.

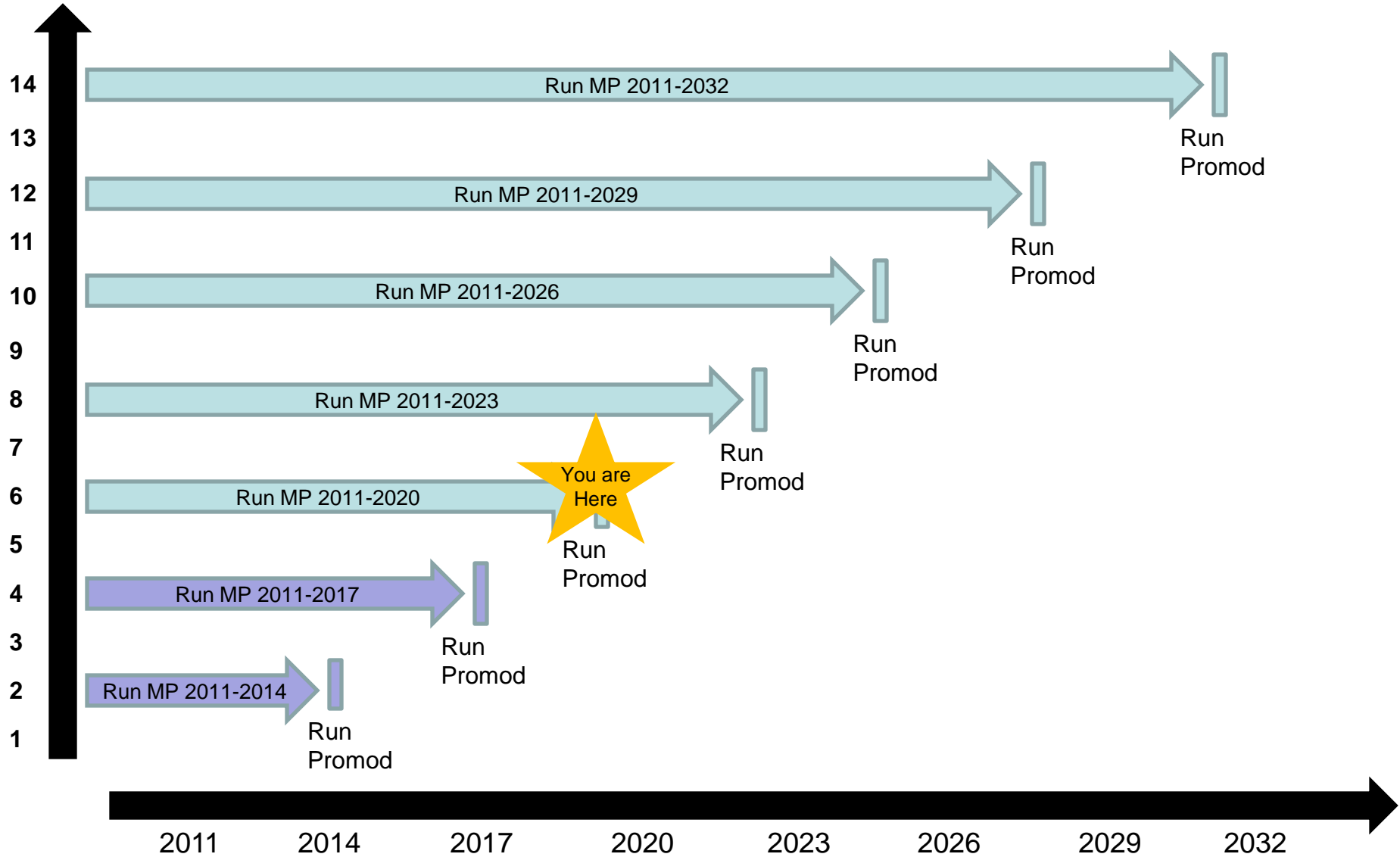
# Market Revenue Issues

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The following items will have an impact on revenues received by generators in the market and are not currently modeled in this analysis:

- **Ancillary Service Revenues**
- **Unconstrained Transmission System**
- **Weather Uncertainty**
- **Scarcity Pricing**
- **Market Bidding Behavior**
- **Commitment Efficiency**

# Process Overview



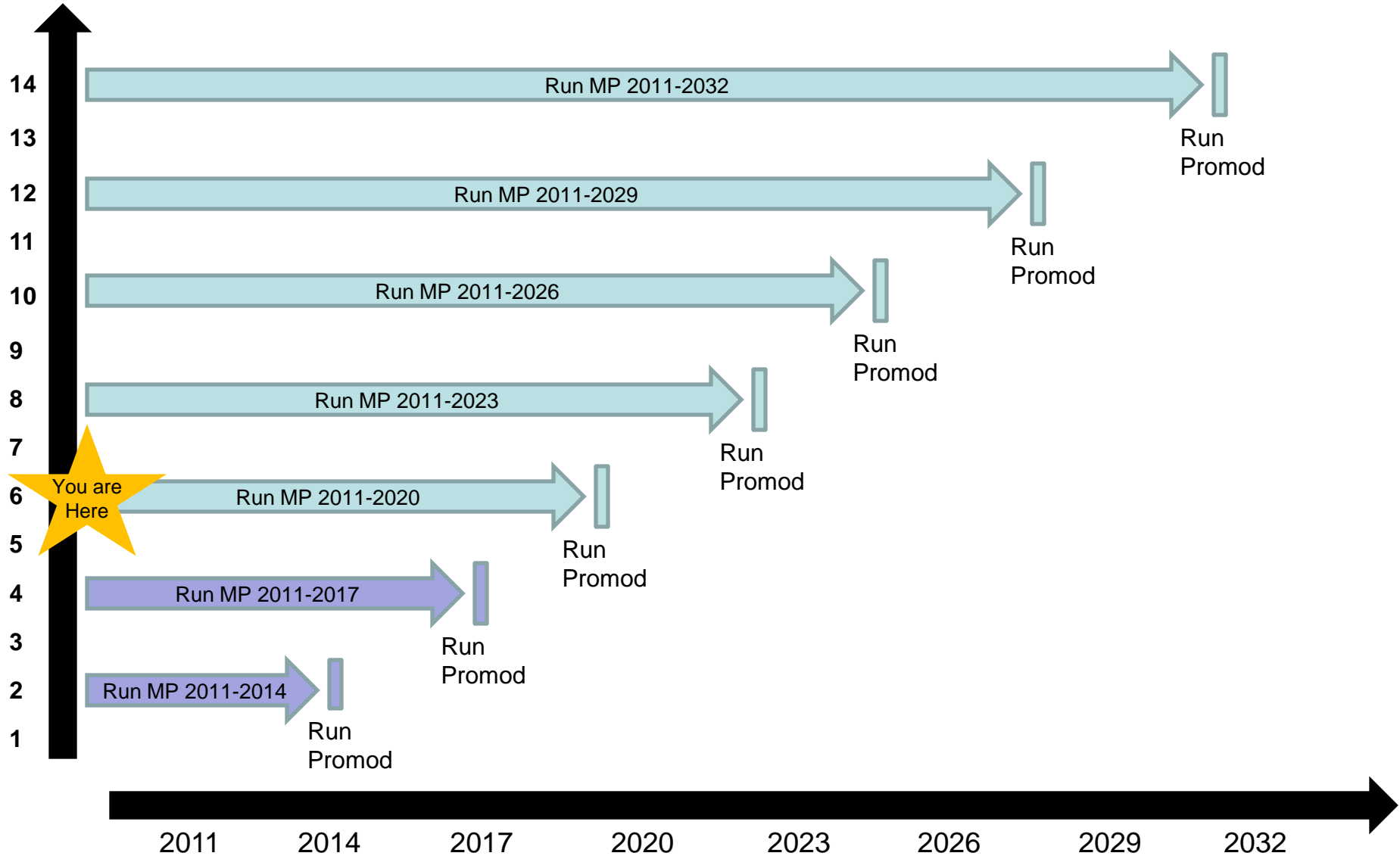


# Run Promod: 2020

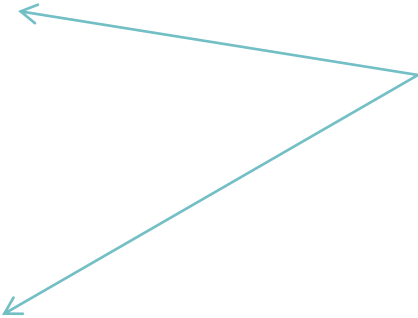
- **Final Expansion Plan for 2017 resulted in 13 ACT units built**
- **Run Promod at 2020 with 1 wind unit**
  - Results of wind unit run
    - Revenue: \$59.74 million
      - \$67.81/MWh
    - Needed :\$89.84 million
      - \$101.98/MWh at \$2,696/kW
    - Difference: **-\$30.1 million**

If PTC were included:  
PTC: \$22.84 million;  
\$25.24/MWh

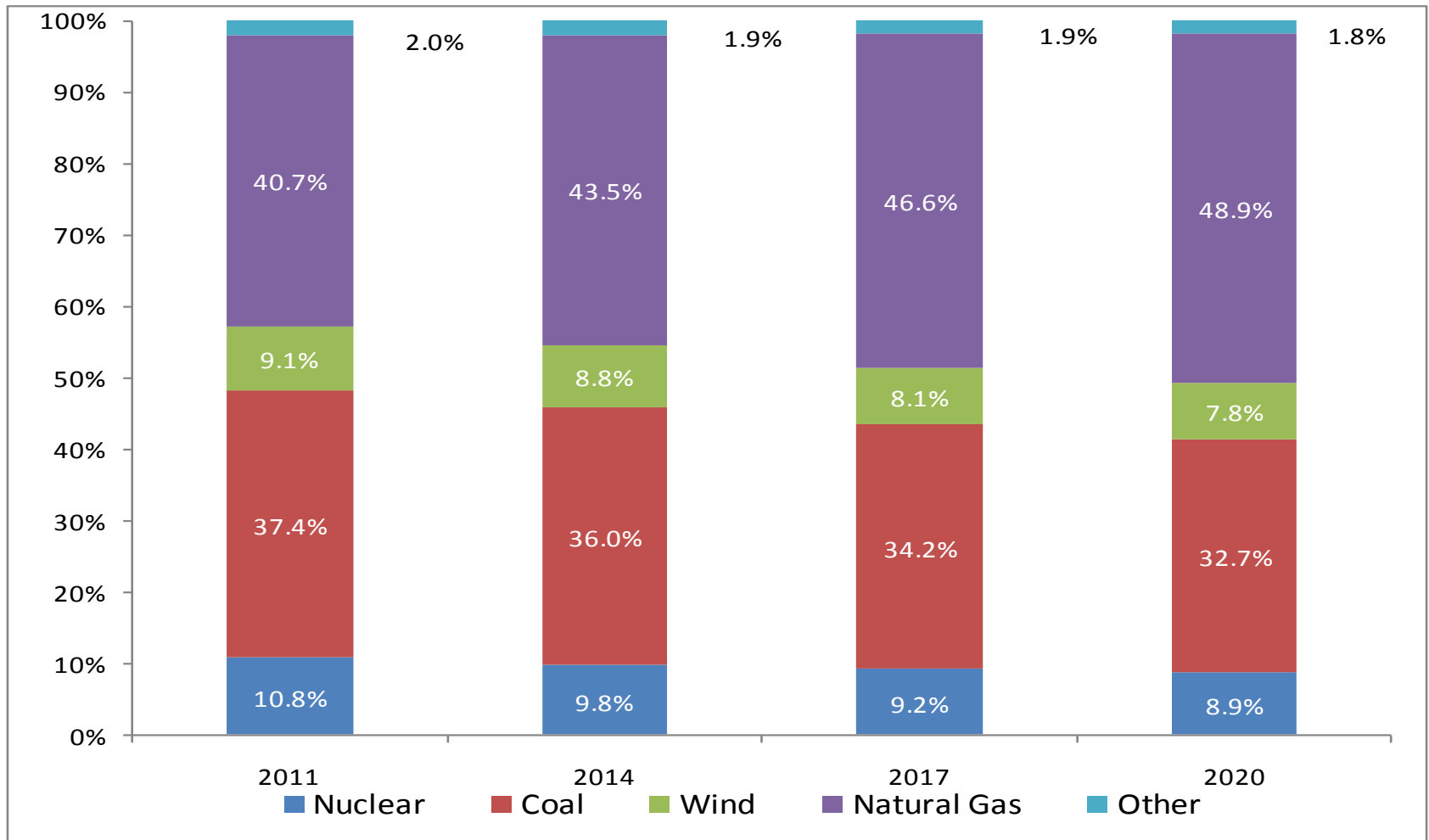
# Process Overview



# MarketPower Expansion Build: 2020

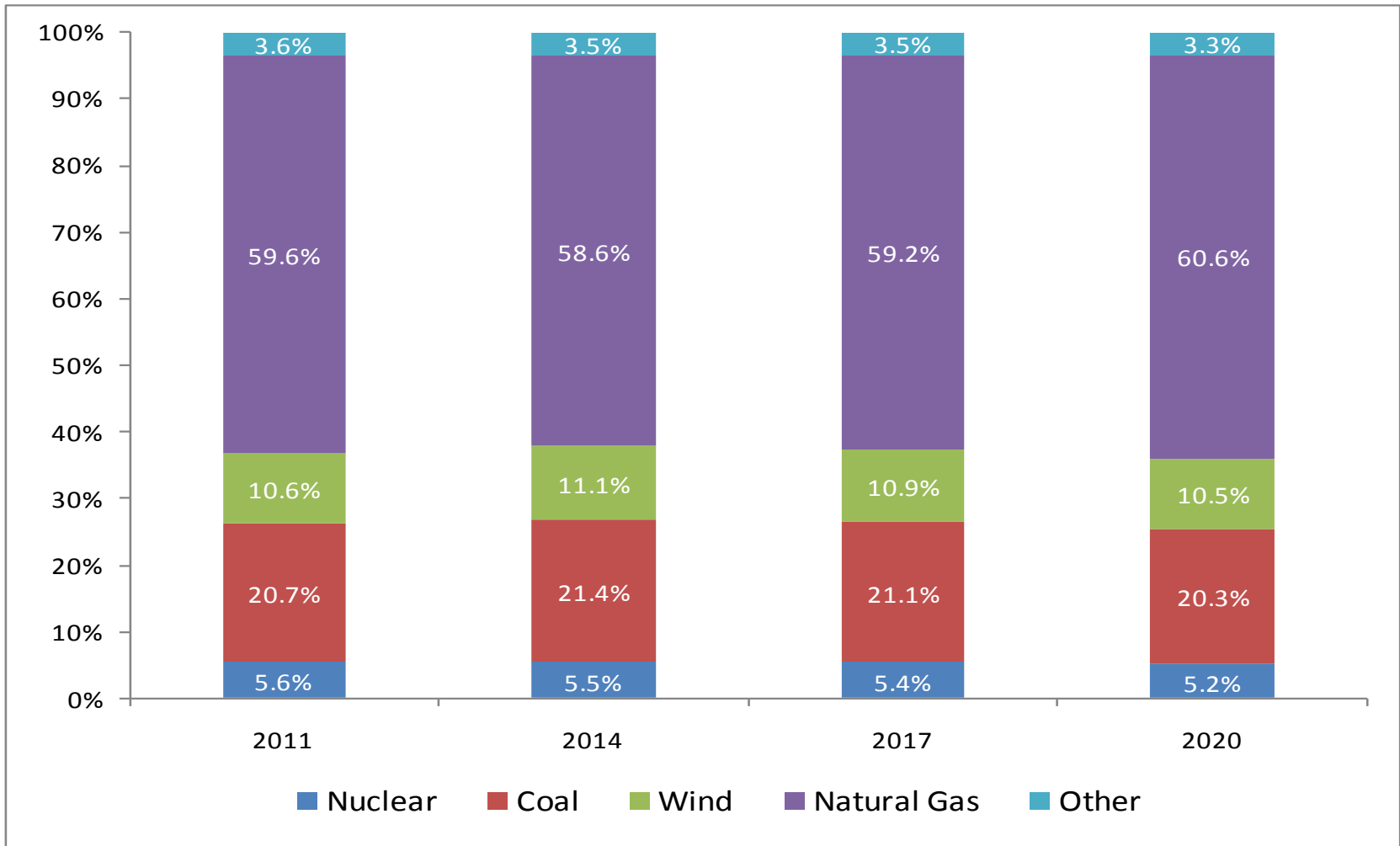
- **MarketPower initially built 27 ACT and 5 ACC units**
    - Using Promod results, the average revenue by technology did not meet the financial criteria
  - **Ran multiple tests of ACT and ACC units to determine a combination where all units were meeting the financial criteria**
  - **Final combination for 2020 was 5 ACCs and 15 ACTs**
    - Results 5 ACCs
      - Revenue: \$230.4 million
        - \$77.68/MWh
      - Needed: \$202.46 million
        - \$68.17/MWh
      - Difference: \$27.94 million
    - Results 15 ACTs
      - Revenue: \$26.73 million
        - \$280.64/MWh
      - Needed: \$15.93 million
        - \$263.55/MWh
      - Difference: \$10.8 million
- Incomplete iteration; Will likely justify additional units
- 

# 2011-2020: Annual Generation (GWh) by Fuel Type



\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2020: Annual Capacity (MW) by Fuel Type



\*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

# 2011-2020 Changes: Promod Output

Description	Units	2011	2014	2017	2020
CC Adds	MWs		0	0	2,000
CT Adds	MWs		0	1,300	1,500
Coal Adds	MWs		0	0	0
Nuclear Adds	MWs		0	0	0
Wind Adds	MWs		0	0	0
Other Adds	MWs		0	0	0
Approximate Reserve Margin	%	18	11	7	6
Average LMP	\$/MWh	37.4	40.8	56.7	67.08
Henry Hub Price	\$/mmbtu	4.50	4.63	5.10	5.68
Average Market Heat Rate	mmbtu	8.31	8.81	11.1	11.8
% NG Gen	%	40.7	43.5	46.6	48.9
Scarcity Hours	HRS	0	0	28	46
Unserved Energy	GWhs	0	0	37.9	62.8

- In 2020, we see scarcity hours where the LMPs hit \$3,000/MWh.

- Unserved energy results from the decreasing reserve margin.

- Current modeling is not capturing all scarcity pricing and A/S revenues.

## Next Steps

- **Final Expansion Plan through 2020 has resulted in 5 ACC and 28 ACT units built**
  - Need to resolve market revenue modeling issues
- **These results will obviously lead to “how would the results change if...” questions**
  - Will run several sensitivities by next month
  - What are the appropriate sensitivities?
- **Potential sensitivities to model inputs driving the current results:**
  - Capital cost projections
  - Natural gas forecast
  - What else???