Process Overview
and
DRAFT Results Discussion

April 2011

Agenda

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

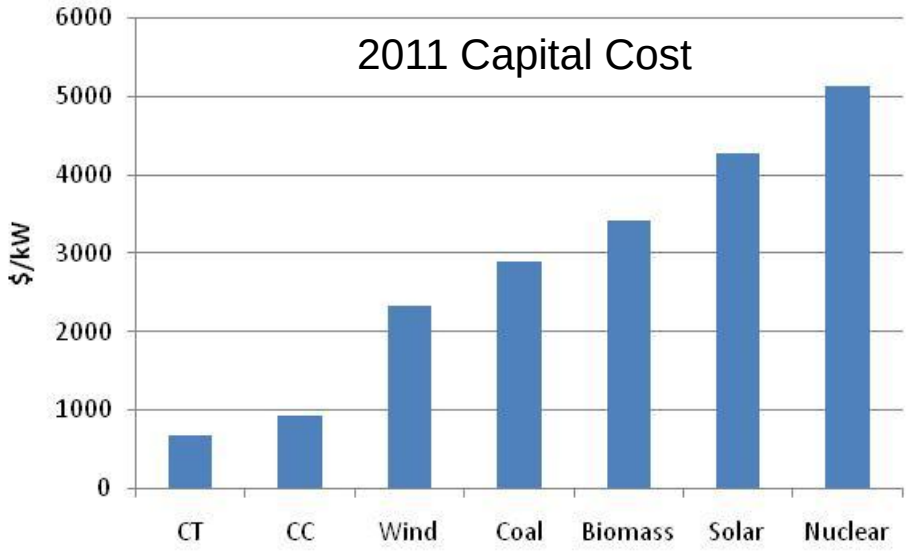
Software Descriptions

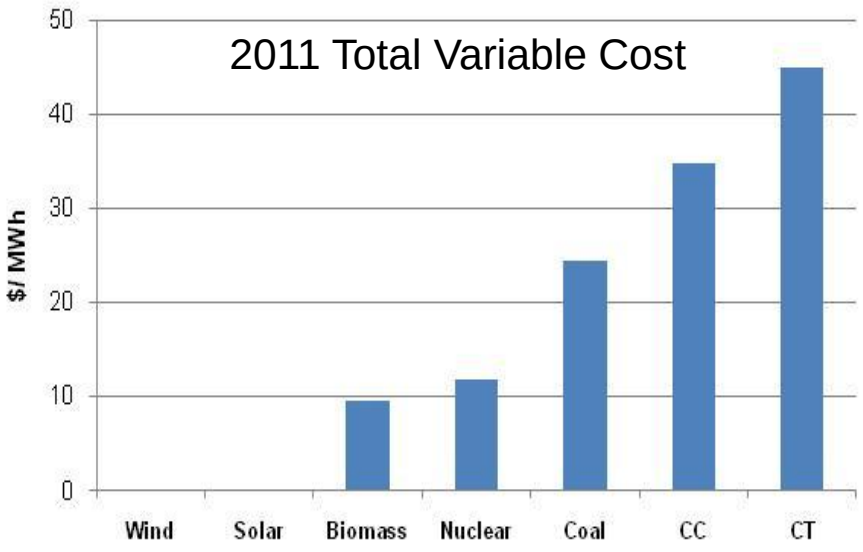
- **MarketPower**
  - Provides the ability to simulate longer term studies of energy and capacity prices along with market based expansion plans

- **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

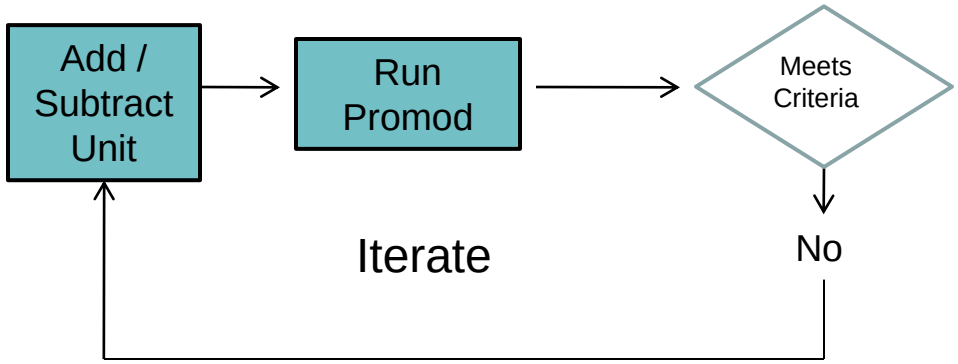
Generic Database

- **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



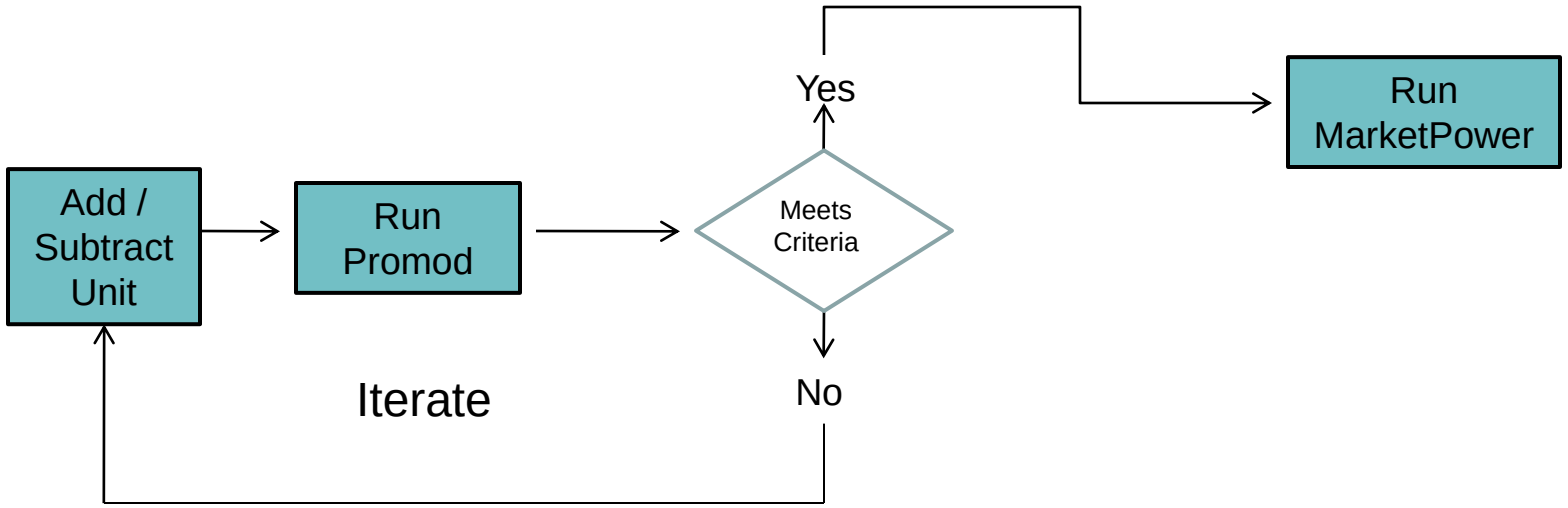


Flowchart of Process



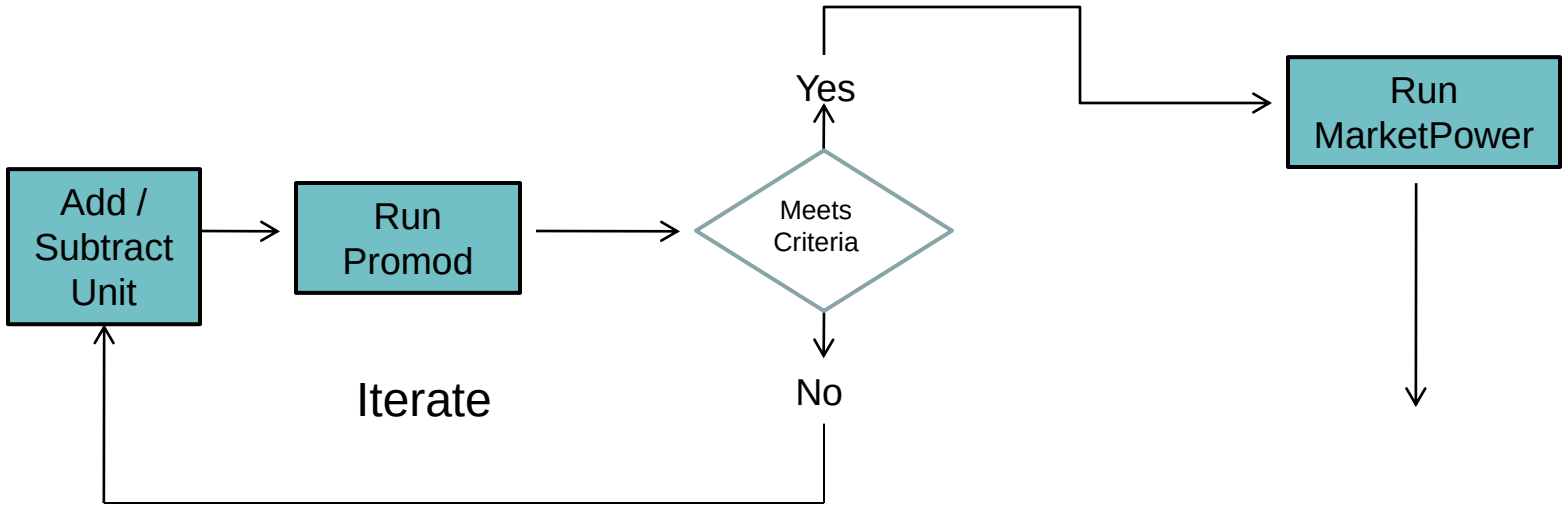
Begin by running Promod with 1 wind unit. Evaluate financial criteria of wind unit. Adjust number of wind units depending on financial viability.

Flowchart of Process



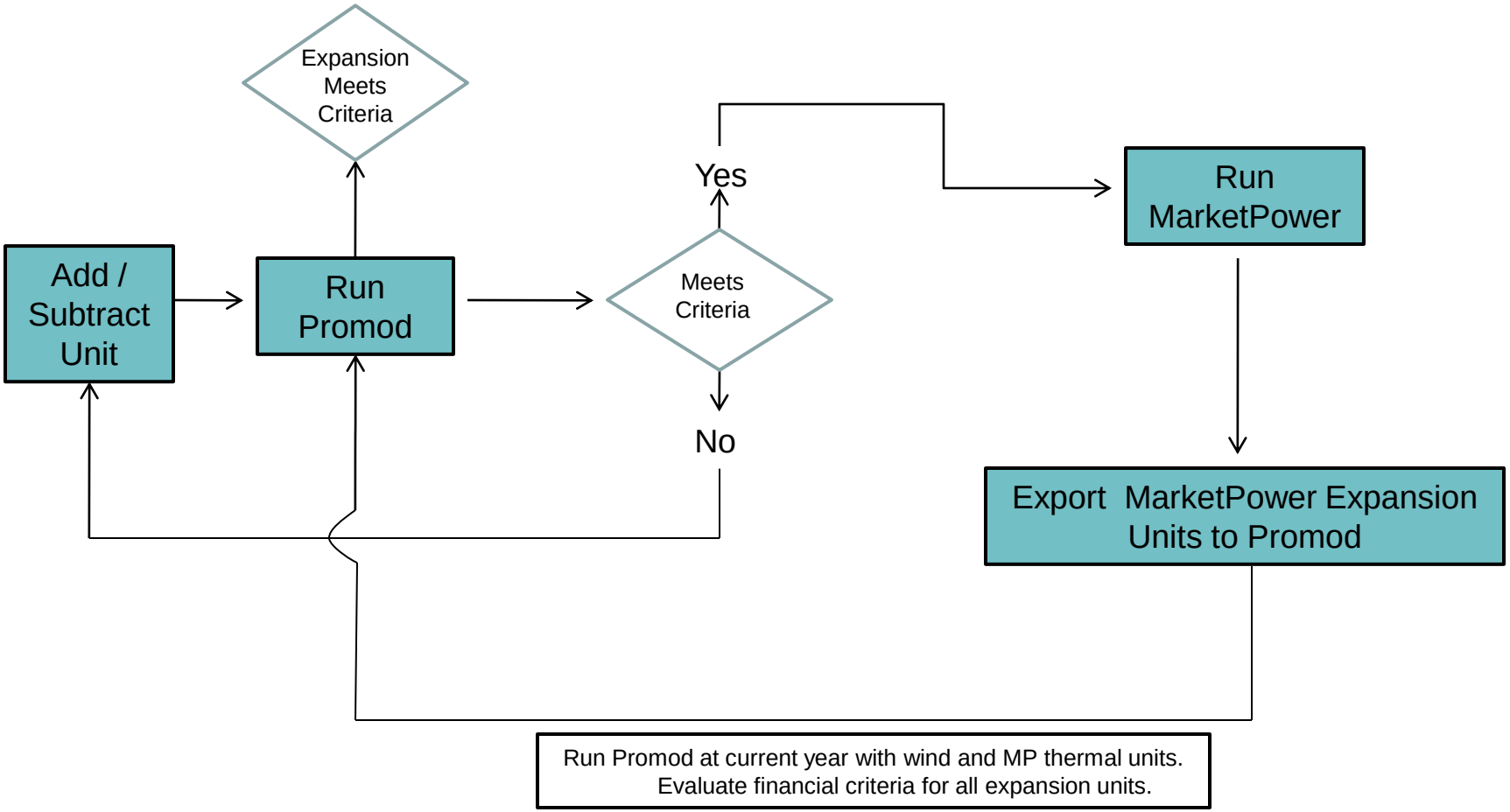
Wind units that pass financial criteria remain in Promod. Export scenario with wind expansion units to MarketPower(MP).

Flowchart of Process



Run MarketPower from current year to end of study.

Flowchart of Process



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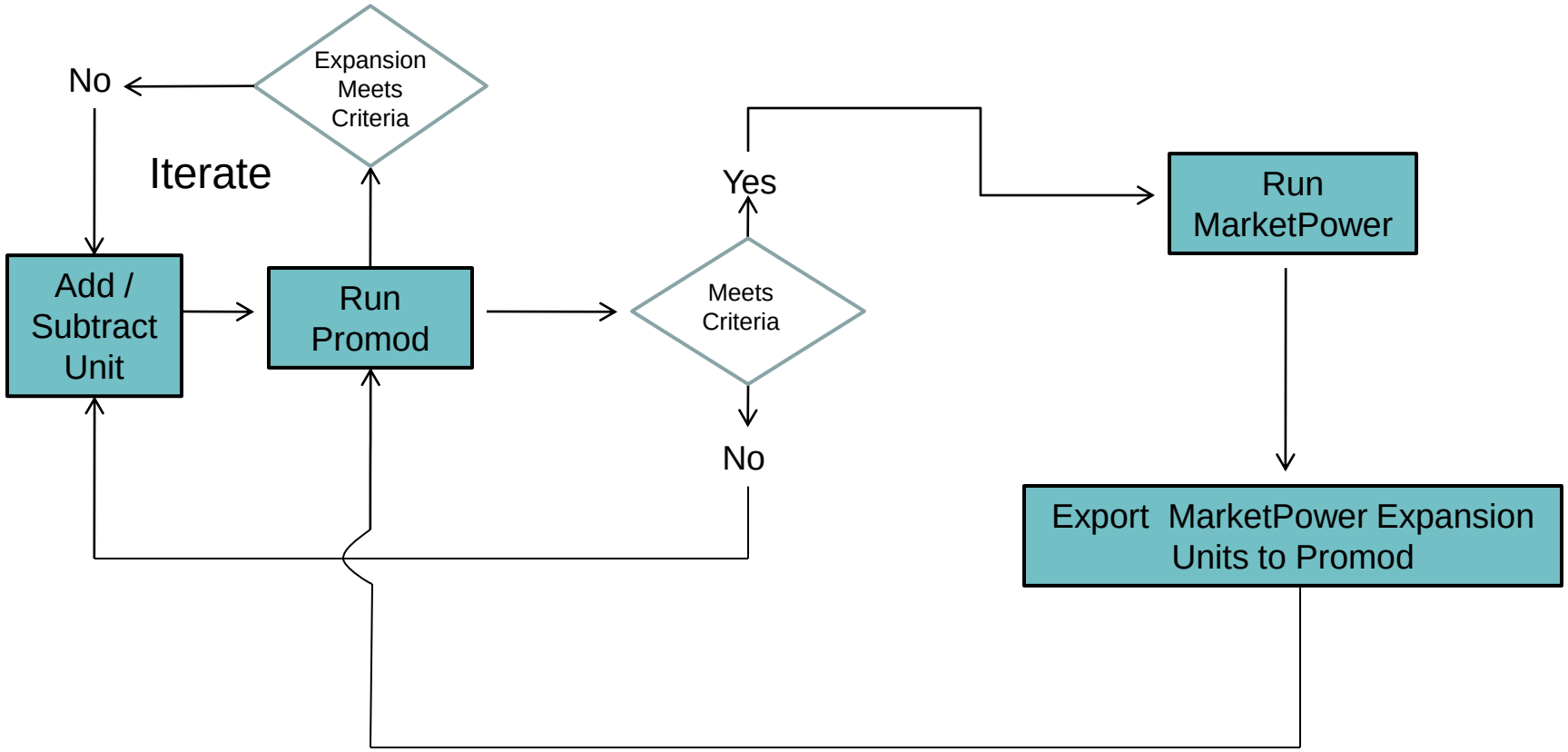
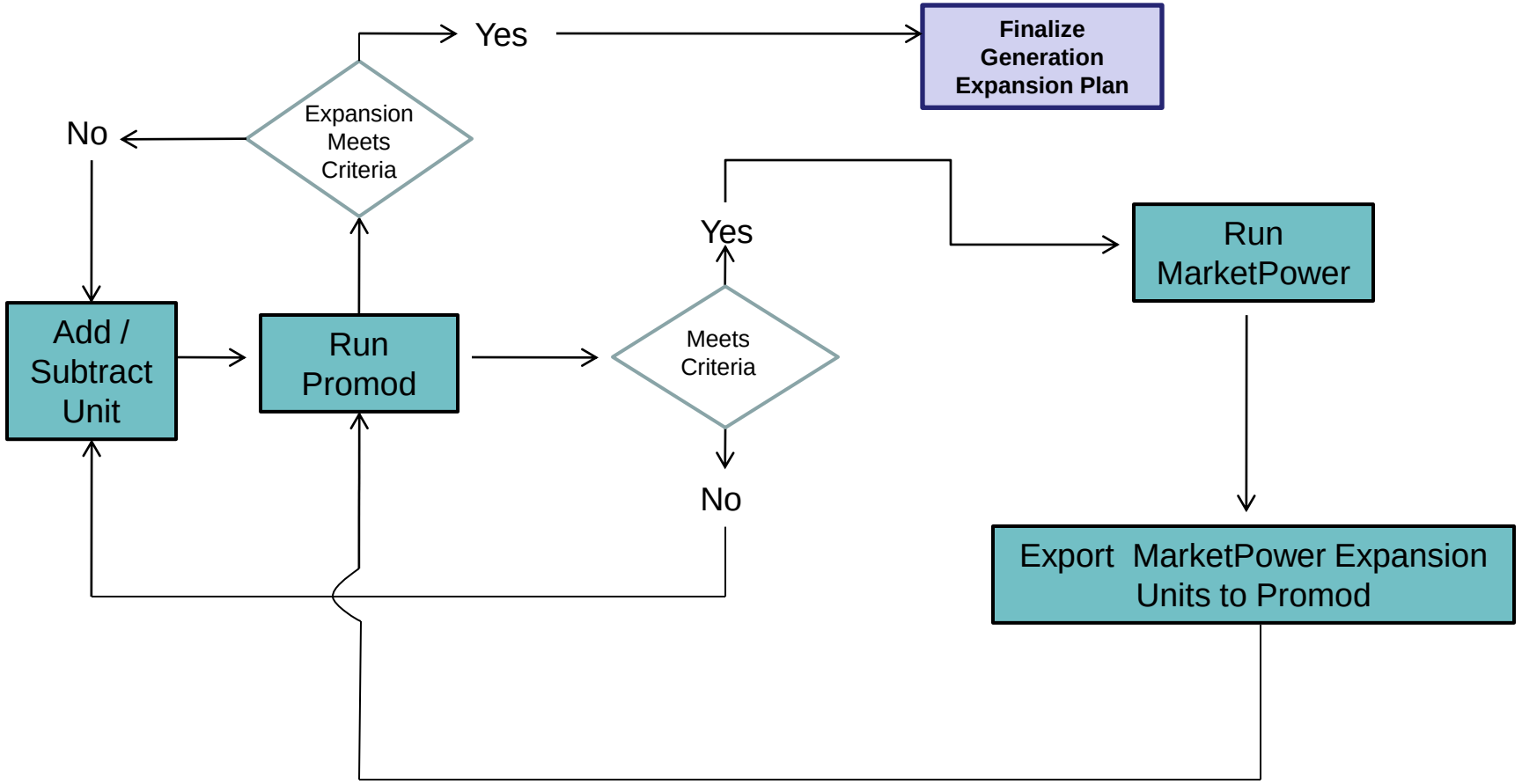


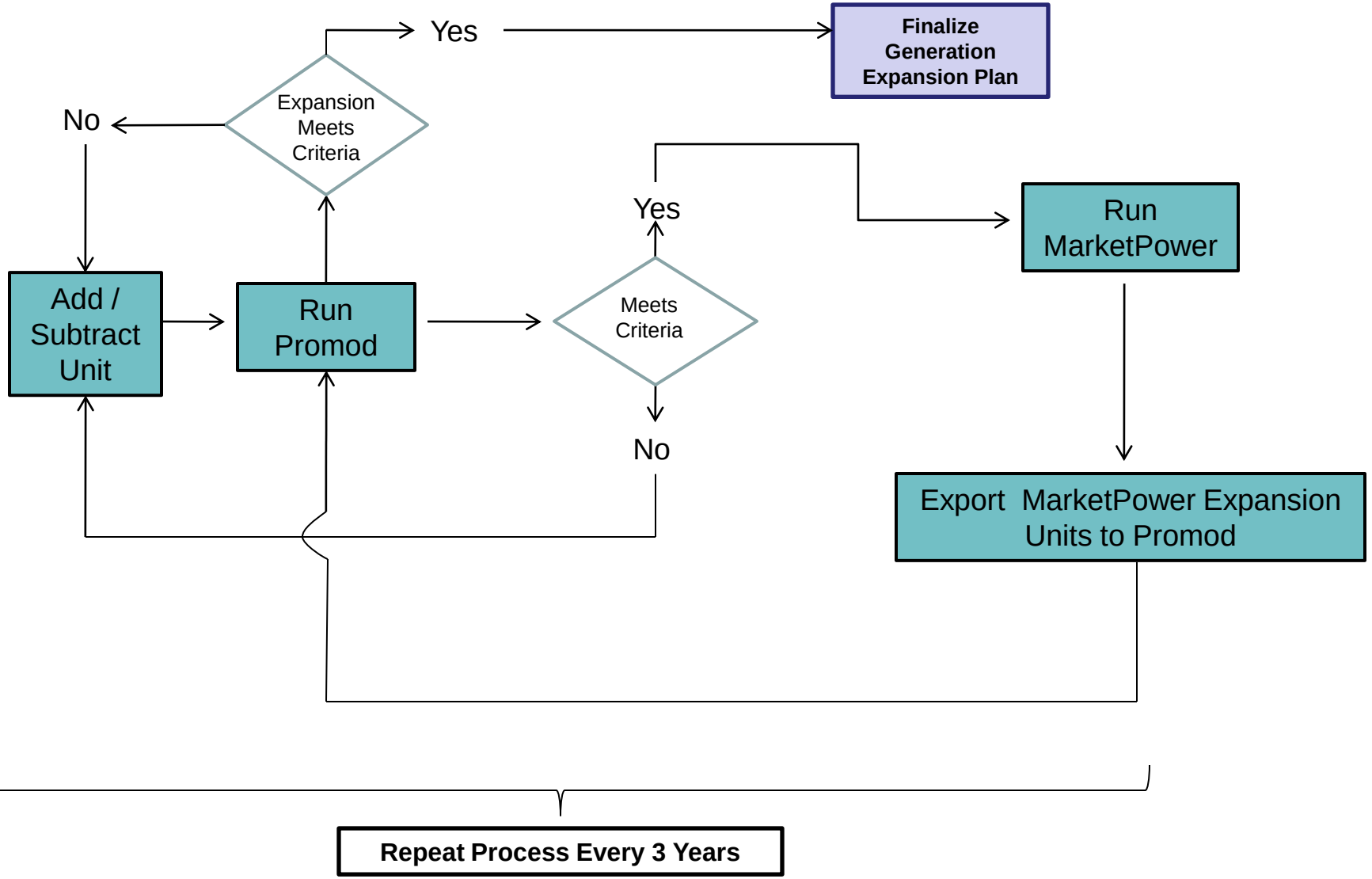
Continue iterations until the next additional unit does not meet the financial criteria.

Flowchart of Process

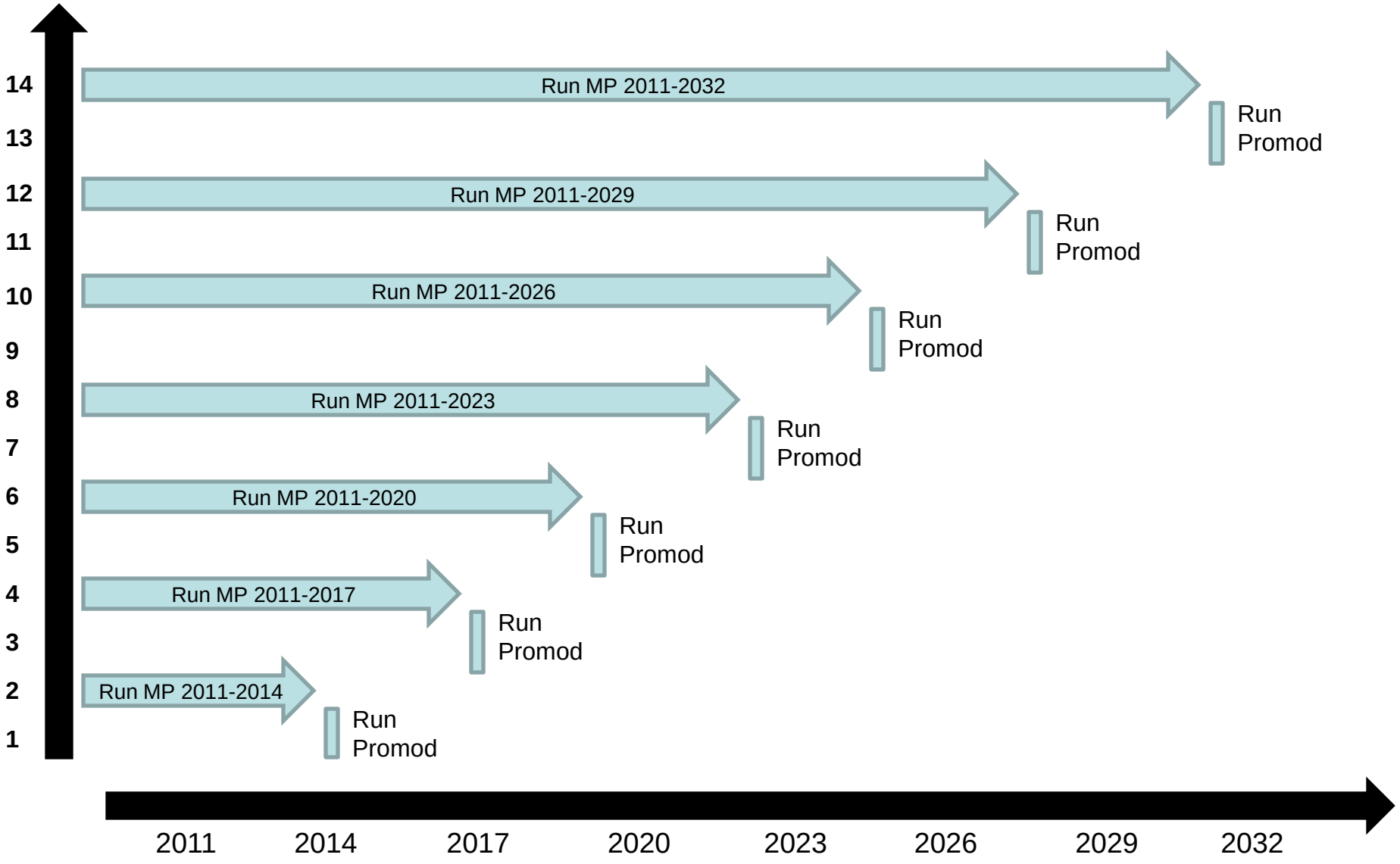


When all additional expansion units meet the financial criteria, move on to the next year.

Flowchart of Process



Process Overview



Financial Criteria

- **Start with input assumptions (from Generic Database Characteristics spreadsheet)**
  - Capital costs
  - O&M
  - Fuel price
  - Heat rate
  - Financing structure
    - Debt/equity (55/45%)
    - Cost of debt (8%)
    - Cost of equity (15%)
    - Tax Rate (35%)
    - Calculated WACC (9.61%)
- **Model uses financial accounting metrics to calculate net cash flows**
  - Revenues
  - Operating Costs
  - EBITDA
  - Depreciation (straight-line)
  - Taxes
  - Etc.

Financial Criteria contd.

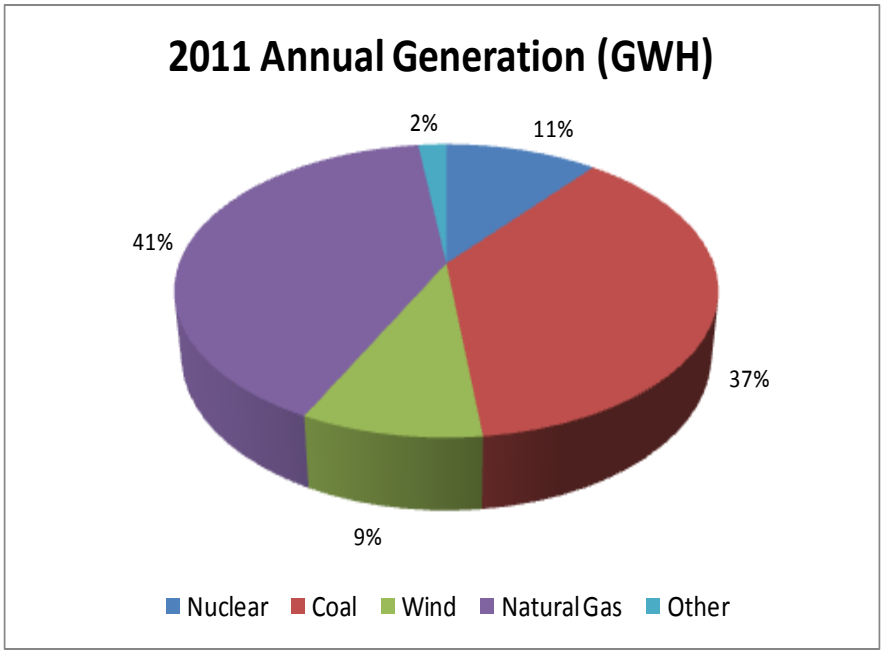
- **Revenue for year 1 results from Promod run**
  - Promod captures hourly LMP's against hourly generation of the unit
  - Revenue from 1 year Promod run is then escalated for future years by respective change in natural gas price
    - Assumption: natural gas remains the marginal fuel
    - This is to develop a forecasted stream of revenues over the life of the project
      - Annual Revenue: natural gas price x market heat rate x generation of unit

- **Determined a Net Present Value (NPV) of the project from the net cash flows**

- **In addition, we calculated the profitability of the project by taking the NPV and dividing it by the initial equity invested**
  - The profitability of the project had to meet a 10% threshold

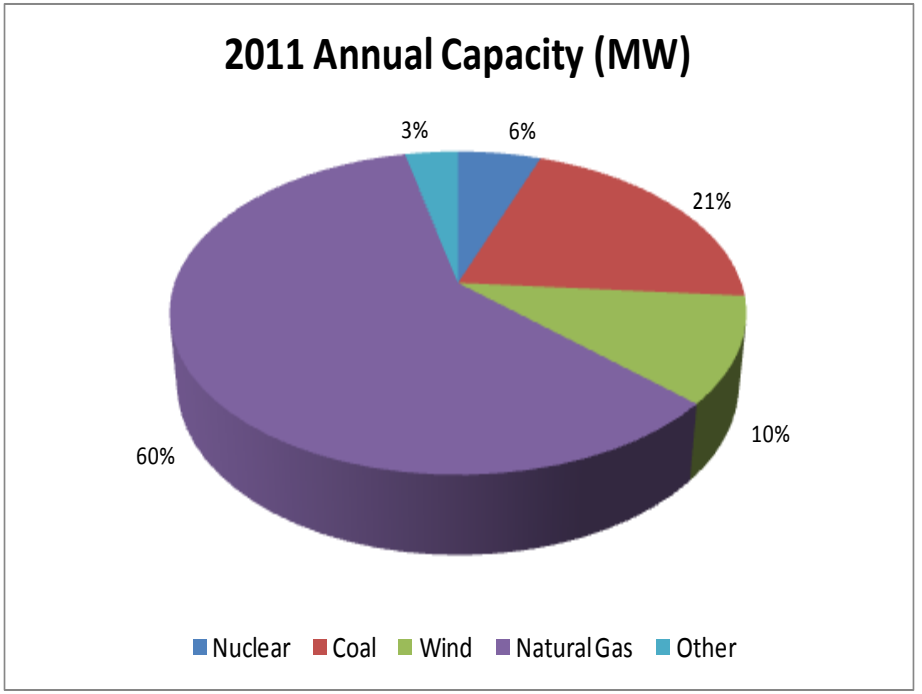
Preliminary Expansion Results

2011 BAU Starting Point



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

BAU Starting Point: 2011

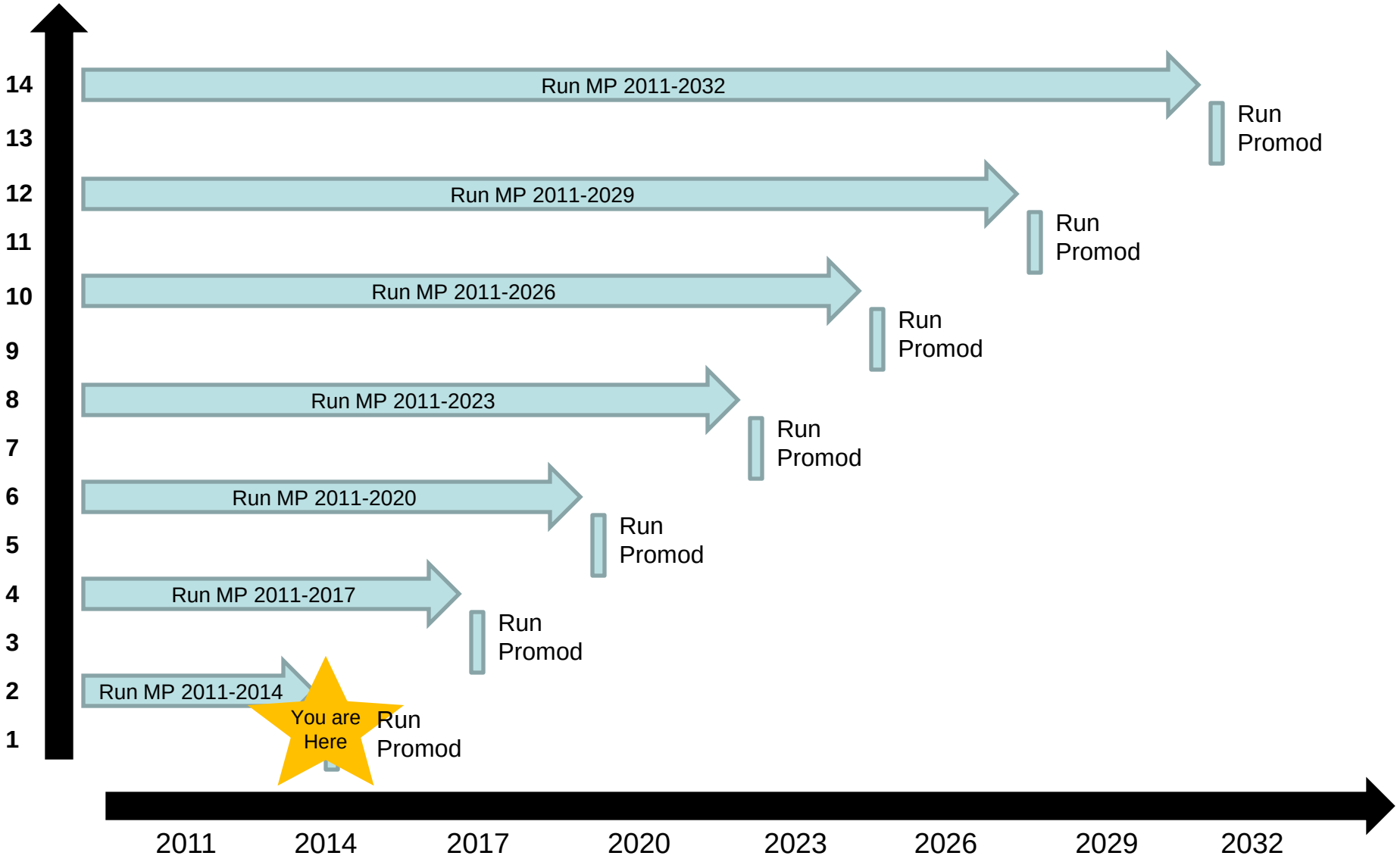
Description	Units	2011
CC Adds	MWs	
CT Adds	MWs	
Coal Adds	MWs	
Nuclear Adds	MWs	
Wind Adds	MWs	
Other Adds	MWs	
Approximate Reserve Margin	%	18
Average LMP	$/MWh	37.4
Henry Hub Price	$/mmbtu	4.50
Average Market Heat Rate	mmbtu	8.31
% NG Gen	%	40.7
Scarcity Hours	HRS	0
Unserved Energy	GWhs	0

- **Initial Model Considerations**
  - -No transmission constraints
  - -Average weather year
  - -Marginal cost bidding only
  - -No Ancillary Services Revenues
    - -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



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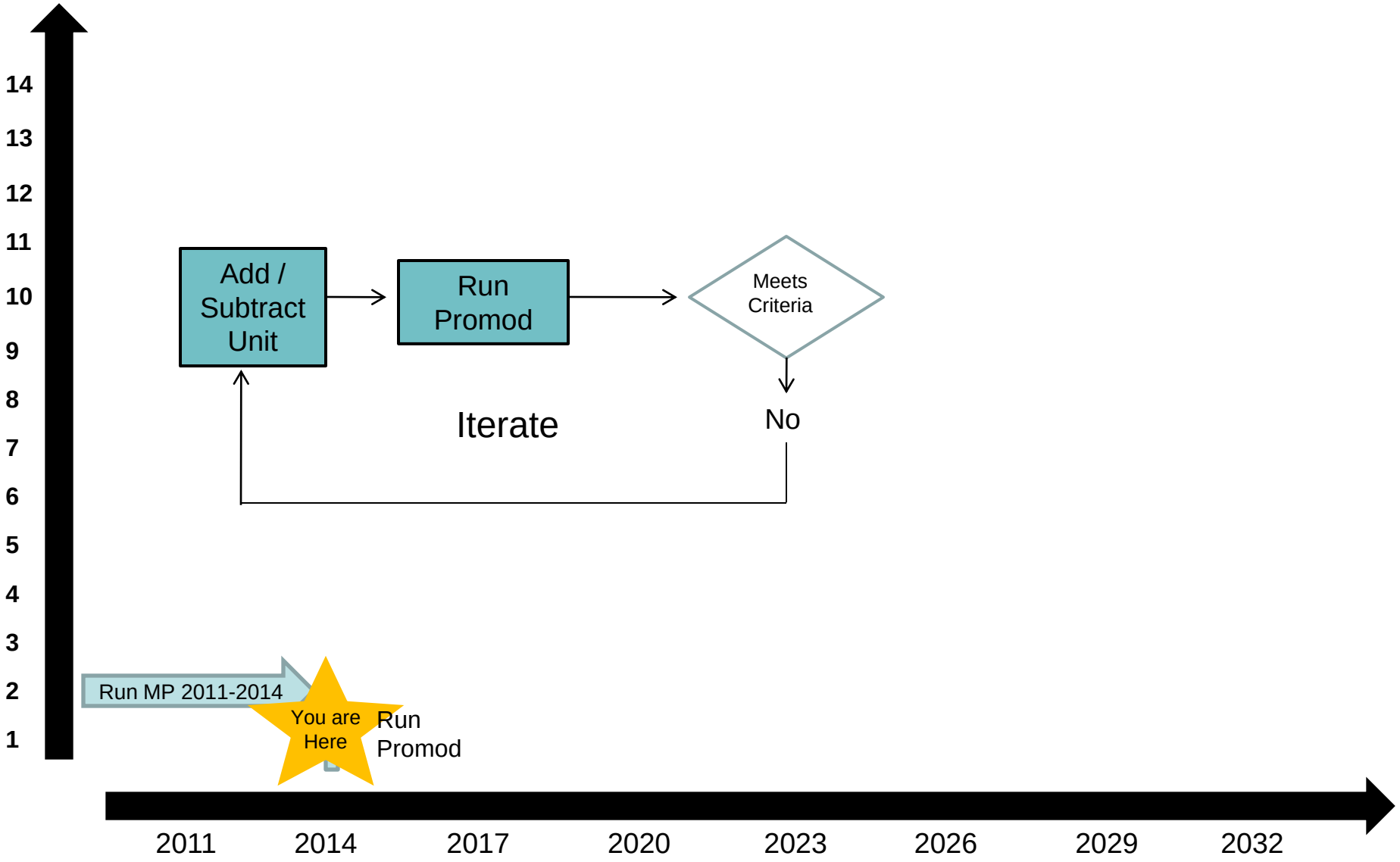


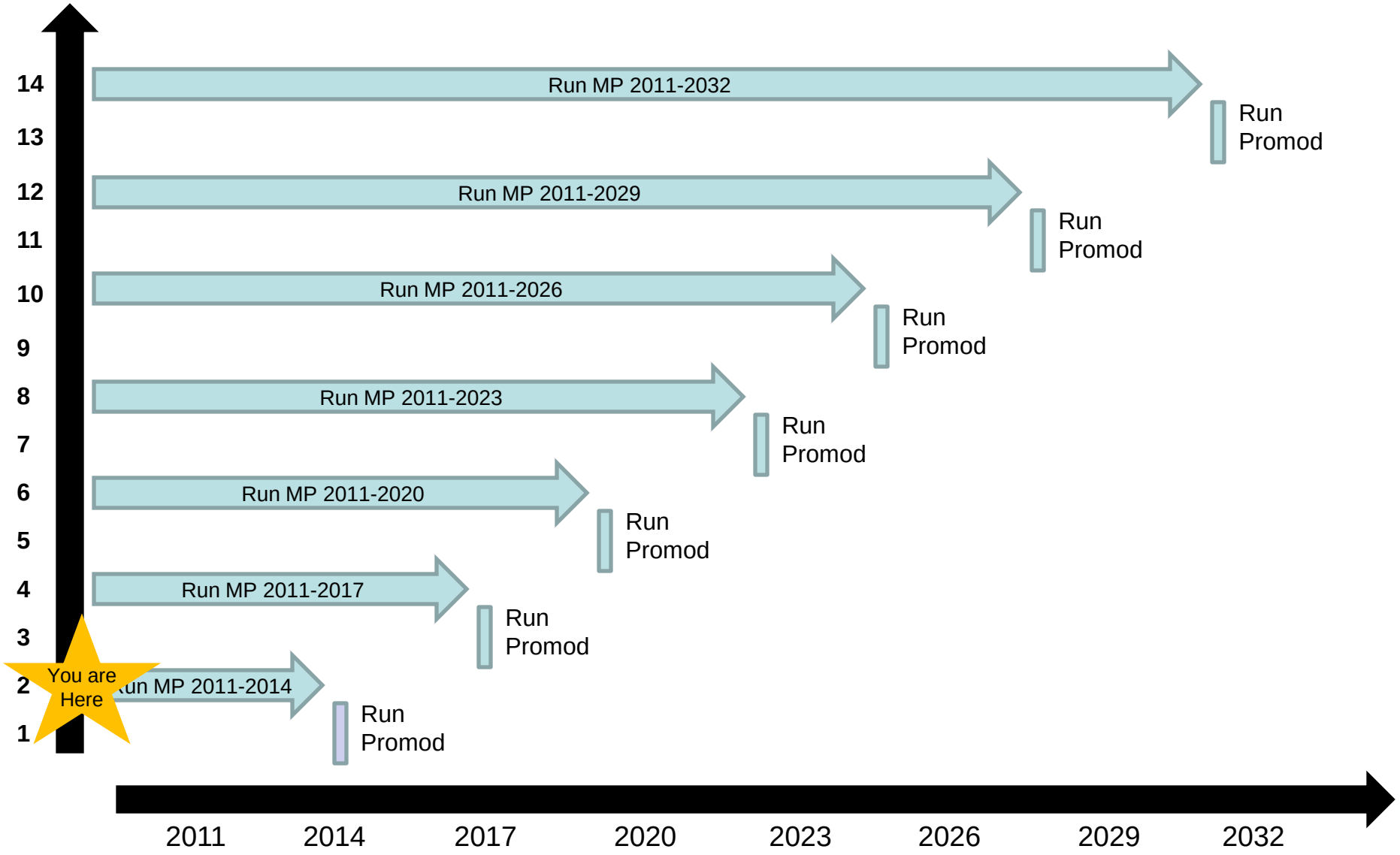
Promod Wind Expansion Unit Results: 2014

- **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
-$47.9	Difference

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

Process Overview



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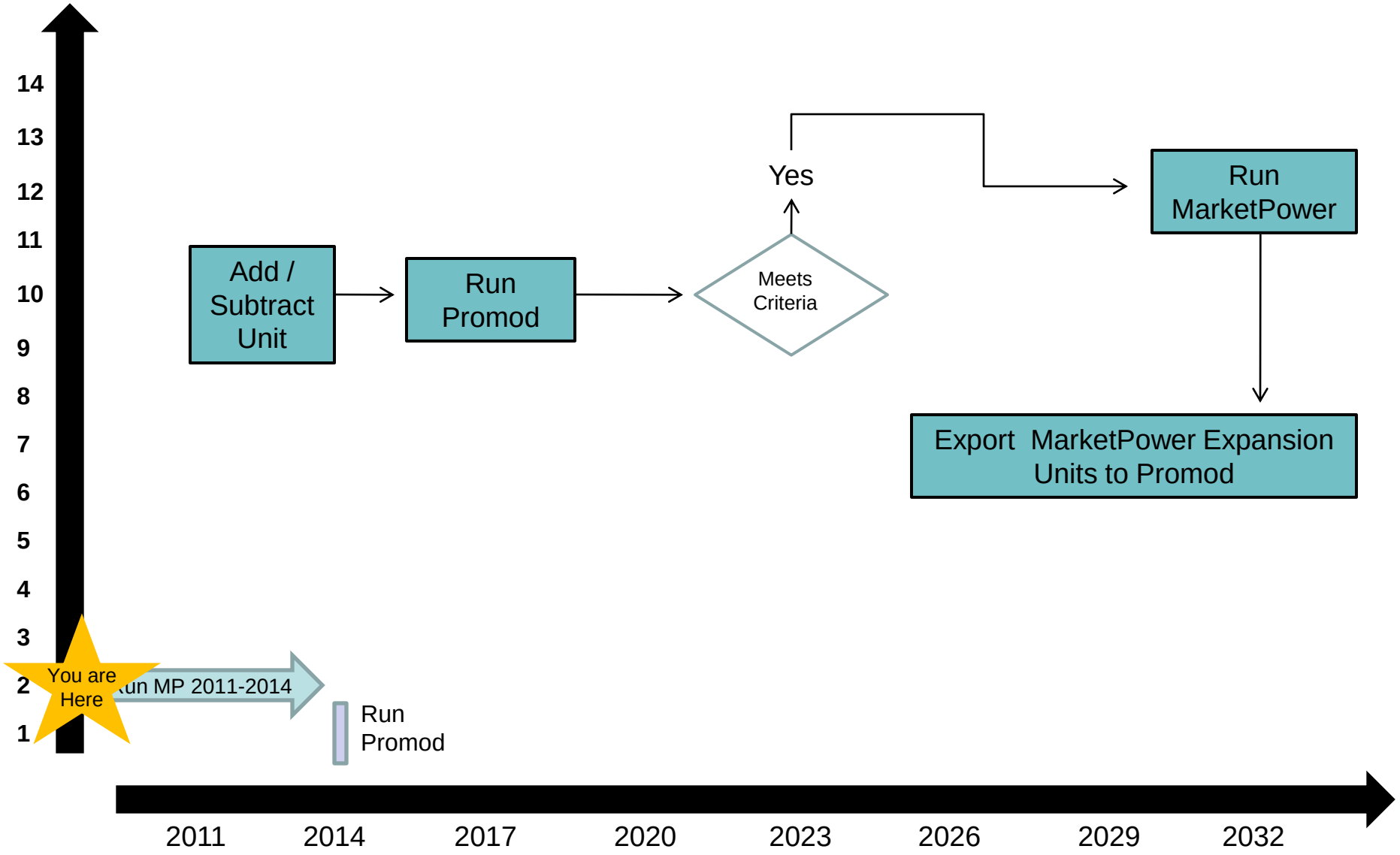
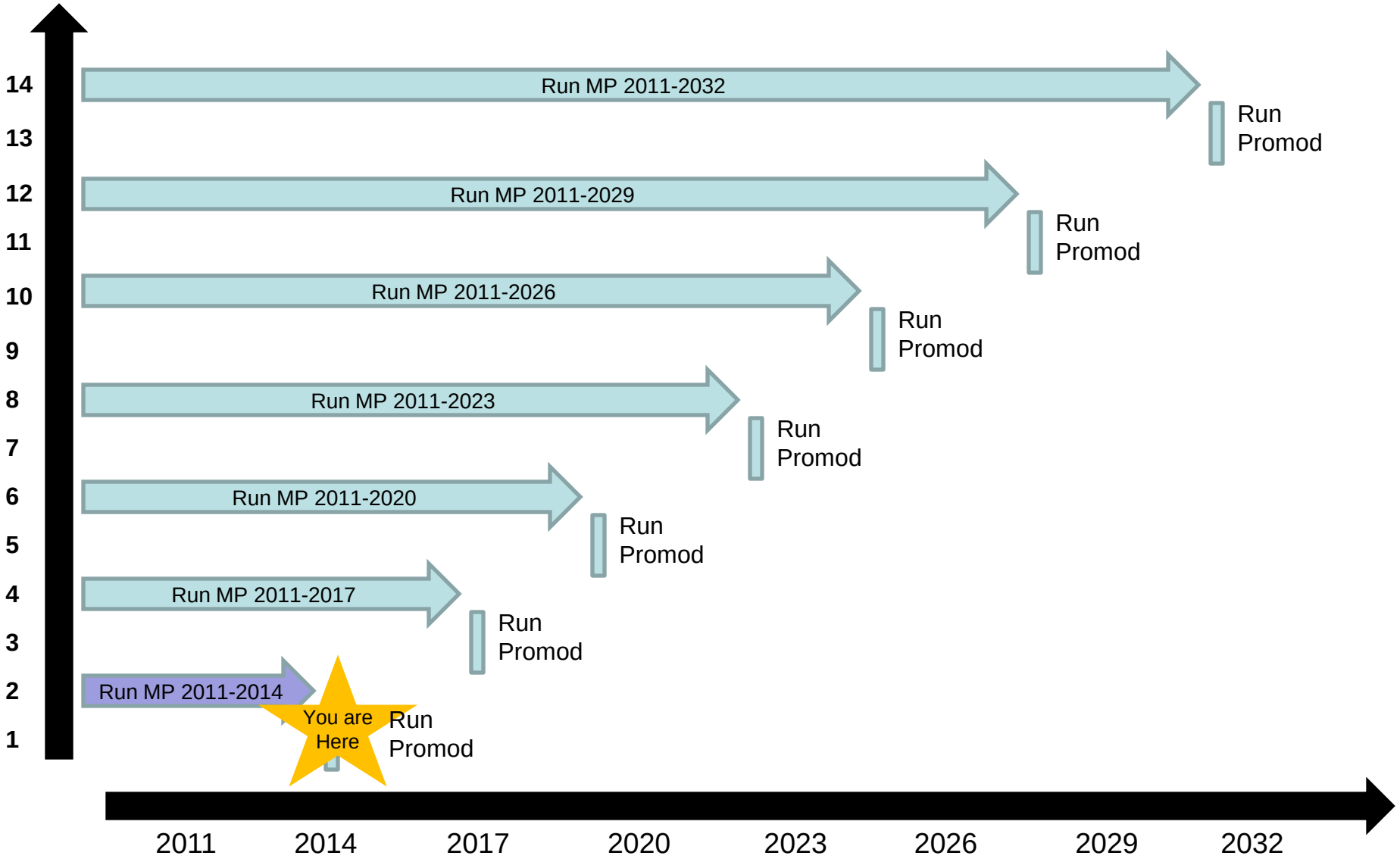


MarketPower : 2014

- **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



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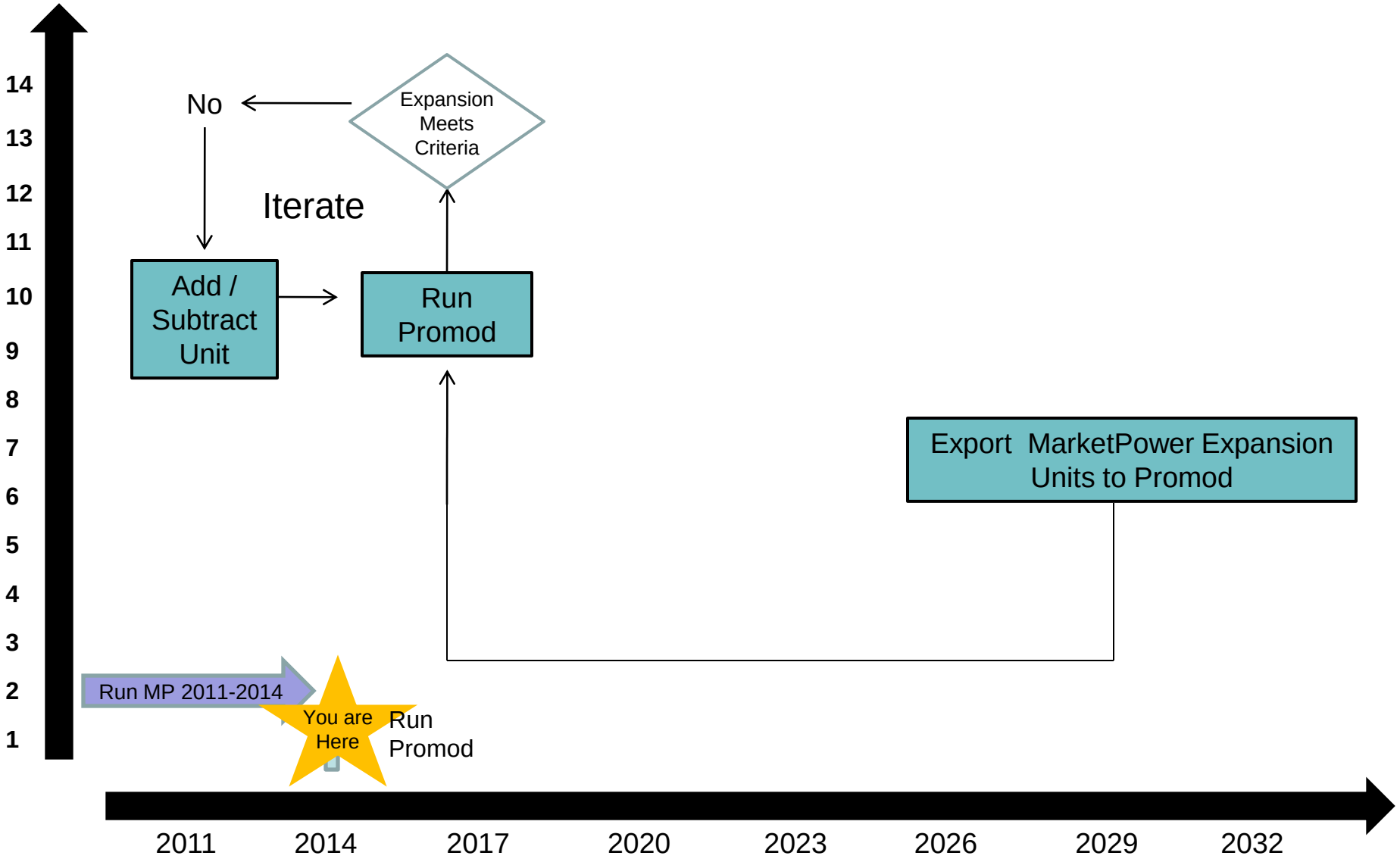

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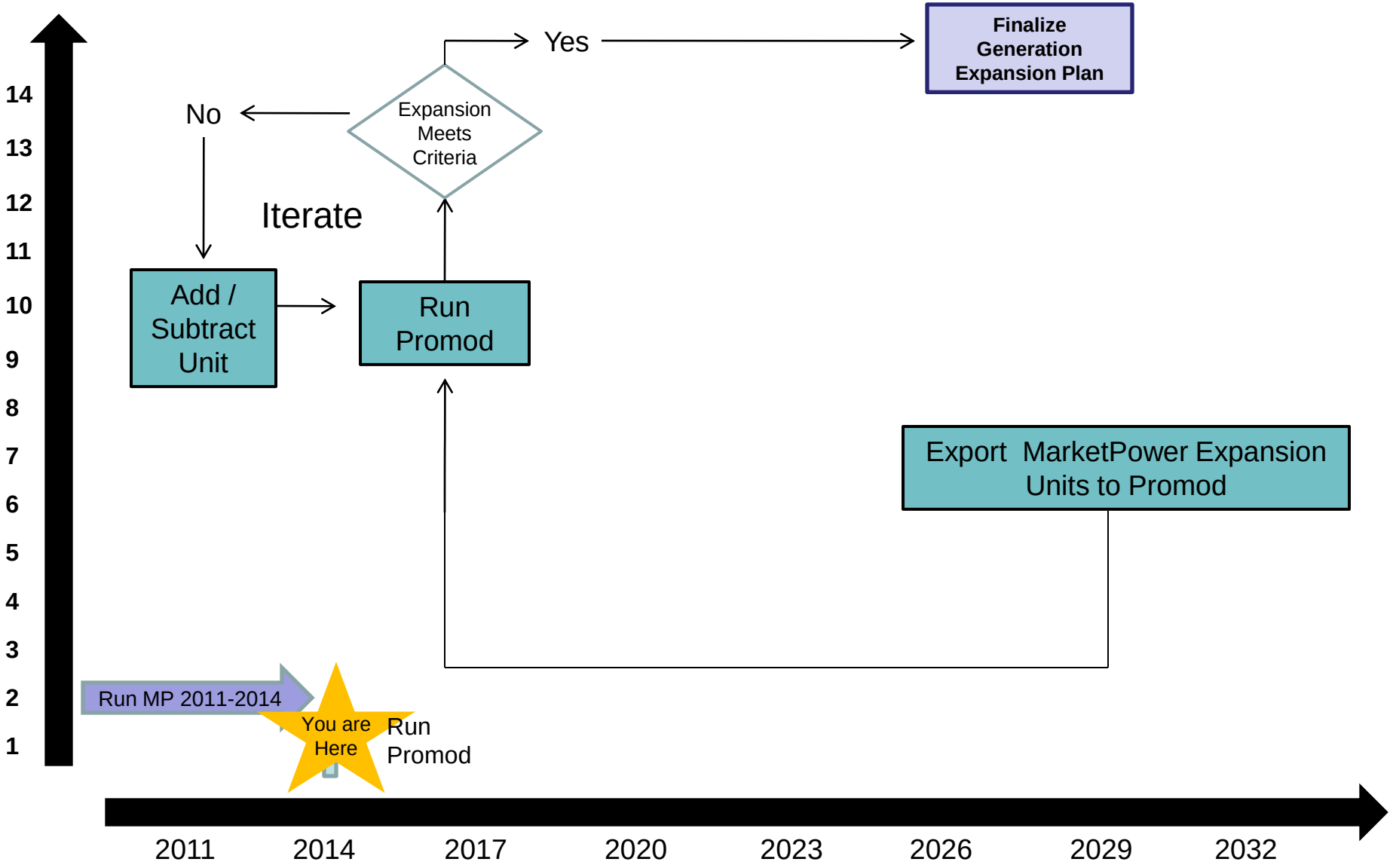


MarketPower Expansion Build: 2014

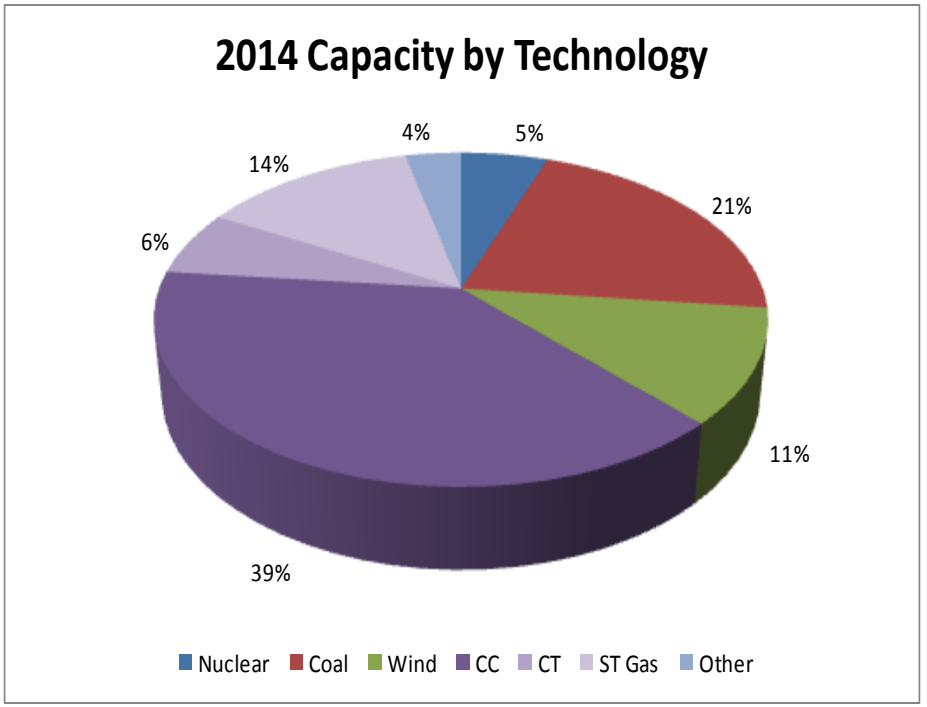
- **MP initially built 15 Advanced Combustion Turbine (ACT) Units**
  - LMS100
  - 100 MW
  - $711/kW Capital Cost
  - $7.08/kW-yr Fixed O&M
  - $56.33/MWh Total Variable Cost
  - $4.63/mmbtu Natural Gas price
- **Operation Results from Promod (average across the 15 units):**
  - Generation: 51,410 MWh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

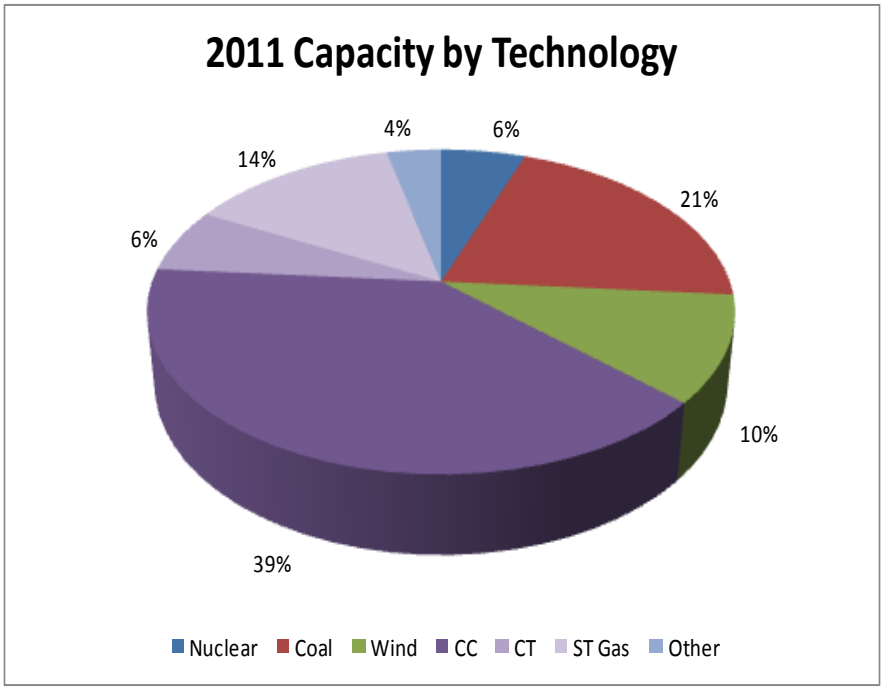
Promod Iterations: 2014

- **None of the 15 ACT units met the financial criteria**
- **Removed expansion units until the remaining units were economic**
- **Reduced number of units to 1 ACT and re-ran Promod at 2014**
- **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



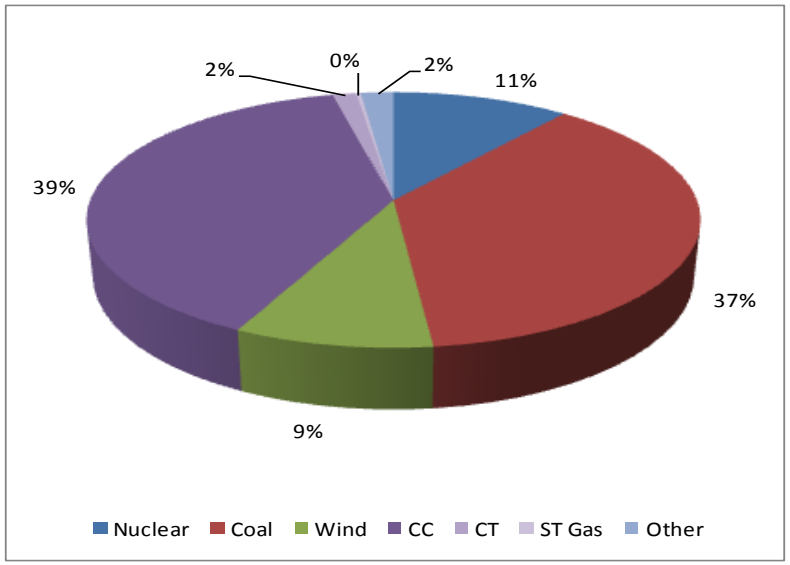


*Other: hydro, biomass, landfill gas, internal combustion, DC ties, and interruptibles

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

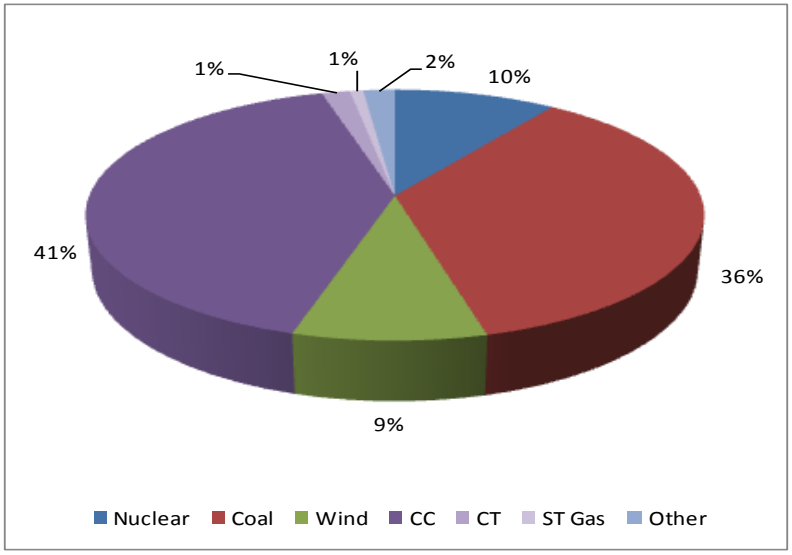
2011-2014 Changes : Annual Generation (GWh) by Technology

- 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



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



2011

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

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

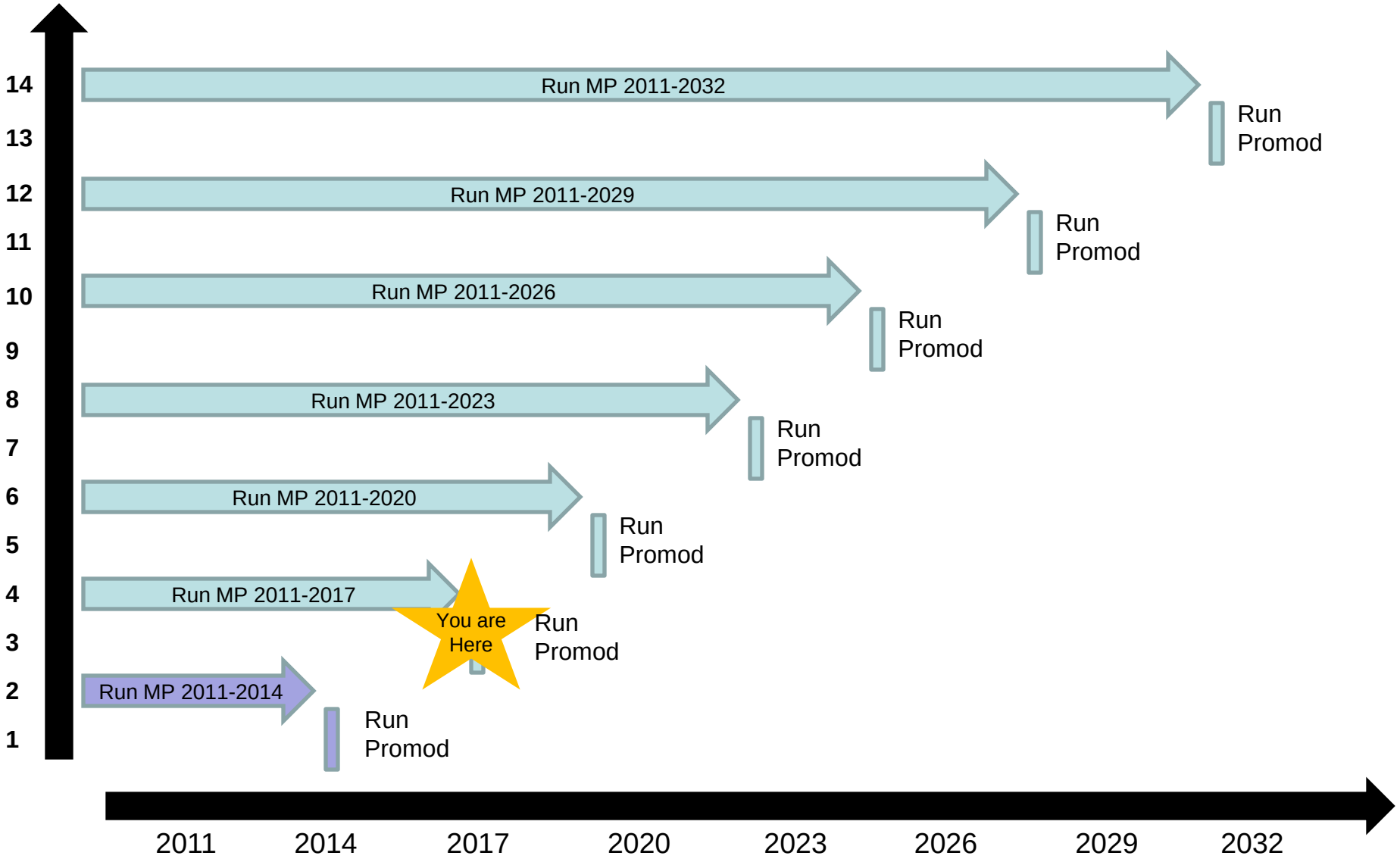
2011-2014 Changes: Promod Output

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

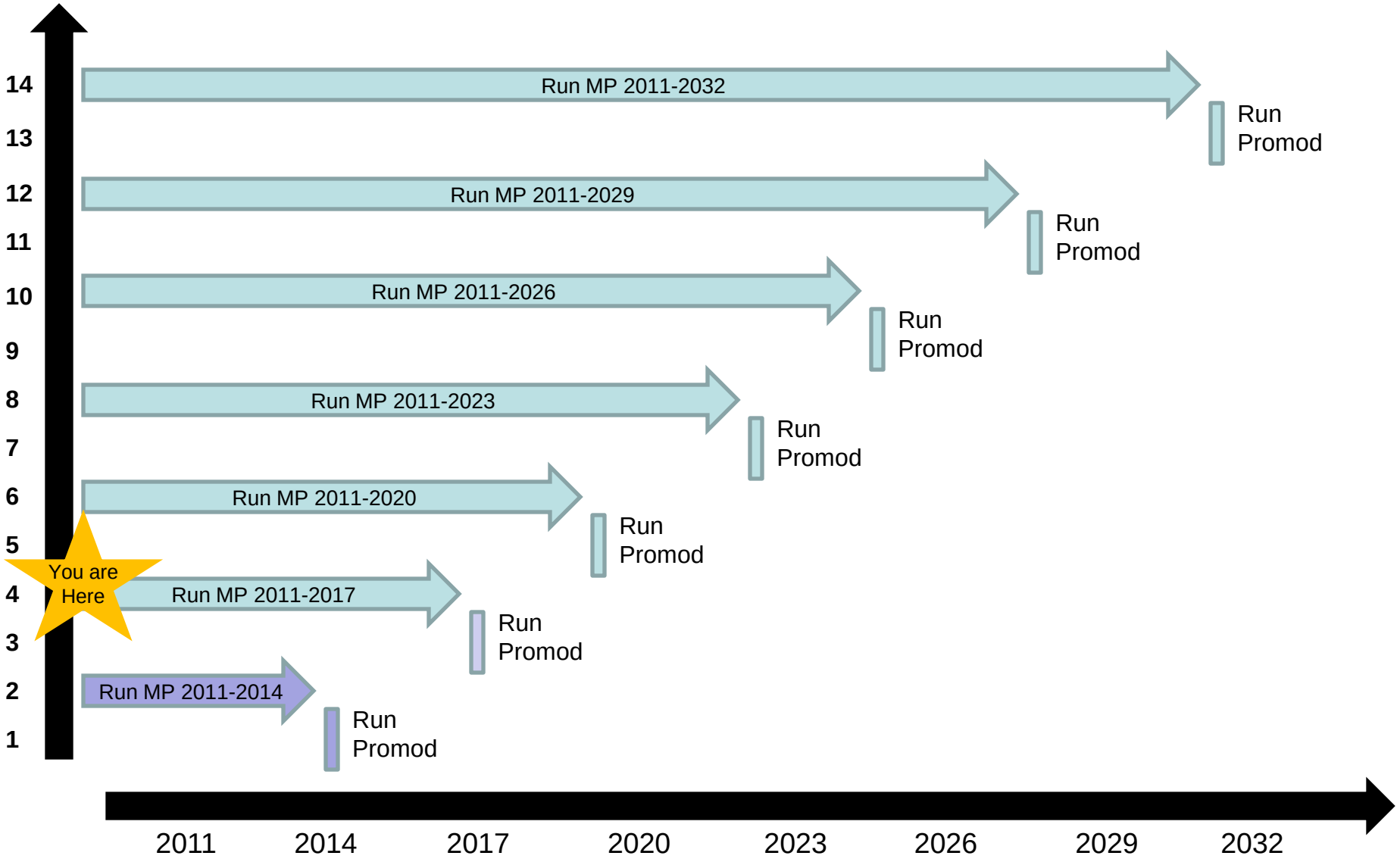


Promod Wind Expansion Results: 2017

- **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

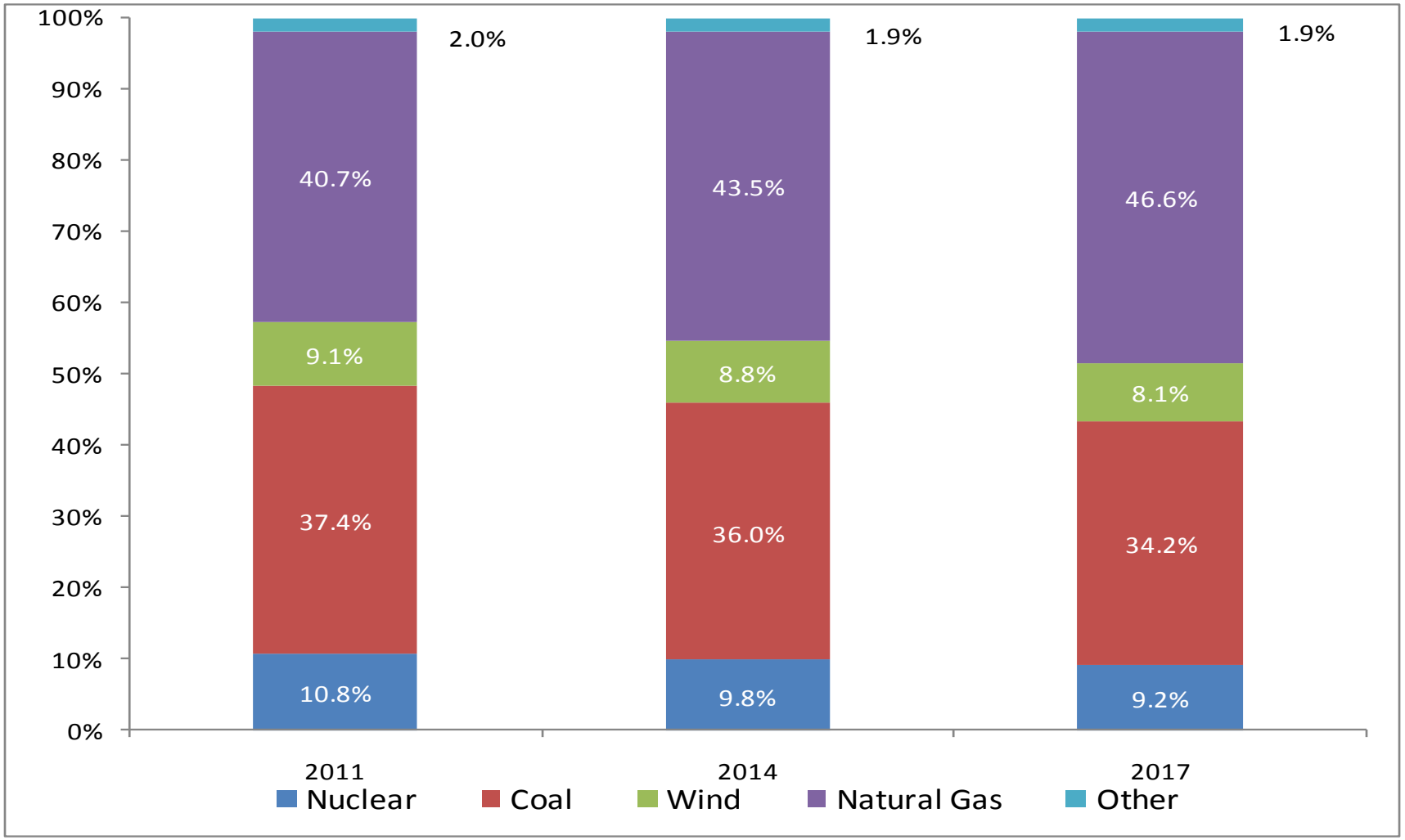
Process Overview



MarketPower Expansion Build: 2017

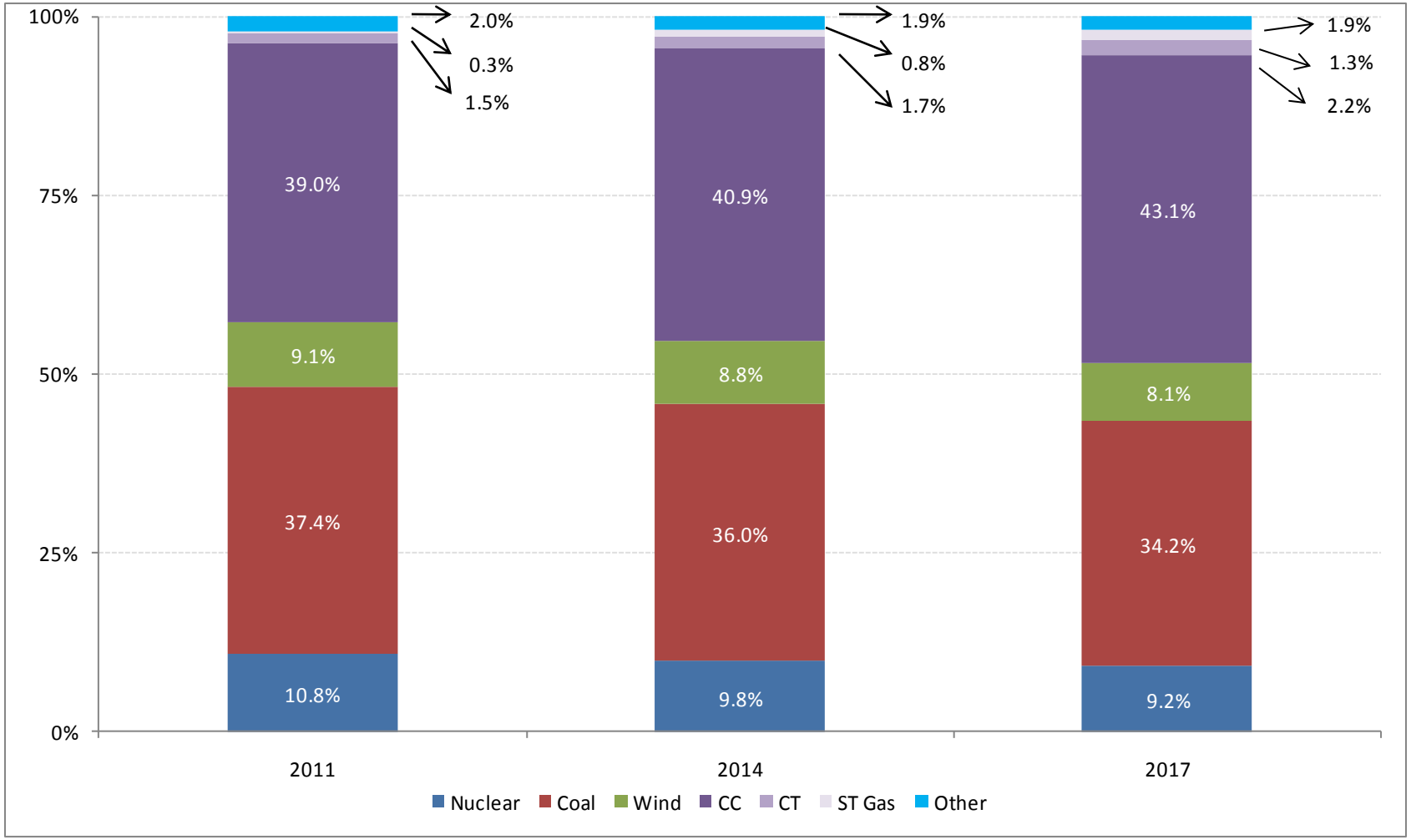
- MarketPower initially built 48 ACT units
  - LMS100
  - 100 MW
  - $742/kW
  - $7.47/kW-yr Fixed O&M
  - $61.38/MWh Total Variable Cost
  - $5.10/mmbtu Natural Gas price
- Re-ran multiple test runs in Promod of different amounts of ACT units to determine the final expansion for 2017 where all units 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



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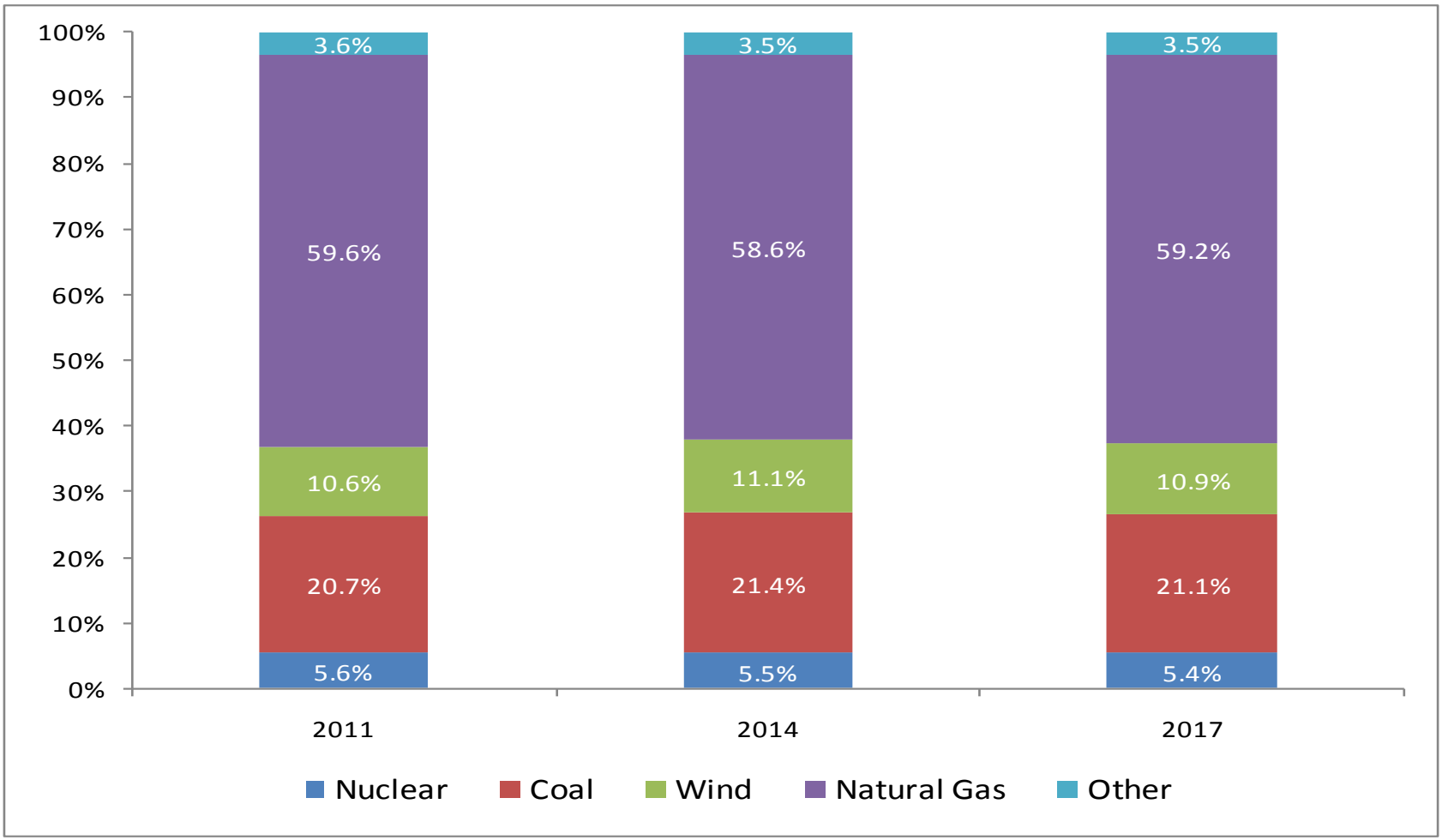
2011-2017 Changes: Annual Capacity (MW) by Fuel Type



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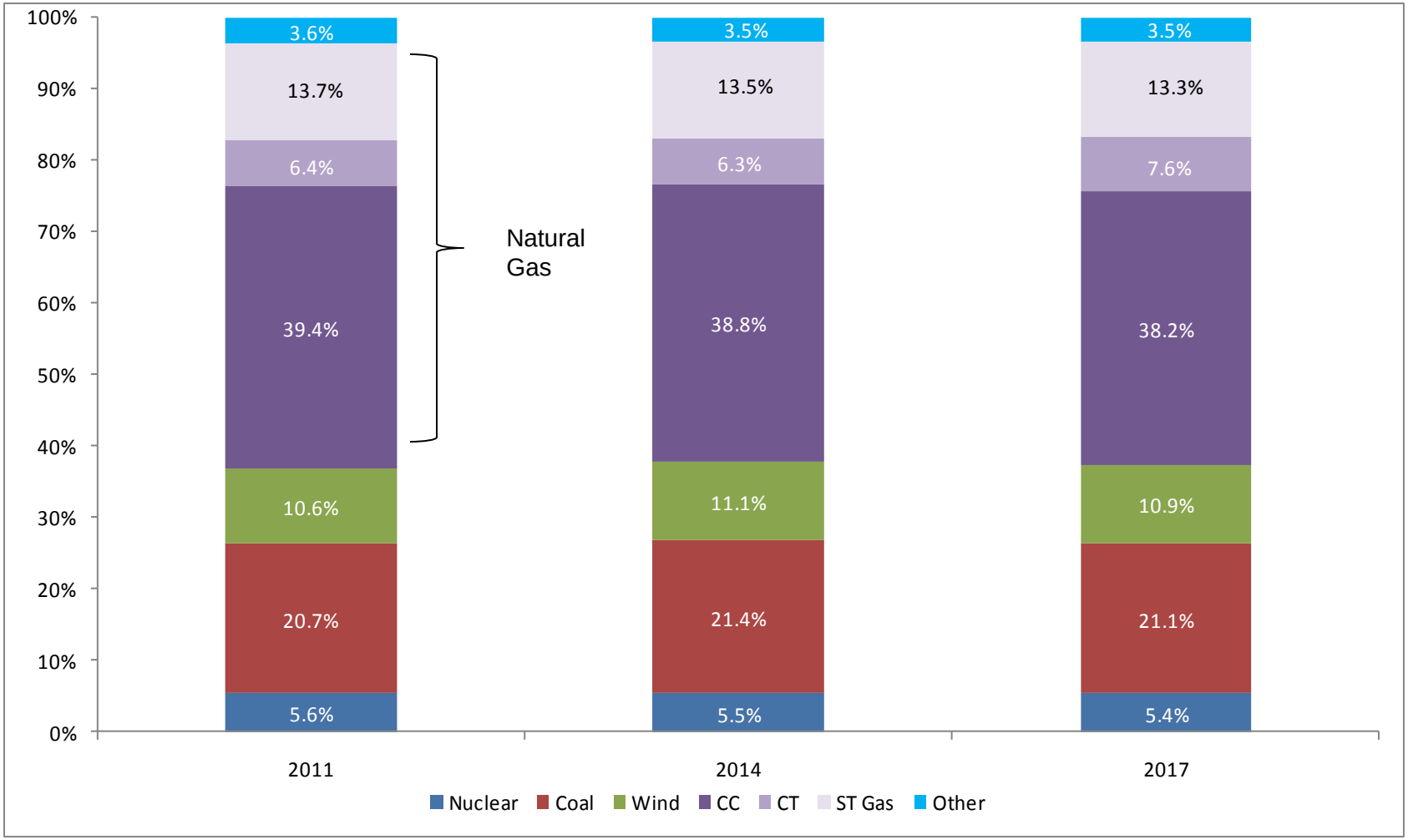
2011-2017 Changes: Annual Capacity (MW) by Technology



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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

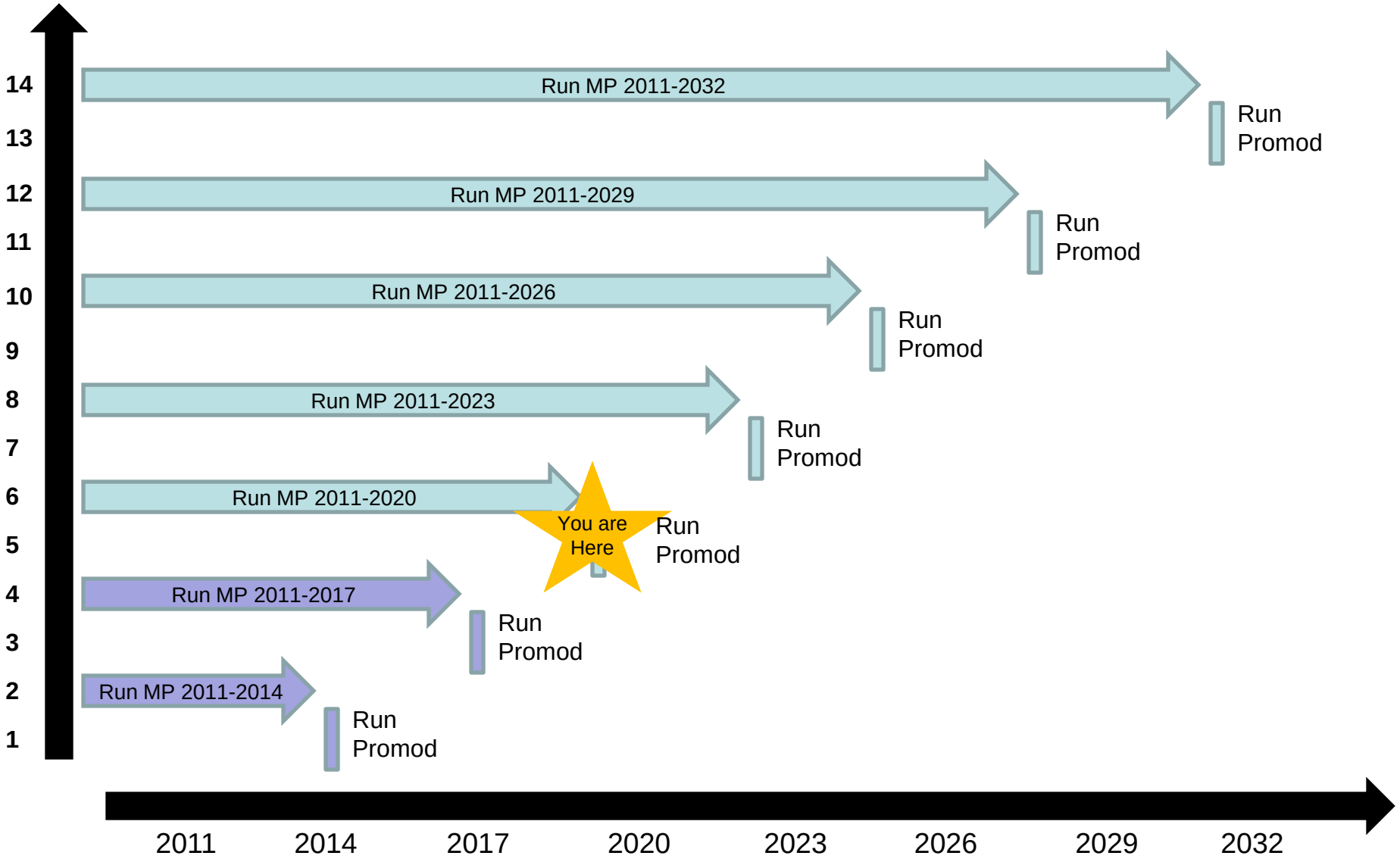
- In 2017, we see scarcity hours where the LMPs hit $3,000/MWh.
- Unserved energy results from the decreasing reserve margin.
- Current modeling is not capturing all scarcity pricing and A/S revenues.

Market Revenue Issues

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

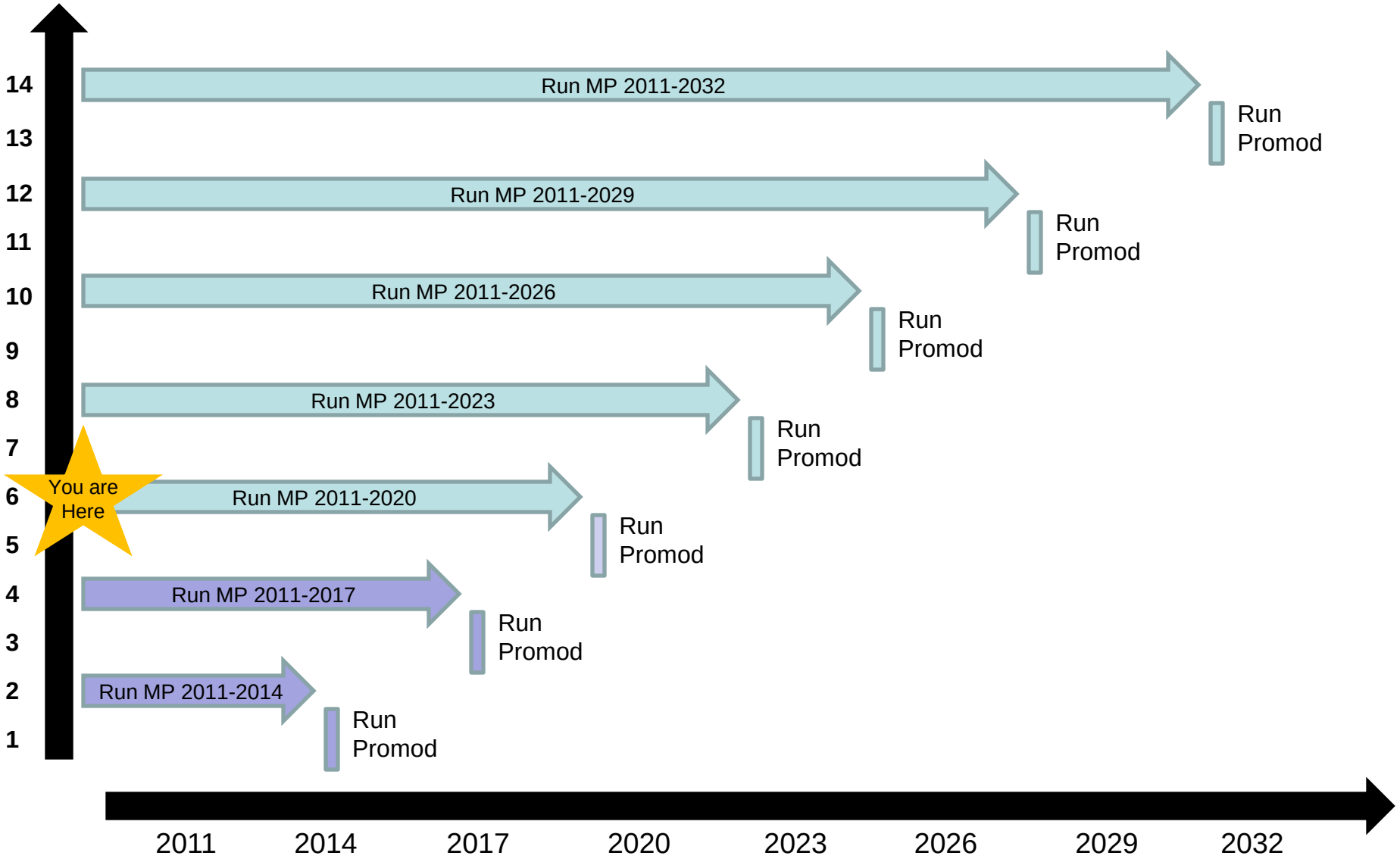


Run Promod: 2020

- **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

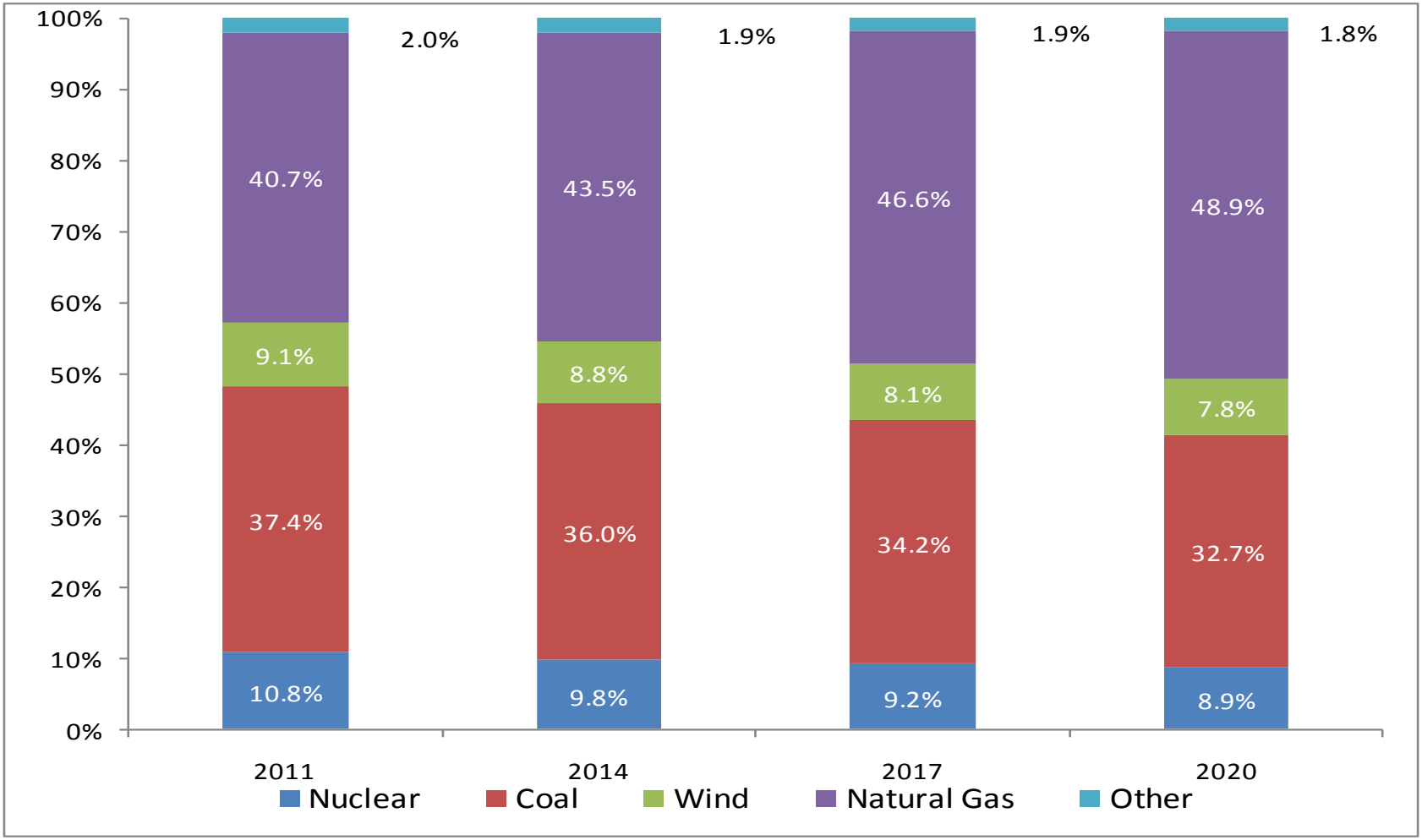


MarketPower Expansion Build: 2020

- **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**
- **Current combination for 2020 is 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

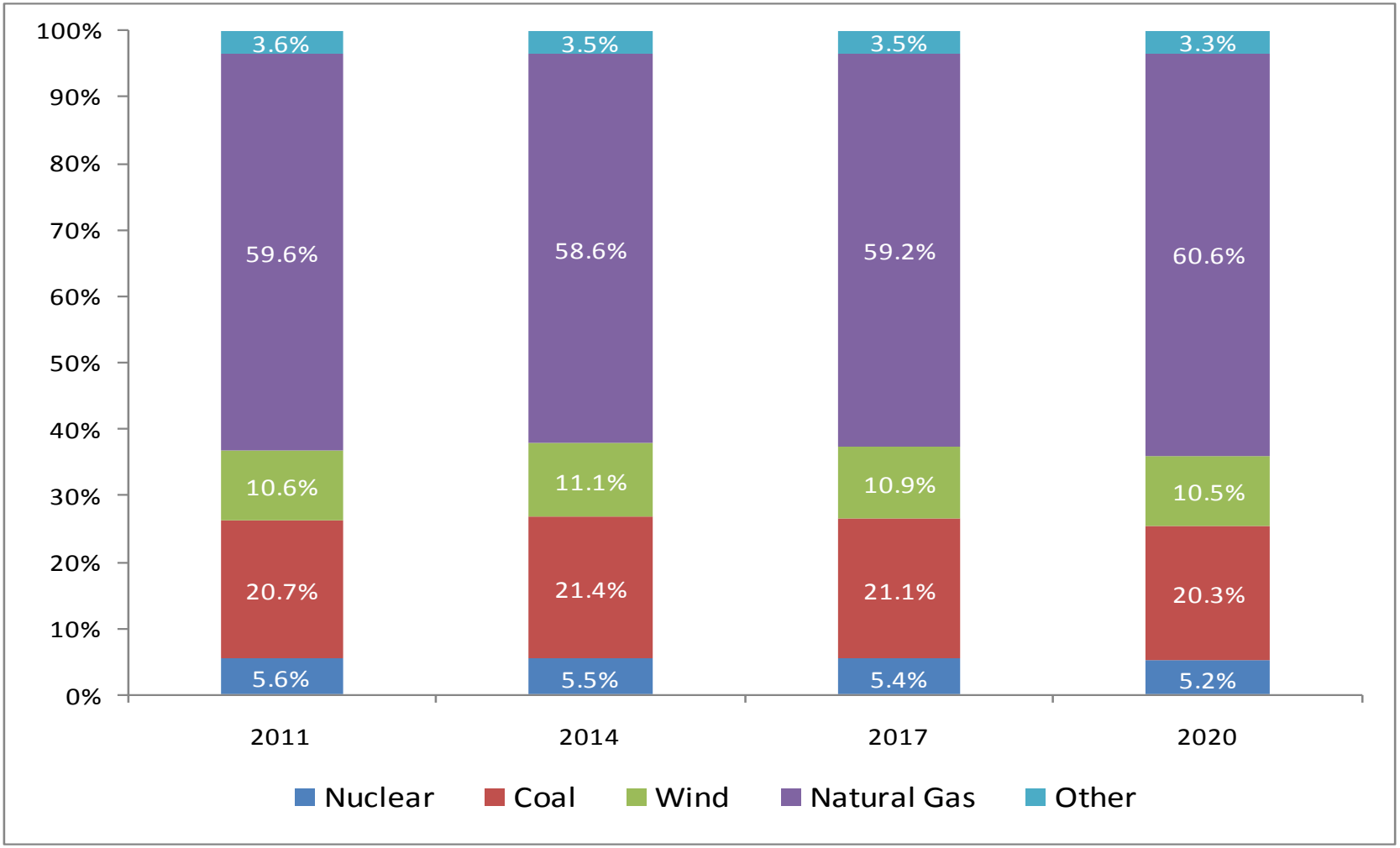
Incomplete iteration; Will likely justify additional units

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



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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

- **Expansion plan for 2020 is still being iterated**
  - So far a combination of 5 ACC and 28 ACT units is meeting the criteria
    - Including the 13 ACTs from 2017
  - 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???