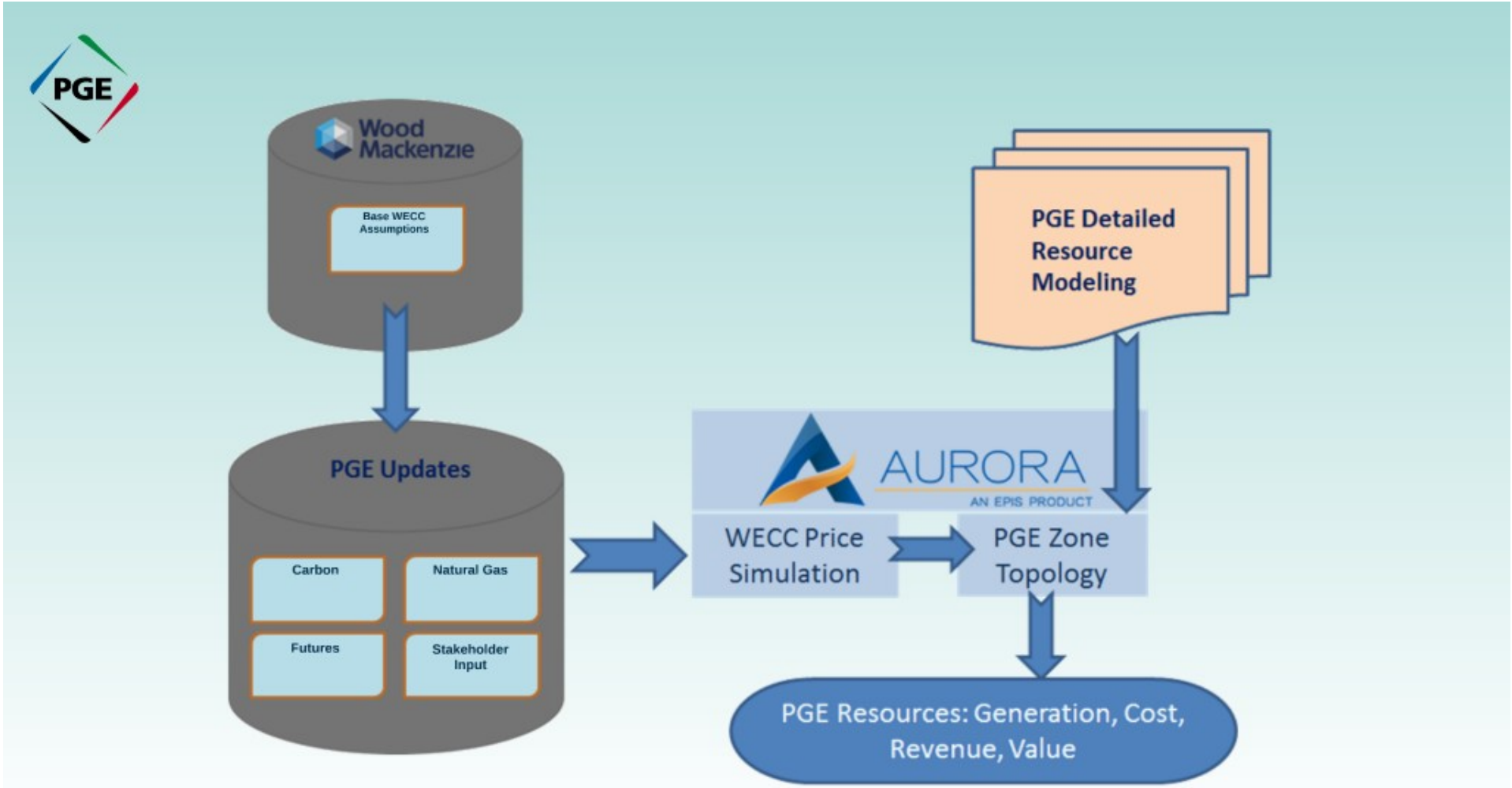
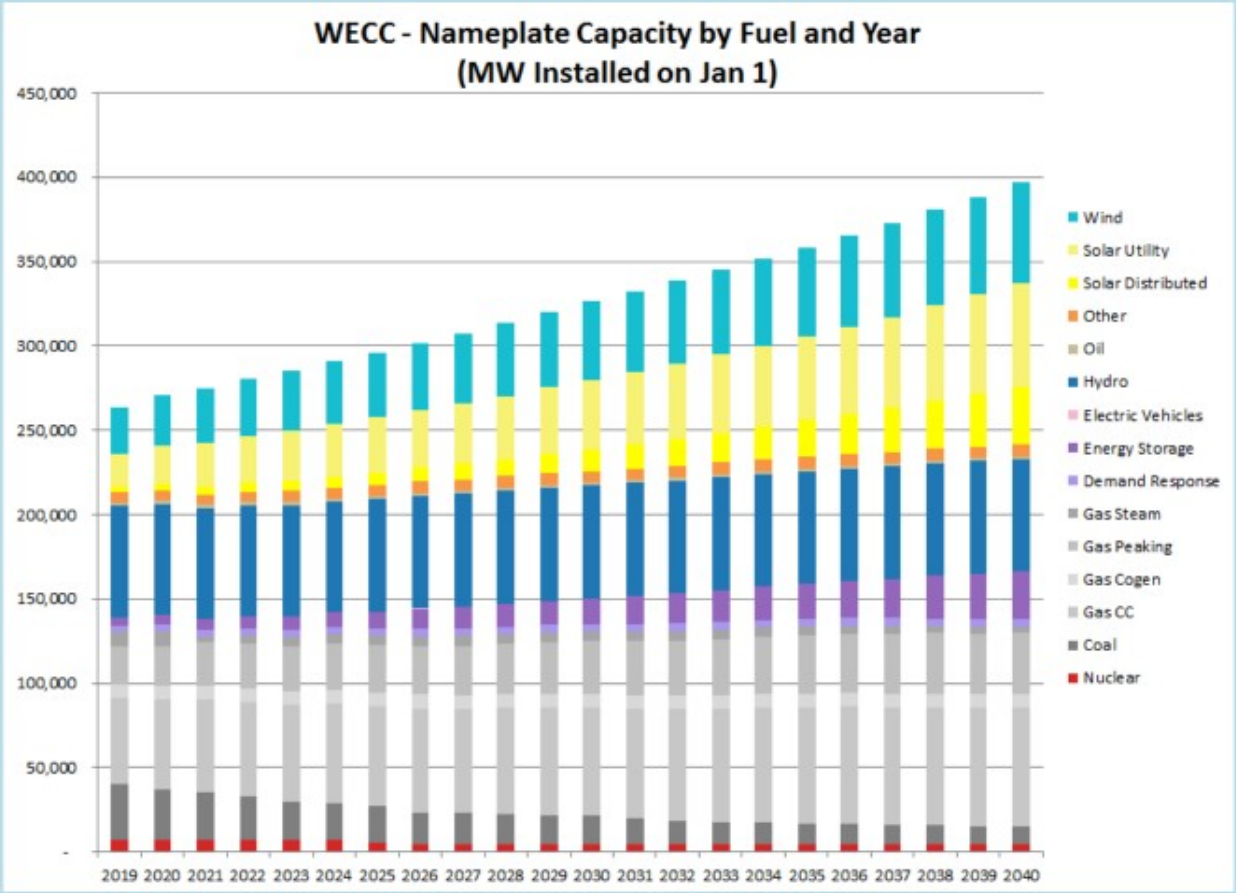
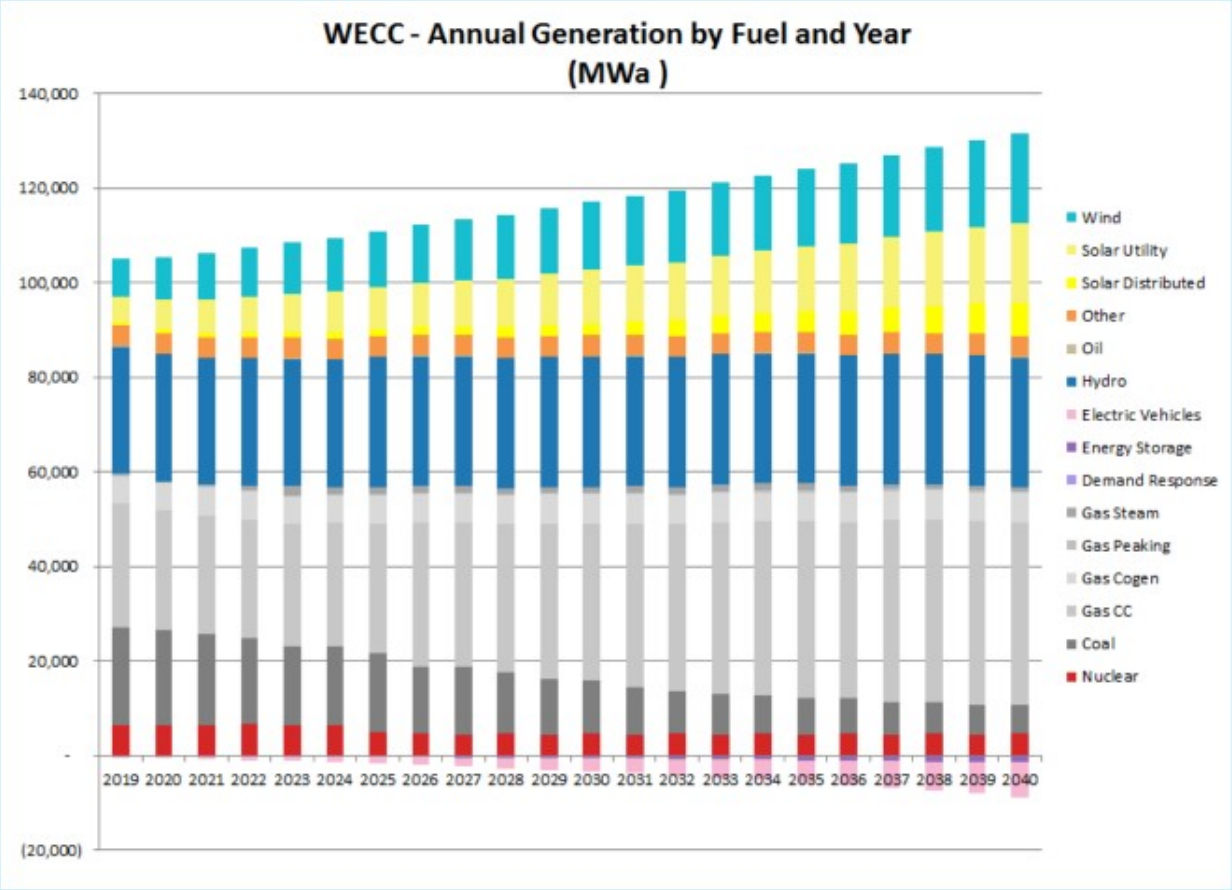

Wood Mackenzie
Base WECC Assumptions
PGE Updates
Carbon
Natural Gas
Futures
Stakeholder Input
PGE Detailed Resource Modeling
AURORA
AN EPIS PRODUCT
WECC Price Simulation
PGE Zone Topology
PGE Resources: Generation, Cost, Revenue, Value



Summary of WECC build-out from default Wood Mackenzie 2017.H2 data base.

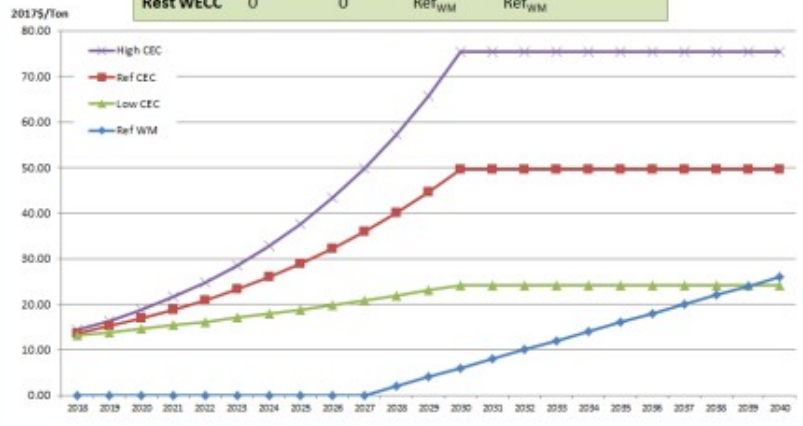


Summary of WECC build-out from default Wood Mackenzie 2017.H2 data base.

Carbon

Proposed Carbon Futures - 2019 IRP

	No addl.	Low	Ref	High
CA	Low_{CEC}	Low_{CEC}	Ref_{CEC}	$High_{CEC}$
OR+WA	0	Low_{CEC}	Ref_{CEC}	$High_{CEC}$
Rest WECC	0	0	Ref_{WM}	Ref_{WM}



Reference Case:

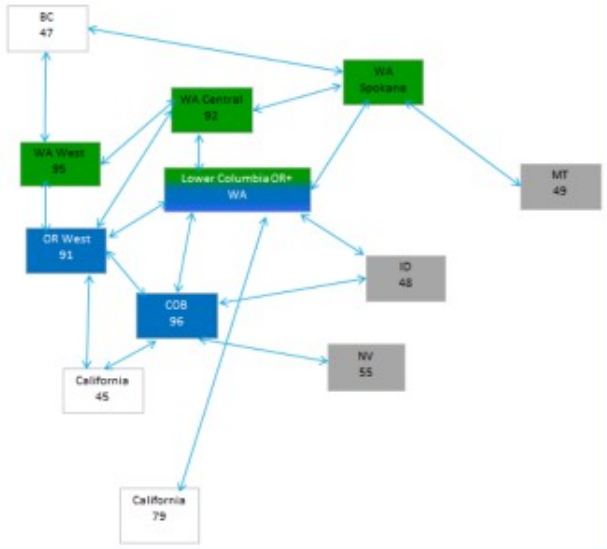
- Approximate potential GHG policies with single carbon price for Oregon, Washington, and California.
- 2021 start year for Oregon and Washington.

Carbon cases compiled from a mix of:

- Wood Mackenzie carbon assumptions from 2017.H2 database.
- California Energy Commission (CEC) carbon price projections.

Carbon

Area from	Area NO. From	To	Area To
California South	79	119	Lower Columbia /WA +OR
California Nord	45	96	COB (treated as California)
		91	Oregon West
COB treated as California	96	48	Idaho
		55	Nevada
		45	California Nord
Lower Columbia (OR+WA)	119	48	Idaho
		79	California South
		96	COB
		91	Oregon West
		97	Washington Spokane
		92	Washington Central
Oregon West	91	45	California Nord
		96	COB
		119	Lower Columbia /WA +OR
		92	Washington Central
		95	Washington West
Washington Spokane	97	47	British Columbia
		119	Lower Columbia /WA +OR
		49	Montana
		92	Washington Central
Washington Central	92	119	Lower Columbia /WA +OR
		91	Oregon West
		97	Washington Spokane
		95	Washington West
Washington West	95	47	British Columbia
		91	Oregon West
		92	Washington Central

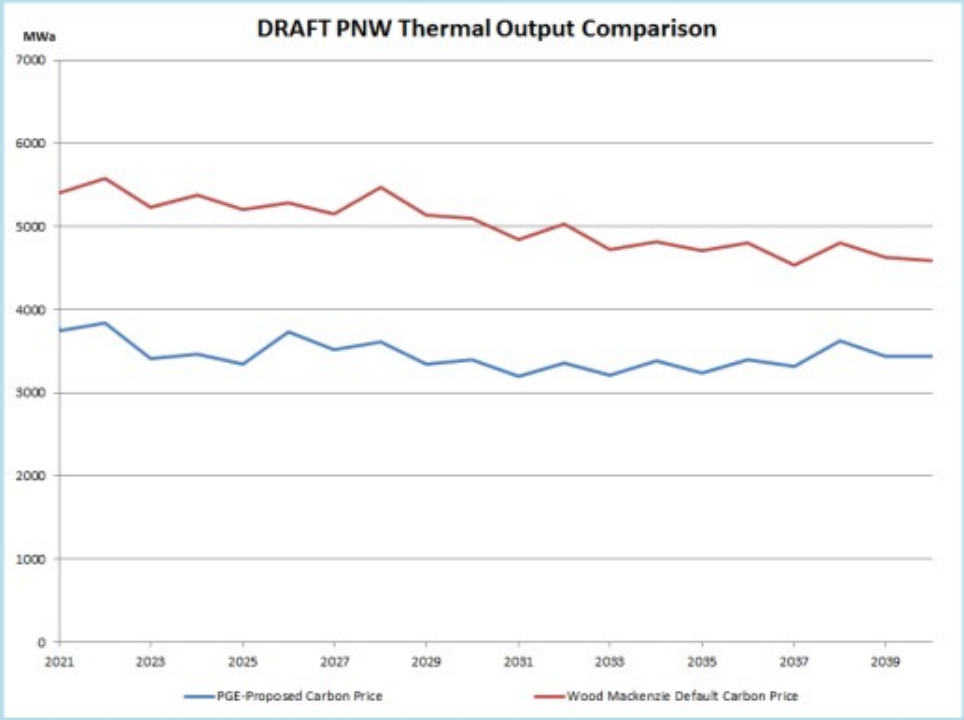


Wheeling Rate Adjustment for CO_2 Hurdle Rates:

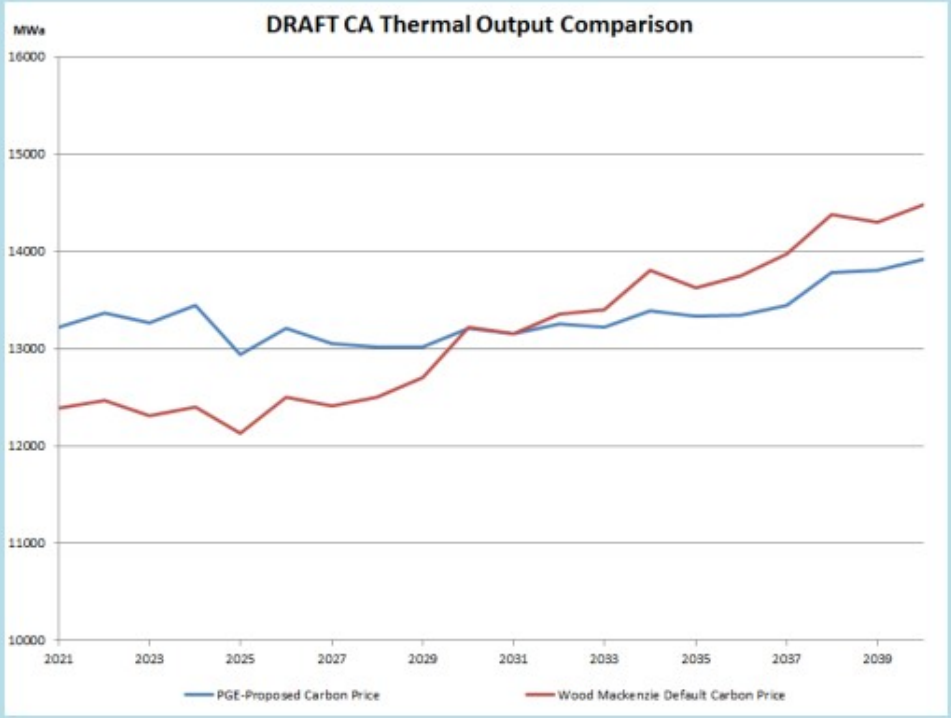
In addition to regional carbon prices, AURORA inputs must account for the difference in carbon prices between zones.

- Subtract CO_2 pricing contribution to transmission wheeling rate from the Wood Mackenzie WECC base case for PNW Zones.
- Calculate new CO_2 hurdle rate for OR, WA, and CA.
- Apply new CO_2 hurdle rate to all zones exporting power to OR, WA, and CA.
- Do not apply CO_2 hurdle rate between OR, WA, and CA.

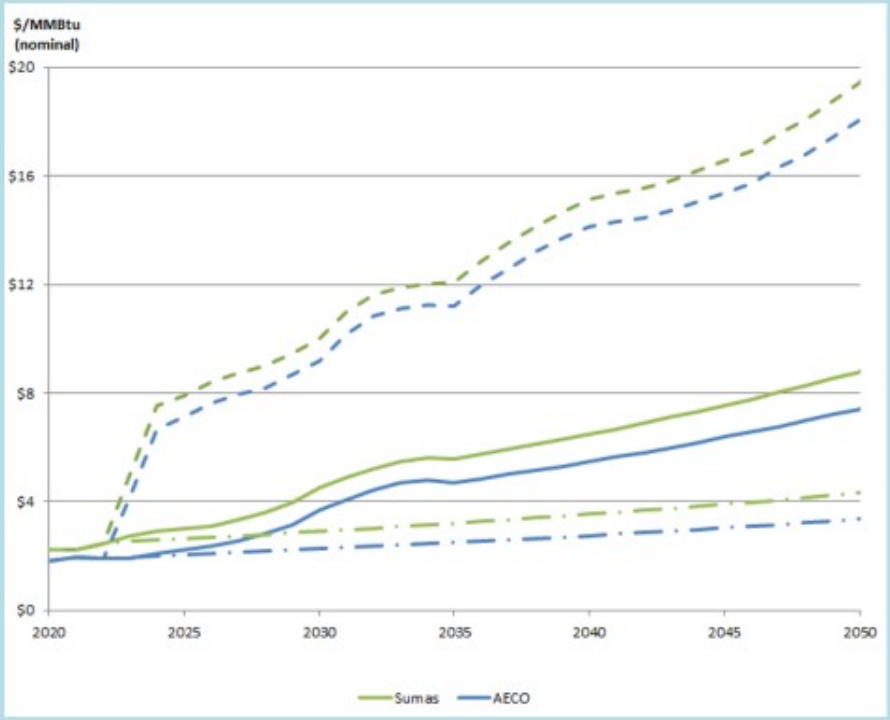
Carbon


DRAFT PNW Thermal Output Comparison
MWa
7000
6000
5000
4000
3000
2000
1000
0
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
PGE-Proposed Carbon Price
Wood Mackenzie Default Carbon Price

Carbon


DRAFT CA Thermal Output Comparison
MWa
16000
15000
14000
13000
12000
11000
10000
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
PGE-Proposed Carbon Price
Wood Mackenzie Default Carbon Price

Natural Gas



Gas Reference Case:

- 2020-2023: PGE forward market curve.
- 2024: Linear interpolation of PGE forward curve and Wood Mackenzie fundamentals forecast.
- 2025-2040: Wood Mackenzie fundamentals forecast.
- 2040-2050: Blend EIA and IHS long-term outlooks.

Gas Low Case:

- Grow at the rate of inflation starting in the linear interpolation year.

Gas High Case:

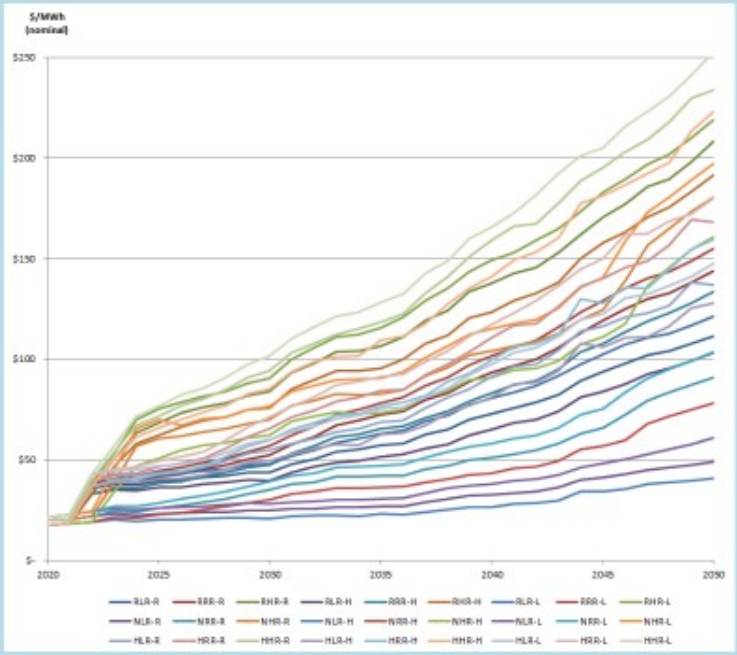
- Near-term: reference prices.
- Mid- and long-term: AEO "High Oil" scenario prices.

Futures

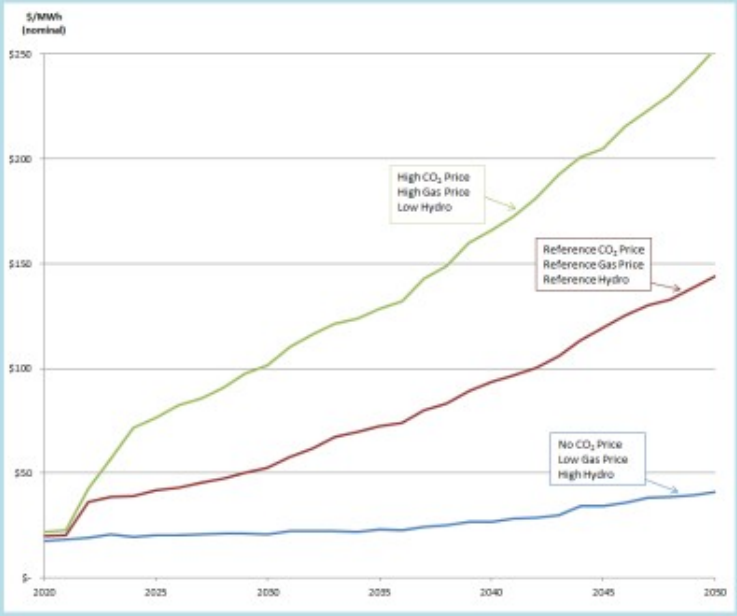
PNW Hydro

- Low/High Cases
  - Annual generation varied approximately one standard deviation from reference case.
  - ~10% based on historic EIA data.

Futures


$/MWh
(nominal)
$150
$100
$150
$100
$50
$-
2020
2025
2030
2035
2040
2045
2050

Futures


$/MWh
(nominal)
$250
$200
$150
$100
$50
$-
2020
2025
2030
2035
2040
2045
2050
High CO_2 Price
High Gas Price
Low Hydro
Reference CO_2 Price
Reference Gas Price
Reference Hydro
No CO_2 Price
Low Gas Price
High Hydro

Futures

Proposed long-term expansion:

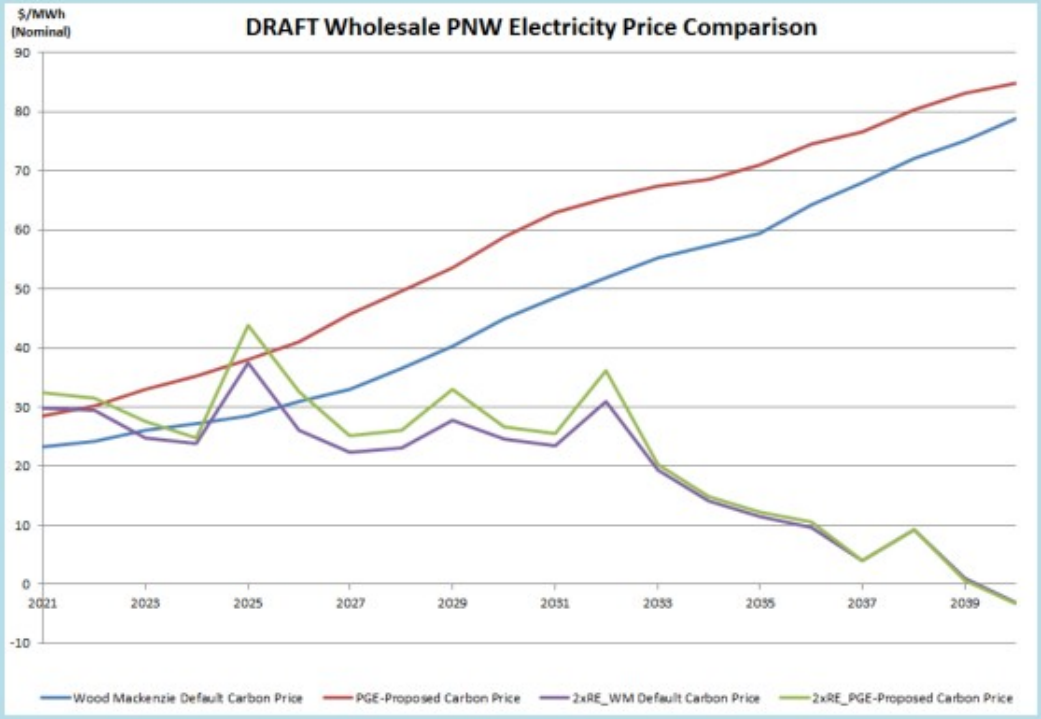
Market prices grow with inflation after 2040.

- Modeling simplification to address uncertainty.

Add a sensitivity to account for accelerated deployment of renewable energy.

- Calculate high scenario.
  - Technological and policy potential.
  - Expanded RPS or city/county goals.
- Investigate potential future that leads to WECC-wide fleet with much higher renewable energy than the projected reference case.
  - Examine wholesale market prices in such a case.
  - What happens to prices when renewables are economically attractive for the entire region, all load-serving entities build and renewables max out?

Futures



High Renewables Test

- Double solar and wind resources in WECC.
- All other resource assumptions unchanged.
- Run under Wood Mackenzie base carbon assumptions and PGE-proposed Reference carbon case.

Stakeholder Input

When you think of a future with high renewables, what do you envision?

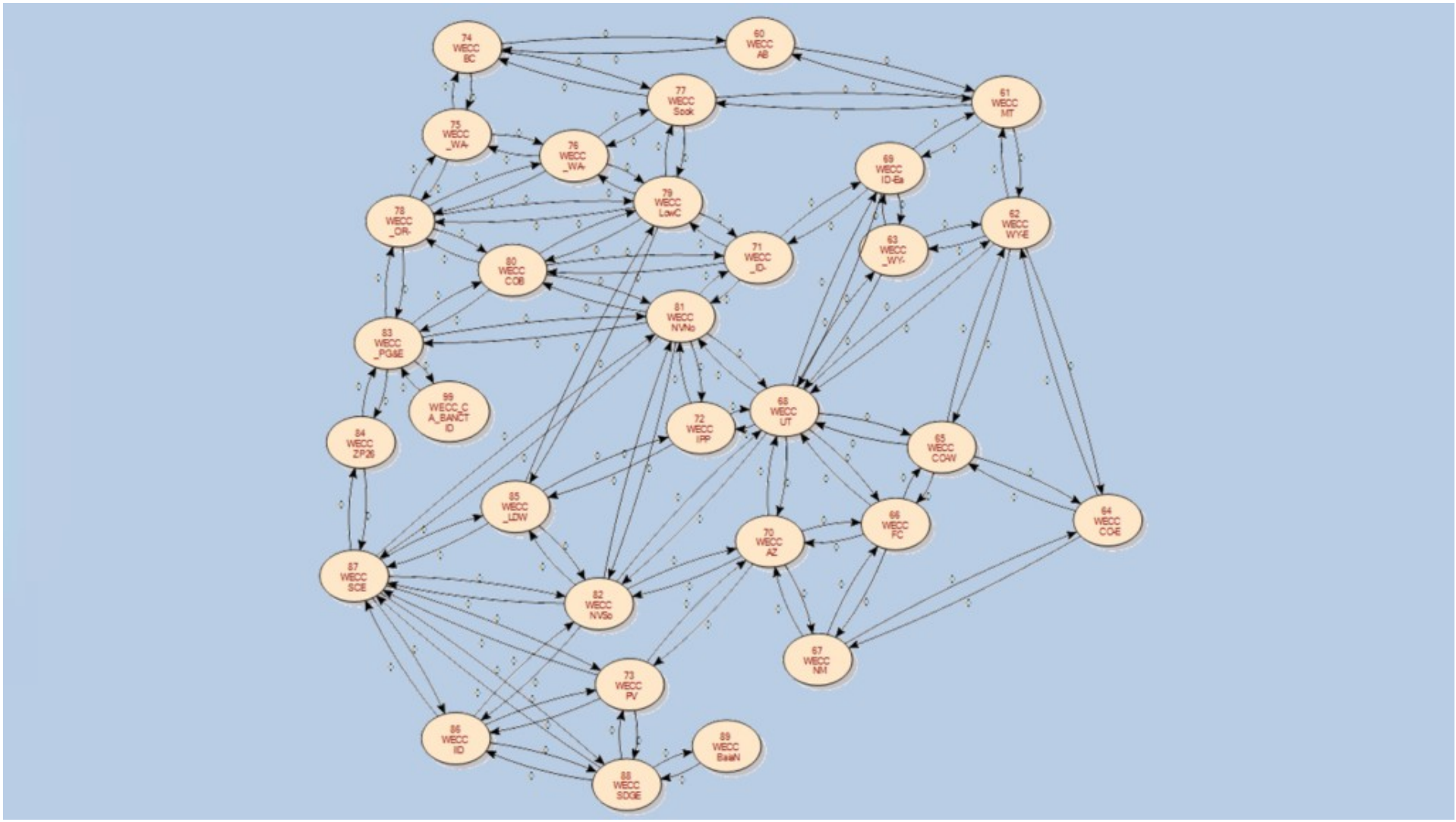
Stakeholder Input

Futures - combinations of variables that are compelling.

What variables should we examine to compile price futures?

Stakeholder Input

Other thoughts?

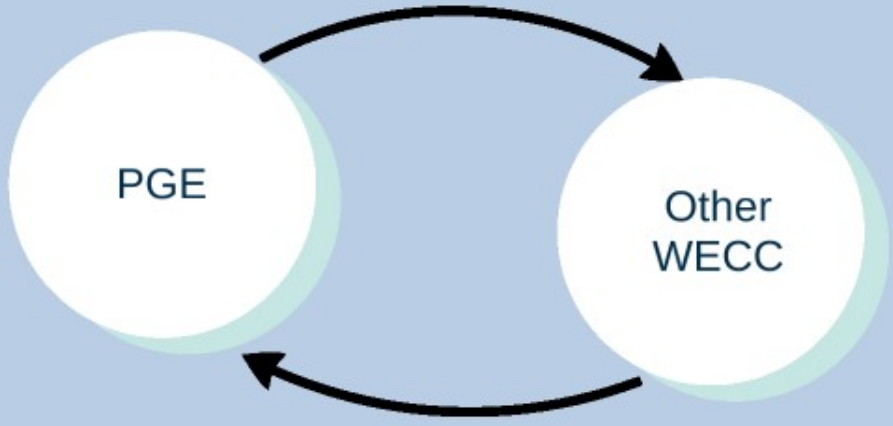

74
WECC
BC
60
WECC
AB
77
WECC
Sask
61
WECC
MT
75
WECC
_WA-
76
WECC
_WA-
69
WECC
ID-Ea
79
WECC
LowC
78
WECC
_OR-
62
WECC
WY-E
63
WECC
_WY-
71
WECC
_ID-
80
WECC
COB
81
WECC
NVNo
83
WECC
_PG&E
99
WECC_C
A_BANCT
ID
68
WECC
UT
72
WECC
IPP
84
WECC
ZP26
65
WECC
COAW
85
WECC
_LDW
66
WECC
FC
64
WECC
COE
70
WECC
AZ
87
WECC
SCE
82
WECC
NVSo
67
WECC
NM
73
WECC
PV
86
WECC
ID
89
WECC
BasN
88
WECC
SDGE

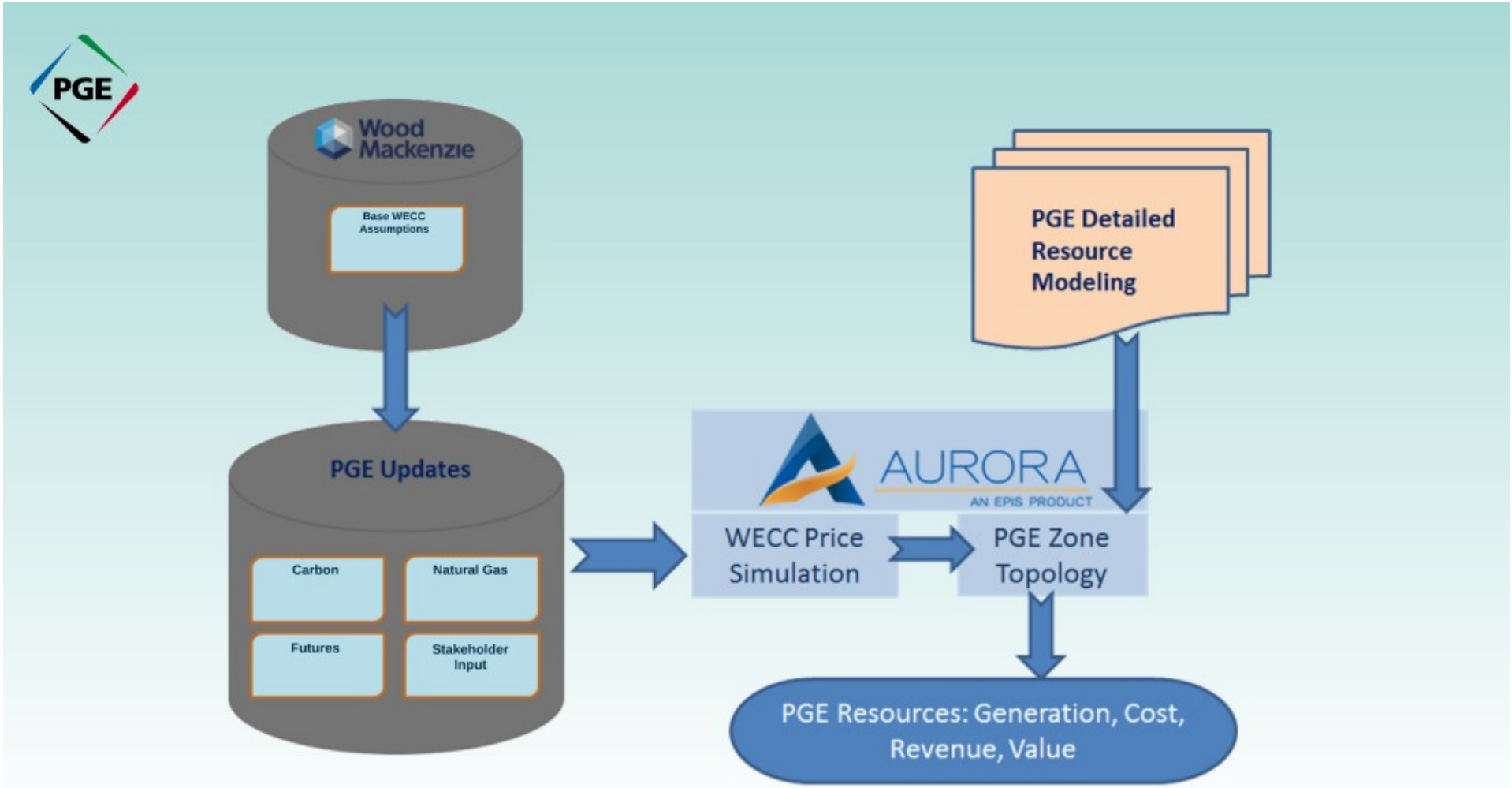
AURORA Dispatch

- Resources do not dispatch in AURORA as a portfolio.
- Resources dispatch individually to market price.
- Aurora calculates market price and revenue, then dispatches according to cost.
- Portfolio value happens post aurora.
- AURORA Outputs: Capacity factor, variable operating costs by resource year future, wholesale market prices, emissions, market revenues.

PGE Zone Dispatch

- Use WECC energy prices from preliminary AURORA dispatch as inputs.
- Dispatch PGE portfolio resources against WECC market prices.

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