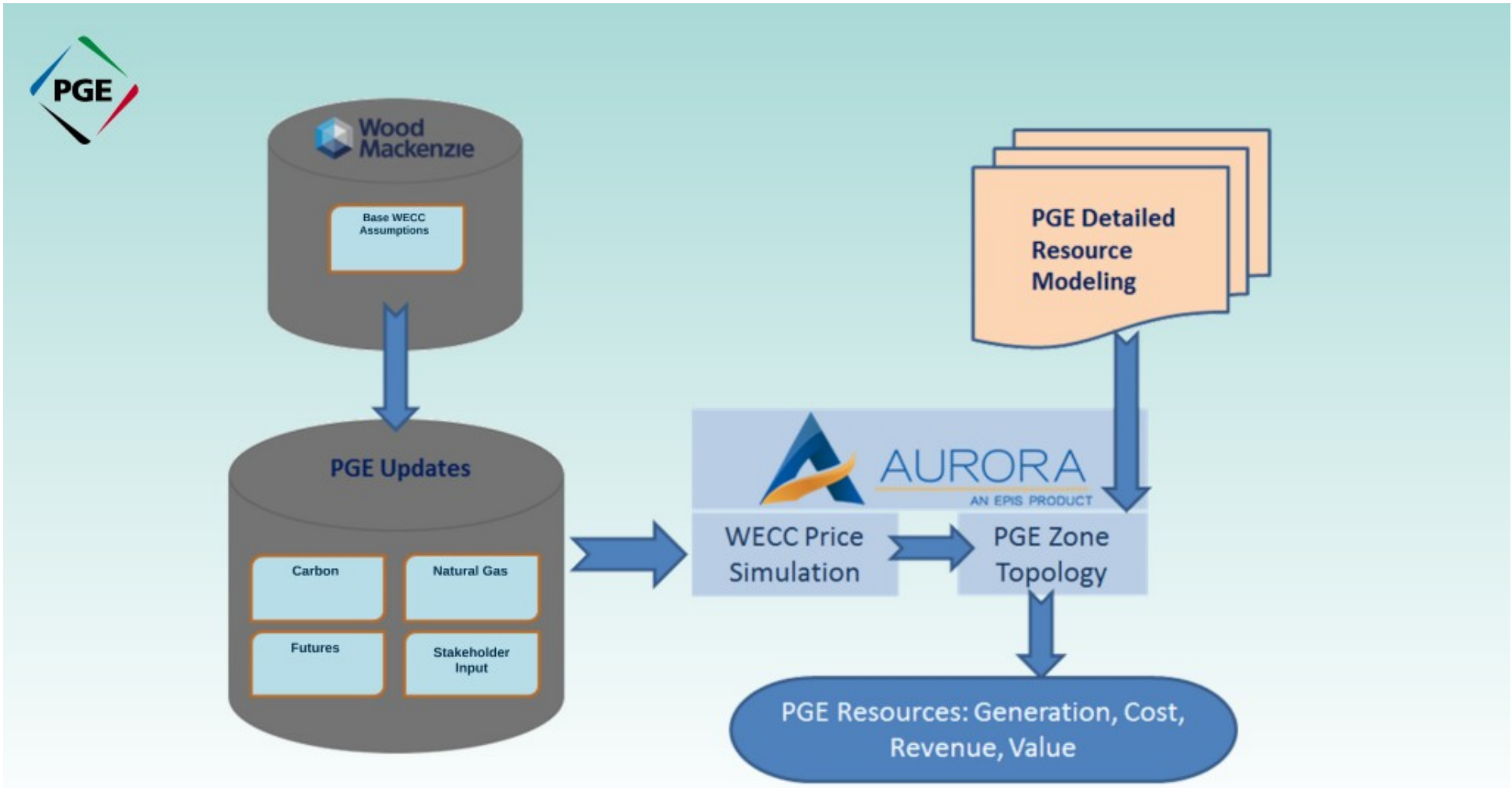
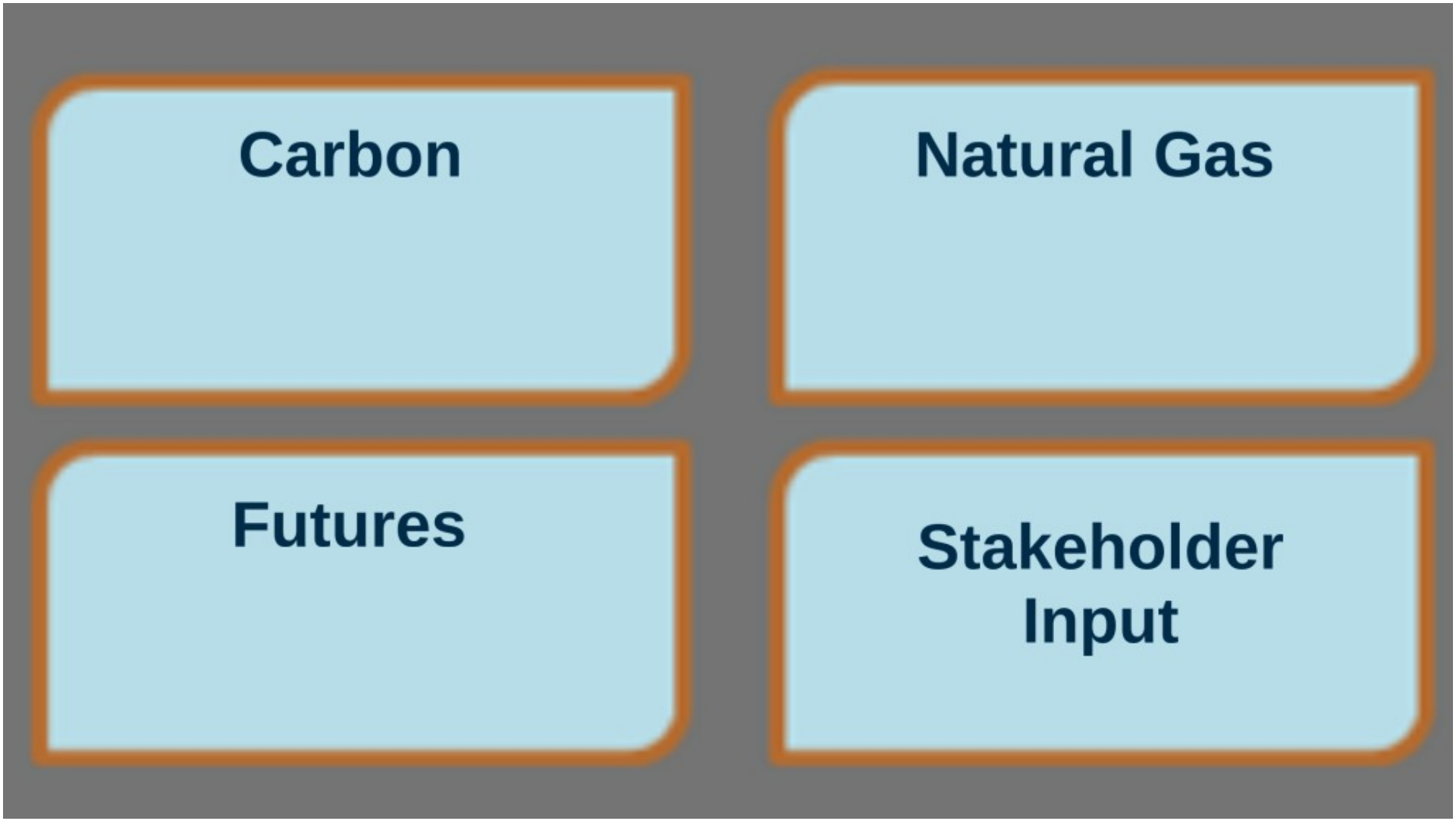
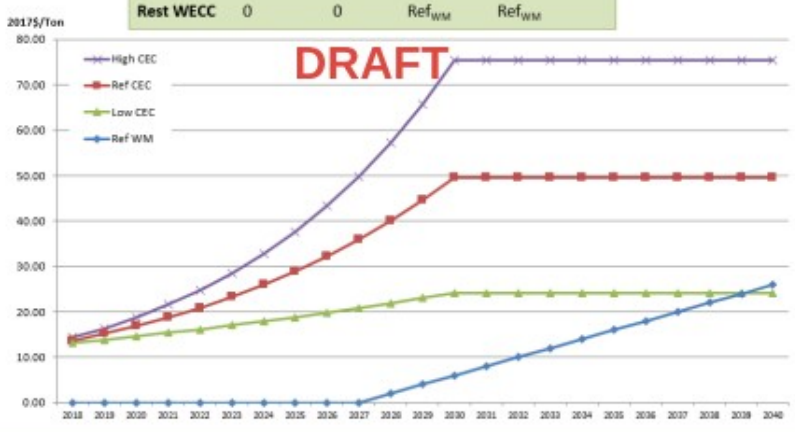

PGE
Wood Mackenzie
Base WECC Assumptions
PGE Updates
Carbon
Natural Gas
Futures
Stakeholder Input
PGE Detailed Resource Modeling
AURORA
AN EPIS PRODUCT
WECC Price Simulation
PGE Zone Topology
PGE Resources: Generation, Cost, Revenue, Value


Carbon
Natural Gas
Futures
Stakeholder Input

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}



Previous Reference Case:

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

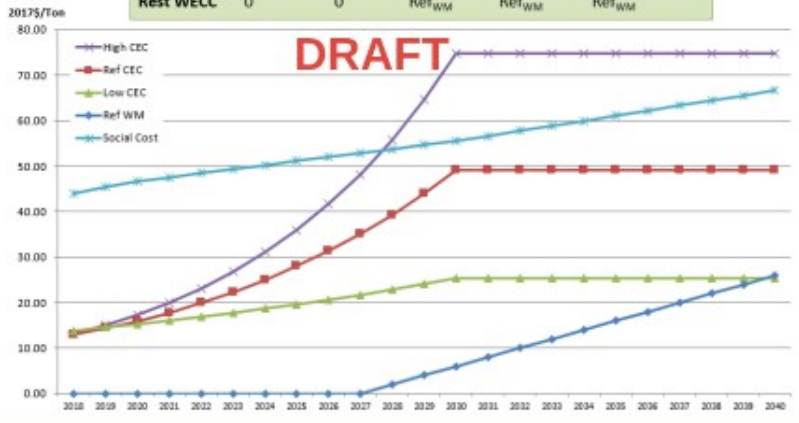
Carbon cases compiled from a mix of:

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

Carbon

Proposed Carbon Futures - 2019 IRP

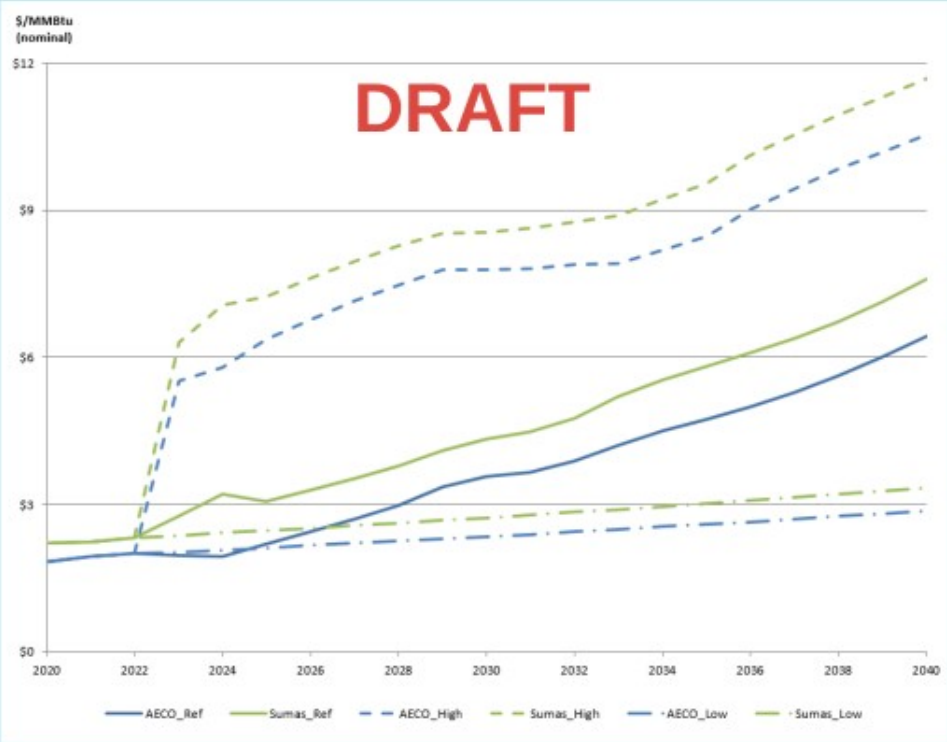
	No addl.	Low	Ref	High	SCC
CA	Low_{CEC}	Low_{CEC}	Ref_{CEC}	$High_{CEC}$	Ref_{SCC}
OR+WA	0	Low_{CEC}	Ref_{CEC}	$High_{CEC}$	Ref_{SCC}
Rest WECC	0	0	Ref_{WM}	Ref_{WM}	Ref_{WM}



Updates:

- CEC released updated GHG prices.
  - No material difference from previous forecast.
- Examined Social Cost of Carbon in comparison to CEC pricing, per Stakeholder request.
  - Trends between CEC reference and high cases in long-term.
  - Displays early step-change for GHG prices in near-term.

Natural Gas



Gas Reference Case:

- Near-Term: PGE forward market curve.
- Transition: Linear interpolation of PGE forward curve and Wood Mackenzie fundamentals forecast.
- Mid-Term: Wood Mackenzie 2018.H1 fundamentals forecast.
- Long-Term: Blend EIA and IHS 2018 long-term outlooks.

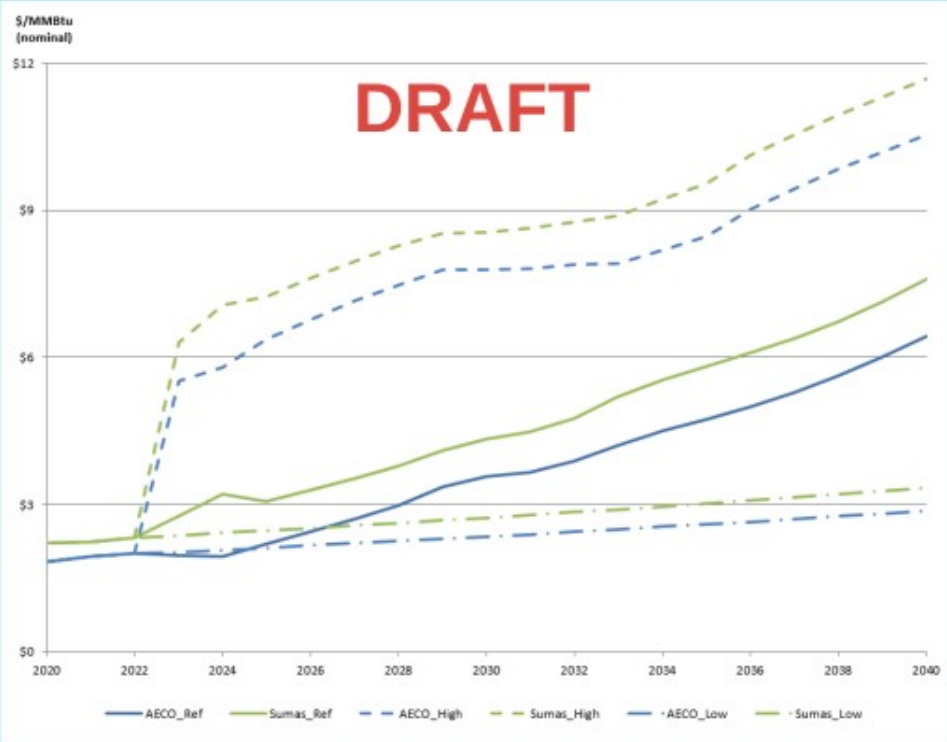
Gas Low Case:

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

Gas High Case:

- Near-term: reference prices.
- Mid- and long-term: 2018 AEO Low Oil and Gas Resource Technology case.

Natural Gas



2018.H1 WoodMackenzie Gas Forecast

- Trajectory extended from 2035 to 2040.
- Lower prices through 2030.
  - Limited export opportunity.
  - Increasing oil-associated gas production.
    - Gas as a by-product of oil production creates deflated prices.
- Steeper price increase 2030-2040.
  - Increased export.
  - Depletion of low-cost wells.

Futures

PNW Hydro

- Wood Mackenzie hydro assumptions are unchanged from 2017.H2 to 2018.H1.
- Low/High Cases
  - Annual generation varied approximately one standard deviation from reference case.
  - ~10% based on historic EIA data.
  - Aligned with 2016 IRP Update methodology.

Futures

Previous 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.

Futures

Updated High Renewable Energy Case

Purpose of the High Renewable Case

- Observe effect on wholesale electricity prices in a future where renewable energy is more widely deployed.

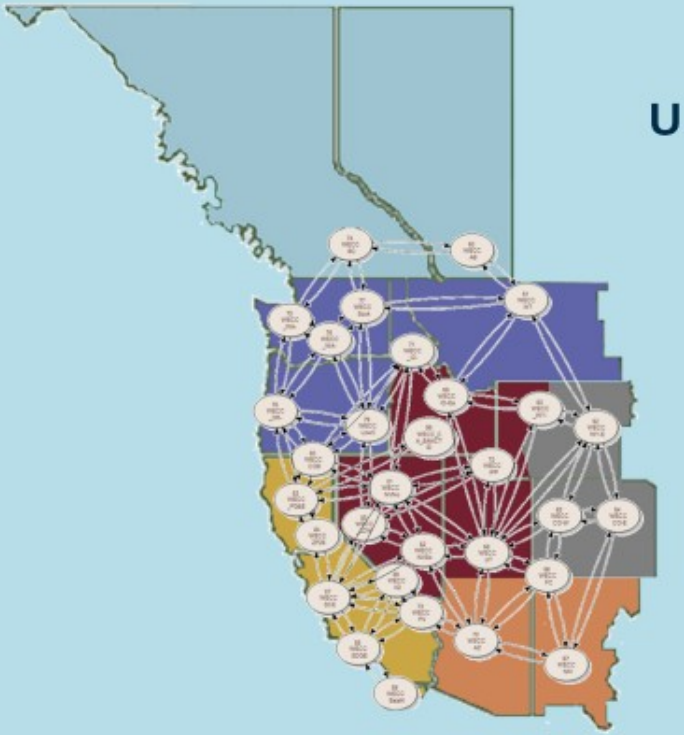
Methodology

- Add renewable resources by aggregate region until carbon-free generation is equal to 100% of load.
- Apply regional weights for solar and wind consistent with Wood Mackenzie specifications in 2017.H2 database.
- Retire WECC coal by 2040 with linear decline starting in 2030.

Outcome

- Portfolio screen for performance in a high renewable energy future.

Futures



Updated High Renewable Energy Case

Purpose of the High Renewable Case

- Observe effect on wholesale electricity prices in a future where renewable energy is more widely deployed.

Methodology

- Add renewable resources by aggregate region until carbon-free generation is equal to 100% of load.
- Apply regional weights for solar and wind consistent with Wood Mackenzie specifications in 2017.H2 database.
- Retire WECC coal by 2040 with linear decline starting in 2030.

Outcome

- Portfolio screen for performance in a high renewable energy future.

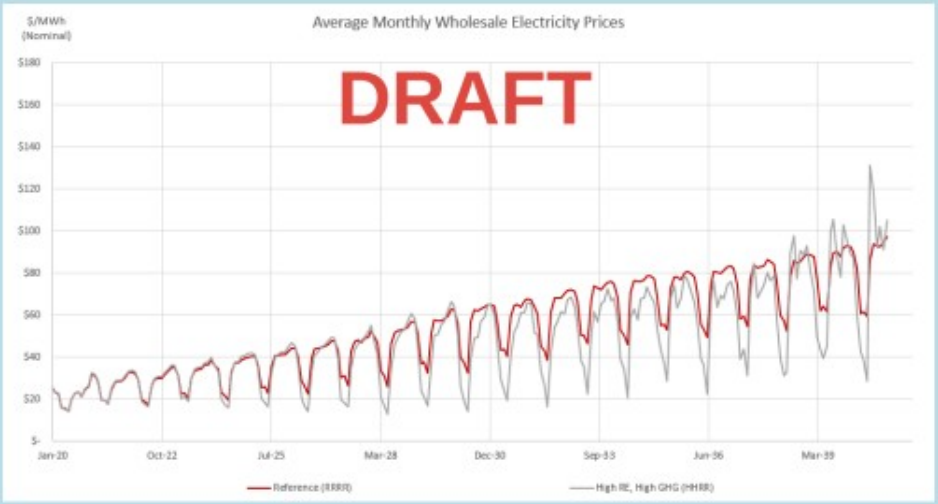
Futures


$/MWh
(Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (RRR)
High RE Base (HRR)


$/MWh
(Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (RRR)
High RE Base (HRR)

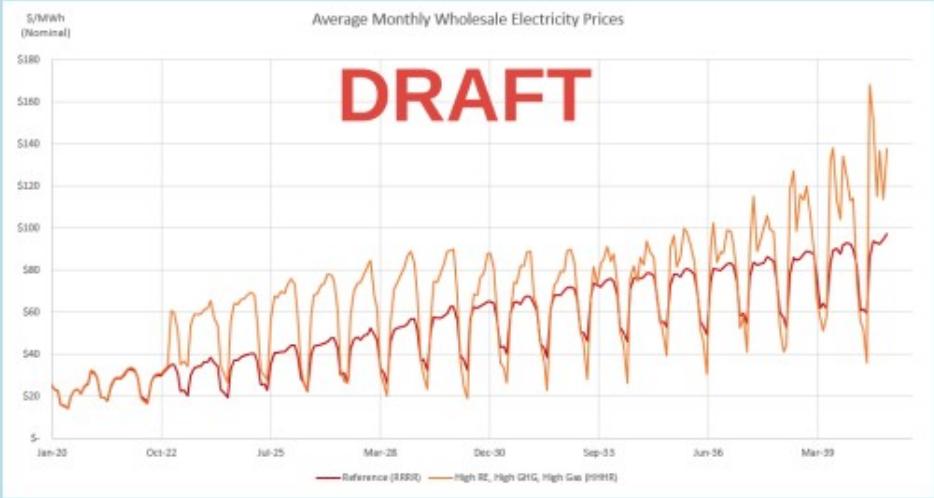
Futures


$/MWh (Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (RRRR)
High RE, High GHG (HHRR)
High RE Base (HRRR)


$/MWh (Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (RRRR)
High RE, High GHG (HHRR)

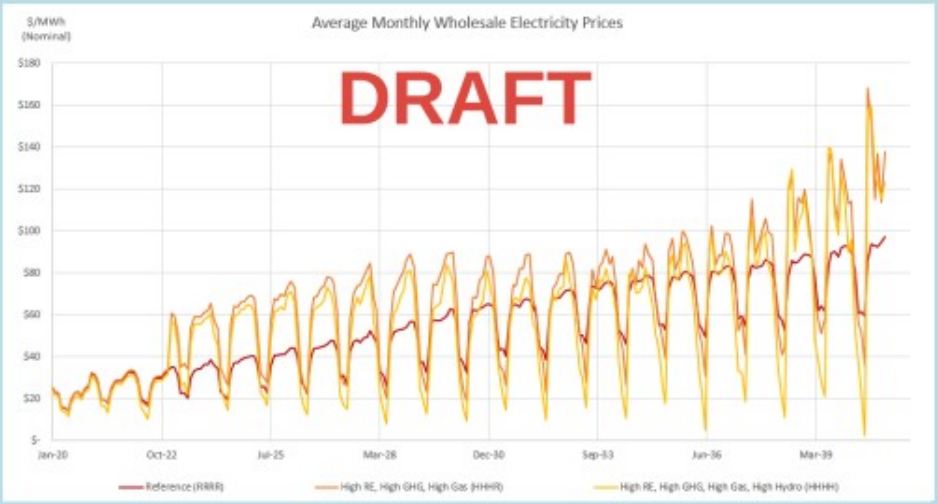
Futures


$/MWh
(Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (IRRR)
High RE, High GHG, High Gas (HHHR)
High RE, High GHG (HHRR)
High RE Base (HRRR)

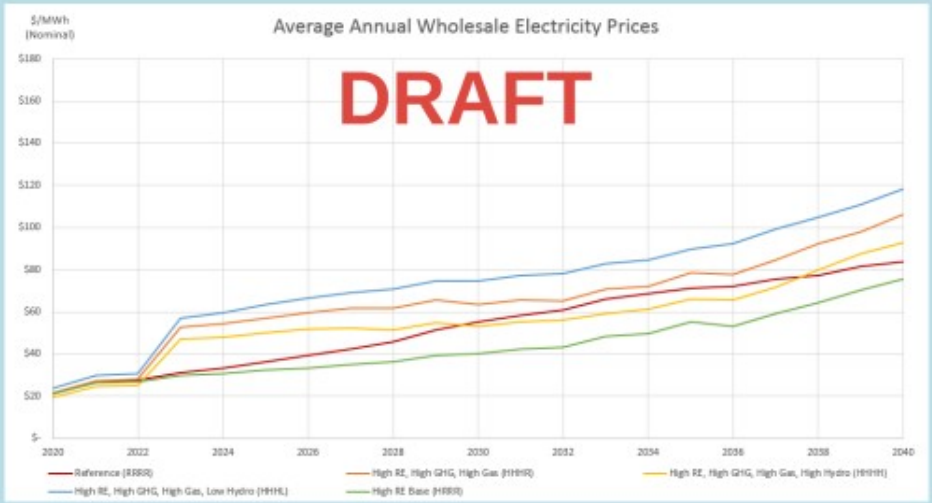

$/MWh
(Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (IRRR)
High RE, High GHG, High Gas (HHHR)

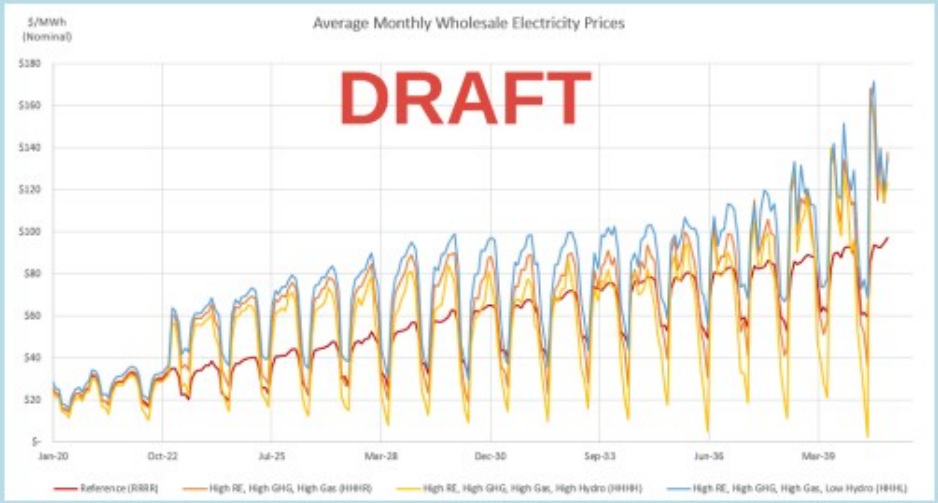
Futures


$/MWh
(Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE, High GHG, High Gas, High Hydro (HHHH)
High RE Base (HRRR)


$/MWh
(Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE, High GHG, High Gas, High Hydro (HHHH)

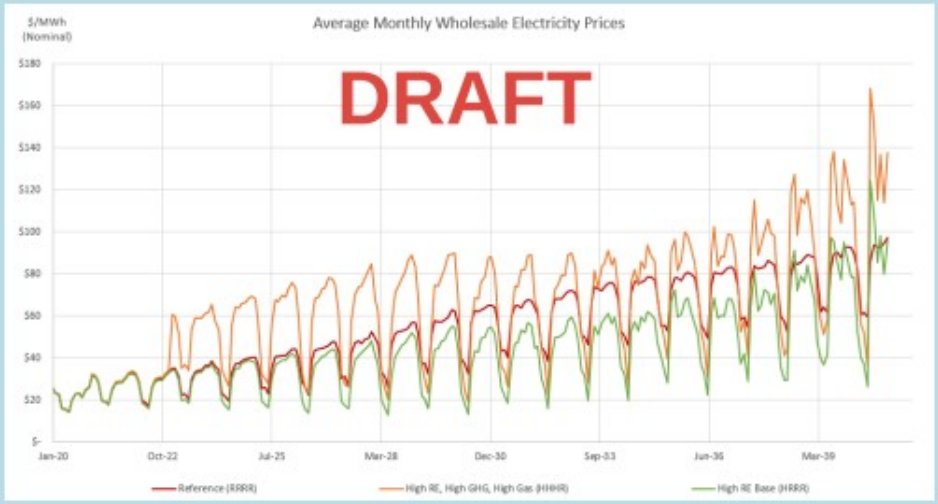
Futures


$/MWh
(Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE, High GHG, High Gas, High Hydro (HHHH)
High RE, High GHG, High Gas, Low Hydro (HHHL)
High RE Base (HRRR)

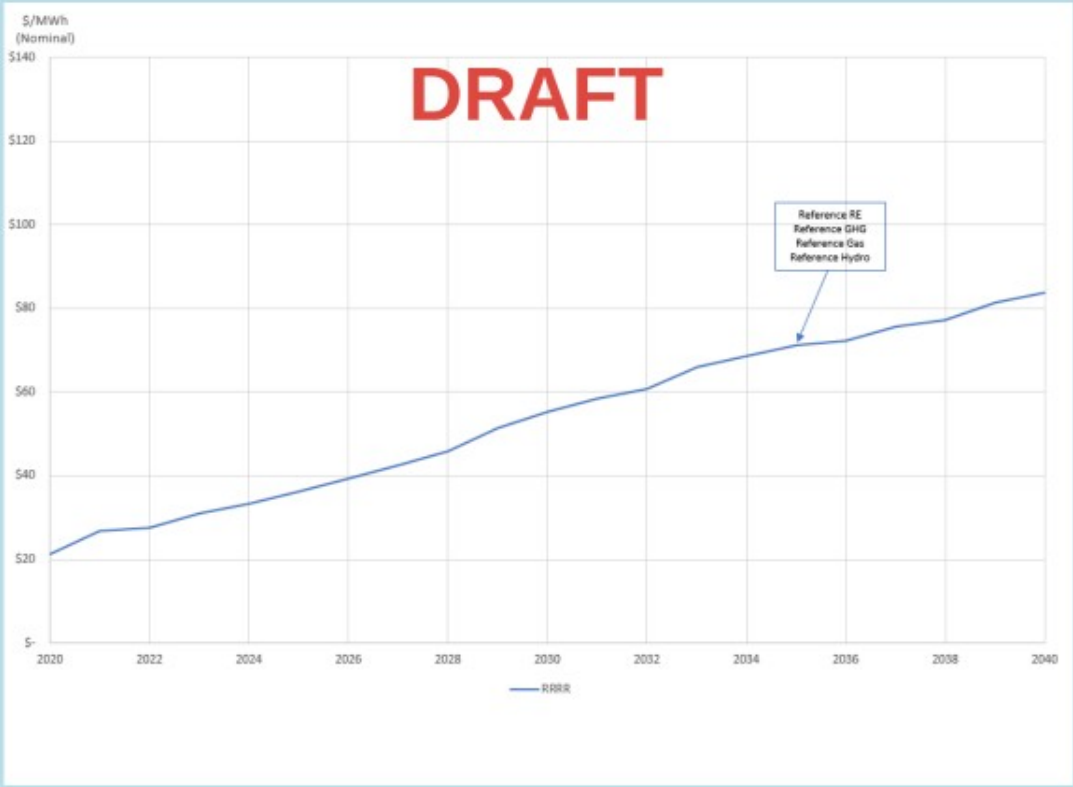

$/MWh
(Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE, High GHG, High Gas, High Hydro (HHHH)
High RE, High GHG, High Gas, Low Hydro (HHHL)

Futures

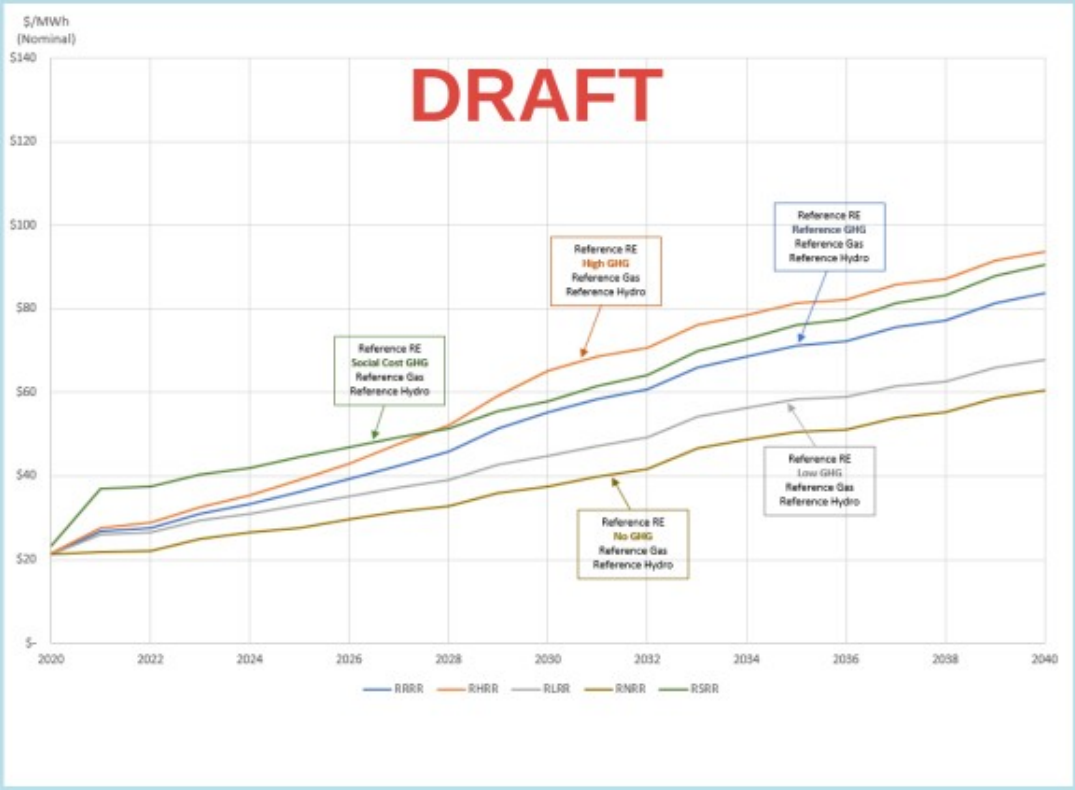

$/MWh
(Nominal)
Average Annual Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE Base (HRRR)


$/MWh
(Nominal)
Average Monthly Wholesale Electricity Prices
DRAFT
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Jan-20
Oct-22
Jul-25
Mar-28
Dec-30
Sep-33
Jun-36
Mar-39
Reference (RRRR)
High RE, High GHG, High Gas (HHHR)
High RE Base (HRRR)

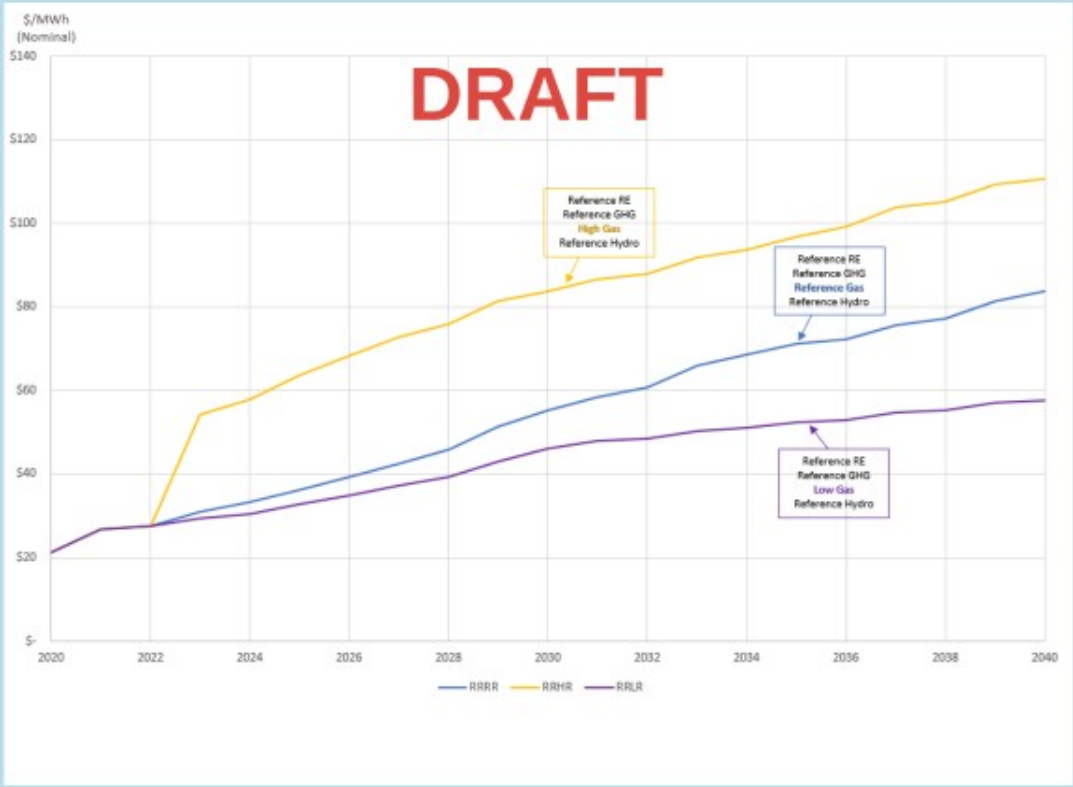
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference RE
Reference GHG
Reference Gas
Reference Hydro
RRRR

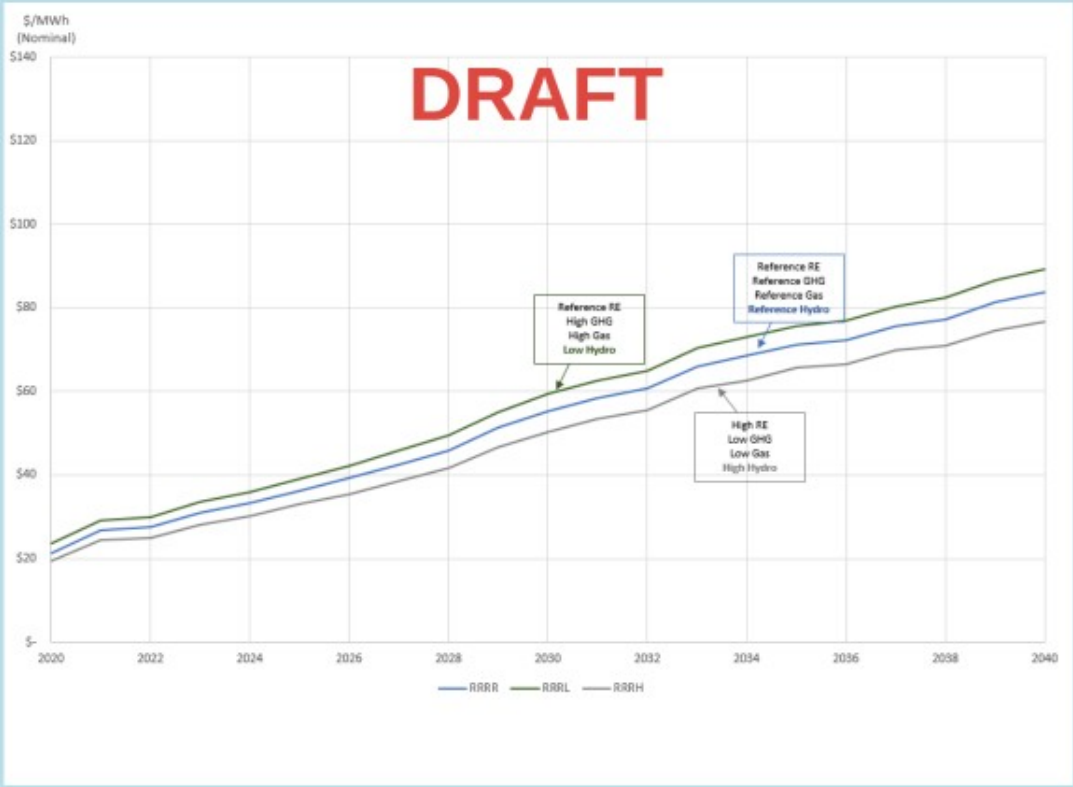
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference RE
Reference GHG
Reference Gas
Reference Hydro
Reference RE
High GHG
Reference Gas
Reference Hydro
Reference RE
Social Cost GHG
Reference Gas
Reference Hydro
Reference RE
Low GHG
Reference Gas
Reference Hydro
Reference RE
No GHG
Reference Gas
Reference Hydro
RRRR
RHRR
RLRR
RNRR
RSRR

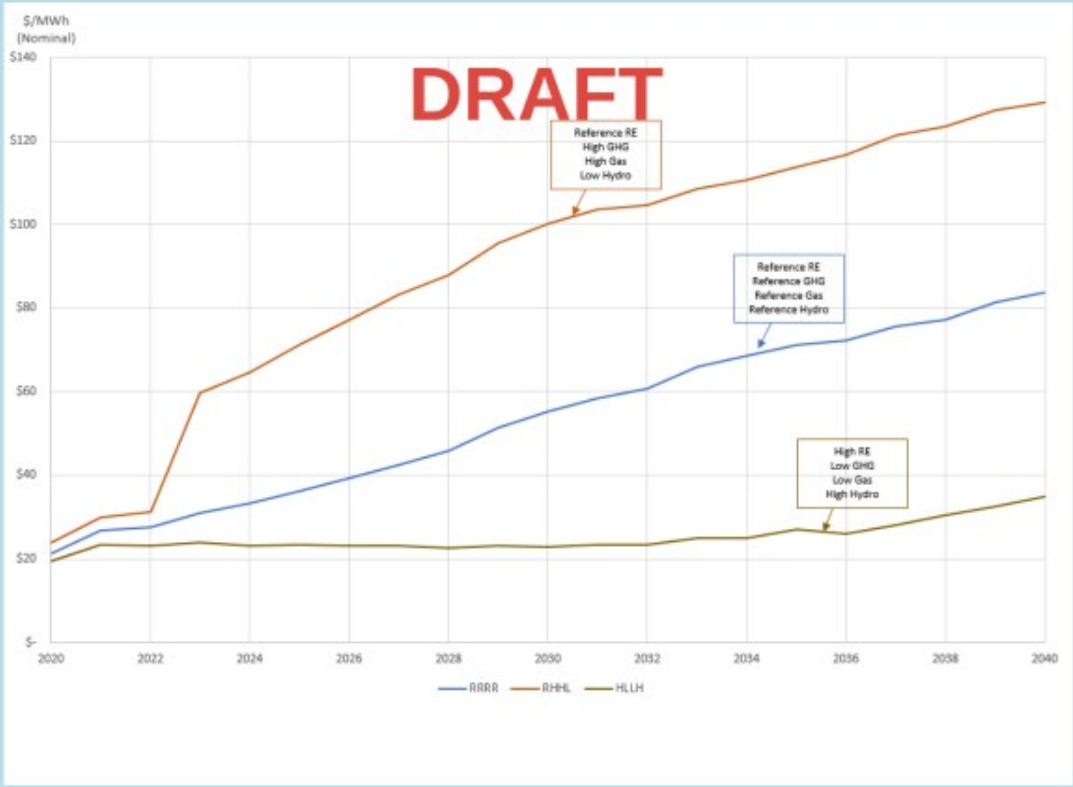
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference RE
Reference GHG
High Gas
Reference Hydro
Reference RE
Reference GHG
Reference Gas
Reference Hydro
Reference RE
Reference GHG
Low Gas
Reference Hydro
RRRR
RRHR
RRLR

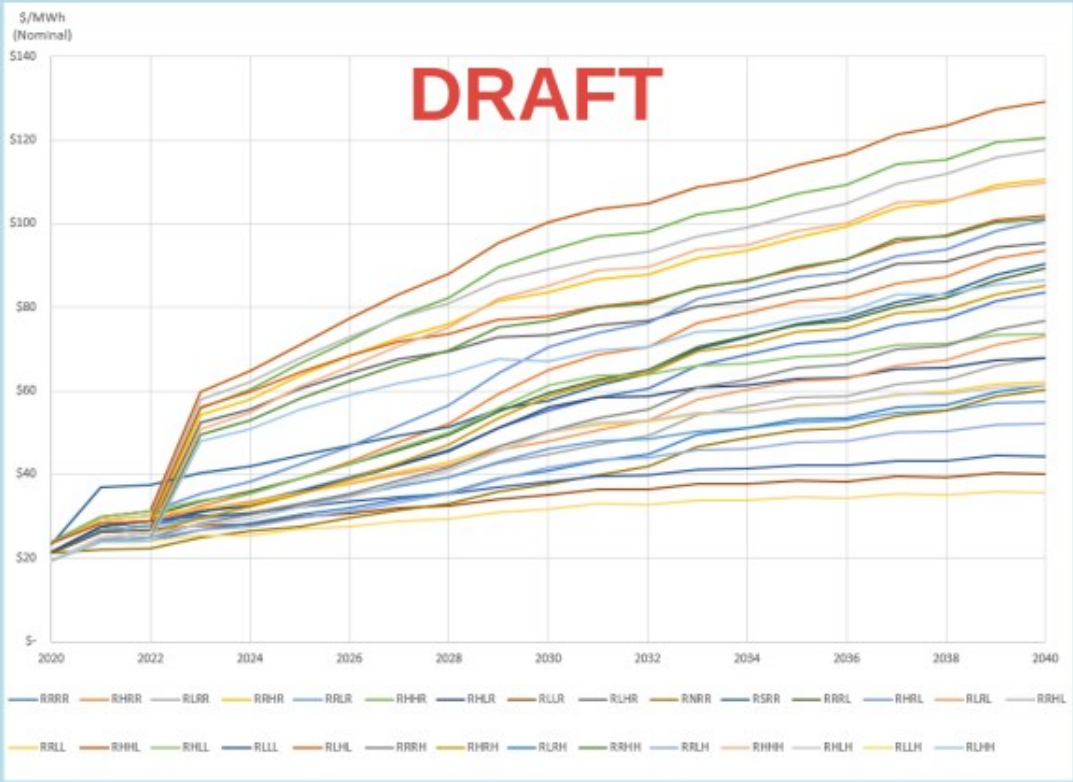
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference RE
Reference GHG
Reference Gas
Reference Hydro
Reference RE
High GHG
High Gas
Low Hydro
High RE
Low GHG
Low Gas
High Hydro
RRRR
RRRL
RRRH

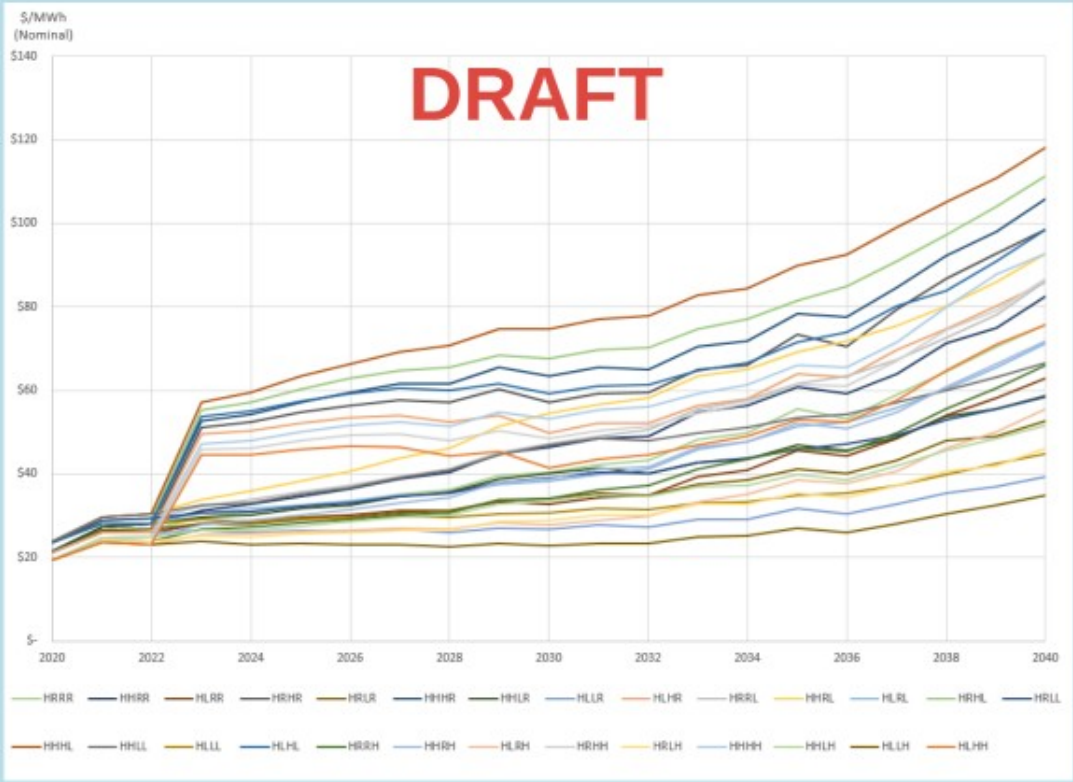
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Reference RE
High GHG
High Gas
Low Hydro
Reference RE
Reference GHG
Reference Gas
Reference Hydro
High RE
Low GHG
Low Gas
High Hydro
RRRR
RHHL
HLLH

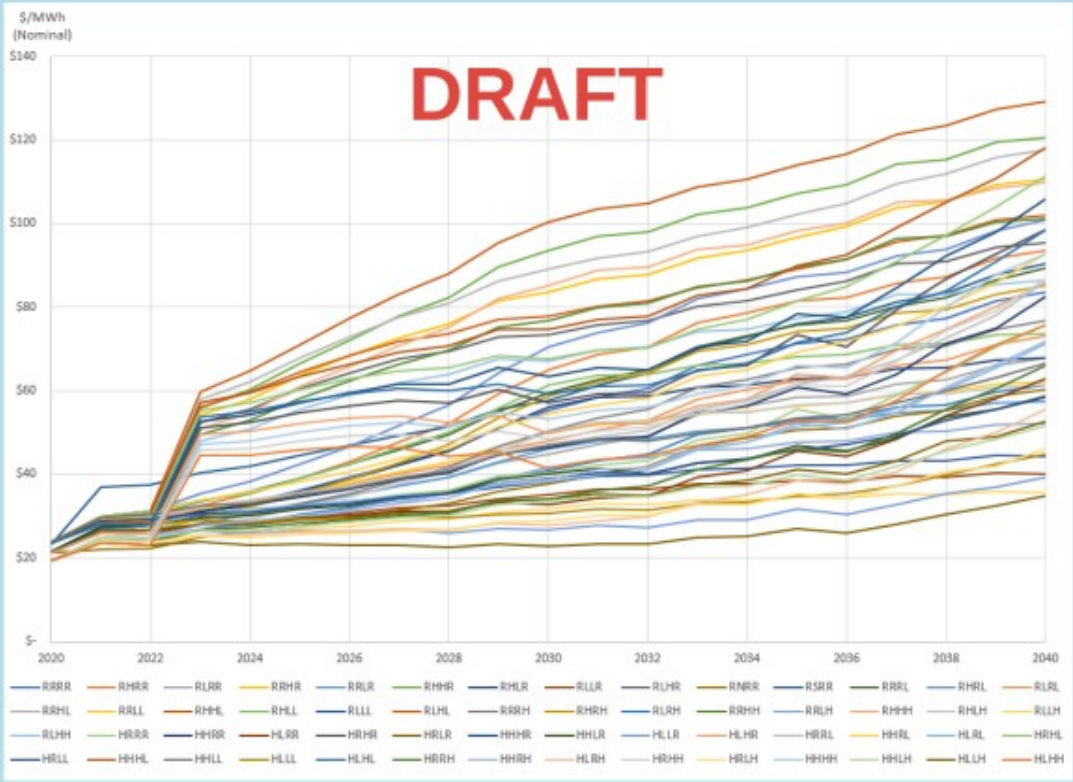
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
RRRR
RHRR
RLRR
RRHR
RRLR
RHHR
RHLR
RLLR
RLHR
RNRR
RSRR
RRRL
RHRL
RLRL
RRHL
RRLL
RHHL
RHLL
RLLL
RLHL
RRRH
RHRH
RLRH
RRHH
RRLH
RHHH
RHLH
RLLH
RLHH

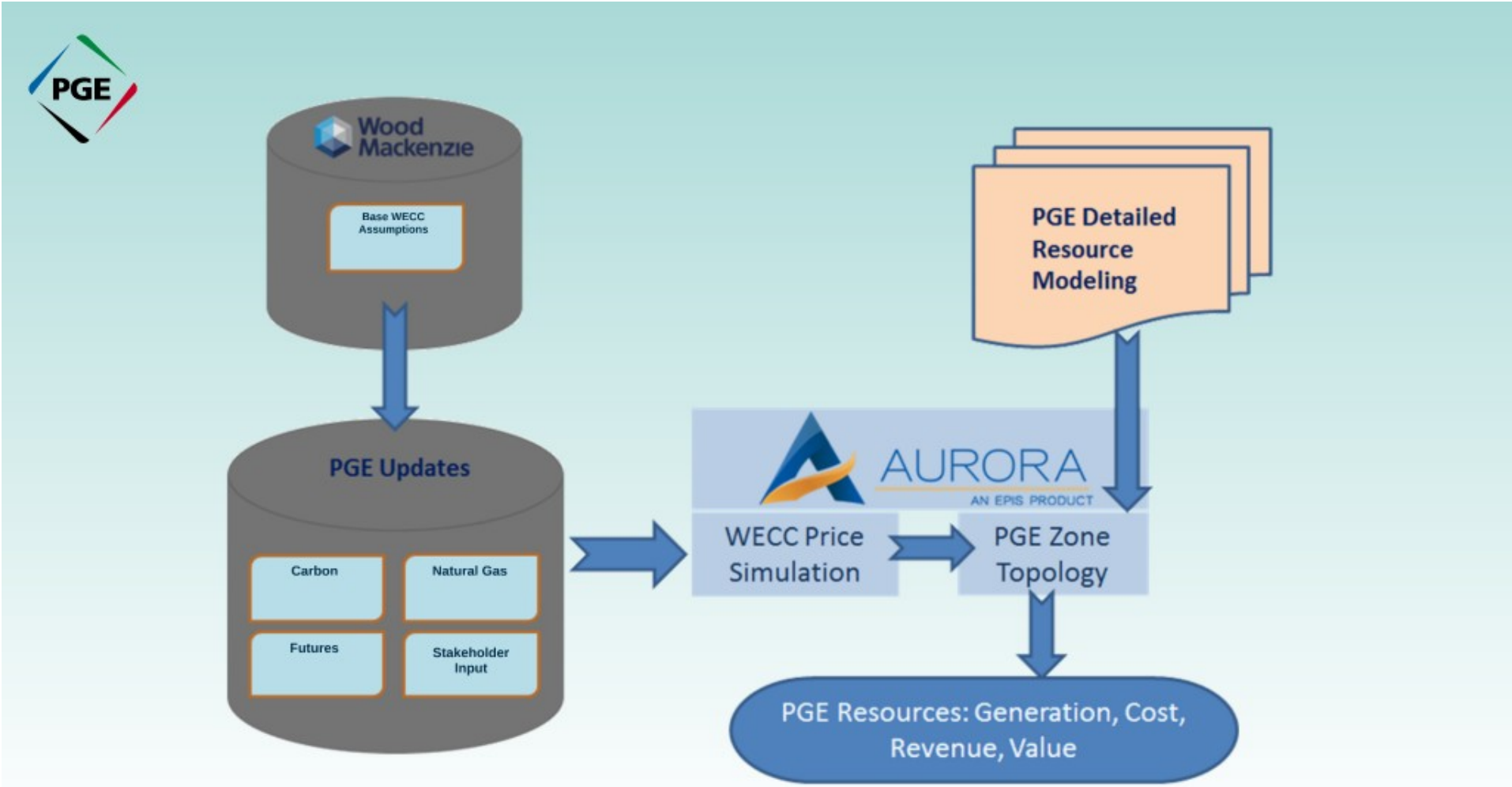
Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
HRRR
HHRR
HLRR
HRHR
HRLR
HHHR
HHLR
HLLR
HLHR
HRRL
HHRL
HLRL
HRHL
HRLL
HHHL
HHLL
HLLL
HLHL
HRRH
HHRH
HLRH
HRHH
HRLH
HHHH
HHLH
HLLH
HLHH

Futures


$/MWh
(Nominal)
DRAFT
$140
$120
$100
$80
$60
$40
$20
$-
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
RRRR
RHRR
RLRR
RRHR
RRLR
RHHR
RHLR
RLLR
RLHR
RNRR
RSRR
RRRL
RHRL
RLRL
RRHL
RRLL
RHHL
RHLL
RLLL
RLHL
RRRH
RHRH
RLRH
RRHH
RRLH
RHHH
RHLH
RLLH
RLHH
HRRR
HHRR
HLRR
HRHR
HRLR
HHHR
HHLR
HLLR
HLHR
HRRL
HHRL
HLRL
HRHL
HRLL
HHHL
HHLL
HLLL
HLHL
HRRH
HHRH
HLRH
HRHH
HRLH
HHHH
HHLH
HLLH
HLHH

Stakeholder Input


PGE
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