ENERGY SECURITY BOARD

POST 2025 FUTURE MARKET PROGRAM

TECHNICAL FOCUS GROUP

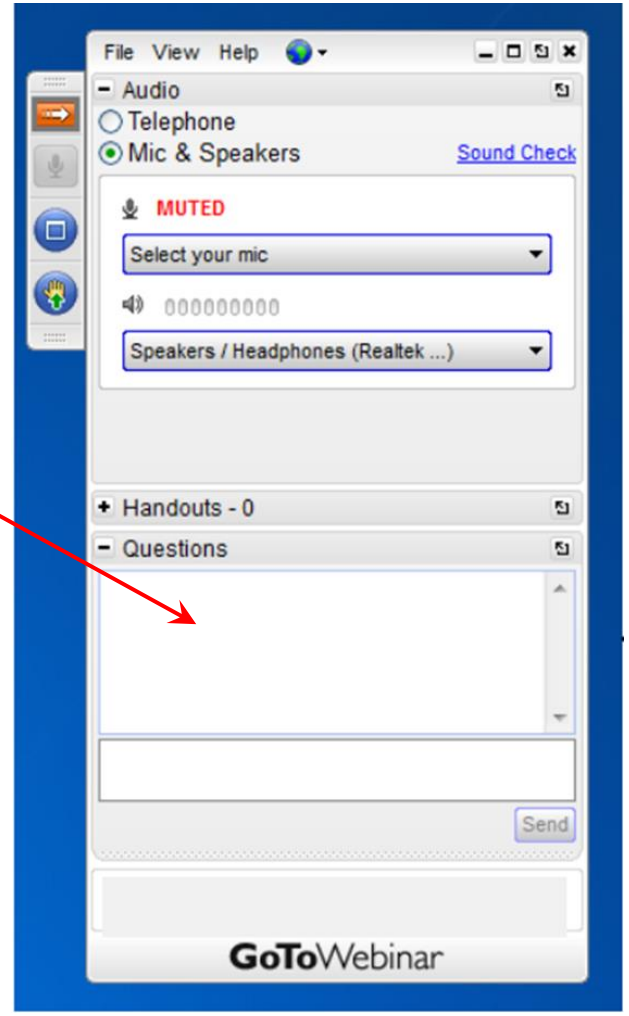
AHEAD MARKETS – MEETING #5 – OPTIONAL KNOWLEDGE SHARING SESSION – 25 AUG 2020

IMPORTANT NOTES

- These slides are solely for workshop purposes only. The content provides general information to support informed stakeholder engagement and feedback.
- The presentation does not represent the official position of the Energy Security Board or any related body.
- The webinar is being recorded and a link to the recording will be provided after the webinar.
- All previous webinar recordings and slides are available here for your reference.

WEBINAR-WORKSHOP LOGISTICS

- All participants are currently in listen-only mode
- We will pause at the end of each page where you see the symbol to answer questions. Please:
  - Type your questions here as we proceed through the content (double-check before sending); and/or,
  - Use the *Raised Hand* to signal that you would like to speak when we open the audio.



AGENDA

- Opening Remarks
- Model based demonstration of standard ahead market process
- Q&A

OPENING REMARKS

PURPOSE OF THIS SESSION

- We presented an ahead market design for system services without a real-time market last week.
- In the next main technical working group session we will cover ahead market design for system services that can be traded in the real-time market (i.e., the more “standard” ahead market design)
- While different products (energy and system services) could be traded in the more standard ahead market, they share similar features and high-level process.
- The purpose of this optional session is to provide attendees with a more detailed, modelling-based overview of the standard ahead market process.
- This is to ensure that participants will have the same base-level of understanding on the key concepts and processes around the more standard ahead market design, in order to facilitate the discussion in future sessions.

WHAT THE EXAMPLE WILL LOOK LIKE

- The worked example will cover the following:
  - Bids and offers
  - Scheduling and pricing
  - Real-time operation and settlement

- We will use energy in our worked example as it is the most familiar product for NEM participants.

- While we have presented “use cases” for an ahead market for energy in a previous workshop, this worked example is not intended to assess the benefit or cost of having an ahead market for energy.

STANDARD AHEAD MARKET PROCESS

- Model setup and methodology
- The base case
- Supply outage shock
- High wind output shock

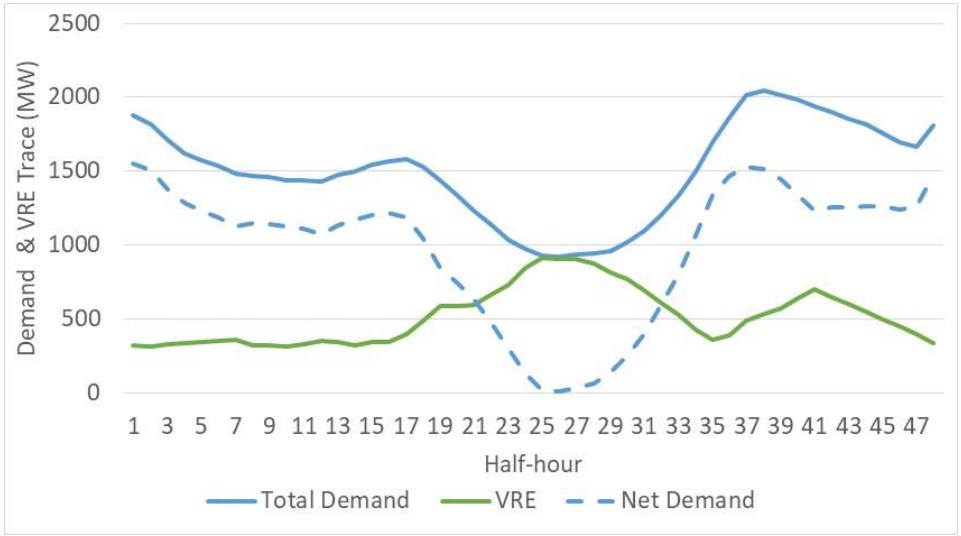
MODEL SETUP – THE SYSTEM

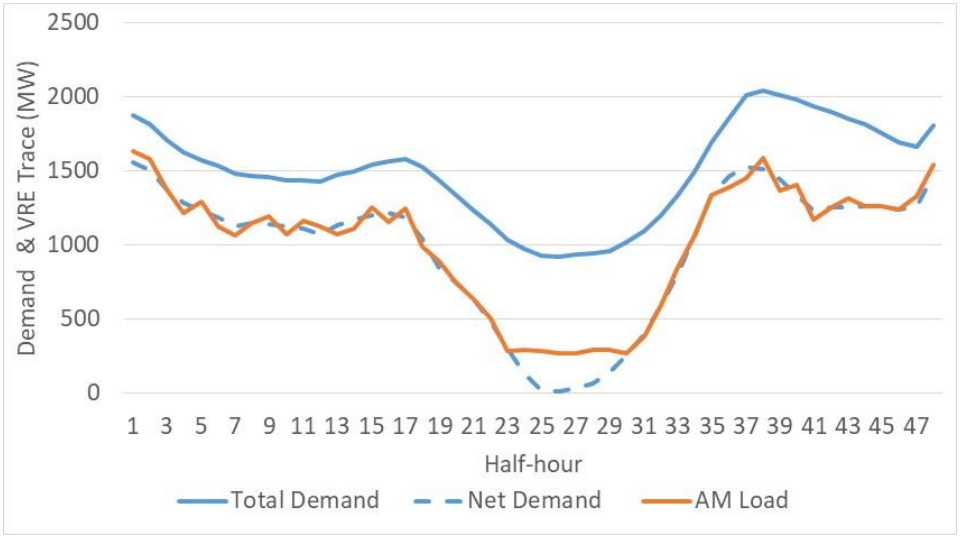
- Model a stand-alone region without interconnector for a day, with max. demand ~ 2000 MW.
- Mixture of baseload, cycling, peaker and VRE plant as summarised below.
- In addition, also incorporated ramping and minimum on/off constraint.
- Voluntary participation in AM – only black coal and CCGT assumed to participate in AM.
- All plant offer into real-time market as per current NEM.

Plant	Participate in Ahead Market?	Capacity (MW)	Min Gen (MW)	SRMC ($/MWh)	Start up cost ($)
2 x black coal	Yes	310 – 320	120	46 - 51	50,000
3 x CCGT		240 – 260	80-100	72 - 88	5,000
4 x OCGT	No	200 – 220	20	150 - 180	10,000
PV & wind		Variable	NA	0	NA

MODEL SETUP – DEMAND IN THE AM

- Load also participates in the AM on a voluntary basis.
- For simplicity, we assume 95 – 105% of net load (total – VRE) bid into the ahead market (more on next slide).
- The exception is in mid-day where we assumed a bit more load is offered into AM (but at very low price, see later) to simplify modelling.





MODELLING METHODOLOGY – BID AND OFFER

Generation offer

- Assume offers are cost based.
- In RT:
  - Generators offer their entire capacity at SRMC.
- In AM:
  - Generators offer their start-up cost.
  - Capacity is offered at SRMC.

Load bid

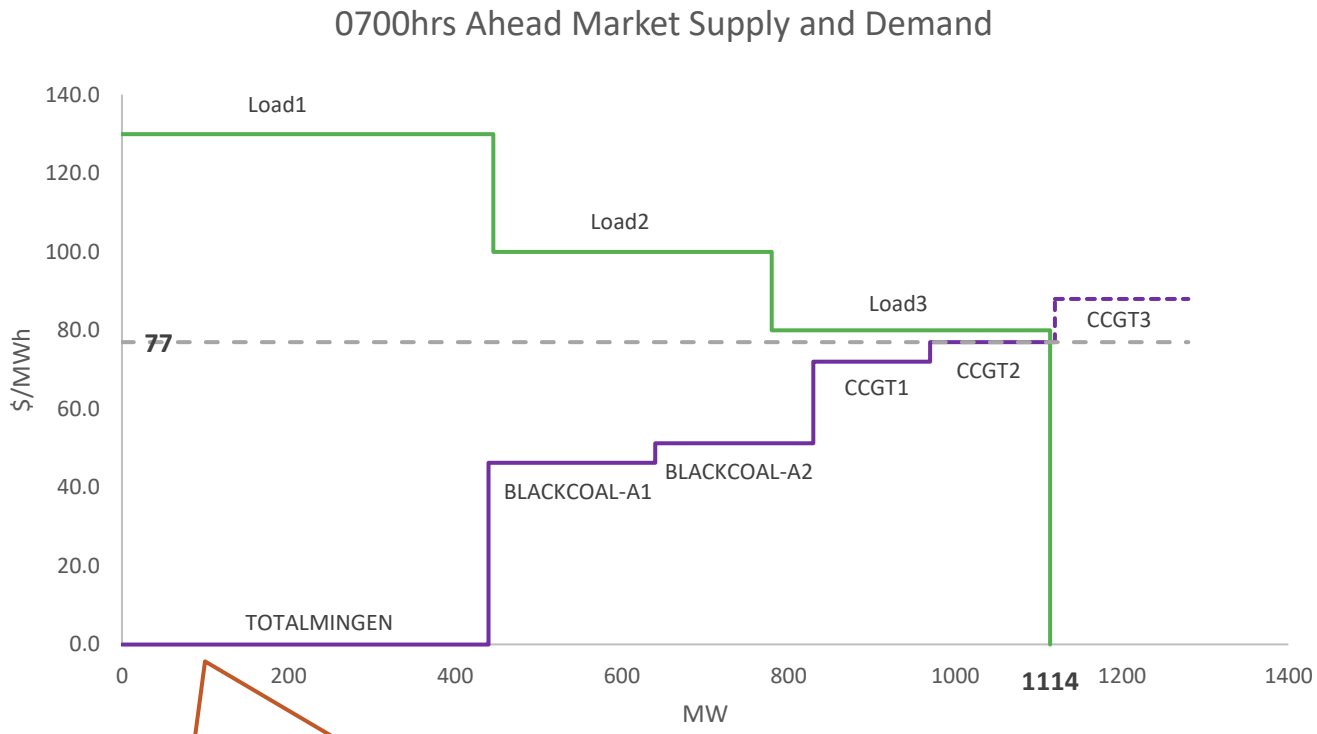
- In RT:
  - Load is treated as inflexible (i.e. modelled as vertical demand curve for each HH)
- In AM:
  - Load has explicit bid prices into the market, based on expected RT prices (informed by preliminary iteration) plus a small premium
  - This mimics the behaviour of “virtual traders” that closes AM and RT gap
  - As the AM is a two-sided market, load bids can set prices

TWO-SIDED VOLUNTARY PARTICIPATION IN AM – SUPPLY SETS PRICE

Price setter

ID	Quantity	MinGen	Bid/Offer	Cleared Quantity
BLACKCOAL-A1	320.0	120.0	46.3	320.0
BLACKCOAL-A2	310.0	120.0	51.3	310.0
CCGT1	240.0	100.0	72.0	240.0
CCGT2	250.0	100.0	77.0	244.1
CCGT3	260.0	100.0	88.0	0.0
LOAD1	445.6	NA	130.0	445.6
LOAD2	334.2	NA	100.0	334.2
LOAD3	334.2	NA	80.0	334.2

Not cleared



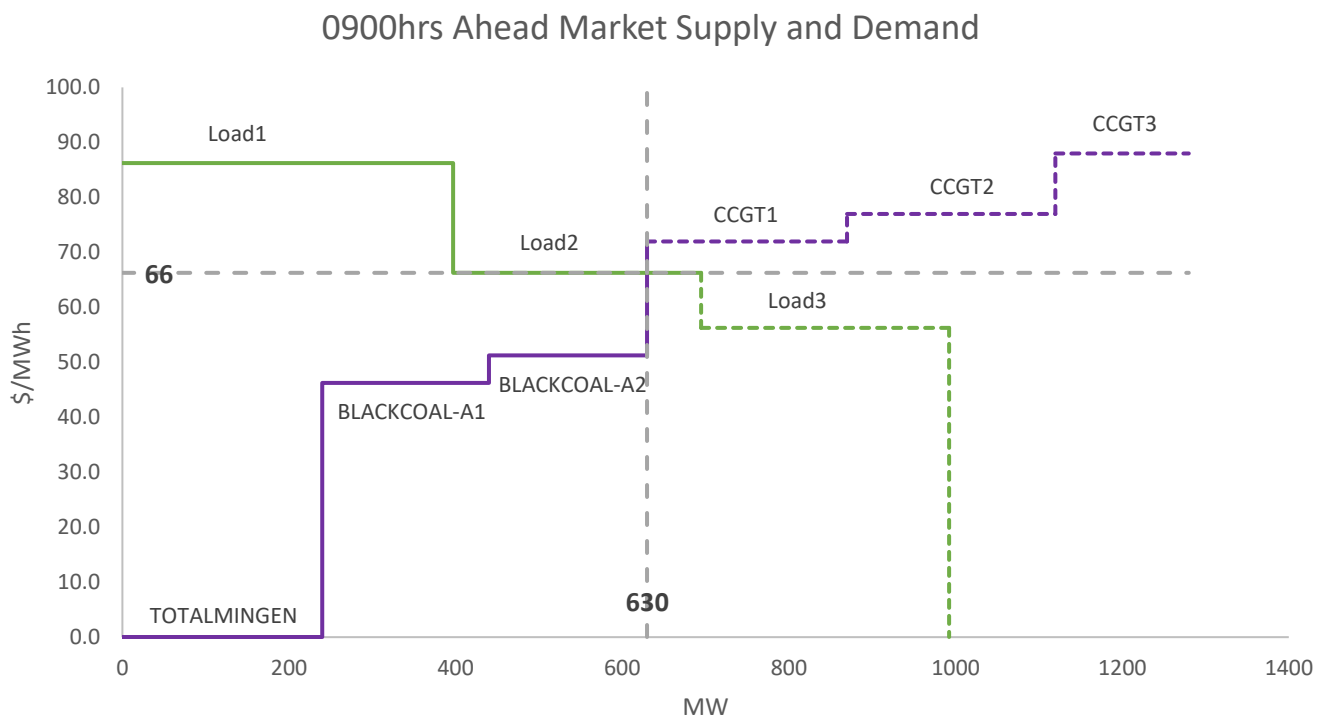
Once unit commitment decision is made, “committed” min-gen capacity is treated as fixed and is not involved in price setting.

TWO-SIDED VOLUNTARY PARTICIPATION IN AM – LOAD SETS PRICE

Not cleared

ID	Quantity	MinGen	Bid/Offer	Cleared Quantity
BLACKCOAL-A1	320.0	120.0	46.3	320.0
BLACKCOAL-A2	310.0	120.0	51.3	310.0
CCGT1	240.0	100.0	72.0	0.0
CCGT2	250.0	100.0	77.0	0.0
CCGT3	260.0	100.0	88.0	0.0
LOAD1	397.0	NA	86.3	397.0
LOAD2	297.8	NA	66.3	233.0
LOAD3	297.8	NA	56.3	0.0

Price setter



MODELLING METHODOLOGY – SCHEDULING AND FINANCIAL COMMITMENT

Ahead market run

- One single solve over 24 hours
- Maximise total surplus (given load bid into AM)
- Explicitly take into account of intertemporal decisions such as start, ramp, etc

Ahead schedule

- Ahead energy and price schedule for each generator and load participating in AM at every HH

RT commitment and output level up to participants and ***not*** constrained by AM schedule

Participants self-commitment in RT dispatch through PDS as now

Real-time market run

- Sequentially solve each HH separately (48 of them)
- End of last interval is starting point of current interval with ramping constraint applied
- Minimise total dispatch cost (given fixed load)

Real-time output

- Real time dispatch and prices for each generator at every HH

Settlement and Payoff

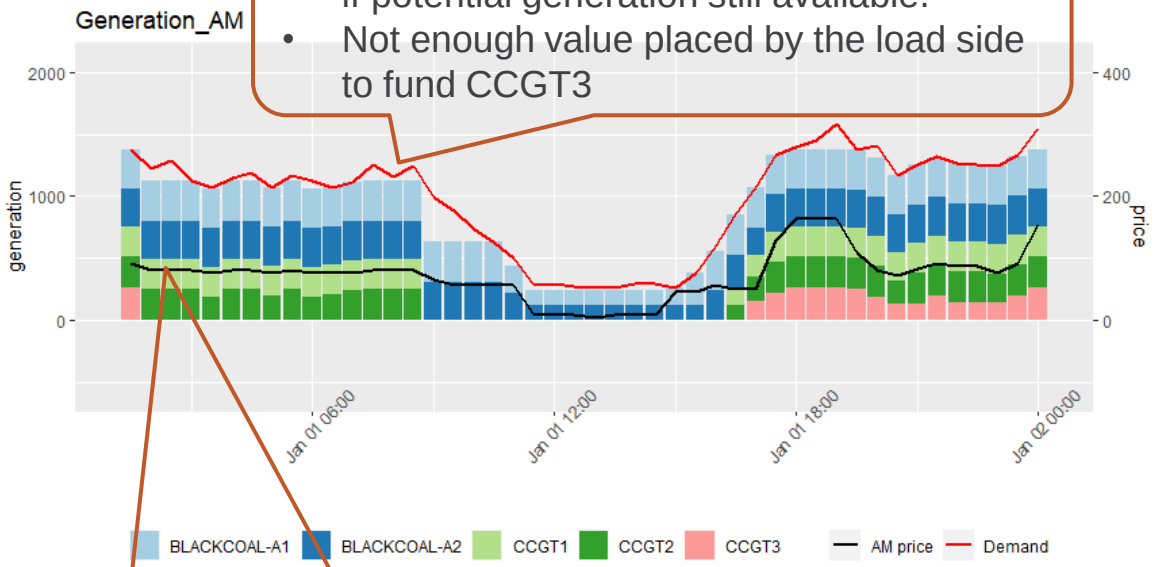
- Financial commitment – RT deviation from AM settled at RT prices
- Reflecting the actual cost incurred in real-time to supply the deviation quantity
- Final payoff to participants:

AM schedule X AM price **+** RT deviation X RT price **−** Operating cost (including start up and generation costs)

BASE CASE – MODELLING RESULT

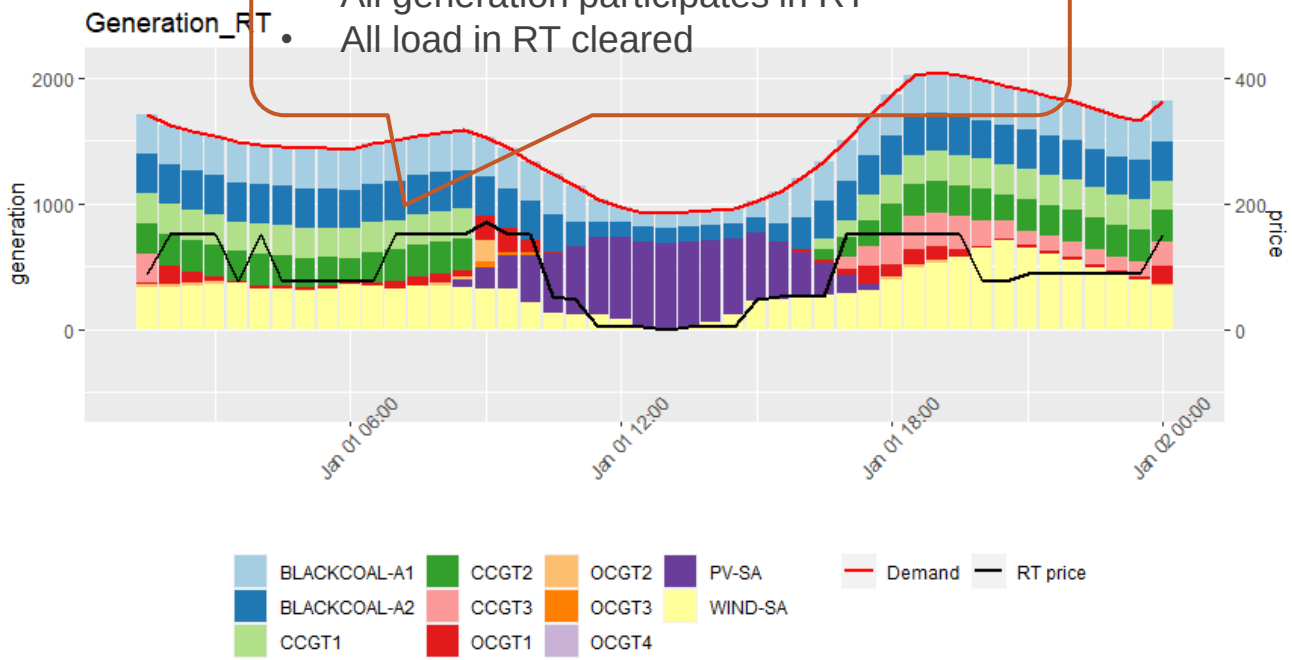
Charts showing ahead market schedule and prices (left) and real-time market output and prices (right)

- Not all load bid into AM gets cleared even if potential generation still available.
- Not enough value placed by the load side to fund CCGT3



- Only a portion of total generation fleet and load participates in AM
- Ahead schedule only applies to participating gen and load

- All generation participates in RT
- All load in RT cleared

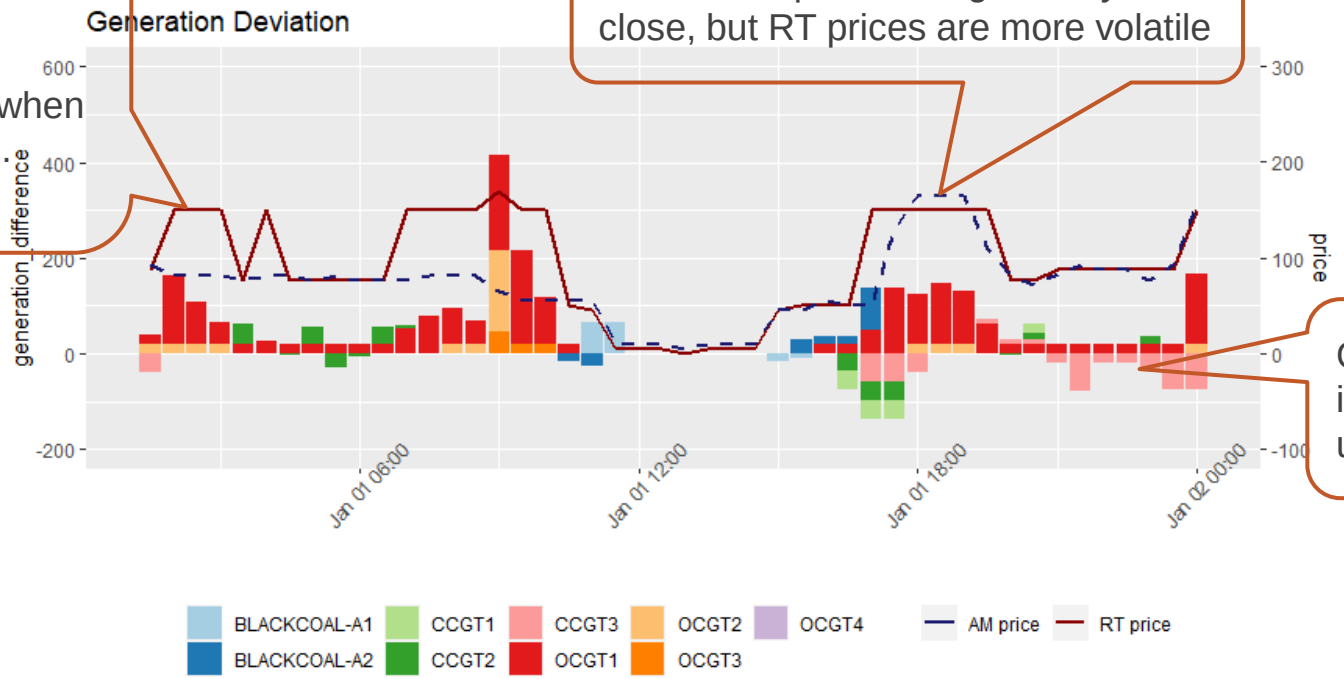


BASE CASE – MODELLING RESULT

Charts showing comparison of RT and AM outcome (VRE output not shown)

- RT prices signals scarcity value.
- Units generally increase (resp. decrease) output when RT price is greater (resp. lower) than their SRMC.

RT and AM prices are generally close, but RT prices are more volatile

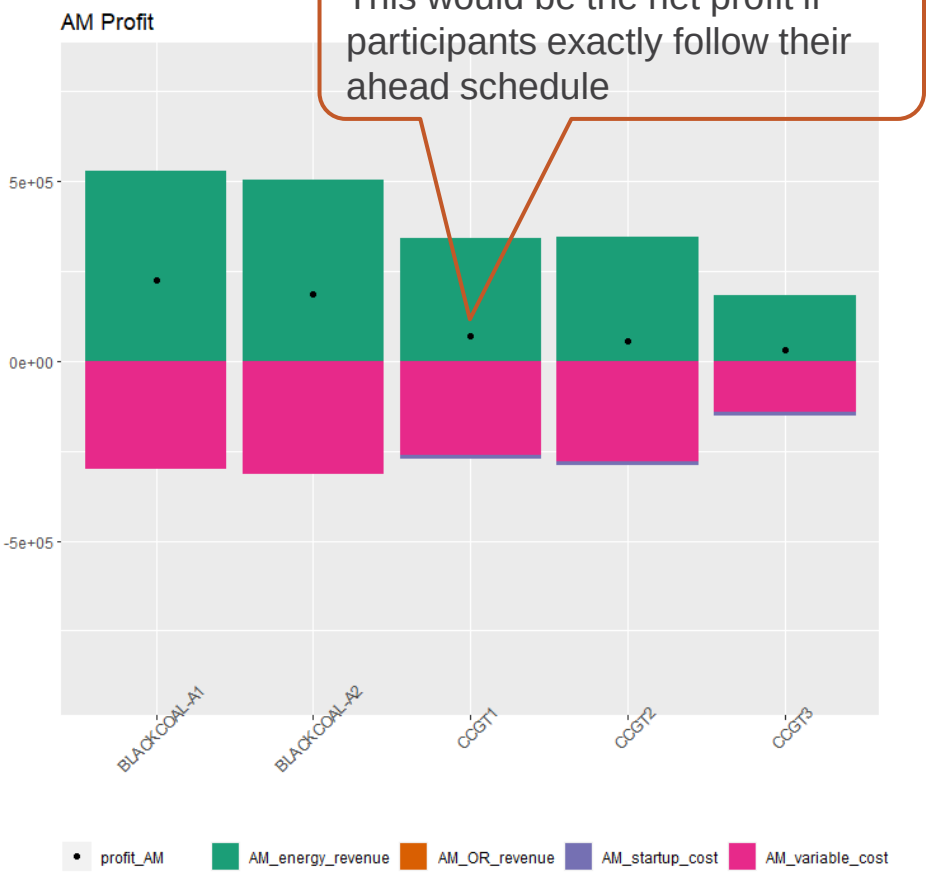


Generally small amount of deviation in RT in the base case without large unexpected shock in RT.

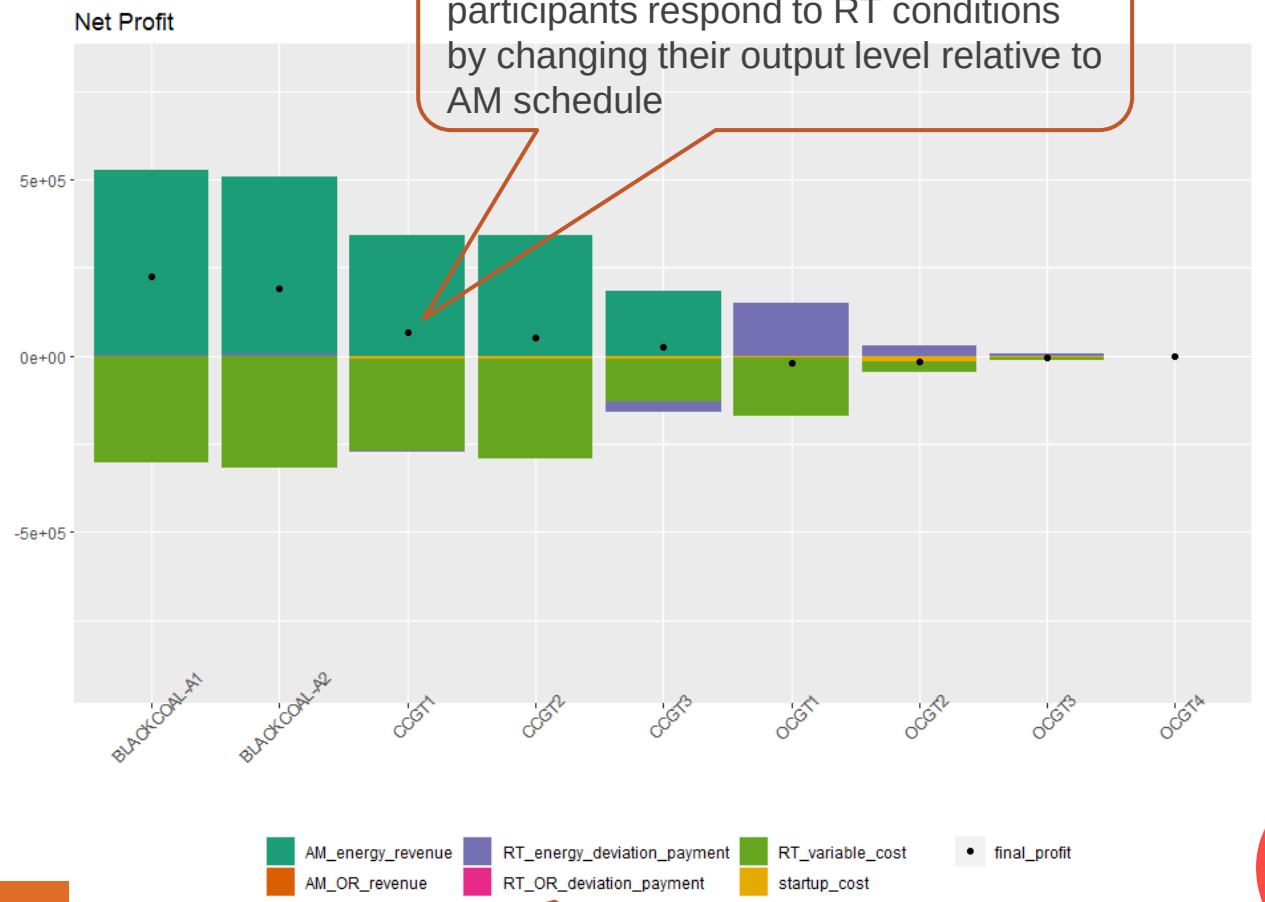
More detailed settlement process will be shown in “shock sensitivities”

BASE CASE – PROFIT AND PAYOFF

This would be the net profit if participants exactly follow their ahead schedule



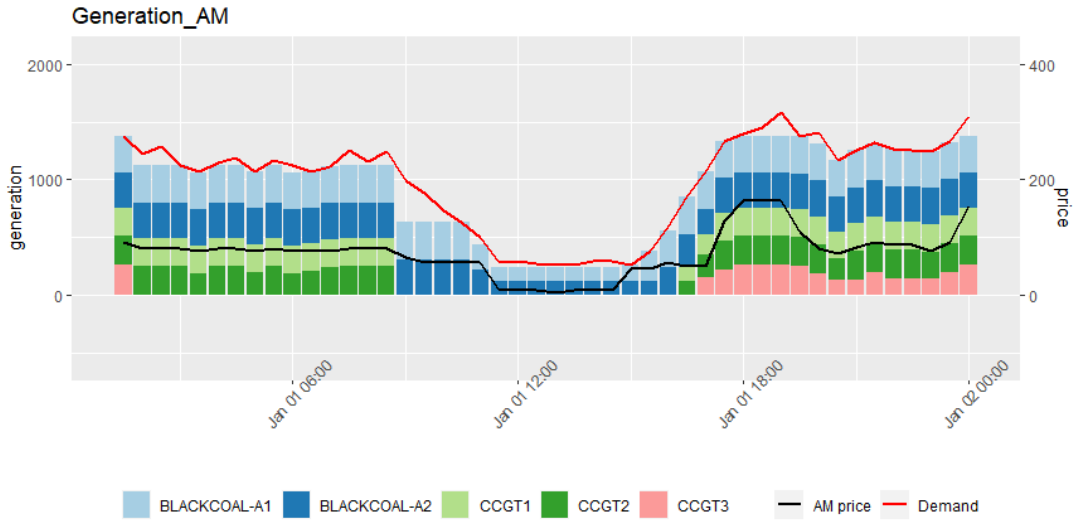
Actual net profit might differ as participants respond to RT conditions by changing their output level relative to AM schedule

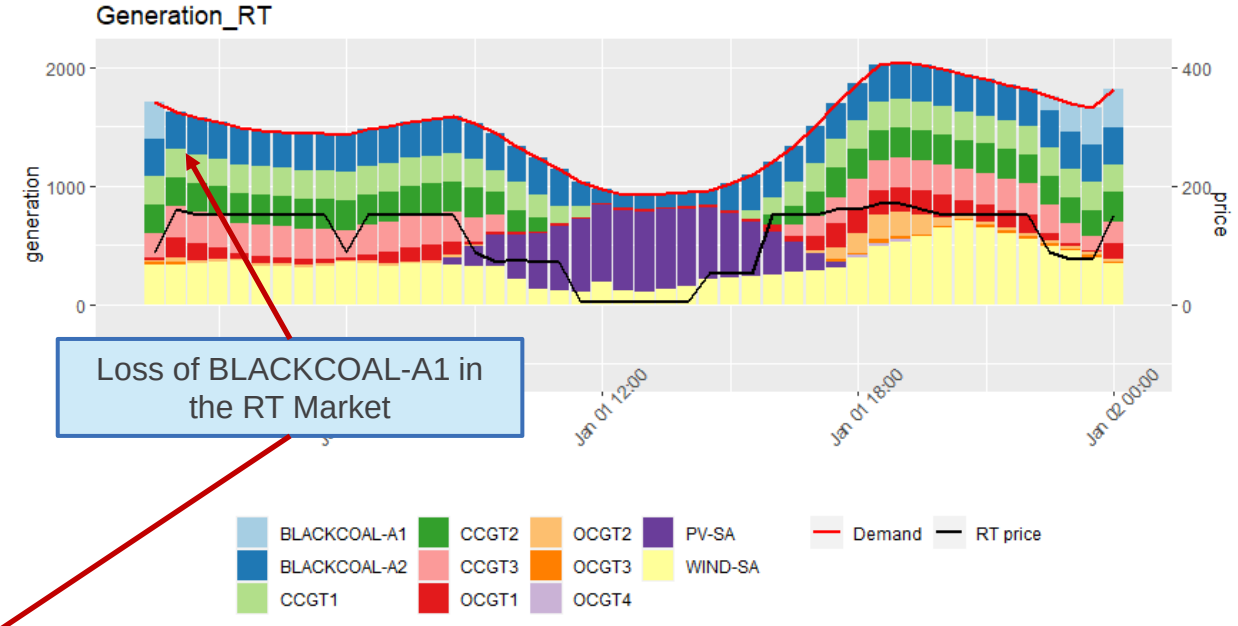


More detailed settlement process will be shown in “shock sensitivities”

* Note in this example we haven’t included operating reserve

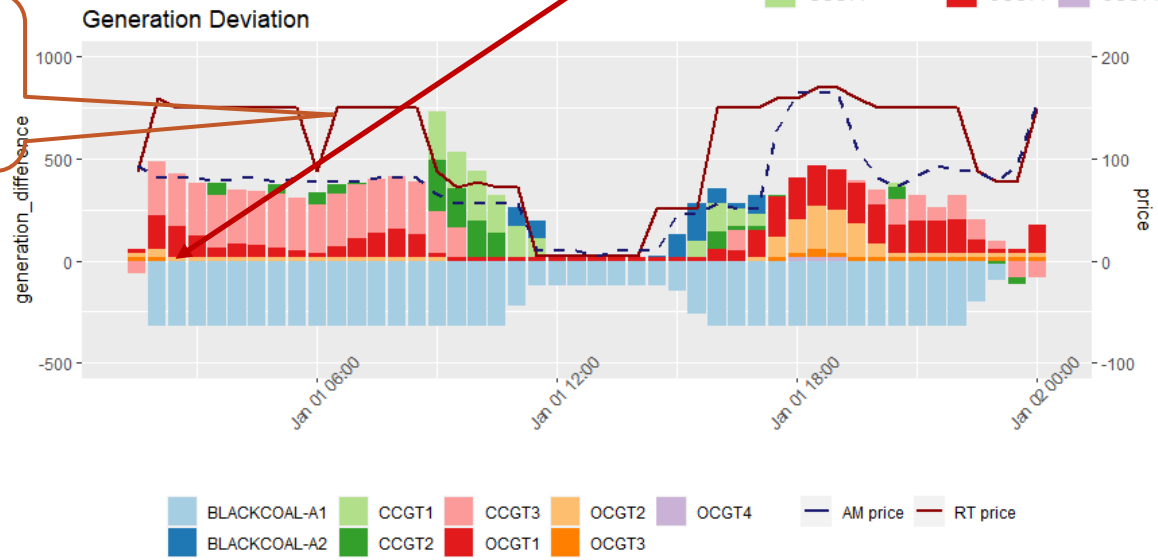
RT SHOCK #1: LOSS OF GENERATION SUPPLY – MODELLING RESULT





Loss of BLACKCOAL-A1 in the RT Market

In response to sustained high RT prices, other units including CCGTs with ahead schedules increase output

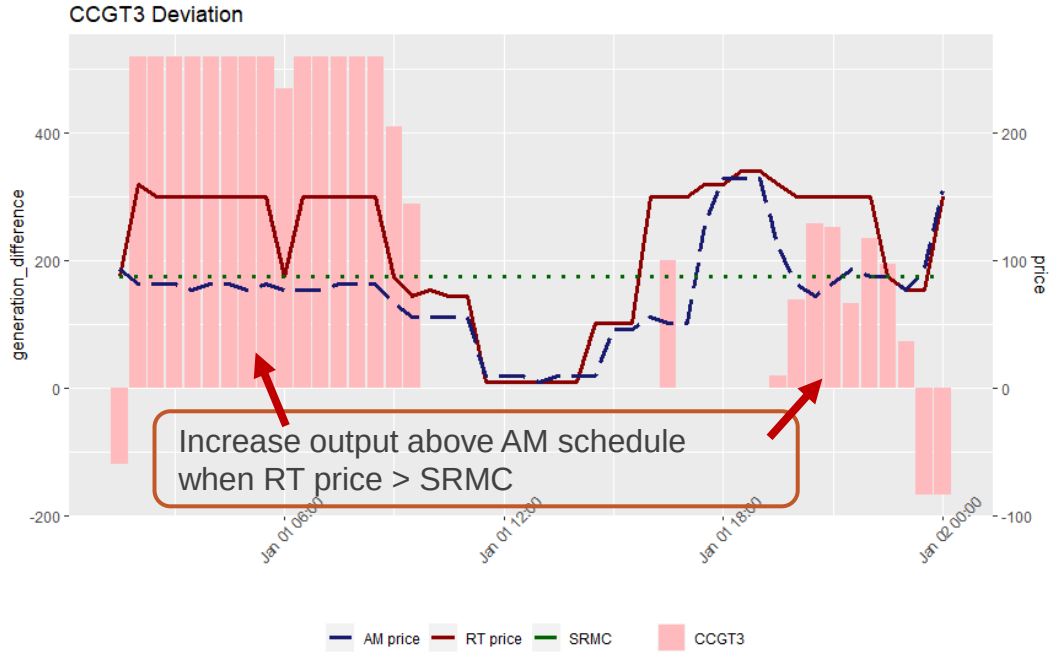


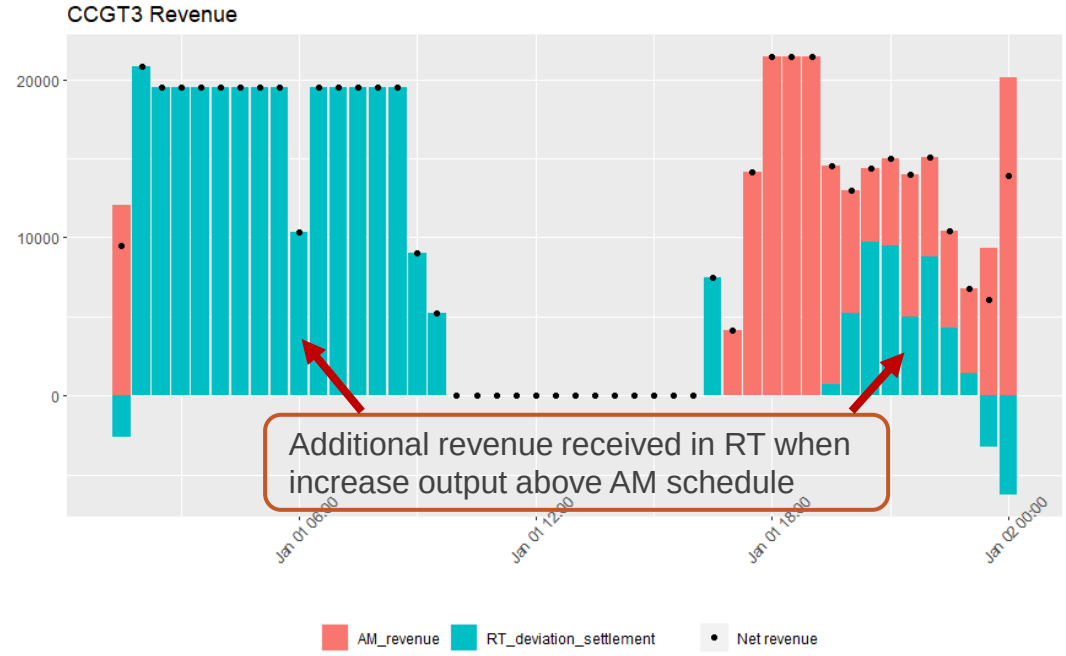
RT SHOCK #1: LOSS OF GENERATION SUPPLY – SETTLEMENT

We use CCGT 3 as an example to illustrate settlement effect

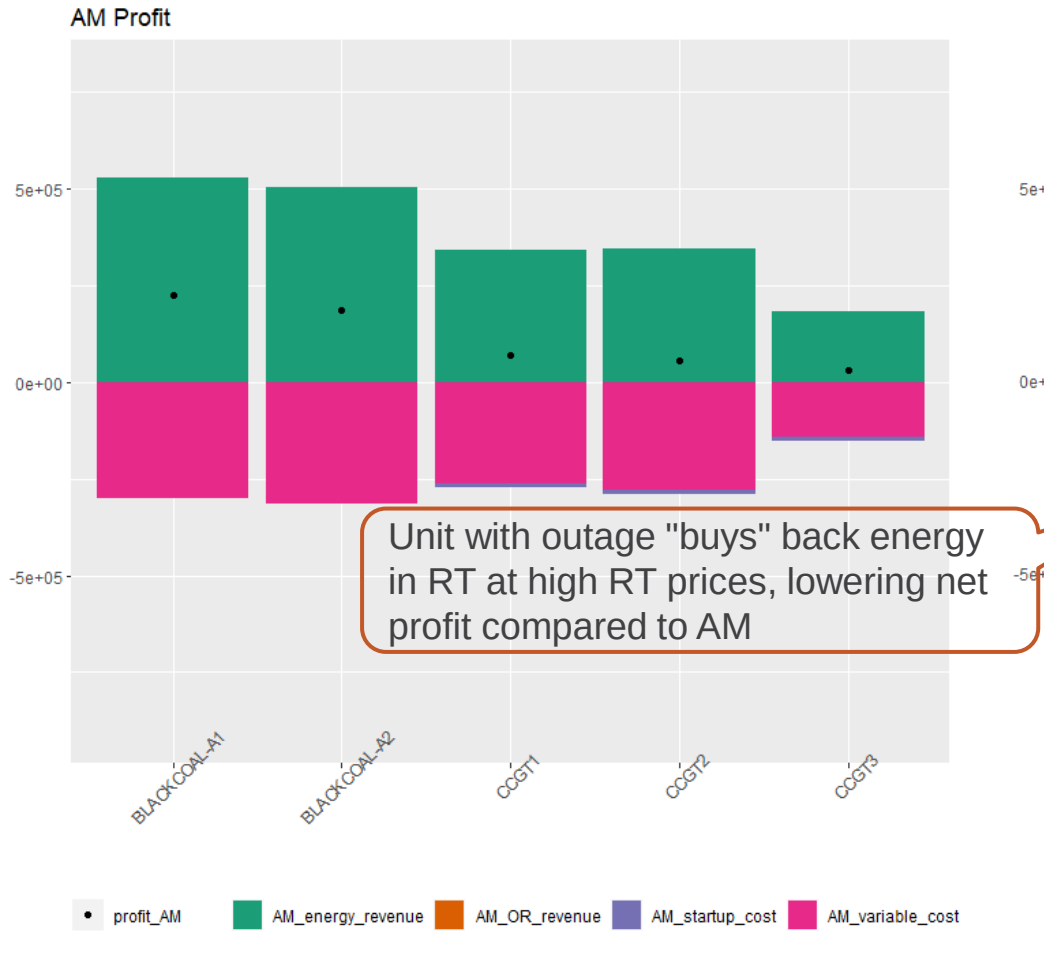
Recall Net revenue = AM price x AM schedule + RT price x RT deviation

Trading Interval	AM Schedule (MW)	AM Price ($/MWh)	AM Revenue ($)	RT Generation (MW)	RT Deviation (MW)	RT Price ($/MWh)	SRMC ($/MWh)	RT Revenue ($)	Net Revenue ($)
01:30	260	93	12,090	200	-60	88	88	-2,637	9,453
02:00	0	82	0	260	260	160	88	20,800	20,800
02:30	0	82	0	260	260	150	88	19,500	19,500
03:00	0	82	0	260	260	150	88	19,500	19,500





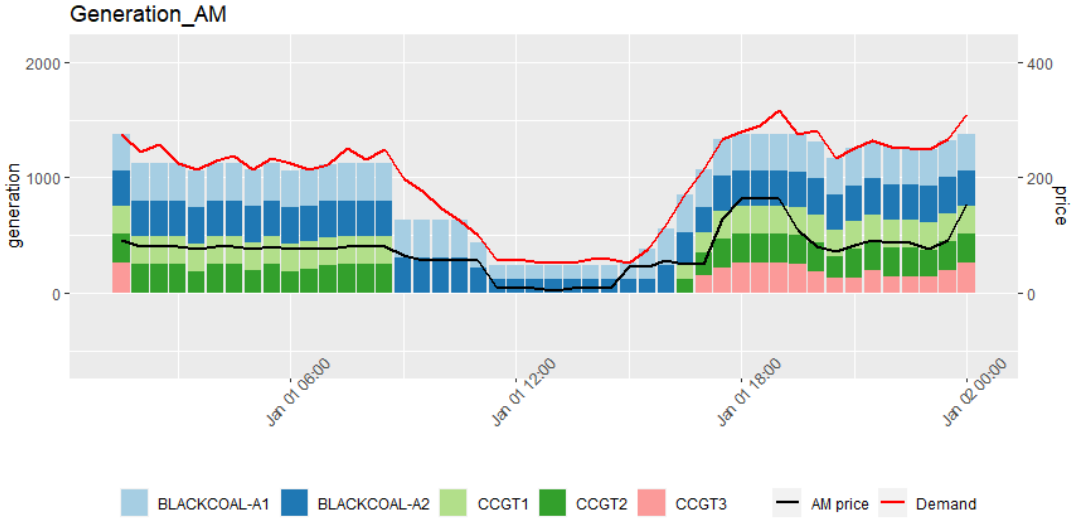
RT SHOCK #1: LOSS OF GENERATION SUPPLY – PROFIT AND PAYOFF

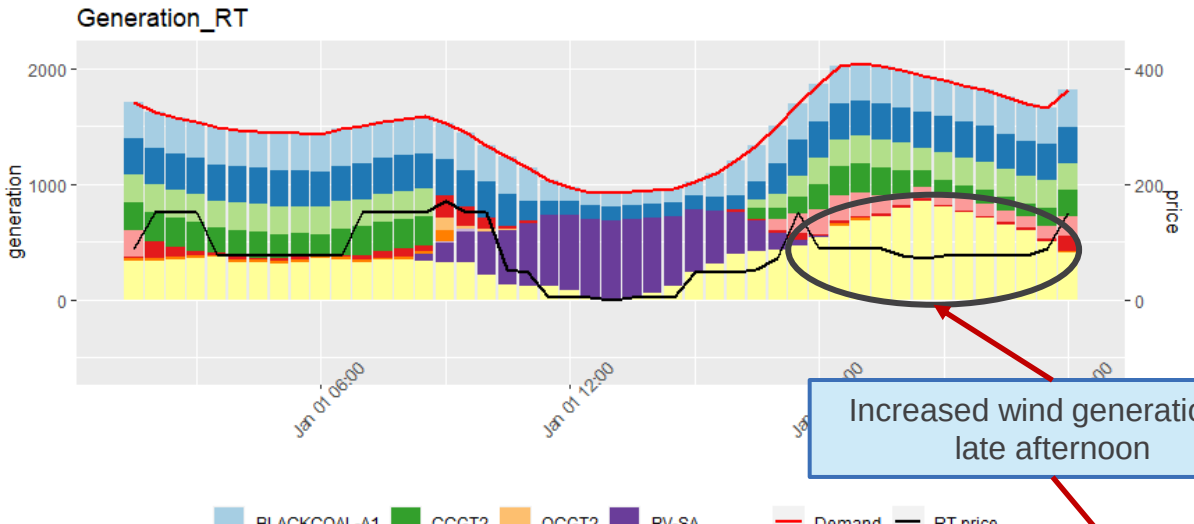


Unit with outage "buys" back energy in RT at high RT prices, lowering net profit compared to AM

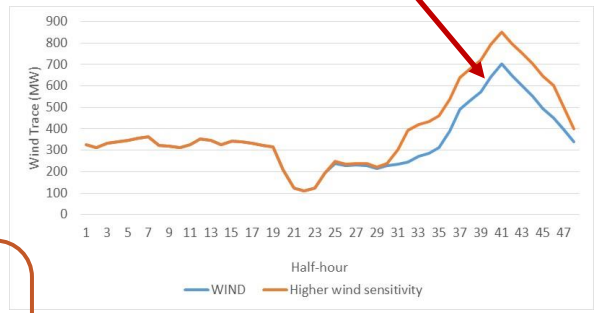
Some other units increase output to catch high RT prices and hence receive higher net profit

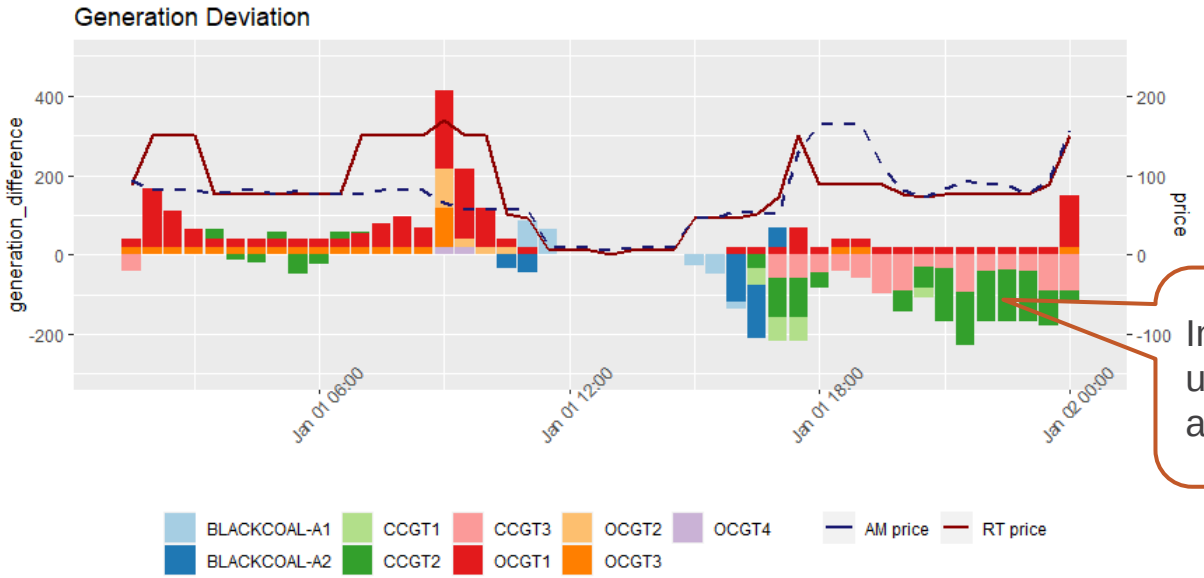
RT SHOCK #2: HIGHER THAN EXPECTED VRE – MODELLING RESULT





Increased wind generation in late afternoon





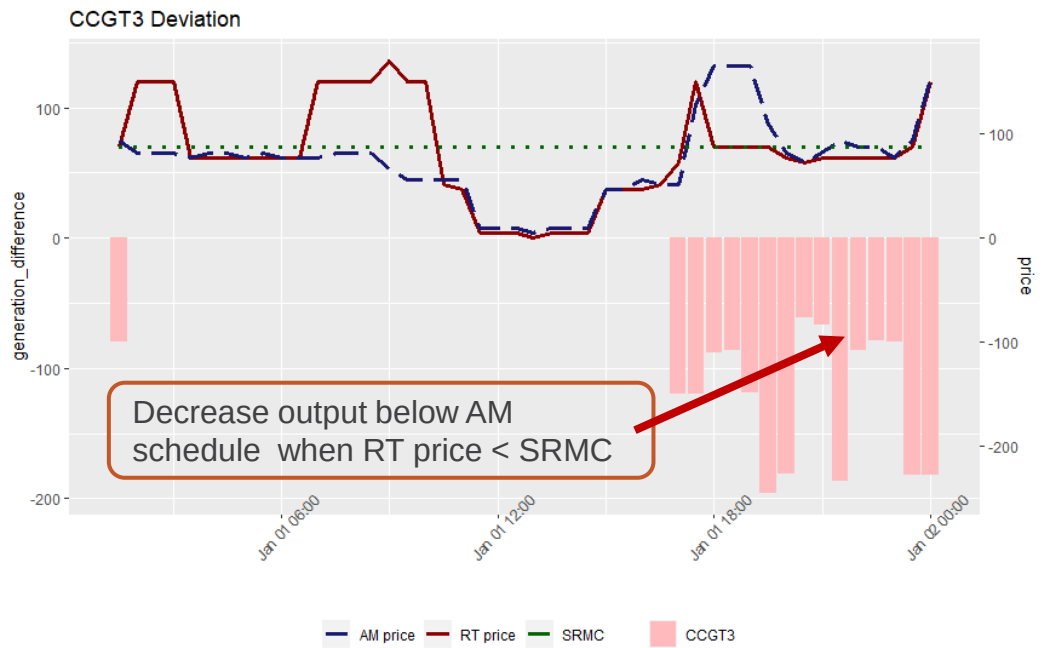
In response to low RT prices, units reduce output relative to ahead schedules

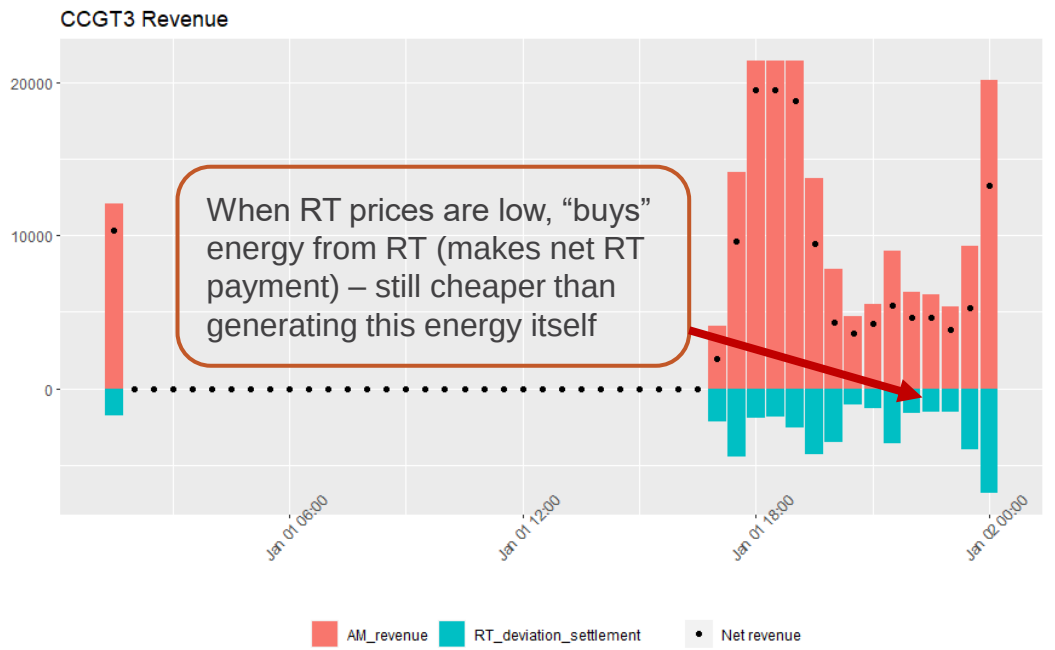
RT SHOCK #2: HIGHER THAN EXPECTED VRE – MODELLING RESULT

We use CCGT 3 as an example to illustrate settlement effect

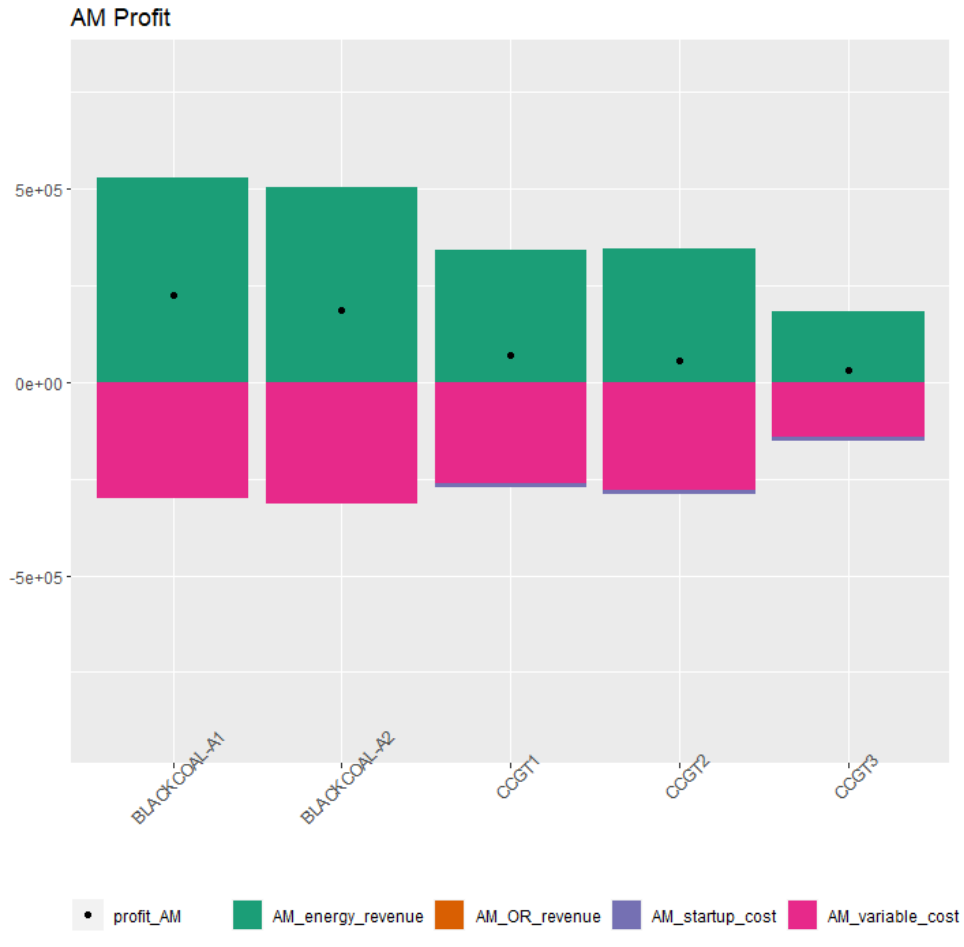
Recall Net revenue = AM price x AM schedule + RT price x RT deviation

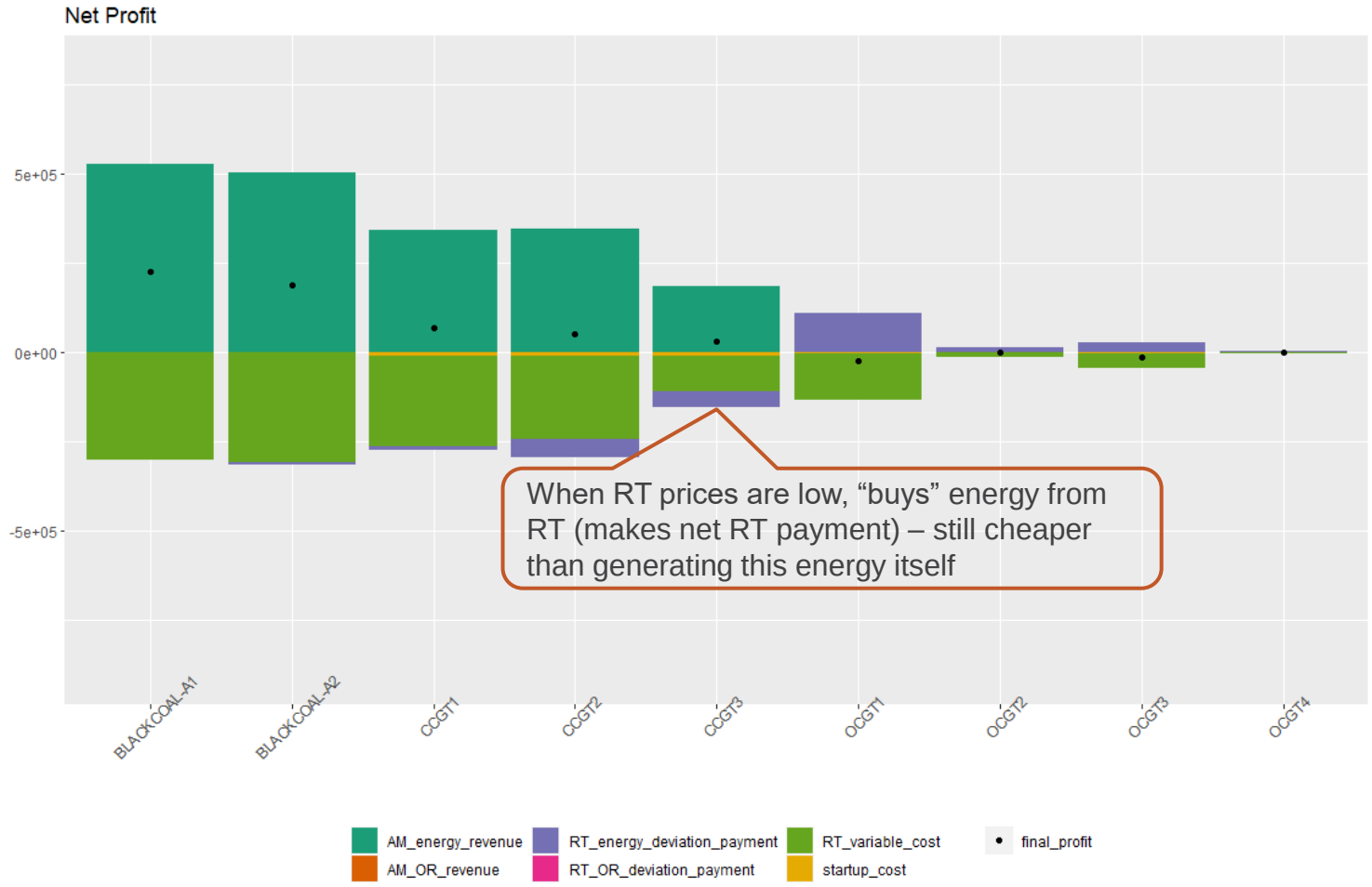
Trading Interval	AM Schedule (MW)	AM Price ($/MWh)	AM Revenue ($)	RT Generation (MW)	RT Deviation (MW)	RT Price ($/MWh)	SRMC ($/MWh)	RT Revenue ($)	Net Revenue ($)
19:00	260	165	21,450	201	-59	88	88	-2609	18,841
19:30	251	110	13,786	153	-98	88	88	-4306	9,481
20:00	191	82	7,817	100	-91	77	88	-3491	4,327
20:30	131	72	4,704	100	-31	72	88	-1104	3,600





RT SHOCK #2: HIGHER THAN EXPECTED VRE – PROFIT AND PAYOFF





Q&A