NZEM with 100% renewables

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Price discovery

How does price discovery work in a market where all generation has zero SRMC?

Overview

- Context: decarbonization
- Price discovery is currently imperfect.
- An approach to help fix this.
- How will this work with zero SRMC?

Context: the decarbonization problem

- Decarbonization needs lots of electricity.
- Many potential capacity/technology paths forward.
- Ideally commercial investment should drive growth in capacity.
- Covid response has decreased trust in markets to solve crises.
  - In a crisis people rely on the Government
  - NZ Battery a Government response
- 2030 is approaching rapidly.
- Resources could be scarce and supply chains fragile.
- Confidence in markets to solve the problem?

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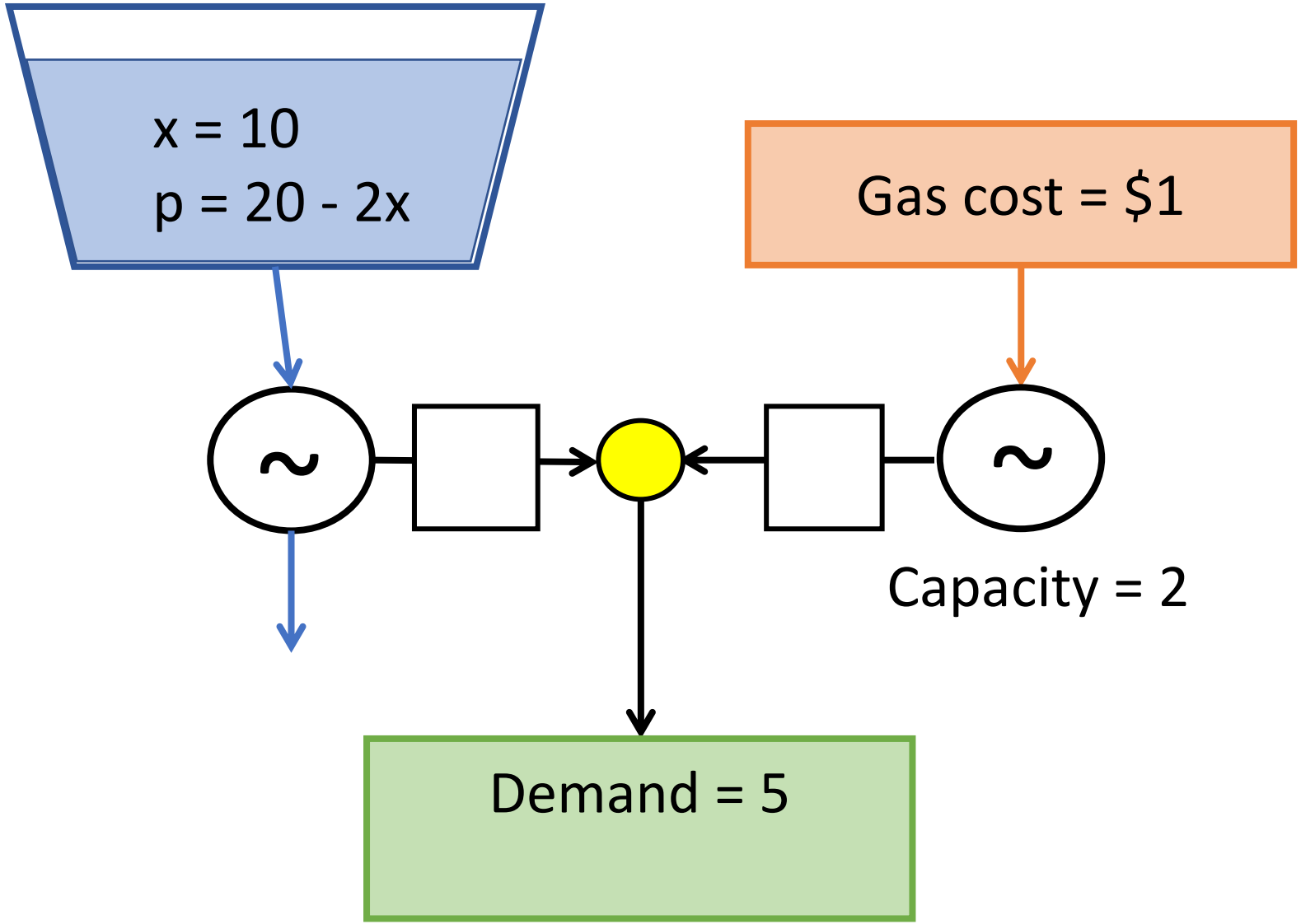
Price discovery is imperfect

- What price is the market supposed to discover?
- Prices in competitive equilibrium
  - Perfect competition?
  - Workable competition?
  - Something else?
- What prices does SPD discover?
  - Predispatch prices with forecast demand gives (irrational) target for offer prices.
  - Offers above SRMC converge to inefficient prices if a forecast overestimates true demand.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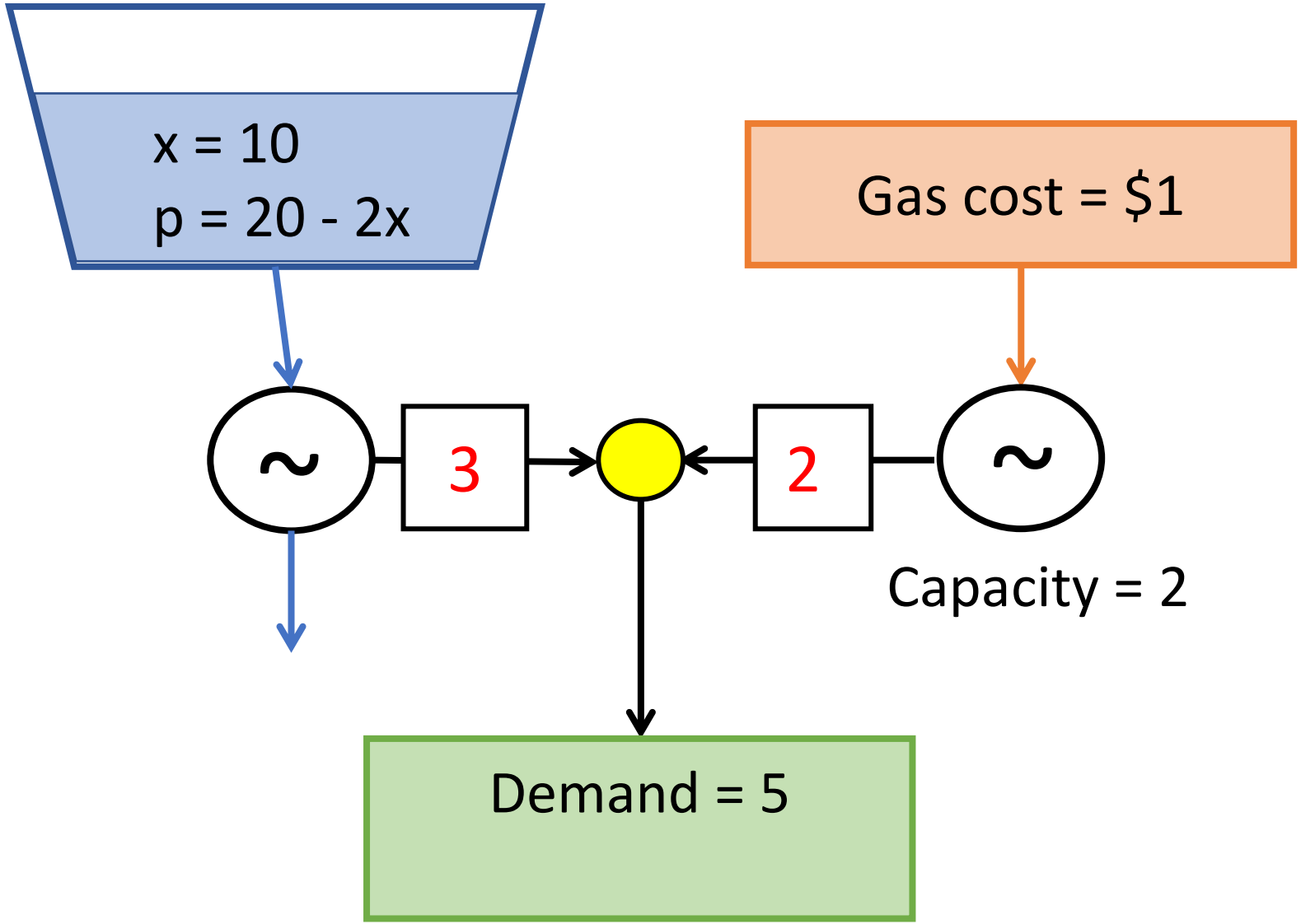
p = 20 - 2x
Gas cost = $1
Capacity = 2
Demand = 5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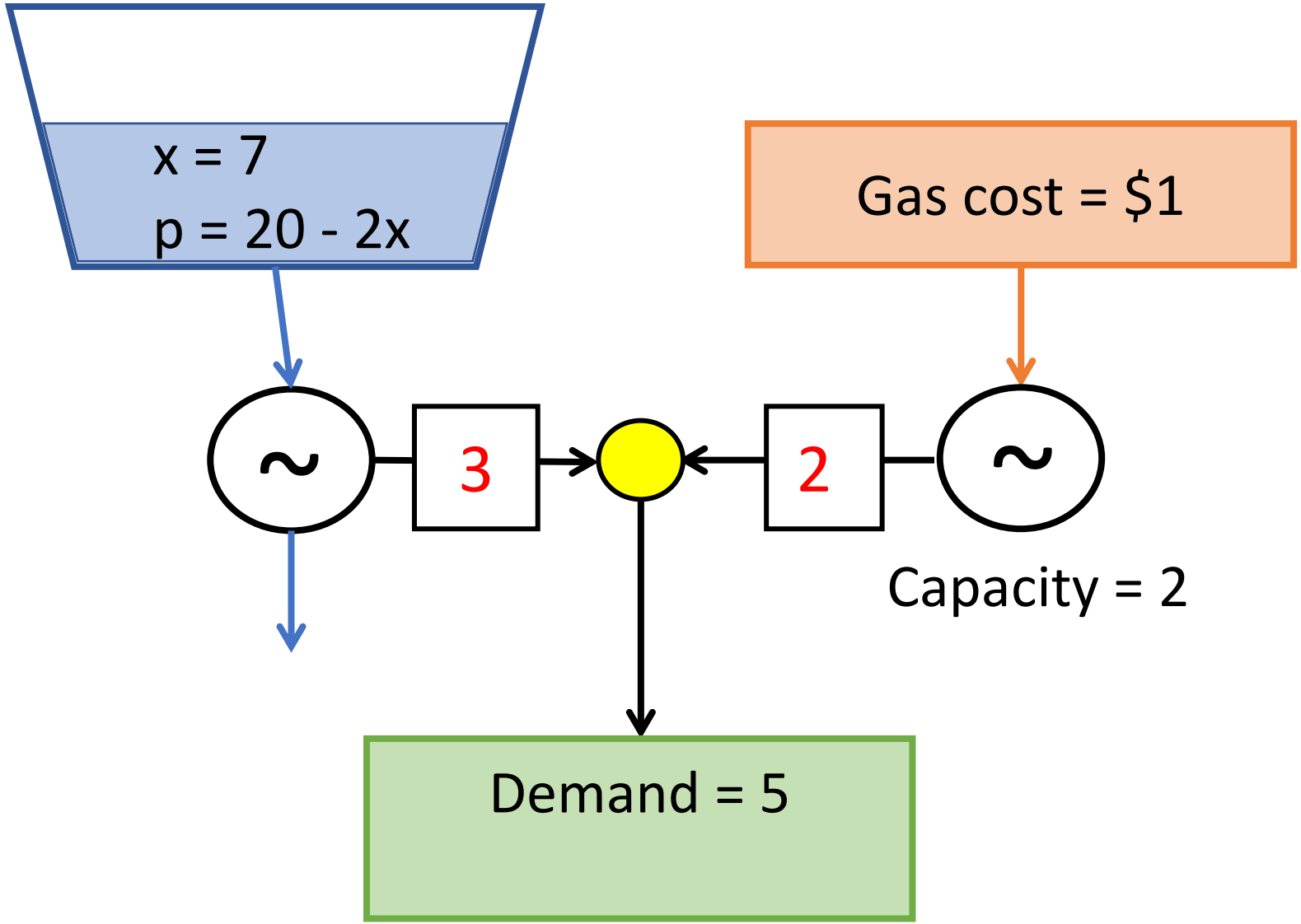
p = 20 - 2x
Gas cost = $1
3
2
Capacity = 2
Demand = 5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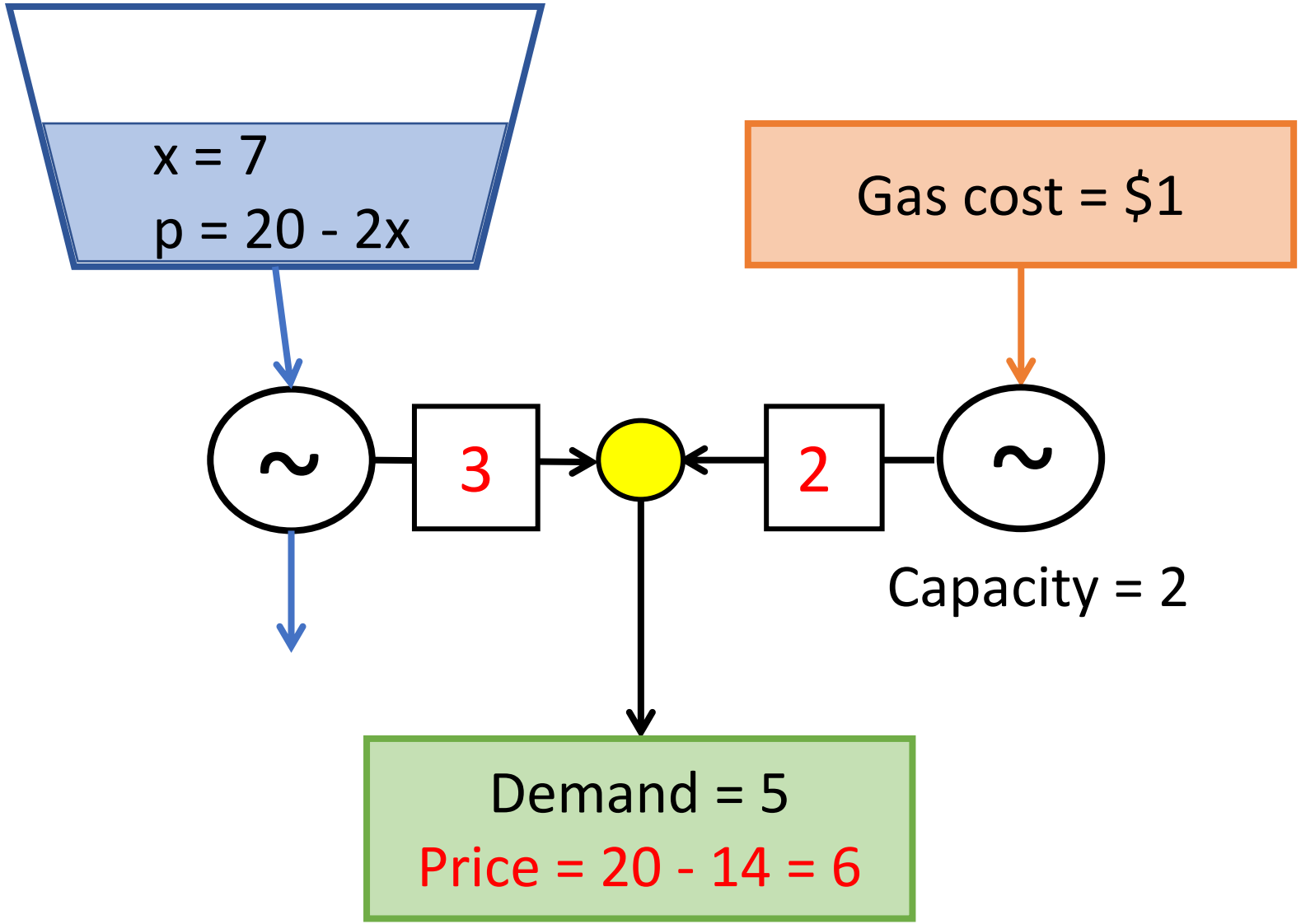
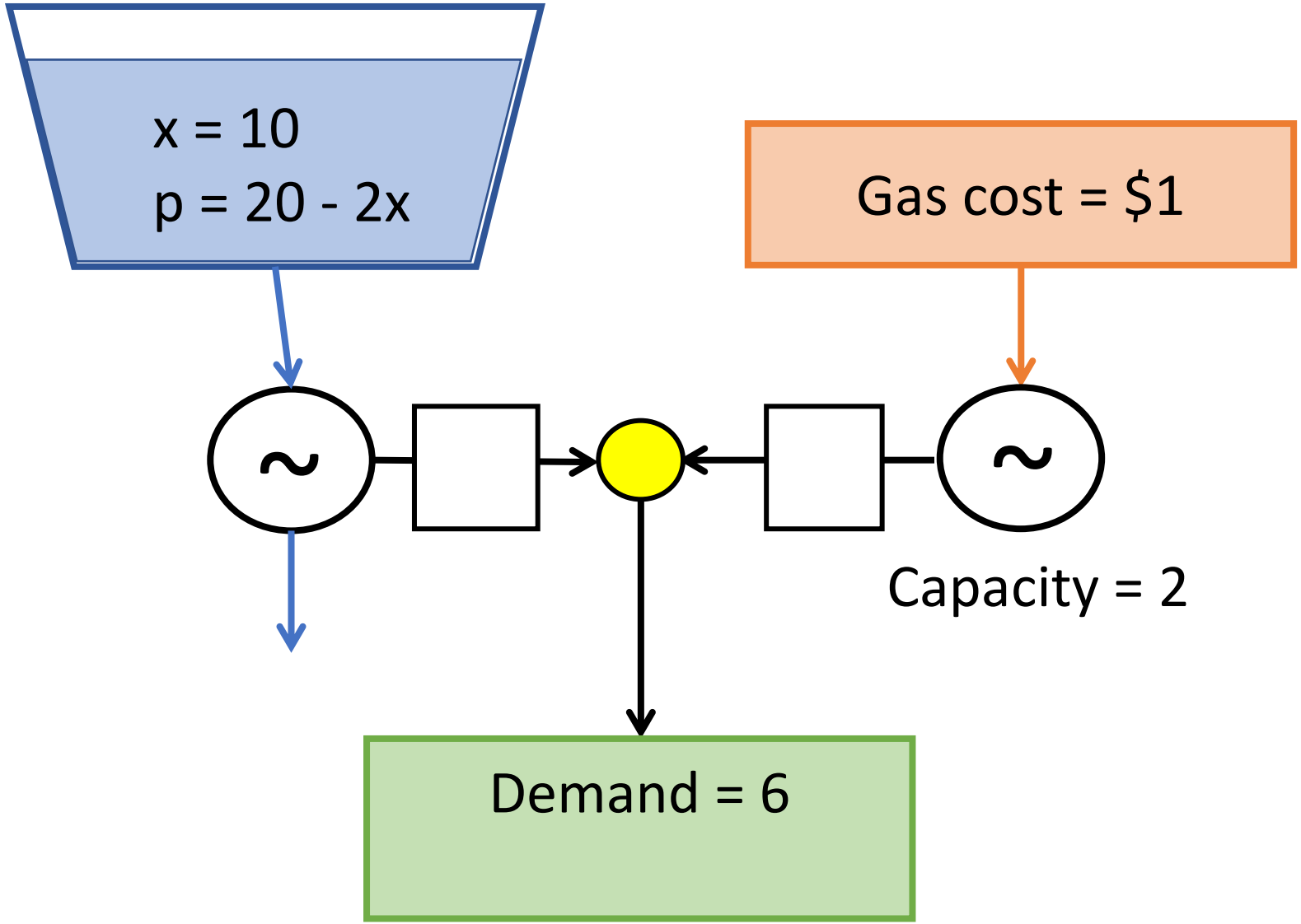
2
Capacity = 2
Demand = 5

Efficient dispatch and prices



Demand forecast =6



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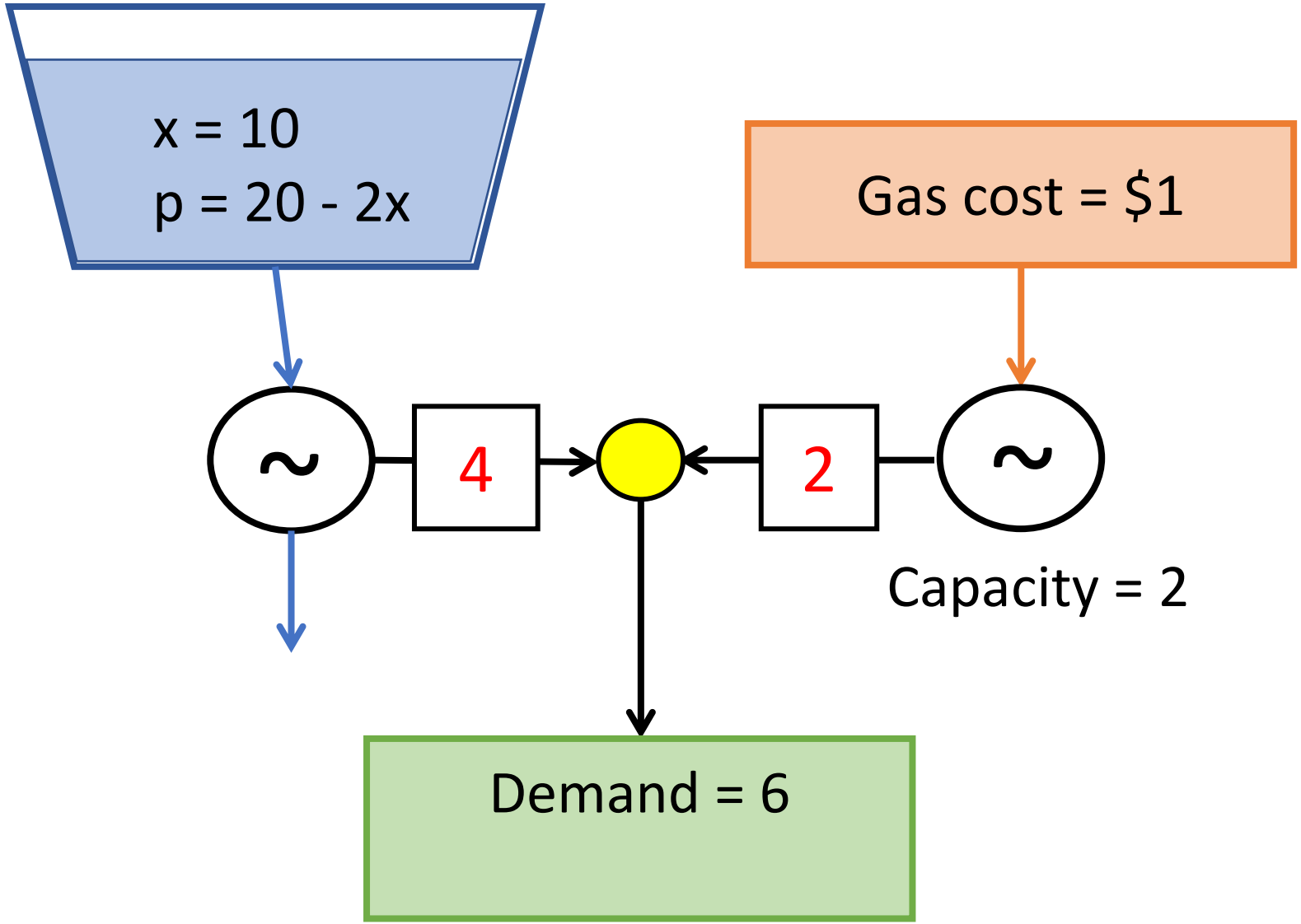

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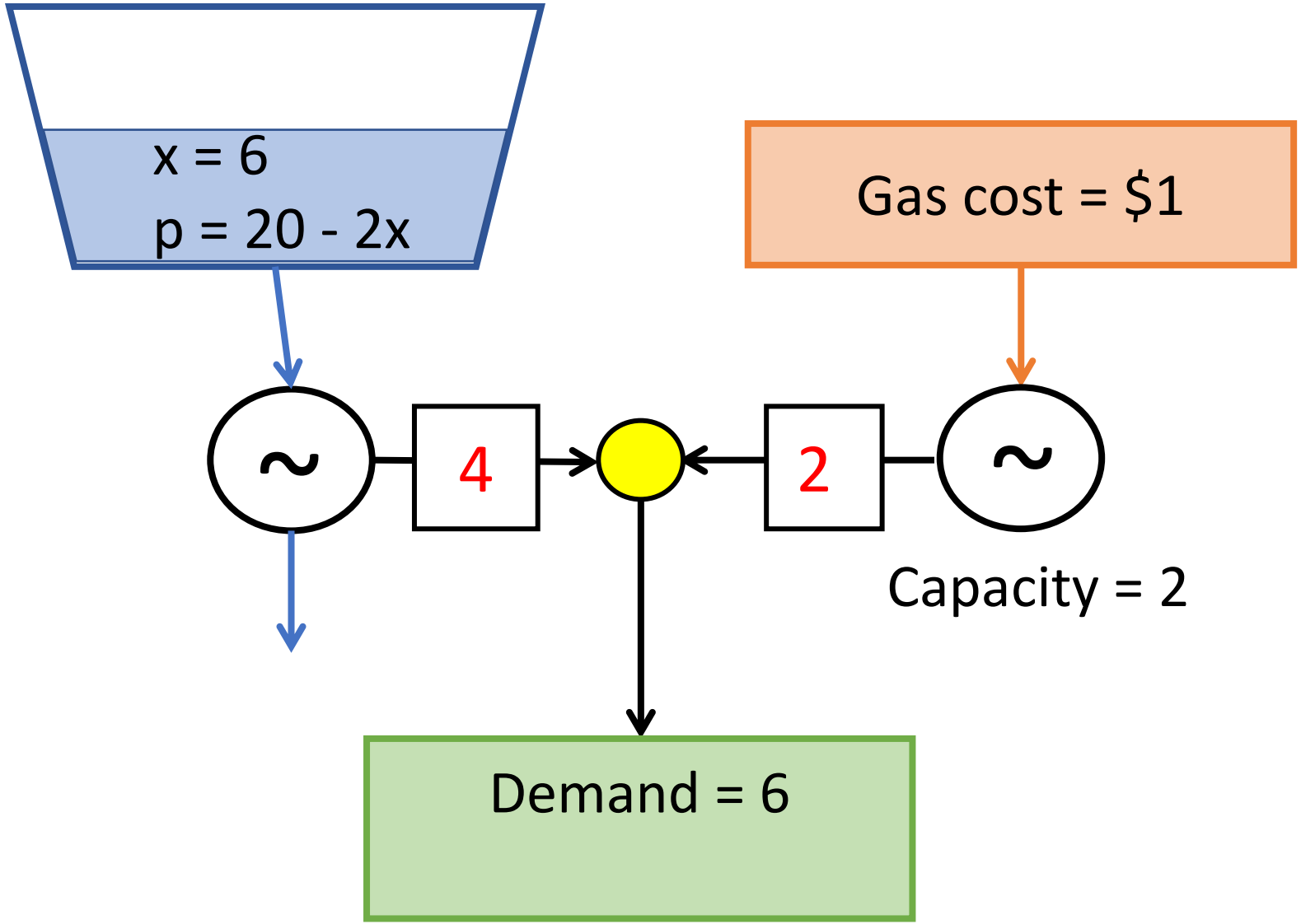

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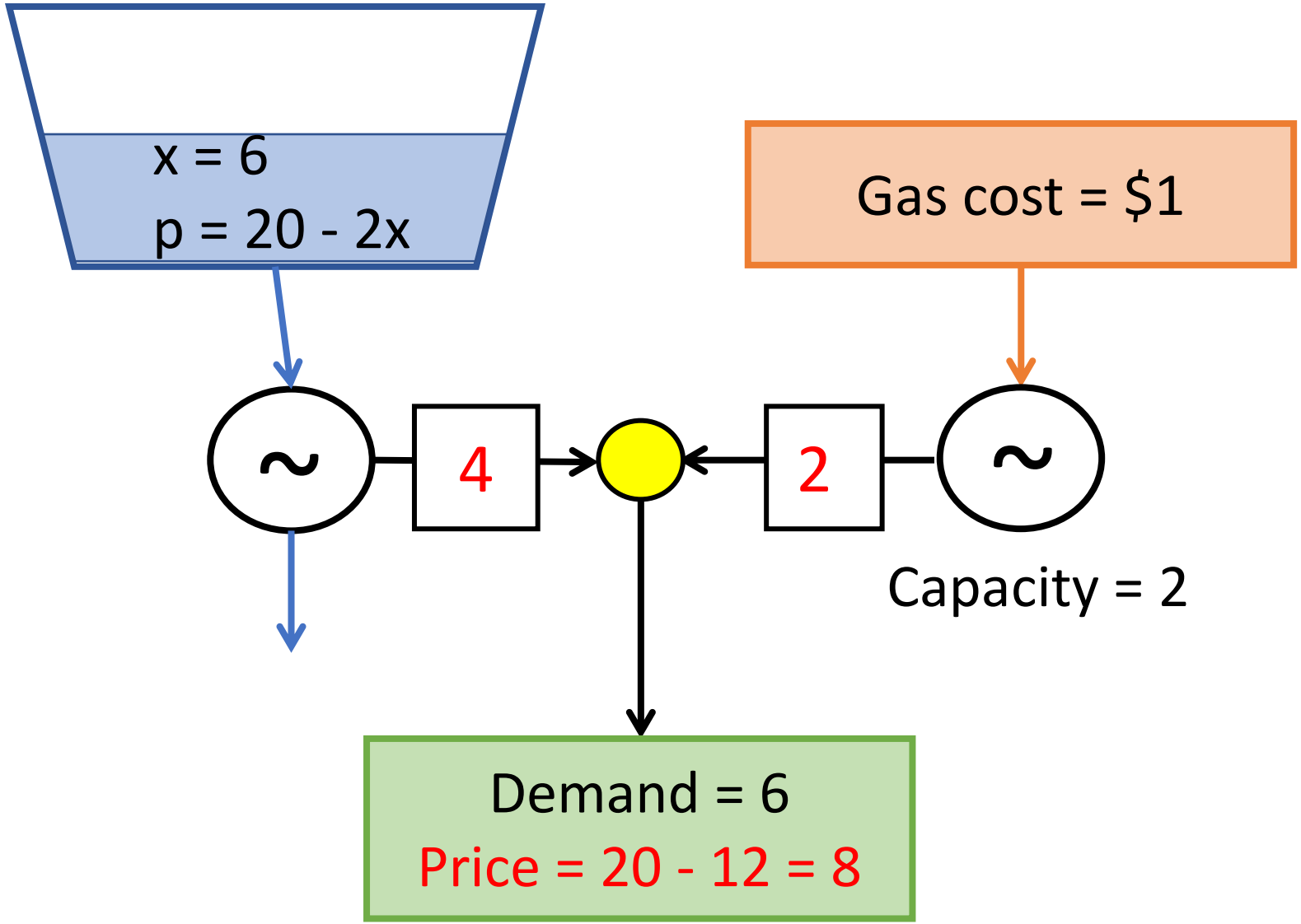
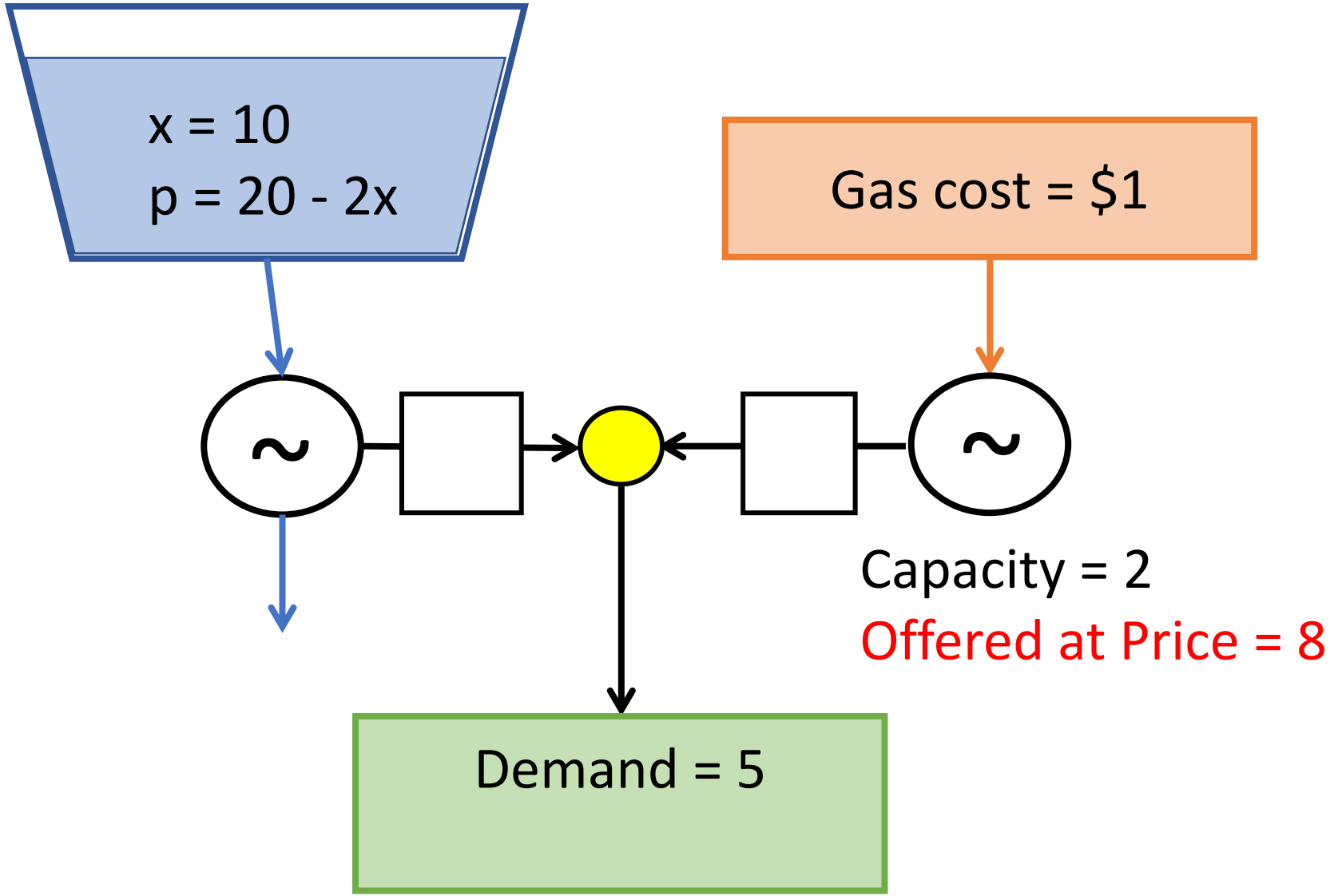


Demand forecast corrected to 5



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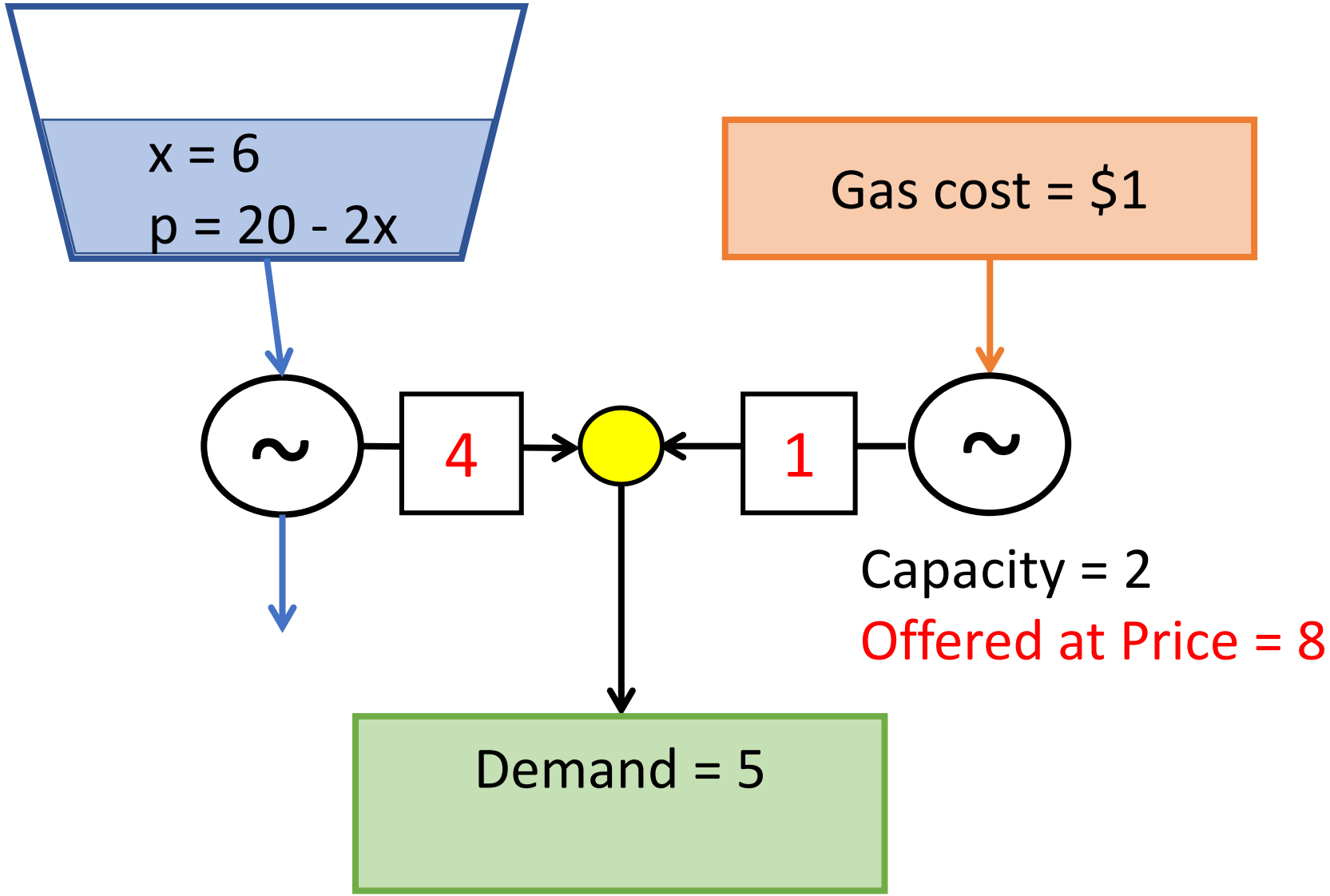

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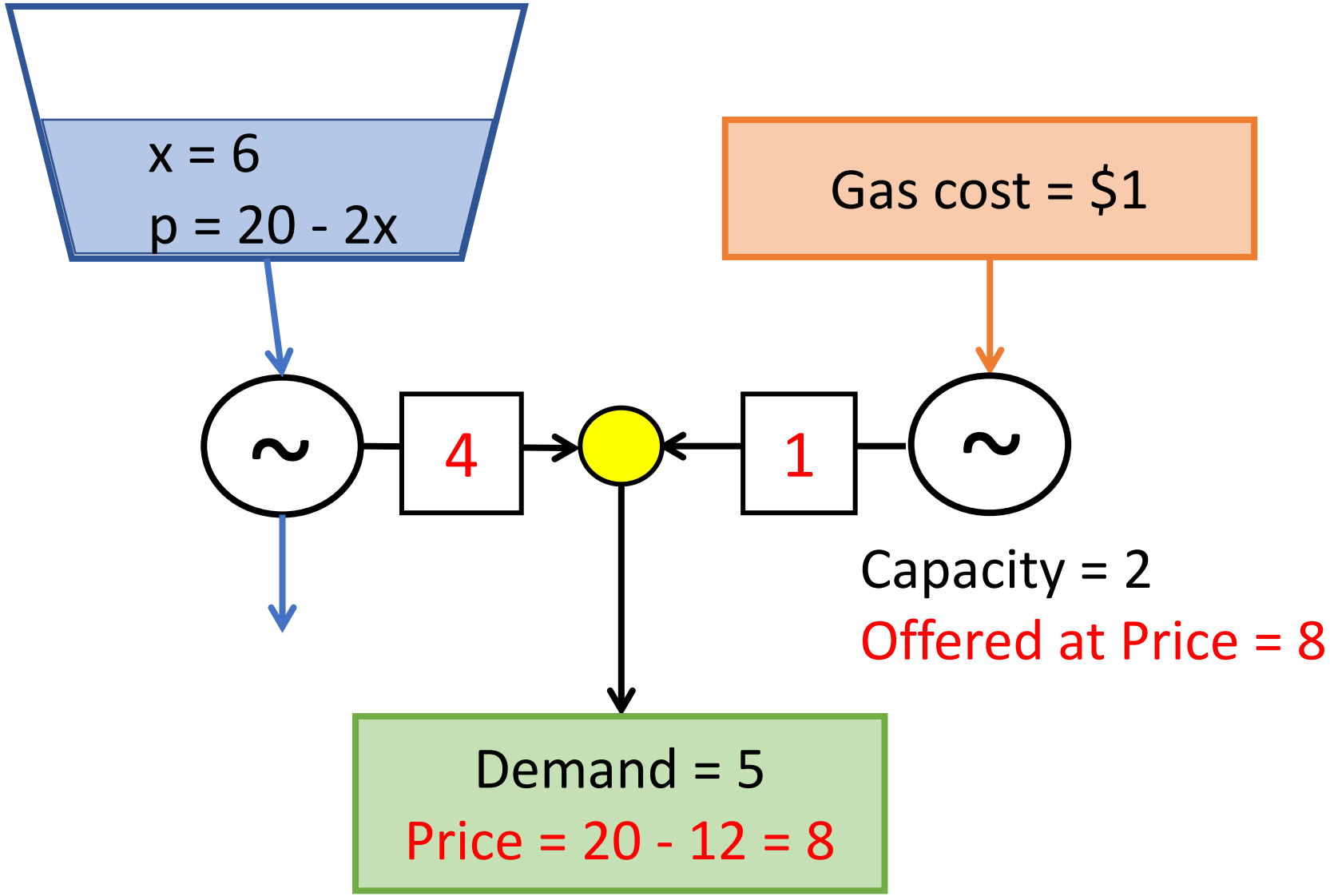

When do prices converge to efficient levels?

- A single trading period
- A hydro plant with increasing supply function.
- A thermal plant offering fixed capacity *b* at single price *c*.
- ISO solves a sequence of dispatch problems *P(k), k=1,2,…* , with demand forecasts $d_k > b$ and $|d_j - d_k| < b$ for all $j,k > 0$, yielding forecast prices $p(d_k)$.

If $c = p(d_{k-1})$ for problem *P(k), k=2,3,…* ,
then
$p(d_k) \rightarrow p(d)$ if and only if $d_k \leq d$ for every *k*.


Huntly offers 14/03/2019
300
250
200
150
100
50
0
0
200
400
600
800
9am
3pm
6pm

Some common fallacies

- Prices based on SRMC result in missing money.
  - “A peaking plant will earn no rent if offering at SRMC.”
  - Not true: rent comes from shortage events.
  - Rent can accrue from invasion of operating reserve (Hogan).
- Offers at LRMC are needed to cover fixed costs.
  - See above.
  - In fact, LRMC offers can give inefficient dispatch and deadweight losses.
- Contract levels affect offers in perfect competition.
  - “It’s smart to offer at low price up to contract level Q to ensure dispatch exceeds Q.”
  - This is price-setting behaviour. Even risk averse optimizers should offer at SRMC.

Key performance indicators (MBIE costs)

2017 Low fuel cost		Historical	Risk neutral	Risk averse
Thermal cost	($m)	309.15	233.98	258.38
Final storage cost	($m)	335.46	364.88	349.14
Total cost	($m)	644.61	598.86	607.52
Demand violation	(MWh)	0.00	7.47	11.88
Hydro generation	(GWh)	19999.25	21281.31	20908.86
Thermal generation	(GWh)	5736.26	4519.45	4877.01
Total generation	(GWh)	25735.50	25800.76	25785.87
Transmission losses	(GWh)	1267.68	1335.14	1320.70
OTA average price	($/MWh)	78.23	63.31	76.86
HAY average price	($/MWh)	77.13	60.65	73.59
BEN average price	($/MWh)	76.55	50.73	49.34
Revenue	($m)	2857.51	2075.78	2183.00
Cost	($m)	309.15	233.98	258.38
Rent	($m)	2548.36	1841.80	1924.62
HVDC rent (S-N)	($m)	3.57	20.59	21.60

Summary KPIs for MBIE gas costs

Philpott and Guan, Benchmarking wholesale electricity markets: 2017 update , www.epoc.org.nz

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Why do we persist with workable competition?

- To elicit private information
- Put your money where your mouth is
  - Government bureaucrats even with best intentions do not suffer commercial consequences of bad decisions.
  - Market agents are best placed to assess risks on investment decisions.
- No more Clyde Dams
  - Fear of political interference in investment decisions (the bad old days of NZED)
- Nothing to see here
  - Market reviews tend to see historical prices match LRMC.
  - Other markets (housing) have price surges so why single out electricity?
- BUT… electricity has a designed market, to which we can apply sophisticated modelling and analysis tools.

If only the world were perfect?

Perfect competition	Workable competition
Agents offer at SRMC	Agents offer at any price
Dispatch is efficient	Dispatch can be inefficient
Rents cover fixed costs	Rents can exceed fixed costs
Regulator disciplines market power	Entry disciplines market power
Contract levels don't affect energy offer	Contract levels affect offer
Hydro SRMC = expected marginal water value	Hydro SRMC based on marginal water value
Water value estimates independent of agent behaviour	Water values estimates calibrated to agent behaviour
Agents' offers decoupled from transmission effects	Agents can influence transmission using offers
Actions maximize expected social welfare in short run	Actions sacrifice short run expected social welfare
Pricing of contracts and FTRs straightforward	Pricing of contracts and FTRs complicated
Cost-benefit analysis defensible	Cost-benefit analysis contestable

If only the world were perfect?

Perfect competition under risk	Workable competition
Agents offer at SRMC	Agents offer at any price
Dispatch is efficient	Dispatch can be inefficient
Rents cover fixed costs	Rents can exceed fixed costs
Regulator disciplines market power	Entry disciplines market power
Contract levels don't affect energy offer	Contract levels affect offer
Hydro SRMC = risk-adjusted marginal water value	Hydro SRMC based on marginal water value
Water value estimates independent of agent behaviour	Water values estimates calibrated to agent behaviour
Agents' offers decoupled from transmission effects	Agents can influence transmission using offers
Actions maximize risk-adjusted social welfare*	Actions sacrifice expected social welfare
Pricing of contracts and FTRs straightforward	Pricing of contracts and FTRs complicated
Cost-benefit analysis defensible	Cost-benefit analysis contestable

* Assuming agents use coherent risk measures and markets for risk trading are complete

The right model for NZ electricity market

- Regulated competition.
- Day-ahead and real-time balancing market.
- Day-ahead offers made at SRMC accounting for opportunity cost of future shortage.
- Opportunity costs based on risk-adjusted future costs.
- Day-ahead offers disciplined by market monitoring.
- Real-time constraints dealt with in balancing market.
- A liquid market for risk-trading instruments.

Why day-ahead?

- River chains currently optimized by agents using energy offers.
- Why?
  - Operators have/use private information?
  - Too hard to optimize the complete system
- Possible to optimize 48 trading periods at once subject to river constraints and paying for water used at marginal water value.
- Price discovery from agents' private water values (based on their risk appetite).
- Balancing market adjusts day-ahead dispatch in real time.

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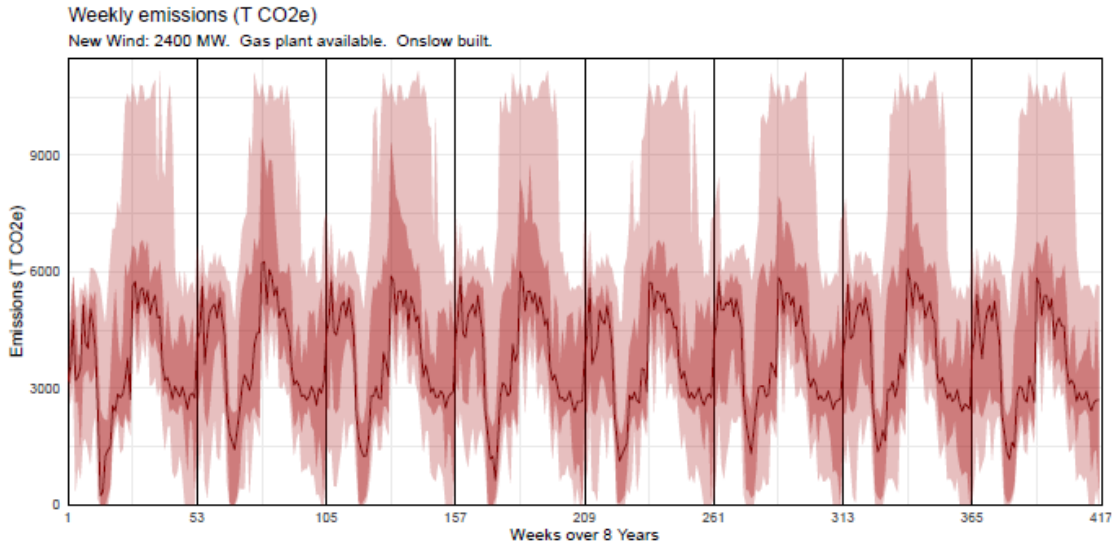
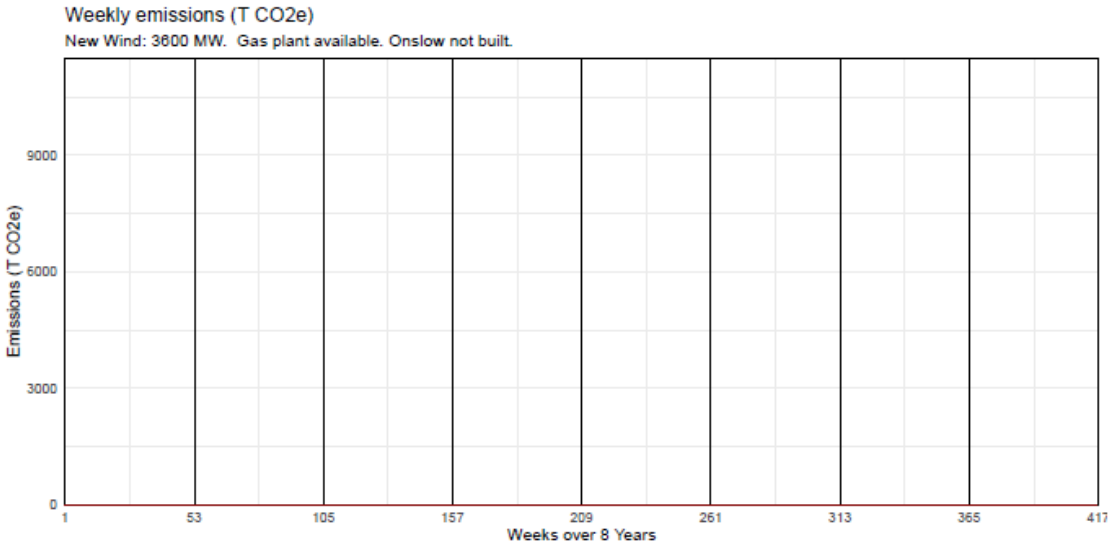
How does this work with zero SRMC?

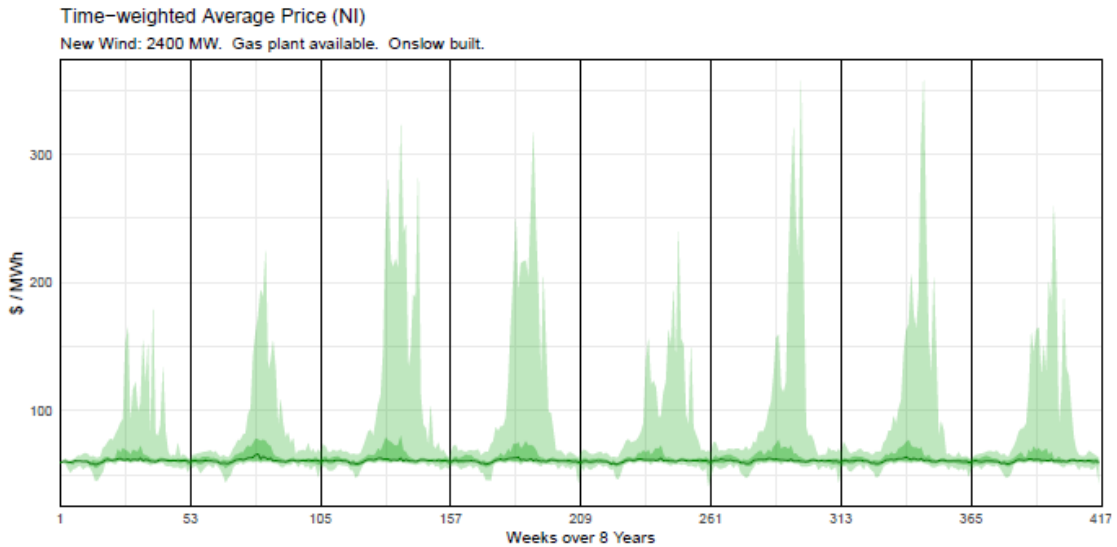
- Capacity shortage events
  - Demand response or operating reserve
- Energy shortage events
  - Opportunity cost of storage (water value) imputed from shortage cost
  - Requires accurate estimates of the real cost of load reduction, or
  - a well-functioning demand-side market.
- Derivatives (firm energy option contracts) smooth risky payments.
- Should these be market or Government backed?
- Are purchasers willing to pay for option? Probably needs to be mandated.

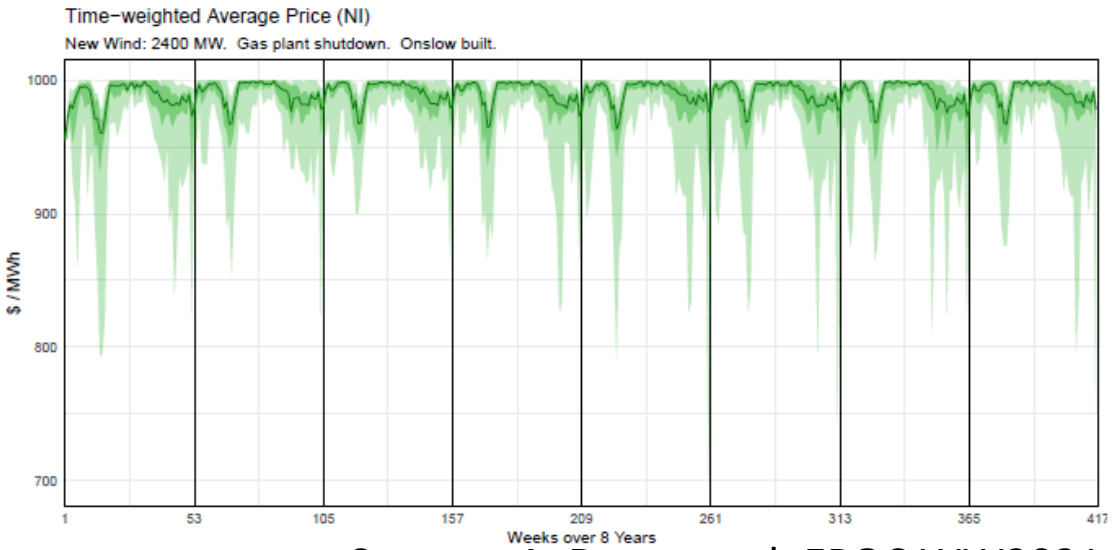
Results and Analysis

2400MW wind, with and without gas generators









Source: A. Downward, EPOC WW2021

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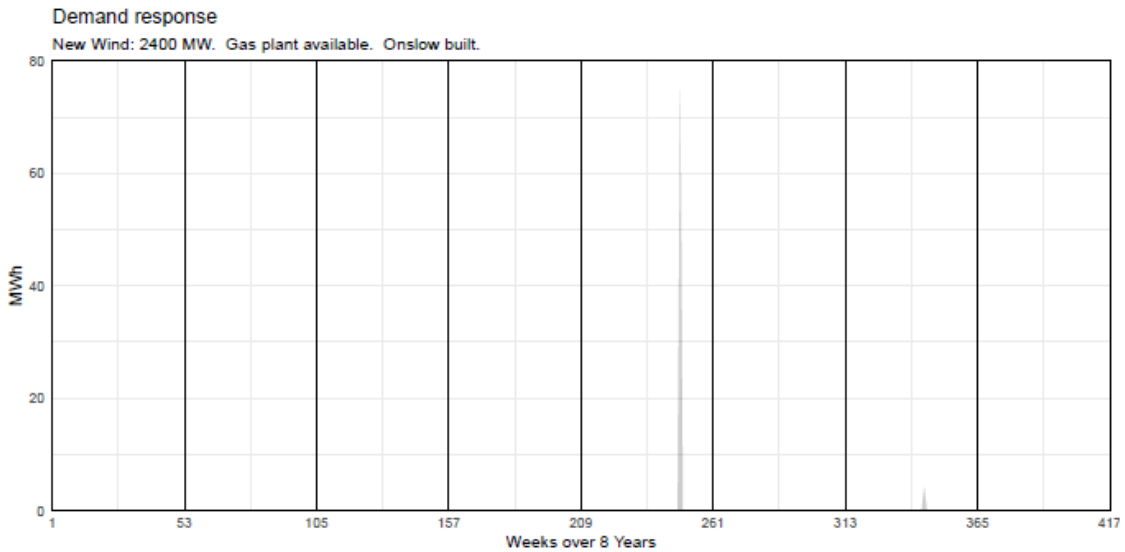

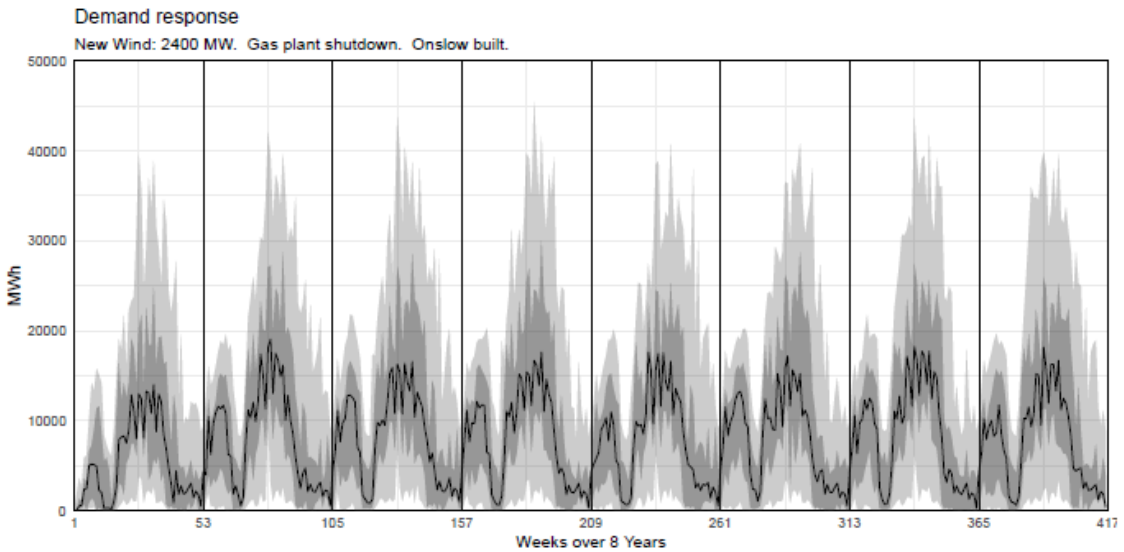

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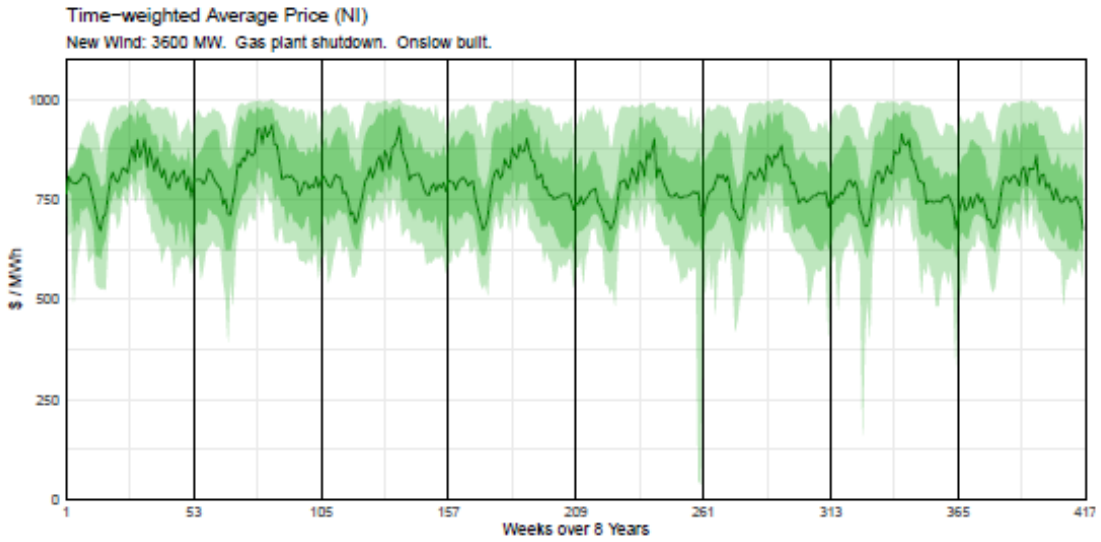
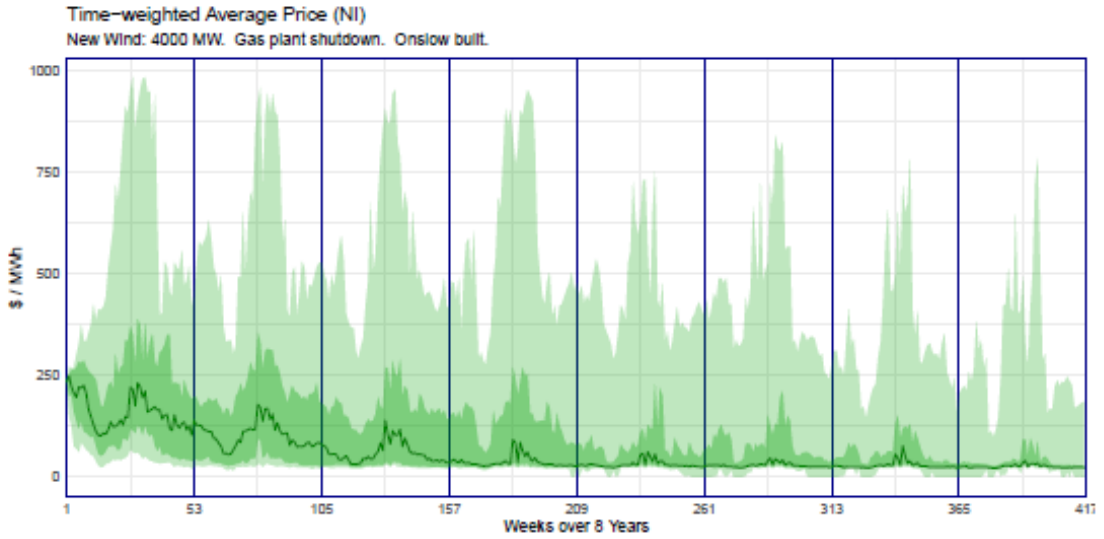
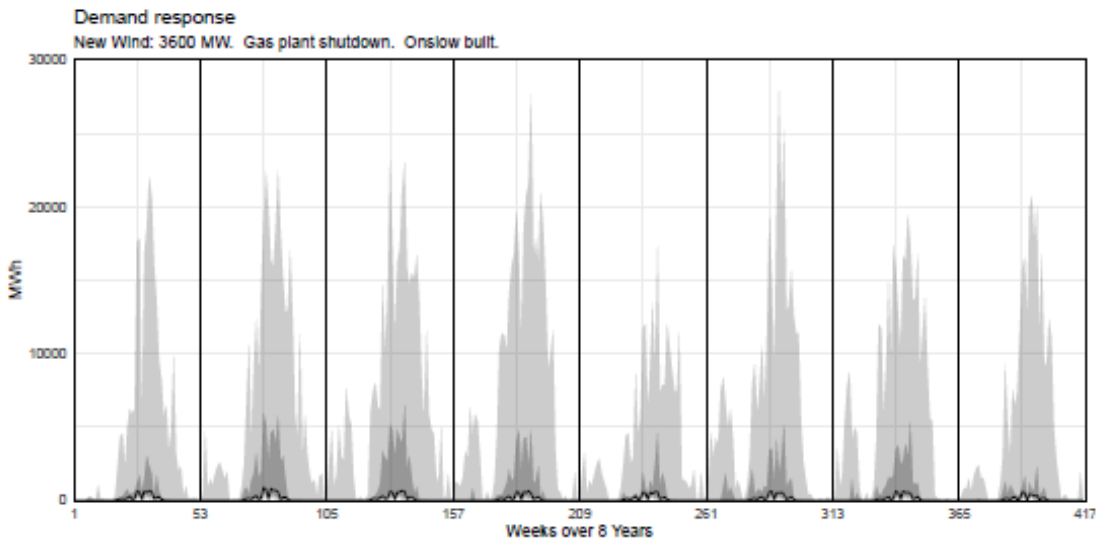
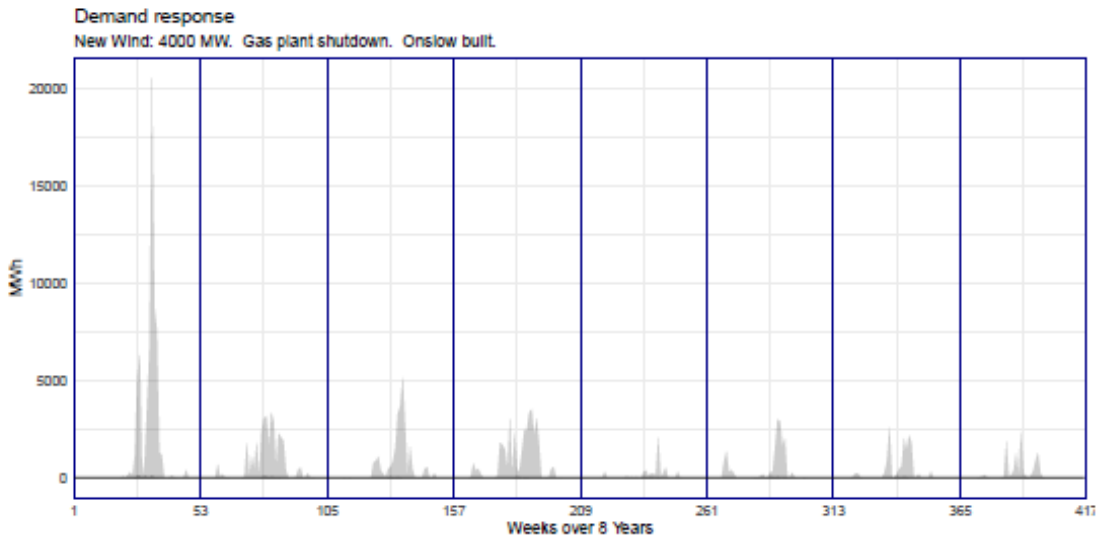
Results and Analysis

3600MW vs 4000MW wind, without gas generators









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Conclusions

- Workably competitive markets have short-term inefficiencies.
- Regulation should be stronger: is market power really disciplined by competitive entry?
- Short-term efficiency enhanced by day-ahead market.
- Can make perfectly competitive energy-only models work by accounting for risk aversion. Agents should make zero risk-adjusted profit in long run (while trading risk).
- Prices with zero SRMC offers come from shortage/demand response.
  - In real time demand response to capacity shortages
  - Through water values from energy shortages.
- If shortages “solved” by NZ Battery then some capacity/firm energy mechanism is needed to avoid commercial divestment.