IPART Independent Pricing and Regulatory Tribunal | NSW

Long Run Marginal Cost of water supply

An IPART Secretariat research paper July 2022

https://www.ghdwoodhead.com/projects/desalination-plant-n-auwi-interpretive-centre.html

Agenda

What is the LRMC?

LRMC is the constant real price that equalises

Present value of future costs of supplying water over a long period of time

Present value of future revenues from supplying water over the same period

Why is it important for pricing?

LRMC signals the opportunity cost of usage

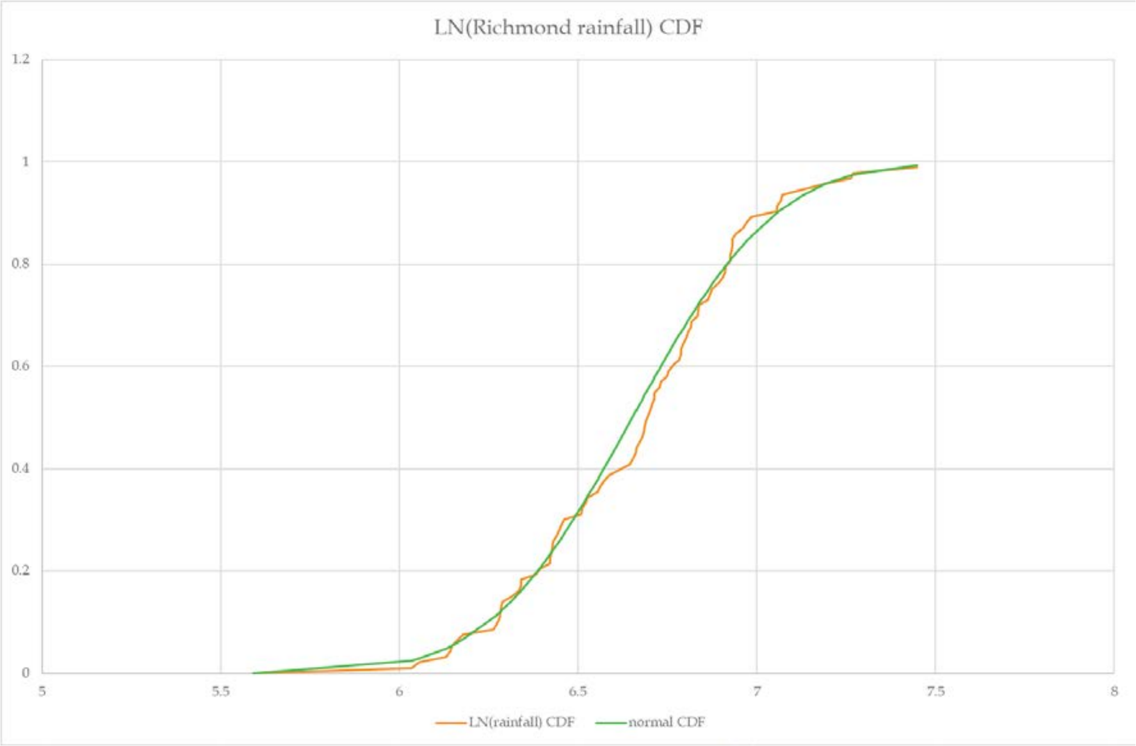
- An upward demand shock will force the water utility to invest in new supply sooner
- Assuming augmentation options are in merit order, that means higher-cost supply will come on stream sooner
- In present value terms, this will increase supply costs
- Therefore, the opportunity cost of extra use is this increase in supply costs

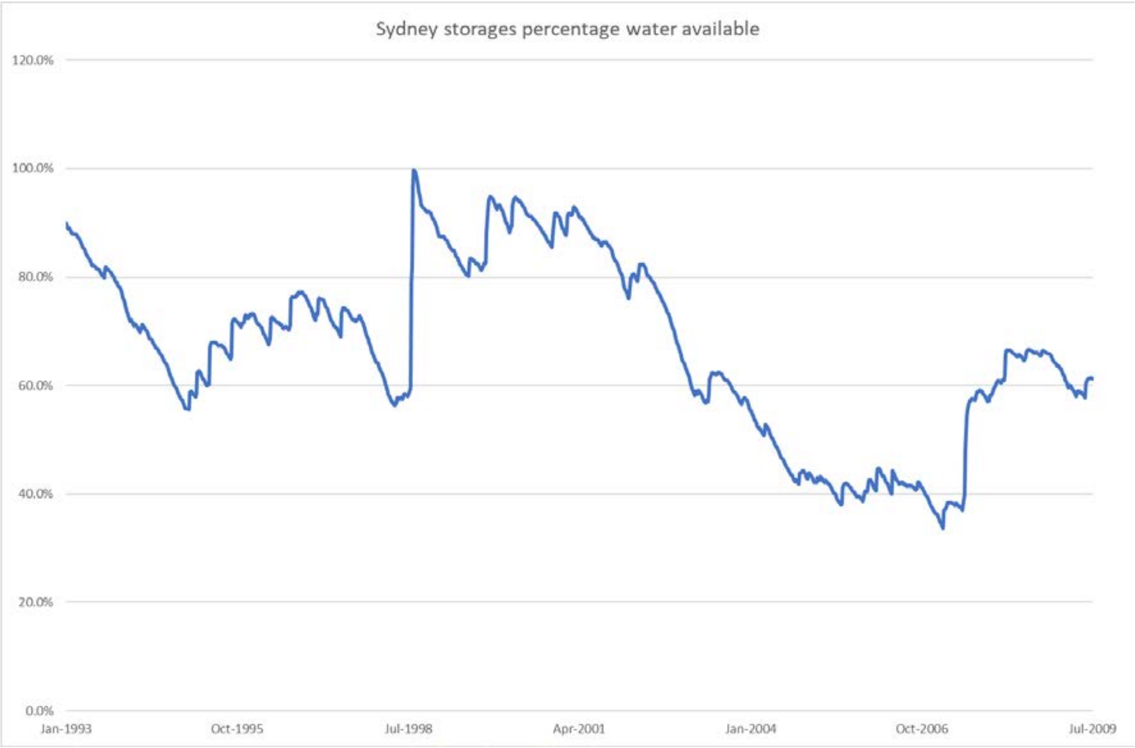
How do you estimate it?

The forecasting problem

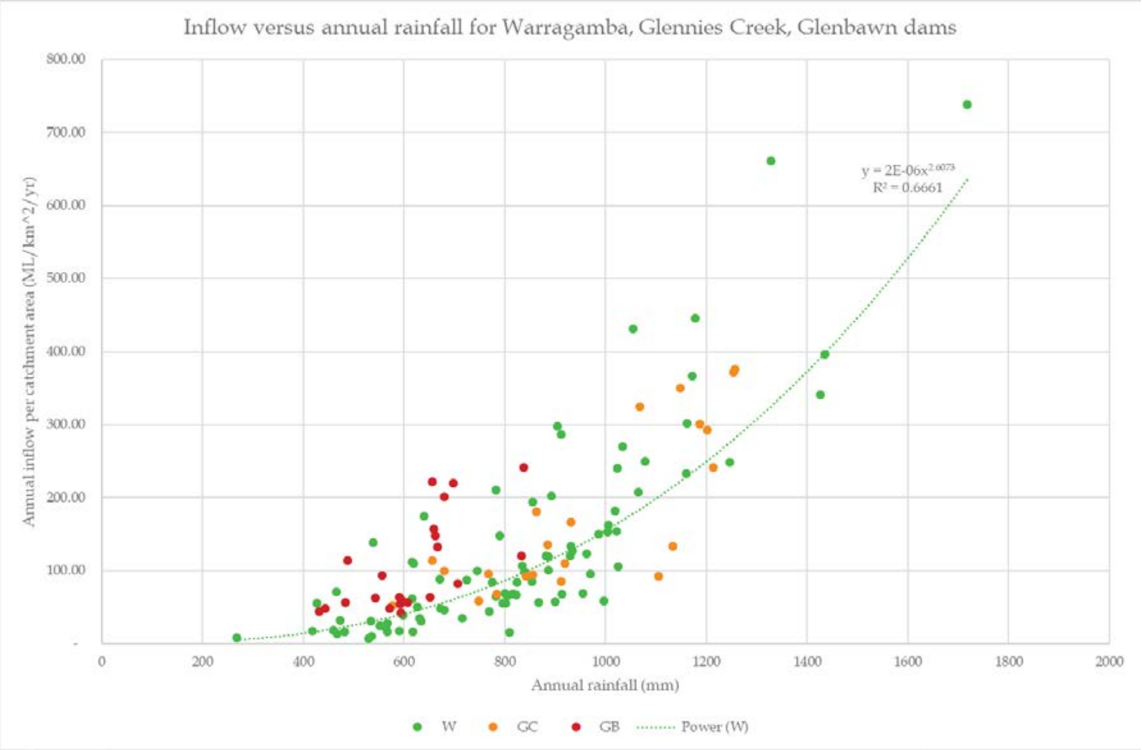
- All methods have to solve the problem of forecasting future costs and supply volumes
- For supply volumes, linear demand growth is usually assumed
- However rainfall uncertainty and water restrictions may require Monte Carlo modelling
- To estimate costs, work out which of a set of augmentation options to implement and when to ensure adequate capacity to meet demand at all times
- Use timing information to discount costs to present values

Rainfall and dam storage—driven by extreme events





Hydrological modelling



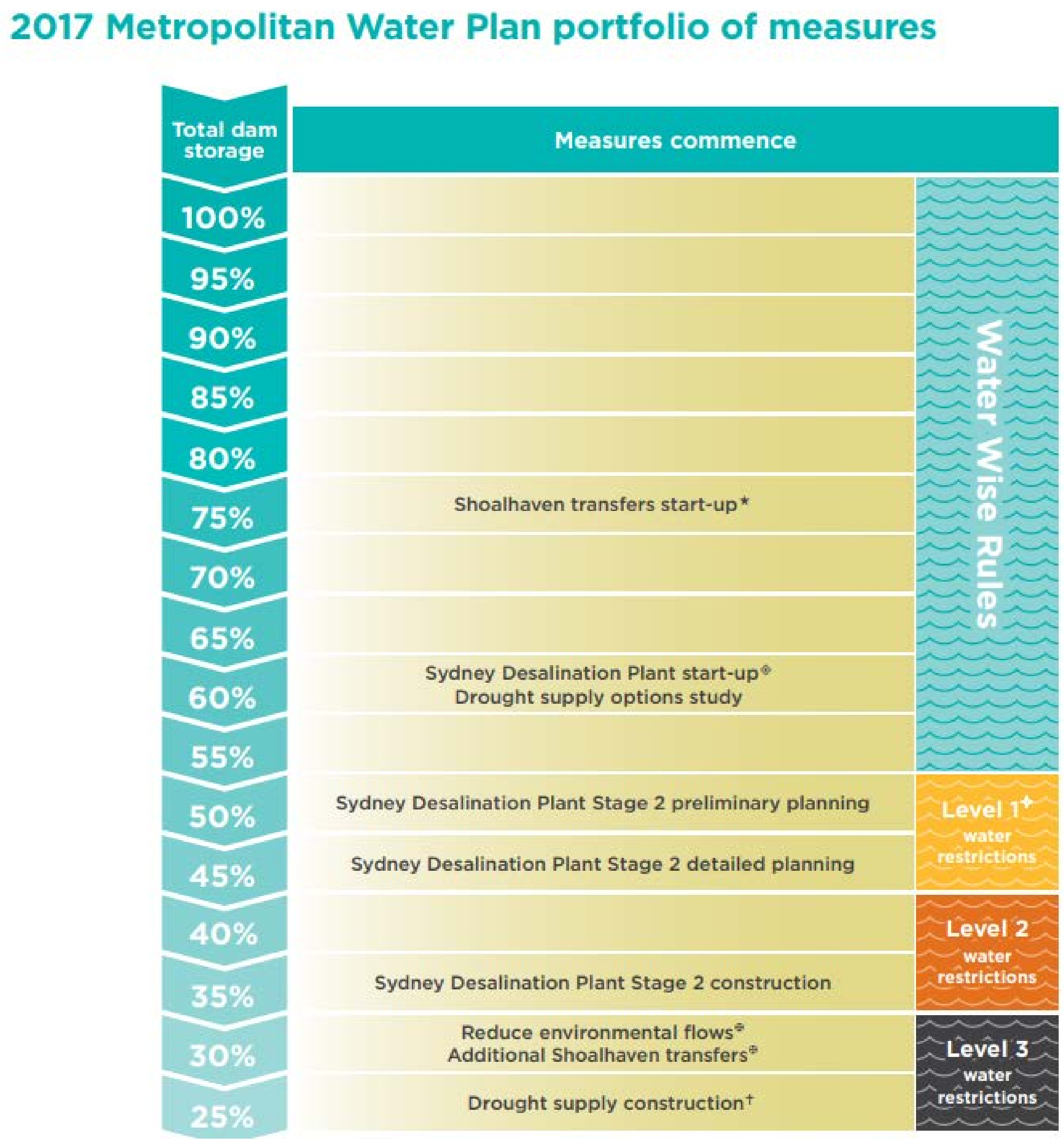
Instead of performing Monte Carlo simulation within the LRMC model, we can rely on detailed hydrological modelling done by bodies such as WaterNSW using models such as Wathnet for estimates of the minimal sustainable yield for an augmentation.

These yield estimates factor in rainfall variability, water restrictions, ideally climate change etc.

Augmentation actions in merit order

Sydney Metropolitan Water Plan 2017 (see p 28)

https://www.planning.nsw.gov.au/-/media/Files/DPE/Other/About-us/Metropolitan-Water/2017-Metropolitan-Water-Plan.pdf



Estimation challenges

The investment sequencing problem

- Given a particular demand profile over time, we need to assemble an efficient sequence of investments in augmentation
- Augmentation options should be activated in merit order (least cost ones first)
- One must account for the lead time between incurring capex and the option producing water
- Investment packages must make sense—some options may be mutually exclusive. Other options may be co-dependent

Deterministic simulation

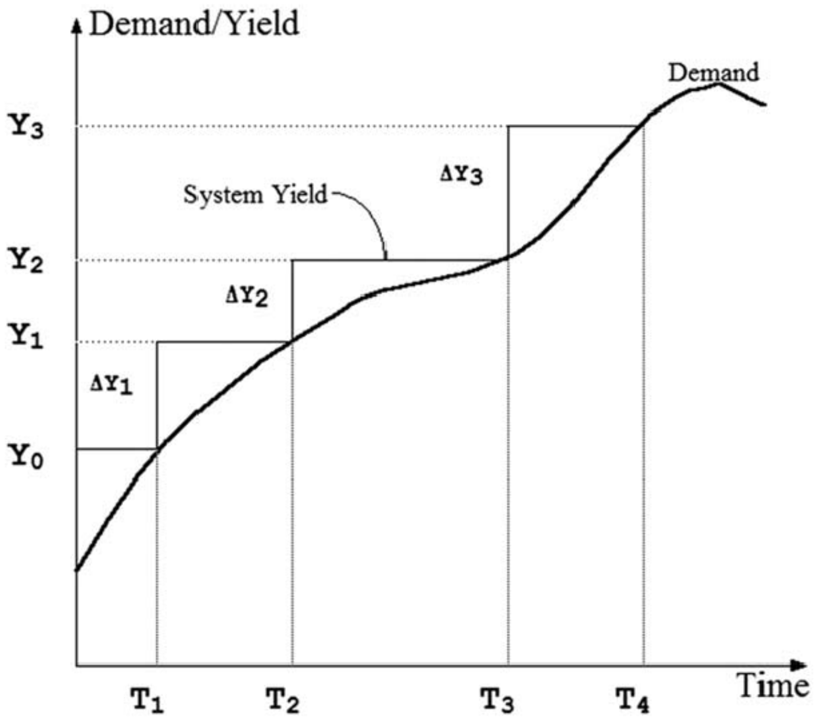


Figure 1. Schematic of scheduling capacity expansion over a planning horizon.

- A series of capacity augmentations is brought on line as needed
- Sustainable yield for each option is determined off line by stochastic hydrological modelling
- Thus a single simulation run is needed to estimate LRMC, rather than 10,000

Which ratio gives better estimates?

Average Incremental Cost

$$LRMC = \frac{PV\ cost\ (lumpy\ new\ investment)}{PV\ supply\ (lumpy\ new\ investment)}$$

- AIC method is simpler to do, but care must be taken to:
  - account for existing spare capacity, which should reduce the PV of new augmentation
  - avoid errors from truncated simulation

Perturbation method (Turvey)

$$LRMC$$

$$= \frac{(PV\ cost(shocked)\ - PV\ cost(base))}{(PV\ supply\ (shocked) - PV\ supply(base))}$$

- Two scenarios are compared:
  - Base demand
  - Shocked (perturbed) demand
- Turvey method gives better estimates when simulation is truncated

Common errors in deterministic simulation

Insufficient supply

Unless the modeller is very careful, the option that is costed may not generate sufficient supply in every year. If so, the LRMC will be under-estimated.

Mismatched cost and volumes

Simulations for a finite period may result in a mismatch between costs (captured in simulation) and future supply benefits (truncated by finite period).

This will bias results to overestimate LRMC

Existing spare capacity ignored

Some interpretations of the AIC method only include the cost of new supply options and new water volumes.

This will unrealistically ignore existing spare capacity

Augmentation out of merit order

If augmentations are done out of merit order it would be inefficient.

Inefficient supply options will overstate LRMC.

What other approaches are available?

Algebraic estimation method

First, consider a single augmentation, infinite time horizon

PV of costs for one augmentation

$$C + E * PV\ water\ supply + \frac{M}{d}(d+1)^{-y}$$

PV water supplied by augmentation

$$\frac{(d+1)^{-y-t^*}}{d}\left[K + \frac{(d+1)^{t^*+1} - d(1+t^*) - 1}{d}u\right]$$

$$LRMC = \frac{C\ d(d+1)^{y} + M}{(d+1)^{-t*}\left[K + \frac{(d+1)^{t^*+1} - d(1+t^*) - 1}{d}u\right]} + E$$

Combining many augmentations

$$LRMC = \frac{\sum_{j=1}^{N} PCj\,(1+d)^{-sj}}{\sum_{j=1}^{N} PWj\,(1+d)^{-(sj+lj)}}$$

Note: d = real Pre-tax WACC

j	augmentation number, starting at 1 and going in merit order to N
sj	build start year for augmentation j, given merit order and rate of demand growth
lj	lead time for augmentation j
PCj	present value of costs of augmentation j, assuming a start year of 0
PWj	present value of water produced by augmentation j, assuming a start year of 0

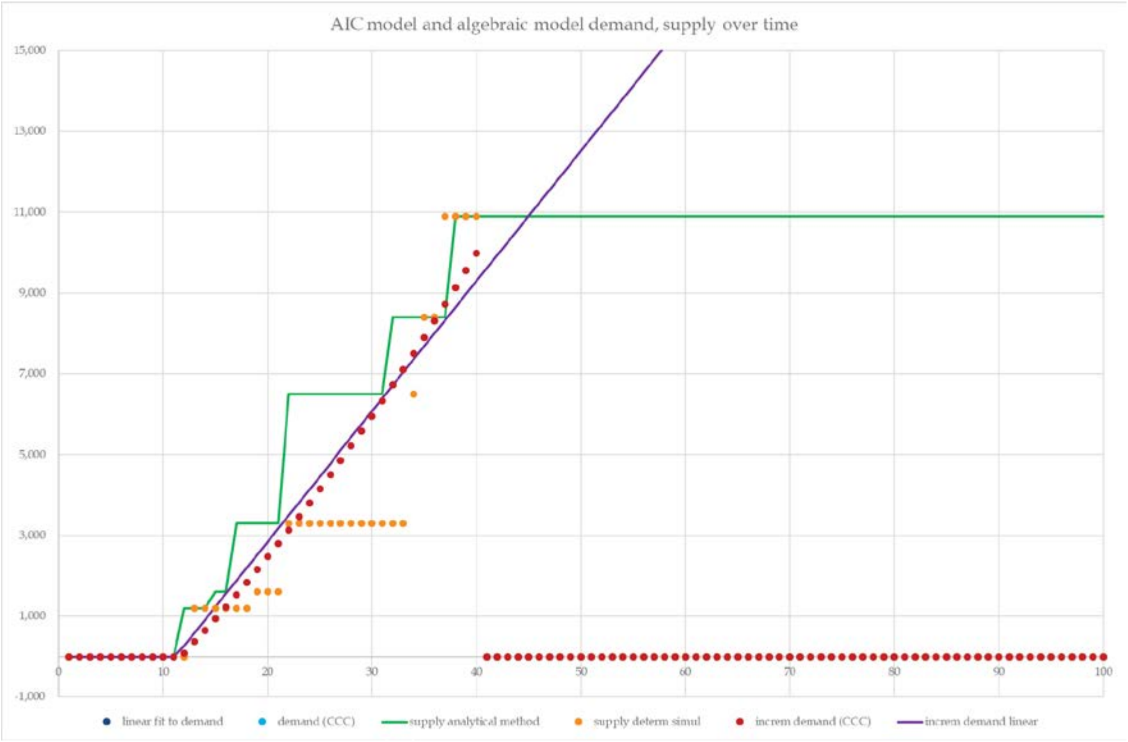
How well does each method work?

Comparing LRMC results ($/kL)

Network	Simulation	Algebraic	Simulation	Algebraic
/option (method)	Increment above existing usage		Increment above existing capacity	
utility 1	Not provided	1.42	2.27	2.31
utility 2	1.52	0.87	Not provided	2.68
utility 3 option 1 (Turvey)	3.26	3.39	Not provided	8.57
utility 3 option 1 (AIC)	6.29	3.39	Not provided	8.57
utility 3 option 2 (Turvey)	2.02	2.16	Not provided	5.79
Utility 3 option 2 (AIC)	3.70	2.16	Not provided	5.79

Two simulation errors identified by algebraic analysis

Simulation built capacity too late



Simulation ended too soon