Oakley Greenwood

9th Annual Water Pricing Summit 2011

Valuing water supply using a market approach

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Overview of Presentation

Objective

- To illustrate a market approach for valuing water in an urban water market using techniques adapted from the valuation for hydro electric generation

The presentation outlines

- The approach used to value water used for hydro electricity generation involves
  - Valuing water in storage using a forward electricity price market
  - Showing the relationship between the value of water in storage and dam levels
  - Showing how to estimate the value of the real option
- How this approach could be used to value potable surface water storage supplies
  - Simulating a forward market for potable water, by modelling the merit order dispatch in the face of uncertain future states
  - Valuing water in store given the opportunity cost derived from this ‘simulated’ forward price curve.
  - Showing how the value of the option could be calculated

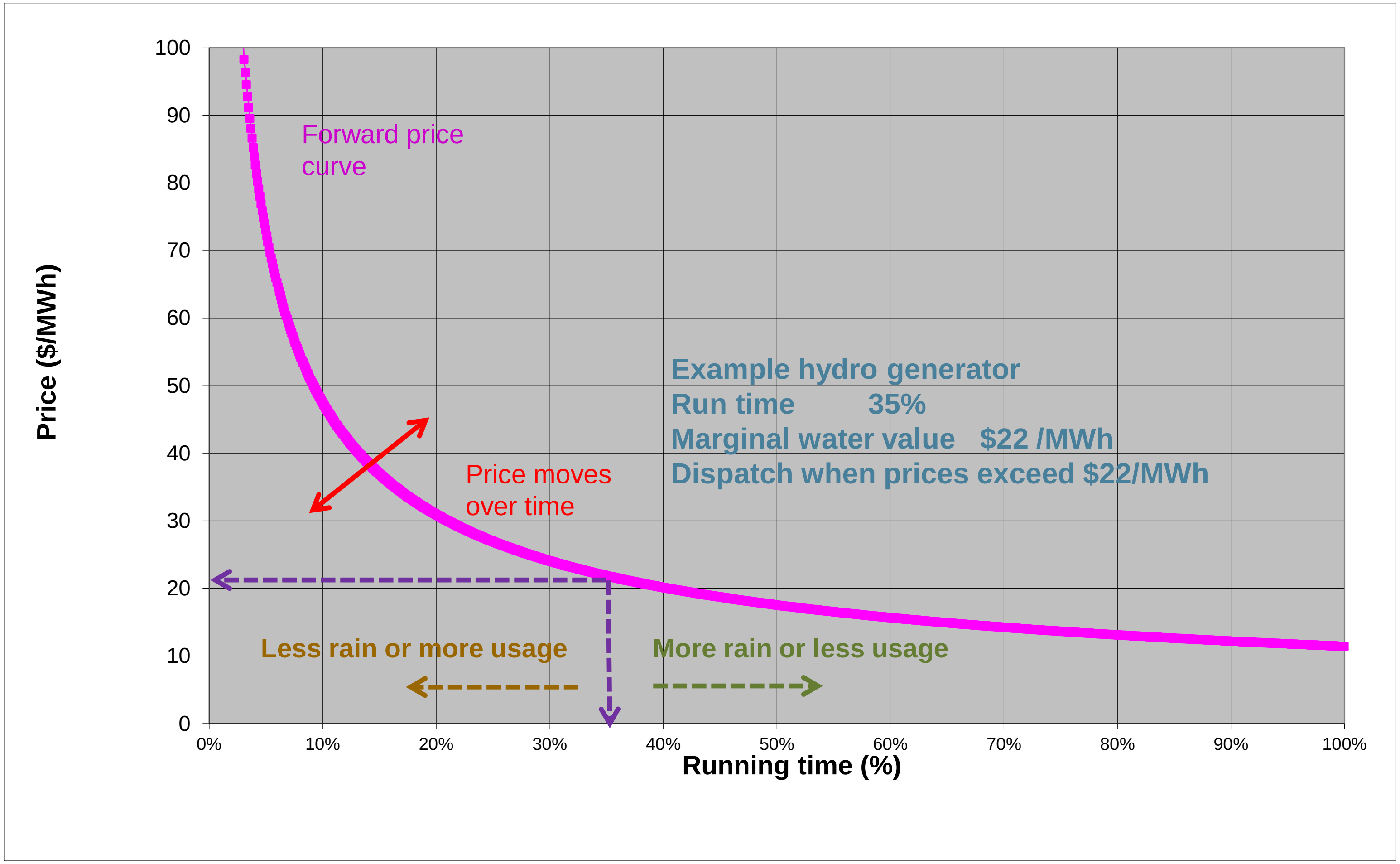
The approach used to value water in hydro generation

Steps in valuing water in hydro generation

1. Consult the forward market, and infer relevant prices. Some translation from available prices to inferred 'relevant' prices (esp. by season and peak prices) is necessary.
2. Work out a forward dispatch schedule which schedules generation into the highest price periods or duty in the future 3 years. Forward inflows need to be forecast.
3. Water availability is limited, so the forward schedule has a 'clearing price' above which the water is dispatched. This is the marginal value of water for electricity for generation.
4. Over time the marginal value will change as there are changes, e.g. to forward prices, rain, dispatch

- We use hydro generation because it has close similarities to water supply
- For simplicity, we assume that the storage is reasonably long term (say a 3 year fill cycle) there are few constraints on dispatch and that we are in the National Electricity Market.
- Note that the NZ electricity market is more similar to water markets because it is hydro dominated and energy constrained

Water valuation in electricity



Based on experience in running Southern Hydro

How this approach can be used to value surface water supplies used for potable consumption

Key principle

- Like hydro electricity, the value of potable water reflects its opportunity cost of supply

Hydro Electricity

- Opportunity cost is based on the forward electricity price curve
  - Dispatching water 'now' to generate electricity, precludes dispatch in the future, which has a cost = the expected electricity price foregone.
  - BUT Electricity in the NEM being capacity constrained is a 'fast moving price', while say in NZ being energy constrained is a 'slow moving price'

Potable water

- Opportunity cost is derived by 'simulating' a forward price curve based on the cost of dispatching alternative options for balancing supply and demand in the future….
  - Dispatching surface water 'now' precludes the dispatch of that water in the future, which has a cost = to the cost of having to dispatch the next marginal supply (or demand) option.
  - Water markets are typically water constrained i.e. the overall volume of water is limited. This means the price is 'slow moving'

The forward price (or cost) varies over time

- Forward price depends on the cost of the marginal plant that may supply in the future period
- This is probabilistic:
  - More rain or less usage lowers price by increasing the likelihood of water supplied from lower cost options
  - Less rain or more usage increases price by increasing the likelihood of water supplied from higher marginal cost options
- The forward price (or cost) is the probability weighted sum of each of the supply or demand options
- Water value in a dam within a supply system depends then on the probability of it displacing higher cost options (e.g. desal. or restrictions)
- The price tends to track slowly, because conditions change slowly

In the absence of a forward price curve, a dispatch model is used to ‘simulate’ a forward price curve

A potable water dispatch model will have regard to, amongst other things

- The projected level of demand
- Storage levels and projected inflows and their variability
- The availability and cost structure of desalinated water or other supply options
- The projected impact of imposing restrictions and its implied cost, or a scarcity price, in lieu of restrictions
- The cost and availability of demand abatement (e.g., water efficiency initiatives)
- The cost and availability of any new potable water sources.

The dispatch model would be stochastic

- A ‘real options’ modelling approach can be used to account for the uncertainty in water inflows

The output would be:

- a probability distribution of the future cost of potable water given (thousands) of potential inflow scenarios modelled
- a forward price curve for water
- expected total cost of water dispatched to balance supply and demand
- expected marginal cost of the marginal water supply (demand side) option dispatched in each period
- volatility of those values.

Water values will vary over time, depending on a range of factors, including: starting storage levels; assumed inflows; demand forecasts etc.

Example water supply curve

and prices at two different times

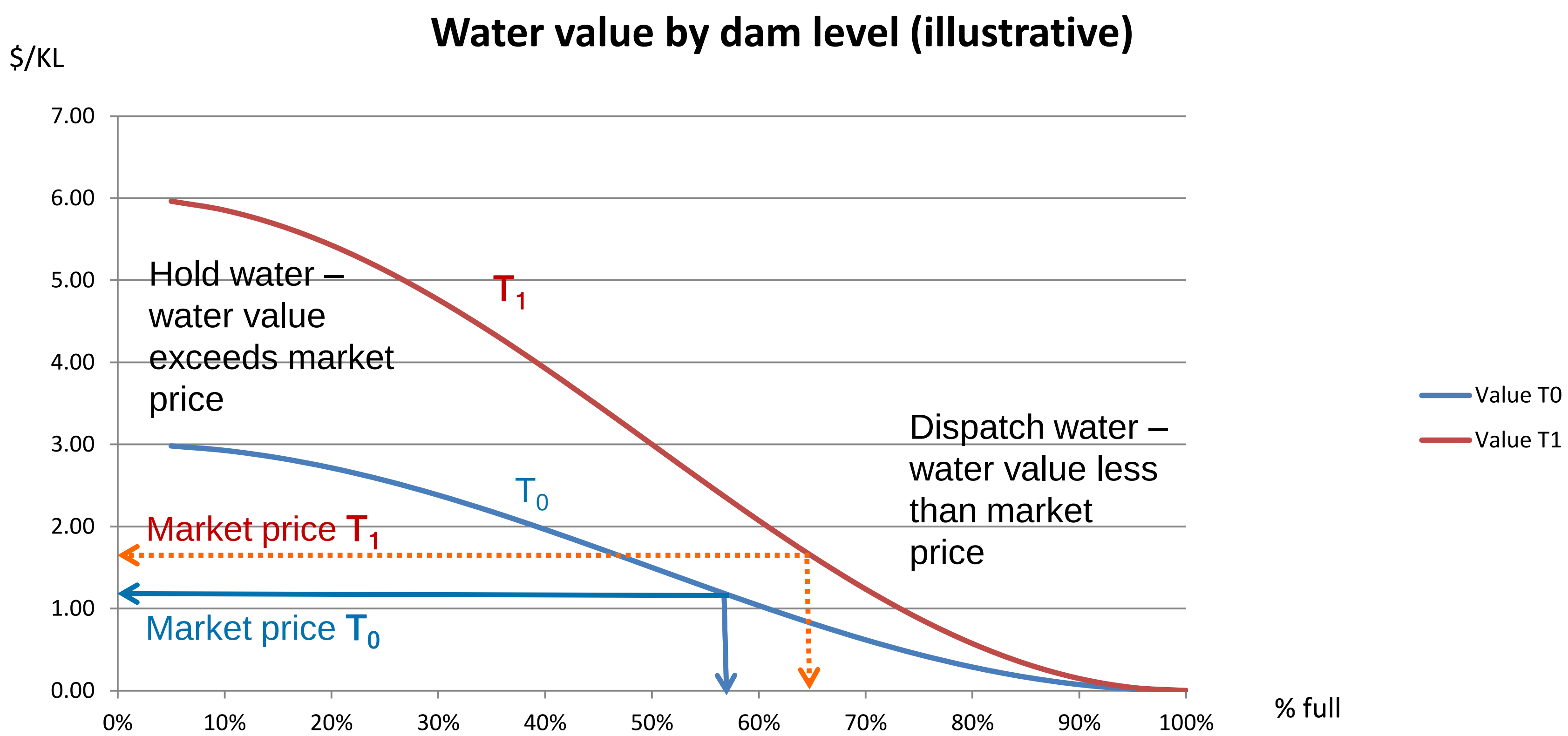
Supply type	Supply cost	Probability of being marginal		Probability weighted price	
		Time = T_0	Time = T_1	Time = T_0	Time = T_1
	$/KL	%	%	$/KL	$/KL
Dam[1]	0	19.8%	4.0%	0.00	0.00
Desal. 1	0.5	20.0%	15.0%	0.10	0.08
Desal. 2	1	20.0%	15.0%	0.20	0.15
Desal. 3	1.5	20.0%	30.0%	0.30	0.45
Restrictions 1	2.5	20.0%	35.0%	0.50	0.88
Restrictions 2	10	0.2%	1.0%	0.02	0.10
Total		100%	100%	**1.12**	**1.65**

1. Simplifying assumption adopted that the marginal cost of water from a dam is zero

Note: where new capex is required, the marginal cost would reflect that.

Water value by dam level

at two different times



Option value of water

- We have illustrated the value of water in storage and the basis of the dispatch decision
- But what about the value of the option to dispatch at some future time?
- The forward price has a volatility dependent on demand, the supply curve and the variability of future rainfall
- For example, if the T_0 price is $1.12/KL, it might be worth say 10c/KL for the right to exercise the option at T_1 if prices exceed say $1.65/KL
- The value can be calculated by probability weighted scenario analysis, or if distributions are normal, the Black Scholes formula can be used
- The option value is useful, because it reflects the probability of the water in the dam being dispatched, or if there were a market it would reflect the insurance value of the water.

Conclusions (1)

Key principles

- Like hydro electricity, the value of potable water reflects its opportunity cost of supply.
- With hydro electricity, the opportunity cost is underpinned by the forward electricity price curve,
- For potable water, the opportunity cost is derived by 'simulating' a forward price curve based on cost of dispatching alternative supply (or demand) options to maintain supply/demand equilibrium.

Modelling and results

- Given the stochastic nature of inflows, the dispatch model accounts for this uncertainty by adopting a 'real options' modelling approach
- As dam levels reduce, the marginal value of the water in the dam increases
- Water is dispatched when the price > marginal value, given current storage levels
- The insurance value of water in storage can be calculated

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Conclusions (2)

Application

Even if there is no water market, these methods can be used

- to optimise water dispatch and minimise costs to water companies and consumers.
- provide a measure of the scarcity price for water and could be used as an investment signal.

Valuing water supply using a market approach

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