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Pricing Water for Power Generation: A Two-Tier Approach

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Abstract

Current arrangements for pricing water for power generation are often deficient in providing signals in which to base investment decisions and in allocating water to its highest valued use. To address these shortcomings, a framework is proposed which relies on a two-tier pricing system. Firstly, joint fixed costs are allocated in the form of a fixed access charge to the various users, thereby recovering costs and providing an incentive in which to proceed with socially beneficial investment. Secondly, entitlements to water are to be traded at prices and conditions negotiated between the relevant parties to facilitate the efficient allocation of the water resource among competing uses.

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1. Introduction

As described in a Report to the Council of Australian Governments (COAG 1995) water is one of the nation's largest industries, with over $90 billion invested in infrastructure - earning some $5 billion in revenue per year. The Report further notes the industry's significant impact on the natural resource base through the harvesting of water for irrigation purposes and the disposal of wastewater. With this in mind, water reforms are being developed at both the state and national level to promote efficient use of the resource and provide signals which facilitate cost-effective investment in the augmentation and maintenance of the infrastructure.

State and national reforms are also moving ahead in the electricity supply industry. A National Electricity Market is being established with the aim of developing a competitive and innovative industry in which productive, allocative and dynamic efficiencies can be maximised *via* a system which encourages efficient operation, trading and investment by market participants.

The conflux of reforms in water and electricity markets provides new opportunities in pricing water for power generation. Ongoing development of clearly defined transferable water rights will provide the mechanism in which the market can efficiently allocate scarce resources to their highest value use. Net social benefits stemming from use of the resource will be further enhanced by ongoing reform of the electricity supply industry. In particular, market driven wholesale electricity prices will send a clear signal in which to efficiently allocate water for use as an input to power generation *vis-a-vis* competing uses such as irrigation.

Nevertheless, the challenge remains to develop a workable framework under which these outcomes can be obtained. Under current provisions, there is seldom a clear link between water charges and the cost of providing access to the infrastructure. Furthermore, water charges for power generation seldom reflect the opportunity cost of putting water through generation plant *vis-a vis* its impact on alternative uses for the water.

The aim of work presented in this paper is to develop a framework for pricing water for power generation which provides a transparent and non-distortionary mechanism to recover costs and which facilitates the efficient allocation of the water resource. At this stage, the scope of this research is limited to a group of medium size hydro-electric facilities in Australia which operate under a broadly similar set of pricing arrangements. The framework developed here has not yet been applied to arrangements to be developed in the Snowy Mountains Hydro-electric Scheme, however, there may be aspects of this work which will be relevant there as well.

2. Current Pricing Arrangements

By and large, dams in Australia have been built out of public funds, with no direct mechanism put into place to recover full economic costs, or to provide for the allocation of the water resource to its highest valued use. Other than the Snowy Mountains Scheme, hydro-electric facilities such as those at Dartmouth, Eildon and Hume dams have, for the most part, used water on a non-consumptive basis through access to water released for irrigation, environmental and flood control purposes. Typically, these hydro-electric facilities are charged on the basis of energy generated on cite in terms of a unit charge per MWh energy generated.[1] In most cases, the unit charge is related to a notional value of energy produced. The rationale behind these pricing arrangements is not clear, but it is tempting to attribute it to what Baumol, Panzar and Willig (1988 p. 508) characterise as the regulatory ethos which strives to equate price to some measure of cost, even where it is completely inappropriate and without logical foundation.

Broadly speaking, there are two general weaknesses with the current pricing arrangement.

- A MWh charge does not draw a clear link between charges to the generators and economic costs associated with their use of the dam.

- At the margin, the economic (opportunity) cost of putting water through generation plant is related to its impact on other competing uses, such as irrigation. A MWh charge does not reflect the opportunity cost of putting water through a turbine and is thereby an inadequate means in which to allocate resource use.

3. The Institutional Setting

As noted above, a key aim of water reform both at the state and national level is to put into place a framework which will promote efficient use of water and provide signals which facilitate cost-effective investment in the augmentation and maintenance of the infrastructure. One important matter which must be addressed in meeting this aim is to put into place an efficient system of water charges related to the cost of operating the water supply infrastructure.

In the Report to the Council of Australian Governments referred to above, the Expert Group on Asset Valuation Methods and Cost-Recovery Definitions for the Australian Water Industry stated that:

"an economic approach to charging is required if resources are to be allocated efficiently and the correct signals are to be given in relation to investment and

[1] A host of additional conditions and charges are applicable to many facilities but are not li. y to be material to the general argument presented in this paper.

consumption. Without these signals, there is the possibility that insufficient attention will be paid to the resource costs, and as a consequence, less than best use made of the resources." (p.12)

The Expert Group recommended that:

- *"the full cost of providing water services attributed to specific identifiable beneficiaries or impactors be recovered by way of charges on them;*

- *the costs of public benefits/impact management which are unable to be attributed and charged to specific beneficiaries/impactors should be treated as community service obligations; and*

- *where costs are subsidised by a jurisdiction or local government authority, any such subsidy or any community service obligation be made explicit and transparent."(p. 17)*

With the above statements in mind, the criteria for developing a framework for cost-allocation and water pricing can be summarised in the following manner (with the understanding that it could be generalised to accommodate externalities):

- That water be used where its economic value is greatest; and

- that investment in capital works; operation and maintenance be carried out in a cost-effective manner and be charged to the parties that benefit.

4. An Economic Framework for Cost-Allocation and Water Pricing

Optimal pricing arrangements call for price to equal the marginal cost of production. However, marginal cost pricing leads to deficit funding of capital costs, as well as those costs related to operations and maintenance which are not influenced by a marginal change in output. In the case of a dam, this is particularly troublesome, because these fixed costs overwhelm those costs which may accrue at the margin.[2] The problem which arises is that marginal cost pricing, without some further means of cost recovery, provides little incentive to invest in capital works, operation or maintenance of the dam.

In the case of large infrastructure projects such as dams, public ownership has most often provided the basis for investment. In this case, cost recovery is not, strictly speaking, essential to economic efficiency. Services stemming from the use of the dam could be priced at marginal cost with the deficit residing with the public authority. Nevertheless, economic efficiency (with respect to the

[2] In the case of a dam, costs related to operations and maintenance are largely unaffected by marginal changes in output. For the rest of this paper, operations and maintenance will be considered as a fixed cost following the economic interpretation of the matter.

investment decision) *does* require that full economic benefits of a project equal full economic costs, even if these costs are not actually recovered. To facilitate this balance in practice, mechanisms must be put into place which provide system managers with appropriate economic incentives and signals in which to base investment decisions. Without such incentives, investment decisions may be misguided or subject to political intervention. Thus, current water reform has generally called for the recovery of costs directly from those that benefit, with the intent that the economic cost of the system be matched by the economic benefits that accrue as a result of such investment.[3]

4.1 Pricing to Recover Costs

An ongoing challenge to economists, regulators and policy makers has been to develop an economically efficient system of cost recovery. Two pricing approaches which have been extensively examined in the literature and widely used in practice are cost based prices and multi-part tariffs (see, for example Brown and Sibley 1986). As will be explained later in this paper, the recommended approach to pricing water for power generation is a hybrid of the two.

Cost-Based Pricing

Fully Distributed Cost (FDC) pricing is a commonly used method of pricing in which each user pays for all costs which are directly attributable to that particular use, and joint costs are then distributed on the basis of some common measure of utilisation such as relative output or revenue. In the case of a dam, the FDC of each use (i) is represented as:

$$FDC_i = \text{Attributable Cost of i} + f_i \times \text{Common Cost},$$

where f_i is the proportion of Common Cost to be allocated to each use, which would include power generation, irrigation and perhaps environmental flows as well.

A difficulty in implementing a cost-based pricing regime is that the allocation of joint costs must be done in a rather arbitrary fashion. That is, one cannot generally say that one allocation is more efficient (in terms of its impact on the allocation of resources) than another. It is clear, however, that the allocation of joint costs will have a direct financial impact on relevant parties, often giving rise to equity disputes.

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[3] Defining relevant costs is no trivial matter. First, one needs to establish under what conditions existing assets should be treated the same as system augmentation, operations and maintenance. Secondly, the terms of valuing such assets needs to be defined. Common approaches are based on historical costs, current replacement costs and deprival costs. See COAG (1995) for an examination of these issues.

Three approaches which have been used in sectors where joint fixed costs are significant are examined by Braeutigam (1980).

- The *Relative Output* approach allocates joint costs to each use in proportion to each use's fraction of total output. In the case at hand, the metric could be the volume of each user's water entitlement.

- The *Gross Revenue* approach allocates joint costs to each use in proportion to each use's share of gross revenue stemming from the project. Presumably, the revenue stemming from electricity sales would be relevant to the generator, and the value of agricultural production used for irrigators. Incorporating other uses such as environmental flows may be difficult.

- The *Attributable Costs* approach allocates joint costs in proportion to the costs that can be directly attributed to the various uses.

The FDC method does have some well documented drawbacks. In particular, it as been criticised on the grounds that it is well off the mark in terms of promoting allocative efficiency since it draws no comparison between incremental costs and benefits arising from the service.[4] FDC pricing, as described above, would lead to allocative in-efficiencies if applied to pricing water for power generation. A fixed unit charge for water would have little or no relation to the opportunity cost of putting water through the turbine. For example, when non-consumptive use of water (water to be released for irrigation or environmental flows, for example) is fed through the turbine, any positive price to the generator could lead to a situation where water might be unnecessarily left untapped for power generation. The reason being that wholesale electricity prices vary considerably. In times where wholesale electricity prices are near zero (which can and does occur in a wholesale market with considerable excess capacity) the hydro-electric generator might forgo power generation, as the charge would be greater than price received for the power. Conversely, the fixed unit charge cannot be used as the basis for allocating (or re-allocating through sale from those with prior water rights) consumptive water rights to the generator since they bear no relation to the opportunity cost of forgoing alternative uses of the water.[5]

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[4] The FDC approach has also been criticised as a means in which to identify subsidy, but this is not crucial to the matter at hand.

[5] This presentation may imply a dichotomy between consumptive and non-consumptive use of water. Clearly, various conditions on the release of water would have different levels of impacts on competing uses of water, leading to a broad spectrum of opportunity costs within what is commonly called consumptive and non-consumptive use of water. The points made in this paper are robust to this more accurate definition.

Two-Part Tariffs

The cost-based approach described above is sometimes referred to as a *uniform tariff*, signifying that the price per unit is uniform across any given level of demand. An alternative is the *non-uniform tariff*, where price per unit is conditional on a purchaser's level of demand. This added flexibility can provide a means in which to recover costs in an economically efficient manner. An example of a non-uniform tariff is the two-part tariff, which is composed of a fixed access charge designed to cover fixed costs, and a unit charge which ideally would reflect marginal costs.[6]

In an application to railway freight rates, Freebairn and Trace (1992) argue that the two-part tariff leads to efficient investment and production decisions since the suppler receives a return on funds invested and receive incentives to expand capacity to the point where marginal returns to investment and costs are equated. Similarly, the user faces proper economic signals since the fixed cost component, if designed properly, will have no impact on their level of operations, and only the second part of the tariff - the marginal cost - affects production plans.

The two-part tariff described above has proven to be a workable means in which to address the often conflicting aims of cost-recovery and allocative efficiency. However, it is not feasible to apply what could be characterised as a "standard" two-part tariff to the case of pricing water for power generation. This is because the relevant marginal cost is largely the opportunity cost of the water, which cannot be defined by a scalar unit of measurement (for example, ML of water) since the value of a given quantity of water typically varies over time and in relation to the certainty of availability. Furthermore, water entitlements are often dispersed, which may constrain any one authority associated with the dam from charging for it in the same way as other utilities or firms might.

4.2 A Two-Tier Pricing System

Standard applications of cost-based and two-part tariffs are arguably deficient or impractical when applied to pricing water for power generation. A hybrid of the two approaches is proposed which also incorporates the developing market in tradeable water rights. This two-tier approach is as follows.

First, costs are to be recovered *via* the cost-based method whereby attributable costs are paid for directly by the relevant user, and joint costs are allocated in the form of a non-distortionary fixed (lump sum) access charge, similar to the first part of a two-part tariff.

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[6] The simple two-part tariff is ideally used where marginal costs are constant. Multi-part tariffs could be developed to approximate other cost structures.

Determining the basis for allocating joint costs on a *fixed charge basis* is largely a matter of equity and practicality. And to drive home an important point, the fixed access charge has been proposed exactly for the reason that by itself, it has little impact on the water usage. This is not the case for the traditional FDC *unit charge* approach which does affect resource allocation, albeit in a perverse manner. Nevertheless, there are several aspects of the market which may favour the Relative Output approach in which joint costs are allocated in proportion to the user's water entitlement: the information required is readily available, it is consistent with the "user-pays" principle underlying water reform, and costing of water for environmental or recreational flows (where based on an entitlement) would be transparent and easy to administer as a Community Service Obligation (CSO).

The second tier of the pricing approach would come about through trades in water rights - either temporary or permanent - at prices to be negotiated between relevant parties. This means that both hydro-electric generators and irrigation agencies would be free to trade water at prices determined by market conditions, ensuring that water is allocated to its highest valued use.

It is important to understand that the cost-based component of the pricing system recommended here (the first tier) only provides for a reasonably non-distortionary allocation of costs, but does not *in itself* provide appropriate signals in which to allocate the use of water. It is essential, therefore, that trade (on-sale of water rights) be allowed at market based prices, irrespective of the cost-based pricing regime (access charge) so that water will move to its highest value use without relying on a central agency to continually allocate resources.

Generators would be able to enter into arrangements to purchase water entitlements for the consumptive (for example, seasonal) use of water for hydro-electric generation. The pricing arrangements would be purely market driven, and independent of the cost-recovery mechanism described above.

Generators and relevant holders of water entitlements would negotiate charges for the non-consumptive use of water, again, independent of the cost-recovery mechanism. The charge should, however, be consistent with competitive principles, possibly similar to access arrangements currently being considered in other industries.

5. Summary

Current arrangements for pricing water for power generation are becoming increasingly out of step with developments taking place in the larger markets of which they are a part of. An approach to pricing water for hydro-electric generation has been proposed which has as its objective that water be used where its economic value is greatest, and that investment in capital works, operation and maintenance be carried out in a cost-effective manner.

Under the two-tier approach developed here, it is proposed that:

- A fully distributed cost based pricing system be established in which all economic costs of operation are recovered from those benefiting from the use of the resource. To do this it is suggested that costs which are directly attributable to a user be funded by that user; and that the Relative Output approach, based on access to water entitlements in volumetric terms, be used to allocate joint costs by way of a fixed access charge.

- That trade (on-sale of water rights) be allowed at market based prices, irrespective of the cost-based pricing regime. Consumptive use of water will be priced within a market for tradeable water entitlements. Charges for the non-consumptive use of water will be negotiated by generators and owners of the water entitlements. Charges will need to be consistent with what would be expected to come from a competitive market.

Reforms in water and electricity open up new opportunities in which to optimise use of scarce resources. Tradeable water rights will lead to increased allocative efficiency whereby water is used where its value is greatest, and cost reflective pricing will provide better signals in which to base investment decisions. The development of a National Electricity Market will likewise lead to more efficient use of existing infrastructure and inputs, and provide market based incentives in which to base future investment decisions. It is hoped that the proposed framework offered here will provide the basis for efficient resource allocation across these two vital sectors of the Australian economy.

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