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Energy-Water Nexus: An Integrated Modeling Approach

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Abstract – *Energy and water are essential for physical, social and economic wellbeing. In recent times, changes to the energy and water industries, brought about by industry reform, environmental considerations and strategies to meet future demand have brought into sharp focus the link between the two - termed energy-water nexus in this paper. The recent emergence of the phenomenon as a critical issue signifies that understanding of the nature of the nexus and models to assist in analyzing it are still being developed. A review of the models indicates that, whilst providing useful tools for localized contexts, the methodologies adopted limit the suitability for policy analysis at an economy-wide level. A more integrated approach, based on input-output analysis, would provide such a framework, and is the basis for an energy-water model presented in this paper. Whilst the model has been developed for New South Wales, Australia, it may be adopted by regions elsewhere, where energy and water industries are being similarly transformed.*

Keywords – Energy-water nexus, input-output analysis, modeling, policy analysis.

1. INTRODUCTION

Energy is fundamental for human life, social wellbeing and economic development. In New South Wales (NSW), and indeed elsewhere in the world, the electricity industry is experiencing significant changes, as a result of industry reform, environmental considerations and strategies to meet future demand. These changes have brought into sharp focus the links that exist between electricity and other infrastructure industries, such as water. In particular, there is growing evidence that the links between energy and water – termed the energy-water nexus in this paper – has a real implication on the efficacy of energy (and water) policies, as reported elsewhere "…water planners at the federal, state, and local levels have largely failed to consider the energy implications of their decisions…the State [of California] appears to not be consciously managing its rapidly evolving water and energy policies in a coherent manner" [1]…there is acknowledgement of the potential synergies in water and energy management that have largely been neglected, as well as recognition that existing national policies to not to any substantial degree link the infrastructure systems…" [2].

What appears to be lacking is an informed understanding of the nature of the nexus and policy tools to assist decision makers develop more integrated energy and water policies. The objective of this paper, accordingly, is to present an energy-water modeling framework and demonstrate its usefulness for policy analysis. By way of background information, this paper begins with a discussion on the nature of the nexus and the implications for NSW in Sections 2 and 3. Existing energy-water models are then reviewed in Section 4, in order to determine their suitability for policy analysis. An integrated energy-water framework, based on input-output analysis, is introduced in Section 5 and preliminary results are presented. While the focus of this study is NSW, the framework and messages are equally relevant for other regions where reforms are underway or are being contemplated.

2. EMERGENCE OF ENERGY-WATER ISSUES

Increasing pressure on energy and water resources around the world has culminated in an emergence of energy-water nexus issues, providing evidence that strong links exist between these two resources. A previous publication by the authors of this paper classified the links into three major categories: upstream, transportation and downstream [3]. This classification system depicts the common flow sequence of water and energy resources from the environment to the end user. Functions closer to the environmental source, such as primary fuel sources, electricity generation, raw water sources and bulk water supply are located in the upstream category. Functions closer to end users, such as retail supply of water and energy, end users, and wastewater treatment are located in the downstream category. The transportation category includes transmission and distribution of energy, and extraction, transfer, conveyance, distribution, and collection of water and wastewater.

Figure 1 depicts this classification clearly and indicates the links between the different functions of the electricity and water industries.

Upstream

A key upstream link is water for electricity generation, specifically cooling water in thermal power stations and as a source of energy in hydropower plants. Typically, water resources used by electricity generators are shared with other users, such as irrigators and river ecosystems,

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raising allocation issues, particularly during dry periods. Another link in this category is electricity for bulk water supply, particularly for energy-intensive technologies, such as desalination.

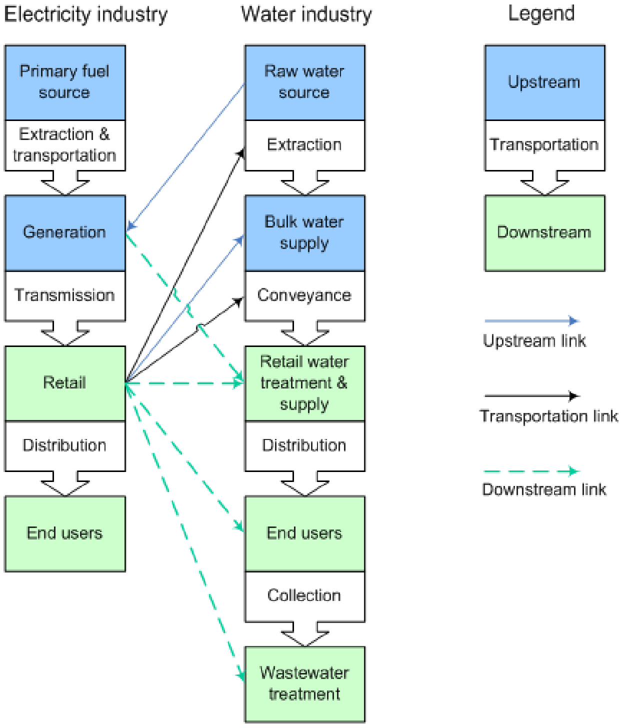

Fig. 1. Links between the electricity and water industries

Transportation

In the transportation category, electricity is required to extract groundwater, and secondly, to convey surface water. Other energy sources, such as diesel, are also used for this purpose, particularly in developing countries. Inadequate provision of water and electricity - which is not uncommon in developing countries - raises further issues. For example, inadequate mains water may be supplemented by tank water, requiring fuel for transportation. If this tank water is stored in underground wells on site, additional electricity (or fuel if electricity supply is also inadequate) would be required for pumping.

Downstream

Four links are identified in the downstream category. Firstly, retail electricity is required for retail water treatment and supply. Electricity disruptions would have serious public health ramifications. To safeguard against this, some water utilities have considered installing microhydro turbines and other electricity generation technologies, representing the second link [4]. Thirdly, consumption patterns of water end users influence demand for retail electricity, a common example being domestic hot water. Lastly, electricity is required for wastewater treatment and increasingly, energy is being recovered from wastewater processes, such as anaerobic digestors.

The abovementioned discussion identifies key examples of the generic nature of the links between water and electricity industries. The following section examines these links in the context of NSW, particularly in light of some of the changes occurring in both industries in the state.

3. IMPLICATIONS FOR NEW SOUTH WALES

The electricity and water industries in NSW are being transformed, as a result of industry reform, environmental imperatives and implementation of strategies to meet future demand. An overview of these changes is provided in this section, with a view to determine how the links between water and energy that have been identified in Section 2 may impact on these changes.

Industry Reform

The electricity and water industries have changed considerably over the last two decades, commencing with internal reforms in the 1980s to widespread reforms in the mid 1990s that were part of the larger suit of microeconomic reform programs initiated by the Federal Government (see [3] for further discussion). The reforms resulted in significant modifications to the structure, ownership and regulatory arrangements of the industries. In terms of structure, vertically-integrated utilities were functionally unbundled, for example, the electricity generation and retail functions were separated. Ownership shifted towards the private sector, as many utilities were corporatized. In the case of the electricity industry, a National Electricity Market (NEM) was established that currently includes the eastern states of NSW, Victoria (VIC), Queensland (QLD) and South Australia. Price regulation and access rights to monopoly segments were also established. In 2004, the reform programs were reinvigorated by the Council of Australian Governments (COAG) with the expectation that additional benefits could be realized.

Implementation of the reform agenda appears to have been undertaken with little regard to the links that exist between the water and electricity industries. This may be attributed in part to the prescriptive nature of the reform programs that were applied across all infrastructure industries, and in part to the traditional ‘compartmentalization’ of expertise in the water and energy fields [3]. These reforms - specifically the establishment of the NEM - are further consolidating the links between water and energy, with less than optimal results. For example, cheap electricity is being imported into NSW from QLD generators that are sourcing cooling water from Brisbane’s main drinking water supply, Wivenhoe Dam. It is argued that the export of electricity from QLD is diverting valuable drinking water away from the state, which is experiencing severe water shortages, due to the current drought. It is also reported that NSW has sufficient capacity to meet peak demand, without needing to rely on electricity imports from QLD. Supporters of the NEM, however, claim that it has brought continuity of supply and significant economic benefits to QLD [5].

The case of the Snowy Mountains Hydroelectric Scheme (Scheme) highlights yet another example of how nexus issues may be exacerbated by industry reform. The Scheme, operated by Snowy Hydro, diverts water from the Snowy River for electricity generation and releases the water to the Murray and Murrumbidge Rivers, which serve valuable farming interests in NSW, VIC and SA. Water allocations are generally defined under Snowy Hydro’s water license, however the company has reduced water releases to irrigators downstream, due to water shortages. Whilst Snowy Hydro maintains that it is acting in accordance with its license, it is also argued that the company is reserving water to power lucrative peak summer demand – thereby maximizing profits - at the expense of irrigators [6]. Further corroboration for this argument is the recent attempt by the NSW, VIC and Federal governments to privatize Snowy Hydro. It was believed that capital from the sale would allow the company to diversify its energy portfolio and expand into the retail market, thereby reducing the risk of losses in revenue and value [7]. The idea was abandoned, primarily due to community concern over selling the Scheme, which is considered a national icon.

Environmental Considerations

The state of the environment has strong implications for the electricity and water industries. Perhaps the strongest short-term implication, mentioned previously, is the shortage of water resources. NSW, and indeed the much of the country, has been in drought since 2002. Already, water shortages have resulted in reduced hydroelectricity production in smaller plants across the state (S. Gough, pers com). Further, continuation of surface water shortages may result in increased reliance on groundwater sources that would require energy for pumping.

From a longer-term perspective, impacts of global warming and climate change from increased levels of greenhouse gas emissions could adversely affect precipitation levels and place further stress on water resources. Australia's heavy reliance on greenhouse gas-intensive fossil fuels for electricity generation[1] is certain to perpetuate this predicament.

Meeting Future Demand

Both the electricity and water industries are exploring strategies to meet increasing demand for their services in the short and longer term. For example, it is estimated that an additional base load of 2,000 MW of electricity will be required in NSW from 2012-13, with 6,000 MW required over the longer term [8]. To meet peak demand in the shorter term, two gas-fired power plants will come on line by 2008/09 and provide an additional 700MW (a privately-owned 400MW plant and a government-owned 300MW plant) [9]. It is envisaged that the plants will source water from estuary lakes, and therefore would not directly consume freshwater. However, development of power plants in the longer-term may increase the industry's reliance on freshwater, particularly if the plants are located inland.

In the water industry, an estimated 200 billion liters of water will be required each year within 25 years, above the 600 billion liters already supplied annually [10]. A number of strategies have been identified to augment Sydney's water supply, including: transferring up to 110 billion liters of water from the Shoalhaven River south of Sydney; accessing deep water from the bottom of existing dams; increasing water recycling; sourcing groundwater; and constructing a desalination plant. These strategies, particularly desalination, will undoubtedly increase the water industry's reliance on electricity and contribute to greater levels of greenhouse gas emissions, unless greenhouse gas neutral energy strategies are adopted.

An alternative to supply-side solutions is demand management. Efforts are being made in the state to promote demand side solutions through, among others, DEUS' Water and Energy Savings Fund [11] and Sydney Water's Retrofit Program [12]. These initiatives would help to slow down the rate of growth of greenhouse gas emissions and reduce pressure on water resources. Further, if demand management efforts are sufficient enough to reduce the need for new supply infrastructure, additional savings would be achieved from energy and water that would otherwise be required for constructing, operating and maintaining the infrastructure. Widespread application of demand management solutions, however, may appear to conflict with the financial interests of utilities that are geared towards revenue raising, particularly if privately owned.

The above discussion highlights the interactions between energy and water in NSW, which have intensified due to industry reform, environmental imperatives and efforts to meet future demand. Elsewhere, particularly in the United States of America (USA), increasing recognition of the significance of the nexus has led to the development of several analytical models that attempt to quantify the links. These models are reviewed in the following section, with a view to inform the development of an energy-water model, that may capture some of the issues discussed previously.

4. A REVIEW OF ENERGY-WATER MODELS

This section compares eight energy-water models, in terms of the main objectives, methodology and main findings (see [13] for a full review). A summary of the models is provided in Table 1 below. This is followed by some observations arising from the review process.

Several observations regarding the objectives and methodologies were noted from the review process:

i) Many of the models are limited to one industry (eg. agriculture in models 2, 3, 4 and 5) or a function within an industry (eg. wastewater treatment in model 8) and would provide useful tools to assess the interaction between energy and water at localized levels;
ii) Such an approach may limit the usefulness of the models for policy analysis, because the interaction between the two industries and the wider economy are not captured; and
iii) Possible reasons for this limitation include: the inherent challenge of collecting data from industries that are traditionally 'compartmentalized'; the move to private ownership that may prevent access to data considered 'commercial in confidence'; and the disciplines-based approach of much research, which lends itself to studies that are narrower in scope.

The following insights were also noted from the main findings:

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[1] In 2000-01, 84% of generation in Australia was derived from coal. Source: ABARE statistics

Table 1. Summary of existing models

No, Ref.	Category	Main objective	Region, Year
Upstream			
1, [1]	Bulk water supply	Estimate energy use for various water sources in urban water cycle	USA, 2004
2, [1]	Competing uses	Estimate energy impact of irrigation diversions upstream of a hydropower plant	USA, 2004
Transportation			
3, [14]	Water extraction	Analyse impact of electricity pricing on groundwater productivity	India, 2003
4, [1]	Water transfers	Evaluate energy required for three scenarios for water formerly used in retired agricultural lands	USA, 2004
5, [15]	Water transfers	Examine water price as a tool to encourage surface or groundwater use depending on availability, and the energy implications	USA, 2002
Downstream			
6, [16]	End users	Estimate energy use for different water conservation options in a commercial or residential building.	USA, 1998
7, [17]	End users	Estimate impacts of water and energy prices on residential water demand.	Denmark, 1998
8, [18]	Wastewater treatment	Evaluate energy demand of activated sludge plants that also recover energy.	Austria, 2003

iv) A definite link was demonstrated between the price of one resource (*e.g.* electricity) and the consumption of the other (*e.g.* water) (see models 3, 5 and 7 in Table 1);

v) Industry reform may contribute to the emergence of nexus issues (see model 2 in [13] for further details); and

vi) Solutions to ameliorate problems resulting from the interaction between energy and water are not necessarily straightforward. ‘Engineered solutions’ need to have political currency and take account of wider social ramifications, whilst ‘pricing solutions’ require the development of supporting institutional structures.

5. AN INTEGRATED MODELING APPROACH

The above models - whilst increasing general understanding of the nexus and providing useful tools at localized levels - offer little scope to quantify the links between water, electricity and the wider economy, and address some of the issues facing NSW and indeed elsewhere. An integrated energy-water-economic model, such as one based on input-output (I-O) analysis, would offer this opportunity and provide policy makers with a tool to develop more integrated energy and water policies.

GENERAL INPUT-OUTPUT METHODOLOGY

I-O analysis was first introduced to modern economics in the late 1930s by Russian economist, Wassily Leontief. Since then, it has been the basis of numerous policy and planning models in various fields, including energy and water. An I-O model is useful for analyzing energy-water nexus issues at an economy-wide level, because it recognizes the interdependence between electricity and water industries and other sectors in an economy. For example, electricity and water are direct inputs to production sectors, which in turn produce goods and services for end users. End users, therefore, not only consume electricity and water directly themselves, but also indirectly through electricity and water embedded in the output of production sectors. These direct and indirect interactions are effectively captured by the input output framework, which is described in more detail below.

Basic Input-Output Framework

The I-O table and the coefficients derived from it form the basis of the technique. Essentially, the table depicts three elements of an economic system (refer to Figure 2): the inter-industry table shows the flow of goods and services between production sectors (outputs form inputs for other sectors and as such is termed intermediate demand); value added refers to the earning of factors of production, such as capital and land and many include imports; and final demand refers to consumption by end users, such as households and government and are considered exogenous.

Outputs to sector *j* Inputs From sector *i*	Intermediate demand	Final demand	Total output
Production sectors	**Inter-industry table (x_{ij})**	(Y_i)	(X_i)
Value added	(V_j)	GNP	
Total outlay	(X_j)		

Fig. 2. Basic structure of an input-output table

The following equation describes an economy with *n* sectors:

$$X_i = \sum_{j=1}^{n} x_{ij} + Y_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i \qquad (1)$$

where X_i is the total output from sectors $i = 1$ to n; X_j is the total outlay from sectors $j = 1$ to n; x_{ij} is the interindustry flow from sector i to j; Yi is final demand for sector I outputs; V_j is value added by sector j; and $a_{ij} = x_{ij}/X_j$ is the direct demand of sector i per unit output of sector j, otherwise referred to as the technical coefficient.

In matrix form Equation 1 becomes:

$$X = AX + Y.... \Rightarrow ....X = (I - A)^{-1} Y \qquad (2)$$

where I is an $n \times n$ identity matrix and $(I - A)^{-1}$ - commonly referred to as the Leontief inverse - is the direct and indirect demand for sector i outputs required to meet a unit of final demand for sector j outputs. Together, direct and indirect demand may also be referred to as total demand.

Equation 2 is considered demand-driven in that total output *(X)* is determined by final demand *(Y)*. The basic assumption of this model is that technical coefficients, a_{ij}, in the A matrix are fixed, *i.e.* there is a fixed relationship between the inputs and outputs of the inter-industry table. The economy is assumed to operate under constant returns to scale. Further information about assumptions may be found in [19].

Monetary values are commonly used in the input-output table, obscuring the fact that it is actually a ‘quantity’ model. That is, flows of goods and services may be represented in mixed physical quantities, such as PJs of energy or MLs of water. Where both physical and monetary values are used, the model is considered a ‘hybrid’. In this case, X_j comprises of mixed units and cannot be summed. Technical coefficients are therefore calculated using X_i, ie $a_{ij} = x_{ij}/X_i$.

To fully represent an economic system, two additional equations are required:

$$P = (I - A')^{-1} V \qquad (3)$$

$$P'Y = V'X \qquad (4)$$

Equation 3 represents the price model, where P is a $n \times 1$ vector of unit prices, such as the unit price of a PJ of electricity or a ML of water. If the quantity model comprises of monetary values then the corresponding unit price is equal to 1. The price model may be used to assess the impact of a change in value added costs or a change in technical coefficients on unit prices (P).

Equation 4 represents the income model and is derived from the quantity and price models (Equations 2 and 3, respectively). The income model ensures that the value of final demand is equal to total value added.

Natural Resources as ‘Value Added’Inputs

Value-added, as described previously, refers to earnings of factors of production such as capital and land that are required by the production sectors to produce their output. Reference [20] suggests that natural resources, such as primary energy and freshwater should be represented properly in the I-O table, rather than being considered ‘free gifts of nature’, thereby better acknowledging the contribution of the environment to the economy. Equations 2 to 4 may be extended to include k natural resource factors of production and their factor prices:

$$X = (I - A)^{-1} Y \text{ and} \qquad (2)$$

$$FX = f \qquad (2a)$$

$$P = (I - A')^{-1} F'\pi \qquad (3a)$$

$$P'Y = \pi' FX \qquad (4a)$$

where F is a $k \times n$ matrix of natural resource factor inputs per unit of output in physical units, f is a k vector of total factor use in physical units and π is a k vector of factor prices.

Equation 2a allows one to calculate the natural resources required to satisfy final demand whilst Equation 3a allows one to disaggregate unit prices P into portions paid directly and indirectly to each natural resource factor of production.

A CASE STUDY OF NSW

The energy-water model presented in this paper is based on a 106-sector I-O table for the NSW economy for 2000-01. The table was aggregated into thirty-two production sectors, in order to match the level of detail available in water and energy data. The model comprises of three water sectors (irrigation and drainage water providers, bulk and retail water suppliers, and wastewater service providers), six electricity generation sectors (coal fired, combined cycle, cogeneration, gas turbine, hydro and other renewables) and four other energy sectors (coal mining, petroleum refining, petroleum and coal products nec and gas).

There are eleven ‘value added’ inputs, including surface water, groundwater, instream use, raw coal, six energy import categories, non-energy imports and an ‘other value added’ category (which would include capital, rent, interest, etc). Surface and groundwater refer to water that has been directly extracted from the environment by production sectors, whilst instream use refers to water that is used in situ (eg. hydro). Water and energy are in physical units and the remaining figures are in dollars.

Preliminary results presented here focus on the quantity model, in particular the demand for electricity by the water sectors, and the demand for water by the electricity sectors.

Demand for Electricity by Water Sectors

Direct and total demand is highest for bulk and retail water suppliers, followed closely by wastewater service providers. As can be expected, it is much lower for irrigation and drainage water providers, whose demand would be confined to extracting groundwater or delivering water to customers in non-gravity systems. Refer to Table A-1 in the Appendix for further details.

Demand for the energy value added inputs of raw coal and energy imports are by comparison not significant and therefore the results have been omitted.

Demand for Water by Electricity Sectors

Water sector outputs: Compared to other electricity generation sectors, combined cycle directly and indirectly consumes the largest amount of water from bulk and retail water suppliers. A reasonable explanation is this sector's use of mains water for process operations, which is used for mainly potable purposes by other electricity generation sectors. Water from the wastewater services sector – namely treated effluent – is directly consumed by the coal fired generation sector, and due to interindustry transactions, is indirectly consumed by all other electricity generation sectors. Indirectly, all sectors consume water from irrigation and drainage water providers (agriculture is the sole direct consumer), because of interindustry transactions and the importance of agriculture to the NSW economy. Refer to Tables A-2 and A-3 in the Appendix for further details.

Water value added inputs: Surface water is directly consumed by coal fired and cogeneration. Due to interindustry transactions, all electricity sectors indirectly consume surface water, with combined cycle having the highest total demand. Groundwater is consumed only indirectly by the electricity sectors. Instream water is used directly by hydro and indirectly by the other sectors. Excluding instream use, the highest reliance on water value added inputs is combined cycle, followed by coal fired. Interestingly, whilst combined cycle does not directly demand water value added inputs, it is one of the highest indirect users, highlighting the importance of examining indirect demand by considering the interactions between energy and water and the wider economy. Refer to Tables A-4 and A-5 in the Appendix for further details.

Overall, aside from a very high demand on instream use by hydro, combined cycle and coal fired are the largest consumers of water in the NSW economy. The most water-efficient technologies are gas turbines, followed by cogeneration.

Some Policy Implications

The results presented above and in the Appendix highlight the importance of capturing both direct and indirect (total) demand for water and electricity. For the case of NSW, the ability to capture total demand for the different electricity generation sectors will provide energy planners and policy makers with a more informed understanding of the water needs of different generation technologies, and may assist with decisions over future investment in the generation sector, particularly if drought conditions persist in the foreseeable future. Reduction in water consumption by the electricity industry would have substantial benefits for other water users, particularly irrigators and river systems.

Some Other Potential Uses of the Model

With further development, the proposed model may also be used to:

- Examine the impact of water shortages (*i.e.* change to the supply of a value added in put) on electricity generation output, and overall output of the NSW economy
- Determine direct and indirect water savings from reductions in electricity consumption by end user groups, and
- Conversely, determine the direct and indirect electricity savings from reductions in water by end user groups, and
- Calculate the direct and indirect electricity required for water supply scenarios, such as desalination and water recycling.

These insights may further assist policy makers with developing more integrated water and energy policies.

6. CONCLUSION

The electricity industry is changing as a result of industry reform, environmental considerations and strategies to meet future demand. These changes have brought into sharp focus the links between electricity and other infrastructure industries, such as water. In particular, implications of the energy-water nexus are already being felt the world over, and understanding of the nexus is evolving. Several energy-water models have been developed in recent years that focus on one industry or a sector within an industry, however, there are no models that link the electricity and water industries to the economy at large. In order to address this shortcoming, the energy-water model presented in this paper offers a framework that considers energy and water in the wider economy and is based on I-O analysis. Preliminary results indicate that the bulk and retail water sectors are the highest electricity users, followed closely by wastewater service providers. In addition, water demand varies significantly between the electricity sectors and should be considered in decisions over future electricity generation investment. These results highlight the importance of considering the energy-water nexus when planning energy infrastructure and developing energy policies.

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APPENDIX

Table A-1. Demand for electricity by water sectors (MWh/ML)

Water sector	Direct demand	Total demand
Irrigation & drainage water providers (I&DWP)	0.0074	0.0096
Bulk and retail water suppliers (B&RWS)	0.3167	0.3817
Wastewater service providers (WWS)	0.2581	0.3458

Table A-2. Direct demand for water sector outputs by electricity sectors (ML/PJ)

Electricity sector	I&DWP	B&RWS	WWS	Total
Coal fired	N/A	13.02	2.02	15.04
Combined cycle		127.65	0.00	127.65
Cogeneration		2.18	0.00	2.18
Gas turbine		0.93	0.00	0.93
Hydroelectric		3.92	0.00	3.92
Other renewables		3.74	0.00	3.74

Table A-3. Total demand for water sector outputs by electricity sectors (ML/PJ)

Electricity sector	I&DWP	B&RWS	WWS	Total
Coal fired	1.99	16.63	2.83	21.46
Combined cycle	2.93	138.19	0.06	141.18
Cogeneration	3.18	5.63	0.07	8.88
Gas turbine	2.05	7.13	0.04	9.23
Hydroelectric	4.43	8.74	0.10	13.28
Other renewables	4.43	8.57	0.10	13.10

Table A-4. Direct demand for water 'value added' inputs by electricity sectors (ML/PJ)

Electricity sector	Surface water	Groundwater	Instream use	Total (including instream)	Total (excluding instream)
Coal fired	110.02	N/A	0.00	110.02	110.02
Combined cycle	0.00		0.00	0.00	0.00
Cogeneration	6.97		0.00	0.00	0.00
Gas turbine	0.00		0.00	0.00	0.00
Hydroelectric	0.00		315,075.52	315,075.52	0.00
Other renewables	0.00		0.00	0.00	0.00

Table A-5. Total demand for water 'value added' inputs by electricity sectors (ML/PJ)

Electricity sector	Surface water	Groundwater	Instream use	Total (including instream)	Total (excluding instream)
Coal fired	117.53	3.04	34.48	155.04	120.56
Combined cycle	137.87	0.38	51.95	190.20	138.25
Cogeneration	12.52	0.16	27.12	39.81	12.68
Gas turbine	10.87	0.18	24.22	35.26	11.04
Hydroelectric	18.19	0.24	315,572.89	315,591.31	18.43
Other renewables	18.05	0.24	37.88	56.16	18.28