SHOULD THERE BE AN INDUSTRIAL WATER POLICY?

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INTRODUCTION

This paper asks whether or not there should be an industrial water policy. The way the question is posed leads one to imagine that we do not have in the U.S., or elsewhere, policies governing industrial use of water. This could not be further from the truth—all societies have *de facto* industrial water policies. The question really asks whether they are conscious, coherent, and sensible policies. For the most part the policies governing industrial water use are a patchwork of inherited public health and water availability concerns which do not allow for modern control and regulation of the water resource as an integrated whole. The question should then be, "What are the components of an environmental, social, and economical industrial water policy?"

The need for an integrated industrial water policy is driven by the fact that water resources have come under increasing competition as burgeoning populations with increasing affluence demand more water for agriculture, industry, domestic supply, and hydropower. The problem is exacerbated by decreasing supplies of clean freshwater. System resilience has dropped for many river basins as the systems are less able to absorb shocks caused by natural variability under these conditions of increased demand and decreased supply. Surface and groundwater reservoirs are under stress due to the constraints placed on them that cannot be satisfied. Increasing competition in water use is a fact of life in many countries and is inevitable for others in the near future. Water has become a major bone of contention both among different users and regions in a state or country and also across international borders.

In the U.S. only about 13 percent of public supplies currently goes to industrial use; 87 percent is privately supplied, hence, there has been little incentive to regulate water supply to industry. Without the perceived need to regulate there has been no need for an industrial water supply policy beyond "benign neglect." This is not true on the wastewater effluent side where discharge permits have been demanded of all industrial polluters. The same holds true for most other countries, industrial regulations have been implemented to address the problem of water quality, but little has been done to regulate self-supplied sources. Also, although most developing countries have strong laws and regulations on industrial discharges they are seldom effectively enforced.

Although the industrial sector accounts for only 10% to 15% of the aggregate annual water demand in developing countries, water is a critical input for process and cooling requirements in a number of major industries. As documented in case studies from Nigeria and India, water shortages, unreliable supplies and high prices adversely affect the expansion of small and medium industries resulting in loss of employment opportunities for the poor. In a number of regions in India (Madras, Hyderabad), China (Beijing, Tianjin), and Indonesia (Jakarta), and countries in the Middle-East, water supply and prices are emerging as one of the major constraints in growth of industries.

In recent years, many international organizations have become heavily involved in water policy (UN, World Bank, Asian Development Bank, the Interamerican Development Bank, etc.). Their interest has been primarily in domestic and agricultural water supply, and rural and urban sanitation. Not much attention has been paid to other aspects, such as industrial water, until now because these uses had always been considered of minor importance and, hence, of little concern to governments. But recent facts, speak otherwise. Although it is true that agriculture accounts for most water withdrawals (69% worldwide), industry is fast catching up, accounting for 23% of all withdrawals (Table 1). This varies tremendously for different countries and regions depending upon their size, population, stage of development, economic opportunities, and national priorities. For example, Pakistan, with a per capita withdrawal of 2000 m^3 has a ratio of 98:1:1 for agriculture, industry, and domestic uses, whereas the United states, with approximately similar annual per capita withdrawals of 1900 m^3 has a ratio of 42:45:13. Many of the developing countries are on the path of rapid industrialization and, hence, industrial water use will rise rapidly in the future.

Despite the overall apparent shortage of water, there are few incentives for efficient use of water in many parts of the world. This is because most countries have not developed instruments (either regulations or economic incentives) and related institutional structures for reallocating water between sectors, or for internalizing the externalities which arise when one user affects the quantity and quality of water available to another group. Water tariffs are typically based, at best, on average cost pricing (rather than marginal cost pricing) and typically ignore the opportunity cost of water (i.e., benefit foregone in alternative uses). Similarly, the effects of damages caused by industries in polluting surface and groundwater are ignored in determination of water tariffs and typically there are no pollution taxes and/or effluent charges to be paid by industrial polluters. As a result, excessive quantities of water are used, and excessive pollution is produced.

Just as industry is catching up with agriculture as a primary withdrawer of water, another quiet revolution is occurring: concern regarding water quality in many water sources is shifting from biological to chemical contamination. At the same time another revolution is occurring in the options open to regulators to deal with the problems caused by water use - both due to water consumption and due to effluent discharge. The number of options available to the regulators has recently increased tremendously. Traditional command and control approaches involving quotas on water withdrawal, limits on discharges, and mandated technologies for processes and treatment have now been augmented with more innovative approaches involving both quantity-based (e.g. bubbles, offsets, tradable permits) and price-based (e.g. effluent charges, more effective water pricing, and taxes) incentives. This has added more instruments in the regulator's arsenal in order to effect the desired changes taking into account various technical and economic factors. This necessarily involves a paradigm shift in the approach to water and wastewater regulation - from expensive effluent standards that provide little incentive for innovation to more comprehensive performance standards that achieve the same ends at lower costs to society.

INDUSTRY AS A USER OF WATER

Demands on the Physical Resource. Table 1 shows a regional and sectoral breakdown of water withdrawal uses worldwide. The total amount of 3,240 km^3 represents about 27% of the estimated 12,500 km^3 of relatively easily accessible runoff. So, with good management we still will have, on average, plenty of maneuvering space between available supplies and human diversions. This does not offer too much solace, however, to those countries already withdrawing high percentages (in some cases over 100%) of available water.

TABLE 1:
Sectoral Breakdown[1] of Annual Water Withdrawals (in Km^3)
(sectoral percentages in parentheses)

Region	Sector		
	Agriculture	**Industry**	**Domestic**
Africa	127 (88%)	7 (5%)	10 (7%)
Asia	1317 (86%)	123 (8%)	92 (6%)
N.&Central America	912 (49%)	782 (42%)	168 (9%)
South America	79 (59%)	31 (23%)	24 (18%)
Europe	118 (33%)	194 (54%)	47 (13%)
U.S.S.R. (former)	232 (65%)	97 (27%)	25 (7%)
Oceania	7.8 (34%)	0.5 (2%)	15 (64%)
World	2236 (69%)	745 (23%)	259 (8%)

Why does industry need water? What does it use it for? If we examine the water use in a few specific industries in the U.S. in terms of the use that the water is put to, we find that a substantial portion of the water (from 30% in the Sugar industry to 91% in industrial organic chemical manufacture) is used not for the actual industrial processes, but for substantially non-consumptive uses such as non-contact cooling. This is encouraging, because under appropriate regulations or incentives, it is possible in many cases to have closed-cycle systems for cooling. The remainder of the water is usually used for process-related items, that are very sensitive to the process technologies employed. The major industries that use a lot of water in the U.S. are pulp and paper and petro-chemical industries, and, to a lesser extent, fertilizer, sugar and the iron and steel industries.

We note that most water is recycled by U.S. industry; however, it is still difficult to determine accurately the recycling rate in industry (defined as a share of the gross water use contributed by recycled water). While the actual consumptive use in industry is small (15% overall in the U.S.) its diversions exceed that of domestic water supplies. Most of the water is either recycled or discharged as wastewater. Much of the water discharged does have the potential to be recycled, and is increasingly being used as such for additional supplies where water is scarce, as in Israel. Between 1985 and 1990 there was an increase of 30% in the amounts of wastewater recycled in the U.S. However, due to the often poor water quality of the effluent from water used in contact processes, it is easier to recycle domestic sewage than industrial water. If we examine the average and maximum recycling rates, we see that there are efficient industries such as synthetic rubber and petroleum refineries, but there are industries such as cane sugar that show a lot of demonstrated potential possible improvement.

Demands on Economic and Financial Resources. Data on the investment requirements for the water sector are very unreliable for industry and irrigation and may be slightly better for urban water supply. For example, the World Bank claims that there are no reliable statistics on global irrigation investment and we came to the same conclusion for industrial water investments.

Predictions of city growth over the next 25 years in the developing world imply for the urban water supply and sanitation services the financial needs will be much greater than at present. A total of US$ 24 billion per year for capital investments in water supply is predicted and, if conventional wastewater disposal technology is to be applied to the additional population needing services,

another US$ 82 billion per year. The World Bank estimates that currently they are spending US$ 26 billion per year. Irrigation expenditures amount to annual capital expenditures of around $11 billion.

For industrial water investments, the capital cost of water and wastewater disposal are typically less than 2% of the total industrial capital investment, this implies that as much as $8 billion per year would need to be invested by industry. These admittedly shaky numbers, do help, however, to put the relative expenditures for water by sector in perspective. They confirm our hypothesis that urban water investments will have by far, the largest demand for capital expenditures during the coming decades followed by agriculture and industry both with about one tenth of the urban water supply capital requirements.

REGULATING INDUSTRIAL WATER AND WASTEWATER

Estimating Economic Incentives for Industrial Water Use Despite the overall apparent shortage of water, there are few incentives for efficient use of water in large and medium industries in many regions. This is because most countries have not developed instruments (either regulations or economic incentives) and related institutional structures for internalizing the externalities which arise when one user affects the quantity and quality of water available to another group. Industrial water tariffs from public supplies are typically based at best on average cost pricing (rather than marginal cost pricing) and ignore the opportunity cost of water (i.e., benefit foregone in alternative use). The cost from self-supply is largely undocumented and left entirely up to the individual industries to determine. Similarly, the effects of damages caused by industries in polluting surface and groundwater are ignored in determination of water tariffs and typically there are no pollution taxes and/or effluent charges to be paid by the industrial polluters. As a result, from an economic viewpoint excessive quantities of water are used, and excessive pollution is produced.

For water supply in general, the magnitude of both the quantity and quality problems lead to costs of supplies of adequate quality that are rising rapidly with the cost of a unit of water from “the next project” often being 2 to 3 times the cost of a unit from “the current project.” Hence, in many situations, demand management, water conservation, and recycling is likely to be more cost-effective than investments in increasing water supply. Further, investments in water conservation, recycling and reuse provide environmental benefits (over and above the economic benefit of lower costs) since these result in reduction in water pollution loads. Thus, conservation and recycling of water in industries provide opportunities where there is no conflict between the objectives of economic efficiency and environmental improvement.

To understand where in industrial water use system economic instruments may be effectively applied one need the have information of where the major savings can come from. Iron and steel are by far the largest water users in the U.S. followed by petroleum refining, textiles, and pulp and paper with much lower total use. Even though the developing countries use a smaller portion of the total water, they pretty much follow the same ordering of water use. Looking at the magnitudes of the actual quantities used, industrial water policy would seem to be a developed country problem. However, this static picture hides the rapid rates of industrialization in large countries like China, India, Indonesia, and Brazil. All of these and the other developing countries, already have large demands placed upon their water resources and the industrial water demand arriving last will have difficulty in assuring supplies.

In the pulp and paper industries, for example, the bulk of the water use is process related with only a smaller fraction going to non-contact cooling. The situation in the industrial organic chemicals industry is radically different with the bulk of the water going to non-contact cooling. The implications of these for changing water use are radically different. There are many easy technical options for non-contact cooling which are very price sensitive, hence, pricing on the input side in these industries could lead to large water savings at relatively low costs. If the bulk of the water goes for process related activities, the policy options are less clear. For example, it will be necessary to change the process technology to achieve significant savings. These are likely to be expensive and are less input price responsive that cooling water options. In this case, both input and output pricing may be indicated as well as some form of product environmental charge.

Before arriving at any conclusions based upon these considerations, it is also necessary to look at the fate of industrial water use. Here we get a sense of how well an industry is already doing in recycling and disposing of its wastes. Pulp and paper industries typically already recycle significant amounts of their waste water, the industrial organics recycle less and discharge more. This clearly indicates more attention to regulating and pricing of the effluent of this industry.

SUMMARY

Regulation and Economic Instruments The problems of industrial water management are often fairly obvious ones; lack of effective regulations on the part of government and lack of appropriate incentives on the part of industry. The primary problem is that few countries have any instruments (regulations, economic incentives, and disincentives) to regulate water use and wastewater disposal. In addition, water has traditionally been considered a common property good and as a result the full price of water is seldom charged to consumers. Even where tariffs are charged, they are usually based upon average costs and also ignore the opportunity costs of water or the real costs of the externalities of wastewater disposal. These factors have led industries to use water inefficiently. Industries have not needed to employ conservation and recycling measures as water has been so inexpensive. Recently, increasing concerns over increasing water scarcity and environmental concerns, and the competition among the users for the scarce resources has led to the consideration of more rational water management strategies. This has led to more rational and innovative approaches being implemented.

Policy Options In Table 2 we give a comprehensive listing of all of the possible instruments that may be used to influence industrial water policy. If implemented, how could these policy options change the water demanded and wastewater disposed of by industries? It is not an easy task to determine the effect of non-economic policies on industrial water management strategies. This is because it is rare that only one control policy change in isolation can be observed. It is also difficult to exactly determine how much a change in water prices would affect the water demanded in industry. Basic economics tells us that a rise in water tariffs would lead to a drop in the water demanded - exactly how much depends on the price elasticity of demand of industrial water. These elasticities are notoriously difficult to determine empirically as it is difficult to control for other variables even in the rare cases when industrial prices have been raised enough to actually make an impact. The effect of policy options is usually obtained by the various case studies involving the examination of the response of nations, regions, industry types and individual firms to changes in one or a set of water policies. Such analyses at least indicate the kinds of policies that have been successful in the past and the industries or regions that appear to be most responsive to policy changes. This kind of information is necessary before any kind of efficient water policy portfolio can be drafted for the various industries in different spatial regions.

Given that a government is facing rationally-acting, profit-maximizing industries, how does it select policy options that will achieve the national goals of sustainable water use? The options are few: Table 2 lists all of the command and control and the economic incentive options available to governments. This list could also be split into the categories of demand management and supply management. There are economic and non-economic policy options that fit on both sides of the demand and supply breakdown. One needs to recall that even price policy can be viewed as a supply enhancing option because as the prices rise supply options that were previously too expensive now become economical.

For the U.S., there is a tremendous asymmetry between the efforts spent by the national government in regulating industrial water pollution as opposed to water supply. The EPA has spent an enormous amount of time and effort in issuing more than 75,000 effluent permits to industry based upon allowable concentrations and masses of effluents and relatively little effort on relating these permits to ambient water quality in other than the grossest of terms. The use of any of the listed economic incentives for both the water supply and the wastewater sides of industrial water use in the U.S. is sorely lacking. With careful planning it might be possible to integrate the price reforms in water supply with incentives for waste water reduction. This challenge needs to be accepted by the federal and state agencies if we are ever to have a sensible industrial water policy.

TABLE 2
Possible Instruments to Influence Industrial Water Policy
(D means predominantly demand side and S means predominantly supply side)

Non-Economic Command and Control Policies

- Water use quotas (D)
- Wastewater generation quotas (D)
- Effluent standards (D)
- Mandated recycling percentage (D)
- Encouragement of research, development, production and adoption of conservation, recycling, and wastewater treatment measures (S)
- Bubbles/Offsets/Banking (S)
- Industrial Ecology - management within industrial complexes (D)
- Licensing of water supply/wastewater disposal (D)
- Enabling conditions - coordinating institutions, legislation, macroeconomic framework (D)
- Technology transfer of efficient equipment/processes (S)
- Information availability and exchange - on products, processes, waste exchanges (S)
- Development of alternative supply options (e.g.: domestic wastewater, desalination) (S)

Economic Policies

- Water supply tariffs (D)
- Effluent charges/taxes (as a function of Quality and Quantity) (D)
- Penalties for violation of quotas (D)
- Tradable permits (D)
- Subsidies on research, development, production and adoption of conservation/recycling processes (including water saving devices/processes) (S)
- Subsidies on research, development, production and adoption of wastewater treatment technologies (S)
- Cross-subsidization of agricultural water conservation (D)
- Privatization of the water sector (supply, distribution, collection, treatment and disposal) (D)

1. A distinction must be made between measured and derived data - many of the data used in water resources planning are derived from an examination of related parameters; agricultural water use is rarely measured - it is often estimated by assumptions about the crop types, planting patterns, water consumption rates, regional climatology and method of irrigation.