Beyond Greater Efficiency: The Concept of Water Soft Paths

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Abstract: Even in "water-rich" Canada, many jurisdictions are having trouble providing adequate, clean fresh water as their populations not only grow but exhibit higher expectations for water availability and water safety. The conventional approach to such problems accepted the history of constantly growing demand for water and responded by extending pipelines, constructing more dams and drilling deeper. The alternative to this engineering approach is to put greater emphasis in demand-side policies promoting water efficiency and conservation. Full-cost pricing along with better information and education programs can help a great deal, but will not likely be sufficient to meet future water problems. Fortunately, there is a stronger, albeit normative, demand-side alternative called the water soft path, which is modelled on the highly successful approach known as the soft energy path. Soft paths can be described as approaches to natural resources management that rely on a multitude of relatively small-scale and renewable sources of supply coupled with ultra-efficient ways of meeting end-use demands. This paper will contrast water soft paths with the conventional (hard path) approaches, and then review the methodology and feasibility of soft path analysis.

Résumé : Même au Canada, où les ressources en eau sont abondantes, de nombreuses compétences territoriales ont du mal à offrir une eau douce propre, satisfaisante ou en quantité suffisante du fait que leur population non seulement augmente mais formule également des attentes plus élevées en matière de disponibilité et de salubrité de l'eau. L'approche traditionnelle face à de tels problèmes a toujours reposé sur l'acceptation pure et simple de la réalité voulant que la demande en eau augmentait sans cesse et que la solution consistait simplement à prolonger les canalisations, à construire plus de barrages et à creuser toujours plus profondément. L'autre solution possible consiste à mettre davantage l'accent sur les politiques de gestion de la demande qui encouragent l'économie et la conservation de l'eau. La tarification à partir du coût complet, s'accompagnant de meilleures campagnes d'information et de sensibilisation, peut aider énormément, bien que ce ne sera pas suffisant pour faire face aux futurs problèmes entourant l'eau. Heureusement, il existe une méthode de rechange plus solide, bien que normative, touchant la demande, qui a pour nom « voie douce pour l'eau ». Cette méthode prend pour modèle l'approche hautement efficace connue sous le nom de « voie douce de l'analyse de l'énergie ». Les voies douces peuvent être décrites comme étant des approches de gestion des ressources naturelles qui reposent sur une multitude

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Submitted June 2004; accepted November 2004. Written comments on this paper will be accepted until September 2005.

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de sources d'approvisionnement à la fois renouvelables et à une échelle relativement petite, combinées à des moyens ultra efficaces de satisfaire les demandes des utilisateurs finaux. La présente communication établira des comparaisons entre les voies douces pour l'eau et les approches traditionnelles (voies fortes) et examinera ensuite la méthodologie et la faisabilité de l'analyse de la voie douce.

Introduction

Even in "water-rich" Canada, problems are developing from over-use and degradation of fresh water supplies. Over one-quarter of Canadian municipalities already face water shortages for one reason or another (Environment Canada, 2004). Others have problems maintaining water at a level of quality that their citizens deserve. The Walkerton Inquiry (O'Connor, 2002) in Ontario came up with almost 100 recommendations and led to Ontario's White Paper on Watershed-based Source Protection Planning. As well, both the *Canadian Environmental Protection Act* (CEPA, 1999) and the *Fisheries Act* are under review with future amendments expected to limit options to take water from the environment and to release wastewater into it.

The conventional approach to water supply problems assumed a link between water use and growth, and responded by extending pipelines, constructing dams and drilling deeper for additional water — and almost perforce larger sewer systems and treatment plants. This capital-heavy approach is increasingly expensive and subject to delays for environmental and social reasons. The alternative is to put more emphasis on policies and programs on water efficiency and water conservation. "Efficiency" refers to technical and economic approaches to reducing the quantity of water to achieve a given task, as with watering lawns with low-flow sprinklers; "conservation" refers to changes in the nature of the task, as with planting greenery that does not require watering.

Water demand management is a powerful tool, particularly when it incorporates, as it should, full cost pricing for fresh water and for wastewater disposal. However, it suffers from three defects: first, it is still commonly seen as a temporary option to be brought into play during a dry summer, or until the next dam or pipeline can be built; second, its main criterion for action, cost-effectiveness, is constrained by the low operating costs and heavy debt loading of water and wastewater systems; and, third, even if avoided future costs are taken into account, shifts in water use do not likely go far enough to deal with our water problems. Fortunately, there is a stronger alternative called the water soft path, which is modelled on the highly successful approach to energy known as the soft energy path, and which can effect more fundamental change. Because "soft water" already has a meaning of low-carbonate water, the adjective and noun are reversed from the terminology used for energy.

This paper will do two things. First, it will contrast water soft paths with hard. Second, it will review the methodology and feasibility of soft path analysis. The contents are based on two recent reports that review, respectively, the methodology (Brooks, 2003) and the feasibility (Brooks *et al.*, 2004) of water soft path analysis, with emphasis on application to Canada.

Characteristics of Soft Paths

Soft paths can be described as approaches to natural resources management that rely on a multitude of geographically distributed, relatively small-scale sources of supply coupled with ultra-efficient ways of meeting end-use demands (Lovins, 1977). In contrast, hard paths rely on large-scale, capital-intensive sources of supply and centralized management. Soft paths aim for use of renewable resources and methods of waste disposal that are analogs of natural processes. Hard paths accept the use of non-renewable resources supply and external inputs, such as chemicals and fossil fuels, for waste treatment and disposal.

Soft paths result in more than marginal adjustments to existing patterns of water supply and use. Contrary to what is commonly alleged, Wolff and Gleick (2002) show that:

- opportunities to increase water-use efficiency are large — studies of specific areas and sectors typically find cost-effective savings of one-third or more (Gleick *et al.*, 2003);

- water use is significantly affected by market forces — comparisons of cities with and without water meters all show lower rates of use when people pay per cubic metre;

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- demand-side measures are typically less risky than supply-side measures — apart from nuclear power, it is hard to think of any project more susceptible to cost over-runs than dams, and their economics depends on climate patterns that we know are changing.

Concept of Soft Paths

Soft path analysis involves a fundamental challenge to the ways in which the demand for natural resources are commonly conceived. The demand is not (with some exceptions) for the resource itself, but for the services provided by that resource. By looking at water or energy as a bundle of services, rather than as a commodity, many more options can be conceived to satisfy demands.

Although the analysis of soft path options is rigorous, the approach is normative in the sense that environmental sustainability plus social and economic equity are taken not just as desirable goals but as imperatives for society. For example, soft paths rule out options that are hard to manage in democratic systems as well as those that impose significant environmental effects. Such choices are critical because the main purpose of soft path analysis is to derive policy conclusions – in effect, recommendations about how to achieve sustainable and equitable natural resource management. Therefore, the real differences between soft and hard paths lie not with the technologies but with the socio-political choices about governance of natural resources (Lovins, 1977; Holtz and Brooks, 2003).

Water hard paths and water soft paths, just as with hard and soft energy paths, yield different policy prescriptions for the near term. Whether they are equally antithetical in the longer term remains to be seen. For a number of reasons, hard and soft paths do not diverge so dramatically for water as for energy. For one thing, water is overwhelmingly used in one form, liquid, whereas energy is used in a multitude of forms. There is also no water source comparable in either technical complexity or emotional content to the nuclear reactor. Certainly, the two paths would co-exist for some time during a transition period. However, the different technologies and management styles reflect different political choices in the broadest sense of that term. The analysis is designed to elucidate the results of those choices.

Experience with Soft Path Analysis

Soft path analysis as a methodology was initially developed in the 1970s in a search for alternatives to conventional energy policy (Lovins, 1977). Its normative base was clear from the start. The early work was done within Friends of the Earth USA, partly as a way to counter the then-growing drive to build nuclear power plants.

Soft energy path analyses: Canadians were among the leaders in the analysis of soft energy paths. Friends of the Earth Canada provided the base for some of the earlier developmental work and later for more sophisticated analysis including a 12-volume report (Brooks *et al.,* 1983) and a more popular book (Bott *et al.,* 1983). The bibliography for the latter includes a list of soft energy studies from a dozen other nations or regions.

Although no government ever fully accepted soft path conclusions as guiding principles, their impact was evident in policies that began to lean toward soft technologies and in results that showed more energy coming from gains in energy efficiency than from all new sources of supply together (von Weizsäcker *et al.*, 1997; Hawken *et al.*, 1999).

Water soft path analyses: From the first, analysts agreed that the soft path methodology could be applied to other natural resources, but only recently has analysis been extended from energy to water. Still today, there has been no water soft path study — at least not one that includes a semi-quantitative model of water scenarios based on soft path methods and relying on soft technologies. However, Peter Gleick and his colleagues at the Pacific Institute have gone further toward water soft path analysis than any other group (Gleick *et al.*, 1995; Gleick, 1997, Gleick *et al.*, 2003). The latest of these studies reviews urban water use in California and shows that adoption of demand-side technologies that are already cost-effective compared with future increments of supply would permit the state to grow as projected without a single additional water project.

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Tate made a start on water soft path analysis in Canada some 30 years ago when he showed that it was possible to adjust conventional projections to allow for "a concerted effort at promoting water conservation" (Tate, 1985). Since then, the field has been dormant in Canada. There have instead been reviews of the potential for water efficiency (Brooks and Peters, 1988; Tate, 1990; Brandes and Ferguson, 2003), and most recently a report that recommends a wide range of policies to improve urban water efficiency (Brandes and Ferguson, 2004).

Methodology of Soft Path Studies

The concept for water soft paths is attractive, but how does one analyse their potential and design policies appropriate to their implementation? The key principles can be reduced to three:

1. The first principle is to resolve supply-demand gaps in natural resources as much as possible from the demand side. Beyond the 50 litres per person-day needed for an adequate lifestyle, there are many ways to satisfy human demands for water. The goal is to apply least-cost approaches to reduce water use at every stage from water withdrawal to wastewater disposal and (ideally) recovery.

2. The second principle is to match the quality of the resource supplied to the quality required by the end use. For both ecological and economic reasons, it is almost as important to conserve the quality of a resource as to conserve its quantity. High-quality resources can be used for many purposes; low-quality resources for only a few. In contrast, we only need small quantities of high-quality resources but vast amounts of low-quality resources. Drinking water gets most of the attention, but it is one of the smallest terms in our water budget.

3. The third principle is to turn typical planning practices around. Instead of starting from today and projecting forward, start from some water-efficient future and work backwards ("backcast") to find a feasible and desirable way ("a soft path") between that future and the present. The main objective of planning is not to see where current directions will take us, but how we can achieve our goals. It is at this stage that appropriate policies and programs, along with transition technologies, must be defined to bring about desired changes.

These three principles frame the remainder of this section.

Primary Emphasis on Demand Rather than Supply

Water soft paths do not ignore any of the gains that can be achieved through demand management. Those gains are achieved through "Technical Fixes" (if the emphasis is on physical efficiency of proposed measures) or "Economic Fixes" (if the emphasis is on cost-effectiveness of proposed measures). However, because most of the cost for either fresh water supply or wastewater management lies with infrastructure, operating costs are low. The difference between short- and long-run marginal costs means that many water saving measures are deemed not cost-effective (unless the system is approaching capacity). Moreover, demand management does not step "outside the box" of existing consumption patterns, as expressed in market transactions or (in the case of public utilities) setting prices to cover direct costs. In a sentence, *demand management increases the efficiency of existing water systems but does not recognize that ultimately sustainable production depends upon sustainable consumption*.

The key to exploring soft path options on the demand side is to ask not about the demand for the resource *per se* but about the demand for the service that the resource is employed to satisfy. For the most part, natural resource commodities are not valued for themselves but for the services they provide to individuals and to society. There are exceptions to this rule, most of which depend on *in situ* uses of the resource where it is not really a commodity. For example, the apparent demand for water to make a lawn grow is more precisely seen as a demand for an area with vegetation agreeable to the eye and perhaps for sitting. The difference is important; cactus might satisfy the eye but not make a good picnic site! The

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demand for water to flush toilets can be seen more precisely as a demand to remove wastes, which can be accomplished by a variety of methods, some of which require little or no water. By deconstructing the demand for a natural resource into a demand for services, it is generally possible to identify many more opportunities to reduce consumption.

The analysis must of course look beyond the individual end-use device to the full service — not just the toilet but also the disposal system. Given that 80 percent of the cost of municipal wastewater systems is for collection and transportation, and only 20 percent for treatment (Gajurel and Wendland, 2004), the economic importance of reducing flow volumes is self-evident, and this in turn depends upon wastewater disposal systems different from the trunkline sewers so common in our cities.

Supply and Demand Matching by Quality

The second principle of water soft path analysis is to ensure that the water supplied to satisfy any service is at a quality appropriate to the end-use need. It is just as inefficient to provide high-quality water to flush toilets as to permit the toilet to leak. Although water quality has many dimensions, for analytical purposes they can be reduced to three. Potable water carries its usual meaning. Secondary quality water contains substances that make it unacceptable for direct consumption but that does not contain pathogens or toxics. Common sources are gray water (residential wastewater other than toilet water) and industrial cooling water. The extent to which secondary quality water is acceptable is specific to the end use. High levels of carbonates can limit use in appliances or boilers; suspended solids may be irrelevant to conventional irrigation but clog the tiny holes used in drip irrigation. Tertiary quality water includes water from toilets, most industrial effluents other than cooling water, and wastewater from such sub-sectors as hospitals and laboratories. For some purposes, it is useful to break down the tertiary quality category into that portion of the wastewater that will reclaim itself naturally as it moves through the ecosystem (human and animal organic wastes) and that portion that requires special procedures to become safe for re-use (toxic organics, heavy metals, etc.).

Just as with an end-use focus for demand, matching by quality provides opportunities to close loops locally. With simple technology available at house or building scales, gray water can be rendered acceptable for lawns and gardens (Redwood, 2004). Dozens of industrial operations have cut costs and avoided environmental damage by cascading from higher to lower quality services (Hawken *et al.*, 1999). Great opportunities exist to close loops in commercial agriculture, particularly with the intensive greenhouses and truck gardens surrounding cities.

Scenario Building and Backcasting

Scenario building and backcasting are the main futures part of soft path analysis and also "the one truly complex portion of the analysis" (Brooks, 2003; p. 35). Four sub-tasks are required to complete this step in the analysis:

1. The first sub-task involves definition of a base case that will include economic and demographic information, on the one hand, and water sources and uses data, on the other. The former are not hard to obtain, but the last year for which Statistics Canada published time series on water usage by sector is 1996. The only option is to use 1996 as the base year for water data and extrapolate those data to the economic and demographic information for, say, 2000.

2. The second sub-task is to project the economy into the future for a minimum of 25 years and preferably longer to allow for turnover of equipment and replacement of infrastructure, along with possible changes in economic structure and living patterns. If funding permits, more than one growth projection can be incorporated into the analysis. Full time series are not required as this part of soft path analysis is a form of comparative statics. In contrast to the base case, water sources and uses are not projected. The purpose of the exercise is to change the water economy, not simply extend the present into the future.

3. The third sub-task is to convert the projection into a scenario by adding soft path choices for sources and uses of water in, say, 2030. The analysis is inherently partial, as it adjusts only

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those parts of the economy related to water inputs and outputs. The objective is to design an economy that has grown as expected but that is now much more efficient in its use of water, biased against drawing upon new sources of water, and orientated toward recycling, reclaiming and re-using wastewater. The preferred economy in the end year of the scenario should be sustainable so far as fresh water is concerned.

The scenario must not be constructed of hopes and wishes. Each adjustment must be demonstrably feasible and economic (in a broad sense) in the year in which the innovation is introduced. Similarly, the rate at which it is introduced must conform to reasonable rates of replacement of capital stock. Information for this part of the analysis can emerge from review of alternative technologies and methods, which is time consuming but not difficult. The fact that new and likely more efficient technologies will emerge over the scenario period adds a significant conservatism to the analysis.

Preferably, two scenarios should be built for the future economy. One scenario maintains current habits and practices so that all reductions in water use come from gains in end-use efficiency plus greater recycling and reclamation. The other scenario adds changes in personal habits, as with shifts toward lower meat diets, and changes in industrial practices. (North American diets require three to five times as much water as Asian.) Water efficiency and water conservation are not entirely additive so they must be distinguished in the analysis.

The most complex part of scenario building is trying to ensure that the water portion of the economy ties together. Declines in one area may require increases in another. For example, lower meat diets would likely imply more dairy products, which is a water-intensive industry. In building the Canadian soft energy study, we had the great advantage of input-output tables based on materials balance equations. These tables, produced by the then-existing Structural Analysis Division of Statistics Canada, ensured that changes in any one sector of the economy were reflected in all related parts of the economy. There are no similar input-output tables for water. In his projections of alternative water futures for Canada, Tate (1985) used conventional input-output tables to which he added a water demand model. The absence of water input-output tables will be a limitation on any soft path analysis and it is not yet clear how to deal with the problem.

4. The final and most time-consuming sub-task is backcasting, which means starting from the scenario of an economy with a sustainable water system and working backwards to find politically, economically and socially acceptable policies that can effect a smooth link between the somewhat idealized future and the current situation. Previous steps have referred to rates of replacement of capital, but those rates can be accelerated by appropriate policies. Leak reduction, changes in industrial operations, and drought resistant planting can all be built in at varying rates. The most difficult task will be finding appropriate measures for agriculture, particularly given the wide variation in farm size and type, and the sensitivity of farm viability to changes in costs, particularly for international markets.

As with any scenario, the essentially normative element must not be neglected. The obvious question about that preferred future water economy is: Preferable for whom? The only honest answer is: For the analysts preparing the scenario. This answer does not mean that backcasting is devoid of rigour, but it does mean that other analysts can define a different future water economy and backcast from that end point.

There are no rules to indicate how much backcasting is enough. The analysis requires a sector-by-sector and use-by-use review of possible policies ranging from regulation and incentives to information and education, plus educated guesses as to what will be acceptable and how much of an impact each will have. All that can be said is that the backcast has to be "good enough" to be persuasive.

Additional Methodological Issues

Despite providing a broadly applicable methodology for water soft path studies, some difficult or unresolved methodological issues remain to be mentioned.

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Wastewater Flows: After passing through an end-use device, most energy flows disappear as exhaust gases, heat or radiation. There are environmental impacts, but, with the exception of some waste heat, these flows are of no economic interest. Not so with water, where soft paths make every effort to re-use water to the extent economically justifiable (in a broad sense of "economic") before freshwater supplies are exploited. At a strategic level, this means volume reduction and source protection, together with closed-loop reclamation and institutional "brokers" to link wastewater from one establishment to potential users in another. At a tactical level, it means looking to new treatment technologies. For example, given enough time and space, wetlands can decontaminate municipal and organic industrial and agricultural wastes. We now know that artificial wetlands can be designed to do the same job with less space and less time, even at winter temperatures typical of southern Canada (Pries, 1996; Smith *et al.*, 1997; Redwood, 2004). Some systems go still further and dispense with water as a waste carrier. As analysts at the Agricultural University of Norway have written (Jenssen *et al.*, 2004): "If the water toilet had been invented today, it would probably not have been certified as sanitation technology meeting sustainability criteria."

In sum, we have many technical options for dealing with wastewater. What we do not have are flexible and robust institutions for dealing with it. What is wastewater worth; who should pay what proportion of the costs; and how can outputs become inputs? These institutional issues will likely prove more difficult than the technical ones.

Ecological Demand: A large proportion of the water found in any water course must remain in place if the ecosystem is to remain healthy. Methods for determining what is called the ecological demand for water are now appearing in the literature (Dyson *et al.*, 2003; Postel and Richter, 2003). The former approach of simply defining a "red line" below which lake levels or river flows are not allowed to fall is insufficient to protect the ecosystem. The goal is to withdraw water for human use in patterns that emulate, as closely as possible, natural fluctuations in levels and flows. Israel, South Africa and a few other nations are building an ecological sector into their water planning framework, and Ontario has indicated in its *White Paper* on source protection that it intends to do the same (MoE, 2004; p. 28).

So far as soft path analysis is concerned, the ecological demand for water is a basic concern, but not one that can generally be analyzed within the study. Instead, independent estimates of the volume of water that must be left in the ecosystem become constraints on withdrawals. Such estimates range from 30 percent (from agricultural groups; SIWI, 2004) to 90 percent or higher (from environmental groups; Dyson *et al.*, 2003).

Direct and Indirect Trade in Water: Only with difficulty can soft path analysis deal with trade in natural resources. Its focus is inward looking, at a particular economy, and not outward toward its interaction with other economies. Fortunately, apart from relatively small diversions of water from the Great Lakes, direct trade in water is minimal.

In contrast to direct trade of water, indirect trade ("virtual water") — the water that is consumed in the growth of crops or the production of goods and services — is very large. Allan (2001), for example, estimates that the volume of grain shipped each year to the Middle East contains a quantity of water roughly equal to the flow of the Nile. Large though it may be, indirect trade in water is not part of soft path analysis. It deserves study, just as with study of indirect trade in energy, but soft path analysis focuses on direct use of water.

Climate Change: The likelihood that the climate in Canada will shift toward warmer winters and more frequent droughts should be taken into account in any long-range discussion of water (Environment Canada, 2004). Given the already large number of variables in soft path analysis, and the uncertainties in hydrological effects, it is not likely feasible to add greater or lesser degrees of climate change to a scenario. The simpler approach is to introduce climate change by reviewing the latest climate model projections and erring on the side of caution. For example, in eastern Canada, the lower end of ranges in historic rainfall and water flow would be taken as more likely than the upper end for 2015 and 2030. In western Canada, projected higher rainfall and meltwater from glaciers would have to be balanced against higher temperatures and greater evaporation.

Conclusions

The most evident conclusion from this review of water soft path analysis is that there is a methodology

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that seems robust and that promises powerful results. Actual analysis in Canada would probably focus at the provincial level. Most water data are collected for provinces and most tools for managing water lie in provincial hands. However, before we get to water soft paths, there are some more proximate conclusions.

Waiting for a Water Soft Path

Water soft path analysis promises to elucidate our long-term options, but we need not — indeed, cannot — wait for the analysis before acting. Throughout Canada, scattered jurisdictions have taken the lead in seeking greater water use efficiency through installing water meters, pricing on a volumetric basis, labelling large appliances for water use, mandating ultra-low-flow toilets, and requiring industrial water audits. Water does have some unique characteristics, but, a few equity issues to one side, at the point of delivery to households, farms and factories, it is a commodity subject to economic laws. The gains are large even viewed from the perspective of the final consumer of water, who typically faces little more than operation and maintenance costs for water. They are much greater when viewed from the perspective of the water manager faced with the prospect of higher costs for the next increment of water supply and wastewater treatment.

There are of course a panoply of barriers between theory and implementation. Apart from under-pricing of water, the most important barrier is the absence of data on water use. One does not have to be a soft path aficionado to recognize the need for Statistics Canada and its provincial counterparts to reinstitute the data series on water use that last appeared for 1996. They should also create new surveys to identify the distribution of water quantity and quality by sector, as well as quantity and quality of wastewater. Recent publication of a feature article on fresh water in the 2003 update of *Human Activities and the Environment* is encouraging, but much more is needed.

Toward a Softer Water Future

Water soft paths are today at the same stage analytically as soft energy paths were in the mid-1970s. Analytical tools are available and some of them have been successfully tested. Statistical data are spotty but sufficient for further analysis. The next step has to go beyond the conceptual and undertake a modest but complete water soft path study at the provincial level — modest because data limitations preclude full analysis of all sectors; complete because it will cover not merely options for efficiency and conservation but go on to scenario building and backcasting.

The proposed water soft path study should provide indicative results about systemic approaches to water management. We do not need a water soft path study to tell us that we should be installing low-flow toilets, nor that we should be reclaiming more wastewater. We do need one to suggest how much water we can allow for household uses, and whether farmers should be increasing water for irrigation or looking to improved use of rainwater. We do not need a water soft path study to tell us that current water institutions are inadequate. We do need one to suggest whether infrastructure must be built in ways that force centralization or whether alternatives involving less concrete can do as well — or even better.

The earth and the people on it are facing critical choices about natural resource use. These choices involve all natural resources, but those of greatest consequence are fossil fuels and fresh water. It is time to test not just the feasibility but the applicability of water soft paths.

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