

ABU DHABI WATER RESOURCES MASTER PLAN



January 2009

Executive Summary

Background

Since the 1960s water use in Abu Dhabi has increased rapidly. This is the result of desert greening policies of the government, and the expansion of agriculture into the lands surrounding traditional oases. Discovery of substantial groundwater reserves at Liwa and between it and Al Ain enabled the expansion of agriculture into formerly desert areas. Large tracts of desert and communication routes have been afforested. Over the same time period the population grew exponentially to its current 1.5 million people. While groundwater provided potable water supplies in the 1960s, the subsequent increase in demand for both power and water required the building of large thermal powered co-generation plants.

The rapid growth of the rural and urban economy over the last 48 years has had a

profound effect on Abu Dhabi's natural resources. Traditional oases dried up and the small pockets of fresh groundwater that sustained rural and coastal communities were exhausted primarily from the huge demand of the agricultural sector. Agricultural water demand around Al Ain and Liwa far exceeds natural recharge of the groundwater reservoir and levels have dropped significantly, far more in Al Ain than in Liwa. At the same time the declining water table has caused the influx of more saline water from lower levels in the aquifer and laterally from surrounding areas. Overall groundwater quality has deteriorated, and this is exacerbated by the liberal application of agricultural fertilizers, large numbers of livestock, and localized dumping of brine and sewage effluent into the desert. In the near-shore regions of the Gulf very high withdrawals

of water for desalination locally threaten the biodiversity of the marine environment and are contributing to raising sea temperatures – currently amongst the highest in the world.

Environmental impacts are not only confined to the aquatic ecosystem. The energy used to desalinate water in power plants, to transmit and distribute water around the Emirate, and to lift and pump groundwater around piped irrigation distribution system is derived from fossil fuels. Overall fossil fuel use in the co-generation plants is around 21 million tonnes equivalent of CO₂ per year and the share attributed to water production and use lies between 20 and 45%. Thus water use probably contributes between 4 and 9 million tonnes of CO₂ equivalent per year.

The future outlook suggests many difficulties unless actions are taken to reduce the rate of water consumption. And reducing water consumption will reduce demand for power and its adverse environmental impacts. It is a resource that is scarcer than oil and prudent management taking into account financial, economic, environmental and social concerns is of paramount importance.

These concerns are captured in the Plan Abu Dhabi 2030 that provides a vision of a global capital city that puts a high premium on environmental sustainability. It states that environment, social and economic considerations should be included in all decision making. Leading the way with the establishment of MASDAR, the government is building scientific knowledge and technology to promote clean industries and carbon-neutral development. And the government ratified the Kyoto Protocol in January 2005. Supporting these forward-looking initiatives, the Abu Dhabi Executive Council approved

the preparation of a Strategic Water Master Plan in January 2008.

The Planning Process

Abu Dhabi Water Master Plan (the Plan) aims to achieve three objectives:

- Strategic environmental assessment of the role of water in the Emirate
- Identifying what needs to be done in the water sector to improve the environment, and
- Strengthening the structure of water and environmental management.

It is about clarifying development objectives and looking at the development options to achieve these objectives. These are subject to the constraints imposed by Abu Dhabi's environment, technology, and the lessons learned from global experience. There are many ways of achieving the objectives - the Plan suggests various pathways to follow, and identifies what needs to be done. Prerequisites will be the development of sound institutions, reformed organizations, capacity building and increased awareness-raising amongst the population. Specifically the government of Abu Dhabi has to position itself on water to better manage policy and strategy, cross-sectoral coordination and regulation, and delegation of hands-on management to others.

In the report water-related activities and processes are linked to the overall hydrological cycle, ecosystems and the atmosphere. Water production and management are related to energy use and environmental impacts in an integrated approach that goes beyond engineering. While it was expected that sufficient information would be available to determine the economics of water production and management, and social issues arising, the dearth of data precluded this. But these are



important tasks. Without sound economic and social analysis it will be difficult to make rational decisions on future choices of technology, their phasing and management.

Reform of Groundwater Use is Key to a Sustainable Future

Agriculture and forestry use two-thirds of Abu Dhabi's water resources that are not renewable. These two sub-sectors compete for the same groundwater source. Neither uses the resource efficiently because of inducements offered by extensive support subsidies, including those supporting farm construction, land preparation and irrigation infrastructure. Electricity and input subsidies reduced running costs while output subsidies ensured good incomes. All contributed to the rapid development of irrigation that peaked in 2007. While the high-level of subsidies have guaranteed farmers good incomes and supported rural settlements, they have rapidly increased the demand for energy and water.

Most notably just a single crop - Rhodes Grass that accounts for a 60 percent of agricultural water use - is responsible for much of the environmental damage and groundwater mining. And fodder from its production, in turn, has supported the dramatic increase in the number of livestock which now exceeds two million. Annual crop and energy subsidies for Rhodes grass alone were about Dh 800 million in 2006. The combined environmental impact of Rhodes grass and livestock is probably responsible for two million tonnes CO₂ equivalent per year or 10% of the national total. This also endangers natural rangeland and ecosystems of amenity value and tourist potential.

Forests are exotic in Abu Dhabi's arid desert climate yet they cover over 300,000 ha of land area and are a source of national pride. While

they potentially offer important ecosystem habitats, many are in poor condition and are maintained only through irrigation by brackish groundwater provided at high cost. Forests and Rhodes grass together account for two-thirds of groundwater abstraction. They use 1.24 GWh of electrical energy a year to provide drip irrigation through 433,000 km of pipes plus the energy used by wells. Annual pumping costs are more than Dh 256 million per year and CO₂ production from energy used is about half million tonnes per year. While this is offset by carbon sequestered in forest vegetation, there is little or no research to determine the amount.

These high rates of agriculture water use jeopardize Abu Dhabi's only strategic water reserve: groundwater. At current rates of agricultural use all of Abu Dhabi's fresh and moderately brackish water will be exhausted in 20-40 years. Groundwater is available all year round over quite large inland areas and can be recovered and treated for water supply at fairly low costs. Currently desalinated water supply systems that are the sole potable water source have only two days storage capacity. Groundwater is the only alternative source of supply.

Agriculture is thus living on borrowed time. If present agricultural and energy policy continue then water quality will continue to deteriorate and electricity demand will increase disproportionately as more water is required to leach irrigated soils and lift water from greater depths.

There are solutions: water demand can be regulated or its supply can be increased. While demand regulation is feasible, the rate and cost of relatively small volumes of groundwater recharge are non-viable.

Supply augmentation has been hotly debated for a number of years and the choices favoured in

Abu Dhabi are using treated sewage effluent (TSE) and excess desalinated water to recharge the groundwater reservoir. Neither is a viable solution. Demand for treated sewage effluent will shortly exceed supply and in the future the supply shortage will be so large that the Municipality and EAD are proposing to adopt desert landscaping in urban areas. Excess capacity to generate desalinated water is available in the winter when power demand is small. However, the marginal cost of winter season desalination becomes very high because energy to desalinate water has to be specially provided independently of power generation. This would raise the average cost of water significantly - now \$1.75 per cubic metre - perhaps by more than half. The exact cost is not known until more detailed financial information is available from the water generation companies. Apart from the cost issue the volume available would be relatively small - about 10% of groundwater demand.

There are three strategic options:

- a) do nothing and allow the agricultural system to gradually fail over the next 20-40 years;
- b) take positive actions to reduce water demand; or
- c) provide agriculture with expensive desalinated water.

Doing nothing is not an option as it would have important social consequences. Option (c) is allowed and officially 11% of the very expensive desalinated water supply is being used. In practice this is likely to be far higher. There are no economic or financial analyses to verify the economic sense of this approach. We are certain that rigorous analysis following the precedent set by the reform of the date industry under the leadership of HE Sheikh Hamed bin Zayed Al Nahyan could be replicated in other parts of the agricultural sector.

As an alternative the government can adopt progressive policies for agriculture and power

and implement option (b). The program to reduce agricultural subsidies should be accelerated and the biggest benefit would accrue from removing that from Rhodes grass and other crops, and supporting drought-tolerant species. This could quickly reduce water usage by half. The biggest impact will be from policies that affect farmers' costs. Power is very under-priced - farmers pay only 14% of actual electricity costs - and there are sound financial reasons to increase the tariffs. They are an effective policy instrument. Global experience shows that a 10% increase in tariffs reduces demand by 4-7%. Thus increasing power tariffs would force farmers to increase water use efficiency and adopt new cropping patterns that use less water - vegetables in preference to field crops. While many farmers may cease to farm, the social consequences are better addressed by direct income support programs that are transparent and do not have such unforeseen environmental consequences.

There is a lobby that argues that continued support for agriculture contributes to food self-sufficiency and is essential for national security. However, it must be stated here that future agricultural management and expansion must be viewed within the context of available irrigation water and energy sources to ensure sustainability of production. Any changes must be considered within the context of international indicators for food production and recent UAE government initiatives to secure future supply.

Excessive household consumption of water is a growing problem

ADWEC's latest projections for peak power demand indicate existing co-generation capacity will be unable to meet demand for water after 2012. New capacity will be needed unless demand can be reduced. As most desalinated water is produced by co-generation of power and



water this will affect the future supply of potable water to meet demand from households, government, commerce and industry. Consideration of gas supplies and alternative energy sources indicate that stand-alone electricity stations may offer the most flexible solutions to meet future demand. And a decision to explore nuclear power generation has been taken. In this sector there are three options to ensure future water supplies:

1. demand reduction
2. supply augmentation
3. or a combination of the two

Currently only 17% of water is lost in transmission and distribution. With state-of-the-art management this could possibly be reduced to 10% but the marginal cost becomes increasingly high for lower-losses. The technologies to achieve this are well-known and are being introduced in the water supply sector which is among the best-managed and regulated in the Middle East. In terms of meeting demand, leakage reduction programs only delay the demand-supply gap from 2012 until about 2014. Beyond that the supply-demand gap rapidly increases. As with electricity, water tariffs have proved to be an effective instrument to lower demand and they behave in a similar way too. Thus a progressive increase in the water tariff could reduce demand by more than half. Rigorously pursued it could completely close the supply demand gap and reduce the need for very expensive and lumpy new investment.

The reason is that three-quarters of desalinated water supplies are used primarily for vegetation – amenity plantations, home gardening, parks and private households. Surveys show that per capita consumption in flats in Abu Dhabi range between 170 and 200 litres per capita per day. In contrast, people living in villas use between 270 and 1,760 litres per capita per day. Extensive survey data from Europe, Australia and Canada

clearly show that developed societies typically consume 150 – 250 litres per capita per day. Notably, households in which water is for free consume far more water than those that pay a tariff. A two-part tariff is indicated and this could be applied specifically to non-household use of desalinated water.

An important finding is that the sewage collection system is very efficient, probably better than 90% at collecting indoor household wastewater. Water tariffs would primarily affect household's outdoor use of water, little of which is captured by the sewerage system. Therefore increasing tariffs will not necessarily lead to a reduction in TSE which is an important water source for landscapes and amenity use. Indeed the conservation of potable water will ensure that household demands in new developments are fully met providing that these new sources of wastewater are connected and efficiently collected.

The instruments to develop a workable tariff policy will require a lot of additional household research and surveys. This is a complex and sophisticated subject but, given its high payoff in terms of deferring large capital investment in desalination, it should be given the highest priority.

Turning to supply, recent new water production plants have been large and very costly, typically more than US\$2 billion. These lumpy investments take up to six years to come on-line considering design, contracting and construction. In the absence of demand management there is no choice but to build new capacity. Global best practice indicates that reverse osmosis plants (RO) have significant cost and environmental advantages over the current multi-stage flash (MSF) distillation processes when not used in co-generation. With the national move towards nuclear energy it is suggested that the immediate future strategy should be to fill the demand-supply gap in

relatively small increments. Brackish groundwater RO could be run at half the costs of seawater. They have the additional advantage of producing between half and three-quarters less concentrated brine and significantly lower greenhouse gas emissions when power supply is factored in. This proposal will run into fierce opposition because of the vested interests that have monopolized water generation in the Gulf region since the 1960s, and this will require much greater in-depth analysis than has been possible in this Plan. Singapore and Australia provide excellent examples of the economic and environmental advantages of RO.

Both demand reduction and supply augmentation are viable. Modest size RO plants could be introduced in inland areas around Al Ain and Liwa. These RO plants and their associated well-fields could supplement potable and/or agricultural water supplies and if connected to existing transmission systems, augment supplies from the Fujairah desalination plants for Al Ain. This would allow the Abu Dhabi coastal plants to supply the growing conurbation of the capital city. If sufficient capacity and emergency generators could be installed, these RO plants would provide a strategic water supply in the event of coastal desalination plants failing.

The feasibility of these various proposals requires far more data than is currently available, specifically full engineering and energy as well as land management and environmental costs in a comprehensive, integrated study. The detailed study approach would involve developing the costs and benefits of each option; making trade-offs to minimize environmental impacts and financial costs, whilst maximizing economic benefits. This would also provide the opportunity to include social dimensions that have not been included in this strategic plan.

Institutional reform will be necessary

To bring about the proposed changes of this strategic assessment, there is a need to develop the institutional structures of Abu Dhabi emirate in both water and environmental management. The most important recommendation is the creation of an Abu Dhabi Water Council which would be responsible for strategic planning and development across all the water sources and users. The present system operates as a series of silos with limited strategic communication between the various major water resources system management groups and user groups. The new Water Council would ensure integrated and coherent water policies in the future. It would provide the independent guidance and oversight to come up with the economically best solutions to meet water needs across the many economic sectors. And ensure that these are balanced within possible water and energy supply futures that meet national environmental policy objectives.

In tandem with this, is the very real need for an environmental regulator. The setting of acceptable standards and practices for using natural resources or discharging to the environment is needed to control the impacts of burgeoning developments, including water and energy supplies. Without this water and other natural resources will be further compromised in the future. Additional planning and support for capacity-building and developing the Emirate's human and financial resources for monitoring and enforcement are essential.

