Water-Energy Nexus Challenges & Opportunities in the United Arab Emirates under Climate Change

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Abstract: The “Water-Energy Nexus” is a concept that identifies the numerous interconnected aspects between water and energy and considers these in planning and policymaking. The use of water covers all stages of the fuel cycle, from extraction of energy resources such as oil and natural
gas, to energy production and electricity generation. Energy is needed for extraction, conveying, purification, and transfer of the water to different forms of consumers in the economy. In addition, the water is used in the treatment of industrial and municipal wastewater. Major development initiatives, fluctuating demographics and more dependency on desalination have currently attracted attention to the links between water and energy use, and the fuels and infrastructure incorporated in their production.

The use of a water-energy nexus method is a highly relevant and specific planning framework for countries in the Gulf region. The framework of the “water-energy nexus” perceives water as a portion of a combined water and energy system, rather than as an independent resource. Until recently, energy and water have been viewed as isolated planning challenges separate from each other. Any connections between water and energy have usually been considered on a case-by-case basis. In the UAE, the management of water resources has been noted as an emerging challenge of high significance to sustainable development in the long-term. At the national scale, domestic, agricultural, and industrial usage of water have grown at yearly rates approximately steady with the population growth rate, hinting that little conservation or efficiency improvement is taking place. However, the UAE depends on desalinated water to keep up with the increasing share of water supply. The amount of energy required for desalination is an order of magnitude higher than the energy needed for either pumping of groundwater or moving water from surface rivers or reservoirs. Thus, energy and water are connected to significantly higher extent in the UAE compared to other countries where the climatic conditions aid in higher annual rainfall and water resources are more abundant. Looking into the future, individual municipalities are projected to grow the capacity of their desalination plants to meet the needs of the increasing population and development in the economy, hinting that dependency on the desalination process is equally an energy and water challenge.

In a situation where there is scarcity of water, supply of fossil fuel-derived energy is abundant, demands for both are high, and issues surrounding climate change are increasing, coupled with the continuous growth in population, links between water and energy can potentially reveal opportunities for enhancements in efficiency or tradeoffs of mutual benefit. Despite the analysis within this paper examining both a demand oriented scenario (High Efficiency) and a supply oriented scenario (Natural Resource Protection), the findings of the analysis firmly propose that the region, specifically the UAE will need to employ demand and supply side policies in a simultaneous manner to accomplish increased sustainable uses of energy and water over the course of the next half century (the Integrated Policy scenario).

Keywords: climate change, water security, energy, nexus, development, UAE.

Introduction

The Water-Energy Nexus is composed of the interconnected nature of water-energy systems, such as energy required for the desalination, treatment, and transportation of wastewater and water, as well as water required for extraction of energy and production. Through its nature, the Water-Energy Nexus creates a set of interactions, tradeoffs, and balances within the system across its component pieces, which contributes to a complex analysis process of the Water-Energy Nexus. The study presented here provides an analysis of the W-E Nexus for the Gulf nations while including specifics concerning sources, demands, and expenses of the water and energy elements (AGEDI, 2016).

Contemporary water and energy planning within the Gulf is classified by a consideration of the energy used in providing water. The expanding population and increasing per capita water demand for public water usage like amenities within the Gulf region have increased the strain on potable resources of water. Since seawater is readily available for desalination, water itself is not a limited resource. However, transforming seawater into water that is fit for human consumption involves a significant amount of energy. Likewise, since groundwater extraction promotes saltwater intrusion into the aquifers, pumping it will introduce energy expenses for the treatment of the water to acceptable potable levels. Wastewater produced in these systems can potentially be reused in the environment after treatment but this also requires a certain amount of energy. The region's water supply will become increasingly dependent on its energy demands, as freshwater resources are depleted. Under climate change, numerous vital patterns in the Gulf recommend the importance of addressing water and energy in a combined and proactive manner (AGEDI, 2015). Firstly, the effects of climate change on rainfall and temperature trends across the region have already begun, as established by the LNRCCP Regional Atmospheric Modeling sub-project. Secondly, patterns of socioeconomic growth within the region show that the population in the Gulf's hyper-arid environment is expected to continue to grow and will need further energy-intensive desalination capacity to meet the increasing water needs. Thirdly, the production efficiency for both energy and water resources can be improved via new energy and water technologies, if introduced within a water-energy integrated framework. Finally, a water-energy nexus strategic method could help to inform future technology research, development, demonstration as well as deployment within several hubs of excellence in the region. The "water-energy nexus" is a framework that views water as part of an integrated water and energy system, rather than as an independent resource. From extraction of energy resources like natural gas and oil, to energy production and electricity generation, water is used in all phases of the fuel cycle. Energy is needed for extraction, transportation, purification as well as distribution of the water to several types of end users within the economy (AGEDI, 2016). . It is also incorporated in the treatment processes of municipal and industrial wastewater. Until recently, energy and water have been perceived as independent challenges for planning. Any interactions between energy and water have usually been considered on a case-by-case basis. However, shifting demographics, large-scale development initiatives and increased dependency on desalination have lately encouraged attention on the links between water and energy infrastructure. As a result, the water-energy nexus is a particularly pertinent framework to apply to explore climate change effects on the Gulf's water resources. For the purposes of the analysis, the spatial focus was on the water-energy nexus situation in six countries: Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates as well as Oman.

Methodology

In a situation where water is in short supply, fossil fuel energy is abundant, demands for both are high, and concerns about climate change are increasing, as well as continuous population growth, links between water and energy can reveal potential opportunities for enhancements in efficiency or mutually useful tradeoffs. The analysis for this study was mainly based on the reports and statistics published by Abu Dhabi Global Environmental Data Initiative (AGEDI) that built and connected water and energy models (WEAP and LEAP, respectively) for the Gulf countries particularly Kuwait, Bahrain, Qatar, the United Arab Emirates (UAE), Eastern Saudi Arabia and Northern Oman. The coupled water-energy models required detailed data, which were obtained via literature reviews of Abu Dhabi Global Environmental Data Initiative reports and projects and consultations with water and energy experts within the region

Findings

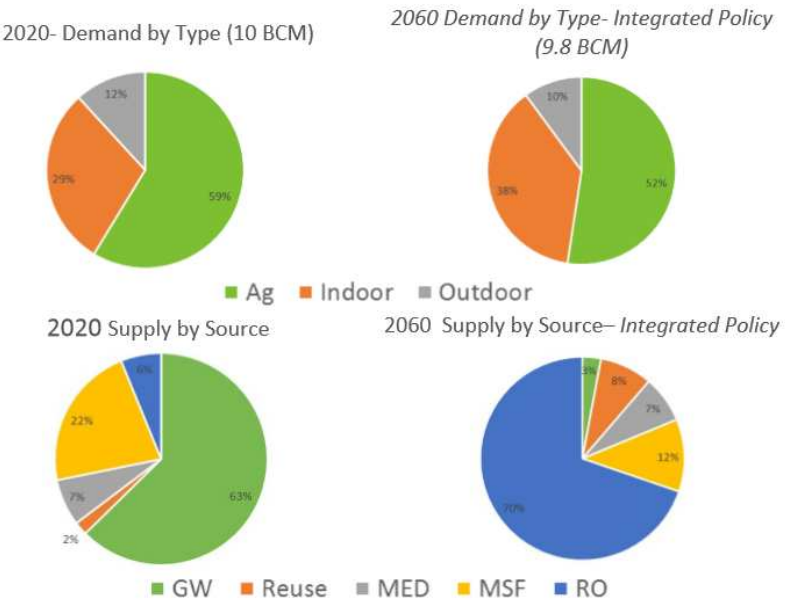
The main findings of the analysis show that the use of water for the Gulf countries can mostly be satisfied in any context via combinations of groundwater, desalination and wastewater recycling, with certain regional fossil groundwater basins potentially pushed towards extinction by 2060 under the most intensive resource-use situations. The scenarios produce different water use for the countries, for example, the Integrated Policy Scenario embeds the implementation of all policies and measures that would reduce water demand in the region, resulting in diminishing indoor water use starting in 2020. As the provision of water affects energy needs (requiring pumping, desalination, and transport), any reductions in water demand will apply similar impacts on the energy sector supporting water provision. As groundwater resources are used up, desalination shifts towards becoming the main source of water in the region, followed by treated wastewater, which will be restricted to service and agricultural sectors.

Some of the groundwater aquifers experience complete or near complete depletion in the Gulf region by the end of model period. Since the climate of the region already needs a significant amount of irrigation to sustain the demands of the agriculture and amenities sector, Climate change does not exert a significant impact on overall water demand. Consequently, the demands of irrigation increase only slightly due to global warming (AGEDI, 2015; 2016).

While the analysis includes both a demand oriented scenario (High Efficiency) and a supply oriented scenario (Natural Resource Protection), the results of the analysis strongly point towards the notion that the region will be required to concurrently follow demand and supply side strategies to attain increased sustainable uses of water and energy over the next half century (the Integrated Policy scenario).

For example, Figure 1 summarizes the portfolio of the production of energy for the Integrated Policy scenario, which assumes a drop in per capita water consumption driven by a goal to meet an indoor standard of 75 M3 per year by 2060, stabilization of outdoor water consumption via enhancements of current procedures, no new land under irrigation for either agriculture or amenity areas and reductions in fossil groundwater use. In terms of the energy side, the aim of the policy is to meet 2005 levels of GHG emissions for the region, which are approximated at 70 mtCO2e. This is being done through the installation of new solar capacity in favor of natural gas, with new solar capacity being added at about a 3:1 ratio to new natural gas capacity (AGEDI 2016.)

Figure 1 represents the supply of water by source and demand type for the 2020 BAU scenarios and the 2060 Integrated Policy scenario. Despite a nearly 40% increase in population, a similar quantity of water is delivered, as shown by figure 1. This is achieved mainly through enhancements in conservation and irrigation efficiency for both amenity and agricultural uses. The percentage of agriculture water use has declined while the percentage of water used for indoor use has increased. Water reuse has grown, as has the percentage of water produced through reverse osmosis.



Source : AGEDI 2016.

Figure 1. Water use by type (Agriculture, Municipal Indoor and Municipal and Amenity Outdoor) and supply source (Groundwater, Reuse Water, and Desalination technology) for 2020 and the 2060 Integrated Policy Scenario.

Conclusion

The region could be separated into water resource demand and supply zones, that takes into account industrial, agricultural, and municipal demands supplied by both groundwater and desalination. Groundwater in the region is dominated by non-renewable, fossil sources mainly serving agriculture, while the majority of municipal and industrial water is provided through desalinization, with regional groundwater supplies, mainly in Central and Western parts of Saudi Arabia. Historically, the bulk of seawater desalination has been performed through energy intensive; fossil fuel based technologies, although it is usually co-generated at power plants that also generate electricity.

Reductions in regional water use are likely more attainable than regional energy use. Policies for agriculture that give respect to the distinct climatic conditions and agricultural heritage of the region could contribute to major drops in water use for agriculture. Over the course of the past decade, this has been demonstrated in Saudi Arabia. Policy-makers will need to examine the significance of fossil groundwater preservation against its exploitation in the short term. While desalination consumes a great amount of energy, it is usually co-generated and hence care must be taken when accounting for water's share of the energy footprint. The penetration of renewable energy sources in the region will have to be significant, to stabilize or even reduce greenhouse gas emissions. The tools developed as part of this study can be used by policy makers to explore if the trajectory of these new energy technologies is at all realistic. Significant increases in solar and nuclear power would be required as implied by the Natural Resource Protection and Integrated Policy scenarios.

In conclusion, a balanced set of both supply-side and demand-side interventions in both the water and energy sectors will be essential to accomplish sustainable resource management targets. "Water Savings" are likely easier to achieve than energy savings in the region. This is already proved by a country like Saudi Arabia, as it has significantly changed its irrigation policies over the course of the past few decades, which have contributed to reductions in irrigated agricultural use and fossil groundwater pumping.

References

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