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The Water-Energy-Climate Nexus – linkages and trade-offs in the Middle East and North Africa (MENA) region

Thomas Fink

Abstract: The Middle East and North Africa Region (MENA) is facing various challenges. Besides the urgent need for the socio-economic development of growing societies, the region is facing increasing pressure with regard to energy and water. The demand for both is increasing rapidly and future trends predict further increasingly difficult dynamics due to the negative impacts of climate change. This development might jeopardize the future stability of the region and requires appropriate strategies for addressing these challenges. The development of energy infrastructures – and especially electricity generation capacities – plays a significant role with regard to water use and the water supply system, but also for strengthening socio-economic development in the region. To prevent any negative impacts on societies by the development of new energy infrastructures and to reduce the vulnerability of the energy system, it is important to understand and to consider the linkages and trade-offs between energy and water decision-making in relation to climate change and sustainable development.

1- Understanding the Water-Energy Nexus

The global energy system is one of the main emitters of greenhouse gas (GHG) emissions, which are responsible for climate change and global warming. Population and economic growth, urbanization and changing consumptions patterns are driving factors for energy demand worldwide, but also for other resource needs such as the demand for water. In securing global social and economic development as well as to achieving the United Nations Sustainable Development Goals (SDGs), the availability, accessibility and affordability of both energy and water is fundamental. This is especially of importance in the MENA – a region that requires socio-economic development but faces issues due to rapid increases in the energy and water demand, associated with growing expenditures for energy and water subsidies.

Global warming puts further pressure on the energy and water sector as demand further increases. Both sectors have long been treated as separate fields, although energy and water are closely interrelated. While fossil fuels and the generation of electricity require for instance water for production and plant operation including in many cases water for cooling, the supply of water requires energy for extraction, treatment and transport. Therefore, increasing demand for water results also in increasing demand for energy and vice versa. These complex linkages and trade-offs between water and energy are known as the Water-Energy nexus, which should be of special interest in the current momentum towards increasing electricity generation capacity worldwide and against the background of the faced challenges especially in the MENA region. Figure 1 illustrates the Water-Energy nexus issue and the importance of integrated technology assessments with regard to electricity generation.

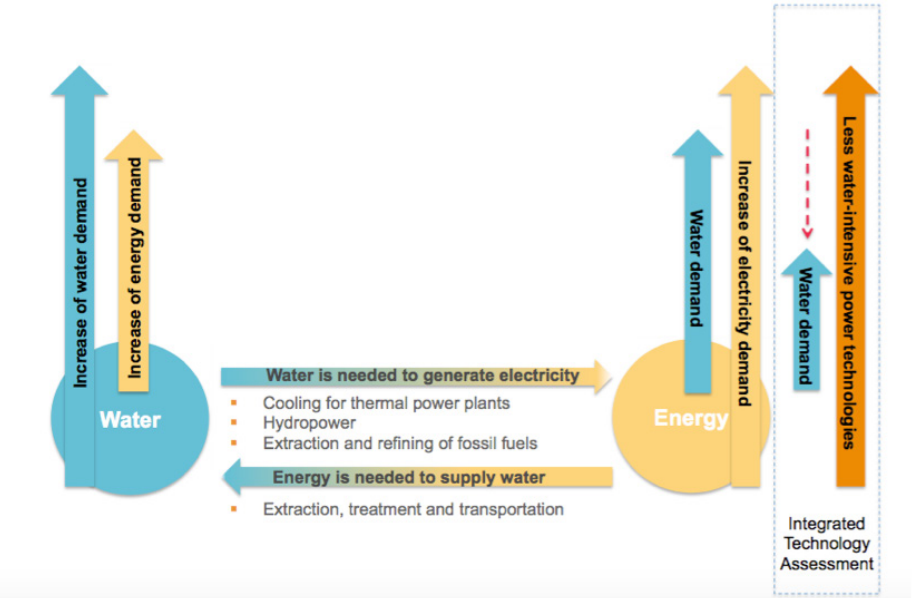

Figure 1 Illustration of the Water-Energy nexus issue

2- Climate Change in the Context of the Water-Energy Nexus

Climate change remains an alarming issue and the global energy system – especially the electricity sector – contributes significantly to the increase of GHG emissions. Over recent years the CO_2 concentration in the atmosphere has risen significantly, and the latest data shows that the threshold of 410 ppm has already been exceeded in 2018 [1], bringing us closer to the critical threshold of 450 ppm. Although energy related carbon emissions stagnated after a peak in 2013, emissions worldwide continued to grow in 2017 for the first time since 2014 [2]. According to the World Meteorological Organization, the earth is already 1 degree Celsius warmer than at the start of the twentieth century today [3]. In case this trend remains unbroken it is likely to accelerate climate change, including a rise in temperatures and a decrease in annual precipitation, as well as an increase in extreme weather events such as droughts and heatwaves. This situation could significantly affect the well-being and livelihood of people in future, and especially in a region like the MENA which is already nowadays one of the most water scarce regions worldwide.

But there are also some promising trends. In 2015, the G7 members agreed at the G7 summit in Germany to work on the decarbonisation of the global economy by 2100. Later that year, for the first time 196 countries agreed at the 21st United Nations Climate Change Conference on the Paris Agreement, which should limit the global temperature increase to well below two degrees Celsius above pre-industrial levels. Even though the U.S. as an important economy and GHG emitter announced in 2017 its intention to withdraw from the Paris agreement, leading economies affirmed their willingness to mutually work on the successful achievement of the agreement. Analysis from the IPCC [4] shows that a two degree Celsius scenario requires a trend reversal till 2020 and the reduction of GHG emissions by 40-70% compared to 2010 until 2050, and 100% by 2100. Else a much higher increase in temperature is possible in future ranging from around 4-5 degrees Celsius.

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Although the linkages between the global energy system and climate change nowadays play a central role in political discussions and decisions about future energy systems, a comprehensive understanding of mutual dependencies and trade-offs between energy

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and water supply – especially at the local level where power plants are installed – is still in an early stage when it comes to decisions about future electricity generation technologies. A study from International Renewable Energy Agency [5] has recently illustrated that water and energy need more attention in future, as predictions of global water and energy demand are associated with an increase in energy needs by 80%, and water needs by 55% until 2050, while additionally the interrelation with the growing demand for food play a significant role. Uncertainties with regard to climate change could increase these numbers further, as the increasing numbers of heat waves regularly result in increased electricity demand for cooling and water supply, therewith intensifying the Water-Energy nexus inter-linkages and trade-offs even more.

This is worrisome, as today water-induced cuts are already an issue for the electricity generation sector. Water constraints are related to rising temperatures and declining precipitation, but also increasing water temperatures have resulted in reduced electricity generation in hydro, coal and nuclear power plants during the last years in several countries worldwide [6]. It is likely that this trend will increase with progress in climate change. As a consequence, the assessment of future energy systems and electricity generation technologies requires us to take the consumption of water into account, to guarantee energy security under aggravating circumstances as a result of climate change, but also to minimize negative impacts from electricity generation on water withdrawal, consumption and quality.

3- The Water-Energy Nexus in the Context of MENA

Energy and water are important issues in the MENA region, as the region is facing increasing demand for energy and water. Economic development, population growth, and high inefficiencies that result from energy and water subsidies in several countries of the region are drivers for the increasing demand in both sectors.

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For satisfying these demands, especially that for electricity, the construction of additional electricity generation capacity is urgently needed to prevent regular electricity blackouts, as experienced for instance in Egypt in 2014. Numbers from the current policy scenario of the World Energy Outlook 2016 shows that from 2014 to 2040 the installation of new electricity generation capacities is projected in the Middle East alone to equal 294 GW. That represents more than a doubling of the 285 GW installed in 2014 [7]. This would not only require huge investments in the coming years, but also the application of holistic assessment approaches for decisions about electricity generation technologies to consider the issues relating to the nexus appropriately, as the consumption of water varies widely among different electricity generation technologies. Today the MENA region is not only one of the world's most water-scarce regions, but several countries in the region face already water stress [8]. As investments in electricity generation capacities usually have a lifetime of several decades, it is of high

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importance to consider water and climate aspects in ongoing planning processes and decisions to prevent any negative impacts on local societies. However, current energy strategies in the region often ignore such aspects and foresee the development of fossil fuel and nuclear power plants that are highly dependent on the availability of water resources, as such electricity generation technologies include cooling systems.

But even among cooling systems, differences in water consumption exist. In comparison to once-through cooling systems, cooling towers are associated with less water demand. Dry cooling systems sometimes even require no water but have reduced electricity efficiency leading to higher electricity generation prices. Compared to fossil fuel electricity generation technologies with cooling systems, wind energy and photovoltaic energy sources not only provide solutions for fighting climate change, but also need considerably less water resources for operation [9]. Such aspects must be taken into account by decision makers in MENA with regard to the installation of new electricity generation technologies to address water stress in the region.

Today many MENA countries already face water gaps that will experience increasing dynamics until 2050. The analysis of individual countries shows that countries with high population numbers will have the highest unmet water demand gaps under average climate scenarios in future. Here, challenges can be foreseen especially for countries such as Iraq, Iran, Egypt, and Saudi Arabia [8]. All of these countries are furthermore countries with crude oil and gas production sectors that contribute significantly to national budgets but also require large amounts of water for the extraction and refining of fossil fuel resources thereby further driving the demand of water.

In future, energy intensive desalination strategies could play a key role in water supply systems in the MENA. However, a typical single desalination plant with a capacity of approximately 100,000m3 of water per day requires as much energy per year as 31,000 world average households and would therefore further increase pressure on the installation of additional electricity generation capacities. Water scenarios with a specific focus on the Middle East that consider mainly the development of fossil fuel electricity generation technologies predict an additional increase by around 40% in the demand for electricity just to secure water supply in 2050 [10]. This would not only require huge efforts in the installation of additional electricity generation capacities, but also high additional investments in energy and water infrastructure that could be challenging for some countries in the region. Renewable energies and efficiency gains offer solutions not only to reduce GHG emissions, but also to address water resource challenges for the Middle East. Efficiency measures alone could reduce the additional electricity demand for water to around 22% [10].

4- Upcoming global energy trends and resulting opportunities and challenges for the MENA

The decarbonization of the global economy and energy system needs solutions beyond the electricity sector. Even though the electrification of processes in buildings and mobility based on renewable electricity plays a significant role in transition strategies, several sectors such as heavy transport, shipping, and aviation as well as many processes in industry cannot be electrified according to the current technological

standards. Here, energy transportation methods such as gas and liquid-carriers are also required in future. With Power-to-Gas (PtG) and Power-to-Liquid (PtL) technologies, innovative concepts exist that could provide solutions for these sectors.

Taking advantage of the well-known process of electrolysis, PtG and PtL concepts use renewable electricity and water for producing hydrogen, which can be applied as an energy carrier directly or synthesized together with captured CO_2 from air (Direct Air Capturing) amongst other methods into synthetic methane, methanol, gasoline, and diesel. By using CO_2 from the air, no additional GHG emissions are released into the atmosphere at a later stage, which makes synthetic gas and synthetic fuels climate neutral. In addition, synthetic gas and synthetic fuels provide further advantages as these energy carriers can be stored, transported and applied in existing infrastructures such as pipelines, shipping, gas stations, and combustion engines.

However, the production of synthetic gas and synthetic fuels is a very energy intensive process and would require large amounts of renewable electricity at very low electricity generation costs to become competitive. Ideal conditions for the development of PtG and PtL industries exist in the MENA, as the region has unique solar and wind potential as well as abundant uninhabited land resources. This opens up promising opportunities for the region to take advantage of existing infrastructures and industries, phase out fossil fuel energy export models on time, and to become a forerunner in the production of sustainable energy carriers in future. Such strategies could furthermore intensify collaboration with countries and regions that are already advanced in their energy transition.

However, such a future scenario is also based on the availability of water as a basic input and would reinforce the Water-Energy nexus again. Even though during the production of PtG and PtF water is produced that can be used again for the production of synthetic gas and synthetic fuels, seawater desalination capacities must be part of such strategies to prevent the use of already scarce surface and groundwater from the beginning. As illustrated above, however, challenges with regard to electricity and water are already highly present in the MENA. The development of PtG and PtF industries result in additional pressure on countries in the region to develop significant electricity generation and seawater desalination capacities but could also provide a promising economic model for both resource-rich and resource-poor MENA countries to become exporters of sustainable energy carriers in future. In addition, this could be a starting point to strengthen the collaboration with Europe by supporting European countries in achieving the decarbonization of their economies. Therefore, investments into such infrastructures should be support by European countries as well as commitments for setting up future markets that finally could result in a win-win situation for both MENA and Europe.

With these future opportunities and challenges in mind, the complexity of future energy and water systems becomes visible, and we have to consider a multi-level concept including cross-regional strategies. This requires the holistic assessment of technologies and strategies including technological, economical, social and ecological aspects to consider linkages and trade-offs appropriately in decision making.

Endnotes

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ABOUT THE AUTHOR

Dr. Thomas Fink, research fellow. Address: Wuppertal Institute for Climate, Environment and Energy GmbH, P.O. Box 100480, 42004 Wuppertal, Germany

ABOUT ALSHARQ FORUM

The Sharq Forum is an independent international network whose mission is to undertake impartial research and develop long-term strategies to ensure the political development, social justice and economic prosperity of the people of Al-Sharq. The Forum does this through promoting the ideals of democratic participation, an informed citizenry, multi-stakeholder dialogue, social justice, and public-spirited research.

Address: Istanbul Vizyon Park A1 Plaza Floor:6
No:68 Postal Code: 34197
Bahçelievler/ Istanbul / Turkey
Telephone: +902126031815
Fax: +902126031665
Email: info@sharqforum.org

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