KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Emerging Issues Facing the Water-Energy-Food Nexus in the Middle East and Asia

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

Key Points

As economies in the Middle East and Asia grow and develop, there will be further strain on water, energy and food resources – each inextricably linked to the others. Much of the Middle East is energy abundant, but population growth and economic development have led to severe water and food scarcity. In Asia, despite a comparative abundance of water, energy and food, the problem is increasingly one of economic scarcity – the inability to finance the mobilization of these vital resources.

Water for agriculture: There is not enough robust data on the interdependencies of water, energy and food. There is an opportunity to improve data collection so that proper economic, environmental and social impact assessments can be performed before policy decisions for resource management are made.

Transboundary governance: Water basins do not respect national boundaries, making their management more difficult. When conflicts occur, bottom up solutions such as cooperation for sub-basin management can provide a platform for international water management. Examples of successful transboundary governance can be found in the Mekong River delta and Nile River basin.

Infrastructure financing: In Asia, securing the least cost water and energy utility provision option is important, given financial constraints. The 'pro-poor public-private partnerships' (5P) experience is one approach that attempts to harmonize private sector efficiency with public sector development goals.

Coordination: Energy and water infrastructure projects are not always considered as a package, for example cooling water for power plants. An integrated planning process can improve coordination among different institutions and result in more resilient and sustainable infrastructure investments.

Summary for Policymakers

As societies grow and develop, more strain is placed on water, energy and food resources – each of which is inextricably linked to the others. This phenomenon is evident in several parts of the world, including the Middle East and Asia, despite the geographic differences of each region. Much of the Middle East is energy abundant, but rapid population growth and economic development have put pressure on water and food supplies. The region currently mobilizes a sizable portion of its vast energy resources to meet its water and food needs at significant economic and environmental costs.

In Asia, similar rapid economic and population growth are beginning to stretch water, energy and food resources, despite a comparative abundance of these resources. Furthermore, economic scarcity – the inability to finance the mobilization of these vital commodities – has made development prospects much more difficult in some emerging Asian countries.

By examining case studies from both the Middle East and Asia, delegates explored to what extent best practices in each region can be transferred, given the geographical and economic differences. The following issues, which are worth considering when making decisions on the nexus were highlighted at the workshop:

Water for agriculture: As demand for water resources increase, it is important for countries to ensure that robust data on the interdependencies of water, energy and food are collected, so that adequate economic, environmental and social impact assessments can be performed before policy decisions for resource management are made.

Transboundary governance: Water basins do not comply with national boundaries, making their management more difficult. When conflicts occur, bottom up solutions such as cooperation for sub-basin management can provide a platform for international water management. Examples of successful transboundary governance is found in the Mekong River delta and Nile River basin.

Infrastructure financing: Securing least cost water and energy utility provision options is important, given financial constraints faced by every economy. In Asia, private sector participation is one approach that is being used to combine private sector efficiency with public sector development goals. This is seen through the ‘pro-poor public-private partnerships’ (5P) scheme, an example of which is the Cinta Mekar micro-hydro project in Indonesia.

Coordination: Energy and water infrastructure projects are not always planned in coordination with one another, for example availability of cooling water for power plants. An integrated planning process can improve work flows among different institutions and result in more resilient, efficient and sustainable infrastructure investments.

Background to the Workshop

In February 2016, KAPSARC hosted a workshop in Singapore to explore emerging issues facing the water-energy-food nexus in the Middle East and Asia. The workshop was jointly organized with the Lee Kuan Yew School of Public Policy at the National University of Singapore. Participants included academics, policymakers, representatives from international non-governmental organizations and the private sector.

Delegates examined the challenges and opportunities facing Middle Eastern and Asian countries in managing the water-energy-food nexus with respect to four key areas:

- Mobilizing water and energy for agriculture.
- Financing water and energy infrastructure.
- Transboundary management of water and energy resources.
- Methods for coordinating water-energy-food policies.

Mobilizing Water and Energy for Agriculture

Roughly 70 percent of global water extractions are used for agriculture, and so any attempt at improving the sustainability of water resources must include an agriculture dimension. If not managed properly, the water-energy-food nexus could become a 'perfect storm,' i.e., rapid population and economic growth exerting incredible stress on global water, energy and food resources. As people become more affluent, changes in diets and land use will increasingly put pressure on biodiversity and the climate. Incorrect management of the nexus could lead to welfare loss and political instability.

The significance of water extraction for agricultural use is seen in both the Middle East and Asia. In Saudi Arabia, about 87 percent of all water extracted is used for agriculture, with over 30 percent of total water extracted used for fodder production *(See Figure 1 below)*. In China, the South-North water transfer project moves roughly 45 km3 of fresh water each year from the south of the country, which has greater water resources, to the north where it can be more easily used for agriculture. Crops grown in the north are then shipped to demand centers back in the south, resulting in the movement of more than 50 km3 of embodied water.

Water use in the Middle East and Asia has important implications for energy use. Significant quantities of energy can be required to provide fresh water. In Saudi Arabia, nearly 200,000 boepd are consumed to provide water from surface, groundwater and desalination. About half of that energy is used to desalinate seawater, which is only 5 percent of total water withdrawals. In China, total energy use to provide water in 2014 was approximately 180 terawatt-hours, of which 41 percent was for agriculture, according to data presented in the workshop. In regions where over extraction increases water scarcity, more unconventional,

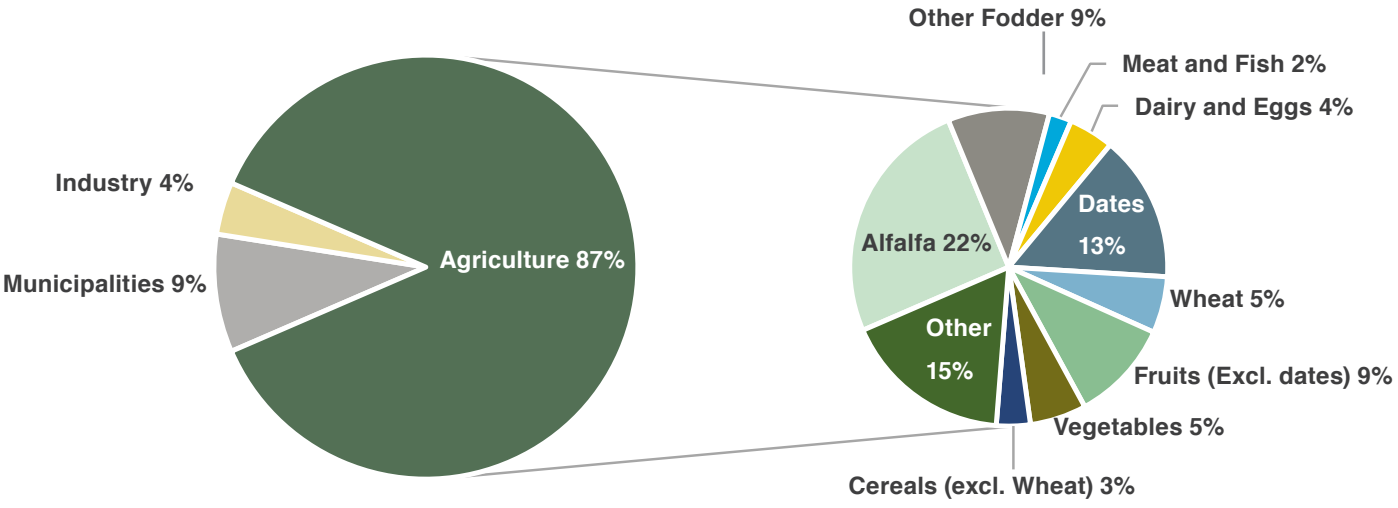

Figure 1. Breakdown of water use in Saudi Arabia, 2012 (FAO statistics).

energy intensive water provision techniques may be required to meet demand. Unconventional methods such as desalination and large water transfers, both of which entail a significant energy footprint, are becoming more common in the two regions.

Crop switching is a short-term policy option that has the potential to reduce significant amounts of water consumption in Saudi Arabia and, consequently, energy consumption. KAPSARC analysis shows that substitutions away from water-intensive, low value- added crops toward more water productive, high value-added crops can result in up to a 70 percent reduction in water consumption for agriculture. In this analysis, 10 combinations of crop switching were considered. An optimization was performed for each crop portfolio to minimize water consumption while not negatively impacting aggregate farmer revenues or the country's current level of food security. As shown in Figure 2, roughly half of all energy consumed for water in Saudi Arabia is used to desalinate seawater, while an equivalent amount is used to extract groundwater.

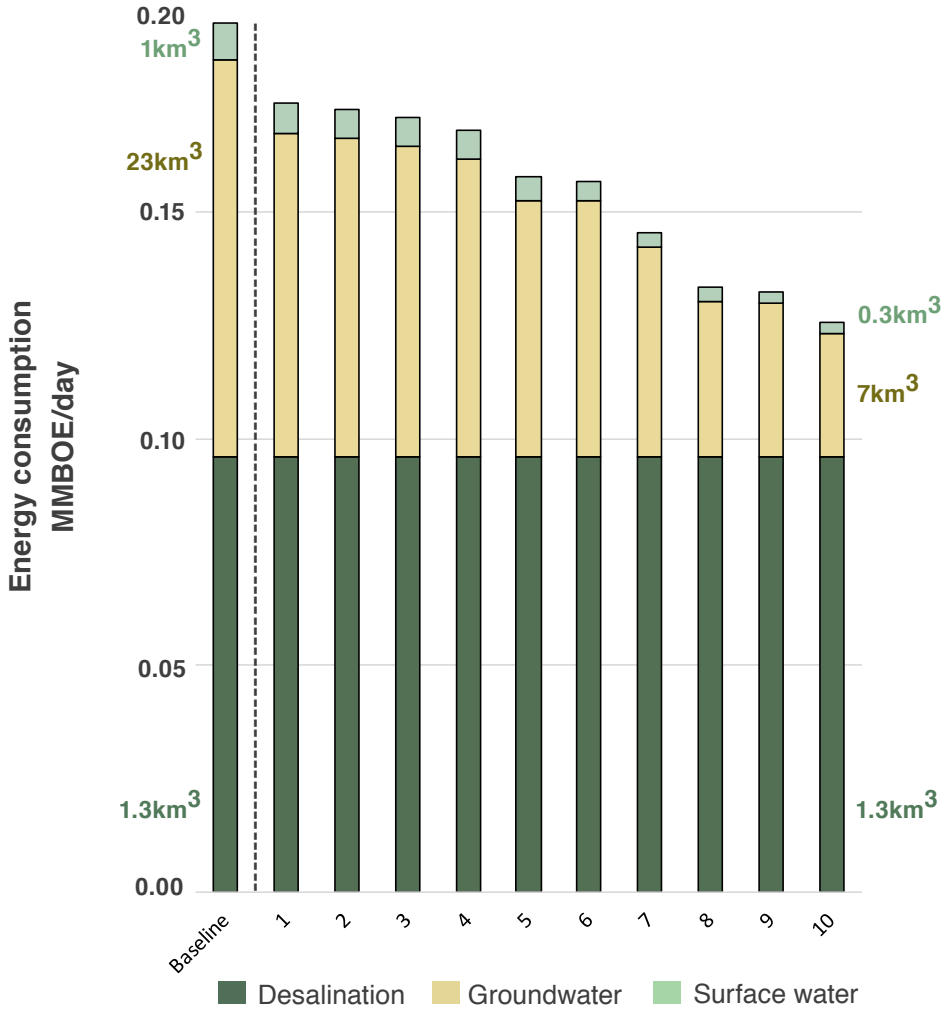

Figure 2. Water reductions in agriculture could lead to 40% reduction in energy consumed for water extraction.

As crop switching becomes more ambitious, water savings will in turn result in energy savings. In the most ambitious scenario, up to 40 percent reduction in energy use by the agriculture could be achieved by offsetting extracted groundwater through producing less water-intensive crops. Even greater energy savings could be realized by offsetting desalinated water first, followed by groundwater.

In addition to crop switching, other options such as improved irrigation and water-efficient crops have the potential to reduce water for agriculture use. It is important to recognize that water savings have significant implications for energy demand. In order to better understand the potential water and energy savings, it is important for countries to collect robust data that include: water consumption, crop production, fertilizer and nutrient inputs, imports, exports and sales revenues. Robust data are a critical component for performing adequate economic, environmental and social impact assessments before policy decisions for resource management can be made.

"Increases in population and wealth, if not managed correctly, will exacerbate water, energy and food stress in some regions of the world"

Financing Water and Energy Infrastructure

Financing challenges facing Middle East and Asian countries are somewhat distinct. In Asia, securing the least-cost water and energy utility provision option is important given their financial constraints. By contrast, in the Gulf region of the Middle East, securing financing is less difficult and more emphasis is placed on securing water and energy provision for a rapidly growing and increasingly wealthy population. Despite this diverse challenge, both regions share the objective of ensuring that water and energy utilities are efficiently run and provided at least cost. Private sector participation can improve efficiency and is a growing phenomenon in both regions. However, a common fear is that the profits earned by private investors will outweigh cost reductions from efficiency gains. This would lead to higher prices of water and energy, which were subsidized or subject to price controls to support social welfare. Providing welfare through alternative mechanisms can provide a route to resolve this problem.

"We must ask ourselves what is the appropriate role of the private sector for water and energy provision?"

An approach that tries to harmonize private sector efficiency with public sector development goals are 'pro-poor public-private partnerships' (5P). Specifically, 5P projects work to establish multi-level stakeholder partnerships in which communities become co-owners of the utilities. The communities involved are generally rural and developing, and often have difficulty accessing conventional financing for utilities. The 5P approach generates opportunities for income in the communities, and helps build capacity within the communities for utility management.

The 5P approach consists of six principles with the aim of developing a sustainable and replicable model (UNESCAP):

- Technology neutrality: baseline survey, socio-economic and energy use assessment, and enterprise and value-chain assessment.
- Policy analysis and gap analysis: agency collaboration on policies such as feed-in tariff and energy subsidy mechanisms.
- Counterpart coordination: grid extension and electrification planning.
- Energy utility formation: focused on community ownership, and private sector innovation, investment and system management.
- Community fund establishment: utility revenue for community empowerment, managed by community.
- Supporting productive uses of energy: irrigation for agriculture, income generating activities such as seed funding for small businesses.

Including communities in decision-making generally results in local buy-in regarding how resources should be provided and priced. One challenge for this approach is that a significant amount of time must be spent building trust within these local communities. Moving forward, greater documentation of 5P success stories could result in this new financing approach being more widely adopted.

5P success story: Cinta Mekar micro-hydro project

One project that exemplifies the strengths of the pro-poor public-private partnership approach is a micro-hydro project in Cinta Mekar, Indonesia. Forming the foundation of the United Nations Economic and Social Commission for Asia and the Pacific's (UNESCAP) 5P model, the hydroelectricity plant has been operating successfully since 2004.

Cinta Mekar, located about 150 km from Jakarta in West Java, is a rural community without access to the country's electricity grid. The village is home to several hundred families, of which approximately 100 did not have access to electricity before the project. Access to the main grid is costly and attracting private investment is difficult given the risk of operating a small capacity power plant and not recovering investment costs. Through UNESCAP, a 120 kilowatt micro-hydro project was started to provide electricity and economic development for the community.

The project is jointly owned by the community cooperative Koperasi Mekarsari and a private investor, Pt. Hidropiranti. Investment was shared three ways between the private operator Pt. Hidropiranti, a grant from UNESCAP and a non-governmental organization IBEKA. Key to the 5P approach is the community's involvement in ownership and also revenue sharing. In this project, revenues from electricity sales are split evenly between the community cooperative and the private investor. The villagers have, therefore, been able to invest the revenues back into the community to fund education, health care initiatives, infrastructure improvements and provide seed funding for residents to start small businesses.

The Cinta Mekar project was successful largely due to the community being a key stakeholder in the sustainable operation of the micro-hydro plant. Training was provided by the private investor to residents so they could operate and maintain the plant. In terms of governance, the community was a decision-maker in how the plant was being operated and resources were being utilized. The community's involvement provided an incentive structure to reduce energy and water waste since they were directly affected by its use or misuse.

Key lessons learned from the Cinta Mekar project are:

- To lead to economic development, rural electrification must be linked with enterprise development activities and access to financing
- Strong linkages must be made between the ground and policy levels for effective public-private partnership and electrification policy development. Lack of understanding at the district/provincial level can also impede progress
- Communication across ministries for energy planning and policy development is necessary to prevent overlap and ineffective field implementation activities

Transboundary Management of Water and Energy Resources

Hydro politics is about optimizing water resources globally in spite of national boundaries. For example, the creation of a hydroelectric dam upstream in the Nile basin or Mekong delta can have a dramatic effect on water users downstream. Countries thinking domestically do not always include these externalities if they exist outside national borders. The solution to this challenge may lie in basin management, in which countries work together to discuss their needs and interests for water and energy resources. Different options for basin management exist; in some instances, it can be easier to get consensus among countries first at the sub-basin level, and then work up to the basin level. These approaches build on concepts in commons governance on managing common pool resources using bottom-up approaches.

"Water basins do not respect national boundaries."

Another important consideration for transboundary water management is how embodied water is traded among countries. For example, countries may improve the sustainability of their domestic water resources by eliminating local production of water-intensive crops and importing them from overseas. Saudi Arabia has taken this approach by eliminating domestic production of wheat and alfalfa, opting to grow those crops in the United States, which are then transported to Saudi Arabia.Figure 3 shows a spatial representation of fresh water consumption for aggregate Chinese energy sectors.

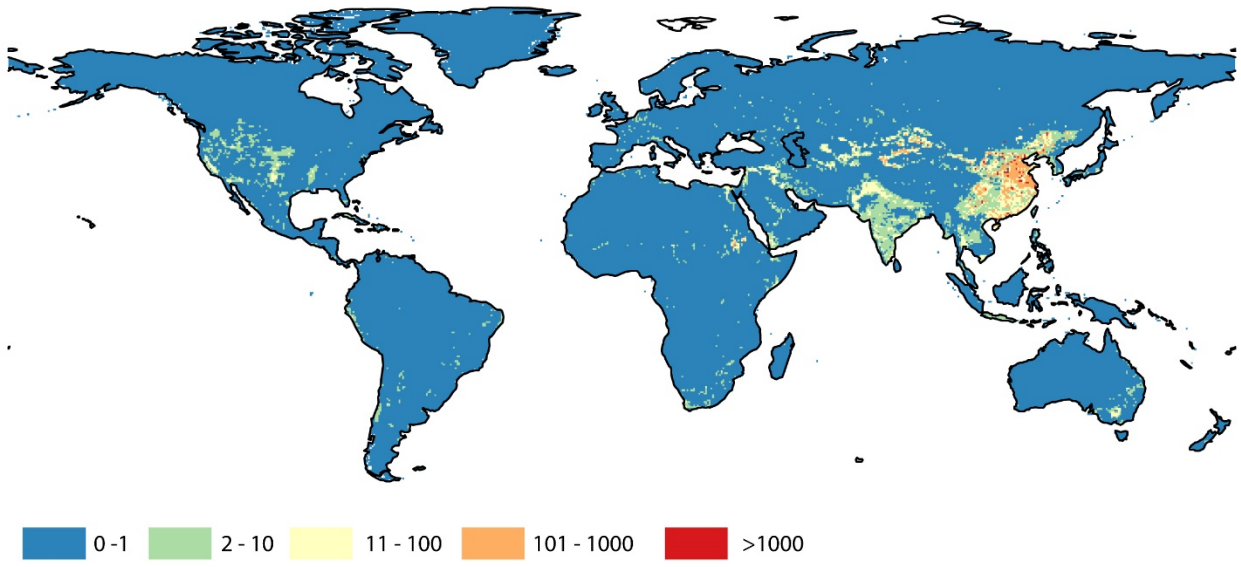

Figure 3. Spatial pattern of global fresh water consumption driven by freshwater demand from the petroleum, gas and electric sectors in China. Numbers represent total freshwater consumption within each 0.5 × 0.5 degree grid cell, standardized per unit area (m^3 yr^{-1} per km^2).

Source: Holland, 2015.

It is useful to analyze embodied water in a similar manner as embodied carbon. Water consumption of products in economic sectors can be accounted for at a country level. For example, researchers at the University of Southampton show the importance of understanding the context of where demand for energy is placing pressures on water resources. They found that by synthesizing trade data from the Global Trade Analysis Project (GTAP) with a hydrological model (WaterGAP), embodied water can be traced throughout the value chain of a country's energy sectors.

Most of the energy-related fresh water consumption is within China, but from the analysis it is also apparent that there is fresh water consumption in India, East Africa, the Middle East and the United States through the supply chain.

Coordinating Water-Energy-Food Policies in the Middle East and Asia

Choices made for the building of water and energy infrastructure assets can lock in usage patterns for 30 to 40 years. Thus, it is important to consider how consumption patterns of each resource will evolve over the long term before making large water and energy infrastructure investments. In both Asia and the Middle East, high growth prospects, rising incomes and changing demographic characteristics make predicting water and energy demand less certain than in other more developed parts of the world.

For example, future coal-fired power generation sites in China will not only take into account coal transportation and electricity transmission costs in the decision-making, but also the availability of water for cooling. Consequently, poor management of water resources could increase the cost of supplying power in the country. In the World Energy Outlook 2015, the International Energy Agency (IEA) considered the role of water in decisions on power station cooling technologies in relation to water resources.

In the New Policies Scenario, as shown in Figure 4, the IEA sees the balance for coal-fired power generation cooling technologies shifting from low-cost, water-intensive options to higher-cost, dry cooling options. Northern regions of China are highly water stressed, not only in remote desert regions in the Northwest, but in highly populated centers in the Northeast.

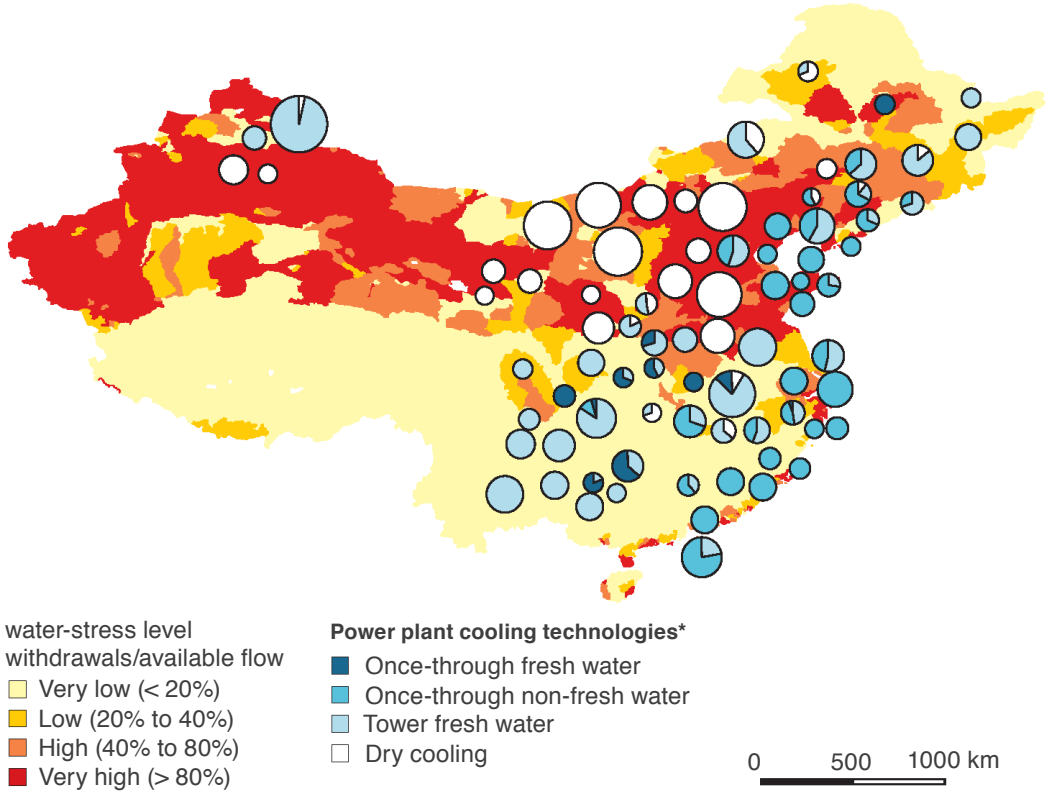

Figure 4. Installed coal-fired power generation capacity in China by cooling technology in the New Policies Scenario in 2040.

Source: OECD, 2015.

Decisions about cooling technology and power plant siting could change when considering the availability of water for cooling as a constraint. Thus, in this example the IEA sees a proliferation of large, dry cooled, coal-fired generation in the northern regions of China, with water-intensive cooling technologies in the south.

Finally, international organizations and national governments are increasingly incorporating the potential impact of climate change in their water and energy infrastructure planning and financing. The objective is to ensure that the infrastructure built is both climate change resilient and contributes only minimally to environmental degradation. One of the greatest challenges for policymakers is bridging the institutional divide among different interests, especially when considering the uncertainties surrounding water resources, efforts to conserve scarce resources and goals to meet climate change obligations.

A coordinated approach to managing water and the other resources is therefore almost mandatory in the face of such robust growth in the demand for water and electricity, coupled with stress on water resources due in part to climate change requirements. Institutions, such as government ministries, can coordinate better both horizontally and vertically within themselves by viewing policy development and assessment through the lens of a water-energy-food nexus.

About the Workshop

The workshop was hosted by KAPSAC in February 2016 in Singapore. It was conducted under the Chatham House rules of capturing discussion in a non-attribution basis. Some 23 international experts participated in the discussions, as follows:

I H.E. Dr. Majid Al-Moneef – Secretary General, Kingdom of Saudi Arabia Supreme Economic Council

H.E. Yaqoub Yousef Alsanad – Ambassador of Kuwait to Singapore

Asit Biswas – Distinguished Visiting Professor, Lee Kuan Yew School of Public Policy

Rejean Casaubon – Councilor, Institute of Energy Economics, Japan (IEEJ)

Carl Ganter – Managing Director, Circle of Blue

Robert Holland – Research Fellow, Center for Biological Sciences, University of Southampton

Shaofeng Jia – Vice Director, Center for Water Resources Research, Chinese Academy of Sciences

Dinesh Kumar – Executive Director, Institute for Resource Analysis and Policy (IRAP)

Thinesh Kumar – Institute of Water Policy

Rui Luo – Senior Consultant, International Finance Corporation (IFC)

Christopher Napoli – Research Fellow, KAPSARC

Omar Ouda – Assistant Professor, Prince Mohammad Bin Fahd University (PMU)

Pradeep Perera – Principle Energy Specialist, Asian Development Bank

Erick Ratajczak – Consultant, United Nations Economic and Social Commission (ESCAP)

Riaz Ahmed Sahi – Hydrogeologist, Almarai

Adnan Shihab-Eldin – Director General, Kuwait Foundation for the Advancement of Sciences (KFAS)

Cecilia Tortajada – Senior Research Fellow, National University of Singapore (NUS)

Hans Van der Beek – Agricultural Councillor to the GCC Countries, United Kingdom of Netherlands

Molly Walton – Energy Analyst, International Energy Agency (IEA)

Sarah Wheeler – Associate Professor, University of Adelaide

David Wogan – Research Associate, KAPSARC

Aaron Wolf – Professor of Geography, Oregon State University

Chunmiao Zheng – Professor, Peking University in Beijing

About the Team

Christopher Napoli

Christopher Napoli is a former research fellow focusing on natural resource economics and energy policy. He holds a PhD from the University of Kent, U.K.

Ben Wise

Ben Wise is a visiting Senior Research Fellow working on models of collective decision making in the Policy and Decision Sciences Program.

David Wogan

David Wogan is a research associate developing energy systems models. He holds master's degrees in mechanical engineering and public affairs from UT Austin, U.S.

Lama Yaseen

Lama Yaseen is a research analyst focusing on energy politics. She holds a BSc in Computer Science from Effat University in Jeddah, Saudi Arabia.

About the Project

The Energy and Water workshop series brings together experts from the private and public sectors, regulatory bodies, international institutions, academia, and think-tanks to explore the interlinkages in the water-energy-food nexus.

Specific attention is placed on how energy is used to meet water demand in both water scarce and water abundant countries. Other issues of importance include how water and energy are mobilized for food production and better policies for transboundrial governance of water and energy resources.

Notes

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