

**WORLD
ENERGY
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World Energy Perspectives | 2016

**THE ROAD TO RESILIENCE –
MANAGING THE RISKS OF THE
ENERGY-WATER-FOOD NEXUS**

IN PARTNERSHIP WITH MARSH & MCLENNAN COMPANIES
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INTRODUCTION

The United Nations has projected that there could be a 40% shortfall of water availability globally by 2030. Water is a daily necessity: for drinking, for growing and processing food, for hygiene and public health, and for the production of goods, and it is also required throughout the energy value chain.

The energy-water-food nexus is the term used to describe the interdependencies, and sometimes competing demands, between water usage and the production of energy and food – an issue that triggers economic and social challenges among numerous stakeholders.

The World Energy Council highlighted the relationship between water and energy in its 2010 Water for Energy report. Since then, technological advances such as ‘recirculating’ systems as opposed to ‘once-through’ systems, the adoption of dry cooling, improvements in desalination processes, and reusing water from oil extraction have been progressively deployed to reduce the water footprint of energy.

Technologies to make energy infrastructure more resilient to the risks posed by the energy-water-food nexus often increase the cost of development. Thus, increased resilience would add to the International Energy Agency’s estimate of US\$48–53 trillion in cumulative global investments needed in energy infrastructure by 2035. The scale of financing required is therefore significant and the private sector will have a crucial role in meeting this challenge.

KEY FINDINGS

- 1 ENERGY IS THE SECOND LARGEST FRESHWATER USER** after agriculture. Water is used all along the energy value chain in primary energy production (coal, oil, gas, biofuels) and in power generation (hydro, cooling). 98% of the power currently produced needs water.
- 2 THE RISKS POSED BY THE ENERGY-WATER-FOOD NEXUS WILL BECOME MORE SIGNIFICANT** because of growing demand for energy, water and food. Moreover, some of the regions that are currently water stressed are also likely to see significant economic development, population growth and changing consumption patterns, and a higher concentration of people and assets in critical areas, intensifying the risks posed by the nexus.
- 3 ALONGSIDE GROWING DEMAND, INCREASING UNCERTAINTY ABOUT WATER AVAILABILITY** and quality – driven by climate change impacts such as declining freshwater availability, increased ocean temperatures and more extreme weather – will further increase the significance of risks posed by the nexus.¹
- 4 ANALYSIS IN NATURE CLIMATE CHANGE²** highlights that from 2014 to 2069, reductions in usable water capacity could impact two-thirds of the 24,515 hydropower plants analysed and more than 80% of the 1,427 thermal electric power plants assessed.
- 5 IN MANY CASES, THERE IS A LACK OF LOCATION-SPECIFIC KNOWLEDGE ON WATER ISSUES** and a lack of modelling tools to adequately reflect risks posed by the nexus in energy infrastructure investment decisions. Such risks can be associated with large economic stakes: in 2015, hydropower facilities in Brazil sustained economic losses of more than US\$4.3 billion due to drought-related energy and water rationing measures.
- 6 THE RISKS POSED BY THE NEXUS ARE OFTEN EXACERBATED** by the lack of sound water governance such as well-defined water rights for competing users, water pricing and trading arrangements.
- 7 CROSS-BORDER COOPERATION IS A KEY ISSUE.** 261 international trans-boundary basins cover 45% of the earth's land surface, serve 40% of the world's population and provide 60% of the earth's entire freshwater volume. This affects the operation

1. Pachauri, R K, Allen, M R, Barros, V R et al, 2014: "Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

2. van Vliet, M T H, Wiberg, D, Leduc, S, and Riahi, K, 2016: "Power-generation system vulnerability and adaptation to changes in climate and water resources". Nature Climate Change.

of planned and proposed energy infrastructures, and there is a need to ensure that adequate cross-border water management frameworks are in place.

IMPLICATIONS FOR THE ENERGY SECTOR

Our recent report on extreme weather highlighted the systemic impact of weather risks that can cause disruptions in energy supply for days or weeks. The energy-water-food nexus poses an equally systemic risk, yet the disruptions from the nexus can impact the stability of energy supply and demand for years or decades.

To mitigate resource constraints, it will be necessary to further reduce the amount of water needed for energy production. Early analysis indicates that the overall water footprint of the energy sector could be lowered if more power or heat were produced by renewables such as wind, photovoltaics, or natural gas, as they show comparatively low water usage.³

Technical changes to existing infrastructures can also help to mitigate nexus risks. Case studies highlighted the utility of decoupling cooling systems from freshwater resources by using salt water or dry cooling, developing better use of wastewater, and integrating renewables in desalination and irrigation. Still, defining which technology is the best available solution requires using methodologies on a case-by-case basis, which take into account the unique geographical and social sensitivities of a given region.

Methodologies that integrate water availability into design must also balance concerns regarding energy security, affordability and environmental sustainability. Some of the technologies highlighted as part of the low-carbon transition, such as biofuels or carbon capture and storage, which nearly doubles the water requirements of a coal power plant,⁴ may in fact increase water stress.

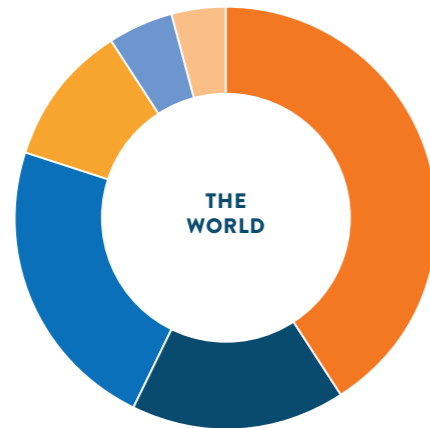
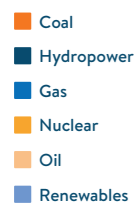
3. International Energy Agency, 2012: “Water for Energy”.

4. Byers, E, Hall, J W, and Amezcaga, J M, 2014: “Electricity generation and cooling water use: UK pathways to 2050”. *Global Environmental Change*, 25, 16–30, doi:10.1016/j.gloenvcha.2014.01.005.

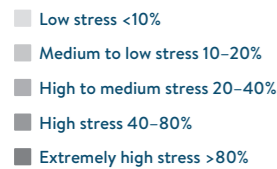
ENERGY TECHNOLOGIES AND WATER STRESS: A WORLD OF INCREASING RISKS

Water is used all along the energy value chain in primary energy production (coal, oil, gas, biofuels) and in power generation (hydro, cooling) and 98% of the power currently produced needs water.

ENERGY RESOURCES IN ELECTRICITY GENERATION



WATER STRESS



ALGERIA, 2015–2016

Water-strained Algeria is unable to access its domestic shale gas reserves – the largest in the world – due to the arid desert landscape where 95% of the nation's shale plays are located, as well as strong social opposition based on real or perceived threats to agricultural water needs.

CANADA, AUGUST 2015

Regulators suspended a number of licenses for oil and gas operators withdrawing water from the Upper Athabasca River in the context of a dry regional climate and diminished river flows. Researchers anticipate that withdrawal disruptions caused by low water levels will rise by up to 40% by 2040, leading to a 22% increase in interruptions to oil sands operations overall.

EGYPT, 2015

Egypt's Intended Nationally Determined Contribution calls for adaptation measures to respond to the impacts of climate change on its electricity sector, including the impacts on hydropower plants of changes in rainfall rates and rain distribution across different regions.

CHINA, MAY 2011

The Yangtze River was affected by its worst drought in 50 years due to a lack of rainfall and downstream impacts from large-scale water diversion projects. The water shortages affected 4.4 million people with its impact on agriculture, drinking supply, transportation, and hydropower utilisation, which dropped by 55% in Hunan province in the month of April alone.

IRAQ, 2014

A lack of reliable water supply to oil fields in the south of Iraq has significantly hampered capacity growth at some of the nation's most significant fields, in part due to disputes over the implementation of a multi-billion dollar common seawater injection scheme. One major plant, West Qurna-1, reported that output had fallen almost 40% between 2013 and 2014 and named water shortages as one of the reasons.

MALAYSIA, 2014

The state of Selangor suffered a severe water crisis caused by hot, dry weather combined with infrastructural problems and political deadlock between the state government and water companies, resulting in water rationing for millions of households and industries, leading to multi-million ringgit economic losses.

PAKISTAN, 2015

The Indus River Basin, which accounts for more than 95% of Pakistan's irrigation and the majority of its food production, is facing increased water stress due to the impacts of climate change on glacial flows. At the same time the country is looking to increase energy supply by tapping into the area's hydroelectric potential, estimated at around 50,000 MW.

PERU, 2008

Ongoing disputes over water rights and pollution in the Rio Santa watershed escalated as local farmers blockaded the Laguna Parón, angry that the upstream hydroelectric plant was failing to allow lake water releases fit for irrigation. Water scarcity is expected to continue due to the recession of Peru's tropical glaciers, which have lost over 22% of their combined surface area since the early 1980s.

POLAND, 2015

Efforts to establish energy security through large-scale shale gas exploitation to tap an estimated 187 trillion cubic feet of favorable shale gas resources were put on hold due to disappointing test results, as well as regulatory uncertainty and social resistance that alleged environmental damage, including water supply contamination.

RWANDA, 2015

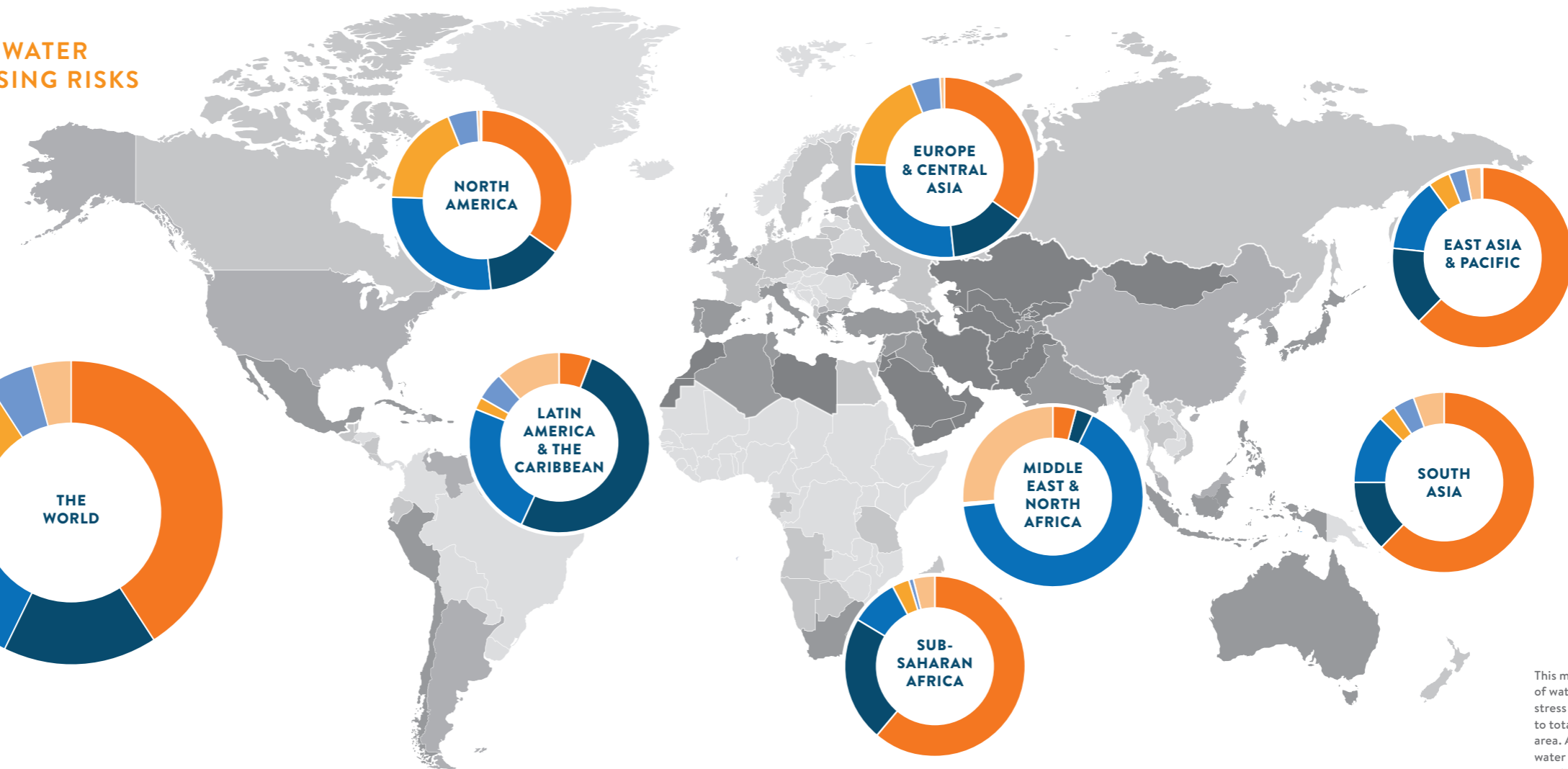
Competing demands of agriculture, industry, and household use in a region of long-standing water stress had led to an annual water short-fall of some 330 cubic meters for Rwanda. A 66 billion Rwandan franc initiative will include a water allocation framework and key strategies including rain harvesting, ground water recharge, and multi-purpose dams that can be used for hydroelectricity, irrigation, and domestic water supply.

SAUDI ARABIA, 2008

After decades of tapping underground water resources for irrigation in a bid to achieve grain self-sufficiency, Saudi Arabia had to abandon the plan in light of rapidly depleting water supplies along with the persistent energy intensity of desalination. Between 2007 and 2010, Saudi Arabia's wheat production declined by more than two-thirds.

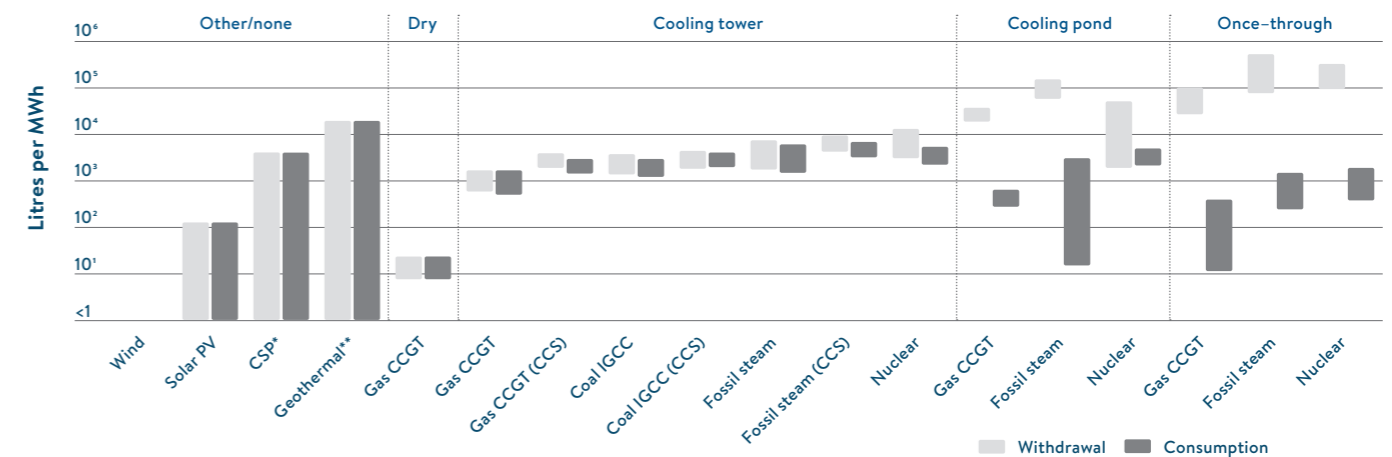
SOUTH AFRICA, 2015

Water scarcity threatens the viability of South African coal production given the water-intensiveness of coal technologies which is used to generate around 90% of its domestic electricity supply. Mitigation efforts to address the effects of acidic water leaking from abandoned mines into surrounding water ecosystems have cost 30 billion rand.



This map shows the average exposure of water users in each country to water stress and the ratio of total withdrawals to total renewable supply in a given area. A higher percentage means more water users are competing for limited supplies.

WATER USE BY ELECTRICITY GENERATION TECHNOLOGY



SYRIA, 2008–2011

Severe water shortages caused by drought and mismanagement helped to cause the displacement of an estimated 1.5 million people. This coincided with rising fuel prices, which tripled overnight in response to fuel subsidy cuts in 2008, and consequently put a strain on food prices. All of this contributed to the nation's social unrest in the build-up to civil war.

UNITED KINGDOM, JUNE 2015

Controversy around the introduction of hydraulic fracturing and concerns around the impact on water supplies, public health, and the natural environment, led to the rejection of a fracking exercise by Lancashire county council and the planned exploitation of an estimated £140 billion of shale gas reserves.

UNITED STATES, 2007–2008

Rising US biofuel production under incentives set by the EPA's renewable fuel standards and the diversion of corn supplies to ethanol were indicated as a key cause of a 38% rise in US food prices from 2007–2008.

UNITED STATES, 2014

The state of New York banned hydraulic fracturing in the face of social opposition and potential concerns over water contamination, along with various health complaints.

Withdrawal is the volume of water removed from a source; consumption is the volume of water withdrawn that is not returned to the source, i.e. it is evaporated or transported to another location.

*Includes trough, tower and Fresnel technologies using tower, dry and hybrid cooling, and Stirling technology.

**Includes binary, flash and enhanced geothermal system technologies using tower, dry and hybrid cooling.

Sources:

Energy resources in electricity generation source: World Bank 2012.

Water stress source: WRI Aqueduct, Gassert et al, 2013. Water use by electricity generation technology source: IEA World Energy Outlook 2012, page 510 (figure 17.4), IEA Paris.

RECOMMENDATIONS

To make energy infrastructure more resilient, policymakers, businesses and governments should carefully analyse the conditions needed to ensure investor and public confidence in projects. To do this, the report recommends the following actions:

1. **Project developers need to be able to better understand the water footprint of energy technology choices** being considered in order to mitigate the risks of potential stranded assets.
2. **Risk assessments should reflect a comprehensive understanding of long-term systemic risks** by incorporating different climate and hydrological scenarios in financial analyses. This shows investors that environmental and social considerations have been accounted for in the design of energy infrastructure.
3. **Water scarcity has to be taken into account and, where possible, priced appropriately** to establish an accurate risk profile that reflects the local context. If no market price can be used, companies can use a shadow water price. Water management and pricing policies must be defined locally to ensure that other policy objectives, such as equity considerations, are also met.
4. **Transparent and predictable regulatory and legal frameworks are needed** to promote efficient solutions that balance the interests of competing users and provide certainty to investors. Governments must improve water resource monitoring and implement sound water governance in order to facilitate planning of resilient energy infrastructure by reducing the risk of unforeseen policy or regulatory changes regarding water usage in the future. This requires managing water resources over entire river basins and stakeholders to address water rights across sectors and jurisdictions.
5. **Measures to minimise finance cost and stabilising returns can be taken** to reduce lingering risk. The financial services and insurance industries offer financial instruments to address adverse weather impacts, weather-related volume exposures and electricity price volatility combined with unplanned power outages. These products are not yet used across the whole industry but could hedge impacts from risks such as water scarcity. They can help stabilise income volatility and reduce risks for investors.

ABOUT THIS REPORT

The road to resilience – managing the risks of the energy-water-food nexus is the second risk dimension investigated as part of the Financing Resilient Energy Infrastructure initiative. The first report in the series, *The road to resilience: managing and financing extreme weather risk*, recommended moving towards a more systemic understanding of resilience, in order to best manage extreme weather risks. This report investigates the risks of the energy-water-food nexus and examines the integrated coordination that is needed for financing resilience. The report methodology is based on contribu-

tions from experts in 92 countries. Case studies have been submitted from the energy, insurance, financial and academic communities to highlight the impact, obstacles and solutions that countries have taken to manage the impacts of the energy-water-food nexus. The case study contributions and final considerations of the nexus will be published later in 2016.

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