UN WATER

Report

WATER AND ENERGY

EXECUTIVE SUMMARY

WWDR 2014

The United Nations World Water Development Report 2014

United Nations Educational, Scientific and Cultural Organization
World Water Assessment Programme
UN WATER


Eight messages about water and energy
Main Messages from the United Nations World Water Development Report 2014

1. Demand for energy and freshwater will increase significantly in the coming decades. This increase will present big challenges and strain resources in nearly all regions, especially in developing and emerging economies.

2. Water and energy supply and provision are interdependent. Choices made in one domain impact the other, for better or for worse.

3. Policy-makers, planners and practitioners can take steps to overcome the barriers that exist between their respective domains. Innovative and pragmatic national policies can lead to more efficient and cost-effective provision of water and energy services.

4. The price of energy and water services can better reflect the cost of their provision and socio-environmental impacts without undermining the basic needs of the poor and the disadvantaged.

5. The private sector can play a greater role in water and energy infrastructure investment, maintenance and operation.

6. Private sector involvement and governmental support for research and development are crucial for developing alternative, renewable and less water intensive energy sources.

7. Water and energy are both at the heart of sustainable development and need to be recognized as such.

8. Decisions about water and energy sharing, allocation, production and distribution have important social and gender equality implications. Water and energy governance needs to be gender-sensitive.

Water and energy are tightly interlinked and highly interdependent. Choices made in one domain have direct and indirect consequences on the other, positive or negative. The form of energy production being pursued determines the amount of water required to produce that energy. At the same time, the availability and allocation of freshwater resources determine how much (or how little) water can be secured for energy production. Decisions made for water use and management and for energy production can have significant, multifaceted and broad-reaching impacts on each other – and these impacts often carry a mix of both positive and negative repercussions.

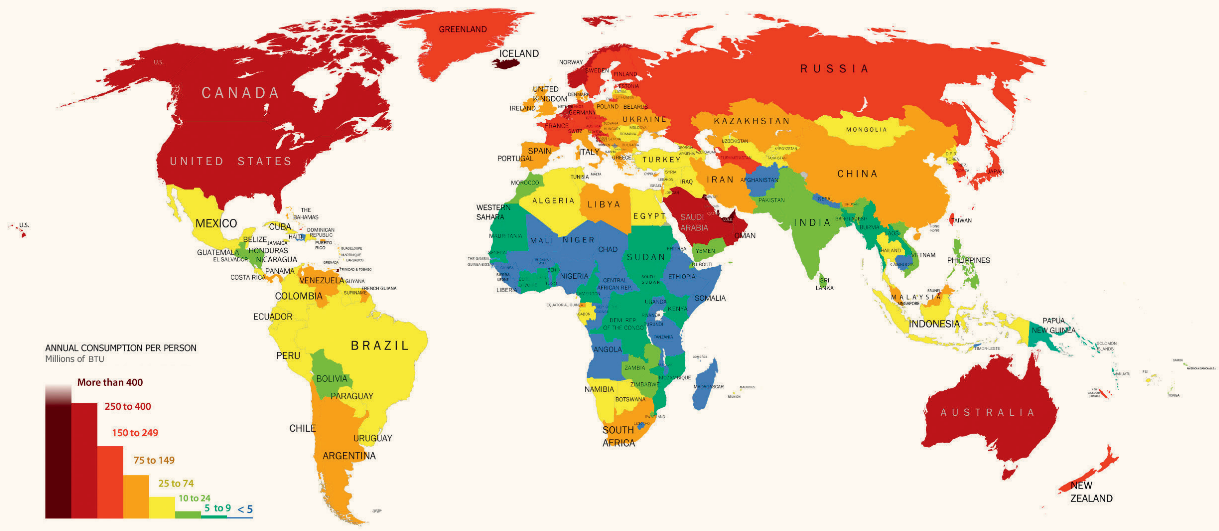
The challenge today: *Extending services to the unserved*

Freshwater and energy are crucial for human well-being and sustainable socio-economic development. Their essential roles in achieving progress under every category of development goal are now widely recognized. Major regional and global crises – of climate, poverty, hunger, health and finance – that threaten the livelihood of many, especially the three billion people living on less than US$2.50 per day, are interconnected through water and energy.

Worldwide, an estimated 768 million people remain without access to an improved source of water – although by some estimates, the number of people whose right to water is not satisfied could be as high as 3.5 billion – and 2.5 billion remain without access to improved sanitation. More than 1.3 billion people still lack access to electricity, and roughly 2.6 billion use solid fuels (mainly biomass) for cooking. The fact that these figures are often representative of the same people is evidenced by a close association between respiratory diseases caused by indoor air pollution, and diarrhoea and related waterborne diseases caused by a lack of safe drinking water and sanitation.

FIGURE 1

Energy consumption per capita by country, 2010



Note: BTU, British Thermal Unit. One million BTU approximately equals the energy derived from 30 litres of petrol.
Source: Burn: An Energy Journal (http://burnanenergyjournal.com/wp-content/uploads/2013/03/WorldMap_EnergyConsumptionPerCapita2010_v4_BargraphKey.jpg, from sources cited therein) (Accessed Oct 2013). Produced by Anrica Deb for SoundVision Productions®, used with permission.

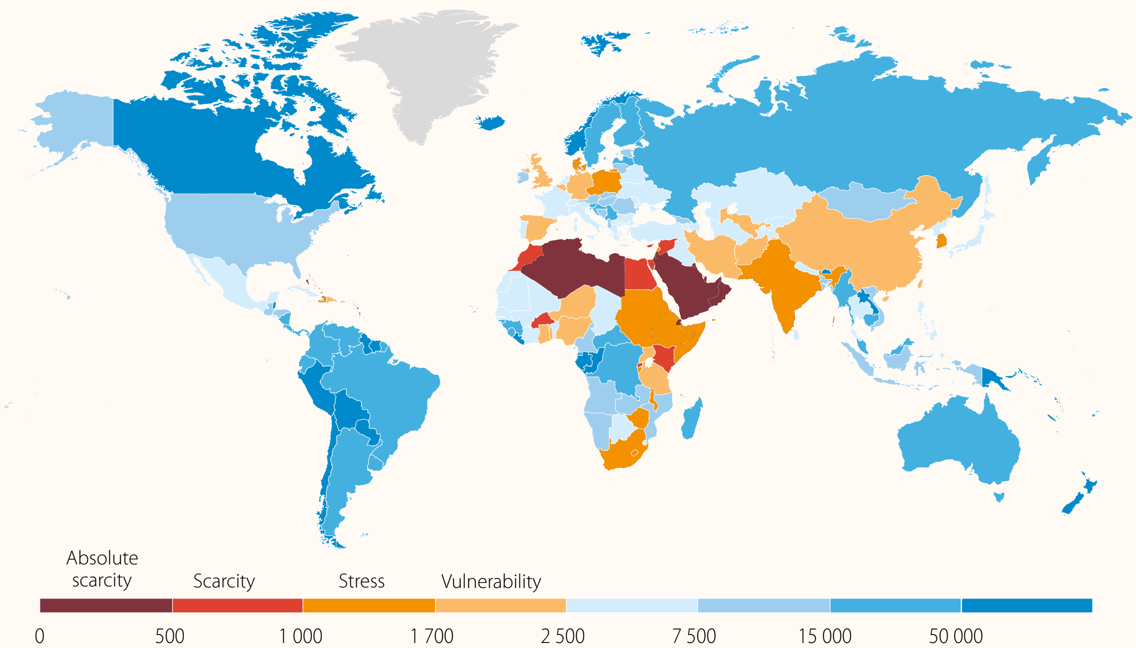
The challenge to come: *Meeting growing demands*

Demands for freshwater and energy will continue to increase significantly over the coming decades to meet the needs of growing populations and economies, changing lifestyles and evolving consumption patterns, greatly amplifying existing pressures on limited natural resources and on ecosystems. The resulting challenges will be most acute in countries undergoing accelerated transformation and rapid economic growth, or those in which a large segment of the population lacks access to modern services.

Global water demand (in terms of water withdrawals) is projected to increase by some 55% by 2050, mainly because of growing demands from manufacturing (400%), thermal electricity generation (140%) and domestic use (130%). As a result, freshwater availability will be increasingly strained over this time period, and more than 40% of the global population is projected to be living in areas of severe water stress through 2050. There is

FIGURE 2

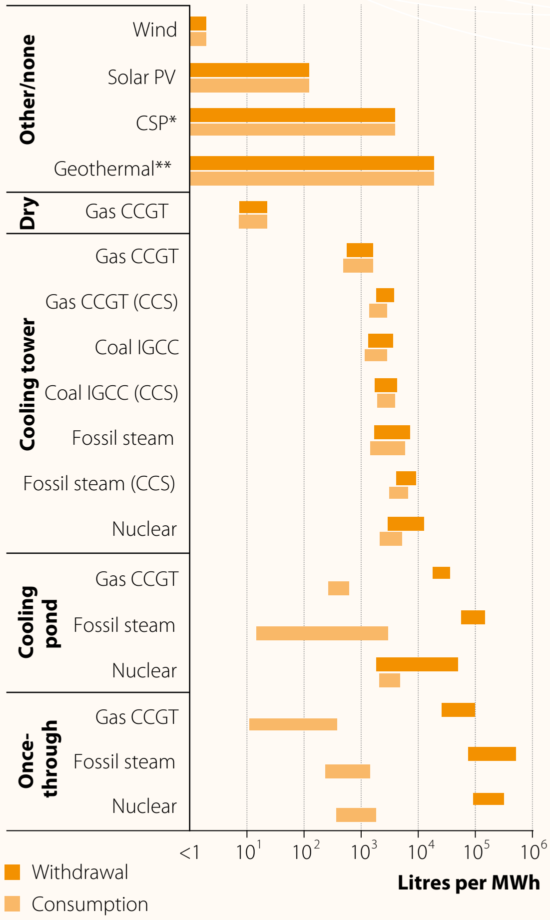
Total renewable water resources, 2011 (m^3 per capita per year)



Source: WWAP, prepared with data from FAO AQUASTAT (aggregate data for all countries except Andorra and Serbia, external data) (website accessed Oct 2013), and using UN-Water category thresholds.

FIGURE 3

Water use for electricity generation by cooling technology



** 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.*

Notes: Ranges shown are for the operational phase of electricity generation, which includes cleaning, cooling and other process related needs; water used for the production of input fuels is excluded. Fossil steam includes coal-, gas- and oil-fired power plants operating on a steam cycle. Reported data from power plant operations are used for fossil-steam once-through cooling; other ranges are based on estimates summarized in the sources cited. Solar PV, solar photovoltaic; CSP, concentrating solar power; CCGT, combined-cycle gas turbine; IGCC, integrated gasification combined-cycle; CCS, carbon capture and storage. For numeric ranges, see http://www.worldenergyoutlook.org.

Source: IEA (2012, fig. 17.4, p. 510, from sources cited therein). World Energy Outlook 2012 © OECD/IEA.

IEA (International Energy Agency). 2012. World Energy Outlook 2012. Paris, OECD/IEA.

clear evidence that groundwater supplies are diminishing, with an estimated 20% of the world's aquifers being over-exploited, some critically so. Deterioration of wetlands worldwide is reducing the capacity of ecosystems to purify water.

Global energy demand is expected to grow by more than one-third over the period to 2035, with China, India and the Middle Eastern countries accounting for about 60% of the increase. Electricity demand is expected to grow by approximately 70% by 2035. This growth will be almost entirely in non-Organisation for Economic Co-operation and Development countries, with India and China accounting for more than half that growth.

What rising energy demand means for water

Energy comes in different forms and can be produced in several ways, each having a distinct requirement for – and impact on – water resources. Thus, as a country's or region's energy mix evolves, from fossil fuels to renewables for example, so too do the implications on water and its supporting ecosystem services evolve. Approximately 90% of global power generation is water intensive.

The International Energy Agency estimated global water withdrawals for energy production in 2010 at 583 billion m^3 (representing some 15% of the world's total withdrawals), of which 66 billion m^3 was consumed. By 2035, withdrawals could increase by 20% and consumption by 85%, driven via a shift towards higher efficiency power plants with more advanced cooling systems (that reduce water withdrawals but increase consumption) and increased production of biofuel. Local and regional impacts of biofuels could be substantial, as their production is among the most water intensive types of fuel production.

Despite ongoing progress in the development of renewables, the overall evolution of the global energy mix appears to remain on a relatively fixed path: that of continued reliance on fossil fuels. Oil and gas extraction yields high volumes of 'produced water', which comes out of the well along with the oil and gas. Produced water is usually very difficult and expensive to treat. Unconventional oil and gas production is generally more water intensive than conventional oil and gas production.

Thermal power plants are responsible for roughly 80% of global electricity production, and as a sector they are a large user of water. Power plant cooling is responsible for 43% of total freshwater withdrawals in Europe (more than 50% in several countries), nearly 50% in the United States of America, and more than 10% of the national water cap in China.

Similarities, differences and divergences: *Beyond the water–energy nexus*

The decisions that determine how water resources are used (or abused) stem from broader policy circles concerned primarily with industrial and economic development, public health, investment and financing, food security and, most relevant to this report, energy security. The challenge for twenty-first century governance is to embrace the multiple aspects, roles and benefits of water, and to place water at the heart of decision-making in all water-dependent sectors, including energy.

Energy is big business compared to water and can command a great many more resources of all kinds. Market forces have tended to play a much more important role in energy sector development compared with the management of water resources and the improvement of water-related services (water supply and sanitation), which have historically been more of a public health and welfare issue. Water resources have been considered by some to be a *public good* (though the economic definition of 'public good' does not apply to freshwater) – with access to safe water and sanitation recognized as a *human right*. Neither concept ordinarily applies to energy. Reflecting this economic, commercial and social disparity, energy attracts greater political attention than water in most countries.

Growing demand for limited water supplies places increasing pressure on water intensive energy producers to seek alternative approaches, especially in areas where energy is competing with other major water users (agriculture, manufacturing, drinking water and sanitation services for cities) and where water uses may be restricted to maintain healthy ecosystems. Uncertainties related to the growth and evolution of global energy production, for example via growth in unconventional sources of gas and oil or in biofuels, can pose significant risks to water resources and other users. Policies that benefit one domain can translate to increased risks and detrimental effects in another, but they can also generate co-benefits. The need to manage trade-offs and maximize co-benefits across multiple sectors has become an urgent and a critical issue.

Water planners and decision-makers involved in assessing the water needs of the energy sector require a suitable level of knowledge about electricity generation and fuel extraction technologies and their potential impact on the resource. Energy planners and investors must take into account the complexities of the hydrological cycle and competing water uses when assessing plans and investments.

Thematic challenges and responses

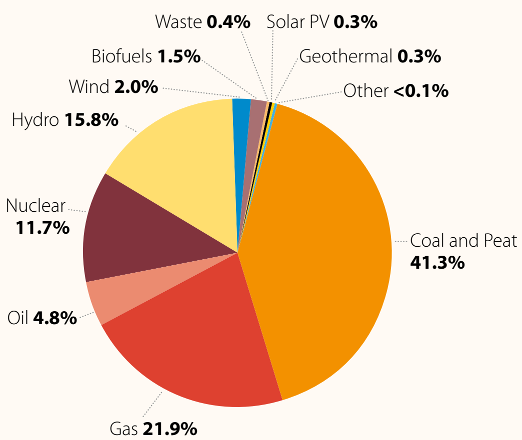
There are many opportunities for the joint development and management of *water and energy infrastructure and technologies* that maximize co-benefits and minimize negative trade-offs. An array of opportunities exists to co-produce energy and water services and to exploit the benefits of synergies, such as combined power and desalination plants, combined heat and power plants, using alternative water sources for thermal power plant cooling, and even energy recovery from sewerage water. Besides the pursuit of new technical solutions, new political and economic frameworks need to be designed to promote cooperation and integrated planning among sectors. Innovative approaches to spending efficiency, such as cross-sector cooperation to leverage possible synergies, integrated planning for water and energy to decrease costs and ensure sustainability, assessing trade-offs at the national level, demand-side interventions, and decentralized services, can help overcome the infrastructure financing gap which, although significant for energy, is far greater for water.

In the context of *thermal power generation*, there is an increasing potential for serious conflict between power, other water users and environmental considerations. Trade-offs can sometimes be reduced by technological advances, but these advances may carry trade-offs of their own. From a water perspective, solar photovoltaic and wind are clearly the most sustainable sources for power generation. However, in most cases, the intermittent service provided by solar photovoltaic and wind needs to be compensated for by other sources of power which, with the exception of geothermal, *do* require water to maintain load balances. Support for the development of renewable energy, which remains far below that for fossil fuels, will need to increase dramatically before it makes a significant change in the global energy mix, and by association, in water demand. Use of geothermal energy for power generation is underdeveloped and its potential is greatly underappreciated. It is climate independent, produces minimal or near-zero greenhouse gas emissions, does not consume water, and its availability is infinite at human time scales.

Agriculture is currently the largest user of water at the global level, accounting for some 70% of total withdrawals. The food production and supply chain accounts for about one-third of total global energy consumption. The demand for agricultural feedstocks for biofuels is the largest source of new demand for agricultural production in decades, and was a driving factor behind the 2007–2008 spike in world commodity prices. As biofuels also require water for their processing stages, the water requirements of biofuels produced from irrigated crops can be much larger than for fossil fuels. Energy subsidies allowing farmers to pump aquifers at unsustainable rates of extraction have led to the depletion of groundwater reserves. Applying energy efficiency measures at the farm and at all subsequent stages along the agrifood chain can bring direct savings, through technological and behavioural changes, or indirect savings, through co-benefits derived from the adoption of

FIGURE 4

World electricity generation by source of energy as a percentage of world electricity generation, 2011



Note: PV, solar photovoltaic.
Source: WWAP, from data in IEA (2013).

IEA (International Energy Agency). 2013. Statistics search. Web page. Paris, OECD/IEA. http://www.iea.org/statistics/statisticssearch agro-ecological farming practices. Knowledge-based precision irrigation can provide flexible, reliable and efficient water application, which can be complemented by deficit irrigation and wastewater reuse.

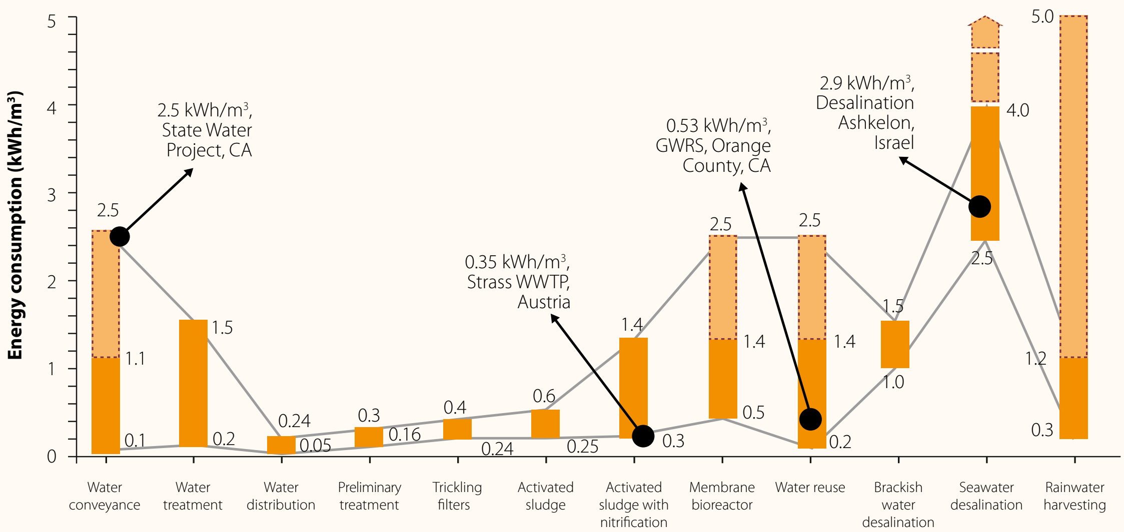
Many *rapidly growing cities* in developing countries already face problems related to water and energy and have limited capacity to respond. As energy cost is usually the greatest expenditure for water and wastewater utilities, audits to identify and reduce water and energy losses and enhance efficiency can result in substantial energy and financial savings. The future water and energy consumption of a new or an expanding city can be reduced during the early stages of urban planning through the development of compact settlements and investment in systems for integrated urban water management. Such systems and practices include the conservation of water sources, the use of multiple water sources – including rainwater harvesting, stormwater management and wastewater reuse – and the treatment of water to the quality needed for its use rather than treating all water to a potable standard. The chemically bound energy in wastewater can be used for domestic cooking and heating, as fuel for vehicles and power plants, or for operating the treatment plant itself. This biogas replaces fossil fuels, reduces the amount of sludge to be disposed of and achieves financial savings for the plant.

Industry seeks both water and energy efficiency though the two are not always compatible, and though a programme of water and energy efficiency can diverge from industry's primary focus: to secure water and energy at the lowest prices. Individually and together water and energy efficiency involve varied trade-offs, which frequently involve short-term cost increases against long-term savings, the balance between water and energy use, and a compromise with other factors such as labour, transportation, raw material costs and market location. Large companies and multinationals, particularly in the food and beverage sector, have been engaged for some time in improving water and energy efficiencies. Such companies see the value of efficiencies in both monetary and societal terms. Small and medium-sized enterprises (with 20 or fewer employees) comprise more than 70% of enterprises in most economies, and although as a group they have the potential for making a significant impact on water and energy efficiencies, they have fewer resources and are commonly in need of equity capital to do so.

The availability of adequate quantities of water, of sufficient quality, depends on *healthy ecosystems* and can be considered an ecosystem service. The maintenance of environmental flows enables this and other ecosystem services that are fundamental to sustainable economic growth and human well-being. Ecosystem services

FIGURE 5

Typical energy footprint of the major steps in water cycle management with examples from different treatment plants using specific technologies



Source: Lazarova et al. (2012, fig. 23.1, p. 316, adapted from sources cited therein). © IWA Publishing, reproduced with permission.

Lazarova, V., Choo, K. and Cornel, P. (eds). 2012. Water-Energy Interactions in Water Reuse. London, IWA Publishing.

are being compromised worldwide, and energy production is one of the drivers of this process. Natural or green infrastructure can complement, augment or replace the services provided by traditional engineered infrastructure, creating additional benefits in terms of cost-effectiveness, risk management and sustainable development overall. The economic value of ecosystems for downstream water users is formally recognized and monetized in payments for environmental services schemes, in which downstream users provide farmers with payments or green water credits for good management practices that support and regulate ecosystem services, thereby conserving water and preserving its availability and quality.

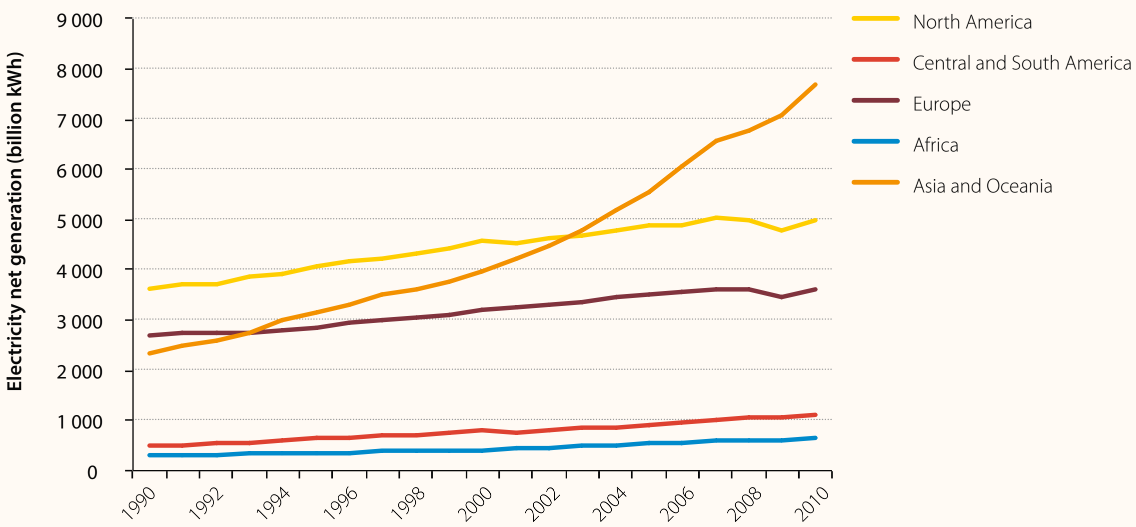
Regional priorities

The expansion of hydropower as a key source of renewable energy is a critical issue across nearly all of the world's regions due to concerns of growing conflicts between various interests over limited water resources.

In *Europe and North America*, water scarcity, hydrological variability and the impacts of climate change on water availability and energy production are increasingly recognized as critical – and related – issues. Targets set to increase the share of renewable energies have led to renewed interest in developing pumped storage while part of the region – notably Central Asia and South-Eastern Europe – are still developing new hydropower capacity, not always compatibly with other water uses. Uncertainties persist over the potential

FIGURE 6

Recent trends in electricity production for world regions including Africa



Source: UNECA, with data from US Energy Information Administration 'International Energy Statistics' Web page (http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm) (Accessed Sep 2013).

risks to water quality, human health and long-term environmental sustainability from the development of unconventional sources of gas ('fracking') and oil ('tar sands'), both of which require large quantities of water.

With its demand for energy increasing exponentially, the *Asia-Pacific* region faces major supply challenges. Coal, the most prevalent energy product within the region, will continue to be the main source of energy, despite serious concerns about water quality degradation as an effect of coal mining and the water quantity required for cooling thermal power plants. The potential for Asia to develop into a significant market for and exporter of biofuels is being increasingly recognized, and there is a hope that it will provide new employment opportunities in several developing nations.

In the *Arab region*, the low to middle income countries are struggling to meet growing demands for water and energy services. Limited understanding of the interdependencies affecting the management of water and energy resources has stymied coordination between water and energy policy-makers, and limited coordination between the water, energy, electricity and agriculture sectors has led to conflicting policies and development objectives. Solar-driven desalination and energy recovery from wastewater are two promising technologies particularly well suited to the region.

In *Latin America and the Caribbean*, there is an increasing interest in biofuels and in how more water efficient (and more energy intensive) irrigation methods and electricity subsidies to farmers impact on aquifer sustainability. The vast majority of water utilities in the region are struggling to attain self-financing and, as energy is often the greatest component (30–40%) of operational costs, increasing energy costs have direct implications for service affordability and for sector financing.

The majority of the rural population in *sub-Saharan Africa* relies on traditional energy supplies, mainly unprocessed biomass, the burning of which causes significant pollution and health concerns. It is the only region in the world where the absolute number of people without access to electricity is increasing. As Africa has not yet tapped in to its rich potential for hydropower development to a substantial degree, it has the opportunity of learning from the positive as well as the negative aspects of hydropower implementation practices that other nations have undergone.

Enabling environments

Recognition of the interconnectedness between water and energy has led some observers to call for a greater level of integration of the two domains. Although this may be possible and beneficial under certain circumstances, an increased level of collaboration and coordination would create favourable outcomes in

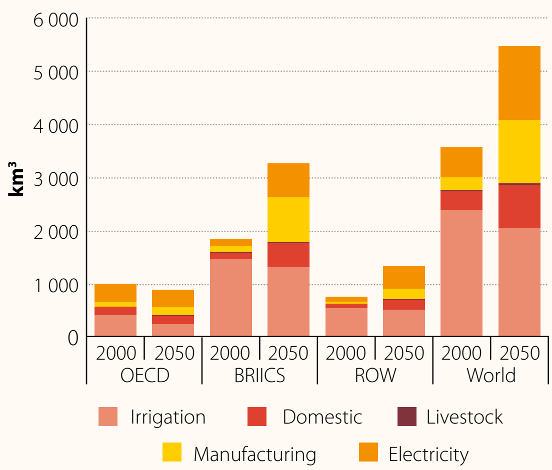
nearly all situations. Effective collaboration does not necessarily require that responsibilities for water and energy are combined into the same institutional portfolio, nor does doing so assure coherent cooperation. Water and energy practitioners need to engage with and fully understand one another. Both domains have been traditionally expected to focus on a narrow mandate in meeting their own aims and fulfilling their own targeted responsibilities. There is often little or no incentive to initiate and pursue coordination or integration of policies across sectoral institutions. Policy-makers, planners and practitioners in water and energy need to take steps to identify and overcome the barriers that exist between their domains.

The most common responses to the dilemmas, risks and opportunities presented in this fifth edition of the United Nations *World Water Development Report* are related to improving the efficiency and sustainability with which water and energy are used and finding win–win options that create savings of both, which can become mutually reinforcing (creating synergy). But not every situation offers such opportunities. There are situations in which competition for resources can arise or there is genuine conflict between water and energy aims, meaning some degree of trade-off will be necessary. Dealing with trade-offs may require and benefit from negotiation, especially where international issues are involved. Where competition between different resource domains is likely to increase, the requirement to make deliberate trade-offs arises and these trade-offs will need to be managed and contained, preferably through collaboration and in a coordinated manner. To do this, better (and sometimes new) data are required.

The incentives to increase efficiency facing the two domains are asymmetrical: energy users have little or no incentive to conserve water due to zero or low prices, but water users normally do pay for energy, even though prices may be subsidized. Water and energy prices are strongly affected by political decisions and subsidies that support major sectors such as agriculture and industry, and these subsidies often distort the true economic relationship between water and energy. Particularly for water, price is rarely a true reflection of cost – it is often even less than the cost of supply.

FIGURE 7

Global water demand (freshwater withdrawals): Baseline Scenario, 2000 and 2050



Note: BRIICS, Brazil, Russia, India, Indonesia, China, South Africa; OECD, Organisation for Economic Co-operation and Development; ROW, rest of the world. This graph only measures 'blue water' demand and does not consider rainfed agriculture.
Source: OECD (2012, fig. 5.4, p. 217, output from IMAGE). OECD Environmental Outlook to 2050 © OECD.

OECD (Organisation for Economic Co-operation and Development). 2012. OECD Environmental Outlook to 2050: The Consequences of Inaction. Paris, OECD. http://dx.doi.org/10.1787/9789264122246-en

A coherent policy – which is to say an adequate public response to the interconnectedness of the water, energy and related domains – requires a hierarchy of actions. These include:

- Developing coherent national policies affecting the different domains
- Creating legal and institutional frameworks to promote this coherence
- Ensuring reliable data and statistics to make and monitor decisions
- Encouraging awareness through education, training and public information media
- Supporting innovation and research into technological development
- Ensuring availability of finance
- Allowing markets and businesses to develop

Together these actions make up the *enabling environment* necessary to bring about the changes needed for the sustainable and mutually compatible development of water and energy. The international community can bring actors together and catalyse support for national, subnational and local governments as well as utility providers, who have a major role in how the water–energy nexus plays out at the national and local levels.

The different political economies of water and energy should be recognized, as these affect the scope, speed and direction of change in each domain. While energy generally carries great political clout, water most often does not. Partly as a result, there is a marked difference in the pace of change in the domains; a pace which is driven also by the evolution of markets and technologies. Unless those responsible for water step up their own governance reform efforts, the pressures emanating from developments in the energy sphere will become increasingly restrictive and make the tasks facing water planners, and the objective of a secure water future, much more difficult to achieve. And failures in water can lead directly to failures in energy and other sectors critical for development.

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