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Putting Water and Energy at the Heart of Sustainable Development

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The United Nations University Institute for Water, Environment and Health is a member of the United Nations University family of organizations. It is the UN Think Tank on Water created by the UNU Governing Council in 1996. The mission of the institute is to help resolve pressing water challenges that are of concern to the United Nations, its Member States, and their people, through knowledge-based synthesis of existing bodies of scientific discovery; through cutting edge targeted research that identifies emerging policy issues; through application of on-theground scalable solutions based on credible research; and, through relevant and targeted public outreach. It is hosted by the Government of Canada and McMaster University.

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Summary for Decision Makers

Water for energy; energy for water — as independent sectors and through their inextricable linkages, water and energy are key drivers of economic growth and social development. Benefits include poverty reduction, improvements in health and education, and a reduction in inequalities. Together, water and energy can promote stable societies and human dignity as well as realize basic human rights.

Optimizing performance within the Water-Energy Nexus can increase energy efficiency, decrease water pollution, reduce costs of energy and water provision, increase access to services, and reduce greenhouse gas emissions. The effective deployment of renewable energy resources around the world can be a stabilizing driver within the context of fossil fuel availability and climate change. Hydropower, as a renewable and stable energy source is the epitome of nexus thinking, yet requires stable water supplies.

Significant advances are required in policy, research, and practice to realize the nexus. The global challenges of climate change and food security create points of tension in the water-energy nexus which will have to be overcome in order to achieve development synergies. These challenges are exacerbated by population growth and urbanization, which create a dynamic baseline against which to address service access. In addition to some tensions in the nexus, the water and energy sectors are currently asymmetrical with respect to size and scale, and are often in competition with each other for capital investments and development resources.

Diversification of energy sources and decentralization of water and wastewater services require policy prioritization, technology mobilization, and investment shifts. Economic tools, such as pricing, subsidies, and other incentives can motivate decentralized renewable energy generation. The private sector is an essential partner in the water-energy nexus and needs to be supported by an integrated and coherent policy approach — one that would enhance in- and cross-sector efficiencies and improve sector interfaces. New technology development must be supported and incubated, especially to address emerging challenges at the water-energy nexus. However, technology is only part of sustainable solutions; changing public opinion and behaviour is essential for long-term uptake.

A dedicated water goal in the post-2015 development agenda, with key interlinked targets in the energy goal, is essential to achieving a sustainable future. The nexus will only be realized through capital mobilization around an integrated development agenda and synergistic actions. Once mobilized, sustained success will require joint accountability.

Together, water and energy promote societal stability and human dignity

UN Water, World Water Day Campaign

Pixabay, David Mark

CHAPTER 1

Global Water-Energy Nexus Considerations

The Nexus

Water and energy are inextricably linked, yet operationally, they have been entrenched, independent sectors with a lack of communication and information sharing between them. From the very start of their supply chains, water and energy depend on each other. Water is especially important and used in large volumes in generating electricity, whether through green energy (hydroelectric power) or heat exchange (steam systems) as well as for cooling (nuclear). In addition, water is required for fossil fuel extraction. All of these uses produce significant water-based wastes, degrading water quality (thermal, heavy metal, and other chemical pollution). Globally, approximately 15% of water withdrawals are for energy production and this is set to increase to 20% by 2035 (International Energy Agency, 2012). Energy is required to source (pumping it to treatment facilities), treat, and distribute water. However, to-date each sector is managed independently, despite the interlinkages and the impacts changes in one sector may have on the other. For example, the energy sector is exposed to water shortage risks, a very real consequence of climate change in many parts of the world, while the water sector, in turn, is susceptible to rising energy prices.

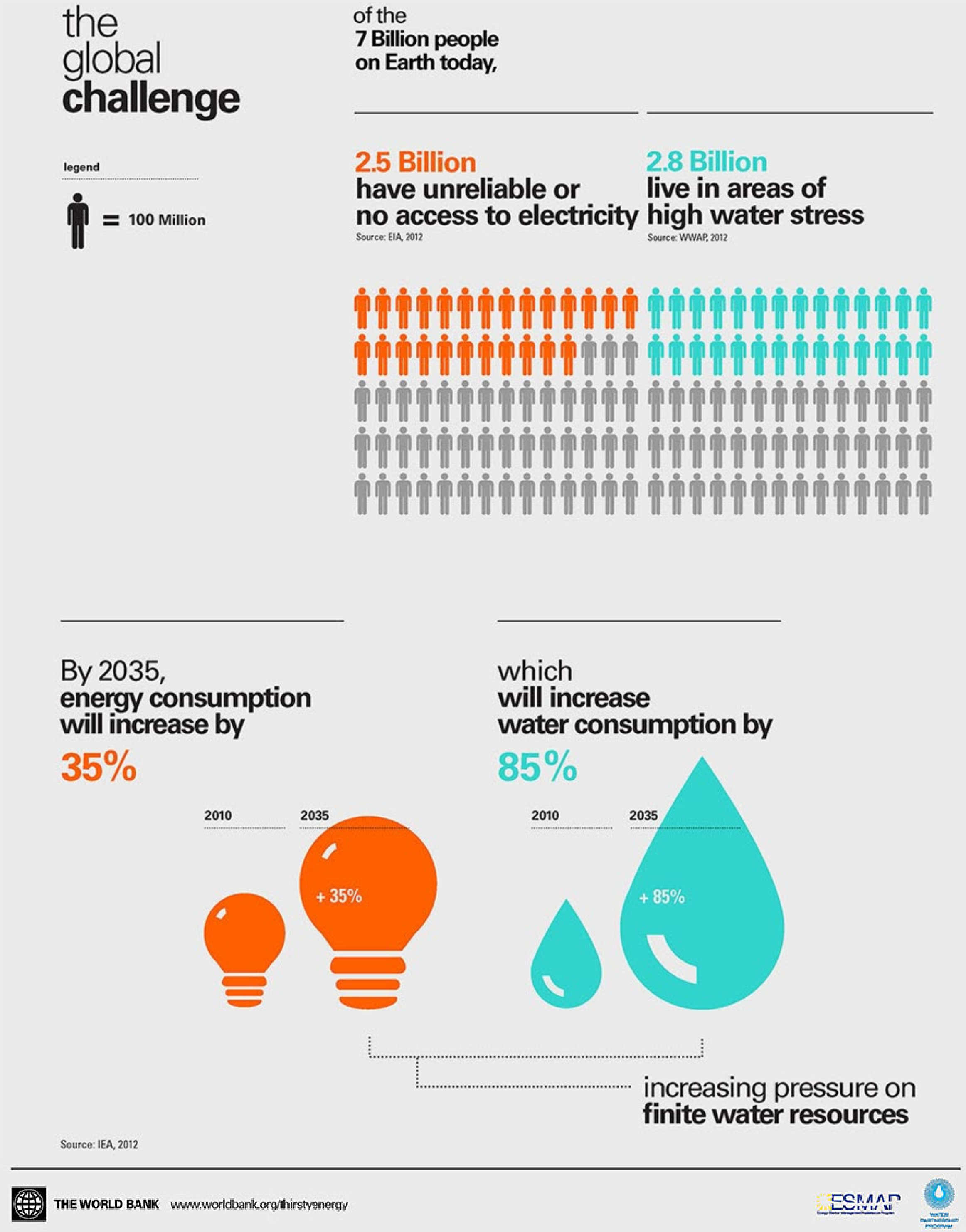
Energy and water are key drivers of industrial development and therefore economic growth, which can improve wellbeing through local economic development and poverty eradication. Despite the silo policy approach to water and energy sectors, both are important to local and national development. Energy supports processing and manufacturing activities, leading to employment and disposable income, especially at the local level. Reliable supplies of potable water, on the other hand, are essential for health, which, in turn, drives productivity of the local labour force. Moreover, both energy and water are essential for agriculture, especially crops grown under irrigation. Access to adequate variety and quantity of food produced determines nutritional status, childhood development, and productivity. Thus, the nexus of water and energy, especially at the local level, are important drivers for economic and social development, leading to improved human wellbeing. Unfortunately, those without access to one service are highly unlikely to have access to the other, although electricity access is far more widespread than its counterpart.

Energy access underpins social development particularly through benefits to education, creation of livelihoods, in procuring, treating, and delivering drinking water supplies, and in reducing dependence on firewood and charcoal. About 1.3 billion people around the world lack access to electricity. The rate of electrification has been slower than the rate of population growth in the most energy-poor countries (Walsh, 2013). Access to electricity enables students to continue their studies after dark. Education has been cited many times in the literature as a key factor for breaking the cycle of poverty, improving family wellbeing (female education), and increasing resilience in general (Noguera, 2011; Walsh et al., 2014). Access to energy further means that families do not have to depend on wood products for fuel. Pneumonia accounts for 1.1 million deaths per year in children under the age of 5 — more than AIDS, malaria, and tuberculosis combined. This can be traced directly to poor indoor air quality which is linked to the use of firewood and charcoal in the home (Wardlaw et al., 2006). Energy expands the extent of arable land through irrigation, securing food provision, and ultimately increasing nutrition. Energy is not only required for irrigation, but for water and wastewater treatment, running equipment and pumps in large treatment plants, to evacuate flood water, or extracting groundwater from boreholes. Through these mechanisms, energy access can improve health and productivity, supporting poverty eradication. Conversely, availability of energy can lead to water use inefficiencies, such as groundwater overpumping.

Together, water and energy can promote stable societies and human dignity as well as realize basic human rights. Social and economic development through expansion and improvements in access to water and energy can catalyse local economic growth. When local households have disposable income available, a positive feedback of economic strengthening and growth will occur. Increased productivity as a result of improved health and wellbeing will compound these economic benefits, stabilizing economies and communities; all leading to actualization of human rights, including that to water and sanitation.

Potential Value of the Nexus

The effective deployment of renewable energy resources around the world can be a stabilizing driver within the context of fossil fuel availability and climate change. The proportion of unrealized renewable energy around the world is significant. Theoretical hydropower potential alone is estimated at approximately 40,000 TWh/yr (Kumar et al., 2011). Solar power potential, especially in the tropics and subtropics, is currently limited only by transmission. Wind power, and offshore wind power, is unlimited — albeit not constantly. Therein lies the core issue with most renewable energy; if the sun is not shining or the wind is not blowing, electricity will not be generated. Of course, flowing water tends to be the exception to this rule as long as water volumes do not change drastically.



Infographic Source: Thirsty Energy - Energy and Water's Interdependence, supported by the World Bank's Water Partnership Program (WPP), Energy Sector Management Assistance Program (ESMAP), and the Korean Green Growth Trust Fund (KGGTF). Download available at: http://www.worldbank.org/thirstyenergy

Hydropower has an inherent strategic advantage over wind and solar power in terms of reliability and storage. While climate change will impact upon water resources and careful longterm planning will be required before capital investment to ensure long-term reliability, water flows continuously, albeit with varying volumes, providing continuous energy. Some regions of the world will experience decreases in precipitation and therefore river flow, while others will experience increases; current hydropower installations depending on icemelt are likely to experience decreasing flows over the long term as glaciers retreat. On the other hand, dams built for hydropower generation can provide flood protection and stored water can be used for agricultural, industrial, and domestic use purposes, or release of water to maintain low flows during the dry seasons. While storage of electricity generated from wind and solar power can require large footprints and be expensive, energy can be stored in water simply through elevated pumping.

Energy Security

Energy security is embedded in the ability to link the water-energy nexus to sustainable economic development. In addition to mobilizing capital and investments, significant advances in policy, research, and practice are required. This can only be achieved through broad capacity development that ensures not only the technical capacity, but the governance, regulation, and oversight capacities required. Most of this economic development must materialize through corporate capital, as opposed to public funding. One way to incentivize this is to capitalize on water and energy scarcity.

While it is important to diversify energy sources in light of future oil reserves and climate change mitigation, expansion of market share for renewable energy is challenging. Despite challenges, renewable energy continues to make up an increasing share of primary energy use. The use of renewable energy, including traditional biomass, accounting for 13% of global primary energy demand in 2010 is expected to reach 31% of total generation in 2035 (International Energy Agency, 2012). While many jurisdictions have initiated policies to increase this market share, retroactive policy changes have, in many instances, compromised investment community confidence in renewable energy, especially solar and wind. Hydropower, as a tried and proven technology, has not been as significantly impacted. However, hydropower requires massive up-front capital investments that can take years to put in place. In 2035, hydropower is expected to provide half of renewable-based generation, wind almost one-quarter, and solar 7.5% (International Energy Agency, 2012).

Hydropower is a core element of the water-energy nexus, but jurisdictional issues can impact upon actual development of potential. Many large water courses with hydropower potential are shared. This can be within countries or between countries. While some have successfully navigated trans-boundary issues to mutual benefit, these jurisdictional challenges have thwarted other attempts.

Showcasing Water Efficiency in Energy: Making the South African TIMES (SATIM) Energy System Model 'Water Smart'

With 60% of total water in South Africa used for irrigation, more water in agricultural production systems is needed to meet the requirements of 52 million people with a population growth rate at 1.3% (Stone et al., 2014). The same applies to energy needs, which are on the increase due to increasing urbanization, transportation, infrastructure, housing, and water and sanitation services. There are five energy demand sectors (industry, agriculture, residential, commercial, and transport) and two energy supply sectors (electricity and liquid fuels) in the country. There are close linkages between water and energy as water is not available evenly over the whole country, impacting the marginal cost of water for new energy-generating plants constructed in different locations, particularly if additional inter-basin transfers are required (Energy Research Centre, 2013). The Energy Research Centre maintains the South African TIMES Model (SATIM), which is capable of representing the whole energy system, including its economic costs and its emissions, and is thus particularly useful in modelling potential mitigation policies. The energy demand sectors vary somewhat in their share of final consumption and consequently greenhouse gas emissions, i.e. transport sector accounting for 27% and industry for 40% while agriculture accounting for up to 3% (Stone et al., 2014). Given these disparities, not all sectors in SATIM have the same level of research, and research funding has tended to concentrate on sectors having a high environmental impact and profile such as the transport and electricity supply sectors. South Africa ranks 30th in the list of most water scarce countries (Stone et al., 2014). This has led authorities to consider using less amount of water per unit of energy production. For example, all new coal technologies are dry, particularly at potential new sites. Water consumption is not zero but of the order of solar thermal technologies and low compared to the SATIM assumption of 1.873 $m^3\ MWh^{-1}$ (Energy Research Centre, 2013).

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CHAPTER 2

Disconnects and Disparities in the Nexus

The global challenges of climate change and food security create points of tension in the water-energy nexus which will have to be overcome for development synergies to be realized. Evidence clearly indicates that water resources will be subject to increasing stress, making water and its management increasingly valuable. These stresses result from global pressures which include pollution, urbanization, and climate change. Climate change mitigation strategies focused on reduction of greenhouse gases (sulphur dioxide) from power generation increases water use within the generation process. Increases in air temperature also decrease thermal energy production efficiency. Water efficiency strategies will reduce the amount of treated water required and therefore reduce energy demand, decreasing revenue for both sectors. The need for food security, and concomitant increasing demand for irrigated land will drive competition for water between sectors, especially in areas of water scarcity and/or decreasing water resources as a result of climate change. Water allocation between food, energy, and water sectors will have to be predicated on maximizing synergies and economies of scale between the sectors as well as balancing profit versus social development and environmental degradation.

In addition to potential tensions in the nexus, the sectors are currently asymmetrical with respect to size and scale. The magnitude of asymmetry varies from region to region. The energy sector is currently worth $6 trillion per year (Freed et al., 2010), approximately several orders of magnitude greater than that of the water sector, which is worth somewhere in the vicinity of $360 billion[1]. As a result, the energy sector has greater leverage for investment and innovation. Moreover, energy is a productive sector, generating revenue to support government programming, including the water sector, and most investments reside with the private sector. Water and wastewater are heavily subsidized in most countries around the world, whether by domestic governments or through overseas development assistance. As such, both sectors have different scales of management and implementation. These asymmetries compound the current entrenched independence of the two sectors, as well as the lack of communication and information sharing.

1 *http://www.snetglobalwaterindexes.com/market.html*

We need to understand **and quantify tradeoffs**

Dry Cooling vs Cost of Electricity

Dry cooling systems require no water for their operation, but decrease efficiency of the plant:

» increasing capital and operational costs
» increasing GHG emissions per kwh

Water – GHG Tradeoff

Some policies to reduce GHG emissions can increase water requirements by the energy sector if not designed properly

» biofuels, carbon capture…

Water for Energy vs. Water for Agriculture

The value of water for energy might be higher regarding economic outputs, but agriculture is often required for:

» national security reasons (food)
» social reasons (people employed in the agricultural sector)

Energy vs. Agriculture Crops

What makes more economic, social and environmental sense?

Hydropower

Assessing tradeoffs, environmental and social impacts and exploring the use of multipurpose dams is necessary for sustainable development.

Source: Interlinkages and trade-offs between water and energy, by Diego J. Rodriguez, Senior Economist, The World Bank. Presentation available at: http://slidesha.re/13X82jI

Pixabay, Public Domain Images

Energy-Water Challenges in India: Coal's clash with Agriculture

Energy generation has rapidly expanded in India, doubling the water inputs needed for power generation in the past 20 years. The large growth of coal power plants to produce energy for industrial uses has led to illegal diversion of water resources from agriculture and exacerbated water scarce conditions. With many additional plants proposed, this will have increasingly severe impacts for agricultural livelihoods that require large inputs of water for irrigation. For instance, according to a Greenpeace study, approximately 1700 million cubic metres of water per year will be withdrawn from the Wardha and Wainganga rivers in Vidarbha for coal-based thermal power plants proposed in the region. These water diversions are occurring on a substantial scale across the country, highlighting the need for increased debate on water and energy issues. India must explore solutions to increase the efficiency of energy systems as well as invest in sustainable energy resources to ensure water and energy security while supporting agricultural livelihoods (Cheng, 2014).

Public perception can be diametrically opposite, depending on whether a water or energy lens is applied to a problem. On the issue of large dams and hydropower, public perception depends on which sector is promoting the concept. Large dam construction is negatively construed because of its large social and environmental costs, flooding large areas of land and displacing people from their homes. On the other hand, hydropower is seen as green energy, a widely available resource that should be harnessed. This conflict in opinion leads to social, political, technical, and financial tension, as solutions are sought to capitalize on hydropower potential while ensuring cost effectiveness and minimizing environmental and social impacts.

While hydropower is the most stable renewable energy sector, it faces significant perceptional and political challenges. Notwithstanding the high upfront capital investments, which may take many years to secure, the huge environmental and social impacts of large-scale dam construction requires an increasingly higher price to pay. Many rivers with hydroelectric power potential are multi-jurisdictioned. Moreover, climate change impacts will largely manifest through the hydrological cycle, altering timing, duration, intensity, and type of precipitation. While some areas will become drier, others will experience more precipitation. Others may continue to receive the same volume, but with very different timing. Much of the hydropower potential exists in steep river runs and many of these are driven by rainfall, snow, and ice. As such, climate change is highly likely to alter future hydropower potential and impact current hydropower stations.

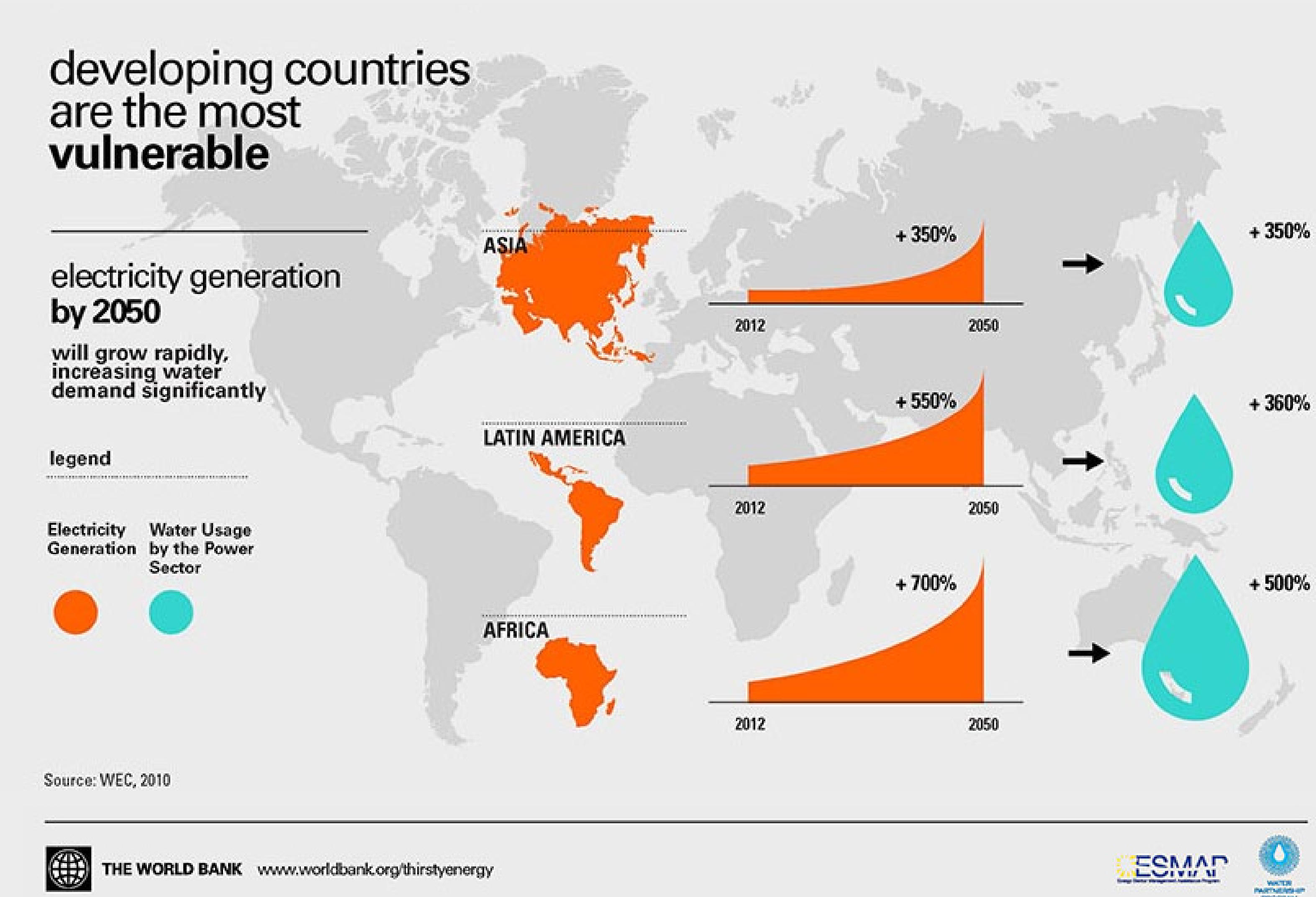
Current financial frameworks and available technologies are sufficient only for achieving universal access if the baseline population were static. However, global population continues to grow and urbanization increases population density in given areas. While the latter serves to increase economies of scale, it is far more difficult to establish infrastructure in highly-built environments. Moreover, as access networks are expanded, infrastructure ages and deteriorates, impacting upon quality of service of those previously served.

> "Let us pledge to develop policies for sustainable water and energy for all."
>
> \- Ban Ki Moon
> UN Secretary-General

UN Photo, Martine Perret

The Water-Energy Nexus: Partnering for Solutions

Approximately 1.3 billion people live without access to electricity and many do not have reliable access to electricity. Water and energy resources are poorly distributed globally, with 30% of the world's population consuming 75-80% of total primary energy and "virtual" energy and water resources transferred to high-income regions. As many traditional energy sources such as fossil fuels are linked to water stress and greenhouse gas emissions, renewable energy sources are an important part of the solution. Although these technologies allow greater self-sufficiency, there are challenges associated with wind and solar energy storage, requiring backup supplies, and some countries must absorb the learning curve to invest in innovative technologies. Hydropower is an established renewable technology that is proven and reliable, and represents an important solution at the water-energy nexus. Globally, hydropower has the capacity to generate much more electricity than all other renewable sources together, and contributes to climate change mitigation by preventing approximately 3 Gt CO2 eq/year. Several initiatives have focused on hydropower solutions to address water and energy challenges. For instance, through the Water Partnership Program potential opportunities to increase power output through cooperative hydropower in the Zambezi's riparian countries were identified. In Central Asia, where hydropower supplies 70% of Taijiksitan's electrical power, the World Bank Energy-Water Development Program aims to increase productivity and efficiency of water use across all member countries. The program seeks to promote highest-value energy investments and improve understanding of linkages between water and energy at national and regional levels. In the Latin American and Caribbean region, the Inter-American Bank is supporting hydroelectric projects through the Climate Change and Renewable Energy Initiative (SECCI), employing thorough environmental and social due diligence such as ensuring minimum ecological flows. Additionally, hydropower projects have been implemented at a micro-scale in Afghanistan through the National Solidarity Programme, providing a source of energy for villagers in Nangarhar province and allowing families to use computers and cell phones. These examples showcase the importance of making efficient use of water and energy in parallel in order to transform development strategies and foster growth (Sancho, 2014).



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Policy Disconnects

Despite obvious synergies and opportunities for economies of scale, the water and energy sectors are typically in competition for capital investments and development resources. This competition comes at the expense of co-operation, which requires trust and mutual benefits. As such, the path forward will require an overhauling of traditional resource allocation mechanisms, requiring cross-sector co-operation beyond the realization of immediate co-benefits. One specific tension is around biofuel versus food production. Biofuel could be an important renewable energy solution (depending upon the inputs used), providing up to 18% of global energy by 2050 (WWDR, 2012). However, this diverts both land and water from food production potentially driving up global food prices. One solution is to use marginal agricultural lands for biofuel production, eliminating competition for resources while providing livelihoods in otherwise difficult environments.

The private sector is an essential partner in the water-energy nexus, but its engagement is often hampered by either lack of incentives or inadequate (too lax or too stringent) regulations. While private sector involvement in the energy sector is fairly well established and motivated through costs passed on to the consumer as part of the manufacturing process, motivation to engage in the water sector is much lower. This is because the incentives are far lower. The water sector is highly subsidized and very few municipalities or individuals pay the real cost of water and wastewater services. Infrastructure, the sectors "hidden" asset, is often neglected and this has led to crisis situations in infrastructure failure in many high-income country urban centres.

In some cases, recipient national government priorities do not always match with overseas development aid (ODA) provider priorities. ODA priorities reflect strengths and economic interests of the donor government. Recipient governments, on the other hand, have national development plans and long-term visions which may establish very different priorities. For example, ODA providers may wish to support flood control technologies, while the recipient government is more focused on drinking water access rather than water management.

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UN Photo, Evan Schneider

CHAPTER 3

Emerging Solutions

Policy Solutions

Essential diversification of energy sources requires policy triggers designed to increase the realization of potential energy resources in specific geographic regions. Specific energy sources tend to be underdeveloped in different regions of the world. For example, only 7% of hydropower potential in Sub Saharan Africa is currently utilized. Offshore wind power and equatorial solar energy are equally underdeveloped. Barriers include ecological footprints, capital costs, and socio-environmental costs. Shifts in priority and investments are essential and can be driven by water and energy scarcity, particularly in regions poised for rapid economic growth.

Economic tools, such as pricing, subsidies, and other incentives can motivate decentralized renewable energy generation. Full-cost accounting of externalities, such as carbon emissions and water footprints, alongside full-cost recovery is one potential mechanism. Political will is essential in driving and supporting sustainable energy transitioning. Historically, back-pedaling on pro-renewable energy policies have undermined trust in political systems and eroded both customer and supplier trust. Hydropower is probably the exception to this, providing a relatively stable, yet capital intensive, opportunity.

An integrated policy approach is essential moving forward in order to coordinate coherent policy making and planning, realize in- and cross-sector efficiencies, and improve sector interfaces. Governments must redesign national development plans and sector strategies in alignment with the water-energy nexus, which will help to address health, sustainability, food security, and disaster risk reduction challenges. Essential mechanisms include national monitoring systems and shared national databases as well as multi-stakeholder and inter-agency working groups to break down sector silos and ensure development of informed policies. Pro-marginalized population strategies (including the poor, rural, women, and disabled) are essential and require disaggregated data collection methods.

Emphasizing Energy Efficiency in Water When Scarce: Using a Mix of Renewable Energy Production Options

In recent years, frequency of varying levels of droughts has increased in Spain. The year 2003 was the driest year in Spain in at least 60 years. Available freshwater resources are expected to decrease. By 2030, up to 14% reduction in freshwater resources is projected in the country. With close linkages between water and energy, this situation necessitates energy efficiency in managing water resources. As the main instrument of the Spanish Ministry of Agriculture, Food and Environment, ACUAMED is working on increasing water resources through desalination projects, and modernizing irrigation systems to save water and improve water use efficiency (Mañueco, 2014). Similarly, water efficiency in energy production and measures to save energy during consumption are undertaken. This is important to water and energy management in Spain as water is a key resource in energy production. The projections suggest that to meet energy needed by the year 2030, up to 25% more water would be needed for energy production in Spain if the country will continue relying on water for energy production. Instead, mix of renewable energy production options can help decrease the amount of water needed for energy production. For example, wind and solar power can reduce water withdrawals instead of biofuels production, which is a water-intensive process (Carrillo and Frei, 2009). Another example, in the transportation sector, if biofuels increased from 1 to 25% of the fuels used for transportation, they would consume almost 6 times the total water consumed by the electricity sector.

Pixabay, R. Read

Given current and predicted urban growth, emphasis must be placed on increased resource efficiency, including both water and energy. Urban areas are probably the most obvious places to begin to establish and benefit from water-energy nexus co-benefits. In order for cities to be sustainable into the future, a new model — the innovative city — must be developed and implemented. This model must balance economic growth, municipal services, and a healthy environment in which people maximize their potential. An interesting model of water and energy conservation is Masdar City, now under development in the United Arab Emirates; it pushes the envelope of urban sustainability much farther than most urban plans of today.

> "Building effective partnerships is like running a marathon, not a sprint."

Private sector participation under strong government oversight is essential for sustainable and successful exploitation of the water-energy nexus. Innovation opportunities exist for entrepreneurs, particularly at the local level in association with decentralized systems in the rural context. Whether international companies or local individuals, there is a role for public-private partnerships and emerging public-private-civil society partnerships. However, in order for these partnerships to be successful, national governments must establish appropriate mechanisms and take responsibility for regulation and oversight. Moreover, these partnerships should be developed in the absence of public funding.

New technology development must be supported and incubated, especially to address emerging challenges at the water-energy nexus. Research and development for new technologies is resource intensive in terms of time, money, and people. It can carry significant risks if investments do not translate into new products. In order to encourage innovation and new technology development, there needs to be international cooperation and capacity sharing between sectors and countries as well as incentives and risk-sharing mechanisms. The United Nations Green Climate Fund, based in South Korea, could potentially play a major role in facilitating technology development and deployment. Key challenges requiring innovation include mutually beneficial solutions to climate change mitigation in the form of emissions reduction, protecting energy, water and wastewater facilities against natural disasters such as floods, hurricanes/typhoons, and tsunamis, and reducing sedimentation particularly in hydropower facilities.

Existing and Emerging Technological Remedies

Emerging and innovative technologies provide an opportunity to re-energize (and reduce water consumption in) energy production. Cooling accounts for up to 90% of water consumption required in power generation, depending on the technology used. Technologies to reduce or eliminate this play a critical role in improving water efficiency of electricity production. Solutions include technologies which facilitate re-capture of heat energy currently lost in thermoelectric energy production, thus increasing the amount of energy generated from using the same water volume input and dry cooling of energy plants, which eliminates the water requirement for cooling completely. Other technologies that increase energy production efficiency will also improve the ratio of energy produced to water consumption. Even more efficient hydroelectric generators will reduce water volume required per unit energy production, thus potentially reducing the footprint and capital investment requirements as well as the social and environmental costs (e.g. low head hydroelectric generators).

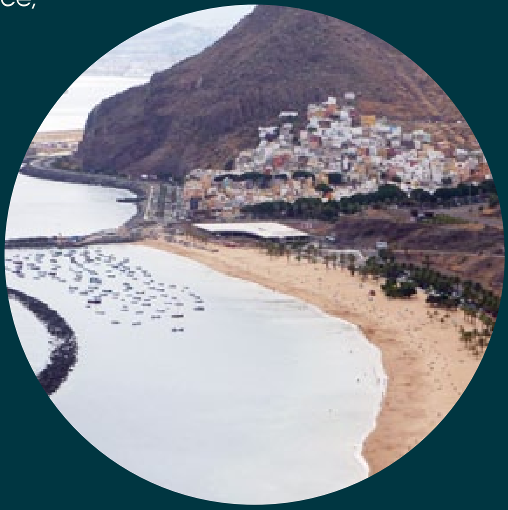
> "Not now, not tomorrow, should we ever accept the high numbers of people who live without access to water, who live without access to sanitation, who live without access to energy."
>
> \- Michel Jarraud
>
> Secretary-General, World Meteorological Organization

Emerging technologies, when coupled with decentralized systems, can significantly reduce energy requirements for water and wastewater treatment. Efficiencies in treatment processes, technologies which reduce power consumption within plants during peak grid demand periods, and, in the case of wastewater treatment, using waste to generate energy (anaerobic digestion), can all play a role in reducing energy demand. Plants can be run using solar power, particularly in the case of small, rural installations. Many claim that in both old and new urban developments, water and wastewater treatment should be decentralized. That would, at a minimum, reduce the energy costs for pumping water and sewage over long distances.

Innovation opportunities exist to strengthen the water-energy nexus through re-imagining WaSH delivery. Private sector, foundations, and national governments alike are incentivizing and seeking innovations for low-resource water and sanitation solutions. Many around the world without access belong to marginalized populations, whether as a result of poverty or geographic isolation. Innovations at the water-energy nexus, such as the microwave toilet and anaerobic digestion, have the potential to solve both electricity and WaSH access, improving health and wellbeing and catalyzing local economic growth.

Technology and the Water-Energy Nexus: The Canary Islands as a World Laboratory for Water and Energy Solutions

In the past, the Canary Islands (Spain) experienced water stress due to low rainfall, high soil permeability, and overexploitation of existing resources. Groundwater catchment, rainwater catchment and storage, and improvements in efficiencies have been used to secure water resources for the 2 million inhabitants. In addition to these conventional solutions, desalination and reuse of wastewater are now being employed to meet the region's water needs, with desalination comprising 2% of the world's total capacity. However, the water sector consumes 15% of electricity supplies that are generated from fossil fuels, highlighting a critical energy-water link that has led to the development of renewable energy technology. As a European Outermost Region, the Canary Islands are considered natural laboratories for developing and piloting new technologies for energy and water challenges. Each island tests and demonstrates a range of innovative technology and policy approaches, such as improved storage of wind energy surplus, more efficient recovery in desalination, and high-capacity desalination to produce water for irrigation. Many of these promising technologies are being adapted and transferred to other European regions as well as developing countries. For instance, desalination plants for brackish water that are powered by solar energy have been installed in Morocco and Tunisia. The Canary Islands have additionally provided expertise on challenges faced by small islands, such as isolated and weak electricity grids, fragile biodiversity, and difficulties deploying large-scale technologies. Solutions such as mini- and micro-grids to distribute energy generation and sub-sea electrical connections have been showcased. As a leader in renewable water and energy technologies, the Canary Islands have also contributed to capacity building activities in other small islands, including energy audits to promote efficiency in desalination in the Cape Verde islands (Piernavieja Izquierdo, 2014).

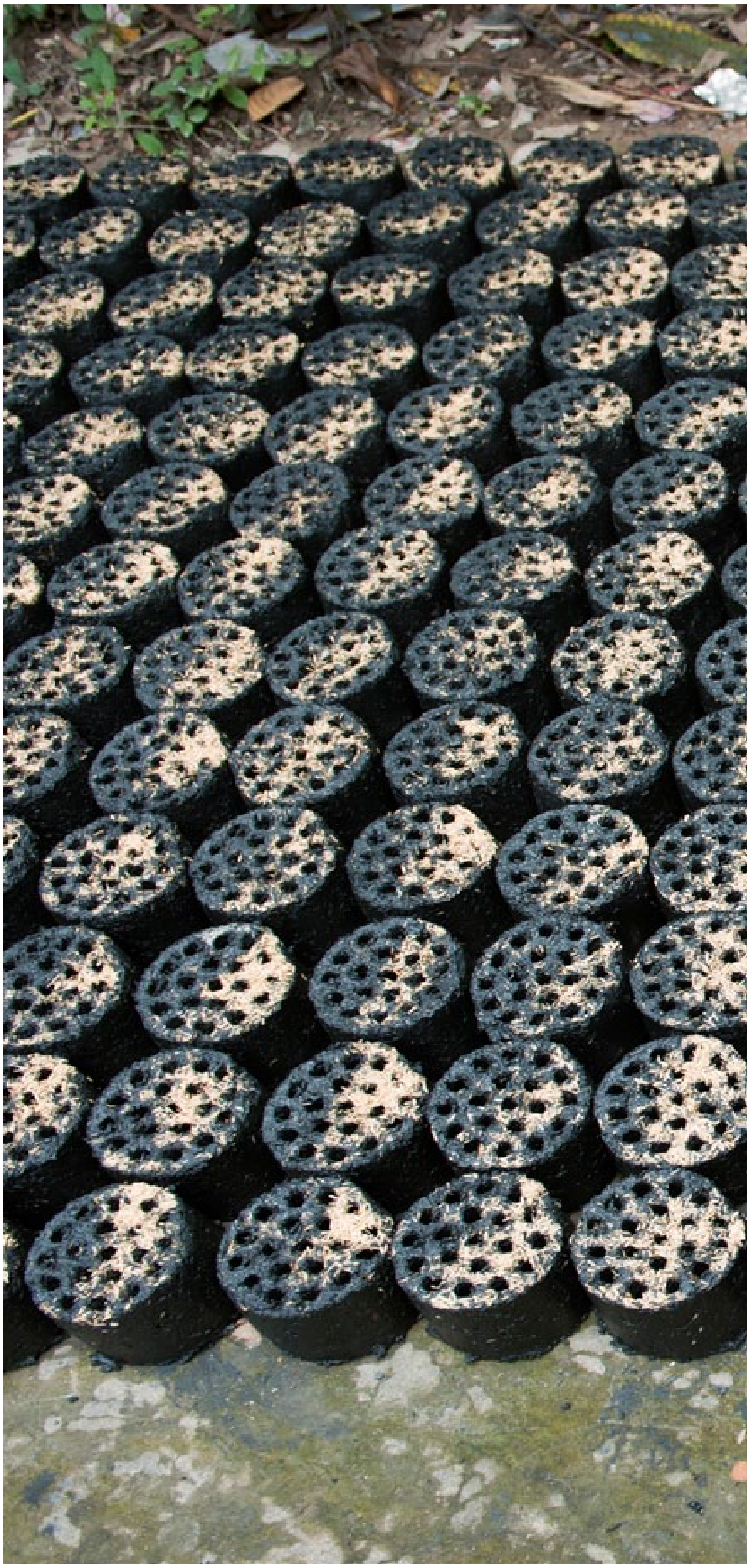


Pixabay, michelinho80

Community-Based Action

Technology is only part of sustainable solutions; changing public opinion and behaviour is essential for long-term uptake of solutions. The general public has to be incentivized to willingly choose environmentally and socially responsible solutions which may be financially more expensive. Education, outreach and social marketing have to be initialized, with messages reflecting cultural and regional contexts and recognizing the different values different cultures place on water and energy. This can be aided by shared experiences — stories of positive impact and benefits accrued when an integrated approach to water and energy is implemented. This has to be supported by incentives and financing options to enable people to follow through with behaviour change once sensitized to the issues and potential solutions.

The general public can be a source of capital mobilization through grass roots financing models. Traditional financing will always have a role to play in development of the water-energy nexus, especially for large-scale implementation. Recently, however, locally-sourced capital is playing an increasingly important role in mobilizing finances, especially for local and smaller scale initiatives. Perhaps the best known grass-roots capital is microfinancing; funds loaned on the basis of social networks and collateral. With the advent of social media, crowdsourcing, and donor-matching sites have increased in popularity.



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CHAPTER 4

Putting the Water-Energy Nexus in Sustainable Development Goals

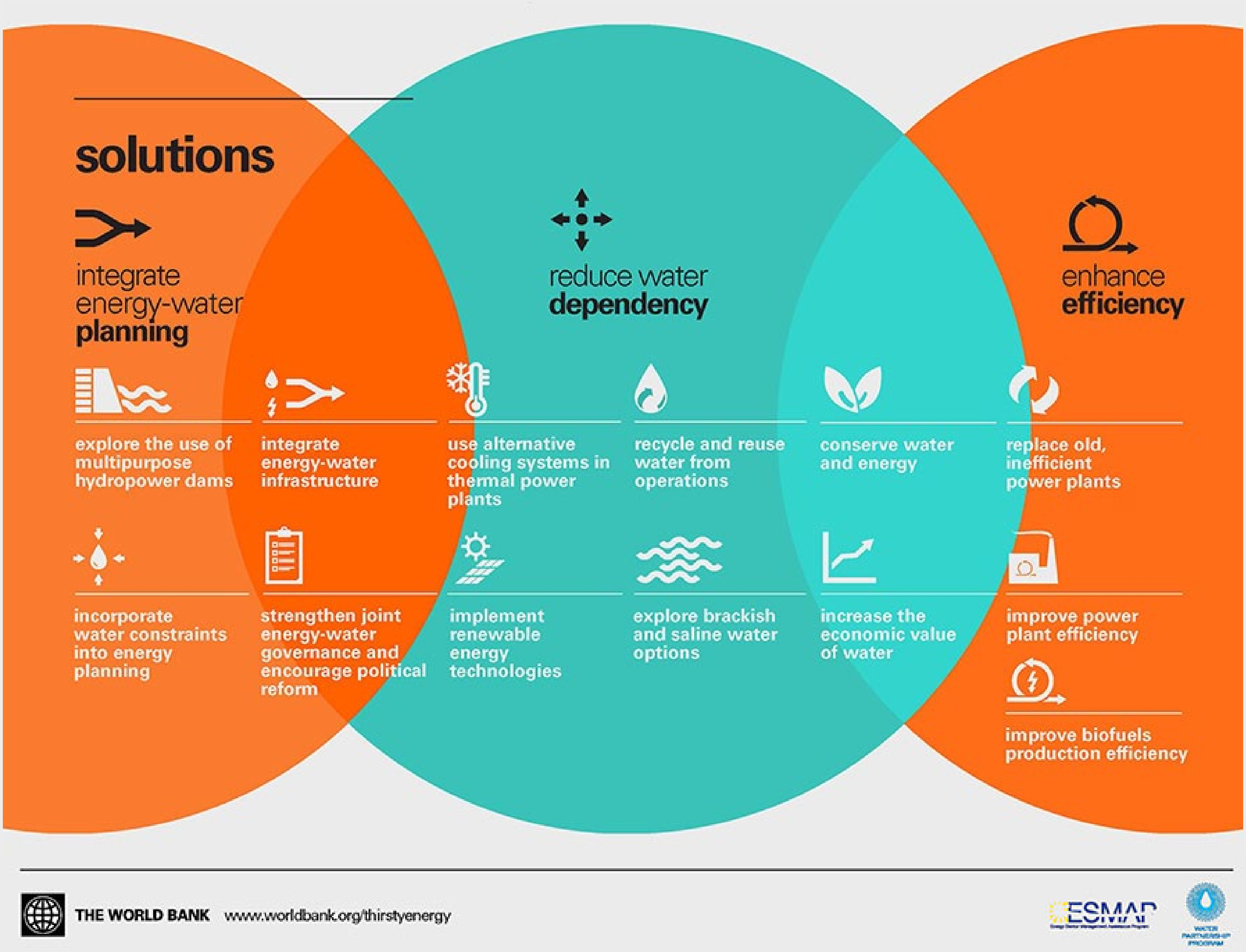
Commonality of Purpose

A green economy necessitates a focus on people, profit, and planet (the so-called triple bottom line), an aspiration that requires greater efficiencies, and synergies around the water-energy nexus. Building on the outcomes of Rio+20 and the predication of the post-2015 agenda in part, on a green economy, and the importance of water and energy for not only economic growth but environmental stewardship and social development, integration of both sectors is crucial. Economic and financial models of integrated systems can demonstrate not only the fluxes and flows, but the benefits which accrue to the triple bottom line. Thus the concept of sustainability may provide a method for conflict resolution; rather than profit maximization, the most feasible sustainable solution will be the determining factor for implementation.

A dedicated water goal in the post-2015 development agenda, with key interlinked targets in the energy goal, is essential to achieving a sustainable future. These interlinked targets, developed as part of the Sustainable Development Goals, include energy efficiencies in water and wastewater processes as well as water efficiency in energy production. Other areas for cross consideration include effluent water quality standards and management of hydropower installations for multi-use water storage purposes and not simply energy (i.e. flood control and irrigation, particularly in drought conditions).

Inserting Water-Energy in the Post-2015 Development Agenda

The Sustainable Development Goals must include universal access to water and energy as endpoints. Universal access to WaSH will be far easier to achieve within the context of universal access to energy. Synergistically, improved health, wellbeing, and productivity as a result of universal WaSH will likely facilitate willingness and ability to pay for energy access. Where affordability is still a barrier, integrated solutions which use either human waste to generate energy, or low-cost renewable energy to provide WaSH services can be implemented.



Infographic Source: Thirsty Energy - Energy and Water's Interdependence, supported by the World Bank's Water Partnership Program (WPP), Energy Sector Management Assistance Program (ESMAP), and the Korean Green Growth Trust Fund (KGGTF). Download available at: http://www.worldbank.org/thirstyenergy

From the many co-benefits achieved in efficiency, access, and sustainability, the importance of target interlinkages are obvious and essential for success. As such, it is essential that these cross-target linkages are well defined and reflected in both the energy and water goal. Metrics should reflect the interdependencies and further reinforce the mutualities between the sectors.

Interlinked targets post-2015 should highlight the benefits leveraged by the water-energy nexus on poverty reduction (Goal 1), empowering girls and women and achieving gender equality (Goal 2), ensuring healthy lives (Goal 4), creating jobs, sustainable livelihoods, and equitable growth (Goal 8) as well as managing natural resource assets sustainably (Goal 9) (Open Working Group, 2014). As indicated in the opening section, the water-energy nexus, and the goal of water and energy for all, are necessary conditions for achieving these other goals. While the extent of the nexus role may be greater or lesser depending on which goal discussed, its absence will result in insufficient conditions for success.

Means for Achieving Water-Energy Sustainability

The nexus will only be realized through the mobilizing of capital for synergistic action. In turn, this will require that international finance corporations take the risk out of private sector investments. Perhaps the newly established financing mechanism by the BRICS countries can lead the way. Changes to the business model of energy companies can further decrease risks, as can using technology to balance risk portfolios (e.g. shale gas extraction not feasible in water stressed regions). Regulators can further include resilience expenses into tariffs, passing on the cost of some risk mitigation to customers, while ensuring pro-poor mechanisms are in place. Funding windows must be created to drive advances in different sectors. While this begins with the water and energy sectors, it must expand into other sectors dependent on these, such as transportation and agriculture.

Once mobilized, sustained success will require joint accountability. This accountability extends from broad governance, regulation, and oversight, to efficiencies in both sectors (i.e. demand and supply), to social and environmental costing. The latter is important in (renewable) energy development, such as hydropower, and water quality management. The ultimate accountability is to the realization of human rights, both specific and implied.

Multi-stakeholder platforms are needed in order to develop and explore science-policy-society linkages and opportunities and to share (learned) knowledge. These platforms will support the creation of coalitions and communities of practice, coordination, and knowledge sharing, as well as stimulation of ideas. In this way it is possible to create space for a marketplace of ideas and examination of the nexus from all facets. Most importantly, it provides the opportunity to share experiences, not only of successes, but of failures.

GDP allocation targets can be implemented as a way of holding governments to account. Embedded in the principle of common, but differentiated responsibilities, these targets can be used to compare progress between countries, as well as in-country progress towards nexus investment and development.

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