# The Water-Energy-Security Nexus: Regional Approaches to a Global Challenge

## Integrating Water and Energy Planning

**BY KEVIN ROSNER AND JAKOB GRANIT**

April 2012

- Lack of effective access to water availability and energy for development purposes continues to impede human development in many of the world's regions. If water and power assets are properly deployed, both can help trigger multiplier effects for economic development in all economies beyond access to water and power at the household level.

- A regional dual water-energy market approach is advocated. It champions the scalability, salability and sustainability of access to water and energy resources based on lessons learned from power markets and trade. This is an outcome-oriented approach that embraces regional markets, real or nominal, as the optimal organizing mechanism for enhancing access to water and energy.

- Water and energy systems and the state of their operating environments are intrinsically linked. An integrated approach to policy, planning, management and development of water resources and energy systems optimizes potential benefits and innovative opportunities for national and regional economic development. This approach has geographic (for example, spatial) and market (economic) dimensions that lay the groundwork for resource access beyond borders and transboundary river basins and promotes access to water and power beyond the capacity of a single state provider.

- National and regional (interstate) security as an enabler or inhibitor to water and energy development is glaringly absent as a key "third dimension" to solving challenges with regard to the WES nexus. Water and energy professionals do not systematically explore this dimension. National intelligence, security analysts and military strategists do.

- Finally, integrated regional systems planning for water and energy use can support a transition to de-carbonizing the energy supply chain from transboundary water and energy flows providing solutions to both meeting growing energy demand and for the management of (transboundary) waters as regional public goods.

# Content

## Background Note

In September 2010, the Stockholm International Water Institute (SIWI), Stockholm, Sweden and the Institute for the Analysis of Global Security (IAGS) Washington, DC convened a meeting of international stakeholders in Stockholm including representation from the North Atlantic Treaty Organization, the World Bank, the Council for Scientific and Industrial Research (CSIR) South Africa, and the South African utility Eskom to discuss and debate challenges with regard to the water-energy-and security nexus (WES). The meeting was noteworthy because stakeholder participants represented the distinct and traditionally often unconnected communities of water, energy, finance, research, defense and security. One deliverable produced as a result of the meeting was a concise research program prospectus entitled, "Development along the Water, Energy and Security Nexus – National and Regional Policy Implications," published in December 2010. The proposed research champions a regional approach to concurrently addressing WES challenges within a South African context. However, the research proposed could be applied globally to any region, state or locality, as defined in this policy brief. A second deliverable that emerged was the creation of a research consortium (WES Consortium) including SIWI, IAGS, and CSIR. This consortium was joined in August 2011 by Sandia National Laboratory (Sandia), a US government laboratory that has pioneered water-energy modeling for knowledge-based policy formulation and decision-making in the United States. This intelligent model could be applied globally to any region, state or locality.

In January 2012 this consortium convened, facilitated by the Washington D.C. office of the German Friedrich-Ebert-Stiftung, a meeting of Washington policymakers, area experts from the Middle East, global water and energy professionals, and representatives from the US government and intelligence communities for the workshop "The Water-Energy-Security Nexus: Regional Approaches to a Global Challenge." Observations and lessons learned from this workshop are presented in this policy brief. Two salient points which arose at this meeting are particularly worth highlighting.

First, problem definition with regard to WES challenges must be driven by a bottom-up analysis. Biophysical characteristics, such as the conversion of rainfall to water, can vary dramatically within a single country. The impact of climate change may vary by region to region within a single country. Every country exhibits geographically specific natural resource endowments. Every country has its own political, economic, ethnic, religious and social histories that directly impact on its development trajectory and in turn complicate the manifestation of transboundary cooperation in the form of integrated power networks and the task of improving the provision of water for human development and economic growth.

Secondly, if problems are defined bottom-up all available solutions drawing on the benefits of integrated water and energy planning and development are maximized when a regional perspective is taken. Our definition of region transcends the traditional concept of transboundary water basins employed by many development organizations and agencies around the world. While additional policy work needs to be pursued in refining what is meant by a "region" this paper advances the important notion that regionally inspired or institutionalized markets provide a pragmatic framework for maximizing the benefits of integrated water and energy planning and development if only because they exist in real terms. Water resources and energy assets are spatially unevenly distributed in all regions of the world.

## Introduction

Lack of progress on access to water and power continues to wreak havoc on the aspirations of the international development community and most importantly on those caught in water and power voids in regions such as sub-Saharan Africa. A nation's access to power (electricity) correlates directly with a nation's Human Development Index ranking. Where there is power there is hope for development; where there is no power there is no development; and where there is no water, there is misery, starvation, and no future. Both assets are also fundamental to achieving food security-related objectives and to ensuring job creation and sustainable livelihoods.

With regard to water and energy, in many parts of the world development and population growth pressures are increasing stress on the pool of existing resources. And the many challenges posed by climate change further complicate decision-making on the provision of affordable baseload electricity for economic growth, as well as sustainable water for economic and human development. When security professionals assess a nation's energy security their focus is on diversification as regards countries of origin, supply, and transport alternatives. These same assessment measures hold true for water and energy (power) security and resiliency. Integrated water and power development will consider the impact of environmental change on water availability and it can also help better assess the cost, price and sustainability of new power generation by fuel choice. Energy use in the water value chain is growing, as is water use in many parts of the energy production chain.

Perhaps in no other region of the world are the opportunities greater for optimizing water and energy development and the risks more pronounced for a larger segment of the population (which is already suffering from an absence of access to one or both of these) than in Africa, which was the most conflict ridden area in the world over the period 1990–2007,[1] accounting for 88 percent of conflict-related deaths. The frequency of conflict and the absence of water and power development in sub-Saharan Africa within a single environment inhibit the overall objective of advancing and supporting human development. Further coupled with the uncertainty associated with potential climate impacts and the threats of ecosystem degradation, the list of potential direct and indirect risks to providing energy and water services in Africa and elsewhere grows longer and more pronounced.

The twin issues of providing water and power to communities exist within local, national or regional operating environments. Each environment has its own political geography, political economy, history of interaction, interdependence and sometimes conflict between states organized around common attributes. These attributes may be a shared border, common access to transboundary freshwater resources or regional markets responsible for inter-state trade. Sometimes these regional markets are grouped into economic communities, such as the European Union or development communities, such as the Southern African Development Community (SADC). Defined regions which benefit from multilateral institutions, and presumably some institutional capacity, are functionally predisposed to benefit from integrated water and energy planning and hence development. A prerequisite is that trust is built to achieve collective action across borders and boundaries and that incentives for each participating country to cooperate are evident. This can contribute to capacity building at the WES nexus, be it commercial or governmental in nature. However, success or failure in transborder cooperation at this nexus will in large part be either facilitated or inhibited by perceived barriers from several perspectives such as political, economic, social, ethnic, religious, cultural and historical characteristics of the operating environment itself, regardless of scale. Taking these characteristics together collectively defines the »third dimension« or »security dimension« of the WES nexus. The hard security environment (defined as threats to or the stability of the state) and the soft security environment (defined as the legal, regulatory, and judicial frameworks that allow for cross-border investment, economies of scale, security of supply in goods, services, or commodities) are antecedent to, and if improved upon, a benefit to integrated water and energy planning and management on a transboundary basis. The third dimension of the WES nexus, the security environment, therefore defines, determines, and enables development pathways to unfold or inhibit core water and power development from occurring.

Although integrated water and energy planning and development are beginning to be advocated by the inter-

1. See: http://stealthconflicts.wordpress.com/2008/12/30/new-world-maps/

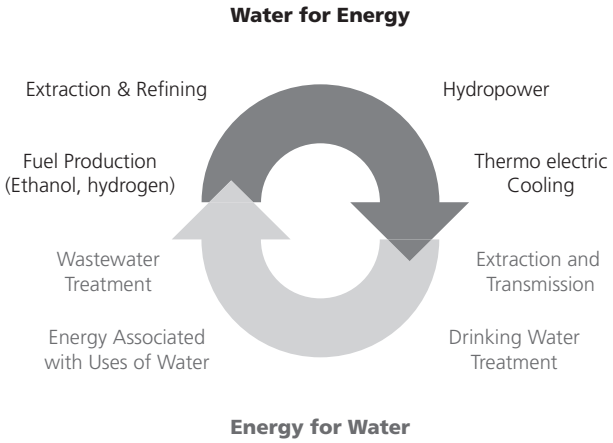
national community – supported by modeling efforts developed by institutions such as Sandia National Laboratory in the United States, and researched and promoted by leading institutions such as the Stockholm International Water Institute – institutionalization is still in its infancy around the world. Water and energy have traditionally been dealt with separately in development discussions. This separation, based on a stove-pipe approach to strategic development and implementation in each of these sectors, unnecessarily leads to problem definitions, identification and solutions that, although improving performance in one area, is detrimental in others.

The reasons favoring integrated water-energy planning are many. The purpose of this policy brief is to explain: (1) why this integrated approach offers greater benefits than pursuing water and energy development policies separately; (2) why an integrated approach will help water experts anticipate and appreciate the energy input into the water value chain; and (3) how an integrated approach will help energy specialists consider water as an input into power generation and therefore enable informed decision-making on fuel choice and generating technologies.

## The Water–Energy Nexus

Understanding the complex interdependencies between water and energy is key to a sustainable and secure future for all nations and regions. Water resources and water resource management at the national and transboundary levels is largely understood as a regional public good.[2] However, water can be extracted in the form of a tradable natural resource (such as fuels) and will therefore also take the shape of a private good.[3] With few exceptions, drinkable water (potable water) is the result of a production process that requires significant investment and energy, with an increasing GHG footprint. In fact, the cost of energy is the single largest cost factor in the treatment and distribution of water since raw water is in most cases is not attributed a commercial value. Developed water systems also provide energy in the case of hydropower, and they consume energy in the case of coal, gas or nuclear power generation, primarily through pumping, cooling and thermal processes. The large majority of energy generating technologies require water for generation, cooling and other purposes and there is a need to improve understanding of the role of water in these value chains. There is therefore a symbiotic relationship between water availability for resource extraction and power production and energy availability for the production of potable water.[4] As advocated by the International Water Association (IWA), having the right pricing, policy and regulatory frameworks are critical to promoting behavioral changes, facilitating innovation and ensuring sustainable use of both water and energy. It also allows simultaneous adaptation and mitigation with regard to climate change.[5]

Traditionally, the water–energy exchange is presented in terms of the following illustration.




Source: World Business Council for Sustainable Development.

2. Jägerskog, A., Granit, J. Risberg, A. and Yu, W. (2007) 'Transboundary Water Management as a Regional Public Good. Financing Development – An Example from the Nile Basin', Report No. 20 (Stockholm: SIWI).

3. Granit. J. (2010) 'Reconsidering Integrated Water Resources Management: Promoting Economic Growth and Tackling Environmental Stress'. Hexagon Series on Human and Environmental Security and Peace (HESP). Ed. Hans Günter Brauch (Heidelberg: Springer-Verlag).

4. Rosner, Kevin, 'Energy, Water and National Security Working Paper,' Institute for the Analysis of Global Security, Washington, D.C., October 2010.

5. IWA (2009) 'Water and energy are linked – within climate change and beyond', Conference Summary of the IWA International Conference Water and Energy 2009 <http://www.iwahq.org/MainWebSite/Resources/Document/Copenhagen_water_energy_output,%20Water%20and%20Energy%20are%20linked.pdf>

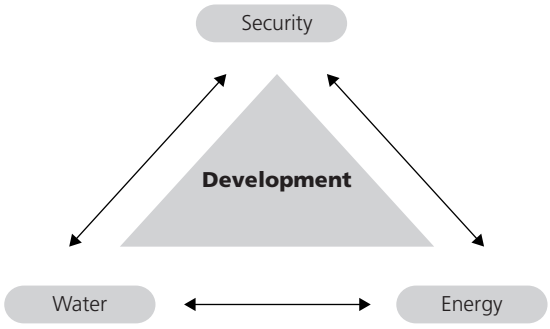
## Adding Security to the Equation

It is generally accepted that most nations seek to maximize domestic stability, security and growth. Non-confrontational growth through the development of markets and employment depend on a stable enabling environment. These responsibilities are largely attributed to the state, with a growing role for regional alliances. The focus here is on state stability, which is antecedent to the development and provision of economic development. Without a stable state and a stable region, complex water and energy projects (which in many cases are transborder) cannot be achieved due to high political and financial risks. Major long-term investments (capital and operational) in water and energy development and transmission demand a stable investment climate. Project identification, design, agreements, due diligence, and construction are long-term processes and volatile regions lower the appetite for risk on the part of both public and private investors. Good governance, effective capital markets and the rule of law in general are also critical elements to encourage investment.[6]

While defense and security institutions understand their mission as protecting state sovereignty from external threats, they have traditionally not been involved in, responsible for, or party to discussions about water and energy security challenges to state security. The same is historically true for their involvement in human development activities.[7] However, water scarcity and energy shortages are pressing security problems for state development or for regional integration processes in their own right. Water and energy professionals have not systematically explored this dimension but they should: development does not occur within a vacuum but within an operating environment with a historical legacy and kinetic real-time determinants, such as state instability or civil unrest, which strongly determine development outcomes.

The WES approach takes into account these explicit considerations which comprise this third dimension of the water energy and security paradigm. This is depicted as follows, with development as the emergent function resulting from successful water and energy development within a stable and secure operating environment.

### WES (Water-Energy-Security) Exchange




## The Regional Context

The WES approach addresses issues that are relevant on a global scale, but which roots discussions in specific regional contexts. While international experience is a fundamental point of departure for considering alternative water and energy technologies and pathways, it is the regional and local context that should guide understanding and appropriate response solutions. Local needs may be short-and medium-term, but options should be considered in a long-term perspective. An integrated decision-making model, supported by lateral engagement from the water, energy and security communities for deeper insight and shared understanding across all three sectors, is therefore fundamental to knowledge-based decision-making. Furthermore, the approach advocated has geographic (for example, spatial) and market (economic) dimensions that promote resource access beyond borders and transboundary river basins, as well as access to water and power beyond the capacity of a single state provider. The challenge is to fashion the concept of a region that has both spatial-geographic dimensions and shared physical features (such as transboundary river basins) with the largely more dynamic market dimensions evidenced in areas with inter-state trade in goods or services. Where an institutional mechanism already exists in the form of an economic or development community, such as the EU or SADC, regional definition is *de facto*. Where no such institutional arrangement exists, markets can help define the region for shared water and energy services.

6. Nile Basin Initiative (2007) Strategic/Sectoral Social and Environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region. World Bank.

7. Summary Report, Experts Workshop, The Water, Energy, Security Nexus, September 30, 2010.

This regional approach at the WES nexus yields numerous advantages:

- Evidence shows that regional integration brings economic success, prosperity and stability[8]

- Electricity is a link between the production of water-related goods and services and water management

- The availability of reasonably priced electricity and water is a major factor in creating sustainable livelihoods

- The generation of electricity through hydropower provides a direct feedback loop to water management

## Regional Power Markets: Lessons for Water–Energy Exchange

The effective transborder integration of power grids provides for and is based on a number of cooperative mechanisms. Integrated grid connections allow for economies of scale in power generation (scalability), greater efficiencies in avoiding adding additional generating capacity on a national basis for meeting peak load demand with supply available for cross-border transmission (salability based on the assumption of cost avoidance of unnecessary infrastructure and generating assets), and significantly enhancing the security of power supply on a regional basis (energy supply security). These mechanisms take their strength from a multi-market, multi-country modality and are presently functioning in several regions around the world. One of the best functioning integrated power markets is the Nordic Power Pool that covers Denmark, Finland, Sweden, Norway and, most recently, Estonia providing a Nordic link to the Baltics. Another power pool in operation is the Southern Africa Power Pool, comprising countries which were members of the SADC as of 1994. And in the Americas, in 2012 Central America is ready to launch the Central American Energy Electrical Interconnection System (SIEPAC) project, aimed at creating an integrated power market across the region.

SIEPAC has taken nearly three decades to negotiate and launch and when completed will run from Panama to Guatemala and interconnect the electric systems of all the countries of Central America. Observers note that electricity market integration is more difficult if not more complicated than forging a water treaty among and between states. Having said that, countries participating in SIEPAC exhibit many characteristics evident in other countries and regions in the developing world that lack access to both water and power. The SIEPAC region has a population of approximately 39 million people with a regional average GDP per capita of US$2000, ranging from US$4500 in Costa Rica to $500 in Nicaragua. Over half of the population lives in poverty and more than one in every two of these in extreme poverty. Over the past 40 years the region has experienced conflicts involving El Salvador, Honduras, Nicaragua and the United States to the North. However, despite socio-economic inequities, poverty, historic energy import dependence and a legacy of conflict the states have pulled together to forge a transborder, integrated power grid that will provide the basis for accessible power sharing, improved water treatment and distribution necessary for industrial development and employment generation. This is governed by an over-arching multilateral agreement incorporating all participating states in the region with the exception of Belize. Lessons from power pooling are a fertile area for further study in order to determine what lessons learned are transferable to linked water–energy development. Furthermore, the contribution of integrated power markets to economic and political stability, again the basis for human development, justifies detailed examination of what mechanisms (power agreements, transborder regulatory authorities, optimization of existent power generating assets and so on) are most effective in realizing WES development objectives.

## The Contribution of Water Treaties and Agreements to a Secure Operating Environment for WES Development

In recent times, dire warnings about water and energy have captured the imagination of scholars and public alike, but many have proved unfounded. Warnings about "Water Wars" have been issued, but we are yet to see any. Statements have been made that "water is the new oil", but we have yet to witness a significant rise in the

8. World Water Week Seminar on Water and Energy Linkages in the Middle East 2009: www.worldwaterweek.org

cost of water. Participants in the Energy Challenges: the Next Thousand Years workshop[9] predicted that "a collapse in non-renewable energy sources will occur in the near-term future" (before 2100). Von Euxkull (2004) displays another water community bias with regard to the use of water resources for energy production by arguing that "we cannot solve the global water crisis without stopping the present energy system's free ride on our water resources."[10] Even in areas with civil strife, cooperation on energy and transboundary waters exists through bilateral trade agreements and transmission interconnection projects. Tackling transboundary water management and development from a practical and outcome-oriented standpoint, as in the case of energy cooperation, demonstrates how tangible benefits can be achieved at the regional level to improve livelihoods and stability in the longer term.[11]

Aaron Wolf, a geographer at Oregon State University, is a leader of the Transboundary Freshwater Dispute Database project, which has tracked water-related conflicts from 1874 to the present. Despite the challenges of managing a shared resource between states, Wolf points out[12] that in the past 50 years, there have only been 37 conflicts over water, 27 of which were between Israel and Syria over the Jordan and Yarmouk rivers. Elsewhere, despite one of the modern world's longest frozen conflicts in Nagorno-Karabakh, both Azerbaijan and Armenia have come to the table along with Turkey, Georgia and Iran to discuss transborder water management along the Kura and Araks rivers. In spite of tense Indian-Pakistani relations both are parties to the Indus Water Treaty that has governed the Indus river basin for the past 50 years. And back in the Middle East, access to Jordan River water is governed by a series of bilateral agreements between Israel-Palestinians, Israel-Jordan and Jordan-Syria.

The entries in the database that Wolf helps maintain are coded by the transboundary basin and countries involved, date signed, treaty topic, allocation measures, conflict resolution mechanisms, and non-water linkages, such as border, capital, energy and land considerations. The question is to what extent can these measurement mechanisms apply directly to integrated power planning and pooling on a transnational basis? To what extent can the avoidance of armed conflict in the 1,800 transboundary freshwater disputes registered in the database be attributed to the over 150 treaties that govern freshwater access and allocation? Finally, what are the fundamental components of these treaties? Are these components appropriate for and transferable to integrated water and energy planning and power pooling on a transboundary basis? In short, in addition to defining the operating or enabling environment for WES development on a local, national and regional basis policymakers should additionally consider focusing on what has worked with regard to water in terms of conflict prevention and mitigation and apply it to power.

## Conclusions and Recommendations for Policymakers

The objective of this policy brief is to highlight the development challenges where water and energy are concerned and the importance of a third 'security' dimension in assessing the operating or enabling environment for knowledge-based problem solving at the WES nexus. Stability in the hard and soft security environment is both antecedent to and the result of sound policy formulation and implementation. Sound analysis begins from the bottom up, from the local to the national and ultimately to the regional level.

At the same time, two areas are suggested for further investigation, which may bolster the operating environment and cross-border cooperation where both grid integration and water cooperation are concerned. First, power sharing or more commonly "power trade or pooling" should be examined in detail in order to identify trading and pooling mechanisms that promote scalability and in turn increase access to electricity in regions that lack it. This is one way of sharing benefits from the development of transboundary water systems through for example hydropower development. Second, water agreements or treaties work but it remains unclear what components of these agreements drive forward cooperation even among states adversely disposed to one another. Hence, a further area for exploration is to identify

9. Foundation for the Future (2007) See: http://www.scribd.com/doc/18132075/
Energy-Challenges-The-Next-Thousand-Years-Workshop-Proceedings

10. Von Euxkull, O. (2004) "Energy and water: the ignored link," Refocus March/April: 40–44.

11. Granit. J. and Löfgren.J. (eds.) (2010) "Water and Energy Linkages in the Middle East – Regional Collaboration Opportunities," SIWI Paper 16 (SIWI, Stockholm).

12. See http://www.goodplanet.info/eng/Contenu/Points-de-vues/The-war-over-water-will-not-take-place/%28theme%29/2717

conflict prevention and mitigation mechanisms that we know work. In short, mechanisms that promote grid interconnection may help facilitate transborder water sharing and management and the framework components of water agreements may contribute to transborder power sharing and economies of scale where they are most needed.

The issue of spatial scales at this nexus is critical. A regional approach that renders the greatest good to the greatest number scattered across national borders is advocated. The definition of any region may be defined *de facto* by different states within a common economic community, such as the EU or SADC, or may be interpreted as a geographic area active with inter-state trade. Market dynamics are a manifestation of economic cooperation and may prove to be a positive indicative precursor of where water and energy development and cooperation will work. Transboundary river basins are seen as a sub-set of a region and not a static measure or even barriers with regard to where cross-border cooperation at the WES nexus should begin or end. It is postulated that scalability is related to salability in terms of rendering optimal power and water resources for economic and human development on a cost-competitive basis to end users. There is no mystery about why states agree to cooperate at the WES nexus: enlightened self-interest. Self-interest is the driver that should be capitalized on for catalyzing regional WES development.

The tool advocated for advancing optimal WES development is integrated or hybrid water and energy planning. WES consortium member Sandia National Laboratory has extensive modeling experience and expertise in this regard, and this knowledge should be exploited and extrapolated for application to specific regions of the world lacking access to water and power resources to stimulate investment and to encourage more integration of markets. Finally, the issue of sustainability is positively confronted and addressed by the WES approach. The hypothesis is that water and energy systems and the security environment are linked and hence an integrated approach to policy, planning, management and development of water resources and energy systems can provide improved benefits and innovative opportunities for national and regional economic development in a sustainable manner. Hence sustainability and the rational analysis of low carbon power generation is an active objective of this approach. The future of hydropower, despite social and environmental objections, should be re-examined as a fundamental source of renewable base-load and peak power providing a constant and resilient backbone for the accelerated introduction of other alternative intermittent power generation, such as concentrated solar and wind power on a cost-competitive basis.

All of the above is premised on the perhaps naïve assumption that, if policymakers can concurrently assess the full range of costs and benefits with regard to increasing access to water for human and industrial purposes and to affordable baseload electricity generation from a variety of fuels, informed decision-making will occur.

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* Note on the WES Consortium. The consortium represents a unique group of expert stakeholders with strong and diverse institutional experience and expertise. Consortium members include:

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**CSIR**: Council on Scientific and Industrial Research (South Arica) – expertise: water, energy, policy in South Africa and Southern African context
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