Perspectives on water and climate change adaptation

Climate adaptation – Aligning water and energy development perspectives

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Energy and water systems are dynamically linked. The production, provision and transportation of one resource cannot be achieved without making use of the other and there is growing scientific consensus that climate change is affecting the supply and quality of both. Thus, if past efforts have concentrated on mitigating climate change, policy-makers are now becoming increasingly aware that climate adaptation must also be an integral part of thinking and action to provide sustainable water and energy futures. Some observers suggest the future water-energy interface is even more fundamental: 'crack energy and you crack water' (for example: break down seawater to basic hydrogen and oxygen components (1) to provide hydrogen to create a low-carbon energy economy (power, transport and heat), and (2) drive advanced forms of desalination – a limitless source of freshwater).

This paper highlights the interlinkages between the water and energy sectors and points out the effects that climate change has on the provision of energy and water resources as well as providing guidance and inspiration for policy makers. Far from giving a pessimistic outlook on the energy future in the climate change context, it will be shown that there are, in fact, numerous ways to adapt to the challenges.

The first part provides an analysis of the effects of climate change on the water and energy sectors and shows that there remains considerable scope for fuel-switching and financing of adaptation strategies. The second part highlights five key issues which investors and policy-makers should take into consideration in designing their future water and energy strategies. The third part deals with the threat of ideological or maladaptive policy prescriptions, which indicate the imperative to drive action in a more practical, collaborative and informed direction.

1 Context

Since ratification of the UNFCCC (1992), which called for all countries to implement measures to mitigate *and* adapt to climate change, worldwide efforts have largely focused on the mitigation side of the equation (i.e. GHG emission reduction). This was reinforced by the commitments made under the Kyoto Protocol (1995). However, as provided for under Article 4 of the 1992 Convention, attention is increasingly moving to adaptation.[i]

Though the science and thinking that it embodies is constantly evolving, consensus is emerging that strategies for sustainable water and energy development must encompass explicit measures to adapt to climate vulnerability, recognising that:

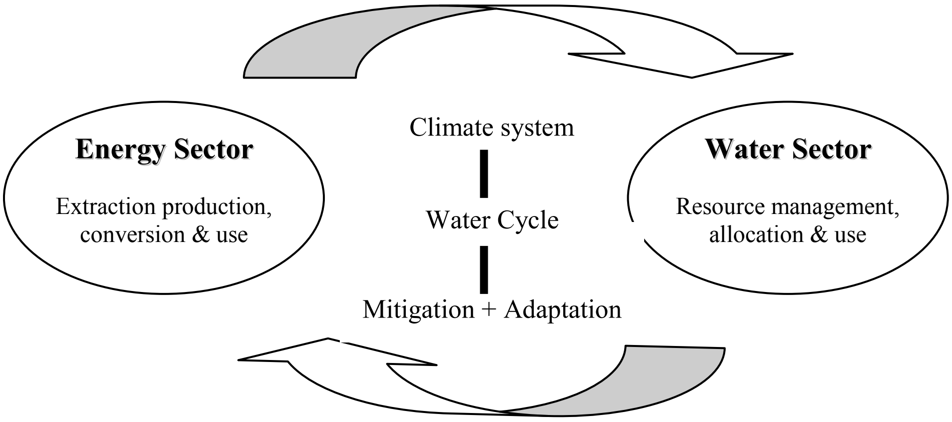
- Pathways to sustainable water and energy futures are intrinsically (1) interdependent, and (2) contextually linked through the water cycle.
- Climate change comes on top of current pressures on resource systems and efforts to protect water resources and expand access to water and energy services.

To coalesce thinking on future adaptation strategies that align water and energy resource development, it is helpful to revisit a few basic principles of the interdependence.

The physical or technical interface

Figure 1 is a highly simplified representation of dynamic physical links between the energy and water sectors, the climate system and the water cycle. The **first aspect** of the physical interface, one which this graphic highlights, is simply that:

- All human-devised energy systems have a water footprint, to one degree or another (e.g. non-consumptive transformation of river flows in the



case of hydropower, consumptive use of water to grow bio-fuel crops).[1]

- The water footprint of energy systems impacts, in varying degrees, the quantity-quality of water available to support other human needs and healthy ecosystems. Scale of course is important (i.e. whether water footprints are localized, manifest at the scale of the river basin, or on international rivers).
- In the other direction, a region's water resource endowment, defined by the features of the regional water cycle, influences the energy options a society can choose and shapes energy needs, in conjunction with other factors.[2]
- The impact of the climate system on the water cycle is complex, dynamic and non-linear - leaving ample scope for informed (and un-informed) debate seeking innovative solutions appropriate to a given setting.

Scientific consensus is that global warming has already, or will in the immediate future, trigger phenomenon like greater hydrological variability (e.g. greater seasonal and year-to-year variation in precipitation, more frequent and prolonged drought spells), and more frequent and intense extreme weather events (e.g. heavy rainfall events and torrential storms) and increased transpiration and evaporation through elevated temperatures.[3]

The effects of global warming of course are expected to vary across of the world. Table 1 is an illustration of the projected first order impacts of climate change on hydrological systems in the Mediterranean region, as an illustration. Table 2 is a simplified typology of how these changes may affect water-energy linkages viewed from an energy system perspective.

At first glance it is apparent that:

- Biomass, still the dominant energy source in global energy statistics (e.g. fuelwood, charcoal, agriculture waste, dung, etc. in the household sector) is vulnerable to adverse effects of water cycle changes on river catchments (combined with elevated temperature) affecting the poorest segments of global society.
- The electric power sector has strong links to the water sector, defined largely in terms of non-consumptive water use and the convergence of issues around the water, energy, and environment security nexus.
- Bio-fuel crops, as a fast-growing consumptive use of water, are potentially in competition with other water uses.

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[1] An energy system harnesses and converts primary or secondary energy sources into useful energy (heat, motive power, electricity).

[2] For instance, hydropower is part of the electricity supply mix in over 150 countries because of water resource availability. Desalination is a major consumer of oil and gas in the hot, water-stressed climates of the Arabian Peninsula and is planned or developed in water-stressed basins from the Western Cape in South Africa to the Jucar basin (Valencia) in Spain.

[3] Many climate scientists agree that the planet is probably in the early stages of more accelerated climate change, whether they agree fully on how to separate the human and natural drivers of climate change. Thus, instead of being a secondary, longer-term consideration, "planned" adaptation requires more immediate attention.

Table 1: Projected First Order Impacts Of CC on Mediterranean Hydrological Systems [ii].

Aspect	Representative Impacts
More variability and extreme weather events: More frequent and intense storms Increased number of days of heavy rainfall events and torrential downpours More frequent and longer lasting droughts spells Greater seasonal and year-to-year variation in precipitation, especially in semi-arid areas	Higher surface runoff with less chance for infiltration Increased variability in river flows through the year More frequent and higher floods, especially over northern parts of the Mediterranean basin Increased soil erosion from intense storms and sediment in runoff (in conjunction with effects of drought making soils erosion-prone) Lower groundwater recharge rates with drought
Wetter winters and dryer summers More precipitation in winter, less in summer, with variability in basins Earlier snowmelt (e.g. shifting to Jan- Mar) More winter precipitation falling as rain (in mountainous and colder climate regions)	Shift in season of peak flows in rivers spring to winter, Runoff in a particular basin may increase or decrease on average, but the seasonal distribution will change Lower groundwater recharge rates in dry summers Less efficient rainwater infiltration feeding inland and coastal areas and fragmentation of fresh water aquifers
Hotter summers and heat waves Warming trend greater in summer than in winter Hotter and longer summers Heat waves becoming the norm	Increased soil evaporation, plant evapo-transpiration Dryer and more erosion-prone soils Acceleration of desertification effects Multiple impacts such as increasing water needs in human, agriculture and natural systems

- Broadly, the water footprint of energy systems is relevant when the technologies involve significant water use, compete with water for humans or nature, or have significant water quality implications.

In addition, there are numerous, complex second order linkages between water and energy resource systems. These could become significant in the future either in a local context or in terms of becoming more widespread -- like the development of hydropower storage (including pumped-storage) for hybrid wind-hydro systems.

How important are these links to adaptation thinking, and is the public aware of these relationships? Clearly, public perceptions are important to generate political support for investments in adaptation and to take action at different levels – local to global.[4]

Perhaps what marks a broader shift in public perception of adaptation in the last few years are (1) the accelerated pace of 'perception shaping events' that help people understand what it means to live in a changing climate system – hence the need to prepare, and (2) the failure to recognize linkages, like unintended consequences of current climate mitigation measures and adaptation policy.

- Witness media coverage of the effect that diversion of irrigated and rain-fed corn production to bio-fuels (25% of the USA corn crop in 2008) had on staple food prices in the Americas (north, central and south), and how it ignited and lent a human face to the 'water for energy' versus 'water for food' debate.

A **second aspect** of the energy-water technical interface is the unique importance of the energy sector both in climate mitigation and climate adaptation.

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[4] Individual consumers must also take action. Public support is needed for the investments that adaptation will entail, including higher costs for water and energy services in many cases.

The essential point is that the synergies between mitigation and adaptation must be fully exploited.

Global production and burning of fossil fuels today account for nearly two-thirds of total anthropogenic GHG emissions. Thermal power generation based on coal, oil and gas alone accounts for up to one third.[iii] Much has been written about the required transition to a low-carbon energy economy, also what it means for global energy security, and how *efficiency* and fuel *substitution* need to be advanced.

There is, for instance, clear evidence of progress in decoupling economic growth from energy intensity in some rich OECD countries. Despite what some voices claim is an impossible task, or that no progress has been made, western society now uses about half the energy per unit of GDP as in the 1970s. Most international energy agencies predict that energy intensity per unit GDP (and per capita) in post-industrial societies will continue to fall, while rising rapidly in the developing world – in line with trends over the last few decades.

Table 2: Simplified typology of energy, water and water cycle linkages – first order.

Energy System	**Energy System Component**	**Water Sector Linkage**	**Climate Change influence On Water Cycle**
Electric Power Sector (Focusing on the grid system)	Hydropower	Factors into IWRM as a non-consumptive water use; evaporative loss from large reservoirs may be an issue; Water storage (multi-purpose) and river flow transformations Watershed conditions (e.g. erosion & sedimentation) Impacts on efforts to maintain healthy ecosystems	Increased variability in river flows through the year: +ve when connected to water storage for multiple needs (water + energy security) -ve when connected to prolonged drought leading to power generation restrictions
	Thermal power (e.g. power stations dependent on fresh water cooling)	Non-consumptive water use Allocation of river flow Potential for acid rain & water quality impacts on lakes	Reduction in river flows / water availability May be a concern in heavily modified river basins; thermal plume
	Nuclear Power (plant depending on fresh water cooling)	Non-consumptive water use Allocation of river flow	Reduction in river flows / water availability May be a concern in heavily modified river basins; thermal plume
	Coal Mining	Potential for localized water pollution	Surface & groundwater systems under more stress
Household Energy Sector	Fuelwood (household cooking, animal husbandry, etc.) Agriculture waste	Rain-fed forests Forests under competition for other land uses (pressure to over harvest)	Sub-catchments under multiple stresses, reduced fuelwood yields Hydraulic functions of forest ecosystems reduced
Transport Sector	Biofuel crops	Rain-fed (water table) and irrigated crops Competition for consumptive	Changes resulting in water scarcity and multiple pressures on water for bio-fuel crops

The fuel-switching or carbon substitution opportunities in energy systems relate to the three main forms of useful energy, namely: heating, motive power and electricity.[iv] Table 3 illustrates the carbon and non-carbon alternatives for each form of energy that the public is now increasingly familiar with. Again, while progress has been made, global fossil fuel use is still projected to double between 2004 and 2030.[5]

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[5] Source: http://www.eia.doe.gov/oiaf/ieo/index.html

Table 3: Fuel Switching.

		Dominant Carbon Energy Sources	**Non-Carbon Substitution**
Heating	(i.e. space heating for shelters, homes and buildings, cooking and a wide variety of traditional sector agriculture needs, industrial process heating, etc.)	Gas, oil Fuelwood, charcoal[v]	District heating from non-carbon sources Passive and active solar Electricity generated from non-fossil sources[vi] Heat pumps, etc.
Motive power	(i.e. engines and turbines powering all modes of transport, and motorized activities such as farming, fishing and construction)	Petroleum products (diesel, petrol, kerosene)	Electric / hybrid mobile systems or all electric (battery systems) charged by non-fossil electric generation Bio-fuels Hydrogen
Electricity generation	(i.e. generation from households, to isolated systems to utility scales)	coal gas oil	Nuclear Hydro Other renewable (wind, tidal, solar PV or towers, wave, ocean, etc.)

Clearly, there is enormous pressure today to increase the share of electricity generation from non-fossil sources, a departure from the 'dash to gas' in the 1990s. The evidence is provided in the trends underway in the electric power sector in OECD and other countries since 2000. These include revival of attention to: (1) supply and demand side efficiency and conservation programs, (2) nuclear power[6], (3) hydropower, and (4) a variety of large and small-scale alternatives including wind, solar, wave, tidal and geothermal to meet new national and regional policies. Minimum portfolio standards like the EU for renewable generation target of 20% in Member States by 2020 are a prime example.

While curbing GHG emissions is an important factor, other motivations to move off-oil brought into focus by the recent turmoil in international oil markets include regional energy security concerns, and the impacts of rising costs of imported fuel for debt sustainability in developing countries as well as prices for consumers in western societies.[7]

A **third aspect** of the energy-water physical interface is the uneven distribution of water and energy resources and rates of consumption across the world and within countries, and how this affects strategies in the global fight against poverty.

For many developing countries, biomass accounts for 85%–90% of total energy supply, mostly traditional forms for household cooking, heating and rural livelihoods. It is not difficult to see how adverse changes in the water cycle can exacerbate the price and availability of this source. Over 2.4 billion people today rely on various forms of traditional biomass. Over 1.5 billion people lack access to electricity. Generally, poor access to traditional and

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[6] Issues that could slow the expansion of nuclear power in the future include plant safety, radioactive waste disposal, and the proliferation of nuclear weapons, which continue to raise public concerns in many countries and may hinder the development of new nuclear power reactors (IEA, 2008).

[7] The motivations are many, including: expanding access to energy services to support the growth and equity targets in the United Nation's Millennium Development Goals; addressing regional energy security concerns and rising costs of imported fuel, which has serious implications for debt sustainability in many developing countries; and to mitigate dangerous anthropogenic interference with the global climate system

modern energy services negatively affects prospects for realizing equitable and sustainable development in line with the Millennium Development Goals.[vii]

The United Nation's coordinating body for the energy sector, UN-Energy, states that 'the world faces twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices, and that of environmental harm caused by consuming too much of it.'[8]

The governance and resource management interface

Ongoing governance reforms around resources and restructuring of the energy and water sectors since the early 1990s provide a dynamic backdrop for evolving climate adaptation strategies linking these sectors. As the reforms move from policy to practice (like IWRM in the water sector, and increasing private investment in the power sector) new opportunities and challenges are created for climate adaptation.[viii]

Box 1 illustrates how such reforms strengthen connections between the power and water sectors. It is important to consider that adaptation strategies cannot be developed in isolation of the wider sector reforms.

In many countries there are divergent views on the infrastructure strategies that should emerge from global water and energy reform processes, including how to balance environmental and social values, share benefits and public versus private sector roles.[ix] Many of these issues are prominent in the water divide. While polarized positions often reflect divergent philosophical approaches to development, one area of common ground is to view adaptation planning in the context of the IWRM framework for water resource planning (e.g. land-water-environment interactions).[9] And within that framework, to consider the water footprint of energy systems and technologies, as well as looking for synergy with water security, environment and energy security strategies.

The finance interface

Money - especially the lack of it - remains a key factor in adaptation. The International Energy Agency (IEA) World Energy Outlook Report (2006) produced a Reference Cost Scenario for the period 2005-2030, in which current laws and policies of countries remain unchanged throughout this period. Thus, the IEA projected a cumulative investment of 20.2 trillion US$ in the energy sector during this time, of which the largest amount, $11.3 trillion US$ (about 56%) would be spent for electricity sector investments (see Figure 2). World net electricity generation nearly doubles in this timeframe.[10]

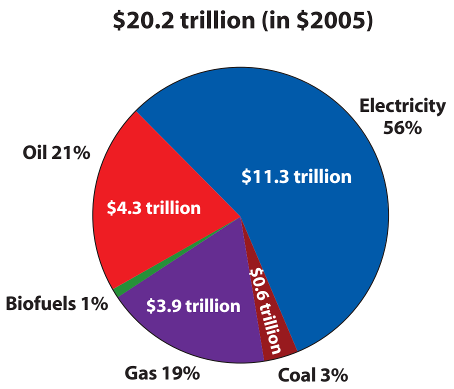

Figure 2: Cumulative Energy Sector Investment 2005-2030 IEA Reference Scenario. Source: IEA World Energy Outlook 2006

Box 2: Projected water investment by region. (2005-2030) $US trillion

Asia/Oceania	9.0
South/Latin America	5.0
Europe	4.5
US/Canada	3.6
Africa	0.2
Middle East	0.2

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[8] Energy in the United Nations: An Overview of UN-Energy Activities, 2006

[9] Responses to climate change would also be integrated with national economic, social and regional development planning, and harmonized with other resource and environmental management activities at both policy and practical levels.

[10] It suggests that global hydropower capacity could reach 1.431 GW in 2030, compared with 851 GW in 2005, equivalent to an average annual increment of about 23 GW capacity. As a point of reference, the International Hydropower Association (IHA) estimates 18.5 GW of hydropower was added globally in 2000.

The IEA's Alternative Policy Scenario for the same period considers how policies driven by concerns for energy security, energy efficiency and the environment, that are under discussion but not yet adopted, could curb the large projected growth in carbon-based energy demand. The scenario features accelerated investments in efficiency, non-carbon power generation and petroleum product substitution in other sectors. While predicting that the infrastructure transition will cost considerably more than the Reference Scenario, the carbon footprint and annual fuel costs would be less, and thus the global economy would become more resilient to international oil price shocks.[11]

Projected water sector investments are equally staggering. Up to 22.5 $US trillion will be spent to create and maintain water supply and sanitation infrastructure (see Box 2 for regional estimates).[x] Other observers suggest even more investment is needed to meet the needs of the 1.2 billion people worldwide who lack access to potable freshwater, and of the 2.6 billion who do not have adequate sanitation facilities. Furthermore population growth will have to be considered.

The relevant points for the energy-water finance interface are:

- Global society needs to rethink how developing countries access the international financing system to invest in water reforms, and adaptation as part of that effort.
- Governments must play a stronger role in facilitating investment, when societies choose more capital-intensive options implicit in moving to a low-carbon energy economy and reducing vulnerability to climate change.
- Clearly there will be competition for available investment resources, thus the many synergies between investment in sustainable water and energy systems need to be exploited to the maximum potential.

2: Key issues

With regards to the interconnection between the water and energy sectors, future actions will have to combine climate change mitigation with climate change adaptation. The following five key issues are offered to inspire thinking on the mechanics of both. Some of these concepts are already found in the climate debate, but deserve emphasis when revisiting the theme of Global Change & Risk Management.

Issue 1: The imperative to reconcile demand and supply to provide climate 'headroom'.

Patterns of water and energy demand must be reconciled with resource availability to take stress off water and energy resource systems already under multiple pressures. This creates room to manoeuvre and enhances physical capacity to adapt. As a risk management strategy, it gives societies more time to cope with rapid or unforeseen climate change that will otherwise cause more severe social, economic and environmental dislocation.

Box 1: Power sector and water sector reforms are linked in many countries

Power sector reform: much has been written about the major transitions in power sector restructuring, where governments are moving to play more of an enabling and regulating role. The shift toward competitive generation markets in China, much of Asia and Central and Eastern Europe illustrate the scope of change. In the 1990s this led to a shift to fossil generation, gas where available. More recently the priority is to maximize indigenous energy resources, including hydropower. Regional power pools and energy grids also change the economy of scale in power generation and have increased attention to regional water resource developments with hydro.

Water sector reform: Similarly, the global transitions in water governance and resource management seek to place decisions about the development and management of water infrastructure and energy projects with large water footprints into a river basin context, applying integrated water resource management principles. One illustration is the European Union (EU) Water Framework Directive (2000) to be operational in all EU countries by 2015. Through the European Water Initiative (EUWI) the EU also aims to align its technical and financial support to developing countries in water infrastructure to WFD principles.

Box 3: Demand-Supply Reconciliation in South Africa

In its post-1994 democratic transition, South Africa introduced progressive water legislation that received international acclaim. A key aspect of the new water resource strategy is reconciling demand and supply as the basis for all planning. In a first test of the laws, approval of the Berg Water Project (a dam diversion scheme) giving an 18% supply increment was contingent on parallel implementation of water demand management programs to reduce projected water demand by 20%.

Opportunity: This imperative applies equally to the management and wise use of water and energy resources. Fundamentally, climate stresses come on top of resource systems already under multiple-stresses when demand exceeds available supply.

While there are local, regional and international dimensions to this issue, the river basin is key as the hydraulic unit to reconcile water demand-supply under IWRM approaches. Similarly, demand-side management and supply-side efficiency are proven to be achievable in the power sector, without compromising growth and human advancement – given the appropriate regulatory framework and market-based incentives. Box 3 refers to demand-supply reconciliation imperative built into South Africa's water legislation.

Strategy elements: In the context of the energy-water interface, adaptation strategies broadly need to encompass:

- mandating demand-supply reconciliation studies when formulating catchment management strategies within the IWRM framework, especially in water-stressed basins;
- introducing statutory requirements for water and energy supply utilities to prepare and implement demand-side management programs with specific targets and timeframes, otherwise another entity supervised by a regulatory body with an explicit demand-supply mandate;
- evaluating the sensitivity of demand-supply balances against scenarios for water cycle change in partnership with the science community; and
- ensuring existing demand-side management programme are funded and benchmarked against successful models that as yet are too few and far between.

Constraints: The chequered global history and total failure of many past attempts at demand-side management in the water sector and electricity sectors will give policy-makers some concern. But it is essential to get past that hurdle. Reasons for past failures need to be clearly understood and tackled; among these (1) lack of pricing signals and communication strategies to influence consumption behaviour; (2) failure to invest in the infrastructure and markets and the supply chain to make energy and water saving devices available; (3) well-known contradictions in promoting demand-side management through supply-side utilities that have incentive structures to optimise sales; and fundamentally (4) regulatory failure.

Issue 2: The electrification imperative in low-carbon energy systems.

Expansion of electricity services is implicit in a low-carbon energy future and therefore in mitigating climate change. Electricity is unique in offering flexibility in terms of: (1) energy source (generation by carbon or low-carbon energy resources), (2) scale of generation, (3) application (e.g. useful energy for electrical services and motive power), and (4) scope for end-use efficiency improvement.

Opportunity: While traditional biomass energy sources (seen as carbon neutral) still dominate the global energy picture, electricity is the fastest growing modern energy form in percentage terms. There are many reasons. Electricity is unique in terms of its flexibility and absence of pollution at the point-of-use in homes, factories, offices and farms in all regions of the world.[12] Few informed observers question whether the proportional share of electricity in the energy economy will continue to increase. As noted in Figure 2 previously, the electric power sector

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[12] Access to electricity permits societies to urbanize, modernise, improve productivity through savings in time and labour, and provides a host of social benefits such as modern health care and education.

is expected to represent 56% of total global energy investment.

Moreover, if a 60% reduction in global GHG emissions is contemplated by 2050, significant penetration of electricity in the transport sector, in particular, is essential (along with bio-fuel and eventually hydrogen technology still in early stages of commercial development – and recognizing processes to produce hydrogen are electricity intensive).[xi]

In the near term, advancing the availability of electric hybrid vehicle-drives coming onto the market and pure electric vehicles (as electric battery storage advances) and certainly for public transport and rail will play a large role. Such developments would see a quantum increase in global electricity generation.[xii] Displacing fossil fuel use in road transport with electric sources (rail and road transport) is part of the EU strategy to combat emissions in the transport sector as noted in Box 4.

Box 4: Transport and electricity

Transportation now accounts for 60% of global petroleum product use. Transport accounts for some 71% of all oil consumption in the EU. Road transport uses 60% of all oil.

EU Transport policy is closely intertwined with energy policy, on the basis of common objectives: lowering CO2 emissions and reducing EU import dependency on fossil fuels by improving fuel efficiency on the vehicle side and gradually replacing oil by other fuels be it bio-fuels, natural gas, hydrogen, electricity or others on the energy side.

Source: European Commission Sustainable Mobility on our Continent (2004-2007)

Similarly, advanced desalination technology (e.g. membrane-reverse osmosis) is expected to expand freshwater supply to coastal and near coastal areas - where much of the world's population resides. Indeed if one looks at a map of projected water-scarcity it is clear what the future holds for desalination. The desalination processes are also electricity-intensive, as are the associated water pumping needs.

On the horizon is the much heralded revolution in distributed power for both stand-alone and grid feeding roles.[xiii] A range of non-conventional and renewable technologies would play an ever-bigger role in extending energy services locally via electricity.

Strategy elements: Consensus must first be reached on the role of electricity in driving toward a low-carbon energy economy, i.e. specifically policies to accelerate electrification in major sectors of the economy as a substitute for fossil fuel use – and as the next step, work on the water footprint nexus.

Generic issues in advancing these strategies include:

- providing a clear regulatory framework for non-carbon generation in the electric power sector: e.g. renewable energy portfolios; priority grid access for renewable energy sources; long-term payment for renewable sources to make them profitable to install and operate; carbon tax, other tax and fiscal incentives, etc.;
- providing industry, markets and the research community with the clear regulatory signals and incentives to: (1) accelerate non-carbon generation in grid and isolated systems, (2) clarify policies to encourage future expansion of grid and distributed power systems, and (3) set out policies and targets to maximize electrical penetration in other sectors, especially the transport sector;
- properly accounting for the water footprint of the energy systems (see Issue 4) and climate proofing (previous Issue 1); and
- aligning research and development budgets, tax and incentives to achieve these objectives.

Constraints: Many voices still ridicule the idea of continued or even accelerated electrification of the global energy economy. Concerns are expressed that it means a larger role for nuclear power, will lead to token levels of investment in other renewable generation options, or will required new technologies like carbon capture from coal power stations. These views are all part of the current debate around energy policy in the United Kingdom, for example. The UK government itself has couched its announcement of a major nuclear re-build around climate and energy security concerns – something virtually unthinkable a decade ago.[13]

Equally, developing countries seeking to diversify and modernize their economies continue to expand electricity generation (still relying heavily on conventional thermal generation) limited mainly by financial constraints, as shown in Energy Outlook Reports produced by international energy agencies.[xiv] Perhaps the core challenge going forward on this aspect is to create consensus on what a low-carbon energy economy means nationally and regionally in terms of the role of electricity and refocus efforts to enhance sustainability of the generation options selected and the adaptation linkages.

Issue 3: 'Climate proof' water, energy and ecosystem services.

Adaptation strategies need to explicitly identify ways to 'climate proof' water, energy and ecosystem services on which human societies and a healthy environment depend.

Opportunity: Climate change will cause changes in the water and energy supply structures of many countries and regions. While some countries will face water scarcity, others will have to manage the negative effects of a water surplus. Planners need to ensure systems and infrastructure for water and energy service provision are robust over a plausible range of climate-induced changes in the water cycle. This notion must extend to aquatic and terrestrial ecosystem services sensitive to changes in water quantity and quality. It includes the hydraulic functions and services that healthy forest and wetland ecosystems otherwise provide, like improved infiltration in catchments to replenish ground water storage, water purification, flood buffering services, and minimization of soil erosion and river sedimentation.[14]

Box 5: Climate proofing wetland systems

Wetlands systems downstream of dams and water abstractions can be climate proofed by introducing sustainable flow assessment and provision measures that recognize different flows required in normal hydrology years and in drought periods to maintain critical functionality of ecosystems.

Protection of water quality is an obvious concern, as is protecting ecosystems (e.g. how much fragmentation or degradation can ecosystems tolerate before they lose critical functionality, as noted in Box 5).

In the electric power sector, the quality and reliability of bulk power supply hinges on having a complimentary mix of energy generators with performance characteristics to ensure grid systems remain stable and responsive to demand. Most segments of the economy are highly vulnerable to power outages and interruption.

Unfortunately it is not as simple as 'plug and play'. This entails considering performance aspects of different generation options from a system perspective and ancillary services (e.g. ability to follow load, quick start, peaking, VARs, outage rates, intermittency, etc.) and taking into account the high variability of most forms of renewable energy generation.[15] Equally, it is important to ensure traditional biomass supply sources and systems (fuelwood, agriculture waste, etc.) are climate proofed in the sense that the adaptation strategies for forest, agriculture and land management are fully integrated.[xv]

Strategy elements: Again there are many ways to climate proof water, energy and ecosystem services. The strategy and emphasis will be unique to a particular river basin context. Generic adaptation strategies may include:

- adopting climate proofing as a specific objective in energy and water sector policy and strategic

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[13] Along-side a large increment funding for building energy efficiency, a mandatory bio-fuel addition to petrol (gasoline) sold in Germany, and expansion of renewable electric generation.

[14] Also providing food, fodder, biodiversity habitat, recreation and a variety of services.

[15] E.g. because of dominant performance characteristics an electric power system based entirely on wind (intermittent) or nuclear (steady, base load) would either be hugely and unnecessarily expensive or unreliable.

planning processes (like SEAs) and in key project-level assessment tools -- planning will have to work with impact assessments taking into account environmental, social and economic aspects;
- incorporating strategies to reduce risks associated with hydrological variability -- this will involve catchment management strategies, infrastructure strategies (both design and operation aspects), drought as well as flood management;
- ensuring that criteria for the reliability of energy systems and ancillary services are factored into electricity sector regulations to advance non-fossil generation and grid connection, and to evolve similar reliability standards appropriate for water service provision – contextually, involving end users in defining levels of service;
- ensuring that environmental flow assessment and provision (taking into account surface as well as groundwater components and environmental as well as social aspects) are adopted in planning energy systems that have a significant water footprint, coupled with ensuring outcomes are appropriately linked to river basin planning and water allocation procedures; and
- ensuring that ecosystem functionality is factored into drought management strategies for surface and ground water systems and water allocation policies.[16]

Constraints: A major constraint is weakness, or the outright lack of integrated planning and management around which to base climate-proofing measures – despite the fact that legislation may (and frequently does) prescribe integrated approaches. Fundamentally climate proofing of services needs multi-stakeholder processes to advocate adaptation thinking within existing planning and water allocation systems.

Issue 4: Understand the water footprint of low carbon energy systems and reconcile water storage holistically, in terms of water, environment and energy security.

Energy systems with low carbon and low water footprints need to be advanced. A distinction must be made between a water footprint characterized by consumptive and non-consumptive water use to avoid unhelpful confusion of issues. Centrally, decisions about surface water storage (i.e. dams) must be holistically reconciled, balancing water, environment and energy security concerns in the river basin context.

Opportunity: There is broad consensus on the need to move towards a low-carbon energy economy.[17] Lately, much consideration has also been given to the water footprint of human activities. Presently no form of energy can be demonized and outlawed. It is important to distinguish between water-consumptive and non-consumptive energy systems. Furthermore, these have to be considered in their context by policy makers.

For example, bio-fuel crops have been criticized for their high water footprint. This is critical if they are grown on fertile, irrigated land. However, no significant adverse impacts on the water table or competition with human or environment needs can be stated for rain-fed bio-fuel crops grown on lands too marginal for other forms of agriculture.

Similarly, the essentially non-water-consumptive nature of hydropower has been diminished by the argument that in some cases reservoirs lose considerable amounts of water due to evaporation.[xvi] All reservoirs (whether for hydropower, or irrigation and water supply) have evaporative losses. Evaporation rates, however, vary considerably according to the surrounding climatic conditions. Logically, higher ambient temperature results in higher evaporation, therefore reservoirs in cooler climates state only neg-

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[16] For informed decisions on climate proofing ecosystem services, for example, there needs to be better understanding of the resilience of ecosystems and their ability to recover after drought episodes, and the functionality of ecosystems in ephemeral rivers. For the electric power sector, much better public communication on technical attributes of the various non-carbon generation options and the unique role they play in the stable operation of modern power grids is essential to inform regulatory policy (e.g. base, peak, or intermittent/variable supply; fuel or capacity displacement, ancillary services, etc.).

[17] From the analytical perspective, a life-cycle or "cradle to grave" analysis, all technologies presently involve some use of fossil fuels. From the policy perspective, non-carbon supply substitutes exist and need to be encouraged, not only in OECD economies but also in non-OECD transitional and developing countries.

ligible losses. In tropical regions, on the other hand, frequent rainfall often counters evaporation losses. The real loss is only determined by the net difference between water losses in the river basin before and after impoundment. It is inappropriate to account as a 'loss' evaporation from a body of water that has been stored (and therefore would not have been available otherwise) for critical water and energy services during water scarce periods.

Two related issues underline the growing importance of the water storage issue in climate change mitigation and adaptation thinking. The first is the ongoing debate around the net change a reservoir may have on the natural GHG emissions in a river basin, particularly in warmer tropical settings. The emissions are due to aerobic decomposition of biomass in river water (producing CO_2) and anaerobic decomposition of biomass, which is more potent (producing CH_4).[18]

Box 6: The water storage nexus

"The reservoirs of the world are losing their capacity to hold water as erosion brings silt down to settle in behind dams, the chief of the United Nations Environment Programme (UNEP) warned today. Speaking to the Bonn International Conference on Freshwater, UNEP Executive Director Klaus Toepfer said that siltation is reducing the capacity of the world's reservoirs to hold water, a result that is hastened by the clearcutting of forests.

The issue of dams can arouse strong passions on both sides," Toepfer told the delegates. "Some people are very much in favor of building dams and others are vehemently against. However, what we are talking about here is the state and fate of the existing stock of dams and reservoirs on whose waters billions of people depend for not only irrigation and drinking water, but also for industry and the production of hydroelectricity."

The second aspect concerns the threat of accelerated loss of the world's existing capacity for water storage – and consequently the loss of climate 'headroom', as noted earlier. This loss of existing surface water storage (variously considered to be 1% to 3% per annum) is due to a host of factors accelerating soil erosion in the world's catchments, which make adaptation even more urgent and difficult.[19]

Despite attempts by UNEP to publicly raise the profile and human development implications of this issue from 2001 (see Box 6),[xvii] it appears to have dropped off policy-makers radar screens. Global warming will, in all likelihood, exacerbate the rate of storage loss from existing reservoirs – in watershed specific ways.[20]

This ongoing and real phenomenon cuts both ways in the debate about adaptation, as it depends on the basin context as to whether replacing lost storage is prudent or not. Certainly, if lost storage cannot be restored or replaced, it can have profound implications for many water-stressed basins around the world.[xviii]

Strategy elements: Among generic steps to connect these considerations to thinking about adaptation are:

- Reflect both the analysis of water and carbon footprints of energy systems in strategic studies linking water, environment and energy security – but in doing so, clearly distinguish between consumptive and non-consumptive uses of water.
- Establish processes to gather the best available information at the international level to help reconcile analytical differences that impede clarity and consensus reaching around key questions about:
  i –calculating net carbon emissions from water reservoirs, particularly those in tropical settings;
  ii – viewing evaporation from reservoirs (for all purposes) in the perspective that water cannot be seen to be 'lost' through evaporation if the body of water would not have existed prior to impoundment; and
  iii – sharing knowledge on the dynamics of reservoir sedimentation and sediment management and control measures.
- Approach decisions about water storage in an integrated way from combined water, environment and energy security perspectives in multi-

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[18] This issue is currently under investigation through an international project hosted by the International Hydrological Programme of UNESCO and the International Hydropower Association.

[19] Loss of live storage capacity in small to large dams globally

[20] E.g. a combination of dryer and more erosion-prone soils due to elevated temperatures, effects of fire removing vegetation cover and intense rainfall events resulting in higher rates erosion and sediment in runoff.

stakeholder processes, within an IWRM framework.
- Plan regional promotion of bio-fuel crops taking into account consumptive impacts on water and agriculture and opportunities for cultivation on marginal land.

Constraints: Perhaps the most challenging issue is establishing 'sufficient consensus' on the meaning of the water footprint of energy systems, and moving objective, evidence-based analysis into debate on policy implications. At the international level it is important to offer ways to bridge the divide on these issues, at minimum, to offer an objective framework for analysis. At the country-level, genuine multi-stakeholder dialogue processes will help cut through confusion and remove barriers to action.

Box 7: The possible effect of carbon-capture on acid rain

The focus on climate change mitigation and on greenhouse gas reduction should not be made without consideration of relating effects. While efforts have been made to reduce the CO2 emissions of fossil-fuel plants by capturing the carbon, this approach may not result in fewer overall emissions. A recent study of the International Journal of Greenhouse Gas Control suggests that emissions of SO2, NH3 and NHx may not decline and even increase during the process. These gases are known to be the causes for acid rain and, from the water sector perspective, are very problematic for the environment and agricultural production. The processes to capture SO2, however, are very different from those of capturing CO2 and are not widely integrated in power plants with CCS. Furthermore, NH3, which can have quite important impacts on acidification, is currently considered negligible and no efforts or restrictions indicate the emissions of NH3 will be reduced in the future.

Issue 5: Build appropriate capacity: knowledge, technology, industry and finance.

Appropriate capacity at national, basin and local levels is needed to make adaptation thinking an integral part of water and energy sector reform processes and to implement agreed upon adaptation strategies and measures.

Opportunity: A guiding principle is that adaptation measures must be practical and involve government, civil society and private sector actors as well as community-based organizations that can take local action. For example, in the water sector, rather than creating new institutional structures for adaptation, it is important to use and strengthen existing institutional structures to the maximum extent. Practical measures that strengthen entities created for IWRM water resource management in the basin can be pursued; and likewise for demand-side reductions can be pursued by reforming water service organizations closely supervised by regulatory authorities.

In the power sector, institutional capacity to implement energy options would rely on strengthening existing power-system institutional capacities and regulatory capacities. The actual public, private or community-based entities that deliver (plan, build and operate) new and renewable energy systems of course would depend on the technologies and the scales. Industry and the private sector would have to gear up in various ways with know-how (knowledge and technology). Much has been written on what this means in terms of job creation globally and 'green' jobs for sustainable development.

On knowledge sharing, it is important to bring together existing water and energy networks and newly-forming, climate change adaptation networks for information and technology exchange. Regional networks and north-south networks are important. Knowledge sharing networks involving arid and semi-arid countries are an example of networks that can be reinforced to deal with climate adaptation issues as a matter of priority. They are high-risk in the sense of being water-stressed and share many challenges.

Finance capacity of course underpins capacity to adapt and is a major factor in what measures are realistic in a given setting. Some of the issues include:

- Many of the required major structural adaptation investments are well beyond the current financial capacity for developing countries to pursue on their own.
- Financing measures unique to adaptation should be incorporated within existing sector investments, otherwise they may be left out.
- Public and private financing will have to play a role due to the sheer scale of investment needed.
- A critical issue is making better strategic use of international public finance in the mitigation and adaptation areas.
- Both top down and bottom-up thinking on finance is needed to harness the private sector and

the creativity and ingenuity in the entrepreneurs in all settings.

It is not just about government investment. It is also about mobilizing community and private investment and providing the appropriate incentives for collaboration.

One logical place to start is the Clean Development Mechanism (CDM) which focuses on mitigation: (1) rethink the approach to project eligibility to reinforce sustainable performance – social, environmental and economic performance; (2) whether an equivalent mechanism on adaptation is needed is a moot point, but otherwise adaptation needs to be an explicit, increasing element in north-south financial cooperation in the water and energy sectors.

Strategy elements: Among those measures generic relevance may include:

- start with 'least regret' adaptation measures.[21] Low cost actions today that can have a large impact in the future – but would be costly to introduce later;
- earmark capacity building funds, but give the mandate to existing institutional structures with clear accountabilities;
- establish knowledge development and dissemination networks (appropriately) i.e. build adaptation themes into existing network co-operation;
- use concise, objective analysis and avoid rhetorical confusion to help improve access to financing for adaptation interventions.

Constraints: Various constraints exist, for example: time, money, lack of appreciation of the need, lack of any sense of urgency, paralysis because of the perception of complexity and lack of champions.

3 Observations – on the way forward

A theme this paper advances is that adaptation planning is a discrete activity which adds tremendous value by mobilizing consensus on adaptation. But to be truly sustainable, adaptation must not be seen in isolation, rather as an integral element of evolving water and energy resource planning and management practice.

It is also important not to underestimate the challenges climate-induced changes in the water cycle pose. A case in point is the Murray-Darling river basin, widely acknowledged to be one of the best-managed watersheds in the world in a drought prone area. Despite many highly sophisticated water allocation measures, trading procedures, statutory allocations for nature, and advanced multi-level regional planning agreements the effects of the recent prolonged drought still led to the basin drying out. This resulted in devastated ecosystems, adverse impacts on the local economy and reduced energy production.

Clearly, adaptation requires long-term significant change in how societies manage and use water and energy. Beyond these concerns, it is increasingly clear that:

- It is best to avoid narrow, ideological policy prescriptions (especially those that limit scope for action and developing countries access to international finance).
- The energy sector is uniquely central in framing local to global strategies for mitigation *and* adaptation. Synergies need to be captured if a 60% reduction in global GHG emission by 2050 have any chance and at the same time make genuine progress in adaptation.
- All countries need to rethink and 're-tool' as needed, to adjust their water resource and energy systems, overcome maladaptive land use practices in catchments and seek to optimise hydrological services of natural ecosystems.
- National Adaptation Programmes of Action (NAPAs) long required under the UNFCCC need to be advanced.[xix] Reasons for the lack of progress in developing NAPAs (or similar instruments for the water and energy sectors) must be addressed, whether it is due to a lack of cooperation, no sense of urgency, or unavailability of funds.

Central to this is investment is rethinking and redefining of international financing mechanisms to

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[21] Adaptation measures that would improve the performance of water resource or energy systems in today's climate conditions, whose further delay could increase vulnerability, or lead to increased costs at a later stage, sometimes referred to as "win-win", or "least-regret" measures. They would be effective and sensible as resource management measures and have high social and economic returns, even in the absence of significant climate change effects (e.g. climate-sensitive land zoning, specific policies not locating strategic energy infrastructure in vulnerable flood plains).

promote investments in energy systems and energy technologies connected to climate change mitigation and adaptation. Instruments like the CDM need eligibility criteria that are not narrow, but more widely cast and designed, for example, to:

- promote knowledge creation, where there is scientific uncertainty or lack of developing country experience in mitigation or adaptation measures;[xx]
- finance enhancements to sustainability dimensions of projects (social, environment and economic performance); and
- reduce transaction costs, minimize uncertainty in eligibility, and be more open and transparent and subject to formal appeal processes.

What is needed is the appetite and means for the 'bolder policy solutions' and thinking outside ideological positions. Facing the water divide as a call for collaboration and not allowing it to remain an excuse for in-action.

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[i] The UNFCCC/IPCC stress that cost-effective strategies and measures for adaptation must be identified and implemented nationally and locally, engaging policy-makers and resource managers at all levels of government, and involving water users, the private sector, civil society and non-government organizations. This would be best achieved in overlapping "top down" and "bottom up" processes. The strategies and measures need to take into account important social and economic implications, and would be implemented on a stage-by-stage basis, in a prioritized way.

[ii] Source: L.Haas, WATER, WETLANDS AND CLIMATE CHANGE Building Linkages for their Integrated Management "Mediterranean Water Resources". Based on various primary sources: IPPC, Scientific Blue Plan Report, Planning and Climate Change Adaptation, for IUCN, 2002.

[iii] IPCC Assessments. Thermal is the fastest growing electricity generation source (in quantity terms) globally. Grid-scale wind generation is growing the fastest in percentage terms, but from a very low base.

[iv] Primary energy includes non-renewable energy and renewable energy. Secondary energy is an energy form, like electricity, which has been transformed from one primary energy form to another.

[v] Biomass is considered to be carbon neutral (IPCCC) though it has a strong water footprint. Biomass fuels can substitute more-or-less directly for fossil fuels in the existing energy supply infrastructures without contributing to the build-up of greenhouse gases in the atmosphere.

[vi] Space heating with electricity however, is not encouraged in most jurisdictions because it is: (1) expensive, and (2) violates the laws of thermodynamic efficiency when generated by fossil sources.

[vii] http://www.unesco.org/water/wwap/facts_figures/basic_needs.shtml

[viii] Lowering the walls between public and private investment has embodied a shift in the rights, risks and responsibilities of all actors in government, civil society and the private sector – but not without problems or controversy.

[ix] The World Commission On Dams (2000) in its Electricity Options Thematic Paper noted that there are divergent viewpoints on:

- national policies, strategic choices and national resource endowments;
- the ability to find common ground on a series of controversial social equity and ecological issues surrounding dam site selection, planning, construction and operation;
- the outlook for competing demand side management and electricity supply options including the emergent renewable sources;
- the evolving context of power sector market reform and regulation, and sources and the availability, structure and cost of project financing;
- the extent of stakeholder participation in planning and decision making; and emerging goals for sustainable development and its implementation, especially with relation to widening access to modern energy services in poorer countries and reducing the risks of environmental degradation at local, regional and global levels.

In particular, there are divergent viewpoints on:

- the impacts of market reform in the electricity sector including effects on investment choices and the potential loss of public benefits, including investments in energy efficiency, renewable energy technologies and widened access to electricity services for the poor;
- whether hydropower in all circumstances should be classed as a renewable energy resource and should enjoy government promotion on that basis. There are also divergent viewpoints on the theoretical, technical and economically feasible hydropower potential and on what may be considered economically feasible related to the extent of internationalisation of all costs and benefits;
- the role of community-based energy planning initiatives, particularly in rural areas of developing countries, and the extent to which they are supported or ignored in governments-based planning;
- the implications of regionalization of planning for electricity generation and the impact on internal political discourse within the country on which options to develop to support regional loads;
- how centralised and decentralised (distributed) power systems will co-exist and their compatability;
- whether leap-frog development in developing countries is likely and the enabling conditions;
- whether access to capital for developing countries is skewed by considerations of ideology, political influence and other vested interests rather than on substantial questions of need;
- the potential for green-power sales in market economies and whether "clean energy" will generally be more expensive than other forms of electrical supply; and
- the need for and likely success of public policy initiatives to increase the market share of efficiency and renewable sources.

[x] Scientific American, Running out of Water: A 6-point global plan to avert a global water crisis. August, 2008.

[xi] Over the next 25 years, world demand for liquid fuels and other petroleum is expected to increase more rapidly in the transportation sector than in any other end-use sector.
http://www.eia.doe.gov/oiaf/ieo/highlights.html

[xii] Transportation now accounts for 60% of global petroleum product use.

[xiii] Distributed energy generally refers to electricity generation from many small energy sources either in combination with large-scale generation feeding grids or in isolated grids. It also encompasses decentralized en-

ergy and shifts to a hydrogen fuel economy. The following description is extracted from the WCD Thematic Review Options Issues Series IV.1, Electricity Supply and Demand Side Management. Options Final Version: November 2000 Prepared for the World Commission on Dams (WCD) Annex 8. Submissions by Organisations: Stakeholder Perspectives. "Some observers suggest the twenty-first century may be as profoundly shaped by the move away from fossil fuels as the twentieth century was marked by the move toward them. Although the details of the new energy economy are far from certain, the broad outlines are becoming clear. They suggest that the new energy economy may be highly efficient and decentralised, using a range of sophisticated electronics. The new energy system may bear the same relationship to that of the 20th century as the personal computer age does to the era of mainframes. Natural gas is likely to be the increasingly dominant fuel of a more decentralised energy system. But over time, new primary energy resources are likely to emerge: the sun, the wind, and other "renewable" sources of energy. And over time, hydrogen – the lightest and most abundant element in the universe – may become the main fuel for the 21st century, derived at first from natural gas and agricultural residues, but later produced from water using solar and other renewable energy sources. Employed in fuel cells, hydrogen could power everything – from automobiles and jet aircraft to electric power plants that are small enough to be deployed in home basements."

[xiv] Total electricity generation in the non-OECD countries increases by an average of 4.0 percent per year from 2005 to 2030, as compared with a projected average increase of 1.3 percent per year for OECD electricity generation. See reference above.

[xv] Such strategies must also take into account the gradual process of fuel substitution (historically to kerosene and then LPG, gas or electric – or a mix) as rural populations adopt modern forms of energy; and equally, also not preclude future small-scale and decentralized options with hydraulic aspects, or those with locally significant water footprints.

[xvi] The water storage issue is often at the frontline of debate about balancing water for people and water for nature, especially in water-stressed basins. There are often complex considerations of scale, e.g. mass small-scale schemes for water harvesting versus reservoirs, or alternative investments in ground water recharge where geology and soil condition permit. Water for energy enters that debate not only with hydropower, but also for other low-carbon systems like pumped storage, or reservoirs to irrigate bio-fuel crops.

[xvii] http://www.ens-newswire.com/ens/dec2001/2001-12-04-03.asp

[xviii] E.g. Mohammad IV in Morocco.

[xix] In COP-7 (2001 decision 28/CP.7) a set of guidelines for National Adaptation Programmes of Action (NAPAs), aimed at non-Annex developing countries were approved. These are cited in Annex B. They were for all sectors, not just water resources. The rationale for developing the guidelines rests on the comparatively higher vulnerability, but low adaptive capacity of many developing counties, which renders them in need of immediate and urgent support to start adapting to current and projected adverse effects of climate change. Activities proposed through NAPAs would focus on those whose further delay could increase vulnerability, or lead to increased costs at a later stage. The decision at COP-8 was that the current versions of the guidelines would be maintained for the time being, and updated at COP-9 based on progress in applying them and working group recommendations.

[xx] The 50 MW hydropower project in Sierra Leone is a case in point. The Governments of Sierra Leone and the Netherlands reached agreement and signed the Emission Reduction Purchase Agreement in 2005, subject to the CDB Board certification (CERs). The ERPA was valued at about $US 10 million for carbon emission reductions between 2007 and 2012. The money was to finance sustainability enhancements in the project over a longer term that the government would have difficulty financing on its own. This included supporting a benefit sharing program with a multi-stakeholder board based on community driven development approaches, financing and environment offset for the project, financing and watershed management entity, and initial payment for claims for resettlement that dated back to the war where agreements were recorded but the war precluded any payments being made. The proposal was submitted three times to the CDM Methodology , each time responding to requests for further analysis and elaboration raised in the previous review. The CDM Methodology Panel summary recommendation to the Executive Board, June 2007, on the last submission, recommended rejection of the proposal. The basis given for rejection was not concerns over the Bumbuna project itself, but the presence of divergent

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views over procedures to obtain samples of the emissions from reservoirs, as noted below.

http://cdm.unfccc.int/methodologies/PAmethodologies/publicview.html?OpenRound=11&single=1&OpenNM=NM0121

“*The Meth Panel considered reports from experts on the scientific agreement on methods for the measurement of greenhouse gas emissions from reservoirs, prepared following the request of the Panel at its twenty-sixth meeting for the case NM0121-rev. The Meth Panel noted that the experts were of the view that the extrapolation of point measurements to estimate reservoir-wide emissions may not be very reliable. The experts also noted that further work is underway to improve measurement procedures and these efforts are not likely to conclude in the immediate future. The Meth Panel agreed to recommend that submissions for project activities involving hydro power plants with a power density less than 4 W/m2 should only be considered after the expert community working on methods for the measurement of greenhouse gas emissions from reservoirs have concluded their work, except for reservoirs where it can be demonstrated that the emissions are negligible.*” The CDM experts took this position despite the proposed use of best practice procedures for emission monitoring so as to help resolve an ongoing, unresolved debate about the level of uncertainty which fuels controversy on this issue. The parties involved in preparing the submission feel that apart from the clear and demonstrated carbon offset benefits, there can be no timelier project than Bumbuna, to obtain a profile of emission changes in the first 5 years of impoundment. This is especially important to the whole CDM community.