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WATER CLIMATE AND ENERGY

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Abstract— **Today Water, Climate & Energy is related to every aspect of human life: social equity, ecosystem & economic sustainability. Water is used to generate energy; energy is used to provide water. Water, energy and climate are inextricably linked, which is of great concern and increasing importance for future. Global primary energy demand is projected to increase by just over 50% between now and 2030, which can be met by more prod., consuming water & other natural resources, adopting better technologies and also encouraging changes in energy use pattern. Water withdrawals are predicted to increase by 50% by 2025 in developing countries and 18% in developed countries. The worst fallouts of the climate change are shrinking of water resources. Climate change acts as an amplifier of the already intense competition over water & energy sources.**

Solving the interlinked challenges of water, energy & climate in a sustainable manner is one of the fundamental goals of the present generation. To achieve this, related research and knowledge should be expanded and discussed with in technical circles. Technology, innovation a sense of shared responsibility and political will are factors that bring real solutions to keep pace with increasing needs. Resolving growing issues will require better and integrated policy frameworks & political engagement for all stakeholders within and across water sheds. Leadership from all parts of society is must for change to happen.

Key words— **Water, Climate, Energy, Sustainability, Ecosystem.**

I. INTRODUCTION

The vast majority of the Earth’s water resources are salt water, with only 2.5% being fresh water. Approximately 70% of the fresh water available on the planet is frozen in the icecaps of Antarctica and Greenland leaving the remaining 30% (equal of only 0.7% of total water resources worldwide) available for consumption. From this remaining 0.7%, roughly 87% is allocated to agricultural purposes (IPCC 2007)

These statistics are particularly illustrative of the drastic problem of water scarcity facing the world. Water scarcity is defined as per capita supplies less than 1700 m3/year (IPCC) 2007)

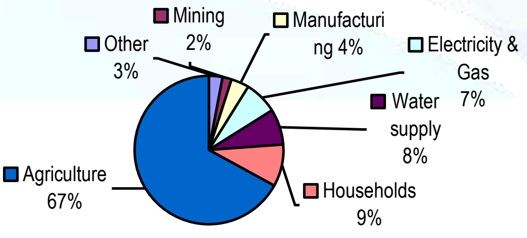

Fig. 1 Water use in the World (2005)

There are four main factors aggravating water scarcity according to the IPCC

- Population growth in the last century, world population has tripled. It is expected to rise from the present 6.5 billion to 8.9 billion by 2050.
- Increased urbanization will focus on the demand for water among a more concentrated population.
- High level of consumption as the world becomes more developed; the amount of domestic water used by each person is expected to rise significantly.
- Climate change will shrink the resources of freshwater.

II. WATER SCARCITY AND WATER STRATEGIES

One of the most urgent challenges facing the world today is ensuring an adequate supply and quality of water in light of both burgeoning human needs and climate variability and change. Despite water's importance to life on Earth, there are major gaps in our basic understanding of water availability, quality and dynamics, and the impact of both a changing and variable climate, and human activity, on the water system. The goal of the Water Sustainability and Climate (WSC) solicitation is to understand and predict the interactions between the water system and climate change, land use (including agriculture, managed forest and rangeland systems), the built environment, and ecosystem function and services through place-based research and integrative models. Variations in evaporation and precipitation patterns due to climate and land use changes, as well as increasing water usage to meet human needs, are the key factors for the above mentioned shortcomings regarding water across the globe.

The central role that water plays in human existence, and the challenges that face our society in adapting to our altered water resources, lead to an overarching question that links societal needs with fundamental science:

How can we protect ecosystems and better manage and predict water availability for future generations given alterations to the water cycle caused by climate variability and human activities?

In order to address this question, we require a holistic, predictive understanding of complex water cycle and water resource processes, the feedbacks associated with the water system, and the vulnerability and resilience of water systems to climate and anthropogenic change. In this context, a water system comprises the drainage basin and its physical, chemical, and biological constituents, including water networks, ecosystems, the built environment, the oceanic and atmospheric systems that govern evaporation and precipitation in the basin, and the source water bodies and terminal lakes or seas into which the water flows. There have been few attempts to study an entire water system with an integrative, systems science approach or even study similar aspects of different water systems in a comparative sense that will develop such a framework.

Agricultural modelling needs related to the sustainability of water resources through climate change "arise from the necessity to project crop, livestock, forestry, rangeland, and aquaculture yields at multiple watershed and ground water scales while balancing ecosystem needs. Increasing air temperature, wide swings of air temperature over short periods of time (e.g., warm conditions followed by a hard frost early during the growing season), increased precipitation or drought in different areas, changing intensity and timing of precipitation and snowmelt patterns increasing length of growing season, conditions accelerating crop maturation, and severe weather are factors that are likely to affect hydrologic processes on different scales, and in different parts of the country.

Developing the next comprehensive integrated watershed / groundwater and climate model is a major challenge requiring engagement by researchers from many disciplines. The next generation hydrologic and climate models will need to be high resolution, enabling predictions in the decadal timeframe and at regional scales. They will need to incorporate and advance sophisticated understanding of natural and human-moderated systems; not only their physical aspects, but also biological and human, including contributions from the built environment. These models include:

- Hydrologic models for watersheds and groundwater yielding data on water availability and quality that can interact with new or existing climate and crop models that can be down-scaled to predict impacts on agricultural production and processing systems, forests, rangelands and grasslands.
- Hydrologic models that can be used to predict the potential impact of climate variability and change, land use, and human activity on water availability for agricultural lands, forests or rangelands and rural community needs.
- Coupled climate and hydrologic models to help manage water allocations from snowmelt, reservoirs, ground water, and surface water, to deal with competing demands from agricultural, energy, environmental, urban/industrial, and western land management uses.

III. RELATIONSHIP BETWEEN WATER AND CLIMATE

The hydrological cycle is intimately linked with changes in atmospheric temperature and radiation balance. Warming of the climate system in recent decades is unequivocal, as is now evident from observations of increase in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level.

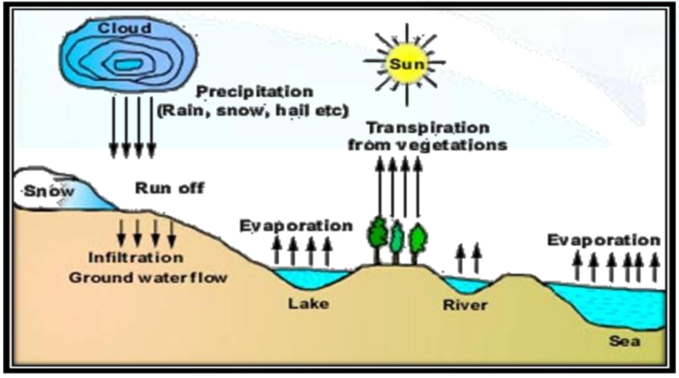

Fig. 2 Hydrological cycle

A large number of feedback cycles, some of them opposite in effect to others, are involved in this distribution of the incoming energy from the Sun. Water vapor in the atmosphere is the most important greenhouse gas, but clouds and ice sheets can cool the Earth by reflecting energy back to space Ocean currents transport heat away from the tropics and release it in high latitudes, but they also bring moisture, which under suitable conditions can induce the growth of ice sheets. Boldly simplified, water acts as the Venetian blind, central heating system and as fridge, all at the same time for our planet.

Water in its various forms has always worked as a great amplifier of changes, such as variations in isolation or tectonic changes that are imposed on the climate system. Similarly, water is intimately involved in the way the more recent addition of anthropogenic greenhouse gases affects climate.

A. PROJECTED CHANGES IN CLIMATE RELATED TO WATER

Water is involved in all components of the climate system (atmosphere, hydrosphere, crysophere, land surface and biosphere.)Therefore climate change affects water through a number of mechanisms resulting in changes in water related variables and projections of future changes. Major climate change projections, indicate that decadal average warming over each inhabited continent by 2030 is very likely to be at least twice as large (around 0.20 C per decade) as the corresponding model-estimated natural variability during the 20th century. Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century, very likely to be larger than those observed during the 20th century. Projected global average temperature change for 2090-2099 (relative to 1980-1999), ranges from 1.80C to 4.00C. Warming is projected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean. It is very likely that hot extremes and heat waves will continue to become more frequent.

IV. RELATIONSHIP BETWEEN WATER AND ENERGY

A. BACKGROUND: ENERGY USE OF WATER

Energy is embedded in water. Water utilities use energy to pump groundwater, move surface water supplies, treat raw water to potable standards, and distribute it to their customers. Customers use energy to heat, cool, and pressurize water; and wastewater treatment plant use energy to treat wastewater before discharging it (figure 3). The amount of energy embedded in water- its “energy intensity” – varies substantially, depending on this source of the raw water, the end use, and water quality requirements for discharge. New water supplies will almost certainly be more energy intensive than existing supplies: Groundwater pumped from greater depths, water conveyed over longer distances, and lower quality water (requiring more advanced treatment) will all demand more energy than existing supplies. The following sections present the energy used for water at each stage of the water supply process.

Fig 3 Energy is used to pump, treat, distribute, use potable water, and to treat wastewater.

Water utilities that rely on groundwater, in contrast, use substantially more energy on their water supplies. The energy used to pump groundwater depends on the depth of the aquifer and whether the aquifer is under artesian pressure.

Pumping and treating just one gallon of water/wastewater requires 14 Watt-hours of electricity, or the equivalent of running a 60 Watt light bulb for 15 minutes.

Energy required to deliver 1 m3 of clean water from…

Source: Amended diagram based on Scientific American, October 2008

Water conservation offers important energy savings; reducing per capita water use results in dramatic energy saving for water utilities. We profile several water conservation measures and assess their energy savings and greenhouse gas reductions. Accelerating implementation of these water conservation measures would provide even greater energy and carbon savings.

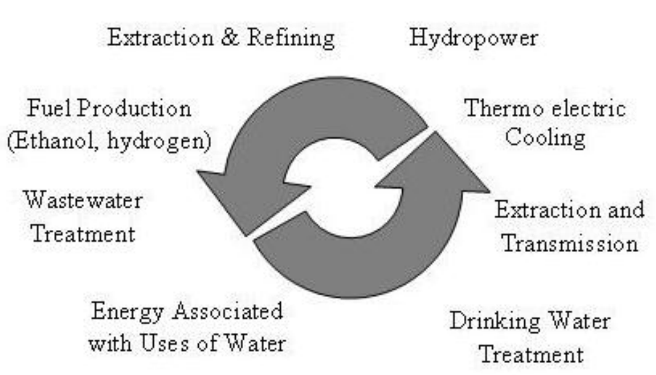

Fig. 4 Water and Energy

B. WATER IN DIFFERENT ENERGY TYPES

1) Hydropower

- Hydropower produced 89% of the world's renewable electricity in 2006, and 16.6% of total electricity generation worldwide. Two-thirds of worldwide economic potential remains unexploited – this resource is concentrated in the developing world.
- 25% of dams worldwide are used for hydropower and only 10% have hydropower as their main use. Most of them are used for flood control or irrigation, or for multiple purposes.
- Hydropower uses and releases water instantaneously or with a delay but do not consume water. Their main losses stem from evaporation when air temperatures are high.
- Energy output from hydropower is dependent on sustainable upstream water use as well as hydrological patterns, and is therefore susceptible to climate change impacts.
- Hydropower reservoirs store both water and energy and are becoming increasingly important for the management of climate change.

2) Solar, wind and ocean energy

- Solar thermal power plant water consumption is about 1 m3 of water per 103 kWh (electric) or 227 m3 of water per 1,000 Gj.
- Wind energy and photovoltaic cells that produce electricity directly from sunlight are considered to have negligible water use.
- Wave energy is still a largely untapped source of renewable energy, which, like hydropower, uses water but does not consume it.

3) Biomass electricity

Non-hydro renewable energy supply technologies, particularly solar, wind, geothermal and biomass, are currently small overall contributors to global heat and electricity supply, but are increasing most rapidly, albeit from a low base. Growth of biomass electricity is restricted due to cost, as well as social and environmental barriers. In general, the substitution of fossil fuels by biomass in electricity generation will reduce the amount of cooling water discharged to surface water streams.

4) Geothermal energy

Geothermal resources have long been used for direct heat extraction for district urban heating, industrial processing, domestic water and space heating, leisure and balneotherapy applications.

Geothermal fields of natural steam are rare, most being a mixture of steam and hot water requiring single or double flash systems to separate out the hot water, which can then be used in binary plants or for direct heating. Re-injection of the fluids maintains a constant pressure in the reservoir, hence increasing the field's life and reducing concerns about environmental impacts.

5) Nuclear energy

There are two types of cooling system for nuclear power plants:

- Open-loop water cooling, where water is withdrawn from a river, lake or the sea, and then returned to it after cooling. The average amount of water consumed is approximately zero and the water required and then returned is approx. 160 m3 / MWh (equivalent to 44, 444 m3 per 1,000 Gj).
- Closed-loop water cooling, where water flows into a closed circuit and part of it is evaporated through a cooling lower into the atmosphere. The average amount of water consumed (through evaporation) is approx. 2 m3 / MWh (555 m3 per 1,000 Gj) and the water required and then returned is approx. 6 m3 / MWh (equivalent to 1,666 m3 per 1,000 Gj).

V. RELATIONSHIP BETWEEN CLIMATE AND ENERGY

Improving observations of ocean temperature confirm that Earth is absorbing more energy from the sun than it is radiating to space as heat, even during the recent solar minimum. This energy imbalance provides fundamental verification of the dominant role of the human-made greenhouse effect in driving global climate change. Observed surface temperature change and ocean heat gain constrain the net climate forcing and ocean mixing rates. We conclude that most climate models mix heat too efficiently into the deep ocean and as a result underestimate the negative forcing by human-made aerosols.

The planetary energy imbalance caused by a change of atmospheric composition defines a climate forcing. Climate sensitivity, the eventual global temperature change per unit forcing, is known with good accuracy from Earth's pale climate history. However, two fundamental uncertainties limit our ability to predict global temperature change on decadal time scales.

First, although climate forcing by human-made greenhouse gases (GHGs) is known accurately, climate forcing caused by changing human-made aerosols is practically unmeasured. Aerosols are line Particles suspended in the air, such as dust. Sulfates and black soot .Aerosol climate forcing is complex, because aerosols both reflect solar radiation to space (a cooling effect) and absorb solar radiation (a warming effect). In addition, atmospheric aerosols can alter cloud cover and cloud properties. Therefore, precise composition-specific measurements of aerosols and their effects on clouds are needed to assess the aerosol role in climate change.

Second, the rate at which Earth's surface temperature approaches a new equilibrium in response lo a climate forcing depends on how efficiently heat perturbations are mixed into the deeper ocean. Ocean mixing is complex and not necessarily simulated well by climate models. Empirical data on ocean heat uptake are improving rapidly, but still suffer limitations.

VI. CHALLENGES ARISING FOR HUMAN SETTLEMENTS AND EARTH

- Shortage of safe drinking water and Unhygienic sanitation conditions.
- Constraints on water withdrawals.
- Energy supply will struggle to keep pace with increasing demand linked to increasing population and affluence.
- Constraints on energy efficiency and reduced emissions.
- Reduced water availability and increasing energy demand.
- Shortage of water for agriculture.
- Rising of water infrastructure cost.
- Adverse effects on human health.
- Extra burdening over water management plans or schemes.
- Ecological imbalances.
- Climatic changes.

VII. CONCLUSION

Encourage best practice through innovation, appropriate solutions and community engagement by

- **Efficiency:** Significant water and energy efficiency gains can be achieved by minimizing water losses in water supply systems, due to not only wasting the water itself, but also the energy used to pump and distribute it.
- **Renewable energy:** Renewable energy use can be encouraged for water treatment processes, as well as wastewater plants.
- **System design:** The design of future water and energy systems needs to take into consideration the trade-offs and synergies between both resources.
- **Policy:** Policy needs to be long-term and flexible to allow for the use of the most appropriate approach, depending on local conditions.
- **Data:** There is a need for both in-situ (via data collection) and satellite observations. This must include a key assessment, both in the short-term and long-term, of the impacts of climate change, not only on water quality and quantity, but also water timing (e.g., seasonal or monthly data, in addition to annual data).
- **Models:** Better predictions and early-warning systems about the effects of climate change at a regional scale are increasingly needed. This includes greenhouse gas (GHG) effects on the hydrological cycle and precipitation patterns, which means understanding the complexity of the water cycle and aquatic ecosystems and how these react to climate change.
- **Analysis tools:** Interim management tools, such as scenario building, are necessary to be able to deal with the complexity of variables including climatic, economic, demographic and regional changes.

Technology, innovation, a sense of shared responsibility and political will are factors that bring real solutions as we strive to keep pace with increasing needs from a growing population.

- Resolving growing issues surrounding water and energy priorities will require better and integrated policy frameworks and political engagement to address them satisfactorily for all stakeholders within and across watersheds.
- Leadership from all parts of society is a condition for change to happen.
- We need:

1) To get more energy out of each drop of water, and we need to get more water out of each unit of energy.
2) Diversified energy mixes and alternative water supplies, e.g., industrial wastewater recycling, municipal wastewater reuse, desalination, even though these are energy-intensive.
3) More natural infrastructure, such as rehabilitating wetlands and mangroves to mitigate flooding, thus reducing the impacts of climate change in optimal combination with the cost of engineered infrastructure.

A. BUSINESS IMPLICATIONS

- Pay for increased operational costs.
- Save water and energy.
- Treat and recycle own water and wastewater (with associated energy costs).

- Recover and reuse water and energy (e.g., using steam or heat, recycle other industrial and municipal wastewater).
- Developed new markets for water-and energy-saving technologies and services.
- Measure water and energy impacts.
- Engage with communities to reduce potential for conflict and risks to license to operate.
- Identity best approach depending on local conditions, for example, in water scarce countries.
- Wave energy is still a largely untapped source of renewable energy, which, like hydropower, uses water but does not consume it.

REFERENCES

[1] Climate change and water, Technical Paper VI by IPCC.
[2] Issue on Water, Energy and Climate change by World Business Council for Sustainable Development (WBCSD).
[3] WBCSD, Powering a Sustainable Future: An agenda for concerted action, facts and trends, 2006.
[4] Research Paper from Water, Energy and Climate Change.
[5] Research Paper on Water Sustainability and Climate (WS)
[6] World Water Development Report 3: Climate Change and Water by UNESCO.
[7] Report on Water Conservation = Energy Conservation for CWCB.