The Energy and Water Nexus:
Turning a Double Problem into a Solution

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The two major challenges facing humanity today are related. Despite technological progress, society is incapable of providing the world's population with two basic needs: energy and water. By 2050, the global population is expected to level off at between 9 and 10 billion people -- 50 percent more of us than there are today. Population growth is pushing food production systems to new limits. Food production, estimated by the FAO to double by 2050, is in turn increasingly water and energy dependent, and in competition with energy for transportation and power. Fighting climate change may further increase the tension between the two and force trade-offs over water use by an increasingly decarbonized energy system. This session brings together experts from the United States, United Kingdom, Germany, and European Union to examine the growing inter-linkage between energy and water systems. Can biofuels or biomass see us through, or do they represent a growing strain on water systems? What is the hidden impact of cooling water needs for "green technologies" such as concentrated solar power, nuclear energy, and carbon capture and storage? The latest insights into innovative, multidisciplinary approaches to solving the energy and water nexus will underpin the discussion.

Moderator: **Evangelos Tzimas, European Commission, JRC Institute for Energy**

Speakers:

Tony Allan, King's College London
The Global Energy Water Nexus

The purpose of the paper is to show how poorly understood the water-energy security nexus is. The significance of this invisible nexus and related environmental uncertainties have gained prominence in the past decade. This prominence has lagged the public profile of the global warming discourse. It has become evident that there is a suite of global uncertainties about environmental and economic security and sustainability – suggesting the acronym GUESS.

Two centuries of the industrialisation of agriculture, of manufacturing, of services and of trade has had very serious impacts on the global natural resources of land, energy, water and the atmosphere. The processes of use, and the outcomes of such use, of these different global resources have not been equally well theorised. Nor has an analytical framework been developed to capture the grand nexus of water-food-trade-energy-climate change. Awareness of the energy/carbon-climate change element of the nexus has risen rapidly in the past three decades helped by concepts such as carbon footprints. The water-food-trade element of the nexus has, over the same period been well conceptualised with ideas such as embedded water and water footprints. It is only in the past decade, however, that the links between the industrialised use of water and energy across the international political economy has been identified. First, major players in the world economy – big-oil, big-auto, big-ag, big-food processing and trading – have been forced to consider the security, cost and finally the environmental sustainability of the ways they source and use natural resources. Sometimes their immediate, and certainly longer term, supply chains have been shown to be insecure. Secondly, important international NGO and some international agency voices have been significant in advancing awareness of the grand nexus. Meanwhile, national governments have been slow to join the discourse and have tended to restrain it.

The paper will rehearse the links and synergies that have been identified in this early phase of conceptualisation of the water-energy nexus. For example clean energy can be generated via hydropower or by producing bio-ethanol from biomass. Clean water can be produced by using energy intensive desalination and other water treatment technologies. These impacts have until now been invisible to water and energy users as well as to policy-makers.

The paper will conclude with a review of the importance of conceptualising the idea of sustainable intensification as seen through the lens of the grand nexus of water-food-trade-energy-climate change. The nearly seven billion current population has only been able to be supported by intensifying their natural resource using systems. This extraordinary achievement is proving to be environmentally unsustainable. It will be necessary to support about nine billions by further intensification. But in ways that are environmentally sustainable.

Kathleen Miller, National Center for Atmospheric Research
Water and Energy: How Will Climate Change Reshuffle the Cards?

Water and energy are mutually interdependent, in that water is needed for the production of energy and energy is needed for pumping, treating and transporting water to a variety of final consumers. In addition, energy is needed to treat wastewater to prevent fouling of natural water bodies. The energy footprint of the water sector is substantial. For example, in California it is estimated that close to one-fifth of electricity demand is associated with managing water. The impacts of climate change on water availability and use will affect energy demand, while changes in energy prices associated with efforts to reduce greenhouse gas emissions will have impacts on the water sector. This talk will focus on the potential impacts of climate change on the water-energy nexus in the western United States, and will explore the impacts of changes in the timing of snowmelt on hydropower generation and consumptive water uses for irrigation and municipal supply. In particular, it will focus on the challenges facing urban water providers as they seek to both achieve water supply security and reduce the energy intensity of their operations. The efforts of cities along Colorado's Front Range to implement a risk-management approach to climate adaptation planning will provide insights on how the planning process can be structured to facilitate joint consideration of changes in water availability and changes in energy costs and supply sources arising from policies to reduce carbon emissions.

Jerry Sehlke, Idaho National Laboratory
What Low-Carbon Energy Technologies Can Do To Improve Water Supply

Low- carbon energy technologies can be thought of as fuels or generation processes that produce fewer greenhouse gasses than traditional fossil fuel (e.g., coal and oil) combustion; although speaking broadly they can also include emission mitigation technologies (e.g., capturing or "scrubbing" greenhouse gas emissions). The imperative for migrating to low-carbon energy technologies is to reduce greenhouse gas releases to the atmosphere and their attendant impacts on the global climate, humans and the environment. One of our grand challenges is to create affordable, sustainable supplies of low-carbon energy to meet society's needs while minimizing its impacts on society and the environment.

Low-carbon energy technologies can help address both water quantity and water quality issues, but none in themselves provide a "silver bullet" that can solve all of our energy, carbon and water challenges. Each technology has its own set of costs and benefits which must be balanced. For example, most renewable electricity supplies are clean and "unlimited" supplies, but added costs arise from the intermittent and distributed nature of these resources. Low-carbon fossil and conventional nuclear are firm sources of electricity, but carbon reduction comes at the cost of higher water demands and either higher energy requirements (e.g., Carbon Capture and Storage [CCS]) or more extensive governmental oversight (e.g., nuclear). For bioenergy crops, there are emissions reductions, but at the cost of increased water demand, and increased competition with food production and ecosystem services.

Depending on the energy technology employed, significant quantities of water may be used or saved in upstream processes (e.g., mining, pumping and processing fuels), fuel combustion/energy generation process and downstream processes (e.g., CCS). And the technology employed may increase or decrease energy production impacts on water quality in each step of the process.

If energy production and use are to become more sustainable, then future energy systems must provide reliable energy supplies, reduce greenhouse gas emissions and ease the growing strain on global water supplies. Our challenge is not to decide which energy technology is THE technology that should be employed; this answer will not be the same in all places. Our challenge is to develop a uniform method for systematically evaluating the full energy supply-carbon-water costs and benefits for each technology and evaluating the various options that can be broadly applied to enable different regions to find the "energy mix" that works best for them.

This discussion will summarize the different water characteristics of commercially deployable forms of low-carbon energy, and the water limitations of different types of environments. It will then provide examples of how different combinations of low-carbon energy technologies can exacerbate or alleviate local or regional water challenges. Finally, it will provide a summary of key opportunities and challenges to transitioning towards a more sustainable low-carbon energy future.

Evangelos Tzimas, European Commission, JRC Institute for Energy
Sustainable or Not? Impacts and Uncertainties of Low-Carbon Energy Technologies on Water

Water is a key element of our energy system. It represents a valuable renewable energy resource, which is converted to electricity in hydro-power plants to meet both baseload and peak demand thus assisting the regulation of our power system. Furthermore, water has an indirect but significant role in the energy system as it drives the turbines, as steam, and provides for the cooling necessary for the operation of coal, natural gas and nuclear power stations, which generate most of the electricity consumed by our society; and is vital for the development of biomass resources, which are used for power generation and as an alternative fuel for transport, as biofuels, albeit today at small quantities.

It is apparent that the anticipated increase in energy demand, mainly for electricity and transport fuels, both in developed and developing economies, will increase water use and consumption in energy applications. It is however frequently overlooked that the future energy technology mix will also have a profound effect on water needs. The pressing need to reduce the emissions of greenhouse gases, which mostly result from the burning of fossil fuels in the power generation and the transport sectors, is currently driving the development and deployment of new technologies with a largely reduced carbon footprint, with the aim to replace the current carbon-intensive energy technology mix in the medium to longer term. While, many of these low carbon technologies will not require water for their operation, such as wind and solar photovoltaic systems, others will require significant water quantities, such as carbon capture and storage and concentrating solar power technologies. In addition, new pumped hydro-plants need to be constructed to offer large scale electricity storage, which is essential for the large scale deployment of wind and solar intermittent energy sources; and the utilization of biofuels is expected to increase as a response to the need to decarbonise the transport sector. Therefore, the future need for water resources for the energy sector will be determined by the degree of increase of energy consumption by our society and the deployed mix of low carbon energy technologies.

This presentation will attempt to assess the needs for water in the European energy system in the medium to long term. Initially, the water consumption for key low carbon energy technologies, such as carbon capture and storage, biomass and biofuels, and concentrating solar power will be identified and will be compared to that for conventional energy technologies deployed on large scale today. Based on this information and on published scenarios for the evolution of the European energy system to 2030, calculations will be presented that assess the needs for water in the power generation and transport sectors and compare them with figures reflecting current consumption. Finally, the areas where low carbon technologies could improve to reduce water needs, whilst maintaining their techno-economic performance characteristics, will be identified.

Joachim Koschikowski, Fraunhofer Institute for Solar Energy Systems (ISE)

Water Desalination: When and Where Will It Make Sense?

The earth is called "the blue planet". The reason is that about 71% of the earth surface is covered by water. Humans consist of about 60% water, some animals up to 70% and some plants even up to 95%. How can water shortage appear if 71% of the earth surface consists of water? The problem is that more than 97% of global water resources are "salty water" meaning that the salt content of the water is too high for drinking and also for irrigation. About 70% out of the remaining 3% of fresh water are stored in the ice of the polar caps. Another share is stored in deep ground water resources which are inaccessible. Finally only about 0.3% of global water resources are available from rivers, lakes or accessible ground water resources. The exponential growth of world population can be found mainly in the dry regions of the world (Africa, India) which leads to a shoot up of food demand causing an additional intensive stress on already short water resources. In many of those regions the groundwater level is dropping down by several meters every year leading to complete shortfalls or high salt intrusions making the water inconsumable. The fast growth of industrialization particular in some parts of Asia leads to a high pollution of rivers and the aquifer due to none sustainable use of the available resources. According to predictions for the year 2025 large parts of Africa and central Asia will be affected strongly by water shortage. It is expected that out of 7.2 billion people living 2025 in the world, 3 billion people (40%) will be strongly affected by water shortage. But even today the shortage of clean potable water is already a significant problem in several regions of the world and the reason for conflicts and war. An option to create new fresh water resources is the utilization of sea water by desalination, which can be considered as inexhaustible source. Particular in the Gulf region some countries do not have any natural fresh water resources but cover 100% of their demand by desalination of sea water. Also countries in southern Europe as Spain must supply part of their water by processing water from the sea. Today about 50mio m³ of fresh water are produced world wide by desalination daily and the number of new installed capacities is rising rapidly. The main draw back of desalination is the very high energy demand. The presentation will provide further information about the development of the desalination market. Different desalination technologies will be introduced and their technical boundaries will be explained. Furthermore some ideas and current trends regarding the employment of renewable energies for desalination will be discussed.