

WATER ISSUES FOR ELECTRICAL ENGINEERS

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REMOTE SENSING AND WATER

- Global Earth Observation System of Systems (GEOSS), Water Theme
 - Leaders: Pai-Yei Whung, EPA Chief Scientist; John Lyon, EPA Senior Scientist
- IEEE Committee on Earth Observation (ICEO), Water for the World
 - Leaders: John Lyon; Tom Wiener, Jay Pearlman, IEEE GEOSS Leads
- “Remote Sensing of Global Croplands for Food Security”, Thenkabail, Lyon, Turrall, Biradar, CRC Press 2009
- ISSUES IN SCIENCE AND TECHNOLOGY, SUMMER 2009, NATIONAL ACADEMY OF SCIENCE, “Abolishing Hunger” Ismail Serageldin
 - “New technologies can now map groundwater reservoirs with satellite imagery. It is imperative that international mapping of locations and extent of water aquifers be undertaken. ... it is likely that as much as 10% of the world’s grain is grown with water withdrawals that exceed the recharge rate of the underground reservoirs on which they draw”



GEOSS

- The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS.
- GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.
- GEO is a voluntary partnership of governments and international organizations. It provides a framework within which these partners can develop new projects and coordinate their strategies and investments. As of June 2009, GEO's Members include 79 Governments and the European Commission. In addition, 56 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations.
- GEO is constructing GEOSS on the basis of a 10 year implementation plan for the period 2005 to 2015. The Plan defines a vision statement for GEOSS, its purpose and scope, expected benefits, and the nine "Societal Benefit Areas" of disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.

GEOSS WATER

- OBJECTIVE-Freshwater is vital for households, agriculture, and industry, and ever larger quantities will be needed for burgeoning human populations over the coming decades. Unfortunately, current observation systems cannot adequately monitor long-term changes and transfers in the global water system and their implications for people, the climate, and biodiversity. The amount of freshwater available for human consumption and for ecosystem services is affected by many variables. The Global Earth Observation System of Systems seeks to track these variables by filling in existing information gaps about water resources, integrating data sets from various monitoring systems, developing better forecasting models, and disseminating the results to a wider range of decision makers. A key next step for the GEOSS will be to combine water-level data from satellite-based radar altimeters with data from ground-level, in-situ monitors. This will improve the ability of water managers to map the water cycles of major rivers. The Group on Earth Observations is also standardizing metadata and improving the accuracy of data and predictions. It aims to establish global prediction models and then develop national-level models and finally river-basin or catchment-level models. These models will eventually become interoperable, creating a “system of systems” that will facilitate the global exchange of observation data and forecasting information.
- ACHIEVEMENTS
 - [Asian Water Cycle Initiative \(AWCI\)](#)
 - [Canada's National Land and Water Information Service \(NLWIS\) –Drought watch](#)
 - [Global Runoff Data Centre \(GRDC\)](#)
 - [Hydrometeorological ARray for ISV-Monsoon AUtomonitoring \(HARIMAU\)](#)
 - [North American Drought Monitor](#)
 - [The WISE \(Water Information System for Europe\) viewer](#)

GEOSS TASK

- *Sub-task Number: WA-08-01e*
- *Sub-task Title: Water Cycle Data Integration*
- *Overarching Task: Integrated Products for Water Resource Management and Research*
- *Area: WATER*
- *Related Communities of Practice: Water Cycle (former IGWCO)*
- *Relevant Committee: (to be determined in 2009)*
- *Related Targets: (to be included in 2009)*
- *Sub-task Definition (as given in the 2009-2011 Work Plan):*

- ***Upcoming satellite launches and plans for new missions provide new global data sets that will supplement the in-situ networks for many water cycle variables. The Coordinated Energy and water cycle Observations Project (CEOP) under the WCRP Global Energy and Water-cycle Experiment (GEWEX) is tailoring and developing tools to access the various data collections and undertake data integration work over the Internet.***

- *Leads (GEO Member or PO, Entity carrying out the work, Contact: e-mail):*
- *WMO,*
- *(CLW/HFWR), Point of Contact: Wolfgang Grabs, WGrabs@wmo.int*
- *Canada (Univ. of Manitoba), Ron Stewart, ronald.e.stewart@gmail.com*
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- *WCRP (GEWEX), Sam Benedict, sam.benedict@gewex.org*



GEOSS/ICEO TASK

- *Sub-task Number: WA-08-01f*
- *Sub-task Title: Pilot Projects for Improved Water Discovery and Quality Assessments*
- *Overarching Task: Integrated Products for Water Resource Management and Research*
- *Area: WATER*
- *Related Communities of Practice: Water Cycle (former IGWCO and IGOS-P), Coastal and Inland Waters and Water Quality (former IGOS-P, could be GOOS and is IOOS)*
- *Relevant Committees: User Interface, Capacity Building, Architecture and Data, Science and Technology*
- *Related Targets: a variety of Tasks and Targets to be enumerated*
- *Sub-task Definition (as given in the 2009-2011 Work Plan):*

- ***Conduct Pilot Projects in cooperation with local, regional, and national groups, and GEO and other organizations to provide water quantity and quality assistance where it is needed, but not now available. These projects over twelve in number are focused on developing countries and realizable in the field within one year, and/or slightly more in time. They will be sustainable, reusable, repeatable, and scalable. Currently, the sub-Task has submitted more than four of the Pilot Projects for potential funding by sponsor groups. A report providing background and justification was available at GEO-V in Bucharest at the IEEE booth describing the efforts, and the report and oral/poster sessions as well as the User Interface Committee booths also presented the efforts at the International Remote Sensing of Environment Symposium in Stresa, Italy in May 2009. Current efforts focus on presenting the proposals to other potential sponsor organizations.***

- *Leads (GEO Member or PO, Entity carrying out the work, Contact: e-mail):*
- *IEEE, John Lyon, Point of Contact, lyonjohn@aol.com; Jay Pearlman, jay.pearlman@ieee.org; Tom Wiener, T.Wiener@ieee.org*
- *USA (EPA), Gary Foley, foley.gary@epa.gov; Pei-Yei Whung, Whung.pei-yei@epa.gov*
- *Motivation/Background*
- *It is vital that GEO and GEOSS serve purposes in developing countries and help shape the advancement of science in a positive and demonstrable sense. The IEEE Water for the World activity was envisioned by a number of thoughtful people, familiar with GEO and imbued with the vision, who have seen opportunities to help in the water arena. This group of Geosec staff, volunteers, caring scientists and engineers, IEEE people, and others have worked hard to create an opportunity through Pilot Projects to advance water issues and their solution and to use the GEO process and GEOSS approach to help.*



IEEE COMMITTEE ON EARTH OBSERVATIONS (ICEO)

- Water for the World
 - Water for the World - an international panel supported by the IEEE New Initiative Committee is defining priority issues and opportunities for developing an Actionable Vision to provide Water for the World. The Vision includes pilot programs that will demonstrate the effectiveness of the Vision and will lead to wider acceptance and dissemination of our engineering approach to water availability.
 - This is a three phase program. Phase One, to be accomplished by December 2008, will develop details of the Vision, and a program plan for a pilot study in the next phase(s). The international expert panel of Phase One will assess and prioritize issues in water availability, address technology and engineering approaches for quantifying both availability and quality of water resources and then focus on one of the three major aspects above for a pilot project. In addition to defining the pilot program, funding for its implementation must be identified. In these efforts, the ICEO will consult with various regional and international authorities. The ICEO plans to enroll these government authorities in the location recommended for the Phase Two Pilot Project with a goal of a 2009 start.
 - The Third Phase, building on the successes and the lessons of the pilot, will look at the reliability and sustainability of the process developed during Phase 2



ICEO PILOT PROJECT PROPOSALS

- Africa-Asia Climate Change Vulnerability
- Amazon Water Quality
- Aquifer Health Assessment
- Bangladesh Arsenic Removal
- Drilling in Mozambique
- Food Processing
- Ghana Weija Reservoir Management
- HydroSHEDS
- Irrigation Management
- Lake Nicaragua Water Quality
- Limpopo Water and Sanitation
- Nano-engineered Purifiers
- Small Irrigation
- India Water Harvesting

PILOT PROJECTS

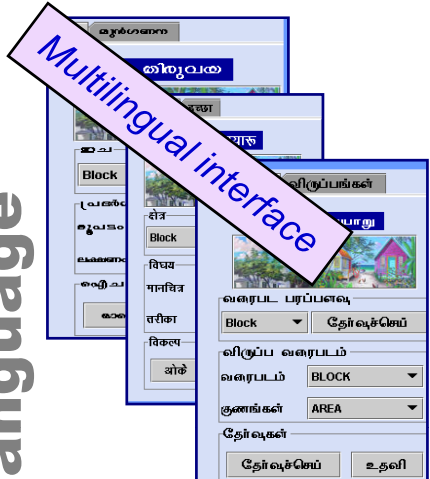
INDIA WATER HARVESTING

- Rainwater harvesting for domestic and supplemental irrigation to upgrade rain-fed farming towards food security and sustainable livelihood in Indian desert
 - Create geo-spatial database using GIS and earth observation data sets
 - Current land use, current agricultural practices, productivity of crops in rain-fed condition, soil resources, quality of water, sources of domestic water, income levels and other socio-economic parameters
 - Construct improved cistern to collect water
 - Roof top water harvesting
 - Supplementary irrigation
 - On-farm training

 - Participants
 - Regional Remote Sensing Service Centre
 - MARWAR GEO-CULTURAL SOCIETY
 - IEEE Committee on Earth Observation



Query Shell in local language



Farmer Detail...

P R A Summary

Name Of The Farmer :	வெங்கிடாஜலம்
Patta Number :	531
Survey Number :	177
Sub Number :	3
Wet Land :	7.5
Dry Land :	

CURRENT LANDUSE

FALLOW

SOIL CHARACTERISTICS

Series : PADOGAN
 Texture : SANDY CLAY LOAM
 Erosion : SLIGHTLY ERODED

ALTERNATIVE CROPS

With Water Available
 Vegetables, Flowers

With Less Water Available
 Groundnut, Sesame, Sugar Beet, Sweet Sorghum

WATER RESOURCE

Farm Ponds
 Dredging of Tank
 Sub-surface Dyke

NR & Socio economic database



Components

- EO based Information
- Advisory related to Agriculture, Fisheries, ...
- Digital Connectivity
- Tele-Education, Tele-Medicine



Unfavorable erratic rainfall distribution, High PET and Subsistence type of rainfed farming

Rain Water Harvesting Systems -improved cistern & tanks

➤ Storage for supplemental irrigation to field crops & Orchard

➤ Increased production of staple food crop and more income from orchard plantation

1020
m³

➤ Storage for annual domestic requirement for family of five people

84 m³

➤ Storage for annual requirement of five cattle per family

110 m³

➤ Food Security and Sustainable Livelihood at Household level

GHANA WEIJA RESERVOIR MANAGEMENT

- Project Goal-Planning for restoration of the ecosystem health of Weija Dam and improvement of water security
 - Develop geo-spatial database for sustainable management of urban water supply systems
 - Develop techniques for using geospatial technology for sustainable resource management
 - Develop a model for application to other urban water supply systems
 - Training and education
 - Participants
 - Geoinformation Services of Accra
 - IEEE Committee on Earth Observation

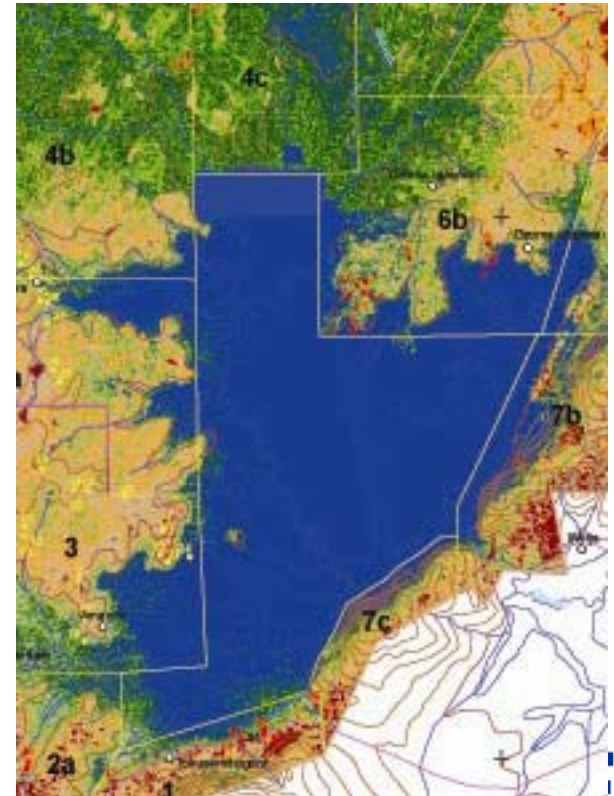
IEEE “Water for the World” Pilot Proposal Accra, Ghana

**GHANA GOVERNMENT FUNDS \$7 MILLION PROJECT TO FENCE OFF THE
CATCHMENTS OF THE WEIJA DAM- Accra, Ghana August 2008 (GNA)**



- PILOT PROJECT PROPOSED TO ADDRESS STEPS FOR ACCRA WATER SECURITY USING GEOSPATIAL TECHNOLOGY

- GEOSPATIAL INFORMATION IS ESSENTIAL FOR PLANNING AND DECISION SUPPORT

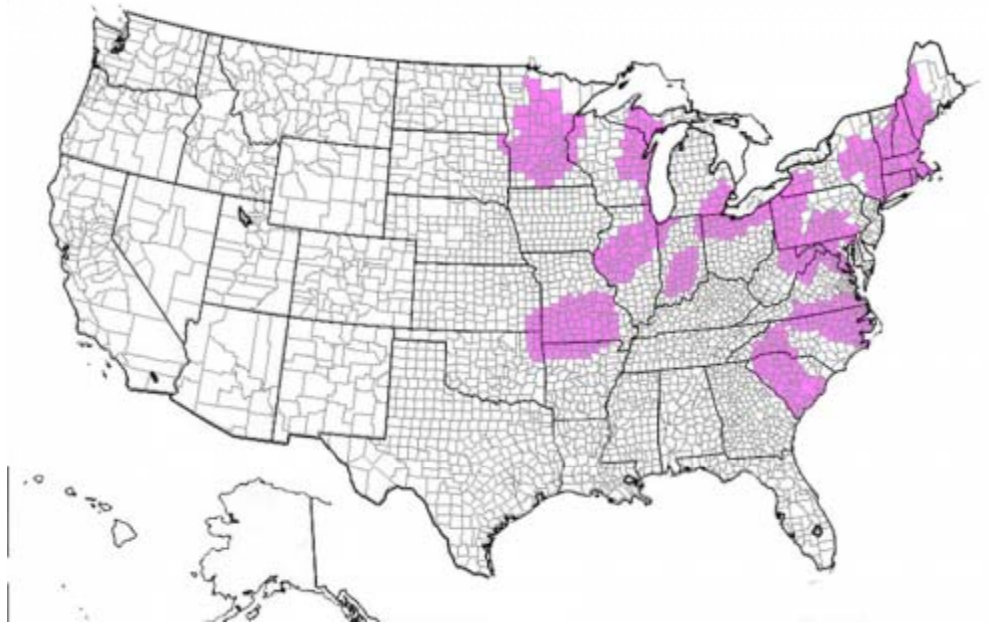


Weija Reservoir (NE of Accra)

WATER-ENERGY NEXUS

- “Energy Demands on Water Resources”
 - Report to Congress on the Interdependency of Energy and Water
 - U.S. Department of Energy, December 2006
- “Technology Research and Development Efforts Related to the Energy and Water Linkage”
 - Hearing-House Subcommittee on Energy & Environment, July 9, 2009
 - Dr. Kristina Johnson, Undersecretary of Energy DOE
 - Dr. Bryan Hannegan, VP Environment and Generation EPRI
 - Ms. Anu Mittal, Dir. Natural Resources and Environment, GAO
 - Mr. Terry Murphy, President SOLARRESERVE
 - Mr. Richard Stanley, VP Engineering Division GE Energy

AREAS WHERE $>50\%$ WATER WITHDRAWALS GO TO ENERGY PRODUCTION (The WaterCAMPWS)



WATER-ENERGY NEXUS

- The amount of fresh water withdrawn nationally for electricity production is more than twice as much as the water used for residential, commercial, and industrial purposes, and is comparable to the amount of water used for agricultural irrigation. Meanwhile, pumping, storing, and treating water consumes huge amounts of electricity—an estimated 7 percent of California's electricity consumption is used just to pump water.
- Testimony of David Garman to the House Subcommittee on Water and Power May 24, 2005

KRISTINA JOHNSON (FIEEE)

TESTIMONY

- Thermoelectric Power
 - April 2007 drought in SE US reduced nuclear power by up to 50%
 - In 2005 147 Bgal/d fresh water withdrawn, 3.7 Bgal/d consumed for cooling systems
 - DOE Research Focus-Advanced Water Management technologies
 - Non-traditional sources of process and cooling water
 - Innovative water reuse and recovery
 - Advanced cooling technology

KRISTINA JOHNSON

TESTIMONY (2)

- Carbon Capture and Sequestration
 - Increase water consumption due to addition of processes that are both energy and water intensive
 - Capturing 90% of carbon emissions could > double water consumed

DOE R&D focus on mitigating potential impact of CO₂ capture

- Sequestration itself can impact underground water

BRYAN HANNEGAN

TESTIMONY

- Thermoelectric power plant cooling uses 40% of withdrawals, 3% of consumption
- Water use per unit of power has declined however growth in power demand has increased use of water
- Largest users of water are nuclear and coal-based plants
- Advanced cooling technologies can reduce water use but leads to increased cost and loss of efficiency
- EPRI with DOE identified a \$40M, 10 year research program. Focus-reduce cost of cooling options and demand for fresh water resources
- Research efforts are urgently needed to mitigate the expected shortfall in water needs

WATER WITHDRAWALS 1950-2000

	1950	1960	1970	1980	1990	2000
Withdrawals (billion gal)	14,500	36,500	62,100	77,000	71,000	71,000
Power Generated (billion MWh)	0.23	0.61	1.28	2.00	2.68	3.45
Water Withdrawal Efficiency (gal/MWh)	63,000	60,000	49,000	39,000	27,000	21,000

OTHER TESTIMONY

- Anu Mittal-Preliminary Observations on the Links between Water and Biofuels and Electricity Production
- Terry Murphy-Molten Salt Technology for Concentrated Solar Power Plants
- Richard Stanley-Challenges surrounding the use of water in power generation, role of current technology and the need for targeted R&D through public-private partnerships

ELECTRIC POWER GENERATION WATER USE

Mike Hightower , Sandia National Laboratory

Table 1-1. Electric Power Generation Water Use

Plant-type	Cooling Process	Water Use Intensity (gal/MWh)		
		Steam Condensing ^a		Other Uses ^b
		Withdrawal	Consumption	Consumption
Fossil/ biomass steam turbine ^c	Open-loop	20,000–50,000	~200–300	~30–90 ^{d,i}
	Closed-loop	300–600	300–480	
	Dry	0	0	
Nuclear steam turbine ^c	Open-loop	25,000–60,000	~400	~30 ^d
	Closed-loop	500–1,100	400–720	
	Dry	0	0	
Natural Gas Combined-Cycle ^c	Open-loop	7,500–20,000	100	10 ^e
	Closed-loop	~230	~180	
	Dry	0	0	
Coal Integrated Gasification Combined-Cycle ^c	Closed-loop	200	170	150 ^{e,e}
	Dry	0	0	150 ^{e,e}
Geothermal Steam ^f	Closed-loop	2000	1350	NA
Concentrating Solar ^{g,h}	Closed-loop	750	740	10
	Dry	10	0	10
Wind and Solar Photovoltaics ^j	N/A	0	0	1–2
Carbon sequestration for fossil energy generation				
Fossil or biomass ^k	All	~30% increase in water withdrawal and consumption		

REFERENCES

- **a** Values are included for a range of plant designs, cooling water temperatures, and locations
- **b** Includes water for equipment washing, air emissions control, restrooms, and other water uses
- **c** U. S. Water Consumption for Power Production—the Next Half Century, Water and Sustainability (Volume 3): No. 1006786. Electric Power Research Institute, 2002. (EPRI, 2002)
- **d** “Comparison of Alternate Cooling Technologies for California Power Plants: Economic, Environmental and Other Tradeoffs,” CEC-500-02-079F, February 2002, California Energy Commission. (CEC, 2002)
- **e** “Cost and Value of Water at Combined-Cycle Power Plants” California Energy Commission, CEC-500-2006-034. (CEC, 2006)
- **f** California Power Authority, personal communication with M. Grande, 2005 (Grande, 2005)
- **g** Final Report on the Operation and Maintenance Improvement Program for Concentrating Solar Power Plants, Sandia National Laboratories, 1999. (Cohen, 1999)
- **h** Fuel from the Sky, National Renewable Energy Laboratory, Golden, Colorado, 2002.(Leitner, 2002)
- **i** “Program Facts: Innovative Approaches and Technologies for Improved Power Plant Water Management.” Department of Energy, National Energy Technology Laboratory (NETL, 2006a)
- **j** “Water and Energy”, in Annual Review of Energy and the Environment, 1994, 19:267-299 (Gleick, 1994)
- **k** “Incremental Cost of CO₂ Reduction in Power Plants”, IGTI ASME Turbo Expo 2002 (Narula, 2002)
- Narula, N.G., H. Wen, K. Himes, (2002). “Incremental Cost of CO₂ Reduction in Power Plants,” Proceedings of IGTI ASME TURBO EXPO 2002, Amsterdam, Netherlands, June 3-6, 2002.

ENERGY AND WATER INTEGRATION ACT OF 2009

S. 531

- Sponsors: Senators Bingaman and Murkowski
- Hearing: March 10, 2009
 - Carl Bauer-Director NETL
 - Stephen Bolze-President and CEO, Power & Water, GE Energy
 - Peter Gleick-President, Pacific Institute
 - Lon House-Energy Advisor, Association of California Water Agencies
 - Michael Webber, Asst. Professor, The University of Texas
 - Peter Williams-CTO “Big Green Innovations”, IBM

Secretary of Energy-NAS analyze impact of energy development on water resources, include assessment of water withdrawn and consumed in production of transportation fuels. Conduct study on maximizing water and energy efficiency in the production of electricity.

Secretary of Interior-Evaluate quantities of energy used in water storage and delivery operations, operate Brackish Groundwater National Desalination research Facility to promote BGD as a method to increase water supply

Conduct assessment of energy consumption in the economy associated with the acquisition, treatment, or delivery of water

Secretary of Energy-Develop an Energy-Water R&D Roadmap



“THE WATER FOOTPRINT OF BIOFUELS: A DRINK OR DRIVE ISSUE?”

• Process	L/MWh
• petroleum extraction	10–40
• oil refining	80–150
• oil shale surface retort	170–681
• NGCC power plant, closed loop cooling	230–30,300
• coal IGCC	900
• nuclear power plant, closed loop cooling	950
• geothermal power plant, closed loop tower	1900–4200
• EOR	7600
• NGCC, open loop cooling	28,400–75,700
• nuclear power plant, open loop cooling	94,600–227,100
• corn ethanol irrigation	2,270,000–8,670,000
• soybean biodiesel irrigation	13,900,000–27,900,000

AUTHORS

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- Susan Powers; Clarkson University
- Joel Burken; Missouri University of Science and Technology
- Pedro Alvarez; Rice University

LINKS

- S. 531
 - <http://thomas.loc.gov/cgi-bin/thomas>
 - [House of Representatives Hearing](#)
 - http://science.house.gov/publications/hearings_markups_details.aspx?NewsID=2540
 - [GEOSS](#)
 - <http://earthobservations.org/>
 - ICEO
 - <http://www.ieee-earth.org/>
 - IGWCO
 - http://www.earthobservations.org/wa_igwco.shtml
- Biofuels
- <http://pubs.acs.org/doi/abs/10.1021/es802162x>

QUESTIONS OR COMMENTS

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REDUCING WATER NEEDS IN THE ELECTRIC SECTOR

- Degraded Water Sources
 - Equipment fouling issues, Cost, Unavailability due to use for irrigation, etc
- Dry Cooling
 - Cost, Size, Noise, Wind Effects
- Hybrid Cooling
 - Becoming popular due to minimizing additional cost by reducing tower size
- Combined Cycles
 - Improved efficiency implies reduced water use
- Water recapture and Water Reuse
- Role of Renewable Resources
- Advanced Desalination

GEOSS EXAMPLE TASK

- **WA-06-07: Integrated Earth Observation Water Resource Management**

This Task is led by IGOS-P and Tunisia.

Initiate capacity building programs to develop tools for using Earth Observation data in support of water management, and to show the value of Earth observations generally in water resource management. The program will be initiated in Latin America and will then be extended to Asia and Africa. Linkages with existing efforts of GEO Members and Participating Organisations will be made.

- **WA-07-01: Global Water Quality Monitoring**

This Task is led by Finland and IGWCO.

Many aspects of water quality monitoring and assessment, both in-situ and remotely sensed are severely deficient. Many countries lack the technical, institutional, and financial resources to conduct proper assessments using in-situ water quality monitoring methods for terrestrial sources and in the coastal ocean. Remote-sensed operational systems of global-scale freshwater quality are non-existent. Operational observation systems need to be developed, and the resulting information systems should be made compatible and interoperable as part of the system of systems. This Task is built on the outcomes of the water quality workshop in 2006 (1st Inland and Coastal Water Quality workshop) and first pilot projects are being planned to begin in Asia as a result of the Asia Water Resource Management Capacity Building Workshop. This Task has relevant synergies with HE-07-0