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Adapting Infrastructure and Civil Engineering Practice to a Changing Climate: Civil Engineering Sectors

American Society of Civil Engineers Committee on Adaptation to a Changing Climate

Editor's Note

The American Society of Civil Engineers formed the Committee on Adaptation to a Changing Climate (CACC) in 2011, to identify and communicate the technical requirements and civil engineering challenges for adapting to climate change. The CACC produced the report "Adapting Infrastructure and Civil Engineering Practice to a Changing Climate." An excerpt from that report is featured here. This report provides valuable perspective for viewing the impacts of climate change through the eyes of civil engineers.

Introduction

Civil engineers are responsible for the planning, design, construction, operation and maintenance of physical infrastructure. Infrastructure includes buildings of all types, communication facilities, energy generation and distribution facilities, industrial facilities, transportation networks, water resource facilities and urban water systems. Infrastructure is expected to remain functional, durable and safe for long service lives, typically 50 to more than 100 years. They are exposed to, and potentially vulnerable to, the effects and extremes of climate and weather, such as droughts, floods, heat waves, high winds, storm surges, fires and accumulated ice and snow. Engineering practices and standards are intended to provide acceptably low risks of failures regarding functionality, durability and safety over the service lives of infrastructure systems and facilities.

There is strong evidence that the Earth is warming. Increases in atmospheric and ocean temperatures, increases in extreme precipitation and intensity in many areas, and global sea-level rise have already been observed. These trends are projected to continue into the future. While there is considerable evidence that climate is changing, understanding the significance of climate change at temporal and spatial scales relevant to engineering practice is more difficult.

The long-lived nature of infrastructure and the even longer-term influence of the associated right-of-ways and footprints suggest that the climate of the future should be taken into account when planning and designing new infrastructure. Considering the impacts of climate change in engineering practice is analogous to including forecasts of long-term demands for infrastructure use as a factor in engineering design. However, even though the scientific community agrees that climate is changing, there is significant uncertainty about the location, timing and magnitude of the changes over the lifetime of infrastructure. The requirement that engineering infrastructure meets future needs and the uncertainty of future climate at the scale of the majority of engineering projects leads to a dilemma for practicing engineers. This dilemma is a gap between climate science and engineering practice that must be bridged.

This article, condensed from the original "Adapting Infrastructure and Civil Engineering Practice to a Changing Climate" report, defines potential impacts on engineering practices and civil engineering sectors. The needs, approaches and changes in practice presented in this article are applicable not only to civil engineering but also to many other engineering disciplines.

Civil Engineering Sectors

Following are reviews of the traditional infrastructure sectors and a special theme:

• buildings and other structures (buildings of all types and structural aspects of other infrastructure)
• transportation (highways, culverts, bridges, rail, airports, ports, navigation, pipelines)
• water resources (dams, levees, irrigation, reservoir management, flood risk management, drought management)
• urban water systems (stormwater, water supply and wastewater systems)
• coastal management (erosion, seawalls, groins, dredging)
• energy supply (power generation: hydropower, wind engineering, thermal plant cooling, fuel supply)
• cold regions (freeze-thaw cycling, changes to permafrost environments, snow accumulation and distribution)

Buildings and Other Structures

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Scope of the sector and its major engineering practices. The term *structure* in engineering and architecture means a body or assemblage of bodies in space to form a system capable of supporting loads. Examples include buildings, aircrafts, ships, bridges, etc. Constructed structures are divided into buildings and non-buildings (i.e., other structures) erected or constructed for particular functions and make up the infrastructure of a human society. Built structures are composed of structural elements such as columns, beams and trusses. The particular case of buildings as a subset of structures can have a permanent or temporary nature, are usually enclosed by walls and a roof, and are constructed to provide support or shelter for an intended occupancy. Buildings and other structures include all attached apparatus, equipment and fixtures.

A life-cycle approach offers a rational basis for examining climate change adaptation for structures. A typical life cycle includes:

• planning (Is this the right structure in the right place? Can it be situated well above projected flooding levels?)
• conceptual design (an important opportunity to control hazards – for example, a buried power line is free from wind and ice loadings but might be exposed to flooding)
• design (applying a low-regret approach or an observational approach while complying with applicable codes and standards)
• construction (e.g., nighttime placement of concrete in case of heat waves and monitoring moisture content)

• commissioning
• operation
• maintenance
• renovation or removal and disposal

The development of an adaptation plan for structural engineering practices should include the reconsideration of the following key aspects:

• natural hazards (fire, flooding, drought, waves, rain, snow, ice, wind, etc.)
• loads and load combinations (service load demands, such as building occupancy, and human-caused hazards, such as terrorist attacks, may be affected by climate change, but attention here is focused on natural hazards)
• strength and degradation models (corrosion, fatigue, air quality degradation due to drought, etc.)
• installation, construction, renovation and removal practices

Adaptation Options. Various uncertainties along with the small scale of infrastructure design (i.e., the area of building footprint) makes determining the effect of climate change difficult. Even if specific environmental extremes are determined not to have significant changes in frequency or intensity, or that changes cannot be determined, changes and uncertainties in socioeconomic conditions, such as population, can cause changes in vulnerability and risk assessments (Melillo et al, 2014).

Regardless, engineers and scientists in relevant fields have an obligation to understand and take into account the possible changes due to climate, the probabilities and uncertainties (NRC 2012) thereof, and how changes may affect future designs. These groups also have obligation to work together to clearly communicate information to the stakeholders and the public in an iterative process (Melillo et al, 2014) to arrive at strategies for climate adaptation.

Changing existing building codes would offer a direction toward adapting structural engineering practices to climate change. For example, increasing design loads to account for wind, precipitation and temperature creates a more robust set of building standards. Of course, these changes would increase the cost of the structures. Raphaël et al. (2009) identified the following strategies to change our current loading requirements:

• not changing building codes until observing full evidence of such effects on structures and the extent of the impacts;
• changing building codes to design safely for the next fifty years and periodically considering additional updates; and
• changing building codes by including a climate change factor, which can depend on the year of construction, to follow the trends in climate.

The third option reflects the uncertainty associated with the science and trends. It offers the means to allow for additional time until more detailed studies on the extent of which these loads will change. Typically, such studies should include the climate information on the spatial and time scales that are relevant to structural design, including some projections and trends. A key challenge is to identify rare events and their associated frequencies that have not yet been observed, but may become relevant in a typical design lifetime.

Another important consideration that goes beyond making changes to building codes is the development of guidelines to assess existing structures. Comprehensive guidelines for assessing existing structures are not available. Existing buildings, designed, built and possibly retrofitted according to the current loading standards, might have an overall level of safety below acceptable levels with increasing climatic loads. The owners of existing structures should be encouraged or perhaps stimulated to take climate change effects into account when renovations are carried out or additions are planned. Such guidelines would help owners to make appropriate decisions within a risk framework.

Need for science and engineering research. In the short term, engineering standards committees and associated researchers may: study trends in the pertinent extreme environments in cooperation with climate and weather scientists; assess current and projected hazard, load and load combination probabilities; assess the uncertainties associated with these projections and the risks and vulnerabilities of the buildings and other structures, and; seek consensus on design loads. Achieving this consensus will be bolstered in part by the targeted acquisition of data from extreme events. This data would include information on the event itself and its subsequent impacts on the built environment and the complexities therein (Seneviratne et al, 2012).]

Interdisciplinary climate, weather and engineering research should attempt to "bridge the gap" between the sometimes disparate communities (Wright et al. 2013). This includes seeking the probabilistic knowledge needed for engineering standards and practices. Such research for extension of climate and weather modeling to the probabilistic forecasting of extreme environments is treated in the *National Research Council report A National Strategy for Advancing Climate Modeling* (NRC 2012, p 202).

Transportation

Scope of the sector and its major engineering practices. Transportation is the foundation for commerce and the economy of the United States. The U.S. transportation system is an intermodal network of highways, rail, inland navigation, deep-draft navigation, ports and aviation. Transportation may be divided into land transportation and facilities, such as roads, highways, rail and runways, and marine transportation that includes both inland navigation and ocean-going deep draft navigation.

Many transportation engineering considerations are affected by environmental conditions. Engineers must try to maximize the reliability and availability of a structure under varying environmental conditions subject to cost constraints. Various transportation modes use different types of infrastructures, but these infrastructures share common design issues. Foundation design reflects subsurface conditions such as soils and saturation conditions. Material selection is another consideration. Asphalt and concrete pavements are affected by highway traffic volume, vehicle weights and freeze-thaw cycles. The erosive action of flowing water can remove bed material from around foundations and structures. This scour can lead to the failure of bridges and other highway and rail structures (FHWA, 2001). Storm drainage systems are designed to provide adequate surface drainage to ensure vehicle safety. Bridges and culverts over streams are designed to be large enough to pass a design flood of an expected frequency of occurrence without inundating the road (Meyer, 2006).

Another consideration of transportation planning is where to locate facilities. Roads, highways, rail and other facilities should avoid hazardous locations such as floodplains. For example, transportation planners use FEMA flood maps to avoid flood-prone areas. Further development often follows new transportation facilities, so the location of facilities in hazardous areas could increase vulnerability to human population and economic development (Meyer, 2006).

Land transportation and facilities. A changing climate may affect both infrastructure and transportation operations. Increases in the number of days with sustained air temperature above 32°C (90°F) may affect pavement integrity such as softening and traffic-related rutting, and cause deterioration in roadway and bridge expansion joints (Schwartz et al. 2014). Increases in very hot days could also cause rail track deformations. A greater number of high heat days per year could also affect construction productivity and costs through curtailed workdays or overnight scheduling (TRB, 2014). Not all potential changes are detrimental; fewer days with freezing, snow and ice may result in less pavement deterioration and frost heave, as well as a longer construction season. Changes in the number of freeze-thaw conditions will vary depending on the location. Fewer days with snow and ice could lead to reduced costs for removal (TRB, 2008). However, agencies might have to plan for larger individual winter storms (TRB, 2014).

Climate projections show that the frequency of heavy precipitation events may increase. More intense precipitation events may lead to overloading drainage systems and road closures due to street flooding, landslides and washouts (TRB, 2014). Increases in erosion could occur more frequently, causing road washout and damage to rail support structures. Soil moisture levels may also increase, affecting the foundations of roads, bridges and other structures (TRB, 2008), especially pavements constructed on expansive clays (TRB, 2014). Scour may increase if heavy flows become more frequent.

The frequency of floods and droughts may change in a changing climate. Bridges and culverts are often designed for floods of a given return period, or in other words, a given frequency of exceedance. If flood frequency and magnitudes increase, the design flood will be exceeded more often than planned. Engineers could use a larger and less frequent design flood, but this action would entail greater costs.

Coastal infrastructure is designed based on potential storm surge and wave action. Rising sea levels and potentially more intense storms, compounded by regional subsidence, might increase the inundation of highways and rail lines in coastal areas (Schwartz et al. 2014; TRB, 2014). Many of these roadways also serve as regional evacuation routes, which could become compromised during extreme weather events. Storm surge and wave action can cause bridge scour and increase erosion of roads and supporting structures (TRB, 2008). Rising sea levels may reduce the vertical clearance of bridges over major waterways, thus limiting the types of navigation that typically use the waterway. Sea-level rise and saltwater intrusion could accelerate infrastructure corrosion in coastal areas, reducing life expectancy, increasing maintenance costs and increasing the potential for structural failure during extreme events (TRB, 2014).

Adaptation options and guidance for decision making. Transportation infrastructure stakeholders should evaluate actions to "avoid, minimize and mitigate potential risks" from climate change impacts (TRB, 2014). There is a tradeoff between the reliability and availability of infrastructure and the cost to build and maintain it. Stakeholders should also consider the co-benefits of adaptive transportation infrastructure and decision timeframes needed. A risk management approach would balance the consequences and likelihood of failure with the life-cycle costs of the infrastructure (Meyer, 2006). Consequences of failure include economic and environmental damages and public safety. Critical facilities would likely require more robust design standards. One consideration in a risk analysis is how a failure would affect the performance of the transportation system as a whole. Additional redundancy could be built into the system. As noted earlier, the challenge of a risk approach with climate change is that the probabilities of future climate states are not well defined.

The location of transportation infrastructure is another consideration. There are several options for infrastructure located in low coastal regions or floodplains. Highways, bridges and rail lines could be elevated. Infrastructure could also be relocated to less hazardous areas (TRB, 2008). Since economic development is often sited around transportation facilities, relocation may reduce the vulnerability of other economic sectors.

Water Resources

Scope of the sector and its major engineering practices. The goal of water resources engineering is to find cost-effective solutions to improve human welfare and support economic development while sustaining the natural environment. Water resources infrastructure has been built for flood risk reduction, hydroelectric generation, to support inland navigation, and to provide agricultural, municipal and industrial water supply. Hydrologic extremes such as drought and floods affect the reliability of this infrastructure. A warming climate may increase the severity and frequency of floods and droughts.

The sustainability of the natural environment and aquatic ecosystems is another significant concern of water resources management. Aquatic ecosystems face multiple stressors, including disruption of natural flow patterns, water quality, overharvesting and invasive species. A changing climate may exacerbate these stressors. Rising temperatures will affect the survivability of cold-water species. Hydrologic patterns may change; spring snowmelt may occur earlier. There will be different effects on different species and the species composition in an ecosystem could change. Water managers will need to monitor the impact of these changes, particularly on threatened and endangered species, and may need to consider ecosystem uncertainty in their planning.

In addition to climate, other changes have a significant impact on water resources management. Land-use changes affect infiltration and evapotranspiration rates and alter runoff. Urbanization increases the amount of impervious area leading to reduced infiltration and an increase in runoff. Excessive groundwater extraction can deplete aquifers, reducing available water supply and base flows in streams. Population increase can increase the demand for water. Economic development in coastal flood plains increases vulnerability to coastal storms and floods. Water resources infrastructure deteriorates over time and deferred maintenance may reduce its performance below its design standard (Brekke et al. 2009). All of these factors can interact and evolve at an uncertain pace.

Floods and droughts have a major impact on society. Water resources management has tried to reduce the impact of these hydrologic extremes on society. Flood risk management can employ both structural measures, such as reservoirs to store flood waters and levees to divert flow away from communities and economically valuable land, and non-structural measures, such as buyouts of homes in vulnerable floodplains and flood warning and evacuation systems. Drought management could include the development of additional infrastructure to store water or nonstructural plans to conserve water. A change in the frequency of extreme events presents a challenge to traditional design and planning methods.

Methods of analyses for water resources planning. Hydrologic frequency analysis is used in water resources planning when there is an adequate record of observed data. Flood frequency analysis is used to estimate the 1%-chance flood, or the 100-year flood for the National Flood Insurance Program (NFIP). NFIP requirements have a large influence on community planning. Hydrologic frequency analysis is also used for water resources planning and design. Methods that depend on statistical analysis of observed records generally assume that the statistical properties of hydrologic variables in the future will be statistically similar to the observed record. This assumption is being called into question due to climate change and recognition of other changes. The return period of extremes that exceed a threshold will decrease if there is a gradual increase in the mean of the probability density function (Wigley 1988). For example, the magnitude of the current flood with a return period of 100 years may in the future become the flood with a 70-year return period.

Water management decisions have long been made under considerable uncertainty in the public sector and various accepted decision processes exist (Stakhiv, 2011). Only recently have water management decision makers been faced with the prospect of incorporating highly uncertain climate change projections into real decision processes that are associated with social, economic and environmental consequences. However, there exists no established method for using climate information for such decisions. A major challenge is to determine how to effectively represent future climate change and then to evaluate the results within a decision framework.

Decision-making approaches based on vulnerability assessment. One type of approach for water resources planning with climate uncertainty starts first with the project or system's vulnerability before considering climate projections. These approaches have been called "climate-informed decision analysis" (Hallegatte et al. 2012), "decision scaling" (Brown et al. 2011; Brown et al. 2012), or a "scenario-neutral approach" (Prudhomme et al. 2010). The approach first determines a project's or system's definition of failure and under what conditions such failure would occur. It then evaluates the plausibility of these conditions occurring in the future.

Urban Water Systems

Scope of the sector and its major engineering practices. Urban water systems are comprised of three primary subsectors: potable or drinking water, wastewater and stormwater. Stormwater is rainwater, snow or any other form of precipitation that has reached the ground or other surface. Stormwater runoff develops rapidly over urban areas that exhibit high imperviousness. The amount of stormwater runoff is directly related to the amount of precipitation falling over a discrete amount of time and space, and is also related to other processes of the hydrologic cycle (e.g., infiltration, evapotranspiration, storage) and land-use factors (e.g., slope of the terrain, roughness, etc.).

Implications of current climate and weather science. Note that demands for infrastructure systems (as well as the design environments) and the natural environments (such as ground cover affecting absorption of precipitation and near ground wind velocities) will be affected by climate change. In Arctic regions, thawing permafrost poses special risks to community water resources that supply urban water systems.

Climate (and climate change) is intricately linked to the hydrologic cycle, in particular, precipitation and evapotranspiration. Municipal stormwater management is further complicated by the multifunctional purpose of the urban infrastructure system and the many different agencies involved.

There is significant uncertainty associated with climate change over the next 20 to 50 years. Changes in the intensity and frequency of precipitation events are expected. Climate change will require that urban stormwater management practices adapt to the uncertainty of extreme events.

Recommendations needed for longer-term improvements of practices. Given the expected changes in our climate, there is a need to account for uncertainty and variability and to replace standards and practices that were once considered permanent with ones that account for climatic nonstationarity. The primary means of projecting future climate are GCMs (Global Climate Models), but they are not well suited to simulate temperatures and precipitation over relatively small geographic areas and timescales. There will be a tradeoff between designing for larger uncertain events and project cost. Thus, decisions about our infrastructure and long-range water resource planning must provide flexibility and viable options, such as:

• designing control systems conservatively to account for potential future increases in rainfall intensities;
• maximizing the infiltration of runoff to the subsurface;
• protecting existing wetlands and constructing more wetlands to hold runoff and recharge groundwater;
• improving the performance of existing systems through enhanced monitoring and improving single-event and multiple-event modeling and feedback;
• updating rainfall statistics frequently and simulate future scenarios accordingly, and;
• implementing real-time internet-based information systems.

The urbanization of an area alters the local water balance. Often overlooked is the potential interaction with subsurface components, such as groundwater levels, flow and contaminant exchanges. Stormwater management also requires knowledge and understanding of the groundwater and surface water interactions prior to finalizing development; this is particularly critical if constructed wetlands are to be considered a stormwater control and treatment BMP (Best Management Practices) option. The large surface area requirement of constructed wetlands helps to minimize the "extreme" water level fluctuations during all but the larger storm events. The occurrence of future extreme climatic events resulting in elongated and more frequent flooding and drought, water quantity shortages, sporadic and uncharacteristic rainfall patterns, increases in high intensity rainfall events, and higher possibility for impaired water quality suggests a probabilistic approach that accounts for uncertainty.

Coastal Management

Scope of the sector and its major engineering practices. When it comes to climate change, flooding and erosion are the primary concerns regarding civil engineering works. As well, adjustments of habitat boundaries in response to changing water level, temperature and salinity are also important considerations. Coastal flooding and erosion risks follow changing frequency, intensity and paths of storms at sea, superimposed on eustatic sea-level rise caused by melting of land ice and ocean thermal expansion. Erosion is also influenced by changes induced by climate change in prevailing coastal winds and by sediment budgets modified by new hydrological patterns of coastal watersheds. Some coastal areas suffer long-term land subsidence. Arctic coastal flooding and erosion problems are made worse by sea ice retreat with diminished ice dampening of winter waves and by thaw settlement of coastal permafrost.

The challenges engineers encounter to develop design criteria for coastal works in a warming world are similar to those for inland water resource developments. Determination of changing probabilities for extreme storm surge using GCMs are not yet reliable. Variable nearshore bathymetry, changed by erosion and new sediment transport patterns, is not addressed in these simulations. Historical trends of shoreline change are useful, especially if they can resolve recent accelerations. Storm surge and erosion risk assessments based on numerical modeling of historical wave generation and propagation (hind-casting) and site-specific measurements remain essential components of well-founded coastal engineering designs.

Design criteria for prevention of damage from coastal flooding to community infrastructure in the United States often follow guidance of FEMA (FEMA 2011). FEMA guidance also addresses design criteria for strong winds that accompany a surge during a storm at the coast, with particular focus on wind, wave and water levels with 1 % joint probability to be exceeded in any year (i.e., the 100-year return period). FEMA criteria are important because they are associated with the National Flood Insurance Program (NFIP). Communities have invested in studies to delineate zones with coastal hazards, as defined by FEMA for the NFIP. The extent of a hazard zone is not stationary in a changing climate. The last 100 years will not have the same statistical characteristics at a particular site as the next 100 years. Changes wrought by global climate change may only begin to be reflected in the last 10 years of measurements, but projections based on so short a record have poor confidence at the level of 100-year return period. FEMA climate change policy (FEMA 2012) promotes additional climate change judgments to define coastal flooding and erosion risks, but does not specify data sources or analytical procedures.

Energy Supply

Scope of the sector. The U.S. energy supply system broadly consists of the infrastructure and fuels needed to supply the economy with electricity, energy for mobility (through refined oil products), industrial feedstock and heat. Energy fuels have specific uses in the economy, with about 28 % of U.S. primary energy used for transportation, 22 % for industry, 11 % for homes and businesses, and the remaining 39 % used to make electricity consumed by homes, businesses and industry (EIA, 2014). There are different levels of fungibility and therefore, different levels of resiliency to disruption between the sources and uses of U.S. energy. For example, transportation energy is overwhelmingly provided by petroleum products, while electricity is provided from a range of fuels.

The energy supply chain largely consists of the production and distribution of fuels and electricity, enabled via multiple and oftentimes interdependent infrastructure. Fuels for energy such as coal, natural gas and oil are extracted, and biomass relies on agricultural production. These fuels are often processed after extraction and then transported via rail and barge (coal, biomass, oil) or pipeline (natural gas and oil). Oil and biomass are then refined into liquid fuels and distributed by pipelines and trucks to end users, predominately in the transportation sector. Natural gas is distributed by pipeline to residential, commercial and industrial users for heating and industrial inputs. Coal and natural gas are delivered to electric power plants to create electricity, which is then delivered to customers through a vast electricity transmission and distribution network.

Several different federal entities have oversight and regulatory authority over U.S. energy infrastructure, including the Department of Energy, the Environmental Protection Agency, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, the North American Electric Reliability Commission, and the Department of Transportation (GAO, 2014). Other stakeholders include state and local regulatory bodies and private firms that design, construct, own, operate and maintain a large portion of the U.S. energy supply infrastructure.

Principal climate change impacts and vulnerabilities. Across all regions and to varying degrees, the infrastructure supporting U.S. energy supply is currently impacted by climate change, and these impacts will amplify in the future. The Third National Climate Assessment of the U.S. Global Change Research Program states that: infrastructure is being damaged by sea-level rise, heavy downpours and extreme heat; damages are projected to increase with continued climate change, and; disruption in one infrastructure system can cascade to others (Melillo et al. 2014).

Under a changing climate, the frequency and intensity of some extreme weather events are expected to change, higher temperatures are expected increase electricity demands, water availability will constrain energy production, and sea level rise and storm surges can affect coastal energy infrastructure (Dell et al. 2014).

Impacts of increased frequency or severity of weather. Energy infrastructure will be affected by an increase in the frequency and severity of extreme weather events, which have begun to occur across most of the U.S. The projected changes could include more frequent and intense precipitation, wildfire and drought (Dell et al. 2014). Increased storm intensity, coupled with sea level rise and storm surge, could affect coastal oil and gas extraction, as well as transport and storage infrastructure. Barges utilize inland waterways and rail transportation often follows riverbeds. Therefore, increased river flooding could disrupt the supply of coal, petroleum products and other liquids, or biomass transported by both train and barge (Dell et al. 2014; DOE, 2013). Increased storms and river flooding could also threaten inland thermoelectric and hydroelectric generation facilities by damaging structural components, sediment deposition and flooded facilities (DOE, 2013; Hauenstein, 2005).

Impacts of increased temperatures. Both the mean annual temperatures and the number of extreme heat days are expected to increase across all regions in the U.S. These increased temperatures will increase cooling needs in every region, while decreasing projected heating needs (Dell et al. 2014). This will increase the summer peak demands of the electricity system, as nearly all cooling energy is provided by electricity. A higher summer electricity peak will require increased usage of expensive and underutilized generation equipment and stress and reduce the capacity of transmission and distribution infrastructure (Sathaye et al. 2013). A regional reduction in heating needs can affect the amount of infrastructure required for fuel distribution and storage, as heating needs are supplied through electricity as well as natural gas, heating oil and other fuels. On the other hand, winter peak electricity needs would be reduced, further altering the need for natural gas and other fuels for electricity in the winter heating season.

Increased temperature could also affect energy generation infrastructure. Higher water temperatures could cause curtailments at thermoelectric plants using rivers for cooling in order to remain within thermal discharge limits. Hotter air and water temperatures will also reduce the efficiency of thermoelectric generation, requiring more fuel to produce similar amounts of electricity. Higher temperatures could also affect the available capacity of hydropower, solar PV, wind power and biofuel production, as well as threaten the stability of the Arctic oil and gas infrastructure located on permafrost (DOE, 2013). Given the very high likelihood of increased temperatures in the future (Dell et al. 2014), engineering decision making in the energy sector should recognize and plan for the potential impacts to long-term supply, distribution and demand.

Impacts of decreased water availability. Energy in the U.S. is enabled through water use. The production, transportation, refining and storage of fuels (e.g. oil and gas, coal, biomass), as well as power generation in coal, natural gas, nuclear, hydroelectric, biomass and solar thermal plants, require long-term access to water (DOE, 2013). Long-term precipitation changes, drought and reduced snowpack, coupled with increasing demands for water, are projected to alter water availability. The impacts will vary by region; longer dry spells are projected in the Northwest and seasonal water constraints are projected in the Southwest and Southeast (Dell et al. 2014).

Reduced water flows and higher water temperatures limit the availability of river water use for thermoelectric power plant cooling, while reduced snowpack affects hydroelectric capacity.

Decreased water availability and prolonged droughts could affect oil and gas exploration, especially unconventional production relying on horizontal drilling and hydraulic fracturing. The costs and availability of conventional oil refining could also be affected, as the process requires between 0.5 and 2.5 gallons of water or more per gallon of gasoline equivalent (DOE, 2013). Reduced river water levels decrease the barge capacity of the inland water transportation system, which transports coal, oil and petroleum products. A one-inch drop in river capacity can reduce a barge tow's capacity by 255 tons on the upper Mississippi, Illinois and Ohio rivers, and by up to 765 tons on the lower Mississippi (DOE, 2013).

Impacts of sea-level rise, storm surge and subsidence. Sea levels have risen globally by about 8 inches since 1880 and are projected to rise 1 to 4 feet by 2100 (Dell et al. 2014). Sea-level rise amplifies the impacts of storm surges, and combined with local subsidence and high tides, can threaten coastal energy infrastructure. These include oil and gas infrastructure in the central Gulf Coast region and power plants and electricity infrastructure throughout the coastal United States (DOE, 2013; Dell et al. 2014). For coastal energy facilities to withstand future storm surges, the performance of existing structural measures should be reevaluated under future sea-level rise, storm surge and subsidence impacts (Brown et al. 2014). Similarly, a scale-up of future coastal thermoelectric power generation, including nuclear power, could face increased costs for hardening against sea-level rise and storm surge (Kopytko and Perkins, 2011).

Approaches for adaptation decision making with climate uncertainty. Infrastructure enabling the U.S. energy supply is designed for a useful life of several decades or more, and is expensive and time-consuming to construct and retrofit. Much of the existing coal and nuclear power plants in the U.S. were constructed during a building boom from the 1960s to the 1980s; decisions are currently being made about recapitalizing, retrofitting or retiring these and other existing energy assets. At the same time, new firms are deploying new infrastructure for renewables, natural gas power generation and unconventional hydrocarbon development. Infrastructure stakeholders in the private and public sectors need to design, construct and operate existing and future energy infrastructure to be resilient against climate change impacts. Energy infrastructure should be responsive to future energy demands as well as dramatically reduce associated greenhouse gas emissions, decrease air, water and waste impacts, and maintain competitive life cycle costs. This enormous challenge, coupled with the range of uncertainties regarding the timing, magnitude and location of climate change impacts, requires new approaches for engineering decision making for adaptation. These approaches must enable decisions in the face of uncertainty and should maximize low-regret alternatives, co-benefits of actions, and robustness under the range of future climate change impacts. Many of the elements of adaptation strategies for infrastructure can be based on existing knowledge (Wilbanks and Fernandez, 2013).

A near-term action is to conduct vulnerability assessments for new energy infrastructure and existing infrastructure with a high likelihood of impact risk (e.g., coastal power plants). Vulnerability assessments should inform the development of robust risk management strategies that iteratively incorporate observation, evaluation and learning (Wilbanks et al. 2013). The civil engineering community should also support data collection, monitoring and analysis of energy infrastructure to update these vulnerability assessments with empirical observations.

The next set of actions include those with low-regret—that is, those decisions that are likely to perform well in the face of climate uncertainty. Low-regret approaches include system designs and infrastructure to manage, store and shift electricity load in the transmission and distribution system, while dramatically reducing the greenhouse gas intensity of power generation. As specific energy infrastructure approaches the end of its service life, finding opportunities to reduce energy system sensitivities to water and temperature impacts could steadily recapitalize the system for resilience (Wilbanks et al. 2013). Other low-regret approaches could couple climate-resilient designs with other national priorities, such public health, economic growth, energy and national security (Bierbaum et al. 2014; DOE, 2013). Improving community resiliency and preparedness for disasters that disrupt energy services may create co-benefits across the planning for both climate and non-climate related disasters (DOE, 2013). Design standards for regional generation capacity reserve margins, power line capacity and distribution infrastructure could be established for performance in a set of expected future temperature, weather and demand conditions, which could be adjusted incrementally and holistically as new climate information becomes available (Dell et al. 2014).

Finally, engineering stakeholders could transition to an integrated climate risk management framework to evaluate major infrastructure investments. This framework should include methods to introduce flexibility into infrastructure designs to manage uncertain future climate impacts and also uncertain future socioeconomic and policy trends (Wilbanks et al. 2013). In addition, these processes need to incorporate the values and goals of the stakeholders, the evolving scientific literature, the available information and the perception of risk (Moss et al. 2014; Chang et al. 2014).

Cold Regions

Implications of climate change. The cold regions of specific interest to the United States are generally recognized to be the northern states and Alaska. For both of these regions, the issues noted under the other infrastructure categories in this section of the report apply. In addition, for the northern states and Alaska, climate change issues are related to: the active layer (the zone at the ground surface that annually freezes and thaws); the timing and magnitude of precipitation in the form of snow; the gradual (permanent) warming of the air temperature (which, over time, will result in a warming of the ground temperature), and; an increase in the frequency of extreme events (for example, the occurrence of two successive, abnormally warm summers or an abnormally wet and heavy snowfall).

The climate change issues for the northern states projected under the IPCC Fourth Assessment (2007) would result in a reduction in the active layer and therefore a reduction in frost heave and thaw weakening in this layer. If the changes in precipitation in the form of snow for the northern tier states are accurate, there may be a reduction in snowfall and accumulation, with the exception of extreme event projections. Finally, there would be a reduction in river and lake ice formation, which would generally result in a reduction of this hazard. Thus, the projected climate change for the northern tier states may not be detrimental but, rather, beneficial.

For Alaska, the consequences of projected and observed climate change are much more complicated. In the northern states and south and central Alaska, the active layer is associated with the annual freezing of the ground surface in the winter and thawing in the spring as the ground at depth is unfrozen. In Arctic Alaska, the active layer is associated with the annual thawing of the ground surface in the summer and refreezing in the winter as the ground at depth is perennially frozen. The Arctic is underlain by permafrost, defined as any geologic material that remains at a temperature below 0° C for two or more years.

The IPCC Fourth Assessment Report projects a global warming of 0.2 °C per decade for the next two decades. Global temperature change at 2090-2099 relative to 1980-1999 is projected to be from 1.1 °C to 6.4 °C (IPCC, 2007). It is expected that the warming in the Arctic will be stronger than the global average.

Increases in air temperature are in part responsible for the observed increase in permafrost temperature over the Arctic and Subarctic, but changes in snow cover also play a critical role (Osterkamp, 2005; Zhang, 2005; Zhang et al. 2005; Smith et al. 2010). Trends toward earlier snowfall in autumn and thicker snow cover in winter have resulted in a stronger snow insulation effect, and as a result, a much warmer permafrost temperature than air temperature in the Arctic. On the other hand, permafrost temperature may decrease even if air temperature increases, if there is also a decrease in the duration and thickness of snow cover (Taylor et al. 2006). The lengthening of the thaw season and increases in summer air temperature have resulted in changes in active layer thickness.

Regression analysis indicates that the Alaskan snowmelt date has advanced by about 10 days since 1941. Melting of massive ground ice and thawing of ice-rich permafrost can lead to subsidence of the ground surface and to the formation of uneven topography known as thermokarst, having implications for ecosystems, landscape stability and infrastructure performance (Walsh, 2005). As ice-rich permafrost warms, it becomes more susceptible to various forms of failure. Coastal erosion rates have doubled along the Beaufort Sea over the last two decades, while slope and riverbank failures have become more common.

Esch and Osterkamp (1990) summarized the following engineering concerns related to permafrost warming:

- warming of a permafrost body at depth
- increase in creep rate of existing piles and footings
- increased creep of embankment foundations
- eventual loss of adfreeze bond support for pilings.
- increased seasonal thaw depth (active layer) increased thaw settlement during seasonal thawing.
- increased frost-heave forces on pilings
- increased total and differential frost heave during winter
- development of residual thaw zones (taliks)
- decrease in effective length of piling located in permafrost
- progressive landslide movements
- progressive surface settlements

The Arctic Climate Impact Assessment (ACIA) (Instanes et al. 2005) discusses engineering challenges and typical engineering projects that are likely to be affected by climate change. For an engineering structure on permafrost, it is not just the change in air temperatures that is important, but also changes in precipitation, wind and solar radiation. It will not be as simple as assuming a trend line for warming in the Arctic based on one or an average projection from an ensemble of GCMs. The greatest threat to Arctic and Subarctic infrastructure may well be associated with an extreme event “upset condition,” related to “two successive abnormally warm summers.”

For certain extremes (e.g., precipitation-related extremes), the uncertainty in projected changes by the end of the 21st century is more the result of uncertainties in climate models rather than uncertainties in future emissions. For other extremes (in particular, temperature extremes at the global scale and in most regions), the emissions uncertainties are the main source of uncertainty in projections for the end of the 21st century (IPCC, 2012).

While there are differences and uncertainties in the various models representing regional climate impacts, all future GCM projections agree that global temperatures will increase over this century in response to increasing greenhouse gas emissions from human activities (Walsh et al. 2014). Understanding the potential regional Arctic impacts, and developing a risk-based framework for Arctic infrastructure development under uncertainty, is an important issue for the engineering and climate science communities that has been recognized by a number of authors (e.g, Instanes and Anisimov, 2008; Schaefer et al. 2012; Markon et al. 2012).

Recommendations

Engineers should engage in cooperative research involving scientists from across many disciplines to gain an adequate, probabilistic understanding of the magnitudes of future extremes and their consequences. Doing so will improve the relevance of modeling and observations for use in the planning, design, operation, maintenance and renewal of the built and natural environment. It is only when engineers work closely with scientists that the needs of the engineering community become fully understood, the limitations of the scientific knowledge become more transparent to engineers, and the uncertainties of the projections of future climate effects become fully recognized for engineering design purposes.

Practicing engineers, project stakeholders, policy makers and decision makers should be informed about the uncertainty in projecting future climate and the reasons for the uncertainty, as elucidated by the climate science community. Because the uncertainty associated with future climate is not completely quantifiable, if projections of future climate are to be used in engineering practice it will require considerable engineering judgment to balance the costs of mitigating risk through adaptation against the potential consequences of failure.

Engineers should develop a new paradigm for engineering practice in a world in which climate is changing, but cannot be projected with a high degree of certainty. When it is not possible to fully define and estimate the risks and potential costs of a project and reduce the uncertainty in the timeframe in which action should be taken, engineers should use low-regret, adaptive strategies such as the observational method to make a project more resilient to future climate and weather extremes. Engineers should seek alternatives that do well across a range of possible future conditions.

Critical infrastructure that is most threatened by changing climate in a given region should be identified, and decision makers and the public should be made aware of this assessment. An engineering-economic evaluation of the costs and benefits of strategies for resilience of critical infrastructure at national, state and local levels should be undertaken

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The Paris Agreement and Its Future

Todd Stern

Editor's Note

The challenge of climate change requires unprecedented international cooperation. The Paris Agreement, signed in 2015, has formed the foundation for climate diplomacy in the years since. Todd Stern, the former United States Special Envoy for Climate Change under the Obama Administration, was the chief negotiator for the U.S. to the Paris Agreement. In a report that he prepared at The Brookings Institution, Stern described the difficulty of climate negotiations and the challenges faced in the drafting of the Agreement that continue to be relevant today. This excerpt is drawn from his report.

The Road to Paris

First, let's look briefly at why efforts to negotiate a workable, effective climate agreement ran aground for the 20 years before Paris.

To begin with, climate negotiations inherently have a high degree of difficulty. There are more than 190 countries in the UNFCCC, grouped into different blocs with their own agendas;[1] 10 long-standing north-south resentments aggravate the debate; and negotiations are governed by what amounts to a consensus rule of procedure,[2] so that everyone, or nearly so, needs to agree on any decision. Moreover, addressing climate change implicates virtually every aspect of national economies, since greenhouse gases are produced mainly by the use of fossil fuels and secondarily from forestry and agriculture. So, limits on emissions have always made countries nervous about economic growth and development, and have made developing countries particularly nervous.

In addition, developing countries traditionally saw themselves as getting the short end of the climate stick. From the perspective of developing countries, developed countries caused climate change; they didn't worry about limiting carbon dioxide (CO_2) emissions when they were developing; it should be their responsibility to take the action required to contain climate change; and they should pay for any actions developing countries voluntarily take as well as for the damages those countries suffer.

Owing to these concerns, the original 1992 climate treaty differentiated between developed and developing countries, notably by establishing separate categories ("Annex 1" for developed, "Non-Annex 1" for developing)[3] and by embracing the principle that countries had "common but differentiated responsibilities and respective capabilities." That general principle was converted into an operational firewall in the 1997 Kyoto Protocol, which assigned legally binding targets and timetables for reducing emissions to developed countries, backed up by rigorous rules for accounting, transparency, and compliance, while asking virtually nothing of developing countries.[4]

Now, the developing country narrative was understandable. The trouble is that it cannot work as the basis for tackling climate change. Do the math. Developing countries, which accounted for roughly 45 percent of energy-related CO2 emissions in 1990, account for over 60 percent today and are projected to account for roughly two-thirds by 2030. China's emissions were about one-third the size of the United States' in 1992, but are about twice the size now. A ranked list of countries with the highest gross domestic product (GDP) per capita today will show a significant number of developing countries ranking higher than some developed countries.[5] These numbers tell us two things. Most importantly, developing countries—particularly the more advanced and industrialized among them—are necessarily a large and growing part of any climate solution. In addition, the material conditions of countries keep changing, with many developing countries becoming more prosperous, so the idea of apportioning climate responsibilities on the basis of an immutable division of countries from 1992 makes no sense.

Finally, on climate, as everywhere across the diplomatic map, domestic politics matter. The Kyoto Protocol failed in the United States mostly because the idea of exempting China and other large emerging economies was politically toxic. And with the United States and developing countries both on the sidelines, Kyoto could never become an effective international regime.

Faced with this reality, the Parties to the UNFCCC agreed at the 2007 climate conference in Bali on a mandate for a new agreement to cover everyone, intended to be completed two years later.[6] That conference, in Copenhagen, quickly descended into recriminations and discord, largely over these same issues of the firewall. In the final 30 hours, the Copenhagen conference was salvaged by the improvisational diplomacy of a small group of world leaders, who produced the three-page Copenhagen Accord.[7] The conference was roundly dismissed as a failure, though the U.S. negotiating team believed that the accord planted important seeds of change, and the years since have validated that belief. Still, the world was far from a broad, workable climate agreement.

Two years later, in Durban, South Africa, the Parties agreed to make another try for a new large-scale agreement to be concluded four years later.[8] That Durban mandate set us on the road to Paris.

The Paris Agreement

The path to a viable agreement in Paris was littered with hurdles. First, the prevailing orthodoxy of climate negotiations said, in effect, that agreements had to be based on top-down, legally binding targets and timetables for reducing emissions, with rigorous associated rules. The new agreement had to call on all countries to act, not just some. It had to be ambitious in combatting climate change, despite nervous resistance from many countries. It needed to be durable, unlike the Kyoto Protocol, whose shortcomings have limited its life-span. It needed to preserve differentiation, but to move beyond the firewall version of that principle. It needed to be legally binding in some respects, but without scaring off countries large and small. It needed to maintain existing commitments to provide financial assistance, recognizing the importance of such aid to recipient countries but the real constraints faced by donor countries.

Put simply, the agreement had to be carefully constructed. Lean too much one way and the structure would fall apart; lean too much the other way, same result. And all of this careful calibration had to take place in an atmosphere of anxiety and unease, where history gave no cause for confidence, and mistrust hung in the air.

In the end, a deal was secured in Paris because the agreement charted a new, paradigm-shifting path for climate diplomacy.[9] It blended elements that were top-down and bottom-up. It was built to last. It found a new way to differentiate but not bifurcate. It blended elements that were legally binding with those that were not. And, crucially, it relied on expectations and norms where binding, or rigid, rules would not work.

First, Paris abandoned the old Kyoto model of top-down negotiated emission targets and instead adopted a bottom-up structure for mitigation (limiting emissions), known in the agreement as nationally determined contributions (NDCs). This bottom-up structure was balanced by a number of top-down provisions. These included aggregate emission goals that all countries adopted both to keep the increase in global average temperature to well below 2 degrees Celsius and to achieve net zero emissions in the second half of this century.

These also included accountability requirements to submit updated NDCs periodically, to provide clarifying information so the NDCs would be understandable, and to report and be reviewed on emission inventories, progress toward achieving NDCs, and support provided and received. This structure, a version of which was first proposed by Australia in a 2009 paper, was essential for an agreement that had to include all.[10]

Second, the agreement was built for the long term, with (1) its long-range, science-based goals; (2) a system of staggered, continuously repeating five-year cycles both to review and ramp up individual targets and to take stock of how the world is doing in the aggregate relative to global goals; and (3) a call for countries to map out longer-term “mid-century strategies” for deep decarbonization.

Third, Paris shifted the paradigm of differentiation. The agreement continues to deliver on the fundamental purpose of differentiation: assuring developing countries that they will not be pushed to take action they see as beyond their capacities or as inconsistent with their priorities for growth and development. But differentiation in the Paris Agreement is no longer a firewall, with one set of rules for developed countries and a different one for developing. This modified form of differentiation is visible in four ways: (1) the nationally determined structure for country targets allows differentiation across the full spectrum of countries, rather than basing it on categories; (2) differentiation in the form of "flexibility" is provided in the transparency system only to "those developing countries that need it in the light of their capacities," not to all developing countries; (3) a new formulation of the classic "common but differentiated" principle adds "in light of different national circumstances," suggesting that differentiated treatment should relate to material circumstances, which evolve; and (4) the substantive paragraphs of the Agreement mostly avoid an explicit call for developed countries to do one thing while developing countries do something else.

Fourth, the legal form of the Paris Agreement is a hybrid, breaking the orthodoxy of legally binding emissions targets, but including legal obligations for elements such as submitting NDCs on a periodic basis, and the transparency system of reporting and review.

Critics who dismiss Paris because of these non-binding targets not only misunderstand what was possible, but also miss a larger point about the Paris idea.[11] They misunderstand the possible, because while a system of binding targets with penalties for failing to meet them might sound good on paper, it was not doable, because too many countries, including the United States, would have balked.

And critics of non-binding targets miss the core point that Paris made a different bet, namely, that the rising force of norms and expectations will make climate action important to global standing and reputation and will goad and prod countries to do better and do more. Norms and expectations might sound weaker than binding targets, but, in reality, such targets would almost surely depress ambition, since many countries would opt for lower targets out of fear of the consequences of coming up short. The opposite will be true if norms and expectations rise rapidly.

Moreover, expectations can play an important role in areas where rigid rules will not work. For example, given the opposition of many powerful and influential developing countries, it is not possible at this time to create formal subcategories of developing countries with different requirements for mitigation, transparency, or accounting. Yet, it is difficult to construct an effective agreement unless countries of very different capabilities—for example, industrializing, emerging economies on the one hand and Least Developed Countries or small islands on the other—can at least be *expected* to act in different ways.

So, a bet on the premise of rising norms and expectations is at the heart of the Paris Agreement. If the Paris regime is to succeed, this bet, above all, has to pay off.

The full report, "The Paris Agreement and Its Future," can be found here: https://www.brookings.edu/research/the-paris-agreement-and-its-future/

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Beyond Paris

A supplement to "The Paris Agreement and Its Future"

COP24

2018 was a pivotal year for international cooperation on addressing climate change. In December, the 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24) convened in Katowice, Poland. The main goal of the meeting, which convenes annually, was to agree on the terms of the Paris Rulebook, a set of guidelines for how countries will plan, implement, and report their national contributions under the Paris Agreement. Development of the rulebook was mostly successful. Countries agreed to provide more detail when making future commitments, formed a set of guidelines for reporting their progress every two years, and set the guidelines for a global stocktake of progress toward the goals set forth in Paris, to be conducted every five years starting in 2023. However, parties failed to agree on guidelines for international carbon markets, postponing such a decision until next conference in 2019.

For more information on COP24 and the Paris Rulebook, follow this link to a summary of the meeting prepared by the World Resources Institute: https://www.wri.org/blog/2018/12/cop24-climate-change-package-brings-paris-agreement-life

UN Climate Summit 2019

The United Nations Secretary-General will host a summit on climate change on September 23, 2019 at the United Nations headquarters in New York. The purpose of the summit is twofold. First, it will mobilize political will to raise real ambition for the achievement of the Paris Agreement goals. Second, it will demonstrate transformative action in the real economy in support of the goals. Together, these developments will send strong market and political signals, and inject momentum in the "race to the top" among governments, sub-national governments, business, public and private finance, and civil society actors, which is needed to achieve the goals of the Paris Agreement.

The secretary-general will invite all heads of state and government to the summit, to present their progress to date and their future ambition. The participation of other relevant stakeholders, who demonstrate the highest level of ambition and action, to profile their efforts will be encouraged.

In order to ensure that the transformative actions in the real economy are as impactful as possible, the secretary-general has prioritized the following action portfolios, which are recognized as having high potential to curb greenhouse gas emissions and increased global action on adaptation and resilience.

- **Finance**: mobilizing public and private sources of finance to drive decarbonization of all priority sectors and advance resilience;

- **Energy transition**: accelerating the shift away from fossil fuels and towards renewable energy, as well as making significant gains in energy efficiency;

- **Industry transition**: transforming industries such as oil and gas, steel, cement, chemicals and information technology;

- **Nature-based solutions**: reducing emissions, increasing sink capacity and enhancing resilience within and across forestry, agriculture, oceans and food systems, including through biodiversity conservation, leveraging supply chains and technology;

• **Cities and local action**: advancing mitigation and resilience at urban and local levels, with a focus on new commitments on low-emission buildings, mass transport and urban infrastructure; and resilience for the urban poor;

• **Resilience and adaptation**: advancing global efforts to address and manage the impacts and risks of climate change, particularly in those communities and nations most vulnerable.

To provide maximum momentum to the processes, the secretary-general is also prioritizing **citizen and youth mobilization**.

For each of the above priorities, facilitators will be appointed to ensure the development of transformative outcomes. All facilitators will be working with coalitions of actors from December 2018 to September 2019 to deliver the most impactful outcomes at the summit. Due to the inherently interdependent nature of the portfolios, the facilitators may develop outcomes across two or more portfolios. These outcomes will consist of multi-stakeholder coalitions that may involve national governments, subnational governments, business, public and private finance, and civil society. The development of these outcomes will be an open process. All those interested may contribute and are encouraged to do so by engaging with the facilitators. However, only the most concrete and transformative outcomes will be delivered at the summit. During summer 2019, the Executive Office of the Secretary-General will conduct an "ascent" meeting, during which the most impactful outcomes will be selected to be featured at the summit.

The summit will have no negotiated outcome. The secretary-general will present a chair's summary of the concrete outcomes delivered during the summit, with hopes that they will spur increased ambition and action in 2020 and beyond.

Regular briefings will be held with UN member states, UNFCCC parties, and all relevant partners to provide updates on the planning for the summit. Details about these briefings will be communicated in due course.

-UN

More information about the Climate Summit can be found at the UN website here: http://www.un.org/en/climatechange/un-climate-summit-2019.shtml

COP25

The next follow-up meeting to the Paris Agreement, COP25, will take place November 11-22, 2019, in Chile. A pre-COP meeting will take place in Costa Rica. Discussions at this meeting will include continuing negotiations regarding the Paris Rulebook, as well as efforts to replenish the Green Climate Fund to bolster international climate finance. Countries will also have the opportunity to present enhanced climate commitments at the conference.

Open Access at a Crossroads

David Kramer

Publishers of scientific journals are facing renewed threats to their business models from both sides of the Atlantic. As European science funders promote a radical new open-access (OA) publishing mandate they unveiled in September, the Trump administration is considering changes to a five-year-old directive governing the public release of research literature sponsored by federal agencies.

A delegation led by Robert-Jan Smits, the European Commission's special envoy on OA, visited with officials of the White House Office of Science and Technology Policy (OSTP) and other federal agencies as part of an effort to gain broad support for the new European policy, known as Plan S. Due to take effect in January 2020, the initiative would require recipients of research grants from a dozen European national funding agencies to publish their research solely in journals whose contents are immediately available for free. It would prohibit researchers funded by those agencies from publishing their findings in most high-prestige journals, including *Nature* and *Science*, which are subscription based and make papers from those agencies available for free only after a one-year delay.

Plan S has been endorsed by both the European commissioner for research, science, and innovation and the European Research Council, which administers the European Union's research program. Officials say it will apply to the EU's next $100 billion, seven-year research "framework" plan, which is to take effect in 2021. "For the last 20 years, libraries, universities, and [others] had the possibility to sort this out. But they did not," Smits says. "Now the funders have stepped in, and they now call the shots."

David Kramer is a news editor at Physics Today. This article is reproduced from Physics Today, "Open Access at a Crossroads." (DOI:10.1063/PT.6.2.20181011a) with the permission of the American Institute of Physics.

Smits said at a 3 October briefing in Washington, DC, that the Plan S coalition hopes to expand its model globally, though it was too early to expect any commitment from the US. "The publishers tell us that we can only flip our journals [to an OA model] if this happens at the global level," he said. Plan organizers have received invitations to visit with officials of South Africa, India, China, and Japan.

Meanwhile, publishers and OA advocates have rushed to meet with OSTP staff in recent weeks upon learning the agency might change its OA policy for US publicly funded research, which for now requires that such literature emerge from behind paywalls after an embargo period of up to one year. An OSTP spokesperson wouldn't comment on the discussions. But some publishers who met with staff at the agency fear that officials may be eying shortening or eliminating the embargo and capping the fees, known as article processing charges (APCs), that publishers charge authors for their papers to be OA. Caps on these charges are also a feature of Plan S, although its framers haven't yet established specific levels.

The developments in Europe and the US come as scholarly journal publishers gradually shift toward a substantial but incomplete embrace of OA. The immense impact of funding agencies adopting a Plan S–like approach would extend not only to publishers but also to academic institutions and individual researchers.

Federal Policy in Limbo

Among the physical sciences publishing societies whose representatives met with OSTP staff over several weeks were the American Physical Society, American Chemical Society, Optical Society, American Institute of Physics (AIP, which publishes *Physics Today*), Society of Rheology, and American Astronomical Society.

Since 2013, when then presidential science adviser John Holdren instituted the one-year maximum embargo before research was made freely available, agencies have taken various paths to OA. The Department of Energy, Department of Defense, and NSF, which collectively account for nearly three-quarters of all federally sponsored nonbiomedical research articles, enlisted CHORUS, a database established by commercial and nonprofit scientific publishers. NASA, NIST, and the Environmental Protection Agency contracted with the National Institutes of Health's long-standing PubMed Central public repository to house their sponsored research articles. In 2008 NIH had established an OA policy that required public release after one year.

Society members attending meetings at OSTP varied as to whether they thought major revisions in OA policy were in the works. These attendees, most of whom would speak only on condition of anonymity, say interpretations depend on which staff member they consulted. "Different staff have different opinions about what should go into the policy," says one source. Most sources believe there will be some revisions.

Publishers are most concerned that cutting back or eliminating the embargo period on OA would greatly reduce incentives for universities and other institutions to pay for their journals. "Twelve months is a natural time period that librarians consider for subscriptions," says Fred Dylla, former CEO of AIP. The concern for embargoes is particularly great for niche journals and those that are published only quarterly, he says.

Some publishers perceive OSTP to be gathering information on whether and how well the existing policy is working. "It didn't seem like they were just going to throw it all out and start over again," says Joel Parriott, deputy executive officer of the American Astronomical Society. "They were looking to see if there were certain areas that could use further attention."

Heather Joseph, executive director of the open-access advocacy organization Scholarly Publishing and Academic Resources Coalition (SPARC), says the OSTP staff seemed to be interested in ensuring agencies were complying with the policy. "My read is their major questions are 'Is this an effective policy?' and 'Is it good enough?' " she says.

Several sources say the OSTP review appears motivated by an overarching Trump administration drive to change whatever policies were set during President Obama's tenure. In this case, says one, the staff appeared to focus on whether the process their predecessors had followed was flawed.

Proposed changes, if any, will likely have to be approved by Kelvin Droegemeier, whose nomination as OSTP director awaits confirmation by the Senate. His views on OA are unknown.

Plan S is Detailed

Plan S was coauthored by Science Europe, an association of 37 European funding agencies and research performers with combined budgets of $23 billion. Its president, Marc Schiltz, expects a majority of his members will sign up. "We went public at the moment we felt sufficiently strong to go public," he says.

The signers of Plan S include the national funding agencies of the UK, France, and Italy, as well as countries with smaller research budgets. Notably absent is the German Research Foundation, DFG. Schiltz and Smits say they are confident that DFG will come on board after the resolution of a court case over a faculty challenge to an OA publishing mandate by the University of Konstanz. A DFG spokesperson, however, says that although the foundation supports all forms of OA, it disagrees with Plan S's mandate of "specific forms of open access" because it impinges on researchers' academic freedom to decide where to publish.

David Sweeney, executive chairman of the funding agency Research England, says the framers of Plan S don't want to specify exact publishing models. But Plan S most resembles the gold form of OA, in which the entire content of the journal in which an article is published is free of charge, without an embargo. And except for a transition period that "should be as short as possible," Plan S won't allow continued publication in hybrid journals, the model that now accounts for nearly three-quarters of the industry (see Physics Today, May 2017, page 24).

Hybrid journals derive most of their income from subscriptions but also accept OA articles at a charge to the authors. Gold journals are funded entirely by APCs. Some funders, including the UK government and the Gates Foundation, provide extra funding in their grants to cover APCs. For US funders, APCs generally must be paid for from grant funding; hence there is that much less money to pay for the research itself.

According to a December 2017 report by Universities UK, 73% of journals owned by the 40 top scholarly publishers in 2017 were hybrid. That's an increase of 17% from 2015. Although the number of subscription-only journals has fallen, fully OA journals still represent only 18% of the journal count.

"Hybrids were promised to us by publishers as a transition tool for a couple years, and then everything would be full and open access," Smits said at the Plan S briefing in Washington. "This transition tool is now being used as a business model, and that is something we absolutely don't want."

As to the caps on APCs for OA articles, Schiltz notes, "We don't want to switch from excessive subscription [costs] to excessive APCs." Caps should scale with the quality of the services being offered by publishers. Ultimately, competition among publishers could do away with the need for caps, he says.

To adapt to Plan S, publishers could also implement a variety of what's called green OA in which the published version of an article in a subscription journal simultaneously becomes freely available in a separate collection. Many publishers now allow authors to publish some form of their articles in repositories such as author websites, arXiv, or scholarly collaboration networks like ResearchGate. But the freely available papers aren't usually identical to the final, citable versions in journals. Sweeney, who coleads a task force that will draw up a Plan S implementation blueprint by year end, says he believes papers posted in an open repository will be compliant—but only if they are identical to the final published version.

Publishers React

Unsurprisingly, many publishers are unhappy with Plan S, particularly its exclusion of the hybrid model.

"A lot of people advance the idea of open science, which is a laudable and a necessary idea, and illogically jump to the declaration that there is one particular model of publishing that is in keeping with open science," says Rush Holt, CEO of the American Association for the Advancement of Science, which publishes the *Science* family of journals. Holt says the plan "runs afoul of what has worked so well for our authors and researchers who use the material in our publications."

Steven Inchcoombe, chief publishing officer at Springer Nature, one of the largest journal publishers, says the hybrid model continues to drive the transition toward full OA. He notes that more than 70% of the company's authors in four European countries make their research available immediately upon publication. A company-sponsored study early this year showed that without the hybrid option being available to UK authors, only around 30% of their published research would have been OA, instead of the actual 77%.

The subscription model also "sustainably works for highly selective journals with substantial news, analysis, and review content like the *Nature* research journals," Inchcoombe says. Since selective journals reject most of the submissions that are evaluated, they have to review many manuscripts to fill their pages. The result is high processing costs and, ultimately, a cost per article that is much higher than for less selective journals. A former Springer Nature executive says the cost per published article in *Nature* is around $39 000.

Smits says Plan S members want to ensure the continued health of nonprofit society publishers, which use the revenues from their publishing operations to finance educational, journalistic, outreach, and other activities. "They are an essential part of the science and research infrastructure, and we recognize they add value," Sweeney adds. "But it may not be done the same way in the future." The two say they will consult with society publishers as they draft the implementation plan, but they wouldn't say what sort of accommodation might be made.

Smits says European governments and universities are fed up paying what he says is anywhere from $10 billion–$25 billion each year in subscriptions worldwide to publishers, some of which are making profits of 30–40%. “There’s something very rotten in the system, and it has to change big-time.”

Neither Holt nor Inchcoombe would estimate what percentage of their respective content is supported by the Plan S funders. Holt would only suggest that the figure is in the single digits. But one society source says as much as one-fifth of some physics journals’ content could be subject to Plan S mandates.

Researchers Caught in the Crossfire

Some European researchers also are unhappy with Plan S. Lynn Kamerlin, a biochemist at Uppsala University in Sweden, says the hybrid ban could prevent some European researchers from publishing in high-quality journals. “If the rest of the world continues to submit their best work to those journals, then researchers outside Europe may think twice about collaborating with researchers who are forbidden from publishing in them,” she says.

Britt Holbrook, a New Jersey Institute of Technology assistant professor and member of an OA advisory panel to the European Commission, says Plan S was essentially drawn up by funders and directed at publishers. “The part that’s missing is … input from the researchers,” he notes. Holbrook says the plan infringes on academic freedom. “Research includes dissemination of the results,” he says. “Part of academic freedom is that faculty give themselves the rules on that.”

Sam Hay, a University of Manchester chemist, says he agrees with the goal of OA. “But the problem with most open access as it stands right now is it’s really expensive for the author,” he says. “We couldn’t afford to publish multiple papers a year.”

Chemists funded by UK Research and Innovation, a Plan S signatory, won’t be able to publish in prestigious journals such as the *Journal of the American Chemical Society* or most of those published by the Royal Society of Chemistry. Indeed, Plan S would bar publication in most of the higher-prestige journals in any of the disciplines, unless they switch to an all-OA publishing model. “That’s an issue because many of our colleagues have drivers to publish in these journals,” Hay says. “You start having issues with mobility and other things as well,” he adds, referring to the repercussions Plan S will have for academic scientists’ reward system.

That system currently prizes publication in high-impact—and mainly subscription-based—journals. The rest of the world is unlikely to change the incentive, flawed as it may be, in response to Plan S, notes Kamerlin. An ambitious student or postdoc might reconsider a position at a lab or research group funded by a Plan S agency, fearing that it could hamper future mobility and career prospects.

Smits acknowledges that the academic reward system must change from what he calls its “obsession” with the journal impact factor. And Sweeney says Plan S “will require steps to be taken by universities in their appointments and promotion procedures, and by funders in their grant assessment procedures.” But he adds, “If we wait for that change to happen, we will be here in 10 more years, if not longer.”

Article available at: https://physicstoday.scitation.org/do/10.1063/PT.6.2.20181011a/full/

Announcements

Renewable Natural Resources Foundation

2018 Congress on Ocean Policy

RNRF hosted the 2018 Congress on Ocean Policy December 6 in Washington, D.C.

Speakers for the 2018 Congress on Ocean Policy included a diverse group of scientists, managers, and professionals who understand the challenges of current ocean management. They presented policy tools and strategies to foster the sustainability of our oceans. Delegate invitations were extended to representatives of state, federal and international agencies, professional and scientific NGOs, the private sector, academia, and congressional offices and committees.

The full report on the Congress presentations and discussions can be found here.

International Centre for Integrated Mountain Development's Transboundary Landscape Program Described at RNRF Lecture

On November 28, 2018, Dr. Rajan Kotru, Program Manager of the International Centre for Integrated Mountain Development's (ICIMOD) Regional Transboundary Landscapes Program, spoke at RNRF's lecture "Landscape-Level Sustainable Development: Transboundary Mountain Management Across the Himalayas."

ICIMOD's Transboundary Landscapes Program is the recipient of RNRF's 2018 Outstanding Achievement Award.

At the lecture, Dr. Kotru discussed the challenges of sustainable development in the Hindu Kush Himalayas and ICIMOD's work to bridge international boundaries in a region where nearly two billion people live and work. The program provides a valuable framework for international cooperation in long-term ecological monitoring and both environmental and cultural conservation, even between countries with geopolitical sensitivities.

The lecture was hosted by the American Society of Landscape Architects at its Washington, D.C. headquarters.

More information on ICIMOD and the Transboundary Landscape program can be found here.

RNRF Welcomes Program Associate Stephen Yaeger

Stephen Yaeger is RNRF's new Program Associate. Stephen earned his B.S. from the Walsh School of Foreign Service at Georgetown University, majoring in Science, Technology, and International Affairs. He gained a foundation in environmental policy through classes on natural resource issues, environmental law, and relevant disciplines. While at Georgetown, he interned for a year at The Mountain Institute. Stephen is from Dallas, Texas.

As the Program Associate, Stephen will be part of a three-person staff responsible for developing, planning, and implementing RNRF programs. His responsibilities will include providing editorial support for the Renewable Resources Journal and assisting in production of reports of RNRF congresses; planning and implementing meetings, workshops, and round tables; and contributing news and policy analysis to the Blog and website.

Representatives of Climate Action Coalitions Speak at RNRF's Fall Meeting "Withdrawing from the Paris Agreement: What's Next?"

Community, city, and state level action on climate change has intensified to fill the gap left by the federal government after Donald Trump announced the U.S. withdrawal from the Paris Agreement in June 2017. Mayors, city officials, and business leaders across the country have committed to reducing their impacts on the environment and over 400 cities have adopted the goals of the Paris Agreement.

RNRF's Fall Meeting, held on October 28, 2018, featured presentations on climate change action at local and state levels from three major coalitions formed in the wake of the Paris withdrawal: We're Still In, America's Pledge, and the U.S. Climate Alliance. Speaker presentations were followed by robust discussion from representatives of over 20 private sector, federal government, and non-profit organizations. The meeting was hosted by the American Society of Landscape Architects at its Washington, D.C. headquarters.

More information can be found here.

American Geophysical Union

AGU-SEG Airborne Geophysics Workshop

June 11-13, 2019. Davie, FL

The AGU-SEG Airborne Geophysics Workshop is being held to share advancements and applications of airborne geophysics for ground water, mineral, petroleum, geotechnical and hazards investigations.

The development and application of airborne geophysics is rapidly accelerating. Airborne methods are increasingly used for groundwater assessment, natural resource exploration and large-scale geotechnical investigations. The workshop will provide a venue for participants to learn about new instrumentation, interpretation software, and applications of Airborne methods to solve diverse real- world problems.

Chapman Conference: Winter Limnology in a Changing World

October 14-18, 2019. Polson, MT

https://connect.agu.org/aguchapmanconference/upcoming-chapmans/winter-limnology

Recent high-profile syntheses of lake water temperatures and ecology under lake ice are galvanizing a scientific community, and new data streams are being amassed by in situ sensors deployed during seasonal ice cover. We are now positioned us to catalyze progress in our understanding of winter limnology inclusive to polar, alpine, and temperate systems. Continued acceleration of winter research by a geographically diverse group of investigators will generate irreplaceable information about lake dynamics and enable future research on lake-climate interactions as we enter an increasingly ice-free world.

To accelerate progress in winter limnology, AGU's Chapman Conference on winter limnology will address hypotheses associated with 5 topics: climate and ice dynamics; winter and cross-seasonal biogeochemistry; biological connections across seasons; temperature dependency of biotic processes and habitat; and trophic interactions under ice.

New AGU Ethics and Equity Center to Combat Sexual Harassment, Bias, and Foster a Positive Work Climate in the Sciences

On February 12, 2019, AGU announced the launch of the AGU Ethics and Equity Center (the Center). The Center aims to tackle the issues of bias, harassment, and discrimination in science by fostering safe work environments and working to ensuring that researchers, students, and institutions have access to leading practices and tools to address harassment and achieve inclusive excellence. AGU was one of the first scientific societies to recognize sexual harassment as scientific misconduct—akin to plagiarism and falsification of data—that harms the individual and the entire scientific enterprise. In addition to providing access to a wealth of professional ethics-related resources, a key unique feature of the Center is to provide access to consultation with a legal advisor, available to AGU members and members of partner organizations, their students, postdocs, and untenured faculty members experiencing harassment, bullying, discrimination, retaliation or other misconduct. This service will empower individuals to make informed decisions with confidence, educate individuals about formal and informal and internal and external remedies, promote effective communication, and offer guidance in charting a successful course forward.

The Center will be regularly updated with professional development and ethics-related resources designed to support individual scientists at all career stages, as well as information for organizations and institutional leaders that are looking to implement leading practices in ethics or equity related topics. It will also be a home for information on upcoming workshops on a variety of related topics, as well as a place where interested parties can request custom workshops tailored to their own specific needs.

Read the full press release here.

American Meteorological Society

2019 AMS Washington Forum

March 27-29, 2019. Washington, DC

https://www.ametsoc.org/index.cfm/ams/meetings-events/ams-meetings/2019-ams-washington-forum/

Collaboration and sharing scientific knowledge grow more critical every year, and this event provides an ideal venue for agencies and companies whose operations and planning are reliant on environmental factors. This year's sessions include:

- Agribusiness and Smart Farming using Weather Analytics
- Augmented Weather Applications from Artificial Intelligence
- Congressional Staffers
- Federal Agency Leadership
- Hurricane Resiliency from Storms of the Future
- Value of Weather Information and Services
- Engaging the Enterprise: Ways to Expand Impact
- Weather Decision Support for Mariners
- And Special Event – The James R. Mahoney Lecture on March 26th

15th Conference on Polar Meteorology and Oceanography

May 19-23, 2019. Boulder, CO

https://www.ametsoc.org/index.cfm/ams/meetings-events/ams-meetings/15th-conference-on-polar-meteorology-and-oceanography1/

The Conference on Polar Meteorology and Oceanography explores the topics of observational and modeling studies of polar clouds, aerosols, and precipitation, sea ice variability and change in the Arctic and/or Antarctic, the state of the cryosphere, as measured by field campaigns and satellites, observational needs for the cryosphere, and much more.

New Studies Published in Bulletin of the American Meteorological Society Reveal Clear Ties Between Today's Extremes and Human Causes

The U.S. Northern Plains and East Africa droughts of 2017, floods in South America, China and Bangladesh, and heatwaves in China and the Mediterranean were all made more likely by human-caused climate change, according to new research published December 10, 2018, in the *Bulletin of the American Meteorological Society* (*BAMS*).

The seventh edition of the report, *Explaining Extreme Events in 2017 from a Climate Perspective*, also included analyses of ocean heat events, including intense marine heatwaves in the Tasman Sea off of Australia in 2017 and 2018 that were "virtually impossible" without human-caused climate change. Also included are analyses of Australian fires and Uruguay flooding.

This is the second year that scientists have identified extreme weather events that they said could not have happened without warming of the climate through human-induced climate change.

The report presents 17 peer-reviewed analyses of extreme weather across six continents and two oceans during 2017. It features the research of 120 scientists from 10 countries looking at both historical observations and model simulations to determine whether and by how much climate change may have influenced particular extreme events.

Read the entire press release, along with some findings from the studies, here.

American Society of Civil Engineers

Geo-Congress 2019

March 24-27, 2019. Philadelphia, PA

https://www.geocongress.org/

From the early days of modern geotechnical engineering, sharing field experiences of the performance of geostructures – dams, foundations, tunnels, landfills – in the form of case histories has driven the advancement of knowledge for the geo-profession. Geo-Congress 2019 will continue this tradition and feature experiences and observations from hundreds of geoengineering projects, including recent "MegaProjects." The conference will include a wide range of informative technical and panel sessions, short courses, and workshops.

World Environmental & Water Resources Congress

May 19-23, 2019. Pittsburgh, PA

https://www.ewricongress.org/

Created in 1999, the Environmental & Water Resources Institute (EWRI) is the recognized leader within ASCE for the integration of technical expertise and public policy in the planning, design, construction, and operation of environmentally sound and sustainable infrastructure impacting air, land and water resources.

This Congress will allow attendees to earn Professional Development Hours, network with industry leaders, learn about the latest trends and techniques being applied in the industry, participate in policy dialogue on water resource and environmental issues affecting the profession, among others.

ASCE Supports Legislation to Expand STEM Education

U.S. Senators Brian Schatz (D-Hawai'i) and Sherrod Brown (D-Ohio) introduced the Inspiring New STEM Professionals by Investing in Renovation of Education Spaces (INSPIRES) Act December 20, 2018. The INSPIRES

Act would increase educational and career opportunities for students attending rural and remote middle and high schools, community colleges, and other education institutions by providing funds to modernize, renovate, or repair STEM facilities.

With the STEM job market expected to continue its rapid growth, the INSPIRES Act aims to improve the quality and availability of STEM and career and technical education instruction by providing grants to rural and Native-serving local educational agencies (LEAs) and community colleges for improvements to facilities.

Organizations endorsing the INSPIRES Act include the American Association of Physics Teachers, American Society of Civil Engineers, American Association of Community Colleges, and National Society of Professional Engineers (NSPE).

Read more here.

American Society of Landscape Architects Fund

Conference on Landscape Architecture

November 15-18, 2019. San Diego, CA

The meeting will feature a diverse spectrum of industry experts speaking on a wide range of subjects, from sustainable design and best practices to new materials and technologies.

More than 130 education sessions and field sessions will be presented during the meeting, providing attendees with the opportunity to earn up to 21 professional development hours under the Landscape Architecture Continuing Education System™ (LA CES™).

Many of the sessions will also qualify for continuing education credit with the Green Building Certification Institute (toward LEED AP credential maintenance), the American Institute of Architects, the American Institute of Certified Planners, and other allied professional organizations and state registration boards.

The American Society of Landscape Architects Condemns Administration Proposal to Weaken Protections of Wetlands and Waterways

The following is an abbreviated statement by ASLA Executive Vice President and CEO Nancy Somerville, Hon. ASLA, on December 13, 2018, regarding the proposed rule issued by the U.S. Environmental Protection Agency and the Army Corps of Engineers to alter the definition of "waters of the United States" under the Clean Water Act in such a way that severely threatens the quality of drinking water and community health and well-being nationwide.

The Trump administration's proposed rule redefining the term "Waters of the United States" (WOTUS) within the Clean Water Act is a direct assault on the health and well-being of American communities nationwide. The proposed definition severely limits which waterways and wetlands are protected from pollutants, and could have catastrophic effects on the quality of the nation's water, human health, the economies of communities, and the viability of wildlife populations.

ASLA supports having one clear and consistent definition of WOTUS that balances the need to have safe, healthy bodies of water with commerce and sound development practices. The proposed rule change significantly alters that balance, endangering communities and ecosystems while allowing polluters to adversely affect communities and ecosystems well beyond the boundaries of their property.

Landscape architects work at the nexus of the built and natural environments, and are at the forefront of planning and designing water and storm-water management projects that help to protect and preserve our nation's water supply and enrich the lives of communities. The administration's replacement rule would be a drastic step backward from the commitment to clean water for all Americans that is at the heart of the original Clean Water Act and the WOTUS rule, and ASLA will work to oppose this proposal.

Read the entire press release here.

American Water Resources Association

2019 Summer Conference: Improving Water Infrastructure through Resilient Adaptation

June 16-19, 2019. Sparks, NV

https://members.awra.org/Members/Events_and_Networking/Events/Summer_2019_Specialty_Conference.aspx

This conference will allow attendees to confer about what engineering solutions and policy conditions are needed for improving water resources resilience of our nation, discuss what has or hasn't worked as we have tried to adapt to water related risks, and review what innovative data and tools are being developed and used to support efforts to improve resilience and adapt to new water realities.

2019 Spring Conference: Setting Conditions for Success of Integrated Water Resources Management

March 25-27, 2019. Omaha, NE

https://members.awra.org/Members/Events_and_Networking/Events/Spring_2019_Specialty_Conference.aspx

Following in the steps of the 2011 and 2014 AWRA Integrated Water Resources Management (IWRM) conferences, the 2019 AWRA Spring Specialty Conference will support dialog, sharing and learning about the tactics, strategies and policies that are helping IWRM succeed across North America and the world. Researchers, practitioners and academics will assemble in Nebraska - a state that has implementing IWRM for over a decade - to consider how IWRM can become the normative model of water management, or simply, "how we do things."

AWRA Appoints New Executive Vice-President Dresden Farrand

Dresden Farrand is the newly appointed executive vice-president of AWRA. Farrand has also joined the RNRF Board of Directors as the American Water Resources Association's representative.

Prior to joining the AWRA team, Farrand was the vice president of membership and chapter development for the Independent Electrical Contractors Association (IEC), a national trade association, where she created strong new sources of revenue and organizational growth. Her other association successes include building programs and services, increasing membership and fostering high performing teams that put members at the center of their work.

Farrand is a certified association executive (CAE), and holds a master's degree in public administration from University of Missouri-Columbia and a master's degree in public policy from St. Louis University.

Geological Society of America

2019 Annual Meeting

September 22-25, 2019. Phoenix, AZ

http://www.geosociety.org/GSA/Events/Annual_Meeting/GSA/Events/2019info.aspx

Attendees can look forward to a modern, exciting metropolitan area with great activities and events. There will also be many field trips throughout the state to study Arizona's extensive geological features. GSA expects to have a strong education program during the meeting because of the emphasis on geoscience literacy promoted by the many natural parks in the state.

GSA Tomorrow: An Open Challenge to Promote the Future of Geoscience

An article posted in GSA Today's "Groundwork" series entitled "GSA Tomorrow: An Open Challenge to Promote the Future of Geoscience" issued a call to action for geoscientists to openly discuss how their work and profession impacts society. The article concludes with:

"Make a difference, get involved, and expand geoscience appreciation! If geoscience is vital to the betterment, sustainability, and continuity of humankind and society, it is our responsibility as geologists to educate the non-geologists who don't agree or understand why. We invite you to contribute to this discussion by coming up with your own succinct, measurable, and clear reasons on the importance of your specific discipline in how it affects all aspects of society. Unconventional and unusual reasons are encouraged, and "succinct" is key: we ask you to add your thoughts to our challenge by sending a two-sentence e-mail to or, for those so inclined, posting your answer in a single Twitter or Instagram post. Be sure to tag @geosociety and #geotomorrow so that your responses may be collected. Responses will be made available for our geoscience community to use, adapt, and advocate with as we continue into the future. As the voice of the Geological Society of America, you are responsible to initiate a surge in geoscience appreciation and understanding. We know what GSA Today is—what is GSA Tomorrow?"

Read the full article here.

Society of Environmental Chemistry and Toxicology

SETAC Africa 9th Biennial Conference

May 6-8, 2019. Cape Town, South Africa

https://saf2019.setac.org/

SETAC places emphasis on basic applied sciences such as environmental chemistry, toxicology and ecology. The primary goal of this joint conference with the Society of Risk Analyses (SRA) is to illustrate how these sciences relate to using health and environmental risk analyses within Africa. The long-term goal is supporting the eventual use of risk analyses and related sciences in policy making and regulatory development.

The conference will include daily plenary panels, joint SRA and SETAC sessions, platform and poster sessions and special symposia.

The program will blend health, environmental and risk sciences from SRA and SETAC as well as abstracts from members from the American Society of Civil Engineers (ASCE), who plan to be a conference sponsor.

From Pollutants to Human Health: Key Questions for a Better Environmental Future in Europe

Degradation of the environment and natural resources, the loss of biodiversity, impacts on health and the crises on food safety are some of the effects of chemical products being thrown into the environment due human activity.

In July 2018, a study published in SETAC's journal *Environmental Toxicology and Chemistry* identifies twenty-two main questions to consider in order to manage sustainably the environmental risks that are related to the chemical products in Europe.

The study, “Toward Sustainable Environmental Quality: Priority Research Questions for Europe,” wants to shape a new guideline – with a more global and coordinated perspective – for several social and economic sectors in the field of chemical products and management of environmental risks in Europe.

The new study is part of the initiatives by Global Horizon Scanning Project (GHSP), Society of Environmental Toxicology and Chemistry (SETAC), to identify the main factors that alter the environmental quality in several geographical areas (Europe, Africa, North America, South America and Asia-Pacific. In particular, the study results from a 2015 initiative during the SETAC conference in Barcelona, in which key aspects of chemistry and environment were debated among key experts and SETAC members.

Read the entire press release here.

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