World Federation of Engineering Organisations

The Committee on Engineering and the Environment

September 2011

All infrastructures were designed and built to the codes and standards existing when they were constructed and embedded within these codes and standards are climatic criteria that are now being called into question.

Infrastructure Assessment and Adaptation Critical in Responding To Climate-Induced Vulnerabilities

Infrastructures, such as these electrical transmission lines in the Republic of Korea, are interdependent on other infrastructures. For example, water-supply systems may provide water for cooling and generation at power plants, In turn, power grids may supply electricity to pump and distribute water. Understanding such interrelationships is vital when adapting existing infrastructures to climate change. (UN Photo/Kibae Park)

By Darrel Danyluk, P.Eng.
FEC, FCAE, FEIC, FCSCE

Darrel Danyluk chairs the WFEO Standing Committee on Engineering and the Environment (CEE).

The world is facing a serious challenge and it will take our best efforts to understand, quantify and adapt in order to minimize the impact of increasingly severe weather that adversely impacts the delivery and sustainability of infrastructure systems.

Water, transport, power, communications and built infrastructures are all at risk, and a failure of one infrastructure can severely impact our economies, our safety and our way of life.

Climate change, manifested through changes in atmospheric and oceanic conditions, will impose increased and new risks on many natural and human systems – notably through changes in climate variability, and in the frequency and magnitude of extreme climatic events.

The United Nations Framework Convention on Climate Change's (UNFCCC) and the Intergovernmental Panel on Climate Change's (IPCC) conclusion that the world is undergoing Climate Change requires the assessment of the relevancy of the climatic criteria currently used to design all infrastructures. Such assessments are an important factor in determining infrastructures vulnerability to climate-induced failure.

We must note that all infrastructures were designed and built to the codes and standards existing when they were constructed and embedded within these codes and standards are climatic criteria that are now being called into question.

Each Element Needs Assessment

Another fact is that individually, these assessments are not complex but since every element within each infrastructure system needs a vulnerability assessment, enormous numbers of infrastructure components require evaluation. A system fails at its weakest link.

Another consideration is that the life expectancies of public infrastructure are based on present and future climate conditions.

Nevertheless, infrastructure vulnerabilities must be identified, prioritized and adaptive actions implemented.

Knowledge on climate variables and climate change is improving; professionals and the risk-management tools and vulnerability-assessment protocols to identify, prioritize and implement adaptation and mitigation action are available.

Responding actions must be closely linked and coordinated, and not be addressed in isolation.

Actions must be sequenced and coordinated to continually inform subsequent decisions and actions that are economically, socially and environmentally responsive, and sustainable.

Significant to note is that not all changes will be detrimental.

Within each country, those who currently manage, plan, design, operate and maintain the infrastructure are central to carrying out this work and today ensure our societies the best infrastructures that they can afford.

Engineers – with climatologists, risk professionals, infrastructure managers and operators – already use vulnerability and risk assessment protocols, such as the Engineers Canada Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering

Continued on back page

Adaptation of Existing and New Infrastructure to Climate Risks

By David Lapp, P.Eng.

David Lapp is Manager, Professional Practice, with Engineers Canada.

Introduction

Adaptation of infrastructure is a necessary strategy to reduce the risks and impacts of extreme weather events in the future. Engineers, planners, managers, operators and other professionals, including climate scientists, are needed to work as a multi-disciplinary team to respond to this risk. While adaptation of infrastructure to the changing climate is a huge problem, with proper assessment and planning, including proper operations and maintenance, it is manageable. The questions are how do we adapt infrastructure to climate change and where do we start? The answer to both questions is risk assessment.

Engineering vulnerability/risk assessment forms the bridge to ensure the changing climate is considered in engineering design, operations and maintenance of civil infrastructure.

Engineering vulnerability/risk assessment forms the bridge to ensure the changing climate is considered in engineering design, operations and maintenance of civil infrastructure. Identifying the highly vulnerable components of the infrastructure to climate-change impacts enables development of cost-effective engineering/operations solutions. It is a structured, formalized and documented process for engineers, planners and decision-makers to recommend measures to address the vulnerabilities and risks to changes in particular climate design parameters and other environmental factors from extreme climatic events. The assessments help justify design, operations and maintenance recommendations and provide documented results that fulfil due diligence requirements for insurance and liability purposes.

Currently, climate-change models do not provide the granularity or level of detail required for the site-specific scales used in engineering design of individual infrastructures. Engineering vulnerability/risk assessment provides a recognized methodology that handles the uncertainties that are inherent in climate-change projections. It enables the identification of key vulnerabilities and risks in a form that enables engineers to exercise their professional judgment for infrastructure design, operations and maintenance recommendations.

PIEVC Engineering Protocol

Since 2005, Engineers Canada, the nation-wide professional organization, has partnered with Natural Resources Canada to complete a national engineering vulnerability assessment of existing and planned public infrastructure to the impacts of climate change. A key outcome is a formalized risk-assessment procedure or tool, known as the PIEVC Engineering Protocol ("the Protocol").

Bearspaw Water Treatment Plant in Calgary, Canada – inside the Pre-Treatment Facility (Photo, The City of Calgary, Water Services)

The Protocol outlines a process to systematically review climate information and identify the vulnerabilities or adaptive capacity of the individual infrastructure. Risk is defined as the probability of the climate event times its severity or impact on the infrastructure, given that the climate event has occurred. The probability and severity estimations use a 0–7 relative scoring system that enables higher-risk components and the critical climate parameters to be identified through a higher-risk score. Higher-risk scores indicate the degree of increased climate impacts on infrastructure components (i.e. deterioration, damage or destruction). Risk profiles of the infrastructure components for current climate, as well as future climate, are developed. This information can be used to make informed engineering judgments as to what components require adaptation and how to adapt them (e.g. design adjustments, changes to operational or maintenance procedures). It is applicable to any type of civil infrastructure, including buildings.

Canadian and International Case Studies

The Protocol has been applied to 22 case studies of individual infrastructures in Canada falling within four infrastructure categories, namely buildings, storm water/wastewater systems, roads and associated structures (e.g. bridges and culverts), and water-supply and management systems. In March 2011, Engineers Canada, through the WFEO-Committee in Engineering and the Environment (CEE), completed the first international application of the Protocol in close partnership with the Costa Rica Colegio of Engineers and Architects. (See separate article in this newsletter.)

The following briefly describes an example of the scope of a case study completed in Canada.

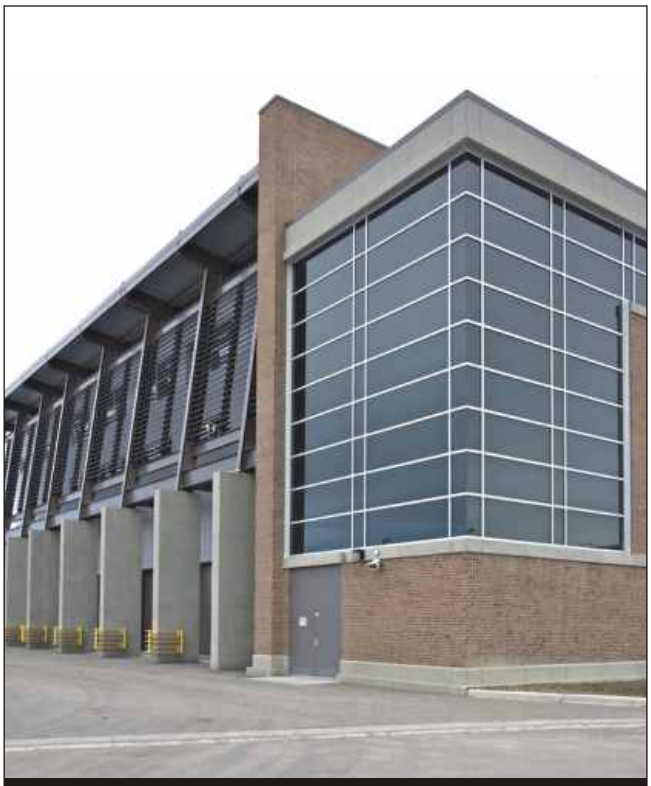
City of Calgary Alberta – Potable Water-Supply System

The City of Calgary, a major centre in Western Canada with a population of about one million, is committed to ensuring the long-term sustainability of its water needs and water resources. Factors that significantly impact the water demand include population, employment, economic cycles, and technology, weather and climate, price and conservation programs.

City staff needed to update current infrastructure plans to take into account new population forecasts, climate change, and new initiatives such as low-impact development, water reclamation and regional servicing. Planning of water treatment plants and their associated linear infrastructure need to be integrated to ensure coordinated investment. There is also a need to link water licensing to the water-supply system's capacity analysis to ensure the system is being analyzed as one system from “the river to the tap.”

The Calgary case study conducted a vulnerability risk assessment to identify any components of the potable water-supply system that are at risk of failure, deterioration and damage from any extreme climatic events or significant changes to baseline climate design values for the years of 2020 and 2050. The project scope includes the source watersheds for Calgary's water-supply. The results for this case study are an input to the city's planning, scoping and costing of water-supply infrastructure in the future.

Further information on this and others case studies is available from Engineers Canada. (www.engineerscanada.ca).



Bearspaw Water Treatment Plant in Calgary, Canada – Residuals Treatment Facility (Photo, The City of Calgary, Water Services)

Outreach, Training and Capacity Building

The Protocol and the results of many of the case studies both collectively and individually have been presented at numerous technical conferences and professional society meetings on infrastructure, climate change and asset management in Canada, the United States and elsewhere. Venues have included events organized by WFEO-CEE at the United Nations Framework Convention on Climate Change meetings in Bonn, Germany; the World Bank, the World Engineering Convention in Brasilia, Brazil; and the Pan American Federation of Engineering Societies (UPADI).

Engineers Canada, in partnership with its constituent associations, has delivered one-day training workshops across Canada to over 650 engineers and other professionals. These workshops include a presentation on the local climate as well as the principles of risk assessment that form the scientific basis for the Protocol. Participants also engage in small group exercises to work with the protocol on a case study of an infrastructure.

Engineers Canada/WFEO-CEE training teams have delivered similar workshops in Costa Rica, Honduras, Guatemala and Panama.

Future Work

Over the next four years, WFEO-CEE will pursue training workshops and international case studies to allow other countries to develop their own capacity by learning and applying the Protocol.

Successfull application of the PIEVC Protocol to assess the Sanitary Sewer, the Treatment System and the Submarine Outfall for the City of Limón, Costa Rica.

By Eng. Freddy Bolaños Céspedes

Freddy Bolanos Céspedes is Chief of Department of the Colegio Federado de Ingenieros y de Arquitectos de Costa Rica and Costarican team project leader.

The first application of the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol in Latin America and the United States was conducted for the sewer system and its treatment facility, as well as the final discharge infrastructure of the City of Limón, Costa Rica. This project applied an analysis period of 30 years.

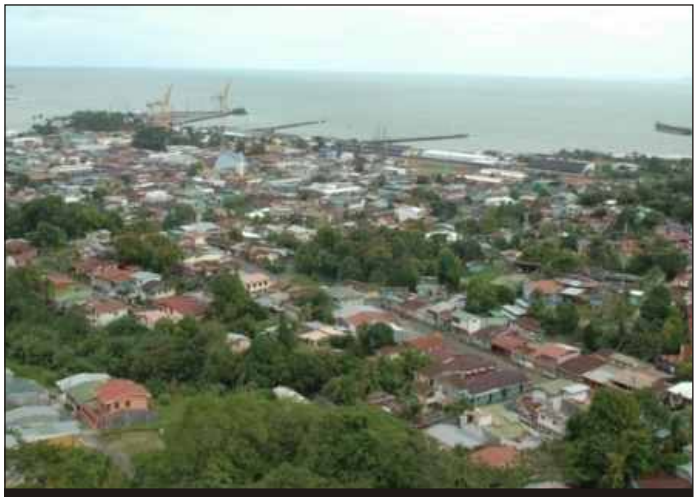
Thanks to a collaboration agreement between Engineers Canada and the Professional Association of Engineers and Architects of Costa Rica, it was possible to conduct the first diagnosis using PIEVC outside Canada to assess the degree of impact on public infrastructure due to climate change. The analysis identified a series of adaptation measures that must be implemented immediately, even if extreme climate events are not present.

The determination of the actions to be implemented was possible due to the application of the protocol developed by the Public Infrastructure Engineering Vulnerability Committee of the Canadian Council of Professional Engineers (Engineers Canada). The Protocol's objective is to evaluate and identify the risks that could be suffered by a given infrastructure due to climate change and therefore, define the specific measures to be implemented to adapt to the new loading conditions.

Increased Temperature and Precipitation Expected

For the Costa Rican project, the institutions involved were the National Weather Agency (IMN), the National Water Agency (AyA), the Professional Association of Engineers and Architects (CFIA), and Engineers Canada.

The City of Limón is located in the Atlantic (Caribbean) coast of Costa Rica. According to the IMN, due to climate change, the region's precipitation is expected to increase by 25% and the temperature to rise by half a degree by the year 2040. These changes will generate a change in the magnitude and the frequency of climate events. Through the application of regional and local models, the probabilities of occurrence for the most important climate parameters are shown in the table below.



Aerial perspective of Limón, Costa Rica, where the PIEVC Protocol was applied for the first time to infrastructure outside Canada.

Risk Analysis Applied

The risk analysis defined the severity for each infrastructure element that was considered for the project. And, even though no element showed high risk, it is important to mention that 32% of the analyzed elements shifted from low to medium risk for the 2040 scenario.

The elements that were identified as medium risks and most probable to be affected by climate change were: sanitary sewer (pipes and pumping stations), treatment facility (infrastructure and micro sleeve units), submarine outfall (concrete anchors) and the wave protection retaining wall.

Parameter	Present Probability	Future Probability
High Temperatures	4	5
Waves	1	2
Marine Breeze	2	3
Lightning	2	2
Flooding Rain	4	5
Overloading Rain	6	7
Hurricane	1	2
Wind	3	3

Used Integrated Approach

All the actions that were determined through the application of the protocol for this specific project did not concentrate only on substitution of infrastructure but a much more integral approach that considered substitution or modification of infrastructure, operational and maintenance aspects, and monitoring in order to provide better adaptation solutions.

The main activities to be implemented for the analyzed system were:

The conclusions of the project were:

Lightning	• Redesign ventilation system at pretreatment station
High Temperatures	• Verify existence of electrical protection of equipment
Flooding Rain	• Install weather station and monitor • Clean and repair gutters • Further engineering analysis replace or install
Overloading Rain	• Program to reduce illegal connections • Installation of weather station to monitor
Wind	• Maintain testing program of FC in areas with no sewer • Verify with wind speed/direction /contamination flume

- The PIEVC Protocol introduces Climate Change in a systematic manner based on a broad climate analysis.
- The best results for the application of the PIEVC Protocol occurred;
  - Where loading capacity was verified against extreme events that did occur
  - Where logs and registering documents were available.
- The application of the PIEVC Protocol allows identification of a loss-in-capacity or an out-of-service condition directly related to a specific climate event.
- The PIEVC Protocol, when used by experienced professionals, can establish a direct link between a specific element of infrastructure and an extreme event of climate change.
- In that sense, the PIEVC Protocol constitutes a powerful tool for planning the actions, and therefore the investments, that are required to adapt infrastructure to the impacts of climate change.
- The Protocol helped determine priorities for adaptation.
- The use of the protocol helped to prioritized research activities through its phase of engineering analysis.

WFEO-CEE and Related Upcoming Events

- Sept. 4, 2011 Geneva, Switzerland, (Centre International de Conférences Genève) WFEO-CEE Face-to-Face Meeting #4
- Sept. 8-9 Geneva, Switzerland (Centre International de Conférences Genève) WFEO General Assembly
- Nov. 2-8, Dec. 9, 2011 Durban, South Africa United Nations Framework Convention on Climate Change, Conference of the Parties Meeting No. 17 www.unfccc.org www.cop17durban.com
- June 4-6, 2012 Rio de Janeiro, Brazil United Nations Conference on Sustainable Development (Rio +20) www.uncsd2012.org
- Joint International Scientific Union (ICSU)-World Federation of Engineering Organizations Rio +20 Forum on Science and Technology – Rio de Janeiro Brazil - Technology Forum – May 28-June 1, 2012

Meetings Relating to WFEO-CEE Themes

Theme 2 – Climate Change Adaptation

- Sept. 6, 2011 Geneva, Switzerland WFEO-CEE Climate Change Sessions 2011 World Engineers Convention (www.wec2011.ch) www.wfeo.net

Theme 3 – Engineering and Agriculture

- Sept. 29-30, 2011 Surfer's Paradise, Queensland, Australia International Conference of Australian Society for Engineering and Agriculture – "Engineering Agriculture - Diverse Challenges - Innovative Solutions" www.engineersaustralia.org.au/seag2011
- Nov. 28-30, 2011 Venice, Italy – International Conference on Agriculture and Natural Resources Engineering www.waset.org/conferences/2011/venice/icanre

Theme 4 – Sustainability

- Jan. 5-7, 2012 Marrakech, Morocco – 5th ASCE-EWRI International Perspective on Water Resources and the Environment ewri@asce.org

WFEO-CEE 2007-11 Summary Report

At the WFEO 2007 General Assembly in New Delhi, India, Engineers Canada began hosting and chairing the Standing Committee on Engineering and the Environment (CEE). A small secretariat provided by Engineers Canada supports Chair Darrel Danyluk, P.Eng. and the committee made up of representatives of 30 countries.

Over the past four years, CEE held four, one-day face-to-face meetings organized in conjunction with the 2009 and 2011 General Assembly Meetings, and the Nov. 2008 and Oct. 2010 Executive Council meetings. From June 2008 through July 2011, four mid-year teleconferences/webinars reviewed progress in the Strategic Plan and received the Chair's report on WFEO and UN activities.

Report on 2008-11 Strategic Plan

The Committee executed a four-year Strategic Plan focusing on six themes summarized in the following table. At the 2009 General Assembly, on the recommendation of CEE, the Disaster Risk Management Theme became its own standing committee and was replaced by the Engineering and Agriculture Theme.

Table 1 – Summary of Themes and Notable Achievements

Theme (and Lead Country)	Key Focus/Additional Background	Notable Achievements
Theme 1 - Environmental Impacts of Major Sporting Events (Greece)	Environmental impact and sustainability issues around recent large-scale Olympic sporting events, and communication with future Olympic organizing committees	Final report accepted for publication in Oct. 2010 and issued in Sept. 2011.
Theme 2 - Engineering and Climate Change Adaptation (Canada)	Assess engineering vulnerability and risks of climate-change impacts on infrastructure. Develop strategies and engineering practices to improve resilience of existing and planned infrastructures to climate change	Project in 2010-11 with the Costa Rica Colegio to assess one of that country's sewage treatment systems by drawing on Engineers Canada's PIEVC Engineering Protocol. (For details, see this newsletter.) Technology transfer and capacity-building sessions in Costa Rica, Honduras, Guatemala, Panama and Brazil
Theme 3 Engineering and Agriculture (Argentina)	Most recently established theme, focuses on engineering and agriculture.	Task group formed to develop action plan for the 2011-15 Strategic Plan.
Theme 4 Sustainable Development Evaluation Framework (United Kingdom)	Sustainable development evaluation	Developed environment and sustainability evaluation framework to apply to engineering projects, policy initiatives.
Theme 5 - Environmental and Sustainable Engineering Practices for Engineers (Canada)	Sustainable Engineering Practices	Drafted international guideline for engineers on sustainable development and environmental stewardship focusing on professional and ethical principles. Results prepared for presentation at the General Assembly.
Theme 6 - Infrastructure in Developing Countries (India)	Developed training and education materials for recommendations arising from the Nov. 2007 international conference held with WFEO General Assembly in New Delhi.	Over the past four years, delivered many training sessions within India.

UN Framework Convention on Climate Change (UNFCCC)

In 2008, WFEO was granted observer status as a Non-Government Organization (NGO) for all UNFCCC meetings, with the Chair of WFEO-CEE as the Designated Contact Person. Since then the Committee Chair and occasionally other Committee members have participated and organized workshops ("side events").

Table 2 – Listing of UN Meetings

UN Organization	Year/Month	Location	Side Event Title
UNFCCC Climate Talks	June 2008	Bonn, Germany	Adaptation of Infrastructure to Address Impacts of a Changing Climate
	June 2009	Bonn, Germany	Engineering Vulnerability of infrastructure to climate change in newly developed and developing countries
	June 2010	Bonn, Germany	Infrastructure Climate Risk Assessment: Principles and Applications
	June 2011	Bonn, Germany	Infrastructure Climate Risk Assessment in Costa Rica: Knowledge Development and Capacity Building Experience
UNFCCC COP-15	June 2009	Copenhagen, Denmark	Danish Society of Engineers KlimateForum - 2009 Adaptation of Infrastructure Best Practices
UNFCCC COP-16	June 2010	Cancun, Mexico	No side event
UN CSD-16	May 2008	UN HQ New York	No side event
UN CSD-17	May 2009	UN HQ New York	Capacity Building – Words Into Action: Physical, Social & Economic Infrastructure
UN CSD-18	May 2010	UN HQ New York	Capacity Building – Words Into Action 2010 "Transport Efficiency and Waste Avoidance – Input for Policy-Makers"
UN CSD-19	May 2011	UN HQ New York	Capacity Building – Words Into Action 2011 "State-of-the-Art Innovative and Sustainable Technologies in Waste Management, Mining, Transport and Chemicals"

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WFEO-CEE 2007-11 Summary Report - Continued from page 6

WFEO-CEE contributed to meetings of the UN Nairobi Work Program within UNFCCC. In 2009 WFEO-CEE submitted an action pledge to the NWP and now provides yearly progress reports.

UN Commission on Sustainable Development (UN-CSD)

For the past four years, the Chair participated in a WFEO Task Force consisting of the Chairs of Energy, Capacity-Building and Engineering and the Environment that participated in 2008-2011 preparatory and full meetings of the Commission by submitting interventions providing the engineering perspective on policy positions and recommendations.

UN Millennium Development Goals

The Strategic Plan directly supported WFEO's mission for engineering to contribute meaningful and recognized support towards addressing the achievement of the UN-MDGs.

Newsletter

Between April 2009 and Sept. 2011, the committee published six newsletters, each focusing on one of the Strategic Plan themes.

2011-15 Strategic Plan

Engineers Canada has confirmed its willingness to host and chair the Committee for a second term. The Chair and Secretary are working with Committee members to confirm themes for the 2011-15 plan to be tabled for approval at the Committee's Sept. 2011 meeting.

Be a Part of *Words Into Action*

On September 6, 2011 at the World Engineers Convention in Geneva, Switzerland, attend a half-day session focusing on: "How will preparing for climate change impact the future of engineering?"

You are invited to join the World Federation of Engineering Organizations Committee on Engineering and the Environment, and Session Chair Paul Fesko of Engineers Canada for a half-day session for engineers on adaptation and mitigation. Find out first hand from engineers who are reducing greenhouse gas emissions and preparing to adapt to the impacts of climate change in their day-to-day work.

When: Tuesday, September 6, 2011 – 14:00 - 18:00

Where: Centre International de Conférences Genève, Room 5-6, Geneva, Switzerland.

When	Topics	Presenters
14:00 - 14:30	Climate Proofing the World's Infrastructure: The Role of Engineering	David Nickols Chair, Expert Panel for Water at the Institute of Civil Engineers, U.K.
14:30 - 15:45	Panel 1: Assessing the Risks of Public Infrastructure	
	Assessing Public Infrastructure Vulnerability to Climate Change: A Central American Perspective	Freddy Bolaños Céspedes Colegio Federado de Ingenieros y Arquitectos de Costa Rica
	Bridging the Gap Between Climate Change Data and Infrastructure Risk Assessment	Heather Auld Environment Canada
15:45 - 16:15	Official Convention Break	
	Coffee available outside room and session speakers available for discussion	
16:15 - 17:30	Panel 2: Engineering Solutions for GHG Reduction	Frida Frost Danish Society of Engineers
	5 ways to Reduce Greenhouse Gas Emissions	Alison Cook Cambridge University
	Get Started on a Country Report: Process and Funding Advice	
17:30 - 18:00	Nature as Infrastructure	Mark Smith International Union for the Conservation of Nature (IUCN)

Learn more about the Agenda and Speakers on line at:
www.wfeo.net and **www.wec2011.ch**; and follow us on Twitter **#ccaction2011**
Please share with your networks!

Danyluk Column - Continued from page 1

Protocol, to proactively address identified vulnerabilities.

The "No-Regrets" approach of embedding climate change assessments into all new capital works and infrastructure rehabilitation and upgrades will, over time, reduce vulnerabilities and climate-proof these systems.

Existing operating and capital budgets can fund this work, and international funding is available for adaptation work in developing countries.

Climate-Related Impacts

Climate-related disasters involving infrastructure may be mitigated only if policy-makers and citizens, administration and other entities appropriately fulfil their roles, and emphasize the importance of awareness-raising and disaster-prevention education.

For example, it is important for water-related parties in each river basin to cooperatively coordinate management of all natural and physical water and inter-related infrastructures.

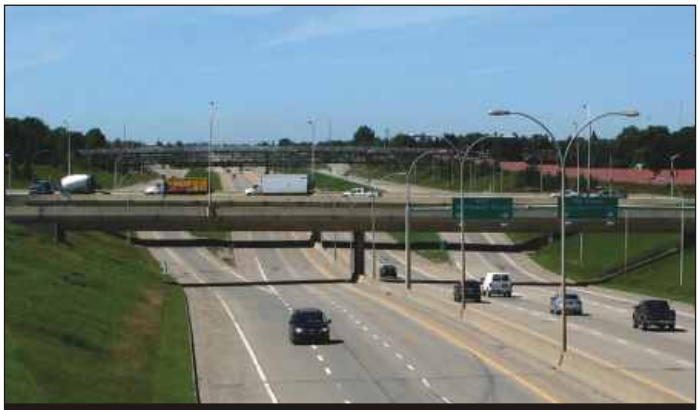
A national report on adaptation for the United Kingdom has been published by The Royal Academy of Engineering on behalf of Engineering the Future. Titled *Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future,* the report clearly states how our critical infrastructures are dependent upon each other.

Using water as an example, the report shows water's dependence on all aspects of infrastructure by noting:

- Energy: water infrastructure is dependent on electricity to power its facilities, particularly pumping and water treatment, and IT systems;
- ICT: it is dependent on ICT to run its centralised IT systems and for communication;
- Transport: there is a dependency on road and rail transport for personnel and supplies to run its facilities, and for transport of waste;
- Water: has an internal dependency on the water infrastructure, in that much of the infrastructure is susceptible to flooding, particularly for treatment works and wastewater removal.

And conversely, the report notes, water has significant impacts on other infrastructures:

- energy is dependent on water for cooling power-generating and oil and gas-processing plants; energy-transmission infrastructure and plants are highly susceptible to flood damage;
- ICT cables are susceptible to flood damage;
- transport systems are also susceptible to flood damage.



Road and rail provide routes to deliver personnel and services to other infrastructure but transportation infrastructures are susceptible to flooding.

And it is noted:

"In addition, any system or process dependent on human intervention is reliant on water for hygiene and drinking: without accessible water workers cannot remain on a site. Similarly, food production and processing is highly dependent on water. The examples are many, and understanding these interrelationships is vital in adapting existing infrastructures to the impacts on the changing climate."

Existing Teams Can Play Key Role

Teams that already design, manage and run the infrastructures provide the essential human resources that will prove useful in identifying climate-related challenges and in recommending adaptive or remedial actions.

So, countries can identify, understand and manage climate-change risks by:

- Increasing awareness and understanding of the impacts of climate-induced risk at all levels within organizations and the society;
- Determining their risk-tolerance level in terms of economic, social, environmental and human criteria;
- Conducting initial risk assessments to identify and prioritize critical areas of land and critical infrastructures vulnerable to a changing climate;
- Conducting engineering vulnerability assessments for priority infrastructures (using engineering assessment tools, such as the PIEVC Engineering Protocol) to identify the vulnerable elements that need adaptive measures;
- Initiating adaptive measures – including changing policies, regulations, operational, and maintenance procedures – and physical interventions to mitigate vulnerabilities;
- Prioritizing adaptation planning and actions – including implementing operational and maintenance procedures that extend the life of infrastructures that are at critical risk of failure, are at high-service demands, are reaching the end of their life cycle, or exceed the risk tolerance level and require significant investment to refurbish or replace;
- Strengthening all decision-making processes by requiring that specific programs and projects include plans and actions to manage risks associated with future, as well as present climate variability and extreme weather events. Such actions will result in the climate-proofing of infrastructure projects (new and refurbished). This is a risk-based "no-regrets" approach.

Impacts of Changing Climate Real

The world is facing a challenging future; the impacts of the changing climate are real and their seriousness cannot and should not be underestimated, and they must be addressed. National plans to assess and prioritize the likely impacts, and systematically implement adaptive actions are required.