Chapter 6. The Built Environment: Cities, Transport, Water Systems, and Energy

The built environment of the former East Bloc is acutely vulnerable to physical changes from climate variability and extremes. Floods are an obvious threat in many cities. Storm surges in the Black Sea and elsewhere are affecting coastal infrastructure. Projected warming trends and changes in precipitation patterns have the potential to impact the entire energy chain—from production, through transmission and distribution, to end use. With the likelihood of many more extreme events—floods and droughts—water quality could be profoundly affected.

This vulnerability is driven mainly by the poor condition of infrastructure. Old, badly maintained or constructed installations take fewer stresses to overwhelm them.

Consider housing: from the mid–1950s through the late 1980s, state enterprises built multi-story, multi-family housing blocks from prefabricated concrete panels, most of them designed for a life of about 30 years. In Poland, for example, there are more than 5 million Soviet-era flats, many in desperate need of refurbishment. Add the stresses of higher winds, more intense precipitation, summer heat waves, or melting permafrost in some regions, and some of the buildings could become less livable still. And transport systems, energy infrastructure and water utilities are similarly vulnerable.

While the most significant impacts of climate change are perhaps decades away, some vulnerabilities are already evident. A flood in Baia Mare, Romania in 2000 brought cyanide-laced waste from a gold mining operation into the Tiza and Danube rivers, tainting the drinking water of 2 million people downriver. It was the mix of extreme weather and past environmental mismanagement that turned a flood into a major threat to public health. Storm surges in the Black Sea are affecting coastal settlements, and more severe conditions may damage the 23 ports along the Black Sea. The more extreme heat conditions of Central Asian summers have exacerbated problems of poor road maintenance and low design standards. Warmer temperatures and resulting ground settlement in permafrost areas of Russia have destabilized a number of structures, including residential buildings, a power station, and an airport runway in Yakutsk.

How well ECA's cities, buildings, and infrastructure can cope with climate change will depend on whether governments improve current management practices, and address quality deficits that leave so many structures vulnerable. Barring runaway catastrophes, climatic changes are likely to be manageable if utilities and structures are well run and maintained.

But it takes far smaller shocks to overwhelm over-stretched utilities, decrepit housing, and poorly maintained infrastructures. Policymakers must identify the most vulnerable structures and accelerate, retrofit, and upgrade programs to improve their energy efficiency and livability while increasing their resilience to the effects of warmer and more extreme weather patterns.

Following are analyses of the impacts of projected climate change on urban structures, energy service provision, water systems, and transport infrastructure. Each shows some of the ways that a warmer, wetter, and more extreme climate may affect existing structures and systems, and suggests a framework, as well as practical steps, to lessen the risks. Proposed actions would support sturdier, better maintained structures and assist governments to protect buildings, roads, ports, energy systems, and waterworks from the damaging effects of climate change.

Urban challenges: making cities livable and viable in a warmer century[44]

About two-thirds of ECA's population lives in cities,[45] many of which are beginning to experience the effects of climate change. Some are encountering water shortages; others are facing increased or variable precipitation, rising temperatures, or more intense extreme weather events. Over time, continued shifts in weather patterns could damage some buildings and make others uninhabitable, stress infrastructure, threaten urban plant and animal life, and increase illness and deaths among vulnerable populations (box 6.1).

But despite the potential risks for cities and their residents, few municipalities in the region have integrated climate adaptation into their planning. To increase the resilience of cities to projected changes, ensure their livability, and maintain the provision of basic services in the long term, local governments need to begin planning today.

Plans will have to address issues such as projected higher temperatures in the summer months, associated increases in pollution and heat outdoors, and altered indoor air quality and temperature in many buildings. While this may be less problematic in the far north, the increased incidence of heat waves across southern and central Europe will require buildings to improve ventilation and cooling, not only for those individuals most vulnerable to health threats from the heat—the elderly, infants, and the disabled—but for the general population as well. In southern cities, projected reductions in precipitation and higher temperatures could also lead to groundwater depletion. In addition to raising concerns about water shortages for urban dwellers, reduced moisture in soils can affect the foundations of buildings.

BOX 6.1 ROMA, ALREADY MARGINALIZED, ARE PARTICULARLY VULNERABLE

Across the world, marginalized communities remain the most vulnerable in times of natural disaster. In the former East Bloc, the Roma—dispersed across the region—face continual stresses. Not only are many Roma neighborhoods overcrowded, but a study conducted in 2000 in Hungary, Romania, and Bulgaria found that the majority of homes in these areas do not have hot running water or central heat and showed an overall state of disrepair (Revenga, Ringold, and Tracy 2002). When floods hit the Slovakian town of Jarovnice in 1998, approximately 140 Roma homes were affected and 45 Roma died, compared to 25 non-Roma homes and two non-Roma deaths. Similarly, when the floods of 1997 hit the Czech city of Ostrava, white, non-Roma residents were offered opportunities to resettle in flats outside of the flood area, while Roma families were offered small workers' cabins or sent back to their flooded homes, even though they were in an area deemed unfit for habitation.

Source: Adapted from MRG (2008); Bukovska (2002).

Another issue cities face, which climate change can aggravate, is the urban "heat island" effect. Most urban areas were built with surfaces that absorb the heat, interrupted by parks and green spaces populated with plants that are suited to historic climate patterns. As temperatures increase, some plants may have difficulty surviving the new climate. When combined with the

[44] This section is based on "Achieving Urban Climate Adaptation in Europe and Central Asia*,"* by JoAnn Carmin and Yan F. Zhang, a background paper commissioned for this report.
[45] The share remains closer to one third in Central Asia.

amount of non-reflective surfaces in cities and the heat generated through rising energy use, cities can become significantly warmer than surrounding areas, raising concerns about heat stress and unmanageable surges in energy demand for cooling.

Coastal cities face additional concerns of infrastructure vulnerability (as already noted in chapter 4). Sea level rise will accelerate coastal erosion, increase the incidence of flooding, and lead to saltwater intrusion into groundwater aquifers in cities, particularly those along the Baltic and Adriatic. Turkey, for example, is highly vulnerable since it is bordered by four seas (Mediterranean, Black, Aegean, and Marmara). A 1m rise in sea level would affect approximately 30 percent of the nation’s total population living in urban areas close to the coastline. Sea level rise has the potential to affect not only natural systems and housing and infrastructure, but also tourism and enterprise (Karaca and Nicholls 2008).

Many northern cities situated along major waterways face the prospect of greater precipitation, leading to river swell and stress on existing dams. Cities have large areas of impervious surfaces. As precipitation increases and soils become waterlogged, existing storm water drainage systems, as well as sewage treatment plants and sewer lines, may be overwhelmed. Sewers that carry both storm water and sewage are common in many cities throughout the region. During the Prague floods of 2002, these systems were stressed, and many sewage treatment plants had to halt operations. Flood waters can transfer contaminants from abandoned industrial sites and operational facilities to populated areas. Along with the other types of wastes that will wash up onto the shores, these conditions can pose threats to human health.

Large, pre-fabricated, and poorly maintained Soviet-era buildings, a dominant feature of so many cities in the region, are vulnerable to projected changes. Formulating plans and mobilizing resources for retrofitting work is a priority across the region. Ideally, retrofits should draw on sustainable technologies to provide for healthier interior conditions and sturdier resistance to extreme weather, while also reducing carbon emissions through energy efficient systems, thus helping to reduce costs for consumers, spikes in energy demand for cooling, the emissions driving the overall climate change problem.

The housing stock is often under-maintained, energy-inefficient, leaky, and a visible weakness in the urban fabric. Table 6.1 shows the extent of prefabricated panel residences and the projected costs of refurbishing the buildings.

TABLE 6.1 PROJECTED REFURBISHMENT NEEDS RELATIVE TO SUPPORT PROGRAMS

	Latvia	Poland	Lithuania	Estonia	Eastern Germany
Number of flats in panel buildings, built 1950–1990	416,460	5,200,600	790,000	406,570	2,150,000
Assumed average refurbishment requirement per flat (€)	8,000	8,000	8,000	8,000	20,000
Overall refurbishment requirement (€ millions)	3,332	41,605	6,320	3,253	43,000
Investments achieved with support programs (€ millions)	3	250	20	30	30,000
Refurbishment covered to date by support programs	0.10%	0.60%	0.32%	0.92%	69.77%

Source: BEEN 2007.

Retrofitting on a large scale is costly, but the technologies and solutions are straight-forward. The major aspects of retrofitting taking place in ECA and elsewhere focus on energy-saving measures. These include thermal insulation, replacement windows, and modernization of central heating systems. In addition to these measures, green roofing is being tested as a further means for improving the quality of the quality of living spaces as well as a way to manage fluctuations in precipitation (box 6.2).

BOX 6.2. GREEN ROOFS TO MANAGE STORM WATER AND HEAT WAVES

A green roof is a roof partially or completely covered with vegetation and soil, planted over a waterproofing membrane. It may include additional layers such as a root barrier and drainage and irrigation systems.

Green roofs are increasingly popular for two reasons. First, they help storm water runoff management: they retain up to 75% of rainwater, gradually releasing it back into the atmosphere via condensation and transpiration, while retaining pollutants in their soil. They also help combat the urban heat island effect. Traditional building materials soak up the sun's radiation and re-emit it as heat, making cities much hotter than surrounding areas. Green roofs can cool the surrounding air by as much as 3 to 11 ºC at the same time as they reduce the need for air conditioning inside the building.

Green roofs have been around for thousands of years (from the sod roofs of rural cabins to the hanging gardens of Babylon) but are now making a major come back. Germany pioneered their modern incarnations by in the 1970s, when existing sewage systems were unable to cope with heavy rains. Now, many local authorities in Germany, Switzerland, and Austria require new buildings to include them. Green roofs are now becoming more common across Eastern European countries—a well-known example is that of the Warsaw library.

Sources: http://en.wikipedia.org/wiki/Green_roof; Kimberly Conniff Taber, "Fight climate change by turning roof green" International Herald Tribune, March 19, 2008.

In recent years, the region has seen more urban sprawl. As cities move to develop adaptation plans, city managers and planners could promote new, compact and sustainable construction and site planning and zoning policies that reflect climate change risks.

For example, by limiting development in areas affected by flooding, high precipitation, or other weather-related events, or by preserving green spaces and waterways, government policies can enhance the hydrological environment's natural ability to adapt. Site planning must extend to consider industrial areas, mining operations, and brownfield sites to address the risks that these areas pose to people and settlements when floods occur. In addition, new building codes and energy conservation ordinances should be aligned with principles of green design.

Operating from a planning paradigm that incorporates climate change will require new processes and new capacities. Municipal governments and government agencies must have the capacity to plan for and implement adaptation measures. Capacity in this case refers to technology, expertise, financial resources, staffing, and inter-agency coordination.

Given the nature of climate change, there must be strong ties to the scientific community so that timely information is received; there should also be mechanisms that retrieve input about changes from local communities so that officials can respond.

Local communities must be part of the decision-making process (see chapter 1), and lessons should be drawn from cities already engaged in adaptation planning (Prasad et al. 2009). In addition, future research can make a significant contribution. Questions that could be explored include:

- Which cities in ECA are most vulnerable to the impact of climate change?
- Where are the vulnerable populations located and what steps can be taken to reduce their risks?
- What are the drivers for municipalities to initiate climate adaptation planning and action?
- What municipal adaptation planning efforts have been most successful, and which problems have surfaced frequently?

Water: basic to all human activity but facing multiple pressures[46]

Extreme precipitation, drought, and heat waves can all have negative impacts on water quality. For example, floods often bring about wastewater overflows and contaminated runoff from farms and factories. Increased sediment loading may occur in areas already stressed from deforestation, resulting in increased water treatment costs. Where drier weather and drought cause a decline in flows from lakes and streams, there will be increased concentrations of pollutants and changed biological properties in water sources that communities rely upon. Hotter days bring increased surface evaporation, lending to greater salinization. Sea surges lead to saltwater intrusions in coastal aquifers.

While climate change promises a mélange of effects—some positive, such as longer growing seasons in northern regions—the fallout for water systems is overwhelmingly negative. Water professionals are confronted with an expanded set of possibilities and extremes and face more complex choices. Where water is less available, communities will have to change their water-consumption patterns, or bring in water from farther away. Hydropower output could be affected by varied or lower in-flows in some regions, straining energy supplies. Storm water drains may prove inadequate.

In general, water structures such as pipelines, reservoirs, and dikes have been designed based on historic climate trends—but new patterns may call for structural shifts. Simple calculations of supply and demand raise other concerns. Population growth plus increased agricultural and industrial demands may coincide with diminishing water resources, particularly in Central Asia. In other parts of ECA, heavily populated coastal areas already face an array of pollution and groundwater problem that will only worsen over time. Sea surges will instigate more saltwater mixing in aquifers and less available freshwater. Throughout ECA, there is the continued risk that sewage and inorganic materials will mix with water supplies.

Most water utilities in ECA face additional challenges that hamper their capacity to adapt. Being overstretched and underfunded, water and sanitation utilities show relatively poor performance, and most can't cover their costs. This has created shortcomings in service delivery, quality, and capacity, some of which are described below.

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[46] This section is based on "Adapting to Climate Change in Europe and Central Asia; Background Paper on water Supply and Sanitation," by Barbara Evans and Michael Webster, a background paper commissioned for this report.

Lower than expected coverage—particularly in rural areas. Although the ECA region has nominally high access to improved water sources and sanitation, 27 million people still lack access to improved water supply. In addition, quality and reliability is often poor. Even in capital cities, possibly even less than 65 percent of connected households enjoy a 24-hour supply, and performance is typically worse in smaller towns. According to a 2005 OECD study, "almost all trends in the water supply and sanitation sector point in the direction of further deterioration of water services," even without climate change.

Highly inefficient systems with low revenues and high investment needs. Non-revenue water rates are high (physical losses alone are in excess of 40 percent in eight countries of the region) as are labor costs (most utilities report 3–5 staff per thousand connections, which can be compared with the UK average of 0.3–1.0 staff per thousand). Cost-recovery is often low, with water utility revenues across the region estimated to cover only around 60 percent of operational costs—for example, 61 percent in Russia and 64 percent in Ukraine (OECD 2005). This is due to a combination of unwillingness to raise tariffs and expensive Soviet-era designs. The low revenue base translates into a cycle of underinvestment, poor maintenance, deterioration of infrastructure, and rising costs. Resources for rehabilitation and major investment are scarce and the poor revenue record makes borrowing difficult. An estimated $15–34 per capita per year of additional finance is needed simply to maintain and renew infrastructure at its current levels.

Transition from centralized economies to municipal government. Most countries in the region have undergone a rapid and almost complete decentralization to the municipal level, placing severe strains on local government capacity and finance. The resulting underinvestment may have had a knock-on impact on technical skills and capacity within utilities.

In general, water utility planning in ECA is only weakly linked to the overall management requirements for water resources as a whole (World Bank 2003)—although there have been notable successes in the Baltic Sea states and slow progress is being made in the Aral Sea basin. Changes are clearly needed to create stronger incentives in the water supply sector through stronger linkages to water resources management and greater efforts to stimulate capital flows to cash-starved utilities. Pilot programs in managing water markets will be useful, in addition to further research to identify the most vulnerable systems.

To address the above shortcomings and improve climate resilience, governments could explore practical steps to improve efficiency in the near and far terms and lower sensitivity to climate-related disruptions. Some possible priorities:

Demand-side management. There is considerable potential to reduce water demand; consumption levels are high by international standards. Cutting energy consumption through a variety of conservation measures and efficiency improvements would not only reduce vulnerabilities in the energy sector, but also save significant amounts of water. This could be further supported through improved metering and tariff-setting. In parallel, water supply infrastructure could be rehabilitated to significantly reduce losses.

Improve water storage. Provide more storage by constructing new dams and reservoirs to help those countries facing probable droughts and exhaustion of water supplies. A lower-cost option is to improve the management of existing reservoirs and dams.

Improve flood protection and drainage systems. Investment in flood protection will be important for dams, treatment plants, and distribution systems, while improved storm drainage could limit flood damage and protect groundwater supplies.

Explore the benefits of desalination facilities. Desalination has long been a costly strategy for expanding water supply, but with high costs for alternative supplies this option may become more attractive in light of changing climate scenarios.

The process of evaluating these and other possible investments demands a capacity to make sound economic judgments about costs, risks, and trade-offs. Climate change calls for new and sophisticated planning skills, which many of the region's utilities lack.

Finally, the significant variation in exposure and sensitivity across the region implies a need for locally determined adaptation plans. While planning models can be similar, each locality must be able to analyze specific risks and to fashion programs that address the most urgent threats.

Energy: new pressure to overcome a legacy of inefficiency[47]

The supply, transmission, and distribution of energy will be affected by climate change, particularly as the region experiences more climate variability and increasing episodes of extreme weather, such as droughts and flash flooding.

First, it should be stated that the region is a contributor to global warming, and although this report focuses on adapting to climate change, there are synergies between future energy strategies that would assist in limiting the region's carbon footprint and those that would help the energy sector adapt to new and more challenging climate conditions (box 6.3).

Rising temperatures across the region will lead to changes in the level and timing of peak demand, resulting in a flattening of the electricity consumption profile across the year as demand for cooling energy rises and heat energy declines. While ECA-specific projections are unavailable, European data is indicative: heating demand is projected to decline by 2–3 weeks per year and cooling demand to rise between 2–3 weeks (in coastal areas) and 5 weeks (in inland areas) by 2050. This represents a decrease in heat energy demand of up to 10 percent.

Other potential climate related concerns for the energy sector in particular sub-regions include:

Lower heating costs, higher cooling costs. The trade-off accompanying warmer winters, with lower demand for heating, is a possible costly demand for cooling. The Baltic countries, along with Poland and Belarus, will likely see lower need for natural gas and electrical power imports. But more days of extreme heat—above 35 and 40ºC— could place new burdens on power systems in southern and eastern regions, particularly for cities that will see enhanced temperatures due to heat island effects. Electricity systems—some already stretched, such as those in Southeastern Europe, Turkey, and Central Asia—may strain to meet heavier demands for air-conditioning, particularly if they rely on hydropower, which could be impacted at the same time by accelerated evaporation and drought.

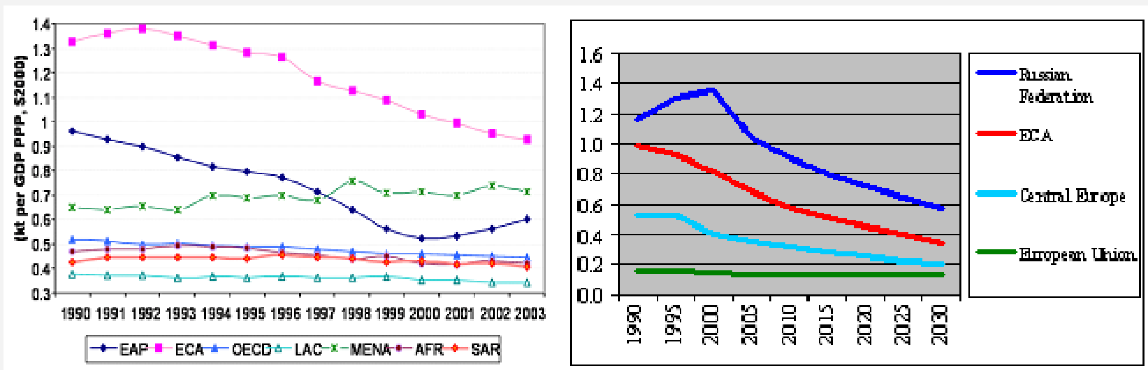
[47] This section is based on "Europe and Central Asia Region: How Resilient is the Energy Sector to Climate Change?" by Jane Ebinger, Bjorn Hamso, Franz Gerner, Antonio Lim and Ana Plecas, a background paper commissioned for this report

BOX 6.3 ECA'S ENERGY SECTOR—IN NEED OF INVESTMENTS AND IMPROVED MANAGEMENT

The ECA region, accounting for 5% of the world's GDP but 10% of its energy demand, is the most energy-inefficient region in the world both in terms of consumption and production of energy (Figure B6.3). Sector assets employ old and outdated technologies, many running beyond design life; the average age of power generation facilities is 35–40 years with nearly 80% installed prior to 1980. Poor maintenance throughout the 1990s has left systems more inefficient, unreliable and polluting.

FIGURE B6.3 ECA HAS THE WORLD'S HIGHEST CARBON INTENSITY

Total primary energy supply in Ktoe (Kiloton oil equivalent) per GDP in millions of US$, 2004 prices



Source: Ebinger et al., with data from WDI, IEA and ECA Energy Flagship Model.

Demand is expected to rise in the period to 2030—electricity consumption grows at an average annual rate of 3.7 percent—and fossil fuels are expected to remain the dominant source of energy. Future gas and electricity shortages are possible in several sub-regions (Southeastern Europe, Central Europe, Turkey, and Russia) threatening rapid growth. Together with rising gas prices and concern about reliance on Russia for fuel, the region is tending towards a growth pattern based on more polluting but locally available coal and resistance to shutting down aging nuclear reactors.

By 2030, coal-fired and nuclear generation are both projected to increase to 35% and 20% respectively, while hydropower and gas fired generation will decline to 12% and 29%. Expectations are that about half of today's infrastructure will be rehabilitated by 2030, while 40% is retired and around 726 GW of new generation capacity is built, mostly thermal (72 percent). Overall, investment costs are estimated at US$1.2 trillion. The renewal of sector assets in the period to 2030 provides a window of opportunity to curtail the carbon footprint and increase the resilience of the sector to climate change.

Source: Ebinger et al. 2008.

Altered contribution from hydropower. Hydropower in southeastern parts of Europe (including Turkey) and Central Asia will see changes in the timing and volume of flow to storage systems. Runoff will significantly decline (in some parts up to 25%) but in the near term may be balanced by glacial melt in the Alps, Caucasus, and Central Asia. The melting will initially increase stream flow but is then expected to decline over time by up to 50 percent. Hydropower potential around the Mediterranean is projected to decline by 20 to 50 percent while increasing in Eastern Europe by 15 to 30 percent and remaining stable in Central Europe (Alcamo et al. 2007).

Changing conditions will affect generation efficiency (sedimentation), reservoir management (storage and use, mudflows, lake outbursts), and seasonal water availability. There may be increased competition with other sectors and/or neighboring countries for scarce water supplies. At stake may be water-export arrangements between the Kyrgyz Republic and Tajikistan—both comparatively rich in water resources—and drier Kazakhstan, Uzbekistan, and Turkmenistan. However, northern parts of Europe and parts of Russia will see increased hydropower capacity.

Pressures on thermal and nuclear power. The operation of thermal and nuclear power facilities will be challenged by water availability and temperature concerns because of their dependence on significant volumes of water for cooling. Lower levels in lakes and rivers, reduced runoff, accelerated evaporation, and warmer water could deplete water for cooling or cause restrictions on cooling water intake or discharge, constraining facilities' generation capacity. Those stresses could translate into interrupted and more expensive electricity generation. Impacts are likely to be less significant than for hydropower, requiring operational management strategies and consideration in design.

Extreme weather effects on network management. Climate change will likely affect power transmission: extreme weather stretches the abilities of power transmission networks to function, reducing efficiency or impacting structural integrity, particularly for older and poorly maintained facilities. Transmission capacity, already constrained in parts of Russia, Southeastern Europe, and parts of the Caucasus and Central Asia, may be hampered by load management issues, especially during summer peak demand. Efficiency can decline with rising temperatures because of issues such as line sag and extreme events that affect line integrity, including heavy snowfall, precipitation, wind storms, and icing.

Mixed impacts for extractive activities in Arctic and Siberian Russia. Rising temperatures in Arctic and Siberian Russia could open up major economic opportunities, such as offshore oil exploration, but will have negative impacts in zones of discontinuous permafrost.

Oil and gas extraction and mining in permafrost areas will have to adjust to changes, including new challenges from thawing and shifting ground. Freeze-thaw processes are already having a negative effect on the structural integrity of buildings, key infrastructure (access routes, power plants, mines), and pipelines, leading to the failure of pilings and heaving structures as well as the erosion of shorelines and riverbanks.

For example, collapsing ground in Yakutsk in western Siberia has already damaged several large residential buildings, a power station, and a runway at the Yakutsk airport. And thawing and ground settling are impeding railways and roads used in energy transport, reducing the number of access days for transit routes and operations sites.

In offshore areas, reduced sea ice will lengthen the navigation season, allowing exploration and exploitation of as yet untapped mineral resources and reduce costs for industries that rely on shipping for transit. However, broken free sea ice and increased storm surges may endanger shipping, enhance the coastal erosion process, and increase the risk of pollution.

Vulnerability to floods. More frequent flooding, from rivers in the interior or from sea surges, threatens all types of structures, including energy infrastructure. In Romania in 2005, six consecutive waves of flooding led to widespread power cuts. And structures near coastlines—such as a Russian oil storage facility on the barrier island of Varandei in the Pechora Sea—are already under threat because of changing sea levels.

Opportunities for renewable energy. Projected higher wind speeds bring new opportunities for wind-power generation, both offshore and inland. In addition, more solar power may be possible for Mediterranean areas.

But wind and solar power are also sensitive to climate—namely, more variable wind patterns and more cloud cover during warm months.

From an adaptation perspective, the key question for regulators and industry alike is how much to invest in adaptation today given the uncertainties in climate forecasting and the build up and impact of greenhouse gases in the atmosphere in coming decades. A growing number of specialists now support a risk-based and flexible approach that focuses on "no-regrets" and "win-win" adaptation solutions, combining infrastructure investment with operational management solutions and further monitoring and research.

Despite many unknowns, it is certain that ECA's energy sector will be affected by climate change, although the nature and degree of impacts will vary across the region. On the positive side, the energy sector is accustomed to working in harsh environments, adapting—at a cost—to the realities that present themselves. The oil and gas industry has a long history of working in harsh environmental conditions and seeking innovative technical solutions to operational challenges. The power sector has vast experience in day-to-day grid management operations based on short-term climate forecasting. Most adaptation measures are already known, and the resilience and resourcefulness of the sector will be important assets; however, financing could present a constraint.

Future strategies will have to include and engage a broad range of stakeholders who will be affected both by climate change and by the various schemes to adjust to it. Some options to address management and structural issues include:

Transfer best practices. Transfer best practice technical solutions developed for the energy sector in other parts of the world to ECA—for example, North American experience offers potential solutions for issues facing Russian Arctic and Siberian permafrost zones today.

Take a look at demand-side management. Energy saving and demand-side management measures provide a cost-effective, win-win solution for mitigation and adaptation concerns surrounding rising demand and supply constraints. Water resource and flood management techniques are well known and will be important for those regions suffering drought conditions; meanwhile, regional cooperation, integration, and trade (for energy and water) can offer potential solutions as well.

Optimize the design for new or retrofitted investments. The anticipated large investment in ECA's energy infrastructure in coming decades provides a window of opportunity for smart climate-resilient design. Targeted refurbishing can help solidify weaker elements of the energy infrastructure assets that have a typical lifespan of 30–50 years. Meanwhile, investment in design standards to reflect projected changes can increase the resilience of new infrastructure.

For example, where permafrost is melting, deeper pilings can be used, and buildings can be raised slightly above the ground and thickly insulated. Lighter weight building materials can be employed to limit subsiding and shifting during thaws. Some lessons might be drawn from recent strategies to offset weather effects on the Trans-Alaska Pipeline.

Introduce proactive maintenance programs. Routine monitoring, regular repairs, and strictly observed maintenance standards will be needed to ensure that preventable deterioration doesn't increase vulnerabilities.

Regional energy cooperation through trade and power swaps can help governments manage supply–demand constraints. Southeastern Europe is currently expanding regional grid interconnections in what may be a promising trend.

Improve knowledge systems to provide more lead time and accurate tracking of climate trends and weather events. Tailor data for sector operations, maintenance, and design needs, and for the development of workable emergency plans.

Provide supporting framework for action. Support the above initiatives through regulation, incentives for change and, most important, outreach to key stakeholders.

Transport: taking on another increment of challenge[48]

Times of more extreme heat, heavier precipitation, and occasional flooding carry implications for the planning, design, construction, and maintenance of transportation infrastructures. The weather conditions may also bring about changes in the ways that people use transportation.

The greatest concerns revolve around a cluster of extremes: rising sea levels, storm surges, heavier rainfall or snow storms, and more days of intense heat. Coastal infrastructure on the Baltic and Black seas may require costly upgrading, or may have to be moved altogether. With higher winds and more storms, railways, bridges, harbor structures, tunnels, and cranes in Central Europe and the Baltic coasts will be more vulnerable. More intense rains can stress transport systems, with pavement sub-grades becoming less stable, and retaining walls and abutments weakening. Flooding can lead to landslides and slope failure, washing out roads and railway lines. At the other extreme, long periods of intense heat or drought—as projected for much of Central Asia, the Caucasus, and Southeast Europe—could lead to soil settling effects beneath key structures and roads.

More extreme temperatures alone can accelerate road deterioration, particularly in Central Asia. In parts of Kazakhstan, the government already has imposed restrictions on truck travel to limit wear and tear during the scorching summer months when the asphalt softens. Elsewhere, changes in the freeze-thaw cycles can result in road damages. Specifically, degradation of the permafrost in northern and eastern Russia may affect a number of structures, including sections of the Trans Siberian Railway and airports serving remote communities in northern and eastern Russia.

Rural communities, already isolated and separated from some essential services, may become more marginalized if roads deteriorate or become impassable as a result of landslides or slope failures. Earth and gravel roads are easily damaged in heavy rainstorms, and shorter, warmer winters shrink the length of time ice roads can be used. This is a critical issue for forestry and oil and gas exploitation in Russia, where these sectors depend on ice-road travel.

Transportation planners and decision-makers will face new challenges. Flooding and storm surges will affect multiple structures and systems across a wide area. At times, broader regional

[48] This section is based on "Climate Change Adaptation in the Transport Sector," by Ziad Nakat, a background paper commissioned for this report.

or cross-border cooperation will be required to solve a particular problem. Financial constraints will complicate and limit the planning process—particularly since climate change issues aren't normally factored into budget plans.

Planners can fashion "no-regret" policies that generate direct or indirect benefits, significant enough to offset the immediate costs regardless of how extreme the climate change impacts turn out to be. Improved maintenance and rehabilitation programs to prepare structures for climate-related stresses are also good investments under any weather scenario. Meanwhile, governments can be encouraged to provide insurance against climate extremes, which can no longer be categorized as unforeseeable events. Public–private partnerships may help in providing this coverage.

There are a number of concrete actions to help limit risks.

• Transportation agencies should establish systems for climate-attuned monitoring of key structures. For example, systems to measure bridge supports for the effects of heat stress or new pressures from changing water levels would be important. Sensor technologies and computer processing advances make it possible to create more "intelligent transportation systems" that in effect track their own stress levels. Development of temperature-resistant materials will allow decision-makers to make more optimal maintenance and rehabilitation choices.

• Planners can update design standards for key transport systems, incorporating current projections for warming, new precipitation patterns, and higher seas.

• New information and communications systems will have to ensure not only accurate and timely storm warnings and weather information, but also efficient communication of key information to transportation managers. More frequent intense storms will require the establishment of permanent evacuation routes and other emergency plans.

• Decision-makers should acquire new technologies to help them understand and manage climate-related challenges. Digital elevation maps, satellite-based monitoring, and computer-assisted scenario planning can be critical.

• Institutionalized mechanisms for knowledge sharing and communication between climate scientists and transportation professionals can help fill in the missing practical information decision-makers need to identify and address the most vulnerable features of the larger transport system.