# *BUILDING A CLIMATE RESILIENT HELLENIC ELECTRICITY DISTRIBUTION NETWORK: IMPACT ASSESSMENT OF EXTREME WEATHER EVENTS THROUGH CASE STUDY ANALYSIS, MITIGATION INTERVENTIONS & ADAPTATION BEST PRACTICES BASED ON LESSONS LEARNT FROM INTERNATIONAL EXPERIENCE*

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## Overview

Climate change impacts (i.e. changing trends, rising variability, greater extremes and large inter-annual variations in the climate parameters at regional level) are expected to have far-reaching effects on the electricity network that could strongly affect energy services and have implications across the entire energy supply chain: from generation, transmission and distribution to demand for electricity. Modern electric power systems are critical and extremely complex infrastructures which are designed to serve the reliable electricity supply of consumers (users) under normal operating conditions and in case that common failures or expected disturbances occur. However, although these infrastructures have achieved high degrees of reliability, they are not capable of effectively coping with unpredictable High Impact, Low Frequency (HILF) events, which are usually caused as a result of extreme weather phenomena, i.e. heatwaves, snowstorms, floods, hurricanes, and wildfires. Such incidents are becoming increasingly more frequent in the recent years around the world, giving rise to major network disruptions and cascading failures leading to blackouts that can last from a few hours to several weeks. The scientific community also warns that their frequency and intensity are projected to increase even more due to climate change, while according to the Intergovernmental Panel on Climate Change (IPCC), Greece will be more and more affected in the forecoming years by global warming and weather extremes. The climate change influence on the grid could cost utilities and customers billions, including the costs of power outages and widespread asset damages, not to mention indirect economic losses.

More specifically, the power distribution network is planned and built based on past or current climate patterns. Because of its long lifecycle, it is likely to be exposed more frequently to extreme climate conditions than those for which it was initially designed, without being able to cope with or quickly recover from unprecedented incidents. Within this context, it becomes an imperative need for Distribution System Operators (DSOs) to reinforce network resilience against multiple climate-related hazards: on one hand, they should withstand potentially disruptive events and, if disrupted, rapidly recover operations to minimise downtime, and on the other hand, they should adapt their network to climate change implications, such as the rising global temperature, changing precipitation patterns, salted humidity, sea level rising, etc. Hence, the establishment of a climate resilience strategy, including targeted actions that will range from incremental steps to systematic, long-term planning and transformational changes for climate risk reduction becomes of paramount importance. For decades, reliability has been the watchword for electric utilities, but now the concept of system resilience, based on the dimensions of robustness, resourcefulness, stability, continuity and integrity, is deemed as key for the effective disasters and crises management, but also for building stronger and safer energy infrastructures that will be capable of "absorbing" disruptions without "breaking", while experiencing a shock.

## Methods

This paper presents mitigation measures and adaptation policies and strategies for the build-up of a climate-resilient power distribution grid. The methodological approach that has been applied consists of the following steps:

- **Examination of Case Studies in Greece for different types of weather extremes** (i.e. 2021 Heatwave and Wildfires in Attica, 2021 MEDEA Snowfall, 2020 Medicane IANOS, 2019 Supercell Storm in Halkidiki, 2017 Mandra Floods, etc.), including: (i) description of the meteorological phenomenon; (ii) impact assessment on network components, evolution of damages and outages; (iii) analysis of response organisation and management, such as mobilisation of human resources, issuance of internal guidelines, progress of fault announcements by the end users through the Call Centre, good practices applied in the coordination and response at resource level, successes and failures; and (iv) identification of challenges, parameters that affect recovery times and contributing factors to electric grid vulnerability. For the elaboration of this section, data has been gathered through a series of interviews and discussions with the involved staff of the Hellenic DSO's Units.
- **Comparative Analysis with similar incidents at international level** deriving from climate change, including concequences of the events, damages to infrastructure, total crews deployed, transportation of

logistics, mean recovery times, number of customers affected, public response, safety compliance, etc.
- **Benchmarking with DSOs at European level**, evaluation of their climate change adaptation strategies and resilience reinforcement measures, synthesis of learnings, key findings and practical applications.
- **Establishment of a Climate Resilience Framework and development of a roadmap** in order to build a climate change proof distribution network, capitalising global climate change adaptation best practices.

## Results

Utilities need to take climate change adaptation measures to limit and mitigate the risks to customers and ensure business continuity. Considering the lessons learnt from past events and experience acquired from international best practices, a holistic and coherent climate resilience framework will be proposed that will be based on four main pillars:

I. **Upgrading operations** at each stage of the Disaster Management Cycle (i.e. Prevention, Preparedness, Response, Recovery), including the setup of a crisis governance structure, determination of climate-resilience metrics / KPIs, exploitation of knowledge management tools and platforms (i.e. record keeping tools, Competence Centre for Climate Change Mitigation and Adaptation, Incident Hub / Repository, etc.), development of annual training programmes and awareness campaigns to build a crisis-prepared culture, what-if planning / regional climate vulnerability assessment, emergency response planning, establishment of Standard Operating Procedures (i.e. prioritisation of restorations, damage recording, etc.), monitoring of spare parts availability, critical stocks and mobile emergency equipment, preparation of Local Operation Control Centers, promotion of mutual aid agreements to support afflicted areas, implementation of an integrated and sufficiently staffed Fault-Reporting Call Centre, media management / public communication policy, community participation approaches, insurance policy, etc.

II. **Smartening the grid** by grid digitisation through Advanced Metering Infrastructure (AMI), smart meter deployment and additional sensor technologies, grid automation (i.e. SCADA), grid modernisation and visualisation (i.e. GIS), large-scale investment for accelerating renewable energy penetration, microgrid deployment, integration of energy storage solutions with advanced control features, telematics in fleet vehicles, utilisation of innovative technologies, systems and tools to build technical intelligence (i.e. Early Warning Systems, IoT, real-time information management / field force data visualisation systems, demand side management tools, emerging communication technology) as well as special equipment (i.e. helicopters, drones, snow trucks) to improve fault diagnosis and speed-up responsiveness, development or enhancement of modelling tools (load forecast, damage and outage prediction, etc.).

III. **Hardening the grid** via a well-formulated and climate-resilience oriented project portfolio, including network strengthening solutions, such as increase of network density, selective undergrounding of overhead lines or critical infrastructure, elevation of substations for flood protection, upgrade of network design standards and building codes to incorporate findings and remedy strategies based on past incident records and improve rehabilitation capacity, lines reinforcement / rerouting, network reconstruction or renovation with improved materials, revision of network maintenance practices (inspections to check the health of critical components, tree trimming / vegetation management, specific preventive actions per climate risk, predictive maintenance, etc.), mechanical interventions to avoid big cascading failures, application of advanced protection schemes, relocation of critical assets to less vulnerable areas, etc.

IV. **Leveraging cross-domain synergies** with scientific workforce, public authorities, municipal / facility stakeholders, and other third parties to create a forward looking vision for a climate resilient future at national level (i.e. effective DSO/TSO coordination, establishment of clear communication channels & protocols with emergency services such as civil protection, fire fighters and the Army, participation in R&D projects, joint emergency preparedness exercises, climate change awareness campaigns, etc.).

## Conclusions

In the upcoming years, adaptation to climate change impacts is a crucial task for European DSOs which should revise their strategies and adopt a systemic approach in developing their transformative pathways and agendas towards climate resilience, based on a common framework for the assessment of climate change hazards. These strategies should entail clear plans and commitments to guide and enable innovation and policy actions, aiming at: (i) reducing risks and system vulnerabilities by hardening critical infrastructure; (ii) ensuring preparedness, effective emergency response and rapid recovery following disturbances in extreme conditions; and (iii) preventing and tackling events that result in cascading (multiple correlated) failures at national level. The stimulation of collaboration with other actors and public agencies becomes of predominant significance in order to build situational awareness, strengthen safety culture and facilitate the transition from Disaster Risk Management (DRM) to Disaster Risk Reduction (DRR). In any case, an evolutive, receptive and open-to-dialogue regulatory environment is deemed as necessary to support efforts towards risk preparedness in the electricity sector, while DSOs are called now more than ever to act as key enablers of the energy transition and contribute to rebuilding a greener economy on the basis of the three key principles of future energy systems (i.e. decarbonisation, decentralisation and digitalisation).