Technology Watch Newsletter

Resilience and energy transition – The energy sector answer to climate change

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Technology Watch is the Elettricità Futura initiative to monitor global technology trends having the power sector at their heart. In our quarterly newsletter you will find an article with our analysis on a specific technology trend, an article by CESI, our partner for the initiative, and technology news from all over the world selected by Elettricità Futura.

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Grid resilience: Main takeaways and overview of the resilience framework in Italy

Author:

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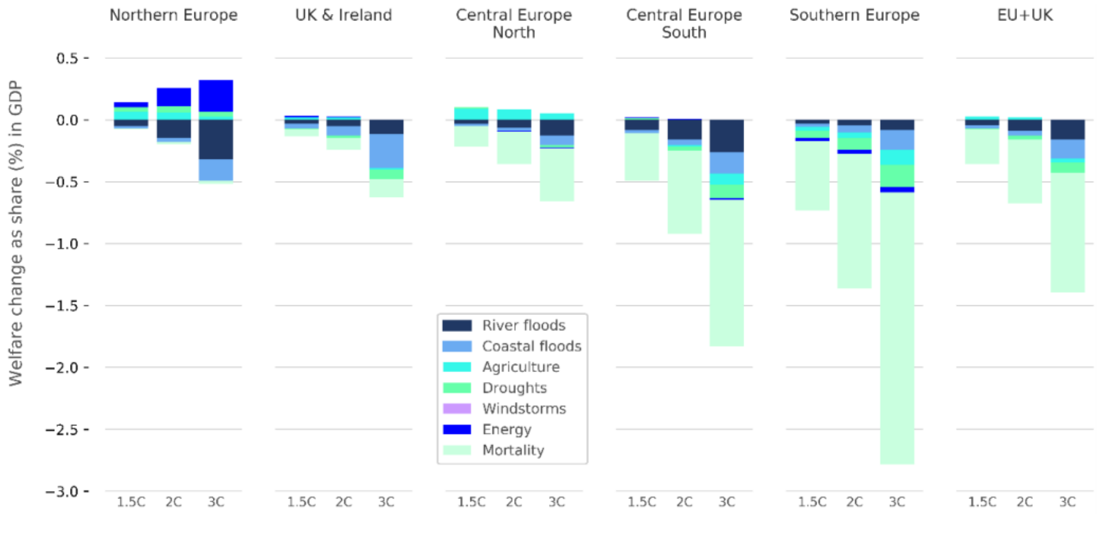
On the 24th of June, the European Parliament endorsed the EU Climate Law, thus fully committing the EU and all its Member States to the common fight against climate change. The objective is clear: do not exceed – or, even better, stay below it – the temperature increase limit of 1.5°C compared to pre-industrial levels by reducing EU greenhouse gas emissions to 55% compared with 1990 levels and achieving climate-neutrality around 2050. This objective, which must be pursued on a national, union, and global level, is crucial to prevent the negative effects that an increase in temperature between 1.5°C and 2°C could have on the environment and consequently on our societies and economies.

As the EU Commission Joint Research Centre (JSR) estimates in their PESETA IV report, if the present economy were exposed to global warming of 3°C, it would experience an annual welfare loss of at least 175 € billion (1.38% of GDP) for the seven impact categories considered in the report (human mortality from heat and cold waves, windstorms, water resources, droughts, river flooding, coastal flooding, wildfires, habitat loss, forest ecosystems, agriculture and energy supply). Under a 2°C scenario the welfare loss would be 83 €billion/year (0.65% of GDP), while a global warming of 1.5°C would reduce welfare loss to 42 €billion/year (0.33% of GDP) [1]. Geographically wise, the impacts of climate change would not be equal across all Europe: while northern European countries may even benefit in some sectors (e.g., energy supply) of an increase in temperatures, Southern Europe would bear the brunt of the losses.



Welfare loss estimates (%of GDP) in comparison to current economy under present climate from considered climate impacts at warming levels for the EU and the UK, and for macro regions (source: JRC PESETA IV)

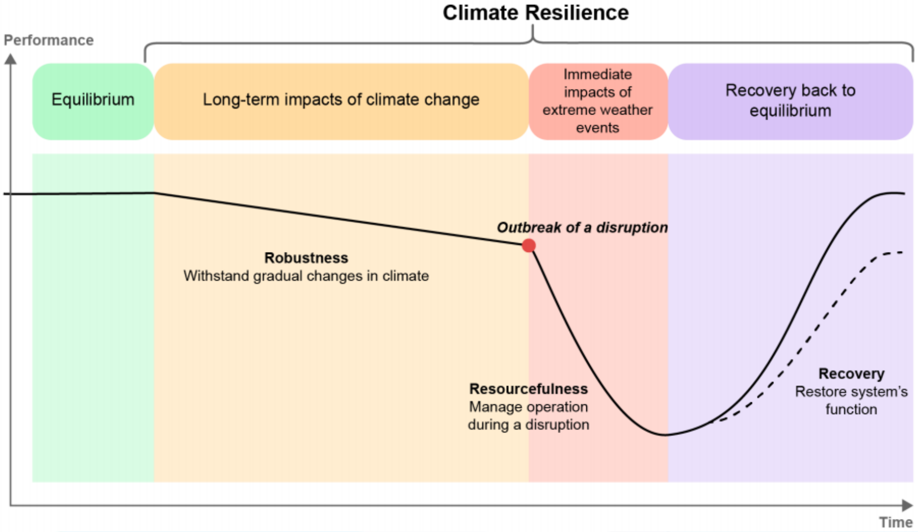
If not properly addressed, climate change is going to negatively affect every segment of the electricity system. Extreme weather events (blizzards, ice storms, floods, wildfires, heat waves and cold waves, hurricanes/cyclones), shifts in the precipitation patterns (some areas will see an increase in precipitation, while others a decrease) and sea level rise may significantly disrupt electricity generation, transmission and distribution, and demand patterns. The continuous rise of temperatures across the globe is already taking its toll and caused an increase in the number of extreme weather events. For example, during 2020 in Italy 239 extreme weather events have been registered – 53 more than 2019, mostly floods due to heavy rain – with 16 of them causing damage to infrastructures [2]. As Terna shows in its 2021 Ten-Year Network Development Plan, over the recent years the Italian transmission grid has been mainly impacted by heavy snowfalls/rainfalls and strong winds [3].

In its recent study “Climate resilience” the International Energy Agency (IEA) gives a comprehensive overview of the main potential impacts of climate change on the electricity system [4]. Those impacts include reductions in the efficiency and the generation potential of generation plants (both RES and thermal), physical risks both to generation plants and transmission and distribution networks, need for additional generation capacity due to higher demand (especially during the summer).

Climate impact	Generation	Transmission and distribution	Demand
Rising global temperatures	• Efficiency • Cooling efficiency • Generation potential • Need for additional generation	• Efficiency	• Cooling and heating
Changing precipitation patterns	• Output and potential • Peak and variability • Technology application	• Physical risks	• Cooling • Water supply
Sea-level rise	• Output • Physical risks • New asset development	• Physical risks • New asset development	• Water supply
Extreme weather events	• Physical risks • Efficiency	• Physical risks • Efficiency	• Cooling

Overview of main potential impacts on the electricity system due to climate change (source: IEA, Climate Resilience)

As shown in the image above, climate change can negatively affect the functioning and the configuration of the electricity transmission and distribution grids. In order to avoid that, resilience measures come into play. When applied to the electricity system, climate resilience is the capacity of the system and all its components to anticipate, absorb, accommodate, and rapidly and efficiently recover from the effects of a potentially hazardous event related to climate change. That can be achieved by: strengthening the existing lines or realizing new ones; having up-to-date emergency plans that outline all the necessary procedures and steps to recover from a service disruption; making use of the latest technological innovations (satellite imagery, IIoT solutions, AIs) to monitor the grid, accurately forecast hazardous weather events that may cause damage and therefore take pre-emptive and real time actions to shorten recovery times.



Conceptual framework for climate resilience of the electricity system (source: IEA, Climate Resilience)

Regarding the normative and regulatory framework in Italy, resilience has a central role in the strategic national plans for the energy and environment sectors. On an institutional level, resilience to climate change and extreme weather events is one of the main objectives of the National Climate Change Adaptation Strategy (Strategia Nazionale di Adattamento ai Cambiamenti Climatici) issued by the Ministry of Environment in 2014, which is in progress of being updated to a Plan [5]. The improvement of the Italian grid resilience is also one of the main staples of the National Energy Strategy (Strategia Energetica Nazionale, SEN) of 2017 and the Italian National Energy and Climate Plan (Piano Nazionale Integrato per l'Energia e il Clima, PNIEC).

On an operative level, Resilience interventions are currently being planned and implemented by Terna, the Italian Trasmission System Operator, and the major Distribution Systems Operators (DSOs that serve more than 50.000 users).

In its 2021-25 Industrial Plan, Terna planned a 1.2€billion investment to strengthen its Defence Plan (Piano di Sicurezza) [6]. The Defence Plan is updated every year – after approval by the Italian Ministry of Economic Development (from now on by the Italian Ministry of Ecological transition) – and outlines the description, planning and expenditure estimates of the activities that Terna will perform in the following four years to ensure the security of the transmission grid. The new funds will be used to improve the dynamic stability of the system and the voltage regulation service, thus strengthening the grid resilience to extreme weather events. In its 2021 Ten Year Network Development Plan (Piano Decennale di Sviluppo della Rete di Trasmissione Nazionale) Terna has already planned several interventions to increase grid meshing and reinforce its protection, control, and automation systems.

Terna is currently making crucial progresses on two more initiatives: firstly, it is finalizing the new "Resilience 2.0 methodology", realized with the support of RSE and endorsed by ARERA (the Italian National Regulatory Authority), that formally requested it with the resolution 64/2021/R/eel [7]. In April-May 2021 Terna held the public consultation on the new methodology for the evaluation of the Italian transmission grid resilience indicator. Secondly, it will use the new methodology to prepare a Resilience Plan (Piano di Resilienza) aimed at identifying new resilience projects to be included into the future Ten-Year Network Development Plans. To accomplish this task and ultimately to define a methodological approach to strengthen the grid against severe winter conditions and phenomena Terna is cooperating with the Distribution System Operators.

While Terna deals with the resilience of the transmission grid, the DSOs are responsible for strengthening the resilience of the distribution system. ARERA demands that the major DSOs (all DSOs directly connected to the transmission grid and with more than 50.000 served users) draw up plans to outline on a three-year horizon the planned interventions to strengthen the resistance of their respective distribution grids to extreme weather phenomena – particularly against severe winter conditions – and shortening supply restoration times. As a result of a workgroup that comprised the NRA, DSOs, Terna and CEI (Electrotechnical Italian Committee), in 2017 ARERA advanced the resilience regulation further by publishing a set of guidelines and criteria for DSOs to follow to prepare their Resilience Plans [8].

With the aim of fostering the system operators' efforts towards increasing the resilience of the distribution grid – both by strengthening its resistance to external stresses and disruptions, and in reducing recovery times – in 2018 ARERA also introduced a premium/penalty mechanism to incentivize interventions to improve their distribution systems. The mechanism is accessible to the so called "main" DSOs (DSOs with more than 100.000 served users) and is based on premiums for the realization within a deadline of high-risk resilience interventions that have positive net benefits, or penalties in the event the deadline is not met. As of now, 7 DSOs (Areti, Azienda reti elettriche, e-Distribuzione, Ireti, Servizi a rete, Set distribuzione, Unareti) have access to the mechanism and in December 2020 ARERA published the list of the 395 eligible resilience interventions to be completed in the 2021-24 timeframe [9][10]. For the 2017-2020 timeframe 1120 interventions had access to the mechanism and ARERA recently approved a total of about 9,6 mln € of premiums – and no penalties – for the interventions completed in 2019.

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Note: weblinks last accessed in July 2021

Strengthening the power grid to fight climate change

Author: CESI

Climate change has now become an increasingly present phenomenon with concrete consequences, and the data at our disposal show a worrying trend. As the recent "Climate Change and Health" report by the World Health Organization (WHO) highlights, "over the past 130 years, the world has warmed by about 0.85 °C, and each of the last three decades has been gradually hotter than any previous decade since 1850." In addition to an impact on people's health, climate change represents a high cost for the economy, because of damage to buildings and infrastructures.

In this respect, climate change is expected to have far-reaching effects also on the electricity grid. Effects that could cost billions and affect every aspect of the electricity sector from generation, transmission, and distribution to energy demand. For example, more frequent droughts and changing rainfall patterns may adversely influence hydroelectricity generation. Furthermore, transmission capacity may be reduced, or distribution lines damaged during increasing wildfire activity in some regions due to warmer temperatures and drier conditions.

Therefore, it is increasingly urgent to invest in the resilience of electricity grids. For instance, the serious and unprecedented accident that occurred in Texas has sent a clear signal urging for an increase in grid modernization investments. In 2020 alone, the United States experienced 22 climate-related disasters, with a total cost of $95 billion in damages to homes, businesses, and public infrastructure. A study by Department of Energy estimated that power outages cost the US economy up to $70 billion annually.

In a report by the European Commission's Joint Research Centre (JRC), it is highlighted that, as the scenario currently stands, the annual damage to critical European infrastructure could increase tenfold by the end of the century because of climate change (rising from the current €3.4 billion to €34 billion). Industry, transport and energy sector, especially in southern and southeastern Europe, are at greatest risk of damage caused by heat waves, drought, coastal and inland flooding, storms and forest fires. For example, due to adverse weather conditions, last January a power supply failure that originated in Croatia had an impact on the Continental Europe Synchronous Area that split in two electric islands. In the north-western island, frequency dropped to 49.74 Hz (nominal frequency 50Hz) and the frequency decline was stopped only thanks to activation of controlled load shedding. In fact, the automatic triggering of security functions in power stations throughout Europe and the automatic activation of contracted load shedding in Italy (1,000 MW) and France (1,300 MW) kept the grid stable. This incident, once again, warned about the risks of the real possibility of a Europe-wide blackout. Therefore, it is essential to study models and elaborate strategies that can deal with climate change, making climate resilience part of infrastructural development.

In order to do so, it is fundamental that governments and regulatory authorities integrate measures for resilience into their infrastructural plans, possibly through partnerships and multi-stakeholder actions. It is equally important, in order to attract private investors (especially after the initial phase, usually supported by public funding), not only to develop analyses and maps, but also to run models of climate change impacted by integrating innovative technology, scientific applications, geological and hydrological studies. Yet, the success of any plan for infrastructural resilience strategy requires the involvement of local policy and communities that are directly interested in having a fully working electric power infrastructure. Finally, experimentation is necessary, and the tests on infrastructures turn into a fundamental activity to ensure their efficiency and reliability. Several enterprises have invested in reinforcing transmission and distribution infrastructures with the objective of preventing or reducing damage caused by extreme weather conditions. For example, in New Orleans, Entergy, which lost 95-125 miles of power transmission lines to Hurricane Katrina, invested no less than one billion dollars to improve the resilience of its substations, transmission and distribution lines, and ensure its resistance to similar strength storms.

Simply reinforcing the grid, however, is not enough. In the more industrialized countries, with technologically advanced networks, such as Italy, greater resilience of electrical systems is also achieved through the innovation provided by smart grids. In this respect, the recently established Ministry of Ecological Transition has approved a series of "smartization" interventions, with the objective to strengthen infrastructures and increase the energy needs covered by renewables. Nineteen projects, for a total investment of 120 million euros, have been recently financed through the funds from the Complementary Operational Program for Energy and Territorial Development:

such projects are set to modernize the power grid in regions such as Basilicata, Calabria, Campania, Apulia and Sicily, while also making it more resilient and reliant on sustainable electricity.

Furthermore, Enel and Terna, respectively one of the main distribution system operators and the Italian transmission system operator, are already heavily investing in grid resilience. Both in Italy and elsewhere. For instance, between 2021 and 2030, Enel will deploy at least 60 billion euros of cumulated investments in distribution networks, of which approximately 70% to further improve quality and resilience while more than 20% in connections, which benefit from the growing demand driven by urbanization and electrification of energy consumption. At the same time, around 10% will be devoted to further digitalizing the infrastructure. Geographically, around 60% of their investments in networks for 2021-2030 will address Europe. On the other hand, Terna's new industrial plan aims to invest 8.9 billion euros on regulated activities in Italy between 2021 and 2025. This is the company's biggest ever spending plan, which is set to help contributing to the country's economic recovery. Specifically, a total of 1.2 billion euros will go towards the so-called Defence Plan, primarily financing the work needed to ensure voltage regulation and dynamic stability of the electricity system. These investments are set to boost the resilience of the power system, allowing the network to deal with extreme weather events. Moreover, such investments aim at minimizing the visual and landscape impact of electricity infrastructure by removing, over the course of the plan, around 500 km of lines made obsolete by new grid developments.

Actions to mitigate the risk of power outages will address the main critical factors that affect the network: the impact of ice on overhead power lines during the winter months, the effects of wind and trees falling on overhead lines, and the consequences of heat waves during the summer months. Such plans include surveillance and protection activities for critical power stations and actions to secure IT infrastructure from break-ins, unauthorized access attempts and cyber-attacks.

Because of this scenario, testing the various components that comprise a power grid is a crucial step to guarantee their resilience and to avoid outages. Tests to verify the condition and the resistance of grid components are fundamental in the process of both safeguarding and modernizing networks.

Through its Testing, Inspection and Certification Division (KEMA Labs), CESI is able to carry out high-power and high-voltage laboratory tests and inspections, assess the operation in perturbed conditions of cyber-physical electrical systems, as well as to offer various certification services through their offices around the world. In their facilities, CESI and KEMA Labs are able to carry out tests in a controlled climatic environment in which, for example, the resistance of the components to freezing or extremely high temperatures is evaluated. Through mechanical stress tests, the KEMA Labs platforms can also simulate so-called "water bombs" and floods to verify the resilience of the grid components involved. Moreover, CESI works on intelligent grids, the so-called smart grids, to guarantee that clients are able to meet their needs for electricity generation and consumption, coordinating the flows of supply and demand. In fact, rigorous impartial third-party testing is the only way to give all stakeholders confidence that systems will work properly when needed. Together with the KEMA Labs High-Power and High-Voltage Laboratories, this is exactly what the new S&ST department offers: trusted and impartial standards-based testing of Metering, Protection and Substation Automation equipment. Moreover, CESI is collaborating with the company E-Distribuzione and other service providers with regard to the execution of integration tests between End User Devices (EUD) and the second-generation smart electricity meters, so called Open Meters. In this case, the verification of the interoperability among these devices is a preparatory step to the activation of the Chain 2 Full 2.0 services, i.e. the involvement of the final users in grid management.

Technology News Worldwide

HIGHLIGHT:
Artificial Intelligence Brings Resilience and Affordability to the Grid

A new white paper from Veritone presents five artificial intelligence (AI)-powered solutions that help those in the electric power industry enhance grid resilience, increase the rate of decarbonization and improve affordability of delivered electricity.

LINK

- **#Solar:** Engineers at the NYU Tandon School of Engineering have created a means of vastly increasing the speed and efficiency of a key doping process for perovskite solar cells, one that also sequesters CO2.
  Link

- **#Wind:** Leosphere, a Vaisala company that specializes in developing, manufacturing, and servicing turnkey wind lidar instruments for wind energy, announced its new WindCube Scan Dual Lidar Ready offering. It enables offshore wind project developers and operators to reduce multiple sources of uncertainty and gain an even more comprehensive picture of wind resource profiles by observing an offshore location from several positions.
  Link

- **#Electric Mobility:** Researchers from the University of Leicester and Birmingham have discovered an ultrasonic delamination technique to return high purity materials of EV batteries at the end of their life to be reused for new battery manufacture.
  Link

- **#Storage:** A new IIASA-led (International Institute for Applied Systems Analysis) study explored the potential of a lesser known, but promising sustainable energy storage system called Buoyancy Energy Storage that uses high-density polyethylene (HDPE) plastic pipelines arranged vertically to form a cube, coupled with an anchor system connected to the sea floor.
  Link

- **#Smart grids:** E-Distribuzione has signed a deal with the European Investment Bank for the provision of a €300 million ($355 million) loan to implement its e-grid project.
  Link

Note: weblinks last accessed in July 2021

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