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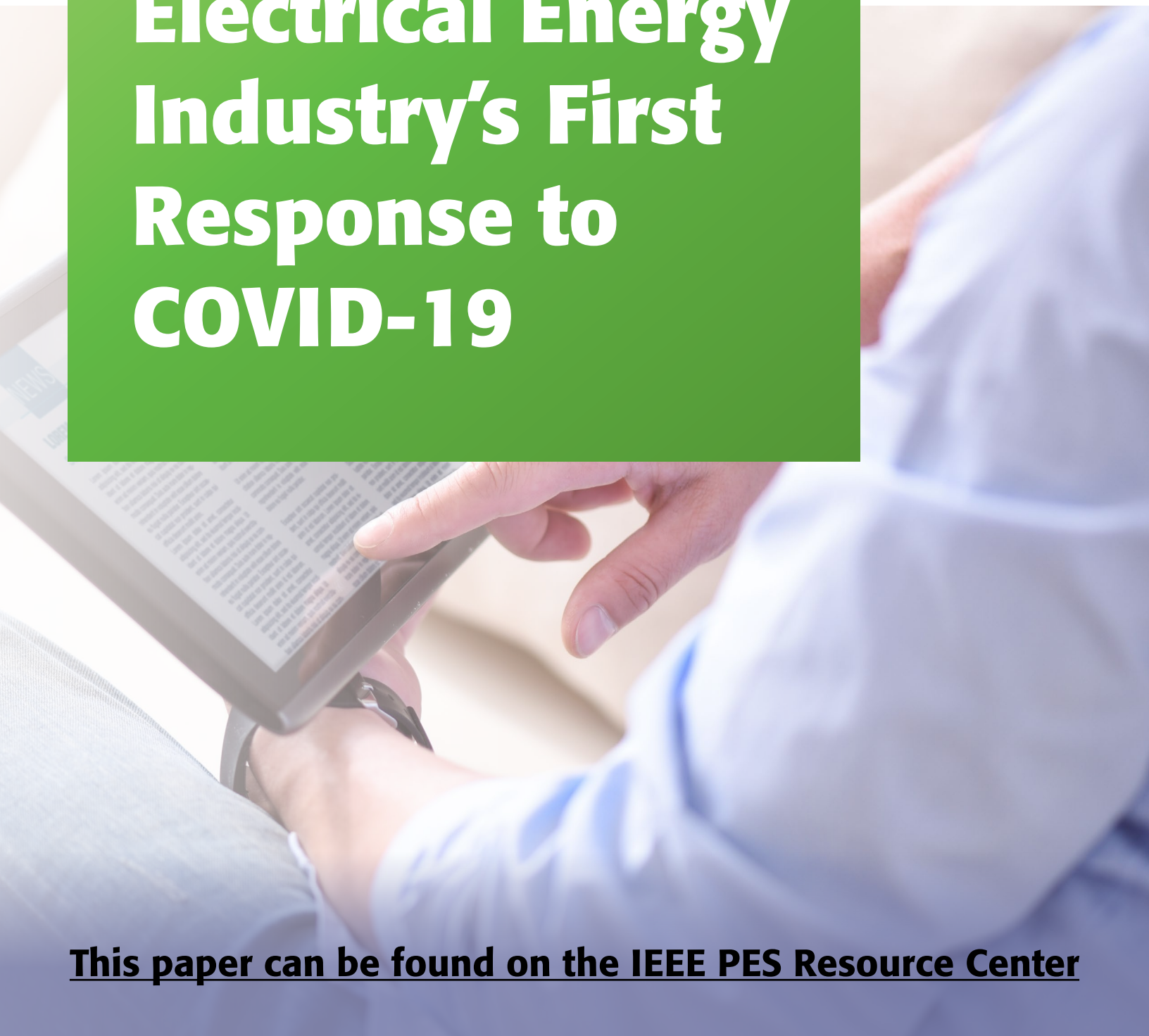
Sharing Knowledge on Electrical Energy Industry's First Response to COVID-19



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Abstract

Electric utilities and system operators have overcome the issues associated with COVID-19 to provide safe and reliable power to communities. The steps taken by industry stakeholders to protect employees' and customers' health, while keeping the lights on, required significant innovations. This document, prepared by IEEE PES Industry Technical Support Leadership Committee (ITSLC), represents a collection of the experiences faced by and practices implemented by several utilities and system operators across the globe to mitigate the effects of the COVID-19 pandemic. The pandemic has shown us how now, more than ever, reliable, resilient, and cost-effective delivery of electrical energy is a necessity for the society to cope with any crisis.

Tags

COVID-19, Emergency Preparedness, Utility Practices, Pandemic, ITSLC

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IEEE Power & Energy Society
Industry Technical Support Leadership Committee
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Executive Summary

COVID-19 represents not just a public health and economic crisis, but a change to how the electric grid that empowers communities across the globe functions. During this pandemic, electric utilities and system operators have continued to provide a high level of service and demonstrated the significance of keeping the power on. As governments and public health experts have been encouraging populations to stay at home, while far too many are facing severe health challenges, businesses have been dealing with new kinds of workforce challenges. Generating, transmitting and distributing electricity is a critical task, not just for the industry, but for the communities who rely upon safe, reliable power.

The IEEE Power and Energy Society (PES) Industry Technical Support Leadership Committee (ITSLC) prepared this whitepaper to collect practical experiences from those across the industry who have been facing this challenge head on, leveraging our member survey results, and focusing on in-depth technical, health, and business perspectives. Over the past few weeks and months, representatives of electric utilities and system operators have been sharing experiences, thoughts, and ideas through frequent phone calls and e-mails. From the earliest days of the industry, it was understood that as utility employees braved the dangers of electricity, it is only collaboration and the free flow of ideas that can help keep us all safe. Today, those same employees continue to face that challenge while simultaneously dealing with this pandemic.

This is happening as the grid itself is facing changing technical realities. As large swathes of the population appropriately follow stay-at-home guidelines, the amount of power used by businesses is declining, while residential consumption is rising. On a macro-scale, many regions appear to be experiencing normal load levels comparable to those that used to be seen on weekends. However, there were no major technical issues due to COVID-19 as our industry has taken the necessary actions to assure reliable and safe delivery of electricity.

In this white paper, we describe the practices deployed by the industry to keep workforces safe and mitigate any technical issues that might occur. These efforts require thinking about issues facing the electric grid on the macro and the micro scale. They require a close consideration of how the grid might need to be rethought, while also responding to the local challenges whose impacts could be great. We also describe how the industry has been adjusting as we learn more about COVID-19 and its impacts on the communities being served. Utilities and system operators are constantly craving the latest, best judgments to inform decisions on how to ensure that their employees are safe and effective. This requires engagement with public health officials, governments, and experts of every kind.

The COVID-19 pandemic shows how, more than ever, reliable, resilient, and cost-effective delivery of electrical energy (implementing holistic and balanced solutions) is a necessity for society to cope with any crisis. This requires continuous investments in grid modernization and workforce development. We thank all of those who took time during this crisis to provide this information and hope that this white paper will make evident the value of that effort.

1. Objectives and Approach

The COVID-19 pandemic has shaken the foundations of every impacted country through human casualties and economic upheaval. Although the human toll and economic impacts of the pandemic have captured the focus of the media and researchers, the full scope and trajectory of its impact are unknown at the time of this paper's writing.

Electric utilities and system operators have been challenged by COVID-19 and have continued to provide the reliable and resilient power that communities require to function. The goal of this work is to examine and address the impact of the pandemic on a critical component of any nation's economic engine – the electric grid and those who operate it. This document represents a collection of experiences and lessons learned by some of the major stakeholders across the global industry. Through this exercise, IEEE PES has highlighted emerging practices in the industry and helped guide the direction the industry must pursue to continue raising the level of service provided to communities when they need it most. Its intent is not to recommend a specific approach/approaches, but to document practices that have been implemented by various utilities and system operators globally. This document is designed to provide the industry a broad view of strategic measures adopted by utilities and system operators around the world.

To do so, the paper intends to document various impacts of the pandemic on electric energy infrastructures around the globe in terms of a varied set of parameters. It provides information related to the impact of the pandemic on the electric grid assembled through a detailed survey of several electric utility and system operator executives, planners, operators and engineering personnel. The responses from the survey have been distilled into the material presented. The white paper then addresses steps taken by electric utility companies and system operators around the world to mitigate the impact on the electric grid, maintain reliable service and shield critical workers from infection.

2. Health, Technical, and Business Impacts

The electric power industry has been significantly affected by the COVID-19 health crisis as a function of the profound changes the pandemic has caused in how people live and work. This global event has had a variety of impacts for which the industry is currently monitoring, addressing and preparing. This section presents a preliminary and general overview of some of the observed impacts on generation, transmission, and distribution systems. Sections 2.1-2.6 discuss impacts in more detail, including results from surveys conducted among electric utilities and system operators around the world. Section 2.7 discusses mid to long-term impacts.

2.1 Resource availability to assure essential services

One of the key impacts of the COVID-19 health crisis is the availability of resources to ensure essential services including operations, outage management and restoration. Electric utilities and system operators are using scenario planning to put business continuity and pandemic response plans in place, (including

planning for infectious outbreaks)[1], and are addressing these needs in a variety of ways, depending on the criticality of operations and infrastructures. For example, control centers and control center employees were the target of the most stringent measures due to their importance to system reliability and continuity of operations.

The practices are, however, not the same around the world. Depending on the perceived risk level and the penetration level of the COVID-19 infections in regions, different approaches are taken. The mitigation measures are described in detail in section 3.

2.2 Criticality of electric infrastructure, reliability and resilience impact

The implementation of stay-at-home orders and the closure of schools and workplaces have effectively made work from home and online/distance schooling the new normal for millions of workers and students around the world. This new reality, along with health care systems operating at full or near full capacity, has made electric infrastructure even more critical. These needs have highlighted the importance of a reliable and resilient electric service for modern society, particularly for residential end users and health care facilities. Commonly used average reliability indices by feeder or substation (e.g., SAIFI or SAIDI) are not able to explain spatial reliability performance differences with enough granularity, requiring additional reliance on customer or grid edge (e.g., at service transformer level) metrics. The growing availability of Advanced Metering Infrastructure (AMI) is enabling stakeholders to track this granular reliability performance, which is particularly critical during stay-at-home conditions.

The need for a reliable grid may only increase. As the duration of the pandemic outbreak and the implementation of these measures continues, it is possible that major weather events, such as hurricanes and wildfires, could occur while these regions remain impacted by the health crisis. Preparation for these events will be especially challenging given potential limitations in mutual assistance programs, limited availability of contractors and service providers, as well as potential restrictions on equipment and materials used for restoration.

Additional issues involve other aspects of resilience, such as ensuring cybersecurity, particularly considering that most organizations are allowing employees to work from home, creating new potential vulnerabilities in enterprise systems. The U.S. Department of Homeland Security (DHS) Cybersecurity and Infrastructure Security Agency (CISA) and the United Kingdom's National Cyber Security Centre (NCSC) have reported an increase in activities by cybercriminal and advanced persistent threat (APT) groups, including[2]:

- Phishing, using the subject of COVID-19 as a lure,
- Malware distribution, using COVID-19-themed lures,
- Registration of new domain names containing wording related to COVID-19, and

[1] http://mydocs.epri.com/docs/public/covid19/3002018602R2.pdf
[2] https://www.us-cert.gov/ncas/alerts/aa20-099a

- Attacks against newly—and often rapidly—deployed remote access and teleworking infrastructure

2.3 Supply chain disruptions

As referenced earlier, electric utilities and system operators and the industry in general might experience shortages of critical parts, components, equipment and materials for emergencies due to constrained production of supplies manufactured in countries highly affected by COVID-19. Shortages may also be caused by disruptions along the supply chain, from transportation to warehousing. For instance, manufacturing activities in the European Union, North America and China have been significantly impacted. This can affect the supply of a variety of products, including industry-critical personal protective equipment (PPE) for mission-essential workers (e.g., nitrile gloves and N95 respirators) and critical components (e.g., photovoltaic cells, turbines) for renewable generation developers. Depending on the duration of the pandemic, supply chain disruptions may also cause delays in the implementation of capital projects (e.g., T&D upgrades), and affect major weather event preparedness and response. For instance, one utility has already reported that they have already had difficulties procuring new transformers from China[3,4,5]. Similarly, the Global Wind Energy Council said its five-year forecast (more than 355 GW of additions) would be impacted by the crisis, due to disruptions to global supply chains and project execution in 2020. According to WindEurope, as of early April 2020, eighteen wind turbine manufacturing sites in Spain and Italy are closed[1,8,6.]

Though some issues have already emerged, the industry has a whole has developed ways to mitigate them. Most utilities and system operators surveyed in April 2020 stated that "to date," the supply chain (other than PPE availability) has not been a significant issue so far. This is the result of identifying manufacturers as providing essential services, so the equipment production does not experience major delays. The major concern is more from mid- to long-term, particularly related to major weather event preparedness. Supply chains could also see constraints due to border closure and travel bans.

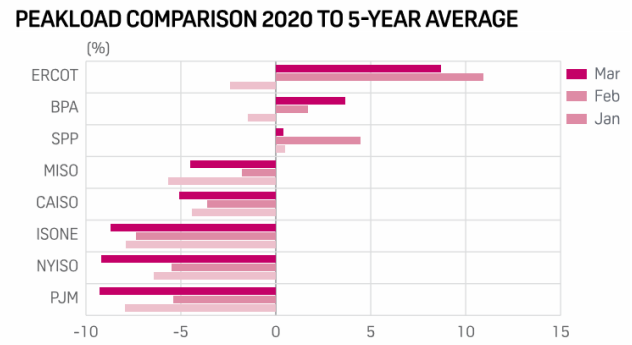
2.4 Impact on energy consumption and peak demand

One of the most evident impacts the health crisis has had on the grid is the reduction in peak demand and delivered energy observed in electric power systems around the world. This is a consequence of the temporary closure of commercial and industrial (C&I) facilities due to lockdown orders issued by local and central governments. This reduction is expected given that C&I customers generally represent most of the demand and consumption of electric utility systems. Although rate decoupling may help alleviate the impact on utility revenue when compared with more traditional volumetric rates, it is worth noting that

[3] https://www.powermag.com/the-power-sectors-most-crucial-covid-19-mitigation-strategies/
[4] https://www.utilitydive.com/news/no-existing-playbook-covid-19-forcing-nv-energy-nypa-and-other-utilitie/575881/
[5] https://www.tdworld.com/disaster-response/article/21126277/covid19s-impact-on-utilities-industry-pros-sound-off
[6] https://www.cnbc.com/2020/04/06/the-coronavirus-is-hitting-renewable-energy-supply-chains-factories.html

only about 44% of electric utilities in the U.S. have some degree of decoupling or a similar lost revenue mechanism. Moreover, rate decoupling is more common for residential customers than for commercial and industrial customers (C&I)[7]. Therefore, actual impacts on revenue are complex to evaluate since they are a function of regulatory framework, decoupling structure (if any), and customer mix (percentage of residential vs. C&I customers), and other such factors.

Figure 1 shows the reduction in peak demand observed by different Regional Transmission Organizations (RTOs) and Independent Service Operators (ISOs) in the U.S. The reductions in peak demand with respect to 5-year average values are particularly noticeable in the Northeast, the most impacted region in the U.S. as of April 2020. For instance, PJM and NYISO experienced a reduction of about 9% in their peak load in March 2020. Demand levels continued decreasing in April 2020. For instance, the hourly demand of the city of New York ranged from about 5% to 21% below typical levels between April 13 to April 17. Moreover, according to NYISO, the reduction in electric demand from commercial customers was the key driver behind the reduction in overall consumption in their system[8]. Other areas of the country, such as Texas (ERCOT), which implemented statewide stay-at-home orders in late March, show no impacts. However, peak demand reductions were observed at ERCOT in April for the week, beginning April 5. Daily peaks decreased by 2% and weekly energy use decreased by 4 to 5%[9]. The participants in our surveys, (see the Appendix A) also reported peak load and energy consumption reduction from 5% to 25%, in line with what is shared in Figure 1.



Source: Platts Megawatt Daily

Figure 1 – Impact of COVID-19 Health Crisis on Peak Demands in the US[10]

[7] https://brattlefiles.blob.core.windows.net/files/18557_impact_on_covid-19_on_the_us_energy_industry.pdf
[8] https://www.nyiso.com/covid
[9] http://www.ercot.com/content/wcm/lists/200201/ERCOT_COVID-19_Analysis_FINAL.pdf
[10] https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/040120-factbox-power-demand-prices-begin-to-slip-as-coronavirus-stay-home-orders-spread

Reduction in peak demands and energy consumption can have direct implications for electric utility revenues and capital investment projects depending on the regulatory framework in which an electric utility operates. For instance, Sacramento Municipal Utility District, one of the largest public power utilities in the U.S., is deferring planned infrastructure projects because the projected load growth that justified such investments is now uncertain. Similarly, the utility was expecting a revenue reduction from 8% to 14%, similar to what was experienced by utilities in Europe[11]. Revenue can also be impacted by the halt of debt collection activities, such as disconnection suspensions, which have been enacted by regulators and government bodies statewide in 25 states including New York, California, Texas and Illinois, along with Washington DC. Examples of utilities that have suspended disconnections in the United States include Ameren, AEP, ComEd, Dominion Energy, Duke Energy, Evergy, First Energy, Georgia Power, NV Energy, PECO, PG&E, SCE, and XCEL Energy [12].

2.5 Modification of consumption patterns

The modification of end user consumption patterns is an additional impact of the health crisis; this can have a direct impact on overall load shapes in the electric power grid. For instance, Figure 2 shows the average weekday load shapes for the lower 48 states of the U.S. and the California ISO (CAISO) system for March and the first week of April for the years from 2017 to 2020. This figure illustrates how load shapes gradually evolved as stay-at-home orders were implemented across the country, leading to a variety of changes depending on the customer mix and weather patterns of each service territory. For instance, some jurisdictions have observed a shift of morning peaks to later hours, while others, such as the CAISO system, have experienced a reduction in demand between 10 AM and 6 PM and an exacerbation of the "duck curve" effect impacted by solar photovoltaic generation. This is shown in Figure 3, which presents a comparison of the normalized net demand on the CAISO system for April 21, 2020 and April 23, 2019, along with net load demand during ramping periods for both days. The Figure 3 shows an increase in net demand ramping rate between 5 PM and 8 PM.

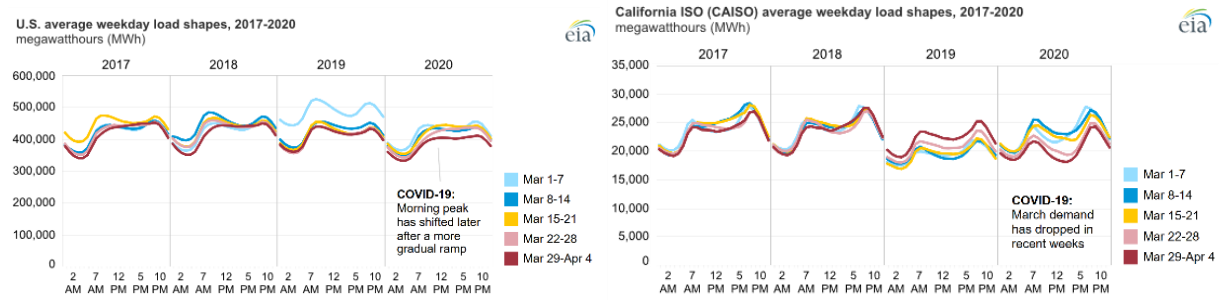


Figure 2 – U.S. and California ISO (CAISO) Average Weekday Load Shapes (2017-2020)[13]

[11] https://www.utilitydive.com/news/no-existing-playbook-covid-19-forcing-nv-energy-nypa-and-other-utilitie/575881/
[12] https://www.energyandpolicy.org/utilities-disconnect-coronavirus/
[13] https://www.eia.gov/todayinenergy/detail.php?id=43295#

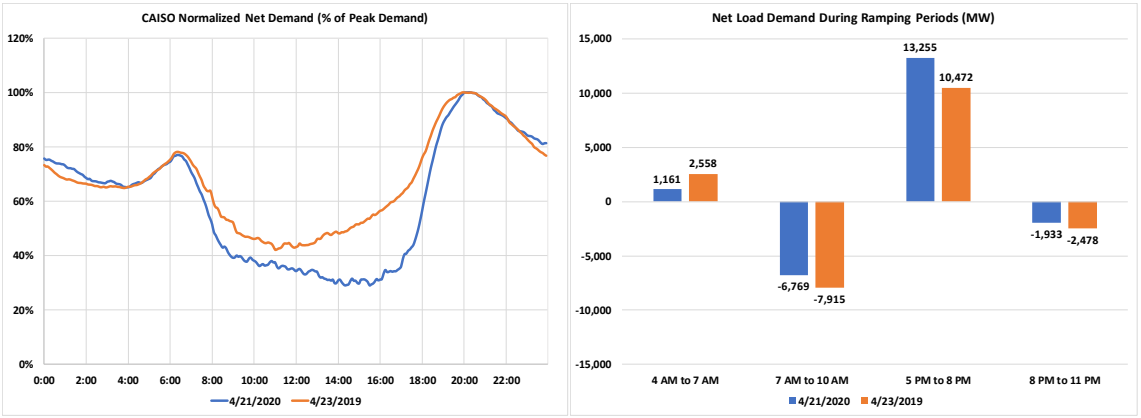
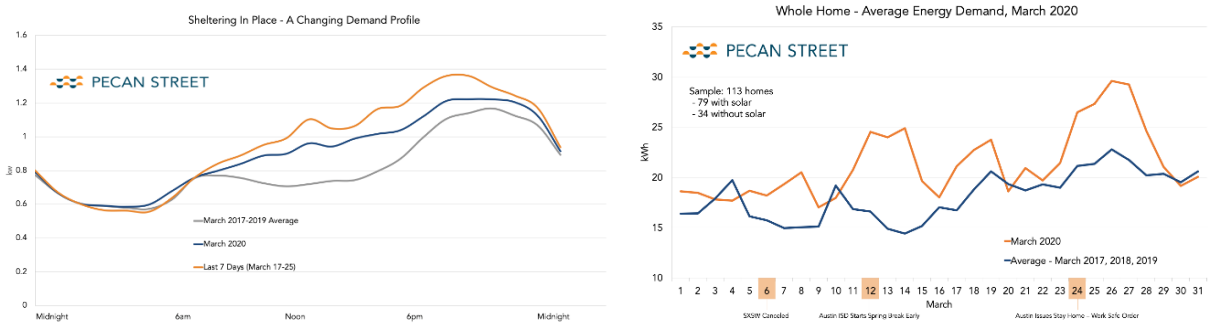


Figure 3 – CAISO Normalized Net Demand and Net Demand Change During Ramping Periods (April 21, 2020 and April 23, 2019)[14]

Changes in load shapes were also observed at the distribution system level, where an increase in demands of residential neighborhoods and utility assets have been observed, along with changes in load shapes of feeders and other distribution assets. For instance, Figure 4 shows changes in the load profile and energy consumption at the household and neighborhood level in the smart community of Pecan Street in Austin, TX.

Most utilities, RTOs, and ISOs surveyed acknowledged that demand has reduced and somewhat flattened, i.e., spread over a longer period during the day, and typically the morning peak has shifted by an hour or two. Additional potential impacts to consider are the increased likelihood of reverse power flow and impacts in protection systems (e.g., risk of sustained unintentional islanding) on feeders with Distributed Generation (DG), as well as the unavailability of C&I loads to provide ancillary services through demand response.



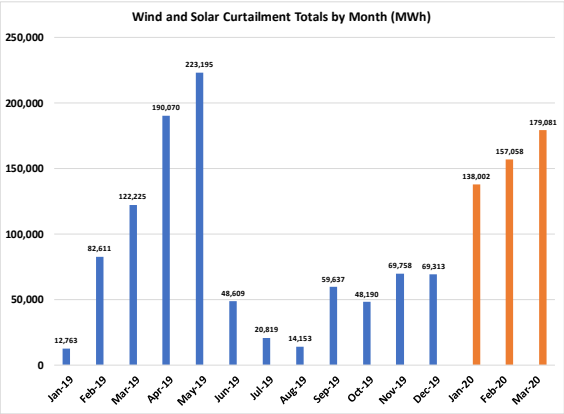
Source: Pecan Street

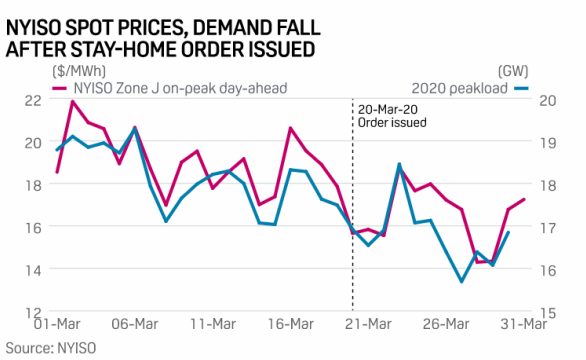
Figure 4 – Changes in residential demand load shapes[15]

[14] http://www.caiso.com/TodaysOutlook/Pages/default.aspx
[15] https://www.pecanstreet.org/2020/04/covid/

2.6 Market reliability and generation mix

The decrease in demand previously discussed has effectively increased the renewable resource percentage share of some electric power systems. This has simultaneously, ironically, led to an increase in the curtailment of renewable generation[16]. For instance, Figure 5 shows wind and solar curtailment totals by month for the CAISO system for 2019 and 2020. The results show a significant increase in 2020[17]. As another example, the generation resources in Peru has generally been a mix of wind, solar, hydro and natural gas. Presently, with about 30% reduction in load due to the suspension of mining, almost all generation is from renewables and hydro. In addition to change to the generation mix, electricity prices are decreasing due to demand reduction and historically low prices of oil and natural gas[18]. These impacts may also lead to an accelerated retirement of aging coal and marginal nuclear facilities[19] and contribute to the delay or cancellation of new generation. For instance, the U.S. Energy Information Administration (EIA) has indicated that COVID-19 impacts may cause a delay or cancellation of 4.9 GW of previously planned utility-scale capacity expansions[20].





Source: Platts Megawatt Daily

Figure 5 *– Renewable Generation Curtailment Increase in CAISO and Spot Prices Decrease in NYISO*[21]

In Europe, the average day-ahead electricity prices have been less than half of the averages observed in the same period of previous years, along with more frequent negative price incidents as shown for Germany in Figure 6. Especially in the second half of April, the amount renewable energy infeed from solar PV and onshore and offshore wind has increased significantly (Figure 6), causing negative day-ahead price incidents.

[16] https://www.greentechmedia.com/articles/read/california-renewable-curtailments-spike-as-coronavirus-reduces-demand
[17] http://www.caiso.com/informed/Pages/ManagingOversupply.aspx
[18] https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/040120-factbox-power-demand-prices-begin-to-slip-as-coronavirus-stay-home-orders-spread
[19] https://www.utilitydive.com/news/the-effects-of-coronavirus-measures-on-electricity-markets/576296/
[20] https://news.bloomberglaw.com/environment-and-energy/covid-19-seen-canceling-up-to-39-of-new-u-s-power-generation
[21] https://www.renewableenergyworld.com/2020/04/09/covid-19-is-changing-residential-electricity-demand/#gref

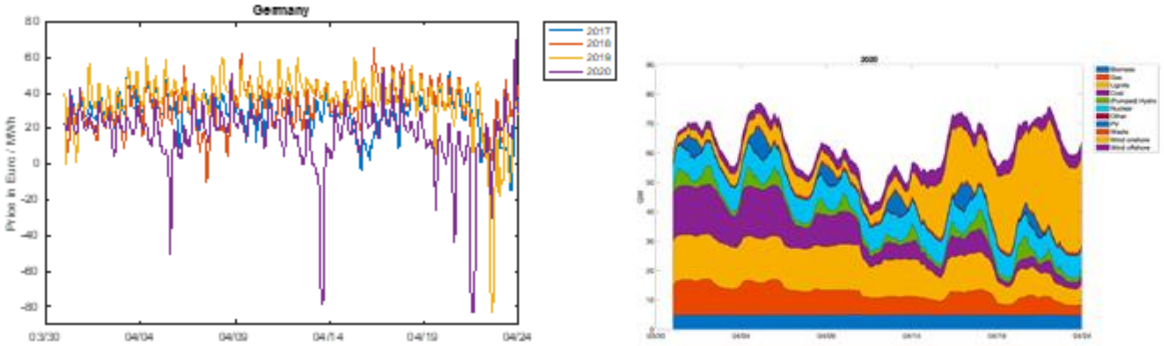


Figure 6 - *Day-ahead electricity prices in Germany from March 31st – April 24th (left) and Power generation mix in Germany March 31st – April 24th (right)*[22]

2.7 Mid- to Long-Term Impacts

As our global society becomes ever more dependent on electricity for its daily functioning, the electric grids that supply those needs will continue to evolve.[23.] The long-term impact on the pace of grid evolution from the COVID-19 pandemic are uncertain at the time of the report. However, the following societal needs will continue:

1. Controlling the costs to build, operate and maintain electric grids to make electricity increasingly accessible and affordable to all users
2. Increasing power supply reliability and resilience in the face of major weather events and other challenges
3. Reducing harmful air emissions

Changes in technology are enabling this evolution of the electric system in many countries. It is quickly shifting from one consisting of centralized power plants and static consumers toward a dynamic combination of distributed producers and consumers with increasing options to control their own production and consumption. This has introduced bi-directional flow of power on distribution systems and created both technical challenges in operation of the system as well as economic challenges in establishing the value and optimum mix of the many new technologies now available.

While the specific grid system changes will vary among systems and locations, both conventional and new technologies will be needed to implement these changes. Some of the power supply, delivery and use alternatives that are being deployed or seriously considered to meet environmental, economic and reliability goals include:

- Distributed energy resources (DER)
- Renewable energy sources (RES)

[22] https://www.energyville.be/en/press/expert-talk-what-can-learn-covid-19-pandemic-renewable-energy-transition
[23] This section draws extensively from material written and published by the IEEE USA Energy Policy Committee

- Energy storage systems
- Microgrids
- Plug-in electric vehicles (PEVs)
- Demand response (DR)
- Transmission additions & upgrades
- Energy efficiency improvements
- Grid system security improvements

Now, however, COVID-19 is requiring an increased emphasis on additional areas. These capabilities, as well as others, are helping utilities to increase their focus during this pandemic on additional areas as follows:

- Ensuring the protection of their workforce and the public they interact with
- Closely monitoring their local economics and impacts to their base of customers
- Watching their cash, especially 3 key variables: revenue, expenses and cash reserves.

These factors are leading expectations that the velocity of some grid modernization efforts mentioned previously may slow, as utilities prioritize expenses and reduce projects to ensure worker safety. However, the pace will likely pick back up as we return to normal. In addition, governments are preparing their responses to mitigate pandemic impacts.

Simultaneously, one of the most noticeable effects of lockdowns put in place by governments around the world is the significant reduction in carbon emissions, partly due to the decrease in global vehicle and air traffic, as well as the temporary shutdown of commercial and industrial facilities. For instance, Spain's passenger and commercial travel dropped by 80% and 40%, respectively, while Italy's decreased by 65% overall. In the U.S., personal travel dropped by 48% in the week of April 4-10, 2020 when compared to a typical week[24]. The combined effect of these measures and consequences of the lockdowns on emissions reduction have been evident. For instance, China's carbon emissions decreased by about 18% (or 250 million tons of CO_2) over a seven-week period between early February and mid-March 2020[25]. In the European Union, a preliminary forecast indicates that emissions may decrease by almost 400 million metric tons (about 9% of the EU's cumulative 2020 emissions target)[26].

This success may inspire further interest in accomplishing incremental benefits through transportation electrification and electrification in general. For instance, electric vehicles and heat pumps are less emission intensive than fossil fuel alternatives in 53 regions of the world (which represent 95% of the global transport and heating demand)[27]. In this regard, lockdowns have demonstrated some of the benefits that can be achieved through electrification. This could be useful evidence for governments

[24] https://inrix.com/blog/
[25] https://www.carbonbrief.org/analysis-coronavirus-has-temporarily-reduced-chinas-co2-emissions-by-a-quarter#update
[26] https://www.nationalgeographic.com/science/2020/04/coronavirus-causing-carbon-emissions-to-fall-but-not-for-long/
[27] https://www.nature.com/articles/s41893-020-0488-7

interested in enacting and implementing this type of initiatives. However, a severe global recession, along with low oil prices, could make these goals more difficult to achieve, at least in the short term[28].

More details on the long-term impacts are documented in Appendix A.

3. Surveyed Mitigation Measures and Practices

Responding to these new conditions, utilities and system operators have been forced to reevaluate their business continuity strategies and multiple event disaster plans for weather events. Utilities and system operators across the continents were surveyed for mitigation measures and practices they have implemented in response to the COVID-19 pandemic.

According with what had been observed in other sources, all respondents indicated that they have seen shifts in demand and loads. Many observed shifts from industrial and commercial customers to residential customers as well as overall reductions in consumption and load. To respond to these changes, most utilities and system operators followed broadly similar approaches, but there were variations. Even in the similarities we see the success of benchmarking efforts that bring practices to those who then provide added value for the customers and communities they serve.

Practices implemented and considered have been categorized into the following sections:

- Control Centers
- Field Operations: Work Prioritization & Staffing
- Customer Operations and Office Staff
- Resilience and Supply Chain Measures
- Mitigating Technical Issues
- Other Practices

3.1 Control Centers

The responses and literature review suggested that for both utilities and system operators, control centers and control center employees were the target of the most stringent measures due to their importance to system reliability and continuity of operations. This is especially significant because due to the work environment in control rooms, there is a particular risk for contagion.

Some utilities and system operators are relying on sequestration and isolation of essential employees responsible for the operation of critical facilities such as control centers to prevent contagion and ensure continuity of operation. New York Power Authority (NYPA), for example, has sequestered 82 power plant control room and transmission control operators, and essential generation personnel who operate in two

[28] https://www.cpr.org/2020/04/23/state-unveils-ambitious-roadmap-to-move-to-electric-vehicles-but-covid-19-could-be-an-obstacle/

12-hour shifts. NYPA has implemented protocols to prevent the potential spread of the virus, including taking temperatures of employees at regular intervals[29]. Similarly, 37 employees of NYISO, including 33 grid operators and managers, volunteered to sequester at two grid control centers near Albany, NY[30]. Moreover, CenterPoint Energy's employees working at control rooms are working in isolation to avoid potential exposure to the virus. CenterPoint has put in place arrangements typically used during hurricanes or other severe storms to house and feed employees for several days[31].

Outside of North America and China, sequestration is not as heavily exercised, even though preparations have been made for sequestration as a last resort. Many utilities and system operators in Latin America, for example, have increased the length of the shifts, typically from 8 hours to 12 hours; reduced the number of people in the control center at the same time; and increased the number of active control centers to allow contact-less shift changes, while allowing the operators to go home when they are off duty.

Furthermore, control centers have implemented the most diligent cleaning protocols (e.g. hospital standards). A system operator in North America indicated that their control centers were cleaned no less than three times between shifts: first by the outgoing operators at the end of their shift, subsequently by the cleaning crew, and then by the incoming operators prior to beginning their shift. Another system operator in North America reported that they had issued personal equipment to each operator as early as January of this year. Several utilities and system operators were experimenting with rotating shifts between different control centers to enable no touch hand offs, isolation of crews from one another, and more diligent cleaning, as well sequestration at multiple sites.

While sequestering of control centers was not universally implemented at the time of the survey, control center employees were generally the priority for issuance of PPE and for sequestration at utilities and system operators across all regions. In China, control center operators at a utility were sequestered when COVID-19 had just been declared an epidemic. Sequestration was usually implemented on longer rotations between 14 and 30 days. In many cases, shifts were also extended to 12 hours (often on a 12 on/ 12 off schedule), where 12-hour shifts were not already in place: this created extra capacity in staffing levels for backup. One North American system operator was sequestering one primary and one backup crew each at two separate control center locations. Contingency plans in the event of an outbreak of COVID-19 at one of the sequestration sites involved breaking sequestration at that site and bringing in new operators.

Many respondents in North America indicated that sequestered employees were volunteers. Sequestering accommodations included catered meals, laundry, cleaning and entertainment, requiring support staff including maintenance crews and training providers to be sequestered alongside the

[29] https://www.publicpower.org/periodical/article/public-power-utilities-sequester-workers-response-covid-19
[30] https://www.publicpower.org/periodical/article/public-power-utilities-sequester-workers-response-covid-19
rk-and-live-in-isolation
[31] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-utilities-divided-on-plans-to-sequester-essential-employees-57741135

operators. Responding organizations in China and Latin America were performing health checks prior to entering sequestration; unfortunately, however, pre-symptomatic and asymptomatic infections cannot be detected through screening methods. Even a system operator in North America, which was performing diagnostic testing on employees entering sequestering sites, needed to be cautious and quarantine employees before a negative test result confirmed that the employee could safely begin work, usually within 24 to 48 hours.

On-site sequestration of control room staff might work well for some utilities and system operators but is not a universal solution across all. Test kits, one of the underpinnings of sequestration, are not available in many areas. It is possible that enaction of sequestration in a control room can lead to personal hardship, which may have unintended consequences, including dispatcher departures. Utilities and system operators have different types of control rooms each has different staffs, physical and technological constraints. Solutions that work in one control room might not work in another. Many utilities and system operators, included many surveyed, are using their back-up control rooms during the pandemic to separate shifts. Other facilities may also be used as new control rooms provide additional flexibility and options to separate dispatch teams. Many organizations have dispatchers that have moved to other groups, and some utilities and system operators are bringing these dispatchers back to support the operations, and some dispatcher may be able to work remotely in conjunction with the control center operations.

3.2 Field Operations: Work Prioritization & Staffing

Utilities have put in place special measures for field operations personnel to ensure social distancing and reduce the risk of contagion. This includes requiring one person per vehicle and using drone and helicopter inspections. These actions result in increase of O&M expenses.

Most utilities indicated that they had reduced workplans for field work, except for a utility in China which indicated that they were adhering to a normal workplan. Reported changes ranged from very minor changes in Germany and North America where all ongoing projects were continuing with adjustments in staffing level to reduce potential for contagion, to a full stop on all construction projects in Belgium and major reductions to critical operations only levels at several Latin American utilities. Several Latin American utilities that used contractors for some of their field work indicated that they had suspended contracts, and one utility had asked all employees who were not mission critical at emergency level staffing levels to go on leaves of absence.

Several European, Oceanian and North American utilities and system operators reported that they were operating on adjusted work plans to accommodate social distancing and reduce transmission among field crew members. All utilities except for one had issued PPE including masks to their field crews. One utility had been unable to procure masks due to a nationwide shortage and was in the process of attempting to source fabric masks, highlighting some of the key supply chain issues that countries and utilities were facing. Several utilities indicated that there were some constraints regarding the availability of masks,

especially N95 and KN95 respirators, and that they had considered but been unable to issue masks to their employees' families.

Almost all utilities and system operators that had responded to the survey had implemented rotation schedules for their crews and were taking measures to keep crews separated from one another to minimize the potential for contagion. Social distancing and the wearing of PPE were encouraged whenever possible. Measures ranged from sequestering to ensuring that crews did not have mutual contacts with other crews.

Protocols for jobs requiring more than one crew member had been modified to minimize touch and time spent in close quarters. Huddles and trainings sessions for field crews had been shifted to online platforms. This was obviously more important for crews that were not in sequestration; one North American utility had rented additional vehicles for crew members to ensure that crews were riding to work sites in separate vehicles.

Some utilities had implemented health checks for field crews, although this practice had not been as widely implemented for this group as for control room operators. Health checks were most often performed for crews entering sequestration, and more commonly included symptom checks (respiratory and temperature, and screening questions) over testing. Several utilities indicated that they would like to implement testing protocols for field crews, but constraints regarding the availability—of rapid testing—was preventing them from proceeding in this direction at the time of the survey.

Many of the survey utilities had also allowed their field workers to take their company vehicles home and implemented various social distancing and cleaning measures to their vehicles (e.g. one person per vehicle). One utility reported that it had rented several hundred light duty pickup trucks to support its fleet operations.

All utilities, whether they had had any confirmed cases within their workforce or not, put protocols in place for quarantining employees who had been exposed to or were showing symptoms of COVID-19; many protocols included testing.

Many utilities were indicating some constraints with regards to testing; constraints ranged from concerns over processing times in North America, where test results required a processing time between 24 and 48 hours and rapid test results (hours to minutes) would have been preferred to more severely restricted situations, particularly in Latin America, where it was indicated that employees would be quarantined long enough for a potential infection to have subsided before a test could be administered.

The importance of testing—and of rapid testing—cannot be overstated given the suspected proportion of asymptomatic cases: the practice of sequestering mission critical groups could backfire if an infected employee enters sequestration undetected. Some utilities in China and Latin America were performing health checks prior to entering sequestration; unfortunately, pre-symptomatic and asymptomatic infections cannot be detected through screening methods. Even utilities who were performing diagnostic

testing on employees entering sequestering sites needed to be cautious and quarantine employees before a negative test result confirmed that the employee can safely begin work, usually within 24 to 48 hours.

3.3 Customer Operations and Office Staff

Electric utilities, like other businesses, have implemented telework protocols for office staff. Most surveyed utilities and system operators have all non-critical staff working remotely from home, for some that is up to 90% of the employees. Utilities have also implemented travel restrictions or bans on non-essential travel and have shut down customer service walk-in centers[32]. For instance, about 8,000 employees of Edison International (out of 13,000) have worked remotely to help minimize risks[33].

Based on survey responses, Customer Operations employees had been transitioned to remote work whenever possible at utilities in North America, Oceania, and Europe as well as in Latin America, although the degree to which this had been implemented varied significantly. Only one utility in Latin America had sequestered Customer Operations employees. One North American utility was considering it within the scope of its sequestration contingency plan.

Measures taken to protect customer operations employees generally included the issuance of PPE, density reduction in work areas, social distancing and enhanced cleaning protocols. Some utilities, namely in China and in Latin America, also provided transportation to and from work to discourage the use of public transportation.

Several utilities in North America reported that they were not suspending service during what typically would be our service suspension period, so they are not calling in the volumes we would typically see in this season. Many also voluntarily implemented a moratorium on service disconnections for non-payment.

3.4 Resilience and Supply Chain Measures

As preparation for weather events during pandemic is especially challenging, electric utilities and system operators are using scenario planning to prepare for these events, including managing inventory and coordinating with service providers, partners, peers and suppliers to ensure, to the extent possible, that critical supplies (e.g., spare parts, equipment, etc.) and contractors are available, establishing minimum staffing levels of on call staff to respond to emergencies and storms.[34] Additional preparations involve other aspects of resilience, such as ensuring cybersecurity protection. IT departments have been working diligently to provide tools to people working from home (e.g. monitors, cameras, headphones) while assuring cybersecurity protection.

[32] https://www.powermag.com/power-industry-weighs-impacts-of-coronavirus/
[33] https://energized.edison.com/stories/sce-offers-bill-help-to-customers-impacted-by-covid-19
[34] http://mydocs.epri.com/docs/public/covid19/3002018602R2.pdf

Though supply chains have not, as noted earlier, been a significant issue regarding in the short-term, as manufacturers are identified as essential business, there remain issues that are being mitigated. The major concern is more from mid- to long-term, particularly related to major weather event preparedness. In the U.S., NERC[35], CISA[36], DHS[37] and FEMA[38] have provided recommendations to prepare for potential supply chain disruptions. This includes evaluating resilience against disruption to the availability of critical components, materials, and support resources with supply chains involving countries or regions severely impacted by the crisis (e.g., organizations with just-in-time inventory practices are vulnerable to global transportation disruptions). Organizations may work with suppliers to understand these challenges and identify potential alternate sources of supply, substitute products and mitigation measures.

3.5 Mitigating Technical Issues

As described in above sections, the COVID-19 pandemic has had major impacts on energy consumption and peak demand, as well as on consumption patterns (e.g. location, time, customer class) in all territories that were covered by the survey. Utilities and system operators have been implementing a range of different practices proactively to mitigate these technical impacts.

Utilities and system operators were expecting the reduction in load to cause high voltage issues in some areas of the power system. Participating utilities and system operators reported the implementation of a range of mitigation measures to address this issue. A large utility in Asia reported that due to the COVID-19 pandemic, a prolonged low load period was observed. To control the power system voltage, several measures were applied: Firstly, during low load periods, Automatic voltage control systems (AVCs) and capacitors were switched off and reactors were switched on. Secondly, some of the 500kV and 220kV transmission lines were switched off during low load period. Thirdly, STATCOM and UPFC devices were utilized to absorb reactive power. In addition, generation plants were encouraged to lead phase operation to adjust power system voltage.

A utility in Oceania assessed possible impacts of high voltage due to low demand and had considered automatic under-frequency load shedding (AUFLS) and reserve arrangements. They were vigilantly monitoring for periods of low demand and identifying suitable mitigation measures. A workstream had been established to look at the high voltage issues over the medium term. This included communicating with key industry stakeholders (generators and connected parties) to seek their assistance as required.

Utilities and system operators in North America also reported load reductions and concerns over low voltage; a range of practices to mitigate voltage impacts have been implemented. This included

[35] https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_R-2020-03-10-01_COVID-19_Pandemic_Contingency_Planning.pdf

[36] https://www.ippny.org/vs-uploads/covid/1586458857_cisa_insights_coronavirus%20updated.pdf

[37] https://www.dhs.gov/sites/default/files/publications/cikrpandemicinfluenzaguide.pdf

[38] https://www.fema.gov/media-library-data/1555328671083-d9422177bd55d9c6fafc327a6b239290/SupplyChainResilienceGuide-April2019.pdf

proactively inspecting circuits and equipment at permanent and temporary critical care facilities like hospitals, testing facilities and critical medical manufacturing sites. Proactive inspections of automatic throw-over (ATO) switchgears, aerial circuits, and vaults serving hospitals, COVID-19 testing sites, special COVID-19 response sites, and nursing homes were provided to ensure that these customers were receiving the service they required at this critical time.

A utility in South America increased the requirement for spinning reserve at a large hydroelectric facility. Overvoltage problems due to reduced demand had been observed; they were addressing the issue by switching capacitors off to reduce reactive power injection into the system and opening lines if required. The changes in the load pattern also brought challenges for load forecasting, which is important for utility planning and to operate the power systems safely and reliably. A utility in Oceania implemented manual changes to load forecasts, and adjusted weekday forecasts to match weekend forecasts. They have also communicated with large industrial electricity users to get early notice of changes and incorporated these into forecasts and reserve models. Several utilities and system operators in North America studied the loading patterns and re-forecasted the feeders that were previously forecasted above a threshold level (such as 95%) to determine if the new load patterns presented a risk of an overloading. Operators had re-trained their forecasting models to better reflect the demand impacts from COVID-19 lockdown measures. In addition, they could bias the operation case and reduce load before approving the security constrained economic dispatch (SCED) case. One North American system operator reported that loading patterns usually observed during holidays were used as a proxy for long-term forecast and scenario analysis.

In recent years, each state in Australia had been recording year-on-year record new minimum operational demand events during Spring due to the high penetration of rooftop PVs at residential and commercial customers. The occurrences of these low demand events would fall on clear mild days with high solar irradiance. The low operational demand has created a challenge for the system operator particularly in the States of South Australia and Western Australia. The issue has manifested in management of voltage and reactive power.

The COVID-19 pandemic has caused many countries to experience reduction of load (Italy down to 25%) which has created concern for Australian system operators if those levels are reached. The system operator has worked with transmission companies to ensure voltage, reactive power and system strength can be managed during times of reduced operational demand and have collaborated on a plan based on operational forecasts. The plan includes disconnecting transmission lines with high capacitance, working with large industrial customers to ensure they stay connected during these times, working with customers with on-site generation to increase their imports from the grid and changing the operational mode of some generators which could operate in synchronous condenser mode. Each action has been rehearsed with transmission companies and trigger levels have been identified.

At the time of the survey the utility was only seeing an average of around 5% reduction in load. Some Australian states had a peak demand reduction of up to 10%; however, since large industrial loads were

remaining operational and residential load was increasing as a result of the large numbers of people working from home, the effects of the load reduction had been comparatively minimal.

3.6 Other Practices

Other implemented practices, identified in the survey, including but not limited to:

- Avoidance of public transport.
- Business travel suspended.
- Very strict hygiene standards.
- All job interviews conducted digitally.
- Extensive work from home.
- No contact between employees from regional offices.
- Remote factory acceptance tests.
- IT staff split to teams.
- Reminders to all staff to be vigilant regarding COVID-19 symptoms.

More details on the practices implemented are documented in Appendix A.

4. Conclusion

The objective of the white paper is to share global knowledge on how the electrical power and energy industry has been impacted by the COVID-19 and what short- to long-term mitigation measures and practices have been implemented to keep the lights on. As lots of material have been published on the COVID-19, the IEEE PES approach has focused on practical and technical, in-depth impacts and measures, based both on publicly available information and surveys conducted by IEEE volunteers.

The industry (utilities, system operators, vendors, and regulators.) has reacted very quickly to the pandemic, with a clear understanding that delivering reliable electric power is an essential service and interruptions would have huge impact on society, which needs to be avoided through immediate actions and well thought out plans. The immediate steps by all industry participants have been taken to protect employees' health, while keeping the lights on. It is remarkable to note that there have been few major outages reported and that reliability levels have been maintained, despite stress on the workforce.

This is the result of leadership of stakeholders across the industry. We are seeing the following trends at utilities and system operators:

- Numerous personnel, at all levels, are teleworking full-time. This can be up to 70% of the workforce.
- Many utilities are performing only the work that is absolutely needed. Other activities are being postponed or even cancelled altogether. This will have impact on capital expenditures, coupled with increase in O&M expenses.

- Some utilities and system operators are seeing very little change in load patterns, others are seeing shifts of 15-20%. These changes in load patterns will be reflected in revenues.
- Most utilities have stopped customer disconnects and are also seeing increases in receivables.

As general social distance measures have been implemented, though most utilities and system operators followed broadly similar approaches, there were distinctions based on COVID-19 impact and global electrical system differences. As the detailed impact and measures are described in the paper, the following are some overarching conclusions:

- Control centers were the target of the most stringent measures at both systems operators and utilities across continents due their importance to system reliability and continuity of operations. For example, sequestration has been exercised in North America and China, and preparations have been made, as a last resort, around the globe. Many global utilities and system operators have undertaken various other measures, such as increasing the length of the shifts, reducing the number of people in the control center at the same time, increasing the number of active control centers to allow contact-less shift changes, etc.
- Field Operations were addressed through special measures to ensure social distancing, such as requiring one person per vehicle, using drone and helicopter inspections, remote factory acceptance test, separating crews from each other, providing personal protective equipment (PPE), conducted on-line training, etc. Most utilities have reduced work plans or adjusted staffing levels, focusing on most mission critical tasks. Contractors have been responsive to the utility needs and have implemented appropriate measures as well.
- Customer Operations employees have been transitioned to work remotely, to varying degrees across the globe. Many utilities voluntarily implemented a moratorium on service disconnections for non-payment to reduce the impact on most vulnerable population.
- Supply Chain has not been a significant issue regarding the power system equipment in the short-term, although there have been some cases reported (e.g. difficulties in procuring transformers from China). This is the result of identifying manufacturers as providing essential services, so the equipment production does not experience major delays. The major concern is more from mid- to long-term, particularly related to major weather event preparedness. However, there have been major disruptions in getting PPE for mission essential workers.

The white paper addresses technical impact and measures, particularly caused by major impact on energy consumption and peak demand, as well as changes of consumption patterns (e.g. location, time, customer class). Shifts from industrial and commercial customers to residential customers, as well as overall reductions in consumption, have been observed across the globe. The demand has reduced and somewhat flattened, i.e., spread over a longer period during the day, and typically the morning peak has shifted by an hour or two in the day. The increase in demand has been observed between 5 PM and 8 PM.

Following are some mitigation measures:

- Reduction in load caused high voltage issues and various measures have been implemented, such as: switching off automatic voltage control and capacitors and switching off reactors; coordination with generators and users to adjust voltage; inspection of mission critical circuits to ensure service, and other related measures
- In areas with high penetration of PVs, load reduction creates unique challenges to manage high voltage and balance reactive power. Some of the additional measures are disconnecting transmission lines, assuring that large industrial customers are connected, and adjusting generator's outputs.
- Increasing spinning reserve and use of load shedding to adjust generation and load balance during potential outages.
- Addressing load forecasting issues, through updating models based on new data, coordination with large industrial users, and adjusting the security constrained economic dispatch, etc.

Since the duration of the pandemic outbreak and the implementation of these measures may extend for several months, it is possible that major weather events, such as hurricanes and wildfires, could occur during this same period in regions impacted by the health crisis. Preparation for these events is especially challenging given potential limitations in mutual assistance programs, and limited availability of contractors and service providers, as well as equipment and materials for restoration. As the survey results show, electrical utilities and system operators have developed or are in the process of developing plans to address such emergencies.

Additional topics addressed in the paper are related to markets, business, and environmental impacts.

The decrease in demand previously has increased the renewable resource percentage share but also led to an increase in the curtailment of renewable generation. In addition, electricity prices are decreasing due to demand reduction and historically low prices of oil and natural gas. These impacts may also lead to an accelerated retirement of aging coal and marginal nuclear facilities.

From the long-term perspective, the following societal needs will continue:

1. Continue to build, operate and maintain electric grids to make electricity increasingly accessible and affordable to all users
2. Increase power supply reliability and resilience in the face of regional storms and natural disasters
3. Reduce harmful air emissions through decarbonization

It has been reported that carbon emissions have been significantly reduced due to reduction in transportation caused by COVID-19. It confirms the fact that electrifying transportation would have a major impact on air pollution and is an important step towards decarbonization. In conjunction with deploying renewable solar and wind generation, as well as storage, this example shows that achieving effective and comprehensive pollution and carbon reduction, the society needs to address all carbon sources, particularly transportation electrification. Additional information on the financial support of EU

and European countries to direct innovations and investments in energy efficiency, decarbonization and sustainability of industry can be found in Appendix A, section a.

In conclusion, the COVID-19 pandemic has shown how, more than ever, a reliable, resilient, and cost-effective delivery of electrical energy (implementing holistic and balanced solutions) is necessary for society to cope with any crisis. This requires continuous investments in grid modernization, in order to ensure that the reliable, safe distribution of electricity can enable communities across the globe.

Appendix A: Regional Impacts & Mitigation Measures

a. Europe

To date, the results presented for Europe are based on the following sources:

- The first part is based on aggregated information obtained from the System Operation Committee at ENTSO-E (European Network of Transmission System Operators – Electricity), representing 42 electricity transmission system operators (TSOs) from 35 countries across Europe.
- The second part is based on aggregated results obtained via E.DSO (European Distribution System Operators), gathering 41 leading DSOs from 24 countries.
- The third part is based on information obtained from one transmission system operator (TSO) in Germany (50Hertz),
- The fourth part is based on information from the Belgian TSO (Elia).

Transmission system operators, TSOs (general information from ENTSO-E)

ENTSO-E – the European Network of Transmission System Operators – Electricity[39], represents 42 electricity transmission system operators (TSOs) from 35 countries across Europe. ENTSO-E was established and given legal mandates by the European Union's Third Legislative Package for the Internal Energy Market in 2009.

Within European TSO's in general, grid maintenance works which are not absolutely essential for maintaining secure operation have, since the beginning of COVID-19 crisis measures widely been postponed, cancelled or adapted. The supply chain and availability of personnel & material is currently not considered an issue. However, this might worsen in the case of enduring transportation and/or travel limitations. National control centers of European TSOs have undertaken measures to maintain the control centers' staff health and to ensure business continuity. These measures are part of the legally mandated business continuity plans which each TSOs has in place, including inter alia: (i) hygiene and sanitary measures, (ii) travel restrictions and (iii) organizational measures.

Hygiene and sanitary measures include amongst others intensified cleaning & disinfection, scanning the temperature, no handshaking and keeping distance. Most TSO's have issued PPE masks to their employees where applicable, e.g. maintenance of grid elements and outdoor equipment with contact with external service providers' staff.

Travel restrictions concern national and international travels, with a move to digital meetings & web-conferences combined with working from home.

[39] www.entsoe.eu

Organizational measures include amongst others:

- Restricted access to control rooms only for staff on shift
- Partial confinement of control room staff: people are required to stay at home when they are not on shift, contacts are limited to their families, no use of public transportation
- Staff on shift working from multiple locations, main and back-up national and, where applicable regional control centers
- Shift staff divided into separate teams with no mixing between the teams and no physical contact at shift-change (change only by phone/video).
- Clear and direct instruction to personnel on how to respect the new rules
- Teleworking for the shift staff for all non-shift activities

In most of European TSOs full sequestration is not applied. TSOs are relying instead on the above-mentioned shift-staff team splitting and on working from different locations, without physical contact between the shift teams. Sharing of information and continuous alignment among the TSOs takes place within the ENTSO-E. As indicated already, each European TSO has detailed business continuity and contingency plans in place, which are confidential and strictly for the respective authorities.

In most European countries, regular teleconferences of National Authorities with TSOs and other stakeholders of energy sector are put in place within the COVID-19 crisis management measures, to verify the continued capability of core activities and services. The coordination of the measures taken works well.

In accordance with the requirements and necessary operational procedures of TSOs, tele- and videoconference alignments are regularly in place with relevant stakeholders (DSOs, generation companies, other energy market players, IT and Telecommunication providers) to ensure the continuity of services.

The current COVID-19 crisis is experienced as a major challenge, which is being managed in accordance with TSOs' planning and business continuity procedures. As part of the information exchange within ENTSO-E, TSOs evaluate the experience in the handling of this unprecedented situation, especially in the context of the development of regional scenarios for legally mandated risk preparedness frameworks.

Weather events are part of the framework information in the regular processes of operational planning and not specially conditioned by the current crisis. ENTSO-E reports that new connection and development projects might be affected with some delays, depending on the duration and gravity of the COVID-19 crisis across Europe.

As a general trend, the system operation remains safe in Europe and all power systems are reported to be in a normal state. The measures taken by national governments, however, have led to a decrease in electricity consumption and in some countries a higher availability of thermal generation units. The reliability and resilience of the European power system is not reported to be affected by changes in the

generation mix. As a general trend, regular operation is reported without significant challenges due to voltage, reactive power, system strengths or concerns over inertia. At some TSOs, issues with high voltages due to lower loading levels and DER penetration are reported, but voltage values are within the range of normal system states and managed by regular reactive power / voltage management measures.

In all European countries, the electricity market is functioning normally without disruptions. Currently, there are no conditions to initiate market suspension as long as adequacy and security of supply are ensured by relying on market mechanisms.

For the moment, there are no adequacy issues expected in short or medium term, but concerns might arise for the winter period 2020, should the COVID-19 crisis and related restrictions persist.

Distribution system operators (general information from E.DSO)

The results for the European distribution system operators (DSOs) are obtained via E.DSO (European Distribution System Operators). E.DSO gathers 41 leading DSOs from 24 countries. In total, E.DSO members serve over 350 million citizens, representing 75% of all connected customers in Europe. The results in this section for European DSOs are thus applicable to E.DSO members.

The main measures undertaken by European DSOs can be grouped into measures regarding (i) dispatching, (ii) operation, (iii) health and safety, (iv) customer service and (v) IT.

Regarding dispatching, measures include the preparation of backup control center rooms (ranging from duplications and triplications to control the network to a move to cloud-based solutions to render them manageable remotely), control center isolation (providing facilities to allow people to live on-site if needed) and relocation to separated operation centers, shift turnovers done via phone or videoconferencing as well as the identification of workers that have previously operated in the dispatch room (e.g. recently retired highly-skilled operators). As far as operation is concerned, E.DSO points at reduced or cancellation of activities for planned work, cancellation of activities inside the customer's house, suspension of power cuts due to lack of payment and a verification of the stock of materials. Health and safety measures focus on the acquisition of face masks (surgical and FFP2), gloves, thermometers for building access and hand sanitizer. Regarding customer service, communication to customers is carefully being managed. There is a shift to remote support of most call center operators and to remote communication tools for communication in general. For IT, there is a widespread access to VPN and remote desktop access solutions for employees, as well as access to laptops for critical workers with a desktop.

Critical aspects observed by the DSOs include (i) staying in close contact to national regulatory authorities, (ii) providing personnel protection equipment as well as assuring that the personnel complies with safety measures, (iii) numerous discrete measures to reorient (e.g. IT, telecom, supply chain and fleets), (iv) guaranteeing the continuity of supply to sensitive sites such as hospitals, and (v) keep contractors active and available.

Within the different DSOs, activity levels vary from a continuity of essential activities (and potentially urgent interventions), limited operational activity to a high level maintained. Actions undertaken regarding control centers range from duplication and triplications of centers, establishing back-up centers to confinement measures or the preparation of containment centers. Health measures for control rooms include reinforced cleaning of control rooms. Regarding protection for employees, DSOs report strict observations of masks (for employees in offices and out on the field), social distance procedures, the use of disinfectant products, hand sanitizers and protection shields for employees in the field.

Regarding coordination, E.DSO organizes regular online roundtable discussions to gather feedback on the various measures taken by the DSOs and to share experiences and best practices. E.DSO also points at an increased collaboration between the transmission and distribution level as an essential part of this information exchange.

Germany

The information gathered from Germany is from one of the four German TSO's, namely 50Hertz.

With 50Hertz, there are no significant concerns with the supply chain at this stage and most asset projects are ongoing. However, company staff and service providers (contractors) are working sequentially and keeping the total number of employees working at the same site to a minimum (maximum of three). This approach reduces the number of people working simultaneously on the same project and, therefore, minimizes the risk of infection while it ensures that projects are ongoing. Field workers use company cars for direct transportation between home and work sites, avoiding public transit to minimize exposure.

The critical risk is considered to be that too many people in positions critical for continuous operation of the grid get infected. This includes operators from the control centers, field workers (for maintenance issues) and IT stuff running critical infrastructure (as well as business IT). All office workers who could work from home started immediately doing so when the lockdown was announced by the government. Almost 1000 employees worked from home, connecting remotely to 50Hertz's server without major incidents.

There are several measures and programs put in place to mitigate the risk, including:

- Establishing special taskforce available to report and consult 7 days a week on the current situation, trends, special events, needs, risks, and decisions and measures to be taken.
- Employees were asked early on to avoid public transport
- Non-operational employees to work from home
- Emphasizing hygiene standards (regular hand wash and disinfection) and introducing additional disinfection facilities
- Business travel restricted, using online tools and telephone to replace travel for meetings
- All job interviews done online and remotely
- Quality control witness testing (factory acceptance testing) with suppliers are done online remotely using webcam

- System operation was split into three work zones (green, yellow and red) with special restrictions based on the necessary level of protection
- Regularly monitoring the health of critical staff (e.g., temperature monitoring) including system operation employees and IT staff required for support of grid and system operation
- Office staff in the regional centers to work remotely from home or use single offices
- Field workers use company cars for the direct way from home to the workplaces
- Staff of regional centers should not have any contact with staff from other regional centers as much as possible
- Introduced changes in shift operations to reduce the risk of infection, increase redundancy and prevent complete isolation of operators in the control room building:
    - Reduction from 3 x 8-hour shifts into 2 x 12-hour shifts
    - Building fixed shift teams with no operator exchange
- Separating the day and night shifts in different control rooms

Sequestration is planned as a last resort, but it is not implemented as seen not necessary yet. If or when sequestration is implemented, the following are some key considerations:

- Isolation must quite likely be kept for a long period of time.
- An infection within an isolated group disqualifies the entire group.
- Within an isolated group, the number of people must be high enough to cover all shifts and to allow for mandatory free time periods. Therefore, an infection within this larger group disqualifies much more people compared to an infection in a regular non-isolated shift group.
- Isolation means psychological stress and can therefore not be used for an unlimited amount of time.

The sequestration would mostly apply to control center operators and IT experts to support operations. In case of sequestration, they will be kept at or near the control centers and their health levels will be monitored regularly. If there is anyone sick in one group, the entire group is replaced at the control center with another group and all members of the first group will be quarantined. PPE and masks are considered for employees in specific cases and use of PPE are being coordinated with government guidelines.

On the technical front, demand for electrical power has decreased because parts of the industry are down for the moment. Nonetheless, there are no issues with balancing power so far and no high voltage or reactive power issues have been observed. Higher voltages due to lower loads have been reported but are not considered typical COVID-19 phenomena since they also have been observed on other occasions (e.g. weekends, public holidays, fluctuating DER). The generation mix has not affected the reliability and resiliency of the power system. All in all, the power system has been well prepared for this new mode of operation; no major incidents have been identified (even though most employees now work from home). Digital sensor systems are used minimally (or not at all) and most power plants run in voltage control mode.

Belgium

The overview for Belgium is based on the information provided by Elia[40], the Belgian TSO. Within the company, over 80% of the construction sites were stopped immediately. The remaining sites continued initially to ensure a safe closure but have been suspended in the meantime. For construction, maintenance and intervention activities, a review has taken place with respect to social distances rules. If it is possible to comply with the social distancing rules and hygiene measures and provided there are no problems with the supply of materials and the availability of internal and external staff, activities will continue incrementally. The strict rules that have been developed apply to both the company's own operational teams and external contractors. Contractors have been asked to conduct a risk analysis for each site, for which Elia provides a template, describing the approach to take and any adjustments that should be made to the working method in order to comply with social distancing rules. An internal working group has been created to look specifically into those situations where social distances cannot be guaranteed, in order to provide additional PPE, as well as clear instructions on its usage.

Documents regarding 'golden rules', 'last minute risk analysis', 'specific risk analysis' and 'Q&A' have been made publicly available to contractors on the company website. The project manager, in consultation with the contractor, will evaluate whether the proposed approach is sufficient for work to resume safely. To begin with, several pilot sites are being reopened and closely monitored. If the test phase goes well, Elia can scale up the activity gradually. For reopening project sites, Elia provides specific instructional materials, including a process definition for site start-up, a checklist, a risk analysis and a Q&A. Elia's own operational teams will also apply the same risk analysis and modified working method and use the same instruction materials. Procedures are being elaborated to restart training and tests for external contractors in order to keep ensuring safe working conditions in substations.

Teleworking is the new norm for the administrative sites. Some 95% the employees at these sites are currently working from home. Employees who do have to go into work to ensure business continuity (security staff, control center operators, duty roles, etc.) and technical teams working out of service centers must comply with the enhanced hygiene measures and social distancing measures. Shift schedules are logically separated in the scheduling of construction, maintenance and intervention activities. Every critical job also has a back-up.

National and regional control centers may only be accessed by a limited number of people performing essential roles. For the national control center this includes close-to-real-time engineers, system engineers, system operators, planning engineers and duty engineers, while for the regional control centers it includes dispatchers, planners and analysts. Additional measures regarding hygiene and contact apply to control center staff, who are on increased standby duties and whose health is checked. They are not allowed to use public transport and the company organizes transportation for them if they require it. Control center staff members have their own personal headset, keyboard and mouse. Before each new

[40] https://www.elia.be/en/company/covid-19_elia-s-initiatives

shift begins, workstations and other surfaces used by more than one person are disinfected. Contacts with the government have been initiated to get priority corona tests for dispatchers (e.g. when a colleague gets sick) to be able to detect new cases as soon as possible.

The implementation of and compliance with the enhanced coronavirus-related measures is coordinated by a transversal task force in close contact with management, meeting more than once a day. Regular consultations are held with authorities, transmission system operators abroad and other companies in the energy sector in Belgium, such as distribution system operators and the gas grid operator. At the time of the report, the task force prepares a come-back scenario, starting with a first pilot project on the main administrative site in the month of May, gradually to be scaled up to other administrative sites. Social distancing will reduce office occupation to 50%, with only 20% allowed during the first phase. Working at home will thus largely remain the norm.

On the technical level, mainly a decrease in consumption is reported. Regional differences are noticeable regarding the reduction in power system loading decrease. By mid-April, Elia noted that the decrease consumption was less pronounced in Germany compared to Belgium, as some industries in Germany diminished their economic activity but did not suspend them (e.g. automotive industry) and other industries augmented their activities (e.g. steel industry) due to the low electricity prices. Additional analysis is carried out to ensure that minimal risks are taken when making topological changes for maintenance. Close contacts with suppliers and contractors abroad have been established to ensure fast interventions in case of emergencies. Official certificates are in place to ensure swift passage at country borders when needed.

A continued coordination with 50Hertz Transmission in Germany (part of the Elia Group) is in place and measures taken within the two companies are reported to be much in parallel. On an international level, coordination with TSOs from neighboring countries continuously takes place, as well as within ENTSO-E.

b. Asia

China

State Grid Corporation of China (SGCC) is the main state-controlled utility in China, providing transmission and distribution services across more than 2/3 of China, with China Southern Power Grid covering the rest. In general, SGCC follows the pandemic response directives from the government very closely, and several key organizational decisions are directed by government decisions. These always include the use of personal protective equipment (PPE) such as masks while outside one's home. Within SGCC the union oversees providing PPE, and all personnel are provided with masks, disinfectants, and disposable gloves. All facilities are disinfected daily. Everyone is temperature screened before entering the workplace each day. Overall, SGCC continues its operations effectively, with enough resources to serve the society/customers as before.

With respect to control center operations, very restrictive processes have been implemented, including sequestering operational critical staff with a 14-day rotation, where critical staff live in company-provided dormitories inclusive of materials needed, entertainment, and training. The process applies to all those who are responsible for the operation and maintenance of ±800kV DC converter substations, 500kV and above substations, and employees in dispatching center. All employees have their temperature checked before being sequestered. Public transit is discouraged, and the company provides shuttle buses. Non-critical employees mostly work from home. There are back-up healthy teams of operators maintained in case one team shows signs of infection (team for team replacement). The families of the sequestered staff are supported by the local government.

Field operations continue with emphasis on hygiene, use of PPE, and social distancing as much as possible. Local contractors continue to participate in field work (with similar process), but contractors form outside the provinces are restricted from travel. Online meetings and remote works have naturally increased; nevertheless, normal work plans get executed with personal protection actions, such as wearing face masks, temperature checking, and disinfecting. The company complies with the latest national policies regarding COVID-19.

Customer service/call centers operate online. SGCC supports COVID-19 critical facilities (e.g., hospitals) with very stable and sustained power supply. The company has not observed a significant change in customer request and call volumes. SGCC has waived a significant number of bills for business customers and provides deferred payments to help those affected by the pandemic.

On the more technical front, the company has developed a "load recovery index" to monitor electric load variations (and as an indicator for recovery of all industrial and commercial users for the government). The generation mix has not changed during the pandemic, and no significant technical operational issues (voltage levels, reactive power, and so forth) have been observed yet. The load reduction has been similar to the low-load periods usually experienced during the Chinese Spring Festival (perhaps a bit extended this year). The measures in place to manage high voltage due to load have been effective, as before. These measures include switching off AVC systems and capacitors (and switching on reactors), switching off some 500 kV and 200 kV transmission lines, using STATCOM and UPFC devices to reactive power, and finally, asking generation plants to go into phased operation. SCADA system have been operating very well and use of digital sensors and automated control have allowed ease of remote control for digital substations. No change in cyber security events are observed.

The business impact on SGCC has been minimal. From a regulatory perspective, the company is very much in line with the government requirements. SGCC has increased critical infrastructure investment, especially in ultra-high voltage DC transmission. There are no issues with IT and having the assets for the change in mode of operation. The workers are covered by government paid services in case of need for medical attention, etc., and continue to collect salary if they are sick. The company provides a series of online training course for employees to help transition to the new mode of operation.

c. Oceania

Australia

Australian Energy Market Operator (AEMO) operates the two major electricity systems in Australia, namely the National Electricity Market (NEM) which is across the East Coast of Australia and includes the states of Queensland, New South Wales (including the Australian Capital Territory), Victoria, South Australia, Tasmania, the longest transmission system in the world; and the wholesale electricity market (WEM) in the state of Western Australia. NEM and WEM are two separate power systems with different markets and rules. As an ISO, AEMO's function includes monitoring supply and demand, voltage and frequency, and managing planned and unplanned outages, and emergencies.

AEMO has enacted its pandemic plan and has made all non-critical staff to work from home. We have split the real-time operations into two shifts across two different control centers which operate as coprimary control centers, reinforced hygiene, physical distancing, and extra cleaning/sanitization. In addition, it carried out scenario planning on what actions need to be taken in case of infection to critical staff. It established a minimum number of staff which can sustainably run the power system and put together a plan to be activated if that threshold is reached. This plan includes having access to local accommodation close to the control centers and requiring the controllers to stay in those accommodations until restrictions can be lifted. Previously retired staff was engaged to operate the power system in case we reach a critical low level of controller personnel. The training of the new controllers was fast-tracked to ensure they can run the power system if needed. From a technology perspective, AEMO is trialing use of "mobile and immersive augmented reality applications glasses" to be used by avatars in the control rooms while the infected controller at home can guide the avatar on how to operate the power system.

AEMO is having weekly meetings with the local governments, generators, large industrial loads and the network companies to discuss week-ahead load forecast, supply issues and to get first-hand information on major issues, outage of generation and network elements. During these meetings, industry concerns have been: travel restrictions (international and interstate for specialist resources for generator/network maintenance/construction/commissioning; intrastate for maintenance activities), essential services workers – provision of PPE/sanitizing agents, priority of COVID-19 testing (for them and others in close contact) and inter/intrastate movement, access to international experts (or manufacturer specialists) required for power system equipment maintenance and Cyber security spikes.

In summary:

- Business Continuity Plans / Pandemic Action Plans were implemented
- Health: Reinforcement of hygiene principles and the provision of sanitization materials (hand sanitizer, wipes, cleaning products)
- Critical roles additional support/protection:

  - Work from home transition for non-critical staff; only control center and related support staff at office
  - Shift changes to enable split critical role shifts (backup control centers stood up, or temporary control rooms) to provide physical separation and ability to undertake additional sanitized cleaning between shifts.
  - Modifying control rooms for larger physical distances.
  - Reducing the number of administrative support (cleaners/security/couriers) coming into control centers
  - Control center staff encouraged to not use public transit / parking provided
  - Letters provided to assist with intrastate movement or in event of lockdown
  - Accommodation options near or at control centers and generation facilities (hotels, on site, portable accommodation)
  - Provision of personal IT equipment to control room staff (e.g. headset, keyboard, mouse).
  - Provision of PPE (including masks).
- Ongoing Operations:
  - Alternative or reduced scope maintenance due to travel restrictions and supply chain issues
  - Future outages being reviewed.
  - Working with key suppliers, key parts and coal/gas suppliers.
  - Seeking compliance leniency, deferral of less essential resource intensive tasks (reforms, rule changes, low value add rule obligations).

New Zealand

Transpower is the transmission company and the system operator in New Zealand. It enacted its pandemic plan in late January and has also resourced the 'Lifelines Electricity Desk' which acts as a channel between the New Zealand Electricity Industry and the national incident management team.

Under the current situation, most team members are working from home, except those needed to complete critical work at offices (e.g. control room), and maintenance contractors needed for essential work. Non-essential maintenance or project work was put on hold but, as restrictions are easing, all work that can be undertaken safely is now planned. There are some supply chain or logistics issues for overseas supplies which are being worked through.

The critical risk is health and protection of the control room and maintenance contractors. To protect control room teams, Transpower has increased protection measures including:

- Separating control room staff into distinct, rostered teams
- Standing up additional control rooms (beyond the existing duplicated facilities) to enable team members to work separately
- Social distancing measures

- Increasing cleaning
- Requiring operators to complete pre-shift health and temperature checks
- Cleaning keyboards and surfaces between shifts
- Restricting contact between shift teams on handover.

The New Zealand nationwide lockdown required everyone to self-isolate at home which allowed operators to remain in their home environment, which has psychological benefits compared to being sequestered. Transpower has arranged accommodation if the spread of COVID-19 should mean key staff need to isolate from their families. To date, there have been no confirmed cases of COVID-19 within Transpower. Transpower is also liaising with its maintenance contractors, who are also increasing protection measures.

From a system operation perspective, overall electricity demand reduced by about 15 to 20% from this time last year, largely due to non-essential industries closing during the nationwide 'lockdown'. This has started to lift as lockdown restrictions have eased. Both morning and evening peaks flattened, and the morning peak delayed. Transpower used manual changes to load forecasts and has been in regular communication with large industrial electricity users to get early notice of changes. Transpower has seen some changes in generation, but no issues affecting reliability, resilience, or security of supply. They have particularly assessed, as well as communicated their approach to, the following issues:

- Possible impacts of high voltage due to low demand
- Automatic Under-Frequency Load Shedding (AUFLS) and reserve arrangements

Transpower's IT has continued to support all systems and remote access working. Transpower is seeing similar levels of phishing and port scanning. As the security controls are already designed for remote working, they are continuing with no change.

d. Latin America

For this section, we received responses from the following organization, Centro Nacional de Control Energía, Costa Rica, Peru System Operator, and Panama Canal Authority, as well as information from IEEE Uruguay section. Generally, the basic business operation runs as usual, with some changes to minimize the risk of infection during the pandemic. Masks are required from everyone physically present at any facility. Cleaning and disinfecting practices are enhanced to hospital standards, and keeping safe distance is required.

There is no sequestration at the time of the report. The shifts for control center operators are extended so that there are typically 2 shifts per day (12 hours each) as opposed to 3 shifts of 8 hours each, with the extra staff (spare personnel) waiting at home in case any operating shift staff gets infected. Shifts work from different control rooms (no physical contact during hand-off), and in some case the DTS (Dispatcher training system) is modified to become a backup control center. So far none of the reporting organizations has had any infections in the staff. Any person with health complications (over 60, anemia, lung problems,

overweight) is sent home. Control center staff temperatures are monitored. Infected employees, if it happens, will be sent home or to hospital depending on their condition. Co-workers will be sent into 14 days of quarantine as a precaution whether they were affected or not. The reintegration to work is conditional upon formal clearance obtained from health ministry/authorities.

Field personnel, where applicable, observe similar precautions (PPE, handwashing, using disinfections, deep cleaning, social distancing, and minimizing team sizes). Dividing groups into on-duty and off-duty groups: the "OFF staff" groups stay home, connected by phone or PC, only to be mobilized in major emergencies. Lower and medium emergencies are handled by the "ON staff" groups. The "ON staff" groups are selected of generally healthier (lower risk) employees (e.g., age, fitness and other similar factors considered).

On the technical front, the peak load has dropped by up to 30%, but there are no problems with forecasting. Reductions are mainly due to key industries (e.g., mining operations reduction) and general business/industry shutdowns during lockdown periods. Generation resources are a mix of wind, sun, hydro and natural gas. Presently, mostly renewables and hydro are used. Spinning reserve has reduced, but the ISOs have increased the requirement of spinning reserve of large hydro to compensate where applicable. There are some overvoltage problems due to reduced demand. The ISOs are using reactive compensation and taking some lines out to control it. No IT or cyber security issues are observed.

So far, there have been no financial or regulatory issues. Employees working longer shifts may get overtime. There are no infected/quarantine cases; and the main concern is impact on workers if current restrictions continue for more than one year.

Costa Rica

Centro Nacional de Control Energía's (CENCE) COVID-19 response has focused on maximizing social distancing by assigning remote enabled employees to work from home where possible. At the time of the survey, control centers had been restricted to operators only. Strict cleaning protocols for control centers had been implemented with an external company sterilizing control rooms. Crews also cleaned during shifts. PPE had been issued to operators and other staff reporting to worksites.

CENCE was not sequestering control room operators at the time of the survey. Operators would be screened for signs of respiratory illness and elevated temperature at the beginning of each shift. They had split crews into three groups which were strictly isolated from one another. Shifts would alternate between the main control room and the training (OTS) room to enable isolation and touchless handoffs. A third crew was working remotely as backup.

Work teams and schedules had been adjusted to enable social distancing, minimize potential for contagion, and to ensure that backup operators were on hand in the event of high absenteeism. CENCE was training new operators on an accelerated schedule to increase backup capacity. They had also

invested in developing new tools to operate the system remotely. At the time of the survey, CENCE was executing workplans as normal.

Contingency planning for high rates of absenteeism among control room operators included identifying minimum staffing levels through identification of critical tasks. A sequestration plan for operators at a nearby hotel had been developed and could be implemented if necessary.

CENCE was following the local authorities' protocol regarding clearing recovered employees to return to work. For Control Center employees, the health authorities recommended that in the event of a positive case of COVID-19 and for anyone returning from a trip abroad, the employee should be quarantined for 21 days to ensure that they would not transmit the virus to others. At the time the survey was completed, CENCE had not had any known cases of COVID-19 within its control room and had not observed a difference in case rates between remote and on-site employees. Employees were advised against the use of public transportation.

El Salvador

Ente Operador Regional (EOR), Central American Market Operator located at El Salvador, adopted strict measures to promote hygiene and prohibited international travel, imposing a 30-day quarantine on all foreign nationals present on Salvadorian soil in accordance with a decree declaring a national state of emergency from the federal government in response to the COVID-19 Pandemic. EOR prepared a contingency plan with the objective of ensuring continuity of operations to protect technical and commercial activity within Central America. All remote-enabled employees were ordered to work from home.

Peru

Peru ISO has responded to the COVID-19 pandemic by implementing remote work protocols for all remote-capable employees. Employees in high risk groups have been working remotely regardless of function. For employees, whose presence is required at work sites, social distancing protocols have been issued, PPE has been distributed, and the wearing of masks is mandatory. Strict cleaning protocols following hospital standards have been implemented, and frequency of cleanings has been increased.

Control center operators have been isolated from the rest of the workforce and from operators covering other shifts. There are three teams of operators who usually rotate every eight hours. As a precaution, shift duration has been increased from 8 to 12 hours per day to ensure that one team can serve as backup. In the event an operator is infected or suspected to have been infected, the entire team will be quarantined, and the remaining two teams can provide coverage.

At of the time of the survey, Peru ISO had not had any suspected or confirmed cases in its workforce.

Panama

At the time of the survey, Panama Canal Authority had implemented extensive measures to protect their workforce and operations from the impact of COVID-19. Workplans had been adjusted to reflect a reduction to essential duties, and a significant portion of the workforce was on leave of absence. Remote enabled employees performing essential functions were working remotely. Social distancing had been implemented for the employees working on site, and PPE including masks had been issued to all, including control room operators and field-based employees. Employees were encouraged to wear PPE outside of work as well.

Control center operators were working on extended 12-hour shifts to ensure that backup operators were available. Health screenings were performed at the start of each shift, and extensive cleaning protocols had been issued. At the time the survey was administered, absenteeism was not an issue, and 100 percent of employees were present for their shifts.

Panama Canal Authority's protocol for suspected cases of COVID-19 included hospitalization or home quarantine for a 14-day period. If they did not show signs of illness at the end of their quarantine, they were cleared to return to work according to procedures issued by national health ministry. Case rates were very low at the time the survey was completed, which was attributed to the effectiveness of the measures that had been implemented.

Panama Canal Authority's emergency contingency included calling employees on leave of absence in the event of an emergency.

Uruguay

As Uruguay entered voluntary quarantine, IEEE Uruguay Sections indicates that the National Administration of Power Plants and Electrical Transmissions (known as UTE) has implemented strict guidelines: remote enabled employees have been working remotely, while strict social distancing guidelines and cleaning protocols have been implemented for the workforce who continues to report to worksites. Transportation to worksites has been organized to limit use of public transit. Unfortunately, at the time of the survey in April 2020, PPE, such as masks, had been out of stock, and UTE has been unable to distribute masks to employees. UTE has been working to procure homemade masks per the Uruguayan government's recommendation.

UTE has implemented an emergency workplan to deliver electricity while reducing noncritical business operations, suspending contracts and all non-mission-critical work. Generation, transmission and distribution control centers have been run on a minimal staffing schedule, isolating teams from one another by shift and rotating control rooms after each shift to permit extensive cleaning.

Operation and maintenance staff have been divided into up to three teams who are isolated from one another and operating on a weekly rotation. Employees in high risk groups have been assigned to remote work regardless of function. At the time of the survey, UTE had sequestered dispatch, generation, transmission and distribution control center operators as well as transmission and distribution field-based crews at hotels during their rotations.

At the time the survey was administered, UTE had tested employees who had suspected cases of COVID-19 after a mandatory 10-day home quarantine, but no cases have been confirmed. Their protocol for clearing an employee to return to work was through a negative test result; when testing was unavailable, quarantine was extended by 14 days, and return was permitted at the end if the employee showed no signs of illness.

Due to the low case rates in Uruguay, UTE is currently not performing extensive health screenings for employees, but employees with signs of respiratory illness are evaluated by the UTE medical services and sent home with instructions for testing and quarantine as appropriate.

UTE's emergency preparedness contingency plans include social distancing protocols and PPE use (as available) in case weather events require storm deployment and rotation and isolation of transmission and distribution field-based crews.

At the time of the survey, UTE indicated that the most significant obstacle for their operation was the availability of testing.

e. North America

There are several different approaches at various organizations to deal with the pandemic crisis. Some of the key factors for differences are proximity to pandemic outbreak hot spots and the nature of the organization, whether an ISO, RTO, transmission and/or distribution utility.

In general, most ISO, RTOs, and larger transmission utilities with critical control rooms either are considering sequestration (have progressed through planning) or have started it. Some of the common themes in North America includes:

- 12-hour shifts
- Using rented RVs or trailer near operating rooms (often in the parking lots) to house the critical (sequestered) staff
- Medical monitoring (temperature, at least once a day) and strong hygiene and deep cleaning practices are observed (with emphasis on surface cleaning)
- Touchless shift changes and personal keyboard, mice, etc. for each staff
- Multiple active control rooms (with some temporary or EMS/DTS training/simulator facilities converted to backup control centers)
- Social distancing within the control rooms

- Complete separation of sequestered staff
- Well-being and mental health monitoring/support services
- Getting help from retired staff as back up, and accelerating training for new operators

Almost all companies have significantly increased work-from-home practices for staff to the extent possible. For field staff, PPE's (e.g. masks and disposable gloves) are provided, social distancing rules are established, and non-essential work are reduced or postponed. In some cases, acquiring the PPEs has been challenging (due to the high demand) but with manageable delays, it has been achieved. Most utilities and system operators have established training courses for staff and are actively refreshing those courses. Field employees ride alone in a car/truck and take the vehicle home from site, minimizing any stops or unnecessary interactions (do not go to the office except to pick up material or tools).

In many cases, away from outbreak hot zones, control room operators are not in sequestration (at least not yet), but operate under several precautionary requirements (similar to sequestration) including minimal (one or two) operator in the control center at a time, temperature and health monitoring daily, deep cleaning daily, not sharing (using personal) keyboard and mouse, etc.

Most organization are taking full advantage of remote meeting and IT capabilities, and are minimally impacted by travel bans, at least for now. In most part, there are no IT or computer resource limitations acknowledged. Most companies were already using laptops that employees could take home. Most call center staff (customer service) work remotely. Most companies have experienced no significant change in cyber-attacks, except for phishing attempts directly related to COVID-19.

On the technical front, almost all regions have experienced a reduction in peak and average loads with peak flattening and extending for longer time. The reduction in the load has been anywhere between 5% to 25%, but manageable in all cases. There are concerns about further reduction in load as the weather gets nicer in spring, especially in regions with large solar PV penetration. Alternatively, some look at this situation as an opportunity to study grid behavior and power quality under extreme low load conditions, which in the future may be more common as a result of heavy penetration of renewables and DER.

On the business front, most surveyed companies were not financially concerned in the short term, but some had concerns if the situation continued for too long and if major capital projects were delayed. Most had good support and understanding with their regulators for now.

Most surveyed companies did not see immediate/short-term impact on grid modernization and decarbonization priorities and investments, but acknowledged it is too early to say. There probably will be some impact in the longer term.

National Grid

Social distancing has been implemented across the workforce at National Grid. At the time of the survey, most office-based employees were working remotely, and work plans have been modified to reduce field work.

Half of the control room operators as well as EMS and maintenance staff had been sequestered in rental trailers for 30-day periods along with food staffers, cleaners and EMS staff at the company facilities. Sequester sites included showers and catering and maintenance provided by vendors. The site was equipped with rented exercise equipment. Trainers were also sequestered to expedite new employee qualifications and any required requalification of back-up staff.

Two employees were assigned to each trailer. Employees were tested before they were sequestered, and all people were questioned, and temperatures taken prior to every shift. Testing was performed by two vendors, which had 24-hour and 48-hour turnaround times, respectively. National Grid had stocked up on cleaning supplies as well as sanitizing wipes, gloves, and disinfectant spray.

Cleaning protocols for the control centers included the application of Nano septic and Goldshield 75, frequent wiping of frequently touched areas. Mail and package delivery guidelines were delivered as well as a process for entering "Dirty Areas" for non-sequestered employees.

Protocols for sequestered employees with symptoms of illness included quarantine in their trailer until symptoms improved or transfer to a medical facility if required.

National Grid observed that most regular work protocols could be modified to accommodate social distancing. Capital work by contractors was performed on a reduced schedule.

Southern California Edison

Starting early April, a volunteer group of SCE essential personnel, union and non-union, were sequestered on-site at designated critical SCE facilities. The work schedule was a 12-hour shift followed by a 12-hour shift off, seven days a week, for the duration of the assignment. Thirteen facilities were sequestered, including grid operations, generation, and energy procurement and management. Sequestered volunteers are receiving compensation throughout the 24-hour period. No visitors are permitted. Other considerations included wellness checks and family provisions (internet access). Workspaces were designed to achieve appropriate physical distancing. Motor homes, trailers and dedicated hotel rooms were provided, depending on availability at the location. Daily cleaning, laundry services, support for mental well-being, individually packaged catered meals and on-site snacks were provided along with entertainment and leisure activities including internet access, TV and gym equipment.

Austin Energy

Austin Energy implemented remote work for personnel who were not required to be on site in mid-March. Personnel required on-site were following the standard industry practices of social distancing, handwashing, and use of masks. Austin Energy had a substantial supply of surgical masks on hand due to the foresight of their emergency management group. Austin Energy has been supplying surgical masks and disposable gloves to employees reporting to onsite locations and was in the process of sourcing fabric masks and distributing them as they would arrive.

Control center operators were protected through standard industry practices that included physical separation, reinforcement of proper hygiene, and limiting access to critical areas to essential personnel only. Control center cleaning protocols were enhanced to include more frequent cleanings, deep cleanings of work areas as required and cleanings of individual areas by personnel. All personnel that reported on-site had been required to go through a temperature and health questionnaire screening process.

To prepare for the possibility of sequestering, Austin Energy had developed a detailed plan that was ready for implementation if needed at the time of the survey. Implementation issues included a lack of test kits. Since continuity of operations was ensured at the time of the survey, sequestering had not been implemented, but was considered as an option in the event the situation were to change. Austin Energy suggested that the main criterion for determining whether sequestering should be implemented was whether it would support continuity of operations based at any given point in time.

The scope for potential sequestering included the control rooms for electric, plants, market operations and chilled water and potentially Customer Care personnel. Nearby hotels were considered as a site for sequestration. Austin Energy was somewhat skeptical on the topic of sequestration, suggesting that it was viewed as a panacea in the industry and could result in distractions or blind spots for the more important objective of continuity of operations. Flexibility with alternate staff that could assist primary personnel as well as flexibility with multiple control rooms were proposed.

Many of the customer care personnel had been transitioned to telework. Call volume had been higher than usual, but this did not pose a problem.

Sites providing health services related to COVID-19 were being added to Austin Energy's Critical Load list. Austin Energy has a key accounts group that was maintaining close contact with these customers.

VELCO

At VELCO, PPE supplies were identified as the primary concern. Measures implemented to enable social distancing included remote work for remote enabled office-based employees, and the provision of individual vehicles and PPE for all field forces. New work protocols were implemented for field-based employees: they were asked to take vehicles home and to stay out of the office except to pick up material and tools.

Control room operators were working in isolation in the control room and backup control room. Only control room operators were allowed in control room. Additional deep cleanings of control rooms had been scheduled twice weekly. Cleanings were timed to coincide with shift changes. A third control room was set up, cleaned and in standby mode in the event one of the control rooms were to be contaminated. Operators were screened for elevated temperature and signs of respiratory illness at the start of each shift. At the time of the survey, no positives on temperatures had been observed in control room operators.

VELCO indicated that they had based their planning on 40% absenteeism per EEI's suggestion. At the time of the survey, VELCO was expressing optimism that Vermont would not see anything near that level.

VELCO had put together a small PPE packet for all field-based crews including hand sanitizer and one N95 mask. Cloth masks were on order for field crews. VELCO's modified workplan included dispersed work which could be performed by one or two crewmembers maintaining social distancing. No significant capital work was being performed at the time of the survey. Rotations had not been implemented at VELCO except for warehouse employees. A sequestering plan involving rental RVs at two separate control center sites was in place but had not been implemented. VELCO indicated that previously sick employees were quarantined for 14 days before they would be allowed to return to work.

ComEd

At the time of the survey, ComEd had taken a proactive approach to providing information about practices related to COVID-19. To further mitigate the spread, ComEd had remote enabled employees assigned to work from home starting in mid-March. Almost two thirds of ComEd customer service representatives were enabled to work remotely as well.

ComEd provided additional resources to support employees working from home who traditionally did not do so, including increased IT resources. For those not working remotely, emphasis was placed on employees to wear PPE and maintain social distancing. Strict protocols had been implemented for PPE requiring employees to wear a mask in situations when they were working in close proximity to others and unable to maintain a 6-foot social distance; entering occupied customer premises; at all times while working in control and call centers, it was mandatory. Masks were issued by ComEd, and included surgical masks, KN95 masks and N95 masks unless fire retardant face protection was required or deemed preferable by the person in charge.

Additionally, to mitigate the spread, a daily cleaning regimen was implemented at all commercial sites on business days, which included:

- Door handles/knobs/ push plates
- Kitchen, breakroom tables, counter-tops, faucets
- Bathroom facilities: counters, sinks, toilets
- Light switches, cover plates, stairwell railings, and elevator call buttons

- Weekly electrostatic clean: In addition to the cleaning protocol above, Facilities was performing an electrostatic spray cleaning weekly to supplement the daily wipe down of all common areas. The cleaning staff would rotate through the various properties to perform this work in the evening and over the weekend to minimize disruption.
- In the event of a confirmed case, the person was notified by its Office of Health and Safety to perform a bio-hazard cleaning at the premises the infected employee had been present at. Bio-hazard cleaning included performing the electrostatic cleaning three times.

To prevent the spread of the virus, ComEd had issued masks to its employees. This PPE was provided in phases, prioritizing field employees and employees working on site in control rooms and call centers. At the time of the survey ComEd was expanding issuance of PPE to remote enabled employees.

Masks and/or cloth face covering use was recommended from the time employees arrived at work or entered company or customer premises to the time they left or entered their vehicles: when an employee interacted in person with a customer or coworker, regardless of distance, and while walking in and around common areas of any company facility including hallways, restrooms, stairways, elevators, lunch and break rooms, etc.

Due to the critical nature of activities performed at control centers, ComEd had taken additional steps to reduce the risk of COVID-19 from impacting its critical control center personnel who are responsible for the safe and reliable operation of the electric system. Control centers were operating in both primary and back up locations. Masks, surgical or above, were mandatory in all control rooms. Only necessary staff could enter control rooms and all staff were health screened by a medical professional (temperature and questionnaire) prior to control room entry. If an individual's temperature was 100ºF or higher, or if there were concerns with their responses, they were instructed to return home. At ComEd Distribution System Operations and Transmission System Operations sequestration had not been implemented at the time the survey was completed.

To ensure the health of field employees, social distancing had been implemented. Guidance on modifications to on-the-job briefings to promote social distancing had also been issued, such as modifying huddles. Additional vehicles had been rented to ensure that all crew members would ride to job sites independently. Training and guidance on the use of PPE, social distancing, hygiene, and minimizing touch were given. Social distancing decals were applied to company vehicles to maintain awareness. Job Aids on whether an employee needed to enter a customer's premises were provided.

ComEd explained that while all their work was critical to providing reliable energy to our customers, they had revised their workplan to minimize opportunities for exposure. Storms, emergent work or essential work requiring more hours due to outage constraints were noted as exceptions because reliable energy supply for customers is always considered essential, and particularly at a time when customers were working at home and home schooling. To quickly respond to workforce changes, ComEd had grouped work into three tiers, based on priority, with tier one work representing the highest priority work. At the

time of the survey, ComEd was performing work in all three tiers. If projections would indicate reduced resourcing levels, workplans would be adjusted based on priority tiers; for example, all work in tier three would be scaled back before any scaling back of work in tier two would take place.

ComEd had also established a multi department COVID-19 Response Inspections Working Group, which continually engaged with municipalities, local Chambers of Commerce, non-profit agencies, faith based organizations, and Commercial and Industrial Customers, to proactively identify any locations that were involved in COVID-19 response and ensure that they had the level of service required. This included proactive inspections of automatic throw-over (ATO) switchgears, aerial circuits, and vaults serving hospitals, COVID-19 testing sites, special COVID-19 response sites, and nursing homes. ComEd had also deployed a mobile bridge to provide additional access to these sites for those who need it.

ComEd is seeing decreased commercial load and longer residential load peaks. It had studied the loading patterns and re-forecasted our feeders that were forecasted above 95% to determine if the new load patterns present a risk of an overload. Study concluded that no overloads are projected on those feeders. Additionally, ComEd had seen a decrease in loading across the system with the daily residential peaks the same as prior to remote reporting and the decrease coming in C&I loading. It also reported to have observed the residential loading flatten out compared to an early evening peak due to the stay at home orders. It continues to monitor the changing loads not only during the stay at home period, but also for the return to work phase as we expect loading on feeders to adjust as the commercial load will ramp back up at the same time the residential load may be following the remote reporting patterns on given feeder.

PJM

In January, PJM canceled international visitors to PJM's campus, all tours of the control room, and PJM international travel. Personal equipment (keyboard, mouse, etc.) was allocated to each operator. In February, all visits (including stakeholders) to the PJM campus were canceled, as well as PJM domestic travel. Enhanced campus cleaning protocols were implemented, and operator shifts were increased to 12 hours to minimize contagion. Contactless shift turnover protocols were developed, control rooms were restricted to operators only.

In March, all non-operation personal was assigned to work remotely. PJM allowed personal equipment to be taken home (monitors and keyboards). Reliability engineers (operators) were doing studies remotely as well.

In April, the operator training simulator (OTS) was repurposed into a third control room. PJM now has a 3 (hot-hot-hot) control room environment. Additional measures to ensure the safety and reliability of control room operations included voluntary use of company-supplied masks, and strict cleaning procedures.

Control room operators were sequestered and put on on/off rotations based on multiple decision criteria including CDC and state guidance, county virus spread, safety of operators, duration of sequestration measures, testing availability, volunteers, and logistics. Employees were tested before sequestering.

To mitigate the potential impact of control room operator illnesses, web and simulation-based training programs were implemented for key personnel (ex-operators) to renew operator qualifications. Bench operators were providing support remotely for specific tasks.

New York ISO (NYISO)

NYISO indicated that at the time the survey was administered, they were monitoring the generator fleet in New York State on a weekly basis through surveys and conference calls, and that their level of concern was low.

All non-critical staff had transitioned to working from home. All stakeholder meetings had been transitioned to conference calls. Operators were considered the most critical staff and had consequently been sequestered at two sites with a minimum of two full operating crews, a manager, and facilities staff for cleaning the sequestered areas in accordance with enhanced cleaning protocols: all surfaces were disinfected after each shift by operators, then by onsite facilities staff, then again by the operators on the following shift prior to use. Each control room was empty for 12 hours following each shift because the operators were working out of two locations to minimize risk of transmission. There was a backup crew at each location to ensure shift coverage in the event of illness.

The decision to sequester was based on the rapid increase of COVID-19 cases in New York state and the local area. Sequestered operators volunteered for the assignment and were accommodated in rented RVs in the parking lot at NYISO's primary and alternate control center locations. Exercise equipment, and online exercise sessions had been made available. A verbal medical screening and testing were performed prior to operator sequestration. Twice daily temperature checks were also performed on operators. Contingency plans involved reducing the size of each shift, or breaking sequestration at one site and rotating non-sequestered operators in to provide shift coverage. At the time of the survey, NYISO had offered families of sequestered employees reasonable assistance but no requests had come in.

Appendix B – Response Knowledge Sharing Questionnaire

a. General questions

- What is your company's responsibility in the electric power supply chain (e.g. generation, transmission, and/or distribution)?
- What is the level of concern around supply chain issues, such as fuel availability or availability of resources, to keep the supply chain at the required level?
- How are travel restrictions affecting your business in terms of maintenance of assets, access to qualified resources, material shortages, supply chain, and other similar issues?
- What general measures and programs has your company put in to place to mitigate the spread of the virus and what are your most critical risks?
- Has your company issued COVID-19 relevant PPE (i.e. masks) to your employees? If issued, have the masks been optional or required? What groups have received masks? What were the triggers for issuance?

b. Control Center Operations

- How has your company managed the risk of infection to your operationally critical staff?
- Has your company implemented sequestering for operationally critical staff? Has it begun using on/off rotations?
- If the sequestering is implemented:
    - What were the criteria to execute?
    - Which groups (e.g. Control Center, Trouble men, crews, etc.)?
    - Where (e.g. In the Control Centers, in nearby hotels)?
    - If in nearby hotels, how are you securing the environment?
    - Has your company done testing of employees before being sequestered?
    - What type of help has your company provided to families of sequestered employees?
    - Please share any other best practices
- If sequestering has not taken place, has your company started to screen certain work groups before their shifts?
- How does your company keep the control center clean; what strategies for cleaning and logistics have you implemented?
- What are your company's contingency plans if you have sick operators in your control rooms or fewer operators in power plants?
- How is your company preparing for and responding to weather events?

c. *Field Operations: Work Prioritization, Staffing & Work Force*

- What measures has your company taken to ensure the health of field employees?
- What levels of absenteeism has your company experienced by different work groups? Are you seeing a difference in case numbers by remote workers vs. non-remote workers?
- What are the attendance triggers used? What levels are you expecting to experience?
- What is the level of absenteeism seen in the contractor workforce?
- What are your company's staffing strategies? E.g. Does your company still execute normal work plans, only emergent work activities, or something in between? What are the field work priorities? Has your company tried an on / off rotation?
- What are the cautions put in place for tasks where social distancing between crew members cannot be maintained (e.g. one or two people in a basket, helicopter inspections, other such options)?
- What additional protocols has your company put into place as individuals who were previously quarantined/infected came back to work? How did you screen them, if at all?
- Did you put in any temperature screening and, if so, for what part of your employee population? Field only; Field and office personnel, etc. How did you handle positives and how did you implement that screening efficiently and in an employee-friendly way?

d. *Customer Operations:*

- Has your company taken any specific actions for your customer operations, e.g. moving to remote contact/call centers?
- Is your company performing additional/special inspections for COVID-19 critical facilities (e.g. hospitals, clinics, testing sites)?
- Has your company seen any impacts in customer call volumes?
- What policies did your company have in place in terms of shutting off power to customers who were not able to afford their bills?
- What has your company seen in terms of percent increase of customers requiring assistance in paying their electricity bills?
- What additional measures has your company had to put into place to stabilize customer bills while not deploying large scale shutoffs? (e.g. payment arrangements, waiving electricity bills)

e. *Technical/Engineering Questions*

- Have you noticed impacts in operational demand/peak demand/consumption patterns? How are you dealing with the challenges of forecasting load in the COVID-19 environment?
- Has the generation mix in your system considerably changed due to the impact of COVID-19? Is it affecting the reliability and resilience of your power system?

- Are you facing challenges in operation of the power system such as voltage, reactive power, system strength, and inertia? How do you manage these challenges?
- Is your company observing issues with high voltage due to lower minimum loads and DER penetration?
- How have your IT and operational systems such as SCADA performed in the new mode of operations, e.g. with staff who may work from different locations?
- Does your company use digital sensor systems for more automated control at either T or D voltage levels?
- Have you noticed increased Cybersecurity threats/attack attempts? What additional mitigation measures have you put in place?

f. Business Impact questions & Lessons Learned:

- Is your regulatory framework supportive of the new mode of operation, or do you find many restrictions which impede the business in dealing with the new operational paradigm?
- What is the financial impact and how well your business is positioned to operate in the new paradigm in the medium to long-term (6-12 months)?
- Does your company receive priority support from local emergency and health authorities? If yes, please explain.
- Did your company implement any special compensation strategies (e.g. hazard or premium pay) for your employees?
- Any best practices, key findings, and success stories? Anything that you would have done differently?
- Did your company have all the required assets (laptops, backup centers, mobile audio and data devices) and ability to change the mode of operations?

g. Additional Questions – Please answer if time allows

- Has your company created trainings for employees to operate under social distancing and remote work paradigms?
- Does your company have data on infection rates by different work groups?
- Based on actions taken (e.g. implementing masks), has your company observed a slow-down in infected/ quarantined cases?
- Have you encouraged your employees to use PPE when not at work? Has that led to a reduction in infections?
- Did your company have a pandemic plan in place prior to the COVID-19 pandemic, and if so, did you have training programs, at what stage did you execute your pandemic plan, and what was the trigger?
- What issues has your company still not found a way to address?

- Do you see an impact on grid modernization priorities and investments?
- Do you see an impact on decarbonization priorities and investments?
- How can the IEEE Power & Energy Society (PES) and its members assist your company in navigating through the pandemic – both in the short and longer terms?
- What are some creative changes that your company has implemented to safely complete field work during the pandemic?