C2-00

SPECIAL REPORT FOR SC C2

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Special Reporters

1. Introduction

CIGRÉ Study Committee C2 deals with the technical functionalities, structures and competences needed to operate integrated power systems in compliance with the social requirements for security and quality of electricity supply.

The field of activities of SC C2 includes securing the physical integrity of power systems, management of strained systems and capacity shortage situations with controlled risks, restoration strategies, functionalities and reliability of Control Centre and training of System Operators.

SC C2 needs to understand, use and integrate results from studies in other Committees to assure that the technical concepts can be applicable in real time in various contexts and implemented by the System Operators. The SC C2, therefore, embraces a wide range of competence areas and interfaces with other disciplines.

2. Group Discussion Meeting Session 2021

For the Group Discussion Meeting, SC C2 has invited written contributions to provide discussion materials pertaining to three specified Preferential Subjects. As a result of this invitation a total of 85 papers have been accepted, categorized into the following Preferential Subjects:

Preferential Subject No 1:
Capabilities Required for Future System Operation (43 papers)
Special Reporter: Marija Zima (Switzerland)

Preferential Subject No 2:
System Operation Interfaces: Improving Observability and Controllability (12 papers)
Special Reporter: Anjan Bose (United States of America)

Joint Preferential Subject C2 and C6
Preferential Subject No 3:
System Operation Challenges with Increasing Distributed Energy Resources (30 papers)
Special Reporter: Renuka Chatterjee (United States of America)

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3. Important Dates

Experts who wish to contribute to the SC C2 Session should upload their contribution on the Registrations platform – "Contributions to Group Discussion Meetings" section - using their existing account and own credentials before Monday **02 Aug 2021** for a prior screening and good organization of the Group Discussion Meeting.

Important points:

- *Access to contribution uploading is given only to duly registered delegates.*
- *As a consequence, registration to CIGRE Session should be finalized before uploading contribution(s) online.*
- *Register now for the Session Click here*
- *Contributions uploading will be open at the beginning of May.*

A guide for contributors as well as templates and sample pages will be available on the CIGRE Virtual Centennial Session website - see Group Discussion Meetings in the top menu bar.

Special Reporters Marija Zima (marija.zima@ch.abb.com), Anjan Bose (bose@wsu.edu) and Renuka Chatterjee (RChatterjee@misoenergy.org) will review the prepared contributions (PowerPoint presentation with a maximum of 3 slides and written version with a maximum of 1000 words). Any recommendations or changes to the contributions will be provided by the Special Reporters directly on the Registration platform by **09 August 2021**. Contributors are encouraged to visit their account on the Registration Platform to see the result of this review. For those contributors who have been asked to make changes to their contributions, a final decision on their acceptance will be provided by the Special Reporters on the same platform by **16 August 2021**.

The 2021 CIGRE Virtual Centennial Session will have a slightly different format. There will be no Poster Session and the **SC C2 Group Discussion Meeting** will be split in two four hours sessions. On Thursday, **26 August 2021**, from 12:00 to 16:00 CEST, the session will cover PS1. PS2 and PS3 will be covered on the next day, Friday **27 August 2021**, also from 12:00 to 16:00 CEST.

During the Session the Chairman may call for spontaneous contributions. Attendees who provide a **spontaneous contribution**, are allowed to deliver a text for the Session Proceedings. This text is required to be forwarded within a maximum delay of two weeks after the SC C2 Session (thus by Wednesday **10 September 2021**) to the Special Reporters.

Preferential Subject 1
Capabilities Required for Future System Operation

- **Operator Training.**
- **Decision support tools including new methodologies.**
- **Wide Area Monitoring and Control.**

Power systems operation and control remains to be highly responsible and challenging task. The complexity of the operations and the potential implications of the suboptimal decisions in the real time operation are increasing. This is triggered by the renewable proliferation, massive deployment of the generation that is behind the power electronics interface, increasing population and load density in urban areas and the ageing infrastructure. Dependency of the human activity on the electrical power supply is growing, and so do the expectations and requirements towards the its reliability.

Simultaneously, new technologies help us to unlock the potential of the existing assets, achieve their full exploitation, support implementation of the new functionalities and capabilities faster and more efficiently. This section discusses evolving role of the control centers, new decision support tools for the operators, further increasing applications of PMUs and WAMS systems, applications or visions of

AI; Furthermore, challenges that have been recognized and addressed in the system operation since some decades, explicitly, short circuit current levels, frequency and voltage control, intertie control are benefiting from the disruptions in both HW technologies and the automation side. Innovation and new opportunities for the improvement of the efficiency and the reliability of the system are also being opened by massive digitalization and connectivity.

Preferential subject one – capabilities required for future systems operation - is addressed by 43 papers.

Papers for PS1

C2-101 presents a simulated approach to low frequency oscillations reduction using WADC measurements. Results of simulations are compared to real measurements of a real event in Continental Europe on December 3rd, 2017

C2-102 discusses the evolution of operational documents used by system operators of the Brazilian Independent System Operator – ONS into a modern potentially AI based content information system that improves real-time decision making.

C2-103 shows the severe event occurred in Taiwan on 15th August 2017, and its consequences on the electric system. It describes the event, the behavior of UFLS scheme and proposes a modification to it to improve the load shedding.

C2-104 presents a tool that utilizes satellite information to improve the inspection of the transmission lines, especially considering frequent fires.

C2-105 presents the theoretical background supported by specific analyses on real oscillatory events occurred on North American Eastern Interconnection power system. Prompt identification and classification of such oscillations (natural, forced, local, interarea etc.) is important.

C2-106 describes M-SSSC is series reactive element to be connected in the transmission line. It is placed on mobile trailer and can be transported easily. It helped increasing the security of power supply during the planned outage.

C2-107 presents a simplified model for real time monitoring of frequency stability whose parameters are tuned based on real frequency transients recorded in the Nordic power system.

C2-108 describes experience of Finland TSO in developing practices for system restoration. Field testing and training of the restoration was included, operators were engaged in identifying the solutions for the black start, which gave them confidence with handling the real situation.

C2-109 provides a description of all the measures taken by GCC to guarantee the security of the system. It presents the existing adequacy, security indices and the defense plan to preserve the Combined System and the connected Member States operation for contingencies beyond N-1.

C2-110 addresses Optimal Phasor Measurement Unit (PMU) placement (OPP) problem for getting complete observability of the system and mentions various algorithms to solve OPP problem.

C2-111 introduces a new software tool to determine the optimal seasonal settings of the step-up transformers at the power plant. The proposed approach is to keep generators terminal voltages as close as possible to rated ones.

C2-113 discusses how HVDC links could offer a solution to low inertia problem with appropriate control strategies. The problem of low inertia is faced by the operators due to replacement of conventional generation by behind-the-converter renewable energy sources.

C2-114 presents a new, nearly real time Intelligent Alarm Processing and root cause analysis system that is designed and implemented in the control room.

C2-115 presents three major inter-area oscillation events that have been recorded in Continental European power system during the last decade. Each of them is described, with main highlights on chronology of the events, triggering causes, control room actions and lesson learned.

C2-116 presents a Wide-Area Monitoring and Control scheme (called Enhanced Frequency Control Capability) specifically designed for providing fast frequency response, from a few seconds to within one second, based on the regional impact of frequency disturbances.

C2-117 summarizes the achievements of collaborative R&D project Security Assessment and System Optimization – SASO a tool has been developed for online close to real time analysis and assessment of the network state and providing decision support to the operator in critical situations.
C2-118 describes experience with online tools in control centers as well as new tools under development to prepare for 70% renewable electricity generation. The new functionalities are e.g. look-ahead stability assessment, day-ahead assessment of planned voltage trajectory of different devices, and ramping margin reserve assessment for scheduling the ramping margin reserve services.

C2-119 an algorithm for solving an optimal transmission line switching problem at 154 kV voltage level in the Turkish Transmission System using genetic algorithm is presented in the paper. Optimal solution is found with consideration to N-1 contingency analysis and short circuit current limit.

C2-120 describes the development of national coordinating system for energy balancing (KJC). KJC has two main functions: to reduce the amount of reserve activation, and to minimize the cost for activating control reserves, on local and national level.

C2-121 describes the challenges that intermittency and Photovoltaic production pose to the electric grid of Jordan - the rapid growth of renewable energy generation facilities is changing the concept of electricity supply. Paper reports first stage of a project to address solar intermittency.

C2-122 describes a stability margin monitoring system (SMMS) that was developed and implemented in UPS of Russia. The SMMS automatically performs calculations for determining actual values of admissible power flows in the specified controlled and identified endangered sections considering the actual power system operating parameters.

C2-123 900 PMU and 90 PDC in 120 power stations and substations have been put into operation in UPS of Russia, WAMS SO in real time receives more than 400 k parameters per second. This paper presents the solutions to improve the efficiency of WAMS System Operator performance.

C2-124 Paper presents operational experiences associated with low system strength conditions and how various interactions (including harmonic resonances) can manifest in undesired operation of IBR or adversely impacting power system security in those conditions

C2-125 presents the modifications done in REE's forecast algorithms for wind and solar energy forecasting. The increased forecast accuracy was more pronounced for solar generation forecasting.

C2-126 gives a general introduction to the on-line DSA applied in SGCC. It is developed based on a power dispatching and controlling platform and can evaluate stability in three operation modes, namely the Real-Time Mode, the Study Mode, and the Trend Mode.

C2-127 analyses the transient process of the HVDC transmission system under faults such as HVDC blocking and commutation failure and shows how to protect sending end of Multi-HVDC converter network from over frequency after one HVDC end is blocked due to fault.

C2-128 discusses how a knowledge base for intelligent management and control strategy can be constructed in a complex power grid, which can automatically provide support to a decision-maker in power grid operation, especially in handling emergency situations.

C2-129 discusses an enhanced EMS architecture comprising a dynamic system model as core component to mirror the system state in real-time, combining DSA and WAMS. The human role related to the operator assistant systems in a system operation environment is discussed.
C2-130 describes how the power flow and overload is monitored in RTE network using automata with adjustable thresholds at local level. These automata have a set of thresholds and time delays such that the action is taken at the end of the time delay.

C2-131 describes power generation forecasting system to be implemented in Thailand. In the first phase the forecast of the generation from the small power producers to be included, while the second phase shall encompass also PV sources.

C2-132 presents automatic abnormal incident notification or alarm processing system that has been developed to support operators in a North-eastern control center of Electricity Generating Authority of Thailand [EGAT], especially during the restoration process following an outage.

C2-133 presents a method for optimal management of fault current by applying various existing and new technologies, including separation of the busbars and transmission lines. The influence of the fault current level on the inverter-based generation and FACTS facilities is also examined.

C2-134 The advisory system has been designed to automate the assessment of transmission system operation plans for the next day. The tool is also planned to automatically generate possible remedial actions in case of contingency.

C2-135 describes the transmission system in Romania and problems with maintaining voltage.

C2-136 presents weather radar technology basics, the scope of information available from real-time radar images and the possible use of this information in the control room, which proved to be very useful in India.

C2-137 describes and discusses the Real Time Fault Level Monitor (RTFLM) that has been developed to free up the spare fault level (FL) capacity. The RTFLM will provide for the first time an actual FL measurement rather than a calculated value based on trends, characteristics and ratings.

C2-138 presents survey of the best practices in all the Load Dispatch Centers (LDCs) and recommendation of the suitable measures and roadmap for institution building and strengthening of the LDCs.

C2-139 describes options for measuring PMU data within generating substation and proposes an overall architecture for synchro phasor technology applications within generating substation.

C2-140 here, the real system is modelled within an Opal real-time simulator representing the IEEE New England 39 busbar system. Transients after fault switching could be analyzed by using wide area control strategies.

C2-141 investigates the impact of HVDC systems on the rotor-angle transient stability in the AC power system. It proposes supplementary controllers for active power modulations of embedded HVDC systems, allowing to enhance the transient stability of the surrounding AC system.

C2-142 a fast-acting special protection scheme based on wide area measurements was set up via clustering the system in different centers of inertia and monitoring the related phase angles.

C2-143 covers the utilization of dynamic line rating (DLR) system of transmission lines in Slovenia, which was introduced in operation in 2016. Integration of DLR system results with SCADA/EMS and 3D visualization platform is explained.

Questions for PS1

Subtopic 1 (PS1-1). One paper, **C2-108** is relevant for the subtopic one – **operator training** for restoration procedures.

Question 1.1:
System conditions are evolving, and RES penetration is increasing. How will system restoration plans be defined in a system with less conventional synchronous machines? Has any consideration been given to the role of renewable generation and/or storage in restoration strategy development? Are there examples of how PMU information can support system restoration real-time? How can more automation be implemented into the restoration process in order to decrease interruption times?

Subtopic 2 (PS1-2) – decision support tools including new methodologies is addressed by 29 papers that can be grouped in several categories.

Papers **C2-131, C2-121, C2-125** discuss **forecasting** of power generation by the renewable energy resources and show the perspective of Thailand, Jordan and Spain.

Question 1.2:
How can the monetary benefits of a reduction in the renewable energy forecast error be quantified? Are there practical examples of how the operational costs reduce due to increased forecast accuracy of renewable energy?

Papers **C2-112, C2-128, C2-102, C2-134, C2-129, C2-107, C2-117, C2-126, C2-122, C2-118, C2-120, C2-130** address variety of aspects of decision support tools for **operational planning and online security** assessment. Experience and vision are presented from several geographical regions and countries, namely: Sweden, China, Brasil, Korea, Germany, Finland, Russia, Ireland, Japan, France. Here papers C2-112, C2-128, C2-102 employ data driven methods to assist operators' decision making.

Papers **C2-119, C2-133, C2-137** focus on the operational planning that considers **fault current levels**.

Papers **C2-132, C2-114** from Thailand and Croatia show opportunities and practices related to automated alarm processing and root cause analysis of the network events.

Question 1.3:
What is the acceptance level of AI by control room operators, especially in applications where the result of decision-making advice by AI algorithms cannot be fully traced, reproduced or explained by control room operators? Are there other AI examples in system operations world-wide? Is AI essential in the future and why?

Question 1.4:
How to develop an aggregation of otherwise complex, detail system models to be applicable for (near) real-time operation (e.g. for dynamic security assessment)? How to validate the model?

Question 1.5:
Frequency stability, ROCOF and frequency deviations are crucial topics in a low inertia power system. For real-time purposes can we implement an alarm that indicates to the control room

operator that the level of inertia is critical? How to guarantee that there are enough reserves available in the system that can be mobilized for inertia? How flexible will it be? Are there similar solutions world-wide? Which kind of energy sources/ technologies are being used?

Subtopic 3 (PS1-3) – Wide Area Monitoring and Control is addressed by 13 papers that can structures in two categories: evolution and the applications of the systems protection schemes (SIPS) and wide area monitoring and control systems (WAMS), as well as practical experience with thereof.
Papers **C2-109, C2-110, C2-139, C2-140, C2-123, C2-138** present contributions from Gulf states committee, Serbia, Canada, Russia and India. These papers outline functionality of these systems, approach to optimal phasor measurement unit (PMU) placement, discuss various applications on PMUs data, test platforms as well as intended upgrade and the expansion of the next generation platforms.

Question 1.6
Risk assessment methodologies, where probability and severity (steady-state and dynamics) are define the way to increase the utilisation of the system in a less risky moment and to decrease it, when the likelihood of sever disturbances is high. Are there example world-wide where system operations is, or (can be) based on risk?

Question 1.7
Looking into the energy transition will PMUs be fast enough to capture system dynamics in a system with massive integration of PEID. Should we replace PMUs by fault recorder like information? What are the implications and acceptance of big data and cloud technologies for the applications in WAMS analysis that are not time critical? Anyone can share examples?

Papers **C2-142, C2-108, C2-116, C2-103, C2-124, C2-101, C2-115, C2-105** bring to the attention of the reader practical examples of the problem solving and the application in the real-world operation, these include separation and islanding, restoration, fast frequency control in systems with low inertia, underfrequency load shedding and the low system strength conditions. Contributing countries are Iceland, Finland, United Kingdom, Taiwan and Australia.

Papers **C2-101, C2-115, C2-105** discuss Inter-Area Oscillations, which were simulated and observed in the Continental European and North American Eastern Interconnection System.

Question 1.8
The energy transition results in more volatile operational points, where faster and less damped dynamic phenomena are expected. Adaptive protection and control solutions may be necessary to cope with a more dynamic system. What are the necessary requirements to develop successfully such adaptive solutions? Are there lessons learned and successful cases world-wide to be shared concerning automatic adaptive solutions?

Preferential Subject 2:
System Operation Interfaces: Improving Observability and Controllability
- **TSO-TSO interface/cooperation/data exchange.**
- **TSO-DSO interaction/cooperation/data exchange.**

With the increasing complexity of system operation, especially with the rapid increase of distributed energy resources (DER), often connected to the distribution system, the coordination and cooperation between the many entities that jointly operate and control the grid have become even more important. In this preferential subject, papers were solicited that cover operational issues that require developing interaction and data exchange across such interfaces to improve observability and controllability. The interchange across the TSO-TSO boundaries and the TSO-DSO boundaries are of specific interest.

Papers and Questions for PS2

There are 12 papers in this section that can be roughly separated into three groups:

There are two papers (C2-203, C2-208) both from Europe, that discuss the need for and the challenges facing this need for increased coordination. Both are premised on the assertion that the new European Commission regulation (2019) called the Clean Energy Package (CEP) will be another major driver as it expects to further open the use of DERs and active customers. The paper C2-203 examines the challenges faced by the TSO-TSO cooperation as the groupings of the TSOs into Regional Security Coordinators (RSC) are emerging and further evolving into Regional Coordination Centers (RCC). This paper points out that this coordination needed to achieve the balancing is made more difficult because of the need for each TSO to work with several DSOs. The paper C2-208 is complementary as it examines more closely how each TSO can coordinate the several DSOs in its area to ensure that the proper balancing and flexibility service can be obtained from the DERs and active customer loads.

Question 2.1
TSO-TSO and TSO-DSO coordination across Europe will require pan-European standards for data, models and communication protocols. As technology is changing rapidly at both the transmission and distribution levels leading to new possible applications, what should the strategy be for the development, enforcement and upgrading of such standards? (This same question is relevant to other continents with large grids.)

The second group of papers – one each from five European countries – describe in some detail how the TSO-DSO interaction is achieved to solve a particular operational issue. Paper C2-204 from Italy shows how they are approaching the restoration problem by utilizing the load and distributed generation. Paper C2-206 from the UK describes a pilot program in which one DSO supplies ancillary services – specifically reactive power and voltage control – to the TSO. Paper C2-207 from Germany reports on how they are using common standards for TSO/DSOs to be able to coordinate reactive power management, congestion management and restoration management throughout the German grid. Paper C2-209 describes how the TSO and DSO in Ireland are coordinating voltage control by utilizing the large penetration of distributed wind generation. Paper C2-211from France shows that the data exchange between the TSO (RTE) and a DSO (Enedis) has allowed better forecasting of load and generation for both parties.

Question 2.2
Each of the TSO-DSO coordination described in the above five papers is motivated by a particular application. Would a common pan-European framework for data and models make the development and implementation of such combined TSO-DSO operational applications easier? The German paper C2-207 describes the development of a German standard but would a common European standard for such applications attract third party application vendors to develop more applications?

Question 2.3
The increase in DERs seems to have raised the common problem of balancing both real power and reactive power across the transmission-distribution boundary thus making the control of frequency and voltage dependent on smooth TSO-DSO coordination. What other applications are possible with better TSO-DSO coordination in normal operation conditions?

Question 2.4
One strategy for increasing resiliency is to allow customers or clusters of customers to continue operation as islanded microgrids under abnormal conditions. Thus procedures like restoration will require even better TSO-DSO coordination especially if a large amount of the generation capacity (and active loads) are on the distribution side. What other applications under abnormal conditions can be developed?

The third group of papers can generally be classified as being on methods and tools of different types. Paper C2-201 recounts the experience so far in implementing the PMU-only Linear State Estimators in the USA for better observability. Paper C2-202 from Egypt shows how the first 220kV interconnection with Sudan will require static Var compensation on the Egyptian side to control the voltage within allowable limits. Paper C2-205 co-authored by several countries in Europe proposes three tools that provide flexibility services to DSOs and TSOs; it complements paper C2-208 mentioned earlier that stresses the coordination part. From the UK, paper C2-210 describes a risk management methodology for combined transmission-distribution systems by calculating the expected value of energy not supplied. Paper C2-212 from Slovenia describes a simulation method to determine the performance of TSO-DSO coordination in power balancing.

Question 2.5

Obviously the planning and design of such applications that encompass both transmission and distribution operation will require the ability to simulate and analyze such combined T&D systems. Similarly, the training of operators will require training simulators that can simulate T&D, together with their controls, in real time. What are the challenges in developing such tools?

Joint Preferential Subject C2 and C6
Preferential Subject 3:
System Operation Challenges with Increasing Use of Distributed Energy Resources

- **Enhancing flexibility, reliability and resilience.**
- **Providing grid services through aggregators.**
- **Aggregator interaction.**

The advent of distributed energy resources (DERs) is changing the way power is generated and transmitted to the electric grid. DERs aggregated can be used to serve the grid and enable a two-way flow of energy. Greater levels of these interconnected resources reinforce the need to ensure the reliability of the Power System during both normal operation and in response to disturbances. Increasing amounts of DER can change how the distribution system interacts with the Power System and may transform distribution utilities into active sources for both energy and essential reliability services such as ramp and frequency response. These dramatic changes for the distribution system, which can alter not just the flow of power but also the responses to various types of disturbances, must be understood and addressed in the planning and operation of the grid.

This preferential subject is addressed by 30 papers.

Papers for PS3

C2-C6-301 presents the latest results of the EPRI contribution to the assessment of the Demand Response for which regards small consumer loads (water pumps, electrical heaters, air-conditioning.

C2-C6-302 presents the latest results of a study to obtain the conditions for which some wind parks can be resynchronized with the network during reconstruction.

C2-C6-303 presents the summary of Brazilian power system and recommendations for addressing the uncertainty and variability of the Renewable Energy Sources and Distributed energy resources including use of Storage

C2-C6-304 provides insights to strike a balance between allowing DER aggregation as widely as possible and the reliability of the transmission grid or the efficiency of the organized wholesale electric markets.

C2-C6-305 presents the results of a research that aims at comparing different kind of control strategies for demand response for FFR.

C2-C6-306 addresses the problem of degrading inertia and primary frequency control as a result of the integration of "intermittent" RE generation into the Senegal power system grid.

C2-C6-307 presents an online special protection scheme for automatic overload elimination on the transmission and high voltage distribution system for a network disturbance by optimally curtailing wind generation

C2-C6-308 presents the results to moving from zonal forecasting to more granular nodal forecasting to address the increased volatility resulting from high penetration of renewable energy resources

C2-C6-309 presents the summary of smart grid implementation in Apulia, Italy known as the "Puglia Active Network"

C2-C6-310 focuses on preventive distribution system operational scheduling, mitigating the impacts of a progressing wildfire by avoiding power interruption of critical loads.

C2-C6-311 presents the objectives and setup of an aFRR-pilot in the Dutch electricity system

C2-C6-312 presents a tool that is designed to forecast system inertia and resulting RoCoF for severe disturbances with respect to local areas.

C2-C6-313 explores the use of Distributed Energy Resources (DER) to facilitate restoration of the power system following a total or partial system shutdown.

C2-C6-314 presents latest developments in the dimensioning procedure for FRR in Germany especially take into account the greater impact of forecast errors of power generation from RES

C2-C6-315 presents two different methods for breaking down centralized optimal power flow problem into distributed sub sections.

C2-C6-316 presents methods to maximize the use of existing transmission grid by incorporating component ratings into contingency analysis for ensuring a secure system(n-1).

C2-C6-317 describes a DER platform that enables matching the demand side and Resource Aggregators based on response speed, capacity and duration.

C2-C6-318 describes an aggregation system of storage devices that enables load frequency control using hierarchical hybrid control (HHC).

C2-C6-319 addresses the frequency regulation in Faroe Islands in light of the 100% RE generation envisioned for 2030.

C2-C6-320 reports on the planning, execution and the results of an experimental power system restoration test at the Amprion transmission grid (Germany and Luxemburg)

C2-C6-321 presents fundamental modelling aspects and discusses key opportunities that can emerge from integration of a low-carbon, distributed electricity system with other energy vectors, and particularly hydrogen.

C2-C6-322 provides summary of practical experience with grid forming converters in the DSO grid in South Australia.

C2-C6-323 describes the participation of a wind farm on AGC control in Spain

C2-C6-324 presents an adaptive synchro-phasor estimator based on multi-self-calibration and multi-self-switching to achieve high precision and fast response for fundamental-harmonic synchronous phasor measurements in a variety of conditions, such as steady-state, sub steady-state, sub dynamic-state, dynamic-state, sub transient-state, and transient-state.

C2-C6-325 presents a ubiquitous power dispatch and control technologies of renewable energy based on Cyber Physical Social Systems(CPSS).

C2-C6-326 presents Software tools for smart grid operations to improve the coordination of distributed generators (DG).

C2-C6-327 focuses on the ability of DR/DGs for inclusion in Automatic Frequency Restoration Reserve (aFRR) services.
C2-C6-328 describes how lift irrigation (LI) projects can be used to aid system operation for controlling frequency and voltages.

C2-C6-330 describes the integration of very large generators with increasing distributed generation in the power system operation of Gujrat, India.

C2-C6-331 Details the Virtual Power Plant concept, architecture and the methodology as well as the applications of the concept that can be scalable for different voltage Levels and for broader generation portfolios (Project EU-SysFlex).

Questions for PS3

Question 3.1
Papers C2-C6-328, C2-C6-323, C2-C6-318, C2-C6-319, C2-C6-313, C2-C6-312, C2-C6-307, C2-C6-306 and C2-C6-305 discuss enabling frequency, regulation and black start services through distributed resources. To what extent can RES and Distributed generation reduce the reliance on large generators for these services?

Question 3.2
The concept of virtual power plant is discussed in paper C2-C6 331. What capabilities for electric storage are required to make this feasible on a large scale? E.g., how much time should be planned for electric storage to supply?

Question 3.3
Papers C2-C6-328, C2-C6-323, C2-C6-318, C2-C6-319, C2-C6-313, C2-C6-312, C2-C6-307, C2-C6-306 and C2-C6-305 discuss enabling frequency, regulation and black start services through distributed resources. How will the role of traditional generation (commit and dispatch type resources such as coal and gas) change in the future with increasing volumes of distributed generation? E.g., will they still be required for back up energy or ancillary services? Similarly, how do we see the role of transmission and interconnections across systems change with increasing DER/RES?

Question 3.4
Paper 316 suggests maximizing wind generation by using ambient transmission ratings. What impact would this have on transmission maintenance?

Question 3.5
Papers C2-C6-330, C2-C6-326, C2-C6-325, C2-C6-324, C2-C6-322, C2-C6-321, C2-C6-317, C2-C6-316 C2-C6-315 C2-C6-308 discuss the tools and technology needed to operate the grid with

high RES and DER generation. Most of these rely on real-time measurements and visibility of the system. What measures should be taken on communication protocols to ensure system reliability? How will we ensure good data to accurately assess system reliability?

Question 3.6

All papers describe various aspects of operating the grid reliability with DERs. A fundamental question remains with regards to reliability. Should system reliability criteria such as n-1 change with RES and DER? Why and why not? If yes, how should it change. For example, contingency reserves plan for single largest generator contingency. With DER, how would we identify the largest generation loss since it could come from multiple DERs due to no wind in the area?