System transformation for an optimized integration of renewable energies in Ukraine – Project Phase 2: Training Report-Action Plans

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1 Introduction

The aim of the consultancy project “System transformation for an optimised integration of renewable energies in Ukraine“ is to **support the transmission system operator Ukrenergo in the system transformation to an energy system with a high share of renewable energies**. A cost-efficient and reliable integration of renewable energies requires a substantial transformation of the energy sector, which includes technical, legal and regulatory fields of action. In view of the complexity of the task, a multi-layered approach involving all stakeholders is required.

As an outcome of previous work, gaps in RES integration in the Ukraine were identified. In this project, in-depth trainings were provided to Ukrenergo’s experts, elaboratings on the main gaps identified in phase 1. The trainings were organized along three strategic areas (‘grativities centers’):

1. **System Development:** Optimal grid expansion for RES deployment
2. **System Security:** Security of supply for the system transformation
3. **Flexibility & Markets:** Framework development for optimal balancing

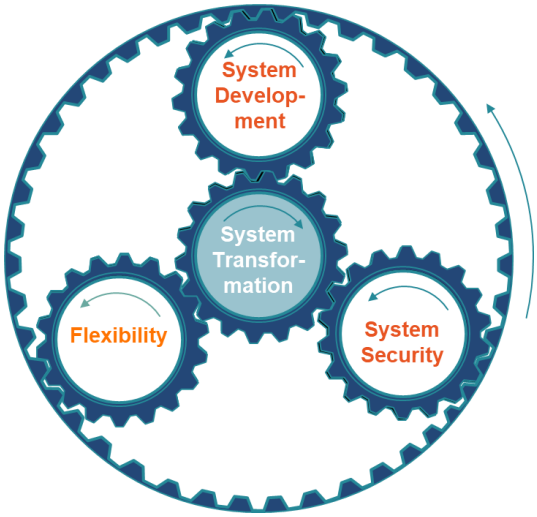

Figure 1: Gravity centres of the system transformation for an optimised RES integration

The trainings on each topic aimed to a) improve the understanding of Ukrenergo experts on key topics regarding the management of the power system with high RES shares, b) demonstrate technological solutions on RES integration from German industry technology providers used for the day-to-day system operation for and c) perform dedicated “action plan sessions” to summarise key learnings on how to enact this implementation in a form of high-level action plans.

The goal of this report is to provide an overview of executed trainings and to present the findings from the action plan sessions. These findings are organized in the form of list of actions (action plans), focusing on topics that are considered important for improving the integration of renewable energy in Ukraine, based on the key lessons learnt from Germany. These action plans aim to not exhaustively answer to all actions, but rather to form a comprehensive roadmap and guideline for the needed priorities for future development and elaboration in each strategic area.

2 Training 1: Scenario Planning Methodologies and Tools

2.1 Training Introduction

In the last 2 decades the German power system has been through a **radical transformation, driven by the need to integrate higher shares of variable RES**. This system transformation called for a high level of grid expansion measures.

50Hertz has developed a **dedicated toolchain to support grid planning decisions**. This toolchain is under continuous improvement to meet the requirements of the Pan-European market integration and increasing shares of RES generation.

The goal of the training is to provide to Ukrenergo an **in-depth insight on the requirements and implementation of the grid development toolchain**, key lessons learnt and ongoing developments in state-of-the-art strategic grid planning. The experts from 50Hertz Strategic Grid Planning department shared their experience about the changing requirements in the last years in the grid planning practice, due to radical changes such as high penetration of wind onshore and offshore wind, coal phase-out, the deployment of HVDC etc. The respective toolset for grid planning and analysis was presented e.g. data preparation tools, interface management tools or tools visualization for study results for an effective decision making. **The training was organized in 4 main domains, as presented in the figure below, according to the structure of the key processes and toolchain functionalities in the 50Hertz grid planning department.**

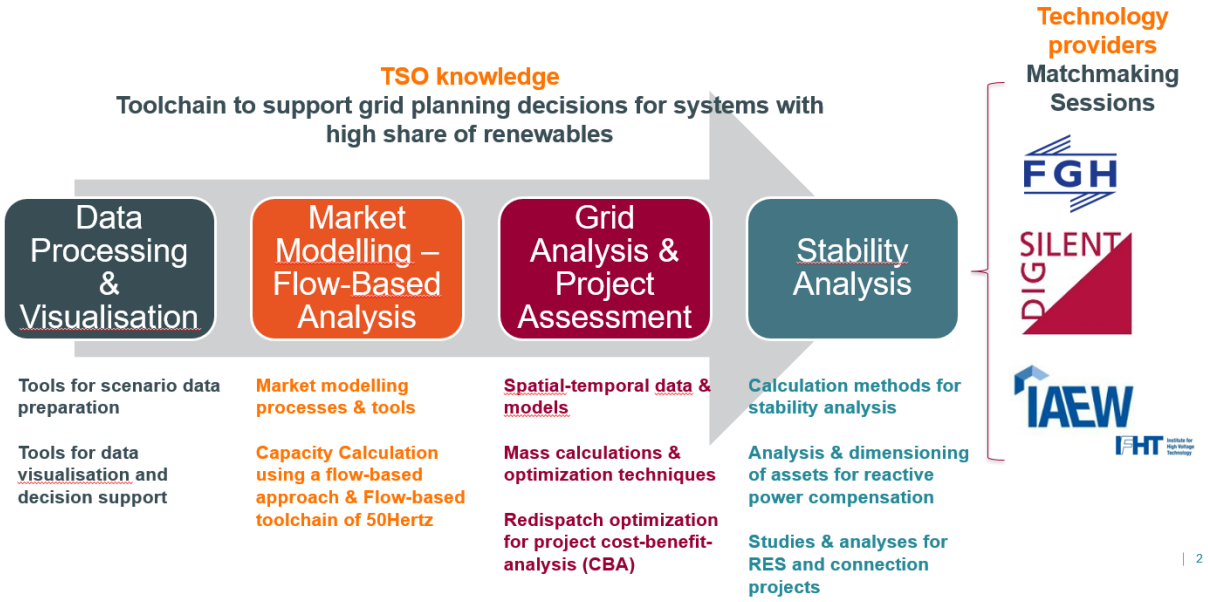

Figure 2: Concept of the "Scenario Planning Methodologies" training

The training on grid planning included demonstration of three key grid planning tools from the respective software providers at 50Hertz. The state-of-the-art software solutions in grid planning were presented

as well as the evolution of the software according to the changing requirements from the grid operators. Ukrenergo therefore could comprehend a) the capabilities of modern grid planning software tools, b) the collaboration between the TSOs and the software providers in tailoring the software solutions to the needs of the TSO, and c) how the software can work together in a toolchain. The three technology providers, namely FGH, DigSilent and IAEW provided demonstration of their tools:

FGH offers network operators, manufacturers as well as plant operators and project planners a diverse range of services with customized solutions in the entire spectrum of topics relating to electrical energy supply and the energy industry. Close cooperation with universities and other research institutes ensures rapid transfer of the latest scientific findings into practice. Since 1921, FGH has been setting new standards worldwide in the field of safety and quality of transmission and distribution networks. The grid planning software of FGH is used by German TSOs for the development of the federal grid development plan and ENTSO-E TYNDP studies.

DIgSILENT GmbH is a software and consulting company providing highly specialised services in the field of electrical power systems for transmission, distribution, generation, industrial plants and renewable energy. DIgSILENT provides a leading integrated power system analysis software package covering the full range of standard and highly sophisticated applications.

The Institute of High Voltage Equipment and Grids, Digitalisation and Energy Economics comprises a team of more than 120 employees including more than 90 research associates at the professorial chairs for High Voltage Equipment and Technology, Transmission Grids and Power Economics and Active Energy Distribution Grids. Furthermore, our team comprises experienced colleagues in controlling, accounting, IT and the mechanical workshop.

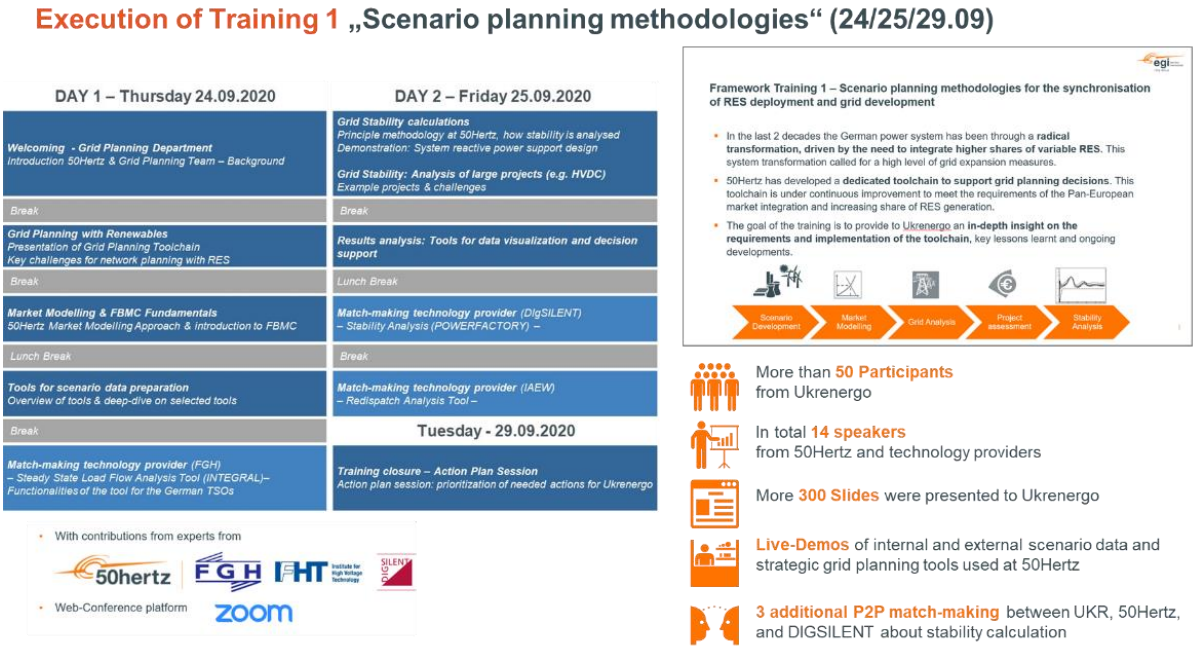

Figure 3: Agenda and general overview of Training 1

2.2 Training Overview

The training was organised as depicted in the agenda and overview shown in Figure 3. The sessions were highly successful, with high participation. In addition to these sessions, a series of additional Peer-to-Peer matchmaking sessions were organised, focusing on the topic of stability analysis, with Elia Group experts (2 meetings of total 2,5 hours) and with DIgSILENT (2 hours).

2.3 Action Plan Grid Planning Methodologies and tools

The training was completed with the 'training action plan session'. This session summarized all learnings and discussions and performed a systematic mapping of future actions for the development of needed toolchain and respective processes for grid planning with RES. The session mapped the respective actions in the four main domains tackled in the training. In total 12 topics were identified, as presented in the figure below:

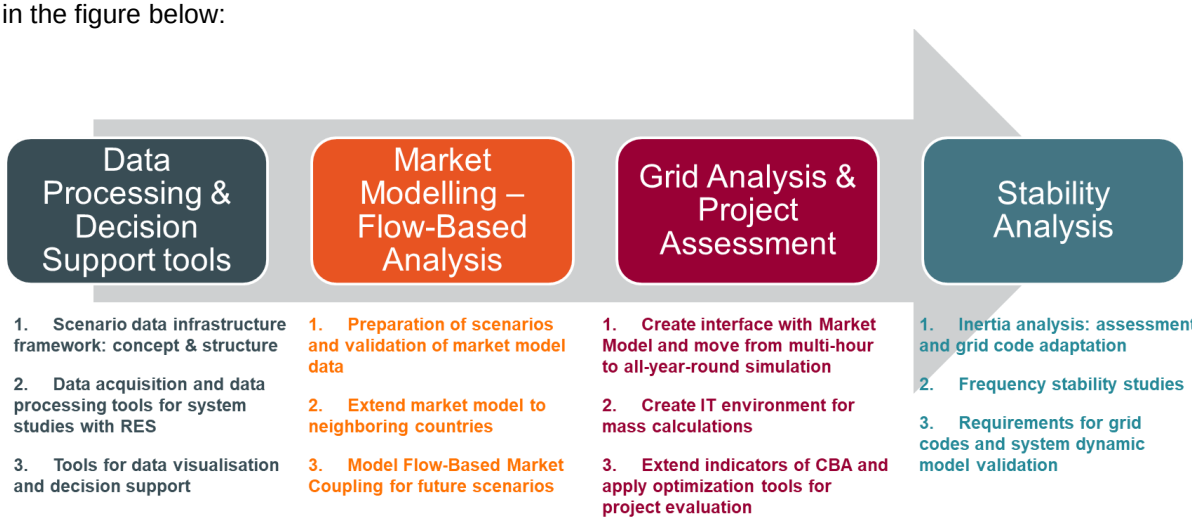

Figure 4: Key Priorities/Actions identified for the future implementation

A. Data processing & decision support tools

For the analysis of system with higher RES shares, the TSO should acquire and process a vast set of data, which impacts significantly the work requirements. In this respect, it is necessary to align the processes regarding data acquisition, processing and decision making. Three main topics were identified in this respect:

1. ***Concept & structure for scenario data infrastructure framework:*** the basis for the whole process is a development of a good database, which is the single-source-of-truth, and an open-source software development environment, where the developers can access and improve the tools according to the changing requirements. Experience shows that it is important to design the database and data processing architecture in an early stage, keeping in mind the interactions with other data domains in the company (e.g. operations and asset management) and enable the access to different tools through dedicated interfaces. It is important to avoid relying on the use of databases integrated in specific tools, as this in the long term may lead to lock-in effects.

2. ***Data acquisition and data processing tools for system studies with RES:*** Generic key design scenario parameters should be transformed into consistent datasets that can be used in the market modelling and grid analysis. This involves some key steps, e.g. the acquisition of data (e.g. historical meteorological data, load data, etc.), the development of proper processing tools for preparation of the input datasets for the models (e.g. wind power converters based on capacity scenarios) and the development of proper quality control processes. A process should be designed with a gradual increase of the temporal and geographical resolution of the data.
3. ***Tools for data visualisation and decision support:*** To ease the communication and decision making, the raw data should be translated in understandable graphs or maps. Tools should be developed to allow grid planners to quickly retrieve important information for decision making with a high level of automation and low exposure to manual errors. Standardised approaches for presentation of results should be developed, to allow the generation of automatic reports and increase the efficiency and transparency of the reporting process.

B. Market Modelling & Flow-Based Analysis

The development of a proper market modelling infrastructure is central for the grid planning practice. Three main topics were identified in this respect:

1. ***Preparation of scenarios and validation of market model data:*** Ukrenergo at the moment bases its market modelling on established commercial tools. As a first step, concise datasets should be developed for describing the system operation in future scenarios of high-RES penetrations, enabling the sequential analysis of the market operation in hourly resolution, for sufficient long periods (e.g. 1 year) that enable capturing the RES variability. The power plant operational constraints should be properly captured, and the model should be validated using real data.
2. ***Extension of the market model to neighbouring countries:*** with the interconnection of Ukraine to ENTSOE, the energy exchange to the rest of the European system will be increased. As shown, for the case of Germany, a market model analysis includes all the European system. For a proper forecast of these developments, Ukrenergo should build a regional market model database, including the detailed development of the power park in all neighbouring countries. This extension will facilitate the support of decisions (by detailed assessment of system benefits) regarding the extension of interconnection infrastructure towards the rest of Europe.
3. ***Model Flow-based Market Coupling for future scenarios:*** the next step in the process is to build a proper representation of the impact of grid constraints to the market exchange, through the incorporation of Flow-Based Market Coupling. This step increases significantly the complexity of the analysis, as it practically entails building a link from the grid analysis toolchain for the importing the market coupling information to the market analysis toolbox. In addition, Ukrenergo should prepare and align these procedures to the respective ENTSOE ones, in order to ensure harmonisation and correct depiction of the grid infrastructure constraints.

C. Grid Analysis & Project Assessment

The grid analysis and project assessment tools are central the analysis of system impact of RES. Typically, the TSO should be able to properly depict the variability of power flows in the different lines of the system, and base its investment decisions on a new set of indicators, taking into account the costs from operational measures to alleviate congestions. We identify three main actions in the needed toolchain development:

1. ***Create interface with Market Model and move from multi-hour to all-year-round simulation:*** the grid analysis tools should be properly linked to the market model infrastructure,

through interfaces that allow correct depiction of the results of market analysis to the grid model. This step typically involves a projection of market model results to a nodal level in the system. Key enhancement to current practices involve enabling the analysis of multiple operational snapshots (typically full year) to allow capturing flow variability.

2. ***Create IT environment for mass calculations:*** Experience with the implementation of the previous step is that specific IT environment should be designed to enable mass calculations. Typically, this entails the use of supercomputers and parallel computing infrastructure that allows the management of multiple analyses and of increasing the computational speed.
3. ***Extend indicators of CBA and apply optimization tools for project evaluation:*** the project evaluation procedures should be enhanced in order to allow the estimation of additional indicators that depict the costs of solving congestions through redispatch measures. This step entails assessment of all different measures available for alleviating congestions in real time, such as use of flow control or redispatching of power plants. Proper assessment of the redispatch costs is central for obtaining approval for the investment decisions from the regulator.

D. Stability Analysis

Stability analysis is the final step in the grid design process. This step is of particular significance for the Ukrainian system, as the system should maintain stability during the connection process with ENTSOE, and afterwards when operating in the confines the European interconnected system. Three main priorities were identified after extensive interaction with the Ukrainian experts:

1. ***Inertia analysis:*** the increasing connection of inverter connected RES generation creates concerns regarding maintenance of system inertia. For this, support is needed on the development of methodologies for the assessment of system inertia (for system planning and design as well as online operation) and determination of the minimum levels of inertia needed in the system. Further, analysis should be performed in order to propose grid code adaptations to enforce future inertia support of the system.
2. ***Frequency stability studies:*** maintaining frequency stability is a key concern for the Ukrainian system. The system should ensure its capability to maintain frequency stability during isolation mode for the interconnection to the ENTSOE system. As a country in the boundaries of the European system, the system will further be prone to more frequency variability, while RES power plants may worsen the stability potential of the system. Finally, the impact of complex system elements to the system stability, such as HVDC links, should be properly defined. For this, a proper analysis framework based on detailed models should be developed.
3. ***Requirements for grid codes and system dynamic model validation:*** it is of utmost importance to develop and validate models that can properly depict the dynamic behaviour of the system. This should be a constant process, aiming to obtain detailed representation of internal elements, but also derive a regional validated model for stability analysis including neighboring countries. For this, the grid code requirements on the data delivered to the TSO from power plant owners (RES producers) should be tightened. Further, processes should be established for the validation of the accuracy based on measurements from PMU/WAMS, including the comparison of different analysis options.

3 Training 2: Balancing Market & Flexibility

3.1 Training Introduction

Due to the high importance for system security, 50Hertz has the role of Single-Buyer of balancing reserves and facilitator/operator of the balancing market. From this role, 50Hertz has been actively involved in the continuous improvement of the balancing market design in order to ensure competition, reduction of prices, and to enable the integration of variable RES. Key achievements have been the development of a) the online tendering platform for balancing services for the management of the balancing market (regelleistung.net) and b) the online prequalification platform for increasing the market liquidity in the process.

The training has provided Ukrenergo with an in-depth insight in the full balancing service procurement process from prequalification, tendering, to settlement. On the one hand, it provided the view of the TSO through detailed demonstrations on the processes and tools, and on the other hand the view of the market players, through dedicated match-making sessions with technology providers, with special focus on aggregators and operators of large battery storage facilities. **The training concept is illustrated in Figure 5, organised in the 3 main domains of the full balancing process.**

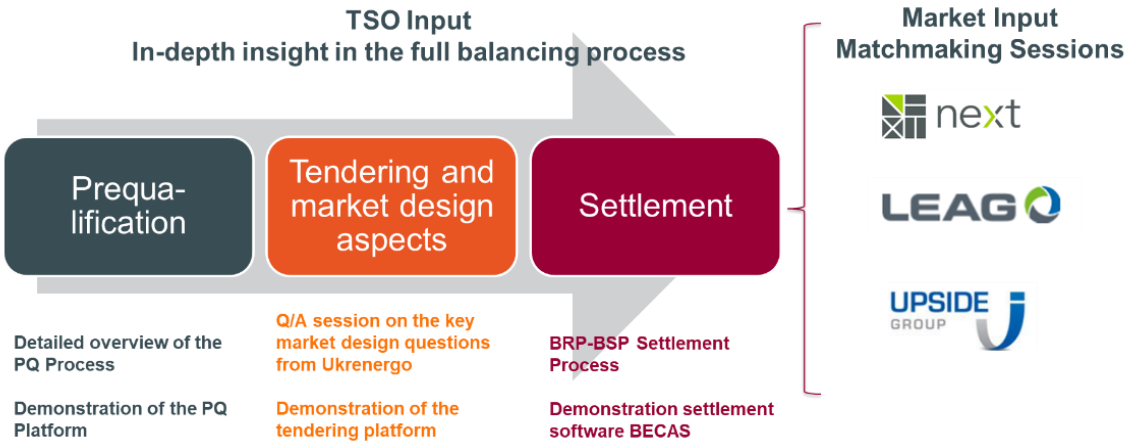

Figure 5: Concept of "Balancing Market and Flexibility" Training

Under the consideration of Ukrenergo's high interest on the usage of battery storages, demand-side management, or other small-scale assets for balancing service delivery, the Consultant included training sessions with three market players / Balancing Service Providers (BSP), namely aggregators of industrial plants, battery storages, small-scale RES generation plants, etc. They introduced the technology of Virtual Power Plants for successful aggregation of small assets and demand side, as well as battery storage technologies in balancing service provision. The three market players were:

Next Kraftwerke is one of the biggest aggregators in Europe. Next' Virtual Power Plant aggregates 9,966 units (biogas, wind, solar, commercial and industrial

consumers, storages etc.) with total capacity of 8,538 MW and trades 15,1 TWh on the market. Next pool is prequalified to provide all three balancing products.[1]

Lausitz Energie Kraftwerke AG is biggest power company in East Germany. LEAG's generation fleet includes the Lusatian lignite-fired power plants and Block R of the Lippendorf power plant near Leipzig (in total 8095 MW). In addition, LEAG's plant portfolio includes the BigBattery Lausitz electricity storage facility (66 MW) and the Welzow-Süd III solar park (10 MW). LEAG is prequalified to provide all three balancing products.[2]

Upside Group is one of the largest operators of electrical energy storage systems (EES) for the provision of primary control reserve in Germany. Their technical units are prequalified and are marketed weekly via the internet platform of the TSO for the tender of control power (regelleistung.net).[3]

3.2 Training Overview

The training concept is depicted in the overview shown in Figure 6. The training was highly successful with high participation from Ukrenergo. In addition to the two days training, the Consultant organised Peer-to-Peer matchmaking sessions between top experts of 50Hertz and Ukrenergo for deep-dive exchanges on specific topics of interest such as Commercial Metering (2 hours) and Balancing Market Design (2 hours).

Figure 6: Agenda and general overview of Training 2

[1] https://www.next-kraftwerke.de/
[2] https://www.leag.de/en/
[3] https://upsidegrp.com/de/top-referenzen

3.3 Action Plan Balancing Market & Flexibility

After all training sessions have been completed, the Consultant has executed a training wrap-up and an extensive discussion round with the training participants. The goal of the discussion is to elaborate and to outline the key action in order to improve the Balancing Market and Flexibility. The action plan is structured according to central aspects of the training, in three main pillars as shown in the figure below. In total 11 topics were identified.

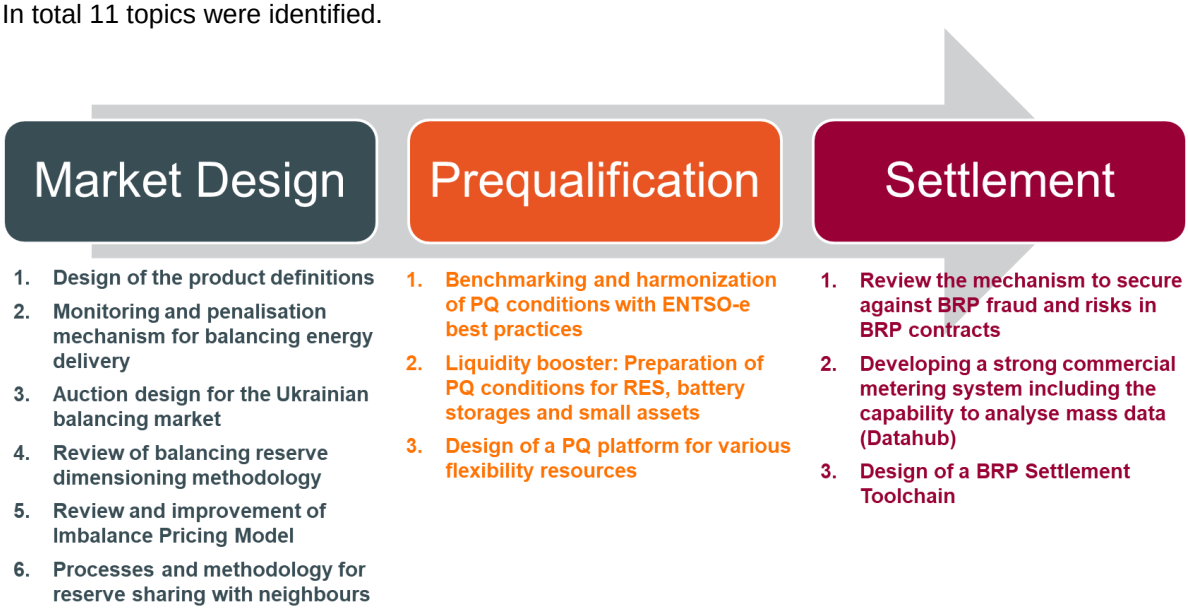

Figure 7: Action Plan for Balancing Market and Flexibility

A. Balancing Market Design and- Processes

The session highlighted a number of topics related to the improvement of Balancing Market Design and related processes:

1. ***Design of the product definitions:*** In ENTSO-e, the product design is pre-defined. Each product has a function and a specific technical requirement. Ukrenergo should align current product design with ENTSO-e balancing products in order to join the pan-European network and the ENTSO-e balancing market integration initiatives in FCR, MARI, and PICASSO. Detailed topics to be assessed are:
   - **Minimum bid size*:*** definition of the minimum bid size per product and of special requirements for new technologies like RES or storages
   - **Role of Replacement Reserves in other markets:** role of RR and activation of RR in different countries and relation to mFRR. Definition of product activation conditions taking into account the activation time requirements for RR and inter-relations between products (reserves like mFRR, RR etc)

2. ***Auction design for the balancing market*** it is important that Ukrenergo gets more information on the specificities of designing of auctions, market clearance and auctioning rules. Several topics can be identified in this respect, as follows:
   - **Merit-Order-Lists (MOLs):** Specifications of MOLs on Balancing Market in different countries and in the European Guideline EBGL are to be analyzed. In Ukraine there are several MOLs, but there is only one final marginal price per direction. The Ukrainian market design differs in this respect from European best practices. In Germany for example, the TSO procures aFRR and mFRR separately in positive and negative direction. For FCR, the TSO procures symmetrically balancing capacity. In each tender, the TSO will have different

MOL for each product, each direction, and each time unit. At the end, there will be different marginal prices forming the product- and direction-specific market prices.

- **Participation of consumers:** On the long-term, consumers can play an important role in increasing the liquidity of the balancing market, especially when the flexibility at the generation side is reduced by increasing RES and nuclear generation. In Germany, flexible consumers can provide flexibility either as interruptible load in a weekly tender organized by the TSO or in the balancing market. The prequalification of the asset is the prerequisite. Ukrenergo should investigate the potential of procuring balancing services from flexible consumers and see how to promote consumer participation. What is of major importance to define strategies on how to incentivize consumer participation taking into account successful experiences from European best practices. Examples of such strategies are advertisement campaigns, performance of common study cases / proof-of-concept with big consumers to demonstrate the benefits, develop tailored-made products for specific consumer categories, simplification and automation of processes.

3. ***Monitoring for balancing energy delivery:*** Ukrenergo is recommended to develop at first a strong and highly automatized monitoring mechanism in order to maintain the high quality of balancing service provision by the BSP. For that purpose, the market rules in Ukraine already define the basic information including:
   - the formula to determination of the provided balancing capacity,
   - the methodology to monitor the provided capacity,
   - the methodology to monitor the interaction in the provision of different products (FCR, aFRR, mFRR).

   Next, all aspects related to metering, communication between technical assets and control system, as well as between control system, and the requirement on data provision have to be defined clearly in the prequalification conditions. Ukrenergo is recommended to benchmark with best practices from TSOs in the ENTSO-e area to identify gaps in the monitoring requirements in the current prequalification and frequency control quality requirements. Topics to be discussed here are for example:
   - Requirements to measuring devices: which provide registration of these parameters (accuracy class, discreteness of measurements, verification, etc)?
   - Telemetric measurements of Battery storage during providing FCR
   - Verification and monitoring criteria of activation
   - Consideration of maneuverability of different technologies in the activation

4. ***Remuneration and penalty mechanism:*** Further, the BSP needs to be encouraged to deliver the contracted amount of capacity and energy by a strong remuneration and penalisation scheme. The penalisation scheme has to be fine-tuned to ensure that it does not hinder suppliers from participating. For example, rules-violating BSP will have to pay for the adding cost of activating the next higher bid, to pay for the imbalance, and it will be disqualified after repeated warnings. For non-delivery due to grid congestion at the DSO grid, the BSP can request the DSO to compensate for the penalty. Ukrenergo is recommended to refine and implement a remuneration and penalty scheme for the balancing service provision that will encourage BSPs to participate and deliver the services.

5. ***Review of balancing reserve dimensioning methodology:*** TSOs typically define the needed balancing capacity based on the security margin that can cover most of uncertainties. 50Hertz has been utilizing a static dimensioning methodology, and is currently moving towards the implementation of a dynamic FRR dimensioning methodology using AI techniques. The static dimensioning methodology is based on a probabilistic approach which includes multiple sources of uncertainties into the dimensioning, such as power plant outages, schedule leaps, load

fluctuation, load and RES forecast errors for the specific operational planning horizon. **Ukrenergo is recommended to start implementing a static dimensioning methodology to achieve a better dimensioning result, using advanced methodologies to capture operational uncertainty (e.g. AI techniques).** For this, two key actions are necessary, a) to implement the dimensioning algorithm, and b) align internal processes to be able to feed this algorithm with the operational data to properly depict all sources of operational uncertainty. In a second stage, more advanced approaches could be implemented towards dynamic reserve dimensioning.

6. ***Review and improvement of Imbalance Pricing Model:*** During the training sessions, it was highlighted how the imbalance pricing model in Germany was adapted gradually to fit to the changing market conditions. For example, a price coupling with the ID market price can be helpful in order to avoid market distortion leading to the situation that imbalance energy price is lower than the intraday market price. This can be achieved by different mechanisms, e.g. by setting the minimum imbalance energy price threshold equal to the Intraday price of the last trade before real-time, or equal to the average ID price of the last 500 MW traded in the ID market. However, the pricing model is not a one-fit-all solution and should be adapted based on the current and future expected the market conditions. **Ukrenergo is recommended to assess and redesign the imbalance pricing model, taking into account solutions like increasing the coupling with the spot market, and introducing a scarcity component, and a reasonable price cap.**

7. ***Prepare processes and methodology for reserve sharing with neighbouring systems:*** If the procured balancing capacity is not sufficient to cover the system imbalance, the TSO needs to have the option to buy additional balancing energy from the Intraday market, to get reserve from neighbouring systems, or activate the contracted interruptible loads. Ukrenergo is recommended to take into account such options in case of capacity shortage. ENTSO-e is currently developing initiatives for a common procurement platform of balancing reserves and the initiative for imbalance netting. **Ukrenergo is recommended to review and harmonise the current processes with its neighbouring systems or with other ENTSO-e members so that the shared usage of the reserves can be quickly realised**. Such a harmonisation will enable Ukrenergo to be ready for initiating sharing of reserves when the ENTSO-E connection is completed.

B. Prequalification

The session highlighted a number of topics related to the improvement of the prequalification process and support the increase of the liquidity of the market:

1. ***Harmonisation with balancing rules and PQ condition with ENTSO-e best practices*:** There are many ENTSO-e best practices with a well-functioning balancing market design and BSP prequalification conditions. Ukrenergo is recommended to harmonise the current PQ requirements with the ENTSO-e best practices (for example, the PQ conditions from Germany at regelleistung.net). This will make sure that Ukrenergo firstly has a strong set of prequalification conditions to test the potential BSP, and secondls it will not have any obstacles in the integration with ENTSO-e balancing market integration initiatives in one day. Focus should be given on PQ test procedures, criteria and special features for the provision of FCR and aFRR from conventional generation technologies, but also from new generation technologies like RES, storages, as well as from consumers.

2. ***Liquidity booster – Preparation of PQ conditions for RES, storages and other small assets***: Ukrenergo is recommended to further develop the PQ conditions in order to encourage

RES, storages and other small scale assets from the demand side to participate in the balancing market. This will increase the competition in the market and maintain future security of supply. Furthermore, Ukrenergo needs to define in the PQ conditions also storage-specific requirements to better integrate storages into the market, due to the fact that energy storages have a limitation in terms of energy volume. For instance, there should be a differentiation between the prequalified balancing capacity and the marketable balancing capacity from storages due to the volume limitation of a storage. Further details can be found in the prequalification conditions from the four German TSO[4]. Additionally, the PQ condition should also include the requirement for a storage management concept to be outlined so that the balancing energy delivery can be ensured during the entire contracted period. Those and further specific requirements for storages can be different for each product, FCR and aFRR, according to the different requirement of availability in each product.

3. ***PQ- and Tendering Platform:*** Ukrenergo is recommended to develop **fully automated Internet platforms** with **APIs** to be provided to BSP to allow a high automation in the prequalification of flexibility providing assets, bid collection, clearing, and result publication. This would ease the market entrance for potential BSPs and encourage them to enter balancing the market. As an example the fully automated PQ-portal at 50Hertz was presented in the dedicated training demonstration sessions. In this portal, the automated process is performed in two general steps a) BSP register the required information for the prequalification such as general information about the technical units, reserve unit, reserve group, balancing group, connected DSO/TSO, etc. b) they can also upload the operating curve while running the prequalification test. The TSO has implemented an intelligent algorithm that is checking these data in order to identify whether the BSP fulfils the PQ requirement for the test run and with which capacity the BSP is prequalified.

C. BSP/ BRP Settlement

The session highlighted a number of topics related to the improvement of the accuracy and efficiency of the settlement process:

1. ***Review mechanisms in BRP contracts to prevent BRP frauds and risk management:*** Ukrenergo is recommended to continuously re-evaluation and development of the BRP contract with regards to any potential risk for BRP fraud. The BRP contract should be a strong instrument to make all the BRPs follow their balancing responsibility and self-balance in the first place the own balance group. Penalisation or any other risk preventing mechanism can be put in place to secure the goal of self-balancing.

2. ***Develop a strong commercial meter management system with a strong datahub***: Ukrenergo has been appointed as Metering Point Operator (MPO) and Commercial Metering Administrator (CMA) in the Ukraine. In order to fulfill this role, Ukrenergo is recommended to **development of a strong and secure commercial metering system and a strong datahub that can collect and process efficiently meter data from various sources.** Furthermore, Ukrenergo needs to have a strong contractual arrangement to ensure the metering data flow, the roles and responsibility of the market players, and the quality of the data.

3. **Design of BRP settlement toolchain:** The current situation in Ukraine does not require a highly automated settlement solution for BSP and BRP settlement. Nevertheless, the future market landscape in Ukraine will be certainly different. Market structure with numerous national and international BRP with sub-BRP is realistic. By then, Ukrenergo is recommended to implement an automation of BSP/BRP settlement with integrated settlement tool solution.

[4] https://www.regelleistung.net/ext/download/PQ_Bedingungen_FCR_aFRR_mFRR

4 Training 3: System Adequacy with RES

4.1 Training Introduction

System adequacy in Germany is considered and assessed in a transnational perspective as the German electricity grid is interconnected with the electricity systems of the neighbouring countries. The cross-border electricity exchange allows that **system adequacy** can be achieved at **lower costs** by enabling geographical balancing of **variations from renewable energy sources (RES) and load as well as higher availability** of power plants**.**

The goal of the training is to provide to Ukrenergo an **in-depth insight in the processes for ensuring system security and adequacy in the presence of high penetration levels of variable RES.** As depicted in Figure 8**,** the training covers all key TSO processes for ensuring operational security and adequacy, in three main domains: a) adequacy of operational input data, b) adequacy of generation supply, c) adequacy of transmission grid, through detailed demonstrations on the processes and tools.

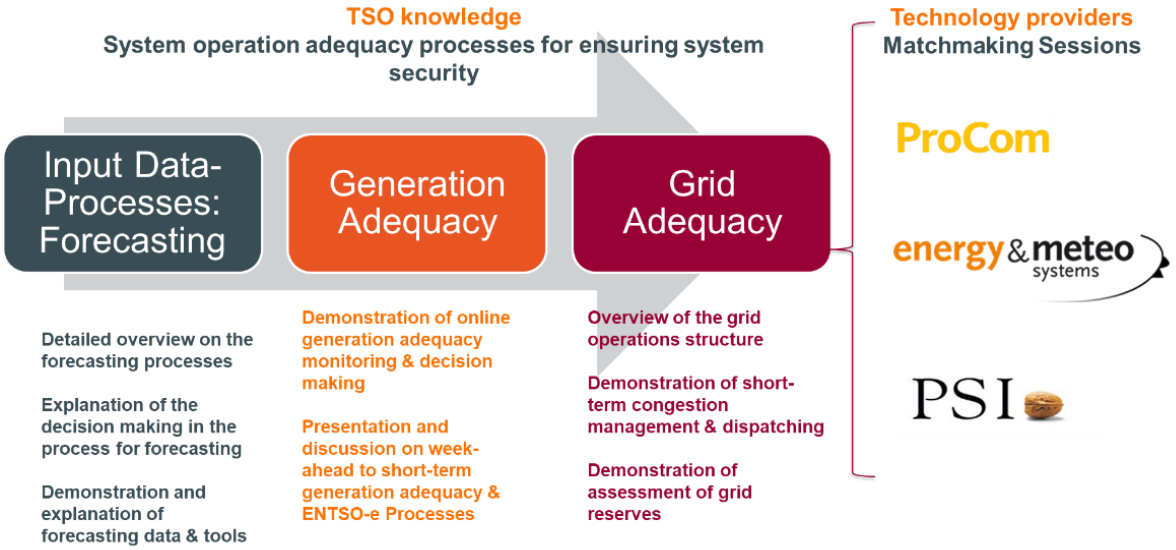

Figure 8: Concept of "System Adequacy with RES" Training

Further, the training provides input from technology providers covering all key tools needed for enabling system security and online assessment of system adequacy in these three domains:

Energy & Meteo Systems GmbH

Energy & meteo systems is among the internationally leading providers of power forecasts and Virtual Power Plants. With our service, we substantially contribute to the efficiency of integrating renewable energies into power grids and energy markets. Since 2004, energy & meteo systems has been engaged in research and development projects in power forecasts, grid operations, power trading and load management.[5]

[5] *Source :* https://www.energymeteo.com/

ProCom GmbH

As an innovative family company, ProCom offers consultancy and IT tools throughout the whole value-added chain from energy production to energy trading. The IT platforms BoFiT and ITA are the core products within different range of solutions. The solutions help to make processes and energy portfolios more transparent in terms of time frames and markets as well as optimizing forecasts. With these and other energy-related aspects ProCom is making an important contribution to the energy transformation.[6]

PSI Software AG

As the European market leader for energy control systems for gas, oil, electricity, heat and energy trading, PSI's customers include almost all the major energy suppliers. Beyond that, PSI provides control system solutions for operational management, network utilisation, pipeline management, leak detection and location, portfolio management, energy trading and sales and virtual power plants.[7]

4.2 Training Overview

Based on the training concept, the Consultant has organised the training as depicted in the agenda shown in Figure 9. The training was highly successful with high participation from Ukrenergo. After the three days training, the Consultant has moreover organised Peer-to-Peer matchmaking between the top experts of 50Hertz, Elia and Ukrenergo for a deep-dive exchange about specific topic of interest such as Contingency Analysis Tool (1,5 hours).

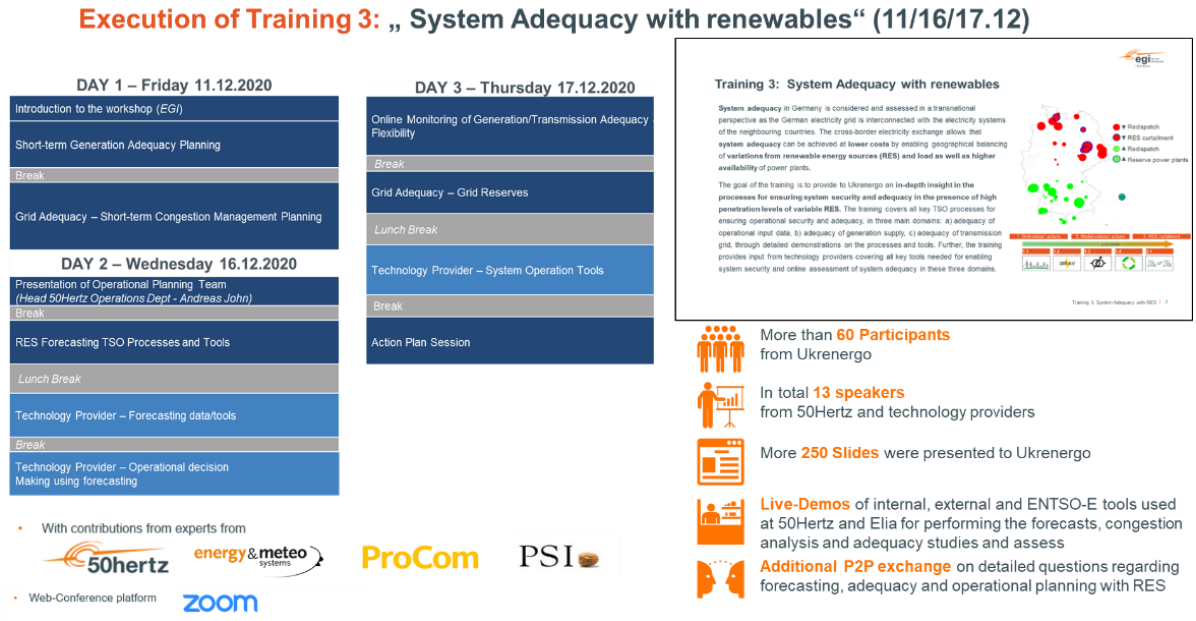

Figure 9: Agenda and general overview of Training 3

[6] *Source : https://procom-energy.de/en/company/*
[7] *Source : https://www.psi.de/en/psi-group/profile/*

4.3 Action Plan System Adequacy with RES

After all training sessions have been completed, the Consultant has executed a training wrap-up and an extensive discussion round with the training participants. The goal of the discussion is to elaborate and to outline the lessons learned and to point out the key actions, to enable Ukrenergo improve the system adequacy with increasing RES shares. The action plan identified 12 main action points, structured according to central aspects of the training, as presented in the figure below.

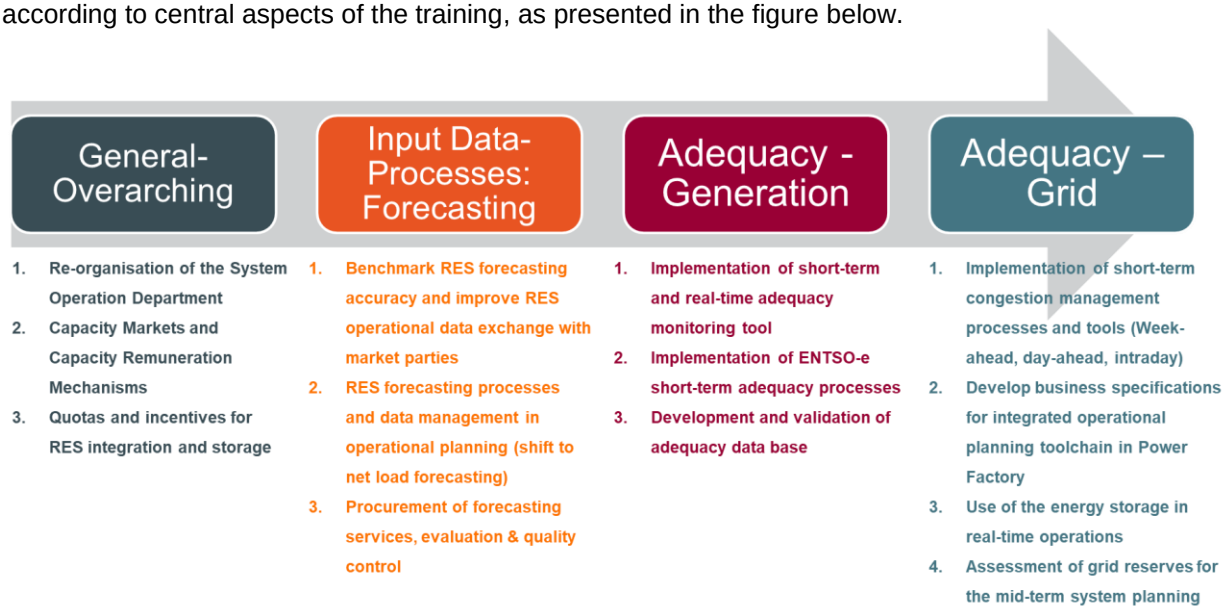

Figure 10: Key priorities identified for the future implementation

A. General-overarching themes

During the action plan session and the respective follow-up peer-to-peer exchanges, three general overarching themes were identified in the topic of system adequacy with RES:

1. ***Re-organisation of the system operations department:*** a key priority is the adaptation of the organisation and alignment of the human resource capital of the department to support the implementation of all new processes related to the operation of the system with higher RES shares, and to adapt to requirements related to the interconnection to the ENTSOE network. The evolution of the organisation in 50Hertz can be used as a benchmark for the new structure, where a new organisational layer on operational planning was introduced to support the real time decision making.
2. ***Capacity markets and capacity remuneration mechanisms:*** to ensure the level of system adequacy during the system transformation with RES deployment sufficient available capacity should be ensured. Capacity remuneration mechanisms (CRMs) are employed in order to solve the missing money problem, where in most cases the TSO is the single buyer. Ukrenergo should be able to provide valuable input to the regulator on the evolution of capacity market and CRMs in Ukraine, by defining the needed levels of adequacy resources based on the state-of-the-art approaches from industry, as well as define the types of CRMs that would optimally fit the adequacy needs of the Ukrainian system.
3. ***Quotas and incentives for RES integration and storage:*** another key topic of interest has been the assessment of the future optimal incentive schemes and quotas for the optimal integration of RES and energy storage. Aspects regarding the operational framework of storage, market responsibility of RES and locational deployment for optimal system operation should be considered.

B. Input data-processes: Forecasting

Four main topics were identified, for the incorporation of RES forecasting in the processes of Ukrenergo:

1. ***Benchmark RES forecasting accuracy and improve RES operational data exchange with market parties:*** currently, Ukrenergo is developing inhouse RES forecasting capacity. As first step, it is necessary to carefully benchmark the accuracy of these forecasts and to assess the capabilities for managing this work package internally. Important step is to take actions to improve the operational data exchange with market parties by providing incentives and proper platform for RES producers to report on daily basis regarding the operational conditions of the plants. In addition to forecasting large-scale RES plants, distributed resources forecasting should be developed. The evolution of distributed PV in the country should be monitored and a detailed register should be developed.
2. ***Implement RES forecasting processes and data management in operational planning:*** As next step, detailed RES forecasting processes should be deployed in the operational planning together with the respective supporting infrastructure. The forecasting processes should be able to deliver information on RES forecasts on different timeframes and be supported by automation tools to incorporate this information to the operational toolchain. In this step, specific processes should be introduced for the constant evaluation & quality control of the data received to ensure the needed input data quality. It is important to test such an change for specific system areas where currently RES plants are deployed in order to see issues that could be faced for a full deployment
3. ***Prepare procurement of forecasting services and evaluation:*** with increasing RES shares, it will become increasingly difficult for Ukrenergo to be able to manage the RES forecasting internally, and should resort to the use of external providers. It is significant to be properly prepared to setup a transparent process to enable cost-effectiveness and quality. A good solution is to include multiple providers in a framework agreement and create a rating system for choice of the delivery parties which is updated in regular intervals.

C. Adequacy - Generation

Three main actions were identified regarding the topic of generation adequacy monitoring in operational planning:

1. ***Implementation of short-term and real-time adequacy monitoring tool:*** the demonstration of the tool utilized in Elia showed the importance of such a tool for the daily management of the system. The high need for implementation of such a tool was identified, as the Ukrainian system faces similar issues regarding generation and flexibility adequacy. Such a tool would allow a reduction of the adequacy risks and optimal planning of the system, bringing direct cost reductions.
2. ***Implementation of ENTSO-e short-term adequacy processes:*** Ukrenergo should align its processes to the ENTSOE STA process. It is recommended that this harmonization process starts immediately, so that Ukrenergo can directly participate and benefit from this process after its synchronization. The training demonstrated the process and explained the respective steps and tools.
3. ***Development and validation of adequacy data base:*** all date utilized for the assessment of the system adequacy should be validated, benchmarked with international standards and be gathered in the system master database. This involves a higher level of weather data information, as well as further set of adequacy-related parameters for the system asset base. It

is recommended to link this database to the system development and asset databases. A process should be created, to regularly update the adequacy database with new information.

D. Adequacy - Grid

Three main action points were identified for the alignment of the operational department processes for ensuring adequacy with RES:

1. ***Implementation of short-term congestion management processes and tools (Week-ahead, day-ahead, intraday):*** The short-term congestion management planning processes are the major cornerstone for the alignment of the operational processes for the transition to higher RES shares. As a first step, Ukrenergo should carefully map its processes to the rolling planning processes, and start aligning them accordingly. Furthermore, it is important that Ukrenergo develops expertise on the use of all the respective tools, and identifies the needs for further development of its toolchains.
2. ***Develop business specifications for integrated operational planning toolchain in Power Factory:*** PowerFactory software is the central tool used in Ukrenergo for system operational planning. The integrated operational planning toolchain presented in the respective session, implemented in PowerFactory is an direct showcase on the needed evolutions in the tool (automisation routines and processes) in order to use it for integrated operational planning. As first step, Ukrenergo should develop the specific business specifications on the implementation of these processes in PowerFactory. In a second phase, based on these specifications, the respective routines and macros should be developed according to the specific requirements of Ukrenergo.
3. ***Use of energy storage in real-time operations:*** the incorporation of energy storage in real time system operations was identified as a key topic of interest for Ukrenergo, in light of the upcoming deployment of energy storage devices in the Ukrainian system. Energy storage can be used for the provision of different system services to support RES integration of (e.g. balancing, congestion management, N-1 grid adequacy support, voltage stability). It is important to specify under which operational framework can energy storage perform such activities simultaneously (value stacking). A suitable regulatory framework to support the use of energy storage by the TSO should be specified.
4. ***Assessment of grid reserves for the mid-term system planning:*** Ukrenergo should develop the internal processes to be able to identify the need for strategic grid reserves in cases of evolving grid bottelenecks. Ukrenergo should develop the respective processes and toolchain to be able to perform such an analysis, in line to the capabilities of the system development toolchain.

5 Summary & Conclusion

In close coordination with Ukrenergo, a consistent training programme has been performed in the period of August 2020 – January 2021. **The sessions covered three thematic areas of major importance for Ukrenergo, namely grid planning, balancing and system adequacy, focusing on the impact of RES deployment.** The structure of the trainings allowed a holistic view in three steps a) TSO application and conception, b) view of the market players and matchmaking with service providers and c) action plan session, outlining the lessons learned and pointing out the key actions in the thematic area. The trainings had at high participation from Ukrenergo, (more than 50 participants per each session) with very high interaction between all participants and experts. Main conclusions from the trainings can be summarised as follows:

Training 1: Scenario Planning Methodologies
The first training focused on the key topic of grid development. It presented in depth the requirements to enable a proper investment decision-making for the development of the grid infrastructure to support the RES deployment. The training presented step-by-step the full toolchain used in 50Hertz and supporting IT infrastructure. Four main areas for the improvement of the grid development processes and toolchain were identified:

Data Processing & Visualisation: an integrated database concept should be developed to support scenario analysis, engulfing the key tools utilised by Ukrenergo, followed by development of full databases and introduction of visualisation tools.

Market Modelling & Flow-Based Analysis: Ukrenergo should prepare concise and validated market models, expand its analysis on regional level and finally shift on the inclusion of Flow-Based analysis for the depiction of the impact of grid congestions.

Grid Analysis & Project Assessment requires in the first place the interface with the market models, then introduction of the all-year-round simulations, followed by preparation of the IT environment for massive calculation and data evaluation and at last extension of the cost benefit analysis for the project evaluation.

Stability Analysis is a key concern for the security of the Ukrainian system and actions should concentrate particularly on development and validation of proper dynamic models, and support in creation of methodologies for inertia calculation and frequency stability studies.

Training 2: Balancing Market & Flexibility

The second training presented in depth the role of the TSO on balancing the system in the presence of high shares of RES. The training has provided Ukrenergo with an in-depth insight in the balancing service procurement process from prequalification, tendering, to settlement. It presented the tools and supporting infrastructure and discussed in detail market design implications for enabling system flexibility. The key action points are identified in three main areas:

Prequalification processes should be harmonised and aligned to ENTSOE best practices. For example, the Ukrainian PQ conditions should include also the specification for the prequalification of

new technologies such as volume-limited battery storages, Renewables, flexible consumers, etc. The final step, this harmonisation could allow the development of automated, internet based PQ platforms.

A large number of topics were identified as priorities for the improvement of the **Balancing Market Design and- Processes.** Key priorities are the alignment of the design of product definitions, the monitoring and penalisation for balancing energy delivery to ensure the quality of balancing service provision by BSPs, the implementation of a static reserve dimensioning methodology taking into account the impact of RES variability based on ENTSOE best practices, the review of the imbalance pricing model to enforce stricter balancing of BRPs, and prepare the processes for reserve sharing with neighbouring systems

For **BRP/BSP Settlement,** key priority is to review the mechanisms in BRP contracts to avoid frauds, develop a strong commercial metering management system and design an automated BRP settlement toolchain.

Training 3: System Adequacy with RES

The third training focused on the key topic of maintaining system operational security and adequacy with hi RES shares. It focused on the specificities of the system operations department, and demonstrated the processes and tools needed for the daily operation of the system. The key action points are summarised in four main areas:

Key **general and overarching themes** identified were the needed re-organisation of the system operations department to align the human resource capital to the changing requirements, the provision of input to the regulator regarding the form of capacity remuneration mechanisms and also regarding the quotas and incentives for RES deployment and storage

Implementation of RES forecasting processes is key for management of higher RES shares in the system. This entails a change in processes and data infrastructure. Even though in first steps RES forecasting could be performed internally, Ukrenergo should prepare itself for procurement of forecasting services from providers.

The implementation of the short-term and real monitoring tool can support the Ukrenergo system operations **Generation Adequacy**. Further, creating reliable data inputs and adequacy data bases is needed to ensure proper analysis of the system requiremetns. Finally, the implementation of ENTSO-e short-term adequacy processes should be initiated.

The implementation of short-term congestion management processes and tools is key priority for ensuring **Grid Adequacy** with RES. As first step, an integrated operational planning toolchain could be implemented in Power Factory, to support system operations. In light of the upcoming deployment of energy storage devices in the Ukrainian system, focus on the incorporation of energy storage in real time system operations should be given. Finally, Ukrenergo should develop the respective processes and toolchain for the assessment of the need for strategic grid reserves.

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