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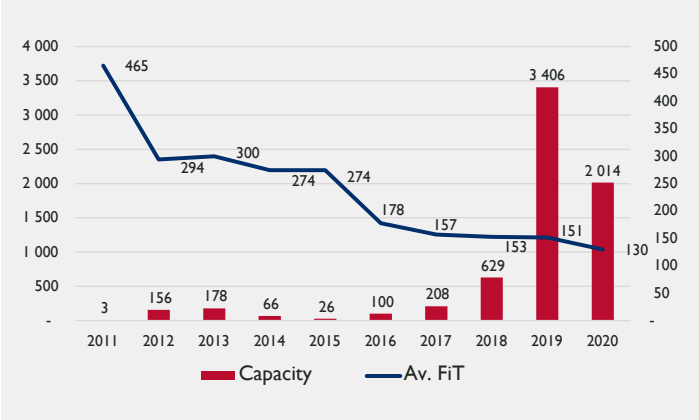
ENERGY SECURITY PROJECT

FLEXIBILITY ASSESSMENT STUDY FOR DIFFERENT RES PENETRATION SCENARIOS

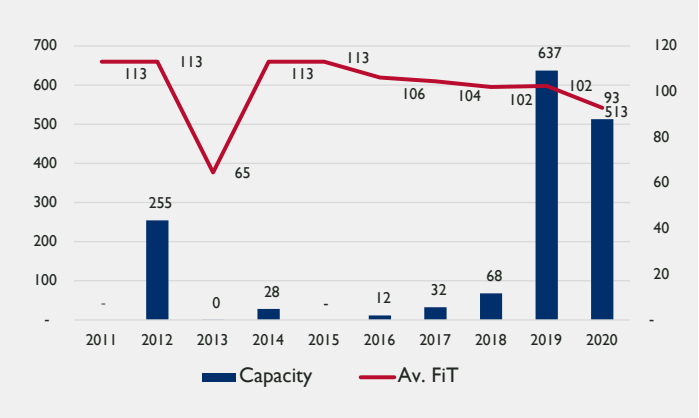
Renewable energy sources (RES) constitute a significant share of generation capacity in the Ukrainian power system. As in many countries with a similar mix of RES generation capacity, it is essential to carefully assess system requirements in order to anticipate and address any challenges upon increasing wind and solar generation, the two resources which dominate Ukrainian RES resources.

Commissioning of intermittent renewable energy power plants (i.e. wind and photovoltaic solar power plants) in large numbers brings in challenges in terms of matching variations in demand and generation patterns. A more effective solution could be increasing ramping capabilities in existing plants and other flexibility options which will play a key role in ensuring secure and sustainable operation of the power network.

Solar Capacities (MW) and FiT (Euro/MWh) of Approved Projects



Wind Capacities (MW) and FiT (Euro/MWh) of Approved Projects



These figures show the yearly total solar generation capacity of approved plants in Ukraine as of August 2020. Historically, very generous feed-in-tariff (FIT) levels have led to very high RES penetration. These levels have increased dramatically in the last two years as investors were expecting revisions in the RES support legislation, including FIT reduction, imbalance responsibility and establish a deadline for existing projects to be commissioned, so they might be exempt from auctions in near future and benefit from fixed FIT in the law. As these renewable power plants have come online, total wind and solar capacity has already reached 6 GW as of September 2020 with many more plants in the pipeline and expected to be approved in the upcoming years. In this context, while most experts agree that the Ukrainian power system needs more flexibility, views vary widely on how to achieve the required level of flexibility at a minimum cost. In this brief, we present the results and findings of the power system "Flexibility Assessment Study for Different RES Penetration Scenarios" developed by the USAID Energy Security Project.

The objective of the study is to answer the following questions:

Does the current generation mix (power plant fleet) allow for the integration of a higher share of fluctuating renewable power sources in Ukraine and which balancing options are most appropriate and cost-effective?

KEY FEATURES OF THE STUDY

- **Time Horizons & Scenarios:** >120 scenarios were evaluated for Years 2021 and 2025, and 3 most representative scenarios were selected as a baseline.
- **Analysis conducted with higher number and better quality of data points compared to similar flexibility studies in the Ukraine PS:** The analysis was performed using extensive set of hourly data and detailed modelling of load and generation.
- **Avoidance of simplification & generalizations:** Recent studies for flexibility assessment have been reviewed and required data has been collected and used to avoid simplification & generalization that may impact the results.
- **Only validated flexibility model:** The results of the analysis have been validated against RES restriction realization in Ukraine between May 2019 – May 2020.
- **Resolution of analysis and results:** Flexibility characteristics of Ukraine PS have been evaluated for each hour of the analysis year.
- **Methodology based on best practices:** Methodology implemented included elements of ENTSO-E best practices, as well as evaluation criteria of KPIs from EPRI guidebooks.

SUMMARY OF RESULTS FOR BASELINE SCENARIOS

SCENARIO DEFINITIONS					ANALYSIS RESULTS					
Year	Yearly Load Growth	Mode of Operation	Installed Capacity		Downward Ramping		Upward Ramping		Maneuvering Capacity Required (MW) (Max)	if Maneuvering Need is Met New Generation
			WPP (MW)	SPP (MW)	Violation duration (hours)	Generation deficit (MWh)	Violation duration (hours)	Generation deficit (MWh)		
2021	0.5%	Interconnected	**2,585**	**6,241**	104	149,009	30	10,555	491	0,25%
2025	1.2%	Interconnected	**3,000**	**9,500**	124	196,248	53	26,306	727	0,42%
2025	1.2%	Isolated	**3,000**	**9,500**	250	380,343	198	95,718	1,351	0,89%

Violation # of hours: How frequent does the hourly ramping deficit occurs in the system.
Ramping Deficit (MWh): Sum of additional ramping power required for each hour (can be upward or downward).
Additional Maneuvering Capacity Required (MW): Additional flexible capacity that Ukraine PS will need.
Capacity Factor: If flexible capacity need is met by constructing new facilities, the annual usage factor of these new plants.
Interconnected: The scenario assuming continuation of synchronous operation with the Russian power system.
Isolated: The scenario assuming that Ukrainian power system works in a mode isolated from the Russian power system.

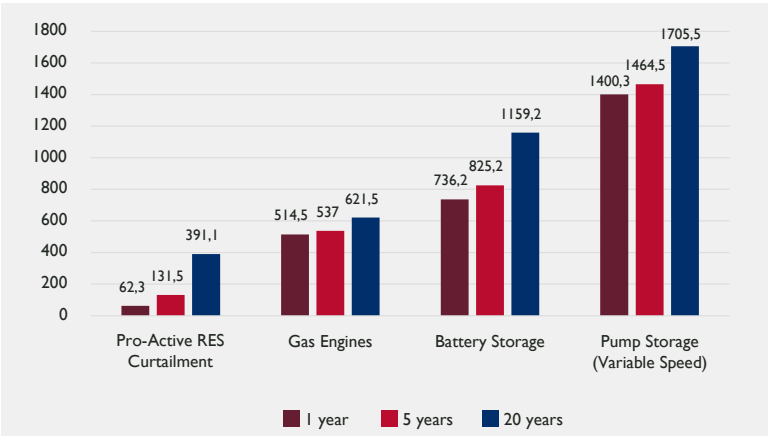
ECONOMIC ASSESSMENT OF FLEXIBILITY OPTIONS

Four different flexibility options have been compared from cost perspective to the power sector of Ukraine.

The assessed flexibility options include the following alternatives:

- Pro-active RES Curtailment
- Gas Peaking Engines
- Battery Energy Storage
- Hydro Pump Storage

Cost perspective for different horizons (million USD)



COST ITEMS	PRO-ACTIVE RES CURTAILMENT	GAS ENGINES	BATTERY STORAGE	PUMP STORAGE (VARIABLE SPEED)
Pre-requisites for Implementation	- RES Curtailment Management System (RES-CMS) - Short Term Load Forecast System (STLFS) - Short Term RES Forecasting System (STRESFS) - Direct Integration of WPP & SPP Controllers to Dispatch Centre (for directly sending set points to PPs)	- Identification of best sites and capacities for optimal provision of flexibility.	- Identification of best sites and capacities for optimal flexibility to be provided.	- Identification of best sites and capacities for optimal flexibility to be provided (Limited available sites (i.e., water availability required). - Incorporation of water usage constraint is key for best design schemes.
CAPEX (Million USD)	45,0	508,9	713,9	1384,2
Annual OPEX (Million USD)	4,5	5,6	22,26	16,1
Annual Cost of RES Restrictions (Million USD)*	12,8	0	0	0
Total Cost (1st Year of Operation) (Million USD)	**62,3**	**514,5**	**736,2**	**1400,3**
Total Cost (5 years) (Million USD)	**131,5**	**537,0**	**825,2**	**1464,5**
Total Cost (20 years) (Million USD)	**391,1**	**621,5**	**1159,2**	**1705,5**

* Cost for RES curtailment consists of costs of up regulation service paid to RES power plants for providing up regulation upon dispatch orders. So, practically, this costs translates into additional revenues for the RES power plants/RES support mechanism.

CONCLUSIONS

- **Ramping Deficits are rare for all scenarios until 2025.** In case the required additional flexibility resource (ramping deficit) is to be met with construction of new flexible power facilities, their capacity factor within the year will be lower than 1-2%.
- **RES Curtailment Levels:** Necessity for RES Curtailment and new flexibility resources are inevitable for all scenarios that have been studied for 2021 and 2025. (Around 1-1.5% of annual RES energy in baseline scenarios).
- **Cross-Border Interconnections as a Source of Flexibility:** Considering the interconnections with neighboring countries as a flexibility resource is an important contributor to reduce the flexibility inadequacy of the system.
- **Reduction of Nuclear Generation in Energy Balance (Green-Coal Paradox):** In order to have a decreased level of flexibility inadequacy in the system, our model has resulted a need of 5-15% (depending on RES penetration levels) reduction in need for nuclear generation.
- **Proactive RES Curtailment is the Least Costly / Most Feasible Solution to Address Occasional Ramping Deficits:** the economic assessment clearly demonstrates an obvious advantage of Proactive RES curtailment for upward/downward ramping in both sort and long term scenarios as compared to other system flexibility options like power storage, internal combustion engines, new pump storage hydro power plants.

RECOMMENDATIONS

- **Dynamic/Proactive RES curtailment** should be considered as an important option for flexibility provision for infrequent extreme ramping rate events. Adaptation of dispatch center operational procedures and tools for proactive RES curtailment applications needed.
- **Telemetry, telecontrol and accurate forecasting analytics:** Implementation of proper telemetry and telecontrol of RES power plants and accurate forecasting analytics are crucial for the future of RES integration in the Ukraine PS.
- **Balancing Responsibility of RES:** ESP advises that, RES power plants should be made responsible for their imbalances.
- **Rehabilitation and retrofit projects** are recommended to be implemented for TPPs, to increase the capacity of automatic reserves.
- **Variable Speed Pump Storage HPPs:** ESP recommends looking into modernizing existing PSHPPs for regulation capabilities or building new units with variable-speed technology.
- **UHE Performance Improvement:** Based on the results of a pre-feasibility study, ESP recommends the installation of battery storage and PV panels distributed to UHE generation sites across Ukraine. Significantly more cost effective compared to standalone batter storage, the new storage / PV plants will be fully integrated with the HPP units to provide streamlined ancillary services to the market, including frequency containment and restoration reserves with quick activation time. These new single units will support the connection of the Ukrainian power system with ENTSO-E and extend the life of UHE turbines.

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