



ELECTRICITY STORAGE AND THE ANCILLARY SERVICES MARKET – POSSIBLE DIRECTIONS IN UKRAINE

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The situation in Ukraine

- Rapid expansion of intermittent renewable resources, at relatively low capacity factors, contributing to a need for more flexible balancing resources.
- Wholesale electricity market evolution – not without its challenges – but a nascent ancillary services market has been established and is operating.
- At present, 10 units have been certified for selling services in the ancillary services market. More are being tested and more certifications are expected.
- The TSO is moving in the direction of acquiring battery storage to help provide ‘operational flexibility.’

But we believe a different path is more suitable for storage development.

Unit testing and ancillary services market (ASM) development

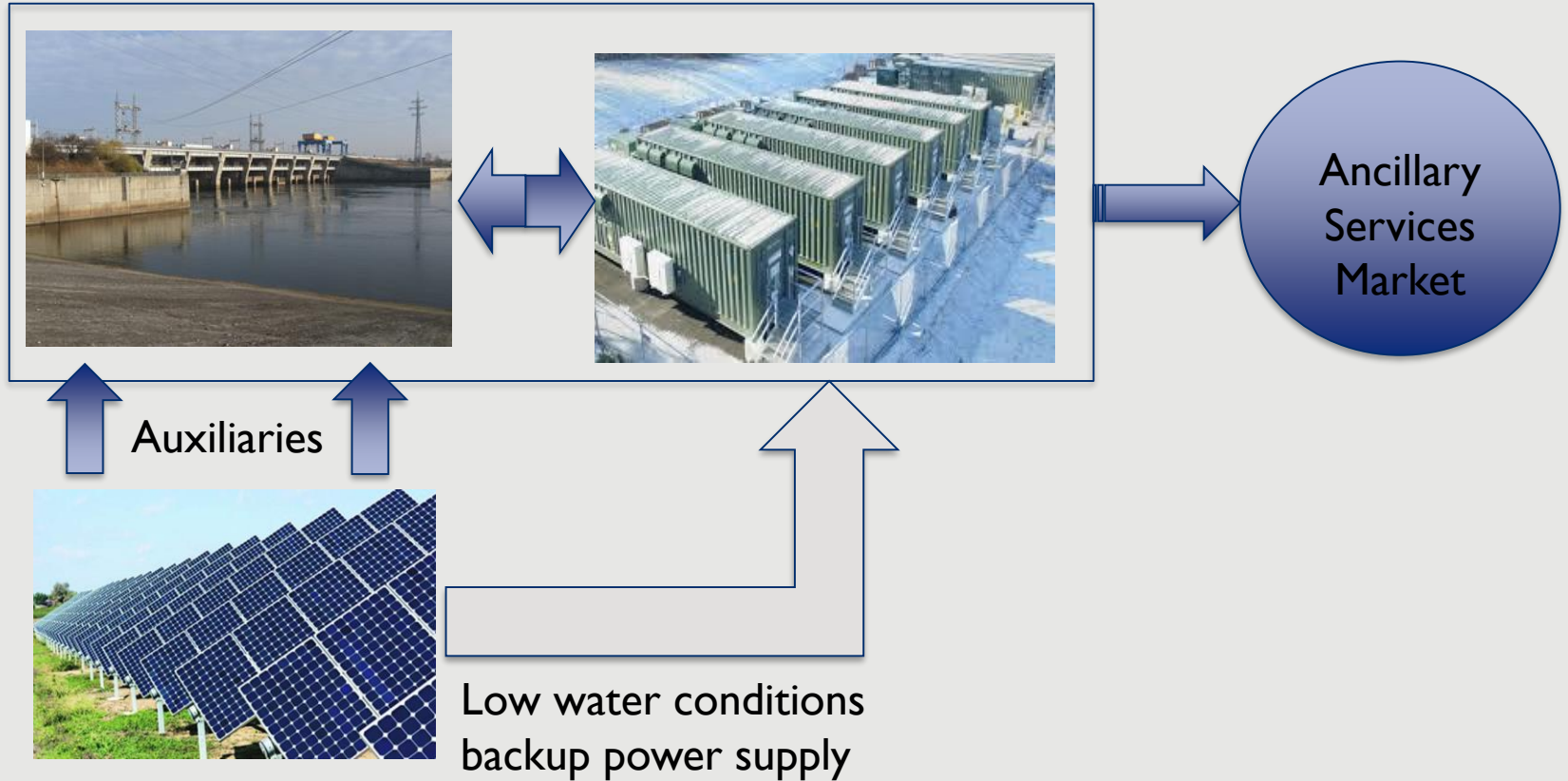
- Real-time system balance requires stability of voltage and frequency, with varying levels of frequency reserves being needed.
- Current amount of reserves are exceeding or will be met shortly as unit testing/certification continues.
- Ukraine has established an auction based ancillary services market, with price caps (to avoid excessive bids).

But if there are sufficient reserves in the system to meet flexibility requirements, then why storage?

Ancillary service provider	Reserve volume, MW*			
	FCR	aFRR	mFRR	RR
Required by TSO as per the Grid Code	±119	±372	628	1000
Currently Certified	±115	±724.5	3483	3900
Dnyprovska-1 HPP	0	183 (±91.5)	495	495
Serednyodniprovska HPP	0	178.8 (±89)	300	344
Kanivska HPP	0	144 (±72)	264	264
Kahovska HPP	0	197 (±98.5)	317	317
Dnyprovska-2 HPP	0	199 (±99.5)	479	479
Kremenchutska HPP	0	142 (±71)	542	645
Kyivska HPP	0	176 (±88)	336	336
Dnistrovska HPP	0	0	460	460
Kurahivska TPP	±88	230 (±115)	230	380
Kharkivska CHP	±27	0	60	180

* **FCR**: Frequency containment reserve
aFRR: Automatic frequency restoration reserve
mFRR: Manual frequency restoration reserve
RR: Replacement Reserve

Project concept focuses on Ukrhydroenergo



Project benefits

- Improvement in the range and quality of ancillary services.
- Support for the integration of renewable energy.
- Support for joining ENTSO-E.
- Reduction in Ukrhydroenergo maintenance costs and hydropower units' life extension.
- All sites examined and investigated on-site solar PV applications.
- Key is to support the nascent ancillary services market.



Project characteristics

Item	Unit	Kyiv	Kaniv	Kremen- chuk	Seredne- dniprovsk a	Total
Lithium ion storage capacity	MW	1 battery 46	3 batteries 22	1 battery 60	1 battery 25	197
Storage investments	Mil USD	33.4	47.6	43.3	18.4	142.6
Solar plant capacity	MW	10.6	13.5	6.5	5.3	35.9
Solar plant investments	Mln USD	7.8	9.2	4.5	3.7	24.7
Total	Mln USD	41	56	47	22	167

Storage project component – storage working in tandem with hydropower unit operation

Name	Unit	Kyiv	Kaniv	Kremenchuk	Seredno-dniprovska	Total
NPV	Mln USD	39	56	51	21	167
IRR	%	21.8%	21.9%	21.9%	21.6%	21.8%
Discounted payback	years	5.0	4.9	4.9	5.0	5.0

Storage plus solar energy

Name	Unit	Kyiv	Kaniv	Kremen- chuk	Seredno- dniprovska	Total
NPV	MIn USD	35.87	52.05	48.93	19.73	156.57
IRR	%	18.4%	18.8%	20.1%	18.5%	19.1%
Discounted payback	years	6.0	5.8	5.4	5.9	5.7

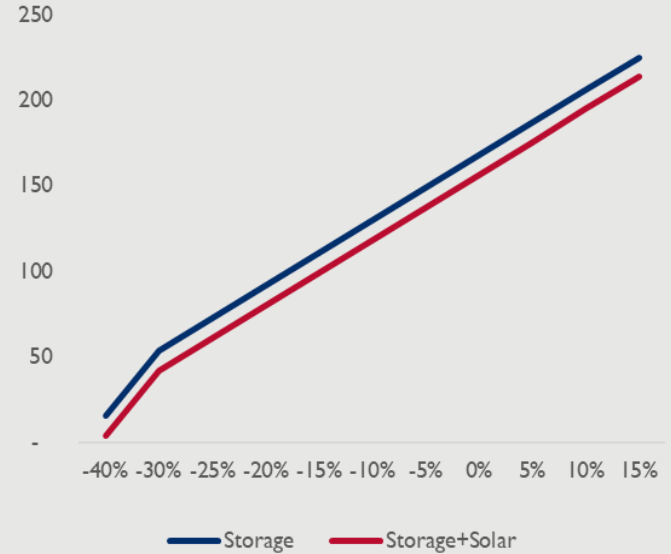
Example: Sensitivity to ancillary services pricing

STORAGE PROJECT COMPONENT

	NPV, mln.USD	IRR,%
	167	21.84%
-40%	14	9.34%
-30%	52	12.73%
-25%	72	14.34%
-20%	91	15.90%
-15%	110	17.43%
-10%	129	18.93%
-5%	148	20.40%
0%	167	21.84%
5%	186	23.26%
10%	205	24.67%
15%	224	26.06%

STORAGE+SOLAR PV PROJECT

	NPV, mln.USD	IRR,%
	157	19.05%
-40%	4	8.31%
-30%	42	11.22%
-25%	61	12.60%
-20%	80	13.95%
-15%	99	15.26%
-10%	118	16.55%
-5%	137	17.81%
0%	157	19.05%
5%	176	20.28%
10%	195	21.49%
15%	214	22.68%



This project is sensitive to ancillary services prices, a decrease in ancillary services prices more than 45 % will make the project financially unviable.

What is next?

- The World Bank has agreed in principle to finance at least one site installation but it aiming to expand to all five sites examined.
- Solar is probably in the project as well, located on each site per the request of Ukrhydroenergo management.

But at the same time, the TSO is also advocating for its own storage project, financed by the EBRD. A decision will need to be made one way or the other.... as the projects are competing.

Our view

Ukrhydroenergo project supports the ancillary services market and is a preferable way to go:

- It has better economics due to the interplay between the storage and the hydropower unit operations.
- A TSO standalone storage project will have poorer economics – e.g., using power from the balancing market (relatively high priced) combined with deeper draw downs.
- A TSO standalone project undercuts, not supports, the development of the ancillary services market.
- The TSO project will also be mostly immune from competitive pressure, with costs recouped through an administratively determined dispatch tariff.

THANK YOU!

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