ARMENIA RENEWABLE RESOURCES AND ENERGY EFFICIENCY FUND

R2E2

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Armenia Energy Storage Program
Energy Modeling and Economic/Financial Analyses

Ordered by:

WORLD BANK GROUP

Performed by:

Electricity Coordinating Center, Ltd.

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Armenia Renewable Resources and Energy Efficiency Fund

OBJECTIVE AND SCOPE OF THE PROJECT

The main objective: of this study is to analyse the requirements of the electricity system to ensure its reliable and smooth operation of storages with the integration of large-scale variable renewable energy sources (VRES).

Expected Outcome: The Government of Armenia will have access to technical and economic information to decide whether and how to move ahead with an energy storage Projects.

The main tasks:

Task 1 - Production modeling, generation dispatch and energy market analysis
Task 2 - Economic and Financial analysis for different business models
Task 3 – Legal Framework Analysis and Reforms Roadmap Development /underway/

BATTERY APPLICATIONS

The following Battery applications have been reviewed:

- Frequency regulation
- Voltage or reactive power support
- Load following or
- System peak shaving
- Arbitrage
- Storing wind and solar generation excess
- Backup power

SELECTED SCENARIOS AND ASSUMPTIONS

Three different Scenarios of possible future states of the Armenian power system have been assessed:

- Scenario 1: Referent Scenario
- Scenario 2: High VRES Scenario
- Scenario 3: High VRES Scenario without new Nuclear Power Plant

Proposed Battery storage variants have been considered:

- Scenario 1: 4 hour storage duration- 30 MW and 100 MW
- Scenario 2: 1 hour storage duration- 5 MW and 15 MW

POWER GENERATION DATA AND DEFINITION OF SCENARIOS AND STUDY APPROACH

Generation capacities in REFERENT & HIGH RES scenarios are presented in the tables

Referent Scenario

Type	Available capacity [MW] 2025	2030	2040
Thermal-gas	955	955	955
Nuclear	407.5	0	600
Hydro	1388	1458	1528
Wind	8	194	404
Solar	418	1031	1499
Total:	3177	3638	4519

High VRES Scenario

Type	Available capacity [MW] 2025	2030	2040
Thermal-gas	955	955	955
Nuclear	407.5	0	600 / 0 *
Hydro	1388	1458	1528
Wind	150	350	750
Solar	500	1250	1750
Total:	3401	4013	5583 / 4983

- (*) Scenario 3: without new Nuclear Power Plant

DEFINITION OF SCENARIOS AND STUDY APPROACH

- Interconnections of the Armenian power system with neighbors are assumed in line with strategic commitment of the Government to increase power exchanges with Georgia and Iran

- TWO different cases are analyzed:

- **CASE A** ➔ unlimited trade scenario which includes the following assumptions:
  - HVDC connection to Georgia with 350MW capacity
  - "Electricity for gas" program with Iran limited to 1,2 TWh annually but with flexible hourly profiles

- **CASE B** ➔ with limited trade opportunities:
  - No commercial exchanges with Georgia
  - "Electricity for gas" program with Iran limited to 1,2 TWh annually with fixed profiles

ECONOMIC ANALYSIS

Table: Economic analysis – NPV of different battery configurations

NPVe		Battery 30MW / 120MWh	Battery 100MW / 400MWh
REFERENCE Scenario	Case A - flexible exchanges with neighbours	-0.02 M$	-74 M$
	Case B - exchanges with neighbours as today	16 M$	2 M$
HIGH RES Scenario	Case A - flexible exchanges with neighbours	-9 M$	-54 M$
	Case B - exchanges with neighbours as today	11 M$	10 M$
HIGH RES Scenario, NO new nuclear unit in 2040	Case A - flexible exchanges with neighbours	-0.4 M$	-38 M$
	Case B - exchanges with neighbours as today	60 M$	91 M$

Table: Economic analysis – IRR of different battery configurations

IRRe		Battery 30MW / 120MWh	Battery 100MW / 400MWh
REFERENCE Scenario	Case A - flexible exchanges with neighbours	-2.1%	-7.2%
	Case B - exchanges with neighbours as today	12.1%	6.3%
HIGH RES Scenario	Case A - flexible exchanges with neighbours	0.92%	-2.4%
	Case B - exchanges with neighbours as today	10.8%	7.2%
HIGH RES Scenario, NO new nuclear unit in 2040	Case A - flexible exchanges with neighbours	5.8%	0.9%
	Case B - exchanges with neighbours as today	20.0%	13.9%

KEY MESSAGES

The Study analysed economic and financial viability for potential battery storage variants and identified an optimal battery storage use case. NPV and IRR were used to assess the economic and financial viability of the battery storage variants

In summary, the results of the economic analysis suggest that realization of the battery storage variant of 30MW/120 MWh brings sufficient monetised benefits to the Republic of Armenia and its society, and it is economically viable for the society and national economy to invest in its implementation.

The overall decision of implementing this battery option depends on Armenian interconnections with neighbours. Battery storages play a more important role in less flexible environment and in a more constrained system operation. These assumptions strongly affect its economic viability.
From financial perspective, again battery storage variant of 30MW/120 MWh shows best results.

CONCLUSIONS

- In Case B batteries could play a more important role with positive benefits. Both battery storage variants of 30MW and 100 MW show positive economic results regardless of the VRE levels.
- Bigger battery storage variant (100 MW) doesn’t necessarily mean better for the overall economic impact, a smaller battery (30MW) is more appropriate option for the Armenian system.
- For an investor-owned battery storage, a smaller battery storage variant (30MW) is financially viable for all analysed scenarios and cases.
- Batteries with a one-hour duration are too small to achieve any significant benefits from arbitrage and should be considered only as battery storage that can achieve benefits from ancillary and balancing services.

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THANK YOU

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