Ex post evaluation – Armenia

Sector: Electric power transmission and distribution (CRS code: 23630)
Project: Safeguarding energy transmission in the South Caucasus (Gyumri sub-station) (BMZ No.: 2007 66 253) *
Implementing agency: High Voltage Electrical Networks CJSV (HVEN)

Ex post evaluation report: 2019

		Project A (Planned)	Project A (Actual)
Investment costs (total)	EUR million	15.2	13.7
Counterpart contribution	EUR million	0.6	0.6
Funding (mixed financing)	EUR million	14.6	13.1

*) Random sample 2017

Summary: As part of the FC measure, a fundamental rehabilitation of the 220kV Gyumri 2 substation was carried out to eliminate a major weakness in the Armenian 220kV transmission network. The facility located in the north-west of the country was built in 1972, severely damaged by an earthquake in 1988, and restored only in a makeshift manner in 1992, which meant its safe and reliable operation was no longer guaranteed.

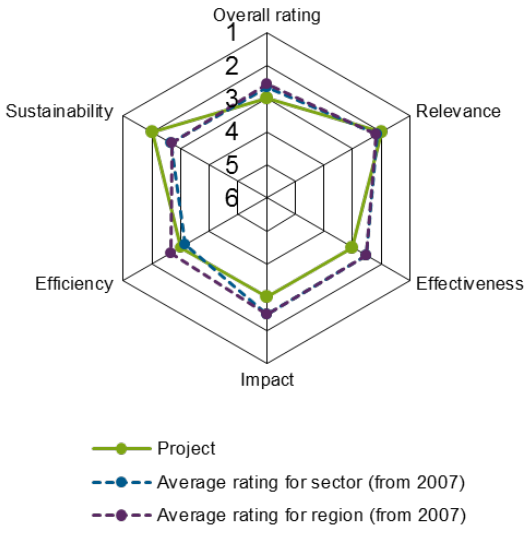
Objectives: Impact: The objective of the FC measure was to contribute to economic growth and to improving living conditions in Armenia as well as to environmental and climate protection. Outcome: The FC measure's aimed at contributing to a secure and reliable electricity supply in the Armenian transmission grid and the planned regional grid, as well as to increasing the efficiency of the transmission grid.

Target group: The FC measure's target group is primarily consumers connected to the grid in Armenia, in particular those living in the region around Gyumri. However, all the other users connected to Armenia's transmission grid benefit indirectly as well.

Overall rating: 3

Rationale: The facility is not utilised as much as expected, especially because the resumption of power exchange with Turkey did not go ahead as planned. This lowers both the effectiveness and the efficiency of the project because a smaller size of the installation would have been sufficient. Overall, however, the project contributes on a sustainable basis to the set objectives with regard to a safe and reliable power supply, as well as the associated economic opportunities and improved living conditions. The facility is in a very good condition.

Highlights: ./.



Rating according to DAC criteria

Overall rating: 3

Ratings:

Relevance	2
Effectiveness	3
Efficiency	3
Impact	3
Sustainability	2

Relevance

A lack of infrastructure in the energy sector has been and continues to be one of Armenia's greatest barriers to development, along with its isolation in foreign policy and a lack of transparency in many public structures.

In terms of the energy infrastructure needed for sustainable development, there were and still are shortcomings in the transmission system, as can be seen from various documents (e.g. Energy Governance in Armenia: Policy Recommendations; Energy Community Secretariat (EC); 31 July 2017)[1] and discussions with partners.

There were and still are sufficient generation capacities. Weaknesses exist in the distribution network (high losses and problems with voltage maintenance) as well as in the transmission network.

In the transmission grid (220kV), the Gyumri 2 substation is an important hub for supplying large parts of Armenia as part of the North-West Ring, and as the starting point for a 110kV transmission line to Georgia. At the time of the project appraisal (2008), the substation was not in a safe operating condition. The 220/110/10kV substation was built in 1972, severely damaged by a major earthquake in 1988, and only restored in a makeshift manner in 1992. The faulty condition led to high error rates and high maintenance costs. In addition, technical problems at the medium-voltage level had a direct and disruptive effect on the high-voltage level due to the lack of safety or protection equipment. Gyumri 2 was therefore in urgent need of a comprehensive rehabilitation, while the other substations had already undergone such work.

Armenia is a net exporter of electricity, partly due to the electricity-for-gas agreement (barter arrangement) with Iran (i.e. Armenia receives natural gas from Iran and returns part of this gas in the form of electricity). As a result of this and given the sufficient generation capacities (both at the time of the appraisal and to date), Armenia continues to give transmission infrastructure high priority.

The results chain rests on sound logic, since a secure and reliable electricity supply (outcome) is necessary for economic growth and for improving the living conditions of the population (impact). As expected, the substation, which was safe to operate after its rehabilitation (output), could rightly be expected to make an important contribution in this context to the Gyumri region and beyond (as a hub). It was correctly assumed that the FC-financed technical measures (input) could restore Gyumri 2 to a safe operating condition. It was clear that the reliability of the power supply would otherwise have been severely impaired due to the substation's lack of industrial safety.

The project is consistent with international development goals (SDG7: ensure access to affordable, reliable, sustainable and modern energy for all), the BMZ's sector concept for energy, and the definition of Financial Cooperation priorities with Armenia.

[1] https://www.energy-community.org/documents/reports.html

In short, we consider the project to be a relevant measure.

Relevance rating: 2

Effectiveness

The project objective (outcome) which has been adjusted slightly for the evaluation was to contribute to a secure and reliable electricity supply in the Armenian transmission grid – and the planned regional grid – as well as to the efficiency of the transmission grid.

The quantitative target indicators at the project appraisal were defined as follows:

(1) Unscheduled outages: reduction of power failures due to operational faults from over 14 hours p.a. at present [as at the appraisal] (220kV and 110kV levels combined) to no more than 5 hours p.a. after the rehabilitation

(2) Transmitted electrical energy: transmission of at least 300GWh/a (at the 220kV level) after completion

(3) Annual peak load: annual peak load of at least 70MW (at 220kV level) after completion

Increases in efficiency are classified as a secondary objective in the evaluation as these impacts are either indirect or likely to be small. This affects both increases in technical efficiency (reduced substation losses) and better efficiency with regard to operating costs.

Indicator	Target value	Actual value at EPE
(1) Unscheduled outages	< 5h/a	0.3h (since start of operation, Feb. 2014)
(2) Transmitted electrical energy	> 300 GWh/a	2014: 252 GWh; 2015: 272 GWh; 2016: 258 GWh 2017: 289 GWh
(3) Annual peak load	> 70 MW	2014: 42 MW; 2015: 55 MW; 2016: 50 MW 2017: 70 MW

Indicator (1) was exceeded, which reflects the faultless condition of the facility and the professional impression made by the operating and maintenance personnel.

Indicators (2) and (3) were not achieved andboth (positively correlated) indicators reveal a lower-than-expected load factor (though the peak load increased significantly in 2017). Relatively conservative target values were applied here. Intensive discussions on the causes revealed the following:

- Progress in energy efficiency – both on the part of industry and private households – meant the expectation of electricity demand growing by around 4% p.a. was adjusted to around 2% p.a. at the time of the appraisal.
- The load factor depends among other things on how the transmission grid works: if Gyumri 2 and other parts of the north-western Armenian transmission grid operate synchronously with the Georgian transmission system, the load is lower due to the changed load flows than in the scenario where only the Armenian network is in operation. In recent years, the first scenario (where the Georgian transmission grid is connected) has occurred relatively frequently due to the abundance of run-of-river power plants in Georgia.

- In addition, the load factor also depends on whether the Mezamor nuclear power plant (NPP) is in operation. The assumption at the time of the appraisal was that the NPP would be decommissioned by 2016. However, Mezamor's operating duration was extended until 2027, despite the risk of earthquakes and the outdated technology. According to official information a new reactor is expected to be built by this time, but this can be called into question given the inefficiency of nuclear power generation (in terms of full costs, i.e. if capital costs are included). When the NPP is in operation, the substation load is much lower than when the NPP is out of operation and the load flows change because of the added gas power in the north.
- Last but not least, the load would be significantly higher if the transmission line to Kars (Turkey) was back in operation, as assumed at the time of the project appraisal. An external risk (deterioration of political relations) came into play here.

The assumptions made at the appraisal that the transmission line to Turkey would be put into operation and that the Mezamor NPP would be shut down did not materialise, which reduced the load factor. Nevertheless, the rehabilitation of the substation clearly contributed to a safer and more reliable power supply in Armenia by significantly reducing outages, and is beneficial for the exchange of electricity with Georgia.

In short, the outcome was not as good as expected at the time of the evaluation owing to the lower load (indicators partially missed), but this was generally outweighed by the positive results. We therefore rate the effectiveness of the measure as satisfactory.

Effectiveness rating: 3

Efficiency

From an economic perspective, it is notable that the executing agency, HVEN, is entitled to a cost-covering grid usage fee, which is adjusted annually by the regulatory authority and also includes the necessary capital costs (for depreciation and financing) and thus maintenance costs as well. As a result, the project executing agency is not dependent on direct subsidies from the Armenian state budget and price signals (in terms of allocation efficiency) are not distorted in this respect. Nevertheless, the grid fees would be higher without concessional financing from FC and other donors. The tariff for using the transmission grid is currently 1.8524 AMD/kWh (equivalent to around 0.32 EUR/kWh).

The situation is more nuanced, however, in terms of production efficiency.

On the one hand, the properly estimated project costs (EUR 15.2 million) were EUR 1.4 million lower amid a rather competitive environment (total costs: EUR 13.8 million). The residual funds are used for working capital. As expected, the operating and maintenance costs within HVEN were also reduced as a result of the rehabilitation.

On the other hand, it became apparent that the facility is underutilised (see Effectiveness). From today's perspective, structuring the capacity of the two transformers with 63MVA each (instead of 125MVA each) would have been sufficient for the foreseeable future – and in the event of a future increase in load, it would also have been possible to subsequently raise the capacity (by replacing the transformers). This view was confirmed by HVEN based on the current environment and conditions. This leaner and more cost-effective design, compared to the one with 2x125MVA, would also be able to guarantee a redundant operating framework (supply reliability). Both 63MVA and 125MVA transformers are common standard sizes in HVEN substations. According to current estimates, the cost difference between the two design versions – taking both transformers into account – amounts to around EUR 1.2 million based on the total costs of the general contractor for planning, procurement and construction. The construction measures at the 110kV level were subject to certain implementation delays, but these did not impair the efficiency of the project to any significant extent.

In short, despite the not insignificant flaws of the overly large design, the efficiency is deemed satisfactory because the positive arguments again outweigh the negative factors. The efficient operation of the facility and the measure's beneficial cost situation (the partial rehabilitation and partial new construction are less expensive than a completely new construction) have improved supply security in the Armenian grid.

Efficiency rating: 3

Impact

The overarching developmental objective of the measure was to contribute to economic growth and to improving living conditions in Armenia, as well as to environmental and climate protection.

Having a safe and reliable electricity supply (outcome) is a necessary condition for economic growth and for improving the living conditions of the population (impact). Since a substation is only part of a larger network and the effects of the facility cannot be geolocalised (or are too small to have a measurable impact on the economy of the whole country), the contribution of the measure to economic growth or improved living conditions cannot be quantified either. Consequently, from an evaluation perspective, it is acceptable that no indicators were established to gauge the measure's contribution to economic growth and living conditions.

The city of Gyumri was an industrial centre in Soviet times, but it collapsed in large part following the strong earthquake in 1988 and the fall of the Soviet Union. High emigration followed, while unemployment remains high. This means that a more secure electricity supply cannot compensate for the structural weaknesses of the region as a whole (nor can this necessarily be expected).

However, anecdotal evidence for the energy supply shows that an improved energy supply exerts a positive influence on the city's location factors. As part of the evaluation, the KfW delegation interviewed two small and medium-sized enterprises in the city of Gyumri. Their consistent statements revealed that power outages are not very frequent (three to four times a year) and generally do not last long, while reliability and voltage quality have tended to improve in recent years. The residual shortcomings in the electricity supply are due to the distribution network (see above), and a (sharp) increase in supply problems together with adverse effects for the regional economy would have been on the cards without the fundamental rehabilitation of Gyumri 2.

Furthermore, the substation is also important for the whole country and the exchange with Georgia due to its position within the network topography, which means positive effects can be assumed for the entire country. Even if the gross domestic product and the Human Development Index for Armenia only exhibit a slight improvement since the project appraisal in 2008 (due to the crisis year of 2009),[2] we can assume that a deterioration in the energy supply situation would have triggered further problems. Economic growth over the past 15 years has been clearly positive overall. However, it must also be assumed that the hypothesized effects on economic growth would have been greater had the utilisation of the facility been greater.

The climate impacts of the measure are very limited. On the one hand, the limited efficiency gains do not bring any significant greenhouse gas reductions (also see Effectiveness section). On the other hand, the electricity exports to Turkey that were assumed at the time of the appraisal (Turkey had a considerably worse, i.e. higher, emission factor at the time) are not taking place. The environmental impacts essentially relate to the lower local environmental risks (correct handling and disposal of transformer oil and insulating oil for the switchboard plant). So far there have been no problems with SF6 refills (insulating gas for the new equipment) or with transformer oil or insulating oil (old equipment).

To sum up, the achievement of the impact targets falls slightly below expectations due to the absence of the electricity exports to Turkey. Nevertheless, the overarching developmental impact of the project is satisfactory.

Impact rating: 3

Sustainability

As mentioned above, the executing agency, HVEN, receives a grid usage fee that is adjusted annually and also includes the necessary capital costs (for depreciation and financing). Due to the (cost-based) revenue regulation approach, the fact that grid usage falls short of expectations does not result in lasting revenue losses, as any excesses or shortfalls in revenues are offset across periods.

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[2] GDP 2008: USD 10.55 billion 2017: USD 12.36 billion (both constant USD from 2010)
HDI 2008: 0.725 2015: 0.743 (rank: 84th)

The executing agency has sufficient working capital and spare parts as well as enough skilled personnel to ensure proper operations; the working capital was also supplemented by the allocation of residual funds.

All in all, the entire facility – both the new and the rehabilitated parts – was in a perfect technical condition. However, not all the recommendations of the final review were implemented. More time is needed to dispose of old dismantled high-voltage equipment because HVEN, as a public company, is prohibited in principle from disposing of assets that are not fully written off. In addition, no firewall was erected between the new AT2 transformer and the control building (distance of around 21 metres) because this is not required under Armenian law (Technical Regulations § 85 II) given that the distance is greater than 18 metres, and HVEN, as a public company, is required to avoid unnecessary expenditure. This is understandable and technically acceptable to the extent that it does not endanger the sustainable operation of the facility. All other recommendations were implemented. There is an increased risk of earthquakes, but this was taken into account in the design of the substation.

To sum up, we can assume that proper operations are ensured in the long term and that the contribution to development will therefore continue.

Sustainability rating: 2

Notes on the methods used to evaluate project success (project rating)

Projects (and programmes) are evaluated on a six-point scale, the criteria being **relevance, effectiveness, efficiency** and **overarching developmental impact**. The ratings are also used to arrive at a **final assessment** of a project's overall developmental efficacy. The scale is as follows:

Level 1	Very good result that clearly exceeds expectations
Level 2	Good result, fully in line with expectations and without any significant shortcomings
Level 3	Satisfactory result – project falls short of expectations but the positive results dominate
Level 4	Unsatisfactory result – significantly below expectations, with negative results dominating despite discernible positive results
Level 5	Clearly inadequate result – despite some positive partial results, the negative results clearly dominate
Level 6	The project has no impact or the situation has actually deteriorated

Rating levels 1-3 denote a positive assessment or successful project while rating levels 4-6 denote a negative assessment.

Sustainability is evaluated according to the following four-point scale:

Sustainability level 1 (very good sustainability): The developmental efficacy of the project (positive to date) is very likely to continue undiminished or even increase.

Sustainability level 2 (good sustainability): The developmental efficacy of the project (positive to date) is very likely to decline only minimally but remain positive overall. (This is what can normally be expected).

Sustainability level 3 (satisfactory sustainability): The developmental efficacy of the project (positive to date) is very likely to decline significantly but remain positive overall. This rating is also assigned if the sustainability of a project is considered inadequate up to the time of the ex post evaluation but is very likely to evolve positively so that the project will ultimately achieve positive developmental efficacy.

Sustainability level 4 (inadequate sustainability): The developmental efficacy of the project is inadequate up to the time of the ex post evaluation and is very unlikely to improve. This rating is also assigned if the sustainability that has been positively evaluated to date is very likely to deteriorate severely and no longer meet the level 3 criteria.

The **overall rating** on the six-point scale is compiled from a weighting of all five individual criteria as appropriate to the project in question. Rating levels 1-3 of the overall rating denote a "successful" project while rating levels 4-6 denote an "unsuccessful" project. It should be noted that a project can generally be considered developmentally "successful" only if the achievement of the project objective ("effectiveness"), the impact on the overall objective ("overarching developmental impact") and the sustainability are rated at least "satisfactory" (level 3).