

3.1 Thermal Power Generation

3.1.1 Assessment of Existing Capacity

The total operational nameplate capacity of the thermal electric generating units in Armenia excluding Vanadzor is about 1,690 MW. The major thermal power stations are Hrazdan (1110 MW, 8 Units) and Yerevan (580 MW, 7 Units). There are also several small industrial co-generation units. Much of the thermal generating capacity in Armenia has deteriorated due to lack of maintenance or abuse. A significant amount of the capacity is still operational or can be rehabilitated. Rehabilitation of existing generating units is more cost effective in the short term than investment in new units.

All of the thermal power plants are configured to burn natural gas as the primary fuel, with mazut as backup fuel. In the last several years, these units were operating using natural gas only, with the supply of gas restored. A general description of the existing power plants is presented in Table 1.

Table 1 – Existing Thermal Generating Units				
Unit	Gross Nameplate Rated Capacity MW	Fuel	Start-up Year	Status
Hrazdan TPP				
Hrazdan 1	200	Gas, Mazut	1971	In Operation
Hrazdan 2	200	Gas, Mazut	1971	In Operation
Hrazdan 3	200	Gas, Mazut	1972	In Operation
Hrazdan 4	210	Gas, Mazut	1974	In Operation
Hrazdan 5	300	Gas, Mazut	--	<i>Under Construction</i>
Hrazdan CHP 1	50	Gas, Mazut	1966	In Operation
Hrazdan CHP 2	50	Gas, Mazut	1967	In Operation, Minimal/No Operation
Hrazdan CHP 3	100	Gas, Mazut	1969	In Operation
Hrazdan CHP 4	100	Gas, Mazut	1969	In Operation, Minimal/No Operation
Yerevan TPP				
Yerevan CHP 1	65	Gas, Mazut	1963	In Operation
Yerevan CHP 2	65	Gas, Mazut	1963	In Operation, Minimal/No Operation
Yerevan CHP 3	60	Gas, Mazut	--	<i>Decommissioned</i>
Yerevan CHP 4	65	Gas, Mazut	1964	In Operation, Minimal/No Operation
Yerevan CHP 5	65	Gas, Mazut	1966	In Operation
Yerevan 6	160	Gas, Mazut	1965	In Operation
Yerevan 7	160	Gas, Mazut	1966	In Operation
Total Operational w/o Vanadzor TPP	1,690			

Table 1 – Existing Thermal Generating Units (continued)				
Unit	Gross Nameplate Rated Capacity MW	Fuel	Start-up Year	Status
Vanadzor TPP¹				
Vanadzor CHP 1	12	Gas, Mazut	1964	Private
Vanadzor CHP	12	Gas, Mazut	1965	Private
Vanadzor CHP	25	Gas, Mazut	1970	Private
Vanadzor CHP	47	Gas, Mazut	1976	Private
Total	2,146			

Many of the thermal units in Armenia are among the oldest in the former Soviet Union, with more than half of the units over thirty years of age. The 300 MW Hrazdan Unit 5, the newest unit in the system, has been in construction since the end of 1980s. Based on estimates by others, the unit is about 70% complete. The pause in construction comes from lack of finance and underestimation of the initial cost (unit was partially financed by the EBRD loan). Current completion and start-up schedules are unclear at this time. Proposed completion/refurbishment proposals are discussed later in this section of the Report.

According to local and international technical experts and plant operational staff, during the past several years the condition of Armenia’s thermal power plants has deteriorated significantly due to aging equipment and lack of funds for maintenance and repairs. The units that have been frequently operated and have been dispatched at loads that are substantially higher (or substantially lower) than their recommended maximum (minimum) levels, and at times when they should have been shut down for maintenance. This has placed additional stress on the equipment.

Hrazdan Thermal Electric Power Plant

The Hrazdan Thermal Electric Power Plant is the largest thermal plant in Armenia. Base load power is presently produced by all four (4) condensing units, with average operational capacity of about 160 MW each, and district heating/industrial steam requirements are supported by smaller 50 MW CHP Unit No. 1. Brief operational history for the power plant is provided below.

¹ Vanadzor TPP was privatized in 1999. The Owner does not have any plans to supply energy to the national grid before 2010. Rehabilitation plans for this plant are not within the framework of this study.

Section/Unit	Since Start till 1/1/98	1998	1999 (as of 9/1)
Operating Hours			
Condensing Side (Block Section)			
Unit 1	153,443	3,197	2,211
Unit 2	147,864	1,833	1,162
Unit 3	141,295	5,176	2,625
Unit 4	151,923	4,378	1,265
CHP Side (Common Header Section, Turbines)			
Turbine 1	195,533	4,007	2,749
Turbine 2	177,871	51	0
Turbine 3	126,714	669	375
Turbine 4	126,264	28	0

Source: Ministry of Energy

Yerevan Thermal Power Plant

This power plant, the oldest of the thermal power plants, consists of two (2) large condensing units and five relatively small CHP units. It was originally designed to provide heat and electricity to Yerevan and surrounding areas and was supplemented by two condensing units later. One 60 MW unit No. 3 is a backpressure turbine and presently preserved and inoperable.

All other units, except for CHP Unit 3, are in poor, but operable condition. Certain amount of investment, within the framework of regular maintenance and major overhauls, is required to sustain normal operation. Brief operational history is described below:

Section/Unit	Since Start till 1/1/98	1998	1999 (as of 9/1)
Operating Hours			
CHP Side (Common Header Section, Turbines)			
Turbine 1	183,648	1,486	1,800
Turbine 2	177,331	0	0
Turbine 3	195,126	Decommissioned	
Turbine 4	180,770	0	16
Turbine 5	156,353	6,109	4,020
Condensing Side (Block Section)			
Unit 6	149,503	837	66
Unit 7	144,885	1,709	282

Source: Ministry of Energy

The following table presents the capital investment requirements for “general” or balance of plant category for Hrazdan and Yerevan TPPs. They are not tied to a specific unit or system but rather to the whole plant. Power plant personnel and MoE primarily identified these

requirements. These activities are not classified as “urgent” but, the very important for normal operation of the facilities in short and long term.

Thermal Plants Rehabilitation Budget (\$US Y2000)

Plant/Category	2000	2001	2002	2003	2004
Hrazdan TPP/Block Units 3 Cooling Towers Refurbishment		6.8		6.6	6.6
Yerevan TPP/ 2 Cooling Towers Refurbishment		0.4	0.4		

Source: TPPs estimates

The remaining part of the required investment needs is classified in specific projects listed in Section 3.1.2 or contained in Fixed O&M budgets for specific units.

3.1.2 Specific Potential Rehabilitation and Re-powering Projects

Several possible projects have been identified for rehabilitation and/or re-powering of units at the Hrazdan and Yerevan TPPs. These projects would restore or increase generating capacity and improve operating efficiency. Additional information for these proposed projects can be found in Section 8. Table 3 below lists the summary estimates of capital costs for proposed rehabilitation.

Unit	Gross Capacity before Rehabilitation (MW)	Gross Capacity after Rehabilitation (MW)	Useful Life after rehabilitation, yr.	Unit Cost, \$/kW (MS2000)
Hrazdan Block Unit 5 Completion/Repowering	300	440	30	\$284.2
Hrazdan Block Unit 4 Repowering	210	280	20	\$115.4
Hrazdan Block Units 1-3 Refurbishment	3x200	3x200	10	\$3.4

Hrazdan Thermal Electric Power Plant

Several possible projects were identified for Hrazdan TPP. One of the major uncertainties for this TPP is related to the unclear future of the steam consumption in the region. Currently, only one 50 MW CHP unit is being operated to supply steam to the Hrazdan city District Heating (DH) grid and for power plant self-consumption. Available steam production at the power plant is about 6 times higher than current utilization levels. CHP technology cannot be economically

used for electricity-only generation. No significant increase in DH steam demand from the current 65,000 Gcal/yr is expected for Hrazdan Region.

Hrazdan Block Units 1-3 Refurbishment

One of the proposed projects includes the permanent shut-down (with possible dismantling for spare parts) of the CHP part of the power plant and consecutive refurbishment of the three 200 MW turbines to provide about 50 Gcal/hour/turbine of low pressure 1.2 atm steam for district heating needs to the new collector system. No in-depth study is available on this option as of yet. However, similar projects were already successfully implemented in several NIS countries and technologically this process is feasible. A major equipment manufacturer has preliminarily concurred with the feasibility of this refurbishment.

The power plant prepared a preliminary estimate for this option that includes partial utilization of the CHP plant equipment and new equipment available at the power plant (in storage) right now. Total capital cost is estimated at \$1.2 million. Since this project was not evaluated in detail, the preliminary budget should be increased to about \$2 million (to include about a 40% contingency). A major benefit of this project can be found in the reduction of O&M expenses for the CHP part, which is about 30-35% of the total Hrazdan TPP O&M budget right now with a very short payback. The project can also have a potential negative social impact, as its organization will need to be restructured and many of its 300 employees would most likely be laid off in any new organization.

This alternative assumes gradual shut-down of CHP Plant. A proposed schedule is as follows: CHP Units 2 and 3 are shut down in 2001 and CHP Units 1 and 4 are shut down in 2002. This option is included in the screening analysis and optimization model cycle.

Hrazdan Block Unit 4 Re-powering

Another possible project at the Hrazdan TPP includes the repowering of the largest operating thermal 210 MW Unit 4 into the combined heat and power plant with a complete fuel re-burn scheme. This option was preliminary evaluated by the power plant and brief assessment report that [1] is currently available. This option was partially evaluated in a previous planning effort [2] and found to be inefficient primarily due to the age of the existing unit.

Active discussions are taking place right now on the technical feasibility of this option, in which several major Western manufacturers may be potentially interested. According to the currently proposed configuration the plant will have steam supply capabilities at 16 atm and 410° C. Major technological improvement for the repowering will include the installation of 70 MW gas turbines, which would yield an estimated heat rate improvement of about 18%. Overall capital investment for this project is estimated at \$32.3 million. The mode of operation for the unit is assumed to be mid to base-loading. This option is included in the screening analysis and

optimization model cycle, but given the current age of Unit 4, the re-powering option will not be available for implementation after 2005.

Hrazdan Block Unit 5 Completion/Re-powering

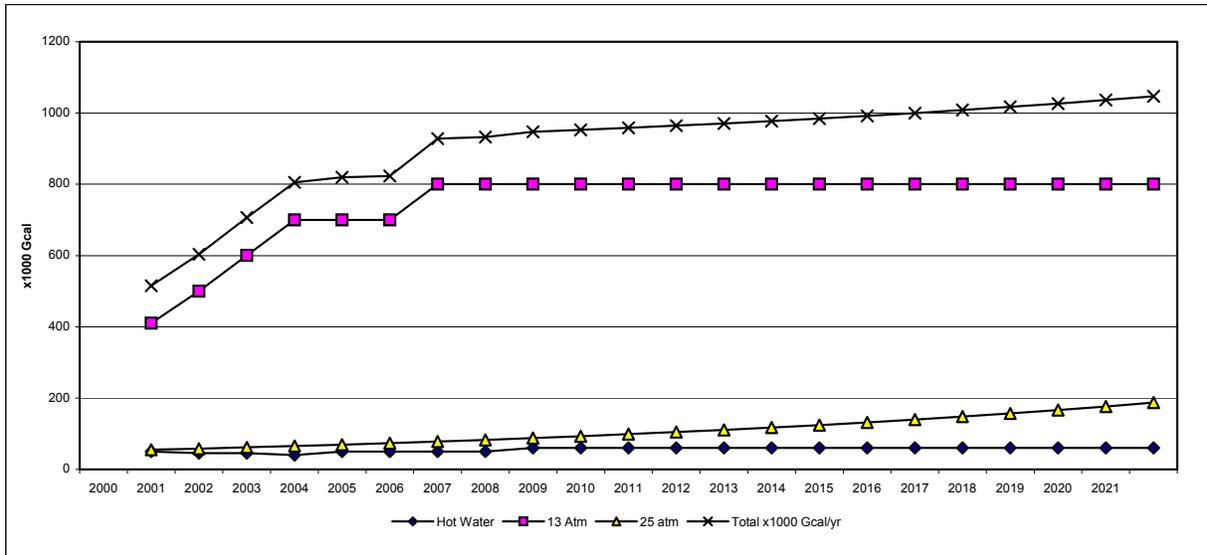
An approach similar to the one above is also proposed for as yet not completed Unit 5. Since the probability of this unit's being completed as originally designed for 300 MW is very uncertain, MoE and other relevant organizations are considering various options, of which the most promising is the completion of this unit and repowering it to a combined cycle. As with Unit 4, a brief assessment [1] has been prepared by Hrazdan TPP specialists and MoE and is available.

Technically, the option is feasible and is currently being implemented at several sites in Russia. The proposed repowering will include the installation of two (2) 70 MW gas turbines. The mode of operation for a repowered unit would not significantly change from currently intended mid-base loading. Unit 5 was designed to the supercritical steam parameters and has efficiencies that are 14% better than Units 1-4. The proposed repowering to combined cycle will reduce that unit's heat rate by about 17% more. Its budget is about \$125 million. This option is included in the screening analysis and optimization model cycle discussed in Section 8 of this Report.

Yerevan Thermal Power Plant

As previously mentioned, the future of district heating in Yerevan is very unclear. Yerevan TPP has a significant steam production capabilities. The following steam demand forecast is proposed for Yerevan area, which is primarily based on the Ministry of Industry steam forecast. The 25 atm steam category was corrected to reflect industrial steam projections assumed for industrial sector development.

Yerevan Region Steam Demand Forecast



Ref: Hot Water and 13 atm steam – Ministry of Energy, 25 atm steam – proposed.

Based on numerous discussions with MoE and Yerevan TPP management, and since the generation of electric energy only at CHP units cannot be accepted as economical, the approach below is proposed.

Existing Yerevan CHP Units

Based on current and forecasted steam demand, only 2 CHP units are required to support Yerevan industrial and DH load, one in operation and one for back-up. Taking into account the proposed growth in steam demand, the remaining 2 units will be available for economic decommissioning in 2001 and can be used for spare parts. A newly proposed 82 MW Co-Generation Combined Cycle is evaluated in the screening analysis and included in optimization options in Section 8.

Yerevan Block Units 6 and 7

Condensing Units 6 and 7 are in relatively poor shape but capable of operating with regular O&M for some time. No capital investment for life extension in addition to major overhauls is proposed for these units. With current level of operation, the physical resource should be depleted in about 10 years. The units are scheduled for decommissioning based on the optimal system configuration. The modeling program is given the option to retire these units during least-cost system optimization starting 2001.

References:

- [1] Feasibility Assessment Report: *Refurbishment of K-300 and K-210 Units at the Hrazdan TPP with Gas Turbines*, MoE, 1999
- [2] Final Report: *1996 Update of Least Cost Power Investment Program*, Lahmeyer International, 1996