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ENERGY, ENVIRONMENT & TECHNOLOGY, and
BUREAU OF RESEARCH & DEVELOPMENT, OFFICE OF ENERGY &
INFRASTRUCTURE

HRAZDAN POWER PLANT - UNIT NO. 5

PRE-LOAN ASSESSMENT REVIEW

FINAL REPORT

FOR

REPUBLIC OF ARMENIA

MINISTRY OF ENERGY and FUEL

DECEMBER 9, 1992
ADDENDUM NO. 1

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1.0 SUMMARY

1.1 BACKGROUND

The Republic of Armenia is suffering from a serious electricity supply-demand gap affecting all aspects of their economy. Only a few years ago installed electricity generating capacity was 3,500 MWe and Armenia exported electricity. Current generating capacity has been reduced by 1,700 MWe due to the shutdown of Armenia's nuclear power plant (850 MWe) and several hydropower plants (550 MWe), derating of aging plants, and uncertain fuel supplies. The nuclear plant was shutdown for safety reasons related to seismic concerns. The shutdown hydro capacity is the result of a severe drop in the water level of Lake Sevan, Armenia's main water resource. This hydro capacity is used only in extreme circumstances. Lack of funds limits Armenia's ability to maintain existing plants. Armenia imports most of its primary fuel and current supplies are tenuous due to the conflict with Azerbaijan and political instability in Georgia.

The Ministry of Fuel and Energy (MEF) estimates that Armenia needs approximately 2,600 MWe just to maintain the economy as it existed under the former Soviet Union. Today, only 1,200 MWe on average are available. This shortfall has affected every citizen:

- Rolling electric power blackouts or electricity service fifty percent of the time;
- Reduction of industrial production capacity by fifty percent;
- Extremely high unemployment (23 percent); and,
- Prospects for sufficient heat for the 1992-93 winter season are bleak.

A major element of the solution to this critical economic development constraint is the completion and operation of Unit No. 5 at the Hrazdan Power Plant. Construction of Unit No. 5

was initiated in 1988 while Armenia was part of the Soviet Union and it is approximately 25 percent complete.

The Hrazdan Power Plant has an installed capacity of 1,100 MWe and is Armenia's main base-load power plant. Unit No. 5 has a design capacity of 300 MWe and is part of an expansion program which includes three additional, identical units (Unit Nos. 6, 7, and 8). The primary design fuel for Hrazdan and its future extensions is natural gas with heavy oil as a supplemental fuel.

The Republic of Armenia has requested a loan from the European Bank for Reconstruction and Development (EBRD) for funds to complete Unit No. 5. Before EBRD can make a decision on this loan request, an assessment of the present situation is required. EBRD also requires a cost estimate and schedule for Unit No. 5 completion with due consideration given to environmental protection and energy efficiency.

Construction and operation of Unit No. 5 is the responsibility of the MEF. This is the MEF's first power project to consider international financing. The MEF, recognizing EBRD loan requirements, requested the services of an international consultant to advise them on the completion and operation of Unit No. 5. As a result, the MEF and EBRD requested the United States Agency for International Development (USAID) to sponsor the pre-loan activities related to Unit No.5. USAID's New Independent States Task Force (NIS/TF), under its Energy Efficiency and Market Reform Project, provided the required funding. The work was performed by USAID Bureau for Research and Development's Office of Energy and Infrastructure (R&D/EI), through the Energy Technology Innovation Project (ETIP).

1.2 OBJECTIVES

Primary project objectives were to support the MEF in assessing the status of the design and construction of Unit No. 5 and identifying actions, costs, and time requirements for its completion. A

secondary objective was to identify innovative practices, procedures, and equipment which have not been previously available in Armenia and are expected to affect: 1) equipment design in order to improve energy efficiency; 2) procurement practices including the introduction of competitive processes; 3) project management; 4) power station operation; and, 5) environmental considerations.

1.3 EBRD REQUIREMENTS

EBRD procurement and environmental policies are essential to loan approval. To make a decision on the Hrazdan Unit No. 5 loan application, EBRD required the following: 1) clear assessment of the status of the project including Unit No. 5 completion status; 2) credible cost estimate and schedule for the completion of the project; 3) assessment of selected environmental, health, and safety and site environmental liability topics; and, 4) determination of equipment and services contracts that can be competitively bid.

1.4 PRE-LOAN ASSESSMENT SUPPORT APPROACH

The NIS/TF realized that this effort needed to take place as quickly as possible to meet MEF's completion schedule for Hrazdan Unit No. 5 before the winter of 1994-5; and, to support EBRD's loan processing schedule.

Consequently, two teams, In-Country and Energy Efficiency, were organized and mobilized within one week after the notice to proceed and a preliminary workplan and schedule were developed. The two teams worked in parallel to meet the schedule needs of the MEF and EBRD. Composition of these teams were:

In-Country: ETIP Manager/Power Engineer
Project Manager/Environmental Specialist
Financial/Procurement Specialist
Economist/Cost Estimator

Information Specialist/Scheduler
Energy Utilization/Construction Engineers

Energy Efficiency:

Power Engineer
Mechanical Engineer
Electrical Engineer
Economist/Cost Estimator

The in-country team required approximately 20 personweeks in Armenia to conduct a plant and site visit, to walkdown and photograph the existing units 1-4 as well as Unit No. 5, to collect and assess data and to confer with NIS/TF, USAID/Yerevan, R&D/EI, MEF, Hrazdan Power Plant staff, plant construction contractors, and EBRD management and staff. During the last week of ETIP's assessment in Armenia, EBRD sent a loan appraisal team to meet with the MEF. ETIP was requested by the MEF to support them during their discussions with the EBRD team. In addition, ETIP responded to several EBRD requests for information. The ETIP in-country team also provided numerous design details and drawings of Unit No. 5 to the energy efficiency team to facilitate their assessment. Over 50 individuals in Armenia were interviewed and over 200 documents were reviewed during the pre-loan assessment.

An important consideration in supporting the assessment was the remnants of past Soviet Union "commercial" practices used under a centrally planned and managed economy. In particular, the NIS/TF not only needed to support the MEF in determining the overall status of Hrazdan Unit No. 5, but also to address EBRD procurement and environmental policies. In the former Soviet Union a central organization was responsible for matters such as determining appropriate power plant equipment manufacturers and ensuring equipment delivery and quality. Current NIS practice appears to be that the manufacturer determines the conditions of sale, including price and schedule. Moreover, pricing, as it might be expected in highly inflationary times, is subject to increases. Exacerbating the procurement process is a legal system which is in transition.

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The legal system that is currently in place appears to be overloaded making orderly and timely legal claims an issue that will not be resolved soon.

1.5 UNIT NO. 5 CURRENT COMPLETION STATUS

1.5.1 Equipment

The majority of equipment required for Unit No. 5 has been delivered or is scheduled for delivery by the first quarter 1993. The boiler, turbine, generator (less stator), condenser, fans, overhead cranes, most pumps, low-pressure feedwater heaters, and a reasonable percentage of bulk materials are at Hrazdan. High-pressure feedwater heaters, ductwork, and generator stator are completed and delivery is expected by December 1992. The main transformer is scheduled to be manufactured within six months after the manufacturer receives a progress payment for the purchase of fabrication materials. Purchase contracts for cable and accumulator batteries need to be placed.

1.5.2 Construction

Plant. The level of Unit No. 5 construction activity has been reduced due to lack of funds, but is estimated to be 25 percent complete. Appendix C provides photographs of existing plant conditions. Excavation and foundation work for the major buildings is essentially complete. Boiler building exterior walls are nearing completion. Erection of structural steel for the boiler is in progress. The machine hall turbine building exterior is approximately 75 percent complete. Installation of the turbine generator pedestals is in progress. A three story laboratory building is partially framed. A cooling tower maintenance shop is approximately 75 percent complete. Switchyard control building is approximately 50 percent complete. The exterior shell of cooling tower is complete to the 110 meter elevation. Final design height of cooling tower is 160 meters. The stack is erected; steel liner and warning lights need to be installed. Most current construction

activity is focused on enclosing the boiler building so that work can continue through the 1992-93 winter months.

Transmission Line. Design and routing are complete for the 71 kilometer high-voltage transmission line from Hrazdan to Yerevan. Easements have been obtained. Five towers and supports of the required 248 are installed. Eight hundred and thirty-six tons of the required 2,530 tons of galvanized steel have been received. One hundred tons of the required 660 tons of aluminum wire have been received. Manufacturers for the galvanized steel and aluminum wire are Plant of High Voltage Towers, Ukraine, and Kirsk Cable, Russia, respectively. All materials except concrete are expected to be of foreign supply.

Equipment contracts are placed and delivery is expected by second quarter 1993. All equipment is foreign supplied. The works contract with Armenergo, an Armenian concern, is placed. The schedule supports the overall project.

Make-up Water Intake and Pipeline. The intake structure pump house has been constructed. The tie-in to the Hrazdan River has not been started. Ten kilometers of the pipeline are partially completed. The majority of equipment, pumps, and pipe have been received at Hrazdan.

1.6 COST TO COMPLETE UNIT NO. 5 AND TRANSMISSION LINE

Table 1.6-1 summarizes the Unit No. 5 project completion cost estimate. The estimate is derived from a MEF estimate of $47.54 million (300 Rubles = $1) and includes the 71 kilometer high-voltage transmission line and make-up water intake and pipeline. An assessment of the project scope, costs incurred to date, and remaining costs was performed. As a result of this assessment, the cost increased by $6.19 million to cover overall project completion costs. The major additions include: ductwork to the new stack; refurbishing equipment in storage; and, construction management support.

Physical contingency and escalation are contained in Table 1.6-1. As the NIS emerges from a centrally controlled and managed economy, pricing is uncertain. Armenia, for example, doubled wages in July 1992 and it was reported that wages will again double in November. Similar wage increases have also been reported in other NIS republics.

TABLE 1.6-1

HRAZDAN UNIT NO. 5 - SUMMARY OF COMPLETION ESTIMATE

	RUBLES (MILLION)	DOLLARS (MILLION)
MEF Estimate	14,622.00	$47.54
Selected Additions	177.00	.59
Other Additions	1,680.00	5.60
Subtotal	16,119.00	$53.73
Contingency	2,094.00	6.98
Price Escalation	8,706.00	29.02
Total	26,919.00	$89.73

Note: $1 = 300 Rubles

ETIP and MEF spent considerable time discussing various scenarios. ETIP suggested several approaches to the MEF for negotiating firm pricing with key equipment manufacturers and works subcontractors. The MEF, however, believes that existing relationships with these firms could be upset if a third party is introduced at this point in the procurement cycle. It is this uncertainty plus unsettled transportation issues that drive the physical contingency and escalation in the estimate. Moreover, the MEF believes NIS prices will reach western prices perhaps by late 1993.

Notwithstanding the uncertainties for pricing and transportation, a comparative cost in the West for a 300 MWe gas/oil-fired power plant is $263 million. Clearly, the difference in ETIP's project completion estimate for Hrazdan Unit No. 5 is quite significant. The explanation lies primarily in pricing practices of the previous centrally planned economy and the strength of the dollar against the ruble. The Hrazdan Unit No. 5 boiler, for example, cost $28,400. Boiler costs of this design are approximately $30 million in the West.

1.7 COMPLETION SCHEDULE

A 23 month project completion schedule for Unit No. 5, the Hrazdan-Yerevan transmission line, the make-up water pipeline, and associated facilities is realistic. This schedule is based on MEF documents, current construction progress, and ETIP's experience. The construction schedule highlights the components that determine the completion duration and gives consideration to project requirements for remaining procurement activity, construction completion, startup, and performance testing. This schedule assumes full project construction resumption in March 1993 with construction and plant turnover completion in December 1994. The critical path items for construction completion of this project are as follows: 1) receipt of outstanding equipment and materials; 2) securing highly qualified (skilled craft) specialists; 3) erection of boiler, (4) erection of turbine-generator; and, 5) installation of bulk equipment and materials.

Unit No. 5 construction peak manpower at the site will be approximately 2500 persons with approximately 50 percent of the construction forces imported to the Hrazdan area. Approximately 1200 craftsmen will be expatriates from other NIS republics or Central European countries. Potentially higher wages earned by expatriate workers will contribute to local inflation of prices of food, fuel, and housing. Addressing potential shortages in housing, subsistence and transportation facilities is essential to minimize impact on the construction completion schedule.

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1.8 DESIGN EFFICIENCY IMPROVEMENTS

Energy use efficiency is important to Armenia's economy because of its need to import most of its primary energy and pay for it with hard currency (or its equivalent). Currently, Armenia's main power sector and industrial fuel is natural gas imported from Turkmenistan. Natural gas is preferred over oil for both price and availability reasons. Energy end-use efficiency is also a consideration in EBRD loans for both environmental and economic development reasons.

Because of the importance of energy end-use efficiency in Armenia, the NIS/TF required an evaluation of potential ways to improve the efficiency of Unit No. 5. Results were intended to be used for subsequent Hrazdan units with possible future retrofit to Unit No. 5.

The natural gas fired steam generator for Unit No. 5 is a supercritical unit with state-of-the art primary and reheat temperatures (545°C) rated at 1000 t/hr of steam. The turbine is of condensing type and rated at 300 MWe. Estimated Unit No. 5 net heat rate at rated load is 2162.4 kcal/kwh when firing natural gas. Because Unit No. 5 is a relatively efficient unit, no design efficiency improvements have been identified for implementation. Unit No. 5 as well as units 6-8 are intended to be used as baseload units and units 1-4 would be used for non-baseload service.

However, specific efficiency improvements identified for future consideration in the event these units would be used as non-baseload units are:

- Conversion of the steam generator to sliding pressure operation. This would improve steam generator efficiency at reduced load conditions.

- Conversion of the steam turbine to variable throttle operation. This would improve steam turbine efficiency at reduced load conditions.
- Use of state-of-the art variable speed drives on main pumps and fans to reduce energy consumption under partial load conditions.
- Improved boiler instrumentation.

1.9 ENVIRONMENTAL CONSIDERATIONS

Hrazdan Unit No. 5, the new Hrazdan-Yerevan transmission line, and a new Hrazdan River intake structure and makeup water pipeline route were examined for selected environmental, health and safety, and site environmental liability considerations. In addition, the existing Hrazdan Power Plant Units were examined to the extent that Unit No. 5 would use shared facilities for water and wastewater treatment, waste disposal, and pollution control.

1.9.1 Atmospheric Emissions

Unit No. 5 will be fueled with natural gas with heavy oil as a supplemental fuel. As a result, emissions will be below European Community standards including NOx emissions. Review of source performance limits guaranteed by the boiler vendor are 200 mg/m^3 for NOx which is below the European Community new source performance standard of 350 mg/m^3.

1.9.2 Solid and Liquid Wastes

Unit No. 5 solid and liquid wastes can be handled by existing treatment/disposal systems in an environmentally sound manner. Because the primary fuel is planned to be natural gas, the quantity of solid wastes produced is expected to be minimal. Current capacities of the water and wastewater treatment systems are sufficient to handle Unit No. 5 wastes as well as wastes from future Units 6, 7, and 8.

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1.9.3 Water Supply

Unit No. 5 will require additional makeup water for the months of August and December through February. This water will be obtained from the Hrazdan River near the Hrazdan Reservoir and conveyed approximately 10 km to the plant via an 0.8 m diameter pipeline. This will augment the water taken from the Marmarik River located northwest of the Plant.

1.9.4 Site History and Environmental Liability

Review of records, historical land use maps, discussions with Hrazdan Plant staff and site inspection of surface and near surface conditions suggests no concerns with potential site environmental liability. The site for Unit No. 5, as well as Unit Nos. 1-4, was open land and never used as a site for waste disposal. The site was developed in the late 1960's. Units 1 and 2 were completed in 1971, Unit 3 in 1972, and Unit 4 in 1974.

1.9.5 Occupational Health and Safety Review

Occupational health and safety is governed by regulations established by the former Soviet Union. These regulations appear to focus primarily on plant operators rather than on construction workers. Construction organizations performing work at the facility, however, are required by contract to adhere to these same regulations. Significant improvements are needed in the awareness and use of construction safety practices.

1.9.6 Construction Activity Impacts

Project construction completion will impact the local community, but with advance planning these impacts can be anticipated and managed.

1.9.7 Transmission Line Visual Assessment

The new Hrazdan-Yerevan transmission line will parallel the existing transmission line. Tower heights are the same as the existing transmission line. This transmission line parallels other corridor features including the highway from Yerevan to Tbilisi and the main railroad from Yerevan to Hrazdan. As a result, a major transportation corridor now exists and the incremental addition of the 220 kv line is judged not to have an adverse environmental impact.

1.9.8 Public Participation

The Republic of Armenia provides for public participation concerning major projects, and the Hrazdan Unit No. 5 planning and development have been done with consideration of this requirement. Relations with the local community have varied over time. Prior criticism of plans for Unit No. 5 have been addressed and the community is supportive of the Plant expansion. Proactive response to community concern is evidenced by the total reanalysis of the seismic design of the plant and the reanalysis of air and waste water discharge criteria and limits to assure the local community of plant compliance with environmental rules and regulations.

1.10 CONCLUSIONS AND RECOMMENDATIONS

1. Design of Unit No. 5 is essentially complete. This includes the additional design evaluation for higher seismic requirements and modification of equipment, structures, and systems to conform with the new seismic requirement.

2. Most major equipment required for Unit No. 5 is currently on site. Remaining equipment and materials have been identified and are expected to be available to support the construction completion schedule.

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3. The design of Hrazdan Unit No. 5 generally meets or exceeds the U.S. and European fossil power plant standards. No design efficiency improvements are recommended.

4. Permanent plant equipment and material storage areas are secure, relatively close to the plant, and accessible to the plant by a combination of rail lines and overhead cranes at both the storage area and the plant. However, the limited storage space for such a large amount of equipment and the manner in which this equipment is stored requires attention.

   Recommendations include: 1) indoor storage of some equipment; 2) resealing of shipping crates to protect equipment (e.g., electrical panels); 3) rearrangement and/or unstacking of equipment to make it more accessible when needed; 4) repositioning of piping and valves to assure proper drainage; and, 5) proper support of fan impellers to protect fan blades.

5. A program exists for the location, traceability, and documentation of plant equipment and materials. Given the magnitude of the items stored and the manner in which these items are currently arranged on-site, it is difficult to locate and retrieve equipment in a timely manner.

   Recommended action in this regard is to identify and withdraw items a minimum of 45 to 60 days prior to installation in order to provide adequate lead time for possible equipment rehabilitation if needed.

6. Construction has progressed on the enclosure of the boiler building so that work may continue in the winter (1992-93) if funding is available. Foundations are complete for the turbine building, main transformers and the central laboratory building and other external plant buildings.

7. The type of plant is similar to other large power projects successfully designed and built elsewhere; thus, Unit No. 5

can be expected to be completed within a twenty-one (21) month period provided the timely delivery of remaining equipment, materials, and specialized labor.

Recommended items requiring a high level of attention in order to assure completion of the project within this period are: 1) identification of needed construction consumable materials and their availability inside and outside Armenia, 2) identification of critical skill requirements and identifying reasonably secure expatriate work forces to meet these requirements, 3) establishing firm delivery dates for the remaining material and equipment to be manufactured and shipped, and 4) securing primary and secondary or backup methods for the transportation of required equipment and materials.

8. Use of natural gas as the primary fuel will assure project conformance with European Community NOx emission standards. The completion of Unit No. 5, as well as subsequent Units 6-8, will reduce the overall Power Plant air emissions. The new units can be used for baseload capacity. The older units can be reserved for peaking service.

9. Estimated overall costs to complete Hrazdan Unit No. 5 is significantly less than a typical 300 MWe gas-fired power plant designed and built in the United States or Western Europe.

10. Absence of project funding has significantly reduced the amount of on-going work for Hrazdan Unit No. 5. Securing project funding and the formation of a highly focused project team will help restore the viability and momentum of Hrazdan Unit No. 5.

11. Successful project completion will benefit from use of an expatriate construction manager with experience in fossil power plant construction. Some internal organizational

changes in project management and procurement management are necessary to assure timely completion of the project. An integrated project controls program should also be established.

Recommended action is the establishment of a project team, including an enhanced procurement management function, that can focus exclusively on the Hrazdan Project to mobilize the resources necessary to resume major construction activity by March 1993. Primary project functions will include construction management, procurement support, project controls, design support, and administration. The focus of construction completion activities should be located at the Hrazdan Plant. Pre-construction planning to prepare for project resumption would be handled by this project organization.

12. Continue existing contractual arrangements with equipment manufacturers, material suppliers, and construction contractors in order to avoid schedule delays and potential cost escalation. Project schedule can support the time needed for international competitive bids of cable and accumulator batteries. Competitive bidding may also be required if present contractors or suppliers are unable to meet completion schedule requirements. Project payments should be disbursed to key equipment manufacturers, material suppliers, and contractors to expedite the timely release and delivery of equipment, materials, and labor.

Recommended action in this area is the acceleration of expediting and traffic services for all equipment contracts in order to assure the required delivery of materials and equipment. These services can augment the existing procurement organization. Specific activities include: close monitoring of traffic routes and modes; examining the use of private security services to escort certain critical material and equipment shipments; developing contingencies in the event of traffic disruptions; maintaining close communication with

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equipment manufacturers, material suppliers, and shippers via cables, faxes, telephone, and shop visits; and upgrading office automation and communications equipment to permit the free flow and timely receipt of information.

Develop a comprehensive plan that addresses the four key procurement issues: payment and escalation, traffic and expediting, quality control, and communications.

13. Existing solid and liquid waste treatment systems are sufficient for Unit No. 5 expansion.

    Recommended for further consideration by the MEF is the review of Hrazdan municipal sanitary waste treatment facility capacity. In addition, construction solid waste disposal practices implemented need to assure protection of surface and groundwater.

14. Occupational health and safety rules exist for the Hrazdan Plant but need to be proactively and followed particularly in the area of construction. Standard safety equipment will need to be provided for worker protection.

15. Project success will depend on timely disbursement of funds to equipment manufacturer and subcontractors and effective project planning.

    Recommended action is the consideration of retractive financing as part of the EBRD loan. This would expedite withdrawals against the loan and facilitate advance payments to equipment manufacturers and subcontractors.

The results of ETIP's in-country assessment were provided to the NIS/TF, R&D/EI, MEF, and EBRD before returning to the US. A number of discussions were held with the MEF and EBRD's loan appraisal team in Armenia and EBRD's management in London to explain the

basis of ETIP's findings and recommendations. The general consensus is consistent with the recommendations of this report.

The current EBRD schedule calls for submittal of the loan appraisal to the Bank's management in mid-December 1992. Assuming EBRD's management approves, the next step involves submittal to EBRD's Board at the end of January or beginning of February 1993. EBRD's decision on the loan to complete Hrazdan unit No. 5 is anticipated in February 1993.

2.0 INTRODUCTION

2.1 BACKGROUND

The Republic of Armenia is currently suffering from a serious electricity supply-demand gap affecting all aspects of the economy. Only a few years ago, before the breakup of the Soviet Union, Armenia exported electricity. Current electricity generating capacity, due to the closure of a nuclear plant and poorly planned hydropower development, is well below demand. The Republic has resorted to rolling electric power black-outs to deal with the power shortages. A further problem is Armenia's need to import most of its primary fuels. Current fuel supplies are tenuous due to the conflict with Azerbaijan and political instability in Georgia.

The Ministry of Fuel and Energy (MEF) estimates that Armenia needs approximately 2600 MWe of electricity generating capacity to maintain the economy as it existed under the former Soviet Union. Today, only 1200 MWe on average are available. This shortfall has caused: rolling blackouts; reduced industrial production (50 percent of capacity); and, severe unemployment (23 percent). In addition, prospects for sufficient heat for the 1992-93 winter season are bleak.

One cornerstone of the solution to this critical economic development constraint is the completion and operation of the 300 MWe, gas/oil-fired Unit No. 5 at the Hrazdan Power Plant. Construction of Unit No. 5 was initiated in 1988 while Armenia was part of the Soviet Union. Unit No. 5 is approximately 25 percent complete.

The Hrazdan Power Plant has an installed capacity of 1100 MWe and is Armenia's main base-load power plant. Figure 2.1-1 identifies the location of the Hrazdan Plant. Unit No. 5 has a design

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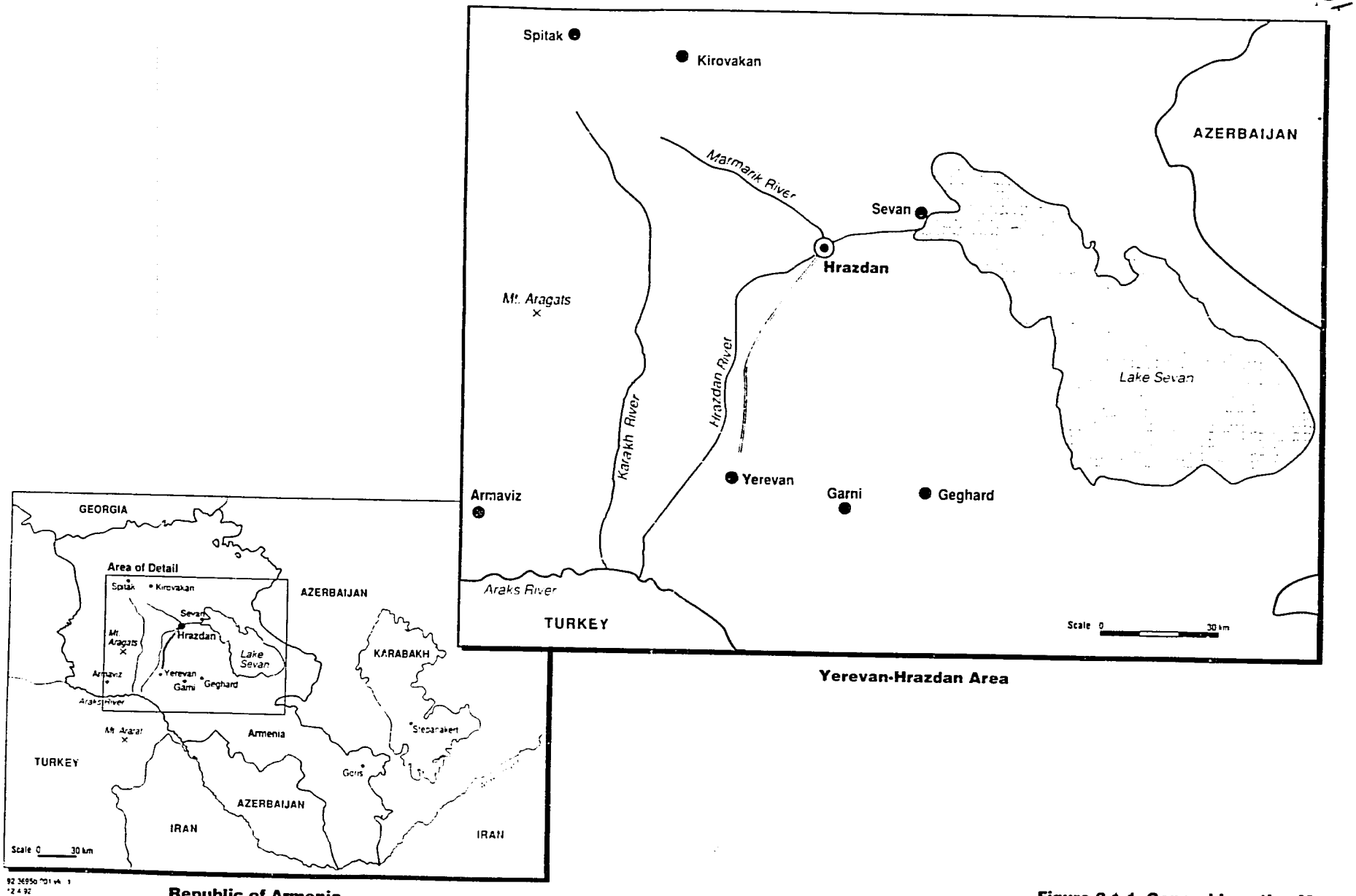

Figure 2.1-1 General Location Map for Hrazdan Power Plant

capacity of 300 Mwe and is part of an expansion program which includes three additional, identical units (Unit Nos. 6, 7, and 8).

Detailed engineering for Unit No. 5, by the Rostov Design Institute, Russia, is essentially complete. The majority of equipment contracts have been placed through several entities in the New Independent States (NIS). The main construction contractor is Armenergo Hydro Energy Company. Figure 2.1-2 provides a summary of the Hrazdan Plant Unit No. 5 construction organization.

The Republic of Armenia has requested a loan from the European Bank for Reconstruction and Development (EBRD) for funds to complete Unit No. 5. EBRD requires an assessment of the present situation and issues that need to be addressed in order to achieve Unit No. 5 operation. EBRD also requires a cost estimate and schedule for Unit No. 5 completion taking into account international standards related to environmental protection and energy efficiency.

In September of 1992, the United States Agency for International's New Independent States Task Force (NIS/TF) Energy Assessment Team visited Armenia and discussed with the MEF a number of technical assistance efforts critical to the Republic of Armenia. The completion and operation of Hrazdan Unit No. 5 was considered essential for Armenia's power needs.

The MEF and EBRD subsequently requested the NIS/TF to fund the pre-loan support activities related to Unit No. 5 completion. The NIS/TF requested USAID Bureau for Research and Development's Office of Energy and Infrastructure (R&D/EI) to provide the personnel from their Energy Technology Innovation Project (ETIP) to undertake the required pre-loan support activities.

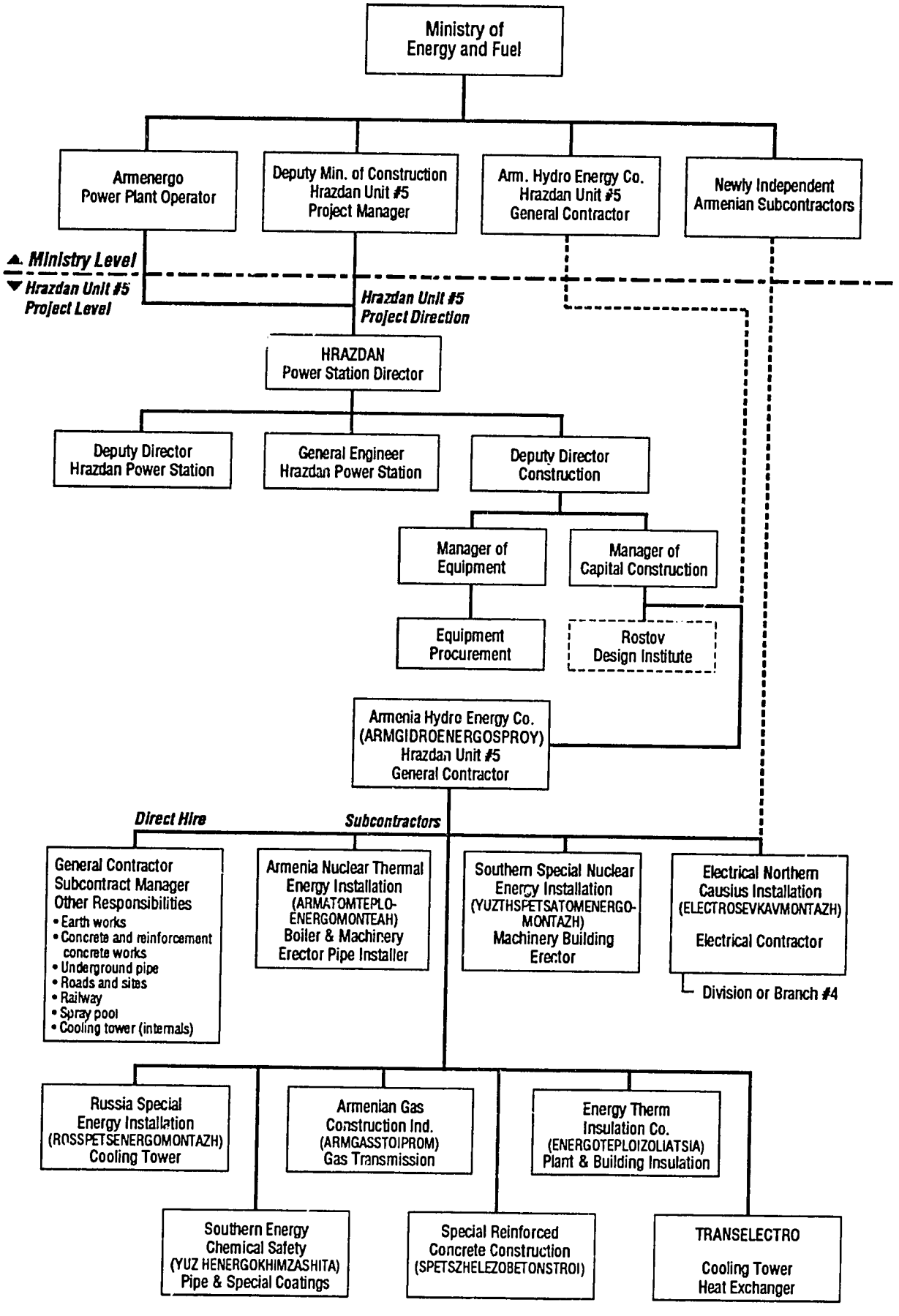

Figure 2.1-2 Construction Organization
Republic of Armenia
Ministry of Energy and Fuel
Hrazdan Unit 5

92-3912b.002 vk:5
10-20-93

2.2 OBJECTIVES

The primary objectives of the project were to support the MEF in assessing the status of the design and construction of Hrazdan Unit No. 5 and identifying actions, costs, and time requirements for its completion. In particular, EBRD required an in-depth assessment of the current procurement status of equipment and erection (works) contracts to determine which contracts could be competitively bid and, to obtain firm pricing, where possible, for existing contracts that could not be competitively bid.

A secondary objective was to identify innovative practices, procedures, and equipment which have not previously been available in Armenia and are expected to affect: 1) equipment design in order to improve energy efficiency; 2) procurement practices including the introduction of competitive processes; 3) project management; 4) power station operation; and, 5) environmental considerations.

2.3 PRE-LOAN ASSESSMENT SUPPORT APPROACH

The NIS/TF realized that the required support effort needed to take place as quickly as possible to meet: MEF's completion schedule for Hrazdan Unit No. 5 before the winter of 1994-5; and, EBRD's loan processing schedule. Consequently, the Office of Energy and Infrastructure mobilized the necessary professionals within one week after a buy-in from the NIS/TF was approved.

An important factor in supporting the pre-loan assessment was the appreciation of previous Soviet Union "commercial" practices under a centrally planned and managed economy. In the former Soviet Union, for example, a central organization was responsible for determining appropriate power plant equipment manufacturers and ensuring equipment price, delivery, and quality. Current NIS practice appears to be that the manufacturer determines the

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conditions of sale, including price and schedule. Moreover, pricing is subject to increases and are determined solely by the manufacturer. Exacerbating the current procurement process is a legal system in transition that is currently overloaded, making orderly and timely legal claims an issue that is not expected to be resolved soon.

Eleven tasks were developed by ETIP to meet the assessment support objectives. These tasks were conducted in both Armenia and the United States, as well as in London with EBRD management, procurement, and environmental staff. The eleven assessment support tasks are described in Appendix A.

Two teams, in-country and energy efficiency (based in the U.S.), were organized to carry out the tasks. Composition of these teams were:

In-Country:
- ETIP Manager/Power Engineer
- Project Manager/Environmental Specialist
- Financial/Procurement Specialist
- Economist/Cost Estimator
- Information Specialist/Scheduler
- Energy Utilization/Construction Engineers

Energy Efficiency:
- Power Engineer
- Mechanical Engineer
- Electrical Engineer
- Economist/Cost Estimator

The two teams worked in parallel and, although communications from Armenia were difficult, exchanged information to support their efforts. Design drawings, for example, were provided to the energy efficiency team as well as other pertinent information needed to carry out the US-based activities. In addition, EBRD sent their

loan appraisal team to Armenia during the fourth week of the ETIP in-country team's efforts. During this time, ETIP supported MEF's discussions with the EBRD loan appraisal team. ETIP also responded to several EBRD requests for additional information.

These tasks required approximately 20 personweeks in Armenia to collect and assess data written primarily in Russian, walkdown the site, and to confer with EBRD, MEF, Hrazdan Power Plant staff, and plant construction contractors. A meeting prior to the in-country effort was held with EBRD in London to obtain their specific concerns regarding procurement and environmental issues. A second meeting with EBRD management was held in London to appraise them of assessment findings. The balance of the effort was completed in the United States.

The results of ETIP's in-country assessment were provided to the NIS/TF, USAID/Yerevan, R&D/EI, MEF, and EBRD before returning to the US. Several discussions were held with the MEF and EBRD's loan appraisal team in Armenia and EBRD's management in London to explain the basis of ETIP's findings and recommendations. The general consensus is consistent with the recommendations of this report.

The current EBRD schedule calls for submittal of the loan appraisal to the Bank's management in mid-December 1992. Assuming the Bank's management approval, the next step involves submittal to EBRD's Board at the end of January or beginning of February 1993. EBRD's decision on the loan to complete Hrazdan unit No. 5 is anticipated in February 1993.

The results of the pre-loan assessment are included in the balance of this report including: UNIT NO. 5 COMPLETION STATUS (Section 3); ENVIRONMENTAL CONSIDERATIONS and ENVIRONMENTAL MITIGATION MEASURES (Sections 4 and 5); DESIGN EFFICIENCY IMPROVEMENTS (Section 6); COMPLETION COST ESTIMATE (Section 7); COMPLETION SCHEDULE (Section

8); and, PROJECT COMPLETION DISBURSEMENT SCHEDULE (Section 9).

3.0 UNIT NO. 5 CURRENT COMPLETION STATUS

The following presents the results of an assessment of the completion status for Hrazdan Unit No. 5. Included in this assessment are power plant and major equipment, a new high-voltage transmission line, and a water supply intake structure and pipeline.

3.1 METHODOLOGY AND DATA COLLECTION

Approximately 25 percent of the existing equipment and works contracts were reviewed to verify information contained in Tables 3.3-1 through 3.5-2. The documents (translated) reviewed included: purchase contracts, works contracts, change orders, related correspondence, trip reports to manufacturer's plants, shipping documents, receiving inspection reports, and payment records. Discussions with Hrazdan Plant personnel, MEF officials, and installation contractors provided information on the status of equipment and contracted works. Walkdowns of the Unit No. 5 site were also performed to verify existing conditions.

The contracts reviewed either had no reference to price adjustment or indicated that the price is subject to escalation. More recent contracts provide a cost breakdown per input on a unit basis such as salaries, energy, and social benefits to workers. In either event, the current economic situation in the NIS, including Armenia, dictates that most manufacturers will not begin production unless advance payments are made. Moreover, the current practice in the NIS dictates that price adjustments are standard practice and are determined by the manufacturer. The extent to which Hrazdan personnel are able to negotiate pricing adjustments is unclear. Notwithstanding rising prices in the NIS, it is also clear that the costs of products are currently significantly less in the NIS than in the West.

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It was noted and confirmed by Hrazdan personnel that the equipment contracts include start-up spares. The costs for transportation to Hrazdan and a value added tax (28 percent), however, are not included in the equipment contracts.

The review of relevant records at the Hrazdan Power Plant found them to be reasonably complete and accurate. A system was confirmed to exist that monitored aspects of procurement and construction activities at the Hrazdan Plant. Improvements, however, are possible in the area of overall administration activities. Adopting simple, easily implemented automated systems would result in better results and increase worker efficiency.

Considerable discussion was held during the initial stages of the in-country effort with Hrazdan personnel and MEF officials to develop a strategy for negotiations with manufacturers and contractors to obtain firm pricing and acceptable delivery schedules for the remaining equipment and works. Appendix B identifies a summary of the project chronology and identifies the major events and actions taken. Initially, direct discussions with key suppliers and contractors were considered. The MEF elected to pursue this matter unilaterally, but with ETIP support. Several approaches for negotiations with equipment manufacturers were recommended by ETIP to resolve pricing and schedule issues. These approaches included: offering hard currency to equipment manufacturers and subcontractors in lieu of rubles in exchange for firm prices and schedules; developing mutually acceptable cost indices with equipment manufacturers and subcontractors to provide for pricing adjustments; and, ETIP would obtain, independently of MEF, firm price quotations for the equipment. The MEF reviewed these approaches and determined that on-going, existing relationships with these firms offered the best solution. Consequently, the MEF decided to handle all negotiations with the manufacturers and contractors. It was agreed that the ETIP team would provide a list of key equipment orders to the MEF. These

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items - main transformer, high pressure heaters, low pressure pipe, centrifugal pumps, and pressure vessels - were selected by ETIP since timely delivery and/or cost are considered significant in meeting the project schedule and estimate. Identifying the remaining key equipment orders and developing a plan to address concerns should help reduce the overall risks associated with cost and schedule. The MEF should enter into negotiations with the manufacturers of this equipment to obtain firm prices and schedule.

Throughout the duration of the in-country effort a dialogue was maintained with appropriate personnel at the Hrazdan Power Plant and the MEF on risk concepts associated with procurement and contract administration. Topics included competitive bidding, bid evaluation, pricing, schedule, escalation, scope changes, warranty, traffic, performance guarantees, and management techniques. EBRD's policy on procurement and a suggested implementation plan were discussed with Hrazdan personnel. Additionally, an outline on EBRD procurement requirements and an implementation schedule (see Appendix D) for procuring goods were provided and discussed with Hrazdan personnel most likely to be involved in this activity.

3.2 PLANT AND MAJOR EQUIPMENT STATUS SUMMARY

3.2.1 Equipment Status Summary

The majority of required equipment has been delivered or is scheduled for delivery by the first quarter 1993. The boiler, turbine, generator (less stator), condenser, fans, overhead cranes, most pumps, low-pressure feedwater heaters, and a reasonable percentage of bulk materials are at Hrazdan. High-pressure feedwater heaters, ductwork, and generator stator are manufactured and their delivery is expected by December 1992. The main transformer is scheduled to be manufactured within six months after the manufacturer receives a progress payment for the purchase of

fabrication materials. Purchase contracts for cable and accumulator batteries need to be placed.

3.2.2 Construction Status Summary

Unit No. 5. The level of Unit No. 5 construction activity has been reduced due to lack of funds. Excavation and foundation work for the major buildings is essentially complete. Appendix C illustrates the status of construction progress to date. Exterior walls of the boiler building are nearing completion. Erection of structural steel for the boiler is in progress. The machine hall turbine building exterior is approximately 75 percent complete. Installation of the turbine generator pedestals is in progress. The three story laboratory building is partially framed. The cooling tower maintenance shop is approximately 75 percent complete. The switchyard control building is approximately 50 percent complete. The exterior shell of the cooling tower is complete to the 110 meter elevation. Final design height of cooling tower is 160 meters. The stack is erected, but its steel liner and warning lights need to be installed. Most current construction activity is focused on enclosing the boiler building so that work can continue through the 1992-93 winter months.

Transmission Line. Design and routing are complete for the 71 kilometer high-voltage transmission line from Hrazdan to Yerevan. Easements have been obtained. Five towers and supports (2 percent) of the required 248 are installed. Eight hundred and thirty-six tons (6 percent) of the required 2,530 tons of galvanized steel have been received. One hundred tons (15 percent) of the required 660 tons of aluminum wire have been received. Manufacturers for the galvanized steel and aluminum wire are Plant of High Voltage Towers, Ukraine, and Kirsk Cable, Russia, respectively. All materials except concrete are anticipated to be of foreign supply.

Equipment contracts are placed and delivery is expected by second quarter 1993. One transformer has been manufactured and shipment is dependent upon payment. Production of the second transformer will begin once an advance payment is made by Hrazdan. All equipment is of foreign supply. The works contract with Armenergo Corporation, an Armenian concern, is placed.

Intake and Make-up Water Pipeline. The intake structure pump house has been constructed. The tie-in to the Hrazdan River has not been started. Ten kilometers of the plant water supply pipeline are partially completed. The majority of equipment, pumps, and pipe have been received at Hrazdan.

3.3 STATUS OF ALL MAJOR EQUIPMENT

Table 3.3-1 identifies the status of all major equipment for Hrazdan Unit No. 5. This table lists the manufacturer, source for financing, actual cost or estimated cost (Rubles and US Dollars), and payment and delivery status. Column 11 provides the estimated price (Rubles) given by the manufacturers to Hrazdan personnel in July 1992. The information in Column 11 formed the baseline for the ETIP equipment cost estimate (refer to Section 7.0). Column 12 represents the MEF's estimate including their estimate of anticipated escalation of the cost for the equipment at the time of delivery. Column 13 provides the dollar equivalent of Column 12. The exchange rate used is 300R = $1. It is recognized that the strength of the Ruble against the Dollar continues to deteriorate and calculations should be adjusted accordingly. The information has been sorted, Column A of the table, to reflect ETIP's initial effort to meet the European Bank for Reconstruction and Development's (EBRD) request that the equipment be grouped into the following three categories:

TABLE 3.3-1

LIST OF MAJOR EQUIPMENT FOR HRAZDAN UNIT NO. 5

INITIAL ASSESSMENT

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

CATEGORY	ITEM NO	DESCRIPTION	MANUFACTURER COUNTRY	UNIT	REQUIRED QUANTITY	CONTRACT #	AMOUNT PAID AS OF 10.10.92 RUBLES	EQUIPMENT NOT DELIVERED PRICE AS ON 01.07.92 RUBLES	ESTIMATED PRICE ON DELIVERY RUBLES	ESTIMATED PRICE ON DELIVERY 300R = $1	DESCRIPTION & QTY OF ITEMS NOT DELIVERED	EQUIPMENT TO BE DELIVERED
A	1	2	3	4	5	6	9	11	12	13	14	15
1	1	BOILER,1000t/hr,p=255KG/SQ.CM	TAGANROG,RUSSIA	COMPLETE	1	NO 3117	8,520.570					
1	2	TURBINE	ST.PETERSBURG METALURGICAL	COMPLETE	1	NO.14762	6,395.990					
1	3	FLUE GAS FANS, GM=1,884,600	SIBERENERGOMAC RUSSIA		2	NO.56R/B-90	202.350					
1	3	FLUE GAS FANS, GM=1,884,600	SIBERENERGOMAC	COMPLETE	2	NO.56R/B-90	250.000					
1	4	FANS	SIBERENERGOMAC	COMPLETE	2	NO.56R/B-90	150.000	220.300	2,220.330	7.40	2.ELECTRIC MOTORS	JAN-MAR/93
1	5	FEEDING TURBINE PUMP	ST.PETERSBURG	UNIT	1	NO.15152	167.360					
1	6	FEEDING ELECTRIC PUMP	PUMP PLANT RUSSIA	UNIT	1	NO.30	250.800					
1	7	DEARATOR	SIBERENERGOMAC	UNIT	1	ECO.COM	1,477.780					
1	8	CENTRIFUGAL HORIZONTAL PUMPS	SVERDLOVSK, RUSSIA	COMPLETE	2	NO.3.18.10.90	150.417					
1	9	ELECTRIC CRANE	ZAPAROZHIE ENERG UKRAINE	UNIT	1	NO.05/1095	121.813					
1	10	BRIDGE CRANE, CAP 16/3.2T	ALEKSANDRIA PLANT RUSSIA	UNIT	2	NO.35/20	81.801					
1	11	CRANES UPTO 10 TONS	BAIKAI CRANE RUSSIA	UNIT	12	NO.1084	164.000					
1	12	HYDRO TURBINE	HUNGARY	UNIT	2	NO.50-(431/910	650.000					
1	13	ELECTRIC CRANE, 10 TON	TASHKENT		1	NO.57601			1,459.200	4.86	1 CRANES	OCT-DEC 1992
1	14	CENTRIFUGAL VERTICAL PUMPS	SHEIKOV PUMP RUSSIA	UNIT	2	N.272		40.300	169.000	0.56	2	APR-JUNE 1993
1	15	ELECTRIC CRANE CAPACITY 50/10T	ZAPOROZHIE ELECT UKRAINE	UNIT	2	NO 05/850	165.108					
1	16	ELECTRIC CRANE CAPACITY 125/20T	ZAPOROZHIE ELECT	UNIT	2	NO 05/952	219.607					
1	17	PUMPS	PUMP PLANT RUSSIA	COMPLETE	54	NO 1493	2,101.800					
1	18	HEATER PV-1550-380	TAGANROG,RUSSIA	UNIT	1	NO.14817 12.12.89		988.000	1,284.000	4.28	1	OCT-DEC/92
1	18	HEATER PN.550-25-1	TAGANROG,RUSSIA	UNIT	1	NO.15219 05.02.90	70.710					
1	18	HEATER PV-1700-380	TAGANROG,RUSSIA	UNIT	1	NO 14817		1,086 000	1,412 000	4 71	1	OCT-DEC/92
1	18	HEATER PNSV-800-2	TAGANROG,RUSSIA	UNIT	1	NO.15219	59 280					
1	18	PV-1250-380-1	TAGANROG,RUSSIA	UNIT	1	NO.14817		914.000	1,188 000	3.96	1	OCT-DEC/92
1	18	PN.550-25-6	TAGANROG,RUSSIA	UNIT	1	NO.15219	69.290					
1	19	HIGH PRESSURE PIPES	BELGOROD,RUSSIA	TON	968.1	NO.TP-528	16,833.090	3,894.620	5,613.500	18.71	112	OCT-DEC/92

TABLE 3.3-1

LIST OF MAJOR EQUIPMENT FOR HRAZDAN UNIT NO. 5

INITIAL ASSESSMENT

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

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A	1	2	3	4	5	6	9	11	12	13	14	15
1	25	VESSELS CAPACITY UP TO 400 CUM	ZAPOROJHE UKRAINE	EA/TON	1/13.6	NO.1	491.900					
1	29	GENERATOR	ST.PETERSBURG ELECTROSILA	COMPLETE	1	NO.4036/91	20,767.450				1. STATOR	OCT-DEC 1992
1	30	SOLID STATE EXCITATION SYS.	ST.PETERSBURG ELECTROSILA	SET	2	NO.1090		38.000	76.000	0.25	2	APR-JUNE 1993
1	30	SOLID STATE EXCITATION SYS.			1	NO.847		1,900.000	5,700.000	19.00	1	APR-JUNE 1993
1	30	SOLID STATE EXCITATION SYS.			1	NO. 1424/92		589.220	765.386	2.55	1	OCT-DEC 1992
1	30	SOLID STATE EXCITATION SYS.			1	NO. 1720/93		5,814.380	29,071.900	96.91	1	JAN-MAR 1993
1	31	B) 32 MWs 20/6, 3x6, 3KV	ZAPOROZHTRANSFOR UKRAINE	UNIT	1	NO363/05	8,419.000					
1	31	C) 6/0, 4KV	DRY TRANSFORMER BAKU	UNIT	27	NO 995/15 09.07.91	60.303	238.270	2,000.000	6.67	13	JAN-MAR 1993
	32	CONTROL EQUIPMENT:										
1	32	F) RELAY ASSEMBLY	OKTIABRSKY PLANT RUSSIA		4	NO.09-1374/92K 15.07.92		86.144	861.440	2.87	4	JAN- MAR 1993
1	32	G) SWITCH GEARS PT30-88	OKTIABRSKY PLANT	UINT	515	NO.09-325/92K		8,078.400	18,281.120	60.94	135	OCT-DEC 1992
1	32	G) PT30-68	OKTIABRSKY PLANT	UNIT	272	NO.09-1116/92K		16,276.480	21,216.000	70.72	272	OCT-DEC 1992
1	32	A) KTPSN	ELECTROTECHNICAL MINSK		178	NO.1427/90K	284.899					
1	32	E) HIGHVOLTAGE SWITCHES	OKTIABRSKY PLANT RUSSIA		40	NO. 3036/91K	39.790	128.025	727.920	2.43	26	OCT-DEC 1992
1	32	KTPSN	ELECTROTECHNICAL		346	NO.09-7/93		34,600.000	69,200.000	230.67	346	APR-JUNE 1993
1	32	C) KTPSN	ELECTROTECHNICAL		44	NO. 1114/91K	109.903					
1	32	D) KTPSN	ELECTROTECHNICAL		16	NO.09-[illegible]93		2,150.400	43,008.000	143.36	16	JAN-MAR 1993
1	32	H)PROTECTION PANELS	SREDAZIAELECTROA	UNIT	6	NO.1114/91K	3.000					
1	32	I) PROTECTTION PANELS	CHEBOKSARY/RUSSIA	UNIT	23	NO.09-302/92K		444.320	980.420	3.27		
1	32	G) PT30-88	OKTIABRSKY PLANT	UNIT	100	NO.09-1116/92K		59.840	179.520	0.60	100	JAN-MAR 1993
1	32	B) KTPSN	ELECTROTECHNICAL	UNIT	23	NO. 550/91K	55.531					
1	33	CONTROL PANELS	ANGARSK ELECTRO RUSSIA	UNIT	49	NO.686	361.475	500.000	910.000	3.03	28	JULY-SEPT 1992
1	34	MEASURING CONVERTERS	VITEBSK BELORUSSIA	UNIT	203	NO.1599/91K	30.000	N/A	160 000	0.53	20	OCT-DEC 1992
1	34	E857/1	VITEBSK	UNIT	INCL	NO.44/10-92K		8.000	16 000	0.05	3	JAN-MAR 1993
1	35	CIRCUIT BREAKER	YEKATIRINBURG RUSSIA	COMPLETE	23	NO.7193		61.824 000	75,331.200	251.10	23	8 IN 1992 15 IN 1993
1	36	HIGHVOLTAGE TRANSFORMER	TOLIATTI, RUSSIA	UNIT	2	NO.2248/91		13.901.380	18,071.790	60.24	2	JAN-MAR 1993
1	37	BUS BAR	OTRADNOIE, RUSSIA	METER	190	NO.120/91 03.06.92		4,634.176	6,024.430	20.08	190	JULY-DEC 1992
1	39	AUTOMATED REGULATION STATION	CENTRE ENERGO	UNIT	2	NO.09-82/92		119.286	155.070	0.52	2	OCT-DEC 1992

TABLE 3.3-1

LIST OF MAJOR EQUIPMENT FOR HRAZDAN UNIT NO. 5

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A	1	2	3	4	5	6	9	11	12	13	14	15
1	40	RESISTORS	RUSSIA ENERGOTECH RUSSIA	UNIT	12	.19.02.02 NO.59	75.468	75.468	226.404	0.75	12	JAN-MAR 1993
1	41	DISTRIBUTION FACILITIES	ROVNO UKRAINE	UNIT	130	20.06.91 P-6,NP-A/92	486.737	7,691.167	9,998.000	33.33	34	JULY-DEC 1992
1	43	ELECTROLIZER, 20 CU.M/HR	UKRALKHIMMACH UKRAINE	COMPLETE	1	26.07.91 NO.231/20	335.860					
1	44	RECEIVERS 20 CU.M	UKRALKHIMMACH UKRAINE	UNIT	3	14.12.90 NO.231/20	884.094					
1	45	CONTROL PANELS	KIEV,UKRAINE	UNIT	2054	NO.04-311	1,597.913	1,597.913	2,077.290	6.92	1964	OCT-DEC 1992
1	46	CIRCUIT BREAKERS	VELIRISE RUSSIA	UNIT	28	NO.141/90	351.640	656.640	7,296.000	24.32	10	OCT-DEC 1992
1	47	TECHNOLOGICAL ALARM SYSTEM	UKRAINE		1	NO.1652/90K	708.100					
1	47	TECHNOLOGICAL ALARM SYSTEM	RUSSIA	COMPLETE	1	NO.1008/90K	1,700.300					
1	47	TECHNOLOGICAL ALARM SYSTEM	GEORGIA			NO.426/81-92K	2,941.500	657.100	3,285.500	10.95	4%	JAN-MAR 193
1	47	TECHNOLOGICAL ALARM SYSTEM	RUSSIA			NO.22/92-09SV	4,625.300	30,613.000	153,065.000	510.22	87%	OCT-DEC 1992
1	48	COMPUTER CONTROL SYSTEM	SEVERODONETSK	COMPLETE	2	NO.951/90K	642.400					
1	48	COMPUTER CONTROL SYSTEM	SEVERODONETSK	COMPLETE	2	NO.256/351	674.2					
1	49	MICROCOPPRESSOR CONTROLLERS	ELECTROPRIBOR	UNIT	11	NO.80	221.900	589.000	589.000	1.96	2	OCT-DEC 1992
1	50	HEAT CONTROL PANELS	PROGRESS PLANT SERPUKHOW	UNIT	46	NO.1881/91K	41.400					
1	51	LOCAL CONTROL PANELS	SREDAZELECTROAPP TASHKENT	UNIT	218	12.11.91 NO.09-260/92K	3,680.500	6,523.400	34,964.200	116.55	141	JAN-MAR 1993
1	52	LOCAL CONTROL PANELS	YEKATIRINBURG	UNIT	59	30.09.91 NO.411.SH	10,307.100	NOT AVAIL	51,535.500	171.79	59	JAN-MAR 1993
1	52		YEKATIRINBURG	UNIT	42	NO.011.SH		7,500.000	37,500.00	125.00	42	JAN-JUNE 1993
1	53	INDUSTRIAL SEISMIC PROTECTION	NPP RESERACH IN YEREVAN,ARMENIA	COMPLETE	2	NO.9209		1,024.000	5,120.000	17.07	2	APR-JUNE 1993
1	54	CONTROL & MEASURING EQUP	RUSSIA			15.06.92 NO.1075		19.400	97.000	0.32	96%	JAN-MAR 1993
1	54	CONTROL & MEASURING EQUP	RUSSIA			NO.93/15-1060	7.400				0%	
1	54	CONTROL & MEASURING EQUP	RUSSIA			NO.504/10-92	4.100	1,525.300	7,626.500	25.42	96%	APR-JUNE 1993
1	54	CONTROL & MEASURING EQUP	RUSSIA			NO.490/10-92K	69.100	4,626.000	23,130.000	77.10	97%	APR-JUNE 1993
1	54	CONTROL & MEASURING EQUP	GEORGIA			NO.2114/91K	55.700	42.900	214.500	0.72	30%	JAN-MAR 1993
1	54	CONTROL & MEASURING EQUP	GEORGIA			NO 876/10-92K		81.700	408.500	1.36	100%	APR-JUNE 1993
1	54	CONTROL & MEASURING EQUP	GEORGIA			NO.3103/91K	719.000	230.000	1,150.000	3.83	32%	JAN-MAR 1993
1	55	SAPHIRE DEVICES	UKRAINE			NO.55	78.700					
		INSTRUMENTATION, P-E	MANOMETER. RUSSIA	UNIT	213	INPROCESS		2,830.800	14,154.000	47.18	213	1993
1	59	COOLING TOWER & CONDENSER	HUNGARY	SET	1	50-0431/	33250.000					

TABLE 3.3-1

LIST OF MAJOR EQUIPMENT FOR HRAZDAN UNIT NO. 5

INITIAL ASSESSMENT

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

CATEGORY	ITEM NO	DESCRIPTION	MANUFACTURER COUNTRY	UNIT	REQUIRED QUANTITY	CONTRACT #	AMOUNT PAID AS OF 10.10.92 RUBLES	EQUIPMENT NOT DELIVERED PRICE AS ON 01.07.92 RUBLES	ESTIMATED PRICE ON DELIVERY RUBLES	ESTIMATED PRICE ON DELIVERY 300R = $1	DESCRIPTION & QTY OF ITEMS NOT DELIVERED	EQUIPMENT TO BE DELIVERED
A	1	2	3	4	5	6	9	11	12	13	14	15
2	13	ELECTRIC CRANE, CAPACITY 10 TON	TASHKENT	UNIT	2	NO.57602		2,886.000	3,752.000	12.51	2 CYCLES	JAN-MAR 1993
2	20	LOW PRESSURE PIPES	CITIES OF ZAPOROR UKRAINE	TON	1556.4	NO.60/5	12,775.500	51,370.000	162,436.500	541.46	1027	APR-JUNE 1993
2	21	LOW PRESSURE PIPES	CITIES OF ZAPOROR		224.53	NO.1550/1589	4,019.300	14,700.000	44,100.000	147.00	210	APR-JUNE 1993
2	22	LOW PRESSURE PIPES	CITIES OF ZAPOROR		7.2	NO.907		1,080.000	3,240.000	10.80	7	1993
2	23	AUX. EQUIPMENT FOR BOILER	BERIOZKI RUSSIA	TON	645.5	I/P &10/P; AGR N28 02.0792	1,845.300	30,790.000	92,370.000	307.90	616	1993
2	24	VESSELS CAPACITY UP TO 75 CUM	ZAPOROJHE UKRAINE	EA/TON	34/42.6	NO.1		3,408.000	10,224.000	34.08	34/42.6	1993
2	26	FITTING, VALVES (10 TO 1600MM)	CIS	EA	6575	NONE		52,980.000	52,980.000	176.60	6575	JAN-JUN 1993
2	31	A) 400 MWe, 242/20 KV	TRANSFORMATOR TOLIATTI, RUSSIA	UNIT	1	NO.0331-08/02 08.10.90		60,310.000	78,403.000	261.34	1 XFORM	APR-JUNE'93
2	38	SWITCHING PANEL	KANSAI, TADJIKISTAN	UNIT	341	NO.235 06.05.92		131.686	171.190	0.57	341	OCT-DEC 1992
2	44	RECEIVERS 80 CU.M	UKRALKHIMMACH UKRAINE	UNIT	8	NO.104/20 13.11.90		9,124.416	11,861.740	39.54	8	JAN-MAR 1993
3	27	NON STANDARDIZED EQUIPMENT	11 MFG'S OUTSIDE ARMENIA	LOT	1	BEING AGREED		50,000.000	65,000.000	216.67	1	JAN-JUN 1993
3	28	EQUIP. FOR CENTRAL STORAGE INCLUDES: MACHINE TOOLS	ARMENIA		1	BEING AGREED	9,698.660	37,873.860	49,936.000	166.45	1	JAN-JUN 1993
3	42	TRANSFORMER SUBSTATION	KHMEINITZKI UKRAINE	UNIT	1	BEING AGREED		60.000	120.000	0.40	1	JAN-MAR 1993
3	56	ACCUMULATOR BATTERIES		SET	1			50,000.000	155,000.000	516.67	1	APR-JUNE 1993
3	57	CABLES: HIGH VOLATGES		KM	1322			500,000.000	1,500,000.000	5000.00	1322	OCT-DEC 1993
3	58	220KV HIGH TRANSMISSION LINE						78,200.000	234,600.000	782.00	1	JAN-MAR 1993

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Category 1 - Purchase contract is substantially complete and/or must be maintained due to the overall Unit No. 5 design.

Category 2 - Purchase contract has been awarded, but little or no significant activity has taken place.

Category 3 - Purchase contract has not been awarded.

Readily apparent in Table 3.3-1 is the inverted cost structure for the equipment for Hrazdan Unit No. 5. For example, the cost of the delivered boiler, which is usually the most expensive plant component, is significantly less than the estimated cost for the main transformer. Typically, boiler costs are approximately $30 million and the main transformer costs $2 million for a 300 MWe gas/oil-fired plant in the West. The boiler for Hrazdan Unit No. 5 actually cost 8,520,570 Rubles ($28,400) and the main transformer is estimated to cost 78,403,000 Rubles ($261,300). The explanation lies primarily in the pricing practices of the previous centrally planned economy, the current movement towards a free market, and the strength of the dollar against the ruble.

3.4 STATUS OF REMAINING MAJOR EQUIPMENT FOR DELIVERY

Table 3.4-1 identifies the remaining major equipment required for delivery to Hrazdan Unit No. 5 and the status. This table is provided to allow the reader to focus on equipment needed to complete Unit No. 5. The table provides an assessment by ETIP for each equipment order from the standpoint of design, schedule, and cost to determine if international competitive bidding (ICB) is warranted. When any of the three criteria are materially affected by subjecting the equipment to ICB the word "yes" is indicated in the appropriate column. The results of this assessment for each order is noted in the table. This information has been sorted into the three categories established by EBRD.

TABLE 3.4-1

LIST OF REMAINING MAJOR EQUIPMENT FOR HRAZDAN NO #5

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

CATEGORY A	ITEM NO 1	DESCRIPTION 2	MANUFACTURER 3	CONTRACT # 6	EQUIPMENT NOT DELIVERED: PRICE AS ON 01.07.92 RUBLES 11	ESTIMATED PRICE ON DELIVERY RUBLES 12	ESTIMATED PRICE ON DELIVERY 300R = $1 13	DESCRIPTION & QTY OF ITEM NOT DELIVERED 14	SCHEDULE FOR EQUIPMENT TO BE DELIVERED 15	DESIGN	SCHEDULE	COST	REMARKS
1	4	FANS	SIBERENERGOMAC	NO. 56R/B-90	220.30	2220.30	7.40	2 ELECTRIC MOTORS	JAN-MAR/93	YES	YES	YES	Component integral to design. Cost to design & procure exceeds cost of component
1	13	ELECTRIC CRANE, 10 TON	TASHKENT UZBEKISTAN	NO.57601	N/A	1459.20	4.86	1 CRANE	OCT-DEC 1992		YES	YES	Manufacturing nearing completion. Cost to design & procure exceeds cost of crane
1	13	ELECTRIC CRANE, 10 TON	TASHKENT UZBEKISTAN	NO.57602	2866.00	3752.00	12.51	2 CRANES	JAN-MAR 1993		YES	YES	Manufacturing begun. Time needed for design evaluation and competitive bid exceeds any benefit to derived.
1	14	CENTRIFUGAL VERTICAL PUMPS	SHEKOV PUMP RUSSIA	N.272	40.30	168.00	0.56	2	APR-JUNE 1993	YES	YES		Manufacturing completed. Integral design – interconnections efficiency, footprint
1	18	HEATER PV-1550-380	TAGANROG,RUSSIA	NO.14817 12.12.89	988.00	1264.00	4.26	1	OCT-DEC/92	YES	YES	YES	Manufacturing completed. Integral design – interconnections efficiency, footprint. Western cost much greater.
1	18	HEATER PV-1700-380	TAGANROG,RUSSIA	NO.14817	1066.00	1412.00	4.71	1	OCT-DEC/92	YES	YES	YES	Same
1	18	PV-1250-380-1	TAGANROG,RUSSIA	NO.14817	914.00	1188.00	3.96	1	OCT-DEC/92	YES	YES	YES	Same
1	19	HIGH PRESSURE PIPES	BELGOROD,RUSSIA	NO.TP-528	3894.82	5613.50	18.71	112.27	OCT-DEC/92	YES	YES	YES	Majority of item shipped. Includes valves. Integral design – interconnections and efficiency
1	20	LOW PRESSURE PIPES	CITIES OF ZAPOROR UKRAINE	NO 60/5	51370.00	182436.50	541.46	1027.4	APR-JUNE 1993	YES	YES	YES	Manufacturing complete and ready for shipment
1	21	LOW PRESSURE PIPES	CITIES OF ZAPOROR	NO.1550/1589	14700.00	44100.00	147.00	210.13	APR-JUNE 1993	YES	YES	YES	Same
1	22	LOW PRESSURE PIPES	CITIES OF ZAPOROR	NO.907	1080.00	3240.00	10.80	7.2	1993	YES	YES	YES	Same
1	23	AUX. EQUIPMENT FOR BOILER	BERIOZKI RUSSIA	I/P &10/P; AGR N2 02.07.92	30790.00	92370.00	307.90	615.8	MARCH 1993	YES	YES	YES	Plant design completed for this equipment. Partial shipment made. Competetive bid would require thorough design review and most likely modifications affecting schedule and price
1	26	FITTING, VALVES (10 TO 1600MM)	CIS	NONE	52980.00	52980.00	176.60	6575	JAN-JUN 1993	YES	YES	YES	Design dictates CIS manufactured items. Significant design review needed to competetively bid affecting price and schedule
1	29	GENERATOR	ST.PETERSBURG ELECTROSILA	NO.4036/91				1 STATOR	OCT-DEC 1992	YES	YES	YES	Stator is integral to generator design. Manufacturing completed. Payment made. Cost would significantly increase

TABLE 3.4-1

LIST OF REMAINING MAJOR EQUIPMENT FOR HRAZDAN NO #5

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

CATEGORY A	ITEM NO 1	DESCRIPTION 2	MANUFACTURER 3	CONTRACT # 6	EQUIPMENT NOT DELIVERED: PRICE AS ON 01.07.92 RUBLES 11	ESTIMATED PRICE ON DELIVERY RUBLES 12	ESTIMATED PRICE ON DELIVERY 300R = $1 13	DESCRIPTION & QTY OF ITEM NOT DELIVERED 14	SCHEDULE FOR EQUIPMENT TO BE DELIVERED 15	DESIGN	SCHEDULE	COST	REMARKS
1	30	SOLID STATE EXCITATION SYS	ST PETERSBURG	NO 1090	38 00	76 00	0 25	2	APR-JUNE 1993	YES	YES	YES	Design integral to generator
1	30	SOLID STATE EXCITATION SYS	ELECTROSILA	NO 847	1900 00	5700 00	19 00	1	APR-JUNE 1993	YES	YES	YES	Same
1	30	SOLID STATE EXCITATION SYS.		NO 1424/92	589.22	765 99	2 55	1	OCT-DEC 1992	YES	YES	YES	Same
1	30	SOLID STATE EXCITATION SYS.		NO 1720/93	5814.38	29071 90	96 91	1	JAN-MAR 1993	YES	YES	YES	Same
1	31	A) MAIN TRANSFORMER 400 MWe, 242/20KV	TRANSFORMATOR TOLIATTI, RUSSIA	NO 0331-08/02 06.10.90	60310 00	78403 00	261 34	1 XFORM	APR-JUNE 93		YES	YES	Manufacturing complete within six months of advance payment. Estimated price is significantly lower than in the west. Leadtime is longer in the west.
1	31	C) TRANSFORMER 6/0, 4KV	DRY TRANSFORMER	NO 995/15	238.27	2000 00	6 67	13	JAN-MAR 1993	YES	YES	YES	Manufacturing nearing completion. Cost to design & procure exceeds cost of item.
	32	CONTROL EQUIPMENT											
1	32	F) RELAY ASSEMBLY	OKTIABRSKY PLANT RUSSIA	NO 09-1374/92K 15.07.92	86 14	861 44	2 87	4	JAN-MAR 1993	YES	YES	YES	Equipment for item 32 is integral to plant design. Much of this equipment is nearly completed. A major design review and modification would be needed. Schedule would be jeopardized and significant cost increases incurred. Western pricing is much greater for comparable equipment.
1	32	G) SWITCH GEARS PT30-88	OKTIABRSKY PLANT	NO 09-325/92K	8078 40	18281.12	60 94	135	OCT-DEC 1992	YES	YES	YES	
1	32	G) PT30-88	OKTIABRSKY PLANT	NO 09-1:16/92K	16276 48	21216 00	70 72	272	OCT-DEC 1992	YES	YES	YES	
1	32	E) HIGHVOLTAGE SWITCHES	OKTIABRSKY PLANT RUSSIA	NO 3036/91K	128 03	727.92	2 43	26	OCT-DEC 1992	YES	YES	YES	
1	32	KTPSN	ELECTROTECHNICAL	NO 09-7/93	34600 00	69200 00	230 67	348	APR-JUNE 1993	YES	YES	YES	
1	32	D) KTPSN	ELECTROTECHNICAL	NO 09-7/93	2150 40	43008 00	143.36	16	JAN-MAR 1993	YES	YES	YES	
1	32	G) PT30-88	OKTIABRSKY PLANT		59 84	179 52	0 60	100	JAN-MAR 1993	YES	YES	YES	
1	33	CONTROL PANELS	ANGARSK ELECTRO RUSSIA	NO 686	500 00	910 00	3 03	28	JULY-SEPT 1992		YES	YES	Cost and schedule would be affected. Effort needed exceeds cost of item. Item nearing completion.
1	34	MEASURING CONVERTERS	VITEBSK BELORUSSIA	NO 1599/91K	N/A	160 00	0.53	20	OCT-DEC 1992		YES	YES	Effort needed exceeds cost. Item nearing completion
1	34	E857/1	VITEBSK	NO 44/10-92K	8 00	16 00	0 05	3	JAN-MAR 1993		YES	YES	Effort needed exceeds cost
1	35	CIRCUIT BREAKER	YEKATIRINBURG RUSSIA	NO 7193	61824 00	75331 20	251.10	23	8 IN 1992 15 IN 1993	YES	YES	YES	Eight of 23 remaining circuit breakers are essentially complete. Average unit price is greater in west. Design review and time needed to procure breakers exceeds cost. The ratings and physical size are integral to overall design
1	36	HIGHVOLTAGE TRANSFORMER	TOLIATTI, RUSSIA	NO 2248/91	13901 38	18071 79	60.24	2	JAN-MAR 1993	YES	YES	YES	The rating and physical size are integral to plant design. Units are nearing completion. Time needed to address procurement issues would place the schedule in jeopardy. Western cost is greater
1	37	BUS BAR	OTRADNOIE, RUSSIA	NO 120/91 03.06.92	4634 16	6024 43	20 08	190	JULY-DEC 1992		YES	YES	Manufacturing nearing completion. Cost to design & procure exceeds cost of bus bar
1	39	AUTOMATED REGULATION STATION	CENTRE ENERGO RUSSIA	NO 09-82/92 .19.02 02	119.29	155 07	0.52	2	OCT-DEC 1992		YES	YES	Manufacturing nearing completion. Cost to design & procure exceeds cost of equipment

TABLE 3.4-1

LIST OF REMAINING MAJOR EQUIPMENT FOR HRAZDAN NO #5

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1	40	RESISTORS	ENERGOTECH RUSSIA	NO.59 20.06.91	75.47	226.40	0.75	12	JAN-MAR 1993	YES		YES	Cost to design & procure exceeds cost of resistors. Currently scheduled to arrive at site on first quarter 1993.
1	41	DISTRIBUTION FACILITIES	ROVNO UKRAINE	P-6,NP-A/92 26.07.91	7691.17	9998.00	33.33	34	JULY-DEC 1992	YES	YES	YES	Majority of items on site. Remaining items either complete or nearing completion. In-country cost does not warrant time and effort needed to competitively bid.
1	45	CONTROL PANELS	KIEV,UKRAINE	NO.04-311	1597.91	2077.29	6.92	1984	OCT-DEC 1992	YES	YES	YES	Design is integral to plant. Manufacturing is nearing completion.
1	46	CIRCUIT BREAKERS	VEURISE RUSSIA	NO.141/90	656.64	7296.00	24.32	10	OCT-DEC 1992				Ten remaining circuit breakers are essentially complete. Average unit price is greater in west. Design review and time needed to procure breakers exceeds cost. The ratings and physical size are integral to overall design.
1	47	TECHNOLOGICAL ALARM SYSTEM	GEORGIA	NO.426/81-92K	657.10	3285.50	10.95	4%	JAN-MAR 193	YES	YES	YES	This system is integral to the plant design. The majority of equipment is nearing completion at the factory.
1	47	TECHNOLOGICAL ALARM SYSTEM	RUSSIA	NO.22/92-09SV	30613.00	153065.00	510.22	87%	OCT-DEC 1992	YES	YES	YES	
1	48												
1	49	MICROCOPPRESSOR CONTROLLERS	ELECTROPRIBOR SERPUKHOW	NO.80 12.11.91	589.00	589.00	1.96	2	OCT-DEC 1992		YES	YES	Cost to design & procure exceeds cost of item. Manufacturing nearing completion.
1	51	CONTROL PANELS	SREDAZELECTROAPP TASHKENT	NO.09-260/92K 30.09.91	6523.40	34964.20	116.55	141	JAN-MAR 1993	YES	YES	YES	Electrical design and interface is completed for this equipment. Unit cost is $2,750. Schedule sensitive for test and start-up.
1	52	LOCAL CONTROL PANELS	YEKATIRINBURG	NO.411.SH	NOT AVAIL	51535.50	171.79	59	JAN-MAR 1993	YES	YES	YES	Electrical design and interface is completed for this equipment. Unit costs are $2,910 and $2975, respectively. Schedule sensitive for test and and start-up. 59 scheduled for delivery by first quarter 1993.
1	52		YEKATIRINBURG	NO.011.SH	7500.00	37500.00	125.00	42	JAN-JUNE 1993	YES	YES	YES	
1	53	INDUSTRIAL SEISMIC PROTECTION	NPP RESERACH IN YEREVAN,ARMENIA	NO.9209 15.06.92	1024.00	5120.00	17.07	2	APR-JUNE 1993	YES	YES		Orders placed for buy-outs. Given the seismic design for this plant, schedule disruption would probably occur.
1	54	CONTROL & MEASURING EQUP	RUSSIA	NO.1075	19.40	97.00	0.32	96%	JAN-MAR 1993	YES	YES	YES	Design complete for this equipment. Interface, characteristics, and size are issues that could require major design changes affecting schedule and price.
1	54	CONTROL & MEASURING EQUP		NO.504/10-92	1525.30	7626.50	25.42	96%	APR-JUNE 1993	YES	YES	YES	
1	54	CONTROL & MEASURING EQUP		NO.490/10-92K	4626.0	23130.00	77.10	97%	APR-JUNE 1993	YES	YES	YES	
1	54	CONTROL & MEASURING EQUP	GEORGIA	NO.2114/91K	42.90	214.50	0.72	30%	JAN-MAR 1993	YES	YES	YES	
1	54	CONTROL & MEASURING EQUP		NO.876/10-92K	81.70	408.50	1.36	100%	APR-JUNE 1993	YES	YES	YES	
1	54	CONTROL & MEASURING EQUP		NO.3103/91K	230.00	1150.00	3.83	32%	JAN-MAR 1993	YES	YES	YES	
1	55	SAPHIRE DEVICES INSTRUMENTATION, P-E	MANOMETER, RUSSIA	INPROCESS	2830.80	14154.00	47.18	213	MARCH 1993	YES	YES	YES	Design complete for this equipment. Interface, characteristics, and size are issues that could require major design changes affecting schedule and price.
1	58	220KV HIGH TRANSMISSION LINE INCLUDES:	TRANSFORMER ELECTROSHIELD RUSSIA	NO.357 01.01.91	78200.00	234600.00	782.00	2	JAN-JUNE 1993		YES	YES	One transformer is completed and is awaiting shipment. Second unit is scheduled to be completed by Mar-Apr '93. Cost is significantly higher in the west.

TABLE 3.4-1

LIST OF REMAINING MAJOR EQUIPMENT FOR HRAZDAN NO #5

COSTS ARE IN THOUSAND RUBLES AND DOLLARS

CATEGOR A	ITEM NO 1	DESCRIPTION 2	MANUFACTURER 3	CONTRACT # 6	EQUIPMENT NOT DELIVERED: PRICE AS ON 01.07.92 RUBLES 11	ESTIMATED PRICE ON DELIVERY RUBLES 12	ESTIMATED PRICE ON DELIVERY 300R = $) 13	DESCRIPTION & QTY OF ITEM NOT DELIVERED 14	SCHEDULE FOR EQUIPMENT TO BE DELIVERED 15	DESIGN	SCHEDULE	COST	REMARKS
2	24	VESSELS CAPACITY UP TO 75 CUM	ZAPOROJHE UKRAINE	NO 1	3408 00	10224 00	34 08	34/42 6	MAY 1993		YES	YES	Time needed for competetively bidding affects installation schedule. Western price is greater
2	38	SWITCHING PANEL	KANSAI, TADJIKISTAN	NO.235 06 05.92	131.69	171 19	0.57	.141	OCT-DEC 1992	YES	YES	YES	Cost benefit to evaluate design and competetively bid is outweighed by cost of panel and potential schedule delays.
2	44	RECEIVERS 80 CU M	UKRALKHIMMACH UKRAINE	NO.104/20 13.11.90	9124 42	11661.74	39.54	8	JAN-MAR 1993		YES	YES	Cost benefit to evaluate design and competetively bid is outweighed by cost of receivers and potential schedule delays.
3	27	NON STANDARDIZED EQUIPMENT	11 MFG'S OUTSIDE ARMENIA	BEING AGREED	50000 00	65000 00	216 67	1	JAN-JUN 1993	YES	YES	YES	Plant design for gas distribution system is completed. Significant design review would be required jeopardizing schedule and costs. There are 11 separate contracts for this system, none are greater than $100,000. Western cost estimated at twice CIS estimate
3	28	EQUIP. FOR CENTRAL STORAGE INCLUDES: MACHINE TOOLS	VARIOUS NS MFG'S ARMENIA	BEING AGREED	37873 86	49936 00	166.45	1	JAN-JUN 1993			YES	Comparable supply from west is estimated to be significantly higher
3	42	TRANSFORMER SUBSTATION	KHMEINITZKI UKRAINE	BEING AGREED	60 00	120 00	0 40	1	JAN-MAR 1993		YES	YES	Cost benefit to evaluate design and competetively bid is outweighed by cost of substation and potential schedule delays
3	56	ACCUMULATOR BATTERIES			50000 00	155000 00	516 67	1	APR-JUNE 1993				This item can be competetively bid.
3	57	CABLES: HIGH VOLATGES			500000 00	1500000 00	5,000 00	1322	OCT-DEC 1993				This item can be competetively bid

In general, for projects in an advanced stage of design and procurement such as Hrazdan Unit No. 5, the standard practice is to avoid design changes and/or major equipment substitution. Another important factor to consider when making procurement decisions is that Unit No. 5, including the equipment, has been designed to withstand a seismic event equivalent to 9 on the Richter scale. Consequently, equipment manufactured by a different firm would need to be seismically qualified, extending deliveries and increasing costs. Effective management of overall construction costs requires most changes to be carefully and thoroughly evaluated before implementing them. The benefit of changes in design and/or equipment must be weighed against their effect on schedule and cost. Given that the MEF needs Unit No. 5 to be operational before the winter of 1994-95, the construction schedule developed by ETIP to achieve this date requires the majority of equipment to be delivered to the site by September-October 1993. Two examples illustrate the process for reaching the decisions in this assessment:

1. Fans (item 4 in Table 3.4-1) were delivered without the required electric motors. Estimated cost for the motors is $7,401. Estimated delivery is first quarter 1993. The schedule, cost, and design are major considerations that affected the recommendation not to competitively bid this equipment. First, a thorough evaluation of all design parameters would need to be made. Second, assuming an equivalent motor with the same dimensions could be purchased, a specification and procurement package would need to be written for ICB. The cost for these steps and the resultant schedule delays in ETIP's opinion outweigh the potential benefit to be gained.

2. Approximately 75 percent of the high-pressure pipe, including associated valves and hangers, has been delivered to the site. The remaining 112.5 tons are

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scheduled for delivery to the site by the end of 1992. CIS design specifications for wall thickness are different than in the West. If bids were obtained from the West, for example, substitution would be necessary effecting efficiency, interconnections, schedule, and cost. The potential benefits of ICB in ETIP's opinion cannot be justified.

Existing orders for equipment should remain intact. Each order has been assessed for design, schedule, and/or price aspects to determine if existing orders should be cancelled and competitively bid. Cable and accumulator batteries can be competitively bid. Estimated cost in both cases is greater than EBRD's threshold of $200,000. The overall schedule (March 1993 start date) can support the time needed to competitively bid this equipment. Availability of cable and batteries in the NIS is low. The required designs are manufactured throughout Europe and the United States. The remaining purchase contracts that need to be placed can be handled under current supply practices.

3.5 STATUS OF WORKS (CONTRACTORS)

Hrazdan Unit No. 5 requires additional work from existing contractors to install equipment and complete the overall project. Table 3.5-1 identifies the scope of work, estimated cost, and source for financing of the major works. The costs for bulk materials are included in the individual works contracts. This table provides an assessment by ETIP for each subcontract involving foreign costs from the standpoint of design, schedule, and cost to determine if ICB is warranted. This information has been sorted into the categories established by EBRD.

Consumable materials such as welding rod and general construction materials such as staging lumber are in short supply in Armenia and

TABLE 3.5-1

LIST OF WORKS FOR HRAZDAN NO. 5

CATEGORY	CONTRACT SIGNED AND WORKSCOPE	CONTRACTOR COUNTRY	COST OF CONTRACTS IN 1991	WORK DONE UNTIL 1.09.92	EXPECTED AMOUNT TO BE PAID AS OF 1.07.92	AT TIME COMPLETION	ESCALATION 1.10630645 TOTAL	LOCAL COSTS RUBLES	FOREIGN COSTS RUBLES	FOREIGN $ COSTS $=400 RUBLES	DESIGN	SCHEDULE	COST	REMARKS
1	COORDINATION OF SUBCONTRACTS & CIVIL WORKS	ARMENIAN	49.30	85.61	421.36	1264.07	1,400.0	1,400.0	0.0					Local cost. Excavation is substantially complete.
1	INSTALLATION OF THERMAL EQUIPMENT	ARMENIAN	28.65	12.54	845.50	2236.52	2,470.0	740.0	1,730.0	$4.33	YES	YES	YES	Insufficient time to competitively bid and maintain schedule. Work started on boiler.
1	INSTALLATION OF MACHINE HOUSE, GAS PIPE	ARMENIAN	19.86	36.71	426.32	1278.70	1,410.0	1,410.0	0.0					Local cost
1	INSTALLATION OF ELECTRICAL EQUIPMENT & CABLES	RUSSIA	20.31	3.62	605.65	1816.94	2,010.0	0.0	2,010.0	$5.03	YES	YES	YES	Insufficient time to competitively bid and and maintain schedule. Expertise with plant & equipment is very important.
1	INSTALLATION OF STEEL COOLING TOWER	RUSSIA	8.88	32.45	33.46	100.37	110.0	0.0	110.0	$0.28		YES	YES	Majority of work is completed. Guarantees could be affected if subcontractor is changed. Lower mobilization cost.
1	GAS PIPELINE LAYING	ARMENIA	3.20	4.00	27.26	81.79	90.0	90.0	0.0					Local cost Substantially complete.
2	THERMAL INSULATION EQUIPMENT & PIPING	UKRAINE	7.80	0.47	283.19	849.58	940.0	0.0	940.0	$2.35			YES	Cost is significantly less than in the west.
2	CHEMICAL PROTECTION TECH. PIPELINE	RUSSIA	5.50	1.98	175.12	525.36	580.0	0.0	580.0	$1.45			YES	Cost is significantly less than in the west.
1	INSTALLATION OF CONCRETE STACK	RUSSIA	2.51	4.92	3.06	9.17	10.0	0.0	10.0	$0.03		YES	YES	Concrete stack completed. Steel liner needs to be completed. Cost is significantly less than west.
1	TRANSMISSION LINE	ARMENIA	10.10			695.80	780.0	780.0	0.0					Local cost.
	TOTAL SUB CONTRACTORS		156.10	182.29	2820.92	8858.31	9,800.000		5,380.0	$13.45				

RUBLES AND DOLLARS ARE IN MILLIONS

require importing. Substantial use of expatriate labor from other NIS republics is anticipated for skilled crafts. The recommended schedule (Section 8.0) includes about two months for mobilizing to accommodate these and related issues.

Existing orders for works should remain intact. Each order has been assessed for design, schedule, and/or price aspects to determine if existing orders should be cancelled and competitively bid.

Table 3.5-2 provides a breakdown of the remaining bulk materials needed for Hrazdan Unit No. 5 and the estimated costs. An assessment for these materials was also performed to determine whether ICB should be used. Two items, structural steel and yard pipe, are beyond EBRD's ICB threshold of $200,000. It is recommended these items should not be subjected to ICB for the reasons noted in the table. The general contractor and Hrazdan plant personnel agreed, however, to solicit more than one bid for all remaining materials.

3.6 SELECTED PROCUREMENT ISSUES

The following identifies several procurement issues to be considered for the completion of Hrazdan Unit No. 5.

Power block equipment and many long-lead items such as the condenser are now at the site. The MEF's anticipated delivery schedule for remaining equipment supports the planned construction effort. Lead times for the equipment appear reasonable. Physical and price contingencies have been factored into the cost estimate (Section 6.0). Four particular issues for this project - payment, traffic and expediting; quality control; and, communications - have a direct effect on the project schedule and cost:

TABLE 3.5-2

ESTIMATE OF CONSTRUCTION MATERIALS NEEDED FOR HRAZDAN NO.5

DESCRIPTION	UNIT	QUANTITY TO GO	ESTIMATED COST	COST TO GO LOCAL	COST TO GO FOREIGN	DESIGN	SCHEDULE	COST	REMARKS
REBAR	MT	200	$80,000	$80,000	$0				Local source
STEEL COMPONENT	MT	2,600	$1,040,000	$0	$1,040,000		YES	YES	Time needed to competitively bid could jeopardize schedule. Western costs greater than CIS.
CEMENT	MT	5,600	$140,000	$140,000	$0				Local source
GLASS SHEETS	SQM	12,000	$48,000		$48,000			YES	Hrazdan personnel will obtain competitive quotes
FLOOR COVERING	SQM	4,000	$28,000		$28,000			YES	Hrazdan personnel will obtain competitive quotes
WALL COVERINGS	SQM	3,000	$30,000		$30,000			YES	Hrazdan personnel will obtain competitive quotes
ELECTRODES	MT	200	$140,000		$140,000		YES	YES	Time needed to competitively bid could jeopardize schedule. Western costs greater than CIS.
STEEL PIPES (UP TO 159 MM DIA)	MT	300	$378,000		$378,000		YES	YES	Time needed to competitively bid could jeopardize schedule. Western costs greater than CIS.
TOTAL			$1,884,000	$220,000	$1,664,000				

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1. Payment. Current economic conditions in the NIS and Armenia require advance payments to most manufacturers for the purchase of fabrication materials. Full payment is also required prior to shipment of most equipment. Progress payments can help to ensure equipment will remain dedicated for Hrazdan and reduce escalation risk. Low-pressure pipe, for example, requires a payment to the mill for the materials needed and for delivery to the pipe fabricator. Until this payment is made prices continue to escalate and no manufacturing takes place.

2. Traffic and Expediting. Traffic disruptions are frequent. Armenia is a landlocked country. Currently, Georgia to the north is experiencing civil unrest. During ETIP's effort, for example, 300 meters of the only open natural gas pipeline to Armenia was destroyed and, although repaired, this episode disrupted gas supplies and exacerbated the energy problem. Such an event can be repeated. Political relations with Azerbaijan to the east are strained and conflicts continue. Relations with Turkey to the west are unsettled. Finally, trade with Iran to the south is limited. Given these factors, Armenia's ability to receive goods in a timely manner is a concern with obvious implications for project completion.

3. Quality Control. Since payment generally precedes the delivery of equipment, selected source inspection points at key production and/or

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test operations would help ensure the equipment complies with the procurement documents. Source inspection also assists with timely identification of problems in manufacturing so that the effects on the construction schedule are reduced.

4. Communications. Communications which are generally efficient and dependable in the west are less so in Armenia. Thirty-six railcars containing the ductwork for the boiler, for example, are enroute from the north to Hrazdan. The status and location of these items are unclear except that delivery cannot be made until the rail lines in the north are open. The local phone lines are not always open. Using dedicated telephone lines, such as AT&T, if available, requires hard currency that is not always available. Plant personnel are faced with making decisions without the full benefit of current and accurate information.

Measures to help ensure the timely delivery of equipment and reduce escalation should be implemented and were discussed with Hrazdan personnel, MEF officials, and EBRD. Methodology and document formats to facilitate decision making were also provided to Hrazdan personnel and MEF officials. These include:

1. Rank remaining equipment relative to its importance to the construction schedule, overall cost, and anticipated time for manufacturing and shipment.

2. Obtain key manufacturing operations and the schedule for the equipment from the manufacturer.

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3. Consider different negotiating strategies for determining prices, schedule, and performance with equipment manufacturers and subcontractors. These might include: hard currency in lieu of Rubles; indices for escalation; performance guarantees; and, incentives and liquidated damages for schedule and performance.

4. The MEF should consider requesting a portion of the loan be considered for retractive financing. This could expedite withdrawals against the loan and facilitate advance payments to equipment manufacturers and subcontractors. Setting up a local account to process smaller payments more quickly is also recommended.

5. Develop a payment plan that ensures advances are given for the highest ranked equipment.

6. Maintain close coordination of shipping options including air freight; consider temporary warehousing off-site for possible consolidation of shipments.

7. Upgrade communication equipment and services.

8. Open regular, and systematic communication with the manufacturers, including timely plant visits, to verify product quality and schedules.

The methodology and results of ETIP's assessment of procurement and contract administration actions and completion status were reviewed with Hrazdan personnel, Ministry officials, NIS/TF, USAID/Yerevan, R&D/EI, EBRD's appraisal team in Yerevan, and, with EBRD's Procurement Manager in London. The general consensus is consistent with the recommendations provided in this report. It is anticipated the EBRD loan appraisal team will request a waiver from

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their procurement policies that require equipment and works to be competitively bid.

4.0 ENVIRONMENTAL CONSIDERATIONS

This section discusses environmental considerations related to the completion of Unit No. 5 of the Hrazdan Power Plant. Each environmental issue is considered in terms of regulatory requirements, Unit No. 5 development and its relation to the existing power plant and shared facilities, and other potential issues which may require attention.

4.1 PROJECT DESCRIPTION

Unit No. 5 is a 300 MWe supercritical plant which will be gas-fired. Boiler conditions include: high pressure steam of 1,000 tons/hour, temperatures of 545°C/542°C, and pressure of 255 kg/cm^2. Units 1-4 consist of four boilers including Unit 1 (200 MWe), Unit 2 (200 MWe), Unit 3 (200 MWe) and Unit 4 (210 MWe) (Figure 4.1-1). Unit No. 5 is the first of four planned supercritical 300 MWe boilers. Power generated from the plant will be transmitted over a 71 km, 220 kv transmission line paralleling the existing 220 kv transmission line from Hrazdan to Yerevan. The project will include makeup water from the Hrazdan Reservoir to augment existing makeup water from the Marmarik River. Water from the new intake will be conveyed by a 10 km pipeline to the plant. The project includes a new 270 meter stack which will collect flue gasses from Units 1-4 and Unit No. 5.

In addition to the electric power plant, the Hrazdan Plant site includes a four unit thermal plant which is used to generate steam and electricity. This plant consists of two 50 MWe boilers (Units 1 and 2) and two 100 MWe boilers (Units 3 and 4) which combined produce 560 gigacalories/hour and 300 MWe. This plant was completed in 1966 and provides steam for district heating.

The existing plant is situated adjacent to the city of Hrazdan, Armenia, with a population of approximately 80,000 people. Both plant and community are located in the Hrazdan River valley which

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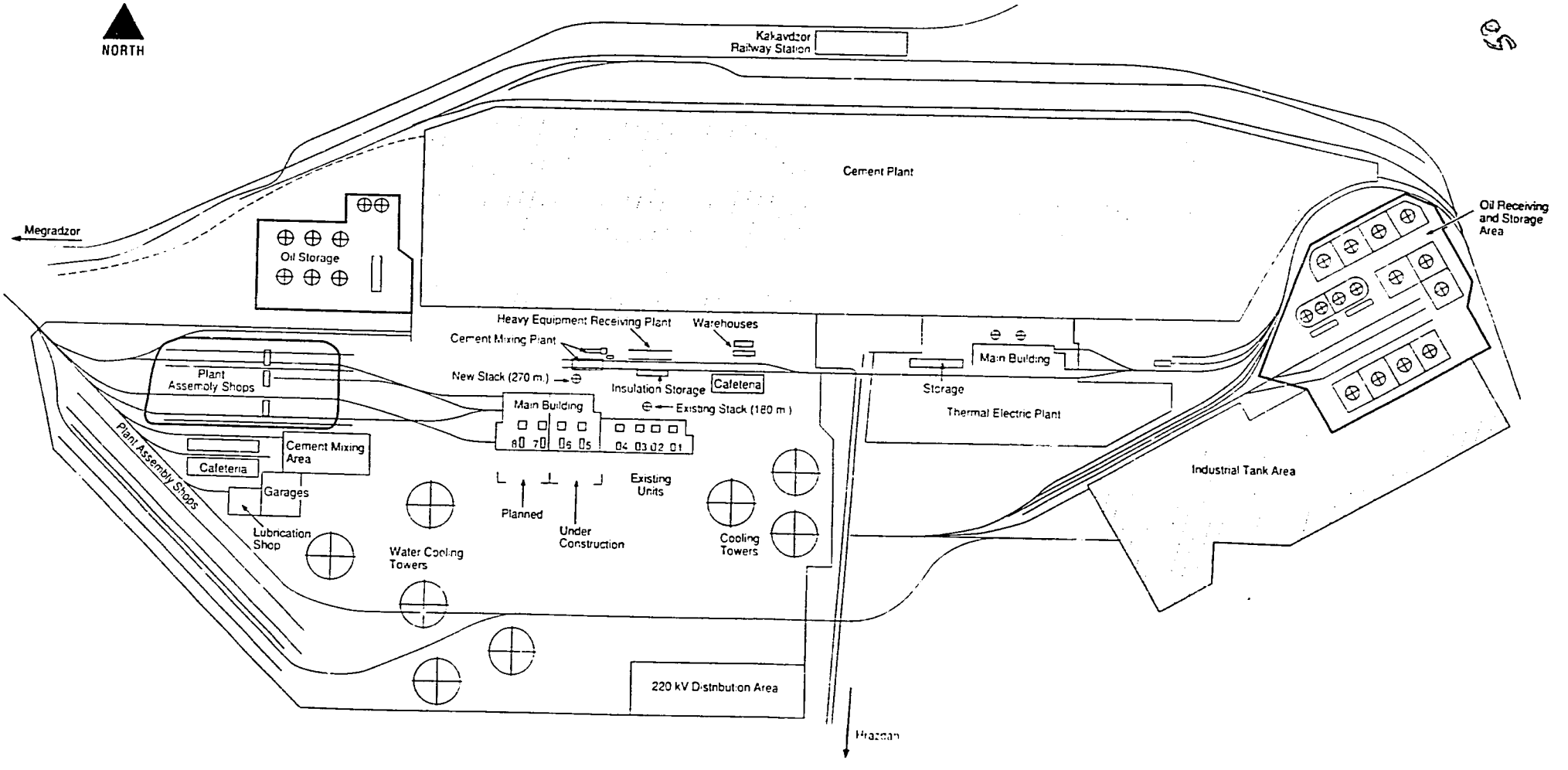

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Figure 4.1-1 General Site Arrangement for the Hrazdan Power Station

is the confluence of the Marmarik and Hrazdan rivers. This valley has local relief of approximately 500 meters and is at elevation of 1,720 meters above sea level. The adjacent uplands have thin soils and are sparsely vegetated with grasses and low shrubs. On the better watered north facing slopes, deciduous woodland vegetation prevails. The climate is typical of interior upland conditions with cool summers and cold winters. Maximum monthly temperatures of 33°C occur during the months of July and August and minimum monthly temperatures of -33°C occur during the months of January and February. Average annual rainfall is approximately 700-800 mm with maximum rainfall during the months of March and April. Limited land is farmed and grazing and livestock raising predominate. Vegetable farming and dairying occur along the two river valleys.

Geologically the lowland areas consist of Recent and Quaternary deposits of sands and gravel which thicken from the uplands to the river valleys. The uplands consist of Lower Quaternary volcanics, Tertiary intrusives, and some metamorphic schists. Hydrologically, the surface and subsurface flow of water is from north to south across the site. Groundwater is at 9 to 10 meters.

The project is planned for resumption in March 1993 and is forecast to be completed in December 1994. Construction manpower peak will occur in 1993 at a level of 2,500 workers.

4.2 AIR EMISSIONS

Air emissions for power plants and other stationary sources are regulated by the Republic of Armenia Ministry of Nature and Environmental Protection. Currently the standards of the former Soviet Union apply and were the basis for the design of the current Unit No. 5 as well as subsequent Units 6, 7, and 8. In planning for the Hrazdan expansion the intent was to use the new, more efficient units as the baseload capacity and to use the older Units 1-4 as peaking units. All units will be gas fired and oil would be used only as a supplemental fuel. With gas as the primary fuel,

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only NOx will be a major emission constituent. The boiler design provides a NOx emission source guarantee of 200 mg/m^3 which is well below the proposed European Community standard of 350 mg/m^3. However, during the planning of Unit 5-8 expansion provision was made to anticipate more stringent NOx control requirements by the addition of ammonia injection and space for gas recirculation equipment in the boiler to reduce NOx emissions to 60 mg/m^3 burning gas.

MEF's long range plans for the completion of the Hrazdan Plant include using Units 5-8 (4-300 MWe) as base load units and using Units 1-4 as peaking units. This plan is intended to reduce overall emissions from approximately 87,000 tons per year to 59,000 tons per year by 1995 and to 40-45,000 tons per year by 2000. Table 4.2-1 reflects current and projected emissions and emissions reductions for both the thermal plant (Units 1-4) and the electric power plant (Units 1-8).

Air emissions are monitored using mobile equipment. Emission levels for the plant are measured and reported regularly to the Ministry of Nature and Environmental Protection and local officials. The plant does not have a continuous emissions monitoring system.

One kilometer from the existing plant is a 700 ton/day cement plant which has two 20.5 ton/hour oil-fired boilers. Particulate emissions are controlled by electrofilters (electrostatic precipitators). These are designed for 90% removal of ash. However, controls appear to be insufficient, since high particulate loading to the atmosphere is constant during plant operation. The plant is planning to install cyclone filters ahead of the electrofilters to reduce or control emissions. Emissions remain confined to the Hrazdan vicinity and locally blanket the plant with cement dust. Plans to close the cement plant were stopped as

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Table 4.2-1

EXISTING AND PROJECTED HRAZDAN
PLANT EMISSIONS FOLLOWING EXPANSION
(tons/year)

Item	Existing		Projected[1]	
	Thermal Units[2]	Elect. Units[3]	Thermal Units	Elect. Units[4]
1. SO_2	14,700	37 600	940	22,870
2. NO_x	5,600	7,360	1,790	5,990
3. CO	5,800	14,000	5,090	2,970
4. Particulate	530	1,340	30	820
S/T	26,630	60,300	7,850	32,650
Total	86,930		40,500	

Notes: (1) 95% gas and 5% oil fuel for all units. (2) Thermal plant produces 300 MWe. (3) Electrical plant produces 1,110 MWe. (4) Expansion will add 4 - 300 MWe units.

a result of the 1988 Armenia earthquake in order to meet the demand for cement by reconstruction projects.

A new 270 meter stack has been constructed to replace an existing 180 meter stack at Hrazdan Plant. All flue gasses from Units 1-4 plus Unit No. 5 and the subsequent new units 6-8 will flow to this stack.

Discussions with the Ministry of Nature and Environmental Protection affirmed their support for the project provided natural gas was the primary fuel. However, they noted that when oil is used as a fuel, the power generation levels should be reduced to lower net emissions. The Ministry welcomed the introduction of newer, more efficient units and suggested using the older units only when necessary.

4.3 SOLID AND LIQUID WASTES

The solid and liquid wastes from Unit No. 5 will be handled by existing treatment/disposal systems in an environmentally sound manner. Expansion of these systems is not expecte to be necessary. Because the primary fuel will be gas, the solid or liquid wastes are not expected to be significant. Current capacities of the water and wastewater treatment system is sufficient to handle Unit No. 5 and Units 6-8 as well. Table 4.3-1 identifies the current and planned treated wastewater discharges. The Marmarik River will receive some additional blowdown water, and the Hrazdan River will receive treated chemical cleaning wastewater. Figure 4.3-1 identifies the current water makeup and treated water discharge points for the plant. This includes discharges from Units 1-4 for the thermal plant, discharges from Units 1-4 for the electricity generation plant, as well as the treated discharges from the oil receiving and storage area on the eastern side of the Hrazdan Plant. Current treated wastewater discharges are 448.9 cubic meters/hour, and the added discharges will be 163.5 cubic meters/hour, or approximately a 36% increase.

Plant expansion may lead to the need for the expansion of the Hrazdan municipal sanitary treatment facility. (Section 5.0.) This facility currently serves the needs of the Hrazdan Plant and communities of Hrazdan (population 80,000) and Sevan (population 30,000). Expansion of this treatment facility will require consideration by the MEF.

Table 4.3-1

SUMMARY TABULATION OF WATER USE AND WATER DISCHARGES FOR EXISTING AND FUTURE UNITS AT HRAZDAN POWER PLANT (m^3/hr)

Make up Water				
Make-up Water Source	Units 1-4	Units 5-8	Change	
			Amt.	%
Marmarik R.	1,237.4	-	-	-
Hrazdan R.	0	256.0	256.0	+20
Treated Water Discharge				
Treated Water Discharge	Units 1-4	Units 5-8	Change	
			Amt.	%
Marmarik R.	35.5	14.5	14.5	+41
Hrazdan R. (west)	359.4	149.0	149.0	+41
Hrazdan R. (east)	54.0	0	0	0
	448.9	163.5	163.5	+36

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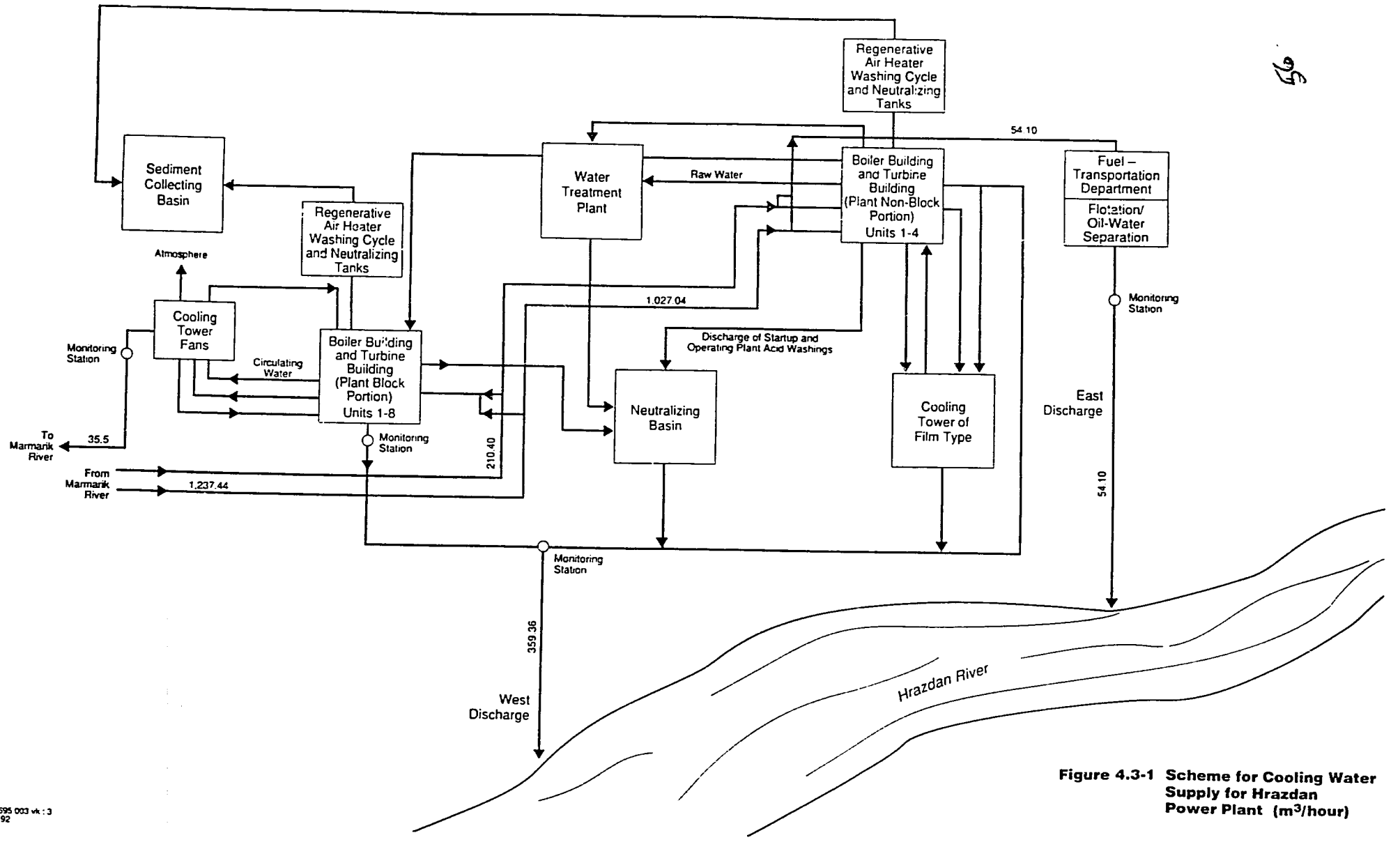

Figure 4.3-1 Scheme for Cooling Water Supply for Hrazdan Power Plant (m^3/hour)

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All wastewater discharges from the plant are monitored and treated prior to release. Agricultural wastes from livestock pens adjacent to the Hrazdan River are contributing to potential water pollution. Each discharge point was inspected as were the several treatment basins used in wastewater treatment, including the basin which receives boiler cleaning waste. Oily wastes are collected and transferred to the oil receiving and storage treatment facility. Oil-water separation is used, and sludges are incinerated. Currently, oily sludges at Units 1-4 are being collected and retained at the plant.

In discussions of the project, the Ministry of Nature and Environmental Protection noted that the current plans are acceptable for Unit No. 5 expansion in terms of industrial wastewater treatment and control. However, plant projected sanitary wastes may exceed the limits of the Hrazdan municipal wastewater treatment facility, and plans should include plant expansion. The facility meets the current needs of Hrazdan (pop. 80,000) and Sevan (pop. 30,000). Plant capacity is 70,000 cubic meters per day and plant capacity should be increased by approximately 10,000 cubic meters per day according to the Ministry of Nature and Environmental Protection.

Provision for solid waste disposal is not an issue for Unit No. 5 expansion given the proposed fuel planned for the unit. Currently, solid waste volumes are small and provision has been made with the city of Hrazdan to receive solid waste at a municipal land fill 20 km from the plant. This facility was not inspected. The materials currently collected and disposed at this facility are not toxic or hazardous. However, in the event that the volume and/or toxicity of solid wastes might increase, some provision should be made to handle and dispose of them. This is not a project completion issue for either Unit No. 5 or for subsequent units given the fuel proposed for the unit. Precedents exist in Armenia wherein incinerators could be installed to dispose of potential hazardous wastes as required.

Because of the high water table and the high porosity and permeability of the site area soils, precautions should be taken during both construction and operation of the plant to protect ground and surface waters. This can be done through the use of liners at temporary solid waste disposal areas and the use of coatings for yard piping to prevent leaching of liquid wastes into the groundwater. Provision should be made to prevent spillage of transformer oil, oils or oily waste in general and similar liquid wastes and if such events occur, to quickly clean up the area to prevent potential ground and surface water contamination.

4.4 WATER SUPPLY

Unit No. 5 will require additional makeup water for the months of August, and December through February. This additional water will be obtained from the Hrazdan River near the Hrazdan Reservoir and conveyed approximately 10 km to the plant by an 800 mm pipeline. This will augment the water taken from the Marmarik River which is above the plant. Figure 4.3-1 illustrates current water requirements and discharges. Table 4.3-1 summarizes these flows in cubic meters per hour for Units 1-4 and for Units 5-8. Approximately 256 cubic meters per hour of added water will be needed for Units 5-8.

The new intake structure and pipeline will locally impact the Hrazdan River. The intake structure has been constructed but not tied into the river. Pipeline construction will parallel the Hrazdan River and will have one stream crossing. During construction, provision should be made to minimize impact on the aquatic and riverine environment.

Discussion with the Ministry of Nature and Environmental Protection suggested the need to depend more fully on the Marmarik River rather than draw water from the Hrazdan River. Repair of the Marmarik Dam would allow for added water removal from the Marmarik River.

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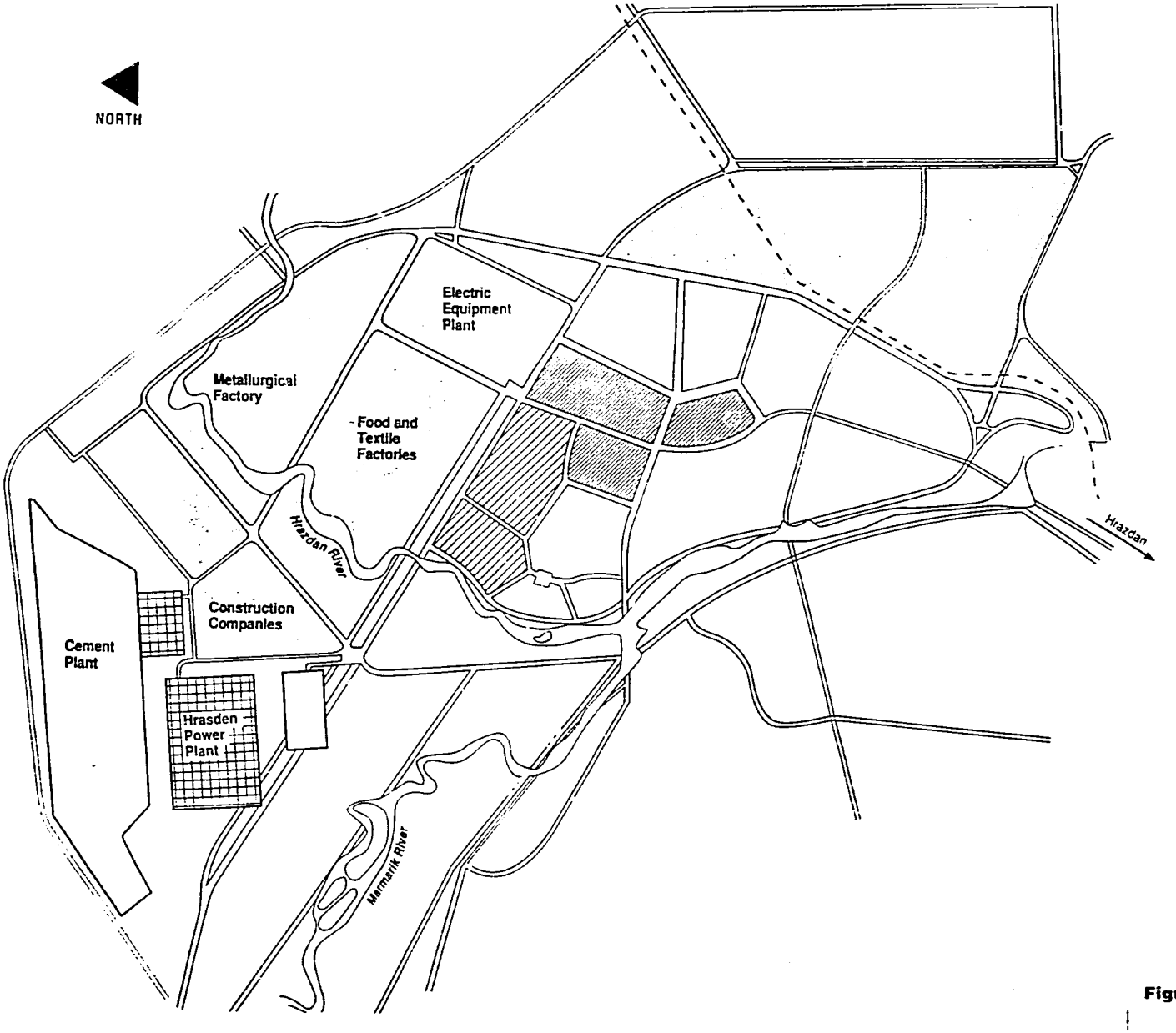
4.5 SITE HISTORY AND ENVIRONMENTAL LIABILITY

Review of records, historical land use maps, interviews with plant staff with responsibility for site development, and a site inspection suggests no issues of potential site environmental liability. Unit No. 5 and the existing units were constructed on the same site. This site was developed initially in 1961 as a large industrial complex which was intended to be used for chemical manufacture. Only the cement plant was included in this complex. Figure 4.5-1 is a map showing initial site planning for the chemical complex as well as the supporting power plants.

The initial thermal power plant consisted of four units and was devoted to the production of steam and electricity for the planned chemical plants. These thermal power plant units were completed in 1966. The site for Unit No. 5, as well as Units 1-4, was open land and was never used as a site for waste disposal, lagoons or ponds. It was developed as a site for the existing electric power units in the late 1960s. Units 1 and 2 were completed in 1971, Unit 3 in 1972, and Unit 4 in 1974. During the construction of these units construction wastes and debris were temporarily dumped on site. A complete walk of the site revealed no surface evidence of extensive waste disposal activity. However, at two locations fiberglass insulation and related debris have been dumped on site. Also one oil transformer stored at an equipment storage area has leaked oil onto the ground and should be cleaned up to preclude oil from affecting the groundwater. Provision has been made with the City of Hrazdan to allow the plant to dispose of such wastes at a municipal landfill 20 km from the site. However, the isolated dumping of solid waste on site is due to absence of gasoline for the transport of solid waste to the landfill area and general lack of enforcement of site disposal practices.



Legend

- Northern Part of the City
- Reserve Lands
- Existing Constructions
- Proposed (projected) Residential Buildings
- Industrial Area
- Hrasdan Power Plant

Sources

Drawing based on the following

a) Topographic records, by Armpromproject in 1962.

b) General plan of the city of Hrazdan, by Armprom in 1964, scale: 1:5000.

c) Locational plan of the Hrazdan Power Plant Site, by РОТЕП (ROTEP), drawing #92-10-07

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Figure 4.5-1 Hrazdan Plant and Vicinity Development Plan, 1966

The site walk included the examination of at least 450 meters of recently excavated trenches for the installation of project-related pipelines. These 1.8 to 2.0 meter deep trenches traversed several extensive cross sections of the site and provided a random sampling of near surface conditions. In no case did these trenches breach any relict landfill, waste dump and/or disposal areas. Inspection of the trenches revealed no collection of fluids, or waste from adjacent walls. In addition, a 9 meter deep dewatering pit near the cooling tower again revealed no evidence of waste and/or fluids in the gravel of the pit wall.

Absence of prior industrial land use and the absence of surface or near surface waste disposal areas or impoundments would suggest no potential environmental site liability. However, a groundwater sampling and monitoring program might be in order to demonstrate future compliance with ground and surface water protection requirements.

4.6 OCCUPATIONAL HEALTH AND SAFETY REVIEW AND RELATED ITEMS

The following addresses occupational health and safety and related items. These include emergency planning, and storage tanks.

4.6.1 Occupational Health and Safety

Occupational safety and health for the Hrazdan Power Plant is governed by the former USSR Instructions on Safety and Health. Responsibility for compliance with these instructions belongs to the chief engineer in safety who reports to the plant director. Operational compliance with the instructions belongs to the work area managers who are responsible for all aspects of safety and health for that work area. Each manager is responsible to have knowledge and training with any hazardous material, safety, and health considerations for the work area. The manager is also trained in first aid and emergency response procedures.

The chief engineer of safety monitors the entire facility for compliance with health and safety instructions. Violations are reported to the work area managers unless the violations are life threatening or serious. These are handled directly and reported to the manager. Work area managers who have more than the allowable violations are fined.

Contractors and subcontractors who perform work on the facility are required to abide by the safety and health requirements of the plant. The Hrazdan Plant has a site physician, a fire brigade, a security officer, and emergency response teams. Oversight is provided by a plant committee which is comprised of the plant director, chief engineer of safety, deputy directors, inspectors and other plant personnel designated by the plant director. This committee meets every three months to evaluate the condition of the overall facility. Action items are identified during the committee meeting which need to be addressed before the next committee meeting.

The fire brigade is a full time, on-site department. It is comprised of operative teams of twelve persons assigned to each team. There are also eight additional personnel assigned during the day for training and equipment maintenance. The fire brigade has five units (engines) of which one is a dry powder unit and one is a foam unit. Both units are primarily used in case of lube oil fires since the turbine-generator sets do not have deluge systems. Fire brigade personnel are required to pass minimum standards examinations every three years.

Emergency medical incidents are attended to by emergency response teams and the site physician. Work area managers are trained in first aid, as well as emergency response requirements, for hazardous materials used in their work areas. Training for the emergency response team members includes a minimum standards evaluation annually.

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Local occupational health and safety standards are generally not consistent with those practiced in the United States. Absent for construction personnel are head, hearing, foot, eye, back and fall protection measures. Improvement in standard safety practices pertaining to barricading open excavations, openings in floors and walkways, handrails around elevated work platforms, hoisting safety, and general housekeeping is warranted. Statistical records of worker injuries and illnesses are maintained and reported to the Ministry of Energy and Fuel and to the Labor Unions.

4.6.2 Emergency Plans

The Hrazdan Power Plant has an emergency plan which is for the facility only and is not coordinated with the local community except to advise them regarding plant chemical use. The local community is not provided information on chemical type and location. The plant uses only a limited amount of hazardous materials - mainly chemicals used for water treatment - as well as natural gas and oil used for plant fuel. Inadvertent spills of treated boiler water have been the object of emergency response efforts. In the past four years there has only been one fire which was extinguished before the fire brigade could arrive at the scene. The fire brigade averages two alarms annually.

The emergency plan places responsibility on the work area managers to manage emergencies in their areas. The managers have been trained in emergency procedures for materials used in the work area they manage. They will request assistance from emergency response teams and the fire brigade as required. The work area managers are also trained in first aid.

The emergency plan is coordinated and approved by the Minister of Energy and Fuel.

4.6.3 Oil Storage Tanks

The primary areas of tank storage are related to fuel oil storage and lubricating oil storage. All such areas were inspected. For the fuel oil storage areas the storage tanks are individually diked with sufficient containment to hold the contents of a full tank. There is a trench system at one end of the containment dikes area which collects significant amounts of oil leakage to a pump house where it is pumped to another storage tank. Containment dikes are sloped for drainage to this trench. There are no polyethylene liners or leak detection measures for these storage areas. However, each tank is placed on a concrete pad and leakage through the tank bottom will seep to the edge of the pad and can be visually detected. Each tank is drained and inspected for metal thickness at the top, sides and bottom every five years.

Soil that becomes contaminated with oil is removed and sent to the disposal site operated by the city of Hrazdan. At the main oil receiving and storage area there is some spillage of oil. Near this same facility is a six meter excavation associated with facility expansion, and oil has seeped to the bottom of this excavation and commingled with groundwater.

The lubricating oil storage area contains tanks in one diked area. The tanks are placed on piers with a bottom drain for each tank. This drain is for emergency purposes in case the tank develops a leak. The drainage from the diked area is conveyed to an oil-water separator where the oil is reclaimed. Currently, one side of the dike has been removed to allow for the enlargement of the area to accommodate more tanks. There is no automatic leak detection system installed at this facility.

4.7 CONSTRUCTION ACTIVITY IMPACTS

Project construction completion will impact the local community, but with some advance planning these impacts can be properly anticipated and managed. Unit No. 5 construction and operational

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staff levels are identified in Table 4.7-1. Total construction manpower will be 2,500 with peak manpower levels reached in 1993. The construction period will extend from March 1993 through December 1994. Maximum construction related impacts are expected during the months of June through August of 1993. Approximately 1,500 individuals will be expatriates from other NIS countries. As a result, temporary housing, subsistence and transportation will need to be provided for this expanded workforce. Other impacts may include increased traffic and community facilities impact. Finally, potentially higher wages earned by expatriate workers may contribute to local inflation of prices for food, fuel and housing.

Table 4.7-1

CONSTRUCTION AND OPERATIONAL
WORK FORCE FOR HRAZDAN UNIT NO. 5

<u>Construction</u>	
• Manual[1]	2,000
• Non-Manual	500
Total	2,500
<u>Operations</u>	
• Units 1-4	960
• Unit No. 5	600
Total	1,560

Notes: 1) Approximately 60% of the manual workforce will be expatriate workers from the other NIS countries.

Control of fugitive emissions from construction activities should be given priority, as well as measures to assure that construction-

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related solid wastes are handled. The current practice of coating major piping at the site has led to commingling of pipe coating materials with groundwater.

4.8 TRANSMISSION LINE VISUAL ASSESSMENT

The Hrazdan-Yerevan transmission line parallels the existing 220 kv transmission line. The new 220 kv transmission line is approximately 71 km long and will be supported on transmission towers which are 18 to 40 meters high. Existing transmission towers are of the same height. Tower height is established by the Rules of Arrangement of Electrical Installations, Ministry of Power of the USSR, Moscow, 1985. Minimum heights from the lowest point of line sag to the ground or building clearance for a 220 kv transmission line is seven meters for unpopulated areas, six meters for high terrain/difficult access areas, four meters for inaccessible mountainous areas, eight meters for populated areas, and five meters for buildings.

The easement for this transmission line expansion has been obtained from local jurisdictions through which the line will pass. The transmission line will cross one 330 kv transmission line, three 220 kv lines, seven 110 kv lines, five 35 kv lines, 30 10 kv lines, 24 overhead telephone cables, 12 asphalt coated roads, two electrical rail lines, and three gas pipelines.

Portions of the existing transmission line were inspected and photographed. The proposed transmission line expansion parallels other linear features including the main highway from Yerevan to Tbilisi, and the main railroad from Yerevan to Hrazdan. As a result, a major transportation corridor now exists and the incremental addition of the 220 kv transmission line is not judged to have a significant adverse environmental impact. Provision has been made in the design to consider minimum heights for the differing land uses along the transmission line. No environmental mitigation measures are suggested.

4.9 PUBLIC PARTICIPATION

Armenia provides for public participation concerning major projects. Planning and development for the Hrazdan Unit No. 5 have been done with extensive public participation. Current rules pertaining to public participation were enacted in July 1991 by the Republic of Armenia as part of their environmental policy. Initial planning for Unit No. 5 was in 1989 and predates this law. However, the planning and development for Unit 5 actively involved the local and regulatory community.

Relations with the local community have varied over time. Some prior criticisms of the plans for Unit No. 5 have been addressed, and overall the community appears to be supportive of the project. Proactive response to community concern is evidenced by two major project actions. The first was a complete reanalysis of the seismic design of the plant to assure the plant's ability to withstand a seismic level Richter 9 earthquake. This was done in response to the December 1988 Armenia earthquake. Secondly, the plant evaluated the air, water, and wastewater discharge criteria and limits to assure the local community of plant compliance with environmental rules and regulations. The latter effort included a five month effort of extensive technical work and monthly meetings for one year (1990) in the local community. Meeting attendees included local community officials, local political party representatives, and some project opponents. Provision was made to involve community health officials, representatives from the Ministry of Nature and Environmental Protection, the community Commission on Environmental Projection, and the Ministry of Health. Briefing documents were provided at these meetings. The plant manager (Director) and members of his key technical staff participated in the meetings, responded to questions, and provided information related to all issues discussed. Project impacts and necessary controls were discussed at these meetings. In 1991 there were no community meetings regarding the project. However, as recently as September 1992 a television program aired on the Unit No. 5 expansion. Technical specialists were interviewed and

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matters related to health, safety, and environment were discussed.

Discussions with the Ministry of Nature and Environmental Protection confirmed the regulatory history of the Hrazdan Unit No. 5 expansion and the associated regulatory reviews the project has received. The Ministry (Nature) remains in contact with Hrazdan Plant staff concerning environmental issues and will continue to do so.

5.0 ENVIRONMENTAL MITIGATION MEASURES

The Hrazdan Power Plant design was reviewed for the addition of potential environmental mitigation measures and costs for Unit No. 5 as well as for succeeding Units 6-8. The following describes the scope and estimated cost to expand the Hrazdan Municipal Wastewater Treatment Facility.

Expansion of the Hrazdan Power Plant may increase the flow of sanitary wastewater which must be treated by the Hrazdan Municipal Wastewater Treatment Facility. This facility currently serves the needs of Hrazdan (pop. 80,000), Sevan (pop. 30,000) and the Hrazdan Power Plant. The Ministry of Nature and Environmental Protection advises that plant capacity is 70,000 m^3/day and current flows are 55,000 to 63,000 m^3/day. Expansion of plant capacity to 80,000 m^3/day was recommended in 1989 at an estimated cost of 4.5 million Rubles. The design is complete but would require a detailed evaluation to finalize a project completion estimate.

A budgetary estimate for the completion of this expansion is $2.5 million which includes design review, procurement, construction, and startup costs.

This mitigation measure would enable the facility to meet current and future sanitary wastewater treatment requirements, provide for the temporary needs in this area for the expected large construction work force, and establish a long-standing positive relationship with the community of Hrazdan regarding the project's plans to mitigate both construction and potential plant operation impacts.

6.0 DESIGN EFFICIENCY IMPROVEMENTS

The design of Hrazdan Unit No. 5 was reviewed to identify potential design efficiency improvements. The following presents a description of the plant design features as currently designed, Unit No. 5 heat rate evaluation, and identifies selected design efficiency improvements which are possible should these units be used as non-baseload units. Current plans, however, will require baseload service from all new units. Regarding Units 6 through 8, it is recommended that gas turbine combined cycle (GTCC) systems be considered as an alternative to the existing design.

6.1 UNIT NO. 5 EQUIPMENT AND DESIGN DESCRIPTION

6.1.1 Boiler

The boiler is a type TGMP-344 AC which is a natural gas/residual oil fired, once-through, supercritical, leaktight unit, with single reheat, and balanced draft. The "design" (equivalent to maximum continuous rating) main steam capacity is 1,000 tons/hour, and design parameters are:

• main steam pressure	255 kg/cm^2 (ABS)
• main steam temperature	545°C
• feedwater temperature	274°C
• reheat steam flow rate	770 t/hr
• reheat steam pressure (inlet)	43 kg/cm^2 (ABS)
• reheat steam inlet temperature	310°C
• reheat steam outlet temperature	542°C
• reheat steam pressure (outlet)	40.5 kg/cm^2 (ABS)

The furnace is equipped with 16 gas/oil burners installed at 2 levels on the front and back walls. Residual oil is atomized by steam at 5 kg/cm^2. Feedwater desuperheater spray is used to maintain main steam temperature at 545°C for the boiler load range of 30-100%.

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Reheated steam temperature is maintained at 542°C for the boiler load range of 30-100% by flue gas recirculation. The recirculation is accomplished by two recirculation fans each having design flow rate of 265 x 10^3 m^3/hr and design pressure of 0.0665 kg/cm^2 (adjusted to the fan performance curve). Recirculation fan flow rate is controlled by adjustable guide vanes.

Combustion air is supplied by two 2-speed forced draft fans each having design flow rate of 591 x 10^3 m^3/hr and design pressure of 0.0677 kg/cm^2 (adjusted to the fan performance curve). Forced draft fan flow rate is controlled by adjustable guide vanes and by fan speed change.

Flue gas is exhausted by two induced draft fans (one is in operation, the second is redundant) each having design flow rate of 1729 x 10^3 m^3/hr and design pressure of 0.0466 kg/cm^2 (adjusted to the fan performance curve). Induced draft fan flow rate is controlled by adjustable guide vanes.

6.1.2 Turbine

The condensing steam turbine is a type K-300-240-3 which has a single shaft and 3-cylinders.

The "design" (equivalent to maximum guarantee point) turbine-generator output is 300 MW, and design parameters are:

- main steam pressure — 240 kg/cm^2 (ABS)
- main steam temperature — 540°C
- main steam flow — 939.6 t/hr
- total pressure drop at the reheater — 9.5%
- condenser pressure — 0.035 kg/cm^2 (ABS)

The turbine regenerative cycle contains the following items:

- steam seal cooler
- low pressure feedwater heaters No. 1, 3, 4 (surface)
- low pressure feedwater heater No. 2 (mixing)
- built-in drain cooler in feedwater heater No. 3
- deaerator with an operating pressure of 7 kg/cm^2, and a design capacity of 1,000 t/hr
- high pressure feedwater heaters No. 6, 7, and 8

Feedwater is normally supplied by one primary turbine driven feedwater pump, type AN-1135-340-1 with a design flow rate of 1137 m^3/hr and a design discharge pressure of 333 kg/cm^2. One motor-driven feedwater pump with a design flow rate of 600 m^3/hr is used as a back-up and during startup.

Turbine exhaust steam is cooled in the mixing condenser by circulating condensate from the Heller type cooling tower. Circulating condensate is supplied by 2 pumps with a design flow rate of 12,500 m^3/hr and a design discharge pressure of 2.35 kg/cm^2.

6.1.3 Makeup Water Treatment

The makeup water treatment facility is a conventional ion exchange demineralizer and contains clarifiers, mechanical (anthracite) filters, cation exchangers (2 stages), anion exchangers (2 stages), decarbonators, and mixed bed ion exchangers. An in-line condensate polisher is designed for iron removal using sulfonated coal bed filters and for demineralization using mixed bed ion exchangers with external regeneration of the resin. Polisher capacity is 800 t/hr.

6.1.4 Automatic Control System

The plant Automatic Control System (ACS) has three means (levels) to perform a continuous management function:

- Level One. This includes the basis for the control system and encompasses all equipment (boiler, steam turbine, cooling tower, heaters, etc.). Data is collected for all operating parameters, including pressure, temperature, flow, alarms, etc.

- Level Two. Both automated distributed control centers and a manual control center are identified. Included are microprocessing controllers as well as a startup system which sequentially controls boiler startup, steam turbine roll, feed pumps, steam flow, etc. This is a step-by-step program through the startup process.

- Level Three. Monitors, data collection, and information storage at this level. Information and system performance calculations are done including the monitoring of key parameters. System has back-up data storage capability.

6.2 UNIT NO. 5 HEAT RATE EVALUATION

The following is a preliminary heat rate evaluation for Hrazdan Unit No. 5. The heat rate is estimated using lower heating values as it is customary in Europe and the NIS. The result is a lower heat rate than expected if higher heating values are used. This evaluation is based on information provided by the MEF. The typical expected gross steam turbine heat rate at a design turbine-generator output of 300 MWe is calculated from the equation:

$$q_{T-300}^{GR} = \frac{Q_o}{N_T + N_{FWP}} kcal/kwh = \frac{588.9 x 10^6}{(300+11.65) x 10^3} = 1,888.7 \frac{kcal}{kwh}$$

where: Q_o = turbine thermal consumption = 588.9 x 10^6 kcal/hr

N_T = design generator output (max guarantee) = 300 x 10^3 kw

N_{FWP} = feedwater pump thermal capacity at nominal feedwater flowrate of 939.6 t/hr = 11.65 x 10^3 kw

Net steam turbine heat rate is calculated from the equation:

$$q_{T-300}^{NET} = q_{T-300}^{GR}\left(\frac{100+q_T^{AUX}}{100-e_T^{AUX}}\right)\frac{kcal}{kwh} = 1,888.7\left(\frac{100+0.1002}{100-1.81}\right) = 1925.4\frac{kcal}{kwh}$$

where: q_T^{AUX} = turbine building heating and hot water supply load = $0.59 \times 10^6 \times 100/588.9 \times 10^6 = 0.1002\%$

e_T^{AUX} = turbine auxiliary electrical load which includes 2130 kw for condensate pumps and other pumps and motors, 700 kw for cooling tower fans and motors, and 2600 kw for circulating condensate pumps, total of 5430 kw = $\frac{5430 \times 100}{300 \times 10^3} = 1.81\%$

Net unit heat rate is calculated from the equation:

$$q_{U-300}^{NET} = \frac{q_T^{NET}}{\eta_B^{GR} \times \eta_{TH \cdot ST}}\left(\frac{100+q_B^{AUX}}{100-e_B^{AUX}}\right)\frac{kcal}{kwh}$$

where: η_B^{GR} = gross boiler efficiency = 0.9393 on natural gas; = 0.9305 on residual oil. (Note: Gross boiler efficiency appears high in comparison with similar supercritical, single reheat boilers in the United States. Reason for the difference is that in the United States the practice is to use the higher heating value of fuel combustion in boiler combustion calculations. In Europe and in the NIS the lower heating value is used. It means that gross boiler efficiency above does not account for heat loss used to evaporate moisture in the fuel.

$\eta_{TH.ST}$ = thermal stream loss factor = 0.9895

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q_B^{AUX} = heat/steam losses associated with boiler operation = $12.48 \times 10^6 \times 100/588.9 \times 10^6$ = 2.12% on natural gas (no moisture in natural gas per the MEF information); = $31.97 \times 10^6 \times 100/588.9 \times 10^6$ = 5.43% on residual oil (1.5% moisture by weight in residual oil per the MEF information)

e_B^{AUX} = boiler auxiliary electrical load which includes 2240 kw for forced draft fans, 2230 kw for induced draft fans, 1136 kw for recirculation fans, and 900 kw for other pumps and motors, total of 6506 KW =

$$\frac{6506 \times 100}{300 \times 10^3} = 2.17\%$$

From the equation above, the typical expected net heat rate of the Hrazdan Unit No. 5 at design envelope conditions (base load of 300 MWe, condensate pressure of 0.035 kg/cm^2, and ambient temperature of 10°C) are:

- Natural Gas Firing $q_{U-300}^{NET} = 2{,}162.4$ kcal/kwh
- Residual Oil Firing $q_{U-300}^{NET} = 2{,}253.6$ kcal/kwh

To evaluate partial load impact on unit overall efficiency, the typical expected net heat rate was also calculated for generator output of 210 MWe as follows:

$$q_{T-210}^{GR} = \frac{422.45 x 10^6}{(210+7.7) x 10^3} = 1{,}940.5 \ kcal/kwh$$

$$q_{T-210}^{NET}=1,940.5\left(\frac{100+0.14}{100-2.33}\right)=1,989.6\ kcal/kwh$$

Natural gas firing @ 210 MWe:

$$q_{U-210}^{NET}=\frac{1,989.6}{0.936\ x\ 0.9854}\left(\frac{100+3.02}{100-2.31}\right)=2,267.6\ kcal/kwh$$

Residual oil firing @ 210 MWe:

$$q_{U-210}^{NET}=\frac{1,989.6}{0.9244\ x\ 0.9854}\left(\frac{100+6.91}{100-2.31}\right)=2,390.4\ kcal/kwh$$

This calculation reflects operational experience in the NIS with identical units; therefore, the heat rates above can be considered representative.

Based on U.S. Department of Energy Information Administration (EIA) document "Historical Plant Cost and Annual Production Expenses for Selected Electric Plants" review for several years (1986 - 1990), the operating heat rates (on a higher heating value basis) for several of the best United States supercritical units with single reheat (in the range of 300 - 800 MWe) average about 2,300 - 2,400 kcal/kwh for the natural gas burning units, and about 2,450 - 2,600 kcal/kwh for the oil burning units.

Considering that the operating plant heat rates identified above reflect a full range of partial loads and startup conditions during the year and that the Unit No. 5 net heat rates were calculated at 100% and 70% loads only, it is concluded that the overall efficiency of Hrazdan Unit No. 5 is comparable to the better performing units in the United States.

6.3 DESIGN EFFICIENCY IMPROVEMENTS

The Hrazdan Power Plant design was reviewed to identify potential design efficiency improvements for Unit No. 5. In general, Unit No. 5 design appears to have progressed to a point such that it

generally meets or exceeds the requirements of EC and US fossil power plant standards of good engineering practice and overall efficiency. The supercritical design quality of Unit No. 5 presents few significant opportunities for overall design efficiency improvement particularly when the unit is intended to be operated as a baseload unit.

Units 6 through 8 provide a better opportunity for design changes and efficiency improvements than Unit No. 5 since material procurement and equipment fabrication have not yet begun.

Because of recent advances in the gas turbine technology, ETIP recommends that GTCC system design be considered as an alternative to the current steam/electric system design for Units 6 through 8. GTCC units have a lower heat rate (higher efficiency) than conventional steam/electric units, lower capital cost, shorter construction schedule, and require a smaller footprint and less water. These advantages of GTCC units, as well as current socioeconomic changes in NIS, warrant a technical and economic reevaluation of Units 6 through 8.

Recent experience in the U.S. indicates that the heat rate for the GTCC units ranges from 1800-2050 kcal/kwh (on a higher heating value basis) at an installed plant cost of about $720 per kw. The fixed O&M cost is about $3.7/kW/year and variable O&M cost is about $3.3/MWh.

The following describes the evaluation and results, and identifies possible improvements should Unit No. 5 operate as a non-baseload unit.

6.3.1 Evaluation

Unit No. 5 was evaluated for possible design efficiency improvements and none were found for a baseload unit. Four possibilities were identified for non-baseload operation including

improvements to the boiler, the steam turbine, selected pumps and fans, and instrumentation. These are described as follows:

Boiler Efficiency. Improvements in boiler efficiency are possible by sliding pressure operation which provides for variable pressure over the load range of a supercritical boiler. In this way the main steam and reheat steam temperature are maintained at rated values through the regulation of pumping and firing rate which together with reduced pumping power improves the heat rate. This system requires extensive furnace wall tubing redesign to minimize temperature transients.

Steam Turbine Efficiency. Improvements in steam turbine efficiency and cyclic life expanditure are possible by variable throttle pressure operation. During load changes variable throttle pressure eliminates throttling with the turbine control valves and associated turbine metal temperature changes/thermal stresses. It offers partial load heat rate gains since the rated superheater outlet steam temperature reaches the turbine at the extended load range. This heat rate improvement can be achieved with conventional constant pressure once-through boiler design by means of installing full capacity pressure reducing valves in the boiler superheater and reheater outlet.

Pumps and Fans. Improvements in pump and fan efficiency are possible by utilizing variable speed operation which offers the most efficient way of handling part load requirements. At reduced speed, both flow and pressure decrease, and input power varies according to the speed cubed. This is a much more efficient method of flow control than using valves or adjustable guide vanes (for fans), which waste energy and increase heat rate.

Instrumentation. Some areas of improvement in plant instrumentation were identified including:

- More accurate primary sensors for measuring flue gas constituents (O_2). Oxygen content in flue gas is measured to provide correct excess air (typically 3% O_2) through modulation of the forced draft fans. Too much excess air will contribute to lower boiler efficiency and can be reduced by means of more accurate measurement.

- More accurate furnace pressure measurement. Typical practice is to modulate induced draft fan flow to achieve a slightly negative pressure in the furnace. More accurate furnace pressure sensors can reduce wasted ID fan horsepower.

6.3.2 RESULTS AND ESTIMATED COSTS

As a result of this evaluation the conclusion was reached to recommend no changes to Unit No. 5. This is based on the fact that Unit No. 5, as well as Units 6 through 8, would be a baseload unit and none of these items would apply. However, ETIP has developed estimated costs for the supply and installation associated with each of these items should they be considered for implementation in the future.

Table 6.3-1

DESIGN EFFICIENCY IMPROVEMENTS AND ESTIMATED COSTS FOR THE HRAZDAN POWER PLANT*
(per unit)

		Cost $1,000
1. Improvement for Boiler Efficiency		
Redesigned furnace wall tubing system based on vendor input/each boiler		$5,000
2. Steam Turbine Improvement		
Use pressure reducing system including:		
• 4 shutoff valves	$400	
• 2 sets pressure reducing valves	$400	
• 2 sets reducing valves	$200	
• Piping and instrumentation	$300	
		$1,300
3. Improvements in Pump and Fan Efficiency		
Use variable speed motors:		
• 2 circ. water pumps	$200	
• 2 FD fans	$200	
• 2 RC fans	$200	
• 2 ID fans	$200	
		$ 800
4. Improvements in Plant Instrumentation		
Flue gas composition measurement and furnace pressure measurement	Allow	$ 400
TOTAL		$7,500

*Primarily applicable to a non-base load unit.

7.0 COMPLETION COST ESTIMATE

An assessment of the remaining costs for completing Hrazdan Unit No. 5 was made. This assessment included: an analysis of the current MEF and EBRD consultants' project completion cost estimate; an evaluation of the remaining costs; identification of additional cost items to be included in the overall project completion cost estimate; physical contingencies; and, escalation. Included in this assessment and in the ETIP project completion cost estimate are the 71 km high-voltage transmission line and the supplemental makeup water intake structure and 10 km pipeline.

Table 1.6-1 in Section 1 provides a summary of ETIP's Unit No. 5 project completion cost estimate. Table 1.6-1 is based on the MEF estimate dated July 1992. The MEF estimate is based upon cost estimates from the majority of equipment manufacturers and subcontractors. Included in their estimate is anticipated escalation for equipment/works costs at the time of delivery/ installation. A review of the project scope and remaining costs was subsequently performed by ETIP. As a result of this review, items were added to the MEF July 1992 estimate to cover the entire scope for project completion costs. A comparison to and reconciliation with the EBRD consultants' cost estimate is also provided.

The following describes the components of the cost estimate including qualifications, approach, exclusions, escalation, and contingency analysis.

7.1 QUALIFICATIONS

The development of the project completion estimate includes a number of qualifications. The following items were reviewed and assessed in developing ETIP's cost estimate:

Table 7.1-1

HRAZDAN POWER PLANT UNIT NO. 5
RECONCILIATION WITH MINISTRY/BECHTEL ESTIMATE
AND ALSTON/VAVRIK ESTIMATE

(Dollars $ Million)

Description	Alston Estimate	ETIP Estimate
A. Total Base (Mid/92)	$44.41	$47.54
B. Additional Cost		0.59
C. Suggested Added Cost		5.6
Subtotal Cost	$44.41	$53.73
Contingency/Escalation		
Physical	$ 4.40	6.98
Price	$19.50	29.02
Total Project Cost on Completion	$68.31	$89.73

Note: Line item A, Total Base (Mid/92)

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1. MEF July 1992 Estimate and EBRD consultants' (Alston/Vavrik) Estimate which was completed prior to ETIP's evaluation (Table 7.1-1)

2. Reconciliation of EBRD consultants' estimate with the ETIP estimate (Table 7.1-2)

3. Appropriate project documents including the equipment list

4. Project-supplied information on subcontractor unit prices, subcontractor unit manhour development, total bulk quantity development, physical completion of work, schedule of major equipment, procurement status of equipment, remaining work for subcontractors, subcontractor work practices, on-site equipment conditions, skilled labor availability, and manual wage projection including all benefits

In addition, extensive walkdowns were conducted at the existing plant (units 1-4), at Unit No. 5 and in the area where Unit No. 6 would be constructed. General comparisons were made concerning plant operation and maintenance and environmental control practices for operating units 1-4 and similar plants in both the United States and Bulgaria. The equipment and material storage and laydown areas were inspected and materials tracking procedures examined. Also, the intake structure area and proposed transmission line route were examined. The construction status for Unit No. 5 was documented with photographs (Appendix C) and field notes were reviewed.

7.2 ESTIMATE DEVELOPMENT APPROACH

The estimate development approach included the use of 100 rubles to the dollar to convert the MEF July 1992 estimate, and the use of 300 rubles to the dollar to convert the MEF completion estimate. In addition, the breakdown of material percentage and labor percentage for subcontracts was based on MEF supplied data.

In addition the estimate scope includes some off-site components such as the supplemental makeup water pipeline and intake structure, the cooling tower pipeline, duct work to tie Units 1-4 as well as Unit No. 5 to the new stack, and the power transmission line.

Part of the development of the ETIP estimate was the general comparison with current experience in the design and construction of gas-fired power plants in the United States. In general, a 300 MWe plant in the United States will cost $263.0 million. The base United States generic plant was used as a basis for comparison with the Hrazdan Plant. This comparison recognized that the boiler and turbine generator were purchased. The resultant estimate as reflected in Table 7.1-2 is the remaining cost of the plant. In addition, but not considered in the United States base estimate was the high seismic design considerations which are now a part of the Hrazdan Plant design to withstand a Richter 9 earthquake including major structures, systems and equipment. This would typically increase the base cost of a United States plant at least 20 to 30%.

7.3 EXCLUSIONS

The project completion estimate reflects the following exclusions:

1. Owner's management, administration and other direct expenses.

2. Owner's development, financing and interest charges.

3. Local sales tax, import duties, in-country income taxes, and customs expenses.

4. Utilities and services furnished by plant and consumed during construction.

5. Startup and operational expenses subsequent to achieving provisional plant completion.

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Table 7.1-2

HRAZDAN POWER PLANT UNIT NO. 5
DETAILED PROJECT COMPLETION ESTIMATE
(Dollars $ Million)

Description	Alston Estimate	ETIP Estimate
A. Base Estimate(1)(Mid/92)		
Equipment Contracts	$15.51	$17.04
Sub Contracts (incl. materials)	$27.20	$28.20
Transmission Line	$ 1.70	$ 2.30
Subtotal Base	$44.41	$47.54
B. Additional Cost		
Redistribution gas pipe line	Not incl	$ 0.05
Waste water disposal sys - allow	Not incl	$ 0.01
Misc. small subcontracts - allow	Not incl	$ 0.01
Duct work for 1,2,3,4,&5	Not incl	$ 0.26
Refurbishing of on site equpt.-allow	Not incl	$ 0.01
Construction support - allow	Not incl	$ 0.10
Foreign subcontractor's per diem		incl/w subcont
Startup & Performance testing		incl/w subcont
Field Engineering		incl/w subcont
Design and other support		incl/w subcont
Project Management		incl/w subcont
Refinancing of Outstanding Loan (Boiler & Turbine only)	Not incl	$ 0.15
Subtotal Additional Cost	0	0.59
C. Suggested Additional Cost		
Expat Construction Management and Procurement Support (2)		$ 4.80
Design Improvement Costs Allowance		$ 0.80
Subtotal "C" Cost	0	5.6
Subtotal Cost	$44.41	$53.73
Physical Contingency	4.40	6.98
Price Escalation Up to Completion	19.5	29.02
Total Project Cost on Completion	$68.31	$89.73

(1) Includes tax (28%) and freight (14%)
(2) EXPAT @ 15 men x 16 months @ $20,000/month

6. Project insurance.

7. Foreign exchange risks beyond estimate assumptions.

7.4 RELATED CLARIFICATIONS

The project completion estimate includes the following clarifications related to project engineering services, field and startup services, equipment, materials, and subcontracts.

1. Project Engineering Services. Remaining project engineering costs are based on input provided by the Rostov Design Institute consultant and are estimated to be 54 million Rubles.

2. Field and Startup Services. Field and startup services including field supervision and startup costs are included in the subcontract packages.

3. Equipment and Materials. Remaining equipment costs have been identified and described by the MEF. A sample of awarded purchase orders were reviewed for required allowances for potential scope growth changes. Adjustments either upward or downward have been made. The remaining quantities have been reviewed and the completion status determined on that basis.

4. Subcontracts. Major contracts and subcontracts have been awarded. A sample of awarded contracts were reviewed for required allowances for potential scope growth changes. Adjustments either upward or downward have been made. The bulk quantities to be purchased were assessed and compared with current experience and adjusted as required.

5. Design Improvement. Unit No. 5 is a relatively efficient unit and design efficiency improvements are not envisioned nor recommended. However, in the normal course of plant startup and initial operation of Unit No. 5, various minor, but important measures can be taken to improve plant performance and efficiency. This normal design growth or plant betterment may include addition of different insulation for steam lines, addition of short piping runs, replacement of small valves, relief valves, changes of gaskets, or related changes to regulate steam flow and improve plant performance.

7.5 ESCALATION AND CONTINGENCY

Escalation was based on the use of 20% escalation from mid-1992 assuming the center of gravity of subcontract expenditures for 18 months. For equipment and materials, 60% has been added to the mid-1992 price in order to cover expected prices reached by mid-1993.

Contingency is calculated on materials and labor. Equipment and materials have been assigned a 10% physical contingency and labor and all other indirect costs reflect a 20% contingency (Table 7.5-1).

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Table 7.5-1

HRAZDAN POWER PLANT UNIT NO. 5
BECHTEL ESTIMATE CONTINGENCY ANALYSIS
(Dollars $ in Millions)

Description	Factor	Total	Material	Labor
A. Equipment		$17.04	$17.04	
Subcontracts		28.2		
Materials	60%		16.92	
Labor + Indirects	40%			11.28
Transmission Line		2.3		
Materials	80%		1.84	
Labor	20%			0.46
B. Added Cost		0.59		
Materials	30%		0.18	
Labor	70%			0.41
C. Suggested Cost		5.6		
Materials	30%		1.68	
Labor	70%			3.92
Total Cost		$53.73	$37.66	$16.07
Physical Contingency %			10%	20%
Contingency $			$ 3.77	$ 3.21
Total Contingency				$ 6.98

Escalation

Per MEF input, local/NIS suppliers are increasing prices at the rate of 100% - 150%. But by mid-1993 price expected to stabilize to mid range as Ruble stabilizes against the dollar.

Use equipment plus material multiplier of 60%.

Local/expatriate labor cost @ 20% per year.

Equipment + Materials	$37.66	60%	$22.59
Labor	16.07	40%	6.43
Total Escalation			$29.02

8.0 PROCUREMENT AND CONSTRUCTION SCHEDULING

8.1 METHODOLOGY

The evaluation process used for the Hrazdan Unit No. 5 procurement and construction schedule entailed three steps.

1. Evaluate existing plans and systems used for forecasting and controlling cost and schedule.

2. Evaluate Hrazdan Plant's proposed 21 month completion schedule for Unit No. 5 including review of current project status, evaluation of completion requirements, and development of a proposed completion schedule.

3. Evaluate procurement schedule.

8.2 SCHEDULING METHODS AND CONTROLS

8.2.1 Schedules

Hrazdan Plant, Unit No. 5, utilizes a hierarchy of schedules which is similar to ETIP experience for similar projects. This hierarchy includes the following three levels:

Milestone Summary Schedule. This is an overall summary schedule that highlights the main activities of Hrazdan Unit No. 5.

Project Master Schedule. The project master summary schedule was reviewed. It reflects the total project scope for Unit No. 5. It is a time-scaled logic diagram and is the basis for determining Unit No. 5 milestones. It reflects construction activities in-progress as of January 1, 1991, and forecasts completion of September 30, 1992 (21 months).

The schedule is divided into scope areas for Unit No. 5, such as: Site Preparation, Main Building (T/G and Boiler), Stack and Gas

Lines, Transformers, Misc. Offices and Buildings, Fuel Storage, Cooling Tower, Process Pipe, Cable Installation, Railroad, Etc. In addition to summary schedule logic for each of these scope areas, the following information is included:

- Total Cost
- Costs Expended as of January 1, 1991
- 1991 Planned Costs
- 1992 Planned Costs
- Scope of Work (description & quantities)

Columns are totalled at the bottom to represent the total Unit No. 5 budget. In addition to the summation of costs at the major scope level, each schedule activity reflects the costs associated with that specific activity, its duration, and its average manpower requirements.

The schedule also includes planned monthly requirements for the workforce (showing persons per day and in total person-days per month), bulk installation volumes, and costs. As well as showing the total monthly manpower requirements, the schedule gives a breakdown for the following categories: construction personnel, erectors, boiler personnel, electrical personnel, and chemists.

Sufficient explanation was included to show that the original primary critical path was through the erection and completion of the boiler, and secondary critical paths were through the installation of the turbine generator and the installation of major plant equipment, piping, and wire and cable. This schedule logic is consistent with ETIP experience. There was also schedule concerns for the erection and completion of the cooling tower and stack which is discussed in Section 8.3.3.

Forecast durations used to establish these critical milestones are:

1. Start boiler steel to first firing - 16 months.
2. Install turbine generator - 9 months.

3. Install major equipment, pipe, and wire and cable - 16 months.

These durations are consistent with ETIP proposals which typically forecast a 28 month schedule (from start of site preparation to operation) for plants similar to Hrazdan Unit No. 5.

Contractor Detailed Schedules. Each subcontractor maintains detailed working schedules supporting the Project Master Schedule. These schedules are reviewed weekly in a project review meeting. Problem areas are discussed to resolve potential delays and maintain project milestones.

8.2.2 Material and Equipment Controls

Hrazdan Unit No. 5 uses a spreadsheet method for documenting the status of procurement activity and the delivery of equipment (pumps, heat exchangers, switchgear, transformers, etc.) and bulk materials (reinforcing steel, pipe, valves, wire and cable, structural steel, etc.).

All commodities required to construct Hrazdan Unit No. 5 are shown in the spreadsheet document entitled Information of Volume of Work for Each Area of Hrazdan Plant as Planned for 1992. Information is sorted by major work area (e.g., Turbine Building), and major commodity. The spreadsheets illustrate quantities and costs associated with each commodity and also reflect the required delivery requirements. Required delivery dates are extracted from the Project Master Schedule. Table 3.4-1 in Section 3.4 reflects the current forecast for delivery of the required equipment for Unit No. 5. The spreadsheet provides the basis for ordering materials and also serves as a cashflow basis for all materials and equipment. The cashflow is illustrated on a monthly basis on the Project Master Schedule.

8.3 CONSTRUCTION SCHEDULE FOR UNIT NO. 5 COMPLETION

8.3.1 Current Schedule Status

Hrazdan Plant personnel estimated Unit No. 5 is approximately 20 percent complete. However, after inspection of actual construction progress, ETIP believes the plant is probably closer to being 25 percent complete. The work is not currently following the established 1992 schedule. Contractors are working in areas throughout the site where they have materials, labor, and authorization to perform tasks. However, the main emphasis is to enclose Unit No. 5 to permit work inside during the winter.

Boiler Building. The structural steel for the outer structure of the boiler is essentially complete for Unit No. 5. The unit is essentially enclosed. The actual support structural steel for the Unit No. 5 boiler is approximately 30 percent complete. Two Boiler Building bridge cranes (50 ton each) have been erected and are operational. They are supporting the erection of internal structural steel and will be used to erect the main boiler parts. Craftsmen are currently working in Unit No. 5, erecting and welding structural steel. According to project personnel and project records all boiler parts have been delivered to the site. Tube sections are currently being prefabricated in the laydown area to the west of the power block. These will eventually be brought into the boiler area by a specially equipped rail car and hoisted into place using the bridge cranes.

Turbine Building. The structural steel for the outer structure is essentially complete for Unit No. 5. The unit is essentially enclosed except for installation of windows along the south (front). Concrete for the turbine pedestal legs has been placed. Reinforcing steel is being installed for the turbine pedestal deck and some initial formwork (underneath) is in place. Precast slabs have been placed from the turbine pedestal, east, to the existing four units. Topping concrete for these slabs has yet to be placed. The turbine building bridge crane (125 ton) for Unit No. 5 is in

place and operational. There is also a large, track-mounted crane working within the building to the west of the turbine pedestal, and two rail-mounted tower cranes (50 ton each) erecting turbine and boiler steel on the west end. Additional work currently in progress includes: erection of interior structural steel; erection of interior walls; and, placement of slabs in the auxiliary bay between the turbine and boiler buildings.

Other Site Structures.

Stack - The concrete exterior of the stack is essentially complete. No work has begun on the metal liner but the liner materials have been delivered. The main fan foundation between the stack and boiler building has been placed.

Cooling Tower - The outer shell of the tower has been erected to 110 meters with a final height 160 meters. The contractor has also erected a building to assemble the radiator sections. This building will later serve as a maintenance facility during operation. Circulating water lines from the turbine building to the cooling tower are approximately 60 percent installed.

Intake Structure - Substructure concrete has been placed.

Circulating Water Pumphouse - Concrete base slab has been placed as well as the exterior walls to grade level.

Fire Fighting Facility - The building's exterior structure is approximately 80 percent complete.

Relay Protection Building - The civil portions of this building are mostly complete. The cable tunnel running to the turbine building is approximately 70 percent complete.

Engineering and Laboratory Building - The precast superstructure and civil construction of this facility is approximately 30 percent complete.

Electrical Substation - The towers and precast concrete piers for the breakers and other equipment are complete for Units 5 - 8. Four of the six transmission towers from the turbine building to the switchyard have been set in place.

8.3.2 Completion Requirements

The plant has ceased preparing schedules and has not developed a revised completion schedule. Their forecast duration for completion (following a complete restart) is 1 year and 9 months (21 months). Their target is to complete Unit No. 5 by October 1, 1994, in time for winter. However, based on current commitments and estimates for future events, ETIP has identified the following list of major completion milestones:

- EBRD Loan Approval and Notice to Proceed - January 2, 1993
- Continue Procurement of Remaining Equipment and Materials
- Mobilize - January 15, 1993
- Resume Construction - March 1, 1993
- Hrazdan Unit 5 Operational- December 1, 1994

The determining factor for this forecast is receipt of a loan by January 2, 1993. The December 1, 1994 completion forecast allows at least two months for the reactivation of the project procurement process and the receipt of needed materials and equipment.

8.3.3 Proposed Completion Schedule

Based on the present status of construction, which assumes the above forecast dates are achieved, a completion schedule has been developed (Figure 8.3-1). This schedule depicts the major procurement and construction activities required to complete Hrazdan Unit No. 5.

The boiler is the primary critical path, which is typical for power plant construction. The boiler parts are on site and some have been fabricated. Approximately 50 percent of the required welding

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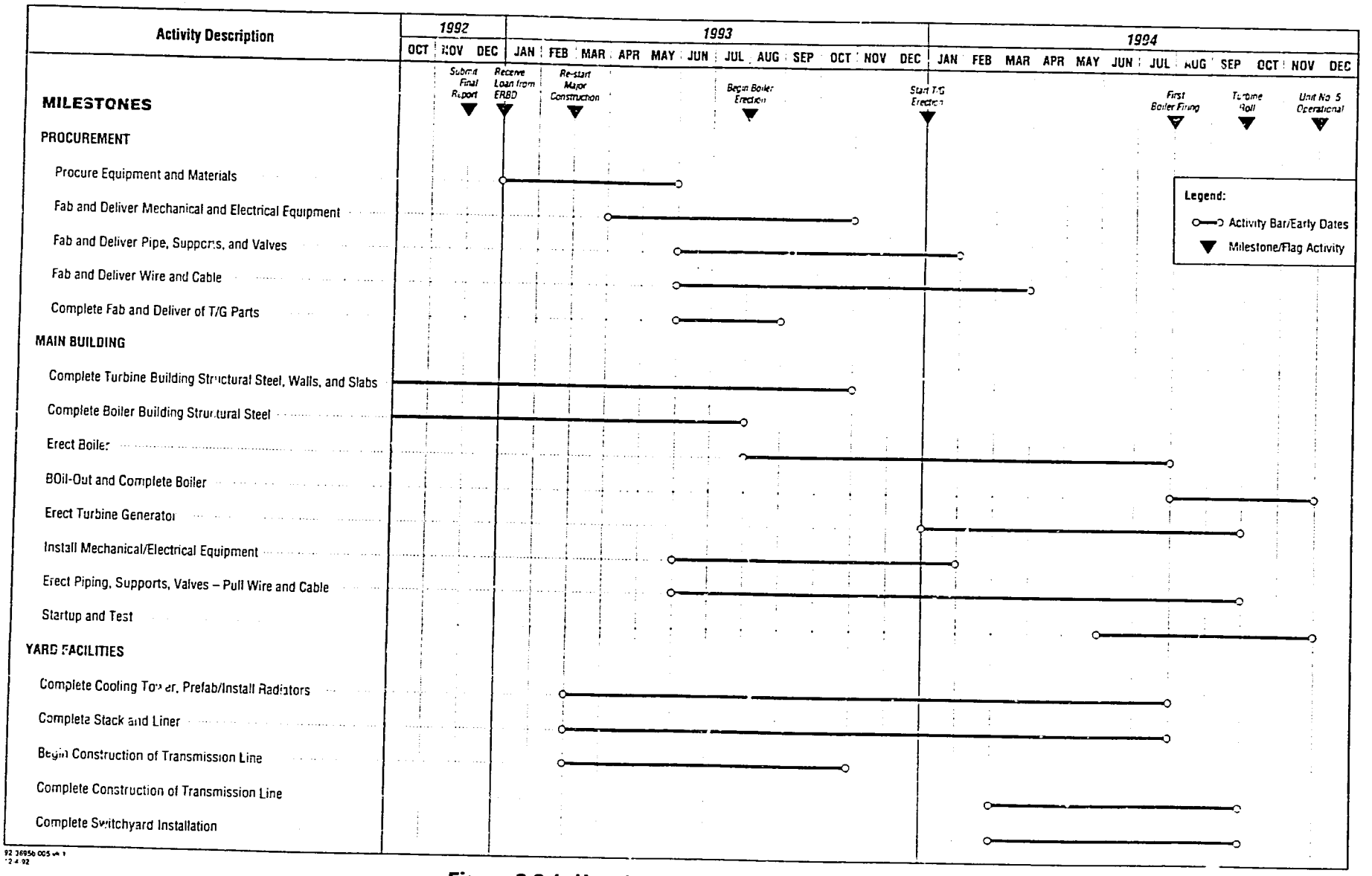

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Figure 8.3-1 Hrazdan Power Plant – Unit No. 5
Milestone Summary Schedule
Project Completion

rod is on site. Consequently, the boiler is not expected to affect the forecast completion of Unit No. 5. In addition, since the turbine and boiler buildings should be enclosed, inclement weather should not affect the resumption of major construction activity for Unit No. 5 in early 1993.

Secondary critical paths (turbine erection and installation of equipment and bulk materials) should not affect the forecast completion of December 1, 1994. This assumes that the stator arrives prior to November 1993 and other equipment and materials arrive within the specified periods to support the beginning of bulk installations in June 1993.

As previously stated in Section 7.2.1, there is concern by the Hrazdan Plant that the cooling tower and stack may be potential critical path items. The cooling tower was being erected by a Russian company which has left the site. Concern was expressed regarding the height and size of the structure. Based on the current stage of completeness of the tower and, assuming a timely return of a qualified erector, completion of the cooling tower should be within the 21 month period. The majority of the remaining work involves fabricating and installing the internals. The fabrication takes place in the cooling tower maintenance facility which is an enclosed building. If necessary, the work week could be extended for this work or a double-shift could be initiated.

Concern was expressed over the height of the stack and the installation of the inner steel liner. However, the concrete portion of the stack is complete and sufficient time exists to complete the liner within the 21 month period.

With respect to other major work areas, such as the switchyard, transmission line, water and fuel support facilities, etc., none at this time appear to be in any danger of not being able to support the forecast completion schedule.

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Therefore, in summary, from a construction logic perspective, the forecast completion duration of 21 months is deemed achievable provided labor and material delivery issues are resolved by the dates indicated on the schedule.

8.4 PROCUREMENT SCHEDULE FOR UNIT NO. 5 COMPLETION

There are sufficient materials and equipment to support resuming construction in early 1993. The main issue with the construction schedule is remaining mechanical and electrical equipment, pipe, supports, and valves need to be delivered during 1993. The construction schedule, however, can support an early 1994 delivery for cables and back-up batteries.

A key assumption in ETIP's construction schedule is that previously placed contracts, which are being fulfilled by organizations familiar with this plant, can be completed and delivered without significant delays.

Excluding batteries and cable, procurement of the remaining major equipment and materials from new sources is not recommended. Replacing existing equipment and installation contracts and subjecting these to international competitive bidding would extend the 21 month schedule.

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9.0 PROJECT COMPLETION DISBURSEMENT SCHEDULE

The Hrazdan Unit No. 5 project completion estimate and schedule was reviewed and a project completion disbursement schedule was prepared and submitted to the MEF. The basis for this schedule was an assessment of overall project completion costs distributed over approximately a 23 month period including the 21 month construction completion schedule. Consideration was given to the need to disburse approved loan funds early in the project completion effort in order to secure needed equipment and materials to support construction work. An initial disbursement schedule was prepared by ETIP. MEF and EBRD reviewed this information and determined that funds would ideally be disbursed over a three year period and that the Bank would finalize a disbursement schedule on this basis and would base it on their estimate and ETIP input and recommendations.

Table 9-1 is a total project disbursement schedule based on the ETIP estimate. Included is an apportionment of foreign and local costs, the latter of which would generally be handled by the MEF. This schedule is subject to final agreement on the agreed upon EBRD loan amount.

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Table 9-1

PROJECT LOAN DISBURSEMENT SCHEDULE*

Period	Equipment	Subcon-tract	Other	Total	Local Costs Eqv US $	Foreign Costs Eqv US $
	$41.34	$42.20	$6.19	$89.73	$27.17	$62.56
1 Qrt/93	$ 8.27	$ 4.22	$ 0.00	$12.49	$ 3.78	$ 8.71
2 Qrt	$12.40	$ 8.44	$ 0.62	$21.46	$ 6.50	$14.96
3 Qrt	$ 8.27	$12.66	$ 1.86	$22.79	$ 6.90	$15.89
4 Qrt/93	$ 4.12	$ 8.44	$ 1.24	$13.80	$ 4.18	$ 9.62
1 Qrt/94	$ 4.12	$ 4.22	$ 1.24	$ 9.58	$ 2.90	$ 6.68
2 Qrt	$ 4.12	$ 2.12	$ 0.62	$ 6.86	$ 2.08	$ 4.78
3 Qrt/94	$ 0.04	$ 2.10	$ 0.61	$ 2.75	$ 0.83	$ 1.92
Total	$41.34	$42.20	$ 6.19	$89.73	$27.17	$62.56

*Total to go cost in US $ in millions

10.0 REFERENCES

The following lists reference documents obtained, reviewed and/or used as part of the assessment, the names and titles of persons contacted, and selected conference notes.

10.1 REFERENCES

Atomteploelektropoject (Atomic and Thermal Electric Projects), Hrazdan Power Plant, Feasibility Study, Expansion of 4-300 MW, Volume I, Explanatory Note, Rostow, 1987.

N. Belovoussov, A. Sahakian, and A. Yakovleva, Electric Cables, Wires, and Laces, Reference Book (Moscow: Energoatom Publishing House, 1987).

Boiler Dimensions and Heat Transfer Surface, schematic drawing

Boiler Feedwater Specification, handwritten

Boiler Section (08 8028 040 CB), 1 sheet

Boiler-Turbine System Heat Balance, hand sketch

Burner Design Data Summary, handwritten data sheet

Civil Drawing (Operation Floor Plan) (92-12-210), 1 sheet

Conclusion of Public Committee on Environment at Hrazdan Power Plant on Questions Concerning the Extension of Hrazdan Power Plant, 1989.

Cooling Tower Water Quality Requirements, handwritten data sheet

District Heating Plan for the City of Hrazdan, Protection of the Atmosphere from Heat Sources, Leningrad, 1990.

Drawing 92-43-377, Technical Water Supply, 7/21/92 (existing and planned water supply system including Unit No. 5)

Electrical Single Line Diagram (92-35-142), 1 sheet

Energostet, Armenian Specialized Branch, 220 KV High Voltage Line, Hrazdan Power Plant to Yerevan Thermal Power Plant (Kharberd), Working Project, Explanatory Notes and Drawings, Yerevan, 1989.

Environmental Substantiation for the Extension of the Hrazdan Thermal Power Plant, Armenergo Corp, no date.

Equipment contracts for boiler, turbine, low pressure pipe, main transformer, auxiliary equipment for boiler, high pressure heaters, pressure vessels, high pressure pipe, and nonstandard equipment.

European Bank for Reconstruction and Development, A Changing Europe, Annual Report, 1991.

European Bank for Reconstruction and Development, Environmental Procedures, 1992.

European Bank for Reconstruction and Development, How to Work with the European Bank for Reconstruction and Development, December 1991.

European Bank for Reconstruction and Development, International Environmental Audit Protocol and Field Notes, January 2, 1992.

European Bank for Reconstruction and Development, Procurement Policies and Rules, January 1992.

Gas Exhausting Pipes (Stacks) of Thermal Electric Stations and Atomic Electric Stations: The Method of Calculation of Special Harmless Impurities and the Choice of Height of Gas Exhausting Tube, Moscow 1987.

Generator Design Summary, handwritten data sheet

Hrazdan Plant and Vicinity Development Plan, Drawing Number 92-60-01, 1966.

Hrazdan Power Plant, Chemical Analysis of Sediments in Wastewater Treatment Basin, 1992.

Hrazdan Power Plant, Current Water Consumption and Discharges, February 1989. (Reported to State Committee of Armenia on Environment, and State Inspection Controlling Underground and Surface Water Resources of the Ministry of Health of Armenia.)

Hrazdan Power Plant, Expansion to Earthquake 9 Balls, Unit 5, Turbine Department, March 1990.

Hrazdan Power Plant, Expansion of 4-300 MW Main Building. Mounting Drawings of Pipe (Condensate Polisher System), Thermal Mechanical Department, Rostow Institute, 1989.

Hrazdan Power Plant, Expansion of 4-300 MW Plant Resistance to Earthquake 9 Balls, Unit 5, Boiler Department Control and Handling of Unit No. 5, March 1990.

Hrazdan Power Plant, Form 2, Air Emissions, June 1991. (Reported to Statistic Organization in the Site Organization, Ministry of Energy and Fuel, and Local Nature Committee.)

Hrazdan Power Plant, Form 2, Water Discharges, July 1990. (Reported to Ministry of Energy and Fuel, Local Organization Regulating Water Usage, Local Statistical Organization, and Sanitary and Epidemological Station.)

Hrazdan Power Plant, Permission on Emission of Polluting Substances into Atmosphere from Stationary Sources, Armenian State Nature Committee, March 1990.

Hrazdan Plant, Prospective Net Schedule K-5, Commissioned September 1992

Hrazdan Power Plant, Protocol of Technical Meeting on the Decrease of Nitrogen Oxide Emissions from Boilers TGMP-344A, Delivered for Hrazdan Power Plant, December 1989. (Attendees: Hrazdan Power Plant technical staff, and Rostow Institute.)

Hrazdan Power Plant, Raw Water Analysis, Hrazdan River, 1992.

Hrazdan Power Plant, Schematic Flow Diagram, Wastewater Treatment System, 1992.

Hrazdan Power Plant, System Structure Schemes of Automatic Regulations (Control Systems Drawings) of 300 MW Unit, no date.

Information of Volume of Work for Each Area of Hrazdan Plant as Planned for 1992

Institute of Energy, Department of Air Condensation Budapest, January 1991, Hrazdan Power Plant, 2-300 MW Units 5 and 6, Instruction on Sourcing and Operation of Air Condensing Installation of Geller

Instructions for Work Safety, no date.

Main Water Treatment Plant Flow Scheme, block flow sheet

Ministry of Energetics and Electrofication of USSR, All Union State Project Institute, Hrazdan Power Plant Project Task, Project Development Plan, Moscow, March 1966.

Ministry of Energetics and Electrofication of USSR, Gidroproject, Expansion of Hrazdan Power Plant for Additional Water, Working Project, Engineering and Geological Conditions, 1988.

Ministry of Energy of the USSR, Rules on the Safety of Operation of Thermal and Mechanical Equipment of Power Plants and Thermal Grids, Moscow, 1991.

Ministry of Energy of the USSR, Safety Regulations for the Operation of Power Equipment, Moscow, 1987.

Ministry of Energy of the USSR, Safety Rules for Work With Instruments and Devices, Moscow, 1985.

Natural Gas Design Specification, handwritten data sheet.

Normal Standards of the USSR, Concrete, State Construction Committee, USSR, Moscow, 1988.

Oil Fuel Design Specification, handwritten data sheet.

Plant Control System Description.

Plant Section (Civil) (Drawing No. 92-12-210) 1 sheet.

Protocols of Black Oil Analysis Issued by the Chemical Department, Hrazdan Power Plant, no date.

Regenerative Air Heater (BU MP 065334.001 CB and 002 CB), 2 sheets.

Safety Rules for Gas Systems for All Ministries, State Agencies and Organizations, Moscow, 1981.

Scheme for Cooling Water Supply for Hrazdan Power Plant, 1992.

Site Arrangement (Drawing No. 92-90-117), 1 sheet.

Steam Generator Burner (Drawing No. 08 83.6076 CB), 2 sheets.

Steam Quality Requirements Boiler Makeup Water Requirements, data sheet.

Steam-Water System Piping Diagram, reduced drawing.

Technical Documentation of Purchased Black Oil With Indication of Sulfur and Ash Content, no date.

Technical Report, "Design Norm Characteristics of 300 MW Unit of the Hrazdan Power Plant," (Dontekhenergo, 1991).

Technical Report for 4 x 300 MW Hrazdan Power Plant, Block No. 5, Mounting Drawings of Pipe, 1989 (condensate polishing data).

Technical Report, Normative Characteristics of Boiler Equipment of Hrazdan 300 MW unit for Gas and Oil Burning, 1991.

Technical Report, Normative Characteristics of K-300-240-3, LMZ Turbine of the Hrazdan Power Plant, 1991.

Teploelectroproekt Institute, Hrazdan Power Plant, Extension of 4-300 MW Plant, Rostow, April 1990.

Topographic Map, Hrazdan Power Plant and Vicinity, 1:10,000, Contour Interval 20 Meters, no date.

Turbine Cross Section (1307309B0), 1 sheet.

Turbine Deck Layout (plan) (Drawing No. 92-221-214), 1 sheet.

World Bank, Environmental Assessment Sourcebook, (3 volumes) (Washington, D. C.: World Bank, Environmental Department, 1991).

World Bank, Environmental Guidelines, 1982.

10.2 CONTACTS

Armenia Ministry of Energy and Fuel

G. M. Galustian, Deputy Minister, Foreign Affairs, Ministry of Energy and Fuel, Yerevan

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10.3 CONFERENCE NOTES AND PROJECT REPORTS

Karlson, F. V. (ETIP) to J. Bever (USAID), Work Plant and Inception Report - Armenia Hrazdan Power Plant Unit No. 5 Loan Appraisal Support Project, dated October 13, 1992.

Mason, P. F. (ETIP) to F. V. Karlson (ETIP), Preliminary Project Review - October 23, 1992, dated October 26, 1992.

Mason, P. F. (ETIP) to F. V. Karlson (ETIP), Section Project Review - October 26, 1992, dated October 26, 1992.

Mason, P. F. (ETIP) to Distribution, Conference Notes: Unit No. 5 Assessment Status Meeting/EBRD Appraisal - October 27, 1992, dated October 27, 1992.

Mason, P. F. (ETIP) to Distribution, Conference Notes: Hrazdan Unit No. 5 Expansion - Environmental - October 29, 1992, dated October 29, 1992.

Mason, P. F. (ETIP) to Suzanne Olds (USAID), Armenia Hrazdan Unit No. 5 Assessment Project - Status Report: In-Country Activities, dated November 1, 1992.

Mason, P. F. (ETIP) to Distribution, Conference Notes: EBRD Appraisal Team Status - November 2, 1992, dated November 2, 1992.

Mason, P. F. (ETIP) to S. V. Tashjian (MEF), Hrazdan Unit No. 5 Assessment Project - Draft Report, dated November 3, 1992.

Mason, P. F. (ETIP) to Distribution, Conference Notes: EBRD Estimate Review - November 3, 1992, dated November 3, 1992.

Mason, P. F. (ETIP) to Distribution, Conference Notes: Review ETIP/Bechtel Report Status with EBRD Appraisal Team, Procurement Department and Environment Department - November 5, 1992, dated November 5, 1992.

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ADDENDUM NO. 1

OCTOBER 19, 1993

POST-ASSESSMENT DEVELOPMENTS

The results of the pre-loan assessment work were largely available to the EBRD in early November 1992 before the ETIP team departed Armenia. EBRD procurement and environmental department management and ETIP discussed these results while in London in November 1992, prior to returning to the United States. Thus, the draft report issued in December 1992 affirmed earlier conclusions and understandings which were essential inputs to the EBRD loan approval process.

EBRD LOAN APPROVAL

EBRD technical staff and management reviewed all Hrazdan Unit 5 completion information and endorsed approval of the loan to the MEF for completion of Unit 5. In January 1993, Armenia formally joined the EBRD based on Bank approval of the country strategy for Armenia including its energy and economic development plans. Hrazdan Unit No. 5 completion was identified as the first public sector project to be funded by the EBRD in Armenia.

EBRD/ARMENIA MINISTRY OF ENERGY AND FUEL SOLICITATION FOR EXPATRIATE PROJECT COMPLETION ASSISTANCE

In March 1993, EBRD in conjunction with the Ministry of Energy

and Fuel announced the request for qualifications (RFQ) for expatriate assistance with project completion and commissioning of Hrazdan Energy and Fuel to finish the construction of the plant and the associated transmission line. The contractor would also provide assistance with procurement and contracting of the outstanding contracts, assist with the introduction of competitive processes, provide construction management assistance and aid with plant startup and commissioning. These consultant services would be financed from the EBRD loan. EBRD received responses to this solicitation on March 25, 1993 and developed a short list of qualified bidders. These firms were invited to bid on the project completion services on April 23, 1993 and bids were submitted May 19, 1993. In June 1993, the EBRD and the Ministry of Energy and Fuel selected a U.S. firm, Hill International, as the consultant to assist the Armenia Ministry of Energy and Fuel with Unit 5 completion. The schedule for commercial operation of Hrazdan Unit 5 is believed to be 18-24 months.

CONCLUSIONS

The twelve month period from June 1992 through June 1993 witnessed several significant events and expressions of organizational flexibility and teamwork. The events relate to the recognition of the need by USAID, the EBRD, and MEF regarding the value of completing Hrazdan Unit 5 and acting upon these

instincts to commission the pre-loan assessment effort in October. Significant steps in this process unfolded over the course of 1992-93 with the approval of the EBRD loan for the project, the solicitation of interest in expatriate project completion assistance, and the decision to resume project completion efforts by June 1993.

Teamwork was and remains the essential element to what can be viewed as a successful undertaking, namely to get a needed electricity supply source on line with a relatively modest capital investment. As noted earlier in this report, the number of organizational entities involved in this undertaking included United States Agency for International Development, the Ministry of Energy and Fuel, European Bank for Reconstruction and Development, various contractors and organizations in Armenia, the Armenia Ministry of Nature and Environmental Projection, and the Energy Technology Innovation Project.

This undertaking was considered successful for several reasons: First, data collection was eased by the cooperative efforts of the Ministry of Energy and Fuel. Second, meetings were timely and effectively managed in-country. Third, the EBRD team was thorough and highly motivated to assess the condition of Unit 5 and work with the ETIP team in answering loan application related questions as well as environmental assessment topics.

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APPENDIX A

ASSIGNMENT TASKS

ASSIGNMENT TASKS

1. **Develop Project Work Plan.** This required the development of the project workplan, inception report, and task plans for project activity to meet the stated objectives in Armenia and in the United States.

2. **Procurement Status and Price Assessment.** This included an assessment of the procurement status of Unit No. 5 and the proposed power transmission line. Included are project completion cost estimates, estimated delivered prices for major equipment and materials to be received on site, and an assessment of contracts that could be competitively bid.

3. **Environmental Review.** This included the review of EBRD environmental requirements and the conduct of an environmental review of the proposed project taking into consideration selected environmental issues and EBRD requirements. Selected health and safety and site environmental liability issues were included.

4. **Environmental Mitigation Measures and Costs.** This task required the identification of potential environmental mitigation measures for Unit No. 5 and for subsequent planned units 6, 7, and 8 and an estimate of the costs.

5. **Design Efficiency Improvements.** This included the review of the Unit No. 5 design and the identification of potential design efficiency improvements for possible implementation on Unit 5 as well as for subsequent planned units 6, 7, and 8.

6. **Design Efficiency Improvements Engineering Support.** This included assistance to the MEF with needed design support and

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suggestions regarding the implementation of selected Unit No. 5 design efficiency improvements.

7. **Unit No. 5 Completion Cost Estimate.** This included the assessment of the current project completion estimate, an evaluation of the costs associated with remaining to-go cost items, a determination of foreign and local costs, and the identification of additional cost items needed to be included in the overall project cost completion estimate.

8. **Hrazdan-Yerevan Transmission Line Completion Cost Estimate.** This included the assessment of the current project completion cost estimate, an evaluation of the costs associated with the remaining to-go cost items and the identification of selected additional cost items to be included in the overall project transmission line cost completion estimate.

9. **Procurement and Construction Schedule.** This included the evaluation of the current project schedule including procurement status, construction status, internal schedule logic, other critical items and the determination of adequacy of the project schedule.

10. **EBRD Procurement Process.** This included a review of the technical, schedule, and delivery requirements for power and control cable and plant emergency battery purchases. Development of a summary level procurement plan and schedule for purchase of these items following EBRD guidelines was provided.

11. **EBRD Loan Disbursement Schedule.** This included the development of a loan disbursement schedule for completion of the project.

APPENDIX B

SUMMARY PROJECT CHRONOLOGY

In the following is a summary chronology of all major events associated with the Armenia Hrazdan Unit No. 5 Assessment

Armenia Hrazdan Unit No. 5 Assessment

Summary Chronology

1. September 23, 1992

   Contract award from USAID.

2. September 29, 1992

   Project kickoff meeting in San Francisco.

3. October 6, 1992

   ETIP (F. V. Karlson, P. F. Mason, D. Vincent) met with EBRD (M. Tomlinson, O. Herbelot, T. Murphy, A. vonHeynitz, W. Kennedy, D. Bulkai) to review procurement and environmental regulations and requirements for Hrazdan Unit No. 5 completion loan approval.

4. October 8, 1992

   ETIP (F. V. Karlson, P. F. Mason, D. Vincent) met with Ministry of Energy and Fuel (MEF) (G. M. Galustian) to review work plan for project and work planned for Hrazdan Plant.

5. October 9, 1992

   ETIP (F. V. Karlson, P. F. Mason, D. Vincent, T. Fallon, D. Bursheim, S. Basu) met with MEF project team to discuss work and plant visit. MEF included H. Hovannissian, A. Vartanian, G. M. Galustian.

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6. October 12, 1992

ETIP (F. V. Karlson, P. F. Mason) met with MEF (S. V. Tashjian, G. M. Galustian, H. Hovannissian) to review status and plans.

7. October 13, 1992

Prepared and issued to USAID/Others workplan and inception report including organization chart, budget and final report outline and project milestones.

8. October 13, 1992

Prepared and issued to EBRD initial procurement status document which categorized the status of orders for the Hrazdan Power Plant.

9. October 14, 1992

F. V. Karlson departs Armenia.

10. October 15, 1992

D. B. Lane arrives Armenia.

11. October 15, 1992

ETIP (P. F. Mason, D. Vincent, T. Fallon, D. B. Lane, S. Basu, D. Bursheim) met with MEF (S. V. Tashjian, G. M. Galustian) to review EBRD requirements and to outline a plan to address them.

12. October 17, 1992

ETIP (P. F. Mason, D. Vincent) met with MEF (G. M. Galustian, V. Sogomonian, Esq.) to review approaches to the development

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of firm prices and schedules for the Hrazdan Plant completion. Advised that MEF would retain lead responsibility for addressing this issue but would expect ETIP support as needed.

13. October 19, 1992

ETIP (P. F. Mason, D. Vincent) provided MEF with a list of critical equipment from the cost and schedule standpoint which should become the focus of MEF efforts in establishing cost and schedule information for Hrazdan.

14. October 20, 1992

ETIP (P. F. Mason, D. Vincent) advised MEF (S. V.Tashjian) of outcome of the 10/17/92 meeting and our interest in supporting MEF as necessary.

15. October 21, 1992

D. Bursheim departs Armenia.

16. October 22, 1992

ETIP (P. F. Mason, D. Vincent) met with MEF (G. M. Galustian) to review strategy and approach to address cost and schedule confirmation.

17. October 22, 1992

ETIP (P. F. Mason) and MEF (G. Galustian) met with Ms. K. Danielian, Minister, Ministry of Nature and Environmental Projection to discuss the Hrazdan Project. Agreed to meet the following week and consider the topic in greater detail.

18. October 23, 1992

ETIP (P. F. Mason, D. Vincent, T. Fallon, D. Lane, S. Basu) met with MEF (G. M. Galustian, H. Hovannissian, A. Vartanian) to offer status report on work and a plan for the EBRD October 27 visit. Mason and Vincent to remain in country for duration of EBRD visit. Provided format for representing the type of information the EBRD will expect to see to support the loan application.

19. October 26, 1992

ETIP (P. F. Mason, D. Vincent, S. Basu, D. Lane) met with MEF (G. M. Galustian, H. Hovannissian, A. Vartanian) to offer status report No. 2, review added information, update the estimate and receive added information on equipment/material status and cost from MEF. Critical items identified by Bechtel were addressed. MEF agreed to provide added information on equipment status and transmission line.

20. October 27, 1992

ETIP (P. F. Mason, D. Vincent, D. Lane, T. Fallon, D. Lane) met with MEF (G. M. Galustian) and EBRD (O. Herbelot, A. vonHeynitz, A. Vavrik, N. Pershad) to review EBRD appraisal team requirements for the period October 27-November 4 in Armenia. MEF/Bechtel agreed to support EBRD efforts. Estimate, schedule and environmental assessment documents were provided to the EBRD team for their review and use. Bechtel agreed to examine for EBRD each contract/works contract and evaluate each for impacts of change regarding remaining work.

21. October 28, 1992

D. Lane, S. Basu and T. Fallon depart Armenia.

22. October 29, 1992

Meeting with Ministry of Nature and Environmental Protection (H. Kirakossian, A. Gabrielian, A. Arakelian, A. Abrahamian), Ministry of Energy and Fuel (G. Galustian) and ETIP (P. F. Mason) to review Hrazdan Plant expansion. Ministry of Nature and Environmental Protection supports project because of potential reduction of overall emissions with the addition of newer units. Emission reduction predicated on gas as primary fuel.

23. October 30, 1992

Meeting with MEF (H. Hovannissian, A. Vartanian) and ETIP/ Bechtel (P. F. Mason, D. Vincent) concerning construction completion assessment data request. Scope of discussion included verification of work completion, concrete testing, cooling tower status, seismic qualification of equipment, and transmission line equipment status.

24. November 1, 1992

Status report provided to USAID's Suzanne Olds. Included in report are initial conclusions, project highlights, and summary of project activity chronology.

25. November 2, 1992

Meeting with MEF (S. V. Tashjian, G. Galustian, H. Hovannissian), EBRD (O. Herberlot, C. Christofides, A. vonHeynitz, A. Vavrik, N. Pershad) and ETIP/Bechtel (P. F. Mason, D. Vincent) to review status and identify remaining issues related to EBRD loan processing. MEF addressed each issue raised by EBRD including need for electricity, fuel supply, tariffs, loan processing requirements, and organizational arrangements to administer and manage loan once approved.

26. November 3, 1992

Meeting with MEF's H. Hovannissian and ETIP/Bechtel (P. F. Mason/D. Vincent) to collect details on transmission line design, equipment status, contracting plans and approximate costs.

27. November 3, 1992

Meeting with MEF (G. Galustian, H. Hovannissian), EBRD (O. Herberlot, C. Christofides) and ETIP/Bechtel (P. F. Mason/D. Vincent) to review EBRD estimate and disbursement schedule plans. Estimate of $81.6 million will increase 6 to 7% based on added items/requirements. Planned disbursement expected to be 55% (1993), 35% (1994), and 10% (1995). Provision made for upgrade of compressors, water/wastewater plant upgrade for city of Hrazdan and other potential improvements to be identified. Project completion management key to project success in order to administer funds and handle reporting. ETIP/Bechtel provided to MEF and EBRD draft report.

28. November 4, 1992

D. Vincent and P. F. Mason depart Armenia with EBRD appraisal team.

29. November 5, 1992

Meeting with EBRD (O. Herberlot, C. Christofides, B. Gouveia, T. Murphy, W. V. Kennedy) and ETIP/Bechtel (P. F. Mason/D. Vincent) to review project status, report conclusions, procurement support to MEF subsequent to loan approval, and environmental assessment results. Strong project completion management function will be needed to minimize risk and improve changes of timely delivery of remaining equipment and materials to Hrazdan Project. Environmental basis will be the use of gas as primary fuel and oil as supplemental fuel.

Reported that Ministry of Nature and Environmental Protection supports project on this basis given that upon overall project completion of Units 5-8 the overall emissions will be reduced. Received draft of EBRD estimate which will be finalized upon receipt of any design energy efficiency improvement items.

30. November 12, 1992

Energy efficiency and environmental mitigation measures identified.

31. December 9, 1992

Issue draft final report to USAID, EBRD and MEF.

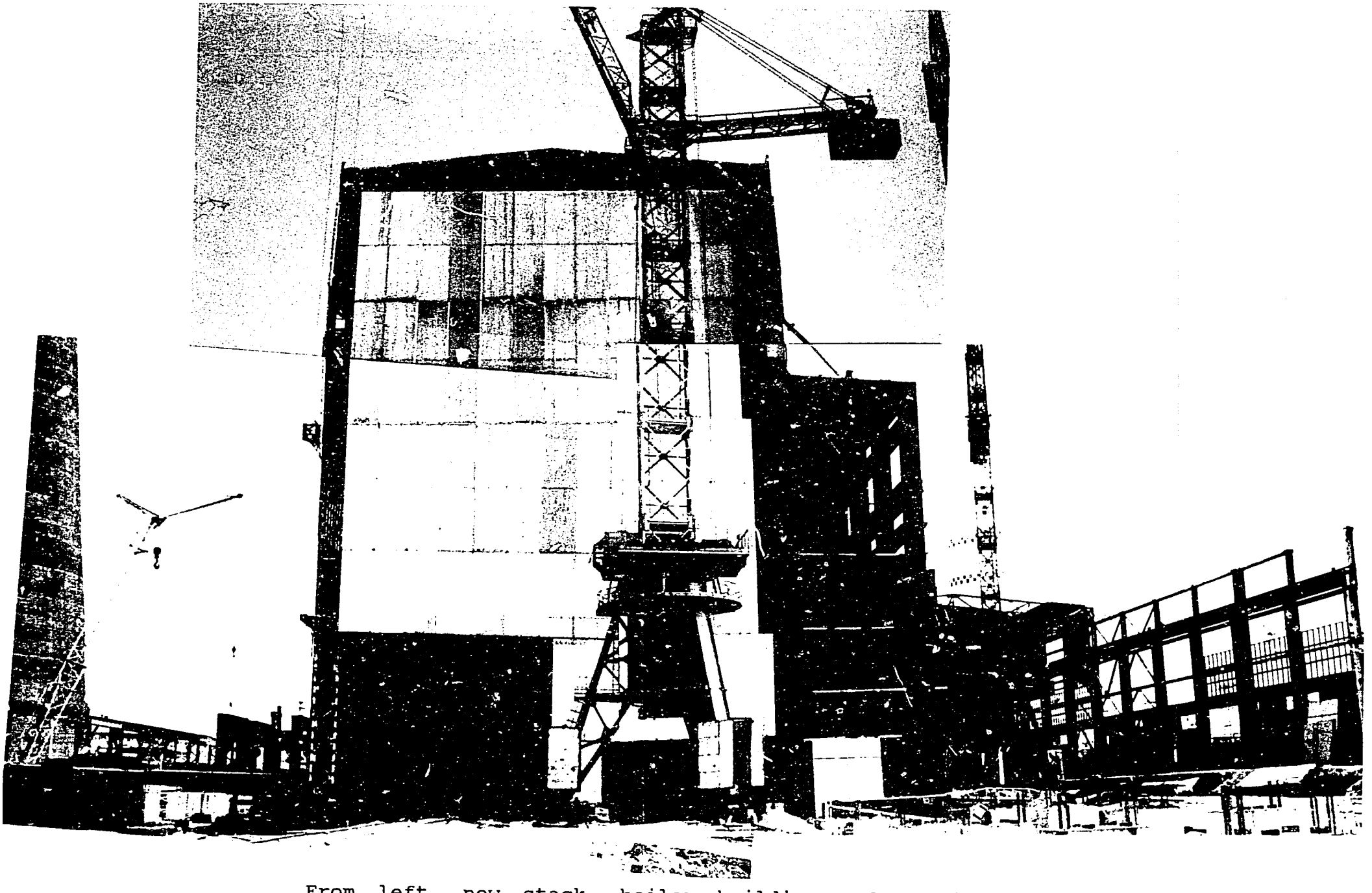
32. October 19, 1993

Issued final report.

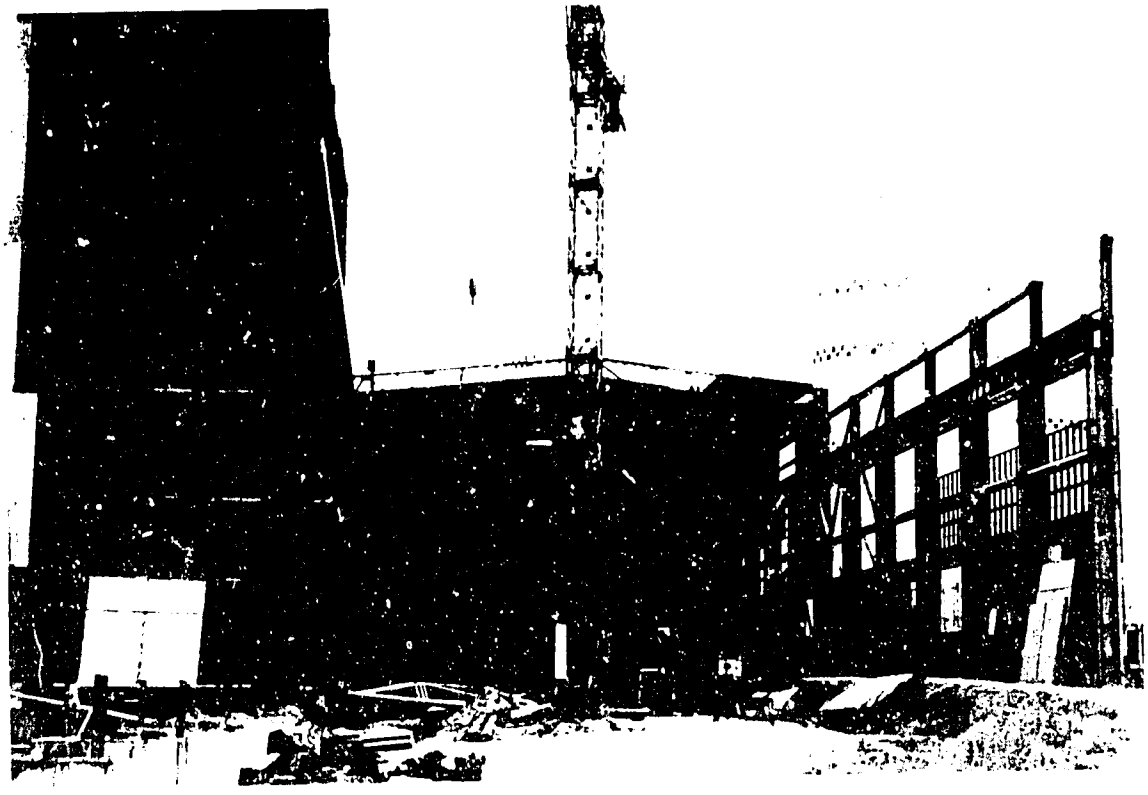
APPENDIX C

SELECTED HRAZDAN POWER PLANT PHOTOGRAPHS

The following pages provide a selection of Hrazdan Power Plant photographs. These illustrate the current status of project completion for major plant components.

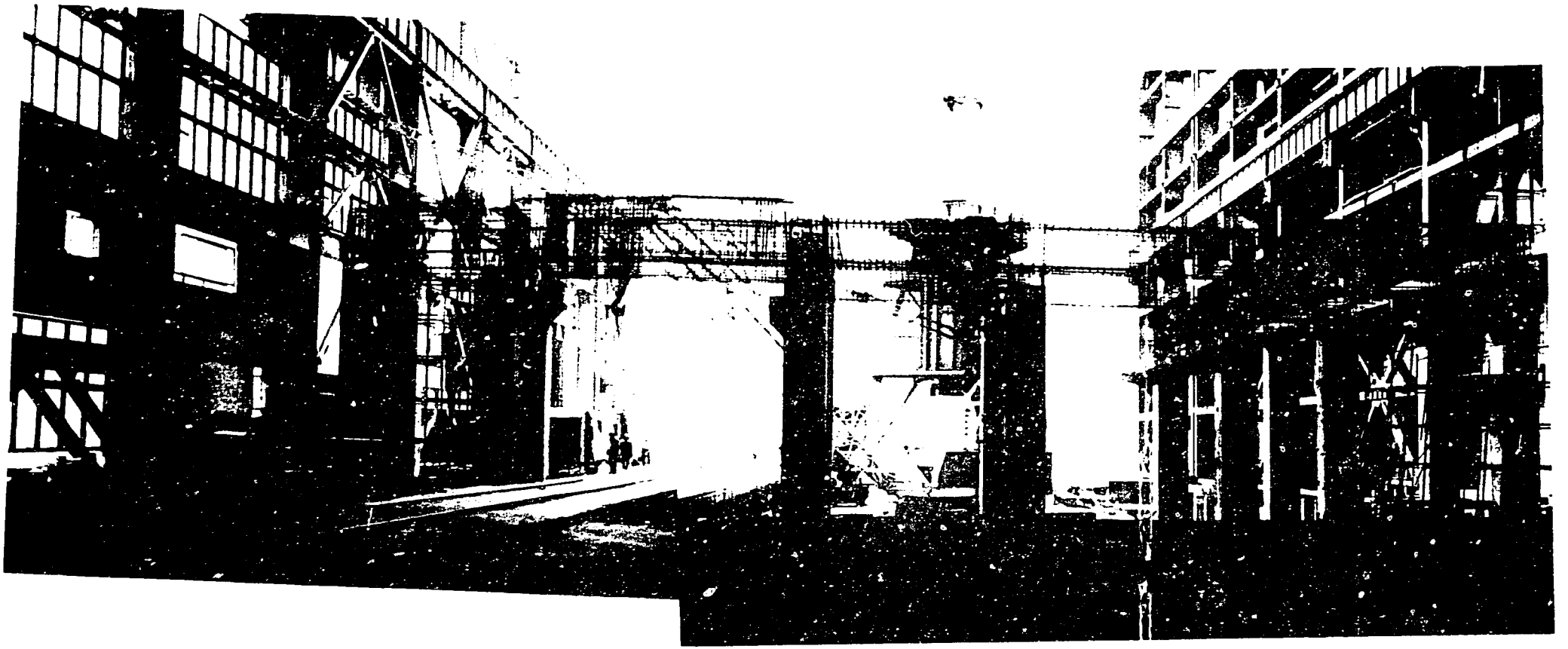


From left, new stack, boiler building and machinery(turbine) building.

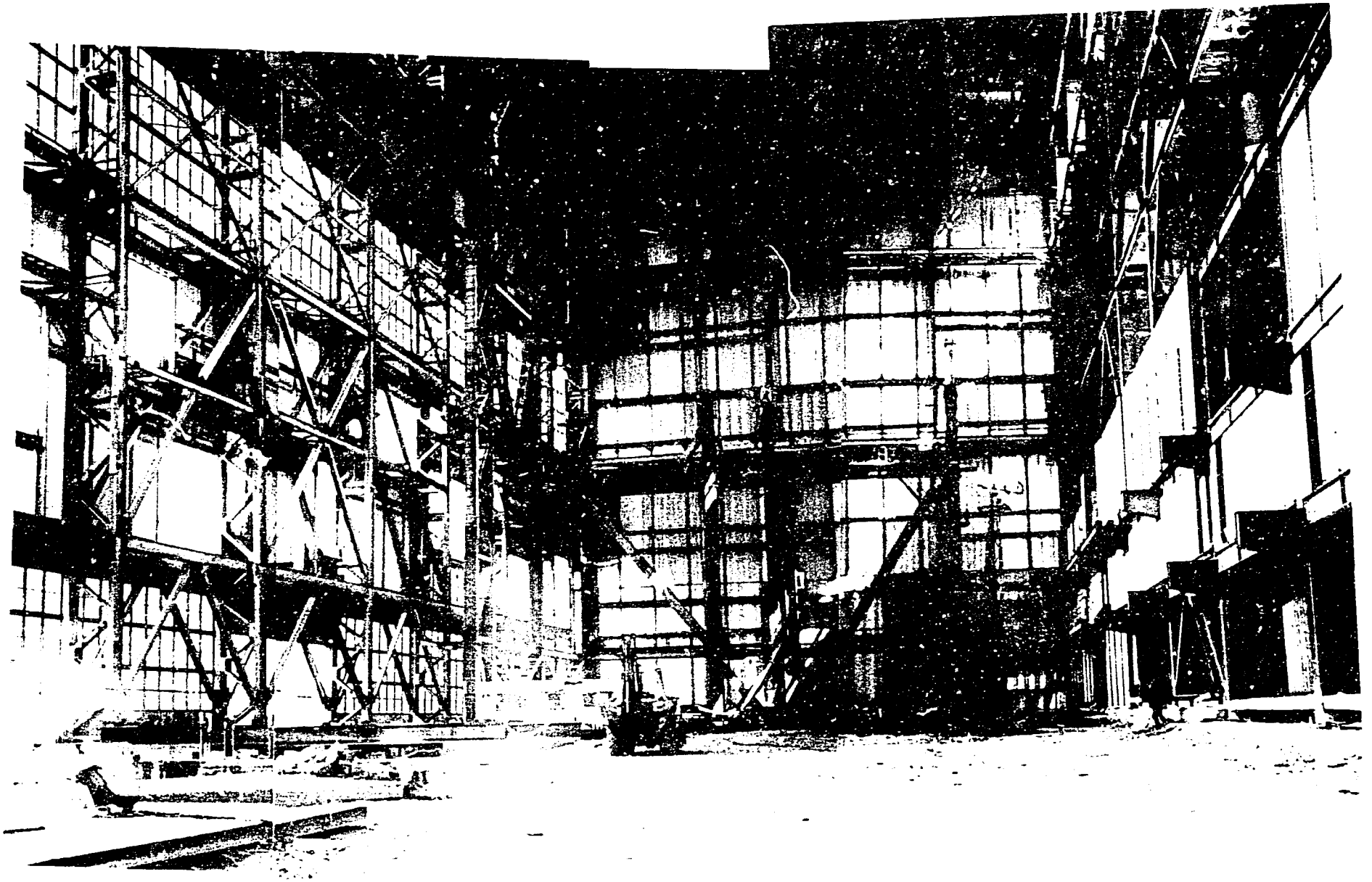


Interior machinery(turbine) building looking east.

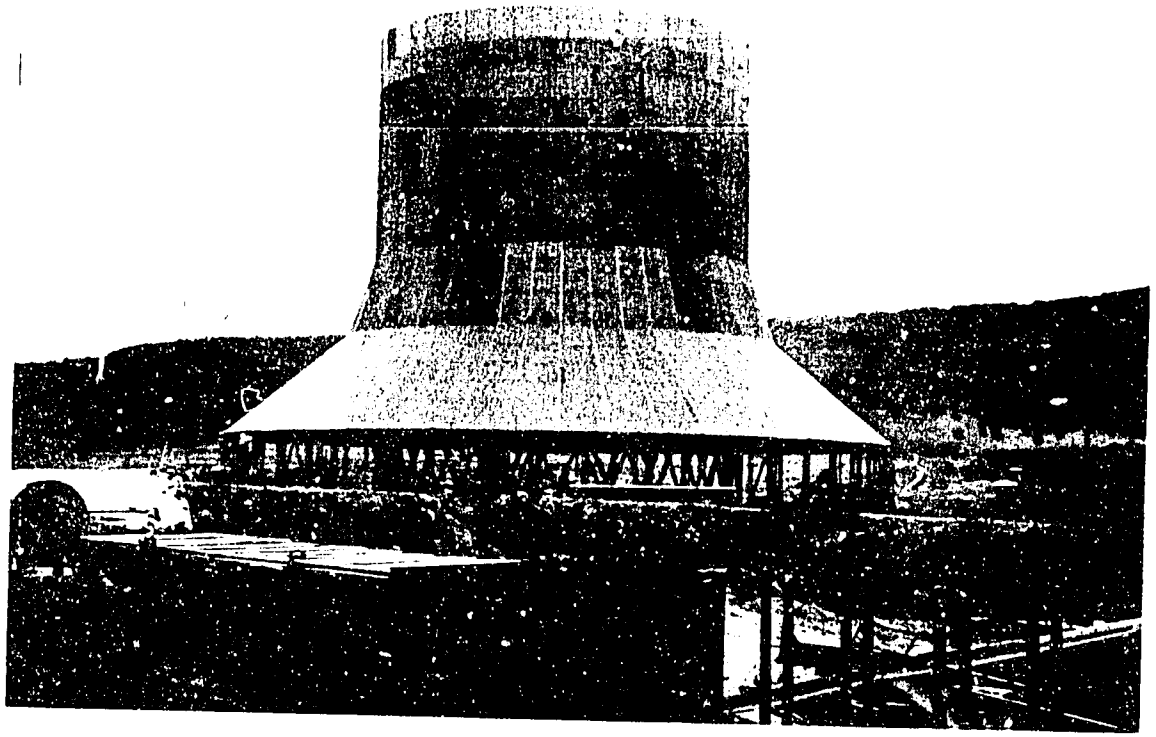
Existing stack, boiler building and machinery(turbine) building looking east.



Interior of machinery(turbine) building and turbine pedestal erection.

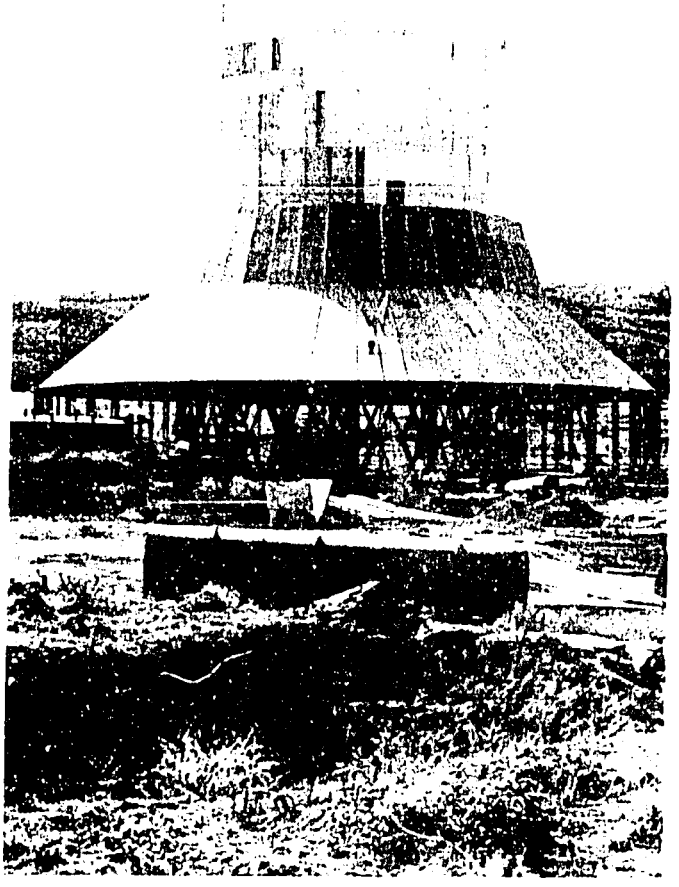


Interior of boiler building, boiler structural steel erection started.

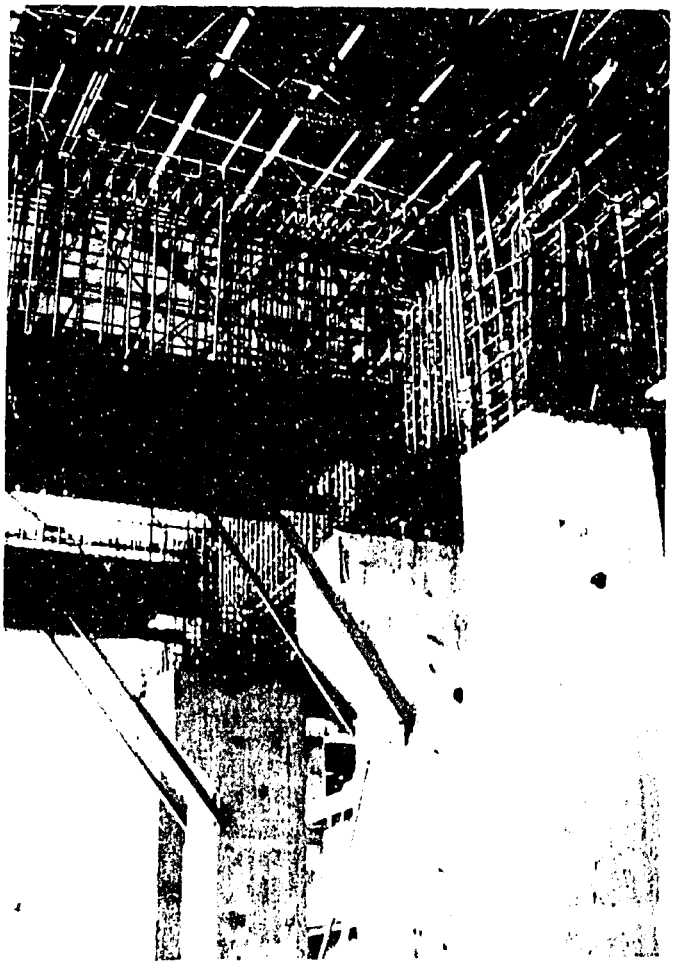


Cooling tower for Units 5 and 6 constructed to height of 110 meters looking southeast.

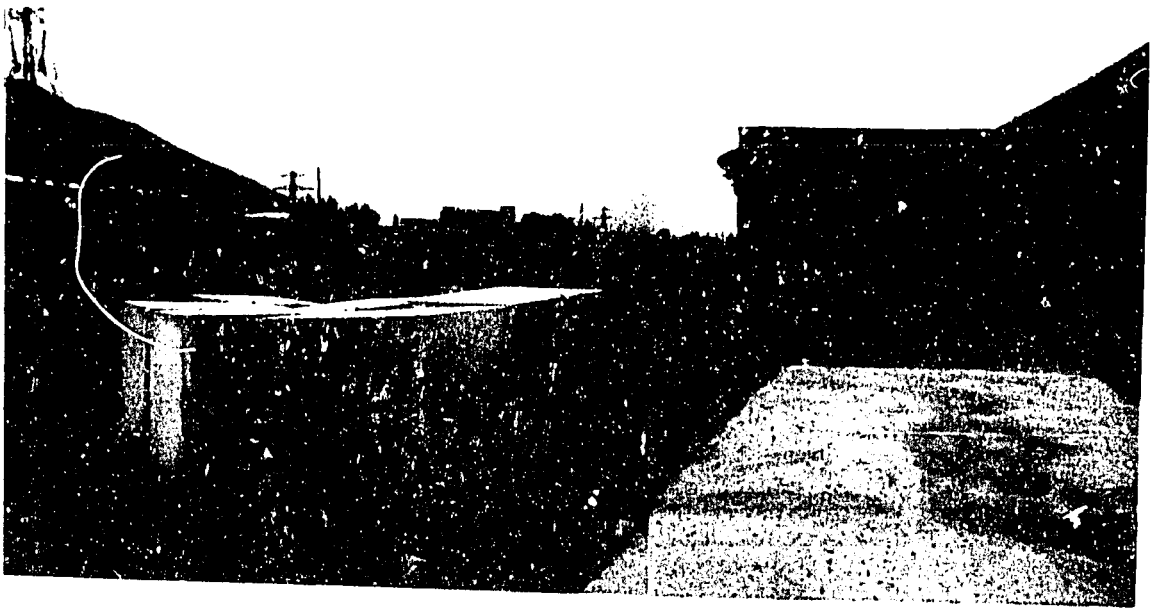
Machine(turbine) hall.



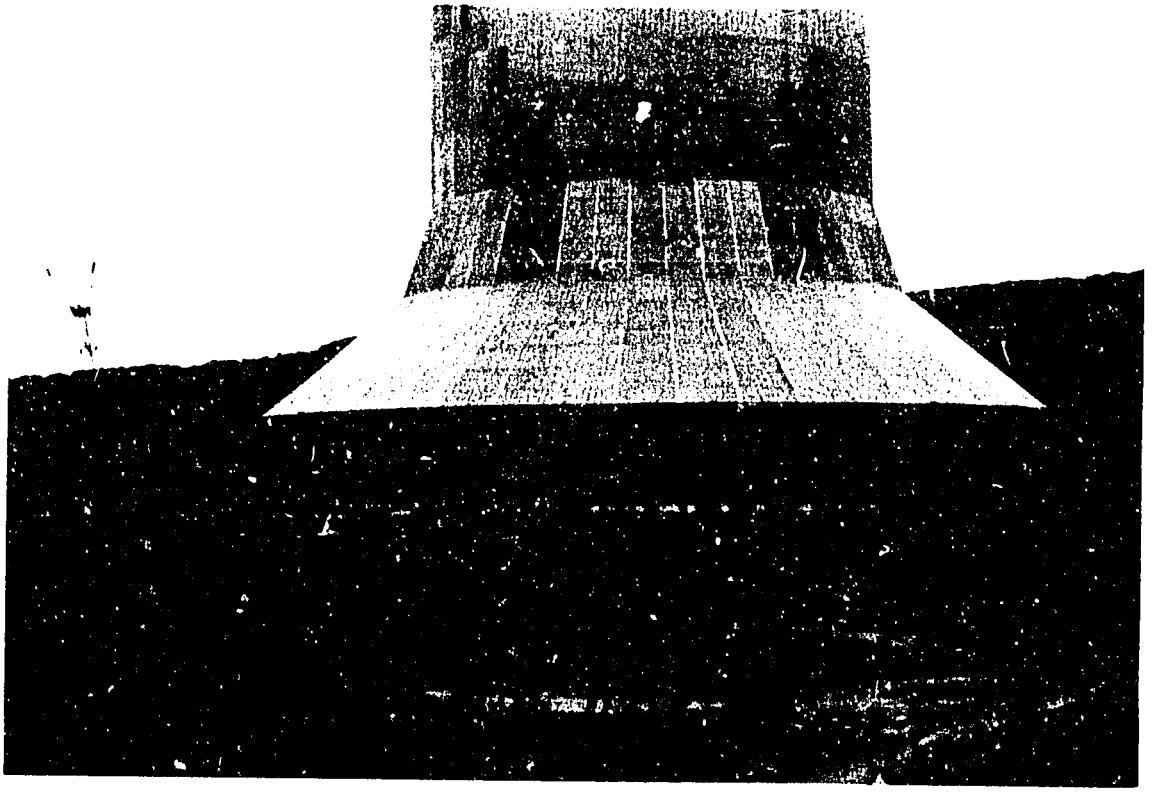
Partially constructed Unit 5 and 6 cooling tower.



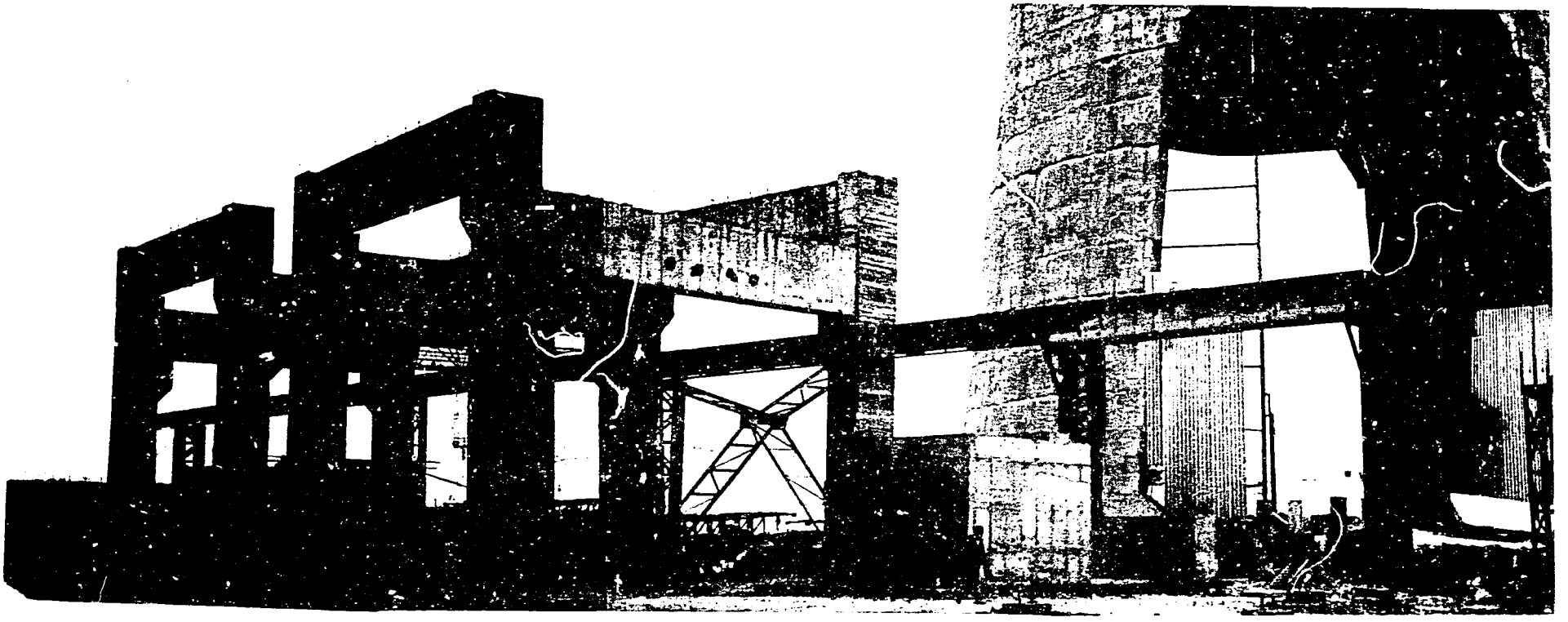
Turbine pedestal.



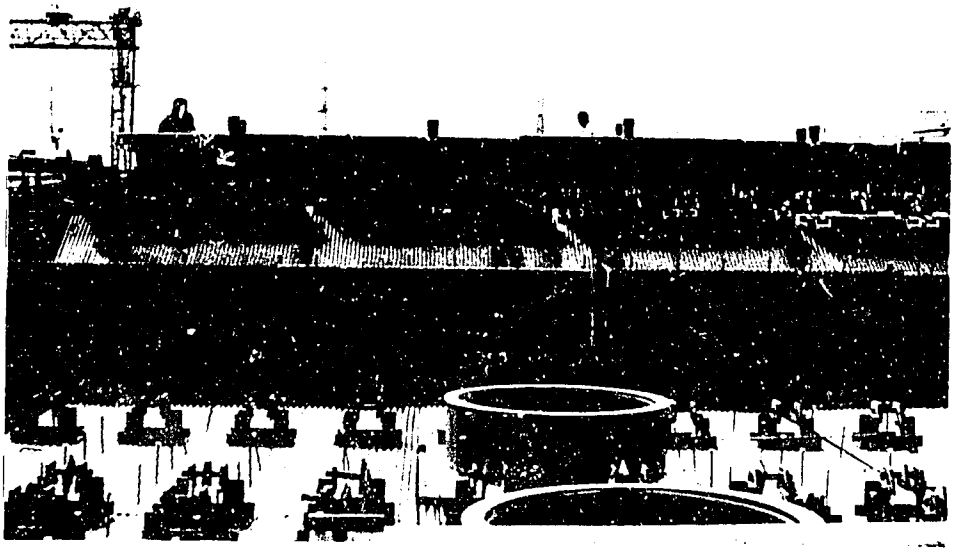
Intake Structure. From left to right the Hrazdan River, intake structure ductwork, and pumphouse looking north.



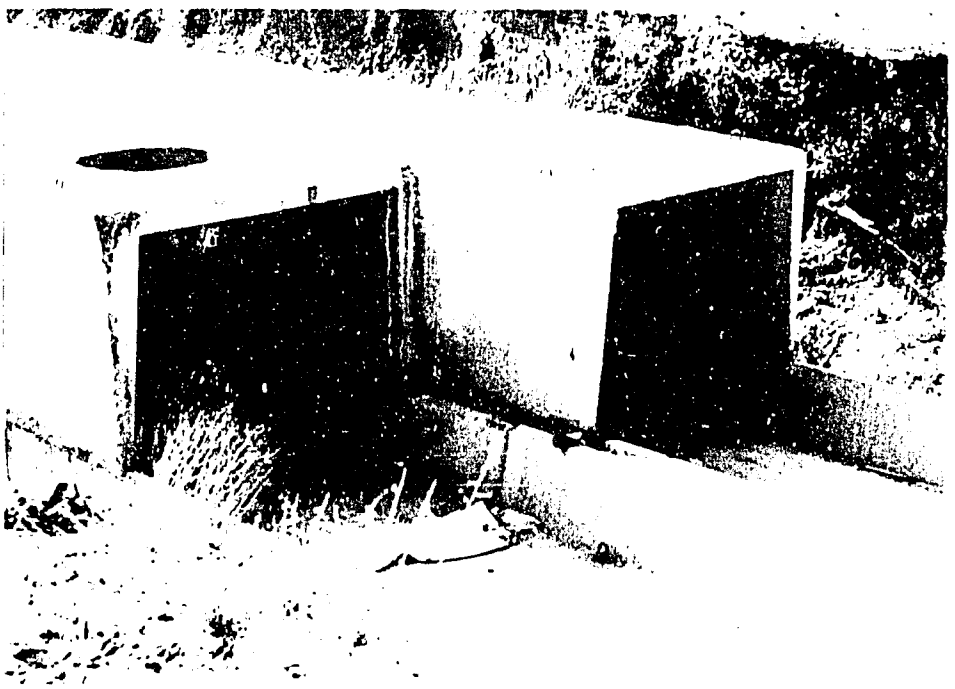
Unit 5 and 6 cooling tower.



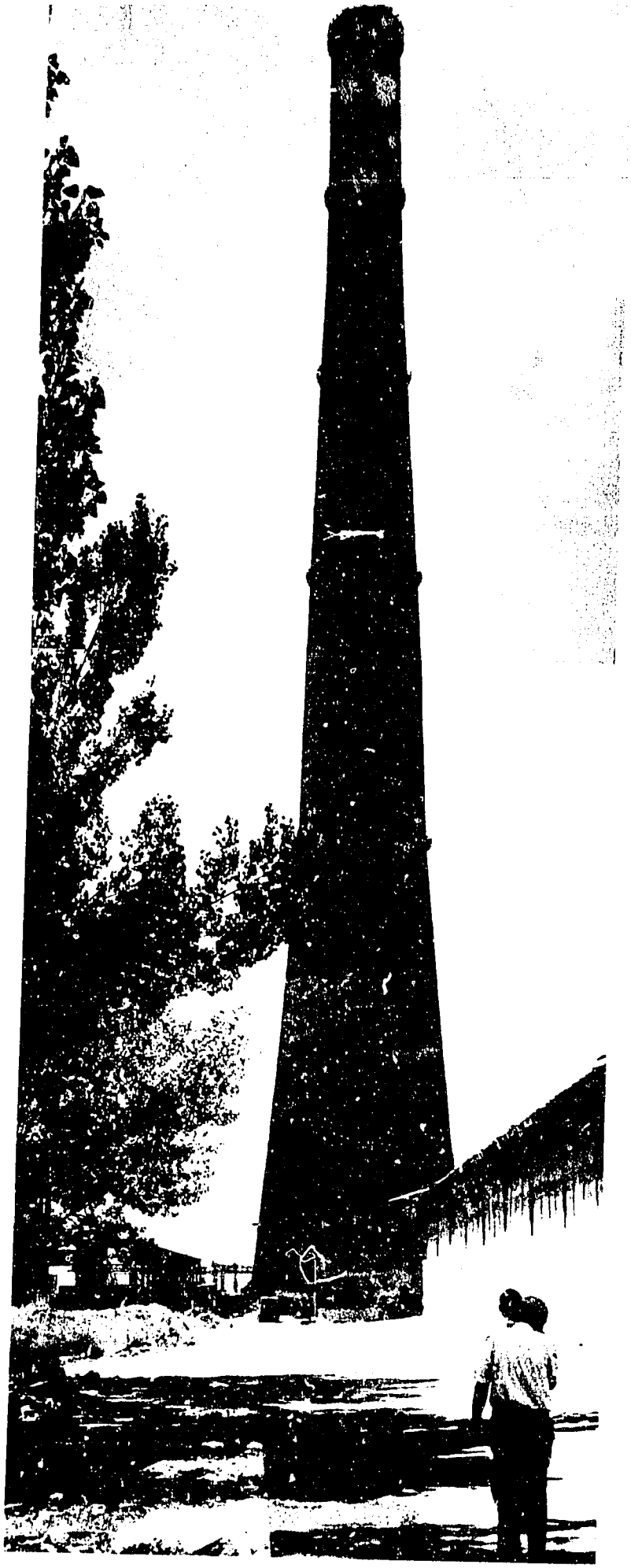
Boiler ID fan concrete foundation support and base of new stack.



Boiler tube walls being fabricated in laydown area.



Precast concrete cable trench between power block and switchyard.



New concrete stack looking west.

APPENDIX D

EBRD PROCUREMENT PROCESS

EBRD PROCUREMENT PROCESS

PROCUREMENT OF GOODS

Bidding Documents:

- Invitation for Bids	Brief letter identifying buyer, source of funds, goods required, where to obtain bid documents, cost of bid documents, bidder's obligation, and, bid due date
- Instructions to Bidders	Outlines details of buyer's requirements to assist bidder in preparation of proposal
- General Conditions of Contract	Provides contractual conditions that are customary and expected in a commercial transaction for goods
- Special Conditions of Contract	Provides contractual conditions that are specific to the goods for Hrazdan Unit No. 5; may reflect certain loan conditions
- Schedule of Requirements	Identifies required items and schedule
- Technical Specifications	Provides technical requirements of goods; includes: scope, quality standards, documentation submittals, service requirements, design requirements, testing, and shipping
- Bid Form and Price Schedules	Certification from bidder that proposal is conforming to buyer's requirements and buyer agrees to obtain a performance bond if given the award; identifies price of goods

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- Bid Security Form	Irrevocable certification, typically by a bank, confirming that buyer shall be paid the specified amount in the bid documents if bidder: withdraws proposal; refuses to execute contract; or refuses to furnish performance security; bid security typically remains in effect 30 days after bid validity
- Contract Form	Binding document that forms the contract between buyer and seller
- Performance Security Form	Irrevocable certification, typically by a bank, confirming that if seller does not comply with the contract (default), buyer can demand payment - generally 110-120% of the contract value

The development of the bidding documents requires coordination with technical, commercial, and legal bodies to ensure comprehensive but reasonable document.

EBRD PROCUREMENT PROCESS

SCHEDULE

Action	Sequential Days	Total Days	Days From Start
Develop Bidding Documents	0	45	45
Ministry Approval	45	15	60
EBRD Approval	60	15	75
Notification	45	60	105
Issue Bid Request	105	1	106
Receive Bids	106	60	166
Qualify/Evaluate Bids	166	20	186
Ministry Approval	186	10	196
EBRD Approval	196	10	206
Final Clarifications	206	5	211
EBRD Approval	211	5	216
Award	216	1	217
Note: Calendar Days			

Schedule based upon past experience with World Bank.

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