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**ARMENIA POWER SECTOR REFORM
METERING PROJECT
SYSTEM NETWORK METERING
IMPROVEMENT PLAN
TASK ORDER NO. 2
CONTRACT NO. LAG-I-00-98-00005-00**

Prepared for:

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EXECUTIVE SUMMARY

This report describes the proposed expenditures under the USAID \$15 Million Armenia Metering Program, Subtask A - Transmission Network System Metering Improvement. The program is designed to improve the commercial operations of Armenergo by:

1. Improving the metering infrastructure at the inflow and outflow nodes (substations) of the transmission network system, and
2. Improve the capability of the dispatch enterprise to utilize this improved infrastructure and information, thereby strengthening the commercial operation of the power market in Armenia.

After a thorough investigation into the state of existing infrastructure, a bottom-up assessment of required new infrastructure and equipment, and in consultation with USAID and host country counterparts; Hagler Bailly recommends five core activities as follows:

- ▶ Install new electronic meters at all substations of the transmission network system which will enable Armenergo and Armtrans to accurately meter all power inflows and outflows across the boundary of the transmission system network, and also monitor critical system data for establishing load flows and profiles,
- ▶ Install ancillary instrument transformers (current and potential), wiring, physical enclosures, etc. necessary to support meter installations,
- ▶ Procure meter calibration and test equipment,
- ▶ Procure and install a local data acquisition system which will enable Armenergo to efficiently collect power flow amounts at substations for commercial billing purposes.
- ▶ Provide training, documentation, and one U.S. study tour for selected Armenian staff to ensure sustainability of the metering equipment and program.

These five activities represent the minimum level of improvement in infrastructure and associated elements which will enable Armenergo to accurately monitor inflows and outflows from the transmission network system, and utilize this information to more accurately bill customers and pay suppliers.

The program is forecasted to need \$ 8.7 Million of the total \$15 Million program budget, itemized as follows:

Item		Cost
Electronic Meters		\$ 1,208,335
Ancillary Equipment	-	\$ 2,759,143
Calibration & Test Equipment	-	\$ 120,000
Data Acquisition Equipment	-	\$ 1,040,750
Training & Support	-	\$ 240,000
Shipping/Insurance	-	\$ 476,864
Contingency	-	\$ 292,255
Technical Assistance		\$ 2,522,969
Total		\$ 8,660,316

All necessary procurement, installations, and commissioning can be accomplished by the task order completion date of December 15, 1999.

Upon acceptance of the basic metering improvement plan, Hagler Bailly will proceed to finalize the equipment list and quantities, obtain quotations for equipment, and initiate the manufacturing process. At that time, we will also analyze the following cost reduction alternatives:

- ▶ Eliminate meter installations at GENCo substations that are not currently in service, and are not likely to be placed in service in the near future. These sites would be candidates for future meter installations. This approach will not affect the integrity of the metering program.
- ▶ Eliminate selected distribution company substations which carry small loads and are higher cost installations (primarily remote sites). Power flows at these substations would be estimated using historical data and spot load monitoring. This alternative will have an effect on the integrity of the metering program as some outflow points in the transmission network will not be metered.

Upgrading of Armenergo's ability to track power inflows and outflows will provide a sound basis for improving commercial operations in the near term, and will ensure that the proper metering equipment is installed for future SCADA/EMS upgrades.

CHAPTER 1 INTRODUCTION

The USAID Armenia Power Sector Metering Improvement Program is designed to support USAID's Strategic Objective 1.5 and is aimed at attaining a more economically sustainable and environmentally sound energy sector in five to seven years. The Program consists of two subtasks: Subtask A System [Transmission] Metering Program, and Subtask B [Distribution] Metering Program. This report is designed to address the metering plan for Subtask A and has been developed in accordance with the deliverable V.3.b. System Network Metering Improvement Plan.

The objective of USAID's Power Sector Metering Improvement Program is to implement a comprehensive project that will achieve the following primary results:

- ▶ Improve cash collections to the levels outlined in the Government of Armenia's Order 551,
- ▶ Increase the transparency of cash flow and financial reporting throughout the electric sector to improve the amount of payments from distribution enterprises to Armenergo, and the transmission and generation sectors,
- ▶ Build public confidence in the management and governance of the electric power sector,
- ▶ Increase the attractiveness of investment in the Armenian power sector, and,
- ▶ Promote and support other Government of Armenia reform projects.

The USAID Armenia Power Sector Reform, Metering Project, Network System Metering Improvement Project is structured to provide technical assistance, training, and procurement targeted to: high voltage network system electricity meters, instrument transformers, test & calibration equipment, data acquisition and processing equipment, and miscellaneous ancillary electric metering equipment. The overall goal of the Project is to improve the commercial operation of ARMTRANS, and thus the Armenian power sector, by establishing an accurate and credible metering system for network inflows and outflows of power transmission.

The Metering Plan will address five principal areas of improvement: high voltage metering, ancillary equipment, calibration & testing, data acquisition, and training. In addition, the procurement and monitoring plan is described herein.

CHAPTER 2

DESCRIPTION OF THE ARMENIAN TRANSMISSION SYSTEM NETWORK

In December 1995 the Government of Armenia began the restructuring of Armenergo, the vertically integrated state owned utility which owned and operated all power sector infrastructure. The plan unbundled generation (GENCOs) and distribution (DISCOs) entities into majority state owned joint stock companies, leaving Armenergo with responsibility for the transmission system, dispatch, and some financial settlement responsibilities. Prior to unbundling, there was little incentive to accurately track custody transfer of electric power between the vertically integrated elements of Armenergo. However, the unbundling process left Armenergo with the new and critical financial accounting responsibility of tracking purchases of electric power from generation facilities, and sales to distribution companies and large industrial users.

In 1998, in accordance with the provisions of the Energy law, the Government of Armenia restructured Armenergo by separation of key functions as follows:

- Armenergo retained dispatch, funds administration, and market operations responsibility
- A newly established state company, “High Voltage Electric Networks – SCJSC - ARMTRANS” was established to own, operate, and maintain the high voltage network system.

The Armenian transmission system network is the high voltage national transmission grid which transmits electric power throughout the country and is divided into nine subgrids: Eastern, Center, North, South, West, Tavoush, Kotayk, Goris, and Zangezur. The transmission system network operates 220kV and 110kV grid systems through 122 substations located throughout the system. There are approximately 1,479 KM of 220kV lines, and 3,122 KM of 110kV lines. The system is in a mixed state of reliability and operational efficiency. Maintenance has been severely lacking over the past eight years and only limited investment has been made in network expansion and upgrades. Metering is seriously deficient throughout the system.

Armenergo has overall responsibility for dispatch functions and operates the National Dispatch Center (NDC) in Yerevan. NDC manages the existing limited SCADA system, daily network system monitoring and controls operations, coordination of unplanned outages, and coordination of maintenance activities and planned outages. The transmission system operates with sufficient reserve capacity and very limited automated controls, thus daily operations usually involve monitoring, maintenance, and voice communications with GENCOs.

In 1997 an Independent Regulatory Commission (ERC) was created with the mandate to exercise regulatory control over all aspects of the Armenian power sector. While the ERC has received strong support, it lacks a sustainable and reliable source of funding. Significant institutional strengthening is needed in order for the ERC to accomplish its mandate.

Until Armenergo has the funding to perform major network system upgrades and improvements, this metering plan will provide necessary tracking and accounting of power inflows and outflows to improve commercial operations. The proposed metering will also be compatible with future system upgrades and sophisticated SCADA/EMS systems.

CHAPTER 3

RECOMMENDED METERING IMPROVEMENTS

Hagler Bailly, in conjunction with Armenergo, Generation Facilities, and the Ministry of Energy has conducted a thorough analysis of the status of metering throughout the transmission system network. The result is that five principal areas in need of improvement were identified:

- Metering
- Ancillary equipment
- Calibration & testing
- Data acquisition
- Training and support

Each of these areas are described in the following subchapters which outline the current status, recommended improvements, expected results, cost, and schedule.

3.1 METERING

3.1.1 Current Status

The transmission network system suffers from a severe lack of metering capability, both due to the absence of meters at critical points, and to old and outdated equipment. Our investigation has determined the following:

- ▶ *The absence of critical custody transfer meters at the inflow (purchasing) nodes of the system and at the outflow (sales) nodes of the system. A certain minimal level of metering is essential in order to be able to balance the system inflows and outflows and accurately meter electric power from sellers (GENCOs) to buyers (DISCOs and large industrial customers).*
- ▶ *The absence of meters at certain control and transfer nodes within the transmission network system. Accurate metering at these nodes is essential in order to be able to balance the load flow throughout the transmission network system. Metering at these nodes is not essential for custody transfer.*
- ▶ *The condition of existing meters is questionable. Many remained beyond their useful life, while others have suffered from inadequate maintenance. All existing meters are of outdated design and do not have the necessary functionality of modern electronic meters to support custody transfer data acquisition and SCADA/EMS systems.*

Hagler Bailly has determined that the program of custody transfer meter replacement and new meter installation will be required to improve the commercial operations of Armergo and fits within the scope-of-work and budget constraints of the existing task order. Likewise, it has been determined that a meter replacement and new installation program for load control and dispatch metering is beyond the scope and budget of the task order. Thus, the recommended improvements concentrate on essential metering to improve commercial operations.

3.1.2 Recommended Improvements

Hagler Bailly and our host country counterparts have conducted a thorough analysis of each meter installation throughout the transmission system network and have developed a complete list of meter replacements and new installations, which is contained in Appendix B. A summary is presented as follows.

Specification: Electronic three phase wathour meter, multitariff, digital readout, transformer rated, SCADA compatible, electronic storage of data and downloading interconnection, measurement and storage of: consumption, demand, active and reactive energy; mono and bi directional, load profile capability:

Table 3-1 Estimated Meters		
Location	Quantity	Cost
GENCO Substations	214	\$ 108,190
DISCO Substations	2,397	\$ 1,057,641
Customer Substations	8	\$ 3,521
Railroad Substations	83	\$ 36,782
Export/Import	5	\$ 2,201
Total	2,707	\$ 1,208,335

3.1.3 Expected Results

The following results of the comprehensive meter replacement and new installation program are expected:

1. Electronic meters will be specified, procured, shipped to Armenia, and installed at all inflow and outflow nodes of the transmission system network.

These meters will provide Armenergo with the essential transmission network system information necessary to balance and track power inflows and outflows for custody transfer (billing) purposes to improve commercial operations.

3.1.4 Cost and Schedule

The cost of these new meters is forecasted to be \$ 1,208,335 in commodities. The meter replacement and new meter installation program is expected to be completed by December 15, 1999.

3.1.5 Cost Reduction Alternatives

At the time final equipment specifications and quantities are determined, it is recommended that the following cost reduction alternatives be investigated:

- ▶ Eliminate meter installations at GENCo substations that are not currently in service, and are not likely to be placed in service in the near future. These sites would be candidates for future meter installations. This approach will not affect the integrity of the metering program.
- ▶ Eliminate selected distribution company substations which carry small loads and are higher cost installations (primarily remote sites). Power flows at these substations would be estimated using historical data and spot load monitoring. This alternative will have an effect on the integrity of the metering program as some outflow points in the transmission network will not be metered.

Both of these alternatives will be analyzed and a cost-benefit assessment made at the time a final equipment list is developed.

3.2 ANCILLARY EQUIPMENT

3.2.1 Current Status

Existing meters generally have the required current and potential instrument transformers installed, and these devices will work satisfactorily with the new electronic meters. Some replacement and/or addition of additional phase instrument transformers may be required. In addition, all new meter installations will require new instrument transformers. Other ancillary equipment associated with the meter replacement and new installations are summarized in the following section.

3.2.2 Recommended Improvements

The replacement and installation of new electric meters will require the simultaneous procurement and installation of ancillary equipment. The amount and type of this equipment is dependant upon the quantity and characteristics of the electric meters. A summary of ancillary equipment is presented as follows:

- ▶ Current and Potential Transformer Specification – Instrument transformers rated to be compatible with line voltages, current, and meter rated voltage and current.
- ▶ Meter Enclosures – Tamper resistant enclosures for meters.
- ▶ Meter Instrumentation Cable Specification – To be provided by the meter manufacturer and in accordance with any Armenergo specifications.
- ▶ Meter Seals – Industrial quality, exact type to be specified by Armenergo.

Table 3-2 Estimated Ancillary Equipment		
Location/Type	Quantity	Cost
Instrument Transformers:		
- GENCo Substations	98	\$ 1,652,000
- DISCO Substations	189	\$ 642,600
- Export/Import	5	\$ 128,400
Meter Instrument Cable	N/A	\$ 292,043
Meter Boxes	N/A	\$ 44,100
Total		\$ 2,759,143

3.2.3 Expected Results

The following results of the ancillary equipment program are expected:

1. Ancillary equipment for electronic meters will be specified, procured, shipped to Armenia, and installed at all inflow and outflow nodes of the transmission network system.

2. Other ancillary equipment will be specified, procured, shipped to Armenia, and installed as necessary.

This ancillary equipment will enable meter operation and complement the metering program which will provide Armenergo with the essential transmission system network information necessary to balance and track power inflows and outflows for custody transfer (billing) purposes to improve commercial operations.

3.2.4 Cost and Schedule

The cost of the ancillary equipment is forecasted to be \$ 2,759,143 in commodities. The ancillary equipment will coincide with the meter replacement and new meter installation program and is expected to be completed by December 15, 1999.

3.2.5 Cost Reduction Alternatives

An analysis of cost reduction alternatives will be made in conjunction with the metering cost reduction alternatives described in Section 3.1.5..

3.3 METER CALIBRATION & TESTING

3.3.1 Current Status

Existing meter calibration and test facilities are limited and, most importantly, are not capable of supporting the new advanced electronic meters to be procured under this program.

3.3.2 Recommended Improvements

Once the new electric meters have been installed, it will be essential for Armenergo to implement a program of meter calibration and testing. This is necessary for three reasons:

- ▶ To provide the equipment and training necessary to maintain and calibrate meters,
- ▶ Timely calibration and testing is necessary to ensure the accuracy of custody transfer accounting,
- ▶ Credible calibration and testing will be required for all participants (sellers, Armenergo, and buyers) to have faith in the metering program for custody transfer.

Hagler Bailly recommends the following calibration and testing equipment be procured:

Specification Fixed and portable electronic meter calibration unit(s) capable of shop and field calibration of electronic meters. Units must be compatible with purchased and existing meters.

Table 3-3 Estimated Calibration Equipment		
Equipment Type	Quantity	Cost
Stationary Test Stand	1	\$ 30,000
Portable Test Stand	3	\$ 90,000
Total	4	\$ 120,000

3.3.3 Expected Results

The following results of the calibration and testing program are expected:

1. Calibration and test equipment for electronic meters will be specified, procured, shipped to Armenia, and installed at calibration and testing shops. .

This calibration and testing equipment will compliment the metering program which will provide Armenergo with the essential transmission network system information necessary to balance and track power inflows and outflows for custody transfer (billing) purposes to improve commercial operations.

3.3.4 Cost and Schedule

The cost of the calibration and testing equipment is forecasted to be \$ 120,000 for commodities. The meter calibration and testing activity will coincide with the meter replacement and new meter installation program and is expected to be completed by December 15, 1999.

3.4 DATA ACQUISITION

3.4.1 Current Status

Armenergo has a limited SCADA data acquisition system in place for the generation facilities only. This system provides intermittent data gathering through a combination of PLC, coax, radio, and direct connections. Voice and FAX communications use the same analog land lines. The system is judged to be too unreliable, limited in capacity, and too outdated to perform the remote data acquisition support for the newly installed network system meters.

3.4.2 Recommended Improvements

Hagler Bailly has conducted a thorough evaluation of the data acquisition options (see Appendix A) and recommends a local data acquisition system be implemented until Armenergo obtains funding for a full scale automated SCADA/EMS system and associated telecommunications infrastructure.

The equipment would consist of a local PC at each substation which will periodically and automatically collect data from substation meters, build a data base of custody transfer and other relevant data, and store this data for downloading to an intermediate device (portable PC or data storage device) for eventual transfer to the NDC. The following equipment is recommended:

Specification: The data acquisition system will consist of computer workstations and software necessary to gather and download transmission system network data to NDC and Armenergo. All systems must be compatible with metering equipment and existing Armenergo computer systems.

Table 3-4 Estimated Data Acquisition Equipment		
Equipment Type	Quantity	Cost
Substation Workstations	94	\$ 940,000
Armenergo Workstations/Software	1	\$ 40,000
Optical Probes	18	\$ 6,750
Laptop Computers	18	\$ 54,000
Total	123	\$ 1,040,750

3.4.3 Expected Results

The following results of the data acquisition system are expected:

1. Data acquisition equipment for electronic meters will be specified, procured, shipped to Armenia, and installed at various locations including: substations, Armenergo, and Armtrans.
2. Transmission network system data will be available to Armenergo for the purposes of tracking and measuring system inflows and outflows.

This data acquisition equipment will complement the metering program which will provide Armenergo with the essential transmission system network information necessary to balance and

track power inflows and outflows for custody transfer (billing) purposes to improve commercial operations.

3.4.4 Cost and Schedule

The cost of the data acquisition equipment is forecasted to be \$ 1,040,750 for commodities. The data acquisition activity will coincide with the meter replacement and new meter installation program and is expected to be completed by December 15, 1999.

3.4.5 Cost Reduction Alternatives

An analysis of cost reduction alternatives will be made in conjunction with the metering cost reduction alternatives described in Section 3.1.5.

3.5 TRAINING & SUPPORT

3.5.1 Current Status

The availability of training for the four meter program activities listed previously is non-existent. The metering program will need to include and fund necessary training and local support services for the new commodities.

3.5.2 Recommended Improvements

Hagler Bailly recommends the following training and support activities be included in the program:

- ▶ Meter installation, maintenance, programming, and general operations training (in-country) for applicable Armenergo personnel. This will consist of sufficient training by a manufacturer's representative, several sessions are envisioned.
- ▶ Meter calibration and testing training (in-country) for Armenergo and National Technical Standards Institute staff.
- ▶ Study tour to the United States. A study tour for selected Armenergo staff to visit a U.S. utility calibration and testing laboratory, as well as various standards setting agencies, and metering/billing system departments.
- ▶ Data acquisition system training for Armenergo and NDC staff.
- ▶ Establishment of manufacturer support capability in Armenia.

3.5.3 Expected Results

The following results of the training and support program are expected:

1. Armenian staff from participating organizations (Armenergo, Ministry of Energy, etc.) will be trained in electronic meter installation, calibration, programming, and maintenance.
2. The calibration and testing study tour will be conducted.
3. Armenian staff from Armenergo will be trained on transmission system network data acquisition and processing.
4. Local manufacturer support for procured equipment will be established.

The training and support program will complement the metering program which will provide Armenergo with the essential transmission network system information necessary to balance and track power inflows and outflows for custody transfer (billing) purposes to improve commercial operations.

3.5.4 Cost and Schedule

The cost of training and support is estimated to be \$ 240,000 for services and materials. The training and support activity will coincide with the meter replacement and new meter installation program and is expected to be completed by December 15, 1999.

3.6 SUMMARY OF METERING IMPROVEMENT COMMODITIES AND COST

The following summary of equipment quantities and costs is presented to illustrate the total budget allocation for the network metering project:

Table 3-5 Summary of Metering Improvement Equipment Costs		
Item		Cost
Electronic Meters		\$ 1,208,335
Ancillary Equipment	-	\$ 2,759,143
Calibration & Test Equipment	-	\$ 120,000
Data Acquisition Equipment	-	\$ 1,040,750
Training & Support	-	\$ 240,000
Shipping/Insurance	-	\$ 476,864
Contingency	-	\$ 292,255
Technical Assistance		\$ 2,522,969
Total		\$ 8,660,316

Notes:

- 1) Equipment costs include: actual commodity cost and installation oversight.
- 2) Technical assistance includes: labor, associated other direct costs (travel, per-diem, etc.), local Armenia support costs, overhead, and fees.
- 3) Contingency is provided at this time to cover unknown costs. Once the equipment bid analysis, shipping, and installation costs are firmed up, the contingency will be allocated to other programs.

CHAPTER 4 PROCUREMENT AND INSTALLATION PLAN

The timely and efficient procurement and installation of task order commodities will be essential given the very short timeframe of the project. Hagler Bailly will procure and install all equipment in accordance with USAID procurement regulations and applicable task order requirements. We anticipate the following major activities:

Request for Quotation – Hagler Bailly will place a Commerce Business Daily (CBD) announcement for the recommended commodities, develop a request for quotation solicitation and commodity technical specifications. Vendors will be given 15 business days to respond.

Bid Analysis – Based on the quotations received, Hagler Bailly will perform a bid analysis and recommend procurement based on conformance to the technical specifications and best value to the Government. This will be completed within 5 business days.

USAID COTR/CO Approval – We will request the appropriate USAID approvals. At the same time, we will inform Armenian counterpart organizations of the results of the technical bid analysis and seek concurrence for the recommended manufacturer. We are requesting USAID review within 10 business days.

Manufacturing – Upon approval, Hagler Bailly will issue purchase orders for the recommended commodities. We will also schedule a site visit by the manufacturer at this time to validate and verify technical specifications prior to manufacturing. Hagler Bailly will monitor the manufacturing process to ensure timely delivery of the commodities. Manufacturing time will vary by commodity, but all manufacturing is scheduled to be complete by July 31, 1999.

Shipping and Delivery – Hagler Bailly will expedite shipping, clearance through Armenian customs, and delivery to the installation location.

Installation – Hagler Bailly will coordinate installation of the commodities and provide installation oversight through short term expatriate technical staff, and local technical staff. Actual installation of meters and associated high voltage components will be the responsibility of Armenergo. All commodities are scheduled to be installed by December 15, 1999.

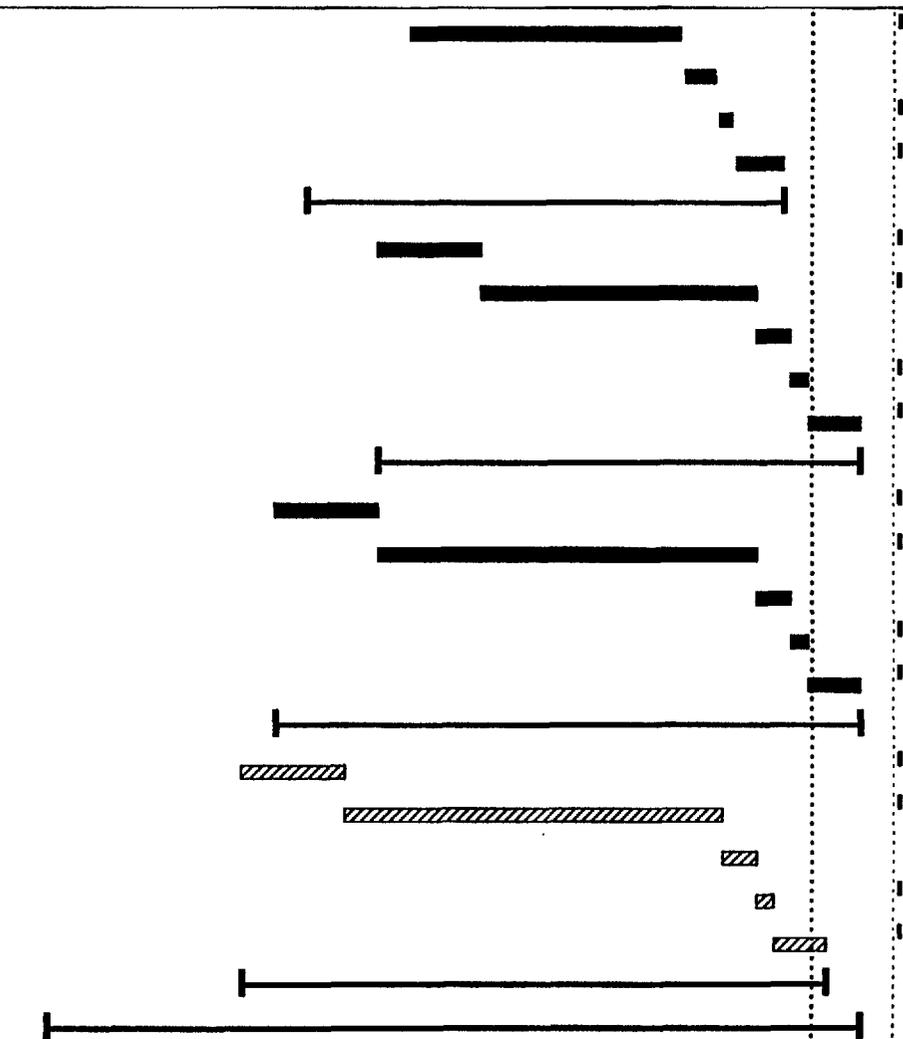
During the course of the procurement cycle, Hagler Bailly will schedule the various training components and the U.S. study tour to coincide with commodity procurement and availability of selected staff to participate in the programs.

The following time-line illustrates the major procurement and installation activities scheduled for 1999.

Procurement & Installation Plan

ID	Task Name	Duration	Responsibility	Start
1	PROCUREMENT	236 days		1/15/1999
2	Metering	170 days		1/29/1999
3	Request for Quotation	15 days	HB	1/29/1999
4	Bid Analysis	5 days	HB	2/19/1999
5	USAID COTR/CO Approval	10 days	USAID/GOA	2/26/1999
6	Manufacturing	110 days	HB/Vendor	3/12/1999
7	Shipping & Delivery	30 days	HB/Shipper	8/13/1999
8	Ancillary Equipment	170 days		1/15/1999
9	Request for Quotation	15 days	HB	1/15/1999
10	Bid Analysis	5 days	HB	2/5/1999
11	USAID COTR/CO Approval	10 days	USAID/GOA	2/12/1999
12	Manufacturing	110 days	HB/Vendor	2/26/1999
13	Shipping & Delivery	30 days	HB/Shipper	7/30/1999
14	Calibration & Testing Equipment	140 days		1/15/1999
15	Request for Quotation	15 days	HB	1/15/1999
16	Bid Analysis	5 days	HB	2/5/1999
17	USAID COTR/CO Approval	10 days	USAID/GOA	2/12/1999
18	Manufacturing	80 days	HB/Vendor	2/26/1999
19	Shipping & Delivery	30 days	HB/Shipper	6/18/1999
20	Data Acquisition	140 days		2/15/1999
21	Request for Quotation	15 days	HB	2/15/1999
22	Bid Analysis	5 days	HB	3/8/1999
23	USAID COTR/CO Approval	10 days	USAID/GOA	3/15/1999
24	Manufacturing	80 days	HB/Vendor	3/29/1999

1999	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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Procurement & Installation Plan

ID	Task Name	Duration	Responsibility	Start	1999														
					Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
25	Shipping & Delivery	30 days	HB/Shipper	7/19/1999															
26	Training & Support	139 days		6/1/1999															
27	Meter Installation, Maintenance, etc.	20 days	HB/Vendor	10/1/1999															
28	Calibration & Testing	20 days	HB/Vendor	11/1/1999															
29	Study Tour	10 days	HB	6/1/1999															
30	Data Acquisition Training	20 days	HB/Vendor	11/15/1999															
31	INSTALLATION	109 days		7/30/1999															
32	Metering	69 days	Armenergo	9/24/1999															
33	Ancillary Equipment	69 days	Armenergo	9/10/1999															
34	Calibration & Testing Equipment	60 days	HB	7/30/1999															
35	Billing Software	78 days	HB	8/30/1999															

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CHAPTER 5 MONITORING PLAN

The task order calls for Hagler Bailly to monitor the impact on the commercial operations of the power sector and document the results in a brief (15 page) impact analysis report. Given that the most optimistic procurement and installation schedule will not be complete until December 15, 1999, there will be minimal opportunity for impact analysis. However, Hagler Bailly will monitor available impact data during the period of installation (September through December) and report on the findings.

The monitoring plan will entail the following activities:

- ▶ Summarize the meter installations, dates of commissioning and in-service, and dates of initial data collection.
- ▶ Compare initial readings with historical information at the meter, substation, area, and system as information becomes available.
- ▶ Establish a monitoring plan spreadsheet for Armenergo to use in comparing new information with historical information.
- ▶ Prepare a brief (15 page) report for USAID and Armenergo on the monitoring results

Ultimately, any improvement in commercial operations will depend on Armenergo's ability to transform accurate meeting information into collections from customers, and more accurate payments to suppliers.

CHAPTER 6
LATE FEBRUARY MODIFICATIONS TO THE ARMENIA POWER SECTOR
REFORM METERING PROJECT – SYSTEM NETWORK METERING
IMPROVEMENT PLAN (DATED 5 FEBRUARY, 1999)

This System Network Metering Improvement Plan has been revised to reflect meetings of the system network working group, and the Government of Armenia, which were held in late February 1999. The meetings were conducted to define the exact equipment specifications and quantities, and the resulting modifications are described in this Section 6:

- ▶ An updated equipment list based on working group meetings and discussions with the Government of Armenia,
- ▶ An updated procurement, installation, and monitoring schedule, and
- ▶ Further definition of procurement and installation responsibilities.

EQUIPMENT LIST

Hagler Bailly, and the transmission working group, have conducted a thorough review of cost reduction alternatives outlined in Section 3.1.5. As a result, cost savings have been achieved by reducing the number of instrument transformers and non-critical meters. In addition, substitution of some single channel meters with multi-channel meters at key monitoring points has been included, as has the provision of contingency funds. This has resulted in a net cost reduction for the transmission program from an estimated \$ 8,660,316 to \$ 8,445,871. The final approved equipment list, based on discussions with the transmission working group and the Government of Armenia, is included in this section as a Table 6-1 Transmission Equipment List.

The overall budget estimate for this approved System Network Metering Improvement Plan is estimated at:

Metering Equipment, ancillary equipment, shipping, etc.	\$ 5,931,648
Technical Assistance labor	\$ 1,547,595
Other direct costs associated with TA labor (travel, per-diem, etc.)	\$ <u>966,628</u>
Total	\$ 8,445,871

PROCUREMENT, INSTALLATION AND MONITORING SCHEDULE

The schedule contained in Chapter 4 has been updated to reflect the current estimated schedule of tender, manufacturing, shipping, installation, and monitoring. The timeframe has been extended by approximately eight weeks from the original schedule and is now projected to run through February 11, 1999. The extension has been incorporated to account for the longer than anticipated time required to achieve consensus on the equipment list. Table 6-2 illustrates the modified schedule.

It is important to note that this schedule is only an estimate at this point. Hagler Bailly is working to complete the project according to the original project completion date of December 15, 1999. During the solicitation and bid evaluation process, manufacturing/shipping schedules and associated costs will be evaluated to determine the most cost-effective means of completing the project within the original contract estimated completion date. If this evaluation merits an extension request, Hagler Bailly will seek COTR 60-day extension approval at the appropriate time.

PROCUREMENT AND INSTALLATION RESPONSIBILITIES

The Memorandum of Understanding between the US Government and the GOA outlines the division of responsibilities between USAID and its subcontractors, and the Government of Armenia for procurement and installation. In summary:

- ▶ USAID and its subcontractors shall be responsible for procuring all offshore equipment and limited locally supplied equipment for the metering program, shipment of such equipment to Armenia, and staging of equipment in Yerevan. Technical assistance in support of installation, training, start-up, and commissioning shall also be provided.
- ▶ The Government of Armenia shall be responsible for receiving the equipment at the Hagler Bailly staging site in Yerevan, transport to the installation site, installation labor and materials, start-up, and commissioning of the equipment. Staging is necessary to ensure the equipment is in a safe and secure location, and to ensure equipment is released only as necessary for installation.

The Government of Armenia will be responsible for obtaining all duty-free importation documentation for the offshore equipment.

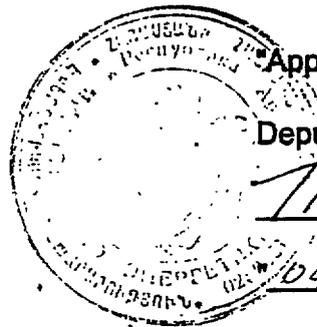
**TRANSMISSION METERING IMPROVEMENT PLAN
LIST OF EQUIPMENT AND COST ESTIMATE**

Table 6-1

#	ITEM	Unit Cost	Armtrans in		Armtrans out		Export/import		Customer's subs		Railroad subs		Total	
			Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	Meters-Demand, kWh, KVARh, TOU, Load Profile													
	- one-directional, mono-channel	\$440	90	\$39,600	2,373	\$1,044,120			8	\$3,520	81	\$35,640	2,552	\$1,122,880
	- bi-directional, mono-channel	\$565	68	\$38,420	21	\$11,865	5	\$2,825			2	\$1,130	96	\$54,240
	- one-directional, two-channel	\$790	9	\$7,110									9	\$7,110
	- one-directional, three-channel	\$1,140	3	\$3,420									3	\$3,420
	- bi-directional, six-channel	\$1,965	44	\$86,460									44	\$86,460
2	CTs													
	-220kV	\$30,000	7	\$210,000			1	\$30,000					8	\$240,000
	-110kV	\$19,200	65	\$1,248,000			1	\$19,200					66	\$1,267,200
	-35kV	\$3,400	20	\$68,000	189	\$642,600							209	\$710,600
3	PTs													
	-110kV	\$21,000	6	\$126,000									6	\$126,000
4	Control cable	\$1,500	14	\$21,000	140	\$210,000			0	\$225			154	\$231,225
5	Power cable	\$2,000			20	\$40,000							20	\$40,000
6	Data acquisition system	\$10,000	10	\$100,000	84	\$840,000							94	\$940,000
7	Hardware & Software	\$40,000	1	\$40,000									1	\$40,000
8	Stationary test bench	\$30,000			1	\$30,000							1	\$30,000
9	Portable test bench	\$30,000			3	\$90,000							3	\$90,000
10	Training and support	\$240,000			1	\$240,000							1	\$240,000
11	Laptop computers	\$3,000			18	\$54,000							18	\$54,000
12	Boxes													
	- large	\$150	22	\$3,300	259	\$38,850							281	\$42,150
	-medium	\$100							3	\$300	14	\$1,400	17	\$1,700
	-small	\$50					5	\$250					5	\$250
13	Shipping/Insurance	\$457,672											1	\$457,672
14	Contingency	\$146,741											1	\$146,741
	Total													\$5,931,848

AG

APPENDIX A
APPROVED EQUIPMENT LIST BY WORKING GROUP



Approved

Deputy Minister of Energy

R. Nazarian
R. Nazarian

04 02

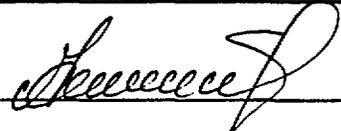
1999

**List of the equipment and estimated costs to be provided by USAID
for metering improvements in the Armtrans**

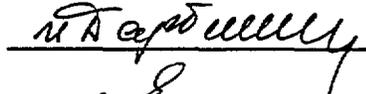
	Measur. unit	Number of units	Cost per unit	Shipment cost	Cost
Armtrans in					
Meters					
- one-directional	pcs	102	\$440	\$20	\$46,902
- bi-directional	pcs	112	\$565	\$20	\$65,500
CTs					
- 220 kV	sets	7	\$30,000	\$3,453	\$234,171
- 110 kV	sets	65	\$19,200	\$3,453	\$1,472,445
- 35 kV	sets	20	\$3,400	\$144	\$70,877
PTs					
- 110 kV	sets	6	\$21,000	\$3,453	\$146,718
Control cable	km	14	\$1,500	\$130	\$22,820
Data acquisition system	sets	10	\$10,000	\$500	\$105,000
Boxes	pcs	22	\$150	\$0	\$3,300
Subtotal					\$2,167,733
Armtrans out					
Meters					
- one-directional	pcs	2,373	\$440	\$20	\$1,091,153
- bi-directional	pcs	21	\$565	\$20	\$12,281
CTs					
- 35 kV	sets	189	\$3,400	\$144	\$669,791
Data acquisition system	sets	84	\$10,000	\$500	\$882,000
Control cable (5*4)	km	140	\$1,500	\$130	\$228,200
Power cable (4*16)	km	20	\$2,000	\$150	\$43,000
Hardware & Software for Armenergo & Armtrans	sets	1	\$40,000	\$0	\$40,000
Stationary Test Bench	pcs	1	\$30,000	\$1,000	\$31,000
Portable Test Bench	pcs	3	\$30,000	\$1,000	\$93,000
Training and Support		1	\$240,000	\$0	\$240,000
Installation		1	\$24,950	\$0	\$24,950
Laptop computers	pcs	18	\$3,000	\$40	\$54,720
Boxes	pcs	259	\$150	\$0	\$38,850
Subtotal					\$3,448,946

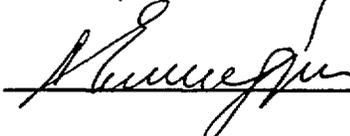
Export/Import

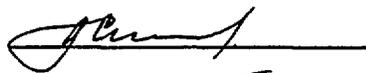
Meters					
- bi-directional	pcs	5	\$565	\$20	\$2,924
CTs					
- 220 kV	sets	1	\$30,000	\$3,453	\$33,453
- 110 kV	sets	1	\$19,200	\$3,453	\$22,653
Boxes	pcs	5	\$50	\$0	\$250
Subtotal					\$59,030
Customer's substations					
Meters					
- one-directional	pcs	8	\$440	\$20	\$3,679
Control cable (5*4)	km	0.15	\$1,500	\$130	\$245
Boxes	pcs	3	\$100	\$0	\$300
Subtotal					\$3,923
Railroad substations					
Meters					
- one-directional	pcs	81	\$440	\$20	\$37,245
- bi-directional	pcs	2	\$565	\$20	\$1,170
Boxes	pcs	14	\$100	\$0	\$1,400
Subtotal					\$38,415
Total for equipment					\$ 5,718,047

R. Abrahamian  Armtrans CSJSC, Executive Director

V. Petrossian  Armtrans CSJSC, Chief Engineer

I. Darbinian  Armtrans CSJSC, Deputy Executive Director

L. Yeghiazarian  Energy Institute CSJSC, Executive Director

V. Sahakov  Energy Institute CSJSC, Head of Department

A. Galstian  Ministry of Energy of RA,
Head of Main Department

F. Tadevossian _____ Ministry of Energy of RA,
Head of Department

APPENDIX B
MEMORANRUM ON DATA ACQUISITION

MEMORANDUM

TO: A. Galstian, Ministry of Energy
FROM: Matt Chwalowski/Mike Ellis, Hagler Bailly
CC: A. Arzumanian, W. Hall, W. McPhie, C. Moulin, D. White
DATE: January 13, 1999
SUBJECT: Data Acquisition Selection and Considerations for Transmission Network System in Armenia, Task Order No. 2, Contract No. LAG-I-00-98-00005--00

RECOMMENDATIONS

Hagler Bailly, in furtherance of the objectives and timeframe of Task Order No. 2, has selected Local Data Acquisition System for installation at the transmission network system to collect meter data at each substation. Additionally, each data acquisition system may be equipped with low cost modems that can be used to transmit data from substations to the National Dispatch Center (NDC), provided that existing telephone system capabilities permit that.

BRIEF DESCRIPTION

The Local Data Acquisition System will enable meter data collection at each substation within the transmission network. This solution avoids having to poll each meter separately, but rather collect all reads within a substation. Meter reads can then be saved on a disk and send to NDC for input to billing or possibly mailed electronically, provided that telephone lines have data transmission capabilities. Such system can be equipped with modems in the event this remote connectivity is possible.

Each system will consist of the following components at each substation:

- A computer to collect data
- Wiring to connect all meters with the computer
- Modem and converter to enable connectivity between meters and a computer at substation
- Software to collect and interpret data

This system will be installed at all ARMTRANS substations, both on the inlet from generation and outlet to distribution companies that are part of Task Order No. 2. It will not be installed at customer and railroad substations since there are too few meters per such substations; laptops will be used to periodically collect data from meters via an optical port.

It is anticipated that the data acquisition vendor will provide assistance with the initial installation at a number of substations and train a local contractor to conduct installations at the remaining substations within the transmission network.

Hagler Bailly

EXECUTIVE SUMMARY

This memo discusses three Data Acquisition systems that are available for any transmission network as well as their fit with the Task Order goals and objectives. The three Data Acquisition systems are as follows:

- **Real-time Data Acquisition System (SCADA)**, including control and economic dispatch capabilities administered from a Central Dispatch, costing approximately \$50 M. Total project length is estimated to be 5 years. This price includes a fiber optics network linking the Central Dispatch and each transmission network substation.
- **Remote Data Acquisition System**, essentially an automatic meter reading system where meter data from substations is transmitted over telephone lines and collected at a Central Dispatch. The cost is approximately \$4 to \$5 M. Total project length is estimated to be 2 years. Meter data is used as an input to a billing system.
- **Local Data Acquisition System**, is a manual version of the above system that allows for collection of meter data on a PC at each substation. Data is to be delivered manually (either on disks or via voice telephone communication) to the Central Dispatch. The cost is estimated at \$1.8 M and project length at one year.

While each system is discussed fully, neither **Real-time Data Acquisition System (SCADA)** nor **Remote Data Acquisition System**, are within the scope of this Project. The time and expense required to implement those two systems goes well beyond that contemplated within this Task Order. Although the functionality provided by those two systems will meet Task Order objectives (i.e., improve electricity market operations and customer bill collections), those objectives can also be achieved by the basic system selected here. Resources thus freed can be made available for distribution system work, which would have been otherwise precluded if the initial system was selected. As the transmission network gets re-built, those two systems can be gradually added to the proposed **Local Data Acquisition System**.

Each system is described and evaluated in the following terms:

- Assumed Installed System Components
- Capabilities
- Complexity
- Communication Requirements
- Costs
- Meeting Task Order Objectives

Comparison of Data Acquisition Systems

<i>Project characteristics</i>	<i>Real-time data acquisition system (SCADA)</i>	<i>Remote data acquisition system</i>	<i>Local data acquisition system</i>
Functionality	Control of power flows in real-time Economic dispatch	Collect meter data at Central Dispatch after the fact	Local collection of meter data
Communications requirements	High speed fiber optics network – does not exist	Functional telephone network – appears to be inadequate	Local, in-station loop
Installation skill level	High	Medium	Low
Operational skill level	High	Medium	Low
Cost	\$50 to \$54 M	\$4 to \$5 M	\$1.8 M
Time to implement	5 year	2 years	1 year
Risk level	High	Medium	Low
Meets Task objectives	Mostly Not	Partial	Yes
• Within budget	No	Possible	Yes
• Complete by 12/99	No	No	Yes
• Improve collections	Partial	Yes	Yes
• Self-contained	No	No	Yes
• Basis for expansion	N/A	Partial	Yes

The above table shows the following:

- The first system is cost-wise well outside of the scope of this project and it cannot possibly be completed by December 1999. Moreover, a large portion of this system's functionality is beyond the Task Order objectives.
- The second system partially meets the Task Order objectives and its cost could be within the project's budget if funds are moved from other proposed areas. However, the time to implement is beyond the December 1999 deadline and half of the cost would be spent on communications and not to improve collection rate. There may be relatively little benefit from remote connectivity, and there is risk associated with unknown cost and time to implement needed improvements. These issues have not been examined at this time.
- The third one, a Local Data Acquisition System is selected for implementation because it achieves, at lowest reasonable cost, functionality needed to meet Task Order objectives. It can be constructed within the desired timeframe, involves little implementation risk and can be upgraded without significant future stranded investment.

Hagler Bailly has thus selected the Local Data Acquisition System to be implemented at transmission network substations. It is proposed that such data acquisition systems be equipped with modems for possible remote data communication with National Dispatch Center over conventional telephone lines.

INTRODUCTION

We have prepared the following general descriptions of these three Data Acquisition systems.

- Real-time Data Acquisition System (SCADA) – it enables real-time data communication between substations and the Central Dispatch. Data is collected from high-speed communication terminals at each substation and transmitted on dedicated, high-speed communication links to the Master Station at the Central Dispatch. This typically happens every 60 to 120 seconds. At the Central Dispatch, the Master Station displays data with systems to issue control commands back to devices located at substations. This system offers sophisticated functionality, but is complex and costly. Most of its functionality is outside of the scope to improve the collection rate.
- Remote Data Acquisition System – suitable for collecting meter data, generally for the purpose of reconciling energy usage among different parts of the system, or between different companies. It is also used to prepare output files to systems that generate wholesale utility bills. This system would permit automatic meter reading and automatic collection of data by the Central Dispatch from substations on a dial-up basis, using suitable conventional telephone and other communications links. This automatic system provides an alternative to manually sending information from substations to the Central Dispatch — either by voice communication or by transferring disks with data files.
- Local Data Acquisition System – suitable for collecting meter data at each substation and it is a manual version of the above system. It would be used to collect data from meters and then to manually transmit that data to the Central Dispatch. Such data acquisition system typically consists of a computer with appropriate software, modems, converters and wiring to meters. It avoids having the staff walk around a substation and take measurements from each meter individually.

COMPARISON OF SYSTEMS

Each system is described and evaluated in the following terms:

- Assumed Installed System Components
- Capabilities
- Complexity
- Communication Requirements
- Costs
- Meeting Task Order Objectives

This information has been collected from vendors who sell SCADA products.

System 1: Real-time Data Acquisition System (SCADA)

Assumed Installed System Components

Substation

Each substation is assumed to have electronic meters. In each substation, transducers are applied to provide instantaneous values of Volts, Amps, kW, kVAR, power transformer temperatures, status of protective relays – and any other data of concern for the purpose of determining quantities of real-time interest. Electronic meters can be used to generate pulses representing integrated quantities such as kWh and kVARh but other transducers must be used for other real-time quantities. All pulse outputs and other digital outputs from transducers are collected by high-speed “RTUs” (Remote Terminal Units) which are powerful, special-purpose computers that have the ability to “buffer” data for high-speed output and communication to a Master Station at the Central Dispatch over dedicated communications systems links.

Central Dispatch

A Master Station is installed at the Central Dispatch to collect and analyze data from substations. It is typically a center of a large, high-speed computer network connected through dedicated communication links to each substation that is polled by the Master Station once every 60 to 120 seconds. Data is retrieved, processed and presented on displays of multiple computer workstations, making critical data of interest available on demand. The system is also programmed to provide alarms to call attention to situations that require operator’s intervention.

It also is typical to construct large “mimic bus” displays on the wall of the control center, providing a visual display of the entire system with indicating lights that show the current status of circuit breakers on the system.

Capabilities

Basic Functions

The basic functions of the SCADA system include the following:

- Monitoring of the system condition with the ability to remotely control key functions which regulate power flow
- Opening and closing circuit breakers
- Connecting power-factor correction equipment
- Controlling static VAR generators
- Raising and lowering voltages through use of load-tap changers on power transformers, etc.

Energy flow data can be collected but generally, basic SCADA systems are not considered to provide sufficiently detailed or accurate data for billing purposes. The billing data functions normally are accomplished off-line on other parts of the systems which gather more detailed energy billing readings on a periodic basis.

Optional Functions

If equipped with suitable additional computing capability and software, the systems also can be expanded to:

- Automate selected control functions in the event of system emergencies.
- Provide economic dispatch by collecting current and projected cost data on various energy sources, doing cost optimization analysis and projecting system loads based on weather, history, time, etc.
- Optimize load flow – to provide suggested control options to the operators (or can be designed for automatic control if there is sufficient computer power)
- Indicate projected conditions that may require load shedding

Complexity

The level of complexity is high. This system requires “instantaneous” data delivery from 140 substations to the Central Dispatch. In addition to a PC at each substation for collecting billing data, multiple Remote Terminal Units (RTU’s) will be required to collect data which must be transmitted to the Central Dispatch. RTU’s are necessary since PCs are too slow for real-time data collection.

Implementation is a long process, summarized in the table below.

<i>Implementation Activities</i>	<i>Time to Complete</i>
Specification development	1 year
Bidding, evaluation and contracting	0.5 to 1 year
Installation, training and commissioning	3 years
Total	4.5 to 5 years

It takes highly qualified personnel to run and operate this system. Expertise is required in all of the following areas:

- Communications technology
- Power systems analysis
- Economical optimizing techniques
- Computer network operation and maintenance, etc.

Communication Requirements

SCADA requires high-speed communication system. Typically, fiber optic networks are more installed for new systems although T1 dedicated telephone lines may be sufficient if the data requirements and polling speed are not excessive. Note that even in the United States, a conventional dial-up telephone network would be inadequate due to low transmission speeds.

Cost

Without conducting a detailed analysis of the geography, location of substations, distances, functions to be performed, and a lot of other parameters, it is impossible to provide adequate estimates. However, based on experience with other similar systems, it is estimated that hardware and software for a fully implemented SCADA with economic dispatch capabilities could be approximately \$20 million. Communication links, engineering services and terminals for fiber optics communications add another \$25 to \$27 M for a total of between \$50.1 to \$54.1 M. For the purposes of cost estimating, we assumed a total of 140 locations under monitoring and control. Each substation relied on real-time monitoring of each phase of each main circuit (40 per substation), and an average of at least 4 analog-digital transducers per circuit, including ancillary measurements of temperature in transformer oil, etc.

Estimated Costs for Real-time Data Acquisition System

<i>SCADA Components</i>	<i>Cost</i>
Typical computer system cost for a large SCADA system to meet the estimated requirements	\$3 to \$4 M
Operating software for data acquisition and basic control for system with 100 substations and 150 data input points	\$2 to \$3 M
Incremental computer and software for economic dispatch and full system economic modeling and optimization	\$2.5 M
RTU's for substations and generating plants estimated 10 units per each location (1,400 units @ \$3,000 each)	\$4.2 M
Transducers for real-time V, A, kW, kVAR, and temperature measurements (150 per location @ \$500 each installed for 140 locations)	\$10.5 M
Mimic Bus display with annunciators for Control Room	\$1.5 M
Basic mechanical and electrical systems installation costs per location \$10,000 (x 140 total)	\$1.4 M
Communications links	\$8 to \$10 M
Engineering services	\$10 M
Communications terminals	\$7 M

Total	\$50.1 to \$54.1 M
-------	--------------------

The above figures represent budgetary estimate based on interviews with equipment vendors and system integrators.

Meeting Task Order Objectives

There are significant concerns about this system since it fails to meet most of the objectives:

- The cost is well beyond the budget imposed by the Task Order;
- It cannot be completed by December 1999;
- It will only partially contribute towards the improvement of the rate of collection. Most of its functionality concerns control over power system operations;
- There will be a need for resources beyond December 1999;
- Re-use in the future: N/A.

System 2: Remote Data Acquisition System

Assumed Installed System Components

Each substation has electronic meters that are connected to a PC that periodically collects data from meters. The meters collect interval-by-interval real and reactive energy and demand data as well as total readings. Once each hour (or at whatever interval is considered necessary) the local PC can automatically read the meters and build a database on its local fixed disk, for later retrieval by the Central Station.

The Central Dispatch workstations would be linked through the communications network with PC's at substations and would collect the aggregated data into a master database for analysis and processing. This database would then be the source for billing data outputs to a billing system and also could provide detailed load information on each substation to facilitate system studies.

Capabilities

This configuration will allow for data communication between PC's at substations and the Central Dispatch on a dial-up basis, possibly several times during a day if desired. The frequency of data retrieval is a function of the number of available communications circuits to the substations as well as the capacity of the computer network installed at the Central Dispatch.

Complete load profile data can be collected from each meter at each location. Net energy flows into and out of a substation can be charted and analyzed for those cases where energy fed from the higher-level supply system may be exchanged between substations serving adjacent regions.

The dial-up communications of data at each substation's PC collection point is an alternative to mailing disks with data from substations to the Central Dispatch and permits data to be collected and analyzed on an hour-by-hour basis if desired. Data collected for billing purposes can also be collected in various forms to permit studies of system loading.

Complexity

The level of complexity is medium. The system will consist of several workstations and network servers running the metering data software over Unix or Windows NT operating systems. An Oracle database is used to store data from meters at substations and support the proprietary metering system software used to analyze data.

It typically takes 6 months to one year of preparation time and approximately one year to install and implement such a system – a total of about 18 to 24 months if the specifications allow the use of standard programs.

Once installed and if using a public dial-up communications network, the primary expertise required will be for operation of the computer network and software at the Central Station. Routine operations and maintenance of the metering system and PCs at the substations is less critical and challenging (although reasonable engineering skills in handling PCs and meter equipment is necessary even at the substations to assure that data is being collected properly and systems remain on line when needed).

Communication Requirements

This set-up (typically) requires a reliable telephone network capable of transmitting data at about 20 kbps. Depending on the availability of other public telephone or radio networks, dedicated power-line carrier phone systems over the transmission lines may be used.

Cost

It is estimated that the typical cost of adequate Central Dispatch software and hardware for automatic meter reading, data collection and data analysis would be in the range of \$1.5 to \$2 M. This estimate excludes the following:

- Data acquisition equipment at substations ;
- Adequate communications links;
- Engineering services estimated at \$1.5 M to 2 M.

The final figure would depend on resolution of functional requirements but is estimated to be between \$3 and \$4 M.

Note: neither system offers billing functionality to reconcile charges.

Meeting Task Order Objectives

This system fails to meet several important objectives:

- This system can potentially be accommodated within this budget, however, that would be at a cost of other, more pressing needs;
- This system cannot be completed by December 1999;
- It will be only partially utilized to improve the rate of collection; about 50% of this system's cost is for remote communication;
- There will be resources necessary beyond December 1999;

- Some of the equipment would become stranded investment when SCADA is deployed.

System 3: Local Data Acquisition System

Assumed Installed System Components

Each substation has electronic meters that are connected to a PC that periodically collects data from meters. The meters collect interval-by-interval real and reactive energy and demand data as well as total readings. Once each hour (or at whatever interval is considered necessary) the local PC can automatically read the meters and build a database on its local fixed disk.

Capabilities

This configuration will allow for data collection on PC's, possibly several times during a day if desired.

Complete load profile data can be collected from each meter at each location. Net energy flows into and out of a substation can be charted and analyzed for those cases where energy fed from the higher-level supply system may be exchanged between substations serving adjacent regions.

Periodically, data can be transmitted from each substation's PC collection point either manually via telephone or on disks. Data collected for billing purposes can also be collected in various forms to permit studies of system loading.

Complexity

The level of complexity is low. The system will consist of a PC at each substation, as a center of data collection for meter data. For the purposes for connectivity, modems, converters and cable will be needed. All meters will be connected through a loop to transmit meter data to PC's. Meter data will be stored on hard disk and later transfer on disks to the Central Dispatch.

It would take less than a month of preparation time to engineer a solution and approximately a week per substation. The total implementation time depends on the number of available resources to conduct installation.

Once installed, the primary expertise required will be for operation of PCs at each substation. Routine operations and maintenance of the metering system and PCs at the substations is neither critical nor challenging (although reasonable engineering skills in handling PCs and meter equipment is necessary even at the substations to assure that data is being collected properly and systems remain on line when needed).

Communication Requirements

Local communications between meters and a PC relies on standard and straightforward set-up which is easy to establish and to operate reliably. There is no data communication outside of each substation.

Cost

It is estimated that a typical cost of hardware and software for each substation is approximately \$10 K for a total of \$1.4 M. Additionally, there will be an approximate cost of \$400K for installation and training at a total of \$1.8 M.

Note: there is no billing capability in this system.

Meeting Task Order Objectives

This system meets most of the objectives:

- The cost may be accommodated within the budget;
- The implementation can be completed by December 1999;
- It will work and it will directly assist in improving the rate of collection;
- There will be no additional resources necessary beyond December 1999;
- This equipment can be used to develop more sophisticated systems in the future.

SUMMARY AND RECOMMENDATIONS

This memo outlined characteristics of three systems of the following data acquisition systems: Real-time Data Acquisition System (SCADA); Remote Data Acquisition System; and, Local Data Acquisition System.

The first two systems do not fit into the scope of the project for the following reasons:

- They are too costly (in the range of \$50 M and approximately \$4 to \$5 M, respectively);
- They will take too long to implement (5 and 2 years, respectively), well beyond the prescribed project timeframe;
- For the first system, there is a need for a high-speed communication network that does not exist today; for the second system, there is a major uncertainty regarding the reliability and data communication capability of present telephone network;
- In the second system, half of the cost goes towards remote communication rather than to improve collections rate.
- Both systems are outside of the scope and objectives of the project.

The third system can be considered for this project for the following reasons:

- The cost is within the project's available budget;
- The system can be implemented within the project's timetable;
- There is no need for remote data communication;
- As a result of the implementation, a workable solution will be delivered;
- Should system #1 or #2 be desired in the future, the set-up developed in this system can be used as a foundation for further work.

Therefore, system #3, a local data acquisition system for each transmission network is recommended for consideration in the project.

Finally, within the scope of the project, it is possible to equip data acquisition systems with modems at relatively low cost for possible data transmission between substations and National Dispatch Center. This functionality will depend on the reliability of telephone lines between different locations.

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APPENDIX C
LIST OF NETWORK SYSTEM EQUIPMENT



Hagler Bailly

USAID Global Energy IQC

Task Order Number LAG-I-02-98-00005-00

Budget Estimation for ARMTRANS Metering

Type of Procurement	Number of Units	Extended Price	Shipment Price	Total Price
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Armtrans				
Control Cable	14,000	\$21,000	\$1,190	\$22,190
Current Transformers	92	\$1,526,000	\$251,493	\$1,777,493
Data Acquisition Systems	10	\$100,000	\$5,070	\$105,070
Meters	214	\$108,190	\$4,241	\$112,431
Power Transformers	6	\$126,000	\$20,718	\$146,718
Subtotal		\$1,881,190	\$282,713	\$2,163,903

Armtrans				
Control Cable	139,989	\$230,375	\$12,762	\$243,136
Current Transformers	189	\$642,600	\$27,191	\$669,791
Data Acquisition Systems	84	\$840,000	\$42,588	\$882,588
Data Processing Software	2	\$20,000	\$0	\$20,000
Laptop Computers	18	\$54,000	\$714	\$54,714
Meters	2,397	\$1,057,641	\$47,509	\$1,105,149
Optical Probes	18	\$6,750	\$0	\$6,750
Power Cable	20,000	\$40,000	\$3,000	\$43,000
Test Bench, Portable	3	\$90,000	\$4,056	\$94,056
Test Benches, Stationary	1	\$30,000	\$1,352	\$31,352
Training and Support	1	\$240,000	\$0	\$240,000
Workstation	2	\$20,000	\$3,028	\$23,028
Subtotal		\$3,271,365	\$142,199	\$3,413,565

Customer Substations				
Control Cable	145	\$218	\$12	\$230
Meters	8	\$3,521	\$159	\$3,680
Subtotal		\$3,739	\$171	\$3,910

Export/Import Substations				
Control Cable	300	\$450	\$26	\$476
Current Transformers	5	\$128,400	\$17,265	\$145,665
Meters	5	\$2,201	\$99	\$2,300
Subtotal		\$131,051	\$17,390	\$148,440

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<i>Type of Procurement</i>	<i>Number of Units</i>	<i>Extended Price</i>	<i>Shipment Price</i>	<i>Total Price</i>
Railroad Substations				
Meters	83	\$36,782	\$1,645	\$38,427
Subtotal		\$36,782	\$1,645	\$38,427

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Budget Estimation for ARMTRANS METERING - SUMMARY

<i>Equipment Purchase</i>	\$5,324,126
<i>Meters Boxes</i>	\$44,100
<i>Insurance</i>	\$32,746
<i>Shipping Expenses</i>	\$444,118
<i>Subtotal</i>	<hr/> \$5,845,090
<i>Contingency</i>	\$292,255
<i>TOTAL</i>	<hr/> \$6,137,345



Hagler Bailly

USAID Global Energy IQC

Task Order Number LAG-I-02-98-00005-00

Price Estimation for Armenia Highvoltage Network Equipment Procurement

Armtrans In

Shipping and Equipment Price: \$2,163,903

Arzni HPP

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Bi-Directional Meter	5	\$2,826	\$99
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	2	\$38,400	\$6,906

Total for Substation

Equipment Price \$42,726

Shippment Price \$7,090

Atarbekyan HPP

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Bi-Direcnoal Meter	11	\$6,217	\$218
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	7	\$134,400	\$24,171
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	2	\$880	\$40
Voltage Transformer	2	\$42,000	\$6,906

Total for Substation

Equipment Price \$194,997

Shippment Price \$31,927

Dzorages HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	5	\$2,826	\$99
Control Cable	1000	\$1,500	\$85
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

<i>Equipment Price</i>	\$18,727
<i>Shippment Price</i>	\$889

Gyumush HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	13	\$7,347	\$258
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	8	\$153,600	\$27,624
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	1	\$440	\$20

Total for Substation

<i>Equipment Price</i>	\$172,887
<i>Shippment Price</i>	\$28,493

Kanaker HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	12	\$6,782	\$238
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	16	\$165,000	\$25,466
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

<i>Equipment Price</i>	\$187,683
<i>Shippment Price</i>	\$26,494

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Metsamor NPP

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Bi-Directional Meter	14	\$7,912	\$277
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	15	\$352,800	\$51,795
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	7	\$3,081	\$139

Total for Substation

Equipment Price	\$375,293
Shippment Price	\$52,803

Razdan TPP

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Bi-Directional Meter	15	\$8,477	\$297
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	12	\$183,000	\$31,509
Data Acquisition	2	\$20,000	\$1,014
One-Directional Meter	27	\$11,884	\$535

Total for Substation

Equipment Price	\$224,861
Shippment Price	\$33,440

Sevan HPP

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Bi-Directional Meter	5	\$2,826	\$99
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	10	\$160,400	\$27,912
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198
Voltage Transformer	2	\$42,000	\$6,906

Total for Substation

Equipment Price \$221,127

Shippment Price \$35,707

Shamb HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	4	\$2,261	\$79
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	1	\$30,000	\$3,453

Total for Substation

Equipment Price \$33,761

Shippment Price \$3,617

Spandaryan HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	6	\$3,391	\$119
Control Cable	1000	\$1,500	\$85

Total for Substation

Equipment Price \$4,891

Shippment Price \$204

Tatev HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	3	\$1,695	\$59
Control Cable	1000	\$1,500	\$85
One-Directional Meter	3	\$1,320	\$59

Total for Substation

Equipment Price \$4,516

Shippment Price \$204

Vanadzor TPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	4	\$2,261	\$79
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	2	\$38,400	\$6,906

Total for Substation

Equipment Price \$42,161

Shipment Price \$7,070

Yerevan HPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	4	\$2,261	\$79
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	2	\$38,400	\$6,906
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	12	\$5,282	\$238
Voltage Transformer	2	\$42,000	\$6,906

Total for Substation

Equipment Price \$99,442

Shipment Price \$14,721

Yerevan TPP

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	11	\$6,217	\$218
Control Cable	1000	\$1,500	\$85
Current Transformers' Sets	17	\$231,600	\$38,846
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	20	\$8,803	\$396

Total for Substation

Equipment Price \$258,119

Shipment Price \$40,053

Armtrans Out**Shipping and Equipment Price: \$3,413,565****Abovjan**

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	520	\$780	\$44
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	29	\$12,764	\$575
Power Cable	1000	\$2,000	\$150

Total for Substation**Equipment Price \$45,944****Shippment Price \$2,139****Agarak**

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	850	\$1,275	\$72
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	16	\$7,042	\$317

Total for Substation**Equipment Price \$28,517****Shippment Price \$1,328****Alaverdi-1**

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	4	\$2,261	\$79
Control Cable	560	\$840	\$48
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	40	\$17,606	\$793

Total for Substation

Equipment Price \$44,306
Shippment Price \$2,002

Alaverdi-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
Current Transformers' Sets	4	\$13,600	\$575
One-Directional Meter	6	\$2,641	\$119

Total for Substation

Equipment Price \$16,691
Shippment Price \$720

Aliq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	150	\$225	\$13
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

Equipment Price \$14,626
Shippment Price \$718

Amasia

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	430	\$645	\$37
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	12	\$5,282	\$238

Total for Substation

Equipment Price \$22,727

Shipment Price \$1,069

Aparan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

Equipment Price \$30,781

Shipment Price \$1,441

Ararat-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	3150	\$4,725	\$268
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	28	\$12,324	\$555

Total for Substation

Equipment Price \$44,049

Shipment Price \$2,049

Ararat-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1500	\$2,250	\$128
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

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Total for Substation

Equipment Price \$16,651
Shippment Price \$833

Aresh-2

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	3	\$10,200	\$432
One-Directional Meter	28	\$12,324	\$555

Total for Substation

Equipment Price \$24,742
Shippment Price \$1,112

Armavir

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	30	\$13,204	\$595

Total for Substation

Equipment Price \$39,023
Shippment Price \$1,803

Armenergo Headquart

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Armenergo Software	1	\$10,000	\$0
Armenergo Workstation	1	\$10,000	\$1,514

Total for Substation

Equipment Price \$20,000
Shippment Price \$1,514

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Armtrans Headquarter

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Armenergo Software	1	\$10,000	\$0
Armenergo Workstation	1	\$10,000	\$1,514
Laptop Computer	18	\$54,000	\$714
Optical Probe	18	\$6,750	\$0
Test Banch, Stationary	1	\$30,000	\$1,352
Test Bench, Portable	3	\$90,000	\$4,056
Training and Support	1	\$240,000	\$0

Total for Substation

<i>Equipment Price</i>	\$440,750
<i>Shippment Price</i>	\$7,636

Artashat

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	2300	\$3,450	\$196
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	21	\$9,243	\$416
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$31,493
<i>Shippment Price</i>	\$1,556

Artavazd

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	10	\$4,401	\$198

Total for Substation

<i>Equipment Price</i>	\$6,620
<i>Shippment Price</i>	\$324

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Artik

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	650	\$975	\$55
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	20	\$8,803	\$396

Total for Substation

<i>Equipment Price</i>	\$29,978
<i>Shippment Price</i>	\$1,390

Artsakh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	900	\$1,350	\$77
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	27	\$11,884	\$535

Total for Substation

<i>Equipment Price</i>	\$23,234
<i>Shippment Price</i>	\$1,119

Ashnak

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	16	\$7,042	\$317

Total for Substation

<i>Equipment Price</i>	\$19,261
<i>Shippment Price</i>	\$950

Ashocq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
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Control Cable	500	\$750	\$43
Current Transformers' Sets	1	\$3,400	\$144
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	11	\$4,842	\$218

Total for Substation

<i>Equipment Price</i>	\$18,992
<i>Shipment Price</i>	\$911

Ashtarak

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	31	\$13,644	\$614

Total for Substation

<i>Equipment Price</i>	\$25,863
<i>Shipment Price</i>	\$1,247

Avan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	23	\$10,123	\$456

Total for Substation

<i>Equipment Price</i>	\$12,342
<i>Shipment Price</i>	\$582

Azatan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	400	\$600	\$34
Current Transformers' Sets	1	\$3,400	\$144
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	14	\$6,162	\$277

Total for Substation

Equipment Price \$20,162
Shippment Price \$962

Azatek(1)

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	980	\$1,470	\$83
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	11	\$4,842	\$218

Total for Substation

Equipment Price \$23,112
Shippment Price \$1,096

Azatek(2)

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	700	\$1,050	\$60
Current Transformers' Sets	1	\$3,400	\$144
One-Directional Meter	9	\$3,961	\$178

Total for Substation

Equipment Price \$8,411
Shippment Price \$382

Baghramyan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	5	\$2,201	\$99

Total for Substation

Equipment Price \$4,419
Shippment Price \$225

Balahovit

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	150	\$225	\$13
One-Directional Meter	9	\$3,961	\$178
<hr/>			
Total for Substation			
Equipment Price			\$4,186
Shippment Price			\$191

Bazum

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	400	\$600	\$34
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	15	\$6,602	\$297
<hr/>			
Total for Substation			
Equipment Price			\$27,402
Shippment Price			\$1,270

Berd

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	700	\$1,050	\$60
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	17	\$7,482	\$337
<hr/>			
Total for Substation			
Equipment Price			\$28,732
Shippment Price			\$1,335

Bjureghavan

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
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Control Cable	200	\$300	\$17
One-Directional Meter	13	\$5,722	\$258

Total for Substation

<i>Equipment Price</i>	\$6,022
<i>Shippment Price</i>	\$275

Charbakh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	37	\$16,285	\$733

Total for Substation

<i>Equipment Price</i>	\$42,104
<i>Shippment Price</i>	\$1,942

Charencavan-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	1	\$565	\$20
Control Cable	970	\$1,455	\$82
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	26	\$11,444	\$515
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$39,064
<i>Shippment Price</i>	\$1,850

Charencavan-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	1	\$565	\$20
Control Cable	300	\$450	\$26

Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	23	\$10,123	\$456
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$29,938

Shippment Price \$1,446

Charencavan-3

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	17	\$7,482	\$337
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$19,932

Shippment Price \$1,019

Dalarik

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	26	\$11,444	\$515

Total for Substation

Equipment Price \$40,662

Shippment Price \$1,867

Darbas

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1320	\$1,980	\$112
Current Transformers' Sets	2	\$6,800	\$288

62

Data Acquisition	1	\$10,000	\$507
One-Directional Meter	27	\$11,884	\$535
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$32,664
<i>Shippment Price</i>	\$1,592

Dashtadem

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	8	\$3,521	\$159

Total for Substation

<i>Equipment Price</i>	\$5,740
<i>Shippment Price</i>	\$284

Dastakert

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	140	\$210	\$12
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	13	\$5,722	\$258
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$17,932
<i>Shippment Price</i>	\$927

Davtashen

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	34	\$14,965	\$674

Total for Substation

Equipment Price \$40,783

Shippment Price \$1,882

Diligen

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	750	\$1,125	\$64
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	18	\$7,923	\$357
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$34,648

Shippment Price \$1,653

Dimac

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1050	\$1,575	\$89
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	30	\$13,204	\$595

Total for Substation

Equipment Price \$24,779

Shippment Price \$1,191

Djrveg

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	27	\$11,884	\$535

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Total for Substation

Equipment Price \$34,302

Shippment Price \$1,599

Eghegnadzor

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	2	\$1,130	\$40
Control Cable	2500	\$3,750	\$213
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	8	\$3,521	\$159

Total for Substation

Equipment Price \$18,401

Shippment Price \$918

Egmiacin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	46	\$20,246	\$912

Total for Substation

Equipment Price \$49,465

Shippment Price \$2,264

Eraskh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	650	\$975	\$55
Current Transformers' Sets	3	\$10,200	\$432
One-Directional Meter	18	\$7,923	\$357

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Total for Substation

Equipment Price \$19,098

Shippment Price \$844

Erebuni

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	550	\$825	\$47
One-Directional Meter	11	\$4,842	\$218

Total for Substation

Equipment Price \$5,667

Shippment Price \$265

Erzrum

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
Data Acquisinon	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

Equipment Price \$14,851

Shippment Price \$731

Gagarin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	270	\$405	\$23
One-Direcnonal Meter	14	\$6,162	\$277

Total for Substation

Equipment Price \$6,567

Shippment Price \$300

Geghamasar

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	100	\$150	\$9
One-Directional Meter	5	\$2,201	\$99
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$2,351
<i>Shipment Price</i>			\$108

Gjumri-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	4400	\$6,600	\$374
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	43	\$18,926	\$852
Power Cable	1000	\$2,000	\$150
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$44,326
<i>Shipment Price</i>			\$2,171

Gjumri-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	540	\$810	\$46
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	18	\$7,923	\$357
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$18,733
<i>Shipment Price</i>			\$910

Gjumry-3

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
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Control Cable	100	\$150	\$9
One-Directional Meter	2	\$880	\$40

Total for Substation

<i>Equipment Price</i>	\$1,030
<i>Shippment Price</i>	\$48

Gndevaz

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	720	\$1,080	\$61
Current Transformers' Sets	2	\$6,800	\$288
One-Directional Meter	9	\$3,961	\$178

Total for Substation

<i>Equipment Price</i>	\$11,841
<i>Shippment Price</i>	\$527

Goris

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	2	\$1,130	\$40
Control Cable	570	\$855	\$48
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	13	\$5,722	\$258

Total for Substation

<i>Equipment Price</i>	\$24,507
<i>Shippment Price</i>	\$1,140

Hacashen

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	8	\$3,521	\$159

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Total for Substation

Equipment Price \$5,740

Shippment Price \$284

Haghtanak

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	14	\$6,162	\$277

Total for Substation

Equipment Price \$18,380

Shippment Price \$910

Hakhum

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
One-Directional Meter	6	\$2,641	\$119

Total for Substation

Equipment Price \$3,091

Shippment Price \$144

Haravayin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	4700	\$7,050	\$400
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	47	\$20,687	\$932
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$39,737

Shippment Price \$1,988

Hjusisajin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	35	\$15,405	\$694

Total for Substation

Equipment Price \$27,623

Shippment Price \$1,326

Hovtashat

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1700	\$2,550	\$145
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

Equipment Price \$16,951

Shippment Price \$850

Hrazdan-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	400	\$600	\$34
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	30	\$13,204	\$595
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$42,804

Shippment Price \$2,005

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Hrazdan-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price **\$20,813**

Shippment Price **\$1,059**

Idjevan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1110	\$1,665	\$94
Current Transformers' Sets	1	\$3,400	\$144
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	29	\$12,764	\$575

Total for Substation

Equipment Price **\$27,829**

Shippment Price **\$1,320**

Kamo

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	2100	\$3,150	\$179
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	39	\$17,165	\$773

Total for Substation

Equipment Price **\$50,715**

Shippment Price **\$2,322**

Kantegh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	42	\$18,486	\$832

Total for Substation

<i>Equipment Price</i>	\$30,704
<i>Shippment Price</i>	\$1,465

Kapan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	4	\$2,261	\$79
Control Cable	1500	\$2,250	\$128
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	27	\$11,884	\$535

Total for Substation

<i>Equipment Price</i>	\$46,794
<i>Shippment Price</i>	\$2,112

Kapujt-litch

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
One-Directional Meter	2	\$880	\$40

Total for Substation

<i>Equipment Price</i>	\$1,330
<i>Shippment Price</i>	\$65

Kentronakan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
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Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	57	\$25,088	\$1,130

Total for Substation

<i>Equipment Price</i>	\$50,906
<i>Shippment Price</i>	\$2,338

Khachik

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	750	\$1,125	\$64
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	13	\$5,722	\$258

Total for Substation

<i>Equipment Price</i>	\$37,247
<i>Shippment Price</i>	\$1,692

Kharberd

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1900	\$2,850	\$162
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

<i>Equipment Price</i>	\$21,213
<i>Shippment Price</i>	\$1,045

Khndzorut

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	400	\$600	\$34
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	13	\$5,722	\$258

Total for Substation

Equipment Price \$16,322

Shippment Price \$799

Kirza

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	45	\$19,806	\$892

Total for Substation

Equipment Price \$38,825

Shippment Price \$1,812

Kotajq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	28	\$12,324	\$555

Total for Substation

Equipment Price \$14,542

Shippment Price \$681

Lichq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	500	\$750	\$43
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

Equipment Price \$32,713

Shipment Price \$1,502

Majisyan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	400	\$600	\$34
One-Directional Meter	12	\$5,282	\$238
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$7,882

Shipment Price \$422

Malatia

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

Equipment Price \$20,581

Shipment Price \$1,009

Maralik

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	550	\$825	\$47
Current Transformers' Sets	1	\$3,400	\$144
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	17	\$7,482	\$337

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Total for Substation

Equipment Price \$21,707

Shippment Price \$1,035

Marash

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	24	\$10,563	\$476

Total for Substation

Equipment Price \$22,782

Shippment Price \$1,108

Marmashen

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	150	\$225	\$13
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	7	\$3,081	\$139

Total for Substation

Equipment Price \$13,306

Shippment Price \$658

Mashtoc

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	1479	\$2,219	\$126
One-Directional Meter	18	\$7,923	\$357

Total for Substation

Equipment Price \$10,141

Shippment Price \$482

Masis

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1950	\$2,925	\$166
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	31	\$13,644	\$614

Total for Substation

<i>Equipment Price</i>	\$40,169
<i>Shippment Price</i>	\$1,863

Metsamor

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	2	\$6,800	\$288
One-Directional Meter	15	\$6,602	\$297

Total for Substation

<i>Equipment Price</i>	\$15,621
<i>Shippment Price</i>	\$711

Mkhchjan-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1500	\$2,250	\$128
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	15	\$6,602	\$297

Total for Substation

<i>Equipment Price</i>	\$18,852
<i>Shippment Price</i>	\$932

Mkhshjan-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
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Control Cable	480	\$720	\$41
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	16	\$7,042	\$317

Total for Substation

<i>Equipment Price</i>	\$17,762
<i>Shippment Price</i>	\$865

Nairit

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	9300	\$13,950	\$791
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	56	\$24,648	\$1,110

Total for Substation

<i>Equipment Price</i>	\$68,998
<i>Shippment Price</i>	\$3,271

Nairy

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	150	\$225	\$13
Current Transformers' Sets	3	\$10,200	\$432
One-Directional Meter	14	\$6,162	\$277

Total for Substation

<i>Equipment Price</i>	\$16,587
<i>Shippment Price</i>	\$722

Norq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	28	\$12,324	\$555

Total for Substation

Equipment Price \$24,542

Shippment Price \$1,188

Noyemberyan

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	700	\$1,050	\$60
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	16	\$7,042	\$317

Total for Substation

Equipment Price \$35,092

Shippment Price \$1,603

Nubarashen

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	2100	\$3,150	\$179
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	21	\$9,243	\$416

Total for Substation

Equipment Price \$35,993

Shippment Price \$1,677

Perlik

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	1479	\$2,219	\$126
One-Directional Meter	11	\$4,842	\$218

Total for Substation

Equipment Price \$7,060
Shippment Price \$344

Poligon

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1250	\$1,875	\$106
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	25	\$11,004	\$496
Power Cable	1000	\$2,000	\$150

Total for Substation

Equipment Price \$31,679
Shippment Price \$1,546

Qagaran

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	2	\$1,130	\$40
Control Cable	1150	\$1,725	\$98
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	21	\$9,243	\$416

Total for Substation

Equipment Price \$32,298
Shippment Price \$1,492

Qarhanq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

Equipment Price \$16,620
Shippment Price \$831

Qashatagh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	130	\$195	\$11
One-Directional Meter	9	\$3,961	\$178

Total for Substation

Equipment Price \$4,156
Shippment Price \$189

Shahumjan-1

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	42	\$18,486	\$832

Total for Substation

Equipment Price \$30,704
Shippment Price \$1,465

Shahumjan-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	33	\$14,525	\$654

Total for Substation

Equipment Price \$26,743
Shippment Price \$1,287

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Shengavit

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	1	\$565	\$20
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	36	\$15,845	\$714

Total for Substation

<i>Equipment Price</i>	\$28,629
<i>Shipment Price</i>	\$1,366

Shinuhajr

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	2660	\$3,990	\$226
Current Transformers' Sets	5	\$17,000	\$719
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

<i>Equipment Price</i>	\$39,353
<i>Shipment Price</i>	\$1,829

Sisian

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	2	\$1,130	\$40
Control Cable	1890	\$2,835	\$161
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	23	\$10,123	\$456
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$46,489
<i>Shipment Price</i>	\$2,176

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Sotq

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	220	\$330	\$19
Current Transformers' Sets	2	\$6,800	\$288
One-Directional Meter	8	\$3,521	\$159

Total for Substation

<i>Equipment Price</i>	\$10,651
<i>Shippment Price</i>	\$465

Spandaryan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	34	\$14,965	\$674

Total for Substation

<i>Equipment Price</i>	\$37,383
<i>Shippment Price</i>	\$1,738

Spitak

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	3400	\$5,100	\$289
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	34	\$14,965	\$674
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$42,265
<i>Shippment Price</i>	\$2,051

Stepanavan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	770	\$1,155	\$65
Current Transformers' Sets	3	\$10,200	\$432
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	27	\$11,884	\$535
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	<i>\$35,239</i>
<i>Shippment Price</i>	<i>\$1,689</i>

Talin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	4	\$13,600	\$575
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	19	\$8,363	\$377

Total for Substation

<i>Equipment Price</i>	<i>\$34,181</i>
<i>Shippment Price</i>	<i>\$1,585</i>

Taron

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	800	\$1,200	\$68
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	18	\$7,923	\$357
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	<i>\$21,123</i>
<i>Shippment Price</i>	<i>\$1,082</i>

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Tashir

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1050	\$1,575	\$89
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	22	\$9,683	\$436
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	<i>\$30,058</i>
<i>Shippment Price</i>	<i>\$1,470</i>

Tsovinar

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Direcnonal Meter	2	\$1,130	\$40
Control Cable	550	\$825	\$47
Current Transformers' Sets	2	\$6,800	\$288
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

<i>Equipment Price</i>	<i>\$23,157</i>
<i>Shippment Price</i>	<i>\$1,079</i>

Urartu

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	4	\$1,761	\$79

Total for Substation

<i>Equipment Price</i>	<i>\$3,979</i>
<i>Shippment Price</i>	<i>\$205</i>

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Vahramaberd

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	300	\$450	\$26
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	10	\$4,401	\$198

Total for Substation

<i>Equipment Price</i>	\$14,851
<i>Shipment Price</i>	\$731

Vanadzor

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	4000	\$6,000	\$340
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	52	\$22,887	\$1,031
Power Cable	1000	\$2,000	\$150

Total for Substation

<i>Equipment Price</i>	\$40,887
<i>Shipment Price</i>	\$2,028

Vanand

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
One-Directional Meter	5	\$2,201	\$99

Total for Substation

<i>Equipment Price</i>	\$4,419
<i>Shipment Price</i>	\$225

Vanashen

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	650	\$975	\$55

Current Transformers' Sets	2	\$6,800	\$288
One-Directional Meter	16	\$7,042	\$317

Total for Substation

<i>Equipment Price</i>	\$14,817
<i>Shippment Price</i>	\$660

Vandzor-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1070	\$1,605	\$91
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	11	\$4,842	\$218

Total for Substation

<i>Equipment Price</i>	\$16,447
<i>Shippment Price</i>	\$816

Vardanidzor

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	250	\$375	\$21
One-Directional Meter	5	\$2,201	\$99

Total for Substation

<i>Equipment Price</i>	\$2,576
<i>Shippment Price</i>	\$120

Vardashen

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Current Transformers' Sets	6	\$20,400	\$863
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	37	\$16,285	\$733

Total for Substation

Equipment Price \$48,904

Shippment Price \$2,229

Vardenis

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	400	\$600	\$34
Current Transformers' Sets	1	\$3,400	\$144
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	17	\$7,482	\$337

Total for Substation

Equipment Price \$21,482

Shippment Price \$1,022

Vorotan-2

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	400	\$600	\$34
One-Directional Meter	8	\$3,521	\$159

Total for Substation

Equipment Price \$4,121

Shippment Price \$193

Vorotan-3

Type of Equipment	Number of Units	Total Equipment Price	Total Shipping Price
Control Cable	210	\$315	\$18
One-Directional Meter	5	\$2,201	\$99

Total for Substation

Equipment Price \$2,516

Shippment Price \$117

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Zovuni

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	1479	\$2,219	\$126
Data Acquisition	1	\$10,000	\$507
One-Directional Meter	31	\$13,644	\$614

Total for Substation

Equipment Price \$25,863

Shippment Price \$1,247

Customer's substations

Shipping and Equipment Price: \$3,910

Arapnja

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	2	\$880	\$40

Total for Substation

Equipment Price \$880

Shippment Price \$40

Constraction site

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	25	\$38	\$2
One-Directional Meter	1	\$440	\$20

Total for Substation

Equipment Price \$478

Shippment Price \$22

Sev Dgjur

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
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509

Control Cable	120	\$180	\$10
One-Directional Meter	5	\$2,201	\$99

Total for Substation

Equipment Price \$2,381

Shippment Price \$109

Export/Import Substations

Shipping and Equipment Price: \$148,440

Alaverdy-2

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	100	\$150	\$9
Current Transformers' Sets	2	\$49,200	\$6,906
One-Directional Meter	2	\$880	\$40

Total for Substation

Equipment Price \$50,230

Shippment Price \$6,954

Kars

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	100	\$150	\$9
Current Transformers' Sets	1	\$30,000	\$3,453
One-Directional Meter	1	\$440	\$20

Total for Substation

Equipment Price \$30,590

Shippment Price \$3,481

Shinuhayr

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Control Cable	100	\$150	\$9
Current Transformers' Sets	2	\$49,200	\$6,906
One-Directional Meter	2	\$880	\$40

Total for Substation

Equipment Price \$50,230

Shippment Price \$6,954

Railroad Substations

Shipping and Equipment Price: \$38,427

Aghin

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	6	\$2,641	\$119

Total for Substation

Equipment Price \$2,641

Shippment Price \$119

Akhtala

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	4	\$1,761	\$79

Total for Substation

Equipment Price \$1,761

Shippment Price \$79

Ani

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	8	\$3,521	\$159

Total for Substation

Equipment Price \$3,521

Shippment Price \$159

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Aragats

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	4	\$1,761	\$79
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$1,761
<i>Shippment Price</i>			\$79

Araks

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	4	\$1,761	\$79
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$1,761
<i>Shippment Price</i>			\$79

Ariashan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	6	\$2,641	\$119
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$2,641
<i>Shippment Price</i>			\$119

Gadjur

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	8	\$3,521	\$159
<hr/>			
<i>Total for Substation</i>			
<i>Equipment Price</i>			\$3,521
<i>Shippment Price</i>			\$159

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Pambak

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	4	\$1,761	\$79

Total for Substation

<i>Equipment Price</i>	\$1,761
<i>Shipment Price</i>	\$79

Proshjan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	2	\$880	\$40

Total for Substation

<i>Equipment Price</i>	\$880
<i>Shipment Price</i>	\$40

Shahali

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	4	\$1,761	\$79

Total for Substation

<i>Equipment Price</i>	\$1,761
<i>Shipment Price</i>	\$79

Shordja

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
Bi-Directional Meter	2	\$1,130	\$40
One-Directional Meter	5	\$2,201	\$99

Total for Substation

<i>Equipment Price</i>	\$3,331
<i>Shipment Price</i>	\$139

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Sovetakan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	16	\$7,042	\$317

Total for Substation

<i>Equipment Price</i>	\$7,042
<i>Shippment Price</i>	\$317

Tsovagjugh

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	5	\$2,201	\$99

Total for Substation

<i>Equipment Price</i>	\$2,201
<i>Shippment Price</i>	\$99

Yerevan

<i>Type of Equipment</i>	<i>Number of Units</i>	<i>Total Equipment Price</i>	<i>Total Shipping Price</i>
One-Directional Meter	5	\$2,201	\$99

Total for Substation

<i>Equipment Price</i>	\$2,201
<i>Shippment Price</i>	\$99

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