USAID | CAUCASUS

ENHANCED EMERGENCY CONTROL SYSTEM FOR THE GEORGIA STATE ELECTROSYSTEM

Installations in Azerbaijan and Turkey

July 31, 2012
This report was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech, Inc.

Foreword

This report was prepared by USAID's Georgia Power and Gas Infrastructure Project (PGIP) under Contract Number AID-EDH-I-00-08-00027, Task Order AID-10-114-10-00003. Tetra Tech, Inc. is the prime contractor on PGIP.

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USAID / GEORGIA POWER AND GAS INFRASTRUCTURE PROJECT (PGIP)

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1 Background

The Georgia Power and Gas Infrastructure Project (PGIP) provides resident professional engineering and other technical services to support power and gas transmission improvements that USAID is undertaking on behalf of the Government of Georgia. PGIP's activities support USAID's objectives of promoting energy security through greater access to electricity and natural gas supplies for households in western Georgia, promoting the development of the Poti Free Industrial Zone on the Black Sea, and securing power exports through domestic reliability-related infrastructure improvements. The activities under the PGIP task order support USAID's larger goal of fostering sustainable development.

This report was prepared in support of USAID's third objective of securing power exports through domestic reliability-related infrastructure improvements. This report discusses the installation, operation, maintenance, and ownership of the Enhanced Emergency Control System to be installed in Azerbaijan at the Sumux Substation and in Turkey at the Borchka and the Muratli Substations. This report is supplementary to a separately submitted document, "The Letter of Consent to Subcontract." The section titles in this report reflect specific questions USAID has asked about the installation, operation, maintenance and ownership of Enhanced Emergency Control System (EECS) equipment provided by USAID Caucasus in the neighboring countries of Azerbaijan and Turkey.

The operation, scope and history of the EECS are explained in a companion report, "Enhance Emergency Control System for the Georgia State Electrosystem," dated 18 July 2012.

2 Objectives

EECS in Azerbaijan and in Turkey supports USAID's objectives.

PGIP's activities support USAID's objectives of promoting energy security through greater access to electricity and natural gas supplies for households in western Georgia, promoting the development of the Poti Free Industrial Zone on the Black Sea, and securing power exports through domestic reliability-related infrastructure improvements. The activities under the PGIP task order support USAID's larger goal of fostering sustainable development.

The EECS contributes to stability and reliability of the electric transmission system by rapidly (within tens of milliseconds) taking corrective actions in order to avoid blackouts. By encompassing the interconnecting transmission lines with Azerbaijan and Turkey the scope, response and value of the EECS increase to include disturbances involving the inter-country transmission lines.

3 Installation

It is expected that the utilities in Azerbaijan and Turkey will grant access to GSE and to Tetra Tech's subcontractor to install the equipment at the substations in Azerbaijan and in Turkey. This is a matter that GSE will take up with their Azerbaijan and Turkey counterparts.

Opposition to installation is not expected since USAID, and eventually GSE, will be owning and maintaining the equipment. That is, funds of the Azeri and Turkish utilities will not be used to support the system.

It is anticipated that GSE will share the phase angle measurements with their Azerbaijan and Turkey counterparts, and so the Azerbaijan and Turkish transmission system can benefit from the measurements if they want.

Custom's clearances are expected to be normal. On the one hand the equipment for the substations in Azerbaijan and Turkey is initially under the USAID's jurisdiction. On the other hand this equipment will be installed in the substations of the Azerbaijan and Turkey national utilities. That is, this is not material being imported for resale or for private use.

4 Operation

The phase angle between two adjacent substations is a measure of how *well*[1] real energy (watts, active energy) is being transferred over the transmission system. Zero phase angle between adjacent substations would indicate no power is flowing. A phase angle at the threshold (limit) is a point of instability in the power system. The phase angle between two stations increases from zero towards the threshold as more power is transferred over the segment of transmission line between the two substations.

Another threshold is the stability limit between power pools; for example, Georgia-Azerbaijan, Georgia-Turkey, and Azerbaijan-Turkey. The installation of phasor measurement units in Azerbaijan and in Turkey enable the EECS to monitor and react to the inter-power pool phase angles and disturbances.

The thresholds mentioned above are to be determined by the study that is part of the EECS Project.

[1] Watts (kilowatts, megawatts) is another measure of how *much* active energy is being transferred over a segment of transmission line.

The figure below shows the major power flows through the Georgian power system after the interconnections with Azerbaijan and Turkey are in service. Annex A contains a more detailed transmission system map overlaying a geographic map of Georgia.

The possibility of phase angle measurements between substations only became practical with global positioning system (GPS) of satellites in orbit, and with the tremendous decrease in price of integrated circuits that support GPS. The GPS satellites provide the highly accurate time signals that are used by EECS to measure the phase angle between substations.

As mentioned above the phase angle across a segment of transmission line (between adjacent substations) is a measure of how stressed the transmission system is. Transmission system operators (dispatchers) become concerned when the phase moves away from zero degrees and approaches 90 degrees. Fast acting control systems such as the EECS also monitor this phase angle and can rapidly take corrective action move the phase angle away from the critical 90 degree point and back towards zero.

International practice on internal and cross-border lines is moving towards greater use of phase angle measurements. Here are some recent installations of phase angle measurement similar to the EECS.

a) Between Salt River Project (Arizona) and Bonneville Power Administration (Oregon)
b) Between the Moro Bay Power Plants on the California coast and the extra high voltage (EHV) transmission systems in the central valley of California (Pacific Gas & Electric)
c) Between the Eccles Substation of the Scottish power system and the Stella West Substation of the England power system.
d) Between the power system of northwest Turkey and the European power system of Bulgaria and Greece.
e) 200 Megawatt AC-DC-AC back to back intertie for Black Hills Power, South Dakota.
f) The east-west transmission corridor of the Idaho Power Company, Idaho.
g) The east-west transmission corridor of the Pacific Power Corporation, Portland, Oregon.

The USEA reports of the Black Sea Transmission System (BSTN) specify the use of phase angle measurements across the interconnecting lines (Akhaltsikhe – Borchka; and, Batumi – Muratli). The EECS provides these phase angle measurements for the two transmission system operators. The Azeri transmission system is included in the EECS in recognition of Azerbaijan's plans to sell electricity to Turkey by wheeling the electricity through Georgia[2].

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[2] At this time an EECS installation is not planned for the Alaverdi 220 kV Substation because the 220 kV line between Georgia and Armenia is permanently open since Armenia at this time is strongly connected to the Iran power system. An EECS installation could be provided at the Alaverdi 220 kV Substation if and when necessary.

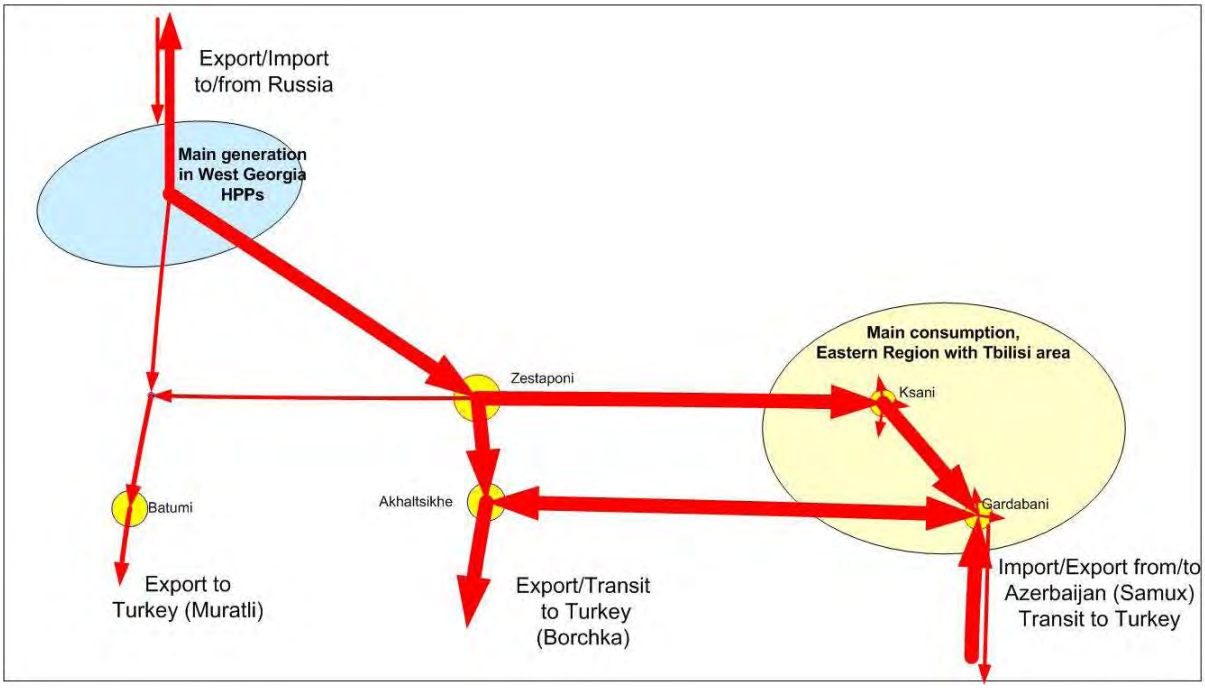


Figure 1: Future main power flows in the Georgian power transmission system

5 Maintenance

5.1 GSE's Capacity to Maintain EECS Equipment

The purchase of the EECS includes training and on-going support by the selected vendor. GSE operates and maintains an existing simpler emergency control system (ECS).

5.2 GSE's Ability to Maintain EECS Equipment in Azerbaijan and Turkey

GSE has the technical capability to operate and maintain ECS and EECS. There is no reason to expect that Azerbaijan or Turkey will not grant access to GSE to maintain the EECS equipment in the Azerbaijan and Turkey substations. Some conditions may apply to maintenance, for example, safety training, day-ahead scheduling of visits, and pre-approved list of GSE personnel authorized to be in the substations. These conditions are customary for access to electric utility substations.

5.3 Host Country

Major power system equipment (lines, circuit breakers, transformers, relays, meters,

power line carrier equipment, current transformers, voltage transformers, surge arresters, wave traps, disconnectors, etc.) are usually maintained by the transmission system operator of a country because these major power system items are used in many other substations in the country. The personnel are trained, spare parts and documentation are on hand, work and safety procedures are established for these major power system equipment.

In the case of EECS, like SCADA systems, the equipment of one utility is unique and not shared by the neighboring utility. Their personnel are not trained on EECS and SCADA equipment, do not have the spare parts, may not have the documentation, etc..

Furthermore, due to regulatory requirements one utility (say, Turkey) cannot work on the equipment of another utility (say, GSE) because the equipment of the second utility (GSE) is not for the direct benefit of the customers of the first utility (Turkey). Arguments of indirect benefit are usually not acceptable to the regulators.

Therefore, GSE will be expected to maintain the EECS equipment in Azerbaijan and Turkey.

6 Ownership, Responsibility

6.1 Ownership and Responsibility by Georgia

Regulatory agencies expect that equipment must be used and useful in order for the equipment to be included in the rate base (and balance sheet) of a utility. For example, EECS equipment in Turkey would not be owned (in the rate base, balance sheet) of the Turkish transmission system since the EECS equipment is not used by nor is useful to the Turkish transmission system. Arguments about indirect benefits are usually not accepted by the regulatory agencies.

Therefore, at this time it is for Georgia to provide the equipment.

In the future, when USAID transfers the ownership of the EECS in Georgia to GSE, USAID could at the same time transfer ownership of the equipment at Sumux Substation to the Azerbaijan transmission system and transfer the equipment on the Borchka and Muratli Substations to Turkey transmission system.

6.2 USAID Caucasus Funding Used

USAID funding the EECS installations in Azerbaijan and in Turkey greatly advances USAID's objectives of facilitating regional power markets and economic development.

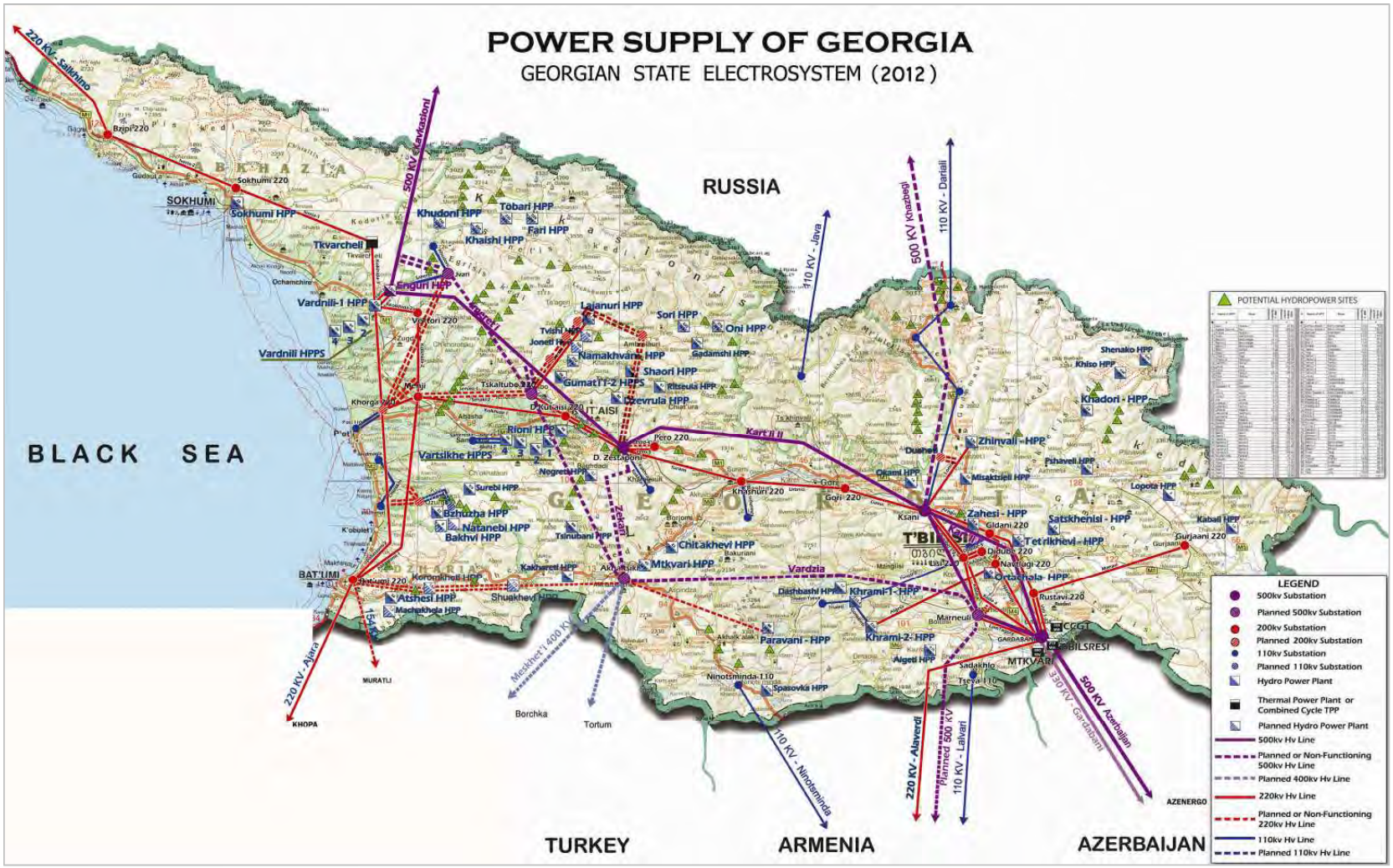
It is unlikely that at this late stage of re-construction of the interconnections with

Azerbaijan and the new construction of two lines to Turkey that EECS would ever be added to the inter-government agreements (Georgia-Azerbaijan; and Georgia-Turkey).

From a commercial point it would be difficult at this point to involve Azerbaijan and Turkey in EECS and to develop some sort of co-financing arrangement.

USAID branding and marking will be on the rack of equipment installed at all substations, including substations in Azerbaijan and Turkey, and so the US will be recognized for facilitating the regional power market.

7 Annex A GSE Transmission Network



8 Annex B Abbreviations

AC	Alternating Current
BSTN	Black Sea Transmission Network
DC	Direct current
ECS	Emergency Control System
EECS	Enhanced Emergency Control System
EHV	Extra High Voltage
GPS	Global Positioning System
GSE	Georgia State Electrosystem
HPP	Hydro Power Plant
kV	kilo Volt
PGIP	Power and Gas Infrastructure Project
PMU	Phasor Measurement Unit
SCADA	Supervisory Control and Data Acquisition
USAID	United States Agency for International Development

The Georgia Power and Gas Infrastructure Project ('PGIP' or 'Project') provides in-country professional engineering and other technical services to support power and gas transmission improvements being undertaken by USAID on behalf of the Government of Georgia. Activities performed under the PGIP will complement and reinforce the activities, project management, and engineering expertise of USAID/Caucasus.

USAID will be undertaking work from 2010 to 2013 in the energy sector in collaboration with the Georgian Oil and Gas Company ('GOGC') and the Georgia State Electrosystem ('GSE') to upgrade, replace, and install critical selected gas and power transmission infrastructure. These companies are state-owned entities charged with the import and transit, and in the case of GSE, dispatch of electricity throughout the country.

The activities under this Project will support USAID's objective of promoting energy security through greater access to electricity and natural gas supplies households in Western Georgia, promote the development of the Poti Free Industrial Zone (FIZ) on the Black Sea, and secure power exports through in-country reliability related infrastructure improvements. The activities assigned are managed by Tetra Tech and support USAID's objective of fostering sustainable development.

The PGIP project includes the following infrastructure projects:

- Construction of a new 31 kilometer, 700 mm gas pipeline from Senaki to the Poti FIZ;
- Construction of a new 76 kilometer, 700 mm gas pipeline from Kutaisi to Senaki;
- Replacement of 58 kilometers of 220 kV transmission lines (referred to as Senaki I and II) which were dismantled in 1992 during Georgia's civil war; and,
- Restoration of the power substations in Tskaltubo and Menji to support the Senaki I and II 220 kV transmission lines.

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