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**HYDRO POWER AND ENERGY
PLANNING PROJECT (HPEP)**

SUMMARY REPORT ON MARKAL INPUT DATA COLLECTION

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(HPEP)

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TABLE OF CONTENTS

1.0 LIST OF TERMS AND ACRONYMS	1
2.0 INITIAL DATA SET FOR MARKAL GEORGIA 2014	2
3.0 FURTHER DATA COLLECTION EFFORTS	6
4.0 ADJUSTMENTS OF INPUT PARAMETERS.....	8
5.0 SUMMARY AND OUTLOOK	9

1.0 LIST OF TERMS AND ACRONYMS

AD	Analytical Department of the Ministry of Energy
AF	Plant seasonal availability factor
AYPEG	Association of Young Professionals of Energy in Georgia
CNG	Compressed Natural Gas
DCOP	Deloitte Overseas Consulting Project
DWG	DecisionWare Group
EC LEDS	Enhancing Capacity for Low Emissions Development Strategy
EFF	Efficiency
ESCO	Energy System Commercial Operator
GEOSTAT	Georgian State Statistical Service
GDP	Gross Domestic Product
GNERC	Georgian National Energy Regulatory Commission
GOG	Government of Georgia
GOGC	Georgian Oil and Gas Corporation
GSE	Georgian State Electrosystem
EE	Energy Efficiency
HPEP	Hydro Power and Energy Planning project
HPP	Hydro Power Plant
LPG	Liquid Petroleum Gas
MARKAL	Market Allocation energy planning model
MoE	Ministry of Energy
MoESD	Ministry of Economy and Sustainable Development
NGO	Non-Government Organization
NPV	Net Present Value
O&M	Operation and Maintenance costs
RE	Renewable Energy
TED	Territory electricity demand (representing Abkhazia region)
TPP	Thermal Power Plant
WEG	World Experience for Georgia

The goal of this report is to provide an overview of data collection efforts for recent (2014) version of MARKAL Georgia under different projects; to identify the relevant sources for particular sets of information that would be useful for future revisions of MARKAL model and filling information gaps by professionals working on the model. The report also highlights the current activities for data improvement. This report does not cover data collection and model development efforts conducted outside the Energy Sector under the USAID EC-LEDS project that are conducted by other organizations to model capacity for estimating greenhouse gas emissions.

2.0 INITIAL DATA SET FOR MARKAL GEORGIA 2014

Data collection for MARKAL Georgia 2014 model was conducted through several consecutive and parallel USAID projects implemented by different contractors. These included Regional USAID EC-LEDS conducted by DWG under TetraTech and with WEG participation, USAID Georgia EC-LEDS conducted by Winrock International and Remissia with DWG participation, and AD Training in the use of MARKAL and Long Term Strategy Development conducted by WEG under subcontract with Deloitte Overseas Consulting Project (DCOP) within the frame of HPEP project. The main data collection activities were mostly concentrated around the analytical department of the Ministry of Energy (AD) and the coordination between the implementing organizations. Such an approach had its positive side in generating the experience of AD in data collection and establishing the inter-agency links in energy sector for future data adjustments and further cooperation. On the other hand it provided the possibility of cross-checking and quality control by different groups and resulted in final better quality of data input to the model. In parallel to data collection, the model development was continued and attempts were made to reflect better the energy sector realities, e.g. sophisticated structure of gas contracts, the gas storage and other specific factors that needed special modeling treatment.

This report reflects the work on data collection conducted up to June 2014. Since the model has a huge number of inputs, data refinement and reflection in the model is almost a continuous work that will be conducted further.

1. Under regional EC-LEDS projects led by TetraTech, DWG has conducted the training of the AD in the use of MARKAL Georgia; DWG also continued its work on improving the model inputs and representation of Georgian energy system in MARKAL Georgia model. WEG was involved as a subcontractor to DWG and took part in preparation of training sessions and tests as well as data collection efforts.

The data were collected mainly through the guided efforts of analytical department who was advised on the nature and extent of information needed and was requested to try to obtain the information through official sources and official communication.

The base year was set to 2012, the main energy supply and consumption data for this base year was collected and the preliminary energy balance was composed.

AD staff was divided into the following groups:

1. Avtandil Todua and Ronnie Kvachadze were responsible for natural gas data, Industry and Commercial sector
2. Akaki Kharashvili and Elene Gokhadze were responsible for wood fuel, coal and geothermal data as well as for Residential sector
3. Ana Gogoreliani was responsible for electricity data and TED
4. Nestan Gaprindashvili and Mariam Khosroshvili were responsible for oil products and Transport sector

Collected information was discussed and assessed at training sessions; however, due to the large volume of data, limited time and the main focus on training in model techniques, the in-depth verification of collected data was postponed for future work. The main focus of the seminars was to train the AD in model operation and conducting energy efficiency and renewable energy target scenarios, therefore, at the end of seminars there were still data gaps remaining and the collected information needed verification and cross checking¹.

Table 1 shows the main data collected by AD with DWG/WEG support and the relative sources for data:

¹ These data gaps are described in previous deliverable “ MARKAL model status”

Table 1. Data Categories and Sources

Data	Sources
Energy balance	
Domestic production of Wood fuel	National Environmental Agency, partly based on assumption
Coal	Geostat, Saknakhshiri
Natural gas	Georgian Oil and Gas Corporation (GOGC)
Geothermal energy	National Environmental Agency
Import oil products (aviation fuel, LPG, gasoline, distillate),	Ministry of Finance of Georgia, The Union of Oil products Importers
natural gas,	GOGC
electricity,	ESCO
brown coal,	Geostat, Saknakhshiri
Export of electricity	ESCO
Final energy consumption of wood fuel	Based on assumptions, AYPEG survey
brown coal,	Geostat, Saknakhshiri (partly based on assumptions)
electricity,	Telasi, Energo-Pro, Kakheti electricity distribution companies
natural gas,	GOGC
oil products (aviation fuel, LPG, gasoline, distillate),	From export-import information given on Ministry of Finance of Georgia's web site, final energy consumption is calculated as IMPORT – EXPORT (assuming zero domestic production of oil products).
geothermal	National Environmental Agency data on ground water usage (to be adjusted to account for water temperatures)
Domestic electricity generation amounts	ESCO
Electricity transmission and distribution losses	ESCO; Telasi, Energo-Pro, Kakheti electricity distribution companies

Gas losses	GOGC
Data for electricity sector	
Hourly load data	Georgian State Electrosystem
Existing capacity of power plants split up by plants type	ESCO
Technical-economic parameters of existing power plants (seasonal and annual AF, contribution to peak, O&M fixed and variable cost, EFF, lifetime, amount generated, capacity, consumed fuel (for TPP only))	O&M fixed and variable cost – GNERC Generation, capacity –ESCO seasonal and annual AF – calculated consumed fuel for TPP – GOGC
Export/ import amounts for 2012	ESCO
Export/import prices for 2012 and their projection	ESCO
List of future HPP projects and their technical-economic parameters (seasonal and annual AF, O&M fixed and variable cost, EFF, lifetime, investment cost, start year of operation, capacity, contribution to peak, construction period (for calculation of future values to be considered in investment costs))	seasonal and annual AF, investment cost (estimated), start year of operation, capacity, generation, construction period - Ministry of Energy of Georgia
Electricity consumption split up by end use sub-sectors and	Electricity distribution companies
energy service demand ² (certain portion is based on assumptions)	Based on assumptions
Transmission lines' capacity	Georgian State Electrosystem
Price of electricity to demand sectors	Electricity distribution companies
Energy prices	
Natural gas import price for 2012	Ministry of Energy, GOGC
Price of natural gas to demand sectors for 2012	GNERC
Price of wood fuel for 2012	Based on assumptions and inquiries
Price of geothermal energy to demand sectors for 2012	"Geothermal Water" ltd
Price of coal to demand sector	Saknakhshiri
Price of oil products for 2012	The Union of Oil Products Importers, Assumptions are made on separate sector prices based on past MARKAL prices

² Energy service demand represents types of useful energy such as heating, cooling, water heating, refrigeration, lighting, etc. These types of useful energy in turn are produced by different demand technologies fueled by different typed of fuel.

Demand sectors	
Amount of vehicles fueled by CNG	Partly based on assumptions (knowing amount of CNG sold)
Fuels consumption by types of vehicles	Ministry of Internal Affairs of Georgia, assumptions
Passenger/kilometers by types of vehicles (based on assumptions for some types of vehicles)	Assumptions and Expert assessments
GDP of each demand sector for 2012	Geostat
GDP growth rate projection for each demand sector	Scenario assumptions
Allocation between dwelling types	Partly based on assumptions
Other parameters	
GDP for 2012	Geostat
GDP growth rate projection	Partly based on assumptions with the account of official projections (e.g. Ministry of Finance and MoE SD)
Population growth rate projection	Assumptions and Expert assessment

3.0 FURTHER DATA COLLECTION EFFORTS

The following data collection and verification actions were conducted after the initial stage of model data input:

GSE Dispatch Center Visit

Together with MoE AD representatives, WEG conducted a meeting in the Dispatch Center and obtained the following information:

- Seasonal export/ import existing constraints with neighboring countries
- Contribution to peak by existing power plants
- Projection of annual export/ import constraints with neighboring countries
- The dispatch center representatives verified that 2012 year was an average year from hydrology perspective and no adjustment is needed for future years modeling.

The obtained data was processed and input in the MARKAL Georgia model by WEG.

Household Energy Consumption Survey

AYPEG under HPEP project conducted a survey of residential energy consumption. The market research on space/water heating, cooking, cooling, lighting, refrigeration and other energy consuming appliances and technologies was a byproduct of this research. Questionnaires also contained questions on energy efficiency. The representative sample for the country as a whole, as well as specific samples for urban and rural areas of Georgia were analyzed. In total AYPEG collected 1081 responses including 500 from rural regions and 581 from urban areas. The findings

of Residential survey will contribute strongly to Reference scenario development and will help to substitute some data that is based on assumptions with the data obtained by statistics. Currently only the major parameters defining the use of fuel wood and the shares of gas and electricity in total residential energy mix are assessed. Further data improvement requires a more in-depth analysis of the data set obtained. The data base was transferred to WEG for further analysis. WEG is analyzing the data to extract the relevant information.

This will improve quality of model results as well as energy balance that was developed for modeling purpose and can serve as country's pilot energy balance for 2012 till real energy balance gets developed by GEOSTAT.

Natural gas volumes and prices

There is a complicated set of arrangements between different entities in the gas sector of Georgia that results in gas price differentiation between different customer categories, and leads to cross subsidies.

Several attempts were made to understand the existing arrangements and prices in the model; however the information was not properly supplied by gas sector entities.

In order to address this issue a formal inquiry and a subsequent visit of WEG and AD representatives was arranged to GOGC commercial department. The peculiarities of a set of contracts in natural gas sector were discussed. The base data and clarifications were provided by the head of commercial department of GOGC.

The obtained information cannot be directly inputted into the model due to its complex structure. Currently WEG and AD are working on data analysis in order to represent properly the structure of gas contracts and prices in the model.

DWG is also working on modeling solutions for representation in the model of "social" and "commercial" gas prices, allowable volumes and their projections.

Khudoni HPP data

Khudoni HPP is the big 700 MW hydropower project that is causing major controversies between the project developers, GOG and public, including environmental NGOs and local population. One of the most questioned issues is the justification of Khudoni construction need in the context of country's general energy strategy. Although MARKAL Georgia cannot provide a decisive justification for Khudoni construction, however, it is a useful tool that can indicate relative preference of this HPP project versus other competing alternatives in various interesting development scenarios. Therefore, correct reflection of Khudoni parameters in the model is an issue of high interest. A potential byproduct of Khudoni construction is the increase in output of Enguri and Vardnili cascade due to increased flexibility of water management. However this opportunity can be seized only through coordinated action and operation of Khudoni-Enguri cascade as one system. AD has input the estimate of 500 GWhs additional generation. however no supporting calculations or written documents have been supplied.

In summary, the above data collection/verification activities helped to improve the data but also to establish the working links between the AD and various energy sector entities where the understanding of work specifics of each party will help in future planning efforts.

4.0 ADJUSTMENTS OF INPUT PARAMETERS

Data collection is not an isolated activity and is closely related to its analysis and input in the model. Closer examination of data inputs revealed a need for certain adjustments and improvements in assumptions and final input parameters. From the beginning of its work under HPEP project WEG, in parallel with training sessions at MoE AD, initiated data gap identification, quality verification, acquisition and input correction based on previous experience and industry contacts. The following adjustments were effected in the reference scenario:

- Hourly electricity load data didn't include data for Abkhazia and, therefore, the peak load in the model differed from the real peak in 2012 by about 200 MW. WEG input the correct load data representing hourly load for the whole country including Abkhazia region and calibrated load data. (*source: GSE hourly load data for Georgia*)
- The latest information was obtained for the price of geothermal water supply to residential sector (2 GEL per m³). The price for geothermal was changed in the model. (*source: "Geothermal Water" ltd*)
- The upper constraint on geothermal energy use in Residential and Commercial sectors was made more realistic based on current knowledge and the upper bound in Agriculture was too high (9.72 PJ). Geothermal use should be restricted in the model, since geothermal water is available only in certain regions and its increased consumption is associated with investments in infrastructure expansion, which has not been considered in the model. WEG restricted possible growth of geothermal use to 200% over the planning horizon. (*Source – geothermal expert G.Vardigorely and WEG studies of 2008 on RE potential www.weg.ge*)
- Amounts of geothermal consumption were recalculated using more realistic temperature estimates. WEG recalculated the volumes and corrected the base energy balance and corresponding sector templates. (*Source – geothermal expert G.Vardigorely and WEG studies of 2008 on RE potential www.weg.ge*)
- The estimation on investment costs of new technologies for geothermal usage expansion were adjusted based on USAID assessments of 1998, USAID/WEG reports of 2008 and experts inquiries. The data was input in the model. A new geothermal energy supply technology was added to the model based on concrete agriculture complex project with estimated investment cost more in line with similar cost in residential sector. (sources: www.weg.ge)
- Corrections of capacities was made in aggregated technologies "Other regulating HPPs" and "Run of River" since they didn't correspond to their real capacity. Some Run of River plants were counted as Other regulating ones which means that some run of river plants were given characteristics (relatively high AFs) of regulating ones that exaggerates AF of existing HPP capacity. Corrected parameters were input in the model. (*source: GNERC and ESCO data*).

- Since the plants were regrouped under existing plant categories relevant seasonal and annual AFs were recalculated and input. Variable and fixed O&M costs were recalculated and inputted. Electricity generated in the base year was recalculated and inputted according to plant categories.
- Data on seasonal peak AFs of existing plants was verified with Dispatch Center and corrected values were input into the model. Previously Enguri and Vardnili HPP and Other regulating HPPs had 100% AF in peak in any season which doesn't correspond to reality. (*Source: GSE dispatch center*).
- Export/import seasonal constraint for electricity trade with Armenia and Azerbaijan were updated based on information obtained from Dispatch Center (*source: GSE*).
- The investment costs of technologies using fuel wood in agriculture had zero investment cost. Such technologies were switched off. In future once data on wood consumption in Agriculture is available there technologies can be switched on. However, according to 2012 year obtained data there is no wood consumption in Agriculture.
- WEG reduced the projection of wood fuel price growth from assumed 50% growth in 2015 down to annual (real) 1 % growth projection. This eliminated a sharp drop in wood consumption in the model.
- Investment cost of efficient wood stoves was wrong in the model. WEG changed investment cost for efficient (70%) stoves. (*Source Technology Needs Assessment for Georgia, own market inquiry*).
- To account for construction and financial risks, the upper limit of new minor HPPs (less than 15 MW) was multiplied by 0.7 per each constraint. This is equivalent to assumption that only 70 of currently acknowledged hydropower potential can be commissioned before 2036.
- To account for delay risks and financial barriers for big HPPs their initial starting year was shifted by one period later (except for Khobi 2 and Dariali, whose commissioning years were confirmed by MoE).

Currently WEG is working on further data quality control and improvement and will start processing results of Residential survey conducted by AYPEG as soon as it gets them.

5.0 SUMMARY AND OUTLOOK

WEG continues the work on data quality control and improvement; it will further review major data inputs and analyze in detail the model results to identify the potential inaccuracies. Data improvement activities shall continue over the project period till the middle of August 2014.

- The data on residential sector energy consumption and end use equipment acquired by AYPEG through the household survey requires further processing in order to derive the relevant parameters and defining the accurate model inputs. The data set of survey has been transferred to WEG. The survey data

will be processed in order to extract maximum amount of information relevant to MARKAL model inputs.

- The gas sector information will be analyzed and converted to model inputs and will be discussed with GOGC in a second round of consultations
- A special meeting will be conducted devoted to Khudoni effect on the rest of the power system including its effect on Enguri/Vardnili output. The results of this inquiry will largely define the final benefit assessment for Khudoni project.
- Any further data shortcomings identified in the course of training and scenario development shall be properly addressed.

WEG will continue the work on Reference Case improvement and will conduct further update and improvements of energy efficiency, renewable energy target, combination of EE and RE and other scenarios that are of particular interest to MoE. Together with AD, WEG will prepare draft of Policy Brief that will contain main findings of Reference case and other conducted scenarios.

Along with data input improvements there is an ongoing work on model upgrade: Under USAID EC-LEDS project led by Winrock International, DWG is addressing issues related to GHG emission reductions in future climate change mitigation scenarios and adding the corresponding structures to the model. It is expected that cooperation between WEG and DWG/Remissia on model improvement will continue. And the process will result in a united MARKAL Georgia model that will be potentially useful both for MoE in energy strategy development and for Ministry of Environment for climate change mitigation modeling.

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