ENERGY TARIFF OPTIMIZATION POLICY IN KYRGYZ REPUBLIC

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Submitted to

Central European University

Department of Economics

In partial fulfillment of the requirements for the degree of Master of Art

in Economic Policy in Global Markets

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Budapest, Hungary

2016

ABSTRACT

The tariff increase up to 100% in 2009 was called to be a ‘trigger’ to Political Revolution of 2010. In 2014, the Government of Kyrgyz Republic has introduced the Mid-Term Tariff Policy (MTTP) for 2014-2017 as a measurement to tackle the energy crisis. The MTTP assumes the gradual increase of the electricity tariff to 1.20 Kyrgyz Som per kWh in 2017, the validity of the tariff methodology has been widely questioned. In this paper, MTTP is analyzed and due to its drawbacks, an alternative tariff is proposed. Findings suggest that MTTP methodology fails to capture the yearly fluctuations of the expense items. Two long-run forecast scenarios using Long-range Energy Alternatives Planning System (LEAP) with additional assumptions on company behavior suggested that ‘New Tariff’ methodology, which was developed as a part of this study, is more preferable over ‘MTTP’ methodology. The tariff of 1.54 Kyrgyz Som per kWh is accepted as the optimal in achieving the energy balance in long run out of two proposed tariff methodologies.

Keywords: energy market balance, tariff optimization, LEAP model

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Professor Istvan Konya, for valuable advice and help during my work. Also, I would like to express my sincere gratitude to Ms. Agnes Kelemen, an Environmental Economist, for helping me building a model in LEAP; to Ms. Ajar Jakypova, USAID RESET Analyst, for valuable advices on energy balance analysis; to Mr. Azat Ishenaliev, Tariff Methodology Analyst at National Energy Holding in Kyrgyz Republic, for consultation on MTTP Methodology and provision of data and to Mr. Abgar Budaghyan, Regulatory Consultant for Energy & Water based in Armenia, for helping in analysis of cost structure of energy. Special thanks to my family, friends and CEU for making this possible.

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List of Abbreviations

HPP – Hydro Power Plant

KGS – Kyrgyz Som (currency)

kV – kilovolt

kWh – Kilowatts per hour

LEAP - Long-range Energy Alternatives Planning

MTTP – Mid Term Tariff Policy

MW – Megawatts

NBKR - National Bank of Kyrgyz Republic

RESET - Regional Energy, Security and Trade Project

TPP – Thermal Power Plant

Introduction

The Kyrgyz Republic is potentially the biggest energy exporter in Central Asia, its hydropower resources are estimated to be 142 billion kWh, out of which only 10% is exploited. The main energy element is the water flow in Naryn River, which holds 72% of water resources of Syrdaria River and 25% of all water resources of the Central Asia. (Juraev, 2009) In the past 16 years the economic downturn and the violation of interstate relations caused structural changes to energy system, which resulted in the reduction of fuel and energy production in 2005 to 52% of energy imports. (Kasymova & Baetov, 2007) The decrease of water reserves along with the major increase in demand for hydropower led to Energy Crisis of 2007-2009 and Electricity Deficit in 2012-2013. The set of inappropriate managerial decision of Government and poorly communicated to end consumers tariff increase up to 100% resulted in negative public outrage and was called to be a 'trigger' to Political Revolution of 2010. The Government of Kyrgyz Republic has introduced the Mid-Term Tariff Policy (MTTP) 2014-2017 as a measurement to tackle the energy crisis. MTTP assumes the gradual increase of the electricity tariff from 0.70 Kyrgyz Som per kWh in 2014 to 1.20 Kyrgyz Som per kWh in 2017. The MTTP had been under close public attention and spiked questions on validity of the methodology of tariff derivation. (Karybekov, 2016)

In the framework of the following Master's Thesis, the attempt to implement the MTTP's tariff derivation methodology to the energy sector data is undertaken. The objective of the study is to analyze the validity of currently adapted Mid-term tariff methodology and to propose an alternative tariff methodology, which would balance out the energy market demand and supply, through modeling two long-run forecast scenarios in Long-range Energy Alternatives Planning System (LEAP). No similar studies with LEAP modeling technique for energy sector of Kyrgyz Republic have been previously undertaken.

Chapter 1 provides an overview of the energy sector structure and details the energy transformation process (generation, transmission and distribution). It introduces the reader to the major energy companies, which operate at each stage of energy transformation process. It also outlines the potential causes of the Energy crisis 2007-2009 and Electricity Deficits of 2012-2013.

Chapter 2 is focused on the Mid Term Tariff Policy. It provides technical details of Midterm tariff methodology, which has three stages: *Required revenue, Classification of Expense Items and their coverage, Consumer segmentation by the required revenue*. Although, the methodology has been discussed with the working group under National Energy Holding in the framework of the following thesis, specific questions on methodology remain open and are presented in this Chapter.

Chapter 3 includes two main parts. First part introduces the reader to LEAP software and explains the system modeling capacities. Second part presents the data processing and the actual modeling using LEAP. Energy sector data includes the macroeconomic energy consumption figures from National Statistical Committee of Kyrgyz Republic and Energy Company's Annual Technical and Financial Reports from 2011 – 2015 provided by National Energy Holding upon request. The 'New Tariff' methodology is developed based on the MTTP results and *additional energy companies behavior assumptions*. Following the newly obtained tariff methodology and the MTTP methodology, two alternative forecast scenarios are modeled using LEAP forecast capacities.

Finally, Chapter 4 presents the results under two scenarios and identifies the difference between 'MTTP' methodology and 'New Tariff' methodology. It provides comparative analysis of Module Cost Balance and Energy Sector Balance for two scenarios.

Chapter 1 Energy sector of Kyrgyz Republic

The monopolistic structure of Kyrgyz Republic's energy market created a vertically integrated energy system. Although, the stages of generation, transmission and distribution are not owned by a single firm, the end consumer does not have access to separate services. This type of vertically integrated monopoly is subject to regulation at the managerial level, consecutively, pricing methodology is also regulated. If in a competitive market theory, the pricing is based on *the marginal cost principle*, in a monopolistic market the most practiced approach of costing is still based on *the average cost pricing principle*. In a monopolistic market regulatory body is responsible for the balance of supply and demand. Given that energy service is an obligation in a monopolistic market, the service is provided to the end consumers at average cost pricing, whereas, the actual marginal cost may be higher, thus exposing energy companies to potential deficit. Compared to a competitive market, a monopolistic market often experiences imbalance at the margin. "In these competitive domains, where customers have choices and pay marginal costs, the market balances supply and demand. The only requirement for an obligation to serve, therefore, arises in the non-competitive, regulated portion of the market". (Hogan, 1993)

Kyrgyz Republic energy market has features of both competitive and monopolistic markets. Although Kyrgyz government has introduced privatization policy in early 2000, the energy companies remain under the control of central government as 51% of company shares belong to Government of Kyrgyz Republic. Despite energy companies have been segregated and gained managerial independence, they still form united vertically integrated energy system. Since independence, the fuel and energy balance of the country was formed during the transition period to a market economy. The economic downturn and the violation of interstate relations caused structural changes to energy system in the past 16 years, which resulted in the reduction of fuel and energy production in 2005 to 52% of energy imports. (Kasymova & Baetov, 2007) The decrease of water reserves along with the major shift of consumption to electro energy generated from hydropower led to energy supply shortage and systematic blackout to households, public and private medical and educational institutions. The set of inappropriate managerial decision of Government and poorly communicated to end consumers tariff increase up to 100% of previous value resulted in negative public outrage and was called to be a 'trigger' to Political Revolution of 2010. (Wood, 2010)

In 2014, the Government of Kyrgyz Republic adapted the Mid Term Tariff Policy 2014-17 that assumes gradual increase of tariff over the course of three years. The policy has been put into force, however, criticism has spiked over the methodology of tariff derivation. (Karybekov, 2016)

1.1 Structure of Energy Sector of Kyrgyz Republic

The primary source of electricity generation is hydro power energy generated by hydro power plants (HPP), the secondary source is thermal energy generated at thermal power plants (TPP). There are 15 individual HPPs and 2 TPPs. The total disposable capacity of 11 HPPs is 2992 MW and 2 TPPs have the capacity of 367 MW as of 2015. (Regulatory Body under National Energy Holding, 2016)

Table 1 Generating Capacities of Power Plants

Name of the Power Plant	**Year of establishment**	**Installed Capacity, MW**	**Disposable Capacity, MW**
Large size HPP			
'Toktogulskaya' HPP	1975	1200	1200
'Kurpsaiskaya' HPP	1981	800	800
'Tash-Kumyrskaya' HPP	1985	450	450
'Shamaldy-Sayskaya' HPP	1994	240	240

'Uchkurganskaya' HPP	1961	180	175
'At-Bashynskaya' HPP	1970	40	37
'Kambaratinskaya 2' HPP	2010	120	90
Sub Total		**3030**	**2992**
TPP			
'Bishkek' TPP	1961	666	350
'Osh' TPP	1966	50	17
Sub Total		**716**	**367**
Small size HPP			
OJSC 'Chakan' HPP	1928-1958	38,5	16
'Kalininskaya' HPP	1954	1,4	0,7
'Ysyk-Atinskaya' HPP	2008	1,6	0,9
'Naymanskaya' HPP	2005	0,6	0,4
Sub Total		**42**	**18**
Grand Total		**3788**	**3377**

Source: National Energy Holding, 2016

At current state, the energy sector operational flow is composed at three stages: energy generation, energy transmission and energy distribution.

Energy Generation

7 large size HPPs and 2 TPPs are owned by Open Joint Stock Company (OJSC) 'Electric Stations'. The energy generation market is limited, as single company owns largest HPP'. There is no competition among energy generating companies. Government of Kyrgyz Republic is the major stakeholder of the OJSC 'Electric Station'. Energy generated by these HPPs account for 81% of total energy output of the country. In accordance with the law of Kyrgyz Republic on "Special Status of the Cascade of Toktogul Hydro Power Plants and the

National Electric Network", the sale or any another form of ownership change is not allowed. (Jogorku Kenesh, 2008)

Energy Transmission

The energy sector is supported by single transmission company – OJSC "National Electric Network". "National Electric Network" owns and operates on all of the transmission lines with capacity above 110kV. Kyrgyzstan power networks include high voltage transmission lines of 110-500 kV voltage (6642 km) and 35 kV voltage (4613 km); high voltage substations of 110- 500 kV voltage (190 units) and 35 kV voltage (334 units); as well as 0.4-6-10 kV transmission lines (50,700 km) and 6- 10/0.4 kV substations (23,689 units). (UNISON in collaboration with USAID, 2013) In accordance with the law on "Special Status of the Cascade of Toktogul Hydro Power Plants and the National Electric Network", the sale or any another form of ownership chance is not allowed. (Jogorku Kenesh, 2008)

Energy Distribution

There are four distribution companies responsible the delivery of energy to entire population of Kyrgyz Republic: OJSC "Severelektro", OJSC "Vostokelektro", OJSC "Oshelektro" and OJSC "Jalalabadelektro". The competition on the market of energy distribution is also limited, as 93% of shares of all four distribution companies is owned by the Government of Kyrgyz Republic.

Previously, Ministry of Energy of Kyrgyz Republic was the governmental body, which also acted as a policy-making institution. At the beginning of 2016 Ministry of Energy was dissolved, National Energy Holding was established instead. It inherited the functions of Ministry of Energy; however, policymaking became an operational part of the Ministry of

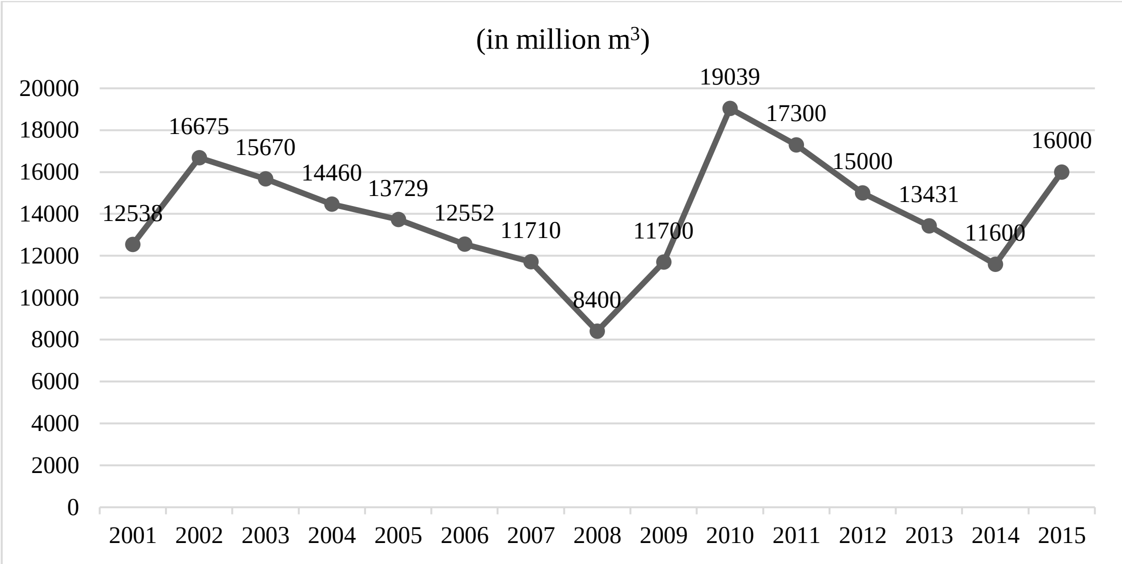
Economy of Kyrgyz Republic. (Kaliev, 2016) This strategic decision had been made after the 2007-09 energy crisis, which spiked over low level of water reserves in Toktogul reservoir.

1.2 Energy Crisis of 2007-2009

The Toktogul water reservoir is a strategic object, which had been under close public attention, since the drastic drop of the level of water storage in reservoir led to sharp decline in energy generation.[1] Five major HPPs (Toktogul, Kurpsay, Tashkumyr, Shamaldysay and Uch Kurgan) steady operations are directly dependent on the Toktogul reservoir's water storage level. In April 2008 the Toktogul Reservoir water storage decreased to 8.4 bln m^3 – the critical level at which HPP's hydraulic turbines could not operate because of the risk of their damage. The energy crisis burst in the country, resulted in limited power supply (rolling blackouts) to consumers including individual enterprises and residential areas for the periods of morning and evening electricity consumption peak hours. The principle of continuous, reliable, quality and affordable power supply to consumers, underlying the Kyrgyz power industry and formalized in the national legislation, was violated. (UNISON in collaboration with USAID, 2013)

[1] Hydro power plants are built on the rivers, where dams and reservoirs are constructed. The dam prevents the flow of the river, thus the water level in the reservoir rises. If the gates in the dam are opened, the water rushes with force into gate 'window' creating a powerful downstream water flow. Under high pressure, water is flowing on to the turbine blades, which start to rotate, thus producing mechanical energy. Mechanical energy is then transmitted to the hydro generator, which produces electricity.

Graph 1Toktogul Reservoir Water Volume Dynamics



Source: The National Institute For Strategic Studies Of The Kyrgyz Republic and Kabar News Agency

Although, the Toktogul reservoir water storage level has been normalized, due to completely depreciated technology and equipment used at HPPs, the efficiency of the energy transformation is critically lower. In 2012, systematic electricity blackouts took place in major cities of the country.

1.3 Electricity Deficit of 2012-2013

Due to insufficient financial inflows, the energy generating companies did not have capacity to build up a reserve for emergency system defaults in the system. In December 2012 one of hydraulic turbine generator of capacity of 300MW failed, it was no longer possible for the generating companies to meet the domestic demand for energy. Government of Kyrgyz Republic entered into agreement with the Government of Kazakhstan on importing electricity from Dzhambul Thermal Power Plant until Kyrgyz Energy sector will be able to restore the balance of energy production and demand. Even though, during the crisis electricity was partially imported, it was insufficient to cover up the domestic demand, thus the systematic blackout continued to take place mainly in densely populated cities of Bishkek and Osh throughout autumn and winter periods of 2011-12 and 2012-13.

The alternative plan to launch the establishment of new HPP “Kambarata 1” and reconstruction of Upper Naryn system of HPPs has been proposed by the Government of Kyrgyz Republic, which would be funded by Russian Federation in form of loan with the annual interest rate of 2.5%. (Tazabek, 2013) The estimated cost varies across the information sources, the officially reported estimated cost is $ 2 billion USD, the project was expected to breakeven in 15 years after the launch date. (Izvestiya, 2016)

The necessity of construction of these hydro power plants was also mentioned in the National Energy Program of the Kyrgyz Republic 2008-2010 and in the Fuel Energy Complex Development Strategy 2025, which were approved by Resolutions of the Kyrgyz Republic Government No. 47 dated 13.02.2008 and of the Kyrgyz Republic Parliament No. 346-IV dated 24.04.2008. (UNISON in collaboration with USAID, 2013)

However, due to the drop of oil prices and the sanctions imposed on Russian enterprises, the Russian Government increased the interest rate of the funding. The further realization of the project under new agreement conditions would eventually lead to higher tariff for end consumers. Therefore, Kyrgyz Government had decided to terminate the Agreement, leaving all projects with no definite date of completion. (Izvestiya, 2016)

Chapter 2 Mid Term Tariff Policy and its methodology

In the following chapter, the Mid Term Tariff Policy 2014-17, adapted by Government of Kyrgyz Republic in 2014, is presented and analyzed. The methodology of the policy has been developed by Regulatory Body under the National Energy Holding in collaboration with international donor organization – World Bank. In the framework of this MA Thesis the Regulatory Body has been requested to disclose and approve the validity of the methodology as not all aspects of the methodology were publicly disclosed. Mr. Azat Ishenaliev, an analyst at Tariff Development department of Regulatory Body has been a contact person, who contributed to clarification of tariff methodology to certain extent. However, the approach to the consumer segmentation as a part of the policy has not been fully clarified and questions on end consumer clustering remains open and presented at the end of Chapter 2.

2.1 Mid Term Tariff Policy

The crisis of 2011-12 demanded an urgent reformation in energy sector and introduction of new tariff policy which would comply with the policy making principles of Kyrgyz Republic. The basic principles of tariff policy of the Kyrgyz Republic were formed on the basis of the Article 9 of the Law "On Energy":

- "tariffs should reflect the full cost of production, transmission and distribution of electricity and heat energy including the costs of operation and maintenance as well as reimbursement of the invested capital";
- "tariffs for each group of consumers should reflect all the costs of electricity and heat energy for this category of consumers";
- "existing cross-subsidies from one group to another group of consumers should be gradually excluded";
- "subsidies should be addressed directly to low income consumers through government social protection programs";

According to international practices, the tariff derivation is based on "cost plus" or a ceiling for tariffs methods. According to MTTP, tariffs are oriented to cover the full cost of the service, however, historically the energy sector had been heavily dependent on the government subsidies, which not only distorted the market equilibrium, but also stimulated costumers to switch from alternative sources of energy, such as coal, oil and gas, to more affordable – electric energy. Cross-subsidization of tariffs was aimed on low-income households.[2]

The electricity and heat generation at TPPs is often less efficient than at HPPs. The cost of electricity generated at HPP is assumed to be ten times less than the cost of electricity generation at TPP. The MTTP reveals that the high cost of heat generation is partially covered though charging higher heat tariffs to industrial consumers and corporate clients. Heat charges to the household (Public Utility) are also subsidized by the state through revenues generated from electricity exports. (Abdyrasulova & Kravsov, 2009)

2.2 Mid Term Tariff Methodology

According to MTTP, there are two methods of energy tariff derivation, the underlying difference between these two methods is the way the capital costs are treated.[3] These methods are referred as:

1) Norm of revenue: $(Capital\ Cost) = (Amortization) + (Norm\ of\ Revenue)$
2) Required revenue

Method of 'required revenue is based on the actual expenses incurred whereas method of 'Norm of Revenue' is based on the rough estimation of calculated expenses. The disclosed

[2] There is no information on criteria of eligibility of household, who are considered low income and, therefore, are subsidized. There is common perception that this part of the methodology is implemented unfairly. Cases of bribery have been reported. As evidence, the manufacturing and industrial areas with high electricity consumption are reported to be classified as 'low-income household consumer', thus avoiding high electricity bills.

[3] Capitals costs are defined as the costs associated with the purchase of new assets and the reconstruction and modernization of existing assets.

methodology does not reveal the details of the first method (Norm of Revenue), as the second method is adapted in Kyrgyz Republic.

The Required Revenue method incorporates the capital expenditures, particularly, debt and accumulated interest payments, reconstruction expenses into the tariff charged to end customers. This method was used in Mid-term tariff policy (MTTP) for electricity for 2008-2012 and Mid-term tariff policy (MTTP) for heating for 2008-2010. (Jogorku Kenesh, 2008)

According to MTTP, tariff formation is a three-step process:

Step 1: Required revenue

$$RR = DS + CR + R + OM + AM - ELC - OR$$

RR: Required Revenue, the total revenue needed to cover the expenses from operating, financing and investing activities of all the energy companies at all levels of energy production, transmission and distribution to the end customers.

DS: Debt Service, payments on long and short terms loans and accumulated interests.

CR: Capital and Reconstruction, future and current investment expenses on reconstruction and purchase of new equipment. Expenses on technical monitoring of technical equipment are also included.

R: Reserve Margin, expenses related to repairment/fix of unexpected system damages. This is a new item in the technical and financial reports of energy companies, has been requested to be reported starting from 2015 by Regulatory Body under the National Energy Holding. (Ishenaliev, 2016)

OM: Operational and Maintenance, expenses incurred during operational or maintenance works have to be classified as variable cost and included into the tariff derivation. The following items are included to Operational and Maintenance costs:

- Material expenses (if depended on quantity of energy produced)
- Salary expenses (if depended on quantity of energy produced)
- Insurance/Social Fund expenses
- Tax expenses
- other expenses (if depended on quantity of energy produced)

AM: Administrative and Maintenance, expenses incurred as of administrative process have to be classified as fixed costs and included into the tariff derivation. The following items are classified as AM costs:

- Material expenses (if independed on quantity of energy produced)
- Salary expenses (if independed on quantity of energy produced)
- Technical modernization expenses
- Bank services
- Consulting services
- other expenses (if independent on quantity of energy produced)

ELC: Extra Losses Correction, expenses on energy losses that are beyond the norm set by Regulatory Body should be excluded from tariff derivation. *There is no disclosure on methodology on derivation of norms for energy losses.*

OR: Other Revenue, energy companies normally have other sources of revenue. Generally, these revenues are not coming from services to domestic market, such as export of energy. Any type of expenses related to these revenue sources should be excluded from tariff derivation methodology.

Step 2: Classification of Expense Items and their coverage

OJSC 'Electric Stations' is the single controlling company of the 7 major HPPs and 2 TPPs, the revenue generated by 'Electric Stations' has to be distributed by the company to power plants on the basis of the type of the energy it generated: hydro or thermal. The cost of the generation of these types of energy is significantly different. 'Electric Stations' classifies expenses to three categories: expenses incurred for the generation of hydro power energy, expenses incurred for the generation of the thermal power energy and administrative expenses. The deterministic distribution of revenues to cover the expenses of energy generation is applied, in other words, the source of the revenue is attached to certain item of expenses. The below table demonstrates the distribution of the revenue sources to cover up specific item of the expenses of HPP and TPP:

Table 2 The coverage of expense items of HPP and TPP by source of revenue

Expense Item	**Revenue Source**
HPP	
All expense items reported under the hydro power energy generation expenses category	Supply of electro energy to domestic market
Subsidies dedicated to support the operations of TPPs. As TPP generate both thermal and electro energy, the subsidies should be distributed proportionally to contribution of specific TPP generated electro and thermal energy into the total energy output in sector	Export of hydro power energy
TPP	
The variable costs of generation of both electro and thermal energies are covered proportionately to contribution of each power plant to the total energy supply in sector	Supply of electro and thermal energy to domestic market

The fixed costs of generation of both electro and thermal are covered proportionately to the disposable capacities of each of power plant to the total energy capacity in sector	Supply of electro and thermal energy to domestic market
HPP and TPP	
Administrative expenses are covered proportionately to the disposable capacities of each of power plant to the total energy capacity in sector	Not defined

Source: Interview with Mr. Azat Ishenaliev, Analyst at National Energy Holding of Kyrgyz Republic, 2016

It is still remains unspecified how expense items under TPP are subsidized, as there is no clearly defined reporting standards for the HPPs and TPPs, the distribution of subsidies to cover up the expenses for specific expense items of TPPs is not possible, unless there is an internal reporting for TPP, which is not disclosed. In the case of cross listing of the sources of revenue (two or more expense items are to be financed by same source of revenue), there must be an additional rule on how the funding is distributed.

Considering that TPP expenses are relatively higher than of HPP due to the fuel costs, it might not be sustainable to finance operational maintenance of TPP at expense of hydropower energy export, as export of energy is reported to be of secondary priority. The first priority, according to the National Energy Holding is to meet the domestic demand for electro energy. It is even reported that National Energy Holding is expecting to import electro energy for the winter period of 2016 as shortage of the energy generation is expected. (Kaliev, 2016)

Step 3: Consumer segmentation by the required revenue

Distribution of required revenue among consumers is the process of segmentation of all consumers into the groups and assignment of the portion of required revenue to the specific group of consumers. The segmentation of the consumers must be based on the specific characteristics of the consumption of the consumers and type of consumers. Different consumers have different features of energy use, the peak consumption hours. Thus, the demand for equipment and administrative requirements from the energy companies might vary to ensure specific consumer's needs are met. Required revenue from the specific customer group should reflect the actual costs of energy generation, transmission and distribution incurred by the energy company to meet the demand of this consumer.

The process of allocating the cost to specific customer groups consists of three phases: *the distribution of direct costs, classification of all costs and allocation of costs to specific customer group.*

The distribution of direct costs

Direct costs of building an infrastructure are distributed among group of customers who are directly benefitting from this specific infrastructural object. In such cases, the investment costs and maintenance costs associated with this infrastructure must relate directly to this group of consumers. Thus, the price for electricity will reflect the costs of provision of power energy to specific group with consideration of the additional costs of energy companies to build an infrastructure.

Classification of all costs

All costs fall into one of three categories described below and at phase three these classification is used to identify the features of consumption by specific consumer:

Type 1: Commodity or product costs, which vary depending on the quantity of the amount of electricity produced. These type of costs include fuel, purchased electric energy and other expense items dedicated to operating and maintenance of capacity.

Type 2: Costs incurred because of exceeding the average loading capacity, these type of costs vary depending on the demand for the electricity. These type of costs include expenses on equipment or facilities required to meet the higher-than-average system load levels.

Type 3: The cost of service to consumer. This type of the costs is not dependent on the volume of services or the rules of the use of electricity. They may include technical equipment support, power lines, billing systems, the costs of metering and monitoring devices.

The classification of costs is also dependent on the type of service, whether it is a generation, transmission or distribution. The table below illustrated how costs are classified by Regulatory Body under National Energy Holding:

Table 3 Classification of the required revenue components at three stages of energy transformation

Required Revenue components/expenses	Generation	Transmission	Distribution
Loan repayment	Type 2	Type 2	Type 2
Technical modernization	Type 2	Type 2	Type 2
Reserves	Type 2	Type 2	Type 2
Material expenses	Type 1	Type 2	Type 1
Salary expenses	Type 2	Type 2	Type 3
Insurance/Social Fund expenses	Type 2	Type 2	Type 3
Other expenses	Type 2	Type 2	Type 3
Tax deductions	Type 2	Type 2	Type 3
Extra Losses Correction	Type 1	Type 1	Type 1
Other sources of income	Type 2	Type 2	Type 1

Source: National Energy Holding, 2016

Allocation of costs to specific customer group

The so called 'cost allocation factor' is assigned to each of the consumer. Cost allocation factor is calculated using data on consumer's characteristics. These characteristics identify required revenue components for each consumer. The general formula for calculating the cost allocation factor is the following:

$$CAF_i^j = \frac{CCD_i}{\sum_i^n CCD_i}$$

where:

CAF: cost allocation factor j of consumer group i

$$\sum_i^n CAF_i^j = 100\%$$

CCD_i: Consumer characteristics data of consumer group i divided by the sum of the characteristics of consumer group i to group n

The data used as consumer characteristics for consumer group includes the number of consumers in the group, the quantity of electricity consumed by the group in kWh, the peak load hours. It is worth of noticing that the peak load hours were not reported in previous years by the energy companies, and are expected to be added as a part of compulsory reporting from 2016 or 2017. [4] (Ishenaliev, 2016)

Thus, based on the cost allocation factor each portion of be required revenue component is assigned to the specific consumer group i. Each consumer group will be responsible for the portion of the required revenue, also known as Assigned Required Revenue (ARR):

[4] While allocating costs to the specific consumer group can serve as a guarantee that all expenses listed as required revenue components are covered, it is not completely explained how the consumer groups were formed. Based on methodology, the CCD_i is the primary consumer clustering tool, the derivation of this variable is based on the number of consumers, the quantity of consumed energy. As there is no available reporting on the peak loading hours/consumption nor data on characteristics is publicly disclosed, it is assumed that peak loading hours/consumption was omitted from the CCD_i indicator derivation. Mr. Ishenaliev stated that the customer segmentation is instead based on the economic activity (household, manufacturing firm, etc).

$$ARR_i = DS \times CAF_j^i + CR \times CAF_j^i + R \times CAF_j^i + OM \times CAF_j^i + AC \times CAF_j^i - ELC \times CAF_j^i - OR \times CAF_j^i$$

The cost components remain as of defined in Step 1. The sum of the assigned required revenue will equal to the required revenue as per following:

$$RR = \sum_i^n ARR_i$$

RR: required revenue is the sum of assigned required revenue of consumer group i to group n

After each component of required revenue is distributed among the consumer groups, the final tariff is set individually for specific consumer group. The tariff setting for the specific consumer group is the following:

$$T_i = \frac{ARR_i}{BD_i}$$

T_i: Tariff charged per unit of electro energy consumed for consumers group i

ARR_i: assigned required revenue of consumer group i

BD_i: billing determinant, unit of measurement of electricity consumption of consumer group i

The formula above is applied and tariff is derived separately by all of the companies operating as a part of energy system (generation, transmission and distribution). The final tariff is a composition of the tariff set by individual energy companies. The tariff is adjusted to exchange rate and inflation rate reported by National Bank of Kyrgyz Republic and Ministry of Economy of Kyrgyz Republic on annual basis.

2.3 Final Tariffs as per MTTP of Kyrgyz Republic, 2014-2017

According to MTTP, the tariffs have been derived for different groups of consumers based on the data of 2014 (annual technical and financial report) of energy companies. The period of implementation started in 2014 and is expected to be completed by 2017 in three stages. Each stage assumes tariff increase by 20%.

Considering real capacities of the energy system, and the average monthly consumption of average consumer, the guaranteed volume of electricity consumption is stated to be equal to 700 kWh per month. The tariff to be charged for guaranteed volume of consumption of electricity is settled the rate of 0.70 som / kWh with the 20% rate increase at each of three stages of implementation. (OJSC 'Severelectro', 2014)

Table 4 Final Tariff Rates according to MTTP of Kyrgyz Republic, 2014-2017

Consumer groups	**Unit of measurement**	**2014**	**2015**	**2016**	**2017**
Population (Public Utilities)					
Consumption of 700 kWh per month	tyiyn / kWh	70	84	100.8	121

Source: MTTP, 2014

Tariff 0.70 soms / kWh represents only 58% of the actual cost of production of kWh electricity. For end consumer exceeding the guaranteed volume of preferential consumption of 700 kWh per month, the tariff rate of 1.4 soms / kWh will be applicable. The tariff also differs across consumers. The fully detailed tariff rate for each consumer group is available in Appendix 1.

Chapter 3 Long-range Energy Alternatives Planning System (LEAP)

In the following chapter introduces the cost benefit modeling capacities in energy sector in LEAP. The inputs of the model can be classified to macroeconomic variables, which form the energy demand, and the energy transformation variables, which form supply. The last is the data on energy company's technical and financial performance from 2011 - 2015. The data processing is also described as a part of energy transformation analysis. Based on recommendations by USAID[5] on energy sector and interview with energy expert, Mr. Abgar Budaghyan[6], the alternative tariff has been developed. Two long-run scenarios (2016-2025) are built in LEAP: energy balance based on MTTP and energy balance under newly developed methodology.

There is no methodology for tariff setting that is universally adapted. As it is directly dependent on individual energy sector factors. There are limited number of the modeling tools currently available for the policymakers, among the widely used models are:

- LEAP
- MARKAL-TIMES
- MESSAGE
- ENPEP-BALANCE

Based on the pros and cons analysis of each of the models it was decided that LEAP would be the most flexible in adapting to the Kyrgyzstani energy sector, primarily due to:

[5] On of the USAID project in Kyrgyzstan was RESET, the three-year Regional Energy, Security and Trade Project provided assistance to the Government of the Kyrgyz Republic in the implementation of its Energy Security and Efficiency policy agenda.
[6] Mr. Abgar Budaghyan, Regulatory Consultant for Energy & Water based in Armenia. In past he an Advisor to the Kyrgyz Republic Energy Sector Regulator.

- The possibility of computation of costs for the tariff derivation: the cost structure can be regulated
- The possibility to create several scenarios of energy balance and long-term forecast. It allows to evaluate alternative scenarios by comparing their energy requirements, their financial costs and benefits, and their environmental impacts. The last is not applicable to case of Kyrgyz Republic, because hydro power energy is a ‘green energy’.
- The low data requirements. Kyrgyz Energy Sector data, specifically energy company reports, were not reported in a single standard. The common reporting standards have been set and adapted in 2011, there is no data available prior to 2011 that could be used to build LEAP model. (Ishenaliev, 2016)

Detailed Pros and Cons analysis of each of the modeling tools and model related details are available in Appendix 2. (Brizard, 2015)

In the framework of the following Master’s Degree Thesis. LEAP modeling tool will be used to build an individual balance model for Energy Sector of Kyrgyz Republic. The license for LEAP for the period of one year has been obtained for the purpose of academic use only.

3.1 What is LEAP

LEAP, the Long range Energy Alternatives Planning System, is a software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute. The LEAP is not a model of particular energy sector, it is very flexible to adapt to specificities of energy sector of Kyrgyz Republic and the available data. There is a range of modeling methods within LEAP, which builds a model based on available data. On the demand side there is range of options from bottom-up, end-use accounting techniques to top-down macroeconomic modeling. On the supply side, LEAP provides a range of accounting and simulation methodologies that are powerful enough for modeling electric sector generation and capacity expansion planning, but which are also sufficiently flexible and transparent to allow LEAP to incorporate data and results from other more specialized models. (The Stockholm Environment Institute , 2015)

LEAP uses an integrated model which allows to track energy consumption, production and resource extraction in all sectors of an economy. It supports methodologies on both the demand side and the supply side (for example, capacity expansion planning). LEAP's modelling technique operates at two basic levels. At the first level, users can enter specific time-varying energy sector data or create a wide variety of sophisticated multi-variable models using the forecast functions. At the second level, LEAP's built-in cost-benefit accounting will calculated the least cost/highest revenue balance of supply and demand. The model will proposed the optimized allocation of supply (whether energy should be imported or exported) based on cost-benefit analysis, which is also based on the (The Stockholm Environment Institute, 2016)

3.2 Modeling capacities with LEAP

The model structure of LEAP is dependent on the inputs and the outputs of interest. The model structure will adapt to the inputs both on supply and demand side and simulate the energy market, either competitive or monopolistic. The market balance will be reached through supply adapting to the demand, in other words, *supply of energy will be driven by demand for energy.* In the case of Kyrgyz Republic, as energy market historically is experiencing shortage on supply side, the model will propose supply side expansion though either building new power plant or importing energy. The option of building alternative scenarios allows forecasting the energy market balance under alternative expansion options and alternative tariff policies.

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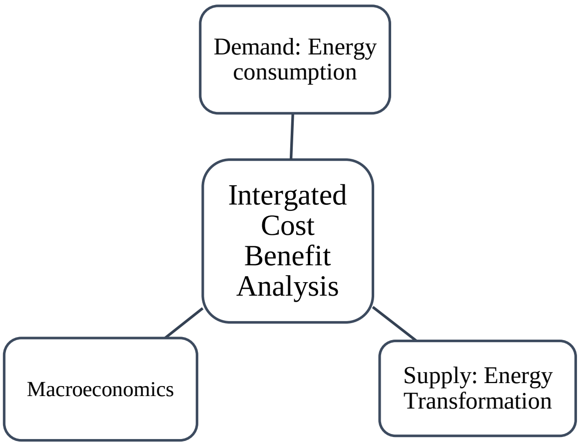
The categories of inputs are macro-economic variables including consumption data, inflation and discount rate. These variables would form the demand side of the LEAP model.

Figure 1 LEAP Structure



The second category is the data on energy transformation variables including energy company level data on generation, transmission and distribution. These variables would form the supply side of LEAP model. Figure 1 provides the composition of the integrated LEAP Model. Two alternative scenarios will be analyzed under the different tariff options, which are going to be derived based on the company's technical and financial data. Scenario 1 will be a model of the currently adapted MTTP, where the tariff was derived based on energy transformation data of 2014. Scenario 2 will be a model of the tariff derived from the energy market balance and energy transformation analysis. Both scenario details are provided in the following subchapters. The historical data range is from 2011 – 2015.[7] The forecast period is 2016 - 2025.

[7] There is no data available on technical and financial performance of energy companies (Ishenaliev, 2016)

3.3 Kyrgyz Republic Energy Sectorial Data as LEAP Model Inputs

Several sources were used to collect all the data, which is needed in modeling with LEAP. Most of the variables had to be reorganized/reclassified to meet the classification of the variables in LEAP, as the reporting items for energy companies have different standards, whereas the LEAP requires a specific classification of the energy company reported technical items. The methodology of classification of expense items plays a critical role in tariff derivation.[8]

3.3.1 The macroeconomic variables

Energy consumption on sectorial level for the period of 2011 – 2015 were obtained from database of National Statistical Committee of Kyrgyz Republic. As of 2015, the following distribution of energy consumption is observed over the period of 2011-2015 (National Statistical Committee of the Kyrgyz Republic, 2016) :

Table 5 Energy Demand Final Units

Units: Thousand Kilowatt-Hours					
Branches	2011	2012	2013	2014	2015
Manufacturing	1,941,700	1,938,300	1,958,300	1,876,900	1,916,500
Agriculture	129,650	111,150	127,790	124,419	124,514
Transportation	185,600	316,600	41,600	231,800	220,393
Construction	58,200	47,100	81,500	64,600	70,273
Public Utilities	6,394,600	7,340,500	7,870,100	8,588,200	8,502,313
Social Services	59,100	42,700	74,000	56,700	50,647
Electricity Consumption Total	8,768,850	9,796,350	10,153,290	10,942,619	10,884,641

[8] The average cost based pricing principle recognized only specific set of expenses to be included in price derivation. In MTTP, expenses from financing, investing and operational activities (2014) have been included in price derivation. The classification of the expenses is different than classification in LEAP. Therefore, some expenses items had to be placed to different accounts.

The LEAP model is limited in defining the *time-varying* inflation rate and the discount rate, but it allows to set a singular parameter based on the historical values. The discount rate as an input to LEAP model is derived as an average of National Bank's policy rate for the period from 2011-2016. (National Bank of Kyrgyz Republic, 2016) The inflation rate used in LEAP is an average value of historical inflation rate for the period from 2005 – 2015 reported by National Bank of Kyrgyz Republic. (National Bank of Kyrgyz Republic, 2016). The actual values of parameters inputted to LEAP are presented below:

LEAP parameter	%
Inflation rate	7.55
Discount rate	6.33

The historical yearly average of National Bank's policy rate are available in Appendix 3. The cost of imported electro power energy from Kazakhstan is in line with official reports of National Energy Holding. (Kaliev, 2016) The exchange rates used in calculation of the costs for imported electro energy are obtained from the official database of National Bank of Kyrgyz Republic.

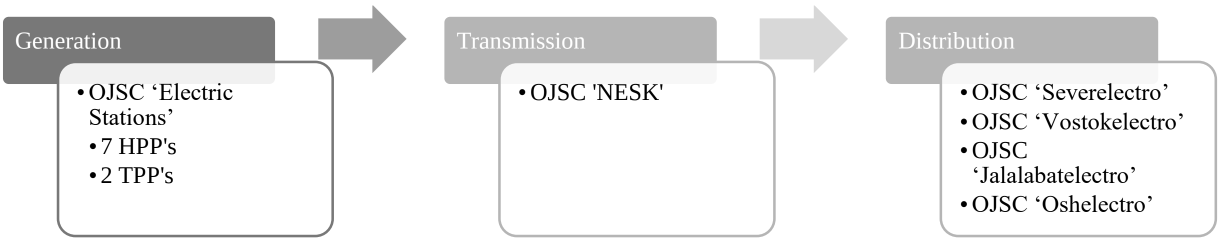
3.3.2 Variables of Energy Companies in Transformation Analysis

Both financial and technical performance of energy companies are reported as a part of Annual Report. Prior to 2011, there were no common reporting standards adapted by energy companies, therefore reports are available for the period of 2011-2015 only. The following reports have been provided by Regulatory Body under National Energy Holding of Kyrgyz Republic:

- The Annual Reports of the OJSC 'Electric Stations' with consolidated items for 7 hydro power plants and 2 thermal power plants for the period of 2011 - 2015.
- The Annual Reports for monopolistic transmission company 'NESK' for the period of 2011 - 2015.
- The Annual Reports of four distribution companies for the period of 2011 - 2015.

The Annual Report of the above listed energy companies differ according to the company's economic activity and its role in the energy transformation chain (whether it belongs to the generation, transmission or distribution).

Figure 2 Energy production chain



As LEAP classification of technical and financial items differ from items classification reported by energy companies, the necessary conversion and reclassification of items provided in the Annual Report was performed. Initially, reclassification was performed in accordance with the principle of accounting. (Ireland, 2005) However, in order to reflect the realities of the Kyrgyz energy sector a, minor changes were introduced to the initial reclassification. (Budaghyan, 2016). As an example the reclassification of items as per OJSC 'Electric Stations' to certain input parameter in LEAP as well as explanations are presented in the table below:

Table 6 Reclassification of Annual Report Items for Generation OJSC 'Electric Stations'

Annual Report	**Input parameter in LEAP**	**Input parameter definition by LEAP**	**Rationale of reclassification**
I. Production items (in thousands kWh)			
Generated Electro power energy before losses	-	-	*Used in derivation of Process efficiency*
Useful Electro power energy produced	Historical production of HPPs	This variable specifies annual energy production (output) for a process.	Annual report item directly reflects the LEAP input parameter

Electro power energy losses in transformation	Process efficiency of HPPs	Process efficiency data can be specified in three different ways: as a percentage efficiency, as a heat rate or as the percentage energy losses.	The ratio of Useful Electro power energy produced to Generated Electro power energy before losses has been inputted as efficiency
Generated Thermal power energy before losses			*Used in derivation of Process efficiency*
Useful Thermal power energy produced	Historical production of TPPs	This variable specifies annual energy production (output) for a process.	Annual report item directly reflects the LEAP input parameter
Electro Thermal energy losses in transformation	Process efficiency of TPPs	Process efficiency data can be specified in three different ways: as a percentage efficiency, as a heat rate or as the percentage energy losses.	The ratio of Useful Electro power energy produced to Generated Electro power energy before losses has been inputted as efficiency
II. Expenses/Costs Items (in thousands KGS)			
Total Material expenses:			
Production type services	Fixed Operation and Maintenance (OM) Cost	Fixed O&M costs are incurred regardless of the energy produced by a process, and are entered per unit of capacity (e.g. per MW).	All of the material type of expenses, except for fuel costs, are classified to fixed OM costs, as those expenses are not dependent on the quantity of generated energy. It is distributed between HPPs and TPPs in line with disposable capacities of the both.
Additional materials			
Fuel as an input	Feedstock Fuel Cost for TPP's only	Fuel Costs can be entered for each feedstock fuel and each auxiliary fuel of each process. Fuel costs are	TPPs energy production is based on many different types of input fuel. It can be coal, natural gas, biomass fuel. In the case of

		used in calculating the module cost balance result type and the costs of production result type and are also used in calculating the optimized least-cost capacity expansion and dispatch in scenarios,	Kyrgyzstan, the natural reserves for feedstock fuel are not exported, therefore the feedstock fuel for generation of thermal and electro power energy by TPP is imported from Uzbekistan. As it is imported primarily for the operation of TPP, it is classified as fuel cost for TPPs. (Budaghyan, 2016)
Petroleum, Oil and Lubricants (POL) Electro power as an input Thermal power as an input Unclaimed VAT	Fixed Operation and Maintenance (OM) Cost	Fixed O&M costs are incurred regardless of the energy produced by a process, and are entered per unit of capacity (e.g. per MW).	All of the material type of expenses, except for fuel costs, are classified as fixed OM costs, as those expenses are not dependent on the quantity of generated energy. It is distributed between HPP's and TPP's in line with available capacities of the both.
Reserve for emergency and repair works	Variable Operation and Maintenance (OM) Cost	Variable O&M costs are entered per unit of energy produced.	Reserve for emergency and repair works became a compulsory reporting item in 2015. It is one of two items classified as Variable OM costs. As without the generation process dependent on the amount of energy produced, no reserves would be spent.
Total expenses on LT debt as of 2015: Total debt as of 2015 Interest expenses as of 2015	Stranded Costs	Stranded Costs represent any remaining costs to be paid on pre-existing processes (typically debt payments on old capital). Unlike other Transformation costs, stranded costs are specified as total amounts (not a value per MW or per MW-Hr). Typically stranded	Annual report item directly reflects the LEAP input parameter. Distributed between HPP's and TPP's in line with available capacities of the both type of power plants.

		costs are only specified for Current Accounts as they do not apply to processes that will be built in the future. The Stranded Costs you enter are used in the calculation of the Module Cost Balance. Because they represent a sunk cost they are not included in the Social Costs result type.	
Total maintenance and capital expenditures:	Capital cost	Capital costs should reflect the total (i.e., non-annualized) capital costs per unit of capacity of each process. Capital costs should include all direct construction costs (i.e. overnight costs) and any capitalized finance costs.	Annual report item directly reflects the LEAP input parameter. Distributed between HPPs and TPPs in line with disposable capacities of the both power plants.
Repair expenditures			
Capital investments: reconstruction, modernization, new construction			
Housing expenses	Fixed Operation and Maintenance (OM) Cost	Fixed O&M costs are incurred regardless of the energy produced by a process, and are entered per unit of capacity (e.g. per MW).	Fixed O&M Costs
Salary expenses			
Deduction for social insurance			
Other expenses			
Taxes paid			
Electro energy import	Variable Operation and Maintenance (OM) Cost	Variable O&M costs are entered per unit of energy produced.	The required amount of electricity imported is depended on the energy output by both HPP and TPP, in the case of deficiency of electro energy supply to meet domestic demand, the energy is imported from Kazakhstan.

			According to the Annual report, electro energy was imported only in *2015*.

The analogical reclassification of the technical and financial data for the OJSC 'NESK', OJSC 'Severelectro', OJSC 'Vostokelectro', OJSC 'Jalalabatelectro' and OJSC 'Oshelectro' has been performed. However, the items under production for generation differ from the transmission and distribution due to different technical and operational purposes. For transmission company historical production is the Useful Electro power energy transmitted from OJSC 'Electric Stations' to one of four distribution companies. For distribution companies, historical production is Useful Electro power energy transmitted from OJSC 'NESK' to the end consumers. In order to avoid double accounting of the energy generation expenses, the expenses reported as a purchase of the electro power energy by distribution companies are omitted from the expenses items in LEAP. The straight-line depreciation has been used to amortize the capital expenses of the energy companies.

3.4 Demand: Energy Consumption

In the competitive market for energy, the quantity supplied is a function of the price in line with economic and technological variables explaining the costs. The demand for energy is assumed to be relatively inelastic. (Barbato & Capone, 2014) Demand for electric energy is determined by the electricity consumption in each sector. Statistical Committee of Kyrgyz Republic provided a data on electricity consumption by sector for the period of 2005 until 2014. Forecasting and building a model for long-term period until 2025 requires assumptions on energy consumption growth rates, forecast functions were used to derive the electricity consumption within each sector for the period of 2016 until 2025. The below table outlines the forecast function of the energy consumption by sector and the rationale behind the decision to apply the specific function.

Table 7 Energy Consumption forecast in LEAP

Sector	LEAP Function for both scenarios	Explanation
Manufacturing	Linear Data Trend[9]	Based on available historical data (yearly data from 2005 to 2014) YoY increase in consumption is observed. Linear function allows us to approximate the future electricity consumption with YoY growth rates close to historical growth rates.
Agriculture	Logistic Forecast[10]	The electricity consumption had a sharp decline in agriculture from 2005 to 2006 and from 2009 to 2010. The logistic function allows us to smooth the sharp up and downs across the yearly consumption.
Transport	Linear Data Trend	Based on available historical data (yearly data from 2005 to 2014) YoY increase in consumption is observed. Linear function allows us to approximate the future electricity consumption with YoY growth rates close to historical growth rates.
Construction	Linear Data Trend	
Public utilities	Linear Data Trend	
Social services	Linear Data Trend	

The forecast function resulted in the annual average growth rate of energy consumption of households by 3.1% (Public Utilities), in manufacturing by 0.4%, in agriculture by -0.2%, in transportation 5.9%, in construction -5.4%, in social services -5.3%. The average growth rate was expected to be in range of 3 – 5% on annual basis, according to official forecast of energy demand for 2008-2010 and for long-term perspective until 2025. (National Council for Sustainable Development of Kyrgyz Republic, 2013)

3.5 Supply: Energy Transformation Analysis

The vertically integrated system operates at three levels (generation, transmission and distribution) which for the transformation system in LEAP. Transformation represents the full process from energy generation at Hydro Power Plant and Thermal Power Plant to the point when energy reaches the end-consumer. All of the energy companies are included in the model.

[9] Linear Data Trend - uses a linear regression (y=mx+c) to fill-in gaps in historical data, but uses actual data values for those years where they are available (LEAP)
[10] Logistic function - forecasts future values based on a fitting a logistic function to the time series data by linear regression (LEAP)

The data from 2011-2015 form the base of model, scenario's first year of stimulation is 2016. The company's technical and financial data underwent reclassification as previously described in Subchapter 3.3.2 Variables of Energy Companies in Transformation Analysis.

The data on disposable capacity does not reflect the true state of technical equipment at all levels of energy transformation. (Budaghyan, 2016) Therefore, the real capacity data had to be included in to the model. The total disposable capacity of HPPs under control of OJSC 'Electric Stations' was reported to amount to 2992 MW, however in reality energy has been imported from neighboring Kazakhstan in conditions of the peak consumption loads taking place primarily during winter periods. As per official statement of Chairman of the Board of Directors of National Energy Holding, Kyrgyzstan is not planning to export energy starting from 2016. (Kaliev, 2016) In order to reflect true capacities of energy companies, the maximum of historical production was assumed and used as disposable capacity; the assumed capacities are available in Appendix 4.

As the result of reclassification of the data on energy companies, the following variables have formed the model transformation system in LEAP on three levels of vertical integrated system under first scenario (MTTP). Each variable has been forecasted in each of two scenarios, the following table provides details of forecast function for Scenario 'MTTP':

Table 8 Energy Company technical and financial performance forecast

LEAP variable	Forecast function for 2016-2025 under Scenario "MTTP"	Function Definition
Historical Production	Dependent on Demand: Energy Consumption	-

Exogenous Capacity	Interpolation	Calculates a value in any given year by linear interpolation of a time-series of year/value pairs. In a scenario the base year value is implicitly included. The model assumes that no new energy companies were build, thus capacities remain unchanged.
Process Share	Interpolation	As there are no changes to the capacity data, the process share per company on each level of vertical integrated system remains the same.
Losses	Interpolation	Efficiency is specified as the percentage of energy lost in a process. This remains unchanged under scenario under Scenario “MTTP”.
Variable OM Costs	Linear Data Trend	It is assumed the variable costs will grow gradually in line with the linear trend.
Fixed OM Costs	Linear Data Trend Interpolation	It is assumed the fixed costs will grow gradually in line with the linear trend or remain unchanged. This is dependent on the company.
Capital Costs	Growth	Calculates the value in any given year using a growth rate from the base year value. It is assumed that energy companies will still have increasing capital costs at rate of 2-3% as per consultation with working group. (Budaghyan, 2016)
Stranded Costs	Interpolation	It is assumed that energy companies will continue to pay off the debts at the same rate as per historical data of 2015.
Fuel Costs	Interpolation	Two types of fuel costs are present in the model: Cost of natural gas for operation of TPP is assumed to remain at the same rate of 4.47 KGS per kWh as of 2015. Cost of electricity imported from Kazakhstan is also assumed to be at same rate of 1.87 KGS per kWh as of 2015.

3.6 Two Scenarios: MTTP and New Tariff

Two alternative scenarios were built using LEAP and forecasted energy balance has been analyzed based on outcomes:

Scenario 1	**Scenario 2**
MTTP	New Tariff

Scenario 1 "MTTP" assumes that tariff follows the Mid Term Tariff Policy, which means that the tariff will gradually increase up to 1.20 KGS per kWh and remain unchanged until the final scenario forecast year of 2025. The energy consumption and energy transformation will be unchanged as per descriptions in Subchapter 3.4 and Subchapter 3.5 consecutively. One of the shortcoming of the LEAP is that price for electricity cannot be differentiated across the consumer groups. As the households (Public Utilities) consumption account for 74 - 80% of total consumption, the tariff derived for this group of consumers is assumed as a price for the electricity consumed domestically by all consumer groups. As no information available on the price of the exported electro energy is available, it is assumed that the price is equal to the price in domestic market. In addition, the two fold tariff structure (consumption over 700kWh per month is charged at higher tariff rates) is ignored due to the same reason of absence the consumer groups related data and characteristics. These assumptions will be taken into account in the comparative analysis of the scenarios.

Scenario 2 "New Tariff" assumes that new methodology is used to derive optimal tariff, which would reflect 'true' cost of production. New methodology is based on the recommendations of USAID Regional Energy, Security and Trade Project (RESET)

Program.[11] The primary difference between two methodologies is the way these 2 methodologies recognize costs.

Under 'New Tariff' methodology, two items of required revenues have been modified. Energy companies at all levels of energy transformation have been reporting energy losses in range from 3-30%, this is primarily due to outdated equipment and frequent system defaults. If the companies consider and implement the strategic plan to decrease the energy losses at transmission lines to the minimum possible level of 2-3% until 2025, it is expected that it will have a large effect on the energy balance.

Under 'New Tariff' Scenario methodology is the following[12]:

$$RR = DS + \underbrace{CR}_{\uparrow 2\%} + R + \underbrace{OM}_{\uparrow 25\%} + AM - ELC - OR$$

RR: Required Revenue

DS: Debt Service

CR: Capital and Reconstruction

R: Reserve Margin

OM: Operational and Maintenance expenses

AM: Administrative and Maintenance expenses

ELC: Extra Losses Correction

OR: Other Revenue

Required revenue is conceptually the same as in MTTP, however, the composition differs from MTTP. At current state, energy companies report that with adapted Mid Term Tariff, energy companies will be able to repay the accumulated debt by 2022-2025. However, this is still questionable, as according to Financial Reports of energy companies for the period

[11] A three-year program aimed to support the reformation of energy sector through provision of consultancy services to energy companies on financial reporting standards and the technical modernization.

[12] Each item's definition and composition remained unchanged as of MTTP described in Subchapter 2.1

2011-15, the negative balance as per each energy company at all levels of energy transformation is reported in Income statements. In the framework of Scenario ‘New Tariff’, the debt and accumulated interest payments remain the same due to absence of relevant data on total debt outstanding of each company.

According to international practice, if the majority of assets have already served their useful life - and in the energy sector of Kyrgyzstan the situation is just that - the revaluation of fixed assets is required. This is necessary to ensure that the profitability of fixed assets and depreciation costs allows replacing worn-out equipment and tools, as well as to upgrade and expand the system in order to ensure uninterrupted power supply and meet the growing demand for electricity. In ‘New Tariff’, depreciation expenses is adjusted to the level that allows on timely replacement of existing outdated assets. The Capital and Reconstruction costs growth rate are set to increase by 2 percentage point higher than in Scenario ‘MTTP’ on annual basis, to reflect the increase of investments and capital expenses needed to eliminate the losses, both commercial and technical. Dilapidated assets also directly affect energy sector balance. Under MTTP Scenario, the assumption is that no major rehabilitation nor new infrastructure are built.

According to international practice, the cost of electro energy should also reflect the uncollected receivables up to 3% to 5% - non-payment on invoices for electricity. This factor is important, as distribution companies reported cash collection of receivables to be at relatively low level (up to 75-95%), particularly in relation to household consumers group. However, under MTTP the costs of uncollected receivables are not considered. In the framework of ‘New Tariff’ scenario, the Variable OM costs are set to increase at rate of 25% (maximum rate of uncollected receivables) at level of distribution to reflect the true cost of uncollected receivables.[13]

[13] All growth rates and assumptions are in line with recommendations as per consultation with Regulatory Body

Chapter 4 Scenario Outcomes and Tariff Optimization

Based on the methodologies specified under each scenario the following tariffs were obtained for two alternative model forecasts:

Average Tariff in KGS per kWh	Scenario ‘MTTP’	Scenario ‘New Tariff’
2011-2015	1.30	1.30
2016-2025	1.64	1.54
2011-2025	1.52	1.46
As of 2014	1.16	1.16

According to the MTTP 2014-2017, the gradually increasing tariff policy was adapted, by 2017 the tariff charged to consumer group ‘Public Utility’ reaches **1.20** KGS per kWh. It is worth mentioning that the methodology was adapted and the tariff was derived from the data of 2014. Since the MTTP methodology remained unchanged, it was expected that the derived tariff as of 2014 would be equal to the tariff declared by MTTP. According to the Scenario ‘MTTP’ the tariff based on the data of 2014 is concluded to be **1.16** KGS per kWh. The difference between two can be due to the assumptions introduced to the MTTP Model simulation in LEAP. All final tariffs for two scenarios are available in Appendix 5.

In the ‘New Tariff’ methodology, the tariffs are also derived for different groups of consumers (similarly to MTTP consumer groups segmentation) based on the data from 2011-2015 (annual technical and financial report) of energy companies. The period of implementation starts in 2016 and is expected to be completed by 2017 in two stages. Stage 1 assumes increase of the tariff to **1.34** KGS per kWh, at second stage tariff is subject to increase to **1.54** KGS per kWh.

4.1 Analysis of Tariffs

Firstly, if the MTTP methodology is adapted to the data for the period of 2011-2015, this results in average tariff of **1.30** KGS per kWh. Mid Term tariff of **1.20** KGS per kWh was derived based on the data of 2014 only, thus it fails to capture the yearly fluctuations of the expense items. Yearly fluctuation of reported expenses by energy companies are obviously too high to be ignored (Appendix 6 and Appendix 7). MTTP may not be valid, considering that it does not capture the yearly fluctuations of expense items. If we consider long-term policy implication, derivation of the tariff based on 1-year energy sector performance is not sustainable.

In long-run, 'New Tariff ' Scenario suggests that the tariff charged in household sector should be as high as **1.54** KGS per kWh, whereas according to MTTP, the tariff is even higher by **0.10** KGS (**1.60** KGS per kWh). In order to understand which of the scenarios are optimal for energy market in Kyrgyz Republic the Module Cost Balance of energy sector should be analyzed.

4.2 Module Cost Balance Analysis

The Module Cost Balance result in LEAP provides an overview of the revenue/expenses analysis for complete energy system. It shows the balance between revenue generated from the sale of outputs from a module net the various operational costs of the module. Revenues generated from sales are shown as positive values, while the negative values (costs) include feedstock fuel costs, capital costs, fixed and variable operating and maintenance (O&M) costs, and any stranded costs associated with pre-existing processes. (LEAP, 2016) The effect of the two methodologies is directly evident, if we look at the level of revenue generation by energy transformation over the forecast period:

Table 9 Revenues in New Tariff Scenario and its difference compared to revenues in MTTP Scenario

Branch: Transformation Units: Real 2015 Million Kyrgyz Soms.							
	2016	2017	2018	2020	2021	2023	2025
Higher than in 'MTTP' by:	-	458.8	470.7	495.5	508.4	535.2	563.6

Sales Revenues in ‘New Tariff’	11,271.1	13,879.8	4,239.4	14,988.2	15,378.1	16,190.4	7,048.3
Total	11,271.1	14,338.7	14,710.1	15,483.7	15,886.5	16,725.6	17,611.9

The difference between revenue generated in the framework of two scenarios reaches its peak in 2025 in amount of 564 million KGS. However, the revenue along is not the indicator of optimal tariff, profitability of the energy system as a whole is of higher importance. Energy companies were not able to recover from the Energy Crisis of 2007-09, which is also reflected in Annual Report of every company at each level of energy transformation. In 2015, the total deficit of the whole energy system amounted to 8,520 million KGS. The MTTP was also aimed to recover from long lasting deficit of the energy sector.

In ‘New Tariff’ Scenario, the energy system is reported to have a deficit in amount of 8,611.6 million KGS in first simulation of 2016, whereas according to MTTP, the deficit accounted for 8,953.7 million KGS. In long run, the gap between two scenarios widens, in 2025 the deficit in New Tariff Scenario is by 38.5% lower than in MTTP Scenario (complete data tables available in Appendix 6 and in Appendix 7).

Figure 3 Trends of Energy System Deficit in two Scenarios

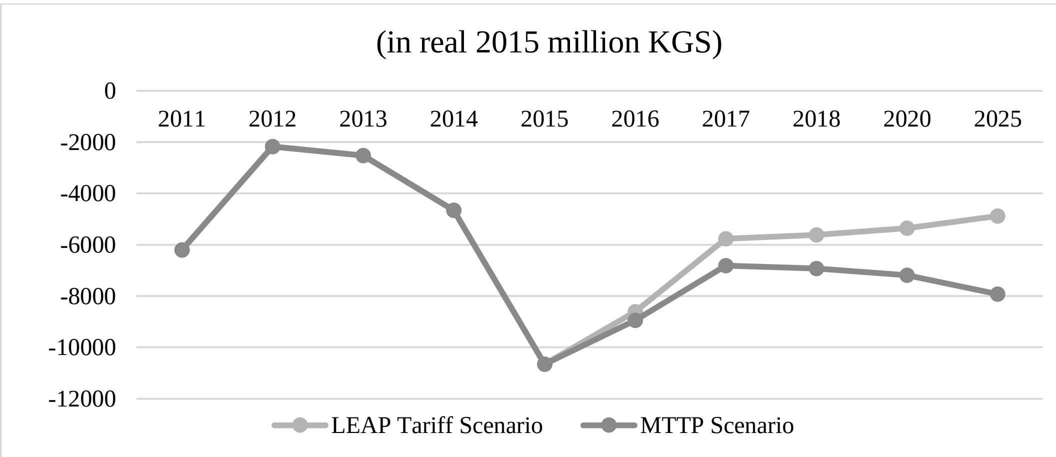
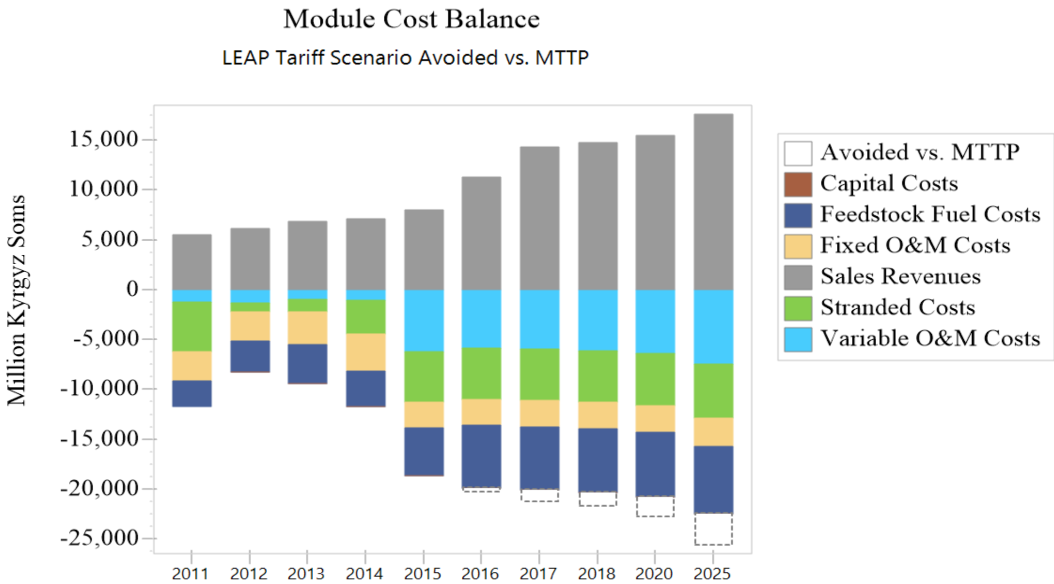


Figure 3 illustrates the historical deficit for the period from 2011-2015 and how it evolved in two alternative scenarios. Meanwhile, under the ‘New Tariff’ scenario deficit is decreasing, it is still large. The tariff based on average costing principle allows for gradual recovery of the whole energy sector. Meanwhile, ‘MTTP’ scenario shows the deficit of energy sector will start to increase in 2017. To recall, in the final stage of ‘MTTP’ it is that the tariff will be increased to 1.2 KGS per kWh by 2017, however. according to forecast, it is still not be sufficient to decrease the deficit.

The module costs balance serves as an evidence that neither ‘New Tariff’ methodology nor ‘MTTP’ can lead the energy system to profit making operational state. The Figure 4 provides the comparison of energy system balances under 2 scenarios. ‘Avoided vs MTTP’ reveals the net difference after accounted for differences in total revenue generated.

Figure 4 The comparison of module cost balances in two scenarios (the Avoided vs MTTP is the net difference of 2 scenarios)



The National Energy Holding does not hold an option and is not authorized to implement sharp tariff increase which would lead to energy sector recovery in 2-3 years, due to the ‘threat’ of public rally, as it happened to in 2010. (Wood, 2010) Therefore, ‘New Tariff’ methodology also follows gradual tariff increase schedule. It also explains the resistance of policy makers to include into tariff methodology future costs of the transmission lines renovation. Transmission lines have been in devastating state for last 10-15 years, as normal useful life of the transmission line is 25-30 years, they should have been replaced in 2000-2005.

4.3 Energy Sector balance

Years of neglect have led to the 3-5% losses at level of transmission and 20-23% of energy losses at distribution level. Under 'New tariff' scenario, as complete elimination of energy is theoretically impossible in energy system, the gradual decrease to minimal level of 2% losses have been set a target at expense of capital costs increase up to 5% by 2 percentage points. Energy balance data provides the following outcomes for historical balance of 2014-2015, the first year of simulation - 2016, 2020 and last year of simulation – 2025:

Table 10 Energy Balance for 'New Tariff' Scenario (2025 is a comparison year)

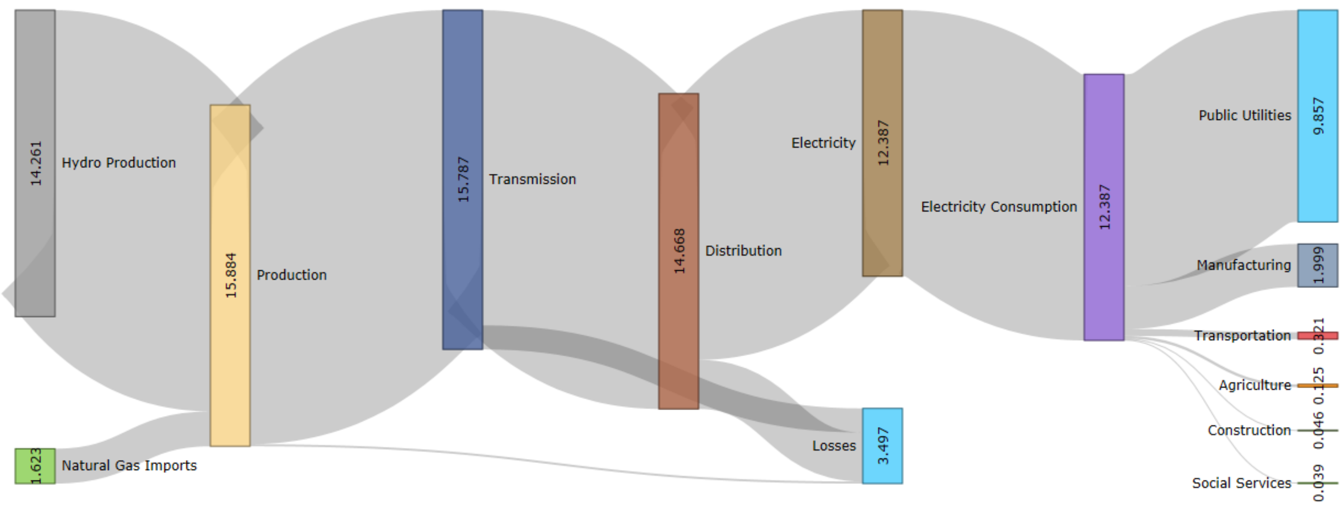
Energy Balance Units: Billion Kilowatt-Hour	**New Tariff**					**MTTP**
	2014	2015	2016	2020	2025	2025
Production	13.176	14.195	12.396	12.762	13.252	16.344
Imports	1.886	2.460	1.411	1.453	1.509	1.860
Exports	-1.262	-3.072	-	-	-	-
Total Primary Supply	13.800	13.584	13.807	14.215	14.761	18.204
Production	-0.040	-0.082	-0.084	-0.087	-0.090	-0.111
Transmission	-0.877	-0.856	-0.691	-0.549	-0.293	-1.408
Distribution	-1.941	-1.760	-1.850	-1.191	-0.288	-2.595
Total Transformation	-2.858	-2.699	-2.625	-1.828	-0.671	-4.115
Electricity Consumption	10.943	10.885	11.182	12.387	14.090	14.090
Manufacturing	1.877	1.917	1.944	1.999	2.068	2.068
Agriculture	0.124	0.125	0.125	0.125	0.125	0.125
Transportation	0.232	0.220	0.246	0.321	0.416	0.416
Construction	0.065	0.070	0.062	0.046	0.027	0.027
Public Utilities	8.588	8.502	8.757	9.857	11.426	11.426
Social Services	0.057	0.051	0.048	0.039	0.027	0.027
Total Demand	10.943	10.885	11.182	12.387	14.090	14.090
Unmet Requirements (Waste)	-	-	-	-	-	-

According to historical data as of 2014 and 2015, it is evident that both import and export opportunities were exploited. However, under the energy balance for 'New tariff' scenario, it is evident that the electro energy should be partially imported at the greater price from Kazakhstan, however none on energy should be exported but instead, firstly, domestic demand should be met (this was an assumption in both scenarios).

Secondly, by comparing the final simulation year results, the effect of the tariff methodology as the well as losses minimization goal is bringing benefits. Becoming efficient and decreasing the losses to 2% allows to save up to 3.44 billion kWh at distribution and transmission lines. Thus, production 13.252 billion kWh and import of 1.509 billion kWh is sufficient to meet the domestic demand. Compared to the 2025 'New Tariff' energy balance data, 'MTTP' Scenario for 2025 is less optimistic. In order to meet domestic demand the energy sector has to generate 16.344 billion kWh and import at higher cost 1.860 billion kWh of energy, due to inefficiency and lower than average cost pricing.

If 2025 is a long run and final forecast year, the model approximation can overestimate the energy balance results, 2020 could serve as an appropriate midterm period to forecast, when the system efficiency did not yet reach its potential minimum. The Sankey Diagram below illustrated the energy balance as per MTTP scenario in 2020.

Figure 5 Sankey Diagram for MTTP Scenario, Year 2020, in billion kWh



The losses amounted to 3.497 billion kWh, which is higher by 91% than the amount of reported losses for 'New Tariff' Scenario in Table 10. The generated energy amounted to 14.261 billion kWh compared to needed 12.762 billion kWh under 'New Tariff' Scenario.

Conclusion

The tariff analysis of validity of MTTP methodology to the data range from 2011-2015 reveals that the Mid Term tariff fails to capture the yearly fluctuations of the expense items. Therefore, for long-term policy implication, derivation of the tariff based on 1-year energy sector performance is concluded to be not sustainable.

Two alternative scenarios have been built using LEAP modeling capacities. Scenario 1 "MTTP" assumed that tariff follows the Mid Term Tariff Policy, which means that the tariff will gradually increase up to 1.20 KGS per kWh and remain unchanged until the final scenario forecast year of 2025. Scenario 2 "New Tariff" assumed that new methodology is used to derive optimal tariff, which would reflect 'true' cost of production with *additional assumptions on company behavior.* Based on the Module Cost Analysis and Energy Sector Balance outcomes, it is evident that from two proposed scenarios, the 'New Tariff' methodology is more preferable due to higher revenue generation and improvement of the efficiency through decrease of losses and, therefore, decreasing the long history deficit in energy system over the course of forecasted period of 2016-2025. It is worth of notice that the 'New Tariff' scenario is also stronger because of additional assumption on energy company behavior, which is also a limitation of the study.

Given that all assumption are accepted for both energy consumption and energy transformation sides of the model the tariff of **1.54** KGS per kWh is accepted as the optimal in achieving the energy balance in long run out of two proposed tariff methodologies.

Policy Implication

The result of the study shows that adapted MTTP does not reflect the cost of the energy production in long-run. The Mid term tariff of 1.20 KGS per kWh will not be sufficient to pull out the energy market of Kyrgyz Republic out of long lasting deficit. There are three available options to reform the energy sector and energy companies and turn them into profit making institutions. First, if all of the given assumption under 'New Tariff' methodology are met, then increasing the tariff to 1.54 KGS per kWh will decrease the energy market deficit in long run. Second, if the tariff remains at the same rate of 1.20 KGS per kWh the necessary actions on the improvement of efficiency of energy transformation have to be unfertaken, otherwise the energy sector will remain the debts for at least 10 years from now on. The improvement of efficiency is possible through strategic transmission lines rehabilitation plan with large investments to the project. Third option is to complete by 2020 the previously launched construction of new HPP 'KambarAta 1' with estimated cost of 2.2 billion USD.

The main challenge of first option is the public resilience to any tariff increase and potential public outrage. However, if the decisions are properly communicated to consumers, it is considered feasible. The second option requires investments from energy companies into the technology and equipment, however, it is assumed to be less costly than option three. The latest is the least feasible as of today due termination of agreement on funding of the construction of 'KambarAta 1' by Russian Federation.

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Glossary

1 Megawatts = 1000 kilovolts

100 Tyiyin = 10 Kyrgyz Som (currency)

Energy E in kilowatt-hours (kWh) = the power P in watts (W) x the time period t in hours (hr) / 1000

Appendices

Appendix 1 Final Tariff Rates according to MTTP of Kyrgyz Republic, 2014-2017

Consumer groups	Unit of measurement	2014	2015	2016	2017
Population					
Consumption of 700 kWh per month	tyiyn / kWh	70	84	100.8	121
Growth	%	0%	20.00%	20.00%	20.00%
When consuming more than 700 kWh per month *	tyiyn / kWh	ny weighted average rate (120.3 ** + import price)	the weighted average tariff (128,7+ import price)	the weighted average tariff (137,7+ import price)	the weighted average tariff (147,4+ import price)
Growth	%	71.80%	7.00%	7.00%	7.00%
Budget users (subsidized)	tyiyn / kWh	the weighted average tariff (138,0+ import price)	the weighted average tariff (147,7+ import price)	the weighted average tariff (158,0+ import price)	the weighted average tariff (169,1+ import price)
Growth	%	4.00%	7.00%	7.00%	7.00%
Agriculture	tyiyn / kWh	the weighted average tariff (138,0+ import price)	the weighted average tariff (147,7+ import price)	the weighted average tariff (158,0+ import price)	the weighted average tariff (169,1+ import price)
Growth	%	4.00%	7.00%	7.00%	7.00%
Industry	tyiyn / kWh	the weighted average tariff (138,0+ import price)	the weighted average tariff (147,7+ import price)	the weighted average tariff (158,0+ import price)	the weighted average tariff (169,1+ import price)
Growth	%	4.00%	7.00%	7.00%	7.00%
Other consumers	tyiyn / kWh	the weighted average tariff (138,0+ import price)	the weighted average tariff (147,7+ import price)	the weighted average tariff (158,0+ import price)	the weighted average tariff (169,1+ import price)

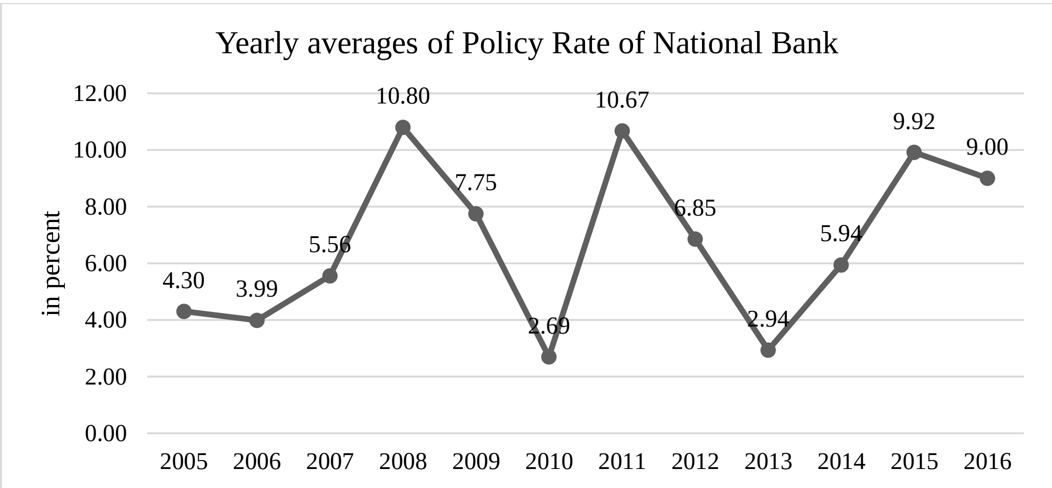
Growth	%	4.00%	7.00%	7.00%	7.00%
Pumping stations	tyiyn / kWh	72.8	77.9	83.3	89.2
Growth	%	4%	7.00%	7.00%	7.00%

Appendix 2 Comparative analysis of the energy modeling tools

	LEAP	**MARKAL-TIMES**	**MESSAGE**	**ENPEP BALANCE**
Developer	Stockholm Environment Institute (SEI)	IEA / ETSAP	IAEA (Planning & Economic Studies Section)/ IIASA	Argonne Laboratory (CEEESA)
Model Type	Spreadsheet / Energy Accounting (econometrics and simulation possible)	Engineering Optimisation	Hybrid Energy Accounting and Optimisation	Non-linear iterative Equilibrium Simulation
Home page	http://www.energycommunity.org	http://www.ieaetsap.org/web/Mark al.asp	www.iiasa.ac.at www.iaea.org	ceeesa.es.anl.gov/projects/Enpepwin.html
Data requirements	Low-Medium	Medium-High	Medium-High	Medium-High
Expertise required	Medium	High	Medium/High	Low/Medium
Flexibility to adapt to energy system	High	Medium	Medium	Low
Cost	Free for NGOs, government and Researchers in non-OECD countries	Commercial: 3,000 to 15,000 EUR (Source code + GAMS + interface)	Free for academic use and IAEA member countries	Free to all users
Coverage	Widely used internationally	Widely used internationally	Widely used internationally	Widely used internationally

Pros	• Simplicity & Flexibility • Transparency • Scenario reporting • Computation of costs possible • Data requirements limited	• Highly detailed representation of technologies • RES cost optimisation • Captures interdependencies Technology options /impact on S&D	• Detailed representation of technologies • Cost optimisation of portfolios of options • Limited training requirements	• Explicit dynamic balancing of energy S&D • Separate electricity demand • Can incorporate non competitive market factors
Cons	• Does not generate easily least-costs solutions (problem if many technology options available)	• Steep learning curve • Data requirements & preparation work • Incorporation of non competitive market factors difficult • Optimal behaviour assumption	• Optimal behaviour assumption	• Market-based /decentralised simulation approach (clearing prices & quantities) not always suitable • Data requirements

Appendix 3 National Discount Rate historical data trend



Appendix 4 Exogenous Capacity of energy companies as of 2016

Branch: Transformation	
Units: Thousand Megawatts	First Scenario Year
Branches	2016
Distribution grid operator 'Jalalabad Electro'	1,411.0
Distribution grid operator 'Osh Electro'	1,989.1
Distribution grid operator 'Sever Electro'	4,833.4
Distribution grid operator 'Vostok Electro'	1,324.1
Production\Processes\HPP's of 'Electric Stations'	14,142.8
Production\Processes\TPP's of 'Electric Stations'	1,022.1
National transmission grid 'NESK'	12,891.4

Appendix 5 The final tariff based on 2 methodologies (MTTP and New Tariff) for each year

Tariff in KGS per kWh	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
MTTP	1.48	0.95	0.96	1.16	1.96	1.77	1.73	1.70	1.66	1.64	1.61	1.59	1.57	1.55	1.54
New Tariff	1.48	0.95	0.96	1.16	1.96	1.74	1.68	1.63	1.58	1.54	1.50	1.47	1.44	1.41	1.39

Appendix 6 Module Cost Balance for ‘New Tariff’ Scenario

Units: Real 2015 Million Kyrgyz Soms.										
Cost Categories	2011	2012	2013	2014	2015	2016	2017	2018	2020	2025
		-	-	-	-	-	-	-	-	-
Capital Costs	-	2.4	3.8	6.6	6.7	6.7	6.7	6.7	6.7	6.7
Feedstock Fuel Costs	-2,609.0	-3,113.7	-3,854.0	-3,564.2	-4,830.2	-6,306.6	-6,350.0	-6,395.5	-6,493.0	-6,742.4
Fixed O&M Costs	-2,885.5	-2,956.8	-3,296.3	-3,690.3	-2,550.2	-2,575.9	-2,601.8	-2,627.8	-2,680.8	-2,817.9
Sales Revenues	5,538.5	6,138.6	6,864.1	7,082.1	8,028.4	11,271.1	14,338.7	14,710.1	15,483.7	17,611.9
Stranded Costs	-5,009.5	-888.4	-1,253.4	-3,381.6	-5,089.7	-5,124.4	-5,159.4	-5,194.8	-5,266.6	-5,452.5
Variable O&M Costs	-1,244.5	-1,352.7	-986.8	-1,102.7	-6,214.3	-5,869.0	-5,983.8	-6,108.3	-6,395.0	-7,480.0
Total	-6,210.1	-2,175.4	-2,530.1	-4,663.4	-10,662.8	-8,611.6	-5,763.0	-5,623.1	-5,358.5	-4,887.6

Appendix 7 Module Cost Balance for ‘MTTP’ Scenario

Units: Real 2015 Million Kyrgyz Soms.										
Cost Categories	2011	2012	2013	2014	2015	2016	2017	2018	2020	2025
		-	-	-	-	-	-	-	-	-
Capital Costs	-	2.4	3.8	6.6	6.7	6.7	6.7	6.7	6.7	6.7
Feedstock Fuel Costs	-2,609.0	-3,113.7	-3,854.0	-3,564.2	-4,830.2	-6,510.4	-6,688.8	-6,872.4	-7,255.5	-8,315.3
Fixed O&M Costs	-2,885.5	-2,956.8	-3,296.3	-3,690.3	-2,550.2	-2,575.9	-2,601.8	-2,627.8	-2,680.8	-2,817.9
Sales Revenues	5,538.5	6,138.6	6,864.1	7,082.1	8,028.4	11,271.1	13,879.8	14,239.4	14,988.2	17,048.3
Stranded Costs	-5,009.5	-888.4	-1,253.4	-3,381.6	-5,089.7	-5,124.4	-5,159.4	-5,194.8	-5,266.6	-5,452.5
Variable O&M Costs	-1,244.5	-1,352.7	-986.8	-1,102.7	-6,214.3	-6,007.4	-6,233.6	-6,468.4	-6,965.3	-8,383.8
Total	-6,210.1	-2,175.4	-2,530.1	-4,663.4	-10,662.8	-8,953.7	-6,810.5	-6,930.8	-7,186.7	-7,927.9