Ministry
for Industry and Energy
Of the Republic of Tajikistan

UNDP in Tajikistan

STRATEGY
for development of small scale hydropower of the Republic of Tajikistan

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Abbreviations and acronyms

ADB - Asian Development Bank
AS RT – Academy of Sciences of the Republic of Tajikistan
CAEC – Central Asia Economic Community
CAR - Central Asian Region
CDM – Clean Development Mechanism
CER – Certification of the reduction of greenhouse gas emissions
CHPP – combined heat and power plant
CIS – Commonwealth of Independent States
GBAO – Gorno-Badakhshan Autonomous Oblast
Gcal – Gigacalorie = 10^9 cal.
GDP – Gross Domestic Product
Ggr – Gigagram = 10^9 gram
GRES – GRES power plant
GWt – Gigawatt = 10^9 Watt
HDI – Human Development Indicator
HEPS – hydroelectric power station
IMF – International Monetary Fund
IRR – Internal Rate of Return of the investment project
KV – kilovolt = 10^3 volt
KVA – kilovoltvar
kWt – kilowatt = 10^3 watt
MCEC - Mechanism for compensation of electricity consumption
MHPP – Mini- (micro-, small-scale) hydro power plant
MWt – MegaWatt = 10^6 watt
NGO – Non-governmental organization
OSHC “Barqi Tojik” - Open Stock Holding Company “Barqi Tojik”
PG – power grid
PPP – Purchasing power parity
PRSP – Poverty Reduction Strategy Paper
RRS –Rayons of republican subordination
RT – Republic of Tajikistan
SPECA – UN Special Program for Economies of the Central Asia
t. c. t. – ton of conditional fuel
TWt – Terawatt = 10^{12} watt
UNDP – United Nations Development Organization
UNFCCC – United Nations Framework Convention on Climate Change
USSR – The Union of Soviet Socialist Republics
WB – World Bank

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INTRODUCTION

In the past few years, the rural population of the Republic of Tajikistan has suffered from a lack of electricity. Today the energy situation has worsened– population in the most rural areas has access to electricity only during the winter which is limited to a few hours per day. The lack of electricity leads to severe consequences in all areas of human activity – economics, education, healthcare and the social sphere.

At the same time, as USSR experience has shown, the construction of huge hydropower stations is not a solution to the issue of rural energy supply because HPPs are oriented to supply separate large industrial enterprises.

Today the same arguments are related to those huge HPPs being constructed at the expense of foreign investments. These HPPs are also built for electricity export. That's why rural areas of Tajikistan, especially the remote ones, can have reliable access to electricity only if small scale HPPs are constructed in their areas. Tajikistan possesses huge potential resources of small scale hydropower which significantly exceeds the need of the country, even taking into account future prospects of population growth.

Despite all these conditions, there hasn't been much success in implementing a development program for small scale hydropower nor in their construction. One of the main reasons behind this, is the lack of a clear defined strategy for the development of small scale hydropower, and the absence of conceptual bases for such a strategy.

Today, as a result, a concept of small scale hydropower defined in relation to the conditions of Tajikistan does not exist.

Definitions such as "non-traditional energy", "alternative energy" are also used along with the definition "small scale hydropower" which leads to confusion and difficulties in making use of the experience of developed countries.

There is also a need to specify the technical parameters of the small scale HPPs to be constructed in Tajikistan. It is especially essential for GBAO region where all base HPPs, those in place and in prospect, are formally considered as "small scale" although functionally they are "large scale". The absence of specified technical parameters can lead to confusion of their status, and consequently, in the role of the state with regards to management and maintenance.

There is a vague idea in the country now that small scale HPPs are just "miniature" large scale HPPs. It seems that there is a need to separate them not only by capacity, but also by the structure of users, mode of operation and other parameters and functions.

It is also essential to determine the resources of small scale hydropower. According to the first and last inventory, the resources are defined conditionally, with a decreasing coefficient of 0,35 and lower.

The issue of status definition of those small scale HPPs already in place in the system of OSHC "Barqi Tojik" is urgent as well, as these HPPs function with different legal status than those small scale HPPs which have been newly constructed.

Issues of property relationship with regards to small scale HPPs and their maintenance, especially of those constructed during the USSR epoch, also remain unsettled.

It is essential to settle upon the status of small scale HPPs with relation to the state energy system, in order to divide responsibilities.

The issues of standardization and unification of the equipment in use, design and layout solutions and structural units are most important for the development of small scale hydropower. In this regard, the small scale hydropower sector of Tajikistan lags behind in the consumer market of such goods and services.

Issues of the production of equipment and the establishment of its maintenance base need to be considered since global prices for energy resources and equipment have been going up last years. Issues of environmental protection, security and safety, trainings, etc. should also be paid attention to.

Most importantly, the issues of tariff policy require special attention in the sector of small scale hydropower and its legal substantiation.

Elaboration of investment policy within small sector hydropower to enable the attraction of internal and external funds is an important issue as well.

Another issue of importance is the attraction of the population and civil community to the implementation of the small scale hydropower development program.

The Strategy for development of small scale hydropower of the Republic of Tajikistan has been elaborated by the Ministry for Energy and Industry of the Republic of Tajikistan with financial support from the Office of UNDP in Tajikistan.

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The Strategy is elaborated on the basis of "The Program for Economic Development of Tajikistan for the period up to 2015", "The Development Concept for Energy Sector of the Republic of Tajikistan for the period of 2003-2015", taking into account "The Long-Term Program for Construction of Small Scale HPPs for 2007-2020" and other programs and plans which have been approved by the Government of the Republic of Tajikistan.

1. Aims and objectives of the Strategy

Energy nowadays increasingly influences all spheres of social life. Energy is the basis of economy of any country; it defines social conditions of human life, and has both direct and indirect influence on the environment.

Although energy is of invaluable use, humanity experiences certain negative consequences from energy development. Initially these consequences mostly related to the secondary effect of energy use. The situation in London and other large cities of Europe in the end of 19^{th}- beginning of 20^{th} centuries is well known. This situation has been dealt with, especially in developed countries, via use of new, effective technologies both in industry and agriculture, as well as in other spheres of economy. But negative trends associated with the development of energy itself emerged and started to increase during the second half of the 20^{th} century. These trends are related to thermal, chemical, radioactive and other types of pollution of the environment.

This situation created a need for a change of strategy in the development and functioning of the energy sector. As a result new sources of energy were developed; an interest arose in those sources of energy which were once but are no longer intensely used.

These are so called "non-traditional", "alternative", "ecologically clean", "renewable" sources of energy. Most of these terms are not accurate enough. The definite meaning contains only the term "renewable sources of energy" – these "are sources based on permanently existent or periodically emergent streams of energy in the environment"[1]. Unfortunately, this definition is also too general and includes a vast amount of different types of energy, not mentioning energy subtypes: solar, photovoltaic, bio, photosynthesis, geothermal, wave and tide energy, thermal energy of oceans and reservoirs, hydropower and wind power. All these types of energy makes the definition even vaguer. The emergence of a vast amount of "new" types of energy is related to the tempting idea of inventing a universal source, organically existing in nature and able to provide sustainable development. Renewable sources of energy are most attractive from this point of view. Firstly, it seems that if these sources permanently exist in nature, their use will not cause pollution of any kind to the environment and will automatically provide reasonable and economic use of energy.

Unfortunately, detailed analysis reveals that this is not always true. The issue is that certain types of renewable sources of energy are not distributed evenly everywhere. It turns out that their economic use does not always correspond to the reality. The calculations show, that only world oceans could produce enough energy to exceed tenfold the amount of energy produced today by burning hydrocarbons. The resources of wind and solar power are vast as well. In favorable conditions the stream of solar power reaches earth at a speed of $1kWt/m^2$, and wind power at 300 Wt/m^2. Therefore, the renewable sources of energy do not include their excessive use and corresponding problems.

The issue of renewable sources of energy being ecologically clean is ambiguous too. The use of renewable sources of energy could lead to the common types of pollution, as well as to the specific ones, which have yet to be even explored. To common types of pollution one can refer hydropower to its floods and water logging of territories; bio energy and photosynthesis to it's pollution by products of chemical processing and combustion; tide power with its construction of isolation structures, which intrude into the balance of sea ecosystem (exemplified by construction of dams on Kara Bogaz-gol and protective structures of Leningrad) etc. With regards to specific types of pollution, one can refer E-field radiation coming from wind installations with large capacity, whose negative effect was first registered in the USA. There could be also other types of pollution as the consequences of large scale use of ocean thermal power still remain unknown. There is another issue. The criterion of the energy sector being "ecologically clean" is vague itself. It seems that such criteria should not relate to a separate object itself, but to a system or territory as a whole. The role of renewable sources of energy and the extent of "cleanness" required will be, in this case,

[1] John W. Twidell and Anthony D. Weir "RENEWABLE ENERGY RESOURCES" London: E. & F. N. Spon, 1986

defined by the energy system as a whole. In this view the situation in Kazakhstan, for instance at Ekibastuz GRE working on coal would radically differ from the situation in remote non-electrified areas of Tajikistan.

Thus renewable sources of energy are in the first place sources of energy. The development program must be viewed as a constituent part of the development strategy for the energy sector of the country i.e. it must be defined by following three factors:

- Available resources
- Needs of the economy of the country and its separate sectors
- Possible opportunities – financial, economic, labor.

Additionally natural, climatic and territorial peculiarities of the country and region (the location scheme of production resources and level of economic development, export and import opportunities) are of importance as well.

The analysis conducted above enables the formulation of the basic theses for the development program of the energy sector of Tajikistan. Its basis is hydropower, i.e. industrial use of the renewable energy sources; strategic direction of the development of the country. At the same time the use of other types of resources available (for instance, coal) at local and domestic levels is not excluded, but welcomed. Their share however would be relatively insignificant.

Taking into account the current need and financial opportunities at hand, the top priority program for the near future in Tajikistan is the national program for development of small scale hydropower.

The next stage of the program for development of energy sector of Tajikistan is the program for the finalization of large HPPs construction whose construction has started but has not been finalized. These HPPs are of complex function which affects irrigation interests of the republics of the Central Asia Economic Community. Since these HPPs have vast export potential, their function affects the interests of foreign countries with relation to energy needs as well. Therefore, considering the need for large investments in such projects, their implementation today is only possible as regional projects or at the expense of attraction of foreign funds. Tajikistan itself could implement this stage of the program only after the stabilization of its economy. However these opportunities are real and the finalization of HPP constructions in the republic is recognized as a top priority at the Government level. best

The greatest quantity of HPPs constructed today in Tajikistan are small scale HPPs. Given the country's conditions, the development of small scale hydropower sector is the most favorable solution. It should be pointed out that even though small watercourses are evenly distributed throughout the whole territory of Tajikistan, their resources are vast. Thus mass industrial construction of small scale HPPs is possible and will reduce the price of whole program.

Nowadays top priorities of the country are the development of market relations, increasing in the level of population employment and equal economic development in all territories, including remote and mountainous ones. These priorities require the construction of small scale HPPs. Small scale HPPs do not require large investments, can be practically constructed within a season, are relatively unsophisticated in exploitation and maintenance and can provide a fast return of investments.

During the USSR epoch when all republics, including Tajikistan, constituted a single country, a sole economic area with development programs (though often poorly implemented) existed for all sectors and regions, both short term (for 1-5 years) and long term (10-20 years).

Top priorities were the well-being of people (though mostly pretentiously stated) and even distribution of productive forces throughout the whole territory of the country (though not attained). Energy balance of the separate republics was a technical issue within the framework of general strategic directions to calculate the needs of all kinds of energy. It also allotted the parts to be covered by their own resources and imports. At the time, the part to be covered by own resources and to be imported did not differ much from a economical point of view with the existent prices of energy carriers.

Moreover the import of energy carriers to the republic was often even more profitable for the development of own base of energy production. There was no incentive to develop industrial production, especially large, power-consuming ones, in the republics. Such large power-consuming industrial enterprises were part of the USSR property, and did not really influence the economy of the republics, however they could drastically deteriorate the environment.

It surely enabled such economically undeveloped regions as Tajikistan to plan and implement sustainable economic development programs. This is illustrated by the development history of energy sector of Tajikistan and perspective development programs of power industry elaborated in 1980s.

Now, after the USSR collapsed and all republics gained independence, the situation has fundamentally changed. Instead of past technical budgeting of available republican funds as separate elements of the USSR budget with preset parameters, the newly independent states are tasked with the elaboration of real and effective energy balances and the implementation of an economic development strategy for their country.

It is an extremely difficult task. First of all, one should take into account that the economic system itself throughout the post soviet territory changed, including Tajikistan. The planning of the economic system managed via command-administrative methods is replaced today by market economy.

Formally it should simplify the situation – instead of taking into account a variety of factors which determine the needs on the basis of interconnected sector plans, energy balance could be developed on the basis of a single principle of supply and demand. However in practice, this principle is used only if energy is sold to solvent consumers.

Unfortunately today this simple principle of market economy is sometimes difficult, and often even impossible to conform to in Tajikistan. The issue here is that as a result of a common economic crisis for all CIS countries, which in Tajikistan was aggravated by consequences of civil war, the level of industrial production and solvency of population in the country decreased by more than two times. As a result even though electricity tariffs are very low, the level of fee collection is less than 100%. At the same time, taking into account the lack of other available energy carriers in the republic, the consumption of electricity considerably increased. In such conditions, cutting off the electricity as a reasonable measure of market economy can lead to unfavorable social consequences.

Apart from this, the power industry, 95% of which is represented by hydropower, is a real basis of the energy sector in Tajikistan. The mass cutting off of consumers could lead to the crisis of the energy system itself. In Kazakhstan, Uzbekistan or Turkmenistan application of such a measure would lead to the release of fuel resources (gas, coal) which could be sold at the market; in Tajikistan the unloading of energy system would lead to blank discharge of water at HPP with no alternative benefits.

The hydro resources can obviously become the basis of Tajikistan's energy system. However to increase the effectiveness of economy, it is essential to reduce domestic consumption of electricity (which increased by 4-5 times in relation to figures of 1980s, along with general decline of economy) for further use of released resources in more effective economy sectors. It is possible only if separate energy sources are developed for the domestic sector.

The analysis conducted above enables us to map major directions and stages of development of the energy sector of Tajikistan, based upon the ultimate goals of: rehabilitation, effective functioning and further sustainable development of the energy sector, both for the satisfaction of its own needs, and the external market.

These include:

Short-term program of rehabilitation.

This program includes breakdown eliminations and the prevention of new breakdowns, as well as the elaboration of legal base for the functioning of the energy system. It is also essential to rehabilitate safety systems of the energy installations which include regular inspections and corresponding preventive and control activities. The primary task is to transfer from current practices to

the establishment of safety systems during the exploitation period of energy system. In its turn it requires the rehabilitation of regular works of those planning and from the scientific research institutions of sector and academic profile that still remain in the country.

The next important stage comprises of effective market reforms in the energy sector which, as a result of the functioning of the energy system, will facilitate increased interest not only of enterprises themselves and potential investors, but also all consumers and citizens of the country. The program of construction of small scale HPPs can become one of the mechanisms, but only if it is implemented within the framework of non-state property.

The core of this stage is the financial rehabilitation of the energy system. It includes the enhancement of legal base, tax code in the first place, payment discipline, elaboration and the implementation of activities for optimization of the structure of energy consumption which provide a reduction in its use in non-effective sectors, including the domestic sector. All these measures should increase the mean tariff on electricity up to 2,0-2,5 cents/kWt.hour by the end of this stage. These reforms will be successful if conducted simultaneously with other sectors of economy. At the same time energy sector itself can be an engine of these processes, stimulating and administering them.

Medium-term program of stabilization and development.

At the second stage, after the energy sector is financially stabilized, work on increasing energy sector effectiveness should be continued. During this stage, according to global price trends, the mean tariff for electricity should be increased up to 3÷4 cents/kWt.hour., which in turn will secure annual profit of energy system totaling 400÷500 mln. dollars.

The modernization and reconstruction of all energy system installations, including electric stations, transformer vaults and power lines, as well as switch lines should be continued and finalized within the framework of medium-term program. Taking into account poor financing of the sector starting from 1992, total expenditures for these purposes will constitute around 1200 mln. dollars.

The major works on finalization of HPP constructions started back in the USSR epoch and should be completed during the second stage. The construction of the cascade of Sangtuda HPPs with total cost of 500 mln. dollars and construction of Rogun HPP with total cost of 2000 mln. dollars should be completed.

It is important to continue the construction of small scale HPPs. Taking into account the necessity of mass production of small scale HPPs, it is essential to organize personal industrial production of hydro technical and electro technical equipment for small scale HPPs in the country.

At the regional scale, the second stage should be characterized by active participation of Tajik energy sector in the external market. The annual export potential can reach 3÷5 billion kWt/hour. taking into account optimization of the structure of electricity consumption and introduction of new capacities.

One of the vital tasks of the second stage is to provide a good start for the future development of the energy sector. First of all it is essential to elaborate new projects and organization of preparatory works for the construction of new, highly effective objects. It includes diversions of runoff in Pyandj-Vakhsh, Zervashan-Ura-Tyube valley, Shurob HPP, “South-North” power lines.

Long-term program of development.

The third stage of the program envisages long-term sustainable development of the energy system. Electricity tariffs by that time will constitute no less than 5 cents/kWt.hour., total profits of the energy system will constitute around 800 mln. dollars at the beginning and 2000 mln. dollars at the end of the third stage.

The basis for development of the energy sector at the third stage will be a new construction. It will include, first of all:

Partial diversion of runoff from the river Pyandj to the river Vakhsh, to increase the effectiveness of the cascade of the Vakhsh HPPs.

The project envisages construction of a dam of 120 m. height on Pyandj river and Pyandj-Vakhsh tunnel of 66 km. If the construction of the cascade of Vakhsh HPPs is completed, it will provide a complementary increase of electricity production in the amount of 20 billion kWt/hour annually and will dramatically increase the level of regulated stream in the Amudarya river basin for irrigation purposes. The economic effectiveness of the project is higher than that with traditional options: at the total cost of 250÷300 mln. dollars, the payback period is not more than a year.

Complex use of Zeravshan river with partial diversion of runoff to Ura Tyube valley.

The project envisages construction of a dam of 200 m. height, an HPP of 50 MWt capacity, a tunnel of 17 km and a cascade of small scale HPPs on main irrigation channels with total capacity of 250 MWt. The cost of the project is 550 mln. USD. The payback of the energy part of the project alone is around 3,5 years. Apart from production of electricity, implementation of this project will enable to irrigate 87 thousand ha of new lands in addition to improved irrigation of 30 thousand ha of previously irrigated lands. Thus, taking into account irrigation part of the project, the total pay-back period of the project equals 1,5 years.

Construction of "South-North" power lines with capacity of 500 kWt

Construction of "South-North" power lines with capacity of 500 kWt is of no separate economic effectiveness; however it enables the country to solve the issue of energy security which is of considerable importance. Power lines will unite two energy systems of Tajikistan, which are currently isolated from each other, and will secure a direct transfer of electricity produced by the cascade of Vakhsh HPPs to Sughd Oblast.

Construction of Shurob HPP.

Shurob HPP on Vakhsh river with capacity of 800-900 MWt. and annual production of electricity of 3 billion kWt/hour. is a intermediate level between Rogunskaya and Baipazinskaya HPPs. The preparatory works on this HPP started in the end of 1980s-beginning 1990s along with construction works of other HPPs of Vakhsh cascade.

The definite periods will depend mostly on the situation in oil and gas situation of the region. Taking into account current trends, there could possibly be a considerable decrease in mining of mineral fuel and the prices will increase; this situation will facilitate increase of the interest of neighboring countries to implement joint programs on hydro power development. The same relates to the participation of other foreign countries in the energy development program of Tajikistan.

Such a detailed analysis of the development strategy of the energy sector of Tajikistan is carried out as small scale hydro power and is only a constituent part of the energy sector. The ultimate goal of the strategy for the development of energy is the sustainable development of the country, which includes three components: economic, ecologic and social.

The goal of the Strategy for development of small scale hydro power of the Republic of Tajikistan is:

Reliable and sustainable provision of electricity to the population of isolated and remote areas of the country, as well as for small and medium business'.

The major objectives of the Strategy implementation are:

- **Development of market relations in the energy sector,**
- **Attraction of population and businessmen to the development and management of the energy sector,**
- **Development of project and construction complexes of the energy sector,**
- **Development of national production of technological equipment and its repair and maintenance base.**

2. Basic principles of elaboration of the Strategy

The development of any country considerably depends upon the goals and priorities chosen.

There are many examples of world history when a choice of right directions led to the successful and sustainable development of the countries, both large and small ones; and vice versa. The USSR experience could be a model of failure – the country with huge material and human resources which due to the wrong development strategy ended up with economic degradation and collapse of the country.

Today an effective economic development (even if "overtaking" one) is not only of current importance but a vital objective for Tajikistan. That's why the elaboration and implementation of the appropriate strategy is of utmost importance.

It fully applies to the strategy for the development of hydro power of the Republic of Tajikistan. It cannot be merely a plan which proved to be ineffective throughout the development history of the USSR.

The concept of strategy itself can be considered in two aspects. Conceptually a strategy is the leading notion which defines the basic idea and maps the way to achieve the objectives set. In this notion the strategy determines major issues and directions of activity, without concretizing the methods of achieving them. This is a strategy-concept; it utilizes an approach of setting objectives. It envisages much freedom and uncertainty of actions. Strategy can also be considered more concretely – as a definite succession of the actions which provides for achievement of the objectives set. It is a strategy-program, it utilizes planning, programming approach and, consequently, larger extent of preset activities and actions.

There are several types of strategy-programs:

- Linear strategy which consists of clear-cut definite succession of stages, where each separate stage is preset, or at least, depends on the results of preceding stages, but does not depend on the following ones,
- Cyclical strategy which assumes the return to the preceding stage if one of the stages failed or finished unsatisfactorily,
- "Branchy" strategy which envisages parallel and even competing directions providing flexibility in corrections of its implementation,
- Adaptive strategy which envisages only the first step, the first enactment,
- Strategy of increment increase which envisages a non-stop process: evaluation of the situation → decision-making → making small changes → evaluation of the situation again, etc.
- Strategy of "search for chances" which is distinguished by complete lack of a primary plan.

The choice of any of these strategies depends on the goals and objectives set. Practice shows that in case of complex tasks a combination of different types of the strategy is utilized. The real success in achieving the objectives set is possible only if the strategy is constantly managed, if the so called "self-organizing process" is maintained. Therefore an elaboration of a separate strategy cannot be detached from its implementation; it is an indivisible process. Especially if it relates to such a complex strategy as the strategy of economic development of the country.

Uncertainty in the elaboration and implementation of development strategies is seen today in all sectors of economy of Tajikistan. Each ministry and agency develops only one type of strategy, the linear one. And the linear strategy per se is turning into groundless plan. Such strategies could be called "wish-strategies". These strategies determine only the desired needs, not real opportunities, both in financial and resource terms. The financial parts of these strategies are also represented as investment needs, while lack of own resources is compensated by external investments- sources of which are unknown. It naturally does not impose any obligations on its implementation upon developers. There is no responsibility as well, lack of external investments being declared the reason of non-implementation of the plans set.

The development strategy for hydro power sector today cannot be a mere plan, i.e. a linear strategy. The Government of the Republic of Tajikistan and the Ministry for Energy and Industry considers it to be an adaptive strategy. The first step for its implementation is

set through the Decree of the Government of the Republic of Tajikistan N449 "Long-term program of construction of small scale hydro power stations for the period of 2007-2020"as of the 3rd October 2006.

The constant monitoring and management is essential for successful implementation of the strategy.

3. Natural and climatic conditions and energy resources of Tajikistan

3.1. Energy resources potential of Tajikistan in the context of Central Asia Region

Focusing on the issue of fuel and energy resources of Tajikistan should not be considered as ignoring the problem in the other surrounding republics.

Balance reserves of separate types of mineral fuel in Central Asia by categories A+B+C are listed in tables 1 (in natural exponents) and 2 (in commensurable exponents). First of all, it should be noted that evaluations are more or less stable only for coal. Evaluations of oil and gas reserves underwent considerable variations within last few decades.

Table 1. Balance reserves of fuel by categories, A+B+C

Type of fuel		Gas, billion m^3			Oil, million tons			Coal, million tons			
year		1971[1]	1976[2]	1989[3]	1971[1]	1976[2]	1989[3]	1971[1]	1976[1]	1980[2]	1989[3]
Republic	Uzbekistan	802,1	1027,9	1786,4	146,0	173,7	78,8	1941,4	1871,3	1938,0	1923,6
	Kyrgyzstan	16,5	15,5	8,8	70,9	76,3	14,7	1256,2	1220,7	1265,0	1352,9
	Tajikistan	32,8	16,8	9,2	27,9	41,3	5,4	677,9	672,5	667,0	260,7
	Turkmenistan	1571,6	1736,6	2884,4	718,4	813,1	215,4	3,0	3,0	3,0	3,0
TOTAL:		2423,0	2796,8	4688,8	963,2	1104,4	314,3	3878,5	3767,5	3873,0	3540,2

[1] "Proposals for development of hydro power in Central Asia up to 2000" Sredazgidroproekt, Tashkent, 1978.
[2] State balance of minerals of the USSR as of 1.01.1981. Soyuzgeofond. Moscow. 1981.
[3] "Hydro power of the Aral Sea basin". Tashgidroproekt, Tashkent, 1994.

Table 2. Balance reserves of fuel as of 1. 01. 1981r. by categories, A+B+C

Republic	Total, gas, oil, coal, mln. t.c.t.	Including		
		gas	oil	coal
Uzbekistan	3554,2	1425,4	190,5	1938,3
Kyrgyzstan	1359,9	7,7	87,4	1264,8
Tajikistan	719,9	15,0	37,0	667,3
Turkmenistan	2815,3	1971,4	840,9	3,0

*) State balance reserves of minerals of the USSR as of 1. 01. 1981. Moscow, Soyuzgeofond, 1981.

It is related both to the increase of reserves due to exploration of new deposits (mostly gas) as well as their decrease due to mining and lack of exploration constituent. This last constituent was added in order to make the reserve balance look better, both at the ministry and republican levels, and naturally it was the largest one in those republics experiencing deficit in one or another type of fuel.

It is characteristic of natural gas and oil. In Uzbekistan and Turkmenistan, the largest reserves of gas in the region increased almost two times from 1970s to 1990s. In Tajikistan and Kyrgyzstan, which do not possess industrial reserves of gas, it decreased more than twice during the same period. As for oil, its reserves decreased on average three times in the whole region during the period of 1970-1990s.

Coal reserves remained practically invariable during the period considered due to the fact that the interest to coal as one of the major types of fuel, decreased.

Taking into account that there are no prospects of large scale investments into exploration of new deposits in the nearest future, increases of mineral fuel reserves should not be expected. Therefore the evaluation of mineral reserves made in 1989 remains most realistic.

As for actual use of reserves by types, it depends on costs for its exploration, processing and transportation. Only gas can be extracted without great costs incurred. Total reserves of natural gas in the region according to the most expanded categories A+B+C equal 3419,5 mln. t.c.t.

Oil extraction and processing also incurs considerable costs. The reserves of oil in the region (according to the categories $A+B+C_1$) equal 1156,4 mln. t.c.t.[2]

Total reserves of coal in the republics of Central Asia equal 3873,4 mln. t.c.t., however its use incurs large anticipatory costs for gas-field constructions. Besides, all gas deposits are located as a rule, in mountainous areas lacking construction fields for large scale thermal stations and transportation network. The construction project of Fan Yagnobskaya GRES power plant in Leninabad Oblast of Tajikistan can serve as an example. It turned out to be economically ineffective in conditions of the first half of 1980s, even though it was oriented towards an operational coal deposit. Therefore one cannot count on the industrial use of coal in the energy balance of the republics of Central Asia, including Tajikistan.

Thus, practically, mineral fuel reserves are evaluated at about 4,5 billion t.c.t.

The needs of Tajikistan and economically advanced Uzbekistan in fuel and energy resources are shown on the tables 3 and 4. Using the data on table 5 with the number of population of the republics of Central Asia it is possible to determine specific needs in energy per person. In more or less stable 1990 this figure for Tajikistan constituted 2,55 t.c.t. per person annually. In 1980s in Uzbekistan this figure constituted 2,7 t.c.t. The figures are quite close to each other.

Consequently even if the region develops at the modest pace with the level of energy needs at 2,6 t.c.t. per person annually, and the number of population remains stable and equals 35 mln., available energy deposits will last 50 years.

Table 3. Fuel and energy needs of the Republic of Tajikistan

Type	**Years**								
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**2000**	**2005**	**2010**
Electricity, billions kWt.hour.	19,4	17,0	15,5	14,1	14,7	13,9	23,3	25,0	27,0
Electricity, million t.c.t. (coefficient=0,3)	5,8	5,1	4,65	4,2	4,44	4,2	7,0	7,5	8,1
Oil and oil products, million t.c.t.	3,5	2,2	1,0	0,43	0,63	0,46	3,2	3,5	3,5
Fuel (not oil products), million t.c.t.	4,1	3,8	3,8	3,8	0,43	4,3	4,9	5,7	7,4
TOTAL, million t.c.t.	13,4	11,1	9,45	8,43	8,5	8,96	15,1	16,7	19,0

Table 4. Consumption of energy and fuel resources in the Republic of Uzbekistan, mln. t.c.t.

Years	**Supply**					**Distribution**	
	Extraction and mining				**Import**	**Total**	**Export from the republic**
	Total	**Oil and gas condensate**	**Gas**	**Coal**			
1965	33,4	2,6	18,5	2,3	7,7	33,3	14,6

[2] Oil reserves are given in accordance with the table 2. It is a maximum evaluation. More real evaluation, as it was mentioned above, is the one of 1989 (table 1), which equals 314,3 mln. t.c.t. or 449,45 mln. t.c.t.

1970	42,1	2,6	37,6	1,9	27,5	71,5	45,2
1975	48,0	1,9	43,6	2,5	125,4	125,4	84,4

*) The USSR fuel and energy sector in 1979 (economic-statistical analysis), USSR Gosplan, Moscow, 1980.

Table 5. Number of population in the republic of Central Asia, thousands

	Years						
Republic	**1979***	**1989***	**1990***	**1995***	**2000**	**2005**	**2010****
Uzbekistan	15391	19905	20322	22020	24750	27300	30050
Kyrgyzstan	3529	4290	4367	4605	5060	5697	6297
Tajikistan	3801	5109	5248	5969	6250	6920,3	8058
Turkmenistan	2759	3534	3622	4370	5030	5654	6335
Total	24480	32838	33559	36964	41549	46096	50740

*) Complex program of scientific and technical progress of the USSR for 1991-2010.
Regional division 4.12 USSR Academy of Sciences. The USSR State Committee for science and engineering. Moscow, 1988.
**) Basic theses of the Aral Sea river basin water strategy. Book. 1. MGS on apertures of the Aral Sea. Almaty-Bishkek-Dushanbe-Ashgabat-Tashkent. 1996.

Taking into account current dynamics of population upsurge and planned economic development, energy deposits will last two times less, i.e. around 20-25 years. The same evaluation was made by the USSR Ministry of Energy (see table 6). Taking into account that all these calculations were conducted, at minimum, ten-fifteen years ago, energy and fuel security of the region of Central Asia is at risk. This fact is confirmed by difficulties which the majority of republics face in provision of energy resources.

Table 6. Period for which mineral fuel resources are available in the Central Asia region (with population needs satisfied), as of 1981.

Type of fuel	**Period of supply availability, by categories, years**	
	A+B	**A+B+C_1**
Gas	6,2	30,0
Oil	11,0	22,0
Coal	141,0	314,0

*) Central Asia Hydro power Development Proposal up to 2000.
Gidroproject Institute. Central Asia Department. Tashkent. 1978.

Thus the region is provided with mineral fuel only for the period comparable to the construction period of one large waterworks facility of Nurek type. As for Tajikistan and neighboring Kyrgyzstan, the mineral fuel resources including those theoretically existent will last for a few years only.

It is clear that in such conditions the sustainable economic development of Tajikistan, and to some extent of Central Asian region, cannot be oriented to mineral fuel alone. The use of other energy sources is essential. One of them is hydro power.

3.2. Hydro power resources of Tajikistan

The basis for energy balance in Tajikistan is hydro power. The systematic research of the hydro power resources of Tajikistan started back in 1930s. The potential energy resources of Tajikistan water courses were evaluated to be 11,5 kWt in 1933, according to the primary data by Prof. Gromov. While conducting inventory of the USSR hydro power in 1934 this figure increased to 26,8 mln. kWt. Later on the most detailed analysis of these issues were conducted by the Central Asian Department of "GidroProekt" Institute after S. Ya. Zhuk under the USSR Ministry of Energy and the Scientific Research Department for Energy of TajikGlavEnergo.

The results of these investigations are shown on the tables 7, 8, 9. It should be pointed out that the hydro power potential of Tajikistan was underestimated by GidroProekt Institute by two times, i.e. the figures provided by GidroProekt Institute and the Scientific Research Department for Energy of TajikGlavEnergo differ two times.

Table 7. Hydro power resources of the republics of Central Asia

Republics	Hydro power Resources, TWt.hour.			
	Potential	Technical	Economic	In use
Uzbekistan	88,0	27,4	15,0	6,8
Kyrgyzstan	143,0	73,0	32,0	9,5
Tajikistan	300,0	144,0	88,0	15,8
Turkmenistan	24,0	5,8	5,8	-
Kazakhstan(south)	20,0	20,0	10,0	1,7
Afghanistan	10,0	10,0	6,0	0,6
Total	585,0	280,2	156,8	34,4

*) Hydro power of the Aral Sea Basin. TashGidroProekt, 1994.

Table 8. Potential hydro power resources of Tajikistan

River basins	Mean annual capacity, MWt.	Mean annual energy, TWt.hour.	Share in total volume, %
Pyandj	14030	122,90	23,2
Gunt	2260	19,80	3,73
Bartang	2969	26,01	4,93
Vandj	1191	10,34	1,96
Yazgulem	845	7,40	1,39
Kyzyl Su	1087	9,52	1,78
Vakhsh	28670	251,15	48,00
Kafirnighan	4249	37,22	7,00
Kara Kul Lake	103	0,90	0,17

Surkhandarya	628	5,50	1,03
Zerafshan	3875	33,94	6,38
Syrdarya	260	2,28	0,43
Total	60167	527,06	100,00

*) Hydro power Resources of Tajik SSR. Nedra, L. 1965.

It is explained by the fact that GidroProekt Institute conducted its hydrological investigations itself only to a very limited extent. It used archive materials of other agencies, and was as well biased towards national leadership in the region and prioritized fuel energy, not hydro power. This priority is also a reason behind the inadequate figures given for economically expedient hydro power resources which is determined by the comparative effectiveness of hydro and thermoelectric power stations. The inadequate figures are a result of the prices for mineral fuel being artificially set too low.

Table 9. Hydro power Resources of Tajikistan, by categories

Rayons	**Industrial resources**		**Potential resources**					
			Large rivers		**Tributaries, L>10km.**		**Tributaries, L<10km.**	
	N, MWt.	**E, MWt**	**N, мВт**	**Э, ТВт.ч**	**N, мВт**	**Э, ТВт.ч**	**N, мВт**	**Э, ТВт.ч**
Leninabad group of rayons	1590,0	13,93	1544,0	13,52	1303,0	11,41	1288,0	11,28
Rayons of republican subordination	17709,0	155,13	22744,0	199,24	3974,0	34,81	16056,0	140,65
Gorno-Badakhshan Autonomous Oblast	5884	51,54	6990,0	61,23	2555,0	,22,38	3713,0	32,53
Total	25183	220,6	31278	274,0	7832	68,61	21057	184,46

*) Hydro power Resources of Tajik SSR. Nedra, L. 1965.

At current prices, virtually any HPP, even constructed at the most difficult natural conditions, is more effective than thermoelectric power station. Therefore the evaluations of the hydro power of Tajikistan conducted by GidroProekt Institute (table 7) cannot be considered adequate.

Evaluations of hydro power reserves, made by the Scientific Research Department for Energy of TajikGlavEnergo (tables 8, 9) are based on direct observations of 530 rivers of the republic (of total 947 rivers) and the data hydro meteorological service. That is why these evaluations are considered more reliable. The total volume of potential hydro power resources of Tajikistan constitutes 527,06 billion kWt/hours annually at the average annual capacity of 60,167 million kWt. As for technical potential, the data shown on the table 9 is calculated just approximately. It is acknowledged by the authors too, who state that “hydro power resources of Tajik SSR are not studied well enough”. Taking this into account one can say that the technical hydro power potential of Tajikistan is indeed much more than that shown on the table. To some extent it was evident for the authors themselves in 1965, while they wrote a monograph “Hydro power Resources of Tajik SSR”. The total capacity of HPPs known at the time, on large rivers only, (both constructed and planned ones)

constituted 27,149 mln. kWt. – more than the industrial reserves shown on the table 9. It was also verified by schematic workup of the river Pyandj data confirming that the total capacity of hydro stations planned to be built on the river would equal 84,9 billion kWt. annually, i.e. 69,1% of total potential reserves of the river basin. It considerably exceeds the figures shown on the table 9, where the portion of industrial reserves in relation to the potential reserves constitutes 41,8%.

The most realistic evaluation of real industrial hydro power potential of Tajikistan which today, at current development of construction, equipment is practically considered economically rational, could be made with the use of empirical coefficients of the same monograph "Hydro power resources of Tajik SSR" representing relation of technical potential to general potential. These are:

- For large rivers (Pyandj, Vakhsh) - 0,85
- For large tributaries (Gunt, Bartang, Vandj, Kafirnighan) - 0,70
- For small rivers (apart from those of Pamir) - 0,35
- For small rivers of Pamir - 0,20
- For surface flows - 0,02

Using these coefficients, and the same data of the table 9, the following value of technical hydro power potential of Tajikistan is obtained even if the coefficient 0,20 is applied for all small rivers:

$$\mathbf{E_{technical} = 274,0*0,85 + 68,61*0,7 + 184,46*0,20 = 317,82 \text{ billion kWt/hours.}}$$

This evaluation is supported by world practice; the more industrially developed a country is and the less mineral reserves it possesses, the more it makes use of hydro power resources. In some developed countries the industrial reserve of hydro power resources constitutes 100% of all reserves. Assuming that as a result of development of its water resources Tajikistan reaches the average level of development in relation to developed countries, and taking into account that Tajikistan does not possess sufficient reserves of mineral fuel, the amount of industrial hydro power resources available for use might reach around 60% of total reserves. It will constitute:

$$\mathbf{E_{technical} = 527,06*0,6 = 316,24 \text{ billion kWt/hours per year,}}$$

i. e. practically the same value, will be obtained above by any different form of calculation.

The analysis given above explicitly demonstrates the availability of a huge amount of hydro power resources in Tajikistan, many times exceeding the level of their current development, and the needs of the country itself even with account of future prospect. The comparative analysis of hydro power resources on the table 10 demonstrates that hydro power reserves are of more logical use on all indicators than other energy resources.

Table 10. Comparative evaluation of hydro power resources of Tajikistan

Resource	Explored reserves	Resource cost (extraction, preparation, transportation)	Additional complex effect	Influence on climate	
				Positive	Negative
Hydro power	Excess	Lacking	High	High	Low
Coal	Sufficient	High	Lacking	-	High
Oil	Insufficient	High	Lacking	-	High
Gas	Insufficient	High	Lacking	-	High
Solar	Insufficient	Lacking	Lacking	High	-
Wind	Non-industrial	Lacking	Lacking	-	Not explored
Geothermal	Non-industrial	Low	-	-	-
Bio	Non-industrial	Low	Medium	-	Low
Trees	Non-industrial	Low	Lacking	-	High
Atomic	Insufficient	High	Lacking	-	High

3.3. Natural and climatic features of Tajikistan and alternative sources of energy

Let's consider the opportunities of wind energy in Tajikistan. Wind energy one of the most popular non-traditional sources of energy. The humanity started making use of it at the dawn of civilization. Later on, the interest to wind energy decreased due to the mass construction of thermoelectric power stations and hydro power plants. The interest grew strong again after the energy crisis of 1970s, when oil price went up. Wind energy is considerably developed in countries where there is no other energy sources sustainable and sufficient enough, e.g. in Netherlands and Denmark. In the countries possessing traditional energy sources to sufficient extent, e.g. in Norway (hydro power), in Arab countries (oil) wind energy is not widely used.

This shows the low level of competitiveness of wind energy. Wind energy is rather expensive; wind installations of even small capacity require disposition of large territories of land (up to 100 m^2 for 1 kWt capacity), large installations can cause drastic ecological problems. As a result, the interest in wind energy is reduced even in those countries where it has been widely spread. It is displayed by the dynamics of budget financing of wind energy in the USA.

Besides, efficient use of wind installations is possible only at the definite speed of wind. Practice of Denmark and Netherlands shows that a cost price 8÷10 cents per kilowatt-hour could be reached only with annual mean speed of wind equaling 5,6 m/sec, and the price cost of 5 cents per kilowatt-hour at the wind speed 8,3 m/sec, at 30 year term of service. If wind speed is less than 5 m/sec., wind installations cease to be efficient.

The characteristics of wind regime of all major districts of Tajikistan are given in the table 11.

Table 11. Mean monthly and annual wind speed on the territory of Tajikistan, m./sec.*

Places	Months												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Khudjand	5,3	5,5	5,6	4,8	4,2	4,0	4,4	4,4	4,0	3,8	4,6	4,8	4,6
Isfara	1,3	1,6	1,9	2,6	2,7	2,2	2,0	1,9	1,7	1,6	1,5	1,2	1,8
Ura Tyube	1,5	1,5	1,6	1,6	1,6	1,8	1,6	1,6	1,6	1,7	1,5	1,4	1,6
Pendjikent	1,6	1,8	2,1	2,4	2,2	2,2	2,1	2,1	2,2	1,8	1,5	1,4	2,0
Dushanbe	1,7	2,1	2,3	2,0	1,8	1,6	1,3	1,2	1,2	1,4	1,5	1,6	1,6
Yavan	2,7	3,4	3,1	2,6	2,6	2,6	2,0	1,7	1,8	1,8	1,7	2,1	2,3
Dangara	1,2	1,6	1,7	1,4	1,3	1,4	1,2	1,2	1,1	1,0	1,0	1,3	1,3
Kurgan-Tyube	1,2	1,5	1,9	1,7	1,5	1,2	1,0	1,0	0,8	0,9	1,0	1,0	1,2
Kulyab	1,3	1,6	1,8	1,8	1,6	1,7	1,4	1,5	1,6	1,5	1,4	1,2	1,5
Garm	3,6	3,5	3,1	2,3	1,9	2,0	1,9	2,1	2,2	1,8	2,8	3,2	2,5
Shaartuz	1,2	1,8	2,5	2,3	2,2	2,2	2,5	2,1	1,6	1,3	1,2	1,3	1,8
Murghab	1,2	2,1	2,7	3,2	3,0	3,0	2,6	2,3	2,2	2,2	2,0	1,5	2,3
Ishkashim	0,9	1,6	2,2	2,4	2,6	2,6	2,7	2,7	2,4	1,9	1,4	1,0	2,0
Anzob	5,0	5,5	5,5	4,7	4,1	4,1	3,9	4,0	4,2	4,5	4,7	4,8	4,6
Iskanderkul	1,6	1,6	1,8	1,8	1,7	1,5	1,4	1,4	1,7	1,6	1,8	1,5	1,6
Khorog	1,6	1,8	2,6	2,7	2,3	2,6	2,8	2,8	2,4	2,0	1,9	1,8	2,3
Shaymak	2,1	2,6	2,5	2,6	2,5	2,1	2,0	1,9	2,1	2,3	2,6	2,3	2,3
Fedchenko Glacier	7,1	7,4	7,2	6,6	5,7	4,8	4,0	4,0	4,8	5,9	7,4	7,1	6,0

*) "Tajikistan (nature and natural resources)", "Donish", Dushanbe, 1982.

As evident from the table above, only one place in Tajikistan, Fedchenko Glacier, which is not suitable for construction of wind energy installation, does the wind speed reache the minimum of more than 5 m./sec. required for efficient work of wind energy installation. All these facts prove there are no possibilities for industrial use of wind energy in Tajikistan.

The conditions for the use of solar energy are far more favorable. The country is situated in between of 37^{th} and 41^{st} degrees of northern latitude and fully enters into so called "world solar belt" (45° of northern latitude and - 45° of southern latitude).

Table 12. Air temperature in major populated areas, C°.

Areas	The coldest five days	The coldest day	Winter, ventilation	Absolute minimum	Absolute maximum	Mean temperature of heating season	Number of days in heating season	The coldest month	The hottest month
Dushanbe	-14	-17	-2,0	-27,0	43,0	3,5	116	I	YII
Khudjand	-13	-15,3	-4,0	-26,0	45,0	2,6	130	I	YII
Kurgan-Tyube	-14	-14,0	-2.0	-26.0	46.0	3.8	97	I	YII
Kulyab	-13	-13,0	-2.0	-24.0	46.0	4.0	96	I	YII
Regar	-12	-12,0	-0.2	-23.0	42.0	4.5	104	I	YII
Yavan	-12	-12,0	-1.0	-26.0	45.0	4.1	92	I	YII
Shaartuz	-13	-13,0	-1.0	-23.0	47.0	4.2	94	I	YII
Nurek	-14	-14,0	-2.0	-21.0	43.0	3.5	116	I	YII
Kanibadam	-12	-16,8	-6.0	-25.0	42.0	1.8	141	I	YII
Ura-Tyube	-14	-17,3	-6.0	-29.0	42.0	1.5	154	I	YII
Pendjikent	-16	-16,0	-4.0	-28.0	42.0	2.5	139	I	YII
Khorog	-17	-23,3	-8.0	-32.0	38.0	-3.1	162	I	YII
Dangara	-14	-14,0	-3.0	-27.0	45.0	3.1	112	I	YII
Djirgital	-17	-22,8	-8.0	-27.0	36.0	-1.4	181	I	YII
Komsomolabad	-16	-19,0	-4.0	-30.0	41.0	0.4	144	I	YII
Garm	-19	-19,6	-5.0	-32.0	40.0	0.2	149	I	YII
Nau	-13	-16,1	-5.0	-29.0	44.0	2.1	130	I	YII
Isfara	-12	-16,8	-6.0	-25.0	42.0	1.8	141	I	YII

The duration of solar radiance on the territory of country varies from 2000 to 3000 hours annually. In mostly populated areas – Gissar and Vakhsh valleys and Leninabad Oblast it exceeds 2700 hours annually. The number of days with no sun in these areas constitutes just 35-40 days annually. At the same time mean monthly air temperature on the most territory of the republic is positive (table 12).

Table 13 displays values of total solar radiation for major districts of the country. This data shows that around 1700 kWt.hour. can be produced annually out of 1 m^2 at full use of solar energy, i. e. much more than the current residential use per person.

Table 13. Total monthly solar radiance in major populated areas of Tajikistan, Wt./m^2

Populated areas	Months											
	I	II	III	IY	Y	YI	YII	YIII	IX	X	XI	XII
Dushanbe	87	122	156	209	275	327	330	294	244	168	112	77
Khudjand	87	114	164	229	290	330	322	290	243	164	100	65
Kurgan Tyube	80	115	153	213	277	333	322	290	232	165	110	73
Kulyab	87	122	156	209	275	327	330	294	244	168	112	77
Regar	87	122	156	209	275	327	330	294	244	168	112	77
Yavan	87	122	156	209	275	326	330	294	244	168	112	77
Shaartuz	80	115	153	213	277	333	322	290	232	165	110	73
Nurek	87	122	156	209	275	327	330	294	244	168	112	77
Kanibadam	87	114	164	229	290	330	322	290	243	164	100	65
Ura-Tyube	87	122	156	209	275	327	330	294	244	168	112	77
Pendjikent	87	122	156	209	275	327	330	294	244	168	112	77
Khorog	96	137	187	320	304	350	340	305	258	172	114	86
Dangara	87	122	156	209	275	327	330	294	244	168	112	77
Djirgital	96	137	187	320	304	350	340	305	258	172	114	86
Komsomolabad	87	122	156	209	275	327	330	294	244	168	112	77
Garm	87	122	156	209	275	327	330	294	244	168	112	77
Nau	87	114	164	229	290	330	322	290	243	164	100	65
Isfara	87	122	156	209	275	327	330	294	244	168	112	77

And at the same time solar energy is not widely in use in Tajikistan. It is explained by several reasons. First of all, the technology of direct transformation of solar energy into electricity is rather complex and expensive. That's why even in developed industrial countries its use is very limited. Secondly it is linked with irrational low prices for all kinds of fuel and energy resources, even those imported, existent in Tajikistan and whole USSR. To some extent there is a trace of it even now in 2006, with extremely low tariffs for electricity of 0,5 cents per kWt.hour., with sale rate of not more than 80%.

Thus solar energy cannot be considered as a reliable and sustainable source of electricity at the industrial scale in today's Tajikistan. However its exploitation for obtaining low potential thermal energy for residential use is possible and rational. It is realistic with current investment opportunities, installations of such type – collectors – are simple in construction and production. Mass production of solar collectors can be developed by the plants of the republic, currently idle. The country possesses aluminum for these installations. At the same time low density of solar energy of 100-300 Wt./m^2, which is usually considered as a drawback, ceases to be of importance. The issue is that powerful streams of energy are not required for residential use, and today the energy of large electricity stations is thinned out by lines: power transmission line of 500 kW. – power transmission line of 220 kW. – power transmission line of 110 kW. – power transmission line of 35 kW. – power transmission line of 10 kW. – power transmission line of 0,4 kW. – 220 W.

Lastly, home use devices using electricity are usually no more than one kilowatt capacity. The coefficient of efficiency of solar collectors is also of no considerable importance. A low coef-

ficient of efficiency in turbines and generators is dangerous because a inefficient part of energy works to destroy the mechanisms. In solar collectors, such energy does not assemble and therefore stays reliable. The calculations display that even with very low coefficient of efficiency the solar energy used for residential needs can sustain the needs of population by 60-80% during at least 10 months throughout the whole territory of Tajikistan.

Nuclear energy from purely technical point of view could have been of favorable prospect in Central Asia, and particularly in Tajikistan with its large reserves of uranium, but its realistic development in the nearest future is problematic. First of all it is linked with high seismic activity of the district, and alerted relation of the whole population to the reliability of atomic reactors, especially after Chernobyl catastrophe. Further on, nuclear stations are rather costly, and the energy is very expensive, more expensive than one of thermal stations, not mentioning hydraulic ones. Lastly, construction of nuclear station in one of Central Asia republics, including Tajikistan, will require agreement and consensus with other countries, both neighboring ones and those located far away, which is currently not possible.

The prospects of industrial use of bio energy is even less than of nuclear energy. First of all, animal husbandry in Tajikistan is for internal use and livestock population, and is of small quantity. Today there are only 719,8 thousands of cows, 75,4 thousands of horses and 1893,4 thousands of sheep. At the same time the population itself traditionally uses all manure for heating and cooking.

3.4. Fuel and energy balance of Tajikistan

To sum up, it can be concluded that the basis of energy resources is renewable and ecologically clean hydro power, whose reserves exceed the needs of the country many times. Even according to potential reserves of hydro power resources, Tajikistan is placed as the eighth country, after China, Russia, USA, Brasil, Zair, India and Canada. As for specific indicators, the hydro power potential per capita (87,8 thousands kWt.hour. per capita annually) it shares the first and second places with Norway, and according to potential reserves of hydro power per km^2 of the territory (3682,7 thousands kWt.hour./км.^{2} annually) holds the first place in the world.

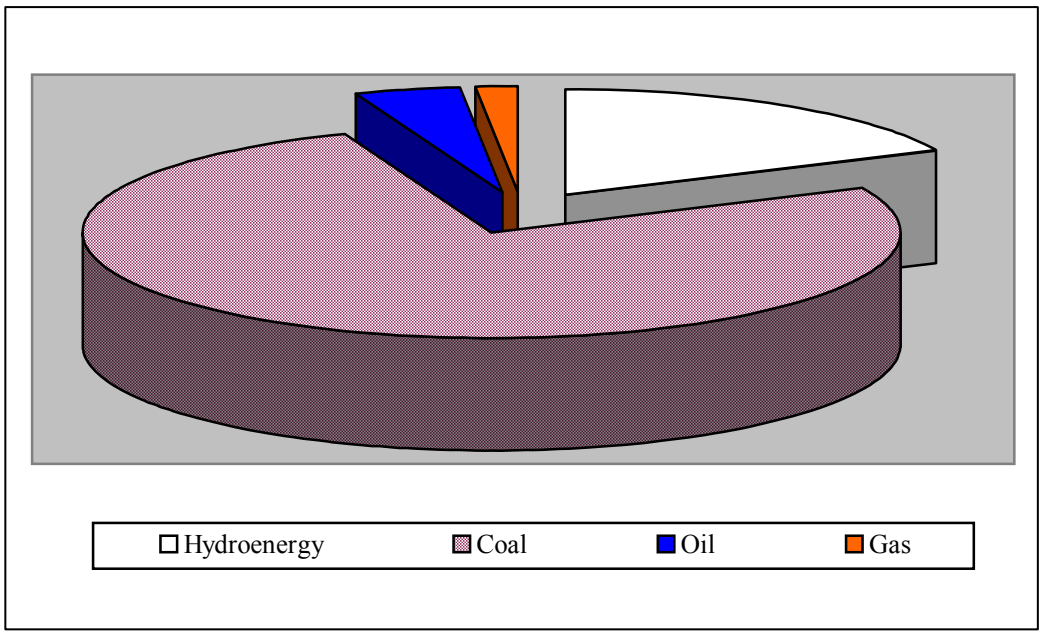
After hydro power the only type of energy whose reserves are sufficient enough for industrial scale use is coal. Taking into account that 95% of Tajikistan's current energy system is based upon the hydro power, there are no limitations for the use of coal from environmental point of view. Unfortunately as it has been stated above, the industrial use of coal in Tajikistan is currently problematic due to technical and economic considerations. Realistically the coal in Tajikistan can be made used of only at the local and residential level. Similarly solar energy can be used at the local and residential level, and to the very limited extent, bioenergy.

Hydro power resources suitable for use in Tajikistan exceed the current hydro generation in the whole Central Asian region two times (130,5 billion kWt.hour. annually) and constitute 56% of the whole consumption of primary energy resources in it, including coal, oil and gas (149,4 mln. t.c.t. annually)[3].

Hydro power resources are practically evenly distributed throughout the whole territory of the republic and are of sufficient amount not only in large rivers, but in medium and small rivers as well.

It must be noted, as a conclusion, that the general structure of energy resources of Tajikistan, according to the analysis made, is as displayed on the table 14 and graph 1.

[3] The United Nations Special Program for Economies of the Central Asia "SPECA". The research "Rational and effective use of energy resources in the Central Asia". Moscow, 2002.



Graph 1. The general structure of energy resources of Tajikistan

Table 14. The general structure of energy resources of Tajikistan, mln. t. c. t.

Hydro power resources	Coal	Oil	Gas
158,12	667,3	37,0	15,0

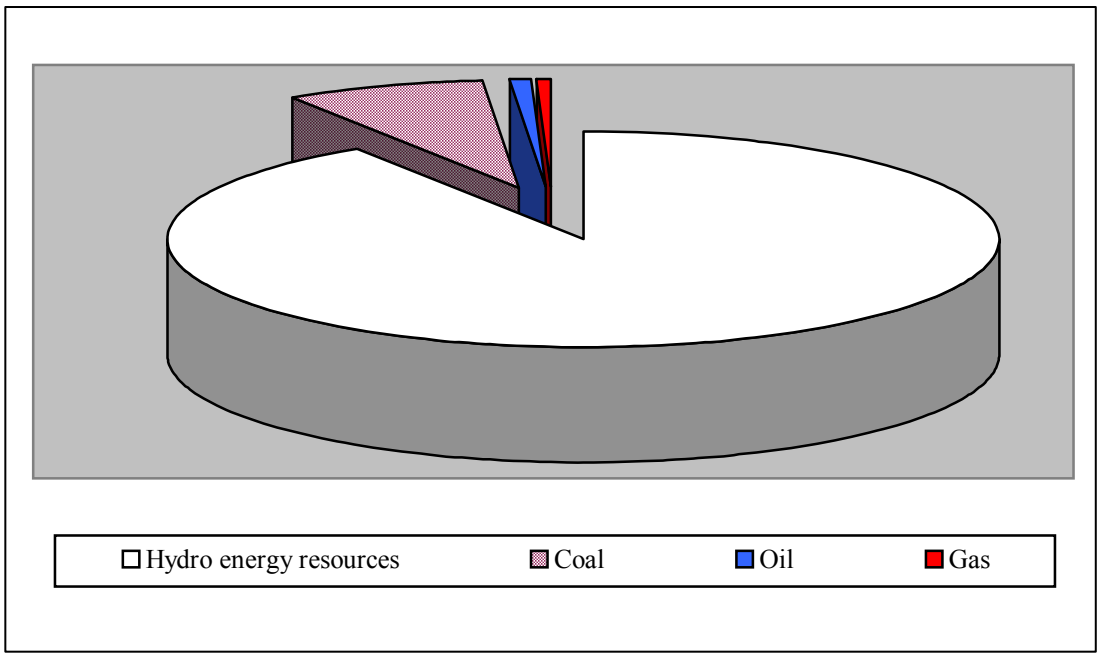
The evaluation given on the table 14 and graph 1 is displayed in a way that is accepted worldwide. It must be noted that given the way the graph of energy resources is distorted, the role of renewable resources is smaller, including the role of hydro power, in comparison with that of mineral resources. It is due to the fact that the mineral fuel is evaluated according to their general reserves while renewable resources are evaluated according to their annual capacity.

In order to make these figures comparable, a notion of "life cycle" mostly used in the investment projects is to be introduced for the mineral deposits. It will enable to determine the annual potential of mineral fuel resources which then can be compared with hydro power potential and other renewable resources.

Let's assume that the life cycle of coal deposits constitutes 50 years, and the life cycle of oil and gas deposits constitutes 20 years. Taking this into account, the general structure of the energy resources of Tajikistan reduced to an annual denominator will be as indicated in the table 15 and graph 2. It drastically differs from the one represented on the graph 1.

Table 15. Structure of annual energy resources of Tajikistan, mln. t. c. t.

Hydro power resources	Coal	Oil	Gas
158,12	13,35	1,85	0,75



Graph 2. Structure of annual energy resources of Tajikistan

Thus, there is no other alternative for Tajikistan in the sector of energy except hydro power resources. However at the same time the reserves of hydro power are utilized only by 5÷6%. In any scenario of development, its total resources will always exceed national needs. Therefore it is reasonable to consider their use at the regional level.

4. Socio-economic characteristics of Tajikistan

Central Asia is a region with complex history; it has experienced diverse political, economic, social and ecological crises. The last such cataclysm occurred in the 1990s after collapse of the USSR. It resulted in drastic decrease of economic potential in all former Soviet republics and lowered living the standards of population. The ecological situation also changed in both positive and negative ways, enhancing because anthropogenic pressure reduced, and deteriorating due to improper use practices.

Such situation cannot last long, and all countries of Central Asia region should make a choice of development path. That is why an elaboration of the sustainable development program is particularly urgent and important.

Sustainable development theory is an ideology oriented towards the survival of mankind. It is a way to sustain a secure and prosperous future, while in synergy settling issues of economic, social development and environmental protection.

Sustainable development envisages economic growth and the satisfaction of peoples' basic needs, enhancement of their living standard and the protection of the environment.

In Tajikistan there are several issues considerably influencing its sustainable development.

Environmental protection, first of all, of its fragile mountainous ecosystem, is one of the most important issues of sustainable development in the country. Environmental degradation is a major concern of scientists, businesses and governments in many countries; environmental crisis alerts global community, and calls for measures to combat environmental issues on national, regional and international levels. Every day human activity influences the environment. Environmental degradation resulting from the activity of just one person can compromise the lives of many.

Territorial positioning of Tajikistan also results in some negative consequences. Situated in the outskirts of the USSR and lacking developed infrastructure, Tajikistan lagged behind the other Soviet republics in development. The severance of existing economic relations especially took a toll on Tajikistan. National conflicts of early 1990s and population outbreak observed during the last decades of the 20th century and social and natural cataclysms also had negative impacts.

Thus since gaining independence, Tajikistan is faced with very severe crisis situations, to construct the new state.

4.1. Poverty and economic rehabilitation

The issue of poverty is not new for Tajikistan; while part of the USSR Tajikistan had the lowest income per capita among all former Soviet republics.

Structure of the economy inherited from the Soviet epoch of 1991 turned out to be uncompetitive in the new market environment, and the civil war delayed the introduction of structural reforms. The transition period and war weakened official and non-official mechanisms of social security and further resulted in an increase in the number of poor. The transition from administrative command system to market economy, breakup of the economic relations with the republics of the former USSR and the civil war resulted in a mass release of labor force, veiled from the public eye. The high level of inflation led to the reduction of real incomes of population, facilitated the increase of economic disparity and disrupted investment climate. Insufficient level of national production resulted in the increase of import, balance of payment deficit and devaluation of national currency.

Poverty level depends on the criteria used for its definition. Poverty level in Tajikistan varies from 17 to 97 % depending on the criteria elaborated by different international and national organizations. Around 60% of population consider themselves as poor. The government undertakes population self-assessment as the criterion for defining poverty (table 16).

Almost three quarters of the population of Tajikistan lives in the rural area; larger proportion of the poor also live in the rural area - 23,4% of population, compared to 18.6% of population in the urban area. The largest proportion of the poor compared to total population live in GBAO (39%).

Table 16. Poverty indicators in Tajikistan

Population, %, under minimum level of consumption	96%
Population, %, under the poverty level	83%
Population, %, under 50% of poverty level	33%
%, the most poor (living on less than 1 ,075 USD per day)	17%

Source: World Bank and State Agency for Statistics of the Republic of Tajikistan, 2000.

As in all other countries of the world, the risk of being poor in Tajikistan is correlated to the level of education. Poverty is mostly spread among those lacking secondary and higher education.

The increasing number of unemployed also aggravated poverty. According to some estimations, the level of unemployment equals one third of labor force in Tajikistan. Old mechanisms for provision of employment do not work now, and new market mechanisms are still too weak to provide new jobs.

In order to increase the living standard of population and to settle socio-economic issues, the national program to combat poverty "Poverty Reduction Strategy" Paper was adopted.

This document acknowledges the need and importance of deep economic reforms and sustainable economic growth. The benefits for majority of population, particularly the poor, are to be created on its basis.

The major directions and mechanisms for poverty reduction are determined in the PRSP. The Government of the Republic of Tajikistan aims to implement the Poverty Reduction Strategy with support from International Monetary Fund (IMF), World Bank (WB), Asian Development Bank (ADB), United Nations Development Programme (UNDP), other international finance organizations and donor-countries.

The main goal of the Poverty Reduction Strategy is an increase of real income in the country, fair distribution of the economic growth benefits, and specifically, increase of the living standards of the poor.

PRSP maps four major directions which determine the Poverty Reduction Strategy:

- Facilitation to an accelerated and socially just economic growth with intensive inclusion of labor resources and emphasis on export;
- Effective and just provision of basic social services;
- Addressed support to the most poor;
- Efficient management and enhancement of security.

Successful strategy for poverty reduction requires an effective management of macroeconomic situation and efficient state management. The major indicators to be accomplished by 2015 are given in the table 17.

Table 17. Target indicators for reduction of poverty level

Indicator	Existing situation	Target indicators for 2015 г.*
Population, %, living on less than 1 USD per day	17 (year 1999)	15
Population, %, with primary education	77,7	90
Child mortality per 1000 children liveborn (2000)	36,7	25

Maternal mortality per 100000 children liveborn (2000)	43,1	35
Population with access to reproductive health services, (%)	21,8	30
Proportion of private sector in GNP, (%)	30	60
Population with access to safe drinking water, (%)	51,2	80
Employment level, (%)	56	65-70
Number of telephones per 100 people	3,6	5

* Target year, established by the United Nations within the framework of Millennium Development Goals.

The financing of the Poverty Reduction Strategy is planned to be provided by three sources: Medium-term budget program, State Investment Program and annual budget.

Approximate expenditures for poverty reduction, with breakdown on external and internal finance needs, are represented on the table 18. The total amount of resources required constitutes around 690 mln. USD.

Table 18. Financing of PRSP action program, thousand of USD

Sector	**Existing external resources**	**Financing needs**		
		External	**Internal**	**Total**
State management	1,322	3,728	258	3,986
Social security	-	70,611	37,981	108,592
Social services	55,000	43,800	14,000	57,800
Education	5,000	43,263	19,673	62,936
Health	25,412	27,647	8,726	36,373
Agriculture	118,140	127,100	18,840	145,940
Privatization, labor and development of private sector	3,985	14,909	2,105	17,015
Energy	58,300	61,520	17,780	79,300
Transport	74,000	83,000	21,000	104,000
Telecommunications	15,000	23,049	1,191	24,240
Water supply	15,000	40,105	4,205	44,310
Environmental protection, tourism	-	3,415	38	3,453
Total	**371,247**	**542,147**	**145,797***	**687,944**

* Including 18,3 mln. USD of non-budgetary financing

It will be possible to achieve the real poverty reduction of the population only if the country economy is rehabilitated. To reach this, it is essential to develop the export potential of the country, to increase the proportion of export in GNP and to accelerate accession to WTO. The development of small and medium businesses is also of great importance.

All these interventions are possible only if hydro power of complex function is developed in a sustainable way as the basis of economy and export. The high effectiveness of the energy of Tajikistan based on hydro power resources should be particularly noted. The total cost price of electricity of Tajik energy system constitutes 0,4 cents per kilowatt hour. Therefore even at the capacity existent nowadays at the tariff 1 cent/kWt.hour., the general profit of the energy system will equal 90 mln. USD.; at the tariff 2 cents/kWt.hour. it will increase up to 240 mln. USD; at the tariff 3 cents/kWt.hour. profits can hit 400 mln. USD annually. The profits of the energy system will proportionately increase with introduction of new capacities. These estimates are more than the current national budget, which constitutes around 200 - 300 mln. USD annually. The hydro power of Tajikistan is competitive not only at the world arena, but at the regional scale as well. Without including the cost of fuel, it is nowadays cheaper per kilowatt hour by 2 cents at minimum, compared with Kazakhstan, Turkmenistan, Uzbekistan. Thus it can turn into major export sector of the republic.

Evidently hydro power can not only be the basis of the economy, but also the budget forming sector of the state. It can prove to play decision-making role in combating poverty as well. With hydro power, not only development of the sector itself is ensured, but also those of irrigation and agriculture. It is undoubtedly also related to environmental protection as well. Financing of environmental projects can be implemented in this case both directly, and with introduction of environmental taxes, rent, etc.

At the same time, to reduce population poverty, of which 70% lives in the rural area, only the acceleration of the development of small hydro power can be employed. It is essential to state that with construction of small HPPs, the challenging and complex issue of transportation infrastructure for energy transmission is settled too, as small HPPs are constructed in the vicinity of consumers.

Another priority for the country is the development of transportation infrastructure (construction of motor roads and railways), which would connect Tajikistan with other countries and would decrease the level of geographical isolation and therefore provide the opportunity to access world markets.

In the area of external economy it is essential to create favorable investment climate for foreign investments into the economy. This includes investments for restructuring the economy and the control of permissible level of external debt. In this case small hydro power is a priority for the near future, both for investments, and the repayment timeframe.

4.2. Social issues of development

Population and living conditions

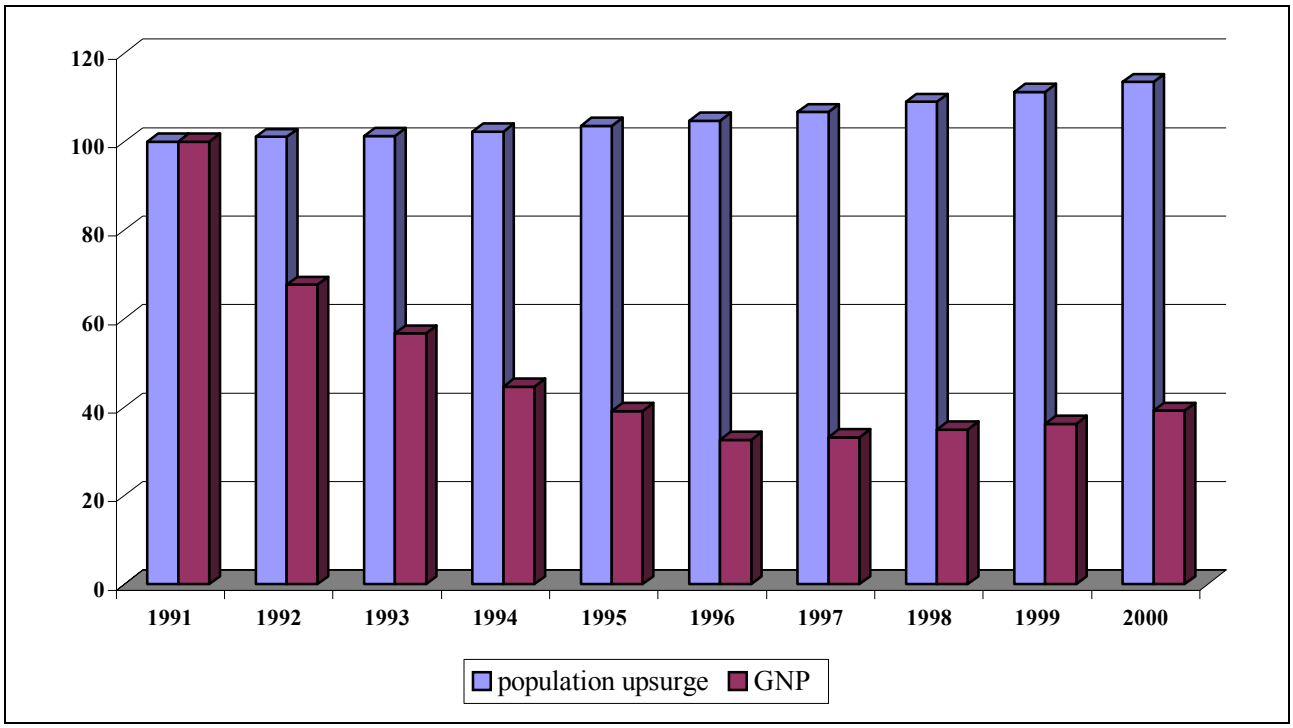
The population in the republic increases at high rates. According to the data of population census of 2000, the number of population equals 6,127, i.e. increased in comparison with 1991 by 14%, and since 1970 it increased twice, since 1960 it increased thrice. According to the data, at the end of 2005, the number of population was equal to 6,9203 mln. people. Preliminary estimations show that at this rate ,by 2010, the population will be around 8 mln. people. Such a drastic increase in population, with current limited resources negatively affects the economic development of the country (graph 3).

The average age of population is 22,8 years. More than 43% of population are children aged between 0-15, the average size of household is 7,1 people, 67% of whom have more than 5 children. During this period an average lifetime decreased from 70,5 years in 1991 to 68,4 in 2000; for men it decreased from 67,6 years to 65,6; for women it decreased from 73,2 to 71,3.

One of the most important conditions for the formulation and implementation of the national sustainable development strategy is an account of diversity and multidimensionality of national and cultural background of Tajikistan, its preservation and development. The processes of sovereignty acquisition requires that specific attention be given not only to the role of native peoples, but to national minorities as well, in the interventions taking place in the society.

Tajikistan is still a multinational state, represented by 120 nationalities and other national minorities. As opposed to economic and social spheres which are in crisis situation, interethnic relations remain stable and tolerant. The state policy is based on the concept that representatives of different nations, being nationals of Tajikistan, have all rights and freedoms and liberties of the state. The legislation of the Republic of Tajikistan allows not a single disposition for discrimination on race or nationality.

Graph 3. Ratio of population upsurge and GNP



Source: State Committee for Statistics of RT, Regions of Tajikistan, statistical resume, Dushanbe – 2001.

The national communities established upon the initiative of citizens serve as an important mean for necessary identification and satisfaction of national minorities. Currently there are 14 national communities in place, including Russian and Armenian communities, Azeri, Uzbek, Kyrgyz,

Turkmen and Georgian communities, Korean association, etc. The majority of these communities are parties to the Agreement on civil accord in Tajikistan.

The knowledge of languages is important for interethnic relations. According to the population census, only 30,3 % of other nationalities fluently speak Tajik, the state language. Russian is the most widely spoken. This language is stated as native or second by 20,1 % of country population (36,4% - in 1989).

The situation with population upsurge formed under the influence of the number of factoes : geographic, economic, social, political peculiarities, as well as national customs, religious and cultural and household traditions. The main ones are as follows:

- Civil war of 1992-1997, the breakup of economic relations with the former Soviet republics and consequently the drastic decrease of production at the high rates of population increase resulted in unemployment of more than 15% of the country.
- Mountains occupy more than 93% of the land in Tajikistan; the area suitable for agricultural produce is very limited. Currently there is 0,11 ha of irrigated land per resident; and at the rate of population increase, especially in rural areas (more than 73% of this population lives in rural area), it will constitute 0,08 ha by 2010. The deterioration of irrigation system during the last years resulted in a decrease of arable land and the development of mountainous and sub mountainous zones by rural population. It all leads, in turn, to the decrease of pasture lands, soil erosion, mudflows and destruction of residential areas.
- The activity of education system and health sector drastically deteriorated, the financing of these sectors decreased several times as well as the number of teachers and doctors as many of them left the country and quit jobs because of low salaries and political destabilization in mid 1990s.

The existent demographic situation urges for the taking of special measures on the regulation of population. The President of Tajikistan made a special speech at the republican meeting named “Family planning is a basis for sustainable development of society” on the 20 February 2002. In accordance with the President’s speech, the Centre for social issues under the Academy of Sciences of the Republic of Tajikistan developed the project concept of “State demographic policy of the Republic of Tajikistan for 2003-2015”. All issues concerning demography are coordinated by the Commission on population and development under the Government of the Republic of Tajikistan. There is also the Committee for women issues and family under the Government of the Republic of Tajikistan.

The collapse of USSR, breakup of economic relations with former Soviet states, and the civil war activated external and internal migration in the Republic of Tajikistan.

A total number of 741,8 thousand people left the country, and 373,3 thousand people arrived during 1991-2001. The negative balance of external migration equals 368,5 thousand people. The basic causes of migration also changed during this period. These included political, interethnic, socio-economic and religious causes.

In accordance with the Decree of the Government of the Republic of Tajikistan on “Priority measures on external labor migration of the nationals of the Republic of Tajikistan” and according to the Decree of Madjlisi Oli of the Republic of Tajikistan on “Basics of external labor migration policy of the Republic of Tajikistan” it is essential to accelerate the conclusion of agreements and contracts with neighboring and foreign countries.

The settlement of demographic issues at the high rates of poverty is a national strategy for sustainable development.

The issue of stable settlements is of great importance for the sustainable economic and political development of Tajikistan. Migration over the last years took place spontaneously, without sufficient state administration. Therefore an integrated state migration policy must be developed. The goal of the state migration policy then would be the formation of the optimal flows of migrat-

ing population taking into account the concrete political, economic and national interests of the country.

The instruments of migration policy then would be economic, legal and educational ones.

Taking into account the development of new valleys and irrigation areas in 1930-40s and 1950-60s, the inhabitants of mountainous districts were relocated to valley zones. The mountainous areas were mostly used as summer pastures. The anthropogenic pressure on the mountainous ecosystem decreased several times. Many mountainous ecosystems were rehabilitated during this period. After adoption of the Governmental Decree on the rehabilitation of mountainous settlements in 1990, many inhabitants moved back to their previous households and started intense use of land, water, forest and other natural resources, thus disrupting ecological balance. The intensive degradation of land, water, forest and other natural resources is taking place, which is primarily linked to the lack of sufficient energy resources for heating, cooking and social needs – sanitation and education.

Governmental and ministerial structures, scientific research centers and civil organizations in Tajikistan are therefore tasked with the elaboration of the National action plan and strategies for the development of mountainous areas.

One of the main issues is provision of sustainable energy for rural settlements. It is only possible if the use of local sources of energy are developed (primarily the hydro resources of small rivers which are evenly distributed throughout the whole territory of the republic) especially in its mountainous areas.

Population employment and income on provision of production freedom and external trade, price liberalization, ban on direct state

The market reforms in the economy, based management of enterprises, denationalization and development of private businesses, heterogeneous economy and equality of property types have been implemented in independent Tajikistan since 1992.

According to the estimations of sociologists, the consumer budget increases annually due to the transition period, the increase in price of food, communal services, as well as inflation. In 2002 it constituted 27,38 somoni (9,2 USD) per month per capita. In 2005, it increased up to 89,2 somoni (28,6 USD). Its proportion for payment of services, taxes, fees, etc. increased from 3,89% to 19,9% accordingly.

The market reforms put as its base for entrepreneurship, both in cities and rural area, the development of agricultural enterprises, dekhkan farms and dekhkan-farmers. Unfortunately the lack of stable energy supply hampers the processes of small enterprise development in rural areas.

It is essential to create favorable conditions for entrepreneurship development for both small and medium businesses in order to enable the sustainable development of the Republic of Tajikistan. The following measures are to be undertaken:

- Provision of equal competition conditions for everybody (taxes, customs, benefits, etc).
- Creation of bankruptcy mechanism for enterprises and legal entities.
- Assessment of unused state resources.
- Provision of sustainable development for banking system.

It requires in its turn:

- Increased state financial support for the development of small and medium business'.
- Support of banks in financing small and medium business'.
- Provision of conditions for the establishment of financial institutions (loan organizations, insurance companies, etc.).
- Creation of favorable conditions in order to attract foreign capital for the development of entrepreneurship in Tajikistan.

The role of entrepreneurs in the economy of Tajikistan had a stable tendency of growth in 1991 – 1998 (table 19). After that, the growth slowed down and even recessed. One of the main reasons for this situation is the lack of energy resources. The drastic deficiency of electricity and introduction of limitations on the use of electricity took place after 1998.

Table 19. Number of population, employed in individual labor activity

Year	1991	1992	1996	1997	1998	1999	2000	2005
Total, thousands of people	8,1	5,7	45,8	47,4	116,0	50,7	62,2	88,6
Employed in consumer services, %	18,6	18,8	22,4	0,3	7,6	7,4	8,5	5,6
Employed in social and cultural sphere, %	2,1	2,1	0,2	0,1	0,2	0,1	-	-
Employed in trade and catering, %	-	-	53,1	84,6	84,1	75,0	77,1	62.4
Employed in other activities, %	79,3	79,1	24,3	15,0	1,1	17,5	14,5	32,0

Source: Statistical Yearbook of the Republic of Tajikistan – Dushanbe, 2006.

Three quarters of the population in Tajikistan lives in rural areas, and the majority of the most poor are among this population. At the same time agriculture is one of the top priority sectors of the economy and will retain this position in the prospective future. Agriculture contributes to one quarter of GNP and employs more than 60% of the economically active population of the country.

Over the past few years, the state has oriented towards the support of and facilitation of agricultural entrepreneurship and dekhkan farms. The allocation of 75000 ha of land to the rural population has contributed a lot to the development of the sector. The volume of production by individual farms constitutes more than 50 percent of total agricultural production in the country. Due to privatization and use of entrepreneurship methods, the sector started to develop actively.

The legal basis for the establishment of agricultural enterprises is formed by the new law of the Republic of Tajikistan "On dekhkan farms", adopted on the 19th March 2002 by Madjlisi Namoyandagon Madjlisi Oli of the Republic of Tajikistan and approved on the 23rd of April 2002 by Madjlisi Milli, which facilitates establishment of dekhkan farms in a simplified form, without acquisition of legal entity rights.

The number of dekhkan farms in the republic is constantly increasing, and their area increases as well (table 20).

There are a number of international organizations working in this area in Tajikistan, such as the German Agroaction, "SEBEKO" Netherlands, Aga Khan Foundation. The loans are also provided by Mercy Corps, Shelter Now, UNDP, ACTED.

At the same time there are great challenges faced by agriculture as a whole, as well as in the development of private enterprises. It is linked to the lack of a stable electricity supply, essential both for arable farming ,the base of agricultural production (around 90% of all agricultural production is produced on arable land), and for the processing of agricultural products.

Table 20. Dekhkan farms

Year	1992	1996	1997	1998	1999	2000	2005
The number of dekhkan farms, unit.	31	2386	8023	10223	9293	12639	23101
Area of agricultural land, thousands ha	0,7	64,2	139,0	287,5	859,6	1395,5	2380,6

Medium size of land plot, ha	22,6	26,9	17,3	28,1	92,5	115,6	103,1

Source: Statistical Yearbook of the Republic of Tajikistan – Dushanbe, 2006.

It is only possible to settle the issue of energy supply to individual agricultural producers if the small scale HPP sector is developed. The construction costs of small scale HPPs are affordable and timeframes of construction are minimal. Their construction can be oriented for energy supply of isolated or prioritized users. Lastly, the construction of small scale HPPs can at the same time settle the issue of water supply.

Population health and healthcare

The health of the population is the most precious wealth and the most important factor of a country's development and wellbeing. From this point of view, healthcare should be considered not as a consumer sector, but as a sphere of profitable capital investments directed towards poverty reduction and resource mobilization, which attract the international community.
The importance of the problem increased during the transition period when, due to the political instability of 1990s and economic challenges, the negative factors influencing population health increased.

Currently most of healthcare problems are stipulated by: an increasing gap of health condition among socio-economic groups of the population, a dramatic increase in the number of some infectious and non-infectious diseases, high injury rate, deficient information database on population health, preservation of old non-adequate financing system, and disproportions between first medical aid and hospital healthcare services. There are inadequacies between rates of demographic, socio-economic and environmental development:

- Life expectancy at birth decreased in Tajikistan from 69.4 in 1990 to 67.6 in 2000.
- The indicator of child mortality still remains high (17.2 for 1000 liveborn in 2002), despite that it decreased in its dynamics for more than 2.4 compared with 1990.
- There is much concern on reproductive health of female population, as there is still high rate of maternal mortality.
- There is a high occurrence of cardiovascular diseases being the most often cause of deaths in the age group up to 65, as well as in the age group of over 65.
- Respiratory diseases death tolls hold first and second places.
- The problem of infectious diseases aggravated. The epidemic occurrence of eliminated or minimally occurring infectious diseases appeared.
- The serious problem posed by diarrhea, often causing death, increased during recent years despite the coordinated strategy for combating the disease
- The number of HIV infected people increased. According to official data, there were no HIV infection cases up to 1997, 7 HIV cases were registered by 2000, 34 cases were registered in 2001, and 30 cases were registered in 2000.

The social and economic instability negatively affected the functioning of healthcare institutions. All these factors together facilitated the recognition of a need for reforms in the healthcare sector with the aim of stabilization and the enhancement of the existent situation.

The aim to implement healthcare reforms resulted in the orientation towards international practices and the introduction of effective and economic approaches to organize, develop and enhance the quality and the population's access to medical services. It also furthered the development of international collaboration in the sphere the Ministry of Health of the Republic of Tajikistan, elaborated the Concept of Healthcare Reforms in the Republic of Tajikistan (further adopted by the Decree N94 of the Government of the Republic of Tajikistan as of the 4th of March 2002), and the Strategy of the Republic of Tajikistan on Healthcare up to 2010 (further adopted by the Decree N436 of the Government of the Republic of Tajikistan as of the 5th of November 2002).

The Ministry of Health of the Republic of Tajikistan leads the preparation of project decree on the approval of "The Strategic Plan of the Republic of Tajikistan on Reproductive Health" from instructions by the Commission on population and development under the Government of the Republic of Tajikistan. Apart from this, the project on "Reproductive Health and Reproductive Health"by sub-commission on reproductive health and reproductive rights under the Government of the Republic of Tajikistan.

The Concept of Healthcare Reforms of the Republic of Tajikistan envisages the strengthening and enhancement of primary healthcare through : reorganization and review of its functions, resource reallocation of healthcare system, introduction of family medicine, staff education, enhancement of physical infrastructure and quality of medical services, supply of medicines and goods for medical purposes.

These reforms and the enhancement of provision of medical services to the population, especially in remote areas, is impossible without stable electricity supply. Thus the importance of small scale hydro energy is acknowledged once more.

Education, literacy and population awareness

Since its independence, Tajikistan formulated the legislative base which provides the development of education in the Republic of Tajikistan.

Madjlisi Oli of the Republic of Tajikistan adopted the law of the Republic of Tajikistan "On education" (1993г). The Government of the Republic of Tajikistan approved "The statute on preschool institutions" (1995), "Standard regulations on comprehensive school in the Republic of Tajikistan" (1995), and "The state standard of comprehensive school", "The standard regulations on comprehensive educational institutions of secondary and higher professional education" (1996), "The state educational standard of secondary and higher professional education" (1996) and "National concept of education of the Republic of Tajikistan" (2002). The Government of the Republic of Tajikistan approved "The state program of environmental education of the population of the Republic of Tajikistan up to 2000 and for the prospect up to 2010" and activities on implementation of this program (1996), and the Program of secondary school computerization up to 2007. There are two other documents on review stage: "On national program of education development of the Republic of Tajikistan up to 2010" and "On program for preparation of teaching staffing the republic".

The Government of the Republic of Tajikistan and the Ministry of Education adopted more than 150 legislative-regulatory documents defining the status of educational institutions and state standards of education.

The second stage of reforms envisages the enhancement of education quality at all levels of educational institutions through the establishment of educational institutions of new type (gymnasiums, lycee, colleges), enhancement of educational plans and programs, provision of textbooks and tutorials and the strengthening of school financial bases and the preparation of teaching staff.

The socio-economic policy conducted by the state aims to enhance the financial system in the education sphere and to improve its efficiency.

In order to created the most favorable conditions for preschool child education and also taking into account family interests and needs, state and private nurseries, kindergartens and other preschool institutions: seasonal, daytime and around the clock kindergartens, kindergartens of boarding type, were established.

However during the transition to market economy many industrial enterprises, kolkhoz and sovkhoz reduced the number of preschool institutions. Their number today reaches 469 with total number of 59.7 thousand pupils.

Currently there are 3677 secondary schools in the country. These include 662 primary schools, 844 nine year schools and 2040 secondary schools with 1 mln. 617 thousand 650 pupils. This number annually increases by approximately 60 thousand pupils.

Apart from schools of comprehensive type, the number of new type schools increases annually (gymnasiums, lycee) both state and privately owned.

The correspondence education is also widely spread in the republic. 17292 people study in 45 secondary correspondence schools, including 5093 girls. Apart from this there are 36.5 thousand people studying at the correspondence courses of higher education institutions.

Educational activities in out-of-school hours are an integral part of the education system of the republic. Currently there are more than 70 out-of-school institutions functioning in the country (clubs, stations, centers of children creativeness, sports and musical and art schools), with more than 150 thousand people involved.

Currently there are 75 institutions of vocational training with 25.5 thousand students. Annually 13.6 thousand specialists graduate and 16.0 thousand students enter the vocational training institutions.

More than 96,5 thousand students study 146 major directions in 30 higher education institutions of the country. There are 5665 professors employed in these higher education institutions, including 304 full professors and 1549 associate professors.

Measures and activities are undertaken to increase environmental awareness and environmental education among the population. The aim is to implement the law of the Republic of Tajikistan "On environmental protection" and "The state program of environmental education".

Starting from 2002-2003 a special course in ecology was introduced to the 8th form of secondary schools. The course program on ecology was elaborated and a textbook on ecology for the 8th forms of secondary schools was developed for publication.

The enhancement of a modern state of multilevel educational system, which collapsed as a result of the civil war and economic crisis, is still one of the most urgent issues of the Republic of Tajikistan.

The issue of particular importance is the access of rural population to the modern methods of education. This issue is to be settled through the use of information technologies. Unfortunately today its use is hindered by the lack of stable electricity supply. Thus the issue of small scale hydro energy development is put as a priority on the agenda.

Interstate collaboration.

Tajikistan is interested in the establishment of long-term and mutually beneficial relations with neighboring Central Asian countries.

The Central Asian Region (CAR) is currently, as a whole, self-sufficient in terms of mineral fuel reserves and in the prospective future. The CAR proportion in the structure of global explored reserves of coal, according to MIRES classification, constitutes around 4 %, the proportion of global explored reserves of oil constitutes 2 %, the proportion of global explored reserves of gas constitutes 4,5 %. Lastly the CAR proportion of global explored reserves of uranium constitutes more than 20 % (Kazakhstan and Uzbekistan). The period of resource exhaustion, i.e. energy provision on explored reserves of coal constitutes more than 600 years, energy provision on explored reserves of oil constitutes 65 years and energy provision on explored reserves of gas constitutes 75 years. These indicators are considerably higher than the global ones.

However these reserves are very unevenly distributed. The larger proportion of gas and coal reserves are situated in Kazakhstan; the largest proportion of oil reserves is in Turkmenistan. Uzbekistan's share of coal and gas is less than of the countries mentioned above, nevertheless is much more than in Tajikistan and Kyrgyzstan, which practically lack any reserves of mineral fuel. At the same time Tajikistan and partly Kyrgyzstan possess vast water resources and potential hydro energy which are needed by the other countries of the region.

The joint use of water and energy resources can provide sustainable development of agriculture in the region. Joint development of hydro resources will make the mineral fuel available for its more efficient use in the industry and will relieve pressure on the environment.

Apart from larger hydro energy projects, Tajikistan can presently propose concrete projects of joint hydro resource use in the area of small scale hydro energy development. It requires an establishment of joint technological equipment production and its maintenance. Tajikistan is also interested in joint projects of concrete small scale HPPs.

The analysis conducted above shows that all socio-economic aspects of lives of Tajikistan population require considerable interventions, reforms and enhancement. It is all possible if all the spheres are provided with a stable and secure energy supply. In Tajikistan's conditions, it is only possible with development of hydro energy. For population, especially the rural areas of Tajikistan, sustainable electricity supply is impossible without development of small scale hydro energy, i.e. construction of small scale HPPs.

5. The modern state of energy sector in Tajikistan and its development prospects.

5.1. The general overview of energy sector in Tajikistan

The industrial energy of Tajikistan is based on hydro energy. Therefore this sector in Tajikistan differs greatly from that of other countries, specifically developed ones, as hydro energy is traditional in the republic and serves as an alternative to such energy sources as coal, oil, gas.

As stated in the principles of sustainable development and Kyoto Protocol, the major goal of global energy development is the reduction of traditional energy generation sources and their substitution by non-traditional ones.

This approach initially appeared in developed countries. For developed countries it is a justified approach since thermal power engineering is traditional for these countries and is the most polluting one, creating the emission of greenhouses gases into the environment. The proportion of thermal power engineering in the developed countries is, as a rule, no less than 80-90%. Thus environmentally clean and renewable sources of energy, such as wind energy, solar energy, hydro energy, etc. are considered as an alternative energy.

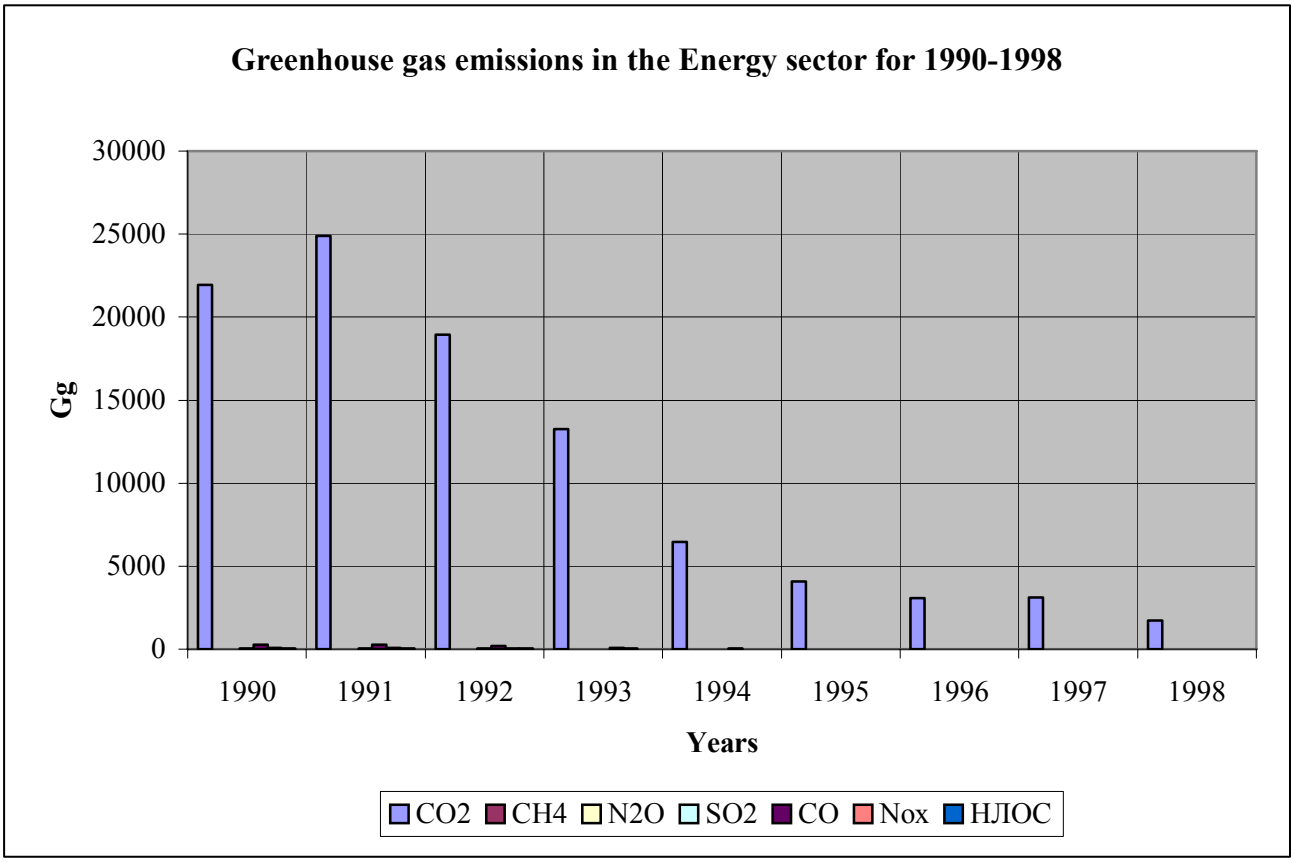
The situation in Tajikistan is just opposite. Tajikistan's base energy generation is hydro energy- renewable and ecologically clean. The alternative energy is of polluting sources: coal, the second in the country from the point of view of resource potential; oil and gas being exhaustible. Thus hydro energy defines the current situation in Tajikistan's energy sector, as well as its strategy for further development.

Tajikistan's hydro energy is a renewable and ecologically clean source of energy. Today, due to the fact that Tajikistan considerably increased the share of electricity and reduced the share of mineral fuel compared with early 1990s, the emissions of greenhouse gases dramatically decreased (table 21 and graph 4). Export or joint production of hydro energy with other republics of Central Asia region can replicate this process within the region.

Table 21. Volumes of greenhouse gas emissions, years

Year	CO_2 emitted	CO_2 absorbed	CH_4	N_2O	CO	NO_x	SO_2	НЛОС	PFC_s
1990	17245	НП	11	0,08	268	63	43	47	НВ
1991	20529	НП	10	0,1	264	76	41	46	НВ
1992	14713	НП	6	0,06	171	48	29	30	НВ
1993	9728	НП	3	0,03	80	27	17	15	НВ
1994	4921	НП	2	0,02	33	14	9	6	НВ
1995	3067	НП	1	0,01	17	8	5,6	3	НВ
1996	2338	НП	0,43	0,01	14	8	4	3	НВ
1997	2423	НП	0,41	0,01	15	8	5	3	НВ
1998	1509	НП	2	0,01	15	10	3	3	НВ

Hydro energy of Tajikistan is very technically efficient. Within CIS, Tajikistan holds second place after Russia for its total hydro resources. However it is related only to absolute reserves. As for technical efficiency of separate watercourses, the situation is rather different. The situation is rather well illustrated by the comparison of main rivers of Tajikistan – Pyandj and Vakhsh with the major river of Russia – the Volga, displayed in table 22.



Graph 4. Greenhouse gas emissions in the Energy sector for 1990-1998.

Table 22. Comparative efficiency analysis of hydro energy potential in Pyandj, Vakhsh and Volga rivers

River	Length, km.	Width in river mouth, m^3/s.	Capacity, mln. kWt.	Electricity production, bln. kWt.hour.	Specific power, thousand kWt./km.
Pyandj	1000,8	2135,6	11,42	100,1	11,4
Vakhsh	691,0	618,3	8,4	74,1	12,2
Volga	3690,0	7790,0	6,2	54,0	1,7

As one can see on the table, despite of the flow, greatly exceeding the flow of Tajikistan's rivers and length, the Volga has considerably less potential, both in capacity and in electricity generation, than the ones of Tajikistan rivers. As for specific power per 1 km. of river length, of the Volga's it is less than the ones of Pyandj and Vakhsh almost by ten times.

And lastly, hydro energy of Tajikistan is economically efficient. The total cost of electricity of Tajik's energy system constitutes 0,4 cents per kilowatt hour. Therefore even at existent capacity at the tariff 1 cent/kWt.hour., the general profit of the energy system will equal 90 mln. USD.; at the tariff 2 cents/kWt.hour. it will increase up to 240 mln. USD; at the tariff 3 cents/kWt.hour. profits can hit 400 mln. USD annually. The profits of the energy system will proportionately increase with the introduction of new capacities. The current national budget constitutes around 200 - 300

mln. USD annually. Evidently hydro power can be not only the basis of the economy, but also budget forming sector of the state.

Tajikistan is, in its turn, interested in the establishment of long-term and mutually beneficial relations with neighboring Central Asian countries. As mentioned above, though Tajikistan experiences deficit of mineral fuel resources, the Central Asian Region (CAR) as a whole is self-sufficient in terms of mineral fuel reserves, both currently and in future prospects[4]. With regard to the Central Asian region, it should be pointed out that it possesses large and diversified resource base of mineral fuel, though not evenly distributed territorially.

A number of objects were envisaged for perspective hydro energy resource development through schematic case studies. The general overview of all these objects is given on the table 23.

In addition to the project case studies implemented during the USSR epoch, two new prospect projects related to the transfer of rivers have been developed in Tajikistan recently.

One of the projects stipulates the partial flow transfer of Pyandj into Vakhsh with the use of additional water volume for additional electricity generation on the functional Vakhsh coordinated hydroelectric system (Vakhsh HPPs)[5]. The construction of energy tunnel with the length of 66 km. and embankment dam on Pyandj river with minimal height of 120 m. is planned by the project. The total cost of the project is around 300-400 mln. USD.

The economic efficiency of this project is larger than of the traditional solutions. Its effect on even those HPPs currently in place on the hydroelectric system is comparable with the capacity of Nurek HPP. The total cost of water conduit tunnel and the embankment dam is much less than the cost of Nurek hydrosystem.

The second project stipulated the complex use of the Zerafshan river with partial flow transfer to the Ura Tyube valley.

The construction of a dam with a water reservoir of over-year regulation and pressure tunnel with the length of 15-17 km., both situated on the Zerafshan river plot opposite to Ura Tyube zone, at the river station nearest to the functioning watercourses (flowing from the northern flanks of the Turkestan mountain range) is planned by the project.

Table 23. Priority projects of hydro energy development in Tajikistan

№	Name	Parameters				
		Capacity, mWt.	Electricity generation, TWt.hour./year	Discharge head, m.	Usable storage, km^3	Capital investment per 1 kWt.capacity, in USD.

[4] United Nations Special Program for Economies of Central Asia (SPECA). UN ECO /ESKATO Project "Rational and efficient use of energy resources in Central Asia". Centre for Energy Policy, Energy Research Institute under the Russian Academy of Sciences. Moscow 2002.

[5] Bashmakov V.M., Sirozhev B. S., Petrov G. N. Efficiency enhancement of coordinated hydroelectric system of Vakhsh HPPs through use of flow part of the Pyandj river. Hydro technical construction, №12. Moscow 1995.

Series of HPPs on Pyandj River						
1	Namangutskaya*	2,5	0,018	36	0	
2	Barsharskaya	300	1,6	100	1,25	
3	Anderobskaya	650	3,3	185	0,1	
4	Pishskaya	320	1,7	90	0,03	
5	Khorogskaya	250	1,3	70	0,01	
6	Rushanskaya	3000	14,8	395	4,1	467
7	Yazgulemskaya	850	4,2	95	0,02	664
8	Granitnie vorota	2100	10,5	215	0,03	477
9	Shirgovatskaya	1900	9,7	185	0,04	536
10	Khostavskaya	1200	6,1	115	0,04	372
11	Dashtidjumskaya	4000	15,6	300	10,2	348
12	Djumarskaya	2000	8,2	155	1,3	279
13	Moskovskaya	800	3,4	55	0,04	313
14	Kokchinskaya	350	1,5	20	0,2	506
15	Nizhne-Pyandjskaya	600	3,0			
Total		18322,5	84,918		17,36	
Series of HPPs on Vakhsh River						
1	Rogunskaya**	3600	13,3	300	8,6	237
2	Shurobskaya	800	3,0	55	0,02	200
3	Nurekskaya*	3000	11,2	250	4,5	
4	Baipazinskaya*	600	2,5	54	0,08	260
5	Sangtudinskaya 1**	670	2,7	58	0,02	250
6	Sangtudinskaya 2	220	1,0	19	0,005	
7	Golovnaya*	240	1,3	26	0,004	
8	Perepadnaya*	30	0,25	39	0	
9	Centralnaya*	18	0,11	22	0	
Total		9178	35,36		13,229	
HPPs on Syrdarya River						
1	Kairakkumskaya*	126	0,6	15,4	2,5	
Total		126	0,6		2,5	
Series of HPPs on Obikhingou River						
1	Sangvorskaya	800	2,0	268	1,5	300
2	Urfatinskaya	850	2,1	280	0,01	259
3	Shtienskaya	600	1,5	150	0,01	350
4	Evtachskaya	800	2,0	185	0,02	3000
5	Kaftarguzarskaya	650	1,7	140	0,01	280
Total		3700	9,3		1,55	
Series of HPPs on Surkhob River						
1	Dzhadbulakskaya	600	2,0	200	1,4	350
2	Saironskaya	500	2,2	135	0,01	440

3	Gorgenskaya	600	2,7	138	0,02	440
4	Garmskaya	400	1,8	90	0,02	500
Total		2100	8,7		1,45	
Series of HPPs on Zerafshan River						
1	Vishkentskaya	160	0,95	40	0,02	
2	Yavanskaya	120	0,18	80	0,02	
3	Dupulinskaya	200	1,0	90	1,6	
4	Pendjikentskaya 1	50	0,27	49	0	
5	Pendjikentskaya 2	45	0,25	46	0	
6	Pendjikentskaya 3	65	0,36	69	0	
Total		640	3,01		1,64	
Series of HPPs on Fandarya River						
1	Iskanderkulskaya	120	0,77	80	0,45	
2	Yaghnobskaya	150	0,97	150	0,3	
3	Ravatskaya	50	0,3	40	0,02	
4	Zakhmatabadskaya	190	1,14	25	0,01	
Total		510	3,18		0,78	
Series of HPPs on Matcha River						
1	Matchinskaya	90	0,56	180	0,8	
2	Riamutskaya	75	0,46	110	0,35	
3	Oburdonskaya	65	0,35	80	0,02	
4	Pakhutskaya	130	0,75	85	0,02	
5	Sangistanskaya	140	0,90	80	0,02	
Total		500	3,02		1,21	
Series of HPPs on Kafirnighan River						
1	Vagdjindinskaya	150	0,6		0,85	
2	Yavrozskaya	400	1,1		0,045	
3	Romitskaya	450	1,4		1,2	
4	Sarvozskaya	250	0,8		0	
5	Vistonskaya	200	0,6		0	
6	Nizhne-Kafirnighanskaya**	120	0,48		0,6	
Total		1570	4,98		2,695	
Series of HPPs on Bartang River						
1	Sarezskaya	150	1,3		3,1	
2	Bartangskaya 1	113	1,04		0,6	
3	Bardarinskaya	135	1,1		0	
4	Bartangskaya 2	94	0,8		0	
5	Bartangskaya 3	89	0,8		0,15	
Total		581	5,04		3,85	
Series of HPPs on Varzob River						
1	Guskharskaya	220	0,55		0,002	

2	Puguzskaya	400	1,9		0,002	
3	Siamskaya	250	0,6		0,08	
		870	3,05		0,084	
Series of HPPs on Gunt River						
1	Yashilkulskaya	15	0,082		0,145	6800
2	Gunt – 0	5	0,026		-	5650
3	Gunt – 1	17	0,090		-	2780
4	Gunt – 2	27	0,157		-	1540
5	Tokuzbulakskaya	17	0,117		0,023	2830
6	Chartimskaya	18	0,120		0,042	1600
7	Takgivskaya	30	0,200		-	2425
8	Zvorskaya	15	0,102		-	2430
9	Gunt – 3	20	0,136		-	2600
10	Gunt – 4	26	0,180		-	-
11	Pamirskie, 1,2,3	80	0,419		0,002	150
Total		**270**	**629**		**0,212**	
GRAND TOTAL		**38366,5**	**162,916**		**46,56**	
Of them:						
Functioning		**4043,4**	**16,158**		**7,084**	
Being constructed		**4390**	**16,48**		**9,22**	

* - functioning, ** - being constructed

5.2. Structure and modern state of energy system in Tajikistan

The general structure of Tajikistan's energy system is defined by its resource potential (table 24). Thus, its basis is formed by hydro power plants. Around 98% of all electricity in Tajikistan today is generated by HPPs.

The HPPs determined the functioning of Tajikistan's energy system during the period since the USSR collapse in 1992 up to now. The stability of Tajikistan's energy system should be stressed, in comparison with other republics. If the average reduction of electricity generation between 1990-1999 on the whole CIS territory constitutes 26,7%, reaching 74,7% in Moldova and 45,7% in Kazakhstan, this figure constituted 12,7% in Tajikistan. It is even less, as the comparison is made with 1990 when electricity generation was more than medium rate, due to high water level.

Table 24. Modern structure of energy system in Tajikistan

N	Name	Capacity, MWt.		
		Установленная	**Располагаемая**	**Рабочая (среднегодовая)**
HPPs				
1.	Nurekskaya	3000,0	2100,0	2035,3
2.	Baipazinskaya	600,0	450,0	471,8

5.	Kairakkumskaya	126,0	126,0	68,3
6.	Coordinated Hydroelectric System onVakhsh River	285,05	162,0	160,9
7.	Coordinated Hydroelectric System onVarzob River	25,43	5,1	8,4
8.	SMALL SCALE HPPS	30,62	26,82	22,33
Total		4067,1	2869,92	2767,03
Thermal stations				
3.	Dushanbinskaya	198,0	198,0	27,2
4.	Yavanskaya	120,0	98,63	8,4
9.	DES	27,64	22,44	
Total		345,64	319,07	35,6
GRAND TOTAL		**4412,74**	**3188,99**	**2802,63**

*) Annual Reports of SSHC "Barqi Tojik".

At the same time the energy system possesses a powerful and ramified system of power transmission lines and substations of different capacity (table 25). However it has not developed during the last years.

Table 25. SSHC "Barqi Tojik"'s Power Transmission Lines and Substations

Years	Length of Power Transmission Lines by right-of-way, km.					Transformer substation, units/thousand kWA
	Total	Breakdown				
		500 kW.	220 kW.	110 kW.	<35 kW.	
1992	56638	226	1203	2838	52371	10085/12466
1993	57756	226	1203	2840	53487	10329/12810
1994	58029	226	1204	2842	53757	10550/12884
1995	49725	226	1205	2842	45452	10550/12884
1996	59245	226	1205	2851	54963	10550/12884
1997	56381	226	1205	2865	52085	10889/13365
1998	59080	226	1206	2896	54752	10959/13424
1999	59147	226	1206	2907	54808	11002/13433
2000	59248	226	1206	2905	54911	11213/13546
2001	59248	226	1206	2905	54911	11213/13546

2002	58658	226	1207	2038	55187	11552/14016
2003	55885	226	1178	2974	51507	10970/13827
2004	56548	226	1178	2979	52165	11237/14219
2005	57256	226	1246	2966	52818	11870/14318

It should be also added that Tajikistan energy system is a part of a united energy system of Central Asia, which allows for the export and import of electricity and services.

5.3. Electricity production and consumption

The total electricity generation and consumption in all sectors of economy of the republic is displayed on the tables 26-27, in dynamics for 1991÷2005.

It can be noted that notwithstanding vast electricity reserves, part of it must be imported into the country. At the same time a stable deficit in electricity is observed in Tajikistan's last years. According to SSHC "Barqi Tojik" the deficit increased since 1995 up to now from 1,5 TWt.hour. to 3,5 TWt.hour. annually. The rural population, having access to electricity only 4-6 hours daily in the wintertime, is particularly vulnerable.

Table 26. Electricity production by SSHC "Barqi Tojik"

Year	**1991**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Hydro power, Gwt.hour.	17,5	15,0	14,0	14,4	15,8	14,3	14,4	15,2	16,3	16,4	17,0

Table 27. Electricity consumption in Tajikistan

Year	**1991**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Hydro power, Gwt.hour.	19,2	14,1	14,1	14,7	15,6	15,6	15,7	16,0	16,3	16,8	17,2

The structure of electricity consumption in Tajikistan is given in the table 28.

Table 28. Electricity consumption structure in Tajikistan (usable delivery), mln. kWt. hour.

Consumers	**1987**	**1995**	**2000**	**2002**	**2003**	**2005**
Industry	10602,1	6731,0	4488,5	5398	5937	7470
Urban transport			29,0	32,0	59,1	34,9
Trade			74,0	46	32,7	
Non-industrial consumers			605,8	760	479	864,4

Consumers in agriculture	3300,0	2913	2256,0	2913	1968	2128
Population	1025,1	3230	4493,7	5603	4426	3932
Street lighting			76,0	40	34,9	
Household needs			17,0	36	23,4	
TOTAL:	15262,3	13535,0	12040,0	14958	13289	14397

5.4. Tariff policy and financial state of the energy sector

The evaluation conducted within the framework of the United Nations Special Program for the Economies of Central Asia shows the drastic increase of electro capacity of Tajikistan's economy during the last years, even compared with its condition of the late 1990s, when it was at minimum twice as much as in developed countries (table 29).

However electricity tariffs are almost the lowest in the world these last years (table 30); and payment rate in the country on average is less than 100% (table 31).

Table 29. Electrocapacity of Tajikistan GNP

Год	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2001**	**2002**	**2003**
кВт.ч/долл.	1,68	12,4	15,13	13,91	13,44	14,47	11,13	10,81	10,49

Table 30. Electricity tariffs and electricity consumption in Tajikistan

Consumers	**Year**	**1980 - - 1990**	**1996**	**1998**	**2000**	**2002**	**2003**	**2004**	**2005**
Population	Delivered, TWt.hour	0,84	3,62	4,4	4,49	4,56	4,43	4,11	3,96
	Tariff, cent/kWt.hour.	3,20	0,07	0,05	0,08	0,10	0,27	0,24	0,38
Total	Delivered, TWt.hour	14,9	12,9	12,5	12,2	12,9	13,3	14,2	14,2
	Tariff, cent/kWt.hour.	1,08	0,56	0,36	0,25	0,32	0,51	0,49	0,52

Table 31. Electricity payments by consumers in Tajikistan

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Payment %	30,5	30,6	71,2	51,9	66,8	98,4*	78,3	83,6	85,6	84,7

Thus the situation in the energy sector of Tajikistan is characterized on one hand, by the poverty of population unable to pay even for very cheap electricity, and on the other hand, by a very low efficiency in electricity use in the economy; thus population poverty persists.

Poverty and inefficiency in electricity use create a vicious circle. It is possible to overcome it only through conducting market reforms in the energy sector.

It is well illustrated by the market reforms conducted in 2003 in GBAO through the transfer to concession of all power plants of the region. Increase of electricity tariffs in GBAO by almost three times compared with republican tariffs enabled the finalization of the construction of Pamir-1 HPP, with increase of its capacity from 14 to 28 MWt (table 36) and to considerably rehabilitate the regional energy system. It should be noted that all these interventions were undertaken in the poorest and least developed region of Tajikistan.

Table 32. Electricity tariffs in GBAO

Years	2004	2005	2006	2007
Winter tariff				
Non-residential	1,26	1,78	2,31	2,67
Residential	0,95	1,18	1,45	1,57
Summer tariff				
Non-residential	0,90	1,27	1,65	1,91
Residential	0,68	0,84	1,03	1,12

5.5. Efficiency and energy sector development scenarios in Tajikistan

It is evident that one of the strategic directions in the energy sector of Tajikistan is to enhance the efficiency of energy. The law on energy saving was adopted in view of these directions in 2002. Today the major task of energy structures of the republic is an enforcement of this law. It is a complex issue and it should be put into action by taking into account concrete circumstances and factors determining the work of the energy system.

First of all, it should be considered that the basis of the energy system in Tajikistan is hydro power – more than 95% of all electricity in the republic is generated by HPPs. And all HPPs, including Nurekskaya, being one of the largest ones in the world, can provide a seasonal overshot of the river flow, but not the water accumulation within multiyear framework. For instance, even if the functioning of HPP is fully stopped and the water discharge of Nurek water reservoir is ceased, the net storage volume will fill in a month and a half at the mean water flow in the river Vakhsh. In case of flooding the net storage volume of the reservoir will fill in fifteen. In such circumstances, there is no sense in conserving such an energy resource. Unlike the countries with energy system based on thermal stations utilizing fuel (e.g., Russia or Kazakhstan)conservation of the resource, and the economy of hydro resources, i.e. reduction of HPP output will result in reservoir overflow and idling discharge water. It shows that the standard mechanism of energy saving through electricity cut-offs of those persons/companies in arrears with payments and non-effective users in conditions of Tajikistan is not applicable. It will not have any economic benefits however and can lead to unfavorable social consequences. Other methods and approaches are to be utilized.

Another important point is the position of energy system stakeholders. First of all, it concerns the energy company itself. Its interest lies in no way in energy saving, but vice versa, in an increase of electricity generation and sale, i.e. increasing profits.

The position of the state is somehow other. On the one hand, taking into account the profitability and competitiveness of Tajikistan's hydro power in the external market, it is profitable to develop its generation via the construction of new HPPs. On the other hand, Tajikistan is interested in developing its economy, cost price reduction and production profitability increase, and it, in its turn, requires the reduction of the cost per unit of electricity. Therefore, there is an interest in energy saving.

The third stakeholder party is industrial consumers, i.e. enterprises. For the major production purposes their interests are similar to those of the state – production increase on the one hand, and reduction of the cost per unit of electricity expended per unit of production on the other hand. There is an interest in electricity saving in subsidiary production not directly related to the production output of the enterprise.

Lastly, the fourth stakeholder party is the population. It is the only stakeholder which is interested only in electricity saving, i.e. reduction of its consumption, after having organized its household.

One can clearly see that the positions of all stakeholders differ from each others, at times very significantly. This situation is natural for a democratic society and market economy. On the other hand, it complicates the choice of the operator to implement the law "On energy saving" and control its enforcement. During the USSR epoch, these functions were executed directly by energy companies. However at that time there existed only one stakeholder party – the state, owner of all property in the country. The energy companies were also property of the state. As a result, there was a single national economic interest realized by the energy company.

Such a situation is impossible today. It is essential to establish a special structure to implement the enforcement policy of the law "On energy saving" and to provide for compromise of all stakeholder interests. GosEnergoNadzor (the state agency for energy control) could fulfill these functions, with appropriate status assigned and enlargement of authority.

In accordance to their positions, all stakeholders involved in an energy system utilize different mechanisms to pursue their interests. The energy company, whose main purpose is to realize profits, strives to achieve it through alteration of consumption structure, i.e. cut-off of those in arrears with payments, decrease the electricity supply of less profitable consumers and transfer electricity supply to the most profitable consumers or electricity export.

The major mechanism of state regulation in the energy system of Tajikistan is a tariff. At the same time, tariffs are not always formed on the basis of economic efficiency. State security in all its aspects, social needs and the development strategy of the country are also of great importance.

The major element of pursuing interest for enterprises and population is the introduction of new, modern energy saving technologies.

All these mechanisms, especially utilized by the state and energy company, often contradict each other and their affects are felt in all areas. This once more confirms the necessity for a special structure with expanded authority to enforce the law "On energy saving".

For its successful implementation, the establishment of special scientific research institutes and centers is essential. These institutions are to implement all preparatory works which include several directions.

First of all, normative documents need to be developed. As mentioned before, the development of complex sub legislative statements, norms, regulations and instructions is essential for the enforcement of the law "On energy saving".

Conducting a wide spectrum of scientific research, from electricity production monitoring and control to the creation of new technologies, is also.

The advocacy of new methods and technologies in the area of energy saving with demonstration of specific examples, conduction of exhibitions, workshops, etc. is also of great importance. Lastly, the establishment of experiment grounds, scientific research ,testing centers and demonstration areas on energy saving is essential. It is also essential to test new technologies, develop energy saving application conditions and economic efficiency for energy saving. These examples serve as a

demonstration for further mass replication of technologies. Such structures are already established in other republics and facilitate a successful enforcement of energy saving programs. For instance, there are demonstration zones in residential sectors established in Bishkek and Alma Ata. Nizhni Novgorod, a city in Russia with adjacent districts, is set as a demonstration area for energy saving. The demonstration area on energy saving is also being established in Georgia.

Such specific activity is the major condition for efficiency increase in the use of energy resources, i.e. energy saving and is the utmost goal of the energy saving program. If there are concrete and exact activities set in place, than the law itself is enforced. Two campaigns of the late 1980s during the USSR epoch, one for energy saving, the second for bread saving, can serve as examples. The posters "Bread is our wealth", "Save the bread at your table", etc. were placed all around. There were TV and radio programs broadcasting about the necessity to save bread. In Tajikistan this campaign continued into early 1990s. Everybody remembers the difficulties with bread in the republic: huge queues and real danger of hunger. Afterwards the market reform of the sector was conducted, the prices for bread products were set free, and the bread issues were resolved. Thus no law on "bread saving" was required.

Unfortunately the situation in the energy system of Tajikistan is far from analogous situation with bread. Instead of specific activities in energy saving, GosEnergoNadzor currently fulfills the supervisory responsibility, utilizing administrative methods, not economic ones. The activity of GosEnergoNadzor is evaluated on the basis of consumers checked and the sanctions applied. It in no way demonstrates unsatisfactory work of GosEnergoNadzor. GosEnergoNadzor today is one of the structural departments of SSHC "Barqi Tojik", the monopolist energy company in the republic, and works in its interests, which, as it has been mentioned above, lie in the increase of electricity sale and profits.

To sum up, the reliable supply of electricity to all consumers, and to the population in the first place, should mostly orientate towards the development of the energy sector, not towards energy saving. Thus, the development of the energy sector should start with the construction of small scale and micro HPPs.

Taking into account the geographic and energy resources of the country, the most reasonable development directions of the energy sector of Tajikistan include:

- Hydro power
- Coal
- Hydro power and coal

The classification of energy development in Tajikistan could still be simplified, by adopting hydro power and coal as an only real development scenario for further analysis but with a different allocation of hydro power: from 0 to 100 per cent.

At the same time, in any scenario of energy development, the use of additional renewable and ecologically clean sources of energy, i.e. solar, bioenergy, wind power and geothermal energy should be considered. These sources should be utilized for domestic use in the first place.

The mineral fuel, i.e. oil and gas, is also of importance in the energy system of Tajikistan, depending on the real possibilities of exploration and mining. The general evaluation of energy development is given in the table 33.

Table 33. Development scenarios for energy sector of Tajikistan

Scenario	Resource	Efficiency

	Basic 80%-90%	**Additional 10%-20%**	**Economic**	**Ecological**	**Export**
Hydropower	Hydropower	Solar energy, oil, coal, gas	High	Positive	Large
Coal	Coal	Solar energy, oil, gas	Low	Negative	Absent
Hydro and Coal	Hydropower+ coal (50% and 50%)	Solar energy, oil, gas	Medium	Medium	Low

A more specific economic analysis of the different development strategies of energy sector of Tajikistan is given in the table 34.

The calculations of specific profits of energy sector in the table 34 were conducted with the use of formulas:

- for total profit value without account of ecological expenditures:
  $\mathbf{P = T - (D_{g.\,en.})\cdot C_{g.\,en} - (D_{coal})\cdot C_{coal.}}$
- for profit with account of ecological expenditures:
  $\mathbf{P = T - (D_{g.\,en.})\cdot C_{g.\,en} - (D_{coal})\cdot C_{coal})\cdot 1{,}1}$

Table 34. Efficiency Comparative Analysis of different scenarios for energy sector development in Tajikistan

Proportion of basic resources, %		Specific profit of energy system, cent/kWt-h			
		Tariff 2 cents /kWt.h.		Tariff 3 cents /kWt.h.	
Hydro power	Coal	without ecological costs	with ecological costs	without ecological costs	with ecological costs
100%	0%	1,60	1,60	2,60	2,60
90%	10%	1,40	1,38	2,40	2,38
80%	20%	1,20	1,15	2,20	2,15
70%	30%	1,00	0,93	2,00	1,93
60%	40%	0,80	0,70	1,80	1,70
50%	50%	0,60	0,48	1,60	1,48
40%	60%	0,40	0,26	1,40	1,26
30%	70%	0,20	0,03	1,20	1,03
20%	80%	0,00	-0,19	1,00	0,81
10%	90%	-0,20	-0,42	0,80	0,58
0%	100%	-0,40	-0,64	0,60	0,36

The following symbols are used in these formulas:

P – specific profit, cent/1 kWt-hour,

T – an operational tariff for electricity, cent/1 kWt-hour,

$\mathbf{D}_{\mathbf{g.\,en.}}$ and $\mathbf{D}_{\mathbf{coal}}$ – corresponding shares of hydro power and coal in total electricity production output, units,

$\mathbf{C}_{\mathbf{coal\ en.}}$ and $\mathbf{C}_{\mathbf{coal}}$ – accordingly, the cost price of one kWt-hour of electricity in coal and hydro power,

1,1 – coefficient taking into account ecological expenditures in coal energy.

The cost price of hydro power in these calculations was adopted in accordance with real data of SSHC "Barqi Tojik" equaling $C_{g.\,en.}$ = 0,4 cent/kWt-hour.

The cost price of coal energy was adopted based upon the cost of fuel constituent, equaling 2 cents/kWt-hour (coal cost at 40 USD/ton at the specific expenditure of coal at 0,5 kg/kWt-hour) and other constituent cost is the same as in the hydro power (0,4 cent/kWt-hour), equaling $\mathbf{C}_{\mathbf{coal}}$ = 2,4 cents/kWt-hour.

The analysis of table 34 displays that from the point of view of economics, the opportunities of coal energy in Tajikistan are considerably restricted. With the electricity tariff set at 2 cents/kWt-hour, its share cannot be more profitable than 30% even with the current price for coal in the republic which will be further increasing, according to all forecasts. It turns profitable only if the tariff is set at 3 cents/kWt-hour.

The energy system of Tajikistan should be not only paying but profitable, too. It is an essential condition for its further development. The minimum required for sustainable development and electricity production around 18 TWt-hour would be an annual profit of 100 mln. USD, with proportion of hydro power no less that 50% at the tariff set at 2 cents/kWt-hour, and 10% if the tariff is set at 3 cents/kWt-hour, as indicated by the table 34. The corresponding cells in the table are highlighted. At the same time, as it has been mentioned above, the annual profit of 100 mln. USD is the minimum required. In 1980s, when there was no discussion about electricity export from Tajikistan,

the annual investments into energy sector exceeded 200 mln. rubles which at that time approximately corresponded to the same sum in USD.

Even more restrictions for the use of coal in the energy sector of Tajikistan are set by ecological requirements. It is related to unavoidable greenhouse gas emissions (CO_2) while making use of coal. In accordance with the atomic weight of chemical elements, 3,67 kg of CO_2 is formed while burning one kg of coal. Let's assume, as in the calculations above, the specific expenditure of coal as equal to 0,5 kg/kWt-hour, the specific emissions of greenhouse gases will equal 1,83 kg/kWt-hour in coal energy sector. In accordance with this data, the calculations of total CO_2 emissions at different development scenarios of the energy sector of Tajikistan at the level of 2015-2020 with total electricity production output of 18 TWt-hour annually are given in the table 35.

Table 35. CO_2 emissions at different energy sector development scenarios in Tajikistan

Tajikistan Energy Sector Development Strategy	CO_2. emissions, Gg/year
Hydropower - 100%, coal – 0%	1554
Hydropower – 90%, coal – 10%	4848
Hydropower – 80%, coal – 20%	8142
Hydropower – 70%, coal – 30%	11436
Hydropower – 60%, coal – 40%	14730
Hydropower – 50%, coal – 50%	18024
Hydropower – 40%, coal – 60%	21318

The zero emission level adopted in the table 35 indicates its current level equaling 1,554 thousand gigagrams (Gg). The analysis of this table indicates that the hydro power proportion into the environmental pollution and climate impact in Tajikistan should be less than 50%. If the share of hydro power in the energy system is lower, than emissions of greenhouse gases in the republic will exceed the level of 1990-1991 equaling 20,770 thousand Gg, and undertaken as a control level in accordance with Kyoto protocol.

6. World experience in small scale hydropower development

6.1. Classification of small scale HPPs

Small scale hydro power has been developing as an essential constituent of the energy system in many countries of the world during last decades.

According to its purpose, operating mode and position in the general scheme of electricity supply to consumers, all small scale HPPs are subdivided into a system as well as autonomous ones.

While operating in the energy system, the small scale HPPs, apart from generating capacities to the consumers, perform functions of daily or weekly regulation as well as utilizing, if needed, the regulation of the frequency of electricity.

The autonomous small scale HPPs are designed to satisfy the needs of isolated consumers, independently or in conjunction with other power stations of the same capacity, based on diesel, wind, solar and bio.

One of the main features the HPPs are classified upon is the installed capacity of the HPP. According to this classification, all HPPs are subdivided into five categories:

- Large,
- Medium,
- Small,
- Mini,
- Micro.

The top capacity margin of the small scale HPP varies to great extent in different countries. It depends on the level of energy sector development, feasible study requirements for small scale HPPs, legislation, licensing procedures and adopted programs of energy system structuring. In some countries the top capacity margin of small scale HPPs varies from 1,5 to 30 MWt:

- In Norway, Switzerland, Venezuela the HPPs with capacity of 1 to 1,5 MWt are considered as small.
- In Austria, Spain, India, Germany, Canada the HPPs with capacity up to 5 MWt are considered as small.
- According to the classification of OLADE, the HPPs with capacity up to 10 MWt are considered as small.
- The HPPs with capacity up to 12 MWt are considered as small in the South-Eastern Asia.
- In the USA, which actively develops the small hydro power sector, the top capacity margin of the small scale HPP has been changed several times. First it was set at the level of 5 MWt, then it increased up to 15 MWt, and in 1980 it was finally set at 30 MWt.
- In Germany, according to the law on energy as of 21. 07. 2004, small scale HPPs are subdivided into categories in accordance with the price of electricity produced: up to 500 kWt., from 500 kWt. to 10 MWt, from 10 to 50 MWt. The price for electricity is set accordingly: 7,67; 6,10; 4,56 Eurocents for kWt-hour. For HPPs with capacity more than 50 MWt the price for electricity is set at 3.7 Eurocents/ kWt-hour.
- The top capacity margin of the small scale HPP in Russia is set at 30 MWt, restricting the capacity of a unit of no more than 10 MWt and the turbine wheel diameter of 2 meters.

The boundaries between small, mini and micro HPPs are also rather relative. These parameters depend on technical, constructive and technological features of equipment and construction conditions. The grading of these HPPs adopted in some countries is given in the table 36.

Apart from all the categories mentioned above, there is another category to be pointed out – mobile HPPs.

Table 36. Classification of small scale HPPs by installed capacity, MWt.

HPP Category	Countries and organizations					
	Italian National Committee	**OLADE**	**Russia**	**New Zealand**	**Austria, Spain, Italy, Canada, France**	**Japan**
Small HPPs	5	10	30	30-50	5	20
Mini HPPs	0,5	1	1	10	2	- 0,1
Micro HPPs	0,1	0,1	0,1	0,1	0,1	

Depending on their construction and assembling, small scale HPPs are subdivided into dam-based and diversion power stations, hose power stations, chain power stations, free assembly line power stations, compact power stations, hull power stations and portable power stations. Depending on the HPP water pressure, small scale HPPs are subdivided into low-head power plant, medium-head power plant and high-head power plant. The boundary values of each of these categories are defined by the engineering industry in different countries, based on their water turbine equipment designs. To sum up this data, the following classification of HPPs based on the HPP water pressure could be adopted:

- Low-head power plants: P < 20 m.
- Medium-head power plant: P = 20-100 m.
- High-head power plant: P > 100 m.

The design and construction of small scale HPPs are carried out on the basis of the same norms and rules, as for large scale HPPs.

For Tajikistan, taking into account local features, it is reasonable to adopt the following classification of small scale HPPs based upon their installation capacities:

- **Micro-HPP: N ≤ 10 kWt,**
- **Mini-HPP: N = 10 ÷ 500 kWt,**
- **Small scale HPP: N = 500 kWt ÷ 10 MWt.**

Micro-HPPs of this capacity should be related to their consumption commodity, i.e. to electrical appliances. There should be a simplified procedure of design, expert examination and licensing in place for mini-HPPs.

6.2. Construction experience of small scale HPPs in other countries

The HPP construction in almost all countries started with the construction of small scale HPPs.

In the beginning of the 20th century, the construction of small scale HPPs was going on very intensively. By mid 1920s, the electricity generated by small scale HPPs covered up to 40% of the world's electricity consumption.

The construction rates of small scale HPPs decreased with the increased construction of medium-head power plants and high-head power plants. This decrease continued into 1970s. In many countries, the construction of small scale HPPs was not only stopped, but small scale HPPs already in place were conserved or dismantled. For instance, out of 1818 small scale HPPs with capacity up to 1 MWt. operational in 1944 in Norway only 250 were operational by 1979. However the con-

struction of small scale HPPs continued in the number of countries, i.e. in Austria, Switzerland, Germany, China.

As a result of world energy crisis of 1970s, small scale hydropower regained significant consideration. It was facilitated by:

- Increase of oil price,
- Tightened requirements to environmental protection resulting in increased costs for heat stations and nuclear power plants,
- Development of the majority of large and easy-to-use watercourses in the developed countries of the world
- The necessity to develop remote and isolated districts and the need for their electrification
- Increased requirements to the complex use of water resources,
- Increased economic efficiency of small scale HPPs,
- Enhancement of design, construction and exploitation of small scale HPPs.

The interest for small scale HPPs by the international community also increased. Upon the initiative of "Water Power" magazine, a number of international conferences devoted to small scale HPPs were conducted including the European Conference of 1982 in Monte Carlo, and international conferences in Singapour (1984), Khanchjou (1986), Mehico (1988), Kuala Lumpur (1990), Deli (1992).

In China (Khanchjou) there is a regional scientific research center on the use of small river energy.

Most countries of the world determine the potential of small hydro power and develop national programs for its development.

The most extensive number of small scale HPPs are being constructed in China. In 1989 the total capacity of all small scale HPPs in China constituted 12,62 GWt, and an annual production output constituted 36 TWt hours.

The most characteristic example for developing countries, as well as for Tajikistan, could be Ethiopia. In the beginning of 1980s there were 8 small scale HPPs with capacity from 100 to 420 kWt with the production output of around 3 GWt hours annually which equals around 1 mln. liters of fuel per annum. In the same 1980s, investigations and research on opportunities for the construction of a number of small scale HPPs started with funding from the United Nations. By 1985, 15 potential suitable dam sites were identified for construction of small scale HPPs with capacity from 300 to 10 000 kWt. In 1990, 11 dam sites were still under consideration and 3 were being constructed. Apart from these, the construction of another 25 small scale HPPs is being planned for the near future. The issue of setting up the production of technological equipment for small scale HPPs is being discussed as well.

The prime cost of one kWt. produced from a small scale HPP in Ethiopia was placed between 3500 up to 5000 USD with any account of electricity grids. Aside the high prime cost, they were considered acceptable due to the high cost of fuel transported to the remote areas of the country.

It is expected that the construction of small scale HPPs will give an economic impetus for the development of remote areas of the country. In 1990, a special student group on the research of small scale HPPs was set up within the technical department of Ethiopis State University.

While evaluating the general trends of small, mini- and micro- hydro power plant development in different countries, one can point out the influence of many various factors:

- Financial opportunities,
- Long-term strategic perspective of development of small scale HPPs,
- Environmental protection issues,
- Water use legislation,
- Development of electricity grids and conditions for their connection,

- Tariffs for production and transfer of electricity,
- Technical standards on parameters of electric energy generated, etc.

Currently there is also experience in all aspects of small scale HPP construction and maintenance around the world. According to the data of Evans Engineering, Great Britain, there is potential for the construction of approximately two millions of micro-HPPs around the world. The key factor in their construction is the cost of installed kWT. Another important characteristic is their adaptability to local conditions. They say it is better to install well-known equipment with simple maintenance requirements, than complex and modern ones. It is exemplified by the construction of small scale HPP in Nepal, where seasonal water intakes are restored annually. It is considered more reasonable to restore them annually than to yse more complex designs in which any shortcoming could lead to their breakdown. It is also noted that the adaptability and reliability of turbines are of more significance than their efficiency. The most suitable type of turbine for a small scale HPP is "turgo impulse". It is also worth mentioning that all ecological issues related with small scale HPPs are easily resolved.

As the analysis of foreign practice shows, the layout solutions for small, mini- and micro-HPP construction are completed according to well-known principles, i.e. in dam, diversion and hybrid schemes. The first scheme is utilized on lowland rivers with insignificant slopes. Diversion and hybrid schemes are widely in use while constructing small scale HPPs in mountainous and submountain areas. Diversions could be placed along the river, while rectifying river course, as well as diverting runoffs from one river into another. The small scale HPPs could also be constructed on the basis of readily available pressure water and existent water reservoirs, i.e. on channels and pipelines of different use.

World experience shows that the program of small hydro power development in light of the mass construction of small scale HPPs, and especially, with their further exploitation, is economically efficient only if there is a technological equipment production base set up in the country. Today there are 138 companies in more than 30 countries producing turbines for small, mini- and micro-HPPs at the international market.

7. Small Hydro Power Resources in Tajikistan

7.1. Energy Resources of Tajikistan's Small Rivers

The energy resources of small hydro power are given in the table 37. Every condition is available for the successful development of small hydro power in the country. Most importantly, small watercourses are evenly distributed throughout the whole territory of Tajikistan, and the resources are vast. It enables the mass industrial construction of small scale HPPs which reduces the cost of the program.

Table 37. Energy resources of small scale hydro energy sector in Tajikistan

Districts	Potential		Industrial	
	N MWt.	**E** TWt.hour.	**N** MWt.	**E** TWt.hour.
Leninabad district group	1288,0	11,28	450,8	3,95
Districts of republican subordination	16056,0	140,65	5619,6	49,23
Gorno-Badakhshan Autonomous Oblast	3713,0	32,53	742,6	6,51
Total for Tajikistan	21057,0	184,46	6813,0	59,69

It should be pointed out that calculations of potential, and consequently all other energy resource categories of small rivers were made with the use of decreasing coefficients:

- For the most territory of the republic – 0,35,
- For GBAO – 0,20

Therefore with further development of science and engineering, the total volume of energy resources could be further specified.

7.2. First priority program of small scale HPP construction in Tajikistan

Currently "The long-term construction program of small scale HPPs for the period of 2007-2020" was elaborated with support of international financial organizations and approved by the Resolution of the Government of the Republic of Tajikistan N 449 as of the 3rd October 2006. The Program determines the priority stages and construction objects of small scale HPPs, indicated in the table 38.

Table 38. First priority small scale HPPs to be constructed in Tajikistan

Short term development program					
№	**Name of small scale HPPs**	**Technical parameters**	**Location, district**	**Prelimi-nary cost,**	**Financing sources**

		N, kWt	E, MWt.h			
1	Marzich	2750	16500	Ainiski	3416	IBD
2	Shash-Boloi	100	600	Nurabadski	195	IBD
3	Sangi Kar	667	4002	Rashtski	813	IBD
4	Fatkhobod	600	3000	Tadjikabadski	624	IBD
5	Pitavkul	850	3600	Djirgitalski	1060	IBD
6	Khorma	360	2160	Baldjuvanski	474	Gov-t RT, SSHC "Barqi Tojik"
7	Todj	500	3000	Shakhrinavski	623	
8	Shirkent-3	700	3000	Tursun-Zadevski	1015	
9	Kukhiston	500	3000	Matchinski	639,8	
10	Cheptura	500	3000	Shakhrinavski	320	
11	Artuch	500	3000	Pendjikentski	600	
12	Tutal	650	3900	Rashtski	780	
13	Pushti Bog	500	3000	Baldjuvanski	600	Gov-t RT, Ministry of Finance, Barqi Tojik
14	Navokandoz	35	200	Varzobski	40	ADB
15	Langar	150	700	Kukhistoni Mastchoh	200	ADB
16	Baldjuvon	100	300	Baldjuvanski	200	UNDP
17	Khovaling	100	300	Khovalingski	200	UNDP
	Total	**9562**	**53262**		**11799,8**	

Medium term development program						
№	**Name of Small Scale HPPs**	**Technical parameters**		**Location, District**	**Preliminary cost, in thousand USD**	**Financing sources**
		N, kWt	**E, MWt.hour**			
1	Nurbakhsh	5000	3000	Dangarinski	4000	National and international investmenrs
2	Saripul	700	4200	Rashtski	770	
3	Madjikhavr	500	3000	Nurabadski	580	
4	Khakimi	500	3000	Nurabadski	532	

5	Djidikul	1500	4500	Vakhshski	1650	
6	Khamodani	100	600	Kulyabski	110	
7	Telmana	200	1200	Vakhdatski	240	
8	Andigon	300	1800	Vakhdatski	330	
9	Gurumbak	500	3000	Tavildarinski	550	
10	Gabirud	1260	7560	Aininski	1386	
11	Karagushkhona	1600	9600	Rashtski	1760	
12	Nazar-Aylok	2400	14400	Rashtski	2640	
13	Khait	250	1500	Rashtski	275	
14	Shirg	1000	6000	Darvozski	1100	
15	Khumb	200	600	Darvozski	220	
16	Kizil-Tumish	2000	12000	Kolkhozabadski	2200	
17	Gultepa	100	600	Faizabadski	110	
18	Lolagi	500	3000	Gissarski	550	
19	Sitora	800	6400	Gissarski	880	
20	Vorukh-2	500	3000	Isfarinski	550	
21	Langar	200	1200	Matchinski		
22	Kattasai	1800	10800	Istravshanski		
23	Sharora	350	2100	Ashtski		
24	Nur	100	600	Gissarski	110	
25	Karosu	100	600	Vakhdatski	110	
	Total	**22460**	**104260**		**20653**	

Long-term development program						
№	**Name of Small Scale HPPs**	**Technical parameters**		**Location, District**	**Preliminary cost, thousands USD**	**Financing sources**
		N, kWt	**E, MWt.hour**			
1	Yazgulem-1	1900	16150	Vandjski	3800	National and international investmenrs
2	Yazgulem-2	1900	16150	Vandjski	3800	
3	Yazgulem-3	1900	16150	Vandjski	3800	
4	Yazgulem-4	1900	16150	Vandjski	3800	
5	Yazgulem-5	1900	16150	Vandjski	3800	
6	Yazgulem-6	1900	16150	Vandjski	3800	
7	Yazgulem-7	1900	16150	Vandjski	3800	
8	Yazgulem-8	1900	16150	Vandjski	3800	
9	Ak-su	1200	7200	Murgabski	2400	

10	Valgon	3000	16653	Kukhistoni Mastchoh	6000	
11	Poldorak-1	300	1800	Kukhistoni Mastchoh	600	
12	Rukshif-1	1200	7200	Kukhistoni Mastchoh	2400	
13	Samdjon	500	3000	Kukhistoni Mastchoh	1000	
14	Djindon	1440	8640	Kukhistoni Mastchoh	2800	
15	Padask	2400	14400	Kukhistoni Mastchoh	4800	
16	Dupula	1250	7500	Kukhistoni Mastchoh	2500	
17	Obi Shurak	2400	14400	Rashtski	4800	
18	Yagman	1520	9120	Rashtski	3040	
19	Beob	840	5040	Rashtski	1680	
20	Okhangaron	2700	16200	Rashtski	5400	
21	Khodango	2240	13440	Rashtski	4480	
22	Shirvoza-2	2460	14760	Rashtski	4480	
23	Shirvoza-3	2460	14760	Djirghitalski	4920	
24	Ayu-Djilgau-1	2546	15276	Djirghitalski	5092	
25	Ayu-djilgau-2	2100	12600	Djirghitalski	4200	
26	Pishkharv	1000	6000	Vandjski	759	
27	Lukharvi			Tavildarinski		
28	Bidjondara	300	1500	Shugnonski	350	
29	Iskich	500	3000	Gissarski	550	
	Total	**47556**	**321689**		**92651**	
	GRAND TOTAL	**79578**	**479211**		**125103,8**	

7.3. The role of small scale hydro energy in poverty reduction and economic development of rural areas

In order to provide access to electricity for the rural population inhabiting remote mountainous areas currently lacking access to electricity almost all year round, and to enable them to satisfy their elementary needs in cooking and heating, basic healthcare services and education, the minimum goal set is the construction of small scale HPPs.

The first researches on the electricity consumption levels were conducted in 1970s[6]. These researches illustrated that even during 1970s, with very low prices for gas, electricity provision for domestic needs of the population was at minimum 30% more efficient than that of liquefied gas.

It was also identified that the electricity consumption of rural population is best estimated by the number of dekhkan farms, not inhabitants.

All the research of 1974 was conducted when there were no restrictions on electricity consumption. At that time, in some districts, the electricity consumption of families varied greatly – from 50 to 2450 kWt-hours annually at the capacity changes of 0.12 to 5,8 kWt-hours. At the same time, mean consumption of separate dekhkan farms was stable and with a
0,95 probability equaled:

[6] Sirodjev B. Electrification of domestic heating for rural population. Review. Gosplan, Tajik SSR. Institute of scientific and engineering information and advocacy. Dushanbe, 1974.

- For the farms using electricity and solid fuel:
  - **E** = 550±10 kWt-hour annually
  - **N** = 0,827±0,23 kWt.
- For the farms using only electricity:
  - **E** = 1365±84 kWt-hour annually
  - **N** = 2,36±0,167 kWt.

Another value for electricity consumption was adopted within the UNDP Project "Development of electricity supply for rural communities of Tajikistan" developed in 2006. For all rural areas (kishlaks) selected for electricity supply development the mean level of need of electricity was determined, including (per household):

- Cooking – 1,6 kWt-hour/day
- Lighting – 0,5 kWt-hour/day
- Heating – 2,0 kWt-hour/day
- TV – 0,3 kWt-hour/day
- Refrigerator – 1,1 kWt-hour/day
- Other – 0,2 kWt-hour/day

Total: 5,7 kWt-hour/day or 5,7 X 365 ≈ 2000 kWt-hour annually.

Taking into account this analysis, it can be assumed that currently the specific electricity consumption of a single household in the rural area which enables implementation of top priority poverty reduction and sustainable development objectives constitutes:

E = 1500 ÷ 2000 kWt-hour annually
N = 2,5 ÷ 3,0 kWt.

Existent industrial resources, not mentioning potential ones, with current capacity can provide the needs of 2.5 ÷ 3 mln. households; with upgraded capacity for 30 ÷ 40 mln. households. With average size of rural family of 6 ÷ 7 people, it exceeds current population of Tajikistan several times.

The implementation of "The long-term program for construction of small scale HPPs for the period of 2007 – 2020" (table 38) can enable provision of electricity to the rural areas, i.e.:

- In short-term – for 30 thousand families,
- In medium-term – for more than 50 thousand families,
- In long-term – for more than 160 thousand families.

In total, electricity can be provided to more than 240 thousand families (households), i.e. around 1,4 – 1.7 mln. rural inhabitants of Tajikistan.

These large scale opportunities of small hydro power indicate that small hydro power can be used further not only for settling priority issues of poverty reduction and providing access of population to social assets, but for economic development as well, first of all, for development of small-scale entrepreneurship.

8. Tajikistan Small Scale Hydro Power Development History

Interest in Small Scale Hydro Power in Tajikistan was roused long before present days. First SHPP, Varzobskaya HPP No.1 with 7.15MW output was constructed in 1936 and successfully operates up to present. A "Small streams hydro resources use scheme for agriculture electrification of Tajik SSR" was developed in the republic in 1949-1950 purposed for overall electrification of the whole rural area of the republic. The scheme studies general and possible hydro resources in detail, indicates most perspective streams for SHPP and layout cascades, indicates consumers, composition and amount of equipment required, requisite investments and settles output issues. SHPP Construction Program proposed by the scheme impresses even today (Table 39). At the same time, the number of plants in the program (1949-1950) had been determined not by possibilities but by the needs of that time. Table 40 clearly shows this for one of the Oblasts – Leninabadskaya, even not the richest one in hydro resources. The Scheme proposed the development of only 28.5% of possible SHPPs and 1.5% of general water resources.

Table 39. Primary indicators of the "Small streams hydro resources use scheme for agriculture electrification of Tajik SSR" (1949-1950)

Rayons	Potential resources	Possible to use		Proposed to use	
	$N_{sum.}$ 000 kW	No. of HPP	$N_{sum.}$ 000 kW	No. of HPP	$N_{sum.}$ 000 kW
Leninabadskaya Group	2120.00	555	111,5	119	31,4
Yujnaya Group	457.76	52	16,67		
Stalinabadskaya Group	4002.27	177	151,67		
Kulyabskaya Group	726.36			141	44.06

The implementation of the "Scheme" virtually started simultaneously with its development. Already 53 SHPP were operating in the republic in 1958 with total output of 12MW, and total number of constructed SHPP reached 69 by 1978, with total output of 32MW. Unfortunately, after that, due to the re-orientation to large energy, SHPP construction program in the republic, as well as throughout the USSR, was cut down. As result by 1990,only 5 plants were left from their total number.

Table 40. Small streams usage program in the Leninabad Oblast of Tajik SSR (1949-1950)

Districts	Potential resources	Possible to use	Proposed to use

	$N_{sum.}$ 000 kW	No. of HPP	$N_{sum.}$ 000 kW	No. of HPP	$N_{sum.}$ 000 kW
Leninabad	1,6	1	0,2	-	-
Proletar	1,7	5	0,6	1	0,14
Naussk	11,5	8	2,4	3	1,85
Chkalovsk	11,5	11	9,3	5	4,80
Asht	42,8	40	4,7	22	2,90
Isfara	197,8	13	14,5	9	7,26
Kanibadam	-	-	-	-	-
Ura-Tuba	4,8	8	1,6	7	1,52
Kalininabad	20,8	26	10,2	6	4,20
Shahristan	9,9	36	4,9	10	1,42
Penjikend	87,9	29	6,8	4	1,52
Kolkhchiyon	313,0	60	31,9	10	1,92
Zakhmatabad	1027,3	143	8,9	25	2,46
Matchin	389,4	175	15,5	17	1,65
Total	2120,0	555	111,5	119	31,74

As we can see now, it was a wrong decision. It was based on the inadequately correct assessment of the comparative efficacy of small and large HPP, which considered only capital investments and operational costs of the plants themselves, without taking into account power transportation and distribution costs. While in Tajikistan conditions these costs could be determinant.

Again interest in small scale HPPs in Tajikistan revived in the early nineties. By this time SHPP layout developed in 1949-1950 has already lost the importance, as inappropriate to new conditions. Therefore new “Small Scale Hydro-Power Engineering Development Scheme of Staro-Matchinsky, Garmsky, and Jirgitalsky Rayons of Tajik SSR” was designed in the republic in 1990-1991, and in 1995 – Scheme Developments of “Use of hydropower resources of the small and middle streams of GBAO by means of small hydropower”, providing SHPP construction first of all in the mountainous, remote areas of republic which had no centralized power supply. Fundamentals of the schemes are shown in the Tables 41 and 42.

Now, a package of the legislative and normative-legal documents regulating, stimulating and providing a preferential treatment in the field of construction and operation of small scale HPP is adopted and operational in Tajikistan.

Considering that the development program for small hydro-power in Tajikistan envisages a mass construction of small HPPs, regional-sector construction norms "Cost budgeting of construction and designing small scale and micro hydropower plants for the mountainous areas of Tajikistan" (Rosn 2-91 PO "Tajikenergo") had been developed by “TajikGIDEP” institute in cooperation

with Moscow "Hydroproject" Institute and "Stroynormirovaniye" Association under USSR Gosstroy in 1992 which reflects upon all specific features of the republic.

The same year, another regional-sector construction norms "Engineering researches for construction of small scale and micro hydropower plants in mountainous areas of Tajikistan" had been developed together with VNEEOSP after H. M.Gersevanov and the same "Stroynormirovaniye" Association, enabling to considerably accelerate and reduce the price of all preparatory works related to the engineering-geological, engineering - geodetic and engineering-hydrological researches during construction of small scale HPPs.

Domestic manufacture of the equipment for small scale HPPs in Tajikistan has been organized in Chkalovsk Engineering Plant "Vostokredmet Joint Stock Company" in Leninabad Region, together with a Russian Company MAGI being one of the founders of Russian Small and Unconventional Power Association. Prior to this, an NGO “CKTI Plant after I. I. Polzunova” (St.-Petersburg) carried out surveys showing that practically all the needs of equipment for small HPPs, envisaged in the developed schemes could be covered by two types of Francis (80 %) and Pelton (20 %) turbines. Such unification allows to considerably lower the cost of the equipment produced. The main range of turbines has been developed for Chkalovsk Engineering Plant on this basis (table 43).

Table 41. Prospective Hydropower Plant in Staro-Matchinsky, Garmsky and Dzhirgitalsky districts (scheme of 1999, TajikGIDEP)

#		**Total for district**			**As well as**								
					Staraya Matcha			**Garmsky District**			**Dzhirgitalsky district**		
		Q-ty of Hydro power Plant	**N**, micro watt.	E,mln kilowatt -hour	Q-ty of Hydro power Plant	**N**, micro watt.	**E**,mln kilowatt -hour	Q-ty of Hydro power Plant	**N**, micro watt.	E,mln kilowatt -hour	Q-ty of Hydro power Plant	**N**, micro watt.	E,mln kilowatt -hour
1	According to the power capacity												
	$N_{sust.}$ = 0,1-1,0 мВт.	63	36,24	189,8	19	9,68	52,20	30	17,87	87,91	14	8,69	48,68
	$N_{sust.}$ = 1,0-10 мВт.	65	145,2	751,9	20	34,39	174,7	21	45,62	228,6	24	65,20	348,7
	$N_{sust.}$ > 10 мВт.	-	-	-	-	-	-	-	-	-	-	-	-
2	According to the pressure												
	H < 20 м.	-	-	-	-	-	-	-	-	-	-	-	-
	H = 20-75 м.	16	19,70	98,03	6	4,10	15,4	8	9,84	46,06	2	5,76	36,57
	H > 75 м.	112	161,8	843,7	33	39,97	212,5	43	53,65	270,4	36	68,13	360,8
3	According to the operating mode												
	Parallel with power system	30	27,20	145,1	3	1,82	8,64	14	9,81	47,24	13	15,57	89,23
	For isolated consumer	70	121,0	610,6	13	16,57	84,45	34	52,27	261,8	23	52,12	264,4
	Isolated and parallel with other system	28	33,29	186,0	23	25,68	134,8	3	1,41	7,47	2	6,2	43,71

Table 42. Prospective small-scale HPPs in GBAO. (scheme of 1995, TajikGIDEP)

#	Districts	Number of SHPP	tech. potential		$N_{garantee}$, for P=0,95 thousand kilowatt	$E_{garantee}$, for P=0,95 thousand kilowatt-hour
			N, average annual, thousand kilo-watt	E, average annual, thousand kilo-watt-hour		
1	**Darvaz**	8	89,39	783,83	11,97	104,86
2	**Vanj**	7	47,91	420,15	8,57	75,07
3	**Rushan**	13	76,08	667,01	10,86	95,13
4	**Shugnan**	14	76,03	666,77	8,92	78,14
5	**Roshtkalin**	12	30,59	268,18	5,53	48,44
6	**Ishkashim**	11	42,24	370,24	11,75	102,93
7	**Murgab**	8	22,33	195,81	-	-
Total for GBAO		**73**	**384,57**	**3372,0**	**57,60**	**504,58**

Table 43. Principal dimension types of turbines produced in Chkalovsk engineering plant

Scope of use				Mode of the maximum capacities			rotating frequency, volume/minute	Weight, kg	LBH, m
Model	Capacity, kW.	Pressure, m.	expense, cubic m. /second	Capacity, kW.	Pressure, m.	expense, cubic m. /second			
Fg-1a	300-600	90-165	0,3-0,56	600	135-165	0,56-0,47	1500	5000	4x3x1.5
Fg-1b	100-250	45-85	0,2-0,44	250	75-85	0,44-0,39	1000	5000	4x3x1.5
Fg-2a	300-600	60-100	0,49-1,01	600	72,5-100	1,01-0,75	1500	5000	3.5x3x1.5
Fg-2b	200-400	35-58	0,48-0,91	400	55-58	0,91-0,88	1000	5000	3.5x3x1.5

The necessary legislative-legal, normative-technical, industrial and financial bases for the successful implementation of the development program for the small scale power engineering in the republic.

The following small scale HPPs have been constructed in 1994-1999 using centralized investments and internal funds of "Barki-Tojik":

- SHPP "Teharv", with 360 kW power capacity, in GBAO – in 1994.
- SHPP "Histevars", with 630kW power capacity, in Leninabad Region-in 1996.
- SHPP "Hazara 1", with 250kW power capacity, in Varzob district –in 1998.
- SHPP "Kyzyl Mazar", with 70kW power capacity, in Soviet District-in 1998.
- SHPP "Andernarg", with 300kW power capacity, in GBAO –in 1999.
- SHPP " Hazara -2", with 250kW power capacity, in Varzob district –in 1999.

The following small scale HPPs have been constructed in GBAO during the same years utilizing the Aga-Khan Fund investments:

- SHPP "Shipak", with 30kW power capacity, in 1997.
- SHPP "Vand", with 60kW power capacity, in 1998.
- SHPP "Deh", with 30kW power capacity, in 1998.
- SHPP "Bardara", with 50kW power capacity, in 1998.
- SHPP "Raumed", with 30kW power capacity, in 1998.
- SHPP "Yanshor", with 30kW power capacity, in 1998.
- SHPP "Bosid", with 75kW power capacity, in 1999.
- SHPP "Pagor", with 100kW power capacity, in 1999.
- SHPP "Barchadev", with 45kW power capacity, in 1999.
- SHPP "Adeshih", with 30kW power capacity, in 1999.
- SHPP "Bodom", with 30kW power capacity, in 1999.
- SHPP "Vezdora", with 30kW power capacity, in 1999.

In 2000 the Government of Tajikistan signed the agreement with the Islamic Bank for Development on the lax credit granted to Tajikistan in the amount of 9 million US dollars for 25 years, including the lead grant of 300 thousand dollars in 2000 for the construction of small hydropower plants. Intergovernmental agreement between the Republic Tajikistan and the Islamic Republic of Iran on granting of credit in the amount of 1 million US dollars was signed in 1998.

Agreements on granting of lax credits for construction of small scale HPPs were reached with the Asian Development Bank, the International Financial Corporation and other financial institutions. The advanced program for development of small power engineering in Tajikistan is developed taking into account all these sources. It is described in the table 44.

Table 44. Construction program for small scale HPPs in Tajikistan for the period till 2010.

#	Name of hydro-power plant	N, kw	cost, mln. rubles	Carried out, as of 1.04.2000	Financing, in mln. rubles		
					total	budget	internal funds
Construction of new plants							
1	Kuhiston SHPP of mastchos district	1200	2459,5	62,38	27,21	27,21	-
2	Artuch SHPP of pend-jikent district	600	1333,4	108,58	93,41	78,1	15,31

3	Tutak SHPP of Garm district	750	1536,1	46,86	26,57	26,57	-
4	Shash Bolo SHPP of Darband district	300	493,6	8,91	4,5	4,5	-
5	Runou SHPP of Garm district	1000	1650,0	8,92	8,92	8,92	-
6	Hait SHPP of Garm district	250	395,6	8,91	7,9	7,9	-
7	Halkarf SHPP of Garm district	45	74,1	7,86	-	-	-
8	Surhav SHPP Tavil-dara district	500	1024,6	10,31	-	-	-
9	Pitavkul SHPP of Dzirgital district	500	1024,6	17,70	6,0	6,0	-
10	Degilmon SHPP of Tajikabad district.	1200	1983,6	5,09	-	-	-
11	Voruh-2 SHPP Isfara district	600	640,8	18,98	18,0	4,5	13,5
Rehabilitation of plants							
1	Fathobod SHPP of Tajikabad district.	500	892,1	8,33	4,0	4,0	
2	Garm SHPP of Garm district	500	827,6	-	-	-	-
3	Cheptura SHPP of Shahrinav district	500	817,6	1,0	-	-	-
4	Gaberut SHPPof Ainin district	3000	4976,5	-	-	-	-
5	Moskva SHPP Kafirnihon district	500	819,8	-	-	-	-
6	Buvak SHPP of Var-zob district	500	791,2	-	-	-	-
Plants design							
1	Katta sai SHPP of Uratube district	500	666,4	-	-	-	-
2	Sangikar SHPP of Garm district	500	834,4	-	-	-	-
3	Kalandak SHPPof Garm district	500	835,0	-	-	-	-
4	Garmo SHPP of Vanch district	500	640,0	-	-	-	-
5	Gurumbak SHPP of Tavildara district	500	672,8	-	-	-	-
6	Tusyan-2 SHPP of Roshtkalin district	350	480,6	-	-	-	-

7	Rudaki SHPP of Pen-jikent district	600	673,0	1,0	-	-	-
8	Kyzyl-Mazar-2 SHPP of Soviet district	500	673,0	8,5	1,0	1,0	

9. Economic issues of small power engineering development

9.1 Comparative efficiency of small scale HPPs

The only alternative for small scale HPPs in the construction areas where the projects are implemented can only be diesel plants. The cost of diesel power plants of the same power capacity as designed small scale HPPs is shown in the table 45.

Table 45. The cost of diesel power plants, as of July 2006.

Brand	Country	Power capacity, kilovoltampere	Cost,∈
SDMO T 22K (in shroud)	France	16	12410
SDMO T 17KM (in shroud)	France	16	13166
SDMO T 27HK (in shroud)	France	22	11342
FG Wilson P27/30E (in shroud)	England	22	18475
AusoniaJOOO30 SWD (in shroud)	Italy	24	11800

As seen in this table, the specific cost of the diesel power plants equipment in the world varies in range:

$$491{,}7 \le \mathbf{C_{des}} \le 839{,}8 \text{ doll/kw, with average price of } 689{,}1 \text{ USD/kW.}$$

As a reserve and with the benefit for diesel plants for the further comparative calculations let's accept a specific cost for construction of a diesel power plant to an equal minimum price of the equipment, that is:

$$K_{dpp} = \mathbf{P_{dpp}} = 491{,}7 \text{ USD/kW.}$$

Thus, unlike small scale HPPs for a variant of diesel plant we will consider neither the cost of transportation of the equipment, nor the expense for all construction work.

Cost of the fuel imported to Tajikistan is showed in Table 46.

Table 46. Cost of the fuel imported to Tajikistan

Year	2000	2001	2002	2003	2004	2005	2006
Doll/ton.	174	262	198	232	313	409	539

The data of this table shows the continuous rise in prices of diesel fuel for all considered periods. Though for comparative calculations with a stock let's accept that for all life cycle of projects the price for a diesel fuel will remain "frozen" on the level:

$$p = 539 \text{ USD/ton} = 0{,}000539 \text{ USD/gram.}$$

Taking into account these data, calculations of maximum-permissible specific investments in small scale HPPs will be defined under the formula:

$$K_{SHPP} = \frac{(P_{эс} + E_H)\cdot \beta \cdot \alpha_H \cdot K_{эс} + \alpha_Э \cdot в \cdot ц \cdot h}{(P_{SHPP} + E_H)}$$

where: $\mathbf{P_{des}}$ – annual costs in the shares from the capital investments into Diesel Power Plants, = 15%,

$\mathbf{E_H}$ – normative capital investment - effectiveness ratio, = 0,08,

β - factor, characterizing share of the established small scale HPPs capacity, which can participate in covering the maximum loading at the most difficult year season:

$$\beta = \frac{N_{\text{monthly average}}}{N_{spec.}}$$

$\mathbf{N_{average\ monthly.}}$ – average monthly power capacity of small scale HPPs in the most unfavourable period of a year.

For our conditions

$\mathbf{N_{average\ monthly.}}$ = N i.e. β = 1

$\boldsymbol{\alpha_H}$ –equivalence factor for power capacity of small scale HPPs and DPP (diesel power plants). For areas with isolated power supply, where DPP requires double duplication:

$\alpha_H = 2$

$\boldsymbol{\alpha_Э}$ – equivalence factor for energy of small scale HPPs and DPP,

$\alpha_Э = 1{,}1$

в – specific fuel consumption on DPP. In mountainous conditions of Tajikistan:

в = 330 gr/kw.h.

h – number of usage hours of fixed power capacity of small scale HPPs,

h = 6000 hours/year,

$\mathbf{P_{SHPP}}$ – annual expenses in shares from investments to small scale HPPs:

P_{SHPP} = 3%.

Substituting these meanings in the formula, we will get:

$$K_{SHPP} = \frac{(0{,}15 + 0{,}08)\cdot 1 \cdot 2 \cdot 491{,}7 + 1{,}1 \cdot 350 \cdot 0{,}000539 \cdot 6000}{(0{,}03 + 0{,}08)} =$$

$$= 13375{,}2\ USD/kWh$$

All small scale HPPs projects in Tajikistan have approximately equal specific costs 2500 USD/kWh, and this is 5,35 times (13375,2 : 2500) less than maximum permissible cost of a small scale HPP. This shows the very high comparative efficiency of the project.

9.2. The commercial analysis of SHPP projects

Nowadays the electric power market in rural, especially in mountainous areas of Tajikistan is in the initial stage of development. Rural areas have a very limited electricity supply and cannot sustain the basic needs of the populations.

The administration, representatives of local business and the population are greatly interested in the local construction of small hydropower plants and are ready to financially support them.

There is no need in advertising the benefits of electric power – everybody knows its advantages.

There is no competition in power industry and there are power networks in all settlements set up for electricity distribution.

The quality of power produced by small scale HPPs also does not pose any problems. The electric energy output is supposed to be delivered to consumers through two (step-up and step-down) transformer substations with modern equipment and automatic control systems.

9.3 The financial analysis of small scale HPP projects

The calculations of absolute economic efficiency of small scale HPPs can be carried out only by common meanings of main indicators. Such calculations are made below for typical conditions of small scale HPP with 20 kW power capacity in Tajikistan,:

- Construction cost of a small scale HPP: I_0 = $49 000 (~2500 USD/kW.)
- Construction deadline: t = 1 year[7]
- Project life cycle: T ≥ 50 years[8]
- Minimum tariff for power energy: p ≥ 0,03 USD./kWh.
- Primary cost of small scale HPP power: c = 0,0125 USD/kWh[9]
- Annual output power of a small scale HPP (including the hours of fixed power capacity usage: h = 6000 h./year[10]), E = 120 000 kWh. per year
- Discount factor: q = 0,9[11]

With the use of these data the calculations of basic indicators of small scale HPP project absolute cost-effectiveness are made below:

1. Operating profitability: **- 140%**
2. Simple payback period: **- 23,8 years**
3. Discounted payback period: **- absent**
4. Internal profitability norm ($\mathbf{q_0}$): **- 0,96**
5. Pure discounted income: **= - 19760 USD.**
6. Income index**: -** **negative**

[7] Acc. to the analogs
[8] Acc. to the analogs and norms of RF
[9] Acc. to the analogs
[10] Acc. to the analogs
[11] Acc. to the World Bank recommendations for Tajikistan.

The same negative results for financial efficiency will take place for any small scale HPP in Tajikistan with existing price rates for construction and electricity. Thus now taking into account absolute efficiency of small hydropower plants is not attractive for investors. Therefore nowadays construction of small scale HPPs in the republic is possible only with support from the state or with the financial assistance of foreign investors.

All above facts show that market reforms required to set up a market for small hydropower are still not in place in the power sector of Tajikistan. As a result, the electricity rate in the republic today is the lowest in the region. It results in a very long project payback periods and negative income[1]. However taking into consideration that Tajikistan has started market reforms one can say that in short time(shorter than service period for small scale HPPs) electricity rates in the republic will meet common global standards. Absolute economic efficiency of small scale HPP projects will certainly be provided in this case. It is impossible to prove this via direct calculations, since there are no official projections of tariffs increase in the future.

To some extent the low economic efficiency of considered projects is due to high discount rate (10 %), which is used in calculations and presently recommended by the World Bank for Tajikistan, a consequence of low electricity rates in Tajikistan following civil war of the 1990-s in Tajikistan. However presently, the electricity rates are gradually increasing, and there is no doubt that the rates will increase even more in the near future.

It is also evident that the economic efficiency of all considered projects will stay at the normal level required for commercial projects.

9.4. Susceptibility analysis of economic efficiency for small scale HPPs in Tajikistan

Generally, all the parameters of economic efficiency for small scale HPPs can be represented as functional:

$$\mathbf{P = f (N, c, T, t, I_0, h, q)}$$

By such representation the susceptibility research turns into the research of the function augmentation depending on an augmentation of its separate arguments.

Taking this into account, first of all, it should be noted that in spite the fact that all key parameters of economic efficiency, except profitability index, are directly proportional to power capacity of small scale HPP – **N**; the last is set by the customer depending on a consumer demand and river possibilities and consequently there is no point of considering it as a random variable and investigating its variability.

The electric power cost price – «**c**» differs a little from it in this sense. It also doesn't undergo casual changes and is defined almost unequivocally by technical requirements, specifications, etc.

The issue of susceptibility of the financial analysis results concerning the SHPP durability – **T** raises more interest in this case. Basically, it can vary from several years to several decades. However practice shows that, as a rule, such stations serve no less than 20 years. Therefore it is viable to only change the **T** parameter to a range of 20 to 100 years. To clarify the importance of these changes, it should be noted that parameter **T** is included in all efficiency equations

[12] At the same time prices for diesel fuel in Tajikistan are already regulated by market. It can be explained only by high comparative economic efficiency of considered SHPP.

only in the expression: $(\mathbf{q} - \mathbf{q}^{\mathbf{T}}) / (\mathbf{1} - \mathbf{q})$. Meanings of this formula and its variables are shown in the table 47, as of below:

Table 46

		q meanings						
		0.99	**0.95**	**0.9**	**0.85**	**0.8**	**0.75**	**0.7**
T meanings	**10**	8.562	7.025	5.513	4.354	3.463	2.775	2.239
	20	17.209	11.830	7.784	5.408	3.942	2.987	2.331
	30	25.030	14.707	**8.576**	5.616	3.994	2.999	2.333
	40	32.103	16.430	**8.852**	5.657	3.999	3.000	2.333
	50	38.499	17.461	**8.948**	5.665	4.000	3.000	2.333
	100	62.397	18.882	**9.000**	5.667	4.000	3.000	2.333

It should be noted that for all real meanings of **q** and **T**, presented in the table as bold and highlighted ones, the influence of last parameter (**T**) on economic result is very slight, maximum a few percents.

T**able 51** also shows that at times, there is a serious influence on economic efficiency of the discount factor **q**. Unfortunately, as mentioned above, this parameter depends on external economic factors, and only partially on political conditions and thus cannot be regulated in the separate project.

Such parameters as **t** and $\mathbf{I_0}$ also cannot be considered as independent variables. They are defined by local market conditions. Besides, from a functional point of view, an alteration of **t** only slightly affects the results.

Finally, the **h** parameter (business hours of the number of small scale HPP units' per year) has a very great influence on economic efficiency. All economic indicators are directly proportional to the meaning of **h**, but in calculations its meaning is accepted with no maximum possibility. Therefore, it can change only with aproportional growth of economic efficiency.

The analysis conducted shows a high stability of results received for economic efficiency calculations and presence of essential space for its further development.

9.5. Stability of small scale HPP projects

Stability of SHPP projects, i.e. their maintenance to ensure safety as well as their work reliability during whole life cycle period is provided by complex measures implemented at the stage of the project preparation, professional training, technical operation and financial management.

At the stage of project development, safety is provided at the account of:

- Selection of construction area for small scale HPPs: sites with minimum risk of dangerous natural-geological processes.
- Selection of the most common layout, and construction and technological decisions.

Application of maintainable designs of basic constructions of water supply points, provides operations and the maintenance of small scale HPPs with a 100 percent construction durability. However it is also impossible for low power capacities of small scale HPPs.

Effective technical operation of SHPP, as well as professional training is possible only in cooperation with the management of small scale HPPs and other similar enterprises. It can also be provided within or by Jamoats Resource Centers.

The specialized support for operation and maintenance of small scale HPPs from the specific organizations would be also of great use. For example, in August 2006 OSHC "Barqi-Tojik" concluded the contract with St.-Petersburg firm "Intek" on such services. It would be useful to extend such practice to all small scale HPPs in the republic, irrespective of their subordination.

To provide normal operation within small scale HPPs, it is necessary to organize constant monitoring and regular inspections of all constructions of water-engineering systems by qualified experts within the field of expertise.

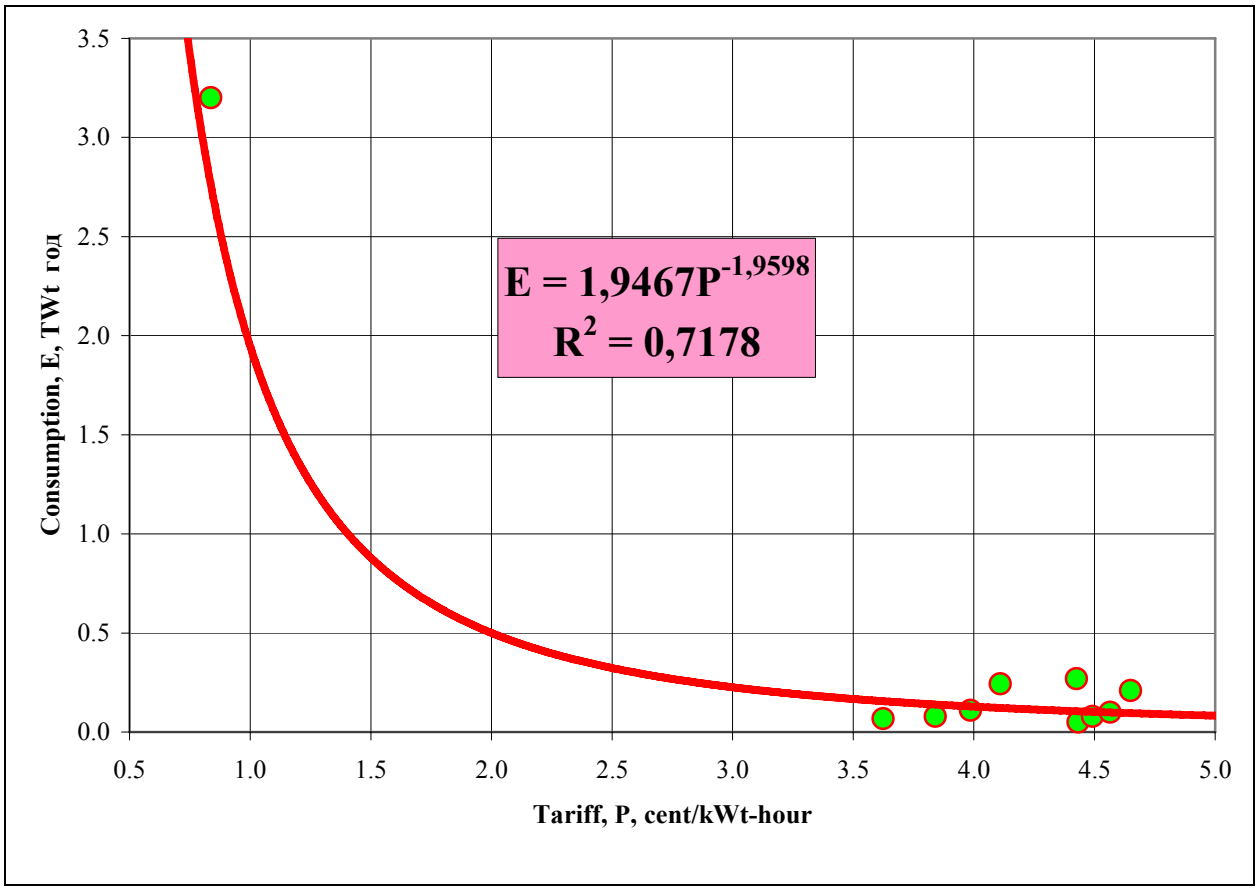
The primary goal of financial management providing stability for all scale HPP projects, is the development and enforcement of well-set payment system for electricity for all consumers, to cover all operation expenses.

Taking into consideration the high poverty levels of Tajikistan, and in order to provide them with grants for construction of small scale HPPs, it is necessary to enforce the mechanism for compensation of electricity consumption accepted by the Government of the Republic Tajikistan in 2003 specifically designed for consumers of electricity produced by small scale HPPs.

10. Tariff policy for the small-scale hydro power of Tajikistan

According to the data of the Ministry for Energy and Industry, there's a constant growing deficit of electricity in the country. In mid 1990s it equaled 1,5 bln. kWt-hour annually. Currently it is estimated to be around 3,5-4,5 bln. kWt-hour. The majority rural districts, home to around 70% of country population, is provided with only (4-6) hours per day in wintertime.

The analysis of economic situation in the energy sector of Tajikistan indicates a distinct link between electricity consumption and its price (tariff). It is illustrated by the graph 5.



Graph 5. Elasticity of demand for electricity by tariff (for population)

In accordance with this graph, elasticity of demand for electricity by its price equals:

$$\frac{dE/E}{dT/T} = 1.9598$$

The high elasticity of demand which provides high regulatory capability of its consumption in the market economy is considered as elasticity equaling to "one". The electricity elasticity by its price is two times higher in Tajikistan. It shows that the cardinal way to settle the issue of the electricity deficit in the republic is to increase its price (tariff).

There are several options to liquidate electricity deficit. One of them is to use other alternative sources of energy. Unlike most countries, such alternative sources of energy for Tajikistan are coal, oil, gas, and only afterwards solar energy, wind energy, biogas. The use of these energy carriers domestically is possible and quite reasonable and one cannot say that these energy sources are inaccessible to the population. The coal and liquefied gas are currently available in the market[13]. The equivalent prices are much higher than those for electricity. For instance, the current price for coal in Tajikistan is around 30-40 USD per ton, which corresponds to 3 cents per kWt-hour and exceeds the current price for electricity by 6-8 times. The same is the situation with gas. The current gas price is 55 USD per 1000 m^3, which corresponds to 1,8 cents per kWt-hour. A double increase in gas price is expected in 2007. This is

[13] The deficit of natural gas which is mostly being imported from Uzbekistan is related to non-payments of consumers, similarly to the case with electricity.

The population uses these sources of energy only because alternative choices no not exist.

The introduction of alternative sources of energy, i.e. coal and gas, into the energy system is possible only if their cost is equaled to that of electricity. Coal and gas industries currently work in the market economy conditions and their prices can hardly be decreased, the only option is the increase of electricity tariffs.

The view that the intensive forest felling practiced today is related to the lack of other energy resources is economically baseless. Forest felling is not explained by the lack of access to coal and gas (these energy carriers are available at the market) but by their price. The forest is free of charge-the reason for mass forest felling[14].

Another way to liquidate the electricity deficit is to import it from neighboring countries. Such an option is quite workable – there are HPP capacities available in Kazakhstan and Turkmenistan. However such import is possible if only the electricity tariff in Tajikistan is no less than the one in the countries mentioned above, as the state energy company of Tajikistan cannot sell the electricity for less than it has been purchased.

The electricity tariffs in the neighboring countries of the Central Asian region equal 1,5-2,0 cents/kWt-hour, and with account of transit cost it will equal 2-2,5 cents/kWt-hour, with the tariff set at 0,5 cents/kWt-hour in Tajikistan. Therefore this option is viable only if the electricity tariff in Tajikistan is increased.

Of course, the issue of electricity deficit could also be resolved if new HPPs are constructed in Tajikistan. These HPPs could be constructed at the expense of own resources (energy system profits) or at the expense of foreign investments. However both these options are viable only if the electricity tariffs are increased. The construction of new HPPs is possible if the electricity tariff is set at 1,5-2,0 cents/kWt-hour. If the new HPPs are constructed at the expense of foreign investments (whether as private property, or credits to the country), then the prime cost of electricity would be not less than 3,0 cents/kWt-hour.

It is possible to liquidate or at least to considerably decrease the electricity deficit through energy saving programs. However, implementation of energy saving programs is only possible through a direct increase in tariffs, or through the introduction of energy saving technologies which require large financial investments at all levels.

Naturally all the considerations above also relate to the development of an energy system –development is possible only if the existent tariffs are increased.

Therefore both the liquidation of the electricity deficit and normal exploitation of energy system securing its reliability and safety, as well as further development of the energy system unambiguously require an increase in current electricity tariffs.

It should be noted that the current situation with tariff containment policy is quite artificial. This policy is linked to the electricity consumption by population. Today the electricity consumption by population has increased 4÷5 times than that in the 1980s. Such growth in consumption is rather doubtful, moreover this data is acquired with no reliable registration of electricity consumption[15]. This artificial growth in consumption by domestic sector is most probably

[14] Therefore in order to prevent forest felling, it is essential to set up an adequate price (or, at least, adequate fines) for forest felling.

[15] Even technically the possibilities for such growth in consumption are doubtful. Internal electric grids for electricity supply of domestic sector were designed and constructed back in 1970-80s and were not reconstructed since then. These grids technically cannot pass through the load five times exceeding the one which was projected by design.

explained by the fact that huge technical and commercial losses while the population consumption is calculated[16].

According to official estimations from SSHC "Barqi Tojik" the losses equal to around 15-16% during these last years. The real figure is undoubtedly much higher[17]. Taking into account the experience of Kyrgyzstan one can assume that the amount of unaccounted losses attributed to population consumption can reach around 30%, i.e. 4-5 billion kWt-hours annually.

The major argument of those against an increase of electricity tariffs is the poverty of the population. The opponents refer to the fact that even today the electricity payments by population are irregular, and if electricity tariffs are increased then it will be unaffordable to population due to its high price.

At the same time it is not clear why poverty is used as an argument in this case, while all other goods and services are priced by the market, and did not become unaffordable for the population.

The non-payment of electricity tariffs by the population cannot be explained reasonably. A total consumption of 4,3 bln.kWt-hour annually within last eight years, with population of 6,7 mln., and tariff of 0,5 cent/kWt-hour and average family size of 5 people, the expenditures for electricity are to be equal to:

$$\frac{4{,}3b\ln.kWt.h.\times 5people/family\times 0{,}5cent/kWt.h.}{6{,}7m\ln.person\times 12months}=1{,}34USD/month$$

Compared with average salary of 31,2 USD/per month in 2006 (102,88 TJS/per month), it is around 4,3% of the salary. With current paying capacity of population today such expenditures are quite affordable. For instance, the regular practice of micro-HPP constructions and purchase of diesel-based electric stations can serve as an evidence. The research conducted within the framework of ADB projects illustrates that each family in this case pays around 5 TJS monthly for the maintenance of micro-HPP. Another example: the inhabitants of Novokandoz kishlak in Varzobski district lacking access to centralized electricity supply were compelled to purchase a diesel-based electric station whose fuel constituent alone equals around 25 cents/kWt-hour. Undoubtedly that in this case electricity is used very economically, only for very basic needs.

It should be also noted that the assessment of poverty level in Tajikistan is also rather relative. It is based on GDP per capita, calculated by official statistical agency on the basis of official USD exchange rate. The GDP per capita equaled 360 USD in 1994 and 169 USD in 2001.

There are other methods to estimate poverty level in the world practice. The living standard of population is estimated on the basis of purchasing power parity (PPP) for which countries such as Tajikistan with a transition economy, can result in very different figures. This data is given in the table 5: it constituted 970 USD in 1994, and 1170 USD in 2001. It is evident that these figures exceed official ones by 2,7-6,9 times [18].

The PPP gives not only more objective assessment of the living standard of population, it also gives a comparison of prices for goods and services. The official statistics given above

[16] By commercial losses here we mean thefts/misappropriation of electricity.

[17] For instance, an effective system for calculations of losses was established in Kyrgyzstan in the end of 1990s; it was determined then that the losses equaled 45%. Currently the losses in Kyrgyzstan are decreased to 25%. Currently the situation in Tajikistan is similar to the one of Kyrgyzstan back in 1990s.

[18] It should be noted as well that while assessing poverty level the official statistics does not take into consideration the contribution of labor migrants which equals several annual budgets of the country and constitutes a considerable portion of GDP.

merely discredits the current policy of Tajikistan. As a result of the considerable efforts of the Government and personally Emomali Rakhmon, President of the Republic of Tajikistan, from the second half of 1990s the country achieved political stability, economy rehabilitation and a considerable increase of the population's living standard.The official statistics however says that the population's living standard decreased (GDP per capita) more than two times, i.e. degradation of economy has taken place.

At the same time, fears that the increase in electricity tariffs will result in social tensions are baseless. On the contrary, introduction of market pricing for electricity will have a positive effect. The bread market can serve as an example in this case. In the 1990s, after the USSR collapsed, the prices for bread products were strictly regulated by the state. The situation with bread back in 1990s was critical, much worse than that with electricity today. The living standard of population was also lower than now. The opponents of the market pricing of bread feared hunger. However the Government introduced the market pricing for bread products, and thus resolved the critical issue.

Therefore one can be assured that introduction of market relations into the electroenergy sector will have a positive effect.

All the arguments above illustrate the need for an increase in the existent electricity tariffs in Tajikistan today. It is required both for economy rehabilitation, and to increase the efficiency in the use of energy sector. The major efficiency index of national economy is its electrocapacity (table 48) is at a very low level compared to 1990.

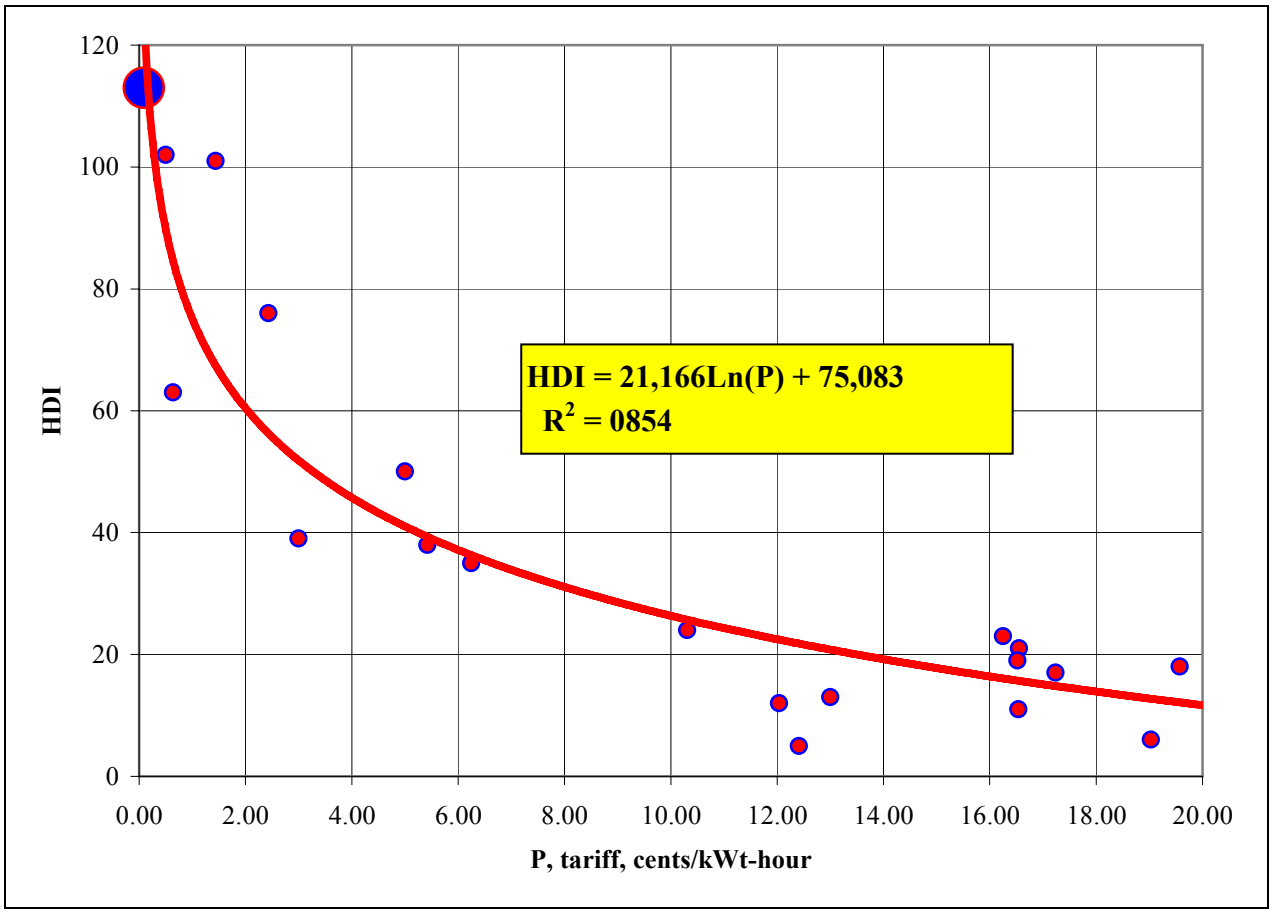
Table 47. Electrocapacity of GDP in Tajkistan

Year	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2001**	**2002**	**2003**
kWt-hour/USD	1,68	12,4	15,13	13,91	13,44	14,47	11,13	10,81	10,49

The tariff increase will enable all four methods of deficit liquidation under consideration and will simultaneously create conditions for sustainable development of hydro power and profitable export of Tajik electricity to other countries.

Reasoning the need for an increase of electricity tariffs is a challenging task. The increase of electricity tariffs is viewed as a negative trend, which will worsen the living standard of population however, it is unavoidable. The issue is not as simple as it seems. The issue here is not an increase of electricity tariff, but to increase from the lowest level (compared with those around the world) to a level which will still be lower than those in the developed countries.

It should be noted that the living standard of population depends not upon the electricity tariff, but upon the efficiency of its use. Worldwide experience shows that there is a direct correlation between electricity tariffs and the efficiency of its use, as illustrated by the graph 6.



Graph 6. HDI of countries in relation to the electricity tariffs (for population)

The increase of electricity tariff should be thoroughly prepared. The process itself should be gradual. It is assumed though that a primary increase of electricity tariffs to the rational level of 2 cents per kWt-hour could be put into practice rather quickly, approximately one year. A further increase in tariffs should take into consideration regional and global trends. All these processes and their results and impacts should be constantly monitored.

The tariff increase should consider the defense mechanism for the poorest, similarly to the humanitarian assistance that they are provided with. The mechanism of state subsidies is already established by the Government of the Republic of Tajikistan which is to be further enhanced.

In conclusion, it should be pointed out that the increase of electricity tariff is not an in itself, nor the target to increase financial profits of the state energy company. The increase of electricity tariff is the means of economic development of the country. Therefore the process of the tariff increase should be constantly accompanied by the monitoring of its results and impacts. The relation of the dynamics of GDP per capita to the dynamics of tariff increase, or the relation of the increase of population income to the dynamics of tariff increase could serve as indicators of the tariff increase results.

The electricity tariff of the energy system of Tajikistan should cover all expenditures for the maintenance of the energy system with account of the profit level sufficient for the development of energy sector. The profit level sufficient for the development of energy sector is determined by the strategy of development. The tariff should have following components:

- production costs;

- profit;
- VAT;
- income tax.

Production costs include the following components:

- production services;
- auxiliary materials;
- salaries including charges for social security insurance, pension fund, according to the regulations set by the country legislation;
- aamortized deductions for renovation;
- repair service deductions;
- land-tax;
- highway user's tax ;
- other costs.

The profit sufficient for the development of the energy sector is a part of gross profit received after electricity is sold and left for the discretion of the energy company in accordance with the agreed regulations

The VAT is defined in accordance with the article 201, Chapter 25, Part VII of the law of the Republic of Tajikistan on "Adoption of tax code of the Republic of Tajikistan", N61 as of 03.12.04, the part of added value defined as a difference between the cost of sold goods and services, and the cost of materials related to the production and distribution costs, i.e. of the sum of salary fund with extra fees.

The income tax is calculated in line with the Decree of the BC Presidium of the Republic of Tajikistan "On introduction of special tax" as of 18 June 1994. This tax is set at the level of 3 per cent of the production (service) sale. Calculation and levying of taxes is conducted in the way set by the legislation on VAT.

This is the general scheme of electricity tariff determination of the energy system. It fully refers to the small scale HPPs as well, however the exploitation costs does not include investment expenses for its construction. In this last case, such HPPs will become unprofitable, and the electricity produced by these small scale HPPs will be unaffordable for the population. In this case the mechanism on electricity consumption compensation in use in the republic, should be extended to the small scale HPPs as well.

The mechanism on electricity consumption compensation (ECC) in force as of January 2003 provides the subsidized billing for gas and electricity. The scheme also ensures monthly direct payments of cash to WWII veterans in the amount of 15 TJS. Such payments are made in addition to the pensions of the veterans. Around 7 000 veterans are eligible for these additional payments. The budget of the mechanism for electricity consumption compensation constituted 12 mln. TJS in 2003, 20 mln. TJS in 2004 and has been increased up to 22 mln. TJS by 2005. Around 545000 families have received discounts on electricity billing, for the amount of 11,2 mln. TJS, and 417000 have received discounts for the amount of 8,4 mln. TJS.

The beneficiaries of the mechanism on electricity consumption compensation received around 200 kWt. electricity monthly in the wintertime (October-March) and 100 kWt. monthly in the summer (April-September). This equals to around 3.2 TJS per month in the winter and 0.8 TJS per month in the summer.

With regards to gas, the beneficiaries of the mechanism on electricity consumption compensation received

around 20 m. of gas per month per member of the family (up to six inhabitants) in the summer, and around 30 m. of gas per month per member of the family (up to six inhabitants) in the winter. The amount of compensation with the number of inhabitants of 6 and less, is equivalent to the norm.

The families are eligible for the mechanism of electricity consumption compensation, is the total income of the family is less than average salary of one person in the district where the family lives. The data on average salary is provided by the State Agency on Statistics.

For instance, in Rudaki district the average salary is 54 TJS per month, consequently the families with total income less than 54 TJS are eligible for the mechanism on electricity consumption compensation.

The families apply to the local committee (Jamoat) for such direct cash payments. The process of application envisages that the following documentation is provided:

- Confirmation of the family income;
- Reference on the family size;
- Confirmation on the registration of the inhabitant, the documents on housing property;

For residents who are unemployed an official confirmation on their unemployment status is required.

After the application for electricity consumption compensation is received, the housing of the applicant is visited by the members of the Jamoat. After the visit, the documents are further forwarded to the district committee. The district committee examines the documents provided by the Jamoat, on the criteria of compliance. Afterwards the general list of all applicants is provided to the Ministry of Energy, to the Ministry of Labor and Social Security in Dushanbe.

The Ministry of Labor and Social Security, as well as the Ministry of Energy approves the list of applicants and returns back the list of beneficiaries per district to the district committees. The aggregate list of beneficiaries is also forwarded to the Ministry of Finance, so that it processes the necessary budgetary payments to the Jamoats through the district committees.

The payments on the electricity consumption compensation are provided for the period of one year. In the end of the year the family should apply for the electricity consumption compensation again, to confirm its status. The new lists for the payments due are prepared, provided and approved on the quarterly basis.

The payments are made by the Ministry of Finance to the Jamoats on the quarterly basis. The Jamoats in their turn process subsidized payments to the local divisions of Barqi Tojik and Tajik Gas on the quarterly basis as well.

All families eligible for the electricity consumption compensation receive electricity bills indicating the full amount of charge for electricity. However, as soon as the Jamoat make the subsidized payments to the service provider companies, the beneficiaries of the electricity consumption compensation receive the bill indicating the reduced sum (e.g. 450 kWt per quarter). Furthermore, the families only pay the reduced amount as per reduced bill either directly to the service provider companies, or via Amonat Bank, which processes payments for Barqi Tojik.

As a result of analysis and comments of the International Bank (World Bank) on efficiency of the electricity consumption compensation, the Government decided to modify the electricity consumption compensation and as well as its administrative aspects.

The quantity of energy received by the beneficiaries in the form of subsidies is planned to be increased from 100 kWt/150 kWt per month in summer/winter to 100 kWt/200 kWt per month in summer/winter for electricity, and from $20m^3/30m^3$ in summer/winter to $25m^3/35m^3$ in summer/winter for gas.

The families are to be provided with a choice between the scheme of electricity consumption compensation or the discount on the electricity and gas billing, or cash compensation.

11. Small Hydro Energy and Clean Development Mechanism

The Republic of Tajikistan acceded to the United Nations Framework Convention on Climate Change (UNFCCC) on the 7th of January 1998, undertaking its obligations as a party not included into the Annex 1 of above mentioned Convention. The obligations of the republic, in accordance to the UNFCCC, include:

- Elaboration and implementation of the climate change mitigation measures by undertaking actions to reduce the anthropogenic greenhouse gas emissions and work towards the adequate adaptation to the climate change;
- Collaboration in development, application and distribution of technologies, facilitating the limitation, reduction or elimination of greenhouse gas emissions and rational use of greenhouse gas absorbers and accumulators, their protection and enhancement of their quality;
- Cooperation in development and adoption of preliminary measures for adaptation to climate change;
- Integration of climate change issues into social, economic and environmental policy;
- Ease towards internationals efforts for the strengthening of systemic observations, capacity and opportunities in the area of climate science;
- Facilitate towards cooperation in the area of the information exchange, education and training, public awareness on climate change issues;
- Provision of the information on implementation of the UNFCCC, including the national cadastre of anthropogenic emission sources and absorption of all greenhouse gases.

The United Nations Framework Convention on Climate Change is the major environmental agreement of the 20th century intending to stabilize the greenhouse gas concentrations in the atmosphere and mitigation of climate change. UNFCCC was adopted on the UN Conference on Environment and Development (Earth Summit) in Rio-de-Janeiro in May, 1992, was enforced in March, 1994. The parties of the Convention have undertaken obligation not to increase the level of greenhouse gas emissions above the one of 1990. Currently 187 countries are part of this Convention.

UNFCCC has divided the countries into two large groups: the countries listed in the Annex 1, including industrialized countries and partially the countries with transition economy (the Russian Federation, Baltic states, the Ukraine, countries of Central and Eastern Europe); and all other countries, not listed in the Annex 1 to the UNFCCC.

According to Kyoto Protocol, the obligations on reduction of greenhouse gas emissions during the first period (2008-2012) apply only to the countries of the Annex 1. Quantitatively these obligations are given in the Annex B to the Kyoto Protocol.

To facilitate the reduction of costs while implementing of the Kyoto Protocol obligations, three joint "Kyoto" mechanisms, dealing with purchase and sale of reduced volumes of emissions, were established. These mechanisms are:

- **International trade on emissions** – enables the countries of the Annex 1 to sell and purchase part of the quota (established quantity of emission reduction units), determined by the Kyoto Protocol for the first period of obligations.

- **Joint Implementation** – enables the countries of the Annex 1 to sell and purchase reduced amount of emissions obtained during the implementation of projects on emission reductions. The deals are eligible only between the countries of the Annex 1.
- **Clean Development Mechanism еханизм чистого развития (МЧР)** – enables the countries, not included into the Annex 1, to sell the certified emission reductions, obtained during the implementation of the projects on emission reduction of their country's territory to the governments or companies of those countries listed in the Annex 1.

The Kyoto mechanisms enable the countries and private companies of the developed countries to invest into the emission reduction project around the globe. However according to the articles of the Kyoto Protocol, any reduction of such kind should be only additional to the internal measures on greenhouse gas emission reductions in the countries listed in the Annex 1.

The Clean Development Mechanism enables the countries of the Annex 1 to finance the projects on emission reductions on the territories of the countries not listed in the Annex 1. The certified emission reduction as a result of project implementation could then be used by the countries listed in the Annex 1 for fulfilling their quantitative obligations on emission reduction. The article 12 of the Kyoto Protocol establishes three goals for Clean Development Mechanism:

- To facilitate climate change mitigation;
- To assist the Annex 1 countries to fulfill their obligations on emission reduction;
- To assist developing countries develop in a sustainable way.

Both state and private companies can participate in CDM. The private companies must have a special permits to participate in CDM project, as the state is responsible in fulfilling its UNFCCC and Kyoto Protocol obligations.
Who and on which conditions the permits to participate in the CDM projects will be issued, will be an internal decision of a state authority.

In order to participate in the CDM project, the recipient countries (not listed in the Annex 1) must meet three requirements:

- Participation in the CDM projects is voluntary;
- A national authority for CDM should be established in the country;
- Country must have ratified the Kyoto Protocol.

One of the most important requirements in participating in the CDM is that the Government must appoint a National Focal Point on Clean Development Mechanism and establish a structure which approves the CDM projects at the national level. This assures the interests of the country while concluding an agreement on the purchase of certified emission reductions.

Any project aimed to reduce greenhouse gas emissions that cannot be implemented without CDM investments could be a CDM project (subsidiary principle).

The certified emission reductions being a result of the CDM project are a commodity that could be sold within the framework of the CDM project implementation. As a rule, the conditions of sale are stipulated in the contract upon signing of the project.

For instance, Prototype Carbon Fund of the World Bank concludes an agreement on the purchase of emissions where the purchase conditions of not only planned certified emission reductions, but also of additional reductions are stipulated. The certified emission reductions received therefore goes to the accounts of the investor companies upon disposal of the remaining reductions.

The future of the global market will largely depend upon the demand for CDM Projects from the side of private companies and countries of Annex 1. The international market for certified emission reductions is at the formation stage. Currently the price level of
the carbon market fluctuates within 3-5 USD per ton of emissions. The usual price, proposed by the Prototype Carbon Fund (PCF) equals 3-3.5 USD. The Center Programme (Netherlands) purchases the certified emission reductions of greenhouse gases at 3-5 EUR, the Government of Finland – at 2.47-3.2 EUR.

The size of emission sale income depends on several factors, the type of CDM project, the period of credit, world prices of the carbon market being the key ones.

The PCF experience shows that the stream of incomes calculated at the cost of 3 USD per ton of certified reductions of CO_2 emissions can considerably influence the modification of the internal rate of recoupment (IRR) of the CDM project. According to Graph 49, the volume of IRR increases by 1-5 %. According to the calculations, a five-year income from sale of the certified emission reductions (at 5 EUR/ton) covers the investment costs from 10 up to 100 % depending on the type of the project.

Generally, the CDM market must follow the same rules as any other commodity market. The payment is made upon delivery of goods, i.e. when the emission reduction is achieved and certified. The prepayment (not more than 25%) is made upon exceptional case. The payment schedule is stipulated in the contract. For instance, as per conditions of the Prototype Carbon Fund of World Bank, the payment for certified emission reductions to the project initiator is made annually, after the emission reduction is certified.

Table 48. Impact of CDM on IRR

Energy area	**IRR %%**
Energy efficiency – projects on heat supply	2-4
Wind energy	0.9-1.3
Hydro energy	1.2-2.6
Bio fuel	0.5-3.5
Biomass with methane	Up to 5.0
Residential waste with methane	> 5.0

The CDM projects are essentially the same investment projects. The main difference between a usual investment project and a CDM project is additional requirements related to the reduction of greenhouse gas emissions and sustainable development. The investment risks are similar and considered for the CDM projects as well. However there are additional risks related to CDM, such as: there is no emission reduction, and consequently no release of certified emission reduction.

The initiators of the project (project implementation unit) is in charge for monitoring of CDM project. The monitoring plan is elaborated and approved by the Executive Council simultaneously with baseline review and project development framework. The CDM project develop-

ers ensure that the implementation of this plan is in place, along with assurance of the planned emission reduction. The monitoring results will be verified by the operational body (independent audit).

One of the major goals of Clean Development Mechanist is to assist the countries not listed in the Annex 1, in achieving sustainable development. There are no leading guidelines to determine the criteria for sustainable development. The issue of national criteria elaboration is the mandate of the recipient country. Generally the criteria of sustainable development to which the CDM project contributes, could be categorized as follows:

- **Social criteria**. The CDM project enhances well-being, reduces poverty and facilitates justice.
- **Economic criteria**. The CDM project provides for financial income of local enterprises, has a positive impact on the payment balance and facilitates technology transfer.
- **Environmental criteria**. The CDM project reduces the amount of greenhouse gas emissions and use of fossil fuel, conserves local resources, reduces the anthropogenic impact on the environment, facilitates health enhancement, has many other environmental benefits and is in lieu with the energy and environmental policy of the country.

As far as an emission reduction at the carbon market as a commodity, it must be certified, as any other commodity. For this, a National Focal Point with respective authority, which conducted the certification of emission reduction of a separate project, must communicate the request for certification to the Executive Council under the UNFCCC Secretariat. The certification of the emission reduction is conducted within 15 days after the request for certification is received from the National Focal Point.

Certification is a written guarantee given to the National Focal Point stating that during the definite period of project implementation there is a verified reduction in greenhouse gas emissions. The National Focal Point, upon the completion of the certification process should inform, in writing that the project parties and the Executive Council on their decision to certify the emission reductions and present a written report for its consideration. The report on the certification should include the request to the Executive Council on the release of certified emission reduction equivalent to the verified reduction of greenhouse gas emissions. If a project party or three members of the Executive Council do not demand a consideration of the request during 15 days, the Executive Council instructs the Clean Development Mechanism to release the certified emission reductions.

The Clean Development Mechanism register, established under the UNFCCC Secretariat, should keep the information on all releases of the certified emission reductions. When the Executive Council releases the certified emission reductions, these should be placed on the pending account in the register of Clean Development Mechanism. From then on, the certified emission reductions will be transferred to the account of the party's legal entity, according to the allocation defined by the parties in the project.

The conducted analysis shows that small scale HPP projects undoubtedly correspond to all requirements and conditions set by the CDM procedures. The use of the opportunities stated by the CDM while implementing the development program of small hydro energy sector of the Republic of Tajikistan will raise the status and economic efficiency of small scale HPP projects, as well as increase their attractiveness for investment purposes.

16. Action matrix on implementation of Tajikistan's small scale hydro power strategy

Priorities	Tasks	Actions	Success indicators	Timeframe	Resources to be involved, internal / external (in mln. USD)
Short-term program for construction of small scale HPPs	Increased access to electricity by population, from 30% to 100%, with the aim to achieve the MDGs.	Creating favorable conditions for investments into small scale HPP projects	Access to electricity for 8 584 families provided	2007--2010	6,7/5,1
Medium-term program for construction of small scale HPPs			Access to electricity for 17 015 families provided	2011--2015	20,7
Long-term program for construction of small scale HPPs			Access to electricity for 51 824 families provided	2016--2020	92,6
Inventory of small scale HPPs	Security enhancement at small scale HPPs	Conducting a complex inspection of small scale HPPs	Reliability criteria for small scale HPPs are developed	2007--2008	
Establishment of small scale HPP database and its constant monitoring	Efficiency enhancement of small scale HPPs	Summarizing the complex inspection results of small scale HPPs	Exchange of experience in small scale HPP exploitation in place	2008--2009	
Specification of Tajikistan's energy resources	Determining the energy potential of small scale HPPs and its allocation	Expeditionary investigation and material analysis of small rivers.	Classification of small scale HPP resources by categories A, B, $C_{1,2}$ completed	2008--2010	

Elaboration of pilot investment project "Development of small rivers' energy potential through construction of small scale HPP series"	Economic and ecological optimization of small scale HPP construction	Elaboration of basic theses of technical and economic assessment	Increased use of small river hydro potential	2008--2009	
Establishment of the Coordination Centre (Agency) for small scale HPPs under the Ministry of Energy and Industry of the Republic of Tajikistan	Coordination of the Small Hydro Power Strategy implementation	Elaboration of the Statute on Coordination Centre	Favorable conditions for small scale HPPs established	2007	
Elaboration and approval of the national and ministerial engineering norms for small scale HPPs	Standardization and unification of small scale HPP projects	Elaboration of standards for exploration, constructions, economics of small scale HPPs	Reliability and economic efficiency of small scale HPPs increased	2007--2010	
Development of proposals for amendments into the legislative and regulatory framework of the Republic of Tajikistan on small hydro power	Establishment of concessionary terms for small scale HPP development	Discussion of and agreement upon with the Ministries, agencies, population awareness campaigns	Internal and external investments for construction of small scale HPPs are being attracted	2007--2015	
Development of proposals on privatization of small scale HPPs and turning them into joint stock companies aiming to introduce market relations into small hydro power sector of the Republic of Tajikistan	Efficiency enhancement in the small hydropower sector	Conducting economic analysis and introducing proposals into the Government of the Republic of Tajikistan	Increased economic efficiency of small scale HPPs; investments are being attracted	2007--2015	

Project analysis of first priority small scale HPPs. Development of proposals on unification and standardization of technology equipment in use	Quality refinement and cost reduction of technological equipment of small scale HPPs	Collection and analysis of small scale HPP project data. Conducting consultations	Dimension-sizes of small scale HPP equipment in use is reduced	2007--2008	
Development of national base for production and maintenance of the small scale HPP equipment	Equipment unification and standardization for small scale HPPs	Elaboration of construction documentation. Establishment of equipment production at the plants/factories	Reduction in construction cost of small scale HPPs	2010--2020	
Development of training programs for maintenance personnel of small scale HPPs. Organization of trainings at SSHC "Barqi Tojik" training centre.	Advanced training of small scale HPP personnel	Organization of daytime and correspondence trainings for small scale HPP personnel	Reliability and functional safety of small scale HPPs increased	2007--2015	