ESMAP

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Kazakhstan and Kyrgyzstan

Opportunities for Renewable Energy Development

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JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run by the World Bank's Industry and Energy Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and 15 bilateral official donors in 1983, it focuses on policy and institutional reforms designed to promote increased private investment in energy and supply and end-use energy efficiency; natural gas development; and renewable, rural, and household energy.

GOVERNANCE AND OPERATIONS

ESMAP is governed by a Consultative Group (ESMAP CG), composed of representatives of the UNDP and World Bank, the governments and other institutions providing financial support, and the recipients of ESMAP's assistance. The ESMAP CG is chaired by the World Bank's Vice President, Finance and Private Sector Development, and advised by a Technical Advisory Group (TAG) of independent energy experts that reviews the Programme's strategic agenda, its work program, and other issues. ESMAP is staffed by a cadre of engineers, energy planners, and economists from the Industry and Energy Department of the World Bank. The Director of this Department is also the Manager of ESMAP, responsible for administering the Programme.

FUNDING

ESMAP is a cooperative effort supported by the World Bank, UNDP and other United Nations agencies, the European Community, Organization of American States (OAS), Latin American Energy Organization (OLADE), and public and private donors from countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

FURTHER INFORMATION

An up-to-date listing of completed ESMAP projects is appended to this report. For further information or copies of completed ESMAP reports, contact:

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Kazakhstan and Kyrgyzstan: Opportunities for Renewable Energy Development

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Preface

The present study was undertaken by the Energy Sector Management Assistance Programme (ESMAP) with the support of the World Bank sector operating division responsible for the countries of Central Asia (EC3IV). The main motivation of the study was the countries' dependence on energy imports, owing to either lack of indigenous energy resources, as in the case of Kyrgyzstan, or adequate development of existing resources and regional imbalances, as in the case of Kazakhstan, coupled with anecdotal information that renewable energy resources are available in abundance in the countries. In addition, and from a global perspective, development of renewable energy resources, especially when they replace the use of fossil fuels, contributes to the mitigation of greenhouse gas emissions, a major goal of the international community of nations as expressed in the Rio Conference of 1992 and the Climate Change Convention. The Global Environment Facility (GEF) and the World Bank Solar Initiative support this goal through projects which preserve the environment and lower barriers to the sustained, cost-competitive, public and private provision of clean energy sources.

The study developed as a collaborative effort in which several international donors participated and contributed and local authorities became an integral and active part of the study work (see Acknowledgments), thus establishing "local ownership" of the study. The work started in March 1996 with a reconnaissance mission, followed by the main mission, in May - June 1996. The study fully took into account existing studies as well as data and inputs provided by local authorities. It also made contact with other donors and took note of their energy-sector related work, for example, the work.

The main objective of the study was to perform a preliminary assessment of the renewable energy (RE) resources in the two countries, identify the resources most promising for development, and perform preliminary analyses of a small number of case studies that appear to hold the most promise for investment in each country. It also worth noting that the study took a regional approach to market development, examining the possibility of joint development and of marketing RE systems in the region's countries.

From its inception, the study was meant to be a first step in a process that could be followed by other actions and steps, leading, as it is hoped, to a renewable energy project and development program. In this sense, it is noted that, after the preliminary results of the mission were issued, the United Nations Development Programme (UNDP) proposed and approved a pre-investment study for wind development in Kazakhstan. Furthermore, at the request of the local authorities it is expected that a regional workshop will take place in Almaty, tentatively in late Spring of 1997, in which the main results and conclusions of the study will be presented as well as studies, findings, plans, and proposals of other international donors and private investors.

Acknowledgments

This study was carried out with the support of the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP), which has traditionally financed studies aimed at strengthening management and institutional structures and practices in the energy sector of developing countries as well as supporting the reform process. More recently, ESMAP has included strategic studies and project identification in energy efficiency and renewable energy. The study was managed by the Power Development, Efficiency, and Household Fuels Division of the Industry and Energy Department of the World Bank. The task manager was Achilles G. Adamantiades, Principal Power Engineer, assisted by Andrew Young, a research analyst, working in IENPD under a secondment agreement and supported through the US Department of Energy. The main contractor for the work was the consulting firm ENERGO Group, S.A. of Athens, Greece, through the services of Messrs. Ioannis Papaioannou (team leader), Nicolaos Saounatsos (hydro specialist), George Betzios (wind specialist) and Constantine Stelacatos (energy sector planner).

The study greatly benefited also from the generosity of international or national grant assistance institutions which contributed to the study as follows: the United Nations, through the participation of Mr. J. Gururaja, focusing on institutional issues and technical assistance needs and plans; the New Energy and Industrial Technology Development Organization (NEDO) of Japan, through the participation of Mr. K. Nishinoiri (solar energy specialist); and the U.S. National Renewable Energy Laboratories, through the participation of Messrs. Dennis Elliott (wind resource specialist) and Brian Parsons (wind project analyst). Their respective contributions were essential to the work of the mission and the completion of the report.

In initiating, planning, and executing the study, the IENPD team received the support and guidance of the World Bank sector operating division (EC3IV), in particular from Messrs. Jonathan Brown, Division Chief, and Salem Ouahes, Senior Power Engineer, as well as of the country operating division (EC3C1), especially from Mr. Motoo Konishi and Ms. Nancy Cooke. Also crucial to the success of the two missions (one exploratory and one main mission) was the genuine interest and active support of the staff of the World Bank resident missions in Almaty and Bishkek, namely Messrs. David Pearce and Ruslan Mamishev in Almaty and Michael Rathnam and Orunbek Shamkanov in Bishkek. Finally, the enthusiastic cooperation and substantial contributions of the local counterparts must be duly acknowledged. In Almaty, the main coordinator of the mission's work was Mr. Sergei Katyshev, of the Ministry of Energy and Natural Resources, while Messrs. Marat Kombarov, Chief of Foreign Relations of Almatyenergo, and Josif Vilkoviskiy, Chief Engineer of Hydroproject, performed much of the local work. In Bishkek, the leader of the local team and main counterpart of the mission was Mr. Alaibek Obozov, of the State Project KUN, whose indefatigable efforts and extraordinary hospitality made the mission's work an unusual experience.

We gratefully acknowledge that his document benefited from the review and comments of authorities too numerous to mention, from Kazakhstan and Kyrgyzstan, and from the World Bank.

Abbreviations and Acronyms

ADB	Asian Development Bank
CIS	Commonwealth of Independent States
CST	Committee on Science and Technology
EBRD	European Bank for Reconstruction and Development
ENVOD	Joint Stock Company for Solar Water Heaters
EU-TACIS	European Union-Technical Assistance for CIS
FSU	Former Soviet Union
GDP	Gross Domestic Project
GEF	Global Environment Facility
HEP	Hydro Electric Projects
IFI	International Finance Institutions
KNHEC	Kyrgyzstan National Holding Electric Company
KUN	State Project "SUN" (Kyrgyzstan)
MoENR	Ministry of Energy and Natural Resources
MoOG	Ministry of Oil and Gas
MoI	Ministry of Industry
NEDO	New Energy and Industrial Technology Development Organization (of Japan)
NIS	Newly Independent States
NREL	US National Renewable Energy Laboratory
O&M	Operation and Maintenance
PV	Photo-voltaic
RE	Renewable Energy
SWH	Solar Water Heaters
USAID	United States Agency for International Development

Units of Measure

Ah	ampere-hour
cal	calorie
GWh	gigawatt-hour (million kWh)
Hz	herz
kg	kilogram
kJ	kilojoule
km	kilometer
kW	kilowatt
kV	kilovolt
kWh	kilowatt-hour
Mcal	megacalorie (million calories)
MW	mega-Watt (1000 kW)
TWh	terawatt-hour (10^9 kWh)
Wh	Watt-hour

Currency Equivalents

US$1	=	65 Kazakhstan Tenge	(June 1996)
US$1	=	17 Kyrgyzstan Som	(December 1996)

Executive Summary

Introduction

The two countries of Central Asia that are the subject of this study have several features in common. They are situated in the same geographical region, are endowed with good renewable energy resources but also experience the problems of the countries of the Former Soviet Union (FSU): a long legacy of a centrally planned economy, severe economic contraction, distorted prices, weak local institutions, and a development path that ignored environmental concerns. In addition, trade relations among the countries of the FSU have been severely strained, resulting in attempts to operate autonomously in a system that was designed to function in a fully integrated mode. In the energy sector, in particular, the governments of these countries are struggling to establish a sense of energy independence, move toward sector reform, and address environmental issues.

In spite of similarities, the two countries examined in this report have different energy sectors. Kazakhstan has a rich endowment of fossil fuels, some of which has been developed, but its vast territory makes energy transfers difficult and costly. As a result, the country, in particular the southern part, is dependent on electricity imports, which are vulnerable to interruption. In addition, its generation system depends mostly (to about 80 percent) on poor-quality coal and has poor environmental controls. Kyrgyzstan, on the other hand, has abundant hydro resources, some of which have been developed, but little in fossil fuels. The use of water for irrigation in neighboring countries makes hydro energy exploitation suboptimal for Kyrgyzstan. At the same time, Kyrgyzstan has a tradition and infrastructure of silicon crystal manufacturing, a material useful in solar energy development.

Based on these assessments and perceptions, the governments of the countries are looking to renewable energy (RE) resources to help alleviate existing problems: provide energy independence, enhance energy production at the local level, improve environmental conditions and extend or strengthen electricity service to remote populations. The governments strongly support the development of renewable energy resources and efforts are in progress to include supportive provisions in legislation in the making.

The study was undertaken jointly with institutions of the countries to support this process and accelerate the development of RE on a rational basis and in the context of overall energy policies supported by the governments and the World Bank.

Study Approach and Structure

The study first examines the energy sector's organizational structure, and legal framework, the energy supply and demand balance, and the impetus for the development of renewable energy. The present status and resource potential is discussed and the potential of various forms of RE is examined. An analysis of institutional issues is made since they can be of critical importance in RE development. Based on the preliminary data collected, and observations made, a set of case studies was selected for further analysis and for possible consideration for investment.

The criteria used in the above selection of RE technologies were: (i) resource availability and quality, (ii) need for and contribution to the energy supply, (iii) technical, economic, and financial viability, (iv) environmental impact, and (v) local institutional and industrial capabilities. Both grid-connected and non-grid-connected technologies were considered. For grid-connected applications, the price paid for electricity imports, present and expected, which would be the avoided cost to the system, were used. For non-grid-connected applications, the willingness to pay, as inferred by current expenditures for fuels were utilized.

Based on these results, recommendations are made as to the most promising investments. Recommendations are also made as to institutional measures and technical assistance needs that would facilitate and accelerate the development of RE resources.

KAZAKHSTAN

Energy Balance and Impetus for RE Development

With large reserves of exploitable oil and gas in Kazakhstan, it is expected that the energy sector will play a significant role in the future economic development of the country. However, Kazakhstan has serious electricity deficits, which have to be covered by imports from Russia for the north and other Central Asian countries in the south. Furthermore, the size of the country's territory and its geography (desert land dividing north from south) together with the concentration of coal deposits in the north, require high investments in transmission systems with attendant high losses and low reliability. The power sector needs considerable rehabilitation and serious upgrading if the country is to decrease its heavy reliance on electricity imports.

The main motivation for RE development in Kazakhstan include:

- replace imports of electricity, especially in the southern region, with clean and competitive RE resources from wind and small hydro;

- extend access to electricity to remote and nomadic populations through dispersed, photovoltaic solar home systems (SHS) rather that through the more expensive and less appropriate grid extension;

- protect the country's delicate ecosystem by reducing the dependence of the electricity generation system on coal (presently at 85 percent) which creates serious environmental impacts; and

- reduce line losses, and improve stability and reliability by installing dispersed and end-of-line generation stations from RE resources.

Renewable Energy Resource Potential

The RE resource potential in Kazakhstan is significant but was largely neglected under the regime of the FSU which favored large, centrally owned and managed projects. At the same time there exist about 5,100 remote villages without electricity service and grid extension would, most likely, be uneconomic. RE development would be suitable for electricity production at the national and local level and is suitable to serve small distributed loads.

Kazakhstan's hydro potential is quite large, amounting to an estimated 170 TWh/yr, of which only about 23.5 TWh/yr has been exploited. Within the total, small hydro potential, defined as units of less than 10 MW, is significant. Based on existing studies, there are at least 453 potential small hydroelectric power projects (HEP) with 1,380 MW of total installed capacity and 6,315 GWh of mean annual production, and approximately 2,350 MW of potential projects under 30 MW. Some of them consist of existing irrigation channels which makes them more readily available for implementation (at lower cost and shorter time period). The small HEP have not been studied in adequate detail but the mission visited a few that appeared more promising and included them in the case studies. The Chillik cascade, and sites identified along the Bartogay and Main Almaty canal show very outstanding investment potential, as revealed in Annexes 1 and 2.

Despite Kazakhstan's high latitude, solar energy resources in the country are stable and adequate owing to its favorable climatic conditions. Sunshine hours are 2,200-3,000 hr/yr and insolation energy 1,300-1,800 kWh/m^2/yr, making it possible to consider PV panels for rural areas, especially portable PV systems for nomadic populations. Based on this insolation level, solar water heaters (SWH), particularly in remote areas without access to gas pipelines, should be also viable in Kazakhstan. The technology is commercial and capabilities to undertake local production are good. However, because fossil fuel resources are abundant in Kazakhstan, the viability of SWH needs more detailed study to compare it with competing technologies and energy resources. Since the resources of the study were restricted, this was left to further investigation.

Kazakhstan offers excellent opportunities for large development of windpower, especially at the Djungar Gate (close to the border with the Xingjian province of China) and Chillik corridors, where annual average wind velocities range from 7 to 9 meters per second and 5 to 9 meters per second respectively. These wind resources are better than those in other locations in the world where wind generation has been developed. Additional factor such as proximity to an existing high-voltage transmission line, good correlation of the wind's seasonality with the power demand of the system, and a local market make development of these resources attractive.

Geothermal and biomass resources were also examined but were considered of much lesser quality and potential for electric power production. Small-scale, specialized cases such as biogas for cooking and fertilizer production, and geothermal for heating purposes are more suitable either for local government or bilateral aid programs to investigate.

Renewable Energy Institutions

At present, no formal institution exists for the development of renewable energy sources. There are various R&D institutes, Design Institutes and state companies with strong technical capabilities involved in work related to renewable sources especially Kazselenergoproject, Almatyhydroproject, and Almatyenergo. However, the sector as a whole is characterized by a lack of coordination, clear policies, and a coherent strategy for development. The Ministry of Energy and Natural Resources has a small unit for renewable energy planning and overview, but it is not adequate to cover the needs of the sector, especially regarding important issues, such as policy development, commercialization and financing of projects.

Case Studies

Based on the findings of the mission, three case studies were selected for quantitative analysis in the following renewable energy resources and technologies: small hydro power plants, PV solar home systems and wind at Djungar Gate.

(i) **Bartogay and Almaty Canal small hydro project**. This refers to the combined exploitation of the Bartogay irrigation dam and the two water falls at the Almaty irrigation Canal. The proposed installed capacity is 20 MW (2 X 10) at the foot of Bartogay, 11.5 MW (2 X 5.75) at the first fall of the Almaty Canal and 10.5 MW (2 X 5.25) at the other fall, thus giving a total capacity for the project of 42 MW and an expected average annual electricity production of 150 GWh. Using conservative assumptions, the capital investment cost is estimated at about US$40 million while the levelized electricity cost would be US¢ 2.85/kWh. Assuming a price of US¢ 5/kWh, the current price paid for electricity imports, the rate of return of the project is 18.3 percent and the pay-back period 7.6 years without taking into account environmental benefits (these could add 1-2 percent in the rate of return).

(ii) **Photovoltaic solar home systems (PV-SHS)**. Based on the data provided by the mission's local counterparts, it was estimated that an upper-bound, technical market potential in Kazakhstan to absorb, in the time span of five years, 20,000 small, portable PV units of 20 W capacity each, with adequate provision of retail or end-user credit. The net cost for the small portable PV units is estimated at US$6.16 million. Avoided cost calculations indicate that these systems are 25 percent percent less costly than the kerosene lantern base-case on a cost per lumen-hour basis. As explained in the Kyrgyzstan section, production of PV panels and systems could be organized locally on a commercial basis and marketed in a region that comprises several countries of Central Asia. While using local technical capabilities should be possible, foreign capital and expertise would be needed designing modern SHS systems, to modernize PV production technology (including production of silicon wafers, solar cells and modules), organizing maintenance and service organizations, establishing spare parts programs and stores, and putting in place small-scale financing mechanisms.

(iii) **Windpower Project at Djungar Gate**. Two sites were explored at Djungar Gate, corresponding to two wind measuring stations: Zhalanaschkol, with an estimated capacity factor of 26 percent, and the Druzhba, with a capacity factor of 33 percent. The analysis assumed for the first plant an installed capacity of 40 MW and was performed with conservative cost assumptions from similar recent cases (capital cost of US$1,100 per installed kW, for example in India), giving a total plant cost of US$44 million. The following variations (sensitivity analyses) were used: four electricity prices were assumed, US¢ 2.5, 5.0, 6.25, and 7.5 /kWh; and three cases: a base case, at constant 1996 US Dollars, a case with a 2 percent electricity price escalation to reflect the effect of economic and price reforms, and a case with a US$10 million grant, possibly from the Global Environment Facility (GEF), to account for the first introduction of the technology, and higher transaction costs. No environmental benefits were accounted for. In the base case, and at US¢

5/kWh, the rate of return is 8.4 percent and 11.3 percent for the two sites. With the assumption of a US$10 million grant (about 23 percent of capital cost), and the US¢ 5/kWh price figure, the IRR rises to 11.6-15.0 percent for the same two sites.

The examination to date, as revealed by the two values of the capacity factor in two measuring stations in the same general region, indicates that large uncertainties exist as to the wind resource; this has a large effect on project economics. Therefore, it is recommended that a thorough resource assessment be undertaken as soon as possible to remove uncertainly and provide guidance as to optimal siting (micro-siting) of the potential future wind plant.

Priorities and steps for Technical Assistance and Institution Strengthening are highlighted by technology in Chapter 11.

KYRGYZSTAN

Energy Balance and Impetus for RE Development

Kyrgyzstan has a good potential for economic development if the key sectors of the economy receive the appropriate attention and especially the agricultural and agro-industry sector, the minerals sector and the services sector including tourism. As regards energy resources, the country depends on imports for about 60 percent of its primary energy supply, while it possesses abundant hydroelectric resources. As a result, Kyrgyzstan imports coal, oil and gas and exports hydroelectricity, mainly to Kazakhstan, generated from the dams of the Naryn river, which are only partly developed.

The main motivations for Kyrgyzstan to develop its renewable energy resources are:

- capitalize on available, financially attractive renewable energy resources in the country;
- reduce the dependence of the country on imported fossil fuels by using RE for heating applications;
- provide electricity to rural areas and nomadic populations not connected to the grid at lower cost than grid extension;

- utilize the country's existing industrial capabilities to produce photovoltaic cells and panels, based on the still operating facilities for silicon crystal manufacturing (that date back to the days of the FSU);

- expand the exploitation of its hydro resources through small hydro development that may offer advantages (small environmental impact, lower total capital cost, local and regional interest and control, etc.); and

- improve system reliability, stability and efficiency by developing generation sources near the consumption centers.

Renewable Energy Resource Potential

Kyrgyzstan has large hydro potential, an estimated total of 163 TWh/yr, but only 73 TWh/yr is technically feasible and only 48 TWh/yr economically exploitable. Hence, in the FSU, Kyrgyzstan was assigned the role of providing hydro generation to the regional interconnected system. Small hydro projects contribute to the total hydro potential; during the mission, 19 small hydroelectric projects were reviewed with a 120 MW total installed capacity and 530 GWh mean annual production.

Despite its high latitude, Kyrgyzstan has stable and adequate solar energy resources, owing to its altitude and favorable climatic conditions. There are about 2,600 hr/yr of sunshine and an insolation energy of 1,500-1,900 kWh /m^2/yr. Kyrgyzstan also claims two important industrial installations that produced about 30 percent of the needs of the FSU in crystalline silicon for solid state devices in the space and defense industries. The Orlovka plant makes single-crystal silicon while the Tash-Kumyr plant, not completed, was designed for polycrystalline silicon. The Tash-Kumyr plant is currently producing silicon blocks for a foreign customer on a toll basis.

The mission also examined wind, geothermal, and biomass resources; these were found to be of much lower value and importance in the Kyrgyzstan energy picture. Wind data indicate rather modest resources that could be commercially promising; however, the country's terrain is such that localized regimes of commercially interesting resources may well exist. It is recommended that a wind resource assessment and monitoring program be undertaken with bilateral or multilateral technical assistance. Geothermal sources are also modest but could be viable for applications such as dairies, health spas, wool-washing, fish farms, and other applications located near the source.

Again, priorities and steps for Technical Assistance and Institution Strengthening are highlighted by technology in Chapter 11.

Renewable Energy Institutions

The State Business Project "KUN" (the Kyrgyz word for SUN) is the principal organization for promotion of renewable energy activities in Kyrgyzstan and functions as the focal point for this sub-sector. KUN was set up in 1993 in accordance with a Presidential Decree. Its governance rules and operational programs have the approval and support of the Government. According to these , the state project KUN is to carry out scientific and technical activities concerning solar, wind, biogas and other alternative energy sources. The project includes not only scientific programs but also design activities and a number of manufacturing enterprises. Although KUN is a government establishment, it does not form part of any ministry or holding company. It is positioned to function in a quasi-independent fashion although technically under the Vice Prime Minister, who is also in charge of energy policy. This arrangement is intentioned to render KUN free from bureaucratic controls, enable it to generate quick responses to project development needs and also seek outside funding. However, KUN's facilities need considerable upgrade and modernization and the staff must address important issues related to the development of renewable energy sources, especially in areas of policy, commercialization, and financing of projects. Other institutions also merit assistance such as the National Academy of Sciences and the Kyrgyz Science and Technical Center “Energy” (KSTC “Energy”), and National Academy of Science, according to their respective competitive advantage for contributing to development of the renewable energy and enterprise.

Case Studies

(i) **Karakol Small-Hydro Project**. This project is part of the exploitation of the hydro potential of the Karakol river in the important commercial and tourist region of Karakol, at the eastern end of Issik-Kul lake. The project envisages the installation of a small hydroelectric plant with 4.5 MW installed capacity and 31.5 GWh mean annual electricity production. With conservative cost assumptions from recent and similar projects, the estimated investment cost of the plant is US$6.7 million, while the levelized production cost is US¢ 2.68 /kWh. Using an electricity price of US¢ 3.5/kWh, the rate of return is 13 percent and the pay-back period 13 years, without accounting for environmental benefits (these could add 1-2 percent to the rate of return). The main justification for the project is that electricity supply is frequently interrupted in the Karakol region and that the special tax-relief measures, instituted in this “industrial zone”, would make the project attractive to local industry.

(ii) **Photovoltaic Solar Home Systems (PV-SHS).** Based on the data and feedback provided by the mission's local counter-parts, it is believed that there is an upper-bound, technical market potential to disseminate 14,000, 20 W portable PV units over a period of 5 years for nomadic populations. The total hardware cost for such a project is estimated at US$4.27 million. Calculation of electricity output is not an adequate measure of the benefits provided, particularly for mobile populations inhabiting remote areas far from the grid. The standard lighting energy source, kerosene, is a much more appropriate comparator. Avoided cost calculations indicate that these systems are 25 percent less costly than the kerosene lantern base-case on a cost per lumen-hour basis. First, in-depth market surveys and several well-designed pilot projects are required to characterize the market and verify the feasibility and economic potential for a full-scale project.

(iii) **Solar Water Heaters (SWH).** Owing to the dominant role of inexpensive hydroelectric power, Kyrgyzstan has no extensive district heating networks and, consequently, solar thermal applications for hot water production appears to have significant market potential. This Case Study assumes a market penetration of 13,000 m^2 of solar collectors for domestic use in five years. Commercial and industrial applications for solar heating also show promise, though are not the subject of this case-study. The total investment cost required for the above solar collectors has been estimated at about US$8.8 millions, including circulation tanks. Based on this investment and assuming a discount rate of 10 percent, equipment lifetime of 15 years and maintenance cost of US$40/year per unit, the levelized cost of the heat produced is around US$0.054 per million calories, a figure that is marginally competitive with conventional systems using high cost fossil fuels. These costs reflect imported equipment as a conservative assumption. It is estimated that with indigenization and installation experience, this costs could fall by 20 percent with no change in service-level. Life-time energy savings will be 41 giga-calories per system.

Conclusions and Recommendations

In addition to the specific case studies that are recommended for further investigation for possible investment, and related recommendations for RE resource assessment as outlined below, general recommendations are applicable, *mutatis mutandis*, to both countries. *Please consult Chapter 11 for an index of ranked renewable options and a prioritized list of technical assistance and institution strengthening measures to enable the economic exploitation of renewable energy.*

As a paramount recommendation, it cannot be over-emphasized that **market distortions, particularly tariff subsidies, must be rationalized for either country to attain economic, sustainable exploitation of its renewable resources.** Without this framework, private power capital will also remain unavailable for investments in renewable energy infrastructure. The next most important step the countries could take is the establishment of a proper legal and institutional framework in which the various players would be able to perform their respective activities with confidence and effectiveness. This process, which is already in progress, needs to be accelerated, but in an orderly fashion and needs to take into account the specific needs of the renewable energy sector. The Government can play a more proactive role in coordinating activities, simplifying procedures, and setting clear policies that can be translated directly into practical measures. The government can also set priorities and impose an effective coordination of bilateral and multilateral technical assistance programs.

Institution Strengthening

Generalizing the focused recommendations of Chapter 11, the study recommends the following measures:

- setting up a dedicated agency or group for the coordination, facilitation, and promotion of renewable energy resources with a clear mandate from the Government;

- establishing a regional renewable energy development center to exploit the scale economies and comparative advantages of the Central Asia as a whole, to set strategic priorities and ensure coherent, complementary donor and government activity, to engage international economic and technical cooperation, and to consolidate and disseminate market information and training resources;

- clarification of roles, to eliminate overlapping and conflicts and to simplify procedures in licensing projects;

- creation of a special fund with favorable funding procedures for RE projects and to implement creative financing mechanisms, especially on the small and local level; and

- emphasis on the participation of the private sector; such participation will be greatly encouraged by a set of incentives. That is carefully designed, targeted, time-bound (i.e., put in place for a designated period of time) and not distortionary:

⇒ price incentives, a higher level of prices for energy derived from RE resources is justified on the basis of the environmental benefits that are not fully reflected in current energy prices; and

⇒ other incentives, such as investment credits, tax holidays, import duty equalization, and non-discriminatory practices.

Technical Assistance

The effective and successful introduction of renewable energy in the two countries would greatly benefit from technical assistance from bilateral and multilateral assistance programs. Particular areas of needed assistance, as was also expressed by local authorities, are:

- strengthening of policy making, institutional structures, and RE promotional activities;
- improvement of RE resource data base and analysis;
- information dissemination and establishment of data bases;
- improvement of local capabilities in completing the legal and regulatory framework;
- methods of investment and trade promotion, and financing mechanisms;
- enhancement of local entrepreneurial skills;
- strengthening an re-focusing research and development centers and programs; and
- establishing standards and certification procedures for equipment and systems.

1

Kazakhstan: The Economy and the Energy Sector

Current Economic Situation

1.1 Kazakhstan is in Central Asia and extends from the Caspian Sea to the Altai mountains, covering an area of 2.7 million square kilometers (8th largest country in the World). It is a landlocked country, bordered on the North by Russia, and on the south by Kyrgyzstan, Uzbekistan and Turkmenistan. To its east lies China; to its west Europe. The country has a population of 17 million people of which roughly 45 percent live in rural areas. The country's currency unit up to 1992 was the ruble; since 1992 Kazakhstan has used the Tenge (June 1996 exchange rate approximately US$1 = 65 Tenge). As is the case of most former Soviet republics, Kazakhstan's GDP has been declining in recent years. In 1995 GDP was approximately 1,000 billion Tenge (about US$15.4 billion), having fallen by roughly 9 percent in real terms during 1994. More than 64 percent of the national product was produced by the industrial sector, which includes energy production. The value of exports reached US$4,975 million in 1995, while the value of imports was US$3,742 million. As of December 1995, the average monthly salary was 7,230 Tenge for the economy as a whole, while the average monthly salary in the industrial sector was significantly higher at 11,230 Tenge. The country suffers from high inflation; according to national statistics the consumer price index was about 160 percent at the end of 1995.

1.2 Kazakhstan's energy resources are abundant and its export potential is huge. Crude oil and gas production are currently modest (at around 21 million tons and 6 billion cubic meters per year respectively), but are expected to increase dramatically once international joint venture partners start to develop the country's existing giant oil and gas fields. The proven exploitable oil and natural gas reserves are currently estimated at around 3 billion tons and 2,000 billion cubic meters, respectively, and it is likely that far greater proven reserves will be discovered with more intensive exploration. Consequently, the energy sector is expected to play the most significant role in the future economic development of the country. During the time of the Soviet Union, Kazakhstan concentrated on the production of raw material and did not develop the necessary processing industry. At the same time as it exported fuel resources, Kazakhstan imported refined energy products as well as electricity. This trend is still followed and today Kazakhstan has to pay international electricity prices for its imports from other countries, in the Commonwealth of Independent States (CIS).

Organizational Structure and Legal Framework of the Energy Sector

1.3 The organizational structure of Kazakhstan's energy sector has undergone significant changes since the country became independent. Prior to the dissolution of the Soviet Union, Kazakhstan's energy sector was part of the then existing centralized energy system, run by central ministries located in Moscow. Energy production targets were assigned to state enterprises in accordance with five-year plans. Electricity tariffs were kept artificially low. Because of low tariffs and payment defaults from consumers, state enterprises suffered considerable financial losses. The restructuring program initiated soon after independence still continues, and further changes in organizational structure are ongoing, with the separation of production from transmission and distribution expected in the near future. Nevertheless, a more comprehensive restructuring policy is needed and future efforts should focus on the development of an energy strategy to include institutional reforms.

1.4 Efforts are underway to establish comprehensive laws providing a legal and regulatory framework for the entire energy. Although there are no laws for the natural gas sector, there are laws for electric power engineering, and for the oil and coal subsectors. Laws on electric power came into effect on December 23, 1995 to regulate production, transmission, distribution, and consumption of electric and heat power, for the state as well as for the private sector. Because the development of the energy sector on a market basis is still a relatively new field for activity for Kazakhstan, further work is needed to implement the laws and to develop procedures for establishing guidelines for issuing licenses, and for enforcing regulations that would ensure the disciplined operation of utilities and private power producers.

1.5 Tariff policies for electric power are determined by MoENR. The Antimonopoly Price Committee develops tariffs and prices for other fuels, which are subject to approval by the Ministry. Tariffs are currently being increased to reflect real costs and market forces. Efforts are underway to create an independent agency with regulatory functions. A speedy decision on this matter and the initiation of practical measures have assumed crucial importance. As for the renewable energy sector, a law on energy conservation and energy efficiency (Energy Conservation Law) has been drafted. This law covers renewable sources of energy and is expected to be enacted in the current year. Once enacted, this law will provide the necessary legal and institutional framework for renewable energy, as well as for energy conservation and efficiency. An energy agency will co-ordinate, promote, and oversee the laws governing energy conservation and renewable energy. Along with the law on electric power, the necessary legal framework for private sector participation will soon be in place. The World Bank mission met the chairman of the Parliamentary Committee on Energy and suggested to him that due consideration be given in the draft of the Energy Law to the introduction of incentives, including: tax concessions, accelerated depreciation, and exemption from payment of customs duty for imports of specified items. In the spirit of regional co-operation, Kazakhstan has proposed the establishment of an association and a center on renewable energy in Almaty for the five Central Asian republics. This proposal, however, needs further elaboration to better define joint activities and mechanisms for coordination. The provision of technical assistance for this purpose would be useful.

Energy Supply and Demand; Trade

1.6 As already mentioned, Kazakhstan has huge reserves of oil, natural gas, and coal. Even today, with moderate production of primary energy sources, the country is a net exporter of energy in calorific terms. At the same time, Kazakhstan has to import electricity, even with today's low demand, especially to cover the needs of its southern regions. The energy trade is mainly with Russia and the nearby Central Asian republics. The energy balance for 1995 is given in Table 1.1.

Table 1.1: Energy Balance 1995

	Coal (million tons)	*Crude oil (million tons)*	*Oil products (million tons)*	*Natural gas (billion m^3)*	*Electricity (TWh)*
Production	83.3	20.5	n/a	5.9	66.6
Imports	2.0	3.5	n/a	7.1	14.2
Exports	23.8	11.2	n/a	2.5	6.8
Change in stock	n/a	n/a	n/a	n/a	n/a
Total use in the country	61.5	12.8	n/a	10.5	74.0
Conversion to electricity	26.6	–	1.0	2.5	–
Conversion to heat	14.0	–	0.8	3.0	–
Losses	3.0	-	-	n/a	10.2
Statistical discrepancies	–	–	–	–	–
Final consumption	58.5	12.8	12.8	10.5	63.8
Industry	54.9	-	3.2	7.5	37.5
Agriculture	1.0	-	1.5	-	7.0
Domestic	1.3	-	-	1.8	9.3
Transport and other	1.3	-	8.1	1.2	10.0

1.7 The electric power system is divided into three major independent grids, northern, southern and western Kazakhstan. The northern and western power systems are connected to Russia, while the southern region, where most of the electricity deficit exists, is connected to the Central Asian system. The main interstate transmission line of 1,900 km (Siberia - Kazakhstan - Ural) is already operational, whereas extension toward the southern region is under construction, linking northern and southern Kazakhstan and providing access to the Middle and Central Asian network. The total installed capacity of Kazakhstan's power plants was 16,300 MW as of 1 January 1996, however, because of various reasons the available capacity is much less at about 13,000 MW. This capacity breaks down approximately as follows:

- 85 percent thermal power, mostly coal-fired
- 14 percent hydropower
- 1 percent nuclear power (Shevchenko nuclear station on the Caspian sea).

1.8 The evolution of the generation of electricity, its consumption, and maximum load since 1990, along with official forecasts up to the year 2010 are presented in Table 1.2. The need for imports has dropped recently, mainly because of a drastic decrease in consumption, but there is still a deficit of more than 10 percent in electricity generation, which is primarily satisfied by imports from Russia and Turkmenistan. According to the ministry projections, demand is expected to reach the 1990 level by the year 2005. By then Kazakhstan will be self-sufficient in electricity generation and would have a small export capacity. This optimistic forecast is based on the current policy of expanding electricity generation in coal-fired plants, with the construction of new plants and the rehabilitation of existing units. Kazakhstan's program toward energy self-sufficiency relies heavily on the maximum utilization of its abundant coal resources. However, the quality of coal is poor as a result of its high ash content. This causes environmental problems; these are mainly due to the inefficiency of the existing technology and the low standards of the available control equipment.

Table 1.2: Electricity Forecasts

	1990	*1993*	*1994*	*1995*	*2000*	*2005*	*2010*
Electricity generation (TWh)	87.4	77.2	66.1	66.6	85.9	105.7	118.8
Electricity consumption (TWh)	104.7	89.1	79.1	74.0	86.0	103.0	115.0
Maximum load (MW)	15,421	14,224	12,773	11,788	13,670	16,500	18,400

1.9 Kazakhstan's nine electricity utilities have slightly different tariff structures for different electricity consumers in order to reflect their real costs. The price of electricity has increased dramatically in recent years, with current average prices for both industrial and commercial consumers at approximately US¢ 2.7 per kWh, whereas households pay less than half this price. It must be pointed out however, that for imported electricity for the southern part, Kazakhstan pays its neighboring Central Asian republics close to world-level prices, with an average cost of more than US¢ 4.5 per kWh.

1.10 Kazakhstan has a well-developed oil and gas industry. Most oil and gas fields are located in the western region of the country. In order to provide plants with oil, a 1,200-km pipeline is planned to connect east and west. Existing oil-processing plants are being refurbished and the construction of three new plants in western Kazakhstan is in the short-term plan. The extraction of liquid hydrocarbons currently amounts to 21 million tons per year and figures for natural gas come to 6 billion m^3. During the coming decade, oil production is estimated to double and gas output should reach 25 billion m^3 to 28 billion m^3. There are currently several operating oil fields in the republic, but all of them need work if output is to increase. Kazakhstan exports around 11 million tons of crude oil annually, mainly through existing pipeline systems to Russia. The Caspian oil pipeline is now being built from Tengiz oil field to the Black Sea with the participation of international companies, including Russia.

1.11 As will be shown in the following sections of the report, Kazakhstan has ample, accessible potential of renewable energy sources, including hydro and windpower. Efforts toward energy efficiency and energy conservation will not only decrease the high energy intensity of the country, but will also address the environmental impacts of low-quality fossil fuels, particularly the adverse effects of the high-ash coal.

Impetus for Development of Renewable Energy Resources

1.12 Global warming and other environmental concerns have given rise to an increased international focus on renewable sources of energy in the past twenty years. Many industrial countries have already achieved a significant contribution of wind, hydro, and solar power, as well as of recyclable waste in their energy balance for heat and other energy needs. Developing countries are also expanding programs to identify sources of renewable energy. This trend is expected to gain momentum in the future. According to a recent UN study, under certain circumstances renewable energy sources (including energy from large hydropower projects) could account for as much as 60 percent of the world's electricity market by the mid-21st century. An international consensus was reached at the Rio Conference of 1992 that to increase the supply of intrinsically clean sources of energy for the future, all nations must act now, not only in the area of technological development, but also in removing social, economic, and organizational barriers.

1.13 Kazakhstan has strong motivations to introduce renewable sources into its energy balance in the near future; potential benefits include:

a. Replacing expensive imports of electricity—largely for its southern region—with clean and relatively economic renewable sources from wind and small hydropower plants.

b. Infrastructure bottlenecks, decaying transmission and distribution infrastructure, vast distances and the high transmission losses (around 14 percent) could be addressed by utilizing renewable sources of power generation closer to demand centers. Wind farms, small hydroplants and end-of-line photovoltaic stations could contribute not only to direct fuel savings but also to improved overall system stability and efficiency.

c. The dispersed populations in its large territory could be better served through renewable energy systems, including hybrids, rather than through the more expensive grid extensions.

1.14 Kazakhstan's renewable energy resources and their potential for development will be reviewed in the following chapters.

2

Kazakhstan: Review of the Renewable Energy Sources

Present Status and Selection of Technologies

2.1 Kazakhstan, like many other central Asian countries, possesses numerous potentially significant sources of renewable energy. Nevertheless, because of policies of the former Soviet republics, which favored large, central energy facilities, very few of these potential sources were exploited or even examined because of each individual project's small impact on the country's energy balance. The country's electricity deficit, which exists mainly in the south (including Almaty), makes it desirable to examine the potential to generate electrical power from local sources including renewables, in order to replace expensive imports. For both economical and environmental considerations, the large size of the country, the geophysical conditions of its vast rural areas and of its steppes, and long transmission lines favor local or regional generation of power. It is estimated that around 5,100 small villages are not connected to the electric grid. Consequently, sizable small hydro and wind projects could provide, possibly in hybrid mode, an economic supply of electricity.

2.2 Based on the above considerations, the authorities in Kazakhstan, at all levels, showed a keen interest in the development of sources of renewable energy and especially in wind and small hydropower projects. The infrastructure of the country is relatively good, both in terms of institutes for research development and in general manufacturing capabilities. Because there is no specific organization responsible for sources of renewable energy, there is a resulting absence of coordination in the efforts of the various institutes, energy companies, and governmental bodies. In recent years, even foreign investors have shown interest in specific windpower generation and small hydropower projects. Although wind and small hydro are by far the most promising of the renewable sources, this chapter briefly reviews other sources that might become important in the future, namely solar energy, geothermal wells, and biomass.

Small Hydro

2.3 Kazakhstan has significant hydro potential concentrated mainly in the east, south and southeastern parts of the country, where roughly 95 percent of the total potential of the country is located. Kazakhstan's total hydro potential amounts to 170 terawatt-hours (TWh), the technical-economic exploitable is estimated at around 23.5 TWh and the already exploited amounts to 7.1 TWh (around 30 percent of the technical-economic exploitable) has already been exploited. It should be mentioned that there are associated environmental impacts even with small hydro power development, and as with all energy sources, these impacts should be reflected in the cost of generation and appropriately mitigated. In this context, run-of river hydro development should also be aggressively pursued where economic.

2.4 According to data provided by the Almaty Hydroproject Institute, there are studies at various levels for 503 small hydroelectric projects (SHPs) units of less than 10 MW in Kazakhstan, account for a potential installed capacity of 1,380 MW and a mean annual energy production of 6,300 gigawatt-hours (GWh). The distribution of these small HEP in the country's districts is shown in Table 2.1. The mission had the opportunity to visit several possible sites suitable for small hydroprojects, including the Chillik river and the Almaty irrigation canal. A more detailed discussion on the hydro potential is given in Chapter 4.

Table 2.1: Small Hydro Power Development Opportunities Throughout Kazakhstan

Region	*HEP Type*	*Capacity range, MW*	*Number of HEP*	*Installed Capacity, MW*	*Produced Energy (GWh/Year) (average*
EAST - KAZAKHSTAN PROVINCE	small HEP	N<=2	28	36.0	143
		2<N<=10	30	140.1	561
		10<N<=30	18	377.0	1669
	Total small HEP		76	553.1	2373
TALDY-KORGAN PROVINCE	small HEP	N<=2	40	49.2	216
		2<N<=10	53	311.1	1412
		10<N<=30	16	273.7	1141
	Total small HEP		109	634.0	2769
ALMATY PROVINCE	small HEP	N<=2	46	41.2	173
		2<N<=10	52	260.2	1328
		10<N<=30	14	199.0	1020
	Total small HEP		112	500.4	2521
ZHMBYL PROVINCE	small HEP	N<=2	61	69.2	356
		2<N<=10	31	138.9	664
		10<N<=30	2	23.6	108
	Total small HEP		94	231.7	1128
SOUTH KAZAKHSTAN PROVINCE	small HEP	N<=2	52	54.4	265
		2<N<=10	60	280.6	1197
		10<N<=30	4	100.2	452
	Total small HEP		116	435.2	1914
ALL KAZAKSTAN*	small HEP	N<=2	227	250.0	1153
		2<N<=10	226	1130.9	5162
		10<N<=30	54	973.5	4390
	Total small HEP (N<30MW)		507	2354.4	10705

Solar Energy

2.5 Kazakhstan is between northern latitudes 42 and 55 degrees, and may hence be classified as a northern country. This would not normally be considered advantageous for solar potential. On the other hand, Kazakhstan's solar energy resources are stable and adequate because of its dry climatic conditions. There are between 2,200 and 3,000 hours of sunshine per year and insolation energy is 1,300 to 1,800 kilowatt-hours per square meter per year (Table 2.2).

2.6 More than 50 percent of the country is made up of desert or semi-desert, both of which receive efficient insolation energy to photovoltaic (PV) installations. Topographical conditions provide yet another advantage. Judging from recent experiences of NEDO, Japan, in areas of Mongolia, reflection from shiny desert surfaces -- including snow -- will contribute further to an increased collection of energy, especially in the winter, when nominal horizontal insolation is decreased. Ample sunshine hours will reduce the chance of over-discharging storage batteries during daytime hours. Kazakhstan's solar resources consequently have fewer site-specific drawback factors, which could be advantageous for rural electrification, especially for nomadic people by using portable PV applications. The insolation data for various locations is given in Table 2.2. A more detailed discussion in solar resources is given in Chapter 4.

Table 2.2: Regional Insolation in Kazakhstan

		kWh/m2/day		
Place	***kWh/m2/year***	***Average***	***June***	***December***
Shimkent	1780	4.88	7.95	1.65
Aktau	1442	3.95	6.71	0.98
Akmola	1297	3.55	6.47	0.83
Semey	1441	3.95	6.74	1.05
Kuigan	703	4.67	7.40	1.58

Wind Energy[1]

2.7 Although historical data exist for about 400 meteorological posts in Kazakhstan, no comprehensive analyses of the data or of wind resource mapping assessments have been undertaken. Monthly averages of wind speed for specific periods are generally available for all of the stations. Additional statistics, such as wind speed and its directional frequency distribution, exist for many of the stations. Measurement heights are typically 10 meters. According to the meteorological service, 249 wind stations are currently in operation. Many other stations have been closed in recent years because of budget cuts. Regarding upper-air weather-balloon data, the meteorological service noted that although sixteen stations collect these data, no detailed summaries are available. Based on the wind data provided by the authorities, as well as other data available from NREL, USA, the wind energy potential of Kazakhstan seems to be very good, with some locations offering excellent opportunities for large development (the Djungar Gate and Chillik wind corridors).

1 It is worthwhile to mention that international studies have now confirmed that the incidence of wind-turbine bird impacts is no greater than impacts with stationary towers. Wind turbines present a very small frontal area to collide with.

2.8 The mission's program included two field trips: one to the Chillik-Chundzha region of southeastern Kazakhstan (about 100-300 kilometers east of Almaty), where windpower, irrigation-canal hydropower, and geothermal power potential were examined on the ground; and the second to the Djungar Gate (about 600 km northeast of Almaty), to gather additional information on the feasibility of a windpower project in the area.

(i) *Djungar Gate wind corridor:* The Djungar Gate is close to the Chinese border and consists of a long, flat mountain pass connecting two large depressions. The pass has a width of 10 to 15 kilometers and a length of 60 to 80 kilometers, and it is a well-known corridor of strong winds. With annual average wind speeds estimated in the range of 7 to 9 meters per second (based on the limited data available from three meteorological stations as well as six months of data from a recently installed 25-meter tall wind measurement tower), the corridor is considered to have a good-to-outstanding wind resource potential. If this high-speed wind resource is available throughout Djungar Gate (as indicated by the preliminary data from the area), then the area could support over 1,000 MW of wind potential. A number of important factors make this an attractive opportunity for investment: close proximity to a high-voltage transmission line, available transportation facilities, wind patterns that coincide with peak demand, and a regional market that includes the possibility of exporting electricity to the adjoining northeastern Chinese province of Xinjiang. The Djungar Gate wind farm project was one of three renewable energy case studies selected by the World Bank mission for further analysis. More information on this project is described in the section on case studies.

(ii) *Chillik wind corridor:* The Chillik wind corridor is a windy area located between the towns of Chillik and Charyn, approximately 110 to 190 kilometers east-northeast of Almaty. The highest wind resource is believed to be in the vicinity of Nurly, where a 30-meter tall wind measurement tower was installed in January 1996. Previous measurements from a meteorological station near Nurly indicate an excellent wind resource potential characterized by an average wind velocity of about 9 meters per second in the winter, and a moderate wind potential characterized by an average wind velocity of about 5 meters per second in the summer. The seasonality of the wind resource coincides with the power demand on the system, which adds value to the wind-generated electricity. The primary wind corridor is believed to extend for about 30 to 40 kilometers in an east-westerly direction; a major wind project of a few hundred megawatts could thus be developed in this area.

The prospects appear encouraging so far, but wind measurements at additional locations are needed to evaluate the wind resource in this area and to determine areas with the highest potential. In the event that these projects are developed, the transmission grid would have to be expanded.

Geothermal Energy

2.9 Kazakhstan has numerous low-temperature geothermal sites. The highest resource temperature found was approximately 96 degrees C in two 3-kilometer geothermal wells near Zharkent. The remaining sources are typically below 55 degrees C and are concentrated around the Arys and Irtysh regions. For the purpose of large-scale power, the identified sites show little promise based on their low temperatures. However, the geothermal field at Zharkent may hold potential for district heating purposes. Temperatures are high enough to justify further investigation, and the wells exhibit low mineralization (400 milligrams per liter) and virtually no salt. This should help avoid the costs of re-injection and of equipment corrosion (please refer to Annex 9 for additional information). Some low temperature geothermal resources are a candidate for geothermal heatpumps as an efficient heating source. The significant first cost for such applications is a significant consumer barrier to overcome, however.

Biomass and Biogas Energy

2.10 The vast tracts of virgin lands in northern Kazakhstan were developed in the early 1960s to increase grain production in order to improve the security of the former Soviet republics' grain and meat supplies. In the post-independence era, however, agricultural output (particularly rice production) has decreased in Kazakhstan. Measured in volume terms, wheat dominates all crops, followed by barley, oats, corn, and limited amounts of rice. Biomass gasification for fixed-bed power gasifiers has been commercially proven only for wood, charcoal, rice husk, and coconut shell feedstocks. Among these four, only rice is grown in any quantity in Kazakhstan, but its production is decreasing. In addition, the forest product industry is very limited and currently shows little promise for large-scale biomass power generation (either gasification or direct combustion).

2.11 A large livestock population, the use of costly commercial fertilizers, and large space-heating loads indicate initial potential for biogas power for fertilizer production, and for heating applications in Kazakhstan. However, major changes in the agricultural sector along with a number of other adverse local conditions challenge the viability of biogas technology for electric power generation. Fertilizer production using thermophylic anaerobic digestion may offer a limited alternative to the use of commercial fertilizers, which are becoming increasingly expensive. Although it lies outside the scope of this assessment of renewable energy sources, fertilizer production may be the most practical application for biogas digestor technology in Kazakhstan. The mission visited three livestock-intensive production districts. The first site was a cattle farm on the eastern outskirts of Almaty with a demonstration project of a fixed-volume biogas plant. The four units operating at full capacity produce about 480 cubic meters per day of biogas for fertilizer production, with the biogas being a by-product. This 2-year old installation was the first of its type and the developer "GYLYM" is now trying to establish a market for the technology. Two of the most promising high-intensity livestock production areas, the Kaskelean and Tomarovski districts, were also visited. Though significant numbers of cattle are raised (as many as 600 to 1400 per large farm), livestock populations in these areas are dwindling according to public statistics, and future plans indicate further down-sizing of cattle and fodder operations.

2.12 In the opinion of the mission, both biomass and biogas development for energy production (electric power generation or space-heating) are currently low priorities for Kazakhstan. The four main reasons for this are: (a) there is widespread access to low-cost, subsidized, bulk energy; (b) there are already competing economic uses of these alternative fuels, e.g., direct fertilization and composting, and in some cases combustion for heating and cooking; (c) there are uncertainties regarding the future production of feedstocks; and (d) there is relatively little national experience with the applicable technologies. At a later stage, however, the groundwork must be laid. A study needs to be undertaken to assess market potential, followed by a strategic market based demonstration.

3

Kazakhstan: Institutional Structure and Policies

Organizations related to Renewable Sources

3.1 There is no formal organizational structure in place for the development of renewable energy sources in Kazakhstan. Supervisory responsibilities are spread over several organizations and institutions, but constitute a relatively small part of their respective core activities. Besides the Ministry of Electricity and Coal, referred to above, other organizations engaged in various aspects of renewable energy sources were visited by the mission. These organizations are:

- Kazakhstan Scientific Research Institute of Power Engineering (Birles K. Aliyarov, Director) -- The institute focuses on small hydropower development and research into new techniques for harnessing windpower.
- Kazakhstan Energy Center (Tadeoz Mandarija, Director) -- The center is mainly concerned with energy conservation and efficiency, but it also works on renewables. It is currently working on a project to establish a renewable energy park in Almaty.
- Institute Kazelenergoproekt (Alexander S. Trofimov; Director, Dalabaev Oleg Bulatovich; Chief Engineer) -- The government-designated lead agency for non-conventional energy development.
- Design and Investigation Institute -- Almaty Hydroproekt (Josif Vilkoviskiy, Chief Engineer). The government-designated lead agency for small hydro power development.
- Scientific and Industrial Association "ISTIK SU" (hot water) (Serik M. J. Muhamedjanov, Director).
- Almatyenergo, (Marat N. Kombarov, Chief of Foreign Relations Dept.) -- This is one of the nine electric utilities responsible for generation and distribution in the Almaty region. This utility is engaged in the evaluation

of wind and small hydroprojects in the region and is the government-designated lead agency for the introduction renewable energy.

3.2 Besides these establishments, research institutes under the Academy of Sciences and several university departments are engaged in scientific research into renewable energy. In the absence of a national program, renewable energy activities undertaken by different institutions are disparate, and there has been little interaction with the international community in this field. The research and development institutions do not seem to have paid much attention to the practical side of technologies, which include costs, maintenance, sustainability, and commercial concerns.

Policies and Plans for Renewable Energy Development

3.3 Now that Kazakhstan is no longer a command economy, but is instead moving toward a market economy, its energy policies will have to be redefined in order to allow for participation from all sectors of the economy -- public, private, and a combination of the two. In the context of the overall development of the energy sector, the evolution of appropriate policies and plans for renewable energy constitutes a significant challenge to the establishment. Policy formulation will have to focus on priorities and must outline strategic plans in order to generate demand for renewable energy applications and to thereby elicit investments. The national effort in this direction is still at a preliminary stage.

3.4 After a preliminary analysis of the information gathered by the mission, it is evident that Kazakhstan's renewable energy resources are indeed quite large. Nevertheless, priority will have to be given to those resources that can be produced most economically in the near term. Favorable conditions exist for harnessing wind, small hydro, and solar resources. Kazakhstan is faced with a deficit of almost 30 percent in meeting electricity demand (in the southern region) and it must therefore import electrical energy from neighboring countries. To supply consumers from distant power plants, long power lines have been installed and there are attendant problems of reliability and of voltage stability. Coal mining and burning in thermal power plants have created environmental problems. There is growing awareness of the benefits of renewable energy for longer-term sustainability. These considerations provide the basis for setting priorities. It is within this context that strong interest in projects for power production based on wind and small hydro resources has developed in the relevant ministry and in Almatyenergo. However, present national plans and programs along with current tariff structures, cannot create the necessary market pull. This area is one that offers considerable room for further work, both at the policy as well as at the practical level.

3.5 The absence of an overall national policy for renewable energy development is problematic, especially given the fact that there are good prospects for harnessing renewable energy sources, particularly wind, hydropower, and solar, and that all of these sources could reduce the deficit in electricity production. A comprehensive national policy should emphasize the government's commitment; promote public awareness; provide support for research, development and feasibility; develop human resources, and incorporate institutional mechanisms. Encouragement of private sector participation through appropriate incentives, including simplified procedures for licensing, for rationalization of taxes and duties, accelerated depreciation, and soft loans would be one of the most effective means to initiate the development of renewables. The emphasis placed on renewable sources of energy in the draft of the Energy Law is an indication of initial steps in the direction of a national policy. Kazakhstan's government would need to make a public policy statement of commitment to renewables to instill greater confidence and encourage investments from within as well as from outside the country. The creation of a favorable policy environment is essential for attracting bilateral and multilateral donor assistance for enhancing the country's capacity in renewables.

3.6 The MoENR's activities do not adequately address commercialization of renewable energy. The facilities for accessing information on technological developments in other countries are inadequate. Kazakhstan urgently needs to generate activities extending beyond those supported by the government in order to broaden the scale in a well-diversified manner. Programs will have to be developed to modernize facilities and production techniques. Up-to-date techniques need to be used to assess potential resources. Mechanisms must be set in place to make data available to interested parties for project development. Further growth is needed in the areas of demonstration, and of deployment.

4

Kazakhstan: Case Studies of Priority Projects

4.1 A major goal of this study is the preliminary identification and examination of the most promising priority projects for Kazakhstan. These projects were selected on the basis of: (a) the country's potential, both in terms of natural and human resources; (b) the economic and technical feasibility of the projects, as well as the prospects for participation of private investors and international financial institutions; (c) local interest and ability to participate in the implementation of the project; and (d) the potential for duplication (pilot projects).

Small Hydro Projects

4.2 The authorities in Kazakhstan showed great interest in the development of small hydroprojects as a way to compensate for the deficit in electricity, especially in the regions of Almaty and Taldy-Korgan. These regions offer excellent opportunities for a great number of small hydroprojects that could both increase the power supply and replace high-cost imported electricity. Many abandoned projects were re-examined at this preliminary stage by the local authorities, and basic data were provided to the mission. These data cover basic power, hydrology, and hydraulic characteristics. Twenty-three projects were analyzed based on our mission's estimates of local construction costs and an average international costs for the installation of mechanical and electrical equipment. The calculation of the financial viability of these projects was based on the following assumptions:

- Discount rate of 10 percent
- Project life of 30 years
- Price of electricity US¢ 5 per kilowatt hour
- Operation and maintenance expenses 2 percent of the investment cost

The results of this calculation are presented in Annex 1 and 2.

4.3 Following this preliminary economic evaluation of these twenty-three small hydroprojects, the identification of the most promising of these projects was based on the following criteria: (a) the amount of energy produced should be high in order to maximize the positive impact on the electricity balance of the region; (b) easy access to construction sites and cheap connections to existing transmission lines; and (c) favorable economic efficiency in terms of cost per unit of electricity produced. These priority projects are shown in Table 4.1.

Table 4.1: Priority Hydroprojects for Kazakhstan

Project /river	*Chinbullak-2 and Panfilov-1, 2, 3, 4 /Oussek*	*Bartogay and two-Canals /Chillik and Almaty Canal*	*Chillik-19, 20 and Bartogay /Chillik*	*Tunkuruz-1 and Kandybulak /Orta and Tentek*
Installed capacity (MW)	42.0	42.0	38.4	47.0
Energy produced (GWh)	210.5	150.0	161.5	189.4
Investment cost (million $)	210.5	33.9	35.2	77.6
Cost of energy (US cents/kWh)	6.38	2.85	2.75	5.17
Rate of return (%)	6.5	18.3	19.0	9.0
Payback (years)	–	7.6	7.3	–

4.4 The two projects on the Chillik River have similar characteristics and are the most beneficial. The project referred to as Chillik-19, 20 and Bartogay, however, requires extra investment in infrastructure in order to gain access to construction sites as well as connection to transmission lines. Consequently, we have selected the other project of Bartogay and the Almaty canal as our case study. This project involves three small hydroplants on the Chillik River, namely Bartogay, and two small hydroplants on the irrigation canal. The total installed capacity adds up to 42 MW, and the mean produced energy is expected to be 150 GWh per year.

4.5 Bartogay is an existing irrigation dam, which has the potential for a small HEP (housing two units of 10 MW each) on the foot of the dam. The proposed plant will operate during the irrigation period (April-September). At the maximum power pool elevation of 1,067.2 meters, the reservoir has a capacity of 320 million cubic meters. With the minimum power pool elevation of 1,041 meters (70 million cubic meters dead volume) the useful storage capacity amounts to 250 million cubic meters. Given that the tailwater level is provided at the 1,001 meter level, the rated head is 52 meters. The estimated cost of the project is US$13.6 million and breaks down into US$10 million for the procurement and installation of the electrical and mechanical equipment, US$2.4 million for the necessary civil works, and US$1.2 million for other costs and contingencies. The Almaty irrigation canal starts at the level of the main intake of the Bartogay irrigation dam. Its total length is 178 kilometers. The canal is concrete-lined and seems to be in good condition. The maximum discharge capacity in the first part of the canal (4 kilometers long) amounts to 90 million cubic meters per second and then drops to 75 million cubic meters per second. In the seventh and eighth kilometers of the canal are two falls of 18.4

meters and 17.3 meters with a length of about 100 meters respectively. The discharge of the canal at these sites varies from 20 million cubic meters per second in April and September to 60 million cubic meters per second in July and August. The proposed power project envisages the exploitation of these falls by constructing two small SHPs, each with an initial installed capacity of 11.5 MW (two units of 5.75 MW) and of 10.5 MW (two units of 5.25 MW). The cost of the project located in the seventh kilometer of the canal is estimated at US$10.6 million and breaks down into US$7.6 million for the procurement and installation of the electrical and mechanical equipment, US$2 million for the necessary civil works, and US$1 million for other costs and contingencies. The corresponding prices of the project in the eighth kilometer of the canal are US$9.7, US$7.0 million, US$1.8 million, and US$900,000.

4.6 An economic evaluation of this case study results in an internal rate of return of 18.3 percent, an energy cost of US¢ 2.85 per kilowatt hour, and a pay-back period of 7.6 years (see also Annex 2). The general design of the project does not seem to present any particular difficulty and only minimal civil works will be required. Access roads to the sites are good and the system's electrical substation is near the projected plants, which will ultimately belong to the local authorities (Community of Chillik city). The district of Chillik is a rural-agricultural area with ongoing development. Much of the energy produced will be consumed by the city of Chillik and the rest could be sold to the national grid.

4.7 The proposed small hydroproject on the Chillik River and the Almaty Canal seems to meet all the criteria of a successful case study. The cost of the project can be financed by the state, utility, by the local authorities, an independent private investor, or by an appropriate mix of investors. The repayment of the financing will be provided by the income of the energy sold to the city of Chillik and to specific local consumers, and excess energy could be sold to the national power system. Kazakhstan's legislation allows for the operation of private independent producers and the state utility is prepared to pay import prices for any electricity it purchases.

Photovoltaic Systems

4.8 Kazakhstan has large rural and mountainous areas inhabited by nomadic shepherds. Stand-alone PV units are a potential energy source for this community and could also be used for special applications, such as water pumping, wool shearing, etc. Neighboring countries in Central Asia have nomadic populations with similar ways of life. The regional PV market should therefore be examined to achieve greater scale economies for an investment operation.

4.9 The basic data envisaged for this case study are as follows:

(i) Portable PV unit

Unit output:	20 W at an insolation intensity of 1.0 kW/m^2. To supply a 60 watt-hour (Wh) daily load at an insolation of 5.0 kWh/m^2/day
Module area:	0.2 m2
Expected generation:	36.5 kWh/year at 1,825 kWh/m2/year
Battery:	Nominal capacity 35 Ah -12 V, deep-cycle battery To supply a 60 Wh/day load for 4 days
Assumed loads:	(Lamp: 15 W – 4 hours/day) = 60 Wh/day 0.06 kW*365 = 21.9 kWh/year

Installed cost (economic): US$308

4.10 The first cost of such systems will in most cases be beyond the ability of rural populations to pay and a retailer or consumer credit program is absolutely necessary. Appropriate financing will help make the system financially accessible for nomadic populations. However, on a per lumen-hr basis the system is at least 25 percent less costly than the kerosene lantern base case as demonstrated below.

Avoided Cost Calculations

SOLAR PV LIGHTING 20 W System	*Insolation (kWh/m2/d)*	*PV Panel Output: kWh/y*	*Lighting Energy Used: kWh/y*	*Levelized Cost/kWh Lighting*	*Lighting Efficacy lm/W*	*Cost Per k-lumen hour ($/k-lm-hr)*
	5	36.5	21.9	1.58	38	0.041

KEROSENE LIGHTING Petromax Lantern	*Kerosene, $/litre (International Market)*	*Specific Fuel Consumption litres/hr*	*Lumen Output k-lm*	*Equipment cost ($/k-lm-hr)*	*Fuel Cost ($/k-lm-hr)*	*Cost Per k-lumen hour ($/k-lm-hr)*
	0.3	0.06	0.40	0.009	0.045	0.054

4.11 The maximum foreseeable market potential of PV units is estimated in Table 4.2 based on projections from the mission's local counterparts.

Table 4.2: Estimated Market Penetration of PV Units

	Portable 20 W each	
Year	*No. of Units*	*Total Cost[2] $ Million*
1st	1000	0.31
2nd	2500	0.77
3rd	4000	1.22
4th	5500	1.68
5th	7000	2.14
Total	20,000	6.11

4.12 Local manufacture of photovoltaic components is highly correlated with the market penetration of PV applications. The costs reflected in Table 4.2 are international costs, which could be reduced with production increase if the units were manufactured locally. The Orlovka plant in Kyrgyzstan (Chapter 7) used to supply monocrystal silicon wafers to semiconductor industries in the former Soviet republics and is presently functional. This industrial capability will enable the Orlovka plant either to supply silicon wafers to the PV industry or to engage itself in the manufacture of PV modules, if Orlovka is supplied with silicon resources from neighboring countries. A joint venture between Orlovka and a foreign partner with both technology and market expertise seems to be the most promising approach for this case study. This strategy would have to take into consideration the Kyrgyzstan market as well as the market of other neighboring countries. Kazakhstan used to play an important role in supplying lead batteries to the former Soviet republics from its plant in Taddi. The Altau Company in Almaty currently makes a few small electronic devices, but has experience in manufacturing electronic equipment such as communication stations. During the time of the former Soviet republics, the plant in Altau operated in two shifts with 5,000 employees. Altau is interested in manufacturing PV modules in cooperation with Kazak State University, which has a test production facility. The company is also interested in manufacturing inverters. The Physical Technical Institute of Kazakhstan is pursuing research in the collection of solar-grade polycrystalline silicon made from mineral waste and, if successful, plans to supply this to the Orlovka plant in Kyrgyzstan. Kazakhstan and Kyrgyzstan are both interested in manufacturing PV modules and silicon wafers. Both countries have good potential to supply PV components and to establish their operation and maintenance organization in a larger market.

4.13 There are some fundamental issues to consider in designing a successful PV project in the Central Asia. As part of the prefeasibility study, a detailed market study and survey will be vital to help confirm and ensure the financial and cultural viability of the program. Given the very low rural incomes, particullarly amongst nomadic shephards, even a 20 Watt PV system will be a challenge to market on commercial terms, and

2 Hardware costs only.

creative term-financing will be a neccessity. *For permanent rural dwellings tied to the weakest parts of the national grid, larger PV systems may be a viable alternative to transmission and distribution system renovation and capacity addition.* According to one local estimate, 15-20 thousand kilometers of medium and low voltage line has been lost since 1991, leaving some of the remote, stationary populations unserved by the grid, and others intermittently served. This market niche was not analyzed due to the constraints and scope of this study, but certainly merits deeper investigation.

4.14 Expectations should be set at a reasonable level from the beginning of the program to avert disappointment, innocent system abuse, and repayment risks. A 20 Watt PV system will supply only the very essential energy service needs, e.g. lighting and communication. Past expectations were set very high when over a decade ago, the government provided gasoline engines (1.8-4.0 kW in size) to nearly all remote shepherds. The units soon fell into disrepair without proper service, however. Global experience also confirms that the long-term viability of the PV market demands the provision of proper maintenance and engineering services. Local service personnel throughout the project areas will be needed. As an additional component to the service chain, collection and recycling of used batteries will be required to complete an environmentally sound product-cycle.

Windpower Project

4.15 The first estimate of economic viability had to be performed with the existing data base. Using also results from a previous study (performed by Jerry Slimak) and the resource data material collected by the mission, the study identified two parameters that have the highest effect on power production estimates and economics; these are resource uncertainty and windfarm losses. With the available data, a preliminary economic analysis has been prepared that translates the resource projections, together with other assumptions, into an internal rate of return (IRR). Kazselenergoproject and Almatyenergo are equipped to provide valuable cooperative assistance, technical input, government linkages, and procedural expertise for windpower projects such as the pilot case study described below.

4.16 Resource Uncertainty. Slimak's study used 6 months of wind speed data from a proposed project site and long-term averages from one of the nearby measurement stations (Druzhba) for the remaining 6 months to compute turbine power production projections. While this is a reasonable approach, close examination of the long-term wind-speed averages for the two closest measurement stations, Druzhba and Zhalanaschkol, shows that the resource in the valley is quite complex. The average annual wind speed at

Zhalanaschkol is higher (7.6 m/s) and has a strong seasonal component, with high winds in the winter and low wind in the summer. The resource at Druzhba is lower (7.0 m/s), but it is more consistent, with less seasonality. Given the relatively close proximity of the two stations and the consistent topography, these differences suggest a complex resource that is not well understood.

4.17 Power Production Predictions. In any case, there is a significant difference between the resources at the two long-term measurement sites. In order to examine this, power production estimates were derived using the long-term, monthly wind speed distributions for the two stations. Even with the higher annual average wind speed, the Zhalanaschkol site produces less energy, since much of the higher wind spectrum lies above the operating range of wind turbines (and the average speed is a numeric speed average while power potential is proportional to the cube of the speed). It must be noted that, in fact, the proposed site may have characteristics that are closer to the Zhalanaschkol site (probably because the authorities, basing their judgment on average speed, believed, mistakenly, that it would be the more favorable site). The main assumptions used in power output calculations are as follows:

- power output was calculated for two turbines: the Micon machine used in the Slimak report and the Zond Z-40;
- power output was calculated for two turbine heights, using the 1/7 power law for wind shear scaling, and assuming the frequency distributions from Kazakhstan are for 10-m anemometer heights; and
- since the turbine and windfarm designs are not determined at this point, the study used an average capacity factor from the two machines, two heights, and the ranges of downrating factors as inputs for the rough economic analysis.

4.18 In summary, the power output calculations indicate a capacity factor of around 26 percent at Zhalanaschkol and 33 percent at Druzhba. In other words, Druzhba will produce around 23 percent more energy from the same turbines (and capital outlay). This kind of variation through the valley has a large impact on project economics; significant gains in energy production may be realized by examining the area for the optimum site (a micro-siting exercise). To provide a firmer base (reliable predictions) for project planning and optimum siting to maximize power output, the study recommends that a thorough resource assessment study, performed by installing multiple anemometer stations throughout the valley, be performed.

4.19 Windfarm Losses. Single-turbine output needs to be downrated to account for the site altitude, wind farm losses and system availability. Losses include such factors as array interference (wakes), blade soiling, electrical gathering system losses, and losses due to controls. A range of losses from 7.5 percent to 12.5 percent is typical, with availability ranging from 0.95 to 0.98. The earlier study, applied only a downrating of 1 percent, which is unrealistically low, even for a linear array with no wake losses. The more realistic downrating factors, suggested in this study, were included in the capacity factors quoted above.

4.20 Economic Analysis. The simple economic analysis follows a spreadsheet technique also used in the small hydro case. In order to start with a modest but also substantial size plant, the study assumes an installed capacity of 40 MW and lifetime of 30 years. It must be noted that turbine purchase and maintenance costs for Kazakhstan may be significantly different from other locations. The following cost figures were used: US$1,100/kW of installed capacity as capital cost (making a total capital cost of US$44 million) and 0.5 US¢/kWh for O&M (these figures are supported by project experience in other countries, for example, India). Ranges for these could be about US$900-1400/kW and 0.7-0.3 US¢/kWh (sensitivity studies may be run with the spread sheets). Only the benefits of electricity sales were accounted for in the benefit column; no environmental benefits were quantified and, therefore, the analysis is conservative.

4.21 Three variants were used and, for each variant, two calculations were performed, for the 26 percent and 33 percent capacity factors as shown in Table 4.3 which summarizes the IRR values. The economic analysis spreadsheets are shown in Annex 10 and 11.

Table 4.3: Windfarm RR Calculations for Three Variants

	Base Case		***2% price escalation***		***$10 million GEF***	
Capacity Factor->	*26%*	*33%*	*26%*	*33%*	*26%*	*33%*
Electricity Tariff US cents/kWh						
2.5	1.3%	3.1%	3.5%	5.4%	3.2%	5.3%
5.0	8.4%	11.3%	10.6%	13.4%	11.6%	15.0%
6.25	11.4%	14.8%	13.5%	17.0%	15.1%	19.4%
7.5	14.2%	18.3%	16.3%	20.4%	18.6%	23.8%

Notes: All figures at constant 1996 US Dollars; "base case" assumes constant real prices of electricity and no grant; "2% escalation" assumes a 2% per year increase of electricity prices in real terms; and "US$10 million GEF" case assumes a US$10 million contribution to capital expenses from the Global Environment Facility.

4.22 Whereas tariffs is a major policy/economic issue, the primary *technical* parameter is the resource certainty and site selection, illustrated by the significant difference in the IRR figures. For example, at 5.0 US¢/kWh, and with the US$10 million GEF grant, the difference amounts to 3.4 percent; at higher tariffs, the difference is greater. Detailed measurements in the valley would clarify this issue and reduce the uncertainty. For a firmer economic evaluation of the power produced, it is also recommended to examine the seasonal and daily variation in output and the matching between power delivery and the utility's load demand profile.

4.23 The main observation from the table is that at tariffs of US¢ 5/kWh and above, the IRR figures are reasonable to very good. The US¢ 5/kWh is a price the local utility is prepared to pay (even US¢ 5.5/kWh would be acceptable, according to the mission's discussions), given the current amount and actual cost of electricity imports being paid to neighboring countries and the prospects of escalating prices, and therefore, a viable assumption for a wind project. This price is not considered generous in most developed countries, where incentive price structures exist for environmentally benign energy sources. Although this cannot be argued strongly in present-day economic conditions in Kazakhstan, a certain escalation for the next several years can be assumed, to allow for the gradual liberalization of the economy and gradual approach of electricity tariffs to international levels. On this basis, a second variant was run, assuming a 2 percent price escalation at least for a number of years. This assumption improves the IRR figures by about two points.

4.24 Finally, a variant was run assuming a US$10 million grant from the Global Environment Facility (GEF) to account for differential cost attributed to the first introduction of the technology in the country, institutional impediments and other, higher-than-normal transaction costs. Furthermore, the dissemination of wind technology in a part of the world where the potential for larger-scale development is high would contribute to the slide down the learning curve that is expected to bring the cost of windpower even to lower levels. It should be noted that the bulk of Kazakhstan's generation is based on low-quality coal that causes local and regional air pollution as well as global (green-house-gas) emissions. With this assumption (a US$10 million grant that would reduce the (equity/loan) capital investment requirement from US$44 to US$34 million), the attractiveness of the project improves significantly: at US¢ 5/kWh and for the 33 percent capacity factor site, the IRR rises from 11.3 percent in the base case to 15 percent in the GEF-grant case. For higher electricity prices, e.g., US¢ 6.25 and 7.5/kWh, the IRR of the Druzhba project increases to 19.4 and 23.8 percent respectively.

4.25 The resource uncertainty, as reflected in the two capacity factors used, is equivalent to about US¢ 1.25/kWh in electricity tariff. This highlights the economic significance of obtaining as good estimates as possible of the wind regime and capacity factor predictions.

4.26 The main conclusion from this analysis is that, at first cut, wind development in the Djungar Gate, on the frontier with the Xinjiang province of China, seems viable on both economic and financial terms. The results obtained in this study explain why considerable interest has been expressed by local and foreign investors to develop windfarm projects in the Djungar Gate corridor. The next steps would be, first, the initiation of a wind resource monitoring program followed by a micro-siting exercise to determine the most favorable locations for a wind project and the more detailed analysis of a windfarm project[3].

[3] The United Nations Development Programme (UNDP) was carrying out a Pre-investment Study of Windfarms in Kazakstan at the time of this report's completion.

5

Kazakhstan: Recommendations and Scope for Further Work

Institutional and Legal

5.1 The transition to a market economy calls for the creation of the institutional structures needed to provide legal safeguards and regulation. Energy reforms and organizational restructuring currently underway should incorporate specific institutional arrangements conducive to the development of renewable sources of energy. Because this sector is just beginning to develop, institutions should play a proactive role in the promotion of renewable sources of energy. These institutions should adopt simplified procedures for project clearance, granting of licenses, and the introduction and administration of incentives. Kazselenergoproject, Almatyhydroproject, and Almatyenergo are vital institutional resources to build upon in this endeavor. These institutions or a new umbrella institution made up of these three, must also have the power to translate government policies into practical measures. The recommended roles of such an umbrella institution for renewable energy include:

- Prioritization and strategy development for renewable energy in accord with the national energy and environmental objectives.
- Inventory and promotion of viable renewable energy projects, investments, and joint-venture opportunities.
- Provision of legislative recommendations ensuring an open, easily-accessible, and competitive market for private renewable energy investment and service delivery.
- Review of renewable energy related state projects and programs.
- Development of standards and certification routines compatible with internationally-recognized protocols and local circumstances.

- Provision of technical assistance and support in identifying financing sources for private enterprises.

5.2 An effective legal and institutional framework is as important as technical developments for the dissemination of renewable energy sources in Kazakhstan. Experience in other developing countries in which the World Bank has been active shows that certain measures can be very effective in the creation of such legal and regulatory frameworks. The main recommendations of the study are:

a. *The creation of an independent agency for Renewable Energy Resources.* This agency could be under the purview of the Ministry of Energy and Natural Resources, working as an umbrella agency over the three renewable energy institutes above. Its role would be to coordinate, encourage, and promote renewable energy activities, and to facilitate project implementation. This agency should have considerable autonomy, sufficient resources, and a clear mandate from the state. It could supervise both the achievement of energy efficiency and the activities in the field of renewables. (Technical assistance for the establishment and organization of this agency could be provided by various donors).

b. *The clarification of roles.* The role of various government organizations must be clarified in order to eliminate redundancy and to consolidate offices. Furthermore, potential investors would be more willing to enter the energy sector if the procedures for preparing, evaluating, and granting licenses for renewable energy projects were simplified.

c. *The creation of a special Fund.* This fund would provide financing for renewable energy (and, possibly, for the achievement of energy efficiency) projects. Such a fund will not only increase the feasibility of possible projects, but will also improve the role that renewable energy will play in the long term. Capital for such a fund could be derived from a variety of sources, for example penalties for the violation of environmental regulations; debt-for-nature swaps; a small surcharge on electricity bills; special grants from environmental funds, such as the Global Environment Facility (GEF); lines of credit from international financial institutions (IFIs); and other sources. Creative financing mechanisms for small, dispersed renewable energy systems, such as stand-alone photovoltaic systems, would make the dissemination of such systems both sustainable and viable.

d. *Participation of the private sector.* Private sector participation would greatly promote renewable energy projects. The government, which is already proceeding with the privatization of energy assets, must provide the legal and regulatory environment needed to provide confidence to the private sector. Encouragement must take the form of practical incentives to participate in investment in renewable energy projects. Such incentives could include:

- price incentives, for the purchases of renewable sources of energy and from energy efficiency projects. These prices should be set somewhat higher than the price for conventional energy to account for environmental benefits from such projects; and

- accelerated depreciation of renewable energy investment, tax breaks, and lower import duties for selected items. It is generally estimated that the loss of revenue to the state from such concessions will be lower than the benefits accrued to the state from the renewable energy projects.

Technical Assistance

5.3 A strong need for technical assistance is required to enable Kazakhstan's institutions to adopt appropriate methods and practices for the development of renewable energy sources under a market economy. This assistance must strive to improve the ability of existing institutions to: (a) provide access to scientific and technical information regarding progress in renewables in the international arena; (b) acquire relevant expertise; (c) modernize institutions for the production of energy from renewable sources; (d) promote private sector investments, including marketing and service facilities; (e) establish legal and regulatory institutions; (f) introduce financing arrangements; and (g) develop tariff structures to give a reasonable rate of return on investments.

5.4 The MoENR responded to a questionnaire on technical assistance needs. Based on the information provided, this study recommends the following:

5.5 *Strengthening of policy, institutional mechanisms and promotional activities.* The MoENR needs technical assistance in the form of advisory services, both to set up the proposed agency as a focal point for policy and coordination, and to develop a framework for promotional activities. We also recommend the use of consultants to accelerate the ongoing institutional reforms and to institute legal and regulatory mechanisms. Advisory services should be made available to the Ministry to develop promotional programs including public information campaigns, incentive packages, tax concessions, and other activities.

5.6 *Improvement of resource data base and analysis.* Although meteorological data on solar radiation and wind resources exist to some extent, data analysis and resource assessment techniques need to be modernized. In view of the large-scale windpower activities being planned in the near term, technical assistance should focus on strengthening the ability to assess and to quantify wind potential in areas of known potential. This will lead to the identification of the most economically viable sites for windpower development. Methodological input and training in wind farm siting as well as in the assessment of wind potential in complex terrain will also be needed. Technical assistance will also be needed for increasing the ability to prepare feasibility studies for assessment of the economic and financial viability for renewable energy projects. Specific personnel from within Almatyenergo should receive training in various technical and operational aspects of windpower from foreign establishments with facilities and experience.[3] Participation in international seminars and workshops should also be encouraged. There is adequate local technical know-how in the areas of field investigation, construction, and operation of hydropower. However, assistance will be needed in training of personnel in the areas of economic and financial analysis and management of hydroprojects.

5.7 *Information dissemination and establishment of data bases.* Public awareness of renewable energy systems is limited and institutional capacity is inadequate. Support in the form of hardware and software to the Kazakhstan Energy Center as well as in the training of its personnel is recommended so that the center can act as the focal point for the dissemination of information. Assistance for establishing data bases at this center as well as for creating link-ups with other data bases is also recommended.

5.8 *Improvement capability for legal and regulatory functions.* Although technical assistance for the establishment of a legal and regulatory framework has been provided during the past four to five years by a number of institutions, including EU-TACIS and USAID -- both of which assisted in the preparation of the draft Energy Law -- the requisite organizational structures and implementation capabilities have not yet been fully realized. Technical assistance should therefore be targeted to assist in the implementation of the Energy and Electricity Laws enacted by Parliament. Consultant service and training in organizational development and implementation should be considered. In order to maximize use of the limited resources, technical assistance for renewable energy should be coordinated with that provided to other energy sectors by EU-TACIS, USAID, UNDP, and others, especially in legal and regulatory functions.

5.9 *Investment promotion and financing.* Technical assistance should be considered to design investment promotion programs and to establish financing

[3] Examples of such facilities are the US National Renewable Energy Laboratory (NREL) in Golden, Colorado, a staff of which was a member of the World Bank mission and the RISO Laboratory of Denmark, which has already performed work in Kazakstan.

mechanisms for viable projects in the area of renewable energy. Experience gained in the creation of financing mechanisms specifically designed for renewables in countries such as India could serve as a model. Although the establishment of a dedicated development fund for financing renewable energy projects would be desirable, considerable efforts are needed to create favorable conditions before such a step is taken. In the meantime, assistance should focus on training a cadre of persons in the financial sector management: (a) in methods and practices for financing private sector projects, (b) the management of such institutions, and (c) assessing credit systems and managing financial arrangements.

5.10 *Enhancement of entrepreneurial skills.* Since renewable energy applications are, to a large extent, decentralized and relatively small in scale, a variety of entrepreneurial skills will be needed and should form an important part of any program. Assistance should also focus on the development of entrepreneurial skills for the local manufacture of renewable energy equipment, for setting up energy service companies, for ensuring the efficient operation and maintenance of plant and equipment, and so on. Assistance will also be needed to support and strengthen the interaction of non-governmental organizations with reputable organizations in other countries. A key area for assistance is in the development of consulting organizations to undertake feasibility studies, provide training, technical, and management services on a competitive basis, assist in contract negotiations, and so on.

5.11 *Strengthening of research and development.* A sound technological base is essential for rapid progress in the development and application of renewable energy technologies in Kazakhstan. Rather than emphasizing fundamental research with its high risk and uncertainties the country should place emphasis on applied research and technology adaptation to take advantage of developments elsewhere in the world. There are qualified personnel in the various research establishments, such as the Kazakhstan Energy Research Institute, the Kazakhstan Energy Center, the Academy of Science laboratories, as well as in other university departments. Nevertheless, assistance is needed to facilitate access to and interaction with scientific and technical establishments in the industrial countries especially to be able to incorporate cost and economic return considerations in their work. Some assistance would be needed to upgrade facilities in the R&D establishments, particularly in the fields of solar and wind energy. Study tours and participation of researchers in international conferences could help to break the isolation of technical persons in Kazakhstan and expose them to evolving ways of thinking.

5.12 *Establishing standards and certification.* Assistance will be needed in the areas of equipment specifications, standards, and certification procedures so as to make them compatible with those internationally in place for trade and investment. Assistance will also be needed to institutionalize these regulations as is the case in other countries.

The establishment of autonomous organizations should be promoted. Facilities for testing and certification need to be modernized and personnel will have to be trained.

5.13 *Transfer of skills and experience in power sector rehabilitation.* Efficient use of existing infrastructure where economically and environmentally justified, will be vital to sustainable power sector development. Of direct relevance to renewable resource development will be the cultivation of modern, standardized techniques for small hydro power rehabilitation and conversion (in the case of municipal water supply and irrigation canals).

6

Kyrgyzstan: The Economy and the Energy Sector

Current Economic Situation

6.1 Kyrgyzstan in Central Asia is bordered on the north by Kazakhstan, on the southeast by China, on the southwest by Tajikistan, and on the west by Uzbekistan. It has a population of about 4,500,000 people, of which roughly 65 percent live in rural areas. Since May 1993, the country's currency unit is the som (June 1996 exchange rate approx. 1 US$ = 12 som). Kyrgyzstan's economy is mainly agricultural, but during the time of the former Soviet republics, the country developed a significant industrial sector, which accounted for about 40 percent of GDP. Most industries are located around Bishkek and are heavily dependent on Russia and on other CIS countries for customers and for inputs, including most of their fuel. As is the case in most former Soviet republics, GDP has been declining in recent years. In 1995 GDP was approximately 16 billion som (around US$1.5 billion). The value of exports reached US$410 million in 1995, whereas the value of imports was US$540 million. As of January 1996 the average monthly salary was roughly 450 som (US$40) for the economy as a whole. The country suffered from very high inflation rates in previous years, but according to recent national statistics the consumer price index was increasing with a monthly rate of less than 4 percent as of January 1996, whereas the average monthly rate of inflation for all of 1995 was around 2 percent.

6.2 The country was among the first of the former Soviet republics to launch systematic reform immediately after independence. Current priorities focus on privatization, and on the restructuring of state enterprises and the banking sector. Kyrgyzstan has good potential for development of the agricultural and agro-industry sectors, of the service sector (including tourism), and of the mineral sector, where there are good prospects for gold and for some rare earth metals. As for energy sources, Kyrgyzstan is a net importer of coal, oil, and gas, and it exports hydroelectric power generated from the dams of the Naryn river to other CIS countries (mainly Kazakhstan). The dams on the Naryn play a key role in regulating the flow of water for major irrigation systems in neighboring countries (especially Uzbekistan). The trade-off between electricity and irrigation is of great importance for Kyrgyzstan, because it allows for an improved sharing of benefits. Kyrgyzstan depends heavily on its Central Asian neighbors and on Russia for approximately 60 percent of its primary energy supply. The country possesses abundant hydroelectric resources, which have been only partially developed. It has limited oil and gas production and a declining coal industry. Because of limited seismic research work, several potentially promising areas of oil reserves have yet to be thoroughly explored.

Organizational Structure and Legal Framework of the Energy Sector

6.3 Kyrgyzstan's energy sector has undergone significant changes since the dissolution of the former U.S.S.R. The country is in the process of adjusting to the new economic environment; further change is possible in the absence of a separate ministry for energy, responsibility for the energy sector is spread over a number of state enterprises and state committees. The state enterprise for electric power (a power utility known as Kyrgyz National Holding Energy Co.- KNHEC), along with a state committee involved in exploration (minerals as well as petroleum) are directly under the control of the deputy prime minister. The Ministry of Trade and Industry oversees production of coal, oil, and natural gas, as well as the state enterprises involved in these areas with a deputy minister in charge. The price commission of the State Committee for the Economy controls the price of electricity, gas and heat; the Antimonopoly Commission controls the price of petroleum products. The State Property Fund is also engaged in energy activities. The entity responsible for the renewable energy subsector is a business project called KUN (which in English would be SUN). KUN is presented in some detail in Chapter 8.

6.4 Current energy policy objectives focus on achieving increased reliance on indigenous energy supplies and on encouraging the private sector to develop domestic energy resources, including renewable energy. The present organizational structure does not seem conducive to the articulation of a coherent national energy policy or to effective coordination among the different entities involved in energy. Most of these entities are still run by the practices of pre-independence days. Data systems have not yet been reorganized to incorporate the ongoing process of reforms with the result that the relevant organizations do not have information on current patterns and projections of energy consumption, production, and trade.

6.5 The legal framework for energy is embodied in the Energy Law, which has been finalized and is expected to be approved by Parliament shortly. This law has the necessary provisions for the organization and regulation of energy sector activities and it applies to all energy enterprises regardless of the form of ownership. The enactment of this law is supposed to achieve efficient extraction, production, and utilization of energy, and reliable and stable supplies, protection of environment, competition, as well as market-oriented prices in the energy sector. A law defining the organization and operation of the electricity sector has been introduced (Electricity Law). This law envisages, among other things, the orderly introduction of market mechanisms and competition into the electricity sector through a process of privatization.

6.6 The energy law has created a state energy agency which is responsible for the regulation of the power sector. This agency will be responsible for monopoly regulation, primarily through the use of incentives, performance agreements, and licensing arrangements. The agency is expected to encourage competition through the adoption of market mechanisms. One of its tasks is to determine and regulate tariffs for electricity, thermal energy, and gas; with the interests of consumers and producers in mind. This is consistent with the socio-economic objectives of the republic. A competitive environment must be created to attract investments, including those from the private sector. The agency will also set and enforce standards of service, introduce simple and transparent procedures for issuing licenses, stipulate safety norms, and oversee environmental safeguards. Significant institutional reforms are still needed for the efficient management of the energy sector, and to provide capital. Institutional capacity will have to be significantly improved to translate the provisions contained in the laws into operational strategies and for the effective management of the transition to a market economy.

Energy Supply and Demand; Trade

6.7 As already mentioned, Kyrgyzstan has a very large hydro potential, of which about 10 percent has been exploited to date. However, the country has to import most of its fossil fuels requirements. The energy trade is mainly with Russia and the nearby Central Asian republics. The energy balance for 1994 is given in Table 6.1.

6.8 The state electricity utility operates 18 hydropower plants. It also runs two cogeneration plants, one in the city of Bishkek (600 MW) and one in Osh (50 MW). The hydroplants are on the Naryn river and have a total installed capacity of 2,770 MW, whereas the average annual generation of electricity is about 10,000 GWh. Kyrgyzstan's hydropower potential is large; total estimates run to approximately 26,000 MW, most of this with low unit cost. All existing hydroplants are downstream from the huge Toktogui Reservoir and their operation is driven primarily by the summer irrigation needs of Kazakhstan and of Uzbekistan, when demand is low in Kyrgyzstan. This situation is

Table 6.1: Energy Balance 1994

	Coal (million tons)	*Crude Oil (thousand tons)*	*Oil products (thousand tons)*	*Nat. Gas (million m³)*	*Electricity (TWh)*
Production	0.85	88.2	38.8	39.0	10.7
Imports	1.35	n/a	657	856.1	1.7
Exports	0.17	n/a	n/a	-	4.2
stock change	n/a	n/a	n/a	n/a	-
Total Energy Supply	**2.03**	**87.6**	**695.8**	**895.1**	**8.2**
Conversion to Electricity	0.88	-	94.4	224.0	-
Conversion to Heat	n/a	-	n/a	n/a	-
Losses	n/a	-	-	n/a	1.5
Statistical Differences	-	-	-	-	-
Final Consumption	**1.15**	**-**	**601.4**	**671.1**	**7.8**
Industry	0.24	-	n/a	n/a	2.1
Agriculture	n/a	-	n/a	n/a	1.5
Households	0.42	-	n/a	n/a	3.1
Transport & Other	n/a	-	229.8	-	1.1

reversed in winter, when electricity demand is high and water has to be stored for summer irrigation needs. There is potential for development of more hydropower generation (2,200 MW) further upstream from the dam. Some construction has taken place since independence, but high investment costs have caused the projects to be put on hold. The authorities forecast moderate demand with an annual increase of roughly one percentage point until the year 2005, consequently any major investment to exploit the hydropower potential can only be justified by electricity exports. Southern Kazakhstan, with its deficit in electricity of about 30 percent, is the most promising market for Kyrgyzstan. The country is connected to the other Central Asian republics by the Central Asian Integrated System, 500-kilovolt lines, controlled by the Tashkent dispatching center. The transmission and distribution system has serious problems attributable to natural disasters, overloading, and its age; reliability is thus poor, especially in the districts of Dzalal Abad, Osh, Naryn, and Issyk Kul Lake. Overloading occurs during the winter because a large part of the population uses electricity for space heating for two reasons: there is no district heating network outside Bishkek and Osh and electricity is currently far cheaper than other sources of heat.

6.9 Prices of imported hydrocarbon fuels are now at international levels. The price of domestic coal is surprisingly high because of problems in transportation between the south (location of mines) and the north (main consumer centers). Despite increases, electricity tariffs are still very low. Domestic consumers are charged 0.12 som/kWh (0.7 US cents/kWh) for the first 300 kilowatt-hours per month (extended to 700 kWh/month for the winter of 1996/97) and 0.25 som/kWh for consumption above this. This price corresponds to less than US cents/kWh. Prices for industrial use of coal are slightly higher, but still far below real generation costs.

Impetus for Development of Renewable Energy Resources

6.10 Global warming and other environmental concerns have given rise to an increased international focus on renewable sources of energy for the past twenty years. Many industrial countries have already achieved a significant contribution of wind, hydro, and solar power, as well as use of recyclable waste in their energy balance for heat and other power needs. Developing countries are also expanding programs to identify sources of renewable energy. This trend is expected to grow stronger in the future. According to a recent UN study, under certain circumstances renewable energy sources including large hydro could account for as much as 60 percent of the world's electricity market by the mid-21st century. At the Rio Conference of 1992 an international consensus was reached that concerted action must be taken as a precaution to mitigate large increases of green-house gases (carbon dioxide, methane, and others). To accomplish this, a shift needs to take place from traditional fuels to renewable energy sources and energy efficiency measures. The Rio Conference informed all nations to take action not only in the areas of technological development but also in removing social, economic, and organizational barriers. To assist in this development, the Global Environment Facility (GEF) was created to provide grant financing for environmental costs. The availability of GEF support has given a strong impetus to RE development in many developing countries. **Kyrgyzstan will not become eligible for GEF grants until it ratifies the Framework Convention on Climate Change (FCCC). Until ratification this will pose a significant barrier to renewable energy investments by multilateral development banks.**

6.11 Kyrgyzstan's motivation for a larger share of renewables into the country's energy balance are the following; assuming that RE resources are available, as will be discussed in the balance of this report:

a. Given the high degree of dependence of the country on imported fuels, the use of renewable energy sources could reduce the country's dependence and export bill; for example, a significant portion of the country's heating needs could be supplied by solar energy.

b. The high numbers of rural and nomadic population with no access to the electricity grid could be supplied by stand-alone (dispersed) renewable energy systems at a cost that is lower than grid extension.

c. Given the high investment required for the rehabilitation and enhancement of the country's existing transmission and distribution system, renewables provide an alternative that is both environment-friendly and cost-effective and that can be placed near consumer centers. Small hydro and photovoltaic stations could contribute not only to direct savings in cost, but also to improved overall system stability and efficiency.

7

Kyrgyzstan: Review of the Renewable Energy Sources

Present Status and Selection of Technologies

7.1 Kyrgyzstan, like many other central Asian countries, possesses numerous potentially significant sources of renewable energy. Nevertheless, because of policies of the former U.S.S.R., which favored large central energy facilities, very few of these potential sources were exploited because of each individual project's small impact on the country's energy balance. The geophysical conditions of Kyrgyzstan's rural mountainous areas along with its necessarily expensive transmission lines favor regional generation of power and its distribution for both economic and environmental reasons. Many rural regions, inhabited by nomads[4], are not connected to the grid. Furthermore, system availability and stability is not guaranteed. RE systems could play an important role in meeting these needs.

7.2 The authorities in Kazakhstan, at all levels, showed a keen interest in the development of sources of renewable energy and especially in solar applications and small hydropower projects. The infrastructure of the country is relatively good, both in terms of institutes for research and development and in general manufacturing capabilities. Furthermore, the state project KUN, as an organization responsible for renewables, could coordinate the efforts of the various institutes, energy companies, and state entities. In recent years, even foreign investors have shown interest in specific small hydropower projects as well as in the manufacturing of PV modules. Local capacity for micro hydro turbine design and production, portable wind turbine production, solar water heating panels, and biogas digestors is also present. These products could, however benefit from international financial and consulting assistance towards their commercialization. Although small hydro is by far the most promising of the renewable

[4] These "nomads" are migratory populations which shift between established pasturelands according to season.

sources, this chapter briefly reviews other sources as well that might become important in the future, namely wind energy, geothermal wells, and biomass.

Small Hydro

7.3 Kyrgyzstan, being a mountainous country, has good sources of hydropower, but its potential has not been investigated in detail up to now. Kyrgyzstan's total hydro potential has been estimated to 162.7 TWh, while the technically exploitable resources are estimated at about 73.0 TWh and the economically exploitable at 48.0 TWh. Roughly 11 TWh has been exploited. The policy of the former Soviet Union (FSU) was to focus primarily on the exploitation of large projects. As a result, many small plants (up to 10 MW) that were in operation in the 1950s and 1960s were abandoned. A new study on hydro potential, which examines the main river basins of the country, is currently being undertaken. This study may prove that the real technical-economic exploitable hydro potential of the country (mainly in relation to small hydroelectric projects) is even greater.

7.4 During the mission, technical data for 19 small hydroelectric projects (representing an installed capacity of 120.1 MW, an annual energy production of 530.7 GWh, and an investment cost of US$146.1 million) were reviewed so that the most economically efficient of these hydroelectric projects could be analyzed. According to their geographical area, these projects are:

1. Three projects (Leninpolsk, Kirk-Kazik, and Kirovsk) on the Talas river, with an installed capacity of 23.4 MW, an annual energy production of 73.3 GWh, and an estimated investment cost of US$26.7 million.

2. Three projects on the Issik-Ata river with an installed capacity of 5.4 MW, an annual energy production of 35.7 GWh, and an estimated investment cost of US$26.7 million.

3. Two small projects on the Chatkal River (Sandalask-1, -2) with an installed capacity of 25 MW, an annual energy production of 147 GWh, and an estimated investment cost of US$30.4 million.

4. Two or three hydroelectric projects (Karakol, Ak-Shoui) in the Karakol area with an installed capacity of 6.4 MW, an annual energy production of 43.7 GWh, and an estimated investment cost of US$9.6 million.

5. Eight small projects dispersed around the country with an installed capacity of 59.9 MW, an annual energy production of 225 GWh, and an estimated investment cost of US$71.3 million.

Many of these projects would attract potential investors if a specific market exists and the required legal framework is developed.

Solar Energy

7.5 Kyrgyzstan is between northern latitudes 39 and 43 degrees. This would not normally be considered advantageous for solar potential. On the other hand, Kyrgyzstan's solar energy resources are stable and adequate because of its dry climatic conditions. There are about 2,600 hours of sunshine per year and insolation energy is 1,500 to 1,900 kilowatt-hours per square meter per year (see Table 7.1 and Annex 8).

7.6 More than 50 percent of the country is made up of low, mountainous desert or semi-desert. Topographical conditions provide yet another advantage. Reflection from shiny desert surfaces -- including snow -- will contribute further to an increased collection of energy, especially in the winter, when nominal horizontal insolation is decreased. Plenty of sunshine hours will reduce the chance of over-discharging storage batteries during daytime hours. Kyrgyzstan's solar resources have fewer site-specific drawback factors; this could be advantageous for rural electrification, especially for nomadic people using portable PV applications. The insolation data for various locations is given in Table 7.1. Kyrgyzstan's direct insolation is high, which is also good for solar water heating applications. Another benefit of this technology is that it depends on radiation which means that heat absorption takes place even on cloudy days.

Table 7.1: Regional Insolation in Kyrgyzstan

	Total monthly horizontal insolation	*kWh/m²/day*		
Location	***kWh/m²/year***	***Average***	***June***	***December***
Bishkek	1544	4.2	7.0	1.6
Issik-Kul	1570	4.3	6.8	1.4
Sysamyr	1643	4.5	6.5	2.0
Tien-Sien	1935	5.3	7.5	2.6

Potential for Domestic Production of Photovoltaic Cells

7.7 Orlovka, Kyrgyzstan's single-crystal silicon plant currently produces semiconductors for foreign clients on a toll processing basis. The plant, with 80 large, modern, and sophisticated "pullers", is potentially one of the world's largest producers of single-crystal silicon, one of the raw materials used in the manufacture of solar photovoltaic cells (it used to produce 30 percent of all FSU electronic-grade silicon). The industry has attracted the attention of foreign companies from various countries, including USA, Japan, and India, on the assumption that its sunk capital cost, low labor cost, and inexpensive electricity would make it competitive in the international market. With the demand for semiconductors growing at a fast rate and with the market for photovoltaic cell material approaching an explosion stage world-wide, the factory could, with appropriate levels of investment, become an attractive business opportunity. In addition to the semiconductor raw material, the plant could also be equipped to produce PV panels for electricity production.

Wind Energy

Resource Assessment

7.8 The June 1996 mission visited Kyrgyzstan and made a first assessment of wind resources in the country. Mr. Alaibek Obozov, General Director of the State Project KUN, was the principal counterpart of the mission. According to KUN, the key person on wind energy development in Kyrgyzstan is Mr. Basiliy Kirillov, Head of Laboratory of Wind Energy and Micro-Hydro Power Stations. The mission visited the laboratory and was informed about the status of wind energy resource information and wind energy projects in Kyrgyzstan.

7.9 The program consists mainly of constructing, designing, and testing micro and small wind turbines. Four different sizes of wind turbines have been built - 50 W, 100 W, 250 W, and 4 kW. Prototypes of some of the wind turbines have been installed at the KUN experimental facility.

7.10 Regarding wind resource data, the information received indicates that the data from the meteorological service of Kyrgyzstan may be old and of poor quality based on the unexpectedly low wind speeds in relation to topography. Wind maps were provided showing the seasonal average wind speeds at about 25 specific meteorological stations in Kyrgyzstan. The data show that the average wind speeds throughout the country are in a range of 0.5 to 4 m/s. Even at Balykchy (west end of Lake Issyk Kul), which is known to be a windy area, seasonal average wind speeds are only 2.7 to 4.2 m/s. The mission obtained the names of four major areas where local staff estimate that good wind potential exists. These are:

- Lake Issyk: west end ("Ulan" is name of the strong wind); and east end ("Santash" is name of the strong wind)
- Chui Valley
- Susamir Valley
- Shamaldisay (this name translates as "Wind River")

7.11 Local authorities requested World Bank assistance to establish wind monitoring stations and collect quality data. Kyrgyzstan is a mountainous country with very complex and localized wind regimes. Although in such terrain good wind resource areas are expected to occur locally, it is difficult to identify the specific sites and quantify the wind resource without a comprehensive wind resource analysis and mapping, following by a monitoring program in those areas that are judged to have good wind potential.

7.12 Information was received from the field listing meteorological stations and including annual average wind speeds. There are 81 stations throughout the country, and annual average wind speeds range from 0.5 to 3.6 m/s. Anemometer heights are typically about 10 m above ground, but wind sensors are typically located in towns or cities where local obstructions (buildings and trees) may reduce the wind speeds thus rendering the data inaccurate. A field trip to the Balykchy meteorological station produced only an old report (from the 1950s) and no average wind speeds.

7.13 *Recommendations*. There is a lack of comprehensive up-to-date, and good-quality data on wind resources in the public domain for Kyrgyzstan. The available data show rather modest resources that are not promising commercially. However, as noted above, localized good wind regimes may well exist and could be suitable for exploitation. To this end, a comprehensive wind resource mapping study and wind monitoring program would be required. Wind resource assessment and mapping tools are available and have been applied to developed and developing countries, for example, in neighboring China. Although the development of wind resources cannot be supported at this time, a wind resource assessment and monitoring program could benefit the country. Bilateral and multilateral aid agencies are the most suitable vehicles for initiating and conducting such a program in Kyrgyzstan.

Geothermal Energy

7.14 At least 20 geothermal springs were identified and drilled in Kyrgyzstan during the time of the former Soviet republics. Examination of temperature and flow data from these sites indicates low-grade heat resources of no greater than 55 degrees Celsius. For the purpose of large-scale power production, the identified sites show little promise, because a temperature of 200 to 350°C is necessary for large-scale geothermal power plant, and most binary cycle plants -- which are typically small -- operate on 120 to 150°C steam. Ak-Soo, in the Karakol region, is the most promising site for geothermal development based on well temperatures and its proximity to a population center. The 55°C resource is in the marginal range of economic feasibility for heating purposes. Aside from the low temperature of the well, its flow rate is also low (83 cubic meters per hour), the replicability of such a project is very limited based on the layout and lower temperatures of the remaining geothermal resources in Kyrgyzstan, and finally, the existing geothermal site is 10 km away from Karakol.

7.15 In the mission's opinion, Kyrgyzstan's low-grade heat resources are clearly inadequate to support geothermal power generation or heating purposes, with one exception. The Ak-Soo geothermal resource could be considered as a supplemental source of heating power for the city of Karakol. Based on the available preliminary information, the site is not an outstanding investment. Both technical and economic investigation of the site must be undertaken, with an assessment of the available thermal resources and a calculation of the cost of integrating this geothermal well with the area's heating system. When ranking investment on a cost per kilojoule (kJ) basis, experience shows that efficiency improvements on existing systems are usually much more economic than developing new, marginal resources. And finally, though it was outside the mission's work scope, there are still a host of possible low-temperature applications for the identified geothermal sites in the country. Among the possibilities are dairies, health spas, wool-washing facilities, fish farms, and other applications.

Biomass and Biogas

Biomass Power

7.16 Kyrgyzstan's dominant agricultural crop is currently wheat. Biomass gasification for fixed-bed power gasifiers has been commercially proven only for wood, charcoal, rice husk, and coconut shell feedstocks. Among these four, only rice is grown in any quantity in Kyrgyzstan and its production is quite low as shown in Table 7.2. The forest product industry also shows little promise for biomass power generation -- either for gasification or for direct combustion. Forest cover in the country has fallen from 7 percent to 3 or 4 percent in recent years, and Kyrgyzstan's wood products are primarily imported from Russia. Not only is the fuel supply limited, but the economics of biomass gasification are less favorable, because disposal costs are low.

Table 7.2: Rice Production Estimates in Kyrgyzstan

Year	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*
Metric Tons	1000	1000	600	600	1200	1600	2100	2500	3000	3000	3000

7.17 National electrification estimates also indicate that the market for power generation gasifiers will continue to be limited. According to local estimates, approximately 95 percent of the population is connected to the grid. In the case of Kyrgyzstan, biomass power will clearly not be able to compete with low-cost, bulk, grid-connected hydropower in the foreseeable future. The limited fuel supplies, small market potential, and the low cost of the alternative (bulk power from the grid) lead our mission to conclude that biomass power development is not currently an efficient use of scarce development resources.

Biogas Power

7.18 Kyrgyzstan's 9 million hectares of natural mountain pastures and its one million additional hectares of arable valley land, helped make livestock production the mainstay of the country's agrarian output. At its peak, Kyrgyzstan provided 40 percent of the former Soviet republics wool and exported large amounts of meat and dairy products to neighboring republics. With the dissolution of the FSU, and a subsequent disruption of traditional supply and trade links, livestock numbers fell sharply. An estimated 75 percent of the farms in Kyrgyzstan have been privatized thus far, and their physical assets have been divided among the constituent families. As a result of the breakup of collectives, there is dispersed ownership of livestock, and the economies of scale needed for economical, grid-connected biogas power generation are clearly absent. Family biogas digestors for cooking and for limited heating purposes show economic potential for the future, however. Rural families in Kyrgyzstan have high numbers of livestock, indicating a significant potential market for household-size digestors. Fossil fuels, primarily imported from Kazakhstan, Russia, and Uzbekistan, are costly in Kyrgyzstan, and many rural families are going back to the use of animal wastes for cooking, or to electricity for cooking and heating, whenever possible. The cost of commercial fertilizers is also high. Six kilograms of wheat are required as payment for every kilogram of fertilizer, signaling a high potential value of fertilizer substitute from biogas digestor slurry.

7.19 Considerable work must be done to realize the economic potential of small biogas digestors in Kyrgyzstan. Experience and market infrastructure for disseminating the technology is limited at this time. Concerted field trials have only recently begun. Between the two local entities working on technology, 14 digestors or so have been built, most of these being for research purposes. Technical assistance along with a series of demonstration projects should be developed before commercial size investments are pursued. Credits now provided by the government for agricultural projects may also pave the way for larger-scale dissemination of biogas technology if the technology is adequately marketed and the equipment maintained and supported.

8

Kyrgyzstan: Institutional Structure and Policies

The State Business Project "KUN"

8.1 The state business project KUN (SUN) is responsible for promoting renewable energy activities and functions as the focal point for this subsector in Kyrgyzstan. KUN was set up in 1993 in accordance with a presidential decree and its rules of governance and operational programs have been approved by the government. Accordingly, KUN is to carry out scientific and technical activities for solar, wind, biogas, and other alternative sources of energy. The project includes not only scientific programs but also design activities and a number of manufacturing enterprises. Although KUN is a government establishment, it is not a part of any ministry or holding company. It is positioned to function directly under the vice prime minister, who is also in charge of energy policy. This arrangement renders KUN relatively free from bureaucratic controls, allowing quick responses to project development. The overall objectives of KUN are (a) to develop a renewable energy strategy for the country; (b) to coordinate the renewable energy activities in various research and industrial establishments; (c) to assist the government in legislative work; and (d) to develop standards and set up testing and certification facilities.

In pursuance of these objectives, KUN has organized its activities under the following branches:

- Science and new technology
- Information and analysis
- Perspective planning and market development
- Manufacture of renewable energy equipment

8.2 The main offices of KUN are in Bishkek. Branch offices have, however, been established in different provinces and these have been entrusted with the task of carrying out market investigations, identifying consumers, evaluating sites, and so forth. KUN has laboratory and test facilities for conducting research and performance evaluations, but most of these facilities are outdated and need modernization. The overall staff strength of KUN, including provincial offices, is approximately 40. The bulk of KUN's budget for salaries, equipment, and operational costs is currently provided by the state, but efforts to direct sales to potential customers (private or state enterprises) are under way.

8.3 With regard to manufacturing, KUN has developed projects for organizing the production of solar collectors and systems, wind energy devices, solar photovoltaics, biogas devices, heat pump equipment, and others. The organization oversees several units, including a joint stock company (ENVOD), which has the capacity to produce solar hot water systems (with a production capacity of approximately 10,000 sq. meters per year), and micro-hydro units of 1 to 20 kW capacity (production capacity 5,000 units). Production is undertaken as orders are placed by government entities. When KUN was established as a business project, enterprises involved in the manufacture of renewable energy equipment were made members of KUN, and projects promoted by KUN were implemented with equipment produced in the member companies. Even so, KUN's relationship with enterprises does not seem to be well-established. Although the relationship between KUN and the enterprises envisages profit-sharing, so far very little profit has materialized. Production is not linked to demand in the market place and competition is lacking. Low energy prices act as constraints for the profitable operation of enterprises.

8.4 KUN has been playing a facilitating role in efforts aimed at rehabilitating the silicon production facilities at Orlovka, which have been dormant since independence. The Orlovka plant, which included some 80 crystal pullers and a number of wafer-slicing machines was one of the main sources of high-purity silicon wafers for the semiconductor and photovoltaic production. A proposal for establishing a photovoltaic production capacity of 5 MW, with a possibility of expansion to 20 MW at a later stage, has been developed in conjunction with both a US company, Minnesota Solar and an Indian company, Flex Engineering. Considerable mobilization is needed to realize a project of this type because production equipment becomes quickly out-dated in this dynamic industry. Financial implications, costs, marketing arrangements, and so on remain unclear. Raw material for producing PV quality Si wafers is supplied from the international "scrap" market of semi-conductor quality monocrystal. Tash-Kumyr will not be able to supply scrap consistently to Orlovka until adequate investments are made in the facility. KUN will need assistance to make further progress in this area and to promote the photovoltaic projects identified in this study.

8.5 Although KUN has qualified personnel in the areas of research as well as in design, engineering and production, its facilities need considerable upgrading. There is a lack of facilities for access to information on the latest developments in the field of renewable energy. Short-term priorities include manpower training, opportunities for participation in international seminars, and the organization of such seminars in Kyrgyzstan. KUN is a young organization with considerable potential for growth. If KUN is to play a more effective role, its capacity must be improved with the help of an assistance program. As KUN has strong and dynamic leadership, enjoying support of the president, it is well-positioned to serve as an effective focal point for the development of the renewable energy sector in the country.

Other Organizations Related to Renewable Energy Sources

8.6 A prominent institute, involved in work relating to renewable energy sources, is the Kyrgyz Energy Research Institute, which comes under the purview of the National Joint Stock Energy Co. This institute was part of the FSU's ministry of energy. Its organizational structure and operational methods remain essentially the same as before. It has seven laboratories and staffing of approximately 80. The institute takes part in solving scientific and technical problems in the energy. Its work encompasses the analysis of the structure of energy consumption, both by sector and by region; policy aspects of energy savings, energy law, energy pricing, generation and transmission of electricity; and so on. The institute started work in renewables in the 1980s and carried out the rehabilitation of small hydroprojects as well as the preparation of feasibility studies for such projects in the Karakol and Talas regions. In cooperation with EU-TACIS, work on legal and regulatory issue has been accomplished. The institute has gained experience in energy sector privatization, including renewables.

8.7 Other organizations engaged in renewable energy activities include the Design Institute, the Committee on Science and Technology, the Slavonic University, and business projects under the ministry of tourism. The Economic Research Institute under the Ministry of Economy is at present marginally involved in the economics of renewable energy. This institute works primarily on the compilation and analysis of data on energy supplies, prices, and tariffs but also assists the state in the area of policy. Considerable training and access to various methodologies will be needed to enable these institutions to reorient their activities to adapt to ongoing reforms.

Policies and Plans for Renewable Energy Development

8.8 Policy objectives for energy development in general and for development of renewables in particular are contained in the draft Energy Law and in the Presidential Decree for the establishment of KUN. The draft Energy Law also stipulates that a national energy program be developed and published. The purpose of the national energy program is to outline the goals for energy development for each of the energy subsectors and the program should address the following issues: reliability of supply, efficient use, market promotion and investment policy, imports and exports, environmental protection, renewable energy, and effective management of energy systems. The establishment of KUN with its wide-ranging mandate has resulted in greater attention being devoted to the development of policies and plans for the renewable energy. Nevertheless, coherent policies and concrete plans for this subsector have yet to materialize. Efforts in this direction should be improved.

8.9 Solar energy applications have received most of the attention of the authorities thus far. During the period from 1990 to 1995, solar collectors for hot water (with a total area of 55,500 m^2) have been installed in establishments such as milk plants, field camps, sanitary inspection centers, automobile service centers, recreation centers, hotels, hospitals, and sports camps belonging to various ministries and departments of the republic. Modular solar hot-water systems, called Nur-Mi, are reportedly the most common because they provide flexibility in making systems fit the customer's needs. The serial production of solar hot-water heaters is underway.

8.10 Plans regarding solar photovoltaic energy development are at a preliminary stage, with these units destined primarily for small power applications in remote locations and for nomadic people. Sample modules of 8 to 10-watt capacity have been built, but there are plans for a joint venture project for the large-scale production of photovoltaic units involving KUN, the Kyrgyz Mining Metallurgy Company, Minnesota Solar (Minnesolar, USA), and Flex Engineering (India). Thin-film photovoltaic production at the Tash-Kumyr semiconductor materials plant is envisaged for the future.

8.11 Regarding the other renewable sources, there are plans to use low temperature geothermal energy for health resorts, and for similar applications. The wind potential in the plains is not suitable for grid-connected power generation, therefore attention has turned to small, low-speed wind for decentralized applications. Further surveys in mountainous regions are foreseen. Small, two-bladed wind electric permanent magnet- based generators produced in a laboratory have been deployed at a few locations. Given the considerable potential of small hydroprojects, plans have focused on the extensive development of small hydro plants. Activities are currently confined to unit sizes of a capacity of 16 to 22 kW, manufactured by the Oremi plant. Activities with portable micro hydro units in the 1-kW range are also under way.

9

Kyrgyzstan: Case Studies of Priority Projects

9.1 A major goal of this study is the preliminary identification and examination of the most promising priority projects for Kyrgyzstan. These projects were selected on the basis of (a) the country's potential, both in terms of natural and human resources; (b) the economic and technical feasibility of the projects, as well as the prospects for participation of private investors and international financial institutions; (c) local interest and ability to participate in the implementation of the project; and (d) the potential for duplication (pilot projects).

Solar Thermal Collectors for Hot Water

9.2 Unlike other former Soviet republics, Kyrgyzstan does not have an extensive heating network in the urban areas. This is because of the dominant role of the hydroelectric plants providing resistance heating. In Karakol, a municipality coal-fired boiler is used to meet the space-heating and hot-water needs of only 30 percent of the population of 82,000 of the city (approx. 4,000 homes). Most of the homes have to rely on expensive coal and sometimes on electricity to meet heating needs on an individual basis. Furthermore, the area has tourist, commercial and industrial needs for hot water, and there is potential for increased needs. The same characteristics are found in other regions of the country, including Bishkek, as well as in regions of neighboring countries. Based on the above, and the country's good insolation hot-water heaters appear to be an attractive technology option. However special attention should be paid to the proper design of the casing for these systems, which must protect the unit from the extreme cold winters.

9.3 Ambient temperatures are well below zero for several months of the year, hence, anti-freeze protection is necessary. Freeze-protected solar equipment was considered in the analysis (i.e. drain-back and glycol systems, which have roughly comparable costs). Solar water heating systems operate at maximum efficiency in cold climates because the high temperature gradient between the solar collector and the water inlet temperature is most conducive to heat transfer.

9.4 A conventional domestic boiler is used to supplement the heat supply and consequently hot water from the solar collectors will be fed to the boiler, whenever needed. Hence, in large buildings the solar heater is to be used as a pre-heater to save energy.

9.5 The recommended solar water heating system configuration is a freeze protected design as described above. The indicative data for a system supplying single family dewellings is outlined below. Significantly improved economies can be realized through local manufacturing and international cooperation.

Solar collector panel:	3.44m^2 effective area
Circulation and storage tank:	0.25m3 forced circulation type
Weight:	350kg (filled)/100kg(empty)
Estimated installed cost:	$1,760
Heat collection:	2,760 Mcal/year for an insolation of 1,160 Mcal/m2/year (solar direct)
Demand for hot water:	0.25m3/day
Total energy demand:	3,200 Mcal/year(250 liter/day, 45 degrees C hot water/10 degrees C feed water)

9.6 Based on the above figures, the life cycle cost (level cost) for the hot water is estimated as follows:

Energy saved: 2,760 Mcal/year/unit

US$0.05/Mcal heat

Discount rate 0.1. Equipment life 15 years. Excluding taxes.
Maintenance cost: US$40/year for one unit.

9.7 Prior to investments in this sector, a comprehensive market assessment should be executed followed by several pilot projects. The market assessment should explore the full range of product sophistication, costs, and service, including a summer-only design for those recipients of winter district heating. Contingent on the confirmed viability of this technology on a commercial basis, and contingent upon a significant market mass with the willingness and ability to pay for this service, a project could be considered. Institutional and commercial markets should also be exhaustively surveyed and analyzed. In these cases there will be an income stream tied to the provision of heat, enhancing the ability to pay, lowering project risks.

9.8 The three-year market penetration of the above solar thermal collectors is estimated in Table 9.1. Penetration rates will be closely related to the level of resources directed at marketing, consumer education, and the quality and care with which the earlier systems are provided and maintained. It is expected that the project will cost about US$ 8 million over the three years of the project.

Table 9.1 Market Penetration: Solar Water Heaters

	Domestic SWH Systems	
Year	Count	$ Million
1st	500	1.33
2nd	1,000	2.70
3rd	2,500	4.40
Total	4,000	8.43

9.9 Although the technology is simple in principal, solar collector systems will still require some professional skill for installation and maintenance. Continued market penetration will not be achieved without proper maintenance and engineering services. A local organization will be needed for servicing, especially for domestic use, even if equipment is imported. Local manufacture is both desirable and feasible in order to meet demand and to have a positive effect on market penetration. *Oremi* and *Shanar* in Kyrgyzstan produce the most advance and best selling solar water heating systems in Central Asia, according to a European Comission study by the International Centre for Energy and Environmental Technology (ICEU). Technologies they produce range from thermosiphon systems to evacuated tube collectors. In addition, the Kirgizaftomash Company, which was a big supplier of car radiators in the FSU, is developing some solar collector prototypes. Another company, Santekma, also has experience in manufacturing and installing solar collectors. Thus there is significant potential for joint ventures and local manufacture, installation, and maintenance of solar thermal systems.

Photovoltaic Systems

9.10 Kyrgyzstan has large rural and mountainous areas inhabited by trans migrating shepherds. The areas they inhabit are typically far from transmission lines and the benefits of energy services.

9.11 Sovkhozy and Kolkhozy (former production communities for the sheep industry in the former Soviet republics) have been transformed into joint stock companies and individual family units. Although the management structure of shepherd families has changed, their life-style has essentially remained the same. Each family takes care of a few hundred sheep and moves around for long periods, especially during the summer. Each farm has several fixed locations that include water pumping and storage facilities for winter sheep housing and wool shearing. A few of these locations have diesel generators, but most of them do not have electricity. Stand-alone PV units could be used for special applications, such as water pumping, wool shearing, and other uses. These PV units could also be used by the non-nomadic population in rural areas. Neighboring countries have needs that are similar to those of Kyrgyzstan. The PV market should be examined in relation to the Kazakhstan project and to the needs of other neighboring countries.

9.12 The basic data envisaged for this case study are as follows:

(i) Portable PV unit

Unit output:	20 W at an insolation intensity of 1.0 kW/m^2. To supply a 60 watt-hour (Wh) daily load at an insolation of 5.0 kWh/m^2/day.
Module area:	0.2 m2
Expected generation:	36.5 kWh/year at 1,825 kWh/m2/year
Battery:	Nominal capacity 35 Ah -12 V, deep-cycle battery To supply a 60 Wh/day load for 4 days.
Assumed loads:	(Lamp: 15 W – 4 hours/day) = 60 Wh/day 0.06 kW*365 = 21.9 kWh/year
Installed cost (economic):	$308

9.13 The first cost of such systems will in most cases be beyond the ability of rural populations to pay. However, on a per lumen-hr basis the system is 30 percent less costly than the kerosene lantern base case as demonstrated below. Appropriate financing will make the system financially accessible for nomadic populations.

Avoided Cost Calculations

SOLAR PV LIGHTING 20W System	*Insolation (kWh/m2/d)*	*PV Panel Output: kWh/y*	*Lighting Energy Used: kWh/y*	*Levelized Cost/kWh Lighting*	*Lighting Efficacy lm/W*	*Cost per k-lumen hour ($/k-lm-hr)*
	5	36.5	21.9	1.58	38	0.041
KEROSENE LIGHTING Petromax Lantern	*Kerosene, $/litre (International Market)*	*Specific Fuel Consumption litres/hr*	*Lumen Output k-lm*	*Equipment cost ($/k-lm-hr)*	*Fuel Cost ($/k-lm-hr)*	*Cost per k-lumen hour ($/k-lm-hr)*
	0.3	0.06	0.40	0.009	0.045	0.054

9.14 The maximum foreseeable market penetration of portable PV units is estimated in Table 9.2 based on projections from the mission's local counterparts.

Table 9.2: Estimated Market Penetration of PV Units

	Portable 20 W each	
Year	*No. of Units*	*Total Cost $Million*
1st	700	0.21
2nd	1,750	0.53
3rd	2,800	0.85
4th	3,850	1.17
5th	4,900	1.49
Total	14,000	4.27

9.15 The costs reflected in Table 9.2 are international costs, which could be reduced with production increase if the units were manufactured locally. The Orlovka plant, also mentioned in Chapter 8, used to supply monocrystal silicon wafers to semiconductor industries in the former FSU. This industrial background will enable the Orlovka plant either to supply silicon wafers to the PV industry or to engage itself in the manufacture of PV modules, if Orlovka is supplied with silicon resources from neighboring countries. A joint venture between Orlovka and a foreign partner with both technology and market expertise could be a successful strategy for this case study, to supply the market not only in Kyrgyzstan but also in neighboring countries.

9.16 There are some fundamental issues to consider in designing a successful PV project in the Central Asia. As part of the prefeasibility study, a detailed market study and survey will be vital to help confirm and ensure the financial and cultural viability of the program. Given the very low rural incomes, particullarly amongst nomadic shephards, even a 20 Watt PV system will be a challenge to market on commercial terms, and creative term-financing will be a neccessity. *For permanent rural dwellings tied to the weakest parts of the national grid, larger PV systems may be a viable alternative to transmission and distribution system renovation.* This market niche was not analyzed due to the constraints and scope of this study, but certainly merits deeper investigation.

9.17 Expectations should be set at a reasonable level from the beginning of the program to avert disappointment, innocent system abuse, and repayment risks. A 20 Watt PV system will supply only the very essential energy service needs, e.g. lighting and communication. Experience also consistently confirms that the long-term viability of the PV market demands the provision of proper maintenance and engineering services. Local service personel throughout the project areas will be needed. As an additional component to the service chain, collection and recycling of used batteries will be required to complete an environmentally sound product-cycle.

Small Hydro

9.18 There is great deal of interest for the development of small hydroprojects in the numerous small rivers and tributaries in the country. Some projects were examined at this preliminary stage by the local authorities, and basic data were provided for analysis. These data cover basic power, hydrology, and hydraulic characteristics. Nineteen projects were analyzed using the mission's estimates of local construction costs and on average international costs for the installation of mechanical and electrical equipment. The calculation of the financial viability of these projects was based on the following assumptions:

- Discount rate: 10 percent
- Project life: 30 years
- Price of electricity: US$0.035/kWh
- Operation and maintenance expenses: 2 percent of the investment cost.

The results of this calculation are presented in Annex 3, and specific technical assistance and institution strengthening measures are highlighted in Chapter 11.

9.19 Following this preliminary economic evaluation of the nineteen small hydroprojects, the identification of the most promising of these projects was based on the following criteria: (a) easy access to construction sites and cheap connections to existing transmission lines, and (b) favorable economic efficiency of the project in the context of the development potential of its location.

These priority projects are shown in Table 9.3.

9.20 Karakol River is in the northeastern part of the country, in the district of Karakol and flows into the Issyk Kul Lake. Two small SHPs, now abandoned, used to be here. The river offers two possibilities. The first consists of the construction of two small SHPs with a total installed capacity of 4.8 MW, an annual energy production of 30.6 GWh, and an estimated investment cost of US$7.2 million. The second possibility,

Table 9.3 : Priority Hydroprojects for Kyrgyzstan

Project/River	***Issik-Ata 2,3,4 Issik-Ata***	***Sandalask-1 Chatkal***	***Sandalask-2 Chatkal***	***Karakol Karakol***
Installed Capacity (MW)	5.4	12.0	13.0	4.5
Energy Produced (GWh)	35.7	72.0	75.0	31.5
Investment cost (million $)	26.7	14.6	15.8	6.7
Cost of energy (US cents/kWh)	2.97	2.56	2.66	2.68
Rate of return (%)	11.7	14.0	13.4	13.2
Payback (years)	17	12	13	13

presented in Table 9.3, envisages the construction of only one small HEP with an installed capacity of 4.5 MW, and an annual energy production of 31.5 GWh. The cost of the project is estimated at US$6.7 million, which breaks down into US$3.7 million for the provision and installation of the electrical and mechanical equipment, US$2.4 million for the necessary civil works and US$600,000 for other costs and contingencies. The second option seems to be more attractive economically. The construction period is estimated at only about 2 years because of the existing infrastructure from the old abandoned plant. Details on the economic analysis of this case study are shown in Annex 4.

9.21 The district of Karakol is a rapidly developing agricultural-commercial-tourist area, on the eastern border of the country, about 500 km from the main hydroelectric power plants on the Naryn River. Its power transmission system is not adequate. The current power supply of the region presents many difficulties, such as frequent interruptions and high losses attributable to overloading and to the length of the transmission lines. According to the local authorities, the annual electricity demand will increase rapidly within the next years. Exploiting the local hydro potential will thus become essential, since the investment needed to rehabilitate and extend the transmission lines is high.

9.22 The small hydroproject on the Karakol River seems to meet all the criteria (technical, economic, social) of a successful case study. The cost of the project can be financed by the state utility, by the local authorities, an independent private investor or by an appropriate mix of investors. The repayment of the financing will be provided by the income of the energy sold to the city of Karakol and to specific local consumers, and excess energy could be sold to the national power system. Kyrgyzstan's legislation allows for the operation of private independent producers and furthermore, local authorities in Karakol are working on legislation to provide incentives to foreign investors.

9.23 Re-powering of existing small hydro power facilities also offers a significant investment opportunity. Below is a table of identified sites provided by KUN:

Table 9.4 Small Hydro Power Rehabilitation Opportunities

Name	River, canal	Set Capacity	Average Productivity per year	Status	Consumption (pressure)	Date Constructed	Investment amount
		Wt million	kWh million per year		m3/sec (m)		
Lebedinovskaya	Western Big Chui Canal	7.6	34	doesn't operate	40(27)		2.6
Kalininskaya	Kara-Balta	1.48	5.26	doesn't operate since 1993, landslide		1955	0.5
Sokuluk-2	Sokuluk	1.2	9.4	conserved in 1972 the major units and sets destroyed		1967	1.9
Djardy-Kaindy	Aspara	0.44	3.1	doesn't operate		1960	0.8
Alamedinskaya-1	Western Big Chui Canal	2.2	6.09	doesn't operate	25(12)	1945	2.2
Alamedinskaya-2	Western Big Chui Canal	2.5	5.7	doesn't operate	30(12)	1949	1.9
Alamedinskaya-3	Alamedin	1.7	11.0	doesn't operate	23(11)	1950	2.6
Alamedinskaya-4	Alamedin	2.1	6.29	doesn't operate	23(11)	1952	1.0
Alamedinskaya-5	Alamedin	6.4	8.94	doesn't operate	50(15)	1957	1.4
Alamedinskaya-6	Alamedin	6.4	7.4	doesn't operate	50(15)	1957	2.4
Arashan	Ak-Suu	1.9	12.2	doesn't operate	3(70)	1961	2.9
Karakol-3	Karakol	1.5	10.8	removed from the list and dismantled	3(63)	1948	2.2
Karakol-4	Karakol	1.5	10.5	doesn't operate	3.0(60)		2.3
Djuuku	Djuuku	0.8	5.6	doesn't operate	2(50)		1.5
Djety-Oguz	Djety-Oguz	1.0	7.0	doesn't operate	2(60)		1.7
Chon-Kyzyl-Suu	Chon-Kyzyl-Suu	1.2	8.2	destroyed	3(50)	50-s	2.2
Barskoon	Barskoon	1.2	8.2	destroyed	2,5(60)		2.2
Tosor	Tosor	0.4	4.1	destroyed	1.5(50)		1.5
Turgen-Aksuu-1	Turgen-Aksuu	1.8	12.8	destroyed			2.1

10

Kyrgyzstan: Recommendations and Scope for Further Work

Institutional and Legal

10.1 To ensure the development of the renewable energy sector, in ways that will have a significant impact on both the energy and environmental fronts, a range of institutional measures are necessary to deal with policies, plans, programs, promotional strategies, project development, investments pricing issues, private sector involvement, legal and regulatory aspects, among others. The overall coordination of Kyrgyzstan's energy activities is presently diffuse. Mechanisms are needed to achieve a better coordination of policies and of the activities of various entities. Consequently, the role of KUN should be significantly increased. In addition to strengthening KUN, the establishment of an institutional mechanism for financing renewable energy projects is recommended and assistance for this purpose is a priority.

10.2 Considerable efforts have gone into the formulation of the draft Energy Law. Immediate action is essential for the creation of institutional mechanisms for providing the legal and regulatory framework to attract private sector investment from within and from outside the country. Pricing reforms should be expedited; the prevailing artificially low energy prices might otherwise render the development of renewable energy projects unattractive. An effective legal and institutional framework is as important as technical developments for the dissemination of renewable energy sources in Kyrgyzstan. Experience in other developing countries in which the World Bank has been active has shown that certain measures can be very effective in the creation of such legal and regulatory framework. The Study's recommendations are as follows:

10.3 *Establishment of a national renewable energy center.* The role of various government organizations must be clarified to eliminate redundancy and to consolidate offices and a national center be established to focus and coordinate renewable energy development in the country. Furthermore, potential investors would be encouraged to invest their capital in energy if the procedures for preparing, evaluating, and granting licenses for renewable energy projects were simplified. Because of its present position, KUN could play an important role in this respect, cooperatively drawing upon the comparative advantages and expertise of other renewable energy organizations in the country such as the National Academy of Sciences and the Kyrgyz Science and Technical Center "Energy" (KSTC "Energy"). In this context foreign technical and financial assistance could provide an important catalytic effect triggering a cascade of renewable energy sector activities. The recommended roles of such a focal institution for renewable energy development would include:

- Prioritization and strategy development for renewable energy in accord with the national energy and environmental objectives;
- Inventory and promotion of viable renewable energy projects, investments, and joint-venture opportunities;
- Provision of legislative recommendations ensuring an open, easily-accessible, and competitive market for private renewable energy investment and service delivery;
- Review of renewable energy related state projects and programs;
- Development of standards and certification routines compatible with internationally recognized protocols and local circumstances;
- Provision of technical assistance and support in identifying financing sources for private enterprises;

10.4 *The creation of a special fund.* This fund would provide financing for renewable energy projects. Such a fund will not only increase the feasibility of possible projects, but will also improve the role that RE will play in the long term. Capital for such a fund could be derived from a variety of sources, for example, penalties for the violation of environmental regulations; debt-for-nature swaps; a small surcharge on electricity bills; special grants from environmental funds, such as the Global Environment Facility (GEF); lines of credit from international financial institution (IFIs), and other sources. Creative financing mechanisms for small, dispersed RE systems, such as stand-alone photovoltaic systems, would make the dissemination of such systems both sustainable and viable.

10.5 *The Participation of the private sector.* Private sector participation would greatly promote RE projects. The state, which is already proceeding with the privatization of energy assets, must provide the legal and regulatory environment needed to give confidence to the private sector. Encouragement of the private sector must take the form of practical incentives that will accelerate investment in RE projects. These incentives could be:

- price incentives, for the purchases of energy from renewable sources and from energy efficiency projects. These prices should be set somewhat higher than the price for conventional energy to account for environmental benefits from such projects; and
- other incentives, such as accelerated depreciation of RE investment, a tax break, and lower import duties for selected items. The loss of revenue to the state from such concessions will be lower than the benefits accrued to the state from the RE projects.

Technical Assistance (TA)

10.6 Based on the mission's assessment of the status of renewable energy development and of the existing institutional capabilities in Kyrgyzstan, it is recommended that TA be targeted to the establishment of facilities and skills that are critical for the growth of the renewable energy sector. A number of donors have been providing technical assistance to Kyrgyzstan to assist in its transition from a centrally planned system to a market economy. Considering that a number of agencies (ADB, EBRD, EU-TACIS, the Islamic Development Bank, and the World Bank) as well as bilateral donors (Austria, Germany, Japan, Norway, Switzerland, and the United States) are involved in the energy sector, it is recommended that the proposed TA for the development of the renewable energy sector be dovetailed into the mainstream energy assistance program, especially with regard to legal and regulatory frameworks.

10.7 Most of the proposed TA should have KUN as its main recipient, however, other government entities may be involved, especially in legal, regulatory, and financial aspects. The following is recommended for future TA in Kyrgyzstan:

a. *Evolution of renewable energy strategies and promotional programs for a market economy.* KUN and the Economic Research Institute could benefit greatly from assistance in the form of advisory services and training to develop skills in the following areas: policy analysis, project design, technology forecasting, modeling and integrated energy planning, the economics of renewable energy, and the analysis of environmental impacts.

b. *Generation of data on resources and strengthening of assessment capabilities.* Data collection and resource assessment capabilities need to be improved. Greater attention need to be devoted to compiling data forms suitable for the purpose of design. More measurements are needed at different locations, especially for generating comprehensive solar and wind data for the entire country. In particular, wind potential in complex terrain need to be assessed, and assistance is needed for this purpose. Technical assistance should focus on introducing modern data collection systems and new tools based on satellite-generated information for solar and wind resources. Possible sources of TA that have already expressed interest include NREL (USA); RISO (Denmark), and ISPRA (Italy).

c. *Establishing mechanisms for information dissemination and data bases.* KUN could benefit from assistance in modernizing its facilities and improving skills for disseminating information, organizing public information campaigns, generating market information, establishing a documentation cell, generating computerized data bases and link-ups. Assistance could be provided in the form of study tours, participation in international workshops and seminars, as well as training programs.

d. *Operation of legal and regulatory functions.* Despite recent efforts to formulate an Energy Law, institutional capacity in respect of legal and regulatory functions is weak. Assistance should, therefore, be directed toward establishing operational capabilities for translating the provisions of the Energy Law into practical mechanisms. Advisory services and training should be developed in close coordination with EU-TACIS, USAID, UNDP, and other interested donors. The focus of this assistance should be on the organizational development of regulatory bodies and their management capabilities. Training should focus on simplified procedures (a) for issuing licenses, (b) for environmental and other necessary clearances for projects, (c) for leasing arrangements, (d) for power purchase agreements, etc.

e. *Establishing investment promotion and financing mechanisms.* In order to create increased opportunities for private sector investments in renewable energy projects, institutional mechanisms financing need to be established. Promoting investment and attracting the private sector should be of high priority. It is recommended that consultant services and training focus on building capacity for designing incentive-based investment promotion programs, as well as instruments for financing. Because renewable energy technologies are just beginning to develop, innovations need to be incorporated into financing programs. In this regard, experience gained in countries such as India could be put to use through bilateral technical cooperation, including the exchange of information, visits, and training. Intensive training on methods and practices followed in financial institutions dealing with the private sector, and on assessing and managing credit systems is recommended.

f. *Introduction of entrepreneur development programs.* Entrepreneurial skills need to be strengthened. Given the diversity of technologies in renewable energy, a variety of entrepreneurial skills will be needed, and their development should form an important part of any technical assistance program. Entrepreneurs should include small scale local manufacturers, energy service entrepreneurs, project developers, and market intermediaries. Consultants for the preparation of feasibility studies, technical backstopping, and project management should be supported through training in order to develop indigenous capacity in these areas.

g. *Modernization of research and development facilities and skills.* The personnel in various establishments engaged in the renewable energy sector are highly qualified. Nevertheless, adequate R&D facilities are lacking. The laboratory facilities need to be modernized. Assistance will be needed to increase access to and interaction with scientific and technical establishments in industrial countries. Assistance will be needed to support activities such as the exchange of scientific and technical personnel, joint R&D projects, participation in international conferences and seminars, all of which are essential for strengthening the R&D base in Kyrgyzstan.

h. *Establishing standards and certification mechanisms.* Standards for renewable energy equipment and for the certification of products are currently weak. Assistance will be needed to build institutional capacity in this area. This will enable Kyrgyzstan to revamp equipment specifications, standards, and certification procedures so as to be compatible with international practices for trade and investments. Facilities for testing and certification need to be modernized. Personnel training programs could be conducted at foreign laboratories that have expressed an interest (including NREL, RISO and ISPRA and others).

11

Institution Strengthening and Technical Assistance Priorities by Technology

11.1 The mission analyzed six renewable energy options for their potential in mitigating the shortfall in regional electric power in Central Asia[6]. Results from the mission's analysis separates the technical options into three priority levels. Some of the renewable options are poised for immediate attention and development based on the analytical inquiry of the mission, the next tier of options should be pursued cautiously, contingent on the successful findings of pilot programs, surveys, and corrections in energy market distortions, and the final category of options have very limited potential for supplanting electric power demand (though they may have significant benefits external to the electric power sector).

Energy Option Rankings

Priority Resources for Development -- Kazakhstan

1. *Small Hydro Power.* The country is replete with small hydro resources. More specifically the Chillik cascade, and sites identified along the Bartogay and Main Almaty canal show significant investment potential, as revealed in Annex 1 and 2.

2. *Windpower.* Kazakhstan is located along the Northern wind-belt which stretches across Asia. As an initial investment project the mission analyzed and recommended in-depth studies be carried out for the development of the 40-MW Djungar Gate wind farm highlighted as a case study in Chapter 3 of this report. A generating capacity as high as a 1,000 MW or more has been estimated, and a follow-up study of the case-study windfarm is now under way through a UNDP/GEF project.

[6] Except in the case of the two silicon plants in Kyrgyzstan which have photovoltaic cell export possibilities

Priority Resources for Development -- Kyrgyzstan

1. *Small Hydro Power.* The Issyk-Ata cascade and the Karakol site show significant investment potential as depicted in Annex 3 and 4 of the report.

2. *Solar Cell Manufacturing, Module Assembly, and Export* Orlovka, Kyrgyzstan's single-crystal silicon plant, and Tash-Kumyr their polycrystalline plant offer promising opportunity for supplying the rapidly expanding international photovoltaic market with the appropriate financial and technical backing.

For Contingent Development -- Kazakhstan and Kyrgyzstan

1. *Solar Water Heating.* Economic analysis indicates that cautious consideration of this technology should be made. Capital costs are considerable, and viability of the technology is site specific because of the sensitivity to competing energy options. It is the recommendation of the mission that a pilot project should be launched focusing on cost cutting solar water heating designs, characterizing the viable target market, and determining market size prior to cultivating this option. Fuel and district heating prices must also be rationalized for this option to become viable.

2. *Solar Photovoltaic Units for Nomadic Populations.* On a cost per lumen-hour basis, the pressurized kerosene lantern base-case is 25 percent more costly than the 20 Watt solar home system, which also provides greater amenity and power for a small radio in addition. The capital cost of solar equipment is much greater however, and the market must be adequately characterized and tested via surveys and pilot projects to verify the viability of full-scale investment.

Low Priorities for the Electric Power Sectors of Kazakhstan and Kyrgyzstan

- *Biogas Energy.* This resource is not well suited for power generation, given the enormous concentrations of livestock required for economic competition with grid-based power. However, the market potential for providing economic cooking fuel and fertilizer does merit attention and quantification in future studies.

- *Geothermal Power.* Kazakhstan and Kyrgyzstan offer no high-temperature geothermal resources suitable for large-scale power generation, and perhaps two possibilities for small-scale binary generation. Outside of this study, the low-heat resources are in some cases suitable for direct heating purposes in small industry, or tourist facilities.

Institution Strengthening and Technical Assistance Priorities

Windpower

11.2 This description breaks down key elements of windpower development into 4 areas. The assessments in each area are not meant to be sequential. Typically, all 4 areas are pursued throughout the process. The time line starts with broad assessments and progresses toward finer detailed analysis. The purpose of early work is to identify potential problems and key issues which need resolution. Later, more detailed studies are used to refine projections and reduce the uncertainty and risk of committing to a project.

Resource Assessment Aspects

Determine the quality of the wind resource, starting broadly then narrowing down to specific proposed development sites

1. *Prospecting*: Opportunity data collection and analysis - This implies mainly gathering available historic wind measurement data. Possible sources include weather stations, weather balloons, airports, military (bases and airplane data), environmental studies (pollution dispersion), etc. Multi-year data sets are preferable. Typically, data is available as hourly average wind speed with coincident direction, and perhaps temperature and pressure measurements. The quality of the data must be assessed during analysis since small changes in average wind speed have a large impact on potential power output. Instrumentation calibration and maintenance has been shown to be a problem in many cases. Prospecting may indicate areas of good potential wind, but because of the typically sparse data and questionable data quality, many good areas may be missed. Other sources of information include local residents knowledge of windy areas and environmental indicators such as deformed trees. Prospecting provides a good, relatively inexpensive starting point, but generally underestimates a country's wind resource potential.

2. *Regional mapping*: narrowing the possibilities - Once an general area is identified as having good potential (from resource, technical, and economic points of view), wind resource experts can produce a regional map using topographical data, resource measurements, and meteorological principles using Geographic Information System (GIS) techniques. This identifies areas that might have been missed in the Prospecting stage as well as giving guidance on the best potential wind areas to place measurement towers within a potential development zone.

3. *Site Validation*: wind targeted measurements - In order to select from several potential development areas, anemometer towers are put in place to measure the resource. This often includes measurements at several heights above the ground, including potential turbine hub heights. Typically, hourly average data is collected for a year or more. Analysis of the data should include trying to correlate the site data to a near-by long term wind data record in order to assess potential inter-annual variability. This allows a specific site to be selected from a number of options. Other factors should be considered as well as the resource when selecting a "best site". To often, the resource alone is considered and development can be delayed or canceled due to other factors like environmental concerns or permitting.

4. *Micro-siting*: for site turbine layout - In order to decide specific placement of turbine towers on a site, the resource variability across the site needs to be assessed. This typically involves 1 anemometer per 3-6 turbines, with more anemometers for more complex terrain. The duration of measurements also depends on resource complexity. For example, if there is a dominant wind season and winds are predominantly from one direction, only a few months of measurement may be necessary. There are micro-siting computer simulations that can be of help as well. A wind energy resource consultant is very helpful with this stage

Technology Aspects (Generation and Transmission Characteristics)

1. *Wind plant energy projections* - As the project evaluation goes on, the complexity and purpose of the energy projections changes. Early examinations look mainly at annual energy output with an eye to overall economic feasibility. Later work will look at potential cash-flow shortfalls in low wind years, the utility system interactions from minute to minute wind variation, and possible reliability/capacity credit issues. This process requires a progression of annual/seasonal/daily/-min resource variations. This analysis would also involve turbine selection and studies of power output as a function of tower height

2. *Generation system operational parameters* - The value and benefits of windpower to a utility system is contingent on the existing system characteristics. Parameters to examine include ramping rates, load following, spinning reserve, and reliability targets. This analysis is often performed by utility operational staff or consultants, with the assistance of wind developers or consultants.

3. *Electric demand*: Issues to be examined include the time correlation of wind output to load shape, projected demand growth and load growth locations, and reliability standards (for example, if the present system is unable to meet normal demand and is experiencing rolling brown-outs, the time delivery of wind is less important).

4. *Wind integration issues*: Utility operators will want an assessment of safety issues, harmonics, reactive power impacts, and other issues.

5. *Transmission system*: The primary issue is how much will it cost to get the windpower to the desired load location. Are there lines near the resource area? Do the lines have excess capacity or the potential to be upgraded? How robust is the transmission system? Putting in long lines or upgrading the existing system can add significant costs. How do these types of cost factors affect the alternative generating options?

Commercial and Economic Aspects

1. *Cash flow*: A year-by-year projection of economic return will include assessment of electric power payments, any subsidies (and the certainty of their payment), income and property taxes, currency convertibility, and any guarantees that reduce the risk of these factors changing

2. *Financing*: This analysis will examine money sources (both debt and equity), interest and rate of return expectations, local/global money sources and requirements, and the impact of financing fees

3. *Duties*: An additional cost factor is import taxes, VAT, etc. on foreign equipment. There may need to be policy reform since wind is capital intensive, and alternative technologies may be fuel intensive, which is taxed differently.

Policy Aspects

1. *Legal* - Key interests lowering risks for developers include contract sanctity and adequate recourse mechanisms, the soundness and stability of the regulatory environment, and land acquisition procedures.

2. *Policy history* - This involves both general country issues such as intellectual property frameworks (which could impact in-country manufacturing potential and joint ventures, consistency of incentives and the current political situation.

11.3 Overlaid on this framework, there are several questions that steer the feasibility investigations. Primary is the deal structure. Will a government owned utility be buying turbines? Buying energy from a independent power producer? [plus all variants like BOT, etc.] All these issues will affect the viewpoints of the deal participants and the amount of investigation into each potential deal factor. For example, if a utility is just purchasing power, the developer is taking the resource risk and technology risk.

Usually the developer has experience with this and can deal with it. However, the developer will want near-iron clad assurance that the key economic parameters that determine profit and viability are stable and assured. If the turbines are being sold to a utility, the key issues will be resources and technology assurance, since the utility will most likely not have extensive experience in wind. In summary, the deal structure determines which risks are critical to completing a successful transaction.

11.4 The deal structure is tied to the countries current electric business and policy structure. One difficulty is that world-wide, electric system structure is being re-examined. Privatization, de-regulation, and setting up bidding systems are often major issues that go well beyond wind technology acquisition. The additional uncertainty imposed by a non-stable electric and policy environment makes risk definition, risk allocation, and risk abatement even more important and must be adequately addressed in the policy framework.

Two good resources on key issues are highlighted in the foot note below.[7]

Small Hydropower

11.5 The following steps will help ensure the economic exploitation of the two countries' small hydropower potential. International assistance should be expressly sought through bilateral and multilateral programs to help accomplish the following objectives:

Commercial Aspects

1. Establish financing mechanisms and well defined incentives to attract private participation
2. Establish explicit legal recourse channels and assurances to reduce project development risks
3. Identify and solicit national and international developers
4. Provide guidance and support for project developers throughout the project cycle

[7] Wind Resource Assessment Handbook: Fundamentals for Conducting a Successful Monitoring Program, prepared by AWS Scientific, Inc., Albany NY, for NREL under subcontract TAT-5-15283-01. This is available in draft form, final coming out in early '97. Primary contact is Marc Schwartz, (303) 384-6936.

Planning your First Windpower Project: a Primer for Utilities, published by EPRI, December, 1994, written by Karen Conover . Kevin Rackstraw is investigating getting the bank a copy.

Policy Aspects

1. Commission a specialized center responsible for small hydro development
2. Draft a standard Power Purchase Agreement to reduce uncertainties and risk for SHP developers and the government
3. Prepare a development plan for:
    i. Public owned projects
    ii. Private projects
    iii. Joint venture projects

Technological Aspects

1. Perform a comprehensive analytical investigation of the country's net hydro potential.
2. Initiate detailed studies of the most promising small hydro electric projects.
3. Develop an action plan for medium and long term introduction of small HE projects in the country's energy balance (including achievable targets, e.g. 5 percent of electricity needs)
4. Simplify and standardize plant designs
5. Incorporate new low cost construction techniques through donor assistance
6. Internalize recent developments in turbines, electronic control systems etc. in plant design

Dispersed Solar Photovoltaic Systems

11.6 As mentioned previously, surveys and several pilot projects to characterize the actual size and nature of this market are a prerequisite to any in-roads in solar photovoltaic development. This market is comprised of the most vulnerable and under-served section of society, the nomadic herding families, and therefore merits focused attention, and careful assessment to nurture private sector provision of this technology.

11.7 Of immediate interest, Kyrgyzstan's inactive single-crystal PV cell manufacturing infrastructure shows significant promise for the reasons cited earlier in the chapter. The portable, high value output of the Orlovka plant conforms with the need of the remote, land-locked country for hard currency.

Technical Assistance

11.8 The following are technical assistance priorities for the exploitation and proliferation of solar photovoltaic power Kazakhstan and Kyrgyzstan:

Commercial Aspects

1. Launch 2-3 small scale pilot projects to characterize the actual PV market size, ability to pay, niche opportunities, and socio/cultural preferences

2. Provide business skill development, specifically in business plan formulation, mobilization of financial assistance, marketing, management, inventory optimization, etc.

3. Train retailers in renewable energy technology application such as system selection and sizing, installation, trouble-shooting and repair, and routine maintenance.

Policy Aspects

11.9 The key role of government in exploiting the potential of solar photovoltaics in Kazakhstan and Kyrgyzstan is to promote an appropriate institutional, regulatory, and commercial environment to establish a sustained market for the technology. Towards this objective the governments can:

1. Rationalize duty and tax structures as well as incentive or subsidy programs to reduce market distortions and facilitate access to credit

2. Develop a PV sector strategy which:

    - Encourages private sector participation
    - Targets regions most promising for development based on market size, economics, and resource potential
    - Defines rational incentives, and benchmark goals to phase out those incentives
    - Creates a credit line for solar investments, and
    - Optimizes indigenous solar PV system content according to local manufacturing capabilities

3. Provide consumer education about the technology (which also appropriately manages expectations).

Technology Aspects

1. Establish technical quality standards and a government cell for testing and certification.

2. (Kyrgyzstan) Technical and financial assistance to scale-up production of single-crystal PV cells, and later the manufacture of modules and subsystems for high value export.

Solar Water Heating

11.10 Internationally, solar water heaters (SWH) are a commercial technology with a competitive and wide market in developed and, to a lesser extent, in developing countries. Results from the case-study analysis indicate that very cautious steps should be taken to establish and demonstrate the economic and financial viability of these systems, particularly given the economically damaging subsidies prevalent in the energy sector. Further development of the solar hot water heating sector should hinge on the proven financial potential of the systems within the local context.

11.11 To introduce the SWH technology to Kazakhstan and Kyrgyzstan, technical assistance would be needed to help these countries come up to speed with technology developments and cost cutting measures, to introduce the necessary incentives, and most importantly to establish sound management practices. The following items would be priority areas of such assistance:

Commercial aspects:

1. Support for pilot projects which lower the costs of SHW systems through relaxed technical standards, and which establish the economic viability of this option in the specific country context.

2. Assistance to local entities interested in SWH manufacturing, in establishing joint ventures with foreign companies; this could include sponsorship of visits by foreign SWH manufacturers to Kazakhstan and Kyrgyzstan as well as visits by Kazaks and Kyrgyz persons in the SWH business to countries and plant where SWH are being made;

3. Assistance in the management of existing companies with capabilities in becoming SWH makers, including market research, marketing, export and trade knowledge-transfer, materials procurement, personnel practices, financial management, strategic planning, business plan, advertising of products and personnel training;

4. Installation of demonstration units to test the technology in practical applications and to provide concrete proof of its commercial viability.

Policy Aspects

1. Assistance to the Government in instituting effective policies and a set of incentives to promote the market of SWH; this would include providing to the Kazakhstan and Kyrgyzstan Governments the incentives introduced by various foreign countries, discussion and critique, explanation of background of policies, results observed, time horizon and phase-out of policies, trade-offs, and assistance in adapting the policies to the legal, institutional and economic environment of these countries.

2. Creation of a center to promote the technology in the country through public awareness campaigns, information dissemination, coordination of support action and government policies, and support to the SWH industry.

Technology Aspects

1. Establishing formal testing and certification facilities, institutions, and procedures or strengthening existing ones. This would include an examination of standards used in the country and the determination of whether they should be revised or upgraded.

2. Strengthening of research and development centers to be in a position to provide technical support for continuous development, industrial testing, and improvement in the technology.

3. Assisting educational or vocational institutions to educate and train professional staff that would be necessary for the design, manufacturing, installation, monitoring and maintenance of SWH facilities; also, to provide training in project preparation and evaluation methodologies to be applied to various technologies, with special emphasis to the application to SWH.

Annex 1: Kazakhstan: Small Hydroelectric Projects

No	Name of the Project	Name of the River or Canal	Total Instal. Capac. (MW)	Mean Produc. Energy (GWh/ year)	Invest. Cost (10^6 US$)	Cost of the Produced Energy (Cents /kWh)	Bene-fit to Cost Ratio B/C	Total Net Benefit (10^6 US $)	Internal Rate of Return	Necessary Operation Time for Recovery of Invest. (Years)
1	Oussek-1	Oussek	3.6	18.0	14.4	10.09	0.48	-7.7	1.59%	>30
2	Oussek-2	"	3.6	18.0	10.4	7.28	0.66	-3.6	4.98%	>30
3	Chinbullak-1	"	6.0	31.0	19.2	7.81	0.61	-7.6	4.23%	>30
4	Malloussek	Maly-Oussek	19.8	78.0	77.6	12.54	0.38	-49.0	1.23%	>30
5	Chinbullak-2	Oussek	16.4	80.0	52.8	8.32	0.58	-22.9	3.56%	>30
6	Panfillov-1	"	6.4	33.0	15.2	5.81	0.83	-2.7	7.58%	>30
7	Panfillov-2	"	6.4	31.7	12.1	4.81	1.00	0.0	9.96%	>30
8	Panfillov-3	"	6.4	32.9	12.6	4.83	0.99	-0.1	9.92%	>30
9	Panfillov-4	"	6.4	32.9	13.8	5.29	0.91	-1.3	8.73%	>30
10	Lesnovka	Canal Babelian	1.8	14.0	4.4	3.96	1.21	0.9	12.72%	14
11	Kojayskaya	Kaskelen	9.4	18.9	15.2	10.14	0.47	-8.2	1.54%	>30
12	Aksay-3	Aksay	4.4	22.7	7.2	3.99	1.20	1.5	12.63%	14
13	Chillik-19	Chillik	6.2	35.1	11.2	4.02	1.19	2.2	12.49%	15
14	Chillik-20	"	12.2	69.4	10.4	1.89	2.54	16.4	27.55%	4
15	Bartogay	"	20.0	57.0	13.6	3.01	1.60	8.3	17.30%	4,,5
16	Irrig. Canal-1	Main Almaty	11.5	48.0	10.6	2.78	1.72	7.8	18.76%	7.5
17	Irrig. Canal-2	"	10.5	45.0	9.7	2.72	1.77	7.6	19.24%	7.1
18	Issyk-1	Issyk	4.2	22.0	6.0	3.44	1.40	2.4	14.96%	18.5
19	Merke-3	Merke	5.1	28.8	16.0	7.00	0.69	-5.2	5.41%	>30
20	Kandybullak-1	Orta-Tentek	15.0	74.6	27.2	4.60	1.04	1.2	10.58%	23
21	Tunkuruz-1	Tentek	32.0	114.8	50.4	5.54	0.87	-6.9	8.16%	>30
22	Pokatillov	Baskan	20.0	34.6	11.2	4.08	1.18	2.0	12.28%	15
23	Bayankol-9	Bayankol	4.0	13.9	12.8	11.61	0.41	-7.7	0.18%	>30

Remarks:

For the economic indexes calculation the following data were used:

a 10% discount rate.

b. 30 years lifetime of the HEP.

c. 5 cents/kwh the price of the sold energy.

d. 2% of the investment cost annual O&M expenses.

Annex 2: Kazakhstan: Small Hydro Project in Bartogay and Almaty Canal

ANALYTICAL ECONOMIC EVALUATION

DATA		RESULTS	
1. Installed Capacity (MW)	42.0	1. Cost of the Produced Energy (US cents/	2.85
2. Produced Energy (GWh/year)	150.0	2. Benefit Cost Ratio (B/C):	1.68
3. Cost of Scheme (US $)	33,900,000	3. Net Benefit in the 32 Years Period (mil U	23.73
4. Discount Rate	10.00%	4.Internal Rate of Return (I R R) :	18.32%
5. Lifetime (years)	30	5. Operation Time necessary for the Recovey of the Investment (Years):	7.6
6. Price of the sold energy (US cents/kWh	5.00		
7. Annual O&M expenses (% of 3.)	2.0%		

No	Investment		Annual Revenues		Annual O&M Costs		Annual Cashflow		Accumulated Cashflow
	Current Prices	Present Worth	Current Prices	Present Worth	Current Prices	Present Worth	Current Prices	Present Worth	
1	16,950,000	15,409,091					-16,950,000	-15,409,091	-15,409,091
2	16,950,000	14,008,264					-16,950,000	-14,008,264	-29,417,355
3			7,500,000	5,634,861	678,000	509,391	6,822,000	5,125,470	-24,291,886
4			7,500,000	5,122,601	678,000	463,083	6,822,000	4,659,518	-19,632,368
5			7,500,000	4,656,910	678,000	420,985	6,822,000	4,235,925	-15,396,443
6			7,500,000	4,233,554	678,000	382,713	6,822,000	3,850,841	-11,545,602
7			7,500,000	3,848,686	678,000	347,921	6,822,000	3,500,765	-8,044,837
8			7,500,000	3,498,805	678,000	316,292	6,822,000	3,182,513	-4,862,324
9			7,500,000	3,180,732	678,000	287,538	6,822,000	2,893,194	-1,969,130
10			7,500,000	2,891,575	678,000	261,398	6,822,000	2,630,176	661,047
11			7,500,000	2,628,704	678,000	237,635	6,822,000	2,391,069	3,052,116
12			7,500,000	2,389,731	678,000	216,032	6,822,000	2,173,699	5,225,816
13			7,500,000	2,172,483	678,000	196,392	6,822,000	1,976,090	7,201,906
14			7,500,000	1,974,984	678,000	178,539	6,822,000	1,796,446	8,998,352
15			7,500,000	1,795,440	678,000	162,308	6,822,000	1,633,133	10,631,484
16			7,500,000	1,632,219	678,000	147,553	6,822,000	1,484,666	12,116,150
17			7,500,000	1,483,835	678,000	134,139	6,822,000	1,349,696	13,465,847
18			7,500,000	1,348,941	678,000	121,944	6,822,000	1,226,997	14,692,843
19			7,500,000	1,226,310	678,000	110,858	6,822,000	1,115,452	15,808,295
20			7,500,000	1,114,827	678,000	100,780	6,822,000	1,014,047	16,822,342
21			7,500,000	1,013,479	678,000	91,619	6,822,000	921,861	17,744,202
22			7,500,000	921,345	678,000	83,290	6,822,000	838,055	18,582,258
23			7,500,000	837,586	678,000	75,718	6,822,000	761,868	19,344,126
24			7,500,000	761,442	678,000	68,834	6,822,000	692,608	20,036,734
25			7,500,000	692,220	678,000	62,577	6,822,000	629,643	20,666,377
26			7,500,000	629,291	678,000	56,888	6,822,000	572,403	21,238,780
27			7,500,000	572,083	678,000	51,716	6,822,000	520,366	21,759,146
28			7,500,000	520,075	678,000	47,015	6,822,000	473,060	22,232,207
29			7,500,000	472,796	678,000	42,741	6,822,000	430,055	22,662,261
30			7,500,000	429,814	678,000	38,855	6,822,000	390,959	23,053,220
31			7,500,000	390,740	678,000	35,323	6,822,000	355,417	23,408,638
32			7,500,000	355,218	678,000	32,112	6,822,000	323,107	23,731,744
SUM	33,900,000	29,417,355	225,000,000	58,431,288	20,340,000	5,282,188	170,760,000	23,731,744	

Annex 3: Kyrgyzstan Hydroelectric Projects

No	*Name of the Project*	*Name of the River or Canal*	*Total Instal. Capa-city (MW)*	*Mean Produc. Energy (GWh/ year)*	*Invest. Cost (10^6 US$)*	*Cost of the Produced Energy (US cents /kWh)*	*Benefit to Cost Ratio B/C*	*Total Net Benefit (10^6 US $)*	*Internal Rate of Return*	*Necessary Operation Time for Recovery of Invest. (Years)*
1	Sokoluk-2	Sokoluk	1.2	9.4	1.9	2.55	1.32	0.62	14.03%	12
2	Sandalask-1	Chatkal	12.0	72.0	14.6	2.56	1.31	4.7	13.98%	12
3	Issik-Ata-2	Issik-Ata	1.8	13.8	2.8	2.56	1.31	0.9	13.97%	12
4	Issik-Ata-4	Issik-Ata	1.8	13.6	2.8	2.60	1.29	0.8	13.74%	12
5	Sandalask-2	"	13.0	75.0	15.8	2.66	1.26	4.3	13.38%	13
6	Karakol-1	Karakol	2.4	15.7	3.6	2.89	1.16	0.6	12.10%	16
7	Alamentin-3	Alamentin	1.7	11.0	2.6	2.98	1.13	0.3	11.66%	17
8	Arashan	Ak-Shoui	1.9	12.2	2.9	3.00	1.12	0.4	11.58%	18
9	Karakol-2	"	2.4	14.9	3.6	3.05	1.10	0.4	11.35%	19
10	Karkara	Karkara	6.1	33.6	8.6	3.23	1.04	0.4	10.54%	24
11	Turgen-Oksu-2	Turgen-Oksu	1.2	7.2	1.9	3.33	1.01	0.0	10.13%	28
12	On-Artsa	Naryn	1.5	8.5	2.3	3.41	0.98	0.0	9.79%	>30
13	Chonkeminsk	Chonkemin	15.0	60.0	16.3	3.43	0.98	-0.3	9.74%	>30
14	Oitalsk	Oital	12.2	48.0	14.8	3.89	0.86	-2.1	8.12%	>30
15	Issik-Ata-3	Issik-Ata	1.8	8.3	2.8	4.25	0.79	-0.6	7.04%	>30
16	Leninpolsk	Talas	1.2	5.6	1.9	4.28	0.79	-0.42	0.07	>30
17	Ortotokoi	Tsou	21.0	47.3	22.9	6.10	0.55	-10.5	3.07%	>30
18	Kirk-Kazik	Talas	1.2	3.7	1.9	6.47	0.52	-0.9	2.47%	>30
19	Kirovsk	Talas	21.0	70.0	22.9	4.12	0.81	-4.4	1.23%	>30

Remarks: The Investment costs are estimated based on data provided by the beneficiaries in US$ 1996, and were revised by the mission

For the calculation of economic indices the following assumptions were made:

a. 10% discount rate.
b. 30 years lifetime
c. 5 US cents/kWh the price of the sold energy.
d. 2% of the investment cost annual O&M expenses.

Annex 4 Kyrgyzstan: Small Hydro Project in Karakol Region

Kyrgyzstan: Case Study on Small Hydroproject in the Region of Karakol Region

ANALYTICAL ECONOMIC EVALUATION

DATA		RESULTS	
1. Installed Capacity (MW)	4.5	1. Cost of the Produced Energy (Cents/KWh)	2.68
2. Produced Energy (GWh/year)	31.5	2. Benefit Cost Ratio (B/C):	1.25
3. Cost of Scheme (US $)	6,700,000	3. Net Benefit in the 32 Years Period (mil US $):	1.73
4. Discount Rate	10.00%	4.Internal Rate of Return (I R R) :	13.23%
5. Lifetime (years)	30	5. Operation Time necessary for the Recovey of the Investment (Years):	13
6. Price of the sold energy (Cents/KWh)	3.50		
7. Annual O&M expenses (% of 3.)	2.0%		

No	Investment		Annual Revenues		Annual O&M Costs		Annual Cashflow		Accumulated Cashflow
	Current Prices	Present Worth	Current Prices	Present Worth	Current Prices	Present Worth	Current Prices	Present Worth	
1	3,350,000	3,045,455					-3,350,000	-3,045,455	-3,045,455
2	3,350,000	2,768,595					-3,350,000	-2,768,595	-5,814,050
3			1,102,500	828,325	134,000	100,676	968,500	727,648	-5,086,401
4			1,102,500	753,022	134,000	91,524	968,500	661,499	-4,424,903
5			1,102,500	684,566	134,000	83,203	968,500	601,362	-3,823,540
6			1,102,500	622,333	134,000	75,640	968,500	546,693	-3,276,847
7			1,102,500	565,757	134,000	68,763	968,500	496,994	-2,779,854
8			1,102,500	514,324	134,000	62,512	968,500	451,812	-2,328,041
9			1,102,500	467,568	134,000	56,829	968,500	410,739	-1,917,303
10			1,102,500	425,061	134,000	51,663	968,500	373,399	-1,543,904
11			1,102,500	386,420	134,000	46,966	968,500	339,453	-1,204,451
12			1,102,500	351,290	134,000	42,697	968,500	308,594	-895,857
13			1,102,500	319,355	134,000	38,815	968,500	280,540	-615,317
14			1,102,500	290,323	134,000	35,286	968,500	255,036	-360,281
15			1,102,500	263,930	134,000	32,079	968,500	231,851	-128,429
16			1,102,500	239,936	134,000	29,162	968,500	210,774	82,344
17			1,102,500	218,124	134,000	26,511	968,500	191,613	273,957
18			1,102,500	198,294	134,000	24,101	968,500	174,193	448,150
19			1,102,500	180,268	134,000	21,910	968,500	158,357	606,508
20			1,102,500	163,880	134,000	19,918	968,500	143,961	750,469
21			1,102,500	148,981	134,000	18,107	968,500	130,874	881,343
22			1,102,500	135,438	134,000	16,461	968,500	118,976	1,000,319
23			1,102,500	123,125	134,000	14,965	968,500	108,160	1,108,480
24			1,102,500	111,932	134,000	13,604	968,500	98,328	1,206,807
25			1,102,500	101,756	134,000	12,368	968,500	89,389	1,296,196
26			1,102,500	92,506	134,000	11,243	968,500	81,262	1,377,458
27			1,102,500	84,096	134,000	10,221	968,500	73,875	1,451,333
28			1,102,500	76,451	134,000	9,292	968,500	67,159	1,518,492
29			1,102,500	69,501	134,000	8,447	968,500	61,054	1,579,546
30			1,102,500	63,183	134,000	7,679	968,500	55,503	1,635,049
31			1,102,500	57,439	134,000	6,981	968,500	50,458	1,685,507
32			1,102,500	52,217	134,000	6,347	968,500	45,871	1,731,377
SUM	6,700,000	5,814,050	33,075,000	8,589,399	4,020,000	1,043,972	22,355,000	1,731,377	

Annex 5 Kyrgyzstan: Solar Water Heating Case-Study

Case Study on Solar Thermal Project in Kyrgyzstan
Basic Economic Data
[Type-1 System]

	Domestic systems
Number of units installed in three years	4,000
Total Solar Collectors Panel Effective Area (m^2)	13,800
Total Installed cost (with tank for domestic) (US$ million)	8.4
Life Cycle Cost (with tank) ($/Mcal)	0.054

Discount Rate:	10 percent	
Equipment Lifetime:	15 years	
Maintenance cost:	US$	40/year

Life-Cycle Cost Calculations and Assumptions

Discount Rate	10%	Average Insolation
Life	15 Years	4.3 kWh/m2/d
SYSTEM COSTS		Panel Area
Equipment	1300	3.44 m2
Transport	64	
Installation	400	Heat
Total Installed	1764	5,100 BTU/d
		7,565 kCal/d
Spares+O&M	480	2,756 MCal/y
Life-Cycle Cost	**$ 2,244**	**Heat, Life-Cycle Cost**
		$ 0.054 /MCal
Pump Electricity		
	360 Wh/day	**Saved Energy, Life-Cycle**
	131.4 kWh/yr	**41,335 MCal**
	0.05 $/kWh	

Annex 6: Kazakhstan and Kyrgyzstan: Economic Analysis Photovoltaics Project

Case Study on Photovoltaic Projects in Kazakhstan and Kyrgyzstan

Basic Economic Data

	Spec.s	Qty.	Cost Whole-sale	Life (Years)
Panel*	20 Wp	1	100	15
Battery	35 Ah	1	70	3
Controller	72W	1	34	7
Wiring, Switches, Outlets		1	20	15
Support Structure		0	-	10
Other Hardware			-	15
Lamp	15 W, 12V DC	1	33	5
Capital Cost			**247**	15
Taxes (Import & Value Added)			0	
Transportation			12	
Dealer Margin (20%)			49.4	
Installed Economic Cost			**309**	
NPV of Recurring Costs			209	
Life-cycle Economic Cost			**517**	

Calculation of Avoided Costs On a Lumen Equivalent Basis

SOLAR PV LIGHTING 20 W System	Insolation (kWh/m2/d)	PV Panel Output: (kWh/y)	Lighting Energy Used: (kWh/y)	Levelized Cost/kWh Lighting	Lighting Efficacy lm/W	Cost Per k-lumen hour ($/k-lm-hr)
	5	36.5	21.9	1.58	38	0.041

KEROSENE LIGHTING Petromax Lantern	Kerosene, $/litre (International Market)	Specific Fuel Consumption litres/hr	Lumen Output k-lm	Equipment cost ($/k-lm-hr)	Fuel Cost ($/k-lm-hr)	Cost Per k-lumen hour ($/k-lm-hr)
	0.3	0.06	0.40	0.009	0.045	0.054

Annex 7: Kazakstan: Geothermal Energy Resources

2 termal well 1-TП and 2-TП
waters of which can used as
sodium water.

The deep of well 1-TП and 2-TП is 3[illegible] and 2900 meters and were made in Sarpuldak region in 35 km south-west from Jarkent sity.

Water expenses of 1-30 liter per second, expenses of 2-22 liter per second.

Water presure is 170 -240 meters upper level of the land or 17-24 atmosphere. The temperature of water in wells is 96 C in the first and 87 C in the second.

Miniralization in the first - 520, and in the second - 476,7 milligram per one litre. The water in both of wells is hidrocarbonat - Natrium or Sodium. The consiste of HCO from 58 to 59 mg equivalent of %, Na^{+} + K^{+} from 90 to 98,5 mg, PH from 8,1 to 8,4.

Hardness: 0,6 - 0,3 mg/eq
carbon 0,6 - 0,3 mg/eq
in Germandegree - from 1,1 to 0,9.

Water expenses and also chemistry consistent is constant. The reservations of water is defend on high categories by territorial commision.
At present time this water from well 1-TП are using in Jarkent city on local plant in producing beer.

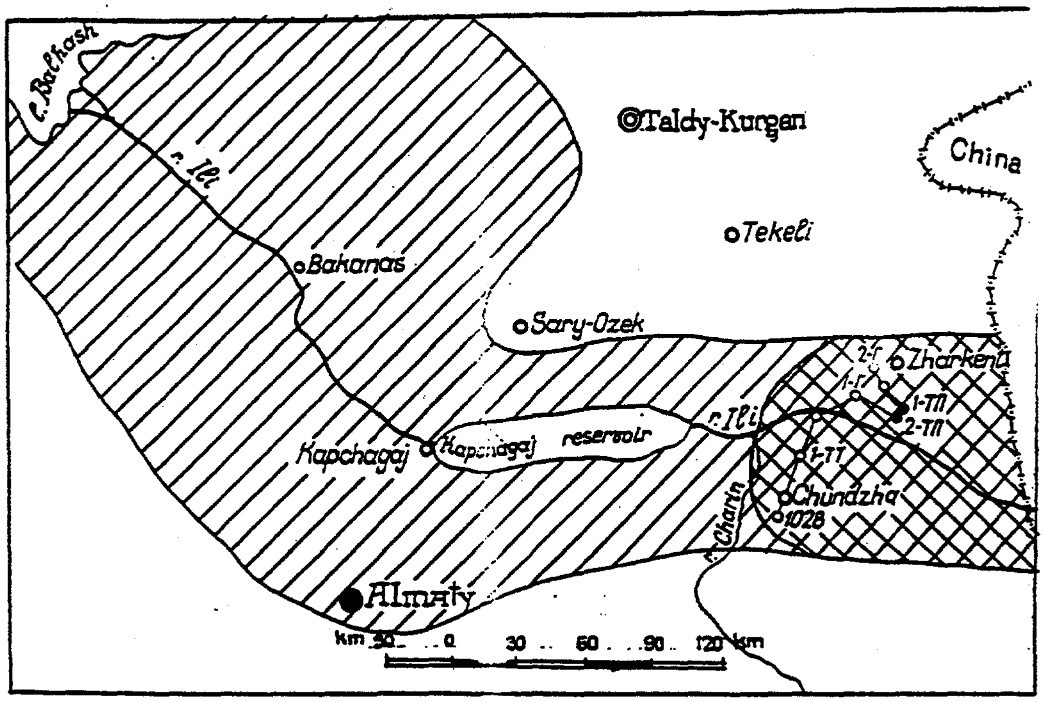
Doctor of geology science
Professor

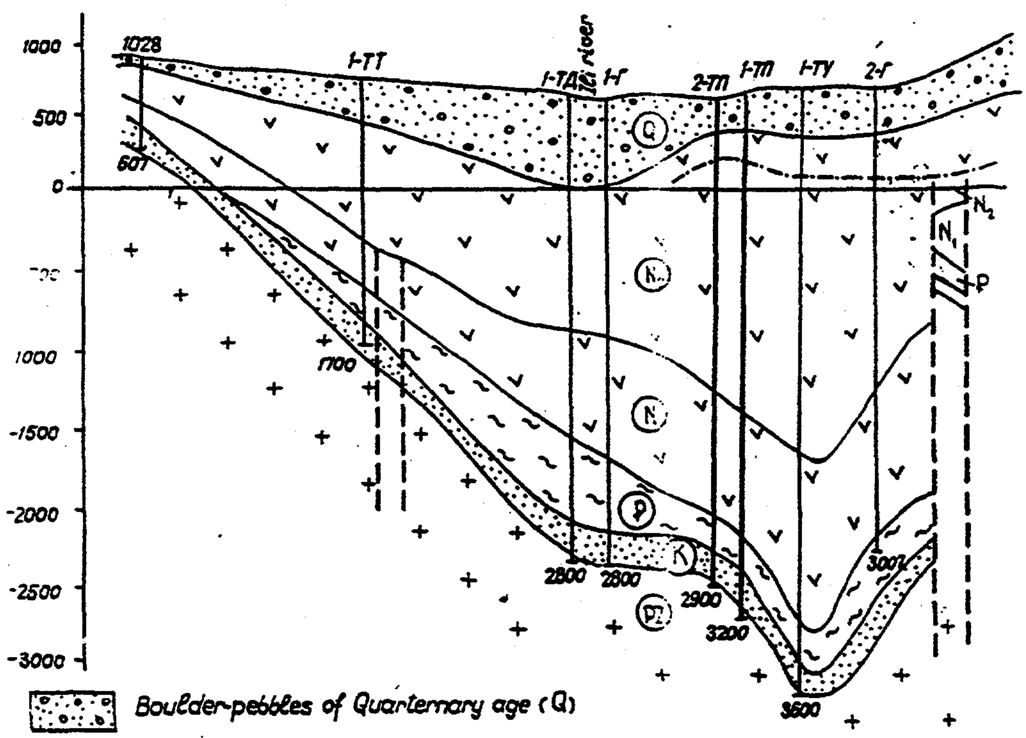
Serik M. Mukhamedzhanov

22 of January 1993.

ZHARKENT

The scheme of disposition thermal wells 1-ТП, 2-ТП





Boulder-pebbles of Quarternary age (Q)

Laminated sand clay, marl deposits of Miocene and Pliocene age (N_1, N_2)

Clay of Paleogene age (₽)

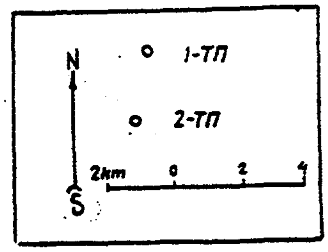
Sandstone of Cretaceous age (K)

Crystalline rocks of Paleozoic age (PZ)

Ili artesian basin

Zharkent depression

Cross-section line



Annex 8: Kazakstan: Wind Power Project Case Study I

Lower Capacity Factor Data Applied (26%)

Economic Analysis - using world bank/small hydro Annex 5.2, China as a template

Data		Results	
Installed Capacity (MW)	40.0	Annual Energy Produced (GWh/yr)	91.104
Capacity Factor	26%	IRR	8.4%
Installed unit cost ($/kW)	1100		
Discount Rate	5.0%		
Lifetime (years)	30		
Price of sold energy (cents/kWh)	5.00		
O&M expenses (cents/kWh)	0.5		

Assume a one year construction time

	Investment		Revenues		Annual O&M		Annual Cashflow		Accumulated discounted c
Year	Price	Present worth	Price	Present worth	Price	Present worth	Price	Present worth	
1	44,000,000	41,904,762					(44,000,000)	(41,904,762)	(41,904,762)
2			4,555,200	4,131,701	455,520	413,170	4,099,680	3,718,531	(38,186,231)
3			4,555,200	3,934,953	455,520	393,495	4,099,680	3,541,458	(34,644,774)
4			4,555,200	3,747,574	455,520	374,757	4,099,680	3,372,817	(31,271,957)
5			4,555,200	3,569,118	455,520	356,912	4,099,680	3,212,207	(28,059,750)
6			4,555,200	3,399,160	455,520	339,916	4,099,680	3,059,244	(25,000,506)
7			4,555,200	3,237,296	455,520	323,730	4,099,680	2,913,566	(22,086,940)
8			4,555,200	3,083,139	455,520	308,314	4,099,680	2,774,825	(19,312,115)
9			4,555,200	2,936,323	455,520	293,632	4,099,680	2,642,690	(16,669,425)
10			4,555,200	2,796,498	455,520	279,650	4,099,680	2,516,848	(14,152,577)
11			4,555,200	2,663,331	455,520	266,333	4,099,680	2,396,998	(11,755,579)
12			4,555,200	2,536,506	455,520	253,651	4,099,680	2,282,855	(9,472,724)
13			4,555,200	2,415,720	455,520	241,572	4,099,680	2,174,148	(7,298,576)
14			4,555,200	2,300,686	455,520	230,069	4,099,680	2,070,617	(5,227,959)
15			4,555,200	2,191,129	455,520	219,113	4,099,680	1,972,016	(3,255,943)
16			4,555,200	2,086,790	455,520	208,679	4,099,680	1,878,111	(1,377,832)
17			4,555,200	1,987,419	455,520	198,742	4,099,680	1,788,677	410,845
18			4,555,200	1,892,780	455,520	189,278	4,099,680	1,703,502	2,114,347
19			4,555,200	1,802,647	455,520	180,265	4,099,680	1,622,383	3,736,729
20			4,555,200	1,716,807	455,520	171,681	4,099,680	1,545,126	5,281,855
21			4,555,200	1,635,054	455,520	163,505	4,099,680	1,471,549	6,753,404
22			4,555,200	1,557,195	455,520	155,719	4,099,680	1,401,475	8,154,879
23			4,555,200	1,483,042	455,520	148,304	4,099,680	1,334,738	9,489,618
24			4,555,200	1,412,421	455,520	141,242	4,099,680	1,271,179	10,760,797
25			4,555,200	1,345,163	455,520	134,516	4,099,680	1,210,647	11,971,444
26			4,555,200	1,281,108	455,520	128,111	4,099,680	1,152,997	13,124,441
27			4,555,200	1,220,103	455,520	122,010	4,099,680	1,098,092	14,222,533
28			4,555,200	1,162,003	455,520	116,200	4,099,680	1,045,802	15,268,335
29			4,555,200	1,106,669	455,520	110,667	4,099,680	996,002	16,264,337
30			4,555,200	1,053,971	455,520	105,397	4,099,680	948,573	17,212,911
sum	44,000,000	41,904,762	132,100,800	65,686,303	13,210,080	6,568,630	74,890,720	17,212,911	

Annex 9: Kazakstan: Wind Power Project Case Study II

Higher Capacity Factor Data Applied (33%)

Economic Analysis - using world bank/small hydro Annex 5.2, China as a template

Data		Results	
Installed Capacity (MW)	40.0	Annual Energy Produced (GWh/yr)	115.632
Capacity Factor	33.0%	IRR	11.3%
Installed unit cost ($/kW)	1100		
Discount Rate	5.0%		
Lifetime (years)	30		
Price of sold energy (cents/kWh)	5.00		
O&M expenses (cents/kWh)	0.5		

Assume a one year construction time

	Investment		Revenues		Annual O&M		Annual Cashflow		Accumulated cash flow
Year	Price	Present worth	Price	Present worth	Price	Present worth	Price	Present worth	
1	44,000,000	41,904,762					(44,000,000)	(41,904,762)	(41,904,762)
2			5,781,600	5,244,082	578,160	524,408	5,203,440	4,719,673	(37,185,088)
3			5,781,600	4,994,363	578,160	499,436	5,203,440	4,494,927	(32,690,161)
4			5,781,600	4,756,537	578,160	475,654	5,203,440	4,280,883	(28,409,278)
5			5,781,600	4,530,035	578,160	453,003	5,203,440	4,077,031	(24,332,247)
6			5,781,600	4,314,319	578,160	431,432	5,203,440	3,882,887	(20,449,360)
7			5,781,600	4,108,875	578,160	410,888	5,203,440	3,697,988	(16,751,372)
8			5,781,600	3,913,214	578,160	391,321	5,203,440	3,521,893	(13,229,479)
9			5,781,600	3,726,871	578,160	372,687	5,203,440	3,354,184	(9,875,295)
10			5,781,600	3,549,401	578,160	354,940	5,203,440	3,194,461	(6,680,835)
11			5,781,600	3,380,382	578,160	338,038	5,203,440	3,042,344	(3,638,491)
12			5,781,600	3,219,411	578,160	321,941	5,203,440	2,897,470	(741,021)
13			5,781,600	3,066,106	578,160	306,611	5,203,440	2,759,495	2,018,474
14			5,781,600	2,920,101	578,160	292,010	5,203,440	2,628,091	4,646,565
15			5,781,600	2,781,048	578,160	278,105	5,203,440	2,502,944	7,149,509
16			5,781,600	2,648,618	578,160	264,862	5,203,440	2,383,756	9,533,265
17			5,781,600	2,522,493	578,160	252,249	5,203,440	2,270,244	11,803,508
18			5,781,600	2,402,374	578,160	240,237	5,203,440	2,162,137	13,965,645
19			5,781,600	2,287,975	578,160	228,798	5,203,440	2,059,178	16,024,823
20			5,781,600	2,179,024	578,160	217,902	5,203,440	1,961,122	17,985,945
21			5,781,600	2,075,261	578,160	207,526	5,203,440	1,867,735	19,853,680
22			5,781,600	1,976,439	578,160	197,644	5,203,440	1,778,795	21,632,475
23			5,781,600	1,882,323	578,160	188,232	5,203,440	1,694,091	23,326,566
24			5,781,600	1,792,689	578,160	179,269	5,203,440	1,613,420	24,939,986
25			5,781,600	1,707,323	578,160	170,732	5,203,440	1,536,590	26,476,576
26			5,781,600	1,626,021	578,160	162,602	5,203,440	1,463,419	27,939,995
27			5,781,600	1,548,592	578,160	154,859	5,203,440	1,393,733	29,333,728
28			5,781,600	1,474,849	578,160	147,485	5,203,440	1,327,364	30,661,092
29			5,781,600	1,404,618	578,160	140,462	5,203,440	1,264,157	31,925,249
30			5,781,600	1,337,732	578,160	133,773	5,203,440	1,203,959	33,129,208
sum	44,000,000	41,904,762	167,666,400	83,371,077	16,766,640	8,337,108	106,899,760	33,129,208	

Annex 10: Wind Case Study Calculation Methodology

Explanation of Windpower Analysis Methodology Written By Mr. Brian Parsons, of the National Renewable Energy Laboratory

After looking at the wind case study performed by Jerzy Slimak and the resource data material provided to Dennis Elliott, I identified 2 areas of first order concern that affect the power production estimates and economics: resource uncertainty and realistic farm losses. My effort has focused on addressing these areas and I believe my analysis supports the conclusion that further resource assessment work in the Djungar Gates area is the logical next step in project definition. In addition, I prepared an economic analysis consistent with the small hydro example that translates the resource projections to internal rate of return.

Resource Uncertainty

Slimak's study used 6 months of wind speed data from a proposed project site and long term averages from one of the near-by measurement stations (Druzhba) for the remaining 6 months to compute turbine power production projections. While a reasonable approach, if you examine the long term wind speed averages for the two closest measurement stations, Druzhba and Zhalanaschkol, the resource in the valley seems quite complex. The average annual wind speed at Zhalanaschkol is higher (7.6 m/s) and has a strong seasonal component, with high winds in the winter and low wind in the summer. The resource at Druzhba is lower (7.0 m/s), but it is more consistent, with less seasonality. Given the relatively close proximity of the two stations and the consistent topography, these differences suggest a complex resource that is not well understood. Dennis Elliott believes that, in fact, the proposed site may have characteristics that are closer to the Zhalanaschkol site.

In any case, there is a significant difference between the resources at the two long term measurement sites. In order to examine this, I ran power production estimates using the long-term, monthly wind speed distributions for the two stations. Even with the higher annual average wind speed, the Zhalanaschkol site produces less energy, since may of the higher winds are above the operating range of wind turbines (and the average speed is a numeric speed average while power potential is proportionate to the cube of the speed). Some of the assumptions I used in calculations are discussed in the notes below, and I have attached the spreadsheets as support. In summary, my results indicate a capacity factor of around 26 percent at Zhalanaschkol and 33 percent at Druzhba. In other words, Druzhba will produce around 23 percent more energy from the same turbines (and capital outlay). This kind of variation through the valley has a large impact on project economics, and significant gains in energy production may be realized by examining the area for the optimum site. Dennis Elliott and I agree that a through resource assessment study, performed by installing multiple anemometer stations through out the valley, would be valuable. Available resource prediction and micrositing models do not have the required accuracy and complexity, without more extensive on site measurements for input.

Farm Losses

Single turbine output needs to be down rated to account for the site altitude, wind farm losses and system availability. Losses include such factors as array interference (wakes), blade soiling, electrical gathering system losses, and losses due to controls. A range of losses from 7.5 percent to 12.5 percent is typical, with availability ranging from 0.95 to 0.98. The Slimak study, as far as I could tell, only applied a downrating of 1 percent, which is unrealistically low, even for a linear array with no wake losses. These downrating factors are included in the capacity factors quoted above.

Two capacity factors were used to reflect the resource uncertainty in the Djungar Gates area. The capacity factor of 26 percent corresponds to the Zhalanaschkol measurement station, while the 33 percent capacity factor corresponds to the Durzhba measurement station. The IRR is calculated on the un-discounted constant dollar (no inflation) cash flow. The "standard case" corresponds to the simple analysis described in the previous memo: total installed capital cost of $1100/kW, with O&M of 0.5 cents per kWh, 30 year project life. In the "2 percent price escalation" case, the payment price was increased by 2 percent per year, corresponding to an assumption that prices will increase at a rate of 2 percent greater than inflation (due to a transition to market rates, competitive fuel price increases, or other factors) . The final set of runs reduces the initial capital cost by $10 million, assuming a GEF grant.

Annex 11: Small Hydropower Case Study Methodology

Explanation of Methodology Written By Energo Group, S.A.

Detailed information on the avoided costs of the existing power system were unavailable, thus as an approximation the calculations depended on the market valued price for electricity import/export:

Kazakhstan: The avoided cost was selected 5 cents/kWh based on import electricity costs.

Kyrgyzstan: It was selected 3.5 cents/kWh in agreement with the beneficiaries and based on electricity export possibilities of the country.

1. The mean annual raise of the energy cost (i.e. 2 percent) was not taken into account. This factor would make the hydroelectric projects (HEP) more beneficial. So the proposed hydroelectric projects are economically feasible under conservative estimations.

2. Technical data for small hydroelectric projects (HEP) was gathered so as to include as many promising project development opportunities as possible. In this way, 23 small HEP in Kazakhstan and 19 in Kyrgyzstan were identified.

3. The necessary data for each candidate HEP were the installed capacity, the produced energy, a short description of the layout and several additional data (hydrological, hydraulic, discharges, heads etc.) so that the energy data could be confirmed. In order to gain direct insight into the potential, the mission visited a number of the proposed sites.

4. The investment cost of each small HEP used for the economic evaluation was estimated by the consultant taking into account the installed capacity and the number of the units of the station, the head, the foreseen discharges of the unit. The cost estimate includes detail engineering, civil works, equipment procurement and installation and contingencies.

5. Based on the above figures, a preliminary economic evaluation of the projects was carried out. This evaluation relied on the following assumptions:

- Discount rate 10 percent
- Project life of 30 years
- Price of electricity 5 cents/kWh (for Kazakhstan) and 3.5 cents/kWh (for Kyrgyzstan).
- Operation and maintenance expenses 2 percent of the investment cost.

After the preliminary economic evaluation of all candidate projects was elaborated, the identification of the alternative case studies followed using the criteria below:

- The projects of each case study should be located in the same area or river basin.
- The access to the works sites and the connection of the new stations to the transmission grid should be easy and cheap.
- The projects should be economically viable .
- Finally, the proposed case study was chosen so that, except for the above criteria (economically feasible, accessible to the roads, connectable to the grid), it must ensure the repayment of the investment and provide the opportunity of investment by local authorities and private interests.

Annex 12: Methodology for Calculation of Avoided Cost of PV Systems

Basic Parameters

Discount Rate	10 percent
Equipment Lifetime	15 Years
Average Insolation	5 kWh/m2/day
Daily Use	4 hours of lighting (with head-room to power a small radio)
Retail Sales Margin	20 percent
Base-line Comparator	Petromax Pressurized Kerosene Lantern
International Kero. Price	$0.30/litre

Methodology

An economic analysis was performed to compare the relative merit of the case-study intervention to the base-case of kerosene lighting. All taxes are therefore internal and assigned a zero value. Equipment costs were taken directly from wholesale product literature and do not reflect the scale economy savings resulting from a large project. A standard dealer margin of 20 percent is included in the installed cost as is a 5 percent premium for transportation of the equipment to the point of sales.

Recurring costs of equipment replacement were brought back to the present at a 10 percent discount rate, and a nominal operation and maintenance cost of $0.25/month (taken from the Indonesia Solar Home Systems Project documentation) was also included. The avoided cost calculations compare the competing options on a cost per kilo-lumen basis. A Petromax pressurized kerosene lantern was taken as the base-case. This is a conservative estimate because simple wick lanterns are seven or eight times less efficacious (in lumen-hrs/litre kerosene) and four or five times more expensive than pressurized lanterns on a life-cycle basis. Petromax users are also more likely to be able to afford a PV home system than their lower-income wick lantern-user counter-parts. The PV system cost per kilo-lumen hour was based the ultimate light output provided by the system, although there is additional energy "head-room" to energize a small radio. The battery is sized to offer about 2.5 days of total autonomy.

Annex 13: Methodology for Solar Hot Water Case-Study Analysis

The cost of the solar water heater equipment and O&M are based on international market prices.[8] Transportation and installation cost are included, however program costs are omitted because, consistent with the other analyses, they will depend on the extent to which the ground has been prepared by previous pilot projects and institution strengthening activities.

The design life of the SWH systems considered are 20-30 years, according to the manufacturers. This number is dependent upon water quality and is conservatively take as 15 years for the analysis. The life of the water tank, typically 13-14 years, is conservatively assumed in this analysis to be ten years. That cost is discounted from year 10 of the analysis at the rate of 10 percent. Recurring costs such as system maintenance and pump motor electricity consumption were summed each year and brought back to the present at the same discount rate. Transport costs were roughly estimated assuming a 20 ft cargo container holding 100 systems to be $3000 total CIF to Turkey and another $3000 by train to Kyrgyzstan plus $400 to ship to site. The analysis is not very sensitive to the cost of transport. Net heat collection by the system is based on a standardized ASHRAE testing protocol. The average insolation was taken from data corresponding to the intended case-study site, Karakol. Assembly and installation is labor intensive and was conservatively assumed to be approximately 2/3 of the cost of installation in OECD countries.

The economic evaluation was carried out according to the following main assumptions:

- Discount rate 10 percent
- Equipment life: 15 years
- Installation Costs: US$ 400
- Operation and maintenance cost: US$ 40/year

[8] Personal Communication: Steven Gorman, The Renewable Energy Group, 3/97

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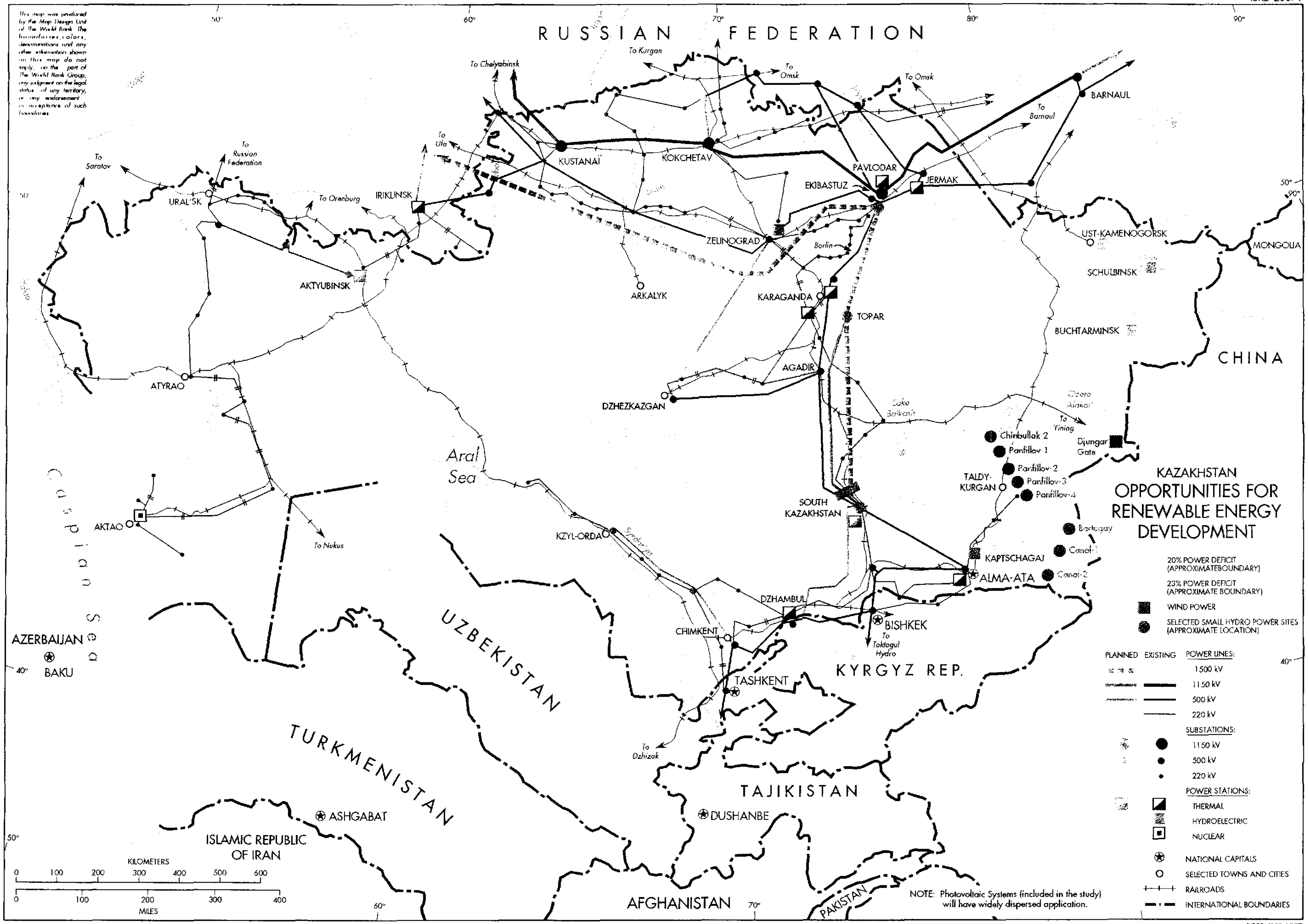

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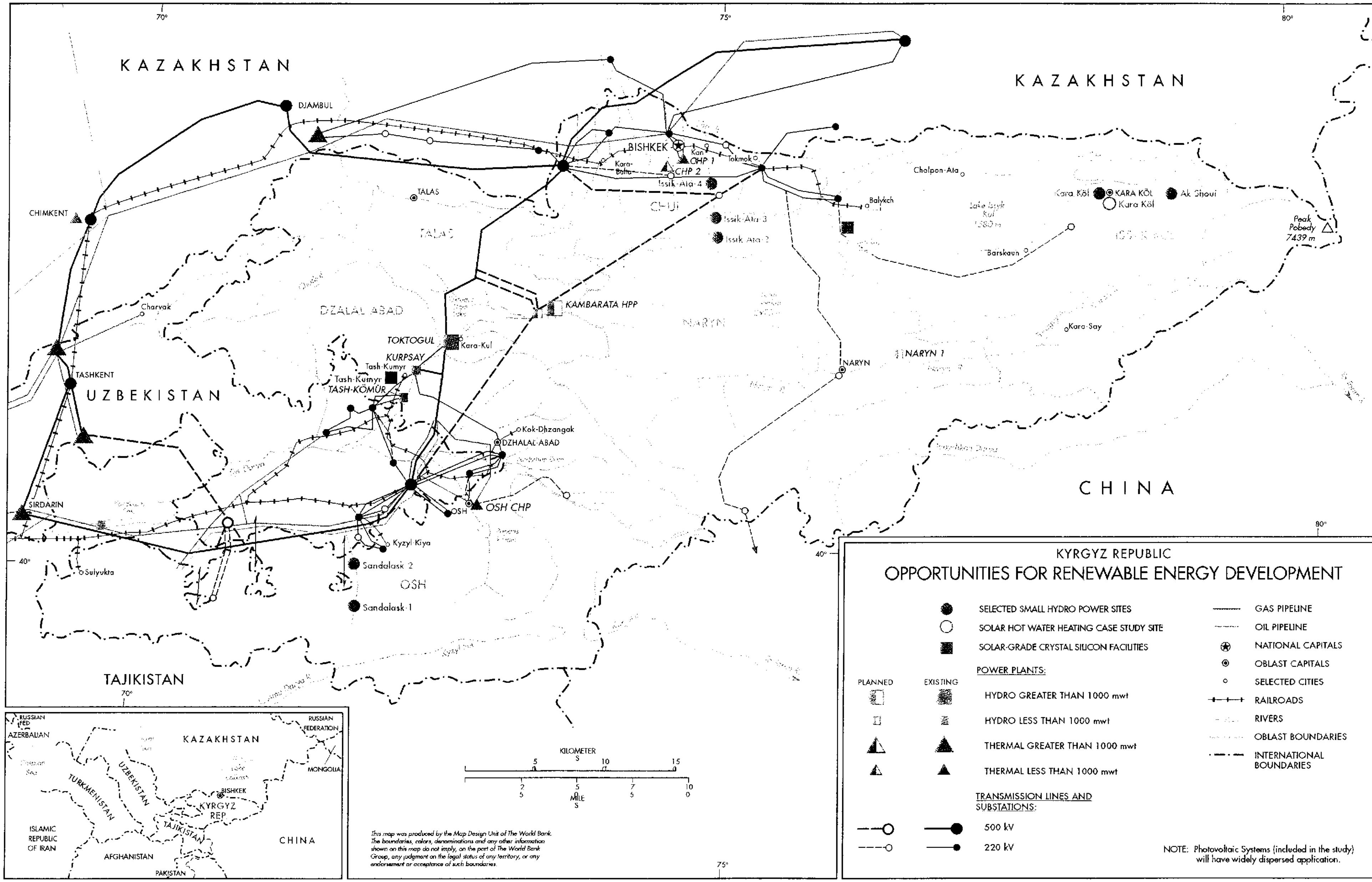

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