

World Bank Draft for Discussion

Key Issues for Consideration on the Proposed Rogun Hydropower Project

[This is a draft document for discussion. It presents key findings of the draft assessment studies that have been disclosed for public consultation and identifies issues for additional consideration.]

Предварительный вариант Документа

Всемирного банка для обсуждения

Ключевые вопросы для дальнейшего

обсуждения по предлагаемому проекту

Рогунской ГЭС

[Это предварительный вариант документа для обсуждения. В документе приводится обобщение ключевых результатов Оценочных исследований, представленных для общественных консультаций, и определяются вопросы для дополнительного рассмотрения.]

Table of Contents¹

1	Objectives and Context.....	3
1.1	Objectives.....	3
1.2	Background	3
2	Summary of the Assessment Process	6
2.1	Riparian Consultations	7
2.2	Additional Measures to Ensure Quality and Inclusiveness	8
3	Summary of Assessment Findings.....	9
3.1	Techno-Economic Assessment.....	9
3.2	Environmental and Social Impact Assessment	13
3.3	Summary Comparison of Alternatives	17
4	Additional Issues Requiring Consideration	17
4.1	Sector and Economic Management Framework in Tajikistan	17
4.2	Trans-Boundary Water Management	20

¹ This report is a product of the staff of the International Bank for Reconstruction and Development/The World Bank. The findings, interpretations, and conclusions expressed in this report do not necessarily reflect the views of the Executive Directors of the World Bank or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Key Issues for Consideration on the Proposed Rogun Hydropower Project

[This is a draft document for discussion. It presents key findings of the draft assessment studies that have been disclosed for public consultation and identifies issues for additional consideration.]

1 OBJECTIVES AND CONTEXT

1.1 OBJECTIVES

1. *Given the water and energy interdependence of Central Asian countries and severe winter energy shortages in Tajikistan, the objectives of the Rogun assessment studies² are to (a) assess the feasibility of a hydropower dam at the Rogun site in Tajikistan from the technical, economic, environmental, and social perspectives; (b) compare various Rogun dam design options with alternative means to meeting Tajikistan's energy needs; and (c) promote a constructive dialogue among the riparian countries (Afghanistan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan)³ by assuring the independence and quality of the studies and sharing the findings with all parties.* The issues are complex and this World Bank report seeks to inform the dialogue on future water and energy needs in order to find mutually beneficial solutions.

2. *The objective of this summary report is to bring together the key findings of the assessment studies and identify additional issues for consideration.* The remainder of this section provides background information. Section two provides a summary of the assessment process. Section three presents key finding of the assessment studies. Section four identifies additional issues that merit attention.

1.2 BACKGROUND

3. *The countries of the Amu Darya river basin are highly interdependent with regard to water and energy resources (see Figure 1).* The Amu Darya is formed by the confluence of the Pyanj and Vakhsh rivers, which originate in the mountains of Tajikistan, Afghanistan, and the Kyrgyz Republic. The Pyanj River forms the border between Tajikistan and Afghanistan and contributes about 45 percent (31

² Techno-Economic Assessment Study and Environmental and Social Impact Analysis.

³ These six countries are part of the Aral Sea basin formed by the Amu Darya and Syr Darya rivers.

billion cubic meters (bcm) to the annual flow of the Amu Darya mainstem (69 bcm). The Vakhsh is located within Tajikistan and contributes about 29 percent (20 bcm) to Amu Darya flows.⁴

Figure 1: The Aral Sea Basin



4. ***The upstream countries are the source of much of the region's water but have limited non-hydro energy resources.*** In contrast, Uzbekistan and Turkmenistan have considerable reserves of gas and oil but are highly dependent for irrigation on flows from the upstream countries. The integrated operation of the region's power grid ended with the withdrawal of Turkmenistan, Uzbekistan, and Kazakhstan from the Central Asia Power System (CAPS) over the last decade.⁵ Regional energy trade

⁴ The remaining 26 percent of Amu Darya flows comes from a large number of small sources in Afghanistan, Tajikistan, Uzbekistan, and Turkmenistan. The total resources of the Amu Darya basin are estimated at 78 bcm (relative to 69 bcm in the mainstem) because many tributaries no longer reach the Amu Darya mainstem but are fully used in their sub-basins.

⁵ The Central Asia Power System (CAPS), developed under the Soviet Union, comprises the national grids of Tajikistan, southern Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan. The system was planned to function in an integrated mode which allowed exchange of power across countries dependent on differences in their

has dropped by 90 percent since the early 2000s, contributing to winter energy shortages in the upstream countries.⁶

5. ***Tajikistan has severe winter energy shortages that cause serious deprivation to its population.*** Its reliance on hydropower produces summer energy surpluses as well winter shortages because of the seasonal variation in water flows, with high flows in summer due to snow and glacier melt and low flows in winter. Alleviation of winter shortages could be addressed by (a) undertaking reforms to improve the operation and financial soundness of the power sector, (b) implementing ambitious energy efficiency plans to reduce uneconomic power usage, and (c) increasing supply (whether from imports, in-country generation, or a combination of both).

6. ***The Rogun hydropower project was initially designed in the 1970s as part of the development of the Vakhsh River cascade for integrated economic development in the Central Asian republics of the Soviet Union.*** The Rogun site is located upstream of the existing Nurek hydropower dam, which has an active storage capacity of 4.2 bcm of water (see Figure 2). The five other hydropower stations located downriver from Nurek are all run-of-river schemes with no significant water storage capacity. Construction of the project began in 1980 but halted with the break-up of the Soviet Union in 1991 and the ensuing civil disturbances in Tajikistan (1992-97). In 1993 the existing coffer dam⁷ was washed away and the tunnels constructed in the 1980s were damaged. The Government of Tajikistan began rehabilitation of the existing tunnels and underground civil works in 2008.

respective energy resources and seasonal demand and supply for electricity. In the winter, Tajikistan and the Kyrgyz Republic would rely on fuel and power imports from the other countries, and in the summer they would supply surplus hydropower to them. Since the fall of the Soviet Union, competing national interests resulted in a shift towards uncoordinated outtakes of electricity from the regional grid that exceeded agreed amounts, an emphasis on securing supply from national sources alone, and the eventual withdrawal from the CAPS of Turkmenistan in 2003 and Uzbekistan and Kazakhstan in 2009.

⁶ From 25 to 50 percent of electricity demand was unmet in recent winters.

⁷ Dam created to divert water and create a dry area for construction.

Figure 2: Map of Tajikistan Indicating Proposed Rogun Dam Site

7. ***When Tajikistan began to consider renewing work on the Rogun project, questions were raised about its safety, downstream impact, and economic and financial viability.*** Given the World Bank's involvement in the energy and water sectors of most Central Asian countries, these questions prompted interest by several of the riparian countries, including Uzbekistan, for Bank involvement in a high-quality and independent assessment of the proposed project.

2 SUMMARY OF THE ASSESSMENT PROCESS

8. ***Tajikistan formally requested World Bank financing in October 2007 to carry out a Techno-Economic Assessment Study and an Environmental and Social Impact Assessment of the proposed project.*** The World Bank agreed to support the Rogun assessment process in order to help ensure (a) an updated analysis of the feasibility of a hydropower project at the Rogun site in compliance with international norms, (b) the independence and technical quality of such studies, and (c) wide consultation on the studies and sharing findings with all stakeholders in order that they might serve as the basis for informed discussions among the riparian countries. The assessment aimed to answer questions about the feasibility of the proposed project and to compare it with alternatives as a first step toward such discussions.

2.1 RIPARIAN CONSULTATIONS

9. *The assessment process has been inclusive and transparent, with preliminary consultations on the terms of reference of the assessment studies as well as [five]⁸ formal riparian consultations on interim outputs and draft final reports.*

10. *In September 2008, the Tajik authorities sent draft terms of reference for the assessment studies to all the riparian countries for comment.* The World Bank conducted in-country consultations on the terms of reference with the country authorities and with civil society organizations in all six riparian countries from September 2008 to September 2009.⁹ The terms of reference were revised to reflect comments received during the consultations. Key revisions related to dam safety issues, particularly seismic risk, and trans-boundary water management.

11. *In order to ensure widespread sharing of the results emerging from the studies, reflect riparian concerns in the studies, and facilitate open discussions among the riparian countries, the World Bank organized multi-country consultations on key outputs of the assessment process as they became available and regularly briefed the downstream countries on the status of the assessment studies and preliminary findings.* Five multi-country consultations, including separate sessions for riparian governments and civil society organizations, were held during 4-6 week review periods for draft documents as summarized below.¹⁰ The international diplomatic community was also briefed on the status of the assessments following each consultation session. The Uzbek authorities were among those who originally requested that the World Bank undertake an assessment of the proposed Rogun hydropower project but they have so far abstained from participating in the consultation meetings because they have not accepted the independence and objectivity of studies that are financed by the World Bank but contracted by the Government of Tajikistan. They have publicly expressed their opposition to the construction of a Rogun dam. In response to the Uzbek concerns, the Bank agreed to play an enhanced role in order to assure the quality and independence of the assessment studies (see section 2.2 below) and has regularly briefed the Uzbek authorities on the progress of the studies and the outcome of the consultations. The Uzbek authorities have made several written inquiries to the Bank concerning the study findings that have helped strengthen the final reports.¹¹

- Consultations were held on May 17-19, 2011, to (a) introduce two International Panels of Experts convened to review the two assessment studies, (b) review the draft inception reports for the two studies and the status of the proposed work program, and (c) seek feedback on the proposed program of information sharing with riparian governments and civil society organizations.

⁸ The fifth consultations are scheduled for July 2014.

⁹ A summary of the in-country consultations on the terms of reference, including the key comments from each riparian country and a list of the participants, is available at www.worldbank/eca/rogun.

¹⁰ The consultations were held during 4-6 week review periods during which the World Bank sought comments on the disclosed documents. Full reports on each of the riparian consultations, including comments received and lists of participants, are available at www.worldbank/eca/rogun.

¹¹ The Uzbek written queries and World Bank responses are available at www.worldbank.org/eca/rogun.

- Consultations were held on November 6-7, 2012, to discuss the draft Screening Report of the Environmental and Social Impact Assessment and the draft Design Criteria of the Techno-Economic Assessment Study.
- Consultations were held on February 11-12, 2013, to discuss the interim findings of the two ongoing Assessment Studies, including the draft Hydrology Report and the draft Geological Investigations Report. The meetings also discussed interim findings on seismicity, Vakhsh River Cascade simulations, site geology, different dam height alternatives, and cost comparisons of resettlement and infrastructure for various dam height options.
- Consultations were held on October 17-20, 2013, to discuss the Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir Summary Report (Phase 0 of the Techno-Economic Assessment Terms of Reference) and Assessment of the Existing Rogun Hydropower Project Works, including caverns and tunnels Summary Report (Phase I of the Techno-Economic Assessment Terms of Reference).
- Consultations will be held in July 2014¹² to discuss the draft *Summary Report of the Techno-Economic Assessment Study* and draft *Environmental and Social Impact Assessment*.

2.2 ADDITIONAL MEASURES TO ENSURE QUALITY AND INCLUSIVENESS

12. ***In order to ensure the independence and transparency of the study process, the World Bank agreed to play a substantially enhanced role in the conduct of the assessment studies.*** This enhanced role included (a) explicit involvement in the selection of the consultants to carry out the assessment studies, (b) direct role in supervision and review of the studies, (c) realization of key additional studies directly by the World Bank, (d) establishment of two International Panels of Experts contracted and financed directly by the World Bank to review the assessments, and (e) structured riparian consultations facilitated by the World Bank (as described above).

13. ***The World Bank approved revised terms of reference for the assessment studies in March 2010 and conducted its own evaluation of the consultant offers received in June/July 2010.*** In line with the World Bank's evaluation, the Government of Tajikistan awarded contracts to a consortium led by Coyne & Bellier for the *Techno-Economic Assessment Study* and another led by Poyry Energy Ltd. for the *Environmental and Social Impact Assessment* in February and March 2011, respectively.

14. ***Additional studies were undertaken directly by the World Bank.*** These include *Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives*, as well as analyses of macroeconomic and fiscal implications, international experience on legal frameworks for trans-boundary water management, institutional options for water basin management, and regional water management.

15. ***The World Bank contracted a techno-economic and dam safety Panel of Experts and an environmental and social Panel of Experts to review the assessment studies beginning in April 2011.*** Both Panels are composed of internationally renowned experts under direct contract to the World

¹² This World Bank report will be finalized after these consultations.

Bank¹³. Members of the two Panels have participated in all the riparian consultations, as well as numerous meetings with the Government of Tajikistan and the consultants undertaking the studies.

3 SUMMARY OF ASSESSMENT FINDINGS

16. **This section summarizes key findings of the Techno-Economic Assessment Study and the Environmental and Social Impact Assessment**, which will be the subject of riparian consultations in July 2014 in Almaty.¹⁴

3.1 TECHNO-ECONOMIC ASSESSMENT

17. **The Techno-Economic Assessment examined basic geological and hydrological data, engineering and design issues, construction costs and schedule, and economic and financial feasibility, as summarized below.**

18. **Three possible dam heights were assessed** (defined as full supply levels of 1290, 1255, and 1220 meters above sea level with total reservoir capacities of 13.3, 8.6, and 5.2 bcm, respectively)¹⁵ and three different levels of installed generation capacity for each dam height, yielding nine different design options. All of the dam height options are “high” dams and for ease of reference are hereafter referred to as the 1290m, 1255m, or 1220m design options.

3.1.1 Safety and Engineering

19. **Overall, the studies conclude that, subject to modifications in the original design and the implementation of identified mitigation measures, a large dam could be built and operated at the Rogun site within international safety norms.** Dam safety is a major consideration as a failure of any large dam on the Vakhsh River would have catastrophic consequences in Tajikistan and downstream countries. The most important issues investigated regarding dam safety concern the safety of works already constructed, underlying geology, landslides, earthquakes, floods, and sedimentation. From a safety and engineering perspective, the studies find no major differences in risks among the different dam height options, although the impact of dam failure could be different for different dam heights. The estimated costs of all the mitigation measures and monitoring are included in the economic and financial analysis of each of the Rogun design options.

20. **The Assessment of the Existing Rogun Works concludes that several of the underground structures, including the two existing diversion tunnels and the powerhouse cavern, would require strengthening and remedial measures, as well as comprehensive monitoring, in order to meet**

¹³ The techno-economic and dam safety Panel of Experts is composed of Roger Gill (Chair, Hydropower Policy Expert), Ljiljana Spasic-Gril (Dam Engineering/Dam Safety/ Seismic Engineering Expert), Paul Marinos (Engineering Geology/Rock Mechanics Expert), and Ezio Todini (Hydrologist). The economic and social Panel of Experts is composed of Torkil Jønch Clausen (Chair), Erik Helland-Hansen, Richard Fuggle, and Frederic Giovannetti.

¹⁴ The final version of this report will also take into account the final reports of the two Panels of Experts.

¹⁵ Full supply levels of 1290, 1255, and 1220 meters above sea level correspond to dam heights of 335m, 300m, and 265m.

international norms. The proposed design changes and rehabilitation would make the tunnels conform to modern design requirements and address the problem of deformation of the powerhouse walls resulting from the prolonged exposure of the excavated siltstone.

21. **The Techno-Economic Assessment concludes that, with implementation of appropriate mitigation and monitoring measures, the Rogun site is suitable for a rockfill dam of any of the proposed heights.** The Salt Wedge Report examined the potential risks to dam safety of the wedge of salt that exists at the Rogun site. The findings indicate that mitigation measures, as well as monitoring throughout the life of the project, are both necessary and feasible to prevent the dissolution of the salt wedge from affecting dam stability, thereby ensuring compliance with international dam safety standards.

22. **The study concludes that the geological setting is conducive to slope stability and specifies mitigation measures and monitoring to deal with the risk of landslides.** In particular, the deformation on the right bank downstream of the site was found to be due to tectonic deformation rather than successive landslides and the risk of landslide on the reservoir banks would require monitoring but would not be a threat to the safety of the dam.

23. **Based on the seismic design parameters derived from a deterministic approach,¹⁶ the assessment study concludes that all three dam height alternatives can withstand the Maximum Credible Earthquake.** It recommended that further analysis using a probabilistic approach¹⁷ be completed before any dam is constructed. The conclusion is based on consideration of the high level of seismic activity in the Rogun area (36 earthquakes of magnitude 5-8 since 1907) and seismic monitoring at the Nurek hydropower station. Potential induced seismicity during reservoir filling would require slow filling of the dam and monitoring. The additional probabilistic analysis was subsequently completed and confirmed that all three dam height alternatives could withstand the Maximum Credible Earthquake.

24. **The design modifications proposed in the Techno-Economic Assessment make all three dam heights capable of withstanding the Probable Maximum Flood.** The existing Nurek dam downstream of Rogun as well as the other projects of the Vakhsh cascade are not designed to withstand the Probable Maximum Flood. The 1290m and 1255m options would have the major additional benefit of also protecting the entire downstream cascade, including Nurek, by storing part of the flood. The lower 1220m option would not be able to protect the cascade and would necessitate large additional investments to protect the cascade from the Probable Maximum Flood. Safe handling of floods during diversion would require building a third diversion tunnel. Safe handling of floods during the construction period would require construction of a series of new tunnels as the reservoir fills.

25. **The study concludes that the large amount of sediment carried by the Vakhsh River (a) makes higher dams more attractive since they provide a longer lifespan (i.e., before being filled with sediment) and (b) necessitates design modifications that incorporate specific end-of-life strategies irrespective of dam height.** The annual inflow of sediment to a reservoir at the Rogun site is estimated to be from 60 to 100 million cubic meters per year based on available data, including surveys of the Nurek reservoir. Additional study would be needed to narrow the range. Assuming sedimentation of

¹⁶ A deterministic approach is based on examination of the faults and calculation of earthquake risks based on their technical characteristics.

¹⁷ A probabilistic approach analyzes the historical seismic data to determine earthquake probabilities.

100 million cubic meters per year, the projected lifespan is estimated to be 115 years for the 1290m option, 75 years for 1255m, and 45 years for 1220m. Assuming sedimentation of 60 million cubic meters per year, the projected lifespan is 200 years for 1290m, 120 years for 1255m, and 75 years for 1220m. The lifespan estimates reflect design modifications to deal with sedimentation. Design changes were introduced so that water can safely pass after a dam is filled with sediment (surface spillways).

26. **If the project were to proceed, approximately two years would be required to complete detailed design work, construct the third diversion tunnel, and reinforce the existing underground structures prior to river diversion.** Subsequent construction is estimated to require from 8 to 11 years depending on the design option. Early electricity generation could begin 4-5 years after diversion. Project costs, including all recommended design changes and mitigation measures, would be on the order of \$3 billion to \$5 billion in 2013 US dollars over 10 to 13 years depending on the design option.

3.1.2 Economic Analysis

27. **The study concludes that any of the Rogun design options (three dam heights each with three generation capacities) is a lower cost option for meeting Tajikistan's electricity demand than the non-Rogun alternatives.** The study first examines the combination of sources--including imports of electricity, new thermal generation from coal or imported gas, and new hydro generation--that would meet electricity demand in Tajikistan at the lowest cost (the "least-cost expansion plan") from 2020 through 2050. This methodology in effect compares the cost of providing electricity from expansion plans that include the nine Rogun design options with the cost of doing so from expansion plans that exclude Rogun. Each of the nine Rogun scenarios meets demand at a lower cost than does any combination of the non-Rogun alternatives.¹⁸ The Rogun design options are then compared based on the present value of savings in total system costs that they generate relative to the least-cost expansion plan if Rogun is excluded. The present value of total system cost savings relative to the non-Rogun scenario range from \$1.1 billion for the 1220m design option to \$1.5 billion for the 1290m option relative to total system costs on the order of \$30 billion.¹⁹

28. **Key assumptions for the economic analysis include:** (a) a discount rate of 10 percent; (b) operation so as to maintain the current transfer of 4.2 bcm from summer to winter release (see section 3.2 below); (c) implementation of the TALCO²⁰ energy efficiency plan as specified in the *Tajikistan Winter Energy Crisis* report which foresees a drop in electricity use of 1,180 GWh by 2018; (d) an income elasticity of demand of 0.9 and a price elasticity of demand of -0.2 for non-TALCO electricity demand in the base case demand scenario; (e) an increase of average domestic tariffs from 2.2 to 7 US cents/kWh

¹⁸ The level of installed capacity has a relatively small effect on the analysis since the amount of electricity generated depends mostly on dam height rather than the level of installed capacity. Hence, for simplicity of presentation, the discussion below focuses on one level of installed capacity for each dam height (3200MW for 1290m, 3200MW for 1255m, and 2800MW for 1220m)—which correspond to the installed capacity option with the largest total system cost savings for each dam height.

¹⁹ Total system costs for Tajikistan is defined as the sum of annualized capital expenditure repayments, non-fuel operating and maintenance costs, fuel costs, and flood protection benefits, less the net financial benefits from net exports. Total system costs for the least-cost expansion plan to meet electricity demand are estimated to be around \$30 billion.

²⁰ Tajikistan Aluminum Company, which accounts for around 40 percent of Tajikistan's electricity consumption.

(in 2012 US\$) over 15 years²¹; (f) reduction of technical losses from 18 percent to 12 percent over 10 years²²; (g) electricity export prices equal to the time-weighted average marginal cost of generating electricity in the export market; (h) Tajikistan coal reserves of 3.6 billion tons; (i) two interconnection capacity scenarios--one assuming 1000 MW interconnection between the Kyrgyz Republic, Tajikistan, and Pakistan by 2017, another assuming no interconnection capacity in 2017, and both allowing economic build of such capacity beginning in 2018 up to a maximum of 3000 MW; (j) crude oil, natural gas, and coal prices as projected by the World Bank (July 2013) up to 2050; (k) decommissioning costs if Rogun were not built; and (l) additional investment costs to protect Nurek if the 1220m option were built. Several of these assumptions carry a significant level of uncertainty given the long-term nature of the projections.

29. **If Rogun were excluded as an option, the least-cost expansion plan would add a large hydro storage dam on the Pyanj River (Dashtijum 4000 MW).** All the scenarios (with or without Rogun) include thermal generation within the limits of Tajikistan's coal reserves and new run-of-river hydro generation. Run-of-river hydropower options alone do not meet Tajikistan's winter electricity demand however, since their generation is skewed even more heavily to the summer months than is that from Rogun or other large dams. As a result, the least-cost analysis results in a different large hydropower dam (Dashtijum) being included into the least-cost expansion plan when Rogun is excluded.

30. **Both Rogun and non-Rogun scenarios involve electricity imports and exports. The non-Rogun** scenario includes higher electricity exports than any of the Rogun options because of greater reliance on run-of-river generation and Dashtijum's larger generation capacity. Given that all the hydropower options produce more electricity in the summer than in the winter, they alone do not fully meet Tajikistan's winter energy demand over the forecast period. After construction and reservoir filling winter electricity generation from Rogun would be around 5.6 TWh under the 1290 option, 4.8 TWh under the 1255m, and 3.5 TWh under the 1220m option which, combined with energy efficiency measures, would initially eliminate the winter shortage. As demand continues to increase, additional generation projects and imports would be needed. Hence all the scenarios, Rogun and non-Rogun, envision some winter import of electricity from the Kyrgyz Republic, some of which are imports from Uzbekistan transmitted through the Kyrgyz Republic. The study assumes zero interconnection between Tajikistan and Uzbekistan in the reference case and 1000MW in the high interconnection sensitivity analysis.

31. **The Rogun options are included in the least-cost expansion plan even with considerable variation in key assumptions.** The study examined sensitivity to changes in four parameters that have the biggest effect on the results: demand growth, fuel costs, total investment costs for non-Rogun projects, and the interconnection capacity with other countries. All Rogun options remain lower cost than the best non-Rogun option when these assumptions are given either high or low values.²³ The 1220m option yields less cost savings in all the sensitivity cases except the low demand growth scenario. In addition, all of the Rogun options yield cost savings relative to the non-Rogun option when the discount rate is reduced to 8 percent or raised to 12 percent.

²¹ As proposed in the *Tajikistan Winter Energy Crisis* report.

²² Idem

²³ High and low values for the four variables are defined as: (a) demand growth at the 75th and 25th percentiles as opposed to 50th percentile in the reference case, (b) fuel costs +20% and -20%, (c) total investment costs for non-Rogun projects +20% and -20%, and (d) interconnection capacity +1GW and -3GW Tajikistan-Pakistan.

32. **All of the Rogun design options also have acceptable and similar economic internal rates of return, ranging from 12.0 percent to 12.3 percent in the reference case.** Given the similar economic rates of return, the net present value of the 1290m design option is greater than that of the 1255m or 1220m options by virtue of the larger electricity output for a higher dam. The probability-weighted net present values range from \$618 million for the 1220m design option to \$835 million for the 1290m option. The sensitivity analysis shows that the economic rates of return and net present values are most sensitive to total investment costs and fuel prices.

33. **The study concludes that the 1290m design option yields the highest total system cost savings and the highest net present value.** Total system cost savings are \$1.48 billion for the 1290m design option relative to \$1.34 billion for the 1255m option. Additional sensitivity analysis shows that the 1290m design option continues to be lower cost than the non-Rogun alternatives if interconnection capacity is delayed, imported gas is available for electricity generation and heating from 2025, construction is delayed by up to six years, or demand growth is reduced by half. The additional sensitivity analysis also concludes that the net present value remains positive if construction is delayed or extended by two years. A 20 percent increase in construction costs would lead to a reduction of 64 percent in the net present value. A breakeven analysis shows that for the net present value of the 1290m option to fall to zero, domestic sales prices would have to decline by 38 percent, electricity export prices decline by 68 percent, or export revenues be delayed until 2032. Simultaneous changes in several assumptions could, of course, either offset each other or lead to greater variation in results.

3.1.3 Financial Analysis

34. **The Techno-Economic Assessment examined four hypothetical financing structures combining various elements of (a) full government self-financing with equity, (b) a preferential loan from a foreign government, (c) multilateral and commercial loans, and (d) foreign bond issuance.** The financial analysis was carried out for the design option with the highest total system cost savings (1290m option). The financial structures yield internal rates of return close to 12 percent. At present, actual sources of financing remain unclear and would require further exploration.

35. **Given the size of the proposed Rogun project and the duration of construction, some sequential financing could increase flexibility in the financial structure, but the assessment study concludes that full financing for "safety critical" capital expenditure would be needed prior to diversion of the river.** There are certain aspects of the project that for safety reasons would need to be fully completed once dam construction (river diversion) has started. Safety critical capital expenditure includes the civil works (dam and tunnels) once river diversion has occurred and hydro-mechanical equipment. Safety considerations would require that this financing be secured prior to river diversion, the earliest date for which is estimated to be 28 months after a decision to proceed with the project.

3.2 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

36. **The assessment concludes that there are two important environmental and social issues that would need to be addressed in detail and that would require mitigation: (a) resettlement of households living near the dam site and in the reservoir area, and (b) potential reductions in summer flows, which could negatively affect downstream irrigation.** Each of these is discussed below. The

assessment concludes that other impacts are relatively small and can be mitigated acceptably. The cost of all mitigation measures is included in the cost estimates used for the economic and financial analyses.

3.2.1 Resettlement

37. ***Resettlement of households living near the dam site or in the reservoir area would be a major impact of building a dam at the Rogun site.*** The first stage of resettlement, which began before the assessment studies were initiated, concerns six villages near the construction site and one village that would be affected by the initial stage of reservoir filling, comprising a total of 292 households. The number of additional households to be resettled in a second stage would depend on dam height and the corresponding size of the reservoir: 5743 households over 16 years under the 1290m design option, 2009 over 13 years under the 1255m option, and 1294 over 9 years under the 1220m option.²⁴

38. ***Resettlement would result not only in physical displacement but also economic displacement. Restoring livelihoods during and after resettlement would be a critical element of the resettlement process.*** There is some potential for direct and indirect job creation due to Rogun construction that could provide employment opportunities to offset negative economic impacts of resettlement but additional strategic planning and multi-sector interventions would likely be required to restore incomes and livelihoods of the affected persons.

39. ***The Environmental and Social Impact Assessment has identified measures to mitigate the impacts of involuntary resettlement and the current estimate of the costs of resettlement is included in the economic and financial analyses for each of the three dam design options.*** A draft Resettlement Policy Framework is under preparation which, among other things, states the resettlement principles and organizational arrangements that would apply for a second stage of resettlement. A draft first stage Resettlement Action Plan is also under preparation and would provide details on project-related resettlement including an analysis of legal frameworks, proposed institutional arrangements, and data on affected people. Lastly, a Resettlement Audit (also under preparation) would inform measures to bring current resettlement (first stage) into conformity with international good practice (consistent with the World Bank's Operational Policy on Involuntary Resettlement (OP 4.12)).

40. ***Additional attention could be given to managing social impacts in order to move forward in a manner consistent with international good practice.*** A detailed social assessment could give greater attention to the broad social impacts beyond just resettlement. Strategic planning could give early attention to livelihood restoration. In addition, the institutional arrangements for implementing resettlement actions could be reinforced, particularly regarding livelihood restoration and community engagement.

3.2.2 Downstream Impact

41. ***A dam at the Rogun site could impact downstream flows in two ways: how it is filled and how it is operated.*** The first would apply during a filling period of up to 16 years. The second would apply for the life of the dam. Both are discussed below.

²⁴ 5743 households corresponds to 40,219 persons; 2009 to 16,003 persons, and 1294 to 10,337 persons.

42. ***Sharing of water in the Amu Darya basin is regulated among four of the five riparian states (Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan) based on existing arrangements and practices, including semi-annual negotiations in the framework of the Interstate Commission on Water Coordination (ICWC), Protocol 566, and the Nukus Declaration.*** Afghanistan, which currently withdraws approximately 2.5 bcm from the Amu Darya, is not party to these arrangements.²⁵ Protocol 566, established by the Ministry of Land Reclamation and Water Management of the USSR and approved by the four riparian Soviet republics in 1987, took account of construction of Rogun and set the overall limit of annual water withdrawal at 61.5 bcm with the following country limits: Uzbekistan 29.6 bcm (48 percent), Turkmenistan 22.0 bcm (36 percent), Tajikistan 9.5 bcm (15 percent), and the Kyrgyz Republic 0.4 bcm (1 percent). The Protocol specifies annual limits and has no provisions regarding seasonal transfers. In 1992 the Aral Sea Basin countries signed the Agreement on Cooperation in the Management, Utilization, and Protection of Interstate Water Resources (known as the Almaty Agreement) which commits the countries to adhere to the principles of water allocations agreed upon during the Soviet era, exchange information, and collaborate on joint research. The Almaty Agreement created the ICWC with the mandate to govern the interstate allocation of water resources in the Amu Darya and Syr Darya rivers. The Nukus Declaration, adopted at a conference of the Central Asian Heads of State in 1995, states that the Central Asian states recognize the earlier signed water management agreements and pledge to continue to implement them. Current allocations are agreed semi-annually among the four countries within the framework of the ICWC.

43. ***Tajikistan has not used its full water allocation as set in ICWC annual allocation decisions but has indicated that it intends to use the full allocation in the future. Doing so would reduce downstream flows.*** If a dam were built at the Rogun site, Tajikistan has indicated that it would use the difference between its allocation and its actual use to date (averaging 1.2 bcm annually for 2005-11) to fill the resulting reservoir and subsequently for irrigation. On this basis and taking into account the technical and construction constraints, the time required for reservoir filling would be 16 years for the 1290m option, 13 years for the 1255m option, and 9 years for the 1220m option.²⁶ For the case of the largest reservoir (1290m option) this would result in an average annual reduction in downstream flows of 0.83 bcm over a 16 year period. Without greater predictability of future allocations, this presents a certain risk for Tajikistan since it would have to either extend the filling period or reduce its water use for irrigation if during the filling phase its allocation were to be smaller than it is today.

44. ***Regarding dam operation, the studies confirm that a dam built at the Rogun site at any of the three considered dam heights could be operated in a way that maintains historical flows.*** The Nurek reservoir is currently used to transfer 4.2 bcm of water from summer (April-September) to winter (October-March) release and maintenance of historical flows is defined in the studies as limiting the summer to winter transfer to this amount. Given the interest of downstream riparians to maintain present seasonal flows in the future, the Government of Tajikistan has indicated that it would operate any future dam at the Rogun site so that the same amount of water is transferred from summer to winter release as is currently done at Nurek. Under such an operating regime a dam at the Rogun site would transfer 4.2 bcm of water from summer to winter release and the Nurek dam would be kept at its full level throughout the year.

²⁵ Afghanistan is both a source of water to the Pyanj/Amu Darya and a user for downstream irrigation. Protocol 566 assumes that the Afghan offtake is 2.1 bcm. Prior to 1980 Afghanistan's water offtake is reported to have been around 5 bcm. It subsequently fell to an estimated 2.5 bcm as a result of the war.

²⁶ Assuming that the difference between Tajikistan use and future allocations remains unchanged.

45. *Operation of a dam at the Rogun site in this manner raises two potential issues for consideration. The first is whether there could be some form of guarantee for downstream countries that Tajikistan would continue to limit seasonal transfers to 4.2 bcm in the future.* Theoretically the storage capacity of a Rogun dam could be used to increase the summer to winter transfer by 7.4 bcm under the 1290m option, 6.5 bcm under the 1255m option, and 3.9 bcm under the 1220 option in order to maximize winter energy production. This would reduce summer flows in the Amu Darya by 19 percent, 17 percent, and 10 percent, respectively. Establishing a guarantee regarding seasonal transfers could provide formal assurances to downstream riparians that Tajikistan would not operate the facility in a manner that transferred more water from summer-release to winter-release. Such a mechanism could also provide additional clarity to existing arrangements as some aspects could be open to interpretation and there are no provisions on seasonal flows.

46. *The second consideration is that a different mode of operation, i.e., one that was not limited to transferring 4.2 bcm from summer to winter release, could potentially increase benefits to both Tajikistan and downstream countries.* In particular, the additional storage capacity of a dam at the Rogun site combined with the existing Nurek storage capacity could in principle be used to increase both summer water release in dry years²⁷ and winter energy generation in harsh winters (see section 4.3.1 below).

47. *The operation of a dam at the Rogun site so as to maintain the current 4.2 bcm summer to winter transfer would in itself have no impact on the amount of water reaching the Aral Sea but flows could be reduced during the filling period.* As noted above, filling the largest reservoir (1290m option) would imply an average annual reduction of 0.83 bcm (around 1.3 percent of the Amu Darya flow) over 16 years. The amount of water reaching the Aral Sea is largely determined by the amount of water abstracted for irrigation by Afghanistan, Tajikistan, Turkmenistan, and Uzbekistan.

48. *Climate change may also affect future river flows as glaciers in the Vakhsh basin are already receding.* Key impacts over the next decades are likely to be (a) a seasonal shift of peak runoff (1-2 months earlier), (b) increased total flow for a few decades (while glaciers melt), and (c) subsequent flows entirely dependent on precipitation with unpredictable changes in volume and distribution. In principle, water storage could be used to mitigate some of the negative impacts of these changes; for example, dams could store earlier runoff until needed by downstream riparians for irrigation.

3.2.3 Other Impacts and Environmental and Social Action Plan

49. *The assessment concludes that other impacts of construction and operation of the proposed dam would be relatively small and a draft Environmental and Social Management Plan specifies the mitigation measures and related monitoring activities that would be needed to meet international norms.* In addition to resettlement and downstream hydrology, the Environmental and Social Management Plan addresses the following issues where mitigation measures would be required: (a) physical environment (air quality, noise, vibration, water quality, topography, soils), (b) biological environment (vegetation and flora, terrestrial fauna, fish, landscape, protected areas), (c) human environment (workforce health impact, land use, fishing, archaeology, emergency preparedness), and

²⁷ The Environmental and Social Impact Assessment characterizes dry/wet years as -/+ 20 percent in flows.

(d) general construction (waste and hazardous materials, use of explosives, occupational health and safety, and traffic and roads).

3.3 SUMMARY COMPARISON OF ALTERNATIVES

50. *The assessment studies (a) conclude that a hydropower project could be built and operated at the Rogun site within international safety norms, (b) conclude that potential social impacts can be mitigated in line with international practice and recommend mitigation and monitoring measures to manage principle environmental risks, as well as issues for further investigation, and (c) conclude that building a dam at the Rogun site is a lower cost solution to meeting Tajikistan's energy needs than any of the alternatives.* Among the three Rogun dam design options, the 1290m option is estimated to yield the largest system cost savings. The difference in the present value of cost savings relative to the 1255m design option is about \$140 million (10 percent of the total system cost savings or around 5 percent of the present value of project costs). Given that the difference between these options is not large, other considerations become more important in the design decision, including (a) downstream flood protection, (b) the sustainable life of the investment, (c) the number of households to be resettled, (d) financing risks and macro-economic implications, (e) the potential benefits and risks to downstream countries of additional water storage (see section 4.2), and (f) opportunities for institutional arrangements that could maximize benefits for all countries (see section 4.2).

51. *The shorter lifespan of the 1220m option and its inability to provide downstream flood protection to withstand the Probable Maximum flood makes this option less beneficial than other dam heights.* The 1290m design option offers higher returns, including for downstream countries if a cooperative operation regime is in place, than the 1255m option but also involves higher costs and the resettlement of a significantly larger number of people. It would be advisable for the tradeoffs between the 1290m and 1255m options to be the subject of further consideration.

4 ADDITIONAL ISSUES REQUIRING CONSIDERATION

52. *The studies confirm the feasibility of a Rogun hydropower dam and power plant but the feasibility of actual construction and the realization of estimated benefits would depend on the availability and terms of financing and the institutional arrangements for its construction, filling, and operation.* Two broad issues would be particularly important to consider in this regard: the policy framework in Tajikistan, including the macroeconomic implications of such a large investment, and trans-boundary water management arrangements.

4.1 SECTOR AND ECONOMIC MANAGEMENT FRAMEWORK IN TAJIKISTAN

53. *Both the Government of Tajikistan and the national power company, Barki Tajik, would need strong sector and economic management capacity to attract international partners for a large hydro project.*

4.1.1 Management, Institutional, and Financial Capacity of the Energy Sector

54. *International experience demonstrates the importance of transparency and financial soundness of the power sector in order to successfully undertake large scale projects such as Rogun.*

At present, Tajikistan's energy sector does not meet generally expected levels of institutional capacity and financial viability.²⁸ The main issues facing the sector are summarized below.

- Barki Tajik faces large quasi-fiscal deficits (\$150 million or 2 percent in 2013) because of chronic loss-making tariffs, poor payment collection, and high electricity losses. Hence, Barki Tajik is neither able to properly rehabilitate and maintain current sector assets nor invest in new energy infrastructure. Barki Tajik is accumulating large arrears (accounts payable equivalent to 17 percent of GDP), including tax arrears, delayed repayment of loans from the Ministry of Finance, and delayed payments to independent power producers and other creditors. As a result it is currently not likely to be credible as a power purchaser from any new large hydro project.
- Current average electricity tariffs of around 2 US cents/kWh are a fraction of long run marginal costs and among the lowest in the world. Tariff increases combined with an effective mechanism to protect poor consumers, improved collection rates, and a credible long-term tariff adjustment mechanism would be essential to attract any large power sector investments.
- Barki Tajik's 2013 cash collection was about 60 percent of billings (76 percent including non-cash collection) compared to 95 percent for a well-performing utility.
- Technical losses currently represent 18 percent of electricity generated.
- Poor transparency and accountability in the sector, together with a lack of commercial and financial management skills, further undermine Barki Tajik's performance and credibility. While there has been some progress on financial reporting, Barki Tajik does not currently possess the capacity necessary to build credibility among its customers and potential commercial partners.
- Energy efficiency is low, including at TALCO which in 2013 represented one third of total electricity consumption in the country.
- Tajikistan's disconnection from the Central Asian power grid since 2009 has aggravated winter power shortages and significantly limited summer electricity exports from clean hydropower sources.

55. **International experience suggests that there are a number of actions that could serve to address many of these energy sector issues and build the credibility needed for any large new investments.** The implementation of many of these actions is assumed in the economic analysis summarized above.

- Restore the sector's financial viability by increasing payment collection, reducing electricity losses, correcting Barki Tajik's operational and financial inefficiencies, increasing tariffs while protecting vulnerable consumers, and implementing a debt restructuring plan to clean up Barki Tajik's balance sheet. Require all state-owned enterprises, including TALCO, to pay their electricity bills in cash and on time.
- Improve transparency and accountability by strengthening Barki Tajik commercial and financial management, holding it strictly accountable for performance, and publishing its operational and financial results on a quarterly basis.
- Promote energy efficiency improvements in industry, agriculture, and public and residential buildings, including through tariff increases, accelerated implementation of proposed TALCO energy efficiency measures, and energy efficiency investments in public buildings.

²⁸ In recent months the Government of Tajikistan has adopted measures to write off certain Barki Tajik debts, increase tariffs, and conduct an inventory of fixed assets and accounts receivable and payable.

4.1.2 Economic Management

56. *International experience shows that sound economic management and the transparency of overall public finances are key to attract international technical, commercial, and financial partners.*²⁹

57. *In Tajikistan, contingent liabilities from quasi-fiscal deficits of state-owned enterprises and from financial sector fiscal risks continue to grow, jeopardizing the viability of public finances.* Enforcement of hard budget constraints is key to eliminate the accumulation of quasi-fiscal deficits that eventually become Government liabilities (SOE arrears amount to 30 percent of GDP).³⁰

58. *Transparency in overall public sector finances is also critical to establish credibility with potential international partners.* . Tajikistan has made progress in transparency of budget operations. Extending this to full transparency on the disposition of public enterprise foreign exchange earnings would facilitate efforts to attract potential international partners.

4.1.3 Macroeconomic Implications of the Proposed Rogun Project

59. *The investment cost of building a dam at the Rogun site is large relative to the size of the economy, on the order of 50 percent of 2013 GDP,³¹ and would present macroeconomic challenges even if it is part of the least-cost solution to meeting Tajik energy demand.* The first challenge concerns the economy-wide allocation of resources. Any of the expansion plans to meet electricity demand from 2020 to 2050 are very large and imply tradeoffs with development needs in other sectors. The second macro challenge concerns fiscal capacity, debt sustainability, foreign exchange availability, and the balance of payments. Its implications depend on the cost split between domestic and foreign goods and services, the sources of financing, the impact of raising domestic financing, and the financing terms. These macro financial concerns apply equally to any expansion plan to meet electricity demand and are not limited to the Rogun options. This report considers only the second category of macro issues.

60. *Different arrangements for the structure of financing have different impacts on I the viability of the project and, given its large size, also on macroeconomic conditions.* If Rogun construction were entirely foreign-financed through public sector borrowing on commercial terms, it could be sustainable from a macroeconomic point of view (i.e., debt would be sustainable) if it were financed at an interest rate of less than 10 percent and if the projected benefits were realized on schedule. The uncertainties about the parameters of such a large project would present substantial macroeconomic risks. This scenario remains hypothetical since the availability of such large commercial financing is unlikely irrespective of the interest rate.

61. *Full domestic financing from tax revenues or government bond issuance, while theoretically feasible, would involve major risks, increase poverty, and cause severe repression of domestic consumption.* Public sector domestic financing would require the Government to mobilize around an

²⁹ See *Key Issues in Public Finance Management*, World Bank, Policy Note No. 4 and *Capital Expenditures and Public Investment Management*, Policy Note No.6.Tajikistan Programmatic Public Expenditure Review, Report No.88050-TJ, June 2014 (forthcoming).

³⁰ See *Fiscal Risks from State Owned Enterprises*, World Bank, Policy Note No. 5. Tajikistan Programmatic Public Expenditure Review, Report No.88050-TJ, June 2014 (forthcoming).

³¹ 2013 GDP is estimated to be \$8.3 billion.

additional 5 percent of GDP annually for a decade. Such resource mobilization might be possible but would imply a large reduction in disposable income for an already poor population (36 percent poverty rate based on 2012 Tajikistan Household Budget Survey). In addition, the vast bulk of Rogun expenditure would be in foreign exchange.³² Even if domestic currency resources could be raised, their conversion to foreign exchange would imply a large depreciation of the somoni. The combined reduction in income and depreciation would reduce private consumption and private investment. At the same time, it would force a reduction in government spending on the social sectors for several years. Given that remittances account for a large share of foreign exchange inflows,³³ it is not clear that such foreign exchange would be effectively available since remittances might decline or take the form of goods rather than foreign exchange inflows. In any case, imports for all other purposes, including basic necessities, would have to be significantly reduced. This income and import compression would imply an increase in poverty over the next decade.

62. ***Financing costs could be brought down significantly in the context of an international consortium approach.*** International experience shows prudent realization of such a large project usually involves shedding risk through equity participation of other countries, possibly including downstream riparians and commercial partners, and broad international support to help improve financing terms. This would reduce investment, operational, and fiscal risks and strengthen macroeconomic stability. The most attractive financing structure could be a combination of Government of Tajikistan self-financing, foreign equity participation, preferential and multilateral loans, and commercial or export agency loans. Such a funding structure could generate the most favorable terms, avoid foreign control of a strategic asset, and provide broad international involvement to assure all riparians of compliance with agreed arrangements. Bold action by the Tajikistan Government to move sector and economic management to international standards (see section 4.1) and a cooperative operation approach on Rogun that generates benefits for all riparians (see section 4.2) would enhance the prospects for such a financing structure.

63. ***The Tajik authorities have expressed interest to develop a financing package based on a variety of sources that includes domestic financing.*** The authorities are actively looking to develop a package that includes domestic financing, multilateral borrowing, and utilization of foreign exchange revenues from various sources. Critical determinants of the viability of the package would be the mix of domestic and foreign currencies, the equity share, borrowing costs, the degree of reliance on domestic revenue generation (via taxes, bond sale, or other means), and the magnitude of trade-offs with other public services.

4.2 TRANS-BOUNDARY WATER MANAGEMENT

64. ***There are three critical issues to consider regarding trans-boundary water management: reinforcement of current allocation arrangements, the choice of operating regime for the proposed Rogun dam, and whether there could be institutional arrangements established that would increase credibility that operations would be managed as agreed.***

³² The Techno-Economic Assessment Study estimates the import content of Rogun construction expenditure to be 87 percent.

³³ Remittances were the equivalent of 51 percent of GDP in 2013.

4.2.1 Strengthen Existing Arrangements

65. ***Existing arrangements for management of water use in the Amu Darya basin have functioned acceptably to date. They may require enhancements to address upcoming issues, including potential increased water offtake by Afghanistan and the possible construction of a dam at the Rogun site.*** Some aspects of existing arrangements may be open to interpretation. Most importantly, they do not include Afghanistan, which may increase its offtake in coming years, and they do not cover management of seasonal flows. It could be in the interest of all the riparian countries to explore options to strengthen the existing water management arrangements in order to provide more predictability and reinforce the existing cooperative decision-making framework. Such discussions could take place in the context of regional efforts in support of a strengthened legal and institutional framework for trans-boundary water management in Central Asia.

4.2.2 Increasing Benefits from a Rogun Dam

66. ***A dam at the Rogun site and the existing Nurek facilities offer potential benefits to Tajikistan in winter energy generation and to downstream riparians from additional water in dry years.*** The extent to which these benefits are realized depends on the operating regime for the two dams. Three possible modes of operation are summarized here to illustrate the opportunities and risks.

67. ***Operating a Rogun hydropower project so as to make no change in the transfer of 4.2 bcm from summer to winter release is possible but may not maximize the benefits for either Tajikistan or the downstream riparians.*** This is a conservative mode of operation designed to demonstrate to riparian countries that a Rogun dam could be operated so as to have no impact on downstream flows. The economic analysis shows that the project is economically feasible under this scenario. Both Tajikistan and downstream countries could, however, potentially gain additional benefits if a dam were operated differently.

68. ***A dam at the Rogun site could also, in principle, be operated so as to maximize winter energy production but this would reduce summer water availability for downstream countries.*** A dam at the Rogun site could be used to increase the transfer of water from summer to winter release by roughly 4 to 7 bcm. This would reduce summer flows in the Amu Darya by 10-20 percent.³⁴ Such a reduction would clearly harm irrigated agriculture in downstream countries and, in effect, turn the average year into the equivalent of a very dry year today. Such a scenario would also involve costs for Tajikistan, including a reduction in revenue from summer electricity exports. Increased export of summer electricity surpluses to neighboring countries increases Tajikistan's incentives for summer water release.

69. ***In principle, a Rogun dam could also be operated so as to both increase summer flows in dry years and generate more winter energy in harsh winters than under the historical flow constraint.*** Preliminary analysis undertaken by the World Bank suggests that such a cooperative mode of operation of the Nurek dam and a Rogun dam could have benefits for downstream countries by assuring extra water in dry years and for Tajikistan by increasing winter energy production in harsh winters and summer exports in dry years. This scenario should be considered as illustrative and the potential gains realizable under actual operating conditions would need to be explored further, but it highlights the

³⁴ Theoretical potential reduction of Amu Darya summer flows by 10 percent for 1220m option, 17 percent for 1255m, and 19 percent for 1290m relative to current average summer flow of 38 bcm at Kerki.

interest of all the riparian countries in exploring options to realize the benefits associated with a cooperative mode of operation. Additional operational modeling could be undertaken to produce estimates of the gains from a cooperative mode of operation. Under such an operating regime total benefits could be increased but there are multiple ways in which the benefits could be apportioned between sectors and countries. Although the highest dam design option would create the largest potential benefits, trade-offs would still emerge between benefits accruing to different countries and could require supplementary agreements among the riparian states.

4.2.3 Institutional and Financial Arrangements to Promote Compliance

70. ***Under any operating regime for an eventual dam at the Rogun site, there would be benefits for riparian countries to develop additional institutional arrangements--whether international legal commitments, financial guarantees, or both--to assure that a Rogun reservoir would be constructed, filled, and operated as agreed.*** Any agreement would need to be seen as equitable and serving the respective national interests of each country.

71. ***Effective arrangements for Amu Darya/Vakhsh trans-boundary water management would be most useful if they could (a) create mutual benefits, (b) include impartial technical and legal mechanisms, and (c) provide guarantees to promote compliance.*** A cooperative operating mode could create mutual benefits for Tajikistan, Uzbekistan, Turkmenistan, and Afghanistan.

72. ***International experience suggests that an agreement on management of the Vakhsh cascade would be most effective if it included impartial technical mechanisms that would permit the resolution of some issues without recourse to the political level.*** Examples of such mechanisms, based on the experience of successfully implemented agreements elsewhere, would include (a) technical monitoring mechanisms and data-sharing arrangements to provide all parties with reliable and up-to-date information on snow cover, water flows, storage, and releases (e.g., joint operation of the control room of the Itaipu dam by a bi-national team from Brazil and Paraguay); and (b) a dispute resolution mechanism where the final step is a binding decision by a neutral third party (e.g., independent expert, arbitration tribunal, or court).

73. ***Some form of third-party guarantee could also be used to ensure impartiality and penalties for non-compliance.*** Technical guarantees could be provided to ensure the impartiality of monitoring mechanisms, data, and analysis (e.g., support by the international community to the countries of the Nile and Mekong basins). Financial guarantees could include third-party payment for experts or administration of compensation, as well as financial performance guarantees such as those provided by the World Bank Group. Legal guarantees could include third-party responsibility for appointment of arbitrators or international experts on dispute resolution (e.g., President of the International Court of Justice for arbitral tribunals deciding on certain investment disputes or the World Bank in the Indus Water Treaty between Pakistan and India). Political guarantees could take the form of third-party co-signature as witness or guarantor to an agreement (e.g., co-signature of the 2000 Algiers Peace Treaty between Ethiopia and Eritrea by the African Union, European Union, UN, and US as guarantors).

74. ***There are many possible operating and institutional options but two illustrative scenarios highlight the possibilities for additional benefits beyond maintenance of historical flows.*** First, at a minimum, operating arrangements might be based on transferring 4.2 bcm from summer to winter but allow for annual negotiation among the parties for modifications (such as greater water release in dry years possibly compensated by a corresponding increase in winter electricity imports). Second, greater

benefits might be realized if, instead of maintaining the 4.2 bcm summer to winter transfer, a Rogun dam were operated so as to increase both summer flows in dry years and winter energy production in harsh winters.³⁵ Under such a scenario, (a) annual water allocations could remain as per existing arrangements , (b) a supplement to the existing arrangements could be added defining summer water share of each riparian country, (c) a new agreement among riparians could provide an explicit formulation for operation of the Vakhsh cascade to provide the specifically agreed levels of water supply and hydropower generation, (d) an independent, international monitoring mechanism could be put in place to document adherence with the agreement; and (e) if requested by the participating riparians, international guarantors (e.g., bilateral partners and development organizations) could be parties as witness or guarantor to the agreement to ensure or enhance compliance.

75. Reducing energy shortages in the short term would require additional measures such as those identified in the Tajikistan's Winter Energy Crisis report. Should countries agree to explore possible cooperative solutions, restarting electricity trade could provide immediate benefits and be part of an interim agreement while a long-term solution is being developed.

³⁵ Lower dams would be able to guarantee only smaller amounts of summer water and winter energy.