



TECHNO-ECONOMIC ASSESSMENT STUDY FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT

OSHPC BARKI TOJIK

Отчет фазы II: Варианты определения проекта Анализ рисков



Анализ Рисков

- **Задачи исследования**

- Обобщить и определить основные аспекты, которые могут повлиять на техническую осуществимость, привлекательность и устойчивость проекта.
- Определить слабые стороны и предложить смягчающие меры.

- **Методология**

- Определение главных рисков
- Оценка уровня риска (Вероятность*Стоимость последствий)
- Регулирование рисков при помощи смягчающих мер
- Переоценка уровня риска (Вероятность*Стоимость последствий) после реализации мер по смягчению последствий.



Методология

- **Определение ПРИЧИН**
 - 3 основные группы
 - Природная
 - Техническая
 - Экономически-финансовая
 - 2-уровневая детализация по каждой группе

LEVEL 1	LEVEL 2	LEVEL 3
Natural	Hydrology	Water availability Sediments Construction floods Rare floods GLOFs
	Geology / Geotechnics / Geomechanics	Salt dissolution in dam foundation Salt intrusion in RB RB-DS important instability Long-term creeping of faults Mudflows from Obishur R. and other streams Leakage from reservoir Co-seismic displacements Reservoir rim slope instability Dam material: inappropriate survey, inadequate material Structures-Caverns: rock excavation Co-seismic displacements Dam excavation: slope instabilities
	Tectonics-Seismicity	Earthquakes
	Weather	Temperature Rain Snow Ice
	Technical	Design
Construction		Diversion/Tailrace tunnels: construction quality Construction experience and technics. Equipment Construction schedule Contractual issues
Fabrication		Fabrication technics, materials, schedule Contractual issues
Maintenance & Operation		Maintenance: Experience of personnel. Schedule and planning Operation: Experience of personnel. Schedule and planning Monitoring programs
Decommissioning		Opportunity - Procedures
Economic-Financial	Market prices	Materials and equipment: Present and future conditions. Availability. Inflation.
	Energy demand	Mid- and long term changes in demand
	Funding	Availability of funds. Rates. Insurances.

Методология

Access		Reservoir system				Construction site			Dam system			Power & Energy system								Flood management system							
Permanent access	Construction access	Guilzidan fault area	Karstic structures	Rogun city	Reservoir rim	Site plants	Site equipments	Workers accommodations	Main dam	Stage 1 dam	Cofferdam	Pre-cofferdam	Energy production	EM: Transmission lines	EM: Switchyard	EM: Cable galleries	EM: Transformers	EM: Generator	EM: Turbines	CW: Tailrace tunnels	CW: Power house & TH	CW: Headrace tunnels	CW: Intakes	Surface spillway	High level Tunnels 1, (2), (3)	Mid Level tunnels 1,(2)	Diversion Tunnels 1,2,3

- **Определение воздействий**

- 6 систем компонентов проекта

- Система плотины
- Строительный участок
- Система водохранилища
- Подходные
- Система управления паводком
- Система электроэнергии и выдачи мощности

Методология

- Таблица оценки риска

- Уровень риска= Вероятность*Стоимость последствий

- Риск выражен в млн. долларов США

		CONSEQUENCE (Amount in M.USD)				
LIKELIHOOD		Insignificant	Minor	Moderate	Major	Extreme
		1	10	100	1 000	
10 %	Almost certain	1 : 1				
80 %	Likely	9 : 10				
10 %	Moderate	1 : 10				
	Unlikely	1 : 100				
	Rare	1 : 1 000				
	Extremely rare	1 : 10 000				

Методология

• 26 Таблиц по оценке рисков

- Общая информация (1)
- Определение (2)
- Описание (до реализации мер по смягчению последствий) (3)
- Меры по смягчению последствий (4)
- Остаточный риск (после реализации мер по смягчению последствий) (5)

(1)

(2)

(3)

(4)

(5)

GENERAL INFORMATION		TEAS Consortium - Phase II - Risk assessment		7/8/2013																																																																																																
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<table border="1"> <tr> <th>CAUSE (S)</th> <th>Likelihood</th> </tr> <tr> <td>1. Leaching of salt wedge within Ionakshah fault.</td> <td>Moderate</td> </tr> <tr> <td>2. Leaching of salt within the right bank.</td> <td>Unlikely</td> </tr> <tr> <td>3. Leaching of salt within the right bank.</td> <td>Unlikely</td> </tr> <tr> <td>4. Leaching of salt within the right bank.</td> <td>Unlikely</td> </tr> </table>		CAUSE (S)	Likelihood	1. Leaching of salt wedge within Ionakshah fault.	Moderate	2. Leaching of salt within the right bank.	Unlikely	3. Leaching of salt within the right bank.	Unlikely	4. Leaching of salt within the right bank.	Unlikely	<table border="1"> <tr> <th>IMPACT (S)</th> <th>Evaluation</th> </tr> <tr> <td>1. Deformation of foundation and dam body (stage 1, main dam).</td> <td>Moderate</td> </tr> <tr> <td>2. Creeping or sliding of power intake foundations.</td> <td>Moderate</td> </tr> <tr> <td>3. Damages to portals of diversion tunnels 1, 2. Damage to tunnel 3.</td> <td>Moderate</td> </tr> <tr> <td>4. Potential damage to mid-level outlet or high-level outlets.</td> <td>Moderate</td> </tr> </table>		IMPACT (S)	Evaluation	1. Deformation of foundation and dam body (stage 1, main dam).	Moderate	2. Creeping or sliding of power intake foundations.	Moderate	3. Damages to portals of diversion tunnels 1, 2. Damage to tunnel 3.	Moderate	4. Potential damage to mid-level outlet or high-level outlets.	Moderate	<table border="1"> <tr> <td style="background-color: lightgreen;">Risk</td> </tr> <tr> <td style="background-color: yellow;">Risk</td> </tr> <tr> <td style="background-color: lightyellow;">Risk</td> </tr> </table>	Risk	Risk	Risk																																																																									
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Comments a. The likelihood of reduction of efficiency of the hydraulic barrier will strongly depend upon its correct design and implementation during construction. It makes reference to excessive leaching. b. The loss of efficiency at long term of the grouting is unavoidable, due to the progressive creep of the Ionakshah Fault, and may be completely inefficient in case of co-seismic movement along this fault. c. Monitoring devices shall be selected and installed with care, in order to guarantee long-term service, within salty water.		Comments a. The hydraulic barrier is mostly necessary for the stage 1 dam. b. It is verified that loss of efficiency of grouting down to 0.3LU does not have any impact, according to salt leaching model; like hydraulic barrier, it is not really necessary for the main dam. c. Having the monitoring means failing to work, especially for stage 1 dam results in that any leaching will occur unnoticed, and damages can appear suddenly; risk is major for the stage 1 dam. d. It is supposed for the residual risk that dedicated investigations were carried out, such as the conditions of right bank are better known than today.		ADOPTED																																																																																																

Оценка рисков до и после реализации мер по смягчению последствий

- Меры по регулированию рисков, предлагаемые ИТЭО, позволяют снизить уровень риска;
- **После реализации мер по смягчению последствий, не наблюдаются никаких крупных или чрезвычайных рисков.**
- Некоторые случаи рисков специально оценены как Умеренные (несмотря на то, что данные риски могли быть оценены уровнем ниже), как напоминание о необходимости проведения дополнительных исследований или реализации мероприятий.

BEFORE MITIGATION						
		CONSEQUENCE (Amount in M.USD)				
LIKELIHOOD		Insignificant	Minor	Moderate	Major	Extreme
		1	10	100	1 000	
Almost certain	1 : 1			6, 14	4B, 11	4A, 7, 17
Likely	9 : 10			10A, 13, 21	16	2, 18, 20
Moderate	1 : 10			5	15C, 19	8A, 12, 15B
Unlikely	1 : 100					1, 3, 8B, 10B
Rare	1 : 1 000		15A			9
Extremely rare	1 : 10 000					

AFTER MITIGATION						
		CONSEQUENCE (Amount in M.USD)				
LIKELIHOOD		Insignificant	Minor	Moderate	Major	Extreme
		1	10	100	1 000	
Almost certain	1 : 1		4B	4A, 11		
Likely	9 : 10		13, 14	7, 17		
Moderate	1 : 10		6, 10A, 12	15C, 16, 18	15B	
Unlikely	1 : 100		21	5	8B, 19	20
Rare	1 : 1 000	9, 15A				1, 2, 3, 8A, 10B
Extremely rare	1 : 10 000					



–Только 6 рисков оценены как “Умеренные”:

- Седиментация (4А)
- Активный разлом с наполнением соли (7)
- Локально низкое качество породы (17)
- Высокое гидравлическое давление на затворы в гидротоннелях (20)
- Ползучесть разломов (11)
- Сейсмичность (15Б)

	BEFORE MITIGATION	AFTER MITIGATION
	6	0
	6	0
	11	6
	2	17
	1	3
Total	26	26

Table 85: Risk Distribution by Severity Level Before and After Mitigation Measures

	Extreme	Major	Moderate	Minor	Cause	Effect
A	4A	●			Sediments	Flood Management
	7	●			Salt Wedge	Dam Safety
	17	●			Rock Quality	Cavern Safety
	20	●			Design Head	Flood Management
	11	●			Creep in Faults	Flood Management
	15B	●			Seism.Displ.	Flood Management
B	18		●		Construction DTs	Flood Management
	2		●		Floods	Dam Safety
	4B		●		Sediments	Power and Energy
	12		●		Mudflows	Flood Management
	16		●		Dam Materials	Dam Safety
	8A		●		Reservoir Rim	Dam Safety
C			6	●	Earthquakes	Dam Safety
			14	●	Landslides	Construction Safety
			10A	●	Landslides	Dam Safety
			13	●	Reservoir Leakage	Power and Energy
			21	●	Constr. Schedule	Overcosts
			15C	●	Seism.Displ.	Power and Energy
			19	●	Design, Data	Overcosts, over delays
			1	●	Floods	Dam Safety
			3	●	GLOFs	Dam Safety
			8B	●	Salt-Gypsum	Structural Collapses
		10B	●	Landslides	Flood Management	
<i>Before:</i> 6 6 11 =23 <i>After :</i> 6 17 =23						

Седиментация (Риск №4А)

- Редкая растительность и крутые речные откосы способствуют смещению и переносу **крупнозернистого грунта** по реке в будущее водохранилище.
- **Через несколько десятилетий** абразивный материал достигнет водоприемник гидротоннелей, поставив под угрозу весь проект.
- Вследствие этого, **поверхностный водосброс был добавлен в проект** на высокой отметке, чтобы радикально продлить безопасный срок службы проекта.
- **Дополнительные исследования и изучения** затем будут проведены на следующих этапах проекта:
 - Для улучшения **сведений** о седиментации (характеристика и объем);
 - Для оптимизации **проекта для поверхностного водосброса**;
 - Для оценки возможности **когда** будет необходима первая часть и полный поверхностный водосброс.

Сейсмичность (Риск №15Б)

- Рогунский Гидроэнергетический проект расположен в **сложной сейсмо-тектонической среде**, где были определены активные разломы со значительным потенциалом колебания и сдвига.
- Сама плотина расположена в тектоническом блоке между **Йонахшским и Гулизинданским разломами**, двумя региональными разломами.
- Был разработан проект каменно-набросной плотины с непроницаемым ядром и соответствующей толщиной фильтрующих слоев, чтобы противостоять Максимальному Вероятному Землетрясению.
- Строительный тоннель № 3 и Водосбросной тоннель среднего уровня № 1 проходят Йонахшский разлом своими частями, расположенными в верхнем бьефе. **Эти тоннели** способствуют управлению паводком во время строительства.
- **У них короткий период воздействия** (период строительства), и соответствующие меры по смягчению были предусмотрены:
 - **Расширение и укрепление участка туннелей** вместе с дополнительным затвором вверх по течению, чтобы обеспечить контроль и ремонтные работы
 - На будущих этапах проекта должна быть пересмотрена уточняющая оценка **вычисления ко-сейсмических смещений** и должны быть уточнены **технические решения** в целях выполнения.

Анализ рисков - Выводы

- Крупные риски на Рогунской ГЭС резко сократились благодаря лучшему пониманию причин и реализации хорошо сработанных проектных решений и других планов по смягчению последствий.
- Из числа наиболее характерных рисков, оцененных в данной фазе исследований, только шесть из них специально были оценены как «умеренные». Данные риски оцениваются как «умеренные» в качестве напоминания для следующего этапа исследования о необходимости реализации комплексных мер по смягчению последствий.
- Пять из них имеют **естественные причины** (седиментация, сейсмичность, активный разлом с соляным заполнением, локально низкое качество породы), в то время как один из них по **причине проектирования** (слишком высокий гидравлический напор на затворах в гидротоннелях). Эти шесть случаев рисков тогда следует рассматривать как образец сложности и трудности проекта.
- На основе этих выводов данного анализа технического риска, **Рогунский Гидроэнергетический проект может продолжить свою разработку для следующего этапа исследований**, то есть детального проектирования выбранного варианта.
- **Дальнейшие анализ и исследования** должны быть проведены на следующих этапах проекта, более подробно согласно рекомендациям.

СПАСИБО ЗА ВНИМАНИЕ



COYNE ET BELLIER
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IPA
Energy + Water Economics

TECHNO-ECONOMIC ASSESSMENT STUDY
FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT