NIS ChBD Shymkent city

NPP in Balkhash

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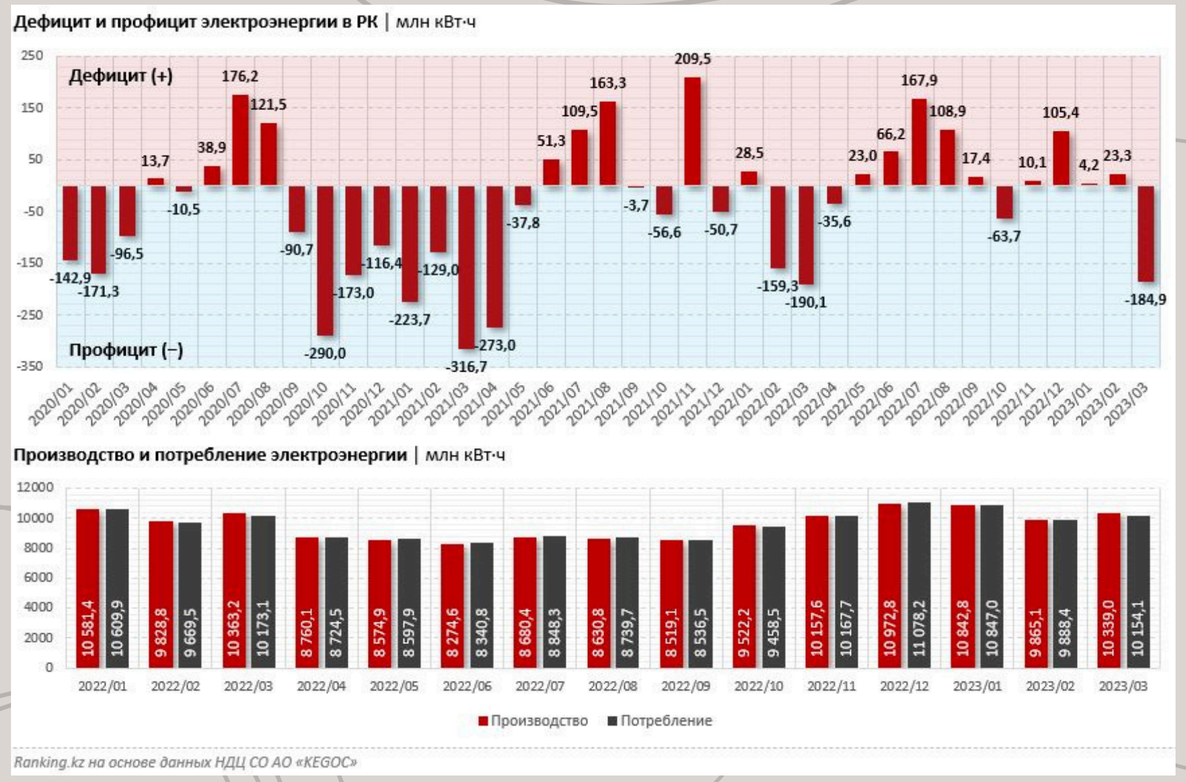
Abstract

Currently, the consumption of electricity in Kazakhstan is increasing exponentially year by year. In the future, it will become increasingly difficult to meet this demand using energy from thermal power plants or similar sources. To address this issue, a project to construct a Nuclear Power Plant (NPP) near Balkhash has been proposed. **In this study, we will investigate the suitability of Balkhash's water for use in the NPP and identify the most efficient reactor type.** This will involve conducting laboratory analyses of the water and performing experiments using a small-scale reactor model.

Background

The region is facing a critical shortage of electricity due to rapidly increasing consumption. This growing demand has exacerbated challenges in securing a stable and sustainable energy source, **highlighting** the need for alternative solutions to meet the region's energy needs.



Problem Statement

Balkhash is an important natural resource of Kazakhstan. With the growth of energy needs, the possibility of using it for cooling the nuclear power plant is being considered. But this may cause some environmental and economic problems, including changes in the level and quality of water in the lake. The purpose of the work is to **assess the water resources and determine the suitability of Balkhash for cooling the nuclear power plant, taking into account all the risks and issues.**

Context

The **USA**, **France**, **Russia**, **China**, and **Japan** use water bodies for cooling nuclear power plants. Their experience highlights the importance of monitoring environmental impact, protecting against natural disasters, optimizing resources and technologies. International cooperation and knowledge exchange aid in developing effective cooling systems, focusing on safety, backup systems, and risk minimization to enhance efficiency.

Context

The most recent proposal for nuclear powerplant construction was mentioned by the current president on 31st August, 2023 and the corresponding referendum is planned to be held on the Autumn of 2024. Previously, the same subject proposed in the years of 1997, 2006 and 2014 by various politicians, though, none of the cases ended in the powerplant construction. Nevertheless, the government itself holds a rather positive attitude towards the use nuclear energy.

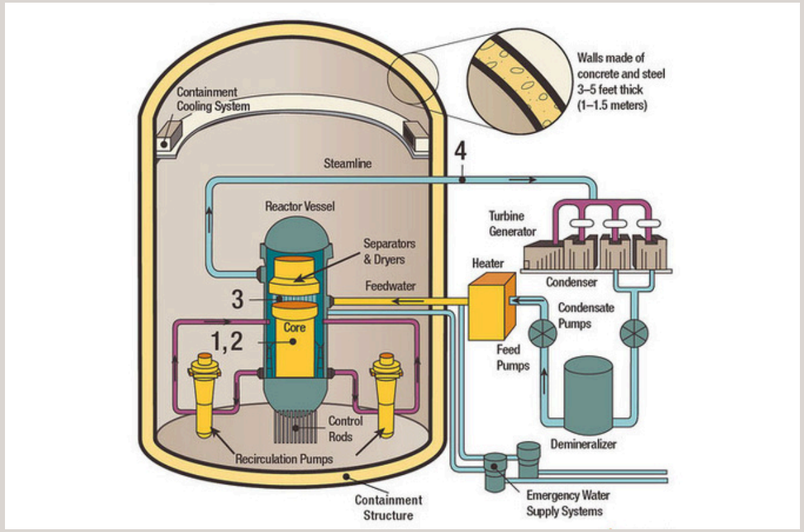
On the other hand, public's opinion is mixed: some admit that there is an urgent need for efficient energy source such as nuclear powerplant, while others are concerned about the danger to the nature in case of its "explosion". The latter groups viewpoint is reinforced by misconceptions brought by previous powerplant malfunction cases. Apart from that, there is the 3rd groups of people, who agree on powerplant construction, but demand the lack of involvement of other countries such as Russia.

Reactor technology

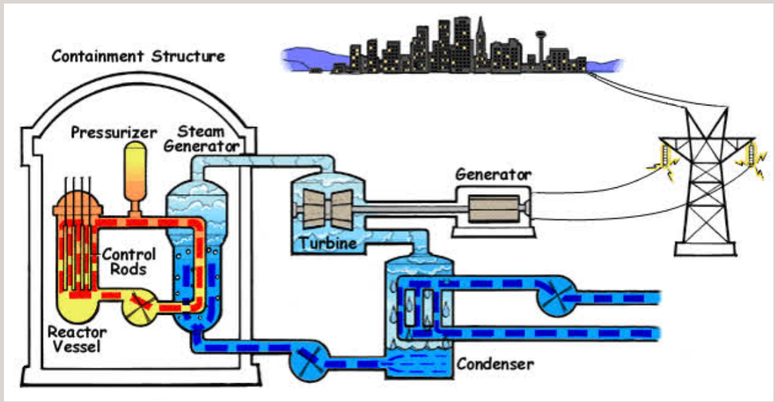
PWR

Pressurized Water Reactors (PWRs) dominate globally, with around 300 of 440 reactors. They use light water for cooling and neutron moderation in a two-loop system. The high-pressure primary loop prevents water from boiling and transfers heat to the secondary loop through a heat exchanger. In the secondary loop, the water turns to steam, which powers turbines to generate electricity.

BWR



PWR



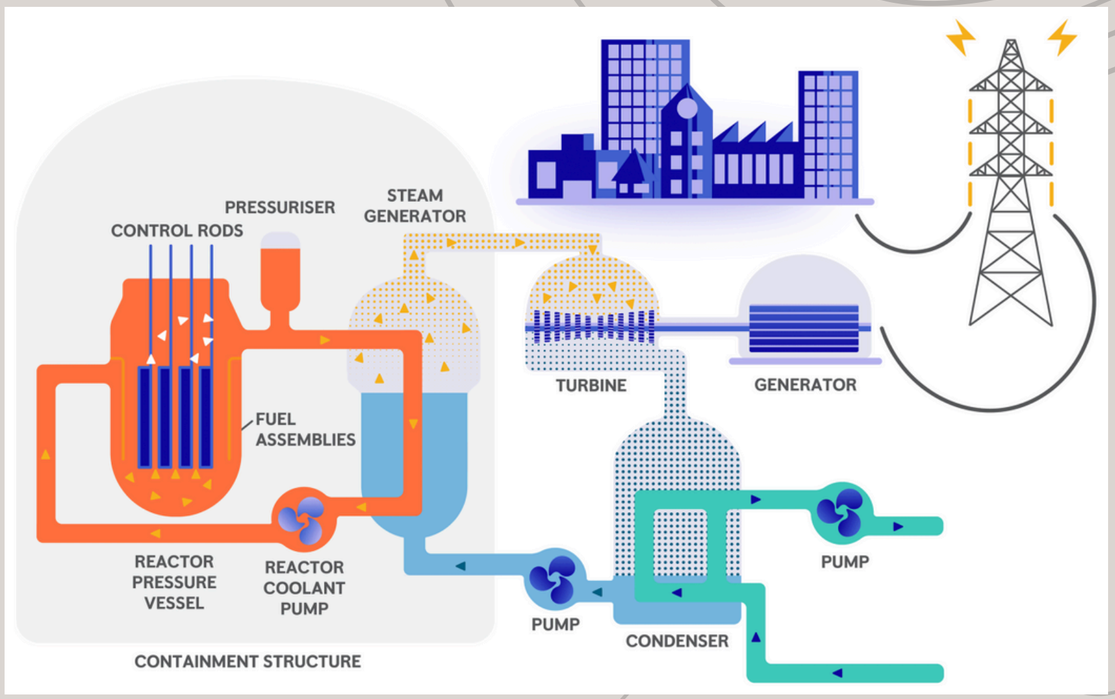
BWR

A Boiling Water Reactor (BWR) is a nuclear reactor using light water as both coolant and moderator. Its key feature is a single-loop system, where water boils in the reactor core to produce steam that drives a turbine, generating electricity. Unlike Pressurized Water Reactors (PWRs), BWRs don't use a two-loop system with pressurized water to prevent boiling.

Reactor technology

SMR

Small modular reactors are a modern type of modular reactors with a capacity of up to 300 Megawatts per power unit. This capacity is one third of the generating capacity of conventional reactors. They are so called because they are several times smaller than traditional nuclear reactors, they are easy to assemble in a factory and transport entirely to the site, and they use nuclear fission to generate power.



Methodology

Aim

Evaluate Lake Balkhash's suitability for NPP cooling by analyzing water quality and predicting ecological impacts.

Biological Analysis

Examine aquatic species and detect pathogens

Water Sampling

Collect samples from various depths and locations

Modeling

Predict thermal impacts and ecosystem changes

Physico-Chemical Analysis

Assess temperature, pH, mineralization, dissolved oxygen, and pollutants

Comparative Analysis

Compare results with similar studies from other cooling water sources

Biological analysis

FLORA

-Emerged macrophytes
-Submerged macrophytes
-Phytoplankton

FAUNA

-Zooplankton
-Benthos
-Fish

BIOMASS

Biomass of phytoplankton: 1.127 [g l-1].
Biomass of zooplankton: 1.87 [g l-1].
Biomass of benthos [g m-2]
For the western part: 3.07.
For the eastern part: 3.75.

Physico-Chemical analysis

- Water temperature [deg C]

Depth [m]	Jan	Feb	Mar	Apr	May	Jun	Jul
S*1	-	-0.2	0.2	-	13.9	19.0	23.4
2	-	0.4	-	-	13.4	17.7	22.7
5	-	0.7	-	-	12.0	17.2	22.4
10	-	1.0	-	-	10.8	16.7	21.7
15	-	1.6	-	-	9.3	16.3	19.9

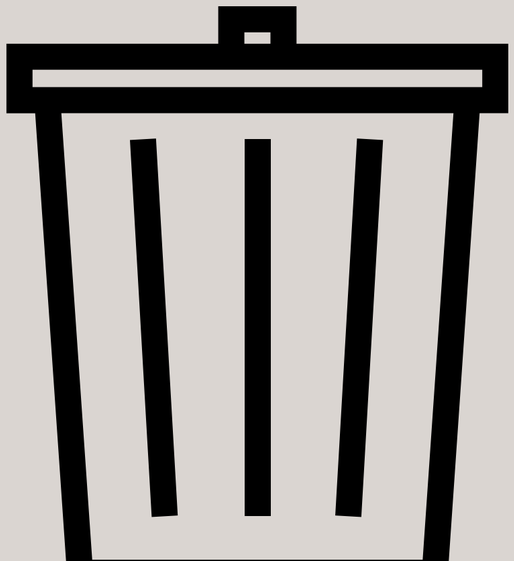
E2 pH

Depth [m]	Jan	Feb	Mar	Apr	May	Jun	Jul
S*1	-	9.0	8.8	-	9.0	-	9.0
N*2	-	9.0	8.8	-	9.0	-	9.0
Station 74, 1981 1983							
S	-	8.6	8.6	8.6	8.6	8.6	8.5
N	-	8.6	8.6	8.6	8.6	8.6	8.5

*1 Surface. *2 Near bottom.

Waste

Name of contaminant	Range of concentrations in water [mg l-1]		
	1987	1988	1989
Oil products	0.000-0.780	0.000-0.320	0.000-0.670
Phenol	0.000-0.004	0.000-0.000	0.000-0.009
Cu	0.012-0.058	0.017-0.051	0.003-0.048



Discussion part

Lake Balkhash presents both opportunities and challenges for use as a cooling source for a nuclear power plant. Seasonal temperature variations, ranging from -0.2°C to 23.4°C, could complicate stable cooling. Water transparency, from 4.2 m in January to 12 m in July, affects aquatic life and water quality, which may be impacted by thermal discharge. The lake's alkaline pH (8.6-9.0) is suitable for operations but may need treatment. High biomass levels of phytoplankton (1.127 g/l) and zooplankton (1.87 g/l) suggest a rich ecosystem that could be disrupted by plant activity. Additionally, contamination from copper (up to 0.058 mg/l) and oil products raises environmental concerns, requiring strict pollution controls and risk mitigation strategies.

Reference

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