Conclusion

In this project we developed a nuclear power plant as an alternative to a thermal power plant that has spent its life and that effects on the reduction of CO_2 emissions into the atmosphere which helps to preserve the environment. We have presented the calculations of the project for the construction of a complete nuclear power plant in addition to a water desalination plant to support this plant. It can also be benefited from the water desalination plant for civil use and be a source of potable water.

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ADVANCED TURBINE REGENERATION SYSTEM WITH DIFFERENT NUMBER OF HIGH-PRESSURE HEATERS

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Introduction

The course of the globe is changing. Our world continues to be heavily dependent on fossil fuels despite the significant efforts to decarbonize the economy and the many billions spent on those initiatives. Over 80% of the world's energy still comes from fossil fuels, and the trend is clear: rather than reducing our reliance on fossil fuels, we are growing it. A global initiative is in way to create a sustainable energy system. The demand for clean, plentiful, and affordable electricity is at the center of this initiative.

The utilization of nuclear energy offers a quick pathway to a high-powered, clean energy system that is inexpensive, results in a healthier environment, and increases a nation's energy security.

The only low carbon technology that has been shown to work and can be implemented at the pace and scale necessary to meet the goals of the Paris Agreement are large-scale nuclear reactors. Regardless of the weather or the time of year, these reactors quietly operate in the background while providing enormous amounts of power constantly. The operational performance of nuclear energy is outstanding on a global scale, with many reactors achieving capacity factors above 80% on average.

Current nuclear power facilities throughout the globe are built on tested technology that has developed and matured over the past 40 years. These reactors, which have capacities ranging from roughly 600MWe to 1700MWe, offer their national systems a safe and reliable source of electricity.

This project's objectives included developing a nuclear power unit with 900 MW, figuring out the best way to balance efficiency and economic concerns, and upgrading the nuclear power plant's Feed water heating system – heat regeneration. These developments were necessary because they would meet the needs of countries in the Middle East and South Asia.

1. Heat regeneration for the feed water heating system

The feedwater heating system typically includes:

- low-pressure feedwater heaters;
- deaerator;
- high-pressure feedwater heaters.

1.1 low-pressure feedwater heaters

Condensate from condensate pumps is then passed via a series of low-pressure feedwater heaters, where heat transfer from steam derived from low-pressure turbines raises the condensate's temperature. The cascade of low-pressure feedwater heaters typically has three or four stages. At around, the condensate leaves the low-pressure feedwater heaters. approximately p = 1 MPa, t = 150°C, and enters the deaerator. A mechanical condensate purification system for eliminating contaminants is also part of the main condensate system. Self-regulating feedwater heaters are available. It implies that the rate of heat absorption from the steam and the flow of extraction steam increase with feedwater flow.

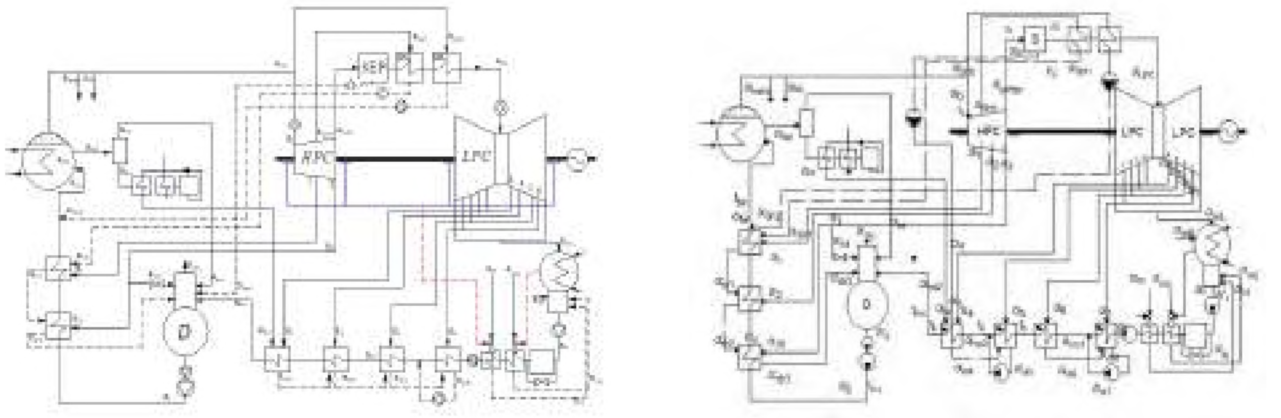

Fig. 1. Scheme of a typical 900 MW steam turbine from VVER

Between the feedwater heaters and the turbine, the extraction steam lines have non-return valves. In the event of a turbine trip, these non-return valves stop the flow of steam or water in the opposite direction, resulting in a sharp drop in pressure inside the turbine. Any water that enters the turbine in this way has the potential to seriously harm the turbine blading.

1.2 deaerator

In the deaerator, the condensate is typically heated to saturated conditions using steam that is taken from the steam turbine. A system of spray nozzles and cascading trays between which the steam percolates mixes the extraction steam in the deaerator. This procedure results in the release of any dissolved gases in the condensate, which are then eliminated from the deaerator by venting to the atmosphere or the main condenser.

The feedwater storage tank is located directly beneath the deaerator, where a sizable amount of feedwater is kept at close to saturation levels. This feedwater can be provided to steam generators in the turbine trip event to keep the necessary water inventory during a transient. In order to provide an appropriate net positive suction head (NPSH) at the entrance of the feedwater pumps, the deaerator and the storage tank are typically situated at a high elevation in the turbine hall.

NPSH is a metric for gauging a fluid's proximity to saturation. Cavitation can be produced by decreasing the suction side pressure.

The chance of cavitation in the pump is reduced by this configuration.

1.3 high-pressure feedwater heaters

The feedwater output from the pumps enters the containment, passes through the high-pressure feedwater heaters, and then enters the steam generators.

By drawing steam from the high-pressure turbine, or HP Turbine, the high-pressure feedwater heaters are heated. Deaerators typically receive drains from high-pressure feedwater heaters. Through the feedwater inlet, feedwater is injected into the steam generator.

2. Initial data:

Table 1. Intial data

$n\ HPH$	2	3
N_e MW	900	900
P_0, MPa	7,3	7,3
t_0, ℃	t_s (288,7)	288,7
P_C, kPa	4	4
$Superheater$	double-stage	double-stage
t_{fw},°C	240	240
P_d, MPa	1,1	0,6

- Reactor Power is 900 MW.
- I took $P_0 = 7{,}3$ MPa, because t_{fw} will be high and will give me a higherefficiency.

Increased initial temperature causes increase in η_t, effects η_{oi} since:

1. As steam expands, its specific volume rises; as a result, the first stage turbine blades' height rises.
2. The ultimate level of moisture declines, resulting in a reduction in moisture-related losses in the last stages of the turbine.

- p_C = 4 ÷ 6 kPa, I have chosen the minimum because

1. Thermal efficiency rises when the final pressure is lower because the cycle's heat losses are reduced.
2. The steam humidity rises at the end of the expansion phase as the pressure at the turbine's outlet decreases, increasing losses in the turbine.
3. Due to the expansion of the heat-exchange surface, capital expenses rise when attempting to approximate the temperature of steam in a condenser to that of cooling water.

The efficiency of the turbine decreases by 1,25 % for every kPa rise in condenser pressure.

- P_d= 1,1 MPa, I have chosen high pressure in deaerator to obtain My goalwhich is high efficiency, the steam system is shielded from corrosive gas effects by deaeration. By lowering the concentration of dissolved oxygen and carbon dioxide to a point where corrosion is minimal.
- Steam is passing through a moisture separator to remove the condensed moisture prior to further expansion in the low-pressure turbines Installation with intermediate double separation. Removal of moisture from the high-pressure exhaust steam helps to prevent low-pressure blading degradation (keep steam humidity below the limited values).
- the second intermediate separation is used as second stage of the separation because of the intermediate turbine cylinder and to keep the quality of the steam.
- t_{fw} = 240 °C, I took feed water temperature to reduce the number of heaters.

  Feedwater temperature increase

  1. Amount of heat added in the SG decreases
  2. Size and cost of low-pressure equipment (LPC, condenser, etc.) decrees.

3. Results

Table 2. Results

$n\ HPH$	2	3
Q_{SG}	$2488\ MW$	$2440{,}74\ MW$
Q_{TS}	$2452\ MW$	$2439{,}27\ MW$
G_{SG}	$1347{,}4 kg/s$	$1341{,}6 kg/s$
bnf	$18{,}73\ ton/year$	$18{,}42\ ton/year$
η_{NPP}	35,00 %	35,70 %

Conclusion

In this work, a 900 MW nuclear power unit with an increased efficiency was developed. This is due to high values steam pressure ($7{,}3\ MPa$) and feed water temperature (240 °C).

As a result of the calculated comparison of schemes with two and three HPHs, it was found that the efficiency of a power unit with three HPHs is 0,7% higher.

The preference for further development was given to a simpler scheme with two HPHs. In addition to simplicity, such a scheme requires significantly less investment.

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ANALYSIS OF THE EFFICIENCY OF STEAM REHEATING SCHEMES AND DESIGN OF NUCLEAR POWER PLANTS

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Goal of MSR:

Moisture separator reheaters (MSRs) are installed after high-pressure; their purpose is to reheat cycle steam and remove cycle steam moisture, High-pressure, high temperature, steam, is used to further heat the cycle steam. High pressure steam passes through the inside tube shell and tube heat exchanger on the tube side. The cycle steam passes over the outside of the tubes and is thus the shell-side fluid. The temperature of the cycle steam increases as it passes over the heat exchanger tubes, Moisture (condensate) that has been separated from the steam, is drained from the system via the condensate drain, condensate is fed back to the steam generator feedwater system. After moisture has been removed from the cycle steam, and the cycle steam has been reheated, the steam is then fed to the low-pressure turbine [1].

Comparison between Vertical & Horizontal MSR:

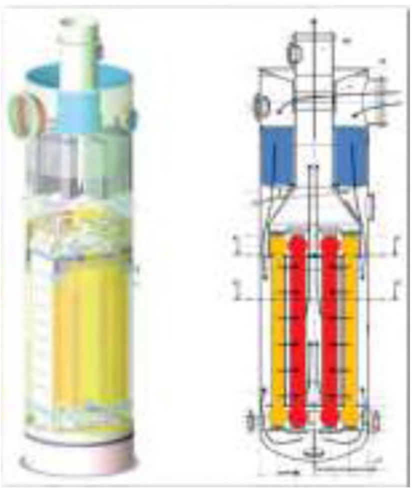

Fig. 1. MSR of the firm Black Durr for Lovisa NPP (Finland)[2]