

# Emission Free Lanzhou

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## Introduction

Lanzhou was once the most polluted city in China, which is why huge steps have been taken to reduce the pollution. As of today only a few fossil power plants are left, of which Guodian Yuzhong coal power plant is one. For the purpose of finding a potential replacement that relies on renewable energy, an analysis has been conducted on the American Crescent Dunes solar power plant. The results of this research are presented on this poster.

The research was done by splitting it up into a few aspects. First, a thermodynamic analysis was done of the current power plant in Crescent Dunes, which works by heating salt and water using the sun. This was done to find the different efficiencies of the power plant. Secondly, there was a selection made of all of the materials suited best for each component. These materials were chosen on a failure mechanisms which were deemed important for said component.

## Thermodynamic Analysis

A T-s diagram is shown in figure 1 which shows the process of the Crescent Dunes Power Plant.

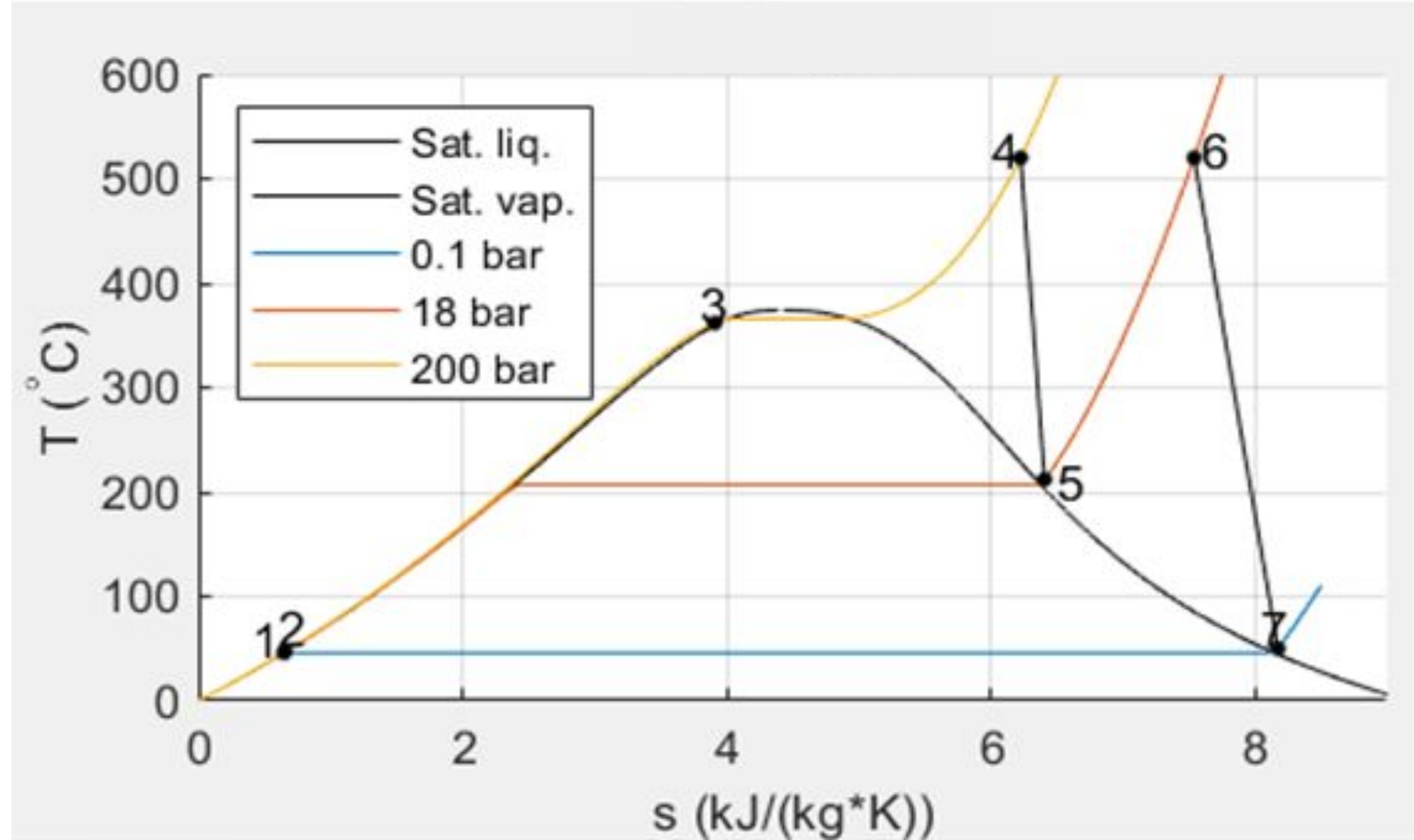


Figure 1: T-s diagram of the Crescent Dunes power plant.

## Sankey diagram

The diagram itself takes into account both circuits, but the information itself can be represented by the water circuit alone. This is due to the fact that the changes in entropy and enthalpy in the salt circuit are negligible. Thus, the whole salt circuit is treated as the direct energy source for the water circuit; they provide the initial energy source through heat exchangers 1, 2 and 3 (as  $Q_{in1}$ ,  $Q_{in,2}$  and  $Q_{in,3}$  respectively).

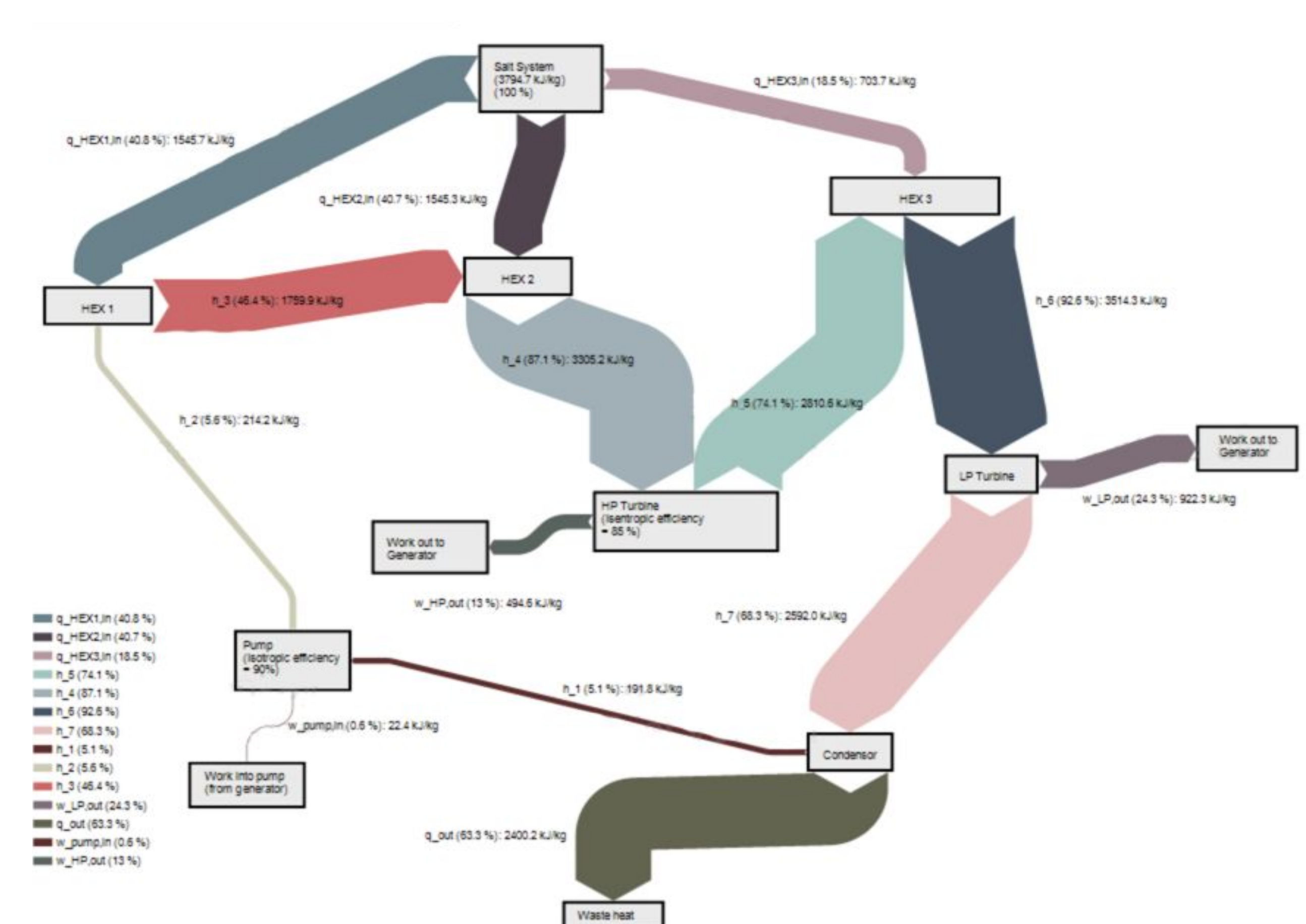


Figure 2: Sankey Diagram of the Crescent Dunes Solar Power Plant

## Efficiencies

After looking at the flow of energy in all points of the thermodynamic cycle, the most important efficiencies could be calculated, using the input heat, output heat and work. Since these were given, it could be calculated:

- $\eta_{thermal}$  = 37.0 %
- $\eta_{carnot}$  = 59.3 %
- $\eta_{electrical}$  = 36.6 %
- $\eta_{second\ law}$  = 62.0 %

## Grassmann Diagram

The Grassmann diagram, much like the Sankey diagram, represents the distribution of exergy. Exergy gives a more in-depth view of the energy distribution, thus a different perspective on energy balances, efficiencies and energy losses.

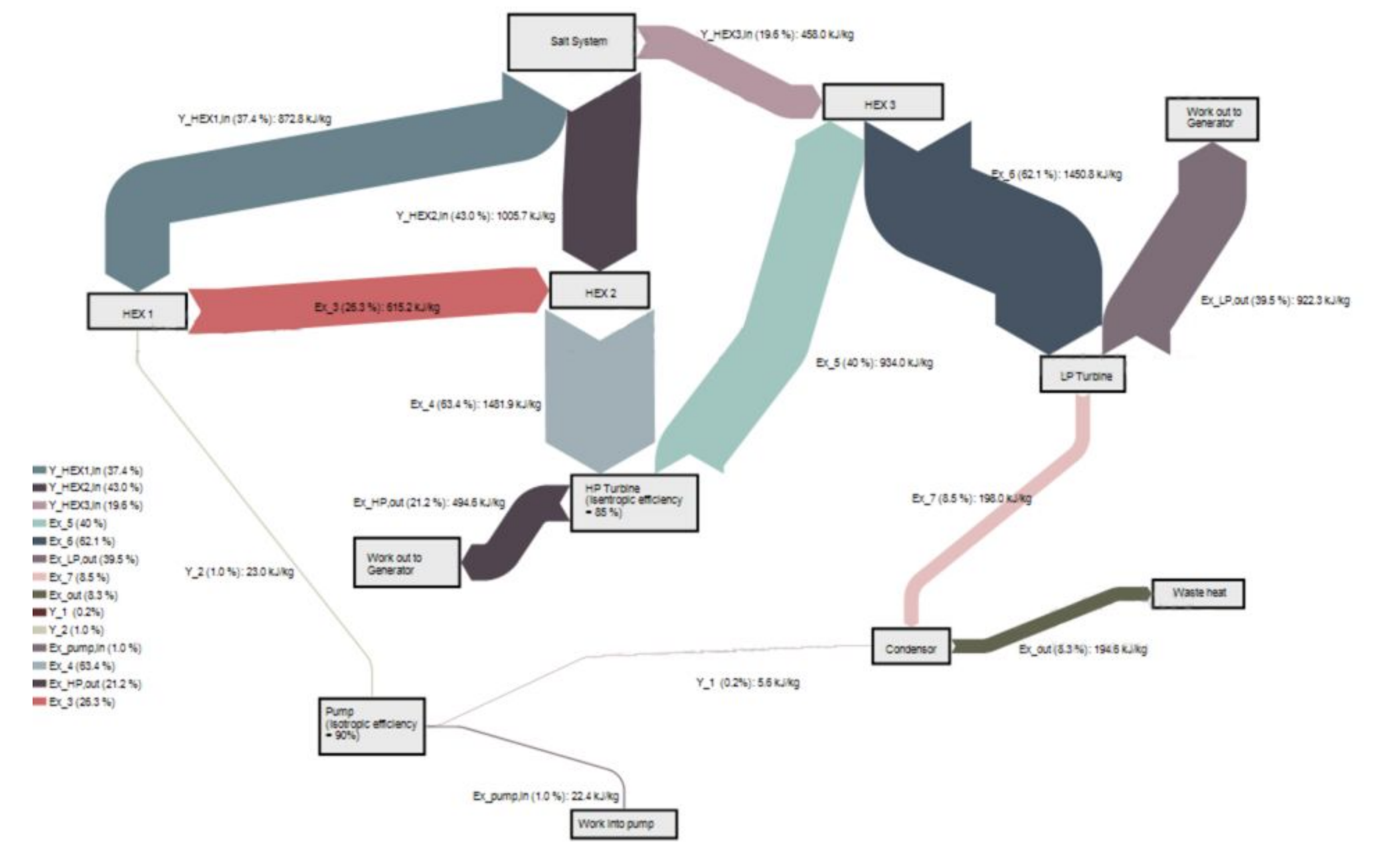


Figure 3: Grassmann Diagram of the Crescent Dunes Power Plant.

## Materials Selection

The material for several parts of the power plant had to be selected. This was done by making a careful selection of several materials for each part and comparing their properties to each other depending on their function and failure mechanisms.

Part	Failure Mechanisms				Materials
	Corrosion	Creep	Fatigue	Leaking	
Cold salt storage					Concrete
Hot salt storage					Concrete
Condenser					Age hardening aluminum alloys
High pressure turbine					Stainless steel
Low pressure turbine					Nickel-based superalloys
Heat exchanger 2					Nickel-based superalloys
Mixing chamber					Nickel-chromium alloys
Salt circulation pump					Nickel-based superalloys
Pipe					Stainless steel

Legend				
Important		Not important	Does not matter	

## Conclusion

Through analysis of different aspects of electricity generation and consumption in the Chinese city of Lanzhou, it can be concluded that a solar power plant that functions like the American Crescent Dunes Solar Power Plant, would not be sufficient for Lanzhou in terms of energy needs as of right now. The Crescent Dunes Solar Power Plant generates 110 MW of power, while the Guodian Yuzhong coal power plant produces 220 MW of power that is used by the city. For the sake of future proofing, the population growth and the solar intensity in Lanzhou also has to be taken into consideration for a new solar plant, resulting in a design that is of a considerably bigger scale than Crescent Dunes.

Furthermore we have found the different efficiencies for the Crescent Dunes power plant in the thermodynamic analysis and some recommendations were made for the material selection of the new power plant.

## References

- (1) Project description. "Sustainable Lanzhou – Analysis of an Energy System," Enschede: University of Twente, 2018.
- (2) Y.A. Cengel, M.A. Boles. And M. Kanoglu, *Thermodynamics, An Engineering Approach*, 9th ed. NYC: McGraw Hill Education, 2019.
- (3) W.D. Callister., *Materials Science and Engineering, an Introduction*, 9th ed. Hoboken, John Wiley & Sons, 2014.