Solar Chimney Power Plant

ABDULLAH ALFARES – GHAITH ALMADANI – IBRAHIM ALBIEBI – WALEED ABOUKHATER

Introduction

- **Project Statement:** Solar chimney power plant system (SCPPS) is a design concept for a renewable-energy power plant for generating electricity from the heat of the solar radiation.

- **Deliverables:**
  - Structural analysis and design.
  - Energy output.
  - Analyze the heat transfer and wind flow.
  - Prototype.

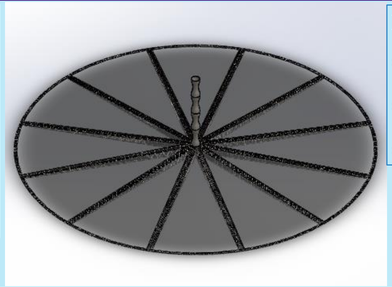
- **Specifications:**
  - **Chimney diameter < 100 m.**
  - **Chimney height < 1000 m.**
  - **Collector radius < 2000 m.**
  - **Power generation = 50 MW.**

- **Constraints:**
  - **High initial cost.**
  - **Intermittent of solar radiation and wind.**
  - **Lack of power generation due to scaling down.**

SCPP Form

Current Process

The SolidWorks form of the actual design with the design of the steel trusses which are needed to hold the glass collector that having a total area of 1.119e+07 m^2 where air will get heated by absorbing the heat from solar radiation.



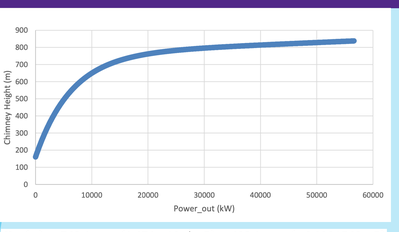
Dimensions:

Chimney height = 832 m.

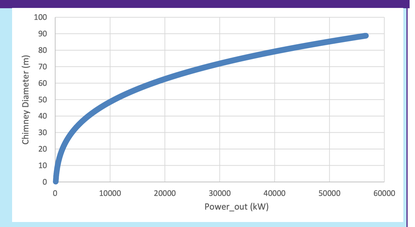
Chimney diameter = 86 m.

Collector radius = 1888 m.

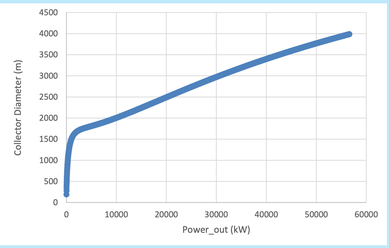
Mathematical Model



$$H_{ch}(m) = 762.4 * \exp(1.674 * 10^{-6} * P) - 602.1 * \exp(-0.0001569 * P)$$



$$D_{ch}(m) = 5.906 * (P)^{0.2662} - 19.93$$



$$D_{col}(m) = \sqrt{\frac{4 * P * (T_{top} + 273) * C_p}{\pi * (\frac{I}{1000}) * \eta_{wt} * \eta_{ch} * \eta_{col} * 9.81 * H_{ch}}}$$

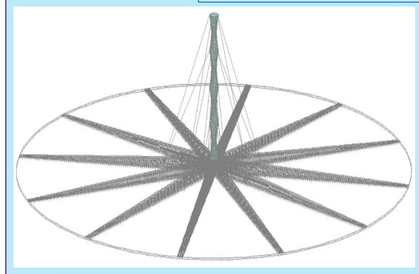
Assumptions:
- Compressible flow.
- 3D flow.
- Negligible body forces.

Bisha's ambient conditions:

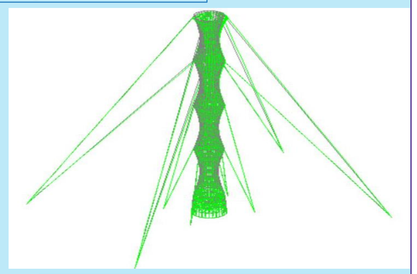
Average	Value	Unit
G	810.8	W/m^2
Ts	297.1	K
Vair	4.9	m/s

Design & Testing

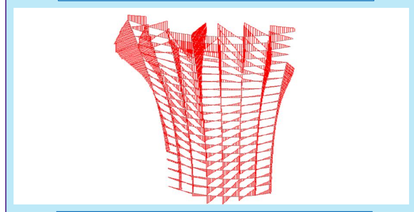
Structural Design using STAAD.PRO



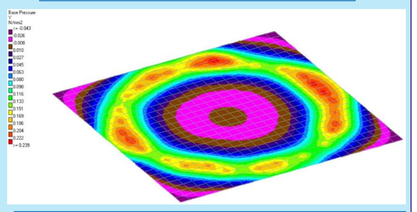
SCPP Structural Design Overview.



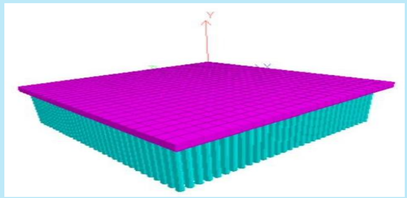
Chimney Deflection Diagram.



Chimney Bending Moment Diagram.

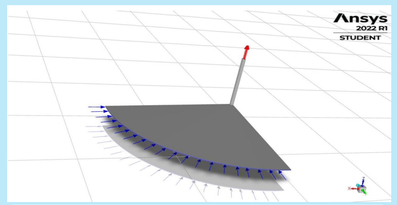


Pressure Distribution on Raft Foundation.

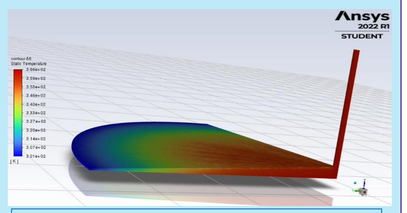


Mat Supported Piles.

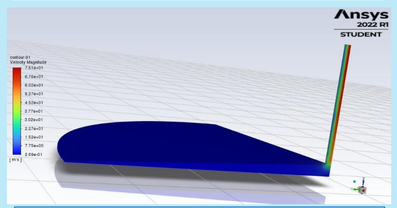
Flow Analysis using Ansys Fluent.



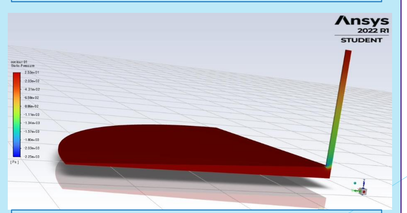
90 Degree design of SCPP in Ansys Fluent.



Temperature distribution of SCPP.



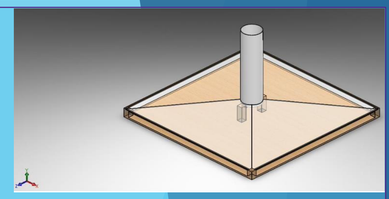
Velocity distribution of SCPP.



Static pressure distribution of SCPP.

Prototype Details

The prototype is made of three parts to complete its shape. It is designed to be a four-sided shape to ease manufacturing of glass. The three parts that we design to complete the prototype are:
1. Base of collector
2. Solar Glass Collector
3. Chimney Tower



Dimensions:

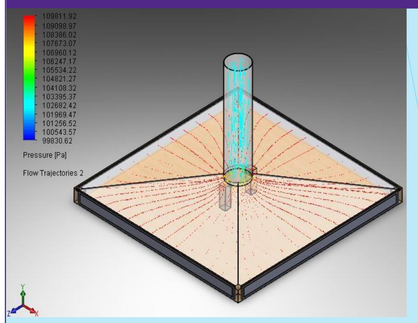
Chimney height = 1 m.

Chimney diameter = 0.22 m.

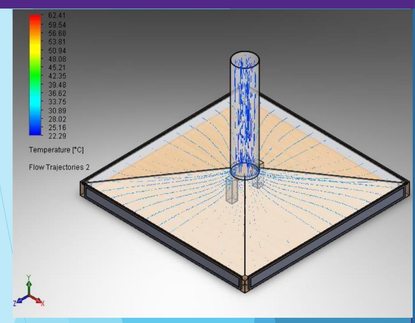
1.7 m x 1.7 m square collector

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Base of collector	wood	1
2	chimney	Plastic	1
3	glass collector try	Glass	1

Prototype Testing

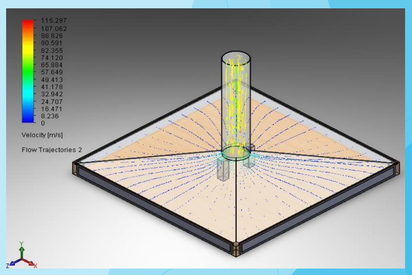


Total Pressure Analysis



Air Temperature Analysis.

By simulating the prototype using SolidWorks a deep view of the working mechanism of the solar chimney effect on air. The next figure is a velocity analysis used to illustrate the effect of the solar radiation and the effect of updraft force on the air. the pressure is moving from the high-pressure point to the low-pressure point.



Air Velocity Analysis.

the temperatures was not affected as expected and it is not totally surprising due to dimension of the prototype is insignificant as compared to the actual design.

Conclusion

The Saudi Arabian government's 2030 vision, which includes a major effort to cut its reliance on fossil fuels by a third and meet this need with renewable energy sources, is another factor in the decision to use SCPPS. By the findings of this project, it can be concluded that SCPP can play a major role in this contribution. finally, a detailed cost estimation showed a total cost of 734,661,187.2 Riyals. also, by finishing this proposal we succeeded to meet our specification by achieving a chimney height of 832 m with a diameter of 86 m and a collector radius of 1888 m while generating a total of 50 MW.