# PHOENICS Case Study: Environmental Flow through a Solar Updraft Tower

A Solar Updraft Tower is a relatively low cost, low tech, renewable energy system to generating electricity from solar power.
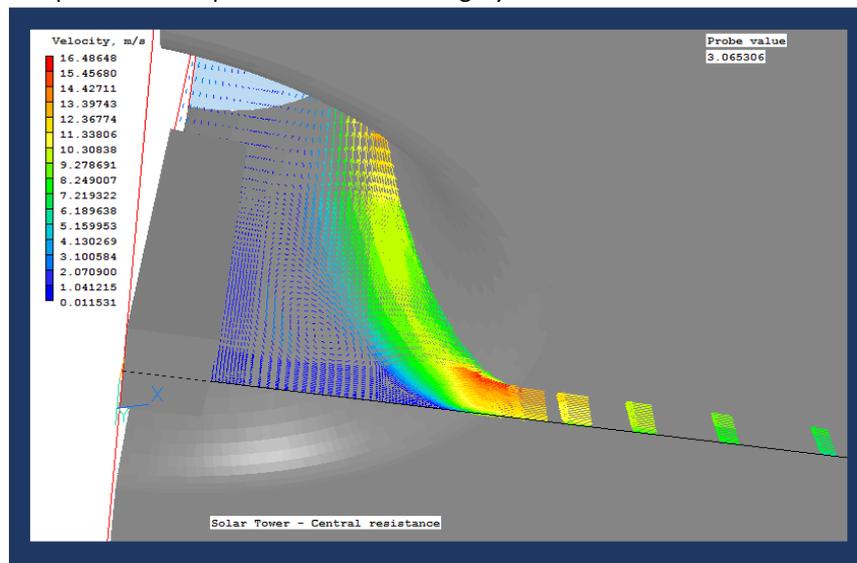
The system combines "chimney" and "greenhouse" effects to drive a wind turbine housed in the tower's base. Air is heated via solar gain through an inclined Perspex roof (or plastic sheeting) of a vast greenhouse surrounding the base of a tall chimney.

The air is drawn towards its centre and the resulting convection causes it to rise rapidly up, through the tower, driving one or more turbines. A secondary benefit is that the greenhouse can still be used for growing produce.
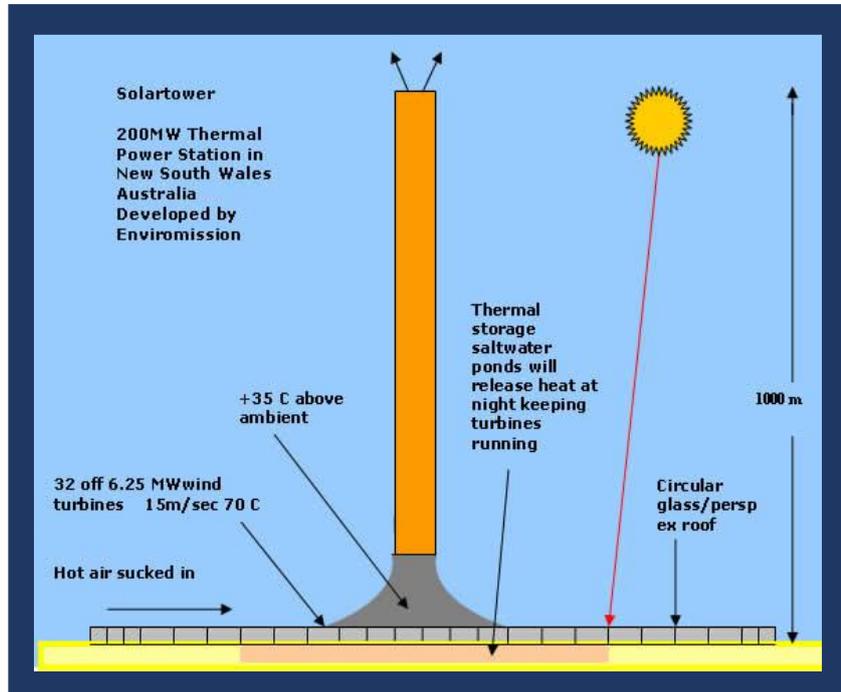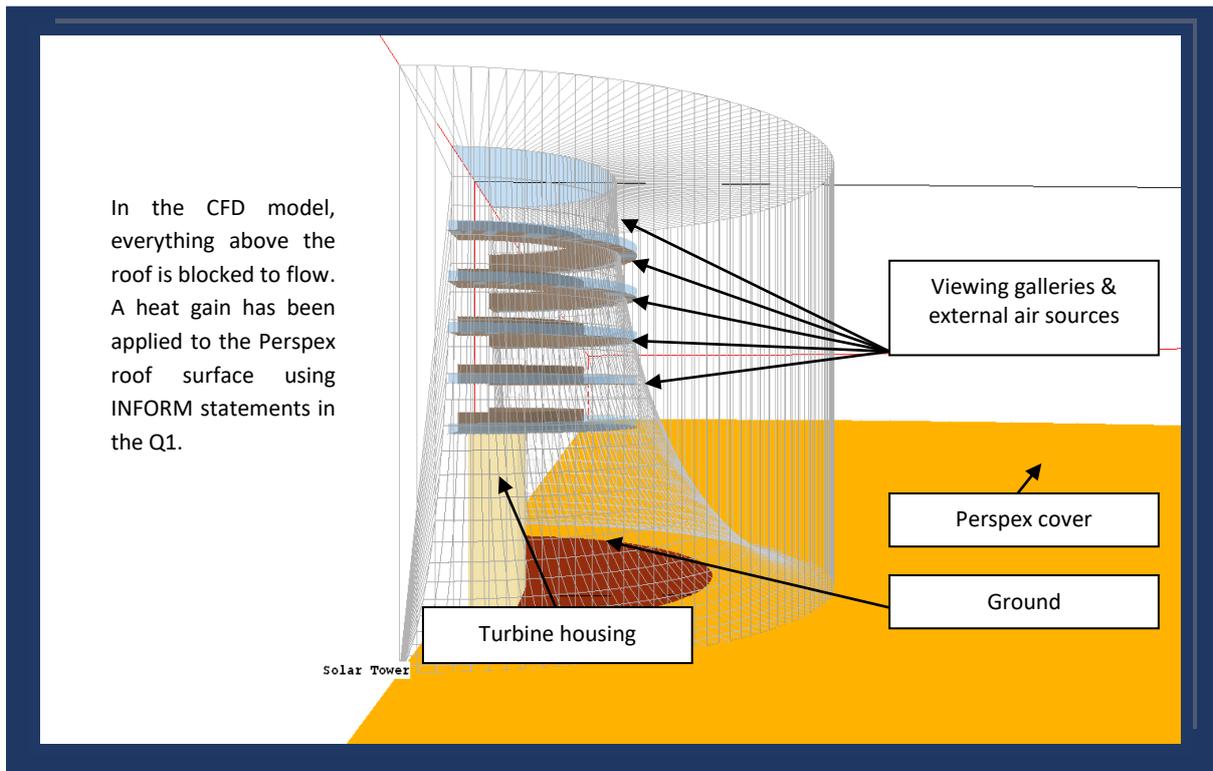

In this PHOENICS demonstration case, the grey cone sits at the centre of a large cylinder (about 6Km in diameter) representing Perspex covering, 3m high at the perimeter and 15m high at the base of the cone.
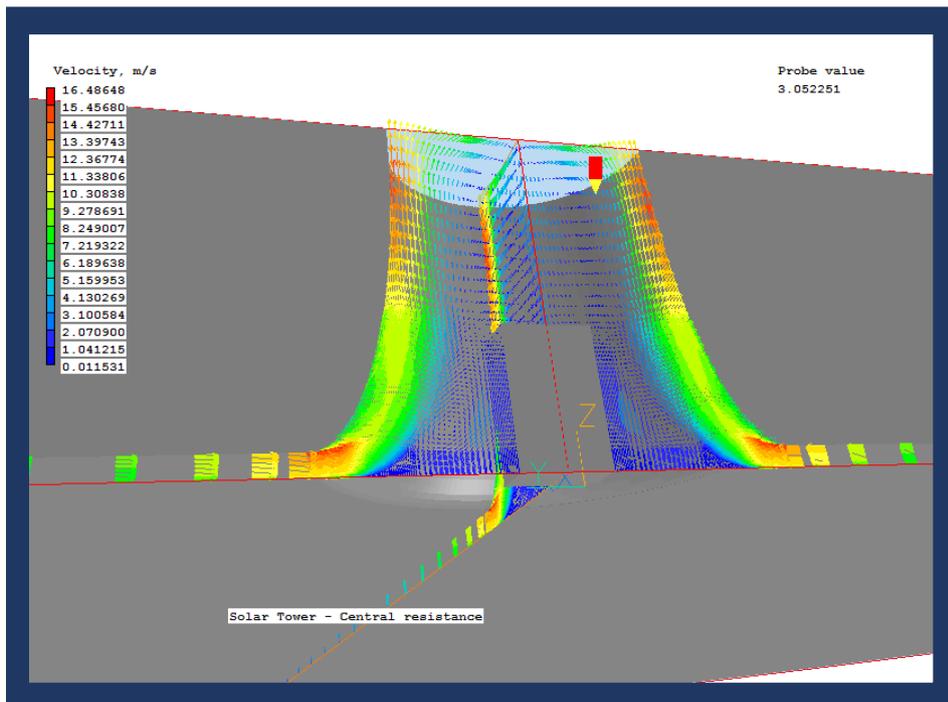
The perimeter is open to let in air. The grey cone is 300m in diameter at its base and 200m at the top, and

250m high. There is a turbine at the top of the cone (and a tall chimney above that - but it's not present in this model.). The cone is quite complicated internally but, for demonstration purposes, is represented simply as a blockage. [There is also a thermal storage reservoir underneath the tower complex to keep the turbine running overnight; this is ignored in the CFD model.]

In the CFD model, everything above the roof is blocked to flow. A heat gain has been applied to the Perspex roof surface using INFORM statements in the Q1.

Viewing galleries & external air sources

Perspex cover

Ground

Turbine housing

Solar Tower

The above image shows the inside of the tower. There are 5 floors inside with viewing galleries, each with a wall at the inner end and an ANGLED-OUT at the outer edge. The ANGLED-OUTs intersect the blockage of the tower and provide fixed-pressure boundaries where they intersect.

Velocity, m/s
16.48648
15.45680
14.42711
13.39743
12.36774
11.33806
10.30838
9.278691
8.249007
7.219322
6.189638
5.159953
4.130269
3.100584
2.070900
1.041215
0.011531

Probe value
3.052251

Solar Tower – Central resistance

InForm is used to apply heat sources to hidden blockages, HEAT & HEAT2. The STOREd variable MARK is set to 1 in all cells which are fluid and have a solid above them (ie on the next Z plane). Fluid cells are identified as having the property marker PRPS < 100, and solid cells as having PRPS > 99. Heat is applied to all cells with MARK=1.
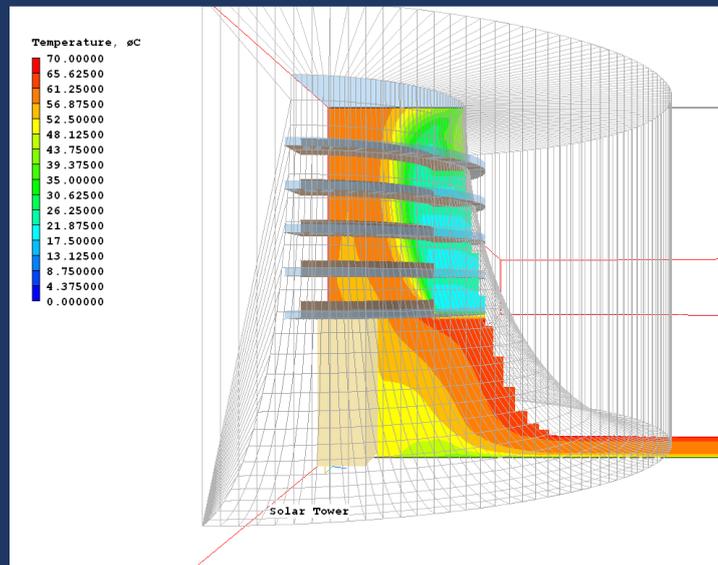
In a similar fashion, in HEAT2, MARK is set to 2 in all cells which are fluid but have a solid in the next Y cell outwards. Heat is applied to all cells with MARK=2. The HEAT2 object covers the whole X extent of the domain, but could be limited to a small section with ease. If there is an external wind, ANGLED-IN objects can be placed on the up-wind side of the internal floors (opposite the ANGLED-OUTs) and the external wind set as the inflow velocity.
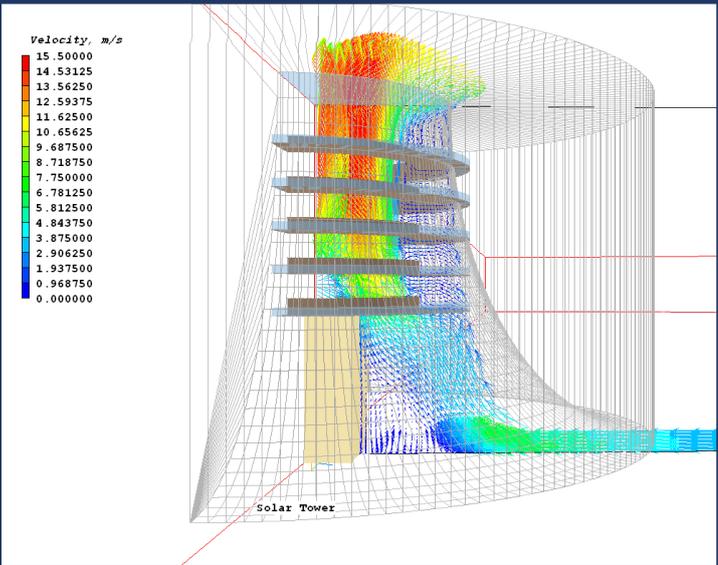
Temperature contours
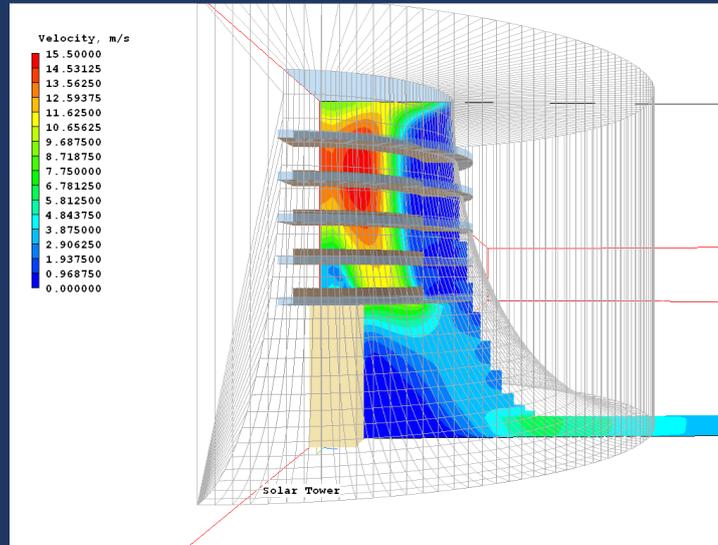
Velocity contours

Velocity vectors