Solar Updraft Tower

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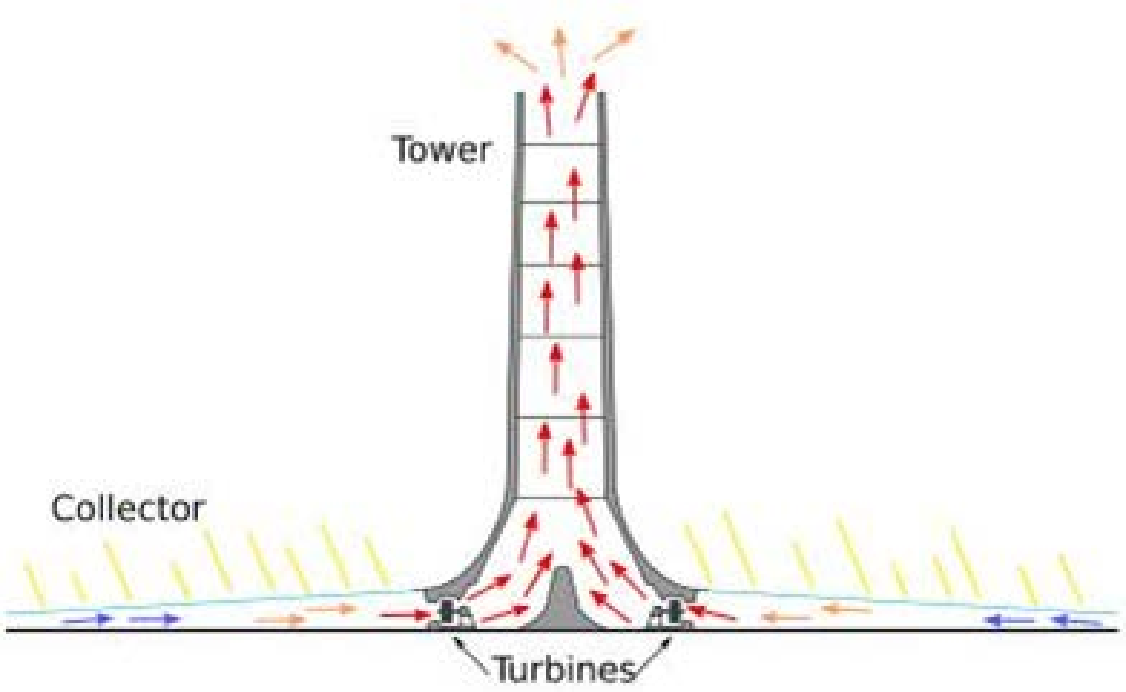
What is a Solar Updraft Tower



The collector unit acts as a greenhouse heating up trapped air. The warmer air moves to the center tower portion.

Tower holds turbines. Acts as a chimney for the warm air. Resulting updraft brings cold air into the collector and expels hot air through the tower.

Collector

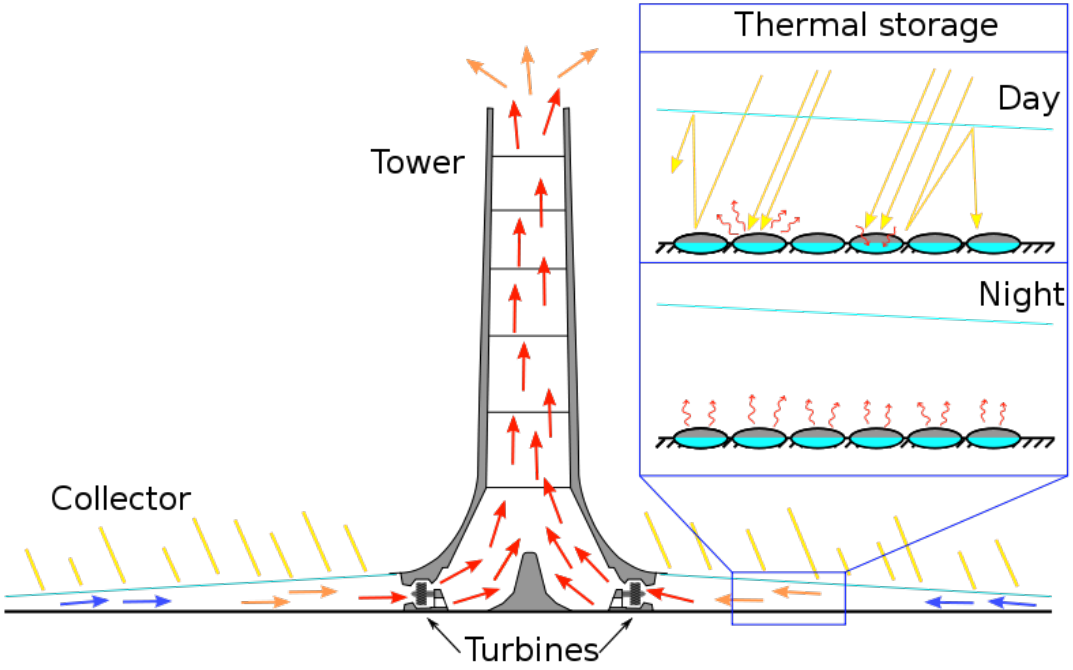
The collector is made of glass or plastic film glazing.

Height of glazing is increased towards the tower.

Heats air in collector using shortwave radiation.

Retains longwave radiation in the ground.

Collector



Ground heat storage allows the tower to be used all day.

Water tubes can be implemented to store more heat.

Collector

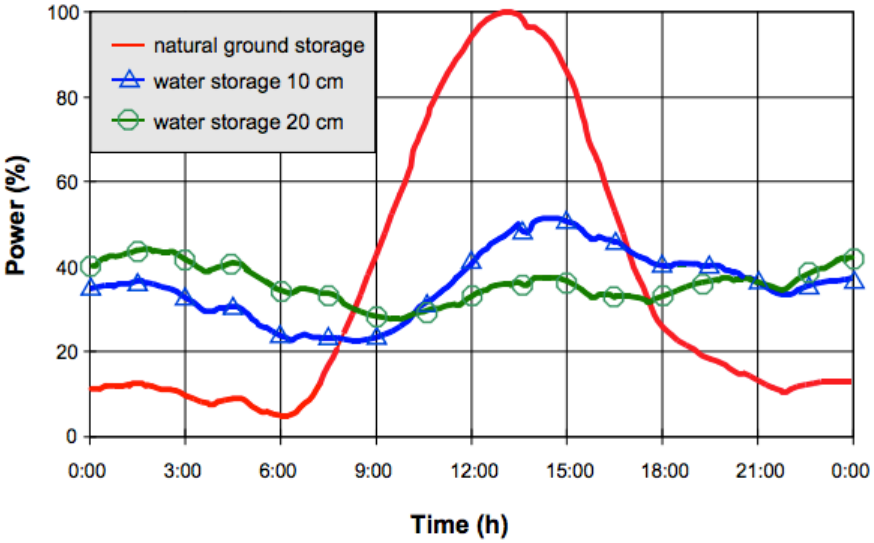


Figure 4. Effect of heat storage underneath the collector roof using water-filled black tubes.

Tower

Primarily made of concrete

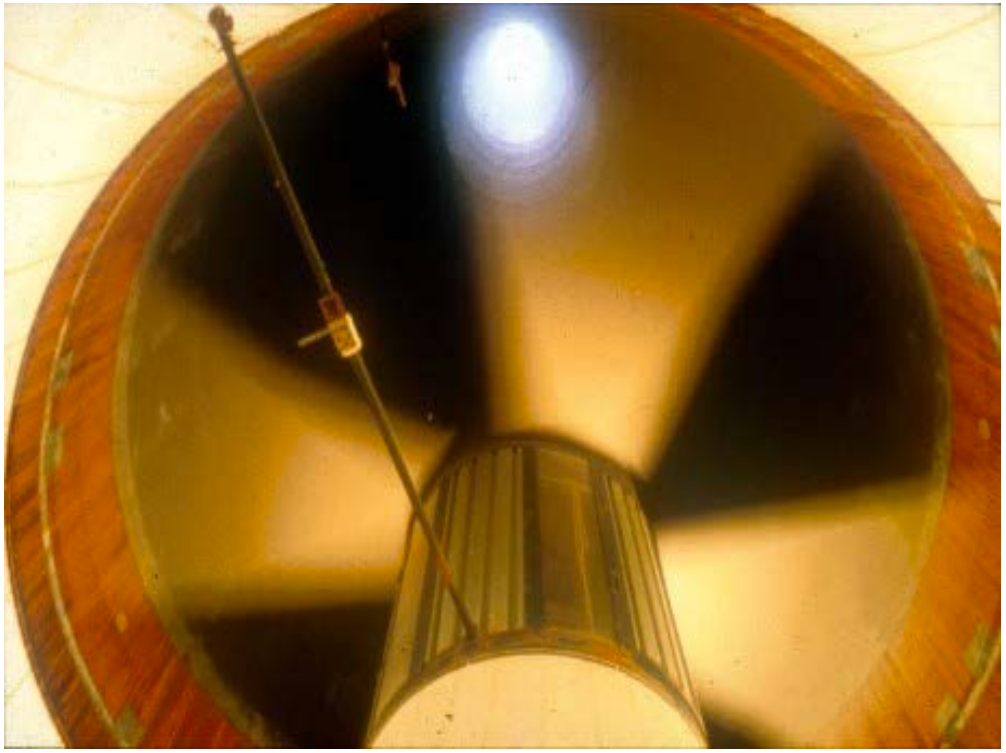
Pressure tube with low friction loss

Airspeed change is negligible after turbines

Tower

Updraft is proportional to the temperature rise and the height of the tower

Output achieved is proportional to product of volume flow per time unit and pressure differential over the turbine



Manzanares, Spain Plant

Test tower funded by German Ministry of Research and Technology

Tower – 200m high

Radius – 5m

Collector Radius ~ 122m

Output – 50kW

Efficiency

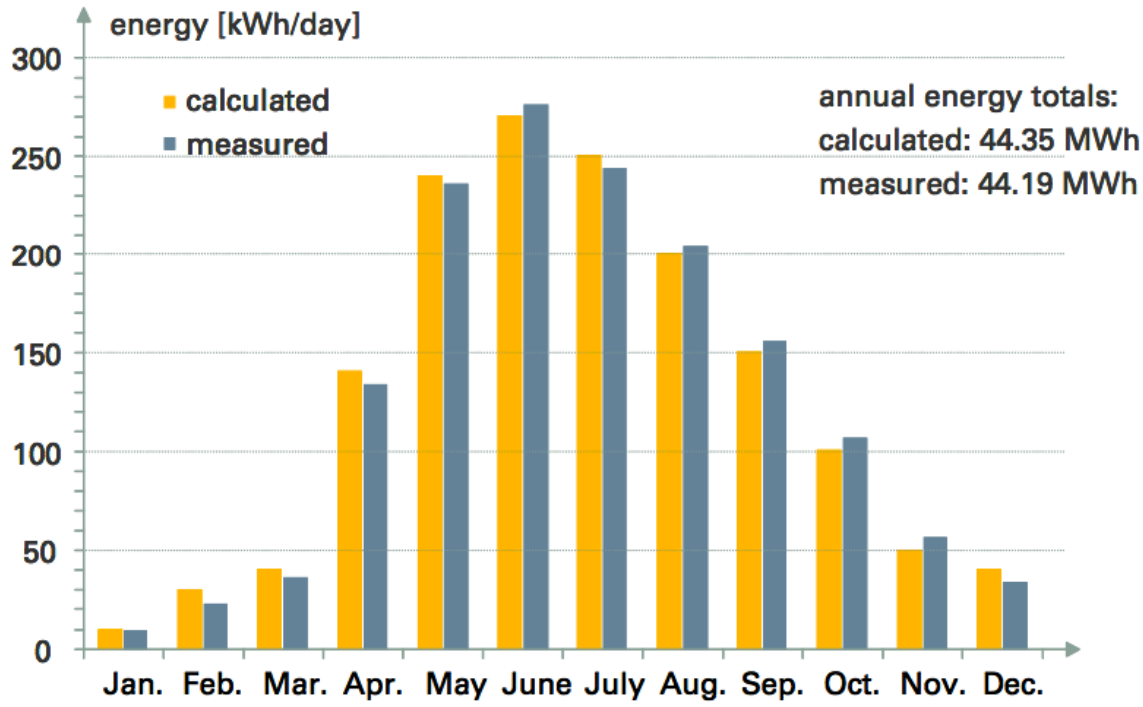


Figure 9. Comparison of measured and calculated monthly energy outputs for the Manzanares plant.

Cost

Capacity		50 MW	100 MW	200 MW	200 MW
Tower Cost	Million	77	189	206	206
Labor Cost		$19/hour	$19/hour	$19/hour	$5/hour
Collector Cost	Million	152	203	509	420
Total Cost	Million	324	536	930	839

Coal plants are estimated at $3500 per KW

700 million for a 200 MW coal facility

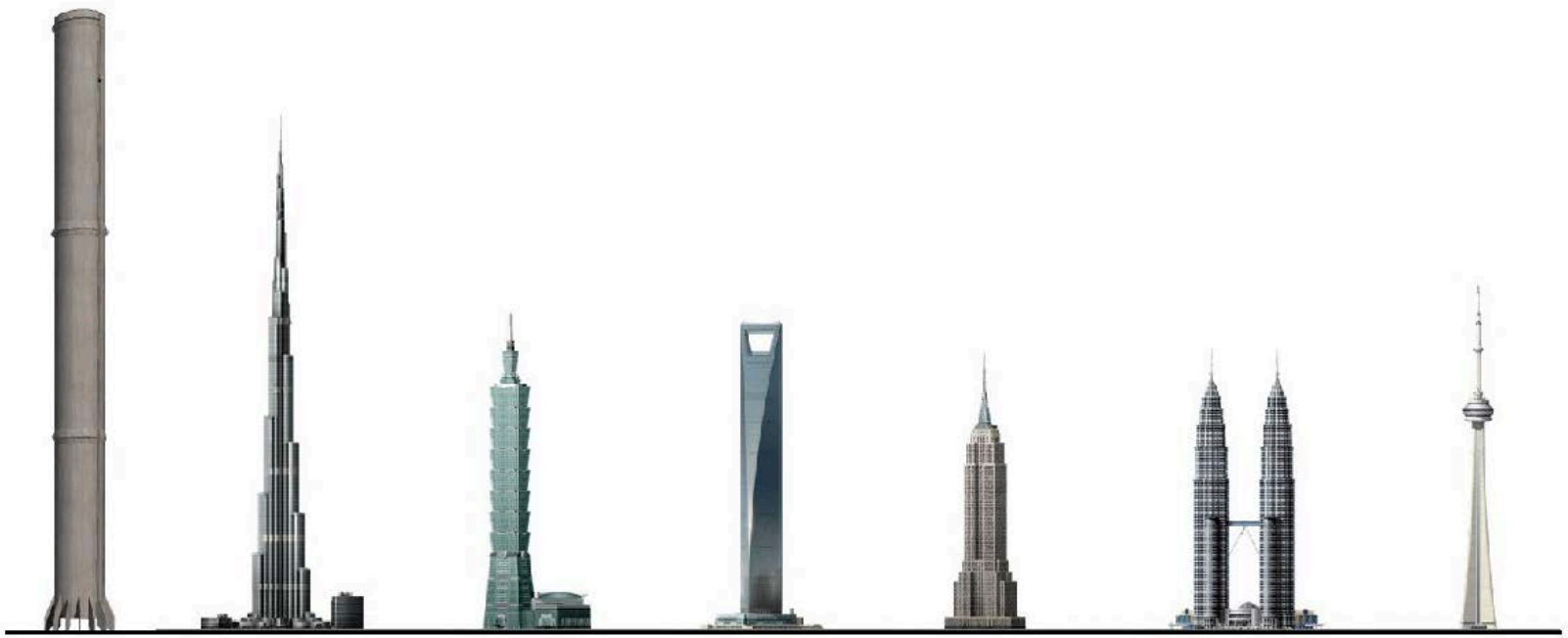
Dimensions

Capacity		50 MW	100 MW	200 MW
Tower Height	m	750	1000	1000
Tower Diameter	m	90	110	120
Collecter Diameter	m	3750	4300	7000

Roughly 3280 feet tall

Area of 200 MW collector is 38,500,000 square meters, roughly 15 square miles

Height Perspective



Burj Khalifa is 830m tall

Maintenance

Wind speed in Collector is 9 m/s

Wind speed in Tower is 15 m/s

Both speeds are safe to operate maintenance under.

3.45 million annual cost in operation and maintenance for 200 MW tower

m/s	km/h	mph	Label
0 - 0.2	<1	<1	Calm
0.3- 1.5	1-5	1-3	Light Air
1.6- 3.3	6-11	4-7	Light Breeze
3.4- 5.4	12-19	8-12	Gentle Breeze
5.5- 7.9	20-28	13- 17	Moderat Breeze
8.0- 10.7	29-38	18- 24	Fresh Breeze
10.8- 13.8	39-49	25- 30	strong Breeze

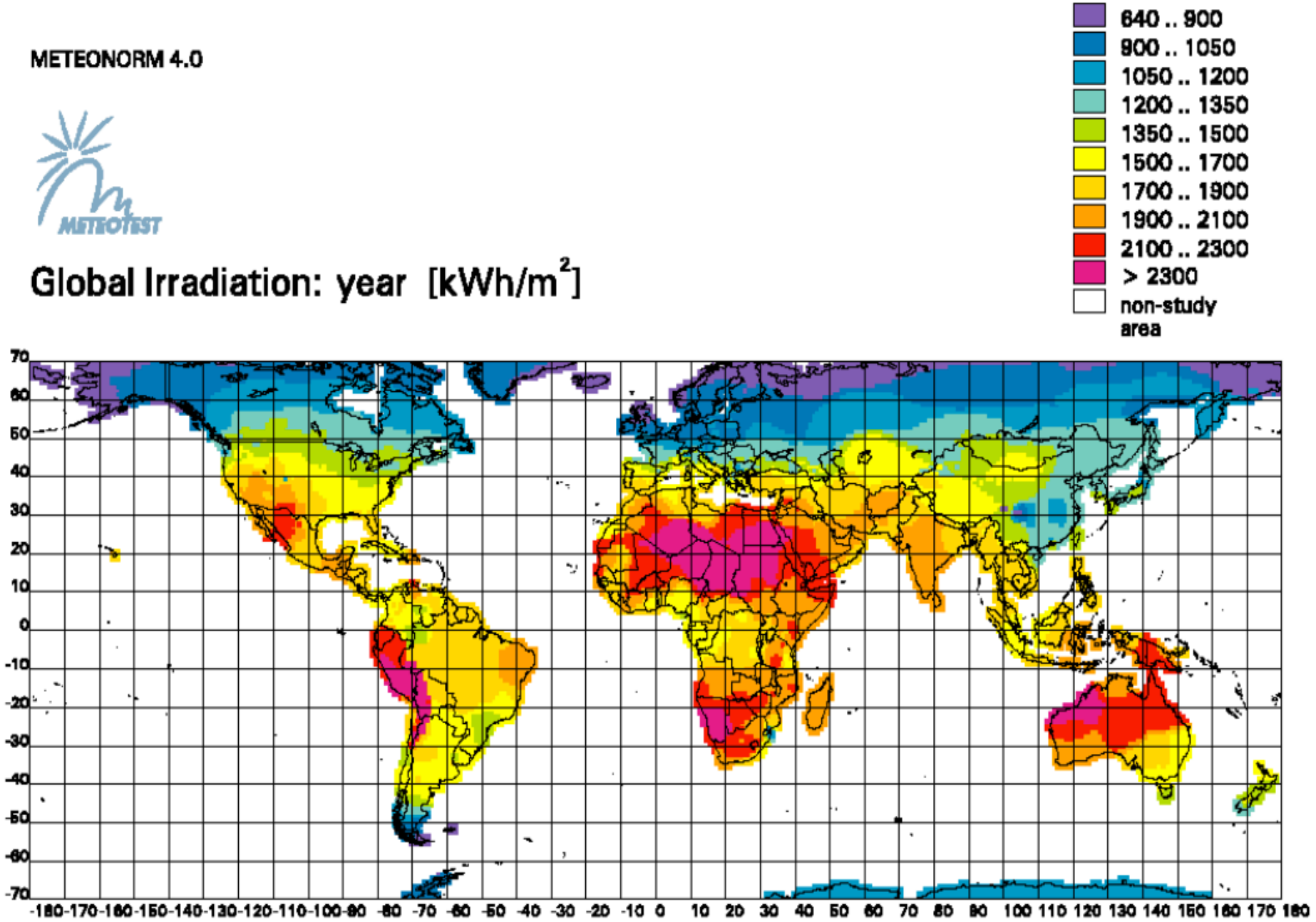


Figure 11: Solar radiation world map (Source: Meteotest, Switzerland)

Location and Practicality

Location requires ideally a location with annual global horizontal radiation of 1800 kWh/m^2 or higher. Mostly in the Sunbelt, which is cheap desert land.

The desert has sand and stone that can be used for the onsite construction.

With increasing oil prices, an oil-fired plant operating with a barrel of oil costing $70 at 35% efficiency (45% is highest) can be operating at the same cost of a 200 MW tower in a 2300 kWh/m^2 location.

Compared to Oil-fired

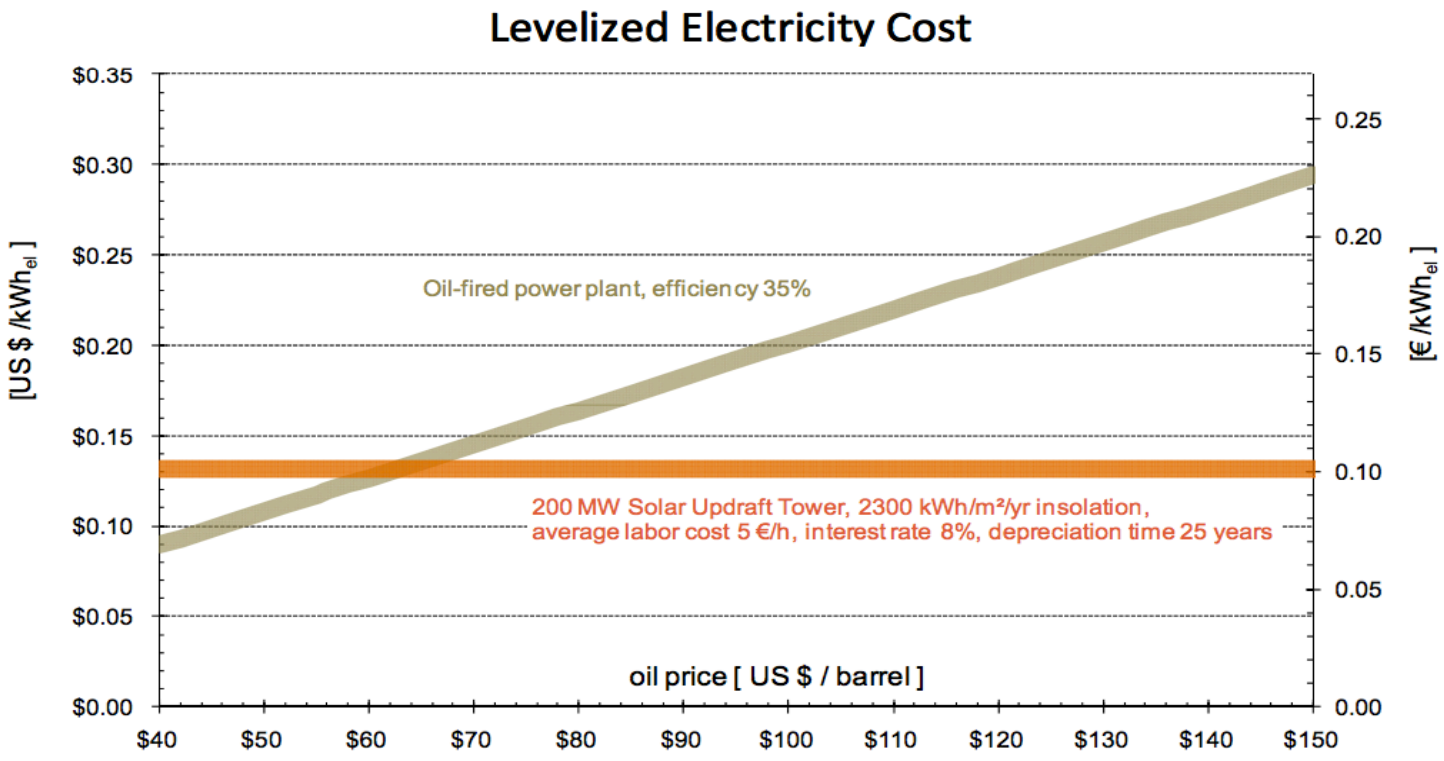
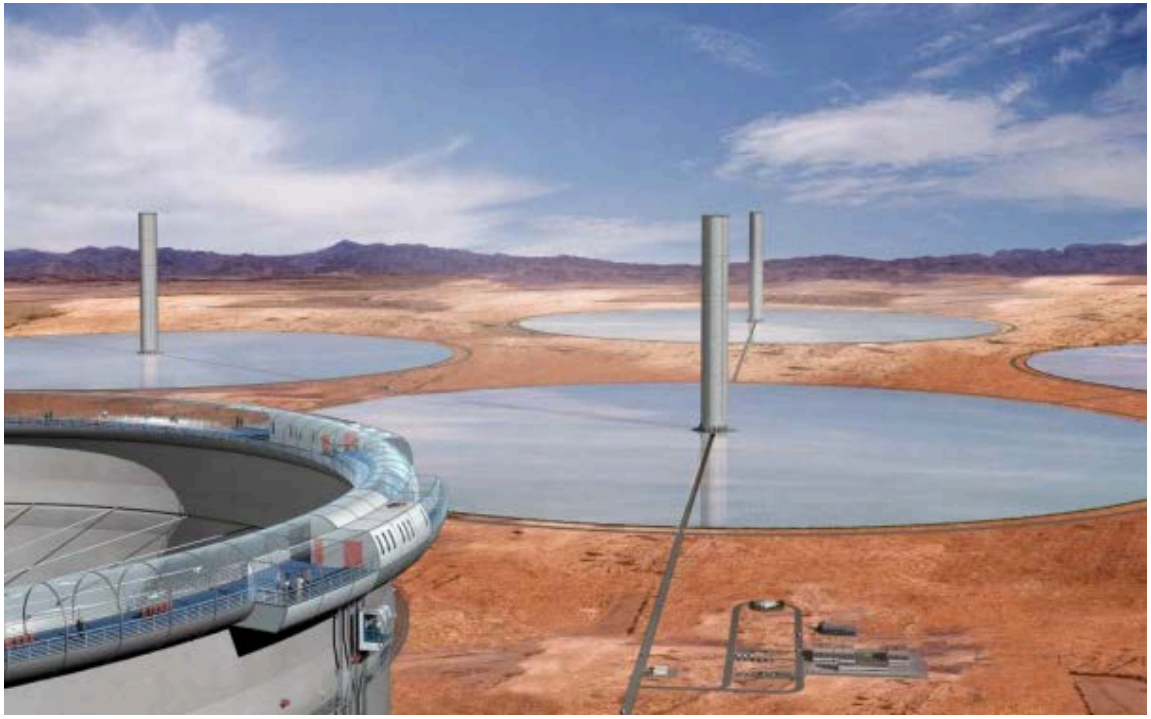


Figure 12: Electricity Cost for Oil-Fired Power Plants and Solar Updraft Towers

Future



References

- http://www.solar-updraft-tower.com/system/attachments/contents/19/background/xlarge_110627_GW_ScaleUp_bearb.jpg
- http://www.solaripedia.com/images/large/5043.jpg
- https://upload.wikimedia.org/wikipedia/commons/thumb/0/00/Solar_updraft_tower.svg/790px-Solar_updraft_tower.svg.png
- http://www.drroyspencer.com/wp-content/uploads/enviromission-solar-tower-arizona-power-0.jpg

References

- http://geospatial.blogs.com/geospatial/2010/01/energy-efficiency-of-fossil-fuel-power-generation.html
- https://architecture.mit.edu/sites/architecture.mit.edu/files/attachments/lecture/SolarUpdraftTower_Project.pdf
- http://www.solar-updraft-tower.com/en/technical_concept/prototype_manzanares
- http://www.windfinder.com/wind/windspeed.htm

References

- http://news.nationalgeographic.com/content/dam/news/photos/000/787/78765.ngsversion.1422285457843.adapt.768.1.jpg
- https://en.wikipedia.org/wiki/Burj_Khalifa