Day 1: Exploration of system technology and performance

New Orleans Room readout

May 23, 2014

Feedback on overall ARPA-E system vision

- The condenser should not be ignored, it has the highest exergy loss out of all of the components of the vision diagram
- Absorption cooling is capable of delivering a COP of 2; however, accomplishing this is challenging and is a mass transfer problem
- It is important to consider existing regulations on steam cycle materials when designing the system. For example, any modification could not affect the steam cycle's ability to meet ASME boiler codes.
- Unlike coal fired plants, NG combined cycle plants are not as sensitive to turbine back pressure; this fact may allow for more design freedom when developing cooling systems for these type of power plants

Radiative cooling

- Largest constraints on radiative cooling are available surface area and associated pressure drop.
- No known compatibility restraints with other technologies – it can be placed on top of other cooling systems leading to straight forward retrofitting
- Restriction on building surface area upwards due to view factor; can tilt but not more than 30 - 40 deg.
- Can go to very low temperatures in principle, in well sealed vacuum systems one can get to 20 – 30 deg C below air temperature, the tradeoff is power consumption from pumping.
- Expensive materials are required for bigger temperature drops especially during the day time. Night time is fairly simple.
- Day time heat transfer of 150W/m^2 is unrealistic, at night heat transfer of 120W/m^2 is likely achievable. 90W/m^2 at peak time during day time is more realistic.

Other technology notes

- Phase change materials – Can be nano- or micro-particles, there are appropriate pumps that don't damage capsules (very specialized) but are expensive. Super cooling is a concern and methodologies for achieving a higher fraction of latent heat need to be researched.
- Ejector cooling is another technique that can be used but the hot side temperature needs to be high. A COP of 2 is challenging but may be more achievable with ejector cooling as compared to absorption cooling.
- Heat pipes that use the ground as a heat sink could be a possibility
- Air-cooled heat exchangers at higher heights where air is cooler might be an option

Fan and natural draft tower thoughts

- Fan technology is an area of expertise of its own and research into optimizing fan aerodynamics and fan variable speed control is likely already at the point of diminishing return
- Cooling systems integrated in fan design
- Natural draft design could lessen load on fan, harnessing solar energy to aid in performance could be a possibility
- Manipulating boundary layer dynamics to optimize technology performance
- Due to costs and permitting challenges it may be important to think about how one could make a 10 m tower behave like a 100 m conventional tower

Scalability

- Radiative cooling - Night cooling is scalable but the unknown is day time. Day time usage without vacuum deposition is scalable. Vacuum to avoid heat transfer from ambient my be necessary to achieve higher performance, especially for larger temperature drops. Durable infrared covers are needed (currently polyethylene is used which is not durable).
  - Heat transfer, compactness and pressure drop for radiative cooling are key.
- Absorption cooling - Still moving a massive quantity of heat, so surface of heat exchangers are not trivial. How do you cool when day time dry bulb is so high? How do you get that extra performance without water or increasing LCOE at scale is the important question.
- Heat pipe – Length a challenge for underground heat pipe.
- Natural draft – The bigger you make it the bigger the natural draft, but height = cost.
- Sound is more of a constraint than land for any alternate cooling technology as power plants tend to be in more isolated regions.
- 100kW is a good size to demonstrate scalability. However, a “third party” testing site would be good for project concepts as cost of building something of this size may limit the type of organizations that could compete in the program.
  - Counter-thought:100 kW demonstration doesn’t necessary scare away a small business. It depends on what is being tested.