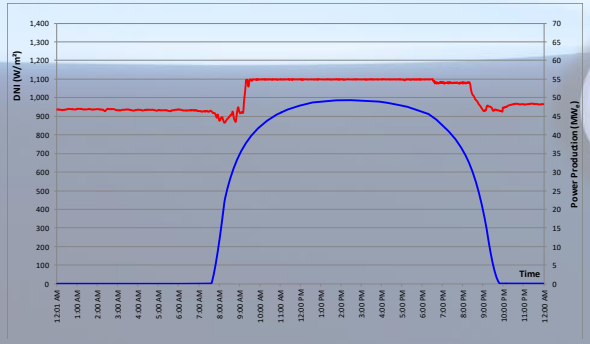
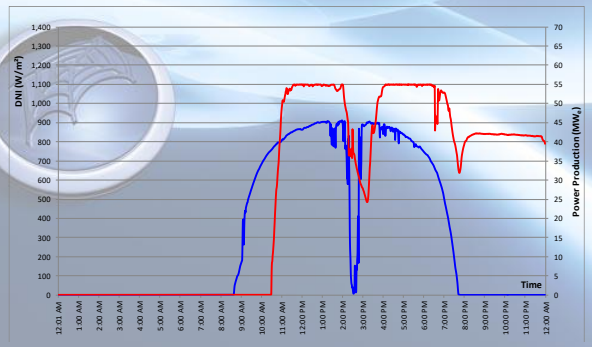
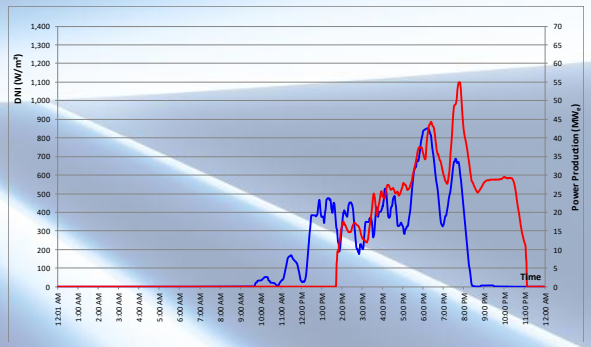
Streamlining Power Generation of Concentrating Solar Power Plants

Current Dilemma

- Varying solar resource → varying HTF flow rates to stabilize HTF temperature
- Varying HTF flow rates in SF → fluctuating steam generation rates in PB
- Varying steam generation rates → oscillating electric power output
- Partial cloud covers further exacerbate those electric power oscillations
- Large SF size & HTF amount → Large residence time → slow control system
- Slow responding control system → oscillations are worse than expected





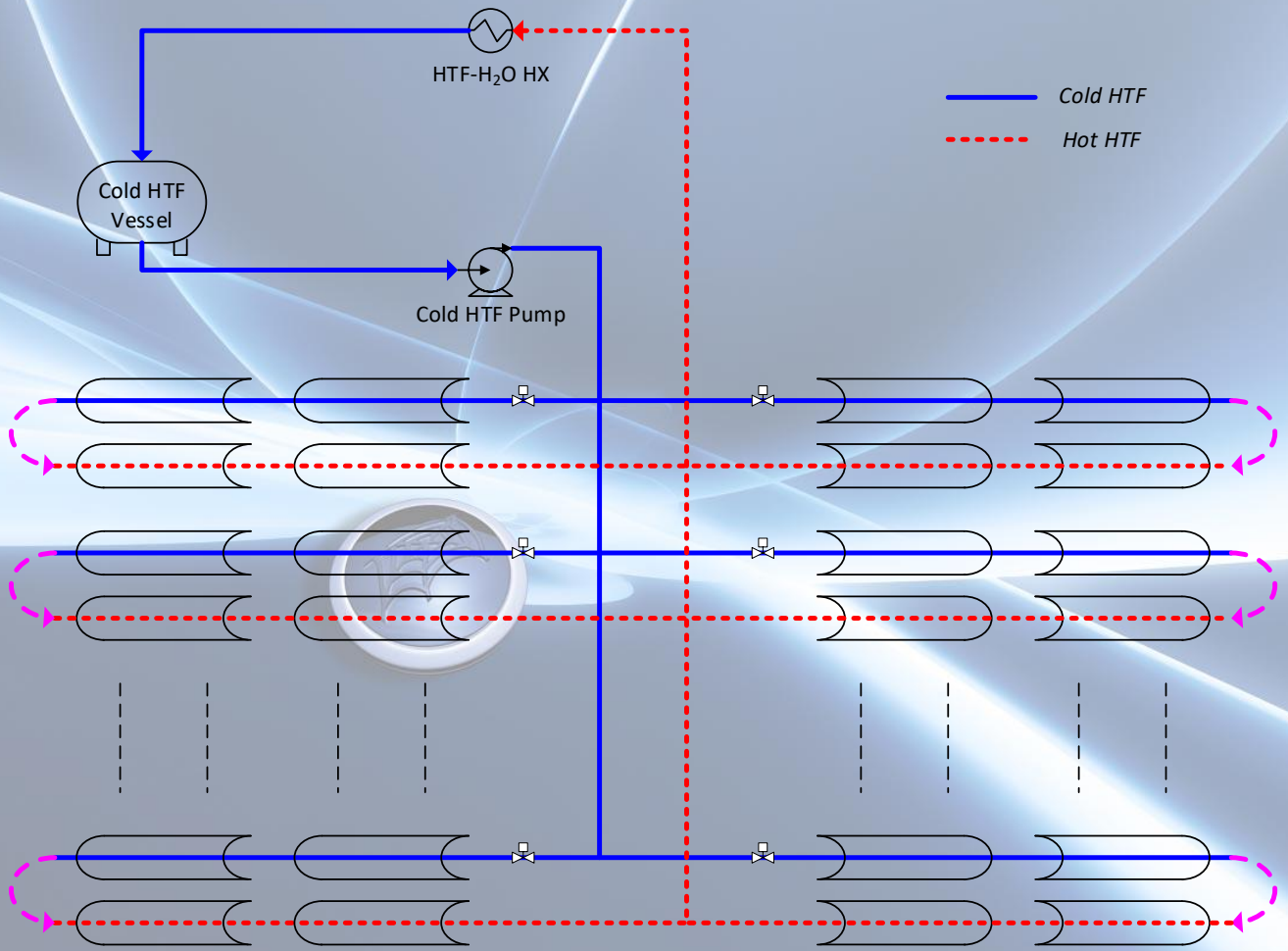


- CSP oscillations is the main reason for limiting their contribution to the grid
- TES systems are used to fill solar heat supply gaps but too slow to avert oscillations

Proposed Solution

- A new HTF network is proposed to even out heat transfer rates from SF to PB
- Stabilizing heat transfer rates will streamline electric power generation
- Conventional HTF loop split into two using an extra HTF vessel and pump
- Heat collection loop: pumps cold HTF from the expansion vessel to the SF to collect solar heat before accumulating hot HTF in the new HTF holding vessel
- Heat delivery loop: pumps hot HTF from the new HTF holding vessel through the HXT to supply PB heat load before accumulating cold HTF in the HTF expansion vessel
- Splitting the HTF loop effectively decouples SF heat source from PB heat sink
- Solar resource variations → varying HTF levels rather than varying generation rates
- The proposed scheme can be applied to CSP plants with or without a TES system
- Existing CSP installations can be easily retrofitted to implement the new scheme
- Schematics are presented next to describe the operation of the proposed scheme

Conventional HTF circuit in a CSP plant without TES



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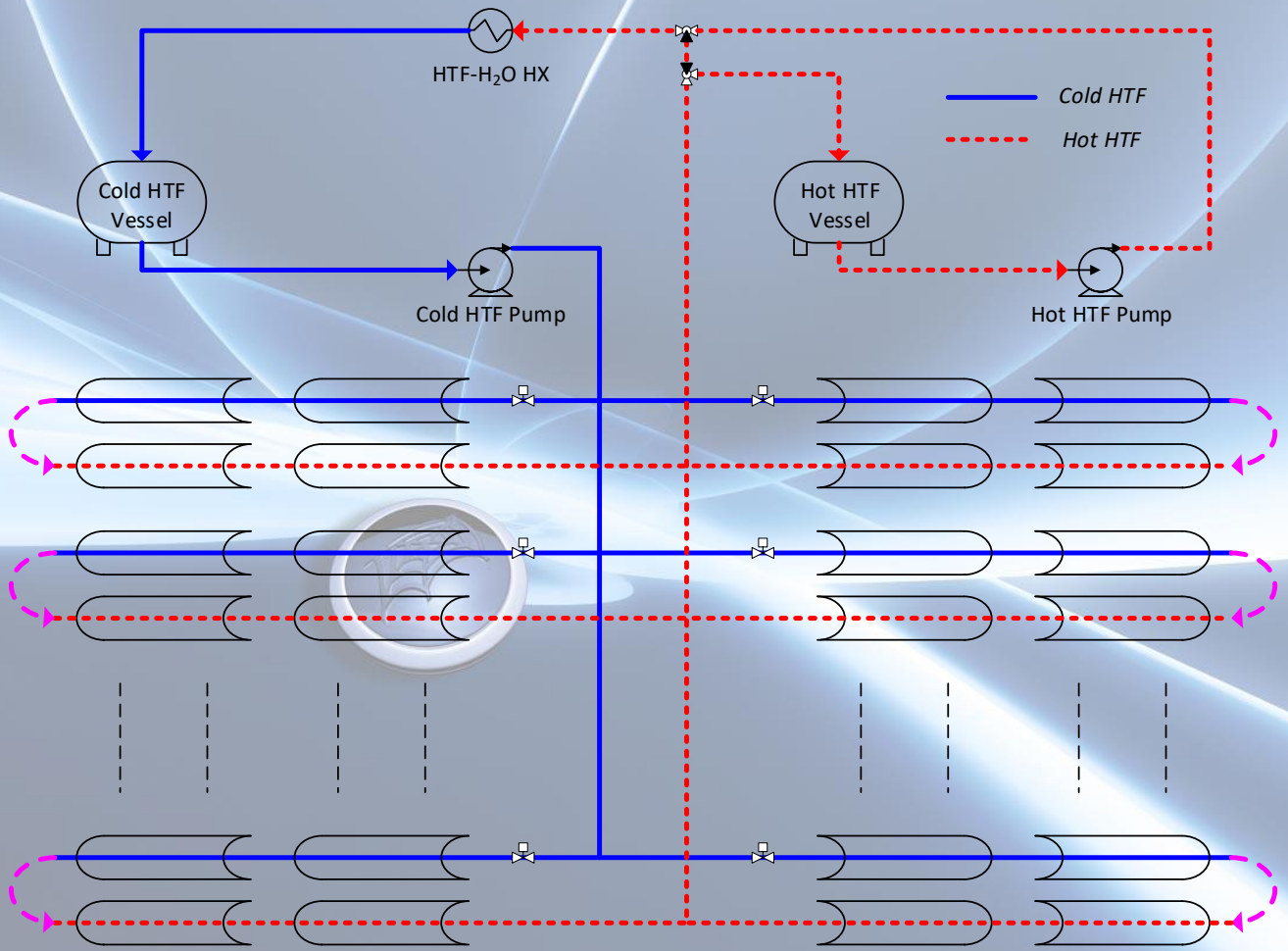
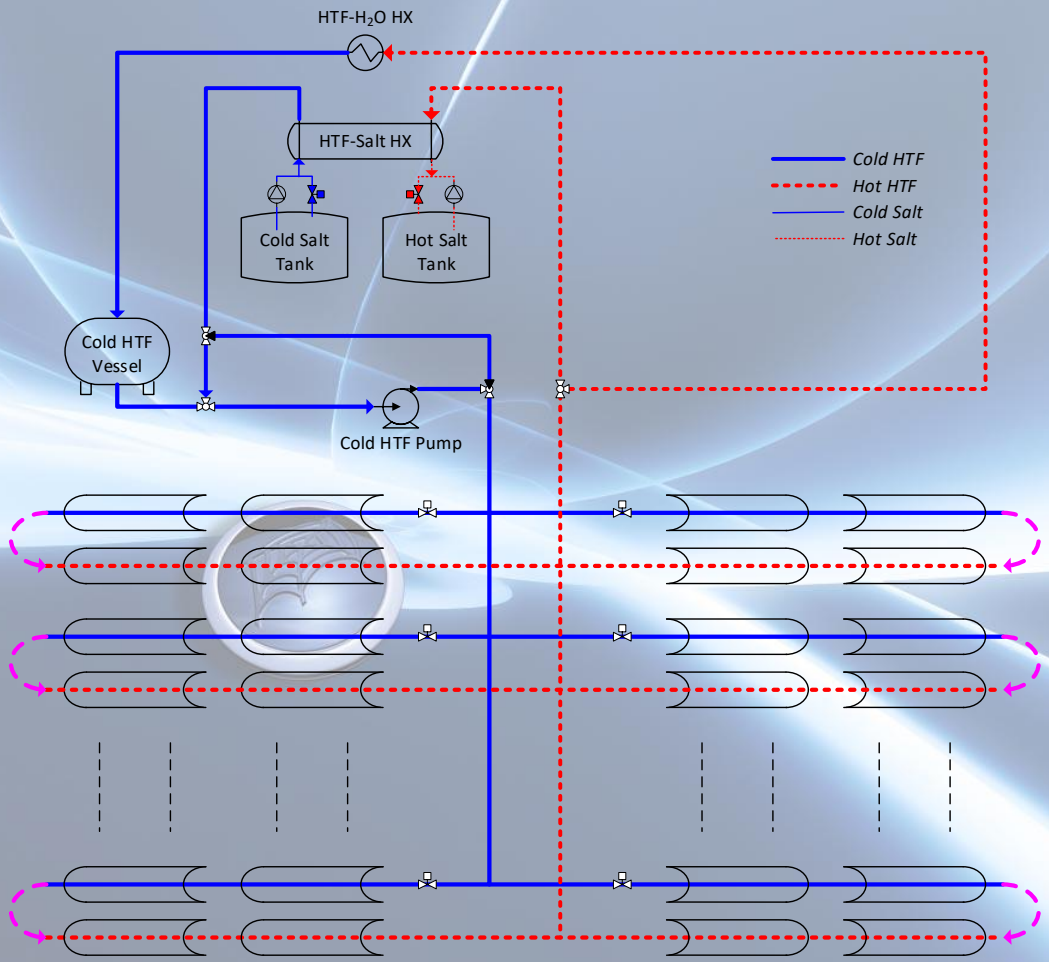
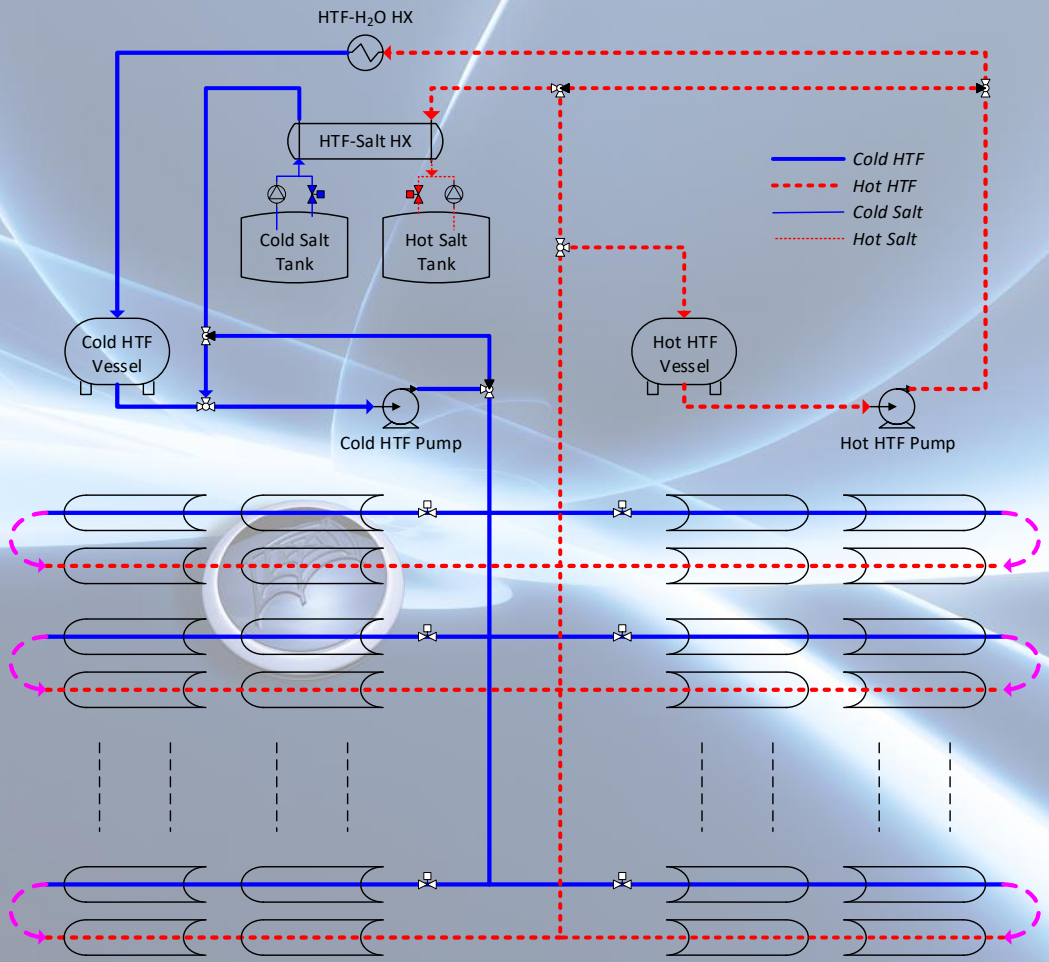


Conventional HTF circuit in a CSP plant with TES

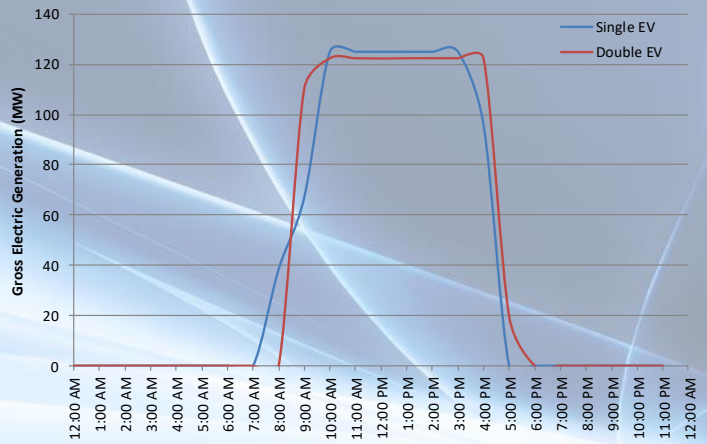


Proposed HTF circuit in a CSP plant with TES

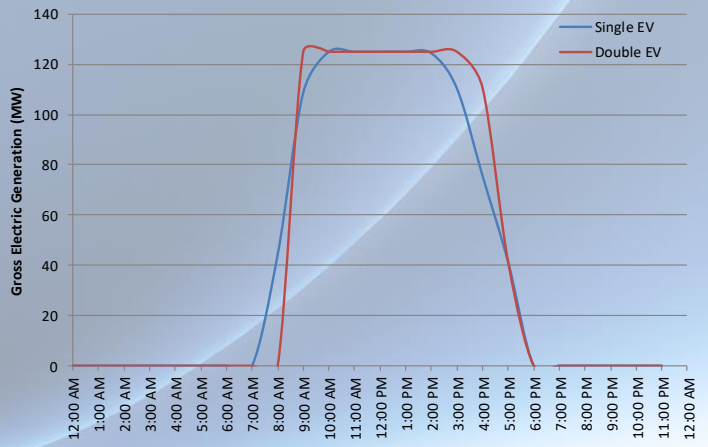


Simulations

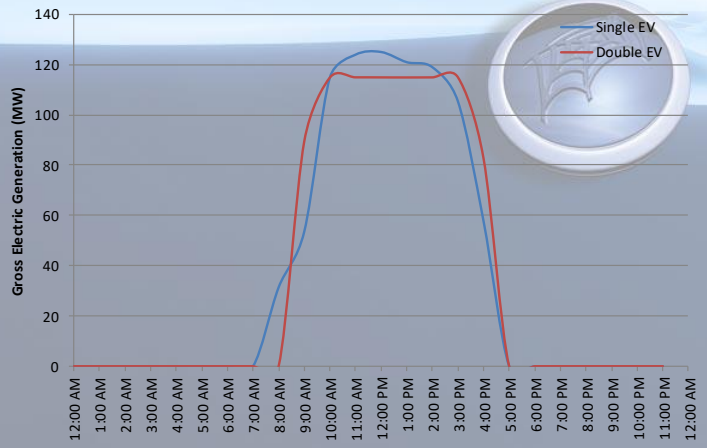
Spring



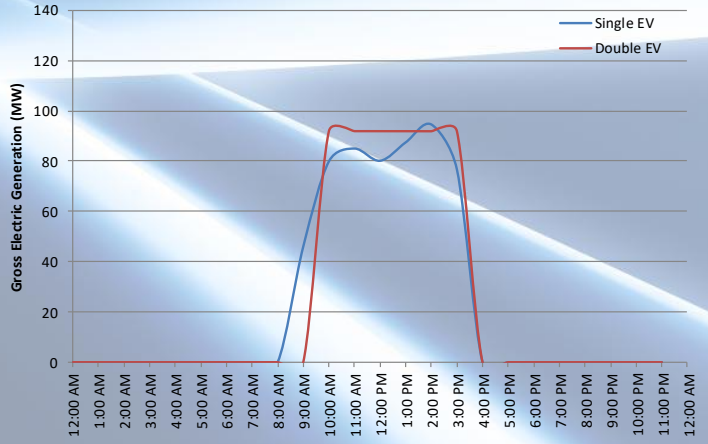
Summer



Autumn



Winter



Conclusion

- A new HTF circuit for PTC–type CSP plants is proposed o streamline their output
- This new scheme seeks to even out heat transfer rates from the SF to the PB by splitting the standard HTF loop into two loops using an extra vessel and an extra pump
- Heat collection loop: cold HTF is pumped from the expansion vessel to the SF to collect heat before accumulating in the newly introduced holding vessel as hot HTF
- Heat delivery loop: hot HTF is pumped from the holding vessel to a HXT to supply the PB with its heat load before accumulating in the expansion vessel as cold HTF
- The new scheme slightly decouples heat supply from heat sink thus allowing for more control of heat delivery rates and in turn more control of power generation rates
- A validated model of a 100 MW CSP plant was modified to depict the new HTF circuit
- Simulation results show a more even profile for electric power generation
- Inadvertently, electric power generation was slightly increased because the PB ran at a slightly higher thermal efficiency due to superior dispersion of solar heat to the PB