PROJECT PROPOSAL: GREEN ENERGY FUND

2016

THERMAL ENERGY STORAGE SYSTEM FOR SOLAR THERMAL POWER GENERATION

Submitted by

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Project Summary

The objective of this project proposal is to design and install a Thermal Energy Storage (TES) system at the Solar Thermal Power generation facility at the USF Clean Energy Research Center (CERC). At present, this facility does not have any thermal storage, which means that it is strongly impacted by transient weather conditions (e.g. passing clouds). The addition of the TES system is a necessity for the solar field to operate continuously and to generate electricity efficiently. The $90,000 thermal energy storage system is expected to produce about 90,000 kWh per year, which represents an annual reduction of 63 metric tons of CO_2 emissions and cost savings of about $8000 per year on USF's electric bill, for a payback period of 11.2 years.

This project will meet USF strategic plan ("SP") goals #1 and #2. SP goal #1 (education) will be accomplished through frequent tours of the solar power plant, which are hosted for a number of USF professors and student organizations, as part of coursework and events, in order to teach students and the community about solar energy and energy storage. Goal #2 (innovation) will be completed by the demonstration of low-carbon energy production that is applicable to the Tampa Bay region and which could be scaled up by energy companies like TECO and Duke Energy.

Project Plan

USF CERC students and faculty involved in this project will design the TES system. Any code compliance will be ascertained by the contractor, Friedrich Watkins of Tampa. The thermal storage system will be added to the existing solar power field, which is owned by the Florida Energy Systems Consortium and operated by CERC, and which already has space and connections for a TES system.

Proposed design

The current system uses water (70%)/glycol (30%) mixture as the heat transfer fluid (HTF). The proposed storage will also use the same HTF for the storage medium and installed in series with the existing system. The capacity of the storage will be in the range close to 3800 gallons.

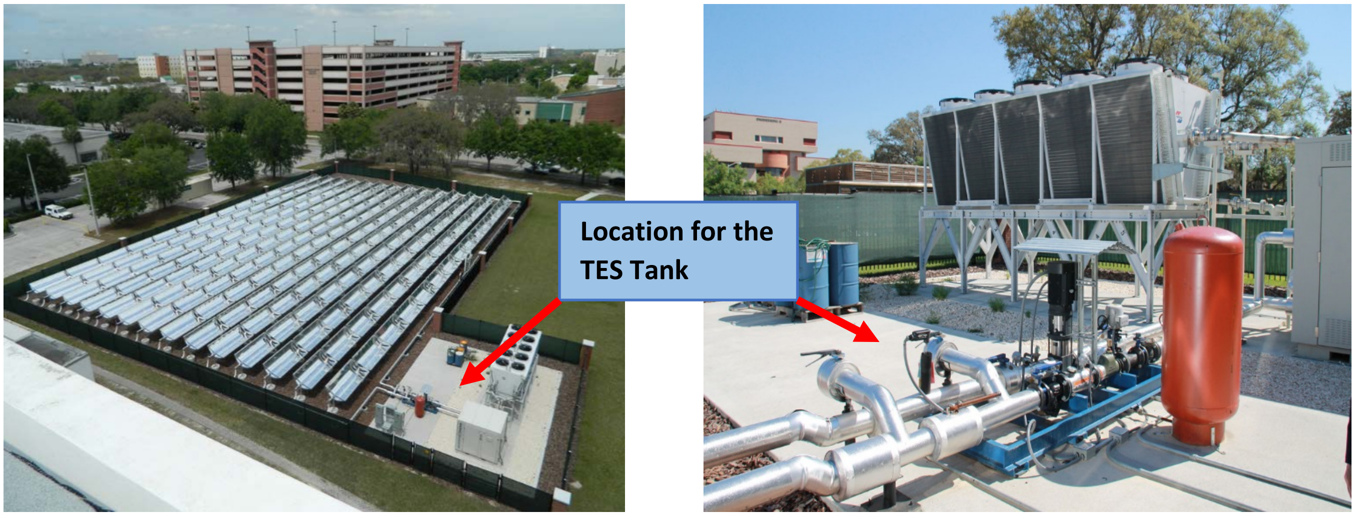


Figure 1: Location of the proposed TES tank in the existing solar power plant

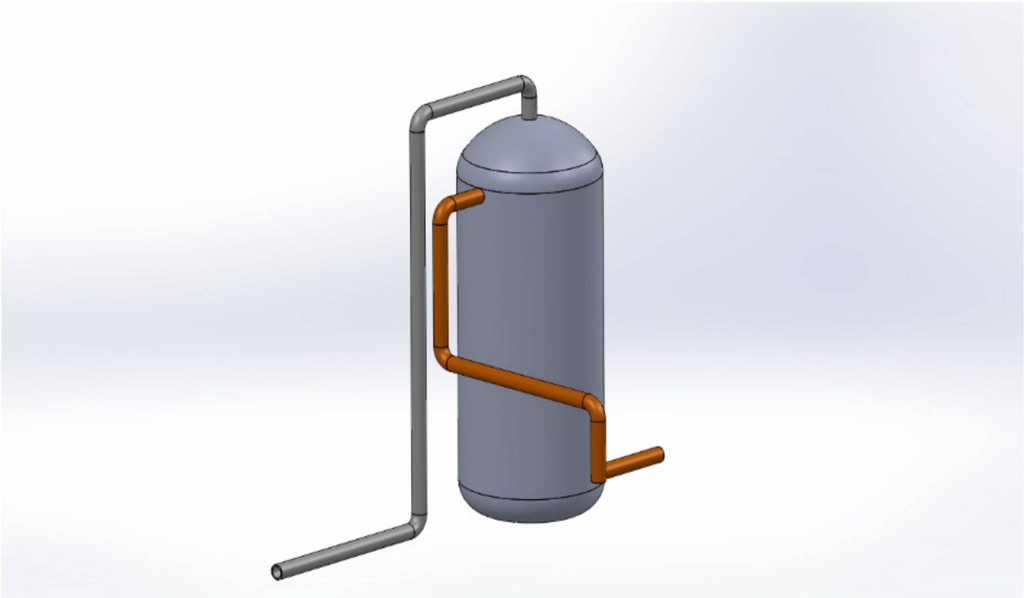
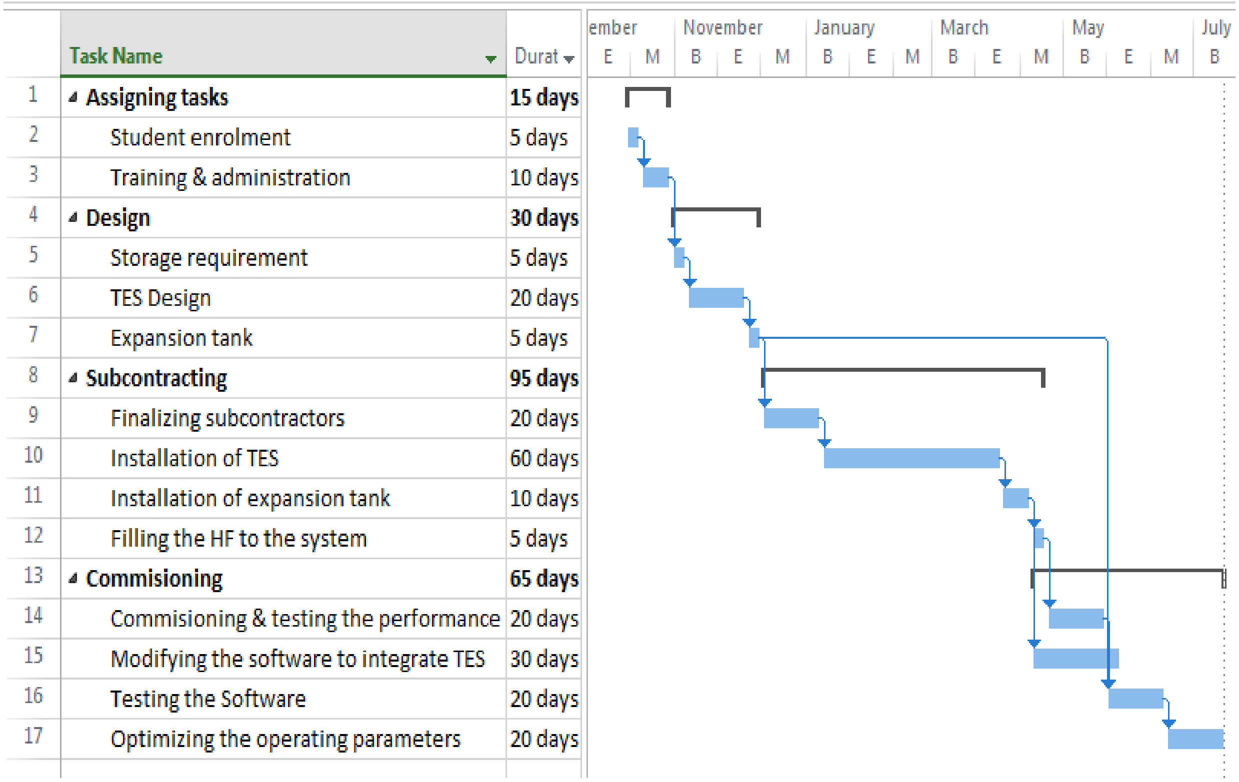


Figure 2: Proposed TES tank design

Project tasks & time schedule



	Task Name	Duration
1	**Assigning tasks**	**15 days**
2	Student enrolment	5 days
3	Training & administration	10 days
4	**Design**	**30 days**
5	Storage requirement	5 days
6	TES Design	20 days
7	Expansion tank	5 days
8	**Subcontracting**	**95 days**
9	Finalizing subcontractors	20 days
10	Installation of TES	60 days
11	Installation of expansion tank	10 days
12	Filling the HF to the system	5 days
13	**Commisioning**	**65 days**
14	Commisioning & testing the performance	20 days
15	Modifying the software to integrate TES	30 days
16	Testing the Software	20 days
17	Optimizing the operating parameters	20 days

Total project duration is close to 9 months.

Sustainability of the Project:

After construction of this thermal energy storage project is completed, ownership will be transferred to the Clean Energy Research Center (CERC), a USF research group, and to the USF Research Foundation, which owns the land where the power plant is sited. Long-term operation, maintenance, and accountability will be handled by the students and faculty members of CERC.

Project Cost

Student engagement

Two students for a period of nine months will be engaged to execute this project. The student activities include the following.

- Calculate the optimal storage size and configuration for the effective operation of the power plant.
- Monitor the progress of the subcontracting work.
- Modify the power plant data acquisition software to incorporate the TES system parameters.
- Final optimization of the system
- Submit status reports and final report to the SGEF council.

Capital investment

Item	**Cost**
TES Tank	$65,000
Expansion Tank	$5,000
Installation and Labor	$10,000
Student Salaries	$10,000
Total	**$90,000**

This project is estimated to cost a total of $90,000, which includes $80,000 for the TES system itself and $10,000 for graduate student salaries (for system design, labor, software development, etc.). These projections were generated based on quotes provided by Friedrich Watkins of Tampa, a large-scale hot water storage tanks manufacturer which was responsible for solar field construction. It is important to note the existing solar power plant was funded by the Florida Energy Systems Consortium.

Project Benefits

Cost Benefit Analysis

The solar field (with thermal storage) is expected to produce about 90,000 kWh per year*. Based on the TECO price structure, the total value of electricity generation will be about $ 7,970.40 per year (see Table 1). Some maintenance will be required, which primarily consists of periodic lubrication and cleaning, and may cost about $ 1,200 to $ 1,500 per year. Simple payback of the project is 11.2 years.

Table 1: Electricity cost savings

Expected kWh produced per day	Expected kWh produced per year	TECO Energy Charge/kWh	Expected Energy Savings per Year	TECO Fuel Charge/kWh	Expected Fuel Savings per Year	Total Expected Savings per Year
300	90,000	$ 0.05495	$ 4,945.50	$ 0.03361	$ 3,024.90	$ 7,970.40

**Based on 6 hours daily operation at 50 kW design power for 300 days per year.*

Sustainability Benefits

The solar power plant with thermal energy storage at USF CERC will generate an average of about 300 kWh per day, with daily variations depending upon the time of the year and weather conditions. While there are no global warming emissions associated with the generation of electricity from solar energy, there are emissions associated with other stages of the solar life-cycle, including manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement. Most estimates for concentrating solar power range from 0.03 to 0.09 kilogram of carbon dioxide equivalent per kilowatt-hour. In both cases, this is far less than the lifecycle emission rates for natural gas (0.3-0.9 Kgs of CO_2-e/kWh) and coal (0.6-1.6 Kgs of CO_2-e/kWh). Table 2 summarizes the reduction of greenhouse gas emissions, with calculations based on an average CO_2 reduction rate for solar thermal in Florida (DOE).

Table 2: GHG emission reduction

Annual power generation	CO_2-e savings (from DOE)	Total annual CO_2-e savings
90,000 kWh	0.7 Kg/kWh	63,000 kg

Educational Benefits

The other main benefit of having an operational on-campus solar thermal power plant is of its educational value. The field is used frequently for educational tours that teach students and the community about electricity generation and solar energy. Several undergraduate and graduate courses (Solar Energy & Application, Design of Solar Power Plants, Mechanical Engineering Lab, etc.) have been using this facility as a part of their curriculum, while the USF chapter of the International Solar Energy Society hosts biannual tours for the Tampa Bay community. Having a fully-equipped plant will serve better in the future for lot of USF students as well as other outside visiting parties.