Sand Thermal Energy Storage (SandTES) Pilot Design - DE-FE0032024

FECM / NETL

Spring R&D Project Review Meeting

Scott Hume
Technical Executive

EPRI

20th April 2023

Sand Thermal Energy Storage (SandTES) Pilot Design

- **Phase I**
  - **Awarded**: 03/01/2021
  - **Funding:** $249k
  - **Timeline:** 03/01/2021–02/28/2022
- **Phase II**
  - **Awarded**: 03/01/2021
  - **Funding:** $995k
  - **Timeline:** 09/01/2022–08/31/2023
- **Site Host:** Southern's Plant Gaston
- **Team:** EPRI (prime), Andritz, CDM Smith, Southern Company, and Technische Universität Wien (TUW)

Objectives

Phase I: Perform a feasibility conceptual study on the integration of a 10 MWhe SandTES system to Southern's coal-fired Plant Gaston.

Phase II: Perform a pre-front-end engineering and design for a next-step pilot at Plant Gaston. By enacting the pilot, SandTES will advance to Technology Readiness Level (TRL) 6 and enable commercial readiness by 2030.

SandTES Overview

How It Works:

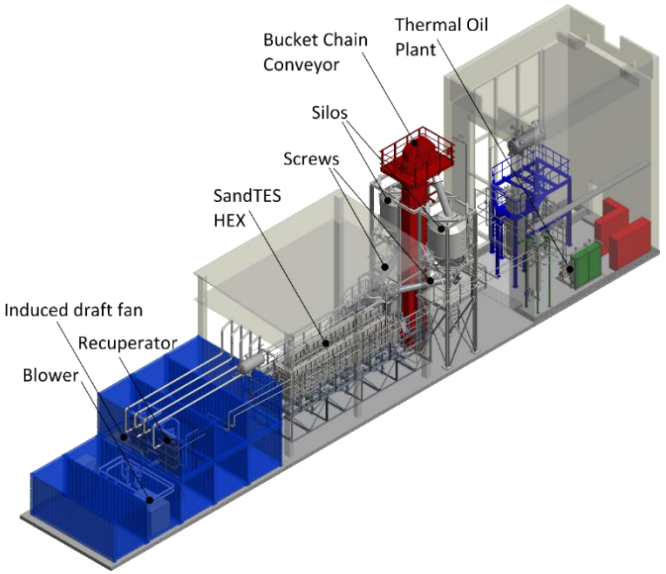
Heat from a thermal plant or electricity transferred to and from sand in a counter-current bubbling-bed heat exchanger to generate steam for a steam turbine generator.

Benefits:

- Low-cost material with high availability: $46/tonne
- Small plant footprint
- System inertia
- Zero fire risk

Challenges:

- Heat transfer process is more complex with a solid material
- Requires extensive solids handling equipment that may introduce reliability issues



Applications:

Integration with existing thermal power plants or pumped heat energy storage systems

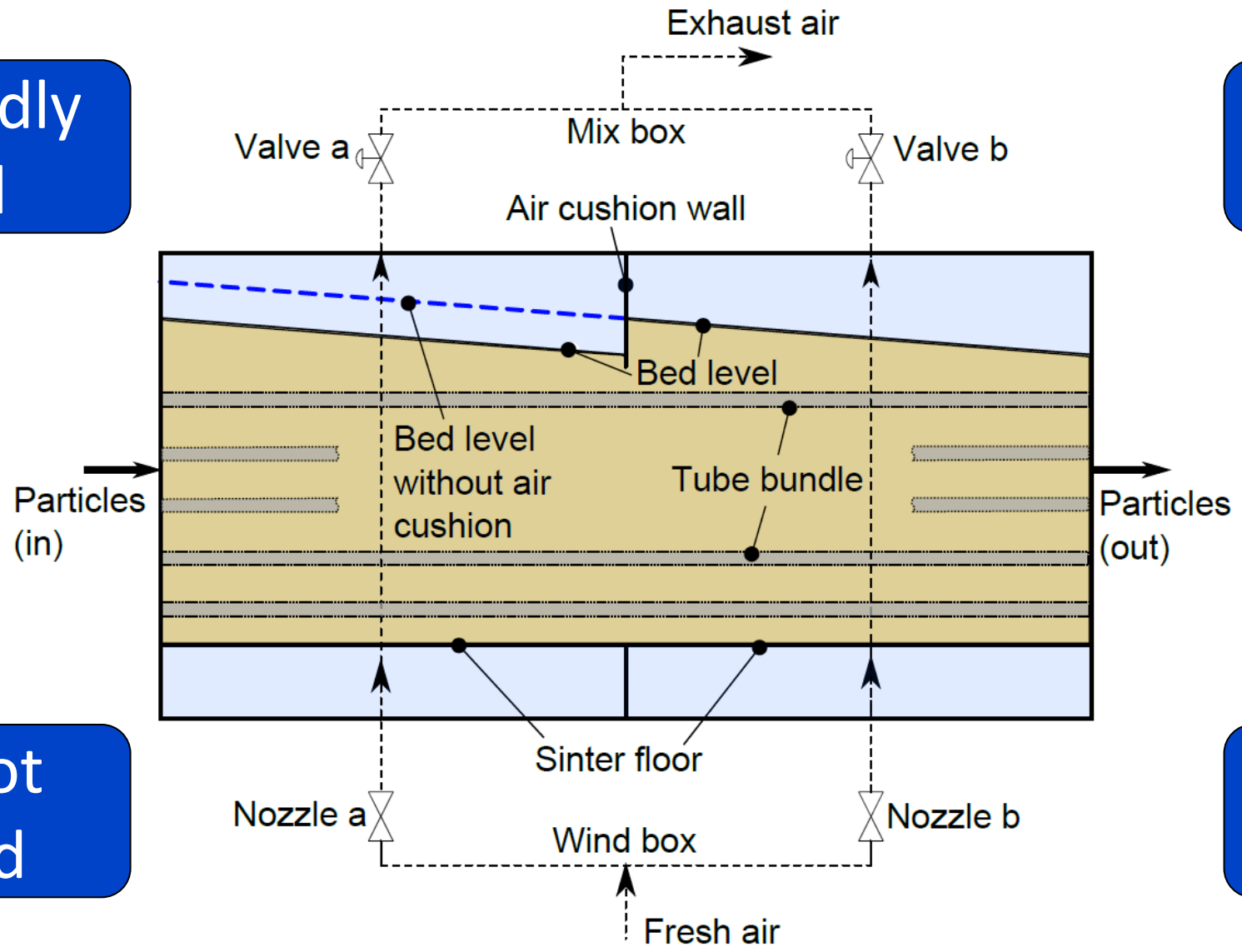
Vital Statistics

AC RTE:	35–45%	**TRL:**	5
Life:	30 years	**Largest Pilot:**	280 kWth

SandTES Heat Exchanger Operation

Sand is mildly fluidized

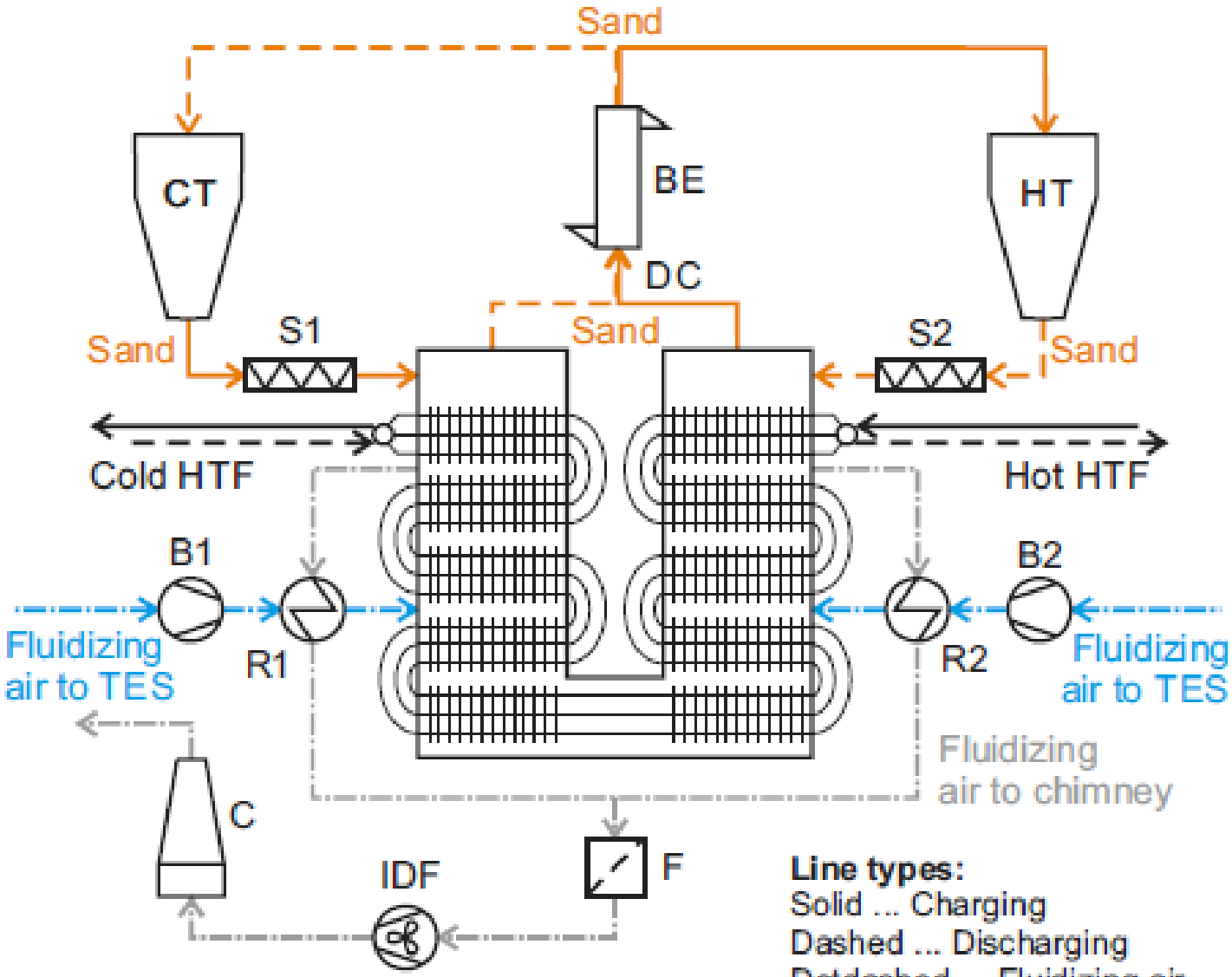
Sand flows countercurent



Sand is not elutriated

Heat transfer enhancement

Overall System Operation



B1 ... Blower 1
B2 ... Blower 2
BE ... Bucket elevator
C ... Chimney
CT ... Cold storage tank
DC ... Downcomer
F ... Filter
HT ... Hot storage tank
HTF ... Heat transfer fluid
IDF ... Induced draft fan
R1 ... Recuperator 1
R2 ... Recuperator 2
S1 ... Screw 1
S2 ... Screw 2

Phase II Goals

- Fit into the existing infrastructure and footprint for the Concrete TES (CTES) → *Proposed concept fits seamlessly, reducing risk and cost – a significant portion of the next-step pilot cost would have been constructing infrastructure (>$2.5M)*
- Large enough to advance SandTES to TRL 6 → *1 MWe with 10 hours duration was chosen to achieve TRL 6. This is a scale up by factor of ~10. 10 hours was chosen to illustrate the capability to go to longer durations.*
- Two tank or four tank? → *Two-tank design chosen to reduce costs and complexity and fits with most of the commercial designs as well.*
- Keep costs under $5M → *Goal as stated in the bid*

Goal: Develop a pilot design with the highest chance of success

Phase II Tasks

1. **Project Management and Planning:** Monitor and control the project and project reporting and review needs for the next-step pilot.
2. **Complete a Pre-FEED Study:** Detailed design effort for the integration of SandTES to the designated host site, Plant Gaston, at 10-MWhe scale, including AACE Class 4 capital costs and performance estimates.
3. **Update the Phase I Technoeconomic Study:** Update on the cost and performance for commercial-scale applications of SandTES integrated with a thermal power plant for several markets.
4. **Update the Phase I Technology Gap Assessment:** Update based on learnings from the pre-FEED study on potential gaps of SandTES and how they will be addressed to be commercial by 2030.
5. **Complete an Environmental Information Volume:** Compilation of an Environmental Information Volume (EIV) for the site, in preparation for the National Environmental Policy Act (NEPA) process.
6. **Update the Technology Maturation Plan:** Update the technical review of the technology readiness level (TRL) for the system and the plan to advance it through TRL 9, commercial readiness.
7. **Update the Commercialization Plan:** Update the plan for commercializing SandTES based on the evolving energy storage market.

Seven tasks in the one-year project

Project Org Chart

DOE-NETL
Project Officer
Jason Hissam

Project Manager
Andrew Maxson – EPRI

Technical Manager
Scott Hume – EPRI

Task 1.0 – Project Management and Planning
PM: Andrew Maxson – EPRI

- **1.1 Project Management Plan** — Andrew Maxson – EPRI
- **1.2 Technology Maturation Plan** — Andrew Maxson – EPRI
- **1.3 Adjust Project Team and Obtain Cost-Share Commitments** — Andrew Maxson – EPRI

Task 2.0 – Pre-FEED Study
PM: Kevin Montesanto – CDM

- **2.1 Update Technical Design** — EPRI, CDM, Southern, and TUW
- **2.2 Capital and Operating Costs** — EPRI, CDM, TUW, and Southern
- **2.3 Performance** — EPRI, CDM, Southern, and TUW

Task 3.0 – Technoeconomic Study
PMs: Scott Hume – EPRI; Markus Haider – CDM
EPRI, CDM, Southern, and TUW

Task 4.0 – Technology Gap Assessment
PM: Scott Hume – EPRI
EPRI and TUW

Task 5.0 – Environmental Information Volume
PM: Kevin Montesanto – CDM
EPRI, CDM, Southern, and TUW

Task 6.0 – Technology Maturation Plan
PM: Andrew Maxson – EPRI
EPRI and TUW

Task 7.0 – Commercialization Plan
PM: Markus Haider – TUW

- **8.1 Market Assessment** — EPRI, Southern, and TUW
- **8.2 Domestic and International Market Applicability** — EPRI, Southern, and TUW
- **8.3 Development of Use Cases** — EPRI, Southern, and TUW
- **8.4 Advantages of the Technology** — EPRI and TUW

EPRI Team:

Dr. Andrew Maxson
Sr. Program Manager

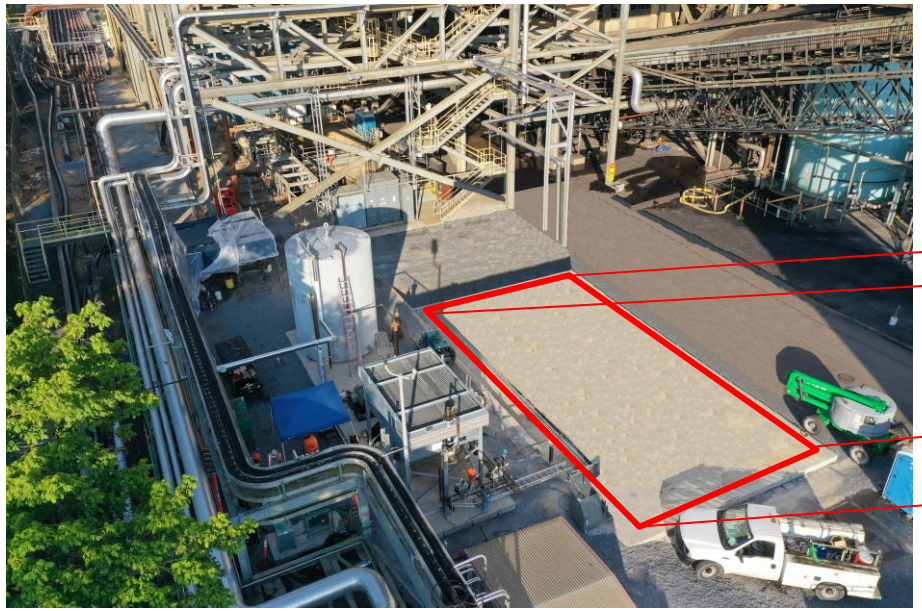
Scott Hume
Technical Executive

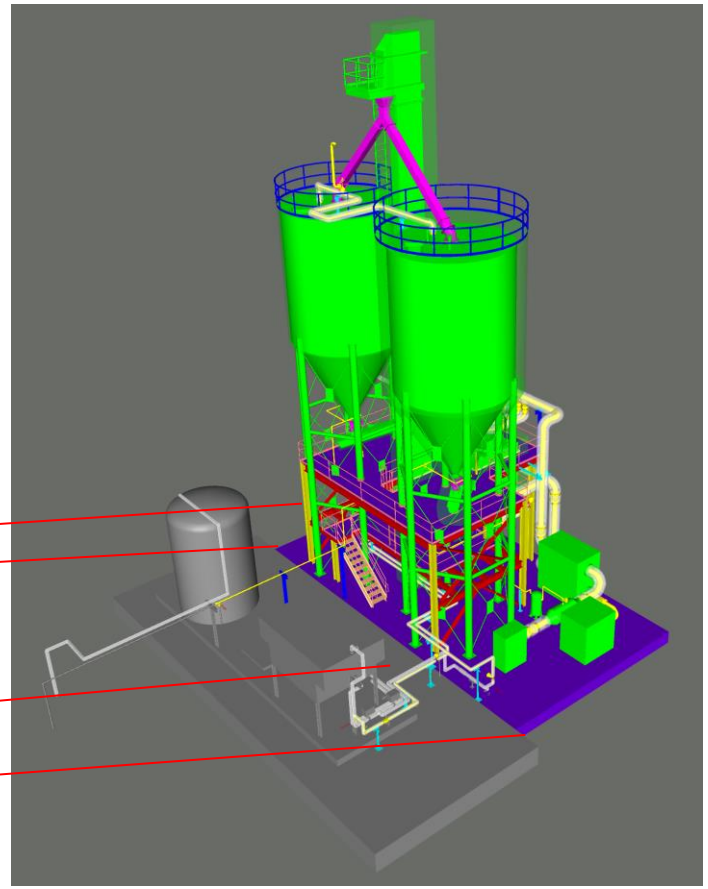
Jacob Rushkoff
Engineer/ Scientist II

EPRI · Southern Company · TU WIEN TECHNISCHE UNIVERSITÄT WIEN · ANDRITZ · CDM Smith

Existing Site and Proposed Pilot

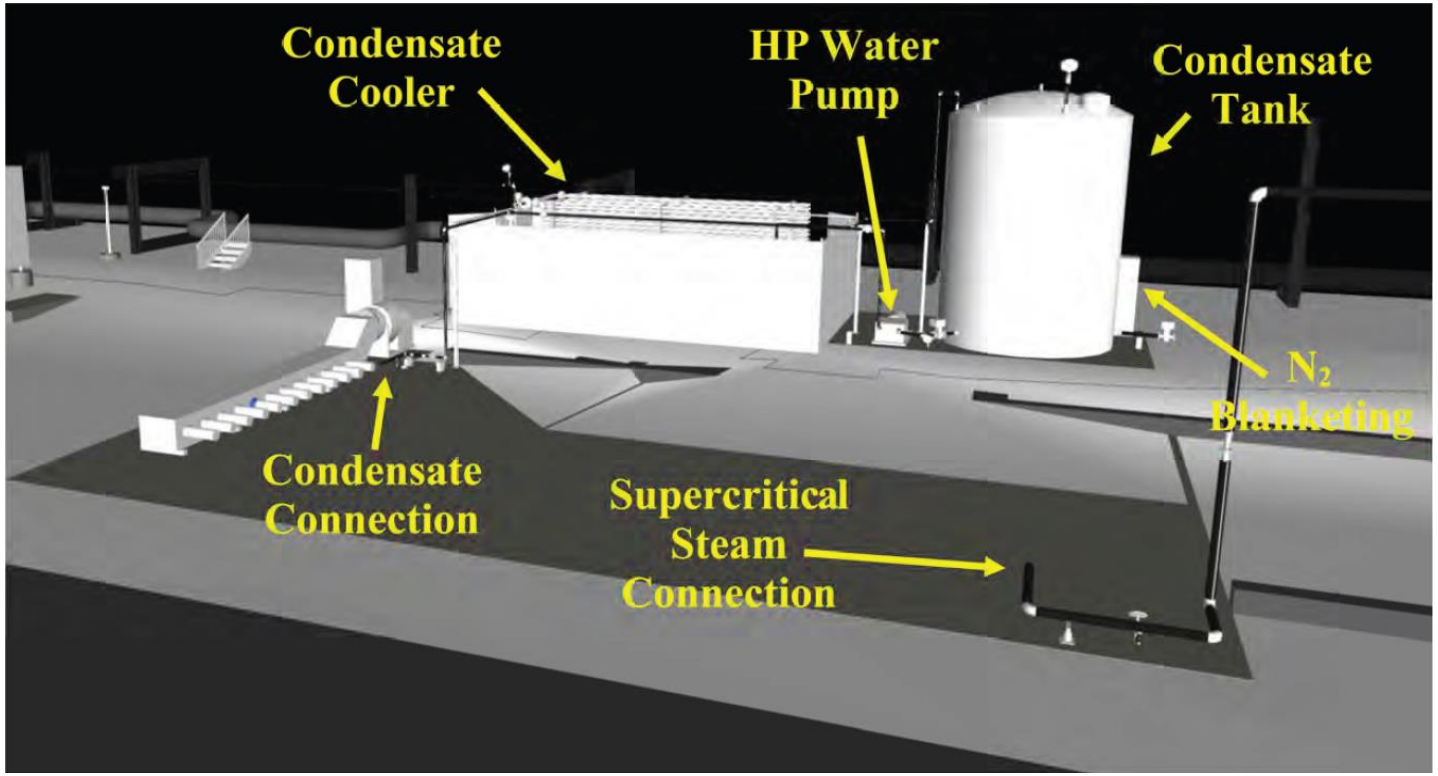
- Concrete TES (CTES) testing underway this year
- CTES modules will be removed, steam supply and condensate management infrastructure will be available for the SandTES installation





SandTES pilot system will utilize existing test site

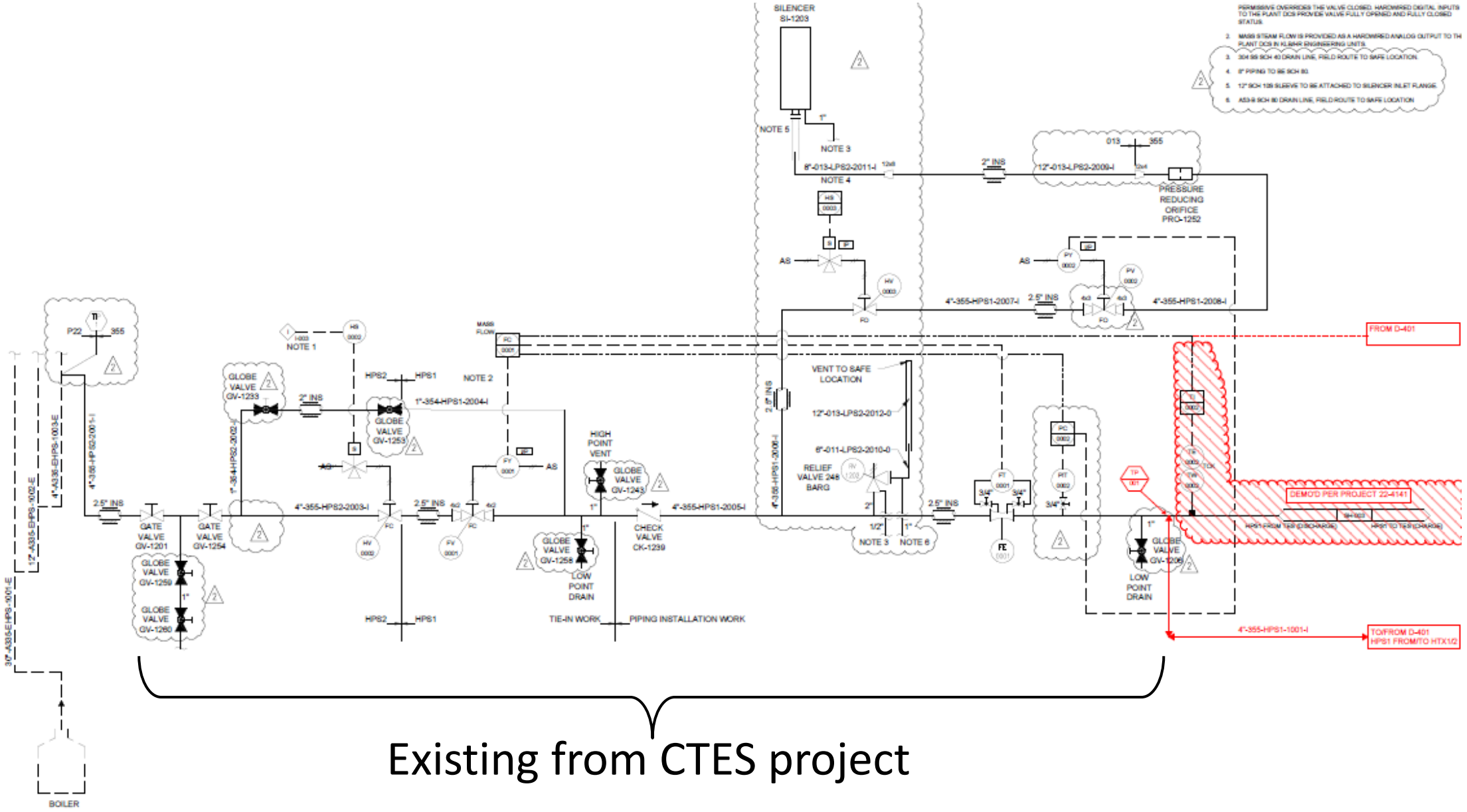
Interface with Existing System



- Electrical panel confirmed to support SandTES pilot loads:
  - Bucket elevator
  - Fluidization fan
  - Damper actuators
- Existing CTES control system will be removed, SandTES dedicated system will be installed

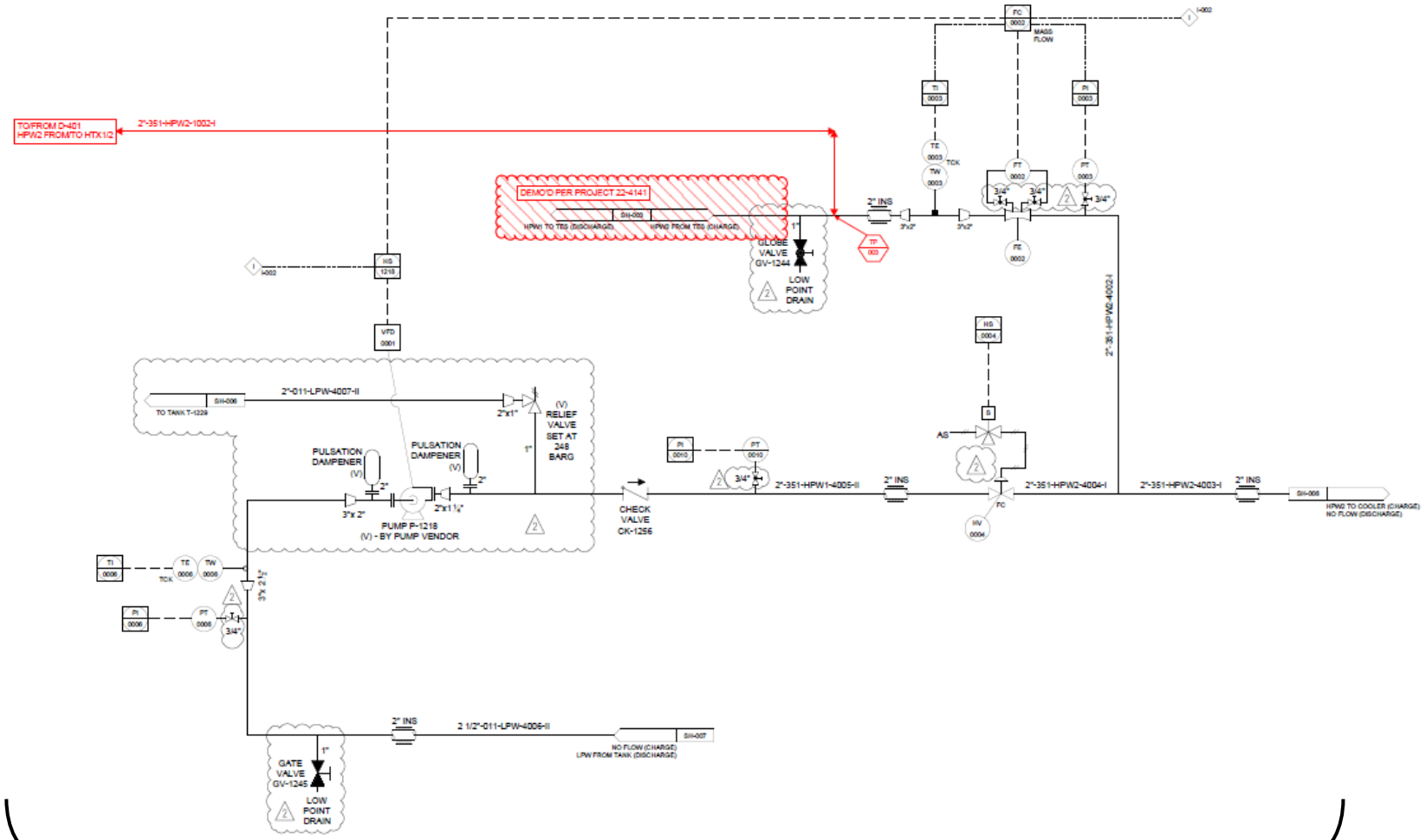
Main steam and condensate lines are only HP interfaces

Interfacing Main Steam System



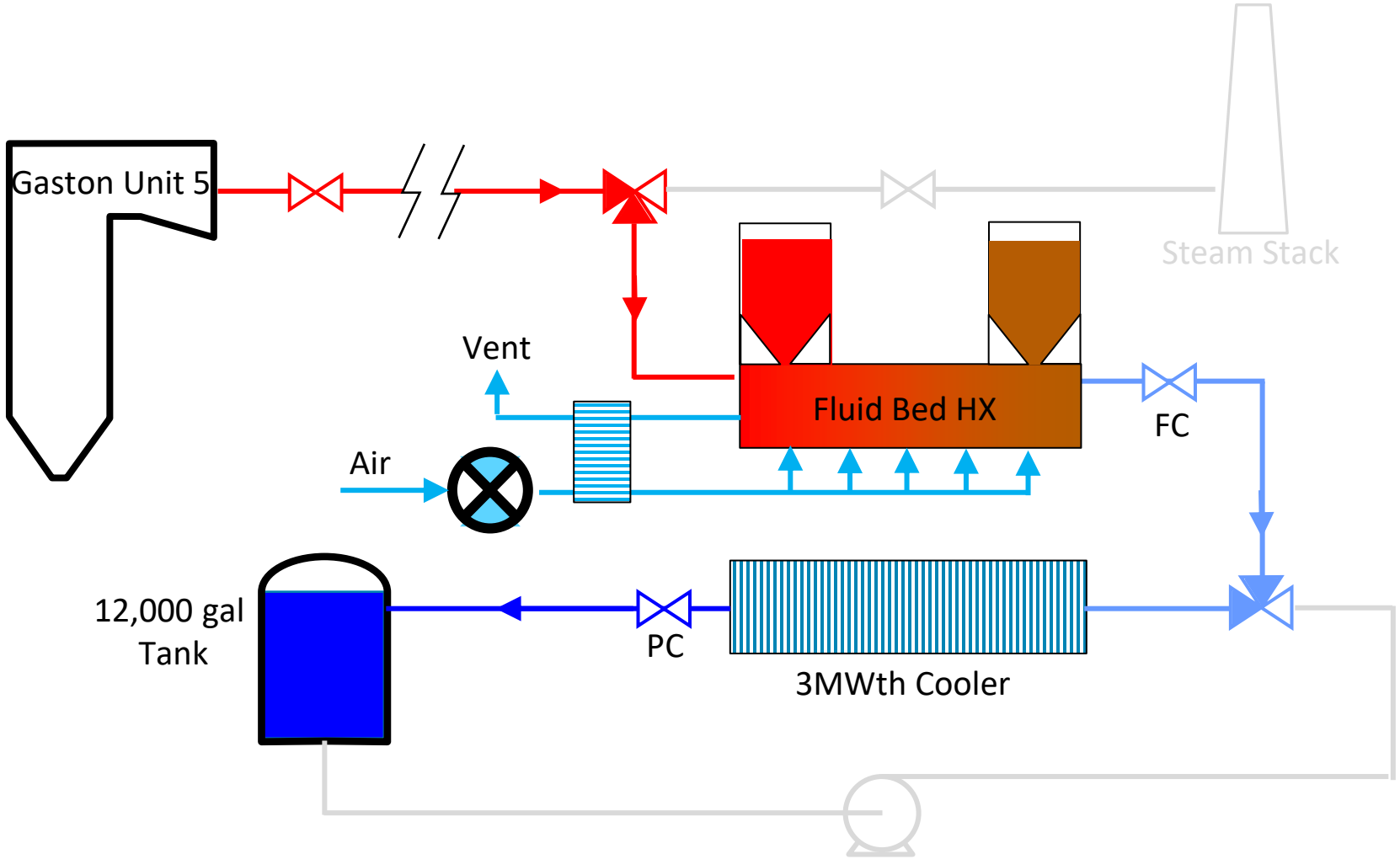
Existing from CTES project

Interfacing Condensate System



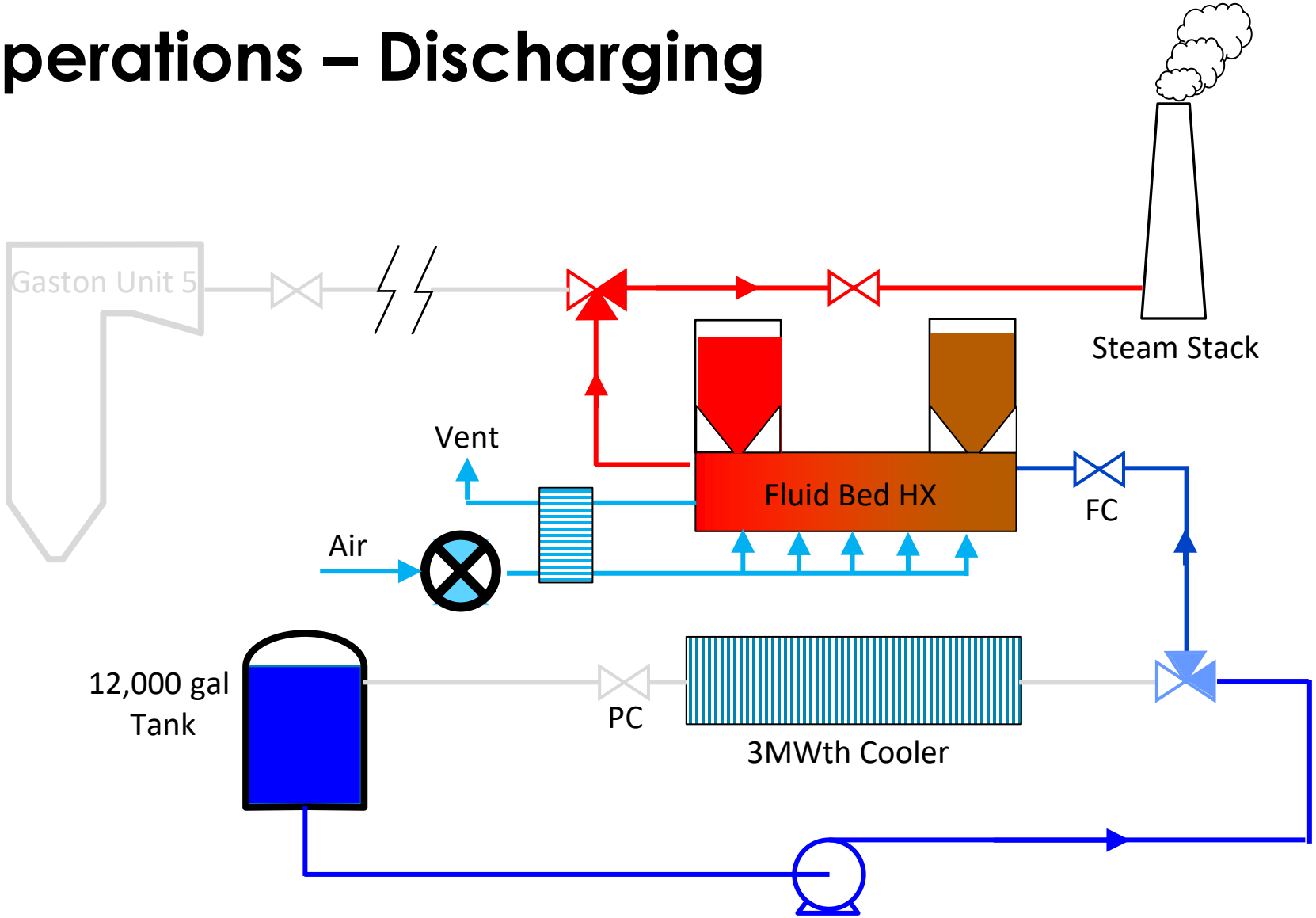
Existing from CTES project

Process Operations – Charging



Supercritical steam condensed, cooled, and stored

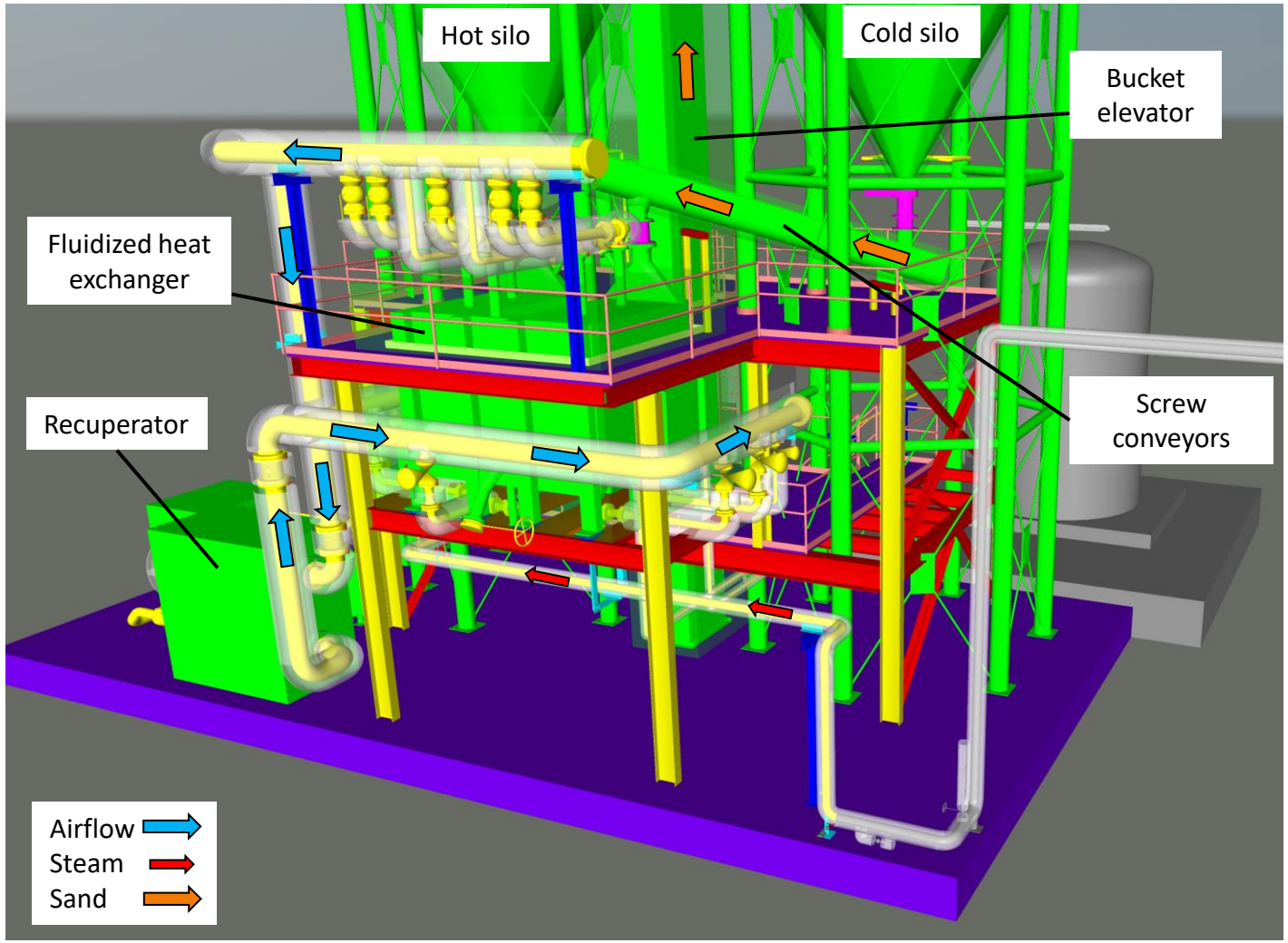
Process Operations – Discharging



Generated steam measured and disposed

SandTES Pilot Detail

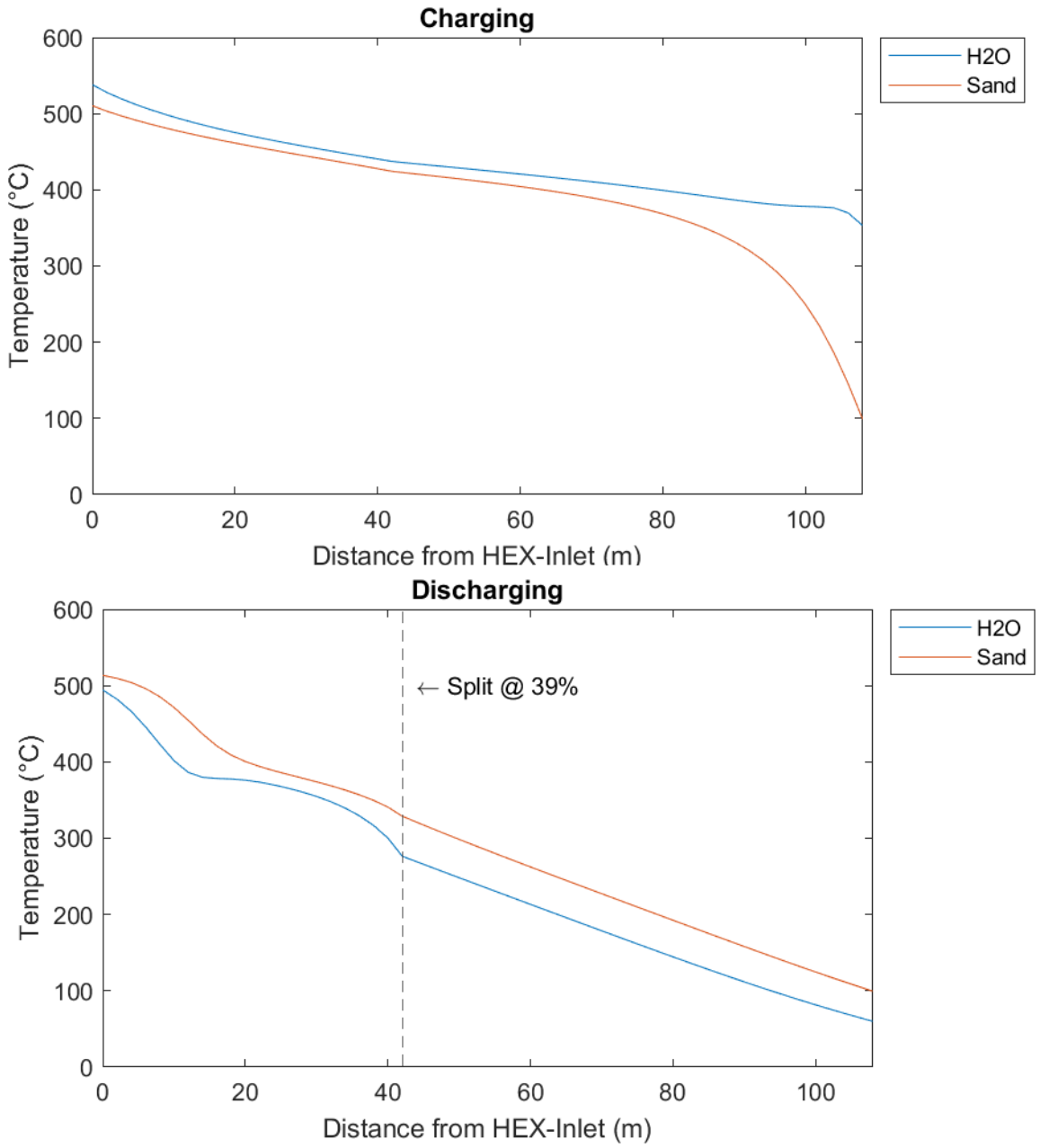
- System is charged using supercritical steam from Gaston Unit 5
- Sand from cold silo is fed into heat exchanger
- Hot sand exits exchanger and drops down to feed chute for bucket elevator
- Sand is lifted to the top of hot silo and falls in by gravity



Compact design developed to fit existing site

Pilot Plant Design Detail

- 2.5 MWth system (1 MWe eq.)
- Charges using full pressure steam from Unit 5 (3500 psig/1000°F)
- Sand stored at 960°F
- Condensate cooled and stored locally for discharge
- Discharged at supercritical pressure and 915°F
- Split needed to balance sand/water heat capacity through water-steam conversion



Pilot Capital Cost Summary

Item	Amount
Structural	$140,000
Electrical	$215,000
Mechanical	$1,039,000
Engineering	$181,000
Construction Management	$139,000
Contractor OH&P	$257,000
TUW Equipment (fluidized-bed heat exchanger)	$1,000,000
Total Costs	**$2,971,000**

Quotes from: Advance Tank (silos) and Materials Handling Equipment Company (sand material handling equipment)

Environmental Information Volume

- Draft completed March 2023
- Information collected:
  - Land Use — No change
  - Atmospheric — Low risk
  - Hydrologic — NPDES permit
  - Geologic/Soil — Developed
  - Wildlife — Low risk
  - Socioeconomic — Low Income
  - Historic/Cultural — Developed
  - Visual Resources — Industrial
  - Health and Safety Factors — Low risk
  - Solid and Hazardous Wastes — Low risk

Remaining Tasks

- Conclude Pre-FEED Activities

- Update the Commercial Design and Costs
- Update Technology Gap Assessment
- Update the Technology Maturation Plan
- Update the Commercialization Plan

- Final Report – August 2023

Q & A

Thank you!

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Acknowledgement and Disclaimer

Acknowledgement

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