U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

SETO CSP Program Summit 2019

Molten Salt Technical Session

Enabling High-Temperature Molten Salt CSP through the Facility to Alleviate Salt Technology Risks (FASTR)

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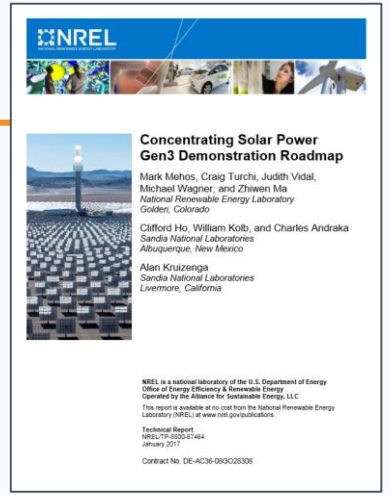
Setting the Stage: CSP Gen3 Roadmap Gaps

- Salt Chemistry
- Materials Selection/Compatibility, Piping
- Plant Sensors
- Thermal Energy Storage
- Salt Solar Receiver, Salt-to-sCO2 Heat Exchanger
- Pumps, Valves, Heat trace and Insulation
- Component Test Facilities

This Session



NREL/TP-5500-67464

SETO Sponsored Efforts Underway In all Areas

Salt Thermophysical Properties

- Density, specific heat, melting point
- Viscosity & thermal conductivity
  - Difficult to measure accurately, correctly
- Challenges:
  - Hygroscopic, high temperature, corrosive, vapor pressure, references

Materials Selection/Compatibility

- A range of materials are being considered
  - Iron based: 316, 347, 304H, *HR 120, …*
  - Nickel based: 625, 617, 600, C-276, 230, 740H, 800H, …
- Compatibility knowledge base is growing
  - Focused research on salt-material interface
  - Growing dataset of static capsules for screening
  - Limited dataset of flowing non-isothermal tests
- Practicalities
  - Code acceptance for industrial application
  - Vendor supply chain

Static Capsules

Thermal Convection Loop

Plant Sensors

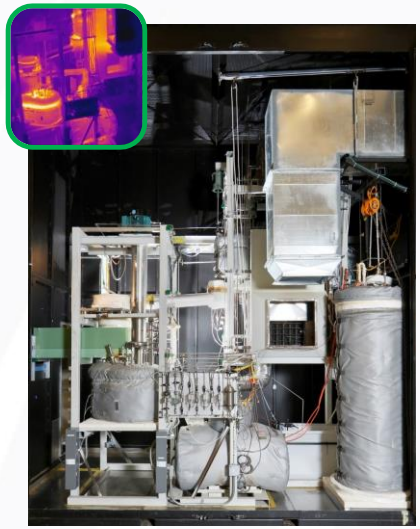
- Salt-specific sensors under development
  - Redox potential
  - Oxygen/hydroxide specie impurities
  - Corrosion specie impurities
- Traditional I&C
  - temperature, level - *available*
  - flowmeters, pressure - *challenges*

ANL multifunctional voltammetry sensor

Component Test Facilities

- Thermal convection loops:
  - Purpose: material compatibility, sensor demo.
  - Recent Operation: ORNL, ORNL, UW
- Forced flow loops (pumped):
  - Purpose: Material compatibility, component & sensor demo., separate effects tests
  - In Operation: ORNL, UW
  - In Development: ORNL, UAriz, VT, ORNL, UMich, UNM, …
- Pilot facilities
  - In Development: NREL (Topic 1 awardee)

EERE SETO sponsor
nuclear energy sponsors



ORNL Liquid Salt Test Loop

FASTR: Facility to Alleviate Salt Technology Risks

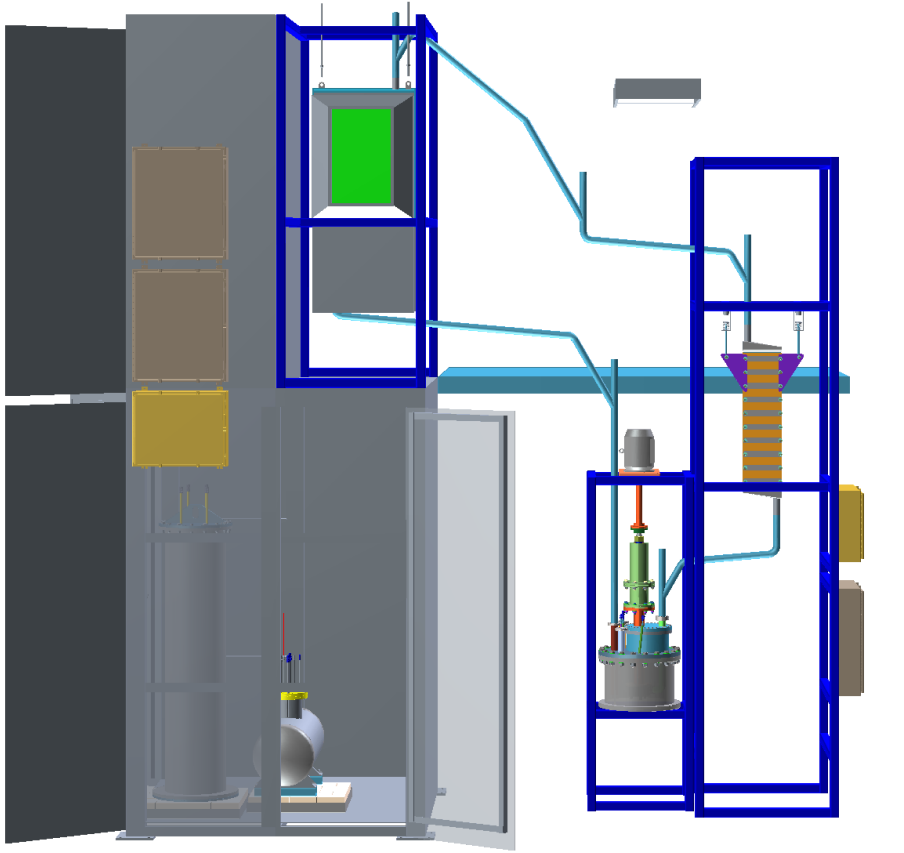
- Objective: Develop and operate a high-temperature (>700°C) molten chloride salt facility designed to enable a variety of testing in support of the Gen 3 CSP molten salt pathway.
  - Demonstrate salt can be circulated without freezing or corrosion issues
  - Demonstrate salt/system can be monitored & controlled
  - Serve as test bed to de-risk sub-components, underlying technology, and vendor hardware
- 3 year project started February 2018

- Within project, ANL developing a multifunctional voltammetry sensor capable of long-duration measurements of salt impurities, corrosion products, and salt redox state

FASTR: Facility to Alleviate Salt Technology Risks

Capability	Value
Salt	NaCl-KCl-$MgCl_2$
Flow rate	3-7 kg/s (30–70 gpm)
Design temp.	725°C (1337°F)
Main heater	350 kW_{th}
Trace heating	60 kW_{th}
Salt volume	120 L (32 gallons)
Main piping	2-inch schedule 40

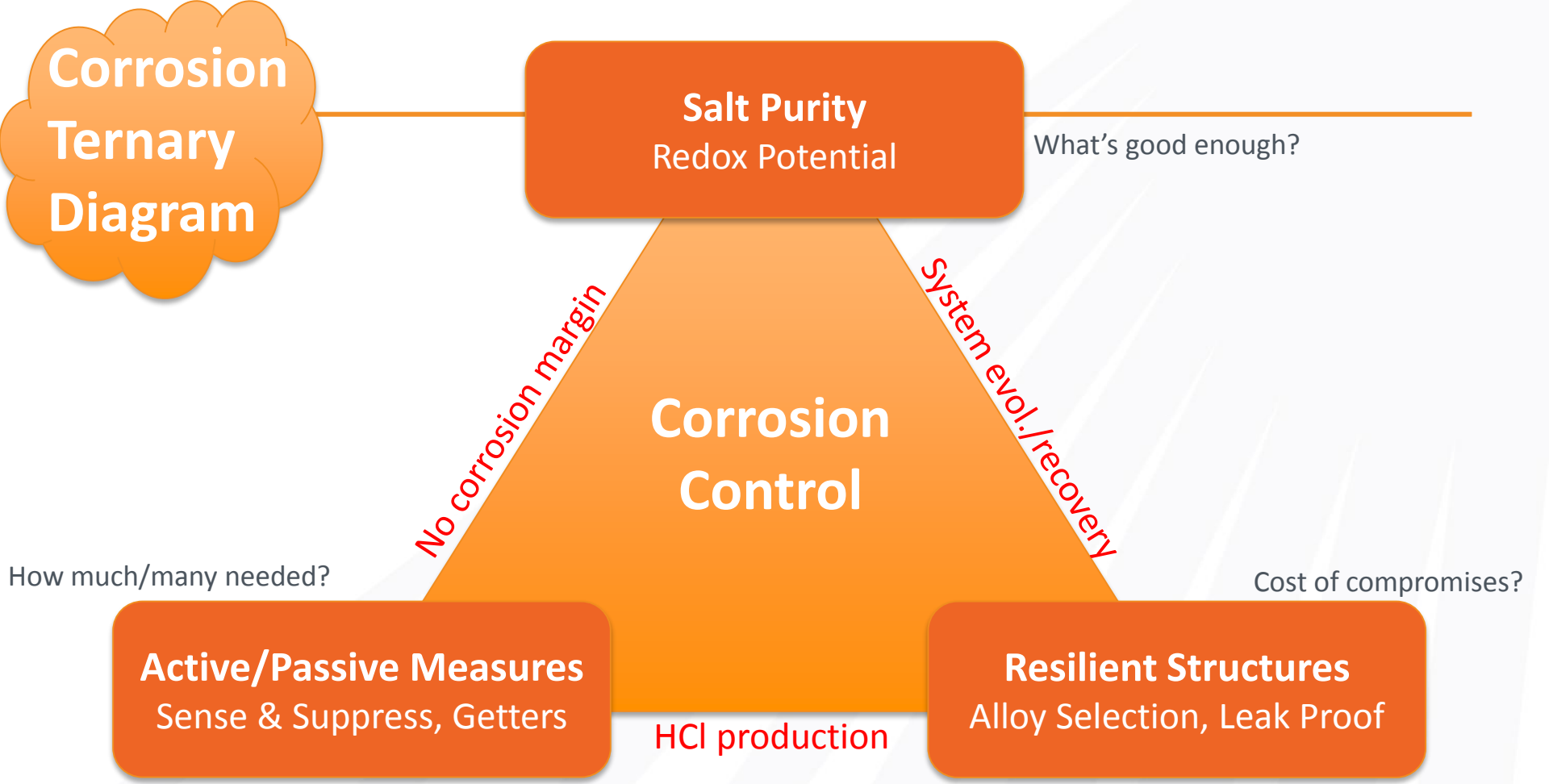
- **Status**: major design complete, components in acquisition phase



*Piping layout still under iteration

Molten Salts – Parallel Session

1. Comparison of Protecting Layer Performance for Corrosion Inhibition in Molten Chloride Salts through Interfacial Studies at the Molecular Scale
   Sheng Dai, Oak Ridge National Laboratory
2. Full Loop Thermodynamic Corrosion Inhibition and Sensing in Molten Chloride Systems
   Brenda Garcia-Diaz, Savannah River National Laboratory
3. Molten Chloride Thermophysical Properties, Chemical Optimization, and Purification
   Judith Vidal, National Renewable Energy Laboratory
4. Progression to Compatibility Evaluations in Flowing Molten Salts
   Bruce Pint, Oak Ridge National Laboratory
5. Development of In-Situ Corrosion Kinetics and Salt Property Measurements
   Li Liu, Rensselaer Polytechnic
6. High Temperature, Raman Spectroscopy Based, Inline, Molten Salt Composition Monitoring System for Concentrating Solar Power Systems
   Kevin Harsh, Sporian Microsystems


Corrosion Ternary Diagram
Salt Purity
Redox Potential
What's good enough?
No corrosion margin
System evol./recovery
Corrosion Control
How much/many needed?
Cost of compromises?
Active/Passive Measures
Sense & Suppress, Getters
HCl production
Resilient Structures
Alloy Selection, Leak Proof