



Thermal Energy Delivery System

Demonstrating flexible heat transfer for power generation, energy storage and other industrial uses

As energy demands increase and additional clean energy standards are established, many communities are turning to a combination of energy sources, such as nuclear, wind and solar, for a more resilient electrical grid. These increasingly complex energy systems reduce the chances that a provider will be a single point of failure for a community. However, this combination of electricity sources can mean that energy output exceeds demand at certain times of day or during certain seasons.

For instance, a nuclear power plant generates excess heat in the form of steam that can be converted to electricity for the grid. To remedy this, some utilities and municipalities are considering implementing integrated energy systems, or

an energy system that uses both electricity and heat to meet energy demands. This heat can also be used for other industrial processes, such as producing hydrogen, or stored for future use, allowing the plant to operate during times of reduced electricity demand.

To optimize the process of transferring heat from one application to another, detailed modeling, simulation and experimental testing are needed. Enter the Thermal Energy Delivery System (TEDS). Located in the Dynamic Energy Transport and Integration Laboratory (DETAIL) at Idaho National Laboratory, TEDS provides the capability to demonstrate simultaneous, coordinated, flexible and efficient transfer of heat for power generation, energy storage and other industrial end uses.

The controllable electric heater installed in TEDS can imitate the thermal energy generated at a commercial nuclear power plant. That thermal energy can then be distributed to co-located users, such as a solid-oxide electrolysis cell demonstration unit, which generates hydrogen by splitting steam molecules. The heat also can be stored in a thermal energy storage tank. Or TEDS can reject heat to a chilled water system to emulate a thermal energy consumer.

Data collected from TEDS will also be used to verify and validate modeling and simulation codes. These software tools are used by researchers and industry to develop optimal system designs and better predict

TEDS is co-located with MAGNET, a testing capability that simulates reactor core thermal behavior and provides researchers the ability to test new microreactor concepts, and High-Temperature Steam Electrolysis (HTSE) unit that uses high-temperature steam, like what a nuclear power plant produces, to research making clean, carbon-free hydrogen.



how an energy system may behave under different operating modes.

TEDS is designed to operate both independently and as part of an integrated energy system. When part of an integrated energy system, TEDS is connected to INL's Power and Energy Real-Time Laboratory, a digital simulator capable of modeling power grids, connecting with other facilities with real-time data transfer, and demonstrating real-time testing of actual energy grid hardware. TEDS will be able to characterize thermal energy inertia (how the heat transfers through a system) and management.

TECHNICAL CAPABILITIES

In its most basic configuration, TEDS is composed of a heater system, oil pump, thermal energy storage system, expansion and storage tanks, and an oil-to-air heat exchanger. TEDS also features a combination of flow sensors, pressure sensors and temperature sensors.

The heater output is variable, which allows operators to emulate multiple behaviors,

such as nominal power operation (e.g., operation of a nuclear reactor) as well as decay heat, or heat released during radioactive decay after a fission reaction. A "working fluid" is the medium used to move heat through the system from where it is generated to be stored or used by a coupled energy user. The variable speed pump allows operation of the system at any working fluid flow rate on a spectrum between the system's minimum and maximum.

Multiple configurations for thermal energy suppliers and users are possible with the TEDS design, which can be interconnected with various co-located systems. For example, work is underway to connect TEDS to the Microreactor Agile Non-nuclear Experimental Test Bed (MAGNET) and a solid-oxide electrolysis cell demonstration unit. These connections will mimic the energy input from a small-scale nuclear reactor coupled to an end user making hydrogen from the heat (i.e., the electrolysis unit). The

TEDS thermal energy storage tank can either store heat or condition it for downstream use where a constant supply of heat is essential. This demonstrates one type of thermal energy storage system is achieved with a thermocline packed bed — a tank filled with alumina beads to store heat. Future modifications to the system could allow inclusion of other candidate thermal storage technologies.

Nominal operating pressure:
14 psig (design pressure – 100 psig)

Nominal oil heater discharge temperature: 325° C
(design temperature – 340° C)

Nominal oil flow rate:
14-33 gpm

Heater power:
200 kW variable

Piping system design basis:
ASME B31.3-2014

INL is a U.S. Department of Energy (DOE) national laboratory that performs work in each of DOE's strategic goal areas: energy, national security, science and environment. INL is the nation's center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

FOR MORE INFORMATION

Technical contact

Shannon Bragg-Sitton

208-526-2367

shannon.bragg-sitton@inl.gov

General contact

Abby Todd

208-526-5327

abby.toddbloxham@inl.gov

www.inl.gov

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