

Compressed Natural Gas Energy Storage

THE CHALLENGE

The integration of renewables to the electrical grid is necessary to reduce overall emissions from electrical power generation. This integration creates challenges for grid operators who must match the power being generated with consumer demand, while ensuring reliability and power quality for the entire system.

Energy storage has been proposed as an alternative to natural gas peaking plants to deliver excess renewable energy to times of peak demand. For energy storage to provide benefits to end customers (energy consumers), it must be reliable, efficient, and cost effective.

COMPRESSED NATURAL GAS ENERGY STORAGE

The natural gas value chain includes raising its pressure (i.e., compression), transporting it in pipelines or storing it (e.g., underground) for later use until it reaches customers, at which time its pressure is reduced for final delivery. Typically, the energy used to compress the natural gas is not recovered at delivery.

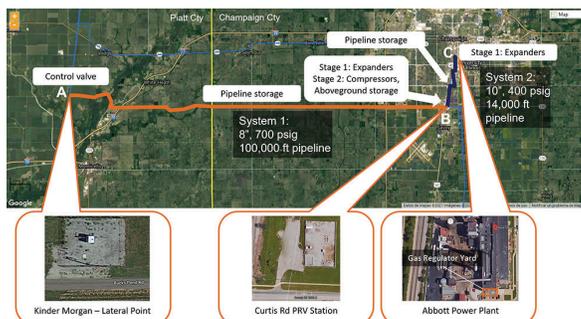
Compressed natural gas energy storage (CNGES) is a faster and more cost-effective way to store and recover energy. It uses existing natural gas infrastructure to convert electrical energy from renewable sources to potential energy during off-peak periods, then back to electricity during peak demand. Clean energy powers existing compressors with new expander generators installed at pressure reduction stations in the gas transmission network. The operating pressure of the pipeline is managed in between the compressors and expanders using new control algorithms.

ABBOTT POWER PLANT DEMONSTRATION PROJECT

ISTC is performing a conceptual (Phase I) study, funded by the U.S. Department of Energy, at the University of Illinois Urbana-Champaign's (UIUC) Abbott Power Plant and will integrate natural gas-based energy storage into its operations. The goal of the two-stage project is to demonstrate the technical and economic feasibility of integrating CNGES technology with an existing cogeneration fossil asset and establishing the path for its maturation and commercialization.

In the first stage, the project will employ new automatic controls to regulate the average pressure (line pack) in two segments of an existing 23-mile-long natural gas pipeline owned and operated by UIUC. The energy in the gas will be recovered while

its pressure is reduced by new expander-generators at two existing pressure-regulating valve stations. The recovered energy will be injected to the UIUC grid. The pressure source is provided by existing compression stations in the Kinder Morgan NGPL pipeline system. The amount of gas that can be accumulated in the existing pipelines between



Project locations

ABOUT ABBOTT POWER PLANT

Abbott Power Plant is a combined heat and power (CHP) facility owned and operated by the University of Illinois Urbana-Champaign. Abbott produces steam for heating of campus buildings and generates approximately half of the electricity supplied to campus. It has an installed capacity of 85 MW and 800,000 pounds of steam per hour.

STAGE 1 CONCEPT: ENERGY STORAGE AT EXISTING PIPELINE

- ▶ Existing facilities: 23 miles of natural gas pipeline in 2 segments, 2 pressure reduction stations, 85 MW combined heat and power plant
- ▶ New facilities: Aboveground pressure vessels, compressors, expander generators and heaters added at 2 pressure reduction stations
- ▶ 12 hours total duration
- ▶ 1.2 MW total new capacity
- ▶ 30 MW total existing combustion turbines
- ▶ 17.4 MWh total electrical energy
- ▶ 370 MWh total chemical energy convertible to electricity at existing turbines
- ▶ 2,442 metric tons of CO₂ avoided each year

their maximum and minimum operating pressures determines how much energy can be stored. This stage will demonstrate whether it is feasible to quickly adapt existing natural gas transportation infrastructure for energy storage and recovery.

At a second stage, the project will include new aboveground pressure vessels that will increase the total energy capacity of the system by adding gas inventory at five times the pressure of the existing pipeline. The pressure at this stage will be provided by new compressors powered by energy from an adjacent solar farm. The stored energy will then be recovered by a new expander and injected to the UIUC grid because the accumulated gas is returned to the pipeline at a lower pressure. This stage will demonstrate the feasibility of modularly increasing energy storage capacity beyond the limits of the existing infrastructure and will increase the reliability and resiliency of the fossil asset to extreme weather events.

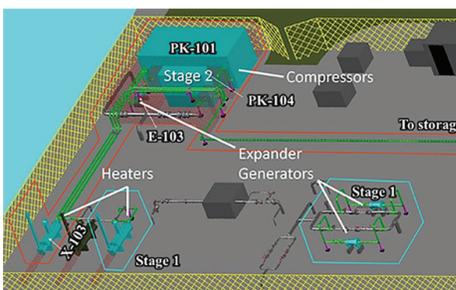
EXPECTED PROJECT BENEFITS

Upon successful completion of the project, this new integrated technology will improve energy efficiency and reduce fuel and maintenance costs at combined heat and power (CHP) plants. Because efficient ramping uses less fuel, the energy storage system will reduce emissions. A control system will provide automated adjustments that reliably and rapidly generate power to help stabilize the grid from fluctuations due to intermittent sources and demands. The project shows how natural gas infrastructure can be repurposed for a non-combustion application and will serve as a demonstration facility if it advances to the build/operate phase.

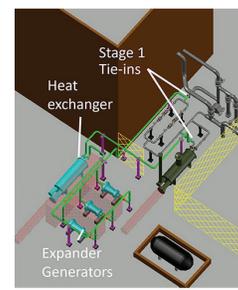
Widespread implementation of wind and solar power will depend on the resiliency of the power grid to maintain supply and of fossil-fired generation plants to fill the gaps inherent in intermittent power sources. Using natural gas for energy storage provides both a mechanical and combustion means to use a critical national resource. It also presents an opportunity to re-train those employed in the fossil fuel energy business, while creating green jobs and using personnel currently involved in the natural gas field.

This fact sheet was developed as part of the Natural Gas-Based Energy Storage at Abbott Power Plant Project, funded by a grant from the U.S. Department of Energy, National Energy Technology Laboratory Office of Fossil Fuels (DE-FE 0032018).

Integration of new equipment into existing facilities



Curtis Rd. and railroad pressure regulation station



Abbott Power Plant station



Prairie Research Institute

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER

TN21-145

©2021 UNIVERSITY OF ILLINOIS BOARD OF TRUSTEES

ABOUT ISTC

The Illinois Sustainable Technology Center is a division of the Prairie Research Institute at the University of Illinois at Urbana-Champaign. ISTC's mission is to encourage and assist Illinoisans, businesses, and government agencies to prevent pollution, conserve natural resources, and reduce waste to protect human health and the environment.

ISTC.ILLINOIS.EDU | ISTC-INFO@ILLINOIS.EDU