Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency

DE-EE0008412
GE Research/GE Renewable
10/1/2018 – 12/31/2020

Ibrahima Ndiaye, GE Research

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 11, 2019

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview

Project Title: Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency

Timeline:

Project Start Date: 10/01/2018

Budget Period End Date: 12/31/2019

Project End Date: 12/31/2020

Barriers and Challenges:

- Economic viability of converter-interface CHP
- Comprehensive modeling of reciprocating engines controls
- Complexity of integrating controls of engines, converter and plant controller
- Integration of evolving grid code requirements, energy markets dynamics and other economic factors

AMO MYPP Connection:

- Combined Heat and Power (CHP) systems

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$1,499,533	$374,883	$1,874,416	20%
Approved Budget (BP-1)	$916,338	$229,084	$1,145,422	20%
Approved Budget (BP-2)	$583,174	$145,799	$728,973	20%
Costs as of 3/31/19	$188,654	$47,164	$235,818	20%

Project Team and Roles:

- GE Research: project management, economic and technical feasibility analysis, development of the control platform, validation tests
- GE Renewable: cost share, steering committee, technical support with converter controls
- National Grid: advisory, support on user cases applications and grid code requirements

Project Objective

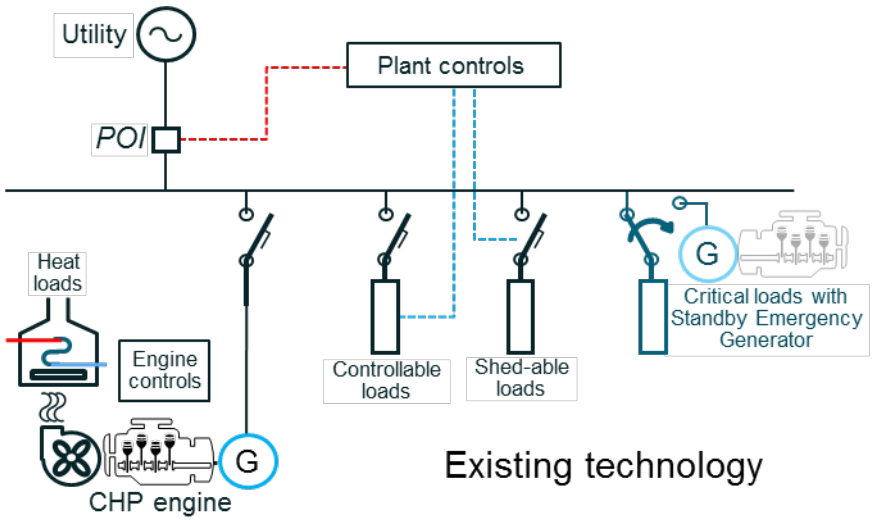
- Interconnection process of small-to medium sized CHP (1-20 MWe) to the distribution grid can be complex, lengthy and costly.
  - Grid code requirements are becoming more stringent due to a more dynamic grid with increasing presence of intermittent renewable resources
  - Limited flexibility of current CHP systems impacts their profitability and discourages participation in grid ancillary services markets

- Solution that simplifies the interconnection process while providing a higher ROI for CHP projects is the key barrier to a broader adoption of CHP systems for small and mid-size manufacturing facilities.

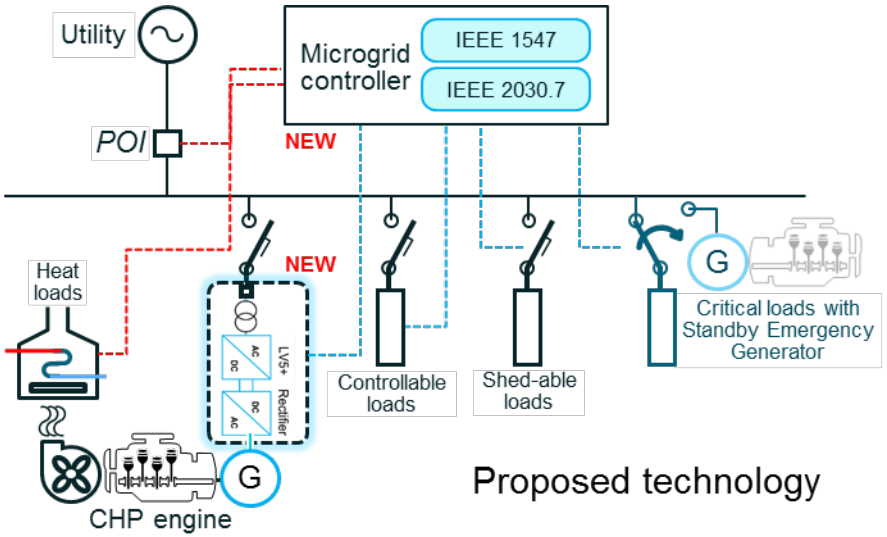
- **Objective**: Develop a grid-interface converter and plant controller for a seamless interconnection of small and mid-size CHP to the distribution grid
  - Approach: Confirm both the technical and economic benefits, Integrate controls of the engine, the converter to the plant controller, Validate compliance with distribution grid standards
  - Target: 15% ROI, meet IEEE 1547 requirements, islanding mode operation

(Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency)

Technical Innovation



Existing technology



Proposed technology

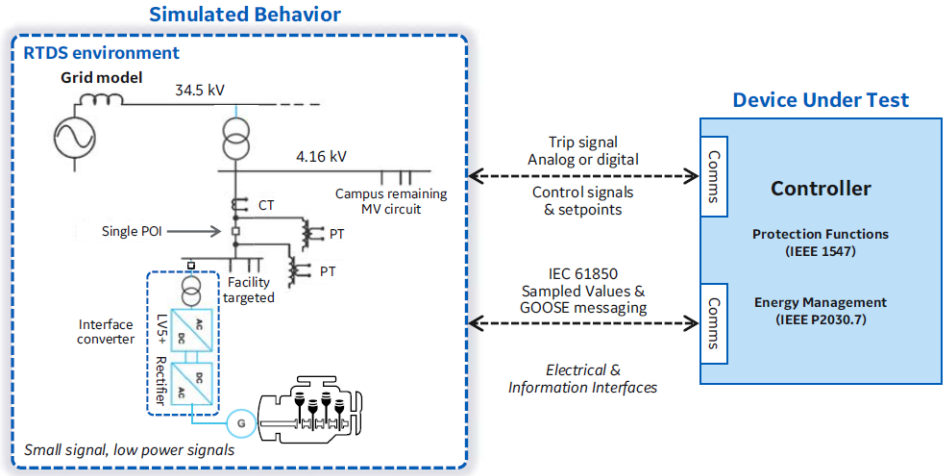
- **<u>Limitations with current practice</u>**:
  - need to demonstrate with comprehensive system studies compliance to all interconnection requirements for "Permission to Operate"
  - can significantly contribute to short-circuit fault level
  - generator oversized to provide reactive power
  - limited reactive power capability
  - Any modification required as mitigation to meet requirements is at the owner's expense
  - limited ROI discouraging numerous projects to go to commissioning

- **<u>Proposed approach</u>**:
  - interconnect CHP systems using a grid-ready inverter which already incorporates the key grid functions.
  - plant controller for energy management
- Critical innovations
  - significantly reduce oversizing of the generator
  - significantly limit the short-circuit fault contribution of CHP eliminating a key barrier to higher penetration
  - decouple the CHP frequency from the grid dynamics
  - streamline the interconnection process of CHP in the distribution grid

(Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency)

Technical Approaach

- Confirm the economic feasibility of converter-interfaced CHP
  - define user-cases (applications, size, ISO, energy markets data)
  - compare ROI between directly-coupled and converter-interfaced CHP
  - Estimate potential additional revenue from grid services
- Confirm the technical performance
  - develop the technical specifications of the key components of converter-interface CHP
  - develop hardware-in-the-loop simulations to validate the controls integration of the engine, converter and plant controller
- Validate the system performance
  - Build an engine emulator around a +2MW inverter
  - Perform system validation tests to confirm performance of the controls integration and capability in isolated mode



Key technical challenges

- integration of the different controls including the engine, the generator, the grid-interface converter and the plant controller
- Mitigation of the harmonics at the generator side
- Controls stability in islanding mode
- Protection coordination in islanding mode with limited short-circuit fault level

The team has an extensive combined field experience with converters and controllers design along with how power generation assets connect to and interact with the distribution grid.

(Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency)

Results and Accomplishments

- Completed the evaluation of the potential market for small-to mid size CHP applications
  - defined 5 user cases as benchmark to evaluate benefits of converter-interfaced CHP
  - evaluated the grid services market in the five ISO corresponding to each user case

- Completed the evaluation of different options for the converter design
  - options evaluated for harmonic reduction (<5%) and reduced sizing of the engine generator (110% maximum) as compared to up to 170% today
  - preliminary evaluation of components ratings, sizes and costs for ROI calculations
  - built simulations platform to compare the dynamic performance of converter-interface CHP with conventional grid-tied

- Preliminary timeseries simulations for the calculation of the energy costs and potential addition revenue from grid support services
  - included CHP operational constraints (minimum power output, reactive power, utility grid code requirements, energy pricing data)

(Converter-Interfaced CHP Plant for Improved Grid-Integration, Flexibility and Resiliency)

Transition

- Technology Readiness Level (TRL) is anticipated to be 7 by project end
- GE Renewable will be the commercialization partner. GE Renewable has a strong presence and large existing customer base in the commercial and industrial manufacturing markets
  - GE Renewable is a key project stakeholder and will provide technical support on the converter controls
  - GE product-line already includes grid-ready inverters and microgrid plant controllers
- National Grid will support the team with connection CHP solutions providers in its territory