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The Fort Collins Renewable and Distributed Systems Integration Project in Colorado

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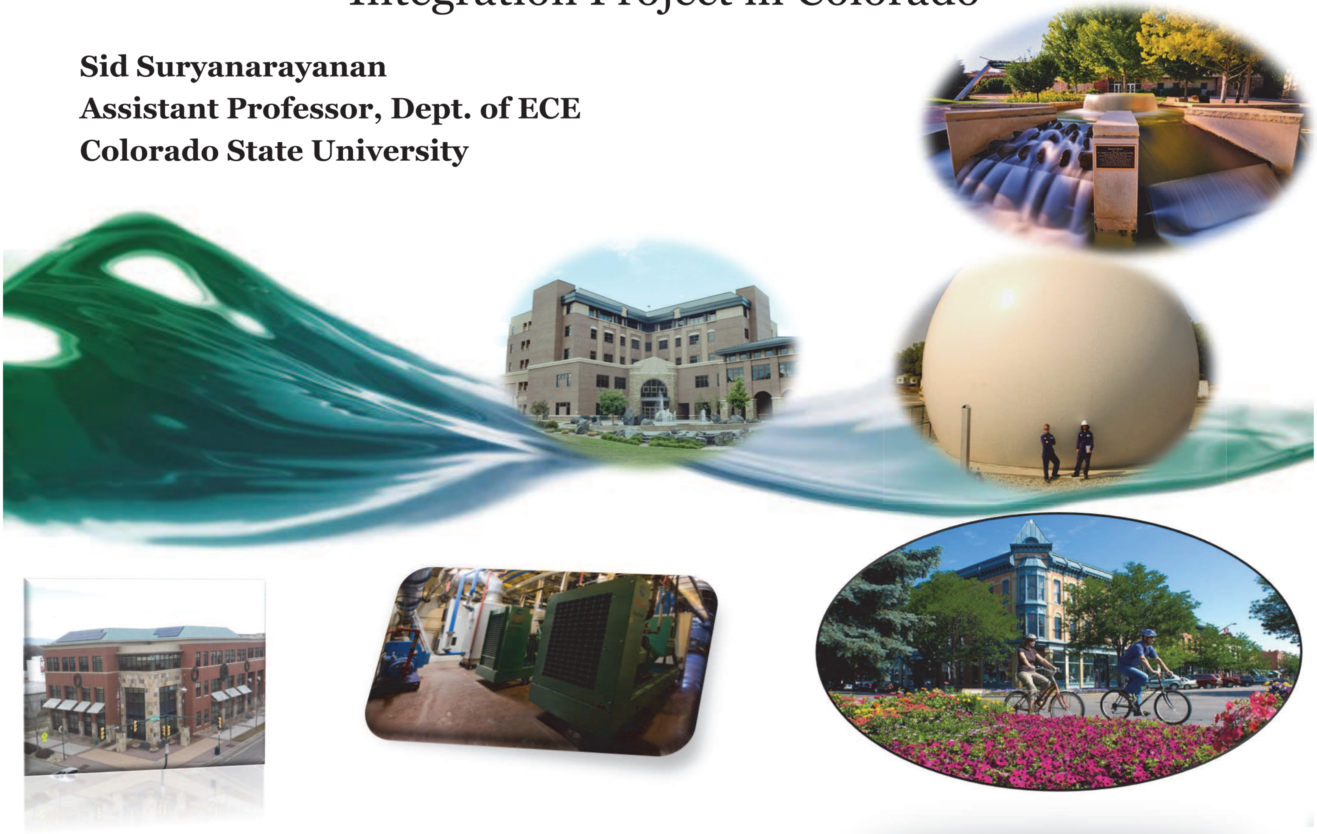
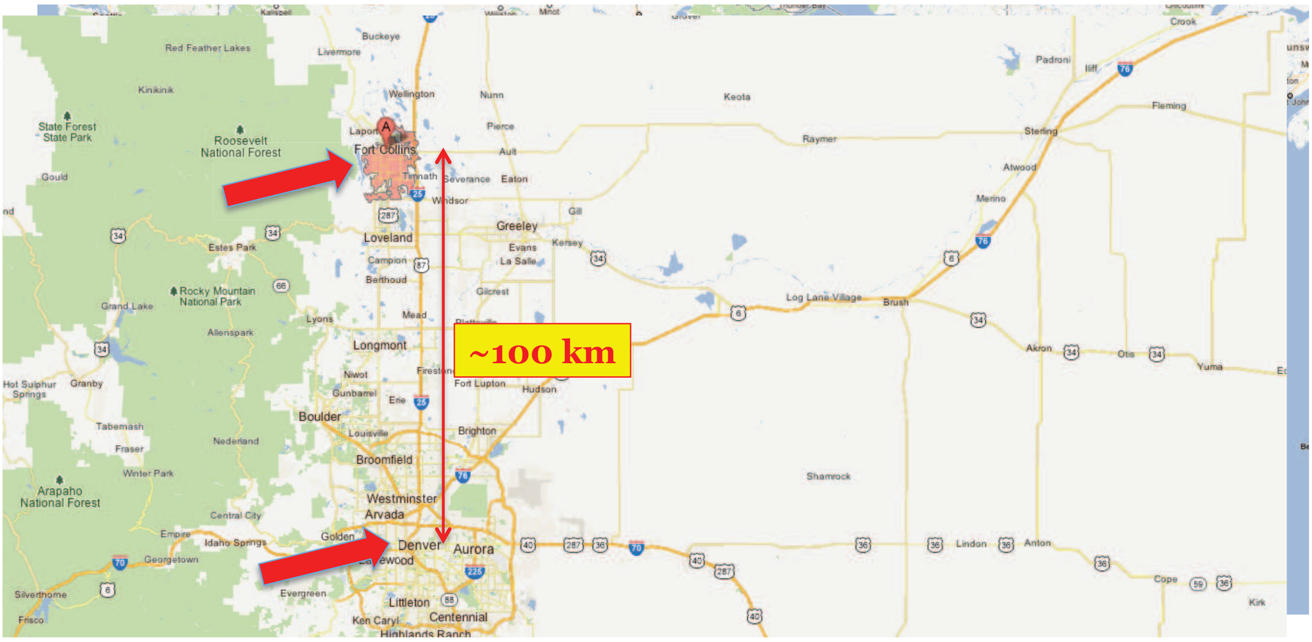


Presentation Overview

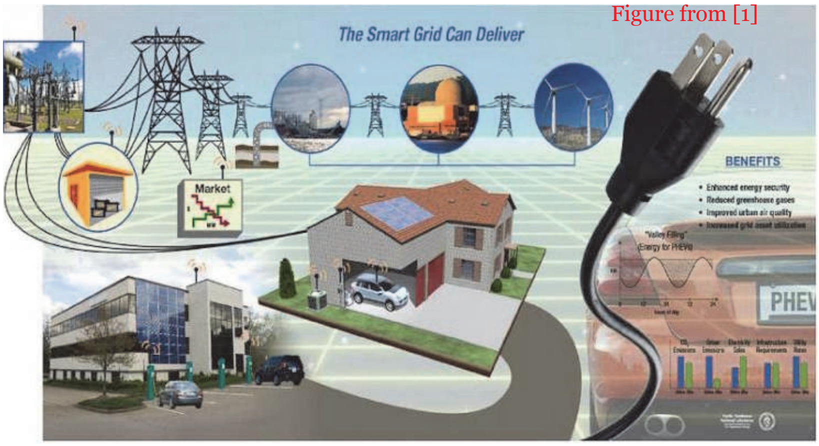
- The Fort Collins RDSI Demonstration Project
  - Background
  - Participants
  - Breakdown of assets
  - Demonstration results
  - Lessons learned

Where is Fort Collins, CO?



The *Smart Grid*

Figure from [1]



- Use of digital information and controls
- Dynamic optimization and cyber security of the grid
- Widespread deployment of distributed energy resources including renewable sources
- Use of demand response and peak-shaving technologies
- Deployment of smart appliances and technologies
- Providing customers with timely information and control options

Renewable and Distributed Systems Integration (RDSI) Background

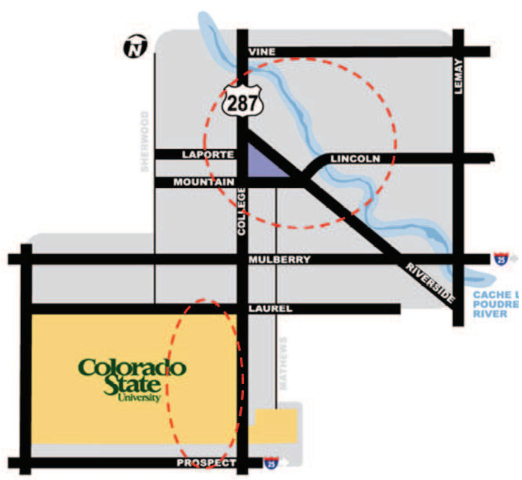
- In 2008, US DOE awarded $55M to 9 RDSI projects across US (overall >$100M).
- Focus on integrating: renewable energy, distributed generation, energy storage, thermally activated technologies, and demand response into the grid.
- Main goals:
  - Encourage use of distributed resources to provide power during peak load periods.
  - Minimum 15% reduction in peak load on distribution feeder or substation.

RDSI Background – Fort Collins

- DOE awarded $6.3M
- Local entities contributed cost share totaling $5.1M.
- CO Governor's Energy Office participation was $250K.
- City of Fort Collins is project lead.

◆ Main goals:

- Demonstrate coordinated system of mixed distributed energy resources
- Reduce peak load by >20% - 30% on two feeders of total capacity 15MW
- Intentional islanding



FortZED: Fort Collins Zero Energy District

Project Lead	
City of Fort Collins	Prime Contractor
Fort Collins Utilities	Utility Company
Demo Sites	**Resource**
City of Fort Collins	DG, DSM, PHEV, and Thermal Storage
Colorado State University Facilities	DG, DSM, and Thermal Storage
InteGrid/EECL	Fuel Cell, MicroTurbine, Conventional DG, Wind Sim, SC/SLC and others
Larimer County	Photovoltaics and DSM
New Belgium Brewing	Photovoltaics, DG, and DSM

Who

Tech Partner	Contribution
Advanced Energy	Photovoltaic Inverter
Brendle Group	Demand Side Management and Program Development
Colorado State University	Robust Controls and PHEV R&D
Eaton	Switchgear/Power Components and Small Generator Switchgear R&D
InteGrid	Platform for Controls R&D, DER Integration and Simulation
Spirae	Smart Grid Platform – DER/Power Management System
VanDyne Super Turbo	Diesel Gensets for added project Power
Woodward Governor	Power Management and Mixed Fuel R&D

The Projects – Load Shedding

- Turn off pumps for fountains
- Reduce fan speed in HVAC
- Increase thermostat set-points during cooling season
- Lock out stages of compressors in building cooling systems
- Lock out plug-in hybrid electric vehicles
- Thermal storage to shift cooling load

CSU Water Fountain

The Projects – Local Generation

- Solar photovoltaic (PV) projects
- Local backup generators
- Dual-fuel (natural gas/biogas) generator

City of Fort Collins Facility

New Belgium Brewing

CSU Greenhouse

Project Highlights – CSU Solar PV Array

- 19 kilowatt photovoltaic (PV) system
- Ability to back-feed electricity to grid during peak demand
- Renewable energy source reduces over 50,000 pounds of greenhouse gases per year

CSU Engineering Building

Project Highlights – Larimer County Justice Center Fountain Control

- Shut off fountain water pump during times of peak electric demand
- Controlled with a Building Automation System
- Demonstration run May-October 2011


Larimer County Justice Center

Project Highlights – New Belgium Brewing

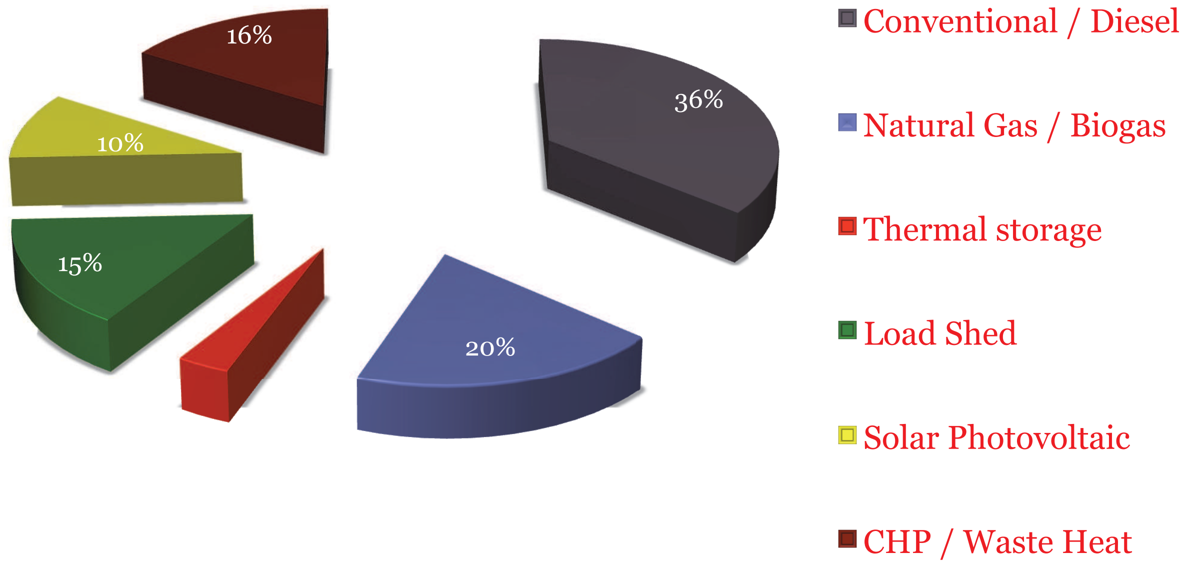
- Thermal Storage - Generate cold water at night when it is easier to cool, eliminating need to run compressors during the day.
- Two engine generators capable of turning biogas from wastewater treatment into 792 kW of dispatchable electric power.

New Belgium Brewing

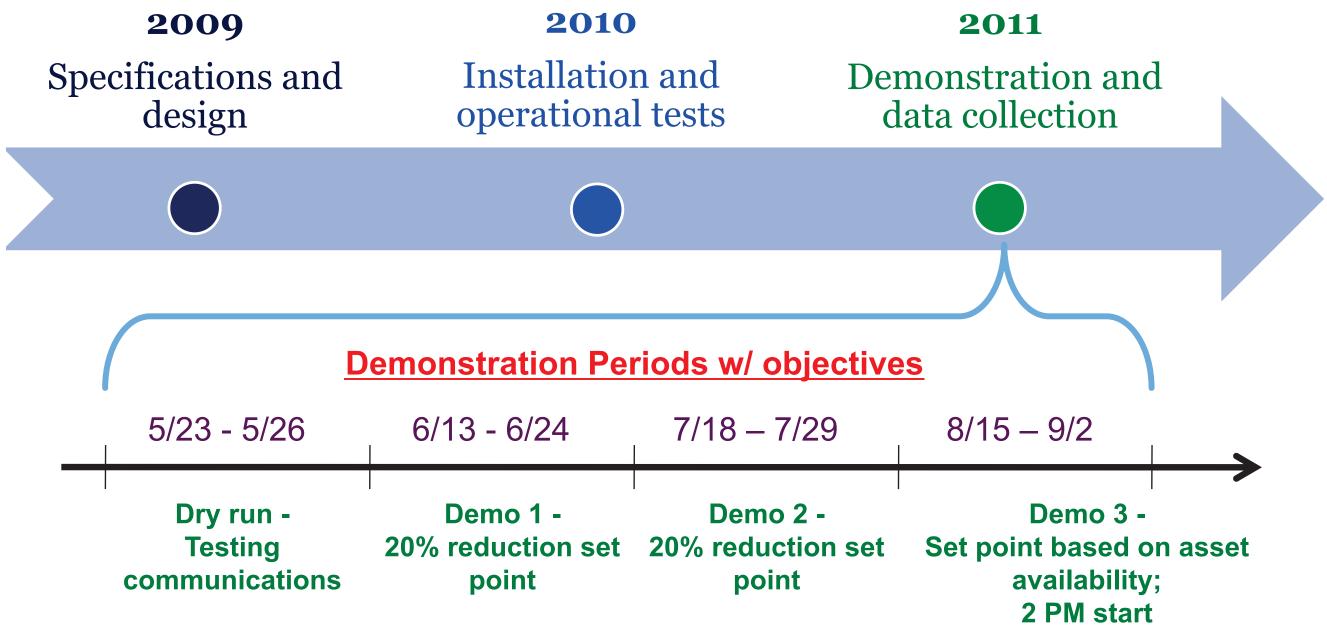
Project Highlights – Integrid/EECL

- Several generation assets form a microgrid, capable of simulating islanding, variable contributions from renewables, and spinning reserve
- 2 x 80 KW gensets
  - Aircooled
  - Used as spinning reserves
  - PV leveling

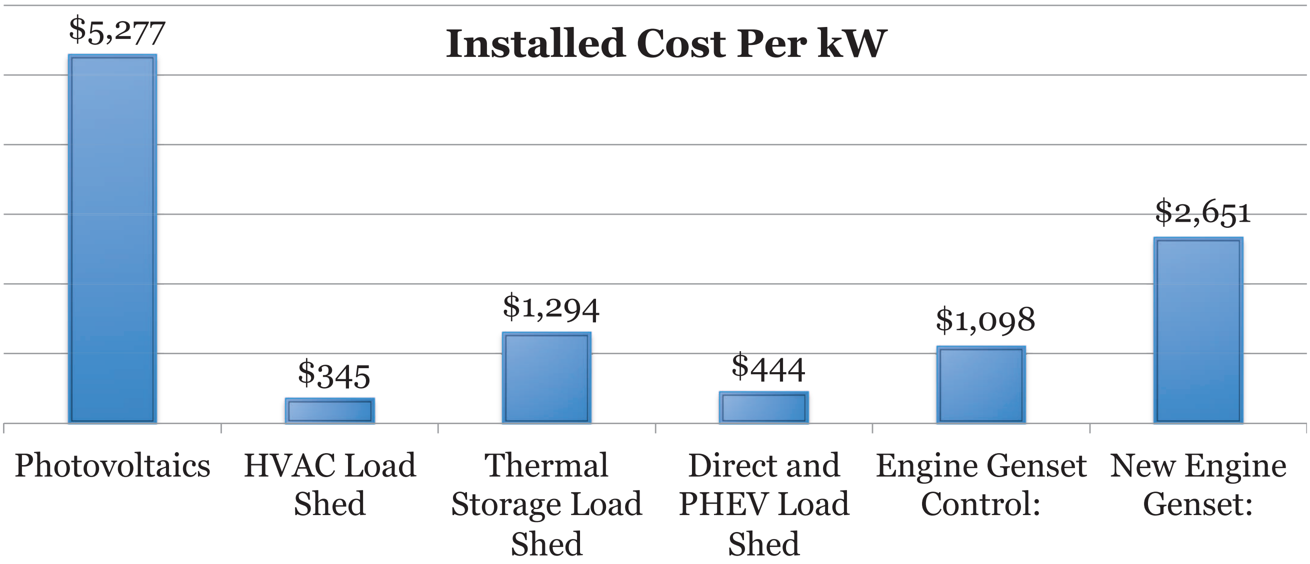
Breakdown of Demonstration Assets (3,437 kW)



Project Timeline



Economic Comparison of Assets



Data Reduction

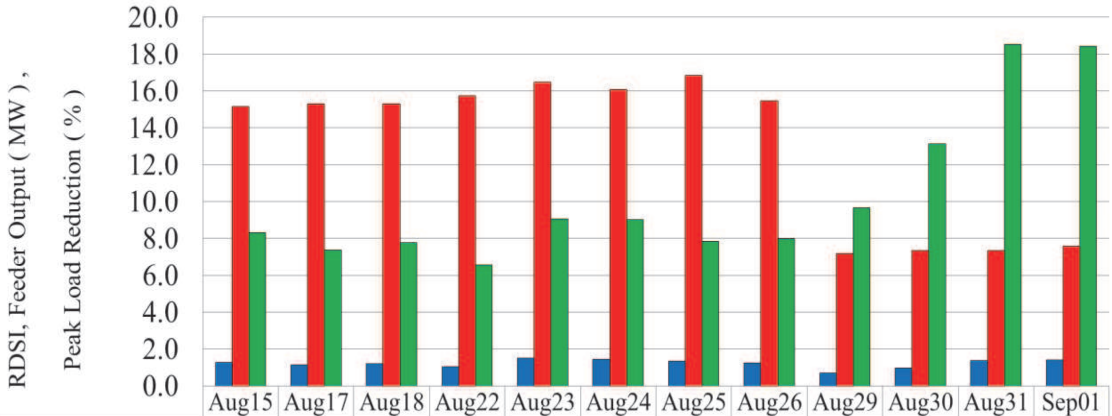
- Raw data from SCADA
  - CSV files for both command and power vectors for each asset
  - Unevenly time-stamped data (resolution = 1s)
  - Any analysis requires evenly time stamped data
- Data handling and preparation
  - Data sampled
  - Only test run data extracted for further analysis
  - Information fields added to structures as required
  - Command data reconciled with power data

FortZED RDSI Capacity Summary

Location	Asset availability (kW)	
	Planned	During demo period 3
City of Fort Collins Operation Services	849	785
CSU Dept. of Facilities Management	1201	746
CSU Engines and Energy Conv. Lab	1335	325
InteGrid Laboratory	320	220
Larimer County Facilities Dept.	29	34
New Belgium Brewing Co.	1279	1279
Grand total	4958	3389

Peak Load Reduction (PLR)

$$PLR = \frac{P_{out}^{\mu grid}}{\sum L_{feeder}} \times 100$$



	Aug15	Aug17	Aug18	Aug22	Aug23	Aug24	Aug25	Aug26	Aug29	Aug30	Aug31	Sep01
RDSI Output	1.3	1.1	1.2	1.0	1.5	1.4	1.3	1.2	0.7	1.0	1.4	1.4
Total Feeder Load	15.2	15.3	15.3	15.7	16.5	16.1	16.8	15.5	7.2	7.3	7.3	7.6
Peak Load Reduction	8.3	7.4	7.8	6.6	9.0	9.0	7.8	8.0	9.7	13.1	18.5	18.4

Performance Metrics

- Reliability
  - Probability of success or success ratio
  - Performance over time
- Calculated using NERC criteria in North America

For individual assets	For group of assets
Starting Reliability	
Service Factor	
Average Run Time	Weighted Service Factor
Net Capacity Factor	Weighted Availability Factor
Net Output Factor	
Availability Factor	

Performance metrics

- *Two new metrics also proposed*
  - Peak reserve ratio – $PRR(t)$
  - Microgrid peak reserve ratio – $MPRR(t)$

$$PRR(t) = \frac{P_{reserve}^{\mu grid}(t)}{\sum L_{feeder}(t)} = \frac{P_{cap}^{\mu grid}(t)}{L_{feeder}^{net}(t) + P_{out}^{\mu grid}(t)}$$

$$MPRR(t) = \frac{P_{cap}^{\mu grid}(t)}{P_{out}^{\mu grid}(t)} - 1$$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Dispatch in Microgrids: Lessons from the Fort Collins Renewable and Distributed Systems Integration Demonstration Project

The divergent needs of the various microgrid participants make the dispatch in microgrids more complicated than typical methods. A review of the experience in Fort Collins suggests that regulations should be developed to address the potential financial conflict issues where generation companies may see microgrids as competition, and also that the cost of integrating assets into a microgrid need to be lowered.

Mayank Panwar, Gerald P. Duggan, Robert T. Griffin, Siddharth Suryanarayanan, Daniel Zimmerle, Marty Pool and Steve Brunner

I. Introduction

Traditionally, electricity has been generated in bulk and transmitted, often over great distance, to consumers. Improved and lower-cost controls, computation, and communications technology has encouraged distributed and renewable energy integration. Microgrids represent a promising method to manage distributed resources, including distributed renewables. A microgrid is an autonomous self-sustainable subset of the electric power system that can operate in parallel

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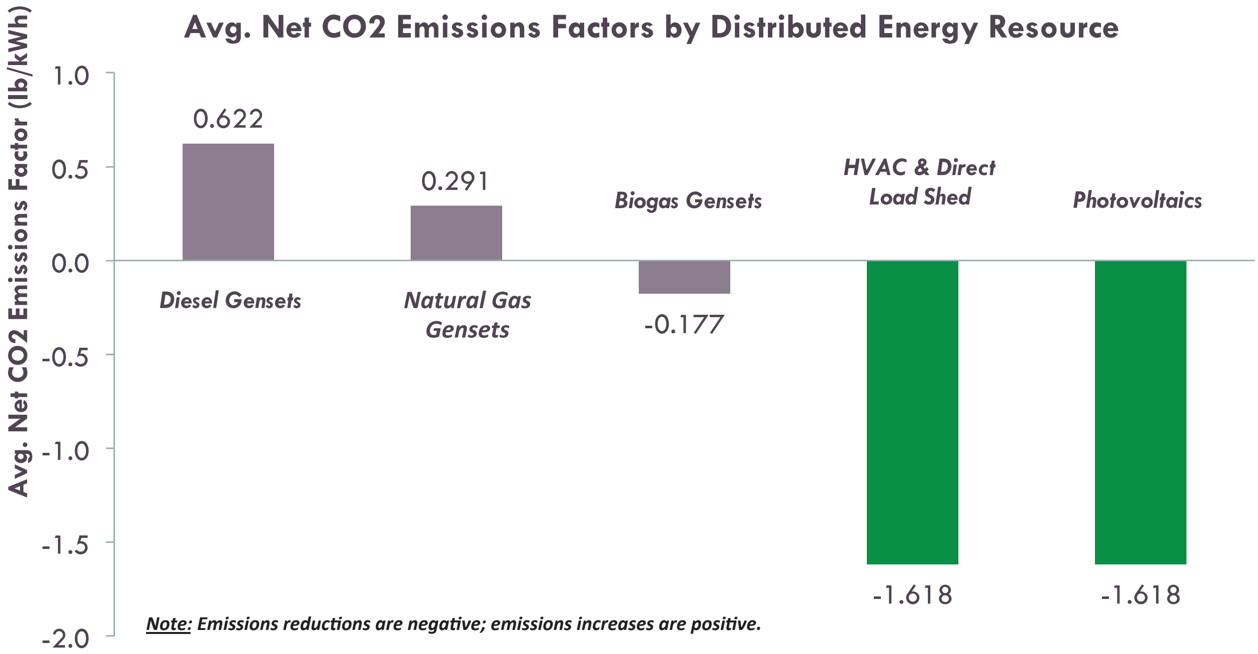
Emissions Comparison of Assets



Lessons learned

- FortZED RDSI project successfully demonstrated peak load reduction capabilities of a microgrid
- Technical lessons learned
  - Protection engineering is non-trivial
  - Reconciliation of feeder level data with asset level data
  - Equipment upgrade issues
  - Asset dispatch method is needed
- Financial and programmatic lessons also learned
- New metrics formulated for microgrid performance assessment and planning

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- Various FortZED RDSI participants

More information:

FortZED- http://fortzed.com

YouTube- http://www.youtube.com/watch?v=Uj4Yjc_xtAQ

Peak Load Reduction

- Approach-I
  - Infinite norm on hour-wise basis
- Approach-II
  - 1^{st} norm on hour-wise basis