CHP and CEA: Facing Dramatic Change in Energy Markets

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U.S. Department of Energy
CHP Technical Assistance Partnerships

Agenda

- Introductions
- Unprecedented Times Ahead in Energy Markets
- Benefits to CEA of CHP
    - Grid Integration – Value Stacking, Revenue Stream
    - Energy Cost Savings
- Implementation and Funding

* Next Steps: How can we help?

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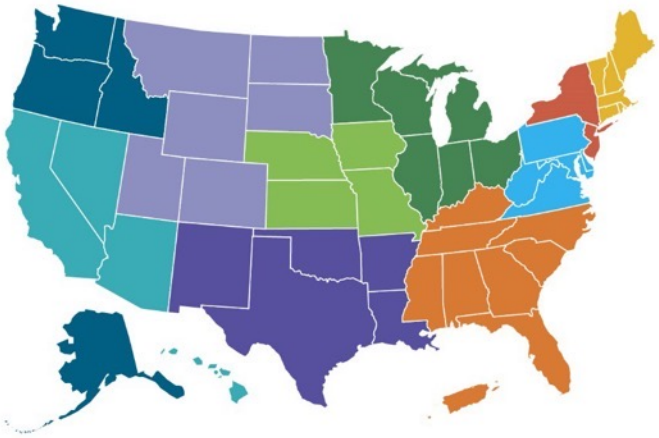

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CHP Technical Assistance Partnerships

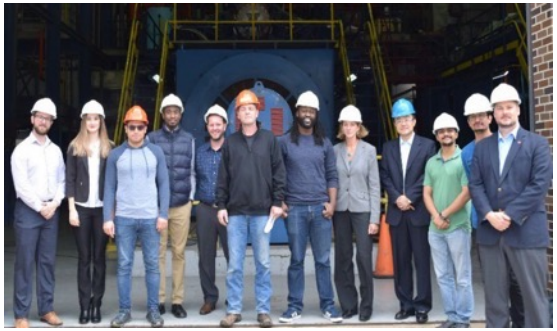
US DOE CHP Technical Assistance Partnership Services

- **End User Engagement**
  Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.

- **Stakeholder Engagement**
  Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.

- **Technical Services**
  As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.

www.energy.gov/chp



National Manufacturing Day 2019 at the University of Illinois at Chicago

CHP Technical Assistance Partnerships

The NY/NJ CHP TAP

Technical Assistance for End-user sites

Fact based Education/Outreach materials directed to stakeholders & policymakers

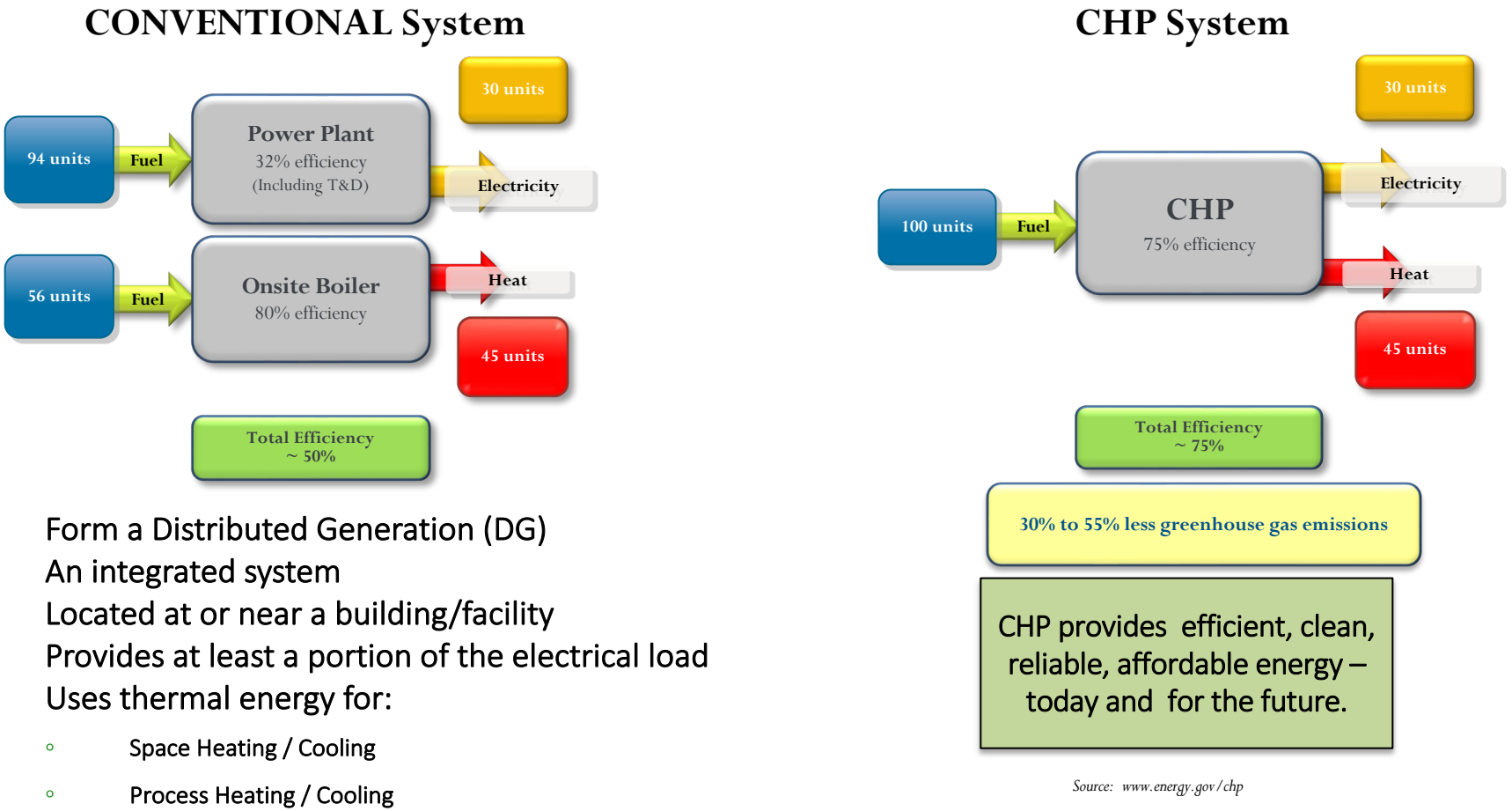
National databases and information repositories to support the market

Identifying our mutual interests, and convening follow-on activities

What Is Combined Heat and Power (CHP)?

- CHP is the concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy.
- A type of distributed generation, which, unlike central station generation, is located at or near the point of consumption.
- A suite of technologies that can use a variety of fuels to generate electricity or power at the point of use, allowing the heat that would normally be lost in the power generation process to be recovered to provide needed heating and/or cooling.

CHP: A Key Part of Our Energy Future



- Form a Distributed Generation (DG)
- An integrated system
- Located at or near a building/facility
- Provides at least a portion of the electrical load
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification

What Are the Benefits of CHP?

- More efficient than separate generation of electricity and heating/cooling
  - Lower carbon and other pollutant emissions
  - Lower operating costs (but requires capital investment)
- Works with any fuel, including carbon neutral fuels
  - Efficiency becomes more important as fuels become scarce
- Increases energy reliability and resiliency
- Provides Potential Revenue Streams – Grid integration
  - Supports intermittent renewable resources

Unprecedented Times Ahead in Northeast Energy Markets:

Challenges and Opportunities for CEA

U.S. Department of Energy
CHP Technical Assistance Partnerships

Unprecedented Times in Energy Markets

* Roughly 7 years from now, an estimated 20 GW's of additional renewable generation needed
    - 12.9 GWs of new generation have been developed since 1999
* Total Installed Capacity must Triple (95 GWs) to meet the 2040 Goal
    - New York currently has 37 GWs of generating capacity
* Extensive Transmission Investment is Required
    - Unprecedented levels of transmission and generation investment will be necessary to achieve clean energy goals while continuing to meet grid needs

- *SOURCE: NYISO 2021-2040-Outlook-Datasheet.Pdf*

Reliability Needs Assessment

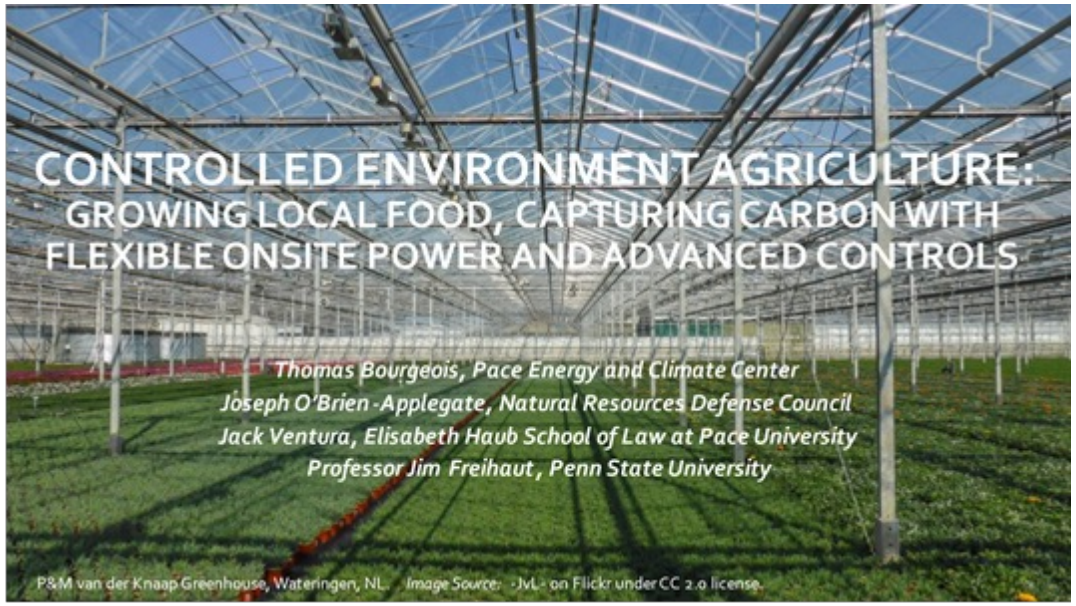
* Short term reliability margin are “thinning” to 2026
  - NYC reliability margin narrows to 50 MW in 2025
* CHPE’s proposed in-service date, is 2026
  - Reliability concerns arise of CHPE is delayed beyond 2026
* NYISO administered markets help mitigate and resolve identified risks
  - “even the slightest deviations from expected conditions, load forecasts, or project delays could trigger future reliability needs”
- *SOURCE: 2022-RNA-Datasheet.Pdf*

DEFRs are Critical for a Reliable Grid

* Dispatchable Emission-Free Resources (DEFRs) must be developed and added at scale to reliably serve demand when intermittent generation is unavailable
    - 25 GWs to 42 GWs of DEFRs required in 2040 Policy Scenarios
* The lead time necessary will require action will in advance of 2040
    - DEFRs must be developed and deployed at scale well before 2040
*"There will be a great need for DEFRs to meet the fleixibility and energy supply needs of the future system"

- *SOURCE: NYISO 2021-2040-Outlook-Datasheet.Pdf*

CHP and CEA: Conjoining Food & Energy for Resilient Communities

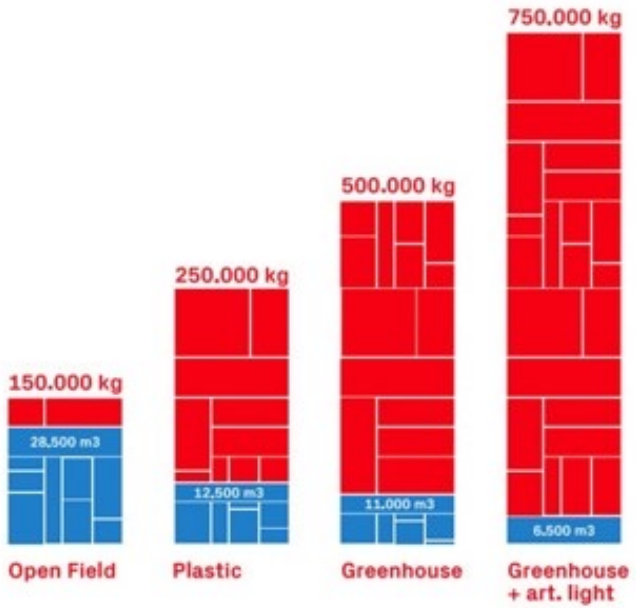


- Locally grown healthy food
- CHP for site resiliency, redundancy, & reliability
- Thermal storage for peak shaving
- Heat recovery for greenhouse, Carbon sequestration from engine feeds plants
- Goodwill toward community
- Educational program opportunities

Energy, Water, Food Nexus

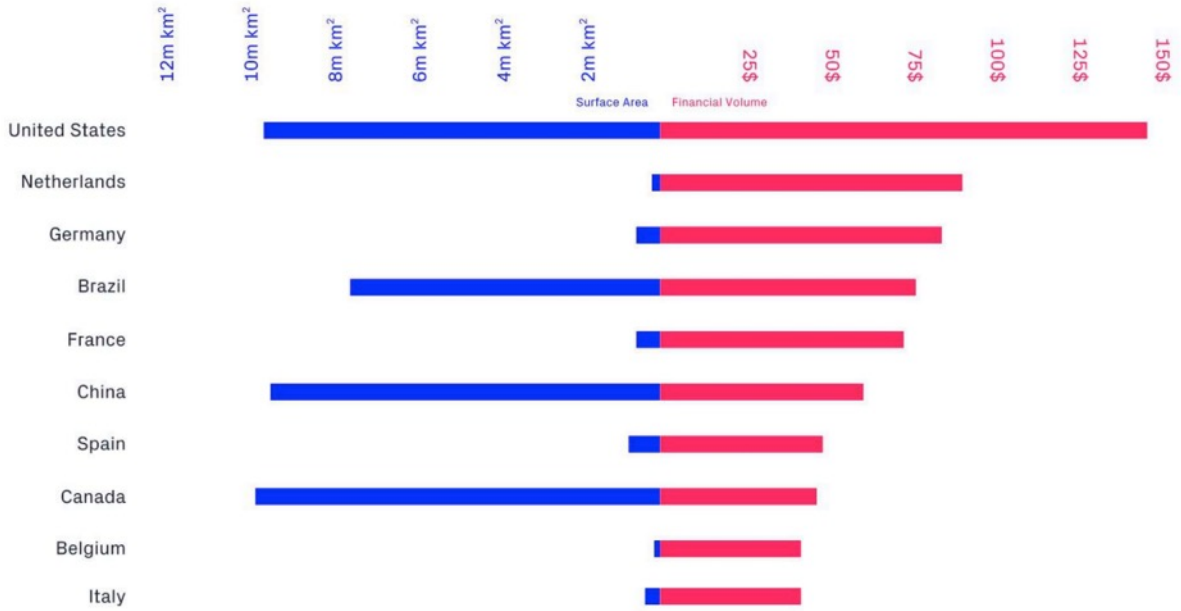
It can be done,
it has been done

The high-tech greenhouse delivers 5 times the output while consuming nearly 78% less water.



Tomato production on one hectare vs. water consumption (Dutch Greenhouse Delta 2021).

Success of CEA in the Netherlands



Country Food Production in Dollars by Land Area. (Dutch Greenhouse Delta 2021)

Dutch Greenhouses and On-Site Power

2020 production of electricity using natural gas fired CHP in greenhouse horticulture in the Netherlands was 10.3 billion kWh.

Deploying CHP in greenhouse horticulture the Dutch reduced total CO_2 emissions by approximately 1.76 million tons (Smit and van der Velden 2021).

Energy/Environmental Impacts	Lifetime Low Estimate	Lifetime High Estimate	Annualized Low Estimate	Annualized High Estimate
Electricity savings (MWh)	65,223	79,717	3,261	3,986
Fuel savings (MMBtu)	231,876	593,206	11,594	29,660
Estimated GHG emission reductions (metric tons)	44,601	70,504	2,230	3,525

Projected Environmental Impacts of Agbiotic Project #1. *Source*: NYGB 2020.

Data to Support Asset Flexibility?

Figure 1. Flexibility of the Production Process: Ability to Time and/or Intensity Shift		
Activity	Example	Citation
Lighting	Lettuce	*Only Extreme Fluctuations in Light Levels Reduce Lettuce Growth Under Sole Source Lighting.* Ruqayah Bhuiyan* and Marc W. van Iersel. Frontiers Plant Science, 28 January 2021 | https://doi.org/10.3389/fpls.2021.619973
VFD's with Horizontal Air Flow (HAF), Vertical Air Flow (VAF), power tubes.	Different vegetable zones: plants at different growth stages, heights, size	Round Table Discussions - Dr. *Greenhouse* - Kelley Nicholson. Polygreens Podcast. Mar 4, 2022. Episode 063. https://www.nickgreens.com/podcast/episode/7b3d4a97/063-round-table-discussions-dr-greenhouse-kelley-nicholson
Top Down air flow	Head lettuce to improve yield (boundary layering)	Round Table Discussions - Dr. Greenhouse - Kelley Nicholson. Polygreens Podcast. Mar 4, 2022. Episode 063.
Thermal Battery makes greenhouse horticulture more sustainable	"Smart" thermal battery decouples production of thermal energy from time of usage of thermal energy. Adding operational flexibility to greenhouse	*Thermeleon makes greenhouse horticulture more sustainable with smart thermal battery*". By Roelant Frijns. January 22, 2022. Innovations Origin. Source: https://innovationorigins.com/en/thermeleon-makes-greenhouse-horticulture-more-sustainable-with-smart-thermal-battery/
Lighting: Dynamic Long-Photoperiod Low Intensity Lighting Strategies	utilizing red lighting for 12 hours during the day, and 12 hrs of blue light at night, it is possible to save 20-35% peak electricity, while not negatively impacting the plants (20% in tomatoes and peppers, 35% in cucumbers).	*Dynamic Long-Photoperiod, Low Intensity Lighting Strategies. Xiuming Hao, Ph.D. Harrow Research and Development Centre, Agriculture and Agri-Food Canada. Canadian Greenhouse Conference. October 6,2021*

	Low Flexibility	Medium Flexibility	High Flexibility
Low On-Site Need	Commercial	-	-
Medium On-Ste Need	-	Manufacturing	-
High On-Site Need	Hospitals	-	CEA

What are "the best" grid assets?

Within the class of dispatchable resources, the most reliable resources are those that are already online. Particular value will be paid for assets that are online, serving a load and are able to shed some load and inject into the grid (Swider, 2022).

Motivation for this work

- Value-Stacking the Benefits of CEA with onsite power
  - Power and heat resiliency | Food resiliency
  - Payments in several markets
- Enhance economic viability / don't sacrifice societal benefits
- Find common ground across diverse interests
- Addressing pressing community concerns
  - Food deserts
  - Public health and equity
- Greenhouses on the Grid, allows for greater penetration of renewables
- Decarbonization, efficiency, equity, resiliency

Areas for further work and research

- Measuring carbon savings of CHP at high-tech greenhouses
- Learnings from Other Areas
  - Mid-Atlantic is defining potentially replicable business models
  - US DOE's CHP TAPs greenhouse initiatives and analyses
- Engage with ISO's
  - "Dramatic" changes ahead as state carbon goals drive grid evolution, market hurdles
- Support CEA with Technical Assistance, Education
  - Outreach to utilities, state governments, and industry

Summary

- CHP gets the most out of a fuel source, enabling
  - High overall utilization efficiencies
  - Reduced environmental footprint through low-carbon fuels
  - Reduced operating costs
- The National CHP eCatalog offers lower perceived risk of CHP in non-traditional markets, also reduced cost and lead time.
- An increasing number of CHP systems can run on low-carbon fuels including RNG and Hydrogen
- Incentives are a crucial part to CHP implementation
- CHP can be utilized in various market sectors and for different strategies including resiliency and reliability.
- The CHP TAPs can assist potential CHP projects at no-cost offering unbiased technical assistance and resources from initial screening through installation.

Project Costs & Funding

- Capital Cost
- Owner/Development Costs
- Engineering
- Procurement
- Construction
- Grants, Loans and Tax Credits
- Financing

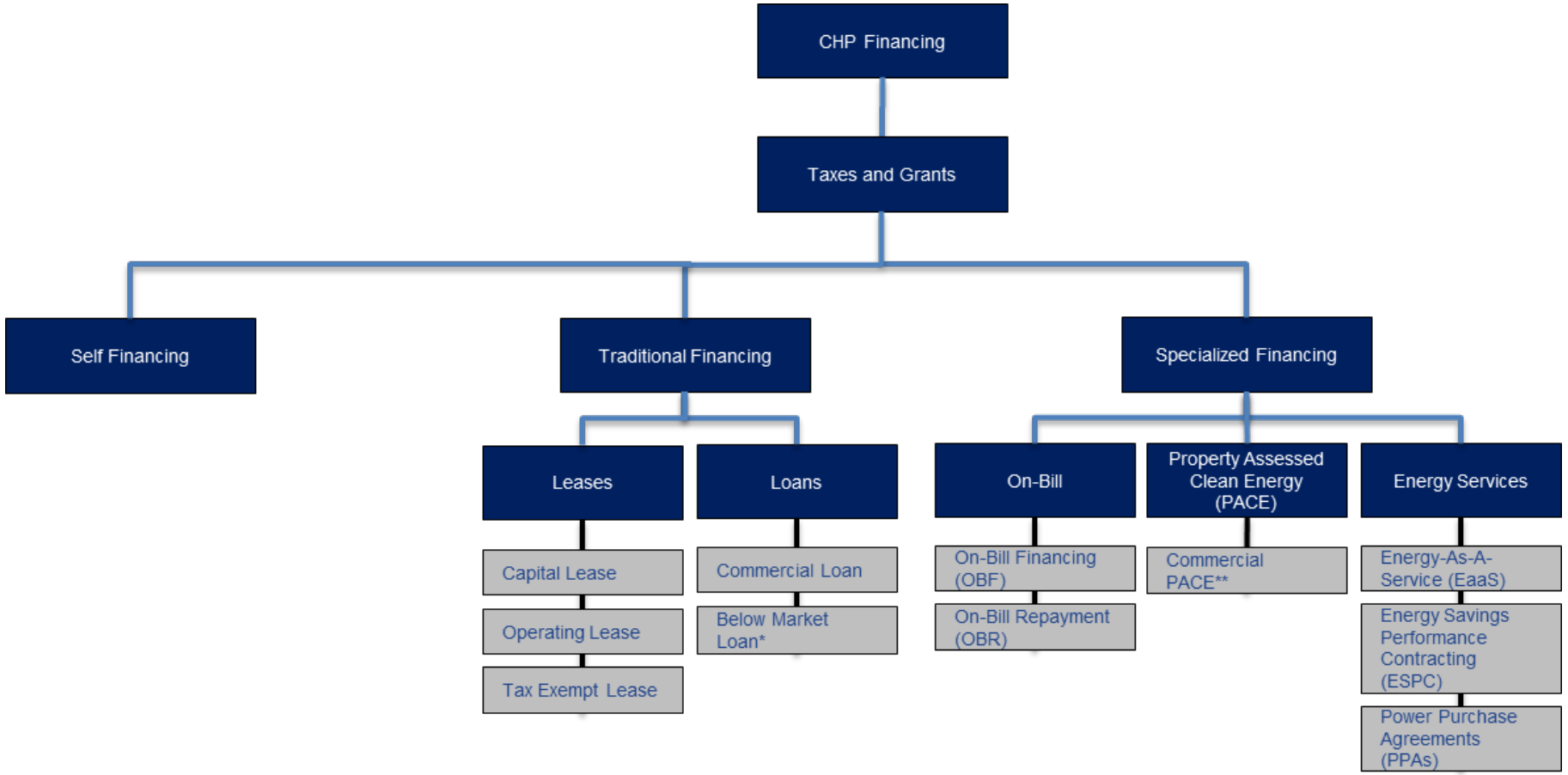
Cost & Performance Assumptions

Table 1. Comparison of CHP Characteristics for Typical Systems [1, 2]

Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Size Range	10 kW–10 MW	1 MW–300 MW	30 kW–330 kW (larger modular units available)	5 kW–2.8 MW (larger modular units available)	100 kW–250 MW
Electric Efficiency (HHV)	30–42%	24–36%	25–29%	38–42%	5–7%
Overall CHP Efficiency (HHV)	77–83%	65–71%	64–72%	62–75%	80%
Total Installed Cost ($/kW) [3]	$1,400–$2,900	$1,300–$3,300	$2,500–$3,200	$4,600–$10,000	$670–$1,100 [4]
O&M Cost (¢/kWh)	0.9–2.4	0.9–1.3	0.8–1.6	3.6–4.5	0.6–1.0
Power to Heat Ratio	0.6–1.2	0.6–1.0	0.5–0.8	1.3–1.6	0.07–0.10
Thermal Output (Btu/kWh)	2,900–6,100	3,400–6,000	4,400–6,400	2,200–2,600	30,000–50,000
Fuel Pressure (psig) [5]	1–75	100–500 (may require fuel compressor)	50–140 (may require fuel compressor)	0.5–45	n/a
Part Load Efficiency	Good at both part-load and full-load	Better at full-load	Better at full-load	Better at full-load	Good at both part-load and full-load
Type of Thermal Output	LP steam, hot water, space heating, chilled water	LP-HP steam, hot water, process heating, chilled water	LP steam, hot water, chilled water	LP steam, hot water, chilled water	LP-HP steam, hot water, chilled water
Fuel	Can be operated with a wide range of gas and liquid fuels. For CHP, the most common fuel is natural gas.			Hydrogen, natural gas, propane, methanol	Steam turbines for CHP are used primarily where a solid fuel (e.g., coal or biomass) is used in a boiler.

https://betterbuildingssolutioncenter.energy.gov/chp/resources-publications

Project Financing Options



* Various entities including green banks, state government and other clean energy funds can provide loans at favorable rates with minimal requirements

** C-Pace provided low interest loans and attaches loan to property

IRA Tax Credits

- Inflation Reduction Act
  - Base & Bonus Rates
    - The base rate for the ITC is 6%.
    - The bonus rate for the ITC is 5 times the base rate (30%)
    - The base and bonus rates apply to the extensions of the PTC and ITC, the technology neutral credits, and other tax credits in the bill.
    - Taxpayers receive the bonus rate for meeting the prevailing wage and apprentice requirements.
  - Projects under 1 MW are exempted
  - Prevailing Wage Requirements
    - Taxpayers must ensure project workers are paid at prevailing locality wages.
  - Apprentice Requirements
    - Taxpayers must ensure the applicable percentages of labor hours are filled by qualified apprentices: Construction begins before Jan. 1, 2023: 10%, Construction begins in 2023: 12.5%, Construction begins in 2024 or later: 15%

IRA Tax Credits

- Plus 10% Points: Energy Community Bonus
  - Energy communities fall into three categories:
    - A brownfield site
    - An area with above average fossil energy employment with above average unemployment or local tax dependence on fossil energy
    - Within or adjacent to a census tract where a coal mine has closed after 1999, or a coal-fired electric generator closed after 2009
- Plus 10% Points: Domestic Content Bonus
  - To meet the domestic content requirement the facility must use 100% domestic iron and steel and a specified percentage of domestic manufactured products, which changes by year: 2023: 40%, 2024: 40%, 2025: 45%, 2026: 50%, 2027 and later: 55%

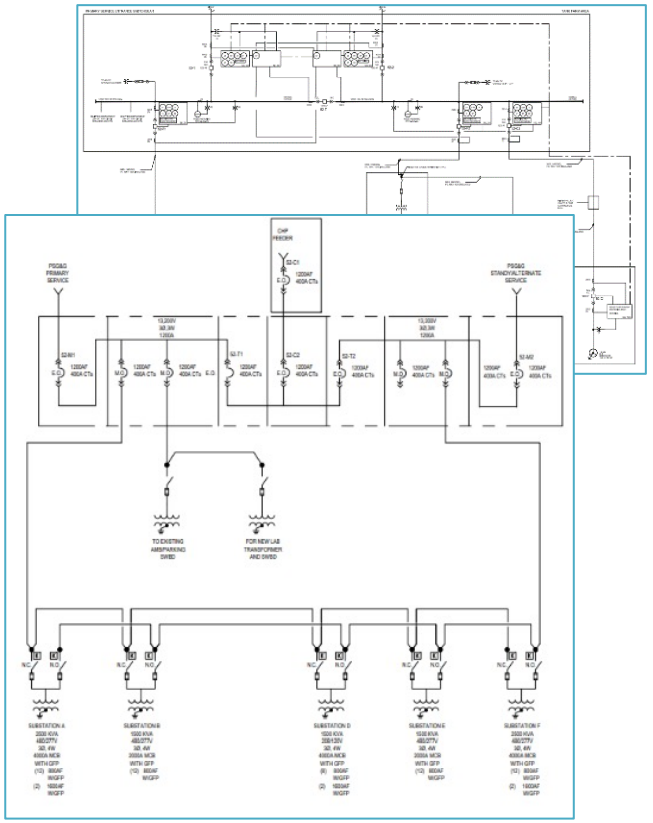
IRA Tax Credits

- Deadline for the sec. 48 ITC to January 1, 2025.

- Tech Neutral Credits (sec. 45Y, 48E)
  - Only zero-emissions facilities placed in service after December 31, 2024, are eligible for the technology-neutral PTC or ITC
  - The technology-neutral credits phase out as greenhouse gas emission reduction targets in the electric sector are reached.
  - The applicable year means the later of the calendar year in which electric sector greenhouse gas emissions are equal to or less than 25% of 2022 emissions or 2032.

Project Implementation

- CHP Project Development is a multi-faceted and highly technical undertaking. Knowledgeable planning is the key to optimal project performance.
- At this point in the project, owner has typically decided on project goals and funding mechanism which may still leave more than one option open but is moving towards making a commitment and incurring some minor costs



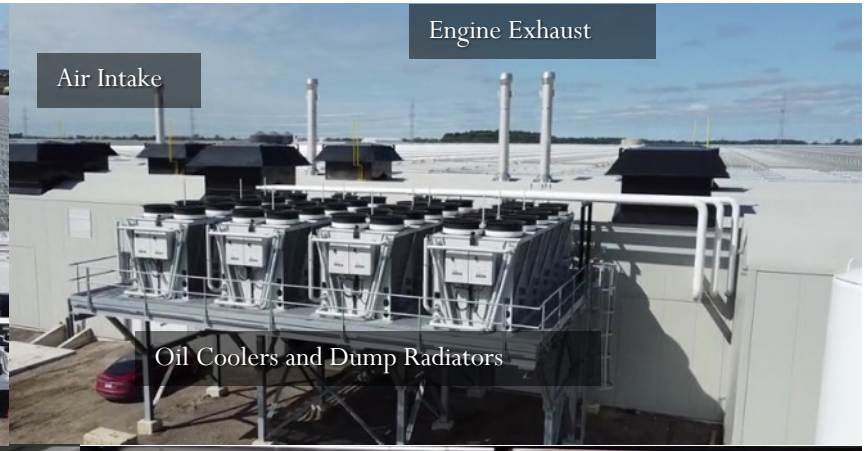
Project Development Tasks

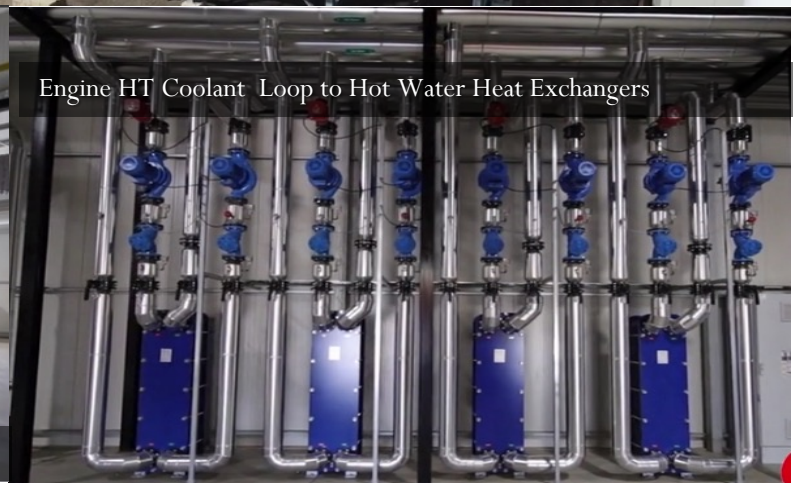
- Carry out project screening
- Conduct financial grade feasibility analysis
- Select CHP configuration
- Create a financial pro forma

- Obtain environmental and site permits
- Secure financing
- Contract with engineering, construction, and equipment supply firms
- Provide overall project management
- Deliver completed and commissioned CHP plant to the owner

Project Implementation

Integrating CHP with CEA





Selecting Vendors

If the decision to develop a project is made, the owner should review the capabilities of multiple contracting firms that meet the owner's general needs including:

- Previous CHP project experience.
- Experience with similar industrial applications
- A successful project track record.
- In-house resources (e.g., engineering, operation), including experience with environmental permitting and siting issues.

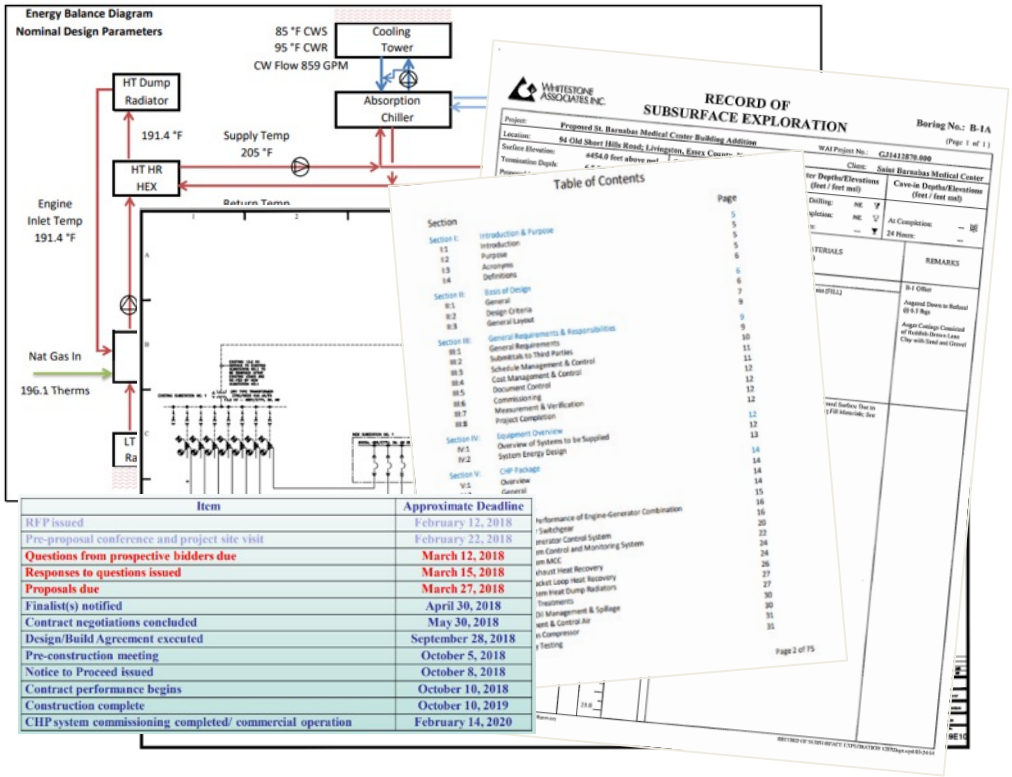
A request for proposal (RFP) can be used to define the project scope and allow comparison of multiple vendors.

RFP Development

In general, if issuing an RFP, respondents should be asked to provide the following information:

- Description of the energy project and available options.
- Scope of services being offered (e.g., installation, developer, long term O&M, financing).
- Project development history and performance.
- Turnkey facility bid (clear scope of work is required).
- Technology description and performance data.
- Environmental permitting, interconnection, and site permitting plan.
- Financing plan (if applicable).
- Schedule.
- Operation and maintenance plan.

Project Snapshot



Item	Approximate Deadline
RFP issued	February 12, 2018
Pre-proposal conference and project site visit	February 22, 2018
Questions from prospective bidders due	March 12, 2018
Responses to questions issued	March 15, 2018
Proposals due	March 27, 2018
Finalist(s) notified	April 30, 2018
Contract negotiations concluded	May 30, 2018
Design/Build Agreement executed	September 28, 2018
Pre-construction meeting	October 5, 2018
Notice to Proceed issued	October 8, 2018
Contract performance begins	October 10, 2018
Construction complete	October 10, 2019
CHP system commissioning completed/ commercial operation	February 14, 2020

An RFP whether for design/bid/build or for complete 3rd party development, needs to be specific on performance requirements, equipment parameters, integration with existing systems, existing conditions (Geotech), schedule, etc.

Zoning/Planning

Project siting and operation are governed by a number of local jurisdictions. It is important to work with the appropriate regulatory bodies throughout all stages of project development in order to minimize permitting delays that cost both time and money. Applicable local agencies include:

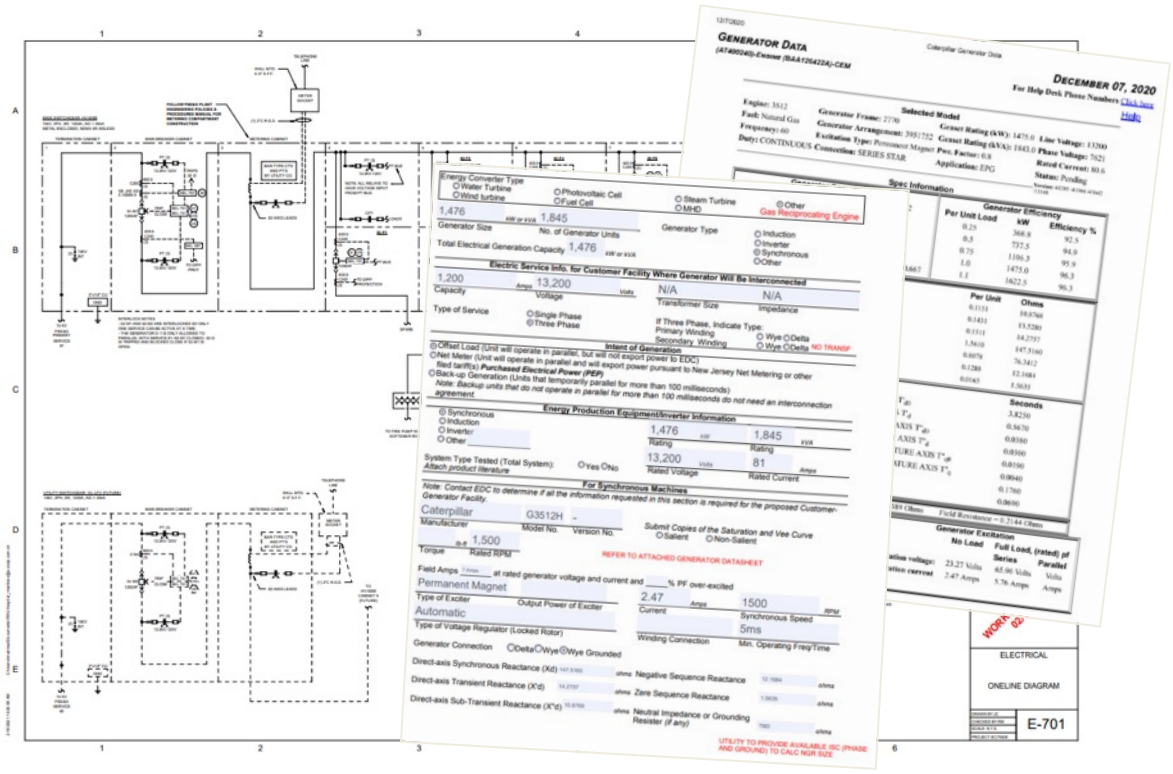
- County and city planning bureaus govern land use and zoning issues. They may conduct environmental impact assessments, including noise studies, and are responsible for compliance with local ordinances.
- State and local building and fire code officials address CHP-related safety issues such as exhaust temperatures, venting, natural gas pressure, fuel storage, space limitations, vibration, gas and steam piping, and building structural issues.

Siting and Permitting

Through plan review, inspection and testing, various agencies must ensure that the project complies with:

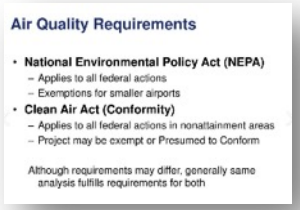
- Local ordinances (e.g., noise, set-backs, general planning and zoning, land use, and aesthetics).
- Standards and codes (e.g., fire safety, electrical, and structural).
- Utility standards and codes (life safety & system protection)
- Air emissions requirements.

Project Snapshot



The electric grid interconnection is typically processed through the local distribution utility company.

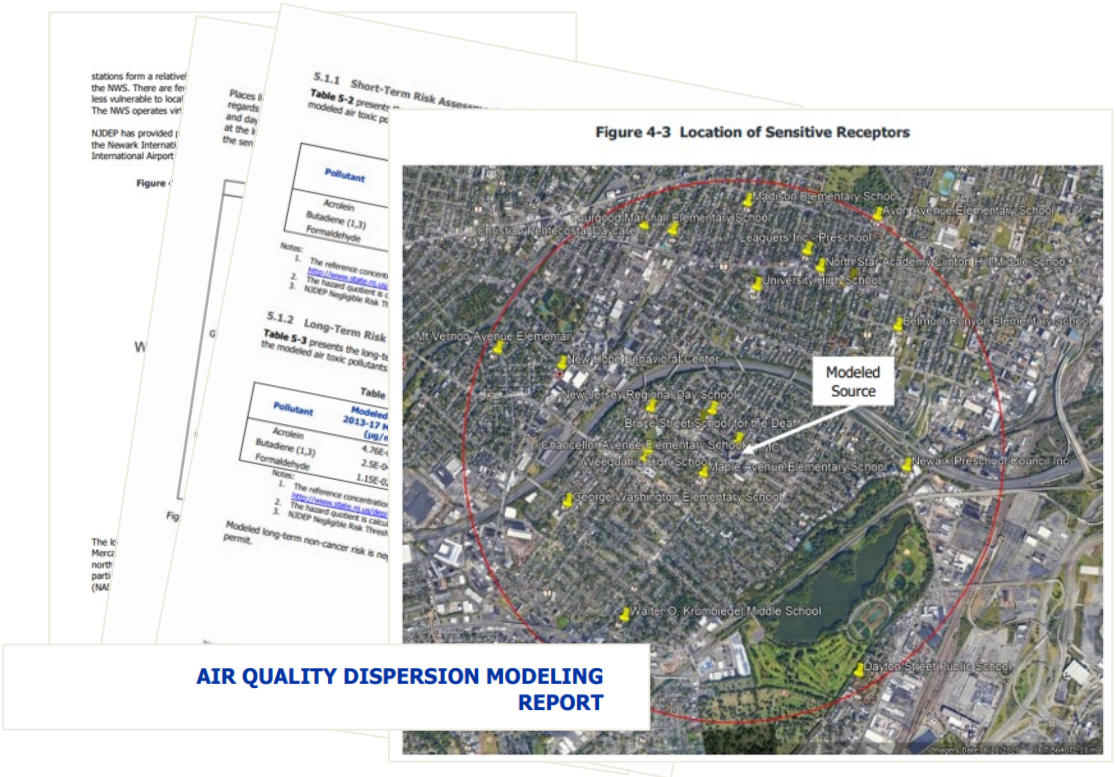
It requires design engineering work to provide the requisite information and field technical questions or interpret directives from the utility.



Air Emissions Requirements

- Air quality agencies/districts at the state and local levels are responsible for administering air quality regulations, with a primary focus on air pollution control.
- The primary criteria pollutants of concern include NO_X, CO, SO_2, particulates, and certain hazardous air toxins.
- These authorities issue construction permits based on their review of project design and performance objectives.
- After construction and installation is complete, projects receive operating permits based on emissions performance relative to applicable emissions thresholds.

Project Snapshot



Depending on local area or state requirements and size of project (volume of emissions), one or more pollutants may be subject to further study including air dispersion modeling.

Siting and Permitting

- Obtaining the required planning/zoning, utility interconnection, environmental compliance, and construction permits is an essential step in the CHP project development process.
- Permit conditions often affect project design, and neither construction nor operation may begin until all permits are in process or in place.
- The process of permitting a CHP system will typically take from 3 to 12 months to complete, depending on the location, technology, and site characteristics.

Packaged Systems

- The industry has rapidly moved toward packaged and modular systems within the past ten years particularly under 3.5 MW for packages and 20 MW for modular systems.
- This can be a means to reduce cost and improve operability, reliability and code compliance.
- When developing your final design, keep this in mind.

Benefits of Packaged Systems

- Self Contained Units or Modules
  - Prime Mover
  - Heat Recovery
  - Controls
  - Ancillary Equipment
- Standardized yet customizable
- Code Compliant
- Tested
- Factory assembled
- Moveable

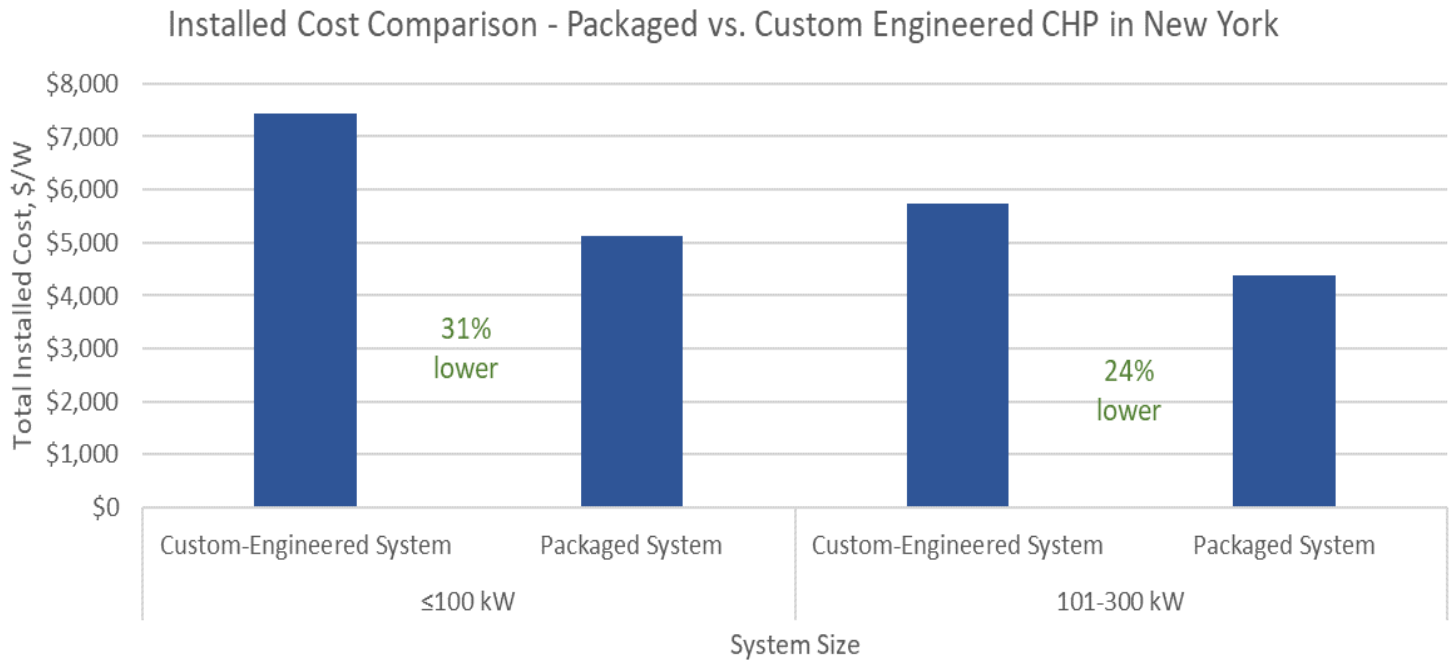
2 MW Package

7.5 MW (3 modules)

3.3 MW (3 modules)

1 MW Package (5 MTs)

Estimating Cost Reductions from Packaged CHP



The DOE Packaged CHP Accelerator compared data on custom engineered systems installed in NYSERDA's CHP Program to data on packaged CHP systems from the CHP Catalog Program.

DOE Packaged CHP eCatalog

- A national web-based searchable catalog of DOE-recognized packaged CHP systems and suppliers with the goal to reduce risks for end-users and vendors through partnerships with:
  - CHP Packagers that assemble and support recognized Packaged CHP Systems
  - Solution Providers that install, commission and service packaged CHP systems
  - CHP Engagement partners that provide CHP market deployment programs at the state, local and utility level
  - Pre-engineered and tested packaged CHP systems that meet DOE performance requirements
- eCatalog audience: end-users with engineering staff, consulting engineers, utilities, state energy offices, regulators, federal agencies, and project developers.
- Users search for applicable CHP system characteristics, and get connected to packagers, installers and CHP engagement programs
- Allows users to compare technology options

DOE CHP Resources

(betterbuildingssolutioncenter.energy.gov/chp)

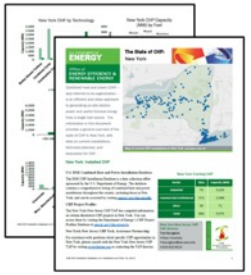
The CHP TAPs are available to guide clients through the following DOE and other resources.

DOE CHP/Microgrid Installation Database

Packaged CHP eCatalog

DOE CHP Technologies Fact Sheet Series

State of CHP Pages



DOE Project Profile Database

DOE Policy / Program Profiles

DG for Resilience Planning Guide

CHP Issue Brief Series

Next Steps

Contact your Regional CHP TAP for assistance if:

- You are interested in having a “no-cost” Qualification Screening performed to determine if there is an opportunity for CHP on-site.
- If you have an existing CHP plant and are interested in expanding the plant.
- If you need an unbiased 3rd Party Review of a CHP proposal.

Thank you. Questions?

CHP
TECHNICAL ASSISTANCE
PARTNERSHIPS

New York/ New Jersey CHP TAP:

Tom Bourgeois, Director
(914)-422-4013, tbourgeois@law.pace.edu

For more information about the TAPs:
https://betterbuildingssolutioncenter.energy.gov/chp/chp-taps

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