Micro-Combined Heat and Power (mCHP)

A Guide to Submitting mCHP Applications for Incentives in Massachusetts

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Disclaimer: *Please acquire and review the latest version of this document before submitting a project for pre-approval of an incentive.*

Ongoing consultation with the applicable Program Administrator during development of a project is essential to maximize the chances for receiving an incentive. There may be circumstances where additional requirements are necessary for the customer to receive an incentive. Similarly, there may be projects where some of the requirements listed herein can be waived by the Program Administrator. Please note that for the reasons discussed within the document, an incentive pre-approval letter should be received prior to initiating the purchase of a mCHP system. Projects which proceed prior to receiving an incentive pre-approval letter may be disqualified from receiving an incentive.

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What is mCHP?

CHP is the simultaneous generation of electric and thermal energy from a single fuel source such as natural gas. For example, when coupled with a generator a natural gas-fired engine produces electric energy. The engine also produces waste heat via engine exhaust gas as well as heat rejected through the radiator to keep the engine and the lubricant at the optimal temperature. This normally wasted heat can be captured to produce steam or hot water for space heating, domestic hot water, or manufacturing processes. The steam or hot water produced by the CHP unit will lower the amount of fuel otherwise used in the facility's boiler for these end uses. The overall efficiency of a CHP system can be as high as 80-85%, exceeding the efficiency of power generation, transmission and distribution system of a central power plant (typically 40 to 45% electric efficiency) combined with on-site production of thermal energy.

The increased efficiency of CHP mostly leads to a lower carbon footprint because of reduced greenhouse gas emissions.

Other significant benefits of the CHP system may include standby power capability at the facility and better control of power factor, depending on type of generator and controls used in the CHP system. If these capabilities are of interest, discuss options and costs with your CHP supplier.

In addition, federal, state and electric energy efficiency program incentives for CHP systems can significantly improve project economics.

Difference between micro-CHP & large CHP

For the purpose of Mass Save, micro-CHP systems are cogeneration systems 50kWe or less in size. The only defined difference between mCHP and large CHP is the electrical capacity. However, many large commercial and industrial CHP applications are using individual components and integrating on site. Micro-CHP systems in smaller commercial applications are more often packaged all-in-one systems. Also, most often mCHP are thermal following where heat is the main output and electricity is the byproduct. Where larger CHP system controls can vary and are often electric following. Lastly, mCHP systems are typically more expensive on a dollar per kW basis. Therefore, the Mass Save PAs offer a higher incentive for these smaller systems.

Successful mCHP Projects

In order to derive the maximum benefit from a CHP installation, thermal energy generated by the CHP unit should be fully utilized by the host facility. The best CHP applications are facilities with high annual hours of operation and continuous thermal load. Facilities in which electrical and thermal loads coincide to a large degree are ideal.

Care should be taken not to propose an oversized system. An oversized system will cost more to install than a properly sized system and will result in a reduced number of equivalent full load operating hours compared to a correctly sized system. This will substantially reduce the likelihood of the project going forward (and will also reduce the likelihood of passing the Program Administrators' Benefit Cost Ratio test) since the over-sized unit presents more financial risk.

Good applications of mCHP systems include:

- Non-hospital health care facilities
- Supermarkets
- Restaurants
- Hotels and dormitories
- Large multi-family residential buildings
- Gyms and health clubs
- Colleges and universities
- Small manufacturing facilities
- Greenhouses/hydroponic farms

mCHP Offering Description

Generally, equipment qualifying for CHP incentives include reciprocating engines, gas turbines (also called combustion turbines), and back pressure steam turbines. A CHP system can use any type of fuel, but the mCHP systems almost exclusively operate on natural gas.

Retrofit and New Construction

It is important to note that for the purposes of receiving an incentive under this program, a CHP system must directly produce electricity and not simply offset the use of electricity. An example of equipment that would not qualify is a gas-fired engine directly coupled to a compressor, which indirectly reduces electricity by reducing or eliminating the use of a motor to drive that compressor. The application for an incentive requires submission of a filled-out Retrofit or New Construction Application form.

CHP equipment is strongly encouraged to have an annual combined electric and thermal efficiency equal to or greater than 60% with fuel input being expressed on a higher heating value (HHV) basis. High system efficiency is encouraged in order to shorten payback period, increase societal benefits, and improve the BCR for incentive eligibility discussed below.

a) Electrical Efficiency = kW nameplate X 3,412 Btu/kWh ÷ Fuel Input (Btu/Hr)HHV
b) Thermal Efficiency = Btu/Hr useful thermal energy ÷ Fuel Input (Btu/Hr)HHV
c) Combined Efficiency = a + b

If an absorber is used for waste heat utilization, the chilled water produced is considered the useful thermal energy.

Please note that many CHP engine manufacturers list their rated natural gas fuel input on a lower heating value (LHV) basis. For natural gas, HHV Fuel Input = 1.1 LHV Fuel Input. Other fuel types have different conversion factors.

In order to qualify for Federal Tax Credits and Federal Grants, a proposed CHP system must have a minimum 60% annual combined electric and thermal efficiency with fuel input expressed on an HHV basis.

Benefit/Cost Analysis: The CHP equipment must undergo a Benefit/Cost Analysis utilizing a methodology prescribed by the Department of Public Utilities (DPU). This methodology considers:

a. The net power (kW) output of the CHP system (net of any incremental parasitic load to operate the CHP system's auxiliary equipment),
b. Annual net kWh generated,
c. Installed cost of the equipment,
d. Ongoing annual maintenance costs,
e. Quantity of fuel and type of fuel being fired in the CHP system as well as fuel displaced by the CHP system,
f. Timing of the power production, such as winter/summer and peak versus off-peak as defined in the Custom Project application.

Above are the inputs to the Benefit/Cost model used to determine the Benefit Cost Ratio (BCR). In order to receive incentive funding for CHP projects, the lifetime benefits must exceed the lifetime cost. In other words, the BCR must be greater than or equal to 1.0.

Assuming a project qualifies for a CHP incentive, as discussed in the above, mCHP units can receive up to $2,000 per kWe based on the system electrical capacity, at the discretion of the PAs. Limited to 50 kW per site in aggregate distributed generation behind one meter.

Interconnection

Timing is critical when trying to install a CHP project especially on the interconnect side. With a huge inundation of Solar projects, the Distributed Generation (DG) on the utility feeders has been significantly increased triggering upgrades in substations and distribution lines sooner than in past years. When an application is submitted, a snapshot of current DG and proposed DG already submitted on the feeder are collected. The impact of this new CHP project is then evaluated to the worst-case scenario, including minimum loading and maximum loading. It is determined how the DG interacts at those load points on the feeder and the protections needed to protect the utility grid system.

Process summary:

- Application is submitted and evaluated to ensure correct documentation is given.
- Application captures current and future DG on the feeder and is summarized with rule of thumb checks at a high level and determines if a further study is required.
- If an Impact study is required, this study determines what protections are necessary to protect the grid utility system from this new CHP and potential hazards caused by this unit. Upgrade costs and scheduling are also returned with that report.
- An Interconnect Service Agreement (ISA) is signed, stating the cost and protections required and operationally how the utility and the customer will interact.
- Distribution Design is started after first payment is collected.
- Construction is started after Design is complete and second payment is received.
- Once construction is complete, and customer is ready with all the required documentation; a witness test is scheduled to ensure all the protection schemes were implemented. (Witness test is a time when the utility completes an on-site test of the protection scheme, as agreed in the ISA).
- Once all protections are tested and verified, authorization to Interconnect is issued.

One other item to note is that once the ISA is signed and if a phone line is required, it is critical to begin the phone line process as soon as possible. Receive written agreement from the phone line company that their process is started and an order is being processed. Keep tabs on this process throughout the construction phase.

Please note that approval of an incentive payment for CHP shall not constitute approval of a project's utility interconnection. There is a separate application process for receiving approval to interconnect a CHP system with the local electric utility. Please contact the interconnection department of your distribution company to learn how to apply for interconnection. Attachment 2 lists the links to the various utilities for the interconnection process. Often there are significant costs associated with interconnection studies and implementation of the upgrades necessary to interconnect with the utility infrastructure. Also, the time required to obtain the interconnection approval from the local utility could be significant and should be considered during the planning process for the project.

Electric utilities conduct Distributed Generation Interconnection seminars several times a year. The following link is provided for dates of previous and upcoming seminars and presentations.

https://ngus.force.com/s/article/MA-Seminars

Incentive Application Process

Early Engagement with the Program Administrator

It is highly recommended that the customer establishes a dialogue with the PA during the early stages of developing a CHP project. By doing so, feedback can be given to the customer in the early stages of the development process regarding the likely cost-effectiveness of the proposed project. If one or more configurations for a CHP are NOT going to meet the minimum criteria for an incentive, it's best for everyone involved to receive early feedback on this result.

A critical path item that should be determined early in the process is to affirm that the electric utility circuit is compatible with a CHP project, i.e. not on an area network. Please note that a circuit compatibility check is not the same as receiving approval to interconnect a CHP project with the electric utility. Please contact the applicable electric account executive to determine compatibility. Since the electric utility interconnection application process and installation may be time consuming and costly, in the early project development stage please contact the applicable electric utility account executive.

For systems firing natural gas, confirmation should be received from the utility gas account executive that sufficient gas volume and pressure is available to supply a facility's total gas requirements for the proposed CHP system and other existing or new gas equipment and appliances. Some early study work may be necessary to determine the range of systems being considered and the gas firing rate for each CHP option under consideration. Find your gas provider using the map and contract your provider for details (https://docs.digital.mass.gov/dataset/massgis-data-public-utility-service-providers)

CHP Application Form

Applications for CHP incentives are submitted using the Custom Application form:

- For Retrofit (existing buildings) projects: Retrofit
- For New Construction (new buildings) projects: New Construction

The application process for mCHP is similar to that of larger CHP. If additional guidance for completing the application is needed, please see the CHP Guidebook

Allocation of Energy Benefits

Other than the energy cost savings realized by the Customer, the PA is entitled to 100% of the benefits and rights associated with the CHP installation. This is described in Section 19 of the Terms and Conditions of the Custom Application form.

However, upon request the PA may waive rights to pursue and retain APS Generation Attributes associated with the Massachusetts Alternative Energy Portfolio Standard ("APS"). In that case the customer shall be solely responsible for all costs associated with the reporting requirements of the APS. The APS program, administered by the Commonwealth of Massachusetts, is an optional program and participation is not required to receive a CHP incentive. Please contact the Massachusetts Department of Energy Resources for more information.

Post-Installation Requirements

Installation of the CHP system must comply with all the local, state and federal requirements and satisfy the permitting requirements including but not limited to air emissions. Meters are installed, in compliance with the governing MRD – see Attachment 1.

Post-Installation Evaluation

PAs are required to evaluate their energy efficiency programs to determine the percentage of predicted energy savings which are actually realized and to utilize those results to make program improvements. Typically, evaluations of such energy efficiency projects are performed on a subset of projects each year. To the extent that metering/monitoring that meets the requirements for regulatory evaluation is already included in proposed CHP systems, such metered data must be provided at no cost to the PA. In those few instances where metered data is not being collected for all the necessary inputs and outputs (or is of insufficient precision), then the PA may subsidize the cost of equipment and/or installation services. Note that meters installed for evaluation purposes may only be in place temporarily and may have different specifications from those more appropriate to permanent use and/or those normally installed with a given CHP system.

System Selection

If you are interested in finding packaged mCHP systems, the U.S. Department of Energy has created a guide and searchable online catalog for packaged CHP systems available in the US. That information is available here: https://chp.ecatalog.lbl.gov/

Appendix

Attachment 1 – Sample Minimum Requirements Document for mCHP Projects

Attachment 2 – Links to Interconnection Requirements

Attachment 1 – Sample Minimum Requirements Document for mCHP Projects

Customer Name		**EI or D2**	
Location		**Applicatio**	
ECM:	35 kW Template		

This document specifies the agreed upon minimum equipment specifications and operational requirements of the proposed system. These requirements shall address the criteria necessary to be met to achieve the demand and energy savings estimated in the engineering analysis for this project. (Use additional sheets if necessary).

Pre-Construction	**SEQUENCE OF OPERATION**: Provide a description of equipment operating sequences, setpoints, operating schedules, balancing requirements (flow, velocity, head, etc.) or any other required operating parameters **Submittals:** Provide major equipment data sheets
Yes ☐ No ☐	Milestone 1. Equipment submittal and approval of Sequence of Operation (SOO). Required Completion Date: Before the start of the combined heat and power (CHP) installation at the site and prior to approving submittals for the major equipment. 1. The **XXXX** CHP plant shall be controlled to follow **ELEC/Thermal** loads. (Thermal "following" is defined as limiting the engine output such that the heat output does not exceed that required to satisfy the connected heating loads.) Accordingly, sustained use of radiators for heat rejection should not be required. The thermal loads connected to the engines shall be as follows: a. XXXXX b. XXXXX c. XXXXX 2. The Generator shall connect to the XXX heating source via the Piping and instrument Diagram (P&ID) titled XXXXX, dated XXXXX drawings attached to this MRD. P&ID will show all the sensors and meter locations as required for measuring thermal and electrical efficiency. Line out how the unit will be connected here, unique to every installation. 3. Trend Data history and export requirements. 4. The electrical output of the generator should not exceed the demand of the connected electrical loads. That is, should the thermal-following approach yield a combined electrical output that exceeds the electrical demand of the connected buildings, the output of the generator(s) shall be reduced such that the generator(s) do not back-feed the grid. 5. The remaining load of the boiler plants shall provide heating water when the CHP thermal output is not able to satisfy the facility thermal demands, either because the

generator is at its maximum output or because the electrical demands limit the generator output.

6. On-Board data will be utilized to verify the proposed operation of the generator. The on-board diagnostics will be exportable to a CSV file output, with required instrumentation points and run hours.
7. Provide a process and instrument diagram showing all CHP plant equipment, fuel gas and hot water piping, and instruments.
8. The 35 kW CHP Plant is designed to meet the following performance criteria for the year:
    a. Annual Production of x,xxx,xxx kWh (accounting for parasitics; see Milestone 2a below)
    b. Facility fuel increase x,xxx,xxx therms (fuel fired for cogen minus boiler fuel saved) HHV
    c. Boiler fuel offset of x,xxx,xxx therms
    d. Electrical efficiency XX% (accounting for parasitics)
    e. Thermal efficiency XX% (accounting for parasitics)
    f. Plant overall efficiency XX%
    g. X,XXX,XXX ton hours of chilled water production.

X _____ X _____

National Grid Inspector Customer or Customer Rep

Post Inspection	**Installation Completion**: Provide a list of equipment or materials installed as part of this project. Include mfr, model, HP, kW, efficiency ratings, etc. and confirm completion
Yes ☐ No ☐	**<u>Milestone 2a. Installation Completion</u>** 1. Install 35 kW, Type of Generator and heat recovery system. Engine shall be XXXXX model or equal. 2. CHP unit shall meet the following criteria derived from the product data sheet: a. electric output: X,XXX kW, not including parasitic loads (pumps and radiator fans) b. thermal output, main hot water: 204 MBH with 170°F jacket water c. overall efficiency: XX% at full load based on XXX,XXX Btu/min (X,XXX MBH) of fuel input (using HHV) d. part-load HHV performance as follows:

	100%	80%	60%
Electrical output*	1,016 kW	813 kW	610 kW
Fuel input (HHV)	10,626 MBH	8,722 MBH	6,851 MBH
Main hot water output	2,719 MBH	2,231 MBH	1,760 MBH

Oil cooler output	365 MBH	351 MBH	334 MBH
Exhaust output	1,976 MBH	1, 658 MBH	1,339 MBH
Total recoverable heat	5,060 MBH	4,240 MBH	3,433 MBH
Electrical efficiency*	36.5%	35.6	33.9
Thermal efficiency*	47.6%	48.6%	50.1%

*not accounting for parasitic loads; based on HHV

e. Thermal output delivered to heating system: X,XXX MBH at XXX°F supply, XXX°F return hot water accounting for exhaust heat recovery heat exchanger, oil cooler heat exchangers, and final heat exchanger as per P&ID.

f. Parasitic loads: estimated at XX kW during full-load operation; inclusive of all pumps and fans; accounting for expected parasitic equipment loading at these conditions.

3. On-board data will be provided for a period on no less than 9 months.
   a. Archived data shall be available in Excel or CSV compatible electronic files.
4. In addition to the above requirements, the CHP plant will meet all the requirements of (a) Section III.2(C) in the **Massachusetts APS Statement of Qualification Application Form** (which is in the "Generation Unit Technical Details" section of the Web-based application) and (b) Section 2 of the **APS Guideline for CHP,** June 14, 2011 Edition (or most recent version), both of which can be found at the **APS Statement of Qualification Applications** page of the Massachusetts DOER website:
   http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/rps-aps/rps-aps-sqa/aps-statement-of-qualification-applications.html
5. During post inspection confirm that data collection system is installed, connected to properly calibrated metering and reporting and archiving data properly.

X _____ X _____

National Grid Inspector Customer or Customer Rep

Yes ☐ No ☐

Milestone 2b. Demonstration of Operability
(Completion of Milestone 2A and 2b is required for the payment of 80% of the incentive)

Confirm that the above noted equipment is installed and operational for completing Milestone 2b. Installed and operational is defined as:

1. All components of the new XXXX kW CHP and XXX ton absorption chillers including all meters are installed and connected to their respective building systems.
2. All equipment, piping (including flushing), electrical and control wiring is completed, so that all CHP units can run in an automatic mode. The minimum performance shall be the following:

	a. Annual Production of X,XXX,XXX kWh (accounting for parasitics; see Milestone 2a below) b. Boiler fuel offset of XX,XXX therms (based on XX% overall boiler efficiency) c. Plant overall efficiency XX% 3. Interconnection facilities are completed and accepted by Retail Connections Engineering, and insurance certificates are in place. This does not absolve the customer from meeting any other jurisdictional permits or other regulatory requirements. 4. 1-hour interval data shall be made available and exported to remote website for access to PA in CSV format for a *time period depending on weather dependence of heat load* 5. Customer and its vendors have completed their own commissioning with reports on major pieces of equipment provided. X _____ X _____ National Grid Inspector Customer or Customer Rep

Post Operational Assessment	**DOCUMENTATION:** List written documentation required to train, verify, operate, or maintain the equipment being installed or controlled. This may include specification sheets, test reports, construction drawings, etc.**:** Provide a list of Trending Requirements required to verify proper system operation. Trends should document operational sequences, setpoints and scheduling of equipment as described in TA Study
Yes ☐ No ☐	**Milestone 3. (Completion of Milestone 3 & 4 is required for the payment of the remaining 20% of the incentive.)** Validate the following items: A. O&M manuals and documentation on site 1. All equipment catalogs and performance specifications for the one, XXX kW CHP units. O&M manuals for the following equipment: a. Engine/generator sets b. Pumps c. Electric motors d. Heat exchangers e. Absorption chillers f. Metering equipment (gas, electric, hot water) 2. Design Drawings (Process and & Instrument Diagrams and Mechanical Piping Drawings, Instrumentation List and equipment Data Sheets) are available on site. B. Waterside economizer sequence is implemented and operational C. Availability of trend data and confirming of its exportability. 1. Provide hourly interval data for the following points as a minimum. Provide the capacity for and enable trend data archiving for a period of at least one year. a. Gross kW and kWh electrical output

	b. Fuel input to CHP plant (therms or MMBtu) c. Hot water generated by CHP plant and utilized by system (therms or MMBtu), sensor points to include supply and return temperature for the CHP, as well as HW pump on/off status for on/off controlled pumps, or pump speed for VSD controlled pumps. 2. Provide ability to manually export weekly data electronically to third party via email or FTP upon request. 3. Post operational assessment process will require functional testing of the CHP and the thermal and electrical interface to the buildings, a *time period depending on weather dependence of heat load* of concurrent 1-hour interval data for all points noted above. If equipment fails to meet expected sequences of operations and corrections are needed, additional trend data shall be provided to confirm any seasonal changes in operations. D. Sequence of operation is working as outlined in MRD, TA report and supporting energy saving calculations. X _____ National Grid Inspector
Post Inspection	**OTHER REQUIRMENTS:** Describe any requirements for demolition, removal, etc. of existing equipment.
Yes ☐ No ☐	**<u>Milestone 4</u>** 1. Customer will have a minimum 3 year or first major overhaul maintenance contract to help achieve long term proposed operational strategies and energy cost savings. Normal planned /routine maintenance shall be conducted where possible during National Grid off-peak billing periods. 2. Provide detailed project cost breakdown by major system components. Provide copies of paid invoices to support the project costs.

The National Grid signature below indicates the National Grid engineer, or their representative, has reviewed and agrees to the requirements stated in this MRD. The customer signature below indicates the customer also agrees with the requirements of this MRD and will implement as stated. The customer should only sign below if this MRD has been signed by National Grid or its representative.

The pre-approved incentive is subject to Retail Companies' POST INSPECTION of final specifications, drawings and operation of the proposed equipment. In the event the proposed system is altered from the above description, notify the Company of the change prior to the equipment purchase and installation as the change in design and operation may impact the available incentive.

National Grid Engineer or Representative	Date	Customer Agreement Signature	Date

Once the installation is complete and the equipment is operational, the post inspector will sign below, confirming all requirements of this MRD have been met, and/or any discrepancies have been noted. National Grid will review any discrepancies to determine their impact on energy savings or incentive. The final customer signature indicates that they agree with the findings of the post inspector, including any discrepancies noted, and are satisfied with the installation.

National Grid Post Inspector	Date	Customer Certification of Installation	Date

Attachment: P&ID dated x/x/20xx

Attachment 2 - Links to Interconnection Requirements

Eversource

https://www.eversource.com/Content/ema-c/about/doing-business-with-us/builders-contractors/interconnections
Eversource MA Interconnection Application:
https://www.eversource.com/content/ct-c/about/about-us/doing-business-with-us/builders-contractors/interconnections/massachusetts/application-to-interconnect

National Grid

http://www.nationalgridus.com/masselectric/business/energyeff/4_interconnect.asp
https://ngus.force.com/s/

Pre-Application

Pre-applications are required for all CHP installations over 500 kw. Any interconnecting customer can request a pre-application. The pre-application report will give the customer the feeder and sub, pending and connected DG on said feeder, insight into whether there is an ASO study hold, pending system modifications, or improvement efforts that might delay interconnection.

Network Maps

Check ESB756C, Exhibit 2, for maps of the Area Networks.

- Lynn https://ngus.force.com/servlet/servlet.FileDownload?file=0150W00000CqjXq
- Worcester https://ngus.force.com/servlet/servlet.FileDownload?file=0150W00000CqjY0
- Brockton: https://ngus.force.com/servlet/servlet.FileDownload?file=0150W00000CqjY5

Non-Effectively Grounded Circuits

There are feeders outside the Network systems which are not effectively grounded, known as NEG Circuits. These networks will potentially require greater levels of system protection. A pre-application will identify whether this is an issue for the customer's specific site. Contact National Grid for assistance in identifying your network status.

Electrical Interconnection Useful Links

National Grid nCAP Portal - https://ngus.force.com/s/
MA System Data Portal General Information - https://ngus.force.com/s/article/Massachusetts-System-Data-Portal
MA System Data Portal - https://ngrid.apps.esri.com/NGSysDataPortal/MA/index.html
(Hosting Capacity, Heat Map, etc.…)
Pre-application Report Request - https://ngus.force.com/s/article/MA-Complex-Pre-Application-Report-Request
ASO Study - https://ngus.force.com/s/article/DG-Stakeholder-Updates
ESB 756 - https://ngus.force.com/servlet/servlet.FileDownload?file=0150W00000E6sFh
DG Links List - https://ngus.force.com/s/article/MA-BUSINESS-Useful-Links

Unitil

http://www.unitil.com/energy-for-businesses/electric-information/tariffs
DOER site on interconnection and heat map:
https://sites.google.com/site/massdgic/home/interconnection