ETP
Emerging Technology Program

gti

TECHNOLOGY SNAPSHOT

Micro - Combined Heat and Power

A micro-combined heat and power (micro-CHP) system is a power plant that provides heat and power to a single building. The heat is generally used for space and/or water heat.

MARKET SITUATION

Baseline

- Traditional electric heat pumps or conventional HVAC equipment
- Possibly backup power

Opportunity

- Energy efficiency: natural gas, electricity, and water savings
- Market potential: retrofit existing systems and for new installations

Segment

- Residential or commercial
- New construction and retrofits

Status

- Several technology have been lab and field tested

Next Steps

- Third party verification of benefits & market analysis

The Technology

Micro-combined heat and power (micro-CHP or mCHP) systems are small generators (generally less than 50kW) potentially suitable to the residential and light commercial markets. They can be fueled by natural gas, LPG, fuel oil, or biomass and use a variety of technologies, including internal combustion engines, Stirling engines, fuel cells, and Rankine cycles. They can provide space heating (hydronic and warm air) and/or water heating along with grid-parallel and backup electricity. While uncommon, some systems can provide space cooling.

For CHP, there are five key factors that drive sizing and operating strategy:

1. Base-load electricity demands
2. Coincident thermal demands
3. Electricity and gas rate schedules
4. System electrical efficiency
5. The availability of net excess generation credit (net metering)

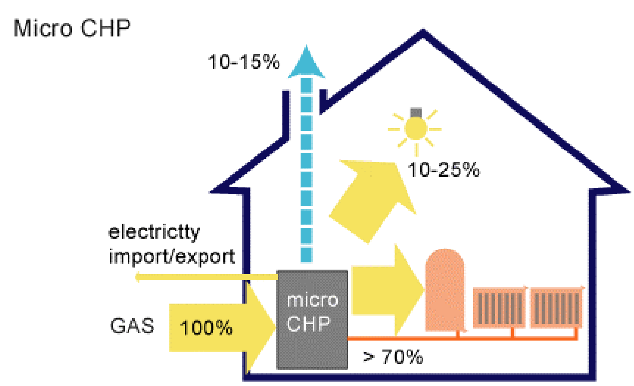

Figure 1: Example of a Micro-CHP Installation
Source: http://www.staffordarea.saveyourenergy.org.uk/what/heating/microCHP

Electrical efficiencies vary across systems. Systems with low electrical efficiencies produce more heat than electricity and are well-suited for high thermal demand applications. Alternatively, systems with high electrical efficiencies produce more electricity than heat and are well-suited for low thermal demand applications.

There are four common mCHP control strategies manufacturers typically incorporate into their controllers. They are implemented grid-parallel and in some cases off grid with inverters (black start).

- Track Electric – system runs commensurate with the building electrical demand up to its maximum capacity, and the thermal energy is used to supplement traditional space and DHW heating, otherwise it is dumped to a radiator.
- Track Thermal – system runs commensurate with the building thermal demand up to its maximum capacity, and the electricity is used to supplement utility power and excess is net-metered. This is the most common mCHP strategy.
- Track Greatest – system runs at full capacity or commensurate with the higher of the building's thermal or electric demand up to its maximum capacity. Electricity is used to supplement utility power and excess is net-metered. Excess thermal energy is dumped to a radiator.
- Full-load – Generally only if net-excess generation credit is available. The system always runs at full capacity and excess electricity is net-metered, while excess thermal energy is removed via a radiator.

Market Analysis

Combined heat and power represents residential and small commercial market opportunity for the gas industry to provide both electric power and space heating with one gas-fired device.

Micro-CHP systems are flooding the U.S. market. However, manufacturers have seen only niche market sales. The costs of mCHP systems vary widely, but are generally high; and potential savings are highly dependent on installation circumstances. Hurdles to mCHP systems gaining market share include: first costs, cost-effectiveness, interconnection issues, few utility or public incentives, and coincident loads. Typically, mCHP manufacturers advertise the environmental benefits of increased efficiency through reduced emissions and the increase in general home value.

Internationally, there are dozens of manufacturers representing micro- CHP products from 1kW to 50kW, including Stirling engines, internal combustion engines, fuel cells, micro- turbines, and Organic Rankine systems.

The future market for mCHP faces potential game-changers. Policy makers are beginning to recognize the benefits of mCHP. Some states have recently included CHP in their net-metering programs and the EPA's Energy Star Program recognizes mCHP. With favorable outlooks for domestic natural gas prices, and residential and commercial markets anticipating "smart grid" and micro-grid applications, mCHP technologies could be poised for greater market impact in the future.

GTI is monitoring market progress of over a dozen mCHP manufacturers as indicated in Figure 2.

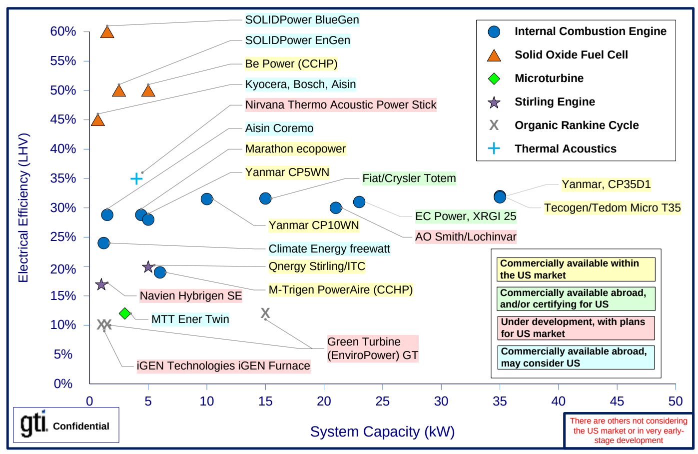

Figure 2 – mCHP Technology Market Penetration

Costs + Benefits

U.S. consumers have demonstrated a motivation to purchase home power systems – tens of thousands of gaseous power units are sold every year. However, these are mainly whole home emergency generators (power only engine generator sets) that operate automatically during a power outage event. Consumers are demonstrating a willingness to pay $5,000 to $15,000 for home power units, but driven by reliability concerns (not energy savings). This dichotomy of the consumer's willingness to pay for reliability but not energy savings is a key issue. If the willingness to pay for reliability exists, it provides more opportunities for mCHP, but only if the incremental cost for mCHP functionality is justifiable.

In addition to applications with high heating demands, a promising opportunity for mCHP also exists in applications where net-metering and favorable net excess generation credit apply to technologies that operate full time and at full capacity, with electrical efficiencies better than what can be provided by grid power. However, long-term sustainability of favorable net metering policies is not certain and affects life-cycle economics. In order for mCHP technology to gain market traction beyond niche markets, GTI suggests the following:

- The cost of mCHP systems is on the order of $4,000/kW to $12,000/kW for equipment alone with installed costs ranging from $10,000/kW to $30,000/kW. The installed cost of mCHP systems must be reduced to about $5,000/kW or less to achieve reasonable paybacks that could generate enough market penetration and volume to drive costs down. This, of course depends on regional energy rates.
- Or, a higher valuation is placed on emergency or standby power service to help reduce first costs.

Barriers

Micro-CHP systems are well established in Europe, Asia, and other regions for many reasons that cause underutilization in the United States, including:

- High energy prices compared to the United States
- Primarily hydronic heating versus forced air heating
- Government and utility support (incentives through feed-in-tariffs, subsidies, and tax exemptions)
- Prioritized carbon reductions
- Heating equipment suppliers that support mCHP technology

Other barriers to mCHP utilization in the United States include:

- High-priced installation
- Lack of awareness of the various products and potential fits with building types and regions
- Lack of developed sales and service infrastructure
- Limited incentives to support market entry

Because of the significant barriers, residential and light commercial markets are mostly vacant of small distributed heat and power technologies that could cost-effectively offer clean energy-efficient value propositions.

Solar PV is an example of a power technology that has gained significant market attention. Yet, a 5kW PV system produces almost three times less electricity on an annual basis than is possible with a 5kW mCHP system and produces no usable heat energy. As a result, annual energy savings are far less with PV than with mCHP. The gas industry recognizes corporate and energy efficiency opportunities with mCHP, but is unclear which mCHP technologies are best to pursue and deploy to maximize economic opportunity.

ETP Activity and Next Steps

Interest in residential and small commercial mCHP is building with several companies developing technologies and others looking to bring existing technologies to the United States market. The ETP's mCHP working group focuses on technologies that show attributes of potential success in the United States market. A list of mCHP Market Success Indicators was developed to help identify technologies appropriate for the ETP working group focus. Manufacturer-specific Technology Snapshots that describe the technologies and how they might fit within utility ETPs and/or energy efficiency programs were developed. The snapshots address as many of the market success indicators as possible. Looking ahead, the snapshots can be used to highlight performance test and demonstration data if such projects materialize.

Micro-Combined Heat and Power

Micro-CHP Success Indicators

Commercial Availability

- Is the technology available in the US, Canada, both?
- When did it become available?
- Roughly how many have been installed in US?
- Roughly how many installed in US are still operational?
- Any challenges or known issues?
- Are dealer, installer, and service networks in place?
  - If not, what is the plan to build out a national network
- Is the technology currently receiving incentives?

For new/newer products to North America that have an existing track record outside of North America

- Where is the product commercially available?
- Approximately how many have been sold to date?
- What applications were they installed in, and what were the total installed kW sizes?
- How old/new is this product? First released?

For new/newer products looking to enter the North American market

- When will the technology be commercially available?
- What needs to be done to the product for US?
- Is the product in the process of being certified by UL & CSA? Expected completion date(s)?
- Any regional barriers or is or will the product be available across all of North America?
- What are the expected barriers?
- Has the technology been evaluated by recognized professionals to confirm its performance, compatibility/compliance with existing building practices and systems, and its ease of installation?

Key performance benefits of the technology

- What are the predicted energy savings?
- What are the predicted emissions reductions?
- What is the life expectancy of the equipment, including overhauls?
- What is the expected price point?
- What additional costs are required for heat recovery?
- What are the primary heat applications (e.g. space heating, DHW, cooling, dehumidification, process)?
- What is the expected simple payback?

Resources

For additional information on mCHP visit the working group website: https://teams.gastechnology.org/

Contact Us

Manufacturers

http://www.marathonengine.com/
http://us.yanmar.com/products/energy-systems/
http://www.totem.energy/features/?lang=en
http://www.qnergy.com/
http://www.mcogen.com/
http://www.ecpower.eu/en/
http://www.bepowertech.com/

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Emerging Technology Program (ETP) is a collaborative program managed by Gas Technology Institute (GTI) focused on accelerating the commercialization and adoption of the latest end use and energy efficiency technologies. The program is designed to help companies assess the benefits of new energy efficiency products and integrated solutions for use in near- to mid-term energy efficiency program implementation.

To learn more about ETP and the program's initiatives, visit www.gastechnology.org/ETP.

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