GREATER USE OF COMBINED HEAT AND POWER TO SUPPORT RENEWABLE INTEGRATION

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It has long been recognized that combined heat and power (CHP) generation can achieve higher end-use efficiencies than conventional systems. By generating electricity at the point of use and utilizing the co-produced heat, CHP generators can achieve net efficiencies in excess of 80%. This nearly doubles the efficiency of our current system, in which large centralized power plants provide electricity, and heat is produced on site with furnaces, boilers or water heaters.

CHP generators may also be well suited to balance intermittent resources, such as wind and solar generation, but two fundamental problems remain. First, adoption of CHP in the United States has been slow and mostly limited to base-load generators in large industrial facilities. These units operate at very high efficiencies, but do little to improve the flexibility of the grid. Second, at present there is little incentive for privately owned resources to cooperate with the grid, an issue that must be resolved if CHP is to ease the integration of renewables.

A broad integration study is needed to better understand the role of CHP generators in a carbon-constrained electricity system. We suggest three areas of research, each discussed in the following sections.

Balancing Intermittent Resources with CHP:

The electricity system is unique in that supply and demand must match precisely at all times. Fast ramping generators are needed to constantly maintain this balance, and gas-fired turbines are most commonly used. Katzenstein et al. [1] showed that ramping gas-fired generators decreases their efficiency and may lead to higher than expected emissions, a problem that could increase with expanded use of wind and solar generation.

It's technically feasible to use CHP generators, rather than centralized power plants, to balance supply and demand. And there is reason to believe that CHP generators may be better suited to the task. Some commonly used CHP technologies, such as reciprocating engines, are more amenable to ramping than large turbines. Further, when operating at partial load, generators will sacrifice electrical efficiency but gain thermal efficiency—potentially useful for CHP generators, but not for centralized power plants.

In CHP applications there will also be times when the full output of the generator is not needed to meet the energy demands of the end user. In these cases, the remaining capacity could be dedicated to balancing intermittent resources. With enough CHP generators operating in this fashion, we may be able to avoid building power plants that would otherwise be necessary to balance intermittent renewables.

To date, no studies have looked at the feasibility, benefits, or costs of using CHP generation to facilitate broader integration of renewables. Research in this area would 1) compare (in terms of both costs and emissions) the "CHP strategy" with traditional, centralized gas turbines and 2) estimate the amount of CHP needed to balance a given penetration of intermittent renewable generation.

Encouraging Privately Owned Resources to Support the Grid:

If privately owned CHP generators are to ease the integration of renewables, some coordination will be needed. Markets for energy and ancillary services are increasingly open to demand-side resources, such as CHP generators[1], but these efforts have had mixed results. Further study is needed to 1) evaluate existing mechanisms for enlisting demand-side resources and 2) provide guidance for new mechanisms where needed.

These mechanisms will need to align the interests of CHP owners with those of the grid operator: how can privately owned generators be encouraged to support grid reliability and facilitating broader adoption of renewable resources? The issue of control will need to be addressed. For example, when is it sufficient to send a price signal and let CHP systems respond accordingly? And, when might it be necessary, for the sake of reliability, for the grid operator to take control of generators owned by end users?

Spurring Adoption of CHP:

The "CHP strategy", as discussed above, will require further adoption of CHP in the U.S. Addressing regulatory barriers and finding creative strategies for improving the economics of CHP investments is critical to this goal. King et al. [2] found that CHP projects serving small aggregates of customers ("microgrids") showed "clear benefits over traditional single customer distributed generation." In most states, however, microgrids are illegal because legacy utilities are given the exclusive right to sell electricity. New regulatory frameworks are needed if exceptions are to be made for small-scale microgrids (see [3]).

As part of a program to reduce greenhouse gas emissions, the Netherlands has been hugely successful in expanding the use of CHP. Strachan et al. [4] performed a detailed comparison between this program and a similar but less successful one in the UK. Strachan found that the Netherlands offered generous net-metering rates, which "allowed investment in larger units, benefiting from economies of scale… and extended DG use to the much larger set of sites with limited electricity base-loads." On a per capita basis, adoption of CHP in the Netherlands was 40 times that of the UK.

In the U.S., changes in the electricity markets may present new opportunities for small-scale CHP. An up-to-date study should explore new mechanisms for increasing the returns and decreasing the risks of CHP installations. These mechanisms may include real-time electricity pricing, a CO_2 tax or cap-and-trade program, and markets for ancillary services. Strategies for reducing the risks of CHP investments may include long-term contracts or clean energy standard offer programs (CESOP)[2].

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[1] Demand-side resources may include interruptible load, "smart" appliances, batteries, or generators on the customer side of the meter.

[2] These are standardized long-term contracts between the demand-side resource and the utility. California's "Market Price Referent" is the most developed example of a clean energy standard offer program.

References:

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