

***Innovative Measures, Mechanisms, or Programs
To Spur Investment in Clean Technologies
That Could be Employed in California***

1. Name of measure, mechanism, or program:

Combined Heat and Power (CHP) for commercial, industrial, and agricultural applications.

2. Description of measure, mechanism, or program:

CHP, as discussed here, refers to on-site distributed electric generation using small, natural gas powered generators where the generator's waste heat is used to meet a pre-existing heat load. Small generators are typically 5-10% less efficient than large central generators at converting combustion heat into electricity. A minimum amount of waste heat has to be utilized to match overall efficiencies. Any additional waste heat utilized displaces fuel that would have been spent on the heat load.

An advantage of distributed natural gas powered generators is the possibility of incorporating anaerobic digesters to produce carbon-neutral biogas onsite from food scraps or agricultural wastes. In the agricultural sector, the widespread use of anaerobic digesters could save as much as 10 Mt/a of CO₂ equivalent by capturing and combusting methane that would have otherwise been released into the atmosphere.

3. Locations or Jurisdictions where implemented:

CHP has been implemented extensively throughout California. For a complete listing of all CHP plants greater than 0.1 MW, see [1].

4. Expected benefits:

Decreased greenhouse gas emissions by displacing fuel that would have been used to produce heat.

5. Observed benefits:

Typically, the observed benefits are the same as the expected benefits. However, in cases where the percentage of heat used is less than the difference in electric conversion efficiency, CHP can result in a net increase in CO₂ emissions. Adequate planning of CHP systems can completely avoid this problem.

6. At what scale has this measure, mechanism or program been implemented? What is the maximum scale at which one could reasonably expect it to make a practical contribution to meeting the goals of AB 32?

So far, CHP implementation in California has decreased CO₂ emissions by an estimated 14 MT/a [2]. Deployed optimally, CHP could reduce emissions by about 7 MT/a CO₂ equivalent by 2020 [3,4].

7. Any unanticipated problems or complications arising during implementation:

If CHP is deployed widely, it will introduce the same types of complication as standard distributed generation. These complications have been well-documented elsewhere, but basically arise from the existing grid being optimized for central power generation.

8. Potential obstacles to implementation in CA:

Potential obstacles include matching heat and electric loads in quantity and timing, financing capital costs, and working with user preferences. For example, a noisy generator would be unacceptable in commercial applications if the noise penetrates into working space.

9. Estimated aggregate cost of measure, mechanism, or program:

An optimal scenario would result in an annual savings of \$3 billion per year. [4]

10. Estimated cost per ton of avoided emissions or alternative measure of merit:

Cost savings of \$428 / ton [4]

11. Author's assessment of suitability for implementation in California:

CHP is an economically viable strategy for moderate reductions in CO₂ emissions that deserves further research.

References and Calculations:

[1] California Energy Commission Database, "California Power Plants Database," 25 September 2007, <<http://www.energy.ca.gov/database/index.html#powerplants>> (October 3, 2007)

[2] Cogeneration plants in California have a combined installed capacity of 9028 MW [1]. Plant efficiencies with CHP and capacity factors are cross-sector averages taken from low penetration scenarios in [3]. Average plant efficiency assumed to be 35% without CHP and 75% with CHP, indicating a ratio of heat captured to power produced of $(75-35)/35 = 1.1$. CHP plant capacity factors were assumed to be 80%, yielding $9028 \text{ MW} * 1.1 * .8 * 8766 \text{ hrs / yr} * 3.6 \text{ GJ / MWh} = 2.5 * 10^8 \text{ GJ}$ of heat offset annually. Assuming the heat would have been produced with natural gas of energy density 0.054 GJ/kg with burners of 90% efficiency, the CHP heat saves about $2.5 * 10^8 \text{ GJ} * (1 \text{ kg} / .054 \text{ GJ}) / .9 * 10^{-9} \text{ MT/kg} = 5.2 \text{ Mega Tonnes}$ of natural gas, or $5.2 \text{ MT CH}_4 * (2.75 \text{ kg CO}_2 / \text{kg CH}_4) = 14 \text{ Mega Tonnes}$ of CO₂.

[3] The optimal scenario from [4] for commercial, industrial, and agricultural sectors, from table 1, standard grid efficiency, was high penetration in small commercial, medium penetration in large commercial and industrial, and maximum penetration in agriculture.

[4] Firestone, R., F. Ling, C. Marnay, and K. LaCommare. "Preliminary Estimates of Combined Heat and power Greenhouse Gas Abatement Potential for California in 2020," LBNL-63319. July 2007.