Building Electrification Policy and Combined Heat and Power Relevance

Why Electrification Policy is Generally Counterproductive to its Carbon Reduction Goals

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Abstract (for complete paper, visit Tecogen Website here)

To reduce carbon emissions, climate change advocates are encouraging municipalities to enact "building electrification" policies, promoting change to local building codes to require that certain types of facilities adopt all-electric heating systems. Inherent in the building electrification concept is that most of the electricity be supplied, if not now, then in the foreseeable future, by carbon free sources (wind, solar, hydro, etc.). Thoughtfully applied to specific geographic regions and building types, electrification can be a sound policy with real climate change benefits. The replacement of an efficient natural gas water heater with the best electric counterpart, however, can increase a building's carbon footprint if the electricity is from high carbon sources. Careful examination of the policy's impact reveals this shortcoming to be true in most power grids as they exist today and likely well into the future. This is because natural gas heating appliances are very efficient (up to 90%) while the additional electric grid load attributed to electrification can only be supplied by low efficiency, high carbon emitting sources. This means that countrywide adoption of building electrification could turn out to be counterproductive to its intended benefits in almost all regions of the country.

Tecogen has analyzed the impact of building electrification policy to identify specific conditions where electrification effectively reduces greenhouse gas emissions and where it does not. Moreover, our analysis shows that cogeneration (or combined heat and power/CHP) will always reduce carbon emissions relative to building electrification because electric grids, even those projected many decades into the future, will require some fossil fuel power to manage the variability of renewable sources; it is this residual, non-renewable portion of the electric grid, called the marginal component, which cogeneration systems offset. Sound climate change policy should be aimed at expanding renewable electricity sources where electric power is the only option (i.e. for lighting, residential AC, etc.) or where it is most impactful (e.g. electric automobiles which replace engines operating at less than 30% efficiency). When it comes to heating, cogeneration should always be encouraged, as the electricity generated will reduce production from the last residual electricity generated by the fossil fuel power plants. Electric heating systems cannot match the carbon benefit as they will only add to the power required from these inefficient plants, effectively negating their benefits. We believe that electrification should only gain modest adoption where it makes sense – for residential housing in moderate temperate regions and where the grid is highly saturated by renewable sources with ample battery storage. This is a narrow slice of CHP markets.

Our analysis is comprised of the following elements which are covered in detail in the paper:

- The US power grid, although having regional differences, is a mixture of renewable and conventional power plants. One critical difference between them is that the grid is compelled to accept all the power that the renewable sources generate. The instantaneous shortfall between

supply and demand must be produced by the conventional sources, generally natural gas turbines. New loads added to the grid, therefore, must be supplied by the non-renewable fossil fueled plants, as the output from the renewable sources is always fully utilized.

- Conversely, new Distributed Generation (DG) sources (such as cogeneration or solar PV) will not displace other clean sources when they operate; rather, the fossil fueled plants charged with maintaining the balance between supply and demand will be curtailed, resulting in a very positive carbon benefit.
- Electrification is only beneficial when the additional power required for policy implementation are highly decarbonized sources or the electric heating appliance is a heat pump with a very high efficiency. A close examination of heat pump water heaters shows efficiencies to be insufficient in most applications and climate conditions. Recent projections from the Department of Energy regarding US electricity production through 2050 show modest gains for renewables while fossil fuel sources continue to dominate. The above dynamic – whereby additional renewable sources are unable to displace the marginal fossil fuel plants to serve the newly deployed electrification loads – will be the case in almost all regions of the country well into the future.

Our major conclusions in the paper are as follows:

- CHP (Combined Heat and Power) will remain the benchmark for low carbon emissions heating well into the future, offsetting marginal power sources (fossil fuel plants). No major power source will eclipse CHP until major reductions are made in the carbon emissions of the "marginal" sources. This seems unlikely even through 2050.
- Given the current effective efficiency (or carbon emissions rate) of electrification, mandating it is substantially counterproductive. When compared to CHP, this would increase overall carbon emissions, even in the most decarbonized states (New York and California), by 50% for the best electric technology (heat pumps) and 200% for conventional electric resistance heaters.
- The carbon benefit from electrification will increase as grid power sources improve - but only if the improvement extends to the marginal power sources. The marginal sources are not likely to improve unless large gains are made in market penetration of energy storage technology. We see the recent DOE projections as compelling reason to anticipate otherwise.
- Undoubtedly, electrification will be effective policy in some cases but will be limited to regions with ample financial resources and moderate weather conditions. Electrification will extend mostly to new residential construction where moderate weather allows greater reliance on solar sources and provides heat pumps with the warm ambient temperatures required for high efficiency (COP) operation (i.e. California).
- It is unlikely, in our opinion, that electrification will extend beyond a narrow slice of markets like California. In areas that have significant heating loads and less viable renewable sources (i.e. the Northeast), electrification will prove uneconomical. This is especially so in existing commercial and industrial facilities where renovation to incorporate heat pump heating would be inefficient due to the cold climate and higher process heating temperatures. Further, the increased electric supply required for electric heating would be highly problematic as most grid transmissions in CHP markets are already constricted.