CHP Implementation: Designing Combined Heat & Power Financial Incentives and Eligibility Requirements for Non-Residential Demand-Side Management Programs

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ABSTRACT

Financial incentive structures and eligibility requirements for combined heat and power (CHP) programs continue to differ widely as states and utilities sharpen their focus toward the demand-side management (DSM) opportunities of this technology. Entities typically pay CHP incentives based on a variety of metrics such as energy generation, installed capacity, project costs, and combinations thereof. With so many options, how does a utility decide which incentive structure and requirements are best for delivering a successful program? Presented with this challenge, Navigant reviewed various commercial and industrial (C&I) CHP incentive programs to inform the design of a utility-delivered, stand-alone CHP DSM program.

This paper examines the pros and cons of the reviewed incentive structures and their influence on the final design of the CHP program. The analysis leveraged existing CHP performance studies and recent CHP program data to develop an interactive model comparing selected incentive structures. Navigant modeled and analyzed the different incentive structures and the effects on the program incentive budget by varying incentive and program delivery parameters. Additionally, Navigant performed an assessment of CHP program best practices to inform the design of program requirements, including incentive caps, minimum technology efficiency levels, and performance monitoring.

Navigant's research and analysis ultimately guided the design of PECO Energy (PECO) prospective utility-delivered CHP program. This paper provides insight into the framework for comparing CHP program design considerations, such that utilities can make informed decisions regarding future CHP programs. Additionally the paper presents a case study of PECO's design requirements and the reasoning behind PECO's new CHP program design.

Combined Heat and Power as a Demand-Side Management Solution

Combined Heat and Power (CHP), also known as Cogeneration, is an approach to generating electric and thermal energy from a single fuel source at significantly higher overall system efficiency. Originally CHP was limited to large utility plants, but advances in turbines and reciprocating engines reduced the cost and complexity of CHP systems. Since the 1980's, industrial facilities with steady base load electricity demand coupled with steady thermal demand can realize the benefits of incorporating CHP into their energy systems. Today CHP systems have reached efficiencies as high as 80%, while producing heat and electricity by conventional methods typically has a combined efficiency around 45%. Additionally, the efficiencies gained at the facility level translate to reduced emissions, enhanced power quality and reliability, and diversification of energy supply.

Because of the potential efficiencies and peripheral benefits, policymakers have increasingly focused on CHP installations as a demand-side management (DSM) solution for utilities. Governmental agencies and investor-owned utilities (IOU) have worked to develop innovative strategies to advance the availability and overcome barriers to achieving the potential of CHP technologies. However, the complexity and variations of CHP installations can confound program designs, both economically and administratively.

Facing such barriers, PECO enlisted Navigant to facilitate the design and regulatory filing for PECO's CHP program as part of the utility's overall DSM portfolio. Navigant researched current CHP DSM programs, reviewed recent evaluations and discussed options with PECO Program Managers to design a program satisfying PECO's goals and capabilities as well as those of the policymaker. The ultimate design of PECO's C&I CHP program will be discussed as a case study in this paper.

CHP Program Design Considerations

CHP incentive programs have many components and options for delivery. Utilities can vary these program design components to meet their regulatory demands and administrative capabilities.

Technology and System Type Eligibility

CHP technologies vary widely, and the optimal facility solution depends on the application, available funding, and anticipated capacity needs. Table 1 shows several common CHP technologies and key energy statistics.

Table 1. CHP Technologies Typical Operating Statistics

Technology	Steam Turbine	Gas Turbine	Recip. Engine	Micro-turbine	Fuel Cell
Overall efficiency (HHV)	80%	70-75%	70-80%	65-75%	55-80%
Typical capacity (MW)	0.5-1,500	0.5-250	0.01-5	0.03-0.25	0.005-2
Typical power to heat ratio	0.1-0.3	0.5-2	0.5-1	0.4-0.7	1-2
Part-load	Ok	Poor	Ok	Ok	Good
CHP installed costs ($/kW)	$430-$1,000	$970-$1,300 (5-40 MW)	$1,100-$2,200	$2,400-$3,000	$5,000-$6,500
Availability	Near 100%	90-98%	92-97%	90-98%	>95%
Hours to overhauls	>50,000	25,000-50,000	25,000-50,000	20,000-40,000	32,000-64,000
Fuels	All	Natural gas, biogas, propane, oil	Natural gas, biogas, propane, landfill gas	Natural gas, biogas, propane, oil	Hydrogen, natural, gas, propane, methanol

Source: EPA. 2008

The array of technologies can create difficulties for utilities trying to incentivize CHP projects. In response, utilities have designed programs in such ways to set minimum efficiency levels for projects. The minimum overall efficiency levels are generally expressed on a higher heating value (HHV) basis and defined as the sum of net power and net useful thermal output divided by the total fuel consumed. Though HHV efficiency depends on the technology and the specific application, utilities tend to use a blanket minimum efficiency level to simplify the application and incentive processes. Sixty to 65% HHV efficiency is a common threshold for incentivized CHP projects.

Incentive Structures

Because of the array of available CHP technologies and their differences, incentive payment methodologies vary across many programs. Utilities must compromise between the complexity of the incentive structure and ensuring projects receive reasonable incentives. Because the capital intensive finances of CHP technologies can impede the implementation of projects, utilities must consider the timing of incentive payments. For example, small capacity projects may not need as much upfront financial support as a large, complex system. Table 2 shows the advantages and limitations of common CHP program incentives structures.

Table 2. Summary of CHP Program Incentive Structures

Complexity ↓

Incentive Payment Type	Payment Unit	Performance Component?	Advantages	Disadvantages
Capacity	\$/MW	No	• Low administrative burden • No system performance calculations	• Incentive disregards system performance
Energy Generation	\$/kWh	Varies	• Low administrative burden	• Generation predictions do not always reflect actual • Incentive typically disregards system performance
Project Cost	N/A	No	• Low administrative burden • No system performance calculation	• Project costs can be very high • Incentive disregards system performance
Tiered Capacity	\$/MW	No	• Reduces relative incentives for large installations	• Incentive disregards system performance
Tiered Capacity w/Performance	\$/MW and \$/kWh	Yes	• Reduces relative incentives for large installations • Increases utility security by incentivizing performance	• Difficult to administer
Hybrid Capacity/ Performance	\$/kWh and \$/MW	Yes	• Creates unique incentive for each project • Reduces relative incentives for large installations • Increases utility security by incentivizing performance	• Difficult to calculate and administer • Performance period can last several years

Note: Capacity payments could be \$/kW or \$/MW. The paper uses \$/MW for simplicity.

Capacity payment. Capacity payments are paid as a fixed \$/kW or \$/MW based on the rated peak energy output. These payments typically benefit project sponsors because utilities provide the payments early on in the project process. Administratively, these payments are easy to implement and track, as utilities do not need to track performance or calculate expected energy production. However, this structure provides risks to the utility in such cases when the CHP installation does not meet the expected outputs.

Energy generation payment. Energy generation payments are paid as a fixed $/kWh for expected annual energy production. Utilities can either pay these incentives upfront based on estimated energy production, or they can pay the incentives based on specified metering periods extrapolated to annual production. By requiring some estimation or metering of actual generation, energy generation structures reduce the utility risk of overpaying incentives based on capacity only.

Project cost payment. Project cost payments disregard capacity and generation and are paid solely on total project cost. Total cost of CHP installations usually includes equipment plus labor and materials and costs associated with the construction phase, such as engineering and project management. Often project cost payment structures cover 50% of total project cost with maximum incentives up to several million dollars.

Tiered capacity payment. Tiered capacity payments are similar to capacity payments, except utilities set capacity tiers with different incentive levels. An incentive rate applies to each tier and only the incremental capacity within each tier receives the corresponding rate.

Tiered capacity with performance payment. Tiered capacity with performance payments are similar to tiered capacity payments, except utilities provide an incentive for energy performance. The capacity payment lessens the capital cost burden on the site, while the performance payment encourages the participant to load and utilize the CHP plant.

Hybrid capacity/performance payment. Hybrid performance payments attempt to reconcile incentive payments and under-performing systems. As described by the California Public Utilities Commission (CPUC), the tiered capacity payment method sets the total available incentive for each project. A percentage of the total available incentive is allocated as the upfront payment to the project sponsor. The remaining available incentive is used to set a fixed energy performance incentive rate. This incentive rate is calculated using the expected generation of the CHP system and the number of years the utility will pay out performance incentives. Thus, all projects receive an upfront capacity payment, and facilities are encouraged to optimize operation of their systems to receive all available incentives.

Other Considerations and Best Practices

Though incentive structures may be the most prominent program design element, many other factors contribute to successful CHP programs.

Total payment maximum. Maximum incentives paid to projects are common in DSM programs. CHP projects can be very costly and, depending on the incentive structure, incentives can be extreme. Customarily, utilities set both absolute incentive maximums as well as incentive maximums relative to project cost. For example, a utility may pay the lesser of $1 million or 50% of the project cost as a maximum incentive.

Total capacity maximum. Because very large CHP installations can use a great proportion of a utility's incentive funding, utilities can set a limit on the capacity level eligible for incentives. High-capacity projects still qualify for incentives, but the incremental capacity above the maximum does not receive incentives.

Equipment and service warranties. The complexity of CHP systems often necessitates significant service during their effective lifetimes. In order to ensure incentivized systems maintain performance, utilities can require proof of warranties covering all equipment and service for a designated period of time, typically five to ten years.

Project sponsor ownership. Facilities personnel do not always have expertise with CHP systems. Utilities can require a point of contact for the system throughout the engineering design phase, installation, and the warranty period. Appointing a liaison with the utility provides the project sponsor a greater responsibility and sense of ownership for the incentivized project.

Review of Existing CHP Program Designs

CHP subsidies are available in several forms. The technology has been primarily available through state-mandated initiatives, but recently more utilities have added CHP as solutions into ratepayer-funded DSM portfolios. Regardless of the funding source, these programs have inconsistent incentive structures and program eligibility requirements. Table 4 shows several financial incentive programs and their corresponding incentive structures and requirements.

Table 4. Sample CHP Program Incentive Structures and Eligibility Requirements

Entity	Incentive Structure	Incentive Rebate	Incentive Cap(s)	Eligibility Requirements
NYSERDA	Capacity w/Performance	Upstate: $0.10/kWh + $600/kW Downstate: $0.10/kWh + $750/kW	$2MM or 50% of project costs	Capacity > 1.3MW Min. efficiency: 60%
MassSAVE	Capacity Payment	Systems less than 150kW: $750/kW Systems over 150kW: Program administrator discretion	50% of project costs	Min. efficiency: 60%
New Jersey	Capacity Payment	Systems less than 1MW: 0-500kW: $1000/kW >500kW: $500/kW Utility match available Systems over 1MW: 1MW-3MW: $550/kW >3MW: $350/kW	Systems less than 1MW: $1MM or 30% of project costs Systems greater than 1MW: $3MM or 30% of project costs	Systems less than 1MW: Min. electrical efficiency of 45% 10 year warranty or service contract Systems over 1 MW: Min. efficiency: 65%
California	Tiered Capacity w/Performance	**See note. $500/kW	60% of project costs; Incentives not provided for incremental capacities over 3MW	Must comply with all applicable performance and safety standards
Southwest Gas (AZ)	Capacity Payment	$400/kW - $500/kW (tiered based on minimum efficiency)	50% of project costs	Min. efficiency: 60%
*Connecticut	Hybrid Capacity	Depends on project economics	$450/kW	Electricity primarily consumed on-site.

*Program offered in 2012, may not be offered in 2013

**California uses a tiered incentive rate with annual performance adders. For projects less than 30 kW, 100% of the total incentive is provided upfront. Systems greater than 30 kW receive 50% of the total incentive upfront, and the balance is paid over five years based on actual performance.

Sampled programs in Table 4 illustrate the popularity of CHP incentive programs using the capacity approach. Determining incentive by this method poses the lowest burden on administrators and do not require field measurement. While focusing on the first cost burden to the facility, the capacity approach does not consider the beneficial economics of the CHP plant production to the facility or to the sponsoring state or utility. Additionally CHP plants in industrial buildings may not run at full capacity and may be dependent on prevailing process heat demands. In such cases a capacity or project cost incentive will equally incentivize a moderately loaded and a fully loaded CHP plant.

Case Study: Designing an Ratepayer-Funded CHP Incentive Program

Navigant recently assisted PECO, an IOU, to facilitate the design of their DSM portfolio. CHP had been included in previous years within the custom program. As such CHP projects had received a flat incentive per projected kWh generation. However, understanding the unique challenges of CHP projects, PECO decided to develop a standalone CHP program.

PECO's Design Parameters

PECO Program Managers, PECO's Conservation Service Provider or implementation contractor, and Navigant collaborated to construct the program design parameters. The design had to be consistent with the statewide regulatory requirements and fit the objectives of PECO's long term planning. After multiple meetings and discussions, the following key parameters were determined:

1. The CHP program would encourage CHP projects across a wide range of capacity levels, realizing that smaller facilities tend to have more cost per kW of installed capacity.
2. Both energy production and a decrease in coincident summer peak demand are goals of the CHP program. PECO has regulated targets for both parameters.
3. The incentive structure would focus on overcoming initial cost as a barrier to installing CHP capability. Capacity was considered a proxy for initial cost.
4. The CHP program would limit free-riders by limiting incentives on projects that have favorable economics without incentives. Additionally project cost would be a consideration when calculating incentives.
5. The incentive structure would encourage high hours of operation, high capacity utilization, as well as metering of the electricity generation.
6. Incentives would primarily be paid at start-up of the facility as PECO has limited mobility of incentive budget from year to year.
7. The CHP Program would encourage best practices within CHP technology by requiring minimum efficiency thresholds for each technology. Efficiencies were set according to typical technology efficiencies and actual project data from PECO's existing custom DSM program.
8. PECO have the ability to adjust incentive levels so that savings targets are met.
9. PECO's incentive exposure would be limited by project incentive maximums.

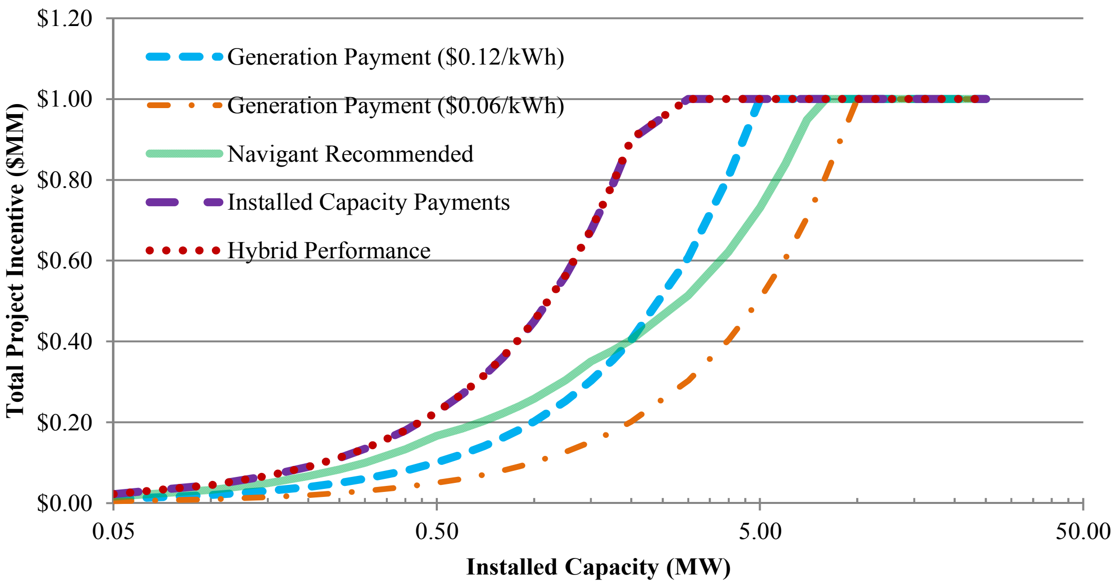
Overall program success will be measured by the ability of the CHP program to deliver energy generation as well as coincident summer demand reduction at targeted levels. PECO's incentive and non-incentive costs would have to be met. PECO would favor long term acceptance of CHP technology as evidenced by enrolling projects across a wide variety of industrial facilities, CHP capacities and CHP technology types.

Incentive Analysis for PECO CHP Program

Navigant developed a dynamic model to analyze and compare various incentive structures. The model included generation payments, capacity payments, tiered capacity payments, tiered capacity with performance payments, and hybrid performance payments. The model used actual parameters from existing CHP programs to estimate project incentives under the different incentive structures.

Navigant compared PECO's previous incentive structure in their custom program to actual incentive rates and parameters from several other existing programs. The model used an estimated $1,200/kW for an installed CHP system.[1] Using their incentive model, Navigant graphically represented the effects of incentive structure and project size on total project incentives. Figure 1 illustrates the estimated incentive amount versus installed capacity for various incentive structures. Note the installed capacity scale is logarithmic.

Figure 1. Estimated Total Incentive Amount versus Installed Capacity



Navigant and PECO staff reviewed the model and manipulated inputs in an iterative, real-time process. The team reviewed capacity tiers, rates, and caps with the objective of an incentive structure that:

- allows for robust incentives at small CHP plants that are challenged by high first-costs and slow returns on investment,
- minimizes risk of freeridership of larger CHP plants that typically can justify the investment without utility incentives,

[1] The EPA uses $1,200/kW as a typical CHP installation cost. However, it should be noted that costs vary greatly by capacity and technology.

- provides the majority of incentives in the year the CHP plant is installed, and program savings are claimed,
- requires the program participant to submit actual performance, thereby assisting in verification and assuring performance is a portion of the incentive, and
- requires steps be taken to minimize performance degradation.

As Figure 1 shows, the incentive levels in the installed capacity payment and hybrid performance payment structures provide the highest incentives for all projects, and the incentives hit PECO's maximum incentive level of $1,000,000 at lower capacities than the other scenarios. The historical PECO incentive of $0.12/kWh provided relatively low incentives for small installations, but the incentive level increased quickly to the maximum. The revised PECO incentive of $0.06/kWh would have lowered the incentives for all projects below the maximum.

Navigant and PECO agreed that both a capacity and a performance incentive would be required if incentives were to be primarily in the year savings is claimed and some assurance of performance were to be required. Additionally a tiered model would be needed to provide larger incentive rates for smaller CHP plants than larger ones. Table 3 summarizes PECO's full program design resulting from this exercise.

Table 3. PECO Proposed CHP Program Design Results

Program Design Consideration	Recommendation
Incentive Structure	Tiered capacity with performance payment
Incentive Rates	\$300/kW for first 500 kW of capacity \$150/kW for capacity between 500 kW and 1.5 MW \$75/kW for capacity between 1.5 MW and 10 MW \$0.02/kWh for first-year electricity generation
Performance Monitoring Period	One year
Capacity Incentive Maximum	40% of project cost
Total Incentive Maximum (Capacity plus Performance)	\$1,000,000 per project or 50% of project cost
Minimum Overall Efficiency Levels	Steam turbine: 80% Reciprocating engine: 70% Gas turbine: 70% Microturbine: 65% Fuel cell: 55% Other: 60%.
Warranty	Require a five-year warranty for all system components and service. Warranty period begins at the date of electric grid interconnection.
Other	Require the project sponsor to designate a primary contact who is responsible for the design, installation, service, and warranty of installed systems.

Source: Navigant analysis.

Based on the results of the scenario modeling and several iterations of inputs, Navigant recommended implementing a capacity tiered incentive rate with a bonus performance payment. Typical CHP utilization would result in a majority of the incentive to be capacity based. By focusing on upfront capacity incentives, PECO can then scale the incentive to the upfront cost of installing CHP technologies. Ultimately, Navigant and PECO used a one-year performance monitoring duration with a \$1,000,000 US dollar total incentive maximum and not to exceed 50% of total project costs. After one year of operation, PECO would also provide a modest performance incentive based on the actual electricity generated. The performance monitoring period will reduce the risk of projecting energy savings while simultaneously collecting data to be used in verification.

Conclusions and Future Work

A combination of technology advances, energy costs, utility costs and societal benefits have generated increased interest in industrial facility CHP systems. Utilities and governmental entities seeking to incorporate CHP programs into their Demand Side Management portfolios have a wide variety of options to fit their individual constraints and design preferences. While more complicated to implement, programs that require performance measurement offer the greatest assurance for utilities quantifying savings. Additionally, a variety of generation technologies offer varying performance and should be considered within their respective technology type.

As a result of Navigant's innovative incentive modeling, the incentive structure designed for PECO met the goals of the stand-alone CHP program by offering the appropriate incentive amount by project size, including a performance-based bonus to limit over-incentivizing under-performing installations, and requiring facility ownership of the project.

Incentive structures to encourage the CHP approach could develop in new directions as the field evolves. Future work may include investigating the effect of technology-differentiated incentive tiers. While this paper acknowledged that generation costs vary depending on the technology chosen, it did not explore the role these technology-differentiated costs should play in determining incentives.

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