LSU Center for Energy Studies

Combined Heat & Power in Louisiana: Status, Potential, and Policies.

Phase 2 Report: Technical & Cost-Effectiveness Methodologies

Prepared for the Louisiana Department of Natural Resources

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

August 11, 2014

LSU CENTER FOR ENERGY STUDIES

Table of Contents

1.0	Executive Summary
2.0	Introduction
3.0	Market Identification
4.0	Technical Potential
5.0	Economic Potential: Overview
6.0	Economic Potential: Energy Savings Benefits
7.0	Economic Potential: CHP Costs
8.0	Economic Potential: Cost-Effectiveness
9.0	Sensitivities
10.0	Conclusions

EXECUTIVE SUMMARY – PROJECT OVERVIEW

The methodological goal for this project is to estimate firm/industry-specific CHP opportunities. The model is based upon four primary components including: (1) market identification; (2) technical potentials analysis; (3) economic potentials analysis; and (4) sensitivity analyses.

The market identification will select the relevant firms and industries that are potential candidates for CHP development.

The technical potentials analysis will screen all firms selected in the market identification for their technical abilities to install CHP, which are based primarily upon each firm's thermal and electrical energy use characteristics.

The economic potential analysis starts with all firms having the technical capability for CHP. Costs and benefits for each of these firms will be evaluated and only those firms with cost-effective CHP opportunities will be selected.

The economic potentials will be subjected to a variety of sensitivities in order to ascertain the robustness of the empirical results.

Section 2: Introduction

Modeling Overview

The empirical model utilized to examine the cost-effective opportunities for additional CHP development is comprised of four primary components that include:

1) Market scope identification;
2) Technical potentials identification;
3) Economic potentials estimation; and
4) Sensitivity analyses.

In addition, data, as well as a number of operational assumptions are necessary in order to make each of the model components tractable. Each of the aforementioned components progress sequentially starting with market identification and working down to the sensitivity analysis.

Schematic: CHP Modeling Components

Market Identification

↓

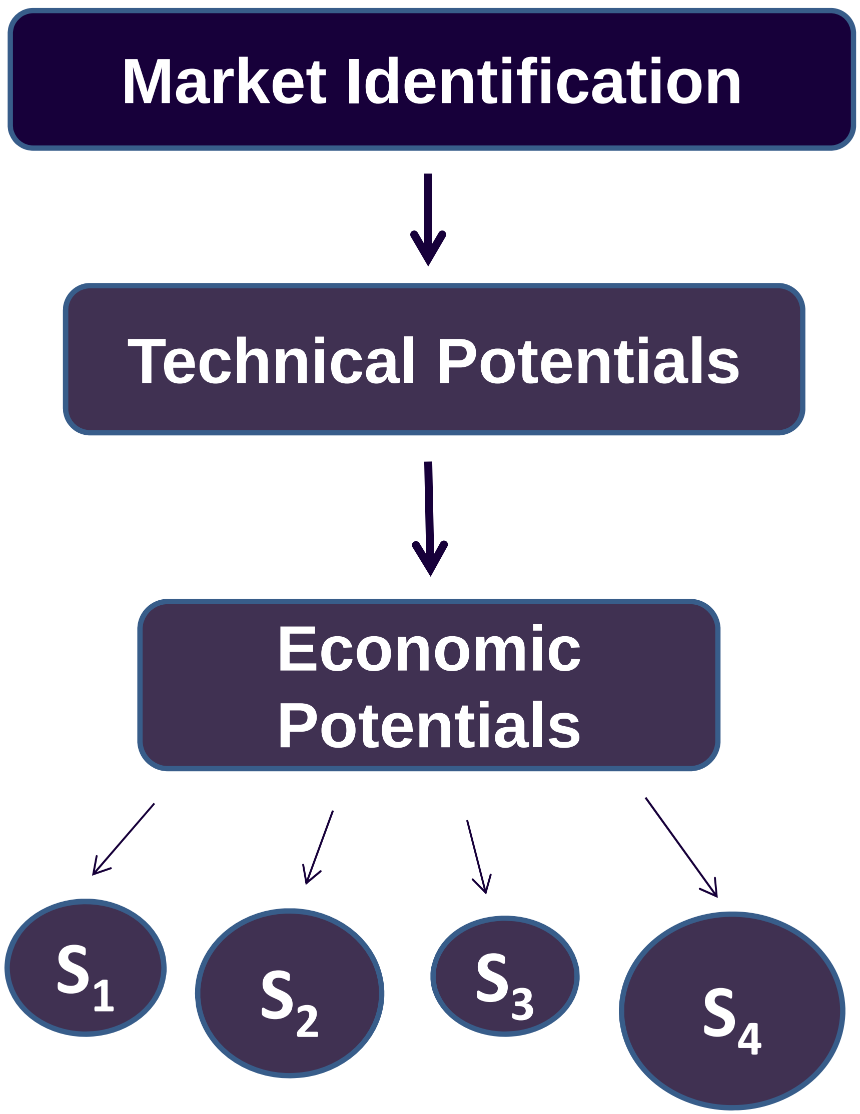
Technical Potentials

↓

Economic Potentials

S_1 S_2 S_3 S_4

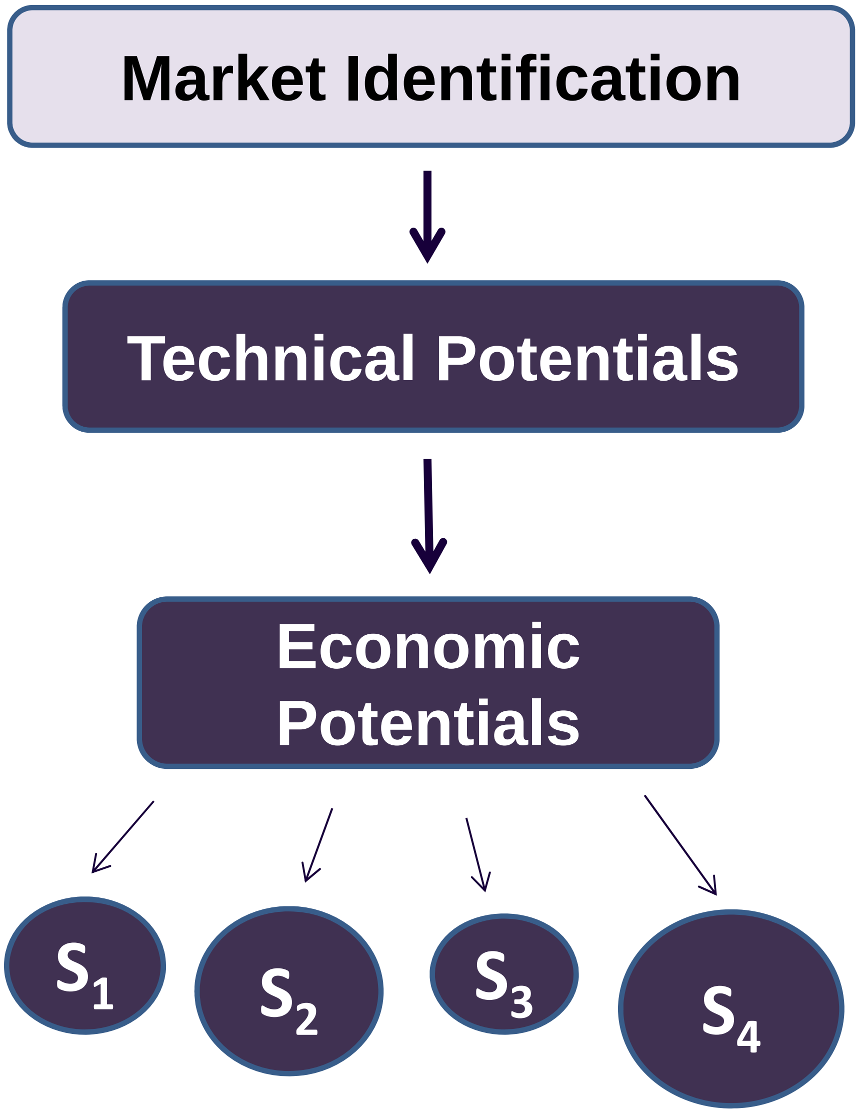
CHP Modeling Components: Market Identification



Each box decreases in size since each represents a sequential component of the modeling process starting from the highest level of aggregation to the smallest. The market is first defined, followed by the technical potentials (which is a subset of the market), followed by the economic potentials (which are a subset of the technical potentials), followed by sensitivities, impacts of which vary depending upon their nature and underlying assumptions.

Section 3: Market Identification

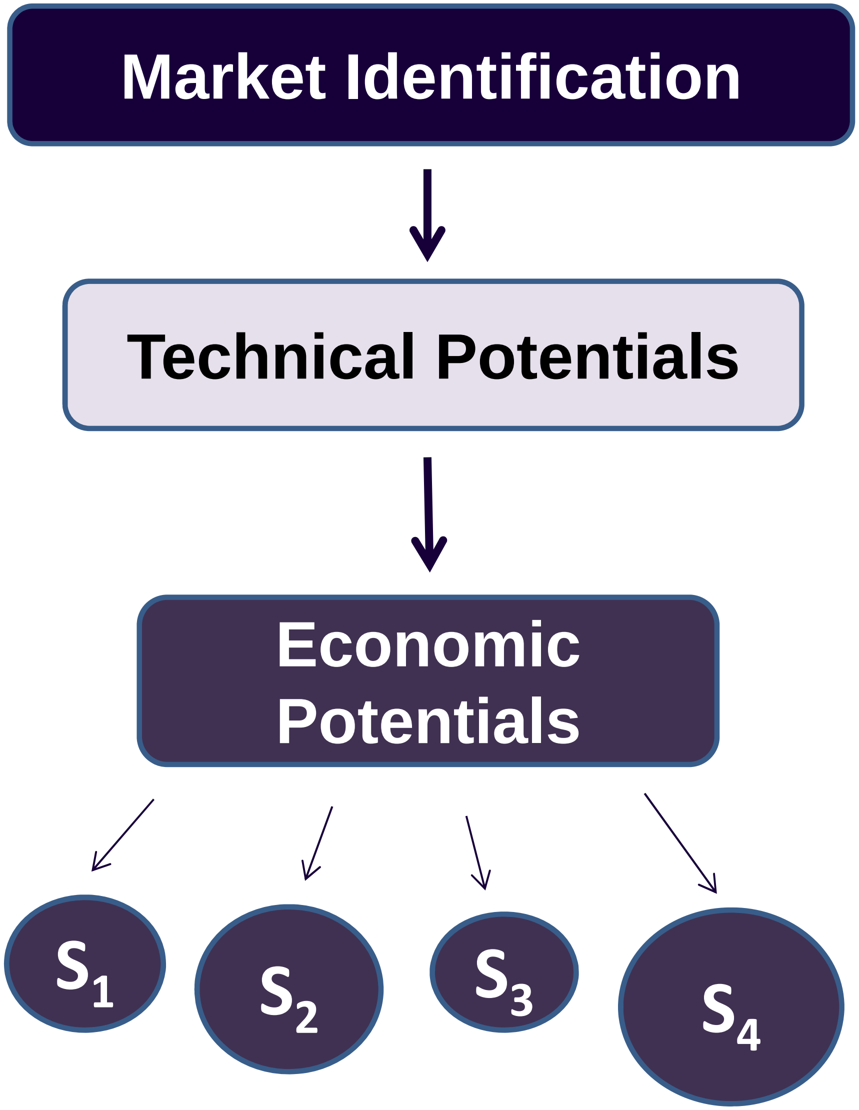
CHP Modeling Components: Market Identification



The first step in the modeling process is to identify the relevant market. For purposes of this research, the relevant market will be restricted to identifying commercial and industrial CHP applications. Thus, all Louisiana businesses and industries will be included for consideration. The unit of analysis will be at the facility level.

Section 4: Technical Potential

CHP Modeling Components: Technical Potentials



The technical potential for installing CHP is based on all candidate sites that have the technical capabilities to install CHP without regards to economics, ascetics, zoning ordinances, or other non-technical factors that would limit CHP development.

Technical Potential Screens

Three different screens were used to examine the electrical and thermal energy use for each Louisiana business and industry included in the CHP eligible market. These screens are:

1) A total thermal energy use screen (S^1)
2) A thermal energy use load factor screen (S^2)
3) An electric to thermal ("ET") energy use screen (S^3).

Business and industries that pass all three screens are considered to have the technical potential to install and operate CHP. These technical CHP candidates serve as the starting point for the subsequent economic potentials analysis.

Thermal Energy Use Screen (S^1)

Credible CHP analyses recognize that not all end users have the operational need for both electrical and thermal energy. CHP applications are capital intensive, and the on-site needs for both types of energy helps to drive down overall average development and operating costs. While recent technological innovations do allow for relatively small scale power operations, these applications often do not have large thermal requirements, or requirements scalable (proportional) with the power application and its heat output. Further, the technical and economic requirements of moving steam to a remote location for alternative use is often challenging if not (cost) prohibitive.

Thus, the first screen in the technical potential analysis is to identify and remove all candidate locations that (1) do not have a thermal load requirement or (2) have an inadequate thermal load requirement for steam that is less than 250 degrees Fahrenheit in temperature and 50 pounds per square inch gauge ("psig") in pressure.

First Screen (S^1) Formulation

The total thermal energy screen, S^1, is given by:

$$S^1{}_i = 1 \qquad if\ U_i > 0\ or$$
$$H_i \geq 100°\mathrm{F}\ \text{and}$$
$$P_i \geq 50\ psig$$

$$S^1{}_i = 0 \qquad otherwise$$

Where i indexes each individual candidate site, U_i is the candidate site's on-site thermal energy use measured in MMBtus, H_i is the candidate site's reported temperature for on-site steam use and P_i is the candidate site's reported on-site steam pressure. When S^1 = 1, the site passes the first technical screen and fails otherwise.

Load Factor Screen (S^2)

Those candidate CHP sites that pass the first total thermal use screen are subjected to a second thermal energy use screen examining their thermal energy use variation.

The load factor screen is used to ensure that thermal energy use is relatively stable and year round as opposed to seasonal and cyclical. The thermal load factor is estimated as the ratio of the candidate site's average to peak thermal energy usage. A ratio of 1.0 indicates that the site has steady year round usage with no variation between peak and average use. Lower ratios indicate higher degrees of thermal energy use variation. These ratios can be expressed in percentage terms by multiplying by 100.

The load factor screen selects only those sites with a thermal load factor greater than 50 percent (0.50)

Second Screen (S^2) Formulation

The thermal load factor screen, S^2, is given by:

$$S^2{}_i = 1 \qquad if\ \frac{A_i}{P_i} \geq 0.50$$
$$S^2{}_i = 0 \qquad otherwise$$

Where A_i is the candidate site's average on-site thermal energy use measured in MMBtus, P_i is the candidate site's reported peak on-site thermal energy use. When S^1 = 1, the site passes the first technical screen and fails otherwise.

Electricity/Thermal Ratio Screen (S^3)

The ratio of a candidate site's electric to thermal ("ET") energy use is used as the last technical potentials screen to recognize that some proportional need for steam and power is necessary in order for a CHP project to be developed. While excess power can be "put" to the host utility grid given PURPA requirements, the same is not true for steam.

The ET ratio screens out candidate sites with a ratio below 2.38 which is the thermal efficiency requirement needed to qualify for avoided cost rates under PURPA. §292.205 of PURPA identifies 42 percent as the required thermal efficiency requirement, the inverse of which, is 2.38.

Third Screen (S^3) Formulation

The ET ratio screen, S^3, is given by:

$$S^3{}_i = 1 \qquad if\ \ 2.38 \geq \frac{E_i}{U_i} \ \geq\ 0.001$$
$$S^3{}_i = 0 \qquad otherwise$$

Where E_i is the candidate site's electricity use standardized to MMBtus and U_i is the candidate site's thermal energy demand also standardized in MMBtus.

When S^3 = 1, the site passes the third technical screen and fails otherwise.

Technical Potentials Selection

Candidate sites are selected as being technically capable for a CHP installation if they pass all three screens discussed earlier. Mathematically, this overall technical potentials screen is defined as:

$$S^T{}_i = 1 \qquad if\ S^1{}_i = 1\ and\ S^2{}_i = 1\ and\ \ S^3{}_i = 1$$

$$S^T{}_i = 0 \qquad otherwise$$

When $S^T = 1$, the site is selected as having the technical potential for CHP and is further evaluated in the second part of the analysis for cost-effectiveness.

Section 5: Overview, Economic Potential

CHP Modeling Components: Economic Potentials

Market Identification

↓

Technical Potentials

↓

Economic Potentials

S_1 S_2 S_3 S_4

The economic potential is defined as those candidate sites that have the technical capabilities to install CHP and where the project life benefits of the CHP installation are greater than the project life costs on a net present value ("NPV") basis.

Economic Potentials Modeling: Overview

In general, candidate sites are identified as being cost-effective if their benefits are greater than or equal to their costs:

$$E_i = 1 \qquad iff\ G^B{}_i \geq G^C{}_i$$
$$E_i = 0 \qquad otherwise$$

Where $G^B{}_i$ are the benefits associated with the candidate site adoption of CHP and $G^C{}_i$ represents the costs of the candidate site adopting CHP. If E_i = 1, the site is identified as being a cost-effective candidate for CHP.

Economic Potentials Modeling: CHP Benefits

The economic benefits of CHP at each candidate site (${G^B}_i$) are determined by the sum of the potential projects avoided energy costs associated with electrical (${S^E}_i$) and thermal energy (${S^H}_i$) as well as any revenues (${R^E}_i$) that may be earned from excess power sales. Mathematically, this can be expressed as:

$${G^B}_i = {S^E}_i + {S^H}_i + {R^E}_i$$

Section 6: Energy Savings Benefits

CHP Benefits: Electricity Savings Determination

Electricity expenditures for most larger commercial and industrial customers are broken into three components: energy charges; demand charges; and customer/facility charges.

Facilities and customer charges are not avoidable since all CHP candidates in this study are assumed to continue to remain interconnected to the host utility grid for emergency and backup service.

Energy and demand charges are potentially avoidable. These charges are unique to each in-state electric utility and are regulated by the Louisiana Public Service Commission ("LPSC")

Electricity Savings: Avoided Energy and Demand Charges (Electricity)

Energy charges are based upon the variable cost of generating electricity which is primarily fuel by will vary in absolute value across utilities depending upon their: (1) fuel cost procurement efficiency; (2) fuel diversity; and (3) generating fleet efficiency.

Demand charges are associated with the cost recovery of capacity developed to serve peak loads and are usually assessed to large customers on a fixed price per kilowatt (“kW”) basis.

[1]Technically, fuel costs are recovered under a separate volumetric charge often referred to as a “fuel adjustment clause or “FAC.” For purposes of discussion in this report, the “energy charge” referenced in this report should be interpreted to include both the base rate and fuel related volumetric rates unless otherwise indicated.

Electricity Savings: Avoided Energy and Demand Charges

Total electricity savings equals the net present value of all the avoided energy and demand charges over the life (t) of the project, valued at discount rate (r):

$$S^E{}_{it} = \left(\sum_{t=1}^{T} E^s{}_{it} + D^s{}_{it}\right)e^{-rt}$$

Where $E^s{}_{it}$ is the avoided annual energy charges and $D^s{}_{it}$ is the avoided annual demand charges for each year (t) such that in each year:

$$(E^s{}_{it} + D^s{}_{it}) = (p^E{}_{it}q^E{}_{it} + p^D{}_{it}q^D{}_{it})$$

Where each p represents the energy and demand charge (or price) faced by firm i in year t and q is the annual quantity of energy and demand purchased by firm i in year t.

Avoided Thermal Energy Charges

Thermal energy savings are derived by taking the summation of all the avoided thermal energy costs over the life of the project as given by:

$$S^{H}{}_{it} = \sum_{t=1}^{T} h^{s}{}_{it}$$

Where $h^{s}{}_{it}$ represents avoided annual thermal energy costs, standardized in MMBtus, for each year (*t*) that the CHP project is operational such that:

$$(h^{s}{}_{it}) = (p^{h}{}_{it} q^{h}{}_{it})$$

Revenues from CHP Electricity Sales

Total electricity sales revenues are derived by taking the summation of all annual excess electricity sales over the life of the project as given by:

$$R^{E}{}_{it} = \sum_{t=1}^{T} p^{a}{}_{it} q^{ES}{}_{it}$$

Where p^{a} represents annual prices for excess energy sales (at avoided costs) for each unit of excess electricity sales q^{ES}.

Section 7: CHP Costs

CHP Costs

The costs associated with CHP development are generally based upon the initial capital costs of purchasing and installing the CHP equipment as well as any other supporting equipment and balance of plant investment. The return on the investment and the return of the investment, through its annual depreciation allowance, represent the annual capital costs associated with CHP development.

Other costs tend to be more variable in nature and include annual fuel costs, annual operation and maintenance ("O&M") costs, and a variety of other miscellaneous costs.

Formulation of CHP Costs

Total CHP costs are the net present value of all the capital and variable costs associated with project development and operation over the life (t) of the project, valued at discount rate (r):

$$G^{C}{}_{it} = \left(\sum_{t=1}^{T} (K^{G}{}_{it} - D^{G}{}_{it}\right)(1-r)$$

$$+ d_{it} + \left(p_{it}^{f} q_{it}^{f}\right) + (p_{it}^{o} q_{it}^{o}) + (p_{it}^{z} q_{it}^{z}))e^{-rt}$$

Where K^{G} is the gross capital cost of the CHP investment, D^{G} is the accumulated depreciation, d_{it} is the annual depreciation expense, $p_{it}^{f} q_{it}^{f}$ are the annual fuel costs, $p_{it}^{o} q_{it}^{o}$ are the annual operations costs, and $p_{it}^{z} q_{it}^{z}$ are other annual costs.

Section 8: Cost Effectiveness

Cost Effectiveness Definition & Formulation

Cost effectiveness is calculated based upon a comparison of the CHP benefits and costs outlined in the earlier two sections of this report. As noted earlier, candidate sites are identified as having cost-effective CHP opportunities if their estimated CHP benefits are greater than their costs expressed as:

$$G^{B}{}_{i} \geq G^{C}{}_{i}$$

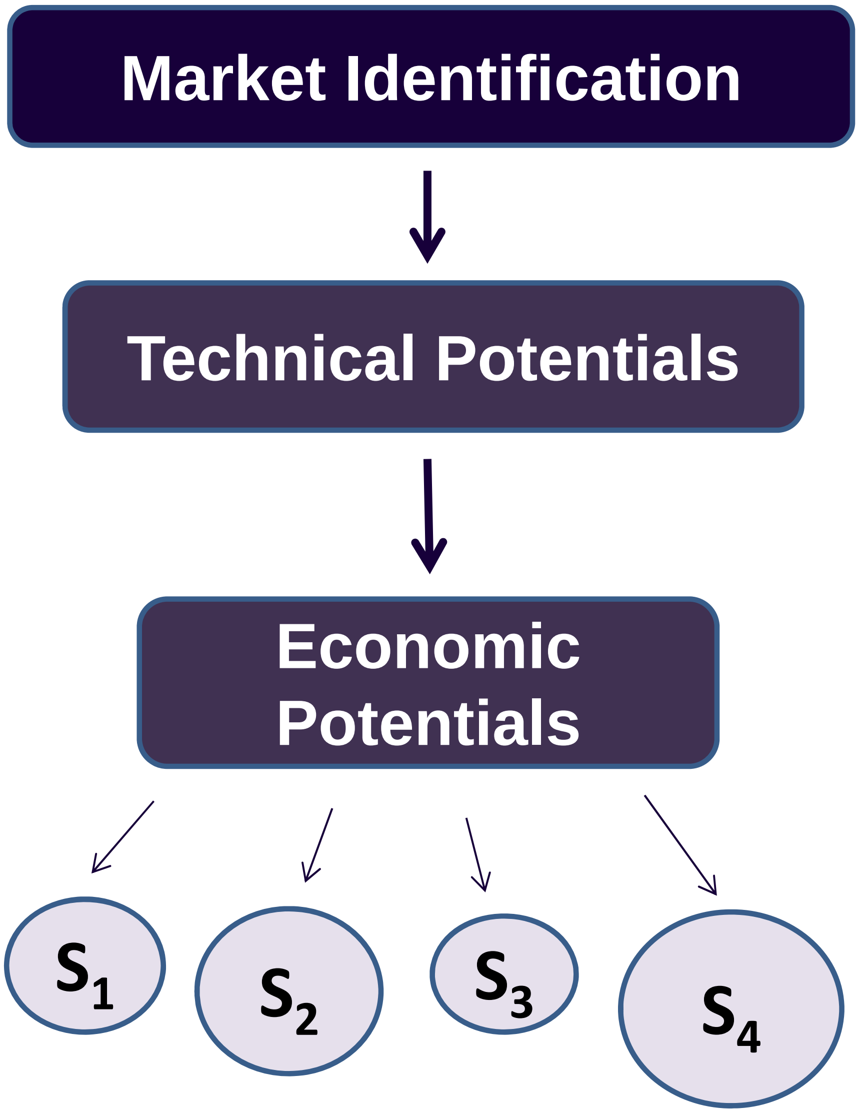
This relationship can be expressed in ratio-form as a benefit-cost ratio given by:

$$\frac{G^{B}{}_{i}}{G^{C}{}_{i}} \geq 1.0$$

A candidate site can be identified as being cost effective if the ratio given above is greater than, or equal to, a value of 1.0.

Section 9: Sensitivities

CHP Modeling Components: Sensitivities



Sensitivities are conducted to test the robustness of the empirical results. Sensitivities are based upon the relaxation of certain assumptions in both the technical and economic potentials analysis. The results of changing these assumptions will likely have differing positive and negative impacts on the size of the estimated CHP economic potentials. Specific sensitivities will be identified in the Phase 3 Report.

Section 10: Conclusions

Summary and Conclusions

The methodological goal for this project is to estimate firm/industry-specific CHP opportunities. The model is based upon four primary components including: (1) market identification; (2) technical potentials analysis; (3) economic potentials analysis; and (4) sensitivity analyses.

The market identification will select the relevant firms and industries that are potential candidates for CHP development.

The technical potentials analysis will screen all firms selected in the market identification for their technical abilities to install CHP, which are based primarily upon each firm's thermal and electrical energy use characteristics.

The economic potential analysis starts with all firms having the technical capability for CHP. Costs and benefits for each of these firms will be evaluated and only those firms with cost-effective CHP opportunities will be selected.

The economic potentials will be subjected to a variety of sensitivities in order to ascertain the robustness of the empirical results.