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Edward J. Bloustein School of Planning and Public Policy

Costs and Benefits of Combined Heat and Power

June 19, 2013

Draft v.2

With minor modifications to the presentation made to the NJ CHP/FC Working Group on 19 June 2013 (marked in red)

Center for Energy, Economic and Environmental Policy,
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AGENDA

1. Context of a Cost-Benefit Analysis (CBA)
2. Approach for analysis
   a. Caveats
   b. Database for major Technical & Financial assumptions
   c. Methodology for cost-benefit calculations
   d. Major assumptions requirement from stakeholders
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We would like to thank Gearoid Foley, Richard Sweetser and the Mid-Atlantic Clean Energy Application Center for their time and valuable inputs.

Note: References used by CEEEP can be found at http://policy.rutgers.edu/ceeep/chp

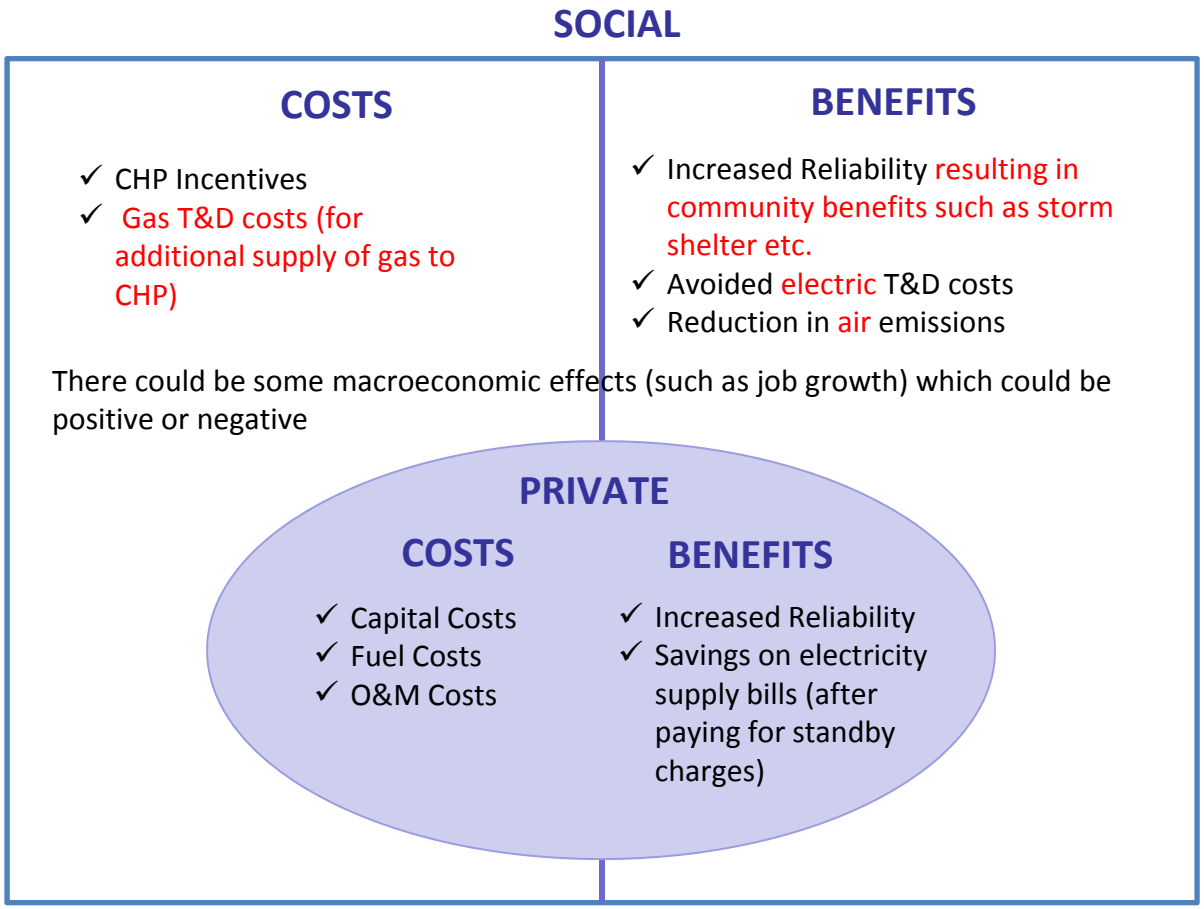
General Remarks on Cost-benefit Analysis

1. Cost-benefit analysis (CBA) is an economic tool that reduces costs and benefits that occur over time into a numerical score
    a. Benefit/Cost (B/C) ratio, Net Present Value (NPV), Return on Investment (ROI), Payback Period
    b. The time value of money and the risk associated with the investment are both captured in the discount rate
2. CBA is relatively easy to use but also easy to misuse
3. CBA only accounts for efficiency but not other values and objectives such as equity and therefore should inform public policy but not be dispositive
4. A CBA can be conducted from different perspectives, e.g., from that of a project developer or society

Private vs. Social Costs and Benefits

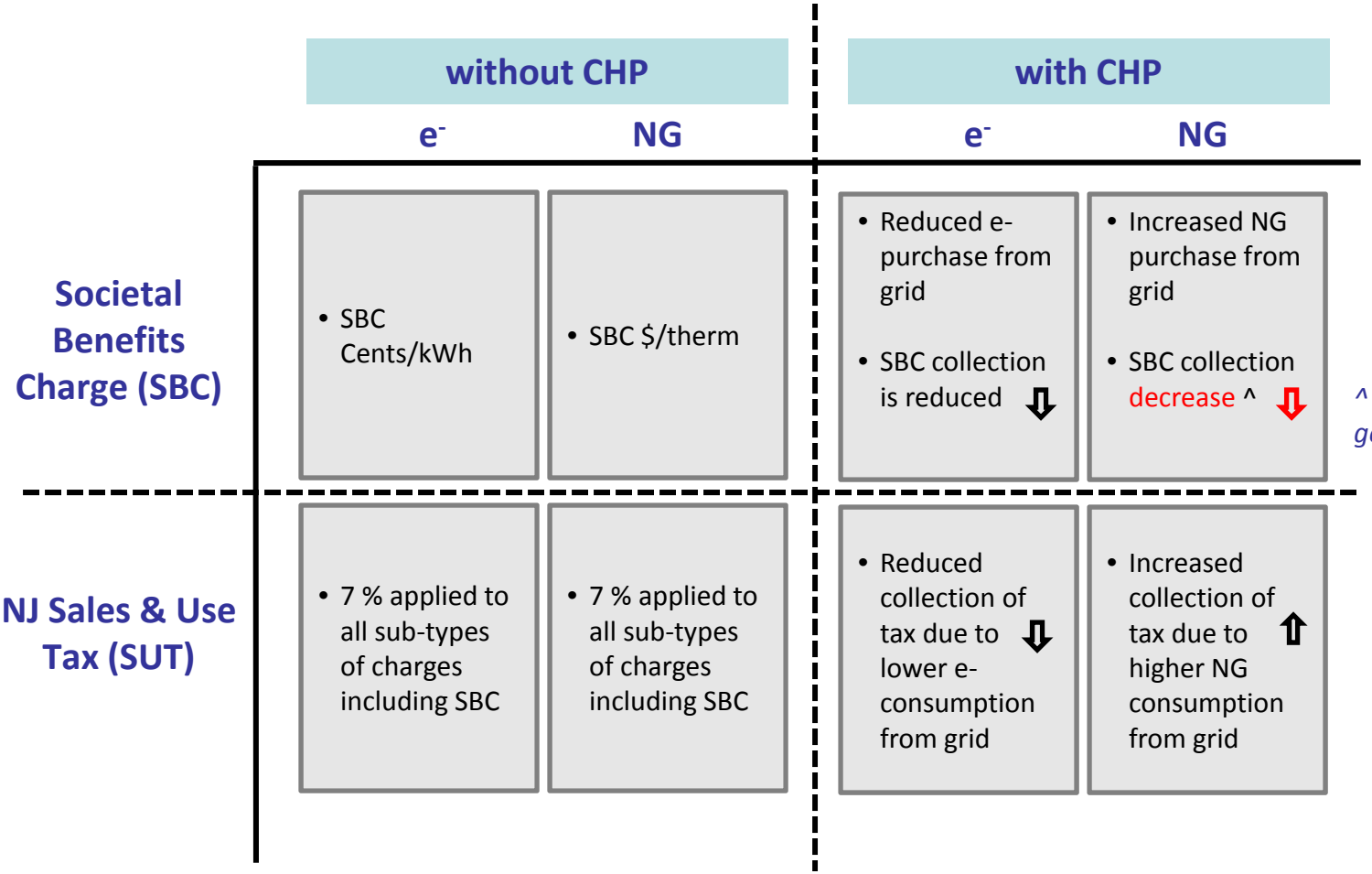
1. Economists distinguish between private costs and benefits and social costs and benefits
2. Actions taken by private individuals or entities that result in society bearing costs or receiving benefits are called externalities
3. A CBA conducted from a private perspective may be different than from a social perspective
4. In a social CBA, payments from one part of society to another are transfers not benefits or costs; of course to the individual parties they are considered benefits or costs
5. The above are incorporated in NJ's CBA of energy efficiency programs

Private vs. Social Costs and Benefits (contd.)



The above does not consider impact of SBC & SUT (discussed on next slide)

Private vs. Social Costs and Benefits – SBC & SUT



^ assuming all electricity generated is self-consumed

Private vs. Social Costs and Benefits – Air Emissions (1)

without CHP

CO_2 emissions from e⁻ generation

Fuel Type	% Marginal Run (2012) PJM State of the Market 2012*	US Avg. Emissions Rate CO_2 (lbs/MWh) EPA*
Coal	58.8%	2,249
Gas	30.4%	1,135
Oil	6.0%	1,672
Wind	4.2%	0
Other	0.5%	0
Municipal Waste	0.1%	2,988
Average 2012		1,770

with CHP

CO_2 emissions from e⁻ generation

CHP Type	Emissions Rate CO_2 (lbs/MWh) #	Source of Information
RE 1 MW	1,142	EPA Catalog
RE 3 MW	1,110	EPA Catalog
RE 5 MW	1,024	EPA Catalog
GT 10 MW	1,404	EPA Catalog

 # does not include reductions for thermal load

** For references pl see the last slide*

Private vs. Social Costs and Benefits – Air Emissions (2)

without CHP

NO_X emissions from e^- generation

Fuel Type	% Marginal Run (2012) PJM State of the Market 2012	US Avg. Emissions Rate NO_X (lbs/MWh) EPA
Coal	58.8%	6.0
Gas	30.4%	1.7
Oil	6.0%	4.0
Wind	4.2%	0
Other	0.5%	0
Municipal Waste	0.1%	5.4
Average 2012		4.3

with CHP

NO_X emissions from e^- generation

CHP Type	Emissions Rate NO_X (lbs/MWh) #	Source of Information
RE 1 MW	1.49	EPA Catalog
RE 3 MW	1.52	EPA Catalog
RE 5 MW	1.24	EPA Catalog
GT 10 MW	0.65	EPA Catalog

 # does not include reductions for thermal load

Private vs. Social Costs and Benefits – Air Emissions (3)

without CHP

SO_X & Hg emissions from e⁻ generation

Fuel Type	% Marginal Run (2012) PJM State of the Market 2012	US Avg. Emissions Rate SO_X (lbs/MWh) EPA	US Avg. Emissions Rate Hg (TPY i.e. tons per year) EPA *
Coal	58.8%	13.0	
Gas	30.4%	0.1	
Oil	6.0%	12.0	
Wind	4.2%	0	
Other	0.5%	0	
Municipal Waste	0.1%	0.8	
Average 2012		8.4	53.0

with CHP

SO_X & Hg emissions from e⁻ generation

CHP Type	Emissions Rate SO_X (lbs/MWh) #	Emissions Rate Hg (TPY) #	Source of Information
RE 1 MW	0	0	EPA Catalog
RE 3 MW	0	0	EPA Catalog
RE 5 MW	0	0	EPA Catalog
GT 10 MW	0	0	EPA Catalog

Particulate Matter (PM) emissions needs to be included

** For references pl see the last slide*

General Remarks on Combined Heat and Power (CHP)

1. CHP applications require the right combination of thermal and electric load
2. Engineering efficiency is different from economic efficiency
3. CHP facilities require black start and islanding capabilities if they are to run when the electric power system is unavailable
4. CHP applications are site specific; a generic analysis is a useful starting point, but individual applications should be examined in detailed

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CAVEATS

1. The analysis presented illustrates the capabilities of the database and model; once feedback is obtained from BPU Staff and stakeholders, preliminary results will be generated
2. Some important and large uncertainties exist in the assumptions such as:
    1. Avoided transmission and distribution costs
    2. Environmental externalities
    3. Value of loss of load
3. For a given standby charge, the CHP CBA analysis can inform policymakers about how that would affect private investment in CHP, but the CHP CBA cannot determine the appropriate standby charge
4. The CHP CBA model could be used to refine the 1,500 MW of CHP goal but that may not be necessary

Key Input parameters for CHP Economics

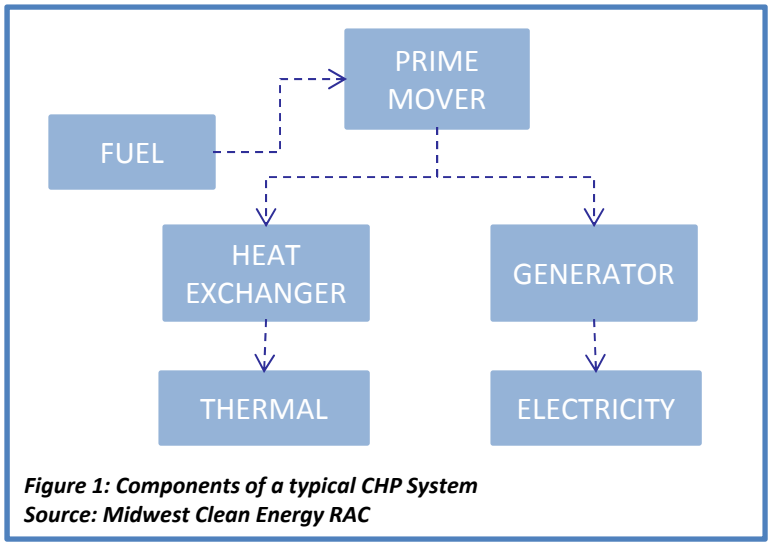
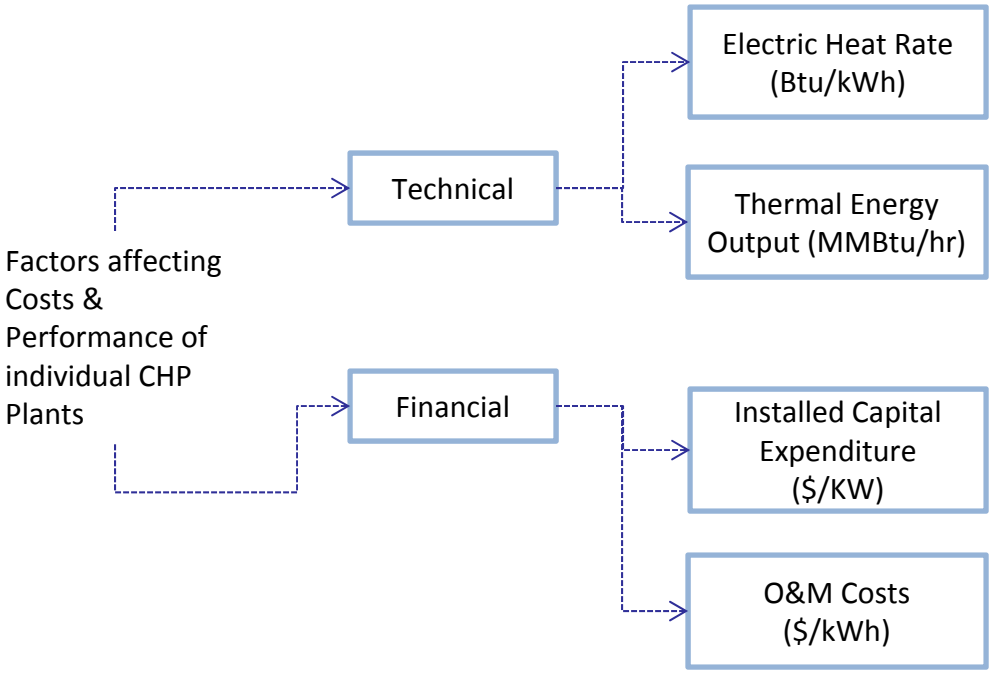
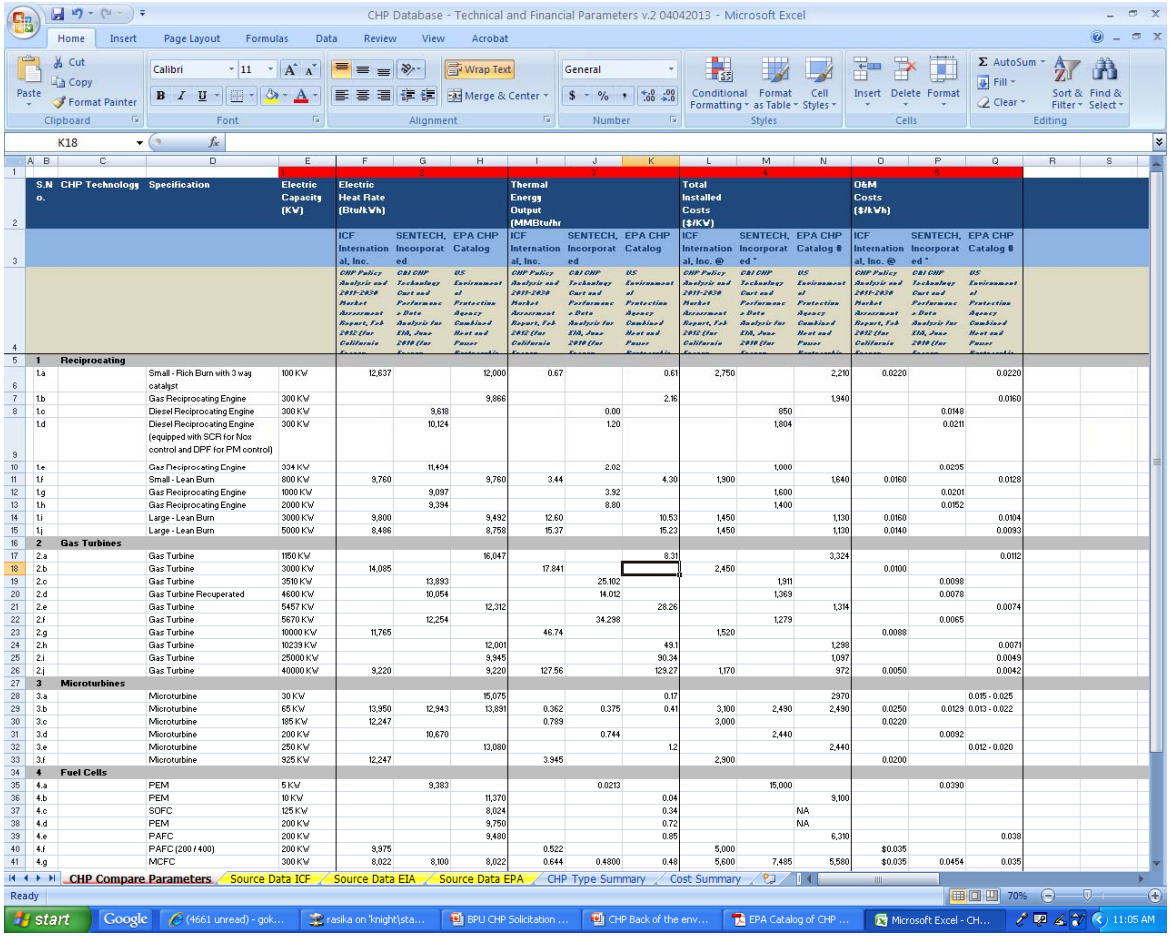


Figure 1: Components of a typical CHP System
Source: Midwest Clean Energy RAC



We have compiled a database of various CHP technologies and their corresponding technical and financial factors

Database capturing CHP Technology Type and key input parameters



Complete Database and References used by CEEEP can be found at
http://policy.rutgers.edu/ceeep/chp

1. ICF International Inc., CHP Policy Analysis and 2011-2030 Market Assessment Report, Feb 2012 (prepared for California Energy Commission)

2. SENTECH Incorporated, C&I CHP Technology Cost and Performance Data Analysis for EIA, June 2010 (prepared for Energy Information Administration)

3. EPA CHP Catalog, Combined Heat and Power Partnership, Dec 2008 (study done by Energy and Environmental Analysis – an ICF International Company)

Observations

1. Numbers from referred studies are for the whole of the US and not for the state of NJ

2. Numbers reported assume 'simple' installations and therefore no major installation costs

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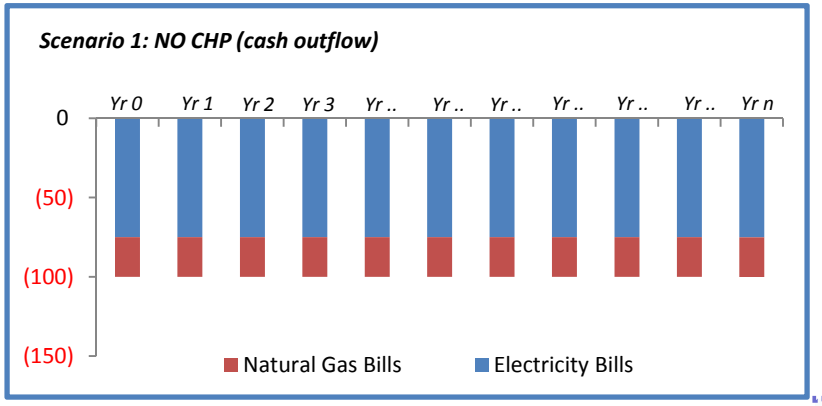
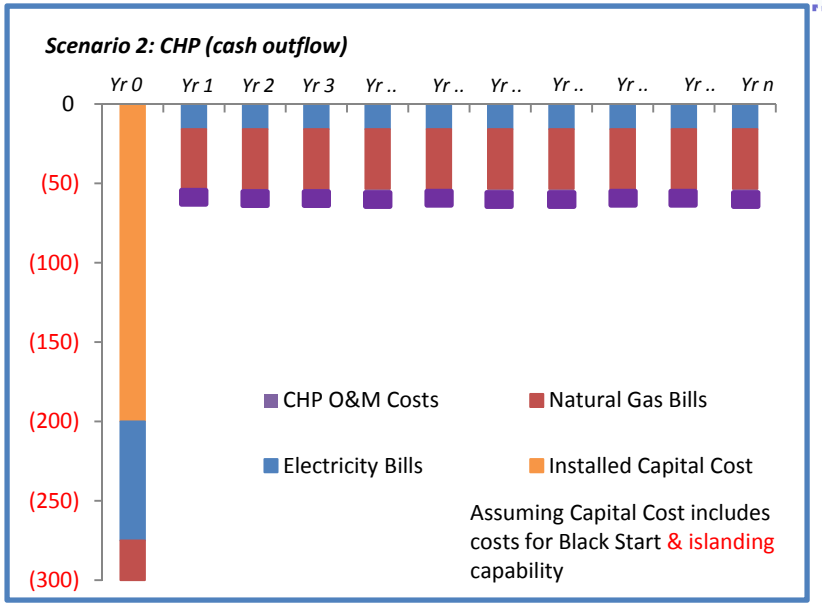
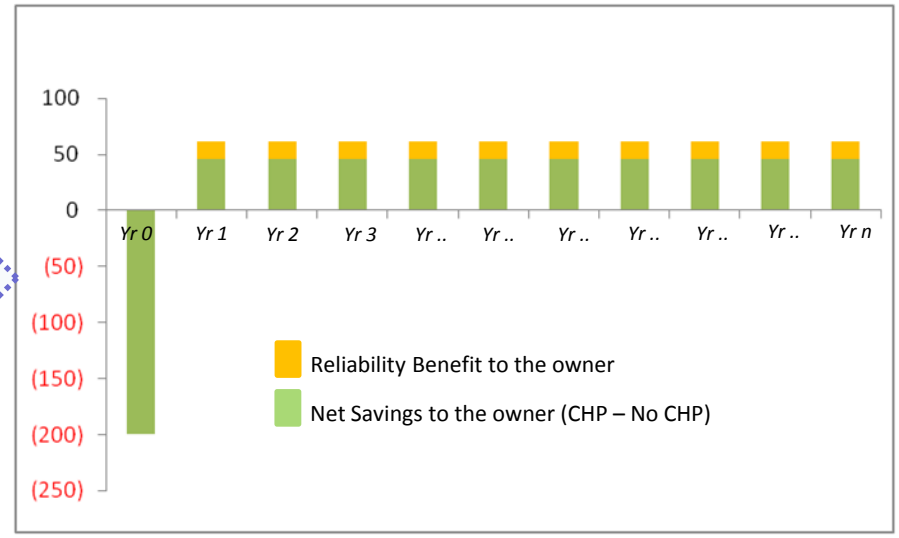
Methodology for CBA – CHP Owner's perspective



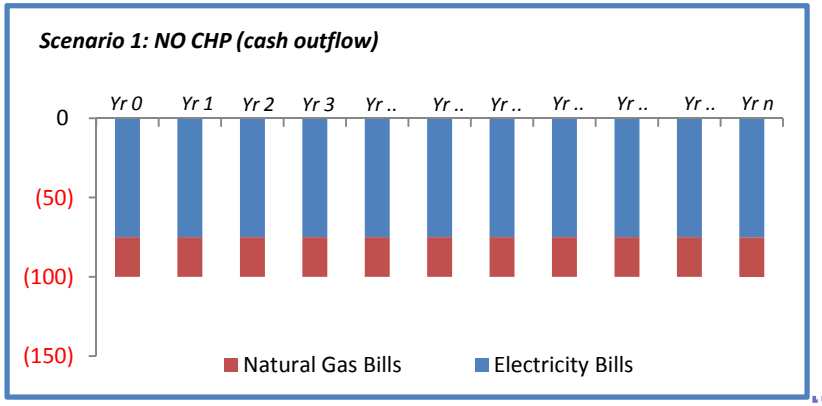


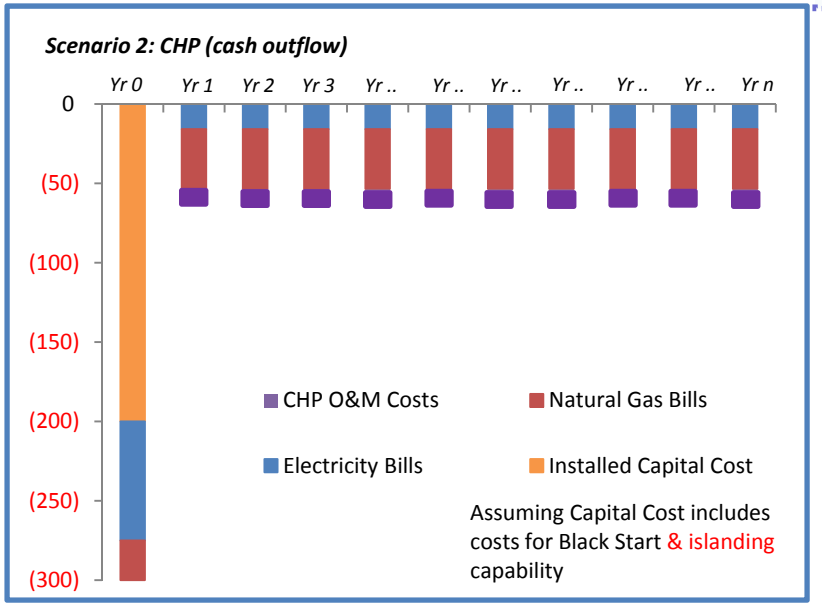


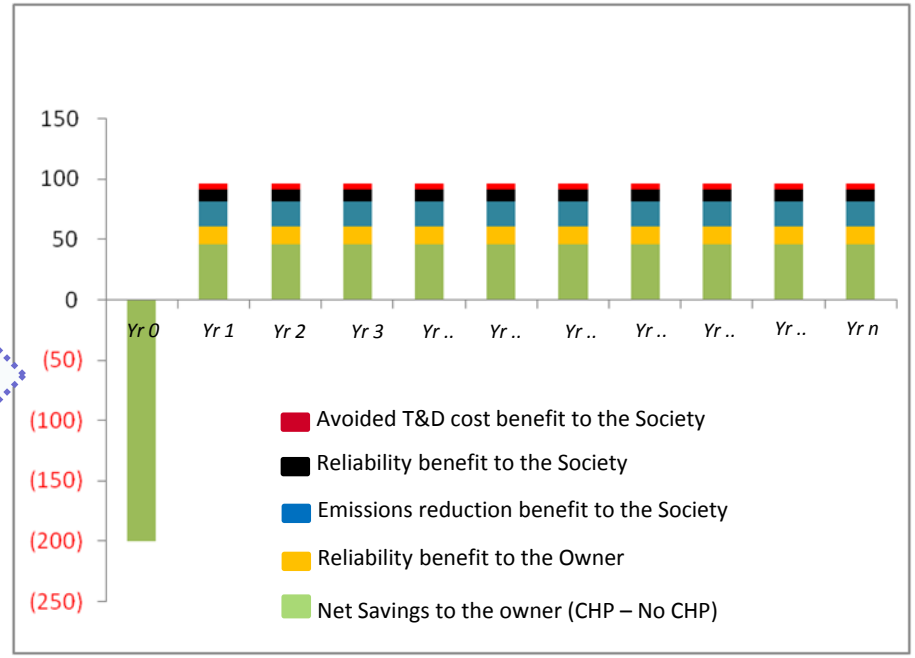
1. NPV, B/C Ratio and IRR can be determined for the above net savings realized as a result of CHP installation
2. Installed Capital Cost would account for incentives, if any, received by the CHP Owner
3. Reliability benefits in part would depend upon the Owner's ability to realize benefits in case of a grid outage

Graph not to scale; for illustrative purpose only

Methodology for CBA – Societal perspective







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Financial assumptions requested for model spreadsheet

CHP Project Key Financial Assumptions	
Debt: Equity Ratio	?
Cost of Equity (%)	?
Cost of Debt (%)	?
Loan Repayment Period (yrs)	?
Depreciation Schedule	?
CHP Project Construction Period (days)	?

NG and Electricity Tariff assumptions requested for model spreadsheet

1. CEEEP would like to meet with utility staff to understand ‘standby tariff’ for CHP users and future rates for consumers of electricity and natural gas

User consumption data required for model spreadsheet

1. CEEEP would like to receive the following data for electricity and natural gas usage by a facility
    1. Monthly Peak
    2. Monthly Usage

Reliability benefit calculation assumptions required for model spreadsheet

1. Capital Cost of Black Start equipment & islanding costs ($/KW)
2. Private & Social assumption for Value of Loss Load ($/MWh)
3. Outage frequency (no. of days/ year)

Outage assumptions depend in part on the utility plans for grid hardening

Avoided costs assumptions for model spreadsheet

1. CEEEP is updating the avoided electricity, natural gas and environmental costs assumptions

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NJ CHP – status of applications received

1. 1st round of Large Scale Combined Heat and Power – Fuel Cells (LSCHP-FC) Program (2012) – run by EDA with technical review by BPU
   a. 6 projects approved (24.8 MW)
   b. 2nd round initiated Jan 2013; 2 new applications received
2. ARRA solicitation Program (2010) - run by EDA with technical review by BPU
   a. 6 projects approved (34 MW)
3. Small-scale CHP Program – run by TRC/BPU
4. We have received detailed applications for – 1.a (6 applications), 1.b (for 1 applicant), 2.a (6 applications), 3. (4 applications)
5. These applications were not part of a competitive solicitation process

We are going through the received applications for CBA Analysis

SUMMARY OF WHAT HAS BEEN COMPLETED

1. A data base of 39 CHP technologies has been compiled using credible sources
2. A CBA model is being developed which would do the analysis of CHP from the perspective of owner and the society
3. Test cases are been run through the model
4. Stakeholders are been asked to provide input assumptions

Stakeholders are requested to provide their inputs on assumptions within a period of 2 weeks from today

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Specific Next Steps

1. Comparison of stakeholder assumptions with information from received applications
2. Conduct CBA from an owner's and societal perspective for received applications and for generic projects

Questions/Comments

Can be addressed to the below email ids

1. ffelder@rutgers.edu
2. rasika.athawale@rutgers.edu

References

1. PJM State of the Market – 2012, Section 2 – Energy Market, pg. 62
2. EPA – Air Emissions - http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html (last updated June 20, 2013)
3. EPA – Sources of Mercury Emissions in the US - http://www.epa.gov/mats/powerplants.html